U.S. DEPARTMENT OF ENERGY

Office of Science

Fermilab Institutional Review Closeout

June 9, 2011

U.S. DEPARTMENT OF ENERGY
Office of Science

(I) Energy Frontier Physics – CDF/D0

FINDINGS

- **CDF/D0 will collect about 10 fb^{-1} by the time the Tevatron stops. Recent operation of both experiments has been very successful.**
- **The collaborations continue to publish at a high rate, each producing about three dozen papers in 2010.**
- **Fermilab personnel have critical and essential roles in all aspects of CDF/DO. Recent Fermilab performance has been excellent as the host of these experiments.**
- **Fermilab CDF/D0 postdoctoral personnel have an outstanding record of obtaining HEP faculty/laboratory positions. About 85% of the last ~50 postdocs have obtained positions in HEP. This is indicative of the high quality of their work at Fermilab.**
- **CDF/D0 have published results that may indicate physics beyond the Standard Model. These results have not yet been confirmed or refuted (including by the LHC)**
- **Limits on (or perhaps indication of) the SM Higgs are expected to be updated over the next year and finalized by summer 2012.**
- **CDF/DO presented plans for targeted further data analysis, taking into account the rapid increase in LHC luminosity.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(I) Energy Frontier Physics – CMS

FINDINGS

- **The LHC integrated luminosity is increasing very rapidly and accumulated luminosity of at least a few fb-1 is expected before the long shutdown needed to increase the LHC energy**
- **The CMS detector is operating very well and data analysis is highly effective**
- **The CMS Fermilab group has leadership roles in the overall CMS collaboration – operations, computing, data analysis and upgrades**
- **The number of CMS publications is already substantial and is expected to grow rapidly. Fermilab personnel have leadership roles in a significant fraction of the first CMS publications.**
- **Fermilab has unique roles as the lead lab for U.S. CMS: overall CMS program management, U.S. Tier 1 site, host of the Remote Operations Center and location of the LHC Physics Center. Fermilab personnel also have leadership positions in the CMS upgrade planning and R&D. Performance in all these roles is excellent.**
- **An integrated luminosity of 5 fb-1 would allow (when combined with ATLAS) 3σ sensitivity(or 95% exclusion) for SM Higgs masses in the range from the LEP limit to about 600 GeV.**
- **The discovery potential for CMS in 2011 – 2012 is substantial and the Fermilab group is well positioned to continue their major contributions.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(I) Energy Frontier Physics

COMMENTS

- **CDF/D0 plan to focus their efforts on physics analyses that might have the most impact - signals beyond the SM , SM Higgs and measurements better than or competitive with LHC results. Very active management by the collaborations with the appropriate oversight and resources from Fermilab will be needed to realize the desired results by mid-to-late 2012.**
- **The resources (computing and human) needed to be able to analyze CDF/DO data in 2013 and beyond has been and will continue to be evaluated by Fermilab. The broader community should be involved in this process through appropriate review of plans.**
- **Personnel movement from the Tevatron to CMS has been very small since 2008. The plan is to allow 6-10 physicists to join CMS as they transition from CDF/D0 in the next 2- 3 years. A new CMS Associate Scientist and other junior staff may be added if budget permits. This likely meets the CMS needs over the next ~ 5 years**
- **LHC results during the ~ 5 years may result in discoveries but in any case will have a major impact on the future direction of HEP. Fermilab is one of the leading and most effective groups in CMS and furthermore is the backbone of U.S. CMS. The Fermilab CMS group should be supported with very high priority during this period.**

RECOMMENDATIONS

- **None**

U.S. DEPARTMENT OF ENERGY
Office of Science

(II) Intensity Frontier Physics – Overall Neutrino Program

FINDINGS

- **Fermilab has an extensive program in neutrino physics producing significant physics results. The program includes: MINOS, MiniBooNE and MINERvA that are in physics phase, NOvA in construction phase; MicroBooNE (CD1) and LBNE (CD0) in planning phase; and MINOS+ in proposal phase. In addition, SciBooNE and ArgoNeuT had fruitful data taking runs and produced interesting and useful results.**

- **Fermilab plans to make the neutrino physics program the center piece of the on-site physics program in the coming decade and possibly beyond.**
- **The 8 GeV Booster and 120 GeV Main Injector have run very well for the last a few years. Especially the Booster improvements have allowed the MiniBooNE to collect more integrated POTs than the optimistic projection, for which the accelerator division and the proton source team should be commended for their excellent work.**
- **There are currently 24.1 FTE staff scientists and 5.0 FTE postdocs working on Fermilab's neutrino program.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(II) Intensity Frontier Physics – Overall Neutrino Program

COMMENTS

- **While there are diverse neutrino programs at various stages with different needs and goals, there was no presentation on overall neutrino program that provided a coherent and big picture view of the Fermilab neutrino program from the point of view of prioritized science goals, and a strategic planning that encompasses all programs. This gave an impression to the committee that there in fact is a lack of such scientific leadership and overall coordination, and the lab responds reactively to the demands of each program. And the committee is concerned that this is indeed the case.**

- **It would be helpful if the lab would articulate their program's importance for the advancement of neutrino physics and present the positioning of the Fermilab neutrino program in comparison with other neutrino programs around the world including time scale.**

- **The neutrino program at FNAL may benefit from stronger support from the theory program.**

RECOMMENDATIONS

- **It is recommended that Fermilab be more proactive in coordinating the neutrino program including beam requirements and provide overall scientific stewardship.**
- **It is recommended that long range planning contingent on the results from the present round of neutrino experiments should be undertaken.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(II) Intensity Frontier Physics – MINOS, MINOS+, NOvA, MINERvA

FINDINGS

- **MINOS has 24 publications in total (9 in 2010-2011). MINOS has the world best measurement of the Δm_{23}^2; made the first observation of the disappearance of the anti-muon neutrinos; and set a competitive limit on the $\sin^2 2\theta_{13}$; and expect to improve the results on $\sin^2 2\theta_{13}$ with more data (8.2 x 10^{20} POT) and improved analysis technique soon.**
- **The oscillation parameters derived from the MINOS muon neutrino disappearance and the anti-muon neutrino disappearance have about 2% probability to have common parameters. To resolve this discrepancy, an extended anti-neutrino run is underway.**
- **There has been an incident of fire in the Soudan mine causing significant down time for MINOS.**
- **There has been three quick failures of the MuMI proton targets within the last six months. Investigation shows failures in the water-cooling mechanism. Two new targets are being delivered from IHEP.**
- **NOvA construction project is progressing well except problems with APD (initial death rate ~20%) and the cracks appearing in the PVC manifolds. Both of the problems have been addressed and fixed.**
- **MINERvA has taken 1.53x1020 POT v and 1.30x1020 POT anti-v data. They desperately want more neutrino beam.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(II) Intensity Frontier Physics – MINOS, MINOS+, NOvA, MINERvA

COMMENTS

- **MINOS has been producing excellent physics. Despite the recent setbacks, MINOS is making stead improvements in their results. The electron neutrino appearance results are impressive considering the fact that MINOS was not designed for this type of measurements. It is a reflection of the collaboration's hard work and inventiveness.**

- **It is not likely the neutrino – anti-neutrino (modest) discrepancy can be resolved easily.**

- **The contingency for the NOvA construction ($34M) seems too low for the present stage of the project. There are several large steps in the construction that remain to be accomplished - such as module production for the far detector and the commissioning of the module rotator.**

- **MINERvA has analyzed data for QE scattering process studies. MINERvA is poised to make important cross section measurements.**

RECOMMENDATIONS

- **None**

U.S. DEPARTMENT OF ENERGY
Office of Science

(II) Intensity Frontier Physics – MiniBooNE, MicroBooNE

FINDINGS

- **MiniBooNE is making a significant impact in the neutrino cross section measurements area.**
- **Recent MiniBooNE's results contain very confusing situation that has not yet been clarified.**
  - **Neutrinos: excess at low energy , no oscillation signal.**
  - **Anti Neutrinos: no excess at low energy, but is consistent with LSND**
- **MicroBooNE is proposed as a part of the necessary R&D for the large scale (> 10 kton) LAr detector. It aims to test feasibility of the following three crucial aspects of the LAr TPC technology: Purity without evacuation; cold electronics; and 2.5 m long drift**
- **One of the main physics motivations of MicroBooNE is to examine the MiniBooNE low energy excess**
- **MicroBooNE received CD1 in June 2010**

U.S. DEPARTMENT OF ENERGY
Office of Science

(II) Intensity Frontier Physics – MiniBooNE, MicroBooNE

COMMENTS

- **MiniBooNE's confusing situation is not likely to be resolved soon. The low energy excess anomaly may be due to the lack of complete knowledge on neutrino cross section and backgrounds at the low energy region**
- **MicroBooNE project has clear objectives and is well managed. The manager appears to be able to focus collaboration's effort and to move the project forward**

RECOMMENDATIONS

- **None**

U.S. DEPARTMENT OF ENERGY
Office of Science

(II) Intensity Frontier Physics – LBNE

FINDINGS

- **LBNE aims to measure $\sin^2 2\theta_{13}$ at better than 0.01 precision, to determine matter hierarchy and to search for CP violation. It also aims to search for proton decays and to observe neutrinos from supernovae.**
- **The LBNE is envisioned as the central on-site physics program for the post-NOvA era.**
- **Unfortunately LBNE took a severe blow by the NSF's decision not to continue DUSEL project. Now, the infrastructure for the far detector site must be included in the LBNE project. They are waiting for the J. Marx committee report on the various DUSEL options and Office of Science decisions.**
- **The collaboration is preparing for CD1.**
- **The collaboration has now ~300 members from 58 institutions.**
- **It now has two far detector options: 150 - 200 kton F.V. WC and 24 – 34 kton LAr detectors.**
- **Fermilab is the lead lab with overall responsibility (project management). BNL is responsible for the Water Cherenkov Detector and LANL is responsible for the Near Detector.**
- **New beamline design option at Fermilab with less underground tunnel is considered to reduce the cost.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(II) Intensity Frontier Physics – LBNE

COMMENTS

- **The LBNE project has been effectively managed by Fermilab considering the great uncertainties involved in the project, and political difficulties in the collaboration and otherwise.**

- **The elimination of one 100 kt WC + one 15kt LAr option as well as multi-module WC option is a painful but necessary step. Now the collaboration must face down selection of the far detector technology.**

- **The publically announced projected schedule seems unrealistic.**

RECOMMENDATIONS

- **It is recommended that the final decision on the far detector technology to be made as soon as possible.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(II) Intensity Frontier – Kaon Physics

FINDINGS

- **P996 proposed a pre-Project-X stopping $K^+ \to \pi^+ \nu\nu$ experiment extrapolating from BNL E787/949 that would accumulate several hundred events. This was not pursued because of the expense of keeping the TeVatron alive to serve as a stretcher.**

- **A new version of the proposal, dispensing with the TeVatron is being prepared.**

- **Such a detector would also be suitable for the Project-X era.**

- **An experiment very similar in technique to the KOPIO $K_L \to \pi^0 \nu\nu$ proposal is foreseen for the Project-X era. It would be superior to KOPIO in that the Project-X kaon flux is sufficient to allow a pencil beam, greatly simplifying the detector.**

- **The charged and neutral K experiments are envisioned to run off a single production target.**

(II) Intensity Frontier – Kaon Physics

COMMENTS

- **The K^+ experiment has the potential to increase the breadth of the program over the next few years, and bring in many new users.**
- **Without a near-term domestic kaon experiment the core of experts in this field is likely to disperse and age-out without passing their expertise on to younger colleagues. This could be problematic for the Project-X program.**
- **A single target for the two kaon experiments may be challenging, but would allow much more efficient use of the Project-X flux.**
- **Other interesting kaon experiments have been suggested for the Project-X era**
- **The Lab should make every effort to launch an early $K^+ \to \pi^+ \nu\nu$ experiment .**

RECOMMENDATIONS

- **None**

U.S. DEPARTMENT OF ENERGY
Office of Science

(II) Intensity Frontier – Rare Muon Processes

FINDINGS

- **Measurable μ^- to e^- conversion in the field of a nucleus and deviations from the SM value of the muon g-2 are commonly predicted in BSM models that were formulated for other purposes such as explaining electroweak symmetry-breaking.**

- **The new g-2 experiment aims to improve on the precision of the BNL experiment by a factor of 4.**

- **The Mu2e experiment aims to reach a sensitivity in the few x 10^{-17} region using an improved version of the BNL MECO technique.**

COMMENTS

- **The goals of these experiments well within the most interesting regions of parameter space of currently popular BSM theories. At these sensitivities even a negative result would be very valuable.**

- **The previous g-2 result has been extremely highly cited because it appears to deviate from the SM calculation. The Fermilab version of the experiment will be very valuable as an opportunity to check the previous measurement and possibly expose an unsuspected source of systematic error.**

- **g-2 is to some extent hostage to the SM calculation, but there's a very active theoretical and relevant experimental effort to improve this calculation.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(II) Intensity Frontier – Rare Muon Processes

COMMENTS (continued)

- **Both experiments benefit greatly from the available Fermilab accelerator infrastructure.**

- **Many experts from the original BNL experiment have signed onto the new proposal, which should shorten the interval between taking the data and making the measurement. There are also a number of MECO veterans on Mu2e.**

- **These experiments will greatly increase the breadth of the Fermilab program in the mid to late part of the current decade.**

RECOMMENDATIONS

- **None**

U.S. DEPARTMENT OF ENERGY
Office of Science

(III) Cosmic Frontier Physics

FINDINGS

- **Fermilab played a major role in the Sloan Digital Sky Survey. This project discovered baryon acoustic oscillations in galaxy distributions, showing that the sound horizon is 150 Mpc in today's universe.**
- **Fermilab has a leadership role in the Dark Energy Survey, DES. DES will measure w, the ratio of cosmic pressure to energy density, improving our understanding of dark energy.**
- **DES will use four methods to probe dark energy: counts of galaxy clusters as function of redshift; weak gravitational lensing to study cosmic shear; large-scale structure of galaxy distributions; distance-redshift relation by using Type 1a Supernovae as standard candles.**
- **The DES camera is nearly complete. It will operate on a telescope in Chile from 2012 – 2017 and will improve the accuracy of the current measurements of w by a factor of 3.**
- **Fermilab has recently joined LSST, which will operate later in the decade and will improve w measurements by another factor of 3.**
- **There are currently 16.2 FTE staff scientists and 2.0 FTE postdocs working on Fermilab's dark energy projects.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(III) Cosmic Frontier Physics

FINDINGS

- **Fermilab is developing four dark matter detectors with 4.9 FTE staff scientists and 3.0 FTE postdocs:**
  - **CDMS, measuring ionization and phonons in germanium.**
  - **COUPP, observing bubble formation in superheated CF_3I.**
  - **DarkSide, measuring ionization and scintillation in a liquid argon time-projection-chamber.**
  - **DAMIC, measuring dE/dx along particle tracks in a thick CCD. This is led by Juan Estrada, supported by a Presidential Early Career Award.**
- **CDMS has a spin-independent limit of 3.8×10^{-44} cm^2 for 80 GeV mass with 2 events for operation of a 4 kg detector at the Soudan mine.**
- **COUPP has a preliminary spin-independent limit of 4×10^{-42} cm^2 for 70 GeV mass, with 18 events for operation of a 4 kg detector at SNOLAB. This run has the best spin-dependent limit of any experiment so far.**
- **A 50kg DarkSide detector will be installed at Gran Sasso in 2012.**
- **A DECAM CCD is being tested for DAMIC in the Minos hall, at 350 foot depth. It has a very low 40 eV energy threshold, and has a competitive limit of 3×10^{-39} cm^2 for small mass dark matter particles (3 GeV).**
- **Fermilab will build large versions of these detectors to study backgrounds, with the goal of doing 100 – 1000 kg scale experiments.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(III) Cosmic Frontier Physics

FINDINGS

- **SuperCDMS has made great progress with their iZIP detectors, further suppressing surface effects, and expect 30 times improvement in sensitivity over CDMS II.**
- **A common CD process will be used to down-select the one or two technologies to move forward.**
- **The Fermilab group believes that two-phase liquid xenon technology has "hit a wall" of background due to relatively poor gamma ray rejection.**
- **Fermilab has participated in the Pierre Auger high energy cosmic ray project for many years. They currently play roles in project management (1.8 FTE scientists), analysis (2.0 FTE scientists) and array upgrades (0.2 FTE scientist). Auger has observed the GZK cutoff at 4×10^{19} eV, resolving controversial results from early experiments by other groups. They have also observed peculiar results involving the relative abundance of protons and iron nuclei above 10^{18} eV which they hope to resolve with new instruments.**
- **Aaron Chou is leading the development of an interferometer experiment to search for the quantum structure of space-time. This effort is supported in part by a DOE Early Career Award.**
- **Chou is also leading a search for axions using lasers and Tevatron magnets.**
- **Fermilab has done microwave detector R&D for the QUIET-II experiment, and is doing R&D on solid xenon for possible use in axion and neutrino-less double beta decay experiments.**

(III) Cosmic Frontier Physics

COMMENTS

- **Fermilab's contributions to SDSS and their strong role in DES place this group among the strongest in the quest to understand dark energy. Some members of this review panel expressed concern that their expertise in this area will be underutilized in LSST unless they quickly establish significant roles in this project.**
- **Fermilab is considering CDMS, COUPP and DarkSide in order to find the best compromise between cost and background rejection for a large scale experiment. The diversity of opinion in the committee reflects the current state of the DM cmmunity.**
- **Fermilab's opinion on liquid xenon backgrounds are not shared by many members of the global dark matter community, and it will take some time and effort to resolve this issue.**
- **The issue of cost will be very important in formulating the strategy to search for dark matter. It may not be possible to develop a ton-scale, background-free technology within current cost-guidelines. In that case compromises may have to be made involving detector mass, detector cost, and the quality of the detector (e.g. the degree to which the detector's operation and backgrounds are well-understood from fundamental principles).**

(III) Cosmic Frontier Physics

COMMENTS (continued)

- **If CDMS is ultimately chosen for a ton-scale experiment over COUPP or the large number of proposed one or two-phase liquid neon, argon or xenon experiments, Fermilab's strong role in CDMS would place them in the enviable position of leading the way in both dark energy and dark matter research.**
- **Fermilab has been a strong partner in the Pierre Auger project for many years. This project has been of historic significance in many ways, including: 1) its refutation of spurious observations of ultra-high energy gamma ray sources by other groups; 2) its demonstration of the existence of the GZK cutoff after other groups claimed to see cosmic rays at higher energies; and 3) its observation of correlations between arrival directions of high energy cosmic rays and locations of active galactic nuclei. The role of Fermilab has been reduced in recent years, becoming at this time mainly one of management.**
- **Fermilab is to be commended for their good fortune and for their support of Aaron Chou and Juan Estrada, two very creative young scientists who are likely to become future leaders in high energy physics.**

RECOMMENDATIONS

- **It is recommended that Fermilab develop and present a plan to phase out their involvement in Auger, so that they can dedicate resources to other programs at the lab more closely related to fundamental particle and cosmic physics. This plan should be delivered to DOE by the end of this calendar year.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(IV) Detector Ops, Accelerator & Detector D&D – Operations

FINDINGS

- **CDF has collected 9.2 fb^{-1} of 11.2 fb^{-1} with customary efficiency at luminosity of up to 4.05×10^{32}. There were minimal problems (broken COT wire, db machine). Dead time was high but behaved as predicted. Many key ops roles were filled by Fermilab staff. At Tevatron shutdown, detector operations will cease, the detector will be made safe with gases purged, cryogenic systems warmed, water drained. The L3 farm will be repurposed. The detector will be turned over for D&D. Computing resources have been used maximally.**
- **D0 has collected 9.95 fb^{-1}. Data taking efficiency has been ~90%. Post operations plans include 12 weeks of calibrations and cosmic ray running before the detector is turned over for D&D. Data is processed for analysis within a few weeks. Reconstruction will be complete by the end of October 2011, with needed Monte Carlo samples generated by March 2012.**
- **The Lab supports the CMS Tier 1 facility for data processing and provides management for CMS data ops, including grid infrastructure. Availability at >98% achieves the goal. Reliability is at 96% (goal 90%). The Tier 1 facility performed about 45% of CMS processing, and supported multiple reprocessing of data samples. Fermilab supports the US CMS Program Office and provides an operations center for performance of some classes of credited shift-taking. The LHC Physics Center is also hosted effectively.**

(IV) Detector Ops, Accelerator & Detector D&D – Operations

FINDINGS (continued)

- **MiniBooNE has been in operation for 9 years. The detector was stable during the most recent run at ~1%, with >99% uptime. Anti-neutrino data was taken for 8.65×10^{20} POT, on the path to collecting $>1 \times 10^{20}$ POT by the shutdown in March 2012. 40% of shifts are remotely manned.**
- **The MINOS near and far detectors have operation with minimal downtime, taking data 93% and 85% respectively. The latter was affected by a fire at the Soudan mine on March 17. The detector was ready for data-taking on May 19. The total anti-ν data sample thus far is 3.2×10^{20} of 4.2×10^{20} requested.**
- **Minerva Detector installation was completed in March 2010. A cryogenic target was added in 4/11. Uptime has been >97% since May 2010. Data sets collected include for neutrinos 1.53×10^{20} POT and for anti-neutrinos 1.30×10^{20} POT. Special target runs were taken to understand incoming neutrino flux in order to reduce uncertainties**

COMMENTS

- **The experimenter teams are to be commended for making efficient use of the beams delivered.**

RECOMMENDATIONS

- **None**

U.S. DEPARTMENT OF ENERGY
Office of Science

(IV) Detector Ops, Accelerator & Detector D&D – D&D

FINDINGS

- **Decommissioning of the Tevatron, CDF and D0 will begin after calibrations and surveys are complete at the beginning of CY2012.**
- **A D&D task force consisting of 20 members from relevant FNAL divisions began to formulate the plan in Feb. 2011. The task force built on earlier plans for D&D. The task force effort thus far sums to ~2.3FTE effort.**
- **The plan has two phases.**
- **In Phase 1, systems will be secured and stabilized. It is proposed that CDF and D0, along with sections of the Tevatron close to CDF, will be prepared for an extension of the Visitor Tour Program which serves about 12000 visitors per year. It is expected that collider tours will be offered to a subset of these visitors. This outreach plan is meant to enhance the visitors' understanding of the experimental enterprise. The task force feels that viewing CDF and D0 will provide complementary experiences.**
- **Phase 2 of the process will be deferred till a later date notionally many years away. In Phase 2, the full D&D would be executed.**
- **Initial planning for Phase 1 has included development of a WBS structure for this work. Costs and schedules have been produced. Eventually this will be extended into a resource loaded schedule. A list of reusable components will be generated.**

(IV) Detector Ops, Accelerator & Detector D&D – D&D

FINDINGS (continued)

- **Phase 1 visitor program experience will include an orientation, visit to a control room, visit to the collider halls as well as new explanatory posters and exhibits. It is expected that these tours can begin in ~1year.**
- **Phase 1 also includes clearing of space for reuse supporting the ongoing lab program.**
- **The cost estimate for Phase 1 is $10.8M without contingency, where $3M is dedicated to the displays. An enhanced visitor experience might involve a further $2M expenditure.**
- **Phase 2 will see all components removed from the Tevatron, and the detectors dismantled. Phase 2 for the Tevatron can be begun as funding becomes available, since only a small part of the accelerator is used for the visitor program.**
- **Phase 2 will be executed under DOE 430.1B and DOE 458.1.**
- **The cost estimate for Phase 2 is $63M, with contingency set at 100% because of the early stage of planning. This includes removal of both the Tevatron components and and the old main ring magnets; disassembly of the 5500 ton D0 detector with his depleted uranium calorimeter; disassembly of the CDF detector.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(IV) Detector Ops, Accelerator & Detector D&D – D&D

COMMENTS

- **Useful to the D&D process is a set of as-built drawings. These are apparently available. The team intends to locate any tooling for the assembly/disassembly of the detectors that exists. This will save design cost. Because of the multi-year duration of Phase 1, personnel familiar with the construction or involved with any upgrades where the structure of the detector was modified are likely to be working on other tasks, or have left the lab for other employment opportunities or retirement. It is crucial, under this delayed disassembly plan, to capture the experience of these people during Phase 1. This should include collection of procedures from the construction days of the experiments.**
- **In order to lower risk (cost, safety), it may be worthwhile to reconsider the decision that both detectors be retained for the Visitor Program. Getting a start on the disassembly of a complex detector, assuming funds are available, while personnel actively involved with the detector are still available, would decrease risk.**
- **The very high level cost estimates for the disassembly of the detectors appear to be reasonable given the large contingency called out.**
- **Maintaining a database to track component inventories and component surveys would likely prove useful.**
- **The approach to D&D is overall reasonable.**

RECOMMENDATIONS

- **None.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(V) Detector R&D

FINDINGS

- **Fermilab has an extensive program in this area with topic leaders in each of thrust areas: colliders, LAr, particle astrophysics, DAQ/simulation, and facilities.**
- **They constitute an advisory group that meets monthly and advises Lab management on detector R&D budgets and issues.**
- **There is R&D relevant to all the HEP frontiers, but in the case of the intensity frontier the emphasis is on LAr.**
- **Several current and potential future cosmic frontier experiments have originated in this program.**
- **The highly subscribed Fermilab test beam facility is funded out of this program.**
- **The test beam gets 4 seconds of slow spill once per minute.**
- **Fermilab's KA15 detector R&D funds are used to support engineers and technicians but not physicists**

(V) Detector R&D

COMMENTS

- **There doesn't seem to have been a study to determine what R&D is needed for the intensity frontier efforts at the lab.**
- **R&D activities are a way to spark interest and ultimately commitment to the intensity frontier program. FNAL should be welcoming and strongly encouraging the participation of external users in the R&D program.**
- **The Lab should consider at least partial support of detector-oriented physicists on this budget.**

RECOMMENDATIONS

- **The lab should develop a plan within 6 months to carry out a systematic study of the detector R&D needs of the upcoming intensity frontier experiments.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(V) Intensity Frontier Detector Projects – MicroBooNE

FINDINGS

- **MicroBooNE has two motivations – (1) to investigate the low-energy excess seen by MiniBooNE, and study neutrino interactions in Argon and (2) to serve as a test-bed for future very large LAr TPCneutrino detectors.**
- **MicroBooNE contains 170t of LAr, of which about 70t constitute the fiducial volume.**
- **Project design is nearing completion. They are shooting for a CD-2/3a review this summer.**
- **They were originally limited to $20M from DOE, but this cap has been lifted. The current estimate for the TPC is $24M.**
- **The detector will be situated in a new building just downstream of MiniBooNE.**
- **Working date for operations is mid-2013, c.f. CD-4 mid-2014.**

COMMENTS

- **As a physics experiment MicroBooNE is precisely targeted, it addresses only one of the current neutrino anomalies**
- **The recent reorganization of the project team seems a good idea.**

RECOMMENDATIONS

- **None**

U.S. DEPARTMENT OF ENERGY
Office of Science

(V) Intensity Frontier Detector Projects – Mu2e

FINDINGS

- **The project has compiled a 550 page draft CDR and an independent design review concluded that overall they are at the CD-1 level of design. Actual CD-1 review is planned for the 4th quarter of this FY, operation is envisioned to start in FY18.**

- **However the same review concluded that more simulation and Fermilab engineering effort needs to be devoted to the project**

- **They propose to use an Al target since it is a good compromise between relative rate and lifetime. The lifetime is a good match to the revolution time of the pbar source.**

- **A major technical challenge is to extinguish the out-of-time proton beam by a factor 10^{-10}. Their goal is a factor 10^{-5} in the debuncher ring and 10^{-7} in the proton transport line.**

- **The solenoids are the cost and schedule drivers of the project, the transport solenoid is to be constructed by the Lab, the production and detector solenoids will be built by industries. Responses to an RFI were encouraging.**

- **There is now a baseline tracker design.**

- **A streaming DAQ with mostly off-the-shelf components is planned.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(V) Intensity Frontier Detector Projects – Mu2e

COMMENTS

- **This project has made a lot of progress in the last year. It has been relatively well supported by the Lab and keeps attracting new outside collaborators**

- **The project survived a ban on new starts in FY11, but if this continues into FY12 it will really slow them down.**

- **This experiment will be an anchor for the program in the latter part of this decade so it should be given very high priority by the Lab.**

RECOMMENDATION

- **The AD engineering and simulation support requested should be provided.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(V) Intensity Frontier Detector Projects – NOvA

FINDINGS

- **NOvA got beneficial occupancy of its Ash River far detector hall on April 13th of this year.**
- **They have a 199-plane prototype of their near detector now taking data on the surface at Fermilab. It has collected several hundred neutrino and anti-neutrino events.**
- **They have a fixed-price contract for their 120 railroad cars of mineral oil, as long as the price of oil doesn't exceed $110/barrel. They have a 30% contingency to cover the possibility that it does end up exceeding this figure.**
- **They need 155,000 gallons of pseudocumene, but this is indexed to the price of Asian naphtha (proportional to the price of oil).**
- **They have 5400km the of the 12,000km of wls fiber they need.**
- **They lost 20% of the first 500 APDs due to fiber strikes, oil, dust, etc. After improved procedures, they have been losing only ~5%.**
- **They have fixed price contracts on their extrusions and have produced 1184 acceptable ones, but problems have limited production by 50%. They expect these problems to be solved by mid-July**

(V) Intensity Frontier Detector Projects – NOvA

FINDINGS (continued)

- **Manifolds on the prototype cracked but could be fixed in place. This triggered development of a new design – new manifolds are due in July.**
- **The prototype pivoter machine with full-height modules still has to be tested.**
- **The project is 70% obligated and 46% complete (detector component only 26% complete). Estimate at completion is $244M, leaving $34M in contingency, of which ~$3M is unassigned.**
- **Unexhausted contingency can be used to increase the detector mass from the current 14kt and the rate of $9M/kt (up to 18kt), increase the near detector size, or several other alternatives.**
- **There has been a six-month schedule slip since last year due to PVC module delays, etc. It is now expected that far detector construction will start Jan 2012. There should be 1 block (500t) in place by March 2012 shutdown. By the end of the shutdown, NOvA detector should be 60% complete.**
- **Extrapolation shows detector complete by April 2014. CD-4 is Nov 2014.**

(V) Intensity Frontier Detector Projects – NOvA

COMMENTS

- **Although they learned a lot in implementing the prototype, they decided it was not suitable as the permanent near detector. Among other things, they want the horizontal modules to have 4.5mm-thick walls instead of 3.0mm.**
- **Unassigned contingency seems very thin.**
- **The problems that have encountered, although well-handled in general, are worrisome, since the detector is only 26% complete.**

RECOMMENDATION

- **The NOvA project team should remain vigilant to ensure adequate contingency and to identify opportunities to advance the current schedule.**

(VI) Accelerator – Tevatron Operations

FINDINGS

- **Tevatron Operation will cease at the end of FY2011**
- **Tevatron Operation has had it best year to-date, with respect to peak luminosity and luminosity per week**
- **Two equipment failures and one scheduled downtime have limited total integrated luminosity, but operation is on track to meet the performance goals for the year**
- **Two weeks of dedicated studies are planned for August and other shorter study periods will be provided June-August6**

COMMENTS

- **Tevatron operations have been an outstanding success, and Fermilab is to be congratulated by the committee and entire HEP community!**
- **The studies are will planned, and of significant value to the global collider community**

RECOMMENDATIONS

- **None**

U.S. DEPARTMENT OF ENERGY
Office of Science

(VI) Accelerator – Neutrino Operations

FINDINGS

- **NuMI operation has been hindered by a series of target failures; in FY11 Fermilab hopes to achieve 2.5E20 POT, better than the base curve**
- **Fermilab is seeking assistance in analyzing failures and redesigning the target from RAL**
- **The refurbished NT01 (first NuMI target) is being installed now, and a newly designed target will be ready this summer. NuMI targets are needed through March 2012.**
- **The 8 GeV neutrino program is ahead of plan, as it profited from the NuMI target problems**

COMMENTS

- **We encourage Fermilab to aggressively pursue the failure analysis of the NuMI targets, and ensure that all lessons learned are incorporated into the NoVA target design**

RECOMMENDATIONS

- **None**

U.S. DEPARTMENT OF ENERGY
Office of Science

(VI) Accelerator – Collider R&D

FINDINGS

- **Significant R&D programs have utilized the Tevatron and MI to develop**
  - **bent crystal collimation,**
  - **hollow beam scrapers,**
  - **beam-beam effects and bench marking to codes**
  - **E-cloud remediation**
  - **Collective effects**

COMMENTS

- **These R&D efforts have greatly benefitted Fermilab, and will now serve to benefit other colliders (RHIC and LHC)**
- **The two week study period scheduled for August is an important last opportunity to use the Tevatron to further understanding of collider accelerator physics issues. LHC and BNL will participate**

RECOMMENDATIONS

- **None**

(VI) Accelerator – Advanced Accelerator R&D

FINDINGS

- **Fermilab has had an AARD user program running at A0**
- **Fermilab intends to see this user program migrate to the NML following the installation and commissioning of the ILC cryomodules, this will occur around 2015**
- **A joint working group has identified three initial high priority experiments, research areas include: x-ray production using channeling radiation; FEL seeding studies, studies of beams in a highly non-linear machine. The unique aspects are high energy and long pulse.**

COMMENTS

- **Fermilab is to be commended for pursuing and defining an AARD program. The results from A0 have been cutting-edge accelerator physics research and have had educational benefits.**
- **The envisioned research at NML is broad, and supports programs beyond OHEP, helping to fulfill OHEP mission of accelerator S&T stewardship**

RECOMMENDATIONS

- **Aggressively continue to develop the scientific case for the NML facility, with community input, in preparation for a future cost/benefit analysis.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(VI) Accelerator – NOvA Project

FINDINGS

- **The accelerator Upgrades for NOvA will deliver 700 kW on target**
- **The components of the upgrade involve slip stacking in the recycler, faster ramping of the Main Injector, and target modifications to handle the higher power, and for neutrino energy configurations**
- **The work will take placed in a shutdown from 1 Mar 2012 – 1 Feb 2013**

COMMENTS

- **Although elements of this program are challenging, Fermilab has demonstrated their capability to perform this work in the past**

RECOMMENDATIONS

- **None**

(VI) Accelerator – Projects, Proton Improvement Plan

FINDINGS

- The goals of the Proton Improvement Plan are to:
  - Increase the beam repetition rate from the present ~7 Hz to 15 Hz
  - Eliminate major reliability vulnerabilities and maintain reliability at present levels (>85%) at the full repetition rate
  - Eliminate major obsolescence issues
  - Increase the proton source throughput, with a goal of > 2E17 protons/hour
  - Ensure a useful operating life of the proton source through at least 2025
- The plan gets underway in 2012 and continues through 2016 at a cost of about $45M plus effort (~33 FTEs for five years)

COMMENTS

- The future of any Fermilab beam based program depends on the linac and booster and related systems until they are replaced (i.e., Project-X), therefore this program must be given priority
- Key people are nearing retirement, Fermilab should have succession plans

RECOMMENDATIONS

- Maintain PIP as high priority to ensure a robust 8 GeV source.

(VI) Accelerator – Projects, Project-X

FINDINGS

- **Fermilab has settled on a Project X configuration that has been stable for more than a year, is unique among facilities in the world, and will give the U.S. leadership on the Intensity Frontier for decades**
- **Revisions since the last review include 650 MHz to end of the CW linac**

COMMENTS

- **The collaborative approach, even during the R&D phase is to be commended, and encouraged by OHEP**
- **International collaboration will require development of new ways of doing business for Office of Science projects, and should be strongly supported at all levels**
- **The present design addresses rare processes and neutrino program. We were not presented a path toward the muon collider driver.**
- **The committee did not see a path toward a muon source for possible future Neutrino Factory and/or a Muon Collider.**

RECOMMENDATIONS

- **None**

U.S. DEPARTMENT OF ENERGY
Office of Science

(VI) Accelerator – SRF

FINDINGS

- **The goal of the Fermilab SRF program is to support the strategic goals of the U.S. HEP program at the intensity frontier (Project X) and at the energy frontier (International Linear Collider and Muon Collider)**
- **Project X cavity R&D is being done in this program**
- **A key activity in this area is the development of cryomodule engineering and testing**
- **The low initial energy of the first SRF stage (perhaps as low as 1.2 MeV) is unique**

COMMENTS

- **Fermilab is building expertise in cryomodule capabilities, including the Cryomodule Test Facility**
- **Fermilab's focus on transferring capabilities to industry is key to keeping US industry involved and is to be encouraged**

RECOMMENDATIONS

- **None**

(VI) Accelerator – Muon Accelerator Program

FINDINGS

- **A national Muon Collider & Neutrino Factory R&D program, hosted at FNAL, has been established**
- **Fifteen organizations are involved with 200 participants**
- **The success of a muon collider rests on a number of technical developments for which there are no solutions at present**

COMMENTS

- **The committee is concerned about the number of technical challenges that confront a successful muon collider**
- **We suggest that muon collider performance projections should be developed using realizable technology and presented along side desired performance**

RECOMMENDATIONS

- **We encourage Fermilab to guide MAP toward a more aggressive approach in developing needed technologies; to be reviewed at next MAP review.**

U.S. DEPARTMENT OF ENERGY
Office of Science

(VI) Accelerator – General Accelerator Development

FINDINGS

- **Fermilab's GAD activities support the national program as well as specific needs of Fermilab (e.g., SRF for Project-X, magnets for MAP/NF)**
- **Funding is expected to be ~$17.5M in FY12. The SRF work, discussed on slide 6.8 is funded from General Accelerator Development**
- **The GAD program is developing 11T dipoles for LHC using Nb3Sn**

COMMENTS

- **Fermilab has used funding from the General Accelerator Development program to advance the technical needs of Fermilab (particularly in the SRF area), and is also making contributions to broad accelerator S&T needs (e.g., Nb3Sn magnets)**
- **Mechanical polishing of SRF cavities is a positive development**

RECOMMENDATIONS

- **None**

(VI) Accelerator – Education and Publications

FINDINGS

- **Twelve PhD students are doing work at Fermilab, two additional soon**
- **Twenty-seven undergraduates are on-site, with two more coming**
- **There have been about 20 peer-review publications from accelerator R&D work in FY10-11; numerous conference proceedings and oral presentations**

COMMENTS

- **The number of both students and publications has increased and a positive indication of the impact of Fermilab accelerator R&D**
- **The number of "Fermilab produced" accelerator scientists is significant and influential throughout the accelerator community**

RECOMMENDATIONS

- **None**

(VII) Management – Management Structure

FINDINGS

- **The laboratory has been reorganized into three kinds of organization**
  - **Line management organizations with most of the resources**
  - **Project organizations that receive matrixed support from line organizations**
  - **Support organizations**
- **This structure has been mirrored in the four sectors**
- **Projects of different size report at different levels of the organization**
- **Adding or deleting projects can be done without affecting the lab structure**
- **The people who lead the organizational units are well known in their fields and have many years of relevant technical and managerial experience**

(VII) Management – Management Structure

COMMENTS

- **The implementation of the new organizational structure is impressive in that it has been applied uniformly throughout the lab – usually, laboratory reorganizations are done piecemeal**
- **The structure is clear, unequivocal, and flexible; it is an excellent match to the requirements of a lab in this transition period.**
- **Whether it will be equally effective when Project X or LBNE is under construction is not so clear, but that is some way off**
- **Like all matrixed organizations, success depends on the interactions between individuals**
- **Most of the senior leadership and middle management have a long history of working together**
- **Stuart Henderson, who is a recent addition, is experienced and well regarded, and has obviously moved successfully into his new position**
- **Raising the profile of Peter Garbincius as Head of the Office of Program and Project Support reporting to the Lab Director is a very positive change**

RECOMMENDATIONS

- **None**

U.S. DEPARTMENT OF ENERGY
Office of Science

(VII) Management – Strategic Vision

FINDINGS

- **Fermilab management has a clear strategy of scientific opportunities for the future**
- **Transition from energy frontier to intensity frontier**
  - **The program has a short term component of existing neutrino experiments (some with upgrades and run extensions), NOvA, MicroBoone, and new projects (Mu2E and g-2) and proposals (K->pi+nunu)**
- **This will be followed by preparation for LBNE, then Project X to enhance the neutrino and rare processes programs**
- **significant effort in dark energy and in DM technology determination.**
- **Small effort in cosmic ray research (Auger)**
- **Remain the premiere US connection to CMS**
- **The very long term plan is a lepton collider or neutrino factory**
- **Management appears to have communicated the strategy clearly to the staff and worked with them to effect the transition**

U.S. DEPARTMENT OF ENERGY
Office of Science

(VII) Management – Strategic Vision

COMMENTS

- **CMS at FNAL is critical for leveraging the US investment in the LHC's exciting physics potential**
- **Focus on the neutrino program provides a world-leading staged program through the next two decades**
- **Dark Energy and Dark Matter are priority activities for the DoE as advocated by all the recent major reviews of the field**
- **The strategic vision that has been developed provides FNAL with a leadership role in HEP world-wide and provides a future for the laboratory**

RECOMMENDATIONS

- **None**

(VII) Management – Strategy Implementation

FINDINGS

- **A comprehensive strategic plan has been developed which covers the short, medium, and long term program**
- **The budget required to support the strategic plan through 2015 is roughly consistent with the FY11 budget escalated by the cost of living adjustment**
- **FNAL management does not believe that the likely budget beyond 2015 would allow for simultaneous construction of LBNE and Project X**
  - **The Lab Director stated that he believed that he did not have to prioritize between these major projects and programs until the latter part of the decade**
- **A priority order in case of budget shortfalls was presented**
  - **Protect the intermediate program: experiments and accelerator improvements**
  - **Slow down the long-term future programs: LBNE, Project X**
  - **Devote minimum efforts (survival) for longer-term projects (Neutrino factory, lepton colliders)**

(VII) Management – Strategy Implementation

FINDINGS (continued)

- **A strategy was presented for LBNE if DUSEL does not go forward**
  - **Concentrate on long-term detector development by building a 1 kiloton Liquid Argon detector for the medium term neutrino program and as a step towards a Liquid Argon detector for LBNE**
  - **If both options do not go forward, boost up beams for Project X for short baseline neutrinos, kaons, muons, nuclei, and deliver 2MW for neutrinos at the NOvA site (studies in progress) with 3 times the mass of NOvA**
- **A staffing plan is being developed (OHAP) to map the skills available in the laboratory onto the strategic plan**
  - **The skills have been broken down into 200 categories and the present staff has been assigned to these categories**
  - **Missing critical skills (cryogenics engineering, etc.) have been identified and a working group established to develop solutions**
  - **Longer term staffing needs are being developed**
  - **This includes moving staff from the Tevatron project (as opposed to all of them moving to CMS)**

(VII) Management – Strategy Implementation

FINDINGS (continued)

- **The present accelerator staffing level roughly matches that required to support the strategic plan**
  - **The short-term accelerator improvement plans are aligned with the strategic plan**
  - **The accelerator R&D focus is also aligned with the strategic vision**
- **The size of the User community was estimated by FNAL management assuming implementation of the strategic plan**
  - **The User community is expected to remain roughly constant in FY15 under the optimistic scenario (~2300) and would be ~500 less in the pessimistic scenario**
  - **The User community is expected to increase to ~2600 by the end of the decade**
  - **This includes moving staff from the Tevatron project (as opposed to all of them moving to CMS)**

COMMENTS

- **The strategic plan presented through 2015 seems financially viable unless the budgets are consistently bad**
- **The impact of budgets fluctuations on the strategic plan is the highest risk that needs to be mitigated; the proposed prioritization seems reasonable and maximizes the science**

(VII) Management – Strategy Implementation

COMMENTS (continued)

- **In the longer term, it seems unlikely that future HEP budgets would allow for simultaneous construction of LBNE and Project X, the laboratory should start to confront this reality in the strategic plan**
- **The OHAP process is a good start for a difficult problem. Despite the errors and approximations inherent in the process, it should be refined, and extended through 2015**
- **There was no presentation on overall neutrino program that provided a coherent and big picture view of the Fermilab neutrino program from the point of view of prioritized science goals, and a strategic planning that encompasses all programs. This gave an impression to the committee that there in fact is a lack of such scientific leadership and overall coordination, and the lab responds reactively to the demands of each program.**
- **Lab management has incubated several interesting small scale projects (e.g. Holometer). Funding of these sorts of new ventures within the B&R codes may be difficult. Setting up an LDRD program may smooth the process of bringing speculative ideas to fruition.**

RECOMMENDATIONS

- **The laboratory should refine the strategic plan integrating LBNE and Project X once the status of DUSEL has been defined**
- **The laboratory should refine and extend the OHAP process at least through 2020**