Work Summary

Liverpool FASER Meeting

March 7, 2025

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My work thus far ...

- 2024 DQ Checks for Tracking Variables
  - Presented in Physics General Meeting on 25 February
  - First version at Physics General Meeting on 17 December
  - Waiting for reprocessed 2024 data for final checks
- ALMA9 Efficiency Checks for DP
  - Presented at Offline s/w meeting
  - Also followed up in the Analysis meeting
  - Minor follow ups remaining
- MC Production
  - Three versions of Calypso being used
  - CentOS 7 branch works fine – Able to produce samples
  - ALMA9 branches still being figured out
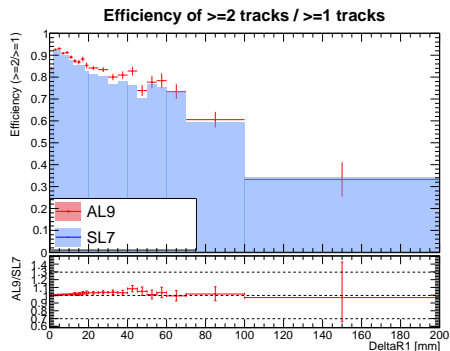- First Look at Dark Higgs Samples

# ALMA9 Efficiency Issue


longTracks vs DeltaR1
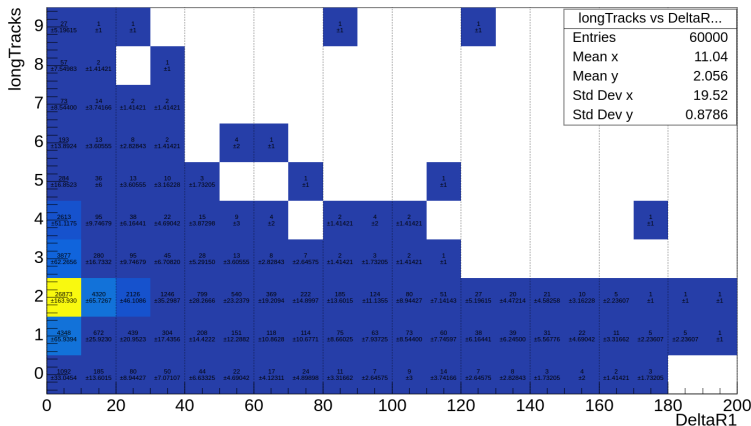
- In bins with separation $\Delta R > 100$, we reconstruct more 1Track Events than 2Track Events. Not sure what is causing this.
- Looking at event displays to better understand the issue

New Efficiency Metric

Efficiency of >=2 tracks / >=1 tracks

- New metric less dependent on the Monte-Carlo Truth Information
- Decay is still visible in the new metric
- Atleast ALMA9 and CENTOS7 are in agreement

Are Events going to the Edge?

Top-view - Run 110033, Event 99

Side-view - Run 110033, Event 99
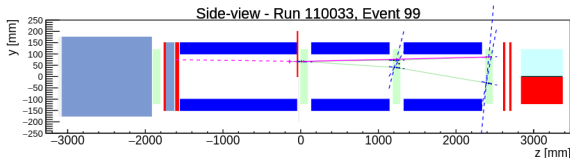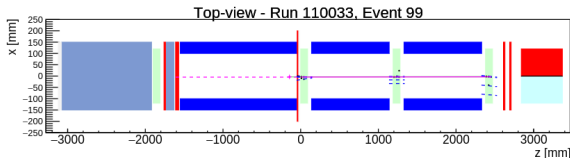
Reconstructed Truth Data
Track 0: p0= 23.3 GeV, pdg=11, hitratio=1.000, Barcode=2, Parent=1

Truth Data
A': P=27.9 GeV, Decayz=-143.9 mm
e+: P=23.3 GeV, R0=63.5 mm, R1=82.8 mm
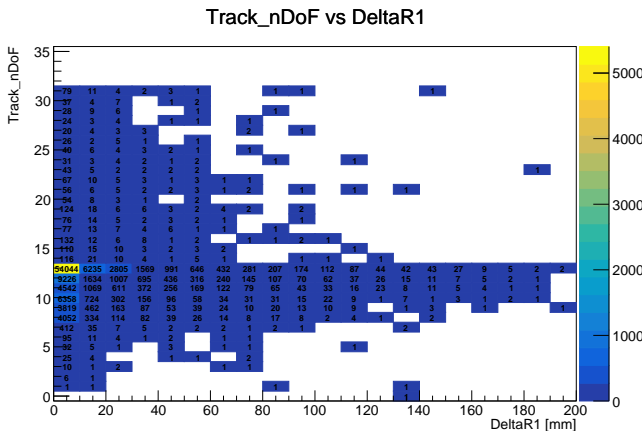e-: P=4.6 GeV, R0=63.5 mm, R1=31.2 mm
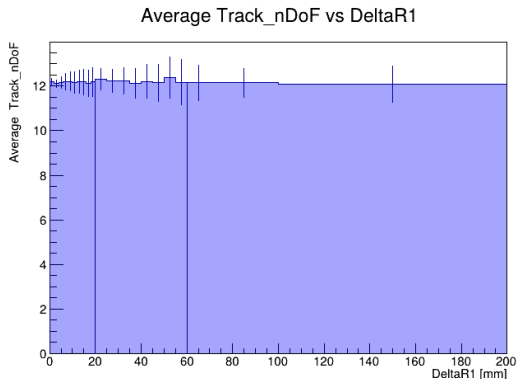Separation between e+, e- : DeltaR0 = 0.5 mm, DeltaR1 = 116.6 mm

Reconstructed Tracks (#longTracks=1)
Track 0: p0= -23.1 GeV, χ^2/lnDof=7.6/12, 9 layers, p1= -23.1 GeV

Are they not Hitting the Detector?

Track_nDoF vs DeltaR1

Are they not Hitting the Detector?

Average Track_nDoF vs DeltaR1

- On average Tracks seem to always have 17 hits
- Maybe a bit biased as it does not really tell us much about the un-reconstructed track.

First look at Dark Higgs Samples

- Shift/Crossing angle in simulations validated
- Preshower deposits is a bit . . .
- First look at Calo Energy Deposits
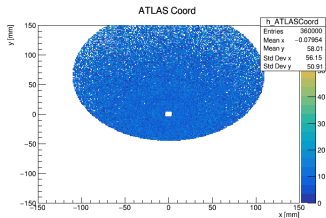
Crossing Angle/Shift Plots

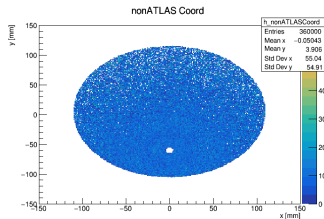Figure: Position of Truth Particles in the ATLAS Coordinate System

Figure: HepMC Level Truth Particles same as ATLAS coordinates

Figure: Position of Truth Particles in the Non-ATLAS Coordinate System (post LoS Shift)

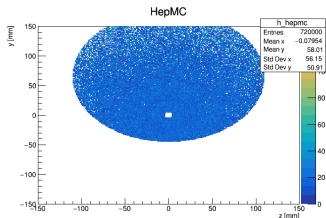- Shifting for LoS seems to work.
- Gap in the bottom half is being investigated
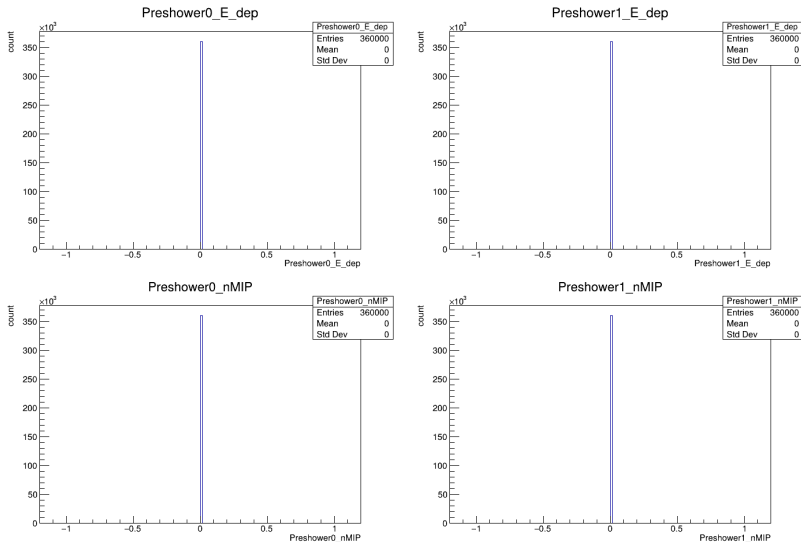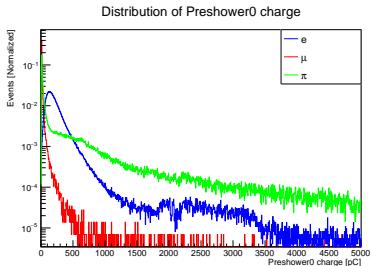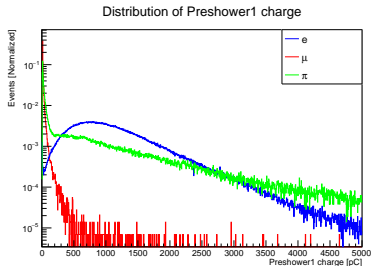
Preshower Energy Plots

Figure: Energy Deposits and nMIPs in the Preshower all seem to be zero. Eric has been informed waiting for a response.

Using Preshower Charge Instead

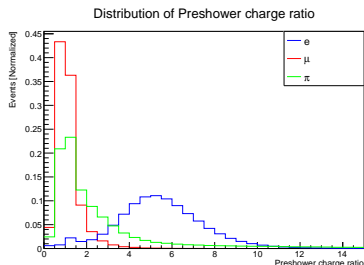**(a)** Distribution of Charge in Preshower 0 for each sample

(b) Distribution of Charge in Preshower 1 for each sample
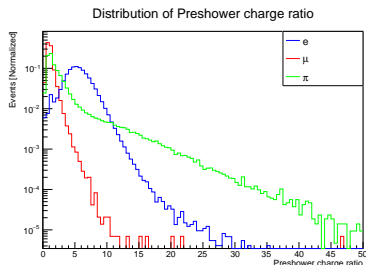
Figure: Charge Deposits in the Preshower does give some extent of PID information.

- Electrons have a wider distribution in Preshower 1
- Muons Peak at 0 in Preshower 1 and 2
- Pions Peak at 0 but have a wide tail

Preshower Charge Ratio

(a) Ratio of Charge in Preshower1 to Preshower0 in Linear Scale

(b) Ratio of Charge in Preshower1 to Preshower0 in Log Scale
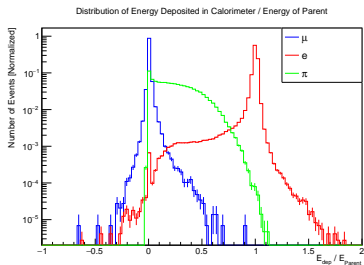
Figure: Ratio of Charge Deposits in Preshower 1 to Preshower 0

- Ratio of charge deposits in Preshower 1 to Preshower 0 seems to be a good PID variable
- Hoping to see if the Energy Deposit/Momenta could be a better discriminator
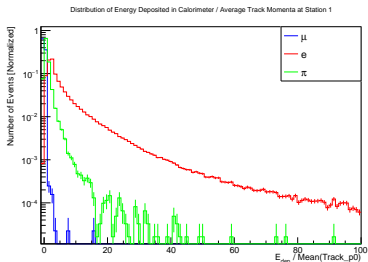
Calo Energy Deposits
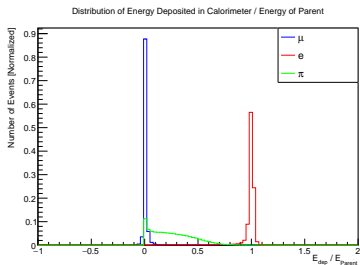
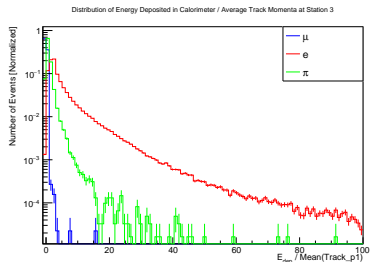**(a)** Energy Deposits in Calorimeter/Truth Energy of Parent Particle [Linear Scale]

(b) Energy Deposits in Calorimeter/Truth Energy of Parent Particle [Log Scale]

- As expected, Electron seem to deposit all of their energy
- Muons deposit very little energy
- Pions deposit some of their energy

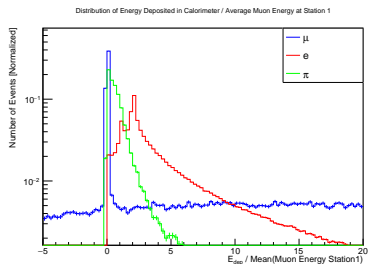# Calo Energy Deposits Continued

(a) Energy Deposits in Calorimeter/Average Track Momenta at Station 1

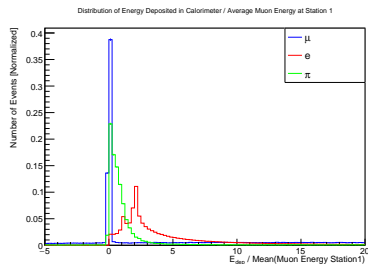**(b)** Energy Deposits in Calorimeter/Average Track Momenta at Station 3

- Nuance here with taking the Average of Track Momenta
- Is dividing by Track Momenta more meaningful?

Calo Energy Deposits Continued

(a) Energy Deposits in Calorimeter/Mean Track Energy in Log Scale

(b) Energy Deposits in Calorimeter/Mean Track Energy in Linear Scale

- Energy calculated under the assumption that the particles are Muons

MC Production

- Started working on MC Production
- Running on Liverpool Cluster
- Currently built three branches of Calypso
  - CentOS 7 branch works fine – Able to produce samples
  - ALMA9 and master branches still being figured out
- Able to produce DarkHiggs Samples in the CentOS 7 branch
- Hopefully will be able to produce the remaining Dark Higgs samples soon
- Contacted Eric for comments on the branch related issues

Work to start on

- Extended Dark Photon/Dark Higgs Samples
  - Get the Preshower Energy Variables checked
  - Start looking at possible selection criteria
  - Hopefully, can produce the remaining samples ourselves
- MC Production
  - Need to understand the alma9-dev and master branches
  - The remaining 2024 samples of the DarkHiggs are similar
  - Only need changes needed are to the crossing angle
  - Should be able to produce them as a starting point
- Follow Ups on Efficiency Issues
  - Relatively minor from my end
  - Need to make collate the event displays
  - Quantify the charge MisIdentifications

Thank you!