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Using an ILC-Style 8 GeV H^- Linac for a Muon to Electron Conversion Experiment

C. Ankenbrandt, S. Geer, and E. Prebys

Fermi National Accelerator Laboratory, PO Box 500, Batavia, IL 60510

Abstract

We describe how the H^- beam from an ILC-Style 8 GeV H- Linac can be collected, rebunched, and slowly extracted to provide a beam suitable for a muon to electron conversion experiment (mu2e). The scheme would permit simultaneous operation of the muon program with the future NuMI program, delivering $O(10^{20})$ protons per year at 8 GeV for the mu2e experiment.

1. INTRODUCTION

In a communication to the Fermilab long-range steering committee, D. McGinnis [1] has proposed to upgrade the Fermilab proton source by replacing the existing Linac/Booster with an ILC-Style 8 GeV H^- Linac delivering 9 mA in 1 ms long pulses at 5Hz. There would be 7 Linac pulses per 1.4 sec Main Injector cycle, each pulse containing 5.7×10^{13} H^-. The first 3 pulses would be injected via H^- injection into the Recycler. The circulating 1.7×10^{14} protons would then be extracted in a single turn and transferred to the Main Injector to be used for the NuMI program. This would leave up to 4 Linac pulses, which could also be injected into the Recycler, available for an 8 GeV physics program. Previous notes have described how 8 GeV protons from the Booster can be transferred to the Fermilab Antiproton source [2], then rebunched and slow extracted [3] to produce a primary beam suitable for a muon to electron conversion experiment [4]. In this note we describe how protons from the McGinnis scheme [1] can be used for a muon to electron conversion experiment. We assume that the scheme described in References [2] and [3] to

deliver protons from the Booster to the Accumulator for the experiment will have already been implemented by the time the new Linac is commissioned. It is also assumed that the present Linac and Booster will be decommissioned shortly after the new Linac is commissioned, so beam for the experiment would have to come from the Recycler. One way to accomplish this would be to run the experiment directly off the Recycler; the other way would be to transfer beam to the Accumulator. The two alternatives are discussed in the following paragraphs.

2. Directly off the Recycler

Once per Main Injector cycle, one Recycler fill (5.7×10^{13} protons) would be used for the muon to electron conversion experiment. The protons would be rebunched into about 7 equally-spaced bunches, then slowly extracted for about 0.7 seconds from the Recycler near MI52 and transferred to the Antiproton Source enclosure via the P150 line. The beam would then be transported directly to the experiment, bypassing the Accumulator. That would require a new beamline in the Antiproton Source enclosure connecting the P150 line to the transfer line to the experiment. The other three available Linac cycles would not be used. This scenario would provide about 50 kW of beam power at 8 GeV with a duty cycle of about 50% for the muon conversion experiment. It would preclude other uses of 8 GeV beam which require the Recycler.

3. Recycler to Accumulator

Various ways to take beam from the Recycler to the Accumulator for the experiment can be conceived. Subsequent beam processing in the Accumulator and Debuncher would then be similar to the plan that uses beam from the Booster. a) In one scheme, one complete Recycler fill is extracted in a single turn at MI52 and transmitted via P150 to the Accumulator. The beam is injected into the Accumulator using multi-turn (7-turn) transverse stacking in both transverse planes. That should be feasible because the transverse acceptances in the Accumulator are each about an order of magnitude larger than those of the Recycler. That scheme would provide about 50 kW of beam power to the experiment with a duty cycle of about 90%. The three other available Linac cycles could be used for other 8-GeV physics. b) Another method would "steal" about $1/7^{th}$ of the beam destined for the Main Injector. The beam occupying one seventh of the circumference of the Recycler would be kicked out and transmitted to the Accumulator via the path described previously. No stacking would then be required in the Accumulator. That would provide about 21 kW of beam power for the experiment with a duty cycle of about 90%. It

would also create a useful abort gap in the Main Injector beam. The four other cycles available from the Linac could all be used for other 8-GeV physics. c) The third method would "steal" Accumulator-length batches from each of the four Recycler fills not destined for the Main Injector. Each of those could then be separately rebunched in the Accumulator, transferred to the Debuncher, and slowly extracted over 200 msec. That would provide about 28 kW of beam power for the experiment with a duty cycle of about 50%. The rest of these four cycles could be used for other 8-GeV physics.

4. Summary

If the proton source is upgraded with an ILC-style 8 GeV Linac, it appears there are several options that would enable an intense beam of 8 GeV protons to be provided, with the appropriate bunch structure, for a muon to electron conversion experiment.

References

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