SiD ECal Studies

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University of Oregon
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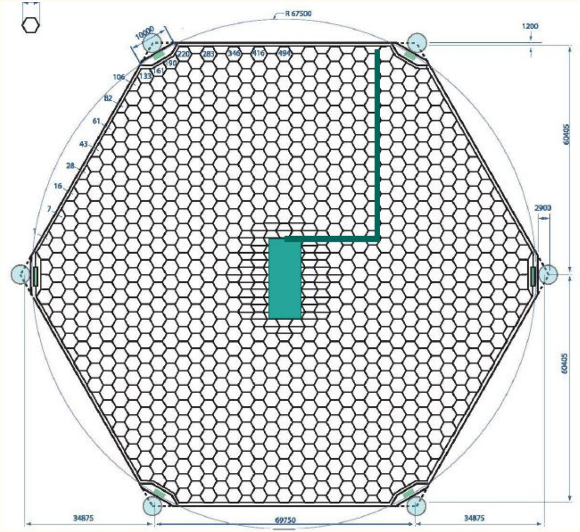
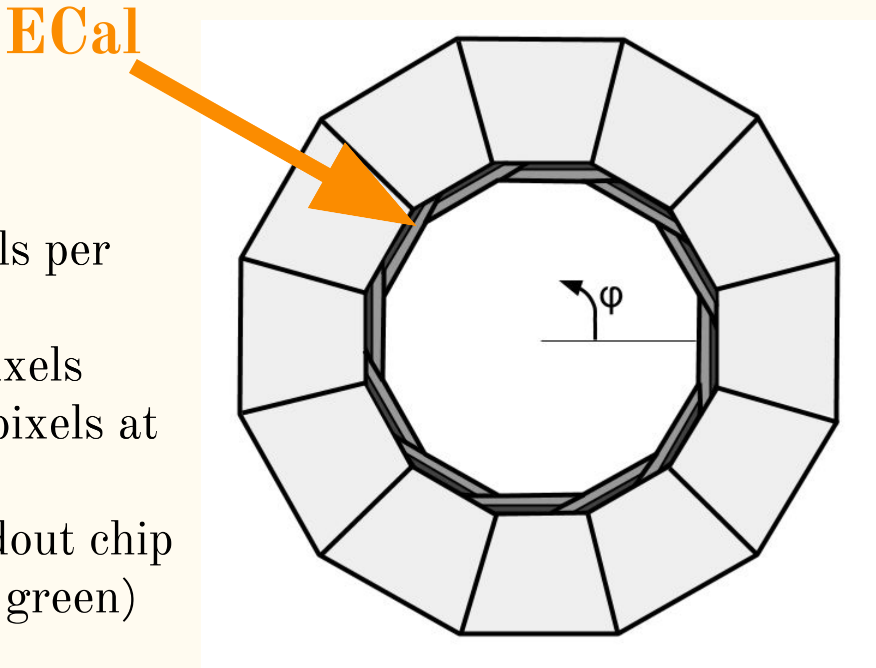
Electromagnetic Calorimeter Geometry

Solid state sampling calorimeter
Tungsten alloy/silicon



- 1024 pixels per wafer
- 13 mm^2 pixels
- Half-size pixels at center
- KPiX readout chip (shown in green)

View from down the beamline

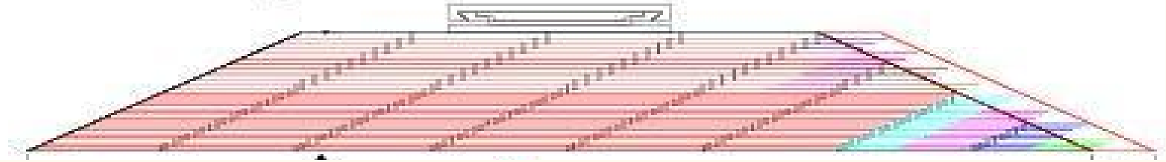


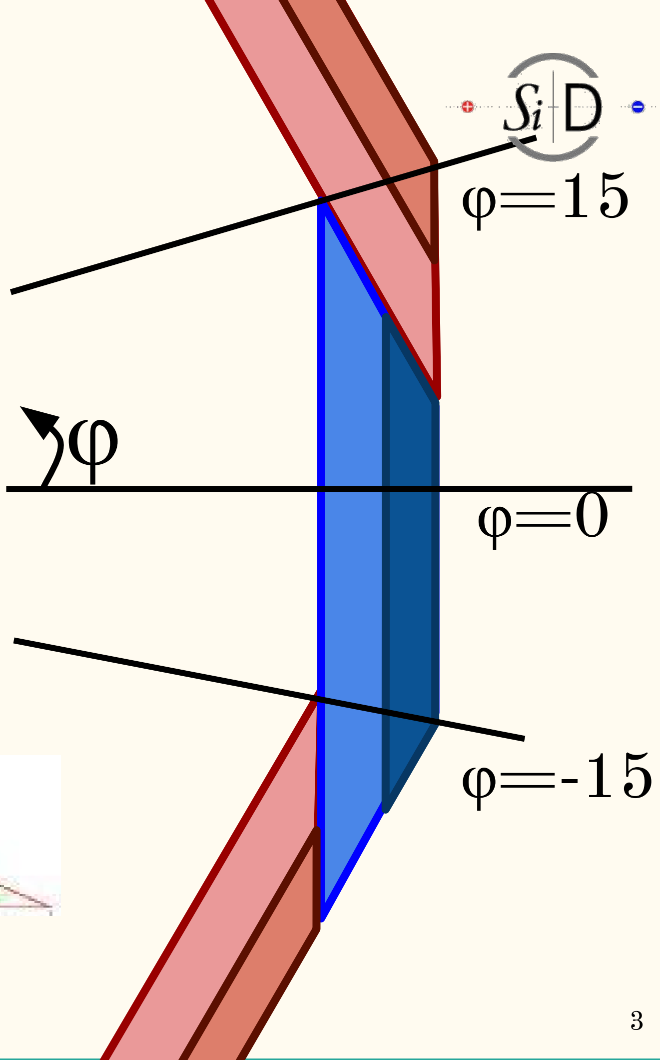
Module Design

Thin W layers

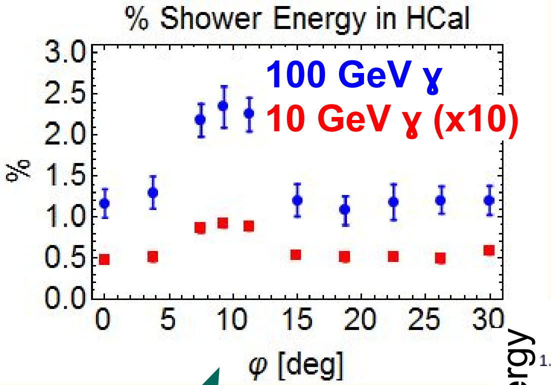
Thick W layers

- 12 identical
  - 20 thin (2.5 mm W, Si in 1.25 mm gap)
  - 10 thick (5 mm W, Si in 1.25 mm gap)
- Overlapping ends
  - No projective cracks



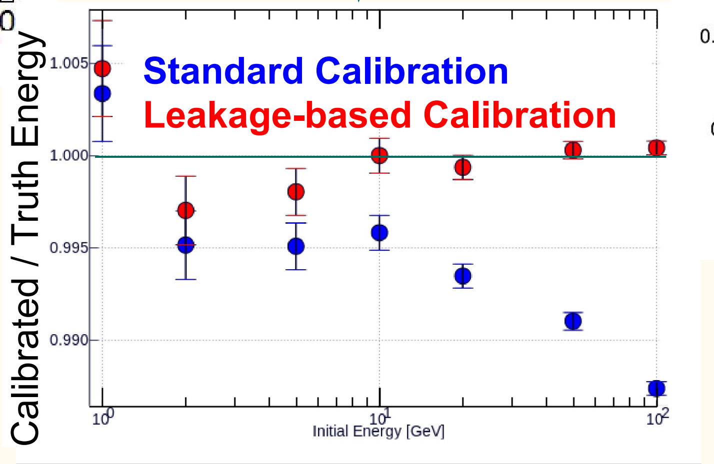


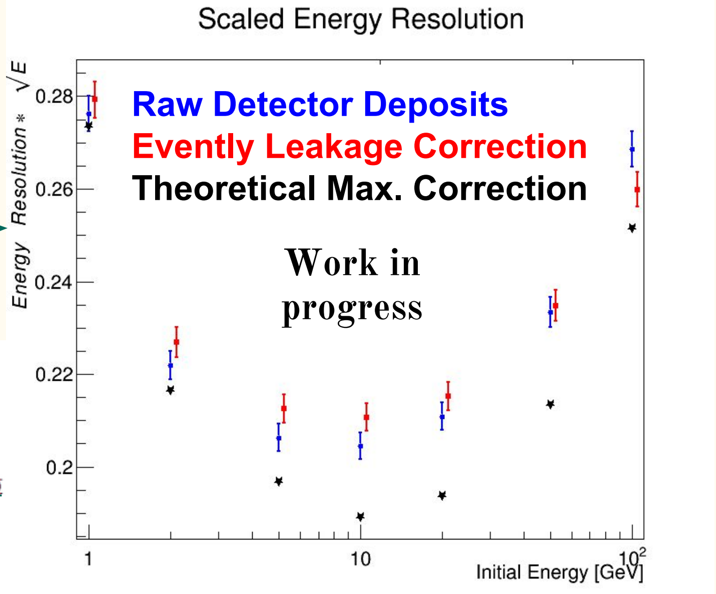
Previous Studies



Detector characteristics (sampling frequency, tungsten thickness) are angle-dependent

Calibration/ energy resolution can be improved by incorporating leakage





Notes containing more details soon to be on Confluence: https://confluence.slac.stanford.edu/display/SiD/Notes

Simulation Information

- Full detector simulation features full DD4HEP integration
  - Current version : SiD_o2_v02 (stainless steel HCal)
    - ilcsoft v01-19-04
  - Default ECal geometry driver features realistic geometry including overlapping module structure
  - Features standard Digitization and Reconstruction processors
    - RealisticCaloDigiSilicon
    - RealisticCaloRecoSilicon
- Presented studies of 250 GeV e^+e^- physics files
  - Preliminary results using 100 events
- Particle reconstruction by Pandora

All presented plots are preliminary!

Higgs → TauTau Studies (J. Carlson)

$$e^+ + e^- \to Z + H$$

$$e^+ + e^- \qquad \tau^+ + \tau^-$$

$$\rho^+ + \overline{\nu}_\tau$$

$$\pi^+ + \pi^0$$

$$\gamma + \gamma$$

Require only one τ to decay via ρ's

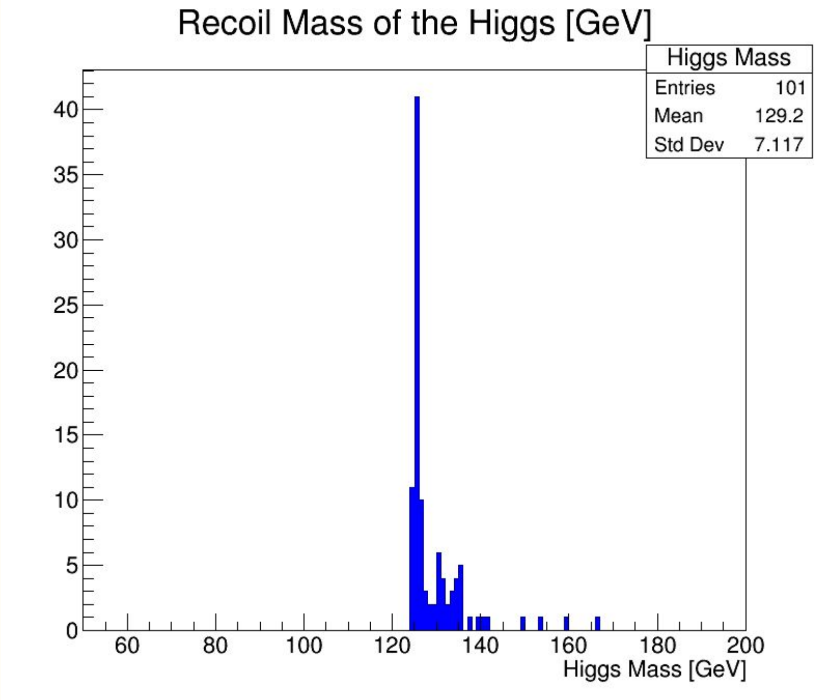
- Leptonic Z decays (all to electrons)
- Leptonic H decays to (all to taus)
  - Tau decays to rho

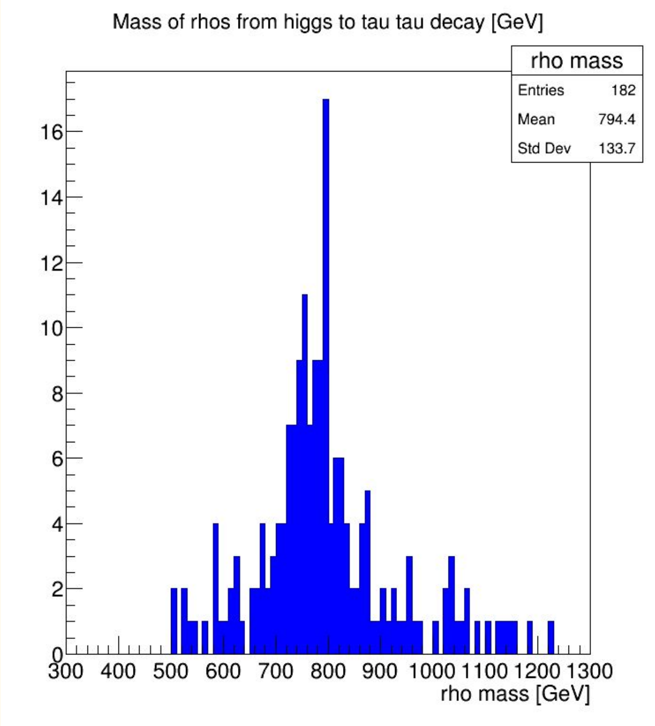
Goals of Study

- Investigate efficiency of ECal reconstructing π^0 decays and how it affects τ reconstruction
  - More difficult for boosted objects
  - Fairly clean sample (no jets)
- Find $H \rightarrow \tau\ \tau$ branching fraction
- Amend ECal design and compare effect on relevant physics cases
  - 25 active layers

Data file: E250-TDR_ws.Pe1e1h.Gwhizard-1_95.eL.pL.I106475.001.stdhep

Mass Distributions (w/truth information)





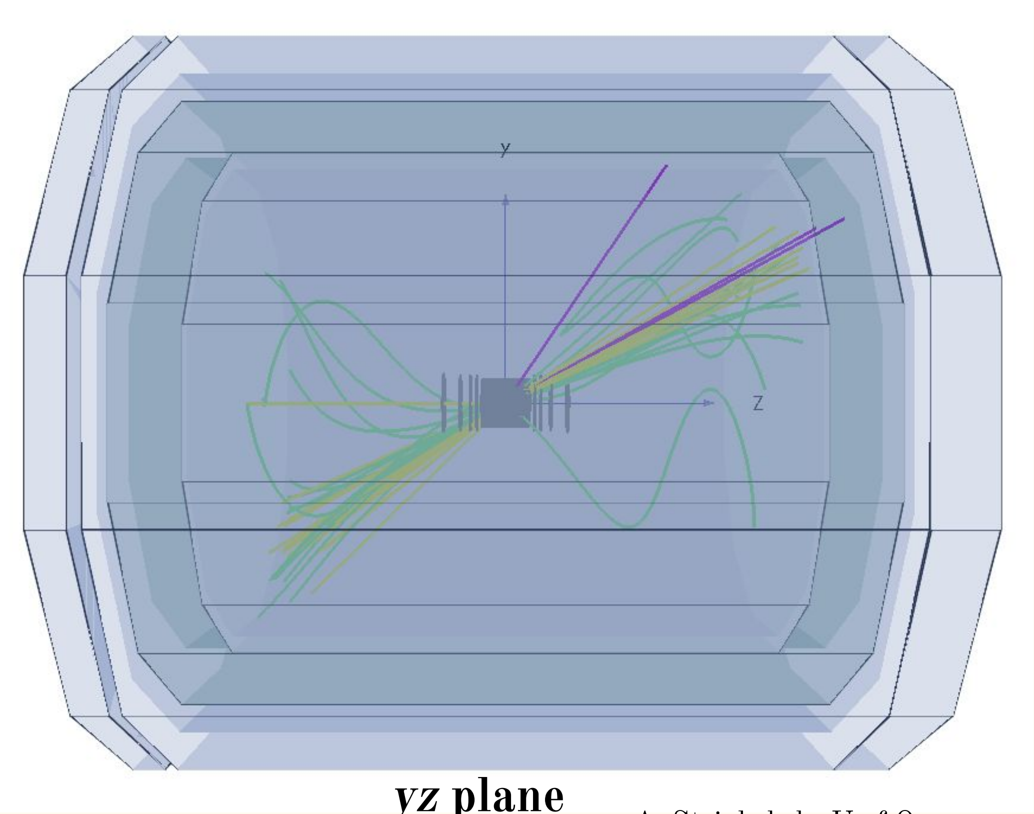
100 events, any Higgs decay mechanism allowed

182 events with desired Higgs decay from sample of 10,000

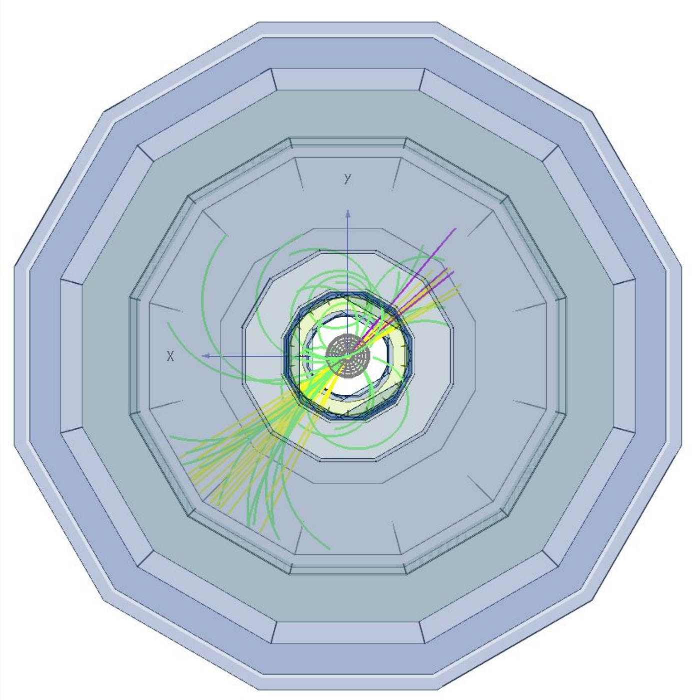
Next Steps

- Generate mass distributions with reconstructed particles and compare to truth information
- Understand calorimeter energy contained within cone around ρ constituents
- Change ECal geometry (number of active layers) to see effect on mass distributions previously shown
  - Consider reducing number of active layers as cost-reduction strategy
- Eliminate truth information crutch to identify $H\rightarrow\tau\tau$ events and branching ratio
- Compare to ILD study: arXiv:1509.01885 [hep-ex]

Dijet Studies (E. Meyer)

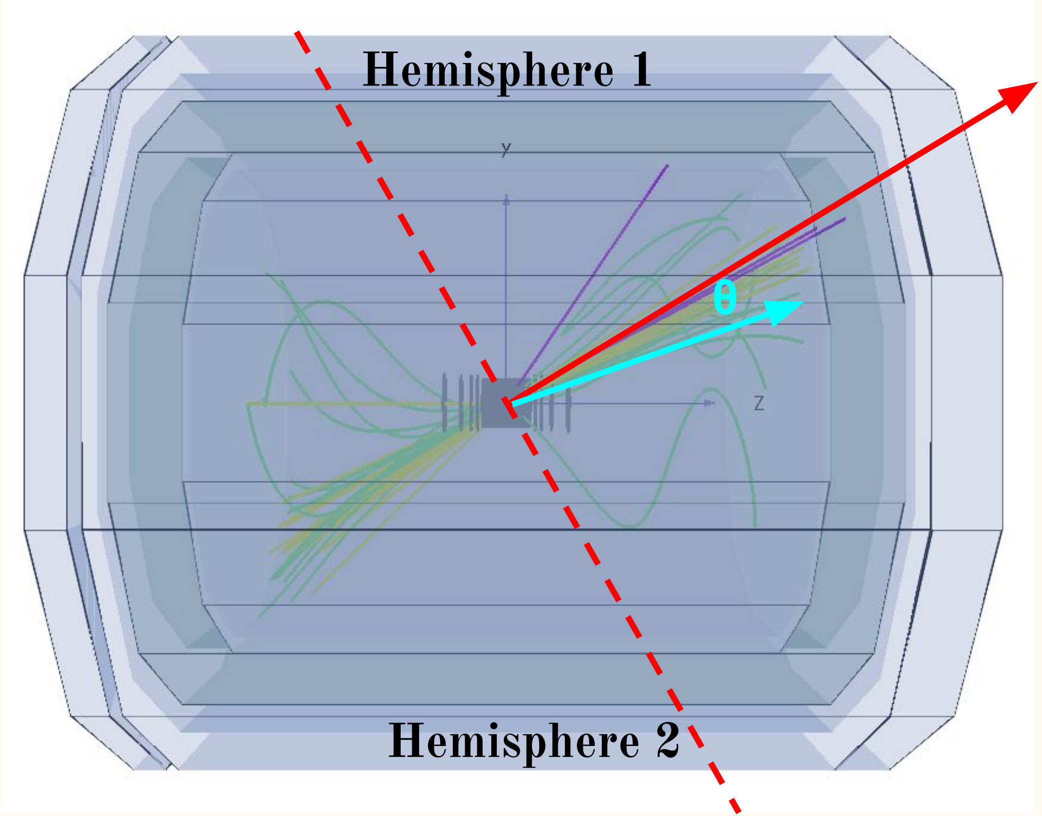


***yz* plane**



***xy* plane (down beamline)**

Dijet Studies (E. Meyer)



True vector of highest p_T initial quark = 'thrust axis'

Angle between component particle and thrust axis ≡θ

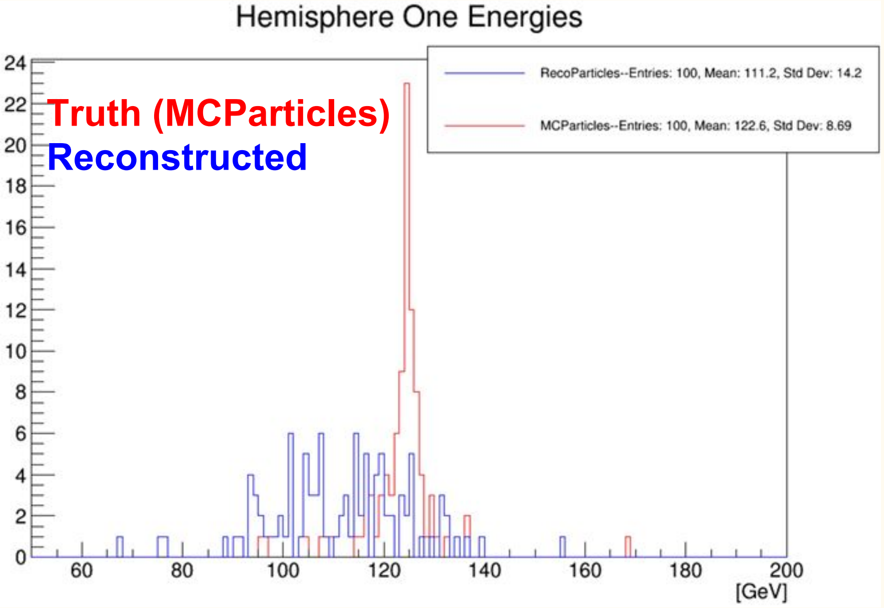
Goals of Study

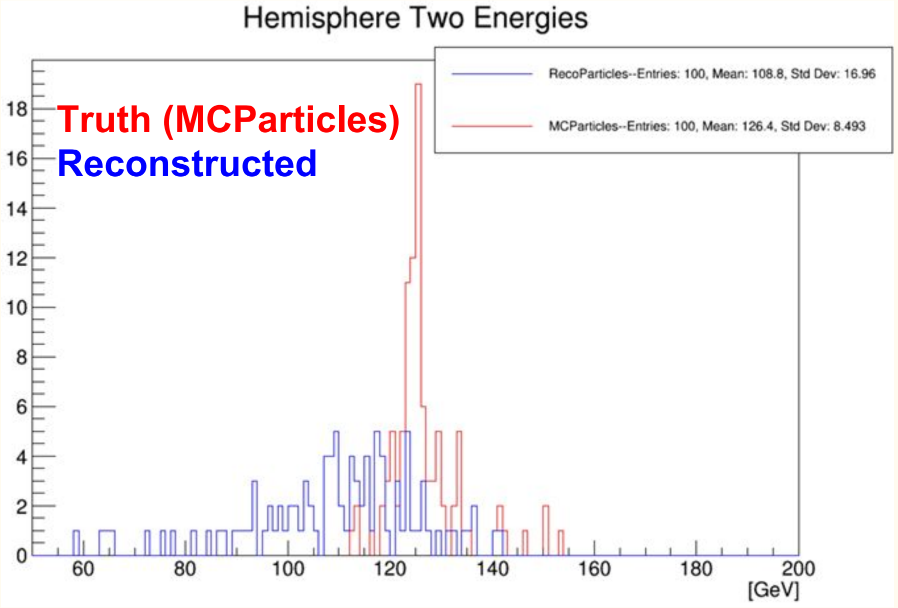
- Investigate efficiency of ECal reconstructing π^0 decays in crowded environments
- Understand ECal's contribution to jet reconstruction
- Ensure that jet behavior is as expected within the detector
- Amend ECal design and compare effect on relevant physics cases
  - Pixel size

Data file:
E250-TDR_ws.P2f-highM_z_h.Gwhizard-1_95.eL.pR.I110011.001.stdhep

(Includes cut on $M(qq) > 150$ GeV to minimize radiative return)

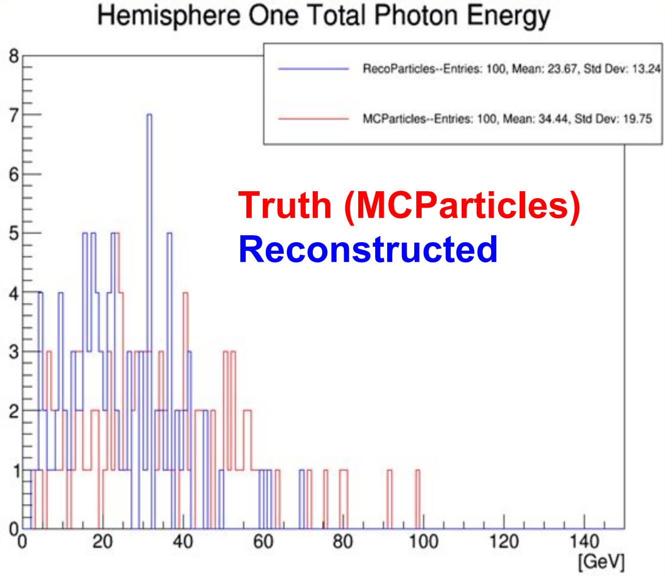
Particle Distributions

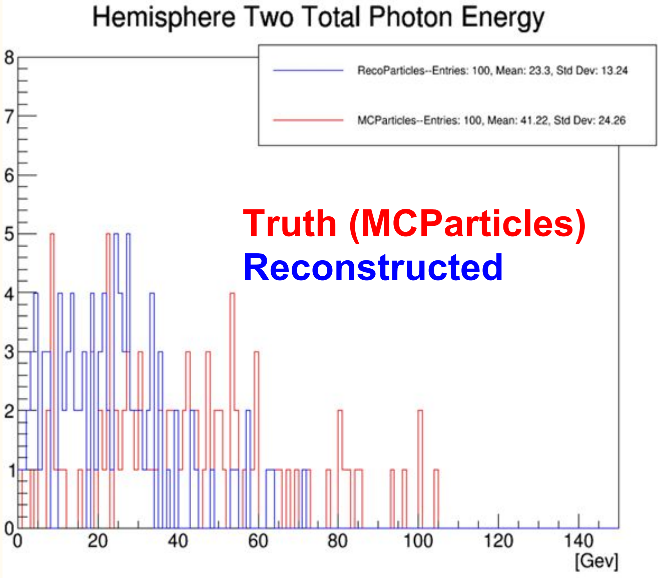




- Both hemispheres reconstruct mean event energy within 10% of truth mean energy
- Symmetric energy reconstructed within each hemisphere (within errors)

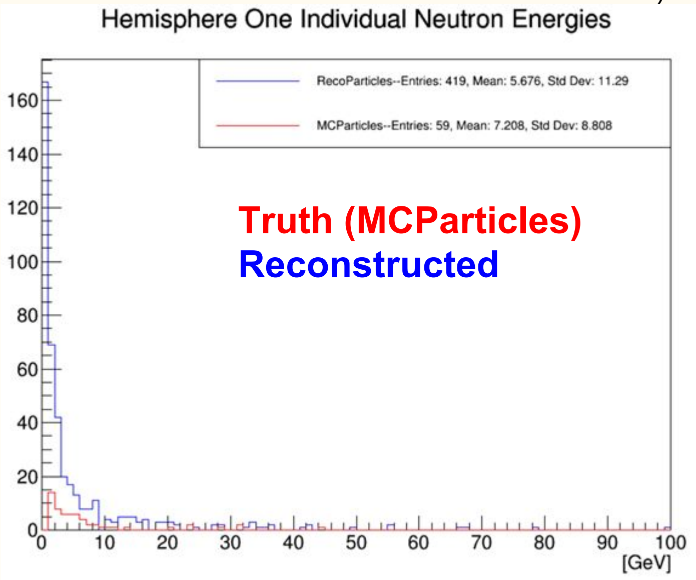
Particle Distributions, Continued (Photons)

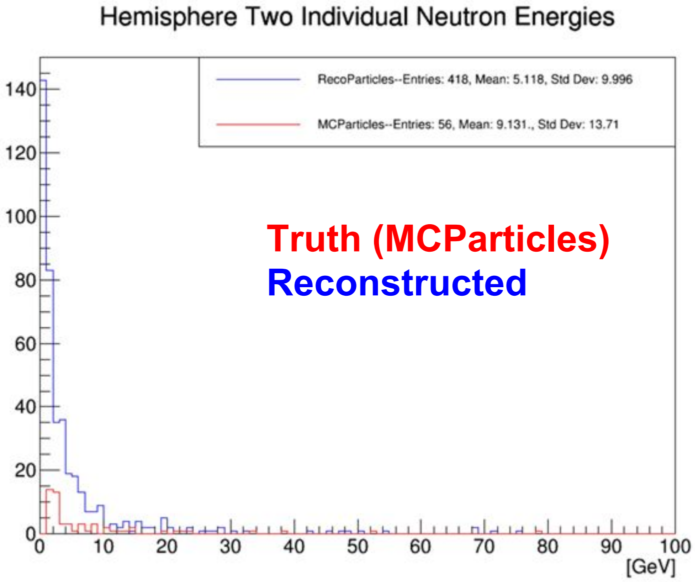




- Open question: Why are photons reconstructed under expected energy?
  - Often reconstructed with 67% of expected
  - In hemisphere 2, reconstructed with 57% of expected
- Equal photon energy depositions in each hemisphere (within errors)

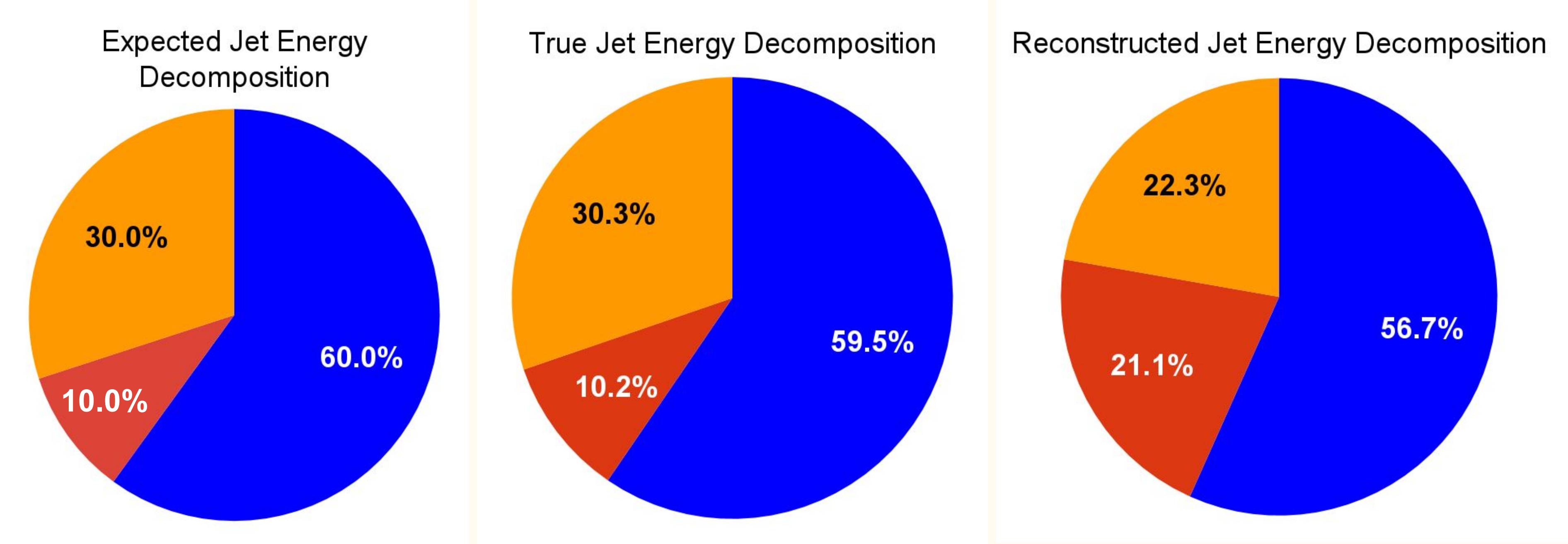
Particle Distributions, Continued (Neutrons)





- Open question: Large neutron flux
  - ~10x more reconstructed neutrons than true neutrons
  - From nuclear interactions with calorimeters? Poor neutral particle reco?
- Open question: High energy reconstructed neutrons with no true counterpart?

Jet Component Energy Fractions



Reconstructed jets have more energy fraction in neutral hadrons and less from photons (as expected from previous “Open Questions”)

Jet Energy

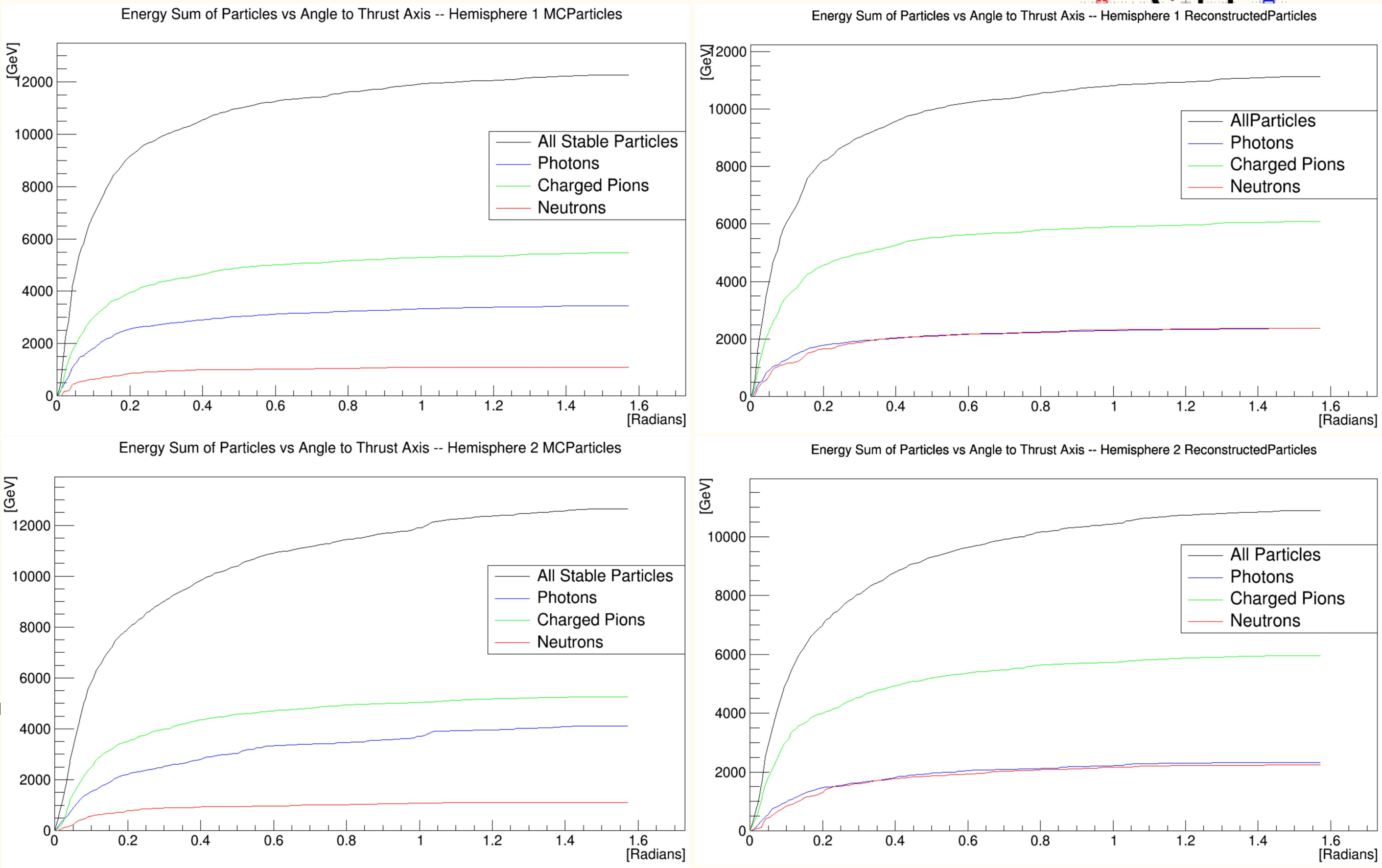
- Sum of all 100 events
- Energy contained within cone drawn around thrust axis
- Reconstructed photons / neutrons contain nearly identical energy

Truth

Reconstructed

Hemisphere 1

Hemisphere 2

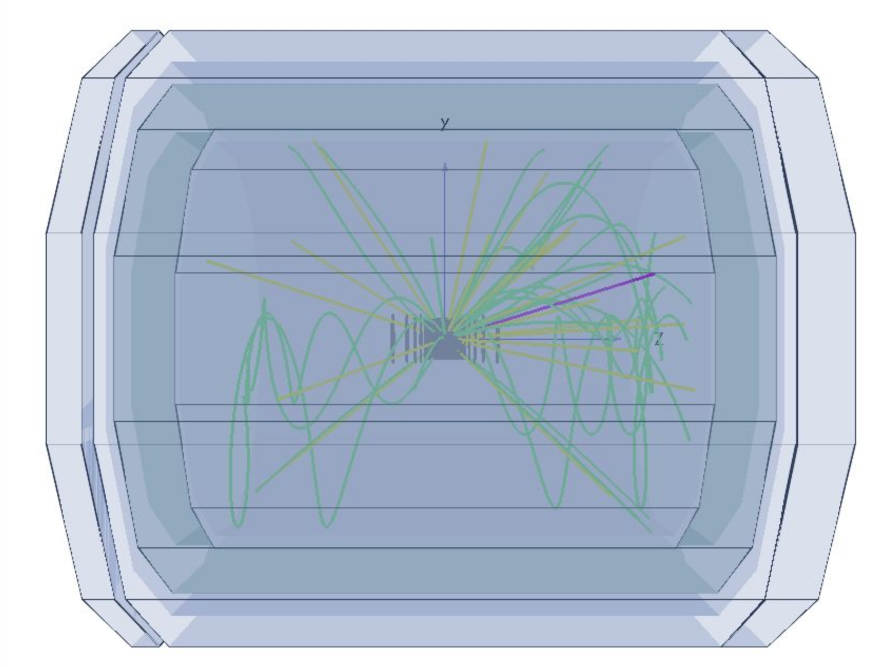


Next Steps

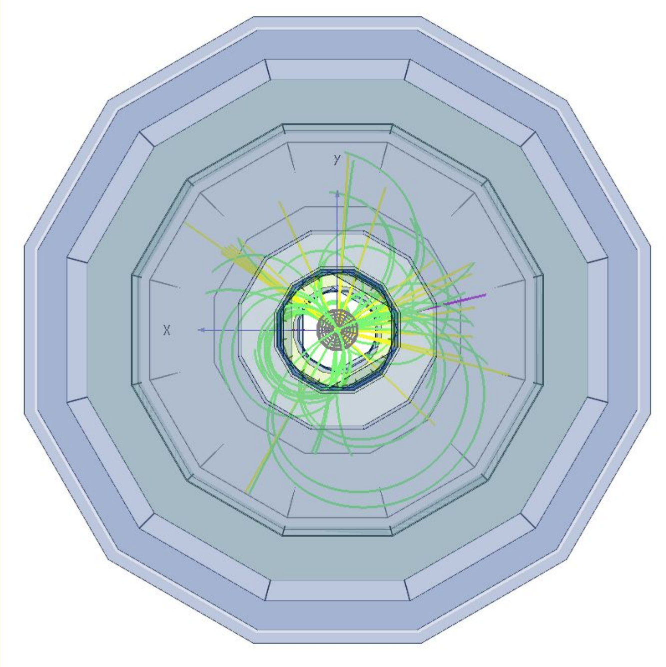
- Understand photon reconstruction energy discrepancy
  - Some ILD hard-coded information hiding in Pandora?
- Understand neutron reconstruction
- Identify and reconstruct π^0's within the jets from EM showers
- Change ECal geometry (pixel size) to see effect on π^0 reconstruction performance

Backup

Example Higgs → TauTau Event Display



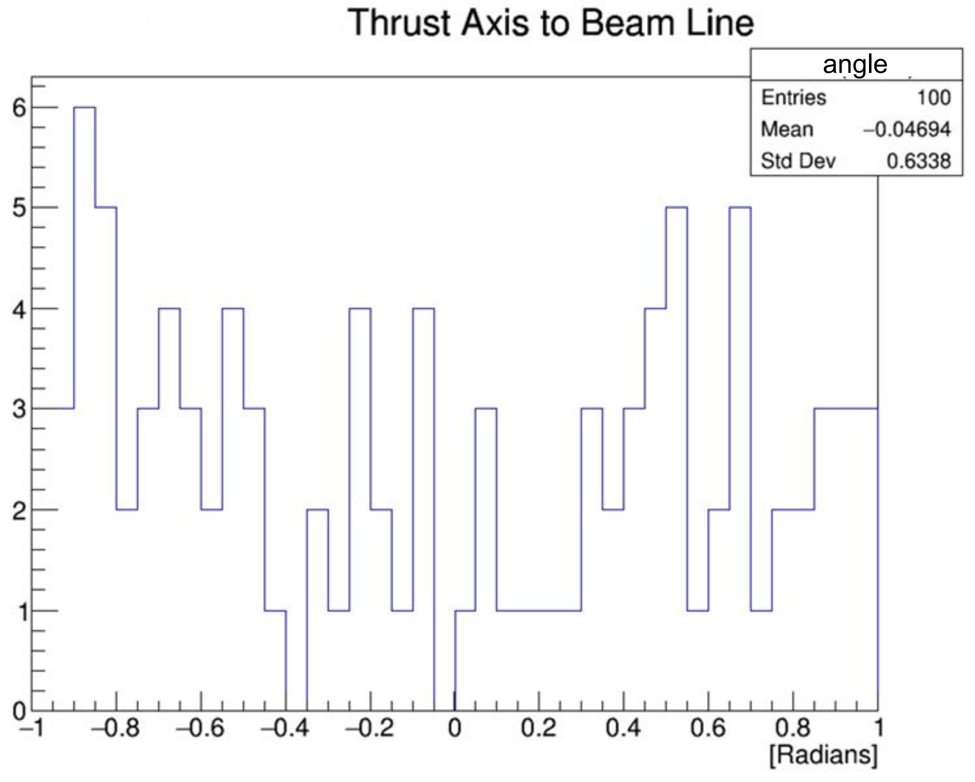
***yz* plane**



***xy* plane (down beamline)**

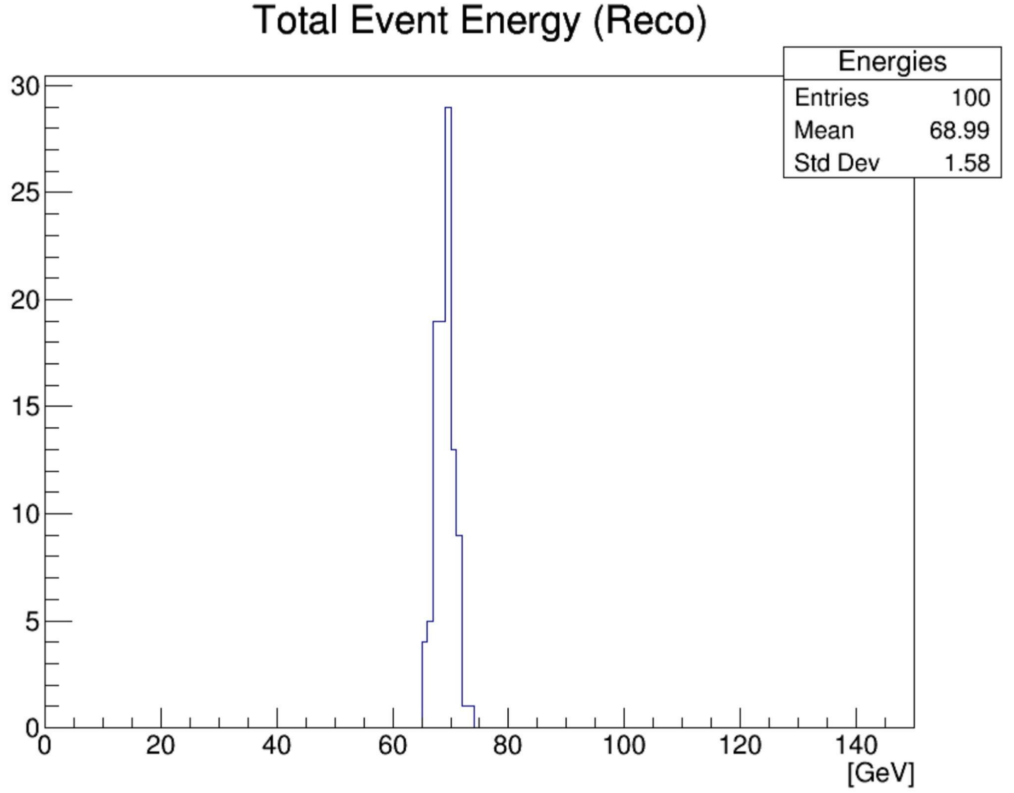
Dijet Event Distributions

Events are roughly isotropic within the detector

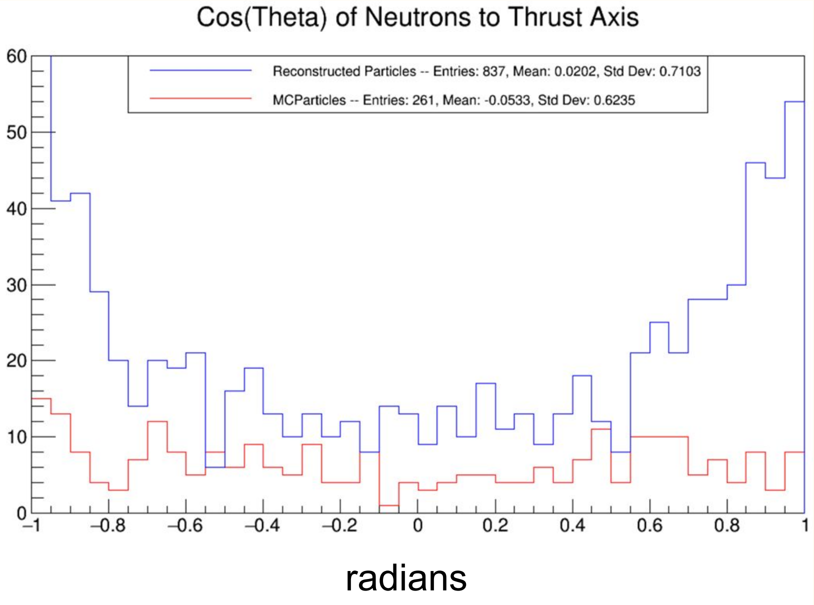


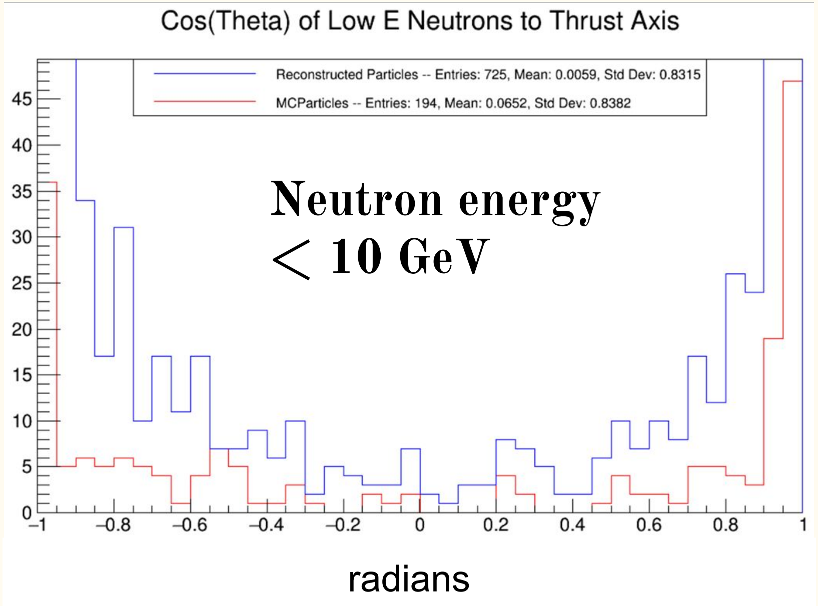
Photon Energy Reconstruction

100 GeV photon beam at normal incidence after Pandora reconstruction



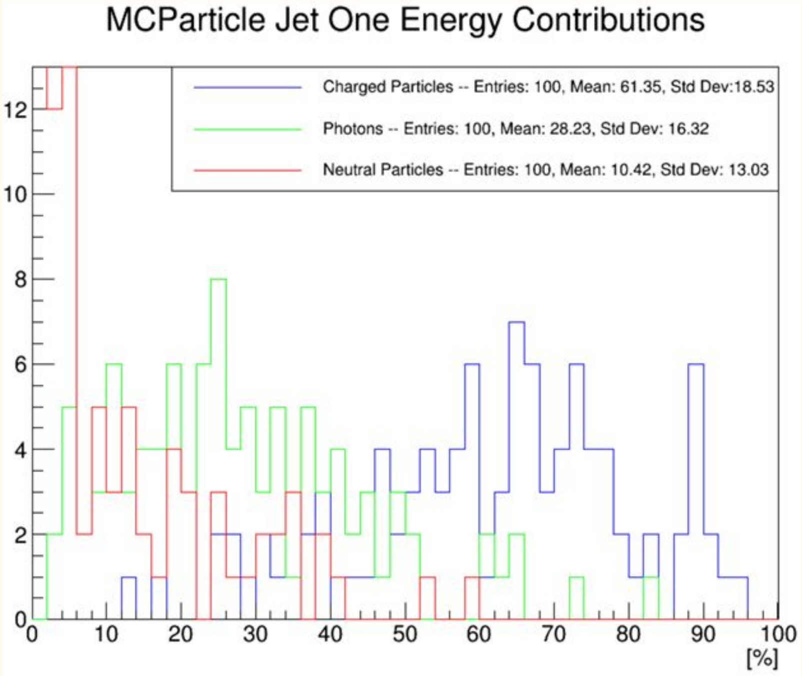
Spatial Neutron Distributions in Dijet Events

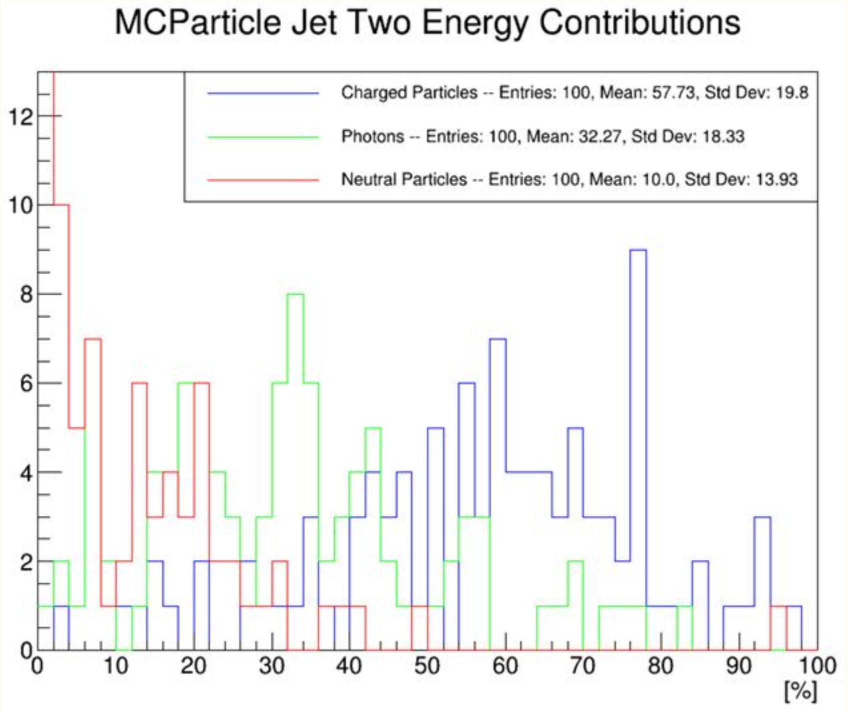




Neutron energy < 10 GeV

True Jet Component Energies by Hemisphere





Reco Jet Component Energies by Hemisphere