Minutes for the
High Energy Physics Advisory Panel Meeting
February 14-15, 2005
Hilton Washington Embassy Row, Washington, D.C.

HEPAP members present:

Joel Butler
Alex Dragt
Frederick Gilman, Chair
JoAnne Hewett
Young-Kee Kim
Paul Langacker
Peter Meyers
Stephen Peggs
Steven Ritz

HEPAP member absent:

Keith Baker

Also participating:

Jonathan Bagger, Departments of Physics and Astronomy and of Mathematics, Johns Hopkins University
Daniella Bortoletto, Department of Physics, Purdue University
Glen Crawford, Office of High Energy Physics, Office of Science, Department of Energy
Joseph Dehmer, Director, Division of Physics, National Science Foundation
Robert Diebold, Diebold Consulting
Jonathan Dorfan, Director, Stanford Linear Accelerator Center
Thomas Ferbel, Office of High Energy Physics, Office of Science, Department of Energy
Michael Harrison, Head, Superconducting Magnet Division, Brookhaven National Laboratory
Robert Cahn, , Physics Division, Lawrence Berkeley National Laboratory
Joseph Kroll, Department of Physics and Astronomy, University of Pennsylvania
Daniel Lehman, Director, Construction Management Support Division, Office of Science, Department of Energy
Laurence Littenberg, Electronic Detector Group Leader, Brookhaven National Laboratory
June Matthews, Director, Massachusetts Institute of Technology Laboratory for Nuclear Science
Marsha Marsden, Office of High Energy Physics, Office of Science, Department of Energy
Timothy Meyer, National Academy of Sciences
Hugh Montgomery, Associate Director for Research, Fermi National Accelerator Laboratory
F. M. O'Hara, Jr., HEPAP Recording Secretary
Raymond Orbach, Director, Office of Science, Department of Energy
Stephen Peggs, Leader, LHC Accelerator Research Program, Brookhaven National Laboratory
Randal Ruchti, Program Director, National Science Foundation

James Siegrist, Director, Physics Division, Lawrence Berkeley National Laboratory
Robin Staffin, Associate Director, Office of High Energy Physics, Office of Science, Department of Energy
James Strait, Head, Particle Physics Division, Fermi National Accelerator Laboratory
Bruce Strauss, Office of High Energy Physics, Office of Science, Department of Energy, HEPAP Executive Secretary
Maury Tigner, Physics Department, Cornell University
Michael Turner, Assistant Director, Mathematical and Physical Sciences, National Science Foundation
Rainer Weiss, Department of Physics, Massachusetts Institute of Technology
James Whitmore, Program Director, National Science Foundation
Michael Witherell, Director, Fermi National Accelerator Laboratory
Andreene Witt, Oak Ridge Institute for Science and Education
John Womersley, Office of High Energy Physics, Office of Science, Department of Energy

In the course of the two-day meeting, about 65 others were also present.

Monday, February 14, Morning Session

Chairman **Frederick Gilman** called the meeting to order at 9:19 a.m. The Panel is still short some new members because the vetting process is still going on. A quorum is met by the two-thirds of the old members present. The Panel is facing a new fiscal year and a new Secretary of Energy, Samuel Bodman. Five advisory committee chairs wrote to Secretary Bodman, supporting his strong support of science. In the FY 06 budget request, the Elementary Particle Physics (EPP) program of the National Science Foundation (NSF) is up 2.3%, and the Office of High-Energy Physics (HEP) of the Department of Energy (DOE) is down 3%. The American Physical Society (APS) neutrino study was distributed to the members. A number of charges will be coming to HEPAP at this meeting.

Gilman asked **James Whitmore** to review the Human Resources Study.

In April 2004, HEPAP asked, "Does the field have the people to adequately carry out the experiments to which it is committed until the end of the decade?" Chairman Gilman appointed a Working Group with Chip Brock, Glen Crawford, and James Whitmore as cochairpersons.

The Working Group sent a letter to all NSF and DOE principal investigators (PIs), asking them to give their plans for the distribution of personnel among four categories: faculty, staff, postdocs, and students for the various projects in which they are involved for each year through FY 09 for a constant level of effort with FY 04 as the base year. They were to give the current personnel in each category, both funded from base and off-base, and to estimate the number of full-time-equivalent personnel working on each project in each category in each year. These data were to be submitted on an Excel worksheet that was supplied with the letter. Six NSF and twenty-nine DOE PIs had not yet responded.

The Working Group also sent a letter to each experiment, asking what required levels of effort are needed to keep their experiment running and producing physics results and

publications through FY 09 and asking them to assess their needs to maintain and operate the experiment at a realistic minimum level of effort. Two major categories were emphasized: (1) maintenance and operations (largely focused on data-taking operations with respect to detectors and beams) and (2) data analysis. All current responses are listed on http://www.pa.msu.edu/~brock/file_sharing/FAQ_survey.htm. At this point, 21 experiments had not yet responded.

For the experiments, 35 requests were sent out, and 14 responses had been received (40%). For the NSF PIs, 78 requests were sent out, and 72 responses were received (92.3%). For the DOE non-theory, non-tech PIs, 89 requests were sent out, and 60 responses were received (67.4%). A fair amount of work remains to be done. The Working Group needs to follow up on nonresponders (PIs and experiments). In addition, some institutions have sent in two (or more) responses, and some PIs responded to both the NSF and DOE requests. The Working Group needs to make sure that the responses are not double counted and to check each response for internal consistency (some DOE theory groups responded). The Working Group is working on a program to collate all responses (in Excel).

The next steps that the Working Group needs to take include

- analyzing the PI responses and summing the total personnel for each year in each category and in each listed experiment (current and planned),
- comparing the PI responses with the experiment responses for each year to see if there are enough people to do the experiments, and
- comparing the responses for planned experiments with the PI responses to see if their needs will be met.

The Working Group would welcome specific questions from the Advisory Panel members. Such questions may be sent to hepexp@ pa.msu.edu.

In summary, the Working Group is a bit behind in collecting the data but is nearly there. The experiments, in particular, have not been very responsive. The Working Group realizes the need for these data and will process them as soon as possible; it has volunteers from the Working Group lined up to help on this as soon as the data are complete.

Ritz expressed worry about the size of the error bar and asked if the numbers have enough robustness for the planning process. Whitmore replied that it will not be known until the numbers are in. Even for those who have needs, the specific needs will not be known until then.

Gilman asked what level of error was expected. Whitmore answered, 10% in experiments. Otherwise, there would not be enough data to analyze.

Gilman called upon **Maury Tigner** to summarize the status of the International Linear Collider (ILC).

The Global Design Effort (GDE) Central Team Director Search received 13 nominations from the three regions and selected four candidates to interview. Three agreed to be interviewed. A common set of questions was addressed to each candidate, and each provided written responses. The interviews were conducted, and a report was made to the International Linear Collider Steering Committee (ILCSC), which has made a recommendation.

All three final candidates would be excellent directors; leadership within the accelerator and HEP communities, energy, vision, and ability to speak for the ILC project

were the largest discriminants. The priority of the candidates was Barry Barish, David Burke, and Satoshi Ozaki. They will be approached in turn. Barish asked that the designated Central Team site be in North America. He also requested that 20% of his time be reserved for research at LIGO (Laser Interferometer Gravitational Wave Observatory). He would ramp up from 25% immediately to 80% this summer.

ILCSC has discussed the character of the Central Team site with Barish. It is now talking about a virtual Central Laboratory sited simultaneously in all three regions, trying to make it as international as possible.

The Host Evaluation GDE Central Team got nine positive responses. The submitted proposals were evaluated, and additional questions were sent to the nine laboratories about costs of labor, housing, availability of educational facilities, etc. A set of criteria for an ideal site was formulated. The committee felt that all the proposed sites met the criteria and differences were minor.

The first Linear Collider Workshop (LCWS) was held at KEK (High Energy Accelerator Research Organization) in November 2004. Working Group 1 was set up to discuss the choice of the initial- and final-stage energies, accelerating gradient, overall machine parameters, conventional facilities, damping-ring designs, positron source, and beam-crossing angle.

Working Group 2 is to consider main linac-system issues, including radio-frequency (RF) power sources, modulators, V-cables, and klystrons; RF power distribution; RF controls on the cavities; cryogenic systems; superconducting magnets; cryomodule engineering; and instrumentation.

Working Group 3 is to consider polarized-electron sources, positron-source system designs, and damping ring designs.

Working Group 4 is to consider collimators, machine protection, final focus, machine detector interface, and beam dumps (i.e., everything downstream of the main linacs).

Working Group 5 on high-gradient cavities is to discuss the accelerating cavities, in particular establishing the baseline performance and going beyond it.

Each working group had one convenor from each region. Convenors were provided with working group speakers, they outlined the group's charge, they coordinated the group discussion, and they gave the group summary. Each Working Group also had a science secretary who got specific tasks. This organization is going to be carried on to the next workshop at Snowmass. Once GDE Central is in place, the organization may change. Three coordinators have been appointed to lead the Working Groups.

Hewett asked how long the ILCSE would last and impact the project. Tigner said that it will be positive. It has no top-down structure from the agencies. It is hoped that the agencies take over by 2007. A good connection is being forged between the committee and the funding agencies.

Langacker asked about the central site and its time schedule. Whitmore replied that Barish has said that he does not want a central site until it is needed.

Montgomery asked if the ad hoc group from the agencies formed by the Particle Physics and Astrophysics Research Council (PPARC) will continue to lead this effort. Tigner responded that there will be a meeting soon to discuss that.

Diebold asked why all the finalists were from the United States. Whitmore replied that North American scientists are more familiar with these processes and organizational

structures. There was no dissent; all three candidates got positive comments from all regions.

Ritz asked how many women candidates were considered. Tigner said that he did not know; he was not involved in that stage of the discussions. One female potential candidate was encouraged, and she refused to be considered.

A break was declared at 10:00 a.m.

Gilman called the meeting back into session at 10:37 a.m. and introduced **Jonathan Bagger** to present the report from the National Academy of Sciences study (EPP2010).

The most recent decadal survey in EPP was in 1998. Since then, there was the discovery of dark matter, the discovery that neutrinos have mass, and the making of precision electroweak measurements. A new survey is needed to lay out the grand questions, find the opportunities, identify tools, articulate connections to other sciences and society at large, foster collaboration, and recommend a realistic implementation plan.

The Committee is charged to

- identify, articulate, and prioritize scientific questions and opportunities and
- recommend a 15-year implementation plan.

The Committee has been trying to work out a strategy to accomplish these tasks. Its emphasis is on ranking science priorities. Several organizations have important roles: National Research Council (NRC), HEPAP, Neutrino Scientific Advisory Group (NuSAG), and P5 (Particle Physics Project Prioritization Panel); they have to communicate.

It is a huge group, representing many fields, and has two chairs. It is not your usual committee. Nonphysicists will play an important role and will strengthen the connection to society and its values. The nonparticle physicists will engage other scientific communities.

The overall goal is to present a compelling vision for our field and to create an action plan. The Committee will have four meetings, two of which have already been held. Subcommittees will visit CERN, Deutsches Elektronen-Synchrotron (DESY), and KEK.

The Washington meeting had physics presentations, agency perspectives, prioritization, and a town meeting. The Stanford Linear Accelerator Center (SLAC) meeting had an introduction to linear colliders and Large Hadron Collider (LHC) physics, flavor physics, astrophysics, and another town meeting (for ideas outside the box). At Fermilab, the meeting will be accelerator-based with an international perspective and will touch on nonaccelerator physics and will have a town meeting. The Cornell meeting will stress connections to astronomy and astrophysics and other topics as necessary and will have a town meeting.

The Committee came together nicely and is asking the right questions. (Outsiders are asking the most obvious questions that we might not want to think to ask (e.g., about the Super Conducting Super Collider and why we need a linear collider). The Committee's leadership is outstanding; Harold Shapiro and Sally Dawson are working together seamlessly.

Community input is essential for this process to work. There is an open forum at every meeting; it is organized by the Department of Particles and Fields (DPF) Executive Committee. E-mail should be sent to epp2010@nas.edu. All communications are public. It is essential for HEPAP to answer some of these questions.

Kim asked if all the information from the nonphysicists can be caught in just four meetings. Bagger replied, yes; they are asking the right questions and addressing the broad sweep.

Ritz asked about the timescale and when HEPAP will be asked these questions. Bagger responded that something will be coming up in the next month or so. He cannot issue a charge to HEPAP, but it is a wonderful opportunity for HEPAP to step forward.

Hewett asked how those questions will be put out. Meyer answered that the APS meeting in April will be a good place to publicize them. Suggestions submitted to the Committee's mailbox would be welcome.

Butler noted that the committee wanted community input, but wondered if HEPAP is representative enough. HEPAP should encourage as broad participation as possible and still be coherent. Langacker commented that only HEPAP and DPF can represent this community, and they should communicate with each other.

Kim asked about the desired input for the agenda at the meetings. Meyer replied that those topics are the prerogative of the Committee. One can send an e-mail to Sally Dawson, co-chair. Bagger noted that most of the outsiders on the Committee are good at sifting through information.

Montgomery asked what role the host facilities played in setting the meeting agendas. Bagger said that they were gracious hosts. Jonathan Dorfan (SLAC) commented that some outreach to the broader scientific community would be helpful.

Kim asked if it were too late to include any international members. Bagger answered that there are already two (Burrows from England and Tajita from Japan).

Ritz asked if there were any nagging issues. Bagger said that the obvious questions are coming up. These are the right questions. Everything is on the table. Ritz went on to ask how HEPAP could help make this a good study. Bagger replied that P5 could have an interface with this process, LHC could contribute, and other things could happen, as well. LHC complementarity is extremely important.

Gilman declared a break for lunch at 11:03 a.m.

Monday, February 14, Afternoon Session

Gilman called the meeting back into session at 1:01 p.m. and introduced **Michael Turner** to present an overview of NSF funding for Mathematics and Physical Sciences (MPS) by telephone linkup.

Since the most recent meeting, the FY 05 budget was enacted with a 3.2% decrease overall for NSF and a 1.7% decrease for research and related activities (R&RA). This was a big surprise; it is only the fourth decrease NSF has seen in 50 years. The Omnibus bill passed quickly, after which numerous public comments decried the decrease.

In the FY 06 request, R&RA was essentially restored to the FY 04 level. NSF has a 2.4% increase overall, which is good: DOE's Office of Science (SC) has a decrease of 3.8%, the Universe Division of the National Aeronautics and Space Administration (NASA) is flat, and the National Institutes of Health (NIH) has a tiny increase.

But one cannot spend request dollars; the story is not over. The new House Appropriations Subcommittee Structure was revamped, with the number of subcommittee chairs reduced from 13 to 10. NSF, NASA, and Office of Science and Technology Policy (OSTP) are being moved to the new Science, State, Justice, and Commerce

Subcommittee (which is generally viewed as good news) chaired by Rep. Frank Wolf (R-Va.).

The goals of NSF's MPS are to ensure that the most compelling science gets done, to ensure it has the capability to respond to new opportunities, and to develop an MPS workforce that reflects the diverse face of the United States. The overall strategies being used to attain these goals include a strong, flexible core (reducing targeted solicitations and decreasing the number of centers as competition permits); facility stewardship [by increasing funding for LHC and Gemini and decreasing it for the Cornell Electron Storage Ring (CESR)]; and broad participation through integration with NSF's research strengths (e.g., LIGO, Partnerships for Research and Education in Materials, Undergraduate Research Centers, Research Experiences for Undergraduates, and the Hampton Physics Frontier Center).

NSF is making significant investments in the Physics of the Universe Initiative; Mathematical Sciences; Nanoscale Science and Engineering (which is being mainstreamed with no more targeted solicitations); Cyberinfrastructure, Cyberscience, and Theory; and Molecular Basis of Life Processes, Sustainability. It is also making investments in facilities with increases for LHC and Gemini, ramping of CESR, construction of the Atacama Large Millimeter Array (ALMA) and IceCube, an appropriation for the new start for Rare Symmetry-Violating Processes Project (RSVP), and putting an Advanced LIGO in the queue for FY 08. It is also looking at investing in future facilities, such as the Giant Segmented Mirror Telescope, the Large Synoptic Survey Telescope, the Underground Laboratory, RSVP, and next-generation X-ray light sources.

The 3.17% decrease had been a 3% increase in the President's request. This year, the NSF to his looking at a 2.42% increase overall. Part of this increase comes from the fact that the NSF will now operate icebreakers for polar research, which was formerly provided by the U.S. Coast Guard. From FY 04 to FY 05, MPS experienced a 1.99% decrease in funding. The smallest decreases occurred in the Division of Astronomical Sciences (AST) and the Division of Physics (PHY) because of their importance. In the current budget request, those divisions are slated for a 1.81% and a 2.31% increase, respectively. Looking at a 10-year funding history produces no surprises. Notable are the facts that physics is the second-highest-funded directorate and that funding for all of the directorates is climbing, including mathematics and astronomy.

In the budgetary outlook, the NSF is almost $3 billion behind its doubling number for FY 06. For the next few years, there will be flat funding or small growth at best. The President and Congress do recognize basic research's and NSF's central roles in supporting the sciences. The budgetary environment is very difficult. There is a huge federal budget deficit of $400 billion. The deficit is approximately equal to all nondefense, discretionary spending. The President's goal is to reduce that deficit to about $200 billion by FY 09. The national priorities are the war on terrorism, homeland security, and the economy. These do not map well to basic research. The country needs to pay attention to China. It is driving up the prices of commodities (oil, steel, nickel, etc.). The United States has a $160 billion trade deficit with China. And China is financing a good deal of the debt of the U.S. Federal Government.

World gross domestic product (GDP) is $50 trillion; the GDP of the United States is $11 trillion. China now has the second-highest GDP at $11 trillion. The U.S. federal

budget is $2.4 trillion; its debt is three-quarters of its GDP. In funding for basic research, NIH has the largest amount, $27 billion.

NSF recognizes the stunning opportunities for breakthroughs in the understanding of the universe and the laws that govern it. These opportunities were articulated well in *The Quantum Universe*. NSF shares stewardship of EPP with DOE and works with DOE to realize the grand opportunities. The program that has been put in place is a strong, broad program that maps well to *The Quantum Universe*. NSF also has bold plans for the future.

It has (1) EPP and Particle Astrophysics/Cosmology Theory Programs; (2) strong experimental EPP that provides support of university groups at Tevatron, LHC, BaBar, MiniBooNE (a detector at the Booster Neutrino Experiment), Main Injector Oscillation Search (MINOS), K2K/Super-K (the Super-Kamiokande on the KEK-to-Kamioka link), and BTeV; and (3) Particle/ Nuclear Astrophysics at the Cryogenic Dark Matter Search (CDMS), Multiple Institution Los Alamos Gamma Ray Observatory (Milagro), High-Energy Cosmic Ray Experiment (HiRes), Auger (Pierre Auger Observatory), Solar Tower Atmospheric Cherenkov Effect Experiment/Very Energetic Radiation Imaging Telescope Array System (STACEE/VERITAS), and the Atacama Telescope. It operates facilities, such as CESR, LHC, IceCube, and LIGO, and other related activities important to particle physics, including the three PFCs (at the Kavli Institute for Theoretical Physics, the Kavli Institute for Cosmological Physics, and Hampton) and experimental tests of gravity.

The first string was installed at IceCube this past January. A hot-water drill made a 2500-m hole, achieving an important milestone.

The future (near-term) investments include the LHC (which addresses the energy frontier), RSVP (which addresses the sensitivity frontier), physics of the universe, and neutrino physics (the new physics frontier).

The Deep Underground Laboratory is to look at dark-matter questions and neutrino-mass issues. A planning grant was awarded for the science community. Site planning grants will be awarded in the near future. In terms of the ILC, NSF is a partner with the university R&D program (with DOE) and sits at the table of the Funding Agency for the Linear Collider (FALC; with DOE). It is looking at muon colliders and neutrino superbeams. Strategic planning activities include *The Quantum Universe*, an important document; the APS Neutrino Study, which has given clear, strategic advice; and EPP2010, which has gotten under way.

Two experiments [the Muon to Electron Conversion Experiment (MECO) and the Kaon Decaying to a Neutral Pion Experiment (KOPIO)] are at the sensitivity frontier to look at very rare processes. RSVP is a joint venture with DOE. It makes parasitic use of the Relativistic Heavy-Ion Collider (RHIC) Complex and its Alternating Gradient Synchrotron (AGS), allowing two experiments to be done with one facility. RSVP was proposed as a Major Research Equipment and Facilities Construction (MREFC) project in 1999. The National Science Board (NSB) approved it for the new-start queue in 2000. Congress appropriated funds for construction in 2004. Baselining activities started between summer 2004 and spring 2005. It is undergoing an NSF cost, schedule, and technical review in spring 2005. Subject to successful baselining, NSB authorization of construction funds is expected during summer 2005. Five years of construction are expected before operations commence in 2011.

However, RSVP hit a bump in the road. Internal reviews have revealed significant increases in the construction cost, operations, and duration of the experiment. The exact costs are not known yet. These increases are largely associated with the parasitic-operation assumption. RHIC will not be operated as much as planned because of funding cutbacks. Advice will be needed on where to go. Good numbers are needed for the RSVP baseline. NSF needs to look at MECO and KOPIO to see how this cutback affects those EPP programs. In spring 2005, NSF will review the cost schedule and technical aspects of the baseline. In summer 2005, with HEPAP advice and the results of the NSF Spring 2005 baseline review, NSF, in consultation with DOE, will make a decision on how to proceed. All options are open: redesign, descope, and termination.

DOE and NSF request that HEPAP appoint a subpanel to provide advice on the science value of the RSVP project in the context of the U.S. and world EPP programs. They would like HEPAP to

- Evaluate the science value of MECO in the context of the U.S. investment in EPP, assuming a sensitivity of 10^{-17}, 10^{-16}, or 10^{-15} can be achieved;
- Evaluate the science value of KOPIO in the context of the U.S. investment in EPP, assuming 10 or 100 events can be observed;
- Place the science value of each in the context of the broad U.S. particle physics program, recognizing the fiscal environment and the impact on other investments at NSF; and then
- Place the science value of each in the broad context of the international EPP program and assess any potential overlap or complementarity with work being planned elsewhere. How has this world-scene changed since 1999, when the RSVP project was proposed?

Littenberg asked whether, as long as RHIC is paying the basic costs for RHIC, if it is not running, you are not getting more for your money. Turner replied that they were trying to understand that relationship. The new view of the AGF is as a driver for RHIC to run at minimal cost to RHIC. Some other issues involve environment, safety, and health (ES&H) that would not be as serious if the AGF were not running full out.

Littenberg suggested that one might be able to finish the program faster at less cost. Turner answered that it is not clear that the accelerator is up to the required intensity. Operating periods are 2 to 4 times longer than originally thought.

Langacker asked if this change in plans happened suddenly. Turner responded that, over the past few years, the Nuclear Physics budget has changed dramatically. This bind came on quickly; stewardship was the main factor. One cannot sit around and kick oneself; one has to figure out how to get out of this hole.

Kim asked if the scientific value of RHIC had been evaluated. Turner replied that there have been several reviews, and a strategic decision was made to end EPP at AGS. Dehmer added that the steward had changed in 1998; the facility went through a dozen evaluations and reviews since then and got high marks, most recently in *The Quantum Universe*. Kim asked why another review was needed. Turner said that the answer had three parts: (1) The two pieces need to be evaluated separately. (2) It is not clear the AGS can achieve the level of operation that was predicated. (3) The world need has changed a little bit. This will be worked through in a rational way. HEPAP will be approached to get the best advice available.

Diebold asked if the AGS was being held hostage. Turner replied, absolutely not. Everyone is under budgetary duress. Staffin commented that there are other items in the Nuclear Physics budget that are greater hostages to the budget. The AGS is being limited, but the situation is similar or worse at other facilities [e.g., the Continuous Electron Beam Accelerator Facility (CEBAF)].

James Whitmore was asked to review funding for Elementary Particle Physics and Particle Astrophysics in the Division of Physics (PHY) of NSF. PHY works closely with AST, the Office of Multidisciplinary Activities, and the new Physics of the Universe Initiative in MPS. PHY treats the areas of Elementary and Particle Physics (EPP) and Particle and Nuclear Astrophysics (PNA) and the subareas of EPP and Cosmology and Astrophysics within the area of Theoretical Physics. Major projects are funded through MREFC.

PHY has partnerships with many other divisions in NSF. NSF shares stewardship of EPP with DOE and works with DOE to realize the grand opportunities. There are spinoffs, such as Particle Astrophysics [with AST/OMA (Office of Multidisciplinary Activities)] and cyberinfrastructure and the cyberscience it enables.

PHY is broadening participation by integrating it with its research strengths [e.g., LIGO, REUs, Hampton PFC, and Florida International University's Center for High-Energy Physics Research, Education, and Outreach (CHEPREO)] and making broader impacts [through Cosmic Ray Observatory Project (CROP), QuarkNet, Astrophysics Science project Integrating Research and Education (ASPIRE), Mixed Apparatus for Radio Investigation of Atmospheric Cosmicray of High Ionization (Mariachi), etc.].

The effective funding for particle physics from FY 02 to FY 05 shows a progression of the total base from $62.20 million, to $71.93 million, to $73.00 million, to $72.05 million. Accelerator-based research with Cornell increased from $42.31 million to $48.06 million during that period. Particle astrophysics increased from $9.05 million to $14.68 million. And EPP-astrophysics theory declined from $10.84 million to $9.31 million because of changes in the bookkeeping methods. EPP-allied funding also occurs at the PFCs and in projects. During this period, the LHC construction was completed, IceCube is ramping up, and RSVP has been projected.

In the NSF FY 06 budget request, NSF has a 2.42% increase from the previous year, R&RA has a 2.68% increase, MPS has a 1.53% increase, PHY has a 2.31% increase, and the EPP base (Theory + Astrophysics + Accelerator-Based + Cornell) has a 1.3% decrease. From FY 00 to FY 06, though, EPP-base funding generally tracks PHY (and R&RA) funding.

In FY 05, PHY experienced a cut in facilities as LHC and the National Superconducting Cyclotron Laboratory (NSCL) increased. The PI base program was maintained at above 50% of the Division's funds. Theory and the Physics of the Universe Initiative also received priority funding.

At the LHC the MREFC funding went to zero when the construction was completed in 2004; at the same time, R&RA funding started increasing rapidly. The LHC is looking at stability and more predictable timing in its research funding. The reviews (with DOE-HEP) of the FY 07-09 guidance are under way this year.

Funding supported by NSF's Computer and Information Science and Engineering (CISE) (along with PHY) includes that for the Grid Physics Network (GriPhyN), International Virtual Data Grid Laboratory (iVDGL), UltraLight, Information

Technology Research (ITR) for Grid activities, OSG-LCG-EGEE [Open Science Grid, LHC Computing Grid, and Enabling Grids for E-Science in Europe] cooperation, and OSG, itself. Some of these awards will be expiring.

The RSVP is an NSF-supported, university-led, particle-physics project that uses accelerator facilities developed by DOE. It includes two experiments: The aim of KOPIO is to measure a rare decay of the neutral kaon that would be a major advance in the study of charge-parity violation and the matter-antimatter asymmetry in the universe. MECO is a search for the forbidden conversion of muons to electrons in an effort to discover new physics beyond the standard model up to 3000 TeV.

RSVP received $6 million for advanced planning in FY 04. MREFC funding began in FY 05 and should peak in FY 07 before declining to zero in FY 11. The RSVP project leadership has been established, and major reviews of components have been performed. The issues that remain are a HEPAP subpanel review of the science, a full baseline review this spring, and the status of AGS/RHIC.

CESR has been a very productive, self-managed laboratory that has studied baryon and now charm physics. It is now in a phased closedown for EPP with CLEO-c (where NSF supports seven groups); from FY 03 to FY 06, CLEO-c's funding has dropped from $19.49 million to $14.71 million. CESR's CHESS (Cornell High-Energy Synchrotron Source) supports 600 to 700 users. It has an award for an energy-recovery linac starting in FY 05.

Other EPP activities that are supported at Tevatron experiments include ten groups at the D0 detector and four groups at the Collider Detector at Fermilab (CDF); at neutrino projects include three groups at MiniBooNE, two at MINOS, and two at K2K and Super-K; at BaBar, two groups; at BTeV, three R&D groups. The Advanced Peer-to-Peer Internetworking (APPI) program has been delayed, but a small amount of funding (about $0.3 million) has been provided to the University Linear Collider Accelerator and Detector R&D (NSF is working closely with DOE in reviewing both areas) and other accelerator projects.

In partnership with AST, OMA, and DOE-HEP, PHY is supporting several particle astrophysics projects: Auger (construction end in 2006?), HiRes (data taking until March 2006), VERITAS (started support in FY 04), CDMS and other dark-matter projects, Milagro and STACEE, Deep Underground Science and Engineering Laboratory (DUSEL), Advanced Compton Telescope (ACT, for which support started in FY 05), and the Physics of the Universe Initiative (+$2 million in FY 05 from MPS). This activity reflects an increase in funding from $1.69 million in FY 00 to $14.68 million in FY 05.

Particle and Astrophysics Theory saw an increase of about 1% this year. However, few new initiatives have been initiated. The new Lattice Quantum Chromodynamics Initiative will begin in October 2005.

A study of the Underground Science Laboratory was published by the National Academy of Sciences (NAS) Board on Physics and Astronomy in December of 2002. As a result, MPS/PHY is taking the lead for NSF, in partnership with the directorates of Geosciences and Engineering, in working to implement a sequence of steps that might lead to the creation of such a laboratory. Three solicitations have been issued or planned:

- One was to establish the site-independent scientific and engineering benchmarks against which the capabilities of the candidate sites for an underground laboratory will be measured (awarded Feb. 28, 2005).

- One invites proposals to support the development of the conceptual design for the infrastructure and an initial suite of experiments for a DUSEL (closed February 28, 2005).
- One is planned through which detailed technical designs will be developed for the most promising combinations of site and conceptual design resulting from prior solicitations (expected award in FY 06).

In summary, PHY is working with many partnerships to bring added value to EPP projects and is entering a new phase of operations with facilities (some with DOE).

Montgomery asked if there was a sense of scale for the third solicitation for DUSEL. Whitmore replied, no.

Hewett asked if funding for the LHC was sufficient. Whitmore responded that these numbers were scrubbed hard. The experimentalists feel they can work with these numbers. Hewett pressed him about the prospects for growing funding for university LHC groups. Whitmore replied that PHY has not been able to ramp that program up; it would like to make larger grants, but there is competition for the available funds.

Meyers asked when it would be decided whether the larger or smaller underground laboratory is the best choice for the science. Dehmer replied that it will be in the work scope, in each of the sites that submit conceptual plans, and in the perceived scientific needs. The need for an underground laboratory is appreciated by everyone involved, but it comes with a high price.

Montgomery inquired about how NuSAG will fill out the path ahead. Dehmer responded that the need has to come before the laboratory.

Ferbel asked whether there had been any discussion about the NSF getting into the LARP (LHC Accelerator Research Program) or accelerators. Whitmore answered that ramping up the LHC is a big lift for NSF. However, universities and NSF should certainly be involved in accelerator R&D and design. Dehmer added that NSF is carving that funding out of its base, and it is up to $2 million now. NSF is putting in a small amount and guaranteeing that it will not go down.

Peggs asked about NSF funding for the LHC. Whitmore responded that no money had been put into that. Peggs stated that providing accelerator R&D funding to universities makes sense for the short and long runs. Dehmer commented that NSF understands the need for research in accelerators, detectors, and other machines. It will fund that research as aggressively as possible but is limited economically.

A break was declared at 2:28 p.m.

Gilman called the Panel back into session at 2:44 p.m., asking **Robin Staffin** to review DOE's Presidential budget request for FY 06.

Like NSF, DOE is also off its doubling curve. In the Office of Science (SC), the FY 06 budget request is 3.9% below the FY 05 appropriation. Approximately $70 million in congressional directives is traditionally put into the Office of Biological and Environmental Research (OBER) budget. FY 06 will see no new construction or fabrication starts. The associate directors (ADs) had to look at what would have to be protected and what would not. They needed to protect the investments they had made by selecting and prioritizing with the advice of their advisory committees. As a result,

Basic Energy Sciences (BES) is up 3.7% from the FY 05 appropriations,

Advanced Scientific Computing Research (ASCR) is down 10.%,

Biological and Environmental Research (BER) is down 21.7%,

HEP is down 3.1%,
Nuclear Physics (NP; RHIC and CEBAF) is down 8.4%,
Fusion Energy Sciences [FES, which includes the International Thermonuclear Experimental Reactor (ITER)] is up 6.1%, and
Other is up 3.1%.

The ADs tried to estimate how much "research" was affected; and in those terms, HEPAP was least affected.

For the first time, the out-year profile for SC is also in the budget; it is flat for several years and then declines.

The priorities chosen for FY 06 are

- Tevatron and the B-Factory will be fully supported,
- LHC will be fully supported,
- Core research at universities and laboratories will be maintained,
- Investment for near-term and long-term new initiatives will be increased, and
- Investment for any new initiative will have to come from redirection.

There is no new money.

The HEP FY 06 budget request calls for a decrease of 3.0% for the Tevatron, Neutrinos at the Main Injector (NuMI) is new and is up and running, the B-Factory is now down because of an accident last October, and LHC construction is down and its operations are up. In terms of infrastructure, NuMI, Run IIb upgrade, and the Gamma Ray Large Area Space Telescope (GLAST) are down 88.8%, and the planned BTeV Model Institutions for Excellence (MIE) is off $7 million. Core research is unchanged: accelerator R&D decreased 2.4% ($1 million), detector R&D decreased 7.1%, BTeV R&D was zeroed out ($4 million less), the Linear Collider increased 8.7% ($2 million; the field has said that this is its highest priority), SNAP R&D is unchanged at $3 million, and neutrino R&D was initiated at $10 million per year (*The Neutrino Matrix* is a compelling document with briefings for all major players). HEP wants to see R&D move forward in a coordinated manner. The grand total is 3.1% less in FY 06 ($23 million) than in FY 05.

GLAST points out the nontrivial nature of joint-agency projects where cultures and fiscal flexibilities are different. There has been one rebaselining. There is now a rather substantial cost increase and schedule delay. One needs to understand the risks involved. DOE failed to understand what portion of its budget was committed. The GLAST increase endangered the B-Factory and other major projects. GLAST is an important joint project. The science is very important and exciting. SAGENAP pointed out in 1998 that the GLAST mission is "further removed" from HEP and worried about the possibility of cost overruns and the effects on other HEP projects. It recommended establishing a funding cap. In NASA, one deals with overruns and moves on. In DOE, there are moral and ethical consequences that must be faced. The Administration has acted to limit DOE's exposure to future cost growth. Lessons learned from the GLAST experience include:

- Ensure that the scale of the contribution expected from DOE-HEP matches the importance of the science to HEP's core mission.
- Listen carefully to the advisory committees and follow up on their recommendations.

- Understand the cost impact of building detectors that can tolerate a force of 10g and a temperature variation of more than 150° and that will have 100% reliability under extreme conditions.
- Clearly define responsibilities for interagency ventures, especially when project rules, performance measures, and culture are very different.
- Be upfront in planning manpower resources.

The Department has decided not to proceed with the BTeV experiment at Fermilab, partly on the basis of recommendations from the P5 Subpanel of HEPAP, but driven by the President's budget request; expectations of funding in the out-years; and the need to support other, ongoing programs. The Office did not see how to maintain this effort in its budget, given other funding requirements. BTeV is an excellent science experiment. We thank and commend the members of the BTeV collaboration and Fermilab for their hard work, which was excellent. However, as P5 noted, the experiment needs to be completed rapidly in order to compete in physics results with the LHC beauty experiment LHCb: "the staging scenario stretches the BTeV schedule as far as we can support. If various constraints, budget or technical, would result in a completion date beyond the end of FY 2010, we would not support a start of the project." This urgency was recognized by the BTeV collaboration, the Laboratory, and DOE, and the approval process was conducted with that urgency in mind. It is now clear, unfortunately, that it was not possible for the experiment to be completed on the schedule stated by P5 as being the latest tolerable. Given this outcome, DOE has decided not to start the project. If the project proceeded, BTeV would not be able to compete as effectively as it was designed to.

What is next for Fermilab? The future of Fermilab past the end of the decade will be the subject of a continuing dialogue between the Administration, Congress, the laboratory, and the broader U.S. and international particle physics communities. This is not a base-closing exercise. Fermilab is the premier particle-based physics laboratory. DOE now looks forward to working with Fermilab management to develop the strongest possible future for the laboratory as well as for the overall HEP program. The Laboratory's Long Range Plan has laid out a broad and exciting program for the next decade, centered on the ILC, significant new initiatives in neutrino physics, the LHC physics center, and particle astrophysics and underground experiments. DOE wishes to see high-energy physics in Fermilab's research agenda.

To inform the Department of HEP's intent to pursue several new scientific initiatives, draft requests will be prepared for approval of a Statement of Mission Need (CD-0), for

- A generic reactor-based neutrino experiment to measure θ_{13},
- A generic off-axis accelerator-based neutrino experiment for θ_{13} and to resolve the neutrino mass hierarchy,
- A generic high-intensity neutrino-beam facility for neutrino charge-parity-violation experiments,
- A generic neutrinoless double-beta decay experiment to probe the Majorana nature of neutrinos,
- A generic underground experiment to search for direct evidence of dark matter, and
- A generic ground-based dark-energy experiment.

To be ready to move forward expeditiously, this process will be conducted in parallel with a Scientific Advisory Group (SAG) and P5 process described during the following day's discussions.

Kim asked if the future of Fermilab is consistent with the $2 million increase in Linear Collider R&D. Staffin replied, yes, it is consistent. With the selection of an LC technology, it is a new ballgame, and the community is reorganizing and needs leadership. The community has said that the Linear Collider is its highest priority.

Michael Harrison asked if both a neutrino program and the LC could be done. Staffin said that he could see both being done.

Cahn asked to go back to the slide of the SC out-year profile. Staffin noted that the error bars increased significantly after FY 06.

Ritz asked what HEPAP could do to order and plan long-range programs. Staffin replied that, in reincarnating P5 for the roadmap exercise, something closer to priorities than to a laundry list was hewed to. An important part of the advisory process would be to have the advisors operate within a budget context. A recent meeting with EPP's Howard Shapiro revealed that Shapiro is excited about the future of this field. That group is very broad in interests and can make a case for staking resources on this field.

James Strait asked if the strictures had to apply to construction. Staffin replied that, unless someone makes a gift, the laws of arithmetic apply to construction, also. HEP has several facilities at Fermilab and one at SLAC. The ends of these experiments will come someday.

Butler believed that it would be beneficial to think in terms of reality-based schedules for the Linear Collider. Staffin replied that the FALC group called for a decision on construction in 2011. We are going through some difficult budget times and hope the pendulum will swing back the other way. I can't give you a clear sense of when it will occur but recognize that the local derivative makes it look like 2011 is too soon.

Staffin turned the floor over to **Michael Witherell** to summarize the status of Fermilab. In terms of science, things have been going well. Run II is going well, and the first neutrinos have been delivered to the MINOS detector on schedule. MiniBooNE is operating well, the LHC Physics Center has been set up, and the astrophysics projects and their project reviews are going well. In terms of funding, things are not going well. Workers and funding are not increasing in science. An annual 4% increase is needed to maintain effort. However, HEP funding has been declining since 2000. Line-item construction and major items of equipment have declined to almost nothing.

BTeV was as good a value for the dollar as anything in SC. It just had a very good baseline review. It was cancelled because the United States could not afford a single project in the years to come. Fermilab has a solid operating program. What facilities are developed 5 to 10 years from now are those that will be needed 10 to 50 years from now. The balance of the present, near-term, and long-term projects must be considered. Fermilab has the Tevatron, B Factory, and neutrino programs and a program in astrophysics. In the near term, it should have some world-class experiments. And projects should be prepared for the longer term. Of those, the ILC is the most important.

In 2009, the Fermilab neutrino program will be the only accelerator project funded by DOE. In 2010, the field will have NuMI-MINOS, MECO, and KOPIO. An accelerator program is critical if the United States is to stay at the forefront of the field.

Neutrinos and BTeV were the right program, and we should be working toward the Linear Collider. What is in the FY 06 budget is not enough to develop either of these properly. The scientific opportunities are there, but they are not being pursued. The Fermilab Long-Range Plan is a good starting point. A roadmap will be put forward for neutrino study and an accelerated plan for more protons. ILC R&D will also be built up. Fermilab must have a more central role in HEP. Strategic decisions have been made in the past. Fermilab must be identified as the home of accelerators for particle-physics research, and the community must support Fermilab as the U.S. center for particle physics. Some value must be given to having an accelerator-operating laboratory. The United States should have one of the three leading laboratories in the world for operating high-energy-physics accelerators.

Glen Crawford was asked to review the DOE HEP budget for FY 05-06.

The House passed the FY 05 Energy and Water bill in late June, which was up $16 million for HEP over the Presidential Budget Request. The Senate never passed a FY 05 Energy and Water bill. In October of 2004, there was a serious electrical accident at SLAC. The Government operated on continuing resolutions through December 2004. Congress passed an omnibus budget bill in December that increased the HEP budget $5 million over the President's request. There was a $5 million transfer from the Science Laboratory Infrastructure (SLI) account to SLAC research (in language, not in the budget tables) and also a $6 million rescission. The net effect for HEP was a decrease of $1 million from the Presidential Budget Request. Subsequently, the House Energy and Water Development Subcommittee staff clarified the Omnibus report language. The FY 06 SLI budget submission recognizes a possible request from DOE to reprogram from SLI to HEP in FY 05 after SLAC restarts B-Factory operations, and it holds aside $5 million for this purpose.

The Congressional budget has gone up over the years, but it has always ended up less than what was in the Presidential Budget Request. In FY 05, HEP ended up with

Proton accelerator-based physics	+4.8%
Electron accelerator-based physics	- 0.1%
Non-accelerator-based physics	-0.1%
Theoretical physics	-0.1%
Advanced technology	-2.2%

This is a tight budget year (+ 0.4% growth). Workforce reductions are expected (an estimated 150 full-time equivalents across the program). There is successful completion of

- NuMI/MINOS; the first events have already seen in the near detector.
- Run IIb detectors will be completed in FY 05.
- GLAST has a planned rebaselining, but the DOE contribution will be completed in FY 05.
- U.S. LHC accelerator project will be completed in FY 05.

Unfortunately, these completions do not free up nearly enough resources in the out years (FY 06+) if budgets stay flat. The total FY 05 funding for NuMI, Run IIb, and GLAST is about $14 million. Based on experience, the annual average cost growth in the HEP program is $20 to 25 million plus directed increases for infrastructure maintenance.

The HEP FY 05 plan is to operate HEP facilities (Tevatron, NuMI, and the B-Factory) as much as possible given technical constraints. The Tevatron and NuMI FY 05

running is "optimal." Under the current budget allocation (without SLI reprogramming), the B-Factory run is going to be about 4 months. Once the SLAC safety restart plan is agreed to, HEP will consider a reprogramming request to extend the run by 3 months (7 total). Ramp-up preparations are being made for the LHC startup. Modest growth in LC R&D ($20 million to $23 million) is expected. Commitments to existing projects will be completed. HEP will begin to develop a future program that is scientifically compelling and that can be afforded.

On the HEP Program Assessment Rating Tool (PART) scorecard, the Office of Management and Budget (OMB) scored all the programs. The HEP overall rating was moderately effective. It recommended three follow-up actions, and two and a half of those have been completed. HEPAP should draw up a roadmap of research milestones. The three major projects had excellent progress toward their goals.

For FY 06, HEP's funding continues the decline it has experienced since 1997. The DOE HEP budget is $713.9 million for FY 06, which is down $22.5 million (3.1%) from FY 05. The impact of the decrease is offset by additional funding (through BES) to pay for SLAC linac operations. This is not a transfer of funds from HEP, rather a transfer of responsibility; BES's role at SLAC is increasing as the LCLS ramps up. Still, even if one includes BES funding for the SLAC linac, the HEP budget is flat, and most program costs (people, power, etc.) are increasing. Therefore, decisions must be made on priorities.

In total, HEP is down approximately 3% for FY 06, but that is better than many SC offices, such as OBER (which is experiencing a decrease of 21.7%) and the Office of Advanced Scientific Computing (which is experiencing a decrease of 10.9%). For FY 06, HEP is seeing

Proton accelerator-based physics	-3.5%
Electron accelerator-based physics	- 7.7%
Non-accelerator-based physics	-17.8%
Theoretical physics	+0.2%
Advanced technology	+12.3%

Assuming that the current HEP facility operations are maintained as long as they are producing cutting-edge, compelling science and providing significantly improved results; that the existing commitments (e.g., LHC) are met; that the highest future priorities (LC, dark energy, and neutrinos) are pursued; and that budgets continue to be flat-flat, then the HEP budget axioms that can be derived from current realities are

- No significant new activities can be started; therefore, BTeV cannot move forward.
- B-Factory operations have to end by 2008 at the latest; this is explicitly stated in the FY 06 President's Budget Request. If the future is to arrive sooner, the current operating program and commitments will need to be balanced with investments for the future. The FY 07 budget planning process begins next month, with real 5-year budget projections (something that has never been done in SC). Those projections will have to reflect recent history; the future does not look bright.

Other highlights of the FY 06 budget request are

- LC R&D increases (to $25M) to support the international effort and a continued leadership role for the United States. A revised R&D plan and a management structure are needed in the wake of the International Technology

Dragt asked what kind of contingency work was being laid. Crawford answered that there is a lot of work being done. In the fusion community, their budget is going up with participation in ITER. It is hoped that something similar will happen with the ILC.

Gilman declared a short break at 4:30 p.m. The meeting was called back into session at 4:40 p.m. Gilman opened the floor to discussion. **Joel Butler** rose to speak on behalf of the BTeV collaboration and project team:

BTeV engaged the efforts of 175 physicists from 28 universities and 3 national laboratories in seven countries. The loss of BTeV produces multiple impacts: the loss of science; the process for advancing scientific projects in the DOE is broken; the effect on Fermilab, US HEP, and our international partners; and the "outsourcing" of HEP.

BTeV would have studied CP violation and rare decays of particles containing bottom and charm quarks. The goal was to look for new sources of CP violation that would explain why the amount of matter in our universe is so much larger than predicted by the Standard Model. The study of these new sources would have complemented the direct observation of them at the LHC at CERN and helped determine the properties of new physics seen there. BTeV would have had the ability to record a wider range of different types of B decays, especially those of the B_s meson, than any other experiment and would have studied decays that contained photons, which are some of the key ones for finding new physics. BTeV had unique capabilities on many key states. Even where two experiments do cover the same territory, the presence of each of them is still crucial to the successful accomplishment of a scientific program. Attacking the same problem with different techniques, and different sources of systematic uncertainty, helps eliminate errors.

The last major project to be approved to operate at a domestic accelerator laboratory in HEP was NUMI/MINOS, but two-thirds of that project was cancelled.

P5 endorsed BTeV. BTeV was also included in the DOE Facilities 20-year plan that Ray Orbach put together. In early 2004, BTeV was included in the President's FY 05 budget. In February of 2004, BTeV received CD0 from Ray Orbach and latter in the fall received a "conditional CD1 (pending resolution of a technical problem with an OECM [Office of Engineering and Construction Management] review of a document)." In December of 2004, BTeV had a CD2/CD3a review that it passed with very high marks and was recommended for baselining and start of limited construction.

The BTeV project used the DOE management structure, understood and complied with the 413.3 order, worked within the Integrated Project Team structure, and has been able to meet the requirements to be a DOE project with success. Yet, it was cancelled. Now, HEP effectively has no major accelerator-based construction projects at a domestic facility.

The first news that the project was cancelled was the announcement by Secretary Bodman on Feb 7. HEP had never requested information from us about the possibility of dealing with funding profiles other than the one provided to us by Fermilab. The shortfall with respect to their expectations for FY 06 was about $8M. BTeV could have executed a new round of value engineering and de-scoping to match the new situation. The BTeV team had also obtained $9.5 million of forward funding from university groups and significant funding from the Istituto Nazionale di Fisica Nucleare (INFN) in Italy. We are confident that we could have maintained the schedule with little slippage had we been given the opportunity. We feel we should have been asked to respond to a range of

budget scenarios. The cancellation of BTeV just as construction was to start resulted in a massive waste of effort and money in a time when both are in short supply.

The HEPAP convened P5 to "prioritize" medium-cost projects with the hope that the ones that survived would be funded. BTeV received positive recommendations from every advisory committee and inclusion in the Office of Science 20-Year Facilities Plan. What, then, does the advisory process mean?

Without a new project, many of Fermilab's best people, who thrive in an environment with technical challenges, will probably leave. Without BTeV, the Tevatron will be turned off in 2009. Our field and future scientific discoveries are being "outsourced." We keep hearing how important Fermilab is to the future of U.S. HEP, but the budget never seems to reflect this importance. It is imperative to strengthen Fermilab and provide it with a future program that is reasonably certain to be supported and makes scientific sense.

The effect on our International Collaborators has been devastating. Our four Italian groups had obtained INFN funding, but now their careers have been negatively affected. We doubt that they will work in the United States again. Our Russian and Chinese collaborators have experienced similar effects. The Russian group has expressed the opinion that it will have a serious negative effect on promoting any future international collaborative effort with the United States.

Basic science is always aggressively pushing technology and demanding more of industry. By working with industry, it helps propel new ideas and products. If we outsource HEP and other basic research, it is likely that our best people will instead work with the best companies in Europe and Asia to help them get a head start on technological innovations. Much of our prosperity since the end of World War II has come from progress in the physical sciences. Innovations in many fields are made possible by using techniques developed in physics. Yet, it is very difficult to attract young people to study and pursue careers in the physical sciences because these are difficult disciplines and not as financially rewarding as other endeavors. "Big ideas" and "big devices" are "first attractors" that fascinate and excite young students. Science as a whole benefits from such programs and facilities. We cannot as a nation afford to lose our "first attractors" or to outsource them to Europe and Asia.

Meyers observed that one has to argue that something went wrong. The question arises whether realistic assumptions are being used in the guidance. Both optimistic and pessimistic scenarios are presented, but reality is always lower than the pessimistic scenarios.

Kroll asked if the research community should rely on DOE to make those decisions or whether the researchers should make those decisions for themselves.

Cahn noted that the budgets are dropping dramatically when one takes into consideration inflation. If one is not optimistic in budget discussions, one is ceding ground. There is a tension between expectations and funding. This tension has to be dealt with, and recognizing the problem is an important starting point.

Matthews asked if there was any way this situation could be reversed. Staffin replied that this is the President's request, and HEP cannot change it. The budget request is a product of the Administration and cannot be talked about; it is not a collaborative project; it is based on the Constitution.

Recommendation Panel (ITRP) decision. FY 06 will be the first year under this new plan.

- In order to provide for a diverse future scientific program, R&D focused on neutrino physics will increase; $4 million will be dedicated in FY 06 plus redirections from within the program.

The information-technology (IT) investment in Lattice QCD (LQCD) will follow on from the QCDOC (QCD on a chip) prototype. This is a joint project of HEP and NP, managed by Brookhaven National Laboratory (BNL), Fermi National Accelerator Laboratory (FNAL), and Thomas Jefferson National Accelerator Facility (TJNAF). About 20 teraflops of dedicated computing resources are expected for the U.S. LQCD community by 2009.

- R&D for SNAP/JDEM (SuperNova Acceleration Probe/Joint Dark-Energy Mission) continues, but funding and the timeline for a space-based dark-energy mission are yet to be determined.

In summary, the FY 05 HEP budget is tight but HEP will operate Tevatron, NuMI and the B-Factory at near "optimal" levels; continue to ramp up preparations for LHC physics; complete commitments to existing projects; and jump start R&D for the future. The FY 06 HEP budget is much the same. Under it, HEP will maintain facility operations and the LHC at needed levels, ramp up LC R&D slowly, operate research and generic R&D programs at flat levels, not start BTeV, and start a program focused on R&D for neutrino physics. The out-years will not get easier. Hard choices will be faced:

- How much longer to operate existing facilities;
- The right balance of research, generic R&D, and new facilities; and
- Which new facilities to support.

HEP is starting to put together processes to address these issues.

Harrison asked where the 5-year projections will come from. Crawford said that HEP will get guidance from OMB and the Director of SC. The primary guidance will come from OMB. The projection process will likely go through multiple iterations. Harrison followed up, asking if there is an implicit guarantee that money will show up. Crawford replied, no.

Hewett noted that, at the EPP planning meeting, the plan for BaBar went beyond 2008 in doubling data and asked how the 2008 end of the program affected this. Dorfan replied that, at some point, the doubling time increases. A doubling in 2005 is projected.

Kim asked what the research included. Crawford answered: university and national laboratory groups and groups working on BaBar, CESR, etc. If one adds up all the research areas, the budget is flat.

Bortoletto noted that this year there was a big cut to universities of 5%, even when there was no change from FY 04 to FY 05 and asked what will happen in FY 06 when there is a 3% decrease. Crawford replied that the groups got a 5% cut at the beginning of the year and that money flowed back during the year (but not to the same recipients). He expected cuts to be made in FY 06, also.

Kim asked what he meant by the highest priorities. Crawford replied that certain projects are going to be ramped up, but this is the best that could be done with what was available.

Montgomery pointed out that, if one tried to put together a plan like what has been offered here, one has to recognize that it will go to zero.

Peggs stated that more transparency with foreign colleagues is needed.

Siegrist noted that there are certain priorities in the President's request, and one should think how to make HEP one of those priorities.

Butler said that the issue of duplication should be addressed. It was in Bodman's talk and in Orbach's publication in *Science*. Scientists are not duplicating others' work; they overlap in areas, but are not covering the same territory. Witherall agreed that there are overlaps in many areas, so this argument should be addressed.

Langacker was alarmed by the implications for the process and disturbed that so much effort and collaboration could be wasted. He believed that the system is broken. The underlying problem is beyond HEPAP.

Montgomery said that, about a year ago, HEPAP and others had tried to assess performance assessments and their effects on international competition and pointed out how they put the United States at a competitive disadvantage.

Ritz commented that, if one plans for a decreasing budget, that is what one will get. One should point out opportunities and the risks associated with those opportunities. It is important for the community to express to the general public what the loss of BTeV means. Butler said that one could do that but could also think more generally. A tremendous number of people were drawn into science because of the large space and science projects. That will not be the case if the loss of HEP continues. CERN promotes its capabilities and promises across Europe. People have to be attracted into science.

Staffin commented that it was not an easy decision, but that is what the numbers were seen to mean. It is important that those on the outside see the real impacts in terms of delivered science. The Secretary said in Congressional testimony the previous week that the nation will lose because the good people go where the facilities are. The Secretary takes it quite personally about the effects on the program and on the people.

Womersley said that there has to be some narrowing of the field of good ideas. As the good ideas move up through the process, the community has to provide more and more support. Other fields of science do better in providing that support than HEP does.

Cahn noted that duplication has served science well in BaBar and BELLE, and in supernova cosmology there would be little belief that the universe is expanding at an increasing rate if there were not duplication and verification.

Ritz asserted that the HEP community needs to develop a way to make the public aware of the impacts of this decision and to highlight the fact that there is not going to be any accelerator-based research for a long time.

Butler said that he believed that the term "outsourcing" is relevant. It is important to note that every important experiment will be carried out in multiple countries. The DOE process is very demanding. We are further along than many others in detectors. DOE is always going to be at a disadvantage because it always has a year of float. Staffin commented that one could not take a 5-year plan with one month of float seriously. HEP also needs to figure out how to talk about a budget that does not exist yet. Butler stated that the BTeV community would have liked to have had the ability to respond to a more austere budget than the one this budget was baselined on.

Dragt asked if the community should try to get an op-ed piece in the *Post* or *Times* about HEP. Gilman said that the case will be much better made by EPP2010.

Siegrist said that his work had been outsourced in 1993 and stated that HEPAP should discuss what the out-year budgets should be.

Gilman adjourned the meeting for the day at 5:50 p.m.

Tuesday, February 15, Morning Session

Chairman Gilman called the meeting to order at 8:30 a.m. and introduced **Raymond Orbach** to put the HEP into the context of the President's request and the FY 06 budget for the Office of Science.

Everyone is aware of the intellectual contributions of science to our society and the state of scientific literacy in this country. Of all the branches of the Office of Science (SC), HEP has the most exciting story to tell, asking questions about the creation; there are surprises out there. Little is known of the makeup of the universe. HEP has the capacity to find that out and to get the word out.

SC supports 42% of all federal science research in the physical sciences. It directly supports the research of about 23,500 Ph.D.s, post docs, and graduate students. Its specialty is large scientific facilities. It takes the advice of its advisory committees like P5 very seriously. This year, the Linac Coherent Light Source (LCLS) begins construction; it will be a wonderful legacy to the world. It will be ten billion times brighter, in the hard x-ray range, than any other light source in the world with a pulse range in the attosecond range.

The Secretary of Energy presented a series of priorities a year and a half ago. But science does change. The opportunities lie in this list of priorities. The Linear Collider is the highest priority for a future major facility.

This is a difficult budget year, and the situation will remain so for the next 3 to 4 years. FY 06 funding is 1.6% below that in FY 05, but is still a vote of confidence in science by the President. SC will do what will keep American science at the forefront. In constant dollars, SC's President's Request for FY 06 is actually more than it was for FY 05. The budget is down only after one takes away Congressional directives.

In the Office of Basic Energy Sciences (BES), the Spallation Neutron Source (SNS) is coming online, four nanoscience centers are opening, the construction of the LCLS is starting, and the leadership-class computer is being assembled. As a result, BES's budget request is up 3.7% from the FY 05 appropriation.

Another office experiencing increases is the Office of Fusion Energy Sciences (FES), which has an increase of 6.1% despite a decrease of 10% in core research. This increase results from the United States' participation in ITER.

These increases are tempered by decreases in the HEP budget request (of 3.1%) and that of Office of Biological and Environmental Research (OBER; 21.7%). The increases reflect opportunities (i.e., ITER) to make significant contributions to the nation's future. Core research, however, is down 8 to 10% across the board (except in HEP, which is unchanged) because of the need to provide world-class facilities. Looking at recent appropriations and this year's budget request, one sees that facility operations are roughly fixed from year to year. The research budget is up for grabs from year to year through solicitations and peer review. The support for the national laboratories is roughly equal to that for universities. A decrease between FY 04 and FY 06 in the percentage of the

budget that goes for research is the cost for keeping the U.S. facilities at the forefront of world research. American primacy is the bottom line of the SC budget.

The President's FY 2006 budget will propel the United States into leadership in

- Fusion: the ITER (whose fabrication begins this year) will demonstrate the scientific and technological feasibility of creating and controlling a sustained burning plasma to generate energy.
- X-Ray Free Electron Laser: construction of the LCLS will start at SLAC, ushering in the field of ultrafast science
- Nuclear Physics: the use of the unique capabilities of the CEBAF at Jefferson Laboratory and the RHIC at Brookhaven National Laboratory (BNL) for studies of the internal quark-gluon structure of nucleons and the properties of hot, dense nuclear matter will continue.
- Climate Change: investments will be made in the scientific infrastructure to develop, test, and run the predictive models used in the international assessments of climate change. In addition, the study of the global carbon cycle and basic research for biological sequestration of carbon in the biosphere will be continued.
- Genomics: Genome to Life (GTL) will accelerate research underpinning the Department's ability to develop microbe-based biotechnology solutions for clean energy, carbon sequestration, and environmental remediation.

Kim asked why the HEP profile has declined each year. Orbach replied that it is up to the HEP community to explain the excitement of your field. BTeV had to be cut; $41M would have to have been cut out of the rest of the HEP budget to meet the schedule set by the P5 Subpanel. Also, a decision was made on the Linear Collider. There is a unified approach now, but the cost is too high. Can it be brought down by redesigning the facility? Figures from DESY for the TeV-Energy Superconducting Linear Accelerator (TESLA) are 3 to 4 times more than expected. A construction date of 2010 will be made with a tight budget, site, and funding profile. It is a gamble. Some programs have been stopped, and we are going for the golden ring: support for Linear Collider research will continue to be increased.

Dragt asked what TESLA's estimated cost is. Orbach answered that it was 3.1 billion Euros, but no contingency and no inflation was included. Daniel Lehman said the Linear Collider would cost $12 billion. That was stunning; it had been costed it at $3.5 billion. A baseline is needed, and it needs to be stuck to. If it remains at $12 billion, it cannot be built. If it can be done for $6 billion (with half coming from abroad), the United States can probably do it. FALC is meeting March 3 to set a real picture.

Butler stated that the reality for accelerator physics is a termination date for the Tevatron and for BTeV. More people are turning to Europe and Japan to do their work. He asked Orbach how he reconciled his optimism with this hard reality seen on the ground. Orbach responded that some very hard choices had to be made. The LHC will turn on luminosity at an intensity of 10^{33}. They are getting 10^{32} at the Tevatron now, and it can be upgraded. Such an upgrade should not be ruled out now, although the silicon detectors are not being funded. Butler pointed out that many scientists at Tevatron have exit strategies to work at the LHC. Orbach said that he would do the same thing. There is uncertainty, but not a gap. There is an optimism for the LHC, and he wanted to see the same for the Linear Collider.

Langacker was disturbed by the 8.1% research cut in physical sciences and asked if Orbach saw this continuing in the future. Orbach replied that a difficult 4-year budget outlook lies ahead. The deficit has to be cut. The FY 06 budget is not set yet. The President has made cuts across the budget in the FY 07 budget projections. The average cuts for the overall Federal Government are all we know.

Hewett asked how to raise the level of excitement. Orbach said that Staffin would put some proposals before this Panel to do just that.

Matthews asked Orbach how he reconciled the cuts with the high costs of RHIC and CEBAF. Orbach answered that it is a matter of the science that is produced. Unfortunately, the costs of detector development had to be balanced by cuts in operating hours. This will be a recurring issue: How does one support current research and still have a future? We need to always try to do the very best science.

Ferbel asked what students will think when they see the cuts in research funding. Orbach responded that these are not the final numbers, even for FY 05. The FY 05 budget is appropriated, yet unallocated.

Montgomery asked what Tevatron's outlook is. Orbach said that Tevatron is the most important machine, and Fermilab is the premier HEP laboratory. SC will continue to support Fermilab in that regard. Fermilab is a natural location for the Linear Collider.

Gilman asked **Robin Staffin** to tell the panel about charges coming to it.

During the previous day's presentations, Staffin had made a point about listening to advisory committees. Orbach had framed the challenges very well. Now it was time to think about how to frame the questions, and there are a lot of questions. When the new world has been made at the LHC, the Tevatron, and the B-Factory, it is hoped that people will recognize the hard work that went into these investments. What needs to be explained is why the ILC is the appropriate vehicle to do the next job. Also, the synergy of the LHC and the ILC needs to be explained, especially to the NAS. The main question is, what is the qualitative difference between the LHC and the ILC?

There is a need to explain to the broad nonscientific community how the ILC and LHC will work together and to answer the questions:

- What discoveries would not be made without the ILC?
- How would one use an ILC in understanding a Standard Model Higgs (or whatever fulfills its role)?
- What would be the role of an ILC in making additional, unique contributions to discoveries beyond the Standard Model, in distinguishing among models, and further establishing connections to cosmology?

New physics studies are not what is wanted. What is wanted is HEPAP's help in distilling the existing body of work into a crisp, accessible, and persuasive case.

The current U.S. accelerator-based program is world-leading, but it has a finite lifetime. At some point, operations no longer produce new science. The B-Factory (PEP-II) and the Tevatron will ramp down toward the end of the decade; MiniBooNE and MINOS also will have certain, scientific lifetimes. LHC participation will be a central piece of the program, which is why that project is being protected. A cost for the ILC needs to be stated up front. That cost needs to be as low as possible while getting the essential physics. The plan should call for a portfolio of medium-scale, medium-term experiments for which construction would start in the period 2007 to 2010.

The scientific opportunities are compelling: neutrino physics, dark matter, dark energy, etc. Resources will become available, but the bulk would have to come through redirection.

Some medium-scale experiments that might be considered include:

- A reactor-based neutrino experiment to measure θ_{13},
- An off-axis accelerator-based neutrino experiment for θ_{13} and to resolve the neutrino-mass hierarchy,
- A high-intensity neutrino beam for neutrino CP-violation experiments,
- A neutrinoless double-beta-decay experiment to probe the Majorana nature of neutrinos,
- An underground experiment to search for direct evidence of dark matter,
- A ground-based dark-energy experiment,
- And others.

One can make reasonable assumptions about the costs involved in the Tevatron and B-Factory operations roll-off, the ILC R&D ramp-up, and what the United States is putting into the LHC. The bottom line is that $50 to 100 million per year may be available to invest in new initiatives by the end of the decade. Several complications arise, however. Any dollar envelope will depend strongly on facility operations and how fast the ILC is ramped up. Not all projects are equal in science or scope, even within a given physics area, so a set of criteria needs to be developed to evaluate and compare projects.

The suggested criteria are

- Scientific Potential: To what extent does the project have the ability to change the fundamental view of the universe?
- Relevance: Is the science important to DOE/HEP's mission (and is not just great science)?
- Value: Is the level of scientific potential commensurate with the level of investment?
- Alternatives: Are there more cost-effective alternatives to get at the same (or most of the same) physics?
- Timeliness: Will the results come at the right time to have sufficient impact?
- International: Are similar efforts under way in other countries, how do they compare with the proposal, and are there potential international partners for this effort?
- Infrastructure: Does the project exploit, or help to evolve, existing infrastructure (including human capital)?

The advisory process is set in tiers: The National Academies study and HEPAP will set the overall shape of field, the "grand strategy." HEPAP is to reestablish the P5 panel to help determine what priority to give to one medium-scale area versus another. They will be asked to do several tasks in the next few years and to keep their recommendations within a budget envelope. Several scientific advisory groups (SAGs) will be asked to report the best project in each of several areas. A NuSAG should be initiated immediately. It will be asked to compare reactor neutrino experiments for θ_{13}, off-axis neutrino experiments for θ_{13} and for resolving the neutrino hierarchy, and neutrinoless double beta decay experiments. NuSAG will be a joint subpanel of HEPAP and the Nuclear Science Advisory Committee (NSAC) and will report through HEPAP to DOE-

HEP and NSF and will report through NSAC to DOE-NP and NSF. How to set up an analogous SAG process for other scientific topics (such as dark matter, dark energy, and particle astrophysics) is being considered.

HEPAP is being asked to set up Subpanel P5 for another two years. As before, an "umbrella" letter will create the panel, and individual charges will follow. Ideally, P5 would be asked to compare the recommended options from the SAG process and prioritize them relative to one another. More realistically, P5 will be given a nominal (optimistic but not "blue sky") envelope of available funding for new initiatives and asked to prioritize within that constraint.

Bigger questions are also being addressed to HEPAP. In regard to the ILC, what is an appropriate planning assumption for the schedule? What level of resources should go into ILC R&D as a function of time? And what are the decision points (and off-ramps) for ILC? For dark matter and dark energy, what is the balance between space-based experiments and something ground-based that is faster but less capable? In terms of the U.S. accelerator-based program, how long should the B-Factory and Tevatron be run, given limited resources? What is the "right" balance of facility operations, ongoing research, and new-facility R&D for the next 5 years?

In summary, the current planning resources available to HEP include the National Academies' EPP2010 study, which addresses broad program priorities and is an important part of the HEP strategy, and the Neutrino SAG, which addresses choices in neutrino physics, and other SAGs to be formed as needed on specific scientific topics.

HEP has a great program, but the time is now right to start planning a portfolio of medium-term, medium-scale initiatives that can be launched around 2007 to 2010. These initiatives will exploit scientific opportunities and require redirection to open new opportunities for the future. P5 is being asked to balance and prioritize areas and to articulate why the ILC and LHC are important. There is a lot of work here, so a start needs to be made right away.

Kim noted that there was approximately $50 million per year likely to be available and asked if there would be additional money for the Linear Collider? Staffin replied that a ramp-up in Linear Collider R&D and the use of existing infrastructure was expected.

Ritz commented that timelines will be important. Different proposals can come up at the same time and both get dropped. There must be the flexibility to make quick, good decisions in such a case. It is hoped new ideas will come up all the time; the evaluating committees have to be conducive to growing such new ideas. Staffin responded that it is important to have a process that facilitates rather than impedes.

Cahn asked if HEP can expect to retain the monies that now go to SLAC. Staffin said that he would not rule out any possibilities. Cahn stated that new money will be needed.

Womersley said that that is a big question: What is the right balance? Cahn said that a key question is how much of the SLAC money will stay in the field. Staffin commented that one starts with a fixed envelope. But if a compelling proposal comes forward, one can use it to push the envelope out.

Siegrist asked if the charge to P5 will go beyond design to basic R&D. Staffin replied, yes. That is one of the questions being put to HEPAP. Input is needed that will jump start the planning process.

Butler said that $50 million is not a big number. It has to cover a lot of effort. Staffin said that he appreciated that fact. The advice that the advisory committees give us is important.

Meyers asked Staffin to give more information about the tiered approach. Staffin gave an example in which a new area is selected, and a subcommittee (like NuSAG) is established to compare and contrast techniques, experiments, etc. That subcommittee reports its findings to HEPAP (and perhaps other advisory committees). HEPAP would ask P5 to compare the "mix and match" among the various areas being proposed to it for consideration. P5 would then come up with a package that fits the budget and has the right physics to meet the missions of DOE and HEP. HEPAP would then advise DOE-HEP and NSF about its recommendations.

Gilman declared a break at 10:03 a.m. He called the meeting back into session at 10:28 a.m. He suggested having the next meeting on May 17-18 in Washington. He opened the floor to discussion of the new charges to the Panel. Bruce Strauss displayed the RSVP charge. Gilman expressed the desire to populate the subcommittee and some subgroups by the end of the week. Dehmer noted that this is a scientific assessment, not a Lehman review of costs. How important is the science, is the question to be answered. He cautioned against conflicts of interest. It does not need to be a large group. Suggestions should be e-mailed to Gilman. A chair will be selected from those suggested.

Meyers asked whether an estimate of the cost would be available. Dehmer said no; that will be worked on in parallel.

Gilman turned the discussion to the reincarnation of P5. Strauss displayed the charge letter. Gilman reviewed the history of P5. Langacker asked about the timing, given that there are no projects to evaluate. Staffin said P5 probably would not have anything to do for 6 months or so. Meyers noted that, if things come to P5 one at a time, it will not be able to compare projects. Staffin answered that they would be expected to consider items by type, such as dark matter. Dehmer noted that the process is always dynamic; new ideas are always coming up. The purpose is to produce or update a roadmap.

Ritz suggested that it would help if there were a timeframe for the roadmap: 2006 is too soon and 2020 is too far away. Staffin expected that they will focus on the mid term.

Kim asked how foreign projects would be handled. Staffin said that some will be foreign; HEP will work with them. Where the U.S. program is going needs to be figured out, and some of that will be international in character.

Gilman commented that suggestions of previous HEPAP members are not precluded. It is a bigger effort than the RSVP Subcommittee, perhaps having 16 or so members. He moved on to a discussion of NuSAG.

Dehmer asked that suggestions for membership along with brief reasons for those suggestions. Membership will be drawn from a number of fields, all related to neutrinos. He asked if there would be subgroups. Langacker suggested not having subpanels but for the whole panel to look at all the issues. Staffin suggested having two-thirds of the panel from outside neutrino physics.

Montgomery asked if the committee should ask who should "own" the field and where the money might come from. Staffin stated that some things are interesting to one office and not to another. Different offices will have different niches of interest. There are no hard-and-fast rules governing funding. Gilman added that different neutrino experiments have been proposed by different offices. If one is recommended by this

subpanel, it would seem likely that the office that proposed it would fund it. Staffin said that it would depend on whether the other office saw it as important to its mission whether it would contribute funding or not. He observed that it seemed that the Panel was resolved that it be one committee. Noting that the Office wanted to move this effort along, he asked how much time might it take to get a good product. Dehmer said that that is not fully developed yet. It will have to be considered in blocks. Gilman suggested that 1.5 years would not be timely. Staffin noted that the FY-07 budget formulations will start the following month. Witherell commented that it is clear that a window may open for funding, and HEPAP should be prepared to use that window. Some work has already been done by the APS report. The first step is to get a chair.

Butler asked where the laboratories' advisory committees fit into this process. Staffin replied that the letter said that proposals to P5 may or may not have laboratory advisory committee prior review and recommendation. National laboratories also need prioritization and assessment, but now the system is highly constrained and coupled. A way needs to be found to facilitate the process. Montgomery said that P5 found the input from the Fermilab Physics Advisory Committee important. That process should not be fully deprecated in the new system. One would learn more about the scientific advisability from the laboratory advisory committees. Witherell added that one needs the best information about the science and costs. One cannot expect that in everything coming in. Some things need a focused review before it comes to the Subpanel. NuSAG will need to know, for example, about schedules. Meyers reinforced that opinion. There is a deep technical component but an assessment of that deep level is necessary before it gets to the Subpanel. It can occur on a rapid time scale. Getting the committee together is the most time-consuming part of the process. Staffin asked if the SAG should have a technical group. Meyers answered that that is very helpful and important.

Gilman asked for suggestions for the chair(s) and other members to be sent to him. He turned attention to LHC-Linear Collider synergy.

Hewett commented that new blood and representatives from outside the community should be on this Subcommittee.

Ritz suggested that the report should follow up on the report *Connecting Quarks with the Cosmos: Eleven Science Questions for the New Century*. He also noted that 10 to 15 pages in Washington is not crisp; the report needs a one-page list of bullets to be used for an elevator speech. It should have time in its preparation schedule for a good series of reader cycles. Gilman said such reader reviews would be crucial.

Kim asked what the time scale for this report was. It could be a good input to EPP2010. Gilman said that he hoped that it will be in draft form by May and to EPP2010 in final form by summer. There are many documents already, but none of them is the right one.

Ruchti asked if this was a one-shot deal, suggesting that it probably has a longer scale, some staying power, and some dwell time. Siegrist suggested having Judy Jackson on the committee. Ruchti observed that she and others write for a particular audience. This report should aim at a broader audience and longer term of use. Witherell noted that the ILC has a communication committee and suggested against multiplying those emerging committees.

Ferbel commented that this report should not be written in such a way as to irritate our European colleagues. He suggested that the PR people from CERN and Asia should be involved, especially as readers.

Kim said that this document should be primarily to convince our own community. Ritz commented that one report does not have to do everything. A series of documents can be distilled from the effort of the subpanel. Kim suggested that HEPAP should be more proactive in bringing up some big questions in addition to those posed in the charge letters from DOE and NSF. Gilman noted that P5 came from HEPAP, more than from the agencies. HEPAP's discussions also partly stimulated these charges from the agencies.

Gilman declared a break for lunch at 11:37 a.m.

Tuesday, February 15, Afternoon Session

Gilman called the meeting back into session at 1:02 p.m. and introduced **Rainer Weiss** to present a status report on the Cosmic Microwave Background (CMB) Task Force. This is an existing group, different from the Dark Matter Subpanel for which the charge letter had just been signed. The Task Force's pre-report had been delivered to the Panel.

The CMB Task Force is an OSTP response to the Turner Panel's "*Connecting Quarks with the Cosmos*," sponsored by DOE, NASA, and NSF. Its purpose is to recommend a program of research of CMB observations to understand the properties of the inflationary epoch of cosmology. The initial objective was to present a plan to measure CMB polarization and to report to HEPAP and the Astronomy and Astrophysics Advisory Committee (AAAC). The full report will be available in mid-May 2005.

The scientific community is trying to get at several questions: How did the universe begin? Is inflation correct, and how can it be tested? What are the fundamental physics associated with the Standard Model? What is the energy scale, and what is the interaction? What are the constituents of the primeval universe (a new question)? How did the universe evolve? What is the nature of the dark energy? What is the geometry of the universe? These are fundamental questions; it is 1900 all over again.

The inflationary epoch leaves relics we can look at: fluctuations in density and gravitational waves. We now look at a plasma wall that has a temperature and spectrum, and it is polarized. These fluctuations led to the first stars and eventually to the present-day universe.

The properties of the inflation are measurable with the CMB. First of all, one can look at the spectrum of spatial temperature fluctuations. They come in two styles, scalar and tensor fluctuations. There is then a scale-invariant spectrum k^n. During the expansion, a Gaussian probability distribution of fluctuations was produced, and tensor gravitational waves were generated because of acceleration during inflation, related to the energy scale of the inflation. The ratio of fluctuations of tensor vs. scalar temperatures is less than or equal to 0.3. This puts some bounds on the models and the energy scale of the expansion.

A plot of the density of the universe vs. the cosmic scale factor shows the cosmic mean density going through several epochs: inflation, reheating, radiation domination, matter domination, and dark-energy domination. That cosmic mean density is diluted as the universe expands. During inflation, there is almost no dilution, causing

the expansion to accelerate. During the reheating, radiation-dominated, and matter-dominated epochs, the expansion slowed, and the quantum fluctuations generated during inflation have been stretched into the fluctuations that we observe today in the CMB. As a result, detecting inflationary gravitational waves with CMB polarization would directly measure the shape of the cosmic-density-curve plot during the inflationary epochs, just as the proposed Joint Dark Energy mission would directly measure the same plot in the dark-energy-dominated epoch.

The tensor-to-scalar ratio (i.e., energy scale) can be mapped against the scalar spectral index. Large portions of this mapping of inflation can be ruled out by CMB and by large-scale cosmological-structure measurements, leaving a small portion of allowed values. The polarization of the CMB comes from Thomson scattering in the primeval plasma . The polarized sky is an example of the Thomson scattering of the radiation from the sun by electrons in the molecules of the atmosphere. (This is really Rayleigh scattering by the molecules, but we are taking some innocent liberties can be taken). The pattern of the polarization of the CMB on the sky provides the signature of the source of the anisotropy. The scalar fluctuations make radial and circular patterns of the polarization fields around the anisotropies (E modes), while the quadrupolar stretching and compression from the tensor parts caused by the gravitational waves make large-scale curl-like patterns (B modes) The E and B modes are distinguishable if large regions of the sky can be observed. It is specifically the measurements of the B modes that provide the evidence for the primeval gravitational waves. There are two well defined times in the evolution of the universe when free electrons existed to cause the Thomson scattering, and there is enough transparency in the universe to observe the scattering directly. The first is near the time when the universe had cooled enough to begin to form hydrogen atoms (the time of recombination), and the second and much later time was when the first stars were formed and the interstellar medium became ionized again (the time of reionization). The two epochs cause correlations in the sky on greatly different angular scales and are distinguishable because of this.

A number of research projects [the Wilkinson Microwave Anisotropy Probe (WMAP), Degree Angular Scale Interferometer (DASI), Cosmic Anisotropy Polarization Mapper (CAPMap), and Polarization Observations of Large Angular Regions (POLAR)] have begun to measure the polarization of the CMB vs. the multipole moment on the sky. To make progress, the foregrounds of the polarized synchrotron emission from our own galaxy and polarized emission by interstellar dust need to be mapped. Another disturbance to the measurement is gravitational lensing by matter between us and the last scattering surface that mixes E and B modes. This lensing needs to be measured as well.

The Task Force recommends the completion of WMAP and the successful launch and operation of the Planck Surveyor Satellite (measuring the temperature power spectrum correlation better, hopefully see the E-mode power spectrum, and help establish some of the foreground). It also strongly recommends a ground-based and balloon-borne program to measure polarization of the CMB and to develop techniques and technology for a space mission (CMBPOL: CMB Polarization) in the next decade designed to measure the B modes to a level limited by the ability to model foregrounds. This should be done first on the ground and then definitively in space.

A program to measure polarized foregrounds is needed. To do this, one needs a program to develop polarization-sensitive receivers incorporating arrays of thousands of

detectors operating at the background limit of the CMB. The task force would like to make this a cooperative interagency program of research supported by DOE, NASA, NSF, and the National Institute of Standards and Technology (NIST). It has mapped out a timeline in great detail for these ground-based, balloon-borne, and space-based missions, leading to CMBPOL, the goal of which would be to produce a polarization map down to the fundamental astrophysical foreground limits and be 10 times more sensitive than the planned PLANCK Project.

CMBPOL would get one further down in the frequency of gravitational waves than any of the current or planned programs. It will be the only way to measure the gravitational-wave background at the level assumed for slow-roll inflation in the next 30 years. PULSAR timing measurements, LISA (Laser Interferometer Space Antenna), and LIGO (Laser Interferometer Gravitational-wave Observatory) cannot get to this level. The Big Bang Observer (BBO), a high-power interferometer in space, could in principle have the sensitivity but must deal with a significant confusion by the gravitational wave emission of compact binary systems throughout the universe. It would be interesting to compare its spectrum with that of CMBPOL. The polarization results from WMAP, when combined with the measurements of the Sloan Digital Sky Survey (SDSS), may be able to detect the primeval gravitational radiation if the tensor-to-scalar ratio is 0.3 or larger.

Dragt asked why NIST was listed as a collaborator. Weiss replied that they are manufacturing SQUID-based [Superconducting QUantum Interference Device] multiplexers for the arrays made by the Jet Propulsion Laboratory (JPL) and Goddard Space Flight Center. The whole community relies on them for bulk bonding these SQUID multiplexers. Dragt asked how pulsars are measured. Weiss said that one tracks a pulsar and measures its period and frequencies. Then one tracks another and looks for correlations in fluctuations in the frequency (from gravity waves). Dragt asked what the difference was between LISA and LIGO. Weiss answered that LIGO is an interferometer with many reflections and high power. LISA gets its sensitivity from very long baselines (5×106 km) and it uses a different, simpler kind of interferometry (heterodyne). BBO uses a 50,000-km baseline and a high-power laser.

Ritz commented that there are lots of great ideas on CMB and asked if the report will give a roadmap of where to go. Weiss answered, yes. The numbers are $7 million to $10 million for detector development and $25 million to $35 million for ground-based and balloon-borne experiments. The Task Force has prioritized detector development. Next, it needs to figure out how many telescopes are needed. That is the battle that is going on now.

With tongue in cheek, Staffin asked if Weiss would be interested in serving on a Linear Collider panel. Weiss answered, NO!

Gilman listed the issues for the Panel's discussion:

- The human resource study is still in progress; a report is needed.
- The global design effort for the ILC is moving forward; it is great to see the three excellent candidates; the fact that all three are from the United States points toward the United States' hosting the design team; it is hoped that a leader of the program will speak at a future HEPAP meeting. Kim asked when information was needed about the Linear Collider for budgeting purposes. Staffin replied that the FY 07 budgeting starts in March and continues through the summer. Barry Barish

will be asked for guidance. Ballpark information for that budget will be needed in the next 6 months. Any input received would help set the stage. Reports and elevator speeches produced by the Panel come into play in influencing others. A ramp-up rate needs to be determined to meet a particular date for construction decision. Also, advice is needed on how to bring the costs down.

- What should be said in a letter to Orbach and Turner in response to Bagger's presentation? Cahn commented that the non-HEP members are open to suggestions from this Panel. Well-written statements to them would have a big effect. Such statements are critical to the outcome and influence of the final report. A bunch of randomly written letters would not do it. Hewett noted that the committee is drawing up a list of questions raised at the meeting at SLAC. Montgomery suggested that HEPAP should write its own white paper and send it to the committee. Gilman said he would ask Dawson and Bagger if a white paper would be desirable.
- The NSF budget is also being developed. Cahn noted that there was a big reduction at CESR and asked if that reduction affected operations in FY 05 or FY 06. Gilman responded that the endpoint (2008) has not changed, but the slope of decline has. Langacker stated that the Panel should express concern about not fully using facilities when they exist. Dragt asked if the Panel should say anything about RSVP. Cahn suggested that the Panel should say that interesting physics programs should go ahead after appropriate budget adjustments. Langacker disagreed, stating that the Panel should not prejudge outcomes. Gilman suggested that the Panel should probably wait until May to comment on this topic. Dragt said that the letter should note that there are very few accelerator-based experiments in United States. Staffin agreed that the Panel should keep that issue in play.
- The next issue was the DOE HEP budget and the cancellation of the construction of BTeV. Meyers noted that the panel had been told that this was a budget, not a science, decision and suggested that the Panel should say that it regrets the loss of the experiments and the science and bemoans the effects on students and foreign collaborators, which will cause major disruptions in professionals' careers and create impediments to future international collaborations. Cahn said that the Panel should make clear that it was not just the FY 06 budget but also the budgets for future years that were the cause of the termination. Langacker added that it is also desirable to have more than one experiment addressing an issue. Staffin cautioned the Panel to be very careful about how it says that. Those outside of science would interpret such a statement differently than a scientist would. This letter will be a public document and will be read by a wide variety of people. Butler noted that this cutback would put the U.S. neutrino program at a severe disadvantage. Ritz suggested that the letter should have a statement saying that the Panel recognizes the need to make decisions based on budgetary priorities. Gilman stated that the letter should point out that something that is high on the list of priorities is not being done. Butler stated that priorities were eliminated. Gilman agreed; instead of the Panel's priorities getting done, nothing is getting done. Cahn pointed out that some of the Panel's priorities are supported, such as BaBar. Staffin commented that there is a view around Washington that high-energy

physics is an area that could not prioritize if its life depended on it. Gilman noted that there are other parts of SC that got hurt worse than HEP. Butler pointed out that the loss of BTeV is a severe impact in that a whole project was cut, and it was the only construction project HEP had. He worried that the whole B community will move to Europe and Asia. Staffin stated that DOE would not shy away from an area simply because other countries are also working in that area; the Secretary recognized that America would lose workers to other nations but hoped that the country would leapfrog to other, newer facilities, programs, and capabilities. Cahn suggested that something should be put in the letter about the $30 million for operations at SLAC, asserting that those funds were not extracted from elsewhere in the HEP budget; the Panel has an interest in countering that perception. Langacker suggested letting sleeping dogs lie. Kim noted that the perception is that facilities are being shut down and support is being lost. Staffin commented that one does not want HEP funds being used to solve other peoples' problems. Hewett said that the Panel should be proactive in setting a plan to move to the science forward after the facilities are shut down. Meyers observed that the ending of these programs is not unnatural; they will continue to operate as long as they are productive and competitive. As they close, other science has to be found and pushed forward to replace the programs that are ending. Ritz observed that that is what Staffin had laid out for the Panel to do. Dragt noted that a comment had to be put in the letter about how the Panel is going to respond to the charges that have been put to it. Meyers added that the letter should also state that the Panel is looking forward to the Linear Collider. Peggs said that the letter also needs to mention the need to keep a junior workforce in the pipeline for the Linear Collider. Ritz added that he would highlight the fact that the Panel was happy with Orbach's statement of support for the Linear Collider. Kim suggested adding that instrument development will likely occur at many U.S. laboratories. Gilman adjourned the meeting at 2:48 p.m.

The minutes of the High Energy Physics Advisory Panel meeting held at the Hilton Washington Embassy Row, Washington, D.C. on February 14-15, 2005 are certified to be an accurate representation of what occurred.

Frederick Gilman
Chair
High Energy Physics Advisory Panel