U.S. Department of Energy

Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs

Topics

FY 2014
Phase I
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Participating DOE Research Programs

- Office of Advanced Scientific Computing Research
- Office of Basic Energy Sciences
- Office of Biological and Environmental Research
- Office of Defense Nuclear Nonproliferation
- Office of High Energy Physics
- Office of Nuclear Physics

Change Control Table	
Date	Change
July 15, 2013	Original Release of Topics
July 19, 2013	Page 67 – Inserted topic description for "Technologies for Subsurface Characterization and Monitoring"
July 24, 2013	Topic 03c – Description re-described and rewritten
September 13, 2013	Topic 21d – Corrected title

Schedule

Event	Dates
Topics Released:	Monday, July 15, 2013
Funding Opportunity Announcement Issued:	Monday, August 12, 2013
Letter of Intent Due Date:	Tuesday, September 03, 2013
Application Due Date:	Tuesday, October 15, 2013
Award Notification Date:	Monday, January 6, 2014*
Start of Grant Budget Period:	Tuesday, February 18, 2014*

*Dates Subject to Change

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TECHNOLOGY TRANSFER OPPORTUNITIES

Selected topic and subtopics contained in this document are designated as **Technology Transfer Opportunities** (TTOs). The questions and answers below will assist you in understanding how TTO topics and subtopics differ from our regular topics.

What is a Technology Transfer Opportunity?

A Technology Transfer Opportunity (TTO) is an opportunity to leverage technology that has been developed at a university or DOE National Laboratory. Each TTO will be described in a particular subtopic and additional information may be obtained by using the link in the subtopic to the university or National Lab that has developed the technology. Typically the technology was developed with DOE funding of either basic or applied research and is available for transfer to the private sector. The level of technology maturity will vary and applicants are encouraged to contact the appropriate university or Laboratory prior to submitting an application.

How would I draft an appropriate project description for a TTO?

For Phase I, you would write a project plan that describes the research or development that you would perform to establish the feasibility of the TTO for a commercial application. The major difference from a regular subtopic is that you will be able to leverage the prior R&D carried out by the university or National Lab and your project plan should reflect this.

Am I required to show I have a subaward with the university or National Lab that developed the TTO in my grant application?

No. Your project plan should reflect the most fruitful path forward for developing the technology. In some cases, leveraging expertise or facilities of a university or National Lab via a subaward may help to accelerate the research or development effort. In those cases, the small business may wish to negotiate with the university or National Lab to become a subawardee on the application.

Is the university or National Lab required to become a subawrdee if requested by the applicant?

No. Collaborations with universities or National Labs must be negotiated between the applicant small business and the research organization. The ability of a university or National Lab to act as a subcontractor may be affected by existing or anticipated commitments of the research staff and its facilities.

Are there patents associated with the TTO?

The TTO will be associated with one or in some cases multiple patent applications or issued patents.

If selected for award, what rights will I receive to the technology?

Those selected for award under a TTO subtopic, will be assigned rights to perform research and development of the technology during their Phase I or Phase II grants. Please note that these are NOT commercial rights which allow you to license, manufacture, or sell, but only rights to perform research and development.

In addition, an awardee will be provided, at the start of its Phase I grant, with a no-cost, six month option to license the technology. It will be the responsibility of the small business to demonstrate adequate progress towards commercialization and negotiate an extension to the option or convert the option to a license. A copy of an option agreement template will be available at the university or National Lab which owns the TTO.

How many awards will be made to a TTO subtopic?

Initially we anticipate making a maximum of one award per TTO subtopic. This will insure that an awardee is able to sign an option agreement that includes exclusive rights in its intended field of use. If we receive applications to a TTO that address different fields of use, it is possible that more than one award will be made per TTO.

How will applying for an SBIR or STTR grant associated with a TTO benefit me?

By leveraging prior research and patents from a National Lab you will have a significant "head start" on bringing a new technology to market. To make greatest use of this advantage it will help for you to have prior knowledge of the application or market for the TTO.

Is the review and selection process for TTO topics different from other topics?

No. Your application will undergo the same review and selection process as other applications.

PROGRAM AREA OVERVIEW: OFFICE OF ADVANCED SCIENTIFIC COMPUTING RESEARCH

The primary mission of the Advanced Scientific Computing Research (ASCR) program is to discover, develop, and deploy computational and networking capabilities to analyze, model, simulate, and predict complex phenomena important to the Department of Energy. A particular challenge of this program is fulfilling the science potential of emerging computing systems and other novel computing architectures, which will require numerous significant modifications to today's tools and techniques to deliver on the promise of exascale science. To accomplish this mission, ASCR funds research at public and private institutions and at DOE laboratories to foster and support fundamental research in applied mathematics, computer science, and high-performance networks. In addition, ASCR supports multidisciplinary science activities under a computational science partnership program involving technical programs within the Office of Science and throughout the Department of Energy.

ASCR also operates high-performance computing (HPC) centers and related facilities, and maintains a high-speed network infrastructure (ESnet) at Lawrence Berkeley National Laboratory (LBNL) to support computational science research activities. The HPC facilities include the Oak Ridge Leadership Computing Facility (OLCF) at Oak Ridge National Laboratory (ORNL), the Argonne Leadership Computing Facility (ALCF) at Argonne National Laboratory (ANL), and the National Energy Research Scientific Computing Center (NERSC) at Lawrence Berkeley National Laboratory (LBNL).

ASCR supports research on applied computational sciences in the following areas:

- Applied and Computational Mathematics - to develop the mathematical algorithms, tools, and libraries to model complex physical and biological systems.

- High-performance Computing Science - to develop scalable systems software and programming models, and to enable computational scientists to effectively utilize petascale computers to advance science in areas important to the DOE mission.

- Distributed Network Environment - to develop integrated software tools and advanced network services to enable large-scale scientific collaboration and make effective use of distributed computing and science facilities in support of the DOE science mission.

- Applied Computational Sciences Partnership - to achieve breakthroughs in scientific advances via computer simulation technologies that are impossible without interdisciplinary effort.

For additional information regarding the Office of Advanced Scientific Computing Research priorities, click here.

1. ADVANCED NETWORK TECHNOLOGIES AND SERVICES

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Network operators face a growing need for advanced tools and services to better manage their infrastructure. Network users also need better tools and services to 1) deal with the increasing amounts of data being generated, moved, and archived; and 2) help in reporting real problems that impact their ability to use the network. Hardening existing tools and services that manage the explosive growth in data will make it easier for users to use the network.

Developing new technologies, tools, or high-level services that promote a modular use of measurement and monitoring data will make it easier for network operators to manage their infrastructure. These new modular tools and services should provide multiple levels of detail to authorized personnel with decisions on the level of detail to release under the control of the infrastructure owner. Applications should also be permitted to retrieve summary information to assist users in reporting problems. This will allow network operators to receive the detailed information needed to fix a problem while simplifying the users' ability to report a problem. Meeting both types of needs using a single measurement and monitoring infrastructure would greatly improve the network experience for a large number of users.

This topic solicits proposals that address issues related to building, operating, and maintaining large network infrastructures, developing tools and services that report performance problems in a manner suitable for network engineers or application users, or hardening existing tools and services that deal with Big Data.

a. Management tools for Network Operators

Network infrastructure must be actively managed to ensure that the infrastructure itself does not become a performance bottleneck. This management requires an understanding of how traffic is currently flowing, making predictions about how traffic flows will change in the future, and, increasingly, how much energy this infrastructure is using. Network operations staff need tools and services to make real-time decisions regarding the current performance of the network. Operators also need tools and services that handle longer term capacity planning activities which balance multiple parameters e.g. cost, performance, and energy usage.

perfSONAR (http://www.perfsonar.net) is an architecture developed by the Research and Education Network community for developing multi-domain measurement and monitoring services. This architecture separates the collection of measurement and monitoring data from the analysis of this data. Using this architecture tools and services that collect unique data values can be developed and deployed by operators and/or users who find these tools useful. Tools and services that analyze data can draw from a wide collection of data sources without needing to deploy boxes in hundreds to thousands of locations.

Grant applications are sought to develop advanced tools and services suitable for managing large distributed network infrastructures. Issues include, but are not limited to: hardening of existing research tools that leverage a modular architecture to generate or consume data; tools that collect data from unique devices or services; data analysis tools that simplify a network operator's task of running a network; data analysis tools that inform network users where performance bottlenecks exist; intuitive displays of performance or operational data tailored to network operators or network users; capacity planning tools that allow operators to determine how to effectively grow the network to meet future demands; or tools that allow operators to optimize the network balancing performance, cost, and energy consumption.

Questions – contact Richard Carlson, richard.carlson@science.doe.gov

b. Optical Network Support Services

Optical networks have revolutionized wide-area network infrastructure deployments, providing ever-increasing amounts of bandwidth at ever-decreasing costs. As costs have dropped, optical network components moved out of the wide area and into the metro area, and now the residential distribution environment. This expansion requires a shift away from small numbers of very expensive optical test gear to a world with large numbers of inexpensive gear that operates over a wide range of speeds and distances. It also requires the mass production of support tools and services to aid in the installation, testing, operations, and growth of this optical infrastructure. Grant applications are sought that address the emerging need for massive deployment of optical network infrastructure. Issues include, but are not limited to: tools that decrease the cost of terminating or splicing optical cables, components to test optical signal quality, components that operate at 100+ Gigabit per sec line rates.

Questions – contact Richard Carlson, richard.carlson@science.doe.gov

c. Big Data-Aware Middleware and Networking

The growing ubiquity, volume, and velocity of data is having a transformative impact on many sectors of modern society including, energy, science, and defense. DOE operates a broad assortment of scientific facilities such as light sources, observatories, and supercomputing facilities that generate vast amounts of data. Over the years DOE has invested in the development of tools, services, visualization systems, data analytic technologies, and network capabilities to manage the massive science data sets being generated by these facilities. These capabilities, originally developed to address DOE's data-intensive science, are now available to be adopted and extended to solve challenging Big Data problems. Grant applications are sought to engage and expose the small business communities working to; a) leverage DOE's vast portfolio of scientific data management technologies to provide production quality Big Data tools and services, and b) develop new innovative technologies to address related Big Data management challenges. These include but are not limited to 1) production quality Big Data management tools, value-added services, cloud-based services, and turnkeys solutions; and 2) Big Data infrastructure sub-systems such as storage systems technologies, data movement services and technologies, data center/Science DMZ networking technologies, and data security systems; and 3) and scalable data analysis and visualization tools and services for knowledge discovery and data mining.

Questions – contact Richard Carlson, richard.carlson@science.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Richard Carlson, richard.carlson@science.doe.gov

e. Technology Transfer Opportunity: Cyberspace Security Econometrics System

Good security metrics are required to make good decisions about how to design security countermeasures, to choose between alternative security architectures, and to improve security during operations. Therefore, in essence, cyber security measurements can be viewed as a decision aid. The lack of sound and practical security metrics is severely hampering progress in the development of secure systems. A Cyberspace Security Econometrics System (CSES) can provide quantitative measures (i.e., a quantitative indication) of reliability, performance and/or safety of a system that accounts for the criticality of each requirement as a function of one or more stakeholders' interests in that requirement. For a given stakeholder, CSES accounts for the variance that may exist among the stakes one attaches to meeting each requirement. CSES is a hardware device for implementing an econometrics-based control system. The device includes a processor, a memory in communication with the processor and configured to store processor implementable instructions. The processor implementable instructions are programmed to correlate a plurality of system requirements with each of a plurality of system stakeholders, identify a stake relating to each of the plurality of system stakeholders and the correlated plurality of system requirements such that the stake is identified by each of the plurality of system stakeholders, determining a mean failure cost as a function of the identified stake and a failure probability, and analyzing the mean failure cost to determine a control strategy. The device may further comprise a communication component in communication with the processor and the memory, the communication component configured to communicate the control strategy to a component operable within the control system such that the component implements the control strategy.

Licensing Information
Oak Ridge National Laboratory – Technology Transfer and Licensing
TTO tracking number: ID 1980, ID 2343
Contact: David Sims (simsdl@ornl.gov, 865-241-3808)
Website: http://www.ornl.gov/connect-with-ornl/for-industry/partnerships

Questions – contact Thomas Ndousse-Fetter, thomas.ndousse-fetter@science.doe.gov

References: Subtopic a:

1. A. Hanemann, V. Jeliazkov, O. Kvittem, L. Marta, J. Metzger, I. Velimirovic. (2006). Complementary Visualization of perfSONAR Network Performance Measurements. Proceedings of the International Conference on Internet Surveillance and Protection (ICISP). Côte d'Azur, France. August 26-28, 2006. Available at http://academic.research.microsoft.com/Publication/4524799/complementary-visualization-of-perfsonar-network-performance-measurements.

2. N. Jeliazkova, L. Iliev & V. Jeliazkov. (2006). UPerfsonarUI - a Standalone Graphical User Interface for Querying perfSONAR Services. Proceedings of the IEEE John Vincent Atanasoff 2006 International Symposium on Modern Computing (JVA06). Sofia, Bulgaria. October 3-6, 2006. pp. 77–81. Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=4022043&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D4022043
3. L. Sampaio, I. Koga, R. Costa, H. Monteiro, F. Vetter, G. Fernandes, M. Vetter & J. Monteiro. (2007). Implementing and Deploying Network Monitoring Service Oriented Architectures: Brazilian National Education and Research Network Measurement Experiments. Proceedings of the 5th Latin American Network Operations and Management Symposium (LANOMS 2007). Rio de Janeiro, Brazil. September 10-12, 2007. pp. 28-37. Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=4362457&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D4362457
4. Lavanya Jose, Minlan Yu & Jennifer Rexford. (2011). Online Measurement of Large Traffic Aggregates on Commodity Switches. Workshop on Hot Topics in Management of Internet, Cloud, and Enterprise Networks and Services (Hot-ICE). Boston, Massachusetts. March 2011. Available at http://www.cs.princeton.edu/~jrex/papers/hhh10.pdf
5. Saurav Das, Guru Parulkar, Preeti Singh, Daniel Getachew, Lyndon Ong & Nick McKeown. (2010). Packet and Circuit Network Convergence with OpenFlow. Optical Fiber Conference (OFC/NFOEC10). San Diego, California. March 2010. Available at http://www.openflow.org/wk/images/4/46/Openflow-OFC10_invited.pdf
6. Chin P. Guok, David W. Robertson, Evangelos Chaniotakis, Mary R. Thompson, William Johnston & Brian Tierney. (2008). A User Driven Dynamic Circuit Network Implementation. Distributed Autonomous Network Management Systems Conference (DANMS 2008). July 2008. Available at http://www.es.net/assets/Papers-and-Publications/DANMS08_1569141354_Guok_et-al.pdf
7. Nagios Monitoring Project. (http://www.nagios.org)

References: Subtopic b:

1. Limin Tang, Wanjun Huang, Miguel Razo, Arularasi Sivasankaran, Paolo Monti, Marco Tacca & Andrea Fumagalli. (2011). A Customizable Two-Step Framework for General Equipment Provisioning in Optical Transport Networks. 15th International Conference of Optical Network Design and Modeling (ONDM2011). Bologna, Italy. February 8-10, 2011. Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5753408&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5753408
2. P.J. Urban & Stefan Dahlfort. (2011). OTM- and OTDR-based cost-efficient Fiber Fault Identification and Localization in Passive Optical Network. Optical Fiber Communication Conference (OFC2011). Los Angeles, California. March 6-10, 2011. Paper ID: JWA064. Available at http://www.opticsinfobase.org/abstract.cfm?uri=OFC-2011-JWA064
3. Kazuo Aida & Toshihiko Sugie. (2011). Remote Measurement Method for Transmission Characteristics of Access Network Fibers with Coherent MPI. Optical Fiber Communication Conference (OFC2011). Los Angeles, California. March 6-10, 2011. Paper ID: JThA7. Available at http://www.opticsinfobase.org/abstract.cfm?uri=NFOEC-2011-JThA7
4. J. Schroeder, O. Brasier, J. Van Erps, M.A.F. Roelens, S. Frisken & B.J Eggleton. OSNR monitoring of a 1.28 Tbit/s signal using a reconfigurable Wavelength Selective Switch. Optical Fiber Communication Conference (OFC2011). Los Angeles, California. March 6-10, 2011. Paper ID: OWC2. Available at

http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5875649&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5875649

References: Subtopic c:

1. The Fourth Paradigm: Data-Intensive Scientific Discovery. (2009). Eds. Tony Hays, Stewart Tansley & Kristin Tolle. Redmond, Washington: Microsoft Research. Available at http://research.microsoft.com/en-us/collaboration/fourthparadigm/4th_paradigm_book_complete_lr.pdf
2. James Ahrens, et al. (2011). Data-intensive science in the U.S. DOE: case studies and future challenges. Computing Science and Engineering. Vol. 13, Issue 6, pp 14-24. Available for purchase at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5999634&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5999634
3. Randal E. Brian. (2011). Data-intensive scalable computing for scientific applications. Computing Science and Engineering. Vol. 13, Issue 6, pp. 25-33. http://www.computer.org/csdl/mags/cs/2011/06/mcs2011060025-abs.html
4. Alexander Szalay. (2011). Extreme data-intensive scientific computing. Computing Science and Engineering. Vol. 13, Issue 6, pp. 34-41. Available at http://www.innovativeparallel.org/Presentations/szalay-inpar-2012.pdf
5. James Manyika, Michael Chui, Brad Brown, Jacques Bughin, Richard Dobbs, Charles Roxburgh & Angela Hung Byers. (2011). Big data: The next frontier for innovation, competition, and productivity. McKinsey Global Institutes. Available at http://www.mckinsey.com/insights/business_technology/big_data_the_next_frontier_for_innovation
6. FastBit: An Efficient Compressed Bitmap Index Technology. (https://www.globusonline.org/)
7. ESnet's OSCARS: End-to-end bandwidth reservation systems. (http://www.lbl.gov/cs/Archive/news073109.html)
8. Nimbus: An open source toolkit for Infrastructure-as-a-Service for clouds. (http://www.mcs.anl.gov/research/project_detail.php?id=88)
9. The Visualization and Analytics Center for Enabling Technologies (VACET). (http://www.vacet.org/about.html)
10. SciDAC Visualization projects. (http://www.scidac.gov/viz/viz.html)
11. SciDAC Data Management Center. (http://www.scidacreview.org/0602/html/data.html)
12. Apache Hadoop. (http://hadoop.apache.org/)
13. E-Center: End-to-end enterprise network monitoring. (http://code.google.com/p/ecenter/)

References: Subtopic e:

1. F. T. Sheldon, R. K. Abercrombie & A. Mili. (2008). *Evaluating Security Controls Based on Key Performance Indicators and Stakeholder Mission*. Proceedings of the 4th Annual Cyber Security and Information Intelligence Research Workshop (CSIIRW08). Oak Ridge, Tennessee. Association for Computing Machinery. Available for purchase at http://dl.acm.org/citation.cfm?id=1413188
2. S. Biffl, A. Aurum, B. W. Boehm, H. Erdogmus & P. Gruenbacher. (2005). *Value Based Software Engineering.* Verlag: Springer: 2006. Available for purchase at http://www.amazon.com/books/dp/3540259937#_

3. K. J. Soo-Hoo. (2000*). How Much is Enough? A Risk Management Approach to Computer Security*. Consortium for Research on Information Security and Policy (CRISP). Stanford University. Available at http://spice.stanford.edu/catalog/how_much_is_enough__a_riskmanagement_approach_to_computer_security/

2. INCREASING ADOPTION OF HPC MODELING AND SIMULATION IN THE ADVANCED MANUFACTURING AND ENGINEERING INDUSTRIES

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Over the past 30 years, The Department of Energy's (DOE) supercomputing program has played an increasingly important role in the scientific discovery process by allowing scientists to create more accurate models of complex systems, simulate problems once thought to be impossible, and analyze the increasing amount of data generated by experiments. Computational Science has become the third pillar of science, along with theory and experimentation. However despite the great potential of modeling and simulation to increase understanding of a variety of important engineering and manufacturing challenges, High Performance Computing (HPC) has been underutilized due to application complexity, the need for substantial in-house expertise, and perceived high capital costs. This topic is specifically focused on bringing HPC solutions and capabilities to the advanced manufacturing and engineering market sectors.

Grant applications are sought in the following subtopics:

a. Turnkey HPC Solutions for Manufacturing and Engineering

HPC modeling and simulation applications are utilized by many industries in their product development cycle, but hurdles remain for wider adoption especially for small and medium sized manufacturing and engineering firms. Some of the hurdles are: overly complex applications, lack of hardware resources, inability to run proof of concept simulations on desktop workstations, solutions that have well developed user interfaces, but are difficult to scale to higher end systems, solutions that are scalable but have poorly developed user interfaces, etc. While many advances have been made in making HPC applications easier to use they are still mostly written with an expert level user in mind.

Grant applications that focus on HPC applications that could be utilized in the advanced manufacturing supply chain, additive manufacturing (3D Printing) processes and Smart Manufacturing are strongly encouraged as well as applications that address the need to have solutions that are easier to learn, test and integrate into the product development cycle by a more general user (one with computational experience, but not necessarily an expert). Issues to be addressed include, but are not limited to: Developing turn-key HPC application solutions, porting HPC software to platforms that have a more reasonable cost vs. current high end systems (this could also include porting to high performance workstations (CPU/GPU) which would provide justification for the procurement of HPC assets or small scale clusters, or to a "cloud" type environment or service), HPC software or hardware as a service (hosted locally or in the "cloud"), near real time modeling and simulation tools, etc.

Questions – contact Richard Carlson, richard.carlson@science.doe.gov

b. HPC Support Tools and Services

Many tools and services have been developed over the years to support the HPC user and development community. These tools (debuggers, profilers, workflow engines, low-level libraries, etc.), although very powerful, take a good deal of time and effort to learn and use. For a company to utilize HPC in the development of their product or service they need to invest a substantial amount in learning these tools and services. This presents an insurmountable barrier for many organizations. If the tools were easier to use and more intuitive, they could be more widely utilized. Grant applications are sought that will help make HPC tools and services easier to use for the experienced (not expert) user, through enhanced or simplified user interfaces, consolidation of tools into a common environment, common frameworks, etc. Grant applications must establish how the proposed tools and services can greatly increase the ease of use for a less-experienced HPC user or developer.

Questions – contact Richard Carlson, richard.carlson@science.doe.gov

c. Hardening of R&D Code for Industry Use

The Office of Science (SC) Office of Advanced Scientific Computing (ASCR) has invested millions of dollars in the development of HPC software in the areas of modeling and simulation, solvers, and tools. Many of these tools are open source, but are complex "expert" level tools. The expertise required to install, utilize and run these assets poses a significant barrier to many organizations due to the levels of complexity built into them to facilitate scientific discovery and research, but such complexity may not necessarily be required for industrial applications. Grant applications are specifically sought that will take a component or components of codes developed via the Scientific Discovery through Advanced Computing (SciDAC) program, or other ASCR programs, and "shrink wrap" them into tools that require a lower level of expertise to utilize. This may include Graphical User Interface Designs (GUIs), simplification of user input, decreasing complexity of a code by stripping out components, user support tools/services, or other ways that make the code more widely useable. Applicants may also choose to harden the codes developed by other projects provided that the potential industrial uses support the DOE mission. In addition applicants may choose to strip out code components, harden them and join them with already mature code tools and/or suites of tools to increase the overall toolset and scalability of commercial software.

Questions – contact Richard Carlson, richard.carlson@science.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Richard Carlson, richard.carlson@science.doe.gov

Note: In addition to local, cluster, or cloud computing resources, applicants may consider using DOE's Open Science (DOE-SC) Computing facilities, the National Energy Research Scientific Computing Center (NERSC), the Argonne Leadership Computing Facility (ALCF), or the Oak Ridge Leadership Computing Facility (OLCF). Applicants wishing to run at the NERSC (http://www.nersc.gov) facility should send email to "consult@nersc.gov" and inquire about the Education/Startup allocation program. Descriptions of the allocation programs available at the ALCF can be found at http://www.alcf.anl.gov/resource-guides/getting-time-alcf-systems. Questions concerning allocations on the ALCF can be sent to Mike Papka, the ALCF center director at "papka@anl.gov". Descriptions of the allocation programs available at the OLCF are available at http://www.olcf.ornl.gov/support/getting-started/. Questions concerning allocations on the OLCF can be sent to Jim Hack, the OLCF center director at "jhack@ornl.gov". Proprietary work may be done at the ALCF and OLCF facilities using a cost recovery model.

References: Subtopic a:

1. Minding the Missing Middle. HPCC Conference Summary. Newport, Rhode Island. March 31, 2011. Available at http://www.hpcwire.com/hpcwire/2011-03-31/minding_the_missing_middle.html
2. John Kirkley. (2011). Making Digital Manufacturing Affordable: A Vendor Perspective. Digital Manufacturing Report. Web. June 14, 2011. Available at (http://www.digitalmanufacturingreport.com/dmr/2011-06-14/making_digital_manufacturing_affordable:_a_vendor_perspective.html)
3. Tiffany Trader. (2011). Digital Manufacturing: Why There's Never Been a Better Time. Digital Manufacturing Report. Web. June 20, 2011. Available at http://www.digitalmanufacturingreport.com/dmr/2011-06-20/digital_manufacturing:_why_there's_never_been_a_better_time.html?featured=top)
4. National Science and Technology Council. (2012). A National Strategic Plan for Advanced Manufacturing. Washington, DC: Executive Office of the President of the United States, NSTC. Available at http://www.whitehouse.gov/sites/default/files/microsites/ostp/iam_advancedmanufacturing_strategicplan_2012.pdf
5. Solid Print: Making Things with a 3D Printer Changes the Rules of Manufacturing. The Economist. Web. April 21, 2012. Available at http://www.economist.com/node/21552892
6. TIME Magazine: What is SMART Manufacturing? (https://smart-process-manufacturing.ucla.edu/about/news/time-magazine-what-is-smart-manufacturing)
7. Unleashing Innovation: Manufacturing. Wall Street Journal, Journal Report. Articles available at http://online.wsj.com/public/page/journal-report-leadership.html

References: Subtopic b:

1. *A Framework for a Regional Modeling, Simulation and Analysis Midwest Pilot Program for the Manufacturing Supply Chain.* (2010). Council on Competitiveness Summit & Workshop. Chicago, Illinois. September 14, 2010. Available at http://www.compete.org/images/uploads/File/PDF%20Files/HPC_MSA_Pilot_WP_022411_v2.pdf
2. *HPC Advisory Committee Re-Launch Meeting*. Meeting Minutes and Report. Council on Competitiveness, Livermore CA, March 21, 2011

3. *Robert Graybill on Integrating HPC's 'Missing Middle'*. HPC In the Cloud. Web. October 6, 2010. Available at http://www.hpcinthecloud.com/hpccloud/2010-10-06/robert_graybill_on_integrating_hpcs_missing_middle.html)

References: Subtopic c:

1. Workshop for Independent Software Developers and Industry Partners Workshop Summary, Chicago IL, March 31, 2011. (https://outreach.scidac.gov/industry_software/)
2. *US Manufacturing—Global Leadership Through Modeling and Simulation*. White Paper. Council on Competitiveness. March 2009. Available at http://www.compete.org/images/uploads/File/PDF%20Files/HPC%20Global%20Leadership%20030509.pdf

PROGRAM AREA OVERVIEW: OFFICE OF BASIC ENERGY SCIENCES

The Office of Basic Energy Sciences (BES) supports fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels in order to provide the foundations for new energy technologies and to support DOE missions in energy, environment, and national security. The results of BES-supported research are routinely published in the open literature.

A key function of the program is to plan, construct, and operate premier scientific user facilities for the development of novel nano-materials and for materials characterization through x-ray, neutron, and electron beam scattering; the former is accomplished through five Nanoscale Science Research Centers and the latter is accomplished through the world's largest suite of synchrotron radiation light source facilities, neutron scattering facilities, and electron-beam microcharacterization centers. These national resources are available free of charge to all researchers based on the quality and importance of proposed nonproprietary experiments.

A major objective of the BES program is to promote the transfer of the results of our basic research to advance and create technologies important to Department of Energy (DOE) missions in areas of energy efficiency, renewable energy resources, improved use of fossil fuels, the mitigation of the adverse impacts of energy production and use, and future nuclear energy sources. The following set of technical topics represents one important mechanism by which the BES program augments its system of university and laboratory research programs and integrates basic science, applied research, and development activities within the DOE.

For additional information regarding the Office of Basic Energy Sciences priorities, click here.

3. DETECTOR TECHNOLOGY TO SUPPORT BES USER FACILITIES

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The Office of Basic Energy Sciences (BES), within the DOE's Office of Science, is responsible for current and future user facilities including synchrotron radiation, free electron lasers, and the Spallation Neutron Source (SNS). This topic seeks the development of detector technology to support these user facilities.

Grant applications are sought in the following subtopics:

a. High Quantum Efficiency Area Detectors for 30-90 keV X Rays

High energy (roughly 30-90 keV) x-rays at synchrotron light sources provide unique information on polycrystallinity and failure modes in lightweight structural materials for advanced transportation applications [1], and on the details of atom bonding in crystalline materials being developed for improved catalytic [2] and energy storage applications [3]. These applications require large area detectors (e.g., > 10 cm2), and spatial resolution ranging from 20-200 microns. Achieving very high spatial resolution at high energies while maintaining high detector quantum efficiency (DQE) is particularly challenging. We are seeking proposals to develop new approaches to large area detectors at high energies in this size range with high DQE and 10,000:1 dynamic range so that x-ray diffraction spots can be recorded simultaneously with diffuse scattering. Frame rates in excess of one image per second are required, and approaches that can in principle be scaled up to 100 Hz or higher frame rates are preferred as well as approaches that allow multiple detectors to work with synchronized data acquisition. Detectors with these characteristics are needed by the Department of Energy's Scientific User Facilities, and will enable new capabilities in the study of materials in the fields such as chemistry, materials science, and transportation systems engineering including the development of advanced jet aircraft engines.

Questions – contact Eliane Lessner, Eliane.Lessner@science.doe.gov

b. Vacuum and Infrared-blocking Windows for Cryogenic X-ray Spectrometers

Cryogenic X-ray spectrometers, such as transition-edge-sensor (TES) microcalorimeters, are of growing importance at synchrotron light sources. This class of detector combines the efficient X-ray collection of a silicon-drift detector with energy resolution approaching that of a crystal- or grating-based spectrometer. Important applications are X-ray emission spectroscopy, partial-fluorescence-yield NEXAFS, and energy-resolved scattering/momentum experiments. Emerging cryogenic detector technologies include TESs as well as microwave kinetic-inductance detectors (MKIDs), magnetic calorimeters (mag-cals), and superconducting tunnel junctions (STJs). These technologies share the common architecture of a pixelated active area that must be held at extreme cryogenic temperatures (~0.05–0.3 K). In the case of TESs, expansion to kilopixel-scale arrays with total active areas of hundreds of mm^2 is a near-term goal. Because the cryogenic-sensing elements must be able to observe ambient-temperature samples, X-ray-transmitting windows are a critical enabling technology. Here we solicit development of a type of X-ray windows that has high transmission in the soft-X-ray band of 250—1000 eV (K lines of organics and L lines of transition metals): vacuum interfaces.

Present, commercially available, high-transmission vacuum windows are made from Beryllium or grid-backed polymers. Those that will support an atmosphere with good transmission down to 250 eV are limited to a diameter of about 10mm. We seek designs with larger active areas. A possibility is a planar window array that could contain multiple, gridded active areas separated by thin support struts – we envision that each sub-window might have an open area of 25—50 mm^2 and the sub-windows might be separated by supports that are several mm wide/thick. Other ideas are encouraged. The awardee would be expected to develop window designs in coordination with developers of cryogenic sensors (such as ANL or NIST) so that the active areas of the windows and the detector arrays can be matched. Window designs that will support ~0.1 atmosphere (in either direction) with much larger active areas are also sought. Improved vacuum-interface windows would also be applicable to conventional, semiconducting x-ray sensors.

Questions – contact Eliane Lessner, Eliane.Lessner@science.doe.gov

c. One Micrometer Resolution Structured Scintillators for Hard X-ray Image Detection

X-ray microtomography studies are providing new insights to the one micrometer resolution 3D organization of mineral deposits and extraction pathways in geological materials [1,2], in crack formation and propagation in lightweight transportation materials under stress [3], and in ageing effects in energy storage materials such as batteries and catalysts as they undergo their functional reactions [4]. In addition, high speed imaging experiments using lenses and near-megahertz frame rate visible light cameras require one micrometer resolution x-ray detection for effective utilization of phase contrast as the dominant detection mechanism for dynamic events in light materials [5]. We are therefore seeking approaches for developing structured scintillators [6] which have sufficient thickness to provide better than 10% efficiency for use with 20 keV X rays, and with one micrometer spatial resolution when used with high numerical aperture visible light optics. Some approaches may emphasize minimum transverse spatial spreading of the signal in the scintillator with millisecond response to changes in localized x-ray intensity, while other technical approaches can emphasize minimal afterglow at microsecond timescales. Advances in the production of structured scintillators of this type can lead to dramatic improvements in 2D and 3D imaging of materials in operation, and are crucial to realizing the full potential of new Department of Energy investments in synchrotron light source facilities.

Questions – contact Eliane Lessner, Eliane.Lessner@science.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Eliane Lessner, Eliane.Lessner@science.doe.gov

References Subtopic a:

1. M. P. Miller, R. M. Suter, U. Lienert, A. J. Beaudoin, E. Fontesa, J. Almer & J. C. Schuren. (2012). High-*energy needs and capabilities to study multiscale phenomena in crystalline materials.* Synchrotron Radiation News. Vol. 25, Issue 6. Available at http://www.tandfonline.com/doi/abs/10.1080/08940886.2012.736834#preview
2. P. Du, O. Kokhan, K.W. Chapman, P.J. Chupas, & D.M. Tiede. (2012). *Elucidating the domain structure of the cobalt-oxide water splitting catalyst by x-ray pair distribution function analysis.* Journal of the American Chemical Society. June 2012, pp. 11096–11099. http://pubs.acs.org/doi/abs/10.1021/ja303826a
3. Y.Sun, Y. Ren, D. Haeffner, J. Almer, L. Wang, WG. Wang & TT. Truong. (2010). Nanophase Evolution at semiconductor/ electrolyte interface in situ probed by time-resolved high-energy synchrotron x-ray diffraction. NanoLetters. Vol. 10, Issue 9, pp. 3747-3753. Available at http://pubs.acs.org/doi/abs/10.1021/nl102458k?journalCode=nalefd

References Subtopic b:

1. J. Uhlig, et. al. (2013). Table-top ultrafast x-ray microcalorimeter spectrometry for molecular structure. Physical Review Letters. Vol. 110, Issue 13, p. 138302. Available at http://prl.aps.org/abstract/PRL/v110/i13/e138302
2. S.R. Bandler, et. al. (2013). Advanced in small pixel TES-Based x-ray microcalorimeter arrays for solar physics and astrophysics. IEEE Transactions on Applied Superconductivity. Vol. 23, Issue 3, p. 2100705. Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6409403&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6409403.
3. M.H. Carpenter, et. al. (2013). Development of Ta-Based superconducting tunnel junction x-ray detector arrays. IEEE Transactions on Applied Superconductivity. Vol. 23, Issue 3, p. 2400504.

http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6397566&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel5%2F77%2F6366258%2F06397566.pdf%3Farnumber%3D6397566.

4. W.B. Doriese, et. al. (2012). Optimization of the TES-Bias circuit for a multiplexed microcalorimeter array. Journal of Low Temperature Physics. Vol. 167, Issues 5-6, pp. 595–601. http://link.springer.com/article/10.1007%2Fs10909-012-0509-7#page-1.
5. G.M. Stiehl, et. al. (2012). Code-division multiplexing for x-ray microcalorimeters. Applied Physics Letters. Vol. 100, Issue 7, p. 72601. Available at http://apl.aip.org/resource/1/applab/v100/i7/p072601_s1.
6. F.S. Porter, et. al. (2008). The EBIT calorimeter spectrometer: a new, permanent user facility at the LLNL EBIT. Journal of Low Temperature Physics. Vol. 151, Issues 3-4, pp. 1061–1066. Available at http://adsabs.harvard.edu/abs/2008JLTP..151.1061P.
7. C.A. Kilbourne, et. al. (2008). Multiplexed readout of uniform arrays of TES X-ray microcalorimeters suitable for Constellation-X. SPIE Proceedings. July 2008, Volume 7011, p. 701104 (2008). Available at http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=1335621.
8. B.A. Mazin, et. al. (2008). Optical/UV and x-ray microwave kinetic inductance strip detectors. Journal of Low Temperature Physics. Volume 151, Issues 1-2, pp. 537–543. Available at http://www.astro.caltech.edu/~golwala/papers/MazinLTD12.pdf.

References Subtopic c:

1. F. Fusseis, K. Regenauer-Lieb, J. Liu, R.M. Hough, & F. De Carlo. (2009). *Creep cavitation can establish a dynamic granular fluid pump in ductile shear zones*. Nature, June 2009, pp. 974-977. Available at http://www.ncbi.nlm.nih.gov/pubmed/19536262
2. Wenlu Zhu, Glenn A. Gaetani, Florian Fusseis, Laurent G.J. Montési, & Francesco De Carlo. *Microtomography of partially molten rocks: three-dimensional melt distribution in mantle peridotite.* Science, Vol. 332, Issue 6025, pp. 88-91. Available at http://www.sciencemag.org/content/332/6025/88
3. J.J. Williams, N.C. Chapman, V. Jakkali, V.A. Tanna, N. Chawla, X. Xiao, & F. De Carlo. (2011). Characterization of damage evolution in SiC particle reinforced al alloy matrix composites by in-situ x-ray synchrotron tomography. Metallurgical and Materials Transactions A. Vol. 42, Issue 10, pp. 2999-3005. http://link.springer.com/article/10.1007%2Fs11661-011-0718-8#page-1
4. Yang-Kook Sun, et. al. (2012). *Nanostructured high-energy cathode materials for advanced lithium batteries*. Nature Materials. Vol. 11, Issue 11, pp. 942-947. Available at http://connection.ebscohost.com/c/articles/82671246/nanostructured-high-energy-cathode-materials-advanced-lithium-batteries
5. Ming-Chia Lai, et. al. (2011). Characterization of the near-field spray and internal flow of single-hole and multi-hole sac nozzles using phase contrast x-ray imaging and CFD. SAE International Journal of Engines. Vol. 4, Issue 1, pp. 703-719. Available at http://papers.sae.org/2011-01-0681/
6. U.L. Olsen, S. Schmidt, H.F. Poulsen, J. Linnros, S.H. Yun, M. Di Michiel, & T. Martin. *Structured scintillators for x-ray imaging with micrometer resolution*. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors, and Associated Equipment, Vol. 607, Issue 1, pp. 141–144. Available at http://www.sciencedirect.com/science/article/pii/S0168900209006275

4. OPTICS DEVICES FOR LIGHT SOURCE FACILITIES

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The Office of Basic Energy Sciences, within the DOE's Office of Science, is responsible for current and future synchrotron radiation light sources, free electron lasers, and spallation neutron source user facilities. This topic seeks the development of X-ray optics devices to support the light source user facilities.

Grant applications are sought in the following subtopics:

a. High Efficiency Hard X-ray Fresnel Zone Plate Optics for the X-ray Regime

Fresnel zone plate based soft and hard x-ray microscopy plays a crucial role in numerous critical science areas including energy storage, catalysis, photovoltaics, energy conversion, and unconventional oil recovery. Despite x-ray microscopy being central to a plethora of breakthroughs over the past two decades, many scientific challenges are just out of reach of the technique due to the present resolution and efficiency limits. In practice, current microscopes are limited to practical resolutions of 15-20 nm in the soft-x-ray range and 50-70 nm in the hard-x-ray range. Pushing resolutions to the 5-10 nm range will allow us to achieve fundamental materials lengths scales yielding dramatic impacts on science and technology and provide unprecedented views into mesoscale systems. Moreover, efficiency improvements are essential to achieving the throughput and signal to noise ratio required to enable statistically relevant scientific research. We seek the development of zone plate fabrication methods ultimately capable of producing resolutions of better than 10 nm and high efficiencies. Solutions are sought for both the soft and hard x-ray regimes ranging from 50 eV to 20 keV with efficiencies ideally exceeding 5% for soft x-rays and 10% for hard x-rays. It is noted that resolution and efficiency are inexorably linked and thus we seek fabrication methods enabling both criteria to be simultaneously achieved. Other important criteria include size (ideally supporting diameters up to 1 mm) and radiation damage resistance.

Questions – contact Eliane Lessner, Eliane.Lessner@science.doe.gov

b. Direct Write Optical Lithography for Fabrication of X-ray Gratings

Gratings are essential components of synchrotron radiation beamline systems and are used in both monochromators and spectrographs covering the photon energy range up to ~ 3 keV. While traditional ruling machines and holographic recording can provide many of the characteristics required, new lithographic methods based on direct optical writing have the potential to revolutionize grating production. In these methods, a sub-micron light spot or array of spots is produced, and a pattern is written in photoresist on a substrate by scanning the sample on an interferometrically controlled stage. This technique offers arbitrary pattern generation combined with very high throughput. Although some of these techniques are used in mature technologies such as integrated circuit and packaging manufacture, x-ray gratings have some unique challenges such as the use of very thick silicon or metallic substrates and a requirement for high precision control of the groove phase coherence over the full grating surface. We are therefore seeking proposals that aim to demonstrate these new direct write grating patterning techniques and show that the methodology will lead to the commercial marketplace in soft x-ray grating production.

Questions – contact Eliane Lessner, Eliane.Lessner@science.doe.gov

c. Integration of Advanced Metrology into X-ray Mirror Manufacturing

Mirrors are an essential component of all synchrotron and Free Electron Laser (FEL) x-ray beamlines. Current and future projected advances in x-ray source performance have led to an enormous increase in source brightness that is in turn driving mirror figure and finish tolerances to significantly lower values than achievable today. The ability of a manufacturer to make a mirror is fundamentally limited by the in-process metrology that is used to measure the mirror slope and height profiles. We are therefore seeking proposals that aim to substantially improve the precision of manufacture of x-ray mirrors through integration of advanced surface metrology into the manufacturing process. Synchrotron and FEL mirrors are typically characterized by lengths up to 1.2 m, with flat, spherical (5 – 100 m typical radii), sagittal cylinders (5-10 cm sagittal radii) or elliptical shape (typically up to 300 mm long with a factor of 2 change in curvature between the ends). We are therefore seeking proposals that demonstrate new technologies in manufacture and metrology of these classes of mirrors that reduce surface slope and height errors to a range well below 100 nrad and 2 nm (rms) respectively.

Questions – contact Eliane Lessner, Eliane.Lessner@science.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Eliane Lessner, Eliane.Lessner@science.doe.gov.

References Subtopic a:

1. W. Chao, . P. Fischer, T. Tyliszcak, S. Rekawa, E. Anderson, & P. Naulleau. *Real space soft x-ray imaging at 10 nm spatial resolution*. Optics Express. Vol. 20, Issue 9, pp. 9777-9783. Available at http://www.ncbi.nlm.nih.gov/pubmed/22535070
2. J. Vila-Comamala et al. (2011). *Ultra-high resolution zone-doubled diffractive x-ray optics for the multi-keV regime*. Optics Express, Vol. 19, Issue 1, p. 175. http://www.opticsinfobase.org/oe/abstract.cfm?uri=oe-19-1-175
3. C. Holzner, M. Feser, S. Vogt, B. Hornberger, S. Baines, & C. Jacobsen. (2010). *Zernike phase contrast in scanning microscopy with x-rays*. Nature Physics. Vol. 6, pp. 883–887. Available at http://www.nature.com/nphys/journal/v6/n11/abs/nphys1765.html
4. G. Schneider, et. al. (2010). *Three-dimensional cellular ultrastructure resolved by x-ray microscopy.* Nature Methods. Vol. 7, pp. 985–987. Available at http://www.nature.com/nmeth/journal/v7/n12/abs/nmeth.1533.html

References Subtopic b:

1. R. Menon, et al. (2005). *Maskless lithography.* Materials Today. Vol. 8, Issue 2, pp. 26-33. Available at http://www.sciencedirect.com/science/article/pii/S1369702105006991
2. T. Sandstorm, et al. *Pattern generation with SLM imaging.* SPIE. 2002. Vol. 4562, pp. 38-44. http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=900200

References Subtopic c:

1. J. Nicolas, F. Siewert, & V. Yashchuck. (2013). *The 4th international workshop on metrology for x-ray optics, mirror design, and fabrication*. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 710, pp. 1-176. Available at http://www.journals.elsevier.com/nuclear-instruments-and-methods-in-physics-research-section-a-accelerators-spectrometers-detectors-and-associated-equipment/
2. P. Takacs. (2009). *X-ray optics metrology*. Handbook of Optics, 3rd ed. Vol. 5. Chapter 46, New York: McGraw-Hill. ISBN: 0071633138. Available for purchase at http://www.amazon.com/Handbook-Optics-Third-Edition-Volume/dp/0071633138

5. INSTRUMENTATION FOR ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The Department of Energy supports research and facilities in electron and scanning probe microscopy for the characterization of materials. Performance improvements for environmentally acceptable energy generation, transmission, storage, and conversion technologies depend on a detailed understanding of the structural and property characteristics of advanced materials. The enabling feature of nanoscience, as recognized in workshop reports sponsored by the Department of Energy and by the National Nanotechnology Initiative, is the capability to image, manipulate, and control matter and energy on nanometer, molecular, and ultimately atomic scales. These fundamental research areas are strongly tied to the energy mission of the Department, ranging from solar energy, energy storage and conversion technologies, and carbon sequestration. Electron and scanning probe microscopies are some of the primary tools and widely used for characterizing materials. Innovative instrumentation developments offer the promise of radically improving these capabilities, thereby stimulating new innovations in materials science and energy technologies. Major advances are being sought for capability to characterize and understand materials, especially nanoscale materials, in their natural environment at high resolutions typical of electron and scanning probe microscopy and with good temporal resolution. To support this research, grant applications are sought to develop instrumentation capabilities beyond the present state-of-the-art in (a) electron microscopy and microcharacterization, (b) scanning probe microscopy and (c) areas relevant to (a) and (b), such as integrated electron and scanning probe microscopy capabilities.

Grant applications are sought only in the following subtopics:

a. Electron Microscopy and Spectroscopy

Electron microscopy and micro-characterization capabilities are important in the materials sciences and are used in numerous research projects funded by the Department. Grant applications are sought to develop components and accessories of electron microscopes that will significantly enhance the capabilities of the electron-based micro-characterization, including improved spatial, energy, and temporal resolution in imaging, diffraction, and spectroscopy with and without applied stimuli (e.g., temperature, stress, electromagnetic field, and gaseous or liquid environment).

New electron sources that can generate significantly brighter electron beams than currently available, including operation in pulsed modes to femtosecond frequencies. Of particular interest are laser-assisted field emission guns for application to pulsed mode operation as a single purpose apparatus for time-resolved diffraction experiment, or incorporated into a conventional electron microscope to achieve more versatile capabilities. Proposed solutions must demonstrate point-source-emitter capability.

Ultra-high energy resolution and collection efficiency electron-induced x-ray, electron energy-loss, and/or optical spectrometers compatible with transmission electron microscopy. Analytical electron energy loss spectroscopy approaches include systems able to achieve high energy resolution (10 meV or better), high energy dispersion (>25mm/eV), efficient trapping of the zero-loss-peak (ZLP) so that spectra at energies <1eV will not be dominated by the ZLP "tail". Energy dispersive spectroscopy approach of interest should include efficient detector materials and improved geometry for maximum signal collection. Single electron detector arrays facilitating ultra high speed counting for electron spectroscopy (~ nanosecond) as well as secondary-electron spectrometers and energy filters to probe electronic states of sample surfaces are of particular interest.

High efficiency and high sensitivity electron detectors. Approaches of interest include CMOS-based electron detectors for high-resolution imaging, detectors with a wide dynamic range (16-20bit) for electron diffraction, and secondary electron detectors for surface imaging. Proposals on ultrastfast electron detectors with time resolution below 1ms and detectors are sensitive to electron-spins are strongly encouraged.

Systems for automated data collection, processing, and quantification in conventional and ultrafast TEM and/or STEM. Approaches of interest should include (1) hardware and platform-independent software for data collection and visualization, (2) automated measurement and mapping of crystallography, internal magnetic or electric field, or strain, and (3) multi-spectral analysis. Proposed solutions must be demonstrated in TEM or STEM mode.

Questions – contact Jane Zhu, Jane.Zhu@science.doe.gov

b. Scanning Probe Microscopy (SPM)

Scanning probe microscopy is vital to the advancement of nanoscale and energy science, and is used in numerous materials research projects and facilities funded by the Department. Grant applications are sought to develop:

New generations of SPM platforms capable of operation in the functional gas atmospheres and broad temperature/pressure ranges, functional SPM probes, sample holders/cells (including electrochemical and photoelectrochemical cells), and controller/software support for ultrafast, environmental and functional detection. Areas of interest include: (1) SPM platforms capable of imaging in the controlled and reactive gas environments and elevated temperatures for fuel cell, and catalysis research, (2) variable pressure systems with capabilities for surface cleaning and preparation bridging the gap between ambient and ultra-high vacuum platforms, (3) insulated and shielded probes and electrochemical cells for high-resolution electrical imaging in conductive solutions; (4) heated probes combined with dynamic thermal measurements including thermomechanical, temperature, and integrated with Raman and mass-spectrometry systems, and

(5) probes integrated with electrical, thermal, and magnetic field sensors for probing dynamic electrical and magnetic phenomena in the 10 MHz - 100 GHz regime, and (6) SPM platforms and probes for other functional imaging modes (including but not limited to microwave, pump-probe, etc). Probes and probe/holder assemblies should be compatible with existing commercial hardware platforms, or bundled with adaptation kits. Complementary to this effort is the development of reliable hardware, software, and calibration methods for the vertical, lateral, and longitudinal spring constants of the levers, sensitivities, and frequency-dependent transfer functions of the probes.

SPM platforms designed for SPM combined with other high-resolution structural and chemical characterization modes. Examples include but are not limited to (a) SPM platforms integrated with high-resolution electron beam imaging in transmission and scanning transmission electron microscopy environments, (b) SPM platforms integratable with focused X-ray, (c) imaging modalities providing local chemical information including mass-spectrometry and nano-optical detection.

A new generation of optical and other cantilever detectors for beam-deflection-based force microscopies. Areas of interest include: (1) low-noise laser sources and detectors approaching the thermomechanical noise limit, (2) high bandwidth optical detectors operating in the 10-100 MHz regime, and (3) small-spot (sub-3 micron) laser sources for video-rate Atomic Force Microscopy (AFM) measurements. Piezoresistive and tuning-fork force detectors compatible with existing low-temperature high-magnetic field environments are also of interest.

Systems for next-generation controllers and stand-alone modules for data acquisition and analysis. Areas of interest include: (1) multiple-frequency and fast detection schemes for mapping energy dissipation, as well as mechanical and other functional properties; (2) active control of tip trajectory, grid, and spectral acquisition; and (3) interactive SPMs incorporating decision making process on the single-pixel level. Proposed systems should include provisions for rapid data collection (beyond the ~1kHz bandwidth of feedback/image acquisition of a standard SPM), processing, and quantification; and hardware and platform-independent software for data collection and visualization, including multispectral and multidimensional image analysis (i.e., for force volume imaging or other spectroscopic imaging techniques generating 3D or 4D data arrays). For rapid data acquisition systems, software and data processing algorithms for data interpretation are strongly encouraged.

Questions – contact Jane Zhu, Jane.Zhu@science.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Jane Zhu, Jane.Zhu@science.doe.gov

References Subtopic a:

1. A BES-Sponsored workshop report. (2012). *Future Science Needs and Opportunities for Electron Scattering: Next-Generation Instrumentation and Beyond*. (http://science.energy.gov/bes/news-and-resources/reports/workshop-reports/).

2. C.E. Lyman. *Proceedings of Microscopy and Microanalysis*. (2013). Annual Meetings, Cambridge University Press. ISSN: 1431927. Available at http://journals.cambridge.org/action/displayJournal?jid=MAM).
3. *Ultramicroscopy,* Vol. 78, Issues 1-4, Elsevier-Holland. June 1999. (http://www.sciencedirect.com/science/journal/03043991).
4. D.B.Williams & C.B.Carter. (1999). *Transmission Electron Microscopy: A Textbook for Materials Science.* Vol. 1-4. NewYork-London: Plenum Publishing Corporation. ISBN: 9780306452475. Available for purchase at http://www.amazon.com/Transmission-Electron-Microscopy-Textbook-Materials/dp/0306452472/ref=sr_1_1?ie=UTF8&qid=1252004198&sr=8-1).
5. *Aberration Correction in Electron Microscopy: Materials Research in an Aberration-Free Environment*. (2001). Workshop Report, U.S. DOE Argonne National Laboratory Argonne National Laboratory. July 2000. Published Oct. 2001. http://ncem.lbl.gov/team/TEAM%20Report%202000.pdf

References Subtopic b:

1. BES-Sponsored workshop report. (http://science.energy.gov/bes/news-and-resources/reports/basic-research-needs/).
2. Paul Alivisatos, et al. (2004). *Nanoscience Research for Energy Needs*. Report of the National Nanotechnology Initiative Grand Challenge Workshop. March 2004. (http://science.energy.gov/~/media/bes/pdf/reports/files/nren_rpt.pdf).
3. S. Morita. (2005). *Roadmap of Scanning Probe Microscopy*. NanoScience and Technology. Springer Publishing, Nov. 2006. ISBN: 9783540343141. Available for purchse at http://www.amazon.com/Roadmap-Scanning-Microscopy-NanoScience-Technology/dp/3540343148/ref=sr_1_1?ie=UTF8&qid=1252005981&sr=8-1).
4. Kalinin, S.V. (2006). *Scanning Probe Microscopy (2 vol. set): Electrical and Electromechanical Phenomena at the Nanoscale*. Springer Publishing. ISBN: 9780387286679; http://www.amazon.com/Scanning-Probe-Microscopy-vol-Electromechanical/dp/0387286675/ref=sr_1_1?ie=UTF8&s=books&qid=1252006052&sr=1-1.
5. Mo Li et al. (2007). *Ultra-sensitive NEMS-based cantilevers for sensing, scanned probe and very high-frequency applications*. Nature. Vol. 2, pp. 114-120. Available at (http://www.nature.com/nnano/journal/v2/n2/abs/nnano.2006.208.html).

6. INSTRUMENTATION AND TOOLS FOR MATERIALS RESEARCH USING NEUTRON SCATTERING

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

As a unique and increasingly utilized research tool, neutron scattering makes invaluable contributions to the physical, chemical, and nanostructured materials sciences. The Department of Energy supports neutron scattering and spectroscopy facilities at neutron sources where users conduct state-of-the-art materials research. Their experiments are enabled by the convergence of a range of instrumentation technologies. The Department of Energy is committed to enhancing the operation and instrumentation of its present and future neutron scattering facilities (References 1-3) so that their full potential is realized.

This topic seeks to develop advanced instrumentation that will enhance materials research employing neutron scattering. Grant applications should define the instrumentation need and outline the research that will enable innovation beyond the current state-of-the-art. Applicants are strongly encouraged to demonstrate applicability and proper context through collaboration with a successful user of neutron sources. To this end, the STTR program would be an appropriate vehicle for proposal submission. Alternatively, applicants are encouraged to demonstrate applicability by providing a letter of support from a successful user. Priority will be given to those grant applications that include such collaborations or letters of support.

A successful user is defined as someone at a research institution who has recently performed neutron scattering experiments and published results in peer reviewed archival journals. Such researchers are the early adopters of new instrumentation and are often involved in conceptualizing, fabricating, and testing new devices. A starting point for developing collaborations would be to examine the annual activity reports from neutron scattering facilities with links at: http://www.ncnr.nist.gov/nsources.html and http://www.ncnr.nist.gov/.

Grant applications are sought in the following subtopics:

a. Advanced Detectors

Develop advanced detectors with high efficiency position sensitive neutron detectors with high spatial and temporal resolution for neutron scattering and imaging using thermal and cold neutrons. With the severe shortage of ^3He and the need for higher resolution detectors for advanced materials characterization innovative alternative detector technologies with better performance are required for the current and future neutron scattering facilities using time-of-flight techniques.

Questions – contact Thiyaga Thiyagarajan, P.Thiyagarajan@science.doe.gov

b. Advanced Optical Components

Develop novel or improved optical components for use in neutron scattering instruments (References 4-6). Such components include, neutron focusing optics, neutron guides, neutron lenses, neutron polarization devices including ^3He polarizing filters, radio-frequency flippers, and Meissner shields for the current and future neutron scattering facilities using time-of-flight techniques.

Questions – contact Thiyaga Thiyagarajan, P.Thiyagarajan@science.doe.gov

c. Advanced Sample Environment

Develop instrumentation and techniques for advanced sample environment (Reference 7, 8) for neutron scattering studies. These environments should simulate conditions relevant to energy-related materials and should provide a novel means of achieving controlled chemical and gaseous environment and extreme sample conditions of temperature, pressure, electric and magnetic fields (or combinations thereof).

Questions – contact Thiyaga Thiyagarajan, P.Thiyagarajan@science.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Thiyaga Thiyagarajan, P.Thiyagarajan@science.doe.gov

References: All Topics:

1. I.S. Anderson, & B.Guerard. (2002). Advances in neutron scattering instrumentation. Proceedings of the SPIE (International Society for Optical Engineering). Vol. 4785, July 2002 ISBN: 0819445525. Available at http://spie.org/x648.html?product_id=457266).
2. Needs for nanoscience application of neutron optics/techniques. National Nano Technology Initiative. (http://www.nano.gov/node/68).
3. K. Anderson. (2009). Neutron optical devices. Neutron Imaging and Applications. Available at (http://www.springerlink.com/content/978-0-387-78692-6.
4. C.F. Majkrzak & J.L. Wood. (1992). Neutron optical devices and applications. Proceedings of the SPIE. Vol. 1738, July 1992. ISBN: 0819409111. Available at http://books.google.com/books/about/Neutron_optical_devices_and_applications.html?id=XdhRAAAAMAAJ.
5. F. Mezei et al. (2003). Neutron spin echo spectroscopy. Lecture Notes in Physics, Vol. 601. ISBN: 3540442936. Available at http://books.google.com/books/about/Neutron_Spin_Echo_Spectroscopy.html?id=4C2MZBM9JGQC.
6. Klose, et al. (2004). Proceedings of the Fifth International Workshop on Polarized Neutrons in Condensed Matter Investigations. Physica B: Condensed Matter. Vol. 356, 2004. (ISSN: 0921-4526; http://www.sciencedirect.com/science/journal/09214526/356/1-4).
7. J. Crow, et al. (2003). Workshop Report. SENSE: (Sample Environments for Neutron Scattering Experiments) Workshop. Tallahassee, FL, September 24-26, 2003.. Available at (http://neutrons.ornl.gov/workshops/tallahassee_workshops_2003/SENSE_report_1-14-04.pdf.).
8. J.E. Rix et al. (2007). Automated sample exchange and tracking system for neutron research at cryogenic temperatures. The Review of Scientific Instruments. Vol 78, Issue 1. (http://www.ncbi.nlm.nih.gov/pubmed/17503933).

7. INSTRUMENTATION FOR ADVANCED CHEMICAL IMAGING

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The Department of Energy seeks to advance chemical imaging technologies that facilitate fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels. The Department is particularly interested in forefront advances in imaging techniques that combine molecular-scale spatial resolution and ultrafast temporal resolution to explore energy flow, molecular dynamics, breakage, or formation of chemical bonds, or conformational changes in nanoscale systems.

Grant applications are sought only in the following subtopics:

a. High Spatial Resolution Ultrafast Spectroscopy

Chemical information associated with molecular-scale processes is often available from optical spectroscopies involving interactions with electromagnetic radiation ranging from the infrared spectrum to x-rays. Ultrafast laser technologies can provide temporally resolved chemical information via optical spectroscopy or laser-assisted mass sampling techniques. These approaches provide time resolution ranging from the breakage or formation of chemical bonds to conformational changes in nanoscale systems but generally lack the simultaneous spatial resolution required to analyze individual molecules. Grant applications are sought that make significant advancements in spatial resolution towards the molecular scale for ultrafast spectroscopic imaging instrumentation available to the research scientist. The nature of the advancement may span a range of approaches including sub-diffraction limit illumination or detection, selective sampling, and coherent or holographic signal analysis.

Questions – contract Larry Rahn, larry.rahn@science.doe.gov

b. Time-Resolved Chemical Information From Hybrid Probe Microscopy's

Probe microscopy instruments (including AFM and STM) have been developed that offer spatial resolution of molecules and even chemical bonds. While probe-based measurements alone do not typically offer the desired chemical information on molecular timescales, methods that take advantage of electromagnetic interactions or sampling with probe tips have been demonstrated. Grant applications are sought that would make available to scientists new hybrid probe instrumentation with significant advancements in chemical and temporal resolution towards that required for molecular scale chemical interactions. The nature of the advancement may span a range of approaches and probe techniques, from tip-enhanced or plasmonic enhancement of electromagnetic spectroscopy's to probe-induced sample interactions that localize spectroscopic methods to the molecular scale.

Questions – contract Larry Rahn, larry.rahn@science.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contract Larry Rahn, larry.rahn@science.doe.gov

References:

1. *Basic research for chemical imaging.* BES Chemical Imaging Research Solicitation. (FY 2006). Available at http://science.doe.gov/grants/pdf/DE-FG01-05ER05-30.pdf
2. *Visualizing Chemistry, The progress and Promise of Advanced Chemical Imaging, National Academies Press*. 2006. Available at http://www.nap.edu/catalog.php?record_id=11663. http://science.doe.gov/grants/pdf/DE-FG01-05ER05-30.pdf)

8. INSTRUMENTATION FOR ULTRAFAST X-RAY SCIENCE

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The Office of Basic Energy Sciences (BES), within the DOE's Office of Science, seeks to advance the state of the art and application of ultrafast x-ray technology, which is a key enabler for research conducted at current and future user facilities, including synchrotron radiation and free electron lasers, as well as for laboratory-based research.

Grant applications are sought in the following subtopics:

a. Instrumentation for Ultrafast X-Ray Science

The Department of Energy seeks to advance ultrafast science dealing with physical phenomena that occur in the range of one-trillionth of a second (one picosecond) to less than one-quadrillionth of a second (one femtosecond). The physical phenomena motivating this subtopic include the direct observation of the formation and breaking of chemical bonds, and structural rearrangements in both isolated molecules and the condensed phase. These phenomena are typically probed using extremely short pulses of laser light. Ultrafast technology also would be applicable in other fields, including atomic and molecular physics, chemistry, and chemical biology, coherent control of chemical reactions, materials sciences, magnetic- and electric field phenomena, optics, and laser engineering.

Grant applications are sought to develop and improve laser-driven, table-top x-ray sources and critical component technologies suitable for ultrafast characterization of transient structures of energized molecules undergoing dissociation, isomerization, or intra-molecular energy redistribution. The x-ray sources may be based on, for example, high-harmonic generation to create bursts of x-rays on sub-femtosecond time scales, laser-driven Thomson scattering and betatron emission, and laser-driven K-shell emission. Approaches of interest include: (1) high-average-power ultrafast sources that achieve the state-of-the-art in short-pulse duration, phase stabilization and coherence, and high duty cycle; (2) driving lasers that operate at wavelengths longer than typical in current CPA titanium sapphire laser systems; and (3) characterization and control technologies capable of measuring and controlling the intensity, temporal, spectral, and phase characteristics of these ultra short x-ray pulses.

Questions – contact Michael Casassa, Michael.Casassa@science.doe.gov

b. Other

In addition to the specific subtopic listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Michael Casassa, Michael.Casassa@science.doe.gov

References Subtopic a:

1. G. Fleming (2007). *Directing matter and energy: five challenges for science and the imagination.* Basic Energy Sciences Advisory Council, US Department of Energy. Available at http://science.energy.gov/~/media/bes/pdf/reports/files/gc_rpt.pdf
2. *Controlling the Quantum World: The Science of Atoms, Molecules, and Photons*. Committee on AMO 2010, National Research Council, National Academy of Science. 2007. (http://www.nap.edu/catalog/11705.html)
3. The Science and Applications of Ultrafast, Ultraintense Lasers (SAUUL): Opportunities in Science and Technology Using the Brightest Light Known to Man. Sponsored by DOE and NSF. 2002. (http://www.ph.utexas.edu/~utlasers/papers/SAUUL_report.pdf)
4. *Report of the Interagency Task Force on High Energy Density Physics*. National Science and Technology Council (NSTC). August 2007. Available at http://m.whitehouse.gov/sites/default/files/microsites/ostp/report_of_the_interagency_task_force_on_high_energy_density_physics.pdf)
5. H.C. Apteyn et al. (2005). *Extreme nonlinear optics: coherent x-rays from lasers*. Physics Today. Vol. 58, Issue 39. Available at http://physicstoday.org/journals/doc/PHTOAD-ft/vol_58/iss_3/39_1.shtml
6. K.T. Phuoc et al. (2005). L*aser-based synchrotron radiation*. Physics of Plasmas 12. Available at http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1007&context=physicsumstadter
7. Y. Jiang et al. (2003). *Generation of ultrashort hard x-ray pulses with tabletop Laser systems at a 2-kHz repetition rate*. Journal of the Optical Society of America. Vol. 20, Issue 1, pp.229-237. Available at http://josab.osa.org/abstract.cfm?id=70903
8. J. Seres et al. (2005). *Laser technology: source of coherent kiloelectronvolt x-rays*. Nature. Vol. 433, Issue 596. Available at http://www.nature.com/nature/journal/v433/n7026/abs/433596a.html
9. 7. X. Zhang et al. (2007). *Quasi-phase-matching and quantum-path control of high-harmonic generation using counterpropagating light.* Nature Physics. Vol. 3, pp. 270 – 275. http://www.nature.com/nphys/journal/v3/n4/abs/nphys541.html
10. 8. V. Malka et al. (2008). *Principles and applications of compact laser-plasma accelerators*. Nature Physics. Vol. 4, pp. 447-453. Available at http://www.nature.com/nphys/journal/v4/n6/abs/nphys966.html)

9. SOFTWARE INFRASTRUCTURE FOR WEB-ENABLED-CHEMICAL-PHYSICS SIMULATIONS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The Office of Basic Energy Sciences (BES), within the DOE's Office of Science, seeks to advance the standards for predictive computational modeling in chemical physics, which is a key for research conducted by researchers in universities, laboratories and industry.

Grant applications are sought in the following subtopics:

a. Webware and Depot for Chemical-Physics Simulations and Data
The Department of Energy seeks to speed delivery of new material- and molecular system for clean energy by enabling prediction of functionalities and processes of such systems prior to

synthesis Such computational predictive capabilities are also of importance to atomic and molecular physics, chemistry, and chemical biology, coherent control of chemical reactions, materials sciences, magnetic- and electric field phenomena, optics, and laser engineering. . Recent advances in theory, algorithms, and hardware in materials and chemical sciences are yet to be widely available to the majority of scientifically and technically capable communities in the United States, especially those in the commercial sector. This topic seeks to reverse this situation and contribute to one goal of the Materials Genome Initiative which includes enhancing the rate of breakthroughs in complex materials chemistry and materials design. Creation of national web-enabled infrastructure for predictive theory and modeling is needed to facilitate the coordination and sharing of information and data, scalable codes, and for their implementation on or transfer to new architectures. In addition, a web-based infrastructure is needed to impose universal standards for data inputs and outputs in the multitude of codes and methodologies or to capitalize upon semantic strategies for bypassing the need for universal standards altogether. Industrial needs that are dependent on rapid insertion of capabilities developed by basic energy scientists include:

- Commercially viable transitioning of validated computational approaches that span vast differences in time and length scales.

- Commercially viable transitioning of robust and sustainable computational infrastructure, including software and applications for chemical modeling and simulation.

Resulting infrastructure should provide economically feasible means that allow networks consisting of one or two primary specialized simulation groups to be linked with researchers in academia, industry, and government.

Grant applications are sought to develop and improve web-based tools for access to predictive theory and modeling.

Questions – contact Mark Pederson, Mark.Pederson@science.doe.gov

b. Other

In addition to the specific subtopic listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Mark Pederson, Mark.Pederson@science.doe.gov

References Subtopic a:

1. *Materials Genome Initiative for Global Competitiveness*. National Science and Technology Council. June 2011. Available at www.whitehouse.gov/sites/default/files/microsites/ostp/materials_genome_initiative-final.pdf
2. *G. Gali & T. Dunning (2010). Discovery in Basic Energy Sciences: The Role of Computing at the Extreme Scale*. Scientific Grand Challenges. Available at http://science.energy.gov/~/media/ascr/pdf/program-documents/docs/Bes_exascale_report.pdf
3. *G. Crabtree, S. Glotzer, B. McCurdy, & J. Roberto. (2011). Computational Materials Sciences and Chemistry: Accelerating Discovery and Innovation through Simulation-Based Engineering and Science. Report of the Department of Energy Workshop, July 26-27, 2010. Available at* http://science.energy.gov/~/media/bes/pdf/reports/files/cmsc_rpt.pdf

4. *Research Needs and Impacts in Predictive Simulation of Internal Combustion Engines (PreSICE).* Workshop sponsored by the Office of Basic Energy Sciences, Office of Science and the Vehicle Technologies Program, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. March 3, 2011. http://science.energy.gov/~/media/bes/pdf/reports/files/PreSICE_rpt.pdf
5. Basic Research Needs for Carbon Capture: Beyond 2010. Report based on SC/FE Workshop. *http://science.energy.gov/bes/news-and-resources/reports/abstracts/#Carbon*
6. Opportunities for Discovery: Theory and Computation in Basic Energy Sciences. Report based on BESAC Deliberations. 2004. http://science.energy.gov/bes/news-and-resources/reports/abstracts/#OD

10. TECHNOLOGY TRANSFER OPPORTUNITIES: BASIC ENERGY SCIENCES

Maximum Phase I Award Amount: $225,000	*Maximum Phase II Award Amount:* $1,500,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Applicants to Technology Transfer Opportunities should review the section describing Technology Transfer Opportunities on page 1 of this document prior to submitting applications.

Grant applications are sought only in the following sub-topics:

a. Improved Ambient Ionization Source for Mass Spectrometry

An improved method and apparatus for surface ionization of samples for analysis by mass spectrometry has been developed. Analytes are probed using a small droplet of solvent that is formed at the junction between two capillaries. A supply capillary maintains the droplet of solvent on the substrate; a collection capillary collects analyte desorbed from the surface and emits analyte ions as a focused spray to the inlet of a mass spectrometer for analysis. The device has been shown to provide superior sensitivity to other methods of surface ionization and is particularly useful for imaging applications of mass spectrometry. Experimental results using the patented technology have been widely published including in Analytical Chemistry 2010, 82, 7979–7986. A need exists for a commercial partner to develop a commercial version of the new instrument for use by the broader research community.

Pacific Northwest National Laboratory information:
TTO information: http://availabletechnologies.pnnl.gov/technology.asp?id=313
Patent Status: USPTO # 8,097,845
USPTO Link http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=1&f=G&l=50&co1=AND&d=PTXT&s1=8097845.PN.&OS=PN/8097845&RS=PN/8097845
TTO tracking number: IPID-16593
Contact: Bruce Harrer; (509) 375-6958; bruce.harrer@pnnl.gov or
Julia Laskin; (509) 371-6136; julia.laskin@pnnl.gov

Questions – contact Larry.Rahn@science.doe.gov

b. Ultra-High Resolution NMR Spectroscopy and Imaging using Inhomogeneous Magnets and Shim Pulses

The objective is to construct an NMR spectrometer based on permanent magnets that, using RF pulses applied through arrays of coils operates without electrically controlled magnetic field shims. In Phase II, the system should be actively and dynamically stabilized with respect to the fluctuation of external parameters such as temperature and meet additional performance metrics. In Phase III, the concept should be extended to MRI experiments incorporating pulsed magnetic field gradients.

When used for chemical identification or anatomical imaging, magnetic resonance experiments are conducted in strong magnetic fields that are homogeneous within parts per million everywhere within the volume under study. Superconducting MRI magnets rely upon a complex set of auxiliary electromagnets, called shim coils that are adjusted empirically to compensate for inhomogeneities in the static magnetic field. Portable NMR and MRI systems based on permanent magnet assemblies are generally designed to be intrinsically homogeneous. They employ adjustable mechanical shims but still rely upon electrically controlled auxiliary coils; both compromise their portability in applications ranging from composite materials inspection, the monitoring of curing in industrial settings, to petro-physical and petrochemical studies of extracted core samples. Both also make it impossible for permanent magnet-based NMR systems to be easily produced in volume, since each must be shimmed by hand.

The implementation of fully functional mobile NMR systems therefore requires an alternate means of counteracting these inhomogeneities. Signal acquisition over a very small region can lead to homogeneous spectra [1,2]; however, many applications require signal acquisition over volumes that are much larger than the length scale of the magnetic field inhomogeneities. An alternative method to accomplish something equivalent to shimming involves the preparation of the quantum state of the spins under study (i.e. their initial phases), such that inhomogeneity is intrinsically compensated by subsequent evolution of the spin system under a pulse sequence. In general, this requires addressing, in a time-dependent manner, the initial phase of spins in each voxel with spatial resolution comparable to the length over which the magnetic field varies. Such methods typically reduce the linewidth of single-sided systems from ~100-500 kHz to <1 kHz[3,4,5]. Such methods have been demonstrated only in laboratory settings using high amplitude pulsed magnetic field gradient systems and RF coils that enclose the sample, and with known or imposed static magnetic field inhomogeneities. The principal technical and scientific challenge to be addressed in Phase I is the generalization of this technique to a planar, single-sided geometry of magnet and surface coils in which the inhomogenities arise from the magnet and its interaction with the sample under study and are not known a priori. This SBIR opportunity thus involves the use of the shim pulse technique to produce single-sided, permanent-magnet based systems of increasing complexity and capability for a wide spectrum of analytical applications.

Phase I: Design a single-sided NMR system incorporating an array of electrically controlled radiofrequency coils (a parallel phased array) for spectroscopy with shim pulses. The system should have an average equivalent magnetic field of >0.35T in an active fluid volume of 1 mL and produce linewidths of better than 50 ppm. The goal at the end of phase I is a working, bench-scale prototype with no elements that preclude its miniaturization to a handheld portable unit. The sensitivity and molecular specificity of the unit must be estimated in the solution phase using mixtures of the fluorinated compounds hexafluorobenzene and perfluorohexane.

Phase II: Based on the Phase I design, construct and demonstrate a spectrometer with an average equivalent magnetic field of >0.5T in an active volume of 1 mL, yielding linewidths of better than 5 ppm. By dynamically adjusting the shim pulses, the system should be compensated against variations in external parameters such as the temperature. Phase II also requires the development of an efficient algorithm to measure and counteract the field inhomogeneity. Further, the spectrometer should implement a graphical software interface for the automated generation and optimization of shim pulse coefficients.

Phase III: The goal of Phase III is the commercial production of a completely portable self-contained automated NMR spectrometer unit capable of solving a variety of spectroscopic analytical problems in a single-sided inspection package.

Lawrence Berkeley National Laboratory information:
TTO information: http://www.lbl.gov/Tech-Transfer/techs/lbnl2026.html
Patent Status: Issued Patent # 7,439,738
TTO tracking number: IB -2026
Contact: Shanshan Li, ttd@lbl.gov 510-486-6457

Questions – contact michael.sennett@science.doe.gov

References:

1. V. Demas et. al. (2007). *Portable, low-cost NMR with laser-lathe lithography produced microcoils.* Journal of Magnetic Resonance. Vol. 189, Issue 1, pp. 121-129. Available at http://www.ncbi.nlm.nih.gov/pubmed/17897853

2. A. McDowell and N. Adolphi. (2007). *Operating nanoliter scale NMR microcoils in a 1 tesla field.* Journal of Magnetic Resonance. Vol. 188, Issue 1, pp. 74-82. Available at http://www.ncbi.nlm.nih.gov/pubmed/17627856

3. John M. Franck, Vasiliki Demas, Rachel W. Martin, Louis-S. Bouchard & Alexander Pines. (2009). *Shimmed matching pulses: simultaneous control of RF and static gradients for inhomogeneity correction.* Journal of Chemical Physics. Vol. 131, Issue 23, p. 234506. Available at http://jcp.aip.org/resource/1/jcpsa6/v131/i23/p234506_s1

4. Daniel Topgaard, Rachel W. Martin, Dimitris Sakellariou, Carlos A. Meriles, & Alexander Pines (2004). *"Shim pulses" for NMR spectroscopy and imaging.* Proceedings of the National Academy of Sciences. Vol. 101, Issue 51, pp. 17576-17581. Available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC539781/

5. Juan Perlo, Vasiliki Demas, Frederico Casanova, Carlos Meriles, Jeffrey Reimer, Alexander Pines & Bernhard Blumich. (2005). *High-resolution NMR spectroscopy with a portable single-sided sensor*. Science. Vol. 308, Issue 5726, p. 1279. Available at http://www.sciencemag.org/content/308/5726/1279.abstract

11. WIDE BANDGAP SEMICONDUCTORS FOR ENERGY EFFICIENCY AND RENEWABLE ENERGY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Wide bandgap (WBG) semiconductors – with bandgaps significantly greater than 1.7 eV — include silicon carbide (SiC), gallium nitride (GaN), zinc oxide (ZnO) and diamond (C). They offer the opportunity for dramatic performance and efficiency improvements in a variety of applications needed for energy relevant applications such as power electronics, solid-state lighting, fuel cells, photovoltaics, and sensing in harsh environments. Compared to today's silicon (Si)-based technologies, WBG-based devices operate at higher ambient temperatures (e.g. higher than 150^{o}C without external cooling), withstand greater voltages (>10's of kV) over time, and switch at much higher frequencies (10's of kHz to 10's of MHz) with lower power losses. While devices employing these materials in bulk or in thin film form have started to be adopted for use in power electronics in areas such as 500 W or higher switch-mode power supplies and solar inverters, widespread adoption in critical energy relevant lower power markets such as 50-150 W external power supplies for consumer electronics and appliances, electric drive vehicles, medium voltage motor controls, and grid power conversion will likely require significant improvements in device reliability – especially for SiC MOSFETs (Metal Oxide Semiconductor Field Effect Transistors). Increasing reliability and overcoming other barriers would improve the integration and interface of renewables at multiple points onto the grid and accelerate the deployment of transportation-based technologies such as electric drive vehicles and fuel cells [1].

Grant applications are sought only in the following subtopics:

a. Reliability of SiC MOSFETs under positive and negative bias stress at elevated temperatures and built-in body diodes

SiC power switches have been commercially available for several years but have been slow to be adopted due to concerns about their reliability. Identification and systematic cataloging of their degradation mechanisms will assist manufactures in solving these problems making these devices available for commercial applications assisting the DOE in advancing its clean energy objectives. The purpose of this experimental subtopic is to understand the failure mechanism of 1200V/20A commercially available SiC Power MOSFETs due to the phenomenon described below.

Reliability problems to be characterized include those due to large density of interface and bulk traps present in thermally grown gate oxide films and other defects present in 4H-SiC epilayers such as threshold voltage (V_{th}) shift under application of gate voltage (positive and negative) at elevated temperatures [2-3] in SiC MOSFETs.

Proposals are sought to better characterize V_{th} shifts due to positive (+15, +20 V) and negative gate bias (-10, -15 V) at 150 °C in commercially available SiC MOSFETs from more than one vendor. Measurements should be modeled using a trap distribution in the gate dielectric layer over many decades of time up to at least 1000 hours. During the positive gate voltage stress, electrons are assumed to tunnel from the SiC conduction band into the spatially and energetically distributed traps either directly or into the conduction band of the gate oxide with subsequent capture by the traps in the gate oxide. Under the application of negative bias, holes are assumed to tunnel from the SiC valence band into the traps in the gate oxide. During extended stress, new traps are generated which accelerate the V_{th} shift.

Applications also should include proposals to study and empirically determine the effects of this phenomenon on lower voltage (1200V) SiC MOSFET devices across multiple vendor products. SiC power MOSFETs have a built-in $p+/n^-$ junction body diode between the interface between the p+ diffusion and the n- epitaxial layer. In certain circuit configurations this diode can become forward-biased for some part of the switching cycle. The forward biased diode injects minority carriers (holes in this case) into the thick n-type drift region and can result in the formation of SFs in a matter of minutes to hours if basal plane dislocations (BPDs) are present in the material. These SFs adversely affect not only the reverse blocking voltage but also the forward on-resistance of the device as has been shown in 10 kV SiC MOSFETs [4]. The BPDs can be present in large numbers depending upon growth conditions for the epilayer, but can also be caused by damage induced by ion-implantation, high temperature activation, oxidation and handling during processing.

This is a serious reliability concern for all SiC MOSFETs (600 V to 15 kV or higher) and even more of a concern for bipolar devices such as p/n diodes, insulated-gate bipolar transistors (IGBTs) and thyristors. The outcome of these results and resulting fundamental understanding that is gained for the above mentioned failure modes should help guide manufacturers to solve these issues and accelerate the commercialization of these devices .

Questions – contact Marina Sofos, Marina.Sofos@hq.doe.gov

b. Increasing Ruggedness of SiC MOSFETs against Cosmic Rays at the Earth's surface

As new WBG high voltage semiconductors and transistor topologies are developed, identification of failure modes and the conditions that initiate them are becoming increasingly important to ensure reliable use for space based applications. Issues with performance degradation and failure of Si power devices attributable to cosmic radiation has been observed in the use of these device in both space and high altitude applications. Although fewer and lower energy cosmic rays reach the Earth's surface, this phenomenon is an increasing concern for terrestrial applications of power devices. Studies have shown that cosmic-ray-induced effects can strongly influence the voltage derating necessary for the safe and long term use of Si MOSFETs and IGBTs, directly affecting their adoption and use in various applications. Cosmic-ray-induced errors—mainly due to neutrons--will only worsen as circuit size continues to shrink. Proposals will need to establish and compare the influence of cosmic radiation on SiC MOSFETs and Si IGBTs under identical conditions in regards to cosmic radiation events. The effects will need to be analyzed to determine the long term reliability and performance of these technologies. Through these results, designers will be able to make better choices in the use of either Si or SiC for different applications. Additionally, semiconductor developers will be better equipped to develop design solutions once their reliabity has been established. Ultimately, the acceptance of WBG devices can result in dramatic energy savings across a broad spectrum of applications including switched-mode power supply, motor control, traction, solar and aerospace industries.

The high energy particles in cosmic rays are known to damage high voltage Si power devices such as diodes, IGBTs, MOSFETs and thyristors resulting in single-event upsets (SEUs) such as single event burnout (SEB) and single event gate rupture (SEGR). SEB is caused by the initiation of destructive avalanching due to drain-source filamentation resulting from activation of parasitic thyristors and/or bipolar transistors present in all devices except diodes. SEB in diodes is simply due to excessive leakage current induced by high energy particles while the device is biased at a high voltage. In MOSFETs and IGBTs, SEGR can occur due to the generation of a high transient field across the gate oxide and subsequent discharge of accumulated holes through the gate oxide. As a consequence of these issues, typical Si devices are limited to approximately 50% of their rated voltage in characteristic usage. Although these devices are likely to be more robust against cosmic ray damage due to the very poor gain of parasitic npn BJTs in SiC power MOSFETs, gate rupture may still occur.

Although initial work has demonstrated the ruggedness of SiC power MOSFETs, more in-depth fundamental experiments are needed [5-7]. The typical testing method, designed to quickly obtain information, is to irradiate devices with high energy neutrons (50-80 MeV, ~10^4 n/cm^2). This method accelerates the failures to enable gathering the necessary data within weeks, but it is expensive and requires access to a high energy neutron beam facility. Another method (called the real-time terrestrial method) is easier to implement but requires a substantial number of devices (>100) for testing. The proposal for this subtopic should be to bias a large number of devices at high voltage and room temperature with a series resistance to limit the current and observe failures over a few months. The devices should be mounted flat to increase the flux of cosmic-rays impinging on the devices. The bias across the devices should be varied from 50- 100% of the rated voltage in stepped increments and readings should be taken at each bias point for an established period of time (e.g. 10 weeks). The goal of this subtopic will be to compare commercially available high voltage Si IGBTs and SiC MOSFETs devices to establish their resistance to radiation effects.

Questions – contact Marina Sofos, Marina.Sofos@hq.doe.gov

c. Other

In addition to the specific subtopic listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Marina Sofos, Marina.Sofos@hq.doe.gov

References:

1. D. Cline, P. Madakasira, Michael Holman, PD, E. Chung, & J. Sheridan. (2012). *Beyond silicon: plotting GaN and SiC's path within the $15 billion power electronics market*. Available at http://www.businesswire.com/news/home/20120403005965/en/Renewed-Innovation-Lift-Power-Electronics-15-Billion
2. A. Lelis, D. Habersat, R. Green, & T. Zheleva. *SiC MOS device physics in support of power device development.* Sensors and Electron Devices Directorate. Energy and Power Division, Power Components Branch. Available at http://www.arl.army.mil/www/pages/shared/documents/SiCMOSDevicePhysics.pdf
3. R.J. Kaplar, S. DasGupta, M.J. Marinella, B. Sheffield, R. Brock, M.A. Smith, & S. Atcitty. *Degradation mechanisms and characterization techniques in silicon mosfets at high-temperature operation*. New Mexico: Sandia National Laboratories. Available at http://www.sandia.gov/eesat/2011/papers/Tuesday/10_Kaplar_EESAT_2011_RevisedAbstract.pdf

4. Anant Agarwal et al. (2007). *A new degradation mechanism in high-voltage SiC power MOSFETs.* Electron Device Letters, IEEE. Vol. 28, Issue 7, pp. 587-589. Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=4252184&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel5%2F55%2F4252183%2F04252184.pdf%3Farnumber%3D4252184
5. Alessio et al. (2012). *Neutron-Induced Failure in Silicon IGBTs, Silicon Super-Junction and SiC MOSFETs*. IEEE Transactions on Nuclear Science. Vol. 59, No. 4, p. 866. Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6145667&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel5%2F23%2F6268392%2F06145667.pdf%3Farnumber%3D6145667
6. C. Vermogenselektronica. (2012). *Cosmic radiation and power MOSFETs.* Federatie Van TechnologieBranches. Available at http://www2.fhi.nl/vermogenselektronica/archief/2012/images/asml.pdf
7. J. Foutz, ed. *Power transistor single event burnout.* SMPS Technology Problem Relevance Solvability Solution. Available at http://www.smpstech.com/power-mosfet-single-event-burnout.htm

12. CATALYSIS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The U.S. Department of Energy recognizes catalysis as an essential technology for accelerating and directing chemical transformation. In particular, catalysis is a key approach for converting alternative feedstocks, such as biomass, natural gas carbon dioxide, and water to commodity fuels and chemical products. Catalysis enables resource-efficient access to chemical products by requiring less energy and materials to achieve a desired chemical reaction. Major advances are being sought in many aspects of catalysis with respect to fuel cells and biofuels development, including using computer modeling to understand and improve catalyst performance to developing new catalytic synthetic routes to chemical products that start from non-petroleum-derived feedstocks.

Grant applications are solicited only in the following subtopics:

a. Catalysis for the Production of Hydrocarbon Fuels or Chemicals from Biomass-Derived Intermediates

In this subtopic, new catalytic routes to hydrocarbon fuels or chemicals that begin with feedstocks derived from lignocellulosic biomass are solicited (for example, new synthetic routes to chemicals starting with succinic acid, furan, raw or processed lignin, and/or other lignocelluose derivatives). Cellulosic ethanol production will not be considered responsive to the solicitation. Process economics will have to be considered, and for a commercially viable process, catalytic conversions would have to be on a par with existing conversion processes. The application should also address the robustness and resistance to degradation of the catalysts in the presence of the oxygenated feed.

Questions – contact Gene Petersen, Gene.Petersen@go.doe.gov

b. Computer-Aided Design of Improved Catalysts for Synthesizing Biomass-Derived Products

In this subtopic, new methods for designing improved catalytic function for catalysts (including enzymes, heterogeneous catalysts, and other catalysts) are sought. Computer-aided design methods, including in-silico modeling of a) active enzyme sites to enhance development of broader specificity for use of 5 and 6 carbon sugars in conversions; b) aqueous phase chemical catalysts for increased specificity; c) approaches to achieving more efficient and stable hydrogenases and dehydratases; and d) approaches to increase stability of enzymes that can function in non-aqueous systems.

Questions – contact Gene Petersen, Gene.Petersen@go.doe.gov

c. Catalysis for the Conversion of Aqueous Biomass Intermediate Streams into Hydrocarbon Fuels and Products

Biofuels can be produced using several different conversion technologies, including thermochemical methods such as fast pyrolysis of biomass and biochemical methods such as enzymatic conversion of sugar intermediates. Many of these conversion technologies result in the production of an aqueous waste stream that contains potentially valuable carbon-containing molecules. Process economics for these conversion technologies could be improved if by-products in the aqueous streams could be converted into value-added products. In this subtopic, new methods for the catalytic conversion of aqueous biomass intermediate streams into hydrocarbon fuels and products are sought. Access to real aqueous waste streams through collaboration with a bio-fuel producer is ideal. Use of a model aqueous waste stream needs to be justified. Any proposed work needs to be benchmarked against the current state-of-the-art.

Questions – contact Gene Petersen, Gene.Petersen@go.doe.gov

d. Discovery and/or Development of Non-PGM Catalysts for PEM- and AEM- Fuel Cells and Electrolyzers

DOE is seeking novel transformative research demonstrating potential to lead to the development of next generation non-precious group metal (PGM) oxygen reduction reaction (ORR) catalysts for polymer electrolyte membrane fuel cells (PEMFCs), bifunctional oxygen evolution reaction (OER)/ORR catalysts for reversible PEMFCs, hydrogen oxidation reaction (HOR) and ORR catalysts for alkaline membrane fuel cells (AMFCs), and bifunctional OER/ORR catalysts for reversible AMFCs. Non-PGM catalysts for electrolyzers are also of interest. Status and R&D needs for AMFCs1 and for reversible fuel cells2 were identified at two workshops held in 2011. For PEMFCs, DOE has targeted PGM total content for both electrodes at < 0.125 g PGM/kW and PGM total loading < 0.125 mg PGM/cm2 (electrode area) by 2017.3 DOE has targeted 300 A/cm3 at 800 mV IR-free by 2017 for non-PGM catalysts.3 The work plan should include a discussion of the catalytic activity testing required to show viability, including RDE and MEA testing, and should demonstrate a pathway toward scientific advancement, which may include development of a better understanding of the active site.

Questions – contact Jacob Spendelow, Jacob.Spendelow@hq.doe.gov

e. Photo- and Electrochemical Conversions in Especially High Heat Transfer Chemical Contacting Schemes

This subtopic solicits new conversion processes involving photo and electrochemical catalysis that use a liquid or vapor contacting scheme that provides extremely high heat and mass transfer rates, such as "microchannel" chemical reactors. The strategy behind such contacting schemes is the conversion efficiencies possible with heat transfer rates high enough to limit hazardous potential of chemical and oxygen contacting within inflammability mixture limits, for example. These chemical reactor contacting schemes have not been extended to involve photo- or electrochemical conversions, which might improve conversion efficiencies even more. The investigation of such new catalytic processes involves long term R&D, which will be a factor considered in the evaluation of grant applications responsive to this subtopic solicitation.

Questions – contact Brian Valentine, Brian.Valentine@hq.doe.gov

f. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Gene Petersen, Gene.Petersen@go.doe.gov.

References: Subtopic d:

1. *Alkaline Membrane Fuel Cell*. Workshop for the Hydrogen and Fuel Cells Annual Merit Review. Arlington, Virginia, May 8-9, 2011. http://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_alkaline_membrane.html

2. "Reversible Fuel Cells. Workshop at the National Renewable Energy Laboratory. April 19, 2011," http://www1.eere.energy.gov/hydrogenandfuelcells/wkshp_reversible_fc.html

3. Fuel Cell Technologies Office Multi-Year Research, Development and Demonstration Plan. Fall 2011. http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/fuel_cells.pdf

References:

1. *Basic Research Needs: Catalysis for Energy*. Report from the U.S. Department of Energy Basic Energy Sciences Workshop. Aug. 6-8, 2007. http://science.energy.gov/bes/news-and-resources/reports/basic-research-needs/

2. *Sustainability in the Chemical Industry: Grand Challenges and Research Needs*. Workshop Report. National Research Council. 2005. (http://books.nap.edu/openbook.php?isbn=0309095719)

3. *Biomass Multi-Year Program Plan*. Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. (http://www1.eere.energy.gov/biomass/).

4. "Hydrogen and Fuel Cells Multi-Year Program Plan, Fall 2011," (http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/fuel_cells.pdf)

13. MEMBRANES AND MATERIALS FOR ENERGY EFFICIENCY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Separation technologies recover, isolate, and purify products in virtually every industrial process. Using membranes rather than conventional energy intensive technologies for separations could dramatically reduce energy use and costs in key industrial processes [1]. Separation processes represent 40 to 70 percent of both capital and operating costs in industry. They also account for 45 percent of all the process energy used by the chemical and petroleum refining industries every year. In response the Department of Energy supports the development of high-risk, innovative membrane separation technologies and related materials. Many challenges must be overcome before membrane technology becomes more widely adopted. Technical barriers include fouling, instability, low flux, low separation factors, and poor durability. Advancements are needed that will lead to new generations of organic, inorganic, and ceramic membranes. These membranes require greater thermal and chemical stability, greater reliability, improved fouling and corrosion resistance, and higher selectivity leading to better performance in existing industrial applications, as well as opportunities for new applications. Materials for energy efficiency include both organic and inorganic types. Their applications can be for supporting structures, such as durable sealing materials to increase reliability of hydrogen storage or for electronics substrates. They also include materials that are the active part of the technology such as electronic organic materials used in organic light emitting diodes.

Grant applications are sought only in the following subtopics:

a. Membranes for Electrochemical Systems

Membrane-based electrochemical systems such as 1) fuel cells, 2) electrolysis cells, and 3) photoelectrochemical cells have significant advantages over liquid systems and can be applied to a wide range of applications such as transportation, energy storage, and grid management. Membrane based systems allow for simplified electrolyte management, gas separation, compact cell design, and low ionic resistance. While each of these devices has somewhat different requirements, all have similar challenges. All three require novel membrane materials and chemistries with high ionic conductivity, low gas permeability, and high mechanical strength and can benefit from basic research to understand fundamental properties to enable material optimization to lower cost and improve efficiency. Electrochemical compression, flow batteries, and electrochemical separations could also benefit from improvements in these areas.

1) Fuel cell operating conditions vary by application, but in some cases operation at low humidity and high temperature is required. For example—as shown in the table below-- some transportation fuel cells operate up to 120°C. In addition, because differential pressure across the membrane is usually minimal, fuel cell membranes tend to be thinner than electrolyzer membranes. Novel R&D approaches to meeting the DOE fuel cell membrane targets shown in the table below are solicited.[2] Areas of interest include novel ionomers (acidic or alkaline), novel supports, and novel additives. Capability to operate in a reversible fuel cell is also of interest.

Phase I should include measurement of chemical and physical properties to demonstrate feasibility of meeting the targets below related to these parameters, while Phase II should address long term durability and development of manufacturing processes to meet the cost targets.

Fuel Cell Technical Targets: Membranes for Transportation Applications[2]

Characteristic	Units	2017 Target
Maximum operating temperature	°C	120
Area specific proton resistance at:		
Maximum operating temp and water partial pressures from 40 to 80 kPa	Ohm cm^2	≤ 0.02
80°C and water partial pressures from 25 - 45 kPa	Ohm cm^2	≤ 0.02
30°C and water partial pressures up to 4 kPa	Ohm cm^2	≤ 0.03
-20°C	Ohm cm^2	≤ 0.2
Maximum Oxygen cross-over	mA / cm^2	2
Maximum Hydrogen cross-over	mA / cm^2	2
Minimum electrical resistance	ohm cm^2	1000
Cost	$ / m^2	≤ 20
Durability		
Mechanical	Cycles w/ < 10 sccm crossover	≥ 20,000
Chemical	Hours	> 500

2) Electrolysis cells typically operate in a flooded environment, so unlike fuel cells, low-humidity operation is not generally required. Electrolyzers based on ion exchange membranes are typically operated at high differential pressures, leveraging the low additional overpotential required to electrochemically compress the hydrogen to eliminate stages of mechanical compression. These membranes must therefore withstand significantly higher mechanical loads than fuel cells in order to maintain stack sealing. In addition, the high differential pressure increases back diffusion of hydrogen, requiring additional design features to mitigate buildup of hydrogen in the oxygen stream, and resulting in efficiency losses. Thick membranes are often used to overcome both issues leading to higher ionic resistance and therefore efficiency losses in the cell stack. Thinner membranes and higher temperatures will assist in reducing this overpotential, but also increase polymer creep and gas permeation. New membrane approaches are needed to enable very high efficiencies at moderate hydrogen generation pressures (e.g. 55 bar and below), and acceptable efficiencies at high hydrogen pressures (e.g. 350 bar and above). Membrane chemistries and

reinforcement approaches are solicited that reduce hydrogen gas permeation while achieving improved LHV stack efficiencies to reach the goal of over 76% LHV stack efficiency by 2015.1 Phase 1 should demonstrate hydrogen permeation below that of commercial membranes while achieving improved ionic conductivity. In Phase 2, stability up to 80°C and improved baseline efficiency should be demonstrated, including development of accelerated tests for electrolysis cells to prove long term durability.

3) Photoelectrochemical Cells: Direct conversion of solar input to fuels, such as through a photoelectrochemical (PEC) cell splitting water, has some similar requirements to the electrolyzer and fuel cell but also has unique considerations. Like the electrolyzer cell, the PEC cell operates in a flooded environment, but based on solar flux, current densities above 10-20 mA/cm^2 are unlikely. Minimization of gas permeation is therefore a critical requirement, due to high efficiency losses even at 2 mA/cm^2 crossover currents, as well as safety due to the lack of oxygen being generated to counter balance the hydrogen diffusing across. At these low current densities, cost is also critical, since large active areas will be required. Proposals should include a feasibility demonstration of lower than 10% efficiency loss with the proposed membrane solution.

Questions - contact Jacob.Spendelow@hq.doe.gov

b. Innovative Durable Materials for Extreme Use Conditions

Hydrogen is used in a broad range of applications such as petroleum refining, NH_3 and biofuels production, hydrogen fuel cell electric vehicles (FCEVs), as well as for energy storage through injection into natural gas pipelines. Use of hydrogen results in the need for innovative durable sealing materials for extreme use conditions that exhibit low hydrogen permeability and high durability in dynamic sealing. In particular, proposals investigating materials at high pressure (>875 bar) and extreme temperatures (>475K and < 33K) and polymeric materials for use as seals in extreme environmental conditions including high pressure (up to 130 MPa) and variable temperatures ($-50 \leq T \geq 200\ ^oC$) are needed for hydrogen applications. Applications include dynamic compressors seals, valve seats and fiber reinforced polymer pipeline and tank liners. In particular the seals currently used in hydrogen compressors have a lifetime of 2,000-8,000 hours. The range in the durability of the seals is largely due to the duty cycle and operating temperature of the compressors. Additionally some seal materials have been found to be susceptible to hydrogen permeation while under high pressure and subsequent blistering on depressurization. This failure mode is not the same as the rupture seen during explosive decompression. Materials development is needed for dynamic compressor seals which can contain hydrogen at pressures of 1,320 bar (1.5x the application working pressure of 875 bar) while operating for >18,000 hours under cyclic pressure loading at 200^oC [1]. Materials developed would also be applicable to other balance of plant components such as the dispenser hoses, valve seals, and high pressure storage tank liners.

Phase I must include identification and preliminary testing of polymers with potential suitability for 18,000 hours of use in hydrogen at temperatures of 200^oC and pressures of 1,320 bar (1.5x the application working pressure of 875 bar) in dynamic sealing applications. Results of phase I should include a report summarizing the findings and suggesting modifications to the polymers to improve their performance. Phase II would include the development and in-depth characterization of the selected or modified polymers. Research should include a scientific exploration of the mechanisms of failure in cyclic high pressure and high temperature hydrogen environments of the application.

Characterization should also include the hydrogen permeation, hydrogen uptake, creep, and other degradation mechanisms needed to provide a better understanding of the durability, mechanical stability, and service life of a material used in severe or extreme service.

Questions – contact Erika Sutherland, Erika.Sutherland@hq.doe.gov

c. Electronic Organic Materials Research for Solid State Lighting

Advancements in Organic Light Emitting Diodes (OLEDs) have produced remarkable improvements in performance and stability since the initial introduction of white phosphorescent devices two decades ago. Like many other electronic organic materials systems that are of interest today, a number of technical hurdles remain and are the subject of the following basic research and commercialization suggestions www1.eere.energy.gov/buildings/ssl/:

1) Development of novel materials and structures that will lead to the production and commercialization of a highly efficient, stable white OLED device. Color stability and consistency, long lifetime and high efficiency even at high brightness are desirable attributes. Viable approaches that are also believed to possess significant IP opportunities include the development of highly efficient, blue emitter materials and hosts or may comprise a device architecture leading to longer lifetime.

2) Novel methods of manufacturing either OLED pixels or panels or devices are also of interest and could depend upon alternative architectures or substrates. Novel system level integration solutions are also sought that would accelerate OLED devices into niche markets creating increased demand for commercial products. Integrating advanced electronics or thin film technologies into OLED structures that might serve power supply, control and networking or some form of information processing tasks are of special interest under this subtopic.

Questions – contact: James R. Brodrick, james.brodrick@hq.doe.gov

d. Other

In addition to the subtopics listed above, the Department solicits applications in other areas that fall within the specific scope of the topic description above.

Questions - contact Erika.Sutherland@hq.doe.gov

References: Subtopic a:

1. *Fuel Cell Technologies Office Multi-Year Research.* Development and Demonstration Plan, Section 3.1: Hydrogen Production. 2012. http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/production.pdf
2. Fuel Cell Technologies Office Multi-Year Research. Development and Demonstration Plan, Section 3.4: Fuel Cells. 2011 (http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/fuel_cells.pdf)

References: Subtopic b:

1. *Fuel Cell Technologies Office Multi-Year Research.* Development and Demonstration Plan, Section 3.1: Hydrogen Production. 2012. http://www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/production.pdf

References: Subtopic c:

1. *Energy Efficiency and Renewable Energy's Solid State Lighting.* U.S. Department of Energy. Program Overview and Resource Locator, October, 2011. http://www1.eere.energy.gov/buildings/ssl
2. *Roundtable Discussions of the Solid-State Lighting Research & Development Task Priorities.* Prepared for Lighting Research and Development Building Technologies Program Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. November, 2011, http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl-rd-roundtable-report_jan12.pdf
3. *Solid-State Lighting Research & Development Multi-Year Program Plan*. Prepared for Lighting Research and Development Building Technologies Program at the Department of Energy. May, 2011. http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2011_web.pdf

References:

1. *Vision2020 Technology Partnership Separations Research & Development Priorities for the Chemical Industry.*Annual Report, 2003. Available at http://www1.eere.energy.gov/manufacturing/resources/chemicals/pdfs/vision2020_annual_report.pdf
2. *2013 Hydrogen Compression Storage and Dispensing Cost Reduction.* Workshop Report. Argonne National Laboratory, March 20-21, 2013. http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/2013_csd_workshop_report.pdf
3. Jimmy L. Humphrey & George E. Keller. (1997). *Separation Process Technology*. McGraw-Hill. ISBN: 9780070311732. Full text available at: http://www.amazon.com/Separation-Process-Technology-Builders%20Guide/dp/0070311730/ref=sr_1_1?ie=UTF8&qid=1251987494&sr=8-1)
4. Kamalesh K. Sirkar. (1997). *Membrane separation technologies: current developments.* Chemical Engineering Communications. Vol. 157, Issue 1, pp. 145-184. Available at http://www.tandfonline.com/doi/abs/10.1080/00986449708936687?journalCode=gcec20#preview

14. ADVANCED FOSSIL ENERGY TECHNOLOGY RESEARCH

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

For the foreseeable future, the energy needed to sustain economic growth will continue to come largely from hydrocarbon fuels. In supplying this energy need, however, the Nation must address growing global and regional environmental concerns, supply issues, and energy prices. Maintaining low-cost energy in the face of growing demand, diminishing supply, and increasing environmental pressure requires new technologies and diversified energy supplies. These technologies must allow the Nation to use its indigenous fossil energy resources more wisely, cleanly, and efficiently. This topic addresses grant applications for the development of innovative, cost-effective technologies for improving the efficiency and environmental performance of advanced large scale industrial and utility fossil energy power generation and natural gas recovery systems. Small scale applications, such as residential, commercial and transportation will not be considered. The topic serves as a bridge between basic science and the fabrication and testing of new technologies.

Grant applications are sought in the following subtopics:

a. Shale Gas Conversion to Liquid Fuels and Chemicals

With the discovery of vast quantities of natural gas available in various shale gas formations in the U.S. comes the opportunity to convert this gas, traditionally used directly as fuel, into more value added products. Traditionally, petroleum has been used to make ethylene, propylene and other building blocks used in the production of a wide range of other chemicals. We need to develop innovative processes that can readily make these chemical intermediates from natural gas.

The methane fraction can be converted into intermediates such as ethylene via oxidative coupling or reforming to synthesis gas, whereas the ethane/propane fraction can be converted into ethylene via conventional steam pyrolysis. Since methane is rather inert and requires high temperatures to activate strong chemical bonds, practical and cost-effective conversion technologies are needed. Attempts to develop catalysts and catalytic processes that use oxygen to make ethylene, methanol, and other intermediates have had little success as oxygen is too reactive and tends to over-oxidize methane to common carbon dioxide. Recent advances with novel sulfide catalysts have more effectively converted methane to ethylene, a key intermediate for making chemicals, polymers, fuels and , ultimately products such as films, surfactants, detergents, antifreeze, textiles and others.

Proposals are sought to develop novel and advanced concepts for conversion of shale gas to chemicals based on advanced catalysts. Processes must have high selectivity and yield compared to existing state of the art. Proposals must be novel and innovative and show clear economic advantages over the existing state of the art.

Questions: Contact Doug Archer, douglas.archer@hq.doe.gov

b. Cost-Effective Interconnect Coating Process Development

Grant applications are sought to identify and develop cost-effective processes for the application of high-quality yttria-stabilized zirconia (YSZ) coatings to SOFC interconnects in a mass production scenario.

High temperature (650°C to 850°C) planar SOFC stacks are comprised of alternating fuel and air chambers, which are sealed from each other by the SOFC cell and interconnect plates - typically ferritic stainless steel sheet (e.g., Allegheny Technology's SS441) stamped to form flow channels for the cathode-side air and anode-side fuel. Cell-to-interconnect and interconnect-to-interconnect seals are required for near-hermitic sealing – glass-based seals are a common approach. Recent research within the SECA has focused on "compliant" glasses that remain vitreous over time in the

SOFC stack operating environment, and are able to tolerate relative motion between the surfaces being sealed without the development of permanent leaks.

Certain glasses (e.g., SEM-COM Company's SCN-1, various compositions under investigation by Alfred University and Mo-Sci Corp., etc.) considered for this sealing application have broadly desirable properties (T_g, CTE, etc.), but have been found to chemically react with both bare stainless steel and alumina coatings applied to the stainless steel as a barrier layer, consequently forming phases that adversely affect the integrity of the seal. It has been shown that these glasses do not undergo similar reactions with YSZ – thus its attractiveness as a barrier layer between the stainless steel substrate and the sealing glass.

Applicants to this topic shall focus on the cost-effective application of thin, dense, adherent zirconia coatings on select portions (e.g., the perimeter) of ferritic stainless steel or alumina-coated stainless steel SOFC interconnects. The Phase 1 work should emphasize proof-of-concept demonstration and production cost assessment. A prospective Phase II shall emphasize application to commercial scale interconnects along with rigorous verification of coating quality and adherence to the substrate.

Questions: Contact Briggs White, briggs.white@netl.doe.gov

c. Development of enhanced durability high-temperature coatings for utility-scale gas turbine hot gas path components

Grant applications are sought for the research and development of new chemistries and architectures for coating systems (Bond Coats (BC) and Thermal Barrier Coatings (TBCs)) with enhanced durability. These coatings should have suitable thermal expansion properties such that they can be used to coat metallic super-alloy components operating within advanced gas turbines with turbine inlet temperatures of 2650° and beyond. Proposed BC/TBC architectures must possess: a combination of high temperature phase stability, sintering resistance, low thermal conductivity and oxygen barrier qualities; hot-corrosion, erosion, and particulate infiltration resistance; long fatigue life; resistance to adverse coating/substrate interaction; adhesion capacity; and high-temperature mechanical performance.

In order to define a novel BC/TBC architecture to solve this critical materials issue for the development of advanced gas turbines, approaches of interest should (1) involve a combined study of both metallic and ceramic components; (2) optimize coating system durability without sacrificing the balance of properties relative to the state of the art; and (3) demonstrate ability to deposit the coating system onto material relevant specimens.

Questions - contact Robin Ames, robin.ames@netl.doe.gov

d. Advanced, High Efficiency Heat Transfer Technologies for Industrial or Utility Applications

Despite their higher cost and larger system size, dry cooling systems are currently the only alternative for industrial or utility power plants unable to obtain permits for cooling water. Because of this, lower cost highly efficient advanced large scale heat transfer technologies that eliminate the need for cooling water would find a market with industrial and utility plants in areas with competing demands on water from agriculture and development. Promising heat transfer technologies in other analogous industries increase the effective surface area and thus the transfer efficiency. They include nano-textured surfaces, micro-grooved surfaces, ablation, coatings, self-similar geometric modifications, fractal fins, fluidic interface treatments, micro-structural modifications to cooling surfaces, or chemical compositions. Validated simulation or mathematical modeling must show reliable operation above 1.8 GWt and at temperatures and pressures associated with an ultra supercritical steam plant. Proposals must show at least a twenty-five percent cost advantage using annualized levelized cost of electricity (LCOE) per megawatt*hour relative to any commercially available dry cooling baseline. Selection criteria will be cost of implementation, effectiveness as determined by water loss avoidance relative to evaporative baseline, heat dissipation, and uptime.

Questions – contact Joe Wong, Joe.Wong@hq.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions: Contact Doug Archer, douglas.archer@hq.doe.gov

References Subtopic a:

1. Quinjun Zhu., Staci L. Wegener, Chao Xie, Obioma Uche, Matthew Neurock & Tobin J. Marks.*(2013). Sulfur as a Selective 'soft' oxidant for catalytic methane conversion probed by experiment and theory*. Nature Chemistry*. Vol.* 5, Issue 2, pp. 104-109. Available at http://www.ncbi.nlm.nih.gov/pubmed/23344430
2. John N. Armor. (2013). *Emerging importance of shale gas to both the energy & chemicals landscape*. Journal of Energy Chemistry. Vol. 22, Issue 1, pp. 21-26. Available at http://dx.doi.org/10.1016/S2095-4956(13)60002-9
3. Ranjita Ghose, Hyun Tae Hwang & Arvind Varma. (2013). *Solution combustion synthesized catalytic materials for oxidative coupling of methane.* Applied Catalyis A. General, Volume 452, pp. 147-154, 15 February 2013. Full article available at https://nam.confex.com/nam/2013/webprogram/Paper8439.html
4. Pierre Schwach, Neil G. Hamilton, Robert Schlogl & Annette Trunschke. (2013). *Structure sensitivity in oxidative coupling of methane over MgO*. Fritz-Haber-Institut der Max-Planck Society. June, 2013. Available at https://nam.confex.com/nam/2013/webprogram/Paper8710.html
5. Ceri Hammond, et al. (2013). *Alkane activation by selective oxidation using FeCuZSM-5.* Catalysis Institute, Cardiff University School of Chemistry, June 2013. Full article available at https://nam.confex.com/nam/2013/webprogram/Paper9107.html
6. Karolina A. Chalupka, Jacek Rynkowski, Jacek Grams, Thomas Onfroy, Sandra Casale & Stanislaw Dzwigaj. (2013). Catalytic activity of NixAlBEA and NixSiBea zeolite catalysts in partial oxidation of methane: influence of zeolite dealumination and ni incorporation. Lodz University of Technology, Institute of General and Ecological Chemistry.
7. Girish Srinivas, Micahel V. Mundschau, Jeffrey Maartin & Steven Gebhard. (2013). *Syngas-to-ethanol using homogeneous catalysis*. TDA Research, Inc., Golden, CO. June 2013. Available at https://nam.confex.com/nam/2013/webprogram/Paper9312.html

8. David G. Hanna, S. Shylesh, Alexis T. Bell. (2013). *Tandem hydroformylation-hydrogenation of propene to butanol using supported catalysts.* University of California, Berkeley, CA. June 2013. Available at https://nam.confex.com/nam/2013/webprogram/Paper7708.html

References: Subtopic b:

1. Raj N. Singh. *Innovative self-healing seals for solid oxide fuel cells (SOFC).* (2011). University of Cincinnati, 12th Annual SECA Workshop, Pittsburgh, PA, July 26-28, 2011. Presentation notes available at http://www.netl.doe.gov/publications/proceedings/11/seca/pdf/Wed%20PM/Stevenson2.%20Interconnect%20Development%20at%20PNNL%20final.pdf
2. J.W. Stevenson et. al. *Development of SOFC Interconnects and Coatings*. Pacific Northwest National Laboratory, Richland, WA, 12th Annual SECA Workshop, Pittsburgh, PA, July 26-28, 2011 Presentation notes available at http://www.netl.doe.gov/publications/proceedings/11/seca/pdf/Thu%20AM/Singh%20SECA%20Review%202011%20sent.pdf

References: Subtopic c:

1. U.S. Department of Energy. (2006). *The Gas Turbine Handbook*. Section 4.1.1-3. Available at http://science.energy.gov/~/media/sbir/pdf/docs/DOEFY13PhaseIRelease1TopicsAmend1081512.pdf
2. Carlos G. Levi. (2004). *Emerging Materials and Processes for Thermal Barrier Systems*. Solid State & Materials Science. Vol. 8, March 2004, pp. 77-91. http://www.materials.ucsb.edu/MURI/papers/Levi-COSSMS2004.pdf
3. R. Vaßen, H. Kaßner, A. Stuke, F. Hauler, D. Hathiramani, & D. Stöver. (2008). *Advanced thermal spray technologies for applications in energy systems.* Surface Coatings and Technologies. Vol. 202, Issue 18, pp. 4432-4437. Available for purchase at http://www.sciencedirect.com/science/article/pii/S0257897208002442

References: Subtopic d:

1. NEI Corporation. Technology promotes efficiency in heat exchangers NEI's SuperCondenser™ technology increases the energy efficiency of a power plant's condensing steam turbine. January 2013. Available at http://science.energy.gov/sbir/highlights/2013/sbir-2013-01-d/
2. NEI Corporation. Advantages of super hydrophobic coatings. (http://neicorporation.com/products/coatings/superhydrophobic-coating/)
3. NETL. (2010). Water – Energy Interface. Sept. 2010 (http://www.netl.doe.gov/technologies/coalpower/ewr/water/index.html)
4. Wurtz et al. (2006). Air Cooled Condensers: Application and Innovative Designs for Today's Power Plants. Power-Gen International Workshop, Orlando, Florida. http://spxcooling.com/pdf/PowerGen_2006.pdf http://www.netl.doe.gov/technologies/coalpower/ewr/water/adv-cooling.html
5. Kraus et al. (2001). Extended Surface Heat Transfer. Wiley & Sons. Available at http://www.google.com/patents/US8249211?dq=Extended+Surface+Heat+Transfer,+Kraus+et+al,+2001,+Wiley+%26+Sons&hl=en&sa=X&ei=pOLJUerZAaXzyAHmwoHQBg&ved=0CDQQ6AEwAA

6. U.S. Department of Energy. (2006). Energy Demands on Water Resources. Report to Congress on the Interdependency of Energy and Water, December 2006. Available at http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAcomments-FINAL.pdf
7. Badin et al. Apparatus and Method for a Natural Draft Air Cooled Condenser Cooling Tower. (2011). US Pre-Grant Publication Number 20110226450. Available at http://www.google.com/patents/US20110226450
8. Kienbock et al. Internal Inserts in Cooling Towers. (2007). US Patent 7,261,285. http://www.google.com/patents/US7261285?dq=%E2%80%9CInternal+Inserts+in+Cooling+Towers%E2%80%9D,+2007,+Kienbock+et+al.,+US+Patent+7,261,285&hl=en&sa=X&ei=VOLJUdP-E-ybyAGU-oHgCg&ved=0CDYQ6AEwAA
9. A. Brusly Solomon & K. Ramachandran. (2012). Thermal performance of a heat pipe with nanoparticles coated wick. Applied Thermal Engineering. Vol. 36, April 2012, pp. 106-112. Available at http://www.sciencedirect.com/science/article/pii/S1359431111007010

10. Cizek et al., "Emerging Ideas Workshop No- and Low-Water Power Plant cooling", 28 March 2012. URL Retrieved from http://arpa-e.energy.gov/sites/default/files/documents/files/Cisek%20No-Water%20and%20Low-Water.pdf

11. Wagman, "Water Issues Challenge Power Generators", Power Magazine, July 2013. http://www.powermag.com/issues/cover_stories/Water-Issues-Challenge-Power-Generators_5707.html

15. ADVANCED FOSSIL ENERGY SEPARATIONS AND ANALYSIS RESEARCH

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

For the foreseeable future, the energy needed to sustain economic growth will continue to come largely from hydrocarbon fuels. This topic addresses grant applications for the development of innovative, cost-effective technologies for improving the efficiency and environmental performance of advanced large scale industrial and utility fossil energy power systems, CO2 sequestration and natural gas recovery systems. Small scale applications, such as residential, commercial and transportation will not be considered. The topic serves as a bridge between basic science and the fabrication and testing of new technologies. The Instrumentation, Sensors & Control element focuses on the development of novel sensors critical to the implementation and optimization of advanced fossil fuel-based power generation systems, including new classes of sensors capable of monitoring key parameters (temperature, pressure, and gases) and operating in harsh environments. This involves development of innovative analytical techniques for on-line industrial use, along with technologies that meet the immediate high-priority measurement need.

Grant applications are sought in the following subtopics:

a. Subsurface CO_2 Sequestration Monitoring

It will be necessary to improve existing monitoring technologies and develop novel technologies, as well as novel application of technology systems and supporting protocols, in order to decrease the cost and decrease the uncertainty in measurements needed to satisfy regulations for tracking the fate of subsurface CO_2 and quantifying any emissions from geologic reservoirs. MVAA tools are needed that are broadly applicable in different geologic storage classes and that have high accuracy. Innovative 2nd and 3rd generation tools are needed that can provide assurance of 99 percent permanence of geologic CO_2 storage. Grant applications are sought to develop innovative subsurface MVAA tools that can be applied in a systematic approach to address monitoring requirements across the range of storage formation(s), depth(s), porosities, permeabilities, temperature(s), pressure(s), and associated confining formation properties likely to be encountered in geologic carbon storage. These tools should have the potential to reduce the cost of permanent geologic storage of CO_2. Increased capabilities of these MVAA tools should also yield the ability to differentiate between natural and anthropogenic CO_2 and account for the location of injected CO_2 and any potential release, thus ensuring the protection of human health and the environment.

Questions – Contact Bill Fernald, william.fernald@hq.doe.gov

b. Advanced Shale Gas Recovery Technologies for Horizontal Well Completion Optimization

Proposals are sought to develop and test technologies that will reduce the amount of water needed for hydraulic fracturing when completing natural gas wells or that will improve the apparent low (<30%) natural gas and liquids recovery efficiency currently associated with horizontal, hydraulically fractured wells producing from shale formations. Proposals should focus on addressing a number of important areas where cost effective improvements may be possible (e.g., wellbore formation evaluation techniques, perforation selection strategies, fracturing fluid selection, and fracturing treatment design). The objective is to increase the efficiency of resource recovery on a per well basis and reduce the volume of fresh water required to produce a unit volume of natural gas.

Questions – Contact Al Yost, albert.yost@netl.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – Contact Doug Archer, douglas.archer@hq.doe.gov

References: Subtopic a:

1. Montana State University. (2009-2012). *Development of a 1 x N Fiber Optic Sensor Array for Carbon Monitoring*. http://www.netl.doe.gov/publications/factsheets/project/FE0001858.pdf
2. Virginia Polytechnic Institute and State University. (2009-2012). *Double-Difference Tomography for Sequestration Monitoring, Verification, and Accounting (MVA).* (http://www.netl.doe.gov/publications/factsheets/project/FE0002108.pdf)
3. University of Texas at Austin Bureau of Economic Geology. Improving the Monitoring, Verification, and Accounting of CO2 Sequestered in Geologic Systems with Multicomponent

Seismic Technology and Rock Physics Modeling. Available at http://www.netl.doe.gov/publications/proceedings/10/doe-epa/Hardage.pdf
4. West Virginia University Research Corporation, CONSOL Energy, Inc. *(2009-2013). In Situ MVA of CO2 Sequestration Using Smart Field Technology*. (http://www.netl.doe.gov/publications/factsheets/project/DE-FE0001163.pdf)
5. Planetary Emissions Management, Inc. Near-Surface Leakage Monitoring for the Verification and Accounting of Geologic Carbon Sequestration Using a Field Ready 14C Isotopic Analyzer. DOE /EPA Collaborative Review. Available at http://www.netl.doe.gov/publications/proceedings/10/doe-epa/Marino.pdf
6. Brookhaven National Laboratory*. (2007-2010). New Approach for Long Term Monitoring of Potential CO2 Leaks from Geologic Sequestration*. (2007-2010). Available at http://www.netl.doe.gov/publications/factsheets/project/FWPAACH139_4P.pdf
7. Oak Ridge National Laboratory. (2000-2012). *GEOSEQ:A Monitoring of Geological CO2 Sequestration Using Isotopes and Perfluorocarbon Tracers (PTFs).* Available at http://www.netl.doe.gov/publications/factsheets/project/FWPA045.pdf
8. University of Pittsburgh*.* (2009-2012)*. Passive Wireless Acoustic Wave Sensors for Monitoring CO2 Emissions for Geological Sequestration Sites*. Available at (http://www.netl.doe.gov/publications/factsheets/project/FE0002138.pdf)
9. Columbia University. (2009-2012). *Tagging Carbon Dioxide to Enable Quantitative Inventories of Geological Carbon Storage.* Available at http://www.netl.doe.gov/publications/factsheets/project/DE-FE0001535.pdf

References: Subtopic b:

1. Pennsylvania State University Marcellus Center for Outreach & Research. (2012). *How Much Natural Gas Can The Marcellus Shale Produce.* Available at http://www.marcellus.psu.edu/news/PDFs/gasreserves_day.pdf
2. D. Gerdon, J. Caplan, J. Terry Jr., K. Witherich, E. Wigger, & K. Walker. (*2013). Geomechanics Key In Marcellus Wells*. American Oil and Gas Reporter. March 2013. Available at http://www.slb.com/~/media/Files/stimulation/industry_articles/201303_og_geomechanics.pdf
3. E. Tudor, G. Nevison, & S. Allen. (2009). *Case Study of a Novel Hydraulic Fracturing Method That Maximizes Effective Hydraulic Fracture Length*. SPE Annual Technical Conference and Exhibition. October 14-17, 2009. New Orleans, Louisiana. SPE 124480-MS. Available at http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-124480-MS
4. C. Miller, G. Waters & E. Rylander Schlumberger. (2011). *Evaluation of Production Log Data from Horizontal Wells Drilled in Organic Shales.* North American Unconventional Gas Conference and Exhibition. June 14-16, 2011. The Woodlands, Texas. SPE 144326-M. Available at http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-144326-MS
5. L. Ribeiro & M. Sharma. (2013). *Fluid Selection for Energized Fracture Treatments*. SPE Hydraulic Fracturing Technology Conference. Feb 4-6, 2013. The Woodlands, Texas. SPE 163867-MS. Available at http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-163867-MS

6. R. Manchanda, M. Sharma, & S. Hozhauser. (2013). *Time Dependent Fracture Interference Effects in Pad Wells*. SPE Unconventional Resources Conference. Apr 10-12, 2013. The Woodlands, Texas. SPE 164534-MS. Available at http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-164534-MS

16. HIGH PERFORMANCE MATERIALS FOR NUCLEAR APPLICATION

Maximum Phase I Award Amount: $225,000	*Maximum Phase II Award Amount:* $1,500,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

To achieve energy security and greenhouse gas (GHG) emission reduction objectives, the United States must develop and deploy clean, affordable, domestic energy sources as quickly as possible. Nuclear power will continue to be a key component of a portfolio of technologies that meets our energy goals. Nuclear Energy R&D activities are organized along four main R&D objectives that address challenges to expanding the use of nuclear power: (1) develop technologies and other solutions that can improve the reliability, sustain the safety, and extend the life of current reactors; (2) develop improvements in the affordability of new reactors to enable nuclear energy to help meet the Administration's energy security and climate change goals; (3) develop sustainable nuclear fuel cycles; and (4) understanding and minimization of risks of nuclear proliferation and terrorism.

To support these objectives, the Department of Energy is seeking to advance engineering materials for service in nuclear reactors.

a. Specialty Steels and Alloys

Grant applications are sought to develop radiation-resistant steels, ferritic-martensitic (FM) steels, oxide dispersion strengthened (ODS) steels, and high alloys that can be used in liquid cooled reactors at 400-850°C, which have improved creep strength, can be formed and joined, and are compatible with one or more high-temperature reactor coolants. Grant applications also are sought to improve the weldability and formability of FM and ODS steels and to develop methods to monitor the in-situ performance of these materials in reactor service.

Questions – contact William Corwin, william.corwin@nuclear.energy.gov

b. Ceramic, Ceramic Composite, or Coated Materials

Grant applications are sought to develop improved ceramic, ceramic composite, or coated materials that can be used in the Generation IV Gas-Cooled and Liquid Fluoride Salt-Cooled Reactors at temperatures up to 850°C, in a thermal neutron spectrum environment during normal operations and accidents. These ceramic or coated materials should have the following characteristics: (1) low thermal expansion coefficients, (2) excellent high-temperature strength, (3) excellent high-temperature creep resistance, (4) good thermal conductivity, (5) ability to endure a high-neutron-flux environment, (6) ability to be fabricated to required geometries, (7) capable of being joined, and (8) ability to survive air and/or water ingress accidents. Because high temperature strength and corrosion resistance may be difficult to achieve with a single material, composite or coated systems may be required.

In addition, grant applications are sought to develop methods for real-time in situ monitoring of the condition of these ceramic, composite, and coated materials. Approaches of interest include the development of sensors that can monitor the mechanical and thermo-physical properties of these materials during their service lifetime.

Questions – contact William Corwin, william.corwin@nuclear.energy.gov.

c. In-situ Mitigation and Repair of Materials Degradation

Grant applications are sought to develop technologies for the in situ mitigation and repair of materials degradation in Light Water Reactor systems and components, in order to extend the service life of current light water reactors. Approaches of interest include new techniques for the repair of materials degradation in metals, concrete, and cables; and methods that can mitigate irradiation and aging effects in existing reactors and components.

Questions – contact Sue Lesica, Sue.Lesica@nuclear.energy.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.
Questions – contact Sue Lesica, Sue.Lesica@nuclear.energy.gov

References:

1. *Nuclear Energy Research and Development Roadmap Report to Congress*. *U.S. Department of Energy.* April 2010. Available at http://energy.gov/sites/prod/files/NuclearEnergy_Roadmap_Final.pdf
2. *Fuel Cycle Research and Development Program.* U.S. DOE Office of Nuclear Energy, Science and Technology. http://www.nuclear.gov/fuelcycle/neFuelCycle.html.
3. *Generation IV Nuclear Energy Systems*. U.S. DOE Office of Nuclear Energy, Science and Technology. (http://nuclear.energy.gov/genIV/neGenIV1.html).
4. S.R. Greene, et al. (2011). *Pre-Conceptual Design of a Fluoride-Salt-Cooled Small Modular Advanced High Temperature Reactor (SmAHTR)*. ORNL/TM-2010/199. Oak Ridge National Laboratory, Oak Ridge, TN. February 2011. Available at (http://info.ornl.gov/sites/publications/Files/Pub26178.pdf).
5. *Light Water Reactor Sustainability*. U.S. DOE Office of Nuclear Energy (http://www.nuclear.gov/LWRSP/overview.html).

PROGRAM AREA OVERVIEW: OFFICE OF BIOLOGICAL AND ENVIRONMENTAL RESEARCH

The Biological and Environmental Research (BER) Program supports fundamental, peer-reviewed research on complex systems in climate change, subsurface biogeochemistry, genomics, systems biology, radiation biology, radiochemistry, and instrumentation. BER funds research at public and private research institutions and at DOE laboratories. BER also supports leading edge research facilities used by public and private sector scientists across a range of disciplines: structural biology, DNA sequencing, functional genomics, climate science, the global carbon cycle, and environmental molecular science.

BER has interests in the following areas:

(1) Systems biology is the multidisciplinary study of complex interactions specifying the function of entire biological systems—from single cells to multi cellular organisms—rather than the study of individual components. The Biological Systems Science subprogram focuses on understanding the functional principles that drive living systems, from microbes and microbial communities to plants and other whole organisms. Questions include: What information is in the genome sequence? How is information coordinated between different sub cellular constituents? What molecular interactions regulate the response of living systems and how can those interactions be understood dynamically and predicatively? The approaches employed include genome sequencing, proteomics, metabolomics, structural biology, high-resolution imaging and characterization, and integration of information into predictive computational models of biological systems that can be tested and validated.

The subprogram supports operation of a scientific user facility, the DOE Joint Genome Institute (JGI), and access to structural biology facilities. Support is also provided for research at the interface of the biological and physical sciences and in radiochemistry and instrumentation to develop new methods for real-time, high-resolution imaging of dynamic biological processes.

(2) The Climate and Environmental Sciences subprogram focuses on a predictive, systems-level understanding of the fundamental science associated with climate change and DOE's environmental challenges—both key to supporting the DOE mission. The subprogram supports an integrated portfolio of research from molecular-level to field-scale studies with emphasis on multidisciplinary experimentation and use of advanced computer models. The science and research capabilities enable DOE leadership in climate-relevant atmospheric-process research and modeling, including clouds, aerosols, and the terrestrial carbon cycle; large-scale climate change modeling; integrated analysis of climate change impacts; and advancing fundamental understanding of coupled physical, chemical, and biological processes controlling contaminant mobility in the environment.

The subprogram supports three primary research activities and two national scientific user facilities.

- Atmospheric System Research seeks to resolve the two major areas of uncertainty in climate change model projections: the role of clouds and the effects of aerosols on the atmospheric radiation balance.

- Environmental System Science supports research that provides scientific understanding of the effects of climate change on terrestrial ecosystems, the role of terrestrial ecosystems in global carbon cycling, and the role of subsurface biogeochemistry in controlling the fate and transport of energy-relevant elements.

- Climate and Earth System Modeling focuses on development, evaluation, and use of large scale climate change models to determine the impacts of climate change and mitigation options.

- Two scientific user facilities the Atmospheric Radiation Measurement (ARM) Climate Research Facility and the Environmental Molecular Sciences Laboratory (EMSL) provide the broad scientific community with technical capabilities, scientific expertise, and unique information to facilitate science in areas integral to the BER mission and of importance to DOE.

For additional information regarding the Office of Biological and Environmental Research priorities, click here.

17. ATMOSPHERIC MEASUREMENT TECHNOLOGY

Maximum Phase I Award Amount: $225,000	*Maximum Phase II Award Amount:* $1,500,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Emissions from energy and other anthropogenic activities have been altering the chemical composition of the atmosphere, both regionally and globally. Such modifications are linked not only to environmental degradation and human health problems but also with changes in the most sensitive parts of the physical climate system – namely, clouds and aerosols. The Intergovernmental Panel on Climate Change (IPCC) is making progress toward its next major report, the Fifth Assessment Report (AR5), which will be released in 2013 and 2014. As part of the IPCC assessment process, it has repeatedly been concluded that innovative measurement technologies are needed to provide both input and comparison data for models used to assess the impacts of e.g. energy emissions on the physical and chemical composition of aerosols with particular attention to their subsequent influence on cloud radiative properties. The technologies that are needed are required to have much high accuracy and time stability than has been available to the research community.

When the last IPCC report was published in 2007, there was a lack of data to adequately represent some of the more climate sensitive regions, namely the Arctic and tropics. The Arctic, in particular, continues to be one of the most difficult places on Earth for year-round scientific observations and research, due to a combination both of remoteness and the difficulty of observing under very cold conditions. One of the major recommendations of an Arctic Research Consortium of the U.S. (ARCUS), 1997 report, “Logistics Recommendations for an Improved U.S. Arctic Research Capability” (www.arcus.org/logistics/index.html), was to increase use of robotic aircraft to meet the growing need for environmental observing in the Arctic. Partly in response to this recommendation, the DOE Atmospheric Radiation Measurement (ARM) program (http://www.arm.gov/) increased its emphasis on arctic observations. In the meantime since the release of the 1997 report, there has been an increasing climate change signal in the Arctic; and models have been dramatically underpredicting the rate of change. The DOE Climate and Environmental Sciences Division identified in its recently released strategic plan to emphasize greater attention to Arctic (and tropical) atmospheric sciences, by investing in the development of science and predictability of the climate system, where more sophisticated measurement methods as well as computational and analysis technologies underpin the development. More advanced measurement capabilities for aerosol absorption and scattering, cloud properties, turbulence, and remote sensing are high priority needs of the atmospheric sciences, particularly when such technologies are deployable on small Unmanned Aerial Vehicles (UAVs). Grant applications that respond to this Atmospheric Measurement Technology topic must propose Phase I bench tests of critical technologies. ("Critical technologies" refers to components, materials, equipment, or processes that overcome significant limitations to current capabilities.) In addition, grant applications should (1) describe the purpose and benefits of any proposed teaming arrangements with government laboratories or universities, and (2) support claims of commercial potential for proposed technologies (e.g., endorsements from relevant industrial sectors, market analysis, or identification of potential spin-offs). Grant applications proposing only computer modeling without physical testing will be considered non-responsive.

Grant applications are sought in the following subtopics:

a. Greenhouse Gas and Carbon Isotope Measurements from UAVs

Stable isotopologues of methane and carbon dioxide can be powerful tracers for identifying the sources of greenhouse gases. Airborne surveys of isotopologues of these greenhouse gases made at sufficiently high precision and speed will be an invaluable tool in the studies of Arctic climate change and the terrestrial carbon cycle. Instruments capable of operating on light-weight airborne platforms such as UAV's with little or no temperature or pressure controls are needed. Therefore, we are seeking miniaturization of airborne instrumentation for light aircraft platforms in the Manta, ScanEagle, or Raven classes of unpiloted aerial vehicles (UAVs) that adhere to Federal Aviation Administration manufacturing specifications. We are particularly interested in sensors and instruments with weights less than 5 kg, and able to fit within the payload restrictions of light UAVs. Available operating power for these instruments will be up to 50 watts.

Measurements must be made with high precision for either methane (CH_4) or carbon dioxide (CO_2) at sampling rates of 1 Hz or better that can be combined with vertical velocity measurements. This type of improved capability would allow for the development of sophisticated land models, that are able to accurately represent the carbon cycle, and atmospheric models in order to project CO_2 concentrations based on system interactions.

Questions – contact Rickey Petty, rick.petty@science.doe.gov

b. Cloud Particle Imager

Previous instrument packages developed to image hydrometeors in Arctic and Antarctic clouds have been successfully deployed from research aircraft and tethered balloons. However, traditional instrument packages typically are too large and heavy to be used on small UAV's. A need exists for an instrument package that is capable of installation on a small UAV, with capabilities to describe the size and shape of hydrometeors ranging from 1 micron to several millimeters. In addition, the package should include an integrated cloud particle imager (CPI) that provides high-resolution images capable of distinguishing cloud drops from ice particles in mixed-phase clouds. The entire package must weigh less than 5 kg and consume less than 50 watts.

Questions – contact Rickey Petty, rick.petty@science.doe.gov

c. Measurements of the Chemical Composition of Atmospheric Aerosols

Enhanced measurement methods are needed for the real-time characterization of the bulk and the size-resolved chemical composition of ambient aerosols, particularly carbonaceous aerosols. Such improved measurements would be used to facilitate the identification of the origin of aerosols, (i.e., primary versus secondary and fossil fuel versus biogenic). Also, improved measurements are needed to help elucidate how aerosol particles are processed in the atmosphere by chemical reactions and by clouds, and how their hygroscopic properties change as they age. This information is important because relatively little is known about organic and absorbing particles that are abundant in many locations in the atmosphere. In particular, there is a need for instruments capable of real-time measurements of the composition of these particles at the molecular level. Although recent advances have led to the development of new instruments, such as particle mass spectrometers and single particle analyzers, existing instruments still have important limitations in their ability to quantify black carbon vs. organic carbon, provide speciation of refractory and volatile organic compounds, and calibrate both organic and inorganic components. Furthermore, instruments that otherwise would be suitable for ground-based operation often have limitations (size, weight, power, stability, etc.) that restrict their application for *in situ* measurements, where critical atmospheric processes actually occur (e.g., in or near clouds using aircraft or balloons).

In order to better understand the chemical composition of atmospheric aerosols, grant applications are sought to develop improved instruments, or entirely new measurement methods, that provide: (1) speciation of individual organics, including those containing oxygen, nitrogen, and sulfur; (2) identification of elemental carbon and other carbonaceous material, so that the makeup of the absorbing fraction is known; (3) identification of source markers, such as isotopic abundances in aerosols; and (4) the ability to probe the chemical composition of aerosol surfaces.

In order to address the deficiencies associated with current techniques, proposed approaches should seek to provide: (1) quantifiable results over a wide range of compounds, which is a deficiency of laser ablation aerosol mass spectrometer methods; (2) measurements over a range of volatility so that dust, carbon, and salt are detectable, which is a deficiency of thermal decomposition aerosol mass spectrometers; and (3) measurements with high time resolution, which is a deficiency of filter techniques. Proposed approaches that can measure aerosol chemical composition from airborne platforms would be of particular interest

Questions – contact Ashley Williamson, ashley.williamson@science.doe.gov

d. Measurements of the Chemical Composition of Atmospheric Aerosol Precursors

In order to better understand the evolution of aerosols in the open air, grant applications are sought to develop instruments that can make fast measurements of gas phase organics or other substances that might either condense or dissolve into aerosols or cloud droplets. Of special interest are volatile organic compounds (VOC) and intermediate volatility organic compounds (IVOC). Although VOCs and IVOCs partition primarily into the gas phase, they may react with gaseous oxidants or with existing aerosol particles and droplets to form a secondary organic aerosol (SOA) mass. Current methods for predicting SOA production rates, based only on precursor organic compounds that have been quantified (both VOCs and oxygenates), underestimate SOA production by factors of 3 or more. One problem is that many gaseous organic compounds are not detected by commonly-used techniques, such as gas chromatographic or chemical ionization-mass spectrometric methods.

Grant applications also are sought to develop instruments to determine the total amount of carbon in these organic compounds. The data provided by these instruments would allow scientific insights to be gained regarding the reason for the underestimation of SOA production. (That is, is the underestimation due to key precursors that are not measured? Or, is it due to the use of extrapolations – from laboratory kinetic and equilibrium data – that were not appropriate for ambient conditions?)

Questions – contact Ashley Williamson, ashley.williamson@science.doe.gov

e. Aerosol and Hydrometeor Size Distributions

Knowledge of particle size distribution is essential for describing both direct and indirect radiative forcing by aerosols. However, current techniques for determining these distributions are often ambiguous because of the assumption that the particles are spherical. In particular, the optical techniques most often used in the 0.5-10 µm size range have inherent problems. Therefore, grant applications are sought for techniques for which the size determination is not based on optical properties, to determine the size distribution of ambient aerosols in the 0.1 – 10 µm size ranges. Proposed approaches must address the influence of relative humidity and must be integrated with the simultaneous measurement of such properties as mass concentration, area (extinction), and particle number.

Grant applications also are sought to develop fast (~ 1 sec) and lightweight (suitable for sampling from airborne platforms) instruments for (1) particle size spectrum measurements in the 10- 600 nm size range, and (2) for cloud droplet/drizzle measurements (10–1000 µm size range). Related airborne measurements of great interest are (3) a fast spectrometer for measurement of cloud condensation nuclei number concentrations over supersaturation ranges of the order 0.02% – 1% and (4) a spectrometer/counter for ice nuclei (IN) number concentrations over effective local temperatures down to -38 °C.

Questions – contact Ashley Williamson, ashley.williamson@science.doe.gov

f. Aerosol Scattering and Absorption (in situ)

The aerosol absorption coefficient, together with the aerosol scattering coefficient, determines the single-scattering albedo. This key aerosol property, along with the factors that contribute to it, are critical for determining heating rates and climate forcing by aerosols. Therefore, grant applications are sought to develop reliable instruments for the *in situ* measurement (using aircraft or balloons) of the single-scattering albedo for particles containing black and organic carbon, dust, and minerals. The measurements must cover the solar wavelengths (UV, visible, and near infrared), must not alter aerosol properties, and must address the influence of relative humidity.

Questions – contact Ashley Williamson, ashley.williamson@science.doe.gov

g. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Rickey Petty, rick.petty@science.doe.gov

References: Subtopics a-b:

1. The Arctic Research Consortium of the U.S. (ARCUS) (http://www.arcus.org/arcus/index.html).
2. J. A. Curry, J. Maslanik, G. Holland & J. Pinto. (2004). Applications of aerosondes in the Arctic. Bulletin of the American Meteorological Society (BAMS). December 2004, pp. 1855-1861. Available at http://curry.eas.gatech.edu/currydoc/Curry_BAMS85A.pdf.
3. C.E. Corrigan, G.C. Roberts, M.V. Ramana, D. Kim & V. Ramanathan. (2008). Capturing vertical properties of aerosols and black carbon over the Indian Ocean using autonomous unmanned aerial vehicles. Atmospheric Chemistry and Physics. Vol. 8, Issue 3, pp. 737-747. Available at http://www.atmos-chem-phys.org/8/737/2008/acp-8-737-2008.html.
4. Stephens, G. L., Ellingson, R.G., et. al.; The Department of Energy's Atmospheric Radiation Measurement (ARM) Unmanned Aerospace Vehicle (UAV) Program BAMS, Vol. 81, No. 12, December 2000; DOI: http://dx.doi.org/10.1175/1520-0477(2000)081<2915:TDOESA>2.3.CO;2

References: Subtopic c:

1. R. P. Lawson, B.A. Baker, C.G. Schmitt & T.L. Jensen. (2001). *An overview of microphysical properties of Arctic clouds observed in May and July 1998 during FIRE ACE*. Vol. 106, Issue D14, pp. 14989-15014. Available for purchase at http://onlinelibrary.wiley.com/doi/10.1029/2000JD900789/abstract.
2. R. P. Lawson, K. Stamnes, J. Stamnes, P. Zmarzly, J. Koskuliks, C. Roden, Q. Mo & M. Carrithers. (2011). Deployment of a tethered-balloon system for microphysics and radiative measurements in mixed-phase clouds at Ny-Ålesund and South Pole. Journal of Atmospheric and Oceanic Technology. Vol. 28, pp. 656-670. Available for purchase at http://journals.ametsoc.org/doi/abs/10.1175/2010JTECHA1439.1?journalCode=atot.
3. M. Sikand, J. Koskulics, K. Stamnes, B. Hamre, J. J. Stamnes & R. P. Lawson. (2010). *Optical properties of mixed-phase boundary layer clouds observed from a tethered balloon platform in the Arctic*. Journal of Quantitative Spectroscopy and Radiative Transfer. Vol. 111, pp. 1921-1930. Available for purchase at http://www.sciencedirect.com/science/article/pii/S0022407310000889.
4. M. Sikand, J. Koskulics, K. Stamnes, B. Hamre, J. J. Stamnes & R. P. Lawson. (2013). Estimation of mixed-phase cloud optical depth and position using in situ radiation and cloud microphysical measurements obtained from a tethered-balloon platform. Journal of the Atmospheric Sciences. Vol. 70, Issue 1, pp. 317-329. Available for purchase at http://journals.ametsoc.org/doi/abs/10.1175/JAS-D-12-063.1

References: Subtopics d-g:

1. U.S. Department of Energy: Biological and Environmental Research Advisory Committee. (2004). *A Reconfigured Atmospheric Science Program.* See: 'Instrument Development', pp. 18-21. Available at http://science.energy.gov/~/media/ber/berac/pdf/Asp.pdf.
2. U.S. Department of Energy: Office of Science. (2010). *Atmospheric System Research (ASR) Science and Program Plan*. Available at http://science.energy.gov/~/media/ber/pdf/Atmospheric_system_research_science_plan.pdf

18. CARBON CYCLE AND RELATED GREENHOUSE GAS MEASUREMENTS OF THE ATMOSPHERE AND THE BIOSPHERE

Maximum Phase I Award Amount: $225,000	*Maximum Phase II Award Amount:* $1,500,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Eighty-five percent of our nation's energy results from the burning of fossil fuels from vast reservoirs of coal, oil, and natural gas. These processes add carbon to the atmosphere, principally in the form of carbon dioxide (CO_2). It is important to understand the fate of this excess CO_2 in the global carbon cycle in order to assess contemporary terrestrial carbon sinks, the sensitivity of climate to atmospheric CO_2, and future potentials for sequestration of carbon in terrestrial systems. Therefore, improved measurement approaches are needed to quantify the change of CO_2 in atmospheric components of the global carbon cycle. There is also interest in innovative approaches for flux and concentration measurements of methane and other greenhouse gas constituents associated with terrestrial systems as well as quantifying root associated belowground processes relevant to carbon cycling.

The "First State of the Carbon Cycle Report (SOCCR)" (Reference 1) and the "Carbon Cycling and Biosequestration Report: (Reference 2) provides rough estimates of terrestrial carbon sinks for North America. Numerous working papers on carbon sequestration science and technology also describes research needs and technology requirements for sequestering carbon by terrestrial systems(References 3-5). Both documents call for advanced sensor technology and measurement approaches for detecting changes of atmospheric CO_2 properties and of carbon quantities of terrestrial systems (including biotic, microbial, and soil components). Such measurement technology would improve the quantification of CO_2, as well as carbon stock and flux, in the major sinks identified by the SOCCR report (see Figure ES.1 therein). Furthermore, the report, "A U.S. Carbon Cycle Science Plan" (Reference 6) provides additional background on critical, overarching research needs related to carbon cycling in terrestrial ecosystems.

Grant applications submitted to this topic should (1) demonstrate performance characteristics of proposed measurement systems, and (2) show a capability for deployment at field scales ranging from experimental plot size (meters to hectares of land) to nominal dimensions of ecosystems (hectares to square kilometers). Phase I projects must perform feasibility and/or field tests of proposed measurement systems to assure a high degree of reliability and robustness. Combinations of stationary, remote, and *in situ* approaches will be considered, and priority will be given to ideas/approaches for verifying biosphere carbon changes. Measurements using aircraft or balloon platforms must be explicitly linked to real-time ground-based measurements.

Grant applications based on satellite remote sensing platforms are beyond the scope of this topic and will be declined.

Grant applications are sought in the following subtopics:

a. Portable Technologies for Fast and Precise Measurements of Atmospheric Nitrogen, Argon, or Oxygen

Fast and precise measurements of atmospheric nitrogen (N_2), argon (Ar), and oxygen (O_2) have the potential to become the foundation of the next generation of eddy covariance technologies and revolutionize the real-time observations of fluxes of atmospheric greenhouse gases between the earth surface and the atmosphere (Reference 9). Measuring such fluxes is crucial in the research fields of climate change, global change biology, and ecology. Measurements of N_2, Ar, and O_2 also have direct applications in agriculture, medicine, and industrial processes. However it is challenging to measure these gases precisely with fast response due to their high ambient abundance. Innovative technologies are sought with the following specifications:

Nitrogen (N_2) – The response time must be less than 100ms. The N_2 can be measured directly in the unit of molar density within the range of 20 to 60 mol/m^3 with a precision of 0.2%. An acceptable alternative would be the measurement of the ratio of an atmospheric greenhouse gas (e.g. carbon dioxide, water vapor, or methane) to N_2 with a precision of 1%.

Argon (Ar) – The response time must be less than 100ms. The Ar can be measured directly in the unit of molar density within the range of 150 to 650 mmol/m^3 with a precision of 0.2%. An acceptable alternative would be the measurement of the ratio of an atmospheric greenhouse gas (e.g. carbon dioxide, water vapor, or methane) to Ar with a precision of 1%.

Oxygen (O_2) – The response time must be less than 100ms. The O_2 should only be measured directly in the unit of molar density within the range of 5 to 15 mol/m^3 with a precision of 0.001%.

Questions – contact Michael Kuperberg, michael.kuperberg@science.doe.gov

b. Innovation and Improvement for *In Situ* Root Measurements

Fine roots (generally < 2 mm in diameter) play a critical role in the carbon and nutrient cycles of ecosystems. Their production, distribution within the soil, and turnover must be measured to have a full understanding of how an ecosystem is responding to perturbations such as climate change (Reference 2, 10 and 11). Currently, the best method available for quantifying fine roots is minirhizotrons (Reference 12), which are used to periodically collect images of intact roots with a camera inserted in a transparent tube installed in the soil. Current analysis of the collected images is difficult, labor-intensive, and subject to operator biases. Quantification and analysis is a particular challenge in certain environments such as rocky soils and wetland ecosystems (Reference 13).

Grant applications are sought for technology innovation to improve current minirhizotron technologies and produce rapid assessments and measurements of in situ fine root measurements. Improvements should be aimed at developing an integrated high-throughput system that captures and processes images in real time and produces an automated replicable and artifact-free analysis of the images. Key capabilities should include state-of-the-art analytical operations, immediate detection and extraction of features (see item 2 below), and use of image-processing filters for comparing images while keeping pace with the rate of image capture. Specific technology developments should include one or more of the following criteria:

(1) Advanced Image Collection System – New, low-cost imaging/camera designs and automated acquisition systems with increased versatility in soil imaging and field conditions. Device flexibility of usage and portability are also sought (Reference 13).

(2) Automated Image Analysis – Software improvements to develop new image-processing algorithms and automated solutions that can reduce the amount of manual intervention required for each image analysis. A reliable, automated minirhizotron image analysis system would make possible more consistency and greater data intensity. An example of a minirhizotron analysis system is RootFly (http://www.ces.clemson.edu/~stb/rootfly/), but this program has proven inadequate for truly automated analysis, especially in systems where there is little contrast between roots and the background soil matrix. Specific high resolution root parameters that should be captured by automated analysis include, but are not limited to: root length, root diameter, color, turnover rates, and fungal presence. Innovative methods for automated analysis of fine root and fungal dynamics (i.e., production, mortality, and turnover calculate between sampling dates) are also highly desired.

(3) Three-dimensional Scaling and Image Analysis – Current analysis methods cannot adequately scale 2-dimensional minirhizotron images to three-dimensional data. There is potential for automated analysis of root edge resolution in order to quantify the image depth of field, or whether a particular root was "in focus" and therefore within a given depth of field (Reference 13).

(4) Other Non-Destructive Belowground Assessment Tools – Additionally, desired measurement characteristics could include other non-destructive, remote quantification or visualizations of fine roots in soil such as ground penetrating radar (References 15 and 16) microscopic or high-resolution X-ray imaging of roots (Reference 14), and portable X-ray tomography (i.e., http://www.emsl.pnl.gov/capabilities/viewInstrument.jsp?id=34132). Such a system could be deployed using the minirhizotron tubes that have been installed in many experimental sites, or newer, miniaturized approaches that are minimally invasive to the experimental system (e.g. soil environment) could be developed.

Questions – contact Daniel Stover, Daniel.stover@science.doe.gov

c. Improved Real-Time Measurements of Nitrous Oxide Emission from Soils

Nitrous oxide (N_2O) is an important greenhouse gas, resulting primarily from microbial activity in the soil, and is partially regulated by soil chemical and physical properties (for example, soil pH, organic matter availability, soil type, temperature, and moisture). Nitrous oxide emission can be highly variable in both space and time due to nitrogen amendments and other biogeochemical perturbations in soils. As a result, improved, real-time measurements of N_2O emission from soils are needed to quantify and eventually model the connection of N_2O emissions to environmental conditions. Current methods are inadequate and often require gas samples to be collected manually and analyzed in a laboratory, thus integrating over heterogeneous environmental conditions and potentially introducing sampling bias and limiting the number of samples collected from the field (References 17 and 18).

Grant applications are sought for technology innovation to provide high resolution, real-time measurements of nitrous oxide gas emissions from soils. Instrument platforms should be durable and withstand typical field deployment. Gas sampling should be reliable, with repeatable measurement precision of 0.01 to 0.2 ppb at least every 60 seconds. For chamber-based measurements of N_2O emissions, the technology should have a response time faster than 1 second. For eddy covariance measurements of N_2O emissions, the technology should have a response time faster than 0.1 second. Technologies that utilize trapping-based approaches will not be considered.

Questions – contact Mike Kuperberg, michael.kuperberg@science.doe.gov

d. Innovation and Improvement for *In Situ* Physical and Chemical of Soil Properties

Quantification and analysis of the physical and chemical properties of the soil are particularly difficult due to the inherent spatial and temporal variability of soils. Current methods require soils to be extracted from the field and transported to a laboratory setting for investigation that could result in artifacts in data analysis (Reference 2, 3, 4, 19 and 20). A number of recent advances have resulted in technologies that provide improved understanding of soil characteristics, many which are minimally destructive. Examples of these technologies include miniature/self contained soil moisture probes, temperature probes, soil nutrient exchange resins, and soil reactivity biotapes. To improve our understanding the role of soil ecology in environmental research, the scientific community needs to quantify a wide variety of soil characteristics which have implications to broader scientific discoveries.

Grant applications are sought for technology innovation to improve the temporal and spatial resolution of soil properties including, but not limited to: temperature, moisture, pH, redox potential, microbial activity, oxygen availability, biogeochemical cycling, and chemical/nutrient properties. Sensors should provide a significant improvement over existing technology and be minimally invasive during installation and/or data acquisition. Sensor technology should require minimal power to operate, be rugged enough to be applied in various environmental conditions. Special consideration is given to technologies that could employ wireless or that achieve multiple soil characteristics simultaneously.

Questions – contact Daniel Stover, daniel.stover@science.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Mike Kuperberg, michael.kuperberg@science.doe.gov

References:

1. A. W. King, et al. (2007). The North American Carbon Budget and Implications for the Global Carbon Cycle, aka The Prototype State of the Carbon Cycle Report (SOCCR). U.S. Climate Change Science Program Synthesis and Assessment Product. Version 2.2, pp. 239. Nov. 13, 2007. Available at http://www.climatescience.gov/Library/sap/sap2-2/default.php
2. U.S. Department of Energy: Office of Science, Biological and Environmental Research. (2008). Carbon Cycling and Biosequestration: Integrating Biology and Climate through Systems Science. Report from the March 2008 Workshop. Available at http://genomicscience.energy.gov/carboncycle/report/CarbonCycle012609LR.pdf
3. Technology Options for the Near and Long Term: 2003. U.S. Climate Change Technology Program. (http://www.climatetechnology.gov/library/2003/tech-options/index.htm)
4. L. Dilling, et al. (2003). The role of carbon cycle observations and knowledge in carbon management. Annual Review of Environment and Resources. Vol. 28, pp. 521-558. Available at http://sciencepolicy.colorado.edu/admin/publication_files/resource-1732-2005.20.pdf
5. National Research Council & National Academy of Engineering. (2004).The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs. pp. 101-103. Washington, D.C.: National Academies Press. ISBN: 978-0-309-09163-3. Available at http://books.nap.edu/books/0309091632/html/index.html
6. A. M. Michalak, R. B. Jackson, G. Marland, C. L. Sabine & the Carbon Cycle Science Working Group. (2011). A U.S. Carbon Cycle Science Plan. Available at http://www.carboncyclescience.gov/USCarbonCycleSciencePlan-August2011.pdf
7. D.S. Sayres, et al. (2009). A new cavity based absorption instrument for detection of water isotopologues in the upper troposphere and lower stratosphere. Review of Scientific Instruments. Vol. 80, Issue 4. Available at http://rsi.aip.org/resource/1/rsinak/v80/i4/p044102_s1
8. T. Watai, et al. (2006). A lightweight observation system for atmospheric carbon dioxide concentration using a small unmanned aerial vehicle. Journal of Atmospheric and Oceanic Technology. Volume 23, Issue 5, pp. 700-710. Available at http://journals.ametsoc.org/doi/pdf/10.1175/JTECH1866.1
9. L. Gu, et al. (2012). The fundamental equation of eddy covariance and its application in flux measurements. Agricultural and Forest Meteorology. Volume 152, pp. 135-148. Available at http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1112&context=usdoepub
10. Root Methods: A Handbook. (2000). Eds. A.L. Smit, A.G. Bengough, C. Engels, M. van Noordwijk, S. Pellerin & S.C. van de Geijn. New York: Springer. ISBN: 3-540-66728-8. Available for purchase at http://www.amazon.com/Root-Methods-Handbook-A-L-Smit/dp/3540667288/ref=sr_1_1?ie=UTF8&qid=1340051783&sr=8-1&keywords=root+methods+a+handbook
11. M.H. Ebinger, et al. (2003). Extending the applicability of laser-induced breakdown spectroscopy for total soil carbon measurement. Soil Science Society of America Journal. Vol. 67, No. 5, pp. 1616-1619. Available for purchase at https://www.soils.org/publications/sssaj/abstracts/67/5/1616
12. M.G. Johnson, et al. (2001). Advancing fine root research with minirhizotrons. Environmental and Experimental Botany. Vol. 45, No. 3, pp. 263-289. http://www.journalogy.net/Publication/2667320/advancing-fine-root-research-with-minirhizotrons

13. C.M. Iversen, et al. (2012). Advancing the use of minirhizotrons in wetlands. Plant and Soil Vol. 352, Issue 1-2, pp. 23-39. Available at http://ecosystems.psu.edu/research/labs/root-ecology/publications/iversen-et-al.-2012-plant-soil
14. A. Pierret. (2008). Multi-spectral imaging of rhizobox systems: new perspectives for the observation and discrimination of rhizosphere components. Plant and Soil. Vol. 310, pp. 263-268. Available at http://hal-bioemco.ccsd.cnrs.fr/bioemco-00392773/
15. D.B. Stover, F. Day, J. Butnor & B. Drake. (2007). Effect of elevated CO2 on coarse-root biomass in Florida scrub detected by ground-penetrating radar. Ecology. Vol. 88, Issue 5, pp. 1328-1334. Available at http://www.planta.cn/forum/files_planta/2007daniel_bstoverecologyeffect_of_elevated_co2_on_coase_root_biomass_in_florida_scrub_detected_by_gpr_195.pdf
16. D. J. Daniels. (1996). Surface-Penetrating Radar. IEE Radar, Sonar, Navigation and Avionics Series 6. London: The Institution of Electrical Engineers. ISBN: 0-8529-68620. Available for purchase at http://www.amazon.com/Surface-Penetrating-Radar-Sonar-Navigation-Avionics/dp/0852968620/ref=sr_1_1?ie=UTF8&s=books&qid=1251900430&sr=1-1
17. K.A. Smemo, et al. (2011. Improving process-based estimates of N_2O emissions from soil using temporally extensive chamber techniques and stable isotopes. Nutrient Cycling in Agroecosystems. Vol. 91, Issue 2, pp. 145-154. Available at http://link.springer.com/article/10.1007%2Fs10705-011-9452-2#page-1
18. J.J. Fassbinder, et al. (2013). Automated, low-power chamber system for measuring nitrous oxide emissions. Journal of Environmental Quality. Vol. 42, No. 2, pp. 606-614. Available at https://www.agronomy.org/publications/jeq/abstracts/42/2/606?access=0&view=pdf
19. D. Sparks. (1996). Methods of Soil Analysis: Part 3--Chemical Methods. Soil Society of America Book Series. No. 5, pp. 1011-1070. Madison, Wisconsin: Soil Science Society of America. ISBN: 0-8911-88258. Available for purchase at http://www.amazon.com/Methods-Analysis-Chemical-Science-Society/dp/0891188258/ref=sr_1_1?ie=UTF8&s=books&qid=1251900878&sr=1-1
20. U. Gamnitzer, A.B. Moyes, D.R. Bowling & H. Schnyder. (2011). Measuring and modeling the isotopic composition of soil respiration: insights from a grassland tracer experiment. Biogeosciences. Vol. 8, Issue 5, pp. 1333-1350. Available at http://www.biogeosciences.net/8/1333/2011/bg-8-1333-2011.html

19. ENHANCED AVAILABILITY OF CLIMATE MODEL OUTPUT

Maximum Phase I Award Amount: $225,000	*Maximum Phase II Award Amount:* $1,500,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Federal investment in the development of climate and earth system models for scientific analysis is dominated by programmatic support from the Department of Energy, National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and National Science Foundation (NSF). Model output resulting from climate change projections is a valuable resource and the DOE has played a crucial role in providing the research and stakeholder communities with datasets containing ensemble runs produced by climate modeling centers that are combined with data sets used for validation and uncertainty analysis. More specifically, the DOE-supported Program for Climate Model Diagnosis and Intercomparison (PCMDI) (http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php) makes available multi-model output derived from all major climate modeling centers worldwide, to researchers for non-commercial purposes only; however, other users, particularly non-researchers who wish to use the data for commercial purposes, have only limited access to multi-model data sets, i.e., given restrictions imposed by some modeling centers for commercialization. As the temporal and spatial resolution of models increases, and as improved downscaling techniques become available from both the public and private sectors, vastly more amounts of climate model output will be generated, some of which allows commercial use and others with more restricted access.

Grant applications are sought only in the following subtopics:

a. Accessibility of Climate Model Data to Non-Researchers

The purpose of this subtopic is to broaden the usage of federally-funded, long-term climate change simulations of high-end climate models, such as the Community Earth System Model, the NOAA Geophysical Fluid Dynamics Laboratory model, and the NASA Goddard Institute for Space Studies model.

Therefore, grant applications are sought to develop technologies for making the output of these models more accessible to a variety of users. Approaches of interest include the development of (1) preferred data formats for users of climate model output in particular applications (e.g., agriculture, water resources, energy); (2) methods for converting the data from existing data formats to formats required by users in the application communities; and (3) improved software frameworks and prototypes for data access by distinct application communities. Applicants are expected to document lessons learned in the experience of providing climate model output data to the non-research community.

Questions – contact Renu Joseph, Renu.Joseph@science.doe.gov

b. Accessibility of Integrated Assessment Models, Data, and Tools to Non Researchers

The purpose of this subtopic is to improve the accessibility of Integrated Assessment data, models, and tools to non-researchers, including improved interfaces and visualization systems for conducting analyses and interpreting data. In particular, efforts should seek to develop and/or improve capabilities for accessing information in ways that accommodate the needs of various sectors, cross-sectoral topics, and spatial and temporal scales that are possible with global, national, and regional integrated assessment models, such as the Global Change Assessment Model, the Integrated Global System Model, the Regional Integrated Assessment Model, and corresponding, broader, inter-model comparison efforts. Additionally, efforts may include focus on the new class of DOE sponsored multi-sector, multi-stressor impact, adaptation, and vulnerability (IAV) model , in particular the Critical Infrastructure Protection Model.

Questions – contact Bob Vallario, Bob.Vallario@science.doe.gov

c. Develop Modeling Capabilities and Tools that will Facilitate a Better Linkage Between Global and Regional Climate Model Output and Wind-Energy Stakeholders

There is a wide range of uncertainties in general circulation and regional climate models that make them unsuitable for direct use in the design and planning of wind-energy systems. In addition, the global climate model output resolution is much too coarse for use by wind energy planners. Modeling tools that are capable of converting the output of global models to local scales and enable better understanding of the interaction between wind farms and regional climate are invited as part of this grant application request. Model output can also be used in conjunction with observations to enable a better characterization of the interaction between wind plants and local/regional/global climate. Applications that can identify and reduce the largest sources of uncertainty to enable an efficient use of future wind predictions are invited. An assessment of the nature and likelihood of extreme wind events in the current and future climate should help protect national investments in wind energy resources. To summarize, the effect of climatology, climate change, and extremes on wind farms and/or the effect of wind farms on regional climate is an important part of this solicitation.

Questions – contact Renu Joseph, Renu.Joseph@science.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Renu Joseph, Renu.Joseph@science.doe.gov

References: Subtopic a:

1. Gerald A. Meehl, et al. (2007). The WCRP CMIP3 multimodel dataset: a new era in climate change research. Bulletin of the American Meteorological Society. Vol. 88, pp. 1383-1394. Available at http://journals.ametsoc.org/doi/pdf/10.1175/BAMS-88-9-1383
2. U.S. DOE Atmospheric Radiation Measurement (ARM) Program. (Provides improved scientific understanding of the fundamental physics related to interactions between clouds and radioactive feedback processes in the atmosphere.) (http://www.arm.gov/)
3. U.S. DOE AmeriFlux. (Provides continuous observations of ecosystem level exchanges of CO2, water, energy and momentum spanning diurnal, synoptic, seasonal, and inter-annual time scales.) (http://public.ornl.gov/ameriflux/)

References: Subtopic b:

1. U.S. Department of Energy Office of Biological & Environmental Research. (2009). *Science Challenges and Future Directions: Climate Change Integrated Assessment Research.* Report from the November 2008 Workshop on Integrated Assessment. Available at http://science.energy.gov/~/media/ber/pdf/ia_workshop_low_res_06_25_09.pdf
2. U.S. Department of Energy Office of Science. *Community Modeling and Long-Term Predictions of the Integrated Water Cycle.* Report from the September 2012 Workshop. Available at http://climatemodeling.science.energy.gov/f/2013/Water_Cycle_Report.pdf
3. Erwan Monier, Jeffery R. Scott, Andrei P. Sokolov, Chris E. Forest & C. Adam Schlosser. (2012). *An Integrated Assessment Framework for Uncertainty Studies in Global and Regional Climate Change: The IGSM-CAM.* MIT Joint Program on the Science and Policy of Global

Change. Report No. 223. Available at http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt223.pdf
4. Global Change Assessment (GCAM) Model. (http://www.globalchange.umd.edu/models/gcam/download/)

References: Subtopic c:

1. S. Schreck, J. Lundquist & W. Shaw. (2008). *U.S. Department of Energy Workshop Report: Research Needs for Wind Resource Characterization.* National Renewable Energy Laboratory. Broomfield, Colorado. January 14-16, 2008. p. 107. Available at http://www.nrel.gov/docs/fy08osti/43521.pdf
2. D.W. Keith, J.F. DeCarolist, D.C. Denkenberger, D.H. Lenschow, S.L. Malyshev, S. Pacala & P.J. Rasch. (2004). *The influence of large-scale wind power on global climate.* Proceedings of the National Academy of Sciences. Vol. 101, No. 46, 16115–16120. Available at http://www.pnas.org/content/101/46/16115.full
3. S.C. Pryor, J.T. Schoof & R.J. Barthelmie. (2005). *Empirical downscaling of wind speed probability distributions.* Journal of Geophysical Research--Atmospheres. Vol. 110, pp. D19109(1-12). DOI:10.1029/2005JD005899. Available at http://opensiuc.lib.siu.edu/cgi/viewcontent.cgi?article=1007&context=gers_pubs
4. K. Horvath, A. Bajić, S. Ivatek-Šahdan. (2011). *Dynamical downscaling of wind speed in complex terrain prone to bora-type flows.* Journal of Applied Meteorology and Climatology. Vol. 50, pp. 1676-1691. DOI: 10.1175/2011JAMC2638.1. Available at http://journals.ametsoc.org/doi/abs/10.1175/2011JAMC2638.1

20. TECHNOLOGIES FOR SUBSURFACE CHARACTERIZATION AND MONITORING

Maximum Phase I Award Amount: $225,000	*Maximum Phase II Award Amount:* $1,500,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

In support of the Department of Energy's (DOE's) secure and sustainable energy mission the Office of Biological and Environmental Research seeks to advance fundamental understanding of coupled biogeochemical processes in complex subsurface environments to enable systems-level prediction and decision support. This basic scientific understanding is applicable to a wide range of DOE relevant energy and environmental challenges including:

- Cleanup of contaminants and stewardship of former weapons production sites
- Underground storage of spent nuclear fuel
- Carbon cycling and sequestration in the environment
- Nutrient cycling in the environment in support of sustainable biofuel development
- Fossil fuel processing and recovery from the deep subsurface.
- Assessing the environmental impacts of natural gas production by hydraulic fracturing

Science-based understanding and solutions to these challenges are constrained by:
- The inherent complexity and inaccessibility of subsurface environments and the strong coupling of biological, chemical and physical processes across vast spatial and temporal scales.

• Lack of well established, holistic approaches for understanding, predicting and controlling biogeochemical and hydrodynamic processes in complex subsurface environments.

The development of new measurement and monitoring tools for interrogating physical, chemical, and biological processes in subsurface environments are needed to develop and test predictive models of subsurface systems and enable quantitative and robust decision support.

Grant applications submitted to this topic must describe why and how proposed *in situ* fieldable technologies will substantially improve the state-of-the-art, include bench and/or field tests to demonstrate the technology, and clearly state the projected dates for likely operational deployment. New or advanced technologies, which can be demonstrated to operate under field conditions and can be deployed in 2-3 years, will receive selection priority. Claims of relevance to DOE sites, or of commercial potential for proposed technologies, must be supported by endorsements from relevant site managers, market analyses, or the identification of commercial spin-offs. Grant applications that propose incremental improvements to existing technologies are not of interest and will be declined. For the following subtopics, collaboration with government laboratories or universities, either during or after the SBIR/STTR project, may speed the development and field evaluation of the measurement or monitoring technology. BER funding to the National Laboratories is primarily through Scientific Focus Areas (SFAs). The Subsurface Biogeochemical Research (SBR) supported SFAs, and the field sites where they conduct their research, are described at the following website: http://doesbr.org/research/sfa/index.shtml. The Terrestrial Ecosystem Science (TES) program also supports several interdisciplinary field research projects focused on carbon and nutrient cycling: http://tes.science.energy.gov/node/89 . These field research sites may also be appropriate venues for testing and evaluation of novel measurement and monitoring technologies. Proposed plans to conduct testing at these DOE supported research sites should be accompanied by a letter of support from the project PI.

Another potential resource available to applicants is the Environmental Molecular Science Laboratory (EMSL) at the Pacific Northwest National Laboratory (http://www.emsl.pnl.gov). EMSL is a national scientific user facility with state-of-the-art instrumentation in environmental spectroscopy, high field magnetic resonance, high performance mass spectroscopy, high resolution electron microscopy, x-ray diffraction, and high performance computing.

Grant applications must describe, in the technical approach or work plan, the purpose and specific benefits of any proposed teaming arrangements.

Grant applications are sought in the following subtopics:

a. Mapping and Monitoring of Hydrogeologic and Biogeochemical Processes

While subsurface characterization methods are improving and yielding higher-resolution data, they are still not routinely used to describe flow and transport processes, to test and validate reactive transport models, or to guide decision support. Grant applications are sought to develop high-resolution geophysical, geochemical, or hydrogeological methods to: (1) characterize subsurface properties that control the transport and dispersion of contaminants and nutrients in groundwater, the unsaturated zone, and soil systems; or (2) monitor dynamic processes such as fluid flow, contaminant and nutrient transport, and geochemical and microbial activity in these subsurface environments. Approaches of interest include the development of:

Integrated approaches where geophysical data are combined with other types of data (e.g., core analyses, well logs, hydrogeologic and geochemical information) to better constrain and evaluate flow and transport models;

Improved tools and methods for hydrogeologic characterization using cone-penetrometers and conventional well logging systems;
Innovative advances of temperature sensing technologies and approaches for hydrological characterization and monitoring from subsurface, surface, or airborne platforms; and

Improved methods for the long-term monitoring (for one year, ten year, and one hundred year time frames) of subsurface systems, using integrated sensor networks.

Improved characterization and monitoring approaches (to support conceptual and numerical model development) for:

fractured-rock and karst systems;

systems with significant underground infrastructure, both known and unknown (pipes, filled areas of variable permeability, basements, tanks); and

source zones with contaminants having unique properties (e.g., elemental mercury, DNAPL)

Questions: Contact David Lesmes, david.lesmes@science.doe.gov

b. Real-Time, In Situ Measurements of Geochemical, Biogeochemical and Microbial Processes in the Subsurface

Sensitive, accurate, and real-time monitoring of geochemical, biogeochemical, and microbial conditions are needed in subsurface environments, including groundwater, sediments, and biofilms. In particular, highly selective, sensitive, and rugged in situ devices are needed for low-cost field deployment in remote locations, in order to enhance our ability to monitor processes at finer levels of resolution and over broader areas. Therefore, grant applications are sought to develop innovative sensors and systems to detect and monitor subsurface geochemical and biogeochemical processes that control the chemical speciation or transport of radionuclides, metals and organic contaminants of concern at contaminated DOE sites (e.g., technetium, chromium, strontium-90, mercury, uranium, iodine-129, plutonium, americium, cesium-137, cobalt, carbon tetrachloride, TCE, PCE, VC, DCE and emerging organic contaminants). The ability to distinguish between the relevant oxidation states of the radionuclide and metal contaminants is of particular concern. Innovative approaches for monitoring multi-component biogeochemical signatures of subsurface systems including nutrients are also of interest. As is the development of robust field instruments for multi-isotope and quasi-real time analyses of suites of isotopes (e.g. CH4, CO2, nitrogen compounds, and water isotopes). Grant applications must provide convincing documentation (experimental data, calculations, etc.) to show that the sensing method is both highly sensitive (i.e., low detection limit), precise, and highly selective to the target analyte, microbe, or microbial association (i.e., free of anticipated physical/chemical/biological interferences). Approaches that leave significant doubt regarding sensor functionality in realistic multi-component samples and realistic field conditions will not be considered.

Grant applications also are sought to develop integrated sensing systems for autonomous or unattended applications of the above measurement needs. The integrated system should include all of the components necessary for a complete sensor package (such as micro-machined pumps, valves, micro-sensors, solar power cells, etc.) for field applications in the subsurface. Approaches of interest include: (1) automated sample collection and monitoring of subsurface biogeochemistry and microbiology community structure, (2) fiber optic, solid-state, chemical, or silicon micro-machined sensors; and (3) biosensors (devices employing biological molecules or systems in the sensing elements) that can be used in the field – biosensor systems may incorporate, but are not limited to, whole cell biosensors (i.e., chemiluminescent or bioluminescent systems), enzyme or immunology-linked detection systems (e.g., enzyme-linked immunosensors incorporating colorimetric or fluorescent portable detectors), lipid characterization systems, or DNA/RNA probe technology with amplification and hybridization. Grant applications that propose minor adaptations of readily available materials/hardware, and/or cannot demonstrate substantial improvements over the current state-of-the-art are not of interest and will be declined.

Questions: Contact David Lesmes, david.lesmes@science.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions: Contact David Lesmes, david.lesmes@science.doe.gov

References:

1. U.S. Department of Energy Office of Biological & Environmental Research: Subsurface Biogeochemical Research (SBR) Program. (http://science.energy.gov/ber/research/cesd/subsurface-biogeochemical-research/)
2. U.S. Department of Energy Office of Biological & Environmental Research: Terrestrial Ecosystem Science (TES) Program. (http://science.energy.gov/ber/research/cesd/terrestrial-ecosystem-science/)
3. U.S. Department of Energy: Office of Biological and Environmental Research. (2012). *Climate and Environmental Sciences Division (CESD) Strategic Plan*. Available at http://science.energy.gov/~/media/ber/pdf/CESD-StratPlan-2012.pdf
4. U.S. Department of Energy: Biological & Environmental Research Advisory Committee (BERAC). (2013). *BER Virtual Laboratory: Innovative Framework for Biological and Environmental Grand Challenges.* Available at http://science.energy.gov/~/media/ber/berac/pdf/Reports/BER_VirtualLaboratory_finalwebHR.pdf
5. U.S. Department of Energy: Office of Biological and Environmental Research. (2010). *Complex Systems Science for Subsurface Fate and Transport.* Report from the August 2009 Workshop. Available at http://esd.lbl.gov/files/about/staff/susanhubbard/SubsurfaceComplexity.pdf

6. Technology Needs, Nevada Test Site, U.S. Department of Energy. July 31, 2009. (http://www.nv.doe.gov/about/nts.aspx)
7. U.S. Department of Energy Office of Environmental Management. (http://www.em.doe.gov)
8. U.S. Department of Energy Office of Legacy Management (http://energy.gov/lm/office-legacy-management)

21. TECHNOLOGY TRANSFER OPPORTUNITIES: GENOMIC SCIENCE AND RELATED TECHNOLOGIES

Maximum Phase I Award Amount: $225,000	*Maximum Phase II Award Amount:* $1,500,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Applicants to Technology Transfer Opportunities (TTO) should review the section describing Technology Transfer Opportunities on page 1 of this document prior to submitting applications.

DOE's Office of Biological and Environmental Research (BER) Genomic Science Program supports DOE mission-driven fundamental research to identify the foundational principles that drive biological systems. Development of innovative approaches for sustainable bioenergy production will be accelerated by a systems biology understanding of non-food plants that can serve as dedicated cellulosic biomass feedstocks and microbes capable of deconstructing biomass into their sugar subunits and synthesizing next generation biofuels from cellulosic biomass. Genomic Science Program research also brings the -omics driven tools of modern systems biology to bear for analyzing interactions among organisms that form biological communities and between organisms and their surrounding environments.

BER established three Bioenergy Research Centers (BRCs) in 2007 to pursue the basic research underlying a range of high-risk, high-return biological solutions for bioenergy applications. Advances resulting from the BRCs are providing the knowledge needed to develop new biobased products, methods, and tools that the emerging biofuel industry can use. The three Centers are based in the Southeast, the Midwest, and the West Coast, with partners across the nation. DOE's Lawrence Berkeley National Laboratory leads the DOE Joint BioEnergy Institute (JBEI) in California, DOE's Oak Ridge National Laboratory leads the BioEnergy Science Center (BESC) in Tennessee, and the University of Wisconsin-Madison leads the Great Lakes Bioenergy Research Center (GLBRC).

The goal for the three BRCs is to understand better the biological mechanisms underlying biofuel production so that these mechanisms can be redesigned, improved, and used to develop novel, efficient bioenergy strategies that can be replicated on a mass scale. Many of these mechanisms form the foundation for the BRC's inventions and tech-transfer opportunities, which enable the development of technologies that are critical to the growth of a biofuels sector.

Successful applicants will propose R&D that will lead to biofuel commercialization utilizing one of the TTOs listed below. Applications that propose technologies related to a TTO but that do not directly utilize a TTO will not be funded. Applications should include sufficient preliminary data and scientific detail so that expert reviewers will understand both the potential benefits and the challenges that may be encountered in carrying out the proposed research. Challenges should be identified, and solutions should be proposed that will explain how the PI's team will overcome the challenges. Applications should address potential risks such as biocontainment challenges as well as strategies to mitigate those risks.

Questions – contact John Houghton, john.houghton@science.doe.gov

a. Isoprenoid Based Alternative Diesel Fuel

Researchers at JBEI have engineered both bacteria (E. coli) and yeast (S. cerevisiae) to produce a chemical precursor that readily converts to bisabolane when saturated with hydrogen gas under pressure. With continuous yield improvements, biosynthetic bisabolane could become a renewable diesel fuel alternative offering comparable energy density and superior cold weather performance to standard D2 diesel fuel. Although bisabolane had not previously been considered as a biofuel, testing revealed that its performance rating, or Derived Cetane Number (DCN), was 41.9, which is within the 40-55 range of standard diesel fuel. In addition, the analysis showed its "cloud point," an important marker for cold weather performance, was -78°C, better than diesel's -35°C, and vastly superior to commercial biodiesel's -3°C. Bisabolene also promises to be an excellent jet fuel.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EIB-2837
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: US Patent Application Filed 05/07/2013 (US application 13/883,987)
USPTO Link: http://www.google.com/patents/WO2012064740A1?cl=en
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2837.html

b. Identification of Efflux Pumps to Improve Tolerance to Toxic or Tnhibitory Biofuel, Biochemical Metabolities or Compounds from Deconstructed Ligno-Cellulosic Biomass

The JBEI has developed a method for providing industrial host microbes with resistance to valuable but potentially toxic molecules, such as solvents and fuel-like compounds. Providing such tolerance is a crucial step in engineering organisms to produce desirable substances. The scientists used efflux pumps to confer resistance on E. coli and developed a library of the most effective pumps for protection against several compounds, such as geraniol, limonene, pinene, and farnesyl hexanoate. These compounds represent biogasoline, biodiesel, and biojetfuel candidates. Moreover, the method for deriving this library is applicable to determining the most effective pumps for any given host and target compound. As metabolic engineering increases the biological production titers of compounds, there is a growing need to overcome limitations posed by each compound's toxicity, inhibition of cell growth, and intracellular feedback inhibition (i.e., the slowing of production by accumulated product). Until now, these problems have been addressed primarily through combinatorial approaches, such as adaptation, genome shuffling, and random mutatgenesis. These techniques may work under certain settings but are often not transferrable to other hosts or target compounds, because they do not identify the mechanism of the resistance. On the other hand, the JBEI technology uses a known, transferrable mechanism—an efflux pump—to optimize the tolerance of various hosts to any compound of interest. In several cases where the target compound is highly water immiscible, successful export of the compound from the cell can also improve product extraction from the culture.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EIB-2845
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: US Patent Application Filed 5/25/2011 (US patent application 13/115,925)
USPTO Link: http://www.google.com/patents/US20110294183
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2845.html

c. Biological Production of Lignification Stoppers Available in fields of use other than poplar, eucalyptus, sugarcane and sorghum

The JBEI has developed a technology that overcomes lignin recalcitrance without negatively affecting plant growth and development. The JBEI researchers produced novel monolignols called "stoppers" that, when incorporated in lignin chains, reduce the incorporation of additional monolignols in the chain. (Monolignols are the building blocks of lignin). As a result, the size and degree of polymerization of the lignin polymer is reduced. This technology is designed to produce the stoppers only in lignified woody tissues, i.e., vessels and fibers, to avoid any interference with plant defense mechanisms against pathogens and UV stress.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EIB-2929
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: PCT Filed 7/13/2012
USPTO Link: http://www.google.com/patents/WO2013010124A1?cl=en
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2929.html

d. Artificial Positive Feedback Loop for Increasing Production of a Biosynthetic Product in Specific Plant Tissues, (Fine-Tuning of Secondary Cell Wall Deposition) (Available in fields of use other than poplar, eucalyptus, sugarcane, sorghum, arabidopsis, rice, corn, soybean, guayule)

The JBEI has developed a technology that can be used to fine-tune desirable biomass traits in plants. A key feature of the invention is the design of an artificial positive feedback loop whereby a transcription factor induces increased transcription of itself. Gene promoters are selected according to the desired outcome, for example, to improve saccharification efficiency or to raise the level of desirable hexose sugars in relation to hard-to-ferment pentoses. Some promoters can boost secondary cell wall deposition of cellulose; others can decrease deposition of lignin or hemicellulose (xylan). With similar promoter engineering, increased wax production can be directed to the epidermal layers of a plant, improving drought tolerance and efficient water use while preserving energy for increased production of biomass. This versatile technology can be used to improve crops used for biofuels and paper production; provide livestock with more digestible forage; extend the range of crops to marginal land; or produce stronger timber for construction, among other applications. Unlike other genetic engineering methods, when applied to increasing secondary cell wall deposition, the JBEI technologies alter biosynthesis in plant fibers but not in vascular tissue or leaves. Thus they do not adversely affect growth, fertility, or the fruit- or grain-bearing capacity of the plants. Because this new method involves dominant traits and uses genetic promoters that are part of conserved pathways, it will be applicable across many species, including polyploids and sterile plants. Moreover, its application does not require sequencing of the entire genome of the target plant or the presence of a particular variety or cultivar. To date, the technology has been applied to three applications:

1. Controlling Lignin Deposition: To fine-tune lignin deposition, the scientists started with a mutant of Arabidopsis that under-produces lignin in all tissues. The JBEI scientists then selectively restored lignin biosynthesis to vascular tissue but not fiber cells by expressing a wild-type allele under the regulation of a promoter that is expressed only in vascular tissue. The engineered plants were morphologically and developmentally identical to the wild type, but they had a total lignin level that was approximately 33% less. When tested with several different pretreatment methods, biomass from the engineered plants had a saccharification efficiency 1.5-2.3 times greater than that of wild types.

2. Controlling Xylan Deposition: Using a method similar to that described above, the scientists started with a mutant with a defective allele for a key gene in xylan biosynthesis. They then selectively restored expression of a normal allele to vascular tissue only. The resulting plants have a reduced amount of hemicellulose relative to cellulose. Thus, compared to wild types, these plants can be pretreated more easily for biofuel production, yield more glucose per unit of biomass, and produce fewer low-value byproducts such as pentose from biofuels production or black liquor from pulping.

3. Increasing Wood Density and Drought Tolerance: In this application, promoters are used in a positive feedback loop to increase traits such as wood density or drought tolerance. To boost wood density, JBEI scientists upregulated a transcription factor that induces the expression of genes involved in secondary cell wall synthesis in native tissues. This upregulation occurs only in fiber cells and in a manner that does not interfere with growth, cell expansion, or nutrient transport. When this technology was combined with the fine-tuning of lignin deposition, stem density was increased by almost 20% and the saccharification efficiency was two- to three-times greater than that of wild types. While boosting yields, the technology can also decrease the cost of transporting biomass from the field to the biorefinery.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EIB-2930
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: PCT Filing 01/30/2012, (PCT/US2012/023182)
USPTO Link: http://www.google.com/patents/WO2012103555A2?cl=en
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2930.html

e. Improved Crops with Increased Galactan Content

Researchers at the JBEI have developed a suite of technologies to engineer feedstock plants with increased galactan content. Galactans are composed of hexoses that are easily fermented, in contrast to the hemicellulose xylan, the most abundant non-cellulosic component of biomass, which is composed of pentoses, which are difficult to ferment. By increasing galactan content, the JBEI technology has the potential to increase digestibility and yield of fermentable sugars of feedstocks. Galactan also has the potential to substitute for pentosans, polysaccharides made of pentoses, in lignocellulosic biomass. Specifically, the technology involves overexpressing

Arabidopsis beta-1,4-galactan synthase genes. These can be expressed alone or in conjunction with genes involved in UDP-Galactose biosynthesis, thus increasing the availability of UDP-galactose to increase both beta-1,4-galactan in the cell walls and, more generally, the galactose component of cell wall matrix polysaccharides. Furthermore, the genes may be expressed in conjunction with genes encoding specific UDP-galactose transporters with a preference for pectin-related transport. The technology is applicable to a large number of feedstock plants including Arabidopsis, poplar, eucalyptus, rice, switchgrass, pine and others.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EIB-3144
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: Provisional filed 05/10/2012, (61/645,537)
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl3144.html

f. Yeast Artificial Positive Feedback Loop as Tool to Enhance Multigenes Metabolic Pathways

The JBEI has developed a technology that employs in yeast cells a trait-changing strategy that has been applied to fine tune desirable biomass deposition in plants. Crucial to this strategy is the design of a genetic switch, or transcription factor, containing an artificial positive feedback loop (APFL) within its DNA sequence. Once inserted in yeast, the switch regulates expression of desired new traits, while the embedded feedback loop induces increased transcription of the switch itself, sustaining the production of those traits. The APFL strategy was first employed successfully to fine tune secondary cell wall synthesis in the model plant Arabidopsis. The new JBEI technology extends this strategy with a feedback loop that works in yeast, which is a model organism for many types of fungal cells. By identifying key genes in yeast that can be controlled in this manner, the researchers have demonstrated that this technology for plants can be adapted to entirely different organisms. In yeast, it confers traits that can potentially transform fungal cell cultures into efficient factories for the production of chemicals ranging from biofuels to pharmaceuticals.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EIB-3293
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: Provisional filed 07/27/2012, (61/676,811)
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl3293.html

g. Production of 1-Deoxyxylulose-5-Phosphate Via Enzymatic Dehydration/Reduction of Xylose-Derived Sugar

Researchers at the JBEI have generated a new synthetic pathway in cells to 1-deoxyxylulose-5-phosphate (DXP). Both routes allow more direct conversion of carbon to terpenoid compounds circumventing the typical, but inherently inefficient, route to DXP. The JBEI process results in the conservation of 17% of carbon being converted to terpenoid products. The novel pathways to DXP entail conversion of xylulose-5-phosphate to DXP, which circumvents the loss of CO_2 and provides a higher theoretical yield, particularly if xylose is included as a carbon source. It also provides a second metabolite pool (the essential pentose phosphate pathway) for isoprenoid biosynthesis. In the case of having a mixed carbon source (for example, xylose and glucose from a hemicellulose feedstock), it is envisioned that a large fraction of the xylose component could be primarily converted to the isoprenoid product since the carbon is diverted at the entry point into metabolism (xylulose-5-P). The novel routes into the DXP pathway could also be used in conjunction with the normal DXP-mediated route to maximize flux.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EIO-3006
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: US patent application filed 8/16/2012, (13/587,826)
USPTO Link: http://www.google.com/patents/US20130052692
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl3006.html

h. Increased Expression of Rice Acyltransferase Genes Improves Tissue Deconstructability Without Impacting Biomass Accumulation

JBEI has identified a rice acyltransferase gene, LOC_Os06g39390, for which increased gene expression reduces ferulic acid composition. JBEI has shown that incubation with cellulases releases more sugars from plant wall leaf material with over expression of the acyltransferase compared with wild type wall material. The plants with increased acyltransferase expression exhibit little or no significant changes in vegetative morphology and seed mass and no change in biomass compared with wildtype plants with normal levels of the acyltransferase. This is the first demonstration that increased expression of a native plant gene modifies ferulic acid cell wall content and affects cell wall digestibility. Unlike dicots, grasses incorporate the phenyl propanoid ferulic acid into the cell wall matrix polysaccharide arabinoxylan. Ferulic acid can then undergo reactive oxygen species mediated reactions to form covalent crosslinks between neighboring phenylpropanoid residues of arabinoxylan and lignin, making the biomass difficult to saccharify.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EJIB-2915
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: Provisional filed 12/21/2012, (61/745,247)
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2915.html

i. Enhancing Fatty Acid Production by Regulation of fadR Expression

Researchers at the JBEI have developed a genetically modified host cell that increases production of fatty acids and their derivatives. Specifically, the JBEI team found that increased concentration of cellular fadR, a transcriptional factor protein that regulates genes responsible for fatty acid activation and several genes in the fatty acid degradation pathway, lowers fatty acid degradation rate and enhances unsaturated fatty acid biosynthesis, resulting in an increase in total fatty acid production. The current approach to increasing fatty acid yield is engineering thioesterase enzymes, which are responsible for converting fatty acyl-CoA into fatty acids. But this method has limited success. JBEI's regulation of fadR expression overcomes these shortcomings. Researchers introduced a plasmid that contained the fadR gene under the control of an inducible promoter and measured its effect on fatty acid production. Total fatty acid yield reached 5.2 g/l, six times more than the yield using a previous fatty acid production strain. Results correspond to approximately 75% conversion of the carbon source. Additional testing to understand fadR's mechanism indicated that fadR increases fatty acid production by changing cells' overall metabolism rather than acting on one specific gene. This technology also includes a dynamic sensor-regulator system (DSRS), developed by the researchers to detect metabolic changes in microbes during the production of fatty acid-based fuels or chemicals and control the expression of the specific genes at work to improve production.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EJIB-2917
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: US Patent Application filed 07/13/2012, (US application 13/549,034, Canadian application 2782916)
USPTO Link: http://www.google.com/patents/US20130059295
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2917.html
Patent Status: US Patent Application filed 07/13/2012
(US application 13/549,034
Canadian application 2782916)

j. Spatially-separated Combinatorial DNA Assembly Device

Scientists at the JBEI are developing a device that can be used to efficiently assemble DNA parts, such as genes encoding enzymes, into multiple combinations, and then screen the resulting combinatorial library to identify combinations with the most desirable properties. The device combines into one microfluidic chip all of the steps necessary for this process: assembly of DNA parts; transformation and expression of these assemblies in whole-cells or cell-free platforms; cell culture; and functional assays using techniques such as colorimetric reporters, cell labeling/sorting, fluorescence imaging, and/or spectroscopy. The JBEI invention could be used in engineering plants and enzymes for better biofuel production, or developing crops that are more resistant to pathogens or drought. The device places each component in the process—DNA parts, reagents, cells, assayable markers—into discrete droplets that flow through microfluidic channels on a chip. Specific droplets are fused at designated times and locations in the channels to precisely control every reaction and incubation step. Throughout the process, each combination of biological parts is kept spatially separated from the other combinations. Thus, each droplet comes off the chip with its function assessed and its combination of parts known. In addition, droplets can be removed from the chip at different points throughout the process to obtain various intermediate products such as recombinant DNA, transformed cells, labeled cells, or protein cocktails.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EJIB-2934
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: US Patent Application filed 04/02/2012, (US application 13/437,727)
USPTO Link: http://www.google.com/patents/US20120258487
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2934.html

k. Recovery of chemically hydrolysed biomass using solvent extraction

Researchers at the JBEI have developed a technology to preferentially produce and extract sugars produced by the direct acid hydrolysis of biomass from an aqueous solution of ionic liquids such as 1-ethyl-3-methylimidaolium chloride. JBEI researchers have extracted over 80% of hexose and pentose sugars, indicating that the JBEI approach is a significant improvement in the field of biomass saccharification using ionic liquid. The JBEI invention uses solvent extraction technology, which is based on the chemical affinity of boronates or other organic acids to complex sugars, to extract sugars from the aqueous phase. Solvent extraction technology has been shown to successfully remove sugars from aqueous solutions in the paper pulping industry. JBEI researchers have optimized this proven technology for the recovery of sugars from biomass pretreatment processes utilizing ionic liquid pretreatment techniques also developed at JBEI.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EJIB-3030
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: Patent Status: US Patent Application filed 3/30/2012, (US patent application 13/436704)
USPTO Link: http://www.google.com/patents/US20120301948
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl3030.html

l. Mixed Feedstock Processing using Ionic Liquids

Researchers at the JBEI have developed a pretreatment technology using ionic liquids that efficiently extracts sugars from a combination of mixed feedstocks. Any ionic liquid used for biomass pretreatment or cellulose hydrolysis by thermostable cellulase may be used. Until now, no known technology could efficiently pretreat and liberate sugars from mixed feedstock streams. The JBEI technology has been successfully demonstrated in a mixture of softwood (pine), hardwood (eucalyptus), grass (switchgrass), and agricultural (corn stover) feedstocks. In tests, sugar yield reached 0.8 mg/ml within 6 hours and 1 mg/ml after a 24-hour period. The ability to recover a higher tonnage of biomass per acre where a variety of crops are present due to intercropping, row cropping, relay cropping and similar cultivation methods has the potential to significantly lower the cost of lignocellulosic biofuel and biomaterials production. A pretreatment that is effective on a wide range of lignocellulosic feedstocks will further lower overall biorefinery costs.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EJIB-3078
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
Patent Status: US Patent Application Filed 7/16/2012, (US patent application 13/550,437)
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl3078.html

m. Rice Os02g22380 Encodes a Glycosyltansferase Critical for Xylose Biosynthesis in the Cell Wall

Researchers at the JBEI have identified a glyco-syltransferase encoded by a rice gene that is critical for xylose biosynthesis in plant cell walls. Inhibiting the expression of the gene, Os02g22380, in bioenergy plants reduces the plants' lignin content, thus reducing recalcitrance of their cell walls and increasing the amount of soluble sugar that can be extracted from them. The technology is applicable to wheat, rice, corn, switchgrass, sorghum, millet, miscanthus, sugarcane, barley, turfgrass, hemp, bamboo and Bracypodium. Mutant rice plants based on this finding demonstrated reduced height with leaves deficient in xylose as well as ferulic acid and coumaric acid, acids linked with the inhibition of microbes' ability to covert sugars to fuels. Using a promoter to limit the action of this gene to non-vascular tissue could improve plant height to compare favorably with wild type plants.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EJIB-3136
Contact: Robin Johnston – rjohnston@lbl.gov, 510-486-5947
Patent Status: Provisional Filed 07/27/2012, (61/676,536)

n. Rapid Discovery and Optimization of Enzyme Solutions Using Tagged Biomass and Mass Spectrometry

Researchers at the JBEI have developed a technology to create a more efficient workflow for hydrolytic enzyme discovery and enzyme cocktail optimization by providing fast, efficient analysis of native glycans using high specificity mass spectrometry-based enzyme assays. In the JBEI technology, native substrates are used for enzyme activity screening and then tagged for efficient mass spectrometry analysis. The tagged mixture is assayed using mass spectrometry-based arrays that enable high throughput screening from microwell plates. Integrating this technology with acoustic printing has yielded extremely high throughput (three minute/384 well plate) mass spectrometry arrays. In the case of hydrolytic enzyme library screening, if incomplete hydrolysis is observed, the mixture can be screened for additional enzymes that would complete the hydrolysis. As enzymes are added, the mixture can be used to screen for other enzymes to add to the cocktail until the desired conversion of biomass is achieved.

Lawrence Berkeley National Laboratory Information:
TTO Tracking Number: EJIB-3262
Contact: Robin Johnston – rjohnston@lbl.gov, 510-486-5947)\
Patent Status: Provisional 2 filed 12/18/2012, (61/738,929)
Provisional 3 filed 3/12/2013, (61/777,617)
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl3262.html

o. Cell-Free System for Combinatorial Discovery of Enzymes Capable of Transforming Biomass for Biofuels

UW-Madison GLBRC researchers have developed compositions and methods that expand the ability to make, express and identify target polypeptides, including enzymes capable of enhancing the deconstruction of biomass into fermentable sugars. This approach uses a cell-free system to express enzymes and other polypeptides in a combinatorial manner. Because the system is cell-free, the enzymes can be assayed without intermediate cloning steps or purification of the protein products. This system also is more reliable than conventional methods for analyzing biomass transformation because it does not utilize living systems, which could rapidly consume soluble sugars. This system could be used to efficiently screen enzyme combinations for effective deconstruction of biomass from different feedstocks and under different conditions.

University of Wisconsin – Madison Information:
TTO Tracking Number: P08301US02
Contact: Jennifer Gottwald – jennifer@warf.org (608)262-5941)
Patent Status: 12/792156; 61/183243

USPTO Link:
http://www.warf.org/documents/pubapps/P08301US02%20Published%20Application.PDF
Website: http://www.warf.org/home/technologies/clean-technology/biofuels-renewable-fuels/summary/cell-free-system-for-combinatorial-discovery-of-enzymes-capable-of-transforming-biomass-for-biofuels-p08301us02.cmsx

p. Translation-Coupling Cassette for Quickly and Reliably Monitoring Protein Translation in Host Cells

UW–Madison GLBRC researchers have developed a method of using translation coupling to quickly and reliably determine whether a given host is capable of expressing the gene product of any given gene. This method could be used to monitor protein translation efficiency in bacterial cells which can be very important in the discovery and screening work around producing microbes to ferment biomass-derived sugars to biofuels and biorenewable chemicals. This method utilizes antibiotic resistant in a way that confers resistance only if the transgene is translated into protein, allowing for more real time monitoring of recombinant protein production.

University of Wisconsin – Madison Information:
TTO Tracking Number: P090401US02
Contact: Jennifer Gottwald - jennifer@warf.org (608)262-5941)
USPTO Link:
http://www.warf.org/documents/pubapps/P090401US02%20Published%20Application.PDF
Website: http://www.warf.org/home/technologies/research-tools/gene-expression/summary/translation-coupling-cassette-for-quickly-and-reliably-monitoring-protein-translation-in-host-cells-p090401us02.cmsx
12/976606; 61/289739

q. Fatty Acid-Producing Microbes for Generating Medium- and Long-Chain Hydrocarbons

UW–Madison GLBRC researchers have developed genetically modified E. coli that are capable of overproducing fatty acid precursors for medium- to long-chain hydrocarbons. The modified bacteria can be used to ferment biomass-derived sugars to fatty acids. These fatty acids can be separated from the fermentation media and subsequently used as feedstock for biofuels and biorenewable chemicals based on medium- and long-chain hydrocarbons. The modified bacteria were transformed with exogenous nucleic acids to increase the production of acyl-ACP or acyl-CoA, reduce the catabolism of fatty acid products and intermediates, and/or reduce feedback inhibition at specific points in the biosynthetic pathway.

University of Wisconsin – Madison Information:
TTO Tracking Number: P09329US02
Contact: Jennifer Gottwald - jennifer@warf.org (608)262-5941)
Patent Status: 12/984343; 61/292918
USPTO Link:
http://www.warf.org/documents/pubapps/P09329US02%20Published%20Application.PDF
Website: http://www.warf.org/home/technologies/clean-technology/biofuels-renewable-fuels/summary/fatty-acid-producing-microbes-for-generating-medium-and-long-chain-hydrocarbons-p09329us02.cmsx

r. Ethanol Tolerant Yeast for Improved Production of Ethanol from Biomass

UW–Madison GLBRC researchers have developed a method to impart ethanol tolerance to yeast. The toxicity of alcohol to microbes such as yeast is a bottleneck in the production of ethanol from biomass-derived sugars through fermentation. The Elongase 1 gene encodes ELO1, an enzyme involved in the biosynthesis of unsaturated fatty acids in yeast. This gene could be incorporated into an industrial yeast strain to increase the amount of ethanol produced from biomass. An industrial fermentation yeast strain with increased ethanol tolerance could be widely applicable in reducing costs and energy consumption.

University of Wisconsin – Madison Information:
TTO Tracking Number: P100228US02
Contact: Jennifer Gottwaldov - jennifer@warf.org (608)262-5941)
Patent Status: 13/232327; 61/838185
http://www.warf.org/documents/ipstatus/P100228US02.PDF
http://www.warf.org/home/technologies/clean-technology/biofuels-renewable-fuels/summary/ethanol-tolerant-yeast-for-improved-production-of-ethanol-from-biomass-p100228us02.cmsx

s. Genes for Xylose Fermentation, Enhanced Biofuel Production in Yeast

UW–Madison GLBRC researchers have identified 10 genes in yeast that are involved in xylose fermentation. Efficient fermentation of biofuels and biorenewable chemicals from biomass-derived sugars would benefit from microbes that can utilize both glucose and xylose. These genes could be used to create an organism by modifying one that normally utilizes glucose to one that can ferment both xylose and glucose for enhanced biofuel production. These genes may be used in various combinations to produce useful industrial strains.

University of Wisconsin – Madison Information:
TTO Tracking Number: P100245US03
Contact: Jennifer Gottwald - jennifer@warf.org (608)262-5941
Patent Status: 13/441381; 61/516650
USPTO Link:
http://www.warf.org/documents/pubapps/P100245US03%20Published%20Application.PDF
Website: http://www.warf.org/home/technologies/clean-technology/biofuels-renewable-fuels/summary/genes-for-xylose-fermentation-enhanced-biofuel-production-in-yeast-p100245us03.cmsx

t. Method and Compositions for Improved Lignocellulosic Material Hydrolysis

UW-Madison GLBRC researchers have identified Streptomyces sp. ActE, isolated from wood wasps, as an excellent source on enzymes capable of efficiently degrading cellulose from both pretreated and nontreated biomass. The secretome of ActE can be utilized to digest a lignocellulosic materials, resulting in feedstock that can be further used to produce biofuels or biorenewable chemicals. Specific genes have also been identified that encode enzymes capable of digesting different substrates such as xylan, chitin, cellulose, or biomass. The secretome or enzyme combinations could be developed into mixtures for efficiently accessing useful subunits of lignocellulosic biomass.

University of Wisconsin – Madison Information:
TTO Tracking Number: P110314US03
Contact: Jennifer Gottwald - jennifer@warf.org (608)262-5941)
Patent Status: 13/709971; 61/579301
Website: http://www.warf.org/home/technologies/clean-technology/biofuels-renewablefuels/summary/enhanced-biomass-digestion-with-wood-wasp-bacteria-p110314us03.cmsx

u. A Source and Production Method for Acetyl-Triacylglycerols (ac-TAGs)

Biodiesel can substitute for conventional petroleum diesel in almost all applications. Oftentimes, use of biodiesel requires engine modification since biodiesel has different solvent properties and often degrades natural rubber. Since use of biodiesel is increasing rapidly, alternative biofuel supplies are needed to accommodate the growing demand. Michigan State University's GLBRC inventions provide a source and production method for novel plant oils, acetyl-triacylglycerols (ac-TAGs), with possible uses as biodiesel-like biofuel and/or as low-fat food ingredients. By combining an ac-TAG-related enzyme with a method for catalyzing large-scale synthesis of ac-TAGs, in a single crop, many benefits can be obtained. The inventions have lower viscosity and fewer calories per mole than TAGs. Pilot experiments by the inventors have achieved approximately a 60 mole percent accumulation of ac-TAGs in seed oil.

Michigan State University Information:
TTO Tracking Number: TEC2009-0108
Contact: Tom Herlache, herlache@msu.edu
Patent Status: US 7,429,473 (issued September 30, 2008), U.S. 13/519,660 (pending)
Website: http://msut.technologypublisher.com/technology/5989

v. Production of Oil in Vegetative Tissues

Production of alternative fuels such as biodiesel is on the rise around the world and in the U.S. due to a strong and growing desire to reduce dependency on petroleum-derived diesel fuel. The acceptance of biodiesel has been slowed due to its higher cost relative to petroleum-derived diesel. The higher cost of biodiesel is directly related to the cost of feedstock used for biodiesel production, which is often derived from crops also used for food. The displacement of food crops by energy crops causes higher food prices and is fueling a rapidly growing social, environmental, economical and political push to move away from food crops for alternative fuel production. Michigan State University's GLBRC technology increases the oil storage capacity in plants and could help lower biofuel feedstock costs by enabling higher oil yields per acre of feedstock crops. The invention causes plant oil to accumulate in the leaf and stem structures of the plant. Plant oil normally accumulates in seeds. By altering the function of the rigalactosyldiacylglycerol (TGD) proteins, oil accumulates in the leaf and stem structures, which have greater potential oil storage capacity. This allows for more oil to be produced per acre.

Michigan State University Information:
TTO Tracking Number: TEC2009-0022
Contact: Tom Herlache, herlache@msu.edu
Patent Status: U.S. application 61/709,447
Website: http://msut.technologypublisher.com/technology/7894

w. High Starch in Plant Leaves at Senescence

Currently, there is a great interest in using plant biomass, instead of grain, to produce ethanol. Starch can easily be used to make ethanol and would improve ethanol production from cellulose. In most plants, though, starch accumulated during the day is usually broken down each night, resulting in very little starch accumulation in the leaves. The quantity of starch present in the leaves of a plant will affect the gross yield and processing efficiency. Since currently existing high starch plants cannot degrade their starch early in their life, they do not grow as fast as plants that can degrade their starch, thus resulting in reduced yields. Michigan State University's GLBRC technology relates to the creation of a genetically modified crop that might be used for the production of bio-ethanol or directly as an animal feed. Specifically, this invention increases the yield of easily degraded polymers, such as starch, in plants by blocking starch degradation at a developmental point late in the life cycle of the plant. The accumulation of starch in plant leaves is controlled through transgenic expression of an RNAi construct that inhibits expression of normal starch turnover.

Michigan State University Information:
TTO Tracking Number: TEC2009-0067
Contact: Tom Herlache, herlache@msu.edu
Patent Status: U.S. application 12/880,988
Website: http://msut.technologypublisher.com/technology/6484

x. Use of Plants with Increased Level of Highly Methylesterified Homogalacturonan for Improving Digestibility of Plant Biomasses

Production of fuels and value-added chemicals from plant biomass often requires pretreatment of the biomass. Pretreatment increases the capital equipment needs and costs of the final product. Additionally, the use of seeds as a feedstock has been controversial, with some claiming that use of seeds for chemical production is increasing the cost of food. What is needed is non-food plant material such as stems or leaves that requires less pretreatment. This GLBRC technology is a method and composition for improving the digestibility of plant biomasses by increasing the methylesterification of homogalacturonan (HG) in the plant cell wall. Methylesterification is increased via the overexpression of certain methyltransferases. The methyltransferases act on HG molecules before they are delivered to the apoplast, thus not interfering with the amount of de-esterified HG in the cell wall. Presence of highly demethylesterified pectin improves digestibility of plant biomasses while maintaining normal amounts of esterified HG prevents negative effects on the plant's mechanical strength and growth. Ultimately, this technology reduces cost of pretreatment in terms of money and time, leading to more efficient biofuel or green chemical production, improved forage crops, and more easily pulped trees.

Michigan State University Information:
TTO Tracking Number: TEC2013-0007
Contact: Tom Herlache, herlache@msu.edu
Patent Status: U.S. provisional application filed, serial number not yet issued.
Website: http://msut.technologypublisher.com/technology/13008

y. Method to Increase Calorific Content and Enhanced Nutritional Value of Plant Biomass for the Production of Fuel and Feed

Production of alternative fuels such as biodiesel is on the rise around the world and in the U.S. due to a strong and growing desire to reduce dependency on petroleum-derived diesel fuel. The acceptance of biodiesel has been slowed due to its higher cost relative to petroleum-derived diesel. The higher cost of biodiesel is directly related to the cost of feedstock used for biodiesel production, which is often derived from crops also used for food. The displacement of food crops by energy crops causes higher food prices and is fueling a rapidly growing social, environmental, economic, and political push to move away from food crops for alternative fuel production. This GLBRC technology is plants modified to divert metabolic activity from carbohydrate storage to oil storage in vegetative tissues. Enhancement of TAG synthesis in Arabidopsis is achieved via up-regulation of the TAG biosynthesis pathway and acyltransferase over-expression. This results in enhanced energy content of plant biomass by up to 6% without any detrimental effects in Arabidopsis. Model experiments indicate that the plant material is excellent forage, with animals fed the high-TAG material showing increased weight gain. The increased energy density makes the biomass particularly suited for pyrolysis.

Michigan State University Information:
TTO Tracking Number: TEC2013-0040
Contact: Tom Herlache, herlache@msu.edu
Patent Status: U.S. provisional application filed, serial number not yet issued.
Website: http://msut.technologypublisher.com/technology/13009

z. Dispersal Containment of Engineered Genotypes in Transgenic Plants

The unwanted dissemination of transgenic genotypes from one plant cultivar to another via pollen dispersal is a significant problem that often prevents field testing and consumer use of commercially-valuable genetically modified plants. Researchers at the University of Tennessee have developed a novel genetic system for rendering male plant pollen sterile without the concomitant cytotoxic effects of the only other pollen sterilization system currently in use. This advance is a watershed for anyone working with transgenic plants where containment of hybrid genotypes to specific plant cultivars or species is essential. This system is functional in dicots (e.g. tobacco) and is currently being tested in monocots, (e.g. switchgrass). This technology represents a major step forward in enabling innovation in fields as diverse as horticulture, agriculture, and biofuel production, permitting economically valuable greenhouse-to-field application in that it renders male plant pollen sterile, thus preventing unwanted fertilization and unwanted spread of transgenic plant genes; works in both monocots and dicots; and has no cytotoxic effects

University of Tennessee Information:

TTO Tracking Number: PD08094
Contact: speckrr@ornl.gov
Patent Status: US patent application number 13/539,601
Website: http://utrf.tennessee.edu/abstracts/08094.pdf

References:

1. U.S. Department of Energy: Office of Science, Office of Energy Efficiency and Renewable Energy. (2006). Breaking the Biological Barriers to Cellulosic Ethanol: A Joint Research Agenda. A Research Roadmap Resulting from the Biomass to Biofuels Workshop. December 7-9, 2005. Rockville, Maryland. Available at http://genomicscience.energy.gov/biofuels/b2bworkshop.shtml
2. U.S. Department of Energy Office of Biological and Environmental Research. (2010). Bioenergy Research Centers: An Overview of the Science, aka Bioenergy Research Centers Report [07/10]. Available at http://genomicscience.energy.gov/centers/BRCbrochure2010webFinalURLs_LR.pdf
3. Bioenergy Science Center (BESC). (http://www.bioenergycenter.org/besc/index.cfm)
4. BESC: Intellectual Property Available for Licensing. (http://bioenergycenter.org/besc/industry/intellectual-property.cfm)
5. Great Lakes Bioenergy Research Center (GLBRC). (http://www.greatlakesbioenergy.org/)
6. Wisconsin Alumni Research Foundation. (http://www.warf.org/)
7. Joint Bioenergy Institute (JBEI). (http://www.jbei.org)
8. JBEI: Available Technologies & Collaborative Research Opportunities. (http://www.jbei.org/industry/index.html)
9. U.S. Department of Energy Office of Biological and Environmental Research. (2012). Biosystems Design: Report from the July 2011 Workshop. July 17-20, 2011. Bethesda, Maryland. Available at http://genomicscience.energy.gov/biosystemsdesign/index.shtml

PROGRAM AREA OVERVIEW: OFFICE OF DEFENSE NUCLEAR NONPROLIFERATION

The Defense Nuclear Nonproliferation (DNN) mission is to provide policy and technical leadership to limit or prevent the spread of materials, technology, and expertise relating to weapons of mass destruction; advance the technologies to detect the proliferation of weapons of mass destruction worldwide; and eliminate or secure inventories of surplus materials and infrastructure usable for nuclear weapons. It is the organization within the Department of Energy's National Nuclear Security Administration (NNSA) responsible for preventing the spread of materials, technology, and expertise relating to weapons of mass destruction (WMD).

Within DNN, the Research and Development (R&D) program office sponsors long-term development of new and novel technology reduces the threat to national security posed by nuclear weapons proliferation and detonation or the illicit trafficking of nuclear materials. Using the unique facilities and scientific skills of NNSA and DOE national laboratories and plants, in partnership with industry and academia, the program conducts research and development that supports nonproliferation mission requirements necessary to close technology gaps identified through close interaction with NNSA and other U.S government agencies and programs. This program meets unique challenges and plays an important role in the federal government by driving basic science discoveries and developing new technologies applicable to nonproliferation, homeland security, and national security needs. DNN R&D has two sub-Offices: Proliferation Detection and Nuclear Detonation Detection.

The Proliferation Detection Office (PD) advances basic and applied technologies for the nonproliferation community. PD develops the tools, technologies, techniques, and expertise for the identification, location, and analysis of the facilities, materials, and processes of undeclared and proliferant nuclear weapons programs and to prevent the diversion of special nuclear materials, including use by terrorists.

The Nuclear Detonation Detection Office (NDD) builds the nation's operational sensors that monitor the entire planet from space to detect and report surface, atmospheric, or space nuclear detonations; and produces and updates the regional geophysical datasets enabling operation of the nation's ground-based seismic monitoring networks to detect and report underground detonations. NDD conducts research and development on nuclear detonation forensics, improvements in satellite operational systems to meet future requirements and size and weight constraints, and in radionuclide sampling techniques for detection of worldwide nuclear detonations.

For additional information regarding NNSA's overall nuclear nonproliferation activities, including, research and development, click here.

22. ALTERNATIVE RADIOLOGICAL SOURCE TECHNOLOGIES

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

The Office of Defense Nuclear Nonproliferation Research and Development (NA-22) has a research objective to:

Develop alternative technologies that reduce the risk from the malevolent use of high-activity radioactive sources.

This objective focuses on the R&D needed to replace high activity radioactive sources that are deemed to pose a significant risk if malevolently used. Our current emphasis is on emerging and innovative technologies and techniques for the replacement of these sources with non-radioisotope based technologies. Radioactive sources serve a number of critical functions including the treatment and diagnosis of disease, the inspection and certification of critical mechanical structures, the sterilization of food and medical products, and the exploration for petroleum. Replacements or alternatives proposed must provide equivalent (or improved) functionality and be less susceptible to malevolent use. Each proposal must address: economic feasibility of the proposed alternative or replacement, ease of maintenance (both the equipment and the source) and relative accessibility in and around the device.

Grant applications are sought only in the following subtopics:

a. Alternative Blood Irradiator Technologies

Irradiation is the only method approved by the FDA for inactivation of T-lymphocytes in blood products to prevent Transfusion Associated Graft-Versus-Host Disease (TA-GVHD). The irradiator is to replace current ^{137}Cs blood irradiators at blood banks. A suitable replacement technology would have minimal downtime and optimal reliability. Improved X-ray tubes and power supplies are needed for the high throughput environment and low maintenance required at 24-hour blood banks. Canisters in current cesium irradiators can hold up to 6 bags. The irradiator must deliver a minimum dose of 1500 cGy to all points within the specimen without exceeding a maximum dose of 5000 cGy. Space and weight are limited in blood banks. Current irradiators are about 3 ft x 5 ft. Exhaust fumes are highly discouraged. Irradiators and associated cooling units should have quiet operation and easy to operate and maintain.

Questions – contact Arden Dougan, Arden.Dougan@nnsa.doe.gov

b. Replacement for Ir-192 Radiography Sources

Proposals are sought for new highly portable, low operating power, and high yield x-ray sources that can be used for replacement of Ir-192 sources for industrial radiography. The proposals must clearly state the advantage of the proposed source in terms of size, weight, power, and output compared with existing Ir-192 sources typically used for nondestructive evaluation.

Questions – contact Arden Dougan, Arden.Dougan@nnsa.doe.gov

c. Optimized Radiation Detectors for Well-Logging

Design and demonstrate a bench-top prototype of a commercially viable radiation (neutron and gamma-ray detector) for (d,t) well logging applications.

Neutron sources for oil well logging currently utilize radioisotopes such as Am-Be and Cs-137. These sources are currently classified as high priority threats to the security of the United States. Compact neutron generators could potentially replace these sources and DT commercial generators are available that could offer a potential solution for logging-while-drilling and wire line well logging applications. Current gamma radiation detectors that have been used for inelastic scattering and neutron capture spectroscopy as well as quantification of both mineralogy and organic carbon. The detectors must be operated at high temperatures, nominally ~150C and survive high mechanical shocks and vibrations. Gamma detectors that have excellent resolution with high counting rates and the ability to measure high energy gamma-rays (see reference 4). Neutron detectors to replace helium-3 for epithermal and thermal neutrons are also needed to measure total neutrons or the neutron energy spectrum.

Questions – contact Arden Dougan, Arden.Dougan@nnsa.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Arden Dougan, Arden.Dougan@nnsa.doe.gov

References: Subtopic a:

1. National Research Council, Committee on Radiation Source Use and Replacement. (2008). *Radiation Source Use and Replacement: Abbreviated Version.* Washington, DC: The National Academies Press. ISBN: 978-0-309-11014-3. Available at http://www.nap.edu/catalog.php?record_id=11976
2. U.S. Department of Health and Human Services, Food and Drug Administration, Center for Biologics Evaluation and Research. (2003). *Guidance for Industry: An Acceptable Circular of Information for the Use of Human Blood and Blood Components, Final Guidance*. Washington, DC. Available at www.fda.gov/BiologicsBloodVaccines/GuidanceComplianceRegulatoryInformation/Guidances/Blood/ucm074940.htm
3. World Health Organization. (2010). *Design Guidelines for Blood Centres*. Manila, Philippines: WHO Western Pacific Region. ISBN: 0978-92-9061-319-0. Available at www.who.int/bloodsafety/publications/DesignGuideBloodCentres.pdf

References: Subtopic b:

1. National Research Council, Committee on Radiation Source Use and Replacement. (2008). *Radiation Source Use and Replacement: Abbreviated Version.* Washington, DC: The National Academies Press. ISBN: 978-0-309-11014-3. Available at http://www.nap.edu/catalog.php?record_id=11976

2. International Atomic Energy Agency. (1999). *Radiation Protection and Safety in Industrial Radiography, Safety Reports Series No.13*. Vienna, Austria: IAEA. ISBN: 92-0-100399-4. Available at http://www-pub.iaea.org/MTCD/publications/PDF/P066_scr.pdf

References: Subtopic c:

1. National Research Council, Committee on Radiation Source Use and Replacement. (2008). *Radiation Source Use and Replacement: Abbreviated Version.* Washington, DC: The National Academies Press. ISBN: 978-0-309-11014-3. Available at http://www.nap.edu/catalog.php?record_id=11976
2. W.A. Gilchrist, Jr., Feyzi Inanc & Loren Roberts. (2011). *Neutron Source Replacement - Promises and Pitfalls,* Presented at SPWLA 52nd Annual Logging Symposium, May 14-18, 2011. Available for purchase at http://www.spwla.org/publications/view/page/174/item/3726
3. A. Badruzzaman, Society of Petroleum Engineers, Chevron Energy Technology Company, S. Barnes, Chevron North America E&P, F. Bair & K. Grice. (2009). *Radioactive Sources in Petroleum Industry: Applications, Concerns and Alternatives,* Presented at SPE Asia Pacific Health, Safety, Security, and Environment Conference and Exhibition, August 4-5, 2009. SPE 123593. ISBN: 978-1-55563-260-1. Available for purchase at http://www.onepetro.org/mslib/servlet/onepetropreview?id=SPE-123593-MS
4. R. J. Radtke, Maria Lorente, Bob Adolph, Markus Berheide, Scott Fricke, Jim Grau, Susan Herron, Jack Horkowitz, Bruno Jorion, David Madio, Dale May, Jeffrey Miles, Luke Perkins, Olivier Philip, Brad Roscoe, David Rose & Chris Stoller. (2012). *A New Capture and Inelastic Spectroscopy Tool takes Geochemical Logging to the Next Level*. Presented at SPWLA 53rd Annual Logging Symposium, Cartagena, Colombia, June 16-20, 2012. Available at http://www.slb.com/~/media/Files/technical_papers/misc/spwla/2012_spwla_spectroscopy_tool.pdf
5. Ahmed Badruzzaman & David Barnes. (2012). Method and System for Pulse Neutron Capture Sigma Inversion. Patent US-2012-0116732-A1. Available at http://www.google.com/patents/US20120116732

23. RADIATION DETECTION

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

The Office of Defense Nuclear Nonproliferation Research and Development (NA-22) is focused on enabling the development of next generation technical capabilities for radiation detection of nuclear proliferation activities. As such, the office is interested in the development of radiation detection techniques and sensors, and advanced detection materials, that address the detection and isotope identification of unshielded and shielded special nuclear materials, and other radioactive materials in all environments. In responding to these challenging requirements, recent research and development has resulted in the emergence of radiation detection materials that have good energy resolution. From these materials, the developments of radiation detectors that are rugged, reliable, low power and capable of high-confidence radioisotope identification are sought. Currently, the program is focused on the development of improved capabilities for both scintillator and semiconductor-based radiation detectors. The objective of this topic is to gain insight into a mechanistic understanding of material performance as the base component of radiation detectors. That is, the program is interested in moving beyond the largely empirical approach of discovering and improving detector materials to one based on a clear understanding of basic materials properties.

Grant applications are sought only in the following subtopics:

a. Multi-Contact, Low-Capacitance HPGe Detectors

Develop a multi-contact HPGe detector with low capacitance to reduce noise at high gamma rates. Off-the-shelf high-purity germanium (HPGe) detector systems with coaxial HPGe electrode geometry tend to be limited to gamma rates in the 10s of kHz at most by long charge collection and electronic processing times, leading to high dead time at higher event rates. One method to improve high-rate performance is subdividing the detector into smaller regions such as pixels or strips with each having their own readout contact or electrode. Total system throughput is increased but at a commensurate cost in additional electronics channels. Particular applications are best served by dividing a crystal into 5 to 30 readout contacts. In addition, multi-site interactions such as Compton scattering followed by photoabsorption must be summed together so rapid charge collection throughout the detector volume is essential at high rates. Ideally all charges would be fully collected in <200 ns regardless of event location in the active detector volume. A further design constraint is that high rates require short shaping times in the digital signal filters and the resolution is significantly enhanced by reducing the element capacitance to be low as reasonably achievable. The capacitance of each individual contact (to all other contacts and ground/HV) should be <5 pF and ideally 1-2 pF.

Meeting these requirements imply a significant modeling task before the electrode design is finalized. Variations on geometry, subdivision, and bias contact(s) designs should be iterated to determine the optimal configuration in terms of capacitance and charge collection time.

Phase I: Design detector geometry, including contact number, locations, and detailed high voltage bias electrode(s). Model each element of the detector to determine capacitance; best- and worst-case drift times, and efficiency for 662 keV gammas. Design detector test platform (cryostat, mounting, preamps etc.)
Phase II: Fabricate the detector, assemble test platform, and test all contacts for drift times and energy resolution.
Phase III: Possible applications: Characterization of high-activity objects; spent fuel assay; gamma-ray imaging in high-rate environments.

Questions – contact David Beach, David.Beach@nnsa.doe.gov

b. Scintillator-Based Radiation Detectors for Emergency Response

We would like to support research on materials that will lead to practical high-brightness scintillators with energy resolution significantly better than the currently available sodium iodide-based gamma spectrometers. Several new and promising formulations have been discovered and synthesized in small quantities, but have not reached the level of commercial availability necessary to make an operational impact. The ideal scintillator for an emergency response handheld and/or backpack would have at least 50% higher resolution and would be sensitivity to thermal neutrons using pulse-height discrimination. A crystal larger than 50 mm by 50 mm would also be desired.

Phase I: Identification of a suitable detector material and demonstration of a lab prototype.
Phase II: The development of a commercial process for the growth and packaging of the material to make a portable radiation detector.

Questions – contact David Beach, David.Beach@nnsa.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact David Beach, David.Beach@nnsa.doe.gov

References: Subtopic a:

1. E. Barat, T. Dautremer, L. Laribiere, J. Lefevre, T. Montagu & J.-C. Trama. (2006). *ADONIS: a new system for high count rate HPGe γ spectrometry*. Nuclear Science Symposium Conference Record. October 29—November 1, 2006. IEEE. Vol. 2, pp.955-958. DOI: 10.1109/2006.356004. ISBN: 1-4244-0560-2. Available for purchase at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=4179158&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D4179158
2. M. Nocente, et al. (2011). *High resolution gamma ray spectroscopy at MHz counting rates with LaBr3 scintillators.* Nuclear Science Symposium and Medical Imaging Conference, October 23-29, 2011. IEEE. pp. 2010-2013. DOI: 10.1109/2011.6154409. ISBN: 978-1-4673-0118-3. Available for purchase at http://ieeexplore.ieee.org/xpl/abstractAuthors.jsp?reload=true&arnumber=6154409
3. V. Mozin, B. Ludewigt, A. Hunt & L. Campbell. (2012). *Delayed gamma-ray spectroscopy for spent nuclear fuel assay.* Journal of Nuclear Materials Management. Vol. 40, No. 3, pp. 78-87. Available for purchase at http://www.inmm.org/source/JNMM_Archive_Search/index.cfm?fuseaction=home.searchResults

References: Subtopic b:

1. N.J. Cherepy, et al. (2009). *SrI_2 scintillator for gamma ray spectroscopy*. Hard X-Ray, Gamma-Ray, and Neutron Detector Physics XI. Eds. R.B. James, L.A. Franks & A. Burger. Proceedings of the SPIE. Vol. 7449. DOI: 10.1117/2012.830016. Available at http://info.ornl.gov/sites/publications/files/Pub20952.pdf
2. P. Bessiere, P. Dorenbos, C. W. E. van Eijk, K.W. Kramer, H.U. Gudel & A. Galtayries. (2006). *Scintillation and anomalous emission in elpasolite $Cs_2LiLuCl_6$:Ce^{3+}*. Journal of Luminescence. Vol. 117, Issue 2, pp. 187-198. DOI: 10.1016/2005.05.005. Available at http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&ved=0CDIQFjAB&url=http%3A%2F%2Fwww.researchgate.net%2Fpublication%2F229383580_Scintillation_and_anomalous_emission_in_elpasolite_Cs2LiLuCl6Ce3%2Ffile%2Fd912f5114d7331e800.pdf&ei=kmnIUeqGLOaHygHMhICYBw&usg=AFQjCNHraqwE6OlvQL5_ldi_knsBxlR31g&sig2=-yAAETUUEzlMM-BRxLfNRQ&bvm=bv.48293060,d.aWc

24. IMPROVING EFFICIENCY IN THE ANALYTICAL CHEMISTRY LABORATORY

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

Analytical chemistry techniques are used in a variety of applications to support DOE missions. For example, chemical separations and detection methods are used for nuclear forensics and other applications to analyze a variety of environmental sample types for both stable and radioactive isotopes that span almost the entire periodic table. These analyses typically include dissolving the sample, isolating several chemical species of interest at relatively low concentrations, and then using a variety of different detection techniques. Efficiency of the analytical techniques is crucial to ensure the overall analysis process is timely, reproducible, and non-labor intensive.

Within the DOE and throughout numerous industries, the process of performing chemical analysis is based on traditional procedures that involve complex acid digestion of solid samples before measuring elemental and/or isotopic composition. These procedures are laborious, hazardous to personnel, generate waste products, and can require days to months before providing results. A transformational enabling technology is required that can provide real-time trace elemental and isotopic analysis without needing consumables or generating waste products and without the need for a man-in-the-loop specialized operator. Such a technology would address critical needs within the NNSA for nuclear forensics, uranium and plutonium detection, and other hazardous materials identification applications.

Grant applications are sought only in the following subtopics:

a. Rapid Element-Isotopic Analysis

New technologies are sought that provide rapid and direct analysis of samples without laborious sample preparation procedures and without requiring consumables. The goal is to provide accurate and precise elemental and isotopic analysis that complements TIMS, but with much faster turnaround time. Recent research in laser ablation has demonstrated performance metrics to meet these requirements. Laser ablation analysis with inductively coupled plasma mass spectroscopy can provide ppm to ppb sensitivity levels, with <1% precision. A second approach to laser ablation analysis is the measurement of atomic emission in the induced plasma: Laser Induced Breakdown Spectroscopy (LIBS). LIBS can provide high elemental analysis with ppm to percent level sensitivity and precision generally at the percent levels. Isotope ratios also can be measured using LIBS but are generally limited by small isotopic splitting of atomic and ionic transitions. A technology of promise for elemental and isotopic analyses of trace species expands on the capabilities of LIBS with a new paradigm to measure molecular species: Laser Ablation Molecular Isotopic Spectroscopy (LAMIS). This technology offers the ability to perform isotopic analyses in the laboratory or field without a mass spectrometer.

Grant applications are sought to develop and demonstrate technologies for real-time trace elemental and isotopic analysis without needing consumables or generating waste products and without the need for a man-in-the-loop specialized operator. The DOE is interested in a commercial system that can provide 'technician-level' operation with methods for elements and isotopes of interest to the NNSA mission, as well as dual-use commercial markets. The proposed Phase I effort should demonstrate metrics using LA-ICP-MS in combination with LIBS and/or LAMIS, demonstrating that the orthogonal technologies provide improved precision of analysis. The following is sought:

- Improvement in the precision by integrating ICP-MS with LIBS/LAMIS,
- Availability of elements that can be addressed with this technology,
- Establish protocol for analysis of selected samples,
- Process data for accurate and precise measurements, including data fusion
- Establish capability for field use, and
- Demonstrate dual-use capabilities for commercialization.

In order for such technologies to become more useful for DOE applications, an automated system (Phase II) is needed that provides valid analysis results without requiring the intervention of a scientific-level operator in intermediate calibration and measurement steps.

Questions – contact Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

b. Preparation of Reproducibly Packed Large Capacity HPIC Columns

High performance ion chromatography (HPIC) can facilitate high resolution and high efficiency separations for many analytes of interest but can be adversely affected by the relatively large quantities of mass commonly found in environmental samples. Large separation columns capable of handling mass loadings of 20 – 50 µg total material are needed to allow HPIC separation of environmental-type samples. Currently, pre-packed HPIC columns suitable for analyzing samples at these mass levels are not commercially available. A commercial process could ensure the columns are more consistently and reproducibly prepared rather than the more inconsistent process of preparing these in the laboratory by hand. Columns using both cation exchange resin as well as anion exchange resin are needed. In order to achieve optimal resolution, small particle sizes are desired that complement the capabilities of HPIC. The columns should be able to flow at a rate of 0.5 to 1.2 mL/min at pressures less than 2000 psi to avoid excessive band broadening due to diffusion.

Questions – contact Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

c. Tools to Automate Routine, Time-Consuming Steps in the Analytical Chemistry Laboratory

Many of the major time intensive steps in analytical chemistry procedures are very simple, routine steps that potentially could be automated. For example, when performing a series of chemical separation steps, often the matrix of the sample needs to be changed at the end of one separation before a sequential separation is performed. This matrix change typically involves evaporating the excess solution the sample is in to near dryness and then reconstituting the sample in a new solvent matrix. This evaporation is done under controlled conditions because of the need to carefully ensure the solvent is fully evaporated while the solute product of interest is not destroyed by overheating. An automated dry-down instrument would be very useful for this process to increase efficiency. Such a system would need to be compatible with various acid vapors (specifically to include HNO_3, HCl, HF, and $HClO_4$). Important features are the sample throughput and routing of off-gases – so as to be able to process large numbers of samples (e.g., as many as 24, each of volume 0.1-10 milliliters) without cross contamination between them. Many of the principles needed for successful implementation of an automated evaporator are laid out in the patents referenced below. Altering these concepts for use with materials with high acid concentrations are needed. For example, to our knowledge no current commercial systems can use perchloric acid ($HClO_4$).

Questions – contact Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

d. Preparation of High Purity Methanol or Other Reagents

For some radiochemical processes, currently available reagents contain impurities that interfere with low level analyses. For example, analytes of interest have been found in commercial methanol reagents, causing an increase in the analytical background. Reagents must then first be distilled to remove impurities prior to analysis, greatly increasing analysis times. Acetonitrile is another example of a reagent that is needed at ultra-high purity for analytical chemistry. Commercially available ultra-high purity reagents in containers of appropriated material (e.g. Teflon®) would eliminate these time consuming steps and improve the overall efficiency of the process.

Questions – contact Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

References: Subtopic a:

1. J.M. Koornneef, et al. (2012). *In situ analysis of ^{230}Th-^{232}Th-^{238}U ratios in titanite by fs-LA-MC-ICPMS*. Journal of Analytical Atomic Spectrometry. Vol. *27,* Issue 11, pp. 1863-1874. DOI: 10.1039/C2JA30162H. Available for purchase at http://pubs.rsc.org/en/Content/ArticleLanding/2012/JA/C2JA30162H?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+rss%2FJA+%28RSC+-+J.+Anal.+At.+Spectrom.+latest+articles%29
2. David W. Hahn & Nicoló Omenetto. (2012). Laser-induced breakdown spectroscopy (LIBS), part II: review of instrumental and methodological approaches to material analysis and applications to different fields. Applied Spectroscopy. Vol. 66, Issue 4, pp. 100A-119A & 347-419. DOI: 10.1366/11.06574. Available at http://www.ingentaconnect.com/content/sas/sas/2012/00000066/00000004/art00004?token=0045107139412f415d763f257345742b595f6c51592530482972715a614f6d4e227a6
3. Richard E. Russo, Alexander A. Bol'shakov, Xianglei L. Mao, Christopher P. McKay, Dale L. Perry & Osman Sorkhabi. (2011). *Laser ablation molecular isotopic spectrometry*. Spectrochimica Acta Part B. Vol. 66, Issues 11-12, pp. 99-104. Available at http://www.lbl.gov/tech-transfer/publications/2901pub1.pdf

References: Subtopic b:

1. Kazutoku Ohta, Kazuhiko Tanaka, Brett Paull, & Paul R. Haddad. (1997). Retention behavior of alkali, alkaline earth and transition metal cations in ion chromatography with an unmodified silica gel column. Journal of Chromatography A. Vol. 770, Issue 1, pp. 219-227. Available for purchase at http://www.sciencedirect.com/science/article/pii/S0021967396010242
2. Packing Instruction for Kromasil® in DAC Columns. (http://www.kromasil.com/technical_support/dac_packing.php)
3. Tsuyoshi Ishikawa, Kenji Sugimoto & Kazuya Nagaishi. (2003). Determination of rare-earth elements in rock samples by an improved high-performance ion chromatography. Geochemical Journal. Vol. 37, No. 6, pp. 671-680. Available at http://www.terrapub.co.jp/journals/GJ/abstract/3706/37060671.html

References: Subtopic c:

1. Daniel L. Newhouse, Ralph H. Waltz & Richard G. Wheeler. (1986). Automatic evaporator system. Patent US-4604363-A. Available at http://www.google.com/patents/US4604363
2. Alvin Fox. (1996). Automated evaporator for chemical analyses. Patent US-5514336-A. Available at https://www.google.com/patents/US5514336
3. Jay W. Grate, Matthew J. O'Hara & Oleg B. Egorov. (2012). "Chapter 18: Automated Radiochemical Separation, Analysis, and Sensing." *Handbook of Radioactivity Analysis* (3rd ed.). Ed. Michael F. L'Annunziata. San Diego: Academic Press. Available at http://books.google.com/books?id=mAfH8KEH3j0C&pg=PA1179&lpg=PA1179&dq=,+Automated+radiochemical+separation,+analysis,+and+sensing,+in+Handbook+of+Radioactivity+Analysis,&source=bl&ots=IXewkpoos7&sig=MFzBrXEhNA7hOM22AIOBTmCXZaY&hl=en&sa=X&ei=z5nJUaDsJ4nmyQGZiYGwCQ&ved=0CDIQ6AEwAA#v=onepage&q=%2C%20Automated%20radiochemical%20separation%2C%20analysis%2C%20and%20sensing%2C%20in%20Handbook%20of%20Radioactivity%20Analysis%2C&f=false

References: Subtopic d:

1. Accuracy in Trace Analysis: Sampling, Sample Handling, Analysis. (1976). Proceedings of the 7th Maerials Research Symposium. Ed. Philip D. LeFleur. Gaithersburg, MD: National Bureau of Standards Special Publication 422. Available at http://books.google.com/books?id=XRPImqRxxIQC&pg=PA1089&lpg=PA1089&dq=1.%09Accuracy+in+trace+analysis:+sampling,+sample+handling,+analysis.++Proceedings+of+the+7th+Materials+Research+Symposium.++Philip+D.+LeFleur,+Ed.++National+Bureau+of+Standards+Special+Publication+422.++1976.++Gaithersburg,+MD.&source=bl&ots=P8PcXnPLNb&sig=xhuAWi69b6zBAO97AfjqmbJfFOU&hl=en&sa=X&ei=2p3JUcylO4eeywH91oDYDA&ved=0CC8Q6AEwAA#v=onepage&q=1.%09Accuracy%20in%20trace%20analysis%3A%20sampling%2C%20sample%20handling%2C%20analysis.%20%20Proceedings%20of%20the%207th%20Materials%20Research%20Symposium.%20%20Philip%20D.%20LeFleur%2C%20Ed.%20%20National%20Bureau%20of%20Standards%20Special%20Publication%20422.%20%201976.%20%20Gaithersburg%2C%20MD.&f=false
2. Ilia Rodushkin, Emma Engström & Douglas C. Baxter. (2010). Sources of contamination and remedial strategies in the multi-elemental trace analysis laboratory. *Analytical and Bioanalytical Chemistry*. Vol. 396, Issue 1, pp.365-377. Available for purchase at http://link.springer.com/article/10.1007%2Fs00216-009-3087-z

3. Alistair Jeffcoate, Tim Elliot, Alex Thomas & Claudia Bouman. (2004). Precise, small sample size determinations of lithium isotopic compositions of geological reference materials and modern seawater by MC-ICP-MS. *Geostandards and Geoanalytical Research*. Vol.28, Issue 1, pp. 161-172. Available at http://onlinelibrary.wiley.com/doi/10.1111/j.1751-908X.2004.tb01053.x/abstract?deniedAccessCustomisedMessage=&userIsAuthenticated=false

25. TECHNOLOGIES AND CAPABILITIES, ASSOCIATED WITH HANDLING LARGE VOLUMES OF DATA TO SUPPORT MODELING AND SIMULATION VALIDATION

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

Discrepancies observed in practice between experimental and computational provide the basic motivation for performing quantitative model verification, validation, calibration through data assimilation, and predictive estimation. Estimation of the validation domain requires computation of contours of constant uncertainty in the high-dimensional space that characterizes the application of interest. Model calibration involves the integration (assimilation) of new experimental and/or computational data for updating (i.e., "calibrating" or "adjusting") the parameters underlying the respective model. Also, the experimental facility must be adequately designed and instrumented in order to facilitate a comprehensive and accurate characterization of the operating, initial, and boundary conditions together with the accompanying experimental uncertainties. (Note here that often the required degree of detail was not routinely reported in published data [1]) Predictive estimation incorporates all of these activities, aiming at a probabilistic description of possible future computational and experimental outcomes, based on all recognized errors and uncertainties. Computational results almost always depend on inputs that are uncertain, rely on approximations that introduce errors, and are based on mathematical models1 that are imperfect representations of reality. Hence, given some calculated quantity of interest (QOI) from the computational model, the corresponding true physical QOI is uncertain. If this uncertainty—the relationship between the true value of the QOI and the prediction of the computational model—cannot be quantified or bounded, then the computational results have limited value [2].

Grant applications are sought only in the following subtopics:

a. Validation Database

Nonproliferation R&D programs seek improved data storage, management and use for validation and quantifying uncertainties in support of predictive modeling and simulation of high explosive tests. Numerical simulations of unprecedented fidelity and complexity demand broad multidisciplinary research on scalable algorithms and models, including hardware, architecture, system software, libraries, workflows, performance, verification, and application software. One example of an ideal proposal would be the development (Phase I) and demonstration (Phase II) of a "smart validation database" including the development and demonstration of an algorithm for searching and categorizing a wide range of multi-parameter experimental and synthetic data (including metadata) for optimal validation purposes. Access to these data is restricted and will require a top secret/Q clearance for demonstration purposes.

Questions – contact James Peltz, James.Peltz@nnsa.doe.gov

b. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact James Peltz, James.Peltz@nnsa.doe.gov

References: Subtopic a:

1. W.F. Oberkampf & T.G. Trucano. (2002). *Verification and Validation in Computational Fluid Dynamics*. Sandia Technical Report: SAND2002-0529. Available at http://cam.zcu.cz/~brandner/PSfiles/validation.pdf
2. Assessing the Reliability of Complex Models-Mathematical and Statistical Foundations of Verification, Validation, and Uncertainty Quantification. (2012). National Research Council. Washington, D.C.: The National Academies Press. Available at http://www.nap.edu/catalog.php?record_id=13395

26. TECHNOLOGY TO FACILITATE MONITORING FOR NUCLEAR EXPLOSIONS

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

The Ground-based Nuclear Explosion Monitoring Research and Development (GNEM R&D) Program is sponsored by the U.S. Department of Energy's National Nuclear Security Administration's Office of Defense Nuclear Nonproliferation Research and Development (DNN R&D). This program is responsible for the research and development necessary to provide the U.S. Government with capabilities for monitoring nuclear explosions. The mission of the GNEM R&D Program is to develop, demonstrate, and deliver advanced ground-based seismic, radionuclide, hydro-acoustic, and infrasound technologies and systems to operational agencies to fulfill U.S. monitoring requirements and policies for detecting, locating, and identifying nuclear explosions (see Reference 1). Proposals that enhance U.S. capabilities that also benefit the international monitoring capabilities in the context of preparations for a Comprehensive Nuclear-Test-Ban Treaty (CTBT) may be submitted.

Research is sought to move toward commercialization of algorithms, hardware, and software that advance the state-of-the-art for event detection, location, and identification. Superior technologies will help improve the Air Force Technical Applications Center's (Reference 2) ability to monitor for nuclear explosions, which are banned by several treaties and moratoria. Grant applications responding to this topic must state (1) the current state-of-the-art, in terms of relevant specifications such as sensitivity, reliability, maintainability, etc., as well as the performance goal of the proposed advance in terms of those same specifications; and (2) address the commercialization path of any instruments or components developed. Due to the small market potential of treaty monitoring technologies, this call is focused toward already existing or emerging commercial products for other applications that could be modified/enhanced for treaty monitoring applications. The resulting "treaty monitoring edition" of the product(s) would hopefully provide a performance advantage that would also benefit the original market and thereby leverage existing markets.

A near zero-maintenance, manufacturable, whole-air gas compressor is needed to improve gas collection technologies used in a variety of environmental sampling applications and nuclear test-ban treaty monitoring technologies. There is a need for an ultra-high reliable whole air compressor that can outperform all other commercially available compressors in terms of regular maintenance and Mean-Time-Between-Failure (MTBF). Current compressors designs have limited life operation before needing to be rebuilt or repaired. No commercially available compressors exist that can perform for years without regular maintenance. This call for an ultra-high reliability compressor is intended to get high performance prototypes transferred to a manufacturer where they can be produced to raise the state-of-the-art of commercially available units. Making these high performance units commercially available to existing applications should also reduce the cost of the high performance units.

The compressor must be capable of compressing ambient pressure whole air into a high-flow air stream and/ or must be able to compress the gas into a high-pressure vessel. The compressors must be designed so a common commercial entity can build the compressor without high cost special machining. Finally, the compressor must be able to run at 100% duty cycle with ambient air-cooling and be able to maintain operation in high vibration environments. The compressor must maintain adequate lubrication throughout the life of usage.

The primary objective of this call is to produce a compressor that meets the requirements of subtopic a. That is, a successful proposal must be able to meet the minimum objectives of subtopic a. However, the stretch goal of this request is that that compressor should be able to meet all the requirements in subtopic subtopics a., b., and c. in a single compressor unit. The differences between the three subtopics are variable flow rates, outlet pressure and power requirements. There are two outlet pressure requirements of 100 psig and 3000 psig between all three sections. Subtopics a. and b. have outlet pressure requirements of 3000 psig and subtopic c has an outlet pressure requirement of 100 psig. The low pressure compressor (100 psig, section c) flow rate must vary from 40 to 100 SLPM with a 220V power requirement. It is conceivable to combine the objectives for the high pressure and low pressure output requirements by only changing out the compressor motor.

The stretch goal for the high pressure compressor (3000 psig, subtopics a. and b.), is to achieve the variability in flow, from 2 SLPM to 500 SLPM, and pressures from 100 psig working pressure to 3000 psig pressurization pressure while meeting the power requirement of 220V, 115V to 28VDC, as stated above, all within a single unit. This may be achieved with a change of the motor of similar size and weight.

Grant applications are sought only in the following subtopics:

a. Technologies and Capabilities, to Improve Sustainment of Radionuclide Technologies--High Reliability, High Flow Rate, High Pressure Compressor

Requirement	Threshold	Objective
Flow Rate Minimum Objectives	120 Standard Liters per Minute.	170 Standard Liters per Minute
Flow Rate Stretch Objectives	351 Standard Liters per Minute	500 Standard Liters per Minute
Outlet Pressure (high pressure)	0 - 3,000 psig max when filling a pressure vessel	
Power	115VAC/3Ø/400Hz/15 Amps per phase and 28 VDC/100 Amps	
Static Pressure (Input Air)	10.1 psia (equivalent altitude of 10K feet)	7.3 psia (.5 Atmosphere)
Temperature (operating)	-18˚C (0˚F) to 54˚C (130˚F)	
Temperature (storage)	-51˚C (-60˚F) to 54˚C (130˚F)	
Temperature Rate of Change	±1.5˚C/minute (±2.7˚F/minute)	
Vibration (aircraft)	Meet the intent of MIL-STD-810F, method 514.5 for on aircraft.	
Acceleration/Mechanical Shock (aircraft)	Meet the intent of MIL-STD-810F, method 516.5 for on aircraft.	
EMI	Meet the intent of MIL-E-6051 D, Electromagnetic Compatibility Requirements, Systems	
Humidity	90% Relative	
Oil	10ppm (mole basis)	0
Water	100ppm (mole basis)	0
Maintainability (remove and replace) (MTTR)	90 minutes	30 minutes
Size (compressor)	7.25" (L) x 10.25" (W) x 11.5" (H) for optimal size	
Weight (compressor)	13 lbs	
Size (motor)	8 15/16" (L) x 6 1/4" (W) x 6 1/2" (H) with the possibility of drops down space 1 3/4" below the mounting plate.	
Weight (motor)	21 lbs.	
MTBF	≥ 5 years	

Questions – contact Leslie Casey, Leslie.Casey@nnsa.doe.gov

b. Technologies and Capabilities, to Improve Sustainment of Radionuclide Technologies – High Reliability, Low Flow Rate, High Pressure Compressor

Requirement	Threshold	Objective
Flow Rate	Variable 2 Standard Liters per Minute to 10 Standard Liters per Minute	Variable 2 Standard Liters per Minute to 100 Standard Liters per Minute
Outlet Pressure (low pressure)	0 -3,000 psig max when filling a pressure vessel	
Power (ground requirement)	115VAC/ 15Amps/ 50-60Hz	12 VDC and 115VAC/ 15Amps/ 50-60Hz
Static Pressure (Input Air)	14.7 psia	7.3 psia
Humidity	3 % Relative	
Oil	0	
Water	0	
MTBF	≥ 5 years	≥ 10 years
Size (compressor)	7.25" (L) x 10.25" (W) x 11.5" (H) for optimal size	
Weight (compressor)	13 lbs	
Size (motor)	8 15/16" (L) x 6 1/4" (W) x 6 1/2" (H) with the possibility of drops down space 1 3/4" below the mounting plate.	
Maintainability(remove and replace) (MTTR)	60 minutes	30 minutes

Questions – contact Leslie Casey, Leslie.Casey@nnsa.doe.gov

c. Technologies and Capabilities, to Improve Sustainment of Radionuclide Technologies--High Reliability, Medium Flow Rate, Low Pressure Compressor

Requirement	Threshold	Objective
Flow Rate	40 Standard Liters per Minute	100 Standard Liters per Minute
Outlet Pressure	100 psig outlet pressure	
Power (ground requirement)	220VAC/3Ø/50-60Hz	115 VAC/50-60Hz/15Amp and 20VAC/1Ø/50-60Hz
Static Pressure (Input Air)	14.7 psia	7.3 psia
Humidity	3% Relative	10% Relative
Oil	0	
Water	0	
MTBF	≥ 5 years	
Size (compressor)	7.25" (L) x 10.25" (W) x 11.5" (H) for optimal size	
Weight (compressor)	13 lbs	

Size (motor)	8 15/16" (L) x 6 1/4" (W) x 6 1/2" (H) with the possibility of drops down space 1 3/4" below the mounting plate.	
Maintainability (remove and replace) (MTTR)	90 minutes	30 minutes

Questions – contact Leslie Casey, Leslie.Casey@nnsa.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic descriptions above.

Questions – contact Leslie Casey, Leslie.Casey@nnsa.doe.gov

References:

1. Nuclear Explosion Monitoring Research and Engineering Program Strategic Plan. (2004). National Nuclear Security Administration. Document No. DOE/NNSA/NA-22-NEMRE-2004). http://nnsa.energy.gov/sites/default/files/nnsa/inlinefiles/2011_NNSA_Strat_Plan.pdf
2. U.S. National Data Center. Air Force Technical Applications Center (http://www.tt.aftac.gov/wrt)

27. REMOTE SENSING

Maximum Phase I Award Amount: $150,000	Maximum Phase II Award Amount: $1,000,000
Accepting SBIR Phase I Applications: YES	Accepting SBIR Fast-Track Applications: YES
Accepting STTR Phase I Applications: YES	Accepting STTR Fast-Track Applications: YES

The Office of Defense Nuclear Nonproliferation Research and Development (NA-22) has a research objective to develop remote sensing technology to support detection and characterization of signatures or activities related nuclear proliferation.

Grant applications are sought only in the following subtopics:

a. Interaction of Optical Filaments with Radiological Materials for Remote Sensing

Remote sensing of nuclear materials is critical to the nuclear security of our nation and to reduce the proliferation of foreign nuclear programs. While laboratory techniques such as laser-induced breakdown spectroscopy (LIBS), laser-ablation inductively-coupled-plasma mass spectrometry (LA-ICPMS) and thermal ionization mass spectrometry (TIMS) can provide accurate analysis of isotope ratio of radiological materials, detecting and identifying radiological materials at standoff distances remain elusive. One technical challenge is the spectral broadening the atomic and ionic emission lines of radiological materials at atmospheric pressure.

However, with the advances in high power femtosecond laser amplifiers, optical filaments have emerged as a viable tool to interrogate nuclear materials remotely. Recent experiments have shown that optical filaments exhibit remarkably different ablation profiles and breakdown spectra when used to ablate solids, compared to focused nanosecond and femtosecond pulses with similar fluences and peak intensities. Understanding the interaction process between a femtosecond laser filament and condensed samples will provide a pathway to practical implementation of filamentation for remote sensing of radiological materials. Research is sought to develop a detection technique for radiological materials at distances beyond 1 kilometer. Thus, the research effort must address the current technical difficulties, including spectral broadening of emission lines in air, through experiments to extend the range and increase the sensitivity limits of detection and isotopic attribution of nuclear materials using filaments. Another focus of this research is the analysis of small-scale filamentation and large-scale filamentation for standoff detection of radiological materials.

Questions – contact Victoria Franques, Victoria.Franques@nnsa.doe.gov

b. Development and Validation of a Polarized 3D Atmospheric Radiation Model

Increasing signature contrast in both the solar and thermal spectral regions, obtained from the Stokes vector data, provides advanced avenues for improving material identification. Analysis of these data requires polarization signature models that incorporate the effects of absorption, emission and scattering in the 3D atmospheric and terrain environment. Although high fidelity, scalar, 1D atmospheric radiative transfer models are readily available [Berk et al. 2006], few 1D polarization models [MODTRAN-P, vector-6S] have been developed. These 1D polarized models have significant limitations in spectral coverage, computational speed, optical polarization databases, and/or physics fidelity. There are currently no available models that treat all the polarized spectral signatures of key 3D scene elements such as clouds, plumes, topographic backgrounds, and man-made objects in a self-consistent, unified approach.
Research is sought to develop a validated 3D polarized atmospheric radiation transport model.

The Phase I effort should focus (1) on assessing current 1D capabilities and available polarization databases, (2) on formulating approaches for upgrades to the 1D models for a fully polarized implementation in Phase II, (3) on designing a 3D polarization model, and (4) on planning validation field measurements in collaboration with a DOE lab. A validated 3D polarized radiance model that incorporates the effects of water clouds, plumes, natural terrain and turbid water backgrounds, and both man-made and natural materials will be developed in Phase II. The new model will be tested against the existing 1D models and validated against DOE field measurements.

Questions – contact Victoria Franques, Victoria.Franques@nnsa.doe.gov

c. Information-Theoretic Compressive Sensing for Efficient Standoff Monitoring

Modern remote sensing systems are characterized by collection of a massive quantity of data, particularly for long-term monitoring. For example, hyperspectral sensors involve measurement of possibly hundreds of wavelengths. In addition, one may be interested in measuring hyperspectral video, potentially at multiple focal points. Research is sought for a new framework that will be

constituted for compressive measurements, in which the complexity (bandwidth and energy) is taken into account within the sensor. Application areas include compressive hyperspectral imagers, compressive video, compressive multi-focus, and compressive mass spectrometry, among many others. The emphasis is not just on systems that may be characterized by Gaussian noise, but also by sensors and data types better characterized with Poisson noise (count measurements).
In addition to developing the theory for such compressive measurements, laboratory experiments will be performed, for demonstration of proof of concept. In Phase II, the final system will be applicable to remote sensing, will substantially reduce the quantity of data collected relative to a conventional sensor, and the sensor complexity will be no greater than that of conventional sensing systems.

Questions – contact Victoria Franques, Victoria.Franques@nnsa.doe.gov

d. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas relevant to this Topic.

Questions – contact Victoria Franques, Victoria.Franques@nnsa.doe.gov

References: Subtopic a:

1. W. Pietsch, A. Petit & A. Briand. (1998). Isotope ratio determination of uranium by optical emission spectroscopy on a laser-produced plasma - basic investigations and analytical results. Spectrochimica Acta Part B: Atomic Spectroscopy. Vol. 53, Issue 5, pp. 751-761. Available for purchase at http://www.sciencedirect.com/science/article/pii/S0584854797001237
2. A. Couairon & A. Mysyrowicz. (2007). Femtosecond filamentation in transparent media. Physics Reports. Vol. 441, pp. 47-189. Available at http://www.teramobile.org/publications/couairon_mysy_filaments.pdf
3. S. L. Chin, et al. (2009). Filamentation “remote” sensing of chemical and biological agents/pollutants using only one femtosecond laser source. Applied Physics B: Lasers and Optics. Vol. 95, pp. 1-12. Available at http://jila.colorado.edu/beckergroup/articles/2009_Chin_APB_95_1.pdf
4. A. Valenzuela, C. Munson & A. Porwitzky. (2012). Filament Ablation of Opaque Solid Materials. Presented at CLEO Conference. San Jose, California. May 6-11, 2012. Available at http://www.opticsinfobase.org/abstract.cfm?uri=CLEO_SI-2012-CM3L.4
5. M. Lenzner, J. Yeak & K. Kremeyer. (2013). Femtosecond Laser Filaments and Aerodynamics. CLEO/Europe: International Quantum Electronics Conference. Available at http://www.world-of-photonics.net/en/photonics-congress/structure/conference-program-2013/~/pagepart/event-detail/r_event_id/27027505/r_struc_id/27027448/r_struc_type/program

References: Subtopic b:

1. A. Berk, et al. (2006). *MODTRAN5: 2006 Update*. Proceedings of the SPIE. Vol. 6233: Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral Imagery XII, p. 62331F. Available for purchase at http://spie.org/x648.html?product_id=665077
2. J. Craven-Jones, M.W. Kudenov, M.G. Stapelbroek & E.L. Dereniak. (2011). *Infrared hyperspectral imaging polarimeter using birefringent prisms*. Applied Optics. Vol. 50, Issue 8, pp. 1170-1185. Available at http://www.opticsinfobase.org/ao/abstract.cfm?uri=ao-50-8-1170

3. S.Y. Kotchenova, E.F. Vermote, R. Matarrese & F. Klemm. (2006). Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part I: path radiance. Applied Optics. Vol. 45, Issue 26, pp. 6762-6774. Available at http://www.opticsinfobase.org/ao/abstract.cfm?uri=ao-45-26-6762
4. S.Y Kotchenova, E.F. Vermote, R. Matarrese & F. Klemm. (2007). Validation of a vector version of the 6S radiative transfer code for atmospheric correction of satellite data. Part II: Homogeneous Lambertian and anisotropic surfaces. Applied Optics. Vol. 44, Issue 20, pp. 4455-4464. Available at http://www.opticsinfobase.org/ao/abstract.cfm?uri=ao-46-20-4455
5. N.J. Pust & J.A. Shaw. (2011). *Comparison of skylight polarization measurements and MODTRAN-P calculations.* Journal of Applied Remote Sensing. Vol. 5, Issue 1, pp. 053529(1-16). Available for purchase at http://remotesensing.spiedigitallibrary.org/article.aspx?articleid=1182393
6. R. Sundberg, S. Richtsmeier & R. Haren. (2010). *Monte Carlo-Based Hyperspectral Scene Simulation.* Second Annual WHISPERS Conference. Reykjavik, Iceland. June 14-16, 2010. Available for purchase at http://ieeexplore.ieee.org/xpl/articleDetails.jsp?tp=&arnumber=5594835&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5594835

References: Subtopic c:
1. D. Guo, S. Shamai & S. Verdú. (2005). *Mutual information and minimum mean-square error in Gaussian channels.* IEEE Transactions of Information Theory. Vol. 51, No. 4, pp. 1261-1282. Available at http://www.princeton.edu/~verdu/reprints/GuoShaVer.Apr2005.pdf
2. D. Palomar and S. Verdú. (2006). *Gradient of mutual information in linear vector Gaussian channels.* IEEE Transactions on Information Theory. Vol. 52, No. 1, pp. 141-154. Available at http://www.ece.ust.hk/~palomar/Publications_files/2006/PalomarVerdu_TransIT2006_gradI_vectorGMMSE.pdf
3. J. Duarte-Carvajalino, G. Yu, L. Carin & G. Sapiro. (2012). *Adapted Statistical Compressive Sensing: Learning to Sense Gaussian Mixture Models.* Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). Kyoto, Japan. March 25-30, 2012. Available at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6288708&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel5%2F6268628%2F6287775%2F06288708.pdf%3Farnumber%3D6288708
4. A. Ashok, P. Baheti & M. Neifeld. (2008). *Compressive imaging system design using task-specific information.* Applied Optics. Vol. 47, Issue 25, pp. 4457-4471. Available at http://www.opticsinfobase.org/ao/abstract.cfm?uri=ao-47-25-4457

28. TECHNICAL NUCLEAR FORENSICS – ADVANCED PACKAGING

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Proper packaging of technical nuclear forensic (TNF) samples is critical to maintaining the forensic integrity of evidentiary material and providing a radiological contamination barrier. Currently available packaging options commonly used in nuclear laboratories and the nuclear forensic community are able to provide the required safety barrier, but have the potential to interfere with some unique nuclear forensic attributes of the evidence.

Grant applications are sought only in the following subtopics:

a. Evidence Packaging & Preservation System

Develop a polymer film packaging system optimized for use with technical nuclear forensic samples and compatible with radioactive material handling, nuclear facilities, and evidence packaging requirements and best practices. Gaps in current TNF packaging fall into the following high level categories each of which has number of desired characteristics listed:

Material Compatibility

- Packaging materials need to be able to function as intended while exposed to radiation fields for extended periods of time (evidence is routinely stored for over a decade). The majority of evidentiary samples will have a dose rate of less than 50 mrem/hr at 5 cm, but can go as high as 2 rem/hr at 5 cm.

- Packaging materials should not accumulate a surface static charge. Static build up can cause radon laden dust to collect on the surface of the package which impedes health physics contamination control protocols.

- Packaging materials should not out gas volatile and semi-volatile small molecule additives (e.g. phenol, di-tertbutylquinone, di-tertbutylphenol, and other ortho- and alkyl-substituted aromatic compounds). These molecules can perturb the surface chemistry of a number of nuclear forensic sample types. Alternatively, the packaging material may have an organic contaminant background of ≤1 picogram/mm^2 that is consistent and highly reproducible in background analysis. Likewise, any residual particles from manufacturing must be of uniform composition and consistent among containers.

Operation Flexibility

- TNF evidence has the potential to be any item contaminated with radiological material. The ability to create custom sizes and shapes of containment in the field is important. Evidentiary items requiring packaging can range from trace evidence (e.g. hairs and fibers) to large items (e.g. furniture, vehicles, etc.)

- The ability to control the atmosphere within the container during sealing (vacuum or dry nitrogen for example) is desirable. Additionally, control over the internal pressure could be used to govern how the packaging comes in contact with the contents.

- Packaging material should be compatible with common permanent markers.

- Packaging should be as transparent as possible to maximize visibility of the contents.

Radiological Contamination Control

- Packaging material should have good puncture and wear resistance.

- Packaging material seams must be of high quality and have similar puncture and wear resistance to the rest of the containment package.

Questions - contact Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

b. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions - contact Thomas Kiess, Thomas.Kiess@nnsa.doe.gov

References: Subtopic a:

1. W. Den, H. Bai & K. Kang. (2006). *Organic airborne molecular contamination in semiconductor fabrication clean rooms*. Journal of The Electrochemical Society. Vol. 153, Issue 2, pp. G149-G159. Available for purchase at http://jes.ecsdl.org/content/153/2/G149.abstract
2. International Atomic Energy Agency. (2006). *Nuclear Forensics Support: IAEA Nuclear Security Series No. 2.* Vienna, Austria: IAEA. Available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1241_web.pdf
3. K. J. Moody, I.D. Hutcheon & P.M. Grant. (2005). *Nuclear Forensic Analysis*. Boca Raton, FL: CRC Press. Available for purchase at http://www.amazon.com/Nuclear-Forensic-Analysis-Kenton-Moody/dp/0849315131
4. J. Sylvia, J. Janni, J. Klein & K. Spencer. (2000). *Surface-enhanced raman detection of 2,4-dinitrotoluene impurity vapor as a marker to locate landmines.* Analytical Chemistry. Vol. 72, Issue 23, pp.5834-5840. Available for purchase at http://pubs.acs.org/doi/abs/10.1021/ac0006573
5. Z. Takats, I. Cotte-Rodriquez, N. Talaty, H. Chen & R.G. Cooks. (2005). *Direct, trace level detection of explosives on ambient surfaces by desorption electrospray ionization mass spectrometry.* Chemical Communications. Issue 15, pp. 1950–1952. Available at http://www.sinoms.net/uploadfile/201003/20100302220353241.pdf
6. U.S. Department of Justice. (2007). *Handbook of Forensic Services.* Quantico, Virginia: Federal Bureau of Investigation, Laboratory Division. Available at http://www.fbi.gov/about-us/lab/handbook-of-forensic-services-pdf

PROGRAM AREA OVERVIEW: OFFICE OF HIGH ENERGY PHYSICS

Through fundamental research, scientists have found that all observed matter is composed of apparently point-like particles, called leptons and quarks. These constituents of matter were created following the "big-bang" that originated our universe, and they are components of every object that exists today. We also understand a great deal about the four basic forces of nature: electromagnetism, the strong nuclear force, the weak nuclear force, and gravity. For example, in the past we have learned that the electromagnetic and weak forces are two components of a single force, called the electro-weak force. This unification of forces is analogous to the unification in the mid-nineteenth century of electric and magnetic forces into electromagnetism. History shows that, over a period of many years, the understanding of electromagnetism has led to many practical applications that form the technical basis of modern society.

The goal of the Department of Energy's (DOE) Office of High Energy Physics (HEP) is to provide mankind with new insights into the fundamental nature of energy and matter and the forces that control them. This program is a major component of the Department's fundamental research mission. Such fundamental research provides the necessary foundation that enables the nation to advance its scientific knowledge and technological capabilities, to advance its industrial competitiveness, and possibly to discover new and innovative approaches to its energy future.

The DOE HEP program supports research in three discovery frontiers, namely, the energy frontier, the intensity frontier, and the cosmic frontier. Experimental research in HEP is largely performed by university and national laboratory scientists, usually using particle accelerators located at major laboratories in the U.S. and abroad. Under the HEP program, the Department operates the Fermi National Accelerator Laboratory (Fermilab) near Chicago, IL. The Department also has a significant role in the Large Hadron Collider (LHC) at the CERN laboratory in Switzerland. The Tevatron Collider at Fermilab was the world's highest energy accelerator for over a decade, until the startup of the LHC. The Fermilab complex also includes the Main Injector, which is used independently of the Tevatron to create high- energy particle beams for physics experiments, including the world's most intense neutrino beam. The SLAC National Accelerator Laboratory and the Lawrence Berkeley National Laboratory are involved in the design of state-of-the-art accelerators and related facilities for use in high-energy physics, condensed matter research, and related fields. SLAC facilities include the 3 kilometer long Stanford Linear Accelerator capable of generating high energy, high intensity electron and positron beams. The first 2 kilometers of the linear accelerator is currently being used for the Facility for Advanced Accelerator Experimental Tests (FACET). While much progress has been made during the past five decades in our understanding of particle physics, future progress depends on a great degree of availability of new state-of-the-art technology for accelerators, colliders, and detectors operating at the high energy and/or high intensity frontiers.

Within HEP, the Advanced Technology subprogram supports the research and development required to extend relevant areas of technology in order to support the operations of highly specialized accelerators, colliding beam facilities, and detector facilities which are essential to the goals of the overall HEP program. As stewards of accelerator technology for the nation, HEP also supports development of new concepts and capabilities that further scientific and commercial needs beyond the discovery science mission. The DOE SBIR program provides a focused opportunity and mechanism for small businesses to contribute new ideas and new technologies to the pool of knowledge and technical capabilities required for continued progress in HEP research, and to turn these novel ideas and technologies into new business ventures.

For additional information regarding the Office of High Energy Physics priorities, click here.

29. HIGH ENERGY PHYSICS COMPUTATIONAL TECHNOLOGY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The DOE supports the development of computational technologies essential for success of the experimental, theoretical, and R&D programs in the Office of High Energy Physics (HEP). HEP funded research is aimed at understanding how our universe works at its most fundamental level through Energy, Intensity, and Cosmic Frontiers [1]. Experiments for HEP science are data intensive, and rely heavily on scientific computing for planning, operations, software, data-taking and data analysis. State of the art modeling and simulation are integral to the planning, development, and success of science at the three frontiers.

Although particle physics computer systems and software development typically occur in large collaborative efforts at national particle accelerator centers, there are opportunities for small businesses to make innovative and creative contributions that can be commercialized. Applicants interested to apply for the SBIR/STTR projects in the HEP Computational Technology area are encouraged to collaborate with active high energy particle physicists at universities or national laboratories to establish mutually beneficial goals. National Laboratories that support HEP research can be found at [2] and on-line directories of appropriate researchers are available by institution at [3]. Prospective applicants are also advised to consult with the SBIR commercialization department and their collaborator's university or laboratory small business offices for appropriate presentation of commercialization plans.

Although some aspects of HEP computing technology may have similarities with other disciplines applicants should consult with their HEP supported collaborators and focus on proposals that enhance HEP research interests. Areas of present interest are outlined below in the subtopics.

All grant applications must clearly and specifically indicate their relevance to present or future HEP programmatic activities as described in the Energy, Intensity, and Cosmic frontiers.

Grant applications are sought in the following subtopics:

a. Distributed Computing Systems

The international nature of HEP experiments and their large computing resource requirements drive the current HEP paradigm of handling and analyzing experimental data in a highly distributed fashion. Grant applications are sought that support the design, implementation, and operation of distributed computing systems comprising distributed Petaflops of CPU power and distributed petabytes of data, middleware development for grid-enabled systems, security assurance tools a distributed environment, and other related technology relevant for high energy physics.

Questions – contact Larry Price larry.price@science.doe.gov

b. Collaboration Software for Distributed Computing

By aggregating world-wide computing resources from HEP and other disciplines, initiatives like the Open Science Grid [4] aim to enable a federated computing model for HEP and other participating disciplines. Grant applications are sought to develop advanced infrastructure technologies to strengthen the ability of dispersed particle physics researchers to collaborate. Examples include client-server frameworks, remote data selection techniques, distributed data management and analysis frameworks, and project management software.

Questions – contact Larry Price larry.price@science.doe.gov

c. Modular Software Performance Monitoring

HEP experiments use complex software which often makes use of routines from multiple sources and multiple authors. Performance optimization is a recurring issue for these extended software systems and it is often difficult to determine where hot spots and bottlenecks occur in the final software system. The problem is made even more urgent and more complex by the growing need for parallelization in the execution of the code. Grant applications are sought for general purpose software monitoring and analysis systems which can provide targeted insights into the operation of HEP software systems and specific parts of the system to focus on for performance improvement.

Questions – contact Larry Price larry.price@science.doe.gov

d. Data Frameworks and Database Development

Grant applications are sought in areas of large data including frameworks for the management, configuration, custody, and dissemination of large data sets (experimental or simulation data), development of data storage, management reliability, and preservation systems and related tools for large data needs of the HEP community.

Questions – contact Larry Price larry.price@science.doe.gov

e. Flexible Geometry Description Tools for HEP Software

Accurate and detailed descriptions of the HEP detectors are crucial elements of the software chains used for simulation, visualization and reconstruction programs: for this reason, it is important to deploy general purpose detector description tools which allow for precise modeling, visualization, visual debugging and interactivity and which can be used to feed information in, e.g., Geant4 based simulation programs and in reconstruction-oriented geometry models; at the same time, these tools must allow for different levels of descriptions, for different uses. Grant applications are sought for development of such a system of detector geometry description.

Questions – contact Larry Price larry.price@science.doe.gov

f. Parallelization of Software and Simulation Tools

Grant applications are sought that facilitate parallelizing HEP community codes on multi core computer systems including clusters, and/or GPU systems that address specific or broad HEP research areas and/or complement use of supercomputers.

Questions – contact Larry Price larry.price@science.doe.gov

g. Enhancing the Geant4 Simulation Toolkit

Grant applications are sought for enhancements or additions to the Geant4 simulation toolkit [4] that would be beneficial to its use in high energy physics while widening its applicability outside high energy physics. Examples might include: a) enhanced simulation of radiation effects in semiconductors to aid in the design of radiation-hard electronics; b) simulation of material activation in high radiation environments; c) improved interface to Computer Aided Design systems enabling tasks such as efficient exploration of shielding configurations; d) improvements to the precision and speed of the Geant4 electromagnetic physics modeling benefiting both high energy physics and other uses.

Questions – contact Larry Price larry.price@science.doe.gov

h. Data and Software Preservation

Long-term preservation of scientific data represents a challenge to all experiments. Even after an experiment has reached its end of life, it may be necessary to reprocess the data. There are two aspects of long-term data preservation: "data" and "software". While data can be preserved by migration, it is more complicated for the software. Preserving source code and binaries is not enough; the full software and hardware environment is needed. Grant applications are sought for systems to preserve HEP data and to make it useful for indefinite periods.

Questions – contact Larry Price larry.price@science.doe.gov

i. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Larry Price larry.price@science.doe.gov

References:

1. Most of these issues are discussed in presentations to the 2012 Conference on Computing in High Energy and Nuclear Physics. See http://indico.cern.ch/conferenceTimeTable.py?confId=149557#all.detailed.
2. U.S. Department of Energy Office of Science: High Energy Physics. (http://science.energy.gov/hep/)

3. Laboratories. U.S. Department of Energy Office of Science: High Energy Physics. Web. (http://science.energy.gov/laboratories/)
4. Open Science Grid (OSG) Consortium: a partnership between the National Science Foundation and the U.S. Department of Energy Office of Science. (http://computing.fnal.gov/xms/Science_%26_Computing/Scientific_Facilities/Open_Science_Grid)
5. Geant4. (http://geant4.cern.ch/)

30. ADVANCED CONCEPTS AND TECHNOLOGY FOR PARTICLE ACCELERATORS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The DOE High Energy Physics (HEP) program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. The strategic plan for HEP includes initiatives on the energy and intensity frontiers, relying on accelerators capable of delivering beams of the required energy and intensity. As high energy physics facilities get bigger and more costly, the DOE HEP program seeks to develop advanced technologies that can be used to reduce the overall machine size and cost, and also to develop new concepts and capabilities that further scientific and commercial needs beyond HEP's discovery science mission.

Please note that this year the topics have been grouped by technology, rather than by the High Energy Physics frontier to which they belong, as was done in prior years.

In many cases the technology sought is closely tied to a specific machine concept which sets the specifications (and tolerances) for the technology. Applicants are strongly encouraged to review the references provided. Applications to subtopics specifically associated with a machine concept that do not closely adhere to the specifications of the machine will be returned as non-responsive.

For subtopics that are not machine-specific (typically labeled "General Topics"), applicants are strongly advised to understand the state-of-the-art and to clearly describe in the application what quantitative advances in the technology will result.

Grant applications are sought only in the following subtopics:

a. Advanced Accelerator Concepts and Modeling

1) Beamline Components for Emittance Re-partitioning: Grant applications are sought to develop phase space manipulation and associated beamline component capable of repartitioning the beam emittances within the three degrees of freedom.

2) Beamline Components for Beam Current Profile Shaping: High transformer ratios (>>2) are essential for practical collinear wakefield accelerators. One promising approach is the use of

the emittance exchange technique to shape the axial beam current profile of the drive beam, for example to generate a double-triangular current distribution.

Grant applications are sought to design and demonstrate phase space manipulation techniques for tailoring the beam current profile to enhance the performance of beam-driven acceleration techniques.

3) Mitigation and Measurement of CSR in Bends: Degradation of high current beams caused by Coherent Synchrotron Radiation (CSR) in pulse compressors and beamline bends is an important concern for accelerators. The emitted rf wave or modes that are trapped inside the vacuum chamber could be diagnosed using either rf detection or witness beam techniques.

Grant applications are sought to study CSR effects in bends, to develop mitigations using lattice or shielding techniques, and to demonstrate the effectiveness of the mitigation techniques at a beam facility.

4) Optical Stochastic Cooling: Grant applications are sought to design and develop a high-precision Optical Stochastic Cooling insert for an electron ring. The insert would consist of a pick-up undulator, a chicane with specific M56 properties and a kicker undulator. The Optical Stochastic Cooling method described in reference [1] has the potential to cool electrons as well as heavier particles, such as muons.

5) Supersonic Gas Jets with Programmable Density Profiles: Grant applications are sought to develop high density (range of 10^{19}-10^{20} /cc), high repetition rate (≥10 Hz) pulsed gas jets with precisely shaped density profiles. Efficient acceleration of mono-energetic proton beams can be achieved with a CO_2 gas laser focused on a pulsed supersonic gas jet with tailored longitudinal density profile. The main goal of a shaped density gas jet is to prevent the appearance of electrostatic fields at the rear surface of the target; these fields are responsible for energy broadening of the ion beam. The most effective way to reduce those fields is to introduce an exponential drop in density over a scale length of a few hundred microns. The density profile at the front of the gas jet should follow a linear increase in density over a distance of 100 to 150 microns. In order to accelerate protons to high energies, the gas jet peak density should be controlled from about the critical density of the laser driver used, which is 10^{19}/cc for CO_2 lasers to as much as ten times the critical density.

6) Novel High Gradient Accelerating Techniques: Grant applications are sought to develop new or improved accelerator designs that can provide very high gradient (>200 MV/m for electrons or >15 MV/m for protons) acceleration of intense bunches of particles, or efficient acceleration of intense (>50 mA) low energy (of order <20 MeV) proton beams. For all proposed concepts, stageability, beam stability, manufacturability, and high-wall-plug-to-beam power efficiency must be considered.

7) Novel Accelerator Topologies: Grant applications are sought to demonstrate efficient low-loss proton acceleration in the energy range of 5-25 GeV using non-scaling, fixed-field alternating-gradient (ns-FFAG) accelerators, superconducting cyclotrons, or integrable optics accelerators. The HEP applications of interest include a proton driver injector for muon colliders and/or neutrino factories, high-intensity proton drivers for neutron production. Applications beyond

HEP include neutron sources for reactor materials testing, waste transmutation, energy production in sub-critical nuclear reactors, and lower-intensity applications such as medical proton therapy (250 MeV), and radioisotope production.

8) Advanced Concepts and Modeling for Mu2e[4]: Grant applications are sought for concepts for high efficiency slow extraction from storage rings with high intensity beams. Of primary interest are concepts for extraction systems capable of extracting proton beams of tens of kilowatts, with efficiencies in excess of 99%.

9) Advanced Concepts and Modeling for Project-X[5]: Grant applications are sought to develop new or improved accelerator designs and supporting modeling that can provide efficient acceleration of intense particle beams in either linacs or synchrotrons with beam losses of less than 1 W/m. Topics of interest include: (1) Linac configurations, either pulsed or CW, capable of delivering >1 MW beams at energies between 1-10 GeV; (2) Halo formation in pulsed or CW linacs; (3) Concepts for high intensity rapid cycling synchrotrons; (4) Space-charge mitigation techniques; and (5) New methods for multi-turn H– injection, including laser stripping techniques.

Also of interest is a multi-MW proton (or H-) source to support intensity frontier programs based on neutrino, muon, kaon, and neutron/nuclei probes. Other possible applications include high-intensity proton drivers for waste transmutation, energy production in sub-critical nuclear reactors, medical proton therapy, and radioisotope production.

Questions – contact Eric Colby, eric.colby@science.doe.gov

b. Advanced Concepts and Modeling for the Muon Accelerator Program

The mission of the U.S. Muon Accelerator Program (MAP) is to develop and demonstrate the concepts and critical technologies required to produce, capture, condition, accelerate, and store intense beams of muons for Muon Colliders and Neutrino Factories [1,2]. Current plans involve staged facilities beginning with neutrino factories, possibly followed by a low energy collider (Higgs Factory), and eventually leading to a multi-TeV energy collider. Muon-based facilities have the potential to discover and explore new exciting fundamental physics, but will require the development of demanding technologies and innovative concepts. Grant applications are sought, as described in greater detail below, related to the production of muon beams, muon cooling, and rapid muon acceleration.

1) 6D Cooling of Muon Beams Utilizing Rectilinear channels: To meet the proposed Muon Collider performance goals, 6D ionization cooling is required down to transverse emittances of less than 0.3 mm-rad and longitudinal emittances of approximately 2 mm. Rectilinear channels have been proposed with demonstrated capability to achieve 6D cooling of muon beams of both charge species simultaneously: a ‘Helical FOFO Snake’ [3]; and a ‘Rectilinear Planar Snake[4,5,6]’. In both cases, plane parallel absorbers are employed and cooling of both signs occurs simultaneously. The Helical FOFO lattice must be modified and scaled in order to meet the above transverse emittance requirement. Scaling of the Planar Snake lattice has been successfully demonstrated.

Grant applications are sought to examine in greater detail either of the referenced lattice types. The magnet designs should be refined, including the use of different conductor materials in areas with differing fields. Required superconductor current densities should then be compared with published conductor performances for the chosen geometry. Radial and other forces and strains within the coils should be calculated, together with the forces between the coils. In a second phase, the dimensions of structures required to restrain these forces should be calculated, and estimates made of the required specifications for such structures. Estimates should also be made of specifications needed for thermal isolation, rf feeds and other needed structures.

2) Large Aperture Kickers for Muon Cooling Rings: A significant cost savings in both capital construction and operations could be realized if cooling rings could be employed in the cooling chain for a Muon Collider. The injection and extraction systems for each ring will be challenging in that the muon beams have large emittances especially at the beginning of the cooling chain. Transverse emittances on the order of 1 to 5 mm-rad are expected; hence the kicker apertures must be larger than typical. Several types of cooling rings [7,8,9] have been considered but all will require these technically advanced kickers. Initial studies of the necessary kicker parameters [10] have confirmed the basic challenge of these kickers.

Grant applications are sought for both the design of kicker hardware and an accompanying pulsed power system.

3) R&D for Rapid Acceleration of Muons/ Dogbone RLA with Multi-Pass Arcs: Recirculating Linear Accelerators (RLAs) are a fast, compact and efficient way of accelerating lepton and possibly ion beams to medium and high energies by reusing the same linac for multiple passes, or to recycle the energy of the beam. In a conventional RLA, the different-energy passes coming out the linac are separated and directed into individual return arcs for recirculation. Thus, each pass through the linac requires a separate fixed energy arc, increasing the complexity, size, and cost of the RLA. A novel RLA concept involves return-arc optics design based on linear combined function magnets with variable dipole and quadrupole field components, which allows two consecutive passes with very different energies to be transported through the same string of magnets [11,12].

Grant applications are sought to develop a complete conceptual design for a scaled electron model of such an RLA (i.e. a model developed by scaling a GeV muon design for electrons yielding a machine that fits in a compact area). Along with a conceptual design, a cost comparison to an alternative separate-arc design should also be done. Proposals are also invited on the conceptual engineering design of the above-mentioned multi-pass arc magnets, capable of handling wide energy ranges, and related systems.

4) A Pulsed Dipole for Muon Beam Acceleration in an RCS: A Muon Collider will require final acceleration of muons to TeV-scale energies. For this purpose, a final acceleration stage based on a Rapid Cycling Synchrotron (RCS) [13,14] is envisioned. At these energies, the RCS lattice contains a sequence of fixed field superconducting dipoles and pulsed warm dipoles capable of +/- 1.8T swings at a rate of 2 to 8 T/ms [15].

Grant applications are sought to develop a detailed magnet design achieving the required performance along with a cost effective pulsed power supply system. In a second phase, prototypes of the magnet and power supply system could be built and tested.

c. Computational Tools and Simulation of Accelerator Systems

1) Improved Accelerator Modeling Simulation Codes: Grant applications are sought to develop new or improved computational tools for the design, study, or operation of charged-particle-beam optical systems, accelerator systems, or accelerator components. These tools should incorporate innovative user-friendly interfaces, with emphasis on graphical user interfaces and windows, and tools to translate between standard formats of accelerator lattice description. Grant applications also are sought for the conversion of existing codes for the incorporation of these interfaces (provided that existing copyrights are protected and that applications include the authors' statements of permission where appropriate).

2) Improved Integration of Accelerator Codes: Grant applications also are sought for user-friendly tools in software integration for different components including preprocessors and postprocessors of existing codes or for different application codes into a framework to enhance simulation of accelerator systems[1].

3) Accurate Modeling and Prediction of High Gradient Breakdown Physics: Grant applications also are sought to develop simulation tools for modeling high-gradient structures, in order to predict such experimental phenomena as the onset of breakdown, post breakdown phenomena, and the damage threshold. Specific areas of interest include the modeling of: (1) Surface emission, (2) Material heating due to electron and ion bombardment, (3) Multipactoring, and (4) Ionization of atomic and molecular species. Approaches that include an ability to import/export CAD descriptions, a friendly graphical user interface, and good data visualization will be a plus.

4) Software for Multi-Physics Modeling of MAP Systems: In the past decade HEP-driven accelerator modeling codes have become increasingly sophisticated. Particularly noteworthy is the fact that accelerator codes now combine multiple phenomena, such as single particle nonlinear optics, space-charge effects, beam-beam effects, and beam-material interactions. But there are some phenomena that are important to the HEP mission that are still missing from accelerator codes.

Grant applications are sought for development and deployment of codes and software modules that are important to HEP projects and for which current capabilities do not exist or are not sufficient. Regarding the simulation of MAP's muon cooling systems [2,3,4], those based on gas-filled rf cavities require complex modeling of the beam-plasma interaction [5]. Such processes are also expected to be relevant to other advanced concepts involving beams and plasmas. Proposals are sought for codes and modules to self-consistently model the interaction of beams with plasmas, including beam-plasma interactions in gas-filled rf cavities, plasma production by incoming beams, and plasma and atomic physics processes. Proposals are also sought for developing code capabilities for modeling collective effects in matter, for modeling polarized muon processes, and for combining beam dynamics codes with neutrino interaction codes to accurately predict neutrino radiation in a muon collider.

Questions – contact Eric Colby, eric.colby@science.doe.gov

d. Particle Beam Sources (electron and ion)

1) High Brightness Electron Sources: Grant applications are also sought to demonstrate technologies that support the production of high-peak current (> 5 kA), low-emittance (< 0.15 micrometer) electron bunches (> 100 pC). Novel emittance partitioning concepts are of particular interest, including developing high compression ratio (>20) bunch compressors based on coupled emittance exchangers that suppress effects from coherent synchrotron radiation.

2) Particle Beam Sources for Project-X[1]/ High Intensity Proton Sources: Grant applications are sought for the design, and demonstration unit(s), of low emittance DC H– sources capable of operating at up to 15 mA with a long lifetime. Long lifetime means greater than one month, minimum, with concurrent high reliability in operations. Of particular interest are sources operating at ~30 keV.

Questions – contact eric.colby@science.doe.gov

e. Novel Device and Instrumentation Development

Novel Device and Instrumentation Development for Project-X[1]: Grant applications are sought for beam deflecting devices that can be used to remove or deflect proton or ion bunches for the purpose of forming variable bunch patterns in high intensity proton accelerators (see also "Deflecting Cavities" in next topic).

Specific areas of interest include:
1) Deflecting structures capable of removing individual bunches within a beam from a ~2 MeV CW source, and with a 162.5 MHz bunch structure; specifically with capabilities of providing arbitrary chopping patterns based on selective removal of bunches spaced at 6 nsec; and
2) Driver concepts, either amplifier or switch based, suitable for driving such deflectors with several 100 volts into impedances of 50 or 200 Ohms.

Fast Beam Kicker: Grant applications are sought for a fast beam kicker with 50 ns rise time and 150 kV total transverse kick.

Questions – contact eric.colby@science.doe.gov

f. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact eric.colby@science.doe.gov

References: Subtopic a:

1. M.S. Zolotorev & A.A. Zholents. (1994). *Transit-time method of optical stochastic cooling.* Physical Review E. Vol. 50, Issue 4, pp. 3087-3091. Available at http://pre.aps.org/abstract/PRE/v50/i4/p3087_1
2. D. Haberberger, et al. (2011). *Collisionless shocks in laser-produced plasma generate monoenergetic high-energy proton beams.* Nature Physics. Vol. 8, pp. 95-99. Available for purchase at http://www.nature.com/nphys/journal/v8/n1/abs/nphys2130.html
3. F. Fiuza, et al. (2012). Laser-Driven shock acceleration of monoenergetic ion beams. Physical Review Letters. Vol. 109, No. 21, 215001. Available at http://arxiv.org/pdf/1206.2903.pdf
4. Muon Accelerator Program. (http://map.fnal.gov)
5. International Committee for Future Accelerators (ICFA) Beam Dynamics Newsletter. August 2011, No. 55. Eds. M.A. Palmer & W. Chou. See information on Muon Colliders and neutrino factories. http://www-bd.fnal.gov/icfabd/Newsletter55.pdf
6. Y. Alexahin (for the Neutrino Factory and Muon Collider Collaboration). (2009). *Helical FOFO snake for 6D ionization cooling of muons.* AIP Conference Proceedings. Vol. 1222, pp. 313-318. Available at http://proceedings.aip.org/resource/2/apcpcs/1222/1/313_1
7. R.B. Palmer, J.S. Berg, R. Fernow & D. Stratakis. *6D Cooling in Periodic Lattices.* Advanced Accelerator Group Meeting: June 6, 2013. Available at http://www.cap.bnl.gov/AAG/GroupMeetings/
8. J.S. Berg, et al. *A Planar Snake Muon Ionization Cooling*. Submitted to NA- PAC13. Pasadena, California. September 29—October 4, 2013. (http://www.cap.bnl.gov/AAG/GroupMeetings/)
9. D. Stratakis, et al. *Studies on New, High-Performance, 6-Dimensional Ionization Cooling Lattices for Muon Accelerators*. Submitted to NA- PAC13. Pasadena, California. September 29—October 4, 2013. (http://www.cap.bnl.gov/AAG/GroupMeetings/)
10. R.C. Fernow, J.S. Berg, J.C. Gallardo & R.B. Palmer. (2003). *Muon Cooling in the RFOFO Ring Cooler*. Proceedings of the Particle Accelerator Conference (PAC03). Available at http://accelconf.web.cern.ch/AccelConf/p03/PAPERS/WPAE027.PDF
11. X.P. Ding, D. Cline, A.A. Garren, H.G. Kirk & J.S. Berg. (2011). *Status of Studies of Achromat-Based 6D Ionization Cooling Rings for Muons*. Proceedings of IPAC2011. San Sebastian, Spain. Available at http://accelconf.web.cern.ch/AccelConf/IPAC2011/papers/mopz030.pdf
12. V. Balbekov. (2003). *Investigation and Simulation of Muon Cooling Rings with Tilted Solenoids*. Proceedings of the Particle Accelerator Conference (PAC03). Available at http://accelconf.web.cern.ch/AccelConf/p03/PAPERS/WPAE033.PDF
13. X.P. Ding, D. Cline, A.A. Garren, F.E. Mills, H.G. Kirk & J.S. Berg. (2012). *Injection/Extraction of Achromat-based 6D Ionization Cooling Rings for Muons*. Proceedings of IPAC2012. New Orleans, Louisiana. Available at http://accelconf.web.cern.ch/AccelConf/IPAC2012/papers/moppc043.pdf
14. S.A. Bogacz, G.A. Krafft, V.S. Morozov & Y.R. Roblin. (2013). *JEMMRLA - Electron Model of a Muon RLA with Multi-pass Arcs*. Proceedings of IPAC2013. Shanghai, China. Available at http://accelconf.web.cern.ch/accelconf/IPAC2013/papers/weoab202.pdf
15. V.S. Morozov, S.A Bogacz, Y.R. Roblin & K.B. Beard. (2012). *Linear fixed-field multipass arcs for recirculating linear accelerators.* Physical Review Special Topics—Accelerators and Beams. Vol. 15, pp. 060101(1-9). Available at http://prst-ab.aps.org/abstract/PRSTAB/v15/i6/e060101

16. J.S. Berg & A.A. Garren. (2011). *A Lattice for a Hybrid Fast-Ramping Muon Accelerator to 750 GeV*. Muon Accelerator Program Document 4307-v1. Available at http://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4307
17. J.S. Berg & A.A. Garren. *Hybrid Fast-Ramping Accelerator to 750 GeV/c: Refinement and Parameters over Full Energy Range*. Muon Accelerator Program Document 4335-v2. Available at http://map-docdb.fnal.gov/cgi-bin/ShowDocument?docid=4335
18. D.J. Summers, et al. (2012). *Test of a 1.8 Tesla, 400 Hz Dipole for a Muon Synchrotron*. Proceedings of IPAC2012. New Orleans, Louisiana. Available at http://accelconf.web.cern.ch/AccelConf/IPAC2012/papers/thppd020.pdf
19. Mu2e Conceptual Design Report. (http://arxiv.org/abs/1211.7019)
20. Project X Reference Design Report. (http://projectx-docdb.fnal.gov/cgi-bin/ShowDocument?docid=776)

References: Subtopic b:

1. Proceedings of the Tenth International Computational Accelerator Physics Conference. San Francisco, California. August 31–September 4, 2009. Ed. J. Chew. Web. (http://epaper.kek.jp/ICAP2009/)
2. Muon Accelerator Program. (http://map.fnal.gov)
3. International Committee for Future Accelerators (ICFA) Beam Dynamics Newsletter. August 2011, No. 55. Eds. M.A. Palmer & W. Chou. See information on Muon Colliders and neutrino factories. http://www-bd.fnal.gov/icfabd/Newsletter55.pdf
4. Y. Alexahin (for the Neutrino Factory and Muon Collider Collaboration). (2009). *Helical FOFO snake for 6D ionization cooling of muons.* AIP Conference Proceedings. Vol. 1222, pp. 313-318. Available at http://proceedings.aip.org/resource/2/apcpcs/1222/1/313_1
5. K. Yonehara, et al. (2013). Simulation of Beam-Induced Gas Plasma in High Gradient RF Field for Muon Colliders. Proceedings of IPAC2013. Shanghai, China. Pre-press version available at http://159.226.222.133/prepress/TUPFI058.PDF

References: Subtopic c:

1. Project X Reference Design Report. http://projectx-docdb.fnal.gov/cgibin/ShowDocument?docid=776

References: Subtopic d:

1. Project X Reference Design Report. http://projectx-docdb.fnal.gov/cgibin/ShowDocument?docid=776

References:

1. *Advanced Accelerator Concepts: 15th Advanced Accelerator Concepts Workshop*. AIP Conference Proceedings. Vol. 1507. Austin, Texas. June 10-15, 2012. Available at http://proceedings.aip.org/resource/2/apcpcs/1507/1
2. ICFA Beam Dynamics Workshops and Mini-Workshops. Complete listing of workshops and links to proceedings available at http://www-bd.fnal.gov/icfabd/workshops.html; http://www-bd.fnal.gov/icfabd/mini.html
3. Conference on Applications of Accelerators in Research and Industry. Fort Worth, Texas. August 5-10, 2012. Information and proceedings available at www.caari.com
4. 2012 Beam Instrumentation Workshop (BIW12). Newport News, Virginia. April 15-19. Proceedings available at https://www.jlab.org/conferences/BIW12/

5. International Workshop on Neutrino Factories, Super Beams and Beta Beams. Williamsburg, Virginia. July 23-28, 2012. Information and proceedings available at http://www.jlab.org/conferences/nufact12/
6. T.P. Wangler. (2008). *RF Linear Accelerators, Physics Textbook* (2nd ed.). Hoboken, New Jersey: Wiley-VCH. ISBN: 978-3527406807. Available for purchase at http://www.amazon.com/dp/3527406808
7. *Applications of High Intensity Proton Accelerators: Proceedings of the Workshop.* (2010). Eds. R. Rajendran & C. Mishra. Batavia, Illinois: World Scientific. ISBN: 978-9814317283. Available for purchase at http://www.amazon.com/Applications-High-Intensity-Proton-Accelerators/dp/9814317284
8. *Handbook of Accelerator Physics and Engineering*. (1999). Eds. A. Chao & M. Tigner. River Edge, New Jersey: World Scientific. ISBN: 9-8102-38584. Available for purchase at http://www.amazon.com/Handbook-Accelerator-Physics-Engineering-Alex/dp/9810238584

31. RADIO FREQUENCY ACCELERATOR TECHNOLOGY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Radio frequency (RF) technology is a key technology common to all high energy accelerators. RF sources with improved efficiency and accelerating structures with increased accelerating gradient are important for keeping the cost down for future machines. DOE-HEP seeks advances directly relevant to HEP applications, and also new concepts and capabilities that further scientific and commercial needs beyond HEP's discovery science mission.

Please note that this year the topics have been grouped by technology, rather than by the High Energy Physics frontier to which they belong, as was done in prior years.

In many cases the technology sought is closely tied to a specific machine concept which sets the specifications (and tolerances) for the technology. Applicants are strongly encouraged to review the references provided. Applications to subtopics specifically associated with a machine concept that do not closely adhere to the specifications of the machine will be returned as non-responsive.

For subtopics that are not machine-specific (typically labeled "General Topics"), applicants are strongly advised to understand the state-of-the-art and to clearly describe in the application what quantitative advances in the technology will result.

Grant applications are sought only in the following subtopics:

a. Radio Frequency Power Sources and Components

1) High Gradient Research & Development : Grant applications are sought for research on very high gradient RF accelerating structures, normal or superconducting, for use in accelerators and storage rings. Gradients >150 MV/m for electrons and >10 MV/m for protons in normal cavities are of particular interest, as are means for suppressing unwanted higher-order modes and

reducing costs. In muon accelerator R&D, structures for the capture and acceleration of large emittance muon beams and techniques for achieving gradients of 5-30 MV/m in cavities with frequencies between 325 and 1300 MHz (including superconducting cavities whose resonant frequencies can be rapidly modulated) are of interest.

2) Mitigation Techniques for Surface Breakdown and Multipactoring: Methods for reducing surface breakdown and multipactoring (such as spark-resistant materials or surface coatings, or special geometries) and for suppressing unwanted higher order modes also are of interest, as are studies of surface breakdown and its dependence on magnetic field. Grant applications should be applicable to devices operating at frequencies from 1 to 40 GHz, or between 325 and 1300 MHz for muon accelerators. Laser-initiated rf breakdown is an important issue in high performance photoinjectors. Grant applications are sought to study the origin and mitigation of laser triggered rf breakdown at the photocathode.

3) Analysis and Mitigation of High Repetition Rate Effects in Dielectric Wakefield Accelerators: The interaction of dielectric materials with beam halo might become a significant limiting effect on the performance of dielectric wakefield devices, leading either to deflection of the beam by the static electric field generated, or to breakdown of the structure. Grant applications are sought which emphasize experimental, theoretical or computational studies of the expected charging rate and charge distribution in a thin walled dielectric device and the physics of conductivity and discharge phenomena in dielectric materials useful in accelerator applications.

4) Low-Temperature Bonding Techniques for Hard Copper and Hard Copper Alloys: Recent research on high-gradient normal conducting accelerator structures showed significant advantages of hard copper and hard copper alloys over annealed copper[1,2]. Hard copper and hard copper alloys (e.g. copper-silver) allow these structures to run stably at higher gradients than annealed copper. However, normal manufacturing techniques, which include brazing and or diffusion bonding, anneal the copper; in the case of copper alloys there are no established bonding techniques. Grant applications are sought that can address the development of manufacturing techniques that preserve the hardness of copper or its alloys while at the same time maintains high degree of surface integrity and cleanliness for high gradient operation. Plating, low temperature brazing, and welding are examples of possible technologies for bonding structure cells; however, we would also welcome other ideas and technologies.

5) Low Cost Radio Frequency Power Source for Accelerator Applications: A magnetron[3] represents a very economical microwave source with a cost of a few $/kW. The development of a low cost and highly-efficient RF source for particle acceleration to energies in the 100 GeV to multi-TeV range would have significant impact on the cost of proposed high energy physics accelerators. Such a source would also be useful for other accelerator applications. Under typical operating conditions, the magnetron is an oscillator rather than an amplifier and control of output power is a problem when used as a source for accelerators. The design of a magnetron can be modified to allow the control of its output power within a limited range, roughly ±10%, by the incorporation of a low-voltage control grid. In principle, this control can be achieved with effective timescales of a few milliseconds by means of adding a low-voltage grid to the standard magnetron design which will allow modulation of the electron current and hence the power. Grant applications are sought to design and simulate the performance of a magnetron with a control grid to optimize the geometry of the grid and cathode. On the basis of the optimized

design, a prototype would be constructed to study the performance over a range of operating voltages and to evaluate the power, frequency, phase and amplitude characteristics.

6) Radio Frequency Power Sources and Components for Project-X[4]: Grant applications are sought for the development of power sources for accelerating cavities operating with 1-5 mA of average beam current in linacs capable of accelerating protons and ions to several GeV. Frequencies of interest include 162.5, 325, 650, and 1300 MHz.

7) Continuous wave (CW) applications are the primary interest. Examples of systems of interest include, but are not limited to: klystrons, solid state, inductive output, and phase locking magnetron devices; their associated power supplies; and associated low level radio frequency (LLRF) control systems.

8) Pulsed applications of interest include sources capable of delivering high peak power (multi-MW) with pulse lengths in the range 6-30 msec at 10 Hz. Grant applications are sought for the following specific rf sources and components:
    - L-Band Power Sources and Components
    - L-Band Medium Power Tube – 1.3 GHz, 350 kW, 1.6 millisecond pulses at 5 Hz or 10 Hz.
    - S-Band Power Sources and Components
    - Solid State S-band Klystron Drivers – Peak output power +60dBm at 0.2% duty, 37 dB gain, 5 microsec, 240 Hz, pulse to pulse added noise jitter (10Hz to 2MHz BW) less than 30 fs rms. The amplifier should be designed for installation in a 19 inch rack mount chassis and weigh less than 30 pounds.
    - S-band Pulse Compressor – Power compression ratio ranging from 4 to 8, efficiency >70%, return loss >25 dB, input power >50MW peak, 120 Hz repetition rate, radiation emissions < 10 mrem/hr.[5]
    - S-Band Power Circulator – 65MW peak, 4 microsec pulse length, 120 Hz repetition rate, return loss >25 dB, insertion loss < 0.2dB.
    - S-Band Dry Vacuum Loads – 30 MW peak power, 5 kW average power.
    - X-band Power Sources and Components[6]
    - X-band Klystron Drivers – 2 kW, 5 µs, 360 Hz, 100 MHz bandwidth, 50 dB gain, low noise (<0.1 degree).
    - X-band Circulator – 50MW peak, 2 microsec pulse length, 120 Hz repetition rate, return loss >25 dB, insertion loss < 0.2dB.
    - X-band Vacuum Loads – Two types are sought: 50 MW peak/5 kW average, and 5 MW peak/25 kW average.

Questions – contact Eric Colby, eric.colby@science.doe.gov

b. Pulsed Power Systems

Thyratron Replacement for SLAC Modulators – Grant applications are sought for a replacement for existing thyratron switch tubes that are used in line type modulators. The replacement must meet SLAC specification PS-235-380-00-R4 with the addition of an increase in peak reverse voltage hold of (10kV) and a MTBF of 10,000 hours with a stable recovery process. A desirable feature would be a design that allows for replacement or repair of the cathode.

Questions – contact Eric Colby, eric.colby@science.doe.gov

c. Deflecting Cavities (aka crab cavities)
(*See also* Beam Choppers and Deflectors *in prior topic*).

Deflecting Cavities for Project-X[1]

Grant applications are sought for beam deflecting devices that can be used to deflect proton or ion bunches for the purpose of forming variable bunch patterns in high intensity proton accelerators. Topics of particular interest include narrowband transverse deflecting superconducting cavities capable of CW operation at a 406 or 427 MHz, and with a total deflection of ~7 MV, and room temperature deflecting cavities operating in CW mode at 243.75 MHz with the total deflection of ~1 MV.

Questions – contact Eric Colby, eric.colby@science.doe.gov

d. Other
In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Eric Colby, eric.colby@science.doe.gov

References: Subtopic a:

1. Lisa Laurent, et al. (2011). *Experimental study of rf pulsed heating*. Physical Review Special Topics – Accelerators and Beams. Vol. 14, pp. 041001(1-21). Available at http://prst-ab.aps.org/abstract/PRSTAB/v14/i4/e041001
2. Valery Dolgashev, Sami Tantawi, Yasuo Higashi & Bruno Spataro. (2010). *Geometric dependence of radio-frequency breakdown in normal conducting accelerating structures*. Applied Physics Letters. Vol. 97, Issue 17, pp 171501(1-3). Available at http://apl.aip.org/resource/1/applab/v97/i17/p171501_s1
3. *Microwave Magnetrons, Radiation Laboratory Series 6*. (1948). Ed. G. B. Collins. McGraw-Hill. Available for purchase at http://www.amazon.com/Microwave-Magnetrons-Radiation-Laboratory-6/dp/B000JDA2FG/ref=sr_1_2?s=books&ie=UTF8&qid=1372448127&sr=1-2&keywords=Microwave+magnetrons
4. Project X Reference Design Report. (http://projectx-docdb.fnal.gov/cgi-bin/ShowDocument?docid=776)
5. Z. D. Farkas, H.A. Hogg, G.A. Loew & P.B. Wilson. (1974). *SLED: A Method of Doubling SLAC's Energy.* Proceedings of the 9th International Conference on High Energy Accelerators. Stanford Linear Accelerator Center. pp. 576-583. Available at http://inspirehep.net/record/94052/files/HEACC74_597-604.pdf
6. S. Tantawi, et al. (2005). *High-power multimode X-band rf pulse compression system for future linear colliders.* Physical Review Special Topics – Accelerators and Beams. Vol. 8, pp. 042002(1-19). Available at http://prst-ab.aps.org/abstract/PRSTAB/v8/i4/e042002

References: Subtopic c:

1. Project X Reference Design Report. http://projectx-docdb.fnal.gov/cgi-bin/ShowDocument?docid=776

References:

1. *High Energy Density and High Power RF: 7th Workshop on High Density and High Power RF*. Kalamata, Greece. June 13-17, 2005. Eds. D.K. Abe & G.S. Nusinovich. (2006). AIP Conference Proceedings. No. 807. ISBN: 0-7354-02981. Available for purchase at http://books.google.com/books/about/High_Energy_Density_and_High_Power_RF.html?id=LjZ7xzjAedkC
2. Advanced Accelerator Concepts Workshop. Austin, Texas. June 10-15, 2012. AIP Conference Proceedings. No. 1507. Available at http://proceedings.aip.org/resource/2/apcpcs/1507/1
3. The 26th International Linear Accelerator Conference (LINAC12). Tel Aviv, Israel. September 9-14, 2012. (http://www.linac12.org.il/)
4. The 2012 IEEE International Power Modulator and High Voltage Conference (2012IPMHVC). San Diego, California. June 3-7. (http://www.nessengr.com/ipmhvc2012/fullsite_index.php)
5. Conference on Applications of Accelerators in Research and Industry. Fort Worth, Texas. August 5-10, 2012. Information and proceedings available at www.caari.com
6. Muon Collider Workshop 2011: Physics-Detectors-Accelerators.Telluride, Colorado. June 27–July 1, 2011. (http://conferences.fnal.gov/muon11/)
7. The 2012 International Particle Accelerator Conference (IPAC12). New Orleans, LA. May 20-25. (http://www.ipac12.org/)
8. International Workshop on Neutrino Factories, Super Beams and Beta Beams. Williamsburg, Virginia. July 23-28, 2012. Information and proceedings available at http://www.jlab.org/conferences/nufact12/

32. LASER TECHNOLOGY R&D FOR ACCELERATORS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Lasers are used or proposed for use in many areas of accelerator applications: as drivers for novel accelerator concepts for future colliders, in the generation, manipulation, and x-ray seeding of electron beams, in the generation of electromagnetic radiation ranging from THz to gamma rays, and in the generation of neutron, proton, and light ion beams. In many cases ultrafast lasers with pulse lengths well below a picosecond are required, with excellent stability, reliability, and beam quality. With applications demanding ever higher fluxes of particles and radiation, the driving laser technology must also increase in repetition rate—and hence average power—to meet the demand.

Grant applications are sought to develop lasers and laser technologies for accelerator applications only in the following specific areas:

a. Ultrafast Infrared Laser Systems at High Peak and Average Power

This area is aimed at developing technologies for ultrafast lasers capable of high average power (kilowatt-class) operating at the high electrical-to-optical efficiency (>20%) needed for advanced accelerator applications. Accelerator applications call for lasers with one of four basic specifications:

	Type I	Type II	Type III	Type IV
Wavelength (micron)	1.5-2.0	0.8-2.0	2.0-5.0	2.0-10.0
Pulse Energy	3 microJ	3 J	0.03–1 J	300 J
Pulse Length	300 fs	30–100 fs	50 fs	100–500 fs
Repetition Rate	1–1300 MHz	1 kHz	100 kHz	100 Hz
Average Power	Up to 3 kW	3 kW	3 kW and up	30 kW
Energy Stability	<1 %	<0.1%	<1%	<1%
Beam Quality	M^2<1.1	Strehl>0.95	M^2<1.1	M^2<1.1
Wall-plug Efficiency	>30%	>20%	>20%	>20%
Pre-Pulse Contrast	N/A	>10^{-9}	N/A	>10^{-9}
CEP-capable	Required	N/A	Required	N/A
Optical Phase Noise	<5^o	N/A	<5^o	N/A
Wavelength Tunability Range	0.1%	0.1%	10%	0.1%

To develop lasers meeting these challenging requirements, we seek applications in the five fundamental technology areas which follow.

Improved Efficiency Laser Diodes for Pumping at Long Wavelength – While pump diodes at 980 nm have achieved efficiencies beyond 50% in commercial products, pump laser diodes for longer wavelength pumping of Erbium and Thulium fibers remain less efficient. Gains of 10% or more in electrical-to-optical power efficiency are needed to enable longer wavelength fiber lasers to achieve high efficiency.

Ceramic-Based Optical Materials – To achieve high average power and high peak power will require new gain materials with superior damage threshold, dopant density, optical bandwidth, and thermal properties. Sintered laser gain materials for ultrafast lasers offer promise of achieving many of these characteristics. Broad bandwidth (>10%) and scalability to high peak power (>10 TW), high average power (>kW) operation is essential. In addition, the development of techniques for producing precisely controlled spatial gain profiles is strongly encouraged.

Mode-Locked Seed Laser for High Repetition Rate Applications – Seeding Type I laser systems for accelerators and photocathode electron sources both require very high repetition rate laser oscillators producing modelocked pulses with exceptional timing, pointing, and energy stability. Applications are sought for a modelocked Erbium fiber laser producing 1 ps pulses at 1.3 GHz with 0.1 microJ per pulse. Technology must support synchronization to an external reference with < 10 fs rms timing jitter, and must be upgradeable to incorporate carrier-envelope phase locking.

Cost Reduction of Ultrafast Fiber Laser Components – Another route to achieving high peak and average power is to coherently combine the output of many (e.g. thousands of) ultrafast fiber lasers. In this case, power efficiency, beam quality, compactness, reliability, stability, and low cost of the individual lasers are each essential. Note that components and subsystems must be developed for propagating and amplifying high-quality (M^2<1.2) ultrafast (<100 fs) laser pulses. Proposals that develop integrated subsystems will be given highest priority, although proposals for individual components that offer revolutionary gains in any of the performance characteristics above will also be welcomed.

Solid State Seed Lasers for Ultrafast CO_2 Laser Systems – Ultrafast CO_2 laser systems operating at high peak and average power could drive compact proton and ion sources for a variety of applications. Developing a solid-state ultrafast seed laser for such systems is a key step towards achieving robust, economic operation. Proposals that develop all-solid-state seed laser systems capable of directly seeding high-pressure CO_2 laser amplifiers with <500 fs pulses of 100 nJ/pulse are sought. Technology must be scalable to 100 Hz repetition rate.

Questions – contact Eric Colby, eric.colby@science.doe.gov

b. Optical Coatings for Ultrafast Optics

The cost and reliability of ultrafast laser systems depend in part on the optical robustness of coated optics such as mirrors and windows. R&D proposals leading to low loss, low scatter, ultra-high damage threshold broad bandwidth coatings that can sustain fluences exceeding >2 J/cm^2 for 100 fs pulses. Coatings must also be stable at incident average powers exceeding 100 W, and provide high quality transmission or reflection properties over >10% bandwidth under both vacuum and in-air use.

Questions – contact Eric Colby, eric.colby@science.doe.gov

c. Timing Synchronization and Feedback

Lasers for accelerator applications must be synchronized to external timing sources, most often in the form of microwave reference signals. As experiments come to depend on increasingly shorter laser and particle bunch lengths, the timing requirement becomes increasingly challenging. Modern commercial laser systems lock with ~100 fsec RMS timing jitter. Applications to develop field-installable upgrades for widely used laser systems (eg. Ti:Sapphire) that can improve the timing jitter with respect to the external reference to 10 fsec are sought.

Questions – contact Eric Colby, eric.colby@science.doe.gov

d. Stabilization of Complex Laser Systems

Lasers for accelerator applications must produce laser pulses with excellent mode quality (M^2<1.1) and precisely controlled spectral and temporal shape (Gaussian or flat-top being typical). The large number of optics involved in very high peak power ultrafast laser systems raises the likelihood of time-dependent mode and profile degradation, and requires considerable expertise and manual intervention to counteract.

Grant applications are sought for passive and active systems that automatically diagnose and mitigate transverse and longitudinal profile drift in ultrafast laser systems. The successful application will begin with a measurement and characterization phase on an existing TW-class laser system, design an appropriate combination of passive and active mitigations based on modern control theory, and implement and thoroughly test a prototype system. The prototype system must be designed as a retrofit kit for existing commercial Ti:Sapphire CPA systems and must not interfere with existing mode locking, timing synchronization, or carrier-envelop-phase locking feedback loops already in place.

Questions – contact Eric Colby, eric.colby@science.doe.gov

e. Simulation and Modeling Codes for Diffractive Optics

Designing diffractive optics requires high accuracy simulation codes. Computer software capable of designing high performance broadband diffractive optics is sought. Codes must support the development of beam combiners and high-efficiency multilayer diffraction gratings for ultrafast laser use. At a minimum, the code must support accurate far-field performance prediction and automated geometric optimization. Proposals for codes which also allow analysis of potential failure modes by local field strength calculation within and near optical surfaces are especially encouraged.

Questions – contact Eric Colby, eric.colby@science.doe.gov

f. Robust Nonlinear Optical Materials

Nonlinear optical materials for frequency conversion are key to producing a wide array of laboratory-scale sources of radiation. Materials supporting conversion of laser power to frequencies in the terahertz to EUV range (λ=300–0.1 micron) at high conversion efficiency, high damage threshold, and at high average power (>100 W, cw) are sought.

Questions – contact Eric Colby, eric.colby@science.doe.gov

g. Manufacturing Centimeter-Scale Periodically Poled Materials

Periodically-poled materials provided engineered optical properties useful for a variety of laser applications, ranging from parametric oscillators and amplifiers to nonlinear frequency generation. Centimeter-thick optical-quality PPMgLN has been produced and used successfully in an OPCPA, but current commercial fabrication techniques remain limited in achievable thicknesses. Development and demonstration of techniques for producing optical-quality periodically-poled materials suitable for high-power use in OPCPA or other optical frequency conversion applications is sought.

Questions – contact Eric Colby, eric.colby@science.doe.gov

h. Drive Lasers and for Photocathode Electron Sources

Applications are sought for developing turn-key commercial laser systems and subsystems for driving high-brightness photocathodes.

a) A self-contained turn-key laser system (including environmental enclosure and controls) producing 50 Watts of 520nm light in 1 psec pulses at 1.3 GHz with no more than 100 fsec rms timing jitter with respect to an external microwave timing reference is sought. The resultant beam must be shaped temporally and spatially, as well as have the ability for producing varying pulse trains.

b) Practical and highly efficient (>90%) methods are sought for advanced laser shaping. The technique must allow a wide range of transverse shapes (elliptical to flattop) and spot sizes (0.3-3 mm) to be projected onto a photocathode to mitigate non-linear space charge effects and concomitant emittance degradation. The shaping system must preserve the laser beam quality and be usable with high powers (10's of Watts of average laser power).

Questions – contact Eric Colby, eric.colby@science.doe.gov

i. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.
Questions – contact Eric Colby, eric.colby@science.doe.gov

References:

1. Workshop on Laser Technology for Accelerators. January 23-25, 2013. Report available at: http://science.energy.gov/~/media/hep/pdf/accelerator-rd-stewardship/Lasers_for_Accelerators_Report_Final.pdf
2. Advanced Accelerator Concepts: 15th Advanced Accelerator Concepts Workshop. Austin, Texas. June 10-15, 2012. AIP Conference Proceedings. Vol. 1507. Report available at http://proceedings.aip.org/resource/2/apcpcs/1507/1?isAuthorized=no

33. SUPERCONDUCTOR TECHNOLOGIES FOR PARTICLE ACCELERATORS

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The Department of Energy High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this research in high-field superconductor, superconducting magnet, and superconducting RF technologies. This topic addresses only those superconducting magnet development technologies that support dipoles, quadrupoles, and higher order multipole corrector magnets for use in accelerators, storage rings, and charged particle beam transport systems, and only those superconducting wire technologies that support long strand lengths suitable for winding magnets without splices.

Grant applications are sought only in the following subtopics:

a. High-Field Superconducting Wire Technologies for Magnets

Grant applications are sought to develop new or improved superconducting wire for magnets that operate at a minimum of 15 Tesla (T) field, with preference for production scale (> 3 km continuous lengths) wire technologies at 15 to 25 T and demonstration scale (>1 km lengths) wire technologies at 25 to 50 T. Current densities should be at least 400 amperes per square millimeter of strand cross-section (often called the engineering current density) at the target field of operation and 4.2 K temperature. Tooling and handling requirements restrict wire cross-sectional area from 0.4 to 2.0 square millimeters, with any transverse dimension being not less than 0.25 mm. Vacuum requirements in accelerators and storage rings favor operating temperatures below 20 K, so high-temperature superconducting wire technologies will be evaluated only in this temperature range. Primary materials of interest are Nb_3Sn, $Bi_2Sr_2CaCu_2O_8$ (Bi-2212), and $YBa_2Cu_3O_7$ (ReBCO); other materials may be considered if high field performance, length, and cost equivalent to these primary materials can be demonstrated. All grant applications must result in wire technology that will be acceptable for accelerator magnets, including not only the operating conditions mentioned above, but also delivery of a sufficient amount of material (1 km minimum continuous length) for winding and testing small magnets.

New or improved wire technologies must demonstrate at least one of the following criteria *in comparison to present art*: (1) property improvement, such as higher current densities and higher operating fields; (2) improved management of property degradation as a function of applied strain; (3) reduced transverse dimensions of the superconducting filaments (sometimes called the effective filament diameter), in particular to less than 30 micrometers at 1 mm wire diameter, with minimal concomitant reduction of the thermal conductivity of the stabilizer or strand critical current density; (4) innovative geometry for ReBCO materials that leads to lower magnet inductance (cables) and lower losses under changing transverse magnetic fields; (5) correction of specific processing flaws (*not* general improvements in processing), to achieve properties in wires of more than 1 km length that are presently restricted to wire lengths of 100 m or less; (6) significant cost reduction for equal performance in all regards, especially current density and length.

Questions – contact Ken Marken, ken.marken@science.doe.gov

b. Superconducting Magnet Technology

Grant applications are sought to develop: (1) improved instrumentation to measure properties (such as local strain, temperature, and magnetic field) which are directly applicable to the testing of superconducting magnets; (2) improved current lead and current distribution systems, based on high-temperature superconductors, for application to superconducting accelerator magnets – requirements include an operating current level of 5 kA or greater, stability, low heat leak, and good quench performance; (3) alternative designs – to traditional "cosine theta" dipole and "cosine two-theta" quadrupole magnets – that may be more compatible with the more fragile Nb_3Sn and HTS/high-field superconductors (including open midplane magnets that may be needed in a Muon Collider design); (4) designs for bent solenoids for muon collider applications; (5) improved industrial fabrication methods for magnets such as welding and forming; (6) improved cryostat and cryogenic techniques; (7) fast cycling HTS magnets capable of operation at or above 4T/s; (8) quench protection in HTS magnets and HTS/LTS hybrid magnets; (9) designs and prototypes for HTS/LTS hybrid solenoid systems capable of achieving 30 to 40T axial fields and warm bores with a diameter ≥2 cm, which are of particular interest for final cooling of a muon beam prior to acceleration and injection into a collider storage ring; (10) reduction in magnetization induced harmonics in HTS magnets; (11) very high field (>20 T) dipoles.

Questions – contact Ken Marken, ken.marken@science.doe.gov

c. Starting Raw Materials and Basic Superconducting Materials

Grant applications are sought for raw materials that result in improved performance and can be incorporated into existing wire technologies under subtopic (a) with minimal disruption. (1) Nb_3Sn and other wire technologies rely upon various pure metal and metal-alloy raw materials containing niobium, tantalum, titanium, tin, and copper. Likewise, REBCO wire technologies depend on textured metal substrates, while Bi-2212 technologies depend on silver alloys. Grant applications are sought to develop improved starting metals and alloys, especially those which improve fabrication of the subsequent superconducting composite wire, reduce requirements for heat treatment and reaction, and reduce cost. (2) Bi-2212 and other wire technologies rely upon the fabrication of high-quality powders of the superconducting material. Grant applications are sought to develop powder fabrication facilities, improved quality control measures and better characterization tools.

Questions – contact Ken Marken, ken.marken@science.doe.gov

d. Superconducting RF Materials & Cavities

Materials and Fabrication Technologies for SRF Cavities – Material properties, surface features, processing procedures, and cavity geometry can have significant impact on the performance of superconducting radio-frequency (SRF) accelerator cavities. Grant applications are sought to develop (1) new raw materials streams, such as those utilizing large-grain Nb ingot slices; (2) new or improved SRF cavity fabrication techniques, such as seamless and weld-free approaches; (3) SRF cavity fabrication techniques that reduce use of expensive metals such as niobium while achieving equivalent performance as bulk niobium cavities; (4) new or improved bulk processing technologies, such as mechanical or plasma polishing; (5) new or improved final surface preparation and protection technologies; and (6) new cavity ideas aimed at breakthroughs in understanding and performance of SRF cavities.

SRF Cavities – Grant applications are sought for the development of superconducting radiofrequency cavities for acceleration of proton and ion beams, with relativistic betas ranging from 0.1 to 1.0. Frequencies of current interest include 325, 650, and 1300 MHz. Continuous wave (CW) cavities are of the greater interest, although pulsed cavities could also be supported. Accelerating gradients above 15 MV/m, at Q0 in excess of 2 × 1010 (CW), and above 25 MV/m at Q0 in excess of 1 × 1010 (pulsed) are desirable. Topics of interest include: (1) cavity designs; (2) cavity fabrication alternatives to electron beam welding, including for example hydroforming and automatic TIG or laser welding of cavity end groups; (3) other cavity and cryomodule cost reduction methods; (4) cw power couplers at >50kW; (5) fast tuners for microphonics control; (6) higher order mode suppressors, including extraction of HOM power via the main power coupler and with photonic band gap cavities; (7) ecologically friendly or alternative cavity surface processing methods; (8) alternatives to high pressure rinsing that would allow in-situ cleaning of cavities to control field emission; (9) high resolution tomographic x-rays of electron beam welds in cavities;

(10) specifically for muon acceleration, design of a cost-effective 325 MHz cavity capable of 20 MV/m with Qo > 109 that is compatible with expansion to a two or three cell cavity system; possible approaches could include: forming a cavity from a bonded sheet of thin Nb on Cu, robust sputter coating of Nb on a Cu cavity, and electroforming Cu on a thin Nb cavity shell

Questions – contact Ken Marken, ken.marken@science.doe.gov

e. Cryogenic and Refrigeration Technology Systems

Many new accelerators are based on the cold (superconducting) technology requiring large cryogenic systems. Grant applications are sought for research and development leading to the design and fabrication of improved cryomodules for superconducting cavity strings. Each cryomodule typically contains four to eight cavities in helium vessels and includes couplers, tuners, quadrupoles, 2K helium distribution system, and instrumentation to measure temperatures and pressures in the cryomodule during cool down and operation. Improvements in cryomodule components, cryomodule design and fabrication techniques which result in lower costs, improved control of cavity alignment, better understanding of cavity temperatures, and lower heat leaks are of particular interest. Other areas of interest include optimized methods for current leads for magnets operation at 2K where the helium pressures are sub atmospheric.

Grant applications also are sought to increase the technical refrigeration efficiency – from 20% Carnot to 30% Carnot – for large systems (e.g. 10 kW at 2K), while maintaining higher efficiency over a capacity turndown of up to 50%. This might be done, for example, by reducing the number of compression stages or by improving the efficiency of stages. Grant applications also are sought to develop improved and highly efficient liquid helium distribution systems."

Questions – contact Ken Marken, ken.marken@science.doe.gov

f. Ancillary Technologies for Superconductors

Grant applications also are sought to develop innovative cable designs and wire processing technologies. Approaches of interest include methods to use stranded conductors with high aspect ratio to make efficient magnet cables, methods to adapt tape geometries to particle accelerator applications; and technologies to increase wire piece length and billet mass.

Grant applications also are sought for innovative electrical insulating materials with reduced thickness to increase block current density in a coil while maintaining or increasing dielectric breakdown strength. Insulating systems must be compatible with the targeted superconductor and magnet processing cycle, (e.g. high temperature reactions in the 750-900 ºC range in the case of Nb_3Sn or BSCCO), be capable of supporting high mechanical loads at both room and cryogenic temperatures, have a high coefficient of thermal conductivity, be resistant to radiation damage, and exhibit low creep and low out-gassing rates when irradiated.

Grant applications also are sought for high-performance epoxies exhibiting the following characteristics: low viscosity regime for full impregnation of complex structures, reasonable pot-life to allow impregnation of large structures, high adhesion strength at cryogenic temperatures, excellent mechanical properties, including tensile, compression, and shear strength at cryogenic temperatures, and excellent radiation tolerance

Questions – contact Ken Marken, ken.marken@science.doe.gov

g. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Ken Marken, ken.marken@science.doe.gov

References: Subtopic a:

1. *Advances in Cryogenic Engineering Materials: Transactions of the Cryogenic Engineering Conference.* Spokane, WA. Vol. 58. Eds. U. Balachandran, et al. (2012). New York: American Institute of Physics (AIP). ISBN: 978-0-7354-1022-0. Available for purchase at http://www.amazon.com/s?ie=UTF8&field-isbn=9780735410220&page=1&rh=n%3A283155%2Cp_66%3A9780735410220
2. R. Scanlan, et al. (2004). *Superconducting materials for large scale applications.* Proceedings of the IEEE. Vol. 92, Issue 10, pp. 1639-1654. Available for purchase at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=1335554&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel5%2F5%2F29467%2F01335554
3. The 2012 Applied Superconductivity Conference. Portland, Oregon. October 7- 12. IEEE Transactions on Applied Superconductivity. Vol. 23, No. 3. ISSN: 1051-8223. Available at http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=77&year=2013

References: Subtopic b:

1. The Twenty-second International Conference on Magnet Technology. Marseille, France. September 12-16, 2011. IEEE Transactions on Applied Superconductivity. Vol. 22, No. 3. ISSN: 1051-8223. Available at http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=77&year=2012
2. The 2012 Applied Superconductivity Conference. Portland, Oregon. October 7- 12. IEEE Transactions on Applied Superconductivity. Vol. 23, No. 3. ISSN: 1051-8223. Available at http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=77&year=2013
3. R.B. Palmer, R.C. Fernow & J. Lederman. (2011). *Muon Collider Final Cooling in 30-50 T Solenoids*. Proceedings of the 2011 Particle Accelerator Conference (PAC2011). New York, New York. Available at http://accelconf.web.cern.ch/AccelConf/PAC2011/papers/thobn2.pdf
4. Y. Shiroyanagi, et al. (2012). *15+ T HTS Solenoid for Muon Accelerator Program.* Proceedings of the IPAC2012. New Orleans, Louisiana. Available at http://accelconf.web.cern.ch/AccelConf/IPAC2012/papers/thppd048.pdf
5. J. Schwartz. (2008). *High Field Superconducting Solenoids via High Temperature Superconductors.* IEEE Transactions on Applied Superconductivity. Vol. 18, No. 2. Available at http://www.magnet.fsu.edu/library/publications/NHMFL_Publication-4090.pdf

References: Subtopic d:

1. R.L. Geng, et al. (2003). *First RF Test at 4.2 K of a 200 MHz Superconducting Nb-Cu Cavity.* Proceedings of the 2003 Particle Accelerator Conference (PAC2003). May 12-16, 2003. Vol 2,

pp. 1309-1311. Available at http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1289688&isnumber=28710

2. W. Singer. (2006). *Seamless/bonded niobium cavities.* Physica C: Superconductivity. Proceedings of the 12th International Workshop on RF Superconductivity. July 15, 2006. Vol. 441, Issues 1-2, pp. 89-94. Available for purchase at http://www.sciencedirect.com/science/article/pii/S0921453406001584
3. S. Bousson, et al. (1999). An Alternative Scheme for Stiffing SRF Cavities by Plasma Spraying. Proceedings of the 1999 Particle Accelerator Conference. New York, New York. March 27—April 02, 1999. Vol. 2, pp. 919-921. Available for purchase at http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=795400&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D795400
4. A. Dzyuba, A. Romanenko & L.D. Cooley. (2010). Model for initiation of quality factor degradation at high accelerating fields in superconducting radio-frequency cavities. Superconductor Science and Technology. Vol. 23, Issue 12. Article ID: 125011. Available at http://arxiv.org/abs/1007.2561

References: Subtopic e:

1. *Advances in Cryogenic Engineering Materials: Transactions of the Cryogenic Engineering Conference.* Spokane, WA. Vol. 58. Eds. U. Balachandran, et al. (2012). New York: American Institute of Physics (AIP). ISBN: 978-0-7354-1022-0. Available for purchase at http://www.amazon.com/s?ie=UTF8&field-isbn=9780735410220&page=1&rh=n%3A283155%2Cp_66%3A9780735410220
2. The 2012 Applied Superconductivity Conference. Portland, Oregon. October 7- 12. IEEE Transactions on Applied Superconductivity. Vol. 23, No. 3. ISSN: 1051-8223. Available at http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=77&year=2013

References: Subtopic f:

1. *Advances in Cryogenic Engineering Materials: Transactions of the Cryogenic Engineering Conference.* Spokane, WA. Vol. 58. Eds. U. Balachandran, et al. (2012). New York: American Institute of Physics (AIP). ISBN: 978-0-7354-1022-0. Available for purchase at http://www.amazon.com/s?ie=UTF8&field-isbn=9780735410220&page=1&rh=n%3A283155%2Cp_66%3A9780735410220
2. The 2012 Applied Superconductivity Conference. Portland, Oregon. October 7- 12. IEEE Transactions on Applied Superconductivity. Vol. 23, No. 3. ISSN: 1051-8223. Available at http://ieeexplore.ieee.org/xpl/RecentIssue.jsp?punumber=77&year=2013

34. HIGH-SPEED ELECTRONIC INSTRUMENTATION FOR DATA ACQUISITION AND PROCESSING

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The DOE supports the development of advanced electronics and systems for the recording, processing, storage, distribution, and analysis of experimental data that is essential to experiments and particle accelerators used for High Energy Physics (HEP) research. Areas of present interest include signal processing, event triggering, data acquisition, high speed logic arrays, and fiber optic links useful to HEP experiments and particle accelerators. Grant applications must clearly and specifically indicate their relevance to present or future HEP programmatic activities.

Although particle physics detector and data processing instrumentation typically are developed in large collaborative efforts involving national laboratories, there are efforts where small businesses can make innovative and creative contributions. Applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals.

Proposed devices must be explicitly related to future high-energy physics experiments, either accelerator or non-accelerator based, or to future uses in particle accelerators. Relevant potential improvements over existing devices and techniques must be discussed explicitly. Areas of possible improvement include radiation hardness, energy, position, and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, compactness, cost, etc.

Grant applications are sought in the following subtopics:

a. Special Purpose Chips and Devices for Large Particle Detectors

Grant applications are sought to develop special purpose chips and devices for use in the internal circuitry employed in large particle detectors. Desirable features include low noise, low power consumption, high packing density, radiation resistance, very high response speed, low-overhead calibration, stability, and/or high adaptability to situations requiring multiple parallel channels. Desirable functions include amplifiers, counters, analog pulse storage devices, decoders, encoders, analog-to-digital converters, analog waveform sampling, power conversion, picosecond-resolution time-to-digital converters, controllers, communications interface devices, and novel power distribution systems.

Questions – contact Peter Kim, peter.kim@science.doe.gov

b. Circuits and Systems for Processing Data from Particle Detectors

Grant applications are sought to develop circuits and systems for rapidly processing data from particle detectors such as proportional wire chambers, scintillation counters, silicon microstrip detectors, pixilated imaging sensors, particle calorimeters, large-area photodetector arrays, cryogenic detectors, and Cerenkov counters. Representative processing functions and circuits include low noise pulse amplifiers and preamplifiers, high speed counters, time-to-amplitude converters, and local time, charge, and signal shape extraction. Compatibility with one of the widely used or evolving module interconnection standards is highly desirable, as would be low power consumption, high component density, and/or adaptability to large numbers of multiple channels.

Questions – contact Peter Kim, peter.kim@science.doe.gov

c. Systems for Data Analysis and Transmission

Grant applications are sought to develop advanced high-speed logic arrays and microprocessor systems for fast event identification, event trigger generation, low front-end data reduction, and data processing with very high throughput capability. Such systems should be compatible with or implemented in one of the widely used or evolving module interconnection standards. Grant applications also are sought for the innovative use of radiation tolerant ultrafast fiber optic links, electro-optic modulators, and/or commodity hard high-bandwidth networks for high-rate transmission of collected data between particle detectors and data recording or control systems. Approaches of interest should demonstrate technologies that feature one or more of the following characteristics: low bit-error rate, radiation tolerance, low failure rate, low power consumption, high packing density, and the ability to handle a large number of channels at very high rates.

Questions – contact Peter Kim, peter.kim@science.doe.gov

d. Enhancements to Standard Interconnection Systems

Grant applications are sought to develop (1) new modules that will provide capabilities not previously available; (2) technology to substantially enhance the performance of existing types of modules; (3) technology to reduce cost and increase the density of interconnection of sensors to readout electronics; and (4) components, devices, or systems that will enhance or significantly extend the capability or functionality of one of the standard systems in HEP applications. Examples include large and/or fast buffer memories, single module computer systems (either general purpose or special purpose), display modules, CMOS monolithic active pixel sensors (MAPS) or vertically integrated (3D) electronics, communication modules and systems, wireless readout systems, and disk-drive interface modules.

Questions – contact Peter Kim, peter.kim@science.doe.gov

e. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas relevant to this Topic

Questions – contact Peter Kim, peter.kim@science.doe.gov

References:

1. Topical Workshop on Electronics for Particle Physics (TWEPP11). Vienna, Austria. September 26-30, 2011. (http://twepp11.hephy.at/). Proceedings available at http://iopscience.iop.org/1748-0221/focus/extra.proc15
2. Proceedings of WIT2010 Workshop on Intelligent Trackers. Berkeley, California. February 3-5, 2010. Available at http://iopscience.iop.org/1748-0221/focus/extra.proc7
3. VME320/2eSST and VXS/VPX specifications. VME International Trade Association. (http://www.vita.com/home/Specification/Specifications.html)
4. PCI Express: Performance Scalability for the Next Decade. PCI Special Interest Group. (http://www.pcisig.com/specifications/pciexpress)
5. Advanced Telecommunications Computing Architecture (ATCA). PICMG Consortium. (http://www.picmg.org/v2internal/specifications2.cfm)

6. SciDAC:HENP (Scientific Discovery Through Advanced Computing Programs in High Energy and Nuclear Physics). U.S. Department of Energy. (http://www.scidac.gov/)
7. DOE UltraScience Net: Experimental Ultra-Scale Network Testbed for Large-Scale Science. U.S. Department of Energy. (http://www.csm.ornl.gov/ultranet/)
8. perfSONAR: Circuit-oriented, high-performance networking. (http://www.perfsonar.net/)
9. Open Science Grid. (http://opensciencegrid.org)
10. Computing in High Energy Physics Conference (CHEP2012). New York, New York. May 21-25, 2012. (http://www.chep2012.org/)
11. 12th Pisa Meeting on Advanced Detectors. La Biodola, Isola d'Elba, Italy. May 20-26 2012. (http://www.pi.infn.it/pm/)
12. 2nd International Conference on Technology and Instrumentation in Particle Physics 2011 (TIPP2011). Chicago, Illinois. June 9-14, 2011. (http://conferences.fnal.gov/tipp11/)
13. 18th Real-Time Conference. Berkeley, California. June 11-15, 2012. (http://rt2012.lbl.gov)
14. 13th Vienna Conference on Instrumentation. Vienna, Austria. February 11-15, 2013. (http://vci.hephy.at)

35. HIGH ENERGY PHYSICS DETECTORS AND INSTRUMENTATION

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The DOE supports research and development in a wide range of technologies essential to experiments in High Energy Physics (HEP) and to the accelerators at DOE high energy accelerator laboratories. The development of advanced technologies for particle detection and identification for use in HEP experiments or particle accelerators is desired. Broadly, the areas of interest are improvements in the sensitivity, robustness, and cost effectiveness of particle detectors. Principal areas of interest include particle detectors based on new techniques and technological developments, or detectors that can be used in novel ways as a consequence of associated technological developments in electronics (e.g., sensitivity or bandwidth). Also of interest are novel experimental systems that use new detectors, or use old ones in new ways, with significant improvement in performance, to extend basic HEP experimental research capabilities or result in less costly and less complex apparatus. Devices which exhibit insensitivity to very high radiation levels have recently become extremely important. Grant applications must clearly and specifically indicate their particular relevance to HEP programmatic activities.

Although particle physics detector development is often concentrated at major national particle accelerator centers, there are many developmental endeavors, especially in collaborative efforts, where small businesses can make creative and innovative contributions that further develop the required advanced technologies. Applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals.

Proposed devices must be explicitly related to future high-energy physics experiments, either accelerator or non-accelerator based, or to future uses in particle accelerators. Relevant potential improvements over existing devices and techniques must be discussed explicitly. Areas of possible improvement include radiation hardness, energy, position, and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, compactness, cost, etc.

Grant applications are sought in the following subtopics:

a. Particle Detection and Identification Devices

Grant applications are sought for novel ideas in the areas of charged and neutral particle detection and identification that could lead to improvements in the sensitivity, robustness, or cost effectiveness of particle detectors. These include ideas to advance the utility of detectors for the Energy Frontier such as at an upgraded or future collider; at the Intensity Frontier such as at a future long baseline neutrino experiment; and at the Cosmic Frontier such as a new Dark Matter detector. Examples include, but are not limited to, semiconductor particle detectors (silicon, CVD diamond, or other semiconductors), light-emitting particle detectors (scintillating materials including fibers, liquids, and crystals or Cherenkov radiators), low radioactivity detectors and associated components, large-area systems used for particle identification and multiple vertex separation, and gas or liquid-filled chambers (used for particle tracking, in calorimeters, and in Cherenkov or transition radiation detectors).

Questions – contact Peter Kim, peter.kim@science.doe.gov

b. Photon Detectors

The detection of photons is fundamental for many detector applications. Applications include the following: 1) High quantum efficiency visible light photon detectors. 2) Development of lower cost photo-detection technology and production methods scalable to large detectors. 3) Photo-sensors for extreme environments including cryogenic temperatures, corrosive conditions, high and low pressures, electric and magnetic fields, and radiation relevant for future HEP applications. 4) Large-area photo-sensors with significantly improved space resolution and time resolution. 5) Photosensors with improved sensitivity in new regions of wavelength such as UV including improvements in windows and coatings. 6) New sensors for light detection. 7) Vacuum technology-based photo detection techniques. 8) Solid state technology-based photo detection techniques. 9) High quantum efficiency X-ray photo-sensors.

Questions – contact Peter Kim, peter.kim@science.doe.gov

c. Ultra-low Background Detectors

Many experiments conducting a direct search for dark matter require that the detector elements and the surrounding support materials exhibit extreme radiological stability. The presence of trace amounts of radioactivity in or near a detector induces unwanted effects. These elements could include: 1) Ultra-low-background neutron and alpha-particle detectors. 2) Development of ultra-radio-pure material for use in detectors. 3) Manufacturing methods of ultra-low- background materials.

Questions – contact Peter Kim, peter.kim@science.doe.gov

d. Radiation Hard Devices

Many experiments must locate detectors within extreme radiation areas, e.g., at high luminosity LHC, or at a Muon Collider with muon beam decay background. For these applications radiation hardened devices are required. Applications include the following: 1) Radiation hardened/resistant optical links. 2) Radiation hardened/resistant power supplies or voltage converters, e.g. point of load converters. 3) Development of ultra-radiation hard material for use as detector elements. 4) Other radiation sensors for extreme environments.

Questions – contact Peter Kim, peter.kim@science.doe.gov

e. Cryogenic

Many detectors utilize cryogenic conditions and require cryogenic systems and devices which operate within a cryogenic environment. Applications include the following: 1) Development of the use, production and purification of cryogenic noble gases. 2) Cryogenic Liquid and Gas Particle Detectors. 3) Cryogenic Solid State Detectors.

Questions – contact Peter Kim, peter.kim@science.doe.gov

f. Mechanical and Materials

HEP experiments frequently require high performance detector support that will not compromise the precision of the detectors. Therefore, grant applications are sought for components used to support or integrate detectors into HEP experiments. The support components must be well matched to the detectors. For many experiments the presence of excess material is detrimental. These applications typically require low-mass and extremely rigid materials. Applications include the following: 1) Development of low mass detector support materials. 2) Novel low-mass materials with high thermal conductivity and stiffness. 3) Very high thermal conductivity, radiation tolerant adhesives. 4) Conventional detectors with substantially improved performance through the use of novel material science developments. 5) Improvements to manufacturing processes for radiation sensors and photosensors relevant for high energy physics. 6) 3D printing technology for rapid prototyping of detector components. The improvements should yield better performance, cost, faster production methods, or entirely new methods that make more efficient use of equipment.

Questions – contact Peter Kim, peter.kim@science.doe.gov

g. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Peter Kim, peter.kim@science.doe.gov

References:

1. J.A. Formaggio & C.J. Martoff. (2004). *Backgrounds to sensitive experiments underground.* Annual Review of Nuclear and Particle Science. Vol. 54, pp.361-412. Available for purchase at

http://www.annualreviews.org/doi/abs/10.1146/annurev.nucl.54.070103.181248?journalCode=nucl
2. International Workshop on New Photon-Detectors (PHOTODET2012). Laboratory of Linear Accelerator, Orsay, France. June 13-15, 2012. (http://photodet2012.lal.in2p3.fr/)
3. 8th Trento Workshop on Advanced Silicon Radiation Detectors (3D and P-type) (TREDI2013). Fondazione Bruno Kessler Research Center, Trento, Italy. February 18-20, 2013. (http://tredi2013.fbk.eu/)
4. J.P. Balbuena, et al. (2012). *RD50 status report 2009/2010: Radiation hard semiconductor devices for very high luminosity colliders.* Report Numbers: CERN-LHCC-2012-010, LHCC-SR-004. Available at http://cds.cern.ch/record/1455062/files/LHCC-SR-004.pdf
5. F. Hartmann & J. Kaminski. (2011). *Advances in tracking detectors.* Annual Review of Nuclear and Particle Science. Vol. 61, pp. 197-221. Available for purchase at http://www.annualreviews.org/doi/abs/10.1146/annurev-nucl-102010-130052
6. J.E. Brau, J.A. Jaros & H. Ma. (2010). *Advances in calorimetry*. Annual Review of Nuclear and Particle Science. Vol. 60, pp. 615-644. Available for purchase at http://www.annualreviews.org/doi/abs/10.1146/annurev.nucl.012809.104449?journalCode=nucl
7. K. Kleinknecht. (1999). *Detectors for Particle Radiation (2nd ed.).* Cambridge, Massachusetts: Cambridge University Press. ISBN 978-0-521-64854-7. Available for purchase at http://www.amazon.com/By-Konrad-Kleinknecht-Detectors-Radiation/dp/B008VR6I82
8. G.F. Knoll. (2010). *Radiation Detection and Measurement (4th ed.).* Hoboken, New Jersey: J. Wiley & Sons. ISBN 978-0-470-13148-0. Available for purchase at http://www.amazon.com/Radiation-Detection-Measurement-Glenn-Knoll/dp/0470131489
9. H. Spieler. (2005). *Semiconductor Detector Systems*. New York: Oxford University Press. ISBN 978-0-198-52784-8. Available for purchase at http://www.amazon.com/books/dp/0198527845
10. The Fourteenth International Workshop on Low Temperature Detectors (LTD14). Heidelberg University. Heidelberg, Germany. August 1-5, 2011. Journal of Low Temperature Physics. Vol. 167, Nos. 3-6. (https://ltd.kip.uni-heidelberg.de/)
11. The Fifteenth International Workshop on Low Temperature Detectors (LTD15). California Institute of Technology. Pasadena, California. June 24-28, 2013. (http://conference.ipac.caltech.edu/ltd-15/)
12. Stereolithography: Materials, Processes and Applications. Ed. Bartolo, P.J. (2011). New York: Springer. ISBN 978-0-387-92903-3. Available for purchase at http://books.google.com/books?hl=en&lr=&id=gf2IuU7xLzwC&oi=fnd&pg=PR5&dq=Stereolithography:+Materials,+Processes+and+Applications&ots=p_j8bA__KX&sig=OM_s-kKtUgTmzZcNctETb5B3S-4#v=onepage&q=Stereolithography%3A%20Materials%2C%20Processes%20and%20Applications&f=false
13. 12th Pisa Meeting on Advanced Detectors. La Biodola, Isola d'Elba, Italy. May 20-26, 2012. (http://www.pi.infn.it/pm/)
14. 2nd International Conference on Technology and Instrumentation in Particle Physics 2011 (TIPP2011). Chicago, Illinois. June 9-14, 2011. (http://conferences.fnal.gov/tipp11/)
15. IEEE Symposium on Radiation Measurements and Applications (SORMA WEST2012). Oakland, California. May 14-17, 2012. (http://sormawest.org/)
16. 13th Vienna Conference on Instrumentation. Vienna, Austria. February 11-15, 2013. (http://vci.hephy.at)

PROGRAM AREA OVERVIEW: OFFICE OF NUCLEAR PHYSICS

Nuclear physics (NP) research seeks to understand the structure and interactions of atomic nuclei and the fundamental forces and particles of nature as manifested in nuclear matter. Nuclear processes are responsible for the nature and abundance of all matter, which in turn determines the essential physical characteristics of the universe. The primary mission of the Nuclear Physics (NP) program is to develop and support the scientists, techniques, and facilities that are needed for basic nuclear physics research and isotope development and production. Attendant upon this core mission are responsibilities to enlarge and diversify the Nation's pool of technically trained talent and to facilitate transfer of technology and knowledge to support the Nation's economic base.

Nuclear physics research is carried out at national laboratories and accelerator facilities, and at universities. The Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF) allows detailed studies of how quarks and gluons bind together to make protons and neutrons. In an upgrade currently underway, the CEBAF electron beam energy will be doubled from 6 to 12 GeV. The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) is forming new states of matter, which have not existed since the first moments after the birth of the Universe; a beam luminosity upgrade is currently underway. NP is supporting the development of a next generation rare isotope beam accelerator facility (FRIB). The NP community is also exploring opportunities with a proposed electron-ion collider.

The NP program also supports research and facility operations directed toward understanding the properties of nuclei at their limits of stability, and of the fundamental properties of nucleons and neutrinos. This research is made possible with the Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory (ANL) which provides stable and radioactive beams as well as a variety of species and energies; a local program of basic and applied research at the 88-Inch Cyclotron of the Lawrence Berkeley National Laboratory (LBNL); the operations of accelerators for in-house research programs at two universities (Texas A&M University and the Triangle Universities Nuclear Laboratory (TUNL) at Duke University), which provide unique instrumentation with a special emphasis on the training of students; non-accelerator experiments, such as large stand alone detectors and observatories for rare events. Of interest is R&D related to future experiments in fundamental symmetries such as neutrinoless double-beta decay experiments and measurement of the electric dipole moment of the neutron, where extremely low background and low count rate particle detections are essential. Another area of R&D is rare isotope beam capabilities, which could lead to a set of accelerator technologies and instrumentation developments targeted to explore the limits of nuclear existence. By producing and studying highly unstable nuclei that are now formed only in stars, scientists could better understand stellar evolution and the origin of the elements.

Our ability to continue making a scientific impact on the general community relies heavily on the availability of cutting edge technology and advances in detector instrumentation, electronics, software, accelerator design, and isotope production. The technical topics that follow describe research and development opportunities in the equipment, techniques, and facilities needed to conduct and advance nuclear physics research at existing and future facilities.

For additional information regarding the Office of Nuclear Physics priorities, click here.

36. NUCLEAR PHYSICS SOFTWARE AND DATA MANAGEMENT

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Large scale data storage and processing systems are needed to store, access, retrieve, distribute, and process data from experiments conducted at large facilities, such as Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC) and the Thomas Jefferson National Accelerator Facility (TJNAF). In addition, data acquisition for the Facility for Rare Isotope Beams (FRIB) requires unprecedented speed and flexibility in collecting data from new flash ADC based detectors. The experiments at such facilities are extremely complex, involving thousands of detector elements that produce raw experimental data at rates up to a GB/sec, resulting in the annual production of data sets containing hundreds of Terabytes (TB) to Petabytes (PB). Many 10s to 100s of TB of data per year are distributed to institutions around the U.S. and other countries for analysis. Research on large scale data management systems and high speed, distributed data acquisition is required to support these large nuclear physics experiments. All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought only in the following subtopics:

a. Large Scale Data Storage

The cost of data storage on magnetic disk media is becoming competitive with magnetic tape for storing large volumes of data (ignoring all costs of servers and of I/O performance). Integrated tape libraries have much lower cost per stored byte than current disk systems, but much higher latency to access an arbitrary file. The infrastructure costs of operating a lower latency many-petabyte-scale disk storage systems can be significant. One important characteristic of nuclear physics datasets is that most of the data is accessed infrequently. Therefore, grant applications are sought for new techniques for multi-petabyte-scale systems that are optimized for infrequent data access, emphasizing lower cost per byte than current disk systems, lower power usage than most disk systems, and lower access latency to data than current tape systems.

Also, many DOE labs have existing investments in large-scale tape robot technologies, which are at this point the most cost-effective way to store petabyte-sized datasets. Grant applications are sought for (1) the development of innovative storage technologies that not only can use existing cartridge and tape formats but also will significantly increase the storage density and capacity, increase data read and write speeds, or decrease costs; and (2) innovative software technologies to allow file-system-based user access to petabyte-scale data on tape; and (3) the development of innovations in software and hardware that leverage solid state drives (SSD) to maximize storage system performance (example: a hybrid SSD/disk storage service with a front end SSD cache.

The volume of data now being generated in these facilities has reached the point at which bit error rates in hardware are no longer low enough to ensure the integrity of data. Cost- effective software and hardware systems potentially spanning disk and tape storage systems are needed which transparently ensure the integrity of data such that silent error rates are many orders of magnitude below what current tape and disk systems deliver, but without the high cost of integrity that is found in high end RAID disk systems today.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

b. Large Scale Data Processing and Distribution

A recent trend in nuclear physics is to construct data handling and distribution systems using web services or data grid infrastructure software – such as Globus, Condor, SRB, and xrootd – for large scale data processing and distribution. Grant applications are sought for (1) hardware and/or software techniques to improve the effectiveness and reduce the costs of storing, retrieving, and moving such large volumes of data, including, but not limited to, automated data replication coupled with application-level knowledge of data usage, data transfers to Tier 2 and Tier 3 centers from multiple data provenance – with an aim for least wait-time and maximal coordination (coordination of otherwise chaotic transfers), distributed storage systems of commercial off-the-shelf (COTS) hardware, storage buffers coupled to 10 Gbps (or greater) networks, and end-to-end monitoring and diagnostics of WAN file transport; (2) hardware and/or software techniques to improve the effectiveness of computational and data grids for nuclear physics – examples include integrating storage and data management services with scalable distributed data repositories such as xrootd, and developing application-level monitoring services for status and error diagnosis; (3) effective new approaches to data mining, automatic structuring of data and information, and facilitated information retrieval; (4) new tools for configuring and scheduling compute and storage resources for data-intensive high performance computing tasks such as in user analyses where repeated passes over large datasets requiring fast turnaround times are needed; and (5) distributed authorization and identity management systems, enabling single sign-on access to data distributed across many sites. Proposed infrastructure software solutions should consider and address the advantages of integrating closely with relevant components of Grid middleware, such as contained in the software stack of the Open Science Grid as the foundation used by nuclear physics and other science communities. Applicants that propose data distribution and processing projects are encouraged to determine relevance and possible future migration strategies into existing infrastructures.

Grant applications also are sought (1) to provide redundancy and increased reliability for servers employing parallel architecture, so that they are capable of handling large numbers of simultaneous requests by multiple users; (2) for hardware and software to improve remote user access to computer facilities at nuclear physics research centers, while at the same time providing adequate security to protect the servers from unauthorized access; and (3) for hardware and software to significantly improve the energy efficiency and reduce the operating costs of computer facilities at nuclear physics research centers.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

c. Grid and Cloud Computing

Grid deployments such as the Open Science Grid (OSG) in the U.S. and the Worldwide Large Hadron Collider (LHC) Computing Grid (WLCG) in Europe provide standardized infrastructures for scientific computing across large numbers of distributed facilities. To support these infrastructures, computing paradigms have emerged: (1) Grid Computing, sometimes called “computing on demand,” supports highly distributed and intensive scientific computing for nuclear physics (and other sciences); and (2) Cloud Computing, often referred to as “elastic computing”, can offer a fast turn-around resource provisioning solution to experiments via virtual machine containing an application-specific computing environment, services and software stack. Accordingly, there is a need for compatible software distribution and installation mechanisms that can be automated and scaled to the large numbers (100s) of computing facilities distributed around the country and the globe including platform independent applications as well as solution supporting the provisioning of resources to multiple experiments at a given site. Grant applications are sought to (a) develop mechanisms and tools that enable efficient and rapid packaging, distribution, and installation of nuclear physics application software on distributed computing facilities such as the OSG and WLCG (b) design innovative solutions for the apportion of resources and achieve resource sharing between many experiments and groups both public and private Cloud environments (c) seek to leverage industry standards such as the Hadoop file system or MapReduce paradigm to enhance the capabilities of Cloud stacks. Software solutions should enable rapid access to computing resources as they become available to users that do not have the necessary application software environment installed.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

d. Software-Driven Network Architectures for Data Acquisition

Modern data acquisition systems are becoming more heterogenous and distributed. This presents new challenges in synchronization of the different elements of this event-driven architecture. The building blocks of the data acquisition system are digitizers, either flash digitizers or integrating digitizers of time, pulse height or charge. These elements respond in real-time to convert electrical signals from detectors into digital form. The data from each detector element is labeled with a precisely synchronized time and transmitted to buffers. The total charge, the number of coincident elements or other information summaries are used to determine if something interesting has happened, that is, forming a trigger. If the trigger justifies it, the data from the elements are assembled together into a time-correlated event for later analysis, a process called Event Building. At present the elements tend to be connected by buses (VME, cPCI), custom interconnects or serial connections (USB). In certain types of experiments at FRIB, low event rates of 1 to 10 kevents/s are anticipated, with dense data streams from FADC-based detector systems. The large latencies possible in highly buffered flash ADC architectures can be used to advantage in the design of the architecture.

A concept of the next generation data acquisition system is that it will be ultimately composed of separate ADC's for each detector element, connected by commercial network or serial technology. Development is required to implement the elements of this distributed data acquisition over commercially available network technologies such as 10 Gb Ethernet or Advanced Telecommunications Computing Architecture (ATC). The initial work needed is to develop a software architecture for a system that works efficiently in the available network bandwidth and latencies. The elements desired in the architecture are to (1) synchronize time to a sufficient precision, as good as 10ns or better to support Flash Analog-to-Digital Converter (FADC) clock synchronization, 100ns or better to support trigger formation and event building, (2) determine a global trigger from information transmitted by the individual components (3) notify the elements of a successful trigger, in order to locally store the current information, (4) collect event data from the individual elements to be assembled into events and (5) software tools to validate the function of the synchronization, triggering and event building during normal operation. The synchronization of time is critical to the success of this architecture, as is the constant validation of the synchronization.

Grant applications are sought for any of 1) development of the software architecture that specifies a functional model for the individual elements of the system, the high level network protocols, and requirements on the communications fabric for given data rates and system latencies, including a portable software implementation of the elements of the architecture, 2) hardware modules to implement the detector digitizer on Ethernet, and 3) time distribution protocols and hardware to support this architecture.

Such an architecture and its implementation could form the basis of a standard for next generation data acquisition in nuclear physics, particularly at the FRIB

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

e. Heterogeneous Computing

Computationally demanding theory calculations as well as detector simulations and data analysis tasks can be significantly accelerated by the use of general purpose Graphics Processing Units (GPUs). The ability to exploit these accelerators is constrained by the effort required to port the software to the GPU environment. More capable cross compilation or source to source translation tools are needed that are able to injest very complicated templatized C++ code and produce high performance codes for heterogenous architectures.
Early work by the USQCD (US Quantum Chromo Dynamics) collaboration has demonstrated the power of clusters of GPUs in Lattice QCD calculations. This early work was manpower intensive but yielded a large return on investment through the hand optimization of critical numerical kernels, achieving performance gains of up to 60x with 4 GPUs. However, realizing the full potential of accelerators on the full code base can only be achieved through a capable and performant automated tool chain.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

f. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

References: Subtopic a:

1. For specifications on cost-effective software and hardware systems needs described above, contact Dr. Chip Watson of Jefferson Laboratory (watson@jlab.org)

References: Subtopic c:

1. For technical specifications in Software-driven Network Architectures for Data Acquisition, contact Dr. Robert Varner of Oak Ridge National Laboratory (varnerrl@ornl.gov)

References: Subtopic e:

1. For more specifications on heterogeneous computing described above, contact Dr. Chip Watson of Jefferson Laboratory (watson@jlab.org)

References:

1. R. B. Firestone. (2000). *Nuclear structure and decay data in the electronic age.* Journal of Radioanalytical and Nuclear Chemistry. Vol. 243, Issue 1, pp. 77-86. ISSN: 0236-5731. Available for purchase at http://www.springerlink.com/content/m47578172u776641/?p=f4fbbe7a000a4718bea6321fdc6e4e11&pi=10
2. Robert L. Grossman, et al. (2003). *Open DMIX - Data Integration and Exploration Services for Data Grids, Data Web, and Knowledge Grid Applications*. Proceedings of the First International Workshop on Knowledge Grid and Grid Intelligence (KGGI 2003). Halifax, Canada. October 3, 2003. pp. 6-28. Available at http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.68.4465
3. Computing in High Energy and Nuclear Physics 2006 (CHEP06) Conference Proceedings. Mumbai, India. February 13-17, 2006. Available at http://indico.cern.ch/conferenceTimeTable.py?confId=048
4. S. M. Maurer, R.B. Firestone & C.R. Scriver. (2000). *Science's neglected legacy.* Nature. Vol. 405, pp. 117-120. ISSN: 0028-0836. Available at http://www.nature.com/nature/journal/v405/n6783/full/405117a0.html
5. National Computational Infrastructure for Lattice Quantum Chromodynamics. (www.usqcd.org/)
6. U.S. Department of Energy: Scientific Discovery through Advanced Computing (SciDAC). (www.scidac.gov/physics/quarks.html)
7. The Globus Alliance. (http://www.globus.org/)
8. The University of Wisconsin's HTCondor: High Throughput Computing. (www.cs.wisc.edu/condor/)
9. Cloud computing and virtual workspaces. (http://workspace.globus.org/)
10. CernVM Software Appliance. (http://cernvm.cern.ch/cernvm/)
11. World Wide Web Consortium (W3C). (2001). Web Services Description Language (WDSL) 1.1. (http://www.w3.org/TR/wsdl)
12. Open Science Grid and the Open Science Grid Consortium Website. Supported by the National Science Foundation and U.S. Department of Energy. http://www.opensciencegrid.org/
13. The Virtual Data Toolkit (VDT). (http://vdt.cs.wisc.edu/index.html/)
14. Worldwide Large Hadron Collider (LHC) Computing Grid (WLCG). (http://lcg.web.cern.ch/LCG/)
15. European Grid Infrastructure (EGI). (http://www.egi.eu/)
16. U.S. National Nuclear Data Center. (http://www.nndc.bnl.gov/)
17. SRB: The SDSC Storage Resource Broker. (http://www.sdsc.edu/srb/index.php/Main_Page)
18. Event Driven Architectures. (http://en.wikipedia.org/wiki/Event-driven_architecture)
19. IEEE 1588 Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems. (http://ieee1588.nist.gov/)
20. XRootD scalable distributed data repository. (http://xrootd.slac.stanford.edu/)
21. Parallel Analysis Facilities. (http://root.cern.ch/drupal/content/proof)

37. NUCLEAR PHYSICS ELECTRONICS DESIGN AND FABRICATION

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The DOE Office of Nuclear Physics seeks developments in detector instrumentation electronics with improved energy, position, timing resolution, sensitivity, rate capability, stability, dynamic range, durability, pulse-shape discrimination capability, and background suppression. Of particular interest are innovative readout electronics for use with the nuclear physics detectors described in Topic ___ (Nuclear Instrumentation, Detection Systems, and Techniques). All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought only in the following subtopics:

a. Advances in Digital Electronics

Digital signal processing electronics are needed to replace analog signal processing in nuclear physics applications. Grant applications are sought to develop: fast digital processing electronics that improve the accuracy of the analog electronics, such as in determining the position of interaction points (of particles or photons) to an accuracy smaller than the size of the detector segments(example: Solenoidal Tracker at RHIC (STAR) decision time ~500 ns with a resolution of < 100ps) . Emphasis should be on circuit technologies with low power dissipation.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

b. Circuits

Grant applications are sought to develop application-specific integrated circuits (ASICs), as well as circuits (including firmware) and systems, for rapidly processing data from highly-segmented, position-sensitive germanium detectors (pixel sizes in the range of 1 mm^2 to 1 cm^2) and from particle detectors (e.g., gas detectors, scintillation counters, silicon drift chambers, silicon pixel and strip detectors, particle calorimeters, and Cherenkov counters) used in nuclear physics experiments. Areas of specific interest include (1) representative circuits such as low-noise preamplifiers, amplifiers, peak sensors, timing sensors, analog storage devices, analog-to-digital and time-to-digital converters, transient digitizers, and time-to-amplitude converters; (2) front-end, digitizing, and multiplexing circuits operating in cryogenic environment, to allow for reduction of noise, power, and number of feedthroughs in highly segmented germanium detectors; (3) multiple-sampling circuits , to allow for pulse-shape analysis; (4) readout electronics for solid-state pixilated detectors, including interconnection technologies, charge sharing processing and correction circuits (pixel pitch below 250 µm), and amplifier/sample-and-hold circuits; (5) systems with exceedingly large dynamic range (> 5000) employing, for example, either dynamic charge sensitive amplifier (CSA) gain changing or combinations of a standard linear CSA with a time-over-threshold (TOT) that works well into CSA saturation; and (6) constant-fraction discriminators with uniform response for low- and high energy gamma rays. These circuits should be fast; low-cost; high-density;

configurable in software for thresholds, gains, etc.; easy to use with commercial auxiliary electronics; low power; compact; and efficiently packaged for multi-channel devices.

In addition, planned luminosity upgrades at RHIC will require fine-grained vertex and tracking detectors (both silicon and gas) for high particle multiplicity environments. Therefore, grant applications are sought for advances in microelectronics that are specifically designed for low-noise amplification, digitization and smart on-chip processing (triggering, neighboring, sparsification, data reduction) of detector signals, and that are suitable for these next generation detectors. The microelectronics and associated interconnections must be lightweight and have low power dissipation. Of particular interest are designs that minimize higher-gate leakage currents due to tunneling and maintain dynamic range.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

c. Advanced Devices and Systems

Grant applications are sought for improved or advanced devices and systems used in conjunction with the electronic circuits and systems described in subtopics a and b above:

Areas of interest regarding devices include (1) wide-bandgap semiconductors (i.e., semiconductor materials with bandgaps greater than 2.0 electron volts, including Silicon Carbide (SiC), Gallium Nitride (GaN), and any III-Nitride alloys); (2) inhomogeneous semiconductors such as SiGe; and (3) device processes such as silicon-on-insulator (SOI) or silicon-on-sapphire (SOS).
Areas of interest regarding systems include (1) bus systems, data links, event handlers, multiple processors, trigger logics, and fast buffered time and analog digitizers. For detectors that generate extremely high data volumes (e.g., >500 GB/s), (2) advanced high-bandwidth data links are of interest.

Grant applications also are sought for generalized software and hardware packages, with improved graphic and visualization capabilities, for the acquisition and analysis of nuclear physics research data.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

d. Active Pixel Sensors

Active Pixel Sensors in CMOS (complementary metal-oxide semiconductor) technology are replacing Charge Coupled Devices as imaging devices and cameras for visible light. Several laboratories are exploring the possibility of using such devices as direct conversion particle detectors. The charge produced by an ionizing particle in the epitaxial layer is collected by diffusion on a sensing electrode in each pixel. The charge is amplified by a relatively-simple low-noise circuit in each pixel and read out in a matrix arrangement. If successful, this approach would make possible high-resolution, position-sensitive particle detectors with very low mass (approximately 50 microns of silicon in a single layer). This approach would be superior to the present technology that uses a separate silicon detector layer, which is bump-bonded to a CMOS readout circuit. Grant applications are sought to advance the development of integrated detector-electronics technology, using CMOS monolithic circuits as particle detectors. The new active pixel detector with its integrated electronic readout should be based on a standard CMOS process. The challenge is to design a sensor with low noise readout (S/N ~ 30:1 for mid-resistivity silicon designs, also see reference on "First Test Results of MIMOSA-26") circuits that have sufficiently high sensitivity and low power dissipation, in order to detect a minimum ionizing particle in a thin "epitaxial-like" or equivalent layer (~10-30 microns).

Grant applications also are sought for the next generation of active pixel sensors, or even strip sensors, which use the bulk silicon substrate as the active volume. This more advanced approach would have the advantage of developing relatively larger signals and allowing sensitivity to non-minimum ionizing particles, such as MeV-range gamma rays.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

e. Manufacturing and Advanced Interconnection Techniques

Grant applications are sought to develop (1) manufacturing techniques for large, thin, multiple-layer printed circuit boards (PCBs) with plated-through holes, dimensions from 2m x 2m to 5m x 5m, and thicknesses from 100 to 200 microns (these PCBs would have use in cathode pad chambers, cathode strip chambers, time projection chamber cathode boards, etc); (2) techniques to add plated-through holes, in a reliable robust way, to large rolls of metallized mylar or kapton (which would have applications in detectors such as time expansion chambers or large cathode strip chambers); and (3) miniaturization techniques for connectors and cables with 5 times to 10 times the density of standard inter-density connectors.

In addition, many next-generation detectors will have highly segmented electrode geometries with 5-5000 channels per square centimeter, covering areas up to several square meters. Conventional packaging and assembly technology cannot be used at these high densities. Grant applications are sought to develop (1) advanced microchip module interconnect technologies that address the issues of high-density area-array connections – including modularity, reliability, repair/rework, and electrical parasitics; (2) technology for aggregating and transporting the signals (analog and digital) generated by the front-end electronics, and for distributing and conditioning power and common signals (clock, reset, etc.); (3) low-cost methods for efficient cooling of on-detector electronics; (4) low-cost and low-mass methods for grounding and shielding; and (5) standards for interconnecting ASICs (which may have been developed by diverse groups in different organizations) into a single system for a given experiment – these standards should address the combination of different technologies, which utilize different voltage levels and signal types, with the goal of reusing the developed circuits in future experiments.

Lastly, highly-segmented detectors with pixels smaller than 100 microns present a significant challenge for integration with frontend electronics. New monolithic techniques based on vertical integration and through-silicon vias have potential advantages over the current bump-bonded approach. Grant applications are sought to demonstrate reliable, readily-manufacturable technologies to interconnect silicon pixel detectors with CMOS front-end integrated circuits. Of highest long term interest are high-density high-functionality 3D circuits with direct bonding of high resistivity silicon detector layer of an appropriate thickness (50 to 500 microns) to a 3D stack of thin CMOS layers. The high resistivity detector layer would be fully depleted to enable fast charge collection with very low diffusion. The thickness of this layer would be optimized for the photon energy of interest or to obtain sufficient signal from minimum ionizing particles.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

f. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

References:

1. The PHENIX Experiment at RHIC: Decadal Plan 2011-2020. Brookhaven National Laboratory. October 2010. (Appendix C) (http://www.bnl.gov/npp/docs/phenix_decadal10_full_refs.pdf)
2. STAR Collaboration Decadal Plan. December 2010. (http://www.bnl.gov/npp/docs/STAR_Decadal_Plan_Final[1].pdf)
3. Jonathan Bouchet, for the STAR Collaboration. (2009). *Heavy Flavor Tracker (HFT): A new inner tracking device at STAR.* Available at http://arxiv.org/abs/0907.3407v2
4. C. Chaseman, et al. *A Heavy Flavor Tracker for STAR*. Brookhaven National Laboratory. Available at http://rnc.lbl.gov/~wieman/hft_final_submission_version.pdf
5. FY2013 Call: Generic detector R&D program to address the scientific requirements for measurements at a future Electron Ion Collider (EIC). Brookhaven National Laboratory. (https://wiki.bnl.gov/conferences/index.php/EIC_R%25D)
6. M. Baker, et al. (2004). *Proposal for a Silicon Vertex Tracker (VTX) for the PHENIX Experiment.* DOI: 10.2172/15007383. Available at http://www.phenix.bnl.gov/WWW/publish/akiba/2004/VTX_rev2/PHENIX-VTX-PROPOSAL.pdf
7. Electronics and DAQ for a TJNAF SVT described in documents and notes for CLAS. (https://userweb.jlab.org/~gotra/svt/doc/clasnotes)
8. Design and assembly of fast and lightweight barrel and forward tracking prototype systems for an EIC. (https://userweb.jlab.org/~gotra/svt/doc/eic)
9. A joint TJNAF and SLAC proposal on Heavy Photon Search: See Electronics and DAQ for a prototype SVT made with D0 sensors read out with APV25 chips. (https://userweb.jlab.org/~gotra/svt/doc/hps/)
10. J. Koster. (2011). *Status of the PHENIX VTX Upgrade*. PHENIX Collaboration. APS April Meeting 2011. Vol. 56, No. 4. Anaheim, California. April 30--May 3. Available at http://meetings.aps.org/Meeting/APR11/Event/146703
11. T.O. Niinikoski, et al. (2004). *Low-temperature tracking detectors*. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 520, Issues 1-3, pp.87-92. ISSN: 0168-9002. Available for purchase at http://www.sciencedirect.com/science/article/pii/S0168900203031310
12. C. Baktash, I.Y. Lee & K.E. Rehm. (1999). *Experimental Equipment for an Advanced Isotope Separation On-Line (ISOL) Facility.* Proceedings of the Workshop on the Experimental Equipment for an Advanced ISOL Facility. Lawrence Berkeley National Laboratory. Berkeley, California. July 22-25, 1998. Available at http://www.osti.gov/bridge/product.biblio.jsp?osti_id=760328

13. G. Deptuch, et al. (2003). *Development of monolithic active pixel sensors for charged particle tracking.* Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 511, pp. 240-249. Available for purchase at http://www.roma3.infn.it/rictec/mimosa/bibliografia/NIMA-511-p240-249.pdf
14. A. Ionascut-Nedelcescu, et al. (2002). *Radiation hardness of gallium nitride*. IEEE Transactions on Nuclear Science. Vol. 49, Issue 6, pp. 2733-2738. Available for purchase at http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=1134213&sortType%3Dasc_p_Sequence%26filter%3DAND%28p_IS_Number%3A25186%29
15. J.R. Schwank, et al. (2002). *Charge collection in Silicon-on-Insulator (SOI) capacitors and circuits and its effect on Single-Event Upset (SEU) hardness.* IEEE Transactions on Nuclear Science. Vol. 49, Issue 6, pp. 2937-2947. ISSN: 0018-9499. Available for purchase at http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=1134244&sortType%3Dasc_p_Sequence%26filter%3DAND%28p_IS_Number%3A25186%29%26pageNumber%3D3
16. Nuclear Science Symposium Conference Records, 2003 IEEE. Vol. 5. IEEE Nuclear Science Symposium and Medical Imaging Conference. Portland, Oregon. October 19-25, 2003. IEEE Nuclear & Plasma Society. ISBN: 0-7803-82579. See section on high-density detector processing and interconnect. Available at http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=9356
17. K. Vetter, I.Y. Lee, M. Maier & D. Radford. (2001). Report of Workshop on 'Digital Electronics for Nuclear Structure Physics'. Argonne, Illinois. March 2-3, 2001. Available at http://radware.phy.ornl.gov/dsp_work.pdf
18. Vladimir Polushkin. (2004). *Nuclear Electronics: Superconducting Detectors and Processing Techniques*. Chichester, West Sussex: J. Wiley & Sons. ISBN: 0-470-857595. Available for purchase at http://www.amazon.com/Nuclear-Electronics-Superconducting-Processing-Techniques/dp/0470857595/ref=sr_1_1?ie=UTF8&qid=1251904350&sr=8-1
19. 7th International Meeting on Front-End Electronics. May 18-21, 2009. Workshop agenda and links to presentations. (https://indico.bnl.gov/conferenceDisplay.py?confId=135)
20. G. De Geronimo, et al. (2011). *Front-End ASIC for a liquid argon TPC*. IEEE Transactions on Nuclear Science. Vol. 58, Issue 3, pp. 1376-1385. http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5752881&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5752881
21. J. Baudot, et al. (2009). *First Test Results of MIMOSA-26, a Fast CMOS Sensor with Integrated Zero Suppression and Digitized Output*. Proceedings of the Nuclear Science Symposium. Orlando, Florida. October 24--November 1, 2009. pp. 1169-1173. Available for purchase at http://www.iphc.cnrs.fr/IMG/baudot_n22-6_nss09proc2.pdf

38. NUCLEAR PHYSICS ACCELERATOR TECHNOLOGY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

The Nuclear Physics program supports a broad range of activities aimed at research and development related to the science, engineering, and technology of heavy-ion, electron, and proton accelerators and associated systems. Research and development is desired that will advance fundamental accelerator technology and its applications to nuclear physics scientific research. Areas of interest include the basic technologies of the Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC), with heavy ion beam energies up to 100 GeV/nucleon and polarized proton beam energies up to 255 GeV; technologies associated with RHIC luminosity upgrades; the development of an electron-ion collider; linear accelerators such as the Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF); and development of devices and/or methods that would be useful in the generation of intense rare isotope beams for the rare isotope beam accelerator facility (FRIB). A major focus in all of the above areas is superconducting radio frequency (RF) acceleration and its related technologies. Relevance of applications to nuclear physics must be explicitly described. Grant applications that propose using the resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization. All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought only in the following subtopics:

a. Materials and Components for Radio Frequency Devices

Grant applications are sought to improve or advance superconducting and room-temperature materials or components for RF devices used in particle accelerators. Areas of interest include (1) peripheral components, for both room temperature and superconducting structures, such as ultra-high vacuum seals, terminations, high reliability radio frequency windows using alternative materials (e.g., sapphire), RF power couplers, and magnetostrictive or piezoelectric cavity-tuning mechanisms; (2) fast ferroelectric microwave components that control reactive power for fast tuning of cavities or fast control of input power coupling; (3) materials that efficiently absorb microwaves from 2 to 90 GHz and are compatible with ultra-high vacuum, particulate-free environments at 2 to 4 K; (4) innovative designs for hermetically sealed helium refrigerators and other cryogenic equipment, which simplify procedures and reduce costs associated with repair and modification; (5) more cost effective, kW-to-multiple-kW level, liquid helium refrigerators; (6) simple, low-cost mechanical techniques for damping length oscillations in accelerating structures, effective in the 10-300 Hz range at 2 and/or 4.5 K; (7) alternative cavity fabrication techniques, such as hydro forming or spinning of seamless SRF cavities; and (8) novel SRF linac mechanical support structures with low thermal conductivity and high vibration isolation and strength.

Grant applications also are sought to develop (1) methods for manufacturing superconducting radio frequency (SRF) accelerating structures with $Q_0>10^{10}$ at 2.0 K, or with correspondingly lower Q's at higher temperatures such as 4.5 K; and (2) advanced fabrication methods for SRF cavities of various geometries (including elliptical, quarter and half wave resonators) to reduce production costs. Industrial metal forming techniques, especially with large grain or ingot material, have the potential for significant cost reductions by simplifying sub-assemblies – e.g., dumbbells and beam tube – and reducing the number of electron beam welds.

Grant applications also are sought to develop (1) improved superconducting materials that have lower RF losses, operate at higher temperatures, and/or have higher RF critical fields than sheet niobium; and (2) techniques to create a layer of niobium on the interior of a copper elliptical cavity, such as by energetic ion deposition, so that the resulting 700-1500 MHz structures have $Q_0>8 \times 10^9$ at 2 K. Approaches of interest involving atomic layer deposition (ALD) synthesis should identify appropriate precursors and create high quality Nb, NbN, Nb_3Sn, or MgB_2 films with anti-diffusion dielectric overlayers.

Grant applications also are sought for laser or electron beam surface glazing of niobium for surface purification and annealing in vacuum. Proposals are invited for dielectric (ceramic) that has good dielectric properties such as loss tangent better than 0.01% at 1 GHz yet exhibits a small dc conductivity to overcome charging by beams or field emission.

Finally, grant applications are sought to develop advanced techniques for surface processing of superconducting resonators, including methods for electropolishing, high temperature treatments, and surface coatings that enhance or stabilize performance parameters. Methods which avoid use of hydrofluoric acid are desirable. Surface conditioning processes of interest should (1) yield microscopically smooth (R_q< 10 nm / 10μm^2), crystallographically clean bulk niobium surfaces; and/or (2) reliably remove essentially all surface particulate contaminates (> 0.1 μm) from interior surfaces of typical RF accelerating structures. Grant applications aimed at design solutions that enable integrated cavity processing with tight process quality control are highly sought.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

b. Radio Frequency Power Sources

Grant applications are sought to develop designs, computer-modeling, and hardware for 5-20 kW continuous wave (cw) power sources at distinct frequencies in the range of 50-1500 MHz. Examples of candidate technologies include: solid-state devices, multi-cavity klystrons, Inductive-Output Tubes (IOTs), or hybrids of those technologies. Grant applications also are sought to develop computer software for the design or modeling of any of these devices; such software should be able to faithfully model the complex shapes with full self-consistency. Software that integrates multiple effects, such as electromagnetic and wall heating is of particular interest.

Grant applications also are sought for a microwave power device, klystron, IOT or tunable/phase stabilized magnetron, offering improved efficiency (>55-60%) while delivering up to 8 kW CW at 1497 MHz. The device must provide a high degree of backwards compatibility, both in size and voltage requirements, to allow its use as a replacement for the klystron (model VKL7811) presently used at Thomas Jefferson Laboratory, while providing significant energy savings.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

c. Design and Operation of Radio Frequency Beam Acceleration Systems

Grant applications are sought for the design, fabrication, and operation of radio frequency accelerating structures and systems for electrons, protons, and light- and heavy-ion particle accelerators. Areas of interest include (1) continuous wave (cw) structures, both superconducting and non-superconducting, for the acceleration of beams in the velocity regime between 0.001 and 0.03 times the velocity of light, and with charge-to-mass ratios between 1/6 and 1/240; (2) superconducting RF accelerating structures appropriate for rare isotope beam accelerator drivers, for particles with speeds in the range of 0.02-0.8 times the speed of light; (3) innovative techniques for field control of ion acceleration structures (1^o or less of phase and 0.1% amplitude) and electron acceleration structures (0.1º of phase and 0.01% amplitude) in the presence of 10-100 Hz variations of the structures' resonant frequencies (0.1-1.5 GHz); (4) multi-cell, superconducting, 0.5-1.5 GHz accelerating structures that have sufficient higher-order mode damping, for use in energy-recovering linac-based devices with ~1 A of electron beam; (5) methods for preserving beam quality by damping beam-break-up effects in the presence of otherwise unacceptably-large, higher-order cavity modes – one example of which would be a very high bandwidth feedback system; (6) development of tunable superconducting RF cavities for acceleration and/or storage of relativistic heavy ions; and (7) development of rapidly tunable RF systems for applications such as non-scaling fixed-field alternating gradient accelerators (FFAG) and rapid cycling synchrotrons, either for providing high power proton beams or for proton therapy.

RF cavities with high gain in voltage >30 kV and fast frequency switching are of interest for applications in fast acceleration of non-relativistic protons or ions with $0.1 < \beta < 0.75$.The goal is to create higher Q cavities where the frequency between two cavities can vary up to 25%. This will allow very fast acceleration to be applied for proton driven sub-critical Thorium nuclear reactors and for proton or carbon ion therapy.

Grant applications also are sought to develop software for the design and modeling of the above systems. Desired modeling capabilities include (1) charged particle dynamics in complex shapes, including energy recovery analysis; (2) the incorporation of complex fine structures, such as higher order mode dampers; (3) the computation of particle- and field-induced heat loads on walls; (4) the incorporation of experimentally measured 3-D charge and bunch distributions; and (5) and the simulation of the electron cloud effect and its suppression

A high-integrated-voltage SRF cw crab crossing cavity is also of interest. Therefore, grant applications are sought for (1) designs, computer-modeling, and hardware development for an SRF crab crossing cavity with 0.5 to 1.5 GHz frequency and 20 to 50 MV integrated voltage; and (2) beam dynamics simulations of an interaction region with crab crossing. One example of candidate technologies would be a multi-cell SRF deflecting cavity.

Finally, grant applications also are sought to develop and demonstrate low level RF system control algorithms or control hardware that provide a robust and adaptive environment suitable for any accelerator RF system. Of special interest are approaches that address the particular challenges of superconducting RF systems, but room temperature systems are of interest as well.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

d. Particle Beam Sources and Techniques

Grant applications are sought to develop (1) particle beam ion sources and/or associated components with improved intensity, emittance, and range of species; (2) methods and/or devices for reducing the emittance of relativistic ion beams – such as coherent electron cooling, and electron or optical-stochastic cooling; (3) methods and devices to increase the charge state of ion beams (e.g., by the use of special electron-cyclotron-resonance ionizers, electron-beam ionizers, or special stripping techniques); methods and /or devices for improving emission capabilities of photocathode sources, such as improving charge lifetime, bunch charge, average current, emittance, or energy spread. (5) techniques for *in situ* beam pipe surface coating to reduce the ohmic resistance and/or secondary electron yield; (6) high brightness electron beam sources utilizing continuous wave (cw) superconducting RF cavities with integral photocathodes operating at high acceleration gradients; (7) techniques and devices for measuring RF resistivity of cryogenically cooled coated tubes.

Accelerator techniques for an energy recovery linac (ERL) and a circulator ring (CR) based electron cooling facility for cooling medium to high energy bunched proton or ion beams are of high interest for next generation colliders for nuclear physics experiments. Therefore, grant applications are sought for (1) design, modeling and proto-type development for a magnetized electron source/injector with a high bunch charge (up to 2 nC) and high average current (above 100 mA) and high bunch repetition rate (up to 75 MHz); (2) designs, modeling, and hardware and component development for a fast beam-switching kicker with 0.5 ns duration and 10 to 20 kW power in the range of 5-50 MHz repetition rate; and (3) optics designs and tracking simulations of beam systems for ERLs and CRs, with energy range from 5 to 130 MeV, and transporting and matching magnetized beams with superconducting solenoids in cooling channels. Examples of candidate technologies include photo- or thermionic-cathode electron guns with a DC or RF accelerating structure; SRF deflecting cavity, pulse compression techniques, and beam-based kicker. Grant applications also are sought to develop computer software for the design, modeling and simulating any of these devices and beam transport systems.

A full utilization of the discovery potential of a next-generation electron-ion collider requires a full-acceptance detection system that can provide detection of reaction products scattered at small angles with respect to the incident beams over a wide momentum range. Grant applications are sought for design, modeling, and hardware development of the special magnets for such a detection system. Magnets of interest include (1) radiation-resistant superconducting (≥ 2 T pole-tip field) septum dipole with electronically adjustable field orientation (+/- 100 mrad); (2) radiation-resistant high-field (≥ 9 T pole-tip field), large-aperture (≥ 20 cm radius) quadrupole; (3) radiation-resistant superconducting (≥ 6 T pole-tip field) large-aperture (≥ 20 cm radius) small-yoke-thickness (≤ 14 cm OD-ID) quadrupole; (4) radiation-resistant super-conducting (≥ 6 T pole-tip field, ~3 cm IR) combined-function magnet with quadrupole and independently adjustable horizontal and vertical dipole field components

Grant applications are sought to develop beam absorbers for energy-recovery linac driven medical isotope facilities. In such facilities an energy-recovering electron beam interacts with a thin high-Z target. After interaction with the thin target, the beam halo generated must be deposited in a controlled way and absorbed downstream of the target but before substantial bending for energy recovery. High efficiency in beam absorption leads to higher electron beam current and to higher possible overall production rates in the facility.

Lastly, grant applications are sought to develop software that adds significantly to the state-of-the-art in the simulation of beam physics. Areas of interest include (1) electron cooling, (2) intra-beam and interbeam scattering, (3) spin dynamics, (4) polarized beam generation including modeling of cathode geometries for high current polarized electron sources, (5) generating and transporting polarized electron beam, (6) beam dynamics, transport and instabilities; and (7) electron or plasma discharge in vacuum under the influence of charged beams. The software should use modern best practices for software design, should run on multiple platforms, and should run in both serial and parallel configurations. Grant applications also are sought to develop graphical user interfaces for problem definition and setup.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

e. Polarized Beam Sources and Polarimeters

With respect to polarizing sources, grant applications are sought to develop (1) polarized hydrogen and deuterium (H-/D-) ^{3}He sources and/or associated components with polarization above 90%; (2) cw polarized electron sources and/or associated components delivering beams of ~10 mA, with longitudinal polarization greater than 80%; (3) ~28 MHz cw polarized sources delivering beams of ~500 mA, with polarization greater than 80%; and (4) devices, systems, and sub-systems for producing high current (>200μA), variable-helicity beams of electrons with polarizations greater than 80%, and which have very small helicity-correlated changes in beam intensity, position, angle, and emittance.

Grant applications also are sought to develop (1) methods to improve high voltage stand-off and reduce field emission from high voltage electrodes, compatible with ultra-high-vacuum environments; (2) wavelength-tunable (700 to 850 nm) mode-locked lasers, with pulse repetition rate between 0.5 and 3 GHz and average output power >10 W; (3) a high-average-power (~100 W), green laser light source, with a RF-pulse repetition rate in the range of 0.5 to 3 GHz, for synchronous photoinjection of GaAs photoemission guns; and (4) a cost-effective means to obtain and measure vacuum below 10^{-12} Torre.

Grant applications also are sought for (1) advanced software and hardware to facilitate the manipulation and optimized control of the spin of polarized beams; (2) advanced beam diagnostic concepts, including new beam polarimeters and polarimeter targets and fast reversal of the spin of stored, polarized beams; (3) absolute polarimeters for spin polarized ^{3}He beams with energies up to 160 GeV/nucleon (4) novel concepts for producing polarizing particles of interest to nuclear physics research, including electrons, positrons, protons, deuterons, and ^{3}He; and (5) credible sophisticated computer software for tracking the spin of polarized particles in storage rings and colliders.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

f. Charge Strippers for Heavy Ion Accelerators

The following simulation studies are of interest: (1) simulation of the interaction of an intense heavy ion beam with the media used in charge strippers; (2) simulation of the effect of the heavy ion beam on a liquid lithium film used as a charge stripper; and (3) simulation of a He gas stripper with counter flows perpendicular to the heavy ion beam studying the heating effect and density variations effects on energy spread. Study of the film stability with high power density deposition is also of interest.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

g. Rare Isotope Beam Production Technology

Grant applications are sought to develop (1) ion sources for radioactive beams, (2) techniques for secondary radioactive beam collection, charge equilibration, and cooling; (3) technology for stopping energetic radioactive ions in helium gas and extracting them efficiently as high-quality low-energy ion beams; and (4) advanced parallel-computing simulation techniques for the optimization of both normal- and super-conducting accelerating structures for the future rare isotope facility.

Grant applications also are sought to develop fast-release solid catcher materials. The stopping of high-energy (>MeV/u) heavy-ion reaction products in solid catchers is interesting for realizing high-intensity low-energy beams of certain elements and for the parasitic use of rare isotopes produced by projectile fragmentation. The development of suitable high-temperature materials to achieve fast release of the stopped rare isotopes as atomic or single-species molecular vapor is required.

Grant applications also are sought to develop techniques for efficient rare isotope extraction from water. Water-filled beam dumps or reaction product catchers, considered in the context of high-power rare isotope beam production, could provide a source for the harvesting heavy-ion reaction products stopped in the water.

Grant applications also are sought to develop techniques for the charge breeding of rare isotopes in Electron Beam Ion Sources or Traps (EBIS/T) prior to reacceleration. High breeding efficiencies in single charge states and short breeding times are required. In order to be able to optimize these values, simulation tools will be needed that realistically describe electron-ion interaction and ion cooling mechanisms and use accurate electric and magnetic field models. Also high performance electron guns with well-behaved beam compression into the magnetic field of the EBIS/T will be required. The electron guns will have to be optimized for high perveance and multi-Ampere electron current output in order to optimize ion capacity, ion beam acceptance, and breeding times.

Grant applications are sought for development of radiation tolerant or radiation resistant multipole inserts in large-aperture superconducting quadrupoles used in fragment separators. Sextupole and octupole coils with multipole fields of up to 0.4 T are required to operate in a 2-T quadrupole field. Minimum cold mass and all-inorganic constructions are requirements that may be partially met with High Temperature Superconducting (HTS) coils or conventional superconductors with non-standard insulation.

Grant applications are sought for development of radiation resistant thermal isolation systems for superconducting magnets. Support links connecting room temperature with the liquid helium structure have to support large magnetic forces, but at the same time have low thermal conductivities to limit heat input. Typically, all-metal links have ten to twenty times higher heat leaks than composite structures. Composites are, however, hundreds or thousands of times more sensitive to radiation damage than metals and so cannot be used in the high-radiation environment surrounding the production target or beam dump areas of high-power heavy ion accelerators. Given the high cost of cryogenic refrigeration, development of radiation resistant, high-performance support links is very desirable.

Lastly, grant applications are sought to develop advanced and innovative approaches to the construction of large aperture superconducting and/or room temperature magnets and/or associated components, for use in fragment separators and magnetic spectrographs at rare isotope beam accelerator facilities. Grant applications also are sought for special designs that are applicable for use in high radiation areas.

(Additional needs for high-radiation applications can be found in Topic 43 Nuclear Physics Detection Systems, Instrumentation and Techniques.)

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

h. Accelerator Control and Diagnostics

Grant applications are sought to develop (1) advanced beam diagnostics concepts and devices that provide high speed computer-compatible measurement and monitoring of particle beam intensity, position, emittance, polarization, luminosity, momentum profile, time of arrival, and energy (including such advanced methods as neural networks or expert systems, and techniques that are nondestructive to the beams being monitored); (2) beam diagnostic devices that have increased sensitivities through the use of superconducting components (for example, filters based on high T_c superconducting technology or Superconducting Quantum Interference Devices); (3) measurement devices/systems for cw beam currents in the range 0.1 to 100 μA, with very high precision ($<10^{-4}$) and short integration times; (4) beam diagnostics for ion beams with intensities less than 10^7 nuclei/second; (5) non-destructive beam diagnostics for stored proton/ion beams, such as at the RHIC, and/or for 100 mA class electron beams; (6) devices/systems that measure the emittance of intense (>100kW) cw ion beams, such as those expected at a future rare isotope beam facility; (7) beam halo monitor systems for ion beams; and (8) instrumentation for electron cloud effect diagnostics and suppression.

Grant applications are sought for the development of triggerable, high speed optical and/or IR cameras, with associated MByte-scale digital frame grabbers for investigating time dependent phenomena in accelerator beams. Image capture equipment needs to operate in a high-radiation environment and have a frame capture rate of up to 1 MHz. Imaging system needs to have memory capacity at the level of 1000 frames (10 GByte or higher total memory capacity). The cameras will be used for high-speed analysis of optical transition or optical diffraction radiation data.

Grant applications are sought for developing point of delivery beam bunch length monitors for the Jefferson Lab CEBAF accelerator. Beam energies are from 6-12 GeV and bending magnetics are available to produce synchrotron radiation. Non-invasive monitoring is preferred. 500 MHz beam currents are typically above 5 uA and bunch lengths are typically below 30 microns rms.

Grant applications also are sought for "intelligent" software and hardware to facilitate the improved control and optimization of charged particle accelerators and associated components for nuclear physics research. Areas of interest include the development of (1) generic solutions to problems with respect to the initial choice of operation parameters and the optimization of selected beam parameters with automatic tuning; (2) systems for predicting insipient failure of accelerator components, through the monitoring/cataloging/scanning of real-time or logged signals; and (3) devices that can perform direct 12-14 bit digitization of signals at 0.5-2 GHz and that have bandwidths of 100+ kHz.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

i. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

References: Subtopic a:

1. For questions related to items 1-7 in the first paragraph of this subtopic, contact Dr. Robert Rimmer of Thomas Jefferson Laboratory (rarimmer@jlab.org) and Ilan Ben-Zvi of Brookhaven National Laboratory (benzvi@bnl.gov).
2. For all other specification questions, contact Dr. Charles Reece of Thomas Jefferson Laboratory (reece@jlab.org).

References: Subtopic b:

1. For further specifications on power sources, contact Dr. Leigh Harwood of Thomas Jefferson Laboratory (harwood@jlab.org) and Dr. Ilan Ben-Zvi of Brookhaven National Laboratory (benzvi@bnl.gov)
2. For more details on technical specifications of TJNAF klystron replacement, contact Rick Nelson of Thomas Jefferson Laboratory (nelson@jlab.org).

References: Subtopic c:

1. For further specifications on fast frequency switching rf cavities, contact Dr. Dejan Trbojevic of Brookhaven National Laboratory (trbojevic@bnl.gov).
2. For questions related to software design and modeling, contact Dr. Ilan Ben-Zvi of Brookhaven National Laboratory (benzvi@bnl.gov).
3. For questions or further specifications on SRF deflecting cavities, contact Drs. Yaroslav Derbenev, Geoffrey Krafft and Yuhong Zhang of Thomas Jefferson Laboratory (derbenev@jlab.org, krafft@jlab.org, yzhang@jlab.org). For questions related to multi-cell SRF deflecting cavities, Dr. Ilan Ben-Zvi of Brookhaven National Laboratory (benzvi@bnl.gov) may also be contacted.

References: Subtopic d:

1. For questions and further specifications on design, modeling and hardware development of full acceptance magnets for EIC, contact Dr. Yuhong Zhang of Thomas Jefferson Laboratory (yzhang@jlab.org).
2. For further information related to coherent electron cooling, contact Dr. Vladimir Litvinenko of Brookhaven National Laboratory (vl@bnl.gov).
3. For further specifications to develop beam absorbers for energy-recovery-linac, contact Dr. Geoffrey Krafft of Thomas Jefferson Laboratory (krafft@jlab.org).
4. For further questions on developing software for state-of-the-art in the simulation of beam physics, contact Dr. Ilan Ben-Zvi of Brookhaven National Laboratory (benzvi@bnl.gov) and Yuhong Zhang of Thomas Jefferson Laboratory (yzhang@jlab.org).

References: Subtopic e:

1. For further specifications on polarized electron sources, contact Dr. Matthew Poelker of Thomas Jefferson Laboratory (poelker@jlab.org). For questions on polarized ion sources, contact Dr. Anatoli Zelenski of Brookhaven National Laboratory (zelenski@bnl.gov).

References: Subtopic f:

1. For further technical specifications, contact Dr. Felix Marti of FRIB/MSU (marti@frib.msu.edu)

References: Subtopic g:

1. For further specifications on rare isotope beam technology, contact the following: for fast-release solid catcher materials, Dr. Dave Morrissey of NSCL/MSU (morrissey@nscl.msu.edu); for charge breeding (EBIS/T), Dr. Stefan Schwarz of NSCL//MSU (schwarz@nscl.msu.edu); for radiation resistant superconducting quadrupoles, Dr. Al Zeller of FRIB/MSU (zeller@frib.msu.edu); and for innovative approaches to the construction of large aperture magnets, contact Dr. Wolfgang Mittig of NSCL/MSU (mittig@nscl.msu.edu).

References: Subtopic h:

1. For further specifications on triggerable, high speed frame grabber cameras, contact Dr. Geoffrey Krafft of the Thomas Jefferson National Accelerator Facility (krafft@jlab.org).

References:

1. DOE Funding Opportunity Announcement (FOA) regarding the submission of applications for the conceptual design and establishment of a Facility for Rare Isotope Beams (FRIB). (http://science.energy.gov/np/news-and-resources/program/frib/)
2. Application of Accelerators in Research and Industry: 17th International Conference on the Application of Accelerators in Research and Industry. Denton, Texas. November 12-16, 2002. Eds. Jerome L. Duggan & Ira Lon Morgan. (2003). New York: American Institute of Physics (AIP). ISBN: 978-0735401495. Available at http://proceedings.aip.org/resource/2/apcpcs/680/1?isAuthorized=no
3. M. Champion, et al. (2003). *The Spallation Neutron Source Accelerator Low Level RF Control System*. Proceedings of the 2003 Particle Accelerator Conference. Portland, Oregon. May 12-16. Paper ID: FPABO38, p. 3377. Available at http://accelconf.web.cern.ch/accelconf/p03/PAPERS/FPAB038.PDF
4. SRF Materials Workshop. Michigan State University. October 29-31, 2008. Conference details available at http://meetings.nscl.msu.edu/srfmatsci/index.php?id=conference_details/main.php/
5. Proceedings of the 3rd International Workshop on Thin Films and New Ideas for Pushing the Limits of RF Superconductivity. Jefferson Laboratory. Newport News, Virginia. July 22-25, 2008. Available at http://conferences.jlab.org/tfsrf/
6. Proceedings of the 2nd International Workshop on Thin Films and New Ideas for Pushing the Limits of RF Superconductivity. Legnaro National Laboratory. Pagua, Italy. 2006.
7. CEBAF at 12 GeV: Future Science at Thomas Jefferson National Accelerator Laboratory. (http://science.energy.gov/laboratories/thomas-jefferson-national-accelerator-facility/)
8. eRHIC: The Electron-Ion-Collider at U.S. DOE Brookhaven National Laboratory. (http://www.phenix.bnl.gov/WWW/publish/abhay/Home_of_EIC/)
9. A. Bogacz, et al. (2007). *Design studies of a high-luminosity ring-ring electron ion collider at CEBAF*. Proceedings of the PAC. Albuquerque, New Mexico. June 25-19, 2007. Available at

http://casa.jlab.org/publications/Conference%20Proceedings.htm#proceeding2007; ELIC Zero[th] Order Design Review available at http://casa.jlab.org/research/elic/elic_zdr.doc
10. Harry Freeman. (2000). *Heavy-Ion sources: the star, or the Cinderella, of the ion-implantation firmament?.* Review of Scientific Instruments. Vol. 71, pp. 603-612. ISSN: 0034-6748. Available at http://rsi.aip.org/resource/1/rsinak/v71/i2/p603_s1
11. I. Ben-Zvi, et al. (2003). *R&D Towards Cooling of the RHIC Collider*. Proceedings of the 2003 Particle Accelerator Conference. Portland, Oregon. May 12-16. Available at http://accelconf.web.cern.ch/accelconf/p03/INDEX.HTM
12. S. Ozaki. (2003). *Report of the 2003 RIA R&D Workshop.* Proceedings of the 2003 Rare Isotope Accelerator (RIA) R&D Workshop. Bethesda, Maryland. August 26-28. Available at http://www.oro.doe.gov/riaseb/wrkshop2003/RIA_Report.html; Presented papers available at http://www.oro.doe.gov/riaseb/wrkshop2003/RIA_Papers.html
13. D. Trbojevic, et al. (2005). *Design of a Nonscaling Fixed Field Alternating Gradient Accelerator*. Physical Review Special Topics—Accelerators and Beams. Vol. 8, Issue 5, pp. 050101(1-10). Available at http://prst-ab.aps.org/abstract/PRSTAB/v8/i5/e050101
14. TESLA Technology Collaboration Meeting. FNAL. April 19-22, 2010. (http://indico.fnal.gov/conferenceDisplay.py?confId=3000)
15. S. Schwarz, et al. (2010). *EBIS/T charge breeding for intense rare isotope beams at MSU*. Journal of Instrumentation. Vol. 5. Available at http://iopscience.iop.org/1748-0221/5/10/C10002/
16. York, R., et al. (2010) *Status and Plans for the Facility for Rare Isotope Beams at Michigan State University.* XXV Linear Accelerator Conference (LINAC10). Tsukuba, Japan. September 12-17, 2010. Available at http/spms.kek.jp/pls/linac2010/TOC.htm

39. NUCLEAR PHYSICS INSTRUMENTATION, DETECTION SYSTEMS AND TECHNIQUES

Maximum Phase I Award Amount: **$150,000**	*Maximum Phase II Award Amount:* **$1,000,000**
Accepting SBIR Phase I Applications: **YES**	*Accepting SBIR Fast-Track Applications:* **YES**
Accepting STTR Phase I Applications: **YES**	*Accepting STTR Fast-Track Applications:* **YES**

The Office of Nuclear Physics is interested in supporting projects that may lead to advances in detection systems, instrumentation, and techniques for nuclear physics experiments. Opportunities exist for developing equipment beyond the present state-of-the-art at universities and national user facilities, including the Argonne Tandem Linac System (ATLAS) at Argonne National Laboratory. In addition, a new suite of next-generation detectors will be needed for the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) Upgrade at the Thomas Jefferson National Accelerator Facility (TJNAF), a future facility for rare isotope beams (FRIB) at Michigan State University, detector and luminosity upgrades at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Lab, and a possible future electron-ion collider. Also of interest is technology related to future experiments in fundamental symmetries, such as neutrinoless double-beta decay experiments and the measurement of the electric dipole moment of the neutron, where extremely low background and low count rate particle detection are essential. This topic seeks state-of-the-art targets for applications ranging from spin polarized and unpolarized nuclear physics experiments to stripper and production targets required at high-power, advanced, rare isotope beam facilities. Lastly, this topic seeks new and improved techniques and instrumentation to cope with the high radiation environments anticipated for FRIB. All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought only in the following subtopics:

a. Advances in Detector and Spectrometer Technology

Nuclear physics research has a need for devices to detect, analyze, and track photons, charged particles, and neutral particles such as neutrons, neutrinos, and single atoms. Grant applications are sought to develop and advance the following types of detectors:

(1) Photon detectors and photosensitive devices, including, photodiodes and avalanche photodiodes, highly pixelated Geiger avalanche photodiodes, also known as Silicon Photomultipliers (SiPMs), in particular radiation-tolerant SiPMs, large area, low noise SiPMs, SIPMs with improved photon detection efficiency, digital SiPMs, etc.,hybrid photomultiplier devices, single- and multiple-anode photomultiplier tubes with reduced sensitivity to magnetic fields, photon detectors capable of working in a liquid helium environment, cost-effective, position-sensitive, large-sized photon detection devices for Cherenkov counters including arrays of silicon photomultipliers sensitive to blue wavelengths;detectors utilizing photocathodes for visible and ultra-violet Cherenkov light detection, and new types of large-area photo-emissive materials such as solid, liquid, or gas photocathodes;advanced CCD and ECCD technology, including fast parallel, low-power readout, and cross-talk control;

(2) Systems and components associated with liquid argon and xenon ionization chambers and other cryogenic detectors;

(3) Electromagnetic and hadronic calorimeters, including new and innovative calorimeter concepts, new high density absorber materials, improved absorber packing schemes to achieve a small Moliere radius and short radiation length for electromagnetic calorimetry, new materials and methods for improving calorimeter energy resolution, and cost effective manufacturing techniques for producing calorimeter components;

(4) Systems for detecting the magnetization of polarized nuclei in a magnetic field (e.g., Superconducting Quantum Interference Devices (SQUIDs) or cells with paramagnetic atoms that employ large pickup loops to surround the sample);

(5) Particle identification detectors such as Multigap Resistive Plate Chambers (MRPCs), high resolution, low radiation length thickness, time-of-flight detectors (<10 ps), such as Micro-channel Plates (MCPs) and other larger area MCP type detectors; Cherenkov detectors with broad particle identification capabilities over a large momentum range and/or large area; affordable methods for the production of large volumes of high-purity xenon and krypton gas (which would contribute to the development of transition radiation detectors and also would have many applications in X-ray detectors); very high resolution (tenths of micrometers spatial resolution and tenths of eV energy resolution) particle detectors or bolometers (including the required thermistors) based on cryogenic semiconductor materials, and radio-frequency techniques; detector technologies capable of measuring energies of alpha particles and protons with less than 5 keV resolution, thereby allowing spectroscopy experiments using light charged particles to be performed in the same way as spectroscopy experiments using gammas;

(6) Precision detector calibration methods such as, controllable calibration sources for electrons, gammas, alphas, and neutrons; pulsed calibration sources for neutrons, gammas, and electrons; precision charged particle beams; pulsed UV and optical sources;

(7) Spectrometers and innovative magnet designs such as development of iron-free magnet systems with tilted crossed solenoid windings and active shielding for a broad variety of superconducting dipoles, which, for example, could be used in high-acceptance spectrometers; innovative designs for high-resolution particle separators and spectrometers for next-generation rare isotope beam and intense stable beam facilities. Developments of interest include both air-core and iron-dominated superconducting magnets that use either conventional low-temperature conductors or new medium to high-temperature conductors for magnetic spectrometers, fragment separators, and beam transport systems. Innovative designs such as elliptical aperture multi-poles and other combined function magnets are of interest; cryogenic systems in the mid-capacity range for use with superconducting spectrometers for nuclear physics. The emphasis is on cryogenic systems with higher capacity, improved efficiency, and reduced maintenance requirements at both low (4-20 K) and intermediate temperatures (50-77 K) relative to the present generation of cryocoolers.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

b. Development of Novel Gas and Solid-State Detectors

Nuclear physics research has the need for devices to track charged particles, and neutral particles such as neutrons and photons. Items of interests are detectors with high energy resolution for low-energy applications, high precision tracking of different types of particles, and fast triggering capabilities.

The subtopic announcements are grouped into solid-state devices and novel gas detectors.

Grant applications are sought to develop novel gamma-ray detectors, including, 1) position-sensitive photon tracking devices for nuclear structure and astrophysics applications, as well as associated technology for these devices. High-resolution germanium or scintillator detectors capable of determining the position (to within a few millimeters utilizing pulse shape analysis) and energy of individual interactions of gamma-rays (with energies up to several MeV), hence allowing for the reconstruction of the energy and path of individual gamma-rays using tracking techniques, are of particular interest; 2) techniques for increasing the volume and/or area, or improving the performance of Ge detectors, or for substantial cost reduction of producing large-mass Ge detectors; and 3) alternative materials, with comparable resolution to germanium, but with higher efficiency and room- temperature operation.

Grant applications are sought to develop advances in the general field of solid-state devices for tracking of charged particles and neutrons, such as silicon drift, strip, and pixel detectors, along with 3D silicon devices.

Approaches of interest include:

- Manufacturing techniques, including interconnection technologies for high granularity, high resolution, light-weight, and radiation-hard solid state devices;
- Thicker (more than 1.5 mm) segmented silicon charged-particle and x-ray detectors and associated high density, high resolution electronics;
- Cost-effective production of large-area n-type and p-type silicon drift chambers;
- Novel, low-noise cooling devices for efficiently operating silicon drift chambers;
- Low mass active-pixel sensors with thickness ~50μm and large area Si pixel and strip detectors with thickness <200 μm.
- Segmented solid state devices for neutron detection, with integrated electronics;

Grant applications are sought in the general field of micropattern gas detectors. This includes:

- New developments in micro-channel plates; micro-strip, Gas Electron Multipliers (GEMs), Micromegas and other types of micro-pattern detectors;
- Commercial and cost effective production of GEM foils or thicker GEM structures;
- Micro-pattern structures, such as fine meshes used in Micromegas;
- High-resolution multidimensional readout such as 2D readout planes;
- Systems and components for large area imaging devices using Micromegas technology associated with the read-out of a high number of channels (typically ~10,000), which requires the development of printed circuit boards that have superior surface quality to minimize gain fluctuations and sparking.

Grant applications are sought for the advancement of more conventional gas tracking detector systems, including drift chambers, pad chambers, time expansion chambers, and time projection chambers such as:

- Gas-filled tracking detectors such as straw tubes (focusing on automated assembly and wiring techniques), drift tube, proportional, drift, and streamer detectors;
- Improved gases or gas additives that resist aging, improved detector resolution, decreased flammability and larger, more uniform drift velocity;
- Application of CCD cameras for optical readout in Time-Projection Chambers;
- New developments for fast, compact TPCs.
- Gamma-ray detectors capable of making accurate measurements of high intensities (>10^{11} /s) with a precision of 1-2 %, as well as economical gamma-ray beam-profile monitors;
- Components of segmented bolometers with high-Z material (e.g., W, Ta, Pb) for gamma ray detection with segmentation, capable of handling 100 -1000 gamma rays per second;

Finally, grant applications are sought to develop detector systems for rare isotope beams with focus on:

- Next-generation, high-spatial-resolution focal plane detectors for magnetic spectrometers and recoil separators;
- High-rate, position-sensitive particle tracking and timing detectors for heavy-ions. Of interest are detectors with single-particle detection capability at a rate of 10^7 particles per second, a timing resolution of better than 0.25 ns, spatial resolution of better than 10 mm (in one direction) and minimal thickness variations (< 0.1 – 0.5 mg/cm^2) over

an active area of typically 1 × 20 cm. In addition, a successful design would maintain performance during continuous operation (at 10^7 s^{-1} particle rate) over multiple weeks. Arrays of diamond detectors would be a possible approach

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

c. Technology for Rare Decay and Rare Particle Detection

Grant applications are sought for detectors and techniques for measuring very weak or rare event signals in the presence of significant backgrounds. Such detector technologies and analysis techniques are required in searches for rare events (such as double beta decay) and searches for new nuclear isotopes produced at radioactive-beam and high-intensity stable-beam facilities. Rare decay and rare event detectors require large quantities of ultra-clean materials for shielding and targets. Grant applications are sought to develop:

- Ultra-low background techniques and materials for supporting, cooling, cabling, and connecting high-density arrays of detectors (such as radio-pure signal cabling, signal and high voltage interconnects, vacuum feedthroughs, and front-end amplifier FET assemblies; purity goals are as low as 1 micro-Becquerel per kg);
- Ultra-sensitive assay or mass-spectrometry methods for quantifying contaminants in ultra-clean materials
- Cost-effective production of large quantities of ultra-pure liquid scintillators;
- Novel methods capable of distinguishing between interactions of gamma rays and charged particles in detectors; and
- Methods by which the background events in rare event searches, such as those induced by gamma rays or neutrons, can be tagged, reduced, or removed entirely.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

d. High Performance Scintillators, Cherenkov Materials and Other Optical Components

Nuclear physics research has the need for high performance scintillator and Cherenkov materials for detecting photons and charged particles over a wide range of energies (from a few keV to up to many GeV). These include crystalline scintillators (such as BGO, LSO, LYSO, BaF2, etc.) and liquid scintillators (both organic and cryogenic noble liquids) for measuring electromagnetic particles, plastic scintillators for measuring charged particles, and Cherenkov materials for particle identification. Many of these detectors require large area coverage and therefore cost effective methods for producing materials for practical devices. Grant applications are sought to develop:

- New high density scintillating crystals with high light output and fast decay times.
- Improved techniques for producing high purity cryogenic noble liquid scintillators (particularly argon and xenon)
- Ultra-high-purity organic liquid scintillators with various dopants
- Large-area, high optical quality Cherenkov materials
- Precision Cherenkov radiators for Detectors of Internally Reflected Cherenkov Light (DIRCs)
- Cherenkov materials with indices of refraction between gases and liquids (e.g., Aerogel)

- Scintillators and Cherenkov materials that can be used for particle discrimination using timing and pulse shape information (e.g., n/gamma separation, dual readout calorimetry, etc.)
- High light output plastic scintillating and wavelength-shifting fibers

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

e. Specialized Targets for Nuclear Physics Research

Grant applications are sought to develop specialized targets, including:

- Polarized (with nuclear spins aligned) high-density gas or solid targets;
- Systems and components for frozen-spin active (scintillating) targets;
- Systems and components associated with liquid, gaseous, and solid targets capable of high power dissipation when high-intensity, low-emittance charged-particle beams are used;
- Very thin windows (<100 micrograms/cm^2 and/or 50% transmission of 500 eV X-rays) for gaseous detectors, for the measurement of low-energy ions; and
- A positron-production target capable of converting hundreds of kilowatts of electron beam power (10 MeV at 10 mA) over a sufficiently short distance to allow for the escape of the produced positrons. Of particular interest would be moving and/or cooled high-Z targets of uniform, stable thickness (2-8 mm), which may be immersed in a 0.5-1.0 T axial magnetic field.

Grant applications also are sought to develop the technologies and sub-systems for the targets required at high-power, rare isotope beam facilities that use heavy ion drivers for rare isotope production. Targets for heavy ion fragmentation and in-flight separation are required that are made of low-Z materials and that can withstand very high power densities and are tolerant to radiation. Interested parties should contact Dr. Wolfgang Mittig, NSCL/MSU

Finally, grant applications are sought to develop techniques for:

- Production of thin films (in the thickness range from a few $\mu g/cm^2$ to over 10 mg/cm^2) for charge-state stripping in heavy-ion accelerators; and
- Preparation of targets of radioisotopes, with half-lives in the range of hours, to be used off-line in both neutron-induced and charged-particle-induced experiments.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

f. Technology for High Radiation environments

Next generation rare isotope beam facilities require new and improved techniques, instrumentations, and strategies to deal with the anticipated high radiation environment in the production, stripping, and transport of ion beams. These could also be useful for existing facilities. Therefore grant applications are sought to develop:

- Rotatary vacuum seals for applications in high-radiation environment: Vacuum rotary feedthroughs for high rotational speeds, which have a long lifetime under a high-radiation environment (order of months to years at 0.5-15 MGy/month), are highly desirable for the realization of rotating targets and beam dumps for rare isotope beam production and beam strippers in high-power heavy-ion accelerators.

- Radiation resistant multiple-use vacuum seals: Elastomer-based vacuum seals have a limited lifetime (~ 10^8 rad, or less, total absorbed dose) due to radiation damage in the high-radiation environment found in the target facility of FRIB and other high-power target facilities. Alternative multi-use vacuum vessel sealing solutions that provide extended lifetimes (> 10^8 rad) and are suitable for remote-handling applications are needed. It is preferred that the multi-use high radiation resistant sealing material does not require high clamping forces or high finish and tolerance sealing surfaces.
- Radiation resistant magnetic field probes based on new technologies: An issue in all high-power target facilities and accelerators is the limited lifetime of conventional nuclear magnetic resonance probes in high-radiation environments (0.1-10 MGy/y). The development of radiation-resistant magnetic field probes for 0.2-5 Tesla and a precision of $dB/B<10^{-4}$ would be highly desirable.
- Improved models of radiation transport in beam production systems: The use of energetic and high-power heavy ion beams at future research facilities will create significant radiation fields. Radiation transport studies are needed to design and operate facilities efficiently and safely. Advances of radiation transport codes are desired for (a) the inclusion of charge state distributions of initial and produced ions including distribution changes when passing through material and magnetic fields, (b) efficient thick-shield, heat deposition, and gas production studies, (c) the implementation of new models of heavy ion radiation damage, and their validation against experimental data.
- Radiation tolerant sensors for video cameras: Cost efficient video sensors with resolutions of VGA (640 × 480 pixel) or better but with enhanced radiation tolerance for prolonged operation in the presence of neutron fluxes of about 105 n cm-2 s-1, would be beneficial in the operation and remote handling of equipment in radiation fields, e.g. at rare isotope production facilities.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

g. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

h. Technology Transfer Opportunity: Nano Structural Anodes for Radiation Detectors

Applicants to Technology Transfer Opportunities should review the section describing Technology Transfer Opportunities on page 1 of this document prior to submitting applications

Scientists at Savanna River National Laboratory (SRNL) have developed a boron-based nano-structured proportional counter (nano-PC) that will obviate the need for He3 in neutron detection. Moreover, the proposed device eliminates the need for high operating voltages and the use of step-up transformers by utilizing inherently high electrical field nanoscale anodes. In comparison with legacy detectors, this new nano-detector design will have a much lower operating voltage, a smaller power supply, enhanced portability, increased sensitivity to radiation, improved detection efficiency, and no need for He3. Applications for this Technology Transfer opportunity are sought to optimize prototype design and develop an integrated system demonstrating the feasibility for use of this detector.

Savannah River National Laboratory information:
Contact: Eric Frickey (eric.frickey@srnl.doe.gov).
Website : http://www.srs.gov/general/srnl/tech_transfer/tech_briefs/Boron-Structured%20NanoProportional%20Counter%20SRNL-L7100-2012-00036.pdf

i. Technology Transfer Opportunity: Low Power, High Energy Gamma Ray Detector Calibration Device

Applicants to Technology Transfer Opportunities should review the section describing Technology Transfer Opportunities on page 1 of this document prior to submitting applications.

Scientists at Lawrence Berkeley National Laboratory developed a low power, high-energy gamma ray detector calibration device that produces much higher energy gamma rays (10 MeV) than are possible with radioactive sources. The gamma ray spectrum can also be adjusted for various applications. These gamma rays have been calibrated by the LBNL Isotopes Project in collaboration with the International Atomic Energy Agency and formerly could only be produced at nuclear reactors. The device is based on a low power neutron generator, which is inherently safe to operate. Unlike radioactive calibration sources the instrument can be switched off -– producing no radioactivity when not in use. The simple, compact design allows the calibrator to be used in the field and laboratories of almost any size as well as for calibrating large gamma ray detectors being developed for homeland security cargo screening and physics experiments. Applications for this Technology Transfer opportunity are sought to optimize prototype design and develop an integrated system demonstrating the feasibility for use of this detector.

Lawrence Berkeley National Laboratory information:
Contact: Shanshan Li (shanshanli@lbl.gov)
Web site: http://www.lbl.gov/Tech-Transfer/techs/lbnl2164.html

References: Subtopic a:

1. R. Bellwied, et al. (1996). *Development of large linear silicon drift detectors for the STAR experiment at RHIC*. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 377, Issues 2-3, pp. 387-392. Available for purchase at http://www.sciencedirect.com/science/article/pii/0168900296000241

2. M.E. Beddo, et al. *STAR: Conceptual Design Report for the Solenoidal Tracker at the Relativistic Heavy Ion Collider (RHIC).* Lawrence Berkeley National Laboratory, June 15, 1992. (Report No. LBL-PUB-5347; (NTIS Order No. DE92041174) (Note: Abstract and ordering information available from National Technical Information Service (NTIS). Telephone: 1-800-553-6847. Web site: http://www.ntis.gov/. Search by order number. Please note: Items that are unavailable via the Web site might be obtained by phoning NTIS.)
3. For information on the development of iron-free magnet systems with tilted crossed solenoid windings referenced above, contact Dr. Daniel Bazin of NSCL/MSU (bazin@nscl.msu.edu).

References: Subtopic b:

1. M. Descovich, et al. (2005). In-beam measurement of the position resolution of a highly segmented coaxial germanium detector. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 553, Issue 3, pp. 535-542. Available for purchase at http://www.sciencedirect.com/science/article/pii/S0168900205014385
2. For questions related to above-listed items under the general field of micropattern gas detectors, contact Dr. Bernd Surrow of Temple University (surrow@temple.edu).
3. For questions related to the advancement of more conventional gas tracking detector systems, contact Dr. Wolfgang Mittig of NSCL/MSU. (mittig@nscl.msu.edu)
4. For items 1-2 listed above concerning the development of detectors for rare isotope beams, contact Dr. Marc Hausmann of FRIB/MSU (Hausmann@frib.msu.edu).

References for Subtopic c:

1. T. C. Andersen, et al. (2003). *Measurement of radium concentration in water with Mn-coated beads at the Sudbury Neutrino Observatory*. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 501, Issues 2-3, pp. 399-417. Available for purchase at http://www.sciencedirect.com/science/article/pii/S0168900203006168 (Free version available for download from the Cornell University Library at http://arxiv.org/abs/nucl-ex/0208010v2)
2. T.C. Andersen, et al. (2003). *A radium assay technique using hydrous titanium oxide absorbent for the Sudbury Neutrino Observatory*. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 501, Issue 2, pp. 386-398. (http://www.sciencedirect.com/science/journal/01689002) (Free version available for download from the Cornell University Library at http://arxiv.org/abs/nucl-ex/0208015)

References: Subtopic e:

1. For questions related to technologies for high-power targets for FRIB, contact Dr. Wolfgang Mittig of NSCL/MSU (mittig@nscl.msu.edu).

References: Subtopic f:

1. DOE Funding Opportunity Announcement (FOA) regarding the submission of applications for the conceptual design and establishment of a Facility for Rare Isotope Beams (FRIB). (http://science.energy.gov/np/news-and-resources/program/frib/)
2. S. Fernandes, et al. Operational performance of ferrofluidic feedthroughs after irradiation with a beam of fast neutrons, protons and gamma rays. To be published.

3. T. W. Burgess, A.M. Aaron, A.J. Carroll, J.R. DeVore, D.R. Giuliano & V.B. Graves. (2011). *Remote Handling and Maintenance in the Facility for Rare Isotope Beams*. 13th Robotics & Remote Systems for Hazardous Environments: 11th Emergency Preparedness & Response. Knoxville, Tennessee. August 7-10, 2011. LaGrange Park, Illinois: American Nuclear Society. Available at http://info.ornl.gov/sites/publications/files/Pub30545.pdf
4. MCNPX. (http://mcnpx.lanl.gov/)
5. PHITS. (http://phits.jaea.go.jp/)
6. N. V. Mokhov & S. I. Striganov. (2006). *MARS15 Overview*. AIP Conference Proceedings 896: Hadronic Shower Simulation Workshop. Sept. 6-8, 2006. pp. 50-60. Batavia, Illinois: AIP. Available at http://proceedings.aip.org/resource/2/apcpcs/896/1/50_1?isAuthorized=no
7. FLUKA. (http://www.fluka.org/fluka.php)
8. T. Nakamura & L. Heilbronn. (2006). *Handbook of Secondary Particle Production and Transport by High-Energy Heavy Ions*. Singapore: World Scientific Publishing. Available at http://www.worldscientific.com/doi/pdf/10.1142/9789812703149_fmatter
9. K. U. Vandergriff. (1990). *Designing Equipment for Use in Gamma Radiation Environments.* Oak Ridge National Laboratory. Available at http://dx.doi.org/10.2172/814580
10. T. W. Burgess, et al. (1988). *Design Guidelines for Remotely Maintained Equipment*. Report No. ORNL/TM-10864. Oak Ridge National Laboratory. Available for purchase at http://www.ntis.gov/search/product.aspx?ABBR=DE89004309
11. R. York, et al. (2010). *Status and Plans for the Facility for Rare Isotope Beams at Michigan State University*. XXV Linear Accelerator Conference (LINAC10). Tsukuba, Japan. September 12-17, 2010. Session ID: MOP046. Available at http://spms.kek.jp/pls/linac2010/TOC.htm
12. For questions related to rotary vacuum seals referenced above, contact Dr. Frederique Pellemoine of FRIB/MSU (pellemoi@frib.msu.edu). For multiple-use vacuum seals, contact Tom Burgess of ORNL/NSED (burgesstw@ornl.gov).
13. For questions related to radiation resistant magnetic field probes referenced above, contact Dr. Georg Bollen of FRIB/MSU (bollen@frib.msu.edu).
14. For models of radiation transport in beam production systems, contact Dr. Reg Ronningen of NSCL/MSU (ronningen@frib.msu.edu).

References:

1. DOE Funding Opportunity Announcement (FOA) regarding the submission of applications for the conceptual design and establishment of a Facility for Rare Isotope Beams (FRIB). (http://science.energy.gov/np/news-and-resources/program/frib/)
2. *Conceptual Design Report for the Neutron Electric Dipole Moment Project (nEDM).* (2007). Los Almos, New Mexico: Los Alamos National Laboratory. Available at http://p25ext.lanl.gov/edm/pdf.unprotected/CDR(no_cvr)_Final.pdf
3. Y. Eisen, et al. (1999). *CdTe and CdZnTe gamma ray detectors for medical and industrial imaging systems.* Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 428, Issue 1, pp. 158-170. Available at http://www.sciencedirect.com/science/article/pii/S0168900299000030
4. C. Grupen. (1996). Particle Detectors (Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology). New York: Cambridge University Press. ISBN: 978-0521552165.
5. D.P. Morrison, et al. (1998). *The PHENIX Experiment at RHIC*. Nuclear Physics A. Vol. 638, Issues 1-2, pp. 565c-569c. Available for purchase at http://www.sciencedirect.com/science/article/pii/S037594749800390X

6. *Proceedings of the Tenth International Workshop on Low Temperature Detectors*. (2004). Ed. F. Gatti. Genoa, Italy. July 7-11, 2003. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 520, Issues 1-3. Available for purchase at http://www.sciencedirect.com/science/article/pii/S0168900203030973
7. K. Vetter, et al. (2000). *Three-Dimensional position sensitivity in two-dimensionally segmented HP-Ge detectors*. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 452, p. 223. Available version at http://radware.phy.ornl.gov/greta/pulse_sens_html.pdf
8. E.V. van Loef, et al. (2002). *Scintillation properties of $LaBr_3:Ce^{3+}$ crystals: fast, efficient and high-energy-resolution scintillators.* Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 486, pp. 254. Available for purchase at http://www.sciencedirect.com/science/article/pii/S016890020200712X
9. Historical Development of the Plans for CEBAF at 12 GeV. U.S. Department of Energy Thomas Jefferson Accelerator Facility. (http://science.energy.gov/laboratories/thomas-jefferson-national-accelerator-facility/)
10. eRHIC: The Electron-Ion-Collider at Brookhaven National Laboratory. (http://www.phenix.bnl.gov/WWW/publish/abhay/Home_of_EIC/)
11. RHIC: Relativistic Heavy Ion Collider at Brookhaven National Laboratory. (http://www.bnl.gov/RHIC/)
12. J. Miyamoto, et al. (2004). *GEM operation in negative ion drift gas mixtures*. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 526, Issue 3, pp. 409-412. Available for purchase at http://www.sciencedirect.com/science/article/pii/S016890020400333X
13. G. Batignani, F. Cervelli, G. Chiarelli & A. Scribano. (2004). *Frontier detectors for frontier physics.* Proceedings of the 8th Pisa Meeting on Advanced Detectors. Isola dElba, Italy. May 25-31, 2003. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 518, Issues 1-2. ISSN: 0168-9002. Available for purchase at http://www.sciencedirect.com/science/article/pii/S016890020302686X
14. C. Arnaboldi, et al. (2004). *CUORE: a cryogenic underground observatory for rare events*. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. Vol. 518, Issue 3, pp. 775-798. Available for purchase at http://www.sciencedirect.com/science/article/pii/S0168900203023374

40. NUCLEAR PHYSICS ISOTOPE SCIENCE AND TECHNOLOGY

Maximum Phase I Award Amount: $150,000	*Maximum Phase II Award Amount:* $1,000,000
Accepting SBIR Phase I Applications: YES	*Accepting SBIR Fast-Track Applications:* YES
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* YES

Stable and radioactive isotopes are critical to serve the broad needs of modern society and to research in chemistry, physics, energy, environmental sciences, material sciences and for a variety of applications in industry and national security. A primary goal of the Department of Energy's Isotope

Development and Production for Research and Applications Program (Isotope Program) within the Office of Nuclear Physics (NP) is to support research and development of methods and technologies which make available isotopes used for research and applications that fall within the Isotope Program portfolio. The Isotope Program produces isotopes that are in short supply in the U.S. and of which there exists insufficient domestic commercial production capability; some exceptions include some special nuclear materials and molybdenum-99, for which the National Nuclear Security Administration has responsibility. The benefit of a viable research and development program includes an increased portfolio of isotope products, more cost-effective and efficient production/processing technologies, a more reliable supply of isotopes year-round and the reduced dependence on foreign supplies. Additional guidance for research isotope priorities is provided in the Nuclear Science Advisory Committee Isotopes (NSACI) report available at http://science.energy.gov/np/nsac/ which will serve to guide production plans of the Isotope Program.

All entities submitting proposals to SBIR/STTR Isotope Science and Technology topic must recognize the moral and legal obligation to comply with export controls and policies that relate to the transfer of knowledge that has relevance to the production of special nuclear materials (SNM). All parties are responsible for U.S. Export Control Laws and Regulations, which include but may not be limited to regulations within the Department of Commerce, Nuclear Regulatory Commission and the Department of Energy.

a. Novel or improved production techniques for radioisotopes or stable isotopes

Research should focus on the development of advanced, cost-effective, and efficient technologies for producing isotopes that are in short supply and that are needed by research or applied communities. This includes advanced accelerator and beam transport technologies such as the application of high-gradient accelerating structures, high-energy/high-current cyclotrons, or other technologies that could lead to compact sources as well as novel beam-delivery/rastering and target approaches needed to optimize isotope production. The development of high quality, robust accelerator targets is required to utilize high-current high-power-density available from advanced accelerators; of particular concern is the design and fabrication of encapsulated salt targets. These targets could be subjected to energies greater than 50 MeV at beam intensity of 100 μA to 750 μA. The successful research grants should lead to breakthroughs that will facilitate an increased supply of isotopes that complement the existing portfolio of isotopes produced and distributed by the Isotope Program. This includes breakthroughs in in-situ target diagnostics, novel self-healing materials with extreme radiation resistance for accelerator target material containment or encapsulation and improved modeling capabilities that will lead to target designs exhibiting high tolerance of extreme radiation and thermal environments.

The development of innovative technologies that will lead to new or advanced methods for production of radioisotopes that align with the priorities of the 2009 NSACI report is encouraged. Other isotopes and isotope related technologies that fall outside of the NSACI report will also be considered but should have strong alignment with the core research areas as outlined in the report. The new technologies must have the potential to ensure a cost-effective and stable supply and distribution of such isotopes. Examples of high priority isotopes include the alpha emitters actinium-225 (^{225}Ac), actinium-227/thorium-227/radium-223, and astatine-211 (^{211}At) that continue to gain importance in targeted alpha therapy applications. Other radioisotopes, considered theranostic radioisotopes, such as high specific activity rhenium-186 (^{186}Re) and tin-117m (^{117m}Sn), and same element radioisotope pairs with emissions useful for both diagnostic and therapeutic applications(e.g. ^{67}Cu and ^{64}Cu) are also of interest. Development oftechnologies advancing production, handling and distribution/transportation of isotopes are encouraged. In addition, new approaches to in-hot-cell target fabrication technologies that will facilitate the recycle of precious target materials used in production of high purity radioisotopes are are of value.

Grant applications are also sought for new technologies to produce large quantities of enriched isotopes – both for enrichment of stable isotopes for production targets as well as isolation of radioactive or stable product isotopes as part of a production scheme. Isotopes of interest include kg to ton quantities of germanium-76 (^{76}Ge), selenium-82 (^{82}Se), tellurium-130 (^{130}Te) and xenon-136 (^{136}Xe), new production methods for grams quantities of transuranium elements such as californium-249 (^{249}Cf), californium-251 (^{251}Cf) and berkelium-249 (^{249}Bk), and mg quantities of einsteinium-254 (^{254}Es), and fermium-257 (^{257}Fm).These and other materials are needed for rare particle and rare decay experiments and heavy element creation in nuclear physics research. Guidance for research isotope priorities is provided in the NSACI report. http://science.energy.gov/np/nsac/). Novel methods are also sought for separation of stable isotopes that are needed in small quantities, as listed in the NSACI report.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

b. Improved radiochemical separation methods for preparing high-purity radioisotopes

Separation from contaminants and bulk material and purification to customer specifications are critical processes in the production cycle of an isotope. Many production strategies and techniques used presently rely on old technologies and/or require a large, skilled workforce to operate specialized equipment, such as manipulators for remote handling in hot cell environments. Conventional separation methods may include liquid-liquid extraction, column chromatography, electrochemistry, distillation or precipitation and are used to separate radioactive and non-radioactive trace metals from target materials, lanthanides, alkaline and alkaline earth metals, halogens, or organic materials. High-purity isotope products are essential for high-yield protein radiolabeling, for radiopharmaceutical use, or to replace materials with undesirable radioactive emissions. Improved product specifications and reduced production costs can be achieved through improvements in separation methods. Of particular interest are developments that automate routine separation processes in order to reduce operator labor hours and worker radiation dose, including radiation hardened semi-automated modules for separations or radiation hardened automated systems for elution, radiolabeling, purification, and dispensing. Such automated assemblies should be easily adaptable to different processes and hot cell use at multiple sites, including the DOE laboratories currently producing radioisotopes.

Although, PET-style equipment (cyclotrons and fluid target systems) using automated chemistry modules are increasingly available, they are generally underutilized. Employing this equipment to supplement commercial production of PET products with additional newer radioisotopes (e.g., Zr-89, Pb-203, Tc-94m), as well as, existing radioisotopes (e.g., I-124, Cu-64, I-111) would be a synergistic and efficient use of resources. Applications are sought for developing commercial methods similar to and compatible with existing commercial PET production method.

Applications are sought for innovative developments and advances in separation technologies to reduce processing time, to improve separations efficiencies, to automate separation systems, to minimize waste streams, and to develop advanced materials for high-purity radiochemical separations. In particular, the Department seeks breakthroughs in lanthanide and actinide separations. Incremental improvements are also encourage, such as (1) in the development of higher binding capacity resins and adsorbents for radioisotope separations to decrease void volume and to increase activity concentrations, (2) the scale-up of separation methods demonstrated on a small scale to large-volume production level, and (3) new resin and adsorbent materials with increased resistance to radiation, and with greater specificity for the various elements.

The following are some new strategies for radioisotope processing and separation technologies. In lanthanide radiochemistry, improvements are sought to a) prepare high-purity samarium-153 by removing contaminant promethium and europium; or b) to prepare high-purity gadolinium-148 and gadolinium-153 by ultra-pure separation from europium, samarium, and promethium contaminants. Sn-117m has gotten a lot of interest in the last few years. It has favorable nuclear properties for both imaging and therapy. However commercial quantities of the isotope at high specific activity are not available. Supply of commercial quantities of high specific activity Sn-117m would be of high interest. Re-186 has excellent nuclear properties for therapy and is chemically similar to Tc-99m which is widely used for diagnostic imaging. Therefore, Re-186 could be used as a therapeutic matched pair for currently available diagnostic imaging agents. However, high specific activity Re-186 is not available. So, alternative methods of production or mass separation to remove stable Re isotopes, which can provide commercial quantities of high specific activity Re-186 are highly desirable. In actinide radiochemistry, innovative methods are sought a) to improve radiochemical separations of or lower-cost approaches for producing high-purity actinium-225 and actinium-227 from contaminant metals, including thorium, radium, lead, lanthanides, and/or bismuth; or b) to improve ion-exchange column materials needed for generating lead-212 from radium-224, and bismuth-213 from actinium-225 and/or radium-225. The new technologies must be applicable in extreme radiation fields that are characteristic of chemical processing involving high levels of alpha-and/or beta-/gamma-emitting radionuclides.

Recent advances in translation and clinical trials of alpha-particle mediated therapies have focused attention on the production and purification of long lived parent radionuclides for radium-223 and lead-212 production. Regulatory approval for the treatment of metastatic bone cancer originating from advanced prostate cancer using radium-223 dichloride has been obtained from the US Food and Drug Administration and initial phase I clinical trials of lead-212-TCMC-Trastuzumab for treatment of HER-2 expressing carcinoma (e.g., ovarian, pancreatic, peritoneal), are currently being conducted in the US. However sufficient amounts of the parent isotopes are not available to support full clinical implementation. Innovative methods are sought for 1) the production of actinium-227 and thorium-228, 2) the purification of actinium-227 and thorium-228 from contaminating target materials and decay chain daughters, and 3) the generation of high specific activity radium-223 and lead-212 for clinical applications

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

c. Other

In addition to the specific subtopics listed above, the Department invites grant applications in other areas that fall within the scope of the topic description above.

Questions – contact Manouchehr Farkhondeh, Manouchehr.farkhondeh@science.doe.gov

References: Subtopic a:

1. For further specifications, contact Dr. Meiring Nortier of Los Alamos National Laboratory (meiring@lanl.gov) or Dr. Suresh Srivastava of Brookhaven National Laboratory (suresh@bnl.gov).

References: Subtopic b:

1. For further specifications, contact Dr. Saed Mirzadeh of Oak Ridge National Laboratory (mirzadehs@ornl.gov) or Dr. Leonard Mausner of Brookhaven National Laboratory (lmausner@bnl.gov).

References:

1. Nuclear Science Advisory Committee Isotopes Subcommittee (NSACI). (2009). Final Report: One of Two 2008 Charges to NSAC on the National Isotopes Production and Applications Program: Compelling Research Opportunities Using Isotopes. Available at http://science.energy.gov/~/media/np/pdf/NSACI_Final_Report_Charge1.pdf
2. J. Norenberg, P. Stapples, R. Atcher, R. Tribble, J. Faught & L. Riedinger. Report of the Workshop on The Nation's Needs for Isotopes: Present and Future. Rockville, MD. August 5-7, 2008. Available at http://science.energy.gov/np/research/idpra/workshop-on-the-nations-needs-for-isotopes-present-and-future/
3. Suresh C. Srivastava. (2012). Paving the way to personalized medicine: production of some promising theragnostic radionuclides at Brookhaven National Laboratory. Seminars in Nuclear Medicine. Vol. 42, Issue 3, pp. 151-163. Available for purchase at http://www.sciencedirect.com/science/article/pii/S0001299811001796