Physics Advisory Committee Meeting

March 5-7, 2009

Comments and Recommendations

Strategic Planning

Laboratory management is actively engaged in the strategic planning for timelines and human resource needs, as well as undertaking timely preparation for upcoming reviews. The management has crafted a sensible 10-year plan covering scientific progress on all three frontiers: the Energy, Intensity, and Cosmic Frontiers. With the increased emphasis in the next few years of the Laboratory programs on the Intensity Frontier, the Laboratory needs a timely transformation of the appropriate human resources. The Committee commends management for starting this process, and for effectively matching personnel to the programs. The Committee is pleased to see that additional senior staff scientists are engaging in experiments on the Intensity Frontier, in particular, Mu2e. In addition, the new Ben Lee Fellowship program, designed to attract theoretical physicists working on the Intensity Frontier, will greatly enhance this effort.

The DOE has begun a new program-based review process of the national laboratories. The Accelerator and Theory programs were reviewed in 2008, and the Detector R&D and Proton programs will be reviewed in the summer of 2009. The Committee commends the Accelerator and Theoretical groups for planning well for these reviews.

The Laboratory is vigorously launching the main components of its medium-term future: Project X, a long-baseline neutrino experiment at DUSEL, and Mu2e. In a tight collaboration with BNL, Fermilab is taking the lead in the project design of the DUSEL neutrino program. Similarly, it would be natural for Fermilab to support, in collaboration with LBNL and SLAC, the R&D and engineering of large DUSEL dark-matter detectors. Discussions are taking place with the DOE Office of High Energy Physics on the role that national laboratories should play in that respect.

Comments on Collider Program

The Tevatron Collider and collider experiments continue to perform superbly, and the Committee congratulates the Accelerator Division and the CDF and DZero Collaborations. The

experiments continue to produce many exciting physics results. The Laboratory is assessing the impact of running the Tevatron in 2011 on its long-term program, and the CDF and DZero Collaborations are assessing the related issues. The Committee is enthusiastic at the prospect of extending the Tevatron Collider run, but does not want to see the future Laboratory programs seriously delayed by doing so.

Comments on Neutrino Program

The Committee was pleased to see the recent announcements on the first MiniBooNE results from antineutrino running, and the first results on electron-neutrino appearance from MINOS. The Committee was also pleased to see the first publication from SciBooNE, and is looking forward to seeing other new results from these experiments in the near future.

E-944 Proposal for More MiniBooNE Antineutrino Data Taking – Van de Water

The Committee recommends continued running of MiniBooNE for up to an additional 5×10^{20} protons-on-target (POT), provided no significant expense is incurred by Fermilab for this extra running. The Collaboration has requested to use the additional POT solely for antineutrino running. Given the low-energy excess in neutrino mode, the Committee recommends the Collaboration address the optimal use of the additional POT.

Long-Baseline Neutrino Program Planning

Substantial progress has been made on the DUSEL long-baseline neutrino experiment (LBNE) program. This program consists of a neutrino beamline, a near detector, and a far detector. As part of this progress, an experiment collaboration has been formed. A study has clarified the necessary depth for the large volume detector. Optimizations of the beam design are being made. The project management structure has been discussed, and a project coordination group is being established. The near-term project goal is a CD1 for the LBNE in the third quarter of FY 2010.

Fermilab is making substantial contributions to the beam design and project management, along with liquid argon R&D. The Committee would like to hear about Fermilab efforts in water Cerenkov detector technology.

E-973 Muon to Electron Conversion Experiment (Mu2e) – Bernstein/Miller

The Mu2e Collaboration presented a progress report dealing with issues under study and plans to address questions that were raised by the PAC at the November, 2008 meeting. Serious work has been initiated on many fronts, including solenoid optimization, background studies, accelerator and extinction issues, civil construction, and budgeting. Some prospects for performing extinction measurements are being evaluated. The Committee was pleased to see

that the project has attracted strong new Fermilab and external collaborators, and that an experienced project manager has been appointed. Collaboration contacts with the J-PARC COMET Collaboration, which has similar goals, were initiated. The Committee looks forward to hearing about substantial developments at future meetings.

P-981 Letter of Intent: Antimatter Gravity Experiment (AGE) - Phillips

The AGE Collaboration proposes to measure the gravitational acceleration of antimatter for the first time. In its previous report, the Committee did not find a 1% measurement scientifically compelling. However, the possibility of a 10^{-9} measurement opens new scientific opportunities.

The Committee was intrigued by the recent developments for trapping and cooling of paramagnetic atoms, but recommends that a proposal be deferred until this technique is experimentally demonstrated for hydrogen. At this time, the Committee does not recommend that the Laboratory provide substantial support for this project.

P-986 Letter of Intent: Medium-Energy Antiproton Physics at Fermilab – Kaplan

A dedicated antiproton experiment offers the possibility of exploring CP violation in the charm and hyperon systems, of very precisely measuring the mass and width of the X(3872), and of measuring some mixings in the D*D system. This experiment could potentially provide a large amount of data and new information on the charm system, thereby also offering the possibility of excellent theses for graduate students. The Committee would welcome a more detailed comparison of the physics potential with that of the super-B factories and the tau/charm factory. To proceed further, it would be necessary to substantially develop the physics case and the plan for the detector configuration, and strengthen the Collaboration.

Detector R&D

The Committee commends the Laboratory for its well-structured R&D effort, which covers the Intensity, Energy and Cosmic Frontiers in a three-prong approach: electronic, mechanical, and civil engineering, with appropriate ambitions and priorities.

This generic R&D, based on the strengths of Fermilab, achieves promising results cutting across various projects, while explicitly striving to build synergies. For example:

1) The Laboratory is leading an impressive worldwide initiative in 3D technologies aiming at applications for detectors at colliders (LHC, ILC and superB).
2) Pixelized Photon Detector applications are being developed for calorimetry for the CMS upgrade, for a new type of calorimeter that uses a dual readout to obtain unprecedented hadronic energy resolution, and for the Mu2e detector.

3) LAr detector scaling issues for the long-baseline neutrino and dark-matter experiments are being tackled.
4) An innovative bubble chamber technique is already producing scientific results, although it is still in its R&D phase.

Strategic Plan for Particle Astrophysics

A draft of the strategic plan for the Fermilab Center for Particle Astrophysics (FCPA) was provided to the Committee, and a presentation reviewing the plan and the status of the center was given by the FCPA Director. The document describes well the exciting science at the Cosmic Frontier and the strengths of the FCPA program.

The Committee is impressed with the success of the ongoing program. The Sloan Digital Sky Survey has been an unqualified success, far exceeding the science reach originally envisioned. The Dark Energy Survey, an important Stage III dark-energy project, is making rapid progress. The direct dark-matter searches CDMS and COUPP together have achieved the best limits on spin-independent and spin-dependent cross-sections. The Pierre Auger Observatory has demonstrated the existence of the GZK cutoff and a correlation of high-energy cosmic rays with active galactic nuclei. GammeV has achieved the best laboratory limits on axion-photon coupling. Planning for the JDEM Science Operations Center is moving forward swiftly, although there are current uncertainties in the overall JDEM program. The Cosmological Computing initiative is coming together well, and important ties are being forged with LBNL and SLAC. Underpinning these activities is a vibrant astrophysics theory group.

New Initiatives

The Committee was impressed by the number of new ideas being explored under the leadership of Wilson Fellows and postdoctoral fellows. The Committee was also very interested in the discussions of ways to measure the "holographic noise" present in some space-time theories. This approach pioneers new experimental ways to look at gravity, and fits well intellectually within the mission of the Laboratory.

At the same time, new major initiatives are being explored. The possibility of joining the Large Synoptic Survey Telescope (LSST) project would be a natural extension of the major survey effort at the Laboratory, and would complement the intended involvement in JDEM. Plans are being discussed for building Auger North, an ambitious complement to the Pierre Auger Observatory. The dark matter program is developing with the extension of the target mass of low-temperature germanium detectors (15kg SuperCDMS at Soudan, 150kg SuperCDMS at SNOLAB, and 1.5 tonne GEODM at DUSEL), and of the COUPP bubble chamber (60kg at Fermilab and Soudan or SNOLAB). The development of (^{39}Ar depleted) liquid-argon technology for dark matter offers a number of synergies with the development of liquid-argon detectors for the long baseline program.

The upcoming FCPA retreat is clearly an important step in the completion of the strategic plan. The resulting document could provide important input in time for the Particle Astrophysics Science Assessment Group, which is asked to give a preliminary report on July 1, 2009 and a

final report by August 15, 2009. More generally, the Laboratory has an important voice in shaping the national program at the Cosmic Frontier.

Importance of Particle Astrophysics Theory

The Particle Astrophysics Theory program clearly plays a critical role in the intellectual vitality of the FCPA. Many of the ideas currently explored in the Center directly originate from these interactions (e.g. GammeV, axion search in CDMS, holographic noise etc.). In a way similar to the particle theory program, the Particle Astrophysics theorists provide strong support to the ongoing experimental/observational effort (e.g. support of the astrophysics surveys through simulations, and interpretation of dark matter data). The Committee was surprised that this strong programmatic aspect was not clearly recognized by the recent DOE review panel. The Committee supports the steps outlined in the Fermilab response to the panel report, in particular in the improvement of the connections with particle theory (joint hires of faculty and postdocs, common seminars etc.). The Particle Astrophysics Theory group should consider ways to broaden its role as a resource to the university community.

Decision Mechanisms

In its November 2008 report, the Committee outlined three roles of the Fermilab Center for Particle Astrophysics:

1) Exploration – generating new ideas and incubating new projects;
2) Experimental projects – participating strongly or leading projects, e.g., the Dark Energy Survey; and
3) National Center – representing and serving the community.

The FCPA is very successful in the exploration role. Investigation at small scale of a number of new ideas is clearly very valuable, and encouragement of the initiative of postdocs and Wilson Fellows is excellent.

Clearer decision mechanisms need to be established for major initiatives falling under the category 2 above. The FCPA faces the standard problem of balancing creativity and focus. In broad terms, decisions on major initiatives have to be based on the comparison of the scientific opportunities, evaluation of the uniqueness of the Fermilab contribution, and assembly of a critical mass of scientists at the Laboratory. The decision process is further complicated by the role of the FCPA as a national resource. Major initiatives should align with national priorities and the needs of the community.

External advice may be critical in providing the FCPA with expertise not available at the Laboratory. It is also important to inform the community about the thinking at Fermilab, and to bridge differences of cultures. Workshops also play an important role in cementing the connections between Fermilab and the outside particle astrophysics community.

P-989 The New (g-2) Experiment: A Proposal to Measure the Muon Anomalous Magnetic Moment to ±0.14 ppm Precision – Hertzog/Roberts

The Committee considered the proposal to improve the high-precision measurement of the muon (g-2) by a factor of four to 0.14 ppm. The muon (g-2) experiments are highly significant due to the accurately calculated value predicted in the standard model (SM), and the sensitivity to a variety of new physics effects at high-mass scales which could result in a deviation from the SM prediction. Although the ultimate limit to the comparison with the SM expectation may be uncertainties in the theory (particularly the light-by-light contribution), the past work at BNL, a tour-de-force demonstration of experimental particle physics technique, was limited primarily by statistics to the 0.54 ppm level (with 0.46 ppm from statistics).

In the present proposal, the improvement in precision possible at Fermilab comes mainly from obtaining increased statistical precision due to improvements to the pion capture and transport aspects of the experiment. The versatile Fermilab beam complex would be used parasitically during high-energy neutrino production, and muons will be injected and stored in the muon storage ring relocated from BNL. Data would be acquired within two years of running. In addition, the Collaboration proposes to make several substantial reductions in systematic uncertainties.

This is an opportune and excellent proposal which is well motivated and represents a technically sound incremental advance over previous work. Realizing the goal would result in an important step forward for fundamental physics measurements, which fits well with Fermilab's other future efforts in precision muon physics at the Intensity Frontier.

The Committee recommends that the opportunity presented by this relatively low-cost and high-quality project be pursued. It would be useful to perform an impact and technical evaluation to understand the implications for other aspects of the Fermilab program, and to validate the cost and schedule estimates, which are significantly reduced from what the Particle Physics Project Prioritization Panel (P5) considered. Also, it would be useful to develop mechanisms to draw upon the technical expertise developed at BNL over many years during the previous (g-2) experiment.