

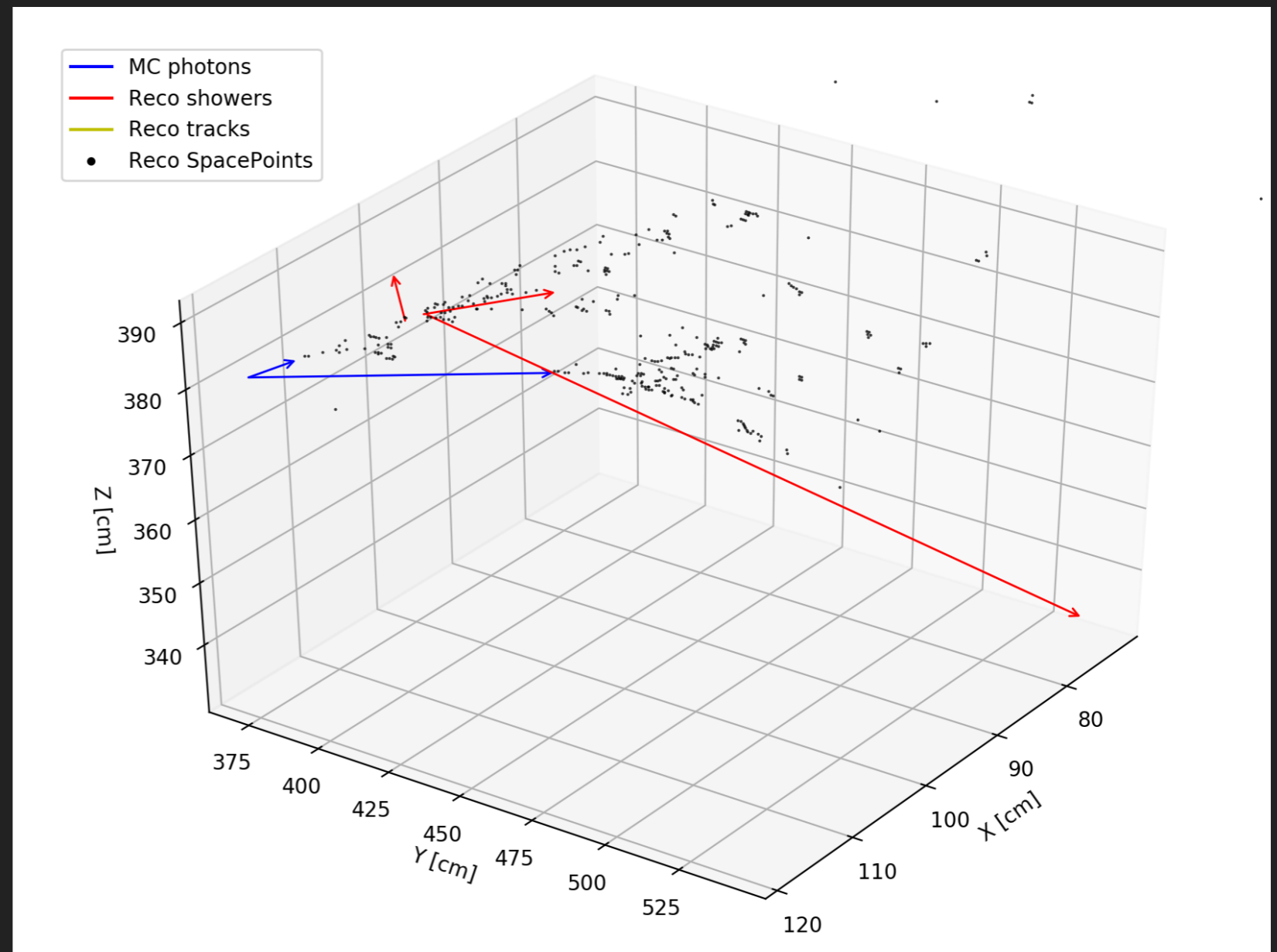
MILO VERMEULEN — 24-5-2019

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**HANDLES ON THE  $\pi^0$**

## PREVIOUSLY

- ▶ Silly  $\pi^0$  showers
- ▶ MC – Reco matching



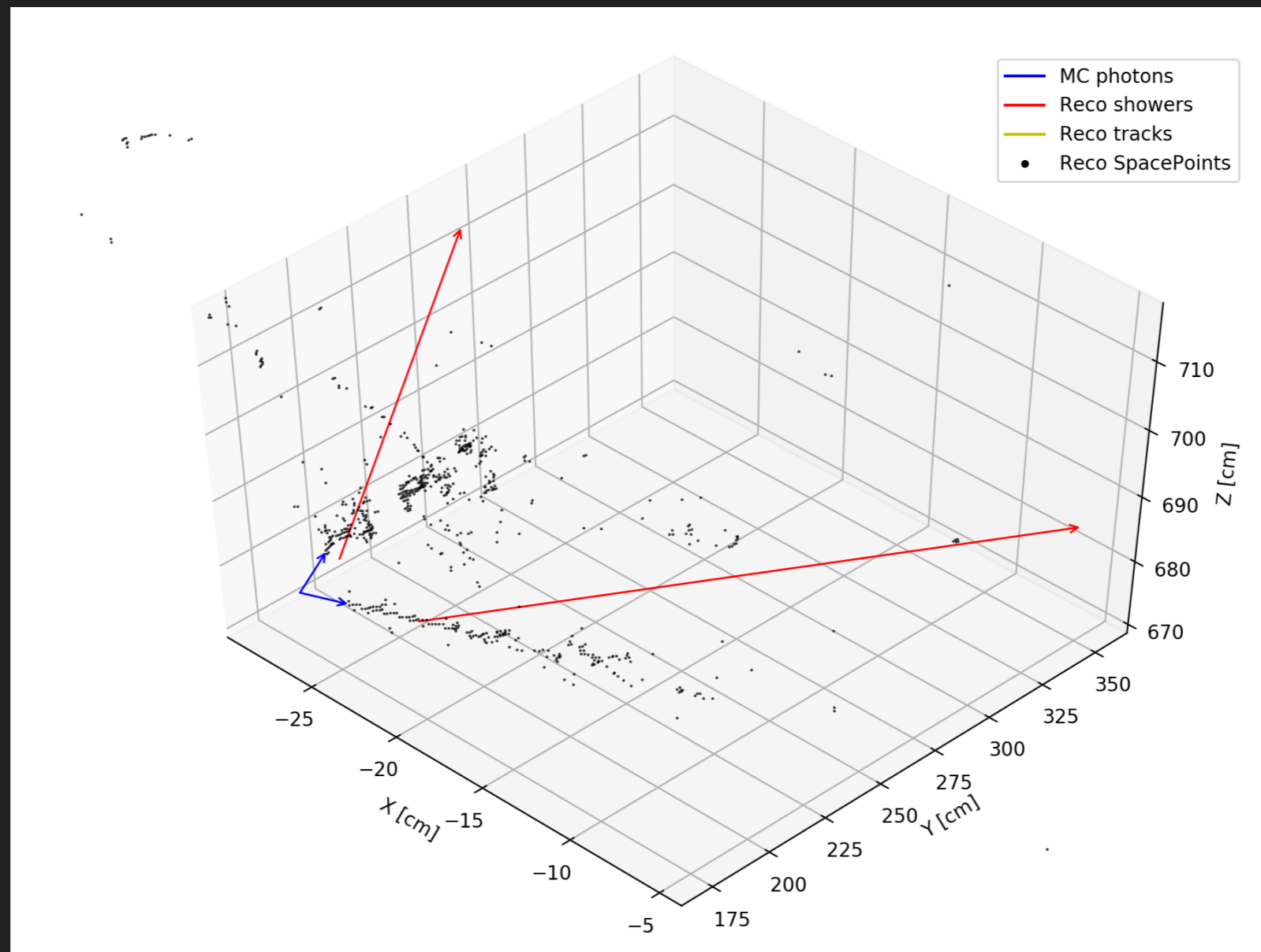
MCPARTICLE

GetRecoShowerFromMCParticle

SHOWER

# $\pi^0$ PROCESS

▶  $\pi^0 \rightarrow \gamma\gamma \rightarrow$  two showers



## $\pi^0$ PROCESS HANDLES

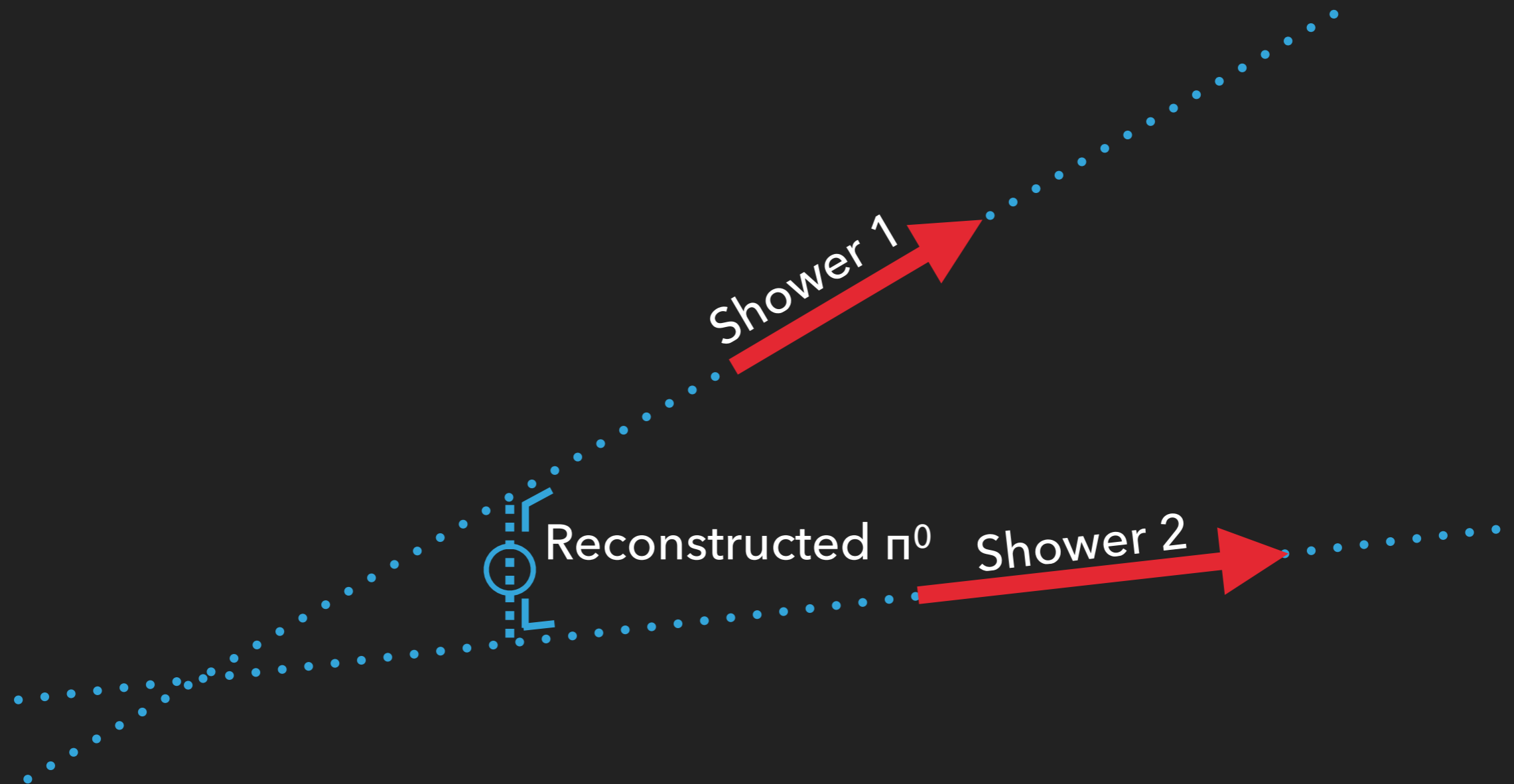
- ▶ Backtraced shower intersection
- ▶ Twin shower invariant mass
- ▶ Individual shower  $dE/dx$

## $\pi^0$ PROCESS HANDLES

- ▶ Backtraced shower intersection
- ▶ Twin shower invariant mass
- ▶ Individual shower  $dE/dx$ 
  - ▶  $\gamma$   $e^{+/-}$  separation → has proved challenging

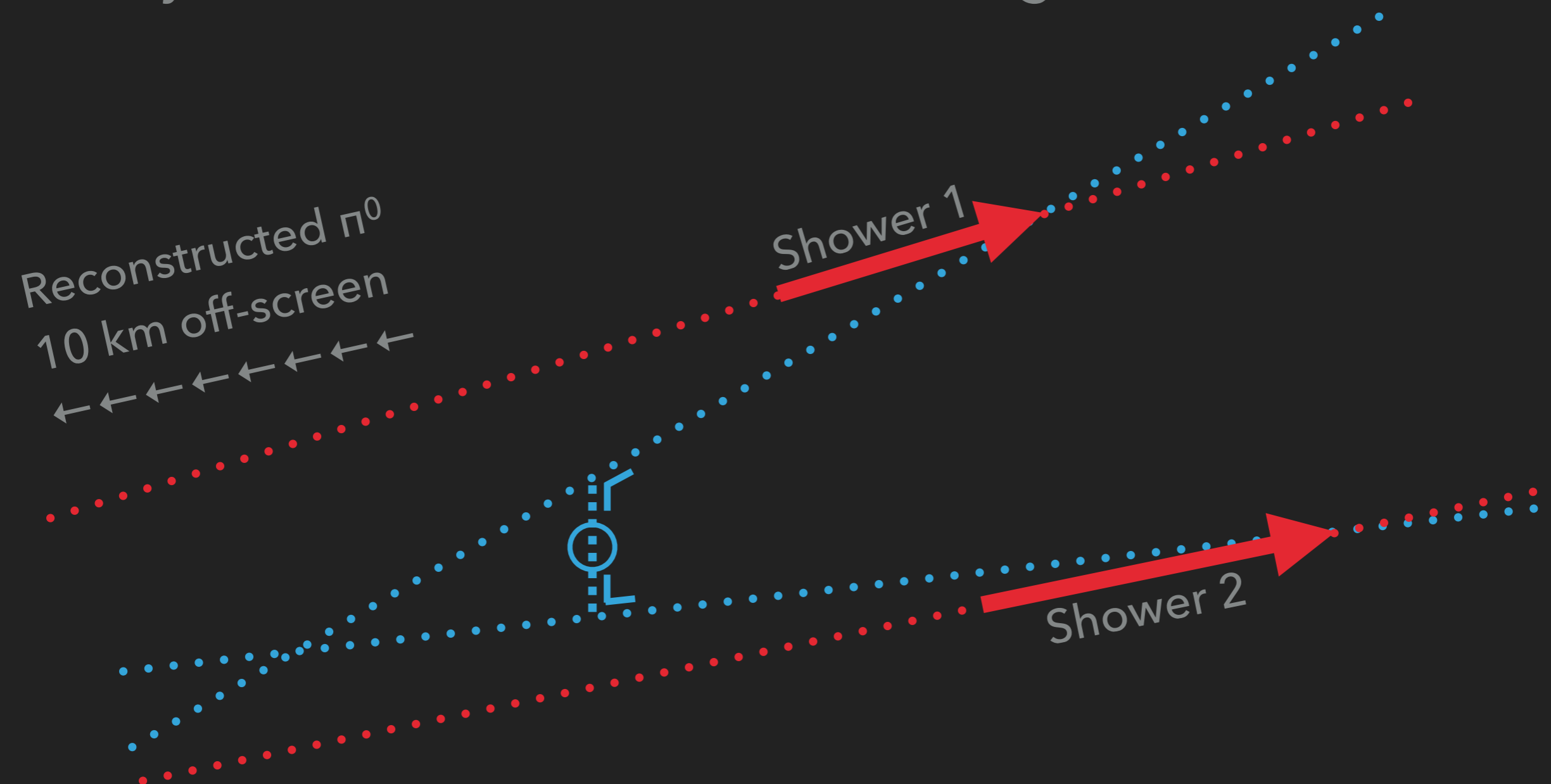
## SHOWER BACKTRACING

- ▶ Trace showers back to  $\pi^0$  vertex



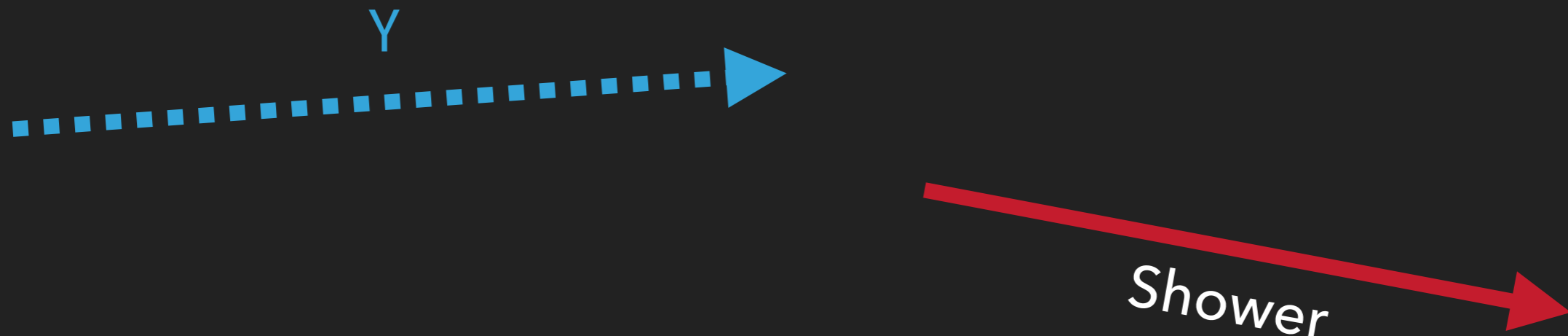
## SHOWER BACKTRACING

- ▶ Very sensitive to errors in shower angle



## SHOWER BACKTRACING

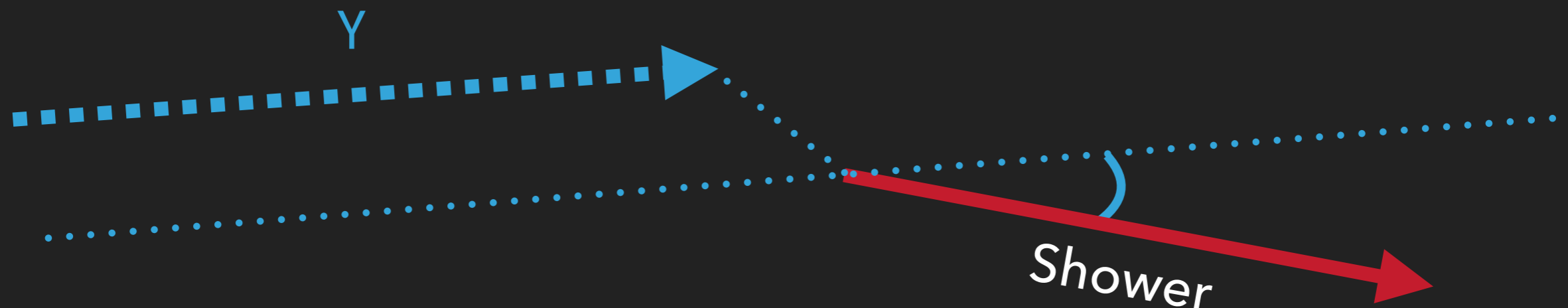
- ▶ Error metrics under investigation:
  - ▶ Relative angle
  - ▶ Energy fraction reconstructed
  - ▶ Photon end / shower begin offset





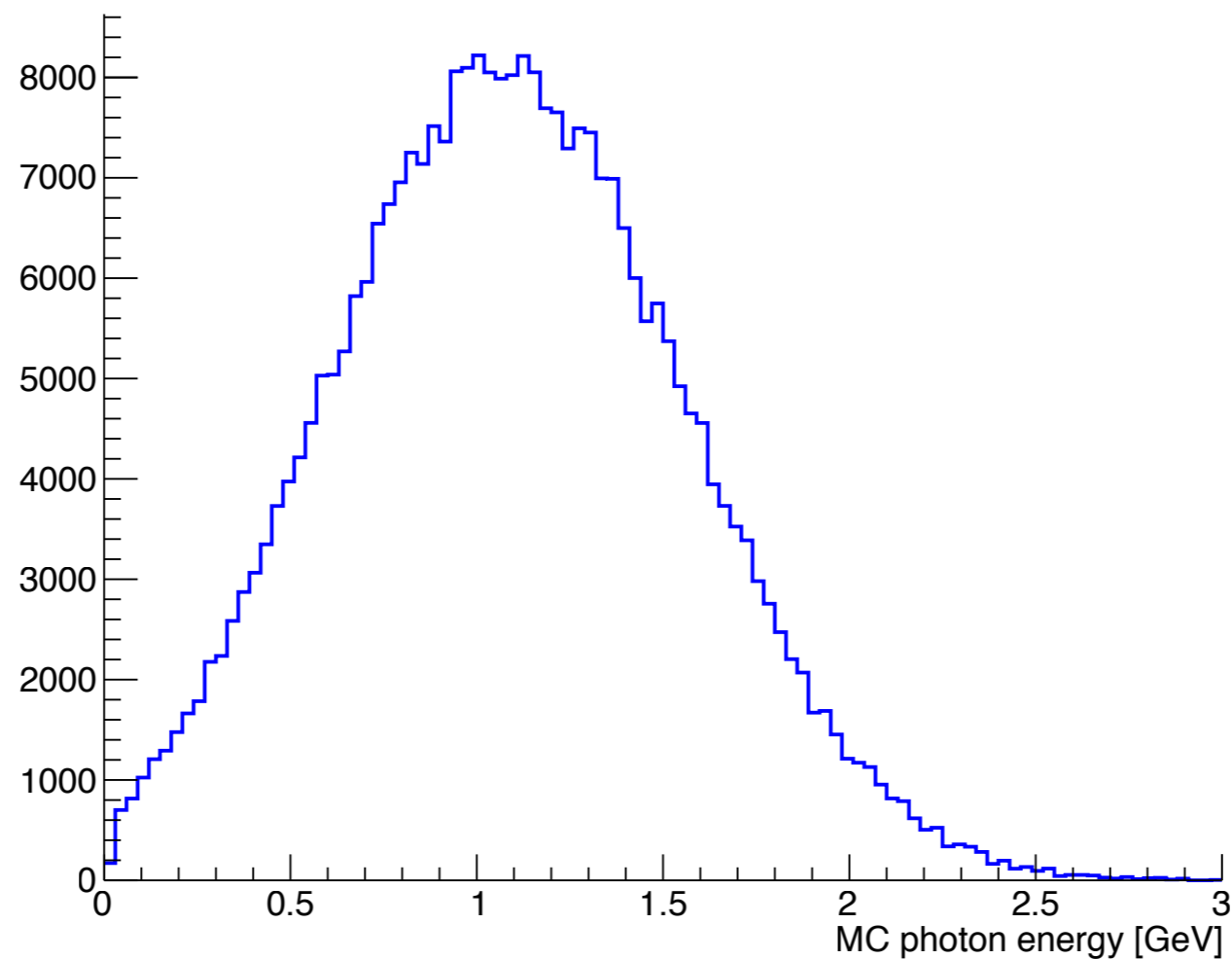
## SHOWER BACKTRACING

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  - ▶ Relative angle
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  - ▶ Photon end / shower begin offset



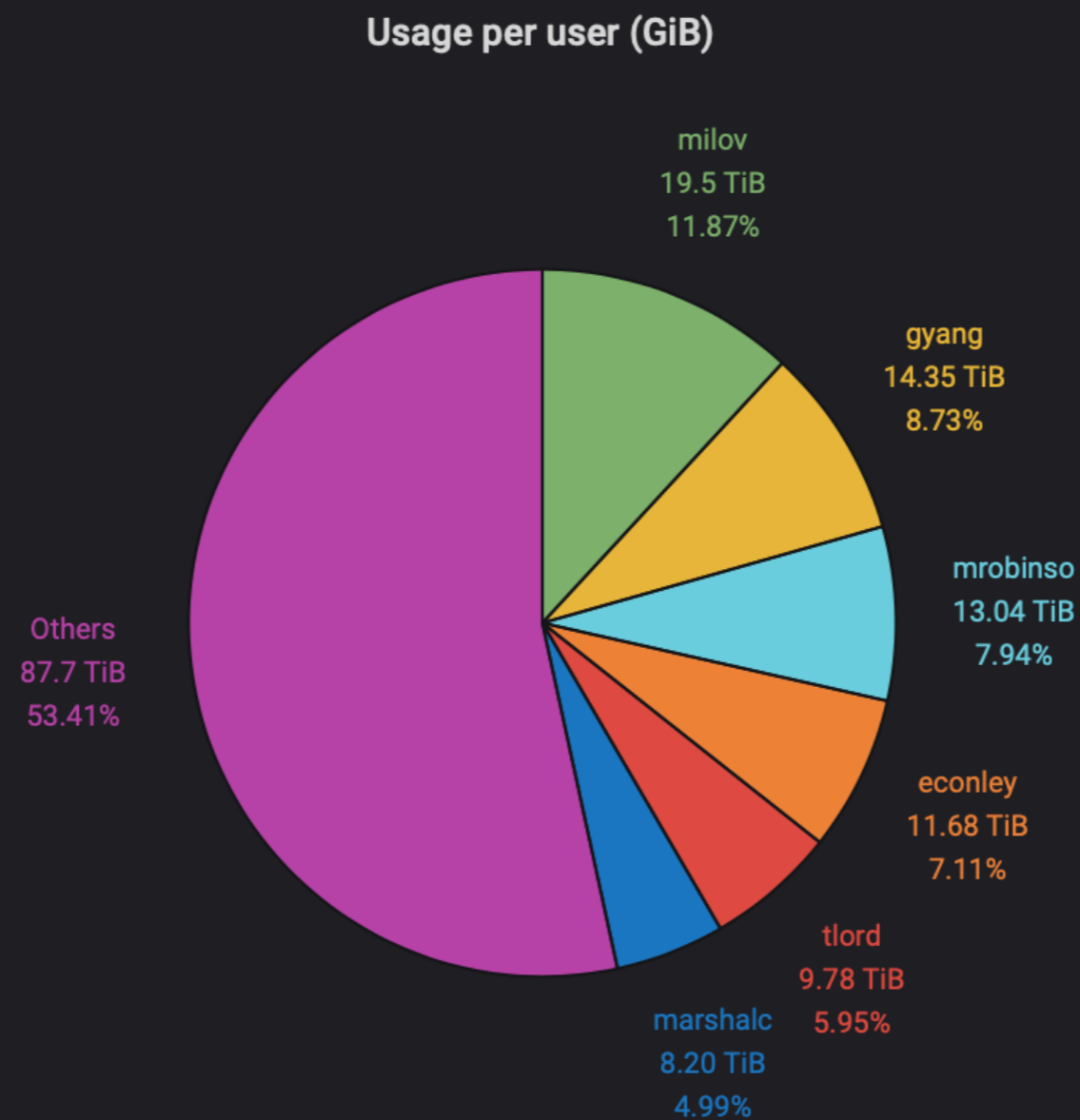
## DATA SET

- ▶ 100,000 single photon events
- ▶ Momentum gaussian around 1 GeV



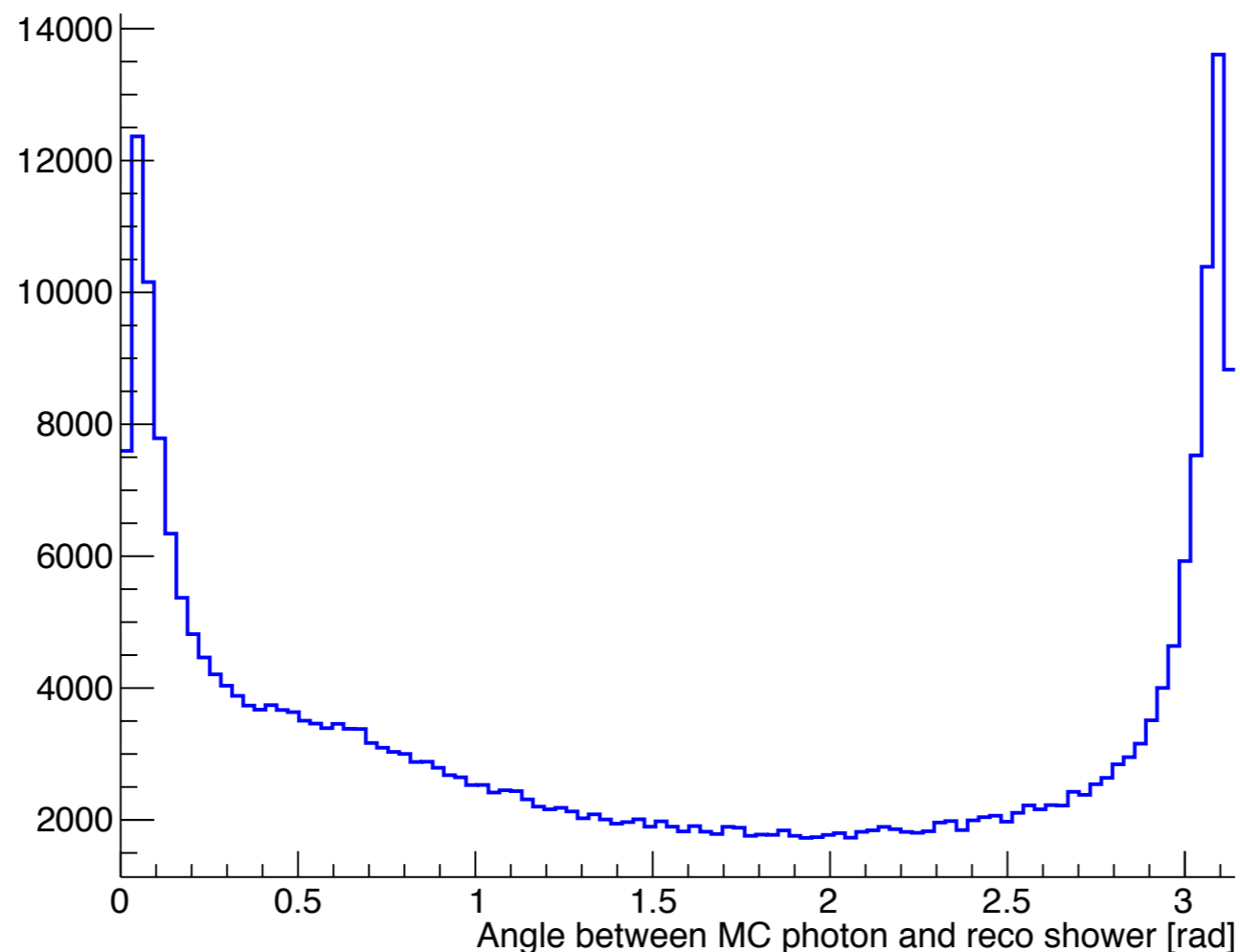
# DATA SET

▶ #1 on the DUNE dCache! 🎉🎉🎉



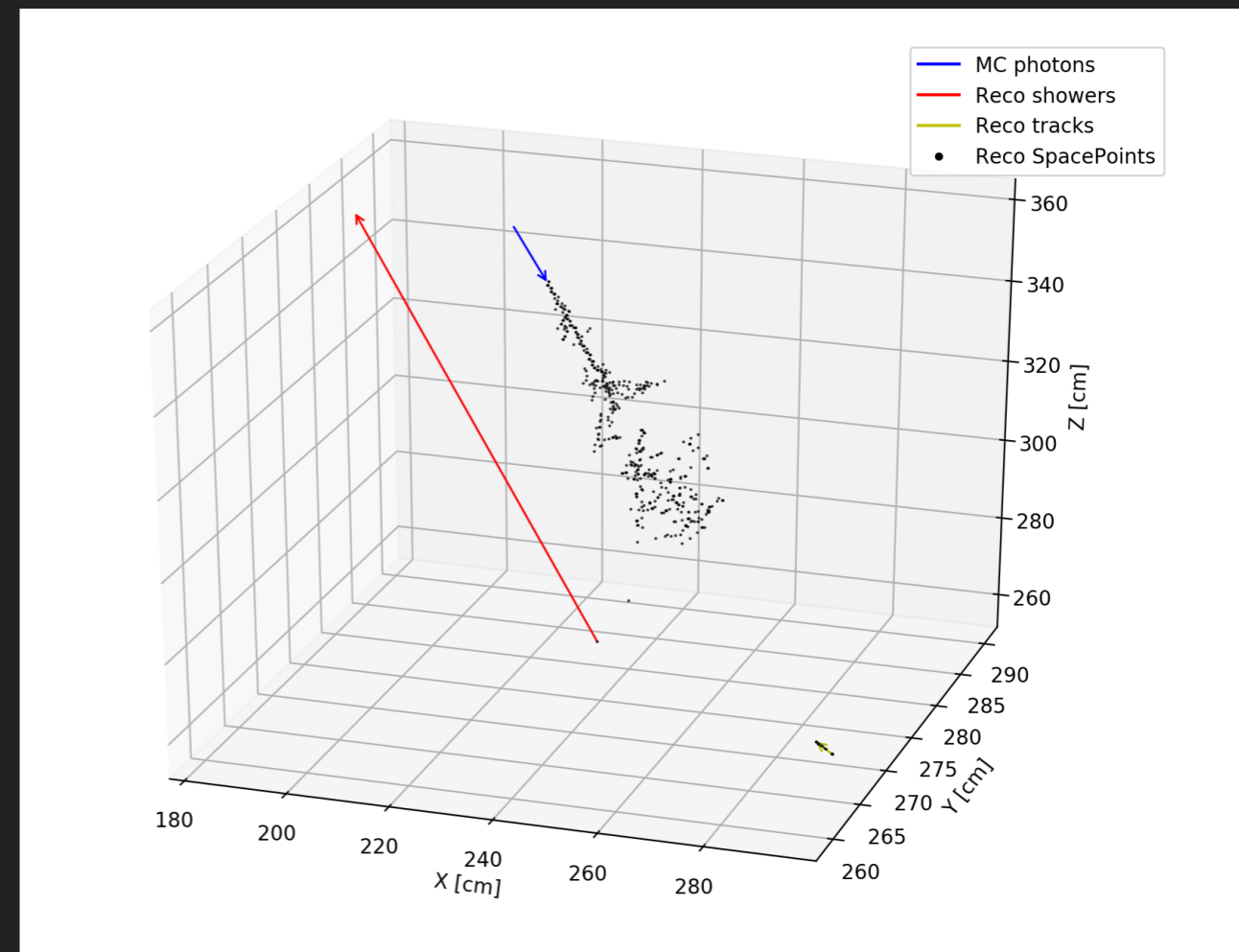
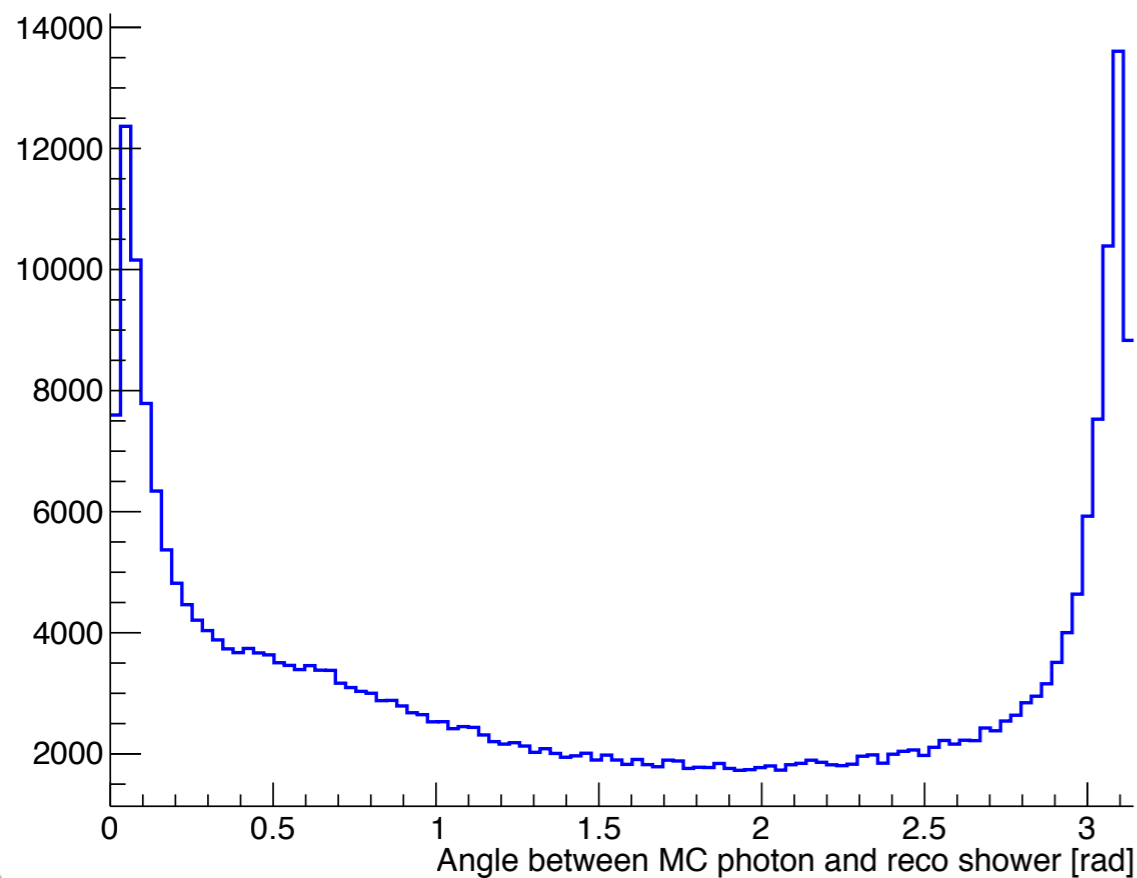
## RELATIVE ANGLE

- ▶ Many showers reconstructed in the opposite direction
- ▶ Many showers reconstructed at random angles



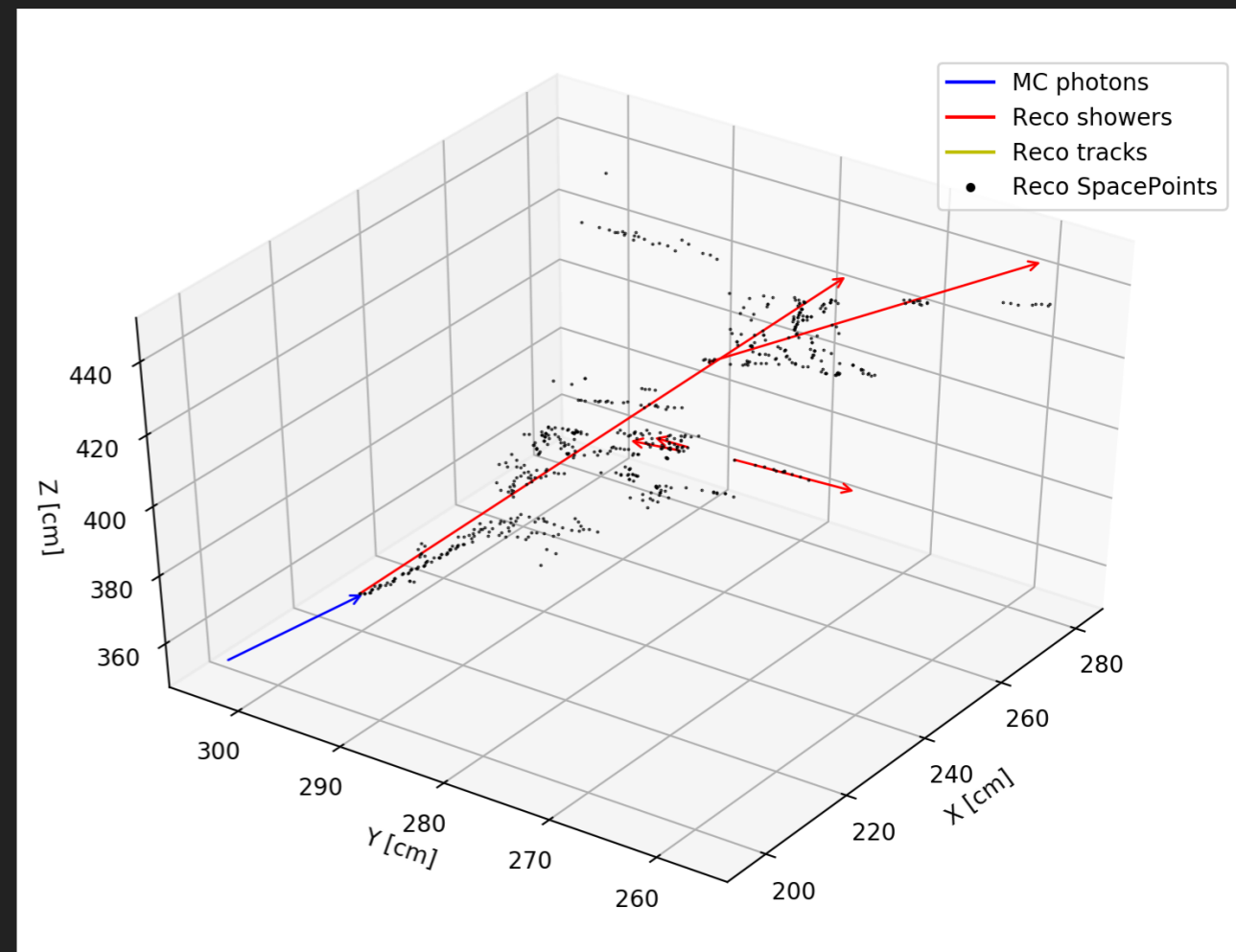
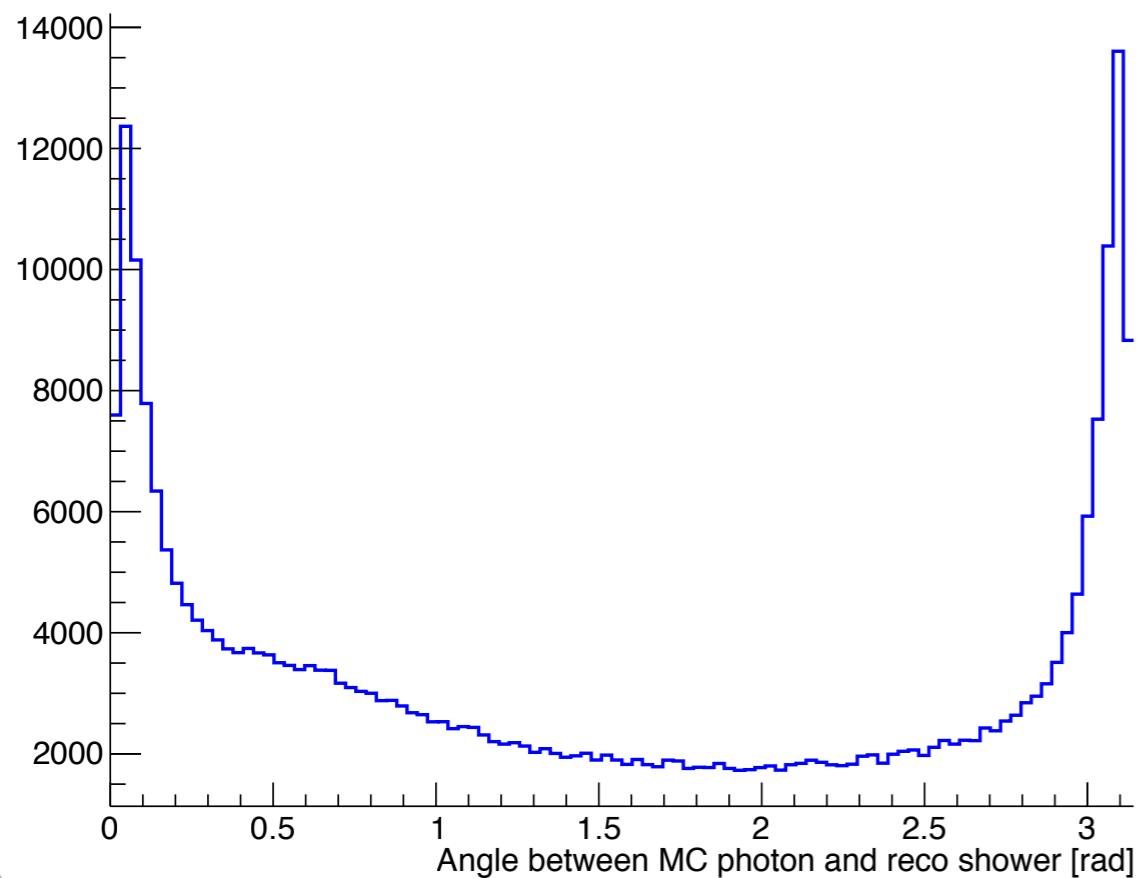
## RELATIVE ANGLE

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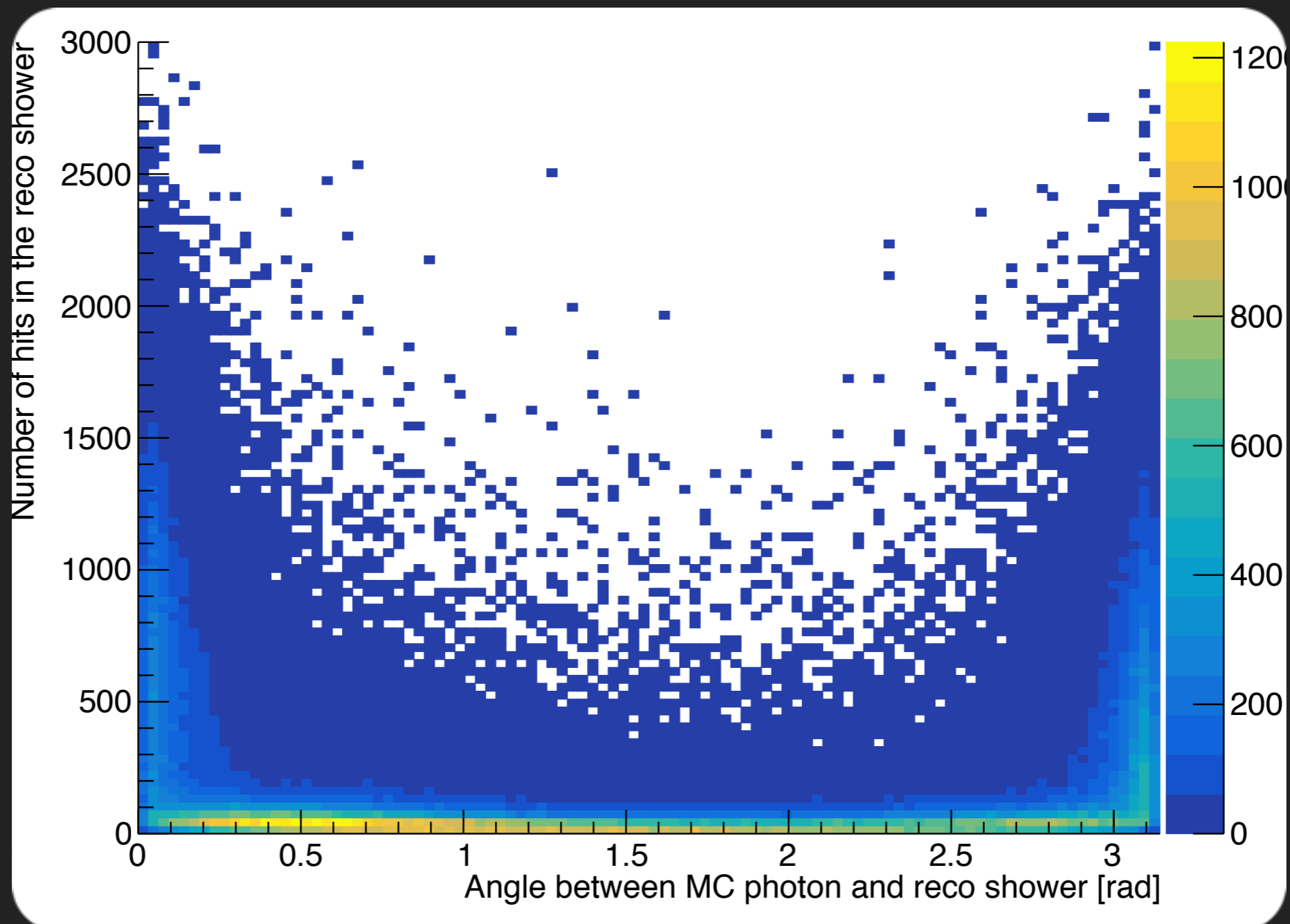
## RELATIVE ANGLE

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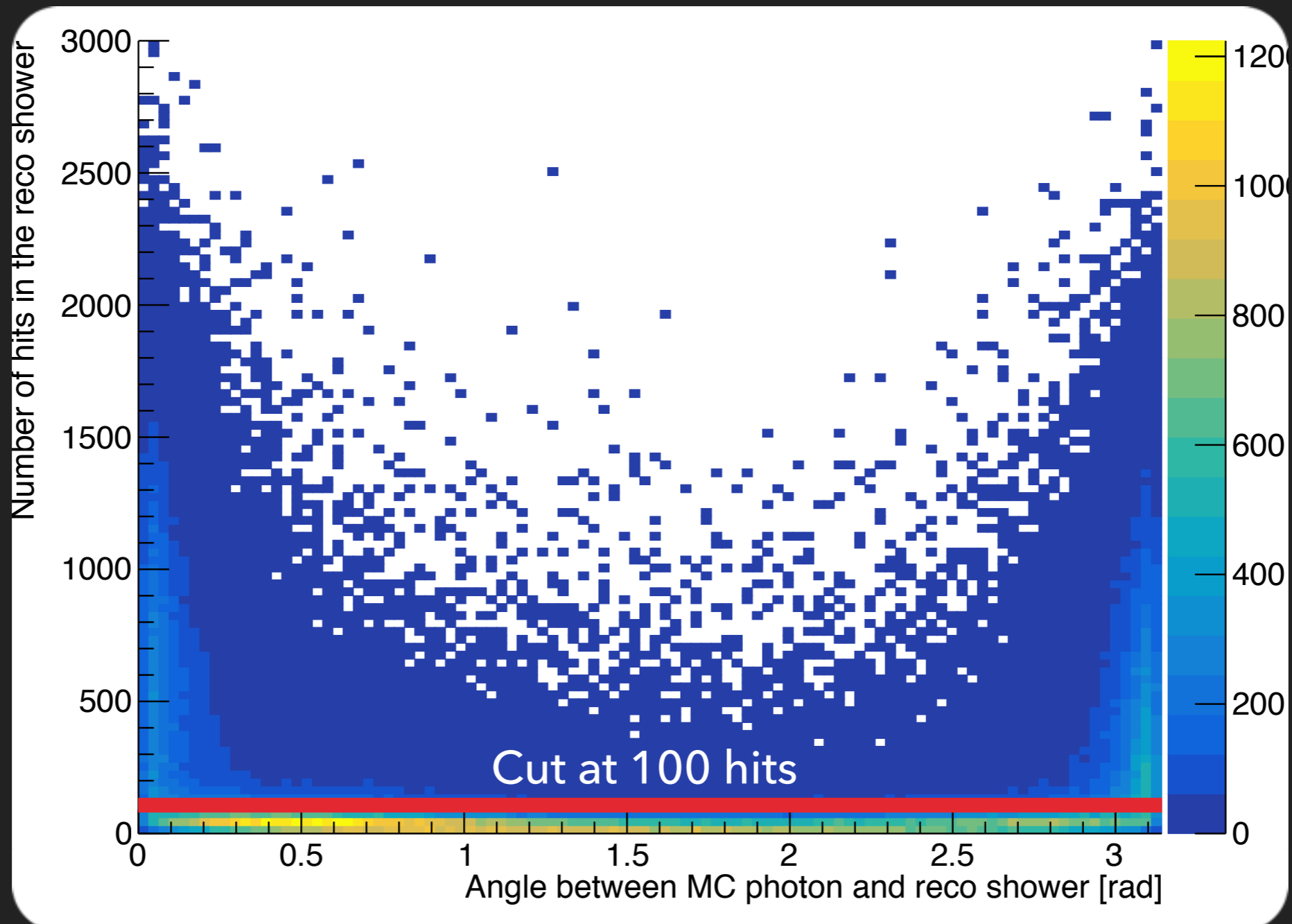
## RELATIVE ANGLE

- ▶ Random-direction showers have fewer hits!



## RELATIVE ANGLE

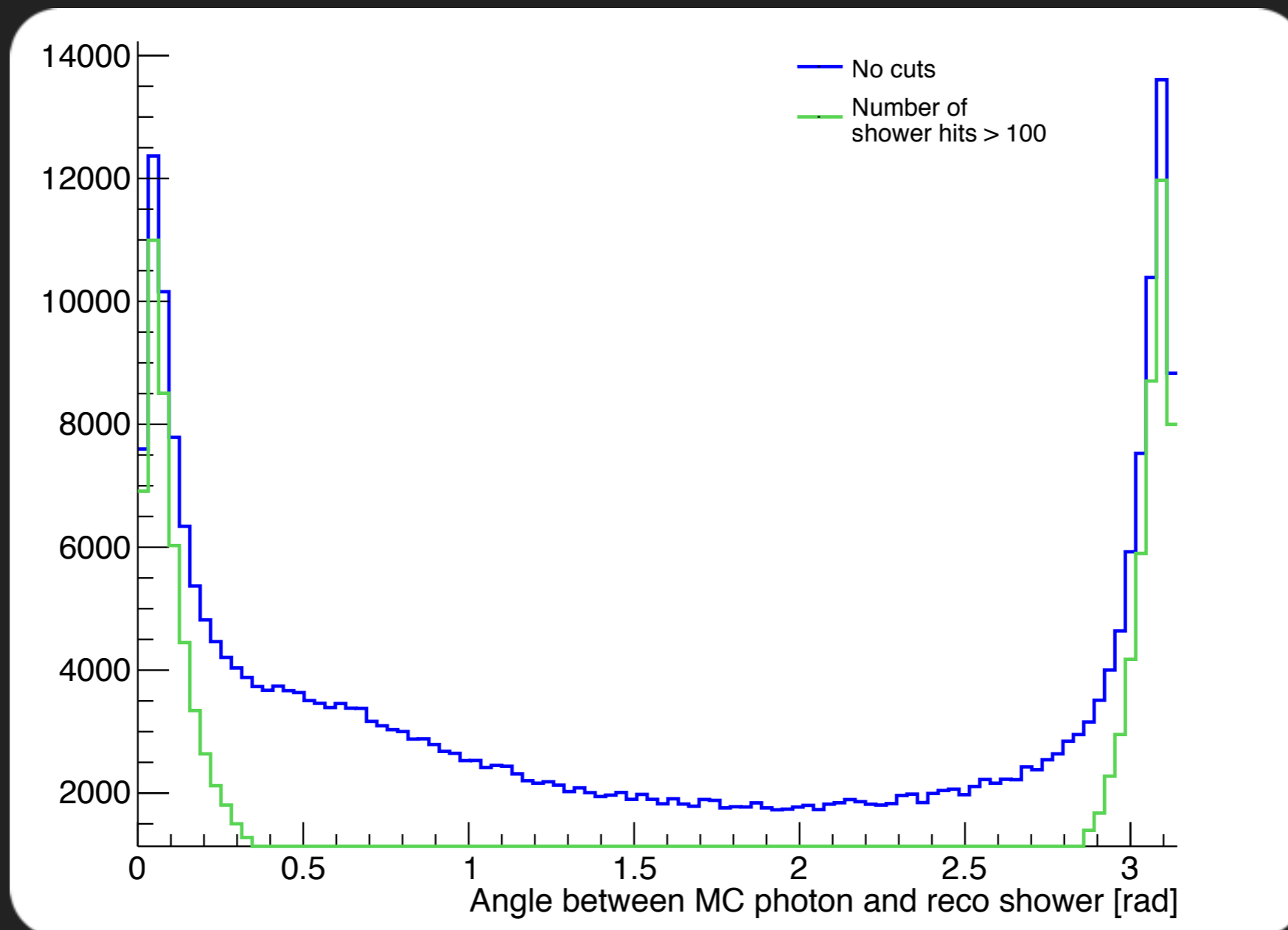
- ▶ Easy cut easy life





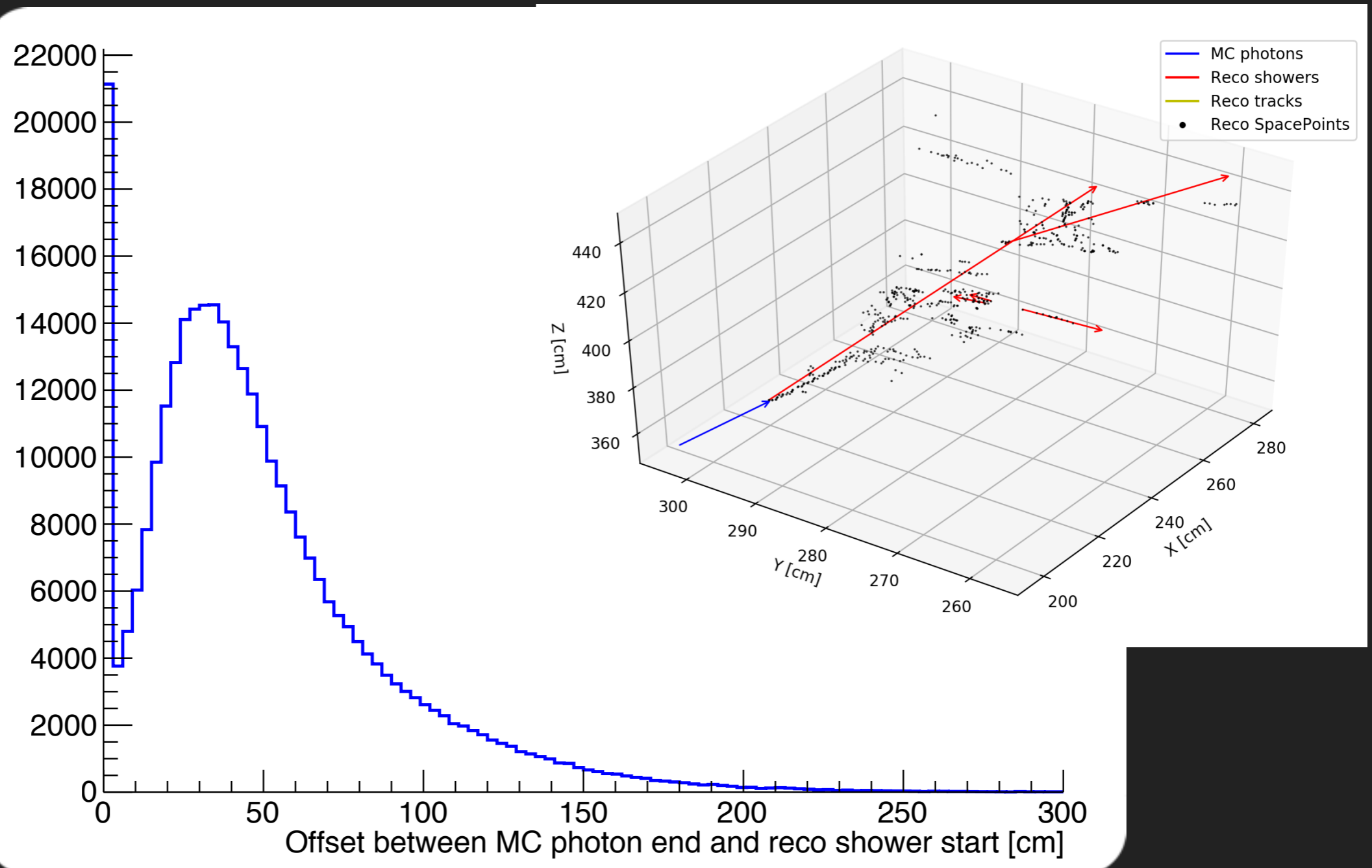
## RELATIVE ANGLE

- ▶ Cut improves relative angle distribution



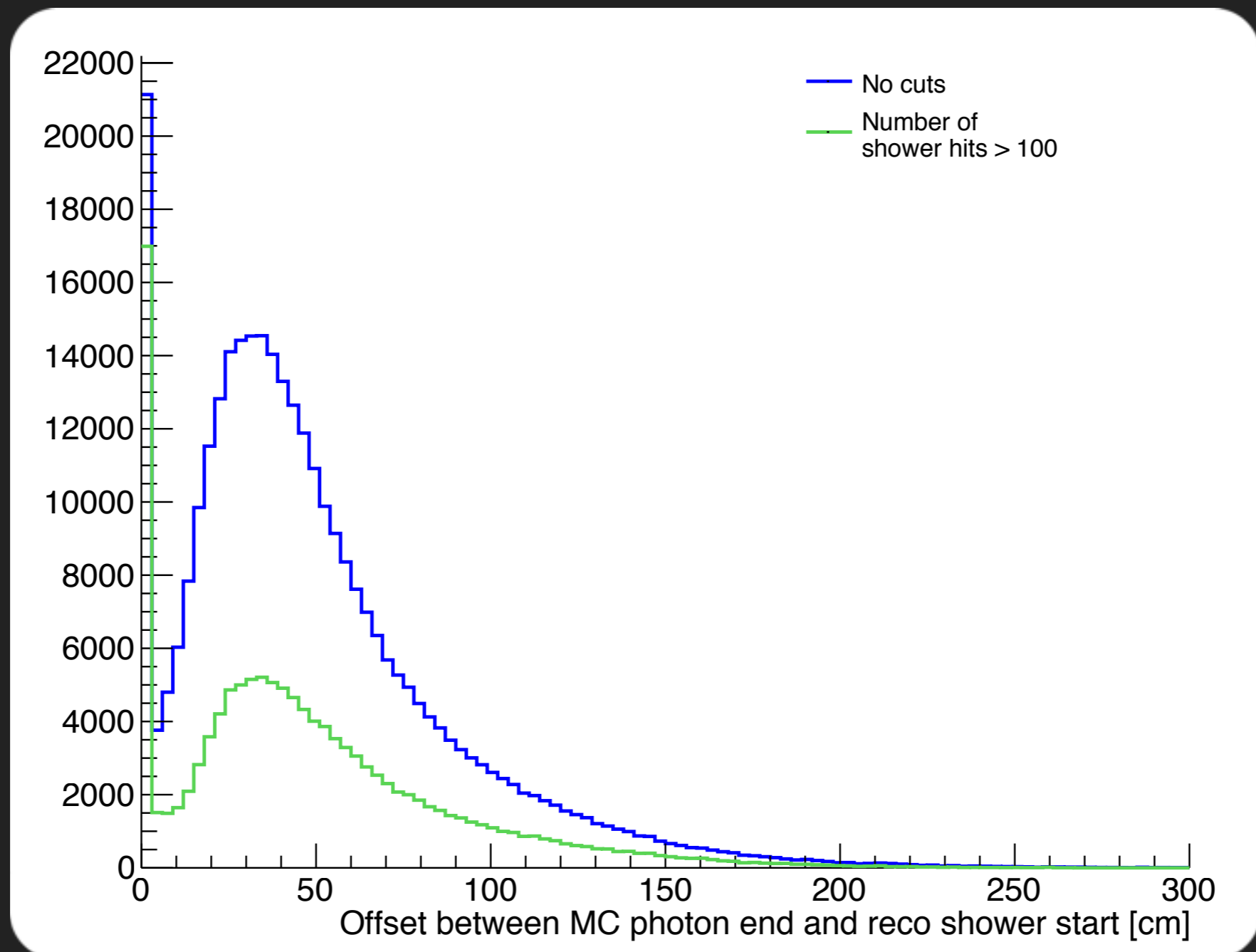
# OFFSET

- ▶ Many showers constructed at large offset



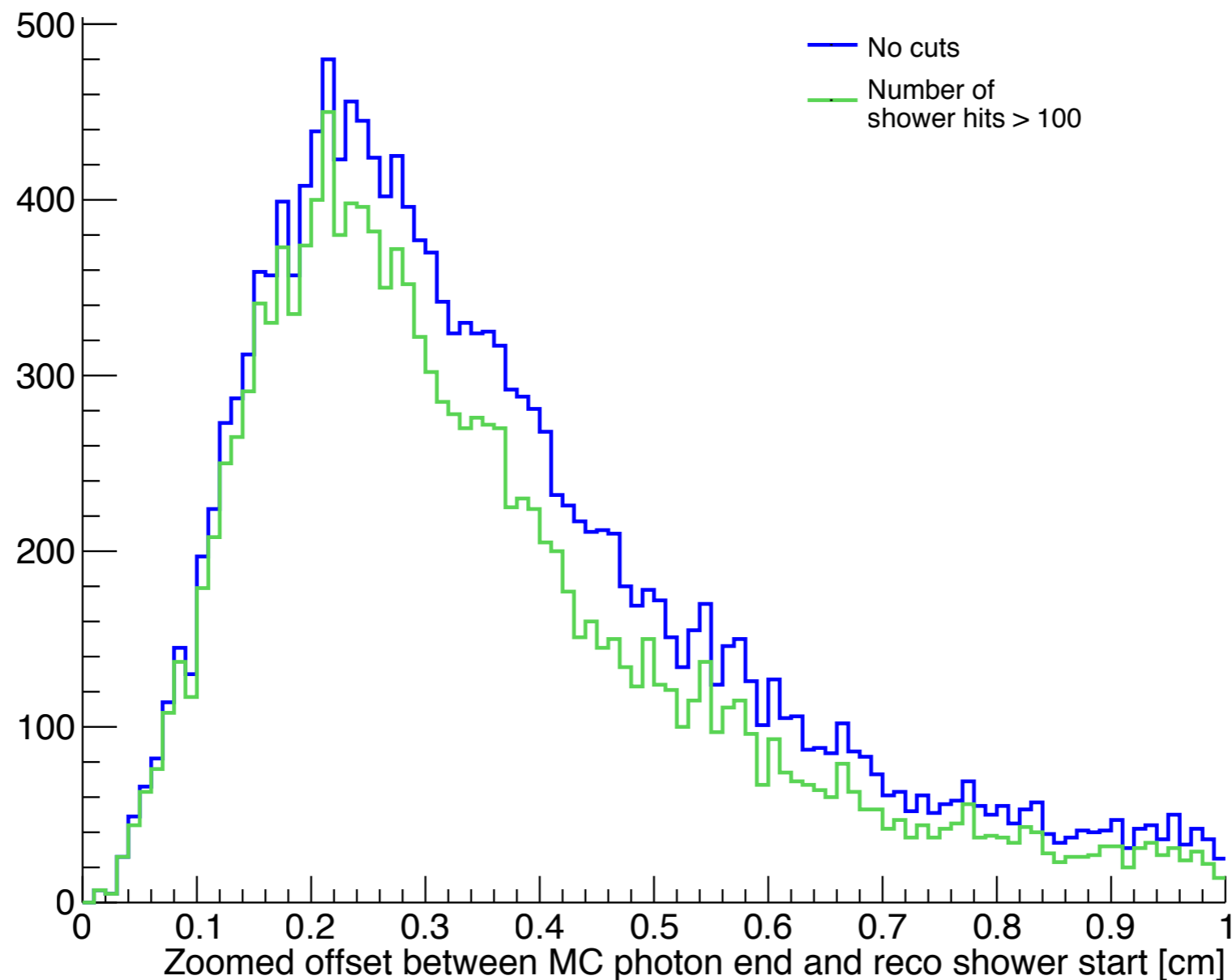
# OFFSET

- ▶ Number of hit cut partially solves this



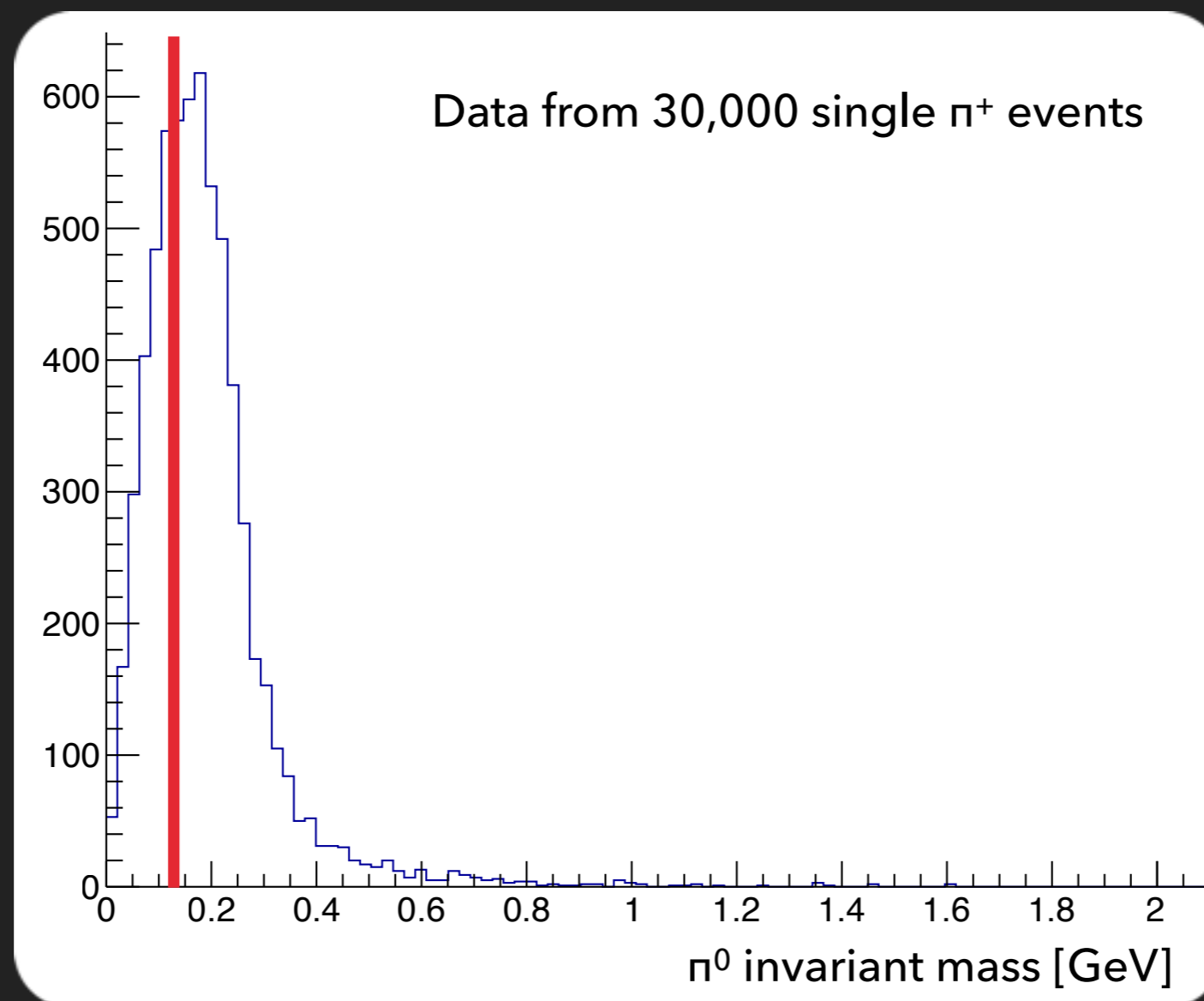
# OFFSET

- ▶ Low part of the range largely unaffected



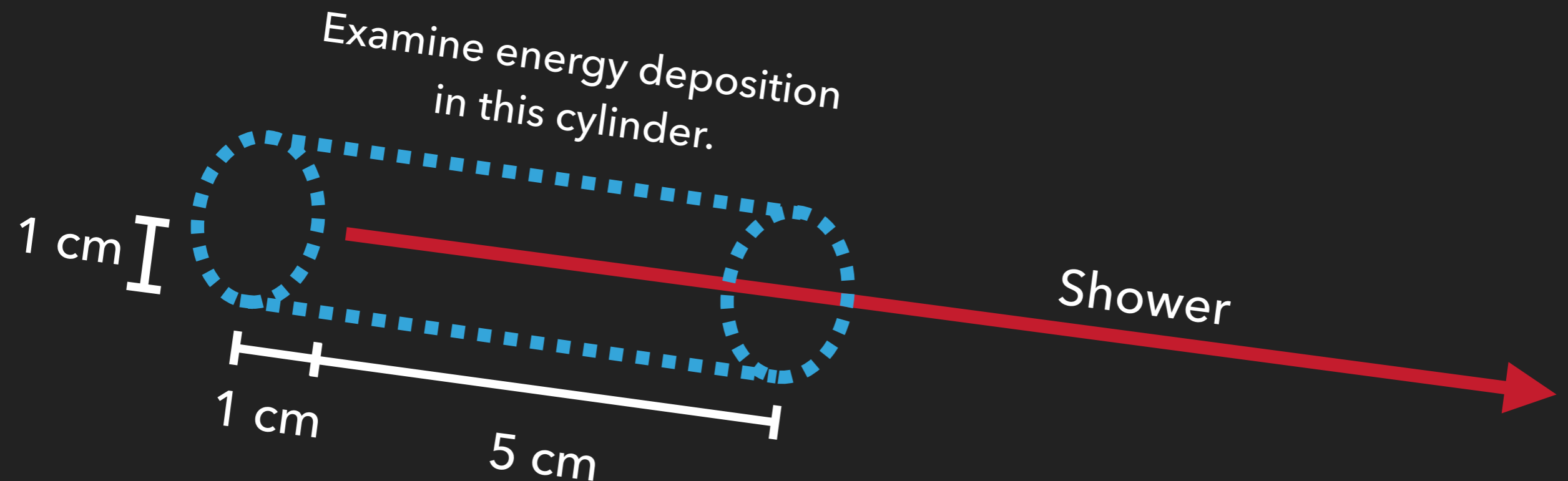
## INVARIANT MASS

- ▶ Truth-selected showers show peak around 135 MeV!
- ▶ Will provide nice check



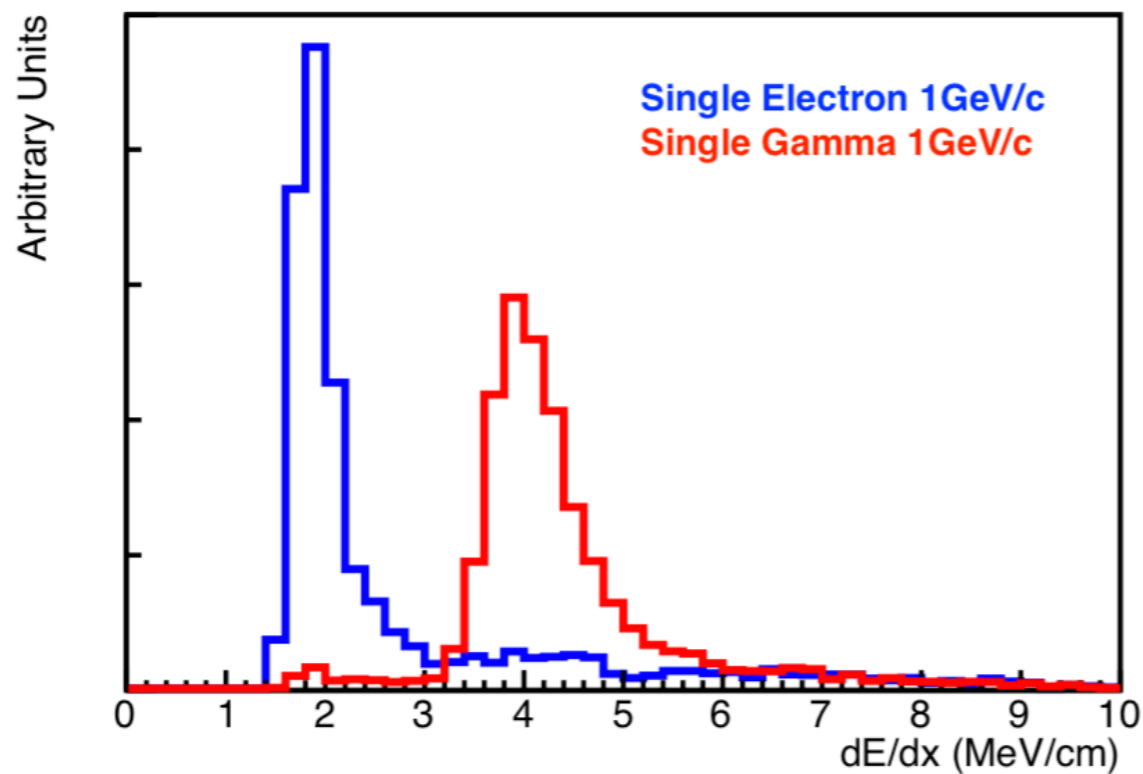
## SHOWER DE/DX

- ▶ Find difference between  $e^{+/-}$  and  $\gamma$  on single shower level

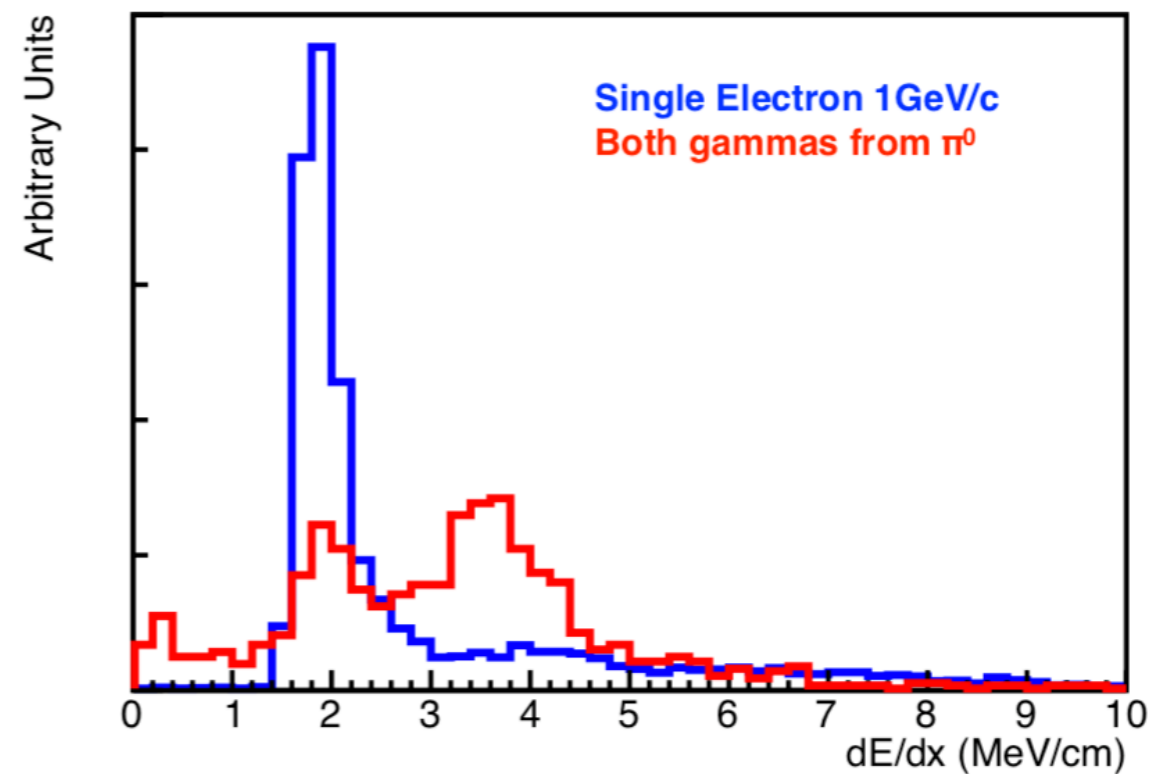


# SHOWER DE/DX

- ▶ Low energy photons form a problem especially



Gammas 1000 MeV/c  
Well developed shower

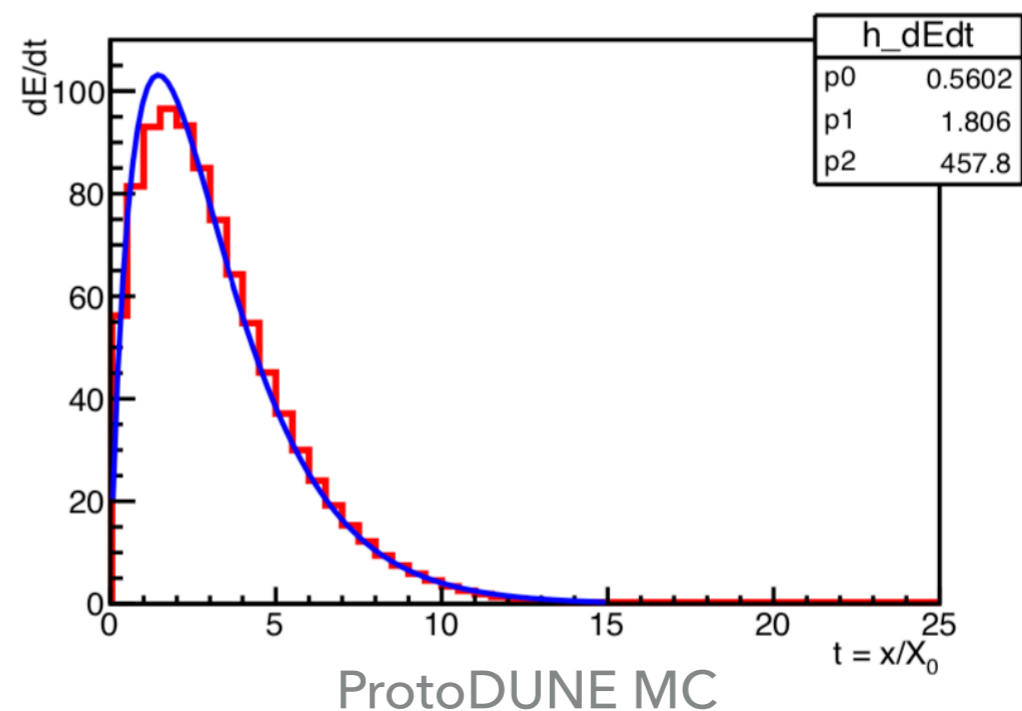
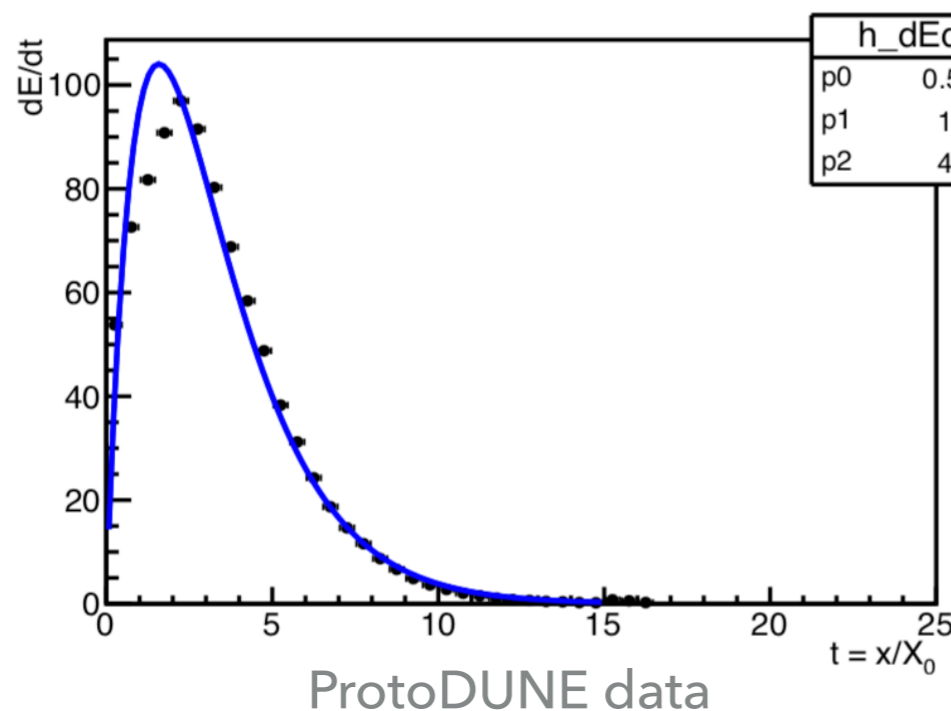


Gammas from  $\pi^0$  are below 500 MeV/c  
Asymmetry from  $\pi^0$  decay  
Isotropically distributed  
etc

# SHOWER DE/DX

- ▶ Alternative: compute entire longitudinal profile
- ▶ Are  $e^{+/-}$  and  $\gamma$  profiles different? Might be dead end

$$\frac{dE}{dt} = E_0 b \frac{(bt)^{a-1} e^{-bt}}{\Gamma(a)}$$





## CONCLUSIONS

- ▶ A couple of handles on  $\pi^0$  processes exist
- ▶ Pointing – need improved shower reconstruction
- ▶ Invariant mass – depends heavily on shower angle and energy reconstruction
- ▶ Shower  $dE/dx$  – needs to be investigated more, might be tricky or dead end