



# Updates on Efficiency With $\omega \rightarrow 3\pi$

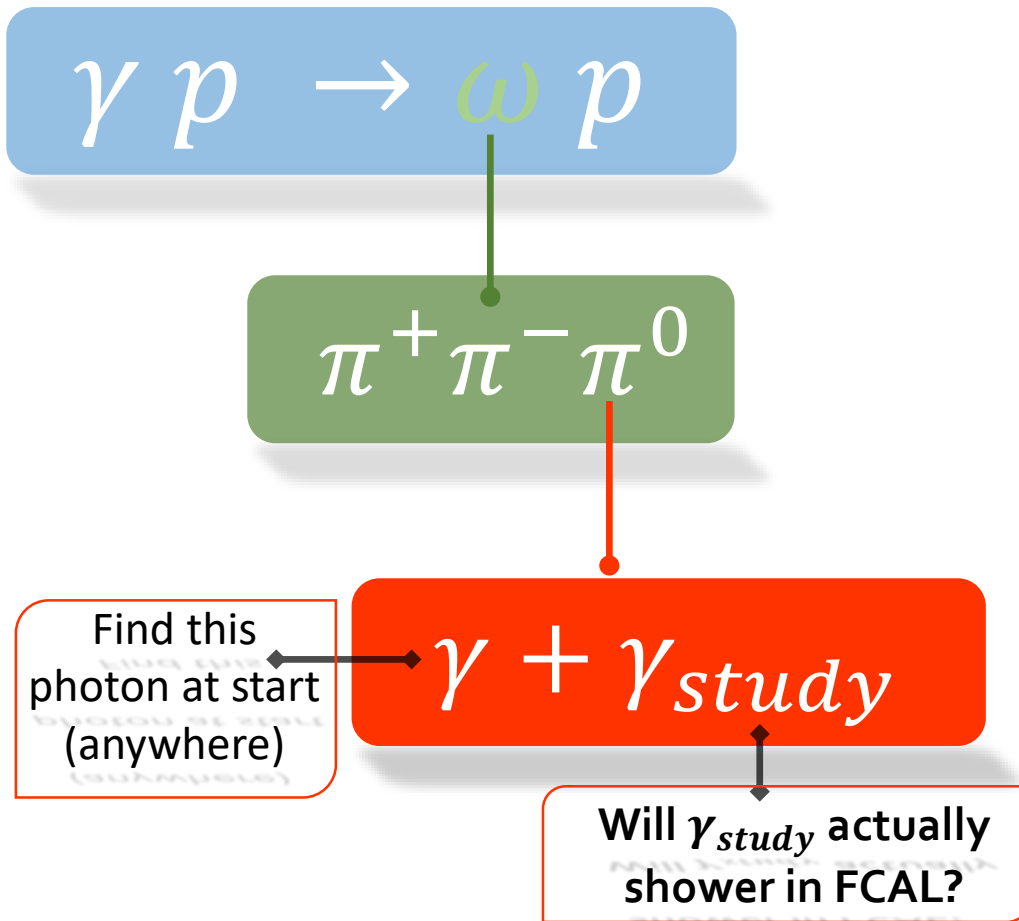
Now with a little bit of BCAL!



# Reminder

- Charge from Physics Analysis Plan 2018:
  - Determine photon efficiency (function of  $E, \theta, \phi$ ) to 5%
  - $\pi^0/\eta$  mass calibrations to 5 MeV
  - Agreement between data and MC better than 5% for photon efficiencies and resolution
  - March 2019 proposed deadline
- Want a data-driven way to compare data and MC efficiencies
  - $\omega \rightarrow \pi^+\pi^-\pi^0, \pi^0 \rightarrow (\gamma)\gamma$  most promising channel

# Efficiency with $\omega$ Mesons



## $\gamma_{study}$

- Missing 4-momentum points to FCAL
- Use fitted yields of  $\omega$  to determine if  $\gamma_{study}$  was found

### Method 1

Fit missing  $\omega$  spectrum before & after loose  $\gamma\gamma$  mass cut

### Method 2

- Fit invariant  $\omega$  mass, if candidate found
- Fit missing mass, no candidate found

Reconstruct:

- $\pi^+ \pi^+ p$  tracks,  $\gamma$  (either calorimeter)
- Extra candidates for  $\gamma_{study}$  in calorimeter of study

# Parameterizing Efficiency

## Method Pros and Cons

### Method 1

$$\epsilon = \frac{\omega_{miss} (2 \text{ good showers})}{\omega_{miss} (1 \text{ or } 2 \text{ showers})}$$

Pro:

- Fitting to same shape in num., den.

Con:

- Cut dependent: efficiency depends how we define “good” candidate

### Method 2

$$\epsilon = \frac{\omega_{inv}}{\omega_{inv} + \omega_{miss}(\text{no candidate for } \gamma_{study})}$$

$\omega_{inv}$ : yield in  $\pi^+\pi^-\gamma\gamma$ , any quality

$\omega_{miss}(1 \text{ shower only})$ : missing mass, no candidate found for  $\gamma_{study}$

Pro:

- No explicit cut dependency

Con:

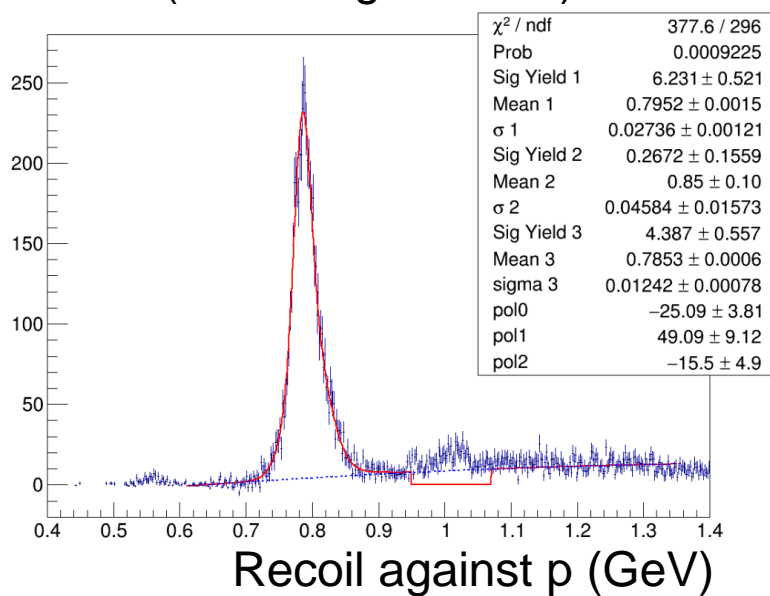
- Different shapes for  $\omega_{inv}$  and  $\omega_{rec}$ 
  - Will probably overestimate efficiency by about 1% (workfest study)



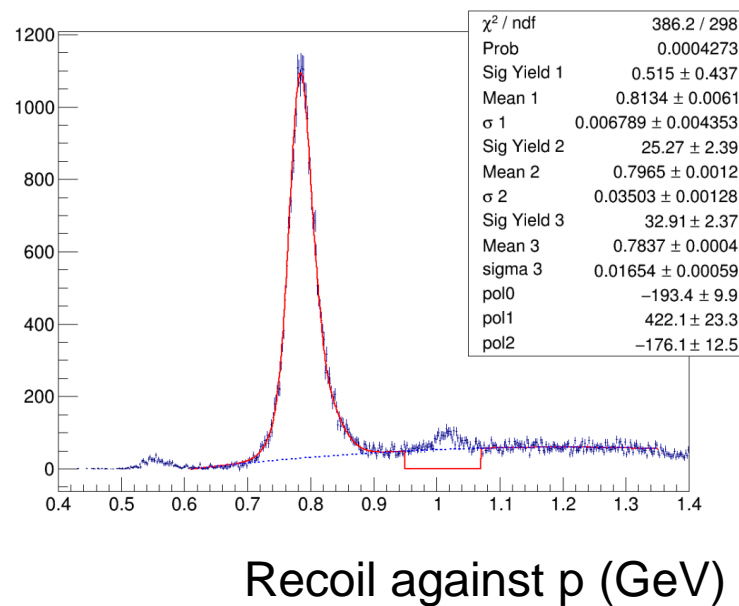
# Example Fits

- $\omega$  yields: 3 gaussian
- 2<sup>nd</sup> order polynomial background

Method 1 Numerator  
(a missing mass fit)



Method 2: Invariant Mass





# Data

- 2017 data, REST ver02:
  - All production runs
  - 8.2-8.8 beam E
  - No extra tracks
  - 1 C kinematic fit
  - $0.1 < \text{missing } \pi^0 \text{ mass} < 0.17 \text{ GeV}$
- ReactionFilter channel requested, waiting on next analysis launch for REST ver03
- (nothing changed here since collaboration meeting)



# MC Samples

- gen\_omega\_3pi generator:
  - Reflects previous measurements of  $\omega$  SDMEs
- Geant3 and geant4
  - ~40 M events generated for each
- Made on OSG in about three days! (thanks Thomas)
- Random triggers
- Up-to-date software and cddb
- Beam E generated: 8 – 9 GeV
- New since collaboration meeting



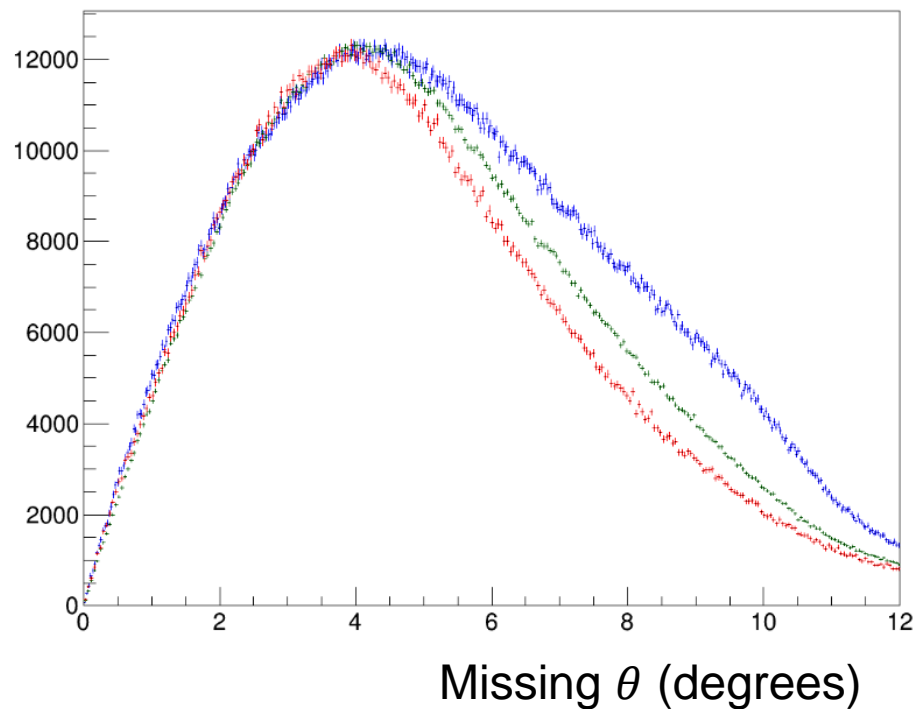
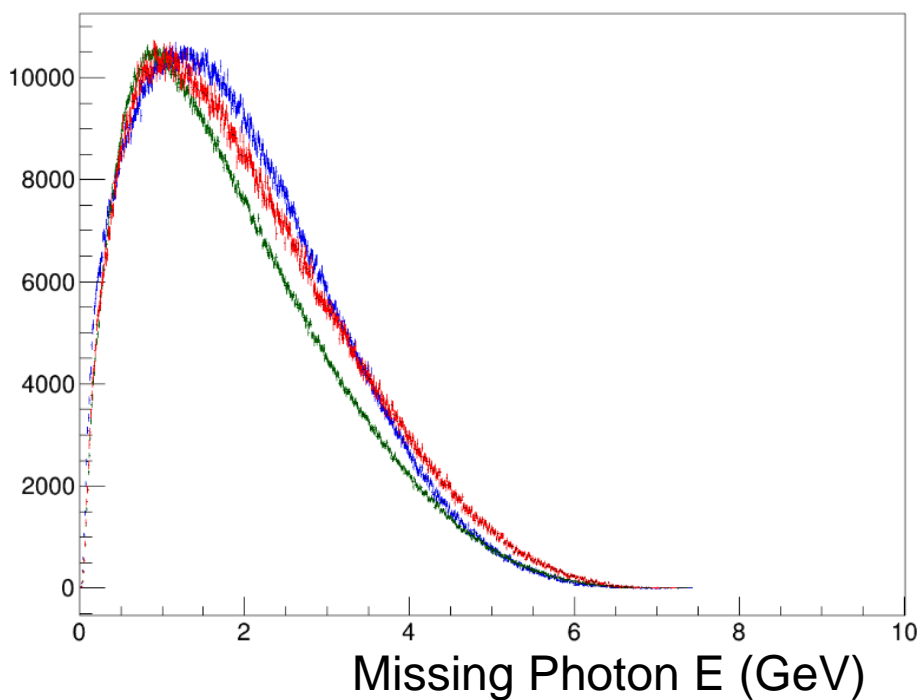
# Missing Photon Reconstructed

- In mass range of  $\omega$

Blue: 2017 data

Green: geant3 MC

Red: geant4 MC



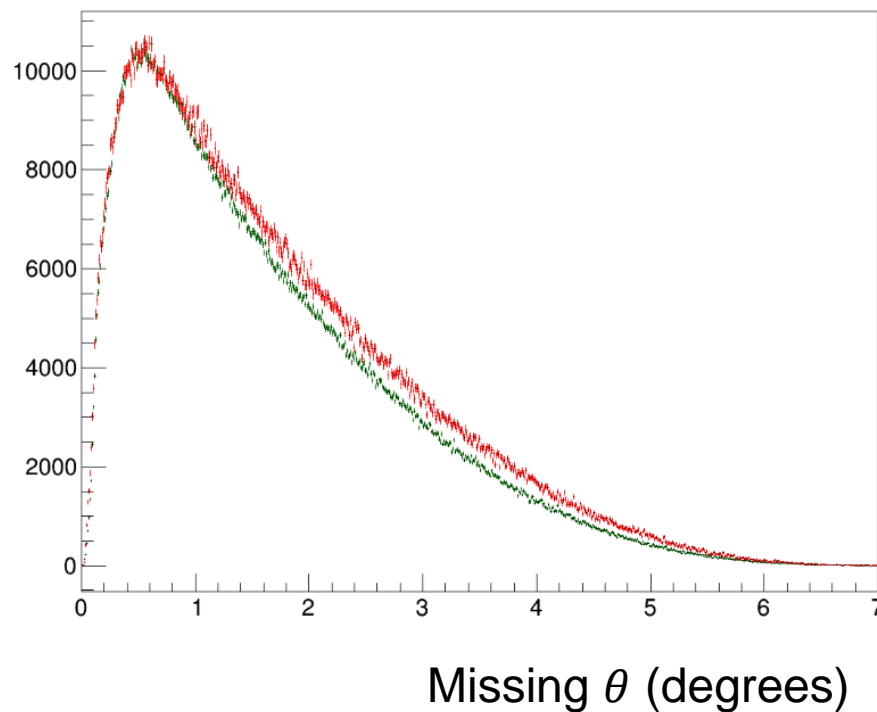
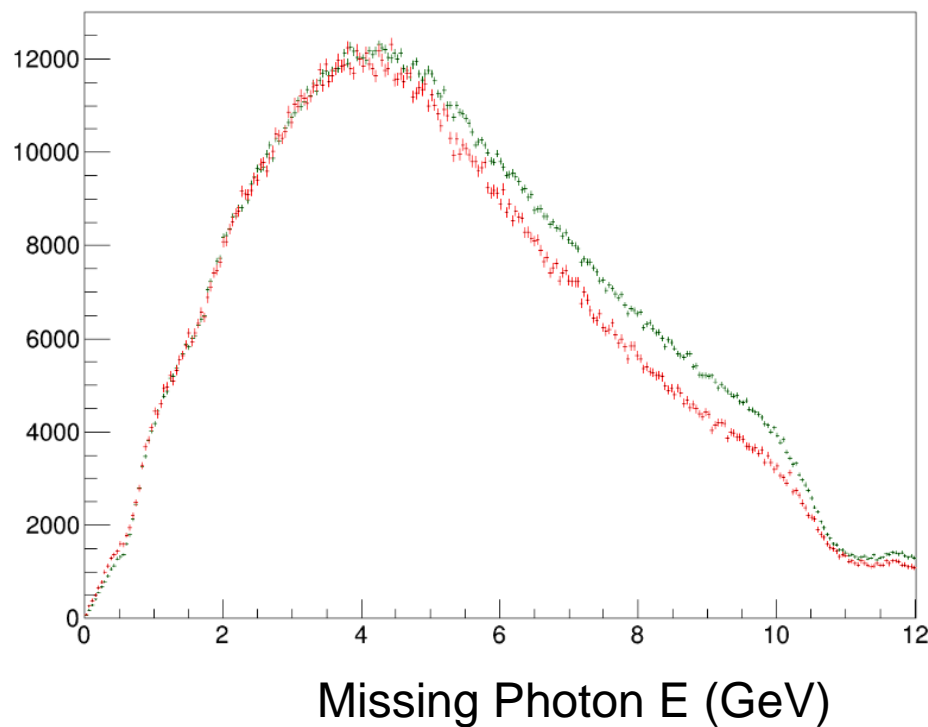




# Missing Photon Thrown

- In mass range of  $\omega$

Green: geant3 MC  
Red: geant4 MC



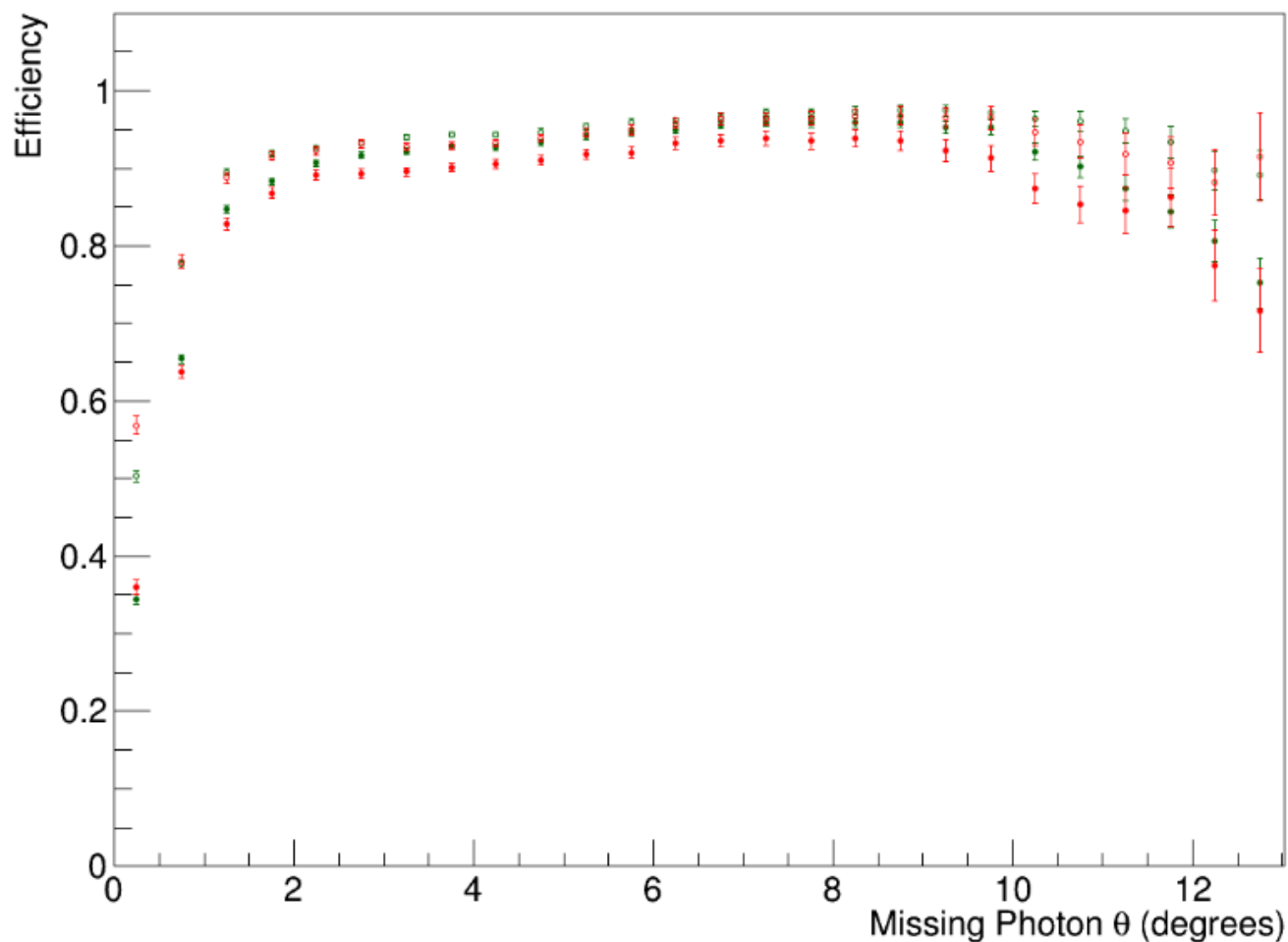


# Geant3 vs Geant4: $\theta$ Efficiency

Green: geant3 MC

Red: geant4 MC

- Filled Circle: method 1
- Open Circle: method 2



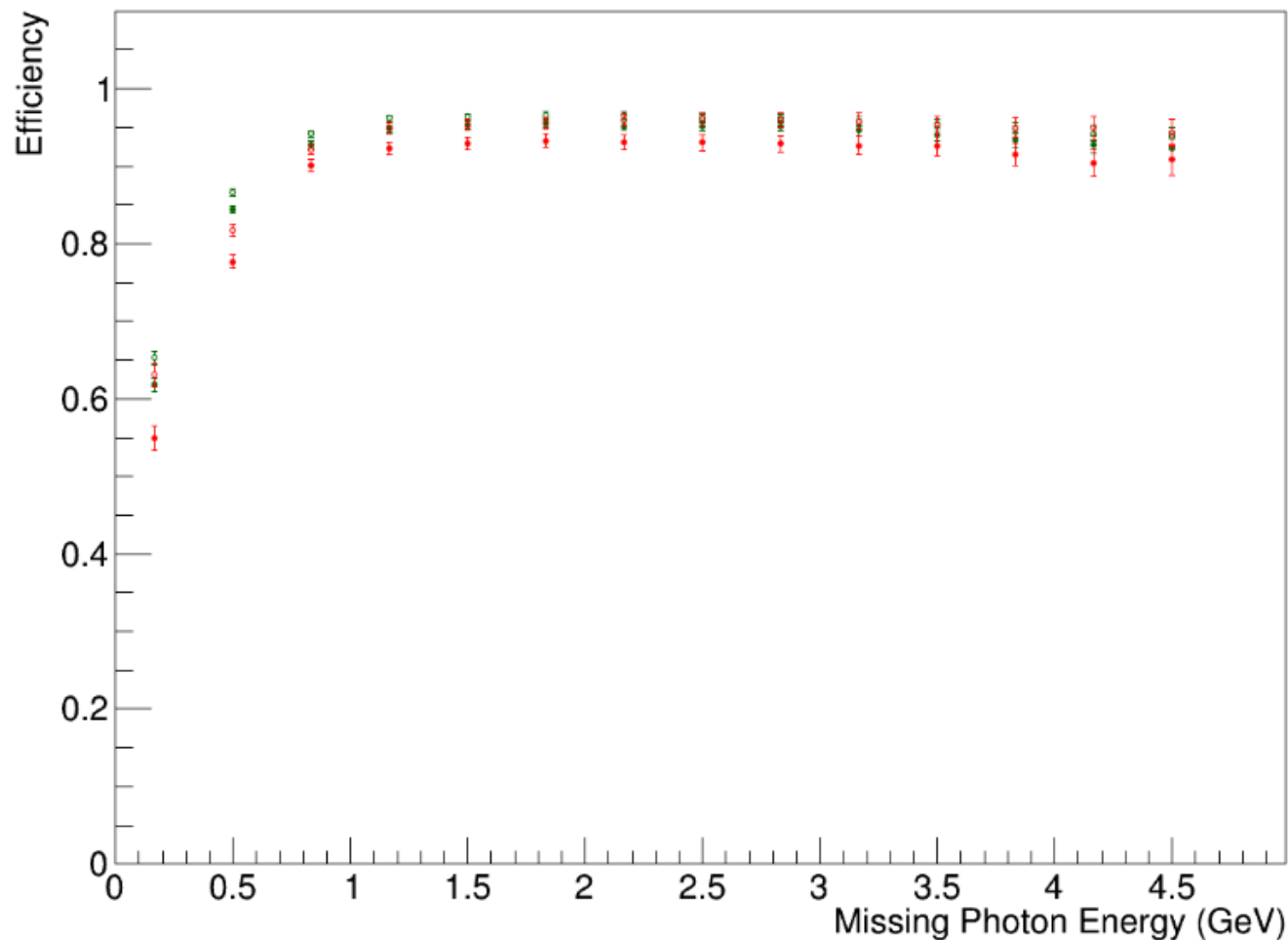


# Geant3 vs Geant4: $E$ Efficiency

Green: geant3 MC

Red: geant4 MC

- Filled Circle: method 1
- Open Circle: method 2





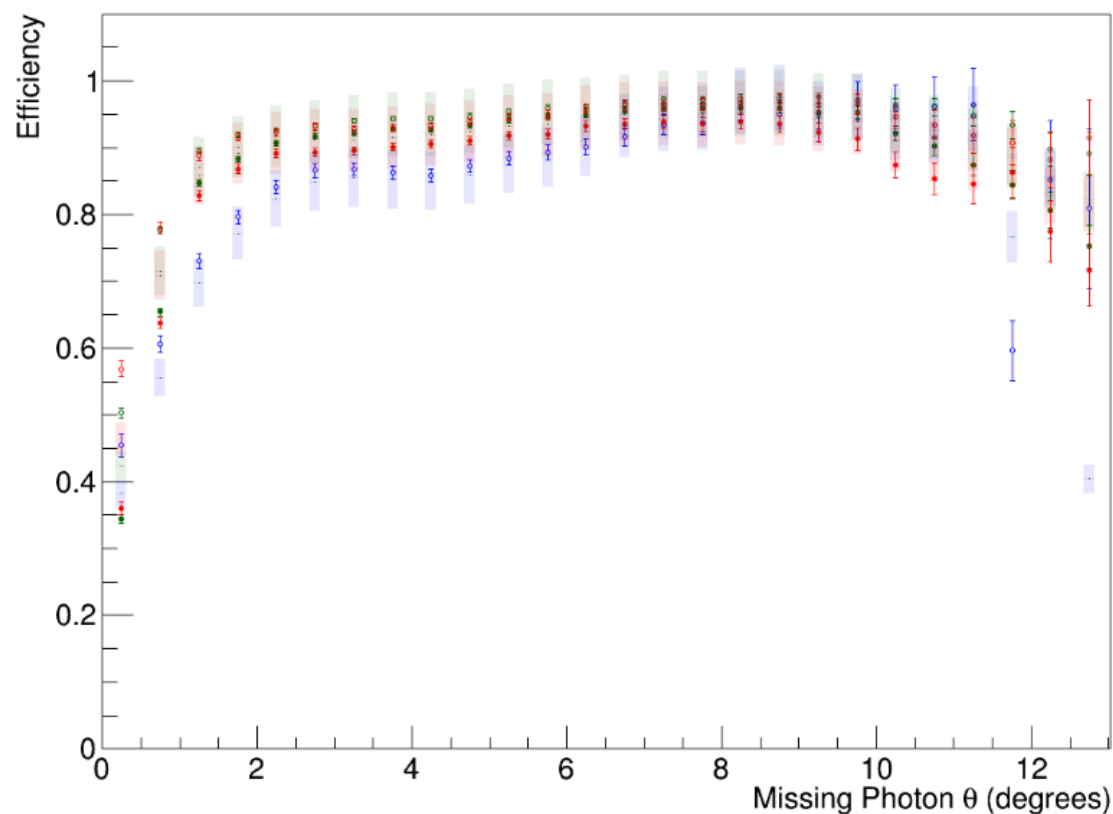
# Geant3 vs Geant4

- More than a factor of 2 total efficiency difference (driven mostly by tracking, I assume)
  - Distribution of events reconstructed is a little different (reflection of tracking again?)
- Clearly there's a difference in measuring efficiencies, ballpark 2-5% effect
- But ignoring that for now, move on to data comparison...



# Efficiency as Function of $\theta$

Efficiency As Function of  $\theta$



Blue: 2017 data  
Green: geant3 MC  
Red: geant4 MC

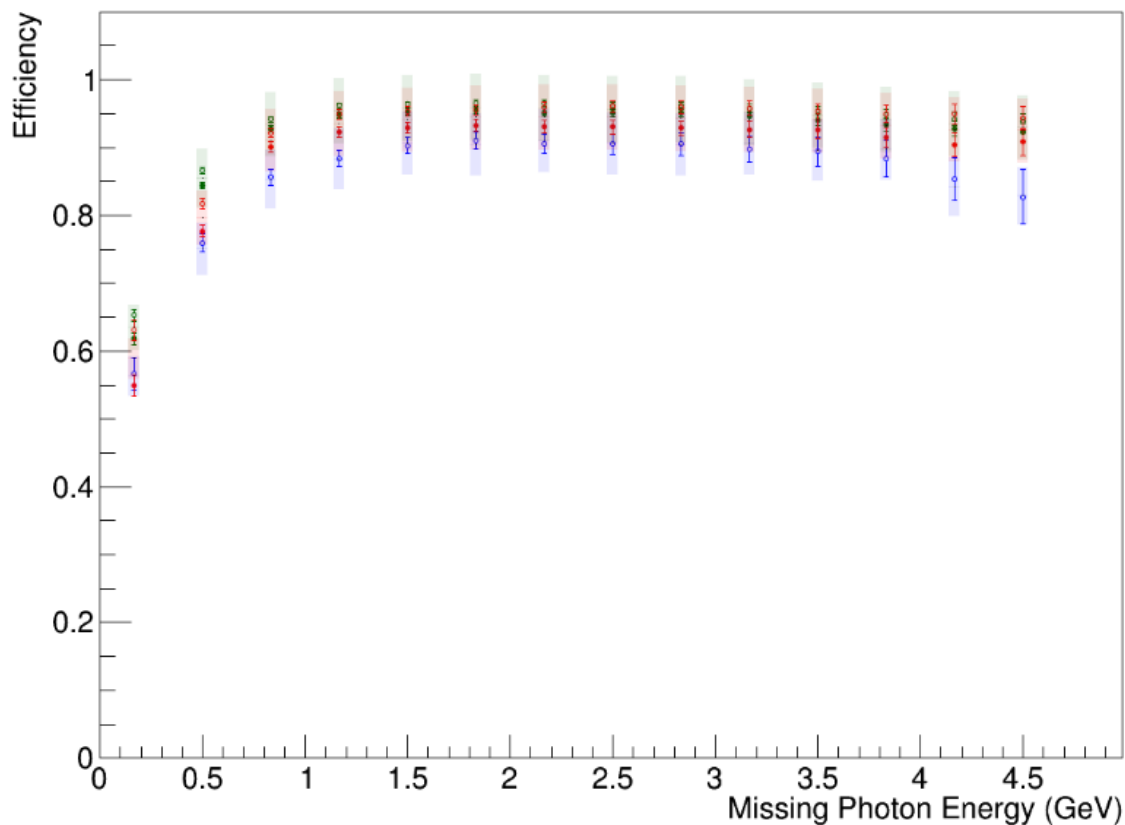
- Filled Circle: method 1
- Open Circle: method 2
- Box: 5% target

Missing photon  $E > 800$  MeV



# Efficiency as Function of $E$

Efficiency As Function of Energy



Blue: 2017 data  
Green: geant3 MC  
Red: geant4 MC

- Filled Circle: method 1
- Open Circle: method 2
- Box: 5% target

$4.5 < \text{Missing photon } \theta < 7.5^\circ$



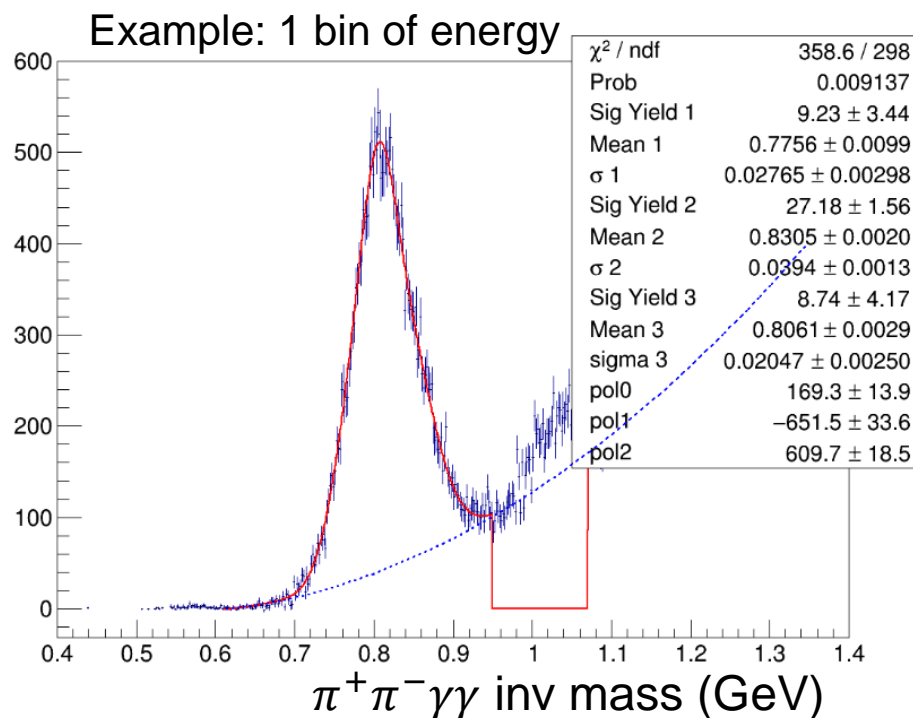
# Comments

- Two methods produce results within 5% target, except for edge cases
- MC efficiency went up significantly
  - Now above REST ver02 data (old MC was below)
  - REST ver03 data might also go up?
- Track matched shower vetos:
  - On here
  - Will need to run over REST ver03 both on and off
- MC shows much higher efficiencies at low  $\theta$ 
  - Lucite? TOF group will add to MC (Ashley)
  - Gains?



# BCAL Case

- Now, do same thing for BCAL
- Purity is a lot lower
  - Fits actually perform surprisingly well even so



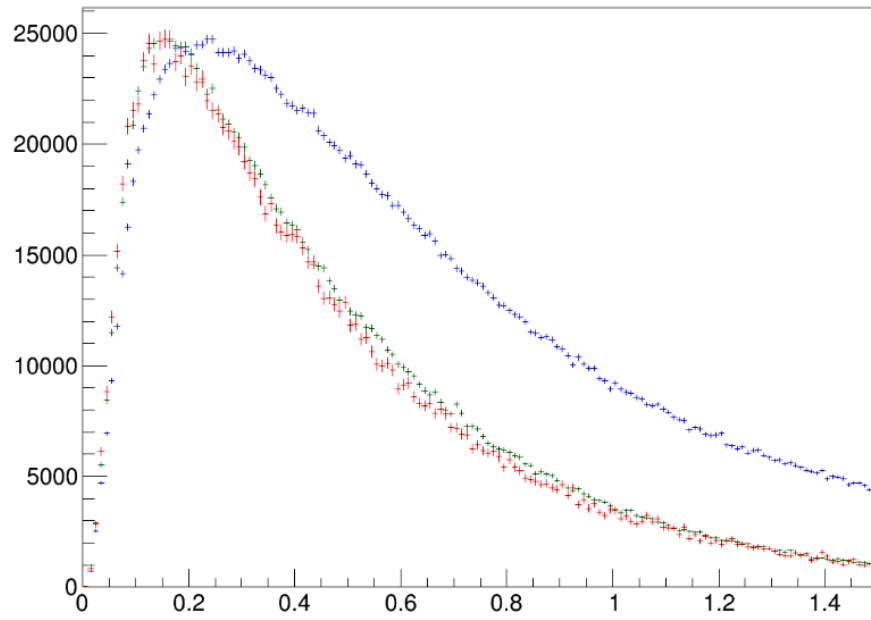




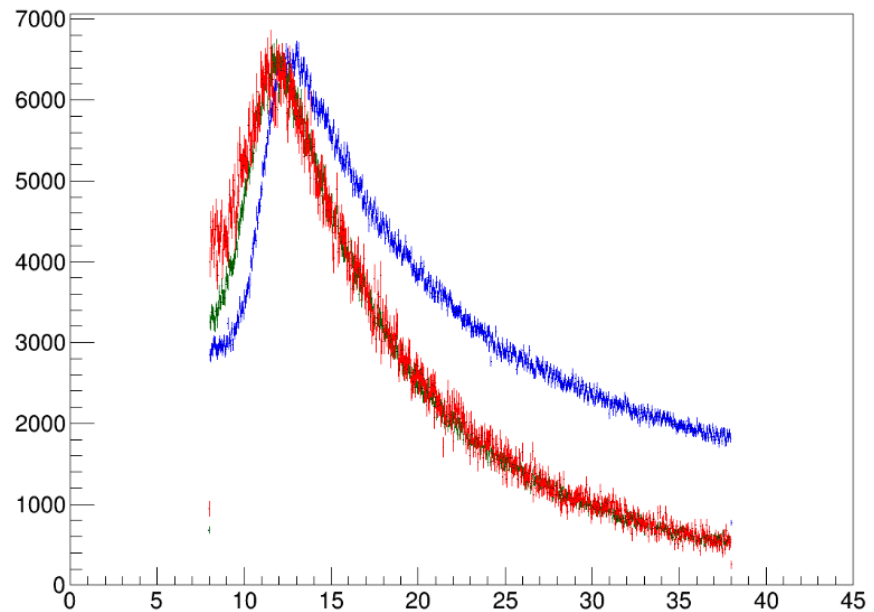
# BCAL

- In mass range of  $\omega$

Blue: 2017 data  
Green: geant3 MC  
Red: geant4 MC



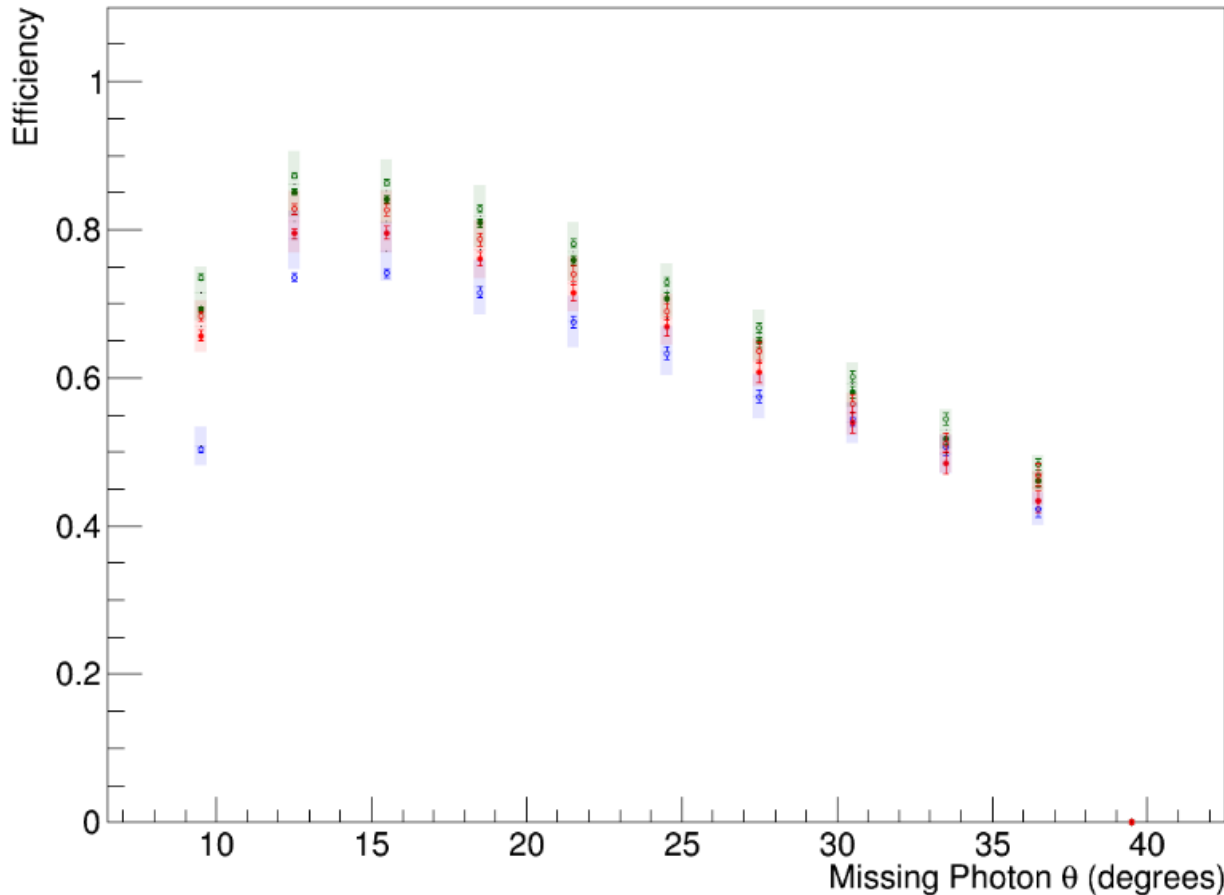
Missing Photon E (GeV)



Missing  $\theta$  (degrees)



# Efficiency as Function of $\theta$



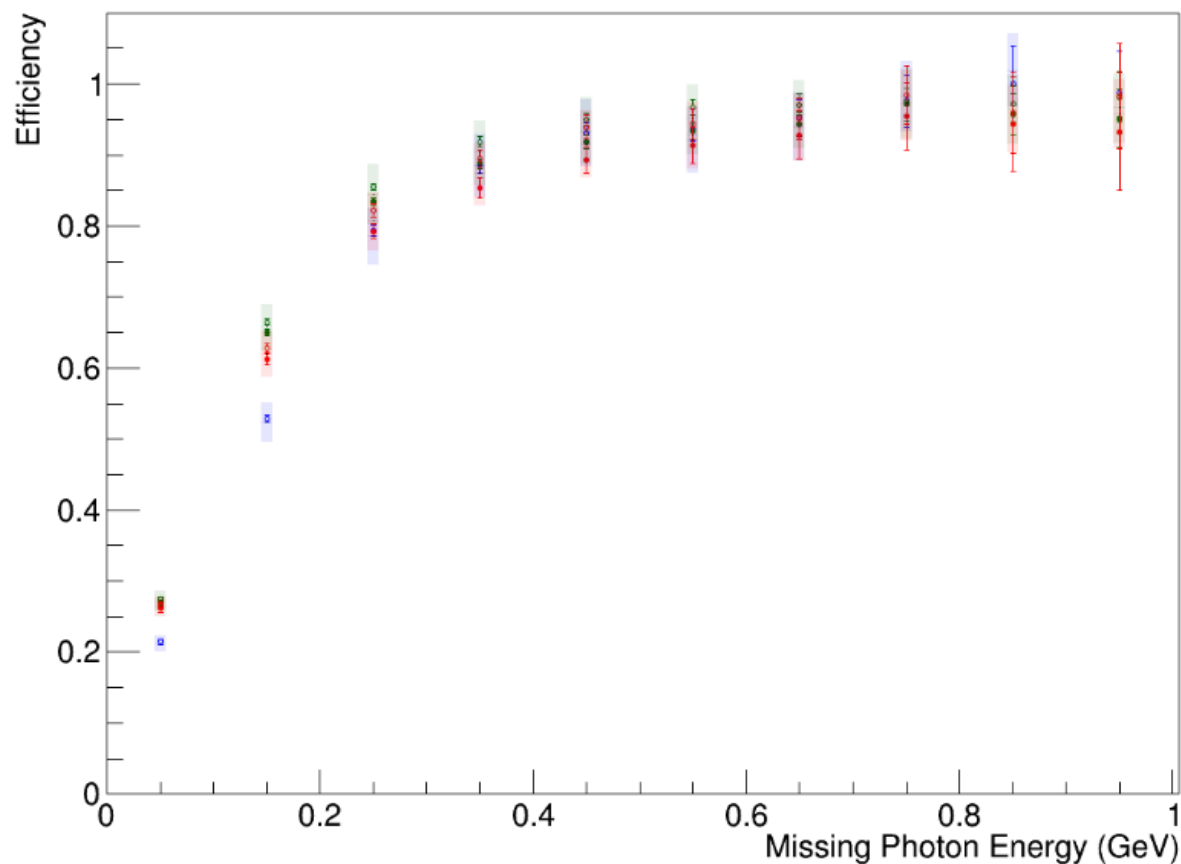
Blue: 2017 data  
Green: geant3 MC  
Red: geant4 MC

- Filled Circle: method 1
- Open Circle: method 2
- Box: 5% target

Missing photon  $E > 800$  MeV



# Efficiency as Function of $E$



Blue: 2017 data  
Green: geant3 MC  
Red: geant4 MC

- Filled Circle: method 1
- Open Circle: method 2
- Box: 5% target

$4.5 < \text{Missing photon } \theta < 7.5^\circ$



# OK, Last Slide, I Promise

- A lot of things to redo:
  - Need to run over REST ver03
  - MC needs TOF lucite
  - With/without track match vetoing
- Two different methods are giving consistent results!
- Might be able to study a little bit of BCAL with method/topology