Office of High Energy Physics
Report on the

Review of the Fermilab Proton Improvement and 700kW Plans

January 21-23, 2015

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Executive Summary

On January 21-23, 2015 the Office of High Energy Physics (HEP) of the Department of Energy (DOE) held a peer review at Fermilab to evaluate Fermilab's plans to provide a reliable 700 kW proton beam to the Nova target within the next two years. There are two major elements to this improvement plan: (1) the Proton Improvement Plan (PIP) to improve the performance and reliability of both the linac and booster, and (2) recycler improvements in beam stability, beam losses and slip-stacking.

The review panel was generally favorably impressed with Fermilab's progress on its plan to achieve 700 kW on the Nova target within the next two years.

This review addressed the following issues:

- Are the goals, deliverables, budget and schedule of the PIP properly defined, well understood, achievable and self-consistent?
  - *Recommendation: Fermilab should provide a plan, with a precise timeline and milestones, to establish 700 kW operations, including identification of hardware and operational prerequisites. This plan should be updated as progress warrants. This plan should span all involved departments (linac, booster, RR/MI).*
- Are the plans to address the Linac vulnerabilities and reliability adequate?
  - *Recommendation: A Risk Registry should be maintained, especially in the case of the linac which has old and vulnerable components and which needs to run at least until 2023 when PIP II will begin.*
- Are the plans for the Booster rf cavities sufficient to support the required beam intensity and extend their life at least until 2030?
  - *Recommendations: none.*
- Are the plans to minimize Booster losses adequate and sufficiently understood to allow for the required higher beam power levels? Are beam losses in the Recycler understood sufficiently to minimize machine and tunnel activation and avoid any degradation of the magnetic elements?
  - *Recommendation: Continue to refine the booster proton loss simulations to assess whether additional loss reduction techniques need to be started.*
- Are the Recycler plans to overcome beam instabilities and losses during slip-stacking adequate?
  - *Recommendation: Lab management should continue supporting the instability task force until the operational impact of the recycler instability is understood.*
- Are the goals of achieving 460 kW (without the slow-extraction program) in 2015 and 700 kW by mid-2016 technically achievable? Are key risks to both goals identified and mitigation strategies defined?
  - *Recommendations: none.*
- How well do the current plans for PIP integrate smoothly into future plans for achieving even higher beam power (PIP-II and beyond)?
  - *Recommendations: none.*

A review team consisting of eight experts in accelerator science and operations participated in this review. The review consisted of plenary presentations as well as breakout sessions that focused on: (1) the linac, (2) the booster, (3) the recycler, and (4) management issues. Preliminary findings, comments, and recommendations were presented at a close-out session on January 23. In addition, subsequent to the review each panel member provided letters in which they evaluated those parts of the Fermilab plans in which they have specialized knowledge and experience. Those letters are the basis of this report.

Introduction and Background

The Fermilab Accelerator Complex is undergoing a transition from Tevatron operations which probed the Energy Frontier to serving the new suite of muon and neutrino experiments operating in the Intensity Frontier. The operating accelerators (linac, booster, recycler and main injector) have been working with high reliability, but their components are very old, some dating to the earliest days of the Robert Wilson era, and the demands on them are ever increasing. In particular, Nova will require a NUMI beam of high reliability (>85%) and power (~700 kW) in the near term and LBNF will require even higher power (>1-2 MW) to be successful.

In order to accommodate these experiments Fermilab has been engaged in a Proton Improvement Plan (PIP) to improve the reliability and performance of the linac and booster. However, to reach the 700 kW power goal, the recycler must also be improved through loss reduction, vacuum improvements and slip-stacking. An extension of the PIP has also been formulated, PIP II, with goals to reaching megawatt powers levels to serve the LBNF era of the lab in the 2023 time frame. PIP II will accomplish this by replacing the aging 400 MeV Linac with a new superconducting pulsed linac of energy 800 MeV which will also be upgradable to continuous wave operations.

The purpose of this review was to assess Fermilab's progress in these activities and to provide guidance to its short and long term planning. The immediate motivation for the review was an understanding of the challenges facing Fermilab in these pursuits, and their importance in Fermilab's near term (Nova) and future (LBNF) ambitions.

This review followed a similar but broader review held by the Fermilab Accelerator Advisory Committee (AAC), chaired by Lia Merminga, in October, 2014. That review concluded that Fermilab is making very good progress in PIP, the 700 kW goal and PIP II planning. However, it noted areas of risk, and areas which need more work, both conceptual as well as engineering. In order the learn the most from their efforts, the AAC review report was available to the committee at this review, and the Fermilab presenters were asked to include their responses to the AAC recommendations in their presentations. In order to integrate the lessons learned in the AAC review into this review, the January 21-23 review committee had two members from the AAC.

The review began with a presentation by Sergei Nagaitsev, Director of Fermilab's Accelerator Division, in which he gave an overview of the Fermilab Accelerator Complex. He stated that the Main Injector beam power is presently ~350 kW and the Fermilab plan is to reach ~700 kW in mid FY 2016. An important part of this goal is the Proton Improvement Plan (PIP) which is a multi-year campaign that is funded through operations, but is managed like a project, to improve the linac and booster. The PIP will refurbish the booster so that its RF can pulse at 15 Hz, the resonant frequency of the Booster. At present the RF is pulsed at 7.5 Hz because of sparking and overheating, issues that should be resolved by the refurbishment program. The Booster has 22 slots for RF cavities. 17 of them must be running at 15 Hz to reach the PIP goals. Fermilab expects to have 17 refurbished cavities by July, 2015. The goals of the PIP are:

1. Increase the beam repetition rate from the present ~7 Hz to 15 Hz

2. Eliminate major reliability vulnerabilities and maintain reliability at present levels (>85%) at the full repetition rate

3. Eliminate major obsolescence issues

4. Increase the proton source throughput, with a goal of reaching >2E17 protons/hour. Presently, it is operating at <1E17 protons/hour

5. Originally the plan was to ensure a useful operating life of the proton source through at least 2025. Now that requirement has been extended to 2030 to accommodate the PIP-II schedule

In addition to these improvements, it is essential to reduce beam losses in the system. Without reduction of beam losses, the power goals of the program cannot be met. Fermilab's strategy to reduce losses include:

1. Move beam notching system to the linac (30% loss reduction)
2. Reduce losses at RF capture
3. Eventually, reduce losses at transition

Improvements to the linac and booster will not be sufficient to reach the 700 kW goal which is required for the success of the Nova experiment. Loss reduction and slip-stacking in the recycler will also be needed. Sergei's talk presented the status and progress in these areas.

William Pellico presented the PIP strategy. He included financial information, a timeline of activities and the major goals of the plan. The present PIP budget is ~$78M and ~$34M have been spent to date for work on the pre-accelerator, the linac and the booster. His presentation included a snap shot of the FY2012 PIP organization and task structure. The scope of PIP was modified in FY2014 in light of emerging plans for PIP II, the plan to replace the linac with a superconducting facility of 800 MeV that could be upgraded to a CW accelerator. These changes include: (1) extend the booster operations to 2030, (2) extend linac operations to 2023, and (3) prepare for the transition to PIP II. The original cost estimate for the PIP was ~$90M, but linac Klystrons were removed from its scope in FY2014 and moved to PIP II resulting in the present cost estimate of ~$78M.

Fernanda Garcia presented the PIP work on the linac. The presentation discussed the major components that are being replaced or refurbished and vulnerabilities of each. These include the RF system, modulator and linac laser notch system.

C. Y. Tan presented the PIP work on the booster cavities. The presentation contained technical details concerning the cavity and tuner refurbishments. The strategy of installing a 2nd harmonic cavity at injection to reduce losses was explained.

Keith Gollwitzer discussed booster losses in his presentation. The booster works with a 525 W "administrative" loss limit. In practice the losses are approximately equal in RF capture, transition and notching. The presentation explained that booster losses must be reduced to run with the proton intensities required by the upcoming suite of experiments and various strategies to achieve reduced losses were discussed.

Steve Holmes presented the lab's strategy to integrate the PIP into their future plans. The major

challenge will be LBNF which needs >1-2 MW of proton power to achieve its goals starting in 2023. In addition, the Muon g-2 experiment, the Muon-to-electron conversion experiment and the Short Baseline Neutrino (SBN) program will have requirements for the lower energy Booster Neutrino Beam (BNB). The linac will be replaced by a 800 MeV superconducting pulsed linac which could be upgraded to a continuous wave facility. The booster repetition rate will also increase from 15 Hz to 20 Hz and other related improvements will have to occur throughout the Accelerator Complex.

Ioanis Kourbanis presented the 700 kW plan. The recycler will require improvements including slip stacking and replacing the vacuum system to reduce losses. Instabilities have been found in the recycler and there is a Task Force studying them. A systematic program has been formulated to reduce losses in the recycler and its status was discussed. E-cloud effects are potentially important and are under study.

Phil Adamson presented the work on recycler losses and instabilities. This work is being actively pursued.

Yuri Alexahin presented the status of recycler instability modeling. The status of computer simulations of the instabilities was reviewed. Work is ongoing and incomplete (the cause and significance of the instabilities are not understood).

The review continued with four breakout sessions (linac, booster, recycler and management), a common breakout session, executive sessions of Q&A with the Fermilab team, report writing and a closeout where preliminary results of the review were presented.

In the closeout the reviewers stated that they were generally impressed by Fermilab's progress, but they had several concerns that led to several recommendations:

1. Fermilab should provide a plan, with a precise timeline and milestones, to establish 700 kW operations. The plan should include the identification of hardware and operational prerequisites needed to achieve the milestones and the plan should be updated as progress warrants. This plan also has to span all of the involved departments (linac, booster, RR/MI).

2. Lab management should continue supporting the instability task force until the operational impact of the recycler instability is understood.

3. Continue to refine the booster proton loss simulations to assess whether additional loss reduction techniques need to be started.

4. A Risk Registry should be maintained, especially in the case of the linac which has old and vulnerable components and which needs to run at least until 2023 when PIP II will begin.

This report includes the findings, comments and recommendations provided in written reports by the individual members of the review team on each of the bullets in the charge to the lab. It also contains several appendices which contain the charge letter to Fermilab, the list of reviewers and the sub-committees of the review and the review's agenda.

Review Evaluations of Charge Points

Are the goals, deliverables, budget and schedule of the PIP properly defined, well understood, achievable and self-consistent?

Findings:

- The committee was presented with the goals, deliverables, budget, and schedule of PIP. These have been modified several times over the past few years, with changes driven by funding considerations and by the evolution of PIP-II.

- The spending to date has been within budget. The yearly budget for PIP has ranged from 8 to 14 M$ for the past four years and the projected budget for the next four years is about 7 to 10 M$.

- The present PIP scope of work has been somewhat reduced, anticipating PIP-II, and its schedule has been stretched to 2019. The linac klystron procurement has been removed, and, and the schedule for the new, upgraded booster cavities has been put on hold while design parameters consistent with PIP-II are defined.

- The PIP has a well-documented database and strong task responsibility structure. The PIP campaign has thirty-two identified tasks. Sixteen have been completed so far and six more will be completed in FY2015. The final tasks are planned to be completed in FY2019.

- The effort available for all Fermilab accelerator projects (e.g., g-2, mu2e) is matrixed, and all projects contend for resources. Although PIP is near the bottom of the prioritization process (in that other projects have firm deliverable dates), PIP has largely gotten the effort it needs.

- PIP is not being done using EVMS.

A yearly plot of the protons needed by the experimental program was compared with the PIP goals. The project is behind in the produced number of protons where they thought they would be at this time. The PIP delivered proton goals are presently modestly below the desired need but are projected to catch up by FY2017.

Comments:

- PIP is being well managed.

- The PIP scope of work done to date has been in budget, and has met technical requirements

- The scope of PIP hardware deliverables are understood, and have been delivered on schedule.

- The PIP work is coordinated with other accelerator activities at FNAL. An updated look ahead for staffing needs for all laboratory accelerator tasks spanning the next four years would be beneficial, covering construction, commissioning and accelerator physics analysis.

- However, the schedule for the deliverable of beam power on target appears to be less clearly defined. The PIP tasks, as defined in its definition documents originating about four years ago, are about half completed. The success of these activities is evident in enhanced beam operations of the accelerator complex for the FNAL experimental program. The remaining parts are going well.

- Now that PIP upgrades are about half finished and most technical issues have evolved, revisit the assessed risk associated with the remaining tasks and make sure the mitigation plans are still valid.

- The risk assessments should be revisited for the Recycler Ring and the Main Injector to make sure they are current and match PIP and PIP-II objectives.

- The goal of delivery of 700 kW on target involves the PIP campaign and work being done in the recycler and main injector. These efforts are strongly coupled, however *the communication between these efforts could be stronger.*

- In the Q&A session, a plan (roadmap) for achieving 700 kW on target by February 2016 was presented. This road map was titled the MI/RR roadmap. The reviewers expressed interest in seeing a roadmap for the entire task of delivering 700 kW on target, and to have it fleshed out with specific requisite hardware deliverables. This roadmap should be considered a schedule to be met by all, and updated as required. This comment forms the basis of the recommendation below.

Recommendation:

- Fermilab should provide a plan, with a precise timeline and milestones, to establish 700 kW operations, including identification of hardware and operational prerequisites. This plan should be updated as progress warrants. This plan should span all involved departments (linac, booster, RR/MI).

Are the plans to address the Linac vulnerabilities and reliability adequate?

Findings:

- Linac projects within PIP are directed more at obsolescence issues and infrastructure improvements than at higher power.

- One aspect of the “pre-injector” PIP program was an RFQ which replaces the Cockcroft-Waltons.

- The drift tube linac modulators depend on many obsolete or nearly obsolete components and are also a major source of linac downtime.

- To address the potential obsolescence of the 7835 tubes (which are still produced by one vendor), Fermilab will build up and maintain a 4-year inventory. Should the tubes become unavailable at any time, Fermilab will invoke a klystron replacement, for which the R&D is nearing completion.

- Modulator design work to replace the failing 201 MHz modulators is a critical necessity. Development work on two technologies is nearing completion, and a final selection is expected in the next few months.

- The linac laser notching system promises to significantly alleviate booster losses. Effective notching of individual linac bunches has recently been demonstrated, and the required laser energy is now determined. Progress of the production laser system should be closely followed, as implementation details for a robust operational production system remain to be sorted out.

- Utilities and infrastructure are included in the linac PIP scope of work.

Comments:

- The linac scope of work is nearly complete and has been successfully done. The remaining portion of work is the modulator replacement.

- This portion of the PIP is well managed and poised to fulfill its requirements.

- There is a short time in the schedule between the last two milestones for the Linac Notcher System. This should be reevaluated to ensure that there is enough time to debug the system and make it fully operational.

Recommendation:

- The linac is old, and needs to run through 2023 at least. Maintaining an up to date risk registry is important, and will be useful in adapting to possible PIP-II delays.

Are the plans for the Booster rf cavities sufficient to support the required beam intensity and extend their life at least until 2030?

Findings:

- There is a two phase plan in place; the first phase is to take the existing booster cavities and refurbish them so that they can support 15 Hz operation. Along with this is the refurbishment of the rf infrastructure (modulators, tuners, bias supplies, anode power supplies) to support 15 Hz operation. The second phase, also a part of PIP, is to replace all of the cavities with a new design. This second phase is on hold while the Fermilab team evaluates the needs of the booster in the PIP-II era to ensure that the newly designed cavity can support all of PIP-II needs.

- The cavity refurbishment program is well underway, and appears to be successful. However Fermilab does not believe that this approach ensures the long-term viability of the program, and thus is planning to move ahead on phase 2 once the input from PIP-II is defined.

Comments:

- The booster cavity refurbishment and upgrade is well managed and will address Fermilab's needs. The delay in design and production of phase 2 is prudent, and while it could delay the completion of the PIP campaign beyond its expected conclusion, it is important to align the design requirements with PIP-II.

- The number of available Booster RF stations and installed cavities required for a specific frequency and beam intensity program was a matter of debate

during the review. A clear set of requirements for each of the operating power regimes should be established.

- Additionally, phase 2 is an important part of PIP. There is still risk associated with the refurbished cavities, which have yet to demonstrate 15Hz operation over an extended time. Thus new cavities of a new design are warranted.

Are the plans to minimize Booster losses adequate and sufficiently understood to allow for the required higher beam power levels? Are beam losses in the Recycler understood sufficiently to minimize machine and tunnel activation and avoid any degradation of the magnetic elements?

Findings:

- Booster losses have been studied and are understood. The committee was presented with explanations and mitigation plans.

- A third of the losses are from injection, a third from notching, and a third at transition and above.

- Fermilab has used various metrics in quantifying the losses. One is a “beam power loss monitor” that computes beam losses from the reduction in intensity and folds in beam energy at the time of the loss to get an overall power loss. A threshold of “power loss” has been set that is not to be exceeded. The second method is a more precise measurement from a distributed loss monitor system.

- Plans are in place to reduce booster losses. These include: an overall increase in rf voltage, moving notching ultimately into the linac, a second harmonic cavity, modification to the cogging strategy, and introduction of well designed collimators and absorbers to control the losses.

Comments:

- Although Fermilab could not present a full quantitative analysis of how each loss mitigation will impact overall losses, there are a sufficient number of well-developed ideas such that the suite of them will allow 700 kW operation. Ultimately, beam power greater than 700 kW should be possible based on the experience gained at 700 kW.

- The introduction of collimators and absorbers to control losses is encouraged, and consistent with the approach now taken at other high power accelerators. This work should continue.

- The use of the “beam power loss monitor” as an operational constraint needs to be reevaluated, and should be done so soon. Firstly, moving to a system of controlling losses in absorbers renders this technique unhelpful for protection as it cannot distinguish between controlled and uncontrolled losses, and secondly, since it has become a part of the operational constraints in booster operations, it may take some investigation to determine how to remove or change this operational “requirement”.

- Several reviewers expressed the opinion that the 2nd-harmonic cavity development carries considerable risk-- no rf cavity of this type (perpendicular bias) has ever operated successfully at high power and ac tuner current. This is one of the important beam loss mitigation measures; if it is delayed a significant amount of beam-loss reduction in the booster will not materialize as planned, putting some pressure on the other measures to work. Success of this development would be a major milestone in rf development.

Recommendations:

- Continue to refine the booster proton loss simulations to assess whether additional loss reduction techniques need to be started.

Are the Recycler plans to overcome beam instabilities and losses during slip-stacking adequate?

Findings:

- A Recycler Instability Task Force was established to investigate beam instabilities and losses during slip-stacking.

- A horizontal coherent multibunch instability with a fast 10-20 turns growth rate has been observed in the recycler when injecting a full-intensity batch. The instability exhibits some properties pointing towards its origin being the electron cloud; but other observations are not supporting this hypothesis and the origin remains uncertain. It is strongly bunch-length dependent and appears to not affect the slip-stacked beam.

- Residual gas in the Recycler is a source of beam loss in the system. The Titanium Sublimation Pumps (TSPs) are at the end of their lifetime. A plan to replace the TSPs is in place. During the FY15 shutdown ~1/3 will be replaced with bake-able ion pumps.

- Beam studies to characterize the losses relative to beam intensity, vacuum pressure and RF parameters have been conducted since October 2014.

- A team was established to develop an instability model that is consistent with observations and to simulate instability thresholds for a range of relevant beam parameters.

- The needed parameters of the injected beam (for efficient slip stacking) are not fully specified and communicated to the Booster group.
- These and other initiatives were initiated at the recommendation of the Accelerator Advisory Committee.

Comments:

- The plans to address slip-stacking need continued work. A detailed plan for the Recycler Stability Task force needs to be developed which covers all aspects of the effort including theoretical simulations and beam-based studies.

- An active damping system may be able to efficiently cure the instability, whatever its cause. The first step in the design of such a system is an understanding of the growth rate vs frequency (mode spectrum; both of multi-bunch modes as well as intra-bunch modes).

Recommendations:

- Lab management should continue supporting the instability task force until the operational impact of the recycler instability is understood.

Are the goals of achieving 460 kW (without the slow-extraction program) in 2015 and 700 kW by mid-2016 technically achievable? Are key risks to both goals identified and mitigation strategies defined?

Findings:

- The present hold-up to running 460kW is evidently a problem with the LLRF in the recycler which has since been addressed. The remaining work to get to 460 kW is commissioning that will take place during this coming February and March. According to the presentation no additional hardware is needed for this and there are no fundamental risks to be addressed.

- Achieving 700kW will need additional rf stations, in that more cycles will need to be slip-stacked requiring a higher booster repetition rate. The needed additional stations (total of 20) will be available after the 2015 summer shutdown, and the plan is to resume commissioning and achieve 700 kW by February of 2016.

- An additional two rf stations will be available in October of 2016, which should lead to better loss control and more stable operation at 700 kW

Comments:

- The format of the plan that we were shown in the Q&A period was helpful, both for communication within the 700 kW effort, for the experimental program, and to the DOE. It should be fleshed out, debated, and used as a dynamic tool going forward. This formed the basis of the reviewers' primary recommendation, which was repeated by multiple reviewers in the close-out.

- These goals are achievable with risks identified and mitigation plans in place. However, the communication between all parties needs to be strengthened and a common roadmap that is dynamically updated should be implemented to quickly address any unanticipated problems.

- There seems to be relatively little push to attempt "2+6" operation as soon as possible to boost proton power at 120 GeV to 400...450 kW. Establishing this mode operationally is an important step in raising the intensity towards 700 kW. Doing this operationally will most likely uncover new issues that need attention.

How well do the current plans for PIP integrate smoothly into future plans for achieving even higher beam power (PIP-II and beyond)?

Findings:

- PIP-II is a plan to replace the present linac with a superconducting linac that accelerates beam to 800 MeV.

- The present completion date for PIP-II is 2023-2024, thus PIP-II, as planned, puts an end-of-life date on the present linac (2024), and therefore changes the requirements of PIP with respect to requiring linac operation beyond this.

- The superconducting linac beam into the booster will be different from the present linac beam, and it is important that work done to the booster in the PIP campaign should be compatible with those changes. This has delayed the design of replacement rf cavities while requirements are defined.

Comments:

- The reviewers believe that the present plans integrate well with PIP-II and beyond.

- The reviewers encourage Fermilab to understand all the risks associated with a delay in PIP-II and have plans to deal with these risks.

- The laboratory's aging HVAC, AC and LCW infrastructure should be regularly evaluated for potential vulnerabilities.

APPENDIX A

Charge Letter to the Fermilab Accelerator Division

Dr. Sergei Nagaitsev
Chief Accelerator Officer
Fermi National Accelerator Laboratory
PO Box 500: 306 (X GLRY)
Batavia, Illinois 60510-5011

Dear Dr. Nagaitsev:

The Office of High Energy Physics (HEP) of the Department of Energy (DOE) has scheduled a review of the Fermilab plans to provide a reliable 700 kW proton beam to the Nova target within the next two years. The Proton Improvement Plan (PIP) is a critical element of this goal because it will improve both the performance and reliability of both the Linac and Booster. In addition, to insure that the Accelerator Complex can meet the needs of the Nova experiment, the Recycler requires improvements in beam stability, beam losses and slip-stacking. The review will occur on January 21-22, 2015, at Fermilab.

This review will address the following issues:

- Are the goals, deliverables, budget and schedule of the PIP properly defined, well understood, achievable and self-consistent?
- Are the plans to address the Linac vulnerabilities and reliability adequate?
- Are the plans for the Booster rf cavities sufficient to support the required beam intensity and extend their life at least until 2030?
- Are the plans to minimize Booster losses adequate and sufficiently understood to allow for the required higher beam power levels? Are beam losses in the Recycler understood sufficiently to minimize machine and tunnel activation and avoid any degradation of the magnetic elements?
- Are the Recycler plans to overcome beam instabilities and losses during slip-stacking adequate?
- Are the goals of achieving 460 kW (without the slow-extraction program) in 2015 and 700 kW by mid-2016 technically achievable? Are key risks to both goals identified and mitigation strategies defined?
- How well do the current plans for PIP integrate smoothly into future plans for achieving even higher beam power (PIP-II and beyond)?

Dr. John Kogut will chair the review and serve as our contact on all aspects of the review. He can be reached at (301) 903-1298 or John.Kogut@science.doe.gov . Please work with him to develop the agenda for the review in accordance with the guidance below. In addition, background materials for the review committee should be posted on a review website at least two weeks before the review. These materials should include PIP planning and execution documents as well as reports from all recent relevant reviews of PIP and the Accelerator Complex.

The first day of the review should consist of presentations by the laboratory and two executive sessions, one at the beginning and another at the end of the day. Breakout sessions in addition to the traditional plenary talks are encouraged. The morning of the second day will be used for a Q&A session followed by an executive session for preliminary report writing; a close-out session will take place in the early afternoon. Preliminary findings, comments, and recommendations will be presented at the close-out.

Each panel member will be asked to evaluate those parts of the PIP in which they have specialized expertise and write individual letters on their findings. The Chairman will collect these letters, and prepare a DOE report based on the information contained therein.

I greatly appreciate your efforts in preparing for this important review. The success of the PIP and improvements to the recycler are essential for the lab's experimental program. I look forward to a very informative and stimulating review.

Sincerely,

James Siegrist

Associate Director of Science for High Energy Physics

c: Michael Procario, SC-25.2
Glen Crawford, SC-25.1
Michael Weis, FSO

APPENDIX B

Reviewers for the PIP+700kW Plan (Fermilab January 21-23, 2015)

1. Rod Gerig (ANL) rod@aps.anl.gov , rod@gerig.org
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8. Sergey A. Belomestnykh (BNL) sbelomestnykh@bnl.gov

Subcommittee Membership of PIP Reviewers

A. *Management* (incl. cost, schedule, evolution into PIP-II)
Seeman, Gerig

B. *Linac* (incl. operations, reliability, intensity goals)
Galambos, Spata

C. *Booster* (incl. RF, losses, operations, reliability, intensity goals)
Fischer, Belomestnykh

D. *Recycler* (incl. slip stacking, losses, operations, reliability, intensity goals)
Wienands, Byrd

APPENDIX C

PIP 700 kW Review Agenda

- Wednesday, January 21, 2015
    - 08:30 - 09:00 Executive Session
    - 09:00 - 09:05 Welcome *5'*

Speaker: Nigel Lockyer (Fermilab)

- 09:05 - 09:35 Introduction *30'*

20 minute talk + 10 min. question/discussion

Speaker: Sergei Nagaitsev (FNAL)

Material: Slides

- 09:35 - 10:20 PIP Overview *45'*

35 minute talk + 10 min. question/discussion

Speaker: Mr. William Pellico (FNAL)

Material: Slides

- 10:20 - 10:40 Break (Comitium Alcove (WH-2SE))
- 10:40 - 11:10 LINAC *30'*

20 minute talk + 10 min. question/discussion

Speaker: Fernanda Gallinucci Garcia (Fermilab)

Material: Slides

- 11:10 - 11:35 Booster Cavities *25'*

20 minute talk + 5 min. question/discussion

Speaker: Dr. Cheng-Yang Tan (Fermilab)

Material: Slides

- 11:35 - 12:00 Booster Losses *25'*

20 minute talk + 5 min. question/discussion

Speaker: Dr. Keith Gollwitzer (Fermilab)

Material: Slides

- 12:00 - 12:50 Working Lunch/Executive Session (Comitium (WH-2SE))
- 12:50 - 13:00 Picture for Reviewers in Atrium

Location: Atrium

- 13:00 - 13:25 Integration into Future Plans *25'*

20 minute talk + 5 min. question/discussion

Speaker: Stephen Holmes (Fermilab)

Material: Slides

- 13:25 - 14:05 700 KW Plan *40'*

30 minute talk + 10 min. question/discussion

Speaker: Dr. Ioanis Kourbanis (Fermilab)

Material: Slides

- 14:05 - 14:45 Recycler Losses & Instabilities *40'*

30 minute talk + 10 min. question/discussion

Speaker: Dr. Phil Adamson (FNAL)

Material: Slides

- 14:45 - 15:00 Recycler Instability Modeling *15'*

10 minute talk + 5 min. question/discussion

Speaker: Yuri Alexahin (Fermilab)

Material: Slides

- 15:00 - 15:30 Break (Comitium Alcove (WH-2SE))
- 15:30 - 17:00 Breakout Session #1: Management
- 15:30 - 17:00 Breakout Session #2: Linac

Location: Snake Pit (WH-2NE)

- 15:30 - 17:00 Breakout Session #3: Booster

Location: ConFESSional (WH-5E)

- 15:30 - 17:00 Breakout Session #4: Recycler

Location: Theory NW (WH-3NW)

- 17:00 - 17:30 Common Breakout Session: Machine interfaces, Injection, Diagnostics, Controls, Machine Protection, etc.
- 17:30 - 18:30 Executive Session
- 18:30 - 19:00 Refreshments (Chez Leon)
- 19:00 - 20:30 Dinner (Chez Leon)

- Thursday, January 22, 2015
  - 08:30 - 09:30 Fermilab Answers to Questions *1h0'*

Material: 0 - Homework Questions (5) 1 - Expected Improvements in Booster Losses 2 - Responses to Oct 2014 AAC Recommendations 3 - Roadmap for Reaching 700 KW 4 - Instabilities: Task Force & Plans 5 - All PIP Milestones

- 09:30 - 10:30 Executive Session - Closeout Preparations
- 10:30 - 10:45 Break (Comitium Alcove (WH-2SE))
- 10:45 - 12:00 Executive Session - Closeout Preparations
- 12:00 - 13:00 Working Box Lunch - Rehearsal
- 13:00 - 14:00 Closeout *1h0'*
- 14:00 - 14:01 Adjourn *1'*

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