News from Fermilab (DPF Newsletter, January, 2010)

Fermilab is moving aggressively on fulfilling the promise of its current program, beginning funded efforts on the next generation of experiments, and doing R&D for the future beyond that. The breadth of the research program should be evident in this brief summary. And, there is recent positive news in all areas.

The Fermilab accelerators came back very fast after a long summer maintenance-and-repair shutdown. That shutdown followed a Collider run lasting about 20 months. After the shutdown, initial instantaneous luminosities returned to the level of 3×10^{32} $cm^{-2}s^{-1}$. The Tevatron Collider continues to provide integrated luminosity at near record levels. Over the last year, several weeks have seen greater than 60 pb^{-1} of integrated luminosity. The record was set in April, 2009, at just over 74 pb^{-1}. Contributing to the excellent performance has been the record number of antiprotons delivered to the Recycler Ring, the record being the 4.04×10^{12} during the week including Christmas, 2009, with nearly as many the following week, giving the best two-week period for antiproton delivery. For fiscal year 2010, the expectation is for an additional 2.25 fb^{-1} for each of the Collider experiments; and a total of about 12 fb^{-1} by the end of the scheduled running through fiscal year 2011. This could allow seeing evidence of the Higgs boson over some of the expected mass range of the Standard Model, or exclusion throughout that range if the Higgs is not there to be seen. There is a host of other results across the full range of collider physics. The two Fermilab Collider experiments are continuing their enviable refereed-journal publication rate of about one each per week.

Also central to Fermilab's productivity is support of and participation in the accelerator, detector, and physics efforts for the Large Hadron Collider program. The recent successes in restarting the LHC and first use of collision data have had major contributions from Fermilab, both in helping understand the accelerator issues associated with the LHC problems of last year and as part of US CMS in analyzing the data. Fermilab is the host institution for US CMS, and operates the Remote Operations Center (ROC), a Tier 1 Computing Center, and the LHC Physics Center (LPC) in support of these efforts.

The neutrino program is also benefiting from record accelerator performance. The protons on target (POT) for the NuMI beam reached 92.1×10^{17} POT during the week of Jan. 4-10 (the third of three weeks in a row with sequential new records for POT), and 14.0×10^{17} POT on January 9, a new record for a single day. The MINOS experiment in the NuMI beamline has provided some of the most interesting neutrino results recently, with a hint of sensitivity to the elusive neutrino mixing angle, θ_{13}, as well as the most precise determination of the atmospheric-mixing mass-difference. Results from 7×10^{20} POT, double the previous data sample, are expected soon. One recent highlight of the neutrino program has been the observation of particle tracks in the liquid argon TPC of ArgoNeuT. In addition, MINERvA is nearing completion of construction of its detector, with regular running using the full detector expected to begin by March 1. Finally, the MiniBooNE experiment has integrated well over 1.3×10^{21} POT in the Booster Neutrino Beam, and both MiniBooNE and SciBooNE have been publishing interesting results. The low-energy excess seen in MiniBooNE remains unexplained.

In particle astrophysics, the Laboratory's involvement in dark-matter searches across a range of technologies has been very visible. The approaches to observing dark matter by Fermilab experiments extend from direct searches via nuclear recoils to the effects of gravitational lensing on a cosmic scale. The most recent stir in the community was created by the new results from the Cryogenic Dark Matter Search experiment (CDMS). Pushing CDMS sensitivity to new, leading levels has resulted in two events with an anticipated background of less than one event. The race for increased sensitivity in various dark-matter particle mass ranges includes the solid-state germanium devices used by CDMS, new CF_3I bubble-chambers used by the Chicagoland Observatory for Underground Particle Physics (COUPP), depleted liquid argon detectors to be used by the DarkSide experiment (which recently received Stage I approval from Fermilab), and laser-“brick-wall” apparatus used by the GammeV axion search experiment. Dark energy is another component of the Fermilab particle astrophysics program. Starting with data from the Sloan Digital Sky Survey (SDSS) 2.5 meter telescope in New Mexico, the dark-energy density parameter has been constrained by the power spectrum of galaxies. More broadly, the SDSS ranks as the facility with the highest impact in astronomy for the fourth year in a row. The Dark Energy Survey (DES) is making good progress on preparing a new camera which should be operational in 2011 at the 4 meter telescope at Cerro Tololo, Chile, and the data handling and analysis software to use the data from the camera. The Pierre Auger Observatory continues to raise interesting questions about the source and nature of the very highest energy cosmic rays, even after demonstrating the GZK cut-off. Beyond DES, Fermilab is planning for participation in the Joint Dark Energy Mission (JDEM), whose space telescope could benefit were Fermilab selected as the JDEM Science Operation Center.

In summary of the current Fermilab program, it is useful to note that the program is providing the most results among all particle physics sources for publications in refereed journals and presentations at recent international conferences.

There is also major progress in preparations for the next round of experiments. With part of the American Recovery and Reinvestment Act (ARRA) funds provided to Fermilab, NOvA, the off-axis neutrino oscillation experiment will be sped up. Part of the NOvA Project is an upgrade of the NuMI beam intensity from 400 kW to 700 kW. NOvA also includes a 14 kiloton detector sited at a distance of 810 km in Ash River, Minnesota. Using technology identical to that of the far detector, a 215-ton near detector is sited off the NuMI beam axis, but on the Fermilab site at a distance of 1 km from the primary target. Recent progress includes the groundbreaking for and construction of the NOvA far-detector hall.

Longer-term initiatives like MicroBooNE, Mu2e, and the Long Baseline Neutrino Experiment (LBNE) all have recently received CD-0 approval by the DOE. These are major projects that will draw strong national and international participation. Proposals for other experiments that are not currently on the roadmap, like the New g-2 Experiment and the proposed measurement of the ultra-rare kaon decay process, $K^+ \rightarrow \pi^+ \nu$ anti-ν using the

Tevatron as a stretcher-ring, are world-class, and have strong collaborations pushing to move their experiments onto the HEP roadmap.

The strategy for the longer-term future has broad support. It is a challenging and exciting program, with Project X the central, first part of a multistep plan. Project X is a high intensity source aimed at pursuing the Intensity Frontier in neutrino and rare-decay physics. The plans for Project X include very flexible capability for the varied beam structures needed for the range of neutrino and rare process experiments. LBNE and next-generation lepton and rare kaon decay experiments, once built, would benefit further from the availability of Project X beams. Fermilab is leading a collaboration of all the major US accelerator laboratories working together on the R&D for Project X. Project X requires advances in superconducting rf technology. This technology is also necessary for any number of future energy-frontier options, as well as other accelerator developments in other fields. The HEP world expects to need a lepton collider once the Tevatron or LHC establishes the energy scale necessary for pursuing expected discoveries. If appropriate, the ILC will be the easiest machine to build. Technology development for Project X will help position the US to be a major player for the ILC. Should an ILC not be capable of reaching the required energies, community interest will focus on the directions of a dual-beam electron accelerator, CLIC, and of a muon collider. Fermilab has been asked to host a national effort on Muon Accelerator R&D. The Laboratory is working closely with the existing collaboration to form a new national Muon Accelerator Program (MAP). MAP will pursue important aspects of a muon collider that require new technologies and will complete a muon collider Design Feasibility Study (DFS) over the next several years. Again, the technology developments for Project X will be a crucial piece in our ability to build a muon collider. The time scale for either CLIC or a muon collider is well beyond a possible ILC.

Fermilab seeks neighboring communities' advice and counsel on every public-related issue, from the effects on local residents of neutrino beamline cavern blasting to the future of US particle physics. The Laboratory has launched a new Community Advisory Board, a group of 26 local residents, who will help the Laboratory analyze the development of its program and the interactions with the surrounding community. The involvement of the laboratory neighbors has been outstanding in the past and continues to be outstanding.