U.S. Department of Energy

Small Business Innovation Research (SBIR) and

Small Business Technology Transfer (STTR) Program

Topics

FY 2015

Phase I

Release 1

Version 3 July 22, 2014

Participating DOE Research Programs

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

Schedule

Event	Dates
Topics Released:	Monday, July 14, 2014
Funding Opportunity Announcement Issued:	Monday, August 11, 2014
Letter of Intent Due Date:	Tuesday, September 02, 2014
Application Due Date:	Tuesday, October 14, 2014
Award Notification Date:	Early January 2015*
Start of Grant Budget Period:	Late February 2015*

* Dates Subject to Change

Table of Changes		
Version	Date	Change
Ver. 1	July 14, 2014	Original
Ver. 2	July 18, 2014	Topic 18 subtopic c has been removed. The DOE SBIR/STTR Program will not accept grant applications to Topic 18 subtopic c.
Ver. 2	July 18, 2014	Point of Contact changed for Topic 2 subtopic e.
Ver. 3	July 22, 2014	Changes to description and references for Topic 13 subtopic c.
Ver. 3	July 22, 2014	Update of reference 5 for Topic 25 (All Subtopics).

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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 subawardee 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 DIGITAL NETWORK TECHNOLOGIES AND MIDDLEWARE 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

Advanced digital network technologies and middleware services play a significant role in the way DOE scientists communicate with peers and collect/process data. Optical networks operating at rates of more than 100 Gbps support the transfer of petabytes of data per day. These networks also peer with commercial networks allowing scientists remote access to instruments and facilities while also allowing citizens access to the data and knowledge that has been produced. Improvements in the tools and services used to manage and operate this infrastructure are needed to meet the needs of both network operators and users.

Scientific instruments and supercomputer facilities generate, consume, process, and store both raw and analyzed data enabling the discovery of new knowledge. Efforts are underway to scaling these computers to support extreme-scale computational science applications and to deal with increasing volumes and velocities of experimental and observational data. Optical components play a role in all parts of this system, ranging from chip-to-chip communications all the way up to wide area networks. Accelerating the development of optical components to meet the data movement needs of these instruments and computing facilities is a major challenge that this topic addresses. This topic also addresses the higher level middleware services and tools that are needed to turn raw data into actionable knowledge

This topic solicits proposals that address issues related to building, operating, and maintaining large digital network infrastructures, developing tools and services that report performance problems in a manner suitable for network engineers or application users, developing optical components that can be used to build digital networks or computer interconnect fabrics, or hardening middleware tools and services that deal with Big Data.

Grant applications are sought in the following subtopics:

a. Management Tools for Network Operators and Users

Operating modern digital networks presents many challenges for both the network operator and the users of those network services. New technologies, tools, or high-level services that promote a modular creation and use of detailed measurement and monitoring data will make it easier for network operators to manage their infrastructure. Data from these modular tools and services could also be used to 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.

perfSONAR (http://www.perfsonar.net) is an architecture developed by the Research and Education Network community for developing multi-domain measurement and monitoring services. Using this architecture engineers can develop tools and services that collect and store unique data values data archives. Other tools and services can leverage this archived data to analyze and display it in a manner that makes sense to the network operator or end user.

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 Components

Optical components and technologies have revolutionized all areas of digital communications. Wide-area network infrastructure deployments, providing ever-increasing amounts of bandwidth at ever-decreasing costs are now common around the globe. 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.

Information processing requirements and capabilities of high performance computing systems have grown dramatically over the past decade. This growth has been accompanied by the need for lower component costs and reduced energy consumption while maintaining the increased performance of such systems. Commercially available optical components and tools could provide an effective and scalable solution to building and operating future extreme-scale computers.

Grant applications are sought that address the emerging need for massive deployment of optical network and computer interconnect infrastructures. Issues include, but are not limited to: tools that decrease the cost of terminating or splicing optical cables; nanosecond solid state switching fabrics; semiconductor or silicon photonic devices and interconnects; reconfigurable optical converters or encoders; components to test optical signal quality; or components that operate at 100+ Gigabit per sec line rates.

Questions – contact: Robinson Pino, robinson.pino@science.doe.gov

c. Big Data Technologies

This subtopic focuses on the development of Big Data Technologies. The efficient and cost-effective technologies to collect, manage, and analyze distributed Big Data is a challenge to many organizations including the scientific community. Database management technologies based traditional relational and hierarchical database systems are proving to be inadequate to deal with Big Data complexities (volume, variety, and velocity), especially when applied to Big Data systems in science and engineering. The focus of this subtopic is on the development of cost-effective commercial grade technologies in the following categories:

- Big Data management software-enabling technologies–these include but are not limited to the development of software tools, algorithms, and turnkey solutions for complex data management such as NSQL to deal with unstructured data; visualization and data processing tools for unstructured multi-dimensional data, robust tools to test, validate, and remove defects in large unstructured data sets; tools to manage and analyze hybrid structured and unstructured data; Big Data security and privacy solutions; Big Data as a service systems; high-speed data hardware/software data encryption and reduction systems; and online management and analysis of streaming data from instruments or embedded systems

- Big Data Network-aware middleware technologies–These include high-speed network and middleware technologies that enable the collection, archiving, and movement of massive amounts of data within datacenters, data cloud systems, and over Wide Area Networks (WANs). This may include but is not limited to hardware subsystems such high-performance data servers and data transfer nodes, high-speed storage area network (SANs) technologies; network-optimized data cloud services such as virtual storage technologies; and other distributed Big Data solutions

Grant applications must ensure that the proposed work goes beyond traditional data management technologies by focusing one or more defining characteristics of Big Data (volume, velocity, and variety).

Questions – contact: Thomas Ndousse, thomas.ndousse-fetter@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: Graphene-Based Optical Modular

This graphene-based optical modulator opens a new path for optical communication. Compared with traditional devices, it could work at a few hundred of gigahertz, much faster than the present integrated devices with a record speed of 40GHz. Also, it can work at a broad wavelength range, from 400 nm up to far-infrared, while other devices are a few picometers to nanometers. Its small footprint (tens of microns) also gives it the potential to be integrated. The price of the device could also be low. All those features make the graphene-based modulator a device that could address a major portion of the optical modulator market.

Licensing Information:
Lawrence Berkeley National Laboratory
Contact: William Shelander (bshelander@lbl.gov; 510-486-4810)
TTO Tracking number: IB-3017 and 2011-018

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

f. Technology Transfer Opportunity: Collective Memory Transfer to Multi-Core Chips

The invention relies on a small hardware unit, which we call the collective memory scheduling (CMS) engine. That engine is responsible for transferring a plane of data as residing to the memory, and distributing slices of it to each processor. For example, the whole 3D space resides in main memory for the heat transfer simulations. As is standard practice to improve computation efficiency, each processor is assigned a title (a chunk) of that space to perform local computations. Processors receive a new tile at every iteration loop. Previously, each processor sent requests for its tile independently. With our invention, the CMS engine takes charge of this collective transfer and reads the memory sequentially, and sends data to the appropriate processor. The key is that memory is read in sequence because our CMS engine is aware of the collective transfer. There is a similar operation for when it is time for processors to store the data that resulted from their computation back to memory. The same CMS engine has a different functionality in that case, that still takes care of the collective transfer by retrieving data from each processor in memory address order. In both cases, memory address order is preserved perfectly, beyond that capable by alternative techniques. By doing so, we demonstrate a gain in memory performance (data per time) up to 39%, as well as a reduction in the energy required by memory to complete a single collective transfer by up to 2.2x. Therefore, we improve on all aspects of retrieving large amounts of data for a wide class of algorithms. The only assumption is regarding the class of algorithms that we use. Specifically, our invention applies only to algorithms that use many processors to compute on the same and vast data. However, this class of algorithms covers a wide variety of high performance computing applications.

Licensing Information:
Lawrence Berkeley National Laboratory
Contact: William Shelander (bshelander@lbl.gov; 510-486-4810)
TTO Tracking number: IB 2013-086

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

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7. ESnet's OSCARS: End-to-end bandwidth reservation systems. (http://www.es.net/services/oscars/).
8. Nimbus: An open source toolkit for Infrastructure-as-a-Service for clouds. (http://www.nimbusproject.org/files/nimbus-cern_June2009.pdf).
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/).

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. 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.

Application complexity, in both the development and execution phase requires a substantial in-house expertise to fully realize the benefits of the software tool or service. High capital equipment and labor costs can severely limit a company's ability to incorporate HPC into their development process. It should also be recognized that changes in HPC hardware including many-core, multi-core processors, GPU based accelerators, and multi-level memory subsystems have made a significant impact on the HPC systems performance and usability. Programming tools and services are required that can hide this hardware complexity without impacting performance.

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). In addition, grants applications that focus on HPC applications for the electric grid are encouraged. 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: Ceren Susut, ceren.susut-bennett@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, IDE extensions that simplify parallel programing for new hardware, 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: Sandy Landsberg, sandy.landsberg@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: Sandy Landsberg, sandy.landsberg@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: Ceren Susut, ceren.susut-bennett@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.

e. Technology Transfer Opportunity: CellSage

CellSage (aka Cell's Age) is an advanced research and development software tool that achieves in-depth battery cell and string performance characterization, as well as diagnostics and prognostics of aging mechanisms. At the heart of this tool is a robust scientific framework built upon the essential contributions from thermodynamics and chemical kinetics of degradation reactions, regarding each cell as a batch reactor that can experience multiple, yet arbitrary, aging parameters or stress factors that can vary over time. The general method under CellSage can be aimed at aging performance of numerous other systems outside the realm of electrochemistry, such as emerging technologies envisioned for prolonged service as well as natural processes. The focus of this topic is to convert CellSage from an expert-user-only scientific tool to one that is amenable to several applications and user levels such as installing user-friendly GUIs to reflect options toward the desired lines of inquiry and input/output options.

CellSage is supported by multiple patents and copyrighted materials. To date, no component of CellSage is restricted by exclusive license to outside parties.

Licensing Information:

Idaho National Laboratory
Contact: Ryan Bills (ryan.bills@inl.gov; 208-526-1896)
TTO Tracking number: BA-435, BA-436, BA-437, CW-10-10, CW-10-11, CW-10-12

Questions – contact: Ceren Susut, ceren.susut-bennett@science.doe.gov

References: Subtopic a:

1. "Minding the Missing Middle", HPCC Conference Summary, Newport, RI. March 31, 2011. (http://www.hpcwire.com/hpcwire/2011-03-31/minding_the_missing_middle.html).
2. "Making Digital Manufacturing Affordable", June 14, 2011. (http://www.digitalmanufacturingreport.com/dmr/2011-06-14/making_digital_manufacturing_affordable:_a_vendor_perspective.html).
3. "Digital Manufacturing, Why There's Never Been a Better Time". June 20, 2011. (http://www.enterprisetech.com/2011/06/20/digital_manufacturing_why_theres_never_been_a_better_time/)
4. "A National Strategic Plan for Advanced Manufacturing", February 2012. (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, April 2012. (http://www.economist.com/node/21552892).
6. "Special Report: What is SMART Manufacturing", Time Magazine, Accessed on Jun 13, 2013. (https://smart-process-manufacturing.ucla.edu/about/news/time-magazine-what-is-smart-manufacturing).
7. "Journal Report: Unleashing Innovation – Manufacturing", Wall Street Journal, June 11, 2013

References: Subtopic b:

1. "A Framework for a Regional Modeling, Simulation and Analysis Midwest Pilot Program for the Manufacturing Supply Chain", Council on Competitiveness Summit and Workshop, Chicago IL. September 14, 2010. (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 360, Champaign IL, October 6 2010. (http://www.hpcinthecloud.com/hpccloud/2010-10-06/robert_graybill_on_integrating_hpcs_missing_middle.html).

References: Subtopic c:

1. "US Manufacturing-Global Leadership through Modeling and Simulation" White Paper, Council on Competitiveness. March 2009. (http://www.compete.org/images/uploads/File/PDF%20Files/HPC%20Global%20Leadership%20030509.pdf).

3. HPC CYBERSECURITY

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

Important large scale and computationally intensive research and development applications rely on High Performance Computing (HPC) systems to enable new kinds of scientific discovery, productivity, competitive advantage, revenue growth, and efficiency. HPC centers and resources are designed to be easily accessible by users over a worldwide network, and securing the HPC infrastructure resources is an important task. An important challenge in HPC is how to enable security against malicious actions that could undermine trust in the computation by intentional manipulation of the result. Is it possible to determine whether an HPC simulation result has been tampered with or manipulated at any stage during computing? Organizations, administrators, developers, and users face an increasing challenge in ensuring computing resources are employed for their intended use and the results of the experiments or simulations can be trusted from the point of view that computations have not been intentionally tampered with. Therefore, it has become increasingly important to transition and apply effective cybersecurity tools and techniques that will ensure trust in HPC computing operations without significant impact to the scientific discovery mission such resources are intended to fulfil. An important metric in the delivery of potential solutions involves minimizing the new tools overhead to the system that are required to deal with the increasing amounts of data parallelism, concurrency, storage and retrieval, hardware heterogeneity, and how to report problems effectively. Security challenges can originate from a variety of sources such as hardware, operating system, compilers, runtime systems, applications, etc. In addition, various commonly used tools and application source code are open sourced and vulnerable to tampering. In addition, today there is a wealth of cybersecurity tools that provide security to the network, database, and host. Some of these existing tools could potentially be improved to help secure HPC resources.

This topic solicits proposals that address issues related to ensuring trust in the computational results and operation of HPC systems.

Grant applications are sought in the following subtopics:

a. Cybersecurity Tools for HPC Systems

HPC systems today are complex and increasingly heterogeneous where in order to increase the overall performance of scientific applications the trend has been to employ accelerators such as Graphics Processing Units (GPUs) and Field Programmable Gate Arrays (FPGAs). This subtopic is focused on the security and trust determination of HPC computing results. Proposals must clearly articulate how the proposed solution applies to DOE leadership-class HPC type systems.
The goal of this subtopic is to develop and deliver software tools or extensions, for example but not limited to HPC hardware or software, or cybersecurity security applications already employed in other domains

tailored to HPC systems. The result is a solution that will recognize when tampering has occurred and appropriately notify the user and/or system administrator. Any submitted proposal will be evaluated against the below additional review criteria:

- The technical approach provides adequate consideration for HPC resource utilization and allocation, and requires low overhead (time, code, memory, compute, I/O, storage, architecture heterogeneity, and retrieval)
- The proposed solution scales to current and future leadership-class computing systems
- The solution's output analysis and report stipulates whether or not tampering has occurred
- The delivered software will demonstrate high concurrency

Out of scope are proposals that include and are primarily focused on: Network-, host-, node-, handheld-, wireless-, hardware-, application-, and homogeneous architecture-based solutions; internet; cloud computing; quantum computing; algorithms research; natural language processing; social networks; encryption.

Questions – contact: Robinson Pino, robinson.pino@science.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: Robinson Pino, robinson.pino@science.doe.gov

References:

1. Report, "Security in HPC Centres," Partnership for Advanced Computing in Europe (Viewed on 6 June 2014). (http://www.prace-project.eu/IMG/pdf/wp79.pdf).
2. Alex Malin, Graham Van Heule, "Continuous monitoring and cyber security for high performance computing," Proceedings of the first workshop on Changing landscapes in HPC security (CLHS 13, New York City, June 18, 2013 pp. 9-14. (http://dx.doi.org/10.1145/2465808.2465810).
3. Eric Phipps, "Exploring Embedded UQ Approaches for Improved Scalability and Efficiency," UQ: Uncertainty Quantification for High-Performance Computing, May 2-4, 2012. (http://www.samsi.info/sites/default/files/phipps_hpc_may2012.pdf).
4. Report: "A Scientific Research and Development Approach To Cyber Security," December 2008 Submitted to The Department of Energy. (http://cps-vo.org/bitcache/eb8bb2080b5e2bf1d07ffd966d27e052f5c8b8bf?vid=12174&disposition=inline&op=view).

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 nanomaterials 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.

4. 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. Fast-Framing Hybrid Pixel Detectors

Time-resolved studies using Pump-Probe techniques or x-ray Photon Correlation Spectroscopy sometimes rely on fast-framing x-ray area detectors. This is particularly the case when the dynamical evolution being studied is non-reversible, or for some other reason not amenable to study in a stroboscopic way. Irreversible dynamics can occur in systems such as photo-, electrically and chemically initiated activity in proteins; phase transition and critical phenomena, laser-produced transitions in plasma, warm dense matter and matter under extreme conditions, and similar phenomena.

Although hybrid x-ray pixel detectors are fairly mature, there is great need for large-area, fast-framing, high-dynamic-range, and small-pixel detectors. Typical area detectors should have from several hundred thousand to a few million pixels. The detector should be sensitive to the single-photon level, in the range between 5 and 10 keV, and able to record images with a wide dynamic range, often more than 4 orders of magnitude. Pixel size on the order of 100 micron or smaller is required. The need for this type of detector is becoming especially acute for new Department of Energy's Scientific User Facilities, both continuous and pulsed, which are able to provide significantly more intense and coherent beams [1, 2].

Questions – contact: Eliane Lessner, eliane.lessner@science.doe.gov

b. Onboard Data Processing for Fast Detectors

Current and future state of the art detectors are generating hundreds to thousands of frames per second, and the resulting data rates are growing faster than network, storage, and analysis capabilities [1]. It therefore becomes essential to reduce the volume and complexity by processing the data inside the detector. Possible solutions include accelerators such as field-programmable gate arrays (FPGA) or general-purpose computing graphics processing units (GPGPU). The complexity of the data and diversity of experiments performed at user facilities require an easy to use and highly flexible framework for data processing while still maintaining high performance, a challenge for FPGAS and GPGPUS due to the steep learning curve required for their programming. We seek a solution to eliminate the low level programming required with such architectures. The solution must allow a fast and relatively user-friendly interaction with the processing architecture inside the detector. Scientists need to be able to change and develop analysis and processing tools in a user friendly environment and transfer the developed algorithms onto the detector without great prior knowledge of the exact processing units inside the detector.

Questions – contact: Eliane Lessner, eliane.lessner@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: Eliane Lessner, eliane.lessner@science.doe.gov

References: Subtopic a:

1. "Evolution and Control of Complexity: Key Experiments Using Sources of Hard X-Rays", ANL, Workshop Report, 2013. (http://www.aps.anl.gov/Science/Publications/Conference_Reports/Complexity%20Workshop%20Report%20ANL-13-11%202013.pdf).
2. "Neutrons and X-Ray Detectors", Report of the Basic Energy Sciences Workshop on Neutron and X-Ray Detectors, 2012. (http://science.energy.gov/~/media/bes/pdf/reports/files/NXD_rpt_print.pdf).

References: Subtopic b:

1. "Data and Communications in Basic Energy Sciences: Creating a Pathway for Scientific Discovery." Report of the Department of Energy Workshop "Linking Experimental User Facility Needs with Advances in Data Analysis and Communications," (June 2012).

5. 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. Advanced *In Situ* Thin Film Growth Monitors

As thin-film technology has advanced over the last several decades, the performance and breadth of application of thin-film based multilayer x-ray optical elements has greatly increased. Physical vapor deposition (PVD) processes that include sputtering, ion-beam assisted deposition, and related techniques remain the most widely used methods for production of thin-film x-ray optics. Two critical parameters during deposition are growth rate and film composition; especially during co-deposition of compound thin films or reactive sputtering. Multilayer optics require growth rate control and repeatability well into the sub - Å/s regime. The most advanced transmission-based multilayer optics (such as multilayer Laue lens) can take several days to deposit. The deposition rate over long time scales is affected by target erosion, environmental changes, and instrumentation repeatability. Commercially available growth monitors based on techniques such as quartz crystal microbalance, electron impact emission spectroscopy, atomic absorption spectroscopy (AAS), optical interferometry, and ellipsometry do not have sufficient performance for *in situ* use when fabricating multilayers with tens of 1,000's of layers and over 100µ total deposition thickness. Since these monitors cannot compete with the repeatability obtained by thoughtful deposition system design, iterative *ex situ* feedback is utilized. Due to the limited progress in the development of *in situ* growth monitors in recent years, especially when compared to *ex situ* metrology tools for thin film characterization, some of the aforementioned *in situ* techniques for monitoring film growth have not been explored to their full potential. In order to correlate the measured value to the actual growth rate on the substrate, the atomic (or molecular) deposition flux density should be sampled by a non-intrusive technique as close to the substrate surface as possible. Specifically; the AAS technique seems to meet most of the requirements, however, development is required to produce an instrument that is production worthy and ready for use with a wide variety of materials. AAS is susceptible to light-path intensity fluctuations due to the light source, window coating, and optical path changes. We seek proposals to develop an advanced film growth monitor that is non-intrusive, with very low long-term drift, high material specificity and sensitivity, fast response time, wide operating pressure range, robustness, production worthiness, and cost-effectiveness. It should show clear advantages over other currently available thin film growth monitors in terms of real-time control of thin film deposition processes. Specifically, we seek an instrument that is capable of measuring atomic (or molecular) flux density of (separately) silicon, aluminum, and metal-silicides (such as silicides of tungsten, molybdenum, and vanadium) at a speed of 0.5Hz or better.

Questions – contact: Eliane Lessner, eliane.lessner@science.doe.gov

b. Refractive Optics

Refractive optics [1] occupy a small but growing fraction of the optics used for hard x-ray photons (E > 4 keV) at synchrotron x-ray beamlines. A typical refractive optic is a specifically shaped lens material [2, 3, 4, 5, 6] of a given refractive index that imprints a desired phase profile on the x-ray beam that passes through the optic. For some materials it is possible to generate 3 dimensional profiles which can provide an x-ray point focus, for example the Be compound refractive lens [2]. For other materials, a 2 dimensional planar technology has proved feasible [3, 4, 5, 6], generating a line focus. The advantages of refractive optics include compactness, in-line utilization, stability, easy alignment, and coherence-preserving optic for modest demagnification. We anticipate increasing use at higher photon energies (E > 30 keV) and in high heat load sources such as Free Electron Lasers, or high power insertion devices. We solicit applications that will improve the materials and methods used in refractive lens fabrication. An important feature for lens material is the ability to imprint a designed profile precisely into the material. Other important features are smooth surfaces, a uniform refractive index and high x-ray transmissivity. Beryllium, Diamond, and Silicon are the most likely materials, but we do not exclude other materials. Of particular interest for this optics will be the problems associated with the high heat loads at 4th generation sources, including, but not limited to, experimental methods for creating reliable thermal junctions and the simulation of the thermal and optical performance of these optics.

Questions – contact: Eliane Lessner, eliane.lessner@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: Eliane Lessner, eliane.lessner@science.doe.gov

References: Subtopic a:

1. H. Yan, R. Conley, N. Bouet, Y. S. Chu. (2014) Hard x-ray nanofocusing by multilayer Laue lens. J. Phys. D: Appl. Phys. 47 263001. (http://m.iopscience.iop.org/0022-3727/47/26/263001).
2. Y. Kasai and S. Sakai. (1997). Atomic absorption spectroscopy system for flux monitoring and atomic-layer control of molecular beam epitaxial growth of BiSrCaCuO. Review of scientific instruments 68, no. 7, pp. 2850-2855. (http://scitation.aip.org/content/aip/journal/rsi/68/7/10.1063/1.1148207).
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References: Subtopic b:

1. Snigirev, V. Kohn, I. Snigireva, B. Lengeler. A compound refractive lens for focusing high-energy x-rays. Nature 384, 49-51 (1996). (http://www.nature.com/nature/journal/v384/n6604/abs/384049a0.html).
2. B. Lengeler, C. Schroer, J. Tümmler, B. Benner, M. Richwin, A. Snigirev, I. Snigireva, M. Drakopoulos. Imaging by parabolic refractive lenses in the hard x-ray range. J. Synchrotron Rad. Vol. 6, 1153-1167 (1999). (http://www.rxoptics.de/resrx/Lengeler_JSynchrotronRad_1999.pdf).
3. V.V. Aristov, M. Grigoriev, S. Kuznetsov, I. Shabelnikov, V. Yunkin, T. Weitkamp, C. Rau, I. Snigireva, A. Snigirev, M. Hoffmann, E. Voges. X-ray refractive planar lens with minimized

absorption. Appl. Phys. Lett. 77, 4058 (2000). (http://scitation.aip.org/content/aip/journal/apl/77/24/10.1063/1.1332401).

4. C. G. Schroer, M. Kuhlmann, U. T. Hunger, T. F. Günzler, O. Kurapova, S. Feste, F. Frehse, B. Lengeler, M. Drakopoulos, A. Somogyi, A. S. Simionovici, A. Snigirev, and I. Snigireva, C. Schug, W. H. Schröder. Nanofocusing parabolic refractive x-ray lenses. Appl. Phys. Lett. 82, 1485 (2003). (http://scitation.aip.org/content/aip/journal/apl/82/9/10.1063/1.1556960).
5. K. Evans-Lutterodt, J.M. Ablett, A. Stein, C.C. Kao, D.M. Tennant, F. Klemens, A. Taylor, A.C. Jacobsen, P.L. Gammel, S. Ustin, G. Bogart, L. Ocola. Single-element elliptical hard x-ray micro-optics. Optics Express 11, (8), 919 (2003). (http://www.opticsinfobase.org/oe/abstract.cfm?&uri=oe-11-8-919).
6. R. Menon, et al. (2005). Maskless lithography. Materials Today. Vol. 8, Issue 2, pp. 26-33. (http://www.sciencedirect.com/science/article/pii/S1369702105006991).

6. HIGH QUANTUM-EFFICIENCY PHOTOCATHODES

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 next generation light source user facilities. This topic seeks the development of models for high quantum efficiency photocathodes to support the light source user facilities.

Grant applications are sought in the following subtopics:

a. Modeling of High Quantum Efficiency Photocathodes

Fast and intense x-ray Free Electron Lasers, Energy Recovery Linacs (ERLs), and next generation light sources address diverse needs such as probing the electronic and magnetic structure of materials, imaging biomolecules, and following the dynamics of chemical reactions [1]. These light sources are enabled by high brightness photoinjectors which in turn place severe demands on the photocathodes that generate electron bunches [2, 3, 4]. Requirements on the pulse lengths and rise-fall times of the bunch, the charge they contain, and trade-offs between high quantum efficiency and low emittance [3, 5, 6] make modeling photoemission complex. An ability to predictively model photoemission and beam optics processes, particularly those targeting desktop platforms, that affect bunch dynamics is essential to accelerator design, as well as mechanisms such as ``dark current'' (field emission) that complicate emittance and space charge interactions that contribute to halo formation and beam degradation during acceleration through the gun and injector [7] for x-ray free electron lasers and other 4th generation light sources. The models should treat time-dependent (delayed) emission associated with high quantum efficiency photocathodes that because of space charge modify the pulse and emittance characteristics, and account for delayed emission [8, 9], submicron-scale geometric features contributing to emittance [10], and dark current effects. The manner the models do so should be compatible with predicting their effects on producing a high quality beam bunch of sufficient charge and with a specific shape. High fidelity models that preserve the details of the longitudinal and transverse phase space from which emittance is determined are emphasized so as to control emittance, energy spread, and beam growth over the length of the photoinjector and further through typical beam line accelerator elements such as steering coils, rf boosters, etc., in next generation light sources.

Questions – contact: Eliane Lessner, eliane.lessner@science.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: Eliane Lessner, eliane.lessner@science.doe.gov

References:

1. J. Feldhaus, M. Krikunova, M. Meyer, T. Möller, R. Moshammer, A. Rudenko, T. Tschentscher, and J. Ullrich, Journal of Physics B: Atomic, Molecular and Optical Physics 46, 164002 (2013). (http://stacks.iop.org/0953-4075/46/i=16/a=164002).
2. J. Feldhaus, J. Arthur, and J.B. Hastings, Journal of Physics B: Atomic, Molecular and Optical Physics 38, S799 (2005). (http://dx.doi.org/10.1088/0953-4075/38/9/023).
3. D.H. Dowell, I. Bazarov, B. Dunham, K. Harkay, C. Hernandez-Garcia, R. Legg, H. Padmore, T. Rao, J. Smedley, and W. Wan, Nucl. Instr. and Meth. A 622, 685 (2010). (http://dx.doi.org/10.1016/j.nima.2010.03.104).
4. C. Bostedt, J.D. Bozek, P.H. Bucksbaum, R.N. Coffee, J.B. Hastings, Z. Huang, R.W. Lee, S. Schorb, J.N. Corlett, P. Denes, P. Emma, R.W. Falcone, R.W. Schoenlein, G. Doumy, E.P. Kanter, B. Kraessig, S. Southworth, L. Young, L. Fang, M. Hoener, N. Berrah, C. Roedig, and L.F. DiMauro, Journal of Physics B: Atomic, Molecular and Optical Physics 46, (2013). (http://stacks.iop.org/JPhysB/46/164003).
5. I.V. Bazarov, B.M. Dunham, X. Liu, M. Virgo, A.M. Dabiran, F. Hannon, and H. Sayed, J. Appl. Phys. 105, (2009). (http://dx.doi.org/10.1063/1.3110075).
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7. J.J. Petillo, C. Kostas, D. Panagos, S. Ovtchinnikov, A. Burke, E. Wright, K. Nguyen, T. Antonsen, E. Nelson, B. Held, J. DeFord, K.L. Jensen, and B. Levush, Status of the MICHELLE Code and Applications to RF Guns, International Conference on Plasma Science (ICOPS) Chicago, IL, 2011). (http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=5993002).
8. S. Karkare, D. Dimitrov, W. Schaff, L. Cultrera, A. Bartnik, X. Liu, E. Sawyer, T. Esposito, and I. Bazarov, J. Appl. Phys. 113, 104904 (2013). (http://link.aip.org/link/?JAP/113/104904/1).
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10. K.L. Jensen, D.A. Shiffler, J.J. Petillo, Z. Pan, and J.W. Luginsland. Emittance, surface structure, and electron emission. Phys. Rev. ST Accel. Beams 17, 043402 (2014). (http://journals.aps.org/prstab/abstract/10.1103/PhysRevSTAB.17.043402).

7. INSTRUCTIONS 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 spectroscopy, (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 in the following subtopics:

a. Electron Microscopy and Spectroscopy

Electron microscopy and microcharacterization capabilities are important in 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 multidimensional imaging, diffraction, and spectroscopy with and without applied stimuli (e.g., temperature, stress, electromagnetic field, light, and gaseous or liquid environment).

New electron sources that can generate significantly brighter electron beams than currently available: Particular interests include field emission electron beam in pulsed mode operation or modulated at high-frequencies (>GHz), and photocathode electron source as a single purpose apparatus for time-resolved diffraction and imaging 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 (1 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 fast 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 include (1) hardware and platform-independent software for data collection and visualization, (2) compressive sensing and related low-signal-to-noise-ratio data reconstruction algorithms, (3) automated measurement and mapping of crystallography, internal magnetic or electric field, or strain, and (4) 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 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 nanooptical 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/).
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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).
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8. 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.

Grant applications are sought in the following subtopics:

a. Specialty Steels and Alloys

Grant applications are sought to develop improvements in radiation-resistant, high-temperature steels and alloys with practical applications for Generation IV reactor systems, such as high-temperature gas- or liquid-cooled systems at 400-850°C. In general, this will be interpreted to mean that those materials which have improved creep strength can be formed and joined, are compatible with one or more high-temperature reactor coolants, and could reasonably be expected to eventually receive ASME Section III qualification for use in nuclear construction.

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

b. Ceramic Composites

Grant applications are sought to develop improved design and fabrication methods targeted at reducing cost and/or allowing joining of nuclear-grade SiC-SiC composites that can be used in the Generation IV gas-cooled and liquid fluoride salt-cooled reactors at temperatures up to 850°C. Additional consideration will be given to proposals for SiC-SiC materials and forms that are also compatible for use as fuel cladding.

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. (http://energy.gov/sites/prod/files/NuclearEnergy_Roadmap_Final.pdf).
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3. Generation IV Nuclear Energy Systems. U.S. DOE Office of Nuclear Energy, Science and Technology. (http://nuclear.energy.gov/genIV/neGenIV1.html).
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9. MATERIALS FOR ENHANCED SOLID STATE LIGHTING

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:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

Wide bandgap (WBG) semiconductor materials such as silicon carbide (SiC), gallium nitride (GaN), zinc oxide (ZnO) and diamond (C) offer the opportunity for dramatic performance and efficiency improvements in a variety of important products needed for energy relevant and environmentally-friendly applications of DOE interest including power electronics, solid-state lighting and fuel cells. Advancements in electric organic materials used to economically manufacture Organic Light Emitting Diodes (OLEDs) have also produced remarkable improvements in device performance, lifetime and stability since the initial introduction of white phosphorescent devices two decades ago. Advanced materials systems such as certain rare earth phosphors, activators, quantum dots and other engineered structures contribute to the efficient production of application-specific spectra and are used in both inorganic and organic solid-state lighting architectures. Despite these significant advancements, a number of technical hurdles remain and are the subject of the following broad basic and applied research topics with significant commercialization potential. Much more technical, market and commercialization information is available in various technical reports and roadmaps that are all available for download at http://www1.eere.energy.gov/buildings/ssl/.

Grant applications are sought in the following subtopics:

a. Efficiency and Performance Advancements in III-V Nitride Light Emitting Diodes

Impressive gains in wide bandgap (WBG) semiconductor technology has yielded important advancements in device performance and efficiency especially in high temperature, high current, high frequency devices. Similar technology advancements with common materials systems like gallium nitride (GaN) alloys have allowed devices made using WBG materials and manufacturing methods such as Light Emitting Diodes (LEDs) to operate at higher temperatures and current densities making energy efficient LEDs a practical reality for general illumination applications in American buildings and in fact, worldwide. Despite these significant technological advancements however, these epitaxially-grown crystalline materials continue to exhibit efficiency limiting properties such as droop and various nonradiative loss mechanism that are not completely understood even today.

The intent of this topic is to encourage innovative approaches or solutions that will enable GaN LEDs to perform at their theoretically predicted maxima in the long run and the aggressive device performance goals established by the DOE in the Solid-State Lighting (SSL) Multi-Year Program Plan (MYPP) available for download at http://www1.eere.energy.gov/buildings/ssl/. Responsive proposals must succinctly address one or more of the key R&D challenges described fully in the SSL MYPP. Innovations that address manufacturing technology and cost of LEDs while simultaneously addressing the fundamental materials challenges as they pertain to general illuminations applications will be especially welcome. The key metric for judging responsiveness of all proposals however, will be commercialization potential and the prospect of making a lasting and positive impact on the rapidly evolving SSL industry resulting in better quality LEDs at reduced cost. Proposals that include technical risk are encouraged provided they articulate a viable plan to retire such risk during the Phase I period of performance with appropriate proof of principle demonstrations. Projects that result in important intellectual property are especially valuable as they may provide future funding avenues beyond SBIR-STTR programmatic limits. Proposals that address other device end uses or WBG materials systems may be the subject of other topics in this FOA and only those proposals that clearly and unambiguously target SSL will be considered here.

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

b. Materials and Device Innovations in Organic Light Emitting Diodes

Organic Light Emitting Diodes (OLEDs) have evolved with remarkable progress since the initial introduction of white phosphorescent designs over 20 years ago. Today, practical OLED materials systems have demonstrated very high internal efficiencies (>80%) with the production of uniform, brilliant white light of excellent color quality and spectrum. Laboratory devices routinely demonstrate small pixel efficiency in excess of 90 lumens per watt and with CRI > 92. Like many other electronic organic materials systems that are popular today, a number of technical hurdles remain and overcoming these challenges is the focus of this topic.

The DOE's Solid-State Lighting (SSL) Multi-Year Program Plan (MYPP) available for download at http://www1.eere.energy.gov/buildings/ssl/ describes a number of high priority research and development challenges that are thought to limit the practical application of these materials to general illumination applications. Among the highest priority areas for research are performance limiting issues associated with electrode materials and light extraction from the device. Solutions should be low cost, easily manufactured and enable highly efficient light extraction. Applicants responding to this topic are encouraged to propose solutions that advance the state-of-the-art technology, price and performance goals without compromising other attributes such as manufacturing ease or compatibility with existing manufacturing lines.

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

References:

1. Solid-State Lighting Research & Development Multi-Year Program Plan. Prepared for Lighting Research and Development Building Technologies Program at the Department of Energy. April, 2014. (http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_mypp2014_web.pdf).
2. 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).
3. 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. May, 2013. (http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl-led-roundtable-summary_2013.pdf).

10. INSTRUCTIONS 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 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 – contact: Larry Rahn, larry.rahn@science.doe.gov

b. Time-Resolved Chemical Information from Hybrid Probe Microscopies

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 – contact: 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 – contact: Larry Rahn, larry.rahn@science.doe.gov

References:

1. Basic research for chemical imaging. BES Chemical Imaging Research Solicitation. (FY 2006). (http://science.energy.gov/~/media/grants/pdf/foas/2005/DE-FG01-05ER05-30.pdf).
2. Visualizing Chemistry, The progress and Promise of Advanced Chemical Imaging, National Academies Press. 2006. (http://www.nap.edu/catalog.php?record_id=11663).

11. 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 ultrashort x-ray pulses.

Questions – contact: Gregory Fiechtner, gregory.fiechtner@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: Gregory Fiechtner, gregory.fiechtner@science.doe.gov

References:

1. G. Fleming (2007). Directing matter and energy: five challenges for science and the imagination. Basic Energy Sciences Advisory Council, US Department of Energy. (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. H.C. Apteyn et al. (2005). Extreme nonlinear optics: coherent x-rays from lasers. Physics Today. Vol. 58, Issue 39. (http://physicstoday.org/journals/doc/PHTOAD-ft/vol_58/iss_3/39_1.shtml).
4. K.T. Phuoc et al. (2005). Laser-based synchrotron radiation. Physics of Plasmas 12. (http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1007&context=physicsumstadter).
5. J. Seres et al. (2005). Laser technology: source of coherent kiloelectronvolt x-rays. Nature. Vol. 433, Issue 596. (http://www.nature.com/nature/journal/v433/n7026/abs/433596a.html).
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11. T. Popmintchev, M.-C. Chen, P. Arpin, M. M. Murnane and H. C. Kapteyn. (2010). The attosecond nonlinear optics of bright coherent x-ray generation. Nature Photonics. Vol. 4, 822-832. (http://www.nature.com/nphoton/journal/v4/n12/full/nphoton.2010.256.html).

12. 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 systems 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 and/or sustainably availing of validated computational approaches that span vast differences in time and length scales.

- Commercially viable transitioning and/or sustainably availing 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 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:

1. Materials Genome Initiative for Global Competitiveness. National Science and Technology Council. June 2011. (www.whitehouse.gov/sites/default/files/microsites/ostp/materials_genome_initiative-final.pdf).
2. G. Galli & T. Dunning (2010). Discovery in Basic Energy Sciences: The Role of Computing at the Extreme Scale. Scientific Grand Challenges. (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. (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).

13. 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:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

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 sought in the following subtopics:

a. 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). Catalytic systems or processes should be novel and innovative to be considered responsive to this solicitation. Cellulosic ethanol production will not be considered responsive to the solicitation. Process economics will have to be considered, and for a commercially viable process, the application's catalytic conversion process economics would have to be on 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: Mark Elless, mark.elless@ee.doe.gov

b. Hydrocarbon Fuels and Products from Aqueous Biomass Intermediate Streams

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. To be considered responsive to this solicitation, novel and innovative 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: Mark Elless, mark.elless@ee.doe.gov

c. Non-Platinum Group Metal Catalysts for Fuel Cells

DOE is seeking novel transformative research and development (R&D) of next generation non-platinum group metal (non-PGM) catalysts for the following applications:

- Next generation ORR catalysts for alkaline membrane fuel cells (AMFCs) that go beyond conventional metallic catalysts and supported metals
- Hydrogen oxidation reaction (HOR) catalysts for AMFCs
- Bifunctional oxygen evolution reaction (OER)-ORR catalysts for reversible PEMFCs and reversible AMFCs.

To be considered responsive, any catalyst proposed must be completely free of PGMs and other precious elements. The DOE Fuel Cell Technologies Office already has an active PEMFC cathode R&D program, so to be considered novel and innovative, any PEMFC catalysts proposed must be capable of bifunctional (OER-ORR) operation. Applicants should address the ability of the proposed technology to meet technical targets and satisfy identified R&D needs. Status and R&D needs for AMFCs [1] and for reversible fuel cells [2] were identified at two workshops held in 2011. 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, and structural degradation or other mechanisms of deactivation, leading to novel strategies to extend electrode durability.

Questions – contact: Jacob Spendelow, jacob.spendelow@hq.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: Tina Kaarsberg, tina.kaarsberg@ee.doe.gov

References: Subtopic a:

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/).

References: Subtopic c:

1. Alkaline Membrane Fuel Cell Workshop. (http://energy.gov/eere/fuelcells/alkaline-membrane-fuel-cell-workshop).
2. Reversible Fuel Cells Workshop. (http://energy.gov/eere/fuelcells/reversible-fuel-cells-workshop).

14. 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:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

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 key to highly pure hydrogen. Material behavior associated with the detection of some contaminants at accuracies of parts per billion (ppb) (in order to provide hydrogen fuel purity that at less than parts per billion levels of contaminants is examined. Finally, conductor materials that promise 50% or more improvement in energy efficiency are examined.

Grant applications are sought in the following subtopics:

a. High Selectivity Membranes

This subtopic is focused on the advancement of manufacturing processes that are able to produce membranes with exceptional selectivity for separations. High performance membranes offer the potential to provide game-changing process energy advances. In principle, a series of membranes of sufficient selectivity could separate air into its raw components of N_2, O_2, Ar, CO_2, Ne, and He for significant energy savings in a wide range of chemical and combustion processes [1, 2], and for greenhouse gas reduction. In desalination, a rate increase of 2-3 orders of magnitude over reverse osmosis is projected for a system with not only controlled pore size but also engineered pore edge composition [3].

We seek grant applications to advance scalable technologies that provide order-of-magnitude increments over the performance of current industrial separation processes. The focus of the application must be on improvements in uniformity of pore size distribution, composition, and structure for enhanced selectivity. Consideration should be given to addressing the other barriers cited in this topic: fouling, instability, flux, durability, and cost. The choice of membrane material should be appropriate to the target separation in a commercial setting. Target separations with high energy impact are preferred. As a deliverable, a minimum of 50% energy savings over separations in current commercial practice shall be demonstrated through the manufacture of exemplar parts or materials, with sufficient experimental measurements and supporting calculations to show that cost-competitive energy savings can be achieved with practical economies of scale. The application should provide a path to scale up in potential Phase II follow on work.

Questions – contact: David Forrest, david.forrest@hq.doe.gov

b. Understanding of Material Behavior for Detection of Hydrogen Contaminants

Improved scientific underpinning is needed to understand material behavior associated with the detection of some contaminants at accuracies of parts per billion (ppb). To enable the successful deployment of Fuel Cell Electric Vehicles (FCEV) hydrogen purity at fewer than parts per billion levels of contaminants needs to be ensured. This new understanding needs to lead to a cost effective device that will in real time detect contaminants as specified in SAE J2719 Hydrogen Fuel Quality for Fuel Cell Vehicles. This is a particularly challenging physical environment. The operating environment can be as extreme as pressures on the order of 100 MPa and temperatures between 230 and 360 K.

Grant applications are being sought to develop improved scientific understanding leading to new materials or technologies through basic research. This new scientific understanding needs to lead to the development of a ppb level real time hydrogen contaminant detection system.

In Phase I, the applicant must demonstrate improved understanding of material behavior and/or a new material that will lead to the development of a technology that can meet fuel quality requirements of SAE J2719 in the physical environment of up to 100MPa and a temperature range between 230 and 360 K. The system response time needs to be on the order of 30 sec making it applicable to real time applications. Phase I must provide a candidate (material or system) that meet the following performance requirements:

- Robust and stable over potential range of pressures (up to 100 MPa) and temperatures between 230 to 360 K found fueling station requirements;
- Reasonable cost compared to the overall cost of the station;
- Does not adversely affect fuel quality and fuel cell performance outlined in the SAE J2719 standard;
- Detection of contaminates must meet a response time of less than 30 seconds.

Questions – contact: Will James, charles.james@hq.doe.gov

c. High Performance Conductors for Energy Efficiency

This subtopic is focused on methods to dramatically increase (+50%) the thermal and electrical conductivity of commercial metals for advanced applications. Electrical and thermal conductivity are thermophysical properties of metals that play key roles in the energy efficiency performance of many applications. In general, we seek to increase both conductivities subject to competing material requirements such as strength and oxidation resistance. There are several new approaches that have seen mixed degrees of technical success but no significant commercial inroads due scientific and technical challenges affecting cost or scalability:

- nanocarbon infusion processes
- multifunctional metal/polymer composites,
- aluminum with severe plastic deformation, and
- metal matrix composites.

Specific challenges include minimizing defects that reduce conductivity in the highly conductive material and establishing a high quality interface between the metal and high conductivity material (such as carbon nanotubes) in metal matrix composites [1-4]. Potential savings from these new approaches include:

- Aluminum made with these processes so as to have high electrical conductivity and high strength provides energy efficiency savings from reduction of electric transmission losses (saving 0.2-0.4 quads), reduction of total ownership costs in high voltage power transmission lines, and replacement of copper for wiring and motor light weighting in certain aircraft and automotive systems.
- Copper made with these processes to have high electrical conductivity and high strength provides potential savings from increasing the efficiency of electric motors and light weighting the motors in aircraft and automobiles.
- Steels and superalloys made with these processes to have high thermal conductivity would increase the performance of heat exchangers and thus improve the efficiency of high temperature processes (including power generation) and reduce material requirements.

Grant applications are sought to advance scalable technologies in these areas that provide at least a 50% improvement over the performance of commercial metal conductors. The improvement can be in either electrical conductivity or thermal conductivity measured on a volumetric or weight basis. The choice should be appropriate to the target component in a commercial setting. Consideration should be given to addressing all aspects of the materials design at the system level (cost, corrosion and oxidation resistance, joining and fabrication procedures, strength, fatigue, hardness, ductility). Industrial uses of the enhanced conductors that will result in high energy impact are preferred. As a deliverable, in Phase I, the path to a minimum of 50% energy savings in service over current commercial practice must be demonstrated. The pathway should include demonstrating the manufacture of exemplar components or materials, with sufficient experimental measurements and supporting calculations to show that cost-competitive energy savings can be achieved with practical economies of scale. The application should provide a path to scale up in potential Phase II follow on work.

Questions – contact: David Forrest, david.forrest@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: David Forrest, david.forrest@hq.doe.gov

References: Subtopic a:

1. Assanis, et al., "Study of Using Oxygen-Enriched Combustion Air for Locomotive Diesel Engines," J. Eng. Gas Turbines Power, 123(1), 157-166 (Mar 16, 2000). (http://gasturbinespower.asmedigitalcollection.asme.org/article.aspx?articleid=1421153).
2. E Kurunov and M. P. Beresneva, "Effect of Enriching the Blast with Oxygen on the Production Cost of Pig Iron," Metallurgist, Vol. 43, Nos. 5-6, 217-220 (1999). (http://download.springer.com/static/pdf/39/art%253A10.1007%252FBF02466966.pdf?auth66=1405093161_9dc2d19915dff70ab26ab135d6813ef9&ext=.pdf).
3. David Cohen-Tanugi and Jeffrey C. Grossman, "Water Desalination across Nanoporous Graphene," Nano Letters, 12 (7), 3602-3608, (2012). (http://www.researchgate.net/publication/225271824_Water_Desalination_across_Nanoporous_Graphene).

References: Subtopic b:

1. SAE-2719 – "Hydrogen Fuel Quality for Fuel Cell Vehicles" September 2011. Development and Demonstration Plan, Section 3.1: Hydrogen Production. 2012. (http://standards.sae.org/j2719_201109/).

References: Subtopic c:

1. Ullbrand, et al., "Thermomechanical properties of copper–carbon nanofibre composites prepared by spark plasma sintering and hot pressing," Composites Science and Technology, 70 (2010) 2263–2268. (http://www.researchgate.net/publication/236256574_Thermomechanical_properties_of_copper-carbon_nanofibre_composites_prepared_by_spark_plasma_sintering_and_hot_pressing).
2. Guangyu Chai, Ying Sun, Jianren Sun and Quanfang Chen, Mechanical properties of carbon nanotube copper nanocomposites, J. Micromech. Microeng. 18 (2008). (http://m.iopscience.iop.org/0960-1317/18/3/035013).
3. Uddin, et al., "Effect of size and shape of metal particles to improve hardness and electrical properties of carbon nanotube reinforced copper and copper alloy composites," Composites Science and Technology, 70 (2010) 2253–2257. (http://www.sciencedirect.com/science/article/pii/S0266353810002691).

4. Liu, et al., "Tensile Strength and Electrical Conductivity of Carbon Nanotube Reinforced Aluminum Matrix Composites Fabricated by Powder Metallurgy Combined with Friction Stir Processing," J. Mater. Sci. Technol., 1-7, 2014. (http://www.sciencedirect.com/science/article/pii/S1005030214000747).

15. 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:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

For the foreseeable future, the energy needed to sustain economic growth will continue to come largely from hydrocarbon fuels. Advanced Fossil Energy technologies must allow the Nation to use its indigenous fossil energy resources more wisely, cleanly, and efficiently. These include R&D activities required to reduce the capital and operating cost and to meet zero emission targets in power systems (e.g., turbines, fuel cells, hybrids, novel power generation cycles), coal conversion (e.g., gasification) and beneficiation, advanced combustion (e.g., oxy-combustion, chemical looping, ultra super critical steam), hydrogen & fuels, and beneficial re-use of CO_2. 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. The topic serves as a bridge between basic science and the fabrication and testing of new technologies. Small scale applications, such as residential, commercial and transportation will not be considered. Generally, electrochemical (SOFC excepted), microwave and plasma processes will not be considered due to high energy requirements. Applications determined to be outside the mission or not mutually beneficial to the Fossil Energy and Basic Energy Sciences programs will not be considered.

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. Surface-Functionalized Powders for Solid Oxide Fuel Cell Cathodes

Research has shown that controlling the surface morphology of Solid Oxide Fuel Cell (SOFC) cathodes can improve their electrochemical performance and stability. This has been demonstrated by infiltrating materials into porous cathodes followed by thermal treatments. It may be possible to bypass the infiltration step and synthesize electrode powders that, when sintered, form a similar, surface-tailored architecture directly. As an example, it has been shown repeatedly that alkaline-earth elements surface segregate in most of the state-of-the-art cathode materials. These elements are initially in solid solution, as synthesized, and then naturally surface segregate during fabrication and/or operation conditions. Similarly, core-shell particles have been designed for other catalytic applications to have a stable bulk "core" with an active surface "shell". While it is recognized that the ideal surface termination has not been identified yet, many materials have shown substantial promise and such a processing innovation would enable materials currently under investigation to be seamlessly integrated with industrial manufacturing routes. Promising surface include, but are not limited to, the following: Lanthanum Strontium Manganese oxide (LSM), Lanthanum Strontium Cobalt oxide (LSC), and doped cerium oxide.

Research and development is sought to develop cathode powders that can be used as a drop-in replacement for state-of-the-art cathode fabrication processes yet result in surface-tailored electrode microstructures. The powder technology should be amenable of replacing or augmenting SOFCs based on composites LSM + Yittria-stabilized Zirconia (YSZ) and Lanthanum Strontium Iron Cobalt Oxide (LSCF) + doped cerium oxide. These structures and their electrochemical performance must be stable for greater than 40,000 hours, under load, at high temperature. Grant applications should include a description of how an anticipated structure will lead to enhanced performance and have sufficient analysis of the proposed manufacturing process to evaluate potential cost and complexity. In particular, evaluations of structural and performance stability over extended periods of time are encouraged.

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

c. CO_2 Use and Reuse

As CCS technologies have advanced, the concept of CO_2 utilization has attracted more interest due to the potential of CO_2 as a useful commodity chemical. Aligning the use of CO_2 with existing industrial centers and operations seems most appropriate considering that the volumes of CO_2 would be relatively small, compared to power plant operation, and could be complimentary to existing operations or for production of new chemicals. CO_2 can serve as a relatively inexpensive raw material and could offset to production of other chemicals, reducing the overall carbon footprint.

Grant applications are sought for the development or enhancement of novel technologies that support DOE's goals to reduce carbon emissions at a relative cost below $40 per tonne of CO_2. It is expected that the revenue generated from these novel utilization processes may result in positive revenue. For this release, the approaches of interest are for technologies which yield high-value products via catalytic processes and can be integrated with existing industrial operations. Preference will also be given to applications that have the potential to be economically viable based on the value of the products produced, considering the existing market for these products. Additionally, the proposal should include a preliminary, high level life cycle analysis to demonstrate that the proposed technology will not create more CO_2 than is utilized and/or show that the CO_2 emissions are less than the process that it would replace.

DOE is currently supporting multiple small- and large-scale R&D projects to demonstrate the technical and economic feasibility of CCS. While advances have been made to reduce the cost of implementation, cost remains a primary concern. Recent studies support the approach that CO_2 utilization should focus on identifying technologies and opportunities that assist in reducing CO_2 capture costs as a means to accelerate industrial-scale implementation of geologic storage. Consequently, technologies that support this approach are of particular interest.

Questions – contact: Danielle Petrucci, danielle.petrucci@hq.doe.gov

d. Exploration of High-Entropy Alloys for Turbine Applications

High-entropy alloys (HEAs) have potential to be used as high temperature materials and in coating material applications due to their combination of strength, ductility, thermal stability, corrosion and wear resistance. The term “high entropy alloys” typically refers to alloys that are comprised of five or more elements, at or near equi-atomic composition, that form simple solid solution alloys on simple underlying lattices such as face-centered cubic and body-centered cubic. The basic principle behind HEAs is that solid-solution phases are relatively stabilized by their significantly high entropy of mixing compared to intermetallic compounds, especially at high temperatures. This makes them feasibly synthesized and manipulated to result in possible compositions and combinations of properties in the HEA field. Due to these considerations, HEAs are considered candidates for structural materials in turbine applications that can withstand higher operating temperatures while at the same time maintaining stability, environmental resistance and mechanical properties.

Grant applications are sought to explore and design high entropy alloys for high temperature and pressure gas turbine applications. Approaches of interest include, but are not limited to:

- alloy development and thermomechanical treatments to tailor the phase constitution and the microstructure in obtaining candidate HEAs that outperform current state-of-the-art alloys that are used for turbine blades and vanes

- fundamental understanding or theoretical modeling of high-entropy alloy (HEA) processing, microstructures, and mechanical (e.g. fatigue, creep), environmental (e.g. oxidation, hot corrosion) and physical properties, as well as long term stability and manufacturing capability for turbine applications.

- development of HEA bond coat compositions for thermal barrier coating systems

Questions – contact: Robin Ames, robin.ames@netl.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. (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. (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 Catalysis A. General, Volume 452, pp. 147-154, 15 February 2013. (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. (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. (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 Ni_xAlBEA and Ni_xSiBEA zeolite catalysts in partial oxidation of methane: influence of zeolite dealumination and Ni incorporation. Lodz University of Technology, Institute of General and Ecological Chemistry. (https://nam.confex.com/nam/2013/webprogram/Paper8940.html).
7. Girish Srinivas, Michael V. Mundschau, Jeffrey Martin & Steven Gebhard. (2013). Syngas-to-ethanol using homogeneous catalysis. TDA Research, Inc., Golden, CO. June 2013. (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. (https://nam.confex.com/nam/2013/webprogram/Paper7708.html).

References: Subtopic b:

1. Enhancing Cathode Performance & Stability through Infiltration, Meilin Liu, SECA Workshop 2012. (http://www.netl.doe.gov/publications/proceedings/12/seca/pdf/Wed%20AM/M%20Liu_GT_2012-07-25_SECA%20Workshop.pdf).
2. Tim T. Fister, Dillon D. Fong, Jeffrey A. Eastman, Peter M. Baldo, Matthew J. Highland, Paul H. Fuoss, Kavaipatti R. Balasubramaniam, Joanna C. Meador, and Paul A. Salvador "*In situ* characterization of strontium surface segregation in epitaxial La0.7Sr0.3MnO3 thin films as a function of oxygen partial pressure", Applied Physics Letters, 93, 151904 (2008). (http://scitation.aip.org/content/aip/journal/apl/93/15/10.1063/1.2987731).
3. Seungho Lee, Hwa Seob Song, Sang Hoon Hyun, Joosun Kim, Jooho Moon, "LSCF–SDC core–shell high-performance durable composite cathode", Journal of Power Sources 195 (2010) 118–123. (http://www.sciencedirect.com/science/article/pii/S0378775309011513).

4. P.A.J. Bagot, H.J. Kreuzer, A. Cerezo, G.D.W. Smith, "A model for oxidation-driven surface segregation and transport on Pt-alloys studied by atom probe tomography" Surface Science, Volume 605, Issues 15–16, August 2011, Pages 1544–1549. (http://www.sciencedirect.com/science/article/pii/S0039602811002160).

References: Subtopic c:

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2. Howard Herzog, Elisabeth Drake, and Eric Adams. CO2 Capture, Reuse, and Storage Technologies for Mitigating Global Climate Change. January 1997. (https://sequestration.mit.edu/pdf/WhitePaper.pdf).
3. CO_2 Utilization Focus Area. (http://www.netl.doe.gov/research/coal/carbon-storage/research-and-development/co2-utilization).

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1. U.S. Department of Energy. (2006). The Gas Turbine Handbook. Section 4.1.1-3. (http://www.netl.doe.gov/research/coal/energy-systems/turbines/reference-shelf/handbook).
2. Daniel B. Miracle, Jonathan D. Miller, Oleg N. Senkov, Christopher Woodward, Michael D. Uchic and Jaimie Tiley, "Exploration and Development of High Entropy Alloys for Structural Applications", Entropy, 16 (2014), 494-525. (http://www.mdpi.com/1099-4300/16/1/494).
3. Yong Zhang, Ting Ting Zuo, Zhi Tang, Michael C. Gao, Karin A. Dahmen, Peter K. Liaw, and Zhao Ping Lu, "Microstructures and properties of high-entropy alloys" Progress in Materials Science, 61 (2014), 1–93. (http://ac.els-cdn.com/S0079642513000789/1-s2.0-S0079642513000789-main.pdf?_tid=3f1e29f8-07a2-11e4-9a35-00000aacb361&acdnat=1404935595_5bd248125379cee5ef5b24fc1c08d8a0).

16. 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:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

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 and natural gas recovery systems. Areas considered include research and technology issues and opportunities for carbon storage, including, geologic storage, monitoring, verification, and accounting, enhanced oil recovery and residual oil zone production using CO_2, advanced simulation and risk assessment, and CO_2 separation . In addition, efforts on enabling technology (e.g., sensors and controls) energy conversion, water issues, advanced modeling and simulation materials critical to the implementation and optimization of fossil power and recovery systems are included. The topic serves as a bridge between basic science and the fabrication and testing of new technologies. Small scale applications, such as residential, commercial and transportation will not be considered. Applications determined to be outside the mission and scope or not mutually beneficial to the Fossil Energy and Basic Energy Science programs will not be considered.

Grant applications are sought in the following subtopics:

a. Novel Mitigation Technologies to Prevent CO_2 Release from Geologic Storage

Mitigation is a key technology that addresses the need to prevent and correct any potential release of CO_2 from its intended geologic storage reservoir. Permanent CO_2 storage relies on the presence of a confining zone that will trap the CO_2 for millennia. Wellbores and natural geologic features, including faults and fractures, could become release pathways for CO_2 to migrate to the surface or into underground formations. Research is needed to develop methods to seal these potential release pathways. Grant applications are sought to develop novel methods, such as nanocomposites and other materials, for permanent mitigation of release pathways.

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. The objective is to increase the efficiency of resource recovery on a per well basis or reduce the volume of fresh water required to produce a unit volume of natural gas. For example, research could include quantitative assessments of the practical and economic limits and potential benefits (if any) of employing mixtures of natural gas (not LPG as is currently practiced) with conventional sand-laden fracturing fluids, as a novel fracturing fluid to partially replace water in the large volume, multiple stage hydraulic fracturing treatments representative of those being applied in shale gas and shale oil plays today.

Examples of analyses could include laboratory experiments and/or computer simulations that quantify the effect on relative permeability to gas in a producing wellbore when mixtures of conventional fracturing fluids and natural gas (versus fracturing liquids only) are employed as fracturing fluids under conditions representative of major shale gas plays. Research could characterize the potential volumes and rates of natural gas/conventional fracturing fluid mixtures required to achieve well productivity similar to that achieved when wells are fractured using conventional fracturing fluids alone.

Other examples of analysis could aim to characterize the suitability of the rheology of such conventional fracturing fluid/natural gas mixtures for large volume hydraulic fracturing, and to prove the feasibility of employing natural gas as a partial alternative to water, as justification for a Phase II field experiment focused on testing the process.

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

c. Advanced Ion-Electron Mixed Conductors for Oxygen Separation

Applications are invited for developing advanced oxygen selective ion-electron mixed conductors (IEMCs) for air separation applications. Current IEMCs are limited by their conductivity ranges. The intent of the topic is to develop second generation IEMCs with ambipolar conductivity properties far superior compared to current IEMCs. The intended result is fast ion-electron conduction to potentially enhance oxygen separation kinetics and flux. The separation process will be driven by partial pressure gradient of oxygen across the advanced IEMC air separation device. Another topic interest is to lower the operating temperature of advanced IEMCs to intermediate ranges, preferably around 600ºC. Applicants are encouraged to conceive novel IEMC material compositions and preparation techniques. Applicants shall list the conductivity values of current, conventional IEMCs and the predicted values of the proposed advanced IEMC research products, discuss the theoretical fundamentals why such advanced IEMCs could potentially enhance oxygen separation kinetics and flux, and present the technical approaches to reduce the concepts to practice. R&D efforts will involve computational synthesis of proposed advanced IEMCs and proof-of-principle scale experimental validation.

Questions – contact: Arun Bose, arun.bose@netl.doe.gov

d. Transferring and Integrating CO_2 Capture Technology for Industrial Applications

The DOE has had success in advancing carbon capture technologies from the lab to the small pilot scale and is in the process of scaling these technologies to commercial scale for coal fired power plants. While DOE research is currently focused on reducing emissions from the electric sector to address proposed CO_2 emissions regulations, opportunities to generate revenue to offset the cost of carbon capture are largely limited to enhanced oil recovery. The manufacturing and commercial sectors may have a broader variety of economic incentives to reduce CO_2 emissions by increasing on site power generation efficiency and/or productively using captured CO_2 emissions to increase profitability, as such these sectors may be especially motivated to explore CO_2 capture and/or re-use applications.

Many of the CO_2 capture technologies being developed also have application for industrial sources (i.e. refineries, chemical production facilities, cement plants, etc.). It may be necessary to consider design changes to these technologies to optimize their integration with industrial or commercial facilities. There are also other applications using advanced CO_2 capture technologies and/or the CO_2 produced by them which might help to improve the efficiency of other processes in these industrial facilities.

Grant applications are sought which look to develop or apply advanced carbon capture technologies in industrial operations which reduce the cost of carbon capture and/or improve the efficiency of other auxiliary systems.

Questions – contact: Danielle Petrucci, danielle.petrucci@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. IPCC, 2005: IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change (Chapter 5). (http://www.ipcc-wg3.de/special-reports/special-report-on-carbon-dioxide-capture-and-storage).
2. U.S. DOE Office of Fossil Energy Carbon Storage Technology Program Plan, September 2013. (http://www.netl.doe.gov/File%20Library/Research/Coal/carbon-storage/Program-Plan-Carbon-Storage.pdf).
3. NETL Carbon Storage Technology Website. (http://www.netl.doe.gov/research/coal/carbon-storage).

References: Subtopic b:

1. Leblanc, D.P. et al, 2011, "Application of Propane (LPG) Based Hydraulic Fracturing in the McCully Gas Field, New Brunswick, Canada," Society of Petroleum Engineers, SPE-144093-MS, presented at the North American Unconventional Gas Conference and Exhibition, 14-16 June, The Woodlands, Texas. (https://www.onepetro.org/conference-paper/SPE-144093-MS).
2. Tudor, E.H., et al, 2009, "100% Gelled LPG Fracturing Process: An Alternative to Conventional Water-Based Fracturing Techniques," SPE-124495-MS, presented at the SPE Eastern Regional Meeting, 23-25 September, Charleston, West Virginia. (https://www.onepetro.org/conference-paper/SPE-124495-MS).
3. GASFRAC Energy Services Inc. Website. (http://www.gasfrac.com/).
4. Nicot and Scanlon, 2012, "Water Use for Shale-Gas Production in Texas, U.S.," Environmental and Science Technology. (http://www.circleofblue.org/waternews/wp-content/uploads/2013/04/Nicot+Scanlon_EST_12_Water-Use-Fracking.pdf).

References: Subtopic c:

1. Bose, A. C., "Inorganic Membranes for Energy and Environmental Applications," Springer 2009. (http://link.springer.com/book/10.1007%2F978-0-387-34526-0).
2. Burggraaf, A.J., Cot, L., "Fundamentals of Inorganic Membrane Science and Technology," Elsevier, 1996. (http://store.elsevier.com/Fundamentals-of-Inorganic-Membrane-Science-and-Technology/isbn-9780444818775/).
3. Bose, A.C., Richards, R.E., Sammells, A.F., Schwartz, M., "Beyond State-of-the-Art Gas Separation Processes Using Ion transport Membranes," Desalination, 144 91-92, (2002). (http://www.ingentaconnect.com/content/els/00119164/2002/00000144/00000001/art00294).
4. Carolan, M.F., Dyer, P.N., Motika, S.A., "Compositions Capable of Operating Under High Oxygen partial Pressures for Use in solid State Oxygen producing Devices," U.S. Patent 5,817,597, October 6, 1998. (http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=5,817,597.PN.&OS=PN/5,817,597&RS=PN/5,817,597).
5. Teraoka, Y., Zhang, H.M., Okamoto, K, Yamazoe, N., "Mixed ionic-Electronic Conductivity of $La_{1-x}Sr_xCo_{1-y}Fe_yO_{3-\delta}$ Perovskite Type Oxides," Mat Res Bull., Vol. 23, pp. 51-58, 1988. (http://www.sciencedirect.com/science/article/pii/0025540888902243).
6. Carolan, M.F., Dyer, P.N., Motika, S.A., Alba, P.B., "Compositions Capable of Operating Under High Carbon Dioxide Partial Pressures for Use in Solid State Oxygen Producing Devices," U.S. Patent 5,712,220, June 27, 1998. (http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=5,712,220.PN.&OS=PN/5,712,220&RS=PN/5,712,220).
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8. Thorogood, R.M., Srinivasan, R., Yee, T.F., Drake, M.P., "Composite Mixed-Conductor Membranes for Producing Oxygen," U.S. Patent 5,240,480, August 31, 1993. (http://patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO1&Sect2=HITOFF&d=PALL&p=1&u=%2Fnetahtml%2FPTO%2Fsrchnum.htm&r=1&f=G&l=50&s1=5,240,480.PN.&OS=PN/5,240,480&RS=PN/5,240,480).

References: Subtopic d:

1. Technology Roadmap: CCS in Industrial Applications – Foldout. (http://www.iea.org/publications/freepublications/publication/name,26001,en.html).
2. Paul S. Fennell, Nick Florin, Tamaryn Napp, Thomas Hills. T. CCS from industrial sources, Sustainable Technologies, Systems and Policies 2012 Carbon Capture and Storage Workshop: 17. (http://www.qscience.com/doi/pdf/10.5339/stsp.2012.ccs.17@cop18.2012.2012.issue-1).
3. Carbon Capture and Storage from Industrial Sources. (http://energy.gov/fe/science-innovation/carbon-capture-and-storage-research/carbon-capture-and-storage-industrial).
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17. 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 (TTO) should review the section describing these opportunities on page 7 of this document prior to submitting applications.

Grant applications are sought in the following subtopics:

a. Technology Transfer Opportunity: Transformational High Energy Density Secondary Aluminum Ion Battery

Current electrical energy storage falls far short of the requirements for transportation, commercial, and residential electrical and heating needs. As increasing amounts of electric power are derived from natural sources (solar, wind), transformational storage technologies become ever more important.

These power sources need effective battery storage both to meet demand and to level the cyclical nature of natural energy sources. Because an aluminum battery is trivalent, it has a distinct advantage in its capacity for energy density over the existing lithium-ion battery (1060 Wh/kg vs. 406 Wh/kg). The ORNL technology uses multielectron redox couples and has the potential to increase the energy density of a cell by several orders of magnitude. Previous attempts to use aluminum anodes in batteries resulted in high corrosion rates, parasitic hydrogen evolution, and sluggish response due to the formation of an oxide layer on the aluminum electrode surface. To overcome these problems, the ORNL battery is composed of an aluminum anode, and a cathode material capable of inserting aluminum ions during a discharge cycle and removing the ions during a charge cycle. The battery features an electrolyte that is electrochemically stable within the operation window of the electrodes. As a result, the electrolyte is capable of supporting the deposition or the stripping of aluminum at the anode, and the insertion or removal of aluminum at the cathode. This new aluminum-ion battery technology includes a broad menu of compositions and methods. In other variations, the battery is a secondary device that is capable of maintaining a discharge capacity of at least 50% of its initial capacity after 50 cycles.

Licensing Information:
Oak Ridge National Laboratory
Contact: Jennifer Caldwell (caldwelljt@ornl.gov; 865-574-4180)
TTO tracking number: ID-2383
Patent Status: U.S. Patent Application 12/895,487, filed September 30, 2010.
USPTO Link: http://www.google.com/patents/US20120082904

Questions – contact: Bonnie Gersten, bonnie.gersten@science.doe.gov

b. Technology Transfer Opportunity: Lithium-Conducting Sulfide Compounds for Solid-State Batteries and Lithium-Sulfur Batteries

High conduction solid electrolytes have the potential to enable high-energy battery chemistry such as Li batteries and Lithium-sulfur (Li-S) batteries with reduced cost and enhanced safety. ORNL has several technologies related to solid electrolytes and Li-S batteries, including cathode structures, solid electrolytes, and additives that improve the electronic and ionic conductivities, and cyclability for solid-state batteries. These particular technologies have the potential to enable the development of diverse electrode materials and electrolytes for rechargeable batteries with high energy densities and improved safety.

Licensing Information:
Oak Ridge National Laboratory
Contact: David Sims (simsdl@ornl.gov; 865-241-3808)
TTO tracking number: ID-2242
Patent Status: US Patent Application 12/874,254 filed Sept 2, 2010.
USPTO Link: https://www.google.com/patents/US20110052998
TTO tracking number: ID-2602
Patent Status: US patent 8,597,838 issued Dec 3, 2013.
USPTO Link: http://www.google.com/patents/US8597838
TTO tracking number: ID-2924
Patent Status: U.S. Patent Application 13/974,854, filed August 23, 2013.
USPTO Link: Not yet published
Website: http://www.ornl.gov/File Library/Main Nav/ORNL/Partnerships/Available Technologies/ID-201202924_FC.pdf
TTO tracking number: ID-3089
Patent Status: U.S. Patent Application 14/104,803, filed December 12, 2013
USPTO Link: Not yet published
Website: http://www.ornl.gov/File%20Library/Main%20Nav/ORNL/Partnerships/Available%20Technologies/ID-201303089_FC.pdf

Questions – contact: Bonnie Gersten, bonnie.gersten@science.doe.gov

c. Technology Transfer Opportunity: Low Cost "Campanile" Near Field Probe using Nanoimprinting Lithography

An ongoing challenge to understanding matter at the nanoscale is the difficulty in carrying out localized optical spectroscopy to obtain location-dependent chemical and optoelectronic information. This nanooptical device provides details of chemical, physical, and morphological properties on the nanoscale, in real time, and at high resolution (approximately 20nm). Replacing an atomic force microscopy (AFM) tip with the 'campanile' probe provides the spatial data available with the AFM tip along with optical data from which scientists can identify chemical composition and details about the sample's electronic structure. This unprecedented level of detail in materials research can lead to the development of more efficient, cost-effective solar cells, battery electrodes, digital storage media and polymers, among other discoveries.

Licensing Information:

Lawrence Berkeley National Laboratory
Contact: Andrea Schoeller (aeschoeller@lbl.gov; 510-486-7951)
TTO Tracking Number: IB 2012-112
Patent Status: US Utility patent filed on Sept. 20, 2013 (publication US-2014-0090118-A1)
USPTO Link: http://www.google.com/patents/US20140090118
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl3314.html

Questions – contact: Jane Zhu, jane.zhu@science.doe.gov

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 National Scientific User Facilities including the DOE Joint Genome Institute (JGI), the Environmental Molecular Science Laboratory (EMSL), the Atmospheric Radiation Measurement (ARM) Climate Research Facility and instrumentation for structural biology research at the DOE Synchrotron Light and Neutron sources.

BER has interests in the following areas:

(1) **Biological Systems Science** integrates discovery- and hypothesis-driven science with technology development on plant and microbial systems relevant to DOE bioenergy mission needs. Systems biology is the multidisciplinary study of complex interactions specifying the function of entire biological systems—from single cells to multicellular organisms—rather than the study of individual components. The Biological Systems Science subprogram focuses on utilizing systems biology approaches to define the functional principles that drive living systems, from microbes and microbial communities to plants and other whole organisms. Key questions that drive this research include: What information is encoded in the genome sequence? How is information exchanged between different sub-cellular constituents? What molecular interactions regulate the response of living systems and how can those interactions be understood dynamically and predictively? 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 at the DOE Synchrotron Light and Neutron Sources. 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.

18. 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:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

Applicants to TECHNOLOGY TRANSFER OPPORTUNITIES (TTO) should review the section describing these opportunities on page 7 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 the biological mechanisms underlying biofuel production from cellulosic biomass so that these mechanisms can be improved, and used to develop novel, efficient bioenergy strategies that can be replicated on a mass scale. Detailed understanding of many of these mechanisms form the basis for the BRCs' inventions and tech-transfer opportunities, which enable the development of technologies that are critical to the growth of a biofuels industry.

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: Prem Srivastava, prem.srivastava@science.doe.gov

Grant applications are sought in the following subtopics:

a. Technology Transfer Opportunity: Synthesis of Novel Ionic Liquids from Monolignols

Researchers at the Joint BioEnergy Institute (JBEI) have developed a technology to convert chemicals derived from lignin into ionic liquids for use in biomass pretreatment and other industrial applications in which ionic liquids are used as solvents or co-solvents. Using the JBEI technology, lignin is depolymerized into targeted monolignols. These monolignols are converted into ionic liquids by way of reductive amination of monolignol aldehydes with secondary amines to produce tertiary amines that can be converted to ionic liquids by treatment with appropriate acids.

Licensing Information:

Lawrence Berkeley National Laboratory
Contact: Robin Johnston (rjohnston@lbl.gov; 510-486-5947)
TTO Tracking Number: 2013-042
Patent Status: PCT patent application filed March 14, 2014 (PCT application PCT/US2014/028684)
USPTO Link: Not yet published
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2013-042.html

b. Technology Transfer Opportunity: Halophilic, Thermal Stable and Ionic Liquids Resistant Cellulolytic Enzymes

Through genome sequencing and analysis, we found a gene cluster in Halorhabdus utahensis DSM 12940, which contains 14 putative cellulolytic enzymes. We have expressed one of these in a halophilic host (Haloferax volcanii) and found that the recombinant protein has significant cellobiohydrolase (CBH) activity in high salt buffer. We named this gene as Hu-CBH1 (Halorhabdus utahensis cellobiohydrolase 1). Hu-CBH1 is a salt dependent cellulase. The enzyme is extremely stable in high salt buffer. For example, in 5M sodium chloride solution, the enzyme is stable at 80 degree Celsius. In addition, it is a alkaliphilic enzymecan tolerant pH11.5. More importantly, the enzyme is resistant to 20% (w/w) of [AMIM]Cl and [EMIM] OAc, in 2M NaCl solution. Our results suggested that halophilic enzymes are good candidates for screening ILs resistant enzymes.

Licensing Information:
Lawrence Berkeley National Laboratory
Contact: Robin Johnston (rjohnston@lbl.gov; 510-486-5947)
TTO Tracking Number: EJIB-3028
Patent Status: 13/493,938, filed 6/11/2012
USPTO Link: Patent Application 13/493,938: http://www.google.com/patents/US20130023015
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl3028.html

c. Technology Transfer Opportunity: Topic 18 subtopic c has been removed. The DOE SBIR/STTR Program will not accept grant applications submitted to this subtopic.

d. Technology Transfer Opportunity: Enhancing Fatty Acid Production by Regulation of fadR Expression

Researchers at the DOE Joint BioEnergy Institute (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.

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

e. Technology Transfer Opportunity: Biosynthetic Methodologies and Methods for Producing Methyl Butanols as Alternatives to Fossil-Fuel-Derived Products

Jay Keasling and Howard Chou of Berkeley Lab and the Joint BioEnergy Institute (JBEI) have invented a fermentation process to produce 5-carbon alcohols from genetically modified E. coli host cells regardless of the feedstock used. This is the first time isopentanol has been synthesized from the isoprenoid pathway. The resulting isopentanol has an energy content of 107.7 MJ/gallon—higher than ethanol (79.4 MJ/gallon) and butanol (102.1 MJ/gallon) and approaching the energy content of gasoline (121.0 MJ/gallon). In addition, isopentanol does not require the use of flexible fuel vehicles or engine modifications. This technology provides a gasoline replacement that is competitive with other alternative fuel products. Production costs for electricity and water use are lower than those for ethanol because the Berkeley Lab fuel can be processed in a centrifuge or siphoned off rather than distilled. Because the new fuel is less soluble in water than ethanol or butanol, less energy intensive processes may be required to separate the fuel from the fermentation broth during production. Low water solubility offers further cost advantages by enabling shipment of the fuel in the existing petroleum pipeline infrastructure. Finally, production need not compete with food crops for land and natural resources.

Licensing Information:
Lawrence Berkeley National Laboratory
Contact: Robin Johnston (rjohnston@lbl.gov; 510-486-5947)
TTO Tracking Number: EIB-239 and EIB-3112
Patent Status: 7985567; 14/345,147, filed 03/14/2014
USPTO Link: Patent 7985567: http://www.google.com/patents/US7985567; http://www.google.com/patents/WO2013040210A2?cl=en
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2895.html

f. Technology Transfer Opportunity: Microbial Platform for the Production of Monoterpenes Such as Pinene

A Joint BioEnergy Institute (JBEI) research team has constructed a metabolic pathway to produce the monoterpene pinene, an immediate chemical precursor to a potential jet fuel. Pinene is typically derived from turpentine, a byproduct of pine resin distillation. Thus, the JBEI technology could open the door to more economical and sustainable production of a vital transportation fuel. The researchers modified host cells, rerouting the isoprenoid pathway to produce geranyl pyrophosphate and then pinene, using selected synthases. Researchers confirmed that their technology is capable of producing pinene from either xylan or cellobiose.

Licensing Information:
Lawrence Berkeley National Laboratory
Contact: Robin Johnston (rjohnston@lbl.gov; 510-486-5947)
TTO Tracking Number: EJIB-2895
Patent Status: 14/091,818, filed 11/27/2013
USPTO Link: Not yet published
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2895.html

g. Technology Transfer Opportunity: 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.

Licensing Information:

Lawrence Berkeley National Laboratory
Contact: Robin Johnston (rjohnston@lbl.gov; 510-486-5947)
TTO Tracking Number: EIB-2837
Patent Status: 13/883,987
USPTO Link: http://www.google.com/patents/US20130298861?cl=en
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2837.html

h. Technology Transfer Opportunity: Method for Constructing Synthetic Transcription Factors

A team of Joint BioEnergy Institute (JBEI) researchers led by Jay Keasling and Howard Chou has developed a method for constructing synthetic, highly specialized transcription factors (TFs) from a trio of peptide building blocks. The first peptide is designed to target a ligand; the second binds to a target sequence of DNA; and the third is a linker that connects the first and second peptide in a compact molecular structure. Depending on the target DNA and the gene of interest, the binding of target DNA by the synthetic TF can either activate or repress transcription of the gene of interest. This system can be designed to regulate specific genes or to modulate the mutation rate in directed evolution strategies to find desired phenotypes. Either approach requires less time and resources than random mutation and screening to develop valuable phenotypes. The advantages are that it is more suitable than natural transcription factors for biotech applications. The rational design enhances in vivo directed evolution of mutant phenotypes. It is broadly applicable in synthetic biology, and the method can be generalized to many different organisms.

Licensing Information:

Lawrence Berkeley National Laboratory
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
TTO Tracking Number: EIB-3211
Patent Status: PCT/US2013/074214, filed 12/10/2013
USPTO Link: Not yet published
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl3211.html

i. Technology Transfer Opportunity: Identification of Efflux Pumps to Improve Tolerance to Toxic or Inhibitory Biofuel, Biochemical Metabolities or Compounds from Deconstructed Ligno-Cellulosic Biomass

The Joint BioEnergy Institute (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.

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

j. Technology Transfer Opportunity: Controlling Metabolic Pathways Using Artificial Positive Feedback Loop in Yeast

This invention allows overproducting FPP, precursor of sesquiterpene synthase such as bisabolene synthase, farnesene synthase used to produce sesquiterpene such as bisabolene and farnesene respectively. This invention can be applied to multigene-engineered pathways since several promoters are induced by Upc2 or Ecm22 transcription factors and can be used to over express several genes.

Licensing Information:
Lawrence Berkeley National Laboratory
Contact: Robin Johnston (rjohnston@lbl.gov, 510-486-5947)
TTO Tracking Number: EIB-3293
Patent Status: PCT/US2013/052578
USPTO Link: http://patentscope.wipo.int/search/en/WO2014018982
Website: http://www.lbl.gov/tt/techs/lbnl3293.html

k. Technology Transfer Opportunity: Rice snl6 Required for Lignin Biosynthesis

We have identified a cinnamoyl-CoA reductase (CCR)-like gene in rice, called snl6, that is required for lignin biosynthesis. Plants lacking a functional version of snl6 contain approximately 1/3 less lignin than wildtype plants. While most published lignin mutants have severe developmental phenotypes, plants that are compromised in snl6 expression, are developmentally normal. Lignin represents a major obstacle in the extractability of sugars from plant cell walls. Thus, reducing lignin content by reducing snl6 expression may lead to more efficient saccharification.

Licensing Information:
Lawrence Berkeley National Laboratory
Contact: Robin Johnston (rjohnston@lbl.gov; 510-486-5947)

TTO Tracking Number: EIO-2763
Patent Status: 13/704,969
USPTO Link: http://www.google.com/patents/US20130160161
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2763.html

l. Technology Transfer Opportunity: Rice Os02g22380 Encoding Glycosyltansferase Critical for Xylose Biosynthesis in the Cell Wall

We have identified a glycosyltansferase encoded by the gene Os02g22380 in rice, which is involved in xylose biosynthesis in the cell wall. T-DNA insertional mutant rice plants with Os02g22380 knocked out are xylose deficient, have a decreased ferulic acid and coumaric acid content, and have a higher saccharification efficiency in the leaves.

Licensing Information:
Lawrence Berkeley National Laboratory
Contact: Robin Johnston (rjohnston@lbl.gov; 510-486-5947)
TTO Tracking Number: EJIB-3136
Patent Status: 13/953,642
USPTO Link: http://www.google.com/patents/US20140033365
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl3136.html

m. Technology Transfer Opportunity: Increased Expression of Rice Acyltransferase Genes Improves Tissue Deconstructability without Impacting Biomass Accumulation

Researchers at the Joint BioEnergy Institute (JBEI) have identified a rice acyltransferase gene that, with increased expression, improves both the extraction of xylan and saccharification without significant changes in plant health, seed mass and biomass, compared to wild type plants. Xylan, an abundant polysaccharide, offers a significant amount of stored energy for biofuel production. Yet, most of the enzymes that synthesize xylan have not been identified, and none of the enzymes specific to grass xylan synthesis have been identified. This technology is the first demonstration that increased expression of a native plant gene modifies cell wall content and affects cell wall digestibility.

Licensing Information:
Lawrence Berkeley National Laboratory
Contact: Robin Johnston (rjohnston@lbl.gov; 510-486-5947)
TTO Tracking Number: EJIB-2915
Patent Status: PCT/US2013/077266
USPTO Link: Not yet published
Website: http://www.lbl.gov/Tech-Transfer/techs/lbnl2915.html

n. Technology Transfer Opportunity: Ethanol Tolerant Yeast for Improved Production of Ethanol from Biomass

UW–Madison 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.

Licensing Information:

University of Wisconsin–Madison
Contact: Zach Ellis (zellis@warf.org; 608-890-2930)
TTO Tracking Number: P100228US02
Patent Status: 8,178,331; 13/232327; 61/838185
USPTO Link: Patent 8,178,331: http://www.warf.org/documents/ipstatus/P100228US02.PDF
Additional Information About TTO: GLBRC WARF ethanol tolerant yeast

o. Technology Transfer Opportunity: Genes for Xylose Fermentation, Enhanced Biofuel Production in Yeast

UW–Madison 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.

Licensing Information:

University of Wisconsin–Madison
Contact: Zach Ellis (zellis@warf.org; 608-890-2930)
TTO Tracking Number: P100245US03
Patent Status: 13/441381; 61/516650; 61/509849
USPTO Link: Patent Application 13/441381:
http://www.warf.org/documents/pubapps/P100245US03%20Published%20Application.PDF
Additional Information about TTO: GLBRC WARF xylose utilization genes

p. Technology Transfer Opportunity: Cell-Free System for Combinatorial Discovery of Enzymes Capable of Transforming Biomass for Biofuels

UW-Madison 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.

Licensing Information:

University of Wisconsin–Madison
Contact: Jennifer Gottwald (jennifer@warf.org; 608-262-5941)
TTO Tracking Number: P08301US02

Patent Status: 12/792156; 61/183243
USPTO Link: Patent Application 12/792156;
http://www.warf.org/documents/pubapps/P08301US02%20Published%20Application.PDF
Additional Information about TTO: GLBRC WARF Combinatorial cellulosome discovery system

q. Technology Transfer Opportunity: Method and Compositions for Improved Lignocellulosic Material Hydrolysis

UW-Madison 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 material, 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.

Licensing Information:

University of Wisconsin–Madison
Contact: Jennifer Gottwald (jennifer@warf.org; 608-262-5941)
TTO Tracking Number: P110314US03
Patent Status: 13/709971; 61/579301; 61/579897
USPTO Link: Patent Application 13/709971: http://www.google.com/patents/US20130189744
Additional Information about TTO: GLBRC WARF ActE biomass digestion

r. Technology Transfer Opportunity: Extending Juvenility in Grasses

UW–Madison researchers have developed methods for locking plants in a juvenile state by modifying genes related to maturation. The genes – GRMZM2G362718 or GRMZM2G096016 – have been analyzed by the researchers and shown to influence growth transition in corn. To alter plant development, these genes and their homologs could be knocked out or inhibited by small molecules or biologics. The process could involve additional genes known to affect juvenile to adult growth development. Juvenile plants may be easier to process for biofuels and more digestible when used as feed, and arrested maturation could boost yields.

Licensing Information:

University of Wisconsin–Madison
Contact: Emily Bauer (emily@warf.org; 608-262-8638)
TTO Tracking Number: P120179US02
Patent Status: 13/834114; 61/651540
USPTO Link: Patent Application 13/834114:
https://www.google.com/patents/US20140013468?dq=13/834114+patent&hl=en&sa=X&ei=AVebU6vxEMKYyATx9IDAAg&ved=0CB4Q6AEwAA
Additional Information about TTO: GLBRC WARF extended grass juvenility

s. Technology Transfer Opportunity: Multifunctional Cellulase and Hemicellulase

UW–Madison researchers have engineered a multifunctional polypeptide capable of hydrolyzing cellulose, xylan and mannan. It is made of the catalytic core of Clostridium thermocellum Cthe_0797 (also called CelE), a linker region and a cellulose-specific carbohydrate binding module (CBM3). C. thermocellum is a well-known cellulose-degrading bacterium whose genome has been sequenced, annotated and published. Multifunctional enzymes could simplify the enzyme cocktail needed for biomass conversion, thereby reducing costs.

Licensing Information:

University of Wisconsin–Madison
Contact: Jennifer Gottwald (jennifer@warf.org; 608-262-5941)
TTO Tracking Number: P120371US02
Patent Status: 14/030290; 61/703063
USPTO Link: Patent Application14/030290:
https://www.google.com/patents/US20140079683?dq=14/030290+patent&hl=en&sa=X&ei=UlebU5nQLoSZyATOxoH4DQ&ved=0CB4Q6AEwAA
Additional Information about TTO: GLBRC WARF multifunctional enzyme

t. Technology Transfer Opportunity: Construction of a Lactobacillus casei Ethanolgen

A UW–Madison researcher and others have modified a Lactobacillus casei strain that exhibits the highest ethanol conversion rates yet reported from the genus. L. casei naturally combines many characteristics of an ideal strain when compared to microorganisms typically considered for biofuel production, like Saccharomyces cerevisiae, Zymomonas mobilis, Escherichia coli and Clostridium sp., which all suffer from various deficiencies. A L. casei strain exhibiting high conversion rates could represent a novel, more efficient path to market for ethanol production. The modified bacterium is derived from L. casei strain 12A. It is made by (i) inactivating genes that encode a competing lactate enzyme and (ii) introducing genes from another organism (Zymomonas mobilis) that encode a pyruvate decarboxylase and an alcohol dehydrogenase II.

Licensing Information:

University of Wisconsin–Madison
Contact: Mark Staudt (mstaudt@warf.org; 608-265-3084)
TTO Tracking Number: P130023US02
Patent Status: 13/964548; 61/682281
USPTO Link: Patent Application 13/964548:
https://www.google.com/patents/US20140045235?dq=13/964548+patent&hl=en&sa=X&ei=k1ebU7W5LMu3yATO6YGoDA&ved=0CB4Q6AEwAA
Website: http://www.warf.org/technologies/summary/P130023US02.cmsx

u. Technology Transfer Opportunity: High Calorie and Nutritional Content Plants or Plant Seeds

MSU researchers have developed a suite of technologies that may be used for several purposes, depending on implementation. The technologies include i) the wrinkle 1 regulatory gene, which switches on expression of enzymes involved in lipid production; ii) pyruvate kinase genes downstream of wrinkle 1, which may be used to increase lipids or certain amino acids, and iii) diacylglycerol acyl transferase

(DAGAT) genes, which may be used to increase lipid production. This suite of technologies may be used to increase oil content in plant seeds or alternatively plant leafy tissues. High oil leafy tissues may be used as enhanced forage crops or for vegetable and biodiesel production. Leaf oil contents of greater than 10% have been demonstrated. Forage crops may also be enhanced by increased production of amino acids.

Licensing Information:
Michigan State University
Contact: Tom Herlache, (herlache@msu.edu; 517-884-1656)
TTO Tracking Number: TEC2000-0092; TEC2005-0025; TEC2009-0022; TEC2013-0040;
Patent Status: Wrinkled 1: US 7,230,160 and foreign equivalents. Target genes of wrinkled 1: U.S. 8,426,676; U.S. 8,362,319. Production of oil in vegetative tissues: U.S. 14/046,504. Increased calorific content of plant biomass, provisional application filed.
USPTO Link: Patent 7,230,160: patft.uspto.gov/netacgi/nph-Parser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearch-bool.html&r=2&f=G&l=50&co1=AND&d=PTXT&s1=7,230,160&OS=7,230,160&RS=7,230,160
Websites: http://msut.technologypublisher.com/technology/6996; http://msut.technologypublisher.com/technology/7894; http://msut.technologypublisher.com/technology/13009

v. Technology Transfer Opportunity: High Starch in Plant Leaves at Senescence

Michigan State University's 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.

Licensing Information:
Michigan State University
Contact: Tom Herlache, (herlache@msu.edu; 517-884-1656)
TTO Tracking Number: TEC2009-0067
Patent Status: 12/880,988
USPTO Link: http://appft.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=PG01&s1=%2212%2F880,988%22&OS=%2212/880,988%22&RS=%2212/880,988%22
Website: http://msut.technologypublisher.com/technology/6484

w. Technology Transfer Opportunity: A Method to Produce 3-Acetyl-1, 2-Diacyl-sn-Glycerols (ac-TAGs)

Michigan State University's 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.

Licensing Information:
Michigan State University
Contact: Tom Herlache, (herlache@msu.edu; 517-884-1656)
TTO Tracking Number: TEC2009-0108
Patent Status: 13/519,660
USPTO Link http://appft.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=PG01&s1=%2213%2F519,660%22&OS=%2213/519,660%22&RS=%2213/519,660%22
Website: http://msut.technologypublisher.com/technology/5989

19. 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:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

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) recently released its Fifth Assessment Report (AR5), where it was reinforced that clouds and aerosols dominate uncertainties associated with future predictions. It was repeatedly concluded that innovative measurement technologies are needed to provide both input and comparison data for models, that in turn are used to assess the climate change impacts to global and regional systems.

The Arctic remains as a region requiring intensive scientific study, 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 under-predicting rates of change. More recently, the IPCC AR5 report reported that Arctic lacks sufficient observing and analysis research to improve climate predictability. In response these needs, DOE decided to increase its investment in Arctic atmospheric research. Specific needs require improved and more sophisticated observing capabilities, i.e., for aerosol absorption and scattering, cloud properties, turbulence, and remote sensing, using in most part miniaturized sensing packages that can be deployed on small unmanned aerial vehicles (UAV) platforms.

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. Aerosol and Hydrometer Size Distributions from UAV Platforms

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 instrument packages capable of installation on a small UAV, with capabilities to measure aerosols, cloud droplets or glaciated hydrometeors. Grant applications are sought to develop lightweight (suitable for sampling from UAS or tethersonde platforms) instruments for (1) particle size spectrum measurements in the 10- 1000 nm size range, (2) for cloud droplet/drizzle measurements (10–1000 μm size range), and for (3) acquisition of high-resolution cloud particle images capable of distinguishing size and habit of ice particles as well as droplets in mixed-phase clouds. Related airborne measurements of great interest are (4) a fast spectrometer for measurement of cloud condensation nuclei number concentrations over supersaturation ranges of the order 0.02% – 1% and (5) a spectrometer/counter for ice nuclei (IN) number concentrations over effective local temperatures down to -38 °C.

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 ScanEagle or Puma 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.

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

b. Measurement of the Chemical Composition of Atmospheric Aerosol and Aerosol Precursors

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 of 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 low volatility 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.

Similarly, to better understand the evolution of aerosols in 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.

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 condensed phase dust, carbon, and salt are detectable, along with compounds with measurable gas phase partitioning; and (3) measurements with high time resolution, which is a deficiency of filter techniques. Proposed approaches that can measure aerosol or precursor chemical composition from airborne platforms would be of particular interest

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

References: Subtopic a:

1. The Arctic Research Consortium of the U.S. (ARCUS). (http://www.arcus.org/).
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. (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. (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. (http://dx.doi.org/10.1175/1520-0477(2000)081<2915:TDOESA>2.3.CO;2).

References: Subtopic b:

1. U.S. Department of Energy: Biological and Environmental Research Advisory Committee. (2004). A Reconfigured Atmospheric Science Program. See: 'Instrument Development', pp. 18-21. (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. (http://science.energy.gov/~/media/ber/pdf/Atmospheric_system_research_science_plan.pdf).

20. 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:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

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 describe research needs and technology requirements for sequestering carbon by terrestrial systems (Reference 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 "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. Return to Top of Document 132.

Grant applications are sought in the following subtopics:

a. Miniaturized Spectroradiometers for Quantifying Terrestrial Ecosystems with Mobile and Unmanned Aerial Systems

Terrestrial models rely on detailed parameterizations representing ecosystem processes using trait data describing the vegetation in a given ecosystem. At the present time, trait data are often incomplete and derived from a single site, thus they are often inadequate in providing sufficient detail on spatial and temporal representation of key vegetation and ecosystem characteristics (References 7-10). Furthermore, most existing vegetative and ecological data are simplistically described as plant functional types (PFTs) (Reference 11 and 12), such that earth system models that rely on PFT data are highly limited in their predictive capacity. As computational power increases, it will be possible to provide models with much more complex descriptions of ecosystems, i.e., whereby PFTs can be replaced with temporally and spatially resolved trait-space descriptions of plants representing global terrestrial ecosystems. Development of the scientific understanding that will underlie robust trait maps will ideally be derived from scale-aware parameterizations derived from remotely observed hyper-spectral signatures that are coupled with surface observations of trait measurements that extend from leaf to landscape scales. Currently, the development of such parameterizations is limited by the difficulty and cost in obtaining appropriate airborne measurements, thus it has been recommended to exploit unmanned aircraft where possible (Reference 13). The availability, sophistication, and ease of use of small to medium payload UAVs has evolved rapidly in the last five years; similarly, the purchase costs of the UAV platforms have decreased considerably. Unfortunately, current spectral and hyperspectral observing technologies are too heavy and too large for most UAV systems; thus, there is an urgent need to develop affordable, lightweight, and miniaturized technologies for routine UAV deployment. If available, such new technology would rapidly accelerate ongoing efforts to scale key ecosystem traits to broader spatial scales and throughout critical vegetation development stages. Once validated at the plot and landscape scales, algorithms can be developed from sensors deployed on UAVs to allow temporal and spatial trait mapping across the globe – this would provide a transformational increase in trait data richness for Earth System Models, and when coupled with improved process knowledge, result in a marked reduction in model uncertainty.

Grant applications are sought for technology innovation to capitalize on the increasing utility of UAV platforms for scientific missions. There is an urgent need to accelerate the miniaturization of existing instrumentation and integration with UAVs. High resolutions, lightweight, durable spectroradiometers, are needed to achieve this goal and should contain the following minimum technical specifications:

Wavelength Range	350-2500nm
Spectral Resolution	<10nm across the full range
Spectral Bandwidths	<4nm across the full range
Minimal Spatial Footprint	30cm diameter
Wavelength Reproducibility	0.1nm
Minimum Integration Speed	10ms VNIR, 1.0ms SWIR

Wavelength Accuracy ±1nm VNIR, ±2nm SWIR
Noise equivalent Radiance (NER) <1.5x10-9 across the full range
Calibration Accuracy (NIST) ±5% @400nm, ±4% @700nm, ±7% @2200nm
Operation Time Sufficient power for 30 minutes of operation
Instrument Dimension Must be compatible with small to medium UAS platforms
Mass Fully operational system must be <2.5kg
Software and Data Integration Capable of storing potential data streams from 30 minute missions. The data management software must be capable of spatial and temporal integration and georeferencing. The software must also be capable of producing a seamless assembly of data streams from multiple sensors e.g. Thermal IR camera - possibly on the same or additional UASs. Instrument software should be capable of synchronizing with the UASs flight planning software to enable instrument actuated transition through the flight plan.

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

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

Fast and precise measurements of atmospheric nitrogen (N2), Argon (Ar), and oxygen (O_2) have the potential to become the foundation of the next generation of eddy covariance technologies and revolutionize real-time methods to obtain fluxes of atmospheric greenhouse gases between the earth surface and the atmosphere (Reference 14). Measuring such fluxes is crucial in the research fields of climate change, global change biology, and ecology. Measurements of N2, Ar, and O_2 also have direct applications in agriculture, medicine, and industrial processes. Unfortunately, direct eddy-flux measurements are difficult for these types of (high ambient concentration) gases, given currently available technologies. *New innovative technologies are needed with the following specifications:*

Nitrogen (N2) – The response time must be less than 100ms. The N2 can be measured directly in the unit of molar density within the range of 20 to 60 mol/m3 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 N2 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/m3 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/m3 with a precision of 0.001%.

Questions – contact: Michael Kuperberg, michael.kuperberg@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: Daniel Stover, daniel.stover@science.doe.gov

References:

1. King, A.W et al. "The N. American Carbon Budget and Implications for the Global Carbon Cycle: EDS, The First 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. (http://cdiac.ornl.gov/SOCCR/pdf/SAP2.2_Entire_Report_Draft4.pdf).
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14. Gu, L., et al. "The fundamental equation of eddy covariance and its application in flux measurements", Agricultural and Forest Meteorology, Volume 152, pp. 135-148, 2012. (http://www.sciencedirect.com/science/article/pii/S0168192311002905).

21. TECHNOLOGIES FOR CHARACTERIZING AND MONITORING COMPLEX SUBSURFACE SYSTEMS

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:* NO
Accepting STTR Phase I Applications: YES	*Accepting STTR Fast-Track Applications:* NO

Reactive transport models are increasingly used to model hydrobiogeochemical processes in complex subsurface systems (soils, rhizosphere, sediments, aquifers and the vadose zone) for many different applications and across a wide range of temporal and spatial (e.g., pore to core to plot to watershed) scales. With increasing computational capability it is possible to simulate the coupled interactions of complex subsurface systems with high fidelity. The predictive skill of these advanced models is limited, however, by the accuracy of the parameters that are used to populate the models and represent the system structure and intrinsic properties. Furthermore, robust testing of these increasingly complex models requires high fidelity measurements of the hydrobiogeochemical structure and functioning of the complex subsurface systems over the relevant spatial and temporal scales.

The focus of this topic is on the development of improved sensing systems for capturing the *in situ* hydrobiogeochemical structure and functioning of complex subsurface systems because they serve as the substrate for natural, disturbed and managed terrestrial vegetation systems.

Grant applications submitted to this topic must describe why and how the 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 field sites or locations under investigation by DOE, 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. 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.

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. Real-Time, *In Situ* Measurements of Hydrobiogeochemical and Microbial Processes in Complex Subsurface Systems

Sensitive, accurate, and real-time monitoring of hydrobiogeochemical processes are needed in subsurface environments, including soils, the rhizosphere, sediments, the vadose-zone and groundwaters. 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 improved approaches for the autonomous and continuous sensing of key elements such as carbon, nitrogen, sulfur and phosphorus *in situ*; improved methods to measure and monitor dissolved oxygen, vertically resolved soil moisture distributions, and groundwater age.

The ability to distinguish between the relevant oxidation states of redox sensitive elements, such as iron, manganese, and sulfur is of particular concern. Innovative approaches for monitoring multi-component biogeochemical signatures of subsurface systems is also of interest as is the development of robust field instruments for multi-isotope and quasi-real time analyses of suites of isotope systems of relevance to hydrologic and biogeochemical studies (e.g. ^{2}H, ^{18}O, CH_4, CO_2, nitrogen compounds, etc.). Grant applications must provide convincing documentation (experimental data, calculations, simulation, as appropriate) 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 micromachined pumps, valves, microsensors, 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 micromachined 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

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: 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/).
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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. (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).

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) currently under construction at Michigan State University. 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.

22. 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 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 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; (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
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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 are 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
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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 solution to providing a computing resources solution to experiments via a 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; and (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 who do not have the necessary application software environment installed.

Questions – contact: Manouchehr Farkhondeh, manouchehr.farkhondeh@science.doe.gov
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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 regarding the next generation of data acquisition systems is that they will ultimately be 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. 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 across all channels to a sufficient precision, as good as 10ns or better to support Flash Analog-to-Digital Converter (FADC) clock synchronization or, at least,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) develop software tools to validate the synchronization, triggering and event building during normal operation. Time synchronization is critical to the success of this architecture, as is the concurrent validation of synchronization.

Grant applications are sought for work on any of the following areas; 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 readout, trigger construction and event building on Ethernet, with sufficient buffering to support 1 to 10 seconds of latency in event readout; and 3) time distribution protocols and hardware to support this architecture. The hardware solutions for time do not necessarily need to rely on standard Ethernet implementations.

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
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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 convert very complicated templatized C++ code and into 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 workforce 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.

Questions – contact: Manouchehr Farkhondeh, manouchehr.farkhondeh@science.doe.gov
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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 general description at the beginning of this topic.

Questions – contact: Manouchehr Farkhondeh, manouchehr.farkhondeh@science.doe.gov

References: Subtopic a:

1. For specifications on cost-effective software and hardware system needs described above contact Dr. Chip Watson at Jefferson Lab (watson@jlab.org).

References: Subtopic d:

1. For technical specifications in Software-driven Network Architectures for Data Acquisition contact Dr. Robert Varner at Oak Ridge National Laboratory (varnerrl@ornl.gov).

References: Subtopic e:

1. For more specifications on heterogeneous computing described above contact Dr. Chip Watson at Jefferson Lab (watson@jlab.org).

References: All Subtopics:

1. NP SBIR/STTR Topic Associate for Software and Data Management: Frank E. (Ted) Barnes ted.barnes@science.doe.gov.
2. R. B. Firestone, "Nuclear Structure and Decay Data in the Electronic Age", Journal of Radioanalytical and Nuclear Chemistry, Vol. 243, Issue 1, pp. 77-86, Jan. 2000. (ISSN: 0236-5731) (http://www.springerlink.com/content/m47578172u776641/?p=f4fbbe7a000a4718bea6321fdc6e4e11&pi=10).
3. Robert L. Grossman, et al., "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), pages 16-28, 2004. (http://papers.rgrossman.com/proc-077.pdf).
4. CHEP06: Computing in High Energy and Nuclear Physics 2006 Conference Proceedings, Mumbai, India, February 13-17, 2006. (http://indico.cern.ch/conferenceTimeTable.py?confId=048).
5. S. M. Maurer, et al., "Science's Neglected Legacy", Nature, Vol. 405, pp. 117-120, May 11, 2000. (ISSN: 0028-0836) (See http://www.nature.com/ and search by title of article.)
6. National Computational Infrastructure for Lattice Quantum Chromodynamics. (www.usqcd.org/).
7. Scientific Discover Through Advanced Computing, SciDAC, U.S. Department of Energy. (www.scidac.gov/physics/quarks.html).
8. The Globus Alliance Website, University of Chicago and Argonne National Laboratory. (http://www.globus.org/).
9. Condor: High Throughput Computing Website, University of Wisconsin. (www.cs.wisc.edu/condor/).
10. Cloud computing and virtual workspaces. (http://workspace.globus.org/).
11. CERN VM Software Appliance webpage. (http://cernvm.cern.ch/portal/).
12. Web Services Description Language Website, World Wide Web Consortium. (http://www.w3.org/TR/wsdl).
13. Open Science Grid and the Open Science Grid Consortium Web site, National Science Foundation and U.S. Department of Energy. (http://www.opensciencegrid.org/).
14. The Virtual Data Toolkit (VDT). (http://vdt.cs.wisc.edu/index.html/).
15. Worldwide LHC [Large Hadron Collider] Computing Grid (WLCG). (http://wlcg.web.cern.ch/).
16. European Grid Infrastructure (EGI). (http://www.egi.eu/).
17. U.S. National Nuclear Data Center. (http://www.nndc.bnl.gov/).
18. SRB – The SDSC Storage Resource Broker. (http://www.sdsc.edu/srb/index.php/Main_Page).
19. Event Driven Architectures. (http://en.wikipedia.org/wiki/Event_driven_architecture).
20. IEEE 1588 - Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems. (http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=1159815).
21. Xrootd scalable distributed data repository. (http://xrootd.slac.stanford.edu/).

22. Parallel Analysis Facilities. (http://root.cern.ch/drupal/content/proof).

23. 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 25 (Nuclear Instrumentation, Detection Systems, and Techniques). All grant applications must explicitly show relevance to the nuclear physics program.

Grant applications are sought in the following subtopics:

a. Advances in Digital Electronics

Digital signal processing electronics are needed to replace analog signal processing, following low noise amplification, in nuclear physics applications. Grant applications are sought to develop: fast digital processing electronics that improve the accuracy 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
You may also contact the NP Topic Associate (TA) listed at the beginning of the Reference section for this topic.

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, silicon photomultipliers (SiPMs), particle calorimeters, and Cherenkov counters) used in nuclear physics experiments. Areas of specific interest include (1) representative circuits such as low-noise preamplifiers, low-noise filters, 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 and noble liquid Time Projection Chambers (TPCs); (3) readout electronics for solid-state pixelated detectors, including interconnection technologies, charge sharing processing and correction circuits (pixel pitch below 250 μm); (4) circuits for high dynamic range, and (5) systems on chip that embody low-noise front-end circuits, analog-to-digital converters, extensive digital signal processing capability tailored to the application, and standard digital interfaces and protocols for compatibility with commercial devices. These circuits should be low-power; low-cost; high-density; programmable to the possible extent; easy to use with commercial auxiliary electronics; 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.

Questions – contact: Manouchehr Farkhondeh, manouchehr.farkhondeh@science.doe.gov
You may also contact the NP Topic Associate (TA) listed at the beginning of the Reference section for this topic.

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:

- 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.

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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).

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e. Present Active Pixel Sensors

Collect charge by diffusion from a field-free region. A major advance would be to introduce an electric field into this region and to deplete it. This would result in charge collection by drift, with much shorter collection time and negligible charge dispersion.

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.

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You may also contact the NP Topic Associate (TA) listed at the beginning of the Reference section for this topic.

f. 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.

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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 general description at the begining of this topic.

Questions – contact: Manouchehr Farkhondeh, manouchehr.farkhondeh@science.doe.gov

References:

1. NP SBIR/STTR Topic Associate(s) for Electronics and Circuits: Kawtar Hafidi kawtar.hafidi@science.doe.gov or Elizabeth Bortosz elizabeth.bortosz@science.doe.gov.
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24. 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 with the rare isotope beam accelerator facility (FRIB) under construction at Michigan State University. 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 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), ceramics 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., RF power couplers, low-impedance bellows 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, half wave resonators and crab cavities) 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 are also sought to develop advanced diagnostic techniques for SRF cavities/resonators, including new methods of temperature mapping, optical inspection and second sound quench detections that will lead to better understanding of the cavity quality factors and its quench limits.

Grant applications are also sought to develop new concepts of dressed SRF cavities (SRF cavities equipped with Helium vessels and tuners) with improved mechanical properties to mitigate He pressure fluctuations, microphonics and Lorentz force detuning.

Grant applications also are sought to develop (1) improved superconducting materials or processes applied to such material 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.

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.

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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, tunable/phase stabilized magnetron or solid state amplifiers, especially class F devices, 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.

Grant applications are sought for investigation of various solid state amplifier device technologies, architectures and classes that when optimized offer the most efficient, effective solution both in hardware and long term operating and maintenance costs. Emphasis on reduced power consumption, ease of manufacture, mitigation of risk with RF Device obsolescence and enhanced reliability measures. The frequency is about 422 MHz, with power level of 5-20 kW cw and bandwidth of several MHz.

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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 (1º 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, 0.4-1.5 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 0.4 to 1.5 GHz frequency and 3 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.

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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* coating of elliptical and other surface contour RF cavities and long beam pipes with thick superconducting films; (6) Novel methods for i*n situ* surface cleaning (scrubbing) of ultrahigh vacuum long narrow tubes and elliptical cavities to reduce secondary electron yield and outgassing; (7) high brightness electron beam sources utilizing continuous wave (cw) superconducting RF cavities with integral photocathodes operating at high acceleration gradients; (8) techniques and devices for measuring RF resistivity of cryogenically cooled coated tubes; (9) CW superconducting RF cavity(s) that integrate with thermionic or field emitting cathodes such as mircotips or carbon nanotubes.

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 prototype 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, (4) transporting and matching magnetized beams with superconducting solenoids in cooling channels, (5) study of synchrotron radiation and its impact on beam dynamics in ERLs and CRs, and (6) development of new concepts for high-energy, high-power electron beam dumps that minimize activation of surrounding structures. 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, including software product for start to end simulations of coherent electron cooling, including both microbunching and FEL concepts. Such product should be easy to use and provide visualization. (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. There is particular interest in porting accelerator modeling codes to the GPU, Xeon Phi, and other emerging architectures. Grant applications also are sought to develop graphical user interfaces for problem definition and setup.

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e. Polarized Beam Sources and Polarimeters

With respect to polarized 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 ~50 mA, with longitudinal polarization greater than 80%; (3) devices, systems, and sub-systems for producing variable-helicity beams of electrons with polarizations greater than 80% and currents > 200μA, that 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.

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You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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 in order to study 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
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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 Facility for Rare Isotope Beams (FRIB).

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 construction 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 subtopic "d" of Topic 24, Nuclear Physics Detection Systems, Instrumentation and Techniques.)

Questions – contact: Manouchehr Farkhondeh, manouchehr.farkhondeh@science.doe.gov
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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 FRIB; (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 magnets 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
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i. Permanent Magnet Development for Future Electron-Ion Colliders (EIC)

One of the options under consideration for EIC is based on the Energy Recovery Linac (ERL) architecture for the electron beam. The ERL requires return passes - beam lines for electrons to be brought back to the linac during acceleration and deceleration. The highest energy electrons are decelerated after collisions with ions by going through the linac with an opposite RF voltage. The beam lines could be built of permanent magnets to reduce the overall cost. In addition if the magnets are designed for use in a Non-Scaling Fixed Field Alternating Gradient structure they can transfer multiple energies within the same aperture. Grant applications are sought to (1) manufacture prototype magnets using a permanent magnetic material. They can be either quadrupoles or focusing/defocusing combined function magnets. The same type of structure could be used for the proton cancer therapy gantries where the 30-250 MeV protons would be delivered under different angles to the patients. There is also a strong interest in the proton cancer therapy for this type of gantry as it simplifies the treatment due to the fixed magnetic field and due to reduction of the magnet size and weight.

Questions – contact: Manouchehr Farkhondeh, manouchehr.farkhondeh@science.doe.gov
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

j. 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) through (7) in the first paragraph of this subtopic, contact Dr. Robert Rimmer at Thomas Jefferson National Accelerator Facility (rarimmer@jlab.org) or Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov).
2. For all other specification questions, contact Dr. Charles Reece at Thomas Jefferson National Accelerator Facility (reece@jlab.org) or Dr. Sergey Belomestnykh at Brookhaven National Laboratory sbelomestnykh@bnl.gov.

References: Subtopic b:

1. For further specifications on power sources, contact Dr. Leigh Harwood at Thomas Jefferson National Accelerator Facility (TJNAF) (harwood@jlab.org), or Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov)
2. For more detail on technical specification of TJNAF klystron replacement, contact Rick Nelson at Thomas Jefferson Laboratory (nelson@jlab.org).

References: Subtopic c:

1. For further specifications on fast frequency switching rf cavities contact Dr. Dejan Trbojevic at Brookhaven National Laboratory (trbojevic@bnl.gov).
2. For questions related to software design and modeling, contact Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov) or Dr. Sergey Belomestnykh at Brookhaven National Laboratory (sbelomestnykh@bnl.gov).
3. For questions or further specifications on SRF deflecting cavities, contact Drs. Yaroslav Derbenev, Geoffrey Krafft or Yuhong Zhang at Thomas Jefferson National Accelerator Facility (derbenev@jlab.org, krafft@jlab.org, yzhang@jlab.org), or Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov) or Dr. Sergey Belomestnykh at Brookhaven National Laboratory (sbelomestnykh@bnl.gov).

References: Subtopic d:

1. For questions and further specifications on design, modeling and hardware development of full acceptance magnets for EI, contact Dr. Yuhong Zhang at Thomas Jefferson National Accelerator Facility (yzhang@jlab.org).
2. For further information related to coherent electron cooling, please contact Dr. Vladimir Litvinenko at Brookhaven National Laboratory (vl@bnl.gov).
3. For further specifications to develop beam absorbers for energy-recovery-linac contact Dr. Geoffrey Krafft (krafft@jlab.org).

4. For further questions to develop software for state-of-the-art in the simulation of beam physics contact Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov) and Yuhong Zhang at Thomas Jefferson National Accelerator Facility (yzhang@jlab.org).

References: Subtopic e:

1. For further specifications on polarized electron sources, contact Dr. Matthew Poelker at Thomas Jefferson National Accelerator Facility (poelker@jlab.org). For questions on polarized ion sources contact Dr. Anatoli Zelenski at Brookhaven National Laboratory (zelenski@bnl.gov).

References: Subtopic f:

1. For further technical specifications contact Dr. Felix Marti, FRIB/MSU (marti@frib.msu.edu).

References: Subtopic g:

1. For further specifications on fast-release solid catcher materials contact Dr. Dave Morrissey, NSCL/MSU (morrissey@nscl.msu.edu).
2. For charge breeding (EBIS/T) contact Dr. Stefan Schwarz NSCL//MSU (schwarz@nscl.msu.edu).
3. For radiation resistant superconducting quadrupoles contact Dr. Al Zeller, FRIB/MSU (zeller@frib.msu.edu).
4. For innovative approaches to the construction of large aperture magnets contact Dr. Wolfgang Mittig, NSCL/MSU (mittig@nscl.msu.edu).

References: Subtopic h:

1. For further specifications on triggerable, high speed frame grabber cameras contact Dr. Geoffrey Krafft at Thomas Jefferson National Accelerator Facility (krafft@jlab.org).

References: Subtopic i:

1. Additional technical contacts are Dr. Dejan Trbojevic at Brookhaven National Laboratory (BNL) (dejan@bnl.gov), Dr. Vadim Ptitsyn at BNL (vadimp@bnl.gov), and Dr. Vasiliy Morozov, Thomas Jefferson National Accelerator Facility (morozov@jlab.org).

References: All Subtopics:

1. NP SBIR/STTR Topic Associate for Accelerator Technology: Michelle Shinn, michelle.shinn@science.doe.gov.
2. Facility for Rare Isotope Beams (http://frib.msu.edu/)
3. "Application of Accelerators in Research and Industry: 17th International Conference on the Application of Accelerators in Research and Industry", Proceedings of the 17th International Conference on the Application of Accelerators in Research and Industry, Denton, TX, November 12-16, 2002, New York: American Institute of Physics, Oct. 2003. (ISBN: 978-0735401495). (http://www.amazon.com/Application-Accelerators-Research-Industry-Instrumentations/dp/0735401497/ref=sr_1_1?ie=UTF8&qid=1252008928&sr=8-1).
4. Champion, M. et al., "The Spallation Neutron Source Accelerator Low Level RF Control System", Proceedings of 2003 Particle Accelerator Conference, Portland, OR. pp. 3377. May 12-16, 2003. (http://accelconf.web.cern.ch/accelconf/p03/INDEX.HTM).
5. SRF Materials Workshop, Michigan State University. October 29 - 31, 2008. (http://meetings.nscl.msu.edu/srfmatsci/index.php?id=conference_details/main.php/).
6. Proceedings of the 3rd International Workshop on Thin Films and New Ideas for Pushing the Limits of RF Superconductivity, Jefferson Laboratory. 2008. (http://conferences.jlab.org/tfsrf/).

7. CEBAF @ 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. Bogacz, A. et. al., "Design studies of a high-luminosity ring-ring electron ion collider at CEBAF", Proceedings of the PAC, Albuquerque, NM. June 25-19, 2007. (http://casa.jlab.org/research/elic/elic.shtml; the ELIC Zeroth order design review: at http://casa.jlab.org/research/elic/elic_zdr.doc)
10. Freeman, H. "Heavy-Ion Sources: The Star, or the Cinderella, of the Ion-Implantation Firmament?" *Review of Scientific Instruments*, Vol. 71, pp. 603. Feb. 2000. (ISSN: 0034-6748). (http://rsi.aip.org/resource/1/rsinak/v71/i2/p603_s1).
11. Ben-Zvi, I. et al. "R&D Towards Cooling of the RHIC Collider", Proceedings of the 2003 Particle Accelerator Conference, Portland, OR. May 12-16, 2003. (http://accelconf.web.cern.ch/accelconf/p03/INDEX.HTM).
12. Proceedings of the 2003 Rare Isotope Accelerator (RIA) R&D Workshop, Bethesda, MD, Aug. 26-28, 2003.
13. Trbojevic, D., et al. "Design of a Nonscaling Fixed Field Alternating Gradient Accelerator", Physical Review Special Topics—Accelerators and Beams, 8, 050101, (2005). (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. Schwarz, S. et al., "EBIS/T charge breeding for intense rare isotope beams at MSU"; Journal of Instrumentation 5, C10002 (2010).

25. 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, facilities worldwide. 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), and at the future facility for rare isotope beams (FRIB) under construction at Michigan State University, and associated with detector and luminosity upgrades at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Lab, and a possible future Electron-Ion Collider (EIC). Also of interest is technology related to future experiments in fundamental symmetries, such as neutrinoless double-beta decay (DBD) experiments and the measurement of the electric dipole moment of the neutron. In case of DBD experiments, 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 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) Ultra-violet and optical photon detectors and photosensitive devices:

- 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 noble gas or liquid ionization chambers and other cryogenic detectors;

(3) Electromagnetic (EM) 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.
- EM calorimeters capable of handling high rates in noisy (very high low-energy background) environments and can withstand high radiation.

(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 Microchannel 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 that can handle and trigger at high rate in noisy (very high low energy background) environments;

  affordable methods for the production of large volumes of high-purity xenon, argon 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 multipoles 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 cryo-coolers.

(8) High-performance fast magnetic field probes with 3D field measurement capability with low noise at measurement rates of the order of 100 measurements per second. Low-noise 3D Hall probes with minimum planar Hall-effect sensitivity would be one possible implementation. Improved orthogonality of the probes for the three different field components would be of interest. Also of interest are calibration devices and techniques for efficient characterization of such probes (in particular position and orientation of individual probes in 3D space

Questions – contact: Manouchehr Farkhondeh, manouchehr.farkhondeh@science.doe.gov
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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:

- Position-sensitive photon tracking devices for nuclear structure and astrophysics applications, as well as associated technology for these devices. High-resolution germanium (Ge) 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.

- 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.
- 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 ~ 50 μm 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 microchannel plates; microstrip, Gas Electron Multipliers (GEMs), Micromegas and other types of micropattern detectors;
- Commercial and cost effective production of GEM foils or thicker GEM structures;
- Micropattern 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 Chamber or other gaseous chamber detector technologies capable of tracking and measuring low momentum (<100 GeV/c) alpha particle, deuteron and proton with better than 10 keV resolution, thereby allowing tagged fixed-target experiments ;
- 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
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

c. Technology for Rare Decay and Rare Particle Detection

Grant applications are sought for detectors and techniques to measure 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, connecting and processing signals from high-density arrays of detectors (such as radio-pure signal cabling, signal and high voltage interconnects, vacuum feedthroughs, and front-end amplifier FET assemblies; radiopurity 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
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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 capable of withstanding high electron or proton beam currents;
- Polarized solid deuteron target with high tensor polarization;
- 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 μg/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
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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:

- Rotary 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 10^5 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.

- Fast neutron and photon dose-equivalent area monitors: Neutron and photon dose-equivalent area monitors that are fast and pulsed beam capable, have dose response to high energy radiation (e.g. neutron energies > 1 GeV), and can meet high safety standard requirements (e.g. IEC 61511) would be beneficial at high power research accelerator facilities like FRIB or medical accelerator facilities where full beam loss accidents can have significant dose consequences. Response times in the range of 0.3 seconds or lower are desirable.

Questions – contact: Manouchehr Farkhondeh, manouchehr.farkhondeh@science.doe.gov
You may also contact the NP Topic Associate (TA) listed at the beginning of the All Subtopics References section for this topic.

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

References: Subtopic a:

1. For development of iron-free magnet systems with tilted crossed solenoid windings listed above interested parties should contact Dr. Daniel Bazin, NSCL/MSU (bazin@nscl.msu.edu).
2. For the development of high-performance fast magnetic field probes listed above interested parties should contact Dr. Marc Hausmann, FRIB/MSU (hausmann@frib.msu.edu).
3. Garutti, E. "Silicon Photomultipliers for High Energy Detectors", Journal of Instrumentation, 2011 JINST 6 C10003. (http://iopscience.iop.org/1748-0221/6/10/C10003).
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References: Subtopic b:

1. For questions related to items above listed under general field of micropattern gas detectors contact Dr. Bernd Surrow (surrow@temple.edu).
2. For questions related to advancement of more conventional gas tracking detector systems contact Dr. Wolfgang Mittig, NSCL/MSU (mittig@nscl.msu.edu).
3. For item 2 listed above under development of detectors for rare isotope beams contact Dr. Marc Hausmann, FRIB/MSU (hausmann@frib.msu.edu).
4. Bellwied, R. et al., "Development of Large Linear Silicon Drift Detectors for the STAR Experiment at RHIC", Nuclear Instruments and Methods in Physics Research A, Vol. 377, pp. 387. 1996. (http://www.sciencedirect.com/science/journal/01689002).

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References: Subtopic c:

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References: Subtopic e:

1. For questions related to technologies for high-power targets for FRIB contact Dr. Wolfgang Mittig, NSCL/MSU (mittig@nscl.msu.edu).

References: Subtopic f:

1. For rotary vacuum seals listed above contact Dr. Frederique Pellemoine, FRIB/MSU (pellemoi@frib.msu.edu). For multiple-use vacuum seals listed above contact Tom Burgess, ORNL/NSED (burgesstw@ornl.gov).
2. For radiation resistant magnetic field probes listed above contact Dr. Georg Bollen, FRIB/MSU (bollen@frib.msu.edu).
3. For models of radiation transport in beam production systems and for fast neutron and photon dose-equivalent area monitors contact Dr. Reg Ronningen, NSCL/MSU (ronningen@frib.msu.edu).
4. FRIB: DOE Funding Opportunity Announcement (FOA) regarding the submission of applications for the conceptual design and establishment of a Facility for Rare Isotope Beams (http://energy.gov/articles/fact-sheet-facility-rare-isotope-beams-frib-applicant-selection).
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References: All Subtopics:

1. NP SBIR/STTR Topic Associate(s) for Instrumentation, Detection Systems and Technique: Kawtar Hafidi: kawtar.hafidi@science.doe.gov or Elizabeth Bortosz: elizabeth.bortosz@science.doe.gov
2. Facility for Rare Isotope Beams (http://frib.msu.edu/).
3. "Conceptual Design Report for the measurement of neutron electric dipole moment, nEDM, Los Alamos National Laboratory, Feb. 2007. (http://p25ext.lanl.gov/edm/pdf.unprotected/CDR(no_cvr)_Final.pdf).
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26. 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, and 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.

Grant applications are sought in the following subtopics:

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 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 Improved thermal and mechanical modeling capabilities that include target material phase change and variable material density are also of interest to assist design of targets 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 that continue to gain importance in targeted alpha therapy applications Other radioisotopes, considered dual-purpose ('theragnostic') 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 of technologies advancing production, handling and distribution/transportation of isotopes are encouraged. In addition, new approaches to hot-cell target fabrication technologies that will facilitate the recycling of precious target materials used in production of high purity radioisotopes are also 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.

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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, In-110, Tc-94m), as well as, existing radioisotopes (e.g., I-124, Cu-64, Y-86) would be a synergistic and efficient use of resources. Applications are sought for developing commercial methods similar to and compatible with existing commercial PET isotope production methods.

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 encouraged, 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 favorable nuclear properties for both imaging and therapy. Scaled up production for the supply of commercial quantities of high specific activity Sn-117m would be of high interest. Re-186 has suitable nuclear properties for therapy and is chemically similar to widely used Tc-99m. Therefore, Re-186 could be used as a therapeutic matched pair for currently available diagnostic imaging agents. Alternative methods of production or mass separation to remove stable Re isotopes are highly desirable to provide commercial quantities of high specific activity Re-186. In actinide radiochemistry, innovative methods are sought a) to improve radiochemical separations of or lower-cost approaches for producing high-purity radium-225, 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. Advanced methods for the preparation of high purity radium-225 and Ac-225 from irradiated thorium targets are of particular interest. 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

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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 LANL (meiring@lanl.gov) or Dr. Suresh Srivastava of BNL (suresh@bnl.gov).

References: Subtopic b:

1. For further specifications contact Dr. Saed Mirzadeh (mirzadehs@ornl.gov) at ORNL or Dr. Leonard Mausner (lmausner@bnl.gov) at BNL.

References: All Subtopics:

1. NP SBIR/STTR Topic Associate for Isotope Science and Technology: Dennis Phillips: dennis.phillips@science.doe.gov.
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