To:

From: William Pellico, PIP Leader

Bob Zwaska: PIP Deputy Leader, Fernanda G. Garcia: PIP Linac Manager, Keith Gollwitzer: PIP Booster Manager, Kenneth Domann: PIP Planning Controls

Subject: Proton Improvement Plan

Project Quarterly Summary FY13 Q3

Report #4 July 03, 2013

Project Milestones

This quarter had only level 3 baselined milestones. Most of the milestones for this quarter were part of the Booster damper upgrade and Linac notch effort. Both of these two PIP task were impacted by budget changes to the original baseline plan. As noted in previous quarterly reports, a new RLS with the updated funding profile is being completed and will be used to generate a new milestone timetable.

Level	WBS	Name	Baseline Finish	Forecase Finish	% Comp
3	1.02.02.03.02.15	MILESTONE: L12 Long Notcher Installation & Commissioning Complete	2/21/13	4/22/13	100%
3	1.02.01.02.01.04	MILESTONE: First 6 Bias Supply Transformers Received	4/29/13	4/29/13	100%
3	1.02.03.02.01.02	MILESTONE: Specifications document for Booster longitudinal dampers complete	12/14/12	7/19/13	0%
3	1.01.02.03.04.08	MILESTONE: Linac Notch Complete 1st 2 stage Fiber Amplifier	3/25/13	8/1/13	0%
3	1.01.02.03.06.09	MILESTONE: Linac Notch Optical Cavity Prototype Certification w/IR Optics	2/22/13	8/1/13	0%
3	1.01.02.03.06.10	MILESTONE: Linac Notch Prototype optical cavity certified (on bench)	2/22/13	8/1/13	0%
3	1.02.01.01.02	MILESTONE: Specifications for Anode Power Supply Documented	1/10/13	9/5/13	0%
3	1.02.03.01.01.03	MILESTONE: Booster BPM Specification Complete	3/1/13	9/27/13	0%
3	1.02.03.02.01.07	MILESTONE: Booster Damper prototype board for transverse system complete	3/5/13	10/3/13	0%
3	1.02.03.02.01.10	MILESTONE: Booster Damper prototype board testing complete	5/6/13	12/6/13	0%

In addition to funding RLS issues related to funding changes, there was some delay due to NoVA shutdown labor shortages and one due to vendor. Milestone 1.01.02.03.04 for Linac Notch had to be postponed until Q4 – FY13 (2 months delay) due to vendor.

PIP Highlights by WBS Section

WBS 1.1 Linac

The vulnerabilities associated with the LINAC are the 200 MHz accelerating system, including power amplifier tubes and other associated systems such as the modulator; utilities for power distribution and vacuum systems; better need for reliable instrumentation along the Linac to improve beam transport and realistic machine model supported by real beam measurements. There are four largest elements of WBS Level 2 in Linac which are further subdivided at Level 3.

WBS 1.1.1 200 MHz RF Power System

The 200 MHz RF Power System represents approximately 40% of the total scope of the PIP project. There are 3 level 4 elements which will be described below.

WBS 1.1.1.1 High Level RF

After a long halt this task regained momentum during this quarter. The team gained strength by acquiring an expert on the field of Klystrons, Dr. Craig Burkhart, and head of the Power Conversion Department in the Accelerate Directorate from SLAC. Also, during this quarter, the PIP upper management encouraged to have a face to face meeting between CPI engineers and CPI management, PIP L2/L3 manager, PIP RF engineer and Dr. Burkhart. This long one-day visit was very constructive to create a relationship bond among the members of this project, and discuss important technical aspects of the project, including cost. At the project quarterly meeting with the Associated Laboratory Director for Accelerators and Accelerator Division Head, the team once again received the approval to proceed

with the R&D Klystron. With this endorsement, the money allocated to this task in FY12, when we first tried to initiate this task which was held back by the Laboratory upper management after receiving all the approvals, was once again release to this project. By the end of the quarter, L3 manager worked close with laboratory business department to validate the bid awarded to CPI in September 2012 and collect an update set of documents to proceed with the generation of a purchase order.

WBS 1.1.1.2 Linac Modulator

Fermilab EE Support continued the design for a prototype 9 cell modulator by completing and testing 2 stages, with a 3rd stage currently in production. Once completed, their 3 cells will be tested together in series and data taken by creating different wave shapes, both trapezoidal and square. A simple control system was built that is only capable of testing the 9 cells and does not contain and voltage or current regulation, but will be adequate for testing of the cells for the prototype run. If this configuration is successful, the remaining 6 cells will be built, and if not, changes to the design may be required. More cell testing will occur in July & August 2013 with the goal of testing the 3 cell configuration at the end of this time.

SLAC presented their results from a test to verify cell hardware at the two cell level, both for main and vernier cell, which showed promising results. Fermilab created an initial controls interface document describing the basic requirements of the present modulator and integration of future designs. These tests, combined with the integration information, will act as a stepping stone for the next line of studies, which emphasis the need for more controls simulation and design, as well as future cell testing; on either a 5 cell version, or a complete prototype, depending on funding and other factors. There is future testing of the P2 Marx that is currently being held up by thermal issues with the SLAC modulator, which is delaying some addition ripple measurements that will be presented to Fermilab

To study the effects of the proposed DTI modulator, a study is ongoing to measure the change in output power of a 7835 tube by affecting either driver power level or cathode biasing. Adjusting driver power level was not achievable with the circuit that was used and will either required a different study topology, similar to the type which was recently shown successful with the RFQ 4616 screen amplifier. The cathode bias data was successfully taken in May and analyzed in June, with the results pointing to many problems when attempting to modulate the 7835 via the grid instead of the anode, as is presently done. More studies may occur depending on review of this information, but for now, the prospect of using a single voltage "switch on" modulator, with beam feed forward and ramping up using either cathode or driver modulator is not looking promising.

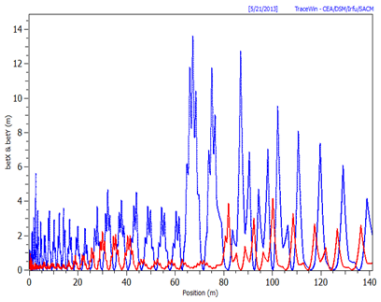
WBS 1.1.1.3 7835 Procurement

At the end of the quarter, the3rd PIP tube test data sheet was received for evaluation and approval. The test results complied with the expectation and the tube was accepted for shipment. This cross quarter boundaries, but the tube successfully was delivered in July 11, 2013.

WBS 1.1.2 Accelerator Physics

WBS 1.1.2.1 Simulations and Studies

Good progress on creating an input file of the Linac DTL using an old version of PARMILA which still has both steering dipole magnets in drift-tubes for an off-line model fitting. A detailed multi-page user manual has been written in conjunction to the code development. Differential orbit studies were performed to help validate and provide code optimization.



In parallel, a preliminary start-to-end Model using TRACEWIN was built, as shown by the figure on the side.

WBS 1.1.2.2 *Not Used*

Some WBS numbering is nonconsecutive at lower levels because of account closings and rearrangements after financial codes were initially established during the period of setting up PIP.

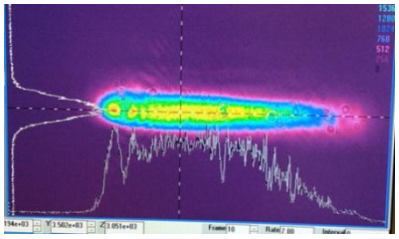
WBS 1.1.2.3 Linac Notch Creation

During this quarter, effort on the Linac Laser Notcher has been toward

1) <u>Optical pulse generation and fiber amplifier characterization</u>

During this quarter efforts were spent on finding a vendor for the final 500W fiber amplifier due to acquisition of the planned vendor. Of all the vendors contacted, one cannot meet spec without some significant NRE and by the end of this period; the team was waiting on additional responses.

2) <u>Beam shaping and transport:</u>

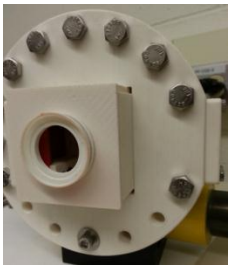


Good progress with beam shaping optics. A successful pulse with narrow horizontally tall vertical profile was obtained which matches the design beam out of the RFQ

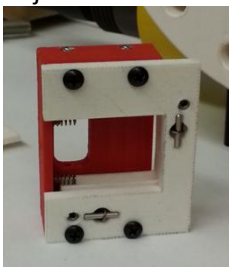
3) <u>Vacuum assembly:</u>

During this quarter, the entire vacuum assembly system, vacuum interface and cavity optical modules, was printed on 3D. The modeling did not revealed any particular problem, rather, helped conceptualize the space restrictions better and helped with planning of what type of machining the team could work with. In addition, the prototype allowed the group to test and calibrate the laser, including bounce patterns,

Bellows connection to MEBT



Mirror holder with adjustments



entry/exit laser clearances, mirror adjustments, etc.

WBS 1.1.3 Instrumentation

WBS 1.1.3.1 Beam Position Monitors

First Linac Level-3 WBS complete (FY13-Q2).

WBS 1.1.4 *Not Used*

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WBS 1.1.5 Utilities

The Linac Utilities, such as power distribution and vacuum systems are composed of mostly 40 year-old equipment beyond its practical service life. There are two Level 4 elements in this WBS.

WBS 1.1.5.1 Power Distribution

Motor Control Center: Little progress was done during this quarter on the programming of the PROFIBUS/SCADA system which was initiated last quarter. The reason is simple, labor conflict with other PIP activities which became priority during this period.

Hatch work: All the pre work required for the hatch installation was complete during this quarter. The prep work involved electrical conduit relocation and lead abatement and relocation of the building cross beam. The purchase order for the hatch was placed early May. We expect the delivery to be in the next quarter. On the previous report was mentioned that the team was considering moving the LINAC substation downstairs at the time of the hatch installation. After some more planning and discussion, the relocation of the substation to the Linac basement area will not happen at this point in time.

WBS 1.1.5.2 *Not Used*

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WBS 1.1.5.3 Vacuum System

The 400 MeV beam valves were delivered early in the year. However, these valves will be installed in the tunnel during small shutdowns as Linac has been operational since middle of FY13 Q2.

WBS 1.2 Booster

Part of the PIP effort for the Booster Accelerator is to address the increase proton beam flux that will be demanded by the Fermilab program in the upcoming years. The increased flux will be achieved by providing beam on more/all of the Booster cycles; certain equipment will increase from an average 7.5 Hz to 15Hz. Overheating of old components is a major concern; several Booster PIP tasks are to upgrade/refurbish equipment to run at 15 Hz.

The aging original equipment and infrastructure of the Booster are vulnerable due to obsolescence and increase wear due to the increase of flux. Some of the PIP effort is to replace these possible reliability problems.

WBS 1.2.1 RF

WBS 1.2.1.1 Anode Supply

The design work, to be based upon the Main Injector anode supplies, will be done when manpower becomes available in FY13. The engineering is expected to start during the four quarter so that purchasing can begin early in FY14.

WBS 1.2.1.2 Bias Supply

The delivery of the heat sinks, silicon-controlled rectifiers (SCRs) and water-cooled transformers have begun during the second quarter. Work on the heat sinks will commence soon. The retrofit of the first bias supply will hopefully begin when manpower becomes available after the accelerator shutdown concludes.

WBS 1.2.1.3 *Not Used*

Some WBS numbering is nonconsecutive at lower levels because of account closings and rearrangements after financial codes were initially established during the period of setting up PIP.

WBS 1.2.1.4 Cavity Test Stand

The desired RF equipment from the Tevatron is not available to power the test stand. Due to the lack of funding available to purchase new power supplies, availability of personnel and that the cavity test stand would arrive too late to alleviate conflict in using the existing test stand, the cavity test stand task will not be done.

WBS 1.2.1.5 Cavity and Tuners Refurbishment

The refurbishment of the six and seventh cavity tuner sets were completed this quarter. The time it takes to refurbish and test each set has averaged over the last three sets is a little more than ten weeks. With each

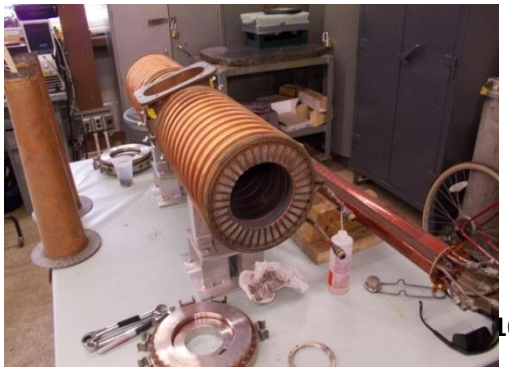

Figure 3 Tuner with suspect RF leak being reworked

refurbishment, we are learning how to make the process better.

Last quarter, the second cavity-tuner set had been removed since it was thought to have an RF leak. Upon the test stand, the set tested fine. Further tunnel investigation showed an RF leak on the adjoining cavity tuner set (which was the first cavity-tuner set refurbished). The front tuner was replaced and further tests showed no problems. The second set was then re-installed in another location and there have been further major problems wither cavity-tuner set.

WBS 1.2.1.6 New Tuners

Previously, a high power test stand for ferrite cores showed that one of four different core sets (two different permeabilities from two vendors) was acceptable. The acceptable core samples have been implemented into a tuner and been certified. A purchase order for one set ferrite cores was done; delivery of these new cores occurred last quarter. However, only four of the nearly sixty cores passed our high power test. The vendor made several batches of these ferrite cores and the cores that passed came from the same batch. The vendor believes that the chemistry/method of this particular batch is understood and is making new set of cores according to this recipe which will be delivered early next quarter. The vendor also believes that they can produce the high permeability ferrite cores; a small order of five cores is being done to be delivered next quarter. The two sets of ferrite cores will be tested (and hopefully certified) next quarter. Additional material to construct several tuners has been purchased.

WBS 1.2.1.7 New Cavities

Comparison of a model developed for the current Booster RF cavities and the temperature measurements taken as part of the refurbishment task continues. Further tests of cooling rates will be done to be compared with the simulation. A preliminary look into making small improvements to the cavity-tuner design is being done.

WBS 1.2.1.8 Cavity 1013

This low priority task requires the same manpower as the refurbishment task; discussions are on-going to locate manpower to complete this cavity. Some resources were found for a short period and work has been done to do a preliminary assembly of the previously rejected cavity parts from the 1970's. The next step will be to vacuum certify the partial assembly.

WBS 1.2.2 Accelerator Physics

WBS 1.2.2.1 Simulations and Studies

Studies were done before the shutdown began. The main person doing the studies and analyses has left. The person was able to visit for several weeks at the end of second quarter and able to train/work with two individuals identified to be the main and secondary Booster optics. This quarter, it was announced

that the main Booster optics person will go to CERN for a year. We are negotiating for a replacement person.

Since the Booster is operational, work is on-going to smooth the orbit to an ideal orbit (see WBS 1.2.2.2) and measure the optics.

WBS 1.2.2.2 Alignment and Aperture

Part of the study period prior to the shutdown was devoted to moving a magnet and re-measuring the local aperture. The increase in aperture seen is in agreement with the expected predictions. A second magnet move was done conclusion of the shutdown during this quarter. Measurements of the aperture were done after the magnet move as well as in regions where the Booster machine was worked upon during the shutdown. The magnet move has been verified to have increased the aperture. Other areas have been identified where the alignment of components will be done in the near future; it is possible that a minor move of a combined function magnet will occur next quarter. The centers of the apertures have been designated as the ideal orbit (see WBS 1.2.2.1).

WBS 1.2.2.3 Booster Notcher

The system was fully commissioned this quarter. Procurement of parts for upgraded notcher kickers and associated power systems continues. Assembly of the power systems will continue after the accelerator start-up. A completed short kicker magnet has been delivered from Technical Division to Accelerator Division for testing.

WBS 1.2.2.4 Booster Cogging

Based upon the current cogging equipment, initial code development for the new magnetic cogging method-system is in progress.

WBS 1.2.2.5 Booster Collimation

The collimation task is to control Booster beam loss after implementing the above notcher and cogging systems.

WBS 1.2.2.6 Radiation Shielding

Beam studies concerning the beam loss profile and measurement of beam loss radiation through penetrations has been done. There are on-going discussions of the results of the studies and simulations. The analysis and write-up of the beam studies concerning beam loss radiation is nearly finished. The next step will to continue discussion with Accelerator Division ES&H. Once accepted by ES&H, they will write the Booster Shielding Assessment for the PIP proton flux goal.

WBS 1.2.3 Instrumentation

WBS 1.2.3.1 Beam Position Monitors

Design work for the Booster beam position monitor system will begin after completion of the Linac beam position monitor system.

WBS 1.2.3.2 Dampers

Studies to verify damper design choices were not done prior to the shutdown and had been postponed to the accelerator start-up period. Initial studies have been performed this quarter with an Instrumentation engineer being assigned to work on the damper system.

WBS 1.2.4 *Not Used*

Some WBS numbering is nonconsecutive at lower levels because of account closings and rearrangements after financial codes were initially established during the period of setting up PIP.

WBS 1.2.5 Utilities

WBS 1.2.5.1 Low Conductivity Water System

The task is done.

WBS 1.2.5.2 Power Distribution

This quarter, one of the two previously purchased transformers was installed for the east side of Booster. The second transformer is being held as a spare for the recently installed one. If another transformer is purchased, the second transformer will be installed. The purchase of transformers occurred earlier than planned due to the result of an inspection of one of the east transformers; it was recommended replacing the transformer before running the Fermilab physics program.

WBS 1.2.5.3 Vacuum System

The aged components will be replaced as opportunities present themselves with downtime of the Booster. Previously purchased vacuum equipment awaits opportunities for installation.

WBS 1.2.7 Solid State Upgrade

The Booster RF solid state upgrade has been going on piecemeal for several years with purchasing of enough components to assemble the main elements of the solid state system: power amplifier, driver module and modulator for several stations. With the Proton Improvement Plan, we have been able to buy components in quantities. The East gallery of the Booster had been previously upgraded in FY12. The West Gallery upgrade was completed early in the second quarter and prior to the start-up of the Booster. The spares of the three main elements were also assembled during this quarter.

PIP Budget – Costs and Obligations Updates (FY13 Q3)

The previous Q2 report mentioned concern over FY12 carry over for several items. The decision has been made by laboratory management that PIP be allowed to now use those funds as originally planned.

The carryover is currently reflected in both the OBL and RIP. These were not shown in the previous report because of their undetermined status. Notwithstanding the carryover, the budget and spending for FY13 Q3 has been tracking the schedule. However, tasks with significant cost and labor, such as new tuners, new Booster cavity and 201 MHz Klystron, will likely need to have schedule modifications in the outlying quarters. These items have experienced either vendor or budget issues as discussed in their respective WBS summary above. Another issue has been the labor shortages due in part to the NoVA shutdown. Several tasks were expecting a bump in labor hours during the quarter that never occurred.

Table 1 Summary of PIP FY13 Q1 Budget

FY13 PIP OBL BUDGET K$	OBL BUDGET	YTD OBL	RIP	BUDGET BAL
M&S	3,783.9	1,169.2	2156.9	457.8
Labor	5,128.1	3,755.2		1,372.9
FY13 Sums (End of Year)	8,912.0	4,924.4	2156.9	1,830.7