ATLAS Muon Track Reconstruction Algorithm

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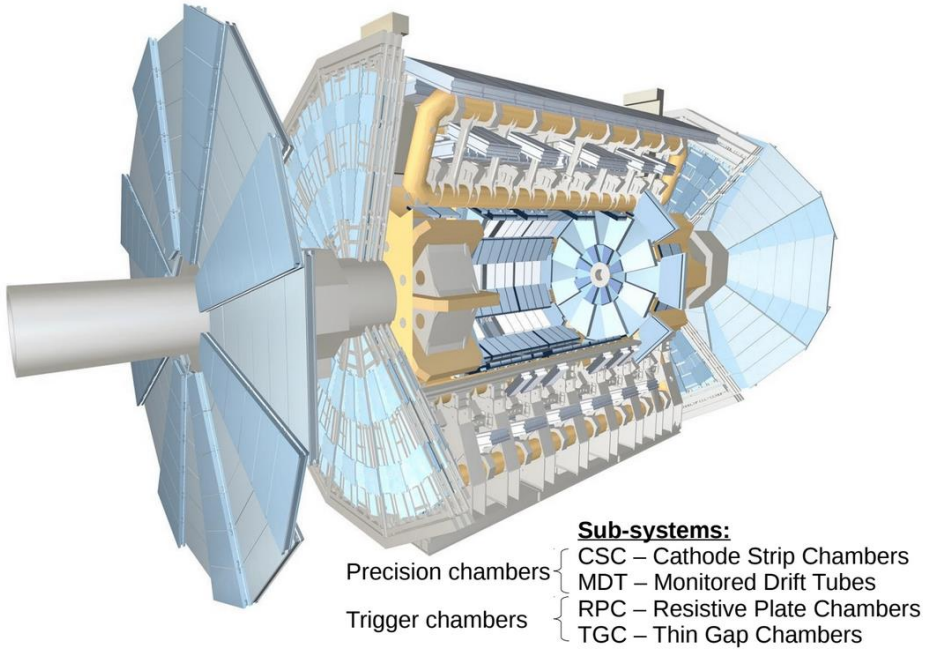
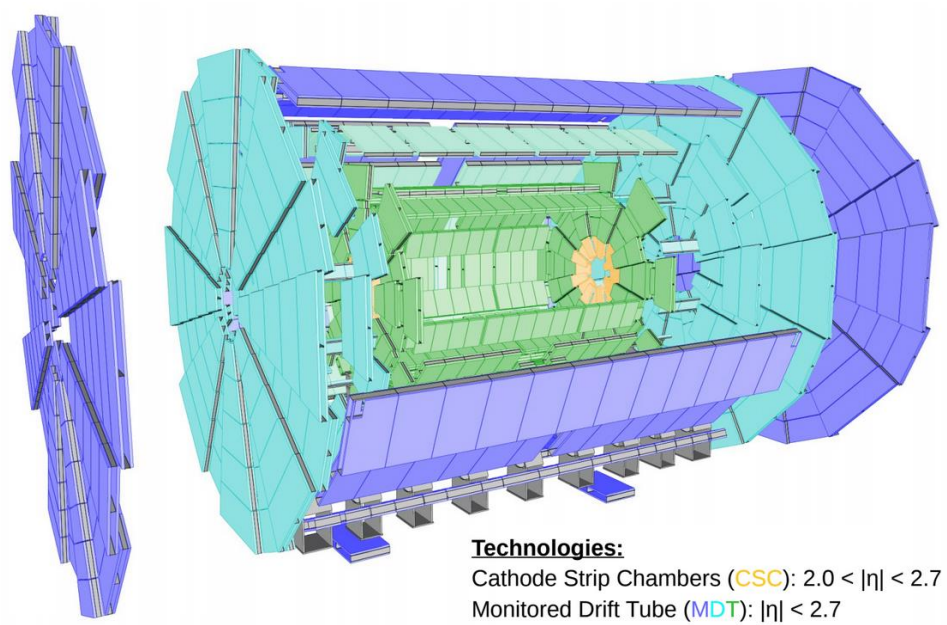
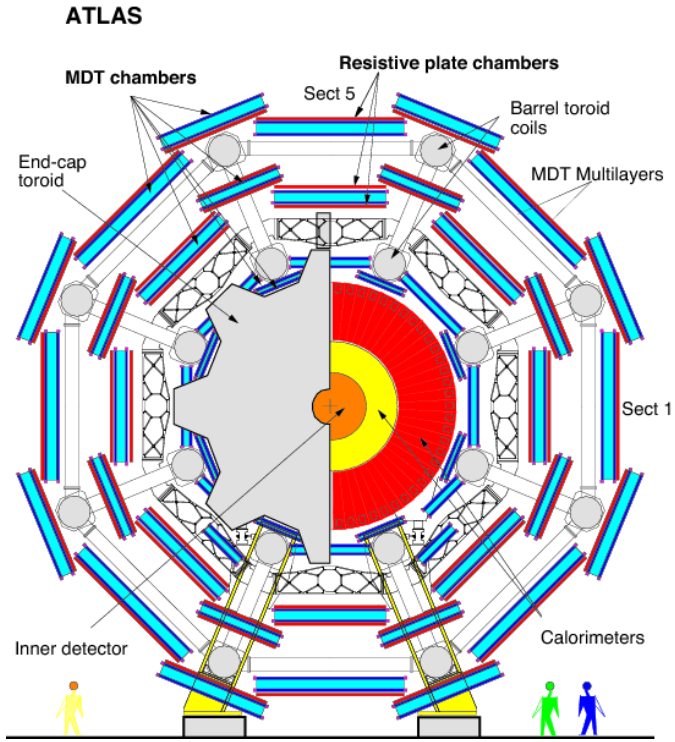
Project Overview



- Goal: create a new algorithm for muon track reconstruction in the outer layers of the ATLAS detector (muon spectrometer)
- Motivation
  - Develop online reconstruction
  - Current trigger rate dominated by "fake" triggers
  - Overall trigger efficiency ~70%
  - Better muon momentum resolution

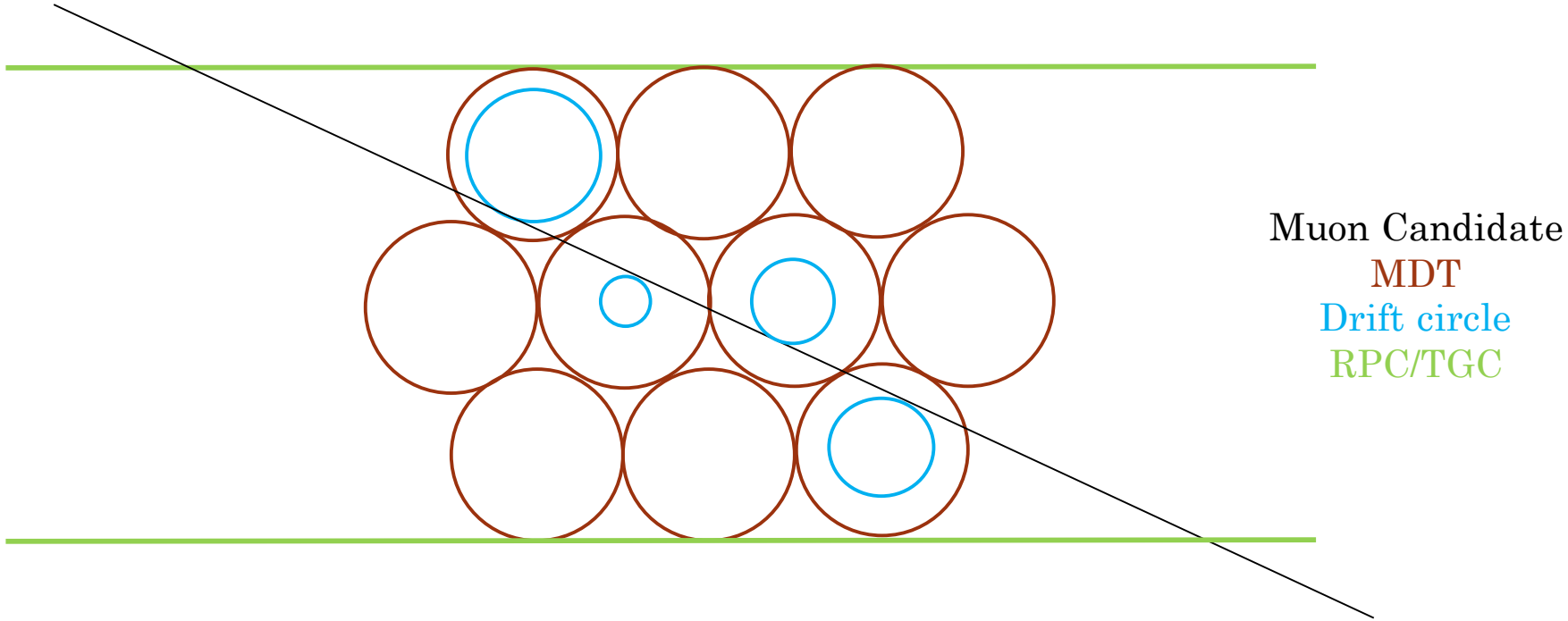
Muon Spectrometer





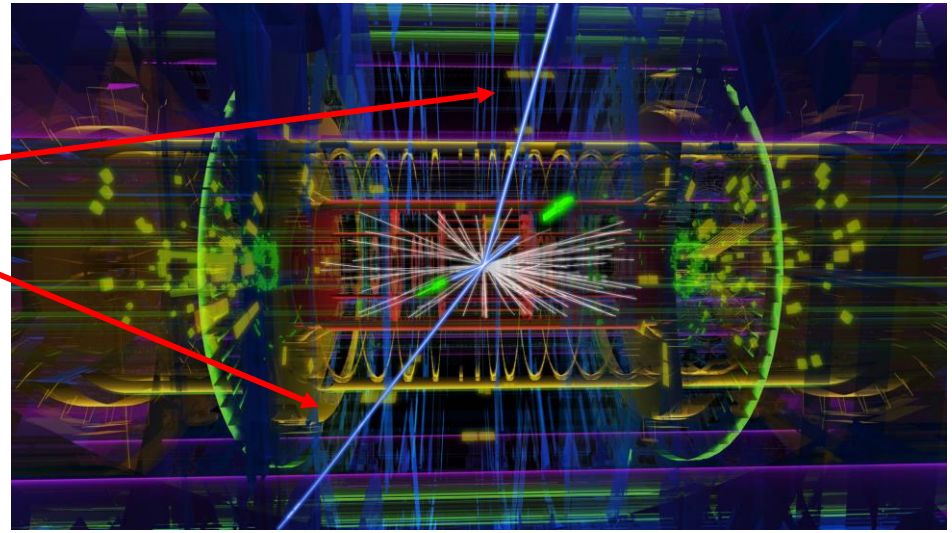
- Barrel/endcap
- Trigger chambers: Resistive Plate Chambers (RPC) / Thin Gap Chambers (TGC)
- Precision chambers: Muon Drift Tubes (MDT)

Muon Leaving Detector



- Level 0: RPCs/TGCs and MDT wires triggered, region of interest (RoI) and drift radius calculated, local track reconstructed
- Level 1: all tracks collected and combined

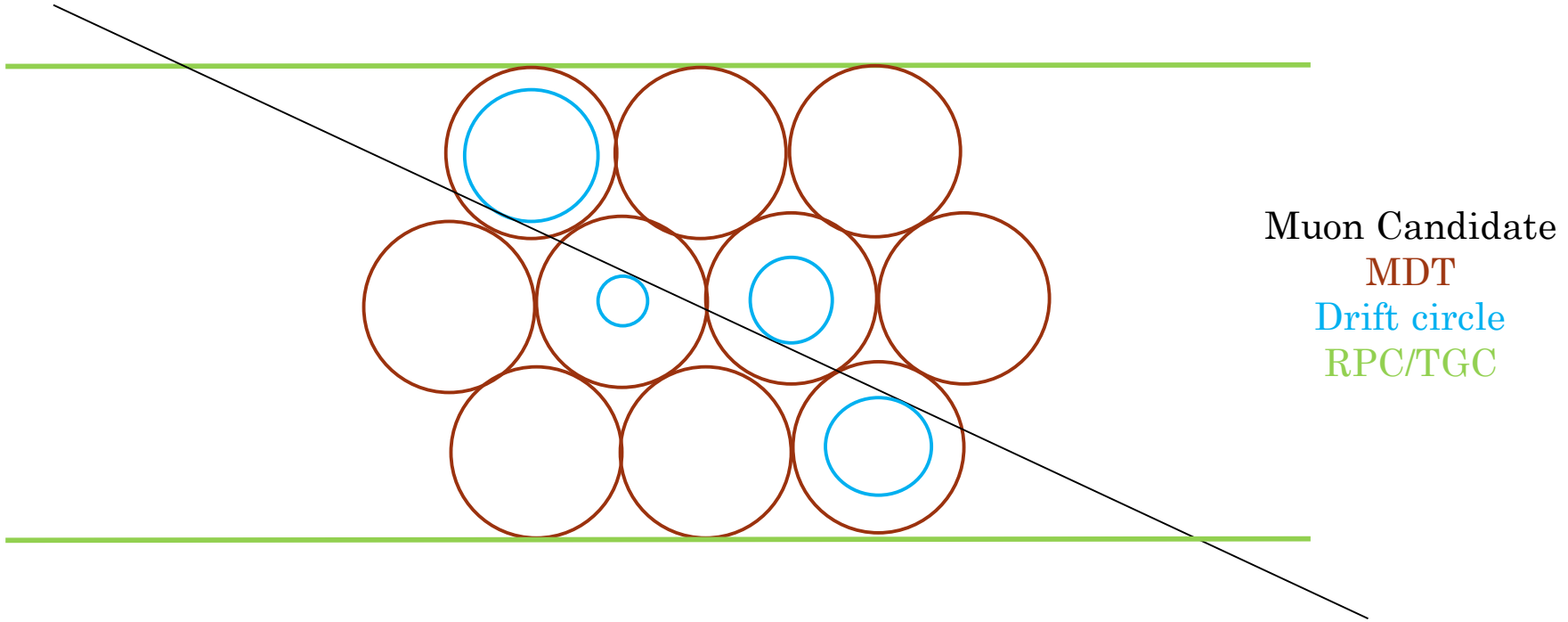
ATLAS event with
2 muons



Algorithm Overview

Uses RPC/TGC triggering and MDT precision

Reconstructing Muon Track



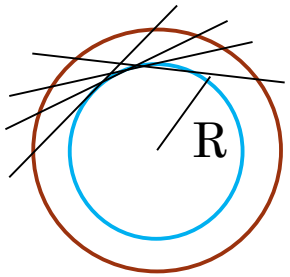
- Common tangent line between all drift circles represents muon candidate
- Legendre transform transforms all possible tangent lines to two coordinates, r and theta

Legendre Transform

$$F(p) = \sup_x [px - f(x)] = -\inf_x [f(x) - px]$$

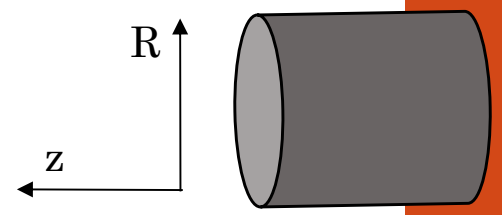
- Shorthand: takes a function f(x) and creates a (p,F(p)) pair which represents a tangent line along f(x)
- Algorithm: creates a tangent line along each point of the drift circle in the MDT

MDT
Drift circle

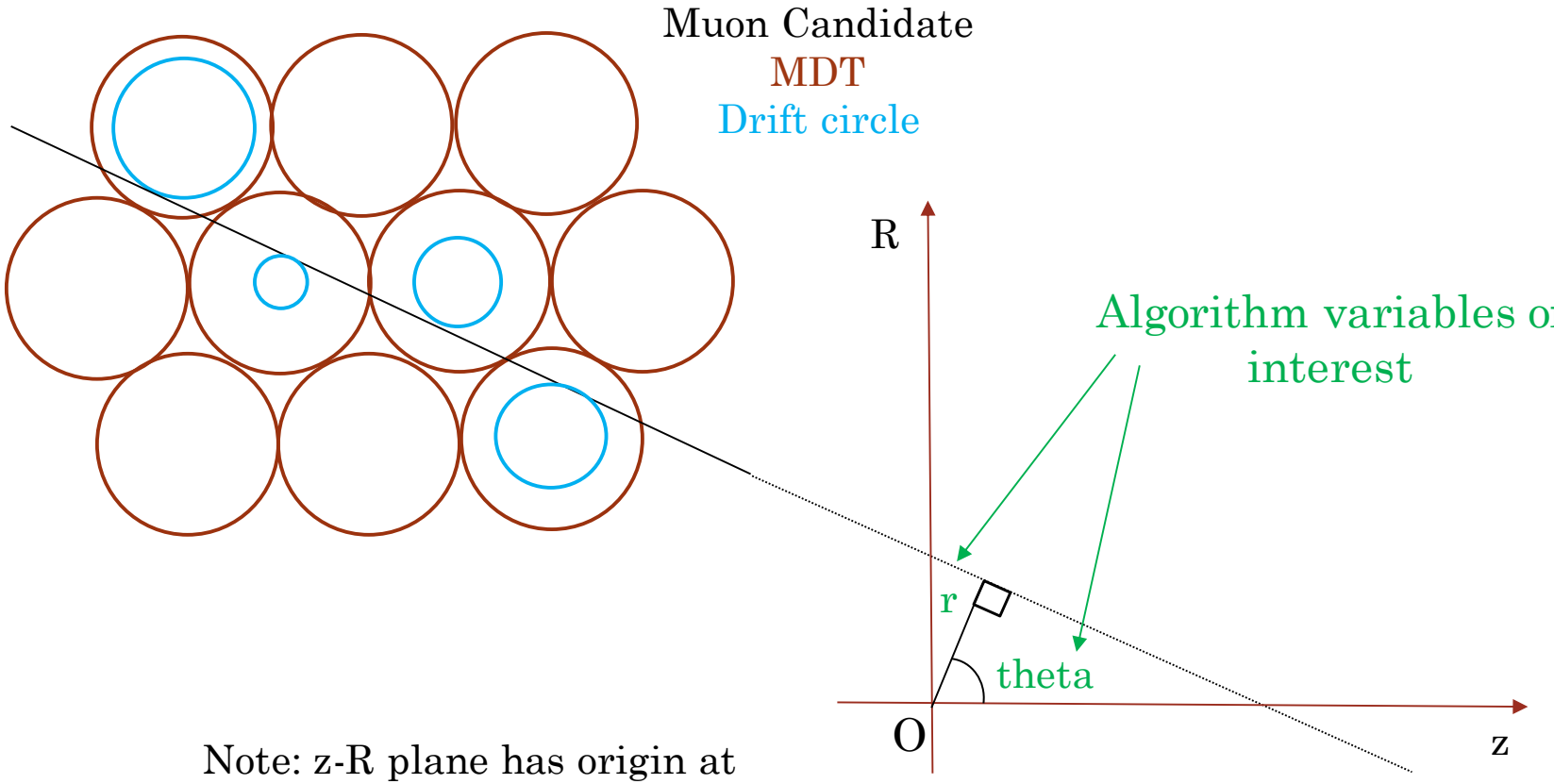


(r, theta) in global coordinates (shown on next slide)

Reconstructing Muon Track

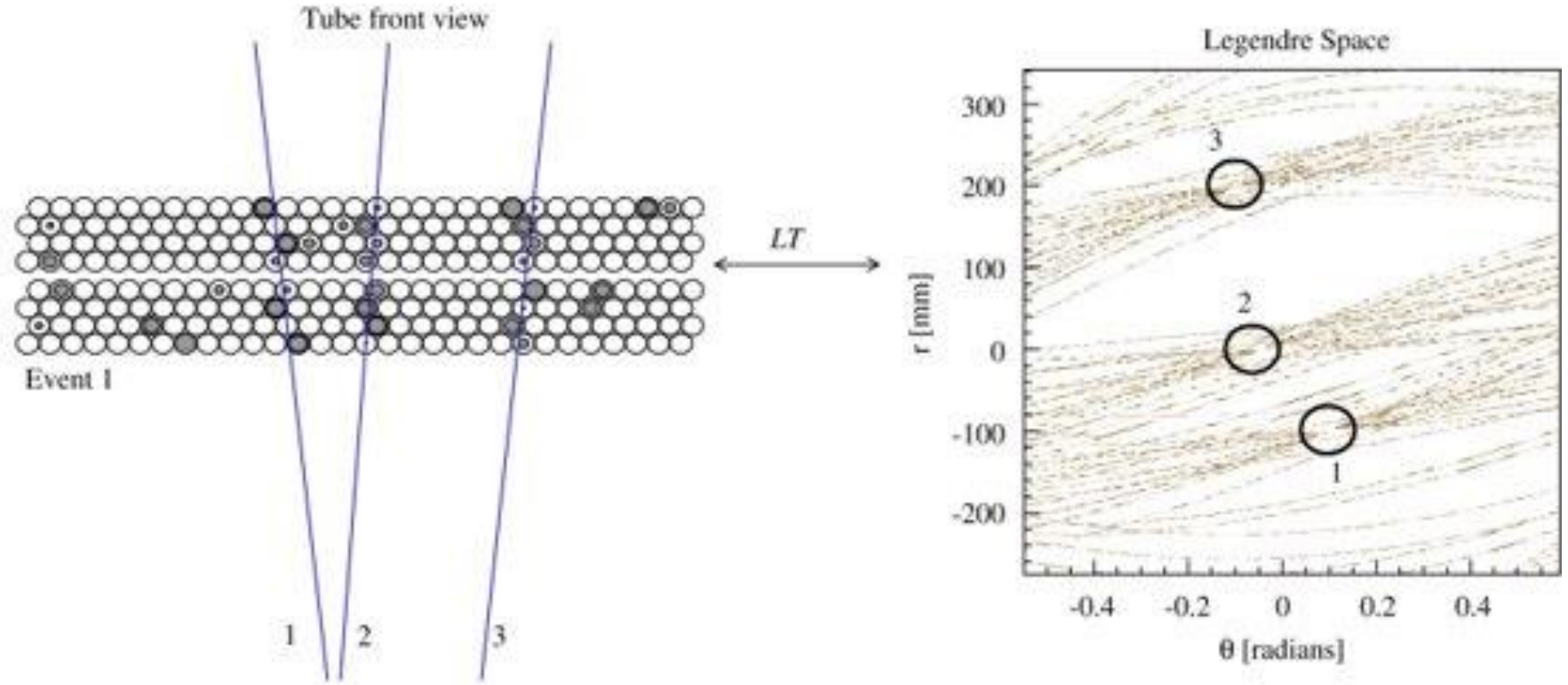


Note: R is radial coordinate in cylinder and z is along axis



Note: z-R plane has origin at center of detector

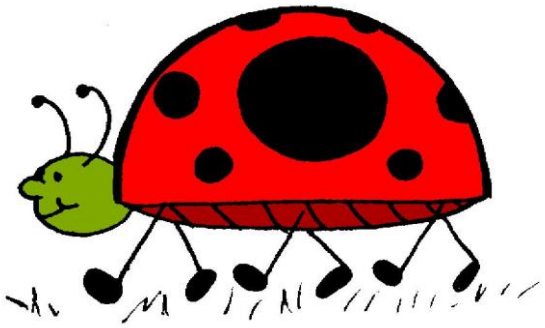
Reconstructing Muon Track



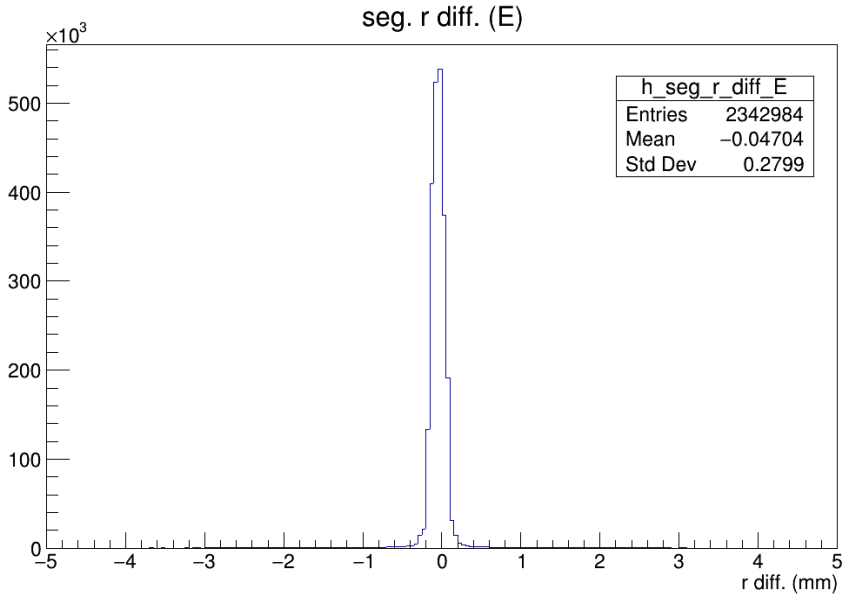
- Legendre space set by RPC/TGC RoI
- Maximum bin in Legendre space is extracted and used to reconstruct muon track

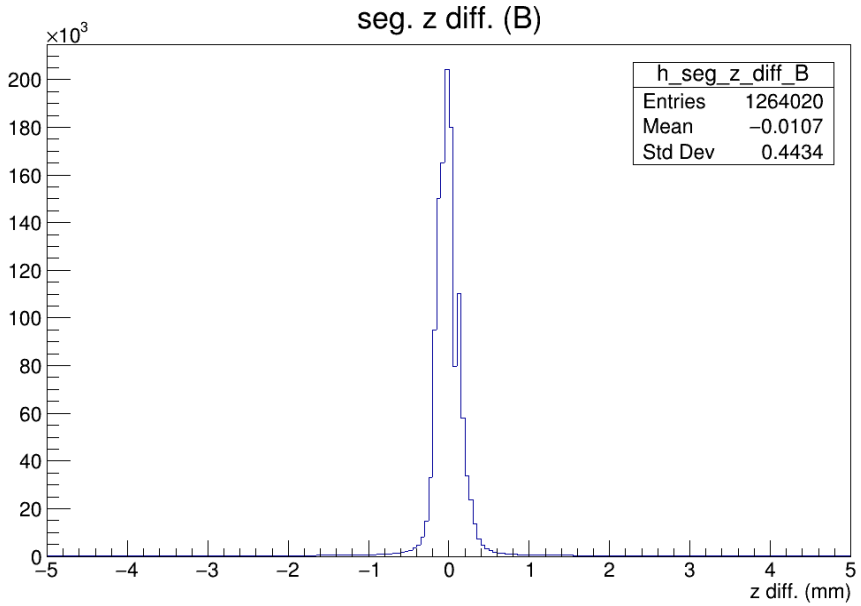
My Project's Focus

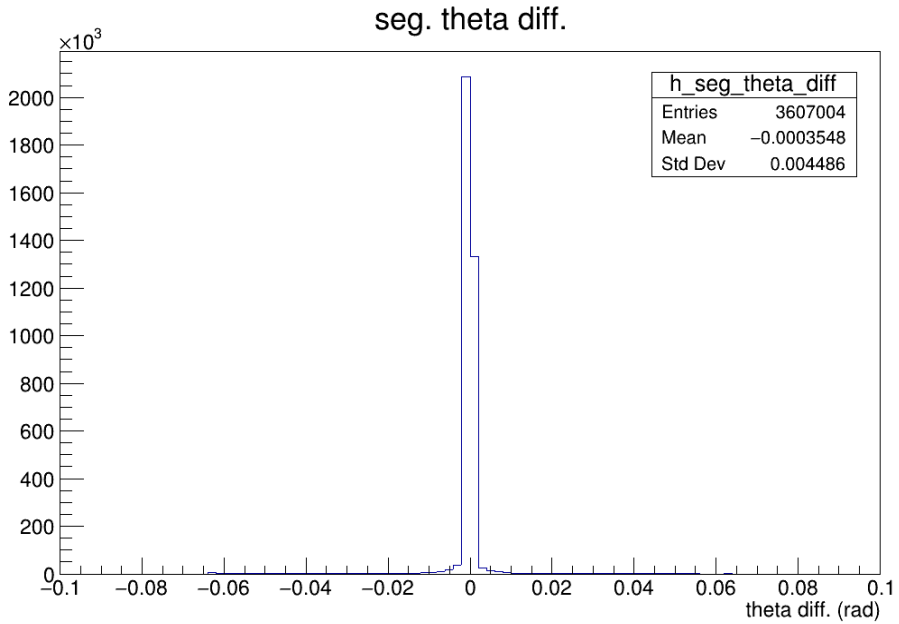
- Compare current algorithm with offline segments
  - Optimize variables
  - Fix bugs
  - Look and understand where algorithm does poorly
  - Introduce new methods to improve algorithm

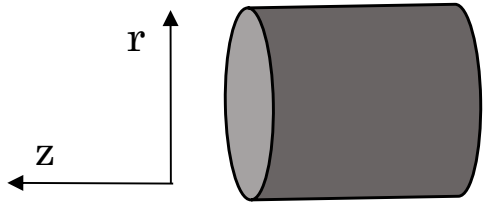


Current Results



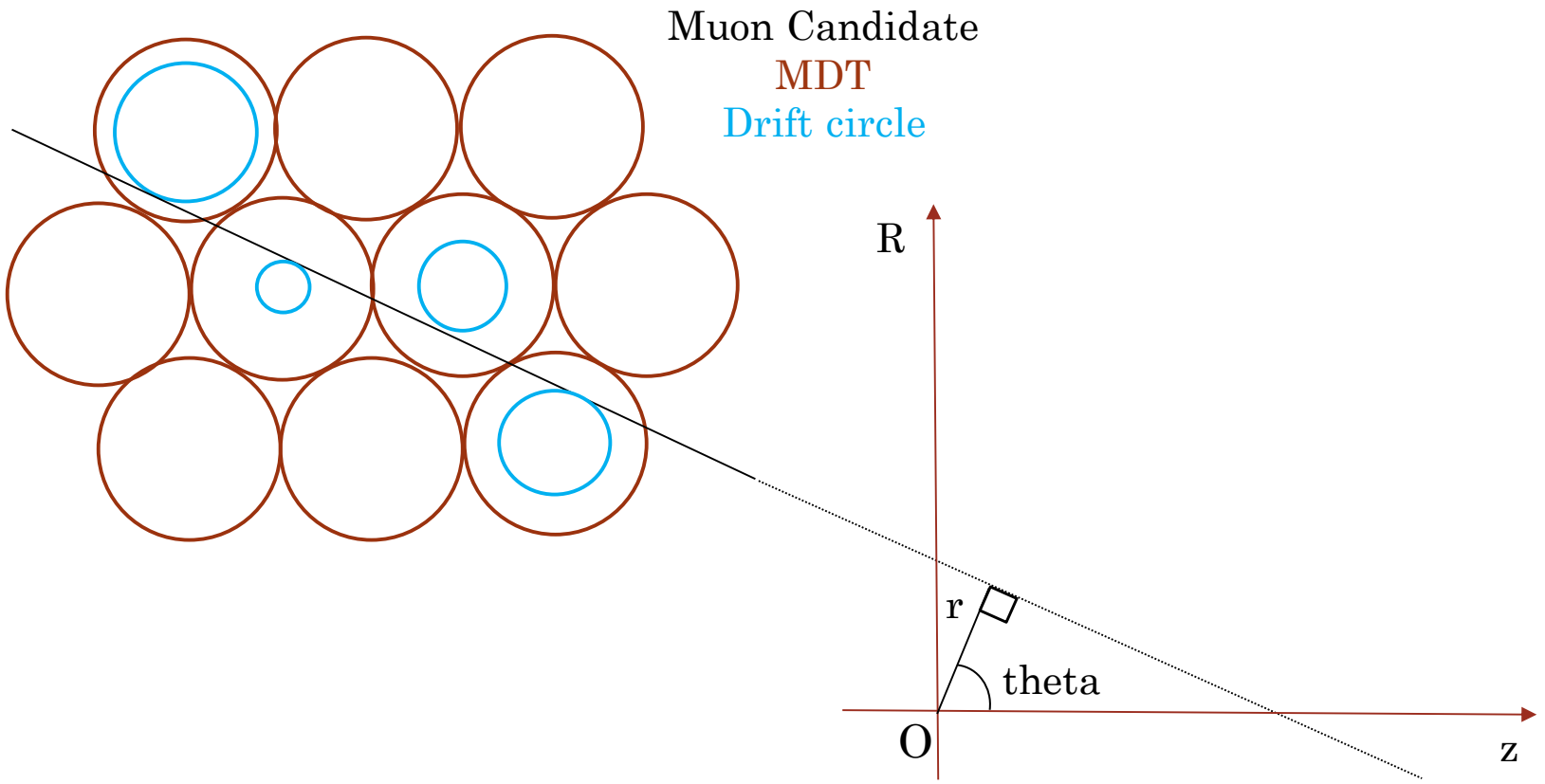






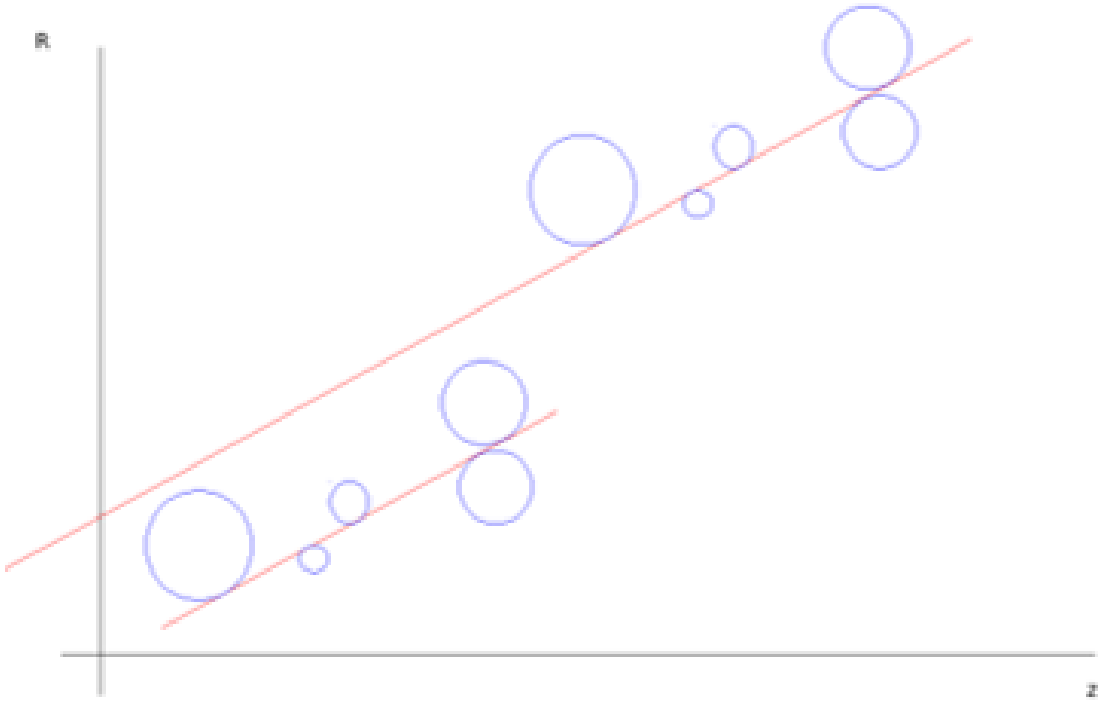
Note: r is radial coordinate in cylinder and z is along axis

Extracting (r, theta) from Legendre Space

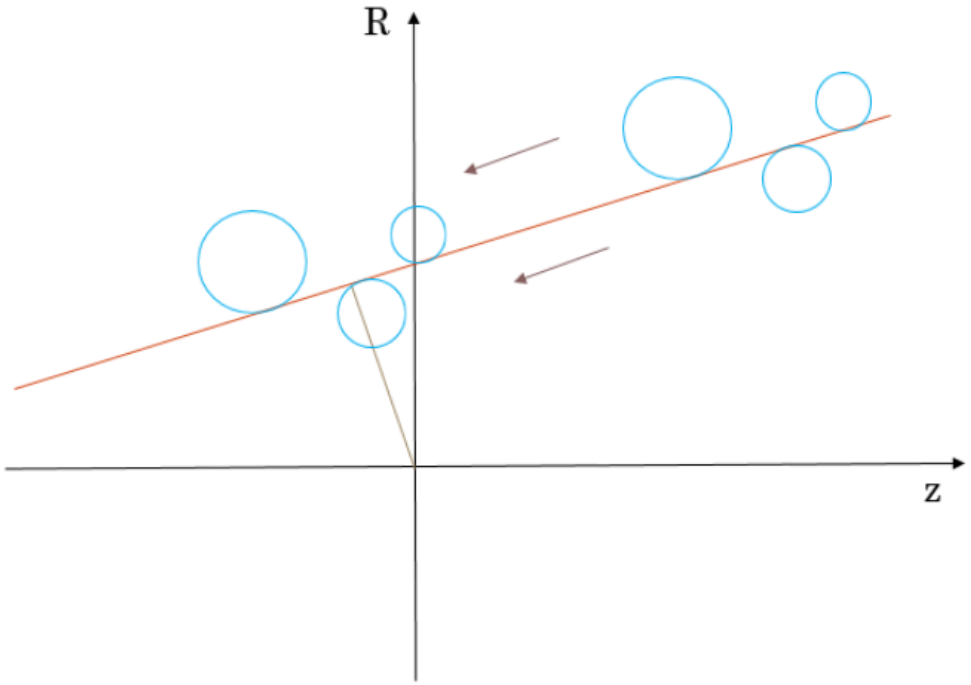


- For FPGA implementation, want to work with smaller values so we offset the drift circle closer to origin before applying Legendre transform
- Issue: where the r/theta "lever" is set changes results

Offset Method vs. Sliding Method



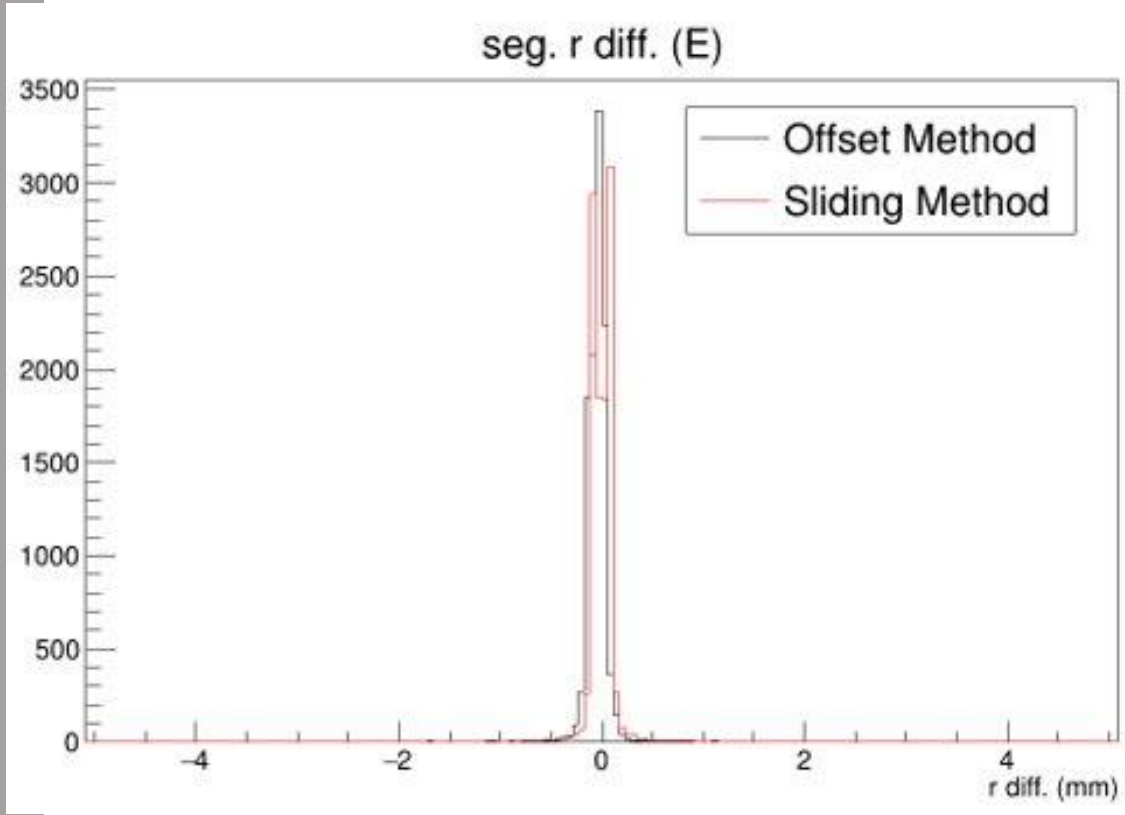
Offset method

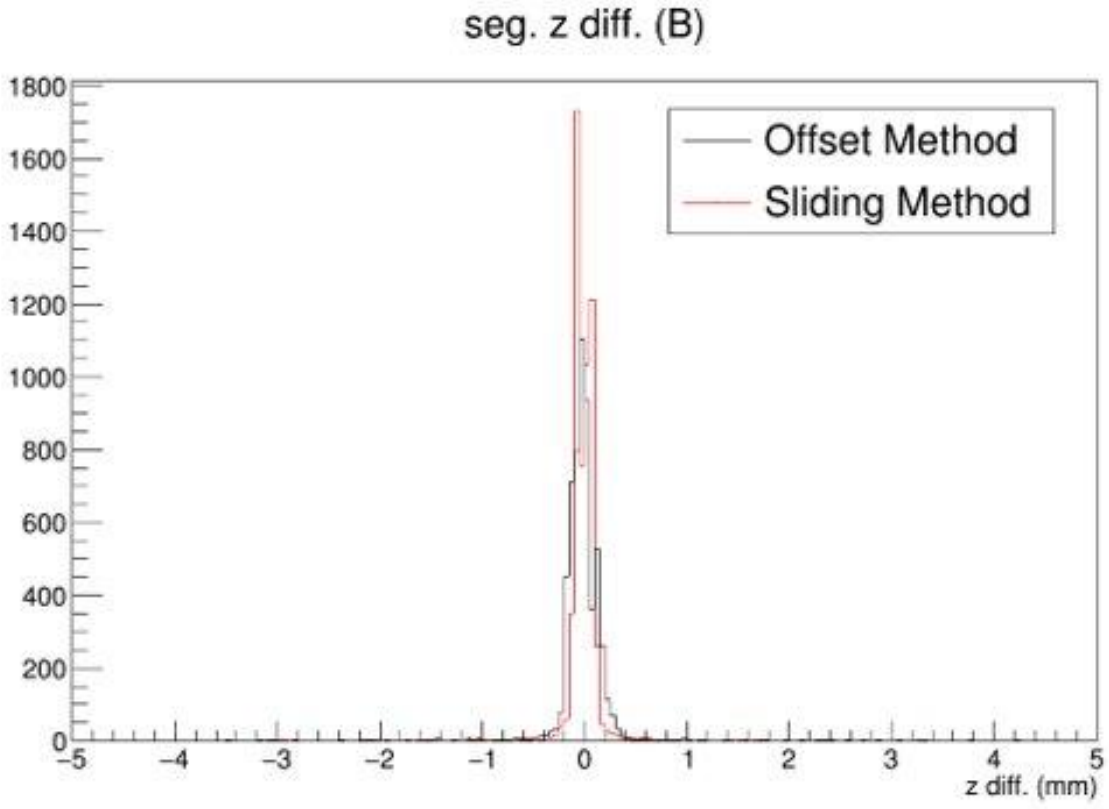


Sliding method

- How do the performances compare?

Offset Method vs. Sliding Method





- Preliminary results
- Sliding method does slightly better

Future Work

- Continue to look at behavior of algorithm
  - Still parts not well understood
- Look at different bin sizes and limits for Legendre space
- Include RPC/TGC trigger data
- Continue analyzing performance of different methods for (r, theta) extraction

- Eventually, transfer code onto FPGA to test
  - Developing code such that it will work optimally on FPGA

Thank you!

- Konstantinos Ntekas – postdoctoral student at UC Irvine
- Anyes Taffard – professor at UC Irvine
- Steven Goldfarb, Jean Krisch, Thomas Schwarz – organizers of CERN Research Semester Abroad program at the University of Michigan
- ATLAS collaboration

Bibliography

- Alexopoulos, T. *et al.*, Nucl. Instrum. Methods Phys. Res. A **592**, 456 (2008)
- "Muon Shift Training General Introduction" slides