# Drift Calibration with Neural Net for Mu2e Straw Tracker

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## Introduction

The Mu2e experiment searches for charged lepton flavor violation (CLFV) through muon-to-electron conversion in the field of a nucleus. The signal is a monoenergetic electron with an energy of 104.97 MeV. Momentum of the conversion electron is determined by reconstructing its helical path through a straw tracker. We get the radial position within the straw using a measurement of the electrical signal produced from ionization. This project uses a neural net to improve the determination of that radial position.

## Background

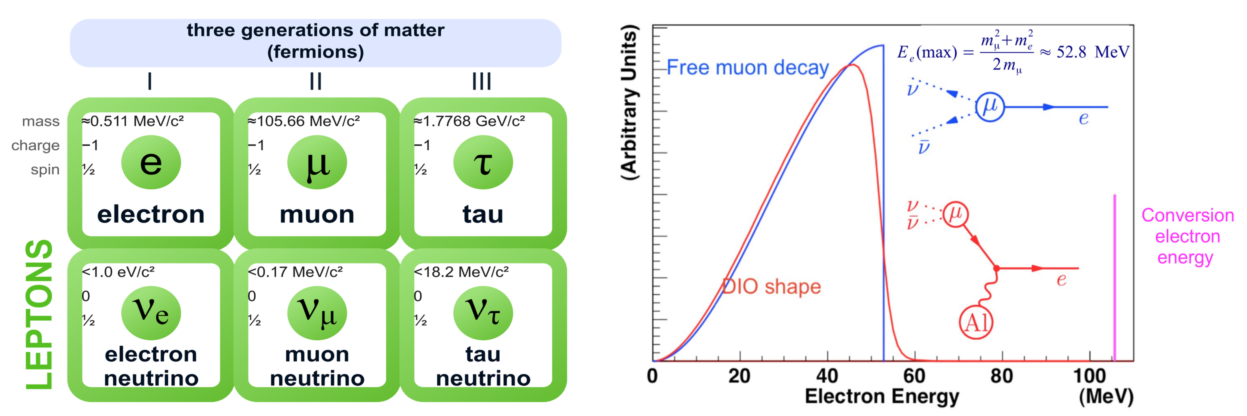


Fig 1. Three generations of charged and neutral leptons; Energy spectrums of free muon decay, decay-in-orbit, and monoenergetic conversion electron

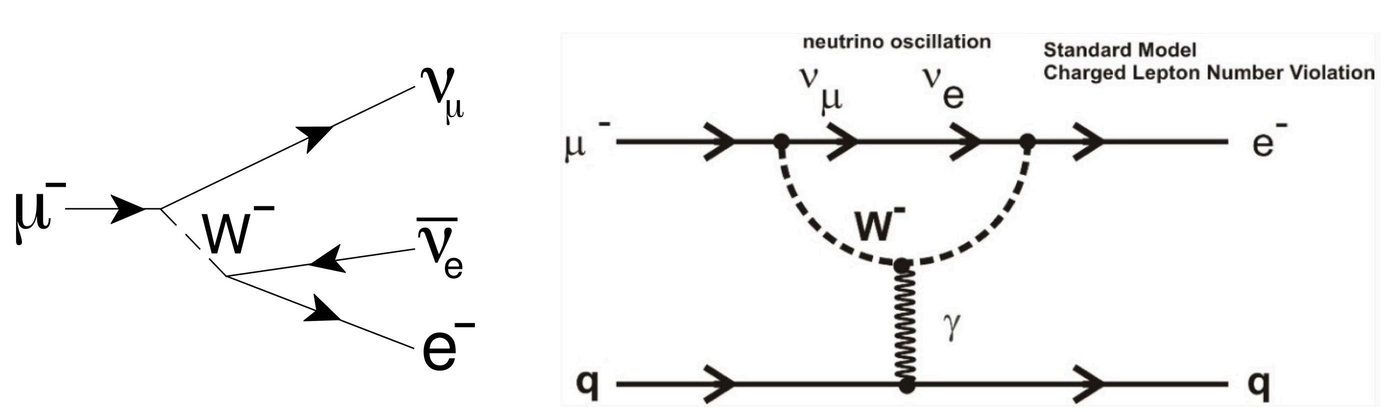


Fig 2. Muon decay and muon-to-electron conversion

- Lepton flavor is conserved in normal muon decay with production of electron and muon flavor neutrinos.
- Standard Model (SM) predicts CLFV < $10^{-50}$ conversion rate; Mu2e sensitivity ~ $10^{-17}$; Beyond SM ~ $10^{-15}$
- Energy spectrum for decay-in-orbit has a long tail that is background for monoenergetic electron signal

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## Mu2e Detector

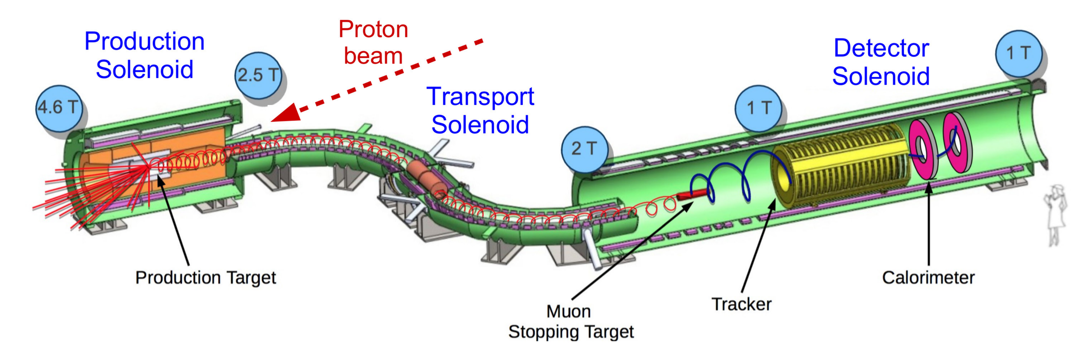


Fig 3. Mu2e detector

- Fermilab proton beam hits tungsten production target and produces muons
- At aluminum stopping target, muons decay or convert
- Resulting particles take helical path through the straw tracker in a constant 1T field

## Straw Tracker

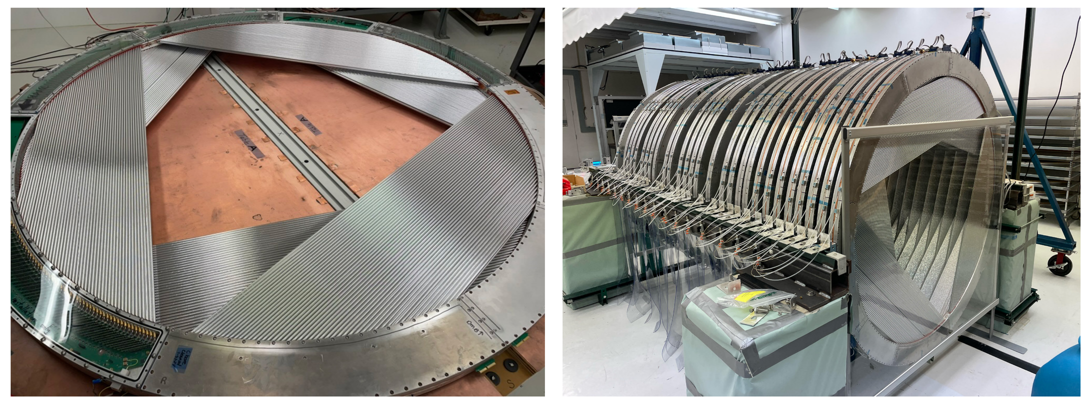

Fig 4. A straw tracker plane and partially assembled straw tracker at Fermilab

- 96 straws/panel, 6 panels/plane, 36 planes totalling 21,000 straws
- Panels stacked and offset to localize path of high energy particle through the tracker

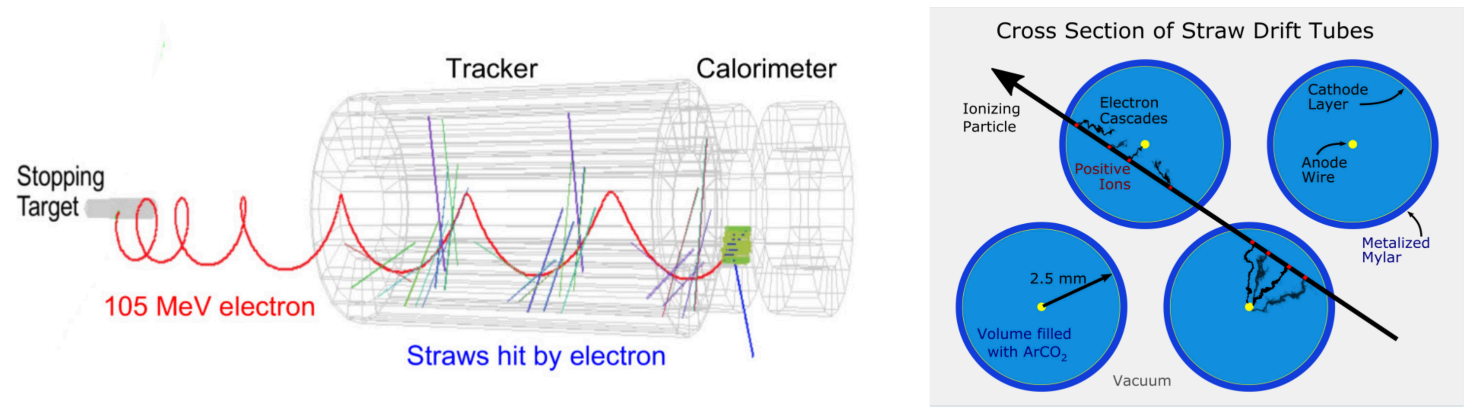


Fig 5. Helical path of high energy particle in straw tracker and ionization electron drift

- Particles produced from stopping target ionizes $ArCO_2$ gas; the ionization electrons drift to a wire inside each straw and produce signals
- Momentum reconstruction uses drift radius determined with signals from both ends of each straw
- Drift radius currently calibrated only with drift time and can be improved with more variables

## Drift Calibration

A deep neural net (DNN) is trained using Tensorflow in the task of multi-variable regression on Monte Carlo simulated data to construct a predictive model for the drift of ionization electrons.

## Training Variables

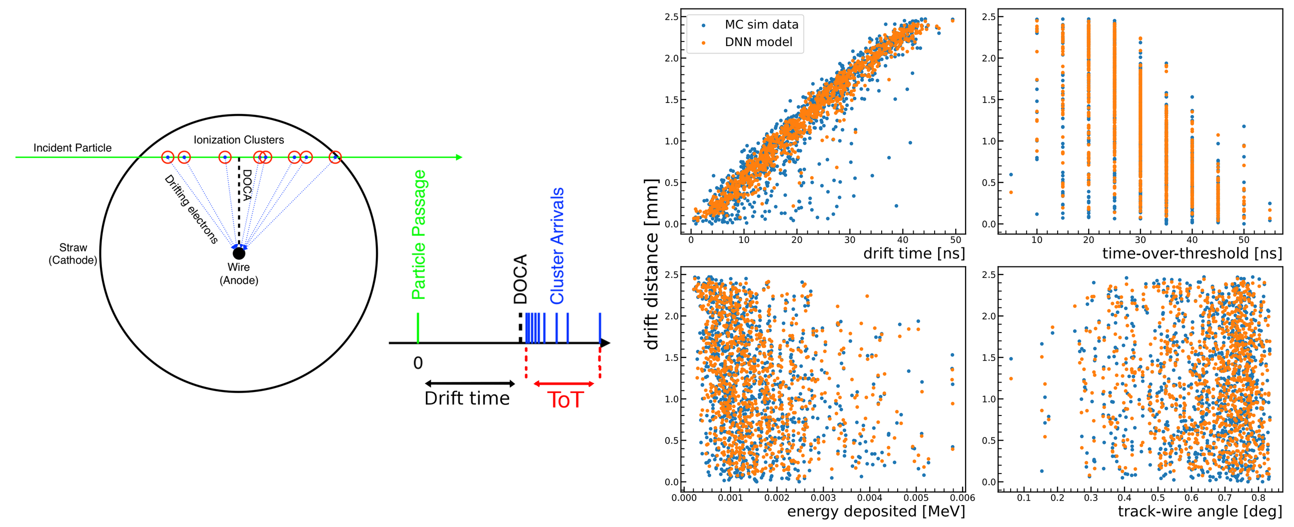

Fig 6. Cross section of straw showing drift of ionization electrons; Correlations between selected input variables and drift distance

- Drift time
- Time-over-threshold
- Energy deposited
- Angle between straw and track
- Lorentz angle

## Model Resolution

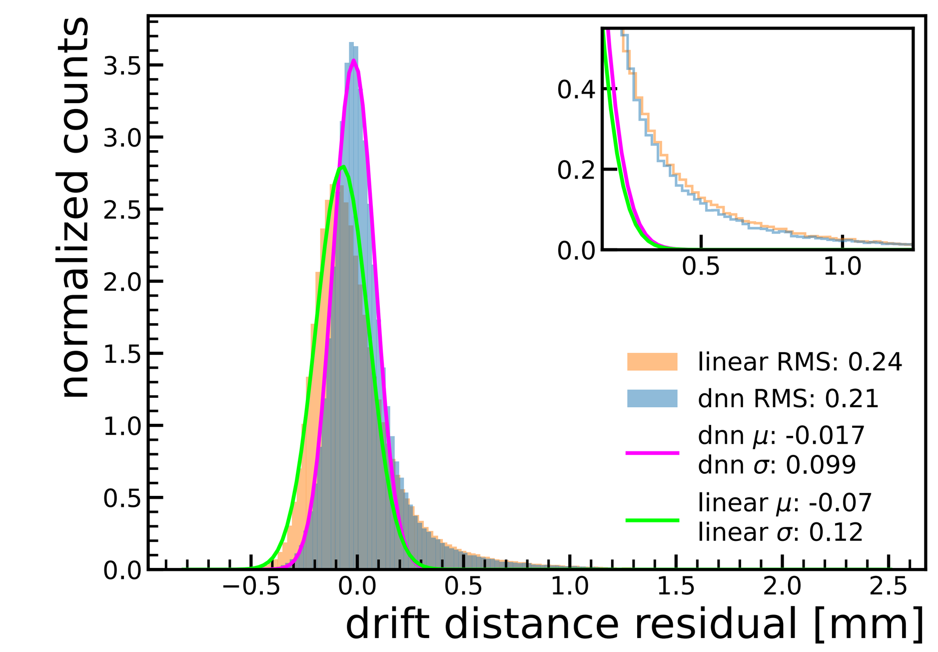


Fig 7. Drift residual from DNN model and linear model

- 20% improvement in core resolution
- Next step is implementation of model in helix reconstruction to improve momentum resolution

## Acknowledgements

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