FCAL Efficiency Report

7/23/19

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Overview

- Goal:
  - Determine efficiency as function of E, θ, ϕ
  - Check to see that data and MC agree
  - Physics Analysis WG charge: 5% uncertainty
- Photon gun MC simulation
  - Develop intuition
  - Determine dominant sources of inefficiency
- $\omega \to 3\pi$ topology:
  - Data and MC comparisons

Overview, cont.

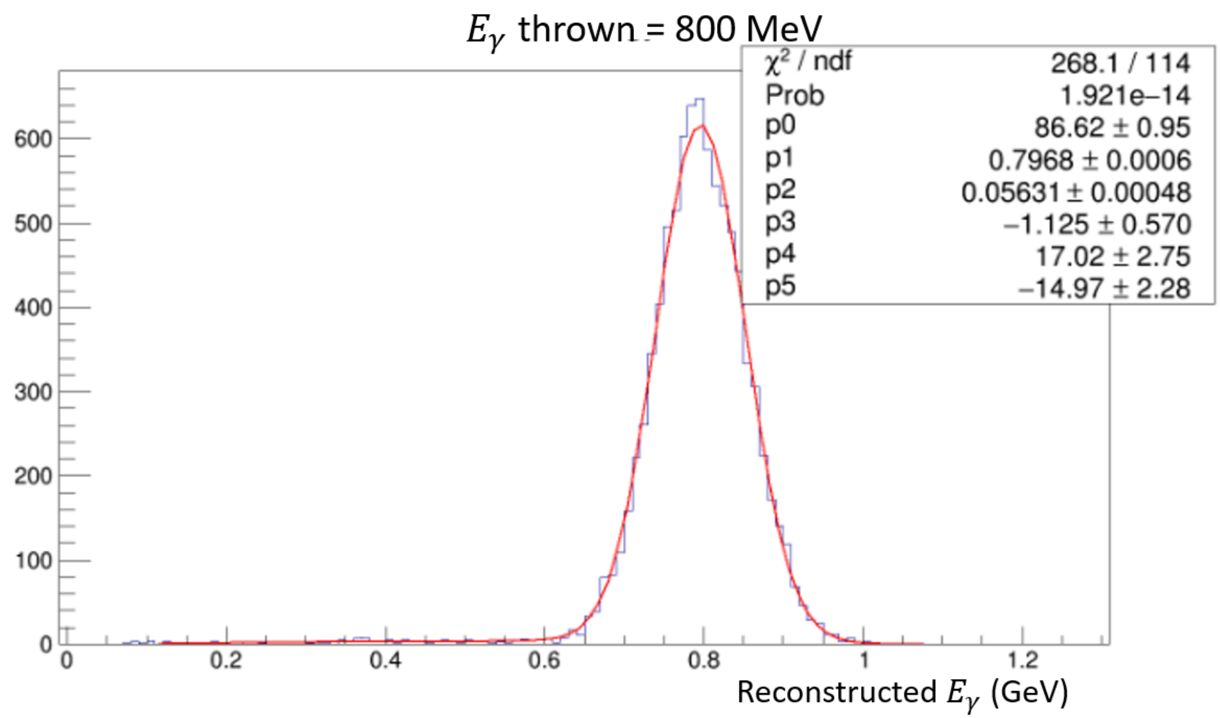
- This talk: mostly summarizing
  https://halldweb.jlab.org/doc-private/DocDB/ShowDocument?docid=4025
- Code repository:
  - https://github.com/JeffersonLab/hd_utilities
  - Contains code for both photon gun and $\omega \rightarrow 3\pi$ analyses

Photon Gun Studies

- Fire photon gun from target
- Fix θ, scan over different points of E_γ (or vice versa)
- What are the dominant sources of inefficiency at high photon energy?
- photon_gun_hists plugin (in hd_utilities)

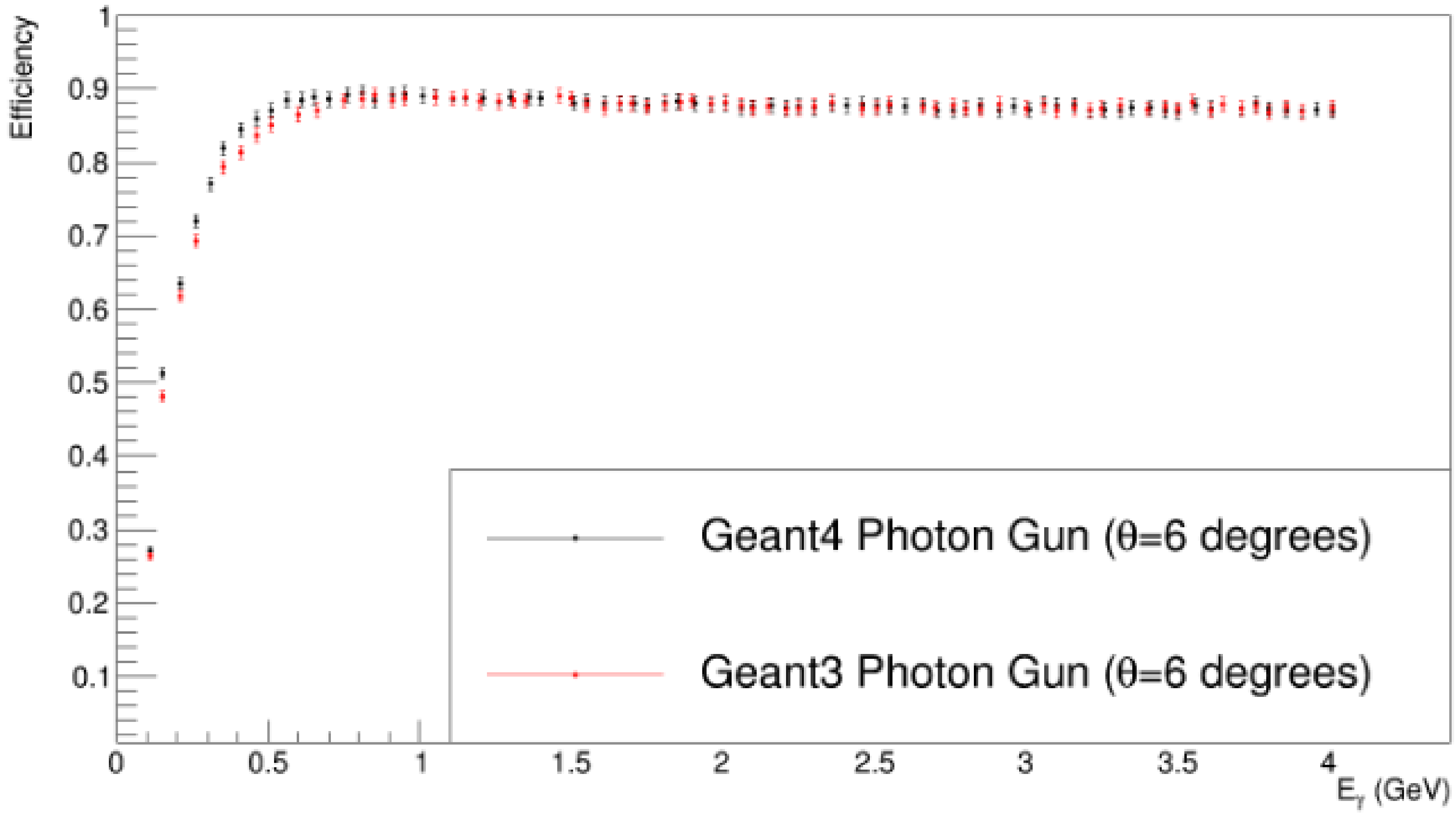
Efficiency Parameterization

- Gaussian + 2nd order polynomial
- Good photons: gaussian portion of E_γ
- $\epsilon = \frac{N_{gaus\,core}}{N_{gen}}$



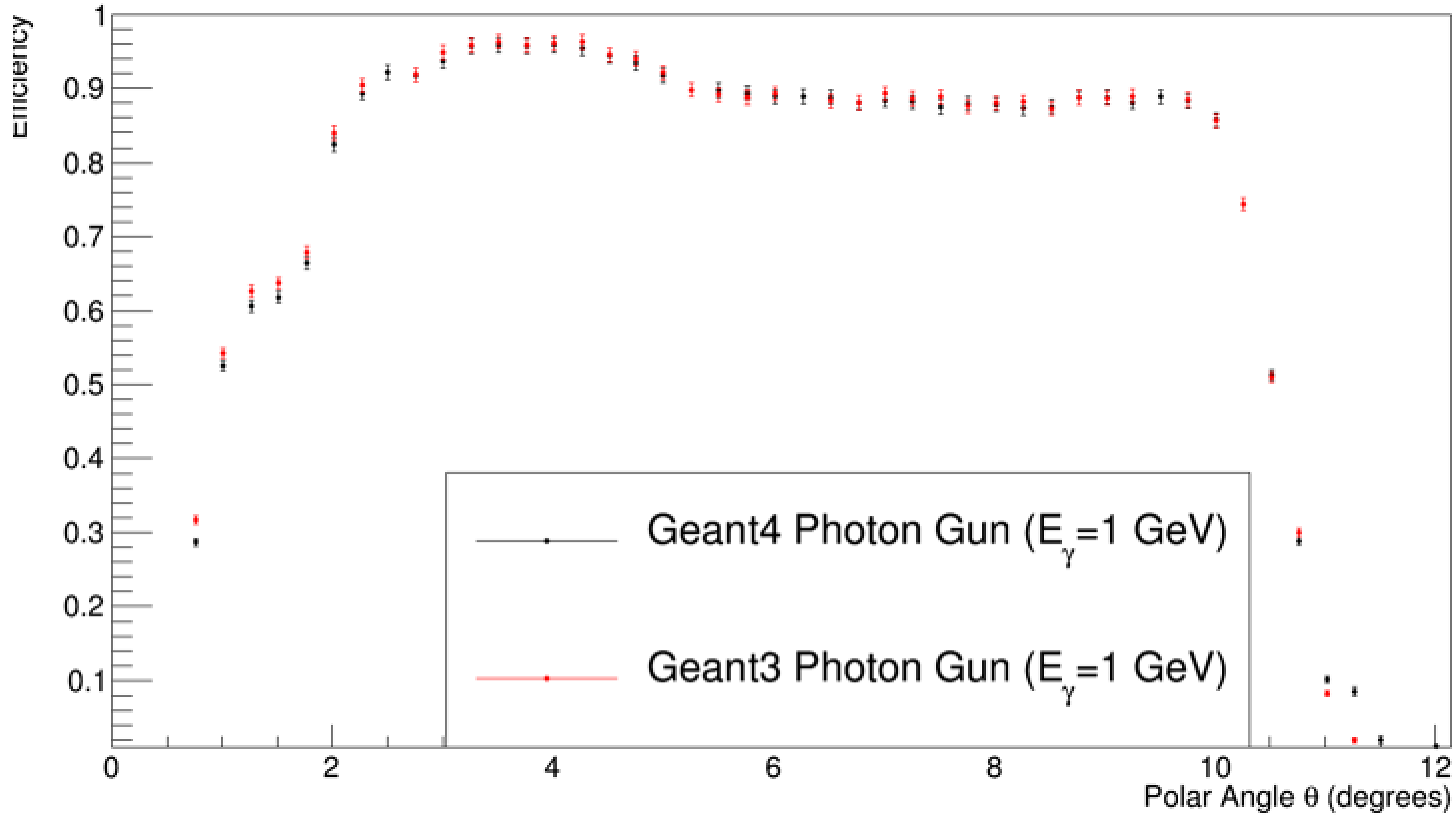
Efficiency: Energy Scan

- Fixed $\theta = 6°$, uniform in ϕ



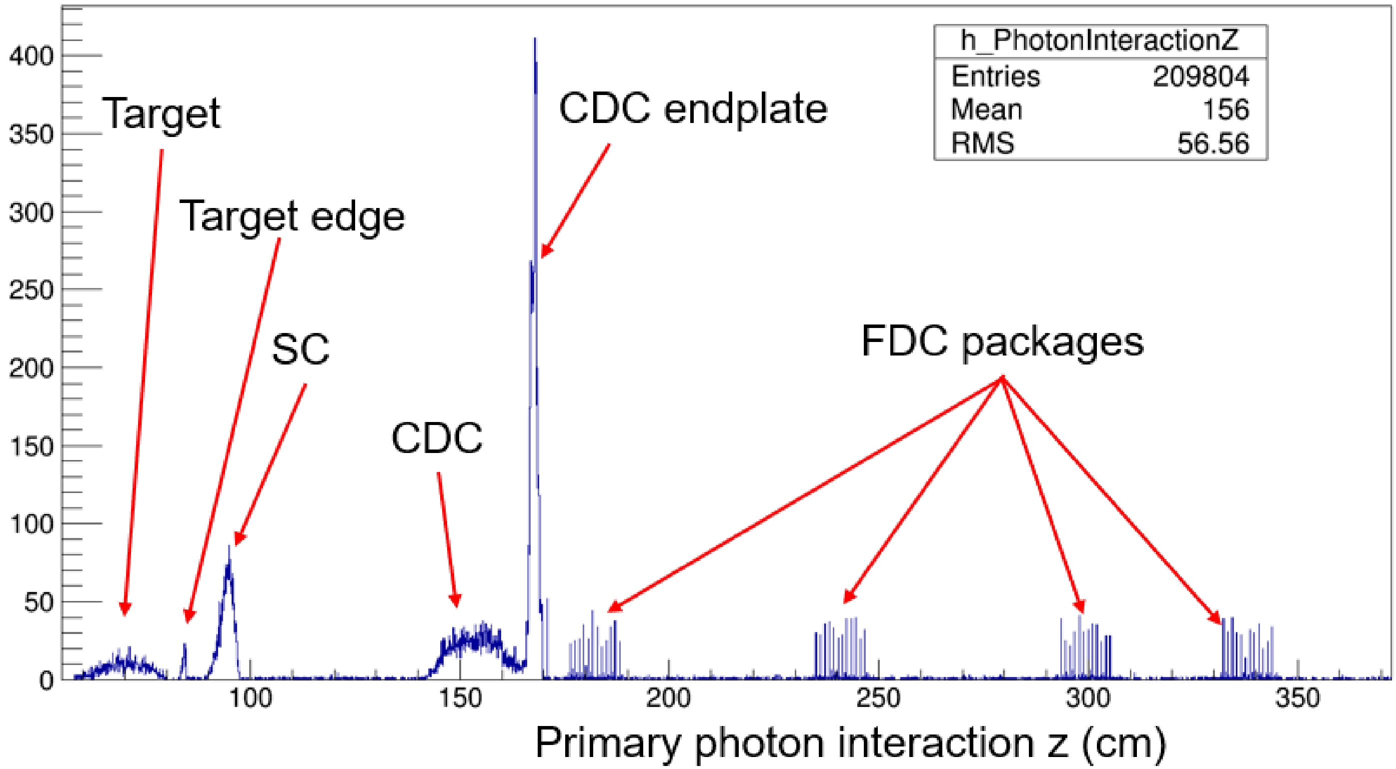
Efficiency: θ Scan

- Fixed $\theta = 6°$, uniform in ϕ



Where/how are photons lost?

- Check at $E_\gamma = 800\ MeV, \theta = 6°$



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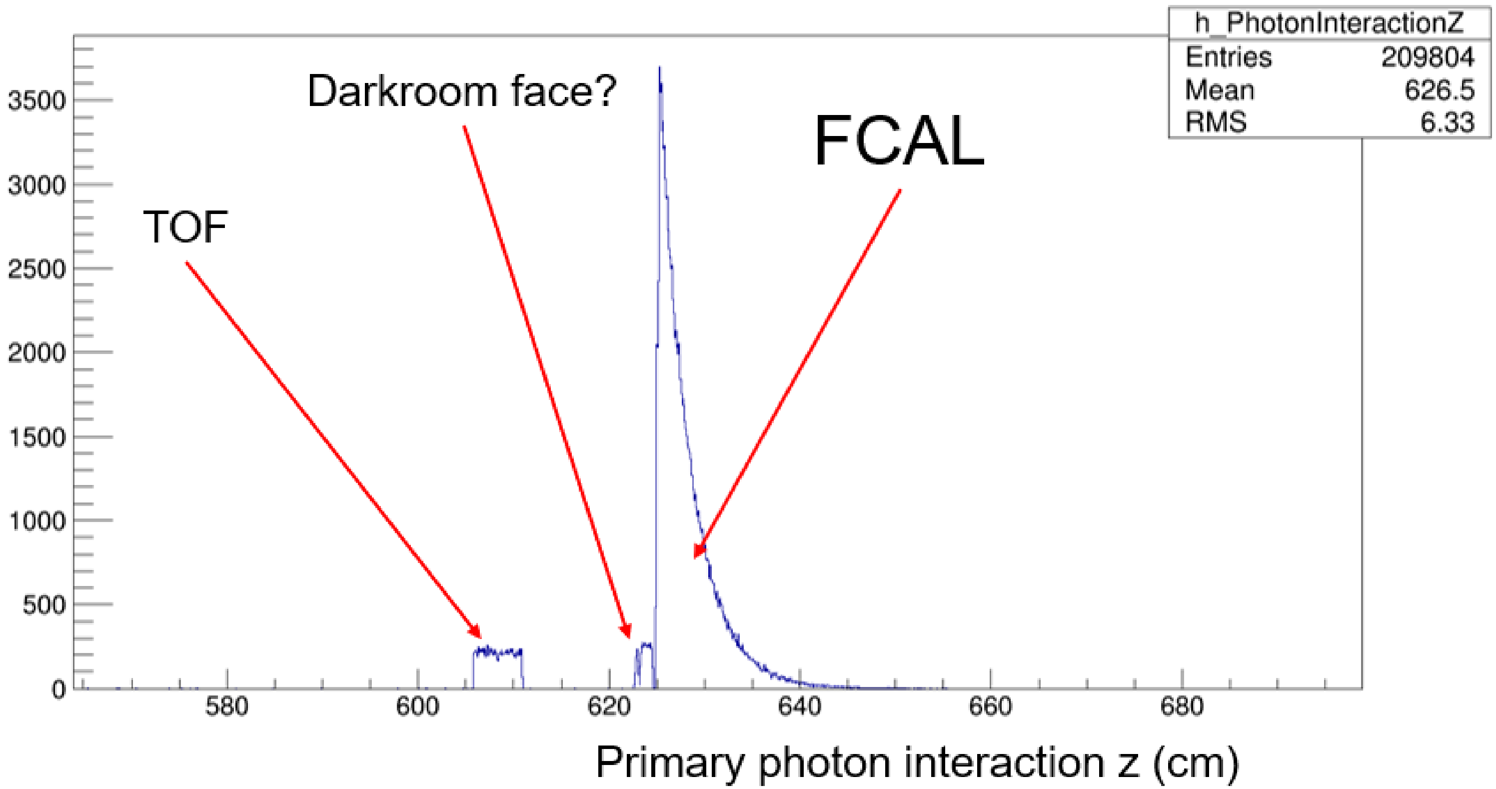
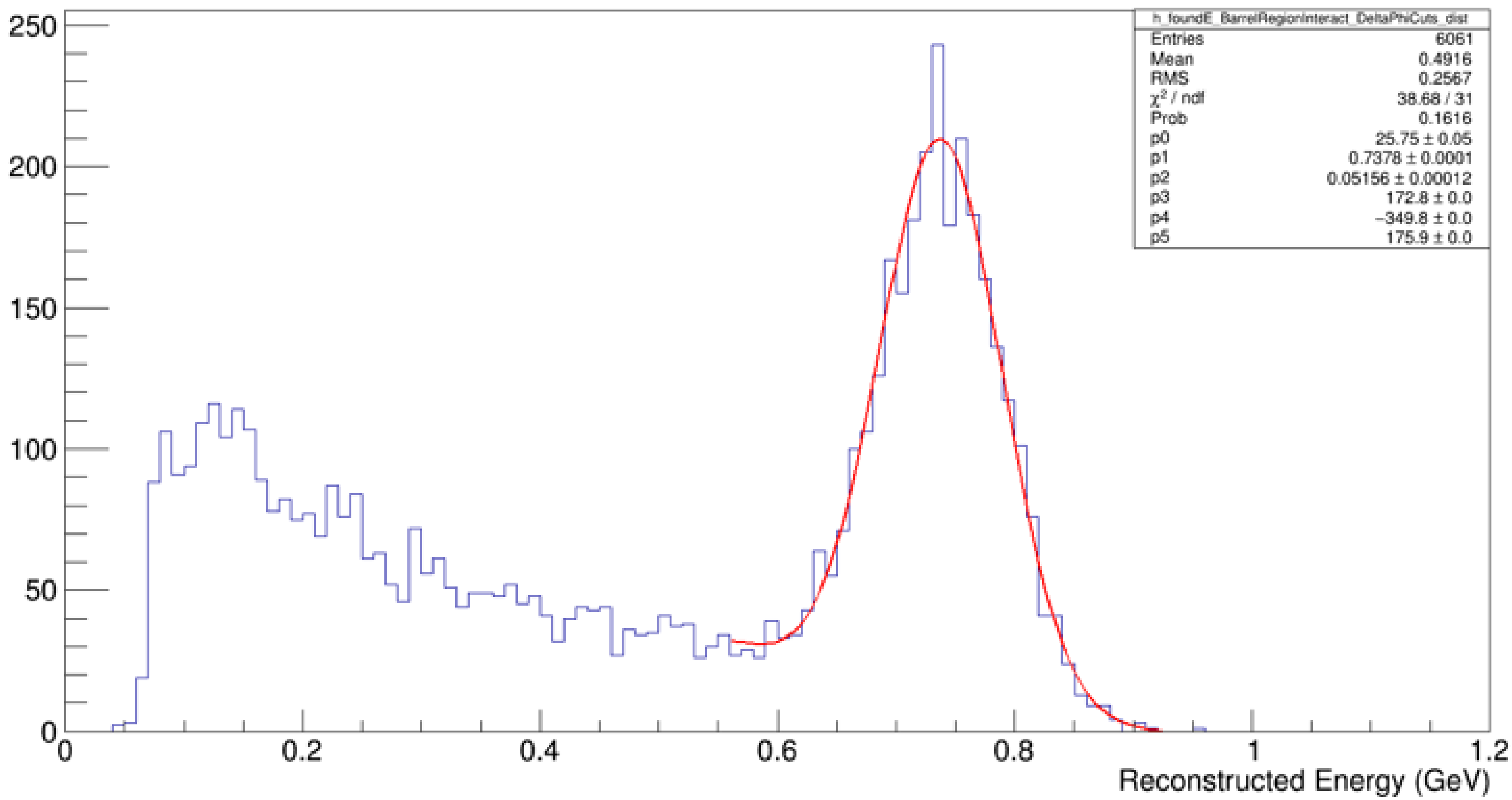


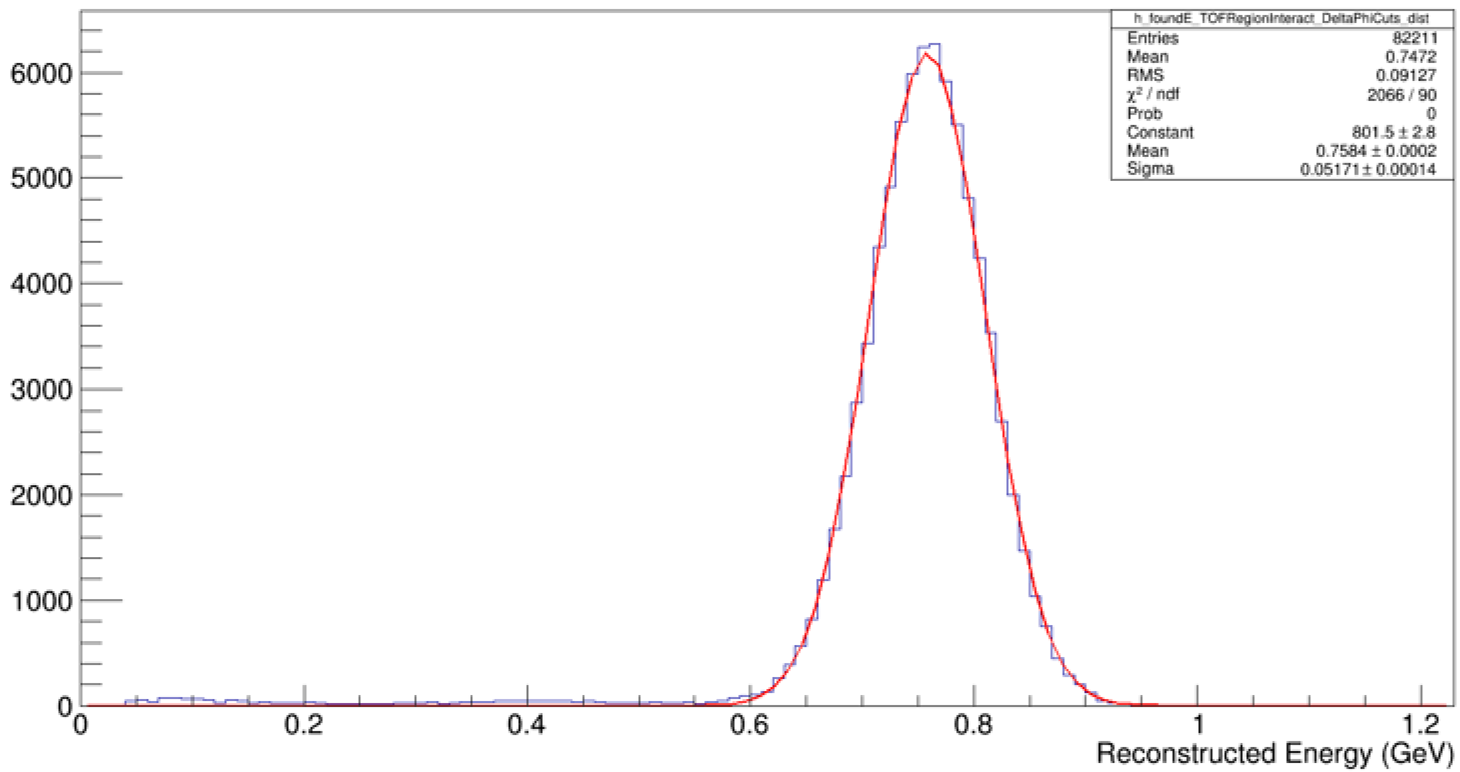
Upstream photon conversion

- Causes low E tail. Few acceptable showers

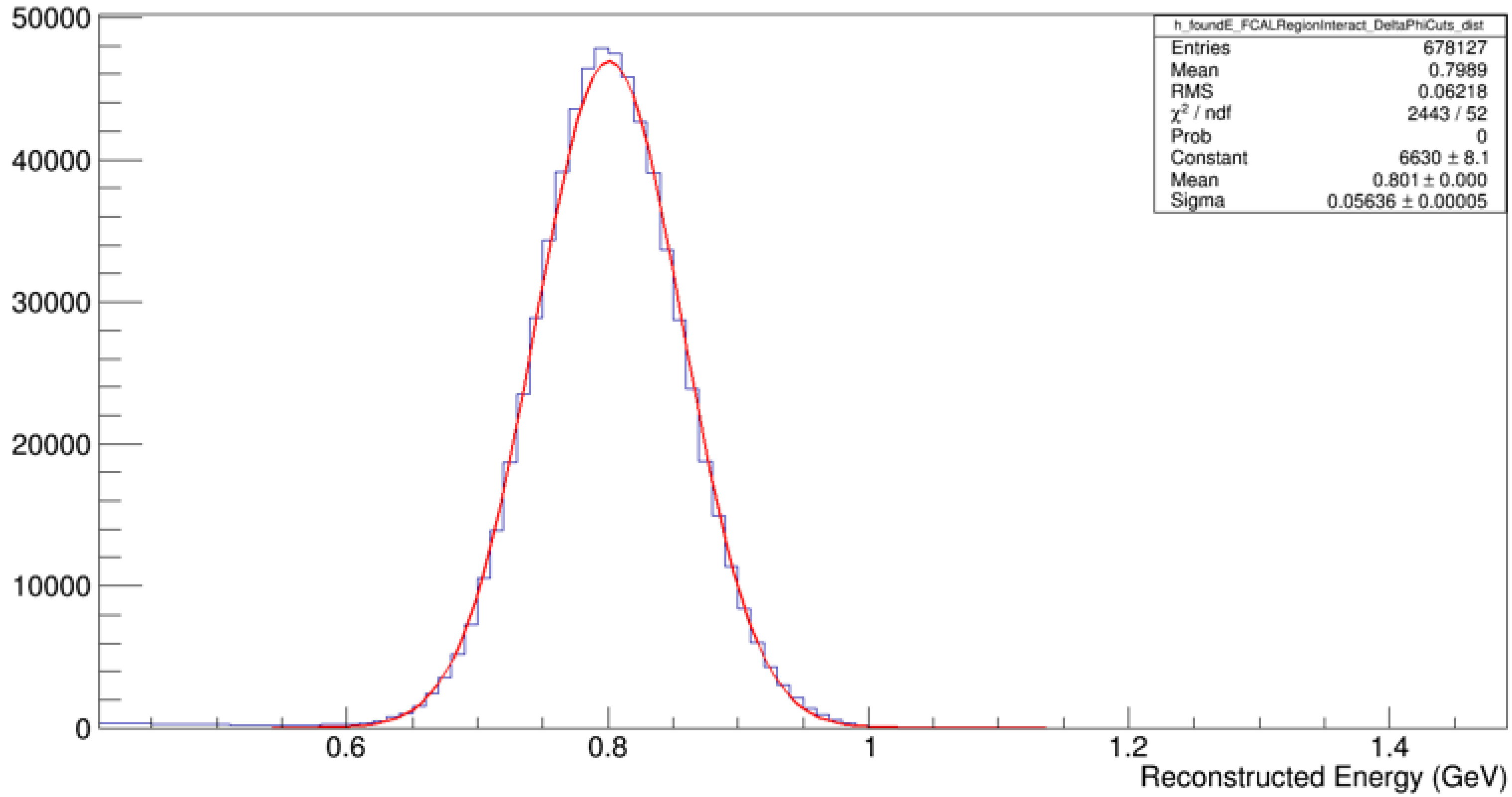


TOF conversions

- Energy shifted, but almost all are still in peaking portion



Photons surviving to FCAL

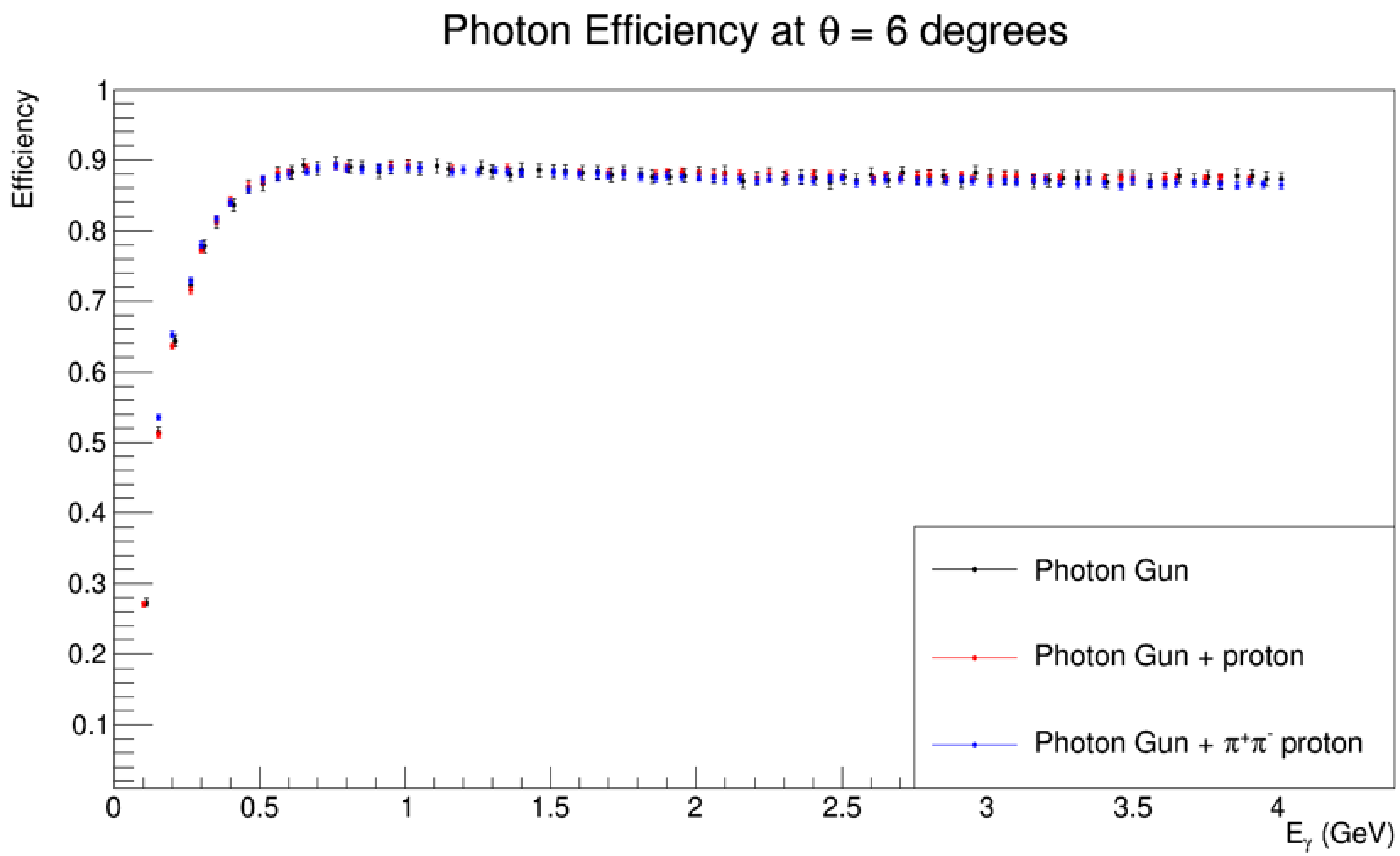


Embedded Samples

- Embed photon gun in simulated topologies:
  - $\gamma\, p \;\rightarrow \gamma\, p$
  - $\gamma\, p \;\rightarrow \gamma\, \pi^+ \pi^-\, p$

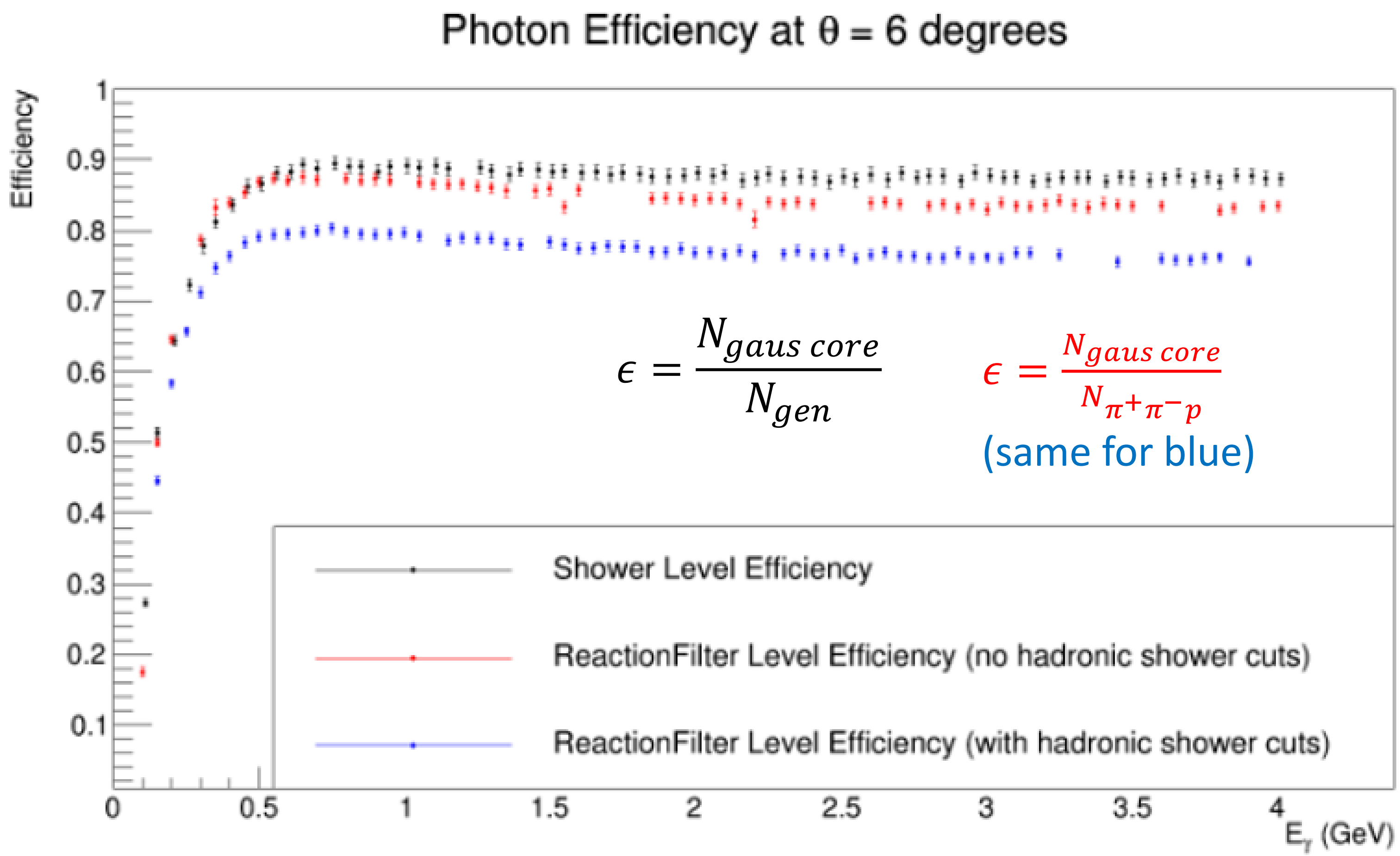
- π^+, π^-, and p kinematics from ω phase space
- Look for γ in tight region of $\Delta\theta$, $\Delta\phi$
- Allows for full physics reconstruction

Low Level Efficiency Comparison



$$\epsilon = \frac{N_{gaus\ core}}{N_{gen}}$$

Comparison: Full Event Reconstruction



- Blue is default in halld_recon.
- Real physic events may have less geometry overlap, less effect?

Take Away Messages

- Can calculate precise efficiencies with photon gun
- In efficient regions of detector + high E, conversion upstream of TOF/FCAL dominate inefficiency
- Relative measurement generally agrees with absolute efficiency
- Hadronic vetoing may also contribute to inefficiency, but magnitude uncertain

$\omega \rightarrow 3\pi$ Method

- Don't have a photon gun for actual data
- Next best thing: exclusive physics reactions
  - Use as a way to "tag" photons
- $\omega \rightarrow \pi^+\pi^-\pi^0$ offers good statistics, good purity, and reasonable (E,θ) coverage.
- Efficiency:

$$\epsilon = \frac{N_{\omega\rightarrow\pi^+\pi^-\gamma\gamma}}{N_{\omega\rightarrow\pi^+\pi^-\gamma(\gamma)}}$$

Comments on Event Selection

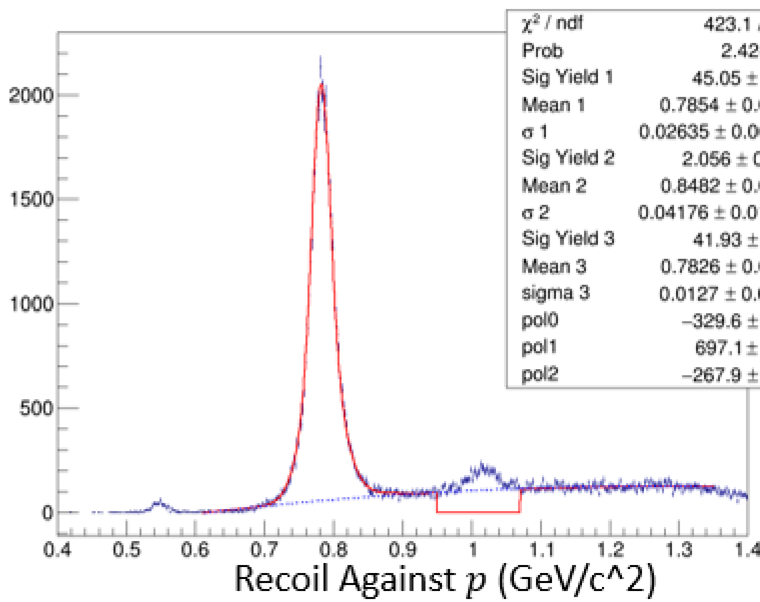
- Goal: make sample as pure as possible, without cutting into statistics too much

- 1C kinematic fit: missing mass = 0
- No more than two neutral candidates allowed
- Cut around missing π^0 mass (recoil against $\pi^+\pi^-p$)
- Spectator photon: $E_\gamma > 500$ MeV
  should remove trigger considerations

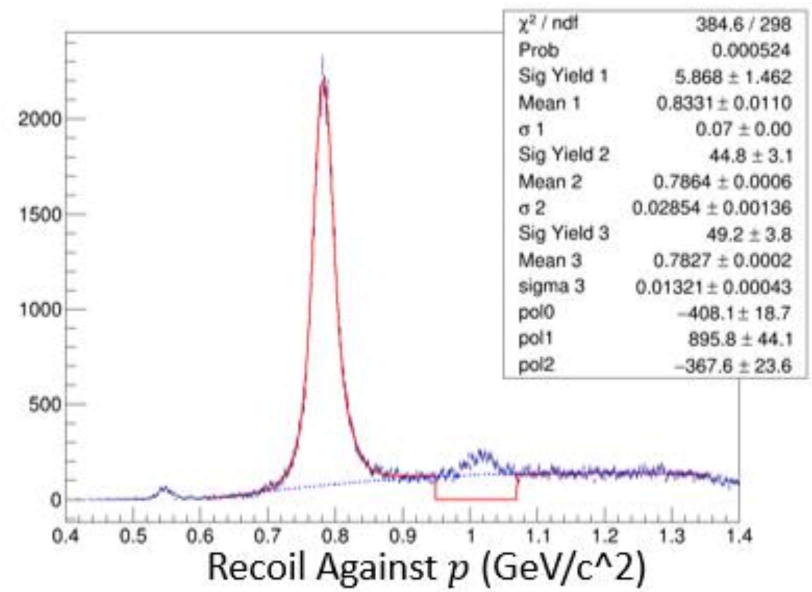
Parameterization #1

$$\epsilon = \frac{\omega_{num}}{\omega_{den}}$$

Numerator:
Exactly two neutrals
$m_{\gamma\gamma} < 0.25$ GeV



Denominator:
One or two neutrals

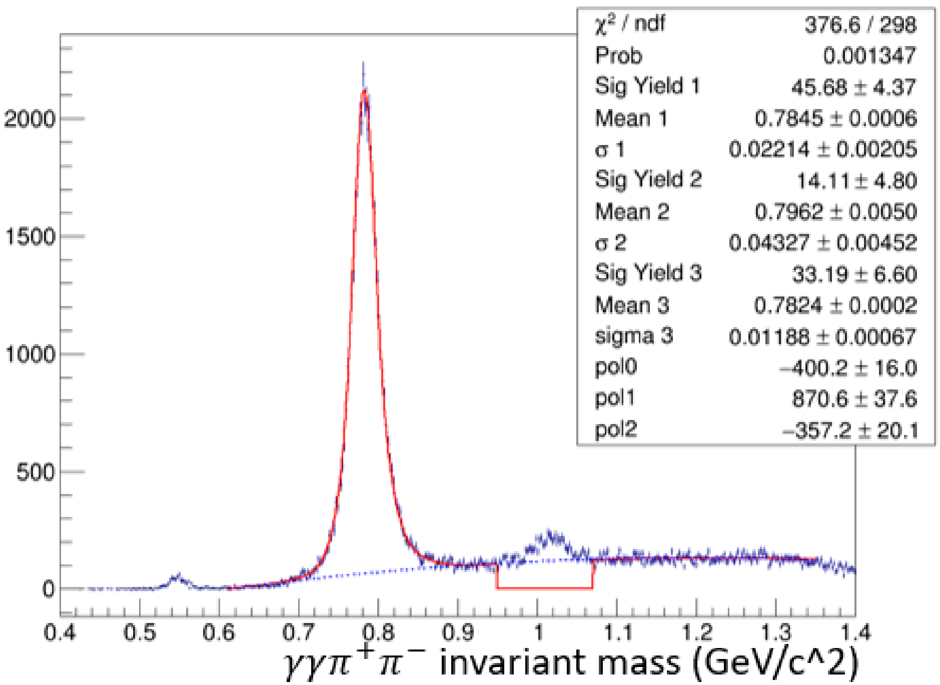


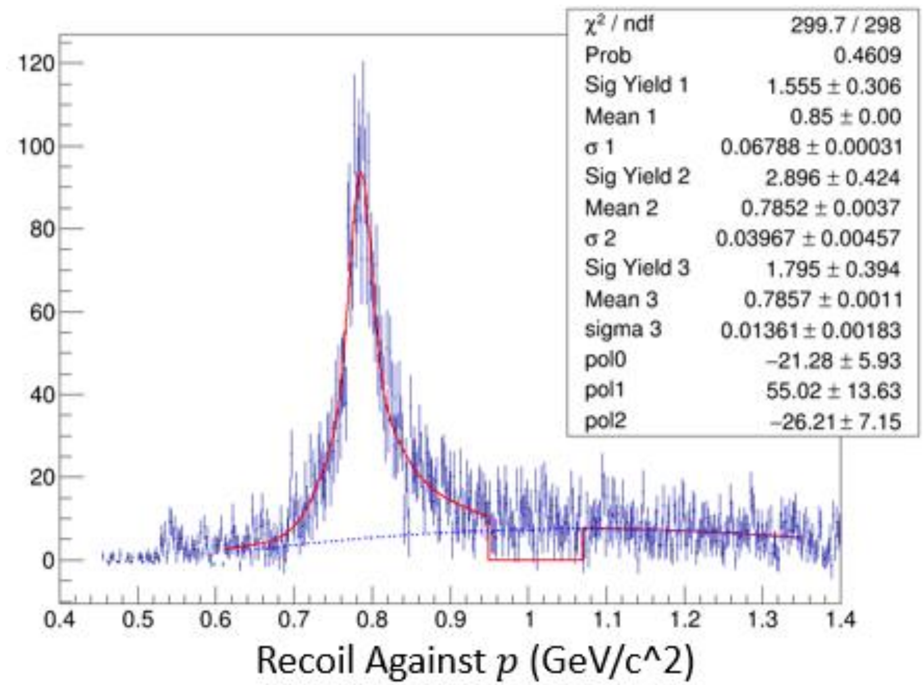
3gaus+2nd order poly bkg

Parameterization #2

$$\epsilon = \frac{\omega_{eff.}}{\omega_{eff.} + \omega_{ineff.}}$$

Efficient: Inefficient





3gaus + 2nd order poly bkg

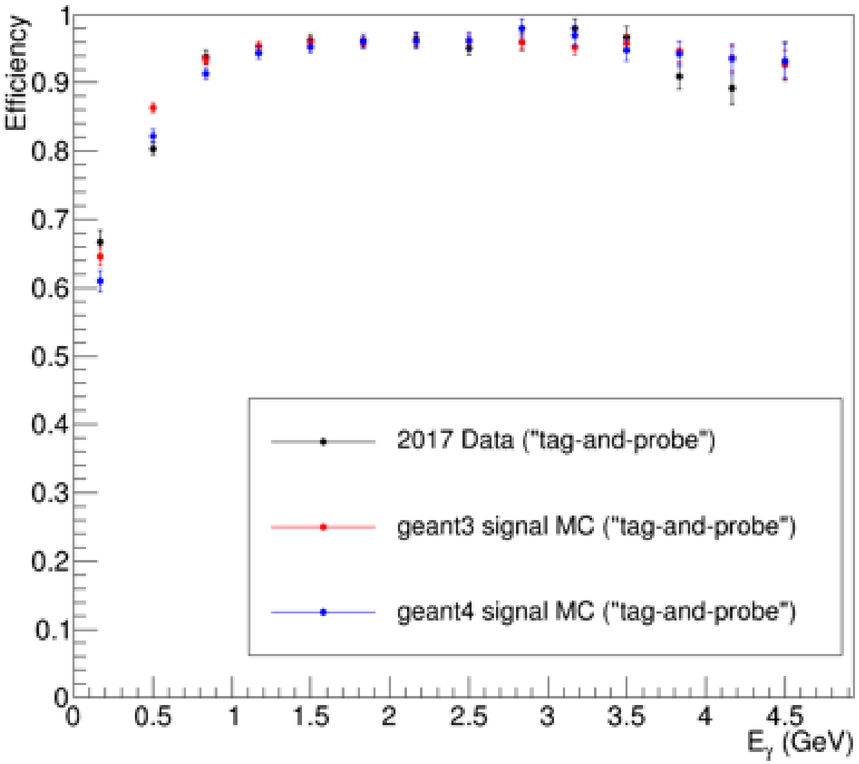
Pros/Cons

- Method 1:
  - Pro: uses same quantity (recoil mass) in both distributions
  - Con: $\gamma\gamma$ inv. mass cut might affect data/MC differently?
- Method 2:
  - Pro: inv. mass in numerator
  - Con: fitting two quantities. Recoil mass undercounts compared to invariant mass (hopefully less than 1%)

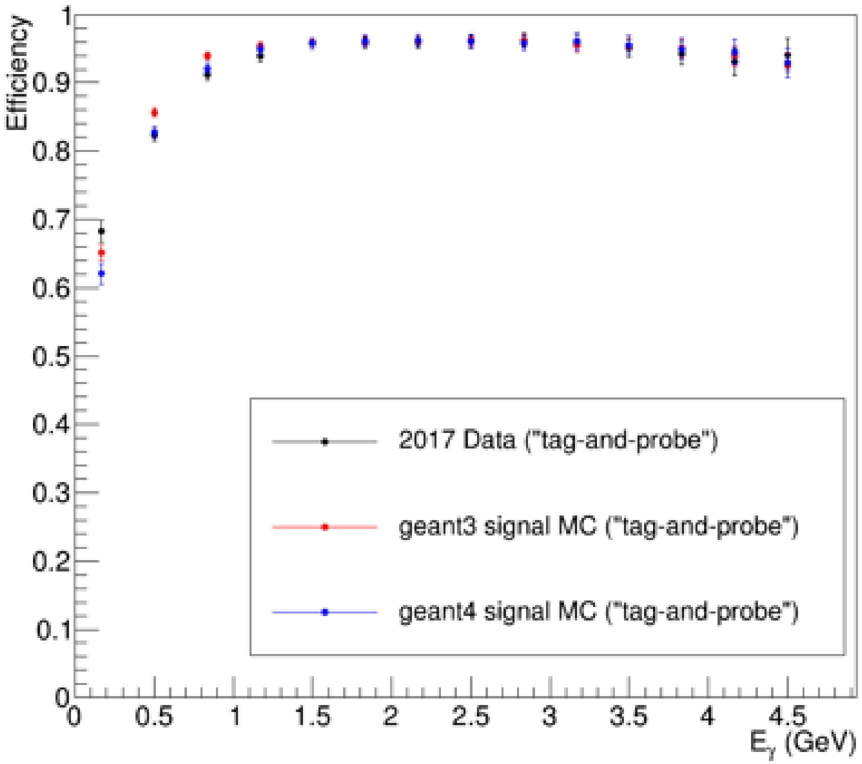
Efficiency over E_γ

Tagged photon: $3.5° < \theta_{(\gamma)} < 9.5°$

Method 1



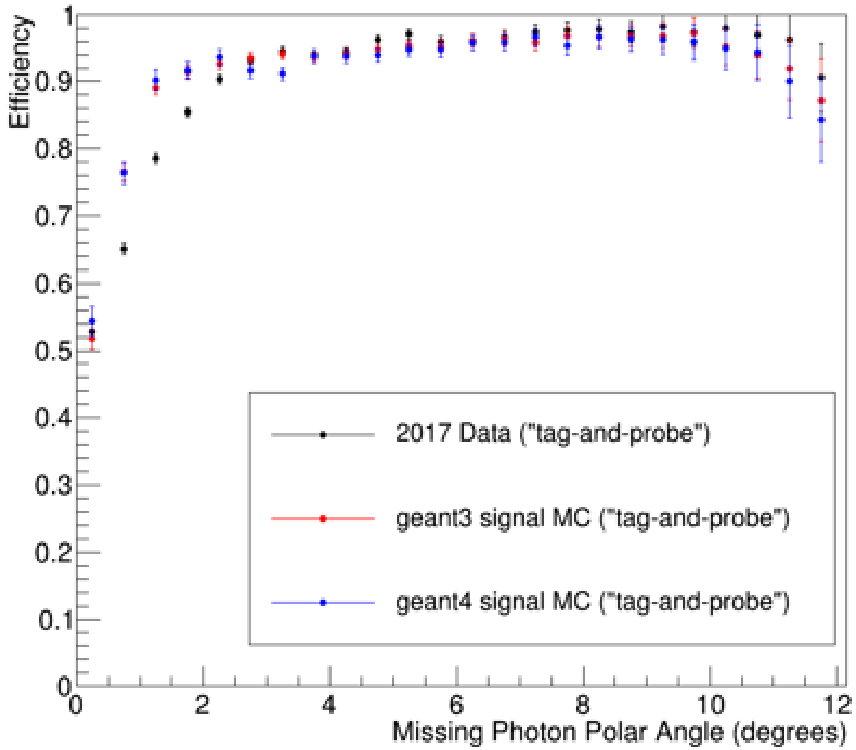
Method 2



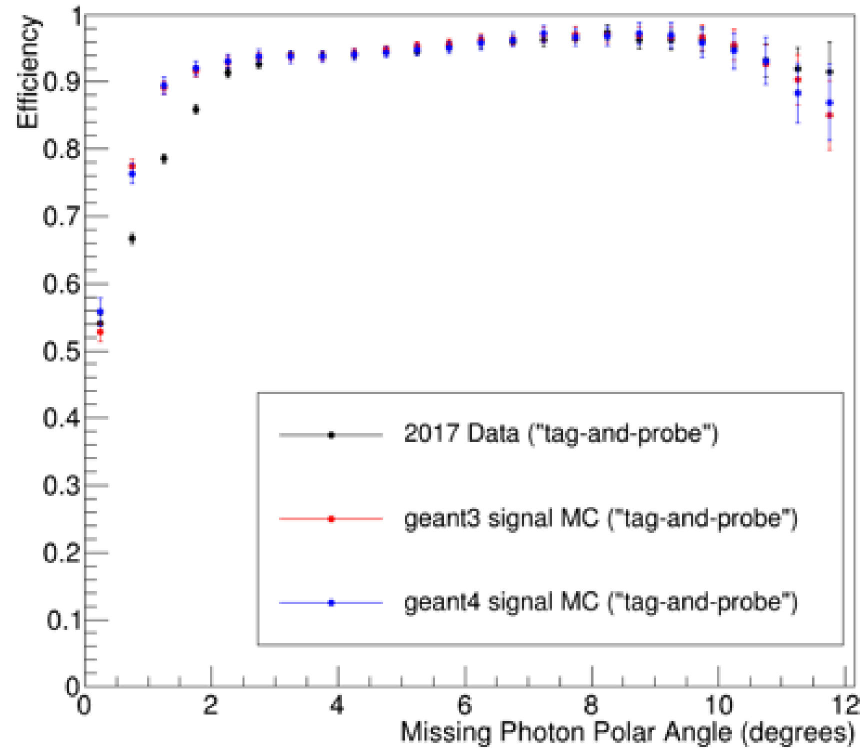
Efficiency over θ

Tagged photon: $E_{(\gamma)} > 800$ MeV

Method 1

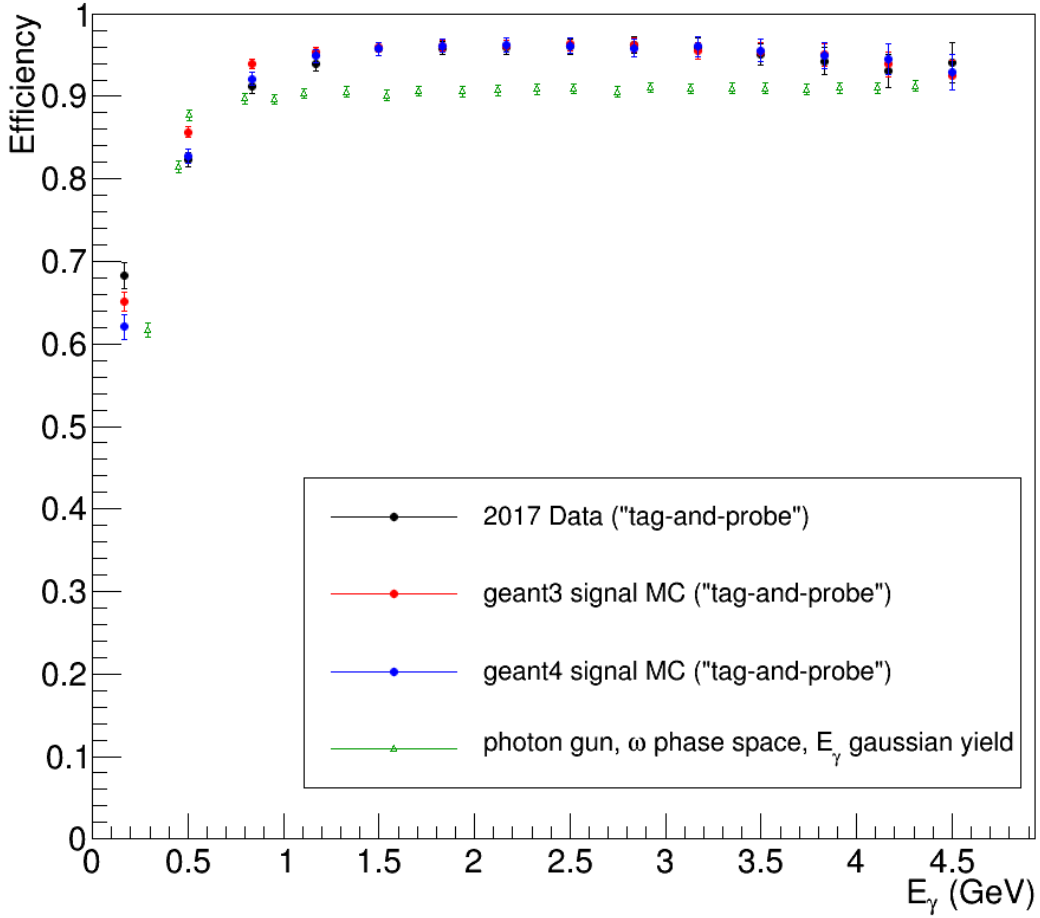


Method 2



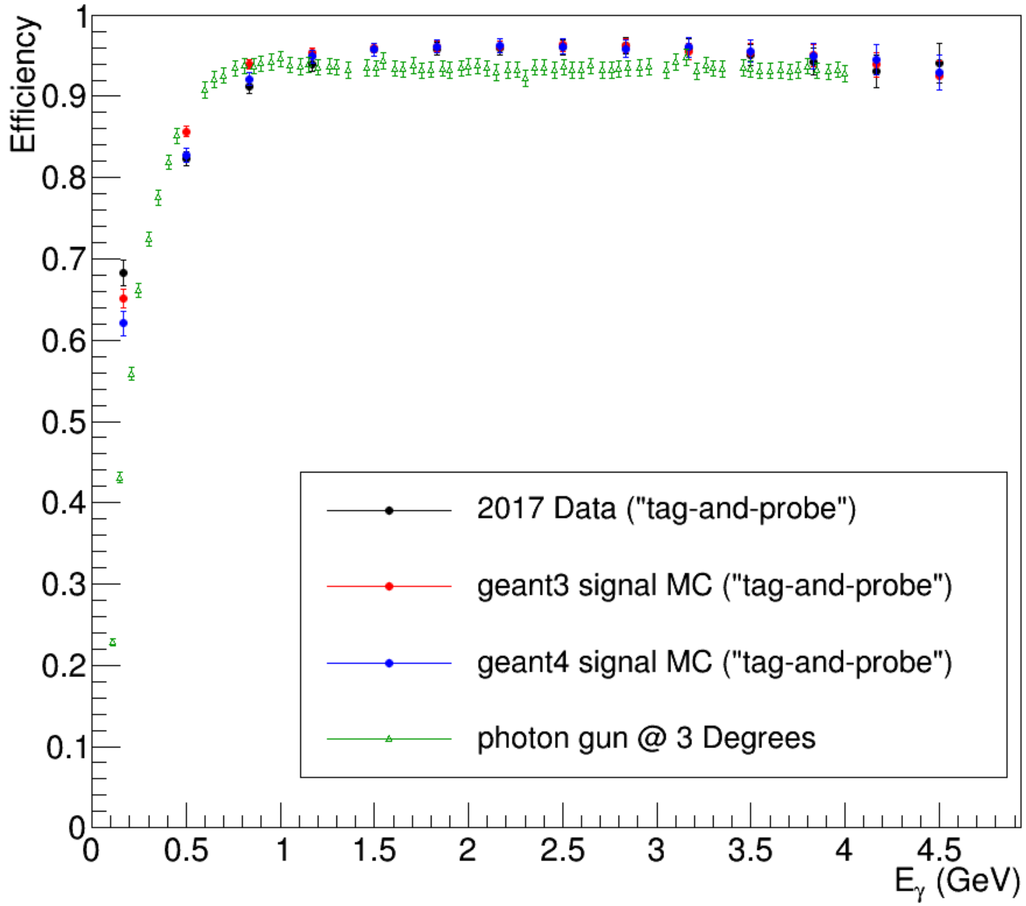
Does Efficiency Make Sense?

Compare to similar photon gun sample:
θ distributed over ω phase space with event selection



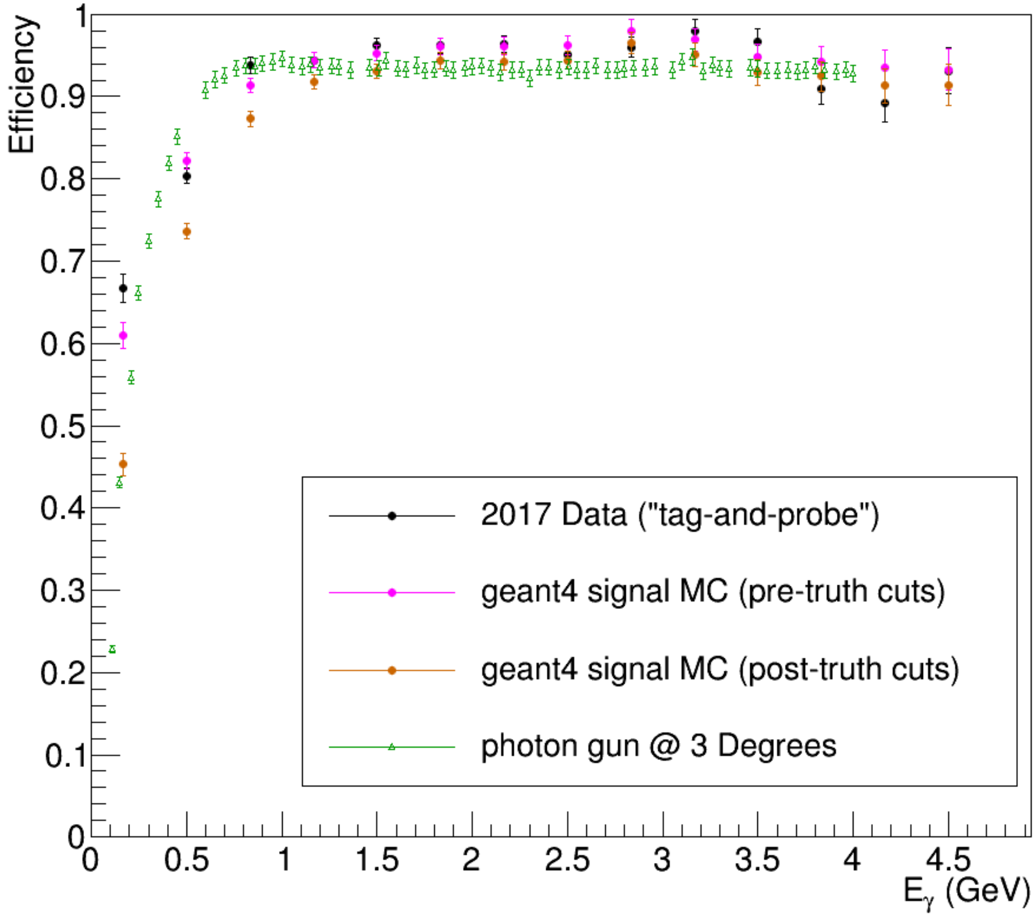
Does Efficiency Make Sense?

Fix $\theta = 3°$, roughly highest efficiency angle



Does Efficiency Make Sense?

Maybe accepting too many bad showers?
Add very tight geometry cuts to remove



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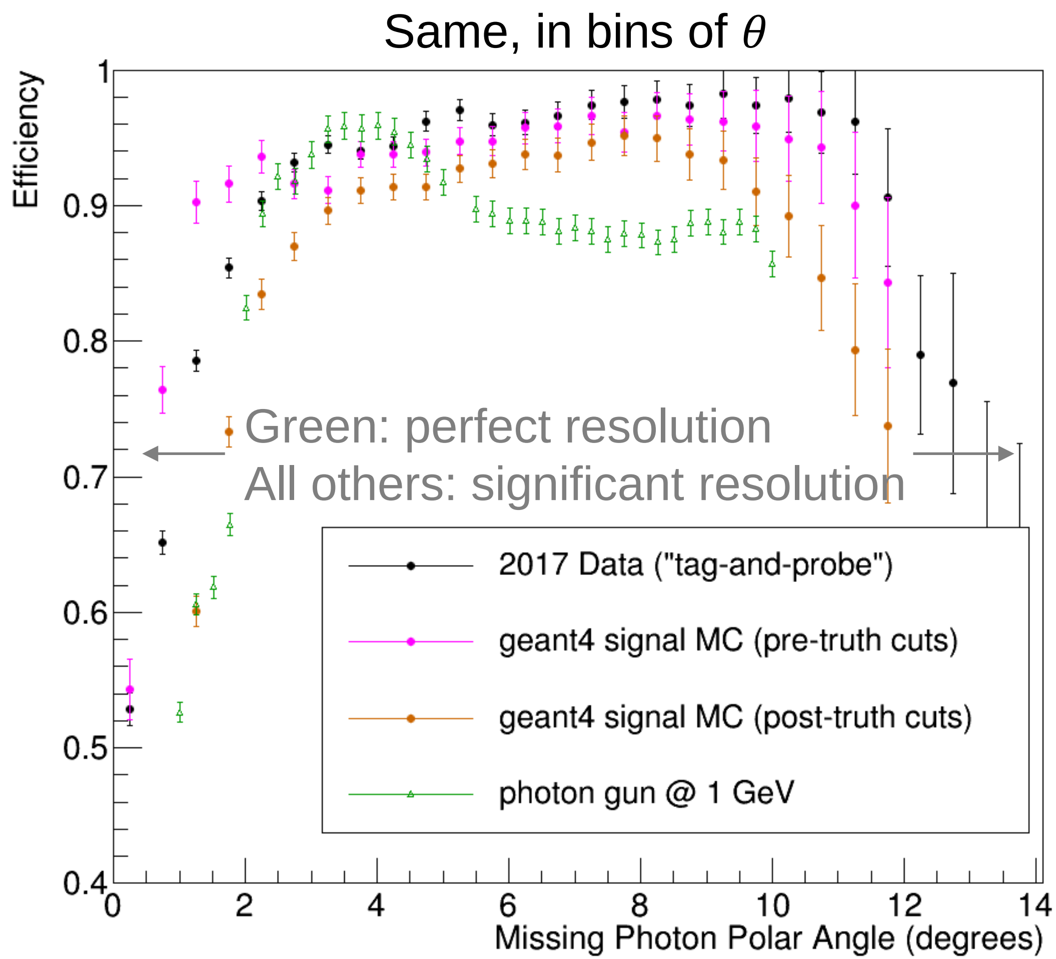
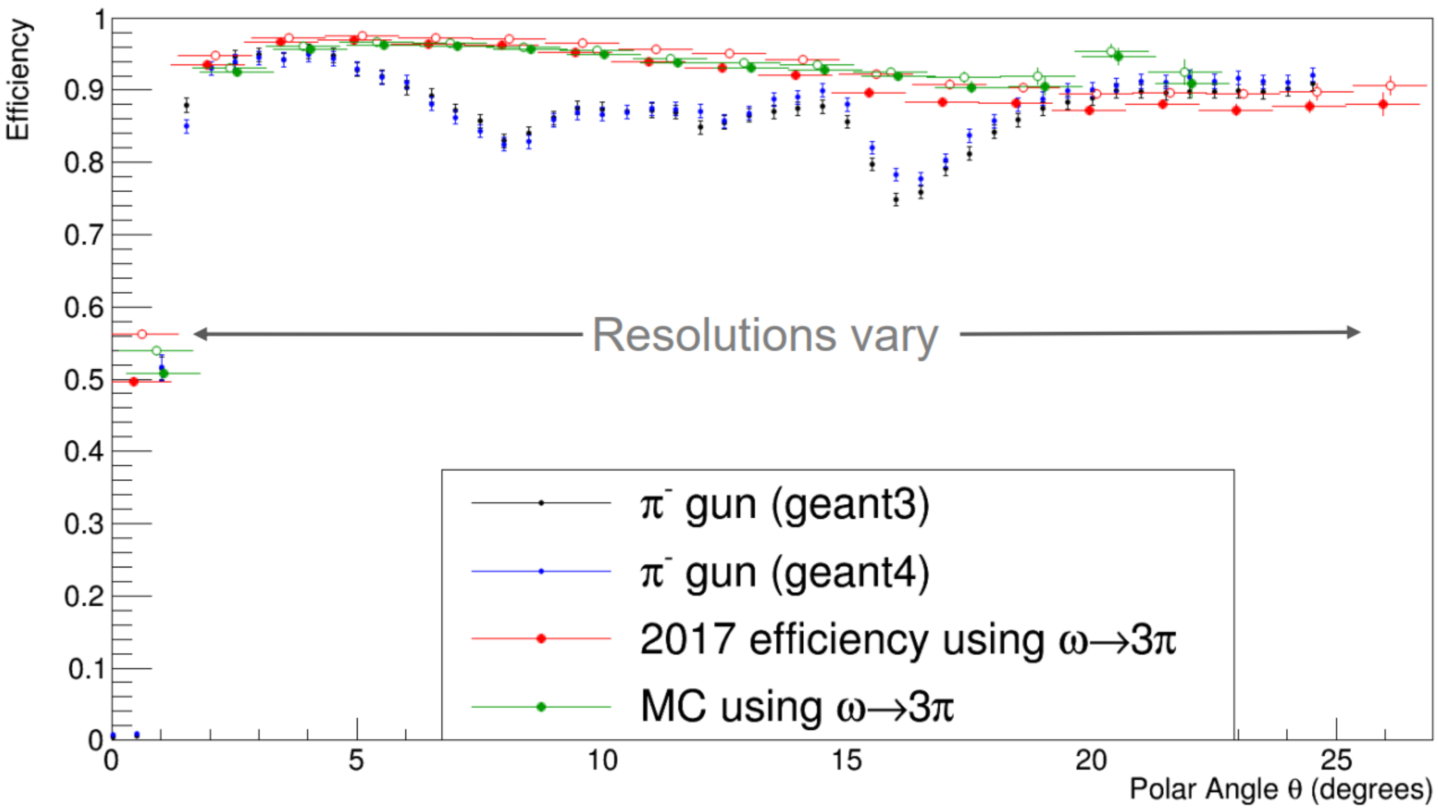


Does $\pi^{\pm}$ Efficiency Have Same Issue?

- I think so
- Reported to analysis & production WG



Summary

- Photon gun: efficiency driven by upstream conversions
  - Track vetoing: also plays a role. Not well quantified yet.
- Study with $\omega \rightarrow 3\pi$:
  - Reasonable data/MC agreement, except at low θ
  - Too high to agree with photon gun. Normalization issue?

Future Work

- Incorporate fiducial volume cuts
- Check pre-kinfit ω_{inv}
- Study efficiency over ϕ
- Apply to BCAL

Backup: Sources of Inefficiency

- Potential sources:
  - Upstream conversion, absorption, or scattering
  - Detector geometry
  - Energy turn-on
  - Clusterizing issues
  - E < 100 MeV rejection
  - Dead channels
  - Accidentally associated with charged particle
  - PID Δt cuts
  - Other ANALYSIS or PID library cuts?