PROGRAM AREA OVERVIEW
ADVANCED SCIENTIFIC COMPUTING RESEARCH

The primary mission of the Advanced Scientific Computing Research (ASCR) program is to discover, develop, and deploy computational science and high-performance networking tools and services that enable researchers in scientific disciplines to analyze, model, simulate, and predict complex phenomena important to the Department of Energy. 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 network research. 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.

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 National Leadership Computing Facility (NLCF) at Oak Ridge National Laboratory (ORNL), the National Leadership Computing Facility (NLCF) at Argonne National Laboratory, 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.

01. ADVANCED NETWORK TECHNOLOGIES AND SERVICES

The Internet is a collection of independently owned and operated networks interconnected in a complex mesh to meet the needs of today's digital society. These networks range from

broadband networks supporting consumer activities (i.e., entertainment, business, and SOHO work activities) to multi-Gigibit/sec Research and Education Networks (RENs) supporting large-scale science experiments at major academic, industry, and government research institutions. Further complications arise when application traffic crosses multiple network domains, as a performance problem anywhere along the path will be visible to the application user, but the resolution may require action on the part of some remote network operator. While low-level tools like NetLogger (http://netlogger.lbl.gov/) can help identify bottlenecks that impact application level performance, it takes an expert in the tool to interpret the results before steps can be taken to eliminate those bottlenecks.

Therefore, it is essential that new technologies, tools, and high-level services get developed and deployed to make it easier for network operators to identify where performance problems exist and to raise user expectations. Dealing with these complex issues will require new multi-domain tools and services that provide authorized personnel access to performance and operations data along the entire end-to-end application path. It should also be recognized that individual users may need summary information to assist them in reporting problems, while network operators need more detailed information to fix problems. Meeting both types of needs using a single measurement and monitoring infrastructure would greatly improve the network experience for a large number of users.

While DOE science applications push the limits of today's networks in terms of absolute performance, all network operators face a growing need for advanced tools and services to better manage their infrastructure. This topic solicits proposals that deal directly with all aspects of building, operating, and maintaining large network infrastructures. **Grant applications are sought only in the following subtopics:**

a. Extensions to perfSONAR—perfSONAR is a framework for developing multi-domain measurement and monitoring services. This framework separates the collection of data from the use of this data. It also provides access control mechanisms and services that allow network providers to control how collected data is shared with peers and other potential data consumers. The ability to separate data collection from data consumption promotes innovation in both areas. Tools and services that collect unique data values can be developed and deployed by operators and users that find these tools useful. Tools and services that analyze data can draw from this wide pool of data sources without needing to deploy boxes in hundreds to thousands of locations. Grant applications are sought that leverage the perfSONAR framework to create tools and services that generate or consume measurement or monitoring data. Issues include, but are not limited to: hardening of existing research tools; collecting 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.

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

b. Management tools for Network Operators—network infrastructure must be actively managed to ensure that the infrastructure itself does not become a major performance bottleneck. This management requires an understanding of how traffic is currently flowing, making

predictions about how traffic flows will change in the future, and, increasingly, how much energy this infrastructure is using. Network operations staff need tools and services to make real-time decisions regarding the current performance of the network. Operators also need tools and services that handle longer term capacity planning activities which balance multiple parameters e.g. cost, performance, and energy usage. Grant applications are sought to develop management tools suitable for managing large distributed network infrastructures. Issues include, but are not limited to: visualization tools that provide deep insights into the current status of the network links, router, switches, and optical gear; traffic engineering tools that allow operators to deal with performance bottlenecks; capacity planning tools that allow operators to determine how to effectively grow the network to meet future demands; tools that allow operators to optimize the network balancing performance, cost, and energy consumption.

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

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

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

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

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3. Aida, K. and Sugie, T., "Remote Measurement Method for Transmission Characteristics of Access Network Fibers with Coherent MPI," OFC 2011 paper JThA7

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

Over the past 30 years, The Department of Energy's (DOE) supercomputing program has played an increasingly important role in scientific research by allowing scientists to create more accurate models of complex processes, simulate problems once thought to be impossible, and analyze the increasing amount of data generated by experiments. Computational Science has become the third pillar of science, along with theory and experimentation. However despite the great potential of modeling and simulation to increase understanding of a variety of important engineering and manufacturing challenges, High Performance Computing (HPC) has been underutilized due to application complexity, the need for substantial in-house expertise, and perceived high capital costs. This topic is specifically focused on bringing HPC solutions and capabilities to advanced manufacturing and engineering market sectors. **Grant applications are sought only 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 are strongly encouraged as well as applications that address the need to have solutions that are easier to learn, test and integrate into the product development cycle by a more general user (one with computational experience, but not necessarily an expert). Issues to be addressed include, but are not limited to: Developing turn-key HPC application solutions, porting HPC software to platforms that have a more reasonable cost vs. current high end systems (this could also include porting to high performance workstations (CPU/GPU) which would provide justification for the procurement of HPC assets or small scale clusters, or to a "cloud" type environment or service), HPC software as a service, etc.

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

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

common frameworks, etc. Grant applications must establish how the proposed tools and services can greatly increase the ease of use for a less-experienced HPC user or developer.

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

c. Hardening of an 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 Scientific Discovery through Advanced Computing (SciDAC) 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, and decreasing complexity of a code by stripping out components, user support tools/services, or other ways that make the code more widely useable.

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

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

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

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Subtopic a:

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Subtopic b:

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Subtopic c:

1. "Workshop for Independent Software Developers and Industry Partners," Workshop Summary, Chicago, IL. March 31, 2011. (https://outreach.scidac.gov/forum/forum.php?forum_id=308)

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PROGRAM AREA OVERVIEW
OFFICE OF BIOLOGICAL AND ENVIRONMENTAL RESEARCH

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

BER has interests in the following areas:

(1) Systems biology is the multidisciplinary study of complex interactions specifying the function of entire biological systems—from single cells to multicellular organisms—rather than the study of individual components. The Biological Systems Science subprogram focuses on understanding the functional principles that drive living systems, from microbes and microbial communities to plants and other whole organisms. Questions include: What information is in the genome sequence? How is information coordinated between different

subcellular 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. 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; experimental research on the effects of climate change on ecosystems; 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 biogeochemical processes on the fate and transport of DOE-relevant contaminants.
- 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 Climate Research Facility (ARM) 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.

03. ATMOSPHERIC MEASUREMENT TECHNOLOGY

World-wide energy production is modifying the chemical composition of the atmosphere. Such modifications are linked not only with 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 Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) examined the effect of changes in clouds and aerosols on the Earth's energy balance. It was determined that innovative measurement technologies are needed to provide both input and comparison data for models used to assess the energetic impacts of clouds and aerosols. These technologies will require high accuracy and time stability, in order to support a strategy of sustainable and pollution-free energy development for the future.

When the last IPCC report was published in 2007, there was a lack of data on the Arctic. The latest scientific data on the rate of Arctic warming show dramatic levels of melting and sea level rise occurring far faster than previous climate model estimates. The U.S. Arctic remains one of the most difficult places on Earth for year-round scientific observations and research. One of the major recommendations of an Arctic Research Consortium of the U.S. (ARCUS), 1997[1] 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. Measurements of the vertical distribution of aerosol properties provide essential information for generating more accurate model estimates of radiative forcing and atmospheric heating rates compared with employing remotely sensed column averaged properties. Therefore, we are seeking miniaturization of airborne instrumentation for light aircraft platforms in the Manta, ScanEagle, or Raven classes of unpiloted aerial vehicles (UAVs). (See sub-topics (a.) and (b). We expect the Instruments for the UAV to fit the payload capacities of light UAVs, ranging from a few kg up to approximately 5 kg. Available operating power for these instruments will be in the range of 10 to 50 watts, depending on the vehicle. We desire that Instrument packages be configurable where possible to allow adaptation for various science mission requirements and UAV platforms.

Grant applications that respond to this 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. Instrument Package for Characterization of Aerosols, Turbulence, and Surface Characteristics in the Arctic—Measurement in the Arctic are needed to provide new insights into atmospheric characterization of clouds and aerosols in the vicinity of ARM's North Slope of Alaska (NSA). Thus we are seeking an instrument package that will include an instrument that measures aerosol size distributions in the 10nm to 10 micron range, a sonic anemometer for turbulence measurements, cloud condensation nuclei counter (CCN), and also providing surface

characterization capabilities utilizing lidar, synthetic aperture radar (SAR), or/and camera (downward) imaging capability.

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

b. Cloud Hydrometeors in Arctic Clouds—We are seeking an instrument package to determine the size distribution of hydrometeors in Arctic clouds, and shape. We will require the instrumentation to document the vertical variability of hydrometeors of various levels.

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

c. Measurements of the Chemical Composition of Atmospheric Aerosols—Improved 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, these measurements could help elucidate how the particles of an aerosol 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, which are abundant in many locations in the atmosphere. In particular, there is a need for instruments suitable for 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, these instruments have important limitations in their ability to quantify black carbon vs. organic carbon, provide speciation of refractory and volatile organic compounds, and calibrate both organic and inorganic components. Furthermore, instruments that otherwise would be suitable for ground-based operation often have limitations (size, weight, power, stability, etc.) that restrict their application for *in situ* measurements, where critical atmospheric processes actually occur (e.g., in or near clouds).

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. Proposed approaches that can measure aerosol chemical composition from airborne platforms would be of particular interest.

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

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

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

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

Finally, grant applications are sought to develop improved measurements of inorganic aerosol precursors. Examples of compounds of interest (with desirable detection limits and response rates listed in parenthesis) include gaseous HNO3 (0.1 ppbv, 1 Hz), O3 (2-3 ppbv, 10 Hz), and SO2 (5 pptv, 1 Hz).

In addition to the free-air measurements described above, grant applications are sought to develop instruments or instrument systems for measuring aerosol precursors in cloud droplets. Such systems must address (1) methods for the efficient sampling of droplets; and (2) a mechanism for transferring the sample to the appropriate analytical instrumentation, in which the organic or inorganic target analytes are measured. Of particular interest are systems that can separate or discriminate between interstitial compounds and compounds that occur dissolved or suspended within cloud droplets. Proposed instruments that are suitable for sampling from airborne platforms (that is, with reduced weight and power requirements, high sensitivity, and fast response time) would be of particular interest.

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

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

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

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

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

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

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

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

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Subtopics a/b:

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04. CARBON CYCLE MEASUREMENTS OF THE ATMOSPHERE AND THE BIOSPHERE

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, and to understand processes and mechanisms of carbon sequestration of the terrestrial biosphere. There is also interest in innovative approaches for flux and concentration measurements of methane and other greenhouse gas constituents associated with terrestrial systems.

The "First State of the Carbon Cycle Report (SOCCR)" (Reference 1) provides rough estimates of terrestrial carbon sinks for North America. A DOE working paper on carbon sequestration science and technology (Reference 2) also describes research needs and technology requirements for sequestering carbon by terrestrial systems. 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).

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, with comparable dimensions for marine systems) 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 and for estimating carbon sequestration. 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. Sensors and Techniques for Measuring Terrestrial Carbon Sinks and Sources— Measurement technology is required to quantify carbon sequestration by natural vegetation and ecosystems (i.e., carbon sinks) as well as CO_2 emissions to the atmosphere from natural or

industrial sources. Grant applications are sought to develop sensors and unique measurement techniques (and associated system technology, if appropriate) to detect and quantify annual net carbon changes of terrestrial vegetation for large areas, or to measure and verify the magnitude of CO_2 emissions from various sources. Approaches of interest include the development of sensors to measure fluxes between the atmosphere and land-surface vegetation, new technology for accurate measurement of soil carbon content and change, and the development of miniaturized sensors to determine atmospheric CO_2 concentration.

For the measurement of CO_2 sinks, the sensor systems or new technology must be applicable for forests, grasslands, shrub lands, agricultural lands, and/or wetlands, and have the capability of producing spatially resolved aggregate estimates of terrestrial carbon changes to an accuracy of 10 to 25 g/m2/yr (or approximately 0.25 tonnes of carbon per hectare per year), with less than 25 percent uncertainty.

For measuring emissions or atmospheric concentrations, the apparatus must be located at a point remote from the actual site of CO_2 release and provide accuracy estimates for CO_2 concentrations of approximately 0.3 ppm or less in dry air.

Mechanical sensors must be durable in the full range of normal environmental conditions and exposures, including exposure to dust, rain, snow, heat, extreme cold, and fog. Operation in unattended, remote locations for weeks at a time, without degradation of the measurement, is also required; however, daily telecommunication with the system for monitoring performance and detecting potential operational problems would be desirable.

Proposed approaches, including both mechanical sensors and non-mechanical technology should consist of new, innovative methodologies that are significant advances over conventional scientific approaches used to measure CO_2, carbon, and methane within the atmospheric and terrestrial components of the global carbon cycle. Specifically, the measurement systems should be different from, or substantially augment, existing techniques for eddy flux (covariance) methods and routine monitoring of atmospheric CO_2 concentrations, or for estimating carbon quantities of land and/or ocean constituents of the carbon cycle. Grant applications proposing *in situ* or in-stream measurement of flue gas emissions will be declined, as will applications that offer only incremental or marginal improvements over existing measurement systems.

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

b. Novel Measurements of Carbon, CO_2, and Trace Greenhouse Gas Constituents of Terrestrial and Atmospheric Media—Improved measurement technology is needed to better characterize processes involving carbon transformations of soil, vegetation, and associated ecosystem components and exchanges with the atmosphere. Particular areas of interest include high resolution measurements of soil carbon/organic matter – i.e., the carbon content of biological tissues in various components (e.g., phytomass, detritus) of terrestrial ecosystems; improved measurement technology for atmospheric CO_2 and its isotopes; and high accuracy and precision measurement of other trace greenhouse gases. Requests for specific grant applications are described in items (1) to (4) below:

(1) For determining the carbon content of biota and soil, grant applications are sought to develop and demonstrate measurement technology for estimating changes of carbon quantities and/or fluxes involving major components of ecosystems, with an accuracy on the order of 10 grams per square meter or less. Quantification of spatially resolved aggregate estimates of terrestrial carbon changes should have an accuracy of 10 to 25 g/m2/yr (or approximately 0.25 tonnes of carbon per hectare per year), with less than 25 percent uncertainty.

(2) Grant applications are sought to design and demonstrate a new CO_2 analyzer that (a) can determine the mole fraction of CO_2 in dry ambient air to a relative precision of 1 part in 3000 or better, in one minute or less; (b) operates with small amounts of gas (30 cc/min or less) to minimize problems due to water vapor and to minimize consumption of reference gases, if employed; (c) is robust enough for unattended field deployment for periods of half a year or longer; (d) costs less than $5000 when manufactured in quantity; and (e) is not sensitive to motion.

(3) Grant applications are sought to develop lightweight sensors (approximately 100 grams) for measuring atmospheric CO_2. The sensors must be capable of measuring fluctuations of CO_2 in air of the order of plus or minus 1 ppm, in a background of 370 ppm. The devices must be suitable for launch on ballonsondes or similar platforms, and therefore must be insensitive to large changes in ambient temperature and pressure. The devices also must be able to operate on low power (e.g., 9v battery) and have a response time of less than 30 seconds.

(4) Grant applications are sought to develop new technology platforms that can be used to measure fluxes and/or concentrations of important trace greenhouse gas constituents, as well as the isotopes of carbon, methane, CO, and other trace species. Instrument designs should (a) place emphasis on determining the sources and sinks of carbon, CO, and trace species, and (b) ensure long-term and robust field deployment. Grant applications dealing with the remote measurement of vascular plant properties and processes will be considered, provided that they meet the requirements described below.

In general, new technology for measuring terrestrial biota and soil must be accomplished by *in situ* and/or non-invasive means, across a range of temporal scales (from seconds to days) and spatial scales (from millimeters to kilometers), depending on the system properties being observed. The remote sensing of organic carbon is also of interest – the term "remote sensing" means that the observation method is physically separated from the object of interest. All instruments must be portable and deployable in remote locations, and must not adversely impact the site of deployment. Two other approaches are also of interest: (1) the development of unique surface-based observations that are used for the calibration/interpretation of other remotely derived data; and (2) potential applications of CO_2 sensors via balloon sonde – however, remote sensing data acquisition by airborne or satellite platforms will not be considered.

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

c. Greenhouse Gas and Carbon Isotope Measurements from Aircraft—Stable isotopologes of methane and carbon dioxide can be powerful tracers for identifying the sources of these greenhouse gases. Airborne surveys of isotopologes of these greenhouse gases made at

sufficiently high precision and speed will be an invaluable tool in the studies of Arctic climate change and terrestrial carbon cycle. Instruments capable of operating on airborne platforms such as UAV's as well as manned aircraft with little or no temperature our pressure control are needed, and measurements must be made with high precision for either methane ($\delta^{13}C$) or carbon dioxide ($\delta^{13}C$, $\delta^{18}O$) at rates of 1 Hz. or better. We seek an instrument of this nature in order to examine the climate issues related to the Arctic. This information is intended to address issues related to adaptive grids in DOE's modeling endeavors in the Arctic.

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

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05. GENOMIC SCIENCE AND RELATED BIOTECHNOLOGIES

DOE's Genomic Science program supports research aimed at identifying the fundamental principles that drive biological systems relevant to DOE missions in energy, climate, and the environment. These principles guide the translation of the genetic code into functional proteins and the metabolic/regulatory networks underlying the systems biology of plants, microbes, and communities. Advancing fundamental knowledge of these systems will enable new solutions to national priorities in sustainable bioenergy production, understanding the fate and transport of environmental contaminants, and developing new approaches to examine the role of biological systems in carbon cycling, biosequestration, and global climate. The major objectives of the Genomic Science program are to i.) Determine the molecular mechanisms, regulatory elements, and integrated networks needed to understand genome-scale functional properties of microbes, plants, and communities, ii.) Develop –omics experimental capabilities and enabling technologies needed to achieve dynamic, system-level understanding of organism and/or community function, and iii.) Develop the knowledgebase, computational infrastructure, and modeling capabilities to advance predictive understanding and manipulation of biological systems. **Grant applications are sought in the following subtopics:**

a. High throughput Methods for Sequencing and Analysis—With the advent of faster and cheaper genomic sequencing technologies, the microbial, plant and metagenomics communities will see an order of magnitude increase in sequencing DNA and RNA to infer microbial, plant and community information. Applications are sought in the following areas:

- High throughput experimental methods for functional assignment/annotation of genes and genomes of relevance to the DOE mission.
- High throughput automated or robotic sample preparation methods focused on DNA and/or messenger RNA.
- Novel DNA sequencing technologies that generate at least 2 Kbases of continuous sequence, with base call error rates less than 5%
- New methods for isolation of DNA or RNA from single cells with accurate amplification and sequencing of >90% of the genomic content.
- New methods for direct sequencing of up to 400 base pairs of RNA, not requiring any intermediate cDNA steps

- New software tools for high throughput and efficient assembly of short read (150< base pairs) fragments of DNA from disparate sequencing platforms.
- New methods for accurate separation of distinct genomes from polyploid (multiplied) nuclei of fungi and plants.

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

b. Software Tools for the Systems Biology Knowledgebase (Kbase)—The Kbase is in a stage of active development and could benefit from complementing software tools. These can include but are not limited to tools for:

- Development or adaptation of Laboratory Information Management Systems (LIMS) to integrate together different types of experimental biological data such as proteomics, transcriptomics, flux and network data with genomic data.
- Software to automatically extract biologically relevant information from different databases, such as microarray, proteomic, metabolomic data;
- Development of web-to-web services for bioinformatic tools.
- Development of software tools to upload, integrate and analyze biological data in a cloud architecture

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

c. High Throughput Phenotyping Methods for Bioenergy Related Plant Systems—Grant applications are sought to develop high-throughput phenotyping methods for plants, particularly non-destructive methods, that target biochemical, physiological, and structural processes and tissues relevant to bioenergy production such as the plant cell wall. Methods should be applicable to the greenhouse or field studies. Radionuclide imaging approaches are excluded from this call.

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

d. High Throughput Characterization Methods for non-pathogenic Microbial Systems—New demands for technologies are needed to meet the research needs for greater understanding of the dynamical molecular organization and function of microbial systems. Achieving an understanding of the dynamic detection and measurements of sub-attomole concentrations (perhaps down to a single protein molecule or metabolite) will enable a systems level understand of metabolic processes. Grant applications are sought to:

- develop rapid, high-throughput characterization tools for single protein sub-cellular localization and quantification
- develop high throughput functional screening for protein analysis.

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

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

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

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2. "DOE Joint Genome Institute Home Page," *DOE Joint Genome Institute: Enabling Advances in Bioenergy & Environmental Research* (:/http /jgi.doe.gov/)

3. "2010 U.S. Department of Energy Joint Genome Institute Progress Report," *DOE Joint Genome Institute: Enabling Advances in Bioenergy & Environmental Research* (http://jgi.doe.gov/whoweare/JGI_Progress_Report_2010.pdf; http://jgi.doe.gov/whoweare/progress.html or requesting copies)

4. "DOE Joint Genome Institute Fact Sheet," *DOE Joint Genome Institute: Enabling Advances in Bioenergy & Environmental Research* (http://jgi.doe.gov/whoweare/JGI_Fact_Sheet.pdf)

Subtopic b:

1. "Overview of Research Projects and Activities Underpinning Development of the DOE Systems Biology Knowledgebase," *Genomic Science Program: Systems Biology for Energy and Environment*. (http://genomicscience.energy.gov/compbio/ComputingProjects_flyer.pdf)

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Subtopic c:

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2. "Plant Feedstock Genomics for Bioenergy – Awards," *Gemonic Science Program: Systems Biology for Energy and Environment.* (http://genomicscience.energy.gov/research/DOEUSDA/awards.shtml#page=news)

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Subtopic d:

1. "Grand Challenges for Biological and Environmental Research: A Long-Term Vision," *Genomic Science Program: Systems Biology for Energy and Environment*. (http://genomicscience.energy.gov/program/beracltv.shtml#page=news)

2. "New Frontiers in Characterizing Biological Systems," *Genomic Science Program: Systems Biology for Energy and Environment.* (http://genomicscience.energy.gov/characterization/#page=news)

06. IMAGING AND RADIOCHEMISTRY

The Radiochemistry and Imaging Instrumentation Program advances the DOE mission by supporting radiochemistry and radionuclide imaging research into the real-time visualization of dynamic biological processes in energy and environmentally-relevant contexts. In particular, the program supports research that could be beneficial for metabolic imaging in living systems, including plants and microbial-communities that are relevant to biofuel production and bioremediation, and that are transferable for use in nuclear medicine research and in applications by NIH and industry. **Grant applications are sought in the following subtopics:**

a. Radiochemistry and Radiotracers for Imaging—Grant applications are sought in three new areas of radiochemistry: (1) development of new chemical reactions to overcome the synthetic constraints of working with radioisotopes at high specific activity, in order to provide more generally applicable radiolabeling techniques; (2) construction of nanoparticle platforms, for incorporation of one or more imaging agents and targeting moieties; and (3) new automation technologies, in order to provide readily adaptable, versatile purification techniques (e.g., microfluidics and kits) that can serve as transformational tools for radiotracer synthesis. Proposed approaches that directly advance the DOE mission will be given preference. Approaches that do not involve radionuclide imaging capability are not of interest and will be declined.

Questions – contact Prem Srivastava, prem.srivastava@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 Prem Srivastava, prem.srivastava@science.doe.gov

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07. ENHANCED AVAILABILITY OF CLIMATE MODEL OUTPUT

Much of the nearly $2 billion annual research budget for the U.S. Global Change Research Program supports research from the Department of Energy, National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and National Science Foundation (NSF) Studies supported by this research budget, include modeling and simulation of long-term climate change. Model output resulting from climate change projections is a valuable resource and the DOE has played a crucial role in providing such datasets to the research community. For example, the Program for Climate Model Diagnosis and Intercomparison (PCMDI) (http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php) makes available a subset of multi-model output from the Intergovernmental Panel for Climate Change (IPCC) Fourth Assessment Report to researchers for non-commercial purposes only. However, other users, particularly non-researchers that intend to use the data for commercial purposes, have been requesting access to the multi-model output. As the temporal and spatial resolution of models increase, vast amount of climate model output are generated; access and analysis of such data by non-researchers is a daunting challenge. **Grant applications are sought only in the following subtopics:**

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

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

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

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

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

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 Renu Joseph, Renu.Joseph@science.doe.gov

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Subtopic a:

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2. DOE's Atmospheric Radiation Measurement (ARM) Program provides improved scientific understanding of the fundamental physics related to interactions between clouds and radioactive feedback processes in the atmosphere. (http://www.arm.gov/)

3. DOE's AmeriFlux provides continuous observations of ecosystem level exchanges of CO_2, water, energy and momentum spanning diurnal, synoptic, seasonal, and interannual time scales. (http://public.ornl.gov/ameriflux/)

Subtopic b:

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08. TECHNOLOGIES FOR SUBSURFACE CHARACTERIZATION AND MONITORING

New measurement and monitoring tools for interrogating physical, chemical, and biological processes in subsurface environments are important elements of Department of Energy (DOE) research efforts to support the assessment of remediation performance and DOE site stewardship. The purpose of these research efforts is to determine the fate and transport of contaminants generated from past weapons production activities, assess and control processes to remediate contaminants, and provide for the long-term monitoring of sites.

Grant applications submitted to this topic must describe why and how proposed *in situ* fieldable technologies will substantially improve the state-of-the-art, include bench and/or field tests to demonstrate the technology, and clearly state the projected dates for likely operational deployment. New or advanced technologies, which can be demonstrated to operate under field conditions with mixed/multiple contaminants and can be deployed in 2-3 years, will receive selection priority. Claims of relevance to DOE sites, or of commercial potential for proposed technologies, must be supported by endorsements from relevant site managers, market analyses, or the identification of commercial spin-offs. Grant applications that propose incremental improvements to existing technologies are not of interest and will be declined.

For the following subtopics, collaboration with government laboratories or universities, either during or after the SBIR/STTR project, may speed the development and field evaluation of the measurement or monitoring technology. In addition, some of these organizations operate user facilities that may be of value to proposed projects. These facilities include:

Integrated Field Research Challenge (IFRC) research sites in Oak Ridge, TN (http://www.esd.ornl.gov/orifrc/index.html); Old Rifle, CO (http://ifcrifle.pnl.gov/); and Hanford, WA (http://ifchanford.pnl.gov/). At IFRC research sites, scientists can conduct field-scale research and obtain DOE-relevant samples of soils, sediments, and ground waters for laboratory research.

The Environmental Molecular Science Laboratory (EMSL) at the Pacific Northwest National Laboratory (http://www.emsl.pnl.gov). EMSL is a national scientific user facility with state-of-the-art instrumentation in environmental spectroscopy, high field magnetic resonance, high performance mass spectroscopy, high resolution electron microscopy, x-ray diffraction, and high performance computing.
Grant applications must describe, in the technical approach or work plan, the purpose and specific benefits of any proposed teaming arrangements.

Grant applications are sought in the following subtopics:

a. Mapping and Monitoring Hydrogeologic Processes in the Shallow Subsurface—While subsurface characterization methods are improving and yielding higher-resolution data, they are still not routinely used to describe flow and transport processes or to guide remediation activities. Grant applications are sought to develop high-resolution geophysical, geochemical, or hydrogeological methods to: (1) characterize subsurface properties that control the transport and dispersion of contaminants in groundwater and the unsaturated zone, or (2) monitor dynamic processes such as fluid flow, contaminant transport, and geochemical and microbial activity in the subsurface. Approaches of interest include the development of:

- integrated approaches where geophysical data are combined with other types of data (e.g., core analyses, well logs, hydrogeologic and geochemical information) to better constrain and evaluate flow and transport models;
- improved tools and methods for hydrogeologic characterization using cone-penetrometers and conventional well logging systems;
- innovative advances of temperature sensing technologies and approaches for hydrological characterization and monitoring from subsurface, surface, or airborne platforms; and
- improved methods for the long-term monitoring (for one year, ten year, and one hundred year time frames) of contaminated sites, using integrated sensor networks.

Questions – contact David Lesmes, david.lesmes@science.doe.gov

b. Real-Time, In Situ Measurements of Geochemical, Biogeochemical and Microbial Processes in the Subsurface—Sensitive, accurate, and real-time monitoring of geochemical, biogeochemical, and microbial conditions are needed in subsurface environments, including groundwater, sediments, and biofilms. In particular, highly selective, sensitive, and rugged in situ devices are needed for low-cost field deployment in remote locations, in order to enhance our ability to monitor processes at finer levels of resolution and over broader areas. Therefore, grant applications are sought to develop innovative sensors and systems to detect and monitor geochemical and biogeochemical processes that control the chemical speciation or transport of metals and radionuclides in the subsurface. Only the following radionuclides and metals are of

interest: technetium, chromium, strontium-90, mercury, uranium, iodine-129, plutonium, americium, cesium-137, and cobalt. The ability to distinguish between the relevant oxidation states of these elements and their chemical species is of particular concern. In addition, the microbes and metabolic processes of interest are limited to those that may be involved in controlling the subsurface fate, transport, and remediation of these elements. Grant applications that address other contaminants will be declined. Grant applications must provide convincing documentation (experimental data, calculations, etc.) to show that the sensing method is both highly sensitive (i.e., low detection limit), precise, and highly selective to the target analyte, microbe, or microbial association (i.e., free of anticipated physical/chemical/biological interferences). Approaches that leave significant doubt regarding sensor functionality in realistic multi-component samples and realistic field conditions will not be considered.

Grant applications also are sought to develop integrated sensing systems for autonomous or unattended applications of the above measurement needs. The integrated system should include all of the components necessary for a complete sensor package (such as micro-machined pumps, valves, micro-sensors, solar power cells, etc.) for field applications in the subsurface. Approaches of interest include: (1) fiber optic, solid-state, chemical, or silicon micro-machined sensors; and (2) 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. Substantial progress has been made in fiber optics and chemical sensing technology in the last decade; therefore, grant applications that propose minor adaptations of readily available materials/hardware, and/or cannot demonstrate substantial improvements over the current state-of-the-art, are not of interest and will be declined.

Questions – contact David Lesmes, david.lesmes@science.doe.gov

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

Questions – contact David Lesmes, david.lesmes@science.doe.gov

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PROGRAM AREA OVERVIEW
OFFICE OF BASIC ENERGY SCIENCES

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

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

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

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

09. TECHNOLOGY TO SUPPORT BES USER FACILITIES

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 technology to support these user facilities. **Grant applications are sought in the following subtopics:**

a. Synchrotron Radiation Facilities—As synchrotron radiation has become a ubiquitous tool across a broad area of forefront science, the DOE supports collaborative research centers for synchrotron radiation science. Research is needed for advanced detectors and advanced radiation sources, including superconducting and short-period undulators. With advances in the brightness of synchrotron radiation sources, wide gap has developed between the ability of these sources to deliver high photon fluxes and the ability of detectors to measure the resulting photon, electron, or ion signals. At the same time, advances in microelectronics engineering should make it possible to increase data rates by orders of magnitude, and to increase energy and spatial resolution. With the development of fourth-generation x-ray sources with femtosecond pulse durations, there will be a need for detectors with sub-picosecond time resolution. Grant applications are sought to develop new detectors for synchrotron radiation science across a broad

range of applications. Areas of interest include: (1) area detectors for diffraction experiments; (2) area detectors for readout of electron and ion signals; (3) detectors capable of ultra-high temporal resolution; (4) high resolution and/or high frame rate imaging detectors; (5) detectors for high rate fluorescence spectroscopy; and (6) detectors for high energy fluorescence spectroscopy. Often, detector concepts or prototypes already exist in the community, and the primary hurdle is commercialization. Proposed approaches that emphasize engineering for commercialization are of interest.

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

b. Beam Diagnostic Instrumentation for Free Electron Lasers and 3rd Generation Light Sources—Advanced electron-beam diagnostic instruments are needed to support the development of X-ray Free Electron Lasers (FEL), as well as the operation and upgrade of 3rd generation light sources. Grant applications are sought to develop monitors for beam position and electron bunch length. The beam position monitor should have nanometer resolution and associated electronics for both linac and storage ring applications. The electron beam bunch length monitor should perform non-destructive measurements, be capable of single-bunch resolution better than 100 fs, and possess a system design that is relevant for the bunch parameters of the future X-ray FEL and 3rd generation light sources.

Grant applications also are sought to develop diagnostic devices for the non-destructive measurement of electron beam emittance and for the energy spread within electron bunches. For FEL applications, measurements of electron bunch properties require resolution on the order of 10 μm, so that the so-called "slice" properties can be determined with sufficient accuracy. Both the beam emittance and the energy spread of the beam are critical parameters in FELs, and the measurement techniques must allow for rapid and noninvasive tuning, as well as for the implementation of feedback systems for systems optimization. Approaches of interest include optical techniques that employ transition radiation or synchrotron radiation. The diagnostics should be small (< 1 m length scale) and suitable for integration into an operational light source.

Grant applications also are sought to develop diagnostics for the measurement of charge modulation within an electron bunch at optical wavelengths in the regime 50-1000 nm. Seeded FELs utilize an inverse FEL scheme to first introduce an energy modulation into an electron bunch; then a dispersive transport region converts the energy modulation into a charge density modulation along the electron bunch. The charge density is modulated with the same period as the laser, i.e., in the wavelength regime 50-1000 nm.

Grant applications are sought to develop a diagnostic technique for the dynamic measurement of the transverse position of the centroid of an electron bunch, as a function of position along that bunch. The transverse wakefields in a linac may introduce the so-called "banana shape" beam as a result of the beam-breakup instability, in which deflecting wakefields introduce a transverse spatial offset in the electron distribution along a bunch. Proposed diagnostics must be able to measure this effect with spatial resolution on the order of 1 μm, and with temporal resolution (along the bunch) of 10-100 fs, in bunches of peak current 10-500 A.

Finally, grant applications are sought to develop high resolution multi-function diagnostics cavity beam position monitors (BPMs), which are well suited for LINAC applications as well as for advanced storage rings and energy recovery linacs (ERLs), represent one approach of interest. Such cavity BPM diagnostics should (1) have measurement capabilities that include sub-micron positioning, beam tilt, and charge; and (2) be physically small and low cost, in order to enable commercialization.

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

c. High Power Mercury Spallation Targets—Technology is needed to mitigate cavitation damage erosion (CDE) in short-pulse liquid-mercury spallation targets. CDE has the potential to limit the power capacity and lifetime of targets. Damage has been observed inside test target vessels irradiated with small numbers of intense proton beam pulses; also, this damage has been studied at length in out-of-beam experiments that mimic the driving mechanism of cavitation. The damage is caused by intense and abrupt pressure waves that are induced by the near-instantaneous heating of the mercury by the proton beam. Although certain surface hardening processes have shown promise in resisting damage, their potential to greatly enhance power capacity is believed to be limited. Therefore, grant applications are sought to develop:

Small gas bubbles to reduce beam-induced pressure. A population of small gas bubbles introduced in the mercury could absorb and attenuate the beam-induced pressure sufficiently to halt the driving mechanism for cavitation. The desired bubble size is approximately 10 μm in diameter and the required void fraction approaches 1%. Grant applications are sought to develop: (1) techniques for generating this population of bubbles in mercury; and (2) credible diagnostics to quantify the generated population.

Protective gas layers: Mercury, with its highly non-wetting characteristic and high surface tension is well suited to the formation and stabilization of large gas pockets. Therefore, one promising option for damage mitigation involves the creation of an interstitial gas layer between the liquid metal and the containment vessel wall.

Innovative gas/liquid flow concepts for utilizing gas layers to protect pressure-vessel surfaces from damage due to the cavitation of flowing mercury. Approaches of interest include: (1) the use of radiation-hard solid materials, such as metallic porous media or screens, as separate structures that are not part of the pressure boundary; (2) extensive surface modifications, such as grooves or cross-hatching to increase surface area; or (3) other geometries designed to trap gas permanently at the desired location. Because the most vulnerable pressure boundary surfaces in the SNS target are vertical, proposed solutions must address the problem of blanketing (protecting) vertical surfaces, where the hydrostatic gradient tends to force the gas to rise.

Alternative and innovative concepts for damage mitigation, aside from small gas bubbles or protective gas walls: grant applications must demonstrate an awareness of spallation target design and environmental requirements, with respect to high radiation and mercury compatibility.

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

d. 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 intramolecular energy redistribution. The x-ray sources may be based on, for example, high-harmonic generation to create bursts of x-rays on subfemtosecond 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 Michael Casassa, Michael.Casassa@sience.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 Eliane Lessner, Eliane.Lessner@science.doe.gov

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10. RADIO FREQUENCY (RF) DEVICES AND COMPONENTS FOR ACCELERATOR FACILITIES

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 radio frequency devices and components to support these user facilities. **Grant applications are sought in the following subtopics:**

a. RF Cavity Input Couplers—Grant applications are sought to develop variable input coupler for both normal-conducting and superconducting RF cavities – approaches must demonstrate a significant increase in mechanical complexity compared with fixed coupler designs and provide for adjustments of the input coupler beta *in situ*, in order to optimize the RF system efficiency.

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

b. RF Power Devices and Accessories—Grant applications are sought to develop (1) higher power Insulated Gate Bipolar Transistors (IOTs) with more than 6000Volts and more than 2000Amps, which are required for the development of high power modulators and power supplies; (2) a very high power (100-400 kW) 350-500 MHz solid state power amplifier to replace klystron amplifiers in synchrotron light sources; (3) new dielectric materials for vacuum-barrier RF windows for high-power applications, in order to significantly improve the power

handling capability and mechanical strength (compared to existing materials), and demonstrate a low secondary electron emission coefficient; (4) a compact, high-power stripline-input broadband R termination, which is capable of 1kW CW input power and could be used for board-mounted components such as circulators and splitters/combiners; and (5) a 4-way resonant cavity RF combiners of IOT power sources (the output of several IOTs must be combined to overcome their low power capability) to drive accelerating structures for high energy and high intensity accelerators that require several hundreds of kWs.

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

c. Devices for the Manipulation of Electron Beams—Grant applications also are sought to develop devices for the manipulation of electron beams in storage rings and linear accelerators. Such devices are used to facilitate deflection of the beam onto a predicted trajectory or to generate a time-space correlation in the beam. Devices of interest include:

(1) Electromagnetic RF cavities operating in a dipole mode, which could introduce a transverse kick to an electron bunch as a whole or provide a "head-tail" displacement within the bunch. Such cavities would need to provide deflecting kick voltages up 10 MV, with phase error < 0.01° and amplitude error < 10-4, with parasitic modes damped to Q-values < 1000 and with minimal short-range wake fields.

(2) Pulsed power supplies that can be used with stripline kickers to provide deflecting fields. Such power supplies should have a repetition rate up to 100 kHz, a voltage pulse 10-15kV, a 10 ns pulse duration, and pulse-to-pulse stability better than 10-3.

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

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

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

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3. "ICFA Beam Dynamics Mini-Workshop on Deflecting/Crabbing Cavity Applications in Accelerators," Presented at SINAP, Shanghai, China. April 23-25, 2008. (http://www.sinap.ac.cn/ICFA2008/Programs.htm)

11. ADVANCED SOURCES FOR ACCELERATOR FACILITIES

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 laser, and spallation neutron source user facilities. This topic seeks the development of technology to support the particle and radiation sources needed for these user facilities. **Grant applications are sought in the following subtopics:**

a. Electron Gun Technology—Grant applications are sought to develop novel electron gun features including:

(1) Robust cathode materials suitable for production of low emittance electron bunches at a high repetition rate, using laser excitation. The intrinsic normalized emittance of the electron beam must be of order 10-7 m-rad, in bunches of order 100 pC charge, duration of approximately 10 ps, and with quantum efficiency of 10-2 or greater. Materials should be robust to environmental

conditions, have small dark current under applied electric fields of order 10-100 MVm-1, and have long lifetime.

(2) Accelerating structures supporting electric fields of 10-100 MVm-1 at a cathode surface, allowing laser excitation of the cathode material and rapid acceleration of the emitted electrons, with minimal emittance growth and an electron bunch repetition rate of 1 MHz or greater. Combined with suitable cathode materials and a photocathode laser, the system should be capable of producing low emittance (less than 1 mm-mrad normalized) electron bunches at a minimum 1 MHz repetition rate, with up to 1 nC charge per bunch.

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

b. Undulator Radiation Sources—Advanced undulator radiation sources are required for current and future light sources. Grant applications are sought for the development of:

(1) Superconducting undulators (SCUs) that can generate tunable, monochromatic x-ray beams in the 2-30 keV photon energy range of medium-energy (2-3 GeV) synchrotrons. These requirements demand that the undulators have a short period (around 1.5 cm) and high peak magnetic fields (around 1.6 tesla). The permanent-magnets commonly used in undulators do not produce sufficiently high magnetic fields to fully cover the desired photon energy range without gaps in the spectrum. Development efforts are underway at several national laboratories and in industry to develop SCUs that promise to overcome these deficiencies. However, current designs suffer from an inability to operate without quenching in the presence of the heat induced by the stored electron beam current and by synchrotron radiation encountered in modern synchrotron light sources. This heat load can be up to 10 watts per meter of undulator length. Novel ideas for SCU design, construction, and thermal management are needed to meet these challenging requirements.

(2) Superconducting undulators with time varying fields. This technology is in its infancy and could offer interesting possibilities for insertion-device radiation sources

(3) Cryogenically-Cooled Permanent Magnet Undulators (CPMUs). When permanent magnet materials are cooled to low temperatures, they exhibit a large coercivity (5-10%) for conventional materials, such as NdFeB or CoSm, and up to 20% for more exotic materials. To make use of this effect, undulators must be cooled to cryogenic temperatures, and, in the cooled down stage, magnetic measurements and adjustments of the permanent magnet must be performed. This requires a complex design.

(4) High coercivity permanent magnet materials for CPMUs. To take full advantage of CPMUs, sintering and manufacturing procedures need to be developed for permanent magnet material like PrFeB, which exhibits large increases in coercivity at cryogenic temperatures.

(5) New superconducting materials for undulator applications. Three types of materials promise a considerable enhancement of undulator performance:
High temperature superconducting materials such as YBCO, which operate at about 90K, would allow current densities up 100kA/mm2. The challenge here is to optimize the conductor design

to maximize the current density and the transport current, leading to the development of coil manufacturing techniques based on such materials (as the next step).
Thin film high temperature superconducting materials such as MgB2, which are operated at ~39K, may become a good material for undulator magnets, depending upon the choice of substrate material, which will determine the mechanical properties of the superconductor. The challenge here is the production of thin films and the choice of optimum substrate materials.
APC (artificially enhanced pinning center) NbTi superconductor, which would allow super-high current densities that exceed the Jc of conventional NbTi superconductor by a large factor (14 kA/mm2 at 2 T). In particular, the high current density might offer an advantage for the design of magnet coils for undulator magnets.

(6) Undulators with period < 1 cm. The resonant condition requires undulator radiation at short wavelength (approximately 1 nm), with low energy electron beams (of 1-2 GeV), and with a shorter period than generally available from existing synchrotron radiation sources. The undulators should be designed with K-value ~1, impedance shielding of pole faces, and a gap that is greater than 2.25 mm.

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

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12. ANCILLARY TECHNOLOGIES FOR ACCELERATOR FACILITIES

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 laser, and spallation neutron source user facilities. This topic seeks the development of computational, control, and superconducting technologies to support these user facilities. **Grant applications are sought in the following subtopics:**

a. Accelerator Modeling and Control—Grant applications are sought to develop new or improved computational tools for the design, study, or operation of charged particle beams. Of particular interest is the development of a front-end design for user-friendly interfaces. The modeling challenges addressed must be relevant to present and future BES accelerator facilities. These challenges include, but are not limited to, beam halo generation and control; generation and synchronization of sub-ps x-ray pulses; wakefield computation; multiple and single bunch collective instabilities; electron cloud generation and effects, especially in high intensity proton rings; and high-intensity operation (beam losses, thermal effects, etc.).

Grant applications also are sought to investigate and develop enhancements to the suite of tools in the Experimental Physics and Industrial Control System (EPICS), in order to better support existing facilities and meet the requirements of future machines. Areas of interest include, but are not limited to, high-availability alternative-communication protocols; enhanced functionality within the Input-Output Controller; highly integrated development environments; and ensuring scalability to very large installations (such as the International Linear Collider). Grant applications should address how the results will guide long-term EPICS development.

As the time scale of interest in modern accelerators is reduced, the required computational resources are becoming prohibitive for currently-available low-order electromagnetic codes; for example, the estimated memory requirement for modeling a typical accelerator structure interacting with a 1-ps bunch is 1 TB. Such an extreme computation is intractable for most accelerator laboratories. Therefore, in order to break the computational bottleneck, grant applications are also sought to develop computational electromagnetic codes with high-order accuracy.

Finally, grant applications are sought to develop large-scale timing and synchronization systems for next generation light sources, with timing stability requirements extending from ~100 femtosecons to 1 femtosecond or less. For example, these requirements include the need to enable the synchronization of multiple radio frequency components and laser systems, over distances of the scale of kilometers, in advanced accelerators and free electron lasers. This precision in timing must be maintained over periods of time on the order of 24 hours.

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

b. Superconducting Technology for Accelerators—Superconducting HOM-damped (higher-order-mode-damped) RF systems are needed for present and future storage ring and linac applications.

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

c. Advanced Laser Systems for Accelerator Applications—Advanced laser systems are needed for photoinjectors, for Free Electron Laser Seeding, for current-enhanced self-amplified spontaneous emission (ESASE), for laser-ion stripping of hydrogen beams, and for laser wire beam profile measurements in proton particle accelerators. Grant applications are sought for the development of:

(1) High power laser oscillator systems for high repetition rate (1-100 MHz) electron guns that can deliver pulses of 10-100 μJ energy in the 1 μm wavelength range, with pulses capable of being expanded to10-50 ps duration.

(2) Laser pulse shaping systems that can modify the laser pulse in 3D, in order to minimize emittance growth due to space charge effect in a photoinjector. Approaches of interest include pulse stacking, laser phase modulation, and others. In general, the pulse should have a homogeneous intensity distribution (10% modulation) confined in a sharp boundary in three dimensions, with either a cylindrical or ellipsoidal geometry.

(3) A mid-IR, carrier envelope phase (CEP) stabilized laser with tens of mJs of energy and a few carrier cycles within a Full-Width at Half-Max (FWHM) of 10-50 fs.

(4) A mid-IR (2.0 micron) laser for E-SASE, with a pulse under 100 fs, possibly CEP-stabilized in the energy range of a few mJ.

(5) Tunable lasers to be used as seeds for free electron lasers (FELs). The central wavelength should be within the wavelength range, 10-50 nm, and the laser should be continuously tunable within a band that is at least 20% of that wavelength range. Pulse duration should be adjustable and on order of 100 fs. Peak power within the pulse should be on order of 100 kW. Optical pulses should be reproducible on a shot-to-shot basis, with good temporal coherence within the pulse, good beam quality (M2<1.3), and a repetition rate of 100 kHz or greater.

(6) Lasers for laser-ion stripping of hydrogen beams. The lasers should have high repetition rate (~400 MHz), high peak power (~1MW), and picosecond 355 nm pulses to match the in-beam structure of the linac for Spallation Neutron Source (micropulses that are 50 ps long, separated by 2.5 ns, gated into minipulses of 650 ns that repeat at 1.058 MHz, and are bunched into 1 ms macropulses).

(7) A laser power-recycling cavity at 355 nm to reduce average laser power requirements for ion stripping. Important design criteria include compactness, a length to match bunch repetition rate, stabilization to a small fraction of a wavelength, protection of mirrors from electron and gamma radiation, and an in-vacuum configuration.

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

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

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

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13. INSTRUMENTATION FOR ADVANCED CHEMICAL IMAGING

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

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

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

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

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

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

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

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14. INSTRUMENTATION FOR ELECTRON MICROSCOPY AND SCANNING PROBE MICROSCOPY

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

resolutions typical of electron and scanning probe microscopy and with good temporal resolution. To support this research, grant applications are sought to develop instrumentation capabilities beyond the present state-of-the-art in (a) electron microscopy and microcharacterization, (b) scanning probe microscopy and (c) areas relevant to (a) and (b), such as integrated electron and scanning probe microscopy capabilities. **Grant applications are sought only in the following subtopics:**

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

Stages and holders that provide new capabilities for in situ transmission electron microscopy experiments in liquid, gaseous, optoelectronic and/or other extreme environments that also provide capability for simultaneous spectroscopy.

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

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

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

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

b. Scanning Probe Microscopy (SPM)—Scanning probe microscopy is vital to the advancement of nanoscale and energy science, and is used in numerous materials research projects and facilities funded by the Department. Grant applications are sought to develop: New generations of SPM platforms capable of operation in the functional gas atmospheres and broad temperature/pressure ranges, functional SPM probes, sample holders/cells (including electrochemical and photoelectrochemical cells), and controller/software support for ultrafast, environmental and functional detection. Areas of interest include: (1) SPM platforms capable of imaging in the controlled and reactive gas environments and elevated temperatures for fuel cell, and catalysis research, (2) variable pressure systems with capabilities for surface cleaning and preparation bridging the gap between ambient and ultra-high vacuum platforms, (3) insulated and shielded probes and electrochemical cells for high-resolution electrical imaging in conductive solutions; (4) heated probes combined with dynamic thermal measurements including thermomechanical, temperature, and integrated with Raman and mass-spectrometry systems, and (5) probes integrated with electrical, thermal, and magnetic field sensors for probing dynamic electrical and magnetic phenomena in the 10 MHz - 100 GHz regime, and (6) SPM platforms and probes for other functional imaging modes (including but not limited to microwave, pump-probe, etc). Probes and probe/holder assemblies should be compatible with existing commercial hardware platforms, or bundled with adaptation kits. Complementary to this effort is the development of reliable hardware, software, and calibration methods for the vertical, lateral, and longitudinal spring constants of the levers, sensitivities, and frequency-dependent transfer functions of the probes.

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

6. A BES-Sponsored workshop report "Future Science Needs and Opportunities for Electron Scattering: Next-Generation Instrumentation and Beyond" that outlines many of the important future directions for electron microscopy and scattering is available on the web. (http://science.energy.gov/bes/news-and-resources/reports/workshop-reports/)

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Subtopic b:

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15. INSTRUMENTATION AND TOOLS FOR MATERIALS RESEARCH USING NEUTRON SCATTERING

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

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

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

a. Advanced Detectors—Develop advanced detectors with high efficiency and high resolution position sensitive neutron detectors for neutron diffraction and imaging. With the severe shortage of 3He innovative alternative detector technologies with similar or better performance are required for the current and future neutron scattering facilities.

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

b. Advanced Optical Components—Develop novel or improved optical components for use in neutron scattering instruments (References 4-6). Such components include, neutron choppers, neutron guides, neutron lenses and focusing mirrors, neutron monochromators, neutron polarization devices including ^{3}He polarizing filters, radio-frequency flippers, superconducting coils, and Meissner shields. Grant applications also are sought for novel uses of such components in neutron scattering instruments.

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

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

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

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

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

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16. INSTRUMENTATION FOR ULTRA-BRIGHT OR ULTRA-FAST X-RAY SOURCES TO ENABLE MATERIALS RESEARCH

The Department of Energy supports X-ray scattering and spectroscopy instruments at synchrotron radiation and free electron laser (FEL) sources where users conduct state-of-the-art materials research. This topic seeks to develop advanced source instrumentation that will enhance materials research by improving the capability and utility of ultra-bright or ultra-fast x-ray sources. Grant applications should define the instrumentation need and outline the research that will enable innovation beyond the current state of the art. Applicants are strongly encouraged to demonstrate applicability and proper context through collaboration with a successful materials science researcher who utilizes ultra-bright or ultra-fast x-ray sources in their research program. To this end, the STTR program would be an appropriate vehicle for proposal submission. Alternatively, applicants are encouraged to demonstrate applicability by providing a letter of evaluation and support from a successful user. Priority will be given to those grant applications that include such collaborations or letters of support.

A successful user is defined as someone at a research institution who has recently performed synchrotron or FEL experiments and published results in peer reviewed archival journals. Such researchers are the early adopters of new sources and source instrumentation and are often involved in conceptualizing, fabricating, and testing new devices. A starting point for developing collaborations would be to examine the annual activity reports from synchrotron radiation or FEL facilities with links at: http://www.lightsources.org/cms/?pid=1000444

In all cases, the proposed instrumentation development must be motivated by at least one specific example of how a state of the art materials research project will be enabled. The proposal should delineate why a type of materials research is not currently possible and how the successful creation of the new instrumentation will enable access to new types or quantities of experimental data. This topic no longer solicits proposals related to detectors or sample environments, but is currently focused on source and optics improvements as described below. **Grant applications are sought only in the following subtopics.**

a. X-ray Sources and Optics—X-ray scattering and spectroscopy experiments are often limited by the beam quality delivered to the research sample. Beam quality requirements depend on specific experiments but usually involve improvements in delivered x-ray flux, brightness, coherence, or focus size. Grant applications are sought to develop advanced instrumentation for creating, focusing, diffracting, or defining the X-ray beam that eventually illuminates the research sample. Areas of interest include source development of university lab scale or "table top" x-ray generators of ultra-fast (fs) pulses and advancements in beam manipulation devices such as mirrors, monochromator crystals, and focusing optics, in such a manner that improves the beam quality available for materials research. Grant applications should demonstrate an understanding of existing source capabilities in terms of beam quality delivered to a materials sample under investigation, and improve on some aspect that enhances the state of the art. Grant applications must demonstrate that proposed components and instruments will be able to handle the heating loads from intense x-ray beams, and meet the necessary stability requirements with respect to motion control and vibration isolation.

Questions – contact Lane Wilson, lane.wilson@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 Lane Wilson, lane.wilson@science.doe.gov

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17. CATALYSIS

The United States continues to rely on petroleum and natural gas as its primary sources of fuels. As domestic reserves of these feedstocks decline, the volumes of imported fuels grow, and the environmental impacts resulting from fossil fuel combustion become severe, the nation must reassess its energy future. The U.S. Department of Energy recognizes catalysis as an essential technology for accelerating and directing chemical transformation, thereby enabling the realization of environmentally friendly, economical processes for the conversion of fossil energy feedstocks. Catalysis also is the key to developing new technologies for converting alternative feedstocks, such as biomass, carbon dioxide, and water to commodity fuels and chemical products. **Grant applications are solicited only in the following subtopics:**

a. Carbohydrate Catalysis for the Production of Oxygenated Chemicals—The chemical catalysis of petroleum naphtha and natural gas liquids to final products that contain oxygen are by the most, energy intensive conversion processes of industrial chemistry. The carbohydrate from cellulose fractions of biomass feedstock contains on the average, more than half oxygen by weight and so these sources are a good starting material for products that contain oxygen including oxygenated fuels and polymeric monomers. In this subtopic, **new** catalytic conversion routes that begin with products derived from cellulosic origin are solicited (for example, new

synthetic routes to chemicals starting with succinic acid or furan). Cellulosic ethanol manufacture is responsive to the solicitation only if a significant contribution to the possible technology is offered. The most careful review of domestic and foreign scientific and patent literature must be made to make such a determination.

Questions - contact Charles Russomanno, Charles.Russomanno@hq.doe.gov

b. Chemical Catalysis of Lignin—Lignin is some half of the weight of dry wood, although chemical conversions to other products using lignin as a starting are generally so difficult that most lignin separated from cellulose in the paper production process is simply burned as fuel. This subtopic solicits new catalytic conversion routes of lignin to commodity chemical products such as phenolics and other aromatics, starting from raw or processed lignin. In this sense, lignin substitutes as coal. Process economics will have to be considered, and for a commercially commercial viable process, lignin catalytic conversions would have to be on a par with coal conversions.

Questions - contact Charles Russomanno, Charles.Russomanno@hq.doe.gov

c. Hydrogen Production, Storage, and Transport—The economical use of hydrogen as transportation and stationary power fuel remains a long-term DOE objective. New catalytic conversions of non-hydrocarbon feedstock sources to hydrogen are solicited, which would also consider the efficient co-production of other products that would be involved in the hydrogen production process (for example, oxygen production along with hydrogen production from water). New and efficient catalytic processes for hydrogen storage are also responsive to the solicitation, so long as the overall economics are considered. The transport of hydrogen in condensed phase (solid/liquid mixture) uses a catalyst to equilibrate the ortho/para hydrogen mixture, and new compositions of these materials are responsive to the solicitation as well.

Questions - contact Charles Russomanno, Charles.Russomanno@hq.doe.gov

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

Questions - contact Charles Russomanno, Charles.Russomanno@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 Charles Russomanno, Charles.Russomanno@hq.doe.gov

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18. MEMBRANES FOR INDUSTRIAL APPLICATIONS

Separation technologies recover, isolate, and purify products in virtually every industrial process. Pervasive throughout industrial operations, conventional separation processes are energy intensive and costly. 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. Industrial efforts to increase cost-competitiveness, boost energy efficiency, increase productivity, and prevent pollution demand more efficient separation processes. In response to these needs, the Department of Energy supports the development of high-risk, innovative separation technologies. In particular, membrane technology offers a viable alternative to conventional energy intensive separations.

Successful membrane applications today include producing oxygen-enriched air for combustion, recovering and recycling hot wastewater, volatile organic carbon recovery, and hydrogen purification. Membranes have also been combined with conventional techniques such as distillation to deliver improved product purity at a reduced cost. Membrane separations promise to yield substantial economic, energy, and environmental benefits leading to enhanced competitiveness by reducing annual energy consumption, increasing capital productivity, and reducing waste streams and pollution abatement costs.

Despite the successes and advancements, many challenges must be overcome before membrane technology becomes more widely adapted. 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. The objective is better performance in existing industrial applications, as well as opportunities for new applications. To advance the use of membrane separations, research is needed to develop new, more effective membrane materials and innovative ways to incorporate membranes in industrial processes. Grant applications must address the potential public benefits that the proposed technology would provide, both from reduced energy consumption and from

the reduction in one or more of the following: materials consumption, water consumption, and toxic and pollutants dispersion. Grant applications should also include a plan for introducing the new technology into the manufacturing sector, in order to access capabilities for widespread technology dissemination. **Grant applications are sought only in the following subtopics:**

a. Membrane Materials with Improved Properties—Grant applications are sought to develop lower cost inorganic, organic, composite, and ceramic membrane materials in order to improve one or more of the following properties: (1) increased surface area per unit volume, (2) higher temperature operation (e.g., by using ceramic or metal membrane materials), and (3) suitability for separating hydrophilic compounds in dilute aqueous streams. Particular membrane materials of interest include nano-composites, mixed organic/inorganic composites, and chemically inert materials. Particular processes/systems of interest include membranes for the separation of biobased products, membranes for hydrogen separation and purification, membranes for CO_2 capture, and membranes for industrial applications.

For industrial applications, high temperature separations of hydrocarbons and other mixtures are of particular interest. For example, low molecular weight hydrocarbons are separated from natural gas by condensing them as a liquid, and the liquid is distilled to fractionate it, or the liquid is hydrocracked to olefins. However, chilling the natural gas in order to recover the condensable portion and then reheating it is inefficient, because the energy used to chill it cannot be recovered. Membranes, either as standalone systems or hybridized with other separation technologies, may provide an energy efficient means of separating mixtures at the high temperatures at which these industrial processes are carried out.

For all membrane processes/systems, grant applications must be targeted toward the development of specific membrane materials for carefully defined commercial applications; efforts focused on generalized membrane material research are not of interest and will be declined. In order to assure the rapid commercialization of the technology, especially for use by U.S. manufacturers, applicants are strongly encouraged to engage in partnerships, so that the costs of the technology development and commercialization can be shared among manufacturers, suppliers, and end users.

Questions - contact Charles Russomanno, Charles.Russomanno@hq.doe.gov

b. Membrane Technologies for the Petroleum and Petrochemical Process Industries—This subtopic solicits innovation research for the development of membrane technology to reduce distillation energy in petroleum refinery and petrochemical separation processes. Large-scale industrial distillation accounts for about one-sixth of the annual energy consumed by the petroleum and petrochemical process industries, making it the single most energy intensive process of all US industrial processing. Since the energy savings potential for reducing distillation is so large considerable R&D for membrane technologies with potential applications in the petrochemical process industries has already been invested; nevertheless, membrane technologies have so far contributed marginally to distillation energy reduction in commercial application.. Cost considerations have been the barrier to industrial hydrocarbon separations assisted by membranes. Grant applications for innovation research in membrane technology development for petroleum and natural gas liquid hydrocarbon separations are solicited that will

reduce distillation process energy in any of the hydrocarbon separation process steps. The application must address aliphatic or aromatic hydrocarbon separations alone, and thus Phase 1 grant applications for innovation research in oxygenated or other chemical product membrane separations are not responsive to this subtopic solicitation. By far the most important aspect of this subtopic solicitation is the understanding of R&D that has already been invested in membrane technologies for hydrocarbon separations, and an understanding of the barriers to the development and commercialization of those membrane technologies. Thus thorough patent and literature searches are imperative to the preparation of responsive applications to the subtopic, and for this and for the promise of eventual commercialization of successful new technologies the partnerships of small technology business and US industrial companies are strongly encouraged.

Questions - contact Charles Russomanno, Charles.Russomanno@hq.doe.gov

c. Industrial Membrane Process Systems—Grant applications are sought to enhance the separation capabilities of membranes used in industrial process streams. Proposed research should be aimed at developing and commercializing innovative membrane systems, using new or currently existing membranes, that can be robust when integrated within real-world processes (e.g., inert gas removal, isomer separation, aromatic/non-aromatic separations, sulfur removal, CO_2 capture, and removal of trace metals). Grant applications should seek to address one or more of the following needs: (1) techniques for overcoming scale-up problems related to contaminants in industrial streams (fouling, oil misting, etc.), (2) manufacturing technologies that would reduce the cost of membrane modules, (3) anti-fouling and anti-flux schemes to improve the long-term operability of membrane systems, and (4) methods to regenerate membrane performance and lower membrane maintenance costs. Also of interest is the integration of membranes with other technologies (such as the integration of membranes with distillation systems, or with adsorption or extraction processes), in order to address specific process issues. For all grant applications, the overriding goal is to enhance U.S. industrial process efficiency to the maximum possible extent by increasing the separation process efficiency. Therefore, priority will be given to applications that carefully examine the efficiency of the proposed membrane technology within the targeted application. Grant applications should also include a process evaluation and an economic analysis along with the R&D effort. Lastly, technology partnerships involving U.S. manufacturers, suppliers, and end users are strongly encouraged.

Questions - contact Charles Russomanno, Charles.Russomanno@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 Charles Russomanno, Charles.Russomanno@hq.doe.gov

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19. ADVANCED CLEAN ENERGY RESEARCH

For the foreseeable future, the energy needed to sustain economic growth will continue to come largely from hydrocarbon fuels. In supplying this energy need, however, the Nation must address growing global and regional environmental concerns, supply issues, and energy prices. Maintaining low-cost energy in the face of growing demand, diminishing supply, and increasing environmental pressure requires new technologies and diversified energy supplies. These technologies must allow the Nation to use all of its indigenous resources more wisely, cleanly, and efficiently.

a. Novel Sequestration Concepts - Carbon Dioxide (CO_2) Conversion to Fuels and Chemicals—Utilization of carbon dioxide (CO_2) has become an important global issue due to the significant and continuous rise in atmospheric CO_2 concentrations, accelerated growth in the consumption of carbon-based energy worldwide, depletion of carbon-based energy resources, and low efficiency in current energy systems.

Proposals are sought to develop novel and advanced concepts for conversion of CO_2 from energy production and utilization systems based on advanced catalysts for CO_2 conversion to produce value-added fuels and industrial chemicals.

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. Genomic Enhancement of Microbial or Biomimetic Means of Solid Hydrocarbon Conversion—At least half of the U.S. solid hydrocarbon fuel deposits are not economically recoverable according to EIA. Uneconomic deposits are usually situated in geologically challenging, environmentally restricted or costly locations. Research is sought that evaluates or demonstrates man-made modifications to existing biomimetic microbial methods of exploiting known genetic attributes of microbial mechanisms for efficiently converting solid hydrocarbon deposits into higher value or more easily transportable products. Examples include modifying methanogenic microbial or biomimetic means for enhanced methane yields in broader temperature ranges, broader moisture ranges or broader solid hydrocarbon fuel species. Although, chemical or processing pathways exist for higher value chemical products such as inks, toners or pharmaceuticals, there are limited studies in near-zero or reduced carbon dioxide emissions using microbial or biologically direct pathways to higher value products from solid hydrocarbon fuel deposits. What is sought are verifiable or validated modifications that yield lower life cycle carbon dioxide emissions, lower costs and greater conversion efficiency of solid hydrocarbon fuel deposits residing in difficult to extract locations at unconventional depths. Verification means can include computational methods backed by appropriate experimental validation.

Other US Government agencies such as USGS, NSF, USDA and NASA previously completed or published research on naturally occurring microbial methanogenic organisms, some of which are referenced herein.

Grant applications are sought for the development of a genomic modification to an existing organism such as an existing methanogenic bacteria species. The objective is to identify a yield improvement that can be reasonably tested and shown to have significant, economically justifiable product yields. Alternatively, research is sought for biomimetic chemical conversion pathways more optimal than pathways observed using said microbial organisms which would reduce carbon dioxide emissions or revitalize uneconomic CBM fields. Proposed approaches must be novel, innovative and show compelling economic advantages over the prior approaches.

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

c. High-Temperature Sealing Systems Based on Viscous Glass—High temperature (650°C to 850°C) planar solid oxide fuel cell (SOFC) stacks are comprised of alternating fuel and air chambers, which are sealed from each other and connected to fuel and air delivery manifolds, respectively. These seals are subject to a demanding set of performance criteria due to the extreme operating environment. The seals must have a low electrical conductivity, be chemically and mechanically stable in a high temperature reactive environment (moist reducing and/or oxidizing conditions), and demonstrate chemical compatibility with the cell and interconnect materials of the particular cell/stack design. **Grant applications are sought to develop viscous glass-based sealing concepts for SOFCs.** Ideally, the viscous glasses would maintain a softening temperature at or slightly below the lower bounds of the SOFC operating temperature (650°C) and retain suitable viscosity to the upper bound (850ºC), over the life of the seal, and be resistant to devitrification within the SOFC environment. Given that such a glass on its own may be unable to withstand the differential pressure across the seal (up to 2 psid) or the stack bearing load, it is envisioned that an engineered composite solution will be required to carry bearing loads and retain the viscous sealing material. The ultimate objective is the development of an economically-viable, manufacturable seal material followed by a composite system design that can provide sealing under all operating conditions for the life of planar SOFC stacks.

For reference purposes, the sealed perimeter for a single fuel cell-interconnect repeat unit seal is approximately 100cm. Approaches of interest should meet the following performance criteria: (1) volatile constituents in the seal should be minimized to less than 1% weight loss over 40,000 hours; (2) fuel leakage should be less than 1%, averaged over the seal area and not catastrophic for the duration of the seal life; and (3) the seal material must be capable of a service life of more than 40,000 hours and dozens of thermal cycles for stationary systems.

Phase I should focus on the identification of candidate viscous glasses and conduct rigorous analysis and experimentation to characterize crystallization, volatility, reactivity, wetting, and viscosity in the SOFC environment. Phase II would entail composite seal design and experimental validation, culminating in larger-scale testing, potentially in partnership with other SECA R&D efforts or one or more SECA Industry Teams.

Questions – contact Briggs White, Briggs.White@netl.doe.gov

d. Long-life Thermal Barrier Coatings (TBC) For High Temperature Applications—Gas turbine efficiency can be improved by maximizing inlet temperature and/or reducing the amount of cooling air required for airfoils. In order to enable the highest temperatures while protecting super alloy substrates thermal barrier coatings (TBCs) are used. Grant applications are sought to develop materials and methodologies that advance the state-of-the-art and address new ceramic top coat and metallic bond coat chemistries for long-life TBC systems capable of operating at temperatures greater than currently available 8YSZ TBC systems.

Approaches of interest include, but are not limited to:

- Develop new ceramic top coat chemistries to: (a) lower the thermal conductivity of the ceramic material; (b) increase the erosion resistance of the ceramic top coat; and (c) minimize the degree of sintering of the ceramic at high temperatures. The new ceramic top coat chemistry shall also remain phase-stable at high temperatures.
- Develop new metallic bond coat chemistries to improve the oxidation resistance of the bond coat at high temperatures and increase the spallation resistance of the TBC system.
- Develop multi-layer top coats and/or bond coats to produce a complete TBC system capable of meeting design requirements for high temperature applications. Deposited TBC microstructures shall demonstrate acceptable levels of strain tolerance to resist cracking and spallation during high temperature service.

Questions – contact Patcharin (Rin) Burke, Patcharin.Burke@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

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20. HIGH PERFORMANCE MATERIALS FOR NUCLEAR APPLICATION

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—Grant applications are sought to develop radiation resistant steels, ferritic-martensitic (FM) steels, and oxide dispersion strengthened (ODS) steels that can be used in liquid metal reactors at 400-750°C, have improved creep strength, and can be formed and joined. Grant applications also are sought to improve the weldability and formability of FM and ODS steels, develop methods to monitor in situ irradiation performance in these materials, and develop improved non-destructive evaluation techniques.

Questions – contact Sue Lesica, sue.lesica@hq.doe.gov

b. Refractory, Ceramic, Ceramic Composite, Graphitic, or Coated Materials—Grant applications are sought to develop refractory, ceramic, ceramic composite, graphitic, or coated materials that can be used in the Generation IV Advanced Gas Cooled Reactors Next Generation Nuclear Plant (NGNP) at temperatures to 800°C and the Fluoride Salt High Temperature Reactor at temperatures to 700°C, in a thermal neutron spectrum environment during normal operations and accidents. These ceramics, graphitic, or coated materials should have the following characteristics: (1) low thermal expansion coefficients, (2) excellent high-temperature strength, (3) excellent high-temperature creep resistance, (4) good thermal conductivity, (5) ability to endure a high-neutron-fluence environment, (6) ability to be easily fabricated, (7) capable of

being joined, (8) low erosion properties in flowing helium (for NGNP applications), and (9) ability to survive air and/or water ingress accidents. Because high temperature strength and corrosion resistance may be difficult to achieve with a single material, composite or coated systems may be required.

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

Questions – contact Sue Lesica, sue.lesica@hq.doe.gov

c. Assessment and Mitigation of Materials Degradation—Grant applications are sought to develop technologies for the assessment and mitigation 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 (1) advanced in situ techniques for the monitoring of swelling in stainless steel, hardening of reactor pressure vessels, and the degradation of concrete; (2) new techniques for component repair; (3) methods that can mitigate or predict irradiation and aging effects in reactors and components, and (4) improved nuclear fuel cladding materials.

Questions – contact Sue Lesica, sue.lesica@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 Sue Lesica, sue.lesica@hq.doe.gov

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21. LOW COST, OPTIMIZED REDOX FLOW BATTERY ELECTROLYTES, NOVEL SOLID IONIC CONDUCTING MEMBRANES, AND RECHARGEABLE AIR-BREATHING CATHODES FOR BATTERIES FOR STATIONARY STORAGE

The projected doubling of world energy consumption within the next 50 years, along with resource constraints and environmental concerns about using fossil fuels , have spurred great interest in generating electrical energy from renewable sources such as wind and solar. The variable and stochastic nature of renewable sources, however, makes solar and wind power difficult to manage, especially at high levels of penetration. To effectively use the intermittent renewable energy and enable its delivery demand electrical energy storage (EES). For example, storage operating near an intermittent, renewable wind energy source can smooth out wind variability, lessen the slope on ramp rates, and, at sufficient scale, can store off peak wind energy. EES is also an effective tool to improve the reliability, stability, and efficiency of the future electrical grid, i.e. smart grid that enables real-time, two-way communication to balance demand and generation and supports plug-in electrical vehicles. Electrical energy storage can shave peaks from a user or utility load profile, increase asset utilization by improving duty factor and delaying utility upgrades, decrease fossil fuel use for ancillary services, provide high levels of power quality, and increase grid stability. Distributed energy storage near load centers can reduce congestion on both the distribution and transmission systems.

Among the most promising electrical storage technologies are redox flow batteries (RFBs) and sodium (Na) batteries. RFBs have the advantage of allowing separationof power and energy. The power (kW) of the system is determined by the size of the electrodes and the number of cells in a stack, whereas the energy storage capacity (kWh) by the concentration and volume of the electrolyte. Varied RFBs have been developed, including the all vanadium redox flow batteries (VRBs) that have recently demonstrated operation at multi-MWs with unlimited cycle life. The use of abundant, low cost Na makes the Na-batteries attractive to further cost reduction for the grid applications. Sodium batteries typically come with either a polysulfide or metal halide cathode. Both deliver good performance but at high capital and levelized costs (>$3,000/kW and >30¢/kWh, respectively). One of the major cost drivers for sodium batteries is the solid-state electrolyte membrane, while for VRBs the cost is attributed to the electrolyte. Finally, the ultimate in low-cost, high energy density energy storage are the metal-air systems, which have been demonstrated in the laboratory but suffer from drastically limited cycle life and low efficiency at the discharge and recharge cathode half-reactions.

Particularly sought this year are research efforts related to novel, high performance and low-cost electrolytes in RFBs, high conductivity solid-state electrolyte membranes either for sodium or for other abundantly available lightweight multivalent cation systems (e.g., aluminum or magnesium), and technologies with promise to extend the life of metal-air cathodes to thousands of cycles at low cost and high cycle efficiencies. **Grant applications are sought only in the following sub-topics**:

a. Cost Effective, Optimized Vanadium Based Aqueous Electrolytes—Liquid electrolyte in RFB serves as a "fuel" to store electricity via redox reactions when flowing through electrodes. The liquid electrolyte determines the energy capacity and is a main component to the overall capital cost and technical performance. This is particular true for the all-vanadium RFBs or VRBs. The current electrolytes in vanadyl sulfate systems account for nearly 40% of the total cost of a 1MW/8MWh all vanadium system. The high cost comes from vanadium and preparation of high purity of the vanadium aqueous electrolytes. There is also a stability issue in the current sulfate electrolytes. When the vanadium concentration is over 2 M, the electrolytes will become super saturated, resulting in formation of precipitation for V^{5+} at the temperatures above 40°C and for V^{2+}, V^{3+}, V^{4+} at the temperatures below 10°C. Accordingly, current VRBs are limited to around 1.7 M and operated in 10-35^{o}C, with heat management required. As such grant applications are sought to develop cost-effective, optimized aqueous vanadium base electrolytes that can demonstrate: 1) high solubility of active components and stability over broad operating conditions, 2) excellent electrochemical reversibility, 3) good chemical compatibility to adjacent components such as electrodes, tubes, etc. 4) acceptance to environment, and 5) most of all, low cost by reduction of vanadium use and simplification of electrolyte preparation.

Questions – contact Imre Gyuk, imre.gyuk@hq.doe.gov

b. Cost Effective, Optimized Na^{+} and Multi-Valent Ion Conducting Membranes—Na-batteries, including both NSBs and NMBs, are built upon a Na^{+} conducting solid state membrane. The most widely used is doped β″-Al_2O_3, a structure of alternating closely-packed slabs and loosely-packed layers that allows for facile transport of Na^{+} in elevated temperatures. For a satisfactory performance, the Na-batteries are built upon a thick solid electrolyte (≥1.0 mm) and operated at 300-350^{o}C. The solid oxide membranes are prepared via sophisticated ceramic processing, including extruding/casting and varied stages of heating or sintering. Alternatively NaSICON has been reported lately for Na-batteries that can operate at lower temperatures than that required for NSBs and NMBs. There however remain challenges for this type of membranes in conductivity, long term stability, etc. In addition to sodium, other membrane chemistries are of interest to enable the usage of other low-cost, multivalent materials (magnesium or aluminum as examples) that would increase energy density and improve cost. Lithium-based chemistries are specifically discouraged from this call. Applications are sought to develop low cost, robust solid state membranes that can allow for satisfactory operation of Na- and other multivalent cation-based batteries at temperatures <250^{o}C. An ideal membrane should exhibit: 1) high cation conductivity, 2) excellent structural and mechanical stability, 3) good chemical stability to adjacent components during operation at elevated temperatures, and 4) low cost in raw materials and manufacturing.

Questions – contact Imre Gyuk, imre.gyuk@hq.doe.gov

c. Low Cost, Robust, Rechargeable Oxygen Cathode for Metal-Air Systems—Metal-air chemistry has the highest theoretical energy density due to the use of an inexhaustible supply of low-cost O_2 discharging 4 electrons per molecule as a cathode. For example, lithium-air yields 13 kWh/kg versus the anemic 0.42 kWh/kg for lithium-ion[6], highlighting the tremendous advantage in energy density of metal-air over existing technology, and important for reducing the

overall cost of large scale stationary storage. Historically, technical limiting factors that vary based on the chosen anode material-electrolyte system have prevented the realization of a specific rechargeable chemistry. Current technology is limited by the high overpotentials of the oxygen reduction reaction (ORR) and its reverse reaction, the oxygen evolution reaction (OER), poor cycle life, and high cost of electrodes using platinum electrocatalysts. Applications are sought to develop a rechargeable oxygen cathode for a chosen battery chemistry that (1) is electrically efficient (roundtrip efficiency >75%), (2) is cost-effective, (3) is mechanically and chemically robust in the intended metal-air battery environment, (4) demonstrates good cycle characteristics (thousands of cycles), and (5) is viable for use with the selected metal-air system.

Questions – contact Imre Gyuk, imre.gyuk@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 Imre Gyuk, imre.gyuk@hq.doe.gov

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PROGRAM AREA OVERVIEW
OFFICE OF FUSION ENERGY SCIENCES

The Department of Energy sponsors fusion science and technology research as a valuable investment in the clean energy future of the nation and the world, as well as to sustain a field of scientific research - plasma physics - that is important in its own right and has produced insights and techniques applicable in other fields of science and industry. The mission of the Fusion Energy Sciences (FES) program is to acquire the knowledge base needed for an economically and environmentally attractive fusion energy source. FES research efforts seek to: (1) understand the physics of plasmas, the fourth state of matter – plasmas constitute most of the visible universe, both stellar and interstellar, and progress in plasma physics has been the prime engine driving progress in fusion research; (2) identify and explore innovative and cost-effective development paths to fusion energy – the current fusion program encourages research on a wide range of approaches including the Tokamak (the leading power plant candidate), other magnetic configurations, and inertial fusion energy using particle beams, plasma beams, or lasers; and (3) explore the science and technology of energy producing plasmas, the next frontier in fusion research, as a partner in a international effort – the cooperative efforts of the world fusion community can be effective in reducing costs, avoiding duplication of efforts, and bringing the best available scientific and engineering talent together to seek solutions to complex problems.

This is a time of important progress and discovery in fusion research. The U.S. has joined an international consortium (consisting of the European Union, Japan, China, Russia, Korea, and India) to fabricate and operate the next major step in the fusion energy sciences research program, a facility called "ITER." ITER will be designed to demonstrate a burning plasma.

The FES program is making great progress in understanding turbulent losses of particles and energy across magnetic field lines used to confine fusion fuels, identifying and exploring innovative approaches to fusion power that may lead to more economical power plants, and encouraging private sector interests to apply concepts developed in the fusion research program. The following topics are restricted to science and technology relevant to magnetically confined plasmas and high energy density physics. Grant applications pertaining to fusion energy concepts not based specifically on the use of plasmas for producing energy/electricity for non-defense purposes will be declined.

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

22. ADVANCED TECHNOLOGIES AND MATERIALS FOR FUSION ENERGY SYSTEMS

An attractive fusion energy source will require the development of superconducting magnets and materials as well as technologies that can withstand the high levels of surface heat flux and neutron wall loads expected for the in-vessel components of future fusion energy systems. These technologies and materials will need to be substantially advanced relative to today's capabilities in order to achieve safe, reliable, economic, and environmentally-benign operation of fusion energy systems. Further information about research funded by the Office of Fusion Energy

Sciences (OFES) can be found at the OFES Website (URL: www.ofes.fusion.doe.gov). **Grant applications are sought in the following subtopics:**

a. Plasma Facing Components—The plasma facing components (PFCs) in energy producing fusion devices will experience 5-15 MW/m^2 surface heat flux under normal operation (steady-state) and off-normal energy deposition up to 1 MJ/m^2 within 0.1 to 1.0 ms. Refractory solid surfaces represent one type of PFC option. These PFCs are envisioned to have a refractory metal heat sink, cooled by helium gas, and a plasma facing surface, consisting of an engineered refractory metal surface or a thin coating of refractory material that minimizes thermal stresses. The materials being considered include tungsten and molybdenum alloys. Grant applications are sought to develop: (1) innovative refractory alloys having good thermal conductivity (similar to Mo, at a minimum), resistance to recrystallization and grain growth, good mechanical properties (e.g., strength and ductility), and resistance to thermal fatigue; (2) coatings or specialized low-Z surface treatments of refractory alloy armor for improved plasma performance; (3) innovative refractory-metal heat sink designs for enhanced helium gas cooling; (4) efficient fabrication methods for engineered surfaces that mitigate the stresses due to high heat flux; and (5) joining methods, for attaching the plasma facing material to the heat sink, that are reliable, efficient to manufacture, and capable of high heat transfer – these new joining techniques may be applicable to either advanced, helium-cooled, refractory heat sinks or present-day, water-cooled, copper-alloy heat sinks.

In addition, grant applications are sought to develop new or improved *in situ* diagnostic techniques to monitor the health and performance of operating PFCs and plasma edge conditions. A carefully selected combination of microelectromechanical (MEMS)-like, robust diagnostics could create an instrumented PFC that monitors important characteristics (such as the temperature and stress gradients) within the PFC or provides real-time information on erosion/deposition rates or tritium uptake during operation. Measurements of current, B-field, plasma edge temperature and density, spectral emissions, and heat flux also would be of interest. Such diagnostics must be an integral part of the PFC, be self-powered, operate at elevated temperatures in the presence of high magnetic fields and neutron fluence, be immune to RF noise, provide for wireless data transmission with high signal to noise ratio, and be compatible with high performance plasma operation.

Another PFC option is to use a flowing liquid metal surface as a plasma facing component, an approach which will require the production and control of thin, fast flowing, renewable films of liquid lithium, gallium, or tin for particle control at divertors. Grant applications are sought to develop: (1) techniques for the production, control, and removal of flowing (velocity 0.01 to 10 m/s) liquid metal films (0.5-5 mm thick) over a temperature controlled substrate; (2) advances in materials that are wet by liquid metals at temperatures near the respective metal melting point and that are conducive to the production of uniform well-adhered films; (3) techniques for active control of liquid metal flow and stabilization in the presence of plasma instabilities (time and space varying magnetic field); and (4) computational tools that model the flow and magnetohydrodynamic response of flowing liquid metals.

Grant applications also are sought to develop and demonstrate innovative computational techniques directly related to modeling surface material properties and/or plasma

surface/interactions, for the purpose designing and assessing PFC surface materials. Finally grant applications are sought to develop cost-effective experimental techniques that integrate multiple approaches, listed in the paragraphs above, in order to allow advanced plasma-material-interaction testing and simulation.

Questions – contact Peter Pappano, peter.pappano@science.doe.gov

b. Blanket Materials and Systems—Blanket systems including an integrated first wall facing the plasma are complex, multi-function, multi-material components that capture neutrons emitted from the burning plasma to both produce tritium via nuclear reactions with lithium, and extract the energy for efficient power conversion. Associated with the blanket are coolant and tritium processing systems, all of which have scientific and technological issues in need of resolution. Proposals that address these issues in areas such as:

- thermofluid and thermomechanical simulation of coolant flows and structural responses under surface and volumetric heat loads;
- mass transport (corrosion and tritium) modeling development and simulations;
- ceramic breeder and beryllium pebbles material fabrication, characterization, and thermomechanics;
- SiC or alternate insulators for electric current and thermal heat;
- tritium permeation barriers and permeator windows, corrosion barriers, etc.;
- chemistry and impurity control in coolants (helium, liquid metals, etc.);
- Flow and other diagnostic sensors compatible with fusion environment; or any blanket and tritium system relevant development issue.

Several areas of particular interest are described in more detail below.

There is a strong need to understand and predict in greater detail both the corrosion, transport and redoposition of materials, and the generation, bubble formation, transport and permeation of tritium in the fusion relevant coolant and breeder material Pb-15.7Li alloy. Both numerical predictive tools and increased database from experimental studies are needed to better characterize the corrosion and tritium transport behavior in Pb-Li alloy under fusion relevant conditions that include operation at 400-700C and the presences of strong magnetic fields in contact with various materials such as ferritic steels, silicon-carbide, and other proposed tritium or corrosion barrier or permeator materials for tritium extraction.

The pebble-bed solid breeder configuration introduces several operational limits: thermo-mechanical uncertainties caused by pebble-bed wall interaction, potential sintering and subsequent macro-cracking, and a low pebble-bed thermal conductivity – all of which result in small characteristic bed dimensions and limit windows of operation. A new form of solid breeder morphology is required that holds the promise for increased breeding ratios – dictated by increased breeder material density; long term structural reliability; and enhanced operational control – compared to packed beds. Grant applications are sought for new solid breeder material concepts that include: (1) increased breeder material densities (~80%); (2) higher thermal conductivities (provided by a fully interconnected structure, as opposed to point contacts between pebbles); (3) better thermal contact, such as reliable bonded contact, with cooling

structures (instead of point contacts between pebbles and wall); (4) the absence of major geometry changes between beginning-of-life and end-of life (such as sintering in pebble beds) in the presence of high neutron fluence; and (5) structural integrity in freestanding and self-supporting structures with significant thermo-mechanical flexibility.

Flow channel inserts (FCIs) act as magnetohydrodynamic and thermal insulators in ferritic steel channels containing, for example, a slowly flowing tritium breeder such as molten Pb-15.7Li alloy. The insert geometry is approximately box-channel-shaped in straight channels, with more complex shapes possible, for insertion in manifolds and other complex-geometry elements in the flow path. Although SiC/SiC composite is a candidate FCI material, its use would differ from its potential application as a structural material in that high thermal and electrical conductivity would not be desirable. In fact, the electrical conductivity should be low, with a target maximum around 1 to 50 $\Omega^{-1}m^{-1}$. In addition, the strength requirements for a SiC/SiC FCI are reduced compared to the composite's application as a structural material, because the primary stresses and pressure loads will be very low. On the other hand, the insert must be able to withstand thermal stresses from through-surface temperature differences in the range of 150-300K, over a thickness of 3 to 15 mm depending on designs. Grant applications are sought to develop manufacturing techniques for radiation resistant, low thermal/electrical conductivity SiC/SiC composites or other suitable, compatible materials that would make for effective FCIs. One approach that has been envisioned is the use of a final "sealing" layer of SiC matrix material, which would be near theoretical density and cover any porosity or exposed fibers in the main body of the insert. Two-dimensional weaves are also thought to be satisfactory, as well as an effective way to reduce electrical conductivity normal to the interface between the insert and the Pb-15.7Li (the more important of the directions). In addition, grant applications are sought to develop experimental techniques for determining: (1) the compatibility between the SiC/SiC composite and such breeder materials as Pb-15.7Li alloy, and (2) the insert integrity under cyclic thermal loading and other in-service conditions.

One of the missions of the ITER project is the integrated testing of fusion blanket modules in a true integrated fusion environment. This ITER fusion environment includes radiation and magnetic fields, along with surface and volumetric heating, under pulsed and/or steady-state plasma operation. The testing of first wall/blanket components will be performed in ITER by inserting "test blanket modules" (TBMs) that will be complicated systems of different functional materials (breeder, multiplier, coolant, structure, insulator, etc.) in various configurations with many responses and interacting phenomena (e.g., thermomechanical, thermofluid, nuclear). As part of the design and validation process an overall simulation of a "virtual" TBM, integrating all of the individual computational modeling simulations at the system level, is essential to define meaningful experiments. Such a simulation would be inherently multi-scale and multi-physics and will require careful code and algorithm design. Therefore, grant applications are sought to develop a TBM and general power reactor relevant simulation code that can provide detailed predictions of: (1) fluid flow and thermal hydraulic characteristics; (2) the thermal response of all materials (structure, breeder, multiplier, coolant, insulator, etc); (3) structural responses such as stress and deformation magnitudes with respect to different loadings, including both steady-state surface heat flux and dynamic loadings; (4) mass transfer characteristics including both corrosion and tritium transport phenomena, and (5) other important performance characteristics of the TBM or blanket system. The overall code framework/structure must effectively link all of

the simulation components of the virtual TBM and serve as an efficient, useful, and user-friendly tool that is extendable from ITER to demonstration power reactor conditions.

Questions – contact Ed Stevens, edward.stevens@science.doe.gov

c. Superconducting Magnets and Materials—New or advanced superconducting magnet concepts are needed for plasma fusion confinement systems. Of particular interest are magnet components, superconducting, structural and insulating materials, or diagnostic systems that lead to magnetic confinement devices which operate at higher magnetic fields (14T-20T), in higher nuclear irradiation environments, provide improved access/maintenance or allow for wider operating ranges in temperature or pulsed magnetic fields.

Grant applications are sought for:

(1) Innovative and advanced superconducting materials and manufacturing processes that have a high potential for improved conductor performance and low fabrication costs. Of specific interest are materials such as YBCO conductors that are easily adaptable to bundling into high current cables carrying 30 - 60 kA. Desirable characteristics include high critical currents at temperatures from 4.5 K to 50 K, magnetic fields in the range 5 T to 20 T, higher copper fractions, low transient losses, low sensitivity to strain degradation effects, high radiation resistance, and improved methods for cabling tape conductors taking into account twisting and other methods of transposition to ensure uniform current distribution.

(2) Novel methods for joining coil sections for manufacture of demountable magnets that allow for highly reliable, re-makeable joints that exhibit excellent structural integrity, low electrical resistance, low ac losses, and high stability in high magnetic field and in pulsed applications. These include conventional lap and butt joints, as well as very high current plate-to-plate joints. Reliable sliding joints can be considered.

(3) Innovative structural support methods and materials, and magnet cooling and quench protection methods suitable for operation in a fusion radiation environment, that result in high overall current density magnets.

(4) Novel, advanced sensors and instrumentation for monitoring magnet and helium parameters (e.g., pressure, temperature, voltage, mass flow, quench, etc.); of specific interest are fiber optic based devices and systems that allow for electromagnetic noise-immune interrogation of these parameters as well as positional information of the measured parameter within the coil winding pack. A specific use of fiber sensors is for rapid and redundant quench detection. Novel fiber optic sensors may also be used for precision measurement of distributed and local temperature or strain for diagnostic and scientific studies of conductor behavior and code calibration.

(5) Radiation-resistant electrical insulators, e.g., wrapable inorganic insulators and low viscosity organic insulators that exhibit low gas generation under irradiation, less expensive resins and higher pot life; and insulation systems with high bond and higher strength and flexibility in shear.

Questions – contact Barry Sullivan, barry.sullivan@science.doe.gov

d. Structural Materials and Coatings—Fusion materials and structures must function for a long time in a uniquely hostile environment that includes combinations of high temperatures, reactive chemicals, high stresses, and intense damaging radiation. The goal is to establish the feasibility of designing, constructing and operating a fusion power plant with materials and components that meet demanding objectives for safety, performance and minimal environmental impact. Pursuant to this goal grant applications are sought for:

(1) Development of innovative methods for joining beryllium (~2 mm thick layer) to RAFM steels. The resulting bonds must be resistant to the effects of neutron irradiation, exhibit sufficient thermal fatigue resistance, and minimize or prevent the formation of brittle intermetallic phases that could result in coating debonding.

(2) Development of fabrication techniques for typical component geometries envisioned for use in test blanket modules for operation in ITER using current generation RAFM steels. Such fabrication techniques could include but are not limited to appropriate welding, hot-isostatic pressing, hydroforming, and investment casting methods as well as effective post joining heat treatment techniques and procedures. Appropriate fabrication technologies must produce components within dimensional tolerances, while meeting minimum requirements on mechanical and physical properties.

(3) Development of oxide dispersion strengthened (ODS) ferritic steels. Approaches of interest include the development of low cost production techniques, improved isotropy of mechanical properties, development of joining methods that maintain the properties of the ODS steel, and development of improved ODS steels with the capability of operating up to ~800˚C, while maintaining adequate fracture toughness at room temperature and above.

(4) Development of high ductility, high-fracture toughness tungsten alloys with isotropic properties. Areas of interest include improvements in the grain boundary strength and fracture toughness, and joining techniques. In addition, development of engineered tungsten/PFC materials to control or eliminate blistering associated with the interaction of tungsten with He and H isotopes from the plasma by providing high diffusivity paths to release He and H and decrease retention of these gases is of interest.

(5) Development of functional coatings for the RAFM/Pb-Li blanket concept. Coatings are needed for functions that include (1) compatibility: minimizing dissolution of RAFM in Pb-Li at 700°C, (2) permeation: reducing tritium permeation (hydrogen for demonstration) by a factor of >100 and (3) electrically insulating: reducing the pressure drop due to the magneto-hydrodynamic (MHD) effect. Proposed approaches must: (1) account for compatibility with both the coated structural alloy and liquid metal coolant for long-time operation at 500-700˚C (2) address the potential application of candidate coatings on large-scale system components; and (3) demonstrate that the permeation and MHD coatings are functional during or after exposure to Pb-Li.

(6) Development of failure assessment and lifetime prediction methodologies of structural materials in the fusion environment, including physics-based methods to determine damage accumulation, residual life, and reliability of structural components under combinations of steady and cyclic loading, high-temperature, and neutron irradiation.

(7) Development of innovative modeling tools for the above joining methods, materials, and coatings. Modeling approaches may range from atomistic and molecular dynamics simulations of atomic collision and defect migration events to improved finite element analysis or thermodynamic stability methods.

Priority will be given to innovative methods or experimental approaches that enhance the ability to obtain key mechanical or physical property data on miniaturized specimens, and to the micromechanics evaluation of deformation and fracture processes.

Questions – contact Peter Pappano, peter.pappano@science.doe.gov

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

Questions – contact Barry Sullivan, barry.sullivan@science.doe.gov

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23. FUSION SCIENCE AND TECHNOLOGY

The Fusion Energy Sciences program currently supports several fusion-related experiments with many common objectives. These include expanding the scientific understanding of plasma behavior and improving the performance of high temperature plasma for eventual energy production. The goals of this topic are to develop and demonstrate innovative techniques, instrumentation, and concepts for (a) measuring magnetized-plasma parameters, (b) for low-temperature and multi-phase plasmas, (c) for magnetized-plasma simulation, control, and data analysis, and (d) for overcoming deleterious plasma effects during discharges. It is also intended that concepts developed as part of the fusion research program will have application to industries in the private sector. Further information about research funded by the Office of Fusion Energy Sciences (FES) can be found in the FES Website (URL: http://www.science.doe.gov/ofes/). **Grant applications are sought only in the following subtopics:**

a. U.S. ITER Diagnostics—The United States has joined the international collaboration to construct and operate ITER, a full-scale experimental fusion energy device that will pave the way to clean energy. In order for U.S. allocated diagnostics systems to better meet the functional measurement requirements for ITER, grant applications are sought to improve some subsystem components. Components of interest include: (1) Faraday isolator for CO_2 (10.6 micron) lasers to eliminate laser instabilities for the ITER tangential interferometer/polarimeter system and the ITER divertor interferometer systems; (2) fiber-optic-based laser endoscope for remote monitoring of optical quality and ablation of coated deposits on diagnostic mirrors; (3) motion-compensating miter bends in overmoded, corrugated microwave waveguide or ITER low-field-side reflectometer and electron cyclotron emission system corrugated waveguide transmission systems; (4) low-loss, broadband quasi-optical frequency multiplexers in the 50 to 200 GHz frequency range to combine different X-mode frequency bands (V, W, D, and G) for the low-field-side reflectometer into a single corrugated waveguide; (5) low insertion loss (<3dB), high rejection (> 50dB) microwave notch filter at the ITER electron cyclotron heating (ECH) frequency for the ITER low-field-side reflectometer and electron cyclotron emission systems; (6) robust, reliable mixers and local oscillators (LO) in the 200-300 GHz range for the ITER electron cyclotron emission system corrugated waveguide transmission system; and (7) *a specially-packaged sensor array based on single photon/particle counting silicon pixel array detectors (PADS) with an upper-level discriminator for high resolution core imaging x-ray spectrometer.* Grant applications must propose the development of hardware for U.S. ITER diagnostics; all other applications will be declined.

Questions – contact Francis Thio, francis.thio@science.doe.gov

b. Components for Heating and Fueling of Fusion Plasmas—Grant applications are sought to develop components related to the generation, transmission, and launching of high power electromagnetic waves in the frequency ranges of Ion Cyclotron Resonance Heating (ICRH, 50 to 300 MHz), Lower Hybrid Heating (LHH, 2 to 10 GHz), and Electron Cyclotron Resonance (or Electron Bernstein Wave) Heating (ECRH / EBW, 28 to 300 GHz). These improved components are sought for the microwave heating systems of the current large facilities in the United States (Alcator C-Mod, DIII-D and NSTX), facilities under construction (including ITER), and smaller machines exploring innovative and alternate concepts. Components of interests include power supplies, high power microwave sources or generators, fault protection devices, transmission line components, and antenna and launching systems. Specific examples of some of the components that are needed include tuning and matching systems, unidirectional couplers, circulators, mode convertors, windows, output couplers, loads, energy extraction systems from spent electron beams and particle accelerators, and diagnostics to evaluate the performance of these components. Of particular interest are components that can safely handle a range of frequencies and increased power levels.

For the ITER project, the United States will be supplying the transmission lines for both the ECRH (2 MW/line) system, at a frequency of 170 GHz, and for the ICRH system (6 MW/line), operating in the range of 40 – 60 MHz.. For this project, grant applications are needed for advanced components that are capable of improving the efficiency and power handling capability of the transmission lines, in order to reduce losses and protect the system from overheating, arcing, damage or failure during the required long pulse operation (~3000s). Examples of

components needed for the ECRH transmission line include high power loads, low loss miter bends, polarizers, power samplers, windows, switches, and dielectric breaks. For the ITER transmission lines, improved techniques are needed for the mass production of components, in order to reduce cost. Lastly, advanced computer codes are needed to simulate the microwave, thermal, and mechanical components of the transmission lines. Components needed for the ICRH lines include high power loads and reliable tuning/matching components.

Questions – contact Barry Sullivan, barry.sullivan@science.doe.gov

c. Fusion Plasma Simulation and Data Analysis Tools—The realistic simulation of fusion plasmas is important for the design and evaluation of plasma discharge feedback and control systems; the design, operation, and performance assessment of existing and proposed fusion experiments; the planning of experiments on existing devices; and the interpretation of the experimental data obtained from these experiments. The simulation of fusion plasmas is very challenging because (1) the range of temporal and spatial scales involved is enormous and these scales often overlap, violating the assumption of scale separation; and (2) the nonlinear physical processes that govern the behavior of these plasmas are strongly coupled in the regimes of interest for fusion energy production. Although, in recent years, considerable progress has been made toward the understanding of these processes – including particle, momentum, and energy transport driven by plasma turbulence, macroscopic equilibrium and stability, wave-plasma interactions, energetic particle physics, and the behavior of the edge plasma – there remains a critical need to integrate the various plasma models, in order to develop an integrated predictive simulation capability for magnetically confined plasmas. In addition, efficient computational tools are needed to manage, analyze, and visualize the enormous datasets resulting from large scale fusion simulations and experiments.

Grant applications are sought to develop computer algorithms and tools that are applicable to simulations of magnetically confined plasmas, incorporate an expanded number of plasma features, and integrate multiple physical processes across multiple spatial and temporal scales. Areas of interest include, but are not limited to: (1) algorithms incorporating advanced mathematical techniques; (2) algorithms targeting novel computing architectures, including GPU and hybrid computing; ; (3) verification and validation tools, including efficient methods for facilitating comparison of simulation results with experimental data and the development of synthetic diagnostics; (4) data management, visualization, and analysis tools for local and remote multi-dimensional time-dependent datasets resulting from large scale simulations or experiments; (5) techniques for coupling simulation codes, including coupling across different computer platforms and through high speed networks; (6) methodologies for building highly configurable and modular scientific codes and flexible data interfaces; and (7) remote collaboration tools that enhance the ability of geographically distributed groups of scientists to interact in real-time.

The simulation and data analysis tools should be developed using modern software techniques, should be capable of exploiting the potential of next generation high performance computers, and should be based on high fidelity physics models. The applications submitted in response to this call should have a strong potential for commercialization and should not propose work that is normally funded by program funds.

Questions – contact John Mandrekas, john.mandrekas@science.doe.gov

d. Components and Modeling Support for Validation Platforms for Fusion Science—The FES Validation Platforms program has the long-term performance measure of demonstrating enhanced fundamental understanding of magnetic confinement and improving the basis for future burning plasma experiments. This can be accomplished through investigations and validations of the linkage between prediction and measurement for scientific leverage in testing the theories and scaling the phenomena that are relevant to future burning plasma systems. This research includes investigations in a variety of concepts such as stellarators, spherical tori, and reversed field pinches. Key program issues include initiation and increase of plasma current; dissipation of plasma exhaust power; symmetric-torus confinement prediction; stability, continuity, and profile control of low-aspect-ratio symmetric tori; quasi-symmetric and three-dimensional shaping benefits to toroidal confinement performance; divertor design for three-dimensional magnetic confinement configurations, and the plasma-materials interface. Grant applications are sought for scientific and engineering developments, including computational modeling, in support of current experiments in these research activities, in particular for the small-scale concept exploration experiments. Overall, support of research that can best help deepen the scientific foundations of understanding and improve the tokamak concept is an important focus area for grant applications.

Questions – contact Sam Barish, sam.barish@science.doe.gov

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

Questions – contact Barry Sullivan, barry.sullivan@science.doe.gov

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2. "ICC2008: Innovative Confinement Concepts" Workshop in Reno, Nevada, , sponsored by the U.S. DOE Office of Fusion Energy Sciences. June 24-27, 2008. (http://www.iccworkshops.org/icc2008/proceedings.php)

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4. Report of the Research Needs Workshop (ReNeW) for Magnetic Fusion Energy Sciences, Bethesda, Maryland, June 8-12, 2009. (http://burningplasma.org/renew.html)

24. HIGH ENERGY DENSITY PLASMAS AND INERTIAL FUSION ENERGY

High-energy-density laboratory plasma (HEDLP) physics is the study of ionized matter at extremely high density and temperature, specifically when matter is heated and compressed to a point that the stored energy in the matter reaches approximately 100 billion Joules per cubic meter (the energy density of a hydrogen molecule). This corresponds to a pressure of approximately 1 million atmospheres or 1 Mbar. Systems in which free electrons play a significant role in the dynamics and for which the underlying assumptions and methods of traditional ideal-plasma theory and standard condensed matter theory do not apply (e.g., Warm

Dense Matter at temperatures of a few eV) can have pressures as low as 0.1 Mbar and are also considered HED plasmas [R. P. Drake, Phys. Plasmas 16, 055501 (2009)]. **Grant applications are sought only in the following subtopics:**

a. Advancing the Science of High Energy Density Laboratory Plasma—The Department has an interest in producing and developing the science of high-energy-density plasmas. Research and development activities are sought to support on-going activities in laser-driven, pulsed-power-driven, and heavy-ion-driven high-energy-density plasma physics. Proposed work should be focused on a specific application, diagnostic or need that would lead to potential commercialization.

Proposed work is sought in the following subfields and cross-cutting areas of HEDLP, as described in the Report of the ReNeW in HEDLP, with additional scope indicated specifically below:

1. **High Energy Density Hydrodynamics**
   Specific areas of interest include, but are not limited to, turbulent mixing, probing properties of HED matter through hydrodynamics, solid-state hydrodynamics at high pressures, new hydrodynamic instabilities, and hydrodynamic scaling.

2. **Radiation-Dominated Dynamics and Material Properties**
   Specific areas of interest include, but are not limited to, radiative shocks, radiation waves and radiation transport, radiative cooling, opacities and equation of state, radiative instabilities, and radiation pressure.

3. **Magnetized High-Energy Density Plasma Physics**
   Specific areas of interest include, but are not limited to, basic properties of magnetized HED plasmas, coupled dynamics and atomic kinetics, phase transitions in the presence of high magnetic fields and current densities, ultra high magnetic fields and their measurements, radiation-dominated HED dynamo, and radiation-dominated reconnection.

4. **Nonlinear Optics of Plasmas and Laser-Plasma Interactions**
   Specific areas of interest include, but are not limited to, the interplay between coherent radiation and nonlinear states in HED plasmas, nonlinear-wave-particle interactions, multiple coexisting instabilities, broadband radiation in plasma, and quantum phenomena in HED plasmas.

5. **Relativistic HED Plasmas and Intense Beam Physics**
   Specific areas of interest include, but are not limited to, relativistic laser and beam propagation, relativistic laser-solid interaction, ultrahigh energy density plasmas at the QED limit, relativistic thermal plasmas, and relativistic shocks.

6. **Warm Dense Matter**
   Specific areas of interest include, but are not limited to, phase transitions in and around the WDM regime, comprehensive theory connecting different WDM regimes, equation of state

dependence on formation history, transport properties of warm dense matter, and quark-gluon plasma similarities to warm dense matter.

7. **Diagnostics for HEDLP**
   Grant applications will be considered for the development of advanced diagnostic instruments, methods and experimental techniques, as discussed in the ReNeW report, to be developed at the home institution or on intermediate scale HED facilities but that would, if the research is fruitful, have proposals to the National Ignition Facility (NIF). The intent here is to fund research and concept development and demonstration, only, and engineering development for fielding on NIF should not be part of the proposed work.

Questions – contact Ann Satsangi, ann.satsangi@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 Ann Satsangi, ann.satsangi@science.doe.gov

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25. LOW TEMPERATURE PLASMAS

Low temperature plasma science and engineering address research and development in partially ionized gases with electron temperatures typically below about 10 eV. Richness of the field comes from the intimate contact between energetic plasmas and ordinary matter in all its phases: gas, liquid, and solid making it one of the highly complicated, usually coupled, and nonlinear systems. Research is supported on the fundamental science issues and applications. **Grant applications are sought only in the following subtopics:**

a. Science Enabling Low Temperature Plasma Engineering and Technology—A weakly to partially ionized gas is often characterized by strong nonequilibrium in the velocity and energy distributions of its neutral and charged constituents. Topics being encouraged include (1) developing experimental, theoretical, and model-based predictive capability for plasma and chemistry processes, plasma kinetics, and interactions between plasma and material surfaces, (2)

development of plasma-enabled technologies and microelectronics, (3) biological applications of plasmas, and (4) development of new diagnostic methodologies for measuring essential plasma properties, three-dimensional structures, etc. Applications should have a strong commercialization potential.

Questions - contact Nirmol Podder, Nirmol.Podder@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 Nirmol Podder, Nirmol.Podder@science.doe.gov

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PROGRAM AREA OVERVIEW
OFFICE OF HIGH ENERGY PHYSICS

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

The goal of the Department of Energy's (DOE) High Energy Physics (HEP) program is to provide mankind with new insights into the fundamental nature of energy and matter and the forces that control them. This program is a major component of the Department's fundamental

research mission. Such fundamental research provides the necessary foundation that enables the nation to advance its scientific knowledge and technological capabilities, to advance its industrial competitiveness, and possibly to discover new and innovative approaches to its energy future.

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

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

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

26. HIGH ENERGY PHYSICS COMPUTATIONAL TECHNOLOGY

The DOE supports the development of computational technologies essential for success of the experimental, theoretical, and R&D programs in the Office of High Energy Physics (HEP). HEP funded research is aimed at understanding how our universe works at its most fundamental level though Energy, Intensity and Cosmic Frontiers [1]. Experiments for HEP science are data intensive, and rely heavily on scientific computing for planning, operations, data taking and data analysis. State of the art modeling and simulation are integral to the planning and development of the particle accelerators that drive experimental research in the Energy and Intensity frontiers. Theory research spanning the accelerator based and non accelerator based HEP research is also strongly dependent on advanced computing and simulations. HEP programmatic activities that

require computational technology are described in the Energy, Intensity and Cosmic frontiers and the various subtopics [1]

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

Although some aspects of HEP computing technology may have similarities with other disciplines applicants should consult with their HEP supported collaborators and focus on proposals that enhance HEP research interests. Areas of present interest include innovative and scalable software and codes for multi core computer systems including parallelizing community codes like GEANT [4]; web tools and collaboration software for distributed computing and data sharing initiatives like the Open Science Grid [5]; development of wide area networks [6] and cyber security systems for distributed data; frameworks and database development including data storage, management, reliability, and preservation systems [7]; research on computing clusters including GPUs [8].

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

a. Software and Simulation Tools—Grant applications are sought to develop innovative computing tools and software for high energy physics simulation and modeling. Topics of interest include simulation and modeling algorithms for high energy physics processes and models, particle accelerators [9], and theoretical calculations. Software and codes for high performance supercomputers should be scalable on such machines. Grant applications that facilitate parallelizing HEP community codes on multi core computer systems including clusters are also welcome. It is to be noted that overall HEP promotes the development and use of open source software as far as possible.

Questions – contact Lali Chatterjee, lali.chatterjee@science.doe.gov

b. Web Tools and Collaboration Software for Distributed Computing—The international nature of HEP experiments and their large computing resource requirements drive the current HEP paradigm of handling and analyzing experimental data in a highly distributed fashion. By aggregating world-wide computing resources from HEP and other disciplines, initiatives like the Open Science Grid [5] aim to enable a federated computing model for HEP and other participating disciplines.

Grant applications are sought to develop advanced web tools and associated infrastructure technologies to strengthen the ability of dispersed particle physics researchers to collaborate. Examples include client-server frameworks, remote data selection techniques, distributed data management and analysis frameworks, project management software, and information sharing and search technologies [10].

Grant applications are also sought that support the design, implementation, and operation of distributed computing systems comprising distributed Petaflops of CPU power and distributed petabytes of data, middleware development for grid-enabled systems, security assurance tools for a distributed environment, and other related technology.

Questions – contact Lali Chatterjee, lali.chatterjee@science.doe.gov

c. Wide Area Networks and Cyber Security Systems—Grant Applications are sought that enable improvements to the wide area network fabric used by the experimental HEP community, the reliability of cyber security systems protecting distributed storage and job management systems, and other technology to support and advance distributed computing and data analysis.

Questions – contact Lali Chatterjee, lali.chatterjee@science.doe.gov

d. Frameworks and Database Development—Grant applications also are sought in areas of large data including frameworks for the management, configuration, custody, and dissemination of large data sets (experimental or simulation data), development of data storage, management, reliability, and preservation systems and related tools.

Questions – contact Lali Chatterjee, lali.chatterjee@science.doe.gov

e. Development of Computer Systems—Grant applications are sought for research on computing clusters including advanced architectures and GPUs that address specific or broad HEP research areas and complement use of supercomputers [8].

Questions – contact Lali Chatterjee, lali.chatterjee@science.doe.gov

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

Questions – contact Lali Chatterjee, lali.chatterjee@science.doe.gov

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5. "Open Science Grid," a partnership between the National Science Foundation and the U.S. Department of Energy's Office of Science (http://www.opensciencegrid.org/)

6. "US LHCnet: High speed TransAtlantic network for the LHC Community" (http://lhcnet.caltech.edu/)

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27. ADVANCED CONCEPTS AND TECHNOLOGY FOR HIGH INTENSITY ACCELERATORS

The DOE High Energy Physics (HEP) program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. The strategic plan for HEP includes initiatives on the intensity frontier, relying on accelerators capable of delivering very high average beam intensity at multi-GeV energies, i.e. beam powers measured in megawatts. Beams are typically composed

of protons or ions. The DOE HEP program seeks to develop advanced technologies that can be used to support MW-class facilities in a cost effective manner. **Grant applications are sought in the following subtopics:**

a. Accelerator Development and Modeling of Advanced Concepts—Grant applications are sought to develop new or improved accelerator designs and supporting modeling that can provide efficient acceleration of intense particle beams in either linacs or synchrotrons. Efficient acceleration refers to beam losses of less than 1 W/m. Topics of interest include: (1) linac configurations, either pulsed or CW, capable of delivering >1 MW beams at energies between 1-10 GeV; (2) halo formation in pulsed or CW linacs; (3) concepts for high intensity rapid cycling synchrotrons; (4) space-charge mitigation techniques; (5) new methods for multi-turn H– injection, including laser stripping techniques; and (6) higher order mode generation, propagation, and suppression in acceleration cavities.

The HEP application of interest is for a high intensity proton source to support intensity frontier programs including long baseline neutrino beams and rare processes experiments. Other possible applications include high-intensity proton drivers for neutron production, waste transmutation, energy production in sub-critical nuclear reactors, medical proton therapy, and radioisotope production.

Questions – contact LK Len, lk.len@science.doe.gov

b. Superconducting Radiofrequency Cavities—Grant applications are sought for the development of superconducting radiofrequency cavities for acceleration of proton and ion beams, with relativistic betas ranging from 0.1 to 1.0. Frequencies of current interest include 325, 650, and 1300 MHz. Continuous wave (CW) cavities are of the greater interest, although pulsed cavities could also be supported. Accelerating gradients above 15 MV, at Q_0 in excess of 2×10^{10} (CW), and above 25 MV/m at Q_0 in excess of 1×10^{10} (pulsed) are desirable. Topics of interest include: (1) cavity designs; (2) cavity fabrication alternatives to electron beam welding, including for example hydroforming and automatic TIG or laser welding of cavity endgroups; (3) other cavity and cryomodule cost reduction methods; (4) cw power couplers at >50kW; (5) fast tuners for microphonics control; (6) higher order mode suppressors, including extraction of HOM power via the main power coupler ; (7) ecologically friendly or alternative cavity surface processing methods; (8) alternatives to high pressure rinsing that would allow in-situ cleaning of cavities to control field emission; and (9) high resolution tomographic x-rays of electron beam welds in cavities.

Questions – contact LK Len, lk.len@science.doe.gov

c. Radio Frequency Power Sources and Components—Grant applications are sought for the development of power sources for cavities operating with 1-10 mA of average beam current in linacs capable of accelerating protons and ions to several GeV. Frequencies of interest include 325, 650, and 1300 MHz. Continuous wave (CW) applications are the primary interest. Examples of systems of interest include, but are not limited to: klystrons, solid state, inductive output, and phase locking magnetron devices; and the associated power supplies/modulators. Pulsed applications of interest include sources capable of delivering high peak power (multi-

MW) with pulse lengths in the range 6-30 msec at 10 Hz. Of particular interest are the high efficiency solid state CW rf sources (30 kW at 650 MHz and 10 kW at 325 MHz) for the FNAL Project X linac.

Questions – contact LK Len, lk.len@science.doe.gov

d. High Gradient Tunable RF Cavities for Rapid Cycling Synchrotrons—Grant applications are sought to develop high gradient cavities that can be utilized in synchrotrons with repetition rates in the range of 5-50 Hz, with frequency swings corresponding to beta variations from 0.9-1.0. Cavity gradients in excess of 20 MV/m are desirable. Topics of interest include: (1) cavity (including tuner) designs; (2) cavity fabrication techniques; and (3) power sources.

Questions – contact LK Len, lk.len@science.doe.gov

e. High Reliability Ion Sources—Grant applications are sought for the design, and possibly demonstration units, of CW proton and H– sources capable of operating at up to 10 mA. The primary interest is in sources that can be fabricated with high reliability, meaning source lifetime of greater than one month.

Questions – contact LK Len, lk.len@science.doe.gov

f. Beam Choppers, Bunchers, and Transverse Deflectors—Grant applications are sought for beam deflecting devices that can be used to remove or deflect proton or ion bunches for the purpose of forming variable bunch patterns of use in high intensity proton accelerators. Topics of particular interest include: (1) wideband beam choppers capable of removing beam from a dc source at energies in the 2-3 MeV range; specifically with capabilities of providing arbitrary chopping patters with a bandwidth of >300 MHz; and (2) narrowband transverse deflecting cavities capable of CW operation at a few hundred MHz, with deflecting fields of ~25 MV/m.

In addition grant applications are sought for buncher cavities that can be utilized in the initial acceleration stages of proton or ion accelerators.

Questions – contact LK Len, lk.len@science.doe.gov

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

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

h. 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 LK Len, lk.len@science.doe.gov

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28. ADVANCED CONCEPTS AND TECHNOLOGY FOR HIGH ENERGY ACCELERATORS

The DOE High Energy Physics (HEP) program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. As high energy physics facilities get bigger and more costly, the DOE HEP program seeks to develop advanced technologies that can be used to reduce the overall machine size and cost. **Grant applications are sought in the following subtopics:**

a. Advanced Accelerator Concepts and Modeling—Grant applications are sought to develop new or improved accelerator designs that can provide very high gradient (>200 MV/m for electrons or >10 MV/m for protons) acceleration of intense bunches of particles, or efficient acceleration of intense (>50 mA) low energy (of order <20 MeV) proton beams. Approaches of interest include: (1) the fabrication of accelerator structures from materials such as Si, SiO2 or GaAs, using integrated circuit technology, where the realization might include photonic bandgap structures or gratings powered by lasers in the wavelength range 1 to 2.5 μm; (2) the development of micro-capillary arrays with arbitrary thickness-to-diameter ratios, with capillary diameters down to 5 μm, and with different diameters and materials in the same plate (which might also incorporate defect structures such as lines and holes); and (3) the development of high-efficiency, high-power, lasers at 1.5-4.5 μm, providing >10 μJ per pulse at repetition rates >10 MHz, excellent mode quality M^2<1.2, and the long-term potential for both carrier-envelope-phase stabilization and excellent wall-plug efficiency (>30%). For all proposed concepts, stageability, beam stability, manufacturability, and high-wall plug-to-beam power efficiency should be considered.

Grant applications also are sought to demonstrate efficient low-loss proton acceleration in the energy range of 5-25 GeV using non-scaling, fixed-field alternating-gradient (FFAG) accelerators and integrable optics accelerators. This demonstration may require an electron

model to directly simulate operation in a space-charge limited regime and fast RF modulation for high repetition rate and ultra-wide tune range operation. The HEP application of interest is for a proton driver injector for muon colliders and/or neutrino factories. Other possible applications include high-intensity proton drivers for neutron production, waste transmutation, energy production in sub-critical nuclear reactors, medical proton therapy (250 MeV), and radioisotope production.

Questions – contact LK Len, lk.len@science.doe.gov

b. Technology for Muon Colliders and Muon Beams—Grant applications are sought for the development of novel devices and instrumentation for use in producing intense low energy muon beams suitable for precision muon experiments, and intense high energy muon beams suitable for neutrino factories and/or muon colliders. Approaches of interest include the development of: (1) new concepts for the generation, capture, acceleration, and colliding of intense muon beams; (2) concepts or devices for ionization cooling, including emittance exchange processes; (3) improved simulation packages for studying ionization cooling of muon beams; (4) novel cooling schemes of optical stochastic cooling, coherent electron cooling, and paramteric ionization cooling; (5) concepts or devices for manipulation and control of the longitudinal phase space of large emittance muon beams, including bunching, phase rotation, and bunch merging; (6) concepts or devices for producing intense polarized muon beams; (7) large aperture kickers for injection and extraction in muon cooling rings; (8) concepts and prototyping elements for cost effective rapid acceleration, e.g., 1 T/s pulsed magnets; (9) instrumentation for muon cooling channels that have muon intensities of 1012 muons/pulse; or (10) fast (on the order of 10 picosecond) timing detectors for muon cooling experiments with low muon intensity (on the order of 105 muons/second).

Grant applications are also sought to develop non-scaling Fixed Field Alternating Gradient (FFAG) and Recirculating Linear Accelerator (RLA) systems for muon acceleration.
For FFAG, approaches of interest include: (1) the development and analysis of FFAG designs that contain insertion sections, (2) engineering design and cost analysis of injection and extraction systems for a neutrino factory FFAG, including the effect of the kicker system on the beam dynamics, and (3) detailed analysis of the dynamics of recently proposed non-scaling FFAG designs, including such features as dynamic aperture (and how it depends on acceleration rate) and sensitivity to errors.

For RLA, approaches of interest include: (1) lattice optimization for a large energy range, (2) examination of the practical upper limit to the number of passes the beam can make through an RLA, and (3) detailed design of a suitable switchyard and its magnets.

Lastly, grant applications are sought for new concepts, approaches, or designs for radio-frequency amplifiers, or pulse compression schemes, for use in the acceleration and ionization cooling channels of a future muon collider. The amplifiers or compressors must have high peak power (>30 MW) and pulsed, low frequency (from 2 ms pulses at 20 MHz to 0.1 ms pulses at 200 MHz). Higher power (>100 MW) pulsed sources at higher frequencies, e.g., 30 μs at 400 MHz, also are of interest. All muon collider amplifiers must have moderate repetition rate

capability (e.g., 50 Hz). Grant applications should address the cost per unit of peak power, including the cost of required power supplies.

Questions – contact LK Len, lk.len@science.doe.gov

c. Novel Device and Instrumentation Development—Grant applications are sought for the development of electromagnetic, permanent magnet, silicon microcircuit, or electron-beam-based charged particle optical elements for particle beam focusing. Examples include, but are not limited to, (1) dipoles, quadrupoles, higher order multipole correctors for use in electron linear accelerators; and (2) solenoids for use in electron-beam or ion-beam sources, or for klystron or other radio frequency amplifier tubes operating at wavelengths from 0.7 to 10 cm. In these optical elements, permanent magnets or hybrid magnets incorporating magnetic materials that have very high residual magnetization, radiation resistance, and thermal stability (low variation of field strength with temperature) are of particular interest.

Grant applications also are sought to develop (1) undulators for bunching high energy electron beams, needed for phased injection in high frequency accelerating structures and for generating coherent transition radiation; (2) electron lenses for compensation of space-charge and beam-beam effects and for particle collimation; (3) novel charged particle beam monitors to measure the transverse or longitudinal charge distribution, emittance, or phase-space distributions of small radius (0.1 μm to 5 mm diameter), short length (10 μm to 10 mm) relativistic electron or ion beams; and (4) devices capable of measuring and recording the Schottky or transition radiation spectrum of these beams (proposed techniques should be nondestructive, or minimally perturbative, to the beams monitored and have computer-compatible readouts).
Grant applications also are sought to develop achromatic, isochronous compact focusing systems with broad energy acceptance and compact broadband (10-100 MeV) spectrometers, suitable for use in laser acceleration experiments.

Lastly, grant applications are sought to develop high density (range of 1018-1020 cm-3), high repetition rate (≥10 Hz) pulsed gas jets, capable of producing longitudinally tailored density profiles with long lengths (centimeter scale) and narrow widths (few hundred microns) for use in laser wakefield accelerators. The gas jet should have sharp entrance gradients, with a transition region/length on the order of 500 μm. The pulse duration of the jets should be less than 500 μs to minimize the amount of gas loading in vacuum chambers. Cluster gas jets, i.e., jets that are cooled and produce atomic clusters, are also of interest.

Questions – contact LK Len, lk.len@science.doe.gov

d. Laser Technology for Accelerators—Lasers are used in many areas of accelerator applications, ranging from plasma channel formation to laser wakefield acceleration. Grant applications are sought to develop lasers for laser-accelerator applications that provide substantial improvements over currently available lasers in one or more of the following parameters: (1) longer wavelengths (up to 2 to 2.5 μm for use with Si transmissive optics), (2) very short wavelengths (< 200 nm) with low mode numbers (M-squared < 100) and high pulse energy (> 0.1 J) for photo-ionized plasma sources, (3) higher power, (4) higher repetition rates, and (5) shorter pulse widths.

Questions – contact LK Len, lk.len@science.doe.gov

e. Inexpensive High Quality Electron Sources—Grant applications are sought for the design and prototype fabrication of small, inexpensive electron sources for use in advanced accelerator R&D laboratory experiments. The following parameters are target values for accelerator research experiments: (1) energy range of 5 to 35 MeV providing, at a minimum, on the order of 10^9 electrons in a bunch less than 5 picoseconds long; (2) normalized transverse beam emittance $<5\pi$ mm-mrad; and (3) pulse repetition rate >10 Hz. Grant applications also are sought for sources with significantly lower bunch charges, energies, and emittances from a matrix cathode, but at comparable or greater peak currents and significantly higher repetition rates. In addition, grant applications are sought to develop a bright direct-current/radio-frequency (DC/RF) photocathode electron source that combines a pulsed high-electric-field DC gun and a high field RF accelerator, operates at a repetition rate of several kHz, and has electron bunch specifications similar to those listed above.

Grant applications also are sought to develop: (1) robust RF photocathodes (quantum efficiencies >0.1 percent) or other novel RF gun technologies operating at output electron beam energies >3 MeV; (2) laser or electron driven systems for such guns; and (3) electron beam sources, such as sheet or multiple beams, relevant to the abovementioned high power RF applications.

Novel electron sources suited for injection into laser-driven structure-based accelerators are also sought. Sources such as the laser-assisted field emission "super-tip" sources are sought, with the capability of providing up to 1 fC/optical cycle bunch charge, normalized transverse emittance of <0.001 mm-mrad, and MHz repetition rates.

Questions – contact LK Len, lk.len@science.doe.gov

f. Precision Corrector Magnet Driver—The present generation of multi-channel correction magnet drivers (e.g. MCOR) is approaching obsolescence and new high availability designs are needed for high energy accelerator systems. Grant applications are sought for systems incorporating 16 channels or more in a 19 inch rack mounted crate with a height of 6U or less. Bi-polar driver cards of up to ±20 A output current should be developed. High accuracy current and voltage regulation and stability are required, <10 ppm/°C, with RMS current noise <0.01%. Digital regulation, with sufficient speed to support a 4 kHz feedback rate, should be employed. Excellent reliability is essential with a target MTBF of 150,000 hours. Additionally, high availability features such as redundancy, hot-swap, embedded diagnostics/prognostics to enhance system availability. Each crate should incorporate an EPICS IOC and support external communication via IP protocol over Gigabit Ethernet.

Questions – contact LK Len, lk.len@science.doe.gov

g. Hardware and Software Solutions for Accelerator Control—Grant applications are sought to develop: (1) improved software systems for command and control functions, real time database management, real-time or off-line modeling of the accelerator system and beam, and status display systems encountered in state-of-the-art approaches to accelerator control and

optimization; and (2) improved decision and database management tools, specifically for use in planning and controlling the integrated cost, schedule, and resources in large HEP R&D and construction projects.

Grant applications also are sought to develop real-time optical networks for pulsed-accelerator control. These networks require timing information to be combined with data-communication functions on a single optical fiber connected to pulsed device-controllers. The single fiber should provide each controller with an RF-synchronized clock that has the following features: (1) an arrival time that is phase-locked to the temperature-stabilized RF reference phase, (2) a phase-locked machine pulse fiducial point, (3) digital data for machine pulse-type selection and specific pulse identification, and (4) real-time-streaming pulsed waveform data-acquisition capabilities. The controllers serve as interfaces to systems that provide such functions as low-level RF signal generation, modulator control, beam position monitors, and machine protection system sensing. The network should provide real-time, fast-feedback loop closure and TCP/IP connectivity for slow control functions such as database access, device configuration, and code downloading and debugging.

Finally, grant applications are sought to develop real-time processors and software for pulsed accelerator control and monitoring. The software should be based on a multiprocessor architecture that can be deeply embedded within pulsed device-controllers, which employ system-on-a-chip, field-programmable gate-array, or application-specific integrated circuit technologies. The architectures should feature distinct processors for real-time pulse-to-pulse functions, and conventional slow control functions. Architectural provisions for supporting machine protection functions via an additional processor or dedicated hardware also should be included.

For the preceding two paragraphs, proposed solutions should be engineered to include: (1) resistance to electromagnetic interference generated by nearby, large pulsed-power systems; and (2) maximum availability in remote deployment locations.

Questions – contact LK Len, lk.len@science.doe.gov

h. Computational Tools and Simulation of Accelerator Systems—Grant applications are sought to develop new or improved computational tools for the design, study, or operation of charged-particle-beam optical systems, accelerator systems, or accelerator components. These tools should incorporate innovative user-friendly interfaces, with emphasis on graphical user interfaces and windows. Grant applications also are sought for the conversion of existing codes for the incorporation of these interfaces (provided that existing copyrights are protected and that applications include the authors' statements of permission where appropriate).
Grant applications also are sought to develop improved simulation packages for injectors or photoinjectors. Areas of interest include: (1) improved space-charge algorithms; (2) improved algorithms for the self-consistent computation of the effects of wakefields and coherent synchrotron radiation on the detailed beam dynamics; (3) improved fully-three-dimensional algorithms for the modeling of transversely asymmetric beams; and (4) explicit end-to-end simulations that provide for more accurate beam-quality calculations in full injector systems.

Questions – contact LK Len, lk.len@science.doe.gov

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

Questions – contact LK Len, lk.len@science.doe.gov

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29. RADIO FREQUENCY ACCELERATOR TECHNOLOGY FOR HIGH ENERGY ACCELERATORS AND COLLIDERS

Radio frequency (RF) technology is a key technology common to all high energy accelerators. RF sources with improved efficiency and accelerating structures with increased accelerating gradient are important for keeping the cost down for future machines. Relevance to applications in HEP must be explicitly described. **Grant applications are sought in the following subtopics**:

a. New Concepts and Modeling Techniques for Radio Frequency Acceleration Structures—Grant applications are sought for research on very high gradient RF accelerating structures, normal or superconducting, for use in accelerators and storage rings. Gradients >150 MV/m for electrons and >10 MV/m for protons in normal cavities are of particular interest, as are means for suppressing unwanted higher-order modes and reducing costs. In muon accelerator R&D, structures for capture and acceleration of large emittance muon beams and techniques for achieving gradients of 5-20 MV/m in cavities with frequencies between 5 and 400 MHz (including superconducting cavities whose resonant frequencies can be rapidly modulated) are of interest. Methods for reducing surface breakdown and multipactoring (such as spark-resistant materials or surface coatings, or special geometries) and for suppressing unwanted higher order modes also are of interest, as are studies of surface breakdown and its dependence on magnetic field. Grant applications should be applicable to devices operating at frequencies from 1 to 40 GHz, or between 5 and 400 MHz for muon accelerators. Grant applications also are sought to develop simulation tools for modeling high-gradient structures, in order to predict such experimental phenomena as the onset of breakdown, post breakdown phenomena, and the damage threshold. Specific areas of interest include the modeling of: (1) surface emission, (2) material heating due to electron and ion bombardment, (3) multipactoring, and (4) ionization of atomic and molecular species. Approaches that include an ability to import/export CAD descriptions, a friendly graphical user interface, and good data visualization will be a plus.

Questions – contact LK Len, lk.len@science.doe.gov

b. Materials and Fabrication Technologies for SRF Cavities—Material properties, surface dynamics, processing procedures, and geometric configurations can have significant impact on the performance of the accelerator cavities. Grant applications are sought to develop (1) new materials that are suitable for the fabrication of superconducting radiofrequency (SRF) cavities, such as large grain or single crystal Nb; (2) new or improved SRF cavity fabrication techniques especially weld-free approaches, and (3) improved understanding and performance of SRF cavities.

Questions – contact LK Len, lk.len@science.doe.gov

c. Radio Frequency Power Sources and Components—Grant applications are sought to develop high peak power, narrow-band, low-duty-cycle, low pulse rate (~100 Hz), high efficiency pulsed X-band RF amplifiers. In particular, 25 MW and 50 MW X-band (11.424) klystrons are sought that produce 2 μs long pulses at 120 Hz. Also, low cost, 2 kW, 2 μs, 120 Hz, 100 MHz bandwidth, low noise S-band and X-band klystron drivers are sought. Of particular interest are low duty X-band solid state sources with 30 fs phase noise or better.

High gradient X-band linacs will require many RF power handling components which have not been fully developed, e.g., RF windows, couplers, mode transformers, RF loads, and high power rings capable of operating at high pulse powers. Consequently, grant applications are sought to develop active or passive RF pulse compression systems capable of handling high peak powers (for example, greater than 300 MW) and pulse widths of approximately 300 nanoseconds at X-band. Grant applications also are sought for passive and active RF components such as over-moded mode converters (e.g., rectangular to circular waveguide and vice versa), high-power RF windows, circulators, isolators, switches, and quasi-optical components. Finally, S-band loads (30 MW peak, 50 MW peak, and 100 MW peak/40 kW average) and X-band loads (50 MW/5 kW average, and 5 MW/25 kW average) are needed.

Questions – contact LK Len, lk.len@science.doe.gov

d. Modulators for Pulsed Radio Frequency Systems—Most RF power sources for high gradient linacs for future linear colliders require high peak-power pulse modulators of considerably higher efficiency than presently available. Grant applications are sought for new types of modulators in the 100 kV – 1 MV range for driving currents of 0.1 – 1 kA, with pulse lengths of 0.2 – 5.0 μs, and with rise- and fall-times that are ~10% of the pulse length or less. Grant applications also are sought for the development of a 2 μs, 420 kV, 420 A, 120 Hz induction modulator that could be used to drive a variety of high power klystrons (from S-band to X-band).

Grant applications also are sought for the development of modulators with improved voltage control for RF phase stability in some alternate RF power systems, as well as cathode modulators that are compact and cost competitive compared to present cathode pulse modulator schemes. Grant applications should address issues related to cost saving, manufacturability, and electrical efficiency in modulators.

Questions – contact LK Len, lk.len@science.doe.gov

e. Switching Technology for Pulsed Power Applications—Existing Insulated Gate Bipolar Transistor (IGBT) packages for high voltage and high pulsed current (e.g., V = 6.5 kV, I = 3 kA peak, 800 A average) are not optimized for very high speed pulsed power applications (10 MW peak for 3.2 μs at 120 Hz) due to failure modes induced by very rapid fall times (di/dt >10 kA/μs) and/or rise times (dV/dt >15 kV/μs) upon device turn-off. Therefore, grant applications are sought to reduce these failure modes through improved packaging of commercial IGBT chips, by incorporating appropriate protective circuitry in a high voltage power package designed specifically for high-speed transients.

Grant applications are sought to develop improved high power solid-state switches for pulse power switching. For some applications, requirements will include the ability to switch high current pulses (0.1-10 kA) at voltage levels of up to 20 kV, with switching times less than 300 ns. These switches must handle very high di/dt (20 kA/μs) at low duty cycle (<0.1%).

Questions – contact LK Len, lk.len@science.doe.gov

f. Energy Storage for Pulsed Power Systems—High reliability, high-energy-density energy storage capacitors are a key component for the development of reliable solid state pulsed power systems. Grant applications are sought to develop and optimize storage capacitors that can: (1) deliver high peak pulse current (0.1-10 kA) in the partial discharge region (less than 30 percent voltage droop during pulse); (2) be designed with very low inductance connections to allow fast rise and fall time discharge without ringing (di/dt ~20 kA/μs); (3) be packaged to meet the requirements of high power solid state board layouts and have minimum production cost; and (4) have an accurately known lifetime of tens of thousands of hours.

Questions – contact LK Len, lk.len@science.doe.gov

g. Deflecting Cavities (AKA "crab cavities")—High luminosity colliders can benefit from the use of a crossing angle between the colliding beams. The crossing angle will provide a larger luminosity gain if the particle bunches are tilted, resulting in what is called a "crab crossing." Grant applications are sought for the development of crab cavities for the LHC and other applications. Approaches of interest, which may include new cavity geometries, should include the demonstration of high-performance prototype superconducting crab cavities. Grant applications also are sought for ancillary technology for use with crab cavities, including the development of (1) fundamental power couplers; (2) high-order, same-order, and low-order mode damping couplers, including design, analysis, and low-power testing; and (3) conceptual and detailed designs for low-cost crab cavity cryomodules and tuners.

Questions – contact LK Len, lk.len@science.doe.gov

h. 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 LK Len, lk.len@science.doe.gov

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30. HIGH-FIELD SUPERCONDUCTOR AND SUPERCONDUCTING MAGNET TECHNOLOGIES FOR HIGH ENERGY PARTICLE COLLIDERS

The Department of Energy High Energy Physics program supports a broad research and development (R&D) effort in the science, engineering, and technology of charged particle accelerators, storage rings, and associated apparatus. Advanced R&D is needed in support of this research in high-field superconductor and superconducting magnet technologies. This topic addresses only those superconductor and superconducting magnet development technologies that support dipoles, quadrupoles, and higher order multipole corrector magnets for use in accelerators, storage rings, and charged particle beam transport systems. **Grant applications are sought only in the following subtopics:**

a. High-Field Superconducting Wire Technologies for Magnets—Grant applications are sought to develop new or improved superconducting wire technologies for magnets that operate at a minimum of 12 Tesla (T) field, with increases up to 15 to 50 T sought in the near future (three to five years). Vacuum requirements in accelerators and storage rings favor operating temperatures of 1.8 to 20 K. Stability requirements for magnets dictate that the effective filament diameter should be less than 30 micrometers. Upgrades of existing particle accelerators will require some magnets that operate under a high radiation (and thermal) load. New or improved technologies must demonstrate: (1) property improvements such as higher critical current densities and higher upper critical fields, (2) the manageable degradation of these properties as a function of applied strain, and (3) low losses in changing transverse magnetic fields, such as for twisted round multi-filamentary wires. Any proposed process improvements must result in equivalent performance at reduced cost. All grant applications must focus on conductors that will be acceptable for accelerator magnets, especially with regard to the operating conditions mentioned above, and must address plans to physically deliver a sufficient amount of material (1 km minimum length) for winding and testing in small dipole or quadrupole magnets.

Questions - contact Bruce Strauss, bruce.strauss@science.doe.gov

b. Superconducting Magnet Technology—Grant applications are sought to develop: (1) improved instrumentation to measure properties (such as local strain, temperature, and magnetic field) which are directly applicable to the testing of superconducting magnets; (2) improved current lead and current distribution systems, based on high-temperature superconductors, for application to superconducting accelerator magnets – requirements include an operating current level of 5 kA or greater, stability, low heat leak, and good quench performance; (3) alternative designs – to traditional "cosine theta" dipole and "cosine two-theta" quadrupole magnets – that may be more compatible with the more fragile A-15, and the HTS, high-field superconductors (including open midplane magnest as needed in Muon Collider design); (4) designs for bent (e.g., bending radius in the range 0.75 to 1.25m) solenoids (e.g., 2 T, 30 cm inside diameter) with superimposed dipole fields (e.g., 1 T) for dispersion generation in large emittance beams; (5) improved industrial fabrication methods for magnets such as welding and forming; (6) improved

cryostat and cryogenic techniques; or (7) fast cycling HTS magnets capable of operation at or above 4T/s.

Questions - contact Bruce Strauss, bruce.strauss@science.doe.gov

c. Starting Raw Materials and Basic Superconducting Materials— High performance niobium-titanium (Nb-Ti) alloys operating above 8 T continue to be required for focusing quadrupole magnets or for graded windings in the low-field portions of high-field magnets. Therefore, grant applications are sought to develop Nb-Ti composite superconductors with properties optimized at 8 T fields and higher at 4.2 K.

Present wires made of magnesium diboride (MgB_2) and its alloyed variants are characterized by a filling factor that is too low, wire cross-sections that have too few filaments, and upper critical and irreversibility fields that are too low. Therefore, grant applications should seek to improve the current density over the wire cross-section, implement restacked round-wire multi-filamentary designs, and extend the field at which a critical current density can be attained over the superconductor cross-section of 1200 A mm^{-2} in the 12-16 T range at 4.2 K.

Lastly, grant applications are sought to develop (1) A-15 compounds, such as Nb_3Sn and Nb_3Al – a minimum current density of 1800 A mm^{-2} at 15 T and 4.2 K must be achieved in the superconductor itself; and (2) high-temperature superconductors (HTS), such as $Bi_2Sr_2CaCu_2O_8$ and $YBa_2Cu_3O_{7-\delta}$ – a minimum current density of 1200 A mm^{-2} (not A cm^{-2}) must be achieved in the superconductor itself, and a minimum current density of 250 A mm^{-2} must be achieved over the total conductor cross section at 12 T minimum and 4.2 K.

Questions - contact Bruce Strauss, bruce.strauss@science.doe.gov

d. Ancillary Technologies for Superconductors—Grant applications also are sought to develop innovative wire and cable design and processing technologies. Approaches of interest include methods to utilize stranded conductors with high aspect ratio, such as Rutherford cables, or low-loss tape geometries in particle accelerator applications; and technologies to improve wire piece length and increase billet mass.

Grant applications also are sought for innovative insulating materials that are compatible with the use of inter-metallic superconductors in practical devices. Approaches of interest should enable the use of inter-metallic superconductors (such as the A-15, HTS, or MgB_2 types) in practical devices. Insulating systems must be compatible with high temperature reactions in the 750-900 ºC range, be capable of supporting high mechanical loads at both room and cryogenic temperatures, have a high coefficient of thermal conductivity, be resistant to radiation damage, and exhibit low creep and low out-gassing rates when irradiated.

Lastly, grant applications are sought to develop HTS conductors suitable for the very-high-field 30-50 T solenoids needed for final ionization cooling stages of a Muon Collider.

Questions - contact Bruce Strauss, bruce.strauss@science.doe.gov

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

Questions - contact Bruce Strauss, bruce.strauss@science.doe.gov

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* Abstracts and ordering information available at: http://proceedings.aip.org/proceedings/

31. HIGH ENERGY PHYSICS DETECTORS AND INSTRUMENTATION

The DOE supports research and development in a wide range of technologies essential to experiments in High Energy Physics (HEP) and to the accelerators at DOE high energy accelerator laboratories. The development of advanced technologies for particle detection and identification for use in HEP experiments or particle accelerators is desired. Broadly the areas of interest are improvements in the sensitivity, robustness, and cost effectiveness of particle detectors. Principal areas of interest include particle detectors based on new techniques and technological developments, or detectors that can be used in novel ways as a consequence of associated technological developments in electronics (e.g., sensitivity or bandwidth). Also of interest are novel experimental systems that use new detectors, or use old ones in new ways or with significant improvement, in order to either extend basic HEP experimental research capabilities or result in less costly and less complex apparatus. Devices which exhibit insensitivity to very high radiation levels have recently become extremely important. Grant applications must clearly and specifically indicate their particular relevance to HEP programmatic activities.

Although particle physics detector development is often concentrated at major national particle accelerator centers, there are many developmental endeavors, especially in collaborative efforts, where small businesses can make creative and innovative contributions that further develop the required advanced technologies. Nonetheless, applicants are encouraged to collaborate with active high energy elementary particle physicists at universities or national laboratories to establish mutually beneficial goals. On-line directories of appropriate researchers are available at http://www.hep.net/sites/directories.html.

Proposed devices must be explicitly related to future high-energy physics experiments, either accelerator or non-accelerator based, or to future uses in particle accelerators. Relevant potential improvements over existing devices and techniques must be discussed explicitly. For example with respect to radiation hardness, energy, position, and timing resolution, sensitivity, rate capability, stability, dynamic range, durability, compactness, cost, etc. Electromagnetic calorimeters, also called shower counters or gamma ray detectors, must be optimized for photons with energies above 1 GeV. X-ray detectors are not relevant to this topic. **Grant applications are sought in the following subtopics:**

a. Particle Detection and Identification Devices—Grant applications are sought for novel ideas in the areas of charged and neutral particle detection and identification that could lead to improvements in the sensitivity, robustness, or cost effectiveness of particle detectors. These include ideas to advance the utility of detectors for the Energy Frontier such as at an upgraded or future collider; at the Intensity Frontier such as at a future long baseline neutrino experiment; and

at the Cosmic Frontier such as a new Dark Matter detector. Examples include, but are not limited to, semiconductor particle detectors (silicon, CVD diamond, or other semiconductors), light-emitting particle detectors (scintillating materials including fibers, liquids, and crystals or Cherenkov radiators), photosensitive detectors that could be used with light-emitting detectors (photomultipliers, micro-channel plates, photosensitive semiconductors), and gas or liquid-filled chambers (used for particle tracking, in electromagnetic or hadronic calorimeters, and in Cherenkov or transition radiation detectors). Grant applications also are sought for systematic studies of radiation aging of materials used in particle detectors.

Questions – contact Fred Borcherding, frederick.borcherding@science.doe.gov

b. Mechanical and Materials—HEP experiments frequently require high performance detector support that will not compromise the precision of the detectors. Therefore, grant applications are sought for components used to support or integrate detectors into HEP experiments. The support components must be well matched to the detectors. For many experiments the presence of excess material is detrimental. These applications typically require low mass extremely rigid materials. Applications include the following: 1) Development of low mass detector support materials. 2) Novel low-mass materials with high thermal conductivity and stiffness. 3) Very high thermal conductivity, radiation tolerant adhesives. 4) Extension of stereo lithography rapid prototyping technology to scintillator materials. 5) Conventional detectors with substantially improved performance through the use of novel material science developments. 6) Improvements to manufacturing processes for radiation sensors and photosensors relevant for high energy physics. The improvements should yield better performance, cost, faster production methods, or entirely new methods that make more efficient use of equipment.

Questions – contact Fred Borcherding, frederick.borcherding@science.doe.gov

c. Photon Detectors—The detection of photons is fundamental for many detector applications. Applications include the following: 1) High quantum efficiency visible light photon detectors. 2) Development of lower cost photo-detection technology scalable to large detectors. 3 Photo-sensors for extreme environments including cryogenic temperatures, corrosive conditions, high and low pressures, electric and magnetic fields, and radiation relevant for future HEP applications. 4) Photosensors with improved response in time, efficiency, or sensitivity in new regions of wavelength including improvements in windows and coatings. 5) New sensors for light detection. 6) Vacuum technology based Photo detection Techniques. 7) Solid State technology based Photo detection Techniques. 8) High quantum efficiency X-ray detectors.

Questions – contact Fred Borcherding, frederick.borcherding@science.doe.gov

d. Ultra-low Background Detectors—Many experiments conducting a direct search for dark matter require that the detector elements and the surrounding support materials exhibit extreme radiological stability. The presence of trace amounts of radioactivity in or near a detector induces unwanted effects. These elements could include: 1) Ultra-low background neutron and alpha-particle detectors. 2) Development of ultra radio pure material for use in detectors. 3) Manufacturing methods of ultra low radioactive background materials.

Questions – contact Fred Borcherding, frederick.borcherding@science.doe.gov

e. Radiation Hard—Many experiments must locate detectors within extreme radiation areas. For these applications radiation hardened devices are required. Applications include the following: 1) Radiation hardened/resistant optical links. 2) Radiation hardened/resistant power supplies or voltage converters, e.g. point of load converters. 3) Development of ultra radiation hard material for use as detector elements. 4) Other radiation sensors for extreme environments.

Questions – contact Fred Borcherding, frederick.borcherding@science.doe.gov

f. Cryogenic—Many detectors utilize cryogenic conditions and require cryogenic systems and devices which operate within a cryogenic environment. Applications include the following: 1)Development of the use, production and purification of cryogenic noble gasses. 2) Cryogenic Liquid and Gas Particle Detectors. 3) Cryogenic Solid State Detectors.

Questions – contact Fred Borcherding, frederick.borcherding@science.doe.gov

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

Questions – contact Fred Borcherding, frederick.borcherding@science.doe.gov

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PROGRAM AREA OVERVIEW
NUCLEAR PHYSICS

Nuclear physics (NP) research seeks to understand the structure and interactions of atomic nuclei and the fundamental forces and particles of nature as manifested in nuclear matter. Nuclear processes are responsible for the nature and abundance of all matter, which in turn determines the essential physical characteristics of the universe. The primary mission of the Nuclear Physics (NP) program is to develop and support the scientists, techniques, and facilities that are needed for basic nuclear physics research and isotope development and production. Attendant upon this core mission are responsibilities to enlarge and diversify the Nation's pool of technically trained talent and to facilitate transfer of technology and knowledge to support the Nation's economic base.

Nuclear physics research is carried out at national laboratories and accelerator facilities, and at universities. The Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF) allows detailed studies of how quarks and gluons bind together to make protons and neutrons. In an upgrade currently underway, the CEBAF electron beam energy will be doubled from 6 to 12 GeV. The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) is forming new states of matter, which have not existed since the first moments after the birth of the Universe; a beam luminosity upgrade is currently underway. NP is supporting the development of a next generation rare isotope beam accelerator facility (FRIB). The NP community is also exploring opportunities with a proposed electron-ion collider.

The NP program also supports research and facility operations directed toward understanding the properties of nuclei at their limits of stability, and of the fundamental properties of nucleons and neutrinos. This research is made possible with the Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory (ANL) which provides stable and radioactive beams as well as a variety of species and energies; a local program of basic and applied research at the 88-Inch Cyclotron of the Lawrence Berkeley National Laboratory (LBNL); the operations of accelerators for in-house research programs at two universities (Texas A&M University and the Triangle Universities Nuclear Laboratory (TUNL) at Duke University), which provide unique instrumentation with a special emphasis on the training of students; non-accelerator experiments, such as large stand alone detectors and observatories for rare events. Of interest is R&D related to future experiments in fundamental symmetries such as neutrinoless double-beta decay experiments and measurement of the electric dipole moment of the neutron, where extremely low background and low count rate particle detections are essential. Another area of R&D is rare isotope beam capabilities, which could lead to a set of accelerator technologies and instrumentation developments targeted to explore the limits of nuclear existence. By producing and studying highly unstable nuclei that are now formed only in stars, scientists could better understand stellar evolution and the origin of the elements.

Our ability to continue making a scientific impact on the general community relies heavily on the availability of cutting edge technology and advances in detector instrumentation, electronics, software, and accelerator design. 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.

32. NUCLEAR PHYSICS SOFTWARE AND DATA MANAGEMENT

Large scale data storage and processing systems are needed to store, access, retrieve, distribute, and process data from experiments conducted at large facilities, such as Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC) and the Thomas Jefferson National Accelerator Facility (TJNAF). In addition, data acquisition for the Facility for Rare Isotope Beams (FRIB) requires unprecedented speed and flexibility in collecting data from new flash ADC based detectors. The experiments at such facilities are extremely complex, involving thousands of detector elements that produce raw experimental data at rates up to a GB/sec, resulting in the annual production of data sets containing hundreds of Terabytes (TB) to Petabytes (PB). Many 10s to 100s of TB of data per year are distributed to institutions around the U.S. and other countries for analysis. Research on large scale data management systems and high speed, distributed data acquisition is required to support these large nuclear physics experiments. All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications are sought only in the following subtopics:**

a. Large Scale Data Storage—The cost of data storage in magnetic disk media is becoming competitive with magnetic tape for storing large volumes of data (ignoring all costs of servers and I/O performance). Because current technology keeps all disk drives powered and spinning, the infrastructure costs of operating a many-petabyte-scale disk storage system can be significant. However, one 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 magnetic disk systems that are optimized for infrequent data access, emphasizing lower cost, lower power usage, and low access latency to frequently used data. To the extent feasible, it is desirable that the cost should scale with the amount of data accessed rather than the total storage capacity.

Also, many DOE labs have existing investments in large-scale tape robot technologies, which are at this point the most cost-effective way to store petabyte-sized datasets. Grant applications are sought for (1) the development of innovative storage technologies that not only can use existing cartridge and tape formats but also will significantly increase the storage density and capacity, increase data read and write speeds, or decrease costs; and (2) innovative software technologies to allow file-system-based user access to petabyte-scale data on tape.

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. Interested parties should contact Dr. Chip Watson at Jefferson Lab (watson@jlab.org).

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

b. Large Scale Data Processing and Distribution—A recent trend in nuclear physics is to construct data handling and distribution systems using web services or data grid infrastructure software – such as Globus, Condor, SRB, and xrootd – for large scale data processing and distribution. Grant applications are sought for (1) hardware and/or software techniques to improve the effectiveness and reduce the costs of storing, retrieving, and moving such large volumes of data, including, but not limited to, automated data replication coupled with application-level knowledge of data usage, data transfers to Tier 2 and Tier 3 centers from multiple data provenance – with an aim for least wait-time and maximal coordination (coordination of otherwise chaotic transfers), distributed storage systems of commercial off-the-shelf (COTS) hardware, storage buffers coupled to 10 Gbps (or greater) networks, and end-to-end monitoring and diagnostics of WAN file transport; (2) hardware and/or software techniques to improve the effectiveness of computational and data grids for nuclear physics – examples include integrating storage and data management services with scalable distributed data repositories such as xrootd, and developing application-level monitoring services for status and error diagnosis; (3) effective new approaches to data mining, automatic structuring of data and information, and facilitated information retrieval; (4) new tools for configuring and scheduling compute and storage resources for data-intensive high performance computing tasks such as in user analyses where repeated passes over large datasets requiring fast turnaround times are needed; and (5) distributed authorization and identity management systems, enabling single sign-on access to data distributed across many sites. Proposed infrastructure software solutions should consider and address the advantages of integrating closely with relevant components of Grid middleware, such as the Virtual Data Toolkit (VDT), as the foundation used by nuclear physics and other science communities. Applicants that propose data distribution and processing projects are encouraged to determine relevance and possible future migration strategies into existing infrastructures.

Grant applications also are sought (1) to provide redundancy and increased reliability for servers employing parallel architecture, so that they are capable of handling large numbers of simultaneous requests by multiple users; (2) for hardware and software to improve remote user access to computer facilities at nuclear physics research centers, while at the same time providing adequate security to protect the servers from unauthorized access; and (3) for hardware and software to significantly improve the energy efficiency and reduce the operating costs of computer facilities at nuclear physics research centers.

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

c. Grid and Cloud Computing—Grid deployments such as the Open Science Grid (OSG) in the U.S. and the Worldwide Large Hadron Collider (LHC) Computing Grid (WLCG) in Europe

provide standardized infrastructures for scientific computing across large numbers of distributed facilities. To support these infrastructures, new computing paradigms have emerged to emerge: (1) Grid Computing, sometimes called "computing on demand," which supports highly distributed and intensive scientific computing for nuclear physics (and other sciences); and (2) Cloud Computing, which can offer an application-specific computing environment by allowing the deployment of application-requested virtual machines. 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. Grant applications are sought to 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. Software solutions should enable rapid access to computing resources as they become available to users that do not have the necessary application software environment installed.

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

d. Software-driven Network Architectures for Data Acquisition—Modern data acquisition systems are becoming more heterogenous and distributed. This presents new challenges in synchronization of the different elements of this event-driven architecture. The building blocks of the data acquisition system are digitizers, either flash digitizers or integrating digitizers of time, pulse height or charge. These elements respond in real-time to convert electrical signals from detectors into digital form. The data from each detector element is labeled with a precisely synchronized time and transmitted to buffers. The total charge, the number of coincident elements or other information summaries are used to determine if something interesting has happened, that is, forming a trigger. If the trigger justifies it, the data from the elements are assembled together into a time-correlated event for later analysis, a process called Event Building. At present the elements tend to be connected by buses (VME, cPCI), custom interconnects or serial connections (USB).

A concept of the next generation data acquisition system is that it will be ultimately composed of separate ADC's for each detector element, connected by commercial network or serial technology, is envisioned. Development is required to implement the elements of this distributed data acquisition over commercially available network technologies such as 10 Gb Ethernet or Advanced Telecommunications Computing Architecture (ATC). The initial work needed is to develop a software architecture for a system that works efficiently in the available network bandwidth and latencies. The elements desired in the architecture are to (1) synchronize time to a sufficient precision, as good as 10ns or better to support Flash Analog-to-Digital Converter (FADC) clock synchronization, 100ns or better to support trigger formation and event building, (2) determine a global trigger from information transmitted by the individual components (3) notify the elements of a successful trigger, in order to locally store the current information, (4) collect event data from the individual elements to be assembled into events and (5) software tools to validate the function of the synchronization, triggering and event building during normal operation. The synchronization of time is critical to the success of this architecture, as is the constant validation of the synchronization.

The software architecture would specify 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. In certain types of experiments at FRIB, low event rates of 1 to 10 kevents/s are anticipated, with large 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 portable software implementation of the elements would be the next step in the development.

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. Interested parties should contact Dr. Robert Varner at Oak Ridge National Laboratory (varnerrl@ornl.gov).

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e. Heterogeneous Computing—Computationally demanding theory calculations as well as detector simulations and data analysis tasks can be significantly accelerated by the use of general purpose Graphics Processing Units (GPUs). The ability to exploit these accelerators is constrained by the effort required to port the software to the GPU environment. More capable cross compilation or source to source translation tools are needed that are able to injest very complicated templatized C++ code and produce high performance GPU code.
Early work by the USQCD (US Quantum Chromo Dynamics) collaboration has demonstrated the power of clusters of GPUs in Lattice QCD calculations. This early work was manpower intensive but yielded a large return on investment through the hand optimization of critical numerical kernels, achieving performance gains of up to 60x with 4 GPUs. However, realizing the full potential of accelerators on the full code base can only be achieved through a capable and performant automated tool chain. Interested parties should contact Dr Chip Watson at Jefferson Lab (watson@jlab.org).

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

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

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

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6. Scientific Discover Through Advanced Computing (SciDAC), U.S. Department of Energy. (www.scidac.gov/physics/quarks.html)

7. The Globus Alliance, a collaboration between the University of Chicago and Argonne National Laboratory. (http://www.globus.org/)

8. Condor: High Throughput Computing, University of Wisconsin. (www.cs.wisc.edu/condor/)

9. Cloud computing and virtual workspaces. (http://workspace.globus.org/)

10. CERN VM SoFTware Appliance. (http://cernvm.cern.ch/cernvm/).

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16. National Nuclear Data Center, Brookhaven National Laboratory (http://www.nndc.bnl.gov)

17. SRB – The SDSC Storage Resource Broker (http://www.sdsc.edu/srb/index.php/Main_Page)

18. Event-Driven Architectures. (http://en.wikipedia.org/wiki/Event-driven_architecture)

19. IEEE 1588 - Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems (http://ieee1588.nist.gov/)

20. Xrootd scalable distributed data repository (http://xrootd.slac.stanford.edu/)

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

33. NUCLEAR PHYSICS ELECTRONICS DESIGN AND FABRICATION

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 35 (Nuclear Instrumentation, Detection Systems, and Techniques). All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications are sought only in the following subtopics:**

a. Advances in Digital Electronics—Digital signal processing electronics are needed to replace analog signal processing in nuclear physics applications. Grant applications are sought to develop: fast digital processing electronics that improve the accuracy of the analog electronics, such as in determining the position of interaction points (of particles or photons) to an accuracy smaller than the size of the detector segments. Emphasis should be on circuit technologies with low power dissipation.

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

b. Circuits—Grant applications are sought to develop custom-designed integrated circuits, as well as circuits (including firmware) and systems, for rapidly processing data from highly-segmented, position-sensitive germanium detectors (pixel sizes of approximately 1 cm^2) and from particle detectors (e.g., gas detectors, scintillation counters, silicon drift chambers, silicon strip detectors, particle calorimeters, and Cherenkov counters) used in nuclear physics experiments. Areas of specific interest include (1) representative circuits such as low-noise preamplifiers, amplifiers, peak sensors, analog storage devices, analog-to-digital and time-to-digital converters, transient digitizers, and time-to-amplitude converters; (2) front-end and multiplexing integrated circuits operating in cryogenic environment, to allow for reduction of noise, power, and number of feedthroughs in highly segmented germanium detectors; (3) multiple-sampling application-specific integrated circuits (ASICs), to allow for pulse-shape analysis; (4) readout electronics for solid-state pixilated detectors, including interconnection technologies and amplifier/sample-and-hold integrated circuits; (5) systems with exceedingly large dynamic range (> 5000) employing, for example, either dynamic CSA gain changing or combinations of a standard linear CSA with a time-over-threshold (TOT) that works well into CSA saturation; and (6) constant-fraction discriminators with uniform response for low- and high energy gamma rays. These circuits should be fast; low-cost; high-density; configurable in software for thresholds, gains, etc.; easy to use with commercial auxiliary electronics; low power; compact; and efficiently packaged for multi-channel devices.

In addition, planned luminosity upgrades at RHIC will require fine-grained vertex and tracking detectors (both silicon and gas) for high particle multiplicity environments. Therefore, grant applications are sought for advances in microelectronics that are specifically designed for low-

noise amplification and processing of detector signals, and that are suitable for these next generation detectors. The microelectronics and associated interconnections must be lightweight and have low power dissipation. Of particular interest are designs that minimize higher-gate leakage currents due to tunneling and maintain dynamic range.

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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 circuits that have sufficiently high sensitivity and low power dissipation, in order to detect a minimum ionizing particle in a thin "epitaxial-like" or equivalent layer (~10-30 microns).

Grant applications also are sought for the next generation of active pixel sensors, or even strip sensors, which use the bulk silicon substrate as the active volume. This more advanced approach

would have the advantage of developing relatively larger signals and allowing sensitivity to non-minimum ionizing particles, such as MeV-range gamma rays.

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e. Manufacturing and Advanced Interconnection Techniques—Grant applications are sought to develop (1) manufacturing techniques for large, thin, multiple-layer printed circuit boards (PCBs) with plated-through holes, dimensions from 2m x 2m to 5m x 5m, and thicknesses from 100 to 200 microns (these PCBs would have use in cathode pad chambers, cathode strip chambers, time projection chamber cathode boards, etc); (2) techniques to add plated-through holes, in a reliable robust way, to large rolls of metallized mylar or kapton (which would have applications in detectors such as time expansion chambers or large cathode strip chambers); and (3) miniaturization techniques for connectors and cables with 5 times to 10 times the density of standard interdensity connectors.

In addition, many next-generation detectors will have highly segmented electrode geometries with 5-5000 channels per square centimeter, covering areas up to several square meters. Conventional packaging and assembly technology cannot be used at these high densities. Grant applications are sought to develop (1) advanced microchip module interconnect technologies that address the issues of high-density area-array connections – including modularity, reliability, repair/rework, and electrical parasitics; (2) technology for aggregating and transporting the signals (analog and digital) generated by the front-end electronics, and for distributing and conditioning power and common signals (clock, reset, etc.); (3) low-cost methods for efficient cooling of on-detector electronics; (4) low-cost and low-mass methods for grounding and shielding; and (5) standards for interconnecting ASICs (which may have been developed by diverse groups in different organizations) into a single system for a given experiment – these standards should address the combination of different technologies, which utilize different voltage levels and signal types, with the goal of reusing the developed circuits in future experiments.

Lastly, highly-segmented detectors with pixels smaller than 100 microns present a significant challenge for integration with frontend electronics. New monolithic techniques based on vertical integration and through-silicon vias have potential advantages over the current bump-bonded approach. Grant applications are sought to demonstrate reliable, readily-manufacturable technologies to interconnect silicon pixel detectors with CMOS front-end integrated circuits. Of highest long term interest are high-density high-functionality 3D circuits with direct bonding of high resistivity silicon detector layer of an appropriate thickness (50 to 500 microns) to a 3D stack of thin CMOS layers. The high resistivity detector layer would be fully depleted to enable fast charge collection with very low diffusion. The thickness of this layer would be optimized for the photon energy of interest or to obtain sufficient signal from minimum ionizing particles.

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

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

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34. NUCLEAR PHYSICS ACCELERATOR TECHNOLOGY

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/amu and polarized proton beam energies up to 250 GeV; technologies associated with RHIC luminosity upgrades; the development of an electron-ion collider; linear accelerators such as the Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF); and development of devices and/or methods that would be useful in the generation of intense rare isotope beams for the next generation rare isotope beam accelerator facility (FRIB). A major focus in all of the above areas is superconducting radio frequency (RF) acceleration and its related technologies. Relevance of applications to nuclear physics must be explicitly described. Grant applications that propose using the resources of a third party (such as a DOE laboratory) must include, in the application, a letter of certification from an authorized official of that organization. All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications are sought only in the following subtopics**:

a. Materials and Components for Radio Frequency Devices—Grant applications are sought to improve or advance superconducting and room-temperature materials or components for RF devices used in particle accelerators. Areas of interest include (1) peripheral components, for both room temperature and superconducting structures, such as ultra high vacuum seals, terminations, high reliability radio frequency windows using alternative materials (e.g., sapphire), RF power couplers, and magnetostrictive or piezoelectric cavity-tuning mechanisms; (2) fast ferroelectric microwave components that control reactive power for fast tuning of

cavities or fast control of input power coupling; (3) materials that efficiently absorb microwaves from 2 to 90 GHz and are compatible with ultra-high vacuum, particulate-free environments at 2 to 4 K; (4) innovative designs for hermetically sealed helium refrigerators and other cryogenic equipment, which simplify procedures and reduce costs associated with repair and modification; (5) more cost effective, kW-to-multiple-kW level, liquid helium refrigerators; (6) simple, low-cost mechanical techniques for damping length oscillations in accelerating structures, effective in the 10-300 Hz range at 2 and/or 4.5 K; (7) alternative cavity fabrication techniques, such as hydro forming or spinning of seamless SRF cavities; and (8) novel SRF linac mechanical support structures with low thermal conductivity and high vibration isolation and strength.

Grant applications also are sought to develop (1) methods for manufacturing superconducting radio frequency (SRF) accelerating structures with $Q_0>10^{10}$ at 2.0 K, or with correspondingly lower Q's at higher temperatures such as 4.5 K; and (2) advanced fabrication methods for SRF cavities of various geometries (including elliptical, quarter and half wave resonators) to reduce production costs. Industrial metal forming techniques, especially with large grain or ingot material, have the potential for significant cost reductions by simplifying sub-assemblies – e.g., dumbbells and beam tube – and reducing the number of electron beam welds.

Grant applications also are sought to develop (1) improved superconducting materials that have lower RF losses, operate at higher temperatures, and/or have higher RF critical fields than sheet niobium; and (2) techniques to create a layer of niobium on the interior of a copper elliptical cavity, such as by energetic ion deposition, so that the resulting 700-1500 MHz structures have $Q_0>8 \times 10^9$ at 2 K. Approaches of interest involving atomic layer deposition (ALD) synthesis should identify appropriate precursors and create high quality Nb, NbN, Nb_3Sn, or MgB_2 films with anti-diffusion dielectric overlayers.

Grant applications also are sought for laser or electron beam surface glazing of niobium for surface purification and annealing in vacuum.

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 / $10\mu m^2$), 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.

For questions related to items (1) through (7) in the first paragraph of this subtopic, contact Dr. Robert Rimmer at Thomas Jefferson Laboratory (rarimmer@jlab.org). For all other questions, contact Dr. Charles Reece at Thomas Jefferson Laboratory (reece@jlab.org).

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

b. Radio Frequency Power Sources—Grant applications are sought to develop designs, computer-modeling, and hardware for 5-20 kW continuous wave (cw) power sources at distinct frequencies in the range of 50-1500 MHz, and for 1 MW cw RF power sources at 704 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. For questions or further specifications, contact Dr. Leigh Harwood at Thomas Jefferson Laboratory (harwood@jlab.org), or Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov)

Grant applications also are sought for a microwave power device, klystron, IOT or tunable/phase stabilized magnetron, offering improved efficiency (>55-60%) while delivering up to 8 kW CW at 1497 MHz. The device must provide a high degree of backwards compatibility, both in size and voltage requirements, to allow its use as a replacement for the klystron (model VKL7811) presently used at Thomas Jefferson Laboratory, while providing significant energy savings. For more detail, contact Rick Nelson at Thomas Jefferson Laboratory (nelson@jlab.org).

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

c. Design and Operation of Radio Frequency Beam Acceleration Systems—Grant applications are sought for the design, fabrication, and operation of radio frequency accelerating structures and systems for electrons, protons, and light- and heavy-ion particle accelerators. Areas of interest include (1) continuous wave (cw) structures, both superconducting and non-superconducting, for the acceleration of beams in the velocity regime between 0.001 and 0.03 times the velocity of light, and with charge-to-mass ratios between 1/6 and 1/240; (2) superconducting RF accelerating structures appropriate for rare isotope beam accelerator drivers, for particles with speeds in the range of 0.02-0.8 times the speed of light; (3) innovative techniques for field control of ion acceleration structures (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, 0.5-1.5 GHz accelerating structures that have sufficient higher-order mode damping, for use in energy-recovering linac-based devices with ~1 A of electron beam; (5) methods for preserving beam quality by damping beam-break-up effects in the presence of otherwise unacceptably-large, higher-order cavity modes – one example of which would be a very high bandwidth feedback system; (6) development of tunable superconducting RF cavities for acceleration and/or storage of relativistic heavy ions; and (7) development of rapidly tunable RF systems for applications such as non-scaling fixed-field alternating gradient accelerators (FFAG) and rapid cycling synchrotrons, either for providing high power proton beams or for proton therapy.

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. For questions related to software design and modeling, contact Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov).

A high-integrated-voltage SRF cw crab crossing cavity is also of interest. Therefore, grant applications are sought for (1) designs, computer-modeling, and hardware development for an SRF crab crossing cavity with 0.5 to 1.5 GHz frequency and 20 to 50 MV integrated voltage; and (2) beam dynamics simulations of an interaction region with crab crossing. One example of candidate technologies would be a multi-cell SRF deflecting cavity. For questions or further specifications, contact Drs. Yaroslav Derbenev, Geoffrey Krafft or Yuhong Zhang at Thomas Jefferson Laboratory (derbenev@jlab.org, krafft@jlab.org, yzhang@jlab.org). For questions related to multicell SRF deflecting cavities, Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov) also may be contacted.

Grant applications also are sought to develop Hi-B solenoids with minimum fringe field – using 9 T solenoids in the same cryo module of a SRF accelerator as niobium cavities requires the external fringe fields to be very low. The problem is complicated by the inclusion of dipole correction coils and limited space, and the reduced field must be small in multiple directions. The development of cost-effective, compact units would make cryo module production simpler and cost effective. For questions, contact Dr. Al Zeller, NSCL/MSU (zeller@nscl.msu.edu).

Finally, grant applications also are sought to develop and demonstrate low level RF system control algorithms or control hardware that provide a robust and adaptive environment suitable for any accelerator RF system. Of special interest are approaches that address the particular challenges of superconducting RF systems, but room temperature systems are of interest as well.

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

d. Particle Beam Sources and Techniques—Grant applications are sought to develop (1) particle beam ion sources 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); (4) techniques for *in situ* beam pipe surface coating to reduce the ohmic resistance and/or secondary electron yield; and (5) high brightness electron beam sources utilizing continuous wave (cw) superconducting RF cavities with integral photocathodes operating at high acceleration gradients. For questions on ion sources contact Dr. Anatoli Zelenski at Brookhaven National Laboratory (zelenski@bnl.gov).

Accelerator techniques for medium energy rings with high space charge are also of interest. Therefore, grant applications are sought to develop methods for maintaining low 4-D emittance in low and medium energy proton rings (10-30 GeV) with high space charge. Approaches of interest could include, but are not limited to, (1) novel magnet lattices designs, (2) advanced beam injection and ejection schemes, and (3) advanced studies on ring impedance and its reduction. Interested parties should contact Drs. Yaroslav Derbenev, Geoffrey Krafft or Yuhong

Zhang at Thomas Jefferson Laboratory (derbenev@jlab.org, krafft@jlab.org, yzhang@jlab.org), for further specifications.

Accelerator techniques for energy recovery linac ERL based electron beam cooling are of high interest for next generation colliders for nuclear physics experiments**.** Therefore, grant applications are sought to develop (1) designs, computer-modeling, and hardware 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 (2) optics designs and tracking simulations of beam systems for energy recovery linacs and electron circulator rings, with energy range from 5 to 130 MeV. Examples of candidate technologies include 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. For questions and further specifications, contact Drs. Yaroslav Derbenev, Geoffrey Krafft or Yuhong Zhang at Thomas Jefferson Laboratory (derbenev@jlab.org, krafft@jlab.org, yzhang@jlab.org). For further information related to coherent electron cooling, please contact Dr. Vladimir Litvinenko at Brookhaven National Laboratory (vl@bnl.gov)

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) intra-beam scattering, (2) spin dynamics, (3) polarized beam generation including modeling of cathode geometries for high current polarized electron sources, (4) electron cooling, beam dynamics, transport and instabilities; and (5) electron or plasma discharge in vacuum under the influence of charged beams. The software should use modern best practices for software design, should run on multiple platforms, and should run in both serial and parallel configurations. Grant applications also are sought to develop graphical user interfaces for problem definition and setup. For questions, contact Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov).

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

e. Polarized Beam Sources and Polarimeters—With respect to polarizing sources, grant applications are sought to develop (1) polarized hydrogen and deuterium (H-/D-) sources with polarization above 90%; (2) cw polarized electron sources delivering beams of ~10 mA, with longitudinal polarization greater than 80%; (3) ~28 MHz cw polarized sources delivering beams of ~500 mA, with polarization greater than 80%; and (4) devices, systems, and sub-systems for producing high current (>200μA), variable-helicity beams of electrons with polarizations greater than 80%, and which have very small helicity-correlated changes in beam intensity, position, angle, and emittance. For questions on polarized electron sources, contact Dr. Matthew Poelker at Thomas Jefferson Laboratory (poelker@jlab.org). For questions on polarized ion sources contact Dr. Anatoli Zelenski at Brookhaven National Laboratory (zelenski@bnl.gov).

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 fast reversal of the spin of stored, polarized beams; (3) novel concepts for producing polarizing particles of interest to nuclear physics research, including electrons, positrons, protons, deuterons, and ^{3}He; and (4) credible sophisticated computer software for tracking the spin of polarized particles in storage rings and colliders.

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

f. Rare Isotope Beam Production Technology— Grant applications are sought to develop (1) ion sources for radioactive beams, (2) techniques for secondary radioactive beam collection, charge equilibration, and cooling; (3) technology for stopping energetic radioactive ions in helium gas and extracting them efficiently as high-quality low-energy ion beams; and (4) advanced parallel-computing simulation techniques for the optimization of both normal- and super-conducting accelerating structures for the future rare isotope facility.

Grant applications also are sought to develop radiofrequency devices for ion transport along surfaces. The transport of ions along walls of gas-filled vacuum chambers by means of a series of electrodes, to which radiofrequency voltages are applied, has gained significant importance, not only in nuclear physics for the stopping and thermalization of rare isotope beams but also in ion chemistry. Ultra-high vacuum compatible large-size printed circuit boards, or similar approaches, together with tailored RF circuitry, are considered most promising for providing low-maintenance reliable performance. Interested parties should contact Dr. Georg Bollen, FRIB/MSU (bollen@frib.msu.edu).

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. Interested parties should contact Dave Morrissey, NSCL/MSU (morrissey@nscl.msu.edu).

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. In the case of interest contact Dr. Dave Morrissey, NSCL/MSU (morrissey@nscl.msu.edu).

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. Interested parties should contact Dr. Stefan Schwarz NSCL//MSU (schwarz@nscl.msu.edu).

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. Interested parties should contact Dr. Al Zeller, FRIB/MSU (zeller@frib.msu.edu).

Lastly, grant applications are sought to develop advanced and innovative approaches to the construction of large aperture superconducting and/or room temperature magnets, 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 35, Nuclear Physics Detection Systems, Instrumentation and Techniques.)

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

g. Accelerator Control and Diagnostics—Grant applications are sought to develop (1) advanced beam diagnostics concepts and devices that provide high speed computer-compatible measurement and monitoring of particle beam intensity, position, emittance, polarization, luminosity, momentum profile, time of arrival, and energy (including such advanced methods as neural networks or expert systems, and techniques that are nondestructive to the beams being monitored); (2) beam diagnostic devices that have increased sensitivities through the use of superconducting components (for example, filters based on high T_c superconducting technology or Superconducting Quantum Interference Devices); (3) measurement devices/systems for cw beam currents in the range 0.1 to 100 μA, with very high precision ($<10^{-4}$) and short integration times; (4) beam diagnostics for ion beams with intensities less than 10^7 nuclei/second; (5) non-destructive beam diagnostics for stored proton/ion beams, such as at the RHIC, and/or for 100 mA class electron beams; (6) devices/systems that measure the emittance of intense (>100kW) cw ion beams, such as those expected at a future rare isotope beam facility; (7) beam halo monitor systems for ion beams; and (8) instrumentation for electron cloud effect diagnostics and suppression.

Grant applications are sought for the development of triggerable, high speed optical and/or IR cameras, with associated frame grabbers of high memory capacity for investigating time dependent phenomena in accelerator beams. Equipment needs to operate in a high-radiation environment, needs to have memory capacity at the level of 1000 frames, and have a frame capture rate of 1 MHz. The cameras will be used for high-speed analysis of optical transition or

optical diffraction radiation data. Interested parties should contact Geoffrey Krafft at Thomas Jefferson Laboratory (krafft@jlab.org).

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

h. Novel Acceleration Methods for Ions—Grant applications are sought to develop laser radiation pressure driven proton and ion beams sources and accelerators of high-brightness and good repetition rate. For questions, contact Dr. Ilan Ben-Zvi at Brookhaven National Laboratory (benzvi@bnl.gov).

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

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

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

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35. NUCLEAR PHYSICS INSTRUMENTATION, DETECTION SYSTEMS AND TECHNIQUES

The Office of Nuclear Physics is interested in supporting projects that may lead to advances in detection systems, instrumentation, and techniques for nuclear physics experiments. Opportunities exist for developing equipment beyond the present state-of-the-art at universities and national user facilities, including the Argonne Tandem Linac System (ATLAS) at Argonne National Laboratory. In addition, a new suite of next-generation detectors will be needed for the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) Upgrade of at the Thomas Jefferson National Accelerator Facility (TJNAF), a future facility for rare isotope beams (FRIB) at Michigan State University, detector and luminosity upgrades at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Lab, and a possible future electron-ion collider. Also of interest is technology related to future experiments in fundamental symmetries, such as neutrinoless double-beta decay experiments and the measurement of the electric dipole moment of the neutron, where extremely low background and low count rate particle detections 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 anticipated high radiation environment for FRIB. All grant applications must explicitly show relevance to the nuclear physics program. **Grant applications are sought only in the following subtopics:**

a. Advances in Detector and Spectrometer Technology—Nuclear physics research has a need for devices to detect, analyze, and track charged particles, and neutral particles such as neutrons, neutrinos, photons, and single atoms. Grant applications are sought to develop (1) photosensitive devices such as avalanche photodiodes, hybrid photomultiplier devices, single and multiple anode photomultiplier tubes, silicon-based photomultipliers, high-intensity ($\sim 10^{20}$ γ/s) gamma-ray current-readout detectors (e.g., Compton Diodes), photodiodes for operation at liquid helium temperatures with a signal-to-noise ratio comparable to a photomultiplier tube, photomultiplier tubes designed to work in a liquid helium environment, and other novel photon detectors; (2) detectors utilizing photocathodes for Cherenkov, visible and ultra-violet (UV) light detection, and new types of large-area photo-emissive materials such as solid, liquid, or gas photocathodes; (3) liquid argon and xenon ionization chambers and other cryogenic detectors; (4) single-atom detectors using laser techniques and electromagnetic traps; (5) particle polarization detectors; (6) electromagnetic and hadronic calorimeters, including high energy neutron detectors; and (7) 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).

With respect to particle identification detectors, grant applications are sought for the development of: (1) cost-effective, large-area, high-quality Cherenkov materials; (2) cost-effective, position sensitive, large-sized photon detection devices for Cherenkov counters; (3) high resolution time-of-flight detectors, such as Microchannel Plates (MCPs), Multigap Resistive Plate Chambers (MRPCs), and Geiger Avalanche Photodiodes (GAPDs), with the goal of attaining a time resolution of < 10 ps over large areas; (4) affordable methods for the production of large volumes of xenon and krypton gas (which would contribute to the development of

transition radiation detectors and also would have many applications in X-ray detectors); (5) very high resolution particle detectors or bolometers (including the required thermistors) based on semiconductor materials and cryogenic techniques;. Of particular interest are 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.

In addition, grant applications are sought to develop devices designed to perform precision calibration of the detectors listed above. Such devices include novel, controllable calibration sources for electrons, gammas, alphas, and neutrons; pulsed calibration sources for neutrons, gammas, and electrons; precision charged particle beams; and pulsed UV optical sources.

Grant applications also are sought for the development of tilted solenoids for spectrometers. In high field devices, iron has the undesirable property that saturation effects change the field characteristics as a function of induction. However, without iron, the stray fields are very often unacceptably high. For superconducting solenoids this problem can be solved by active shielding. The development of magnet systems with tilted crossed solenoid windings and active shielding could provide a solution for a broad variety of ironless superconducting dipoles, which, for example, could be used in high-acceptance spectrometers like the ISLA spectrometer planned for FRIB. Interested parties should contact Dr. Daniel Bazin, NSCL/MSU (bazin@nscl.msu.edu).

Finally, grant applications are sought for innovative designs of high-resolution particle separators and spectrometers for research programs associated with 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 conductor or new medium to high temperature conductors. Such magnets are needed for magnetic spectrometers, fragment separators, and beam transport systems. Innovative designs such as elliptical aperture multipoles and other combined function magnets are of interest. Also, there is a need for cryogenics systems in the mid-capacity range for use with superconducting spectrometers for nuclear physics. The emphasis is on cryogenic systems with higher capacity, improved efficiency, and reduced maintenance requirements at both low (4-20 K) and intermediate temperatures (50-77 K) relative to the present generation of cryocoolers. Interested parties should contact Dr. J. A. Nolen, Jr. at Argonne National Laboratory (nolen@anl.gov).

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

b. Position Sensitive Charge Particle and Gamma Ray Tracking Devices— Nuclear physics research has a need for devices to track charged particles, and neutral particles such as neutrons, neutrinos, photons, and single atoms. Grant applications are sought to develop advancements in the technology of solid-state tracking devices such as highly-segmented coaxial and planar germanium detectors; silicon drift, strip, and pixel detectors; and silicon 3D devices. With respect to solid state tracking devices, approaches of interest include (1) manufacturing techniques, including interconnection technologies for high granularity, high resolution, light-weight, and radiation-hard solid state devices; (2) highly arrayed solid state detectors for neutron

detection, with integrated electronics to read-out pulse height; (3) thicker (more than 1.5 mm) segmented silicon charged-particle and x-ray detectors and associated high density, high resolution electronics; (4) cost-effective production of n-type and p-type silicon drift chambers with active areas greater than 16 cm^2; (5) novel, low-noise cooling devices for efficiently operating these silicon drift chambers; (6) and other solid state detectors described in (2)-(4); and (7) techniques for substantial cost reduction of large-mass Ge detectors.

Grant applications also are sought to develop micro-channel plates; and gas-filled tracking detectors such as proportional, drift, streamer, microstrip, Gas Electron Multipliers (GEMs), Micromegas and other types of micropattern detectors, straw drift tube detectors. For straw tube detectors grant applications are sought for automated assembly and wiring techniques. Interested parties should contact Dr. Bernd Surrow (surrow@mit.edu).

Grant applications also are sought to develop position-sensitive charged particle and photon tracking devices, as well as associated technology for these devices, including (1) position-sensitive, high-resolution germanium 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; (2) hardware and software needed for digital signal processing and gamma-ray tracking – of particular interest is the development of efficient and fast algorithms for signal decomposition and improved tracking programs; High speed triggers using FPGA's capable of decision making in less than 1 us; (3) alternative materials, with comparable resolution to germanium, but with significantly higher efficiency and relatively higher temperature operation (in order to overcome the costly and bulky requirement to cool germanium detectors to liquid nitrogen temperatures); (4) improvements and new developments in micropattern detectors – this would specifically include commercial and cost effective production of GEM foils and other types of micropattern structures, such as fine meshes used in Micromegas, as well as novel approaches that could provide high-resolution multidimensional readout; (5) advances in more conventional charged-particle tracking detector systems, such as drift chambers, pad chambers, time expansion chambers, and time projection chambers (areas of interest include improved gases or gas additives that resist aging, improve detector resolution, decrease flammability, and offer larger/more uniform drift velocity); (6) high-resolution, gas-filled, time-projection chambers employing CCD cameras to perform an optical readout; (7) 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; (8) for rare isotope beams, next-generation, high-spatial-resolution focal plane detectors for magnetic spectrographs and recoil separators, for use with heavy ions in the energy range from less than 1 MeV/u to over 100 MeV/u; (9) a bolometer with high-Z material (e.g., W, Ta, Pb) for gamma ray detection with segmentation, capable of handling 100 -1000 gamma rays per second; (10) detectors made of more conventional materials (silicon or scintillator), capable of reconstructing multiple-Compton gamma-ray scattering with mm resolution; and (11) advances in CCD technology, particularly in areas of fast parallel, low-power readout, and cross-talk control. In the context of (4) we are developing large area imaging devices using the Micromegas technology associated with the read-out of a high number of channels (typically ~10,000) we will need to develop PCB boards that have an extremely good surface finish (in the

sub-micron domain), in order to get minimize gain fluctuations and sparking. Interested parties should contact Dr. Wolfgang Mittig, NSCL/MSU (mittig@nscl.msu.edu).

Finally, grant applications are sought to develop high-rate, position sensitive particle tracking detectors and timing detectors for high-energy heavy-ions, (for example diamond detectors). Future rare isotope beam facilities like FRIB will provide beams with unprecedented intensity, creating a challenge for single particle tracking and beam profile measurements. The development of position sensitive fast particle detectors for particle tracking/timing and with high rate capability would be desirable. Ideally these detectors would provide both position and timing measurements in a transmission mode and be radiation resistant and of very homogenous density and thickness. Interested parties should contact Dr. Marc Hausmann, FRIB/MSU (Hausmann@frib.msu.edu).

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

c. Technology for Rare Particle Detection—Grant applications are sought for particle detectors and techniques that are capable of measuring very weak, very 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 for applications in extending our knowledge of new nuclear isotopes produced at radioactive beam facilities. Rare decay and rare phenomenon detectors require large quantities of very clean materials, such as clean shielding materials and clean target materials. For example, neutrino detectors need very large quantities of ultra-clean water.

Grant applications are sought to develop (1) ultra-low background techniques of contacting, supporting, cooling, cabling, and connecting high-density arrays of detectors – ultrapure materials must be used in order to keep the generated background rates as low as possible (goal is 1 micro-Becquerel per kg); (2) advanced detector cooling techniques and associated infrastructure components (high-density signal cabling, signal and high voltage interconnects, vacuum feedthroughs, front-end amplifier FET assemblies), in order to assure ultra-low levels of radioactive contaminants; (3) measurement methods for the contaminant level of the ultra-clean materials; (4) novel methods capable of distinguishing between gammas and charged particles; and (5) methods by which the backgrounds to rare searches, such as those induced by cosmogenic neutrons, can be tagged, reduced, or removed entirely.

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d. Large Band Gap Semiconductors, New Bright Scintillators, Calorimeters, and Optical Elements—Nuclear physics research has a need for developing cost effective new detector and scintillation material with high light outputs and shorter decay times compared to NaI and CsI, for manufacturing practical devices to detect charge particles and gamma rays. Therefore, grant applications are sought to develop new materials or advancements for photon detection, including (1) large band gap semiconductors such as CdZnTe, HgI_2, AlSb, etc.; (2) bright, fast scintillator materials (such as LSO, LYSO, $LaHA_3$:Ce, where HA=Halide and other related compounds), and scintillators with pulse-shape discrimination (PSD) (n/gamma and charged particle); (3) selenium based detectors (perhaps using GaSe, CdSe or ZnSe); (4) plastic

scintillators, fibers, and wavelength shifters; (5) cryogenic scintillation detectors (LXe); (6) Cherenkov radiator materials, such as Aerogel, with indices of refraction up to 1.10 or greater, and with good optical transparency; and (7) new and innovative calorimeter concepts, including new materials, higher packing densities, or innovative fiber and absorber packing schemes to achieve a small Moliere radius and short radiation length.

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e. Specialized Targets for Nuclear Physics Research—Grant applications are sought to develop specialized targets for the nuclear physics program, including (1) polarized (with nuclear spins aligned) high-density gas or solid targets; (2) frozen-spin active (scintillating) targets; (3) windowless gas targets and supersonic jet targets for use with very low energy charged particle beams; (4) liquid, gaseous, and solid targets capable of high power dissipation when high intensity, low-emittance charged-particle beams are used; and (7) very thin windows for gaseous detectors, in order to allow the measurement of low energy ions.

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 (mittig@nscl.msu.edu).

Also required are targets that would be used with high-power light ion beams for the production of exotic isotopes by spallation reactions.

Finally, grant applications are sought to develop techniques for (1) the production of ultra-thin films needed for targets, strippers, and detector windows – regarding next generation rare isotope beam facility, there is a need for stripper foils or films (in the thickness range from a few micrograms per cm^2 to over 10 milligrams per cm^2) for use in the driver linac, with very high power densities; and (2) the 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.

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f. Technology for High Radiation Environment of Rare Isotope Beam Facility—The establishment of next generation rare isotope beam facilities requires new and improved techniques, instrumentations and strategies to deal with the anticipated high radiation environment in the production, stripping and transport of ion beams. Therefore grant applications are sought to develop:

(1) Rotating vacuum seals for application in high-radiation environment: Vacuum rotary feedthroughs for high rotational speeds, which have a long lifetime under a high-radiation environment, 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. Interested parties should contact Dr. Wolfgang Mittig, NSCL/MSU (mittig@nscl.msu.edu).

(2) Radiation resistant multiple-use vacuum seals: Elastomer-based multi-use vacuum seals have a limited lifetime due to radiation damage in the high-radiation environment found in the target facility of FRIB and other high-power target facilities. Alternative solutions that provide extended lifetimes and are suitable for remote-handling applications are needed. Interest parties should contact Tom Burgess, NSTD/ORNL (burgesstw@ornl.gov).

(3) 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. The development of radiation-resistant magnetic field probes (possibly based on new techniques like ion traps) for 0.2-5 Tesla and a precision of dB/B<1E-4 would be highly desirable. Interested parties should contact Dr. Georg Bollen, FRIB/MSU (bollen@frib.msu.edu).

(4) Techniques to study 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. Further improvements to radiation transport codes and models of secondary radiation production, shielding, and heat deposition – along with their validation against experimental data – are necessary. Heavy ion transport calculations in general take significantly longer computational time than for light ion transport. Therefore, improvements in calculation efficiencies are needed. Currently available heavy ion transport codes do not account for the production and intensity of the ions, or for changes in charge-state distributions as the ions pass through matter or magnetic fields. The development and incorporation of charge-state distribution models into radiation transport codes would enhance both the design of beam stripping and beam absorption components and the safety and lifetime consequences of produced radiation fields. Interested parties should contact Dr. Reg Ronningen, NSCL/MSU (ronningen@nscl.msu.edu).

(5) Techniques for modeling radiation damage with heavy ions: The use of energetic and high-power heavy ion beams at future research facilities will create significant levels of radiation damage to facility components, thus limiting their useful lifetimes. Sparse experimental data taken at low energies indicate that the radiation damage caused by heavy ions may be orders of magnitude higher than that predicted by existing models, such as those currently implemented in radiation transport codes. It is purported that phenomena such as the Swift Heavy Ion effect, which are not accounted for, may be important. New and/or improved models are needed to reliably estimate the effects of radiation damage by heavy ions, in order to better design and optimize the performance of future facilities. Interested parties should contact Dr. Reg Ronningen, NSCL/MSU (ronningen@nscl.msu.edu).

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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 topic description above.

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36. NUCLEAR PHYSICS ISOTOPE SCIENCE AND TECHNOLOGY

Stable and radioactive isotopes are critical to serve the broad needs of modern society and are critical to scientific research in chemistry, physics, energy, environment, 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 in support of the production of 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 no or insufficient domestic commercial production capability; some exceptions include 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-around and the reduced dependence of 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.

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 the research and 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 topologies that could lead to compact sources; and novel beam-delivery/restoring and target approaches needed to optimize isotope production . 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. Research is also of interest to push the state of the art in high current, high power density accelerator targets for radioisotope production.

Grant applications are also sought for new technologies to produce large quantities of separated isotopes – such as kg quantities of germanium-76 (^{76}Ge), selenum-82 (^{82}Se), tellurium-130 (^{130}Te), xenon-136 (^{136}Xe) – and other materials that are needed for rare particle and rare decay experiments in nuclear physics research. Further guidance for research isotope priorities is provided in the Nuclear Science Advisory Committee Isotopes (NSACI) report available at (http://science.energy.gov/np/nsac/). Interested parties may contact Meiring Nortier, meiring@lanl.gov

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b. Improved Radiochemical Separation Methods for Preparing High-Purity Radioisotopes—Separation of isotopes from contaminants and bulk material and the purification of the isotope to customer specifications is a critical process in the production cycle of an isotope. Traditional strategies and techniques rely on old technologies and still require an extensive workforce to operate specialized equipment, such as manipulators for remote handling in hot cell environments. Conventional separation methods may include liquid-liquid extraction, column extraction, 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 radiochemical separation methods can be achieved and costs of isotope production can be reduced by a) improvements in separations chemistry methods, and b) implementing automated systems and robotics. Of particular interest are developments that automate routine separation processes in order to reduce operator labor hours and worker radiation dose, including semi-automation modules for separations or automated, micro-processor controlled 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.

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 improvements in (1) lanthanide and actinide separations, (2) in the development of higher binding capacity resins and adsorbents for radioisotope separations to decrease void volume and to increase activity concentrations, (3) the scale-up of separation methods demonstrated on a small scale to large-volume production level, and (4) new resin and adsorbent materials with increased resistance to radiation.

The following are some new strategies for radioisotope processing and separation technologies. In lanthanide radiochemistry, improvements are sought to a) prepare high-purity samarium-153 by removing contaminant promethium and europium; or b) to prepare high-purity gadolinium-148 and gadolinium-153 by ultra-pure separation from europium, samarium, and promethium contaminants. Sn-117m has gotten a lot of interest in the last few years. It has favorable nuclear properties for both imaging and therapy. However commercial quantities of the isotope at high specific activity is not available. Supply of commercial quantities of high specific activity Sn-117m would be of high interest. Re-186 has excellent nuclear properties for therapy and is chemically similar to Tc-99m which is widely used for diagnostic imaging. Therefore, Re-186 could used as a therapeutic matched pair for currently available diagnostic imaging agents. However, high specific activity Re-186 is not available. So, alternative methods of production or mass separation to remove stable Re isotopes, which can provide commercial quantities of high specific activity Re-186 is highly desirable. In actinide radiochemistry, innovative methods are sought a) to improve radiochemical separations of or lower-cost approaches for producing high-purity actinium-225 and actinium-227 from contaminant metals, including thorium, radium, lead, 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 or radium-225. The new technologies must be applicable in extreme radiation fields that are characteristic of chemical processing involving high levels of alpha-and/or beta-/gamma-emitting radionuclides. Interested parties may contact Dr. Russ Knapp (knappffjr@ornl.gov).

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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.

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