

Physics Advisory Committee Meeting

March 27-29, 2008

Comments and Recommendations

Introduction

The Committee heard status reports from many of the ongoing experiments, along with four proposals/LOIs/EOIs. In addition, it heard an update on Project X and the associated physics possibilities. A number of important areas of research, including US CMS, NOvA and ILC detector R&D, were not discussed in public session, but the Committee was briefed on these programs by Laboratory management.

The Committee recognizes that the unfortunate current budget situation makes this a difficult time for the Laboratory, and it commends both the management and staff for facing this challenge with grace and determination. The Committee is encouraged by the breadth of world-class physics results presented to the Committee at this meeting to hope that budget problems will be resolved soon.

The Committee is asked to consider experiments which could be a part of the long-range strategic plan for the Laboratory at its June meeting. This strategic plan will be formed in light of the P5 recommendations expected in May. At that time, the Committee will consider the suite of future physics possibilities in the post-Tevatron era, and make recommendations of relative physics priorities. In light of the strategic plan, and the need to await P5 recommendations, most formal recommendations are postponed until the June meeting.

Project X Physics Program

The Committee heard from Laboratory management on the work in development of Project X. To insure that all relevant input was obtained, the Lab has made many presentations to various agencies, review panels, and other forums, and has held a series of workshops to get input from the community. The Laboratory has done an excellent job on involving the university, laboratory, and international communities in the development of Project X. A well-defined accelerator project, with a possible physics program, is emerging.

This work has culminated in a document called the 'Golden Book' that includes descriptions of the proton source road map and the physics potential for programs based on neutrinos, muons, kaons, charm, and antiprotons. The 'Golden Book' represents a significant step towards the understanding of the physics discovery potential of Project X. The Committee heard additional presentations based on the compiled information on the neutrino, muon, and kaon physics.

The Laboratory presented explorations of neutrino oscillations as the cornerstone of the physics effort. The Committee strongly supports the high priority of this program as the flagship physics for the Project X effort. The Laboratory, in anticipation of a possible program of neutrinos at DUSEL, and especially as DUSEL now contains an appropriate detector as part of its initial suite of experiments, is forming a group to understand the relevant accelerator and beam design issues. The Committee feels this is an appropriate effort. The Laboratory is making progress towards understanding the detector configuration options available for optimizing the physics program and their physics sensitivities. Now the Laboratory should concentrate on determining the best strategy for the detectors and their locations.

The Committee was impressed by the progress made on defining a world-class program in flavor physics as part of the Project X suite. These experiments are sensitive to physics beyond the standard model in unique ways, and they can probe very high energy scales. Since there are plans for exciting flavor physics experiments using muons and kaons throughout the world, the Committee encourages continued close communications with the international community for coordination and collaboration on these efforts.

This work is currently being considered by the P5 subpanel of HEPAP. The Committee looks forward to hearing their recommendations as input to the June meeting.

Proposals/LOIs/EOIs

Liquid Argon R&D and Experiments

MicroBooNE and LAr5 concepts were presented as steps towards the goal of a future ~100 kt LAr detector. The Committee strongly encourages the Laboratory and the proponents to work together on the development of an optimized and unified program of LAr TPC R&D as part of the overall strategic plan to be considered at the June PAC meeting. It also realizes the importance of projects combining R&D and physics goals, as well as the necessity of a staged approach to achieve a future ~100 kTon LAr detector for exploring the neutrino sector and investigating proton decay.

P-974 MicroBooNE Proposal Addendum (Fleming)

The Committee greatly appreciates the response of the MicroBooNE proponents to the Committee's questions from the last meeting. There has been significant improvement in the design with consequent cost savings. The R&D is now more appropriately aligned with a larger scale detector. The Committee agrees that the proposed physics measurements appropriately test relevant facets of LAr detector and performance for doing neutrino physics.

In June, the Committee would like to have additional feedback on technical scaling questions including drift length, purity, and electronic issues (such as preamplifier location, multiplexing, signal-to-noise ratio, and power dissipation). In addition, the Committee requests

updates on the physics potential based also on the best knowledge of the MiniBooNE low-energy electron excess at that time (as to be reported at Neutrino 2008 in late May). These updates may provide very useful input to consideration of MicroBooNE. Specifically, it is important to know by what factor can the MicroBooNE detector be reduced in size while still retaining the capability to study the above technical questions as well as to establish sufficient (e.g., 5σ) evidence that the low-energy excess is due to electrons without testing the photon hypothesis. The Committee also requests more quantitative clarification of the suitability of the MicroBooNE detector to be the near detector of a larger oscillation experiment, e.g., involving LAr5 as the far detector.

The Committee recommends that consideration of Stage I approval for P-974 be deferred until the June PAC meeting, when the Laboratory's strategic plan is discussed in detail.

P-982 Letter of Intent: LAr5 – A Liquid Argon Neutrino Detector for Long Baseline Neutrino Physics (Rameika)

The Committee feels that the proposed 5 kt LAr detector size is a reasonable choice technologically, representing a possible module size for a ~ 100 kt detector. Such a 5 kt detector also has potential for good physics sensitivity for a medium-term neutrino experiment.

The siting of the detector would have to fit with the Laboratory's strategic plan that will be discussed at the June PAC meeting. The Committee encourages the Laboratory to support the request for some level of dedicated engineering and design personnel in order to develop a solid proposal on the time scale of one year. The Committee encourages the proponents to identify further cost reductions and industrialization opportunities, as a central part of the R&D program, looking forward to a ~ 100 kt detector. The Committee encourages the Laboratory and the proponents to continue efforts to seek additional collaborating institutes and resources.

P-975 Terascale Physics Opportunities at a High Statistics, High Energy Neutrino Scattering Experiment: NuSOnG (Conrad / Fisher)

The Committee commends the NuSOnG collaboration on its extensive and informative response to the Committee's suggestion that its physics case needs to be more fully developed. NuSOnG will be among the possibilities considered when the Committee discusses the experiments for the long-range strategic plan of the Laboratory at its June meeting. The Committee notes that a discovery at the LHC whose nature could be explored through neutrino scattering (e.g., a Z') could make an experiment like NuSOnG compelling.

P-981 Letter of Intent: Antimatter Gravity Experiment at Fermilab (AGE) (Kaplan / Phillips)

The AGE Letter of Intent discusses an experiment to measure the acceleration of antihydrogen in the earth's gravitational field. The technique involves deceleration of antiprotons in the Main Injector followed by a degrader system to reduce the energy to ~ 1 MeV

to enable trapping in a Penning trap. The cooled antiprotons are then combined with cooled and trapped positrons to form a beam of antihydrogen which is then incident upon an interferometer capable of measuring the vertical deflection. The stated experimental goal is to measure g for antihydrogen with 1% accuracy.

While it is true that there is, at present, no direct experimental information related to the gravitational interaction of antimatter with matter, it is important to understand the theoretical motivation underlying the proposed 1% measurement. The physics motivation for this experiment needs to be clarified. It needs to be established, perhaps with the participation of appropriate theorists, that existing observations do not preclude anomalous behavior of antimatter in the vicinity of the earth at a level that would be detectable by this experiment. This should include the relation to other processes, such as the effect on $K - \bar{K}$ mixing.

The proposed scheme for deceleration of antiprotons to 1 GeV/c in the Main Injector requires further study. These studies should include simulations and closer coordination with personnel in the Accelerator Division who have current knowledge of the Main Injector characteristics and capabilities.

Further reduction of the antiproton energy is proposed by employing a degrader system. While some details were presented, the Committee was not convinced that this scheme is viable, and that all effects leading to inefficiencies such as multiple scattering and annihilation-in-flight were properly considered. A detailed comparison with the capabilities available at CERN should also be presented.

The interferometer method for measurement of the gravitational acceleration is quite novel. It is very important to demonstrate that the method can actually measure g for normal atoms. The Committee recommends that the proponents present quantitative evidence that they have the method fully developed and implemented for normal atoms. Additional details associated with using this method for antihydrogen would be important, including the detection method and background estimations.

Status Reports

Accelerator

The Committee heard about the outstanding recent performance of the accelerator. Despite two unplanned short shutdowns since October due to the failure of a Tevatron magnet and both the lithium lens and its high-gradient spare, the Tevatron is very close to having delivered the projected luminosity. Records have recently been set both for the stacking rate and the integrated luminosity per week despite using the lower-gradient spare lithium lens, which may be reducing the stacking rate by 12% compared to the better lens. This is especially impressive given the disruptive effect of the mandated furloughs for all employees. The Accelerator Division plans to continue incremental improvements to the delivered luminosity, including delaying the next major shutdown until spring 2009. The Committee was quite

impressed by the continued accomplishments of the Accelerator Division which are essential to the physics program of the Laboratory.

The integrated number of protons on target delivered to NuMI since October is not yet at the level predicted, due to problems with dehumidifiers installed to mitigate the tritium problem and a water leak in Horn 2. However, the Committee notes that, because of the successful implementation of slip stacking, the average beam power is up 30% and the number of protons per pulse has increased as well, so that the goal should be met soon if no other problems occur. Because of the problems with the NuMI line, the number of protons delivered to the Booster Neutrino Beam (BNB) is considerably above expectations.

CDF and DZero

The Committee heard presentations from the CDF and DZero collaborations. These experiments are the flagship efforts of the Laboratory, and are operating extremely well. Both detectors were shown to be in excellent working condition; both experiments have high live times (>85% efficiency), are reconstructing their data promptly, and are producing timely results with the new data. They are still continuously improving their data analysis algorithms so as to improve the efficacy of the analyses faster than just scaling with the increased integrated luminosity would give. The physics output is continuously providing new information from the world's energy frontier, and is both vibrant and diverse, with results in areas such as searches for the Higgs, for new particles from beyond-the-standard model, precision results on physics with W and Z bosons, the top quark, and the strong force, and interesting new results on CP violation in B decays, among other topics.

Based on these presentations, the Committee reaffirms its previous recommendation that it would be prudent to plan for the possibility of a run in 2010. The collaborations have shown that there is enough commitment to maintain the necessary manpower. Such a run would continue to produce world-class physics.

E-875 MINOS (Plunkett/Wojcicki)

The Committee appreciates the diverse range of interesting and high-impact physics results from MINOS, and eagerly looks forward to ν_e and sterile neutrino analysis results.

The Committee recommends determining the MINOS potential for running with antineutrinos with the current beam, as well as the expected sensitivity to ν_e appearance, assuming a 700 kW beam and a few years of running (i.e., sensitivity vs. protons-on-target). The Committee also recommends that the ultimate sensitivity of MINOS, including when irreducible systematic uncertainties become dominant, be estimated.

E-954 SciBooNE (Nakaya/Wascko)

The Committee commends SciBooNE for successfully obtaining a great deal of experimental information in a short time. The Committee recommends that SciBooNE provide a clearer picture of how it plans to determine normalized neutrino cross sections from its observed event rates. The Committee also recommends that SciBooNE update its estimate of the precision it expects to obtain in the cross section values, and how this anticipated precision compares with the needs of T2K.

The Committee recommends further coordination of the efforts and analyses of MiniBooNE and SciBooNE to maximize their joint scientific impact.

E-944 MiniBooNE (Brice/Van de Water)

The Committee heard an interesting update on the status of MiniBooNE, which has now studied events induced in its detector by neutrinos from the NuMI beamline. With neutrinos from their own Booster Neutrino Beam, MiniBooNE has measured many cross sections and is examining a number of backgrounds that could contribute to its observed low-energy excess. It is also working on a combined oscillation analysis of LSND, MiniBooNE, KARMEN, and Bugey results. The Committee encourages further analysis of the NuMI-beamline data to see whether the low-energy excess appears to depend on beamline length L and beam energy E as L/E , as would be expected for neutrino oscillation. The Committee looks forward to the results of the low-energy background analysis, which the collaboration aims to complete in time for Neutrino 2008 at the end of May.

The Committee recommends further coordination of the efforts and analyses of MiniBooNE and SciBooNE to maximize their joint scientific impact.