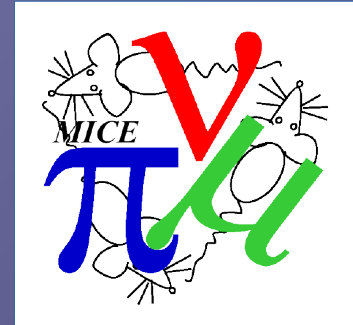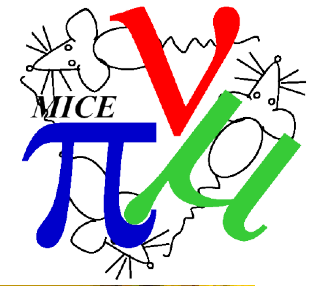# MICE Tracker Simulation and Reconstruction
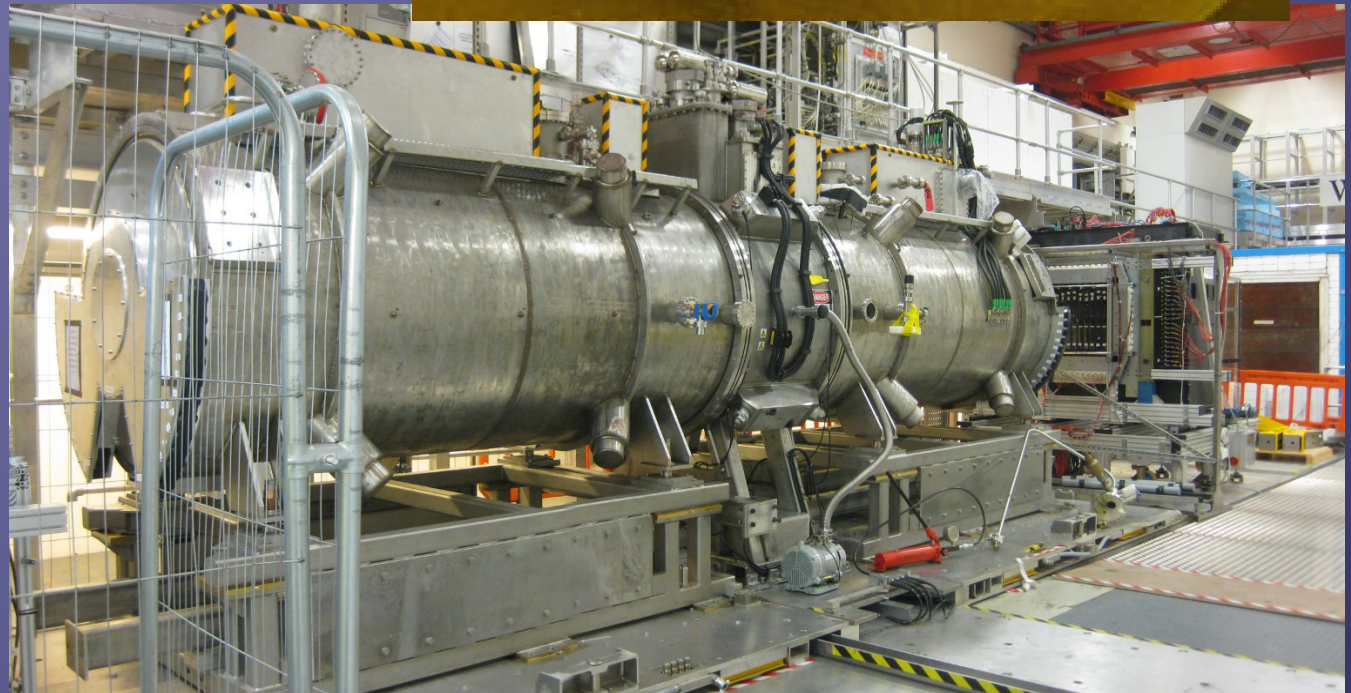
Chris Heidt
University of California at Riverside
MAP 2014 Winter Meeting

Outline

- Overview
- Geometry
- Tracker MC
- Reconstruction
- Preparing for Step IV

MICE Scintillating Fiber Tracker Overview

- Upstream and downstream of MICE Absorber
  - Will make the measurement of beam emittance within 0.1%

- Spectrometer Solenoids
  - 4T field
  - Measurement of P_T and P_Z

- Consist of:
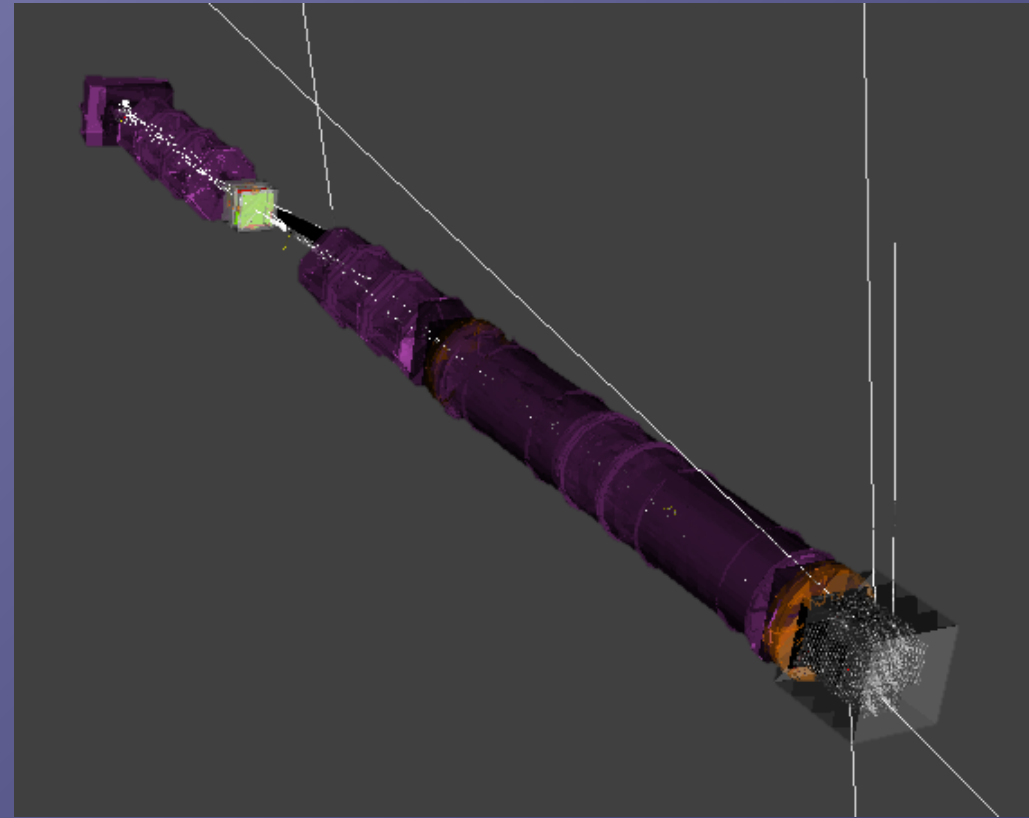 - 5 stations
  - 3 doublet layered planes

Fibre Exit

Station 5   Station 4   Station 3   Station 2   Station 1

3
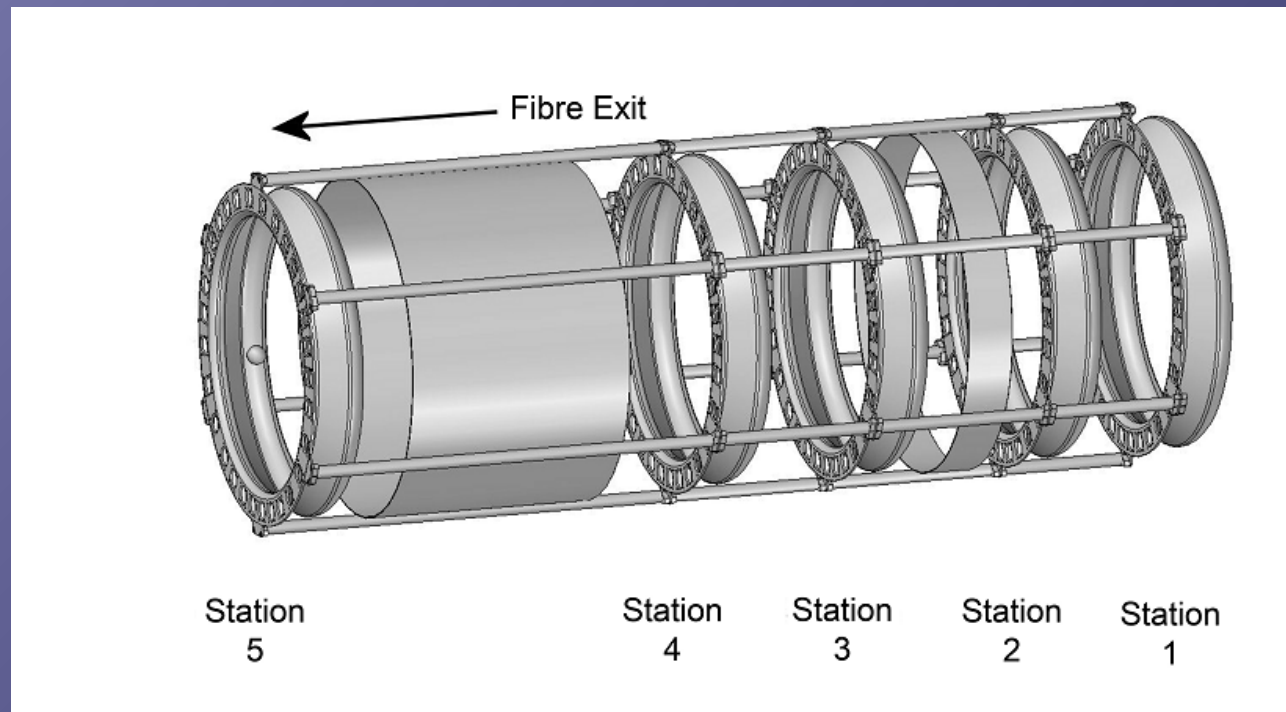
MICE Scintillating Fiber Tracker Overview

- Doublet Layers
  - Ensures no gaps
  - Fiber diameter: 350 µm
  - Fiber pitch: 427 µm
  - Ganged into groups of seven for readout
  - Position resolution of 470 µm
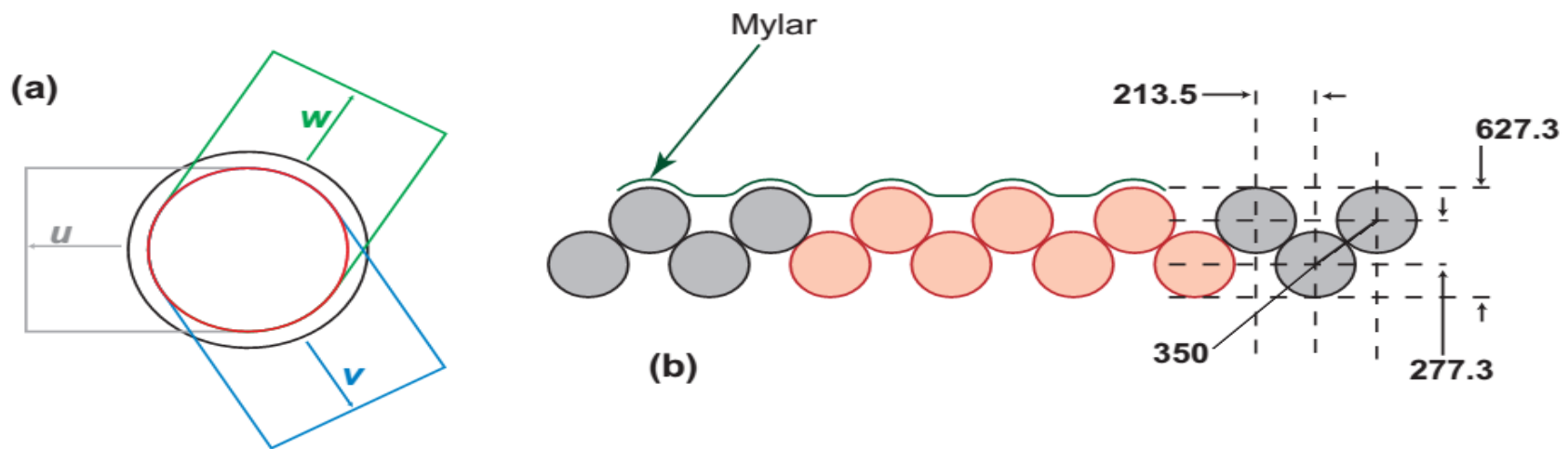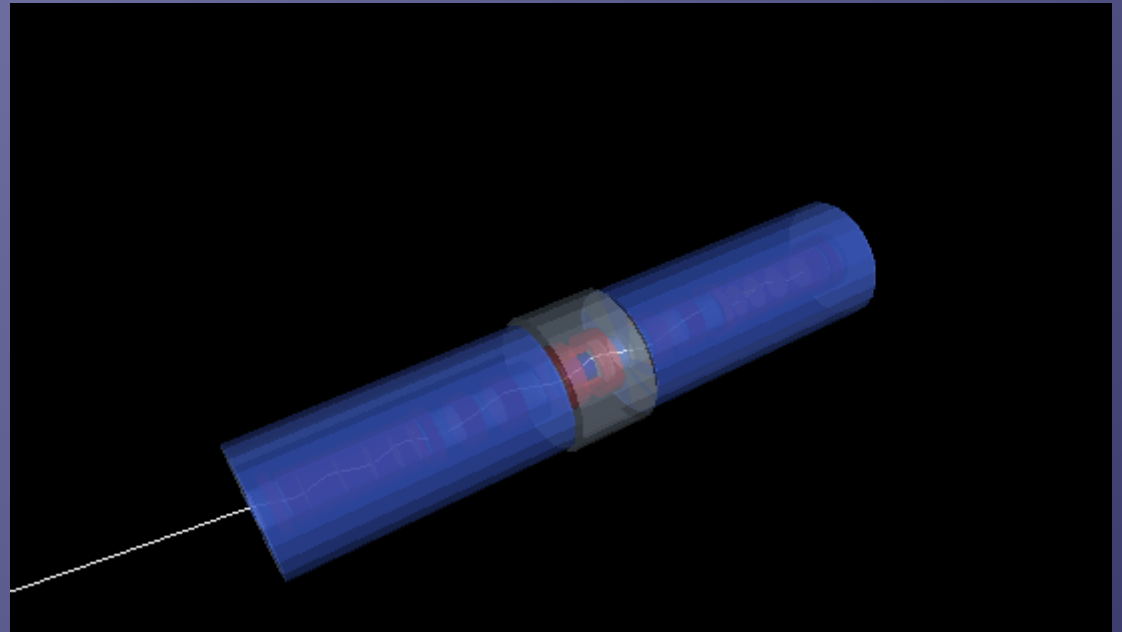
Tracker Geometry

- Two geometry solution
- Step IV Configuration Database geometry
  - Pro:
    - Includes everything
    - Good version control
    - Maintained
  - Con:
    - Slow
  - Useful for MC Analysis studies

*Provided by Ryan Bayes, University of Glasgow

Tracker Geometry

- Two geometry solution

- "Simulation" Geometry
  - Pro:
    - Quick
  - Minimalistic Step IV geometry
    - Just the facts
  - Useful for code development

MC Tracker Geometry

- Position of stations from CMM measurement at Imperial
  - Gives positions relative to axis through first and fifth stations
- Planes built fiber by fiber
- Other material
  - Glue used to hold fibers in place
  - Mylar sheets separating planes
- Not in MC
  - Carbon fiber tracker body
  - Light guides
  - Aluminum connectors

CMM at Imperial

Tracker MC: Basics

- Module of MAUS MC (MICE Analysis User Software)
  - Built on GEANT4
  - Python wrapper, scripts in C++, results in ROOT
- Stripped down, very simple
  - GEANT4 determines:
    - Deposited Energy
    - Scattering
  - MAUS records:
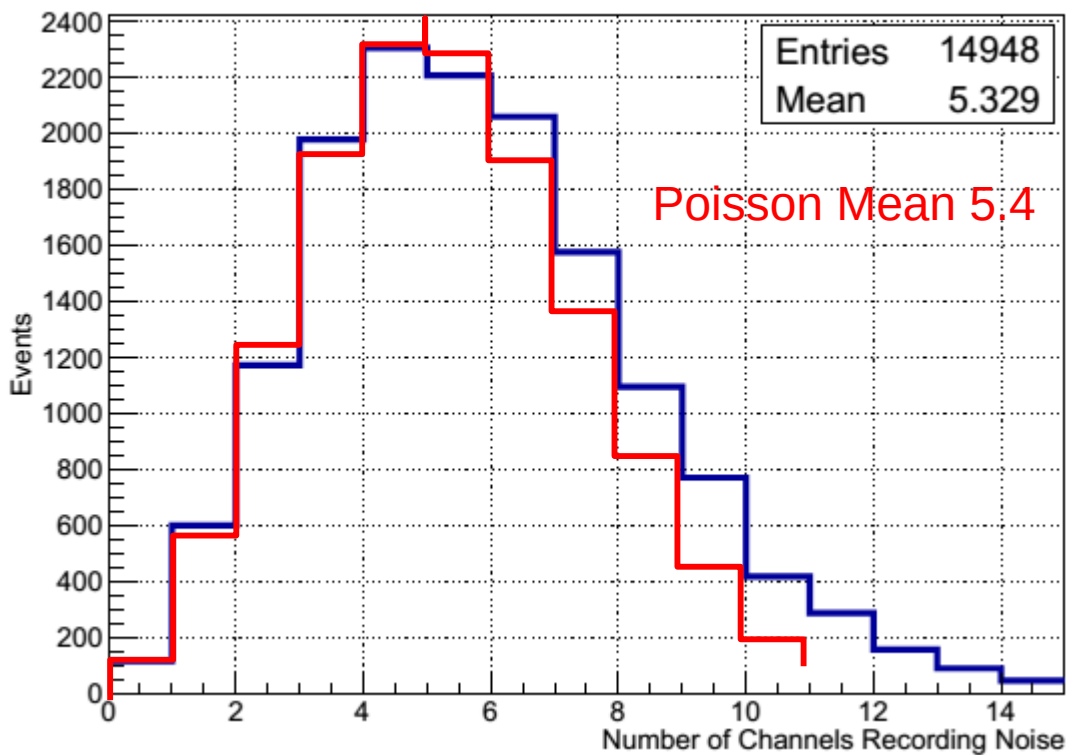   - Fiber number
    - Deposited energy

Tracker MC: Reconstruction

- Reconstructed backward to front
  - Energy deposition converted to photoelectrons (PE)
  - PE converted to ADC counts
  - Smearing due to electron showers
  - Converted back to PE
  - This process does not accurately simulate the electronics!
- Digits created
  - Fibers mapped to readout channels
  - PE, tracker, station, plane, and timing information written out
- Design Philosophy
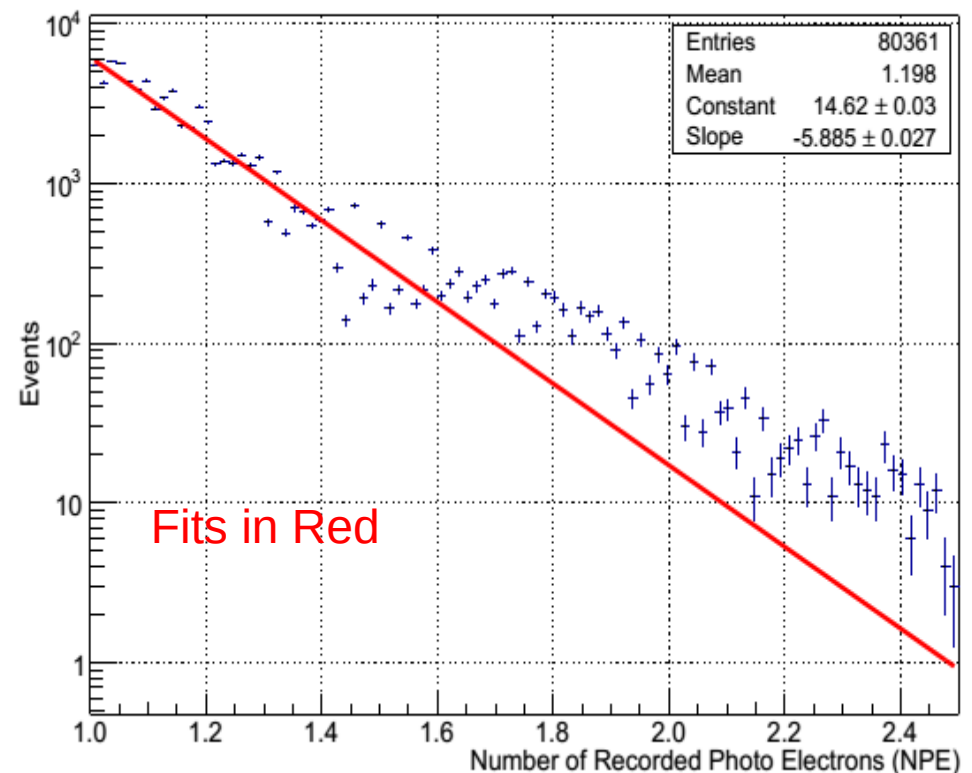 - At this point the MC should be indistinguishable from data

Tracker MC: Noise

- Developed from single tracker station run in May of 2012
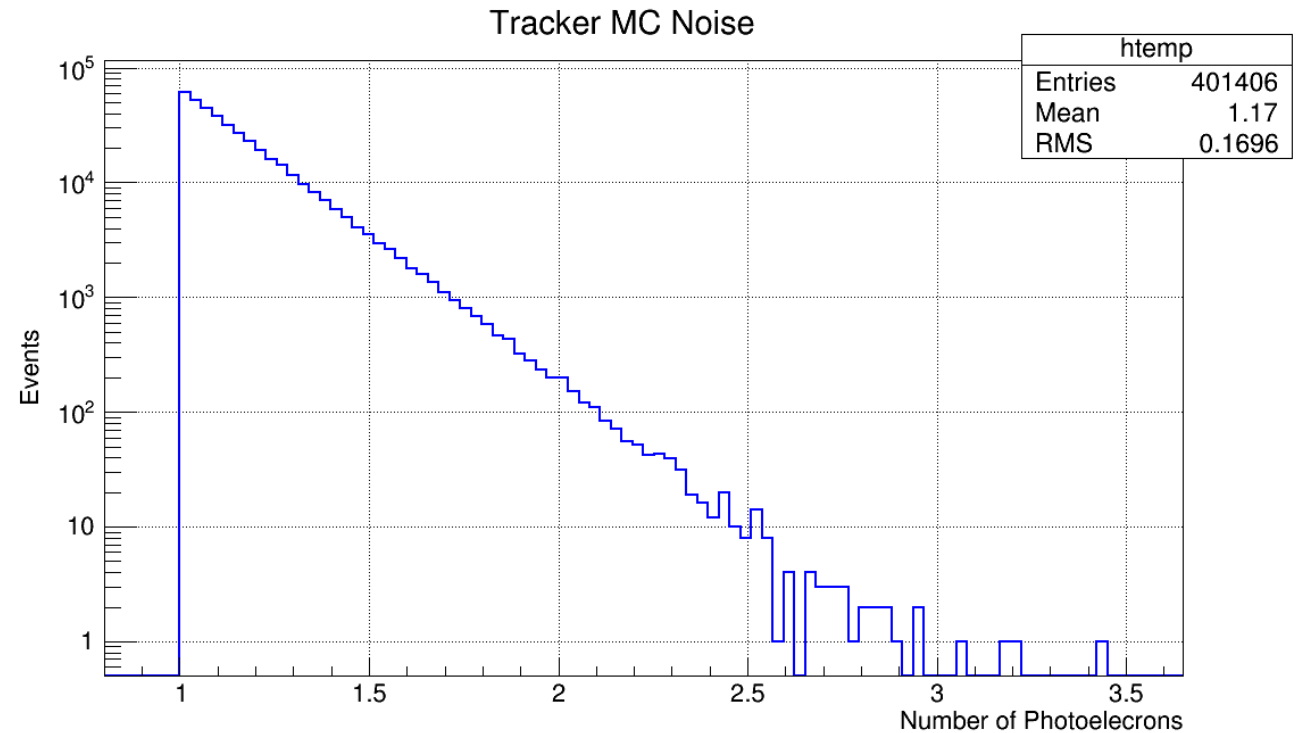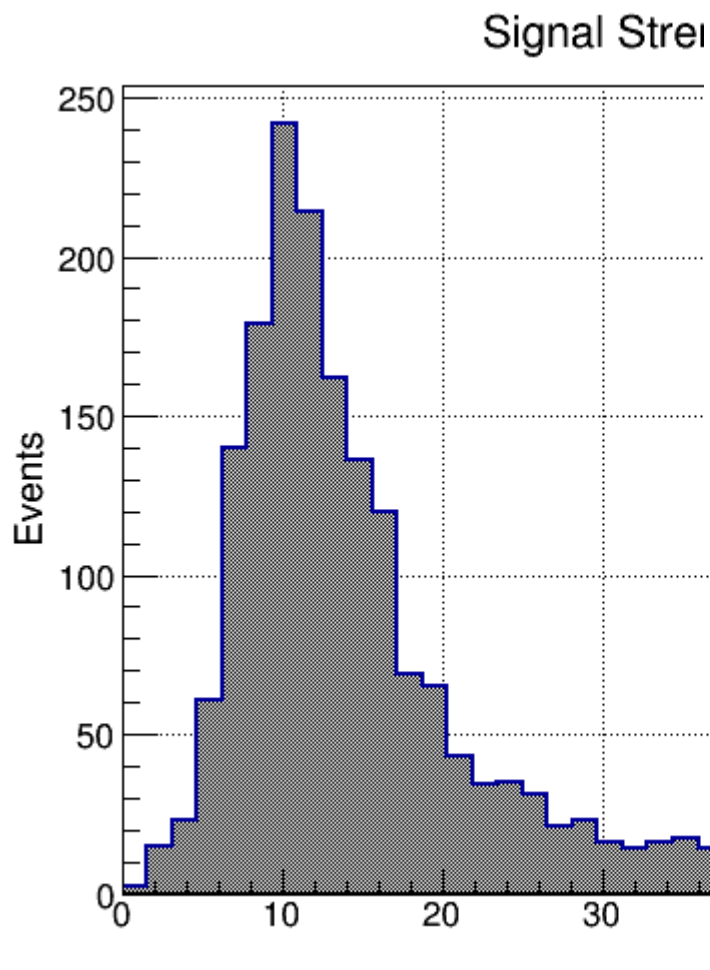
  – Ensemble from all channels

Number of Channels With Noise per Particle Event

Entries	14948
Mean	5.329

Poisson Mean 5.4

Number of Channels Recording Noise

Magnitude of Noise in NPE

Entries	80361
Mean	1.198
Constant	14.62 ± 0.03
Slope	-5.885 ± 0.027

Fits in Red

Number of Recorded Photo Electrons (NPE)

Tracker MC

Tracker MC: Electronics

- Looking at a single channel reveals a hidden truth.
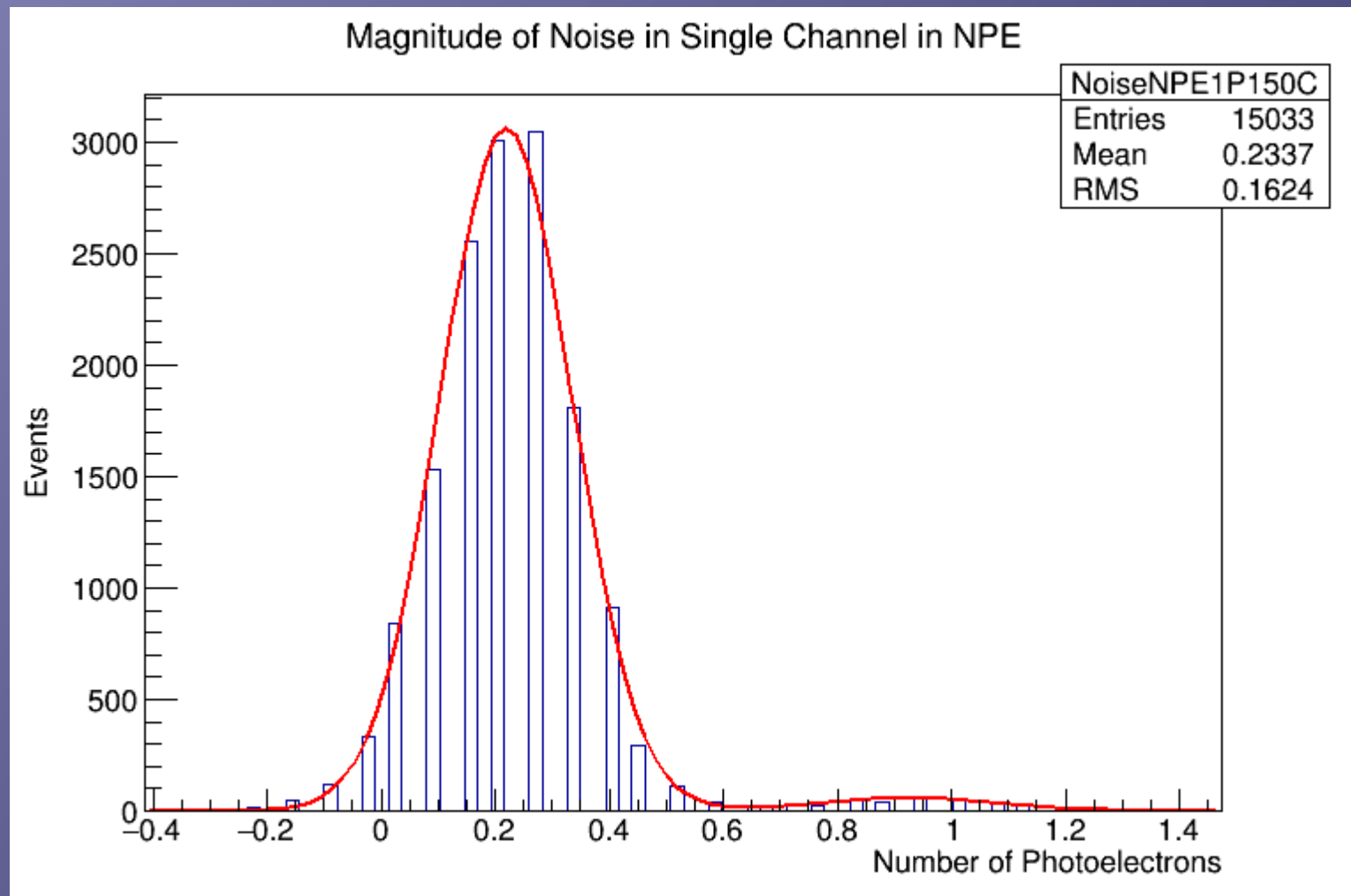
$\mu_1 = 0.219$

$\sigma_1 = 0.116$

$\mu_2 = 0.928$

$\sigma_2 = 0.150$

Diff between pedestal and first signal: 0.708 PE

Correcting:

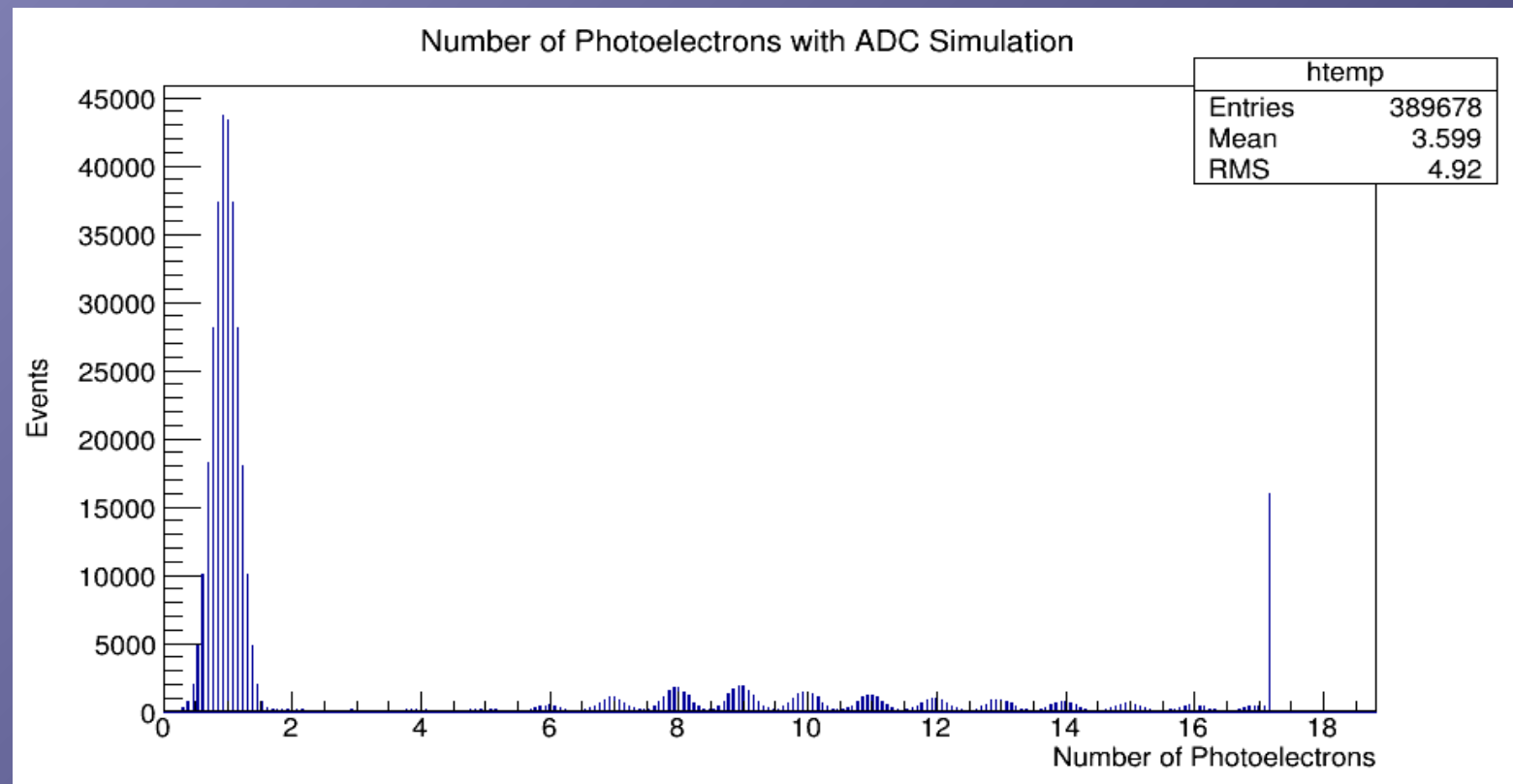$\sigma'_1 = 0.163$

$\sigma'_2 = 0.212$

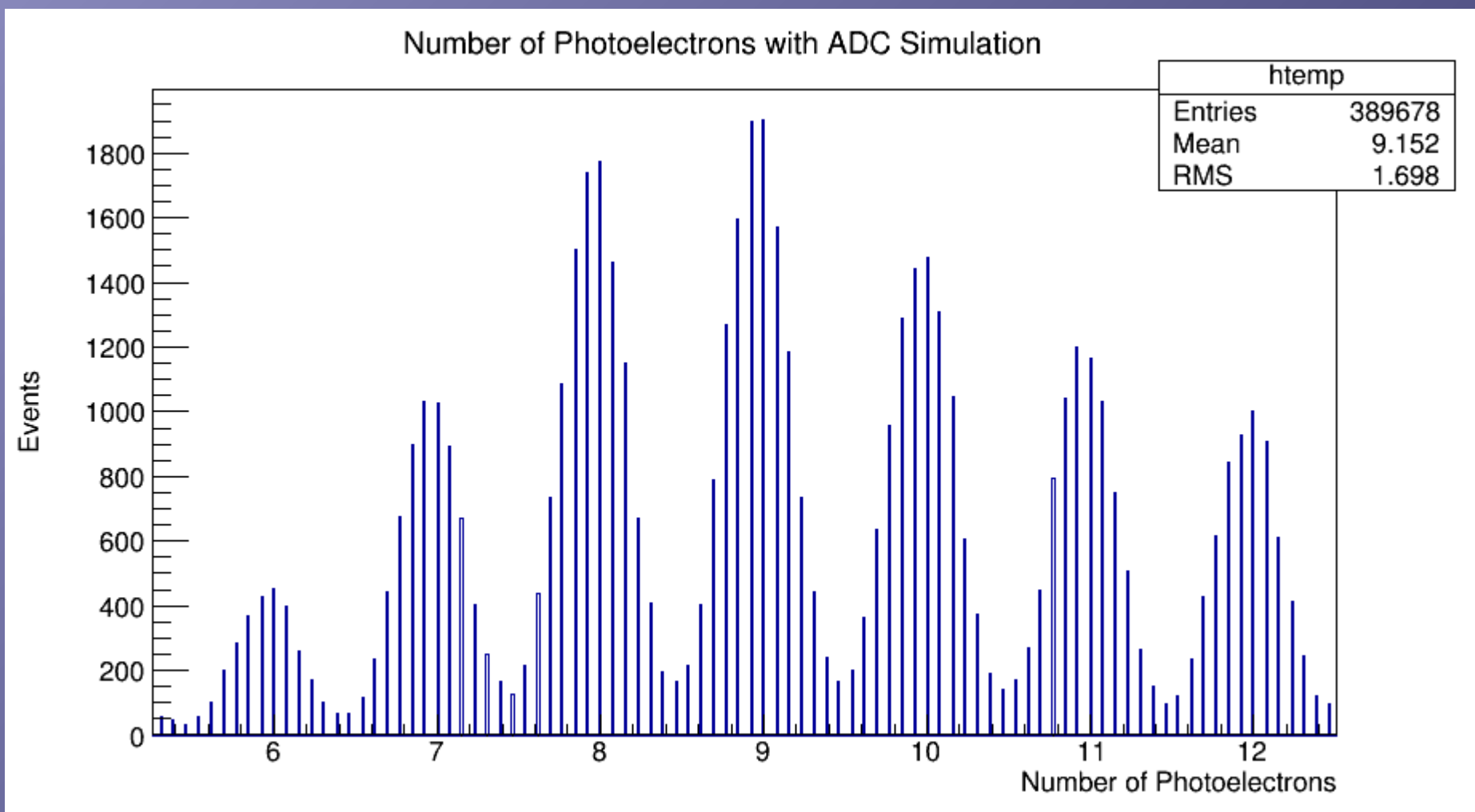

Magnitude of Noise in Single Channel in NPE

Tracker MC: Modeling Electronics

- Bin to nearest integer

- Smear and convert to ADC according to previous adjustment figure
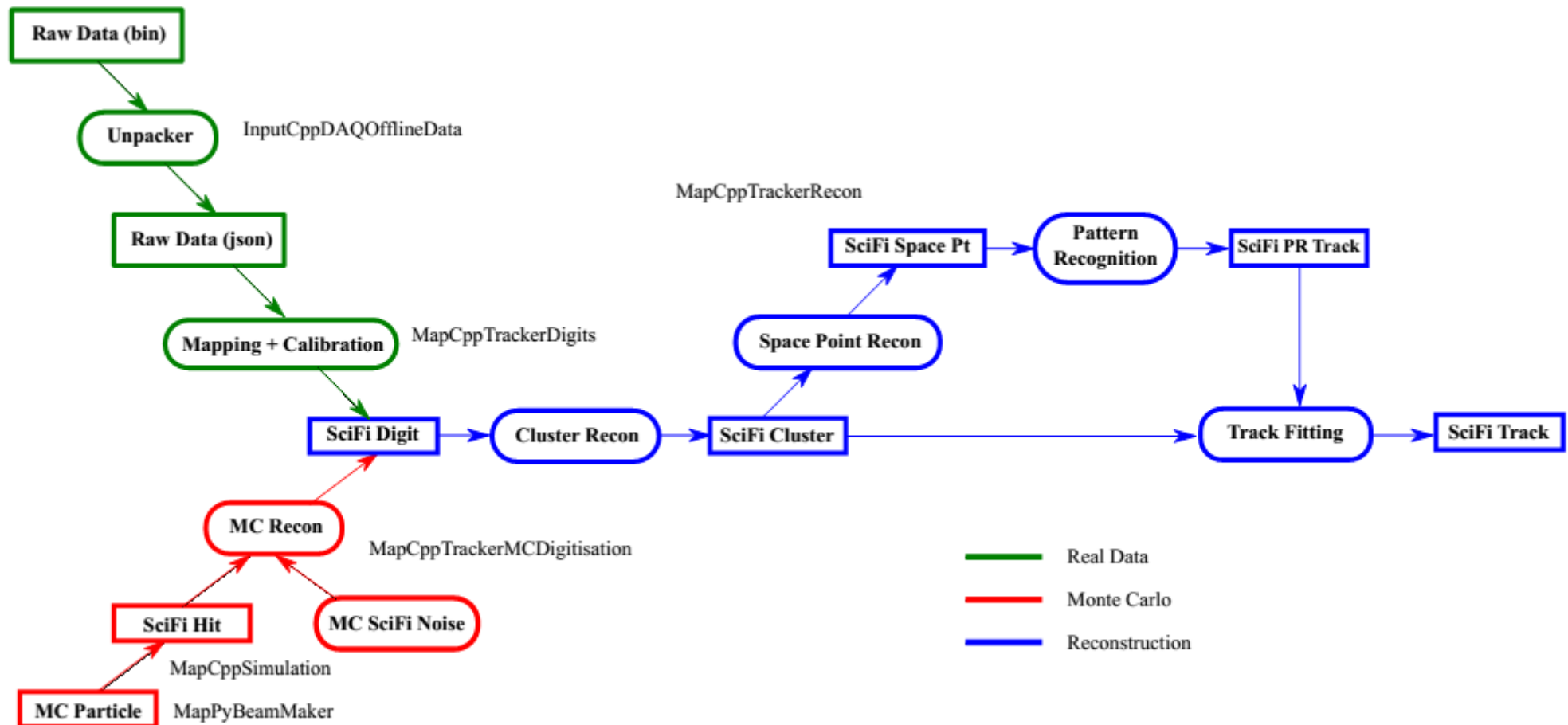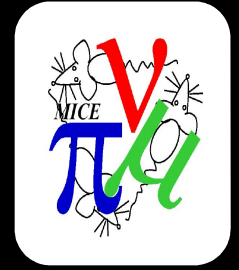
Tracker MC: Modeling Electronics

Not too much effort to add in individual channel calibrations

Tracker Software

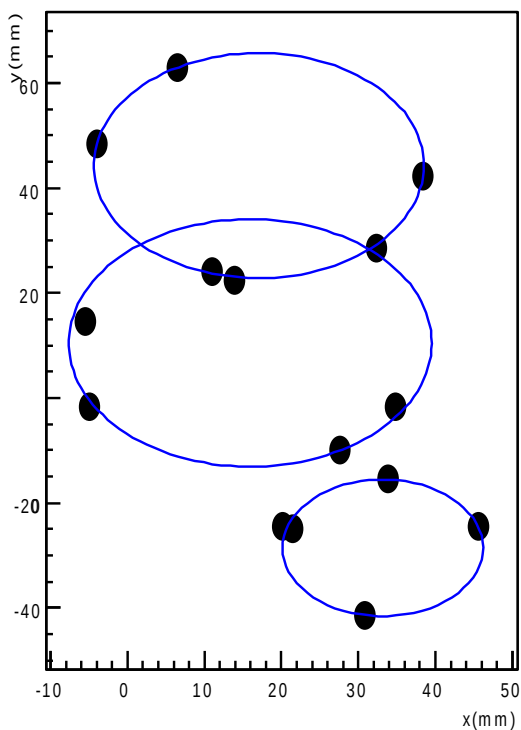# Reconstruction

- Digitisation – unpack the real data or digitise MC data

- Clustering – look for adjacent channel hits and group them

- Spacepoints Reconstruction – look for intersecting clusters on different planes

- Pattern Recognition – use a linear least squares circle fit in x-y, and straight line fit in s-z to associate spacepoints with tracks

- Final track fit – use a Kalman filter to smooth and filter the tracks, accounting with multiple coulomb scattering and energy loss
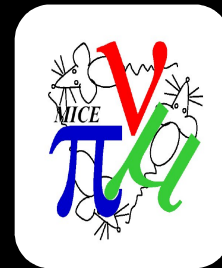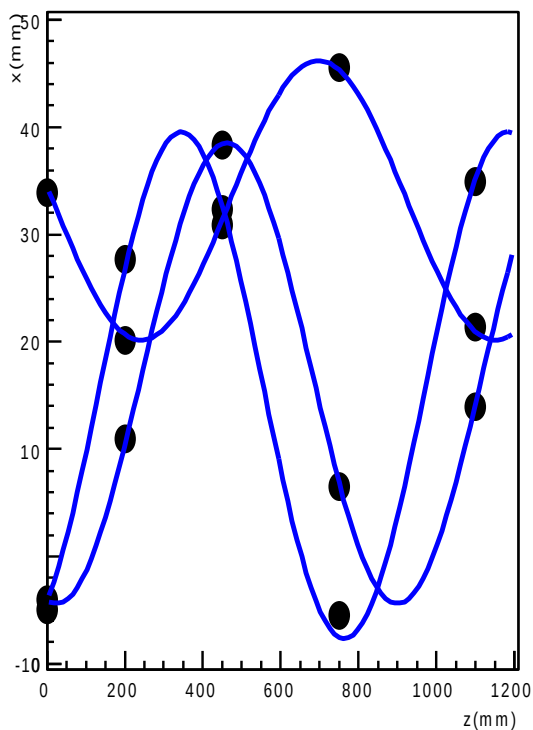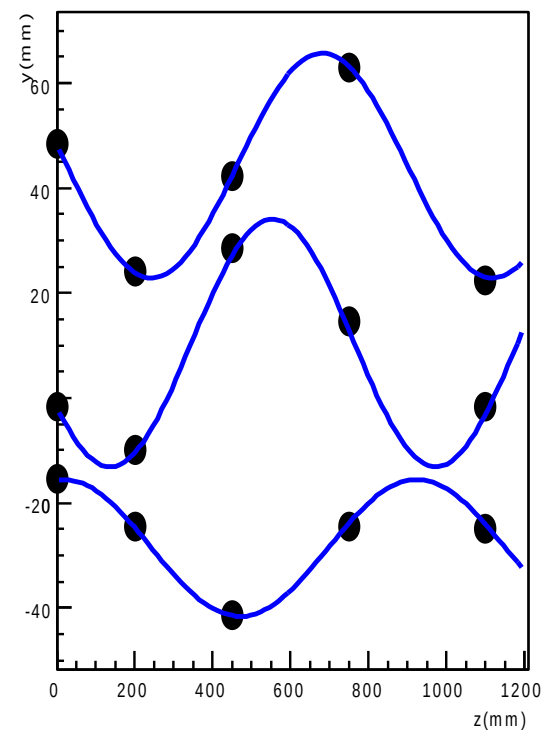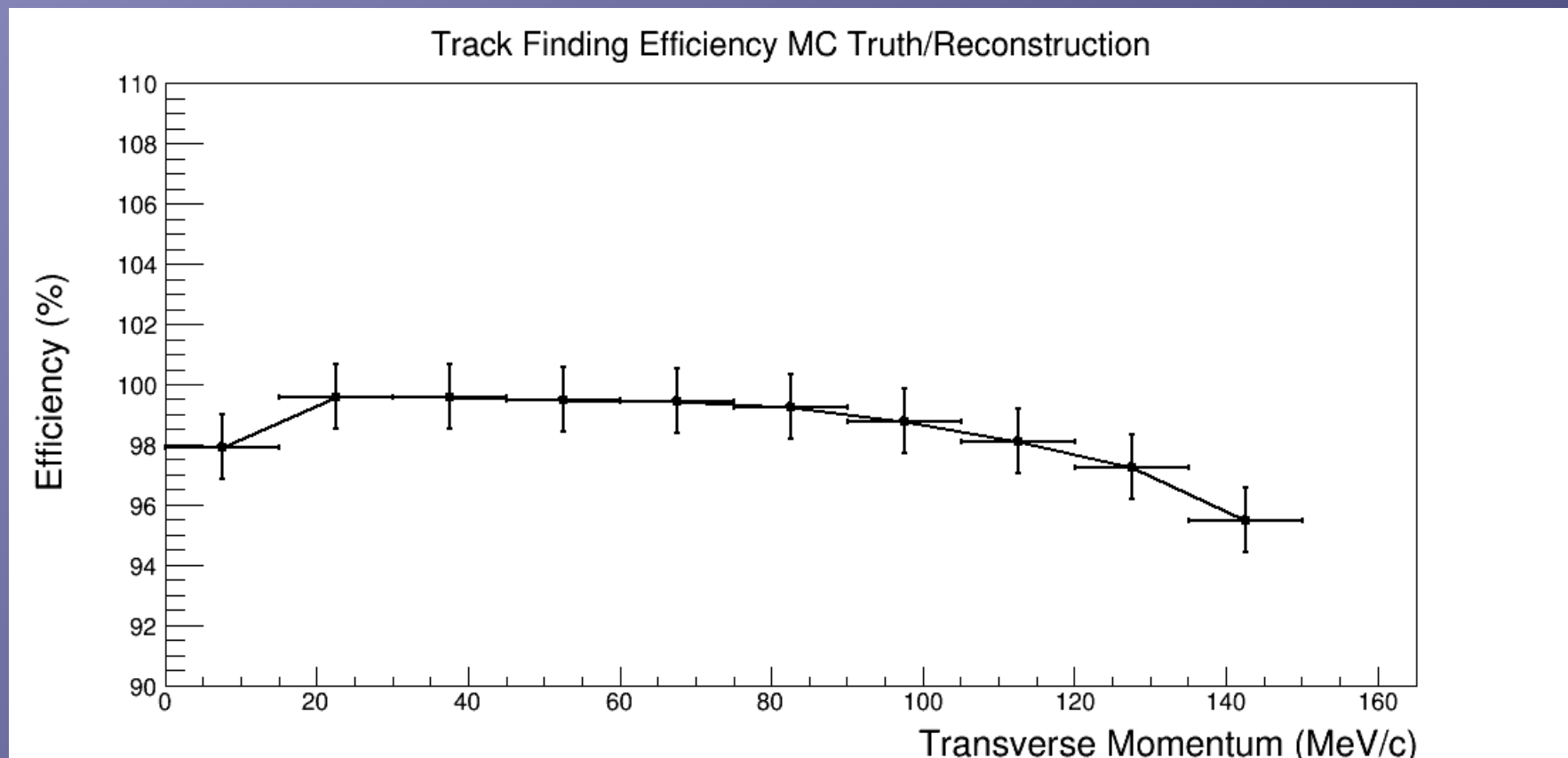
Results I: Pattern Recognition

Helical Pattern Recognition tracks in T2, shown using a Reducer

Reconstruction Efficiency

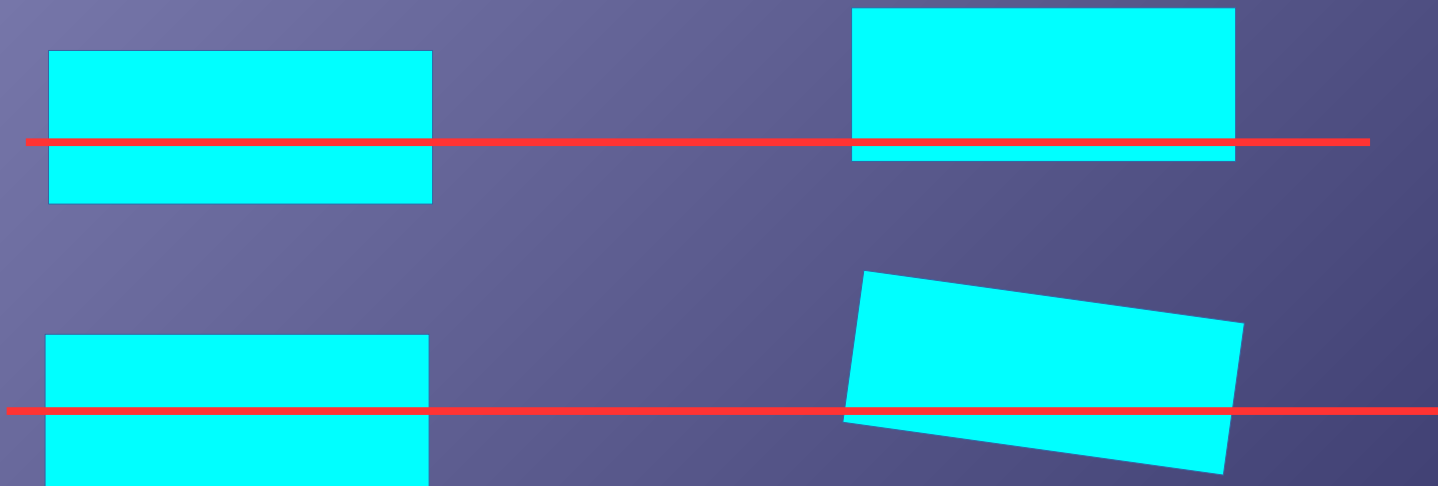- Testing MC truth
  vs reconstruction

Track Finding Efficiency MC Truth/Reconstruction

*Provided by Chris Hunt,
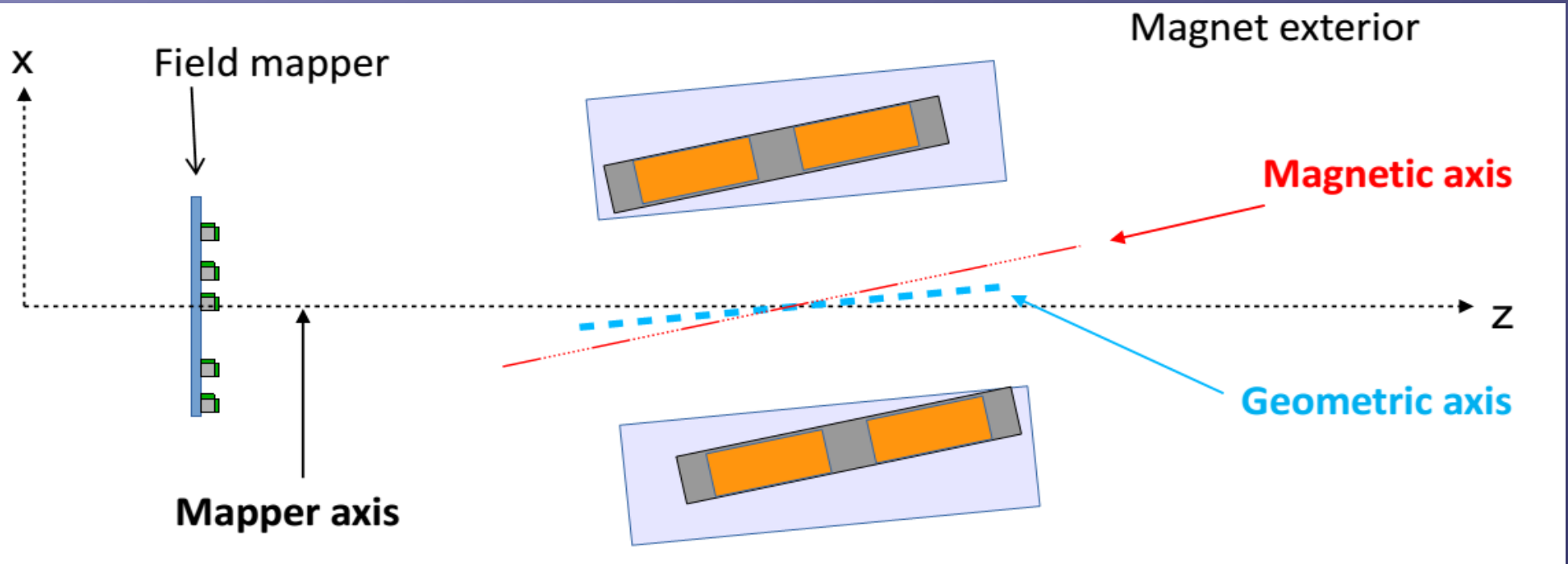Imperial College London

Preparing for Step IV

- Tracker Alignment
  - What kind of tolerance do we have on tracker position
  - List of geometries drawn up, study will begin soon

Preparing for Step IV

- Field Alignment
  - Offsets in magnetic axis
  - Slope in field strength

Conclusion

- MC in place ready to test analysis tools
  - Some fine tuning
  - Determine how much time we want to spend modeling electrons
- Tracker reconstruction in good order
  - Needs testing
  - Unravel Kalman black box
- Analysis tools are in the process of being written
- Next few months should show robust and quantitative results of exactly what we can expect from tracker software