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Proton Source Workshop

Morning Session Minutes, December 7, 2010

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Agenda

07 Dec 2010, 08:30 | **Operational and Accelerator Physics Issues** | **Users Center Piano Room**

Start	Title	Author(s)	Topic(s)	File(s)	Length
08:30	*Workshop Purpose, Charge Protocol* *Defining the Objectives of the Proton Improvement Plan*	*Bob Webber* *Stuart Henderson*	*Workshop Purpose* *Proton Improvement Plan Objectives*	*Beams-doc-3735-v1* *Beams-doc-3739-v1*	*00:30*
09:00	*Overview of the Proton Task Force*	*Bill Pellico*	*Task Force Charge*	*Beams-doc-3731-v1*	*00:30*
09:30	*Preaccelerator*	*Dan Bollinger*	*Machine Operating Description*	*Beams-doc-3734...pdf*	00:20
09:50	*Break*				00:20
10:10	*Linac*	*Fernanda Garcia*	*Machine Operating Description*	*Beams-doc-3729-v2*	*00:30*
10:40	*Booster*	*Todd Sullivan*	*Machine Operating Description*	*Beams-doc-3737-v1*	*00:30*
11:10	*Booster Beam Notching and Cogging*	*Bill Pellico*	*Booster Cogging*	*Beams-doc-3740-v2*	*00:30*
11:40	*Linac and Booster Radiation Shielding Status, Plans and Constraints*	*John Anderson*	*Proton Source Radiation Limitations*	*Beams-doc-3732-v1*	*00:20*

Notes on the Discussion

Webber: Workshop Purpose, Charge, Protocol

Bob Webber opened the workshop by stating that its main purpose is to highlight the condition and performance of the Linac and Booster in order to determine what should be done to keep the machines running for at least 15 more years. He stated that the driving force behind this effort is the anticipated demand for protons from current and future experiments.

Bob noted that by the end of January 2011, a plan will be devised that specifies the target goals for Booster and Linac operations (proton flux and rep rate) and outlines in great detail what activities should be done to meet those goals, when it should be done, why it needs to be done and how much it will cost to get it done. Bob mentioned that he was chosen by Roger Dixon to develop this plan, and he has enlisted Bill Pellico, Dave McGinnis and Valerie Lebedev to assist him.

Bob realizes that the most important aspects of a justifiable and executable plan are to choose the elements of the plan correctly and carefully, and to completely identify the manpower and time accurately that are required to pull off each element in the plan. Thus, the plan will include a resource loaded schedule (RLS) that addresses the manpower needed and the time frame in which the plan can be completed.

Bob also mentioned that th recent Proton Source Task Force Report that addressed hardware system concerns given the expectation of another 15 years of operational life and upgrades to Booster systems to achieve a 15Hz repetition rate, but that report did not tackle increasing proton flux. The new plan must focus on both issues - proton flux and accelerator systems viability.

Henderson: Defining the Objectives of the Proton Improvement Plan

Stuart Henderson began his talk by pointing out that the outcome of the workshop is a Proton Improvement Plan (PIP) that meets the goals of Proton Source throughput while maintaining good availability at acceptable residual activation. The PIP objectives are:

- Scope, cost, schedule and human resource requirements
- Proton Throughput requirement
- Good availability
- Acceptable beam loss

The PIP should also address any necessary hardware modifications, increased repetition rate and improved beam. The goal of PIP is to ensure viable operations until 2025.

Stuart went on to say that we will not afford to eliminate every vulnerability; thus the PIP should include backup plans for these vulnerabilities. The plan should identify all possible risks and how these risks will be mitigated, as well as “hard limits” beyond which it is too costly to precede.

Stuart mentioned that his personal thoughts are that we have to deliver on our commitments to the physics programs. He said that if there’s something that can’t be done, it should be noted and stated why.

Most importantly, Stuart showed a performance timeline which mapped the proton throughput needed for each current/future experiment over the next decade or so. **The bottom line is the PIP should deliver:**

- **1.8e17 pph at 12Hz repetition rate by May 1, 2013**
- **2.25e17 pph at 15Hz repetition rate by January 1, 2016**
- **Linac/Booster availability > 85% while maintaining residual activation at acceptable level**

Discussion:

- What is the assumed # of protons/cycle? Plan should give this parameter.
- Need to have a consistent way to measure efficiency (e.g. Booster toroids between MI toroids). Mu2e is designed for the perceived output from Proton Source. There is a lot of flexibility for the experiments.
- 2013 is very ambitious and why no mention of a Run II extension? It is third scenario which is not in Stuarts's consideration. 2013 is staring us in the face.
- G-2 utilizes new machinery in the Recycler. Not clear how to do G-2 with MI and Recycler. There are a lot of uncertainties.
- Is DTL replacement off the table completely? You guys should figure out the goals and necessities within the given time frame. As a practical matter, it is hard to argue for replacing DTL because of time and money.

Pellico: Overview of the Proton Source Task Force

Bill Pellico presented an overview of the activities of the Proton Source Task Force. The task force was formed in 2008 to analyze the operability of the Proton Source to meet increased demand of the machines for the next 15 years. The task force compiled a report (TFR) that covered three main issues: spares, manpower and reliability of the Proton Source. The TFR only addressed increasing Booster repetition rate to 15Hz, not proton throughput increase.

Bill noted that presently the Proton Source provides 1.1e17 pph because of many upgrades that came from the 2004 Proton Plan. The projected 1.8e17 pph is no small task, and some think it is impossible.

The TFR identified two systems that stood out as major problems, Booster magnets and the Cockcroft Waltons in the Preaccelerator. Bill went through a list of suggested upgrades and modifications that are in the TFR and gave a reason why and status report for those that are in progress. He also provided a list of the major issues that still need to be addressed. Please see the presentation for a list of these activities.

Suggestions were made to perform repetition rate experiments to see what breaks first in order to learn the real limitations of the systems.

Discussion:

- Repetition rate should be addressed first, before throughput and proton requirements. Upgrades are required to go to 15Hz. Has to be done the right away. This gives flexibility to

other users rather than only NOVA. Manpower resources will be limited during NOVA shutdown. e.g. cooling in the bias power supplies cannot be done until NOVA shutdown. Solid state can be done before shutdown. High repetition rate tests have been proposed in the past but never done because of fear that old equipment failures would negatively impact the ongoing program. But we need to try to run to identify the problems. Beam loss activation is an issue. What is the level that is acceptable in activation and radiation? What is the allowable loss limit for the test? For all hardware system improvements, we will design for 15Hz and not 12Hz etc.

Bollinger: Preaccelerator Machine Operations

Dan Bollinger opened his talk by stating that the Preaccelerator needs two sources for redundancy, one H- and one I-. After explaining how the sources work, he stated that the source is inefficient (9mA/Kw) and has a lifetime of approximately 3.5 months. He explained that the source ages fast because high arc current causes erosion of the cathode and clogs the aperture or shorts the anode to the cathode. The source has to be pulled out to fix this problem. Dan pointed out that an upgrade is currently in progress to copy the Brookhaven source (67mA/Kw efficiency) design that will help with the source aging.

They were able to get a source to run for 4 months, which is a record. There are other source issues that still need to be worked out. For instance, replacing a column for the I- source was a brutal and timely process, and there are still unknowns as to why it took so many tries to get a source to survive after the column replacement. Many of the reliability issues are not understood yet.

Dan reminded everyone that the Haefely (Preaccelerator high voltage power supply) experts recently retired and that was a loss of 40 years of experience. The current operators/techs are trying to understand the maintenance that is required to keep operations going. The combination of failures in the Haefely system and the limited source experience puts us at significant risk.

Discussion:

- Once the RFQ is installed, the Cockcroft Waltons are removed for good. The RFQ helps address a lot of the issues that were present with the Cockcroft Waltons. RFQ is scheduled to be installed in 2012 shutdown.
- Biggest concern is operability and maintenance/improvements of the source.

Garcia: Linac Machine Operations

Fernanda Garcia started her talk by noting that the Linac just celebrated its 40th Birthday of providing beam with 90% availability for operations.

The Linac operates at 15Hz and only sends beam when requested. NTF takes spare cycles when available, they get 3-4 hrs of beam per week but not continuously. The Linac group tries to maintain 34mA or better. Fernanda gave a description of how beam is requested and how the Linac operates (see presentation).

Fernanda mentioned that majority of Linac issues are due to the source and most of the beam is from the H- because of problems with the I-. H- source is at 52mA, thus Linac output averages 33.9mA with efficiency of approximately 74.6%. She also noted that the Proton Plan funded a LLRF upgrade which improved amplifier regulation, provided phase stability and reduced beam loss. Beam sent to dump reduced from 10us to 2us.

She mentioned the biggest concern is activation. One major radiation concern is the 400MeV dump which has a vacuum leak. A titanium window was used to separate the vacuum spaces, but this causes more activation. It is believed that the leak has gotten worse so a working group was formed in February 2009 to come up with a long term solution.

Alignment of the Linac is difficult because of the mechanical design of cavities and quads. There are spots in the line that will be up to 700mR on contact at 15Hz.

Discussions:

- Instrumentation upgrade needed to measure beam lattice. HE is not fully instrumented and wire in dump area not working. Effort there to reduce beam loss. Tune by taking base line trajectories and try to match to it.
- Alignment is a tricky issue because of mechanical design of cavities and quads. There are spots in the line that get up to 700mR on contact at 15Hz. Losses in Booster are a more serious issue than in the Linac.

Sullivan: Booster Machine Operations

Todd Sullivan reported that the Booster repetition rate is 7Hz and includes two initial non-beam cycles to pulse the Proton Source prior to the beam cycle. See the presentation for more Booster cycle operating parameters. Beam efficiencies are normally 90%. Booster throughput is limited by shielding assessment and repetition rate. Gradual improvements have increased throughput and beam efficiency over the last decade. The Booster operates at 1e17 pph now. The MCR warning limit is 1.09e17 pph, the operations limit is 1.22e17 pph and the beam permit is 1.35e17 pph.

Radiation is huge issue in Booster. Radiation damages tunnel components, which is noticeable in cables, hoses, high voltage insulators, vacuum seals, etc. Booster is experiencing increased above ground activation. Booster RF experiencing more cavity and tuner failures and limitation is 100mrem to keep the limit below radiation safety's limit for a safety escort. ALARA planning is need for any repair > 100mrem. One hour of cool down needed before Booster accesses. Typical department radiation exposure is now 1220mRem, not including mechanical support.

Discussion:

- Booster RF needs to be upgraded for reliable running.
- Where does beam loss happen in Booster cycle? Injection, transition and cogging and notching (50%). Collimation of the Linac beam and fast kicker will lower losses.
- Major problem is strong space charge.

Pellico: Booster Beam Notching and Cogging

Bill Pellico explained how cogging and notching work in the Booster. To do NOVA, all the cycles have to be cogged. LLRF determines where to put the notch depending on the revolution marker to reduce the amount of cogging. Booster needs to fire 5 extraction kickers in a 3 bucket gap. Kicker rise time is 28ns. Want to keep losses down at extraction. Booster syncs the gap to a Main injector marker. Booster will extract +/- 1 bucket because RPOS may move the beam by +/- 1 bucket. This will be a problem for NOVA. The proposed solution is to make new phase lock system in LLRF upgrade.

Overall, dynamic aperture is an issue. There are higher losses on the cogged cycles and there's lots of hardware to maintain for this system. The system works better than expected, but an upgrade is needed.

Discussions:

- A fast enough kicker would eliminate the cogging issues.
- There is no space or aperture to kick 700 MeV beam into some dump. A specific dump design for the notcher rather than using the collimators.

Anderson: Linac and Booster Radiation Shielding Status, Plans and Constraints

John Anderson reported the beam intensity limit is based on the FRCM and the accelerator safety envelope (ASE) based on 10mrem accident to the public. The intensity limits are DOE approved and may or may not be equal to the operating limit. Three permit limits are established to stay within the safety envelope: MCR limit which is the beam permit based on ASE and approved by the division head, operating limit which is about 5-10% less than beam permit and warning limit which is some % less than operating limit.

John stated that the 1993 Linac shielding assessment gave the following limits that exceed future programmatic needs:

- Operating Limit: 3.54e17 pph
- MCR Limit: 3.34e17 pph
- Warning Limit: 3.185e17 pph

There are no plans to do anything further, except continued monitoring. The 1998 Booster assessment sets current operational and ASE limits to 1.8e17 pph, the MCR operation limit is 1.22e17 pph and the warning limit is 1.09e17 pph. The MCR warning limit can be raised to 1.5e17 pph.

The main fear about increasing limits is tripping machines downstream. There is not sufficient shielding in Booster to prevent FRCM limits from being exceeded anywhere around the ring under accident conditions to meet current goal of 1.35e17 pph. Routinely see radiation in offices and stairwells in the West Booster Tower.

John noted that machine modifications may change the loss locations and invalidate the assessment. Machine modifications have occurred since 1998 so there's a question as to how the validity of the current Booster assessment. There's limited information about penetration dose rates and studies. A current assessment is in the works, which assesses for 2e17 pph under Roger Dixons guidance. The assessment is due January 2011.

Discussion:

- Keeping dose rates down important because 100mrem requires ALARA and 1000mrem requires ES&H head approval.

Appendix 1: Abbreviations

These abbreviations are utilized:

Resource Loaded Schedule	RLS
Proton Improvement Plan	PIP
Protons per hour	pph
Task Force Report	TFR
Fermilab Radiation Control Manual	FRCM
Main Control Room	MCR
Accelerator Safety Envelope	ASE