Department of Energy
Review Committee Report

on the
review of

TEVATRON OPERATIONS AT FERMI NATIONAL ACCELERATOR LABORATORY

March 2005

EXECUTIVE SUMMARY

The Department of Energy (DOE) review of Tevatron Operations at the Fermi National Accelerator Laboratory (Fermilab) was conducted on March 29-31, 2005. The review was requested by Robin Staffin, Associate Director for the Office of High Energy Physics. The purpose of the review was to evaluate Fermilab's performance in operating the Tevatron Complex, priority setting, resource plans, and its management practices.

Overall, Fermilab is well managed. The management team is dedicated to accomplishing Fermilab's mission. The reorganization of the Accelerator Division in 2003 has paid dividends in the form of results in the Run II program and progress in Tevatron upgrade projects. Open and frequent communications between the leadership of the experiments and the Laboratory Directorate will be increasingly important as declining budgets reduce Fermilab's ability to support the experiments.

Fermilab is meeting Run II integrated luminosity goals. Since the March 2004 DOE review, new operational modes (combined shot and Neutrinos at the Main Injector) have been introduced, peak luminosity and stacking rate records have been set, and there have been significant improvements in Tevatron diagnostics. However, the design luminosity goal is challenging. To meet the design goal, beam study time needs to be allocated as planned. If the lack of beam study time continues, it will likely have an impact on meeting the out-year luminosity goals.

The "Proton Plan" is a collection of equipment upgrades, operational improvements, and maintenance targeted at high-impact failure risks. It is modeled on the Run II upgrades, and the plan is still being developed. It will be implemented over the next four years to increase the Neutrinos at the Main Injector intensity to 3.4×10^{20} protons per year.

Fermilab has successfully executed its plans for luminosity improvements during the past year. The Committee was pleased to see the migration of project management practices from the Run II Upgrades campaign to other areas of the laboratory. The management team is planning for necessary staff reductions in a manner that retains key skills and competencies. Fewer people from the collaborations and the laboratory are available to maintain the experiments and analyze data—a situation that will get worse in the future. Although not part of this review, laboratory infrastructure remains a risk, especially if proposed infrastructure project funds are shifted to other priorities.

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1. INTRODUCTION

On January 27, 2005, the Office of High Energy Physics (OHEP) requested that the Office of Project Assessment perform an independent review of the operations and maintenance of the Tevatron complex at the Fermi National Accelerator Laboratory (Fermilab). OHEP requested that the review committee examine the activities associated with facility operations to determine the funding needed to effectively support the research mission and the actual costs (especially manpower) incurred for each activity, and to advise on the importance of these activities.

The Fermilab mission is the goal of particle physics: unlocking nature's secrets, and learning how the universe is made and how it works. In support of this mission, Fermilab has several program elements:

1. A research program in particle physics based on the Tevatron, the Laboratory's world leading 2 TeV proton-antiproton collider, operated by Fermilab as a national user facility. This program is wholly funded by the Department of Energy's (DOE) High Energy Physics program. Fermilab is deeply engaged in Run II, a program with a "design" goal of delivering more than 8 fb^{-1} to the CDF and D-Zero detectors, and a "base" goal of at least 4 fb^{-1}. This must be accomplished before the high energy leadership passes to CERN with the commencement of Large Hadron Collider (LHC) operation.

2. Fermilab is committed to a neutrino physics program including a short baseline experiment, MiniBoone, operating from a Booster beam, and a long baseline experiment, MINOS, that operates in the Soudan mine in northern Minnesota and is fed by the Neutrinos at the Main Injector (NuMI) beamline, developed for the Main Injector (MI). Fermilab plans improvements to the proton source, which consists of the Linac, Booster, and the MI, to ensure reliable operation for at least five to six more years and adequate proton production to achieve the physics goals of the neutrino program.

3. Fermilab makes major contributions to the LHC machine and is the host laboratory for the U.S. CMS collaboration.

4. Fermilab has a significant program in particle astrophysics, and is a contributor to the Sloan Digital Sky Survey, Cryogenic Dark Matter Search, and the Pierre Auger project.

All of these efforts are supported by staff whose responsibilities include accelerator and detector improvements, operations and maintenance, theoretical particle and astrophysics, advanced accelerator and detector R&D, and administration and operations support. The scope of this review was limited to the Tevatron complex maintenance, operations, accelerator improvements, detectors that use the Tevatron complex, and the associated indirect costs.

The review was conducted on March 29-31, 2005, at Fermilab, and was chaired by Daniel R. Lehman, Director of the Office of Project Assessment. To address the charge, the Committee was divided into subcommittees that examined the detector operations, accelerator operations and integration, proton source, antiproton source, Tevatron, and management. The Committee members were drawn from other Office of Science laboratories. The DOE area office observed the proceedings.

The review was based on formal presentations given by Fermilab staff, detailed discussions with Fermilab employees, and the Committee members' extensive experience. The first day of the review was devoted to presentations given by Fermilab. These presentations provided an overview and response to the charge letter. On the second day, members of each subcommittee met with Fermilab counterparts in working sessions to further discuss details in the functional area for their respective subcommittees. The remaining time was spent on subcommittee working sessions, Committee deliberations, and report writing. The Committee discussed the results of the review with Fermilab management in a closeout briefing on March 31, 2005.

2. DETECTOR OPERATIONS

2.1 Findings and Comments

Responses to the Charge

Charge Point 1: Has the laboratory successfully executed its plans for the operations of the accelerator and detectors and for the luminosity improvement during the past year?

Generally the Run II and Neutrino programs are proceeding well. The CDF improvements will be complete this year. The Central Outer Tracker problem from last year has been resolved. D-Zero silicon is a bit delayed, but proceeding well. The remainder of Run IIb improvement plans seems to be on track.

To deal with budget shortages, Fermilab's plan is to achieve efficiency from improved operations for detectors, software and computing support. In addition, a number of potential improvements are possible in CDF and D-Zero data taking.

The Committee saw no detailed plans to deal with the efficiency improvements in either detector or computing areas.

Charge Point 2: Does the laboratory have plans to effectively achieve the goals of the Run II and neutrino programs?

The plans to achieve the goals for luminosity for Run II are clear. Due to the risks, meeting the Run II goals will be challenging. The plans to achieve the goals of the neutrino program are also clear but the collaborations would now like to have more protons on target.

Charge Point 3: Have adequate resources (i.e., manpower, funding, etc.) been identified and allocated to carry out the plans?

Particle Physics Division (PPD) resources are "balanced" between Run II/Neutrino running and future possible projects.

Resources are tight for detector and computing resources for Run II. For example, the Committee heard that the addition of one "slot" for a technical person to shift running would have a large effect.

Collaboration resources are the largest uncertainty due to the potential for resources moving to the LHC.

There are parallel computing support groups in different divisions at Fermilab and potential duplicative support of everything beyond networking (note 2004 Recommendation 3.CP2).

The Committee applauded the Computing Division's "lights out" (unattended) operations for computing including mass storage. In addition, critical general plant project funds were allocated to support the new GRID Computing Center, and work-flow planning in the Computing Division is becoming an effective tool.

The merging of the computing resources for MINOS and MiniBoone is efficient. Next, CDF and then D-Zero system administrators will be integrated with the Computing Division. The Computing Division is implementing a comprehensive grid strategy for Fermilab called "FermiGrid".

Due to the limited scope of this review, the Committee could not evaluate the "balance" between Run II/Neutrino scope and long-term investments.

Even after the FY 2005 planned RIFs, a large part of the PPD budget is for "Other Direct Support", which is mainly devoted to future experiments and general infrastructure.

Charge Point 4: Are there any programmatic, technical, and infrastructure risks? Has the laboratory developed an adequate risk analysis with identified fallback plans?

There is a risk of reduced funding agency support, as well as collaborators moving to LHC. There are three major risk areas in computing, networking, and information technology:

1. Wide Area Networking (WAN) planning and resources (U.S. and international) at the Office of Science level are insufficient for Run II (and LHC) requirements.

2. Planning and resources for GRID computing infrastructure at the Office of Science and National Science Foundation level are insufficient for Run II (and LHC) requirements.

3. Government (Presidential/Office of Management and Budget/DOE) directives on managing Information Technology are intrusive and increasingly they negatively impact the programs. This could affect every layer of the network, desktops, servers, cyber-security, access to resources by foreign nationals, and remote users.

There are risks from increasing the luminosity in the aging Run II detectors. The D-Zero silicon and trigger upgrade are well planned but come with some risk of not being sufficient for the increase in luminosity.

As the volume of data rapidly expands, grid performance may be stretched. There is also the reliance on off-site resources for GRID computing that could be moved to non-Tevatron related activities.

Moore's Law, as it applies for computing cost performance, may hold for the time period covered by this review, but there are some hints that the Law may be approaching its limits.

Consolidation of PPD facilities may remove some technical abilities due to the budget constraint.

Cooling and power may not be adequate for computing plans.

Fermilab continues an active program of mitigating the risks.

Charge Point 5: Is the laboratory management effectively setting priorities, tracking progress, and resolving problems for a successful execution of the proposed plans?

The Committee found plans were driven by top-down guidance.

CDF and D-Zero keep good track of the delivered and recorded luminosity, and the failures and repairs.

The Computing Division's website provides informative and meaningful "metrics" and shows most services increasing.

The bottoms-up planning is complete in Computing Division and partially complete in PPD (2004 Recommendation 3.2.2)

It is important to ensure that the work effort reporting system being developed at Fermilab will be useful for division programmatic requirements.

Charge Point 6: ***The committee is also asked to assess the laboratory's responses to the comments and recommendations from the February 2004 Tevatron Luminosity review and from the March 2004 Tevatron Operations review?***

The following recommendations resulting from the 2004 DOE reviews are still open:

- 3.CP2 (Centralizing computing and engineering support)
- 3.2.1 (Memorandum of Understanding—process is underway)
- 3.2.2 (Bottoms-up Planning—underway).

2.2 Recommendations

1. Determine possible improvements in data taking efficiency in both CDF and D-Zero and make plans to implement the most cost effective elements.

2. Optimize on a laboratory-wide basis, the resources needed for Run II with a possible goal of adding resources for detector operations and computing.

3. OHEP should follow up on the Programmatic risks: Run II Collaborators, WAN, GRID Infrastructure, and Governmental Directives.

4. Complete the laboratory-wide bottoms-up planning (2004 Recommendation 3.2.2) so that the prioritization process can be completed.

5. Address recommendations from the 2004 reviews.

3. ACCELERATOR and INTEGRATION

3.1 Findings and Comments

Responses to the Charge

Charge Point 1: Has the laboratory successfully executed its plans for the operations of the accelerator and detectors and for the luminosity improvement during the past year?

Operations have increased in complexity during the last year, primarily due to two new modes of operation. The first of these is called "Combined Shot Operation", which utilizes the recycler to store antiprotons when the stack in the accumulator gets large and significantly impacts the stacking rate. Refilling the Tevatron involves taking antiprotons from both the recycler and the accumulator. This has had an impact on peak luminosity. A new addition to the operational complexity of the Tevatron complex is providing protons to NuMI. The laboratory has integrated this into its operational sequence.

Slip stacking the antiproton accumulation batch in the MI has increased the antiproton stacking rate. Fermilab has achieved stack rates of 16.2×10^{10} antiprotons per hour. The best achieved stacking rate was around 13.0×10^{10} antiprotons per hour (as of the March 2004 Tevatron Operations review).

The largest improvement to peak luminosity in the last year has come from restoring the β^* values to nominal.

The Tevatron Beam Position Monitor (BPM) system has been designed and is being installed at present. This is behind the projected schedule of installation during the October 2004 shutdown that was given during the February 2004 Tevatron Luminosity review. The approach taken allows the 27 subsystems, corresponding to the different service houses, to be brought on as ready while still maintaining the orbit measuring capability for sections of the ring that have not been upgraded. The installed elements of this system show good performance with protons for both closed orbits and for turn-by-turn monitoring of injection. The initial results for antiprotons are promising, but it remains to be investigated systematically and in detail.

The AP2 beamline BPM system is in a process of design and procurement. The basic system architecture builds on the BPM system for the Tevatron, but it is more complex because of different beams, intensities, radio frequency (RF) structure, etc., that must be accommodated. It is estimated that this system will be completed in mid- to late summer 2005 (which is later than the planned March 2005 completion date, presented at the February 2004 Tevatron Luminosity review).

Work on the MI BPM system will begin soon with the winding down of the Tevatron and AP2 line BPM work. The same basic system architecture is planned. This system is complex because of the variety of operating modes of the MI.

There is a new Beam Loss Monitor system that has been developed for the Tevatron complex. This system has a variety of functions in different accelerators that include quench protection, loss minimization, etc. Prototype systems have shown good performance, and the full system is expected to be online and operational in February 2006.

The 1.7 GHz Schottky system and the monitor beam system for the abort gaps are starting to present interesting results. Measurements from these devices show interesting correlations with other devices, and should prove valuable as they are better understood and integrated into operation.

The Integration Department has several important functions. First, it provides a support staff for senior managers in the Accelerator Division and provides them with a trouble shooting team. Second, it has the responsibility of bringing together information for division-wide use. Examples of the latter are common format lattice files, shot-by-shot data information, and survey and multipole data.

Overall, the accelerator has successfully executed its plans for operation of the Tevatron and neutrino program. The Accelerator Integration Department has successfully carried out its role providing data analysis tools, operational and physics models, a lattice repository, and rapid response to urgent problems.

The effort that is being devoted to instrumentation is appropriate for the future performance projections.

Charge Point 2: ***Does the laboratory have plans to effectively achieve the goals of the Run II and neutrino programs?***

The laboratory has two "project level" plans intended to achieve the goals of Run II and the neutrino program. The first is the "Run II Luminosity Upgrade Plan", which is now approximately 60 percent complete. These improvements will be largely done in FY 2006 with a final completion in FY 2007.

The second major project plan is the "Proton Plan", beginning in FY 2005 and continuing through FY 2008. The plan is still being formulated and, in fact, is being rescoped based on recent budget guidance. However, it is noted that losses in the MI will become the limiting factor in increasing the intensity. At present, protons are being lost at the start of the acceleration cycle due to a mismatch between incoming beam emittance and the MI acceptance phase space. Additionally, 0.5×10^{12} protons are being lost in transport from the MI to the antiproton target.

The present luminosity performance of the Tevatron complex can, in part, be attributed to the large fraction of the available time being devoted to colliding beams for luminosity. This strategy has had very good benefits—primarily, the positive change in the morale and spirit over the past two-and-a-half years. However, this approach has limits, and the total integrated luminosity to date is only ten percent of the design goals. Accelerator time must be devoted to work that will have longer term impact, and some degree of risk should be taken to facilitate future improvements.

Fermilab has plans that have effectively achieved the goals of Run II thus far. The effectiveness of the Run II plan in the future depends on a number of uncertain factors including electron cooling and the ability of the Tevatron to handle the higher antiproton intensities. The Committee felt that detailed plans are needed to address these issues.

It was noted that the losses associated with slip stacking "beam leaking" problems in the MI are related to the longitudinal emittance at booster extraction. The Committee felt that the Integration Department can contribute to the solution of this problem.

The Proton Plan is just being developed; it is too early to assess if this plan will be effective. However, a more detailed plan dealing with MI losses will be needed.

Charge Point 3: Have adequate resources (i.e., manpower, funding, etc.) been identified and allocated to carry out the plans?

Fermilab presented considerable detail regarding the resources allocated to the project level plans. Each of these two plans has a project manager and project management support. The plans employ a rigorous WBS system so that resources are identified with the components of the plan. Actuals are tracked for each WBS component.

Flexibility is maintained in that the manpower related to these projects does not reside in the project, but is matrixed in primarily from the Accelerator Division, but also from the Computing Division and the PPD.

The Committee was not presented sufficient information to make an independent judgment of this charge point. However, the staff doing this planning over the past two years has established their creditability, and that is important for having confidence that resources have been identified and allocated.

The path to higher peak luminosity will become more challenging as the final components of the Run II Luminosity upgrade plan are implemented. The Committee felt that the resource of study time in order to commission these systems will be greater than what has been made available thus far.

Charge Point 4: Are there any programmatic, technical, and infrastructure risks? Has the laboratory developed an adequate risk analysis with identified fallback plans?

There are a number of risks that Fermilab has identified. Some of these are straightforward engineering issues (e.g., procurement of the model 7835 power tubes for the drift tube linac) that are presently being solved. Fermilab personnel have been working with the tube manufacturer (Burle Industries) to understand and address problems with tube manufacture and lifetime. Fermilab has since placed an additional order for 12 new tubes, intended to be sufficient for at least two years of operation. Burle has agreed to aggressively deliver two tubes per month. Based on comparisons with Brookhaven National Laboratory (BNL) and Los Alamos National Laboratory (LANL), lifetime of the tubes appears to be limited by the peak output power. There have been some studies performed to reduce linac operating current (and hence peak RF power), but further machine optimization studies would be needed to properly investigate the trade-offs between tube lifetime and machine performance. Beyond this, a task force has been set up by the Accelerator Division Head to develop a fall-back plan in case the tubes cease to be available. This plan is slated to be complete by early July 2005.

Another category of risk is the possibility that needed technical upgrades will not work.

In this case, the analysis predicts the expected reduction in integrated luminosity. Particularly critical is the success of electron cooling in the recycler. The expectation of electron cooling has lead Fermilab to plan a different way the accumulator is operated. With the hope of being able to store significant antiprotons in the recycler, plans have been been made to upgrade the accumulator stack tail cooling system with an emphasis on fast stacking, but smaller stack sizes. In this scenario, antiprotons will be transferred to the recycler every 30 to 60 minutes. This approach will not be possible if the electron cooling does not work to specification.

The Committee also noted the risk associated with the loss of skilled people. Fermilab is adequately dealing with these risks.

Charge Point 5: Is the laboratory management effectively setting priorities, tracking progress, and resolving problems for a successful execution of the proposed plans?

Fermilab is setting priorities, tracking progress, and resolving problems. Project management tools are being used extensively as noted above.

In general, the Committee believed that Fermilab is successfully addressing this charge point, particularly at the higher levels—there is some concern at the detail level. An example is the priority placed on Tevatron studies.

Charge Point 6: The committee is also asked to assess the laboratory's responses to the comments and recommendations from the February 2004 Tevatron Luminosity review and from the March 2004 Tevatron Operations review?

While Fermilab has closed action items from the February 2004 Tevatron Luminosity review and the March 2004 Tevatron Operations Review, the Committee believed that there are remaining benefits that can be realized by further follow-up. Several are repeated below.

Two recommendations from the instrumentation subcommittee of the February 2004 Tevatron Luminosity review were addressed:

> *Recommendation 1: To investigate the source of kicker noise in the APP2 beamline BPM's during the March shutdown and improve the AP2 line BPM system to work with reverse protons over its entire length by the end of the summer 2004 shutdown.*
>
> The kicker noise problem has been solved, and there is an upgrade of the AP2 line BPM system that is now scheduled for completion in mid to late summer 2005.

The schedule for integrating this system into operations was not given.

Recommendation 2: Perform a study of possible methods to measure the emittance evolution during the Booster ramp by May 1, 2004.

These measurements are being made at the present time.

3.2 Recommendations

1. Continue to investigate beam-beam effects in the Tevatron, both experimentally and theoretically with the goal of validating Tevatron performance at full Run II design intensity.

2. Explore areas where efficiencies can be gained by consolidating skill sets. Last year the Committee noted several areas where effort was duplicated across Accelerator Division Departments (e.g., Information Technology, technician support).

3. Analyze baseline and luminosity scenarios, across multiple machines, under various fall back conditions, supported by a comprehensive model of the Collider complex. Report on progress at the next review.

4. PROTON SOURCE

4.1 Findings and Comments

The proton source, consisting of the 400 MeV Linac, the 8 GeV Booster, and the MI, has performed well over the last year, successfully supplying protons to the Tevatron, antiproton production target, and 8 GeV production target and horn for the MiniBoone experiment.

The proton intensity of the Tevatron is presently not limited by the source but by the onset of instabilities in the Tevatron. Slip stacking of two Booster batches to produce an increased proton bunch intensity for the antiproton production target was commissioned and is now operational. A bunch intensity of 7×10^{12} protons was reached with a bunch length of 1.5 ns before the shut-down. The same performance could not be repeated after the shut-down due to an (as yet) unexplained longitudinal emittance growth in the Booster.

Protons-on-target (POT) for MiniBoone increased from 4×10^{18} to 8×10^{18} POT/week since last year with a peak of 8×10^{16} POT/hour. This increase is mostly due to successfully localizing losses in the new Booster collimators. The goal of integrating 5×10^{20} POT will soon be reached.

The beam line to the NuMI target and horn was also successfully commissioned and around-the-clock operation started on March 14, 2005. A peak of 25×10^{12} protons per two-second MI cycle was reached. Sustainable operation is limited to about 15×10^{12} protons per cycle due to significant losses introduced by the slip stacking of the batches for the antiproton target. NuMI operation was suspended after a few weeks when a water leak developed in the target/horn assembly. A thorough investigation was underway. The NuMI target assembly may have to be redesigned.

The critical spare situation for the model 7835 power tubes for the five 200 MHz drift tube linac tanks has been brought under control. This situation originally arose because, from 1991 to 2001, Fermilab reduced the annual procurement of 7835 tubes to below the usage level of three to five tubes per year. At present, the spare inventory consists of six tubes with 20 tubes on order for delivery over the next year.

The Committee was presented with a plan to increase the proton capabilities for NuMI and the Booster Neutrino Beam (BNB) that is presently used by MiniBoone. This Proton Plan would be implemented over the next four years and increase the NuMI intensity to 3.4×10^{20} protons per year and the BNB intensity to 2.2×10^{20} protons per year. The upgrade mainly focuses on increasing the repetition rate of the Booster from 5 to 8.3 Hz and a MI RF upgrade for a 60 percent increase of the MI intensity to 6×10^{13} protons per cycle.

The collimators in Booster are operational and effective in reducing activation due to uncontrolled beam loss. The activation limit for Booster throughput is now near 1×10^{17} protons/hr.

The longitudinal emittance extracted from the Booster is twice as large as before the last shutdown. This is causing losses during slip stacking in the MI, and these losses are limiting the proton source performance. Also, there is a ±25 percent variation in bunch lengths in a single batch. The causes are under investigation. Beam study time should be allocated to resolving this issue. The study should be thorough, since it ultimately impacts the planning for future upgrades to proton throughput for neutrino production.

A space charge model of the Booster exists, which successfully explains some of the features of the losses on the first few turns; however, there appears to be little reliance on this model for understanding existing limits. For example, there is an observed nonlinear dependence of Booster losses on linac intensity, leading to an apparently optimal H^- current of 38mA. Simulations should be performed to thoroughly understand this effect.

The Proton Plan is in a very early stage. New injection orbit bump magnets and new trim magnets are in the prototyping stage. These have the potential of raising Booster throughput by decreasing the losses. The transition jump scheme is not yet implemented; it is expected to be ready at end of this year. There is a study to add second harmonic to the magnet circuit, which could increase batch intensity by ten percent. This increase seems quite modest compared to the significant cost of $1.8 million. Similar or larger intensity increases could be obtained from a thorough understanding of the space charge effects in the Booster.

A major component of the Proton Plan is to upgrade the MI RF ($10.8 million). One idea is to stabilize the MI RF by adding resistive loads to the cavities, adding 3MW power consumption. It was not clear to the Committee that this is the most economical solution.

Finally, without clear performance requirements for the Proton Plan, the risks associated (with the plan) are unknown.

Responses to the Charge

Charge Point 1: Has the laboratory successfully executed its plans for the operations of the accelerator and detectors and for the luminosity improvement during the past year?

The proton source has performed well for the Tevatron and the MiniBoone experiment during the past year.

Charge Point 2: Does the laboratory have plans to effectively achieve the goals of the Run II and neutrino programs?

The proton source portion of the Run II upgrade is essentially complete with the commissioning of slip stacking in the MI.

Charge Point 3: Have adequate resources (i.e., manpower, funding, etc.) been identified and allocated to carry out the plans?

As mentioned above, the proton source portion of the Run II Upgrade Plan has essentially been completed on time.

No further upgrades of the proton source are needed to meet the goals of the neutrino experiments. For the purpose of this review, the Committee understood that Fermilab's goals for MiniBoone and MINOS are 5×10^{20} and 8×10^{20} POT, respectively. The MiniBoone goal will be reached by the end of March 2005. The initial tests with the NuMI beamline indicate that the goal for the MINOS experiment can be reached in three to four years provided that the beam loss issues with slip stacking are resolved.

Charge Point 4: Are there any programmatic, technical, and infrastructure risks? Has the laboratory developed an adequate risk analysis with identified fallback plans?

The risk of failure of the 7835 linac tube has been mitigated well with enough spare tubes available and on-order to allow for the development of an alternative supplier in case the present supplier stops to manufacture these tubes.

No plan exists if slip stacking for the antiproton target continues to impact the intensity delivery to the NuMI target. No fallback plan exists if the NuMI target assembly continues to fail.

Charge Point 5: ***Is the laboratory management effectively setting priorities, tracking progress, and resolving problems for a successful execution of the proposed plans?***

Generally yes, as demonstrated by the on-time completion of the slip stacking.

Charge Point 6: ***The committee is also asked to assess the laboratory's responses to the comments and recommendations from the February 2004 Tevatron Luminosity review and from the March 2004 Tevatron Operations review?***

All of the proton source recommendations from the September 2004 DOE Luminosity Upgrade review were closed-out; however, not all of the recommendations were addressed—a repeat recommendation is listed below in Section 4.2.

4.2 Recommendations

1. Develop an aggressive plan for machine studies to increase beam intensity and brightness in the Booster beyond its present state by May 2005. This plan should include making the gamma transition jump operational and should be guided by the space charge model that is being developed.

2. Understand and mitigate the increased beam losses during slip stacking in the MI. This is necessary to reach NuMI intensity requirements and will also help to define future upgrade options.

3. Develop alternative designs, for the NuMI target assembly that avoid the possible failure modes of the present design.

4. Schedule a sufficient amount of beam studies and perform simulations to allow the full development of the upgrade plan of the proton capability (Proton Plan).

5. Present the completed Proton Plan at the next review.

5. ANTIPROTON SOURCE

5.1 Findings and Comments

Responses to the Charge

Charge Point 1: ***Has the laboratory successfully executed its plans for the operations of the accelerator and detectors and for the luminosity improvement during the past year?***

The past year has, to a very large degree, been successful.

5.1.1 Protons on Target

Slip stacking has been successfully put into operation. The full potential of slip stacking has not yet been fully exploited due to: the lack of intensity goal, significant (15 percent) losses, and the bunch length on target remains 20 percent above goal. The predominant cause for these shortcomings is a Booster longitudinal emittance that is too large.

5.1.2 Recycler and Electron Cooling

Recycler readiness (RR) has been demonstrated. Mixed mode transfers (combined transfers from AR and RR) to the Tevatron are successfully in operation with beneficial effects upon average stacking rate, peak luminosity, and integrated luminosity. Occasional loss of antiprotons from the Recycler is due to coherent transverse instabilities—a resistive wall is suspected to be the cause. The transverse damper should cure this when installed. Required bandwidth has been determined.

Electron cooling tests in the test area were completed within the schedule and were close to target values for electron beam quality and intensity in the test cooling section. Installation of electron cooling in MI31 and a cooling section in the recycler ring were completed and ready for commissioning only one month behind schedule. Commissioning has started.

5.1.3 AP2 and Debuncher Aperture

There was a significant increase in the zero-stack stacking rate, mostly due to an increased number of proton on target achieved during the past year, however, aperture upgrades have also contributed significantly.

Tight spots in both the AP2 and Debuncher ring aperture have been addressed during the last year according to plan. Measured Debuncher apertures (A_H, A_V) = (29.5 π ,24.9 π) at Δp/p = 0 are about 80 percent of expected nominal acceptances (A_H, A_V) = (36.0 π, 29.9 π) has been achieved. A horizontal aperture restriction near the Debuncher extraction region has been identified. Thanks to this discovery, a horizontal Debuncher aperture >35 π, has been achieved with reverse protons using a horizontal bump in the extraction region. To exploit this aperture increase with antiprotons, a ramped local bump is being commissioned. An aperture limitation in the AP2 downstream of the proton dump was also identified and fixed, which resulted in a ten-percent increase in secondaries yield at the downstream end of AP2.

Achieving the FY 2005 design goal in the zero-stack stacking rate (24×10^{10}/hour) will be a significant challenge, requiring much progress in both the AP2 and Debuncher aperture, as well as a higher intensity of the production beam (eliminating longitudinal losses in the MI).

Although significant work has been carried out on the “Running Wave” method using reverse protons, it still does not appear to identify limiting apertures reliably. During this running period, trial-and-error localized bumps have been used with antiprotons that appear to reflect the fact that the “Running Wave” method is not working well. Trial-and-error localized bumps will have great difficulties in locating two simultaneously limiting apertures.

The “Accumulated Minimum Free Space Method”, which was developed by Simon van der Meer at CERN and worked very well in the CERN AC and AA rings, has not been pursued. With the larger number of correctors and quadrupole movers now installed, this method should be very powerful in locating limiting obstacles and it does not rely on loss monitors to localize loss point. It also works well when several simultaneously limiting obstacles are present.

5.1.4 Rapid Transfers

The Committee found very significant progress in instrumentation, software, and power supply regulation for this mode of antiproton transfer in preparation for full recycler mode integration. The Committee was convinced that it will be ready when needed. Transverse injection error dampers were being commissioned in the MI. BPM upgrades for P1, P2, AP1, AP3, A1 are in progress.

Preparations for this important upgrade appear to be progressing more or less on schedule.

5.1.5 Stochastic Cooling Upgrades

After installation of the optical notch filters in the Debuncher, the extraction momentum spread is below the target value of 6 MeV. Machine studies have revealed possible shortcomings in achieving maximum repetition rate—D to A line limitations are suspected.

A machine study using proton stacking is planned for the fall (in the shadow of a significant Tevatron shut-down) to verify the stochastic cooling flux limits of the Debuncher and stack tail systems. This has been on the list of recommendations of the DOE committee for several years.

Charge Point 2: Does the laboratory have plans to effectively achieve the goals of the Run II and neutrino programs?

There are detailed plans to achieve the goals of the Run II, but there are significant challenges and risks ahead, primarily in the area of electron cooling but also in the area of AP2 and the Debuncher aperture upgrade.

Charge Point 3: Have adequate resources (i.e., manpower, funding, etc.) been identified and allocated to carry out the plans?

According to a project progress analysis done by the end of January 2005, the various Run II luminosity projects are progressing more or less according to plans. This appears to indicate that adequate resources are being identified and allocated.

There was a plan to install a dynamic η scheme in the Debuncher that could improve the mixing during transverse cooling and further reduce ΔE at Debuncher extraction. This is still being pursued, but apparently with low priority resulting from lack of resources.

Significant resources are being allocated to instrumentation upgrades that are essential to commission and fully profit from the various components of the luminosity upgrades.

A 50 MHz transverse damper will be installed in the Recycler by the end of 2005 and is urgently needed to ensure stability of the cool antiproton stack.

Charge Point 4: Are there any programmatic, technical, and infrastructure risks? Has the laboratory developed an adequate risk analysis with identified fallback plans?

There are several risks: Will the electron cooling work as planned? Will effective use of the full repetition rate of the Debuncher transverse cooling be achieved after fixing suspected limitations in the D to A line? Will the full nominal apertures of AP2 and the Debuncher ring be achieved?

There are back-up plans in place that reflect the reduced integrated luminosity resulting if the electron cooling and/or the stacking rate improvements are less successful than expected.

Charge Point 5: ***Is the laboratory management effectively setting priorities, tracking progress, and resolving problems for a successful execution of the proposed plans?***

It appears that a high priority is set for most antiproton source items of the luminosity upgrade plan and that progress is being carefully tracked by management. There is a significant amount of machine study time addressing the various items of the plan. An appropriate amount of study time has been allocated to Recycler readiness, beam-based aperture search, stack tail flux studies, Debuncher cooling rate studies, and limitations suspected to be associated with aperture limitations. Overall progress of Tevatron complex performance is being tracked by the Accelerator Integration Department and their Shot Data Analysis.

Charge Point 6: ***The committee is also asked to assess the laboratory's responses to the comments and recommendations from the February 2004 Tevatron Luminosity review and from the March 2004 Tevatron Operations review?***

Fermilab has followed and implemented most of the recommendations from the March 2004 DOE review. The "Running Wave" method does not appears to be very effective in identifying limiting apertures in the Debuncher. It has been replaced by trial-and-error localized bumps using antiprotons parasitically with antiproton production. As a consequence, dedicated machine study time has been reduced.

Dedicated antiproton source studies have been significantly reduced in 2005 and replaced by parasitic studies. There is currently no working beam based limiting aperture localization procedure available that works with antiprotons. Trial-and-error localized bumps may not be effective to identify and eliminate two simultaneously limiting apertures.

5.2 Recommendations

1. Address the causes of losses in MI for the slip stacking antiproton production beam. Identify and fix emittance dilution in Booster.

2. Maintain pressure on MI and Booster teams to deliver bunches as short as reasonably possible for antiproton production, and identify and fix causes of longitudinal emittance dilution.

3. Continue to develop a reliable beam-based method (antiproton or reverse protons) to identify location of aperture limiting obstacles in the Debuncher.

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6. TEVATRON

6.1 Findings and Comments

Responses to the Charge

Charge Point 1: Has the laboratory successfully executed its plans for the operations of the accelerator and detectors and for the luminosity improvement during the past year?

The general answer is “yes”. The Tevatron has made excellent progress as a result of the well-planned improvements that were implemented both before and during the last shutdown. The peak luminosity has further increased from 0.6×10^{32} $cm^{-2}sec^{-1}$ in spring 2004 and has now surpassed 1.1×10^{32} $cm^{-2}sec^{-1}$, which is only a factor of 2.5 away from the design goal. Within the Tevatron department, priorities for Run II are carefully planned and well communicated. At the same time, the complex continues to operate at very high availability, reaching peaks of 150 store hours per week, and maintaining 100 hours/week on average. It is very likely that for FY 2005, assuming continuing good progress, the goal of 0.47 fb^{-1} for the design integrated luminosity will be met and possibly exceeded. As such, Fermilab has executed its plans effectively and is on track to meet the integrated luminosity goals. The Tevatron team is to be congratulated for achieving their performance goal for FY 2004 as predicted and for having such a good start-up of operations again in November 2004, after completing the shutdown on time.

The upgrade campaign for the Tevatron infrastructure and especially the diagnostics continues to be advantageous, significantly in peak and in integrated luminosity. The complex continues to operate at very high availability and increasing antiproton intensity. The statement that was made during the February 2004 DOE review, that “the desire to integrate as much luminosity as possible has impacted the ability of the Tevatron group and many technical groups to have regular beam study time”, is still true. A backlog of required beam study time (less than 30 percent of requested study shifts have been scheduled from November 2004 to March 2005) shows that at the present rate (with one shift per week), it would take a year to go through the proposed beam physics program. Near-term, immediate needs to meet luminosity goals are currently the major focus. However, the longer-term operation at much higher intensity, while currently in the planning stage, needs more focused attention.

Management should seriously consider allowing more time to perform the proposed studies thoroughly. A proper balance between luminosity operation and commissioning time does not seem to be in place, especially since integrated luminosity requirements keep increasing over the next years.

Charge Point 2: Does the laboratory have plans to effectively achieve the goals of the Run II and neutrino programs?

Fermilab has a detailed plan for achieving the goals of Run II, including a number of essential upgrade projects for the Tevatron. Several significant elements of the upgrade are already incorporated into Tevatron operations and have led to improved luminosity performance. Improvements in beam quality from the injector chain have provided smaller emittances to the Tevatron with consequent increase in luminosity. Incorporation of the Recycler into the antiproton chain has increased the antiproton intensity, and therefore the luminosity. The successful implementation of corrected interaction region (IR) optics at collision with lower β^* has resulted in a 28 percent increase in peak luminosity.

The understanding of IR optics and the helix closure has made a great deal of progress and the integration of more and stronger separators allows larger orbit separations to minimize beam-beam effects. Plans for achieving further luminosity upgrade milestones (i.e., electron cooling in the Recycler) are being implemented and a comparative analysis of overall Run II integrated luminosities for different upgrade outcomes has been presented.

Comments made under Charge Point 1 largely apply. While the plans have been developed in great detail and the hardware to support these upgrades is being built and installed, commissioning time should be made available to integrate these components and execute the planned tests.

Charge Point 3: Have adequate resources (i.e., manpower, funding, etc.) been identified and allocated to carry out the plans?

Adequate resources have been allocated throughout various divisions at Fermilab to support Run-II goals in general and in particular to develop and build all the hardware required for the upgrades. Sufficient manpower for beam studies preparation is also available.

A great deal of effort and resources have been correctly devoted to the upgrade of instrumentation and diagnostic systems for all machines in the accelerator complex and specifically for the Tevatron, and that will play a key factor in the luminosity development.

Many of these systems are close to being finished and commissioning has begun, but they need to be fully integrated and made operational. Diagnostics that allow continuous monitoring of orbit, tunes, chromaticity, emittance, and bunch length during the ramp are becoming available, but it is not clear if they are being used yet for optimization.

New diagnostics systems include: the upgraded BPM system, the Schottky monitor, a monitoring system for beam in the abort gap, the updated BLM system, and the Tune Tracker.

Adequate resources from all parts of Fermilab, as well as other laboratories have been allocated for the substantial alignment campaign to realign the Tevatron, which is paying dividends with increased aperture for beam tuning. The team is to be congratulated for fulfilling this task in time. A total of 412 dipoles have been shimmed, with approximately 200 remaining to be done in the next shutdown.

There is a substantial list of machine development items—currently 48 machine development shifts. At the present rate of machine development allocation, this will take more than a year to complete. Many of these topics could yield immediate benefits in luminosity, and nevertheless many of these studies must be performed in preparation for higher intensity operation of the Tevatron once more antiprotons become available.

With the recent substantial effort dedicated to instrumentation and diagnostics upgrades, many of these systems have the potential of yielding immediate benefits in operations, and ultimately in luminosity (i.e., the use of the upgraded BPM system for optics measurement necessary for the planned further β reduction at the interaction points). Moreover, improved diagnostics are essential to prepare for higher intensity operation of the Tevatron once more antiprotons become available. This being the case, it was not clear to the Committee why making these systems fully operational and available to operations is not receiving higher priority.

There are many new diagnostic tools under development for the Tevatron. The high-priority items, especially the BPM, have a very aggressive implementation plan that requires coordination across divisions. A coordinator is in place and careful tracking of the various subprojects is necessary to guarantee completion (now scheduled for May 2005). This represents a slight delay from the original schedule, but is not yet critical to impact the luminosity program.

More specific plans should be developed to complete system commissioning and integration into routine operation, and to study future expansion of capabilities. The staged commissioning of the BPM system is progressing well—the goal of routine orbit measurements for protons and antiprotons simultaneously on a timescale of June should be given high priority. An example of expansion of system capability would be to extend turn-by-turn measurements available now at injection to the ramp and store for optics and coupling measurements. The initial focus of Schottky development for store measurement is correct, and priority should be given to establish calibration of emittance and chromaticity measurements, along the lines of what has been done for tunes and dp/p. With that accomplished, the Schottky store system should be made available to operations. The slow-tune feedback for antiprotons at store has the potential of immediate operational usefulness to minimize beam-beam effects. Future expansion of Schottky development for ramp measurements should be explored. The development of the tune tracker allows continuous measurement of tunes and chromaticities on the ramp, which can help machine tuning and make configuration changes (such as changes in working point) faster and easier.

Charge Point 4: Are there any programmatic, technical, and infrastructure risks? Has the laboratory developed an adequate risk analysis with identified fallback plans?

A potential risk item relates to Tevatron performance at the highest bunch intensities envisioned in Run II.

The numbers of protons per bunch is still about 2.4×10^{11}, while the typical antiproton intensity per bunch has increased from 3.1×10^{10} to 3.8×10^{10}, corresponding to beam-beam parameters per IP of about 0.009 for the antiprotons and 0.002 for the protons. (The value of 0.009 is the largest hadron beam-beam parameter ever achieved, anywhere.) With two collisions the total head-on tune-shift for the antiprotons is about 0.018, while the total long-range tune-shift is about 0.006.

Losses at injection, which were a dominant limiting factor at the start of Run II, have been significantly improved over the last few years through a dedicated program of improvements, including beam quality improvements in the injector chain, alignment and shimming of Tevatron dipoles, and incorporation of octupoles for Landau damping and differential chromaticity control. Proton losses during injection are driven at present by a longitudinal, coupled-bunch instability, as well as by beam-beam effects.

Studies are in progress to measure and analyze the lifetime vs. helix amplitude. A larger than anticipated improvement in lifetime was observed with larger helix amplitude in collisions. Unlike Run I, large chromaticities (12-18 units) are now required to maintain beam stability during collisions. Explanations include reduced proton tune spread due to lower antiproton bunch intensities relative to those in Run I, and the presence of coherent multi-bunch beam-beam modes that lie outside the proton tune-spread.

Proposed cures for the longitudinal coupled-bunch instability include adjustment and control of the damper system gain and adjustment of the RF system resonant frequency to increase Robinson damping. Mitigation of the proton longitudinal coupled-bunch instability should yield immediate benefit to Tevatron performance and should receive immediate and adequate machine studies time.

Longitudinal and transverse feedback systems that allow better emittance preservation during injection and at high energy need commissioning time to be integrated into routine operation.

Beam-beam effects are playing a significant role in the Tevatron performance and operation. Beam-beam effects are leading to proton losses at injection, antiproton and proton losses during the ramp and the squeeze, as well as antiproton emittance growth and proton and antiproton losses during collision. Total losses are about 20 percent from injection to collisions.

Experience from other machines, in which beam-beam effects heavily influence the beam dynamics, shows that substantial progress can be made in understanding these effects and mitigating them with appropriate lattice, tune, orbit, helix, chromaticity control, etc. Experience from these machines also shows that it may require substantial dedicated machine studies time and aggressive tuning to fully optimize machine performance in the presence of strong-strong primary and parasitic beam-beam interactions.

Given the influence of beam-beam effects already on Tevatron performance and operations, one can expect that at ultimate Run II intensities (270×10^9 protons and 130×10^9 antiprotons), these effects will become more severe, and may limit the luminosity performance unless mitigation strategies are aggressively pursued. A number of approaches are proposed or are underway: optimizing the various helices by incorporating new separators and making use of polarity reversing capability, utilizing the Tevatron Electron Lens (TEL) for beam-beam compensation, as well as working point optimization, among others ideas.

Proper helix design is essential for maintaining adequate separation at full Run II intensities. The installation of additional separators will provide greater separation at the near-IR parasitic crossings in the collision helix. Good progress is being made in separator conditioning to allow reliable operation at larger helix amplitudes. The installation of polarity switches, and the installation of additional separators are important efforts toward improving the beam separation in the various machine configurations. The Committee encouraged continued effort in understanding the lifetime versus helix amplitude, and in comparing those observations with simulations.

There are still programmatic risks in the sense that the design intensity for antiprotons and protons has not yet been demonstrated or validated. The risk has been appropriately addressed in the form of the “design luminosity” and “base luminosity” goals.

Charge Point 5: ***Is the laboratory management effectively setting priorities, tracking progress, and resolving problems for a successful execution of the proposed plans?***

Fermilab management clearly sets and communicates goals based on the desire to achieve the luminosity goals set on a year-by-year basis. The plans are tracked globally (achieving luminosity performance), as well as on a detailed level for the individual subprojects. Problems are quickly identified and addressed. The plan has been executed very successfully.

There is a strong focus on the integrated luminosity goal that drives the schedule for operation, commissioning, and beam study time. This results in a lack of long-term planning of machine development time that is instead evaluated on a day-to-day basis. Allocated study time depends on the availability of the Tevatron for these studies, which presently is driven by unscheduled downtimes of other subsystems.

Charge Point 6: ***The committee is also asked to assess the laboratory’s responses to the comments and recommendations from the February 2004 Tevatron Luminosity review and from the March 2004 Tevatron Operations review?***

The recommendations from the various reviews are listed and tracked—responses are presented in a comprehensive way. Some of the recommendations from the February 2004 and March 2004 DOE reviews are still valid, remain open, and should be closedout thoroughly as soon as possible. Of particular importance are the comments with respect to the dampers, diagnostics integration, and the availability of beam study time.

6.2 Recommendations

1. Develop a long-term schedule that allocates sufficient beam study time for the Tevatron (i.e., a quarterly/yearly schedule).

2. Encourage (management) continuous use of parasitic machine studies by providing time for projects that have minimal disruption to high energy physics data-taking, after careful analysis of potential impact on routine operations.

3. Give priority to commissioning and integration of new diagnostics into operation by making efficient use of parasitic beam study time.

4. Continue to investigate beam-beam effects in the Tevatron, both experimentally and theoretically with the goal of validating Tevatron performance at full Run II design intensity.

5. Increase the study time dedicated to machine development in the Tevatron to accomplish the presently existing beam physics study plan.

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7. MANAGEMENT

7.1 Findings and Comments

Overall, Fermilab is well managed. The management team is very able, and dedicated to carrying out Fermilab's mission. They work well together, are aware of each other's issues, and share resources to achieve laboratory goals. One manifestation of the effectiveness of this management approach is the turnaround in the Run II performance during the past several years.

The laboratory's record of safety in the past several years has improved significantly, reflecting its ISM commitment. Progress also has been made in integrating contractors into the laboratory's safety culture.

Run II performance is very good and at this stage is on track to meet the 8 fb-1 design goal. However, there remain significant challenges ahead, especially in implementing electron cooling (expected to increase luminosity by a factor of about two) and in allocating adequate machine study time for the many improvements being implemented.

The reorganization of the Accelerator Division in 2003 has paid significant dividends as indicated by the high-quality performance of the Run II program in the past year and the excellent progress in the Run II upgrade projects. The planning processes introduced into the Accelerator Division are now increasingly being utilized in other parts of the laboratory.

Fermilab has established a well-defined process for annually planning and budgeting project, operations, and support activities. Laboratory management is now confronting a significant decrease in FY 2006 and then flat-flat budgets without any expected relief for the next several years. This is necessitating staff reductions, consolidation, and the need for rigorous priority setting across Fermilab.

The Proton Plan being developed is a good example of this process and will help ensure the success of the neutrino experiments.

The management team is very cognizant of future challenges facing Fermilab due to the current funding climate for basic research with its severe constraints on high energy physics funding and to the end of the energy dominance of the Tevatron when LHC begins operation.

Management is planning for the needed staff reductions in a manner that assures key skills and competencies are retained at Fermilab.

In this era of declining budget and with LHC on the horizon, there is an increasing challenge to Fermilab management to get the full scope of physics from the collider. The decreasing research support in the field and shift of people's efforts to LHC leads to fewer people to maintain the experiments and analyze data—this will only get worse in coming years. Fermilab may not be able to provide enough support to enable the community to fully exploit the scientific opportunities of CDF and D-Zero.

The Fermilab Director, Michael Witherell, is stepping down in June 2005. Dr. Witherell has successfully led the laboratory in addressing the difficult challenges of the Run II luminosity upgrades. As a result of his leadership and vision, Fermilab is home to the world's leading collider program and has a solid platform on which to build for its future.

Pier Oddone will succeed Dr. Witherell. Dr. Oddone brings expertise and experience well suited to provide Fermilab with first-class leadership to meet the challenges of decreasing budgets and the impending contract competition.

Limiting the scope of this review exclusively to Tevatron operations makes it difficult for the Committee to fully assess the health of the laboratory because of the strong coupling between operations, research, and other components Fermilab.

Open and frequent communications between the leadership of the experiments and the Directorate will be increasingly important as declining budgets reduce Fermilab's ability to support experiments.

The involvement of experimental collaborations in appropriate accelerator activities and planning might significantly benefit the Laboratory. It could provide additional resources and closer collaboration between the experimenters and the accelerator staff.

Fermilab needs goals that challenge and motivate the staff to optimize the physics from the laboratory. These goals must be realizable but not too conservative. For the Tevatron, the design goals are challenging and meeting them requires balance between near-term needs for luminosity and longer-term benefits of accelerator studies. For the neutrino program, protons-on-target goals should be ambitious, but realizable, to assure a successful experimental program.

Responses to the Charge

Charge Point 1: ***Has the laboratory successfully executed its plans for the operations of the accelerator and detectors and for the luminosity improvement during the past year?***

Generally yes. This is a positive outcome of the management changes made in the past two years in the Accelerator Division and elsewhere in the laboratory.

Charge Point 2: ***Does the laboratory have plans to effectively achieve the goals of the Run II and neutrino programs?***

Generally yes. However, the plans assume a flat-flat funding scenario and significant efficiencies from consolidation of facilities and support staffing. The efficacy of such consolidation is yet to be demonstrated. Sharper-than-planned budget cuts would threaten the viability of these plans. Development of the Proton Plan should continue and be based on clear goals established jointly with the neutrino program.

Charge Point 3: ***Have adequate resources (i.e., manpower, funding, etc.) been identified and allocated to carry out the plans?***

Generally yes, in the context of the anticipated flat-flat funding between FY 2007 and FY 2010. But concerns remain that investment in the aging laboratory infrastructure will be inadequate and that such investments may be reduced further should funding restrictions increase. A key aspect of providing adequate resources for high-priority activities will be the laboratory's ability to shift resources from lower-priority activities without regard to organizational boundaries. There is also concern that the minimal investment in Tevatron detector facilities planned for FY 2008-2009 was scoped to match budget guidance and may not be realistic.

Charge Point 4: ***Are there any programmatic, technical, and infrastructure risks? Has the laboratory developed an adequate risk analysis with identified fallback plans?***

Many programmatic, technical, and infrastructure risks exist and the likelihood of mitigating all of them in the restricted budget climate seems small. Management is identifying the items of risk and considering their impact and mitigation within declining budgets.

Charge Point 5: ***Is the laboratory management effectively setting priorities, tracking progress, and resolving problems for a successful execution of the proposed plans?***

Generally yes, although there are areas for improvements such as the balance between data taking and accelerator study time.

Charge Point 6: ***The committee is also asked to assess the laboratory's responses to the comments and recommendations from the February 2004 Tevatron Luminosity review and from the March 2004 Tevatron Operations review?***

The laboratory has provided a scorecard that documents the action items it considers open and closed, as well as the steps taken to address the action items. Following on previous recommendations: further action is needed on comparing Fermilab practices with comparable operations at other laboratories. Continued exploration of the feasibility of centralizing common support activities is also needed.

7.2 Recommendations

1. In the future, DOE should set the scope of this review so that the committee can get a complete picture of the operations of the laboratory.

2. For the next review, Fermilab should identify several areas with high potential for savings and compare its practices, staffing, and costs with comparable operations at other laboratories.

APPENDIX A

CHARGE MEMORANDUM

DOE F 1325.8
(08-93)

United States Government | Department of Energy

memorandum

DATE: January 27, 2005

REPLY TO
ATTN OF: SC-20

SUBJECT: Request to Conduct a Review of the Tevatron Operations at Fermi National Accelerator Laboratory

TO: Mr. Daniel Lehman, Director, Construction Management Support Division, SC-81

This memorandum is to request that you organize and conduct a review of the Tevatron Operations on March 29–31, 2005 at Fermilab. The purpose of this review is to evaluate the past performance, and the resource requirements and management practices needed to effectively support its research missions for FY 2005–FY 2009.

The High Energy Physics program supports the Tevatron program at Fermi National Accelerator Laboratory (FNAL), carrying out the world-class research program at the energy frontier. The Tevatron program includes the operation of and performance improvements to the Tevatron accelerator complex and the operation of both the collider detectors and the neutrino experiment.

One of the major components of Tevatron Operations is the luminosity improvement. The scope of the review should include the assessment of the performance of the Tevatron collider since the February 2004 Tevatron Luminosity review and the evaluation of the remaining luminosity improvement plan.

The committee should address the following specific items:

1. Has the laboratory successfully executed its plans for the operations of the accelerator and detectors and for the luminosity improvement during past year?

2. Does the laboratory have plans to effectively achieve the goals of the Run II and neutrino programs?

3. Have adequate resources (i.e. manpower, funding, etc.) been identified and allocated to carry out the plans?

4. Are there any programmatic, technical and infrastructure risks? Has the laboratory developed an adequate risk analysis with identified fallback plans?

5. Is the laboratory management effectively setting priorities, tracking progress, and resolving problems for a successful execution of the proposed plans?

6. The committee is also asked to assess the laboratory's responses to the comments and recommendations from the February 2004 Tevatron Luminosity review and from the March 2004 Tevatron Operations review.

Michael Procario is the program manager for Fermilab in this office and will serve as the OHEP contact person for the review.

We appreciate your assistance in this matter. As you know, these reviews play an important role in our program. I look forward to receiving your Committee's formal report within 60 days of the review.

Robin Staffin
Associate Director
Office of High Energy Physics

cc:
R. Orbach, SC-1
J. Decker, SC-2
M. Procario, SC-20
A. Byon-Wagner, SC-20
M. Witherell, Fermilab
J. Livengood, FAO

APPENDIX B

REVIEW PARTICIPANTS

Department of Energy Review of Tevatron Operations at Fermilab
REVIEW COMMITTEE PARTICIPANTS

Daniel R. Lehman, Chairman (DOE)

SC 1

Detector Operations

* Jim Siegrist, LBNL
Howard Gordon, BNL
Roy Whitney, TJNAF

SC 2

Accelerator Operations and Integration

* Rod Gerig, ANL
John Carwardine, ANL
Will Oren, TJNAF
Bob Siemann, SLAC

SC 3

Proton Source

* Thomas Roser, BNL
Rick Baartman, TRIUMF

SC 4

Antiproton Source

* Flemming Pedersen, CERN
Fritz Caspers, CERN

SC 5

Tevatron

* Norbert Holtkamp, ORNL
Stuart Henderson, ORNL
Fulvia Pilat, BNL

SC 6

Management

* Jay Marx, LBNL
Klaus Berkner, Consultant
Marty Breidenbach, SLAC
Stephen Meador, DOE/SC

Observers

Robin Staffin, SC-20
Aesook Byon-Wagner, SC-20
Michael Procario, SC-20
Ronald Lutha, DOE/FSO

LEGEND

SC Subcommittee
* Chairperson
[ ] Part-time Subcom. Member
Count: 19 (excluding observers)

APPENDIX C

REVIEW
AGENDA

Department of Energy Review of
Tevatron Operations at Fermilab

AGENDA

Tuesday. March 29, 2005—Comitium

8:00 am	DOE Executive Session	D. Lehman
9:00 am	Welcome and Laboratory Overview—**One West**	M. Witherell
9:25 am	Overview of Accelerator Operations	S. Holmes
9:45 am	Run II Operations: Current Status and FY05 Plan	D. McGinnis
10:15 am	BREAK	
10:30 am	Run II Luminosity Upgrade Plan	P. Bhat
11:00 am	Fixed Target Operations (Switchyard 120, MiniBoone, NuMI)	C. Moore
11:30 am	Proton Source Upgrade Plan	E. Prebys
12:00 pm	Resource Planning for Accelerator Operations and Development	R. Dixon
12:30 pm	LUNCH	
1:30 pm	Overview of Detector Operations	H. Montgomery
1:50 pm	CDF and D0 operations	R. Roser
2:20 pm	CDF and D0 computing	A. Boehnlein
2:50 pm	Neutrino detector operations	G. Bock
3:10 pm	Resource Planning for Detector Operations and Development	J. Strait
3:40 pm	BREAK	
4:00 pm	Breakout Sessions	
5:00 pm	DOE Executive Session—**Comitium**	
6:30 pm	Adjourn	

Wednesday, March 30, 2005—Rooms TBA

8:30 am Breakout Sessions
- Run II Operations and Upgrades Contact: M. Martens
- Fixed Target Operations and Upgrades Contact: P. Lucas
- Detector Operations Contact: G. Bock
- Resource Planning Contact: S. Holmes

12:00 pm Lunch
1:00 pm Breakout Sessions
2:30 pm Subcommittee Executive Session
3:00 pm Summary
3:30 pm DOE Executive Session

Thursday. March 31, 2005

8:00 am Subcommittee Working Sessions
9:30 am DOE Full Committee Executive Session Dry Run
1:30 pm DOE Summary and Closeout with Laboratory Management
2:30 pm Adjourn