Comment on the PIP-III RCS Location

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Abstract. The Booster replacement RCS should be located within the Main Ring circle near MI-60, with injection into the Main Injector in the MI-60 or MI-62 region.

COMMENT

The next major upgrade for Fermilab is a Booster replacement, which could be an 8-GeV RCS or an 8-GeV Linac. [1, 2, 3, 4, 5] In both cases the plan is to direct the proton beam toward injection at MI-10 or RR-10. (see figure 1) However, MI extraction toward the LBNF target plans to use MI-10, which makes use of the MI-10 straight section for injection impossible.[6] The fallback for injection would be to inject into the Recycler Ring at RR-10, just above MI-10, and use the Recycler Ring (RR) as an initial accumulation ring for both Linac and Booster scenarios.

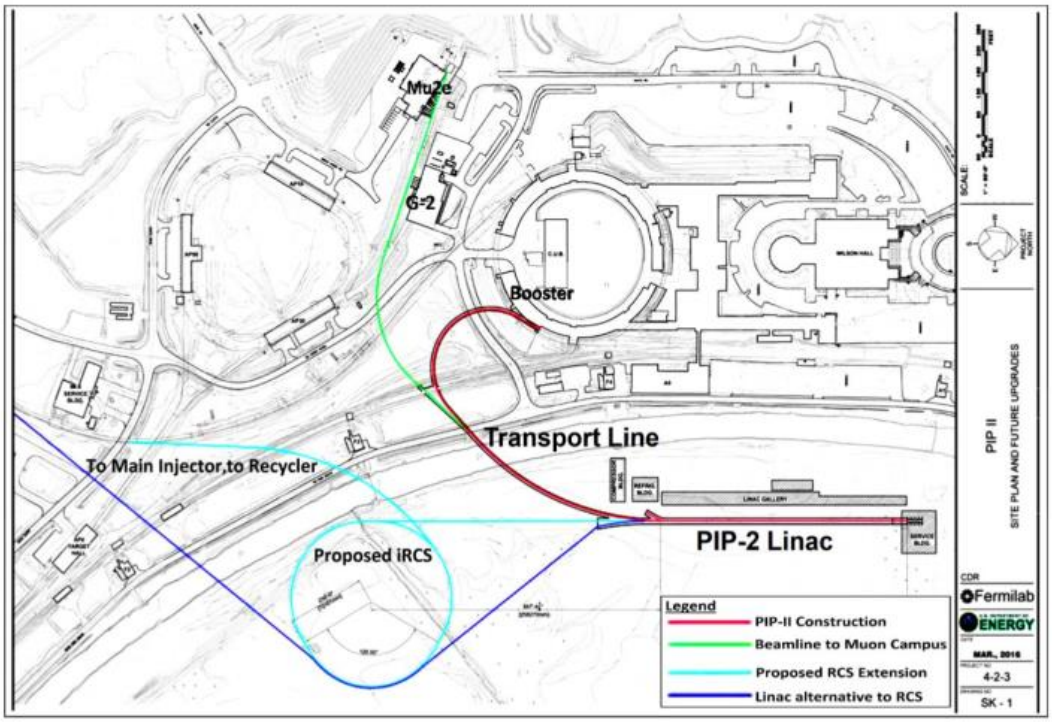

FIGURE 1. View of a RCS booster replacement with transports from PIP-II to the ring followed by a transfer line to the Main Injector. An 8 GeV Linac Booster replacement could follow the Blue lines shown above. Both versions are directed toward injection at the MI-10 straight section. [4]

If the RR is not used for accumulation, the recycler would be used as a transport line from RR-10 to MI-22 or MI-30 for injection into the Main Injector (MI). These are the nearest straight sections suitable for injection following MI-10, but they are about a kilometer downstream. This would work for protons from the RCS but not for H^- from the Linac, since H^- ions would be stripped by the magnetic fields in the Recycler dipoles. It significantly restricts the proton beam to 8 GeV energy, because of the fixed Recycler magnetic fields, and restricts the proton emittance to the smaller acceptance of the RR.

RCS Booster Replacement versions are also being developed that inject into the MI at higher energies, to increase potential intensity.[5] These would require replacement of the RR-10 to RR-30 transport by entirely new magnets. This is ~ 1km of transport, and would be a non-trivial cost.

As a possibly more practical alternative, we suggest moving the 8 GeV RCS to a location where injection into MI-60 (or MI-62) is possible. A possible layout is shown in Figure 2, where the 8 GeV ring is placed just outside the MI near MI-60, where a fairly direct transfer into the MI is possible (similar to the old Booster-Main Ring transfer). As shown in figure 2, the PIP-II linac is extended to 2 GeV, followed by a transport to the new ring for H^- injection and acceleration. An important advantage is that the Recycler can be completely avoided, and the output energy of the RCS can be tuned to any value, with an emittance matched directly to the MI. If the RR is required for beam accumulation or storage (or rf manipulations), a transfer line to RR-60 or RR-62 can be readily added.

This requires the added ~500m transport from PIP-II to the new ring, which should be affordable, and is not longer than the transports it replaces in the previous version. (The previous ring to MI-10 transport weaves itself through relatively occupied transports and utilities of the Fermilab complex.) It enables the considerable savings of eliminating the need for a RR-10 to MI-22 (or MI-30) transport.

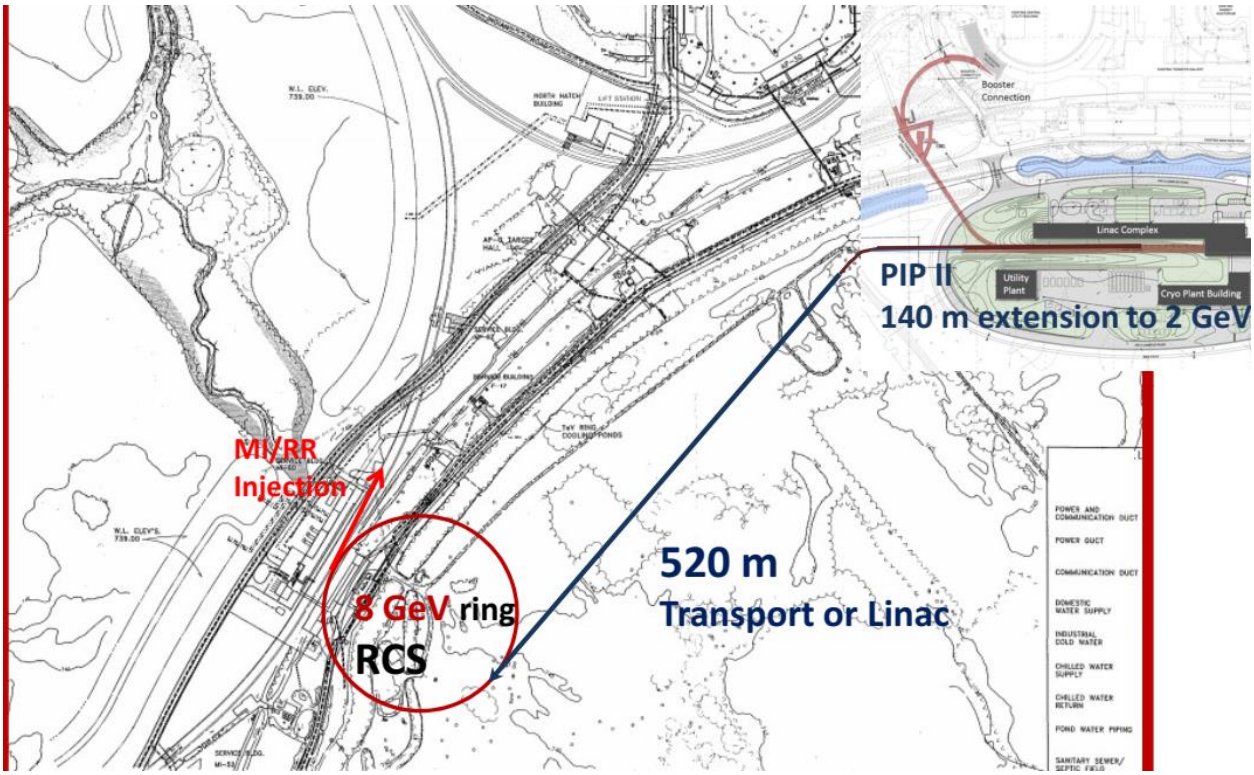

Figure 2. Alternative layout of the PIP-II to RCS to MI facility. The PIP-II Linac is extended to 2 GeV, followed by a ~500m transport to the new 2-8 GeV storage ring. Injection into the MI would be at MI-60 or MI-62. The 500m transport could also instead be used for a 2→8 GeV Linac, which would inject into a fixed field 8 GeV ring for accumulation, to be followed by injection into the MI.

This geometry could be adapted to a Linac-based Booster replacement. The 500 m transport could include a 2--8 GeV Linac containing 1300 MHz cryomodules and the ring would then be a fixed energy accumulator with H^-

injection, which would then transfer beam into the Main Injector at MI-60 or MI-62. The accumulator ring would, however, add significant cost to the baseline Linac scenario.

This location of the booster replacement would have the important advantage of supporting supply of ~8-GeV protons to the muon campus, including potential continuations of the g-2 and mu2e experiments. It could also supply 8 GeV primary protons to the existing Booster neutrino program, using the Recycler RR-60 to RR-10 as an intermediate transport. Beam transport to the Fermilab test beam area will also be possible. Supply of beam to new experimental areas inside the main ring would also be possible.

ACKNOWLEDGMENTS

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