Minutes
High Energy Physics Advisory Panel
February 24–25, 2009
Hilton Rockville Hotel
Rockville, Md.

HEPAP members present:

- Marina Artuso
- Alice Bean
- Priscilla Cushman
- Lance Dixon
- Graciela Gelmini
- Larry Gladney
- Boris Kayser
- Robert Kephart
- Steven Kettell
- Wim Leemans
- Daniel Marlow
- Ann Nelson
- Stephen Olson
- Kate Scholberg
- Melvyn J. Shochet, Chair
- Sally Seidel
- Henry Sobel
- Paris Sphicas
- Maury Tigner
- William Trischuk
- Herman White

HEPAP members absent:

- Hiroaki Aihara
- Patricia Burchat
- Sarah Eno
- Lisa Randall

Also participating:

- Tony Chan, Assistant Director for Mathematics and Physical Sciences, National Science Foundation
- Glen Crawford, HEPAP Designated Federal Officer, Office of High Energy Physics, Office of Science, Department of Energy
- Joseph Dehmer, Director, Division of Physics, National Science Foundation
- Patricia Dehmer, Deputy Director for Science Programs and Acting Director, Office of Science, Department of Energy
- Bonnie Fleming, Department of Physics, Yale University
- Neil Gehrels, Chief, Astroparticle Physics Laboratory, Goddard Space Flight Center, National Aeronautics and Space Administration
- Marvin Goldberg, Program Director, Division of Physics, National Science Foundation
- Steven Kahn, Director of Particle and Particle Astrophysics, SLAC National Accelerator Laboratory
- Young-Kee Kim, Deputy Director, Fermi National Accelerator Laboratory
- John Kogut, HEPAP Executive Secretary, Office of High Energy Physics, Office of Science, Department of Energy
- Dennis Kovar, Associate Director, Office of High Energy Physics, Office of Science, Department of Energy
- Marsha Marsden, Office of High Energy Physics, Office of Science, Department of Energy
- Piermaria Oddone, Director, Fermi National Accelerator Laboratory

Frederick M. O'Hara, Jr., HEPAP Recording Secretary, Oak Ridge Institute for Science and Education
James Siegrist, Associate Laboratory Director for General Sciences, Lawrence Berkeley National Laboratory
Michel Spiro, Director, National Institute for Nuclear and Particle Physics, Centre National de la Recherche Scientifique
Michael Strayer, Associate Director, Office of Advanced Scientific Computing Research, Office of Science, Department of Energy
Steven Vigdor, Associate Laboratory Director for Nuclear and Particle Physics, Brookhaven National Laboratory
Andreene Witt, Oak Ridge Institute for Science and Education

About 50 others were present in the course of the two-day meeting.

Tuesday, February 24, 2009
Morning Session

Before the meeting started, a member of the General Counsel's Office of DOE presented the annual ethics briefing to the Panel members.

The meeting was called to order by Chairman **Melvyn Shochet** at 10:00 a.m. He welcomed the new Panel members and thanked them for their service. He introduced **Patricia Dehmer** to present the news from the Office of Science (SC).

The nation has a new President and Secretary of Energy who believe that energy is a critical part of our society. The Department is dealing with the American Recovery and Reinvestment Act (ARRA) of 2009, the FY10 budget request and out-year estimates, and the FY09 appropriation. All of these are informed by the recession, energy prices, and urgency of climate change. The energy plan is to:

- Within 10 years save more oil than the United States currently imports from the Middle East and Venezuela combined.
- Put 1 million 150-mile-per-gallon plug-in hybrid cars on the road by 2015.
- Generate 10% of our electricity from renewable sources by 2012, and 25% by 2025.
- Implement an economy-wide cap-and-trade program to reduce greenhouse-gas emissions 80% by 2050.

Chu's five priorities and goals for DOE are to

- Invest in science to achieve transformational discoveries;
- Change the landscape of energy demand and supply;
- Create millions of green jobs and increase competitiveness;
- Maintain nuclear deterrent and prevent proliferation; and
- Position the United States to lead on climate change policy, technology, and science.

The follow-up chart on science and discovery calls for (1) a focus on transformational science, that connects basic and applied sciences, re-energizes the national laboratories as centers of great science and innovation, doubles (over 7 to 10 years) the SC budget, embraces a degree of risk-taking in research, and creates an effective mechanism to integrate national laboratory, university, and industry activities; (2) the development of science and engineering talent by training the next generation of scientists and engineers and by attracting and retaining the most talented researchers; and (3) universal collaboration by partnering globally, supporting the developing world, and building research networks across departments, government, the nation and the globe.

The FY08 budget for SC was $3.9 billion. The DOE budget fell short of the Presidential Request for several years. The House and Senate conference markup is $4.7 billion, just 1% less than the request, which called for a 19% increase over FY08.

There were $62 million in the supplemental appropriation last year, half of which went to the Office of High Energy Physics (HEP). All programs have now been brought up to near the America Competes Initiative (ACI) level.

Looking at the 10-year funding profiles of the various offices of SC, one can see that the Office of Advanced Scientific Computing Research (ASCR) is the most robust, the Office of Basic Energy Sciences (BES) has grown by virtue of the infrastructure it has put in place, and the Office of Fusion Energy Sciences is declining and is only half of what the ACI called for.

The final FY09 ARRA funding is still embargoed. The Washington Post gave a good graphic representation that showed the Committee on Water and Energy as a major player in the ARRA. In the drill-down of energy and water funding, the Office of Energy Efficiency and Renewable Energy (EERE) gets $18.5 billion, energy-related loan guarantees get $8 billion, modernizing the energy grid and other projects get $17.4 billion, the Army Corps of Engineers gets $4.5 billion, and other offices get $0.5 million.

The National Institutes of Health (NIH) ended up with $10.5 billion, and DOE got about $1.6 billion. That DOE funding is scheduled to be used for facility construction, improvements in facility operations and infrastructure, selected research, computing, and fellowships. Funds were allocated to provide improvements in infrastructure without mortgages and to pay down or eliminate out-year mortgages.

The national energy sources and consumption chart needs to be “burned into your cortex.” The energy-flow diagram shows that one-third of the nation’s energy is imported, mostly petroleum. The United States produces 71.7 quads of primary energy, imports another 34.6 quads, exports 5.4 quads, and consumes 101.6 quads. However, the U.S. energy flow in 2006 shows that almost 50% of the energy produced in the United States is unused. The key RD&D strategies are

- Zero-emission electricity generation
- Fuel switching
- Carbon capture
- Energy storage (batteries)
- Electricity distribution
- Improved end-use efficiency
- Conservation
- Climate and environmental impacts

Shochet asked if the bullets on priorities are in the same order as Chu’s priorities. Dehmer replied, yes.

Marlow noted that the unused energy looks like low-hanging fruit and asked how much of it was actually achievable. P. Dehmer replied that one will not get to zero, but one can make huge impacts (e.g., through solid-state lighting).

Cushman asked what congressionally directed projects were. P. Dehmer answered, pork. Those projects will be detailed in the report language from the Joint Committee.

Spiro asked if there were any chance of increasing nuclear power. P. Dehmer replied that the President is taking another look at nuclear.

Oddone noted that the legislation calls for an Office of Advanced Energy Research. P. Dehmer responded that there have been many proposals on how such an office should look. Chu is looking at these proposals and consulting experts. The legislation has $400 million for such an office, but that funding may not be continued.

Artuso asked if the Secretary really believes in transformational science. P. Dehmer replied, yes. He looks for the top people to work on strategic problems. He puts a huge stock in scientific talent. He will lean on the whole Department to do the same.

Trischuk asked if there were a problem in getting funding for the International Thermonuclear Experimental Reactor (ITER). P. Dehmer responded that the reduction in funding is a recognition that the original request probably could not have been used this year.

Dennis Kovar was asked to present an update on the DOE Office of High Energy Physics (HEP).

It has been an interesting ride in the past year. The Office has dealt with a large funding reduction, developed a new strategic plan, and reorganized the Office and how it does business. Scientifically, it was a good year. The Large Hadron Collider (LHC) came online. The Tevatron is running well. The last runs of the SLAC National Accelerator Laboratory's B Factory detector (BaBar) were very productive. The Pierre Auger Observatory (Auger) is detecting the highest-energy cosmic rays.

The Office has three fiscal-year budgets and one stimulus bill in play: the FY09 ARRA has $1.6 billion for SC, the FY09 Appropriations Bill is still up in the air, the FY10 Congressional Request has not formally been submitted to the Office of Management and Budget (OMB) yet, and the FY11 budget is in the planning stages. There will be extensive tracking of the expenditure of ARRA funds by OMB.

The FY09 budget is down about $9.5 million, predominantly the reduced funding for the NuMI Off-Axis ν_e Appearance experiment (NOvA), balancing a previous appropriation. There is funding to operate to March because of supplemental funding, termination of B-Factory operations, and changes in responsibilities for general plant projects (GPP). If the Continuing Resolution continues beyond March, things will start to fall apart. There has to be an increase for Fermilab. There are a lot of complexities that resulted in shifts in funding; supplemental funding increased this complexity. Some of those funds were redirected to NOvA, and most projects were supported at constant levels. Out-year funding in managing projects, in infrastructure investments, and in research will be aided by ACI funds, which will change funding and plans for all programs. SC has allocated funding for science programs in its FY10 budget. HEP will be reviewed by OMB this week. ARRA funding could reduce out-year commitments. The FY11 budget is due to OMB in August!

The accelerator R&D workshop may be held in August 2009 to inform HEP's stewardship of advanced accelerator R&D. Accelerators now play an important role in areas beyond scientific research. The workshop goals are to identify and understand the role of accelerators in society; their current status with regard to capabilities, costs, and deployment; the stakeholder requirements (intensity, resolution, timing, and energy); the organization of current accelerator R&D efforts; and a path forward to meet society's needs. A report will be produced to document the findings and recommendations of the workshop. This Panel should be considering whether more workshops should be planned to address the specific scientific and technical challenges identified by this workshop. Generic R&D should address the grand challenges in accelerator science, and this workshop is intended to identify what those challenges are and where the resources should go. Another charge will be issued to look at directed research in the future.

The European Space Agency has joined in the Joint Dark-Energy Mission (JDEM). Combining JDEM and Euclid will ensure a strong dark-energy mission. Agencies are re-evaluating their roles and responsibilities.

The Baryon Oscillation Spectroscopic Survey (BOSS) is a dark-energy study on the Sloan Digital Sky Survey Phase III; HEP has provided R&D and instrumentation funds in FY07 and FY08; DOE recently approved operations funding starting in FY09; NSF and the Sloan Foundation are also providing funds.

The Alpha Magnetic Spectrometer (AMS) is now on the Shuttle manifest for a 2010 launch.

The Office participated in the first meeting of the Deep Underground Science and Engineering Laboratory (DUSEL) Joint Oversight Group (JOG), which is comprised of representatives of NSF/Physics, DOE SC HEP, and DOE SC Office of Nuclear Physics (NP). It was established to keep the agency offices informed on the status of DUSEL and to coordinate planning on possible experiments at DUSEL. At its December meeting, NSF outlined the status of their planning for DUSEL, and DOE HEP and NP outlined their plans for possible experiments. HEP discussed how it planned to proceed within DOE on pursuing a Long-Baseline Neutrino Oscillation Experiment (LBNE) major item of equipment (MIE). HEP has been invited to participate as observers at NSF reviews.

In the LBNE, the two agencies are supporting each other to achieve their shared scientific goals. NSF will lead the design, construction, and operation of DUSEL, DOE will lead the design, construction and operation of the LBNE beam and detector, and each agency will follow its own procedures and project management policies in exercising its roles. The Office is seeking approval from the Department for a Mission Need (CD-0) for the project. The Office has identified the Fermi National Accelerator Laboratory (FNAL, Fermilab), working with Brookhaven National Laboratory (BNL), to take responsibility for performing the work needed for approval of CD-1 (Exploration of Alternatives). This includes conceptual design, alternatives analysis, etc. DOE and NSF will work together closely to coordinate their efforts, avoid duplication, and optimize their investments.

Alan Stone and John Boger have joined the Office. Three positions are open in Nonaccelerator Research, Instrumentation, and Theory. Another position has just been approved.

Shochet commented that the accelerator R&D workshop document will help the field advance.

Marlow pointed out that another product is students, and asked how many students trained at accelerators, and of those, how many go into industry. Kovar replied that the Office does not have that information. It needs to be collected. A presentation was made at the previous meeting on the difficulties in producing such data. Prior reports have bits and pieces of such data, and some of those data are outdated. Marlow asked where the people working in these areas came from. Kovar responded that the Office has looked at that question for the national laboratories but not the weapons laboratories. It got only about a 15% response rate to its queries, skewing the data.

Kahn asked if there would be a joint oversight group. Kovar replied that the Office will have a JOG, and it will evolve through partnerships.

Siegrist asked if a follow-on workshop on instrumentation was envisioned. Kovar answered that there will be a series of workshops, and instrumentation should be thought about at that time.

Michel Spiro was asked to report on the European priorities for astroparticle physics.

The Astroparticle Physics European Coordination (ApPEC) was created in 2001 by the national funding agencies of France, Germany, Italy, the Netherlands, and the United Kingdom; then others joined. ApPEC aims to promote and facilitate cooperation within the European particle astrophysics (PA) community; develop and promulgate long-term strategies for European PA; assist in improving links and coordination between European PA and the scientific programs of organizations like the Conseil Européen pour la Recherche Nucléaire (CERN, now Organisation Européenne pour la Recherche Nucléaire), European Space Agency (ESA), and European Southern Observatory (ESO) and express their collective views on PA in appropriate international forums.

The AStroParticle ERAnet (ASPERRA) is a program funded by the European Union (EU) for 3 years to coordinate work in astroparticle physics. It has determined the status of astroparticle funding in Europe, linked existing large infrastructures, developed a roadmap of infrastructures, and launched a common call for support of design studies of the priority projects.

A representative of the ApPEC SC attends the European Strategy sessions of the CERN Council; a representative of the ApPEC Peer Review Committee (PRC) is a member of the scientific secretariat for the European Strategy sessions of the CERN Council; and the working group on the scientific and geographical enlargement of CERN will include an ApPEC representative. CERN consults with ApPEC when astroparticle physics experiments request the recognized-experiment status from CERN.

In the high-energy universe, one studies the origin of cosmic rays and nonthermal processes, seeks access to energies beyond the LHC, searches for dark-matter annihilation, seeks extreme phenomena serving as cosmological markers, and probes intergalactic space and/or the space-time fabric itself. The infrastructure used includes the Cubic-Kilometer-Scale Neutrino Telescope (KM3NeT) in the Mediterranean, the high-energy gamma-ray Cherenkov Telescope Array (CTA), beyond the Auger South Observatory (Auger-North), and the Einstein Telescope (ET) for gravitational wave detection wave detection [an extension of the Laser Interferometer Gravitational Wave Observatory (LIGO)].

In high-energy neutrinos, there has been a 100-fold increase in sensitivity in 15 years. IceCube plus KM3NeT gives full-sky coverage. KM3NeT points to the galactic center with a projected sensitivity and resolution that is 3 times better than that of IceCube.

In the high-energy gamma rays, CTA increases sensitivity by a factor of 10 and angular resolution by a factor of 2 to 3.

In charged cosmic rays, Auger North is looking at the sources of ultrahigh-energy cosmic rays, the acceleration mechanism, their propagation and cosmic structure, particle physics at 300 TeV, and multi-messenger astrophysics.

In gravitational-wave research, there have been results from a worldwide network: Virgo, LIGO, Advanced LIGO, ET, and Laser Interferometer Space Antenna (LISA).

In underground science, the dark-matter and neutron-mass detectors are moving toward one ton, and proton decay and neutrino detectors toward the megaton.

In Europe, there are four large underground laboratories and three smaller ones. ApPEC supports their coordination.

In dark matter, there are three types of searches, and there are European projects and foreign participation in all three types. These include (since 2003) the Experience pour Detecter les WIMPs en Site Souterrain (EDELWEISS), Cryogenic Rare-Event Search with Superconducting Thermometers (CRESST), and Wimp Argon Programme (WARP); (in 2007-2008) the Cryogenic Dark Matter Search (CDMS)/XENON10; (in 2010-2011) the XENON100, WARP140, EDELWEISSII, and CDMS; and (in 2015-2016) the 1-ton Bolometer/Noble Liquide. The understanding of the cross-section and mass of wimps is increasing by an order of magnitude every 5 years.

Three facilities are looking at the mass of the neutrino: Germanium Detector Array (GERDA), Cryogenic Underground Observatory for Rare Events (CUORE), and Super Neutrino Mediterranean Observatory (SuperNEMO).

Three other facilities are looking at proton decay and neutrino physics: Megaton Mass Physics Detector (MEMPHYS; 700 kt), Low Energy Neutrino Astronomy (LENA; 50 kt), and Giant Liquid Argon Charge Imaging Experiment (GLACIER; 100 kt).

Dark energy is not prioritized in the roadmap because dark energy depends also on other non-ApPEC agencies. The ApPEC/ASPERA roadmap does support participation in existing and future U.S. programs and supports a common U.S.–EU dark-energy mission.

The magnificent seven projects are KM3NeT, CTA, Auger North, ET, the 1-ton dark matter experiment, the megaton proton decay experiment, and the 1-ton neutrino mass experiment.

The projected schedule for the programs is: CTA and KM3 have a high priority in the Astrophysics Roadmap, and both are in the European project European Strategy Forum on Research Infrastructures (ESFRI) roadmap. KM3's advanced Design Study and Preparatory Phase are in progress. Both CTA and KM3 could start construction by 2012. Auger North's start of construction depends on the U.S. evaluation process. Dark matter and neutrino mass continue with a few techniques at the 10- to 100-kg scale; by 2011-2012 a decision should be made on the technology(ies) of the ton-scale detector(s). The EU Design Study for the megaton-scale detector for proton decay is in progress; decisions are expected in 3 to 4 years about a start in mid-decade. The ET is expecting decisions by 2016 after VIRGO/LIGO detection results. Most projects would profit from coordination either of a distributed type (e.g., the VIRGO/LIGO network) or by the creation of a global-scale single infrastructure (e.g., Auger South).

The projected budget for these seven programs plus existing facilities increases from €70 million to more than €160 million in the next 10 years.

In summary, the European astroparticle physics community has prepared a phased priority roadmap that enjoys large acceptance by the agencies and the community, and a discussion has started about a more sustainable coordinating structure that would manage the realization of the program. Its eventual relationships to the existing pan-European structures are being examined. These efforts must be coordinated with those of other regions. This process has started in the context of the Organisation for Economic

Cooperation and Development (OECD) Global Science Forum and could continue in other bodies [e.g., the Funding Agencies for the Large Collider (FALC)].

Shochet asked how the committees have viewed international collaboration for the large detectors. Spiro answered that they have considered collaboration for each program and generally look to FALC for guidance.

Scholberg asked if there were plans for the megadetectors to have beams pointed at them. Spiro replied, yes, there are discussions.

Gelmini noted that there is a facility similar to CTA in the United States and asked if this competition were good. Spiro responded that the facilities work together to get complete coverage.

Kayser asked about the expected role of Europe in Auger North. Spiro replied that it was a priority, but the United States is the primary player.

Oddone noted that CERN is considering expansion and asked what effect that would have on ApPEC. Spiro answered that ApPEC will have a representative on that CERN working group. It is looking at participation by all European countries and others (e.g., Turkey).

A break for lunch was taken at 11:58 a.m.

Tuesday, February 24, 2009
Afternoon Session

The meeting was called back into session at 1:30 p.m., and **Tony Chan** was asked to present an update on the activities of the NSF related to high-energy physics.

The NSF is working on four budgets at the same time: the FY09 Congressional Request, which appropriation is likely to pass by March 6, 2009; the FY09 ARRA in which NSF is awarded $3 billion; the FY10 Congressional Request, which is under development and is expected to be delivered in late March or early April; and the FY11 Congressional Request, for which the planning process begins this spring.. The ARRA $3 billion infusion is a one-time 50% increase.

The ACI went out with the Bush administration. It has turned into the America Competes Act (ACA), which is a law authorizing specific funding but not appropriating actual funds. ACI emphasized doubling the budget for critical physical sciences. ACA calls for doubling the budget in 7 years, but its emphasis is on a balance across scientific disciplines and science education, not the physical sciences alone.

The Obama administration is expected to emphasize science with a focus on basic research, climate change, energy, and innovation and education.

The FY09 NSF budget request asked for an overall 13% increase with a 16% increase for research and related activities (R&RA) and a 33.2% decrease for major research equipment and facilities construction (MREFC). Mathematical and Physical Sciences (MPS) is looking at a 16% increase.

Funding for major projects (FY08 estimated/FY09 requested) is: Advanced LIGO ($32.75 million/$51.43 million), Atacama Large Millimeter Array (ALMA; $102.07 million/$82.25 million), IceCube ($25.91 million/$11.33 million). Advanced technology and the solar telescope will be dealt with in the FY10 budget.

The ARRA awarded NSF $3 billion, of which 2.5 billion will go for R&RA with $200 million specifically dedicated to the modernization of academic research facilities, $100 million for education and human resources, and $400 million for MREFC. The guiding principles for funds' use are to increase funding rates, support young investigators, and provide for "shovel ready" projects. The NSF spending plan must be approved by OMB and Congress before the funds may be used. The goal is quick deployment of funds. There is some confusion about how quickly these funds can be spent.

NSF and DOE are practicing joint stewardship over the LHC, International Linear Collider (ILC) research and development at the Cornell Electron Storage Ring (CESR), DUSEL, Large Synoptic Survey Telescope (LSST), and many other projects.

In MPS, the P5 [Particle Physics Project Prioritization Panel] report was accepted, the Physics Division Committee of Visitors (COV) was completed, the DUSEL first annual review was completed, an Accelerator Physics Session was held at the February 2009 American Association for the Advancement of Science (AAAS) meeting, and the National Science Board (NSB) is considering a new MREFC process.

The Physics Division COV gave high marks to the Division's review process; the balance of the portfolio between core research and facilities was endorsed; the use of life-cycle planning and the strengthened project management were endorsed; DUSEL started well but needs more agency commitment and adequate up-front design and development (D&D); it commended the LIGO Laboratory and LIGO Science Collaboration; it questioned how to support young principal investigators (PIs) in this economic crisis; and it recommends a mid-scale instrumentation program.

At the Chicago meeting of the AAAS, a panel posed the question whether there was a U.S. plan for accelerator science. Lots of exciting new science and technology is coming up, but there is no U.S. coordinating plan. The NSF light-source panel recommended NSF stewardship, research and related (R&R), and training rules. A DOE workshop will be held on accelerator science later in 2009.

The NSB is looking at possible changes to the MREFC process. Being considered are NSB's prioritizing candidate MREFC projects following the issuance of a conceptual design report (CDR) rather than after the issuance of the preliminary design review (PDR); the possible augmentation of the sponsoring division's budget, beginning during PDR; NSB's assessing candidate projects within the constellation of competing opportunities, existing facilities, and balance of support for infrastructure and individual PI research; and NSF's providing to NSB a full picture for how the potential new facility fits into the broad program of activities NSF supports, including the opportunity costs for pursuing the proposed activity instead of others. NSB wants to have input early in the conceptual-design process, giving a project more of a mandate in going on to the next step.

Kayser worried that the NSB only meets occasionally and could slow down the budgeting process. Chan said that he worried about that a lot. The NSB meets two or three days every other month; but to their credit, they know a lot about NSF.

Kahn asked if the new process would grandfather in projects that are already in the pipeline. Chan said that that is unclear, but he expected that this new process would be applied as new projects came along.

Kim asked how DUSEL would employ collaboration and if NSF had any vision on how one could do better in training with DUSEL. Chan replied that DUSEL is one of the most complex projects that NSF has undertaken. It just received the first set of costs. NSF cannot do the LBNE by itself; it needs Fermilab. Many parties are involved in DUSEL.

NSF is trying to do all the right things at each stage so that DUSEL can become an MREFC project. NSF has been getting letters from advisory committee members suggesting many ways to extend training opportunities. It has already adopted several of the suggestions and is considering many others. Some of these possibilities will not meet the requirements of the ARRA.

Joseph Dehmer was asked to talk about the NSF Division of Physics. The ARRA has been passed, and allocations are being made to NSF divisions today and sent off to Congress for approval, which will probably occur in about two weeks. It includes $2 billion to be spent on R&RA, and the Physics Division is 2% of R&RA. This is a major opportunity. The trick is to help the physics community in a way that does not have any unintended consequences. The funds will be used as standard grants to fund proposals that have already gone through peer review. This approach will spread the stimulus money over 3 years, producing a drop-off in 2012, but a drop-off that would be less than that if all the money were granted in 1 year.

Projects under construction are IceCube and Advanced LIGO. IceCube has two seasons to go, and Advanced LIGO is starting in FY08 to extend LIGO by a factor of 10. The new project in the preliminary design phase is DUSEL. An upgrade of the LHC detectors has been proposed.

NSF held an annual review of the DUSEL design on January 28–30, 2009. This review was very useful. It gave an idea of the needed design investment and what was needed to get to the endpoint.

The MREFC is envisioned to consist of both facility and experiments. Solicitation 3 governs facility and infrastructure design. Solicitation 4 (S4) governs designs for candidate experiments. The S4 proposal deadline was January 9, 2009; 25 proposals were received; they will be reviewed in the spring,, and awards will be made during the summer. The two solicitations will cost a total of $150 million. The timeline is: July 2008 was the internal project review of facility and infrastructure. January 2009 was the NSF Project Review #1. January 2010 will be the NSF Project Review #2. December 2010 will be the NSF PDR; the project readiness and planning will be assessed at this milestone. Spring 2011 will be the presentation of DUSEL MREFC package to NSB. FY13 is the earliest construction funding (MREFC) start, if approved. Planning with potential partners is being integrated into this schedule.

There are a lot of astroparticle physics projects. The portfolio in the Physics Division includes 22 projects in 9 categories. Many of these projects involve partnerships. This is a big portfolio and a rich source of physics. All of them want to upgrade. The scientific significance and strategic value of each project upgrade need to be evaluated.

Since 2000, the Physics Division has added four new programs. There are now six traditional programs, four new (and small) programs, and one proposed program. Accelerator Physics and Physics Instrumentation (AP&PI) is waiting to become a program. About $30–40 million is needed to support a new program. This might happen for AP&PI in FY10.

The funding level of the Physics Division is not quite doubling in 10 years. The 10-year funding profile shows a 6.1% increase per annum. In the FY09 request, the NSF is up 12.69%, MPS is up 19.77%, and the Physics Division is up 18.3%. For FY10, the Physics Division request reflected an 18% increase, but the NSF as a whole is getting 13% rather than the 16% that was requested.

The core or base research funding (PI grants) is the most important investment NSF makes. The PI grants are kept at more than 50% of the overall NSF funding. The facilities are funded between 30 and 40% of the budget. Centers are funded at 10% or more (as recommended by the COV). An effort is being made to increase the participation by women and under-represented minorities. The number of awards going to female PIs or co-PIs has increased dramatically since 1999, and the number of other minorities receiving awards has also increased. However, although the percentage of women receiving awards has increased (from 12 to 17%), the percentage of awards to minorities has increased only from 7 to 8%. Minority PIs or co-PIs have increased from 40 to 60. As a percentage of all awards, new awardees are steady at about 27% each year.

Shochet noted that, among the major projects, the LHC upgrades are time critical and asked how one can ensure the timing of funding. J. Dehmer responded that NSF is trying to insert that request as an upgrade of very high merit.

Kahn asked how NSF viewed the new Accelerator Science Program. J. Dehmer replied that that program would provide a home for accelerator science students and would be a capitalization mechanism for instrumentation.

Marlow asked how many solicitations for DUSEL would be funded. J. Dehmer responded that, each year, NSF funds five projects for 3 years.

Vigdor asked what NSF's current path forward for DUSEL was. J. Dehmer replied that the COV said that NSF was doing well with planning. P5 has approved DUSEL. The Particle Astrophysics Scientific Advisory Group (SAG) view is forming. There is not any set of rules that will knock it out. LSST, DUSEL, and others are not going to go back to square one.

Kim asked whether the new programs will come out of some other program. J. Dehmer replied, no. A new entity will be created and grown. It will not be carved out of high-energy physics.

Kayser noted that LSST and DUSEL are in similar areas and asked how their schedules compare. Dehmer said that DUSEL is a little bit ahead in the planning process but they will not block each other.

Olson asked if there were any intention to fund research in exotic detectors. Dehmer responded that NSF was open to that.

Cushman asked if all the ARRA funding would go into domestic programs. Dehmer replied, yes; the intent is to create jobs in the United States.

A break was called at 3:17 p.m. The meeting was called back into session at 3:34 p.m. **Bonnie Fleming** was asked to comment on the R&D program and plan toward a liquid argon–time projection chamber (TPC) at DUSEL.

Liquid-argon TPC detectors are being developed for neutrino physics and nucleon decay. These unique detectors make precision measurements in neutrino physics and appear scalable to large volumes.

In the United States, researchers are moving toward a modularized detector to optimize the mass of each module and the number of modules against cost, schedule, technical feasibility, and safety. A 100-kt fiducial volume gives an impressive physics reach for charge-parity violation and proton decay.

The main challenges for massive liquid argon TCPs are

- Purification issues associated with large, industrial vessels
- Cold, low-noise electronics and signal multiplexing

- Vessel design, materials, and insulation
- Safety and installation problems produced by siting the vessel underground
- Understanding the costs of these detectors

These issues are being addressed rapidly by DUSEL working groups.

The big-detector baseline plan for the total detector calls for a mass of 90 kt comprised of smaller (5 kt on up) detector modules.

Why a modularized detector?

- It allows for first physics results early on.
- It provides flexibility in construction and costs over time.
- It is easier to protect against purity and safety problems.
- It avoids some of the construction and cost issues of very large caverns.
- The physics reach is nearly the same.

The Argonaut Project has a 0.3-ton active volume, it has a $0.5 \times 0.5 \times 1.0\ m^3$ TPC and 500 channels that allow one to see neutrino interactions (about 150 events/day) under long-term running conditions underground. Argonaut was commissioned with liquid argon for the first time on August 4, 2008. The first cosmic tracks were seen on August 9. There were a few missing channels. Those were fixed, and the detector was lowered down the Neutrinos at the Main Injector (NuMI) shaft. It is now being filled. Fermilab Materials Purity Test Stand is a system to study the impact of different materials on the purity and effectiveness produced by different purification techniques. The system is running and taking data with different filtering techniques and with samples of the materials that are to be used in the detectors. This will be a testbed for the life of the program.

To achieve purity, the tank is being flushed with pure argon gas and then it is being filled with pure argon gas. An intermediate filling with a liquid as a getter is also being considered and will be tested. The MicroBooNE (a detector at the Booster Neutrino Experiment) purge test is a 6-week program that will precede the physics run. It will use ten volume changes of argon gas to reduce oxygen concentrations to 10 ppm. The filtered gas will be recirculated, or a small amount of liquid argon will be introduced as a getter, and purification will be continued for about a month. Then liquid argon will be introduced and tested for purity.

In terms of cold electronics development, there is a need for pre-amplification and multiplexing in liquid argon. The concerns are the signal-to-noise (S/N) requirements (one needs to limit capacitance to the electrodes only), the geometry (they must read out on the sides of the TPC in liquid argon), and the signals must be multiplexed to avoid ~1 million channels of readout (which would be messy and produce heat leaks). There is some experience in electronics in liquid argon, but more is needed for DUSEL-scale detectors. The MicroBooNE readout electronics design is one step towards fully cold electronics. For full-scale DUSEL detectors, a fully integrated application-specific integrated circuit (ASIC) with complementary metal oxide semiconductor (CMOS) technology is needed and is expected by 2012.

The MicroBooNE is also providing data on TPC and detector overall strengths and shortcomings.

Why 5 kt?

- It gives good physics reach.

- It is sized well for the initial suite of experiments at DUSEL, allowing an early start.
- It is an appropriate step in size beyond MicroBooNE (and a technically reasonable step).

The physics reach for a 5-kt detector is as good as or better than that for NOvA. Also, in 10 years, it surpasses the reach of Super Kamiokande for $p \rightarrow K^{+}\nu$ because it is so much more efficient. The 5-kt unit also fits in the largest of the caverns planned for the initial suite of experiments. Initial concepts for getting cryogenics underground are being developed.

Argon leaks can be mitigated by designs developed by other industries.

One of the main focuses of the liquid-argon subgroups is to go hand in hand with design during the upcoming year. Already, there have been a number of preliminary costing studies for massive liquid-argon TPCs. The rule of thumb is that there will be about equal costs ($100 million) for the liquid argon, the cryostat/cryogenics, and the inner detector (TPC/electronics) for a total cost of about $300 million.

A lot is under way, but there is still a lot to do. Interest in the liquid-argon program is growing rapidly in the United States. There is a test-stand program at FNAL, BNL, and universities. The MicroBooNE has nearly doubled in size to more than 50 scientists since approval in July 2008. And there is a liquid-argon subgroup of the Long Baseline–DUSEL collaboration. The team of people pushing this effort is strong and expanding. Growing support for the effort is needed to stay on an aggressive timescale. Ways are being looked at to enlist international collaborators.

The baseline plan for 90 kt of liquid argon gives an impressive reach in physics. 5 kt is a great way to start the program. It fits in the caverns for the initial suite of experiments, producing physics early on. While massive liquid-argon TPC detectors seemed far off a few years ago, progress in the United States has proceeded very rapidly. There is still lots of R&D to do, but it can be done on a timescale that is do-able for DUSEL physics. Pushing on the timescale for MicroBooNE and finding resources for developing a 5-kt liquid-argon detector will keep the program on this timescale.

Marlow asked why freeze-thaw was being considered. Fleming replied that it was being designed in so it does not spill, but one has to have provisions against accident. Marlow asked whether cryogenic safety experts had looked at this design. Fleming answered that one cannot make it too safe. Experts have looked at this and not seen any showstoppers. However, there should be cryogenic safety engineers on the review panels.

Olson asked why it was so deep. Fleming responded that it was that deep to shield against the noise of cosmic particles.

Neil Gehrels called in with his presentation on the Joint Dark Energy Mission (JDEM), which is a precision cosmology instrument with a 2015–2016 launch date with a 5-year dark-energy mission and potential for an extended mission. It has the potential for an order-of-magnitude improvement in the figure-of-merit for joint errors on the equation-of-state parameters w and w_a (plotted against each other) compared with current experiments. It also will measure the growth-factor exponent to distinguish Einstein's theory of general relativity from alternate theories. JDEM is designed for the greatest leverage to determine what dark energy is. There are profound implications on understanding the universe in terms of the universe's density (dark energy is 73% of the mass-energy density of the universe); the existence of a cosmological constant; a signal of new gravitational physics; the relations among dark matter, inflation, and neutrino mass; and the connections to superstring theories and extra dimensions. It will answer the question of whether the universe is headed to a big freeze or a big rift.

JDEM will conduct high-sensitivity large-scale visible and near-infrared (NIR) galaxy surveys and also gather data on weak lensing, baryon acoustic oscillations (BAO), and supernovae. The weak-lensing probe will produce a precision shape measurement of galaxy shapes and measure photo-z redshifts; 1 to 2×10^9 galaxies will be mapped. The BAO probe will conduct a spectroscopic redshift survey in which emission-line galaxies will be positioned in 3D; a few hundreds of millions of galaxies will be mapped with spectroscopic redshifts. The supernovae probe will use Type 1a supernovae detected into the NIR with color and lightcurve parameters for standard candles. All three probes needed to be included in JDEM.

Precision measurements of dark energy probes are necessarily systematics limited. Space offers broadband NIR coverage, there is no blur from atmospheric scintillations, low-background sky regions are accessible, stable systematics control is obtainable at L2 (e.g., of the point-spread function over a large field of view), all of the sky is available day and night, and precise repetition of measurements can be obtained. JDEM focuses on space-unique capabilities that are complementary with ground-based measurements. JDEM could be built today.

It was only in 1998–1999 that the expansion of space was seen to be accelerating. In 2007, the National Research Council (NRC) Beyond Einstein Program Advisory Committee (BEPAC), which was commissioned by the National Aeronautics and Space Administration (NASA) and DOE, recommended JDEM as the first Beyond Einstein mission to fly. And in 2008, JDEM was formulated as a strategic agency-led mission.

The Dark Energy Task Force (DETF) was commissioned in 2005, and the Figure of Merit Science Working Group presented its findings in 2008.

The Science Coordinating Group (SCG) was formed by NASA and DOE in September 2008 for community input on JDEM. Its final report will be published in March 2009.

The SCG concurred with the prior assessments, particularly that all three techniques should be represented in the mission. It stated that the primary strengths of space measurement are the NIR coverage, observations over full sky at any time, and tight systematics control.

The mission will produce a rich legacy of data, mapping hundreds of millions of galaxies in three dimensions and providing NIR data about large-scale structure; galaxy clusters; high-redshift active galactic nuclei (AGN); galaxy evolution, structure, and formation; stellar populations; star formation history; and solar-system objects.

The Project Office has been formed at NASA's Goddard Spaceflight Center (GSFC) and is supported by DOE through a project office at Lawrence Berkeley National Laboratory (LBNL). Discussions are in progress with the European Space Agency (ESA) about its possible participation. This mission is on a fast schedule. Phase A of the mission-concept review will start in March 2009, and Phase B (preliminary design) will start in 2010.

Shochet asked if there were a consensus on the SCG that the experiment had been optimized for all three techniques. Gehrels replied that there is a consensus on how the three should be put together. There was a lot of discussion about the greatest scientific advantage that could be gained. The group came up with a configuration that gives an order-of-magnitude advance in the figure-of-merit errors. Ground-based data will be depended on to complement, for example, the weak-lensing observations.

Shochet asked what the sensitivity for *w*' was. Gehrels responded that it is really *ww*' that is the key metric.

Gladney asked how flexible the design will be when the statement of opportunity comes out. Gehrels answered that the group is just beginning Phase A of the conceptual design, so there will be a great amount of flexibility. The two configurations [JDEM and Euclid (of the ESA)] are very similar.

The meeting was adjourned for the day at 4:40 p.m.

Wednesday, February 25, 2009
Morning Session

The meeting was called back into session by Chairman Shochet at 9:03 a.m. **Glen Crawford** was asked to report on the laboratory reviews.

HEP has three types of reviews: annual facility operations reviews, institutional reviews, and research reviews, which are new. The focus of an institutional review is the role and importance of the national laboratory's program to the national HEP program and an assessment of its performance and planning. It replaces the annual site review but is similar in scope. It is a 2- to 3-day site review with outside consultants. For years in which there will not be an institutional peer review, it is expected that a program-manager visit will be scheduled. This is the year for review of the theory research groups.

The OHEP COV recommended that the Office develop a process to globally optimize and comparatively review the balance of support for HEP research at Fermilab, the universities, and the other national laboratories in light of the evolving program. To do this, a new HEP organization was formed to manage by physics thrust and to make the review process as transparent and as uniform as possible between the national laboratories and universities. This process is based on 3-year proposals, peer review on standard criteria, and comparative evaluation.

Research reviews are comparative reviews of the research and technology development activities at the national laboratories. This is a multiday panel review at DOE, reviewing theory and accelerator science one year, proton accelerator-based and detector R&D the next, and electron-accelerator-based and nonaccelerator R&D the third. These reviews entail identifying excellent reviewers, issuing charge and guidance to focus inquiry, standing back and letting them have at it, assembling the report, and conveying to laboratory management any issues that require action. The charge to the reviewers is to produce a final report that outlines the quality and impact of recent research, merit and feasibility of proposed research, competence and promise of the research group, adequacy of resources and cost-effectiveness, quality of national laboratory support and infrastructure, and how the group enriches the national laboratory's experimental program and how well the group's activities relate to the HEP mission. Also requested are a discussion of the unique and important elements that the laboratory programs bring to bear in addressing these research topics and a comparative assessment of each national laboratory's overall performance in these areas relative to its peers as well as versus comparable university groups.

The theory review found that the laboratory research groups contain some very prominent members of the theoretical physics community and that research at the national laboratories has been at the forefront of the parts of theoretical particle physics that make direct contact with experiments. Included is research on the predictions of the standard model for precision electroweak-physics and research directed toward understanding the predictions of proposed extensions of the standard model for HEP that is done, at some level, by all the laboratory groups.

The review found that

- One of the most important current topics in high-energy theory research is the computation of cross sections for the scattering of elementary particles when the strong interactions are involved and the processes involve several partons in the final state.
- Research staff at the national laboratories have played a crucial role for the development and application of lattice quantum chromodynamics (QCD) methods.
- Laboratory research staff have played important roles in the development of effective field theory approaches that have been crucial for understanding various experimental results.
- Monte Carlo event generators for hadronic collisions were pioneered at DOE laboratories, and those laboratories continue to develop more-accurate generators.
- Research on string theory/quantum gravity at the national laboratories is not a large effort.
- Cosmology and particle astrophysics have played an important role in shaping our ideas about physics beyond the standard model and in constraining possible extensions of the standard model; hence, DOE support for theoretical research in this area is appropriate.

The review addressed what the role of theory groups at national laboratories is. They commented that, over the years the national-laboratory staff members and their postdocs and visitors have helped to define the HEP program by being advocates for new initiatives and contributing to an understanding of the physics reach of various proposed experimental facilities. These programs are also important for creating an environment of intellectual activity that is crucial for understanding and promoting the experimental research being done at a national laboratory. Currently, the total DOE support of high-energy-theory groups at national laboratories is about the same as for all the DOE-supported theory groups in universities, although the number of permanent theorists in laboratory groups is only about one-fifth of that in universities.

Over time, the nature of high-energy experimental laboratories in the United States has changed, and recently the model for theory funding has changed, with laboratory and university theory groups now in a more direct competition for funds based on their contribution to physics thrusts determined by the DOE. Although no longer so closely associated with experiments run at their laboratories, laboratory theory groups and laboratory theorists still have a major role to play. It is mainly they who are responsible for the theory support necessary to make the U.S. high-energy experimental physics program successful. Besides providing support to the high-energy experimental program, the national laboratories also play an important role in the U.S. lattice QCD effort by hosting the supercomputers required to perform state-of-the-art calculations in that field.

This assessment formed a basis for who was judged as doing a good job. The review panel enthusiastically endorsed the quality of the research done by the particle astrophysics and cosmology groups. They are comparable in quality to very good university groups. However, there are some concerns looking to the future. The review panel would like to see the DOE-OHEP supported theory efforts more aligned with what would traditionally be considered particle astrophysics and cosmology.

Many panel members noted that laboratory theorists cost much more to the DOE than university theorists, by a factor of about 4 to 5 per permanent theorist depending on the laboratory. This is partly caused by the fact that university theorists have their base salary paid by the university, but is also due to the fact that laboratory theory groups have more postdocs per permanent staff member than do university groups. Many panel members felt that it is important that laboratory groups clearly identify missions that will distinguish them from university groups and that will allow them to make important contributions to high-energy physics that would normally not be done in a university group. In the case of particle astrophysics and cosmology, the focus should be on issues that have an impact on particle physics and particle physicists.

The Accelerator Science review was held December 2–4 in Gaithersburg, Maryland. The charge was to evaluate the national laboratories' research contributions (as applicable) along the programmatic thrust lines of accelerator and beam physics, novel accelerator concepts, muon collider/neutrino factory, high-gradient acceleration, and beam sources and instrumentation. The national laboratories were asked to present information along these thrust lines. The same criteria were used as in the theory review. The reviewers were also asked to provide general findings and comments about the current status and future promise of the programmatic thrust areas.

The next steps are to discuss a response to the theory review with the national laboratories, develop the accelerator science review report and deliver it to the national laboratories by next month, and conduct the proton research review in June and the detector R&D review in July. Feedback received on these reviews has mostly been very positive. The Office appreciates HEPAP's comments and suggestions, as well.

Nelson asked if the level of funding will be affected by the review results. Crawford replied that it may. The Office is pointing out the results to the national laboratories. Three years from now, the review will show how they have changed in response to this review's recommendations. Kovar added, the answer is yes.

Dixon stated that the astroparticle physics field has changed. Crawford replied that that was discussed. The answer is not clearly black or white. The program managers will discuss that issue.

Marlow said that he found the language of the report to be biased. Crawford responded that there is plenty of praise in this theory-review report. His presentation was only highlighting the issues.

Gelmini noted that costs per person for postdocs are four to five times larger at national laboratories than at universities and asked if that would continue going forward. Crawford observed that that is where it is right now. The Office does not set salaries, but it does support postdoctoral research. It is likely that the laboratories will continue to be competitive.

Olson asked if there would be an overlap in membership on the next review panel. Crawford answered that he would like to see some overlap.

Tigner noted that the number of postdocs at the national laboratories reflects the overlap of theory with the work done at the national laboratories and asked if that had been discussed by the reviewers. Crawford replied, yes. The issue of how best to balance the phenomenologic postdocs between the national laboratories and universities is being discussed at the Office now. Shochet noted that the university process for hiring people for new slots is very slow.

Kovar said that he always asked why *any* theory is done at the national laboratories. This review satisfied him in that respect. He walked away with the feeling that the national laboratories had answered the question. This review was very informative to the Office. In astrophysics, it will need to be explained what role HEP will play and what is expected to be gotten out of it. There is an opportunity for HEP to play a big role and get credit for it.

Cushman asked what the reason was that the successful groups were successful. Crawford responded that the panel did not delve into that in detail. Kovar offered the opinion that (1) the long-standing history of expertise allowed the national laboratories to provide a core competency and (2) this is an area in which there is a real need for theoretical explanation.

Trischuk said that the panel was not asked to do a head-to-head comparison between national laboratories and universities and asked if such a comparison would be done in the future. Crawford said that that might be done down the road.

Kayser stated that the mechanism to encourage phenomenology at the universities might parallel the Institute for Advanced Physics at the University of California at Santa Barbara, which was founded to encourage multidisciplinary physics.

Dennis Kovar was asked to me present a new charge to the panel for a Particle Astrophysics Scientific Assessment Group (PASAG). The charge letter says:

The scientific opportunities for the U.S. particle-physics program have been most recently identified and articulated by the Particle Physics Project Prioritization Panel (P5) report submitted in May 2008. At this time, the opportunities and scientific challenges available at the Cosmic Frontier should be explored in further detail. DOE and NSF are requesting that HEPAP initiate a PASAG to address these questions. The agencies request that the PASAG re-examine current and proposed U.S. research capabilities in particle astrophysics, assess their role and potential for scientific advancement, and determine the time and resources (the operations costs, facilities, personnel, research and development, and capital investments) needed to achieve an optimum program in the context of the various budgetary scenarios indicated below. PASAG should then identify and evaluate the scientific opportunities and options that can be pursued at these different funding levels for mounting a world-class program that addresses the highest priority science in particle astrophysics.

The scientific scope of this review should be limited to opportunities that will advance understanding of the fundamental properties of particles and forces with observations of phenomena from astrophysical sources. The following scientific areas are within the scope of this study:

- Exploring the particle nature of dark matter,
- Understanding the fundamental properties of dark energy, and
- Measuring the properties of astrophysically generated particles (including cosmic rays, gamma rays, and neutrinos).

Some of these areas have been previously studied in detail by other ad hoc panels and advisory groups, and the PASAG should make use of this existing body of work. Some of these research areas will be within the scope of the National Research Council's Astronomy and Astrophysics Decadal Survey (Astro2010) and the OECD Global Science Forum's Working Group on Astroparticle Physics. An appropriate sharing of information should be explored. These evaluations should be done in the context of the increasing internationalization of particle astrophysics, while recognizing the need to maintain a healthy, flexible, domestic research infrastructure, and respecting the funding agencies' different but complementary scientific missions and the varied ways they intersect with this research.

The report should provide recommendations on the priorities for an optimized particle-astrophysics program over the next 10 years (FY10–19) under the following four funding profile scenarios:

- Constant effort at the FY08 funding level (i.e., funding in FY10 at the level provided by the FY08 Omnibus Bill, inflated by 3.5% per year and continuing at this rate in the out-years)
- Constant effort at the FY09 President's Request level (i.e., funding in FY10 at the level provided by the FY09 Request, inflated by 3.5% and continuing at this rate in the out-years).
- Doubling of funding over a 10-year period starting in FY09 (i.e., funding in FY10 at the level provided by the FY09 President's Request, inflated by 6.5%, and continuing at this rate in the out-years)
- Additional funding above the third funding scenario, in priority order, associated with specific activities needed to mount a leadership program that addresses the scientific opportunities identified in the EPP2010 or P5 reports.

Details of current funding for particle astrophysics, out-year planning, operations costs, and project profiles will be provided to the PASAG by the agencies.

The report should discuss the facilities and instrumentation that can be used to carry out the current program as well as new facilities (including dedicated research centers, as appropriate) and instrumentation that will need to be developed by the DOE and NSF to mount a productive, forefront program for each of the funding scenarios. The report should articulate the scientific opportunities that can and cannot be pursued and the impacts on training of physicists as well as on the broader scientific community under each of the funding profile scenarios. Continued operations of existing facilities will have to be balanced against the opportunities to develop new or upgraded facilities with advanced capabilities. The report should also provide a detailed perspective on how the pursuit of possible major initiatives would complement the program recommended under each of the scenarios. Submission of PASAG's preliminary comments by July 1, 2009, and a final report by August 15, 2009, would be appreciated. This is a difficult task; however, PASAG's considerations on these issues will provide essential input for both DOE and NSF planning.

Sobel asked what the mechanism for incorporating previous studies would be. Kovar replied that that would be up to the group. Shochet said that he believed that that is adequately spelled out in the letter. There is not a lot of time available to the group.

Nelson asked if funding for nonaccelerator experiments that do not fall within the charge but are still part of the cosmic frontier (e.g., Daya Bay) would be discussed by the

PASAG. Kovar responded that, in the nonaccelerator program, there is money for those experiments, so funding for them would be considered separately. A funding profile will be provided with some tentative numbers for this area. Shochet said that that clause was added because the letter would have been ambiguous and open to misinterpretation without it.

Cushman asked if this charge took the place of the new SAG expected in a year. Kovar replied, yes.

Gelmini asked if particle astrophysics theory will be included. Kovar replied that, unless the theory is focused on fundamental particles and forces of nature, it should not be in the HEP program. Right now, theory is not included, but the panel can do whatever it wants.

Dixon noted that several experiments have dual purposes and asked how the panel would consider them. Kovar answered that, if they address the issues in the charge, they should be on the table.

Gladney asked if the panel would cover JDEM. Kovar replied, yes.

Sobel asked what would happen to the other nonaccelerator physics. Kovar replied that double-beta decay and others do not fit into particle astrophysics and will be dealt with separately. J. Dehmer noted that a lot of these issues were recently discussed by the Neutrino Scientific Assessment Group (NuSAG). This exercise reflects the community's participation in future funding decisions. Lack of precision gives the group greater flexibility to tell the agencies what the group wants to tell the agencies. Kovar added that this is an area that has been on the table for years with no guidance available. There has been a lot of guidance on double-beta decay and other topics from several other SAGs and other sources.

Olson asked if there were proposals on the table that need to be evaluated. Kovar responded that this group will see a lot of opportunities. Shochet added that the group will put together a list of proposals and evaluate them

Kettell asked if the charge included proposed experiments in the intensity frontier. Kovar replied that the charge does not ask the panel to look at proton decay. However, if there were a detector that would give information about fundamental particles and forces, it should be on the table. Shochet said that, if one had a megaton detector, the answer is no, it is not in the charge. J. Dehmer said that there are a lot of aspirations in these topics, and the agencies need advice on their relative scientific significance. There are more opportunities than can be funded. Shochet said that he did not believe that proton decay would enter the charge in any way. Kovar cautioned the Panel that it should look at the charge and follow the words. If it were to come back with something that was not expected, that result would have to be dealt with.

Shochet mentioned that DOE and NSF need applications to fill personnel slots. Robert Cahn and Daniela Bortoletto have rotated off the Agency Position Group, and White and Seidel have taken their places. The demographics group also needs rotating members. Scholberg and Cushman have agreed to join that group. A look needs to be taken at the universities to look at systemic problems. A group is being formed to do that and to report in the fall. Sara Eno will chair that group, which will also include Bean, Sobel, Marlow, and Artuso. Steven Ritz has agreed to chair the Particle Astrophysics Scientific Assessment Group.

A break was declared at 10:29 a.m. The meeting was called back into session at 11:00 a.m. Both NSF and DOE have large-scale computing initiatives. **Michael Strayer** was asked to describe DOE's extreme-scale computing initiative. The ASCR program has been around for 20 years, but was pushed to the forefront by Raymond Orbach. It has been a world-leading program for simulation and computation for 3 years. It delivers petascale computing for DOE's science applications. It provides high-performance computing tools to the entire DOE SC research community. It provides high-performance production computing at the National Energy Research Scientific Computing Center (NERSC) at LBNL and delivers high-end capacity computing at its leadership computing centers at Argonne National Laboratory and Oak Ridge National Laboratory.

The request for proposals for the NERSC-6 project upgrade was issued in September 2008, and proposals are currently being reviewed. Argonne's IBM Blue Gene/P is currently operating at 556 TF. Oak Ridge's Cray XT5 has a peak performance of 1645 TF with 362 TB of system memory and 10,750 TB of disk memory. ASCR also operates and updates the Energy Sciences Network (ESnet), which is being upgraded from 10 to 40 Gbps.

ASCR has Scientific Discovery Through Advanced Computing (SciDAC) to deliver computational tools and techniques to advance DOE-science through modeling and simulation. It also has an active research portfolio in mathematics and networking. Of last year's top-10 science accomplishments in high-performance computing, six were SciDAC projects and four were Innovative and Novel Computational Impact on Theory and Experiment (INCITE) projects, all running on ASCR machines. They included such topics as high transition-temperature superconductivity, the molecular basis of Parkinson's disease, and a billion-particle simulation of the Milky Way's dark-matter halo.

Under the INCITE program, 80% of the time on the leadership-class facilities (LCFs) is given away to anyone in the world with a great proposal.

Computing is changing. The traditional sources of performance improvement, which has been growing exponentially for 15 years, are flat-lining. The limit of how much heat can be pumped into the chip has been reached. There are hundreds of thousands of cores in these LCFs. Complexity increases factorially with increasing size (e.g., in CPUs). There is a wide variety of multicore processors. More and more cores of different types are being parallelized in different ways. This massive parallelism will continue to the 50- to 100-petaflop level. Then novel architectures will need to be invented to advance computing performance.

To determine what is next in computing, three town-hall meetings were held in 2007. They established that the extreme scale is going to be very complicated with huge numbers of processors consuming hundreds of megawatts. These workshops were led by other program offices in DOE: HEP, Biological and Environmental Research (BER), and NP. The HEP workshop had breakout sessions to identify priorities, and the priority research directions were to

- Design and optimize a high-energy lepton collider linac module for cost and risk reduction
- Predict beam loss and resulting activation in intensity-frontier accelerators
- Shorten the design-and-build cycle of accelerator structure
- Develop and design an ultra-compact plasma-based collider

The key questions identified were (1) What is dark matter? (2) Does the Higgs field exist in nature? (3) Are there additional dimensions of space? (4) What are neutrinos telling us?

In the President's FY09 Budget request to Congress, funds were identified in the ASCR program for "direct support for science application leading edge developers willing to take on the risks of working with new and emerging languages and tools." This support will be provided in partnership with other program offices, and a call for proposals can be expected in late summer.

The question is now being asked, what computing will be needed to enable the grand challenges in high-energy physics? SciDAC-1 operated at the terascale, SciDAC-2 will operate at the extreme scale, and SciDAC X will operate at even beyond the extreme scale.

Olson stated that one way to proceed is to design computers for specific research programs. Strayer replied that that has been tried. A computer was built at Columbia University to do QCD computing. ASCR invested in that. The gravitational interaction code in Japan has not been able to produce any science. One needs a specific engineering problem. He could not envisage a compelling-enough case to justify building a specific-purpose computer. The general-purpose computers have overrun the specific ones in performance.

Leemans asked how strong the motivation was to exploit peak machine performance. Strayer replied that the question comes down to how well one can use the processors. If one has an efficiency of 15%, that weakens the need for a large machine. However, scientists tend to do science, not engineer codes for efficiency. These are large, costly machines. To use them, one needs teams that include software engineers along with the scientists so the greatest use can be made of the machines' capabilities.

Marlow asked if ASCR gets involved in multicore design and development. Strayer answered that it does and it doesn't. It has 13 centers and institutes in SciDAC to help teams to optimize codes. The next SciDAC competition will emphasize these centers strongly.

Kovar asked, if HEP put together a team internally, whether it could analyze HEP data in SciDAC. Strayer answered, yes, but there is also a program, Pioneer Applications, to help DOE researchers, and that program does not require competition. ASCR does not fund the complete teams, except on rare occurrences.

Shochet asked the panel what items should be discussed in the summary letter. He offered:

- P. Dehmer listed Chu's priorities for science, and HEPAP was happy to see science discovery leading the list along with university funding for SC and HEP.
- Kovar reported significant science progress being made this past year as judged by the American Physical Society, establishing a panel on particle astrophysics, and holding a workshop on accelerator-science R&D.
- Spiro described the planning for astroparticle physics in Europe; they are looking for coordination with the United States and Asia.
- Chan reported that ARRA funding to the NSF is a significant portion of the Physics Division's budget; the NSB is taking a stronger role in reviewing NSF construction projects.

- J. Dehmer reported that funds for young faculty and researchers will generate new jobs; DUSEL is to be presented to the NSB; new NSF programs in accelerator physics and physics instrumentation may be instituted in FY10.
- Fleming reviewed large liquid argon detectors in terms of cost, safety, and efficiency.
- Gehrels reviewed the JDEM announcement of opportunity to be released this spring.
- Kovar submitted a charge letter.

The floor was opened to public comment; there being none, the meeting was adjourned at 11:47 a.m.

Respectfully submitted,
F. M. O'Hara, Jr.
HEPAP Recording Secretary
Apr. 9, 2009

Corrected by
Melvyn Shochet
HEPAP Chairman
May 5, 2009

The minutes of the High Energy Physics Advisory Panel meeting held at the Hilton Rockville Hotel, Rockville, MD on February 24-25, 2009 are certified to be an accurate representation of what occurred.

Signed by Melvyn Shochet, Chair of the High Energy Physics Advisory Panel on May 5, 2009.

Melvyn J Shochet