Minutes
High Energy Physics Advisory Panel
November 13–14, 2008
DoubleTree Hotel, Washington, D.C.

HEPAP members present:

- Hiroaki Aihara
- Jonathan A. Bagger, Vice Chair (Thursday only)
- Alice Bean
- James E. Brau
- Patricia Burchat
- Robert N. Cahn
- Priscilla Cushman (Thursday only)
- Sarah Eno
- Larry D. Gladney
- Robert Kephart
- William R. Molzon
- Saul Perlmutter (Thursday only)
- Tor Raubenheimer
- Kate Scholberg
- Melvyn J. Shochet, Chair
- Sally Seidel
- Henry Sobel (Thursday only)
- Maury Tigner (Thursday only)
- William Trischuk (Thursday only)
- Herman White
- Guy Wormser (Thursday only)

HEPAP members absent:

- Daniela Bortoletto
- Joseph Lykken
- Stephen L. Olsen
- Lisa Randall
- Angela V. Olinto

Also participating:

- Charles Baltay, Department of Physics, Yale University
- Barry Barish, Director, Global Design Effort, International Linear Collider
- Gary Bernstein, Department of Physics and Astronomy, University of Pennsylvania
- John Boger, Office of High Energy Physics, Office of Science, Department of Energy
- Joel Butler, Particle Physics Division, Fermi National Accelerator Laboratory
- Hesheng Chen, Director, Institute of High Energy Physics, Beijing, China (by telephone)
- Glenn Crawford, HEPAP Designated Federal Officer, Office of High Energy Physics, Office of Science, Department of Energy
- Joseph Dehmer, Director, Division of Physics, National Science Foundation
- Lyndon Evans, Director, Large Hadron Collider, CERN
- Gary Feldman, Department of Physics, Harvard University
- Marvin Goldberg, Program Director, Division of Physics, National Science Foundation
- Stephen Holmes, Accelerators Directorate, Fermi National Accelerator Laboratory
- Steven Kahn, Director of Particle Physics and Particle Astrophysics, SLAC National Accelerator Laboratory
- Young-Kee Kim, Deputy Director, Fermi National Accelerator Laboratory
- John Kogut, HEPAP Executive Secretary, Office of High Energy Physics, Office of Science, Department of Energy
- Jonathan Kotcher, Program Officer, National Science Foundation

Dennis Kovar, Acting Associate Director, Office of High Energy Physics, Office of Science, Department of Energy
Michael Levi, Physics Division, Lawrence Berkeley National Laboratory
Marsha Marsden, Office of High Energy Physics, Office of Science, Department of Energy
Frederick M. O'Hara, Jr., HEPAP Recording Secretary, Oak Ridge Institute for Science and Education
Hasan Padamsee, Laboratory for Elementary-Particle Physics, Cornell University
Helen Quinn, Department of Theoretical Physics, SLAC National Accelerator Laboratory (by telephone)
Eli Rosenberg, Office of High Energy Physics, Office of Science, Department of Energy
Michael Salamon, Program Scientist, National Aeronautics and Space Administration
John Henry Scott, Senior Policy Analyst, Office of Science and Technology Policy, Executive Office of the President
Kathy Turner, Office of High Energy Physics, Office of Science, Department of Energy
Michael Tuts, Physics Department, Columbia University
Andreene Witt, Oak Ridge Institute for Science and Education

About 60 others were present in the course of the two-day meeting.

Thursday, November 13, 2008
Morning Session

Chairman **Melvyn Shochet** called the meeting to order at 9:00 a.m. He asked **Dennis Kovar** to update the Panel on the activities of the DOE Office of High-Energy Physics (OHEP). It has been an "interesting" year for the DOE HEP program. It has dealt with the largest funding reduction in recent history (–8.4%). Later in the year it had a supplemental appropriation, and most of the serious impacts were mitigated. It was a productive year, and the program is poised to deliver outstanding science in the near term. With the help of the community, a new strategic plan was developed for U.S. high-energy physics at three scientific frontiers. Under this plan, the United States will deliver significant outcomes. The plan is realistic and robust to changes brought about by funding changes and by scientific discoveries. The Office of HEP and how it does business were reorganized.

The FY09 budget request is large, $805 million. However, a 6-month continuing resolution is expected, under which the Tevatron plans to run 6 months into FY09, the Large Hadron Collider (LHC) program will be supported (but see no growth), some projects will be delayed, the Joint Dark Energy Mission (JDEM) selection will proceed, discussions on participation in the LHC Phase I upgrade will continue, the Advanced Plasma Accelerator Facility project will be delayed, and the higher-priority programs will be supported. If there is a year-long continuing resolution, the impacts will be significant: there will be reductions in force of 175 to 200 at the national laboratories and about 80 at universities, Tevatron operations will be terminated at the end of 6 months, the NOvA [NuMI Off-Axis ν_e Appearance] project will be cancelled, and other projects will be delayed or cancelled. The FY09 appropriation is pivotal.

The FY10 request is to be submitted by the new administration. Transition documentation has been prepared. DOE has been developing plans at different funding levels. OHEP is using the P5 [Particle Physics Project Prioritization Panel] findings and recommendations in its plans. The P5 major findings are

- Progress in achieving the goals of particle physics requires advancements at the energy, intensity, and cosmic frontiers.
- An opportunity exists for the United States. to become a world leader at the intensity frontier.
- Promising opportunities for advancing particle physics have been identified at the cosmic frontier.
- At its core, high-energy physics is an accelerator-based experimental science.

P5 recommended:

- Support for the Tevatron Collider program should be continued for the next 1 to 2 years.
- The LHC program should have the highest priority, including U.S. involvement in the planned detector and accelerator upgrades.
- An accelerator and detector R&D program should be conducted for lepton colliders.
- A world-class neutrino program should be pursued as a core component.
- A large detector at the Deep Underground Science and Engineering Laboratory (DUSEL) and a high-intensity neutrino source at Fermilab should be supported.
- A program of rare decays (e.g., muon-to-electron conversion) should be conducted.
- Dark matter and energy should be emphasized [JDEM in collaboration with the National Aeronautics and Space Administration (NASA), the Large Synoptic Survey Telescope (LSST) in collaboration with NSF, and direct dark-matter-search experiments with NSF].
- Accelerator R&D should be supported to develop technologies that are needed by the field and that benefit the nation.

As a result of FY08 funding, the B-Factory program was terminated early. SLAC/BaBar [Stanford Linear Accelerator Center] had put together a plan to run on the 2S and 3S states, and support was provided for a 4-month run, a plan that has already led to physics advances.

At the energy frontier, the Tevatron is running extremely well. Its 2008 integrated luminosity was about 1800 pb^{-1}. The detectors are 90 to 95% efficient. Recent results include the top mass with an accuracy of 0.7%, all di-boson final states being observed, and the first Higgs exclusion. It plans to run in 2009 with no long shutdown and to run in 2010 if funds and personnel are available.

There has been a momentary delay of the LHC. The detectors are using the time to get calibrated. Planning has begun for contributions to accelerator upgrades and R&D for detector upgrades. The LHC is a very high priority.

During the past year, the U.S. regional team of the International Linear Collider (ILC) has looked at what the United States can contribute at $35 million per year.

At the intensity frontier, a worldwide effort in neutrino oscillations has led to an ambitious program that can do this, subject to the values of the unknown parameters. The DOE Program includes Fermilab (MiniBooNe, MINOS, Minerva, NOvA, and the Long

Baseline Experiment), Daya Bay Reactor Neutrino Detector, Double Chooz, Tokai-to-Kamioka (T2K), and the Enriched Xenon Experiment. Funding is not at the planned level, but programs will not be significantly impacted. The status of these programs will need to be assessed in 6 months.

In the accelerator-based neutrino program, DOE's OHEP is proceeding to explore and analyze alternatives. During this time, we are collaborating in detector research. A joint oversight group (JOG) will be set up with the NSF.

In the reactor-based neutrino program, Daya Bay, Double Chooz, and T2K are under way, and OHEP is supporting R&D.

At the cosmic frontier, the existing and proposed experiments are

- In gamma-ray astrophysics: the Very Energetic Radiation Imaging Telescope Array System (VERITAS) and the Gamma Ray Large Area Space Telescope (GLAST);
- In cosmic-ray astrophysics: Auger;
- In antimatter, dark matter: the Alpha Magnetic Spectrometer (AMS);
- In dark matter (WIMPS): the Chicagoland Observatory for Underground Particle Physics (COUPP), the second phase of the Cryogenic Dark Matter Search (CDMS II), and the Large Underground Xenon (LUX) dark-matter experiment;
- In dark matter (axions): Axion Dark Matter Experiment (ADMX);
- In dark energy (ground-based): the Sloan Digital Sky Survey (SDSS), the Dark Energy Survey (DES), and LSST; and
- In dark energy (space-based): JDEM.

In dark energy, the operating experiments are the Supernova Cosmology Project, Nearby Supernova Factory, and SDSS-II. Under Construction and/or Review are the DES and the Baryon Oscillation Spectroscopic Survey (BOSS) on SDSS-III. R&D funds are being provided for the LSST and JDEM. A JDEM plan for going forward has been developed and is discussed later in this meeting.

The LSST experiment is to study dark energy, near-Earth objects, plus many other astronomical measurements. NSF is the lead agency. DOE's interest is in dark-energy measurements. There are also contributions from L'Institut National de Physique Nucléaire et de Physique des Particules (IN2P3) and private sources. DOE has been supporting R&D for the camera through SLAC. LSST is among the projects being evaluated in the Astronomy/Astrophysics Decadal Survey under way by the National Academy.

Dark matter searches include the

- CDMS-II
- ADMX
- LUX
- COUPP

Other technologies are being evaluated for the future, as recommended by the Dark Matter Science Assessment Group (DMSAG).

The Office has implemented a new organizational structure that is organized according to scientific and technical campaigns and aligned with the Congressional Budget Request. It has implemented a new review process for laboratories, reviewing laboratory research groups on a rotating basis. In FY08, the review of theory and accelerator-science subprograms went well. In FY09, the nonaccelerator and detector

R&D subprograms will be reviewed; and in FY10, the proton-based and electron-based subprograms will be reviewed.

The Office obtained approval to fill/advertise 12 new permanent federal positions during the next 2 years. John Boger is a new employee performing strategic planning. His is one of six positions that have been filled. Five IPA [Intergovernmental Personnel Act] detailees arrived this year, and four IPAs are continuing.

The 2007 Committee of Visitors (COV) found the overall functioning of the OHEP office to be very professional. The draft 2007 COV report has 18 specific recommendations. In response, the Office has implemented some of the recommendations, particularly the staffing issues. It has completed six of the recommendations; seven recommendations are in-process; and five recommendations are ongoing. In addition to addressing the staffing issues, the other actions of note are

- The Office has completed development of a process to globally optimize and comparatively review the balance of support for HEP research at Fermilab, the universities, and the other national laboratories in light of the evolving program.
- The Office has discussed but has not yet provided a template to reviewers to provide guidance and greater uniformity of reviews.
- Two advisory committees are being established to advise the Office on the expansion of the peer-review process in accelerator research to cover midterm accelerator research to provide comparative evaluation of the merit of different research efforts.

An analysis of the demographics of the OHEP programs has been completed and shows the research workforce broken down by area and by job classification.

Cahn asked why NOvA might be canceled. Kovar responded that the Office will get the FY09 and FY10 budgets at about the same time, so it will need to make a decision about what can be done sustainably.

Bagger asked to what extent DOE is supporting the Decadal Survey. Kovar answered that it is supportive. Cahn asked if there would be a DOE representative on the survey panel. Kovar noted that it is an independent survey of the National Academy of Sciences (NAS).

Tigner asked what the new staff positions were in. Kovar said that every program manager should have a budget, and there should be a federal employee for each program. The Office is now functioning only because of the presence of IPAs and detailees.

Shochet congratulated Kovar for receiving the Presidential Rank Senior Executive Award.

Kovar announced that Glenn Crawford is the new HEPAP Designated Federal Officer (DFO).

Joseph Dehmer was asked to give an update on NSF activities.

The agency is planning for the possibility of a year-long continuing resolution. It is also preparing an FY10 budget with an 18% increase.

Baseline planning is being done for the Deep Underground Scientific and Engineering Laboratory (DUSEL).

The major projects include IceCube, where half of the strings are in. Advanced LIGO [Laser Interferometer Gravitational Wave Observatory] was approved for the beginning of construction in FY08. DUSEL, which addresses long-baseline neutrinos, dark matter, proton decay, neutrinoless double-beta decay, low-energy nuclear reactions, and supernovae/primordial neutrinos, is in preliminary design. There is also a proposed upgrade to the LHC detectors.

At DUSEL, the main physics would be done at 4850 and 8000 feet. The NSF is forming a JOG to coordinate DUSEL plans and operations.

The main purpose of DUSEL is to address the questions

- Of what is the Universe made?
- What is dark matter?
- What are neutrinos telling us?
- Where did the antimatter go?
- Are protons unstable?
- How did the universe evolve?

The experiments that flow from those questions are

- Direct detection of dark matter,
- Neutrinoless double-beta decay,
- Nuclear astrophysics,
- Accelerator-based cross-section measurements,
- Solar neutrinos, and
- long baseline experiments.

Major Research Equipment and Facilities Construction (MREFC) funding for DUSEL would support the construction of forefront experiments in nuclear physics, particle physics, and astrophysics in partnership with DOE's HEP and Nuclear Physics (NP) and with international partners.

The configuration of a megadetector at Homestake, which is more than 1000 km from a high-intensity beam from Fermilab, offers an opportunity for transformational discovery that is unique in the world. This activity started in 2000. The idea was stated in the Bahcall Report and developed in the *NSAC Long-Range Plan*, *HEPAP Long-Range Plan*, *DOE 20-Year Facility Plan*, *Quantum Universe,* the *P5 Strategic Plan for the Next Ten Years*, *Connecting Quarks to the Cosmos*, *Physics of the Universe*, and other studies and reports. DOE, NSF, and the NASA put out a joint action report in 2004 on the intersections of physics and astronomy. NSF was named as the lead agency, and DOE/NSF would plan experiments.

P5 recommended a world-class neutrino program as a core component of the U.S. program, with the long-term vision of a large detector in the proposed DUSEL laboratory and a high-intensity neutrino source at Fermilab. It endorsed the importance of a deep underground laboratory to particle physics and urged NSF to make this facility a reality as rapidly as possible. Furthermore, it recommended that DOE and NSF work together to realize the experimental particle physics program at DUSEL. The Fermilab/DUSEL program recommended by P5 constitutes the primary element of the on-shore U.S. particle physics program during the coming decade.

A series of solicitations were held to determine the site-independent science, scope, and infrastructure needs; unify the community; develop conceptual designs for one or more sites; complete a facility design for an MREFC candidate; and develop technical designs for candidates for the DUSEL suite of experiments (the solicitation now on the street). The most recent (fourth) solicitation (S4) provides $15 million over 3 years; Jon Kotcher is managing this effort.

The S3 goal was to select a single site and team to develop a technical design for the facility. Four proposals were reviewed by a multidisciplinary 22-member expert panel. The review included site visits and reverse site visits. The panel unanimously voted by secret ballot to recommend the Homestake proposal to the NSF for funding. NSF concurred. The Homestake mine has 600 km of drifts with two access shafts, which is good for safety.

After the site selection, there was a town meeting and several workshops with up to 350 participants. The project had a self review last July. A draft memorandum of understanding (MOU) for a JOG has been written. A life-cycle funding plan is being developed. The proposals for S4 are due January 9, 2009. There will be a review of the facility baseline plan in late January. An environmental impact statement and a geotechnical board review will be conducted.

$124 million has been dedicated to the South Dakota Science and Technology Administration (SDSTA). SDSTA began mine re-entry late July 2007. Dewatering began April 21, 2008. Beneficial occupancy of 4850L is scheduled for CY09. This process is decoupled from the MREFC process but integrated into DUSEL facility planning.

On a different topic, the European Union has AStroParticle ERAnet (ASPERA), which sets priorities and reviews the entire portfolio on gravity waves, cosmic neutrinos, underground physics, dark matter, cosmic rays, neutrinos, structure of the universe, polarization of the cosmic microwave background radiation, and the origin of the elements. At its most recent meeting, Carlo Rubbia said that the discovery of supersymmetry may be a real bonanza for the present (and future) colliders, but its relation to the now credible dark matter is by no means obvious or granted. Likewise, the neutrino sector may offer incredible new discoveries. Proton decay will never be observable with accelerators. Gravitational waves are about to be discovered in the laboratory and in space. Events from the sky and underground have an immense role to play in the future. Now that LHC is on the verge of operation, European physics and Conseil Européen pour la Recherche Nucléaire (CERN) [now Organisation Européenne pour la Recherche Nucléaire] have the obligation of concentrating some of the efforts and funding also on a broader range of other activities in the framework of a wider collaborative effort with the rest of the world. That is, essentially, what P5 has done. However, one does not know where the next clue will come from.

The ASPERA meeting last month brought together the European Union, United States, Canada, Russia, Japan, China, and India. The United States is very strong in astroparticle physics, but everyone agrees international collaboration is essential for the field. Multiple major discovery experiments allow each region to have a key role. In the case of underground activities, an international discussion group could identify the most cost-effective way to get science results and keep regions active in the field. This coordination could also be done more broadly [e.g., via the proposed Organisation for Economic Cooperation and Development (OECD) astroparticle physics activity]. This effort represents a multi-experiment, distributed international collaboration model different from the centralized CERN, International Thermonuclear Experimental Reactor, and Superconducting Super Collider models. This approach has an appropriate scale.

Shochet asked how long it would take to get down to the 8000-ft DUSEL level at the current pumping rate. Kotcher replied, about 2 years.

Wormser asked whether the LSST and DUSEL would compete with each other. Dehmer replied that both should get done. There is no clear resolution seen yet.

Kim asked what the response was when Shochet and Baltay presented the P5 report to the agencies. Shochet answered that the response was quite favorable and positive. People appreciated the details. Baltay said that the agencies [DOE, NSF, and the Office of Science and Technology Policy (OSTP)] were very appreciative. They also met with congressional aides. The responses from them varied. Dehmer added that the NSF senior leadership brought up all the hard questions, and the answers were on target and satisfied the questioners.

A break was declared at 10:15 a.m. The meeting was called back into session at 10:53 a.m., and **Hesheng Chen** was asked to discuss (by telephone) the HEP program in China.

The Institute of Modern Physics was established in 1950. Out of this Institute grew the Institute of High-Energy Physics (IHEP) in 1973. It is a comprehensive and the largest fundamental research center in China, with 1050 employees, two-thirds of whom are physicists and engineers. There are 400 PhD students and postdocs. The goal of the IHEP is to be a multidisciplinary research center. The major research fields at IHEP include particle physics, accelerator technology and applications, and radiation technologies and related disciplines.

The Beijing Electron Positron Collider (BEPC) at IHEP has undergone a series of upgrades; the construction of Phase III of the Beijing Spectrometer (BESIII) is completed, and it is running now. With BESI and BESII data, precision measurement of the τ mass has been improved by a factor of 10. Measurements of R have improved uncertainties by a factor of 2 to 3. And some new particles [X(1835)] have been observed, which are difficult to interpret as conventional hadrons.

Precision measurement requires high statistics and small system errors, prompting a major upgrade to BESIII between 2004 and 2008.

The BEPCII is a high-luminosity, double-ring collider with two rings in one tunnel. The beam intensity has been increased by a factor of 100. The energy range has been increased to 1 to 2.1 GeV; the optimum energy is 1.89 GeV; the luminosity is 10^{33} $cm^{-2}s^{-1}$; the positron injection rate is >50 mA/min with 93 bunches 1.5 cm long; the beam current is 0.91 A; and the synchrotron mode produces 250 mA at 2.5 GeV.

The BESIII detector has a superconducting magnet for momentum measurement and time-of-flight measurements. Detector installation was completed this April, and the detector was moved to the interaction region (IR) in May 2008, and joint commissioning started June 22. The first physics event was detected at BESIII on July 19, 2008. The main-drift-chamber noise problem was solved, and 10 million Ψ' events were collected for calibration. In collision mode, a beam current of up to 700 mA and a bunch current of more than 10 mA were achieved, and a luminosity that was 0.11 of the design value was reached. An effort is being made to increase the luminosity.

The physics being performed include precision measurement of CKM [Cabibbo-Kobayashi-Maskawa] matrix elements, precision test of the Standard Model, quantum chromodynamics (QCD) and hadron production, light-hadron spectroscopy, charmonium production/decays, and a search for new physics and new particles.

In the search for glueballs, lattice QCD (LQCD) predicts the 0^{-+} glueball mass in the range of 2.3 to 2.6 GeV. The mixing of the glueball with the ordinary qq meson makes the situation more difficult.

X(1835) was observed at BESIII with excellent signal-to-background. That significance can be increased with 2 years of running. A number of other charmonium states can also be investigated, and precision CKM measurements will also be pursued.

BESIII is collaborating with institutions in the United States (7), Europe (5), Japan (1), and China (24).

The precision measurement of neutrino mixing angle θ_{13} is being conducted with the Daya Bay reactor neutrino experiment. The Daya Bay nuclear power plant has four reactor cores, producing 11.6 GW; two more will be added in 2011 for a total of 17.4 GW. Because of the nearby mountains, it is easy to construct a laboratory with enough overburden to shield cosmic-ray backgrounds. Data-taking with the near–far configuration will begin in December 2010. A sensitivity of 0.01 is expected to be reached with 3 years of running.

To reach a sensitivity of 0.01 is a great challenge. Identical near and far detectors will be used to cancel reactor-related errors. Multiple modules will be used for reducing detector-related errors and cross-checks. Three-zone detector modules will be used to reduce detector-related errors. Overburden and shielding will reduce backgrounds. Multiple muon detectors will be used for reducing backgrounds and for cross-checks. The experimental halls are connected by a 3000-m tunnel. The signal rate will be about 1200/day at the near detector and about 350/day at the far detector. The backgrounds will be about 0.4% background/signal at the near detector, and about 0.2% at the far detector. The overburden will be about 350 m. An attempt is being made to push the schedule of the construction. Daya Bay has about 200 collaborators from North America, Europe, and Asia.

At the LHC, China has close collaborations with CMS [Compact Muon Spectrometer]; ATLAS [A Toroidal LHC ApparatuS]; LCG [LHC Computing Grid], Tier-2; LHCb [LHC beauty experiment]; and ALICE [A Large Ion Collider Experiment].

The institute is conducting R&D on superconducting cavities, dumping-ring design, positron source, detectors, and X-ray free-electron lasers (XFEL); many of these are also very useful for ILC R&D. The IHEP is providing funding of 8.5 million yuan renminbi (RMB) for superconducting cavities; some funds come from the Chinese Academy of Sciences and the National Natural Science Foundation of China in various ways.

There is a cosmic-ray observatory at Yangbajing. A new anisotropy component was observed in the sky and a co-rotation of galactic cosmic rays. The first big magnet in space was the Alpha Magnetic Spectrometer. A second magnet is under construction.

For the Chinese Moon project, a gamma and X-ray spectrometer was launched in October 2007. It scans the sky with high resolution. A hard X-ray sky survey with very high sensitivity will produce a high-precision hard X-ray full-sky map to discover highly obscured supermassive black holes and new types of high-energy objects (e.g., black holes, neutron stars, relativistic jets, and galaxy clusters).

As the Chinese economy grows quickly and steadily, the Chinese government is increasing its support to science and technology significantly and constantly. With construction of BEPCII/BESIII, the Shanghai light source, and the Chinese Spallation Neutron Source (CSNS), the new generation of Chinese accelerator and detector teams is growing fast, producing strong demands on the large accelerator facilities and the development of accelerator and detector technology. The Chinese particle-physics projects will, in the medium and long terms, pursue charm physics, international collaborations, particle astrophysics, cosmic-ray measurement, neutrino experiments, and the South Pole Dome A (a 4-m telescope). They will also work for the high-power proton accelerator, an advanced light source, and extending research fields.

The Space Variable Objects Monitor (SVOM) multi-wavelength gamma-ray-burst (GRB) project is a China–France collaboration. The main purpose is to measure the polarization of the gamma-ray flux.

The Polarization Observations of Large Angular Regions (POLAR) mission is scheduled for China's spacelab TG-2 to be launched in 2011 or 2012. Its field of vision is about half the sky. Its minimum detectable polarization (MDP) is 10%.

At Yangbajing, the high-mountain cosmic-ray measurement complex will expand the size of its detector by an order of magnitude, improving γ/p identification. The tentative design of the complex detector array calls for a 1-km^2 complex array for γ rays and cosmic rays >30 TeV and a 90-km^2 water Cerenkov detector for $\gamma > 100$ GeV.

Dome A is on the highest point at the South Pole, where the atmospheric boundary layer occurs as low as 9 m, observations are possible in 99% of the time, it is likely the driest place on earth, and it is the coldest spot on earth. The scientific program data will search for dark matter and the first light, time-domain astronomy, and extrasolar planets. Dome A will be the best site on earth for K-band observations because of its low temperature and thermal-background emission.

The Chinese Small Telescope Array (CSTAR), four 14.5-cm telescopes, each with a field of view 5°, is already in operation. The Antarctic Schmidt Telescope (AST3), three Schmidt telescopes, each 75 cm in diameter and a field of view of 3°, will be installed in November 2009. The Dome A 4-m-wide-field telescope is under serious study and would be highly complementary to the SuperNova Acceleration Probe (SNAP). The off-axis 8-m telescope is also under study for deep optical-IR surveys.

A very-long-baseline neutrino experiment from JPARC [Japan Proton Accelerator Research Complex] to Beijing is very interesting for many important physics, if $\sin^2 2\theta_{13}$ is not too small. There is a good tunnel 20 km north of Beijing near the highway to the Great Wall. It is 560 m long, 34 m wide, and 13 m high with 150 m of rock on top of it. Good infrastructure is available. It would provide a 2200-km baseline to JPARC with a 9.5^{o} dip angle. A second neutrino beamline is required.

Multidisciplinary research at the Beijing Sychrotron Radiation Facility; the CSNS; a high-current, slow-positron source; and the Beijing Advanced Light Source would investigate biological effects of nanomaterials, nuclear imaging and applications, protein structure and function, environmental topics with nuclear methods, and nanomaterial science.

Initially, the CSNS will produce 100 KW at the target and support seven spectrometers at Dongguang, Guangdong. Its proposal was approved at the end of September 2008. The feasibility study report is under way. IHEP is in charge of the project in cooperation with the Institute of Physics. It will be a branch of IHEP. It will have a budget of 1.4 billion RMB plus local funding. Construction and commissioning will take 7 years. This will be the next major project for the machine and detector teams after BEPCII/BESIII. The design and R&D are going smoothly. Many prototypes are undergoing testing.

The Institute appreciates the great U.S. cooperation and looks forward to more close cooperation between China and the United States.

Gary Feldman was asked to discuss the NOvA Experiment.

NOvA is a second-generation experiment on the NuMI [Neutrinos at the Main Injector] beamline, which is optimized for the detection of $\nu_\mu \rightarrow \nu_e$ oscillations. It will give an order of magnitude improvement over the Main Injector Oscillation Search (MINOS) in measurements of ν_e appearance and ν_μ disappearance. The detectors are "totally active" tracking liquid-scintillator calorimeters, sited off-axis to take advantage of a narrow-band beam. The NOvA project also includes accelerator upgrades to increase the Main Injector beam power from 400 to 700 kW. NOvA's unique feature is its long baseline (810 km), which gives it sensitivity to the neutrino mass ordering. NOvA is complementary to both T2K and Daya Bay. The Ash River site is the farthest available site from Fermilab along the NuMI beamline, maximizing NOvA's sensitivity to the mass ordering.

The basic detector element is liquid scintillator in a 4-cm-wide, 6-cm-deep, 15.7-m-long, highly reflective polyvinyl chloride cell. Light is collected in a U-shaped 0.7-mm wavelength-shifting fiber, both ends of which terminate in a pixel of a 32-pixel avalanche photodiode (APD). The APD has a peak quantum efficiency of 85%. It will be run at a gain of 100. It must be cooled to -15^{o}C and requires a very-low-noise amplifier.

These cells are made from 32-cell extrusions. Twelve extrusion modules make up a plane. The planes alternate horizontally and vertically. There are a minimum of 930 planes, for a total mass of 14 kT. There is enough room in the building for 18 kT, which can be built if half of the contingency can be preserved. The detector can start taking data as soon as blocks are filled and the electronics are connected because the detector is modular. The near detector will be placed in a cavern off of the MINOS access tunnel on the same off-axis line as the far detector. The event quality is determined by the longitudinal sampling of 0.15 X_0, which gives excellent μ–e separation.

In the neutrino section of the P5 report, eight questions were raised. NOvA addresses seven of these eight questions:

1. What is the value of θ_{13}? NOvA searches for ν_e appearance down to ~0.01 at the 90% confidence level.
2. Do neutrinos violate charge-parity? NOvA provides the first look at the CP-violating parameter, even at relatively small θ_{13}.
3. What are the relative masses of the three known neutrinos, normal or inverted? The ordering has important consequences for interpreting the results of neutrinoless double-beta decay experiments and for understanding the origin and pattern of masses in a more fundamental way, restricting possible theoretical models. The strategy for determining the mass ordering is: If the CP-violating term goes in the same direction as the matter effect, then there is no ambiguity, and NOvA can determine the mass ordering by itself, given sufficient integrated beam. If the CP-violating term goes in the opposite direction as the matter effect, then there is an inherent ambiguity, and NOvA cannot determine the mass ordering by itself. But that ordering can be determined, in principle, by comparing NOvA and T2K. If the neutrino oscillation probability is larger in NOvA than in T2K, it is the normal mass ordering; if the opposite, it is the inverted mass ordering.
4. Does θ_{23} have maximal mixing? Because of its excellent energy resolution, NOvA can make ~1% measurements of ν_μ disappearance using quasi-elastic

events. [A related question (which P5 did not ask) is, if θ_{23} is not maximal, does the third mass state couple more strongly to ν_μ or ν_τ? This question is not (easily) answerable by accelerator experiments alone, but can be resolved by comparing NOvA with a reactor experiment, such as Daya Bay, because NOvA measures $\sin^2(\theta_{23}) \sin^2(2\theta_{13})$, while Daya Bay measures $\sin^2(2\theta_{13})$.]

5. Are neutrinos their own antiparticles? NOvA cannot answer this question, but if NOvA establishes inverted hierarchy and the next generation of neutrinoless double-beta decay experiments see nothing, then it is very likely that neutrinos are Dirac particles.
6. What can we learn from neutrinos from a supernova? NOvA would see burst of 5000 events from a supernova at the center of the galaxy.
7. What can neutrinos reveal about other astrophysical phenomena? NOvA has nothing to say about this question.
8. Do sterile neutrinos exist? NOvA's fine segmentation allows for clean neutral-current measurements facilitating searches for sterile neutrinos

For NOvA, Fermilab stage-1 approval was granted in April 2005; CD-0 was granted that November; it received recommendations from the Neutrino Scientific Assessment Group (NuSAG) and P5 in 2006; CD-1 was granted in May 2007; it passed its CD-2/3a review in October 2007; its funding was zeroed out by the Omnibus Funding Bill of FY08; a supplemental funding bill restored $9.5 million in July 2008; CD-2 was granted in September 2008; and CD-3a was granted in October 2008 with $10.4 million for far-site preparation, $6.3 million for the accelerator and NuMI upgrade, $2.3 million for scintillator wave-shifters, and a $4.9 million contingency.

The far-site building design is converging toward a request for proposals in February. An external review of structure verified the buckling stability of a free-standing block. The lifting fixture and glue-machine prototype at Argonne are proceeding. The Minnesota factory started outfitting extrusions for a six-plane full-scale assembly prototype at Argonne, to be completed in February 2009. 4500 gallons of scintillator have been mixed, and the quality-control plan is converging.

A short set of extrusions is measuring cosmic rays at Cal Tech, exceeding the expectation of 25 photoelectrons. Offline software has been moved to a new unified framework. The effort is beginning to attract new students and postdocs and will form the basis for calibration studies. A preliminary engineering study and cost estimate of the near-detector cavern have been completed.

The Integration Prototype Near Detector (IPND) will give NOvA its first experience with all of the components of the experiment. Planning is continuing. The working prototype will be 3 modules high, 2 modules wide, and 124 planes long. It will sit in the MINOS support building 107 mrad off-axis to the NuMI beam to see narrow-band ν_μ and ν_e beams from kaon decay. The NOvA Calibration Committee is studying the advisability of also placing it in a test beam at Fermilab.

The restart after the supplemental appropriation has been slower than optimal, largely because of the difficulty of pulling back key personnel, who had been assigned to other projects. The schedule has probably slipped 12 months, compared to the schedule prior to the Omnibus Funding Bill. Future progress will, of course, depend on funding profiles. The best estimate of the schedule is for construction to start in April 2009, occupancy of the far-detector building in June 2011, the first 2.5 kT of the far detector to be online in August 2012, and the full far detector to be online in January 2014.

Shochet asked if any thought had been given to ways to minimize the impact if the continuing resolution goes another 3 months beyond March. Feldman answered that the schedule is not technically limited but does depend on a building existing.

Kovar asked if the construction contract might have to be renegotiated. Feldman responded that no funds have been allocated as yet, so there is no construction contract yet.

Scholberg asked if the construction of the detector could be sped up. Feldman replied that one could go to three shifts a day to speed up assembly and filling.

A break for lunch was declared at 12:21 p.m. The meeting was called back into session at 2:00 p.m. **Stephen Holmes** was asked to report on the status of the Fermilab proton source.

Fermilab is the sole remaining U.S. laboratory providing facilities in support of accelerator-based elementary particle physics. The Fermilab long-term strategy is fully aligned with the P5 plan. Project X gains a foothold in returning high-energy-physics excellence to the United States.

On the energy frontier, P5 recommended a broad accelerator and detector R&D program for lepton colliders that includes continued R&D in support of the ILC international effort and R&D for alternative accelerator technologies to permit an informed choice when the lepton collider energy is established. On the intensity frontier, it recommended an R&D program to design a multimegawatt proton source at Fermilab and a neutrino beamline to DUSEL and that Fermilab proceed with the upgrade of the present proton source by about a factor of 2, to 700 kilowatts.

Fermilab sees the evolution of the accelerator complex as going from the Tevatron to the ILC or Muon Collider and of the NuMI morphing into NOvA, a very-long-baseline experiment, a muon-to-electron conversion experiment, and a multimegawatt proton source. The initial stages would be supported by the accelerator and NuMI upgrade (NOvA) to 700 kW. In the Fermilab view, the most effective implementation of a multimegawatt proton facility would be based on a superconducting 8-GeV linac, which would provide alignment with ILC technology development and flexibility for the future. The proton accelerator is also known as Project X.

The initial configuration is geared to the mission need, which has three legs:

- A neutrino beam for long-baseline neutrino-oscillation experiments, in which a new 2-MW proton source with proton energies between 50 and 120 GeV would produce intense neutrino beams.
- Kaon- and muon-based precision experiments exploiting 8-GeV protons from Fermilab’s Recycler, running simultaneously with the neutrino program, which could include a world-leading muon-to-electron conversion experiment and world-leading rare-kaon-decay experiments.
- A path toward a muon source for a possible future neutrino factory and, potentially, a muon collider at the energy frontier, which would require that the new 8-GeV proton source have significant upgrade potential.

The design criteria call for 2 MW of beam power over the range of 60 to 120 GeV; at least 600 kW of beam power at 8 GeV; and compatibility with future upgrades to 2 to 4 MW at 8 GeV. It would run at 20 mA for 1.25 msec at 5 Hz.

A provisional site has been selected on the Tevatron infield.

Seven beam pulses would be produced every 1.25 seconds, but only two are needed; the other five would be available for other uses.

The primary goal of the research, design, and development (RD&D) program is to support CD 2 in 2012, leading to a 2013 construction start. This program would entail design and technical component development; a fully developed baseline scope, cost estimate, and schedule; and the formation of a multi-institutional collaboration capable of executing both the RD&D plan and the follow-on construction project. The secondary goals would be the coordination of Project X and ILC superconducting radio frequency (SCRF) programs to provide maximal benefit to each and retaining the alignment of Project X and the Neutrino Factory and Muon Collider programs to assure that Project X could serve as a stepping stone to either facility. The current Fermilab cost estimate is about $100 million (fully burdened) through CD-2.

An Initial Configuration Document (ICD) is being developed to meet the design criteria and program goals. The current RD&D Plan is being revised and updated on the basis of the ICD. The existing plan is being revised to emphasize the reduction of risk. An initial re-edit will be available for the November collaboration meeting. A preliminary cost estimate is being created on the basis of the ICD and will be available in early 2009.

An effort is being made to establish a multi-institutional collaboration for the RD&D phase, in which Fermilab holds overall responsibility as host laboratory; a maximal alignment is achieved with institutional expertise and experience; recognition is made that it would be natural for responsibilities to carry over into the construction phase. CD-0 is hoped for in FY09 which would likely require an independent review and would be coordinated with the very-long-baseline and muon-to-electron projects on the basis of the ICD, preliminary cost estimate, and P5 mission definition.

The working timeline calls for, in FY09, the completion of the ICD, the development of the upgrade concept for 2 to 4 MW at 8 GeV, the formation of an RD&D collaboration, the establishment of a project management team, the revision of the RD&D plan, the initiation of work, completion of a preliminary cost estimate, completion of a mission needs statement and a mission need independent review, receiving CD-0, requesting project engineering and design funds for FY11, initiating work on a conceptual design report, and developing a National Environmental Protection Act (NEPA) strategy. All of these can largely be accomplished under the FY09 (half-year) continuing resolution.

For FY10, the timeline calls for alternative implementation studies, the initiation of an Environmental Assessment and of permitting documentation, and the production of a draft of all CD-1 documentation.

In FY11, it calls for CD-1. In FY12, it calls for CD-2/3a. In FY13, it calls for CD-3. And from FY13 to about FY17, it calls for construction.

The facility has a front-end superconducting linac, operates at 325 MHz, uses spoke resonator cavities and 38 ILC-like cryomodules. The ILC cryomodules would have a gradient of 25 MV/m, a beam current of 20 mA × 1.25 msec × 5 Hz, and a quadrupole element in each cryomodule to make it consistent with the upgrade path. There will be close coordination between Project X and the Global Design Effort (GDE) of the ILC during the development phase. The strategy will be based on ILC "plug compatibility" and will retain the ILC cavity spacing and primary interface dimensions.

The production of the 38 ILC-like cryomodules in the United States over a 2- to 3-year period is consistent with cryomodule-assembly-facility capabilities circa 2013; however, the production rate remains well *below* that required by ILC.

The High-Intensity Neutrino Source (HINS), with a 60-MeV front end operating at 27 mA × 1 msec × 10 Hz, will demonstrate novel technologies for a high-intensity nonrelativistic linac, will establish technical feasibility and cost basis by about 2011, and will be integrated into the Project X R&D effort at the time of CD-0. An integrated SCRF plan has been developed.

Project X shares many features with the proton driver required for a Neutrino Factory or Muon Collider. The *International Design Study for a Neutrino Factory* shows 4 MW at 10 ± 5-GeV proton energy. The Muon Collider requires a similar power but requires the charge to be consolidated into a single bunch. There is a natural evolutionary scheme through neutrino superbeams: NOvA to very long baseline to neutrino factory to muon collider.

Fermilab is trying to align itself with muons and to develop an upgrade concept for the Project X linac, aimed at 2 to 4 MW. The ICD includes such a concept (up to 4 MW). A performance specification is being developed for a proton driver supporting a Neutrino Factory and Muon Collider, consistent with Project X concepts. The issues are average beam power, repetition rate, particles/bunch, and bunch intensity. These issues are likely to require a new storage ring downstream of the linac. A conceptual design is being developed for the Neutrino Factory/Muon Collider Proton Driver on the basis of the Project X linac and downstream accumulation/packaging ring(s).

The intention is to organize and execute the RD&D Program via a multi-institutional collaboration. The goal is to assign collaborators complete subprojects along with responsibility for design, engineering, cost estimating, and potentially construction if/when Project X proceeds. The Project X R&D Collaboration is to be established via a series of MOUs that outlines the basic goals of the collaboration and the means of organizing and executing the work. It is anticipated that the Project X RD&D program will be undertaken as a national project with international participation. The expectation is that the same structure of MOUs described above would establish the participation of international laboratories. A draft MOU has been circulating for comment among the potential U.S. laboratory collaborators. The hope is to finalize/sign it at the initial Project X Collaboration Meeting on November 21–22, 2008, at Fermilab.

In summary, Project X is central to Fermilab's strategy for the future development of the accelerator complex. It is aligned with ILC technology development and preserves Fermilab as the potential site for the ILC or a Muon Collider. The ultimate goal is a 2-MW beam to a very long baseline neutrino experiment and >1 MW to rare-process experiments. It preserves Fermilab as a potential site for a Neutrino Factory. An initial configuration has been established meeting requirements as specified in the P5 report. The initial configuration can be upgraded to 2 to 4 MW at 8 GeV. A Project X RD&D plan has been developed that integrates the effort on Project X, ILC, SCRF, and HINS. A collaboration is being formed.

Wormser said that it would be good to discuss having a collaboration with the XFEL. Holmes agreed. Wormser asked if meeting the deadline would require work to be done in parallel. Holmes said that that is to be determined.

Helen Quinn joined the meeting by telephone to report on the informal demographics group. The group has been working since about 1999. Its goal is to understand the flow of young people into and out of the field of high-energy physics. Some of the challenges faced include accessing and analyzing the data from the Lawrence Berkeley National Laboratory (LBNL) database and collecting the relevant data. Some progress has been made in these areas. The database has been ported to a more modern form, and new fields have been added to track more information, such as where a person has moved to and the person's gender.

Error-checking reviews are being conducted on the data from 2006 to 2008 to find and correct common errors. The group doing these reviews suggests the establishment of an individual identifier number to follow individuals. In addition, definitions change as the field evolves; today it is unclear how to count particle astrophysicists.

The system effectively relies on the continuity of cooperation of individuals who are entering the data. If the community sees no feedback, there is little motivation to comply. There is a high incomplete-response rate even after multiple requests for compliance. In addition, external error checking is time consuming but finds many errors, even after the internal error checks are done. As a result, the uncertainties of the numbers of interest are still large. These include uncertainties on who went where. At transitions, it is difficult to follow people. Faculty populations are relatively stable. The number of graduate students is going up. The percentage of females getting PhDs is going up. The error checking has a large influence on the numbers of students perceived to be moving out of the field. On the first pass, about 50% of the submissions required an external check. On the second pass, this value was 5 to 10%.

In 2008, of the people going out of graduate school, 69 followed a physics career path, 34 left the country, and 231 went into other categories of employment. Of those staying in high-energy physics, 45% of the graduate students were in theory, and 40% were in experimental physics; 61% of the postdocs were in theory, and 53% were in experiment physics. Is this a pattern that is wanted? Of those leaving, the largest class is that for which no data are available.

After 10 years of "oversight," the group still cannot really answer the original questions. We must understand by whom this work is valued and for what. Clearly, this effort needs ongoing external oversight, but whose responsibility is that?

There needs to be better data collection, improved data cleaning, formal oversight, and a cross-checking responsibility. Further, a report needs to be circulated to the community every year, not just to HEPAP.

Cahn asked if anything were being done with these data. Quinn wondered what these data do for the field as a whole. Are they relevant to DOE and NSF? Kovar said that he would have to get feedback from the OHEP staff. In NP, such data were collected, and they were of benefit to DOE. Part of this process is knowing how many postdoctoral fellows are being supported. It is important to know what will happen if funding declines. People who leave the field are often lost track of. These data are also needed to know about the quality of postdoctoral education. Generally, it is the people who are unhappy who are most likely to respond.

Shochet noted that, when one goes to Congress for funding, one is asked about the importance of a technologically trained workforce, and hard data would be helpful in responding to such questions.

Kovar stated that this is an important issue despite the fact that these are difficult data to collect.

Bagger asked if NSF had anything to add. Goldberg replied that these data go into an annual report by NSF and are used to underscore the value of the field to industry. He added that, if these questions were included in the next funding request form, all the questions would be answered. One could ask each PI where his or her people have gone. Shochet added that that approach could also influence institutions to respond. Kovar requested a list of the DOE-supported nonrespondents so he could send them an e-mail.

Quinn observed that the question of continuity is the most difficult one to deal with. Bean said that finding a way to publicize this information in the community may help get responses. Quinn said that there also needs to be an established deadline for providing the data.

A break was declared at 3:19 p.m. the meeting was reconvened at 3:45 p.m. **Barry Barish** was asked to discuss the present status of the ILC Global Design Effort (GDE).

The Reference Design Report has been published in four volumes, all conceptual. The next step is a technical design phase to (1) complete crucial R&D to reduce technical risk, (e.g., the SCRF gradient, final focus, and electron cloud); (2) optimize the ILC design for coherence, simplicity, and cost/performance; and (3) develop a capability to industrialize, construct ILC worldwide, and develop an international model for governance. This is the Project Implementation Plan.

Without warning, severe budget cuts occurred in the United States and the United Kingdom this past year. In the United Kingdom, support was preserved for key scientists and their teams, but the broader program [40 full-time equivalents (FTEs) to about 15 full-time equivalents] was lost. This was very serious because the United Kingdom had invested in accelerator science and attracted back the best scientists in the world. In the United States, the FY08 budget was reduced to $15 million, which was essentially already spent last December. The U.S. program has effectively been on hold for 9 months. The global program has impressively moved on in the face of these devastating problems because the core of the program is focused on large R&D facilities and global coordination and because collaboration increased toward prioritized goals.

This year, the R&D Plan was released in June. It is a 50-page document with details of all the programs and schedules (planned to be updated each 6 months).

A big piece of the program is SCRF research. A nine-cell-cavity R&D program is being put together. The gradient has been improved by ethanol rinse, surface processes, and differently shaped cavities. For this process, an optical-inspection system has been developed in Japan and is in use at DESY [Deutsches Elektronen-Synchrotron]. The technical design phase is expected to extend to 2012. It will include cavity-gradient R&D to address process yield and production yield, a cavity-string test, and a system test with a beam.

Plug compatibility has been a big deal this year. R&D is needed to improve the gradient performance. Improvement comes from some change (e.g., in cavity type, material, surface treatment, tuner type, or input-coupler). This improvement can allow optimization of costs, but maintenance may be very complicated.

The 9-mA test allows evaluation of energy stability to <0.1% with high beam loading, operation close to cavity limits, low-level-radio-frequency performance, the development of a higher-order-mode absorber (cryoload), and controls development.

The STF-2 [Superconducting Test Facility] setup has one power source, two cavities, and three cryomodules. SCRF has other purposes than high-energy physics accelerators (e.g., the pharmaceutical industry is using the technology).

The damping ring R&D is looking at a flexible race track design with a 6.4-km circumference with >1-km straights, which contain RF, wigglers, chicanes, and injection/extraction systems. Two critical components require a successful demonstration: fast injector/extractor kickers and suppression of the electron cloud in the positron ring. The fast kicker is being worked on at SLAC; Lawrence Livermore National Laboratory (LLNL); Diversified Technologies, Inc. (DTI); Istituto Nazionale de Fisica Nucleare–Laboratori Nazionali di Frascati (INFN–LNF); and the High Energy Accelerator Research Organization (KEK). Tests in DAFNE (Double Annular Factory for Nice Experiments) and the Accelerator Test Facility (ATF) are driven by machine-upgrade plans (efficient beam injection for DAFNE and a 30 to 60 multibunch train to the ATF2 beam line) but are directly relevant for the damping-ring R&D program.

In electron or proton storage rings, low-energy electrons are accelerated by the high-energy beam into the wall of the vacuum chamber, where more electrons are emitted, leading to the formation of an electron cloud. For the ILC damping ring, the electron cloud must not blow up the positron-beam emittance. This topic is studied through simulations. Ways to mitigate this problem are known and need to be extrapolated to the ILC. This work is being done at the Cornell Electron Storage Ring (CESR). The goals are to understand cloud buildup, interaction of the cloud and the beam, cloud-buildup validation and cloud dynamics, and cloud-suppression techniques.

The accelerator R&D is being done at KEK with the ATF with a large worldwide collaboration. The facility is being commissioned this fall. The beam-delivery system is being studied to demonstrate a near-50-nm beam spot by 2010; stabilize the final focus by 2012; and assemble broad international collaboration for equipment, commissioning, and R&D.

"Minimum Machine" refers to a set of identified options (elements) that may simplify the design and be cost-effective: the klystron-cluster concept, central region integration, the low-beam-power option, a single-stage compressor, quantification of the cost of TeV-upgrade support, value engineering, and the single-tunnel solution(s). These elements are intertwined, allowing R&D to be simplified, saving 5 to 10% of the cost.

The two-tunnel approach is expensive, so two alternative approaches are being looked at: shallow sites and a single tunnel.

The klystron cluster concept is also being considered, in which RF power is piped into the accelerator tunnel, the service tunnel is removed, and access to the klystrons and modulators is maintained. R&D is needed to demonstrate power handling.

The interaction-region and detector designs need to be optimized to ensure efficient push–pull operation, and agreement is needed on the machine-detector division of responsibility for space, parameters, and devices.

A project-implementation plan is expected to be produced as a companion to the project plan. A group has been formed to look at governance and project structure.

Finance models, in-kind contributions, and globally distributed mass production also need to be studied.

Five ILC–Compact Linear Collider (CLIC) working groups were formed in 2008 to optimize the use of resources in civil engineering, beam-delivery systems, detectors, beam dynamics, and cost and schedule. Two new groups will be added on positron sources and damping rings.

The U.S. program was turned off last December. An effort is being made to maintain a program that follows P5's recommendations. The continuing-resolution supplement allowed the program to continue.

Following the P5 recommendations, the ILC R&D program of the U.S. ILC FY09 baseline budget was established at $35.3 million. This amount was reduced to $29.5 million because of the continuing resolution. This level is an effective rate of 84%, which is equal to the overall reduction in OHEP funding. This is sufficient to restart. Guidance at this level was sent out at the start of FY09, and work is now ramping up at the national laboratories. The CESR TA [Test Accelerator], a skeleton SCRF gradient program, and certain elements of the GDE program were maintained with NSF funding. Current planning assumes that the continuing resolution goes away in March. The $35.3 million for FY09 would go to nine institutions.

Because of the continuing resolution, money was held back at Fermilab from labor, and funds were reduced in materials and supplies (M&S). At SLAC, the manpower ramp-up was delayed, and M&S was reduced.

The global ILC R&D program has proven resilient to the budget crisis. The technical design phase is now under way and will culminate in 2012 with the completion of crucial R&D and optimization of cost, performance, and risk design. The U.S. ILC program is being re-integrated, but it needs to develop a long-range strategy. Collaborative work with CLIC is strengthening the effort and will help prepare for an ILC proposal if the science case is justified by LHC.

Tigner asked what the integrated plan would look like. Barish replied that the United States would like to host the machine. That activity is not included in the current plan, but P5 says that that option should be kept open. An integrated plan would lay out a strategy to keep that option open.

Hasan Padamsee was asked to discuss SCRF R&D.

RF has become a core technology in HEP, NP, Basic Energy Sciences, and other users of high-intensity proton sources. The community meets each year, the Tesla technology collaboration meets each 6 months, and the ILC collaboration meets monthly. The national laboratories that have SCRF capabilities are Argonne National Laboratory [ATLAS and Facility for Rare Isotope Beams (FRIB)]; Brookhaven National Laboratory [Electron–Relativistic Heavy Ion Collider (eRHIC) and RHIC-II]; Cornell University [CESR/Cornell High-Energy Synchrotron Source (CHESS), the Energy Recovery Linac (ERL), and ILC]; Fermilab (ILC and Project X); Jefferson Laboratory [the Continuous Electron Beam Accelerator Facility (CEBAF), ILC, and the Electron Light Ion Collider (ELIC)]; Michigan State University (ReAccelerator and FRIB); and Oak Ridge National Laboratory (SNS).

Examples of cavity shapes include Tesla, low-loss, and re-entrant. As the velocity of the particle goes down, drift tubes of various designs are used. Crab cavities can also be used to deflect the beam. Closely related technologies are also present in the cryomodules.

Common issues for all SCRF applications include

- Niobium material control
- Good fabrication procedures (the key element is electron-beam welding)
- Good surface preparation procedures (chemical treatment, furnace treatment, high-pressure rinsing, and clean-room assembly)
- Operation (accommodation of a gradient distribution for maximum energy gain and reliability of operation with a very low trip rate)
- Production and testing capacity/rate of cavities and cryomodules

Likely U.S. upcoming projects call for more than 1000 cavities and 150 cryomodules. There is a need to broaden the industrial base for cavities and cryomodules. The industrial capability in Europe is strong and growing; in the United States it is developing slowly; and in Asia it is growing.

Niobium is common to all projects. The basic material specifications for good cavities have been defined, and the starting-material quality-control procedures have been developed (residual resistance ratio, grain size, yield strength, and eddy-current scanning to screen out defects). A new development is large-grain material, which holds the possible advantages of cost reduction and skipping intricate electro-polishing. However, it is not valid for the highest gradients, some fabrication issues still need to be worked out, the overall performance is the same as that for small-grain, and using a single crystal is too hard for mass production.

The outstanding issues for the highest-gradient applications are the gradient yield at 35 MV/m is low, the gradient spread is high, and the best nine-cell cavities are not known.

There has been improvement in the gradient yield this past year (from 27% to 40%). But this is far from the target of 90% in 2012. The yield has improved because of field-emission reduction. Some success has been accomplished in identifying sources of quench: the current goes around pits or bumps or rough spots in the surface. Pits get hot and lose their superconducting properties.

Outstanding issues for other continuous-wave applications with a medium gradient include

- High Q_0 and high Q_{ext} .
- If $Q = 10^{10}$ at 2 K, 450 cavities are needed. This number is reduced by a factor of 10 if $Q_0 = 10^{11}$ at 1.6 K.
- Does higher Q outweigh the increased refrigeration cost from 2 K to 1.6 K?
- Need excellent shielding for Earth's magnetic field in a cryomodule.
- If beam loading is negligible, only RF power is needed to reach the operating field.
- Operation at the highest Q_{ext} allowed by microphonics would reduce RF power demand to <5 kW per cavity.

For high-intensity proton applications, the challenges include the flexibility needed to make optimal use of the gradient spread, the online gradient distribution, beam loss, and reliability.

One question is whether niobium is the end of the road for superconducting-cavity material. Experimentally, the answer is no. A new approach goes beyond the Ginzburg–

Landau predictions and theoretically calculates the maximum possible H_{sh} from advanced formulations of BCS theory for perfect samples of Nb_3Sn and MgB_2 at realistic operating temperatures. The method indicates gradients of 120 MV/m for perfect Nb_3Sn and 200 MV/m for perfect MgB_2. However, it is only valid for high-kappa materials.

A program to develop such materials should be strongly advanced.

Shochet asked how much of the R&D is being done as part of specific projects. Padamsee replied that, in terms of basic R&D, the high gradient is pushing it. There is almost nothing but the theory.

Trischuk asked if there had been a push to bring in experimentalists to address this question. Padamsee answered that a lot of people are working on SCRF, but almost nobody is working on this more esoteric work. More money is needed to attract people to these questions. In the case of niobium, it is medium-term work (5 years); in niobium–tin, it is much longer.

Crawford noted that there is a solicitation outstanding to address a lot of these questions, but funding will depend on Congress. Kephart added that the university program, NSF, and DOE researchers are working on these topics, and they are having workshops to exchange information, but coordination is lacking.

Shochet asked **Dennis Kovar** to explain the NASA/DOE JDEM process.

Since about a year ago, NASA, DOE, and OSTP have been meeting twice a month to discuss cooperation. A Figure of Merit Science Working Group was formed to update the work of the Dark Energy Task Force. A Science Coordination Group was formed to lay out the top-level science requirements. A Letter to the Community regarding the draft contents of the Announcement of Opportunity (AO) was released on November 3, 2008. And DOE and NASA signed a JDEM MOU on November 7, 2008.

NASA should lead the overall mission. DOE wants to participate in the science instrumentation, operations, and data analysis. It will not participate in mission-level components. For the hardware contributions, DOE will need clean interfaces and will follow its own procurement practices. As is typically done, a project manager will be assigned for DOE's deliverables. DOE plans to provide about $200 million in FY08 dollars to the JDEM project for construction and operations.

Letters have been exchanged between Edward Weiler and Raymond Orbach, and DOE and NASA have agreed to partner in a JDEM, a medium-class strategic mission with a competitively selected, PI-led dark-energy-science investigation with a science payload that includes a wide-field telescope and appropriate focal-plane instrumentation. Cost control will be a central tenet of JDEM project management and mission design.

The selected PI-led science investigation team will perform the dark-energy-science investigation. The selected team will not provide flight hardware.

The Government will provide the mission-level components, including launch services and the spacecraft bus, as well as the science payload. DOE and NASA will partner in the fabrication of the instrumentation necessary to execute the dark-energy-science investigation. Both agencies will contribute to the science operations and data-analysis activities.

The specific responsibilities of each agency will be detailed in an Implementation Agreement that will be established after the competitive selection of the dark-energy-science investigation that defines the mission architecture. DOE and NASA will each contribute funding as necessary to fulfill the particular responsibilities each agency agrees to accept. Each Agency will use its normal procurement rules in the construction of its contributions. A public release of JDEM data will occur after an appropriate period of time following its acquisition. In consultation with DOE, NASA will investigate the possibility for international contributions. As the lead U.S. agency, NASA will be the principal point of contact for the JDEM project in negotiating and executing any international partnerships with foreign space agencies. There will be joint participation in the selection of the principal investigator-led dark-energy-science investigations and in the construction and operations of JDEM.

A JDEM Project Office (PO) has been established at Goddard Space Flight Center. This Office has overall management responsibility for the mission and will interact closely with JDEM scientists during all phases of the mission. DOE has set up a PO at LBNL that will work within the framework of NASA's PO.

A Science Working Group (SWG) was convened by DOE and NASA in June 2008. The Chair is Rocky Kolb. The purpose of this SWG is to continue the work of the Dark Energy Task Force (DETF) in developing a quantitative measure of the power of any given experiment to advance knowledge about the nature of dark energy. The DETF did an outstanding job, but with passage of time, the community recognized that the original figure of merit (FoM) may no longer be optimum. The JDEM SWG has been charged to

- Update or replace the original DETF's FoM with a new, superior measure or measures of the scientific power for advancement in our knowledge of dark energy. This measure will presumably be a function of the accuracies that any given experiment can provide for a set of parameters associated with the dark-energy equation of state.
- Determine a threshold value for this measure
- Attempt to minimize bias toward a particular methodology or theory

The initial findings were presented to the agencies on Sept. 25, 2008, and to the Astronomy and Astrophysics Advisory Committee and JDEM Science Coordination Group in October. The final results will be available by the end of November.

A letter to the community with draft information about the AO was posted November 3, 2008, on the JDEM website. The notice was also sent out over the listserve of the Division of Particles and Fields of the American Physical Society and to national laboratory directors and grant PIs. It is anticipated that the AO will solicit six types of proposals:

- Dark-energy baryon-acoustic-oscillation (BAO) science investigations using the relevant JDEM data set;
- Dark-energy supernovae (SN) science investigations using the relevant JDEM data set;
- Dark-energy weak-lensing (WL) science investigations using the relevant JDEM data set;
- Dark-energy science investigations based on other techniques, using the relevant JDEM data set;
- A leader for the JDEM SWG; and
- Interdisciplinary non-dark-energy science investigations using the relevant JDEM data set.

It is anticipated that the PIs selected under this AO, plus possibly one or two co-investigators proposed by each PI, will constitute the JDEM SWG. The JDEM SWG will work with the NASA JDEM PO and the NASA Project Scientist (Neil Gehrels) in the design, development, and operation of the JDEM observatory. All members of a selected science investigation team will have access to the JDEM data necessary for the execution of their proposed science investigations.

The proposers will describe their dark-energy-science investigation using the JDEM Reference Mission pre-conceptual design. Subsequent to the AO-based selection of the JDEM SWG, the JDEM design may evolve from the Reference Mission. The AO will require proposers to use the methodology defined in the JDEM FoMSWG report to document the relevant figures of merit of their proposed investigation and thereby quantify its science performance. JDEM data, including suitable calibration and processing tools, must be made available to the public within one year following data acquisition.

The JDEM MOU was signed in early November. A press release will come out soon, and the MOU will be posted on the JDEM website. The agencies continue to investigate international participation. By the end of 2008, NASA will release the AO, jointly written with DOE, which will be an open solicitation for proposals for PI-led dark-energy investigations using the JDEM facility. A letter to the community will be released and will provide advance information regarding the AO. In January 2009, Phase A starts, and the JDEM POs at DOE and NASA will develop a proposed split of the scope of work and present it to the agencies for approval. During the summer of 2009, the selected investigations will be announced, and the PIs and their collaborators will work with the JDEM POs at both agencies throughout the development of the mission and will execute the dark-energy-science investigations after launch and commissioning. Launch is expected in the middle of the next decade.

Shochet asked who would optimize the mission for scientific output. Kovar replied that it will happen in two stages. The first stage will be a scientific coordination group's looking at whether the design will produce the science. Later, discussions between the PO and the SWG made up of the PIs selected will lead to the decisions.

Cahn noted that the DOE commitment was $200 million and wanted to know what the NASA commitment was. Salamon replied that it is $800 million.

Kahn asked how cooperation between NASA and the European Space Agency (ESA) would be factored in. Salamon answered that NASA is discussing cooperation with Euclid (an ESA mission to map the dark universe) during a meeting the following week. The hope is to get a good idea where each agency is heading and whether collaboration is possible. Any foreign collaborator can be involved in any proposal but not without a partner. JDEM and Euclid could move forward independently.

Gladney asked how these teams are going to work and whether a large team can propose addressing multiple goals. Salamon responded affirmatively and that individual members from a team can submit their own additional proposals.

Cahn asked whether foreign participants might contribute funding. Salamon replied that they could but that the cost policy is uncertain, so it is unsure how such a contribution would alter the overall funding.

Burchat asked what the scientific coordinating group was doing. Kovar replied that they are working with the NASA-Goddard science group. There has been close and useful cooperation.

Cahn asked how one would make a commitment of ground-based observations. Salamon answered that it is not known when the LSST will go online, so it is not known how that commitment will happen. Getting an institutional agreement will be similar to getting the foreign commitments.

Kahn asked at what stage funding would be tracked and whether it would come through the Laboratory Directed Research and Development Program (LDRD). Kovar responded that, in DOE, there will be an MIE [major items of equipment] for construction and use of hardware. The clock will start ticking with the CD-0. There will also be support for other activities (e.g., the program offices). But not all of these will count toward the $200 million cap. At some point when the path is clearly defined, the funding will start being tracked very carefully.

Cahn asked what criteria would be used to select the projects. Salamon answered that that will be in the AO.

Levi noted that there is an intensive process to make this happen. The scientific community has to come together to make sure that the best science return is obtained.

Shochet stated that clarifications are needed because the OHEP did not know how to parse the language of the announcements. Levi agreed that more questions and communication are needed.

Perlmutter asked how the people who are building instruments will interact with the teams. Levi answered that it is critical that scientists are in contact with those who are bending the metal. Salamon added that NASA is providing an entire launch and payload. The selection of the science team will impact the science of the mission. Perlmutter asked again about the scientist builders. Salamon said that NASA often collaborates with scientist builders but that is not the case here. The agency will take responsibility for all the instruments. Kovar said that he could not imagine DOE doing things much differently then it had done before.

Kahn asked whether the payload might be contracted to universities by NASA. Salamon said that that is possible but seems unlikely.

The meeting was adjourned for the day at 6:04 p.m.

Friday, November 14, 2008
Morning Session

Chairman Shochet called the meeting to order at 8:46 a.m. **Lyndon Evans** was asked for an update on the LHC. One billion people watched the startup of the LHC.

The machine was precooled from room temperature to 80K with 1200 tons of liquid nitrogen (64 trucks of 20 tons each). It took three weeks to cool down the first sector. Seven out of eight sectors were fully commissioned for 5-TeV operation, and one sector (3–4) was commissioned up to 4 TeV. The team was well prepared. The beam was taken in a clockwise direction and stopped and corrected at each obstacle. A circulating beam was quickly established. Then the RF was turned on. The injected bunch was about a nanosecond long.

In a proton storage ring, there is no synchrotron radiation damping, so noise in the RF system is a crucial issue. A lot of noise-reduction work was necessary to produce an excellent RF system. Klystrons are noisy but are needed for the high frequency. A closed orbit was established by correcting an energy error of about 0.9 per mil.

Trouble came on September 19. The sector that had not been commissioned to 5 TeV had a failure of a busbar splice, arcing to ground and burning a hole in a pipe. There were 600 MJ in the machine. There were 200 MJ missing from the shutdown dump and must have been lost near the short. Each sector has a set of vacuum barriers. When the pressure rose, 30 tons of lateral pressure hit those barriers, producing more physical damage: the anchors of the barriers were ripped out of the concrete floor.

There are 10,000 busbar splices in the machine, and there is no way of testing them warm. They are taken into the cryolab to be tested. The busbar failure mechanism is not known.

A task force analyzed the failure. Recommendations made by the task force aim at two different goals, namely to prevent any other occurrence of this type of initial event and to mitigate its consequences should it ever reproduce accidentally. Possible precursors of the incident in Sector 3–4 are being scrutinized in the electrical and calorimetric data recorded on all sectors, in order to spot any other problem of the same nature in the machine. An improvement of the quench-detection system is under way both to generate early warnings and interlocks and to encompass magnets, busbars, and interconnects. The relief devices on the cryostat vacuum vessels will be increased in discharge capacity and in number, so as to contain a possible pressure rise to below 0.15 MPa absolute even in the presence of an electrical arc. The external anchoring of the cryostats at the locations of the vacuum barriers will be reinforced to guarantee mechanical stability.

Before the initial startup, a few watts of excess power were detected in the busbar as it was cooled down, but the significance of that excess was not appreciated at the time. Microcalorimetry can be used to monitor the performance of the busbars as they are cooled.

There are about 22 dipoles to be changed out and refurbished. The whole sector is now warm, and the repairs are under way. The dipoles will be taken down the week after this meeting. The concrete work will be done over the holidays. The detectors are scheduled to be ready the beginning of May. It is not known if a beam can be brought up by that time.

A key question is, when a beam *is* established, how long will it take to get up to a luminosity of 10^{34}? In 5 years or so, the machine will need to be upgraded to increase the luminosity by, say, a factor of 2. This upgrade can be accomplished with current technology. A modern injector like the stripper injector at Fermilab will allow the superpositioning of bunches to increase the luminosity. Design studies for this upgrade are going ahead. A balance will have to be struck between the luminosity and the luminosity lifetime.

During early operation and the first upgrade phase, peak luminosity will increase slowly from 2009 to 2016 and then level off at about 3×10^{34} cm^{-2} sec^{-1}. With new injectors and the interaction-region upgrade, the peak luminosity will rapidly increase between 2017 and 2020 to about 10×10^{34} cm^{-2} sec^{-1}. After that second upgrade phase, the integrated luminosity will increase at a correspondingly faster rate.

Shochet asked if they had studied the possibility of ground-loop induced noise with their proposed mitigation. Evans replied that they were quite surprised with the low noise level. It was down to the level of 2 to 4 μv. Work is proceeding with a prototype card so that it can be tested and then put into production to continue to mitigate this problem.

Rosenberg asked what the situation was on the quadrupoles. Evans answered that the quadrupoles always contain a correction package. A compromise will have to be struck in a few situations.

Kephart asked if it were understood why the pressure rise was so large. Evans responded that it may have been caused by arc heating from the beam-derived energy loss. This possibility was unseen.

Michael Tuts was asked to update the Panel on the status of ATLAS. The ATLAS Detector is made up of magnets, a muon system, an inner detector, calorimeters, and a trigger data-acquisition system (TDAQ). It is a huge collaboration, about 20% of which is from the United States (600 people).

Recently, the full computing chain was checked in the first full dress rehearsal, the beam pipe was closed, a second full dress rehearsal was completed, and the detector was readied for first beam. Work on the detector included testing the magnet system, re-installing and debugging the inner-detector evaporative-cooling plant, commissioning the inner detectors, fixing assorted calorimeter problems, completing the forward muon system, commissioning the resistive plate chamber (RPC) system, performing the final installation of the luminosity detector (LUCID), buttoning up the detector, taking cosmics and first-beam data, and starting the shutdown activities.

The toroids and end-cap toroids are now operating stably at 20.4 kA. An on/off cycle takes about 5 hours. The inner detector evaporative cooling system compressors had failed earlier, and seven have been repaired, causing a delay of about 3 months. As a result of that delay, the pixels had little commissioning time before close-up. There are about 200 cooling loops in the detector. Some minor leaks were detected and are being repaired. The detector is operating with less than 1% dead channels, well within specifications.

The Level-1 system is fully installed. Much has been done with cosmics and splash events, but colliding beams are needed for some aspects. In the L2 and high-level trigger, about 35% of the system is installed. More than 200 million cosmics have been recorded since mid-September. Secure remote monitoring has been developed, and the remote partition decoupled from network is being used in the ATLAS control room.

The detector is being commissioned with cosmic rays. The inner detector is producing an integrated readout with good noise performance. The transition radiation tracker (TRT) is fully operational and is now running with the final xenon gas. Cosmic-ray tracks have been observed going through the detector.

The liquid-argon calorimeters have been operational for 3 years. All channels are operating. The problem of the low voltage power supply in the magnetic field was solved with shielding. The tile calorimeter has also been operational for years. All of its channels are operating, and the refurbishments are complete.

All Muon chambers have been installed and used in global runs. The cathode-strip-chamber read-out drivers are still being debugged. Noise is under control. Excellent timing for RPC and thin-gap-chamber (TGC) triggers has been achieved, and the trigger system is stable at a 100-kHz trigger rate.

Recent computing activities include work focused on Tier-1 centers. Work has focused on preparing for data taking, with two full dress rehearsals testing end-to-end performance. Software performance was optimized to meet computing-model targets for central processing unit (CPU), memory, and disk; and CPU-use efficiency was improved by a factor of 2. Event-storage and data management are important issues. Successful support was provided for many hundreds of terabytes of cosmic and single-beam data. There is a growing demand for access to detector data; the scalability is all right now but may require future work. The U.S.-developed tagged database was used for event-level selection. In terms of production and distributed analysis, PanDA was rolled out ATLAS-wide. So far, it has been handling 500,000 jobs per week with headroom to spare. There has been lots of operations-driven development. The data get sent to the ten Tier-1 centers around the world.

For 2009 planning, a number of assumptions had to be made. A full-detector cosmic-ray run has been completed, but individual subsystem runs continue, collecting 960 TB until April 2009; these will be kept through 2009. Increased Monte Carlo simulation data will be produced in light of no collision data. Eight million seconds of LHC collision data were produced. User event size will be reduced until collisions start. N-tuple size will be reduced to 50% of the previous value, and reco-based size [reconstructed physics objects] reduced to 20%. Simulation will be doubled.

For 2009, the level of computing requests for Tier-1 and Tier-2 resources is unchanged from the 2007 estimate (even with current LHC delay). Computing is distributed around the world, with most of it occurring outside of CERN. The United States makes up about 23% of the total. ATLAS exports all RAW and processed data from Tier-0 to Tier-1 and Tier-2 centers according to the computing model. The system can sustain the required rate of 1.2 GB/s. Data-distribution patterns are periodically revised as data types (triggers) and processing needs change. The U.S. ATLAS Tier-1 at Brookhaven National Laboratory (BNL) has demonstrated sustained data rates greater than 500 MB/s. Tens of thousands of jobs get sent every day. The Tier-1 and Tier-2 centers do the majority of the production work.

At 10:19 a.m. on September 10, 2008, the first beams were observed in ATLAS. Synchronization worked on the first try, and splash events were recorded. The first-beam events were used for determining the timing of the detector and for determining the effect of concurrent data access from centralized transfers and user activity. There was an overload of the disk server.

It is likely that the initial collision data will be at 10 TeV rather than at the full luminosity of 14 TeV. As a result, cross-sections at a few hundred GeV will be lower by a factor of 2 with more dramatic losses at TeV scales.

The U.S. operations budget shows the expected growth and escalation over the years and the possible effects of a continuing resolution.

Now, during the shutdown, the past few weeks have been used to finalize plans on commissioning-completion activities, starting yearly maintenance, and readiness for beam resumption. Specifically, the electronics/low-voltage problems in the calorimeters were fixed; cooling loops, distribution racks, and optical readout problems were fixed in the inner detector; damaged thin-gap chambers in the muon small-wheel chambers were replaced; gas leaks in the monitored drift tube (MDT) and RPC systems were fixed; muon MDT wheels readout fibers were replaced with radiation-hardened ones; assorted maintenance was performed on all systems; and access controls were preserved.

Planning for the upgrade in luminosity consists of supporting R&D activities for the upgrade. Two coordinating bodies, the Upgrade Steering Group and Upgrade Project Office, will maintain synergy with CMS on R&D, develop a coherent and realistic upgrade plan, conduct the design with detector constraints in mind, and retain technical experts in ATLAS. The upgrade would significantly increase both the instantaneous luminosity *and* the integrated luminosity. This sets the conditions and timescales. The Phase-1 upgrade will occur during the 6- to 8-month shutdown at the end of 2012 and will achieve a luminosity of 3 x 10^{34} $cm^{-2}s^{-1}$. The Phase-2 upgrade will occur during the 18-month shutdown at the end of 2016 and will achieve a luminosity of 10^{35} $cm^{-2}s^{-1}$. However, there is still a need to understand the impact (if any) of the LHC delay.

For Phase 1, a new inner-layer pixel layer would be inserted, the TDAQ would be upgraded, and TRT optimization is being investigated. The implication for all systems is being studied. For Phase 2, an all-silicon tracker would be installed; the calorimeter electronics and readout and forward calorimeter detector would be upgraded; additional TDAQ enhancements would be made; and the forward muon chambers, beryllium beam pipe, and shielding would be upgraded. The magnets and most detectors would remain in place.

The time scale for this change would call for a letter of intent for ATLAS changes to be signed and a technical design report for the new B-layer pixel system in 2009. A technical proposal for ATLAS changes for Super LHC would be written in 2010. Technical design reports would be written in 2011. The Phase-1 changes would get installed by the end of 2012. And the Phase-2 changes would get installed during a long shutdown in 2016. These plans would remain adaptable, guided by detector performance, physics results, and the machine schedule.

The most recent JOG meeting called for U.S.-supported R&D activities on pixel-readout chip development; 3D-pixel-detector development; silicon-strip-detector development; electronics for the silicon strip and liquid argon; stave design; and tracker simulation. FY09 R&D will help form the basis of the tracker design report. The preferred plan for Phase 1 of the upgrade was presented on Sept. 11, 2008. This proposed upgrade included a full replacement of the tracker, forward calorimeters (FCal), and TDAQ starting in 2010 and ending in 2018 at a cost of about $130 million. DOE said that there would be no money until 2011 and that the time scale was too long; 2010 funding may be possible for NSF.

A reduced-scope proposal is being considered. It would include the pixel insertion and the TDAQ. However, the full tracker replacement needs to start around 2012, so there could be two projects starting very close to each other. Further guidance is expected from DOE and NSF soon.

In summary, ATLAS has conducted successful single-beam and cosmic-ray data runs, has demonstrated success in the critical steps in capturing these data, and is ready for collisions. The detector is working at the 98–99% level, although maintenance is taking place. There are no showstoppers on the horizon. Computing is capable of handling the first data and distributing it worldwide. Planning for future upgrades is under way and, given the U.S. funding time scales, must start soon. By this time next year, data from actual collisions are expected to be available.

A break was declared at 10 a.m. The meeting was called back into session at 10:29 a.m. **Joel Butler** was asked to give an update on the status of CMS, which is a very large solenoid, 6 m in diameter and 13 m long. Tracking and calorimetry fit inside the solenoid. Particle energies are measured before they pass through the solenoid coil and cryostat, which would degrade their resolution. It has a very strong field, 4 T. The only fixed piece is Yoke Block 0; everything else can be moved in and out for maintenance and upgrades. It coils up soft charged particles and provides excellent momentum resolution. Tracking chambers in the return iron track and identify muons, making the system very compact. The weight of the CMS is dominated by all the steel and weighs 12,500 tonnes. Tracking is based on all-silicon components. A silicon pixel detector (with 68 million pixels) extends out to about 20 cm. A silicon microstrip detector with 11 million channels and 200 m^2 extends from there out to 1.2 m. This configuration gives CMS excellent charged-particle tracking and primary and secondary reconstruction. The high segmentation results in very low occupancy. The silicon detectors are very radiation hard. CMS was built on the surface. The pieces, some greater than 2000 tonnes, were lowered into the Collision Hall. The hall was made available late, so installation did not begin until November 2006, and utilities did not appear until the spring of 2007.

Everybody has been happy with the final installation push. From July 17 to July 31, the components were marched in and installed. Final closure was accomplished.

After almost 20 years, from conception through design, construction, and commissioning, CMS became a working experiment in September 2008. At startup, the detector included the barrel and endcap pixels; the silicon-strip tracker; the barrel and both endcap electromagnetic calorimeters; the hadron calorimeter; the muon detectors (drift tubes, cathode strip chambers, and RPCs); the Level-1 trigger with about a 40-kHz data-acquisition system (DAQ). Not available at startup were the endcap electromagnetic preshowers and the remaining capacity for the TDAQ, which was deferred. For the initial running with a beam, the solenoid and the inner tracker were left off because of machine issues.

The first event put about 2×10^9 protons on the collimator, about 150 m upstream of the CMS. The DAQ worked as did the display packages.

After September 19, the Cosmic Run at Four Tesla (CRAFT) was conducted. CMS ran for four continuous weeks 24/7, collecting (finished this week) nearly 300 million cosmic events with $B = 3.8$ T, showing that CMS was ready for the LHC. There is a wealth of lessons from this exercise.

During the shutdown, priorities have been worked on. The highest priority is modifying the opening/closing system of wheels, disks, and shielding to produce safer opening and closing of the CMS, reducing the risk to the detector and the beam pipe as well as reducing exposure of personnel to activated parts. Modifications were made to access platforms to reduce the risks to the detector and the beam pipe and to speed up changes. Infrastructure was diagnosed, repaired, and improved to fix and reduce the risk to the detector, underground-experimental-cavern access requirements, and inefficiency. Repairs were made to achieve the required 2009 performance. Repair or re-work was done that was necessary for final performance in areas that will acquire significant activation. The preshower installation needs a complex logistic set-up and thus a long shutdown; the work area will acquire significant activation. Full radiological screening and material tagging, classification, and tracing were set up for the 2009 run. The need to work around the fragile beam pipe created new problems.

The opening up starts November 17 for the preshower installation in February and March. The detector will be closed and operational by the end of May. There will be a parallel re-commissioning as soon as possible in 2009. Limited cooling and power will be made re-available as soon as possible to test new or repaired items. The biggest uncertainty in all of this is the LHC schedule. There is a well-thought-out schedule of future activities.

In terms of the preshower, all 520 ladders will be assembled and stress-tested. Ladders will be mounted, cabled, and tested on four of eight absorbers. All channels (about 50,000 silicon strips) are operational. Two stuffed absorbers were tested inside an environment-controlled tent to –15 ºC. The target is to get the preshower endcap ready for installation by the end of 2008.

The computing model has the user submitting jobs, and the workload management system submits the job to where the data are. Data movements are triggered by operators, physics organizers, or users. The data are distributed to the Tier-1 and Tier-2 centers. The data-transfer goals are 600–800 MB/s to the seven Tier-1 centers, 100 MB/s between Tier-1 centers, and 50–500 MB/s bursts between the Tier-1 and Tier-2 centers.

The Fermilab Tier-1 has reached all its goals and specifications: 7500 batch slots, 2.0 PB on Disk T1, 0.5 PB on Disk LPC, a transfer rate of 20 GB/s, and 30 FTEs.

The U.S. Tier-2 centers are extensively used for simulation and analysis. All seven U.S. Tier-2 sites reached nominal capacity this past summer. The FY09 Tier-2 ramp-up will double storage and increase CPUs by 50%. The Tier-2 program is a great success thanks to very engaged sites. The sites in CMS have been organized to support physics analysis for users by associating sites with specific physics/detector performance groups and allocating disk space for groups and individual users.

Moving the data around is a key issue for CMS. All of the goals have been accomplished.

For physics production, there is a strong emphasis on the integration of the efforts of

- groups working on commissioning and understanding the detector,
- groups developing physics objects (photons, electrons, muons, taus, etc.) for analysis, and
- groups extracting physics.

There is a strong emphasis on what can be done with early physics samples of 10 pb^{-1}, 100 pb^{-1}, and 1000 pb^{-1}. There is great excitement about seeing the first data at this new energy frontier.

The first phase of the luminosity upgrade will start in 2013 with a luminosity of 2–4 × 10^{34} cm^{-2} s^{-1}. Phase 2 will be decided on in 2011 with a luminosity between 8 and 10 × 10^{34} cm^{-2} s^{-1}. The U.S. CMS upgrade plan will be based on the detector needs to run for sustained periods at luminosities well above 10^{34} cm^{-2} s^{-1}. Issues that must be addressed include radiation damage, high occupancy affecting reconstruction or triggering, high occupancy that leads to buffer overflows and to problems with link bandwidth, and pileup creating dead time or affecting the trigger. The CMS is accessible, has been designed to be opened, and is therefore easy to upgrade.

The upgrade R&D is now ramping up to deal with collision rates that are well beyond the requirements of the original detectors. Detailed upgrade plans are being developed. The initial plan for CMS is being developed, and the corresponding U.S. component of it has been presented to DOE and NSF. The upgrade includes pixel replacement, an increase in the longitudinal segmentation of the hadron calorimeter, the muon detectors, the TDAQ, and the electromagnetic calorimeter.

A CMS workshop will take place from Nov 19 to 21 at Fermilab to develop the Phase-1 upgrade.

The United States has important leadership capabilities. CMS has 39 countries, 181 institutions, and 1940 scientific authors, with 1283 paying an M&O share. There are 639 U.S. scientific authors, 442 with PhDs, and 197 graduate students (about one-third of the total). The full-time people at CERN include 26 professors, 16 scientists, 57 post docs, 86 graduate students, 24 professionals, 4 technicians, and 4 staff, for a total of 217 (about one-third of the U.S. team; the other two-thirds are back in the United States).

There is a very large U.S. full-time community at CERN and a large transient component, as well. This creates special problems that are rather new for the U.S. program.

After 20 years of planning and an incredible "finishing kick" in July, CMS was closed and ready for the first beam. During the limited beam, collimator splash events and circulating-beam halo events were recorded and are being analyzed to extract all possible information on the detector. After the shutdown, a month of highly successful cosmic running was completed with the CMS solenoid on at 3.8 T, and analysis is already in full swing. A thoughtful, focused, and flexible plan of improvement is scheduled for the remainder of the shutdown. CMS is continuing to prepare for the physics analysis of the early runs, and upgrade planning and R&D are in full swing. There is a large U.S. community, with about one-third of the total residents at CERN while the remaining two-thirds is actively engaged from the United States, eagerly awaiting the first collisions.

Molzon asked whether the CMS upgrade included replacing the lead tungstate. Butler replied that most of it will survive well except at the endcaps. What to do about that is being discussed. There are many options.

Rosenberg asked whether the upgrade discussions were including the Tier-1 and Tier-2 computing. Butler responded that they had not been, but they are now. The number of events will change. The statistical fluctuation in the events after the upgrade will be very challenging. It is way off what anybody understands. A lot of thought will have to be put into it. Although there will be a factor of 10 more collisions, computing needs will not scale linearly.

Gary Bernstein was asked to report on the work of the JDEM Figure of Merit Science Working Group. The charge to this working group was to continue the work of the Dark Energy Task Force (DETF) in developing a quantitative measure of the power of any given experiment to advance knowledge about the nature of dark energy. The measure may be in the form of a "figure of merit" or an alternative formulation.

The science payoff is seeing whether w ($= P/\rho$) departs from -1 at any time in the universe. The DETF defined a figure of merit that was an ellipse around $(w, w') = (-1, 0)$.

The FoMSWG is to produce a quantitative evaluation process and formulae and prose containing qualitative statements that state the importance of presenting systematic error analyses, finite precision of the FoM analyses, and scientific robustness.

The figure of merit is a quantitative guide; since the nature of dark energy is poorly understood, no single figure of merit is appropriate for every eventuality. It is hard to put a single number to it.

The FoMSWG (like the DETF) adopted a Fisher (information) matrix approach toward assessing advances in dark-energy science. The Fisher matrix is the multidimensional version of $1/\sigma^2$. It describes the error ellipsoid of an experiment. Bigger is better. It can be summed over experiments and priors to evaluate a total constraint.

First one has to pick a fiducial cosmological model. There is not much controversy here; lamba cold dark matter (LCDM) assumes Einstein gravity (GR). Then one must specify cosmological parameters of the fiducial cosmological model (including parameterization of dark energy). There is not much controversy in non-dark-energy parameters [the Wilkinson Microwave Anisotropy Probe 5-year data (WMAP5)are used]. Dark energy is parameterized as a function of redshift or a scale factor of cosmic evolution. The FoMSWG used something more flexible than the *w* used by the task force. It wants to know a function but can only measure parameters. The FoMSWG therefore described 36 piecewise constant values w_i defined in bins between $a = 1$ and $a = 0.1$. The advantage is that this approach can capture more complicated behaviors. The disadvantage is the 36 parameters (an issue for presentation, not computation). Merit is based on excluding $w \neq -1$.

The parameterization of growth is also an issue. The DETF discussed the importance of growth of structure but offered no measure. There are many (bad) ideas on how to go beyond Einstein gravity; there is no community consensus on any clean universal parameter to test for the modification of gravity. FoMSWG made a choice, intended to be representative of the trends:

$$\text{Growth of Structure} = \text{Growth of Structure (GR)} + \Delta\gamma \ln \Omega_M(z) \ ,$$

where $\Delta\gamma$ is a one-parameter measure of the departure from Einstein gravity.

The third step deals with the most difficult issue, producing "data models," including systematic errors, priors, nuisance parameters, etc. This is the most time-consuming, uncertain, controversial, and critical aspect of the process. One has to predict pre-JDEM (circa 2016) knowledge of cosmological parameters, dark-energy parameters, prior information, and nuisance parameters. Then one has to predict how a JDEM mission will perform. All of these actions depend on systematics that are not yet understood or completely quantified. Then one needs to predict how well JDEM will do in constraining dark energy. This is what a Fisher matrix was designed to do. It can easily combine techniques, and it is a tool for optimization and comparison. This approach has technical issues but is fairly straightforward. This information also has to be quantified into a figure of merit.

The FoMSWG says that no single figure of merit is appropriate, but a couple of graphs and a few numbers can convey a lot. One must determine the effect of dark energy on the expansion history of the universe by determining $w(a)$ and determining the departure of the growth of structure from the result of the fiducial model to probe dark energy and to test gravity.

To determine the effect of dark energy, one must assume the growth of structure described by GR; marginalize over all non-*w* "nuisance" parameters; perform a principal-component analysis of $w(a)$; assume a simple parameterization [e.g., $w(a) = w_0 + w_a (1 - a]$; and then calculate $\sigma(w_p)$, $\sigma(w_a)$, and z_p.

To determine the departure of the growth of structure from the result of the fiducial model to probe dark energy and test gravity, one must calculate a fully marginalized $\sigma(\Delta\gamma)$.

Proposers should be able to support new figures of merit because different proposals will emphasize different methods, redshift ranges, and aspects of complementarity with external data. There is no unique weighting of these differences. Proposers should have the opportunity to frame their approach quantitatively in a manner that they think is most compelling for the study of dark energy. Ultimately, the selection committee or project office will have to judge these science differences, along with all of the other factors. The FoMSWG method will supply one consistent point of comparison for the proposals.

The FoMSWG end game is to provide (1) a letter to Kovar and Morse without too many technical details, (2) a technical paper posted on the archives, and (3) Fisher matrices and software tools on a website. It is wrapping up the technical details on data models and software, a discussion of the threshold issue, and the technical paper.

The FoMSWG concluded that figures of merit should not be the sole criteria. Systematics, redshift coverage, departure from $w = -1$, ability to differentiate "true" dark energy from modified gravity, multiple techniques, and robustness also come into play. It is crucial to have a common fiducial model and priors. The Fisher matrix is the tool of choice. No one figure of merit gives a complete picture.

Shochet asked how much of the advantage was due to the fact that one is looking at a larger surface area in the increased dimension parameter space. Bernstein answered that one has to ask what the increase in merit is. The DETF has just one value that one is looking for deviation from. However, a 40-measure mode is not interesting. One has to put a floor on it.

Kahn asked about the recommendation of how good the figure of merit has to be so that JDEM could proceed. Bernstein replied that the FoMSWG did not feel any strong theoretical guidance on that issue. Looking at the range of theoretical models, one could see whether any thresholds were observed. There was no agreement within the working group because the LSST may contribute a lot.

Cahn opined that the figure of merit is important both before and after the selection of the proposals and asked if Bernstein agreed. Bernstein responded that he did not know how the AO process will go forward.

Gladney asked if there would be a chance for this to influence setting up the importance of the ground-based data. Bernstein replied that the FoMSWG is supposed to finish its final report by the end of the month. It would be up to the proposer to justify the need for ground-based data.

Cahn asked what software would be supplied. Bernstein answered that the software provided would be for producing figures of merit from Fisher matrices.

Shochet announced to the Panel that there were to have been two new charges, but these will be postponed until the next meeting. This meeting had no decision actions, just informational presentations. In his letter to the agency, he would summarize the presentations. He polled the panel for nonobvious issues that should be noted in the summary letter to the agencies. Eno asked what the next step should be for the Demographics Group. Shochet said that they should meet with the agencies about direction and report back. A draft of the summary letter will be circulated to the panel. The next meeting will be February 24–25, 2009.

The meeting was adjourned at 11:50 a.m.

Respectfully submitted,
Frederick M. O'Hara, Jr.
Recording Secretary
Dec. 2, 2008

Corrected by – M.J. Shochet, 1/5/09

The minutes of the High Energy Physics Advisory Panel meeting held at the DoubleTree Hotel, Washington, D.C., on November 13-14, 2008, are certified to be an accurate representation of what occurred.

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

Melvyn J Shochet