# Minutes of the Meeting of the
# Department of Energy and National Science Foundation
# Nuclear Science Advisory Committee
# Marriott Crystal Gateway Hotel, Arlington, Virginia
# August 21, 2008

**Members Participating:**

Robert Tribble, Chairman
Douglas Bryman
Richard Casten (morning only)
Vince Cianciolo
Charlotte Elster
Rolf Ent
Ulrich Heinz
Xiangdong Ji
Roy Lacey
Roy Lacey
I-Yang Lee
Christopher Lister
Gail McLaughlin
Richard Milner
Hendrik Schatz
Thomas Ullrich
Ubirajara van Kolck
John Wilkerson

**Members Absent:**

Naomi Makins
Michael Ramsey-Musolf
Johanna Stachel

**Others Participating:**

Robert Atcher
Joseph Dehmer
Patricia Dehmer
Donald Geesaman
Eugene Henry
Bradley Keister
Jonathan Kotcher
Jehanne Simon-Gillo

**Presenters in Order of Appearance:**

Patricia Dehmer
Jehanne Simon-Gillo
Bradley Keister
John D'Auria
Jehanne Simon-Gillo
Jonathan Kotcher
Geoffrey Greene
Martin Cooper
Peter Conti
Lawrence Cardman
Steven Vigdor
Thomas Glasmacher
Robert Janssens
Glenn Young

About 25 others were in attendance during the course of the meeting.

Chairman **Robert Tribble** called the meeting to order at 8:25 a.m. He introduced **Patricia Dehmer** to present news from the DOE Office of Science (SC).

The House and Senate markups of the SC budget request are instructive. The House committee members stressed (1) certain research priorities and (2) coordination. The Committee expressed pleasure that the Department had taken steps in these directions, including the completion of 20 planning workshops arranged by SC in consultation with the applied technology programs; integrated budget documentation for six key research and development areas; and the proposal to fund more than two dozen

Energy Frontier Research Centers (EFRCs). The Committee directed the Department to continue to support and expand these efforts and take the steps needed to ensure that R&D integration is implemented at all levels across the Department in planning, budgeting, and execution. It also directed the Department to provide the Committee with a report detailing progress on these efforts no later than March 1, 2009. Both SC and Renewable Energy (EERE) are well funded under the House markup. However, a continuing resolution until the swearing in of the new administration is a certainty. The Senate committee expressed pleasure with the efforts made by the Department to improve energy research and development integration across SC and with the applied energy programs. The Committee expressed concern, however, that the integration efforts have been either top-down, being undertaken at the level of Under Secretaries, or unique events (such as workshop series and EFRCs). This Committee wants SC to work with the energy-technology programs. In total, SC would receive more than $4.649 billion, which is $623 million above FY08, under the Senate subcommittee appropriation.

In FY08, SC received a supplemental appropriation, half of which went to the Office of High Energy Physics (HEP), and most of the rest being split between the light sources and the International Thermonuclear Experimental Reactor (ITER). The FY09 request for SC is about $1 billion more than the final appropriation. The House mark added money to SC and many other programs, $115 million over the President's request. The Senate mark cut funding for the Office of Basic Energy Sciences (BES) by one-half of the increase requested and moved a $60 million program in basic solar research away from BES. It also cut federal-staff increases and boosted climate-change funding.

In regard to nuclear physics, the House increased funding by $7 million over the President's request. The Senate mark provides the full request (only). Both the House and Senate are looking closely at the radioisotopes program. It is a charge to the Office of Nuclear Physics (NP) that must be taken seriously. These numbers are only markups; this is not spendable money, yet.

The 12-year history of SC offices' funding indicates that computing had large growth; the fusion program had a large increase of requested funds for ITER; the Office of Biological and Environmental Research (BER), HEP, and NP are down a little bit or flat; and BES is up largely because of major new initiatives.

SC has been reorganized to incorporate three deputy directors. Three new permanent associate directors have been named (Kung at BES, Palmisano at BER, and Kovar at HEP). Fusion Energy Sciences and NP will be the next offices to seek permanent associate directors, and recommendations for those positions are being sought from the respective advisory committees.

Elster asked why the radioisotope program was being so closely watched. Simon-Gillo responded that it has a huge impact on society through the medical environmental, and homeland security communities. A stable supply of critical isotopes is needed. This is not a shy community, and it is bringing a lot of issues to the table.

Lister asked why NP was asked to look at fuel-cycle research when it is not funded. Patricia Dehmer responded that that topic and other technologies will likely go forward with the new budget.

**Jehanne Simon-Gillo** was asked to review the activities of NP. The FY08 budget was $39 million less than the Congressional Budget Request. The impacts of the shortfall were that several construction and instrumentation projects had to be stretched out, research programs were nearly flat funded with FY07, increases in research efforts supporting ongoing initiatives were reduced, generic R&D related to a rare-isotope-beam capabilities was reduced, operations and all support for the advanced fuel cycle initiative and theoretical topical collaboration went unfunded, AFCI proposals were declined, and efforts had to be made throughout the year to mitigate reductions in force. The Office did receive $1.5 million in FY 2008 supplemental funding. This all went to the Relativistic Heavy Ion Collider (RHIC) to mitigate any reductions in force and ensure a minimum 19-week run in FY09.

The FY09 budget request returns the Office to the FY05 level. University and laboratory research efforts are strengthened. User-facility operations are increased [RHIC to 25 weeks and the Continuous Electron Beam Accelerator Facility (CEBAF) to 34 weeks]. Important instrumentation projects are continued. The 12-GeV CEBAF upgrade initiates construction. Conceptual design and R&D are funded for a facility for rare isotope beams. Support is increased for advanced fuel cycle initiatives and theoretical topical collaborations. And the Isotope Production Program is transferred to NP. The Continuing Resolution will clearly impact all of the above. NP is at a crossroads. This is the last year for possibly implementing the President's American Competitive Initiative. No one knows what the position of the new administration will be. FY06 was a dismal year for NP, and the FY07 and FY08 appropriations were also difficult. Under Secretary Orbach has said that the community needs to make a case for the science and its efforts to the nation, to Congress, and to the public. Funding is not an entitlement.

The House mark is an increase of $7 million over the budget request. The requested funding will support operations of the Jefferson Lab and RHIC. An additional $7 million above the budget request is provided to initiate and accelerate construction of the CEBAF upgrade. The request also includes funding for the isotope production program, which would be transferred to NP from the Office of Nuclear Energy (NE).

The Senate mark is the same as the budget request. Within the available funds, the Committee recommends $24.9 million for the Isotope Production and Applications Program. This is a tough year for NP. The recommended level of support for the isotope program is $5 million above the President's request. But, assuming a flat 6-month continuing resolution and then the resumption of the President's request, the Advanced Fuel Cycle Initiative (AFCI) initiative would be reduced from $6.6 million to $2.6 million (about 40 to 60 researchers) and laboratory and university research would be reduced by $1 million (10 to 15 researchers). The recommended level of support for the research isotopes is $2 million above the President's request, and the other $3 million can be distributed within the isotope program. The Senate Committee directs SC to complete a study on the feasibility of expanding the capabilities of the University of Missouri research reactor to supply up to half of the United States' demand for feedstock medical imaging compounds in the form of $^{99}$Mo and $^{99}$Te. The Committee also requests that the Department outline options for preserving U.S. production of $^{252}$Cf. A bottom-up costing exercise at Oak Ridge National Laboratory (ORNL) on californium production has been completed. There was a meeting with 17 representatives from californium suppliers and oil industries on August 14, 2008.

A lengthy continuing resolution is expected for FY09 with approximately flat funding from FY08. SC is working closely with the laboratories to mitigate reductions in force.

Operations of national user facilities will be decreased. Jefferson Lab will receive $1.5 million in additional funds above FY 2008 levels in FY09 to mitigate potential reductions in force caused by unanticipated power-rate increases. An attempt will be made to optimize major items of equipment (MIE) funding. Throughout the NP program, there are hiring freezes, lack of promotions, restrictions on salary increases, and an inability to support new postdocs and graduate students. Researchers will experience restrictions on travel. New research programs that had been identified to start or increase in FY09 are on hold. Initiation of construction of the 12-GeV upgrade cannot commence during a continuing resolution without appropriate language. The isotope program will not transfer from NE to NP until there is an appropriation.

Under the President's Request, the Isotope Production Program will be transferred to NP, which has the expertise and experience in operating facilities and developing technologies relevant to the production of stable and radioactive isotopes. The transfer will allow the strengthening of synergy between the two communities and will offer opportunities for new collaborations. NP is working closely with NE and isotope stakeholders in anticipation of the transfer. NP has played the lead in setting up a federal DOE/NIH [National Institutes of Health] working group to address issues of mutual concern and interest. A workshop on this subject was held August 5-7, 2008, to determine who uses radioisotopes, who produces them, and what are they used for.

In 2008, a lot of projects were reviewed. The Gamma-Ray Energy Tracking Array (GRETINA) achieved critical decision (CD) 2b/3b, the Fundamental Neutron Physics Beamline (FNPB) achieved CD 4a, the High-Level Trigger System for the LHC ALICE [Large Hadron Collider A Large Ion Collider Experiment] achieved CD 2/3, the Cryogenic Underground Observatory for Rare Events (CUORE) achieved CD 1, and the CEBAF upgrade achieved CD2. The nosecone calorimeter at Brookhaven National Laboratory is not being pursued. Six solicitations have been issued in FY08, and one was deferred.

The Rare Isotope Beam (RIB) experiments are an initiative to allow U.S. researchers to participate in the forefront of rare-isotope-beam studies while the Facility for Rare Isotope Beams (FRIB) is being constructed. NP issued a solicitation for pre-proposals in FY08. Formal applications will be accepted only from pre-applicants who are encouraged to submit a formal application. The criteria will be based on traditional considerations plus whether there is some particular outstanding scientific opportunity afforded by facility and U.S. investments, there is the opportunity for a significant role by U.S. participants, and the activity has relevance to the planned U.S. FRIB facility and program. Thirty-one pre-proposals were received, and the request for formal applications is in progress.

The solicitation for FRIB was published on May 20, 2008. The proposals were due on July 21, 2008. There is no FY08 funding associated with the award, which identifies a site that can proceed with facility establishment. The merit review panel has been formed and peer review is about to begin.

For the 2008 Outstanding Junior Investigator awards, 16 applications were submitted that included nuclear structure, nuclear astrophysics, nucleon spin, heavy ions, neutrinos, or fundamental symmetries. From these, NP selected three.

NP continues to jointly support Deep Underground Science and Engineering Laboratory (DUSEL) R&D with NSF and DOE HEP. Discussions have been held about a program of nuclear- and particle-physics experiments at DUSEL. A memorandum of understanding between the programs at NSF and DOE is in the final stages. NP has not committed to siting an experiment at DUSEL. However, the NP community has a clear interest in double beta decay, for which DUSEL is a potential site.

Three program-manager positions have been filled in the Office, and the filling of two positions is on hold because of budgetary restrictions. One position has been filled with a detailee, and other such appointments are open.

Heinz asked about the status of the topical theory centers. Simon-Gillo replied that EBAC at TJNAF is the only active facility. A solicitation will not be put out for additional centers until there are appropriations.

Tribble noted that the language of the House and Senate markups request a lot of information and he asked how the Office would handle those requests. Patricia Dehmer responded that a lot will happen between now and when those reports are due and the Office is currently in a holding pattern on how it will manage those responses.

**Bradley Keister** was asked to review the activities at the NSF. In FY08, the National Superconducting Cyclotron Laboratory (NSCL) operations were flat (in contrast to the planned $1M increase), and most programs were down 5%. The FY08 supplemental appropriation went to facility operations and partial restoration of the NSCL operations.

For FY09, the request level follows the America Competes Act trajectory with an 18.8% increase for physics. Of that, research and education grants are up 31% and the NSCL is up 10%.

Special programs include DUSEL R&D, Physics at the Information Frontier, Cyber-Enabled Discovery and Innovation (CDI), Major Research Instrumentation (nuclear physics did quite well), and Domestic Nuclear Detection (the latter with DHS).

The deadline for program proposals is Wednesday, September 24, 2008.

In the Nuclear Physics Program office, A. Opper has joined the staff.

Joseph Dehmer commented that CDI is a very big program in the eyes of the Director and *will* move forward. It is focused on multidisciplinary approaches, and proposers should be aware of that. Competition for MRI funding is very strong.

Tribble noted that the latest version of the performance measures report was sent to all Committee members four days before this meeting. The topic was opened for discussion. Heinz had forwarded some suggested changes to Tribble. The Committee was polled about the adoption of the report. The results were unanimously in favor of adopting the report. Glenn Young was thanked for the outstanding job done by his Subcommittee. A draft transmittal letter had been distributed to the Committee and was projected on the screen. The content of the letter was reviewed paragraph by paragraph. Some minor changes in wording were suggested and adopted. The corrected transmittal letter was approved by consensus by the Committee.

**John D'Auria** was asked to report on the August 5-7 workshop on the Nation's Needs for Isotopes: Present and Future. The workshop involved a complex set of communities and personnel and had 170 attendees. All of the workshop presentations are on the web.

The workshop did not include setting priorities, making business deals, discussions on future pricing policy, or discussions of propriety information. It had plenary sessions, working groups, and a poster session. Each participant was asked to fill out a background information form, and about 30 responded. A tremendous diversity in the background of the users and uses of radioisotopes was uncovered. Most demands are being met by either domestic or foreign suppliers. No new active domestic production of separated stable isotopes has occurred since the U.S. electromagnetic (calutron) enrichment facility at ORNL was put into standby in 1998. In the domestic inventory, all isotopes are available for the next 20 years, depending upon spike demands, with some exceptions. For double-beta-decay experiments, there is no stockpile or production facility for the large (1000-kg) quantities of the required isotopes (e.g., $^{76}$Ge). Russia is the only supplier. The demand for $^{3}$He (for neutron detectors etc.) exceeds supply and will continue to rise. Certain isotopes are not available anywhere, such as $^{96}$Ru. There is increasing demand for special enriched isotopes ($^{48}$Ca) to produce neutron-rich beams. There is concern about the cost of isotopes, purity, and availability when there is only one supplier.

In R&D, there also is a wide diversity of users and uses. Radioisotope micropower sources (nuclear batteries) are of particular interest. Most demands are being met by either domestic or foreign suppliers. The availability of isotopes is often time-dependent and dictates research plans. Medical needs for R&D can vary significantly, which makes planning difficult. There is concern about the supply of actinides and especially $^{252}$Cf. Other production concerns include:

- Facilities are not fully utilized nor matched to the production needs of the community.
- There is a shortage of trained personnel for processing.
- There is a need for qualified shipping containers.
- Costs might not be restrained by competition.

In radioisotopes for applications, the major needs are for $^{252}$CF and $^{99}$Mo. Better coordination is needed, as is efficient use of existing production resources. There are implicit vulnerabilities with dependence on foreign supply (e.g., for $^{99}$Mo). Some isotopes have only a single or no supplier (e.g., $^{252}$Cf) and need multiple suppliers. The availability of alpha emitters is diminishing. A supply for certain medical-research isotopes ($^{225}$Ac and $^{211}$At from $^{229}$Th) is needed. The extraction of $^{229}$Th from $^{233}$U is feasible but becoming impossible. Cradle-to-grave husbandry is needed. Public/private partnerships are needed. The strategic importance of key isotopes needs to be identified and socialized. More and better training and education programs are needed for related programs.

The workshop was a success, namely good communication among academic, medical, industrial, commercial, federal, and national laboratory personnel. The lines of communication between separate groups are now opening. It was suggested that the workshop should be repeated annually. NP learned a good deal of the needs of the nation for isotopes. There are a number of key issues that need addressing. The final report is in preparation and is to be completed in October 2008.

D'Auria observed that the "same old, same old" has to be avoided. The transfer of the program to NP opens up new opportunities. Costs of research isotopes are of concern. The lack of supplies is important. France, Korea, South Africa, and Australia have built new accelerators for isotope production.

Ent asked how well represented the medical community was. D'Auria replied that about one-third of the 170 attendees were from the medical community.

Heinz asked how much international participation there was. D'Auria responded that there was a summary presented from the International Atomic Energy Agency, a summary of Canadian production, and other but incomplete summaries of international activities

Schatz asked if there were international coordination. Pantaleo answered that DOE has gotten away from commercial isotopes, and provides only a small piece of the overall supply. International suppliers back each other up.

Ji asked how DOE's isotope production operates. Pantaleo replied that representatives of DOE attend meetings to meet customers. A meeting of all users and manufacturers is important so all the needs can be understood. Research isotopes are produced in batches. What is needed is a continuous flow of isotopes.

A break was declared at 10:27 a.m. The meeting was reconvened at 10:58 a.m. **Jehanne Simon-Gillo** was asked to describe the new charges to the Office. NP's budget for commercial isotope production and development is $16.7 million. Commercial isotope production is conducted on a full-cost-recovery basis. Operations of the program are supplemented by additional funds from sales, which are collected in a Treasury revolving fund. This is a business. The FY09 President's Request also includes $3.2 million for R&D on and production of research isotopes.

There are many techniques and locations for isotope production. Isotope production at the Brookhaven Linac Isotope Producer (BLIP) and the Los Alamos Neutron Science Center (LANSCE) will become part of the NP portfolio. Some production facilities are in the portfolios of other DOE offices. $^{252}$Cf production used to be jointly supported by NNSA. With additional industry funds, $^{252}$Cf production is expected to continue. The transfer of the isotope program is an extraordinary opportunity for the NP program with a phenomenal impact for the nation. Synergy needs to be built between basic research programs and isotope production and development, and new and effective mechanisms of communication need to be defined between the program and its stakeholders. The program is constrained and underfunded; it cannot meet growing demands, its facilities require investment for robust operations, and staffing levels are inadequate. Setting priorities, developing a strategic plan, making optimum use of existing resources, and exploring partnerships with other federal agencies and commercial entities are necessities.

In the charges, DOE NP requests that NSAC establish a standing committee, the NSAC Isotope (NSACI) Subcommittee, to advise NP on specific questions concerning the National Isotope Production and Applications (NIPA) Program.

The first charge states that, as part of the NIPA Program, the FY09 President's Request includes $3,090,000 for the technical development and production of critical isotopes needed by the broad U.S. community for research purposes. NSACI is requested to consider broad community input regarding how research isotopes are used and to identify compelling research opportunities using isotopes. The Subcommittee's response to this charge should include the identification and prioritization of the research opportunities; identification of the stable and radioactive isotopes that are needed to realize these opportunities, including estimated quantity and purity; technical options for producing each isotope; and the research and development efforts associated with the production of the isotope. Timely recommendations from NSACI will be important in order to initiate this program in FY09; for this reason, an interim report is requested by January 31, 2009, and a final report by April 1, 2009.

The second charge requests NSACI to conduct a study of the opportunities and priorities for ensuring a robust national program in isotope production and development and to recommend a long-term strategic plan that will provide a framework for a coordinated implementation of the NIPA Program over the next decade. The strategic plan should articulate the scope, the current status and impact of the NIPA Program on the isotope needs of the nation, and the scientific and technical challenges of isotope production today in meeting the projected national needs. It should identify and prioritize the most compelling opportunities for the U.S. program to pursue over the next decade and articulate their impact. A coordinated national strategy for the use of existing and planned capabilities, both domestic and international, and the rationale and priority for new investments should be articulated under a constant-level-of-effort budget and under an optimal budget. To be most helpful, the plan should indicate what resources would be required, including construction of new facilities, to sustain a domestic supply of critical isotopes for the United States and should review the impacts and associated priorities if the funding available is at a constant level of effort (FY09 President's Request budget) into the out-years (FY09 to FY18). Investments in new capabilities dedicated for commercial isotope production should be considered, identified, and prioritized but should be kept separate from the strategic exercises focused on the remainder of the NIPA Program. An important aspect of the plan should be the consideration of the robustness of current isotope production operations within the NIPA program in terms of technical capabilities and infrastructure, research and development of production techniques of research and commercial isotopes, support for production of research isotopes, and current levels of scientific and technical staff supported by the NIPA Program. An interim report containing the essential components of NSACI's recommendation to the Department is to be submitted by April 1, 2009, followed by a final report by July 31, 2009.

Tribble noted that many other resources are producing isotopes (e.g., with accelerators) across the country that are not part of this program. Ent asked how the isotope strategic planning efforts are to be integrated into the NP program R&D efforts and the long-range plan. Simon-Gillo replied that a long-range plan was just finished for NP. The isotope effort will have to be done separately this year, but they are expected to be merged in the future. People are willing to work with this program, even industry. A lot of key individuals will provide valuable input. Integration with these other communities will be necessary. When one looks at past reports, the needs reflected are the same over time.

Heinz asked if this charge addresses only isotopes that cannot be commercially produced or whether there is a possibility that commercial capabilities could be expanded. Simon-Gillo said that there are a lot of commercial proposals out there that would have private sources contribute to the solution. However the DOE program only produces isotopes that are not commercially available.

Milner observed that a trained work force is needed. The academic preparation of that work force might be a focus of this Subcommittee.

Lee asked how big the turnover of the rotating fund was. Simon-Gillo replied that that amount varies from year to year. It started at about $14 million. Sales are about $12 million per year. The staff costs are partly covered by appropriations.

Tribble noted that the work of the Subcommittee will be substantial. There will be two co-chairs, one for each charge. These co-chairs have been identified. The other positions on the Subcommittee (up to 18 more seats) need to be filled. The user communities have never thought about a long-range plan or strategic plan; that will be a key capability that NSAC can bring to the table. Finding the boundary between public and commercial production will be tricky.

Simon-Gillo said that the Subcommittee will identify gaps; it will identify opportunities for DOE to get involved in satisfying national needs.

Geesaman asked what SC's commitment to this program was. Patricia Dehmer replied that SC is very committed and is receiving an appropriation to operate the program. Geesaman asked if the Office were comfortable with assuming responsibility for the legacy facilities (e.g., hot cells). Patricia Dehmer replied, yes. Information on facilities for isotope production can be provided to the Subcommittee.

D'Auria noted that plutonium is not included. Simon-Gillo replied that plutonium will remain an NE responsibility for supply to the National Aeronautics and Space Administration and to the National Institute for Standards and Technology.

**Jonathan Kotcher** was asked to provide an update on DUSEL, an underground laboratory supporting unique science and engineering research. The primary motivation has been for fundamental physics research, exploiting the shielding from cosmic rays. DUSEL, if approved, would be the world-leading underground laboratory, resulting in transformational and innovative streams of research. The questions it is intended to address include:

- Given that only 4% of the mass of the universe is observed, of what is the other 96% composed?
- Is visible matter stable?
- What are the mass and fundamental properties of the neutrino?
- What is the spectrum of neutrinos from supernovae and the Big Bang, and what can this tell us about the history and evolution of our universe?

The aforementioned questions are addressed at DUSEL via a variety of experimental probes:

- Direct detection of dark matter
- Neutrinoless double-beta decay
- Nuclear astrophysics
- Accelerator-based cross-section measurements
- Solar Neutrinos
- Long baseline experiment, proton decay, and supernovae remnants (megadetector)

DUSEL funding for major research equipment and facilities construction (MREFC) would support the construction of forefront experiments in nuclear- and astrophysics, and in particle physics using the Fermilab accelerator as a high-intensity neutrino source.

As stated by the "Neutrinos and Beyond" report from the NRC, a national underground laboratory offers the United States some vital scientific opportunities that will affect a number of important international efforts and provide a center in the United

States for some of the most exciting physics at the beginning of the 21st century. The community is now detailing the case.

A solicitation process was initiated in 2004. Solicitation 1 (S1) defined the site-independent science scope and infrastructure needs. S2: developed conceptual designs for one or more sites. S3 developed a facility design for an MREFC candidate. The awards totaled $15 million over 3 years, starting in September 2007. S4 will develop technical designs for candidates for the DUSEL suite of experiments. It will award $15 million over 3 years.

The goal for S3 was to a select single site and a team to develop a technical design for a facility. Four proposals were reviewed by a multidisciplinary 22-member expert panel. The review included site visits and reverse site visits. The panel unanimously voted by secret ballot to recommend the Homestake proposal to the NSF for funding. NSF concurred. A cooperative agreement was negotiated with the University of California at Berkeley in September 2007, and $10 million was awarded in FY07 and FY08. The final allotment will be awarded near in FY09.

The scope is being driven by the needs of physics experiments. Only the most compelling, transformational experiments will be considered for DUSEL. This is one factor that will contribute to determining the overall DUSEL scope. Cost is another. The DUSEL solicitation process provides funds to allow the community to estimate costs, including operations, up front. It also allows NSF approval decisions and potential scope adjustments to be made in an informed manner.

S4 is a call for proposals to develop project plans for potential candidates for the DUSEL suite of experiments. Design funds are to address the question of what is needed to execute the proposed experiment. Up to $15 million is available from Physics/MPS, spread over 3 years. This solicitation is under review by NSF upper management.

In addition to the criteria of intellectual merit and broader impacts approved by the National Science Board (NSB), some general DUSEL-specific criteria under consideration for evaluation of the S4 proposals include:

- Compatibility with the envisioned DUSEL science and engineering program;
- Appropriateness for inclusion in the envisioned facility and experimental-suite-related concerns, physical-access requirements, etc.; and
- The potential for developing a complete, realistic preliminary design for a world-class research project matched to the DUSEL mission, capabilities, and time scale.

The S1 Panel passed the baton for continuing the definition and development of experiments to the DUSEL Experiment Development Committee, which will coordinate the development of the superset of candidate experiments and project plans.

The South Dakota Science and Technology Authority (SDSTA) holds $124 million for the development of the Sanford Underground Science and Engineering Laboratory (SUSEL). It will fund an education center, refurbishment of 4850L and 7400L (partial), and operation and maintenance of Sanford Laboratory activities. An initial allotment ($60 million) has been released and is in use. Release of the remaining funds is conditional. Key staffing is under way, including naming a laboratory director. The SDSTA began mine re-entry in late July 2007. Dewatering began April 21, 2008. Access to 4850L is scheduled for February 2009. These activities are decoupled from the

MREFC process but integrated into DUSEL facility planning. Town meetings, workshops, and a conference have been held.

NSAC was charged by DOE and NSF in July 2006 with developing a long-range plan. The Particle Physics Project Prioritization Panel (P5), a subpanel of the High Energy Physics Advisory Panel (HEPAP), was charged in January 2008 by NSF and DOE with recommending a 10-year road map for particle physics. It recommended a world-class neutrino program as a core component of the U.S. program, with the long-term vision of a large detector in the proposed DUSEL laboratory and a high-intensity neutrino source at Fermilab. It also endorsed the importance of a deep underground laboratory to particle physics and urged NSF to make this facility a reality as rapidly as possible. Furthermore, the Panel recommended that DOE and NSF work together to realize the experimental particle physics program at DUSEL. The Fermilab/DUSEL program recommended by P5 constitutes the primary element of the on-shore U.S. particle physics program during the coming decade. The Long Baseline Experiment would produce a neutrino beam at Fermilab and extend 1300 km to the megadetector at DUSEL.

A Joint Oversight Group (JOG) is being established to oversee those DUSEL physics experiments jointly implemented by NSF and DOE. The roles and responsibilities are being based on past models. Four meetings have been held, and a draft memorandum o understanding has been drawn up. The first JOG meeting date and agenda are under discussion.

The project team has established a baseline target date of December 2009, but recent events have prompted a reconsideration. A schedule update will be announced at an appropriate venue in the fall. The facility design team held an internal review of the facility, and planning for the initial NSF review is under way. It will review the facility and experiments, as appropriate.

The working model for DUSEL facility planning assumes facility infrastructure construction costs would be borne by NSF. Partnerships with DOE and others are anticipated for experiments. At this early stage, the Physics Division is using the following rough planning targets: $500 million for MREFC, split evenly between facility and experiments, and a 7- to 8-year construction period, with experiments being deployed as they are ready. The operations costs for facility infrastructure would be borne by the Directorate for Mathematical and Physical Sciences (MPS).

DUSEL-related R&D funding was awarded to successful proposals that were submitted to both agencies, reviewed, and prioritized in March 2007. The program was continued in 2008 and will continue in 2009, funding permitting.

Lee asked about the relationship between SUSEL and DUSEL. Kotcher replied that state money is being used for refurbishment of the site, and that SUSEL was part of DUESL planning, but that this was a state initiative being done independently.

Ent asked when the completion date was, and how operations funding would be interleaved with that. Kotcher replied that full operations may be reached before the completion of the facility, and would ramp up during construction to support experiments as they came on line.

Geesaman asked what the path forward was to the megadetector experiment. Kotcher replied that the depth of the caverns for the megadetector is still under debate, being investigated by the community. The NSF would dig the caverns, and the costs of the experiments would be shared between DOE and NSF.

Bryman asked what the magnitude of the total cost for the megadetector was. Kotcher replied that that amount is unknown at this time.

Ji asked what other decisions must be made before construction commences. Kotcher replied that the design must be mature and well-founded. The design must be reviewed and sent to the National Science Board for approval before it can be submitted for congressional funding.

A break for lunch was declared at 12:00 p.m. The meeting was called back into session at 1:31 p.m. **Geoffrey Greene** was asked to give an update on the FNPB at the Spallation Neutron Source (SNS). The SNS is an accelerator that produces pulsed neutrons 60 times per second at high peak intensities. The first SNS beam was on target in April 2006. The facility is running slightly ahead of the projected ramp-up in terms of the neutrons available to users. One beamline has been allocated for nuclear physics. That FNPB has undergone many reviews and is highly leveraged with \$9.2 million from DOE for construction of the beamline itself, \$1.4 billion from BES for the construction of the SNS, and \$120 million per year from BES for operation of the accelerator and target. Experiments are selected by a proposal-driven, peer-review process. The physics being addressed include accurate measurement of parameters that describe the beta decay of the free neutron, precision measurement of parity violation in the interaction of low-energy neutrons with simple nuclear systems, and the search for a non-zero permanent neutron electric dipole moment. These experiments are being investigated with a cold-neutron, broad-band beam and a monochromatic beam at 8.9 Å for ultra-cold neutrons (now under construction). Ten proposals have been received and reviewed; five have been approved, four have been deferred, and one has received a beam allocation. The first experiment that will be run will be the $n + p \rightarrow d + \gamma$ experiment (npdgamma). The FNPB cold guide is to be commissioned this September, the first beam to npdgamma is scheduled for Spring 2009, the cold-beam operation with liquid hydrogen is scheduled for summer 2009, and the building for the electric dipole moment work will be available in late summer 2009.

Wilkerson asked how beam time will be allocated. Greene replied that it will be decided by a committee on the year-by-year basis.

**Martin Cooper** was asked for an update on the Neutron Electric Dipole Moment (nEDM) Project at Los Alamos National Laboratory. The neutron electric dipole moment is a small change in charge along the direction of spin of the neutron. The current value is $<3 \times 10^{-26}$; it is hoped to obtain $<2 \times 10^{-28}$ in superfluid helium by looking for a precession frequency $\omega_d$ that will show up in SQUIDs [superconducting quantum interference devices] as a phase shift in scintillation light that is proportional to the electric dipole moment of the neutron. Neutrons here are made with the superthermal process. The collaboration's foci are demonstration of technical feasibility, development of preliminary engineering, and project management. R&D risks have been assessed by the R&D team. The $^3$He-spin relaxation is has been measured, the multiplier tubes were certified at 8 K, the SQUID signal-to-noise ratio was characterized, and the experimental hall and central detector are being engineered. DOE funding totals \$11.8 million, and NSF funding totals \$7.5 million. The conceptual design was approved in February 2007. The technical feasibility, preliminary engineering, cost, and schedule baseline will be approved by February 2009. Construction approval is expected in August 2009 and beneficial occupancy in January 2010. The project is expected to be completed in 2015 with the first results published in 2018 and the experiment concluded by 2020.

Ji asked about the ILL [Institute Laue Langevin] reactor. Cooper responded that the ILL will start running fairly soon but will require a long learning curve; their problems will take a long time to solve.

Lee asked what would be done if something positive is seen (e.g., in a dipole moment). Cooper replied that the other atomic systems will be pursued in parallel.

**Peter Conti** was asked for an overview of the National Research Council report on improving nuclear medicine through innovation. Imaging is evolving from the anatomical to the functional to the molecular with the goals of (1) providing a mechanism for rapid translation of developments in cellular and molecular biology and other basic sciences into improvements in patient care and (2) facilitating the understanding of the molecular basis of disease. Some of the applications are to visualize tissue metabolism, biochemistry, and molecular targets/receptors with labeled or tagged biologically active compounds; to be an adjunct to diagnosis and staging of disease in the absence of anatomic findings; to determine the biological response to specific therapeutic agents; and to understand the pharmacology of new drugs with labeled analogues. The technologies include positron-emission tomography (PET)/computed tomography (CT), single photon emission computed tomography (SPECT)/CT, Magnetic Resonance spectroscopy (MR) spectroscopy, contrast-enhanced ultrasound/doppler, bio-active MR contrast agents, and PET/ magnetic resonance imaging (MRI).

PET is widely deployed across the United States. The number of imaging sites has increased to 1500 since the turn of the century. Fluoro-2-deoxyglucose (FDG) sales have increased at a rate of 34% per year. Three million PET scans are taken each year (out of 20 million nuclear-medicine procedures per year). The benefits of both PET and CT can be used to improve diagnostic accuracy and to optimize patient care. Data from concurrent studies is often essential for timely diagnosis and management decisions. Virtually all scanners are now hybrids in nature. CT is used for multi-slice scans, breath-hold studies, arterial studies, and cardiac exams. In oncology, FDG/PET is used in diagnosis and staging, treatment planning, treatment response, detection of recurrent or residual disease, and re-staging. The addition of CT to PET allows acquisition of anatomical information and improved diagnostic power.

Several isotopes can be used as PET emitters. PET has a number of approved applications, and the list is growing. Isotope access is an important issue.

1-(2'-Deoxy-2'-fluoro-D-arabinofuranosyl)thymine (FMAU) is an alternative to 3'-deoxy-3'-fluorothymidine (FLT) as a cell-proliferation marker. The properties are most reflective of the natural substrate except it is non-catabolized. It is in clinical trials. The lack of bone uptake and bladder activity may have clinical advantages over other agents. It is prepared with C-11 or F-18. The FDA and industry are interested in it for multi-center expansion.

A whole spectrum of technologies can be applied to small-animal studies, making experiments easier, more numerous, and more informative in a shorter time. The goal is to streamline drug discovery, finding the right drug against the right target to treat the right disease in the right patient. Standardization of the imaging-technology platforms and protocols used in clinical trials is essential for the incorporation of molecular-imaging technologies and the development of surrogate markers.

The work force that underpins these technologies is aging and needs to be reinforced. Radiochemistry faculty are also aging and waning in numbers. The number of doctorates in radiochemistry is declining.

Several sophisticated molecular-imaging technologies are currently available for use in clinical trials at academic institutions throughout the United States. The need for the use of radio-, optical, and other forms of biologically active tracers or contrast agents to diagnose disease and assess the efficacy of novel therapeutics is growing, particularly with the use of cytostatic drugs. Hybrid imaging is becoming increasingly important as more biologically targeted tracers are introduced. Translational research and drug discovery/development will depend increasingly on targeted imaging for success. However, the regulatory burden, work-force shortages, and lack of protocol standardization have the potential to create the "perfect storm" in imaging research. Reduction in federal funding at NIH threatens the success of the movement towards personalized healthcare. Elimination of DOE funding in nuclear medicine will have a long-lasting negative impact on development of the next generation of imaging devices and radiopharmaceuticals.

A National Academy of Sciences (NAS) panel was convened to assess the future needs of radiopharmaceutical development for the diagnosis and treatment of human disease. It found a loss of federal commitment for nuclear medicine research, a cumbersome set of regulatory requirements, an inadequate domestic supply of medical radionuclides for research, a shortage of trained nuclear-medicine scientists, and a need for technology development and transfer. There is no short- or long-term programmatic commitment by any agency to funding the chemistry, physics, and engineering research and associated high-technology infrastructure (accelerators, instrumentation, and imaging physics) that are at the heart of nuclear-medicine-technology research and development. There is no domestic supplier for most of the radionuclides used in day-to-day nuclear medicine practice in the United States and no accelerator dedicated to research on the medical radionuclides needed to advance targeted molecular therapy in the future. Training for nuclear-medicine scientists, particularly for radiopharmaceutical chemists, has not kept up with current demands in universities and industry, a problem that is exacerbated by a shortage of university faculty in nuclear and radiochemistry. The Medical Applications and Sciences Program under BER is now grossly underfunded after decades of support for the field. The NE Isotope Program has not met the needs of the community, and its activities have not adequately been coordinated with BER and NIH. Public Law 101-101, requiring full-cost recovery for DOE-produced isotopes, has restricted research isotope production and radiopharmaceutical research. The NAS report made a number of recommendations:

- Support for the BER nuclear-medicine research program should be re-instated; the national nuclear-medicine research program should be coordinated by DOE and NIH, with the former emphasizing the general development of technology and the latter disease-specific applications; and strategic planning should include academia, national laboratories, and other sources of expertise.
- Complex U.S. Food and Drug Administration (FDA) toxicologic and other regulatory requirements should take into account differences in diagnostic and

therapeutic agents; specific guidelines should be developed by the FDA; and standardized imaging protocols should be developed for clinical trials.

- FDA should clarify and issue final guidelines for performing pre-investigational new drug evaluations; FDA should issue final current good manufacturing practices (cGMPs) for radiopharmaceuticals, graded commensurate with the properties, applications, and potential risks of the agents; and prototypes of standardized imaging protocols should be developed for multi-institutional clinical trials.
- There is no domestic source for most medical radionuclides used in day-to-day nuclear medicine practice; a dedicated domestic accelerator and reactor for production of isotopes for nuclear medicine research is lacking; the parasitic use of high-energy physics machines has failed to meet the needs of the medical research community with regard to radionuclide type, quantity, timeliness of production, and affordability.
- A dedicated accelerator and an appropriate upgrade to an existing research nuclear reactor are needed.
- There are (1) a critical shortage of clinical and research personnel in all nuclear-medicine disciplines and (2) fewer U.S. students with careers in chemistry; the restriction of training grants to U.S. citizens and permanent residents, as required by the Public Service Act, is a substantial impediment to the recruitment of chemists.
- NIH, DOE, and professional societies should organize expert panels to discuss shortages and remedies, including curriculum development and funds for training grants; innovative programs should be created to engage overseas recruits.
- There is a need for the development of high-specific-imaging technology and targeted radiopharmaceuticals for disease diagnosis and treatment; improvements in detector technology, image-reconstruction algorithms, and advanced data processing, as well as lower-cost radionuclide production technologies, are needed; the transfer of technology discoveries from the laboratory to clinical use is critical for future success; and federally funded research and development has historically driven the field of nuclear medicine worldwide.
- BER should continue to encourage collaborations among physics, chemistry, computer sciences, and imaging laboratories; multidisciplinary centers should be considered to stimulate flow of new ideas and next-generation radiopharmaceuticals and imaging instrumentation; and the role of industry should be considered along with mechanisms to hasten technology transfer.

Ji asked why suppliers were moving overseas. Conti replied that the investments are being made overseas; they are making money from us. It is cheaper with less regulation, and that is where the trained work force is.

Heinz asked why foreign sourcing was a problem. Conti replied that taking dangerous materials across borders and reliance on foreign sources are the issues. Health-insurance companies will not pay for this technology, and trained people are being lured away by industries' higher wages.

Bryman asked if they had looked at emerging technologies. Conti replied, just a little bit but not in much detail.

Joseph Dehmer asked what the post-report strategy was. Conti said that this study was underwritten by DOE and NIH. The big impact was the shock that the programs were not already being done. The number one issue was management, and the committee was not allowed to address that question.

Lee asked how much money is being talked about. Conti said that a couple of hundred thousands of dollars a year would go a long way in training new people for the system. A couple of new dedicated cyclotrons would go a long way to meet demand. About $15 million would be needed for reactor upgrades over a period of time.

**Lawrence Cardman** was asked to report on the Jefferson Laboratory user facility. The 6-GeV program is running at about 80% utilization and continues to produce outstanding science. Nucleon-structure experiments are establishing the validity of the generalized parton distributions (GPDs) and factorization, demonstrating the complementarity of neutron and proton data and establishing neutron measurements as essential in the hunt for quark orbital momentum. Neutron-structure functions were investigated with spectator proton tagging to select the low-momentum part of the d-wave function and to tag the motion of the struck neutron. The program presents additional outstanding opportunities between now and the 2013 shutdown. However, budget limitations may keep it from realizing its potential. The 12-GeV upgrade is progressing toward a 2015 project completion. It is on cost and ahead of schedule and is ready to start construction according to a Lehman review. Its CD-3 is anticipated on September 3, 2008. Successful tests have been run on the quarter-sized cryomodules, the digital controls for phase and amplitude, and the designs for the beamline magnets. Budgets and an impending continuing resolution may delay the 12-GeV upgrade by 6 months and add $6 million to the cost. Budget levels; increased infrastructure investments; and increased environmental, health, safety, and cybersecurity requirements are reducing the amounts available for science.

**Steven Vigdor** was asked to report on the RHIC user facility. An optimal run is 30 cryoweeks, which includes 23 weeks of physics production. In each of the past 3 years, RHIC has been able to support only about 20 cryoweeks per year. Despite the loss of beam time, the beam has functioned very well with close to the maximum projected luminosity each year and with the design goal luminosity being exceeded in 2007. A run completed in 2008 provided an integrated luminosity that was a factor of 10 greater than the previous record. There has been a significant learning curve with unique and complex polarization-preserving equipment. 60% beam polarization was achieved reliably in 2006. Polarization survival to 250-GeV maximum energy has been demonstrated. RHIC has begun to characterize the "perfect" liquid, is searching for the QCD [quantum chromodynamics] critical point, and is improving constraints on the polarization of gluons and sea antiquarks in a polarized proton. Plans for Run 9 give the highest priority for both the Solenoidal Tracker at RHIC (STAR) and Phenix to p + p, with a long run at 200 GeV plus first results at 500 GeV. The President's FY09 budget request would support about 28 cryoweeks. It is planned to start cooldown in mid-February 2009. Under a continuing resolution, cash-flow problems would begin about April 1. If at least half of the budget were received during the third and fourth quarters, RHIC would run for 19 cryoweeks, emphasizing 200 GeV. If the continuing resolution lasted more than 6 months, some of the spending would be delayed to squeeze out 8 cryoweeks for a minimal 500-GeV polarized-proton run. If the budget situation were resolved early, cooldown could start February 1 to accommodate both 200- and 500-GeV polarized-proton runs. A suite of detector upgrades is ongoing, guided by a 6-year plan. Some performance milestones will be missed if budgets do not permit two-species-per-year runs in FY10 to FY14. RHIC-II science could continue well beyond the current 6-year plan, fueled by further possible luminosity improvements from stochastic-cooling upgrades for heavy ions and by electron lenses for polarized protons.

**Thomas Glasmacher** was asked to report on the NSCL user facility. The facility is studying the production and properties of nuclei far from stability, nuclear processes responsible for the chemical evolution of the universe, the equation of state (EOS) of neutron-rich nuclear matter, and beam dynamics and accelerator physics related to superconducting cyclotrons, linacs, and magnets. All of these programs are supported by two cyclotrons. New isotopes were discovered: $^{40}$Mg, $^{42,43}$Al, and $^{44}$Si. Also, the first direct angular and energy correlation measurement was made in two-proton decay. Accurate masses were determined for more than 30 isotopes of more than 10 elements: $^{32,33}$Si, $^{29,34}$P, $^{37,38}$Ca, $^{40\text{-}44}$S, $^{63\text{-}65,65m}$Fe, $^{64\text{-}66}$Co, $^{63\text{-}64}$Ga, $^{64\text{-}66}$Ge, $^{66\text{-}68,80}$As, $^{68\text{-}70,81,81m}$Se, and $^{70m,71}$Br.

Rare-isotope beams are produced reliably and predictably. New experimental apparatuses are being installed. For the next 3 years, the facility will have state-of-the-art experimental equipment. A new office wing is to be finished by July 2009.

**Robert Janssens** was asked to present news from the ATLAS user facility. The facility is operating 6 days per week, and construction of the Californium Rare Ion Breeder Upgrade (CARIBU) and the energy upgrade are ongoing. There is a $100,000 shortfall in funding, and the energy upgrade is not yet complete because of a lack of manpower. New instrumentation capabilities are being developed to capitalize on CARIBU and ATLAS. However, instrument development has been limited by a shortfall in capital-equipment funding in FY08.

CARIBU gives access to exotic beams not available elsewhere. The energy upgrade provides beams in the regime of 12 MeV/u, ideal for transfer-reaction studies. The HELIcal Orbit Spectrometer (HELIOS) will greatly expand the effectiveness of both the fission-fragment beams and the existing in-flight rare-isotope beam (RIB) program at these higher energies. All three projects are funded. In FY08, 47 experiments were conducted with 5200 beam hours and 40 beams, serving 459 users. The νp process has been ruled out as the origin of the anomaly in the relative production abundances of $^{92}$Mo and $^{94}$Mo. A new test of ab initio calculations in A = 10 nuclei has been developed. The first observation has been made of single-neutron states in $^{101}$Sn.

If there were a continuing resolution, the scientific and technical work force could be protected for 6 months at most, and anticipated hiring would be postponed, delaying the start of CARIBU. In addition, the available beam time would be decreased, and the next Physics Advisory Committee meeting would be postponed by 1 to 2 months. The lack of capital-equipment funding puts ATLAS operations and the experimental equipment at risk in the event of a major equipment failure.

**Glenn Young** was asked to report on the Holifield Radioactive Ion Beam Facility (HRIBF). A second Injector for Radioactive Ion Species (IRIS-2) is under construction and will be commissioned in 2009. Holifield uses the ISOL [isotope separator online] technique; 175 radioactive ion beam (RIB) species are available, of which 32 are proton-rich and 143 are neutron-rich, giving ORNL the capability to produce neutron-rich nuclei in or near the r-process path and to measure transfer reactions with them. In FY07, the facility produced 3648 beam hours with a 91% reliability. The reaction $^{17}F + p \rightarrow {}^{18}Ne + \gamma$ was directly measured for the first time at HRIBF. Radiation emitted during the spontaneous decay of several exotic nuclei near doubly magic $^{78}Ni$ and $^{100}Sn$ has been observed for the first time, advancing the understanding of the evolution of nuclear structure and providing information on the path of rapid stellar processes responsible for the formation of elements in the universe. The fastest known alpha decays were identified at HRIBF. Ion beams of 12 elements have been produced with the Laser Ion Source; nine of these elements were ionized for the first time with Ti:sapphire lasers.

If there were a 6-month continuing resolution followed by full FY09 budgeting, the overall operating hours could probably be maintained, but an increased risk of having to recover from a major breakdown would have to be accepted; planned hiring would be cut in half and delayed at least 6 months. A decrease in the third and fourth quarter budget would require some scaling back in hours as well.

The floor was opened for public comment. **Robert Atcher**, the President of the Society for Nuclear Medicine, noted that the availability of many of the isotopes identified at the recent workshop is critical for moving nuclear-medicine research forward. The community has been impressed by the NP staff's interest in nuclear medicine. Isotopes are also important for homeland security. Better engagement between the nuclear-medicine and nuclear-physics communities is important. NE was not interested in user-facility models. Also, expanding thinking beyond the national laboratories is important in the strategic planning process.

Milner asked for an updated report on nuclear theory in the future.

The next meeting date will be determined by an e-mail poll. There should be a meeting before the December 5 expiration of the terms of some of the Committee members.

A call for further public comment was made. There being none, the meeting was adjourned at 4:26 p.m.

These minutes of the DOE/NSF Nuclear Science Advisory Committee meeting held at the Marriott Crystal Gateway Hotel, Arlington, Virginia on August 21, 2008, are certified to be an accurate representation of what occurred.

Robert Tribble
Chairman
DOE/NSF Nuclear Science Advisory Committee