Department of Energy
Review Committee Report

on the

Technical, Cost, Schedule, and
Management Review

of the

TEVATRON Run II LUMINOSITY UPGRADES

February 2004

EXECUTIVE SUMMARY

The Department of Energy (DOE) review of Fermi National Accelerator Laboratory's (Fermilab) Tevatron Run II Luminosity Upgrade Program was conducted on February 24-26, 2004 at the request of Robin Staffin, Associate Director of the Office of Science for the Office of High Energy Physics. The purpose of this review was to assess the performance of the Tevatron since the July 2003 DOE review, and to evaluate the luminosity improvement plan for the Tevatron during the period FY 2004-FY 2006. The Committee was specifically tasked to determine if: the updated (version 2.0) Run II Plan was reasonable, adequate resources were identified, schedule for improvements was credible and appropriate, risks were assessed, management structure was adequate to successfully implement the updated Plan, and responses to comments and recommendations were satisfactory.

Overall, the Committee was impressed with progress since the July 2003 DOE review. A majority of recommendations from that review have been completed or are well underway. Based on Fermilab's progress since the July review, "…the Committee now views the base goal of 4.4 fb^{-1} by the end of FY 2009 as having a good probability of being met or exceeded. Meeting the design goal of 8.5 fb^{-1} by the end of FY 2009 remains very challenging."

The Tevatron reached new highs in luminosity (6.3×10^{31} $cm^{-2}s^{-1}$) and store hours (> 30 per store and > 130 per week) in February 2004 after a very successful shutdown late last year. The Recycler has achieved major improvements in beam lifetime and emittance growth. Fermilab delivered a major update of the Run II Luminosity Upgrade Plan to DOE in January 2004. The updated Plan now includes the Recycler and Electron Cooling and was the major focus of this review.

A significant amount of work on the upgrades has been done, but none is complete. Some examples include:

- Alignment work during the last shutdown has resulted in significant improvements in the reliability of the Tevatron, but currently only the largest misalignments have been corrected.

- Significant progress has been made in the Recycler and Electron Cooling projects.

- Projects in the antiproton source such as the lithium lens, slip-stacking, and the aperture increase are making progress.
- There is an increased emphasis on and appreciation of instrumentation. The beam

position monitors are being upgraded across the complex with common technology choices and approaches.

- Many installed upgrades await machine studies time so that they can be commissioned.

Updated cost estimates for the luminosity upgrades and maintenance and reliability projects were provided during the review. The total cost of these activities over a four-year period is approximately $53 million including contingency (approximately 50 percent of the total estimated cost). The Committee did not conduct a detailed cost and schedule assessment; however, the estimates for the Upgrade activities and contingency are supported by a well documented basis. Approximately 80 milestones (between July 2003 and September 2007) have been developed that represent physical progress evaluation points, major scope decisions, and planned internal technical reviews. The timing, nature, number, and sequence of milestones seem appropriate.

Overall the resources assigned to the various Run II subprojects appear reasonable. However, it is essential for the management to fully assess the staffing and resources needed to reach the luminosity goals (this includes operations, commissioning, and maintenance activities).

The successes in the past seven months indicate the capabilities of the new management team to lead, organize, and integrate the efforts of the Accelerator Division. The systematic approach applied to the complex has had a major impact, and is an important platform for future success. Morale, pride, and discipline are on the upswing.

In summary, great progress has been made since the July 2003 DOE review. A successful shutdown during late 2003 was accomplished and as a consequence, the Tevatron Complex has never operated better. The Run II Luminosity Upgrades Plan has been completed and Fermilab as a whole appears to be focusing on Run II, and providing the support at the level needed for success. However, there is a long way to go in the complex campaign of operations, maintenance, upgrades, R&D, and studies that must succeed if the luminosity goals are to be reached.

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1. INTRODUCTION

1.1 Background

The Fermilab Tevatron was operated as a 900 GeV on 900 GeV proton-antiproton collider in Run Ib from December 1993 until February 1996. The typical peak luminosity at the beginning of stores in Run Ib eventually reached 1.6×10^{31} $cm^{-2}s^{-1}$ and the total luminosity integral was approximately 140 pb^{-1}. Fermilab has completed a major upgrade of the accelerator complex to increase the luminosity for Run II. The centerpiece was the construction (1992-1999) of a new 150 GeV synchrotron, the Main Injector (MI). The MI was designed to replace and improve on the performance of the Main Ring for delivering a proton beam to the Antiproton Source and injecting protons and antiprotons into the Tevatron. A new 8 GeV antiproton storage ring, the Recycler, was also constructed and installed in the MI enclosure to increase the antiproton storage capacity of the complex. The upgrade also included additional stochastic cooling in the Antiproton Source, various beam-mode dampers, and a six-fold increase in the number of both proton and antiproton bunches in the Tevatron (from 6 to 36) to limit the number of interactions per crossing at increased intensity.

Before Run Ib began, it was envisioned that the typical peak luminosity for that run would reach 1×10^{31} $cm^{-2}s^{-1}$ and that the upgrade program would subsequently provide a five-fold increase to 5×10^{31} $cm^{-2}s^{-1}$ for Run II. The projection for Run II peak luminosity was moved to 8×10^{31} $cm^{-2}s^{-1}$ after 1.6×10^{31} $cm^{-2}s^{-1}$ was reached in Run Ib, and then to 2×10^{32} $cm^{-2}s^{-1}$ when the Recycler was added to the MI project in 1997.

Run II of the Tevatron (without the Recycler) began in March 2001 with the beam energy increased to 980 GeV. Commissioning of the accelerator did not proceed smoothly. By the end of 2001, the seriousness of the problem was widely recognized, progress continued to be slow, and in 2002 the Office of High Energy Physics (formerly Division of High Energy Physics) asked Fermilab for a written plan to improve the luminosity and conducted a review of that plan in October 2002, chaired by Dr. David Sutter. The conclusion of that review was that a complete resource-loaded plan that extended beyond FY 2003 was needed.

1.2 The Luminosity Improvement Plan

A plan including a resource-loaded schedule from FY 2004 through FY 2009 was delivered to the Department of Energy (DOE) on June 15, 2003. It described the technical changes needed to continue to improve the luminosity, including:

- Slip-stacking in the MI,
- Antiproton yield improvements,
- Improved transfer into the Tevatron,
- Lithium lens gradient upgrade,
- AP2-Debuncher aperture upgrade,
- Antiproton stochastic cooling improvements,
- Electron cooling in the Recycler,
- Rapid antiproton transfers between the Accumulator and the Recycler, and
- Tevatron beam-beam compensation.

The Plan showed two different projections of the integrated luminosity assuming the same technical scope of work but used different assumptions to estimate the projected increase in the luminosity.

The "base" projection is a conservative projection that includes schedule contingency. Project management believes it is highly likely that the "base" projection can be achieved. It uses historical data on the number of hours the Tevatron can run per week and models the increase of luminosity from very low to normal values after shutdowns. It has explicit schedule contingency added to the bottoms-up derived schedule.

The "design" projection assumes that operational parameters will reach values closer to the maximum achievable. It has no explicit schedule contingency. It assumes that the operational hours will improve with time, and its model of return to normal luminosity after shutdowns has a faster rate of increase. The Fermilab management team believes there is a reasonable probability of achieving the "design" projection and it may even be exceeded.

This Plan was reviewed by a committee chaired by Mr. Daniel Lehman in July 2003. The conclusion from that review was that there was a reasonable chance of achieving an integrated luminosity of 4 pb^{-1}, but that the Plan was still incomplete. The most serious omission of the Plan was in the area of electron cooling and the Recycler. This part of the Plan suffered from difficulties that Fermilab experienced in commissioning the Recycler during 2003.

An updated Plan, delivered to DOE in January 2004, is the subject of this review. It contains a plan to commission the Recycler and electron cooling. The luminosity projections have been updated and are shown in Table 1-1.

Table 1-1. Integrated Luminosity (fb^{-1}) Per Year

	Design	**Base**
FY03	0.33*	0.33*
FY04	0.31	0.23
FY05	0.56	0.37
FY06	1.50	0.47
FY07	1.70	0.80
FY08	2.00	1.10
FY09	2.10	1.10
Total	8.50	4.40

***actual performance**

1.3 Current Performance

At the time of this review, the Tevatron had shown significant improvements in performance. The most notable was the increased reliability. The average length of stores in February 2004 was over 30 hours compared to 15 hours in FY 2003. The number of store hours per week was 140 compared to 85 hours per week in FY 2003. The reliability has had a positive effect on peak, as well as integrated luminosity. The average initial luminosity increased from 3.1×10^{31} $cm^{-2}s^{-1}$ at the end of FY 2003 to 5.3×10^{31} $cm^{-2}s^{-1}$ in February 2004. The highest initial luminosity achieved so far has increased to 6.3×10^{31} $cm^{-2}s^{-1}$.

The failure of the Recycler to achieve adequate performance was one of the key issues preventing a complete Plan to be delivered in FY 2003. Extensive work on the Recycler during the fall shutdown has remedied this. Key performance parameters such as transverse emittance growth (3π mm-mrad/hr versus 15π mm-mrad/hr), beam lifetime (>600 hours versus <100 hours), and injection efficiency from the MI to Recycler (greater than 90 percent versus 75 percent) showed dramatic improvement.

1.4 Charge to the Committee

In a memorandum (Appendix A) dated November 28, 2003, Dr. Robin Staffin, Associate Director of the Office of Science for the Office of High Energy Physics, requested that Mr. Daniel R. Lehman conduct a review of the Tevatron Run II Luminosity Upgrades. The charge asked the Committee to assess the performance of the Tevatron in FY 2003, as well as the plan for FY 2004 – FY 2006. It included a series of specific questions to be addressed by the Committee, including:

- Is the laboratory's plan reasonable to achieve the luminosity improvements projected in the completed Plan?
- Have adequate resources (i.e., manpower, funding, etc.) been identified and allocated to carry out the Plan?
- Is the proposed schedule credible and appropriate in light of the technical tasks required?
- Has the lab developed an adequate risk analysis with identified fallback positions for the critical elements of the Plan, such as electron cooling and the Recycler?
- Is the management structure appropriate for implementing the proposed Plan to a successful completion?
- Assess the laboratory's response to the comments and recommendations form the July 2003 review.

1.5 Membership of the Committee

The DOE Review Committee was chaired by Daniel R. Lehman of the Office of Science, Construction Management Support Division. The Committee was organized into six subcommittees with members drawn from DOE national laboratories; U.S. universities; accelerator laboratories in Canada, Germany, and Switzerland; and the DOE Office of Science. The Committee membership and subcommittee assignments are found in Appendix B.

2. TECHNICAL

2.1 Accelerator Physics

2.1.1 Findings

The July 2003 DOE review recommendations have more or less been addressed, sometimes in innovative ways that were not foreseen by the Committee.

Current performance is very good: new records have been set on peak luminosity. Integrated luminosity for FY 2004 is ahead of schedule. The number of store hours per week has increased 59 percent from FY 2003. Reliability statistics for FY 2004 are very good. Some of these improvements are due to the successful realignment campaign at the end of 2003, stemming in part from earlier Accelerator Physics studies. Others are due to “good housekeeping” in many forms, and to rapid response to “fire fighting” situations, enabled by the recent reorganization.

Accelerator physicists from the Beam Physics group have been re-distributed among several machine departments, and the new “Integration Department”. This department consists of approximately 13 permanent members, distributed into four teams: 1) Shot Analysis; 2) Accelerator Operations Co-ordination; 3) Accelerator Physics; and 4) Rapid Response. While this innovative re-structuring still needs to be given time before an accurate evaluation is possible, the preliminary indications are that it is successful (or very successful) in providing specialized technical resources in an integrated fashion across all of the Tevatron complex accelerators: Linac, Booster, Debuncher, Accumulator, MI, Recycler, and Tevatron.

The Shot Analysis team has further developed a parametric model of the Tevatron, with inputs derived from Shot Data Analysis and operational statistics.

The Accelerator Operations Coordination team brings more expertise to bear on shot-to-shot and week-to-week issues in the control room, in a more efficient fashion than first observed.

The Accelerator Physics team is charged (among other tasks) with developing a “web portal and repository” for standardized configuration control of the lattice optics, and related information such as survey data, for all the accelerators. While the Accelerator Physics team is charged with maintaining the configuration data repository, it is the mandated responsibility of each system group head to certify these data. The Committee applauds this approach for the benefits that it will deliver.

The Rapid Response team tackles specific problems on a timescale of a few weeks or a few months. Its membership is dynamic, with dedicated manpower assigned to it on an "as needed" basis from appropriate machine groups. This approach has achieved impressive success on two recent activities: the CDF/D-Zero realignment and the Fermilab MI slow spill. This approach appears to be very effective.

The extra attention given to the Booster has resulted in a factor-of-three reduction in beam loss activation for fixed proton throughput. The "Finley Report" is being used to create a plan for upgrading the proton source. However, this report deals only with the mitigation of beam loss; it does not place any priority on studies to explore and understand intrinsic limitations on beam brightness.

There has been considerable R&D progress in the electron cooling system, including optics modeling of the electron beam line. However, unexplained slow trajectory drifts are observed, possibly related to unshielded stray magnetic fields. Successful reduction of the electron beam angular divergence down to its low target value has yet to be demonstrated. Such beam dynamics represent a significant technical risk to the successful early commissioning of the electron cooler.

2.1.2 Comments

Some of the improvement in performance and reliability can be attributed to a better-than-linear dividend accruing to any given improvement. For example, more efficient transfers anywhere result in less beam required from the Booster, in turn requiring fewer turns of Linac beam into the Booster. This results in better proton emittance, yielding even better transfers.

The Booster is still thought of as a machine which, in regard to Run II objectives, is meeting its goals. Recommendation 4 in Section 2.1.3 of the July 2003 DOE review appears to have been misunderstood. It stated: "*Develop a comprehensive model of the Collider complex, to analyze baseline and fall-back luminosity scenarios under various conditions, and to help establishing evolving target performance for each accelerator and relative priorities for beam studies or new equipment.*"

The intent was to encourage development of a model of the Collider complex, from linac to collisions. Such a model would answer questions such as: "Would improved proton source brightness obviate the need for slip-stacking, and how would the resulting improvement in longitudinal brightness impact the rest of the chain?", independent of previously agreed-upon goals for the Booster.

A more comprehensive model of the Collider complex, from linac to collisions, would help to establish target performance parameters for each accelerator, and relative priorities for beam studies. It would also help in the specification and commissioning of new equipment (such as a transverse damper for the antiprotons in the Recycler, and slow orbit feedback for the electron cooling beam).

The number of people having the required expertise in impedance estimates, collective effects, and cures may well be smaller than the number of machines/departments in the Accelerator Division. Therefore collective effects require some "intellectual mobility" and would ideally be dealt with at the level of the Integration Department. It is natural for the Accelerator Physics team to also include beam coupling impedance database and instability calculations in its mandate. Although impedance data can be gathered by the individual systems groups, these groups do not appear to have the necessary expertise to answer questions related to collective effects. Specific emittance reduction studies or impedance reduction campaigns could be handled by the Rapid Response team.

The re-distribution of Accelerator Physicists from the Beam Physics group into several Accelerator Departments is likely to increase their commitment to short- and medium-term Run II objectives, and to enhance their sense of ownership for machine studies and performance achievements. While the reorganization may lead to further short- and medium-term improvements in accelerator performance, in the longer term it may weaken the capability to preserve and increase the overall Accelerator Physics resources and expertise at Fermilab.

The strong-strong, beam-beam effect could limit the ultimate luminosity achievable at the Tevatron (see additional comments and recommendation made in Section 2.4, Tevatron). Adequate beam physics studies time must be assigned to long-term issues such as this, as well as to shorter-term luminosity production issues.

2.1.3 Recommendations

1. Expand integrated modeling across the accelerator complex (from linac to collisions) to include collective effects, impedance budgets, emittance preservation, and intensity limitations, such as space charge effects in the Booster. Pursue an aggressive emittance reduction campaign with these tools, supporting the urgent investigation of cold antiproton beam instabilities in the Recyler that might necessitate the use of a broad-band transverse damper. Report on progress at the next review.

2. 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.

2.2 Proton Source

2.2.1 Findings

Fermilab responded positively to most of the recommendations in Section 2.2.3 of the July 2003 review, with the noted exception of Recommendation 2 that requested a reexamination of the proton source capabilities and its benefit to the collider operation. A similar, updated recommendation is made again. Recommendation 6, which concerned the supply crisis of TETRODE 7835 rf power tubes for the five drift tube tanks of the Linac was addressed appropriately. A spare tube budget over the next few years has been established.

In general the work on the proton source upgrade (WBS 26.1) is progressing according to schedule.

The implementation of a new four-magnet dogleg for Booster extraction, featuring smaller deflection angles, has largely eliminated the strong edge focusing that completely changed the dispersion and thus the horizontal acceptance. A new re-optimization allowed to cut beam losses at 4.5 e12/pulse (MiniBoone beam) by a factor-of-three and to push the intensity limit beyond 5e12/pulse. The Committee congratulates the team for this remarkable success, not the least because of its beneficial effect on the proton beam brightness, decisive for Tevatron performance.

With the advent of MiniBoone and the Neutrinos at the Main Injector (NuMI) project, the Booster becomes the workhorse of the complex and is likely to stay the beam intensity bottleneck. The beam loss must not exceed 400 W so as to enable hands-on maintenance. An improved two-stage collimation system was installed in fall 2003 and will be commissioned shortly. Realignment of the Booster, scheduled for the forthcoming shutdown, will also help.

There are still beam losses at transition in the Booster that could be eliminated with the existing gamma-t jump system. Further work is needed on orbit correction and magnet alignment.

Regular monitoring of emittances, along the injector chain, starts only at MI injection. In order to improve the understanding of what happens in the Tevatron complex, Linac and Booster data needs to be included in the emittance budget.

Between Linac and Booster output energies, the transverse emittances grow by more than a factor-of-two. There is no beam profile monitor data showing when and how the blowup occurs, which is required for understanding beam dynamics effects (space charge, stop-bands) that drive it.

At present, the MI does not constitute a performance limit, and consequently there was not as much emphasis on the MI as at the last two reviews.

Longitudinal dampers have been installed and partially commissioned. The beneficial effect has been immediate by relieving the Booster from having to increase its longitudinal emittance, thus producing shorter bunches in the MI and the Tevatron. The Committee commended the group for this success and suggested speedy completion of the commissioning.

Upgrade projects are in place for beam-position monitors to replace aging electronics and add functionality, and for the beam-loss monitors to allow readings of integral data for more monitors in any given cycle.

Work on the 2.5 MHz rf system, necessary for capturing and accelerating pbars from the Recycler, has progressed well.

Good progress has been accomplished in the development of the slip-stacking technique of combining two proton batches from the Booster in the MI. A maximum intensity of about 6e12 protons was reached. With beam-loading compensation and after proper voltage matching the longitudinal emittance after slip-stacking two 0.1 eVs bunches was measured to be 0.3 eVs. It is expected that after acceleration and bunch rotation this will result in proton bunches with a full width of less than 1.5 ns.

The higher bunch intensity after slip-stacking will lead to significant beam-loading of the 53 MHz rf system causing longitudinal emittance growth. A test of beam-loading compensation on a single rf station was successful and the full complement of additional rf amplifiers has been ordered and should be delivered for installation in time for testing before the next major shut-down. Making slip-stacking operational also awaits the implementation of reproducible cogging between the Booster and the MI during the transfer of the second batch.

2.2.2 Comments

Good progress has been reported on a number of critical projects in the proton accelerator chain. However, after reports at the July 2003 DOE review of very promising and successful initiatives to better understand the limitations especially in the Booster, the Committee was disappointed about the apparent stalling of this line of work. More effort should have been spent on understanding the limits on batch intensity and the causes for emittance growth, longitudinal and transverse, and on mitigating these limits and causes. There may be opportunities to further optimize luminosity performance for Run II.

The spectacular success of cleaning up the optics error in the Booster, caused by the four-magnet dogleg, highlights the importance of experienced machine physicists addressing long-standing, unsolved beam dynamics issues. Is the Booster now working at its absolute limit or can it be pushed further? In view of its impacts of the Tevatron performance, the Committee does not understand why these efforts are not vigorously pursued.

MiniBoone and NuMI, together with operation of the Tevatron, will lead to a four-fold increase of the proton throughput in the Booster. The Committee is confident that the two-stage collimation system will help managing the additional beam losses.

The recent beam dynamics work also proved beneficial for the collider beams (pbar production and protons for the Tevatron). These bright beams are generated in the Booster, therefore including Linac and Booster beam characteristics is a necessity to correctly assess overall performance.

Ionization profile monitors installed in the Booster are supposed to measure transverse beam emittances throughout the cycle. However, profiles are strongly distorted at high beam intensity. Obtaining reliable beam emittance information throughout the Booster cycle is important for improving beam brightness.

The diagnostics upgrades for the MI are well motivated, but the time scale appears somewhat more long-term, limiting the benefits for Run II. The team is encouraged to unify the effort across machines, especially the MI and the Tevatron.

The reduced longitudinal emittance, as a result of the longitudinal dampers, is very encouraging. However, the bunch length is a prime factor in the pbar stacking rate and as such deserves significant attention. The importance of reducing the bunch length as far as possible does not appear to be fully recognized. The Committee encouraged the group to investigate means to further reduce bunch length; this includes alternatives to slip-stacking.

The momentum spread of 0.07 percent of the beam from the MI is causing problems in the Tevatron. The MI and Tevatron groups are encouraged to collaborate and resolve this.

For 2.5 MHz operation, the phase control of the rf cavities to be used to manipulate the 53-MHz rf voltage when recapturing the beam will be challenging under high-beam-loading conditions. Beam-study time need is anticipated in July and the Committee suggested this request be given appropriate priority to ensure these important studies will be completed in a timely matter.

Slip-stacking two Booster batches in the MI leads to an unavoidable increase of the longitudinal emmittance by more than a factor of two, which leads to longer bunches and thus increased pbar momentum spread after bunch rotation. To maintain the advantage of slip-stacking, great care has to be given to keeping longitudinal emittance growth to a minimum. The MI longitudinal damper and beam-loading compensation are the main tools to achieve this goal and adequate study time should be scheduled for testing and commissioning.

The lack of reproducible cogging between the Booster and MI prevents slip-stacking from being used for operation at present. This should be implemented as soon as possible. The beam intensity achieved with slip-stacking exceeds the present intensity used for pbar production. Therefore, it might already be useful for operation and this should be tested as soon as possible.

2.2.3 Recommendations

1. Determine the zero-stack pbar stacking rate using slip-stacking including cogging necessary for multi-batch transfers and beam-loading compensation by May 2004.

2. Make short proton bunches for pbar production a priority.
3. Develop an aggressive plan for machine studies to increase beam intensity and brightness in the Booster beyond its present state by May 2004. This plan should include making the gamma transition jump operational.

4. Provide emittance measurements in the Booster throughout the cycle and include Linac and Booster beam characteristics into the performance overview of the Tevatron complex by May 1, 2004.

2.3 Antiproton Source

2.3.1 Findings

The ingredients of the Run II Upgrade Plan (version 2) necessary to provide substantial increases in antiproton flux and stack sizes to support higher luminosities in the Tevatron have not changed since the July 2003 DOE review; they are:

1. More protons on target: slip-stacking in MI. Target beam sweeping to avoid target damage;
2. More antiprotons per proton (antiproton yield) through larger acceptances in the AP2 transfer line and Debuncher, as well as a higher gradient lithium lens of new design;
3. Improvements in stochastic cooling systems in the Debuncher to accommodate the larger emittances and increased flux of antiprotons;
4. Rapid transfer of antiproton stacks from Accumulator to Recycler;
5. Commissioning of the Recycler storage ring and achieving the required goals for emittance growth;
6. Satisfactory completion of electron cooling in Wideband test area, installation and commissioning in the Recycler; and
7. Accumulator stack tail stochastic cooling upgrade for higher flux at the expense of a reduced total stack capacity in the Accumulator.

The priority of the target beam sweeping system (#1) has been lowered as it is not needed until after the slip-stacking is successfully commissioned at high intensity. Sweeping the beam upstream of the target has been demonstrated and downstream sweeping magnets will be installed during the next shutdown.

With respect to the AP2 and Debuncher acceptance (#2) upgrade, collection of drawings and documentation required to establish aperture and beam envelope tables has been completed. Based on this work, limiting apertures have been identified mostly in the Debuncher, and design and modifications are in progress to remedy these. A large number of trims and motorized jacks are being installed to facilitate orbit correction and limiting obstacle identification. An rf cavity (DRF3) was moved to a region of lower dispersion during the fall 2003 shutdown, but only a modest 12 percent increase in horizontal acceptance was achieved. It is claimed that the stochastic cooling band's four vertical pick-ups and kickers are the main limiting vertical apertures, and design work to modify them is in progress with expected installation during the 2005 shutdown. A new quadrupole and a larger vacuum chamber (D4Q4) will be installed in the injection region during the 2004 shutdown. Improved instrumentation, optics verification, beam based alignment, and beam based limiting aperture identification are in progress. A new beam position monitor (BPM) system has been installed and commissioned in the Debuncher. A new study has been launched in collaboration with Lawrence Berkeley National Laboratory to study and remedy chromatic effects in the AP2 line.

The new redesigned lithium lens, with a diffusion-bonded titanium body, have been tested to 1.5 10^{12} pulses at nominal gradient without failure so far and testing continue. However, it does not have the full one-centimeter radius of the lithium body, but only 0.8 centimeters. Prototype #2 of similar design, but with the full radius, will be available for test by the end of 2004 and has the nominal diameter.

The Bulk Acoustic Wave (BAW) notch filter imperfections (#3) are limiting the asymptotic value of the final Debuncher energy spread to a value of 8 MeV, while a value of 6 MeV or less is required. The planned equalizer improvements to remedy this were not successful. Instead, an improved optical notch filter has been designed and built. It has a three-times smaller notch dispersion than the BAW based notch filter and its installation is imminent.

The relatively large momentum width injected into the accumulator increases the gain requirements of the stack tail cooling system. This gain however has to be reduced below optimum when there is a dense stack present due to a combination of instability problems and transverse heating of the stack due to imperfections in the stack tail kicker.

A detailed plan for commissioning the Recycler with performance goals and milestones, aimed at demonstrating its readiness for installation of the electron cooler, was presented. A rf gymnastic scheme for producing 36 antiproton bunches of 1.5 eVs each for the Tevatron was presented and is under commissioning in the Recycler. The schedule and shutdown planning mostly driven by the Recycler installation work was presented. While commissioning of the Recycler was stopped during almost a year due to a vacuum incident, the full bakeout during the 2003 fall shutdown was successful, and rapid progress has been made in achieving the Recycler readiness milestones prior to June 2004 deadline. Pbar shots delivery to the Tevatron via the MI has been demonstrated.

Progress of the high energy electron cooling experiment is satisfactory. The operation of the prototype device at Wideband at the reduced energy of 3.5 MeV at the design electron current of 500 mA is promising. The beam has been circulated through a cooling section almost as long as required for the Recycler. The electron beam properties were reported to be close to satisfactory. The electron beam RMS angle fluctuations in the cooling section are almost twice as large as desired. A magnetic shielding efficiency of the cooling section of a factor-of-5,000 has been reported. The recuperation efficiency was one order of magnitude smaller than in the former U-turn experiment, but the losses can still be safely compensated by the Pelletron. The final voltage of 4.3 MV could not be attained due to vertical space restrictions of the experimental hall at Wideband. Only after adding another acceleration section of the Pelletron there is reasonable hope to reach the beam parameters needed for Recycler operation. Unexplained drifts in electron position were reported, as well as occasional voltage breakdowns.

2.3.2 Comments

While the recent impressive progress in integrated luminosity is remarkable, it is not due to progress in stacking rate as anticipated in the Run II Upgrade Plan presented at the July 2003 DOE review. A successful test of more protons on target using slip-stacking will have to wait until the additional solid state driver amplifiers are installed in the 18 MI rf stations. This is expected to happen during the fall 2004. The recent reduction in effective bunch length of the proton production beam from approximately 1.5 ns to 0.6 ns due to the longitudinal bunch-by-bunch damper in the MI is very encouraging. If the same degree of emittance conservation can be maintained with slip-stacking where the initial emittance is about three times larger, a bunch length in the order of one ns appears feasible, which is very good.

The lower priority and delay of the installation and commissioning of the target beam sweeping system appears reasonable.

With respect to the acceptance increase in the Debuncher and AP2 line, a more detailed and focused plan is now available. Limiting elements and tight spots have been identified and the plan to remedy these limits looks reasonable. The program to add more motorized jacks and correctors looks good and is essential to make beam based identification of limiting apertures a success.

The successful implementation of a beam based semi-automatic identification of the limiting aperture in the Debuncher is still not operational, mainly because sufficient machine study time has not yet been made available. There is urgency to allocate sufficient beam study time with reverse protons in the Debuncher to make such a procedure operational as soon as possible, especially in view of the very large discrepancy between measured acceptance (28x20 pi mm-mrad versus 35x30 pi mm-mrad expected in present configuration). The limiting aperture should be promptly identified and corrected such that the measured Debuncher acceptance approaches the expected value in the current configuration. There were indications during the review that about six hours of machine study time was allocated to antiproton source studies every second store. The Committee strongly supports this. Many correctors and instrumentation upgrades have been installed and it is crucial to achieve measurable results in stacking rates from these improvements so as to inspire confidence in the acceptance Upgrade Plan.

The proposed beam based obstacle finding method was proposed and implemented by Simon van der Meer at CERN and was used with great success in the AC ring at CERN in the vertical plane from 1987 to 1997. In addition, the BPM situation in the AP2 line is still not satisfactory and it is equally urgent to improve this such that BPM beam response matrices with reverse protons can be made to verify optics and steering in the line.

The study and correction of chromatic effects in the AP2 line should be continued, and could potentially give a ten percent increase in antiproton yield. However, it may be difficult to find suitable locations of sextupoles in the line without major rebuild of the line.

The successful tests of the first prototype of the re-designed lithium lens is very encouraging and this program should be continued with adequate funding and priority.

The quality of the notch dispersion and the notch depth of the new optical notch filters is encouraging and an immediate improvement in the final Debuncher energy spread is expected as soon as they are installed in a few weeks. The Committee agrees that the proposed solution is technically the best choice to achieve an improvement of this very critical parameter. It will be useful for luminosity improvement, until the Recycler is successfully integrated and as fall-back if the Recycler integration fails. Nevertheless, the feasibility of the η modulation in the Debuncher proposed during the July 2003 DOE review is pursued with low priority and a decision about its feasibility and usefulness is expected in June 2004.

A higher longitudinal density produced by the Recycler reduces the required maximum stack tail gain. This should improve on the stacking rate reductions (caused by being forced to back off from optimum gain) at high stack values. This is caused by a combination of transverse heating of the stack core and instabilities involving the stack tail system and the BTF of the dense core.

The Committee congratulated the Recycler team with the impressive progress in commissioning following the very successful bake-out of the complete Recycler ring during the fall 2003 shutdown. The presented commissioning plan, aimed at achieving well defined performance milestones prior to June 2004, is well focused and seems reasonable but is still very tight. Like other high intensity accumulators, the Recycler needs a transverse damper to combat resistive wall instabilities. Detailed analysis of thresholds, growth rates, required damper bandwidth and amplifier power are still missing. Possibly a large bandwidth (10 kHz to 200 MHz?) may be required and such amplifiers may not be off the shelf items in industry. The existing strip-line kicker structures foreseen for this purpose in the Recycler may be too long for the required bandwidth. While not a major, or very difficult project, parameters and milestones should be designed immediately since such a damper will be urgently needed some time in spring 2005 if the electron cooling works as anticipated.

Also the achievement of the design current (0.5 A) at the design pelletron gradient (V = 3.5 MV) in the electron cooling test stand is an extremely important achievement. Unfortunately, the simultaneous achievement of design current and voltage (4.3 MV) can only be achieved after installation of the electron cooling at the MI. The achieved recirculation efficiency and electron beam quality in the cooling section is remarkable although still below design specifications.

Responses to the recommendations from the July 2003 DOE review are shown below:

1. *Re-evaluate the need to deploy the target sweeping system, in view of the relatively minimal gain in antiproton yield (a few percent) that it can provide, and the added operational complexity it introduces.* The priority has been reduced and complete installation and commissioning postponed to after the fall 2004 shutdown. It is prudent to maintain it as a good insurance policy against target damage.

2. *Optimize the delivery of small-energy-spread antiproton beams to the Accumulator, in collaboration with the Proton Source Department*. Remarkable reduction in effective bunch length during/after initial commissioning of the longitudinal damper in the MI has been achieved.

3. *Develop a beam-based Debuncher ring aperture limitation identification procedure as soon as possible*. Software has been written and five hours of machine study time in the Debuncher allocated so far. It is urgent to allocate sufficient machine study time.

4. *Re-evaluate the benefits of a η modulation in the Debuncher with respect to costing rates and asymptotic $\Delta p/p$ value (by the end of calendar year 2003).* This is being pursued as a low priority. A decision will be made in June 2004 about its feasibility.

5. *Continue strong efforts to better understand and suppress effects that currently limit stack tail cooling performance at high stack sizes*. This has not been pursued actively.

6. *Perform a timely and thorough review of the scientific staffing needs in the Recycler and electron cooling areas, with particular efforts to engage experienced accelerator physicists in these challenging projects (by the end of calendar year 2003).* The Committee is pleased about the level of scientific manpower resources applied to the Recycler commissioning and to electron cooling. The progress in these areas is impressive, but these projects are still challenging and carry significant risk.

2.3.3 Recommendations

1. Allocate pbar source study time in the order of six hours every second store to implement beam based alignment and obstacle finding procedures and reduce the discrepancy between expected and measured acceptances

2. Continue instrumentation upgrades, in particular improvements to AP2 BPM to enable response matrix measurements with reverse protons in AP2.

3. Try slip-stacking as soon as possible, by May 2004.

4. Continue efforts to better understand and suppress effects that currently limit stack-tail cooling performance. Impacts of further reduction of Debuncher momentum spread below the current design value of 6 MeV should be studied. Important fallback scenario if Recycler with electron cooling fails.

5. Perform urgently detailed design and performance requirements of transverse damper in the Recycler for resistive wall instabilities—this is required by spring 2005.

6. The Committee recommends installation of further BPMs in the electron cooling return line in case of recirculation problems in the MI tunnel.

2.4 Tevatron

2.4.1 Findings

The Tevatron has made excellent progress as a result of the well-planned improvements that were implemented during the last shutdown and before. The peak luminosity has increased from 2.6 x 10^{31} $cm^{-2}sec^{-1}$ in spring 2003 to 4.5 x 10^{31} $cm^{-2}sec^{-1}$ by summer 2003 and has now surpassed

6.0×10^{31} $cm^{-2}sec^{-1}$. As a result, Run II is about a factor of four away from achieving the design peak luminosity. At the same time the availability of the complex has increased tremendously, at least during the first few weeks of this run, so that more integrated luminosity than foreseen in the design for this period of time has been delivered. With more than 130-hours-per-week in collision, the luminosity time has almost doubled since July 2003 (70 h) and the complex has certainly set a record. Assuming continued good progress, it is very likely to exceed the base total integrated luminosity goal of 0.56 fb^{-1} in FY 2004. The Tevatron team is to be congratulated for achieving their performance goal for FY 2003 (as predicted) and having such a good start after implementing most of the upgrades that were presented during the July 2003 DOE review.

A careful analysis of coupling observations revealed the source of the very large global coupling, emittance growth and intensity and lifetime limitations in the Tevatron. The source was identified as systematic relative displacements of the superconducting dipole magnet coils relative to the iron yoke, giving rise to skew quadrupole fields. While skew quadrupole corrector circuits are tuned to eliminate the global coupling, there are substantial portions of the machine circumference not populated by skew quadrupole correctors, so that local coupling remained uncorrected in portions of the machine. Magnets in these regions (106 of a total of 774) were identified for cold-mass shimming during the down period. After shimming, the resulting correction circuit currents have been reduced accordingly, as has the vertical dispersion and better performance has resulted. Significantly, the emittance dilution that was driven by coupled transverse motion has been reduced. It is very encouraging to see that presently after all 106 dipoles have been shimmed and more than 60 dipole stands have been replaced and realigned emittance growth is reduced and the lifetime has improved. The newly set up network has paid off in many other areas where misalignments were identified and removed. This has been a very involved exercise, with many people from different divisions and laboratories contributing, that resulted in a great success and reflects itself in better overall luminosity performance. In more detail, corrector currents around the ring were reduced significantly and the geometric and dynamic aperture has obviously increased, reflecting itself in much better lifetimes at injection. Coupling of the beam, as well as orbit distortions are significantly reduced.

The other area of concern was diagnostics in general and BPMs specifically. It is very encouraging to see that an aggressive implementation plan is in place to have the BPMs available by October 2004. Many other systems that will be useful and/or necessary as the intensities in the Tevatron further increase are in various stages of development and implementation. All of them will need time to be tested, integrated, and prepared so that high-level applications allow operators to make use of them. In particular, diagnostics that allow continuous monitoring of tunes, chromaticity, orbits, coupling, and bunch length during the ramp and in collision, while functional in principle are not routinely available to the operators. 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.

The Tevatron is operating with several known optics defects in the high energy physics conditions that will be corrected, resulting ultimately in higher luminosity once adequate Machine Studies time is made available. Linear optics measurements at low-beta show substantial beta function errors. These errors in turn further complicate the understanding of interaction region optics and helix closure. Indirect machine observations, as well as direct observation of the luminous regions by the collider detectors show beta-star values larger than design. An optics correction campaign directed at restoring the low-beta design optics, beta-star and helix is necessary, and will yield increases in luminosity, as well as more stable and forgiving machine conditions. In addition to Tevatron optics work, a plan is in place for correcting the large vertical dispersion injection mismatch from the P1 transfer line by rolling four quadrupoles in the line.

A thin conducting liner was installed in the F0 Lambertson Septum magnet to reduce its transverse impedance. This has improved beam stability and has allowed stable operation at lower chromaticities, which in turn increases the dynamic aperture. Further lowering of the chromaticity is anticipated by powering octupoles in order to provide additional tune spread.

The numbers of protons and antiprotons per bunch is currently about 2.4e11 and 3.1e10 respectively (a ratio of 8) corresponding to beam-beam parameters of about 0.009 for the antiprotons and 0.002 for the protons per interaction point. 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.

Off-line measurements on a Tevatron dipole allowed the determination of persistent current sextupole components in the magnet as a function of time. The tabulation of this data enabled fitting of corrector current curves that allow almost complete cancellation of this effect on the ramp. While the original plan was very involved, this solution seems to solve the problem and is certainly much more cost effective. Similar measurements will be performed for quadrupole magnets and corrections for higher multipole fields will be done accordingly if necessary. In addition, a more appropriate parameterization is suggested for use in feed-forward compensation of the observed “snapback”.

Other technical improvements and upgrades to the Tevatron continue. Most of them have already had internal reviews and the evaluation process has helped to improve performance and better define scope. The reviews are well documented and recommendations are implemented.

2.4.2 Comments

The improvements that were implemented over the last seven months have shown significant success in peak and in integrated luminosity. Most prominently, the luminosity time with very long runs of more than 30 hours several times a week, and the Tevatron has demonstrated excellent availability and higher pbar intensity. Nevertheless, 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 and continue to advance the understanding of the Tevatron, as well as being able to test and integrate new hardware. A backlog of urgently required tests of approximately six weeks with two shifts per week has accumulated and in some cases technical decisions are awaiting experimental results.

A lot of new diagnostic tools are under development for the Tevatron. It is difficult to assess at which state of completion each of the diagnostics is and how much progress was made as compared to the July 2003 DOE review. 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 in time completion in October. For many of the other systems, it would be beneficial if the Tevatron physics group would prioritize the individual diagnostics tools and in return have a firm completion date to be able to integrate and use it as soon as possible.

With the alignment and shimming of many dipoles in the Tevatron, emittance preservation and lifetimes at injection have dramatically improved. Various other significantly misaligned components (kickers, IR quadrupoles) were found after establishing the network in the ring and only the electrostatic separator positions have not been determined yet, but will and should be as soon as possible. The present basis of alignment should be well documented and further alignment campaigns are necessary when orbit distortions or beam optics changes indicate local variations. The Committee noted that large global coupling is still present in the machine. While the skew quadrupole correction circuits can adequately correct the distributed errors, it is likely that some local coupling remains. Further optimization and characterization of the coupling and its improvement after the shutdown is worthwhile.

As a part of this campaign, the determination of the acceptance and dynamic aperture in the Tevatron should be done and documented as soon as possible to have a consistent basis for the coming years. Beam study time is necessary to be able to do this, while it can be minimized with modern automated procedures. It is clear that greater beam separation in the Collision Helix would reduce the destructive effects of the parasitic beam-beam interaction, particularly from near-misses in the interaction regions. It is also likely that the helices could be further optimized to better "smooth" the Injection helix. These desires have not yet been turned into quantitative requirements on beam separation that could then direct the separator efforts. While production of polarity switches is underway, the remaining options range from operating existing separators at higher voltage to deployment of additional separators. Further information, obtained through a combination of simulation and Machine Studies measurements is needed in order to define the requirements for beam separation at Run II Design intensities. A decision on the number of additional separators and their required performance is pending.

An important manifestation of beam-beam effects in the Tevatron is seen in the evolution of pbar emittances that occurs rapidly at peak intensities after the squeeze. The resulting "scallops" in the bunch-by-bunch emittances, together with observed bunch-by-bunch tune, chromaticity and beam position modulation along the bunch trains show that the beam dynamics in the Tevatron are already heavily influenced by beam-beam effects. These effects are already reducing potential Tevatron luminosity. With anticipated increases in the proton and antiproton intensities, these effects will become more severe, resulting in decreased luminosity and more difficulty in operating the machine.

The beam-beam effects suffered by the antiprotons are very strong. Currently, Beam-Beam Compensation (BBC) is being considered using one or two Tevatron Electron Lenses (TEL) to correct for the head-on effect. Although the use of TEL BBC is not at present part of the nominal Run II Upgrade Plan, nonetheless a spare TEL is included in the budget, at a cost of $1.25 million.

If necessary, it might also be possible to use a wire BBC for the long-range effect, such as has been proposed for the Large Hadron Collider. The use of a wire BBC is quite difficult in the Tevatron context, because of the distribution of long-range beam interactions around the ring, their fully two dimensional nature, and the very limited number of available locations where a wire BBC could be placed. There is currently no budget allocation for a wire BBC. While TEL BBC might be invoked in combating head-on beam-beam effects suffered by the antiprotons, they clearly do not work for proton BBC.

Modest beam-beam effects of the antiprotons on the protons have already been seen, even with a proton beam-beam parameter of only 0.002 per IP. This parameter will increase, because most of the projected increase in ultimate luminosity comes from an increase in the number of antiprotons per bunch from 3.1e10 to about 1.3e11. This will not only increase the proton beam-beam parameter to about 0.008, but will very clearly move the Tevatron from the weak-strong to the strong-strong beam-beam regime. Copious experience with electron storage rings (and preliminary experience with protons in the Relativistic Heavy Ion Collider) shows that the appearance of strong-strong behavior can be very damaging.

The strong-strong beam-beam effect could limit the ultimate luminosity achievable at the Tevatron. To date there has been only limited investigation of this topic at Fermilab, although collaborative activities with other laboratories already exist.

The Machine Studies program for evaluating beam separation requirements and studying parasitic and primary crossings will require substantial machine time. This is important work that needs a carefully formulated plan and the allocation of adequate machine time. While such studies will not improve the immediate luminosity, they are nevertheless essential for planning Tevatron improvements and priorities to achieve Run II design goals.

The collider detectors CDF and D-Zero are providing important information on the luminous region. Continued close interaction between the Tevatron and collider detector groups will benefit both.

The Committee understands the reasons for changing the reference magnet plan one more time. The solution that is applied is very elegant and cost effective. The same approach for quadrupoles is encouraged and the committee sees this as a problem solved.

It is very encouraging to see that management has been able to fully support the staffing requirement, as well as the capital funds required for the Tevatron upgrades. The Committee encouraged refining the upgrade and reconsidered the feasibility of rolling off staff beginning this fiscal year given the many things that there are still to do.

The Committee was satisfied with the response to the recommendations in general, but has listed one again that was not previously completed. Nevertheless, the Committee does not understand the rationale of optimizing tunes, chromaticity and coupling, etc., only every two weeks or so, while long- and short-term orbit drifts indicate that this would be required much more often.

2.4.3 Recommendations

1. Provide sufficient time (at least two shifts per week on average) for beam studies and commissioning of new hardware.

2. Commission the transverse injection dampers within the next three months.

3. Reevaluate the resource loading of the Run II Upgrade Plan and develop appropriate tracking tools to easily assess the status of each subproject.

4. Develop and carry-out a program of beam-based measurements and simulations to establish beam-separation requirements and helix design criteria for the design parameters in Run II. Present results at the next review.

5. Pursue a vigorous investigation of beam-beam effects, including strong-strong beam-beam effects, to evaluate possible limitations on the ultimate Tevatron luminosity, and to evaluate possible amelioration. Present results at the next review.

6. Characterize the Tevatron aperture to quantify gains after alignment and optics improvements. Present results at the next review.

7. Complete and document the alignment of the Tevatron.

2.5 Instrumentation

2.5.1 Findings

There is increased emphasis on and appreciation of the value of instrumentation. BPMs are key systems, but in addition, there are other important systems and they are receiving attention.

Tevatron

There is a new BPM system being implemented, and the installation should be completed at end of October shutdown. The BPM upgrade is a joint project with key people from the Computing and Accelerator Divisions. The BPM system will have the capability to measure both protons and antiprotons at the same time. A modest amount of accelerator time is needed to develop algorithms for separating proton and antiproton signals. There are other systems under development, including:

- A new beam loss monitor that will be integrated into the BPM system.
- An Ionization Profile Monitor is being developed for turn-by-turn emittance measurements.
- 1.7 GHz Schottky monitors.
- Tune tracker.

- Abort gap monitor.

Taken as a whole this is reasonable and appropriate instrumentation. An alignment grid has been established for the Tevatron. Realignment based on it proved very useful. A quadrupole vertical level measuring system has shown over 10 μm drifts of position over one month.

Antiproton Source

The upgrade is critically dependent on increasing the antiproton yield and rapidly transferring stacked antiprotons to the Recycler Ring. Among other things, increasing the yield requires understanding the orbit, optics, and chromaticity in the AP2 line and in the Debuncher. The BPMs in the AP2 line cannot detect antiprotons, but they can be used with reverse protons to tune and perform beam based alignment. However, kicker noise is still a problem for some of them. The BPM system in the Debuncher has been upgraded with new electronics and data acquisition. It will be used imminently to improve understanding of the ring.

BPM systems will be needed for rapid transfers from the Accumulator to the Recycler. This project is underway and is based on the Tevatron BPM technology and is scheduled to follow that project. The planned completion is March 2005. There should be additional BPMs in the electron cooling return line is case of problems with recirculation in the MI tunnel.

Main Injector

A new BPM system will be available at the end of 2005. It will use the same technology as the Tevatron and antiproton transfer lines and will follow them in the schedule. The major justification for this is the replacement of outdated hardware. There are a variety of other instrumentation projects (flying wires, tune measurement, beam loss monitors, etc.). They are reasonable and appropriate.

Booster

A new Lambertson magnet was installed at the end of the 400 MeV linac. It has lower leakage fields and this should lead to better linac emittance measurements. There are possible improvements (i.e., electron collection from an IPM) and/or new techniques (gas fluorescence) that could be applied to measure the emittance evolution during the acceleration ramp.

Controls

There was a talk about migration to modern computers and operating systems. The preferred solution is to port existing VAX code to Intel/Linux computers. There were no specifics about the scope or cost of the work.

2.5.2 Comments

The present emphasis on instrumentation is appropriate and will yield long-term benefits. The instrumentation projects have had adequate resources identified and the schedules are credible and appropriate.

Measurements of the Booster emittance during the ramp would give important data on the emittance evolution.

The long delay before the MI BPM system is installed is not pleasing, but it is a reasonable priority decision.

The realignment of the Tevatron elements proved very useful. The procedure should be repeated on yearly basis now that a grid has been established.

A detailed plan to migrate controls to the modern computing hardware and software still needs to be developed.

2.5.3 Recommendations

1. Investigate the source of kicker noise in the AP2 line BPMs 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.

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

3. COST ESTIMATE

3.1 Findings

A revised cost estimate is included in the updated (version 2.0) Run II Upgrades Plan. This new estimate reflects improved definition of existing scope and incorporation of new scope identified by a series of technical reviews coordinated and tracked by the Upgrades Project Office. Changes to the Plan were made using a newly established change control process. The estimate includes only the activities associated with the Plan—estimates for operations' cost were not included in the Plan.

Overall, there was a relatively small increase to the Upgrades total cost estimate, but costs for several individual work breakdown structure (WBS) elements varied significantly. Contingency is included in the cost estimate (roughly 50 percent of the total cost). A comparison of the estimates supporting versions 1.0 and 2.0 of the Plan is included in Appendix E. A summary of the two cost estimates is provided in Table 3-1:

Table 3-1. Summary of Cost Estimates

$K (in $FY03)	**v2.0**	**v1.0**
M&S Base estimate	16,461	14,965
M&S Contingency estimate	7,356	7,462
M&S Total	**23,817**	**22,427**
Labor Base estimate	17,980	18,194
Labor Contingency estimate	9,213	9,706
Labor Total	**27,193**	**27,900**
M&S+Labor Total	**51,010**	**50,327**

At the review, the Committee was provided an updated WBS Dictionary and Basis of Estimate document that supports the new cost estimate and provides information on activity duration, labor categories and materials and supplies. Since the July 2003 DOE review, the WBS has been slightly modified to correspond to new cost accounting system codes established by Fermilab.

3.2 Comments

The Upgrades Project Office has addressed the July 2003 DOE review recommendations. The cost estimate will serve a cost “benchmark” against which progress and performance will be tracked. This process is described in the management procedures appended to the updated Plan.

The Committee did not conduct a detailed cost assessment, however, the estimates for the Upgrade activities and contingency are supported by a well documented basis of estimates and overall appear reasonable.

3.3 Recommendation

1. Maintain the current level of rigor in developing and updating the cost estimate as the Project Office transitions to tracking and monitoring progress and performance against the cost benchmarks.

4. SCHEDULE and FUNDING

4.1 Findings

The Upgrades schedule has been developed in MS Project. The updated (version 2.0) schedule contains nearly twice the number of activities (1,360) in the schedule developed for version 1.0 of the Plan. Activity start and finish dates are documented in the Basis of Estimate. Many of the scheduled activities are performed in parallel. Efforts are underway to identify critical paths associated with five key operating phases. A summary schedule is included in Appendix F.

Approximately 80 milestones (between July 2003 and September 2007) have been developed that represent physical progress evaluation points, major scope decisions, and planned internal technical reviews. The Project Office changed the definition of the milestone hierarchy to give visibility to milestones that drive the luminosity profile.

The funding profile for the Upgrade activities is shown in Table 4-1.

Table 4-1. Upgrades Activities

In actual year $K	FY03	FY04	FY05	FY06	FY07	Total
M&S						
26 M&S Base	937	8,437	3,605	651	0	13,629
26 M&S Cont	0	2,531	2,524	607	0	5,662
26 M&S Total	**937**	**10,968**	**6,129**	**1,258**	**0**	**19,291**
27 M&S Base	258	1,383	739	1,083	0	3,463
27 M&S Cont	0	415	517	1,029	0	1,961
27 M&S Total	**258**	**1,797**	**1,257**	**2,112**	**0**	**5,424**
26&27 M&S Total Base	**1,195**	**9,819**	**4,344**	**1,734**	**0**	**17,092**
26&27 M&S Total	**1,195**	**12,765**	**7,386**	**3,370**	**0**	**24,715**
SWF						
26 SWF Base	3,569	8,102	3,553	2,012	454	17,690
26 SWF Cont	0	3,066	3,557	1,838	332	8,793
26 SWF Total	**3,569**	**11,168**	**7,110**	**3,849**	**786**	**26,483**
27 SWF Base	152	345	478	171	10	1,155
27 SWF Cont	0	138	502	171	7	818
27 SWF Total	**152**	**482**	**981**	**341**	**17**	**1,973**
26&27 SWF Total Base	**3,721**	**8,446**	**4,032**	**2,183**	**463**	**18,845**
26&27 SWF Total	**3,721**	**11,650**	**8,091**	**4,191**	**802**	**28,456**
Total	**4,916**	**24,415**	**15,476**	**7,561**	**802**	**53,171**

4.2 Comments

Again, similar to cost the Committee did not conduct a detailed schedule assessment, however, the timing, nature, number, and sequence of milestones seem appropriate.

Plans to meet every two weeks with the Level 2 and 3 managers to status milestones and measure schedule progress will aid in improving the quality of the schedule and reinforcing the newly established management procedures.

4.3 Recommendations

None.

5. MANAGEMENT

5.1 Overall Management

5.1.1 Findings

Fermilab defines two integrated luminosity goals: 1) a “base” goal of delivering 4.4 fb^{-1} by the end of FY 2009, characterized by Fermilab as conservative; and 2) a “design” goal of delivering 8.5 fb^{-1} that is the target of their efforts and requires all components to perform at design specifications. These goals are essentially the same as those presented six months ago.

Successful implementation of antiproton stacking and cooling upgrades remains the key to achieving “design” projections.

The very high quality and enthusiasm of Fermilab staff working on Run II is a significant asset.

There has been very significant progress since the July 2003 DOE review. The goals set for the shutdown were achieved. Current performance is above FY 2004 design projections and major milestones for the past six months have generally been met. In the last few weeks the Tevatron complex has been operating better than ever.

The successes of the past seven months indicate the capabilities of the new management team to lead, organize, and integrate the efforts of the Accelerator Division towards commissioning, maintenance, and upgrading of the Tevatron complex. Morale, pride, and discipline in the Accelerator Division are on the upswing. Everyone seems to be pulling together.

A reorganization of the Accelerator Division to more effectively address the Run II goals was successfully completed.

The Upgrade Plan was revised and improved to include integration of the Recycler and a number of schedule changes including the elimination of the long shutdown for detector upgrades in FY 2006.

Tracking of resource utilization against expected progress (e.g., percent complete) for the upgrade project is not yet effectively utilized and it is not yet part of the management culture.

The project office needs more staff (four full-time equivalents) for tracking and monitoring resource usage and progress.

It appears that the level of support and focus from the Laboratory Directorate and from other parts of the laboratory is at an appropriate level for successfully carrying out Run II activities (witness the shutdown success). Adequate levels of resources (people and funds) are being provided to the Run II effort.

5.1.2 Comments

Fermilab correctly characterizes Run II as a, "…complex campaign of operations, maintenance, upgrades, R&D, and studies" (HEPAP Briefing, D. Lehman, 2003). Evaluation of management processes and planning should be in this overall context.

It is impressive that a number of people have commented on the greatly improved morale, pride, motivation, and discipline in the Accelerator Division. This is attributable to the new management team and is a major achievement.

The reorganization of the Accelerator Division Management has clarified lines of authority and has emphasized integration of all Run II activities. The Integration Department now reports directly to the Associate Division Head for Accelerators and focuses on a systematic approach to operation and improvements of the accelerator complex. This is a very positive development.

Staffing for upgrades is at a peak now and is planned to roll-off in a few months. The Committee had concerns that the roll-off is premature. The staffing plan for Upgrades, which indicates a significant roll-off in a few months, should be reevaluated in light of the current status of Upgrade activities.

Accelerator Physics is now deployed to various machine departments and to the Integration Department. It is no longer a single, stand-alone department.

Run II management must develop procedures that utilize the Upgrade Plan as a basis to monitor, track, and evaluate progress and resource usage against expectations. This is an important management function.

It is essential for the management to fully assess the staffing and resources needed to reach the luminosity goals. This includes operations, commissioning, and maintenance activities. A detailed plan for the operations and maintenance components of Run II would provide an important tool to assure that the right level and mix of staffing and other resources are identified and for monitoring progress and tracking resource utilization against expected progress.

Software manpower is often underestimated in the planning stage. Run II management should evaluate the software manpower needed for the whole Run II effort, and prepare to manage software development in a more project-like fashion.

Fermilab management should assess the resources (e.g., staffing, funding, proton economics) that would be needed to meets its other commitments, current and planned, and assure that these commitments are at a level that does not interfere with the Run II effort. Management must assure that adequate beam time is devoted to studies that will enhance performance in the longer term.

5.1.3 Recommendations

1. By June 1, 2004, produce a comprehensive plan addressing manpower needs and expected progress for the operations, commissioning, and maintenance components of Run II.

2. By May 1, 2004, develop and implement procedures to utilize the Upgrade Plan as a basis to monitor and track and evaluate progress on the upgrades against expectations.

5.2 Organization

5.2.1 Findings

The Accelerator Division (formerly Beams Division) was reorganized to maximize the performance of the Accelerator Complex to achieve the goals of the Run II physics program. A major change since the July 2003 DOE review has been the deployment of the accelerator physics effort within the Division to the machine systems departments, so that all systems departments now have dedicated accelerator physics support. The Rapid Response Team is used to solve pressing operational or accelerator physics problems that have a life span of three to six months. The team, which focuses on one or two problems at a time, has a two-man core and draws on necessary expertise from within the Accelerator Division.

Accelerator operations are coordinated by a team from the integration department, including: the integration department head; the operations coordinator; the shot analysis coordinator; and the accelerator physics coordinator. This team:

- Defines guidelines for the Operations Department (when to shoot, when to fix things, when to call in experts, etc.);
- Defines study strategy;
- Defines and implements accelerator physics strategy and an integrated view across machines;
- Controls deployment of Rapid Response Team;
- Defines study strategy;
- Leads shot data analysis;
- Sets priorities of instrumentation projects;
- Interfaces with the Directorate and the Experiments; and
- Makes decisions for unusual operational situations.

Daily 9:00 a.m. meetings are used as the vehicle for near-term coordination across the complex.

5.2.2 Comments

The daily 9:00 a.m. meeting seems to be very effective in assuring communication across departmental lines and has contributed to establishing an esprit-de-corps for the Run II team. The resulting near-term schedule should be posted on the website for broader access.

The Accelerator Division Head has introduced organizational discipline to the operation. Examples include: 1) the successful completion of a very complex shutdown with a large number of tasks completed as scheduled; 2) machine study requests have to be goal oriented and well defined to get approved; and 3) design reviews are firmly embedded throughout the Division.

The Rapid Response Team was successfully deployed to resolve several important problems: CDF beam position; 16-house quench investigation; SY120 extraction; etc.

The Integration Team appears to be an effective organization to manage the integration and operation of the complex.

5.2.3 Recommendations

None.

5.3 Management Processes

5.3.1 Findings

Management procedures have been developed to support the Run II Luminosity Upgrades. These procedures document newly established protocols for defining the Run II Upgrades organization's roles and responsibilities, scope, cost and schedule benchmarks, change control thresholds, and performance and progress reporting processes. These initial procedures highlight the project management discipline that will be used to track planned and ongoing Upgrade activities.

Fermilab and Accelerator Division management have expressed their intent to leverage these management procedures across the Accelerator Division to bring rigor and consistency to systems used to plan and execute all Division activities.

The operation and Upgrade activities are coordinated via: 1) a daily operations meeting, chaired by the Division Head for Accelerators and attended by senior Fermilab management, Associate Division Head for Engineering, Run Coordinator, Shot Data Analysis Coordinator, and the systems department heads; 2) the weekly "All Experimenters' Meeting"; 3) the monthly Run II Strategy meeting; 4) the monthly Run II Accelerator PMG; and 5) a weekly meeting with the Accelerator Division and Technical Division heads. The Accelerator, Technical, Particle Physics, and Computing Division heads all participate in meetings #3 and #4.

An updated resource-loaded schedule and plan for FY 2004 and the out years has been prepared and reviewed internally. The Run II Upgrades Plan (version 2.0, Project Plan and Resource-Loaded Schedule) includes specific milestones for technical reviews and evaluations. These include milestones to review engineering designs prior to proceeding with major procurements, evaluation of R&D programs and decision on proceeding to a production phase, and evaluation of the commissioning plans for subprojects.

5.3.2 Comments

The new management procedures appropriately distinguish the nature of the Upgrade activities from more conventional projects. Flexibility has been incorporated into the procedures to account for the R&D and operations nature of the Upgrade activities.

The Accelerator Division and the Upgrades organization, as planned, must effectively monitor progress against the Plan, respond rapidly and effectively to problems and update the Plan so it remains an effective tool.

5.3.3 Recommendation

1. By April 1, 2004 develop and implement procedures to utilize the Upgrade Plan as a basis to monitor and track and evaluate progress on the upgrades against expectations.

5.4 Planning and Plans

5.4.1 Findings

Fermilab has developed version 2.0 of the Tevatron Run II Luminosity Upgrades Plan. The Plan recognizes the successful operation of the Recycler, and is ready for detailed planning for pbar accumulation and electron cooling. The Plan has a base luminosity of 4.4 fb^{-1} and a design goal of 8.5 fb^{-1}, integrated through FY 2009. These numbers are essentially the same as in version 1.0.

The project-like WBS and resource-loaded schedule for the Tevatron Run II Luminosity Upgrades has been further developed in version 2.0 of the Plan.

The Committee was surprised to find that all the groups seemed to have adequate resources or rational commitments for them.

The Accelerator Department has a daily 9:00 a.m. short-range planning meeting, and a weekly meeting for medium-range planning.

There is preliminary planning for the protons that will be needed for Run II and the neutrino experiments.

There is some concern among the experimenters regarding planning for the commissioning of BTeV systems.

5.4.2 Comments

The planning is based on a systematic strategy for reaching the luminosity goals, and appears to be rather effective. In the words of one senior manager, "In the machine area, fuzzy plans are not accepted anymore." The medium-range planning may not be disseminated widely enough for all the people who might benefit.

5.4.3 Recommendations

1. The Upgrade Plan should continue to be internally reviewed and updated quarterly.

2. The Upgrade program and progress should be reviewed a few months after the 2004 shutdown.

3. Necessary critical manpower should be explicitly identified as soon as possible.

4. Consider publishing (website) more of the operational schedules, even though they might be quite dynamic.

APPENDIX A

CHARGE MEMORANDUM

DOE F 1325.8
(08-93)

United States Government **Department of Energy**

memorandum

DATE: NOV 28 2003

REPLY TO ATTN OF: SC-20

SUBJECT: Request to Conduct a Review of the Tevatron Run II Luminosity Upgrades

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

I would like to request that you conduct a review of the Tevatron Run II Luminosity Plan at Fermi National Accelerator Laboratory on February 24-26, 2004. The purpose of this review is to assess the performance of the Tevatron since the review in July 2003 and to evaluate the luminosity improvement plan for the Tevatron collider during fiscal years 2004-2006.

One of the conclusions of the July 2003, Department of Energy (DOE) review was that the Laboratory's plan was incomplete with the role of the recycler and electron cooling not fully detailed. The completed plan which will integrate the recycler into the Tevatron complex is scheduled to be delivered to DOE by the end of January 2004.

As part of a general assessment of the current status and evaluations for the luminosity improvement plan and the identification of potential issues, the committee should address the following specific items:

- Is the laboratory plan reasonable to achieve the luminosity improvements projected in the completed plan?
- Have adequate resources (i.e. manpower, funding, etc.) been identified and allocated to carry out the plan?
- Is the proposed schedule credible and appropriate in light of the technical tasks required?
- Has the lab developed an adequate risk analysis with identified fallback positions for the critical elements of the plan, such as electron cooling and the recycler?
- Is the management structure appropriate for implementing the proposed plan to a successful completion?
- The committee is also asked to assess the laboratory's response to the comments and recommendations from the July 2003 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
Office of Science

cc:
R. Orbach, SC-1
J. Decker, SC-2
L. Dever, SC-80
M. Procario, SC-20
A. Byon-Wagner, SC-20
M. Witherell, Fermilab
J. Monhart, FAO

APPENDIX B

REVIEW PARTICIPANTS

Department of Energy Assessment of the Run II Luminosity Plan at the Fermilab Tevatron
February 24-26, 2004

Daniel R. Lehman, Chairman (DOE)

SC 1 Accelerator Physics	SC 2 Proton Source	SC 3 Anti-Proton Source	SC 4 Tevatron
* Steve Peggs, BNL	* Thomas Roser, BNL	* Flemming Pedersen, CERN	* Norbert Holtkamp, ORNL
Rick Baartman, TRIUMF	Uli Wienands, SLAC	Fritz Caspers, CERN	Stuart Henderson, ORNL
Francesco Ruggiero, CERN	Karlheinz Schindl, CERN	Fritz Nolden, GSI	Georg Hoffstaetter, Cornell
	[Rick Baartman, TRIUMF]	[Francesco Ruggiero, CERN]	[Steve Peggs, BNL]

SC 5 Instrumentation	SC 6 Management and Systems Integration	Observers
* Bob Siemann, SLAC	* Jay Marx, LBNL	Robin Staffin, SC-20
Massimo Placidi, LBNL	Klaus Berkner, Consultant	Aesook Byon-Wagner, SC-20
	Marty Breidenbach, SLAC	Michael Procario, SC-20
	Stephen Meador, DOE/SC	Ronald Lutha, DOE/FAO
		Jane Monhart, DOE/FAO

LEGEND

SC Subcommittee

* Chairperson

[ ] Part-time Subcom. Member

Count: 19 (excluding observers)

APPENDIX C

REVIEW
AGENDA

Department of Energy Assessment of the
Run II Luminosity Plan at the Fermilab Tevatron

AGENDA

Tuesday, February 24, 2004

8:00 am	**Committee Executive Session—Comitium .... Lehman**		
9:00 am	Welcome and Opening Remarks—**1 West** .... Witherell		
9:05 am	Introduction .... Holmes		
9:15 am	Accelerator Division Organization and Management Issues .... Dixon		
9:55 am	Tevatron Run II Status and FY04 Plan........ McGinnis		
10:45 am	Break		
11:00 am	Tevatron Run II Plan, Rev 2.0 (Cost, Schedule, Milestones, Contingency) .. Spalding/Bhat		
12:00 pm	Lunch		
1:00 pm	Recycler Status and Commissioning Plan .... Nagaitsev		
1:30 pm	Protons on Target .... Kourbanis		
1:50 pm	Antiproton Production .... Werkema		
2:10 pm	Antiproton Stacking and Cooling .... Derwent		
2:35 pm	Break		
2:50 pm	Tevatron .... Shiltsev		
3:20 pm	Reliability and Maintenance Upgrade Status .... Czarapata		
3:45 pm	**Breakout Sessions**		
	Management and Systems Integration	SC 6	Room 1 North
	Protons	SC 2, 5	Room Race Track (7th)
	Antiprotons (Production, Stacking, and Cooling)	SC 3, 5	Room 12NE
	Tevatron	SC 4, 5	Room 9SE
	Accelerator	SC 1	Room TBD
4:45 pm	**Subcommittee Executive Sessions—Rooms same as above**		
5:00 pm	**Full Committee Executive Session—Comitium**		

Wednesday, February 25, 2004

8:00 am	**Breakout Sessions**		
	Management and Systems Integration	SC 6	Room 1 North
	Protons	SC 2, 5	Room Race Track (7th)
	Antiprotons	SC 3, 5	Room 9SE
	Tevatron	SC 4, 5	Room 1 East
	Accelerator	SC 1	Room TBD
12:00 pm	Lunch		
1:00 pm	**Breakout Sessions Continued**		
2:00 pm	**Subcommittee Executive Sessions**		
3:00 pm	**Full Committee Executive Session—Comitium**		

Thursday, February 26, 2004

10:00 am	**Full Committee Closeout Dry Run—Comitium**
12:00 pm	Lunch
2:00 pm	**Review Closeout Presentation—1-West**
3:00 pm	**Adjourn**

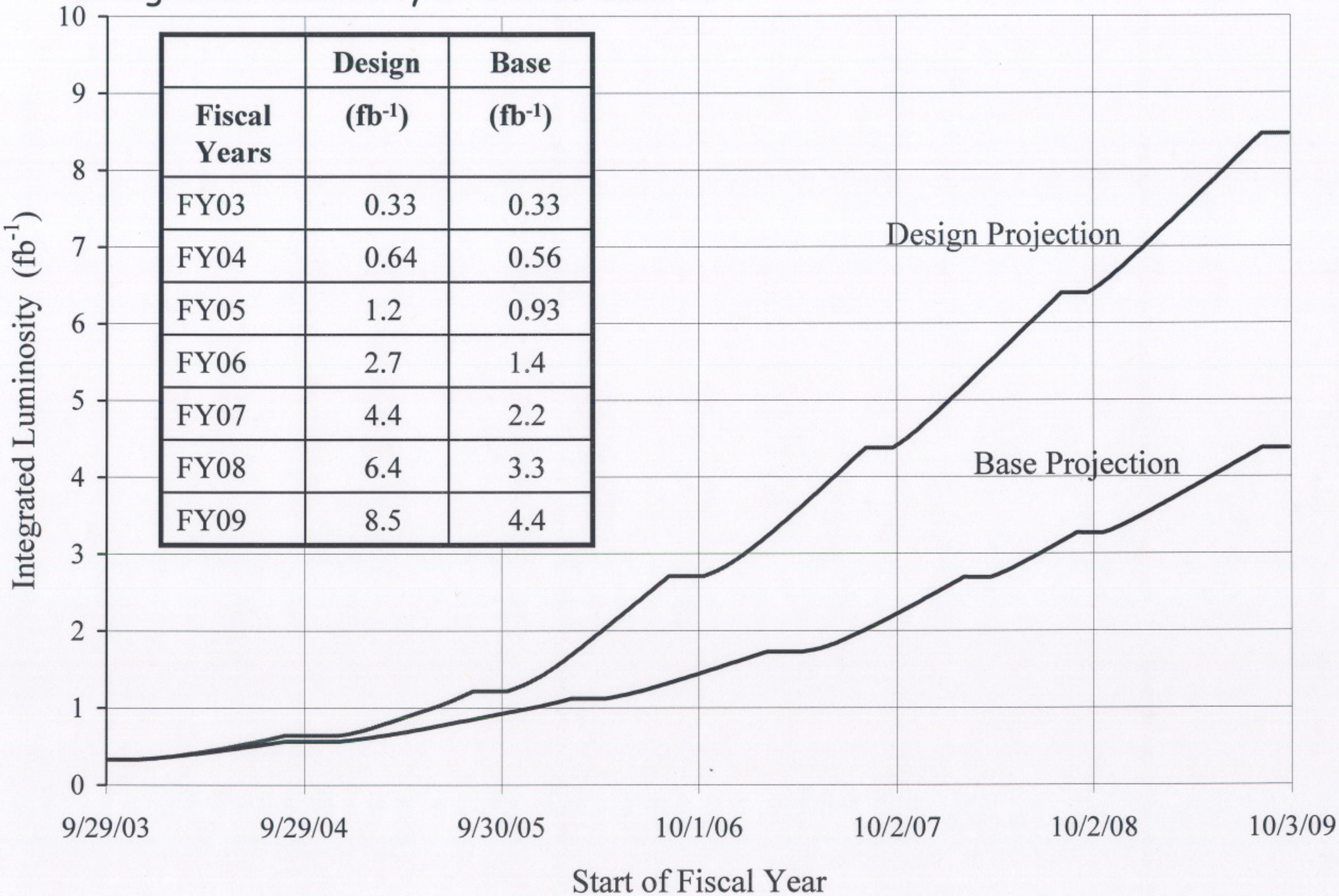
SC Subcommittee

APPENDIX D

LUMINOSITY PROJECTIONS

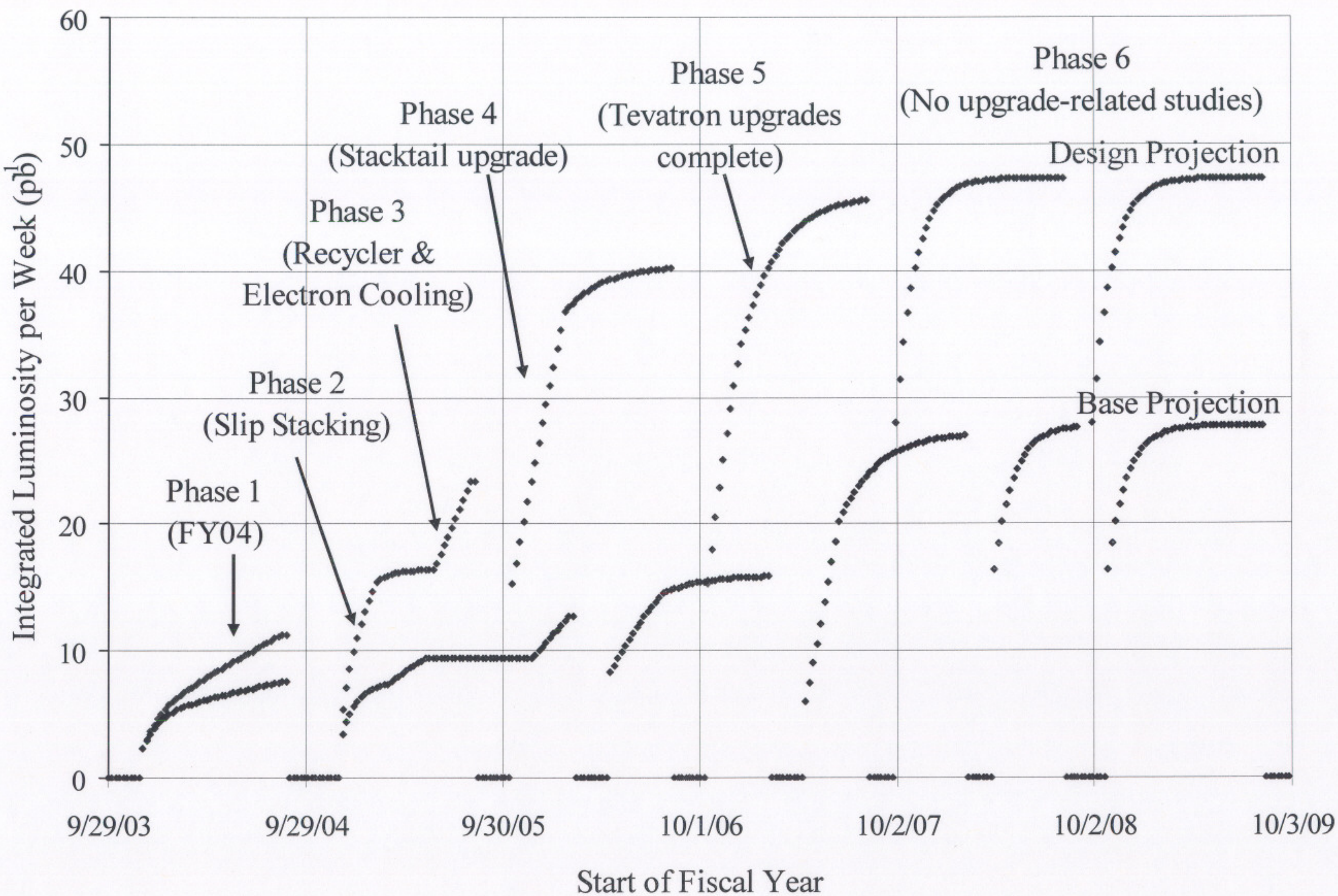
Luminosity Projections

Integrated luminosity at end of each FY



Fiscal Years	Design (fb^{-1})	Base (fb^{-1})
FY03	0.33	0.33
FY04	0.64	0.56
FY05	1.2	0.93
FY06	2.7	1.4
FY07	4.4	2.2
FY08	6.4	3.3
FY09	8.5	4.4

Upgrade Contributions to Luminosity Projections



APPENDIX E

COST TABLE

Summary Cost Comparison – v2.0 Plan to v1.0 Plan

WBS	NAME	v2.0 Base M&S	v1.0 Base M&S	Difference	Difference Drivers
26	Luminosity Upgrades	$13,158,426	$11,561,460	$1,596,966	
26.1	**Protons on Pbar Target - Ioanis Kourbanis**	**$1,911,500**	**$2,331,500**	**-$420,000**	
26.1.1	Slip Stacking	$895,000	$1,310,000	-$415,000	PA's cheaper
26.1.2	Pbar Target and Sweeping	$91,500	$96,500	-$5,000	
26.1.3	MI Upgrades	$925,000	$925,000	$0	
26.1.4	Booster-MI Cogging	$0	$0	$0	
26.2	**Pbar Acceptance - Steve Werkema**	**$1,794,960**	**$1,870,960**	**-$76,000**	
26.2.1	Lithium Lens Upgrades	$471,000	$463,000	$8,000	
26.2.2	AP2 and Debuncher Acceptance	$1,325,960	$1,407,960	-$82,000	improved plan
26.3	**Pbar Stacking and Cooling - Paul Derwent**	**$3,871,998**	**$2,256,000**	**$1,615,998**	
26.3.1	Stacking and Cooling Integration	$0	$0	$0	
26.3.2	Debuncher Cooling	$0	$0	$0	
26.3.3	Stacktail Cooling	$1,004,000	$1,171,000	-$167,000	dropped Betatron
26.3.4	Recycler Stacking and Cooling	$774,998	$0	$774,998	Recycler upgrade added
26.3.5	Electron Cooling	$1,556,000	$568,000	$988,000	re-est and re-plan
26.3.6	Rapid Transfers	$537,000	$517,000	$20,000	
26.4	**Tevatron High Luminosity - Vladimir Shiltsev**	**$5,577,968**	**$5,103,000**	**$474,968**	
26.4.1	Tevatron Task Force	$0	$0	$0	
26.4.2	Beam-beam Limitations	$5,000	$5,000	$0	
26.4.3	Active Beam-Beam Compensation	$1,250,000	$1,380,000	-$130,000	dropped Wire BBC
26.4.4	Increased Helix Separation	$1,488,500	$1,847,000	-$358,500	long -> mini separators
26.4.5	Luminosity Leveling	$0	$0	$0	
26.4.6	Improved Control and Diagnostics	$2,463,468	$1,500,000	$963,468	Tev BPM, BLM-Abort (new)
26.4.7	Tevatron Vacuum Improvements	$90,000	$90,000	$0	
26.4.8	Tevatron Alignment	$281,000	$281,000	$0	

APPENDIX F

SCHEDULE CHART

Top Level Milestones that Drive the Luminosity Profile

WBS	Class A Milestone	v2.0	v1.0	DAYS
26.1.2.1.4.3	New Target in Operation (Milestone)	01/02/04	12/30/03	3
26.6.2.2	Review Recycler Commissioning Plan	02/09/04	12/16/03	55
26.3.4.9.16	Recycler commissioned for Electron cooling	06/01/04	7/2/04	-31
26.1.2.2.4.2	Beam Sweeping Operational (Milestone)	08/25/04	1/21/04	217
26.4.4.3.1.5	New standard separators operational	10/25/04		
26.2.2.10	Initial AP2&DB Improvements Complete (Milestone)	11/22/04		
26.1.1.10	Slip Stacking Operational	12/23/04	12/14/04	9
26.6.2.4	Start Phase 2 (Slip Stacking)	12/23/04	12/14/04	9
26.3.5.12	Electron Cooling Operational (Milestone)	06/01/05	1/25/05	127
26.6.2.5	Start Phase 3 (Recycler with Electron-cooling)	06/01/05	2/22/05	99
26.2.1.4	New Lens Operational (Milestone)	06/10/05	4/11/05	60
26.3.6.7	Rapid Transfers Operational (Milestone)	06/14/05	5/5/05	40
26.2.2.11	Intermediate AP2&DB Improvements Complete (Milestone)	10/03/05		
26.3.3.1.9	Stacktail Momentum Operational (Milestone)	12/06/05	11/17/05	19
26.6.2.6	Start Phase 4 (Stacktail Upgrade)	12/06/05	11/17/05	19
26.2.2.12	Final AP2&DB Improvements Complete (Milestone)	10/02/06	12/4/06	-63
26.4.4.4.14	New helix operational	12/05/06	3/22/07	-107
26.4.3.1.11	TEL System Operational	02/12/07	5/23/07	-100
26.6.2.7	Start Phase 5 (Helix and TEL)	02/12/07	5/23/07	-100

APPENDIX G

ACTION ITEMS

ACTION ITEMS

Resulting form the February 24-26, 2004
Department of Energy Assessment of the
Run II Luminosity Plan at the Fermilab Tevatron

Action	Responsibility	Due Date
1. Conduct mini-review	DOE/Fermilab	September 8, 2004
2. Conduct status review	DOE/Fermilab	February 2005

R. Dixon
Accelerator Division Head
Fermilab

D. Lehman
Review Chairman
Department of Energy

S. Holmes
Associate Director for Accelerators
Fermilab

M. Procario
Program Manager
Department of Energy

M. Witherell
Director
Fermilab

J. Monhart
Fermi Area Office Manager
Department of Energy