Energy Frontier Physics

Findings

Achieved 1.8 fb^{-1}, which is the same as last year but in only 8.5 months.

Ruled out standard model Higgs between 160-170 GeV.

Top Quark measurements with 1% precision.

So far in 2009, 100+ CDF talks given in conferences and 28 papers submitted

CDF is averaging 30 PhD's per year. D0 produced 14 PhD's so far in 2009 and 36 in 2008.

D0 Submitted 165 articles to journals based on Run II data and over 60 abstracts to 2009 Summer Conferences.

Projecting between 10 and 12 fb^{-1} integrated luminosity by end of 2011.

Comments

The energy frontier physics results from the Tevatron in the last year are the highest quality and importance in the field.

The CDF and D0 detectors should be able to operate at a sufficiently high level through 2011 to produce the same physics performance as in the previous years. This includes the silicon tracking detectors, which will not suffer sufficient degradation by 2011 to significantly affect physics performance.

The projected physics yield from continued Tevatron operation of both CDF and D0 through the end of 2011 will continue to yield physics results of the highest quality and importance in the field.

The number of people to sustain CDF and D0 operations appears sufficient, so that all tasks are sufficiently covered for now. The laboratory should formalize commitments of individuals to CDF and D0 to make sure that all essential support tasks are covered through FY 2011.

Recommendations

- The laboratory should continue to evaluate the optimum time for ending the Tevatron program that achieves the goal of ruling out the SM Higgs at 95% taking into account:
    - Statistics for other Tevatron measurements
    - Starting up NOvA
    - Resources at the Lab for future experiments and other activities
    - Deferred maintenance of collider components

Intensity Frontier Physics

MINOS

Findings

MINOS is a mature experiment that has been running since 2005. The experiment has collected a total of 7×10^{20} Protons on Target (POT) thus far and has reported results based on 3×10^{20} POT. The experiment has provided the most precise measurement of the mass splitting Δm_{23}^2 from the study of ν_μ disappearance. In addition, the experiment has set limits on antineutrino disappearance (with lesser significance) and also on sterile neutrino mixing. Comparison of neutrino disappearance and antineutrino disappearance is sensitive to potential violation of CPT invariance.

The collaboration is reporting a new analysis of ν_e appearance, which is sensitive to the last unknown mixing angle θ_{13}. The search for ν_e appearance events reported finding 35 event candidates with an expected background of $27 \pm 5 \pm 2$ events. If this is interpreted as a genuine signal, this would correspond to a value of $\sin^2(2\theta_{13}) \approx 0.2$ which is at the CHOOZ limit for electron appearance. This result however has 100% errors. Thus the MINOS result for θ_{13} is not yet sensitive at the level of the present CHOOZ limit, but with 4 times the exposure (12×10^{20} POT) MINOS could begin to provide significant new information on θ_{13}.

Comments

The electron appearance measurement, which used about ½ the existing MINOS data, has 100% errors, so it is not significant yet, however this measurement is extremely important for early determinations of the value of $\sin^2(2\theta_{13})$. Their result depends on background uncertainties, which may be reduced with additional running. The MINOS group should complete the analysis with the full 7×10^{20} protons on target dataset and estimate the improvements possible with additional running. An improved measurement of $\sin^2(2\theta_{13})$ would be extremely valuable to the future of the neutrino program.

The laboratory needs to carefully plan in consultation with the collaboration the remaining MINOS running configuration to optimize the scientific impact of MINOS, taking into account the rest of the neutrino program.

Recommendations

None

MiniBooNE

Findings

The MiniBooNE experiment has been successfully collecting data since 2005, with a total exposure of almost 10^{21} POT. The experiment has produced important results on ν_e appearance that rule out the straightforward interpretation of the LSND anomaly (assuming CPT invariance). In addition, the collaboration has reported an observation of excess ν_e events at low energy (<450 MeV), which do not appear in antineutrino mode. The experiment continues to run in antineutrino mode, but the sensitivity is less than for neutrinos and will not be able to definitively rule out the LSND result for antineutrino appearance.

Comments

The low energy excess ν_e events are not understood. The collaboration has expended significant effort to identify all sources of background, but does not have an explanation for the observed events. It seems unlikely that collecting additional data will improve the situation.

Recommendations

None

SciBooNE

Findings

The SciBooNE experiment has completed acquiring data on neutrino and antineutrino cross sections, and the detector has been decommissioned. Some results have been reported on charged pion production cross sections as well as neutral current π^0 production, and there are preliminary results on quasielastic scattering and elastic neutral current scattering. The quasielastic scattering result is in agreement with that of MiniBooNE. The reported neutral current π^0 cross section is

$$\frac{\sigma\left(NC\pi^0\right)}{\sigma\left(CC_{inclusive}\right)} = (7.7 \pm .6 \pm .6) \times 10^{-2}.$$

Further data analysis is in progress, and a combined analysis with MiniBooNE is planned.

Comments

This was a very successful experiment, executed on an impressively rapid schedule.

The neutral current π^0 cross section is very important for estimating the backgrounds to the electron appearance measurement to be done by T2K and NOvA.

Recommendations

None

Current Detector Operations

Findings

CDF recorded 85% of delivered luminosity, 80% with full detector, which is an improvement on the Run II average: 83% acquired, 71% good with full detector.

CDF deadtime: ~1% at run startup and ~7% due to trigger and DAQ.

D0 luminosity in the last 12 months: recorded 91.6% of delivered luminosity. Run II average: 88.4% acquired.

Depending upon the data quality requirements, this Run II data sample provides available exposures between 5.3 fb^{-1} and 5.8 fb^{-1} for extraction of final physics results

Comments

Both experiments demonstrated good operational performance and shows steady improvement.

The lab and collaborations need to retain the personnel that have been responsible for the good performance of the operation of the detectors up to now. The international fellowships and the visitor's fund are a valuable contribution to this.

Recommendations

None

CDF & D-Zero D&D

Findings

The CDF and D0 detectors will need to be decommissioned in 2012.

Comments

There should be a realistic estimate made of the resources and manpower to handle the D&D, including radiological survey and inventory of objects. There are many issues of safety, security, and monitoring to be addressed.

A special issue is how to handle the dismantling of the D0 calorimeter and test calorimeter.

There should be a call for proposals for salvaging equipment from the detector. There should be a plan for when the call will be issued, what can be salvaged, criteria for judging the proposals, time-line, requirements on what can be salvaged and how. This should be a transparent process.

The lab needs to produce a detailed plan for the CDF and D0 decommissioning.

Recommendations

- The lab should identify the owners of the detector components by the next S&T review with the goal of developing the D&D plan.

Accelerator Operations

Findings

- 1.8 fb^{-1} of integrated luminosity was delivered to D0 and to CDF in FY 2009 at 1.5 times the rate of FY08. The total from Run II is 6.8 fb^{-1}. These are excellent numbers, close to the optimistic scenario from the later Run II Reviews.
    - Antiproton stacking rate & cooling; Tevatron reliability
- 1.3E20(≈design) protons for MiniBooNE, 2.1E20 (2.5E20 design) for MINOS in FY09, again, very good.
- The proton delivery is limited mostly by Booster throughput (beam loss <570W); the planned upgrades (corrector magnets) may help that. A second limit is MI activation (1 kJ/pulse, 500 W).
- Overall uptime is very good (for an HEP facility), Tevatron (≈90%) is better than FT (≈85%).

Comments

- Projections for Tevatron (8–9 fb^{-1} for FY10, 10–12/fb for FY11) appear reasonable and can be expected to be met.
- Accelerator physicists for new projects come from reduction of Tevatron support. Reasonable but not without risk.
- All in all, very impressive and praiseworthy performance
- It would be useful to begin assembling a list of machine experiments—possibly at elevated risk—that could be done before the end of the run.

Recommendations

None

Tevatron D&D

Findings

- The lab proposal for the Tevatron after the completion of Run II is for 2 years of cryogenic standby followed by warm-up of ring & back-fill with dry nitrogen. The situation would then be re-evaluated after that.
- Last year's recommendation to prepare detailed estimate was well addressed.
    - The laboratory stated that two buildings would be needed for storage of magnets & components in order to deal with the metals moratorium.

- No planning to recover value of parts/components was presented.

Recommendations

- Perform a cost-benefit analysis for keeping the Tevatron in a “cryogenic stand-by” state for an extended time versus warm-up and purge followed by a later restart in the context of the planned program.

Future Accelerators

Accelerators in support of Neutrino/Muon Programs (Pre-Project X)

Findings

The proton requirement for NOvA is 700 kW of 120 GeV proton beam on target. This corresponds to 4.8e13 protons per pulse with a repetition rate of 0.75 Hz requiring 4e12 protons per pulse from the Booster at 9 Hz. In addition 4.5e12 protons per pulse at 8 GeV are required for MicroBoone with a rate of 2–3 Hz and for Mu2e with a rate of 4–6 Hz.

The main improvements to achieve these proton fluxes consist of upgrading the duty factor of the Booster RF system to support 15 Hz operation of the Booster and increasing the Main Injector repetition rate from 0.4 to 0.75 Hz. The upgrades are part of the “proton plan” developed by the Laboratory.

Comments

Although the number of protons per pulse is not much higher than already achieved during present operation the proton throughput is about twice as large as presently. The challenge is therefore to reduce the beam losses in both machines by a factor of two. Several approaches for this have been presented in the past and at this meeting.

These upgrades are scheduled to be completed over the next two years although no resource-loaded schedule was presented.

Project X

Findings

Project X consists of an 8 GeV linac accelerating H^- pulses of 32 mA peak current with a 2.5 Hz repetition rate. The beam is strip-injected into the Recycler Ring and transferred to the Main Injector (MI) for acceleration to a maximum energy of 120 GeV. The beam power on target is 2 MW over a 64 to 120 GeV energy range. The beam can also be extracted from the Recycler Ring for the Mu2e experiment. The superconducting linac would use cavities similar to ILC cavities and will therefore benefit from the worldwide effort to develop 1.3 GHz SRF systems. To reduce the need for multiple klystron sources it is planned to use high power vector modulators to phase individual cavities.

Comments

The throughput for the MI will increase about six-fold compared to today's operation. This represents challenges that will need to be addressed, the most significant ones are a new MI RF system and the potential need to coat the inside of the MI vacuum chamber with a low-secondary-emission coating. Also, accumulation of the beam in the Recycler and subsequent transfer of the intense bunch-train to the MI may present significant challenges.

While the laboratory is aware of these needs it was not clear from the presentations whether these needs have found their way in to the resource planning process.

The “High Intensity Neutrino Source” (HINS), a front-end development effort started in 2006, is now refocused to possibly be the actual Project X front-end and also a test bed for the vector modulators. It is an excellent idea to advance the completion of the vector modulator development to a new target date of 2010.

An alternative initial design for Project X was presented based on a 2 GeV CW superconducting linac that accelerates both protons for Muon and Kaon experiments and H^- for further acceleration possibly in a Rapid Cycling Synchrotron to 8 GeV. This scenario would not allow for a future upgrade to 2-4 MW beam power at 8 GeV. With this in mind it appears prudent for the laboratory to evaluate the limits of the present Booster with 2 GeV injection and to assess its potential to support Project X beam requirements. Note that the 2 GeV CW linac cavities are now closer to the parameters of other CW linac cavities and different from the Tesla cavities.

Project X aligned Programs: ILC/SRF/HINS

Findings

Fermilab's SRF programs were presented as Project X Aligned Programs: ILC and HINS indicate the central role of SRF in the lab's future. Project X was initially based on proton beams having ILC current specifications. This has now started to change and the hardware will now be somewhat different between the two projects. However, attention has been paid to ensure that the synergy between the two projects is not lost.

Comments

Progress on the HINS cavities was very positive, with one cavity making three times the design gradient. The early RF tests on the High power vector modulators using the HINS cavities are especially useful to the ILC and Project X.

This is a good example of the integration of the SRF program. The progress in actually using the new cavity-processing infrastructure to obtain good results is encouraging.

Muon Facility R&D

Findings

The Muon Collider Collaboration has proposed, as a next phase of their activities, to prepare a feasibility study of a 4 TeV Muon Collider with a luminosity of 4e34. The study is to be completed in five years at a total cost of about $90M. The effort also includes some hardware R&D to make technology choices and a first cost estimate.

Comments

It is very appropriate to embark on this effort at this time since a similar effort is underway for CLIC, the main competing concept for a multi-TeV lepton collider. The study should focus on the feasibility of the elements of the collider with the highest risk. For the Muon Collider this is certainly the muon beam cooling section where the 6-D emittance has to be reduced by six orders of magnitude. There are several proposed techniques to achieve this.

It is important that a realistic simulation of the cooling channel based on at least one of these techniques is completed.

Recommendations

None

Future Detectors

The laboratory is doing a good job in positioning itself to become a leader in intensity frontier physics and has five experimental efforts under various stages of design: Minerva, NOvA, MicroBoone, LBNE and mu2e.

Minerva

Findings

Minerva has successfully taken a prototype run with 20% of the detector constructed. Exclusive final state data has been collected with this partial detector using the booster neutrino beam with $4x10^{19}$ POT. Once the analysis of this data is complete a publication is envisioned. This test run produced 15K events, which should yield publishable results.

By May 2009, they have completed about 70% of the detector and they are on track to complete the entire detector on schedule and within their budget by Spring 2010.

Fermilab has set up a 2^{nd} assembly line to speed up the construction and has supported some university faculty to work full time at Fermilab.

Comments

Excellent progress has been made and the collaboration is functioning well. Local project management has been very effective at integrating many subsystems from collaborating institutions. Minerva is in good shape and the integration of university and laboratory resources and personnel should serve as a role model for future projects. There is some concern as to how the neutrino beam schedule for Minerva running is coordinated with the other neutrino experiments NOvA and MINOS. Minerva has also requested more lab computing support.

Recommendations

See below.

NOvA

Findings

NOvA is now back on track, a solid construction plan is in place and the collaboration is making excellent progress. Earlier, NOvA work was stopped by the FY08 omnibus bill funding cut, but recent funding became available via the ARRA and funding was restarted in FY09 where eventually >$80M was provided by late FY2009.

The experiment is composed of large PVC tubes filled with liquid scintillator and fiber readout and is constructed in a 222 ton near detector at Fermilab and a 14,000 ton far detector in Minnesota. This initial funding has been spent on building the far detector site. The project was granted a CD3a in October 2008 and is on track for CD3b by July 2009.

The current schedule has detector installation beginning in mid-2011 and CD4 in Nov. 2014, with 700kW beam becoming available in late 2013. The aim is to achieve a $\sin^2(2\theta_{13})$ sensitivity of 0.01 after 6 years of running with the 700kW beam. If the beam starts up at the nominal design value, NOvA will achieve this sensitivity goal by the end of 2019.

Comments

Even with the accelerated funding available due to ARRA, the schedule for NOvA to obtain significant physics results is rather late, significantly behind the reactor experiments and T2K. Nevertheless, it remains true that NOvA is the only near term experiment capable of addressing the neutrino mass hierarchy.

Recommendations

- The laboratory should optimize its resources to minimize any additional delays in the NOvA construction and the accelerator NuMI beamline upgrade, which should achieve 700kW design operation.

MicroBooNE

Findings

The MicroBoone project involves construction of a liquid argon detector with TPC readout for neutrino detection. This detector will hold ~170 tons of liquid argon, with a fiducial volume of ~70-80 tons inside a TPC with three readout planes. This project is part R&D for the future LBNE detector and part physics to measure neutral current π^0 events and ν_μ and ν_e interactions over a 2-year running period on the surface near the MiniBooNE enclosure. Reconstruction of the data with this detector will benefit from the work being done with much smaller 300kg Argoneut detector. The MicroBooNE physics goals include determination of the neutrino interaction cross-section at the neutrino energies which will be present at the location of the LBNE far detector. The detector should have excellent capability to separate neutral current π^0 events from electron neutrino events in the liquid argon. The project anticipates CD-0 mission need to be approved this summer and the conceptual design CD-1 review to take place at the end of this year.

Comments

While MicroBoone is proposed as being an equal mixture of a physics project and a detector R&D project, it appears to be primarily a detector R&D project. This should be its primary focus and the ability to use the detector to make measurement should be considered as a secondary aspect. The MicroBooNE is an important step towards a proof of principle of the large liquid argon TPC technology. However, MicroBooNE will not be sufficient to validate all the engineering challenges in building a 50 kiloton liquid argon detector. Other larger scale prototypes will be needed after MicroBoone is built.

Recommendations

See below

LBNE

Findings

The Long Baseline neutrino experiment is a proposal to build a 2MW beamline to send a neutrino beam to the far detector which would detect neutrinos in either a 300 kiloton water Cerenkov detector or a 50 kiloton liquid argon detector. Project is getting organized, hoping for a CD-1 in late 2010, a CD-2 in 2011 and a construction start in 2013. It recently received $15M ARRA funding to support administrative and engineering personnel who will be used complete a CD1 proposal by the very end of 2010. Budget planning for a total of ~$20M was presented with personnel grouped into working, available, and new categories. The actual FY09 personnel budgets have been presented.

The water Cerenkov design proposes to use 60K 10” PMTs in each of three 100 kiloton water tanks. The liquid argon design proposes the building of three 17kt LAr TPCs. A 5 kiloton prototype is proposed to be built after the MicroBoonNE detector is completed.

Comments

Fermilab and BNL are ramping up project management rapidly, which is important for this project. There are many challenges that need to be addressed, including coordination with funding agencies and possible foreign participants.

The collaboration is carrying forward 2 technologies (water Cerenkov and liquid argon TPC). However, this is probably necessary until further information on the feasibility and cost is available.

Completing the proposed work for CD1 by the end of 2010 will be extremely challenging.

μ2e

Findings

The μ2e project is in its very early stages, receiving stage 1 approval from the Fermilab PAC in November 2008. It is based on the previous (unfunded) MECO proposal at BNL. The goal is to search for $\mu \rightarrow e$ conversion on Al with a branching ratio of less than 10^{-16}. It is a technically challenging experiment, with a total cost of ~$200M that could be constructed by about 2016.

Comments

This is an important experiment with an impressive potential physics reach. It is a good match to the Fermilab program and facility. There are many technical issues that require substantial R&D before this project can proceed.

The collaboration urgently requires additional strength, with more substantial commitments from the collaborators.

Rare decay experiments usually require a sequence of long runs and extensive work to understand the detector and achieve the desired precisions.

A substantial effort to attract international collaborators would also be appropriate. This may require consideration of and coordination with, a similar project being proposed in Japan.

Recommendations

- Laboratory management and the collaboration should develop a plan that details the resources needed by both the project and the collaboration to successfully mount and execute the experiment.

General Comments.

- The current separation of ArgoNeut, MicroBoone and the larger 5 kiloton prototype as separate projects should be reevaluated to see if having a coherent multistage project would be more suitable.
- The laboratory has identified the intensity frontier as its future emphasis and has developed a project oriented plan to align its activities. We encourage the lab to examine the balance between staff working on the energy frontier detectors and staff working on the intensity frontier detectors.

GENERAL Recommendations

- Lab management should develop an integrated running plan that addresses the needs of all the neutrino experiments as a function of time.
- The laboratory should develop a detailed plan for development of the LAr/TPC technology with clear milestones for each aspect of this plan by the end of year. MicroBoone should be considered as part of this development.

Strategic Planning

Findings

The strategic plan for Fermilab is based on the concept of the triple frontiers: energy, intensity and cosmic. The energy frontier is based on operating the Tevatron for one more year (through FY11) as the machine and detectors are working extremely well and LHC physics will be delayed. The focus will then shift to LHC, with Fermilab acting as the host lab for US CMS while participating in the LHC accelerator Upgrades. Roughly half of US particle physicists will be active at LHC in this era.

The next phase has been primarily based on ILC, with Fermilab being the lead laboratory for the Americas. There is now a concern that there is no sign of the Higgs particle at the Tevatron, and a contingency plan is needed if it is seen at LHC at higher energies than can be reached by ILC. In this scenario, Fermilab would focus on a muon collider rather than CLIC, which is currently favored by CERN. This is a new focus and an approach has been developed which speeds up the muon collider studies so a paper design can be prepared in 2012.

The intensity frontier is initially based on continued running of MINOS and the startup of Minerva and construction and then, in 2013, operation of NOvA, a neutrino experiment using a 120 GeV, 700 kW proton beam from the Main Injector. This is backed up by a neutrinos and high intensity proton program for rare processes (MicroBoone and LBNE).

The centerpiece of the future program at the intensity frontier is Project X, around which all of the future programs at Fermilab revolve. The long baseline neutrino experiment (LBNE) requires >2MW of beam power, a baseline of 1290 km, and 100 to 300 kiloton detectors. There is also a multi-stage mu2e experiment and a future K program, which requires Project X.

The pivotal role of Project X means that it has three distinct Mission Needs:

1. A neutrino beam for long baseline oscillation experiments.

2. 2 MW proton source at 60 -120 GeV high intensity 8 GeV protons for kaon and muon based precision experiments.

3. A path toward a muon source for a possible future neutrino factory and/or a muon collider at the Energy Frontier.

At present, ICD-1 addresses the requirements 1 and 3, but only partially addresses the second. Some initial ideas were proposed to modify the Project X layout to enhance the applicability to requirement 2 at the expense of the muon collider.

Comments

Fermilab has presented a credible long-range vision, which is steadily evolving due to external technical input (can ILC see the Higgs?) as well as the availability of ARRA funds, which are opening up options that had previously been excluded. The scope of this vision is exciting and will provide an exciting future for Fermilab.

Physics

The laboratory should continue to evaluate the evolution of the physics reach of NOvA and the other Fermilab Neutrino experiments vs. the competition over time, e.g. measurement of theta-13 for cases of large and small theta-13.

The laboratory should understand more clearly the roadmap to a decision between LAr and WC detectors for LBNE and the role that MicroBOONE plays in this program as an R&D project.

The Mu2e project may is very challenging and its schedule is aggressive. The lab should conduct a systematic review of the performance required of each of the critical components and what is required in terms of R&D and demonstrations to show that this performance is achievable. The actual experiment may need several tries to reach its full potential. The lab should ascertain the needs for long-term commitment of lab resources and personnel to see this through.

Accelerator

The missing element is an overall plan that delivers the vision. How do the different components of the neutrino program coexist? What is the layout of Project X that meets all of the Mission Needs? What is the optimum investment in R&D towards a muon collider or a neutrino factory?

The overall scope of the vision is ambitious and may well over-tax the staff in their ability to build and exploit everything that was presented. Once the overall plan is complete, the OHAP (Organization and Human Asset Plan) should be continued, analyzing differences between the resources available and the needs. A plan should then be developed for retraining, redirecting, retaining, and recruiting the necessary workforce.

Recommendations

- Complete the OHAP including analyzing differences between the resources available and the needs from all projects and programs.
- The laboratory should evaluate interference effects between MINOS, NOvA, and Minerva in terms of low vs. medium energy and neutrino vs. antineutrino and produce an integrated plan for all experiments in the neutrino program that also considers expected results from other experiments not at Fermilab.