OPTIMIZING MUON INJECTION FOR THE MUON g-2 EXPERIMENT

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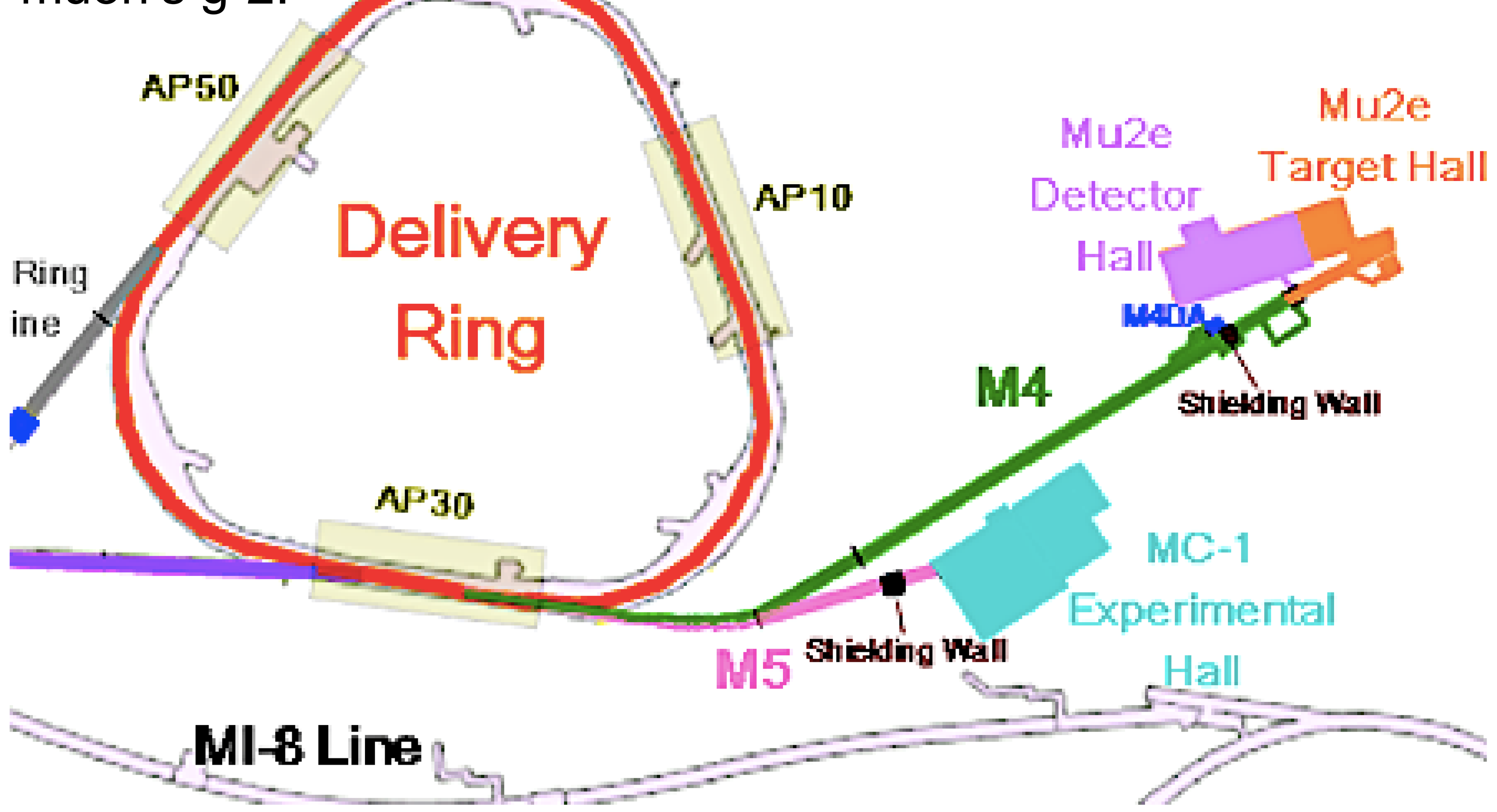
Introduction

The Muon g-2 experiment seeks to measure the anomalous magnetic moment (g-2) of muons to a .14 ppm uncertainty.

The measurement takes place in the muon storage ring (SR), which only accepts muons with momentums within ~.2% of 3.094 GeV/c, dubbed the 'magic momentum' (MM). However, there exist a few challenges to measurement:

- The beam has a large momentum spread beyond the MM. A wedge was installed in the beam path in order to narrow this spread, but it also lowers the average momentum away from the MM.
- A magnet called the inflector shields the 1.45 T magnetic field and allows muons to enter the SR. However, it is designed in a way that increases scattering and loss. FNAL wishes to install a redesigned inflector, but it is not known how much it will increase performance.
- The muon beam does not travel directly along the z=0 axis of the beam pipe. This variable is called the beam offset and can be optimized. It is not known which offset value optimizes experimental yield.

The goal of this work is to address these challenges in order to increase the number of muons inside the SR and therefore increase our certainty in the measurement of value of the muon's g-2.



A schematic of part of the FNAL Muon Campus showing the locations applicable to this work. Left: Comparing the # of muons within .2% of the MM at the end of the M4/M5 line for different wedge offsets, relative to the no wedge case. Also: the drop in avg. momentum as a function of wedge offset.

Methodology

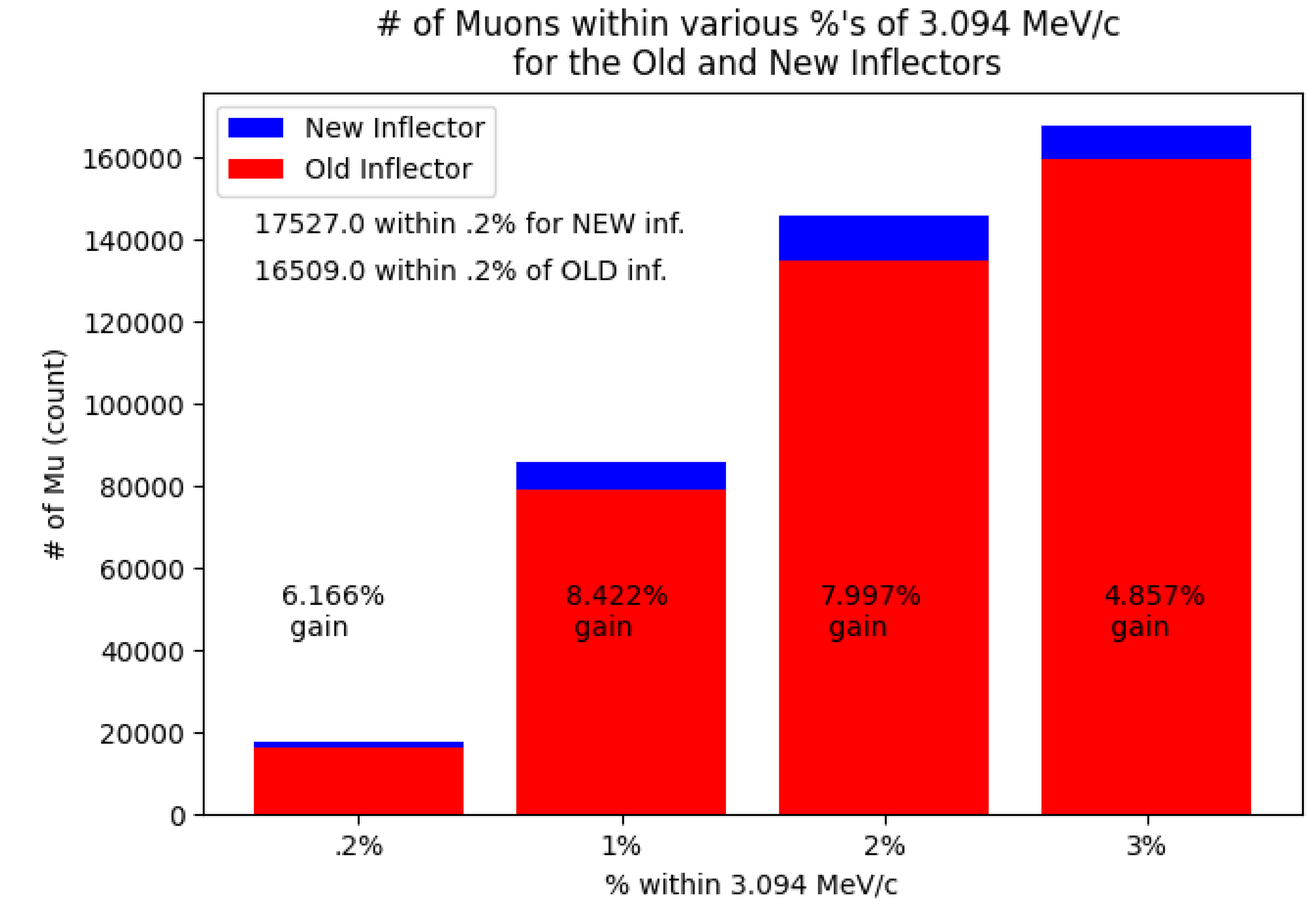
This work was conducted using the Geant4beamline program in the National Energy Research Scientific Computing Center (NERSC). Muons were tracked through separate simulations for each hardware item: the output of the M4/M5 simulation would become the input for the inflector, and so on. The efficacy of variables would be assessed by the number of muons within .2% of the MM.

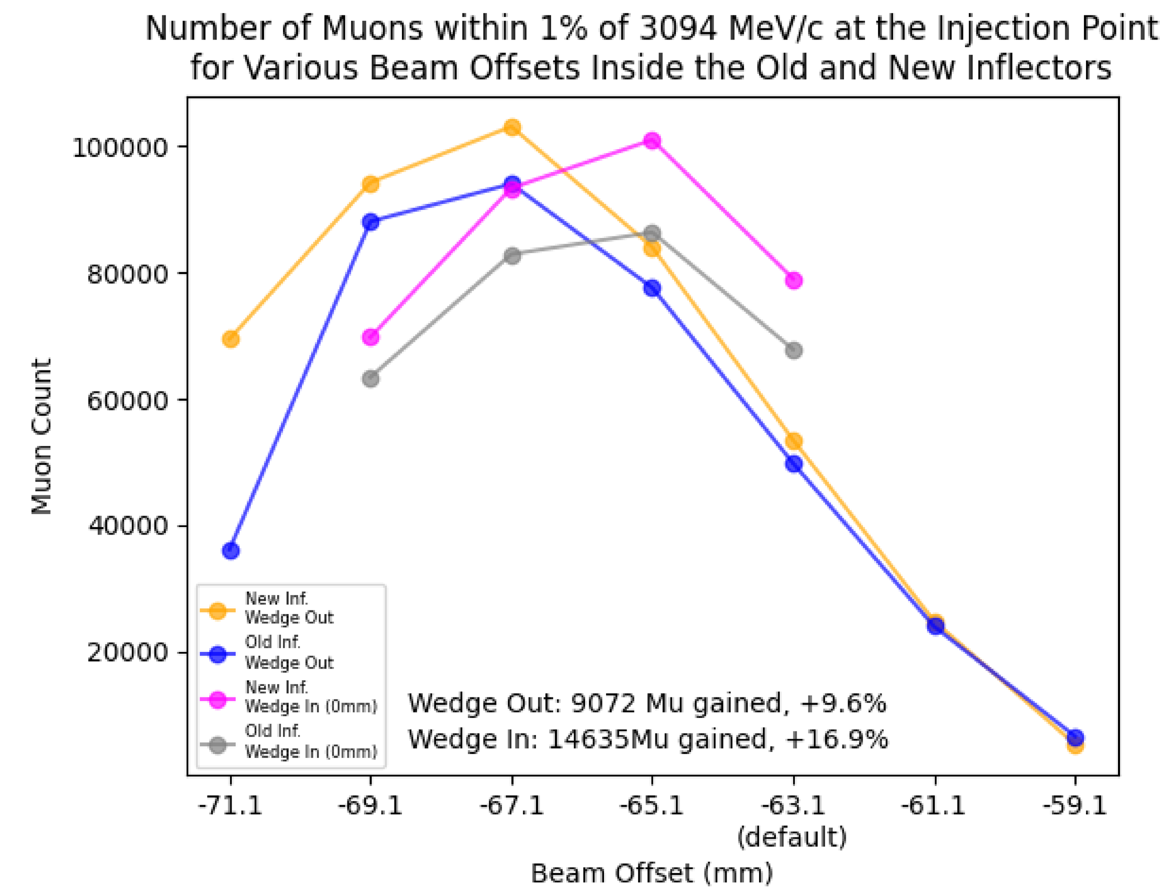
Assessments of the Wedge and Beam Offsets, Energy Increases, and the Inflectors

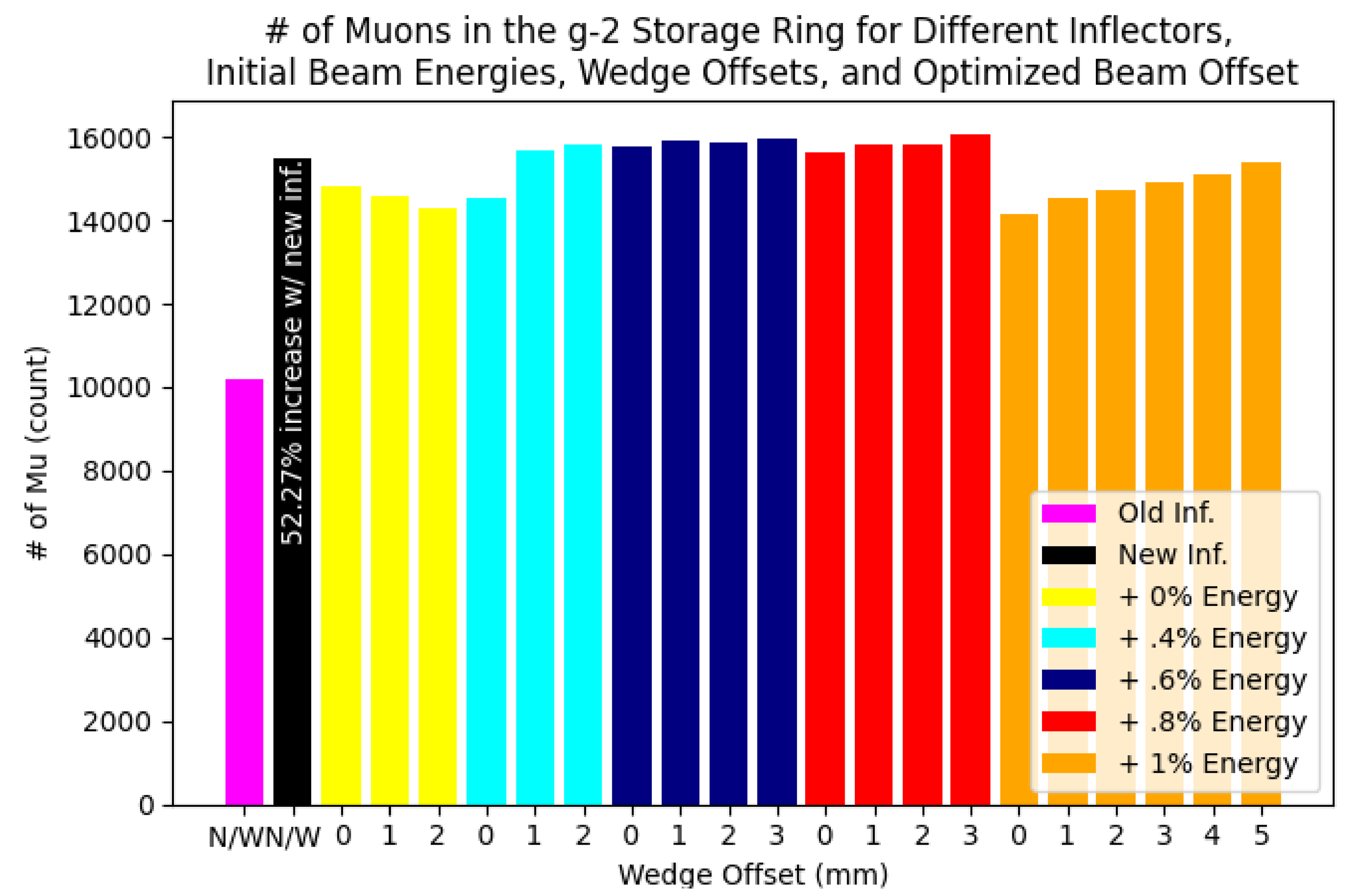
Simulations for different wedge offsets taken until the end of the M4/M5 line initially indicated that wedge placement increased the number of measurable muons.

Beam Offset: It was found that a -67.1 mm offset optimized the performance of both inflectors for the wedge-out case, while -65.1 mm optimized performance for the wedge-in (0mm) case.

Wedge Offset and Raised Energy: Simulations of beams with raised energies were tracked through the inflectors and 50 turns around the SR in order to attempt to restore the beam momentum to the MM. However, this study revealed that improvements in experimental yield would mostly result from the use of the new inflector, and not wedge use, as optimizing both wedge offset and energy increase only yields a maximum muon gain of ~4%.







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