MCenter Proposal to Add Shielding in the Space Following The Primary Beam Target to Reduce Muon Flux in the Lariat Detector

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1 Introduction

This document outlines a proposal to add shielding in the space immediately following the Meson Center primary target. The shielding will not obstruct the secondary beam path but will serve as an added mechanism for pion absorption. The theory is that by absorbing pions before they decay into muons, one can reduce the total muon flux measured within the Lariat liquid Argon detector located in the MC7 enclosure. Figure 1 shows first a vertical profile of the MCenter secondary beamline, followed by a horizontal profile of the tertiary beamline and instrumentation including the Lariat detector.

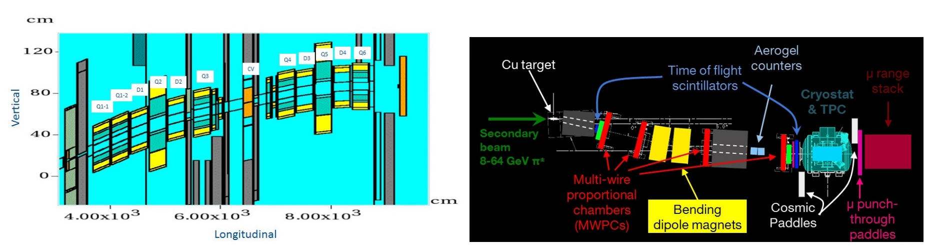

Figure 1: Meson Center secondary and tertiary beamlines

2 Lariat Detector Response to MCenter Beam

The lariat detector has a 350 μsec drift time. With 11 μsec per Main Injector orbit and 588 buckets per revolution, 18709 possible buckets pass within a 350 μsec time window. Pile up can occur if candidate events overlap in the detector. Initial detector tests with Meson Center filled the detector with many unwanted events as shown in figure 2. The Lariat collaboration quickly installed multiple scintillators to assist in understanding the source of these tracks. Table 1 lists this instrumentation.

Beam studies referenced in this paper can be found in the accelerator division elog at:

https://www-bd.fnal.gov/Elog/?entryIDs=61608

These studies, summarized in figure 3, suggest the particles that are being detected in the Lariat detector are not a product of collisions occurring due to the secondary beamline. The secondary beamline was turned off and the detector problems still occurred. The problems are likely a result of higher momentum muons produced through pion decay after the 120 $\frac{GeV}{c}$ proton beam collision with the target and shielding pile in the upstream portion of the MC6 enclosure.

To make the best use of the MCenter proton beam experts found that proton intensities must be limited to no greater that $2E9$ protons per spill. These intensities provide a good balance between good events and a detector full of tracks.

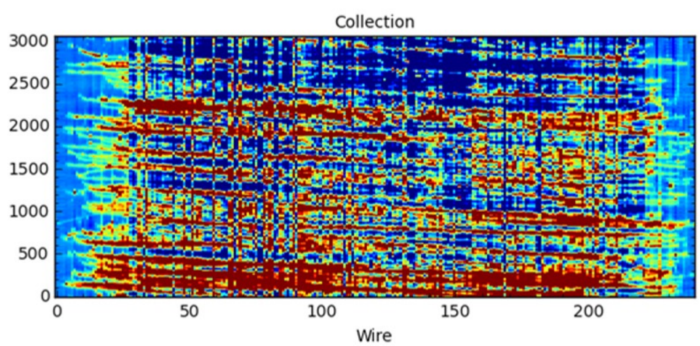

Figure 2: Lariat detector event with lots of parallel tracks

Acnet Name	Description
F:MC7U09	Lariat Cosmic Detector
F:MC7U10	Lariat Tertiary Halo Detector
F:MC7U11	Tariat TPC Trigger
F:MC7U12	Lariat Fast Trigger

Table 1: Lariat instrumentation used for tuning beam characteristic to fit the needs of the experiment

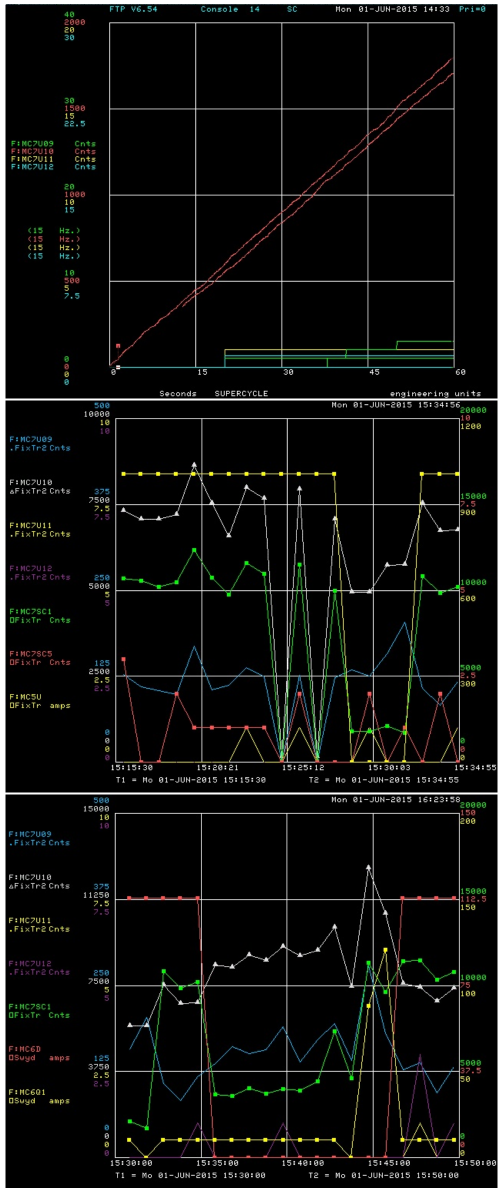

Figure 3: The top image shows that MC7U10 (the Halo Counter) integrates between 1500 and 2000 counts with no beam. The second image shows that with MC5U off the Halo counter still integrates over 5000 counts. With MC5U off the primary beam should totally miss the MCenter primary target. The last image shows that, with MC6D off the halo counts also stay stay high. MC6D is the secondary momentum selection dipoles. With these four dipoles off, secondary beam is not collected. This data show that what the experiment is calling halo is actually particles from the primary beam's collision with both the target and its shielding.

3 Improving the Rate of Good events

The goal of this proposal is to improve the rate of good tertiary events without increasing the muon flux in MC7. A better understanding of the causes and remedies could assist all future experimental users of the MCenter beamline. The MCenter beam permits currently limit MC7 to $1E11$ protons per spill, far greater than the $2E9$ limit caused by stray particles.

Doug Jensen proposed a simple solution to this problem. It involves stacking additional shielding in the open space between the MCenter primary beam target and initial collimation that occurs after the target as shown in figure 4. If the extra signals in the Lariat detector are caused by muons that come from pion decay following the primary beam target, then absorbing those pions before they become muons could be a viable alternative for reduction of unwanted signals. By adding shielding immediately after the primary target but not in the path of the secondary beam, this might be accomplished. A MARS model as shown in figure 4 was created. The model was ran with and without the additional shielding, and the flux was recorded in the pink cylinder shown in the last image of figure 4 which represents the Lariat liquid argon detector.

The muon flux at the detector in MC7 without the new shielding was $3.204 * 10^{-9} \frac{mu}{cm^2}$. With the additional shielding the flux became $1.279 * 10^{-12} \frac{mu}{cm^2}$. The MARS model suggest a reduction in muon flux at Lariat by a factor of 1000.

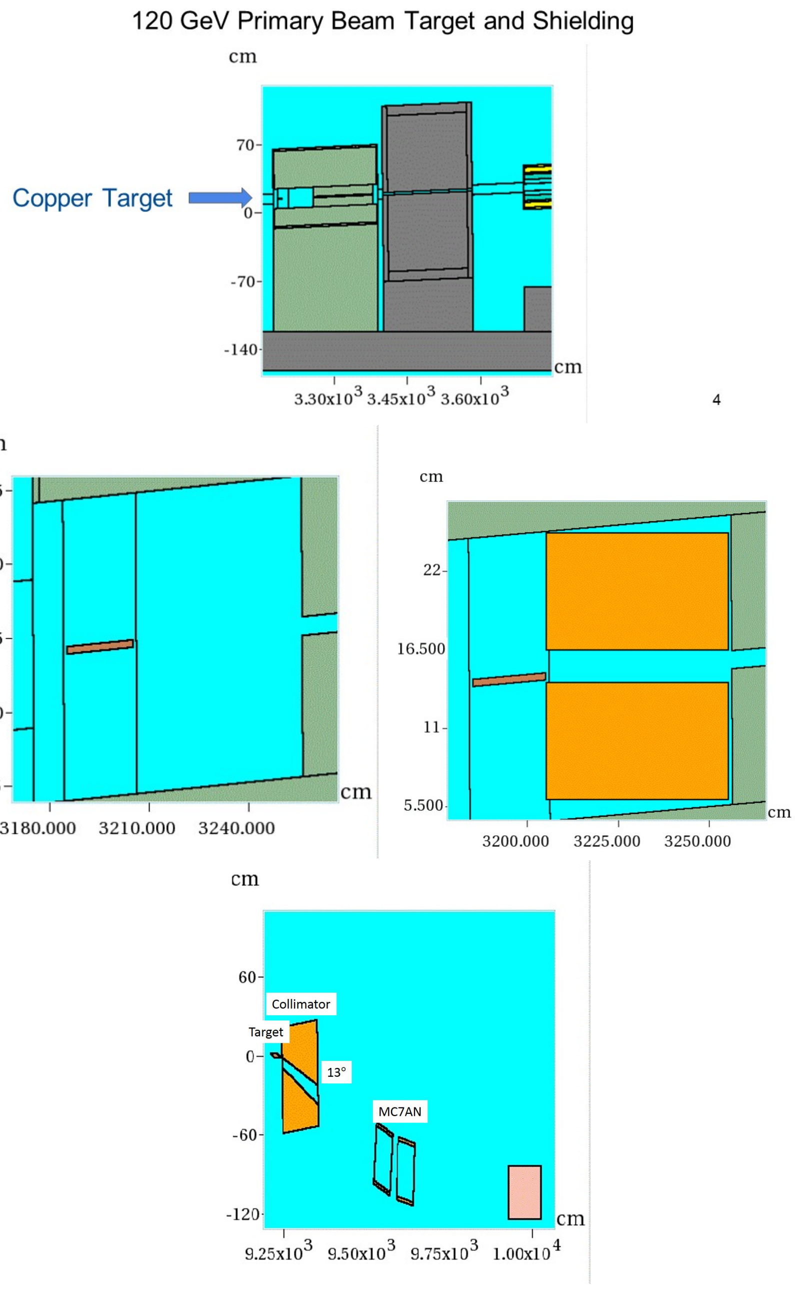

Figure 4: The top image shows a vertical profile of the basic layout of the MCenter primary beam target and collimation. The second and third images show the air gap after the target and the proposed addition of iron which was used in the Mars model. The last image shows a horizontal overview of the Tertiary beamline used in the model.

4 Proposed Tests

The external beamlines group proposes performing a series of tests that involve using the portable scintillator stand shown in figure 5 to measure the particle flux at three different locations in MC6. Scintillators from table 1 in MC7 will also be used to better understand impact at the Lariat detector. Beam studies will be performed before and after the installation of the proposed shielding material. Following is a basic outline of the proposed studies:

1. Lock out MC6D power supply in order to ensure no secondary beam delivery into MC7
2. With no additional shielding, establish beam to primary target noting relationships between scintillators in table 1 and intensity
   (a) With portable scintillator in position 1 from figure 6 establish relationship between portable scintillators and intensity
   (b) With portable scintillator in position 2 from figure 6 establish relationship between portable scintillators and intensity
   (c) With portable scintillator in position 3 from figure 6 establish relationship between portable scintillators and intensity
3. Install additional shielding then establish beam to primary target noting relationships between scintillators in table 1 and intensity
   (a) With portable scintillator in position 1 from figure 6 establish relationship between portable scintillators and intensity
   (b) With portable scintillator in position 2 from figure 6 establish relationship between portable scintillators and intensity
   (c) With portable scintillator in position 3 from figure 6 establish relationship between portable scintillators and intensity

5 Conclusion

The simplest way to improve the Lariat experimental program is to create a higher tertiary beam intensity. To benefit from this one must reduce background signals from stray particles created at the primary target. We would like to perform the studies proposed in this document in either late November or early December.

Figure 5: Brandon Soubasis of Lariat built a portable scintillator stand which has been used to better understand particle flux at different locations in MC7. This is now installed in MC6. The first image shows a view from upstream looking downstream near the target shielding. The second picture is from donwstream looking upstream at the same location.

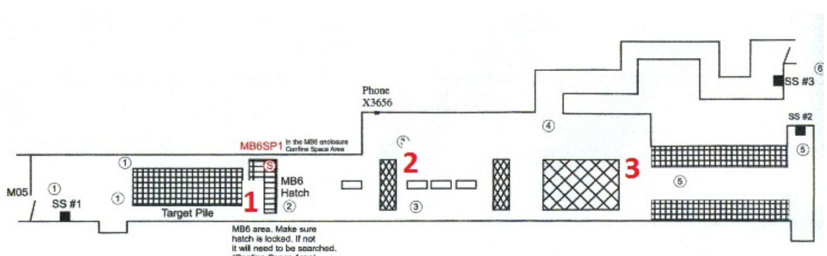

Figure 6: Beam will be delivered into MC6 with the secondary beamline off. By moving the portable detector into the 3 different locations as numbered here, a baseline is established for particle flux through three different shielding locations. Following this, steel will be stacked in order to fill in the air gap as shown in figure 4. The beam studies will then be repeated to compare the results before and after the shielding.