Emulsion Reconstruction Efficiency Analysis in SND@LHC

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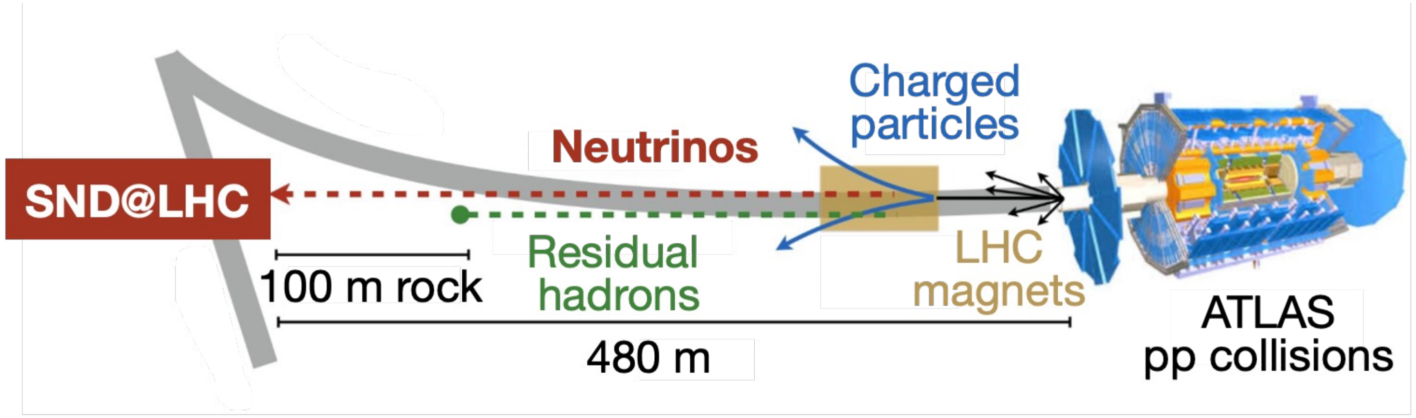
SND@LHC Overview

- Compact standalone neutrino experiment at the LHC
- Optimized to identify the 3 neutrino flavors and detect feebly interacting particles
- Pseudo-rapidity range: $7.2 < \eta < 8.4$
- Explore heavy flavor production at the LHC, explore this pseudo-rapidity region for future experiments, and search for scattering of feebly interacting particles

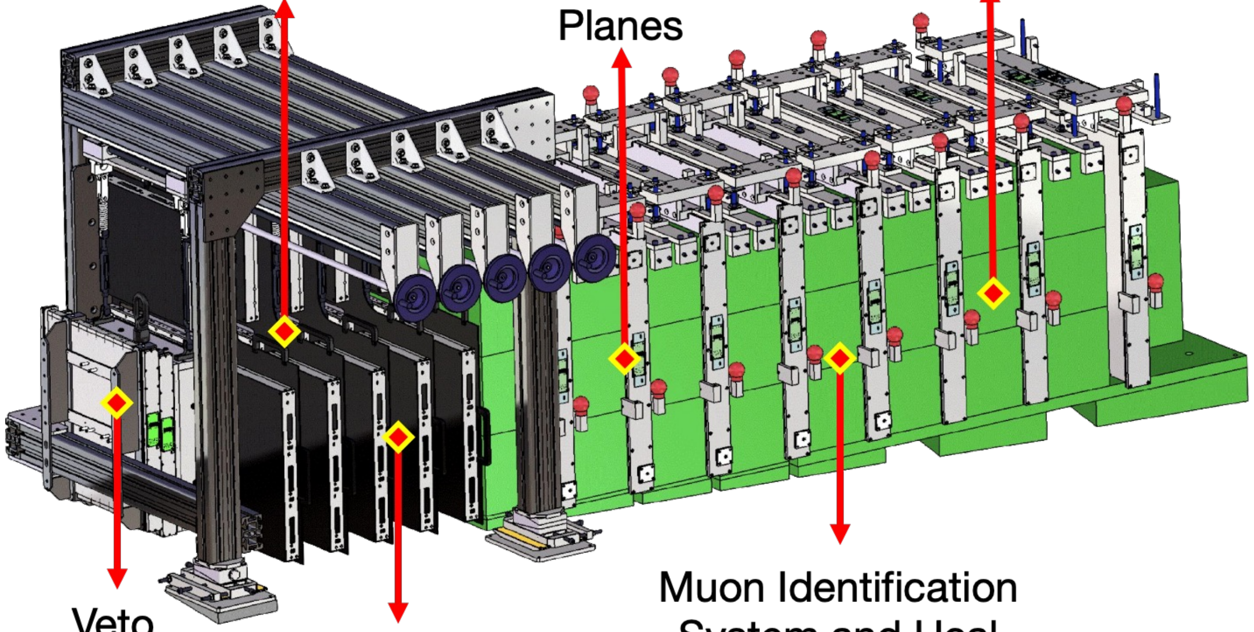


LHC Run 3:

250 fb^{-1} data (~2000 neutrino events)

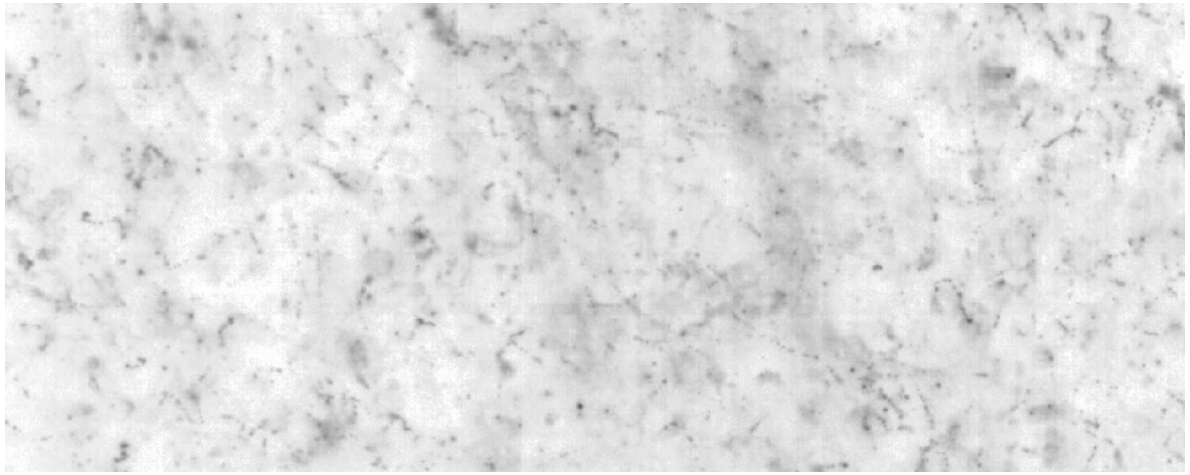
SND@LHC Overview

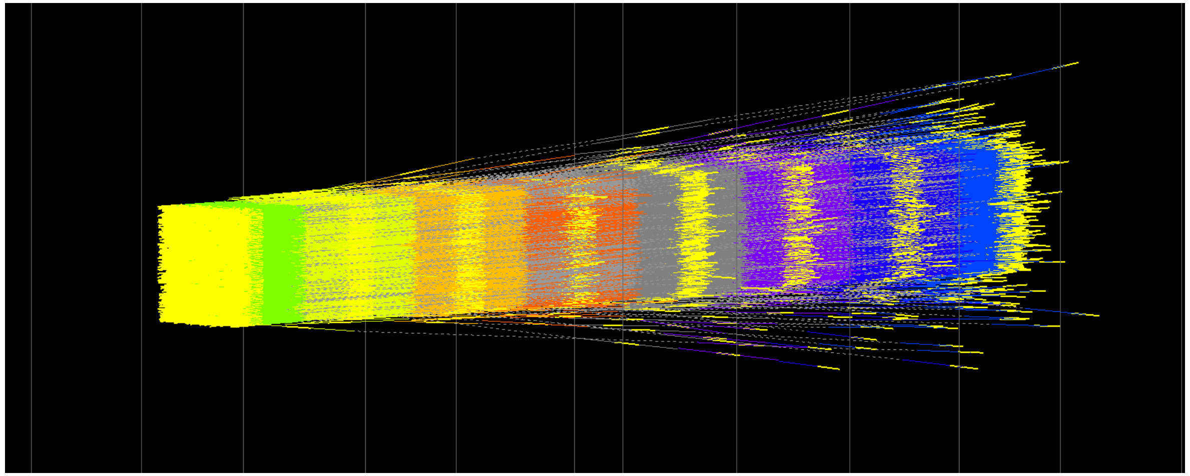
- Hybrid detector: collects online and offline data, later combined in analysis
- Target region: 800kg of tungsten interleaved with emulsion and electronic trackers



Emulsion Reconstruction

- Emulsion Cloud Chamber (ECC) for sub-micrometric position and milliradian angular resolution
- Emulsion films replaced every 20 fb^{-1}
- Each emulsion film contains segments (base tracks)
- Combine base tracks from several emulsion films to reconstruct tracks and vertices



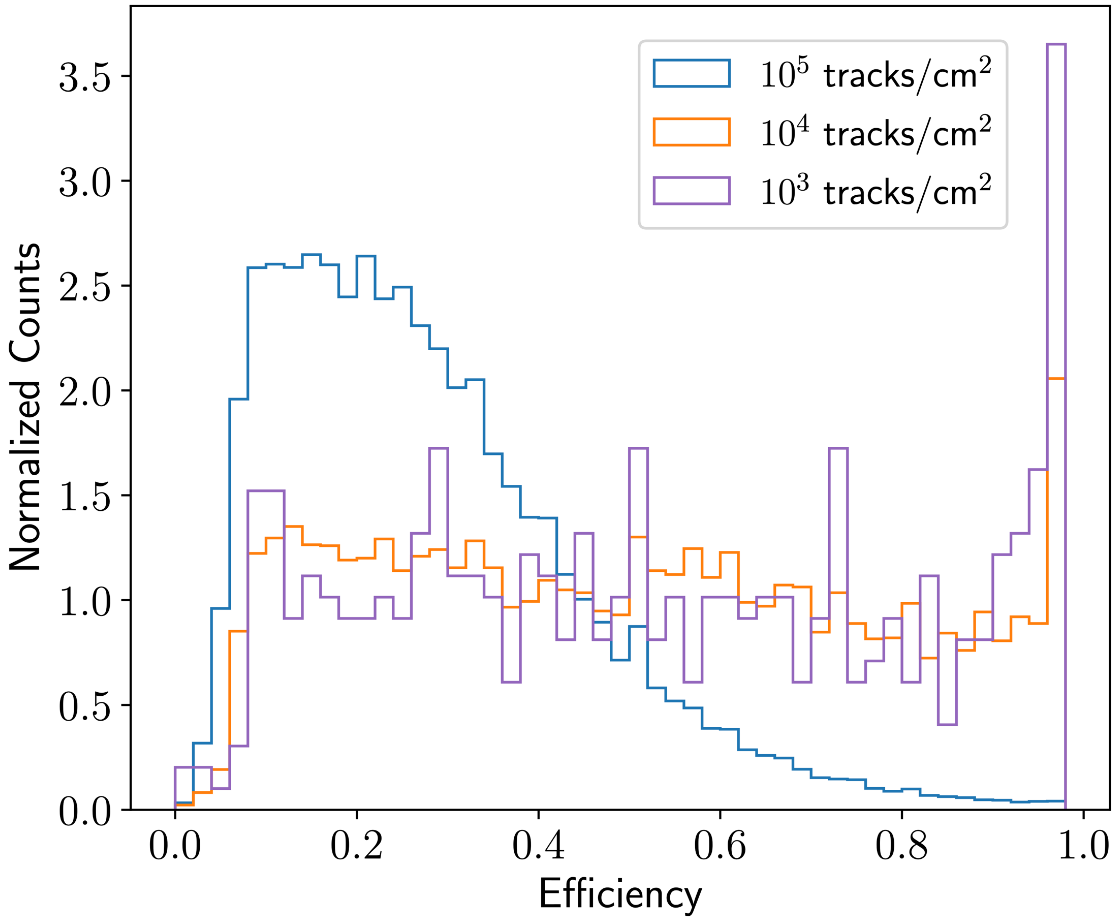


Improving Reconstruction

- **Reduce emulsion track density**
  - Apply cuts prior to reconstruction
- **To also improve signal-to-background ratio:**
  - Omit shallow ZX and ZY angled segments
- Tested proposed methods using MC simulations of muon and neutrino events and real data from emulsion target 1

$$\text{Efficiency} = \frac{\text{\# of base tracks reconstructed}}{\text{\# of base tracks simulated}}$$

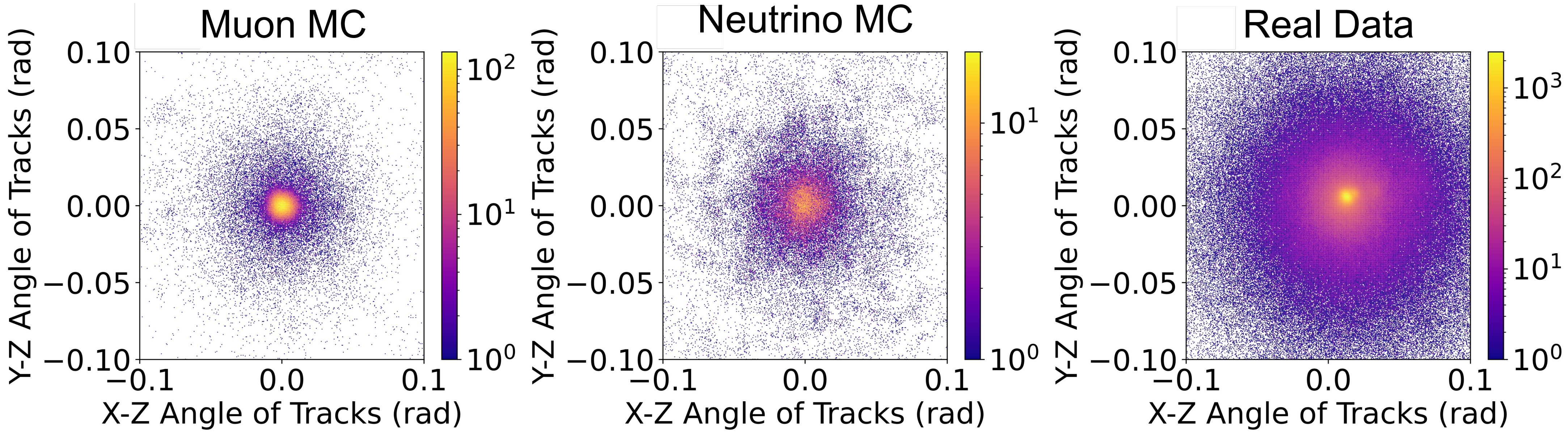
Emulsion Density Analysis



- Modified density of muon MC tracks simulated in emulsion films
- Significant improvement from 10^5 to 10^4 tracks/cm^2, but plateau beyond that
- Reduce track density (using cuts) by order of magnitude prior to reconstruction to maximally increase efficiency

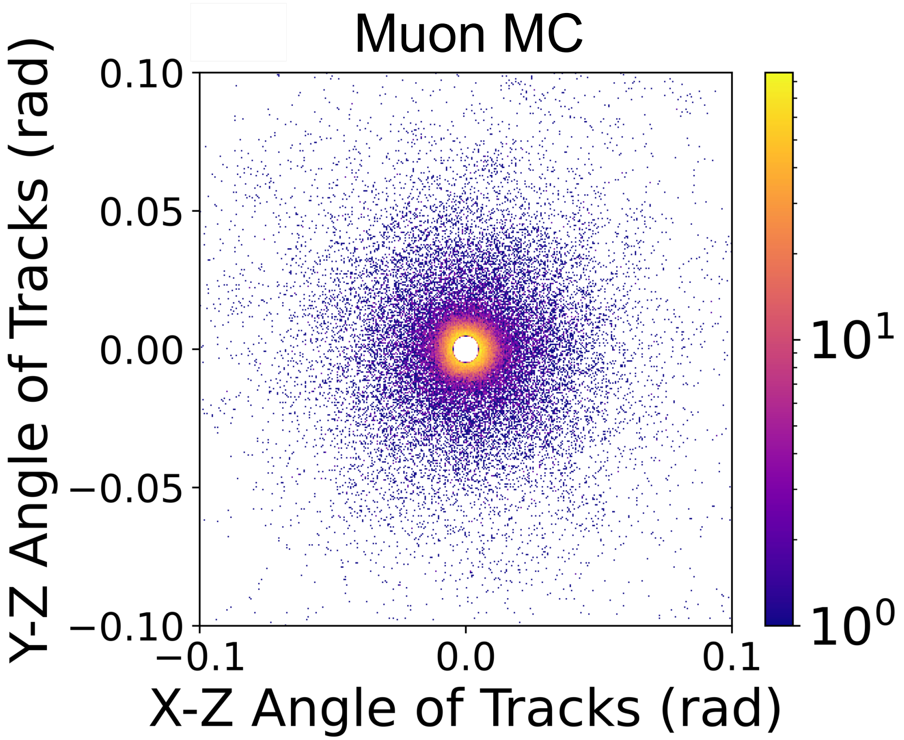
Angular Cut Analysis: Motivation

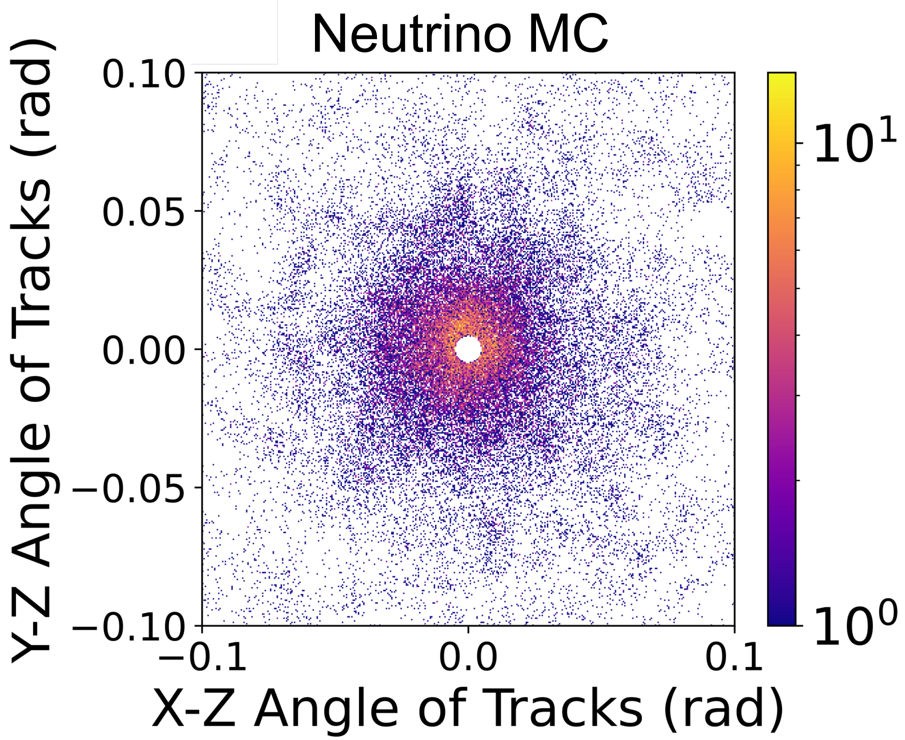
- Background segments (passing muons) have smaller angles than signal segments (neutrino interactions) on average
- Omit shallow-angled segments → reduce track density but preserve signal



Angular Cut Analysis: Cut Selection

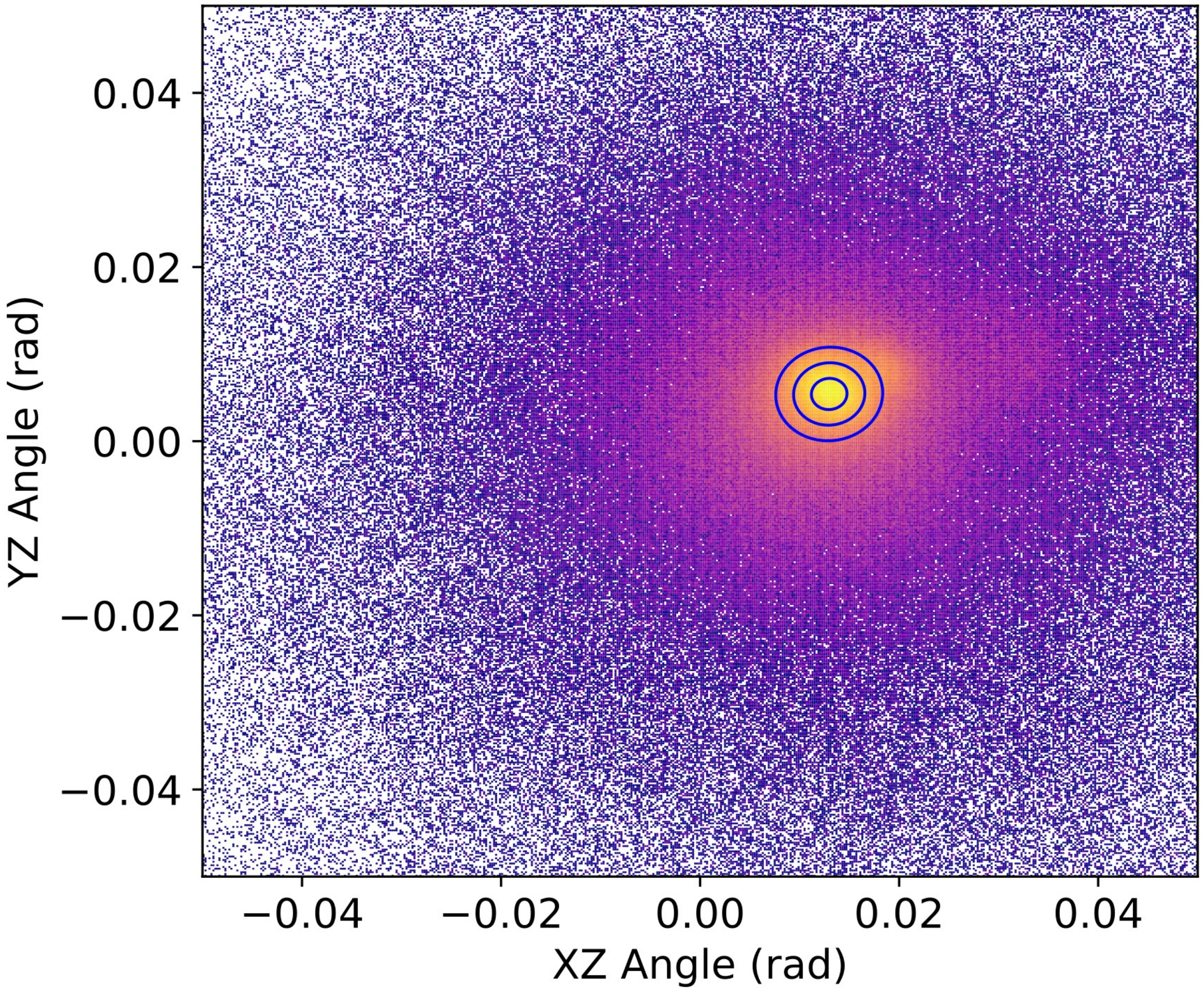
- MC is radially symmetric
- Remove base tracks where $\sqrt{{\theta_{XZ}}^2 + {\theta_{YZ}}^2} \leq \theta_{min}$





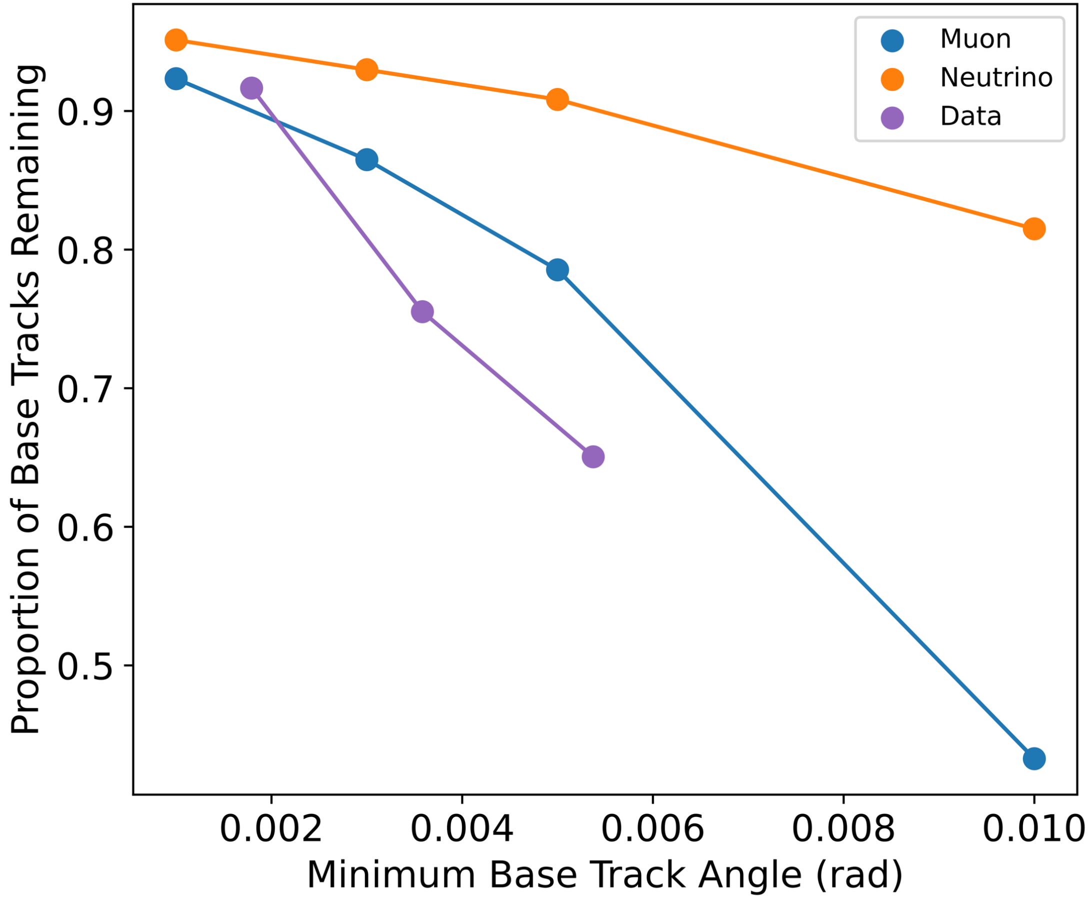
Angular Cut Analysis: Cut Selection

- Real data is asymmetric
- Apply elliptical cuts derived from elliptical confidence intervals about the mean



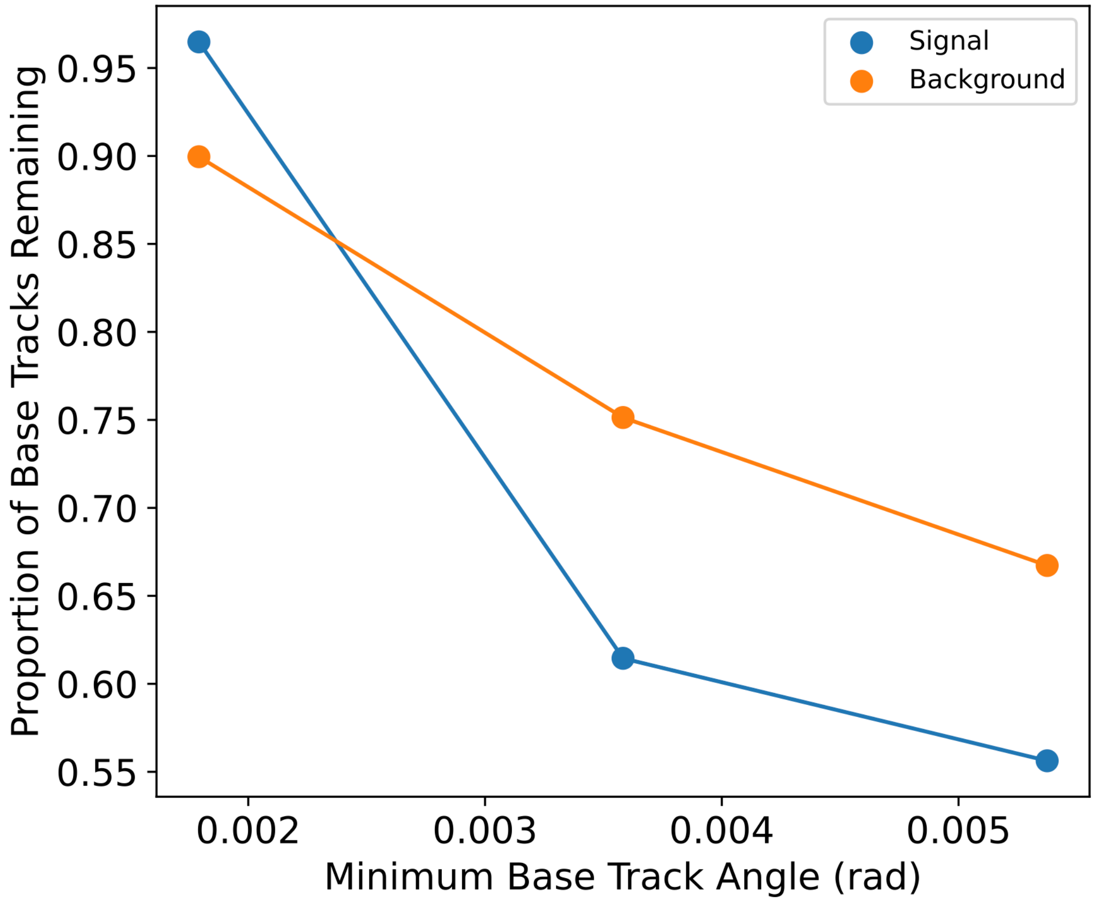
Angular Cut Analysis: Results

- Plotting the following ratio $\frac{\#\text{ segments reconstructed given cut}}{\#\text{ segments reconstructed with no cuts}}$



Angular Cut Analysis: Results

- Use cut on BDT output from existing multivariate analysis to separate signal and background in data



Conclusions and Next Steps

- Reducing track density prior to reconstruction

    → improve reconstruction efficiency

- Removing shallow-angled segments before reconstruction

    → also improves signal-to-background ratio

- Next step: Improve reconstruction quality in large track densities

Thank you for listening! Questions?

Backup Slides

Calculation of Elliptical Cuts

Cut of the form:

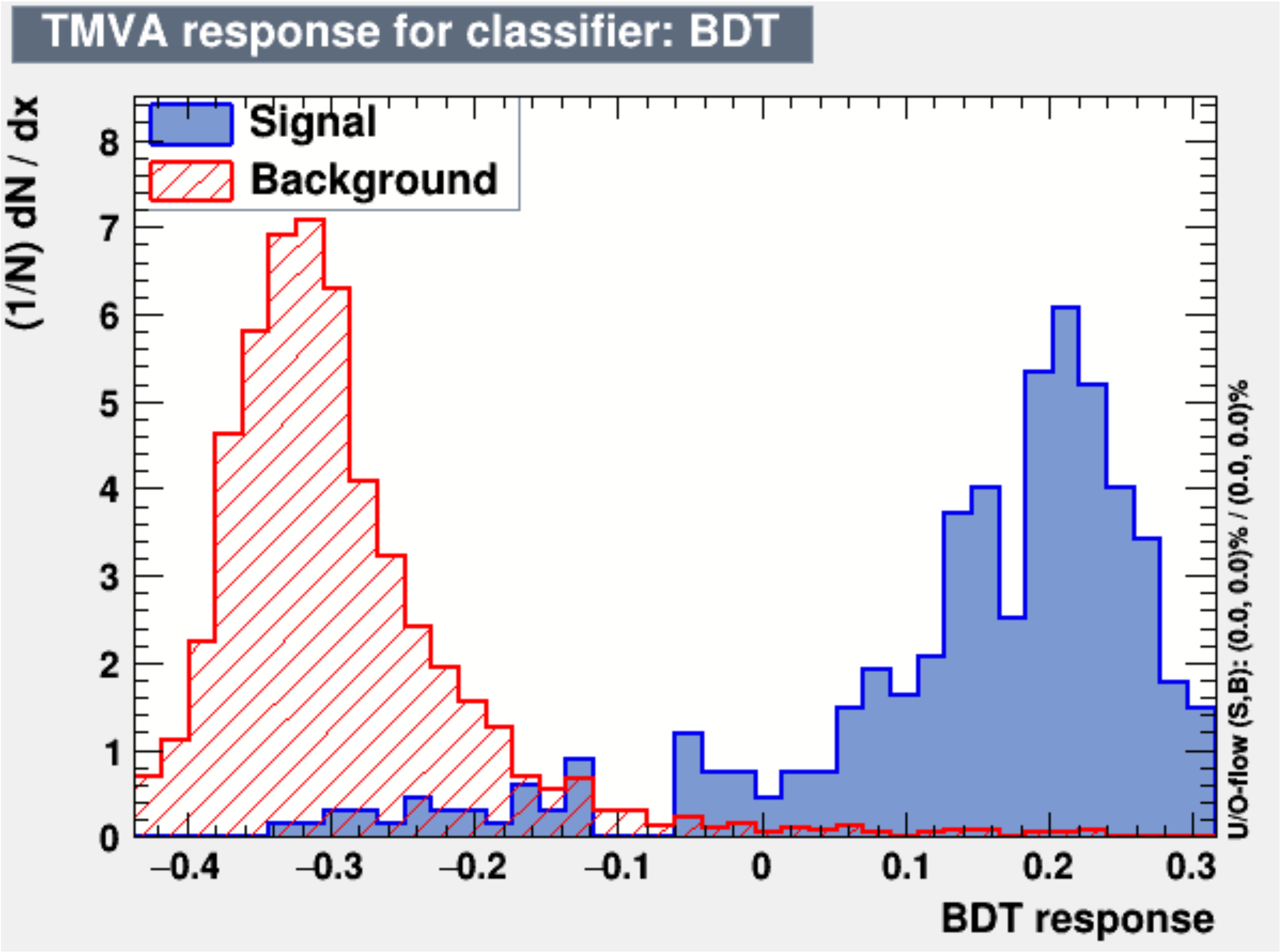
$$\frac{((x-\bar{x})cos\theta-(y-\bar{y})sin\theta)^2}{\left(\frac{h}{2}\right)^2}+\frac{((x-\bar{x})sin\theta-(y-\bar{y})cos\theta)^2}{\left(\frac{w}{2}\right)^2}>1$$

- h, w = length of major and minor axes of ellipse
- $\bar{x}, \bar{y}$ = center position of ellipse
- θ = tilt angle of major axis of ellipse

To compare to MC, get effective radius of circular cut with same area as ellipse

$$\frac{\pi hw}{4}=\pi r^2$$

BDT Training



BDT response > -0.0622

Signal efficiency: 92.48%

Background rejection: 97.43%