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Fermilab

Final Report

Director's Status and Progress Review of the Proton Plan

August 15-16, 2006

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Table of Contents

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Executive Summary

Technical

The goal of the Proton Plan campaign is to increase the proton intensity for the neutrino program at Fermilab to a level of 400 kW. The Proton Plan team has made tremendous progress since the last Director's Review a year ago including: receipt of twelve 7835 Linac power amplifier tubes from Burle, major installations during the recent shutdown, Booster corrector magnet prototype, and demonstration of 2+9 slip stacking at low intensity in the Main Injector. Proton intensity delivered in FY2005 was on the plan but has fallen below the projections in FY2006. Revised projections have been made that will deliver 3.2E20 p/yr to NuMI and 1.8E20 p/yr to the Booster Neutrino Beamline as had been planned. However, the realization of these ultimate performance levels has been delayed by approximately one year relative to last year's plan due the delay in implementing 2+9 slip stacking.

Cost

Cost performance has been good on this campaign which is nearly half done. At present there is an ~39% contingency on $9784K cost to complete. Nineteen Change Requests have been processed with 3 additional CRs pending.

Schedule

An MS Project schedule is used to plan the campaign and track performance. A one page summary level Master Schedule has been prepared that highlights critical path and near critical path activities. The project is 46% complete, nearly half done, with the many tasks that were finished during the recent extended shutdown. A separate more detailed "Shutdown Project" schedule was developed and used to manage Proton Plan work during the 06 shutdown. We encourage the team to continue this practice during the 07 and 08 shutdowns. The Correctors are the primary critical path items, the long straight correctors being scheduled for installation in the 07 shutdown and the short straight correctors in 08. The project is slightly behind schedule overall, with RF resources identified as a limiting item. The team is taking steps to beef up these resources.

Management

It is heartening to see young people like Cullerton and Berenc critically involved. Responses to recommendations from the last review were outstanding in some areas (e.g.the Main Injector) and less so in other areas. Given the "campaign" nature of this activity some descopes have occurred and two upscopes at approximately $250K each are pending: the APS (Anode Power Supply) Rectifier Transformer upgrade and the SSD (Solid State Driver) Power Supply Upgrade, both of which go into the Main Injector. With the announced departure of the Deputy Project Manager, a search for his replacement is underway.

1.0 Introduction

A Director's Status and Progress Review of the Proton Plan was held on August 15-16, 2006. The charge was to focus on Proton Plan's progress relative to the plan presented during the August 2005 Director's Review; the results of the 2006 shutdown work; and the plan for the work to be done in the 2007 shutdown. The assessment of the Review Committee is documented in the body of this report.

Each section in this closeout report is generally organized by Findings, Comments and Recommendations. Findings are statements of fact that summarize noteworthy information presented during the review. The Comments are judgment statements about the facts presented during the review and are based on reviewers' experience and expertise. The comments are to be evaluated by the project team and actions taken as deemed appropriate. Recommendations are statements of actions that should be addressed by the project team. A response to the recommendations is expected and the actions taken will begin to be reported by the Proton Plan's Project Management within two months from the review closeout. Progress on the recommendations is to be reported during the Proton Plan's Project Management Group (PMG) Meetings with a complete set of responses to be provided at the next Director's Review.

Reference materials for this review are contained in the Appendices. Appendix A is the Charge for this review. The review was conducted per the agenda shown in Appendix B. The Reviewer's assignments are noted in Appendix C and their contact information is listed in Appendix D. The Review Participants are listed in Appendix E. Appendix F is a table that contains all the recommendations included in the body of this report.

2.0 Linac Upgrades (WBS 1.1)

Findings

- The 200 MHz section of the Linac uses the 5 MW 7835 power triode which is now available from a single source, Burle Industries. The low yield on the successful production of these tubes put the Linac in a vulnerable position with scarcely any spares on hand. To address this situation 12 tubes were ordered by Fermilab, which apparently stimulated Burle to invest in its production facility with the result that Fermilab now has the 12 tubes (a two-year supply) plus the normal complement of spares. The new tubes are in the process of being tested.

- The option of developing a new power amplifier with the power tube from Thales has been dropped. The outlook from the Los Alamos project to develop this amplifier is not good and has been given little support there. Consequently the Thales option has been descoped from the Proton Plan.

- The cost-benefit estimate of replacing the low energy Linac Quad Power supplies showed that the small possible improvement in reliability does not justify the expense. These power supplies account for only 5% of the Linac down time, which in turn, is only 3% of the program down time. In fact, most of the failures from the Linac quads are caused by the problems with the control cards for these supplies. Therefore it was decided to scale back the project and only replace the control cards. The first of the two types of cards that will be replaced has been designed and tested. The full production run for the card has been ordered and the cards will be installed as time permits. The design of the second card awaits the availability of an engineer.

- The performance of the Linac is known to be limited by the accuracy of the 200 MHz tanks' amplitude and phase regulation. The feedback circuits that regulate the tanks were designed in the 1960s and employ outdated components. The RF voltage and phase are perturbed by beam loading, making the first 10 microseconds of the pulse unusable. Shot-to-shot variations of the Linac energy have been shown to lead to beam losses. It is estimated that 5 to 10% more beam could be delivered with an improved low-level RF system for the 200 MHz section of the Linac. An effort is under way, and well advanced, to characterize and model the elements of the Linac power chain, including beam loading, and regulation system. The model will be used to optimize the tuning of the system and guide development of new regulator concepts and circuits. A straightforward improvement would be to install a phase reference line from which the absolute phase of each tank could be independently measured and then corrected.

Comments

- The fortunate development of an ample supply of 7835 power tubes seems to be the resolution of a longstanding worry. The idea to buy 12 tubes looks like a stroke of genius. The good news is contingent on test results for the entire inventory of tubes and on the operational experience with tubes put into service. The testing should be aggressively pursued. The failure of the power amplifier in

test stand is troubling in light of the remark that this type of failure is unfamiliar to everyone and the repair procedure is unclear. The high voltage capacitor that shorted appears in all the operational power amplifiers as well. It is plausible that the other capacitors may be reaching the end of their lifespan and the staff should be knowledgeable of the procedures for an emergency repair.

- The low-level RF regulation goals of +-0.2% and +-0.5 degree were presented with little explanation of their derivation, or even a precise definition. For example, are they rms or peak-to-peak quantities? Do they apply to fluctuations during the pulse, or do they include shot-to-shot and day-to-day variations? These considerations may dictate choices between technical options in the feedback architecture.

- The modeling project has stimulated a great deal of learning and reverse engineering about the RF system of the 200 MHz Linac. This is recognized as being hard work and also invaluable for the on-going support of the Linac. For this reason alone the effort should be supported with sustained priority.

- It is planned to install a phase reference line to which each Linac tank phase can be independently compared. This aspect of the new design should be incorporated into the system model. After all, it is the inter-tank phase that is relevant to the beam dynamics and it must be confirmed that the new approach is a step forward, in light of the realistic performance expectations of the new phase regulation.

Recommendations

1. It is important that enough resources are allocated to fully test and characterize twelve 7835 tubes. Even with warranty provided by Burle, it is important to test these tubes to determine early problem associated with fabrication and performance specifications.

2. Repair of the 7835 test stand power amplifier should proceed with priority so that the testing of tubes can resume, the nature of the failure can be understood and standard repair procedures can be worked out.

3. The work on QPS control cards is essential and should be given higher priority to proceed on a reasonably fast track. This work seems to have slowed down due to lack of adequate manpower.

4. Design effort should also be dedicated to come up with an acceptable design for the timing card. This also seems to suffer from lack of adequate manpower.

5. Perform consistent Linac beam measurements and characterizations to quantify beam energy spread, and transverse emittance variations due to magnetic elements under different Linac settings. This needs to be done in collaboration with machine physicists with the required booster beam parameters at the injection.

6. Based on the model, which is 99% complete, take the decision about the cavity amplitude and phase regulation architecture and proceed with design. Decide if direct RF feedback is realizable (in light of the drive saturation of the 7835s) and called for, or if feedforward is sufficient and cost effective. Consider if shot-to-shot adaptive feedforward, as opposed to beam current feedforward, is applicable.

3.0 Booster Upgrades (WBS 1.2)

Findings

- The scheduled 2006 shutdown work was accomplished. The two major efforts were:
    - Install new injection region (ORBUMP) configuration and portion of 400 MeV line
    - Remove Long 13 extraction elements and install new beam dump system in the MI-8 line.
- The major remaining tasks are the installation of new correction elements and their power supplies, and the new Booster chopper. The correction element effort is divided into two AIPs; the correctors (24) for the long straight sections are to be installed in the 2007 shutdown, and the correctors (another 24) for the short straights in the 2008 shutdown. Each of the correction elements has six independently controlled coil packages. A prototype magnet has been fabricated and is being tested at the Magnet Test Facility (MTF). The magnet production will involve procuring coils and core subassemblies from outside vendors, and doing the final assembly in-house. The coil bid package is underway, with an RFP to be issued in September 2006. A prototype power supply is under development in AD/EES; an outside vendor also has suitable supplies (except for the skew quadrupole) at a higher cost. The decision will be made in the near future whether to build the power supplies in-house or use an outside vendor.
- An internal review was held in July 2006 to evaluate the benefits of the 30 Hz harmonic and the Gamma-t jump. That review concluded that the 30 Hz harmonic was only marginally beneficial with a Gamma-t jump, and actually detrimental without a Gamma-t jump. Therefore, the 30 Hz harmonic has been descoped from the Proton Plan. A decision has not yet been made on the Gamma-t system.
- The solid state driver upgrade to the Booster RF has been removed from the Proton Plan; this work will be performed by the RF Dept.

Comments

- The 2006 shutdown work was motivated in part in increasing the rep rate capability of the Booster, but also towards increasing the flexibility and reliability by lowering kicker voltages, and in increasing the aperture through the removal of the Long 13 extraction. The committee appreciates that increasing Booster performance is a slow, iterative process. However, none of the talks presented any information on beam performance improvements, either through increased single-pulse intensity or through reduced losses. (This was answered to a limited extent in the response session on the second morning.) The timing of this review was planned so that this information would be available.

- Completing the correction element package prototype is a major accomplishment, from which much was learned. The coil winding was not as difficult as feared, and the cooling works well. The prototype magnet meets the field strength and field quality specifications for DC operation; AC measurements are underway. With 144 individual coils to be connected to power supplies during each of the shutdowns, a major QC effort needs to be mounted to assure each coil is connected to the correct supply and with the proper polarity. Simple hand-held Hall probe measurements may not be adequate for the higher-order elements.

- There appears to be little or no progress with regard to accelerator physics calculations and modeling of the injection process in Booster. This effort could show the need for expanded scope in the Proton Plan to include phase-space painting devices, and could guide the Linac LLRF effort. Accelerator physics work is essential in guiding the design, fabrication, and commissioning of complex systems like the Booster correction system. Extensive beam dynamics calculations are needed to guide the location and specification of each type of corrections to maximize their benefit. For example, with the normal quadrupole to strategically vary the transverse tunes along the cycle, one may significantly reduce the beam loss caused by resonance effects induced by space charge, chromatic tune spread, and magnetic nonlinear excitation, resistive wall instabilities, and optical mismatching. Such strategy needs to be developed. Effective higher order resonance corrections also require detailed analysis of the expected resonance strength, corrector power supply strength and family, and excitation strategy.

- The goal of the Proton Plan demands a factor of two increase in the total Booster intensity, and about 20% increase in the pulse intensity. Correspondingly, the uncontrolled beam loss needs to be reduced by at least a factor of two. Beam loss mechanisms need to be systematically investigated and mitigation plans need to be correspondingly developed. For example, a list of major loss mechanisms may include transverse and momentum aperture limitation, H- and Ho stripping loss, resonance due to space charge, chromatic tune spread and magnet nonlinearities, closed orbit variation due to magnet misalignments, instabilities due to external impedance, and transition-specific losses. To address the aperture aspect, one needs to survey the aperture around the ring and compare with expected beam envelope and closed orbit deviation.

- The simulations of the Gamma-t jump system indicate it would be extremely beneficial in pushing the Booster to higher intensities, both in terms of reduced beam loss and lower longitudinal emittance. Studies are planned for the next few months. The working assumption is that new Gamma-t magnets will be fabricated and installed in the 2008 shutdown. This would change only if the studies show unforeseen effects.

- The Booster chopper was not discussed in great detail. Effort has just begun on specifications and modeling. Although this is thought to be a low cost,

straightforward task, the desire to install it in the 2007 shutdown suggests some urgency in getting it well-defined.

Recommendations

7. Develop an installation plan and in-situ field test for the new correction elements to verify the proper connections.

8. Strengthen accelerator physics efforts to guide the implementation and commissioning of the correction systems. In particular, with respect to tune and resonance control, utilize the experiences of other accelerators, both in performance and calculations, to aid in this effort. Develop a commissioning plan for the new correction elements.

9. At the next review, present the status of accelerator physics calculations for the injection process and for tune and resonance control.

10. At the next review, present the status of Booster beam performance (intensity and losses) with comparisons to prior years (pre- and post-2006 shutdown).

11. Pursue the Gamma-t beam studies over the course of the next six months and firm up the decision on the implementation of the Gamma-t system. Use available codes to continue the modeling of transition crossing, including momentum aperture limitation, chromatic nonlinear effect, space charge and impedance induced bunch mismatch, microwave instabilities, and electron cloud.

12. Monitor the progress of the Booster chopper by presenting its status at PMGs as needed (approx. every three months?).

13. As requested at last year's review, consider implementing RF feedback and beam loading compensation in the Booster to improve stability of bunch rotation required for slip stacking as well as reducing the RF power requirements associated with paraphrasing.

14. Until improved stability of Booster RF during the bunch rotation process has been achieved by RF feedback, consider implementing the required matching of the Booster bunches to the MI slip stacking by gradually building up the quadrupole motion of the bunch by modulating the RF amplitude with twice the synchrotron frequency for a few synchrotron periods prior to extraction. This avoids the use of very low voltages in the Booster.

4.0 Main Injector Upgrades (WBS 1.3)

Findings

- The items scheduled for completion in the spring 2006 shutdown were completed on schedule: MI-8 injection line collimators, 7 WQB large aperture quads in MI-60 extraction region, and the MI-10 injection kicker upgrade (cooling and waveshape improvement).

- While the single power tube per cavity design is still deemed adequate, a power analysis has revealed 3 weak points: STM (Series Tube Modulator) dissipation, anode power supply transformer upgrade, and SSD (Solid State Driver) power supplies. The first item has already been addressed during the shutdown (new voltage regulation scheme), and the latter two are subjects of CR's (change requests).

- The growth rates of the longitudinal coupled bunched modes due to the fundamental RF impedance have been calculated and compared with the synchrotron frequency and the Landau frequency spread. Maximum detuning needs to be controlled and active damping of mode -1 may be needed.

- While most items necessary for successfully migrating from 2+5 to 2+9 batch operation are already complete, it is nevertheless proposed to delay the operational use of 2+9 batch operation until after the 2007 shut-down.

- The review of the MI ring collimator system (in June 2006) was delayed until a good agreement between observed and simulated loss pattern due to un-captured beam was obtained and fully understood.

- A detailed plan for the fabrication and installation of the MI ring collimators was not presented.

- Simulations of the electron cloud density in MI as a function of the intensity per bunch were presented with a sharp threshold close to current bunch intensities.

Comments

- The Proton Plan team has responded very well to most recommendations from the previous review and should be congratulated on their progress.

- While an increased aperture in the MI-60 extraction region has been demonstrated, no measurements of the actual MI acceptance was presented. The move of the Lambertson has been postponed until the 2007 shutdown for technical reasons.

- The slip stacking capture efficiency has been simulated (ESME) as a function of Booster bunch momentum spread and imperfections in the beam loading compensation. The simulations confirm the need for a very good beam loading compensation of the MI RF as well as a sufficiently injected bunch energy spread,

which means sufficiently small longitudinal emittances as well as correct bunch rotation. These simulation results should be compared with measurements from actual machine studies as soon as possible.

- The MI RF team has made a lot of progress since the last review in understanding and documenting the limits of the current 53 MHz MI RF systems and the suggested improvements looks very reasonable.

- The MI-8 line collimator was installed during the 2006 shutdown, but commissioning of it has been delayed. This collimator should reduce losses in the Main Injector due to tails on the Booster beam, and the Proton Plan team is encouraged to proceed expeditiously with its commissioning and full utilization.

Recommendations

15. Continue studies of MI 2+9 batch operation at high intensity to fully understand and remedy capture losses. Compare capture losses with the results from simulation.

16. Present a detailed plan for the MI ring collimation studies, design, fabrication, installation, and commissioning as soon as possible to permit installation in the 2007 shutdown.

17. Address and decide upon the MI RF upgrade CR's as soon as possible.

18. Continue machine studies related to possible e-cloud effects and compare with simulations based on realistic data from SEY measurements.

5.0 Project Management

Findings

- The Proton Plan is being managed as a "campaign." The management team is implementing project management principles, and using project management tools, at an appropriate level to plan and manage work and costs. The team is using Microsoft Project to develop schedules with milestones against which progress can be tracked and measured.

- A formal change control process is in place and being used to manage and document changes in work scope and cost. Through August 15, 2006, nineteen Change Requests have been reviewed and approved, resulting in a contingency draw down of $2.619M to support additional SWF and M&S costs. It appears that the change control process is being used effectively.

- The management team places a high priority on safety. There was one reportable injury during the summer 2006 shutdown work, as the result of an improperly mounted beam pipe cutter. Prompt follow-up action resulted in a procedural change in set up to preclude further accidents. Daily meetings at the start of work shifts provided an opportunity for safety concerns to be discussed and addressed. Walk-arounds by a "floor monitor" provided a mechanism for proactively monitoring the workplace to help ensure safe working conditions.

- Project management is abreast of cost and schedule performance. Through July 31, 2006:

    - Schedule performance: 46.3% actual vs. 49.3% planned.

    - Schedule variance: ($523K), due largely to resources being diverted to the recent shutdown efforts, and a general lack of RF resources.

    - Cost performance: 46.3% complete with 41% of contingency spent.

    - Cost variance: $75K ($592K less $517K tube credit).

  The Project Manager and Deputy understand the sources of variance and intend to execute Change Requests in the near future to re-plan subprojects.

- The management team has identified the more significant remaining tasks and is in the process of factoring these into the master project plan.

- The Proton Plan is one of the driving forces in the schedule for the summer 2007 shutdown.

- The management team has responded to, and closed, all management recommendations from the August 2005 Director's review.

- Progress has been made in addressing the majority of recommendations from the August 2005 review. Over the course of the last 12 months, 39 of 55 recommendations have been addressed and closed (71%). The remaining 16 recommendations are spread primarily across the Linac, Booster, and Main Injector Upgrade sub-projects.

- The quad power supply (QPS) upgrade is focused on replacing the QPS control cards, based on a cost/benefit analysis. Failures account for 5% of the 3% of Linac downtime, so completing this upgrade in a timely way will have a positive programmatic impact. However, resources are limited to complete the upgrade, which has put the project behind schedule (12% complete vs. 35% plan).

- The management plan for the Booster Corrector Magnets appears to be well in hand and under control. Deploying standard Technical Division (TD) operating processes and procedures, coupled with the deep expertise base within the division, reduces schedule and cost risk. Twenty-four magnets each are required for the long and short straight sections; an additional twelve magnets will serve as spares. Although raw material costs are a small fraction of total magnet cost (magnet cost being dominated by labor), concerns over volatile commodity prices have been factored into the contracting process. This attention to detail indicates the level to which TD staff have performed a comprehensive assessment of potential cost risks.

Comments

- Project management appears confident and competent. From the Project Manager and Deputy, through the Level 3 managers who made presentations to the committee, the management team appears to understand system-wide goals and objectives, and the work required in their respective areas to achieve these goals. Communication across the project appears to be effective.

- MS Project is being to plan/track project work and costs. Two versions of the project file exist: a master schedule showing tasks at the summary level; and a detailed schedule providing more granularity. There is a concern that the granularity in the detailed schedule file is still too coarse to track progress against plan.

- The lack of RF resources is a potentially serious problem. Efforts should remain focused on filling open positions as quickly as possible. Comments were made during the review that some RF resources will come from different pools (i.e. AD RF techs) that will not compete for time. This should help the Proton Plan team complete some of the planned work.

- The status of recommendations from the August 2005 review is tracked by the project management team; completed tasks seem to be reasonably well-documented. The majority of open recommendations are listed as ongoing, but the extent to which work is actually being done is not clear from some of the status descriptions, or if these are still open pending resource availability. It

would be good to indicate the priority of open recommendations and provide a more comprehensive statement of the current level of effort, as well as planned completion or target date(s). This was done on recommendations 4.2.3 and 4.4.1; these could be used as templates for reporting status on all open recommendations.

- With regard to the quad power supply (QPS) upgrade, the management team should review priorities against resource availability and adjust schedules as appropriate. There are approximately 1000 cards in the system, which will be replaced on a best-effort basis as new cards are received and tested; installation is planned to occur during scheduled downtimes. The Level 2 manager for the Linac upgrade does not foresee any technical problems associated with testing new cards. Rather, concerns are related to the availability of personnel to perform the work. The Accelerator Division is currently seeking to hire an additional technician to support this work. The amount of work required to complete this testing may result in this work moving into the critical path (for example, it would take 20 weeks to complete given a testing rate of 50 cards per week). The management team should include this work in the master schedule to help ensure that installation is complete by the end of the summer 2007 shutdown.

- The level of effort to successfully plan and mange the work associated with the Booster Corrector Upgrade will be significant. It is clear that the Level 3 manager for this effort would benefit from additional staff support. It was reported that the management team is currently seeking to fill an open position to obtain this support.

- From the presentation materials, the perception is that there are many details to be worked out prior to installation of the Booster Corrector Upgrade (e.g., addressing ES&H issues). Additionally, completing the planned work in time for a summer 2007 installation will be challenging, given delays already incurred to date. A brief review of the scheduled tasks for WBS element 1.2.3, from the detailed MS Project file, suggests that the full scope of work has not yet been flushed out. For example, the scope of work for power supplies is only scoped through "approval for production" with a target date of 08/15/06. However, there is still the issue of deciding whether to make or buy these power supplies, and then performing the remaining work associated with the decision. The project work plan should be scrubbed to identify other areas in which the remaining work is not fully defined.

Recommendations

19. Provide additional detail when reporting on the status of follow-up activities associated with the recommendations from the August 2005 Director's review. For the longer duration tasks, status information should include an indication of priority, detailed statement of the work actively being performed, and target completion dates.

20. Provide a similar level of detail when reporting progress and status on recommendations from the 2006 review.

21. Update the project plan and scope of work to account for the resources required to address and close the recommendations from the August 2005 review. This represents real work with potential impact on the resource loaded schedule.

22. Process pending Change Requests soon in order to factor the impact into the next round of schedule and cost forecast updating.

23. Flesh out the remaining work on developing subprojects and update the project schedule file with this information: (e.g., Linac LLRF, Gamma T magnets, booster chopper, MI collimation, extraction kicker mods). Task durations should be limited to two months or less in order to properly measure progress.

24. Assertively pursue resources to fill missing personnel slots (e.g., support for the management of the Corrector Systems Upgrade, RF engineering, tech to test QPS control cards).

6.0 Cost and Schedule

Findings

- The Proton Plan's cost as of the end of July 2006 is shown in the table below, in $K:

	Current Baseline	Actuals	Remaining Planned	Remaining Contingency	% of Cont. of Remaining Work
SWF	8,504	3,858	4,646	1,957	42%
M&S	8,637	3,499	5,138	1,851	36%
Total	**17,141**	**7,357**	**9,784**	**3,808**	**39%**

- The Proton Plan percent complete for planned vs. actual as of the end of July 2006.

WBS	Name	EV	
		Planed % Complete	Actual % Complete
1	Proton Plan	49.3%	46.3%
1.1	Linac Upgrades	77.1%	66.4%
1.2	Booster Upgrades	31.4%	30.8%
1.3	Main Injector Upgrades	72.0%	67.5%
1.4	Management	43.5%	43.5%
1.5	Proton Study Group	100%	100%

- The Proton Plan's Microsoft (MSP) Project schedule consists of 621 lines, 444 tasks and 51 milestones. The remaining work consists of 238 tasks and 22 milestones. Out of those 238 tasks, 75 are greater than 2 months in duration and 52 of those 75 tasks are greater than 4 months in duration.

- The Proton Plan schedule shows a completion date of April 17, 2009.

- The MSP schedule has the start of the 2007 shutdown on June 4, 2007 and the 2008 shutdown starting June 2, 2008.

- Many of the milestones to be completed have a Milestone Dictionary Description contained in the notes field of the MSP schedule file.

- A few of the open activities in the schedule have a WBS Dictionary Description in the notes filed of the MSP file.

Comments

- The Proton Plan has implemented most of the cost and schedule recommendations from the August 2005 Director's Review. The cost and schedule presented during

this review has improved in quality and the progress reporting significantly enhanced.

- With slightly less than 1/3 of the remaining tasks being greater than 2 months in duration and the lack of a WBS Dictionary description of the work to be performed, it is hard to assess if the work has been estimated correctly and it also makes it difficult for the campaign to accurately determine the % complete for a monthly status.

Recommendations

25. The remaining long duration tasks (i.e. greater than 2 months in duration) should be broken down into shorter duration detailed activities. This will help improve the accuracy of estimating resources and reporting progress. An alternative to breaking down the long duration activities is adding milestones that reflect interim deliverables that will indicate progress is being made to complete the long duration task.

26. A WBS Dictionary description should be completed for the remaining tasks. This will better define the work to be accomplished, which improves the accuracy of estimating the resources needed to complete the work and gives the people assigned to the tasks a better understanding of the deliverable.

27. The committee recommends that the Proton Plan analyze the critical and near critical path activities to determine what activities can be crashed to gain schedule contingency for the work scheduled to be performed in the 2007 and 2008 shutdowns.

Appendices

Charge

Agenda

Report Outline and Reviewer Writing Assignments

Reviewers' Contact Information

Participant List

Table of Recommendations

Appendix A

Charge

for the Director's Status and Progress Review of the Proton Plan August 15-16, 2006

Please review progress relative to the plan presented in the August 2005 Director's Review.

- Closely review progress through the recent extended shutdown.
- Review the plan to complete, looking most closely at effort planned in detail through the summer 2007 shutdown.
- Identify any outstanding technical and/or management issues that require attention.

As you review progress to date please note the team's responses to Recommendations from the prior Director's Review held in August 2005.

The Committee is asked to present findings, comments, and recommendations in a closeout session with the Proton Plan team, AD Management, and Fermilab Management at the end of the review and in a concise written report soon thereafter.

Appendix B

Agenda

for the Director's Status and Progress Review of the Proton Plan
August 15 - 16, 2006

Tuesday, Aug. 15

8:00 – 8:30M	30	Executive Session (Racetrack, WH7Xover)	Ed Temple
Plenary Talks in the Racetrack			
8:30 – 8:40 AM	10	Introduction	Steve Holmes
8:40 – 9:15 AM	35	Proton Plan Overview, Progress, and Parameter Table	Eric Prebys
9:15 – 9:45 AM	30	Response to Director's Review Recommendations	Jeff Sims
9:45 – 10:25 AM	40	Summary and effect of shutdown work	Eric Prebys
10:25 – 10:40 AM	15	BREAK	
10:40 – 11:00 AM	20	General Linac Upgrades (WBS 1.1)	Larry Allen
11:00 – 11:30 AM	30	Linac LLRF (WBS 1.1.4)	Ed Cullerton
11:30 – 12:00 Noon	30	General Booster Upgrade (WBS 1.2)	Bill Pellico
12:00 – 12:30 PM	30	Booster Corrector System (WBS 1.2.3)	Craig Drennan/ Dave Harding
12:30 – 1:30 PM		LUNCH	
1:30 – 2:00 PM	30	General Main Injector Upgrades (WBS 1.3)	Ioanis Kourbanis
2:00 – 2:30 PM	30	Main Injector RF (WBS 1.3.4)	Tim Berenc
2:30 – 3:00 PM	30	Projections	Eric Prebys
3:00 – 3:15 PM	15	BREAK	
3:15 – 3:45 PM	30	Cost and Schedule	Jeff Sims
3:45 – 4:00 PM	15	Summary	Eric Prebys
4:00 – 6:15 PM		Executive Session (Racetrack, WH7Xover)	Ed Temple

Wednesday, Aug. 16

9:00 – 1:00 PM	Closeout Dry Run with working lunch (Racetrack, WH7Xover)
1:00 – 2:00 PM	Closeout (Racetrack, WH7Xover)

Appendix C

Report Outline and Reviewer Writing Assignments

for the Director's Status and Progress Review of the Proton Plan
August 15 - 16, 2006

Executive Summary	Ed Temple
1.0 Introduction	Dean Hoffer
2.0 Linac Upgrades (WBS 1.1)	Mike Brennan, Ali Nassiri
3.0 Booster Upgrades (WBS 1.2)	Phil Martin, Jie Wei
4.0 Main Injector Upgrades (WBS 1.3)	Flemming Pedersen, Ali Nassiri, Greg Bock
5.0 Project Management	Bill Boroski, Dean Hoffer, Ed Temple
6.0 Cost and Schedule	Dean Hoffer, Bill Boroski, Ed Temple

* Note underlined names are the primary writer.

Appendix D

Reviewers' Contact Information

for the Director's Status and Progress Review of the Proton Plan
August 15 - 16, 2006

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Appendix F

Participant List

for the Director's Status and Progress Review of the Proton Plan
August 15 - 16, 2006

Role	Last Name	First Name	Affiliation
Reviewers	Bock	Greg	Fermilab
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Appendix G

Table of Recommendations

for the Director's Status and Progress Review of the Proton Plan
August 15 - 16, 2006

#	Recommendation	Assigned To	Status/ Action	Date
	2.0 Linac Upgrades WBS 1.1			
1	It is important that enough resources are allocated to fully test and characterize twelve 7835 tubes. Even with warranty provided by Burle, it is important to test these tubes to determine early problem associated with fabrication and performance specifications.			
2	Repair of the 7835 test stand power amplifier should proceed with priority so that the testing of tubes can resume, the nature of the failure can be understood and standard repair procedures can be worked out.			
3	The work on QPS control cards is essential and should be given higher priority to proceed on a reasonably fast track. This work seems to have slowed down due to lack of adequate manpower.			
4	Design effort should also be dedicated to come up with an acceptable design for the timing card. This also seems to suffer from lack of adequate manpower.			
5	Perform consistent Linac beam measurements and characterizations to quantify beam energy spread, and transverse emittance variations due to magnetic elements under different Linac settings. This needs to be done in collaboration with machine physicists with the required booster beam parameters at the injection.			

#	Recommendation	Assigned To	Status/ Action	Date
6	Based on the model, which is 99% complete, take the decision about the cavity amplitude and phase regulation architecture and proceed with design. Decide if direct RF feedback is realizable (in light of the drive saturation of the 7835s) and called for, or if feedforward is sufficient and cost effective. Consider if shot-to-shot adaptive feedforward, as opposed to beam current feedforward, is applicable.			
	3.0 Booster Upgrades WBS 1.2			
7	Develop an installation plan and in-situ field test for the new correction elements to verify the proper connections.			
8	Strengthen accelerator physics efforts to guide the implementation and commissioning of the correction systems. In particular, with respect to tune and resonance control, utilize the experiences of other accelerators, both in performance and calculations, to aid in this effort. Develop a commissioning plan for the new correction elements.			
9	At the next review, present the status of accelerator physics calculations for the injection process and for tune and resonance control.			
10	At the next review, present the status of Booster beam performance (intensity and losses) with comparisons to prior years (pre- and post-2006 shutdown).			

#	Recommendation	Assigned To	Status/ Action	Date
11	Pursue the Gamma-t beam studies over the course of the next six months and firm up the decision on the implementation of the Gamma-t system. Use available codes to continue the modeling of transition crossing, including momentum aperture limitation, chromatic nonlinear effect, space charge and impedance induced bunch mismatch, microwave instabilities, and electron cloud.			
12	Monitor the progress of the Booster chopper by presenting its status at PMGs as needed (approx. every three months?).			
13	As requested at last year's review, consider implementing RF feedback and beam loading compensation in the Booster to improve stability of bunch rotation required for slip stacking as well as reducing the RF power requirements associated with paraphrasing.			
14	Until improved stability of Booster RF during the bunch rotation process has been achieved by RF feedback, consider implementing the required matching of the Booster bunches to the MI slip stacking by gradually building up the quadrupole motion of the bunch by modulating the RF amplitude with twice the synchrotron frequency for a few synchrotron periods prior to extraction. This avoids the use of very low voltages in the Booster.			
	4.0 Main Injector Upgrades WBS 1.3			
15	Continue studies of MI 2+9 batch operation at high intensity to fully understand and remedy capture losses. Compare capture losses with results from simulation.			

#	Recommendation	Assigned To	Status/ Action	Date
16	Present a detailed plan for the MI ring collimation studies, design, fabrication, installation, and commissioning as soon as possible to permit installation in the 2007 shutdown.			
17	Address and decide upon the MI RF upgrade CR's as soon as possible.			
18	Continue machine studies related to possible e-cloud effects and compare with simulations based on realistic data from SEY measurements.			
	5.0 Project Management			
19	Provide additional detail when reporting on the status of follow-up activities associated with the recommendations from the August 2005 Director's review. For the longer duration tasks, status information should include an indication of priority, detailed statement of the work actively being performed, and target completion dates.			
20	Provide a similar level of detail when reporting progress and status on recommendations from the 2006 review.			
21	Update the project plan and scope of work to account for the resources required to address and close the recommendations from the August 2005 review. This represents real work with potential impact on the resource loaded schedule.			
22	Process pending Change Requests soon in order to factor the impact into the next round of schedule and cost forecast updating.			

#	Recommendation	Assigned To	Status/ Action	Date
23	Flesh out the remaining work on developing subprojects and update the project schedule file with this information: (e.g., Linac LLRF, Gamma T magnets, booster chopper, MI collimation, extraction kicker mods). Task durations should be limited to two months or less in order to properly measure progress.			
24	Assertively pursue resources to fill missing personnel slots (e.g., support for the management of the Corrector Systems Upgrade, RF engineering, tech to test QPS control cards).			
	6.0 Cost and Schedule			
25	The remaining long duration tasks (i.e. greater than 2 months in duration) should be broken down into shorter duration detailed activities. This will help improve the accuracy of estimating resources and reporting progress. An alternative to breaking down the long duration activities is adding milestones that reflect interim deliverables that will indicate progress is being made to complete the long duration task.			
26	A WBS Dictionary description should be completed for the remaining tasks. This will better define the work to be accomplished, which improves the accuracy of estimating the resources needed to complete the work and gives the people assigned to the tasks a better understanding of the deliverable.			
27	The committee recommends that the Proton Plan analyze the critical and near critical path activities to determine what activities can be crashed to gain schedule contingency for the work scheduled to be performed in the 2007 and 2008 shutdowns.			