Draft Minutes
High Energy Physics Advisory Panel
March 11–12, 2010
Hyatt Regency Hotel
Bethesda, Md.

HEPAP members present:

Marina Artuso (Thursday only)
Edward Blucher
Raymond Brock
Andrew Cohen
Lance Dixon
Bonnie Fleming
Graciela Gelmini
Donald Glenzinski
Donald Hartill
Stuart Henderson
Steven Kettell
Wim Leemans
Daniel Marlow
Ann Nelson
Regina Rameika
Ian Shipsey (Thursday only)
Paris Sphicas
Kate Scholberg
Melvyn Shochet, Chair
William Trischuk
Herman White

HEPAP members absent:

Hiroaki Aihara
Patricia Burchat
Henry Sobel

Also participating:

William Brinkman, Director, Office of Science, USDOE
Joel Butler, Manager, US-CMS Research Program, Fermi National Accelerator Laboratory
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
Marvin Goldberg, Program Director, Division of Physics, National Science Foundation
Robert Hamm, CEO/President, R&M Technical Enterprises
Walter Henning, Argonne Distinguished Fellow, Argonne National Laboratory
Judith Jackson, Director, Office of Communication, Fermi National Accelerator Laboratory
John Kogut, HEPAP Executive Secretary, Office of High Energy Physics, Office of Science, Department of Energy
Steven Koonin, Under Secretary for Science, USDOE
Dennis Kovar, Associate Director, Office of High Energy Physics, Office of Science, Department of Energy
Joseph Kroll, Department of Physics and Astronomy, University of Pennsylvania
Marsha Marsden, Office of High Energy Physics, Office of Science, Department of Energy
Stephen Myers, Director of Accelerators and Technology, CERN (via telephone)

Sergei Nagaitsev, Associate Division Head, Accelerator Division, Fermi National Accelerator Laboratory
Piermaria Oddone, Director, Fermi National Accelerator Laboratory
Frederick M. O'Hara, Jr., HEPAP Recording Secretary, Oak Ridge Institute for Science and Education
Edward Seidel, Acting Assistant Director, Directorate for Mathematical and Physical Sciences, NSF
David Sutter, Institute for Research in Electronics and Applied Physics, University of Maryland
Vigdor Teplitz, Physicist, Goddard Space Flight Center, National Aeronautics and Space Administration
Maury Tigner, Director, Laboratory of Nuclear Studies, Cornell University
Robert Tschirhart, Computing Division, Fermi National Accelerator Laboratory
Harry Weerts, Director, High-Energy Physics Division, Argonne National Laboratory
Andreene Witt, Oak Ridge Institute for Science and Education

About 130 others were present in the course of the two-day meeting.

Thursday, March 11, 2010
Morning Session

Before the meeting, new members of the Panel were sworn in by members of the DOE Human Resources staff, and the Panel was briefed on ethics issues by a member of the DOE General Counsel's Office.

Chairman **Melvyn Shochet** called the meeting to order at 10:00 a.m. He welcomed the new members. He noted Herman White's leadership of the Agency Position Working Group, Scholberg's leadership of the Demographics Working Group, and Marlow's leadership of the University Working Group.

He introduced **Edward Seidel** to present an update on the NSF's Mathematical and Physical Sciences (MPS) Directorate FY11 budget request. The total budget request is $1.41 billion with which to support innovation in healthy core programs, advance a strong scientific and technical workforce, invest in research addressing national priorities, support center activity, and invest in facilities with large increases in the Faculty Early Career Development (CAREER), postdoc, graduate research fellow, and Research Experience for Undergraduates (REU) programs.

The discovery portfolio increases 6.7%. The Directorate increases 4.3%. The Physics Division discovery portfolio increases 11.2%.

In FY10, MPS received $490 million from the American Recovery and Reinvestment Act (ARRA) and $146 million in Major Research Equipment and Facilities Construction (MREFC). Of that, $402 million went to R&E grants, $88 million to facilities and instrumentation, and $146 million to MREFC for the Advanced Technology Solar Telescope (ATST).

Many of the projects need to have people from many disciplines. Those projects range from the evolution of the universe to biophysics. Desktop machines are now able to produce data at the same rate as the Large Hadron Collider (LHC).

NSF has a new theme, the Cyberinfrastructure Framework for 21st Century Science and Engineering (CF21), which has a series of teams on high-end computation, data, and visualization; MREFCs and collaboratories; software, tools, science applications, and virtual organizations; campus linking with a campus-bridging task force; and people.

Sustainability of the computing programs is a central concern. A balance has to be found between sustainability and competition. Emerging CF21 concepts are to provide more sustainability for computing centers and their expert workforce. New architectures will emerge. Software-institute investments are planned along with individual-investigator awards. Such individuals will be sustained as members of teams that are coordinated by the centers.

For Science, Engineering, and Education for Sustainability (on the planet) (SEES), $110.5 million has been requested to work in energy and climate, inter alia. There will be more activity in these areas; they are an administration priority.

The Advanced LIGO [Laser Interferometer Gravitational Wave Observatory] construction will be started next year. The LHC is a priority. The status of the Deep Underground Science and Engineering Laboratory (DUSEL) is

- The majority of geotechnical investigations are complete.
- Integrated Safety Management plan is being developed.
- Environmental Impact Statement planning is under way.
- Design and development of potential DUSEL experiments are under way.
- Funding for the preliminary design has been awarded to UC Berkeley.
- An independent review of DUSEL by the National Academy of Sciences has been initiated.
- A Ph.D.-granting program in physics has been established in South Dakota.

Collaboration at DUSEL is coordinated through the Joint Oversight Group (JOG). NSF will steward the facility; DOE's Office of High Energy Physics (HEP) will steward the Long-Baseline Neutrino Experiment (LBNE). Partnership models to inform planning have been agreed to. "Critical Decision 0" (CD-0) has been granted to the LBNE by DOE, and planning has started for CD-1. The Office of Science and Technology Policy (OSTP) is now engaged to help guide the NSF-DOE joint planning process.

In summary, a $1.41B budget has been requested for FY11 for MPS for sustaining research in fundamental science, supporting young researchers, investing in national priorities, completing the DUSEL Preliminary Design Report (PDR), and working through challenges. There are many opportunities for the high-energy physics community here. NSF is looking forward to working with DOE to complete the final design of DUSEL.

Marlow asked where NSF was on boosting success rates in career awards. Seidel replied that the rate has gone up significantly this past year. As funding continues to increase, NSF will push up the slack in funding them. Marlow asked if NSF had a policy on reviewing such grants. Seidel answered, no. There might be some individual grants, but no broad program.

Artuso asked Seidel what he was thinking about in terms of sustainable software. Seidel responded that the concept applied to all software: tools, communication-specific development, incentives to work with sustainability centers.

Sphicas asked what the primary vehicle will be for providing computing power to the biosciences. Seidel answered that the Open Science Grid (OSG) is a good model, but such a level of connecting will put a great stress on networks. Recommendations from the working group are being awaited.

Marlow noted that it is hard to get a large-bandwidth connection to the backbone, and it needs to be done at the university level. Seidel responded that the NSF has been working with the Department of Commerce, Lambda Lightrail, Internet2, and others to find ways to address that problem.

William Brinkman was introduced to present news from the DOE Office of Science (SC).

SC has six main divisions. The top three [Advanced Scientific Computing Research (ASCR), Basic Energy Sciences (BES), and Biological and Environmental Research (BER)] have the most to do with the energy problems faced today. ASCR has built the two largest computing machines in the world. BES has a lot of activities in the simulation of internal combustion engines and other simulations. In the biological world, DOE is not in competition with the National Institutes of Health (NIH). It deals with biofuels and with microbes that determine the uptake of carbon in the soil. In fusion, the management of the International Thermonuclear Experimental Reactor (ITER) has been straightened out with a new schedule and organization. It is a burning need, and DOE is trying hard to make it happen. In HEP, DOE is supporting the LHC. The FY11 budget has money to continue operating the Tevatron. The Office of Nuclear Physics (NP) got a bump-up from the upgrade at the Jefferson Laboratory.

There are now 26,000 people using SC's user facilities each year across the country. The light sources are the biggest class of these facilities.

Some organizational structures are being built around some areas of research, called hubs. They will provide focus and leadership for progress in these areas. A new one is on batteries and energy storage. Many trillions of dollars are going to be needed to deal with climate change. In DOE, there are pockets of expertise on climate science. These pockets will be pulled together in a more integrated fashion. The Energy Frontier Research Centers (EFRCs) now number 46, representing 103 institutions in 36 states plus the District of Columbia. In computing, a possibility of exascale computing is being investigated; the challenges (power, architecture, failure rates, etc.) are huge.

SC has 28 user facilities. It has two of the three hubs in FY10 (Fuels from Sunlight, Energy-Efficient Building Design, and Modeling and Simulation of Advanced Nuclear Reactors). One hope is to get beyond light-water reactors.

Many people are using the Jaguar Cray XT5 at Oak Ridge National Laboratory (ORNL). The Innovative and Novel Computational Impact on Theory and Experiment (INCITE) and SciDAC programs use the National Energy Research Scientific Computing Center (NERSC) machine at Lawrence Berkeley National Laboratory (LBNL).

The light sources of the world have been doing structural biology for many years. NIH has about 30 beamlines on SC's light sources. The 2009 Nobel Prize work used all four BES light sources.

The LCLS has been turned on at the Stanford Linear Accelerator Center (SLAC); it is the world's first hard X-ray light source. It allows single-molecule protein crystallography. This opens an advanced area of science.

There are three Bioenergy Research Centers (BRCs): the Joint BioEnergy Institute (JBEI), Great Lakes Bioenergy Research Center (GLBRC), and BioEnergy Science Center (BESC). They are focused on converting cellulose to ethanol through genomics and microbiotics.

The genomic revolution is sequencing the 1.1-billion-base-pair soybean genome, publishing the Genomic Encyclopedia of Bacteria and Archaea [DOE/Joint Genome Institute (JGI)], and investigating viable microbes in toxic subsurface environments.

In Nuclear Physics, the United States is a leader in studying the compelling questions of nuclear science, advancing our knowledge of the world, and leading to applications in energy research, medicine, national security, and isotopes for a wide variety of purposes. In HEP, the United States has developed components for the LHC at CERN {Conseil Européen pour la Recherche Nucléaire [now European Organization for Nuclear Research (Organisation Européenne pour la Recherche Nucléaire)]} and hosts centers for data analyses. With data collection through FY11, the Tevatron could rule out the existence of a Standard Model Higgs particle. The United States is uniquely positioned for a world-leading program at the intensity frontier. $16 million will be available in FY 2011 to fund about 60 additional Early Career Research Program awards at universities and DOE national laboratories.

Shochet asked what the outlook was for HEP in the difficult budgetary outyears. Brinkman replied that DOE recognized its stewardship responsibilities. There are many competing research directions.

Teplitz noted that there had been no mention of nanotechnology. Brinkman responded that SC has five nanotechnology centers. They will be continued.

Trischuk observed that Canada had been struggling with similar questions about funding people or facilities. Brinkman answered that this is a question of balance. Investments need to be made in both computers and light sources. Trischuk asked who stewards accelerator science in DOE. Brinkman replied that that stewardship had shifted to include BES

Joseph Dehmer was asked to present an update on the NSF Physics Division. The Division's $300 million budget supports a broad swath of science: the Atomic, Molecular, and Optical Sciences Program, gravitational physics (LIGO), theory, etc. An effort in accelerator physics and physics instrumentation is being proposed. It supports a wide array of physics projects: LIGO/Advanced LIGO, IceCube (cosmic neutrinos), DUSEL, dark matter, neutrinos, the structure of the universe, etc.

The Physics Division budget went up 2.8%, which is anemic. But the program will do well. The low growth rate was caused by a decrease in DUSEL. The average annualized increase at MPS is 5%. A doubling time of the Physics Division's budget is 14 years.

If DUSEL begins construction, the funds would come from the MREFC budget, which is proposed to increase from $117 million to $165 million this year. Looking at the bottom line in future years, MREFC funding will peak in FY12-13. Things are favorable for conceptualizing new projects.

In FY10 in particle physics, the Elementary Particle Physics (EPP) Program increased 38.6% to $26 million, EPP Theory increased 9.6% to $12 million, astronomy/cosmology theory increased 5% to $1.25 million. In Particle and Nuclear Astrophysics, the non-DUSEL funding increased 5.0% to 21 million, and DUSEL increased 31.0% to $29 million. All principal investigator (PI) programs received 5%, and other priorities included Quantum Information Science, Physics of Living Systems, plasma physics, LIGO research, educational programs, and mid-scale instrumentation. The FY11 funding will build on these gains.

The opportunities of note are in major research instrumentation (which will have an FY10 competition with $90 million available) and Physics Frontier Centers (which will have an FY11 competition for 5-year awards running from $1 million to $5.5 million). The PI projects are an NSF priority; they are incredible talent magnets.

The NSF priorities include nanotechnology, cyberscience, etc. The Physics Division can participate in these through focused solicitations. This process does not play to NSF's strengths. NSF is going to open the door to big thinking and seek funding for the physics enterprise.

The nine Physics Frontier Research Centers (FRCs) are spread across the country and the discipline. They are very competitive. They might get 50 applications for three awards. The successful proposals for FRCs have not necessarily been founded in large institutions.

DUSEL has been extensively reviewed and vetted during the past 10 years. The PDR is now due at the end of this year. P5 said that future high-energy physics should be partially built around neutrinos with a world-class neutrino experiment at its core carried out in an underground laboratory. The National Science Board (NSB) awarded the University of California at Berkeley $29 million for a preliminary design. A long series of project reviews have guided and will guide the design, construction, and operation of DUSEL. The deadline for the PDR was chosen to allow putting DUSEL into the President's budget request for FY12.

NSF/DOE agreed to establish the DUSEL Physics JOG immediately after the release of the P5 report through which they will jointly coordinate and oversee the DUSEL experimental physics program. The JOG is meeting monthly. Both agencies are closely collaborating in defining and realizing the DUSEL physics program. NSF will steward the DUSEL facility, dark matter, and other disciplines, DOE/NP will steward neutrinoless double-beta decay, and DOE/HEP will steward long-baseline neutrinos and proton decay. An interagency memorandum of understanding (MOU) is planned for the end of the summer.

The mid-level campus is 1 mile underground with three large detectors and three laboratory modules. This is where the neutrino experiments will be located. The deep laboratory will be at 7400 feet underground.A new laboratory module will be 15 m by 15 m by 75 m. The large cavities at the mid-level would each hold the Tevatron's Wilson Hall.

A life-cycle funding plan has been developed for DUSEL and covers 20 years. For physics, some funding will come from the phasing out of other programs and from start-up grants. The safety reviews showed that significant investments need to be made in upgrading shafts. The state of South Dakota's appropriation for dewatering and controlling access to the mine runs out at the end of this year. The FY11 NSF request for DUSEL is $19 million, down from $36M this year. If that number comes to pass, the project would be phased out in FY12. This is a serious problem, but the effect on DUSEL was not appreciated. A way through this needs to be (and will be) found. This request is being reconsidered.

Shochet asked how the funding for DUSEL fell through the cracks. Dehmer replied that there are thousands of people involved in making the budget. Shochet asked how this will affect keeping pumps running. Dehmer answered that the situation is stable through 2010. The FY11 budget is critical. There is still time in 2010 to address the problem. Marlow asked at what level in the government this deletion occurred. Dehmer responded that it happened at the executive-level synthesis. There is a strong base and support for this project.

Marlow asked about risk tolerance. Dehmer replied that there is a risk tolerance in mining that the scientific community cannot accept. The safety standards have to be upgraded significantly. Miners are better prepared to deal with risks than are scientists. In addition, scientists have a lot more hazards (e.g., cryogens) then miners do.

Leemans asked what impact this loss of funding will have on the small experiment now operating in the mine. Dehmer answered that the experiment will be delayed. At this point, only trained miners may go underground.

Hartill asked how much confidence there was in the geology of the site. Dehmer responded that the Cavity Board is extremely professional. They say that this is the best rock they have ever seen. It is very strong and unfractured. This response was an enormous relief.

Artuso asked what the key goals in 2011 were. Dehmer replied that the money in FY10 should pay for the PRD. The final design report (FRD) cannot proceed until the National Science Board (NSB) approves it.

Leemans asked where the water came from if the rock is so solid. Dehmer noted that the mine has a 600 gallon per minute infiltration, which is, in the industry, a dry mine. There are 600 km of tunnels with creeks and lakes above.

Dennis Kovar was introduced to present news from DOE's Office of High Energy Physics (HEP).

The Office is pursuing a long-range plan developed by the community, which has the major elements of maintaining a strong, productive university and laboratory research community; enabling U.S. leadership roles in the Tevatron and LHC programs at the Energy Frontier; achieving the vision of a world-leading U.S. neutrino and rare-decay program at the Intensity Frontier, building on the existing accelerator infrastructure at Fermilab; deploying selected, high-impact experiments at the Cosmic Frontier; and supporting accelerator R&D to position the United States to be at the forefront of advanced technologies for next-generation facilities.

In FY09, the budget was $795.7 million. The FY10 appropriation is $810.5 million, a 1.90% increase. The FY11 request is $829.0 million, a 2.3% increase.

The highlights are that the Tevatron will operate in FY11; the LHC program is supported; ongoing major items of equipment (MIE) projects [NuMI Off-Axis ν_e Appearance (NOvA) and Daya Bay] are supported; the first investments [the MicroBooNE detector, Muon-to-Electron Conversion Experiment (Mu2e), and LBNE] are made for the next-generation U.S.-leadership program; ongoing programs [e.g., Fermi, Alpha Magnetic Spectrometer (AMS), Very Energetic Radiation Imaging Telescope Array System (VERITAS), Pierre Auger, Baryon Oscillation Spectroscopic Survey (BOSS), second Cryogenic Dark Matter Search (CDMS-II), Chicagoland Observatory for Underground Particle Physics (COUPP), Large Underground Xenon (LUX) detector, and Axion Dark Matter Experiment (ADMX)] are supported; ongoing MIE projects [the Dark Energy Survey (DES) and SuperCDMS-Soudan] are supported; R&D for possible future experiments is supported; EPP research is supported; and Advanced Technology R&D is supported for high-risk, high-impact initiatives, development of infrastructure, and core competencies. The core research will support the community. The money will be focused on infrastructure and core competencies.

In the FY11 budget, SLAC is phasing down, there are some savings at Fermilab, and the core research increase is above the cost of living. In research programs, the increase in the cost of doing business is exerting some pressure.

Daya Bay is ramping down along with Minerva and NOvA.

The LHC collided beams at 900 GeV and ramped up to 1.2 TeV. HEP will participate in the mid-term plan with modest upgrades to the detectors and accelerator.

The Next-Generation Linear Collider (NGLC) decision awaits results from the LHC and commitments of interested participants. What will be done in FY12 is under discussion. A 5-year plan for a national muon accelerator R&D program is being developed. DOE and NSF are coordinating planning for LBNE and for DUSEL.

Italy would like to use Positron Electron Project (PEP-II) components in its SuperB. Giving these components to Italy would actually decrease demolition and decontamination costs for SLAC. An analysis came up with three possible scenarios:

1. Provision of reusable PEP-II and BABAR detector components;
2. 1 + additional funding for U.S. participation in the detector program; and
3. 2 + additional funding for U.S. participation in the accelerator program.

A proposal is now being awaited to participate in BELLE-II at Super KEKB [the B factory at the High Energy Accelerator Research Organization in Ibaraki, Japan] and for implementing the g-2 experiment at Fermilab. HEP will conduct peer reviews of these opportunities.

DOE and NASA continue to work to identify the path forward on a Joint Dark-Energy Mission (JDEM). Two concepts [the International Dark Energy Cosmology Survey (IDECS) and the Observatory for Multi-Epoch Gravitational-lens Astrophysics (OMEGA)] were presented to Astro2010 in June 2009. The costs are not compatible with current budget projections, and the project offices have been charged to develop a $650M-capped mission concept. Advice is being provided by the Interim Science Working Group (since December 2009). We are looking for guidance from Astro2010. The Europeans are looking at research in this field, and the United States should coordinate its efforts with the Europeans. If that opportunity does not go forward, information from Astro2010 will guide what other work will be funded instead.

The Particle Astrophysics Scientific Assessment Group (PASAG) report recommended an order of priority of research in particle astrophysics. Those priorities are generally aligned with the recommendations for cosmic-frontier research in the HEPAP (P5) report. Those priorities would focus on two areas of research: dark energy funding should not significantly compromise U.S. leadership in dark matter, where a discovery could be imminent. Dark energy and dark matter together should not completely zero out other important activities. DOE HEP funding is somewhere between the two lower budget scenarios (A and B).

In dark matter, there were a number of scenarios. A joint DOE/NSF staged program should be put together with milestones and decision points and with proposals for R&D efforts submitted to review panel(s). There will be insufficient funds for each of the efforts to go to the next generation; agencies will have to decide what they will contribute and to which efforts.

In dark energy under Scenario B, there may be just enough funding for significant participation in one large project, but there are risks because costs are uncertain; a fast start may not be possible. DES is under fabrication, BOSS is operating, and there are a number of smaller research efforts. Some R&D funding is being provided for JDEM and the Large Synoptic Survey Telescope (LSST). BigBOSS has sent a letter of intent in response to a call for proposals from the National Optical Astronomy Observatory (NOAO) for new instrumentation. Guidance is being looked for from Astro2010.

In research on high-energy cosmic particles, under Scenario A, the effort is severely curtailed to preserve viable programs in dark matter and dark energy; the VERITAS upgrade and the High Altitude Water Cherenkov (HAWC) observatory should be priorities; and Auger-North and the Advanced Gamma-ray Imaging System (AGIS) are not possible. Under Scenario B, the VERITAS upgrade and HAWC would be funded; there would be a reduced but leading role in an AGIS that is merged with Cherenkov Telescope Array (CTA); and Auger-North is not possible. Currently DOE is supporting VERITAS, Auger-South, and Fermi. Again, guidance is looked for from Astro2010.

In cosmic microwave background (CMB) research, Scenarios A, B, C, and D call for Phase-II of the Q/U Imaging Experiment (QUIET-II) to be supported along with other small investments that meet the prioritization criteria. Currently, DOE is not supporting any CMB projects but does have a number of small research efforts. Fermilab and SLAC are proposing roles in QUIET-II. The NSF recently held a review of the QUIET-II proposal (with DOE attending as an observer).

HEPAP is being charged to conduct a Committee of Visitors (COV) to examine/evaluate operations of DOE HEP. The report from the Accelerator Workshop will be used in developing the strategic plan for the HEP Accelerator Science/R&D Program. The Early Career Award Program will be discussed by Glen Crawford. There have been two recent appointments, but there are still several open federal positions in HEP. There is a need for Intergovernmental Personnel Act staff members (IPAs) and/or detailees; several appointments are ending in FY10 and FY11. New personnel have been selected for a program analyst and an instrumentation program manager. Other program-manager positions being filled are in non-accelerator physics, computational high-energy physics, theoretical physics, and accelerator science.

Phil Debenham is retiring on April 2 after 30 years of federal service. [He was recognized by the Panel.]

Henderson asked how the accelerator report would be used by the Office. Kovar responded that he had not received the report. When the report is received, the Office will consider how to address the issue.

Marlow asked when the ARRA funds for upgrades at universities would arrive. Crawford responded that, as of the previous day, 2 have been awarded, 24 are awaiting release, and others are being considered. Kovar noted that processing the applications turned out to be a time-consuming task.

Gelmini asked how NSF’s DUSEL funding would affect DOE. Kovar responded that DOE will proceed with the CD-0. In FY11, a solution needs to be found to continue operations at the mine, and both partners need to go forward.

Sphicas asked if there were an option *not* to send anything to Italy. Kovar acknowledged that there was that option, but it would require a cost-effective plan to dispose of the components. Marlow asked why that should be linked to scientific participation. Kovar responded that, for SuperB in Italy, their proposal for participation is based on their getting the components.

Tigner asked if BES were interested in those components. Kovar said that he would love to just leave these components for BES, but that does not seem to be an option.

Trischuk asked about SNOlab [the Sudbury Neutrino Observatory]. Kovar replied that a proposal had just come back from CDMS that includes a new detector design. The previous week, a group of experts was put together to consider this new scope of the proposal and to see whether it would be desirable to move that detector to SNOlab. Crawford added that it was also desired to see some of the results from the current detectors.

Nagaitsev noted that Project X was not mentioned and asked about the strategy for that project. Kovar replied that Project X is discussed by the P5 report. This proposal will be put on the table, and eventually the Office will decide on when would be the right year for CD-0, all depending on future funding. If there is enough money and a scientific case, the Office will go forward with CD-0.

A break for lunch was declared at 12:45 p.m.

Thursday, March 11, 2010
Afternoon Session

The meeting was called back into session at 1:46 p.m., and **Steve Myers** reported by a telephone from CERN in Switzerland on the status of the LHC.

On September 19, 2008, the accident happened. At 8.7 kA, a resistive zone developed in the dipole busbar splice between Q24 R3 and the neighboring dipole. An electrical arc developed that punctured the helium enclosure. After the accident, a review committee was set up, which came up with a fault tree. An absence of soldering was observed on the magnet that produced a thermal runaway and a subsequent chain reaction through the vessel and beyond. All the other magnets were inspected, and there were similar problems with the soldering in 14 quadrupole magnets and 39 dipole magnets; 54 electrical interconnections were fully repaired, and 150 more were partially replaced. More than 4 km of vacuum beam tube were cleaned. A longitudinal restraint system was fitted to 50 quadrupole magnets, and helium pressure-relief ports were installed. 6500 detectors are being added to the magnet-protection system.

The hardware commissioning was started in 2008 and lasted until September 2009. It included measuring each splice’s resistance.

On November 20, 2009, the LHC came back online with a circulating and stable beam. The first collision events occurred at 0.9 TeV and 2.36 TeV.

Some milestones that occurred were the first collisions at 450 GeV on Nov. 23, the ramp-up to 1.18 TeV on Nov. 29, the machine protection was considered ready for safe operation with pilots on Dec. 5, stable beams were established on Dec. 6, stable beams were collided on Dec. 11, two bunches per beam were ramped to 1.18 TeV and collisions were held for 90 min on Dec. 13, bunches were squeezed to 7 m on Dec. 16.

All optics systems worked beautifully. There were 26 days of successful beam commissioning with many firsts for the LHC and the detectors. The phases leading to beam operation were repair, consolidation, hardware commissioning, and preparation for the beam. The final phase was highly visible.

The simulations for safe current used pessimistic input parameters but had no safety margins. For 2010, 3.5 TeV is safe. Without repairing the copper stabilizers, 5 TeV is risky. For confident operation at 5TeV, repairs to the “outlier” splices and better knowledge of the input parameters would be needed. With the present input parameters, the limit splice resistances are 43 $\mu\Omega$ for RB and 41 $\mu\Omega$ for RQ [quadrupoles].

For confident operation at 14 TeV, all splices need to be replaced with new clamped shunted ones.

There are two possible scenarios for 2010-2011: The first is to run at 3.5 TeV/beam up to a predefined integrated luminosity with a date limit and then to consolidate the whole machine for a 7-TeV/beam. The second is to run until the second half of 2010 and then do minimum repairs on splices to allow 5 TeV/beam in 2011.

Some studies were launched about a year ago and are ongoing. The performance aim is to maximize the useful integrated luminosity over the lifetime of the LHC. Targets set for the detectors are 3000 fb^{-1} by the end of the life of the LHC and 250 to 300 fb^{-1} per year in the second decade of running of the LHC. The goals are to check the performance of the present upgrades and to check the coherence of the present upgrades in terms of accelerator performance limitations, detector requirements, manpower resources, and shutdown planning for all activities.

The present peak performance limitations of the injector (in 10^{11} protons per bunch) are Linac 2/Linac 4, 4.0; Proton Synchrotron Booster (PSB) or Super Conducting Proton Linac (SPL), 3.6; Proton Synchrotron (PS) or PS2, 1.7; and the Super Proton Synchrotron (SPS), about 1.2. The bottleneck is the SPS column, but the other injectors are limited by a fundamental limitation, the space-charge effect, which does not obtain in the SPS. This intensity limitation in the SPS can be mitigated by modifying the electron cloud, the transverse-mode coupling instability, and/or RF effects. Immediately after Chamonix, a hardware task force was set up to investigate the removal of this SPS bottleneck for the long-term future.

From the Linac2 to the SPS, there are aging machines that need consolidation or replacement. A proposed scenario is to replace Linac2, PSB, and PS. A recent study shows the time scale for operation of the PS2 to be, at earliest, 2020 and likely 2022. The existing injector chain needs to be aggressively consolidated to allow reliable operation of the LHC until at least 2022. A task force was set up late last year. But the resources needed for the consolidation of the existing injectors are in direct competition with those needed for the construction of SPL/PS2. Thus, the LHC performance implications of not constructing SPL/PS2 must be considered.

If these changes are made, the intensity limitations for the PSB or SPL and for PS or PS2 would be 4.0×10^{11} protons per bunch.

The alternative scenario would be to consolidate existing injectors for the life of the LHC (2030) and to improve the performance of the PSB/PS as injectors for the LHC during that consolidation. The new idea put forward was to increase the extraction energy of the PSB which would allow an increase of the injection energy of the PS: a 2-GeV injection energy in the PS would allow about 3×10^{11} ppb with the same space-charge tune shift. Immediately after Chamonix, a project was set up to look into this possibility.

With these changes, the intensity limitations of PS or PS2 would be 4.0×10^{11} protons per bunch with SPL-PS2 and 3.0 with 2 GeV in PS.

Four to six years are needed to profit from an upgrade.

The IT (insertion) upgrade has the goal of reliable operation at 2×10^{34} cm^{-2} s^{-1}. However, the same resources are needed for both the splice consolidation and the IT upgrade. The questions are: Will the Phase 1 upgrade produce an increase in useful integrated luminosity? And are there the resources to complete the task on a time scale that is reasonable with respect to Phase 2? A task force was set up immediately after Chamonix to answer above questions. The task force will then define the parameters for the Super Large Hadron Collider (sLHC).

The long-term upgrade (Phase 2) would achieve luminosity optimization and leveling. The detector people have said that their detector upgrade would be much more complicated and expensive for a peak luminosity of 10^{35} because of the pile up of events and radiation effects. For LHC high luminosities, the luminosity lifetime becomes comparable with the turn-around time. Preliminary estimates show that the useful integrated luminosity is greater with a peak luminosity of 5 to 6 $\times 10^{34}$ cm^{-2} s^{-1} and luminosity leveling than with 10^{35} and a luminosity lifetime of a few hours. Luminosity leveling would be achieved by beta*, crossing angle, crab cavities, and bunch length.

Collimation has the highest priority. We need to consider radiation effects on the electronics. We also need to study how to give LHCb 5 $\times 10^{33}$ cm^{-2} s^{-1} and how to get higher luminosity with lead collisions [for A Large Ion Collider Experiment (ALICE)].

The conclusions are that the luminosity targets set for the detectors are 3000 fb^{-1} by the end of the life of the LHC resulting from 250 to 300 fb^{-1} per year in the second decade of running of the LHC. To attack these goals, SPS performance improvements are needed to remove the bottleneck, the existing injector chain must be aggressively consolidated, the performance of the injector chain must be improved to allow Phase 2 luminosities, and a new sLHC must be defined that involves luminosity leveling at about 5 to 6 $\times 10^{34}$ cm^{-2} s^{-1} and at least one major upgrade of the high-luminosity insertions. The SPS upgrade will start next year, and a 2-year cycle will be started. A major concern is how to increase intensity, and a series of stages to do that has been laid out. The number of bunches is to be increased in steps. The stored energy is the critical measure here.

In 2011, at 3.5 TeV, running flat out would produce about 100 pb^{-1} per month. The beam stored energy would be 17 MJ at 50 ns, 28.2 MJ pushing the intensity limit, and 26.6 MJ pushing the bunch-current limit. With these parameters, the LHC should be able to deliver 1 fb^{-1}.

In summary, to achieve an integrated luminosity of 1 fb^{-1} in 2010/2011, a peak luminosity of 2 $\times 10^{32}$ cm^{-2} s^{-1} must be reached in 2010. To do this, there must be a rapid progression in stored beam energy in parallel to a lot of commissioning activities, done much faster than in previous machines, with the potential to cause damage, and coupled to an excellent machine uptime. The beam is back; the machine is highly reproducible; and the first collisions at 7 TeV are planned by the end of March.

Henderson noted that the strategy for DOE participation in LHC upgrades seems to be changing. Kovar replied that discussions have been held about the developments. The task force will report in March. Discussions will be held with CERN in April to see what the path forward will be and the scope of the project. Myers added that the task force has reported that the earliest the magnets could be ready for upgrade would be 2016 and that the upgrades could be completed in 2018.

Oddone asked how the turn-on was going. Myers replied that there had been no major surprises. The machine is totally reproducible. Also, we have a certain theta value for the machine (important for the collimation system); increased the injection energy to 450

GeV; and corrected the beta beating to 20%, the specification for high energy. The other parts of the machine are working incredibly well. The quench-protection system is being designed.

Glenzinski asked about the concern about delivering adequate luminosity to LHCb and ALICE over the next couple of years. Myers responded that they had not forgotten about ALICE and LHCb but had other concerns to deal with right now.

Joel Butler was asked to report on the status of the four major LHC detectors.

All four experiments had >97% of all installed channels working. The detectors did extensive cosmic runs. The detector simulations were done in great detail and were tuned with input from test-bench, test-beam, and cosmic runs. Computing systems, reconstruction software, and analysis systems were exercised at full scale in several major challenges mandated by CERN.

In November and December of 2009, there were collisions in all four interaction regions. All four experiments recorded good data at 0.45 TeV × 0.45 TeV; and 1.18 TeV × 1.18 TeV. All experiments were ready with their tools for reconstructing and analyzing this early data to understand the detectors and to extract whatever physics could be learned. These efforts have already led to publication of results.

About 500,000 events were observed by each detector. A lot has been done with those results. More than 97% of the channels were operational. There was excellent overall performance with a remarkably good understanding of the detector for this stage. There was often agreement within 1% of Monte Carlo. There is great agreement between pixel hits and Monte Carlo for ATLAS. The liquid-argon calorimeter-cell energy distributions for 900 GeV collisions were very well described by Monte Carlo simulations; similarly for the tile calorimeter. There have not been many muons from collisions, and but the group has done a great job of extracting data from the meager number of events. The known particles are being detected. The first physics are now being produced (i.e., minimum bias distributions).

More than 97% of the channels are working in the Compact Muon Spectrometer (CMS). The inner tracking and pixels have produced data and excellent agreement with the Monte Carlo calculations to four orders of magnitude. Even at 2.36 TeV, spectacular jets have been seen with the calorimeters with very good agreement between data and Monte Carlo.

The particle-flow algorithms look into the jets and see what they are really made of. Excellent tracking is being seen over a large field. The algorithm seems to work with these data. Again, the particles we know about can be reconstructed with high agreement between the data and Monte Carlo simulations.

The first CMS paper on LHC data was on the transverse momentum and pseudo-rapidity distributions of charged hadrons at $\sqrt{s}$ = 900 and 2360 GeV. This paper was a complete analysis with three different methods to control better systematics. It is another confirmation of the excellent tracker performance and good Monte Carlo description of the pixels and strips. It is an important test of the capability of producing high-quality physics results in a timely manner. And it is the first detailed look at the minimum bias and the underlying event to prepare for high-luminosity and high-intensity running.

In ALICE [A Large Ion Collider Experiment], the components that have been completed have 97% of their channels operating. The particle-identification system and transition radiator and tracking (TRT) system are working well. Some ALICE physics results have already been published despite the fact that ALICE is a work in progress.

In LHCb, the Vertex Locator (VELO) is working well and producing data in good agreement with the Monte Carlo simulations. The same can be said about the Ring Imaging Cherenkov (RICH) detector and calorimeter performance. For charm, we expect about 4×10^6 $D^{*+} \rightarrow D^0(K^-K^+)\pi^+$ for 100 pb^{-1}

For ATLAS and CMS, great physics is in reach: supersymmetry (SUSY) up to about 800 GeV, W′ up to about 2 TeV; Z′ up to about 1.5 TeV, and the Standard Model Higgs exclusion in the range of about 165 ± 10 GeV/c^2, entering the range of new-physics sensitivity.

In conclusion, all four detectors have their equipment for the run in place and working and are ready to take data and to analyze it expeditiously. Every opportunity to use particles from cosmics and the LHC has been exploited. Pushing the early collision data through to publication has created a discipline that has advanced our capabilities. The luminosity expected over the next two years will allow addressing the remainder detector issues and, with luck, will offer the opportunity for new physics. This run has the potential for a new discovery.

A lot of the ability and experience to do this originated in earlier and concurrent experiments.

A break was declared at 3:28 p.m. The meeting was called back into session at 3:50 p.m. **Sergei Nagaitsev** (Fermilab) was asked to report on the status of Fermilab's Project X.

The configuration of the project has been changed, and the technical approach and costs have been optimized. Project X would support a long-baseline neutrino experiment and the rare-processes experiments (for which there is now a good grasp on the beam requirements). In addition, it could provide a neutrino factory/muon collider platform.

In September 2007, Fermilab proposed a proton linac based on International Linear Collider (ILC) technology with 2 MW in the Main Injector for neutrinos, with 100 to 200 kW at 8 GeV for rare processes (muons and kaons) and as a replacement for a booster and a linac that were about 40 years old.

In spring 2009, the coupling to the ILC was reduced, and the physics program was approved. The issues with the original designs were that rare processes require a stream of bunches with a ~100% duty cycle; there is a fundamental limit to slow extraction caused by losses at the electrostatic septum; and at the end, slow extraction is the bottleneck.

In March 2009, Fermilab decided to focus on a continuous-wave (CW) proton linac to support (1) the LBNE from the Main Injector; (2) a diverse program with muon, kaon, and nuclear physics; and (3) an 8-GeV program with a single-turn extraction ≥100 kW (e.g., g-2), a path to a muon collider/neutrino factory (MC/NF), and experiments in other fields. The Continuous Electron Beam Accelerator Facility (CEBAF) is an example of such a machine with an electron beam.

The new configuration would be a 2.0-GeV CW linac, potentially "unlimited power," RF separation plus bunch-by-bunch chopping, multiple experiments operating simultaneously, and independent bunch structure control, "pulsed" 2- to 8-GeV acceleration (10 Hz, 4.3 ms, 5% duty cycle) to support the Main Injector program. Both a synchrotron and a pulsed superconducting (SC) linac are good choices. 95% of the output would go to the three experiments running concurrently. With a 1-μs period at 2 GeV, the different particles can be separated into three pulsed beams (μ 2e, kaon, and other nuclear physics). This process has been demonstrated at CEBAF.

The facility would consist of an ion source, radiofrequency quadrupole (RFQ), medium energy beam transport (MEBT), single-spoke resonators (SSRs), test storage ring (TSR), and ILC cryomodules. The base cost would be $798.4 million, overhead $187.5 million, escalation $144.0, and contingency $452.0 million for a total of $1581.9 million.

2 GeV is sufficient for muons but not for kaons, which would need 3GeV. Fermilab knows that it has beam requirements that it can support. This reconfiguration solves the problems of slow extraction, but two issues remain: low proton-beam energy (2 GeV instead of 3 GeV) and inefficient acceleration in the linac.

The 1300-MHz section is not an efficient accelerator for protons. The primary culprit is the transit factor. The maximal gain at zero synchronous phase is 17 MeV; but for a 2-GeV proton beam, it is close to 15 MeV. How to make it more efficient was studied, and four schemes were derived. Option 4 is a 3-GeV CW linac with a 650-MHz intermediate system based on five-cell cavities. The gain per cavity is much smoother. It would have 250 cavities and would be about 20% longer than a 2-GeV linac.

Fermilab will develop an estimate for a 3-GeV CW linac operating at 1.5 to 2 MW, retain RCS within the estimate but limit work to the issue of injection, investigate options for pairing a 3- to 8-GeV pulsed linac to a CW front end, update the RD&D Plan to cover the CW linac, archive the Initial Configuration Document and the associated cost estimate, and develop a proposed strategy for CD-0. It will attempt to get the cost of a 3-GeV linac at or below $1.0 billion.

The goals of the director's review will be to validate the cost estimate for the second version of the initial configuration and a cost range. The upper end of the range will be the IC-2v1.0 with a 3.0-GeV/1.0-mA linac, an RCS, a recycler, and the Main Injector; and the lower end of the range will be the IC-2v2.0 with a 3.0-GeV/0.5-mA linac with no rapid cycling synchrotron (RCS), a recycler, and the Main Injector.

A multi-institutional collaboration has been established to execute the Project X RD&D Program. It is organized as a "national project with international participation" with Fermilab as the lead laboratory and international participation via in-kind contributions established through bilateral MOUs. The first MOU with India is in place. A collaboration MOU for the RD&D phase outlines the basic goals and the means of organizing and executing the work. Collaborators are to assume responsibility for components and subsystem design, development, cost estimating, and (potentially) construction.

In conclusion, the configuration for Project X has evolved to maximize physics outcome since the initial proposal in 2007. At every step the performance has been improved. A new approach is being taken to high-duty-factor beams and rare processes. This is not another rendition of the Japan Proton Accelerator Research Complex (JPARC). This project would increase beam power by a factor of 10 over the IC-1 rare-process program and a factor of 7 over JPARC and capture the leadership on the intensity frontier. We now know what we want to build: a 3-GeV CW linac. It could be constructed in 5 years, producing a multi-user facility concurrent with LBNE. An rf splitter would send beams to three 3 users (muon, kaon, and nuclear physics), but the technology is not limited to three users.

Nelson asked what drove the cost estimate of $1 billion. Nagaitsev replied that this is an estimate for a 2-GeV, not a 3-GEV, facility. It is what would be needed to support the experiments. What is being attempted is to increase the energy of the linacs and reduce the cost. It is not desirable to increase the cost beyond the earlier estimate. Kovar pointed out that, if it costs too much, it cannot be done. If one can reduce the cost, perhaps it can be done. Accelerators are in competition with other national priorities. The more efficient the accelerator is, the lower the cost will be, and the more competitive the proposal will be. It is unlikely that there will be a big bump in funding in the out-years.

Dixon asked if the CW linac were being designed with ILC-design cavities. Nagaitsev responded that they produce the greatest gradient. The cryogenic losses need to be conserved, and the quality factor needs to be maximized. The optimum design maximizes these three factors. This *may* feed back into high-gradient cavities. Several of the components would be passed on to the ILC (i.e., pulsed cryomodules).

Leemans asked how much thought had been given to the halo of the beam. Nagaitsev answered that this linac design is being done in cooperation with the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory (ORNL). Leemans observed that the SNS does not operate at 1.3 GHz. Nagaitsev said that, as one goes higher in energy, one might be able to use 1.3 GHz, but it is an issue to be looked at.

Kettell asked if a cost range that, at the low-end, would not support the LBNE was being proposed. Nagaitsev replied, yes, for the purpose of the discussion of costs and benefits. Kovar said that he had wanted to challenge the designers to see what could be done and what the pieces of the facility would each cost. All options should be explored. This strategy has produced a lot of imaginative thinking.

Marlow stated that the energy seems low for a kaon factory and asked what the kaon/kW curve looked like. [Robert] Tschirhart replied that the curve saturates at about 4 GeV. The optimized energy is between 4 and 8 GeV.

Trischuk wanted to know who decided on the trade-offs of different physics experiments. Kovar replied that this would go to a Science Advisory Committee at Fermilab with recommendations to the Office. P5 gave a lot of guidance; another P5 will be needed in 2014 or even sooner. At the expected level of funding, participation can be undertaken in all three frontiers, but a leadership role in all of them would not be possible. Choices will need to be made. Oddone said that an international collaboration would need to be built. That will help with costs.

Dennis Kovar was asked to present the charge for a COV.

A COV review is required every three years as part of the management responsibilities. The Deputy Director for Science Programs has issued a guidance document for SC COVs, to wit: The COV subcommittee should assess the efficacy and quality of the processes used to solicit, review, recommend, monitor and document application and proposal actions and the quality of the resulting portfolio, including its breadth and depth of portfolio elements, its national and international standing, and the progress HEP has made toward its long-term program goals since the previous review of these milestones by HEPAP. Comments and suggestions for improvement in these processes and their implementation and on the observed strengths or weaknesses in any component or sub-component of the HEP's portfolio would be appreciated. The COV should also comment on what progress has been made in addressing action items from the previous COV.

The chair of the COV should work with the Associate Director of Science for High Energy Physics in setting up the logistics for the onsite review at Germantown. The results of this review should be documented in a report with findings, comments, and recommendations clearly articulated. The report should be presented at the fall HEPAP meeting in mid-November and submitted to the agencies shortly after.

The guidance calls for a review of all actions and responses. It also talks about scheduling and conducting SC COV reviews, distributing COV reports, and responding to findings and recommendations. It also provides a report template.

Shochet announced that James Alexander had agreed to chair the COV. The Subpanel will be filled out during the next few weeks. The COV reviews will be in mid-October.

Glen Crawford was asked to present an update on the DOE Early Career Program (ECP).

The ECP got $85 million in FY09 ARRA funding, and 69 awardees were selected from 1750 proposals. It was coordinated and managed at the Office of Science (SC) level. The HEP component got $16 million and awarded 4 laboratory and 10 university 5-year awards in FY10. Steady-state funding of about $16 million will be established for such awards in the out-years. This amount is 4 to 5% of HEP's core research program. There is a real push to raise the visibility and support for young scientists.

This program supplements the Outstanding Junior Investigator (OJI) program. HEP got 150 proposals; each got at least two mail reviews and one panel review. The review criteria (for all of SC) were

1. Scientific and/or technical merit of the project
2. Appropriateness of the proposed method or approach
3. Competency of the personnel and adequacy of the proposed resources
4. Reasonableness and appropriateness of the proposed budget
5. Relevance to the mission of the specific program to which the proposal is submitted and (if a lab proposal) the DOE national laboratory mission
6. Leadership within the scientific community

Each panel met separately and identified two or three clearly outstanding proposals plus three to five other excellent-to-outstanding proposals. The HEP program staff met in December to select the final nominees from the pool of about 25 finalists. They considered panel rankings, mail reviews, program balance, innovation, risk/reward, contribution to HEP priorities, impact of the early career award in program context. In the end, four national laboratory and ten university awards (including all eight "clearly outstanding" proposals) were selected.

Reviewers often looked for innovative proposals, usually something a bit off the beaten track, speculative but not too risky. This was hard to do in established large experiments. Reviewers often looked for proposals that would make a significant impact. Many national laboratory and some university proposals suffered from "isn't the lab/project going to do that anyway?" There were many LHC experimental proposals. There were many solid proposals but few standouts. There was a strong pool of theory proposals.

Ten university awards were made, five in experiment and ten in theory. Four laboratory awards were made, three in experiment and one in theory.

There were six theory awards out of 49 proposals and eight experiment awards out of 105 proposals. Three women and eleven men got awards. There were six East; four Midwest; and four West, evenly distributed in year since PhD. The average mail-review scores were very similar to the average panel scores.

"Lessons learned" are currently being collected for the next round of Early Career Awards. Peer reviews have been sent to all Early Career PIs so they can better prepare. The proposal timeline may shift. General guidance was provided on adding new faculty to DOE/HEP grants last week. All new faculty members must submit a proposal to be considered for funding by DOE. If a DOE HEP group's grant is due for renewal, the PI of that grant may incorporate the junior faculty research proposal(s) into the group grant renewal proposal at his or her discretion. However, peer reviewers will be asked to specifically evaluate the new faculty on the basis of their individually proposed research. If the research plan for the new faculty is not clear, the peer reviews for that component of the proposal are likely to suffer.

Another new program is the SC Graduate Fellowship Program, which is managed by the Office of Science Office of Workforce Development for Teachers and Scientists (WDTS). The program is funded for three years with $12.5 million of ARRA funding. There is an additional $5 million from the FY10 appropriation for the first year. WDTS will establish steady-state funding in the out-years. The program is open to fourth-year undergraduates through second-year graduate students who are U.S. citizens.
About 3200 applications were received; about 160 awards across DOE/SC are expected. The applications are in the final review stages now. Winners will be notified March 30. Each Fellow is to receive $55,500 per year for 3 years: $35,000 for living expenses, $10,500 for tuition assistance, and $5,000 for research support research support.

In addition, there is also the new HEP Theory Fellowship, which responds to the 2007 HEPAP University Subpanel. It is a set-aside supplemental budget for competitive fellowships. These 2-year fellowships are not renewable; they automatically end if the fellow obtains a Ph.D. degree before the 2-year term ends. To qualify, a candidate must have satisfied the Ph.D. candidacy requirements and be ready to conduct thesis research and must be nominated by the thesis adviser. Only one application per current DOE university grantee. The deadline this year is April 5, 2010. A panel will make recommendations based primarily on the soundness of the proposed research and the demonstrated potential of the nominees. An annual competition is planned. The target is five fellows this year and five additional in each of the subsequent years.

The Office is considering laboratory-visitor theory fellowships to enable theory students to spend research time working with national-laboratory mentors. It is trying to launch a pilot program at Fermilab this year. The Office is open to other suggestions for new/innovative student programs.

Marlow said that these programs are very good, but reducing a grant by the amount of the person's start-up funds is problematic. Crawford replied that the Early Career Awards do not disallow startup funds. In the other programs, one can have competing proposals from people who have startup funds and from others who do not. To make the best impact on the field, the person with no startup funds may be given some preference. Shochet observed that that might reduce the net funding to particle physics since Deans would put their start-up funds elsewhere. Crawford said that the Office was open to HEPAP's help in deciding how to get the most return from an investment. Brock said that for the features of a new faculty member's start-up package to undercut the awarded funding is surprising. Crawford replied that it is a concern that is thought about when deciding how to support the field. If a university is interested in attracting an excellent person, the Office looks at how much it is willing to invest in attracting that person. It is not done to discourage people from applying. However, they should not feel obligated to apply, either. Shochet stated that it will drive down the amount of nonfederal funds that goes into particle physics.

Nelson asked Crawford if he meant to imply that sometimes awards would be made to weaker candidates because otherwise they would not have enough support. Crawford responded that the challenge comes in when some reviewers liked a proposal and some did not but it got a strong ranking. One has to decide where one's money will be best spent. Some proposals have more risks than others. That risk is not quantifiable. The letter sent out by the Office may have been too strong.

Sphicas commented that the curse of big science is that one who is working in a large project cannot claim to be outstanding. It will be difficult to hire excellent personnel into the big experiments because their relative importance will be zero. Crawford replied that, when a senior faculty member proposes joining a group, there are various factors in play (resources available etc.). The leaders of that group would understand how that person would fit in. There were LHC proposals that made the list; it is not impossible, just more difficult to stand out.

Kroll noted that the number of laboratory awards seemed large and asked how they used the funds and whether it costs less to give an award to a current OJI. Crawford said that OJI awards did not factor into the award process. With an ECA to an OJI, the OJI money goes back to that program. There were eight proposals that were head and shoulders above the rest. The program managers decided among the second-tier of proposals. Part of the purpose of the ECA was to recognize outstanding researchers at the laboratories. If one looks at the budget sheets for the laboratories, there are more personnel. Kroll restated the answer: if a laboratory gets an ECA, money is freed up to hire more people. Crawford added, if they choose to use the money that way. Kovar commented that one does not have to be at a university to be an outstanding young researcher. The laboratories will have a problem in 5 years when the money runs out.

Blucher stated that that seems to be in conflict with how money is handled for universities. Kovar said that the Office gets the message loud and clear. If one gets a startup package, that should be a plus, not a negative.

Marlow asked whether, in both HEP and SC, the amount of money is for this year or for the 5 years. Crawford responded that it is for all 5 years of the awards. White commented that some may not last 5 years and asked if the awards can be taken to another institution. Crawford replied that the awards are for the research. There are guidelines for changing institutions.

Leemans asked if there were a correlation between award size and success rate. Crawford answered that each program did its reviews separately. The dollars were preset.

Dixon asked if the Graduate Fellowship Program competition would be by office. Crawford replied, no; it will be competed SC-wide.

Sphicas re-emphasized that there *are* excellent people in the national laboratories and asked whether there would be no university grants if the only two proposals were from laboratories. Crawford said that it would be a difficult decision, but highly unlikely.

Kovar added that the $3 million that was put in this year has to be increased each year to $16 million per year.

Nelson asked whether the office intended to maintain the discrepancy between university and laboratory funding levels. Crawford said that that will be an SC decision. Shochet observed that there are very good reasons for part of the differential. Kovar noted that this group of 14 awardees is very impressive and that there were strong ones that the Office was unable to fund.

The meeting was adjourned for the day at 5:46 p.m.

Friday, March 12, 2010
Morning Session

The meeting was called to order at 8:30 a.m. **Steve Koonin** was introduced to describe science in DOE. As the Under Secretary for Science, his responsibility is to look across the Department to find gaps, synergies, connections with the external community, collaboratory opportunities, etc.

This budget is the one with which this leadership team will have the most influence on the programs. It represents a common plan and vision for the Department. Priorities are

- Helping the country with jobs and competitiveness
- Nuclear security
- Energy innovation (driven by energy security and greenhouse gas reductions)
- Discovery, including keeping the fields of science vital

Integration across the Department is a major strategy, bringing more science and engineering into energy technologies. Another strategy is to shift the research of SC toward work that responds more to the needs of society by bringing the talents of SC into the National Nuclear Security Administration (NNSA) and to mine the NNSA for energy technology.

SC's talents need to be focused on the energy needs of the nation. Exascale computing needs technological advances. In inertial fusion energy, the National Ignition Facility (NIF) is working and will make a run at energy production this year. Discovery science is important, but the case will need to be made for applicability to society's problems through spinoffs and other mechanisms.

Marlow stated that the Panel members knew what spinoffs are. The biggest spinoff is the training of students. He asked how the Department views this. Should the universities be pointing students to more practical problems? Koonin replied that there are needs for smart people in all fields. In biotechnology, there are people who produce and sift through huge amounts of data.

Shochet stated that there is a delicate balance in talking with decision makers in choosing to talk about the science and talking about the applications and implications of the science. Koonin responded that one has to tailor the message to the audience.

Sutter asked what was going to happen to heavy-ion inertial fusion. Koonin answered that there are many paths toward fusion energy. A National Academy study is being started to consider options. He favored a broad approach.

Blucher asked about what strategies were being thought about for making the research of SC more applied. Koonin replied that it was useful for academia to split between pure and applied because those researchers would have different interests and objectives. The Advanced Research Projects Agency-Energy (ARPA-E) is one way to approach applied science, and hubs are another; cross-agency projects are being talked about, also. In the energy part of DOE, the last success was civilian nuclear power. Goals for today might be an internal combustion engine that is 50% more efficient or small, modular nuclear reactors.

Sphicas noted that the clarity of this U.S. thinking is refreshing and asked where Europe comes into this picture and where large, international projects fit in. Koonin answered that CERN brings a lot to the United States. ITER is an international effort of countries with different goals and interests. There is no general principle in the management of such relationships; one has to take them one by one. High-performance computing is not internationalized. Cooperation with India, China, etc. is essential to solve energy problems.

Oddone said that discovery science seems valued for its contribution to the national needs. Discovery needs to be valued for itself. If society and its leadership do not value discovery, the strategic plan will do this field in. Perhaps DOE should not be looked to as the steward of discovery science. Where society is going to end up will be determined by the fundamental science that is done now, not the short-term R&D. Koonin responded that the country is in real trouble in many ways. In time of trouble, the smart people in society need to pitch in to solve those problems. The government has always stressed applications and societal benefits to justify discovery science.

Henderson stated that funding for research and applied technology is missing in this country. Koonin responded that DOE is a large institution to turn around, and all the energy technologies have long time scales for development and deployment, a lot longer than the time scales of political interest. Companies are command driven and revenue driven. Academia is just the opposite. Government is consensus driven. As a result, government by design moves slowly.

Sutter said that the time to rebuild the culture, infrastructure, and talent will be long if those elements are destroyed. Koonin pointed out that science is a global enterprise. One cannot get by without discovery science.

Teplitz asked if the President appreciates the significance of high-energy physics. Koonin said that he did not know; he did know that the President is captivated by science.

Robert Hamm was asked to describe accelerators in industry.

99% of the accelerators sold are for medical or industrial purposes. Accelerators have a major socio-economic impact on society, including all digital electronics, many consumer products, and health and environment. Many of these applications grew from worldwide accelerator technology developments, including nuclear and high-energy physics. If one develops a new type of accelerator, someone will figure out how to use it, but it will take 10 to 20 years to break into the sales cycle.

A book on this topic is under development. It covers ion implantation, electron-beam material processing, electron-beam material radiation, production of radioisotopes, ion-beam analysis, applications of neutrons, nondestructive testing, and synchrotron radiation. This is the range of industrial accelerators.

Industrial-accelerator technology includes (1) direct-voltage machines in which a directly applied high-voltage gradient is used to accelerate charged particles (electrons or ions); (2) rf linacs that use an rf-generated voltage to accelerate "bunches" of charged particles (e.g., electron linacs and ion linacs); and (3) circular accelerators in which a magnetic field is used to maintain a circular orbit with rf acceleration (e.g., cyclotrons, betatrons, rhodotrons, and synchrotrons).

The field of ion-implantation accelerators has narrowed down to a few big vendors and a lot of specialty vendors. The machines have to be very reliable. Annual sales total $1.5 billion for accelerators and $140 million for dopant materials.

All complementary metal oxide semiconductor (CMOS) transistor fabrication is done with ion-beam implantation, covering 10 orders of magnitude in ion dose. This technology is used for all integrated circuit devices, cell phones, digital communication, hardening of cutting tools, biomaterials, and hardening of ceramics and glasses. All digital electronics are now dependent on ion implantation. The typical integrated circuit has 25 to 30 implants during fabrication.

A very old field employing industrial accelerators is electron-beam material processing. These are just electron guns for drilling and cutting. There are 4000 systems in operation worldwide with 1000 in the United States. This business is expanding rapidly in developing countries. It is critical to automotive production, deep welding of dissimilar metals, precision cutting and drilling, and recovery of refractory metals. This industrial application is so old, many factory systems are fully automated.

Electron-beam irradiation accelerators are used to change the character of a material. They are used in a wide range of applications and of technologies. Now there are more than 1500 dedicated facilities worldwide; they are used to vulcanize rubber, produce surfaces on furniture, etc.

Electron-beam irradiators are the largest class of machines and applications. They are used for cross-linking of materials, the sterilization of single-use disposable medical products, and food and waste irradiation, involving many consumer products. The costs of equipment are typically recouped in a year or two.

Radioisotope production is used for industrial gauging and calibration and medical diagnostics and treatment. Cyclotrons and linacs (with both protons and deuterons) are used for producing isotopes for positron emission tomography (PET) and single photon emission computed tomography (SPECT).

Ion-beam analysis has a lot of applications in semiconductor quality, environmental monitoring, geological studies, oceanography studies, biomedical science, and renewable energy. Most of the electrostatic accelerators are made by only two vendors. These applications are still widely used at many research laboratories. Many analysis techniques employ this technology.

High-energy X-ray inspections are used for radiography of large castings, examination of rocket motors and munitions, and port examination of containers and semi tractor-trailers. (The biggest application now is the verification of manifests and the collection of taxes and tariffs.) There are now more than 1000 systems, growing at 15% per year worldwide.

Neutron-production accelerators are used in oil-well logging (the largest application), security, trace-element analysis (including bioscans), bulk-material analysis, and nuclear-weapon production. A broad spectrum of ion energies and neutron yields are available.

Synchrotron radiation is a modern, precise probe for many types of analysis. Most synchrotrons are at large facilities. Only three or four machines were built for industry for lithography (which use was supplanted by other technologies). They are now used for protein crystallography by consortia of drug companies. About 80% of the capacity of these facilities is used by pharmaceutical companies.

It is estimated that more than 22,500 machines have been built (the installed base is about 80% of that number). The industry is approaching $2 billion in annual sales and is growing at 10% per year, even in the recession. All the products that are processed, treated, or inspected by particle beams have an annual value exceeding $500 billion.

Future technologies that will soon become commercial include free-electron lasers (FEL), superconducting linacs and cyclotrons, and fixed-field alternating-gradient (FFAG) cyclotrons. Other R&D is under way but is kept secret for competitive reasons. This is a highly competitive business.

White noted that the delivery time includes a lag between order and delivery and asked if that lag time were improving. Hamm replied, no. The companies can only push the accelerators out so fast. The recession has only made production slower.

Dixon asked how technology is transferred from research to industry. Hamm replied that the Small Business Innovative Research (SBIR) program is one of the most efficient transfer programs ever done. It was responsible for the success of his company. He had left Los Alamos National Laboratory and started a business. It took 10 to 15 years to get accepted in the commercial market.

Jackson asked if there were anything possible to help business people become aware of innovations and to accept them. Hamm replied that it has become important to the current administration to apply scientific discoveries. If you build it, they will come.

Trischuk asked what the accelerator business was inside and outside of the United States. Hamm answered that, 30 years ago, the United States predominated. Now, Europe and the Far East manufacture large numbers of accelerators. Accelerator science is not supported in academic programs anymore (with a few exceptions). More education in accelerator physics is needed along with the recognition of the field of accelerator physics within the discipline of physics.

Walter Henning was asked to report on the Workshop on Accelerators for America’s Future, which was held October 26–28, 2009. The workshop was held to provide a more direct connection between fundamental accelerator technology and applications; the HEP program sponsored the workshop to identify the R&D needs of the various users of accelerators. The workshop focused on the role of accelerators in the nation’s efforts in science, medicine, energy, national security, and industry. HEP will use this report to develop a strategic plan for accelerator technology R&D that recognizes its broader societal impacts.

The one-day symposium had distinguished presentations and a poster session. The two-day follow-on workshop had five working groups focused on discovery science, medicine and biology, energy and environment, security, and industry. Community-input white papers were solicited.

The meeting was to examine what the challenges are for identifying, developing and deploying accelerators to meet the nation’s needs. The results will be presented in the form of a report. The goals were to identify current and future needs, to seek out crosscutting challenges whose solutions may have transformative impacts, to provide guidance to bridge the gap between basic accelerator research and technology deployment, and to identify the areas of accelerator R&D of greatest promise.

The working groups submitted their draft reports at the beginning of December. The drafts were used for drafting the final report. The draft final report is now out for review. The report has findings; the workshop was not charged to produce recommendations. It identifies areas of needed R&D and policies; points to future opportunities and possibilities (the technological advances needed to reach the frontiers of energy, intensity, and precision); makes the case for accelerator science being a science in itself; and points to the education and training needed.

Possible accelerator applications include transmutation of nuclear waste, energy production through fission and fusion, environmental studies and waste management, production of radioisotopes for diagnostics and therapy (e.g., PET, SPECT, and targeted therapy), cancer therapy with electron/X-ray and ion beams (including heavy-ion therapy), targeted radiotoxicity therapy, biomolecular studies and pharmaceutical developments, national security, and nondestructive testing. R&D is needed on reliability, size, and effectiveness.

The total number of systems sold up to 2010 may be as many as 40,000; 1400 systems are sold each year. There are $3.6 billion in sales each year worldwide.

In industrial applications, nuclear reactions and activation are undesirable and avoided, but other effects of ionizing radiation are researched.

BFGoodrich patented electron-beam technology for vulcanization of tires in 1932.

A lot of accelerator usage is at the interface of research and industry from archaeology and art to geophysics, climate research, ocean circulation, erosion studies, forensics, atmospheric studies, groundwater and aquifers, actinides, pharmaceuticals and drug development. They have been used to look at ocean circulation, the Ötzi neolithic man, and the dating of ice cores.

Accelerator innovation happens and is used in research and by industry/society. There are large interactions between similar R&D and industrial systems. R&D identified by these usages should lead to additional innovation, development, and translation.

The findings of the workshop are

- R&D in superconducting radiofrequency (SRF) is progressing.
- Wake-field technology is very promising.
- Accelerator physics is at the forefront of science (in general).
- Important R&D is needed for major advances in performance.
- R&D is needed to make accelerators more rugged, reliable, compact, and economical.
- Accelerator science *is* science in itself.
- Interagency and interprogram communication and collaboration are needed.
- World-class facilities are required to help industrial users bridge the translational gap to commercial deployment.
- Mechanisms are needed for new public-private partnerships.
- Accelerator education is needed.
- The United States must compete by optimizing its knowledge-based resources, particularly in science and technology, and by sustaining the most fertile environment for new and revitalized industries and the well-paying jobs they bring.

Glenzinski asked how many policymakers attended the workshop. Henning replied that most of the policymakers present were program managers from SC, NNSA, and NSF along with a few from industry and congressional offices.

Marlow asked how many machines were needed for ^{99}Tc production. Henning answered, one with a low-enriched uranium target. Simulations have shown that an optimized machine can fulfill the U.S. demand with established technology. The proposal is from industry. Hamm added that two U.S. companies are undertaking such development, both using particle-beam fission.

Weerts asked if the companies developing these accelerators would be willing to contribute to research costs. Henning answered, yes. Some mechanism needs to be set up to bridge the gap between research and industry.

A break was declared at 10:46 a.m. The meeting was called back into session at 11:15 a.m. The final speaker could not be reached, so her presentation was deferred to the June meeting. The chair reviewed what had transacted at the meeting, took suggestions about other items discussed, stated that he would compose a draft summary letter to the representatives of the agencies, and promised to circulate that draft to the Panel members for review before submission to the agencies.

The meeting was adjourned at 11:44 a.m.

Respectfully submitted,
Frederick M. O’Hara, Jr.
Recording Secretary
April 21, 2010

Corrected by
Melvyn Shochet
HEPAP Chairman
May 11, 2010

The minutes of the High Energy Physics Advisory Panel meeting held at the Hilton Embassy Row Hotel, Washington, D.C., on Oct. 22–23, 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 11, 2010.