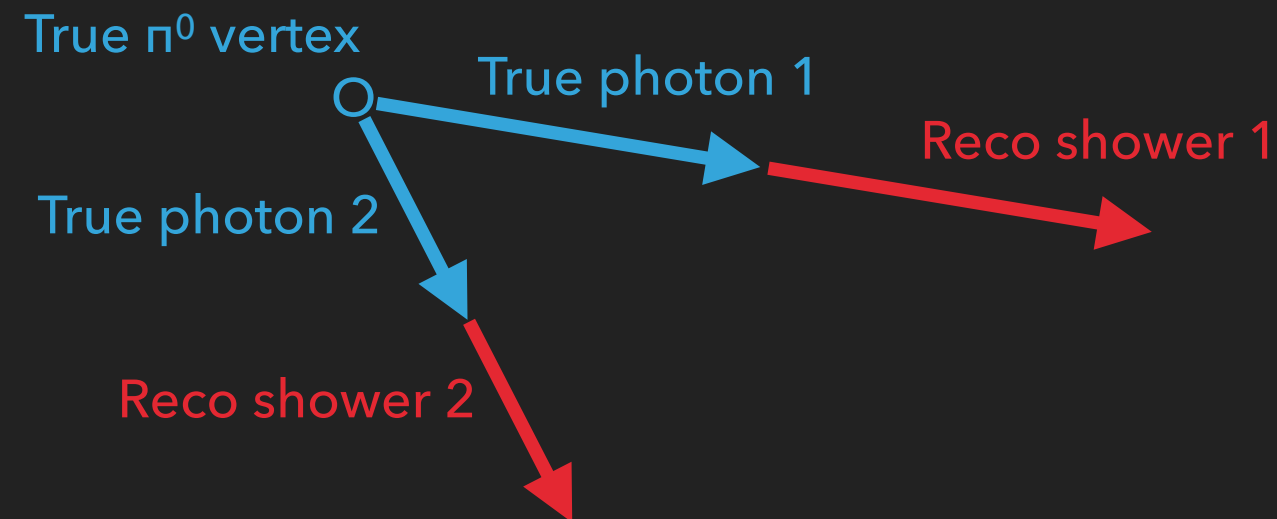


MILO VERMEULEN — 10-10-2019

TRACK CONTAMINATION IN π^0 SHOWERS

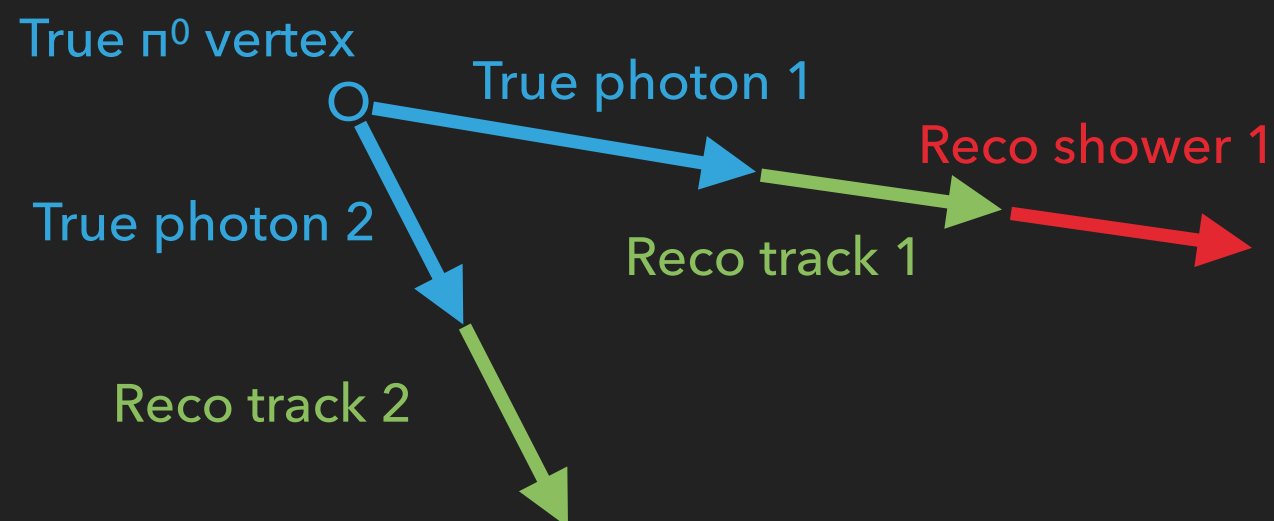
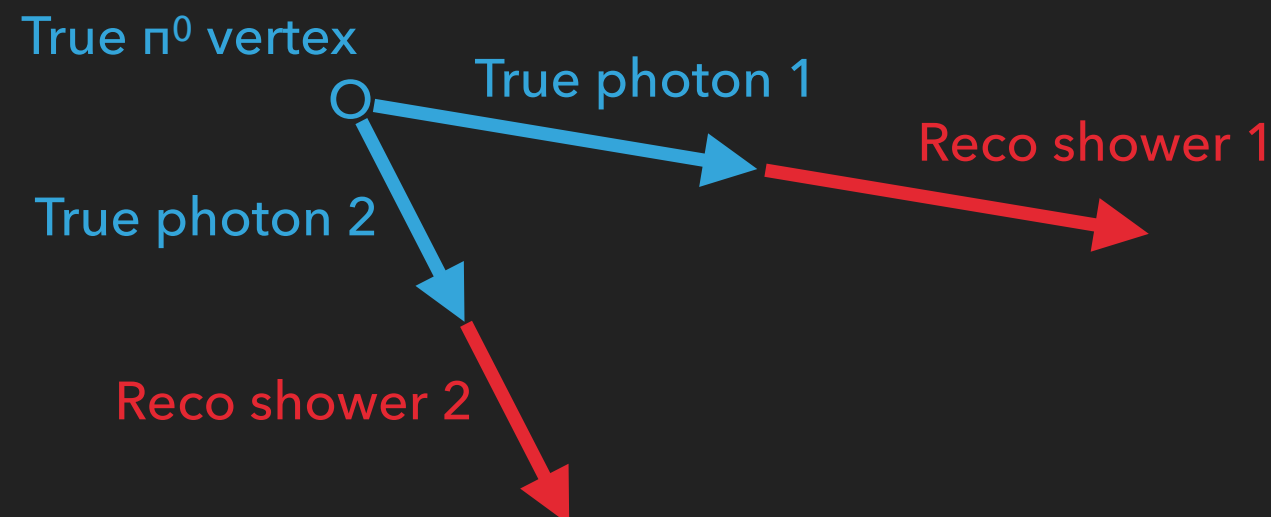
π^0 SIGNATURE

- ▶ $\pi^0 \rightarrow \gamma\gamma \rightarrow 2$ showers
- ▶ Often only 1 shower



π^0 SIGNATURE

- ▶ $\pi^0 \rightarrow \gamma\gamma \rightarrow 2$ showers
 - ▶ Often only 1 shower
- ▶ In this presentation: track contamination in shower reconstruction
 - ▶ Pandora sometimes reconstructs a track instead of a shower or in addition to a shower



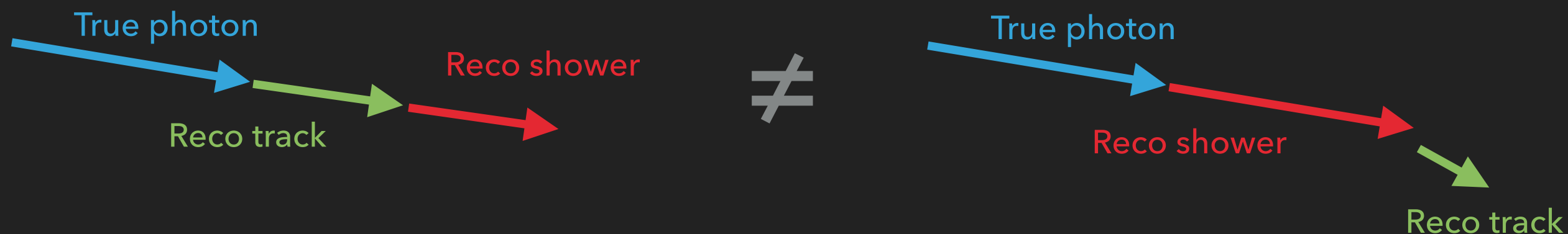
METHOD

- ▶ 30,000 single 2 GeV π^+ events in ProtoDUNE
- ▶ ~20,000 produced π^0
- ▶ ~24,000 π^0 showers
- ▶ ~4000 π^0 photons (initially) reconstructed as tracks
- ▶ ~7000 dual π^0 showers

- ▶ See collaboration meeting talk for more details on sample used:
<https://indico.fnal.gov/event/21445/session/13/contribution/75/material/slides/0.pdf>

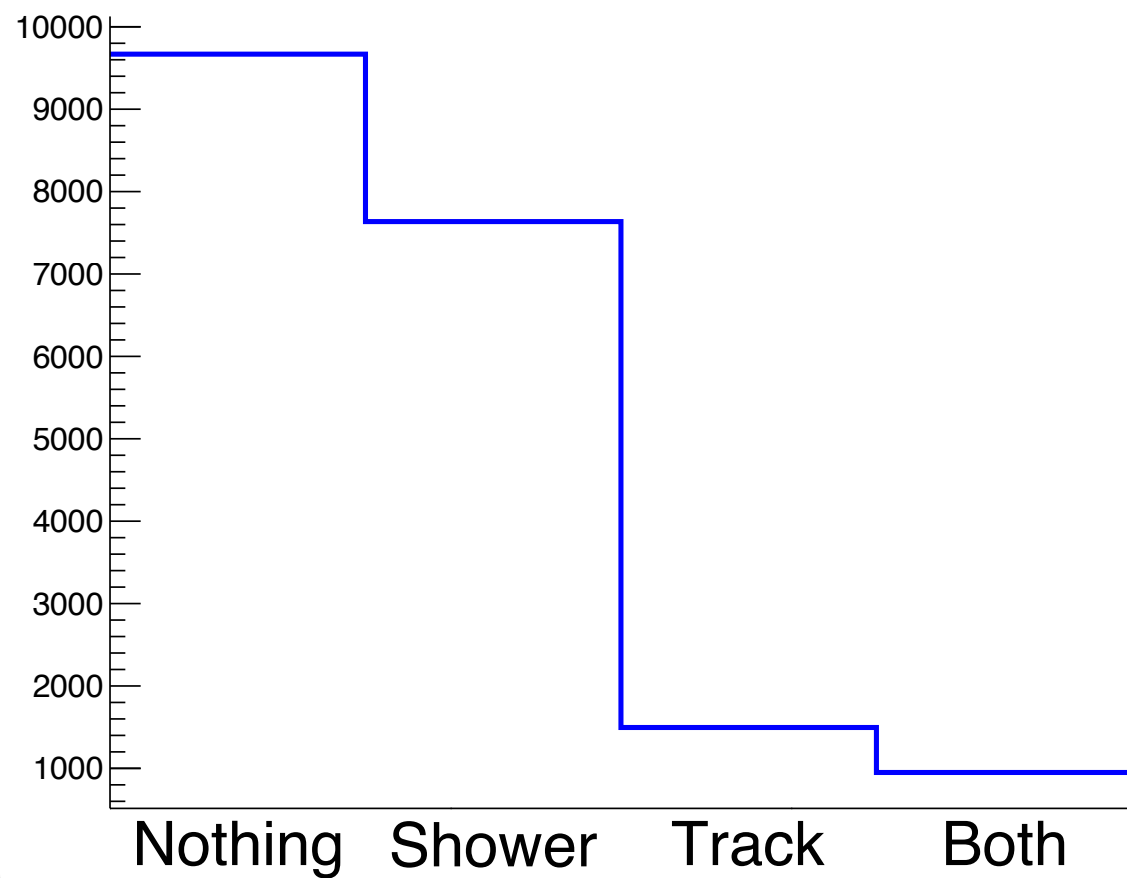
METHOD

- ▶ Start at true π^0 photons and consider their reconstructed objects
 - ▶ Truth-reco matched through ProtoDUNE truth utilities
`dunetpc/dune/Protodune/Analysis/ProtoDUNETruthUtils.h`
- ▶ For this preliminary analysis, only consider tracks that begin closer to the photon than the shower

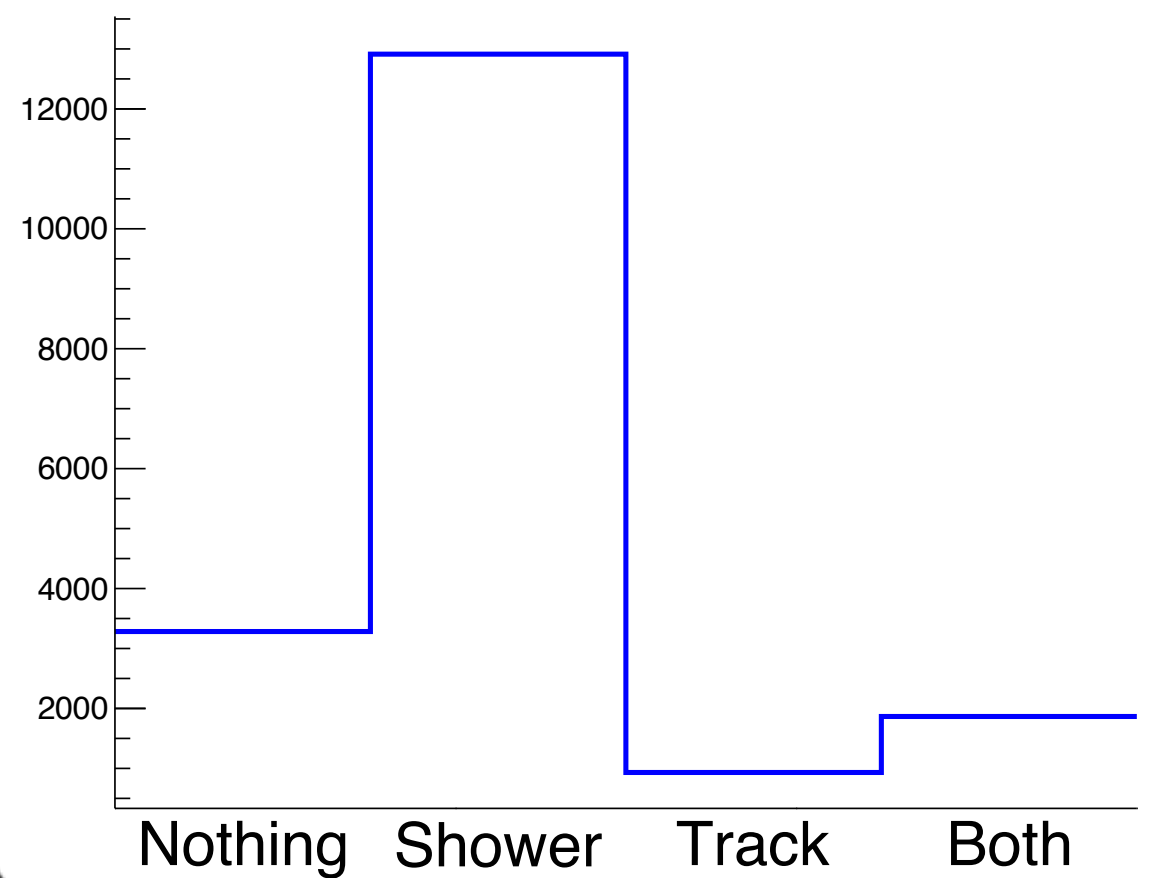


HOW OFTEN DOES CONTAMINATION OCCUR?

Reconstructed objects of
least energetic π^0 photon

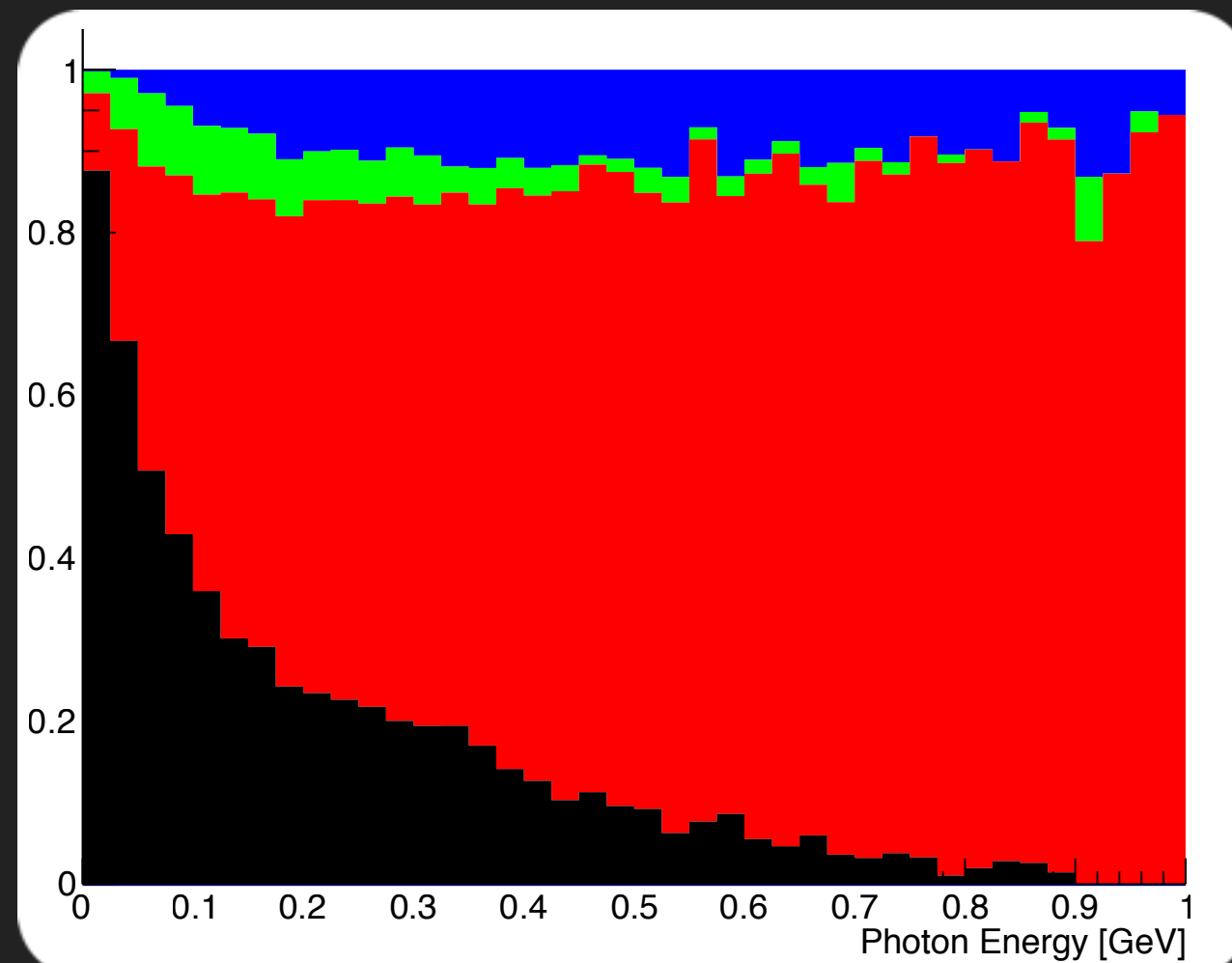
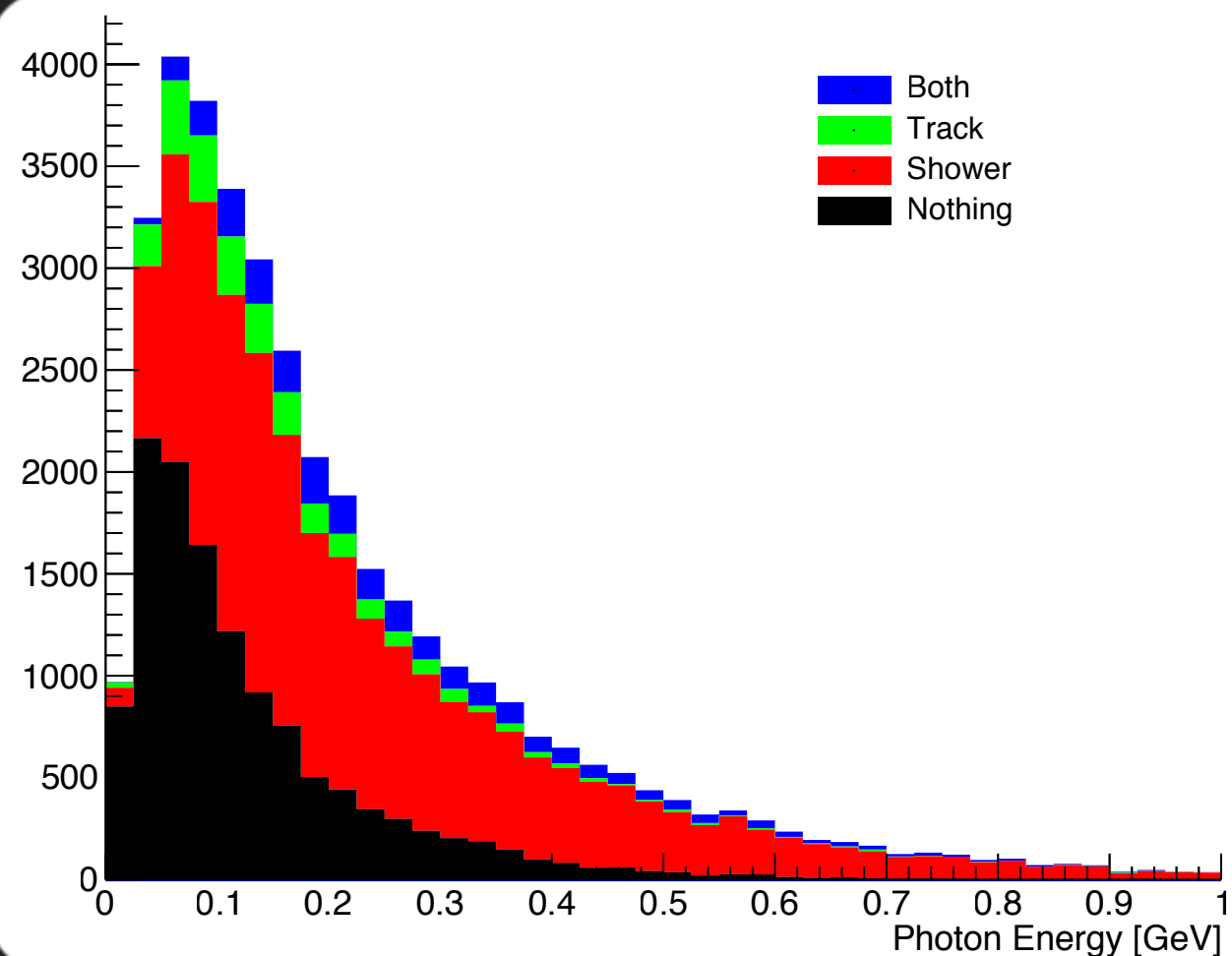


Reconstructed objects of
most energetic π^0 photon



HOW OFTEN DOES CONTAMINATION OCCUR?

- ▶ Figures: reconstructed objects of all π^0 photons
- ▶ Photon shower reconstructed (partially) as track in $\sim 15\%$ of the cases

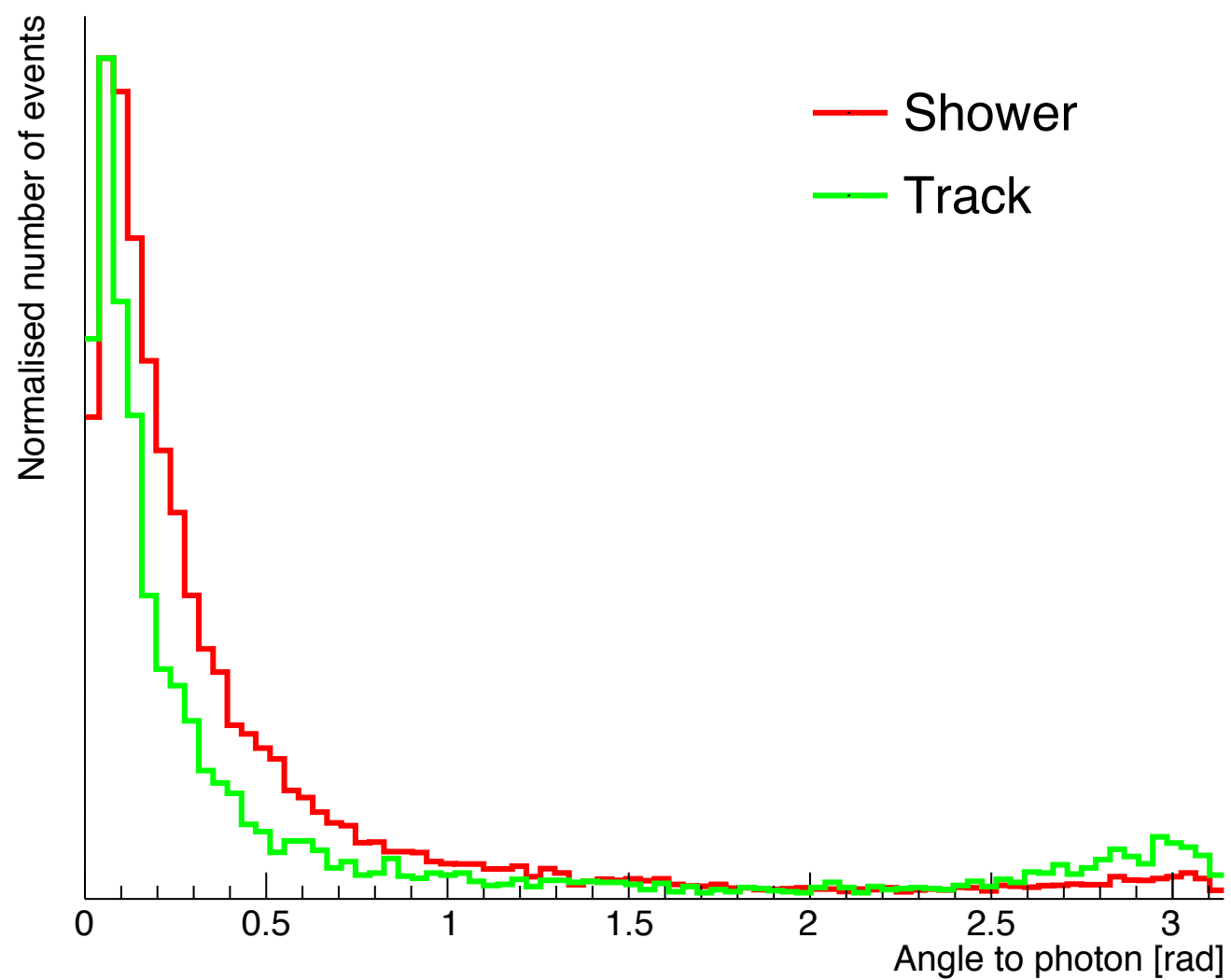


USEFUL METRICS FROM RECONSTRUCTED TRACKS

- ▶ Direction
 - ▶ Supposedly better than from shower
- ▶ Added completeness
 - ▶ Useful for e.g. photon energy reconstruction, pointing, etc.
- ▶ Increased π^0 detection in case a photon is reconstructed as just a track

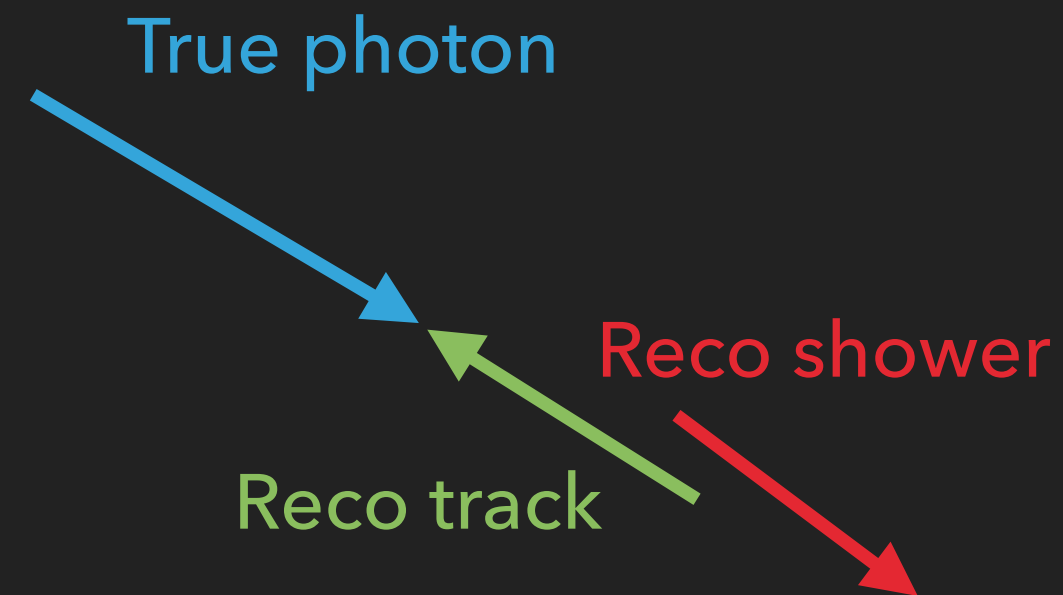
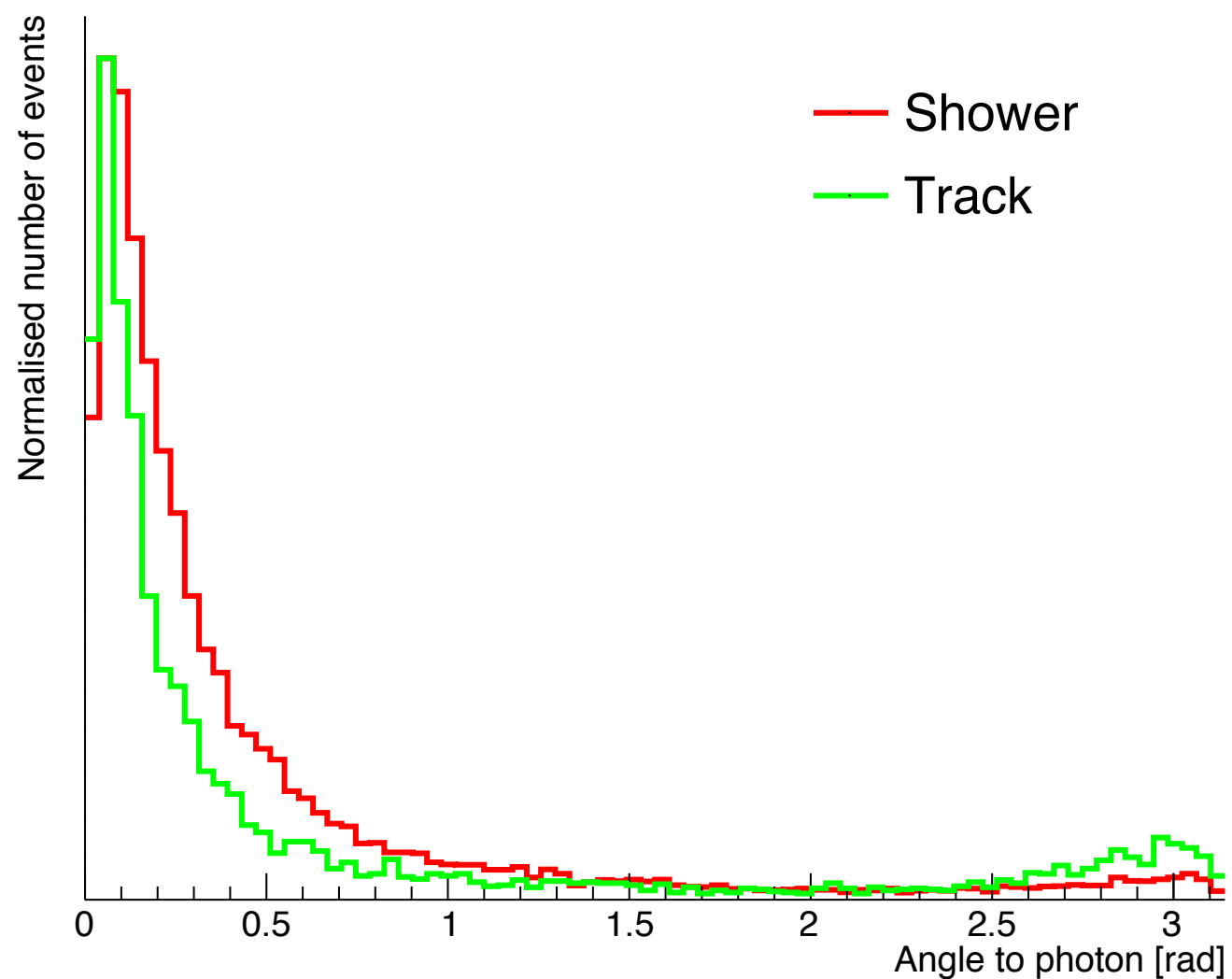
TRACK DIRECTION

- ▶ Tracks overall have better pointing



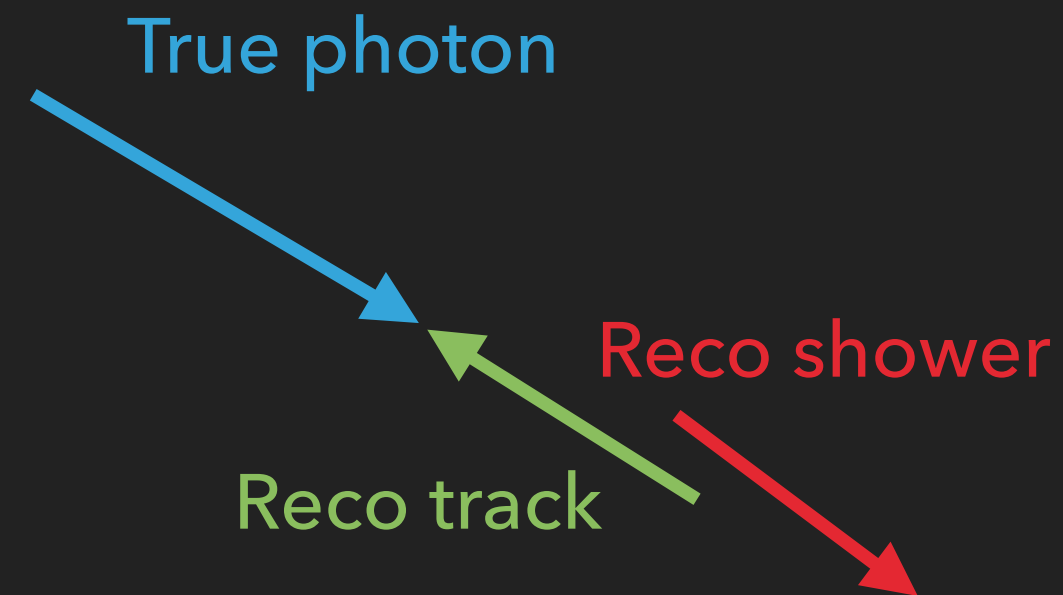
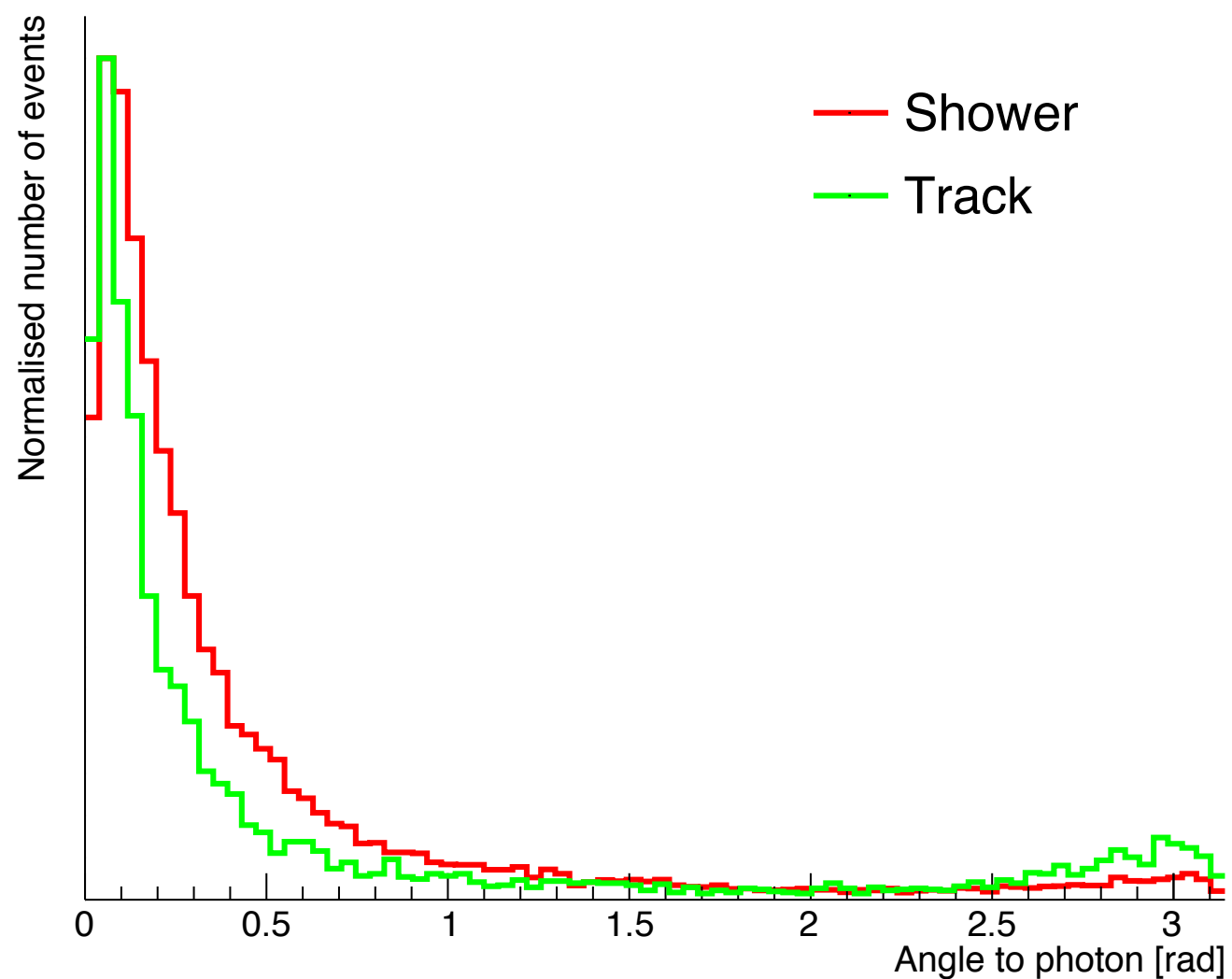
TRACK DIRECTION

- ▶ Tracks overall have better pointing
- ▶ But: some reverse tracks could be discarded in selection



TRACK DIRECTION

- ▶ Pointing of track-shower combination could be even better than that of the track



COMPLETENESS

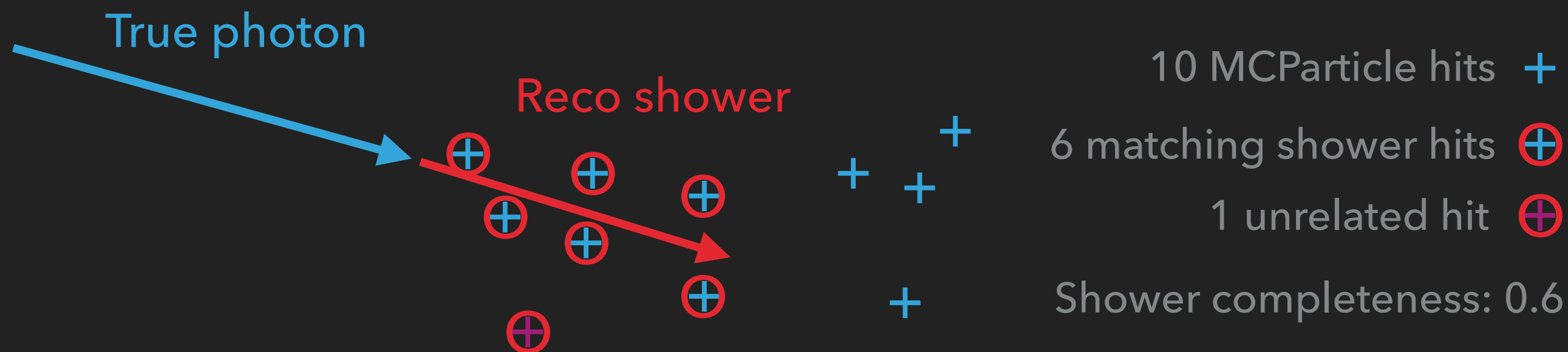
- ▶ Defined as the fraction of hits in an MCParticle that are shared with its matched track/shower

$$\frac{\text{Number of hits shared between a MCParticle and track/shower}}{\text{Total number of hits in the MCParticle}}$$

COMPLETENESS

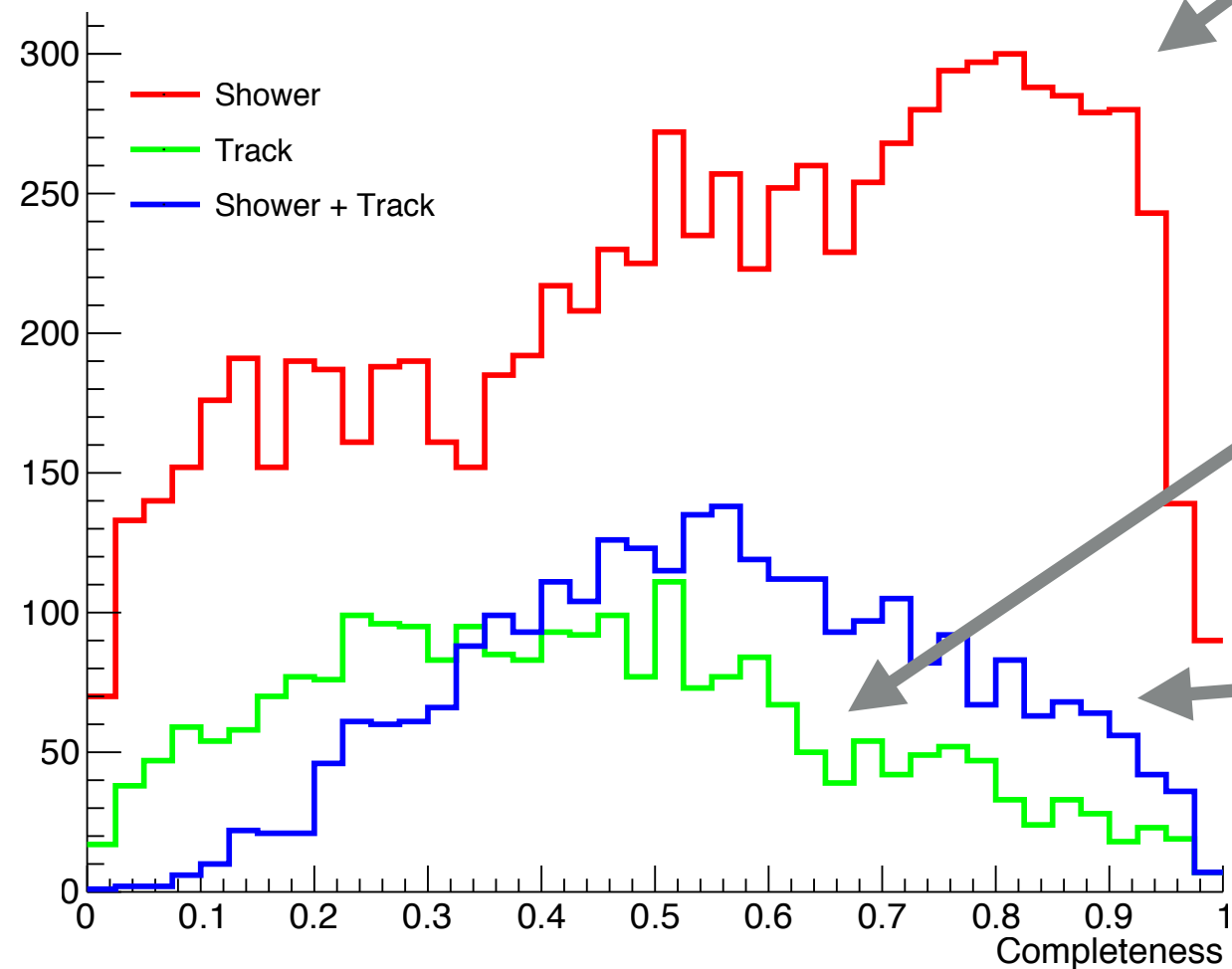
- ▶ Defined as the fraction of hits in a MCParticle that are shared with its matched track/shower

$$\frac{\text{Number of hits shared between a MCParticle and track/shower}}{\text{Total number of hits in the MCParticle}}$$



COMPLETENESS

- ▶ Here: all shower and track events
- ▶ Some improvement



True photon

Reco shower

True photon

Reco track

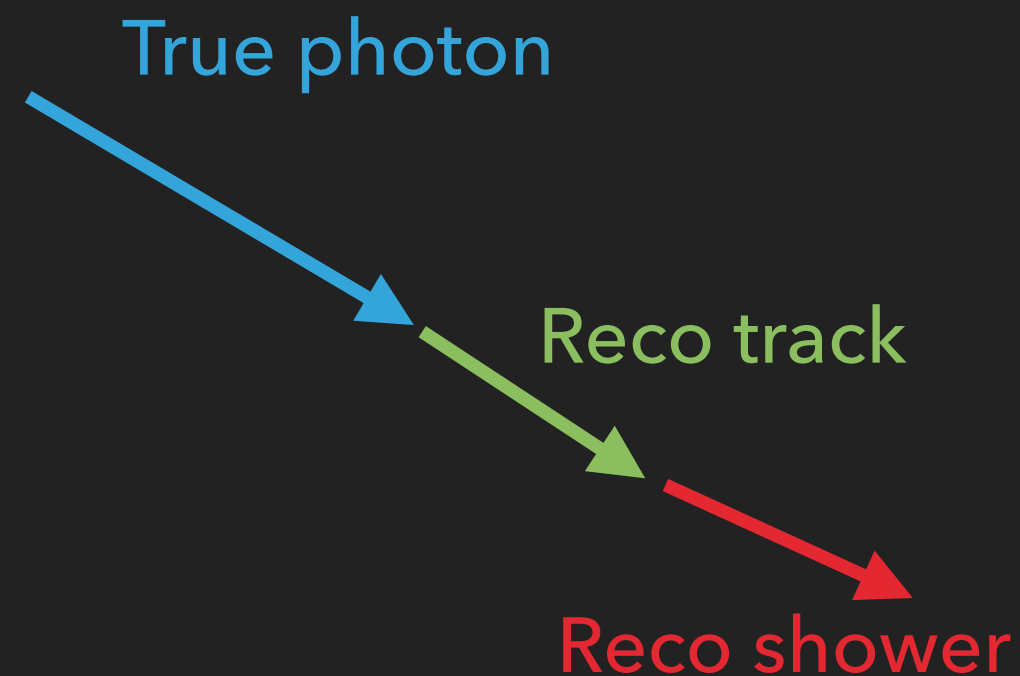
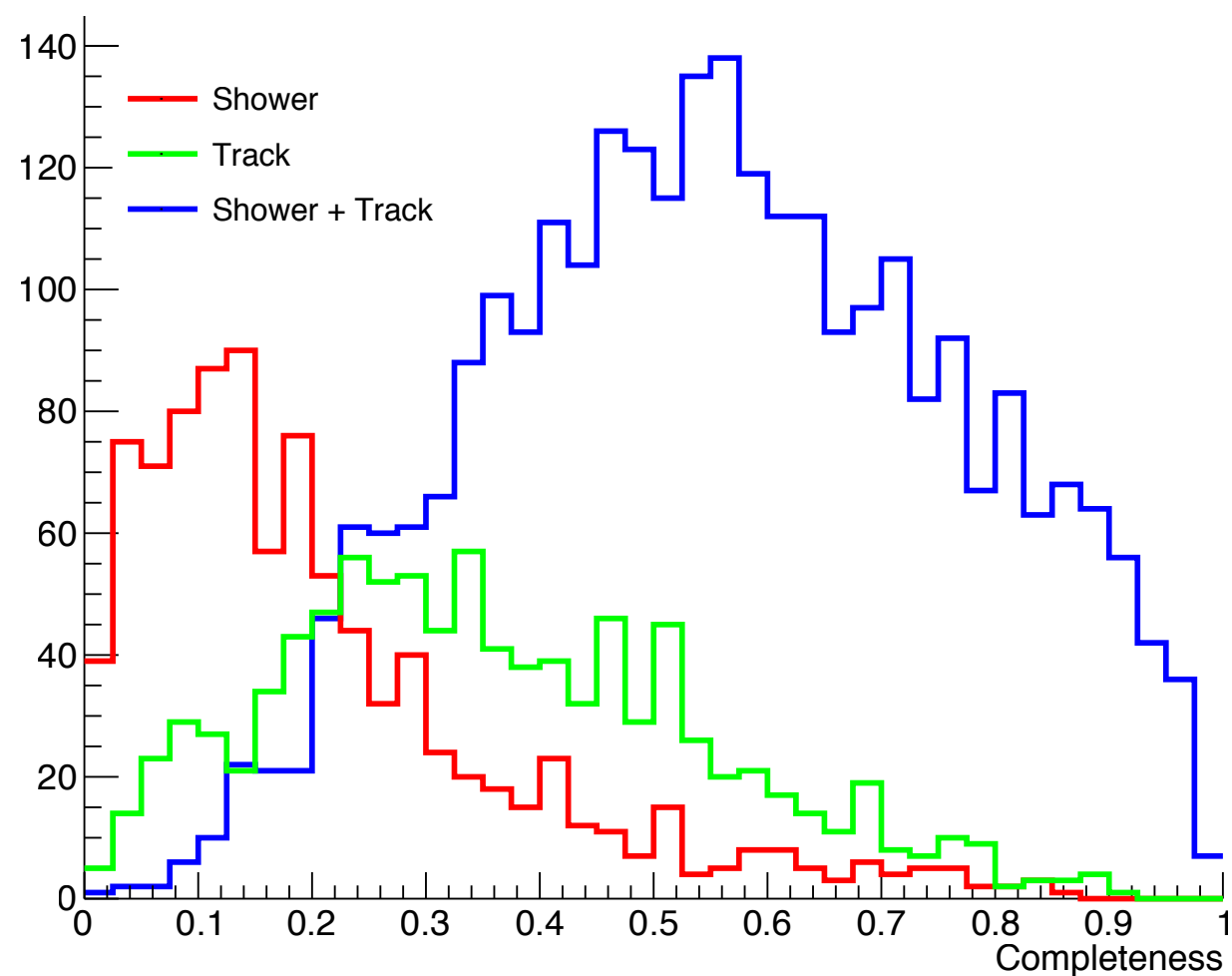
True photon

Reco track

Reco shower

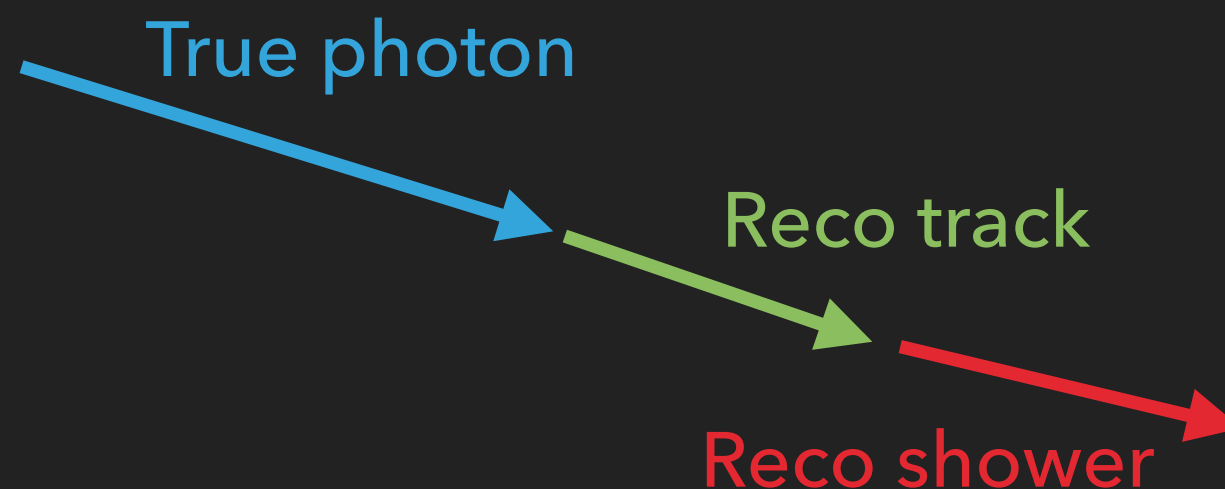
COMPLETENESS

- ▶ Improvement comes from the events that have both a track and shower



HARNESSING THE TRACKS

- ▶ Distinction made in the clustering stage of Pandora
- ▶ Unsure how to reliably detect track contamination
- ▶ Extra Pandora information would be helpful:
 - ▶ How sure is it that a PFParticle is a track or a shower?



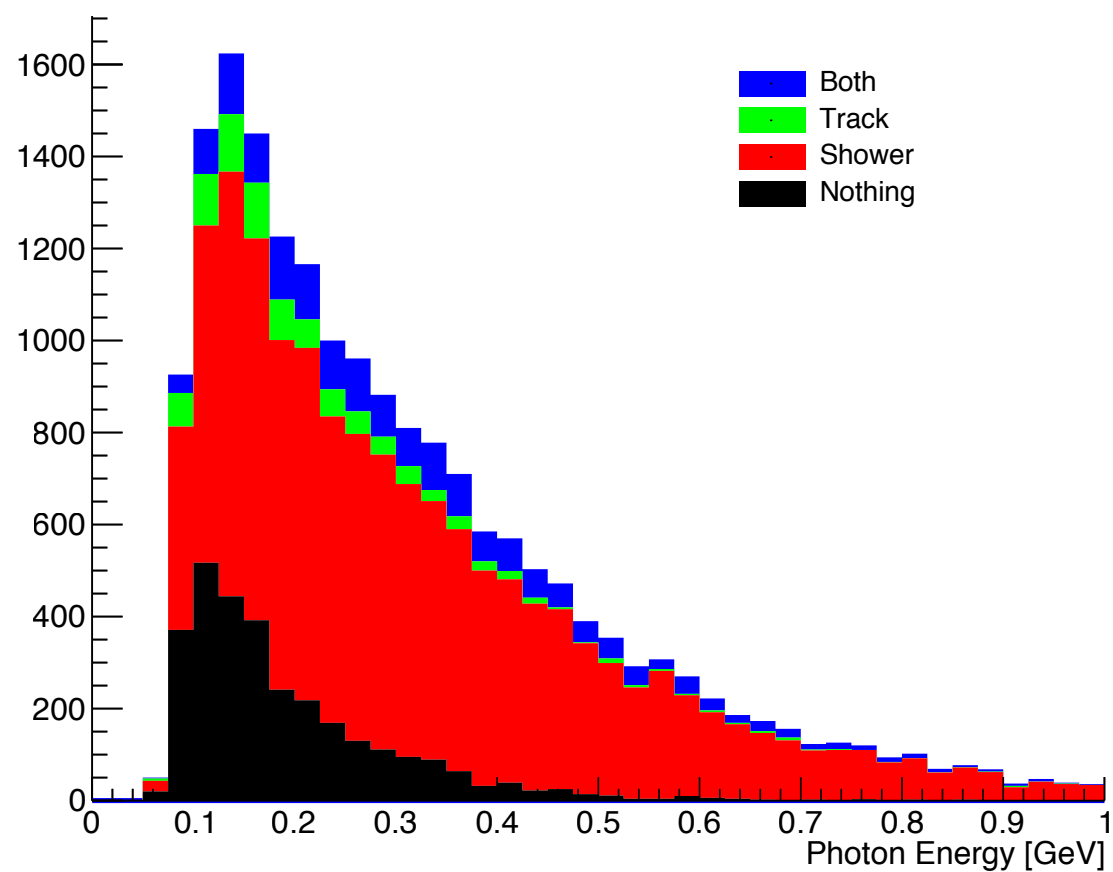
CONCLUSION

- ▶ Tracks very relevant when looking at showers
 - ▶ Improved pointing and completeness
- ▶ Might be difficult to reliably detect tracks that are part of showers
 - ▶ To be looked into

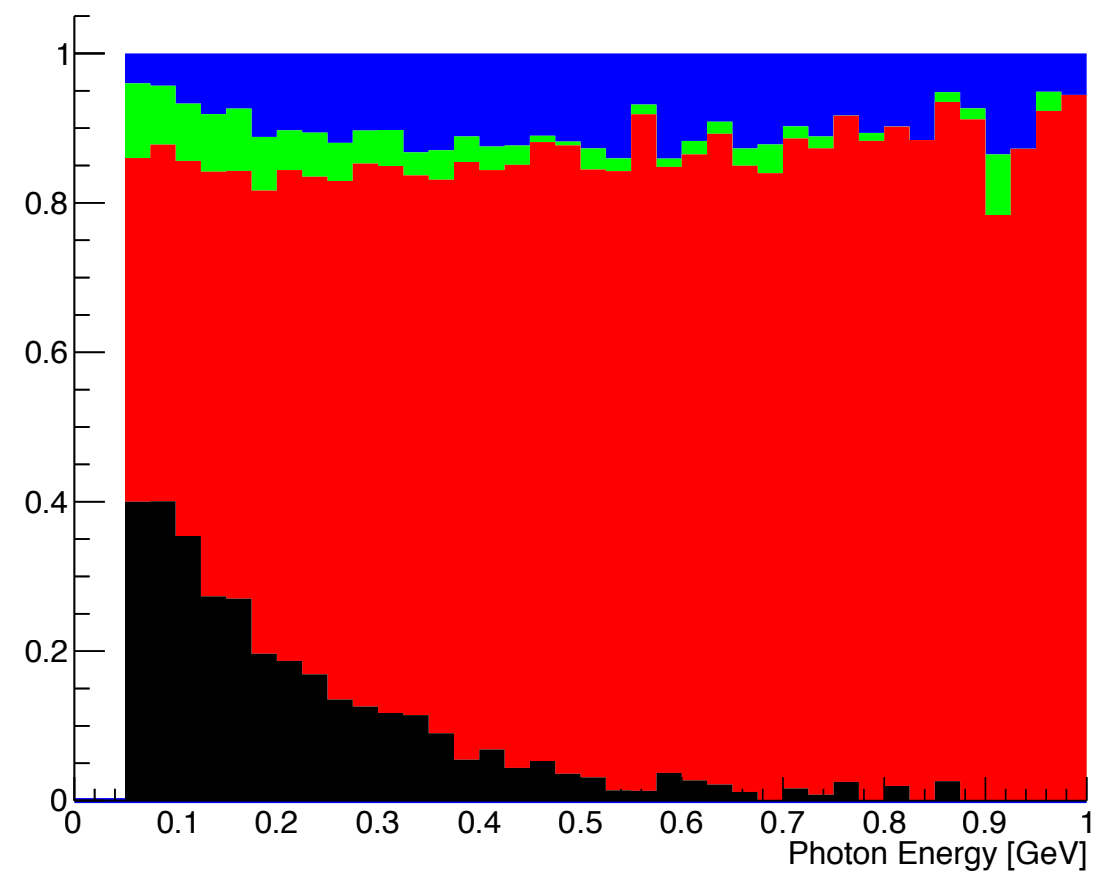
BACKUP

► Most energetic π^0 photon

Reconstruction vs photon energy



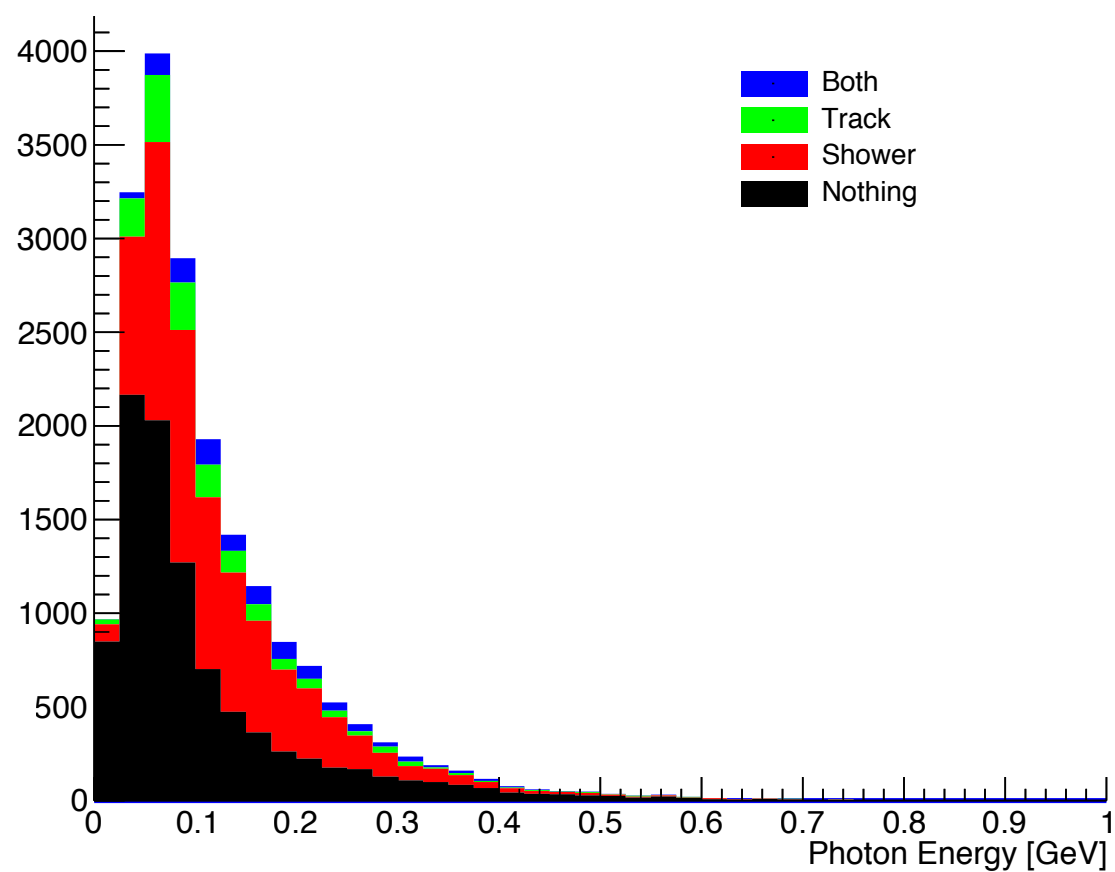
Normalised reconstruction vs photon energy



BACKUP

► Least energetic π^0 photon

Reconstruction vs photon energy



Normalised reconstruction vs photon energy

