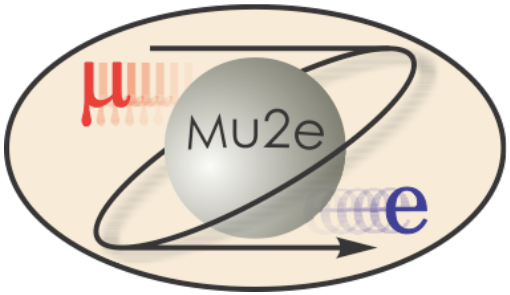

Calibration of the Mu2e absolute momentum scale using $\pi^+ \rightarrow e^+ \nu_e$

- Jul 14, 2021

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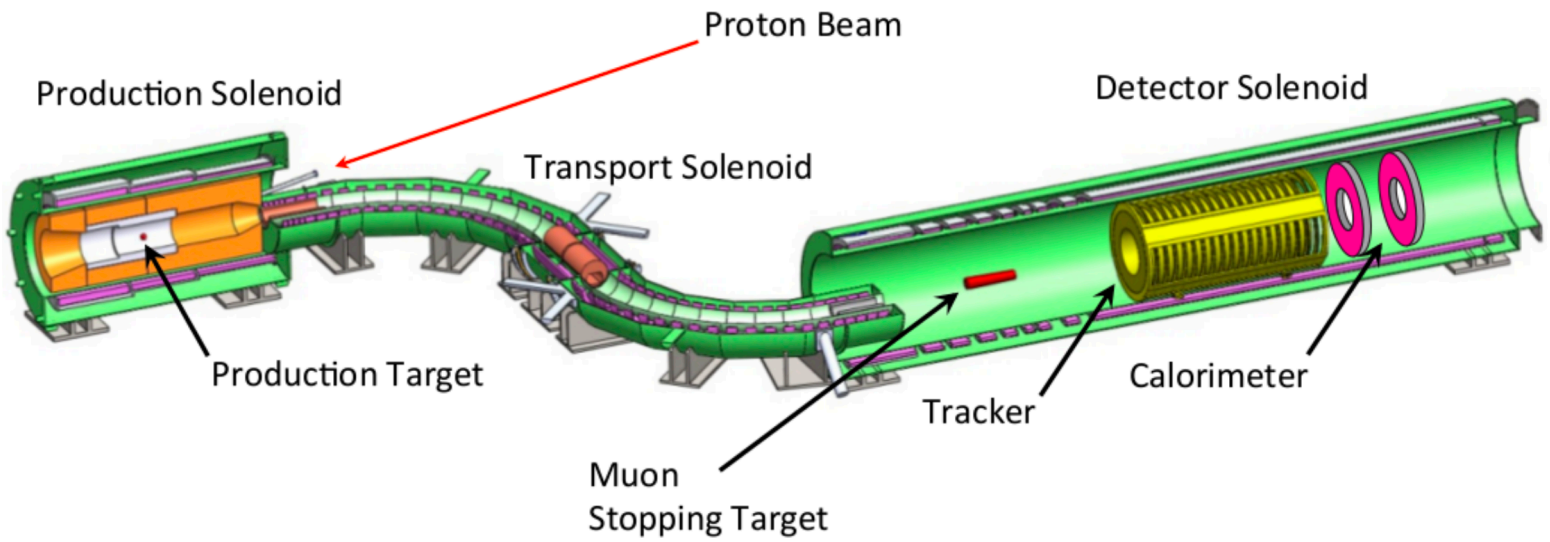
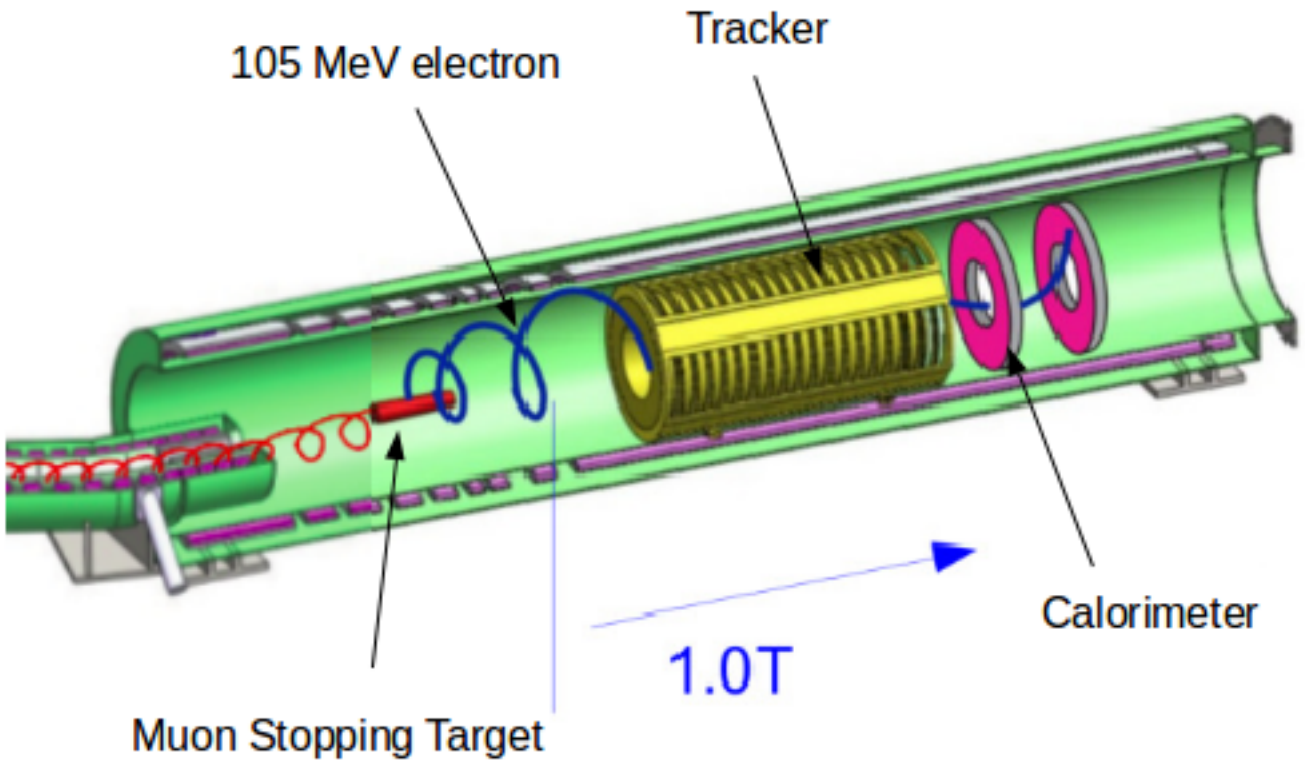
Introduction

- The Mu2e experiment will search for Charged Lepton Flavor Violation (CLFV) via the coherent conversion of a muon to an electron in presence of an aluminum nucleus
- Predicted branch ratio of $\mu^- \rightarrow e^-$ conversion in Standard Model is un-observably small (10^{-52} for aluminum nucleus)
- The current upper limit is $R_{\mu e} < 7 \times 10^{-13}\ (90\,\%\ \mathrm{CL})$, and Mu2e will measure $R_{\mu e}$ with single event sensitivity of 3×10^{-17}
- Any observation of $\mu^- \rightarrow e^-$ conversion would be an unambiguous sign of new physics
- Many beyond Standard Model physics models predict a significant rate of CLFV process

The Mu2e experiment



Mu2e Signal

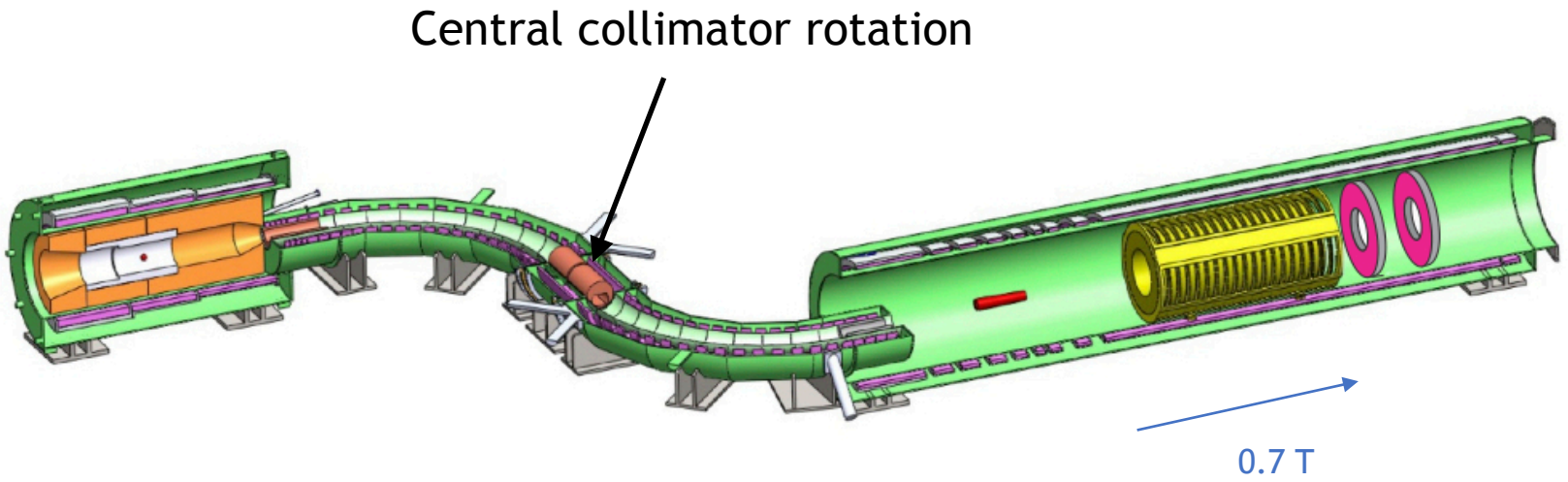

105 MeV electron
Tracker
Calorimeter
1.0T
Muon Stopping Target

Momentum Calibration

- All background processes are suppressed in Mu2e
- We expect to have less than one background event during the whole run time
- How can we calibrate the absolute momentum scale for a low signal, low background experiment?
- We need particle source:
  - Narrow peak in momentum with 100 keV/c resolution or better
  - High rate
  - Low background

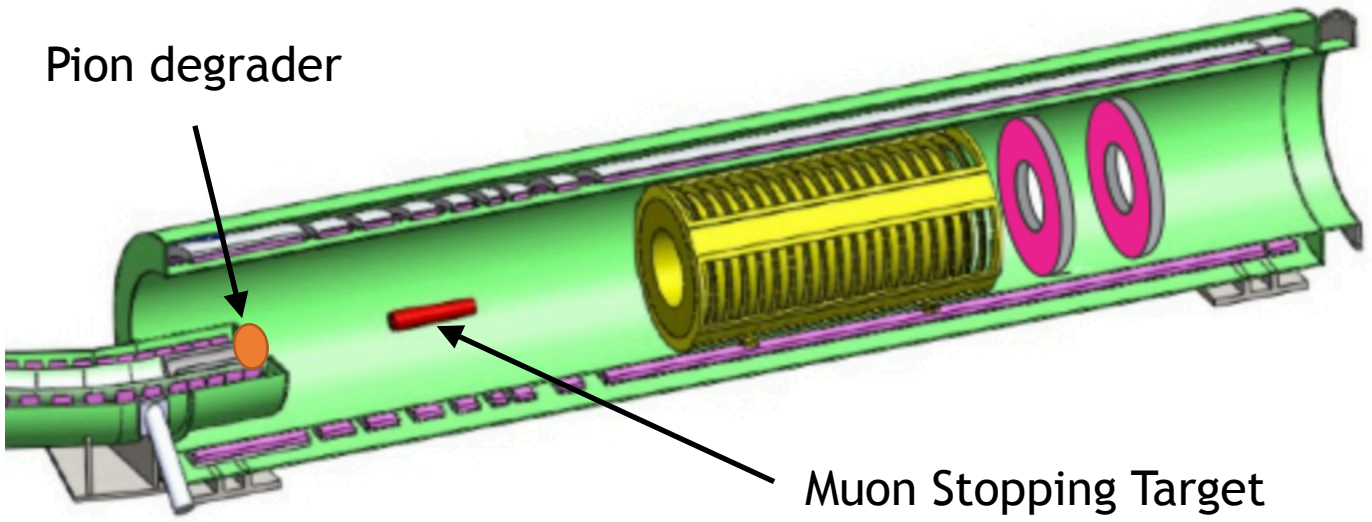
Calibration with $\pi^+ \rightarrow e^+ \nu_e$

We propose to calibrate the absolute momentum scale using 69.8 MeV signature from $\pi^+ \rightarrow e^+ \nu_e$ pions that stop in the Muon Stopping Target.

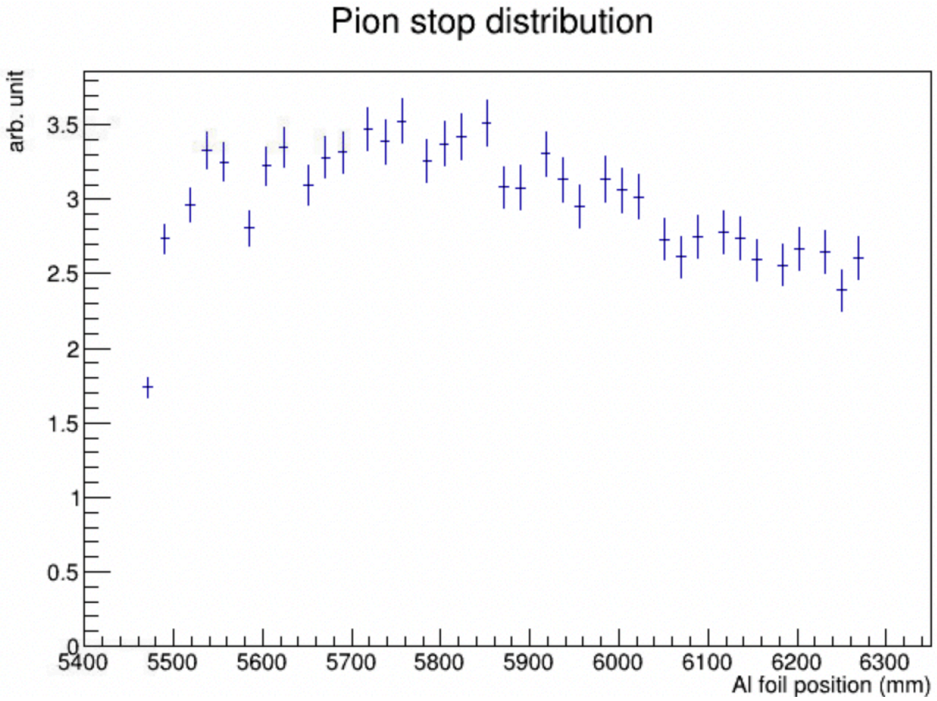


Pion degrader

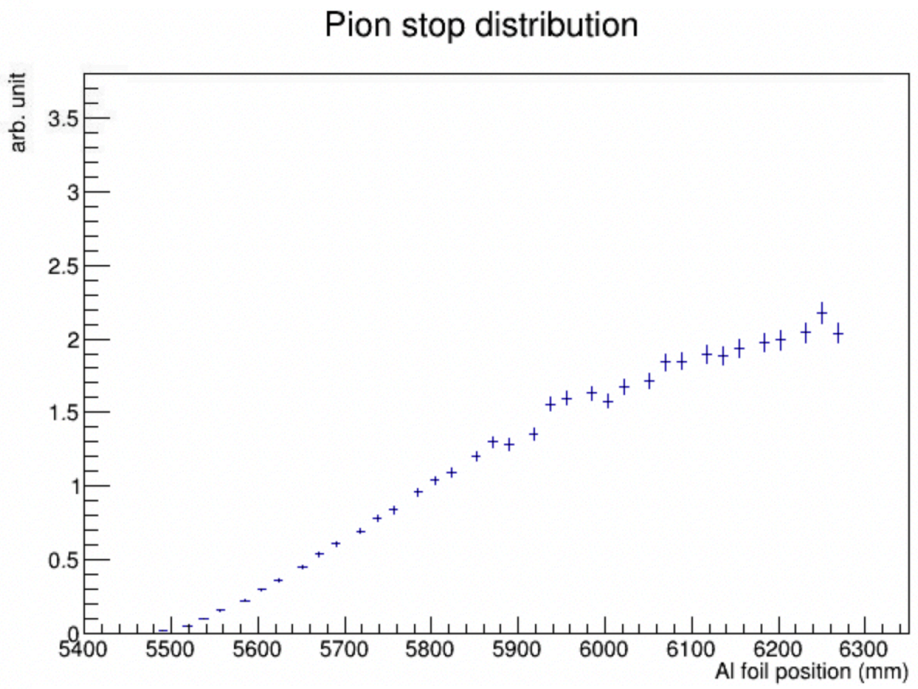
- The Muon Stopping Target is designed to maximize stopped muons
- The degrader can increase pion stops in Muon Stopping Target and suppress μ^+ decay-in-flight in Detector Solenoid



Pion stops in Muon Stopping Target

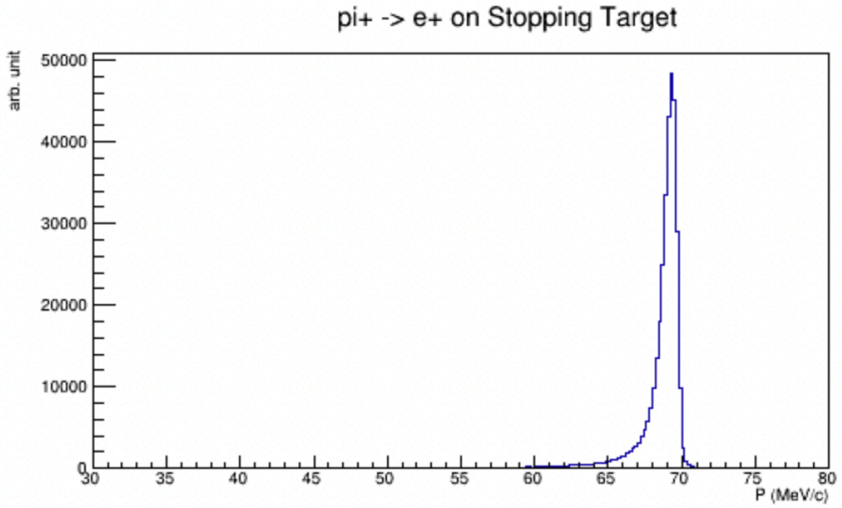


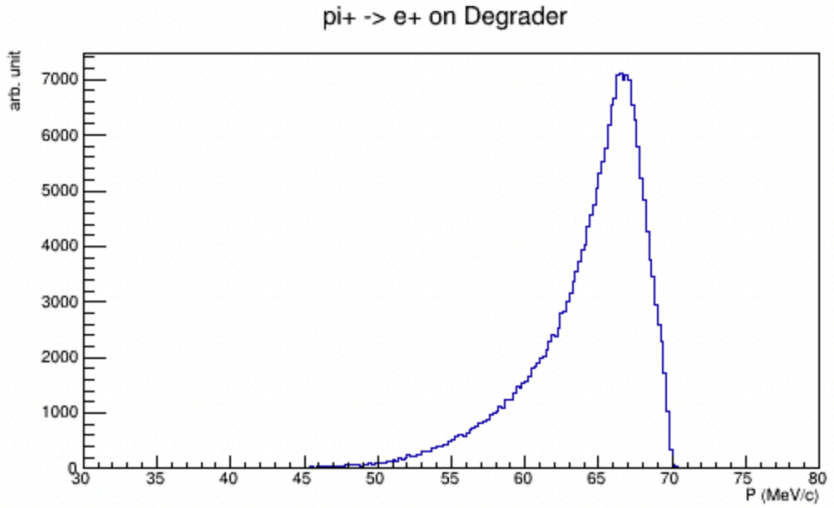
3mm titanium degrader

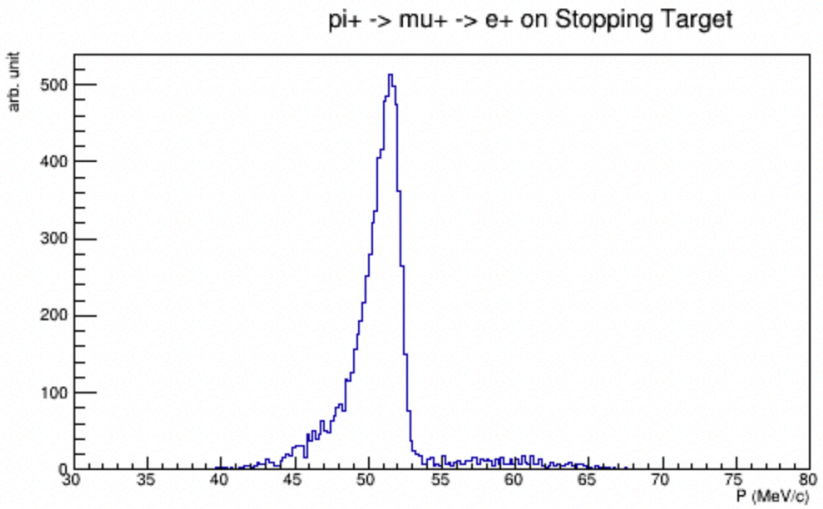


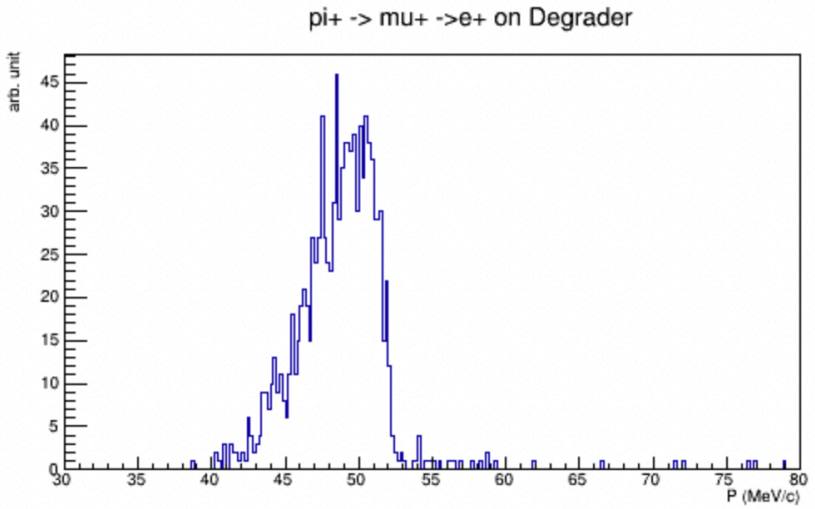
No degrader

Calibration Signal and Background









Summary

- Investigation of feasibility of absolute momentum scale calibration using stopped pion decay is ongoing
- We have found that a pion degrader will:
  - Increase number of pion stops in stopping target
  - Suppress muon decay-in-flight
- Further optimization of pion degrader geometry may lead to significant improvements
- We have begun to simulate the following samples of events:
  - Stopped $\pi^+ \rightarrow e^+$ in muon stopping target (S) & pion degrader (BG)
  - Stopped $\pi^+ \rightarrow \mu^+ \rightarrow e^+$ in muon stopping target & pion degrader (both BG)
  - Stopped $\mu^+ \rightarrow e^+$ in muon stopping target & pion degrader (both BG)
  - In-flight $\pi^+ \rightarrow \mu^+ \rightarrow e^+$ and $\pi^+ \rightarrow e^+$ (both BG)

Thanks!