Minutes of the Meeting of the
Department of Energy and National Science Foundation
Nuclear Science Advisory Committee
Sheraton Crystal City Hotel
Arlington, Virginia
March 8-9, 2007

Members Participating:

Robert Tribble, Chairman
David Dean
Charlotte Elster
Rolf Ent
Thomas Glasmacher
Ulrich Heinz
Xiangdong Ji
Roy Lacey
I-Yang Lee
Naomi Makins
Richard Milner
Michael Ramsey-Musolf
Guy Savard
Susan Seestrom
Thomas Ullrich
Ubirajara van Kolck
John Wilkerson
William Zajc

Members Absent:

Douglas Bryman
Heino Nitsche

Others Participating:

Lawrence Cardman
Joseph Dehmer
Konrad Gelbke
Eugene Henry
Calvin Howell
Bradley Keister
Dennis Kovar
Thomas Ludlam
Blaine Norum
Jehanne Simon-Gillo

Presenters in Order of Appearance:

Eugene Beier
Joseph Dehmer
Raymond Orbach
Bradley Keister
Dennis Kovar
Brian Fulton
Elizabeth Beise
Peggy McMahan
Calvin Howell
James Symons
Michael Ramsey-Musolf
Robert Janssens
Xiangdong Ji
Thomas Ullrich
I-Yang Lee
David Dean
Rolf Ent
Susan Seestrom
Peggy McMahan

About 20 others were in attendance during the course of the two-day meeting.

Chairman Tribble called the meeting to order at 9:18 a.m. He welcomed the new members and had all the members introduce themselves. He introduced **Eugene Beier** to present a status report on the activities of the Neutrino Scientific Assessment Group (NuSAG) dealing with its second charge. That charge is to consider the scientific potential, detector options, timeline, needed scientific inputs, and addressable additional physics of a megawatt-class proton accelerator as a neutrino source for a multiphase off-axis program or a long-baseline broad-band program of neutrino research. Tokai-to-Kamioka (T2K) and the NuMI Off-Axis ν_e Appearance (NOvA) experiment will use off-axis neutrinos to create narrow-band beams. Brookhaven National Laboratory (BNL) and Fermi National Accelerator Laboratory (Fermilab) have created a working group to study the options.

The main scientific objectives are to determine the mixing angle θ_{13}, the neutrino mass hierarchy, and the presence or absence of CP violation in oscillation experiments. There is a world-wide effort to do this. Currently, reactor experiments at Double Chooz in France and Daya Bay in China and accelerator experiments with T2K and NOvA are planned. The following round of accelerator experiments would extend the mass-hierarchy and CP-violation sensitivity to $\sin^2 2\theta_{13}$ down to about 0.01. A major uncertainty is the size of θ_{13}. Theoretical models give a large range of possible answers. If it is small, it is difficult to measure. If it goes below 0.01, a new beam technology will be needed to investigate it.

If $\sin^2 2\theta_{13}$ is large enough to be observed, it opens a new era of discovery perhaps allowing for the resolution of the mass hierarchy problem and searching for possible CP violation in the neutrino sector. Both off-axis and wide-band beam approaches have been considered using a high-power proton beam. The experimental options all start with the Fermilab Main Injector, which has achieved a maximum beam power of 315 kW. It will initially be upgraded to 700 kW and then to 1.2 MW. Less beam power is produced at lower energies. The off-axis approach uses about 100 kt of liquid argon on or near the surface, the NuMI beam, and one or more detectors. The wide-band beam, very-long-baseline experiment would use a 300- to 500-kt water-Cherenkov detector underground [in the Deep Underground Science and Engineering Laboratory (DUSEL)] with a new neutrino beam. With the wide-band-beam approach, the location of DUSEL affects the discovery contours. If the baseline is too short, a matter effect is small; if it is too long, some sensitivity is lost.

Other physics, such as that on nucleon decay and low-energy neutrino astrophysics, may be possible with these facilities, although they may accrue additional costs.

The water-Cherenkov technology is known, is large, requires an underground facility, and has high costs and long construction times determined by the manufacture of the photomultiplier tubes. It would benefit from R&D on new light sensors. The liquid-argon technology can reconstruct events in detail, leading to excellent neutral pion rejection; requires aggressive R&D to prove its feasibility at scale; and must demonstrate that it can work at the surface. These factors translate to the two approaches under consideration as follows:

- The positive aspects of the off-axis approach are the reduced neutral-pion background, the known neutrino energy, the use of the existing NuMI beam, the common detector technology for near and distant detectors, and the possibility of an incremental deployment. The negative aspects of the off-axis approach are the need to deal with the ambiguities associated with a single energy if operating at a single oscillation maximum, the very low event rates at the second-maximum site, the need to be on the surface, the intensive R&D needed on liquid-argon detectors, and the differences in the beam quality between the near and far detectors.

- The positive aspects of the wide-band-beam approach are the full energy spectrum for resolving ambiguities, the proven detector technology, the broader physics program allowed by DUSEL, and the encouraging recent progress in neutral pion rejection in the water-Cherenkov technology. The negative aspects of the wide-band-beam approach are the large, all-at-once cost; the possible timeline constraints imposed by DUSEL; the cost uncertainties associated with the photomultiplier tubes tube coverage; and the need for different types of detectors at the near and far locations.

In summary, NuSAG is educated on the issues, the findings on technical issues are mostly in place, the BNL/Fermilab study group is working on directly comparable sensitivity calculations for the different scenarios, the need for an observation of a nonzero θ_{13} is clear, the value of θ_{13} determines the needed detector masses (and costs), and the needed R&D has been identified. The NuSAG report will be available before the next NSAC and High Energy Physics Advisory Panel (HEPAP) meetings.

Tribble asked if 100 kt was the fiducial volume. Beier answered affirmatively; the total volume is larger. Zajc asked if there are safety concerns about operating 100 kt of argon in a cavern. Beier answered, absolutely. The question is if those concerns are manageable. The problem with liquid argon is that you cannot determine a design until the R&D problems are solved.

Wilkerson said that the only other option is liquid argon on the surface, but you would lose a lot of physics. Beier noted that that will be in the report; it is in the charge.

Milner asked at what temperature this experiment would operate. Beier replied, at cryogenic temperatures.

Ji asked if the water-Cerenkov detector option would be possible at Fermilab. Beier replied that it would. Fermilab has drawings with different beam lines. Ji asked what the size of CP violation was and which detector scenarios gave the best results. Beier replied that two maxima have to be covered with two detectors; either scenario can do that.

Ramsey-Musolf asked if Phase I included discovery of the appearance of θ_{13}. Beier replied, yes. Ramsey-Musolf asked whether, if it is measured, there is any motivation to go further. Beier said that, having observed the appearance of θ_{13}, Phase II is designed to increase the sensitivity to discern the mass hierarchy and CP violation. There is a factor of 2 in sensitivity between appearance and measurement of θ_{13}. The first is a 20-kt experiment; the second is a 300-kt experiment.

Dean asked what would happen if one does not see anything in Phase I. Beier said that one would then need another beam technology, which is outside NuSAG's charge.

Ji asked what would happen if one found supersymmetry at the Large Hadron Collider (LHC). Beier said that that is a very big question.

Ent asked why it was so difficult to define the best energy. Beier said that one can trade beam power for detector mass, but the working group is just now getting results for 120 GeV.

Ji asked if Daya Bay was a go. Beier said that he understood that it was a high priority.

Wilkerson asked how comfortable NuSAG was with background. Beier said that there are substantial uncertainties about background-process cross-sections. However, work is underway to reduce those uncertainties.

Ramsey-Musolf asked how T2K and Japan Proton Accelerator Research Complex (JPARC) worked together. Beier said that more sensitivity is achieved by putting them together (at the same E/L) than each separately. Ramsey-Musolf noted that one could know the mass hierarchy without going to Phase II. Beier agreed that that was possible.

Tribble asked whether, if one knows the mass hierarchy in Phase I, one would find CP violation (or its absence) in Phase II. Beier answered, yes.

Ji asked if there were commonalities. Beier said that there will be systematics that are the same in the detectors; there will be differences in the beams.

Savard asked if it was reasonable to build such a big facility to do just one scientific task. Beier replied that NOvA is a $250 million machine. These facilities are significantly larger than NOvA. It certainly would be attractive to do more than one task with such a large facility.

Ji asked what was happening at Kamiokande. Beier said that they were building a detector that would be much larger; they cannot increase their beam power. Ji asked if there was any talk of international collaboration in this area. Beier replied that there was not at the moment but a next generation detector might motivate international cooperation (as opposed to building one in Japan and one in the United States).

van Kolck asked if there is a technology selected. Beier replied that 1 MW is under consideration; 2 MW would be difficult; and 4 MW is being talked about, but they only have initial studies.

Tribble asked how the Committee should react to the final report. Beier said that the issue will be whether the current research sees a non-zero θ_{13} . If not, we are out of business. If yes, the question is whether one can enhance the sensitivity by upgrades or whether one needs new facilities. One will need to identify R&D to be done. The report suggests R&D on both approaches.

A break was declared at 10:47 a.m. The meeting was called back into session at 11:02 a.m. to hear **Joseph Dehmer** review the activities at the National Science Foundation (NSF).

Dehmer began by noting that this is the most exciting time for scientific discovery. Nuclear physics is a major player in that intellectual ferment, but there is a lot of competition.

The LHC will change particle physics in the next few years. The NSF is ramping its budget up to $18 million per year for research at the LHC. It is working by all measures.

The DUSEL has four candidate sites that will be reviewed by a very heterogeneous committee. The project is a joint, coherent vision for the future. There is a lot of demand for the services it will provide.

The Laser Interferometer Gravitational Wave Observatory (LIGO) is operating at its design sensitivity and will collect a year of data this year. Advanced LIGO will be started in FY08.

The NSF's flagship collider, CESR/CLIO [Cornell Electron Storage Ring], will run during FY07 and FY08 and will be shut down in FY09. The IceCube detector has finished its third season and has installed new strings of sensors. It now has 22 strings. It has been highly successful and will be completed in three more seasons. Borexino is filling and will be taking data this spring.

The budget perspective has changed a lot. The American Competitiveness Initiative (ACI) has changed the science R&D perspective. The Physics Division got a 6% increase for research and related activities (R&RA), its full request. That increase will be used to ramp up to $18 million for the LHC. Theory funding is being increased 5% per year for 5 years. It will go up 10% under the new FY07 budget.

In FY07, there is R&D funding for DUSEL.

The 2007 budget levels are not approved at the divisional level yet, and will not be until March or April. In FY07, Physics has increased, with $8 million of that for particle physics. In FY07, it was extremely fortunate to get a 6% increase. The Physics Directorate would increase even more (8%) in the FY08 budget. That is when a lot of information will be coming in from many programs.

There will be a Physics Frontiers solicitation next year.

The National Superconducting Cyclotron Laboratory (NSCL) is the flagship nuclear physics facility. It got a 1% increase in the FY07 budget. It has many discoveries on the horizon. NSAC has the Rare Isotope Accelerator (RIA) as its next high priority. RIA is in the DOE plan, and NSF is advancing DUSEL. Nuclear physics is supported by both DOE and NSF, and both are dedicated to advancing nuclear physics. A process to determine the path forward for RIA is undetermined at this point.

NSAC has a reputation as an outstanding advisory committee. Scientists naturally tend to make recommendations based on expectations. They need to stick to the science priorities that will stand the test of time. What will have effect over time will be integrity and scientific arguments.

Savard asked where the additional two DUSEL sites came from. Dehmer said that the site list was expanded for reasons that do not need be gone into here. All four sites are being considered on an equal footing. The implementation will be very difficult. It is expected that the selection will be made in May. DUSEL construction could start in 2010.

Makins asked what the key disciplinary elements of DUSEL were. Dehmer replied that about half of the initial funding would go to infrastructure and half to science in neutrinoless double-beta decay, dark matter, geo-engineering, and deep-mining safety. Biology and geology experiments tend to be less expensive, and there will be joint funding of some experiments, so the distribution of Major Research Equipment and Facilities Construction (MERFC) funding will not be uniform.

Wilkerson asked when DUSEL would go to the National Science Board (NSB) for approval. Dehmer replied that it would go in about a year from now, and it will go to the NSF director the summer after that.

Ji asked what the Physics Frontier Centers were. Dehmer said that some physics frontiers are difficult to advance with principal investigators (PIs). A system was set up for funding activities at $0.5 to 4 million per year for 5 years. After 5 years, they are recompeted. The NSF investment contributes to education and diversity. The bar is high, and the process is wide open.

Ramsey-Musolf asked what the DUSEL competition was to be. Dehmer said that the director will have to decide what science projects will go into DUSEL. Lifetime prospects and needs of different directorates will come into play. The competition will come from Large Synoptic Survey Telescope (LSST) and Giant Segmented Mirror

Telescope (GSMT) and other large projects. DUSEL will serve four directorates, a strong plus.

Raymond Orbach was introduced to discuss the FY07 Office of Science (SC) budget, the 5-year plan, the FY08 budget, and the FY09 budget.

The FY08 presidential request is based on the ACI. The congressional request is quite different from the 10-year Presidential plan of doubling the core research of NSF, DOE, and the National Institutes of Health (NIH). However, the President's strong support for basic research was evident in his State of the Union Address. This is not a partisan stance. Nancy Pelosi has echoed the President's intent to double support for physical sciences over 10 years.

The FY08 budget enhances U.S. competitiveness through transformational science, national scientific facilities, and a scientific workforce for the nation's future. This is a balanced picture for the Office of Science (SC). In 2006, a choice had to be made between facilities and people; 2300 people were lost. In FY08, 3600 people will be added, a 7% increase over the President's request. The mortgages on the facilities make this very difficult, but SC are reestablishing parity between facilities and core research.

The FY07 budget is still under discussion and development. It will go to Congress the week following this meeting for review. SC is working not only on the FY08 budget but also the FY09 budget. The FY08 budget includes an increase to $4.4 billion for SC. The increase will allow running the facilities at optimal rates and participating in International Thermonuclear Experimental Reactor (ITER). The FY08 request is very reasonable.

FY06 was a difficult year. Significant increases in the FY07 and FY08 Presidential requests repaired some of the damage with an increase of 32% for NP compared to FY06.

The issue of core research funding is central to the FY08 budget, which requests a 7.1% increase over the FY07 request for SC. We will ask for a $776 million increase in FY08 over the FY06 appropriation. That will get us back on the doubling trajectory. To accomplish this, some construction has to be delayed. The President's FY08 request is critical for the health of science. The ACI is the country's hope for the future.

Workshops help identify scientific research opportunities and lead to initiatives. Here, far-out ideas can be proposed and tested. Congressional directives bypass peer review and are a matter of concern.

Research capabilities and tools to drive U.S. competitiveness include:

- Three bioenergy research centers that have been granted $375 million of risk capital over 5 years ($25 million per year for each center for five years). The government buys down the risk capital to encourage broad partnerships to address our energy issues.
- The Spallation Neutron Source (SNS) is the world's forefront neutron-scattering facility by an order of magnitude; it was completed and began operations in 2006. It is a $1.4 billion machine at Oak Ridge National Laboratory (ORNL) that was built on time and slightly under budget. It has restored the credibility of DOE before Congress and the world.
- The Linac Coherent Light Source (LCLS) is an x-ray free-electron laser that will allow examinations of chemical reactions in real time at the single-molecule level. The timescale, 300 attosecs, will show chemical bonds (electron clouds) change as reactions take place one molecule at a time.

- The National Synchrotron Light Source-II (NSLS-II) is a light-source facility with the world's finest capability for x-ray imaging, capable of nanometer resolution. It was the highest priority in the third epoch, but the science has progressed so fast that it is in the design stage now.
- Five nanoscience research centers will be operating in FY08 with $100.5 million of funding.

The advanced computer science centers are extending the frontier of science. By the end of 2008, SC will have petaflop computing in Oak Ridge, changing the way scientists conduct research. Three machines are coming into the 100-teraflop regime: ORNL, Argonne National Laboratory (ANL), and the National Energy Research Scientific Computing Center (NERSC). They have different architectures for different scientific problems. Time will be allocated in million-CPU hours.

The Tevatron and B-Factory will be shut down after FY08. The health of high-energy physics will stand with the LHC and Fermilab. High-energy physics leadership has been off-shored and will be very difficult to get back.

ITER was a successful negotiation of a large, international project. This is a hard experiment to solve the world's energy problem.

We intend to remain the leader in nuclear science. The Continuous Electron Beam Accelerator Facility (CEBAF) upgrade maintains its status as the world's most powerful "microscope" for studying the quark structure of matter. The Relativistic Heavy-Ion Collider (RHIC) is continuing its studies of the internal quark-gluon structure of nucleons and the properties of hot, dense nuclear matter. R&D is being continued to develop advanced rare isotope beam capabilities and to initiate a solicitation for design of a next-generation U.S. facility for nuclear structure and astrophysics. The site will be that of these submitters of the successful design proposal.

Accelerator R&D is a major issue for the United States. We must maintain our strength in this area.

People matter; the budget for training the future workforce was increased from $6 million to $11 million. SC intends to increase the inspiration of America's youth with DOE Academies Creating Teacher Scientists (ACTS) and the National Science Bowl for High School and Middle School Students. The scientific workforce supported by SC increases by 3600 in FY08 compared to FY06. Half of our facility users are from universities, and they are supported by NSF, NIH, and other agencies. When one opens up one's facilities, one gets the best scientists and science.

Our Nation's large-scale scientific facilities and research capabilities lead the world, enabling remarkable discoveries that drive our economy and excite our youth to pursue science and engineering. The FY08 President's request for SC will help ensure continued U.S. leadership in the physical sciences and prepare the scientific workforce we will need in the 21st century to address our nation's challenges.

Makins asked if NOvA was a high-priority item. Orbach replied, yes, it is the next step. We are struggling with the future for Fermilab as a proton driver. What happens in the future depends on the value of θ_{13}.

Ramsey-Musolf asked if there was a slowdown on R&D for the International Linear Collider (ILC). Orbach answered that the R&D for the ILC was being doubled from FY07 to FY08; in addition, there was $23 million for superconducting cavities. It will take 3 to 5 years to get the cryomodules developed and manufactured. An international agreement has to be negotiated, engineering design has to be completed, and then construction has to be initiated. It will likely take 10 years before construction can start. If one tries to be realistic, that means it will be 2027 before any science is produced. The United States needs to keep its capabilities in accelerator design construction alive for those 20 years. There will be at least a decade when there are no HEP accelerator activities in the United States. Some people see that as a slowdown. The Particle Physics Project Prioritization Panel (P5) will look at their plan for ILC in 2010 in light of the LHC and Fermilab results. R&D will be supported, and Fermilab will be pushed as hard as possible.

Tribble noted that nuclear physics has a strong overlap with high energy physics to help keep this going. Orbach noted that the Thomas Jefferson National Accelerator Laboratory (JLab) was the inventor of superconducting cavities in the United States. The developments there are exciting. Medical accelerators are going to be based on that work.

A break for lunch was declared at 12:22 p.m. The meeting was called back into session at 1:27 p.m. to hear **Bradley Keister** review nuclear physics activities at the NSF.

For FY07, the Physics Division is up 6%, NSCL operations are increased by $1 million, nuclear theory is up 5% (by increasing the grant size), the nuclear experimental program is flat, DUSEL R&D receives new money, and three CAREER awards will be made. The FY07 initiatives are DUSEL R&D and Physics at the Information Frontier in the Physics Division, Major Research Instruments, Explosives and Related Threats, and Domestic Nuclear Detection. The last initiative is funded by the Department of Homeland Security (DHS); NSF is conducting the review process for proposals.

Mathematics and Physical Science (MPS) is the largest directorate in the NSF. Its FY08 request reflects an 8.9% increase over the FY07 request. Tony Chan has joined the organization as MPS Assistant Director, and Ani Aprahamian has also joined the staff.

Keister then elaborated on Dehmer's reply to an earlier question about NSF Physics Frontiers Centers.

A successful Frontiers Center has value added for research and discovery opportunities. The awards are competitive; in the first round, there were 55 preproposals. The director has to have vision and energy and a way to document successes that would not have occurred otherwise. These centers are an attractor for the very best young people in their areas.

Savard asked how much money was being talked about. Keister replied, $500,000 to $4 million per year.

Heinz asked if the centers ran out of money last year. Keister said that the centers came online at different times, so they got different amounts. From now on, there will be 5-year grants.

Ji asked what makes a successful proposal. Keister answered using the Joint Institute for Nuclear Astrophysics (JINA) as an example. Historically, theorists, observers, and modelers in the various subareas have not worked together. With these groups now working together through JINA, new collaborations are established, and even the scientific goals of the respective subareas can change due to these connections.

Heinz asked if these centers are localized. Keister replied that they are local with outlying partners.

Elster commented that the new initiatives seemed to be very applied. Keister answered that this is someone else's money, separate funding. The conventional explosives initiative is funded by the NSF Engineering Directorate. The nuclear detection initiative is funded by the DHS, and DHS will assume management of the awards. Wilkerson said that the solicitation seems to indicate that the NSF will review the first year's work. Keister said that he will have to look at the agreement again.

Dennis Kovar was introduced to review the DOE/NP budgets.

Under the continuing resolution, SC's funding is $200 million over that of FY06. This is about $305 million less than the Congressional Budget Request. SC has the flexibility to distribute funds among its offices and programs. The general instruction is "no new programs." The FY07 NP budget request was $454 million. Actual NP funding will be less than the amount under the continuing resolution.

The FY07 SC request to Congress was a 14% increase over the FY06 appropriation, and the FY08 request is a 7% increase over the FY07 actual funding level.

For NP, the FY06 budget was a 9.3% reduction from the FY05 budget. However, the FY07 request was a 23.7% increase over that FY06 budget. For NP facility operations, the FY07 request was a 21.7% increase over the FY06 budget, a little above what was needed to maintain all facilities. In the FY07 budget request, university and laboratory research efforts were restored to approximately FY05 levels, the National User Facilities were able to operate at near-optimal levels, important instrumentation projects were continued and started, the 12 GeV CEBAF Upgrade project was continued, and R&D was continued to address next-generation capabilities.

The proposed FY08 budget tries to optimize the funding for research, increasing 5.6% over the FY07 level. Facility operations increased 2.2% over the FY07 level, with the HRIBF/ORNL and ATLAS/ANL accelerators receiving continued investments. Construction is increased 9.9% over the FY07 level to support the CEBAF upgrade and the Electron Beam Ion Source (EBIS) at RHIC. Stewardship funding increases 3.7%, and the total nuclear physics budget increases 3.8% over the FY07 level.

In FY08, research efforts are being maintained, although RHIC will operate for 30 weeks, and CEBAF will see some reduction (to 90%) in optimal level of operation. New operators will be hired at the HRIBF and ATLAS facilities. The CEBAF upgrade project continues, and a solicitation for proposals for design of a rare isotope beam facility is planned. The President's FY08 budget request has increases for SciDAC, LQCD, Gamma Ray Energy Tracking In-Beam Nuclear Array (GRETINA), PHENIX silicon vertex tracker, Heavy-Ion LHC, and Cryogenic Underground Observatory for Rare Events (CUORE), representing a significant investment in capital equipment that is a 225% increase over the FY06 allotment. Once it is known what money is available under the continuing resolution, all of these numbers will have to be revisited. The hope is that planned starts for Major Items of Equipment (MIEs) will be allowed to proceed in FY07.

Heinz asked if the delay in funding affected facility operations. Kovar replied that, in RHIC, they will only get 20 weeks of running. At JLab, they should be all right; they were running well in FY06. ATLAS was down a lot in FY06, so they will be adversely affected by that in FY07.

A big question is what will happen in FY08. Will funding get back on the ACI trajectory? The FY08 budget will be important in determining the future funding of SC. In FY07–FY12, the nuclear physics program is going to pursue promising high-impact scientific opportunities. It will participate in heavy-ion studies at the higher energies of LHC, it will start studies of nuclear structure with GRETINA, it will start measurements of fundamental neutron properties at the SNS, it will participate in neutrinoless double-beta decay measurements, it will use leading-edge computers to make progress in nuclear physics, and it will perform accelerator R&D for the next generation of nuclear-physics research capabilities. SC's plan is revisited each year in the budget-formulation process to address changing out-year projections, new projects and programs, and address new high priorities established by the administration.

The Outstanding Junior Investigators (OJI) program had 20 applicants; awards will be announced soon. The RIA review panel met in December 2006 and considered 32 proposals totaling $11.2 million; projects totaling $3.5 to $4 million are expected for FY07. The Office is preparing for the FY09 budget exercise for which the Radioactive Ion Beam Facility (RIBF) Task Force report will be an important input, as will be the NSAC Long-Range Plan.

The position of program manager for nuclear physics instrumentation is in the process of being filled, three unfilled positions are planned be advertised in FY07, and two detailee positions are unfilled.

Ji stated that nuclear theory is critically underfunded and asked what the best path forward would be. Kovar said the answer was being able to submit a proposal that points to what you are going to do in the next 5 years. Ji pointed out that theory developments are different from facility operations. Theory is very important in designing new facilities, experiments, and analysis techniques. Kovar responded that, since the most recent long-range plan, funding for experiments has stayed flat, but that for theory has increased significantly. The question is, what is the case in the context of other investment opportunities? What will optimize the delivery of significant output? Ji said that there was a steady decrease in postdocs in nuclear physics, which will be a long-term detriment to the field. Kovar answered that the most successful part of the program has been the OJI program, where theory has done very well. It is difficult to predict innovation and paradigm shifts. Topical centers are very good, but they have to deliver something in 5 years. They need to pick a significant problem and solve it. The committee report has to be followed up by proposals.

Heinz asked what recommendations of the Committee the office had implemented. Kovar replied: (1) investments in computing; (2) dealing with the issue of attracting the most outstanding students of theory; (3) getting faculty positions at research universities; (4) institution of topical centers (which is now underway); (5) the OJI program, which has placed outstanding researchers in permanent positions; and (6) fellowship programs, which are under investigation. The field needs great theory.

Brian Fulton was asked to summarize the activities of the Nuclear Physics European Collaboration Committee (NuPECC), an Expert Committee of the European Science Foundation. It was started 15 years ago by the nuclear physics community and is funded by subscribing national agencies who nominate expert scientists as representatives. Its objective is to strengthen European science through the promotion of nuclear physics and its transdisciplinary use and application in collaborative ventures between research groups within Europe. Currently, there are 28 members from 23 countries. NuPECC does not dictate national policy or European policy nor does it react to specific charges from member states.

The committee meets three times a year, and a chair is elected to serve for 3 years. A scientific secretary looks after the administration. Working groups are established, as required, to prepare reports and meet with other organizations. Town meetings are organized when issues of particular importance are being considered. It publishes *Nuclear Physics News* four times per year and issues long-range plans at approximately 5-year intervals, a *Handbook for Facility Access*, topical reports, a *Survey of Resources*, brochures, and outreach publications.

The *Long-Range Plan* identifies the top priorities for European facility development. NuPECC's vision is for two flagship radioactive beam facilities in Europe. It recommends the building of the international Facility for Antiproton and Ion Research (FAIR) at Darmstadt and then the construction of EURISOL [European Isotope Separation Online]. It also recommends the construction of intermediate-generation facilities that will benefit the EURISOL Project in terms of R&D and will give the community an opportunity to perform research and applications with radioactive-ion beams of the ISOL scheme. It also recommends pursuing the ongoing French project SPIRAL-2 (Système de Production d'Ions Radioactifs Accélérés en Ligne 2) at Caen and SPES (Study and Production of Exotic nuclear Species) at Legnaro as well as the further upgrade of REX-ISOLDE (High Intensity and Energy ISOLDE) at CERN and the very specialized project MAFF (München Accelerator for Fission Fragments) near Munich.

NuPECC recognizes synergies with other areas of physics. Next year, it is intended that NuPECC will begin the process of developing its next long-range plan.

In Europe, more than 90% of funding for research comes through national research-funding bodies. However, the national funding bodies increasingly look to follow a European agenda, large-scale facilities are increasingly considered on a European basis, and European Union central funding can have a major impact in a field. Funding rules are very complex. Research funding is allocated in 3- to 4-year periods called Framework Programmes (FP). Within each FP, funds are divided among different instruments, each of which is designed to achieve some aspect of EU policy. Unfortunately, the European Commission (EC) does not award grants but issues contracts. Although there is no formal link, NuPECC enjoys a good relationship with the EC.

The European Strategic Forum for Research Infrastructures (ESFRI) is a new body that was established by the EC to advise them on the need for large-scale facilities in Europe. ESFRI produced its first roadmap last year, listing 34 major facilities required in Europe. This roadmap is important because FP funding for facility construction is only open to facilities on the roadmap.

The Organisation for Economic Cooperation and Development (OECD) Global Science Forum has established a Working Group on Nuclear Physics, and the International Union of Pure and Applied Physics (IUPAP) has established a Committee on International Collaboration in Nuclear Physics.

Like any other area of scientific endeavor, nuclear physics needs a coherent network, ranging from equipment-development facilities in universities to small-scale accelerators in universities or institutes to medium-scale facilities in national laboratories to the few flagship facilities of international scale.

EURONS (EURopean Nuclear Structure) has Integrated Infrastructure Initiative funding of €14 million for three integrated activities: facility access, joint research projects, and networks. It also has Integrated Infrastructure Initiative funding of €17.4 million for hadronic physics, involving 70 institutes and more than 2000 scientists. It provides access to facilities, joint research projects, and networks.

NuPECC's interests include the ongoing operation of existing facilities, construction of new facilities, better coordination among funding agencies, taking the EURISOL design to the next stage, and planning for the future. NuPNET is being proposed as an ERANET in nuclear physics. ERANETs are FP funded and bring together the different national funding agencies in a forum where they can discuss how to coordinate and fund particular areas of science. Several have been established and judged to have been very successful. A NuPNET could solve the problem of coordinating the funding for projects.

EURISOL has issued a feasibility study, and a design study is now being funded to provide engineering studies and technical prototyping. Work is going on in targets and ion sources, accelerators, safety, and beta-beam aspects.

Dean asked if there were any subdisciplinary groupings in European nuclear physics. Fulton replied, yes, but it differs from country to country. That is one of the challenges the organization faces.

Elster asked if there were money available to organize people. Fulton said that the networks have been very successful with very little funding. They have focused their resources and raised their ambition levels.

Ramsey-Musolf noted that SPIRAL looks a lot like the RIB facility and asked what the differences were. Fulton replied that there *is* overlap because there is one best way of doing the job. The physics will differ, as will the radioactive ions used.

van Kolck asked what the timeframe was for the new EURISOL. Fulton said that the timeframe ran through 2010; it could start construction in 2013 to 2020. The first stage of FAIR will operate in 2012.

Savard asked if there is a special relationship with CERN. Fulton answered that CERN is a long-standing, pan-Europe organization. It is keen to take on the European mantle. There is hadronic work being done at CERN.

Zajc asked how they worked with scientists in Asia. Fulton said that they do not; that relationship needs to be built up.

A break was declared at 3:16 p.m. the meeting was called back into session to hear a report by **Elizabeth Beise** on the Committee of Visitors (COV) to the DOE Office of Nuclear Physics. The COV was charged with providing an evaluation of the effectiveness, efficiency, and quality-of-process in the solicitation and evaluation of reviews; the monitoring of active programs; the depth and breadth of the portfolio; and the national and international standing of the program. It was also asked to comment on progress since the 2003 COV and possible improvements to the process.

The COV got a full day of presentations from NP staff, access to all documentation, informal discussions with managers, and additional requested information. About one-third of the 180 grant jackets; all available documentation on laboratory research; documentation on facility operations, including science and technology reviews of the national user facilities; and the full range of funded projects were reviewed.

In general, the reorganization of the office since 2003 has been very beneficial to the program. There are several vacant positions, and new positions are expected to have a big impact. Detailees and IPAs [Intergovernmental Personnel Act] should be used to relieve the workload on the staff. The office makes excellent use of and responds well to the broad range of NSAC reports, Academy studies, and program reviews. Examples include project starts, relative enhancement of the theory program (for which FY07 would have been the first year that this report would have affected), and strategic response to the difficult FY06 budget. The COV was very impressed with the collegiality, management, and exceptional work ethic found during its visit. The frank and open discussions held with the program managers and division directors were essential to the process.

In terms of university grants, the solicitation of reviewers and reviews of proposals are excellent. Documentation on the decision process is outstanding. A new set of explicit instructions for submission of annual reports has been implemented, along with a deadline (November 1) for new submissions. This change seems to help with making timely decisions. Annual progress reports are a major portion of workload and are used to make decisions. Grants cover the full spectrum of research, and boundaries appear to be permeable. The OJI program is a big benefit in attracting and promoting promising young scientists. New PIs are also started as existing grants evolve. However, there is a perception of low turnover and difficulty in breaking into the system; statistics should be taken on this phenomenon.

In terms of laboratory research, this review process is new since 2004. Four areas are reviewed on a 4-year cycle. Three such reviews had been completed as of January 2007. Generally, the process was found to be very effective. Annual progress is monitored with field work proposals (FWPs), science and technology (S&T) reviews, and laboratory budget briefings. The 4-year review includes both written reviews and an international panel of experts. The process is still evolving, and the COV has several recommendations:

- There should be a better match between the review criteria and the materials requested from the groups.
- Uniformity should be developed in the metric to determine cost-effectiveness.
- Reviewer comments should be solicited as part of the evaluation of graduate-student and postdoc mentoring.

In terms of facility operations, the management is generally outstanding, despite difficult budgets. During the past 3 years, two facilities (a Berkeley cyclotron and a Massachusetts Institute of Technology-Bates accelerator) have been shut down. Funds have been redirected to new programs, including accelerator R&D. Cancellation of the RIA request for proposals (RFP) was also a setback, but resources have been directed to existing low-energy facilities to maintain U.S. strength in this area. Science and technology reviews have been conducted for HRIBF and ATLAS. In both cases, one result was a proposed budget increase for FY07. The COV endorses the Accelerator Technology R&D Program at its present level, which is largely directed toward rare isotope beam development, and it encourages further development of a more general initiative, which could include graduate fellowships.

The COV found the projects to include a wide span from the JLab upgrade to relatively small fundamental neutron physics experiments and from accelerator improvement to capital equipment and information technology. The COV found that a tailored approach is used in which the management approach is matched to the size, scope, duration, and risk of a project. Oversight and monitoring is very complete, and review mechanisms are very rigorous. Excellent use is made of NSAC reports in deciding on priorities and timing for new projects. However, very few unsolicited proposals are received. A good aspect of unsolicited proposals is that those tied to laboratories require the laboratory to take ownership of the project. It is a perception that the community does not have a good understanding of how to get new projects started, particularly when the project is not based at a facility.

In terms of international standing of the programs, the COV did not attempt to fully assess the international standing of the U.S. nuclear physics program. It focused on how decisions have affected the perceived quality of the program. The two large laboratories and their respective science programs are unique and have clear international impact. Access and partnerships with the international community are significant. The strategic use of special programs, such as SciDAC, has brought leadership in the areas of theory and modeling of stellar evolution and lattice QCD [quantum chromodynamics] theory. More measured investments have been made in fundamental symmetries and nuclear structures/astrophysics and add important and necessary breadth to the program. However, there is substantial international competition, although individual U.S. researchers are often leaders.

The 2003 COV had nine major recommendations. All have been acted on, and only one is still ongoing. The COV again recommends an increase in travel funds for program managers. The proposal submission deadline was implemented and is working well. Workforce development is now tracked in the S&T reviews, and that information should be used more in the review process.

For 2007, the COV recommends:

- A common database of reviewers for university grants, shared among program managers, would be very valuable, especially as the overlaps between subprograms increase.
- Statistics from university grants should be used more to keep track of the health of the program (e.g., turnover, grant size, PIs per grant, time to notification, and international investments and returns).
- Vacant positions should be filled as soon as possible; detailees should be used where appropriate.
- The community needs a better understanding of the process, approach, and constraints to starting projects.
- For the review process of the laboratory research groups, the suggested list of materials to be provided for a review should better correlate with the review criteria, particularly for outreach and workforce development.
- There should be more consistency in the method for determining cost-effectiveness for laboratory research groups.
- Informal site visits by program managers to laboratories should be increased; this recommendation is tempered by a concern about vacant positions.
- The accelerator R&D program should be further developed.
- A fellowship program in accelerator physics should be considered.

Tribble complimented Beise on her work and the report. Ent asked why the encouragement of the Accelerator Physics Fellowship Program was not one of the formal recommendations. Beise replied that the COV wanted to bring this item forward but not make it a recommendation that DOE had to answer for the next time.

Lee asked whether accelerator R&D was outside the charge. Beise said that the COV saw accelerator R&D as something that had to be done with and by other offices of SC.

Ji asked what kind of data one could collect on breaking into the field. Elster pointed out that, when there is a new PI, the presence of the new PI may not be noted, so the perception is that there are no new grantees. This situation is easy to change. For theorists, there is more money flowing in than for experimentalists. The charge has been followed.

van Kolck asked what happened to Appendix E. Beise replied that it exists but had not gotten copied. van Kolck asked what the Centers of Excellence were. Kovar answered that three or four of them were set up before the term Centers of Excellence started to be used. The concept has undergone an evolution, and there are now six such centers. van Kolck asked if women were seeing less advancement than other minorities. Beise responded that the COV was not asked to address that issue. The numbers for women and other minorities are increasing apace. Beise suggested changing the wording of the report to make that clear. van Kolck commented that the recommendation on new PIs does not seem to be supported by the text. Beise replied that the COV did not intend to say that new entries do not happen but to encourage the process of incorporating new PIs; it did not believe that the current process needs to be changed. van Kolck said that there is a perception that OJIs start their own grants and that others inherit grants. Beise said that the COV did not look at that issue.

Ji asked if the COV looked at the broadness and accuracy of agency statistics. Beise said that they did not have time to look into that question, although the COV did call for some more statistics. Elster pointed out that one can ask only for statistics that the agency is allowed to give.

Glasmacher suggested removing the first sentence in paragraph 3 on page 12 because it seems to contradict what is said elsewhere in the report about controls on university-based capital projects. Simon-Gillo pointed out what funding mechanisms for equipment investments at universities and national laboratories are. That might be what was being referred to. Simon-Gillo pointed out that the project management oversight from the Program Office is similar whether the project is at a university or laboratory.

Dean asked if the early FWPs were helping. Henry replied that the Office does not have the FWPs, yet, and it is already working on the budget. They will be used retrospectively to set expectations and requirements, but they are not a prospective planning tool, yet.

Kovar asked Ji what statistics he would consider to be wrong. Ji said that he would not say anything is wrong but that things are very dynamic. Kovar pointed out that the agencies are just bookkeepers for the data that the community supplies. If anyone knew of any inaccuracies in that data supplied, the agencies would make inquiries.

Cardman noted that JLab keeps statistics on people at the Laboratory but has great difficulty getting data on those people. There is no standard way to collect those data.

Peggy McMahan was asked to give a report on the workshop and town meeting on education and public outreach in nuclear science. The charge was to look at the education of young scientists; to discuss the contribution of education in nuclear science to academia, medicine, security, industry, and government; and to determine strategies to strengthen and improve the education process and build a more-diverse research community.

The workshop looked at the problems the community faces, set some goals, and discussed strategies for implementing those goals. The workshop used the NSAC education report and surveys as a starting point. The white paper will be available April 1.

Recent reports paint a dire picture for the future of America in science and technology. The number of young people entering science and engineering is declining. The science and engineering workforce is aging. Post-9/11 policies and better opportunities abroad make it harder to lure international scientists and students to study and work in America. The need for physical scientists is expected to increase 14% between 2002 and 2012. Between 1973 and 2003, the percentage of foreign-born academic staff in the physical sciences has doubled from 13% to 25%. The number of foreign students planning to stay in the United States after graduation is leveling off or decreasing.

There is bipartisan support in Washington for increased funding for science and for training more science and mathematics teachers. The difficulty is tying this concern to nuclear science.

In 2006, DOE and NSF supported about 700 graduate students, 53% of whom were foreign nationals. Of the 440 postdoc or temporary positions in nuclear science, one-third were filled in by U.S. citizens, one-third by foreign nationals from U.S. universities, and one-third by foreign nationals from foreign universities. Of graduate students who go directly into the workforce, about 25% go into nuclear-related careers, about 20% go into other careers (e.g., business, education, industry, and government), and about 10% go abroad. Of postdocs and temporary employees that enter the workforce full-time, about 25% go into nuclear-related careers, and about 40% go into other careers. For all career stages, the size of the nuclear-science workforce has remained essentially the same since 1996. The number of nuclear-science PhDs awarded decreased 25% since peaking in 1994. The root cause of this decline is unclear. The number of physics graduate students has rebounded slightly in the past few years.

The portion of PhDs in nuclear science in the workforce who are women increased from 12% to 19% between 2004 and 2006. However, the distribution among races has changed little.

The Nuclear Energy Institute estimates that, over the next 10 years, the industry will have to hire 11% of all mechanical engineers (or 150% of all nuclear engineers) to maintain the current nuclear capabilities. In addition, the number of nuclear workers retiring is increasing each year. All of these need to be replaced. However, 37% of nuclear-science PhDs end up outside nuclear science.

In summary, the NSAC education report recommended an increase in the number of PhDs in nuclear science over the next decade to maintain the health of the field and to contribute to projected needs in nuclear energy, medicine, and national security. However, the number of nuclear-science PhD’s has been declining. The workshop participants agreed that the trend needs to be reversed.

Only 28% of graduate students had an advanced undergraduate course in nuclear physics or chemistry. However, it should be noted that 87% of U.S. male and 92% of U.S. female graduate students in nuclear science had an undergraduate nuclear science research experience. The recommended strategy is therefore to increase involvement and visibility of nuclear science in undergraduate education and research by expanding the undergraduate research experience, ensuring that undergraduate physics majors are exposed to nuclear physics early and often, and making nuclear science visible to as many undergraduates as possible. That visibility can be achieved through undergraduate research, conference experience, pre-research summer school for rising juniors, integrated mentoring, and distinguished lecturers' visiting small schools that have no nuclear faculty. Strategies should include a coordinated nationwide effort to aggressively recruit under-represented groups into all present and future programs. Although this recommendation focuses on undergraduate education, the Subcommittee endorses the recommendations of the NSAC education report in the areas of graduate and postdoctoral education on shortening the median time to the PhD degree.

The Subcommittee also recommends that, because "nuclear" is an unreasonably scary word to many people, we need nuclear science to be understood and appreciated as exciting, modern, value-adding, and worth supporting. This goal should be accomplished by developing and disseminating materials and hands-on activities that illustrate and demonstrate core nuclear-science principles to a broad array of audiences. Major outreach activities should include a nationally coordinated website; the expansion of present best practices, such as PAN [Physics of Atomic Nuclei], Quarknet, and Plasma Camp; and an expanded summer camp in nuclear science for high school teachers and students.

In summary, the community is doing a lot of great things now at all levels. The two biggest problems are to increase the number of PhDs in nuclear science and to improve public perception of nuclear science. The recommended strategies are to foster undergraduate research and education and to conduct a coordinated outreach effort.

Tribble noted that this effort could have a lot of coordination with workplace statistics that will be discussed next. These statistics have to be documented carefully.

Heinz pointed out that the number of PhDs going directly into the workforce in Europe is much higher. The report might be underestimating the ability of the private sector to absorb these personnel.

Ramsey-Musolf asked if it was known for a fact that outreach to undergraduates is the best strategy. McMahan replied that it is known that if undergraduates do undergraduate research in nuclear physics, they are more likely to go to graduate school in nuclear physics. Ramsey-Musolf asked if a pilot study should be done before a broad-based strategy is deployed. McMahan said that she would like to see a collaboration look into this problem. The American Physical Society might fund such research.

van Kolck asked why there was the up-and-down movement in the first-year physics students. Howell replied that it tightly correlates with R&D federal funding.

Zajc said that he was not convinced that quantitative statements could be made to guide the Long-Range Plan (LRP). McMahan noted that very few facilities sent data tracking the students at the national laboratories. Kovar added that DOE is restricted in the data that it can collect and share. Its survey has tremendous leverage in getting data, but it is only head counts. When funding levels go down, head counts can go up because of the double or triple counting that occurs as the funding of a person is split among organizational divisions.

Milner said that there has been a surge in physics at universities in the past 5 years and that the American Physical Society (APS) membership is at a record high. If there had been more funding at MIT, they could have doubled the number of students.

Elster suggested that one could track undergraduate research. McMahan replied that they were trying to track where the undergraduate research program participants ended up. Keister noted that about 90% of graduate students had had undergraduate research experience; this is a telling statistic. McMahan commented that there may be an influence there, but these people may also be self-selected.

Lacey saw a factor of 2 difference between the decline in first-year physics majors and PhD graduates. That told him that there is a big problem.

Calvin Howell was asked to report on the Workshop on the ACI and the Nuclear Science LRP.

The main question posed to the workshop was: In what areas will increased funding be invested under the ACI? Stated another way, what makes the nuclear-science community unique and able to contribute to the competitiveness of the United States, particularly in areas of national security and energy? Information was gathered with community input, electronic communications, and a dedicated workshop. The prime output is to be a white paper that will be used in the development of the LRP.

The workshop set out to (1) collect examples on how the nuclear-science community is contributing to the areas of energy, medicine, security, and industry; (2) identify the opportunities and challenges for our community in these areas during the next decade; and (3) make recommendations on how DOE's NP and NSF's Nuclear Physics Program might better facilitate the engagement of the nuclear-science community in these important areas in response to national needs.

The workshop started with plenary sessions on the Global Nuclear Energy Partnership (GNEP), advanced fuel cycles, national nuclear security, finding bombs, radiation-effect testing, charged-particle-beam therapy, and medical imaging using nuclear-physics techniques. One working group discussed nuclear energy and nuclear data, and another discussed national security and other applications.

The workshop participants recognized several examples of technologies and services made possible by nuclear science: accelerator technologies for medicine and industry, particle-detection technologies used in medicine, radiation effects on electronics and materials, and nuclear-reaction data and nuclear-science information used by industry. The areas of opportunity for nuclear science are in continued online nuclear-data and nuclear-information services, national security, energy, and medicine (for detectors, accelerators, and polarization technologies). The main challenges faced by nuclear science are facility stewardship and the transition of knowledge to technology.

The Subcommittee members have been given writing assignments, and the white paper will be submitted to NSAC by April 13, 2007.

Tribble said that the ACI has a basic premise: investments in technology have payoffs in benefits to society and in strengthening the economy.

Wilkerson said that this effort has to be tied to reasons for funding.

Milner said that he would have liked to have seen more partnership with industry (e.g., in superconducting radio frequency). The most recent LRP in Europe had a section on partnership with industry. There should be a story to tell here, also. Howell answered that the United States has a different model than does Europe in how investments in accelerator science and technology are made.

Dean said that Joel Parriott of OMB would say that nuclear science is discovery science and BES is applied science. Howell responded that nuclear science has people in diverse portfolios driven by curiosity, not missions. Strong recommendations have to be drawn up, and comments need to be collected from the working group's members. The utility of facilities already invested in is one such possible recommendation.

Kovar noted that, within NP, the ACI is focused on BES, ASCR, BER, and fusion energy. Whether this is true needs to be known. Do the nuclear-data people have a plan to influence nuclear-reactor design? One needs to see if there is something in the technology that will affect society down the road. There is also the challenge of nuclear-data stewardship. There should be three or four examples of technologies that will have an impact. If the United States does not have a strong nuclear-science program and facilities, it would negatively affect the development and quality of the nation.

Wilkerson pointed out that nuclear science operates very differently from the rest of society. It does not patent ideas with an eye to commercialization. It has made nuclear data open.

Seestrom asked if it would be useful to have additional workshops in specific technological applications. Kovar responded that BES's function is to do the R&D for the next generation of energy production. NP is not set up for that. On the other hand, the Energy Production Act of 2005 set up the Under Secretary for Science to pull together scientific knowledge for technological development. In all of these areas, the offices (e.g., BES) do not want to become applied R&D programs. It must be maintained that basic research is being done. The Office would certainly think about such workshops, though.

Seestrom said that these connections between basic science and applications need to be made. Keister pointed out that the NSF charter was driven by national security. Cardman added that most universities and national laboratories have patent offices that could be encouraged to follow through on the commercialization of ideas. A certain amount of general R&D crosses the boundary where funding is not proper because of the possibility of narrow commercial application. The NIH model does not work in DOE.

Howell said that the transformation to technology requires a period of transition. Milner said that, if new mechanisms are needed, they should be discussed. Kovar wondered whether some funding should be directed to prototype development. Seestrom said that that would be dangerous to do. People doing applied research cannot do the really hard problems that research scientists are good at.

Cardman said that NIH tried to start an advanced-technology effort but that it never coalesced because the people were not right. Maybe NIH and DHS should have a Small Business Innovative Research (SBIR) program to push these technologies.

Tribble called for public comment. **Blaine Norum** rose to address the Laser Electron Gamma Source (LEGS), a photon source facility with a well-characterized, variable polarization and extremely low background beam. The machine made its last run in November 2006 at BNL. It was not producing any new science, but then a new HD target was made to work. The machine ran for only four weeks with the new target until the experiment was terminated in November. It was not outrageously expensive. It has a beautiful detector that gives very good data with small error bars. The data correlate well with existing data. The decision to shut down LEGS should be revisited because it has some unique physics capabilities. There are no other facilities in the world where some of the proposed science could be done with such high precision. There is a significant investment in LEGS, and it is a necessary component of the U.S. electromagnetic program. It is time to reap the benefits; the philosophy is still sound. But the program was canceled, with jobs ending by September 30, 2007. The best case for senior people is to relocate to JLab and to start over. That is a terrible message to young researchers. LEGS should be continued through to the NSLS closure (about 5 years), and a modest capital investment should be made to ensure effective operation.

Elster asked what the critical experiment was that needed to be done before shutdown and what physics could not be done anywhere else. Norum referred to the first two experiments on Slide 5. The quality of the measurement is a question of systematics. Very high-quality data are needed. It is essential for a complete, consistent picture of deuteron disintegration. The timing of the shutdown was unfortunate.

Milner asked how much money is involved. Henry replied, about $2 million per year.

Tribble pointed out that, in less than two months, decisions on the entire program will be made. That would be the proper forum for this debate.

Heinz said that he could not make a decision on something where the physics had not been explained.

Ludlam said that, at BNL, this has been an experiment, not a program. There has been great support for it for years. Its ending is not a horrible event. The target can be used in other experiments.

The meeting was adjourned for the day at 7:08 p.m.

Friday Morning, March 9, 2007

Chairman Tribble called the meeting to order at 8:35 a.m. and initiated a discussion of the COV report. He had received several editorial comments on the draft report since the previous day's presentation and he displayed those comments for the Committee to read and review.

- Seestrom asked if the recommendation for a fellowship program (pp. 5 and 15) was outside the charge to the COV. The sense of the Committee was that it was not outside the charge.
- Appendix E was added.
- The language about project management of capital projects was clarified to accurately reflect current DOE practices.
- The comment on grant size and grant turnover was edited down so the resultant language encouraged DOE to engage young investigators.

Tribble polled the Committee on the acceptability of the amended draft. All agreed with the report's content, as amended. The report was accepted by the Committee as amended, pending concurrence of the COV on the amendments.

The cover letter for the report was displayed and reviewed by the Committee. The consensus was unanimous to approve the cover letter as written.

James Symons was asked to update the Committee on the Rare-Isotope Beam (RIB) Task Force's activities. The Task Force had been working since the previous summer and is a few weeks away from completing its final report, which is due the end of March.

In 2001, nuclear science gave the Rare Isotope Accelerator (RIA) the highest priority for new construction. In 2003, SC gave RIA a very high ranking in its 20-year facilities plan. In 2006, DOE announced that it would not proceed with construction of RIA but would be interested in a lower-cost facility to be constructed early in the next decade. This decision was viewed by the community as a major setback.

The NSAC RIB Task Force was charged to perform an evaluation of the scientific reach and technical options for the development of a world-class facility in the United States for rare-isotope-beam studies within the prescribed funding envelope and in the context of existing and planned research capabilities worldwide. They wanted the international context to be surveyed to ensure no duplication. The results of this study should determine whether a forefront facility that will produce outstanding science within the funding envelope can be defined, and if so, should identify the best option(s) for this facility. The report of the Task Force should contain sufficient details of the scientific capabilities and reach of the facility to inform the scientific community and NSAC in the development of the Long-Range Plan, and sufficient technical detail so as to provide the guidelines to define such a facility in a request for proposals.

The Task Force met with the agencies and clarified the budget guidance and other matters. It held a three-day meeting in Chicago to hear detailed presentations from Michigan State University (MSU) and Argonne National Laboratory (ANL) about their facilities, learn about upgrade plans of existing RIB facilities, learn of the challenges of using existing light-ion drivers, and hear from the chairs of the National Academy of Sciences (NAS) RISAC study. Presentations were made on cost analysis and scientific reach. A follow-up meeting was held to discuss recommendations. The NAS analysis was not reworked; it is a good report that should be embraced by NSAC. It said:

- Nuclear science is entering a new era of discovery in understanding how nature works at the most basic level and in applying that knowledge in useful ways.
- There is a compelling scientific agenda for a future facility.
- Studies of nuclei in nuclear astrophysics constitute a vital component of the nuclear-science portfolio of the United States. Failure to pursue such a capability will not only lead to the forfeiture of U.S. leadership but will likely erode our current capability and curtail the training of future American nuclear scientists.
- The next-generation radioactive beam facility represents a unique opportunity to explore the nature of nuclei under conditions that previously existed only in supernovae and to challenge our knowledge of nuclear structure by exploring new forms of nuclear matter.
- As a partner among equals, a U.S. rare isotope facility constructed in the next decade could be well matched to compete with the new initiatives in Asia and Europe.
- Instead of arriving early on the science scene with a new facility, the United States might arrive last with a facility for rare isotope beams (FRIB), although the facility could have unique capabilities compared with other facilities available at that time.

A world-class facility must address at least some of the outstanding scientific opportunities endorsed by RISAC; must complement other facilities worldwide; and must have a compelling, day-one science program.

How can one achieve a reach comparable to that of RIA at half the cost? Beam power is not the only parameter, but it is an important parameter for isotope production. Linac costs scale with energy. If one can decrease the energy of the driver but maintain the power, costs can be reduced. The RIA R&D program has shown that one can use multi-charge-state acceleration to do this. ANL and MSU have developed designs for drivers with half the energy of RIA and twice the current to make lots of isotopes, although a number of other things are lost.

Two comprehensive, thorough, different cost estimates were conducted and show that a high-intensity radioactive ion-beam facility can be constructed at a much reduced cost relative to RIA. However, if 60% is taken out of the budget, multi-user capability, the

The Task Force's report is to be submitted to NSAC by the end of March in time for the discussion at the LRP meeting in Galveston. This issue has to be gotten right this time. DOE wants to hold a design competition for this facility next year.

Makins asked how this facility compares with EURISOL. Symons replied that FRIB does something no one else will do: produce heavy ions, slow them down in an ion-guide gas cell and re-accelerate them.

Elster asked how one accommodates day-one running. Symons responded that NSAC should keep track of costs. When costs are scaled back, some choices have to be made on the science base. Seestrom noted that, in the LRP, one must lay out the long-term costs (e.g., for detectors).

Ji asked if the facilities in Germany and Japan will be able to do equation-of-state science and whether that will be a serious loss. Gelbke answered that the higher intensities will give a broader range of isotopes.

Ent asked if the Task Force had discussed the science that could be done. Symons replied affirmatively. Cardman noted that there is a complication: ion sources have been improved, but the energy is as low as one can go. New technologies are needed. However, dramatic cost changes are highly unlikely. One needs to explore cost-cutting and make a definitive statement on the bottom-line costs. Symons added that reach versus cost is not a linear function. Reach drops off rapidly as the beam energy decreases.

Dean asked whether, if one drops the energy from 200 to 100 MeV, one would lose a lot. Symons responded that the Task Force was asked about the technical options for cutting costs. That is a narrow charge. It has not explored all the options from 0 to 580 MeV. Cardman commented that one should identify a science niche for this machine and look at where it no longer produces world-class science as one cuts costs.

Milner asked what pieces of the scientific problems could be addressed. Symons answered that the Task Force will have examples in the final report. It is not a selection committee. It will evaluate the capabilities of the proposed approaches.

Ji said that he got the feeling that saying that one can do the same work with a machine for half the cost is not believable. Tribble noted that RIA had a lot of traction on Capitol Hill. The work will be done much more slowly because productivity is being cut by the elimination of multi-user capability.

A break was declared at 9:48 a.m. The meeting was called back into session at 10:19 a.m. to hear **Michael Ramsey-Musolf** describe the Town Meeting on Neutrinos, Neutrons, and Fundamental Symmetries. Nuclear science has played a role in developing and confirming the current standard model. There is now an opportunity for developing the new standard model.

The primary science questions are: What are the masses of neutrinos, and how have they shaped the evolution of the universe? Why is there more matter than antimatter in the present universe? And what are the unseen forces that disappeared from view as the universe cooled? Related scientific questions include: What is the internal landscape of the proton? What causes stars to explode? And what is the origin of the heavy elements from iron to uranium?

The past 5 years have been scientifically productive with the discovery of flavor oscillations in solar neutrinos; the discovery of flavor oscillations in reactor neutrinos; the world's most precise measurement of ($g_\mu - 2$); and the most precise measurement of $\sin^2\theta_w$ of the Z^0 resonance with PV Moller scattering. In nucleon structure, we have definitive determinations of strange-quark contributions to nucleon electromagnetic form factors with PV electron-proton and electron-nucleus scattering; and quark-lepton universality was tested to 0.05% with superallowed nuclear beta decay, yielding the most precise value of any CKM [Cabibbo-Kobayashi-Maskawa] matrix element (V_{ud}). There was the completion of a comprehensive set of computations of supersymmetric effects in low-energy electroweak observables; reduction in the theoretical hadronic uncertainty in extraction of V_{ud} from neutron and nuclear beta decay; as well as new theoretical breakthroughs in simulating neutrino flavor transformation in supernovae, modeling neutrino flavor transformation effects, nuclear synthesis with supernovae, and understanding weak-interaction effects in supernovae shock dynamics. There was the development of effective field theory (EFT) treatments of parity violation in the nucleon-nucleon interaction that will guide the future experimental program at the SNS and National Institute of Standards and Technology (NIST); reduction in the theoretical uncertainty in quasiparticle random phase approximation (QRPA) computations of neutrinoless double-beta decay matrix elements; and substantial technical developments opening the way for searches for the permanent electric dipole moments (EDMs) of the neutron, neutral atoms, deuteron, and electron with 2- to 4-orders-of-magnitude greater sensitivity.

In tandem with those accomplishments, there have been many investments in several efforts [beta decay and neutrino mass and the total lepton number and the neutrino mass term]. There are also investments in DUSEL, the Fundamental Neutron Physics Beamline at the SNS, the 12-GeV upgrade at CEBAF, the muon storage ring at BNL, and RIAcino.

What role can low-energy studies play in the LHC era (and beyond)? The low-energy measurements of NS will complement the LHC measurements.

Scientific opportunities lie in neutrinoless double-beta decay, EDM, neutrino mixing and hierarchy, weak decays, parity-violating electron scattering (PVES), ($g_\mu - 2$), and hadronic PV and νN scattering.

Two major discovery potentials are

- The energy budget of the universe is not understood. Our mission is explaining the baryonic portion: when and how it was produced.
- Does neutrinoless double-beta decay conserve or violate lepton numbers (i.e., are they Dirac or Majorana)? The next probes will look at the region that might answer that question.

EDM probes of new CP violation will have 4 orders of magnitude greater sensitivity, which might give the baryonic supersymmetry of the universe. We have a powerful tool in these EDM experiments.

Things that look for footprints of new particles are

- mixing angle θ_{13} (Daya Bay is the gateway)
- Mass hierarchy (MiniBooNE and long-baseline experiments)

- solar neutrinos (IceCube, Kamland, etc.)

At JLab, one can study the weak mixing angle. One can also look for supersymmetry.

A muon anomalous magnetic moment is given rise to by hadrons. We do not know if we have not done the experiments right or if there are supersymmetry (SUSY) loops.

The recommendations of the Neutrino and Fundamental Symmetries Working Group are:

- The highest priority should be DUSEL, including its complement of experiments, the first of which should be immediate support for a suite of neutrinoless double-beta decay efforts.
- Strongly recommended is capital investment in and support for the nEDM [neutron EDM] experiment at the Fundamental Neutron Physics Beamline (FNPB) at the SNS along with support for searches for rare-isotope EDMs and R&D toward a storage-ring-based deuteron EDM measurement.
- Strongly recommended is a targeted program of precision electroweak studies at such facilities as FNPB, JLab, Los Alamos Neutron Science Center (LANSCE), NIST, and BNL.
- A unified experimental and theoretical program in nuclear physics to construct a standard supernova-neutrino model to understand how elements are produced in these explosions and to develop a secure foundation from which to investigate other astrophysical cataclysmic events, such as gamma-ray bursts, is recommended.
- Support for nuclear physicists involved in interdisciplinary efforts, such as measurements of the neutrino mixing angle θ_{13} through reactor and long-baseline experiments, direct and indirect searches for dark matter, and sensitive tests of charged-lepton flavor violation, is recommended.
- Substantially increased support for nuclear theory is critical to realizing the outstanding scientific opportunities in neutrinos and fundamental symmetries; the recommendations of the 2003 NSAC report on nuclear theory should be implemented with a particular focus on recruiting, nurturing, and supporting young scientists in this field.

Projected resources include project funding for neutrinos and fundamental symmetries of $514 million (including DUSEL funding) over 10 to 12 years. This is big enough for a new initiative (the New Standard Model Initiative), encompassing about $750 million over more than 10 years, a major new facility (DUSEL), and a targeted program at other NP facilities.

Tribble pointed out that the purpose of these presentations is to spur the production of the white papers and to look for gaps and problems.

Dean asked what the optimal operating costs were. Wilkerson said that that information was being collected; it is greater than $8 million.

Makins said that she did not see EXO [Enriched Xenon Observatory] mentioned in the presentation. Ramsey-Musolf said that that is a High-Energy Physics (HEP) program.

Savard said that the background level needs to be reduced significantly to go to the 1-ton germanium detector. Wilkerson responded that one needs to know about CUORE and germanium. The United States and European germanium effort would probably be a joint one. The background problem does need to be resolved at the small scale.

Zajc asked, if one has limits on the neutron's and proton's electric dipole moments, whether one needs the deuteron. Ramsey-Musolf asked where else one would get the proton. Zajc asked if there had been any prioritization of these findings. Ramsey-Musolf replied affirmatively; it is in the recommendations.

Savard asked if the Task Force had received any feedback from the agencies. Ramsey-Musolf was confident that they would get a lot of comments from the agencies. Wilkerson added that prioritized experiments need to be ready to be proposed when the DUSEL funding is bid out.

Simon-Gillo asked what the bumps in the funding were. Ramsey-Musolf said that he would clarify that with the author of the graph.

Ji pointed out that the picture shows only neutrinoless double-beta decay being supported. Ramsey-Musolf said that that was not correct. Right after neutrinoless double-beta decay in the priorities is neutron electric dipole moment and then a bunch of much-less-costly experiments.

Tribble pointed out that this Committee needs to project 5 to 10 years down the road.

Keister pointed out that Recommendation 5 could be considered to be particle physics and asked if that recommendation is down in the list because it is particle physics or because of scientific importance. Savard said that that was for the agencies to decide.

Robert Janssens was asked to comment on the Town Meeting on Nuclear Astrophysics and the Study of Nuclei, which started with a joint session with the town meeting on neutrinos, neutrons, and fundamental symmetries and then had plenary sessions on nuclear astrophysics and the structure of nuclei. It held working-group sessions on nuclear theory, experiments with hot nuclei in dense matter, nuclear structure and reactions, nuclear astrophysics, and facilities and instrumentation.

The five main themes of this field are

- What is the nature of the nuclear force that binds protons and neutrons into stable nuclei and rare isotopes? Neutron-rich systems amplified components of the interactions hidden near stability, and new magic numbers appear.
- What is the origin of simple patterns in complex nuclei? Collectivity returns at the highest spins in a regime where it had been thought to be destroyed.
- What is the nature of neutron stars and dense nuclear matter?
- What is the origin of the elements in the cosmos? How were the elements from iron to uranium made? What is the chemical history of the galaxy and its components? What is the distribution and origin of radioactive nuclei in the galaxy?
- What are the nuclear reactions that drive stars and stellar explosions? How do stars form? Which elements do they make? How old are globular clusters? How do supernovae explode? Which elements do they create? What can new observations tell us about x-ray bursts and novae?

There is tremendous excitement and interest in this field because of the bright prospects in theory and experiment. The nuclear astrophysics and nuclear structure communities are increasingly one; the interactions between the various subfields continue to grow and develop, making for an increasingly connected community. Serious worries about the future include (1) the delay in RIA and what FRIB should look like and (2) the present funding situation that translates into grave concerns about manpower and education. However, the community agrees about the required science reach for FRIB:

there is a theory game plan, upgrades proposed for the facilities, and excellent ideas for new detectors.

The Town Meeting resulted in two resolutions, each with one or more recommendations.

The first resolution was that the physics of the nucleus is a fundamental component of modern science, and understanding exotic nuclei is essential to address this physics. The study of rare isotopes is therefore compelling not only for the breakthroughs it will allow in understanding nuclei and their role in the cosmos, but also for the many cross-disciplinary contributions it will enable in basic sciences, national security, and many societal applications. To pursue this science, to educate the next generations of nuclear scientists, and to maintain its cutting edge in this field, it is imperative that the United States initiate a major investment in a powerful rare-isotope production facility as early as possible.

The recommendation that followed from this resolution was that the highest priority in low-energy nuclear physics should be the construction of a heavy-ion linac-based rare-isotope facility, including the capabilities for stopped, re-accelerated, and in-flight beams. NSAC has already endorsed RIA/FRIB six times, and it was endorsed in the SC Facilities of the Future Plan and the RISAC report.

The second resolution was that forefront research must be continued at existing facilities to make new discoveries, train new people, and develop new detector and accelerator technologies.

The recommendations that followed from this resolution were that

- Appropriate funds for operations and near-term upgrades of existing rare-isotope and stable-beam research capabilities at ANL, NSCL, ORNL, and other national and university facilities should be supported, together with a strong theory program and interdisciplinary initiatives. In particular, it is critical that funding be increased immediately to allow the effective use of the U.S. national user facilities.
- Construction of the Gamma-Ray Energy Tracking Array (GRETA) should begin immediately upon the successful completion of the GRETINA array, the state of the art of detectors. Timely and cost-effective completion depends critically on steady production of germanium detectors and the availability of a highly specialized workforce. Interruption of this effort would be very damaging
- Support for nuclear theory to address key questions in nuclear structure, nuclear reactions, and nuclear astrophysics should be strongly increased to nurture young scientists in this critical area of research in concert with an overall increase in nuclear theory, as recommended in the 2003 NSAC Theory Subcommittee report. There is a high level of enthusiasm and optimism in the nuclear-theory community. The low-energy-theory community has organized itself to take a coherent approach to resolving the scientific challenges it faces.

Concerns about education were present throughout the Town Meeting. Education in low-energy nuclear science (physics & chemistry) is important for societal applications. To attract the best and the brightest, new facilities are essential. Without adequate support today, the highly skilled manpower base required in the next decade will not be available. Education and outreach are key components of any vision of the future of the field of nuclear science. We therefore fully endorse the recommendations of the education white paper.

The white paper will contain resolutions, a roadmap for the next decade, a response of the low-energy community to the questions in the NSAC charge, summaries of the working groups, and links to other documents and white papers. The draft is with the organizing committee for comments; the final version will be ready by end of March.

Dean asked if the workforce concern was on the research, theory, or what side. Janssens said that it was from all sides; even the weapon laboratories are concerned. Dean noted that the recommendations are not in the report. Janssens said that they will be in the Executive Summary next week.

Heinz said that theory support needs to be tied to new developments and to the experimental program. Janssens replied that the working group members wanted to highlight a general support for theory. In the white paper, there is a direct link between theory and the experiments that should be done.

Ent asked whether the agencies had not already done the "effective utilization of U.S. user facilities." Janssens pointed out that some facilities are not running at all. It looks encouraging in the FY07 and FY08 budgets, which were not available when this report was written.

Xiangdong Ji was asked to review the Hadron-Physics Town Meeting, which had 112 participants.

The key questions in hadron physics are: What is the role of gluons (which are electrically neutral and constitute most of the mass of the nucleon) in the nucleon and nuclei? What is the internal spin and flavor landscape of hadrons? How do hadron final states emerge from QCD quarks and gluons in high-energy scattering? What are the effective degrees of freedom describing hadron spectroscopy? What happens to nucleons at short distances in a nucleus: do they merge or stay separate?

A number of accomplishments have been made in this area since the most recent long-range plan. People have mapped out the G1 structure function. The first measurements have been made of the transverse-momentum-dependent Parton distributions and fragmentations. JLab has seen neutron spin asymmetry at large x. Experiments have shown the existence of Compton scattering and model-dependent results. Much progress has been made on the spin-dependent gluon distribution inside the nucleon. The nucleon form factors show improvement since 1997, with remarkable new results for the proton form factor. Several experiments are now giving a rough but good picture of the strange-quark form factor. The CEBAF Large Acceptance Spectrometer (CLAS) has provided new baryon states; this program will for the first time provide complete amplitude information on the KΛ final state and nearly complete information on the Nπ final states. A lot has been learned about nuclear short-range correlations, where the spectral function shows many-body correlations. Lattice QCD calculations allow extrapolation to the pion mass. Some have calculated the moments of generalized Parton distributions. In calculations of two baryons in a box, theoretical calculations come out close to what is observed.

Opportunities in this area lie with the 12-GeV upgrade at JLab, the Electron-Ion Collider (EIC), international collaboration, and theory. The 12-GeV upgrade can increase the accuracy of the flavor structure as x goes to 1. There are several proposed EIC designs; this type of collider has a great physics reach: one can get precision of

DVCS [deeply virtual Compton scattering] unpolarized cross-sections. And the FAIR Project has the PANDA [Proton-ANtiproton annihilation DArmstadt] Program.

The recommendations coming from this town meeting were:

- The highest priority is the timely completion of the 12-GeV upgrade of CEBAF and the start of its exciting research program. The science case is very compelling.
- It is imperative that funding be provided to make effective use of our major research facilities [CEBAF, RHIC-Spin, and the High Intensity Gamma-ray Source (HIγS) at Triangle Universities Nuclear Laboratory (TUNL)]. Federal investment in both people and equipment should be increased at universities to support science and education activities associated with these facilities to finish work under way.
- Support for nuclear theory is critical to achieving the short- and long-term scientific goals of the U.S. nuclear-physics program and should be substantially increased, particularly for recruiting, nurturing, and supporting young theorists.
- A high-luminosity EIC facility is the highest priority of the QCD community for new construction after the JLab and RHIC II upgrades.
- The recommendations of the Workshop on Education and Public Outreach in Nuclear Science are strongly supported.

Tribble asked if the white paper was further along than an outline. Ji replied that the parts will be assembled in mid-March and a final product will be available the beginning of April.

Savard asked how big this community was. Ji responded that this can be estimated from the number of users at JLab and other facilities; that amounts to a few hundred users at each.

Thomas Ullrich was asked to present a report on the Town Meeting on Phases of QCD Matter, which had a joint meeting with the QCD and Hadron Physics Town Meeting. The participants looked at opportunities associated with RHIC II, EIC, the RHIC theory upgrade, and LHC.

Its first recommendation is to pursue a dramatic advance in understanding of QCD matter through quantitative comparison of theory and experiment and through further exploration of the QCD phase diagram at nonzero baryon density, where a critical point has been predicted. From this, the highest priorities are

- Effective use of the RHIC facility and completion of the ongoing detector upgrade program;
- The RHIC II luminosity upgrade, which will enable quantitative study of rare processes; and
- Strong support for the ongoing theoretical studies of QCD matter, including finite-temperature and finite-baryon-density lattice QCD studies and phenomenological modeling, and an increase in funding to support new initiatives enabled by experimental and theoretical breakthroughs. The experimentalists believe that a lot of work on the theory side is needed to explain what has been found, including massive modeling.

The second recommendation is for significant and timely participation of U.S. groups in the LHC heavy-ion program, which will study QCD matter at the highest energy densities and temperatures available in the laboratory. This program will test and extend the insights reached in the RHIC program, and has the potential to make important new discoveries about QCD matter. The LHC will have higher temperatures and densities.

The third recommendation is that an EIC facility is the highest priority of the QCD community after the JLab and RHIC upgrades. EIC will address compelling physics questions essential for understanding the fundamental structure of matter, particularly the precision imaging of sea-quarks and gluons to determine the full spin, flavor, and spatial structure of the nucleon; and the definitive study of the universal nature of strong gluon fields manifest in nuclei. This goal requires that R&D resources be allocated for expeditious development of collider and experimental design.

Further recommendations will be made on theory, education and outreach, and accelerator R&D.

Opportunities perceived at RHIC II include exploring the low-energy frontier, rare probes, higher densities with uranium-uranium collisions, asymmetric collisions, extended phase-space coverage, and forward physics. Heavy ions can be investigated at the LHC. And quantitative phenomenology can integrate data analysis with a complete dynamical description of the collisions.

The resources needed include facility operations and detector upgrades, the RHIC luminosity upgrade, and increased support for theory.

The white paper is well under way.

Tribble noted that the group had three recommendations that had not been drafted and asked if those recommendations had been discussed in sufficient detail at the town meetings. Ullrich replied that they had, indeed, been discussed fully. Heinz said that there had been a conference call after the town meeting, and there may be another to set the language.

Ramsey-Musolf noted that it would be wise to emphasize the research questions and the resources needed to answer those research questions, rather than attempting to make a connection to string theory. Ullrich agreed. There are people who are interested in string theory, but the group needs to be cautious. Heinz pointed out that this is a new door opened by RHIC, and we will see where it goes.

Savard said that the first two recommendations seem to indicate that RHIC is more important than the LHC. Ullrich replied that both are necessary.

Ramsey-Musolf asked what the costs of upgrades are. Ludlam said they are about $30 million for detectors and $90 million for RHIC II. Heinz said that at the LHC, the cost would be about $12 million for manpower and some redirection of funds. Funding of theory is an additional $2-3 million.

Tribble asked if the white paper will be ready in three weeks. Ullrich responded that it will be ready pretty close to that. Tribble said that one needs to keep in mind the proper balance between upgrades and new research.

A discussion of the long-range plan was initiated by Tribble by presenting a suggested outline for the one-week LRP-Resolution Group Meeting. Dean noted that this is a 5- to 10-year planning exercise. Tribble said that he was trying to assemble a list of topics (both large and small) to be discussed.

Glasmacher said that the NSCL should be included. Lee said that GRETA should also be included. Tribble said that he would be reluctant to put a line in for HIγS right now.

Kovar said that the small facilities need to be included along with a reference to their importance. They are embedded in the fundamental research. One could look at how many students and papers they are producing per year.

Ramsey-Musolf asked what the goal of the LRP meeting was. Tribble said that it was to set relative priorities among these topics.

Savard noted that there were questions about these experiments and that proponents were needed to answer those questions. Specific presentations might be made on each of these topics. Glasmacher suggested identifying deliverables for 5 years and beyond and then defining priorities based on the importance of those deliverables.

Tribble said that the first three days are open meetings. Visitors could be asked to leave at certain times. Heinz pointed out that, as chairman, Tribble had the prerogative to close the meeting. Tribble asked if it would be desirable to have each laboratory tell what it is doing. Wilkerson said that context would be needed on the first day. Heinz said that it would be good to have a white-paper report from a community representative and then a report from the national laboratories on each topic.

Ji stated that the time devoted to international activities seems too extensive. What is relevant to this meeting could be presented in less time. Heinz agreed and noted that international representatives could best comment on their capabilities after a cut has been made on priorities.

Milner said that, in terms of underground laboratories, it was not obvious how DUSEL would compare with the foreign underground laboratories. Wilkerson suggested that these international activities be tied in with the new initiatives.

Kovar said that a half day is needed on the international context, and the best way is to get the heads of the laboratories to tell what they are doing. In the past, the international context has not been taken seriously, and that has been a flaw. Tribble agreed. These are billion-dollar, multipurpose facilities that need to be paid attention to. Glasmacher noted that SNOLab is funded, and such underground laboratories should be included.

Tribble asked whether proponents for new efforts should be heard before or after the international facilities. [The general consensus was that they should be heard after.] It would seem the input phase would be finished by noon on Wednesday. Tribble raised the question of how to discuss priorities with 60 attendees.

Makins asked whether people can come in and make 10-minute presentations in the open meeting. van Kolck asked whether that was not what the town meetings were for. Tribble suggested making up a list and voting on priorities. The outcome by Friday afternoon would be a list of the priorities.

Ramsey-Musolf asked if the output was to be (1) four major recommendations and (2) major initiatives that were not priority recommendations. Keister noted that it takes hours to work out wording. That has to be done on Thursday. There will be little time to make hard decisions. Heinz suggested doing a first draft on Wednesday afternoon and doing wordsmithing on Thursday. One has to use the white papers and compress the input into Monday and Tuesday. Tongue in cheek, Kovar said that the workshop could go on until 9:00 p.m. and start at 6:30 a.m. the next day.

Tribble said that he would include international participants and be through the input information by Tuesday evening. On Wednesday, the workshop will start projecting priorities and see how they integrate with the budget issues. Glasmacher asked if people will be asked to come with budget figures for their projects. Tribble said that that information will be needed. Kovar said that someone will have to be the budget guru. Tribble said that he had several people in mind for that position.

I-Yang Lee was asked to report on the activities of the Facilities and Equipment Subcommittee. They have prepared a snapshot of current facilities and the facilities' plans for the next 5 to 10 years.

The first section of the report will describe the current facilities, starting with major accelerator facilities: the high-energy nuclear physics facilities, the nuclear structure and nuclear astrophysics facilities, and other facilities. It will go on to describe the major detectors: neutrino detectors; detectors for neutron experiments; detectors for nuclear structure and nuclear astrophysics; detectors for exploring the quark structure of matter; and detectors at RHIC for exploring hot, dense matter. The third subsection will describe accelerator technology for the 12 GeV CEBAF Upgrade, RHIC II, EIC, radioactive beams, and other accelerators; and detector technology and electronics, including those for CEBAF, RHIC, EIC, Electron–Light Ion Collider (ELIC), LHC, low energy, neutrons, the underground laboratory, and neutrinos. The final subsection will be devoted to advanced computing and nuclear physics, including computing at the major research facilities, the grid, and QCD computing.

The second section on facility plans describes the 12 GeV CEBAF Upgrade, FRIB, RHIC II luminosity upgrade, EIC, electron-driver accelerator for radioactive ion-beam work, SuperCARIBU [CAlifornium Rare Isotope Breeder Upgrade], GRETA (a 4π gamma-ray energy-tracking array), and CLAIRE (a high-intensity, low-energy accelerator for astrophysics).

van Kolck asked about deuteron EDM. Lee said that that should be added. Henry asked what was included in QCD computing. Lee answered, the computers at the three facilities (BNL, JLab, and Fermilab) plus science programs.

Tribble asked what belongs where. Lee answered that the Subcommittee just collected what people think is nuclear physics. The Subcommittee believed that duplication was all right between facility descriptions and science descriptions.

David Dean reported on astrophysics. The report will cover an overview, the science, the origin of simple patterns in nuclei, what binds protons and neutrons into nuclei, what characterizes nuclear matter and neutron star crusts, how the nuclei in the universe were created, the nuclear reactions that drive stars and stellar explosions, and a look ahead with the major recommendations.

Tribble noted that a coherent, uniform report that has a uniform audience was needed.

Elster stated that the prior LRP had been too machine-oriented.

McMahan asked if each chapter should stand on its own. Tribble replied, not if that requires a lot of repetition. Dean noted that the science sometimes spreads over several sections.

Makins asked how much should be included about accomplishments during the past 5 years. Tribble said that it is critical to be mentioned, but the balance between past and future will vary from section to section. All of this is to be put together by the end of the summer.

Rolf Ent presented the outline for the section on QCD and the Structure of Hadrons. It covers an overview, major achievements, theoretical advances, the binding of protons and neutrons, the spin structure of protons, the spatial structure of protons and neutrons, the hadron spectrum, the emergence of nuclei from QCD, and the outlook. About 16 people are contributing to this section.

Susan Seestrom outlined the ACI section. We will need to push the technology and pull examples out of the rest of the report, explicitly connecting it to the needs of the broader community and building on societal contributions of the past.

Henry suggested including something about the Grid, which could revolutionize society the way the Internet did. Ji said that there would be a section on international collaboration. One section will summarize international facilities, and a second will describe international collaborative possibilities. Tribble cautioned that the focus should be on facilities for nuclear physics and those who are competitors for proposed facilities. Dean noted that such lists get very long very quickly. Heinz suggested having examples of international give-and-take in the past.

Peggy McMahan described the education and workforce section, which will present data on manpower, students, and educational programs. Glasmacher said that that section could point out discrepancies between projections and reality. McMahan agreed and said that the numbers need to be understood correctly.

Tribble stated that the previous LRPs should be reviewed by those putting together this year's LRP. Sidebars are useful. NSAC should probably meet a couple of more times this year. An early-August meeting could review the reports from the subcommittees, and one in late November to early December could approve the LRP.

The meeting was adjourned at 2:42 p.m.

Respectfully submitted,
F. M. O'Hara, Jr.
Recording Secretary
April 2, 2007

These minutes of the Nuclear Science Advisory Committee meeting held at the Sheraton Crystal City Hotel, Arlington, Virginia, March 8-9, 2007, are certified to be an accurate representation of what occurred.

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Robert Tribble, Chairman
Nuclear Science Advisory Committee
April 11, 2007