NUCLEAR SCIENCE ADVISORY COMMITTEE
to the
U.S. DEPARTMENT OF ENERGY and NATIONAL SCIENCE FOUNDATION

PUBLIC MEETING MINUTES

Rockville Hilton
1750 Rockville Pike, Rockville, MD 20852

November 17, 2014

NUCLEAR SCIENCE ADVISORY COMMITTEE
SUMMARY OF MEETING

The U.S. Department of Energy (DOE) and National Science Foundation (NSF) Nuclear Science Advisory Committee (NSAC) was convened at 9:00 a.m. EST on Monday, November 17, 2014, at the Rockville Hilton, Rockville, MD, by Committee Chair Donald Geesaman.

Committee members present:

Donald Geesaman, Chair	Suzanne Lapi	Kate Scholberg
Robert Atcher	Paul Mantica	Jurgen Schukraft
Vincenzo Cirigliano	Jamie Nagle	Matthew Shepherd
Abhay Deshpande	Filomena Nunes	Raju Venugopalan
John Hardy	Erich Ormand	Michael Weischer
Karsten Heeger	Patrizia Rossi	

Committee members unable to attend:
Ani Aprahamian

NSAC Designated Federal Officer:
Timothy Hallman, U.S. Department of Energy (DOE), Office of Science (SC), Office of Nuclear Physics (ONP), Associate Director

Others present for all or part of the meeting:
Cyrus Baktash, DOE
Elizabeth Bartosz, DOE
Peter Bond, Brookhaven National Laboratory
Alan Briees, Massachusetts Institute of Technology
Denise Caldwell, NSF
Lawrence Cardman, JLab
Altaf Carim, White House Office of Science and Technology Policy
Julie Carruthers, DOE
Jolie Cizewski, Rutgers University
David Dean, Oak Ridge National Laboratory
Jim Decker, DOE
James Dunlap, Brookhaven National Laboratory
Jerry Draayer, SURA
Rolf Ent, Jefferson National Laboratory (JLab)
George Fai, DOE
Juan Fernandez, Los Alamos National Laboratory (LANL)
Bradley Filippone, California Technical University
Marc Garland, DOE
Konrad Gelbke, MSU
Thomas Glasmacher, FRIB/MSU
Geoffrey Greene, University of Tennessee
Joel Grimm, DOE
Ken Hicks, NSF
Andrew Hutton, JLab

Peter Jacobs, Lawrence Berkeley National Laboratory
Robert Janssens, Argonne National Laboratory
Ben Kallen, Lewis-Burke Associates
Krishna Kumar, Stony Brook University
Randall Laviolette, DOE
Dan Lehman, DOE
Ming Liu, Los Alamos National Laboratory
Augusto Machiavelli, Lawrence Berkeley National Laboratory
Bob McKeown, JLab
Hugh Montgomery, JLab
Berndt Mueller, Brookhaven National Laboratory (BNL)
James Nagle, University of Colorado
Ken Olsen, Superconducting Particle Accelerator Forum of the Americas
Allena Opper, NSF
Erich Ormand, Lawrence Livermore National Laboratory (LLNL)
Mike Osinski, DOE
Hamish Robertson, University of Washington
Guy Savard, Argonne National Laboratory
Heidi Schellman Northwestern University / Oregon State University
Kate Scholberg, Duke University
Lee Schroeder, University of California-Berkeley/TechSource
Michelle Shinn, DOE
Jim Sowinski, DOE
James Symons, LBNL
Michael Wiescher, Notre Dame University
Sarah Wilk, Pacific Northwest National Laboratory
Scott Wilkes, LANL
Sherry Yennello, Texas A&M University
W.A. Zajc, Columbia University

NOVEMBER 17, 2014

OPENING REMARKS

The U.S. Department of Energy (DOE) and National Science Foundation (NSF) Nuclear Science Advisory Committee (NSAC) was convened at 9:00 a.m. EST on Monday, November 17, 2014, by **Committee Chair Donald Geesaman**. The meeting was open to the public and conducted in accordance with Federal Advisory Committee Act (FACA) requirements. Attendees can visit http://science.energy.gov/(URL) for more information about NSAC.

NATIONAL SCIENCE FOUNDATION DIVISION OF PHYSICS UPDATE

Dr. Denise Caldwell, Division Director of the NFS Division of Physics (PHY), provided an update. The PHY staff has undergone a change of personnel to include the reassignment of Brad Keister to Deputy Division Director and the departure of Gail Dodge, and the arrival of Allena Opper, Kenneth Hicks, and Bogdan Mihaila.

PHY is embedded in Mathematical and Physical Sciences (MPS), and MPS is part of a larger R&RA funding request. The PHY budget for FY14 was $266M. PHY has been lower due to the impact of the FY13 sequestration.

About two percent of the PHY budget supports PHY operations. About 30 percent supports facilities, around eight percent supports the Physics Frontier Centers, of which there are 10, and about three percent goes to Education and Broadening Participation. Around 57 percent, $151M, supports research and investigators and goes into six major areas of physics.

NSF's R&RA budget for FY15 emphasizes six specific priorities, at least two of which are especially relevant to physics. Budget decisions are made with a focus on these priority areas. One area is the Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF21).

The funding total for nuclear physics programs at NSF is $48M with $43M in base funding. The total includes cross-cutting resources that are not directed to specific disciplines but are available upon review for co-funding for a specific period of time. This includes mid-scale, the Physics Frontier Centers, and accelerator science.

One major PHY undertaking in FY14 was the launch of a new academic-based program in accelerator science. There is a dearth of resources for this in the U.S. Funding supports the science behind accelerators and aims to recognize accelerator science as an academic discipline and identify new ways of doing business. The focus is on fundamental science and workforce needs. The program is not set up for direct R&D, incremental improvements to existing facilities, or as a supplement to an award or program. This resource area is listed on the PHY website with a solicitation deadline in February 2015. The first competition in 2014 generated 60 proposals and 12 awards at $9M total.

Mid-scale instrumentation was addressed in FY14 through the creation of a new fund. It is funded at $7M per year. A "Dear colleague" letter announced the funds. Researchers cannot directly apply to this fund -- proposals should request funding for mid-scale instrumentation in a regular proposal to show the link of instrumentation to science. Four awards were made in FY14 with two in the nuclear science community. Mid-scale instrumentation funds are one-time only, non-renewable and are not intended to cover the cost of operations for equipment constructed using the funds. These costs must be borne by the disciplinary program.

Discussion

Patrizia Rossi asked why NSF cannot fund R&D but can support the development of new ideas in the accelerator program. **Caldwell** shared that PHY wants a new idea that is not necessarily something that has been built. PHY wants to initiate new thinking and do something transformative and not help researchers simply improve something they already know how to do.

Caldwell responded to **Jorge Piekarewicz's** question about PHY's funding for operations, noting that PHY's budget has been about the same percentage throughout her tenure. NSF does not say that it will target a specific amount of funding for private investigators (PIs) but it will not reduce the individual PI funding to less than 50 percent of the budget. Funding for operations and other activities has to stay under 50 percent in order to support PIs, students and post-doctoral researchers.

Caldwell told **Geesaman** that there is nothing significant in PHY's current plans that will change its view on operating costs. PHY is slowly ramping up operations for advanced LIGO, as an example. LIGO received more support in FY13 but there is nothing else that will cause shifts.

Abhay Deshpande asked what proof PHY needs to decide if something will be operational if, in mid-scale projects, it will only support construction and not operations. **Caldwell** shared that proof will be shown in the review process, showing the need for proposal reviews and viewing the whole context. Many mid-scale projects refer to projects that are significantly intensive such that they have to be planned in advance. Planning has to occur for a few years. PHY determines if there is something significantly important to the physics community. If someone needs a smaller amount such as $200k, then there are funds for that.

John Hardy noted that the mid-scale budget is about $8M. **Caldwell** shared that PHY would be lucky if this is kept flat. She does not anticipate any major funding shifts.

Michael Wiescher suggested that mid-scale work can involve construction and asked about splitting one-time funds over three years. **Caldwell** shared that PHY is looking for numbers to slide over time. Total project cost could be from $4M up to $20M over a number of years. It will take a few years to build things in this area.

NATIONAL SCIENCE FOUNDATION NUCLEAR PHYSICS OVERVIEW

Allena Opper, Experimental Nuclear Physics Program Director, NSF MPS/PHY shared an overview. She noted that all proposals sent to PHY must go through a solicitation process with specific deadlines. Opper mentioned the solicitation for the new Investigator-Initiated Research Projects program. PIs who anticipate or have an additional concurrent source of support must explain the difference between this proposal and other awards. The assessment will consider the ability of researchers to carry out the proposed research.

A list of collaborators in a proposal that extends beyond the biographical sketch limits should be submitted as a separate document. Proposers should check the solicitation details to ensure that it is not sent back by NSF.

Opper shared an update on the Accelerator Science Program. Proposals for this should be in the PHY Solicitation and then this program should be identified in the proposing process. The submission deadline is February 4, 2015.

The Mid-Scale Instrumentation effort funds projects above $4M. Proposals have the same deadlines as the Investigator-Initiated Research Projects.

The Major Research Instrumentation (MRI) program supports projects up to $4M. Some new elements to the solicitation include a revision to the description of the single and multiple instruments. Acquisition proposals should have at least 70% of the total project cost going toward equipment.

In Computational Physics, funding comes from a new cross-directorate program in Computational and Data-Enabled Science and Engineering. Submissions should go through the Investigator-Initiated Research solicitation and applicants must select the Computational Physics program. The POC is Bogdan Mihaila and the deadline is December 4, 2014.

REU supplements are available to grantees to fund undergraduate students. As NSF is operating under a continuing resolution (CR), decisions about this will be made at a time when Federal funding decisions are more certain.

The Career Life Balance program seeks to attract, retain and advance graduate students, postdocs and early-career researchers.

PHY is undertaking a year-long study on diversity in the research community. It hopes to learn what is most successful, where to focus funds, what resources to provide beyond funding, and how to engage researchers in the field. Researchers may be contacted for data.

Researchers were reminded to share highlights about their work. PHY is often contacted for information about achievements and things that the community is accomplishing. Information that should be embargoed should be noted.

The PHY FY15 funding request is $264M. Overall, the NSF request is $7,225M. R&RA will stay relatively unchanged at $5,807M, and MPS funding is requested at $1,296M. Overall funding trends for Nuclear Physics indicate a steady rate over the past few years albeit with a significant hit in 2013.

Fifty-three proposals were submitted to the Experimental NP Program (ENP) with a total request of $14.4M. In FY15, there is an anticipated $16M for the ENP R&RA with $10.5M committed.

Opper noted a list of personnel changes in NSF, MPS and Nuclear Physics.

Discussion

Geesaman asked for details on the Diversity study. **Caldwell** shared that over the past two decades, NSF has invested in supporting groups not typically represented in science. There have been programs for women but the number of underrepresented minorities has been too small to generate a useful sample size. This time, NSF seeks to know if awards set aside for this have a significant impact. Awards include taking action to enhance diversity. Caldwell asked MPS/PHY Program Director, Kathy McCloud to look just at PHY and focus on the physics community. The analysis will look at past investments to identify hurdles and things that seem to be working. All PHY program directors are involved. A plan will be produced around July 2015 with actions that PHY might take to achieve specific goals. Community members are asked to provide insights on what may work.

Geesaman asked about the MRI grants for equipment only, and that other costs for equipment must be through cost-sharing. **Opper** explained that for MRI acquisition awards NSF can only support equipment purchases. Other costs such as transportation, installation, technical support or other things need to be in the cost-sharing portion of the proposal. Cost-sharing is any funding not being provided by a federal agency.

Venugopalan asked if there are postgraduate scholarships and fellowships already being directed to underrepresented groups. **Caldwell** shared that at NSF, eligibility cannot be limited in any way. A program can have a goal to improve diversity and this must be done in a way that does not exclude any specific groups from applying. Some other divisions in NSF such as Astrophysics do have a high proportion of applicants that are underrepresented.

Weischer shared that the community is doing better in terms of attracting women, but is not effectively working with minorities. Efforts should begin at the K-12 level. This type of consideration was done in the Genome Project.

Weischer asked for an explanation of the Career Life Balance Initiative. **Opper** noted a "Dear colleague" letter that discussed this and the opportunity for CAREER awardees and the request for additional funds to address career life issues. PHY would like to broaden this to be able to consider these types of requests from all awardees. As an example, a graduate student may need to conduct research for six to seven years and any addition to their families may present difficulty relative to their work. These things are being considered in the PHY budget.

Heeger asked about the scope of the diversity study. **Caldwell** shared that the focus will be on NSF and not necessarily the community beyond that. PHY will focus on what it can do in PHY on top of the broad spectrum of initiatives that come and go. Community members that have ideas should share effective practices. McCloud is heading this up and knows the field. At

a recent meeting of the Physics Frontier Centers, directors were asked what they have done and shared observations from which PHY can learn.

Atcher shared confusion about what is acceptable for accelerator science. **Caldwell** suggested looking at the PHY webpage to see what has been funded to learn more about investments in accelerator science. The nine recent awards made by the program are shown. There is significant support at present for laser wakefield that came out of the plasma physics field. The investments are very cross-disciplinary. Another example is materials behavior on the surface of cavities and trying to understand the things that destroy the materials. This is a materials science cross-over. Another is use of an accelerator on a chip with a focus not especially on energy but a desire to make a more compact accelerator that is not necessarily designed for nuclear physics but to really understand the fundamentals behind taking particles and moving them to a certain energy. There will be support for this program for nuclear scientists.

It was noted that the American Physical Society (APS) hosts an annual conference for undergraduate women in physics. It has received NSF support. There will be more than 1,000 women participating in January and many in this community have hosted events. It may be a model for supporting underrepresented students more broadly. **Caldwell** shared that she has participated in past conferences and notes that part of the challenge is keeping women interested and attracting them to graduate school.

There used to be programs to attract minority students to NSF. The program was successful but the problem was sustaining the pipeline for more than a few years. **Caldwell** explained that NSF will look at prior investments such as the POWER Program that was a pre-cursor for the Advance Program. Corporate memory at NSF is short due to turnover so an overall look can be informative..

Caldwell emphasized the need for researchers to share highlights of their work. The NSF Office of Public and Legislative Affairs is eager to share highlights and there are ongoing efforts to effectively communicate research stories.

Caldwell shared that PHY will have its tri-annual Committee of Visitors (COV).

DEPARTMENT OF ENERGY NUCLEAR PHYSICS OVERVIEW

Timothy Hallman, Associate Director for Nuclear Physic at the DOE, shared that the agency is mission-driven and reviewed the scientific challenges being undertaken by DOE Nuclear Physics (NP). One major effort is developing a new long-range plan for nuclear science. Several town hall meetings have provided community input on nuclear physics challenges going forward. A publication of these inputs will be shared in 2015. The Long Range Plan is chaired by Geesaman and will be produced in October 2015.

There is a subpanel looking at new opportunities and priorities to develop a long-range strategic plan for isotopes.

Several reports were produced by NSAC in 2014. A report published in April gave a strategy for implementing a possible second generation U.S. experiment on neutrino-less double beta decay (NLDBD) capable of reaching the sensitivity necessary to determine whether the nature of the neutrino is Majorana or Dirac. A report in May assessed the effectiveness of the National Nuclear Security Administration-Global Threat Reduction Initiative's Domestic Molybdenum-99 (Mo99) Program, in accordance with direction given to the DOE in the National Defense Authorization Act for FY 2013. A report issued in July described potential gaps in training and workforce development impactful on NP and the DOE SC.

Hallman described the Competitive Research Review in nuclear science. Eighty proposals were considered. DOE is funding 41 at a total request of $60M.

The FY15 budget request is $593M. The House and Senate independently requested more than that. A large part of the increase in FY15 is the planned increase for the construction of the Facility for Rare Isotope Beams (FRIB). Since FY08, funding for construction has increased while research and other NP efforts have been reduced. Prior construction efforts include the Thomas Jefferson National Accelerator Facility (TJNAF or J-Lab) and the Relativistic Heavy Ion Collider (RHIC). The Long Range Plan will address how to find the right balance between research, construction and operations.

Hallman shared findings from the TJNAF PVDIS Collaboration that show that the parity-violating coupling in electron-deuterium deep-inelastic scattering is non-zero as predicted by the standard model and this has implications on where research should look for new physics. The results were published in Nature. Other activities include the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) Upgrade. The construction effort has been granted CD-4 and the ability to conduct science is nearing.

A highlight from RHIC in 2014 was that the luminosity collected in one run was more than all previous runs combined. RHIC continues to be important for nuclear science. No other facility can match its range and versatility.

Recent science from RHIC shows that spin carried by the glue is non-zero based on double-spin symmetries. Results show where the spin might be. The gluon sector could contribute around 60 percent of the spin and that is a dramatic new result.

RHIC continues doing studies in heavy ion collisions. Differences between theoretical predictions versus measurements in the laboratory are getting smaller. The most perfect liquid would be in the RHIC energy range.

Another exciting capability is the acceleration of a new suite of species such as uranium and work showing how the uranium ions interact.

The long-range planning exercise will look at the EIC science. More needs to be known about protons, nuclei and black holes.

ATLAS has a new capability using the Californium Rare Isotope Breeder Upgrade (CARIBU). Work continues to improve the beam intensities and purities for experimenters. Until FRIB begins operations, ATLAS needs to run efficiently and effectively for the user community. There have been a number of upgrade projects and the facility continues to run well.

FRIB will come into operation near the end of this decade. There has been a great deal of work accomplished and the project is moving along well.

The Majorana demonstrator (MJD) experiments is located at the Sanford Underground Research Facility (SURF) as low background and low cosmogenic background is desired. The real effort is in understanding low-background counting and sources of low-background. MJD will deliver some of its first results soon.

Nuclear theory is a key to the entire NP portfolio. In response to recommendations from the previous long range plan, Theory Topical Collaborations were established as fixed-term, multi-institution collaborations established to investigate a specific theoretical topic. Collaborations have delivered on a promise to generate productive results. In listening to the community, all have shown strong support for this collaboration, and DOE will try to pursue this despite the constrained budget scenario.

NP also hosts the DOE isotope program. In 2013, there were more than 225 customer orders and 470 shipments. There has been an increased availability of isotopes. Hallman shared the wide range of isotopes that are under development. Another highlight is interest among the medical community for the DOE to produce alpha-emitting materials to support medical intervention around specific tissue. Actinium-225 is now a real contender for this work.

Hallman shared that all funding proposals must have a data management plan as of October 2, 2014. It should describe how data will be made available to others and curated. There is also a requirement describing open access in the literature.

Hallman shared other news to include the examination of DOE labs' roles and management. DOE NP has posted descriptions for several new positions. There is no news to report on the SC Director nomination. Hallman shared concerned about the low percentage of research funding within the NP budget portfolio, and noted the need for articulating an interface with High-Energy Physics on fundamental symmetries as there is mutual interest to avoid duplication of this effort.

Discussion

Geesaman asked about fundamental symmetries and if classifying things differently in two places is causing concern. **Hallman** shared that there can be confusion about what is being done in NP and DOE High-Energy Physics (HEP), and there can be difficulty communicating the differences to elected officials who may lack a scientific background. Communicating the interface can alleviate confusion.

Heeger noted that the long range plan can help differentiate these areas. **Hallman** shared that community conversations can help alleviate confusion. The two offices need to discuss how to communicate clearly and needed terminology. This concern comes about through the development of the long range plan. One could be confused when reading about fundamental symmetries and the HEP P5 Report.

Hallman shared with **Wiescher** that the long-range planning group has to understand Argonne's role and what the direction should be. The SC supports FRIB. Once the FRIB effort comes online, the ATLAS work will be complementary, with both facilities supporting two different areas of science.

Berndt Mueller noted that high energy physics investments are often viewed as global and needing investment with other regions of the world. He asked how the NP views this as it may impact how the office moves forward. **Hallman** shared that collaboration with other countries would be done in a usual way, and NP is welcoming collaboration with other countries. Hallman's personal vision is that important scientific projects may become complex enough that no one country could do these things on their own, such as the high energy nuclear ion collider. What comes to mind is CERN where governance is international. HEP is envisioning this for the long-baseline neutrino facility. This decision and how to do it depends on direction from the community and what it wants to scale.

Brad Filippone asked about the comparative review in light of the long range plan. **Hallman** was satisfied with the process but sees the need to identify which efforts are world-changing versus those that are nice to pursue. The goal was to really understand from everyone at the same time using the same criteria to inform what the distribution and competiveness looks like. NP discussed information gathering with sub-program managers and discussed committee recommendations. In most circumstances, they thought that the planning committees were on target. In terms of giving NP a critical assessment, that was accomplished. The prior plan also refreshed the field, as some groups were already top-notch but were stimulated through this

exercise. It helped refresh the field and support young PIs to bring newness to the field. Feedback on this exercise has been positive but is not something to do more than once per decade. NP would then go back to its usual method of collecting community inputs through the normal mail process.

Hugh Montgomery asked about sharing information on data management for projects in place to avoid more panic than what may occur. **Hallman** noted that labs do have general data management plans and future proposers should refer to those as things as resources for managing data. People should not panic that this is some new requirement that will complicate their lives. This and open access are advancing the field. Hallman believes that access in Europe is farther along that in the U.S. SC has been careful to enact this in a way that presents the lowest burden.

Rossi discussed international collaboration, sharing that as much as 30 percent of some national lab's researchers are from other nations. Signing an MOU can be a big problem. **Hallman** shared that lab-to-lab MOUs wherein collaboration is proposed are sent to SC for review. He is not aware of problems in general as most things are not sensitive but does know that some technical arrangements can be proposed that hit a brick wall.

STATUS OF LONG RANGE PLAN ACTIVITIES

Geesaman described the Nuclear Science Long Range Plan. It is the sixth plan to be developed. The charge for the plan was presented in April 2014 and the schedule calls for the plan to be published in October 2015. It will propose what can be done at varying budget levels and draws from town hall meetings with community members. Comments can be submitted to the authors and suggested through white papers. A draft of the plan will be done by April 2015 in time for a review. The effort will include input from an EIC costing subcommittee.

Discussion

Deshpande asked about the span between producing the EIC subcommittee report and the next NSAC meeting. **Geesaman** will discuss the timeframe with the agencies. The previous reports have been about 10 pages and give an overview helpful to long range plan development.

Schukraft asked if there are any other big ticket items to be discussed. **Geesaman** suggested that the neutrino-less double-beta decay experimentation may need review. The writing group received notes on other investments, and sees that the big question is the number of activities that they want to propose.

STATUS OF THE ISOTOPE SUBCOMMITTEE ACTIVITIES

Larry Cardman, Chair of the Nuclear Science Advisory Committee's Isotopes SubCommittee (NSACI), shared an update on the subcommittee activities. The NSACI is developing a new long range plan, reviewing activities since the last plan, prioritizing what needs to be done, and proposing the budget for the proposed activities. The subcommittee membership includes some representatives from NSAC, industry and the community.

The subcommittee met in September and heard presentations to include the DOE Isotope Program, managed by the Office of Nuclear Physics. A follow-up meeting in November will consider input from additional agencies and commercial producers, and the NSACI will hear from professional societies and DOE isotope production facilities at a meeting in January 2015. Input has also been requested from professional societies.

The NSACI will produce a first draft report around February 21 with a final draft report presented to NSAC in March 2015.

Discussion

Geesaman noted that the deadline for this charge will influence the scheduling of the next NSAC meeting in March 2015.

Schukraft noted that a request was sent to large federal agencies. Many of the responses are from DOE prompting the notion that they are simply more responsive. **Cardman** shared that agencies were picked due to their identifying a need for isotopes and having received isotopes from DOE. The list of agencies that have been contacted was shown. **Schukraft** reiterated that it is important to avoid confirmation bias and get a good selection of users. **Cardman** shared that most who have responded see things as being positive. He has followed-up with some who have not responded at all. **Geesaman** added that efforts were made to contact federal agencies who funded research and the societies consisting of those who are doing the research.

Hardy asked which issues have been brought up. **Cardman** shared that the biggest has been a demand for helium-3. There was significant early demand and concern about availability. Another issue is the desire for a full inventory of the isotopes available to be published online. Some of the isotopes available are of national security interest and supply data cannot be made public. **Cardman** believes that the current process is more efficient and useful.

Atcher noted that he has received requests for input from four different organizations and responded to one, and complimented **Cardman** on the subcommittee's outreach efforts.

UPDATE ON ATLAS NATIONAL USER FACILITY

Guy Savard gave an update on ATLAS, the DOE low energy physics national user facility. It provides beams and facilities enabling research around the Coulomb barrier energy, answering key questions in the fields of nuclear structure, nuclear astrophysics, low-energy tests of the Standard Model, and applications of low-energy nuclear physics.

ATLAS now has two injectors with the CARIBU injector producing neutron-rich radioactive isotopes. The facility runs for more than 5,000 hours per year at about 95 percent efficiency. It also produces about 10 PhD theses per year.

Savard shared CARIBU's front end layout. It includes a thin 1 Ci252 Cf source that is difficult to fabricate. CARIBU has just started but already experiments have been performed with more than 150 isotopes . More than 500 neutron-rich species can be extracted at > 1/s.

ATLAS provides in-flight radioactive beams. These are all light species and are close to stability. The compromise between beam properties, intensity and purity has been successful.

A typical experiment done at ATLAS is the Coulomb excitation of ^{144}Ba with GRETINA / CHICO2, which gives excellent Doppler reconstruction. The charge breeder with the upgraded ATLAS provides post-acceleration with ~10% total efficiency and exquisite beam properties. This is higher than is achievable elsewhere in the field.

In the future work on single-particle structures will allow for looking at particle-particle and hole-hole excitation through high resolution materials and the beam provided by CARIBU or the AIRIS in-flights seperator. An example is work being planned with calcium isotopes.

Nuclear astrophysics is a focal point and includes work in n-rich masses for r-process and reactions for rp-process. The former allows for probing a critical region. There is a need for more beams for this critical region. There are sensitivity studies that look at outer regions. CARIBU populates two of the regions. The work being done is unique to this energy region.

Fundamental interactions are conducted at ATLAS. Ion traps are used with a detector system to search for tensor and second-class current via beta-neutrino correlation.

Applications are another area of work at ATLAS as it can be used as an AMS device. The same technology used for basic science can be used in working with actinide and beta-delayed neutron measurements.

There is a suite of experimental equipment placed at the facility and provided by the community. A lot of maneuvering is required to get equipment in place for specific experiments.

ATLAS is working to become even more efficient and achieve higher intensities. It is pushing back the rate limitations for nearly all experiments. Baseline funding will help ATLAS achieve upgrade goals and counter limitations by FY20.

Recent upgrades have allowed ATLAS to run at a high level with high transmission, both of which are essential. One upgrade underway is the installation of an EBIS charge breeder for operation in 2016. It will remove stable beam contaminants of reaccelerated beams that are seen from the ECR charge breeder.

The AIRIS upgrade will provide for a new in-flight separator at ATLAS.

Work at ATLAS is accessing new regions to reach the far north-east of the nuclear chart. There is very good production potential and the physics is great. There are several beams that can work in this region with particle exchange between projectile and target in deep-inelastic scattering reactions. The production mechanisms have been available for a long time, but now there is a way to separate the beam through a CARIBU-like gas catcher and separator.

A multi-user upgrade is proposed to help make up for the loss of beam time for the community due to the closure of other facilities. Ultimately the upgrades to ATLAS have given interesting capabilities and benefits in a cost efficient way.

Since 2012, ATLAS has moved from stable beams of 200 to 500 pnA to 10,000 pnA, greater reacceleration efficiency, and higher intensity. AIRIS will be installed by 2017 and with a multi-user upgrade, the number of beam hours for the users could reach 9,000 per year.

By 2024, ATLAS will be one of two low-energy user facilities in the U.S. It will provide the highest intensity stable beam, work close to stability, and provide more testing of new equipment for low-energy and reaccelerated beams.

Discussion

Nunes shared concerns about the relationship of theory with ANL and ATLAS. **Savard** commented that the theory group is striving to enhance connections with ATLAS. Depending on funding levels, it is planning to focus on new items in theory and on low-energy in support of the type of physics that ATLAS and FRIB will be doing.

Deshpande asked about the operation of ATLAS. **Savard** reviewed current and future upgrades, and shared that the total cost for operations is about $17M per year.

Schukraft asked about the combination of users and being oversubscribed. **Savard** described ways to achieve high intensity and how charges can be simultaneously sustained. A CARIBU beam is sent to some experiments and a stable beam to other experiments. About 20 to 25 percent can be run simultaneously. **Savard** shared that ANL is looking at the type of beams that are running now and possible changes in composition. There are experiments that should be run for one month but that would only serve a small group for a long period of time. The program can grow based on reactor efficiencies.

Venugopalan noted that there is a plan to run through 2024 and asked about the goal. **Savard** shared that ATLAS is trying to address all of the intensive issues in the field. Whenever something new comes up and the community has needs, there is a variety of beams available at ATLAS. The current budget does not include support for theory. **Geesaman** noted that the real

question is that there are scientific questions that may not be answered by 2024 and asked for a list of what those might be. **Savard** shared that the process for calculating masses cannot produce the masses known for certain things. You will get changes in the argon that are very significant. You actually need to make measurements. Nobody has an idea of the artificial nuclei at specific areas. In five years, this problem will not be resolved at the n=126 area. In the last five years, there have been five new elements produced but it turns out that this is running out of steam. There is a program building up to separate various components into the n=126 area. There is information in some regions that have been available for 50 to 60 years but ATLAS will be required to enable understanding.

Nagle asked when the program would be done and the priorities for the next five to 10 years. **Savard** shared that this will be shown in the long-range plan. ATLAS provides the capabilities.

Nagle asked how much of the instrumentation would be provided to FRIB. **Savard** shared that at present, the fragmentation facilities are prepared for this. There are new instruments being built. There are instruments being placed at FRIB and there are spectrometers that can be built. The technology needed is all based on the types of objects to be measured.

UPDATE ON THE CONTINUOUS ELECTRON BEAM ACCELERATOR FACILITY

Robert McKeown shared an update on the Jefferson Laboratory (TJNAF / JLab) future science program. The Continuous Electron Beam Accelerator Facility (CEBAF) looks at the structure of hadrons and provides impacts across a variety of sub-fields. The lab has an international community of users from 33 countries. Despite being off for a few years during an upgrade, results have continued as described in a recent publication on the 12 GeV Upgrade and in several recent articles in Science magazine.

The facility is driven by a series of 21st century scientific questions.

The 12 GeV Upgrade will double the energy for the CEBAF accelerator system. It is a $338M DOE upgrade project to be completed by FY17. The upgrade is about 91 percent complete and beam commissioning is in progress. The commissioning process for the upgrade was achieved about five months earlier than expected.

A simultaneous beam is in development for three of the four halls at CEBAF. Hall D is the newest of these and will study exotic mesons to explore the origins of confinement. The facility plans additional experimental equipment, to include the Super BigBite Spectrometer, MOLLER experiment, and the SoLID which uses the CLEO Solenoid and focuses on deep-inelastic scattering.

The halls will explore 70 12 GeV experiments covering 4,430 days of experimentation, sufficient for an entire decade of experimentation. Hence, the facility is nearly over-subscribed.

One area of experimentation is the hybrid mesons. There is a lot of excitement around looking for these and early work shows that the hybrid mesons should be represented in the spectrum.

The nucleon spin puzzle has been around for some time. There has been recent progress on this at RHIC. There is still a question about orbital momentum. A new formulism has been developed over the past few years to address this question. Exploiting this advance is possible through TJNAF. There has already been initial data from Hall A and Hall B and the images produced show the value of the TJNAF upgrade.

SIDIS electroproduction of pions allows for measuring Sivers and Collins effects.. TJNAF will give precise results on these observables sensitive to the orbital motion of the partons.

Parity violation is being addressed. All of the technology has been redirected to new types of measurements and more recently has led to an experiment on calcium 48. There is a lot of interest in these measurements in the future. There are efforts in Qweak, MOLLER and SoLID.

There is a new opportunity in the search for heavy photons. This was partially motivated by the g-2 experiment at Brookhaven National Laboratory. The process produces A' with high intensity electrons beams. Recent results show that the g-2 favored region is covered by new experiments. There are three proposals that address this at JLab..

TJNAF has an active theory group that provides strong support for its experimental program and serves as an intellectual center for a global theory effort.

The lab's funding view for nuclear physics reflects the end of some experiments, completion of the upgrade by 2017, increased funding for research and theory, and increases for operations.

McKeown described the potential experimentation possible with the 12 GeV JLab upgrades.

The electron ion collider is something that should be considered, and TJNAF produced a white paper describing how it would work and why it would be needed.

The lab serves as a world-leading facility that is operational and ready to support global physics potential.

Discussion

Nunes noted the combination of theory with research and the lattice effort, and asked about the percentages of funding for each. **McKeown** shared that the majority is experimental research and that the group working in this area could give more details. **Rolf Ent** added that research efforts for the experiment are about $6M and theory is about $4M, including lattice efforts.

McKeown shared with **Heeger** that beam use can sometimes run simultaneously and varies on PAC days and operational weeks. Creating schedules is not always a clear endeavor. The cost of running for a few weeks is not a linear function but takes detailed calculation.

Piekariewicz asked about budget information expressed in a 16 week increment. **Montgomery** shared that the 16 weeks came out of the operating budget and three came out the other budget. With mark-ups, TJNAF believes it can get close to 30 weeks of run time.

McKeown confirmed for **Nunes** that theory comes out of a separate budget and not the operations budget.

UPDATE ON THE RELATIVISTIC HEAVY ION COLLIDER

Berndt Mueller shared an update on the RHIC and described its science program and science mission plans. RHIC is the first heavy ion collider. It has a wide energy range for nuclei and can collide a large number of species with a detector in the center-of-mass frame.

Luminosity will be increased through a new cavity and electron cooling will increase luminosity. This is part of the upgrades underway and proposed. Increased luminosity will be possible to the extent that is exceeds all possible luminosities.

The domain covered by RHIC will cover the region of greatest interest and is the only effort in existence or planned that will cover the largest swatch of the phase diagram for Quark-Gluon plasma in the preferred collider mode.

RHIC is the first polarized proton collider. Ongoing upgrades compensate for beam-beam interactions. A test run in 2013 showed that RHIC will be able to take in more data in one year than in all previous years combined.

There are two detectors -- STAR and PHENIX. Both have more than 500 collaborators. There were recent upgrades made to the detectors. STAR has seen the completion of the heavy

flavor tracker. The new muon telescope detector has been completed and the Muon Piston Calorimeter extension (STAR) will be installed.

Mueller described the scientific discoveries achieved at RHIC. Relativistic heavy-ion collisions allow for understanding and asking new questions that include determining the conditions for hydro-dynamic expansions and determining them unambiguously, and determining the scale at which the shift from asymptotically free quarks and gluons to the QGP liquid occur.

Hot QCD matter properties can be determined. For example there is radiation by the QGP and the need to measure the screening of the color field.

Recent research looked at a comparison of flow conditions with gluon density fluctuations. Work showed that the sheer viscosity measured at RHIC is lower than at the LHC and about 40 percent above the quantum limit. A precise determination depends on assuming the scale of graininess of the density of the colliding nuclei.

The versatility of RHIC helps answer these questions. Looking at most central U+U collisions, they can be separated by looking at the multiplicity in the final state. The dependence on orientation can separate the relative importance of fluctuations. Another approach is to look at the spectrum of the multipoles of the flow. The spectrum allows for separating the fluctuation in colliding nuclei. The calculations show that a simple Glauber model of the fluctuations does not fit for elliptic flow.

Data from LHC and RHIC show how small a QGP droplet can be. This is tested by looking at helium-3 -gold collisions. Results were obtained after about 2 billion events over a three-week run that would normally have taken one year. This shows the value of the upgrades. Results will show that this is really hydro-dynamic expansion.

Work at RHIC looks at charm quark flow. There are recent theory developments from jet collaborations. Improvements in theory are ongoing and more high precision measurements will help narrow the region of uncertainty.

Quarkonium melting is being studied. RHIC should produce stronger J/ψ suppression than LHC and is the better machine for studying this.

RHIC is probing scales of the QGP structure. There is currently no experimental measurement for that. The combination of LHC and RHIC studies will help determine the scale at which the coupling medium becomes strong.

The equation of state: v1 is being explored. As you approach the phase transition line, the pressure generated is low. The deflection of two nuclei colliding is low. This was observed as a clear minimum as a bounce of directed flow correlation. You want to pin down measurements of the same. This cannot be done with current data, but will be possible in the future with STAR.

Additional scientific studies include the quest for critical fluctuations.

To accomplish all of these physics challenges, RHIC is making hard choices on what it can accomplish in the near term. The RHIC science mission proposes specific work through 2025 then a transition to eRHIC.

Mueller discussed low energy e-cooling for Au+Au. Commissioning for this proposed upgrade is expected in 2018. The sPHENIX upgrade is proposed to allow for extending the range of jets emission of hard hadrons and direct photons by a factor of two. It is built around the BaBar solenoid.

Mueller shared expected deliverables that will result from first, second and third campaigns taking place incrementally between now and around 2023. The RHIC facility would operate through 2016, electron cooling would be installed, and then after two years, operations would

resume. By performing an eRHIC installation, physics otherwise impossible can be done and the work that would take 10 years to complete will now be more cost-effective. A plan for maintaining this schedule and the budget for doing so has been delivered to DOE.

Discussion

Schukraft asked about work with pA. Mueller shared that the pA, dA and helium experimentation will be done in the next year, and that will allow for making a clear determination. This year, RHIC ran for 22 weeks and will run for 22 weeks in the coming year.

Piekarewicz asked about competition from Europe. **Mueller** shared that in the current plan, SIS100 (at FAIR) will conduct precision experiments at the very highest densities. This range is likely too narrow to identify a change as a function of beam energy to make a conclusion about the change in behavior around the critical point. It will determine certain properties of the material in a well-defined region of the phase diagram. The scan needed and exploration of the range where the critical point exists is not possible in facilities other than RHIC.

Mueller shared with **Rossi** that reviews conducted by DOE NP during the summer asked that sPhenix collaborators to look at data taking capabilities with b-jets and the resolution possible to obtain Upsilon states in tracking. Collaborators did this and are ready to resubmit a proposal to NP at the end of November. It looks like it is possible to reach in-mass resolution of Upsilon states at about 100 MeV resulting in different states and allowing for extremely high opportunity for taking b-tag jets.

Geesaman noted that there are some compelling choices about which science areas on which to focus. There are ideas out there that would let researchers do other luminosity upgrades to RHIC that have not been fully tested but could be possible in this timescale. **Mueller** commented that coherent electric cooling is being looked at now. That may be possible and it would be interesting to implement at high energies. A problem for a nucleus-nucleus version is that it would push the detector capabilities. For events with high luminosity, more powerful detectors are needed. For heavy ions, a limit has probably been reached that makes sense.

UPDATE ON THE NATIONAL SUPER CONDUCTING LABORATORY

Konrad Gelbke gave an update on the National Super Conducting Laboratory (NSCL) and the FRIB as the flagship facility for rare isotope research and education. It is supported by DOE, NSF and Michigan State University. NSF's role is to operate the lab as the current RIB flagship facility for users, research and education. DOE's role is to construct the world's premier rare isotope user facility. MSU is making a strong commitment to users with a $95M cost share for FRIB and identifying in-kind contributions of $320M. DOE and NSF coordinate via a FRIB Joint Oversight Group (JOG).

The biggest challenge now is securing sufficient funding for operations and running at 4,500 hours at a minimum of $26M in FY16. This does not include infrastructure upgrades. Increased NSF funding is needed for operations and to complete an ReA6-12 upgrade. Gelbke described commitments made by MSU to enable technology updates, and for projects and the construction of a six-story building for staffing. MSU's investments have exceeded its initial commitments to meet user needs.

NSCL's scientific objectives are aligned with national priorities. The identification of the properties of nuclei will be a national movement. There are also efforts to tie in to a new computational science department, astrophysical processes, testing of fundamental symmetries, and identify societal applications and benefits.

Gelbke described the exotic beams produced in flight at NSCL's CCF possible through its cutting-edge research and the equipment available. It is the only facility in the world that can stop the beams and reaccelerate the beams when needed. Significant investments in instrumentation have been made that allow for additional scientific accomplishments. Of note, is work done with GRETINA in FY12 – 13, and GRETINA will return to NSCL in FY15. The NSCL is also looking at how it might harvest rare isotopes. From an NSF side, the most important facet is how to expand the existing lead by upgrading the beam capabilities.

NSF plays a role in stewardship for maintaining and evolving the equipment at NSCL. The additions to the facility are being made naturally to build a compelling case for reaccelerated beams above the Coulomb barrier.

The ReA 6-12 upgrade will be an extension of existing technology and will feature the effective use of the entire arsenal of proven tools developed for low-energy nuclear science. Doing so will allow for leveraging proven techniques.

Gelbke reviewed the funding needs and opportunities for NSF support to help carry the science forward. Most important is achieving 4,500 hours of the CCF+ReA3 operations at $26M in FY16 and inflation for out-years. DOE support could further the achievement of SECAR, establish the high rigidity spectrometer (HRS) + High Bay, upgrade GRETA, take advantage of opportunities for isotope harvesting, and support ISLA.

Gelbke noted that MSU is one of the highest producers of graduate students. It is making efforts to establish a FRIB Theory Center with ties to high-performance computing to achieve high-impact science with FRIB. Other critical interests are updating and maintaining equipment. Gelbke noted the opportunity to fill a world-wide shortage of capacity with sufficient funding.

Discussion

Venugopalan asked about a FRIB Theory Center. **Gelbke** believes that modern science cannot be contained within one institution. A network must be created with MSU as a central convener. It can create a critical mass for student learning with the help of a national steering board.

Wiescher asked about the cyclotrons and if there are plans for them. **Gelbke** suggested that the immediate plan is to leave them there. There are opportunities to run experiments with them but there are more ambitious thoughts even 20 years down the road with high-quality beams. Cyclotrons could be refurbished.

Wiescher noted that the NSAC was told that funding is very tight and asked about NSCL using some of the equipment newly installed at other facilities. **Gelbke** has looked at this and it did not look promising as aging equipment cost more to refurbish. AIRIS is one possibility and NSCL has considered instrumentation at Oak Ridge. He does not know how funding will flow but NSCL wanted to at least lay out the opportunities and they are very clear. The biggest concern is maintaining the facilities. The bold new initiative would be the upgrade of the accelerator. It makes sense for NSF to play a significant role way into the time that FRIB becomes operational.

Gelbke explained to **Deshpande** that the ReA6 is self-contained. Everything is done now at low energy facilities with stable nuclei. It can be done at NSCL with the same methodology and calibrations. Relegating the facility to only do astrophysics would miss out on gathering in a larger community.

UPDATE ON THE FACILITY FOR RARE ISOTOPE BEAMS

Thomas Glasmacher shared an update on FRIB. It is under construction and will enable beam fragmentation. The FRIB project is on schedule and will achieve CD-4 by December 2020, originally scheduled for June 2022. Current civil construction is about nine weeks ahead of schedule.

The science behind FRIB was endorsed by the National Academies of Sciences in 2007 and 2013. The NSAC long range plan recommended FRIB construction in 2007. In 2009, FRIB started through a cooperative agreement between DOE and MSU. Since then, progress has advanced to technical construction in October 2014.

The technical design is complete and technical construction started in 2014.

Glasmacher listed the national and international partners providing equipment development. The design is integrated and includes options for science-driven upgrades to include new cryomodules and opportunities for isotope harvesting. There is also opportunity for higher-energy acceleration.

Scientists have self-organized into the FRIB Users Organization (FRIB UO) of 1,386 members and 19 working groups.

Advanced isotope harvesting was not part of the original plan for the FRIB but now opportunities for this are clear.

The user community has developed a proposed suite of equipment to fully exploit the potential of FRIB. Theory plays a key role in the scientific challenges that will be addressed by FRIB.

Before FRIB begins there are significant scientific possibilities with NSCL. Users can start doing experiments, make discoveries, and build detectors. FRIB will replace two cyclotrons and there is opportunity until then for scientists to make discoveries.

The FRIB feature significant involvement by other national laboratories and universities.

Discussion

Geesaman reviewed the funding profile identified by DOE.

NEW BUSINESS

None

PUBLIC COMMENTS

Atcher noted that the radiochemistry world is on the verge of losing an educational and training program managed by APS for many years. The group of students going from this into nuclear science is very high. The loss may be due to politics and other issues. Atcher shared that Dave Roberston, current manager for the program, was at a meeting at MSU for education innovation. Atcher is not sure what about this program will end up in the meeting white paper. The program has been terrifically successful. **Hallman** responded that this program has been a recurring issue. It has recently been reemphasized by the DOE Director and Program Directors in the isotope program. Hallman intends to engage on this as a high priority, as a near-term funding issue, and for the coming year, but also generally to engage the SC Director to see if DOE can preserve this. **Geesaman** noted that the NSAC workforce development report emphasized the value of this program.

Lee Schroeder shared that DOE Nuclear Energy has supported the Summer School for Nuclear Chemistry for many years, and that program is also going down.

CLOSING REMARKS AND ADJOURNMENT

There were no additional comments by the committee or audience. NSAC Chair Donald Geesaman adjourned the meeting at 4:20 p.m. EST.

The minutes of the U.S. Department of Energy and National Science Foundation Nuclear Science Advisory Committee meeting held at the Hilton Hotel in Rockville, Maryland, on November 17, 2014, are certified to be an accurate representation of what occurred.

Donald Geesaman

Chair, Nuclear Science Advisory Committee