

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

PUBLIC MEETING MINUTES

**Hilton Washington DC/Rockville Hotel & Executive Meeting Center
1750 Rockville Pike, Rockville, MD 20852**

October 18, 2019

NUCLEAR SCIENCE ADVISORY COMMITTEE SUMMARY OF MEETING

The U.S. Department of Energy (DOE) and the National Science Foundation (NSF) Nuclear Science Advisory Committee (NSAC) was convened at 9:00 a.m. EST on Friday, October 18, 2019, at the Doubletree by Hilton Washington DC – Crystal City, 300 Army Navy Drive, Arlington, VA by **Committee Chair David Hertzog**. The meeting was open to the public and conducted in accordance with Federal Advisory Committee Act (FACA) requirements. Attendees can visit <https://science.osti.gov/np/nsac> for more information about NSAC.

Committee Members Present

David Hertzog (Chair)	Geoffrey Greene	Sofia Quaglioni
Joseph Carlson	Tanja Horn	Thomas Schaefer
Jozef Dudek	Silvia Jurisson	Rebecca Surman
Olga Evdokimov	Yury Kolomensky	Boleslaw Wyslouch
Renee Fatemi	Suzanne Lapi	Sherry Yennello
Bonnie Fleming	Zein-Eddine Meziani	

Committee members unable to attend

Mei Bai
Robert Janssens
Jenifer Shafer
Artemis Spyrou

NSAC Designated Federal Officer

Timothy J. Hallman, U.S. Department of Energy, Office of Science (SC), Office of Nuclear Physics, Associate Director

Others present for all or part of the meeting

John Arrington, ANL (Argonne National Lab)	Jonathan Engel, UNC (University of North Carolina)
David Asner, BNL (Brookhaven National Lab)	Rolf Ent, JLab (Jefferson Lab)
Kate Bannan, DOE	George Fai, DOE
C. Denise Caldwell, NSF	Chris Fall, DOE
Joseph Carlson, LANL (Los Alamos National Lab)	Joe Formaggio, MIT (Massachusetts Institute of Technology)
Julie Carruthers, DOE	Glenn Fox, LLNL (Lawrence Livermore National Lab)
Leland Cogliani, Lewis-Burke	Jehanne Gillo, DOE
T. Reneau Conner, ORISE (Oak Ridge Institute for Science and Energy)	Vincente Guisepe, ORNL
Marcel Demarteau, ORNL	Thomas Glasmacher, MSU (Michigan State University)
Matt Dietrich, ANL	Ian Cloet, ANL
James Dunlop, BNL	Kawtar Hafidi, ANL
	Mike Heffner, LLNL

Stuart Henderson, JLab
 Ken Hicks, Ohio University
 Bogdan Mihaila, NSF (National Science Foundation)
 Barbara Jacak, LBNL
 Kareem Kazkaz, LLNL
 Mike Kreisler, NNSA (National Nuclear Science Administration)

Robert McKeown, JLab
 Celia Merrbacher, SRI International
 Russell Moy, SURA (Southern Universities Research Association)
 Swagato Mukherjee, BNL
 Allena K. Opper, NSF
 Erich Ormand, LLNL
 Alan Poon, LBNL
 David Radford, ORNL

Robert Redwine, MIT
 Gunter Roland, MIT
 Ed Sadowski, SRNL (Savannah River National Lab)
 Martin Savage, University of Washington
 Brad Sherrill, NSCL (National Superconducting Cyclotron Lab)
 Ron Soltz, LLNL
 Sharon Stephenson, DOE
 Alan Stone, DOE
 James Symons, LBNL
 Jim Thomas, NSF
 Fredrik Tovesson, NNSA
 Brent VanDevender, PNNL (Pacific Northwest National Lab)
 James Whitmore, NSF
 Richard Witt, DOE

Friday, October 18, 2019 Morning Session

WELCOME AND INTRODUCTIONS

NSAC Committee Chair **David Hertzog** welcomed everyone and asked the NSAC members to introduce themselves. Hertzog reviewed the agenda and mentioned the charges issued to NSAC.

PERSPECTIVES FROM THE DEPARTMENT OF ENERGY, Chris Fall, Director of the Office of Science

Fall was confirmed in May 2019. He expressed his sincere thanks to all the NSAC committee members and imparted that he and the DOE leadership team recognize the incredible value the committee members provide, saying the advisory committee is how the DOE connects to the scientific community.

Fall imparted that his perspective is one of a scientist. He has had experience with the Office of Naval Research, ARPA-E (Advanced Research Projects Agency–Energy), and the OSTP (Office of Science and Technology Policy). These experiences provided knowledge about the ways agencies like the NSF and the DOE invest in science and technology. These experiences gave him an appreciation for international science and technology and the U.S.’s international role, as well as the value of partnerships for science, relationships, and diplomacy. ARPA-E is doing interesting science and technology, but it is also a place for reinventing government. ARPA-E is a laboratory of how to do things differently and achieve a remarkably well-functioning jewel of science and technology in a short period of time.

Fall understands the agenda for the Office of Nuclear Physics. FACAs (Federal Advisory Committees) and the Administration provide priorities for the SC and the Office of Nuclear Physics. The President has priorities that are largely communicated through the OSTP. Congress makes its intent clear through the annual appropriations. With the science priorities in

artificial intelligence, quantum, exascale computing, biosecurity, and microelectronics there is no intent to compromise the core research mission or the longstanding plans. Fall's priorities are continuing exceptional project management, investing in the laboratories, and communicating the science stories to the public.

Fall recognized the contributions of the public servants in the Office of Nuclear Physics and the leadership of SC who are driving the science agenda forward. He extended his willingness to listen to new ideas from the community and interact with the scientists in the national labs and universities.

Discussion

Greene inquired about Fall's vision for the implementation of quantum computing and quantum information science (QIS). **Fall** explained that Congress is interested in these topics and outlined their goals for the SC in these areas, including the QIS centers. However, the implementation is dependent on the FY20 budget appropriation, because formally QIS centers and quantum computing activities would be a new start. The Under Secretary, Paul Dabbar, has asked the SC to take a step back, and through a RFI (request for information) process, entertain new ideas. It is unlikely that the QIS centers will be funded without academic, laboratory, and commercial industry components, but the management, interaction, and collaboration model is open to exploration. OTA (Other Transaction Authority) allows the SC to create new models and the DOE leadership team is willing to exercise OTA. Nothing has been implemented yet; the leadership team is trying to be generative rather than prescriptive in the design of the centers.

Hertzog asked for comments on university grants, research infrastructure, and the research health of university groups. **Fall** explained the SC devotes about twenty-five percent of the budget extramurally, maintaining consistency in the percentages of spending for facilities, operations, and research. The DOE leadership team wants to make sure the labs, and expertise at the labs, are accessible to industry. While that is part of the equation it does not mean less attention is being paid to universities.

Fall closed saying he looks forward to visiting the labs and interacting with those who perform the science and build and run the supercomputers. He welcomed emails from the committee members and invitations to visit the labs.

DOE OFFICE OF NUCLEAR PHYSICS OVERVIEW, Timothy J. Hallman, Associate Director, Office of Science.

The President's FY20 budget request for Nuclear Physics is \$625M; the House recommended \$735M for Nuclear Physics and the Senate \$736M. Of the top four recommendations in the 2015 Long Range Plan, two (capitalize on investments in U.S. nuclear science; increase investment in projects and initiatives at universities and labs) are close to complete and two (ton-scale neutrino-less double beta decay; electron-ion collider (EIC)) are works in progress. Discussions with NSF about a new long range plan are anticipated in a year.

The 12 GeV CEBAF (Continuous Electron Beam Accelerator Facility) science program is in full swing, operating for 32 weeks in 2019. MOLLER (Measurement of a Lepton-Lepton Electroweak Reaction) is a must-do experiment for new physics. The President's request for MOLLER was \$0.3M, the House mark was not less than \$2.5M, and the Senate mark was \$5.33M. RHIC (Relativistic Heavy Ion Collider) continues to set new performance records. The current focus is searching for the critical point in the phase diagram of nuclear matter. One of the features of RHIC is an upgrade to the PHENIX (Pioneering High Energy Nuclear Interaction

experiment) detector, the sPHENIX. The House and Senate marks include \$9.25M for the upgrade, but it is not new money, rather it is from the RHIC base. FRIB (Facility For Rare Isotope Beams) at MSU, is more than 91% complete and anticipated to be completed on time, on schedule, and on budget. GRETA (Gamma Ray Imaging Tracking Array) is one of the key instruments at FRIB, it is ~15% complete. The President's request for GRETA is \$2.5M, but House and Senate marks are \$10.2M. The FY20 budget request for HRS (High Rigidity Spectrometer) at FRIB is \$1M; House language did not mention HRS, but the Senate marks included \$1M.

The FRIB-Theory Alliance has annual funding of \$720K and is up for renewal in 2020. There are two bridge positions at Washington University in St. Louis, and one at North Carolina State University, there are currently three fellows and plans for an additional two positions. Recently the Alliance held a summer school on machine learning, topical programs in EDM (electric dipole moment), and a TALENT (Training in Advanced Low Energy Nuclear Theory) course on nuclear reaction experiments. TEC (total estimated cost) funding of \$1.44M is in the President's budget request; R&D (research and development) funding is continuing.

The ton-scale double beta decay experiment is not mentioned in House language, but the Senate mark is \$5M. The National Academies' assessment report of a U.S.-based EIC has four findings; the fourth states that an EIC would maintain U.S. leadership in the accelerator science and technology of colliders. EIC is liable to be the only accelerator of its kind built in the U.S. for decades. A mission needs statement for EIC has been approved by the DOE, the independent cost review has been completed, and there has been forward movement for CD-0 (Critical Decision-0). Both House and Senate marks are \$10M for OPC (other project costs) and \$1M for TEC. In the Senate marks, the isotope program received \$30M for a U.S. Stable Isotope Production and Research Center, SIPRC, and \$1.5M for the Stable Isotope Production Facility, SIPF.

Hallman mentioned potential areas of collaboration with the NSF and the NIH (National Institutes of Health) in accelerators, detectors, image reconstruction, storage and mining of big data, pattern recognition via artificial intelligence and machine learning (AI/ML) and system optimization in AI/ML. There are two QIS awards at LLNL and MIT. The DOE FY20 budget request for a quantum center is \$168.5M; SC's ML request is \$71M.

Seven Early Career Awards were given in 2019. Two FOAs (funding opportunity announcement) for QIS and for nuclear data are currently under peer review. Nuclear Physics has hired four new program managers, Paul Sorensen, Sharon Stephenson, Arne Freyberger, and Jon Neuhoff. SC continues to be focused on diversity and inclusion; SC has a policy on harassment. Hallman made clear that anyone found to be violating the SC policy on harassment will have their funding from the SC withdrawn and emphasized that anyone on the wrong side of this statement needs to reconsider his or her position.

Discussion

Lapi asked about the isotope program and enhancement of the collaboration between the DOE and the NIH. **Hallman** said the slides were showing the overlap from the Nuclear Physics discovery program. The isotope program's interaction with the NIH is fairly advanced and has been active on for many years.

Kolomensky asked about balancing the challenges presented in the House and Senate budget marks with the 2015 Long Range Plan recommendations. **Hallman** explained it depends

on the language in the appropriation. If the language is prescriptive, Nuclear Physics must follow that guidance and economize in other places.

Evdokimov inquired about the source of information for the prescriptive allocations from Congress, remarking it seems the projects outlined in the House and Senate mark ups are not necessarily fully aligned with the community's desires. **Hallman** explained the process is a bit different than it has been in the past. There is more independent data gathering by the appropriators.

Kolomensky asked about the timeline for the EIC. **Hallman** expressed hope for a timely resolution. Both the House and the Senate put in TEC funding of \$1M. To avoid losing this opportunity, Nuclear Physics must take advantage of those funds. The timescale for the funding sets an upper limit on the timetable for action. **Kolomensky** asked if there is a timeline for down select or starts in double beta decay. **Hallman** indicated double beta decay is a discussion that needs to happen between the NSF and the DOE; he imagined important steps may be taken in the coming year.

PRESENTATION ON DIVERSITY AND INCLUSION IN THE OFFICE OF SCIENCE, Julie Carruthers, Senior Science & Technology Advisor, Office of Science

The SC has been engaged in efforts to promote diversity, equity, and inclusion (DEI). The SC has changed methods of oversight with the national labs and how the national labs support DEI; initiated a process to look inwardly at the SC's business practices; created a website with consolidated policies and procedures and the statement of commitment issued in April 2019 and coordinated with other parts of the DOE and other federal agencies.

Until 2015, oversight of the national labs' DEI requirements and policies had been done by the federal site offices. In October 2016 the SC Director issued a memorandum establishing uniform guidance for lab communication of their DEI strategies, including posting the annually updated demographics of their workforce on their public website. This memorandum shifted oversight from one of compliance to one of actionable strategies. The guidance set up common topics for the labs to report on: institutional challenges, leadership and staff roles and responsibilities, and lab-specific goals. These were discussed with their annual lab review. In 2019, the lab review for DEI strategies was decoupled from the annual lab review.

The laboratories have a number of good processes and practices in place including conducting climate surveys and pulse surveys, establishing a lead diversity and inclusion manager, holding lab management and supervisors accountable, openly posting and competing all positions, including post docs, requiring diversity and implicit bias training, screening office commercial software programs, supporting employee resource groups, and adopting policies for competitive benefits and family-friendly policies. The SC is convening a panel of experts this fall to evaluate whether the strategies and actions to promote DEI in the laboratories is effective. The intent is to provide independent feedback to inform the SC on how its laboratories can more effectively advance their DEI efforts.

Review of the SC's DEI efforts consisted of a Request for Information (RFI) on current SC practices and an analysis of those practices, a deep dive into major areas of the SC's business practices including financial assistance policies and regulations, solicitation language, letters of intent and pre-applications, review process and the running of workshops and meetings, SC policies and procedures, and known policies and practices of other federal agencies and organizations.

An internal SC working group is developing a report to the Associate Directors for their review and acceptance or modification of the recommendations. The hope is to initiate an implementation phase by the end of 2019. The website, launched in April 2019, contains information about the resources available for assistance and complaint reporting, as well as the SC Statement of Commitment.

The OCRD (Office of Civil Rights and Diversity) has primary responsibility for administering the DOE's policies and practices with regard to civil rights requirements in two areas: financial assistance or grants in cooperative agreements and supporting the federal workforce. OCRD performs two functions with financial assistance recipients: conducting pre-award assurance reviews and post-award compliance reviews; the DOE has conducted more onsite compliance reviews than any other agency. The OCRD communicates on a regular basis with the DOE counterparts in the NSF and NASA (National Aeronautics and Space Administration). Also the OCRD coordinates with the Department of Education who has the federal lead on compliance, and the Department of Justice who has the federal lead on enforcement. At the interagency level, the SC Director Chris Fall has identified safe and inclusive research environments as one of his priorities. Carruthers is the representative for the DOE on the subcommittee looking into this issue with other agency counterparts.

Under the NSTC (National Science and Technology Council) on STEM (Science, Technology, Engineering, and Math) education is a working group focusing on inclusion in STEM. The working group is focusing the STEM pipeline, STEM programs that federal agencies support, and the STEM federal workforce.

Discussion

Yennello asked if the findings from the working group, to be given to the Associate Directors for review, will be available to the COV (Committee of Visitors) in December. She also inquired if the labs are sharing the site-wide climate assessments amongst themselves. **Carruthers** was unsure if the report would be available by December. She explained the climate surveys are internal. Every laboratory has workforce needs and institutional challenges and differences. They are doing their own independent culture climate surveys. In some cases, the labs are collaborating with one another to identify what has worked, what kind of organization they brought in to conduct the surveys, and getting advice from one another.

Hertzog dismissed NSAC for a break at 10:45 a.m. and reconvened the meeting at 11:01 a.m.

PERSPECTIVES FROM THE NATIONAL SCIENCE FOUNDATION, Denise Caldwell, Director, Division of Physics, NSF

The MPS (Mathematics and Physical Sciences) Directorate houses the PHY (Division of Physics) which includes chemistry, mathematics, astronomical sciences, and materials research. PHY now has a new Deputy Associate Director, Sean Jones, and a new Director for Astronomy, Ralph Guame. Two Nobel Prizes to MPS-funded researcher were awarded in 2019 in Chemistry and Physics. Two Breakthrough Prizes in Physics and Mathematics were also awarded to MPS-funded researchers.

NSF's budget appropriation for FY19 was \$8B; \$1.5B was for MPS. The FY20 budget request was lower than 2019 (\$1.25B), but the House and Senate marks are higher. Divisions in MPS use funds slightly differently. Mathematics' funds support the research programs, chemistry is similar although a small level of support is given to facilities. Materials Research

has support for facilities and the bulk of Astronomy's funds go to facilities, the telescopes, with a small component going to their research program. PHY spent one-third of their resources in operations and management of the facilities, including support for NSCL which will be moved to the DOE once FRIB construction is completed.

The NQI (National Quantum Initiative) was passed at the beginning of December 2018. NQI requires the U.S. government, industry, academia, and private foundations to develop a plan for ensuring the nation retains leadership in the area of QIS and all of the attendant technologies that result. The NSTC subcommittee on QIS, chaired by MPS Director Anne Kinney, is in the process of developing the plan for ensuring U.S. leadership in QIS. MPS carried out four activities related to QIS through the Quantum Leap Big Idea: called for proposals for establishing a materials foundry for quantum materials (awarded to University of California, Santa Barbara); established a QIS faculty fellows program to partially support junior faculty in computer science who want to work in quantum computing (three awards in 2019); Quantum Idea Incubator – TAQS (Transformational Advances in Quantum Systems), 19 awards in 2019; and Quantum Challenge Institutes (solicitation is on-going).

Four awards were given for Midscale-RI-1 (Research Infrastructure-1) projects between \$6M and \$20M to investigators at the University of Delaware, Ohio State University, University of Michigan, and the Smithsonian Institution Astrophysical Observatory. Windows on the Universe is an implementation that takes place through a metaprogram. In 2019, 66 full or co-funded awards were made. Three examples are data analysis of IceCube, a Supernova early warning system, and the Scalable Cyberinfrastructure Institute for Multi-Messenger Astrophysics. NSF has announced the National AI Research Institutes program. Proposals for institutes in six specified themes, and for planning, are due in January 2020.

Discussion

Yennello asked if the NSCL roll off to the DOE will benefit the other nuclear facilities. She highlighted infrastructure money will become available that could stay in the nuclear program and help those facilities. **Caldwell** said that is an option; there are lots of options.

Fatemi asked how QIS solicitations will fit into the larger picture and if they will include nuclear physics. **Caldwell** stated the NSF has a long history of investment in QIS, back to the late 1990s. The technology was not developed enough to move the field forward so the investment remained small until the late 2000s. Part of the driver for the NQI, and the new emphasis on QIS, has been tremendous scientific advances over the past five years in materials and in technologies. Now a quantum computer is truly imaginable, it is at a realization point. Sensors are key technologies in the nuclear field where QIS can have an impact. All scientists who see a possible quantum technology that can make a visible difference in their research should reach out to the NSF to become part of the QIS centers. She encouraged open thinking; looking for areas where scientists can benefit from the quantum efforts and opportunities.

Kolomensky appreciated the designated program officer for QIS and asked if that individual will coordinate efforts within MPS and with other agencies. **Caldwell** said absolutely, and expressed excitement about the degree to which the PHY program directors have started to work across programs effectively. Twenty-five percent of the proposals in PHY were co-funded with Divisions outside of physics.

NSF NUCLEAR PHYSICS PROGRAM OVERVIEW, Allena K. Opper, Program Director, Nuclear Physics, NSF

MPS/PHY will accept investigator-initiated research proposals for Particle Astrophysics, Elementary Particle Physics, and Experimental and Theoretical Nuclear Physics until December 3, 2019. The MRI (Major Research Instrumentation) programs' submission window is January 1 through the 21, 2020. Four of the ~ 10 MRI proposals in experimental nuclear physics were funded in FY19; these went to the University of Tennessee, Indiana University, Wittenberg University, and University of Wisconsin, Lacrosse.

There is an open permanent position for a Program Director with expertise in QIS. The new solicitation on AI Research Institutes, available now, is to support the advancement of multidisciplinary, multi-stakeholder research on a larger scale and longer time horizons than are currently supported in the regular programs.

Mid-scale RI-1 is a mechanism to fund projects between \$6M and \$20M. In FY19 awarded projects were so compelling that Divisions and Directorates co-funded them at \$121M. Mid-scale-RI-2 is for projects between \$20 and \$70M; those awards will be made near the end of summer 2020.

PHY has had a Midscale Instrumentation program for a number of years for projects between \$4M and \$15M. This funding opportunity is for projects that are shovel-ready. There are currently three nuclear physics projects funded: MUSE (MUon proton Scattering Experiment), neutron EDM, and LEGEND 200 (Large Enriched Germanium Experiment for Neutrinoless Double-Beta Decay).

The FY20 House and Senate marks are higher than the President's budget request. The research budget would go down by twenty percent if the FY20 President's request were funded. PHY has always allocated at least fifty percent of its budget to the support of individual investigators and group grants, and that will continue to be a priority for PHY. NSCL has been funded at \$24M a year since 2016; \$18M for operations and maintenance and \$6M for research programs of the nuclear science faculty at MSU. NSCL has been instructed to have one-third of the faculty roll off in each of the last three years of the cooperative agreement. In response to the month-long shutdown last year NSF used FY19 funding to forward-fund three months of the operations and maintenance for FY20 for all NSF facilities, so that the impact of any future lapse of funding would not negatively affect the operations of facilities..

Opper shared science highlights that included an MRI project with MSU for a Helium-Jet Ion-Guide System and the HBCU (Historically Black Colleges and Universities) Collision Collaboration, made up of Florida Agricultural and Mechanical University, Texas Southern University, and Howard University. NSF Faculty Early CAREER Development (CAREER) proposals are being reviewed now. Two recent CAREER awards went to Megan Connors (Georgia State University) and Nick Hutzler (CalTech).

Discussion

Evdokimov mentioned the CAREER program budget line was cut more severely than regular research and inquired about the effect on junior researchers. **Opper** explained scientists submit proposals to both the regular and the CAREER programs. The CAREER program requires an education component that is not required in the regular program. **Caldwell** added PHY has placed an emphasis on starting junior faculty, and that holds for the programs as well. In the normal base program, all of the program directors are constantly looking out for funding for junior investigators. The CAREER program is a special program within NSF that places a

much higher emphasis on the educational component than the normal emphasis expected of any awardee. A CAREER proposal should go above and beyond the normal expectation of a faculty member. The CAREER number shown in the slides should not be taken as an indication of the emphasis, or the lack of emphasis, PHY and the NSF place on funding junior faculty.

Hertzog noted that unfortunately from the university side there is an interpretation that the CAREER award is a particularly special honor. The tenure committees view CAREER awards as a special stars. **Opper** agreed that Hertzog had identified where there is miscommunication and incorrect assumptions. The CAREER program is intended to identify excellent research, but it also requires a strong education component. The research program has to be excellent, but that education component is often challenging, especially for new faculty. When speaking to principal investigators she explains that if they are passionate about education that will likely transfer to a stronger CAREER proposal. And for universities or tenure committees seeing Careers a kind of a hoop, that certainly was not the intent of the NSF. **Caldwell** said this is a topic that the PHY COV looked at in great detail. Their recommendation was to clarify what has just been stated, namely the expectation of the CAREER program from the NSF perspective.

PRESENTATION OF NEW CHARGE: MOLYBDENUM-99, Timothy J. Hallman,
Associate Director, Office of Science

NSAC is charged with conducting another assessment of NNSA efforts to ensure an adequate domestic supply of molybdenum-99. Molybdenum-99 is particularly important because its daughter, technetium-99, is used in thousands of heart stress tests. This assessment requirement was placed on NSAC by statute, by the Congress, some years ago. This will be the sixth assessment.

There is no specification on how these assessments are to be done; the process could be streamlined. Historically, these assessments have been conducted in a classical review mode where a panel is commissioned or convened, there are talks from various people in industry and NNSA, and then a discussion ensues and a report is written. However, there may be other ways to conduct the assessment and that is being explored by Hertzog and committee members.

Discussion

Hertzog noted that Lapi is a content expert and finished the report last time. There are considerations of asking NNSA to provide reports to NSAC prior to any exercise and to see what has been done since the last report. A letter to NNSA, from NSAC, will be delivered asking for the transfer of the update from the committee's recommendations, as well as an update on the program since the last time the assessment subcommittee was convened in December 2018. A virtual meeting is being considered as well. **Lapi** added that the assessment subcommittee needs new members and that a virtual meeting seems appropriate.

Hertzog dismissed NSAC for lunch at 12:13 p.m. The meeting was reconvened at 1:25 p.m.

Friday, October 18, 2019
Afternoon Session

PRESENTATION OF THE QUANTUM COMPUTING AND QUANTUM INFORMATION SCIENCE SUBCOMMITTEE REPORT, Martin Savage, Subcommittee Chair University of Washington

The subcommittee's charge focused on determining the relationship between QIS and Nuclear Physics, how one could contribute to the other. Nuclear Physics contributions to QIS is the focus of the report which identified synergies with other domains. The U.S. NQI, passed in 2018, will establish a 10-year plan to accelerate basic research in QIS and technological applications; invest in fundamental R&D, workforce, interagency coordination, partnerships with industry and universities; and leverage existing investments. The report outlines potential contributions from QIS and QC (quantum computing) to Nuclear Physics in simulation and from Nuclear Physics to QIS and QC in entanglement and sensors. Three recommendations and four comments were made. Recommendations focused on QC, simulation, and nuclear physics; quantum sensing in nuclear physics; exploratory techniques and technologies in combined nuclear physics and QIS activities; and the nuclear physics workforce. Comments were about QCDC (Quantum Co-Development Consortia) attributes, future-proofing QC and simulations, and developing the quantum-ready workforce.

DISCUSSION OF THE QUANTUM COMPUTING AND QUANTUM INFORMATION SCIENCE REPORT, NSAC

Kolomensky asked about collaborations with technology companies and recommended the emphasis on interagency collaboration be more pronounced, suggesting it appear in the Executive Summary of the report. **Savage** noted that the list of attributes for the QCDCs and smaller activities have strong ties with technology companies. Adding a sentence to the executive summary is feasible.

Schaefer indicated that the report is fairly detailed on the QCDCs, however support for smaller programs is also necessary. The second recommendation mentions smaller programs in a cursory sense, but a more nimble vehicle to support smaller ventures is needed. **Savage** explained that is one of the functions QCDC is expected to fulfill. He agreed the smaller scale exploratory activities are essential going forward.

Dudek pointed out there was passing mention of international collaborators in the QCDCs and asked if it was intentional to focus solely on U.S. collaborators. **Savage** said those collaborations were not deliberately excluded.

Wyslouch expressed confusion about the implementation plan for the interagency and multi-center collaborations and creating a coherent, government-wide, picture. **Hallman** said the discussion has not progressed to that point because QCDCs are complex and nuanced. Discussions of community self-organization, agency funding methods, and internal administration need to occur. The QCDCs are challenging, and different from other programs; they should be integrated into the core research program, but they also may need a program manager. **Savage** added it is clearly desirable for community-wide engagement. The American Physical Society's Division of Nuclear Physics has had discussions about holding a larger open meeting in early 2020 to discuss how to optimally organize the community. **Hertzog** said the QCDC's will require an environment where people can come together and create productive collaborations.

Jurrison noted the report talks about consortia, collaborations, and workforce development. However, the report does not specify helping junior researchers. **Savage** explained there were discussions about career paths and QCDC is one element. It is important

for junior researchers to show creativity and independence, but the consortia are designed to provide an environment of growth and activity, where they can flourish and be recognized. The lack of clarity on this aspect was unintentional.

Quaglioni stated the consortia will help create bridge positions that transition into permanent posts. **Carlson** mentioned analog programs have been successful in getting young people into positions and advancing their careers. **Kolomensky** said the team suggested a program director to shepherd and oversee the program, to be a champion of the cause and hopefully help career advancement.

Meziani asked about mechanisms to attract researchers from different disciplines. **Savage** said the QCDC's must have a certain level of communication. At the moment it is word of mouth. The NQI centers are expected to be a much larger umbrella organization to have stronger communications with the nuclear physics community, a more effective conduit. Currently cross-disciplinary meetings have proven important.

Fatemi asked if the structure of the QCDCs has been discussed with industry representatives and about their incentive to participate. **Savage** explained that one of the readers of the report was in private industry and supportive of the suggestions. Individuals in private industry have made overtures to collaborate. The next decade will be a science-first period. The technology companies will need to interface with university researchers and national labs.

Fleming asked about connections and funding in the agencies that cross boundaries between quantum sensing, nuclear physics, and high energy physics. **Savage** remarked that was beyond the scope of the committee, however, those discussions are already taking place at meetings. **Hallman** added that regarding funding, within the DOE QIS is recognized as a cross-disciplinary focus. Basic Energy Sciences, Advanced Computing Research Sciences, and High Energy Physics program offices are jointly funding this activity. As result of this report, Nuclear Physics is hoping to get more involved as well.

Yennello expressed concern about bringing tangentially connected students along, worrying because they are not quantum experts. She was curious how the whole community would be engaged and supported rather than having a subgroup in quantum. **Savage** said the committee agreed completely, one of the attributes is flexibility and it needs to be built into the system.

Schaefer commented there needs to be a less bureaucratic mechanism for small efforts. The QCDCs also need to facilitate access, by individual researchers, to the large scale efforts. The collaborations must interact down, with individuals, and up, with larger entities like large technology companies. **Savage** responded part of the suggested design is the points of contact and interfacing with the NQI centers. Nuclear physics researchers are fully expected to be involved in NQI; as far as the nuclear physics connection, these centers would provide a portal.

Greene quantum mechanics is relevant to entangled systems but the normal undergraduate and graduate curriculum provides no such introduction. He asked if this was brought up in discussions. **Savage** said the causes and possible course modification were discussed. The intent is to have a modified curriculum on quantum mechanics. **Kolomensky** commented that the U.S. Particle Accelerator School is an example to consider. He added that in the report, the connections between the NQIs and QCDCs is somewhat informal and asked if a more formal relationship would be useful. **Savage** explained this is for the community to discuss, particularly with technology companies.

Surman asked why the word nuclear is not in the name of the report, since one of the defining characteristics is the inclusion of nuclear physics. **Savage** said it was an oversight.

Horn made two comments, that the implementation must be integrated in the Nuclear Physics core capabilities, and that Nuclear Physics' identity be incorporated in the consortia.

Meziani remarked that there needs to be clear ways to enter the consortium and young people need a mechanism to bring fresh ideas to fruition quickly, perhaps with an advisory committee.

Hertzog mentioned a possibility for reserve funds, offering the idea that it could be a board who recommends the DOE hold money in reserve and make an allocation.

Evdokimov said the community can take advantage of training opportunities with companies, beyond conferences and workshops. She mentioned using the consortium umbrella for training programs from industry. **Savage** noted there is movement in that direction already. It is not community-wide but exists in certain spaces.

Yennello suggested co-funding of such things as nuclear physics and quantum implementation from the Office of Nuclear Physics. **Hallman** said Nuclear Physics has to consider how to implement this and he welcomed the interest. A familiar model is the Institute of Nuclear Theory. They use their budget to stimulate workshops for different segments of the community. He added that as the QCDC grows in scope, it may require dedicated oversight.

Hertzog asked for final comments and a vote on the report. NSAC members expressed their appreciation to the subcommittee for their work and the report. **Greene** expressed his hope that the stewardship of this program focuses on the intention. **Schaefer** said implementing the recommendations will strengthen Nuclear Physics. **Yennello** appreciated the sidebars in the report. NSAC unanimously accepted the report.

THE sPHENIX PROJECT, Gunther Roland, MIT

sPHENIX's science mission was reaffirmed in ECFA (European Committee for Future Accelerators) heavy-ion discussions. sPHENIX is a major upgrade to the PHENIX detector. sPHENIX repurposes >\$20M in existing PHENIX equipment, infrastructure, and support. The detector is optimized to measure jet and heavy quark physics. The sPHENIX collaboration includes 77 institutions (25% non-U.S.). Final project design approval and authorization to execute was received in 2019. Installation and commissioning will occur 2021-2022 and data taking will begin in early 2023. The sPHENIX detector is a qualitative improvement on 20 years of studies at RHIC through higher statistics, full calorimetry, and higher precision tracking.

Non-U.S. contributions are the INTT by Riken assembly/texting at National Central University, Taiwan; Sampa TPC FE chip sPHENIX specific v5, University of Sao Paulo; PHENIX MBD by Hiroshima University; EMCAL prototype blocks from Fudan University, and Block production to extend EMCAL acceptance by a Chinese Consortium.

Six physics case studies illustrated the role of sPHENIX in the context of the LHC (Large Hadron Collider) and previous RHIC studies. These are the photon-jet balance, jet angular correlations, b-tagged jets, B mesons, Dijet mass ratios, Λ_c - Hadronization, and Y(nS) family.

In summary, the goal of the 2015 LRP was to understand the microscopic structure of QGP (quark-gluon plasma) and the emergence of its unique long-wavelength properties. sPHENIX relies on proven, cost-effective technology to bring qualitatively new capabilities to RHIC. The project entered construction phase in 2019 and is preparing for first physics data in 2023.

Discussion

None.

Hertzog suspended the NSAC meeting for a break at 3:15 p.m. and reconvened at 3:26 p.m.

THE DOUBLE BETA DECAY TOPICAL COLLABORATION, Jonathan Engel, University of North Carolina

The goal of the double beta decay collaboration is to improve accuracy and quantifiable error bars in calculations of the nuclear matrix elements that affect the rate of neutrinoless double beta decay, atomic EDM, cross sections for scattering of dark-matter particles from nuclei, and parity-violation experiments.

The collaboration involves physics at all scales, from quantum chromodynamics through effective field theory for light nuclei, to nuclear structure for heavy nuclei. Engel shared some of the collaboration's accomplishments with double beta decay and touched on collaborations in general. Experiments in double beta decay have resulted in huge uncertainties; designing optimal experiments and interpreting the results requires better predictions which relies on nuclear physics in addition to neutrino properties.

There are twice yearly meetings to discuss new developments and to plan the collaborations' work. The collaboration has had a large impact and has been extremely successful. With current funding resources, those who were unable to spend time on double beta decay now have financial support and are interested in the problem; the field would not be as far along without those funds. The collaboration has faced challenges balancing productivity and successful proposal writing, funding dictates people's ability to contribute which in turn requires more oversight by the organizers.

Discussion

Hertzog asked if the contact diagram comes with a known sign that would increase the probability. **Engel** said it comes with a known order of magnitude, but not a known sign.

Thomas stated the calculations have been very large and unstable and at some point the calculations may be precise enough for new physics. He asked how small the error bars have to be before new physics can be done in the future. **Engel** explained if there is one measurement of double beta decay it does not matter how accurate the calculations are because the responsible new physics mechanism will be unknown. Engel said greater accuracy means stronger conclusions about everything. The goal is uncertainty at 50% or 100% with absolute confidence and a real error bar.

Greene was curious if Engel anticipated reaching a level of confidence to shed light on the choice between nucleonic selection. **Engel** thought these results will be available by the end of the 5-year period (18 months from now).

THE BEAM ENERGY SCAN THEORY (BEST) TOPICAL COLLABORATION, Swagato Mukherjee, Brookhaven National Laboratory

BEST (beam energy scan collaboration) is a topical collaboration in nuclear theory with a focused, well-defined goal which will be achieved in a 5-year timeframe. The beam energy scan program at RHIC focused on identifying the phases and properties of quantum chromodynamics matter in the temperature and variable potential plane. Significant accelerator and detector upgrades make phase 2 possible. BEST will construct a comprehensive theoretical framework for interpreting BEST results.

BEST involves 14 core institutions and has generated over 60 publications with 1200+ citations and more than 50 conference proceedings. BEST has a steering committee, inter and intra working groups, core institutions and groups, and an annual all-hands meeting. BEST has trained 12 graduate students and six postdocs to date.

In summary, BEST is delivering excellent, world-leading science and is on track to achieve its goals. BEST is effective in teaching and retaining talent and successful in facilitating and promoting junior faculty positions. And BEST is connecting and liaising with communities outside of nuclear theory.

Discussion

Wyslouch said the model was impressive and potentially one that can be used for NQI.

PUBLIC COMMENT

Ken Hicks, Ohio University, commented that from discussions with the executive officers, the Division of Nuclear Physics is happy to help organize an impartial body for the QIS report, at the invitation of NSAC and/or the DOE.

Hertzog adjourned the October 2019 NSAC meeting at 4:29 p.m.

The minutes of the U.S. Department of Energy and the National Science Foundation/Nuclear Science Advisory Committee meeting, held on October 18, 2019, at the Doubletree by Hilton Washington DC – Crystal City, Arlington, Virginia, are certified to be an accurate representation of what occurred.

David Hertzog, Chair of the Nuclear Science Advisory Committee on February 5, 2020.

A handwritten signature in black ink, appearing to read 'D. Hertzog', with a long horizontal flourish extending to the right.