



Review Closeout



Review Committee:

Eric Prebys (FNAL), chair , presenting
Michael Plum (ORNL),
Izumi Sakai (Fukui University, JPARC),
John Thomason (RAL),
Gianluigi Arduini (CERN).



Mandate



The mandate of the “Review of PS Booster with Linac4” review committee is to give advice and guidance to the project management by making assessments and by providing recommendations on the modifications and operating modes foreseen for the PS Booster with Linac4.

In particular the committee should provide feedback on the following issues:

- Assess the technical approach and identify possible hidden showstoppers and problems.
- Provide feedback on whether operational aspects are sufficiently covered, based on practical experience at other facilities
- Provide advice on further simulation and design studies that may be required.
- Review concepts on the operation of the PSB with Linac4 within the CERN accelerator complex.
- Provide advice on the finalization of the injection region layout including the proposed reduction of the machine acceptance.
- Estimate whether the proposed schedule and resources are realistic.



Assess the technical approach and identify possible hidden showstoppers and problems.



- For the most part, the proposed Linac4/PSB injection is *in principle* no more complicated than similar systems elsewhere, and we find no reason it shouldn't work.
- Locating the chicane magnets outside of the (conductive) beam pipe is unique, and possible effects on the field quality should be carefully evaluated. (see later comments)
- The operational challenges of both the proposed chopping system and the four separate injection regions are significant, and should not be underestimated.



Provide feedback on whether operational aspects are sufficiently covered, based on practical experience at other facilities.



- N.B. The most complex operational aspects are the ones you already do. If those were being proposed for the first time, we would be much more skeptical.
- The proposed longitudinal painting scheme is extremely complex, considering the rather marginal benefit.
 - The advantage was not clearly quantified in the presentations.
 - We recommend that this capability not be implemented until all other aspects of the system have been reasonably optimized.
 - Careful thought should be given to the controls and diagnostic interface for this system.



Operational aspects (cont'd)



- Generally, charge exchange injection systems require careful tuning, and the concept of repeating this four times is rather daunting.
 - It's important to provide enough instrumentation to sufficiently characterize the injection regions that repeatability can be achieved.
 - This includes the beam measurement systems discussed, as ways of monitoring the targeting at the stripping foil (see separate instrumentation comments)
- The loss on the head and tail dumps within the septum is significant, and the resulting activation will likely make the system unserviceable
 - Consider an external stop.
 - A spare should be constructed
 - A “hot handling” procedure will probably be required.



Operational aspects (cont'd)



- The load on the stripping foil is lower than elsewhere, and the foil is more likely to be damaged mechanically, than by beam.
 - Don't need a large number of foils available.
 - Consider a separate system to rotate in the beam screen, rather than exercising the carousel.
- In addition to the already complex operation of the linac/PSB, you are adding a chopper (about which we heard very little) and the new injection system
 - Ion sources are generally less reliable than proton sources (assume this is discussed in separate Linac review)
 - A very careful evaluation of the reliability impact is recommended.
- In light of the single pulse accident risks, it's important to have a robust, prompt abort if the pulse to any one booster ring exceeds the operational maximum.



Provide advice on further simulation and design studies that may be required.



- We feel that at least at this review, the case has not been strongly made that “the PSB is space charge limited”.
 - The Fermilab linac energy upgrade improved performance, but did not achieve the predicted increase.
 - We recommend efforts be made to get better agreement between space charge models and measured emittance growth.
 - N.B. Space charge studies are much easier *after* you have an H-system.
- Specifications should be made as to the field quality required by the chicane magnets, in terms of allowed closed orbit distortion and tune shift, and this should inform the design of the magnets and power supplies.
 - Must consider effect of beam pipes
 - Field quality must be maintained during ramp down
 - Discussion should include magnet and power supply experts
 - Most existing systems use single power supplies to insure field matching.



Further studies (cont'd)



- Injection into an accelerating bucket introduces significant operational complexity, and we were not shown any strong motivation.
 - A study should be made of the benefits of this scheme versus a much simpler capture scheme.
- Besides linear painting, other wave forms should be considered.
 - For example, J-Parc uses parabolic painting
 - Important that any painting scheme preserve the ability to quickly move beam off of the foil, since the chicane ramp down is quite slow.



Review concepts on the operation of the PSB with Linac4 within the CERN accelerator complex.



- Again, if we were being shown this for the first time, we would be very skeptical of the ability to generate this large variety of beam types reliably, but for the most part, this has been admirably demonstrated.
- Consideration should be given to how the low intensity bunches are produced.
 - Lowering intensity through a foil “sieve” is very straightforward on an H- linac, even on a pulse by pulse basis at these rep rates.
 - If partial turns are required, careful consideration should be made of the implications for the feedback loops and instrumentation.
- Consider using the transverse damper to blow the emittance, when required.



Provide advice on the finalization of the injection region layout including the proposed reduction of the machine acceptance.



- Again, carefully evaluate the quality requirements for the chicane magnets, both uniformity and higher harmonics, including the effects of eddy currents in the beam pipes.
 - For example, the septum within the chicane can introduce sextupole moments.
 - This should include the requirements on the power supply regulation
- Aperture restrictions were discussed at some level, but this clearly needs more thought
 - The potential benefits of a collimation system as a means to reduce extraction losses should be carefully evaluated.
 - The alternative or addition of collimation in the injection transfer line should also be considered. *It's much easier to collimate an H-beam than to construct a full collimation system (repeated four times) in the ring.*



Estimate whether the proposed schedule and resources are realistic.



- The committee was not given much information on schedule and resources.
- Based on previous experience, the proposed time scale appears “reasonable”, as does the three month commissioning period.
- It’s important to allow sufficient time to commission the new RF system in view of all the complex synchronization required.
- A more thorough review of the cost and schedule is recommended
 - Internal is probably sufficient (or even superior).



Instrumentation



- In view of the complexity of repeating the injection system four times, the importance of accurate beam characterization cannot be overstated.
- The proposed beam line instrumentation, including the laser profile/emittance monitor, is recommended, and should possibly include a second laser monitor closer to the PSB.
- Instrumentation at the injection region is extremely important. Suggestions for consideration include:
 - Monitoring the electrical signal from the foil.
 - A system that can monitor both the incoming and circulating beam at the injection region is desirable (perhaps a large luminescent screen)
 - Instrument H0/H- dump with view screen and current measurement. This helps tune injection and also quickly identifies foil problems.
 - Ability to physically view foil is desirable.
- BPM's near the end of the injection line, and first turn BPM's near the injection region are important.



Additional comments



- To go above present operational intensity, the C02 RF system and transverse damping system will require upgrades.
 - It's important that these be adequately funded.
- Consider whether a chromaticity correction system may be required with higher intensity.
 - This would be a very complex system.
- Considering the beam load on the head and tail dumps, methods of minimizing the head and tail should be investigated.
 - Consider chopping them out at lower energy, for example.



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