Working with ω Mesons: A Case Study In Progress

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Omega Mesons: A Practicum in 3π

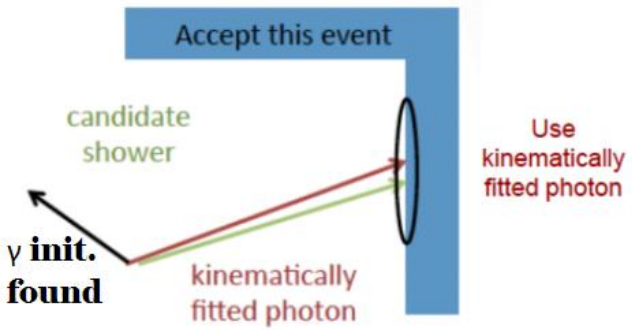
- Reaction: $\gamma p \to \omega p, \omega \to \pi^+\pi^-\pi^0, \pi^0 \to \gamma\gamma$
- A really great channel to work with!
  - Second biggest meson cross section at our energies (after $\rho \to \pi^+\pi^-$)
  - Nice and narrow, can get relatively pure sample
  - Requires tracking and calorimetry to be working
- Good laboratory for:
  - Efficiency studies (reconstruct with single missing $\pi^\pm$ or γ)
  - Cross sections (efficiency + flux)
- But everything matters! Basic reconstruction, accidental subtraction, kinematic fitting, resolutions, etc.

The Idea: FCAL Shower Efficiencies

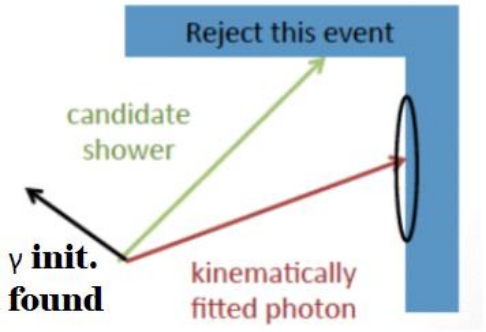
- Do MC and data shower efficiencies agree?
- Use $\gamma p \rightarrow \omega p, \omega \rightarrow \pi^+\pi^-\pi^0, \pi^0 \rightarrow (\gamma)\gamma$ events as a "photon gun", exploit channel exclusivity
  - Look for second photon later
- Similar in spirit to studies performed at BES III, except they use $J/\psi \rightarrow \pi^+\pi^-\pi^0$
  - See reference on workfest wiki page under "previous studies"
- Eventually: bin in $E, \theta, \phi, etc.$

How to Accept Showers?

- Not everything reconstructed shower will be the photon we want (others come from splitoffs, noise, backgrounds, etc.)
- Resolution is pretty wide at GlueX, so just accepting within a circle/cone is tricky



Reasonable circle of acceptance at GlueX: ≈ 4.5°
FCAL: ≈ 11 °



Other Ways To Accept/Reject

- Can use yields to form a numerator and denominator
- $\epsilon = \dfrac{inv.\,\omega\ yield}{missing\ \omega\ yield}$
- Events with $\pi^+\pi^-\gamma\gamma$ peaking above background at ω mass are counted as “efficient”
- Missing ω provides normalization for events with good $\pi^+\pi^-\gamma$, may or may not have a second good γ

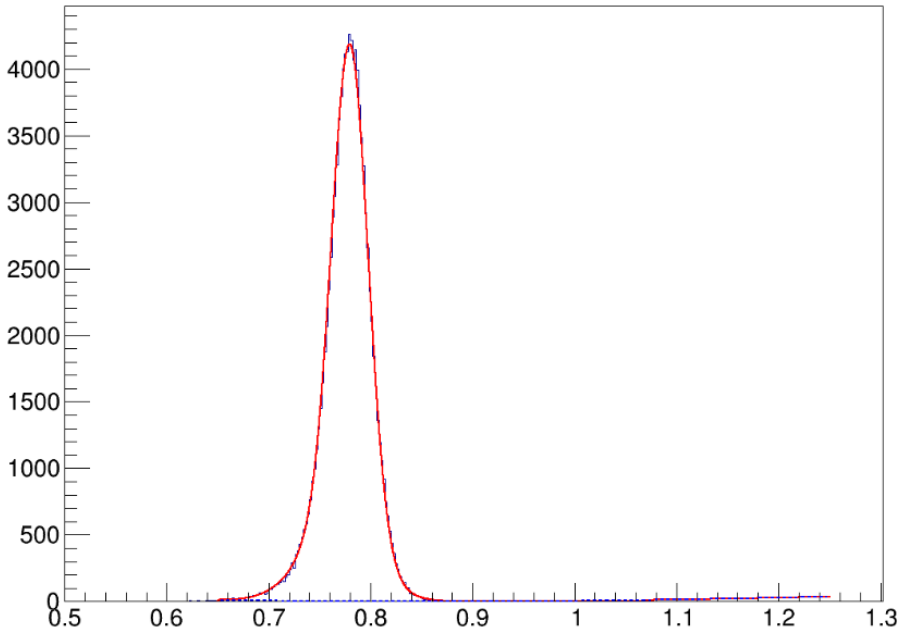
Data Samples / Event Selection

- A bit bigger than workfest data samples
- 2017 coherent peak data
- 10 million MC events
  - Genr8
  - 8.5 GeV beam E
  - No random trigger backgrounds
- Event selection matching analysis launches/ReactionFilter, and:
  - Second photon: must be in FCAL, no more than 1 candidate
  - 1C kinematic fit: constrains missing mass to be 0
  - Initially found photon has > 500 MeV
  - No extra tracks
  - 0.11<recoil against $p\pi^+\pi^-$< 0.16 GeV
  - $\beta < 0.9$ on proton (cuts out $\pi^\pm$ leakage)

Nice Clean MC

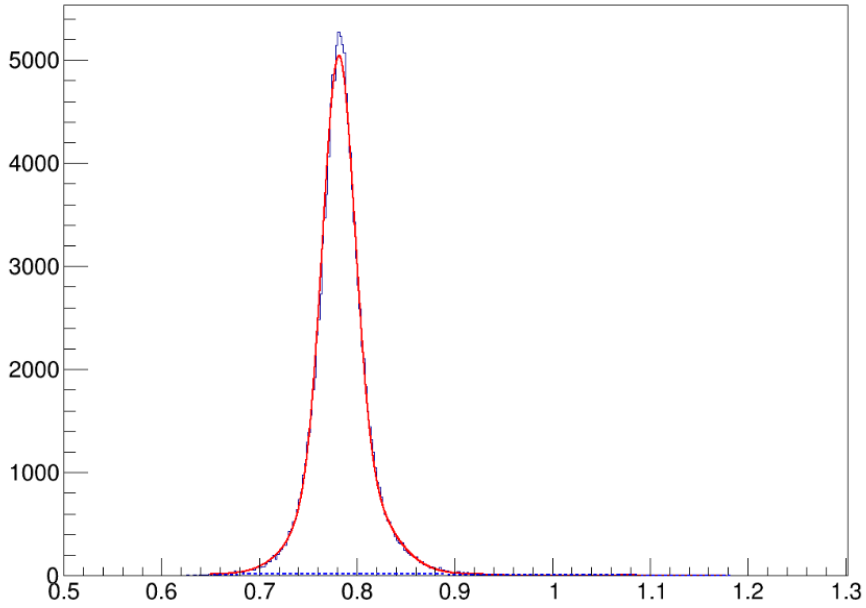
8.5 GeV channel efficiency in FCAL: $\epsilon = 0.812 \pm 0.004_{stat}$

Simple MC Numerator (2 gaussian)



$\gamma\gamma\pi^+\pi^-$ inv. mass (GeV)

Simple MC Denominator (3 gaussian)

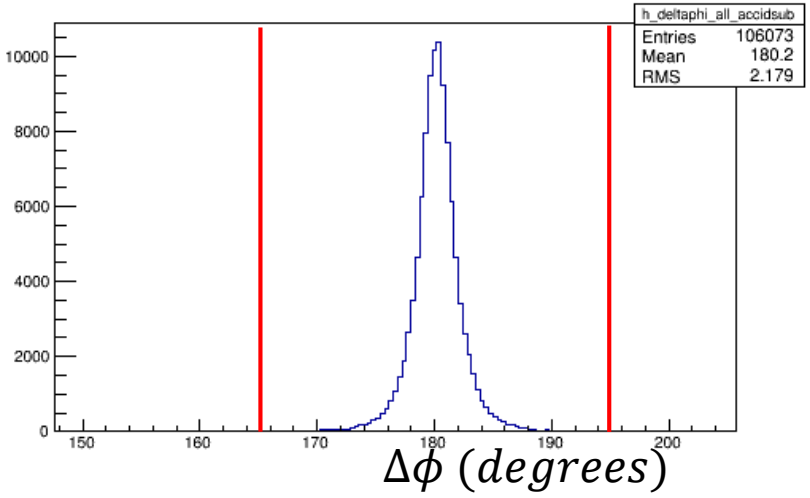


Recoil against proton mass (GeV)

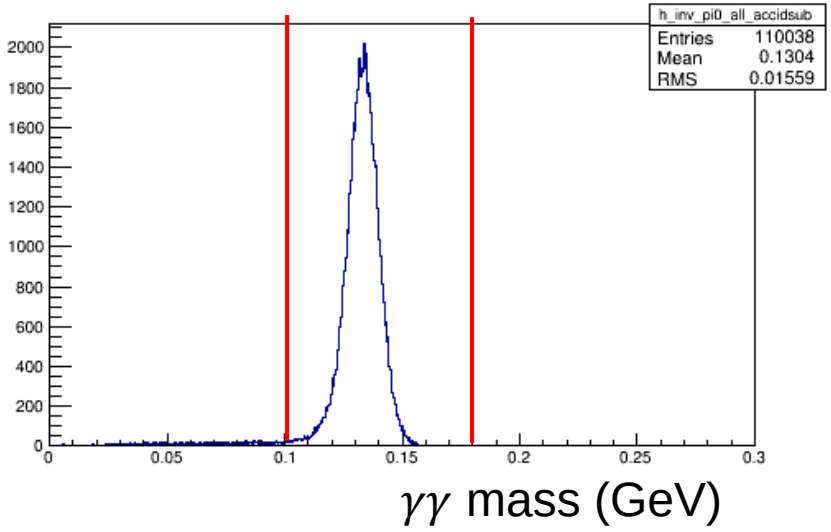
Quality Cuts on ω Invariant Mass

Extremely loose here, cuts a little in data

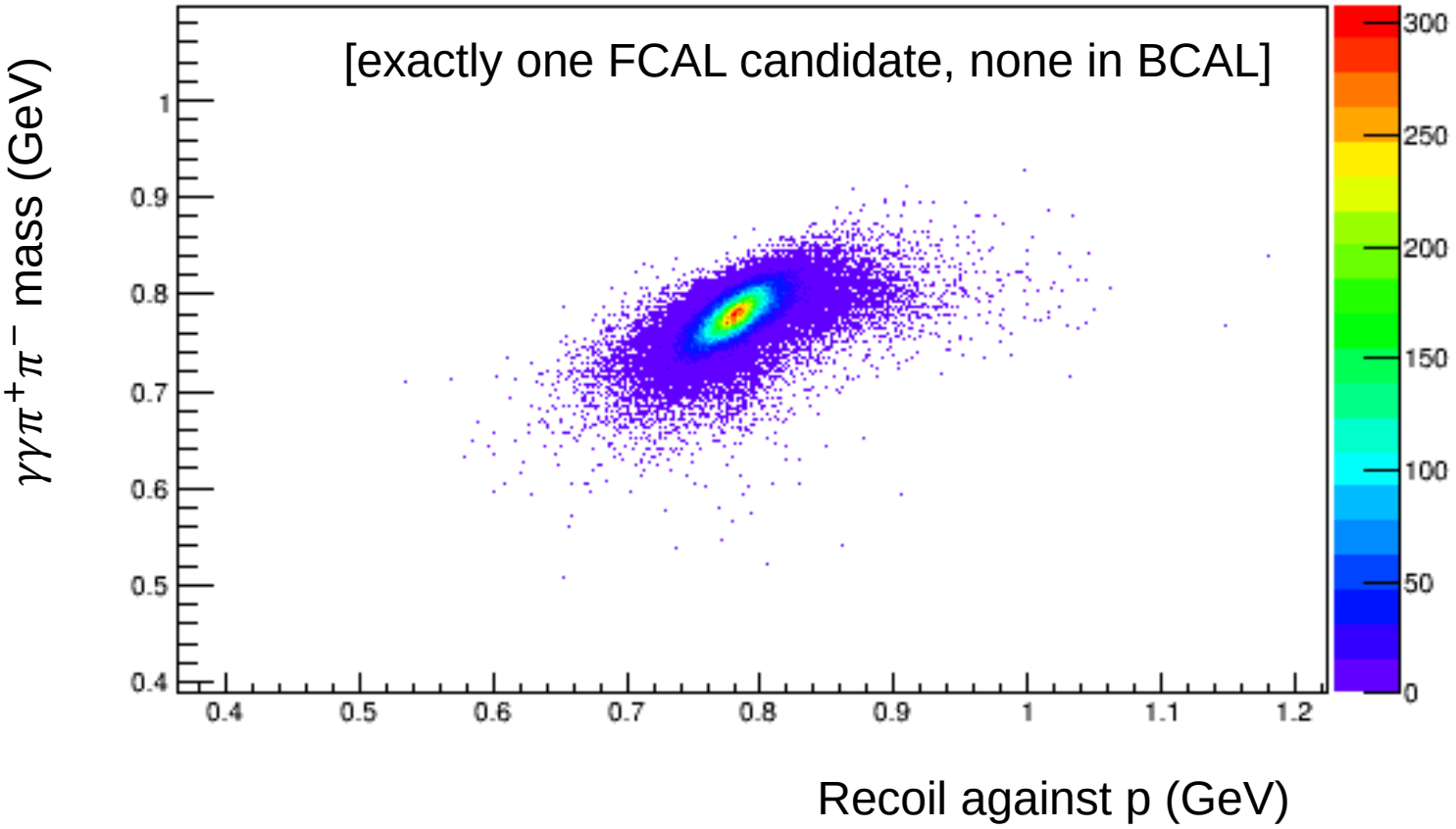
$\Delta\phi = \phi_{proton} - \phi_{\pi^+\pi^+\gamma\gamma}$



π^0 mass cut



Signal MC: 2D Plot

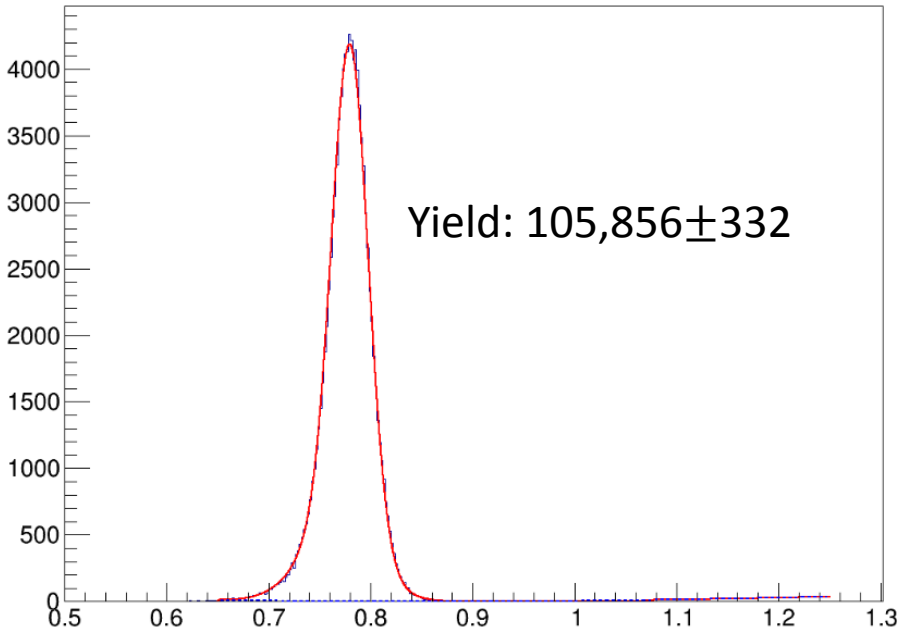


Can't see vertical stripe associated with inefficiency

Are MC Yields Consistent?

- Pretty darn close, at least
- Histogram entries: 106,073

Simple MC Numerator (2 gaussian)



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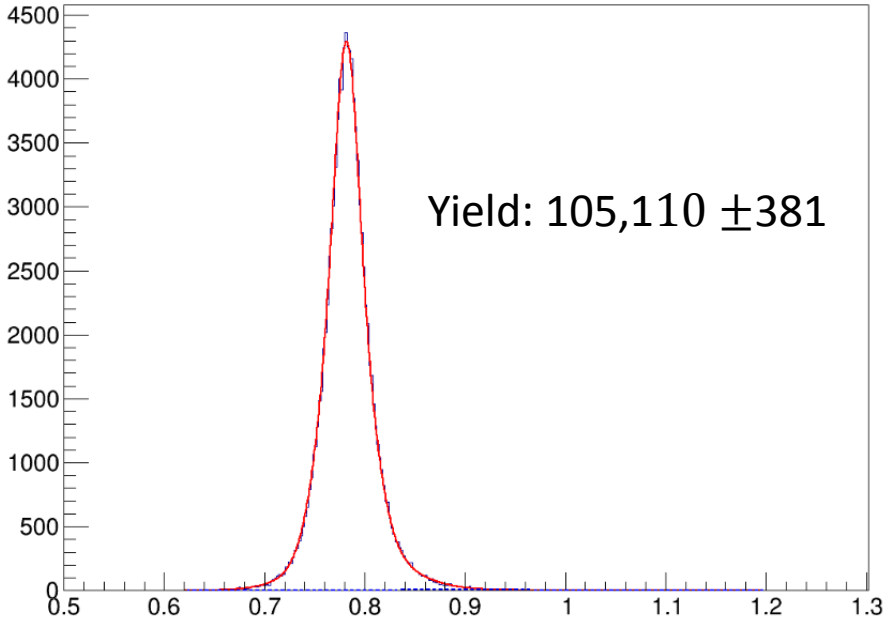
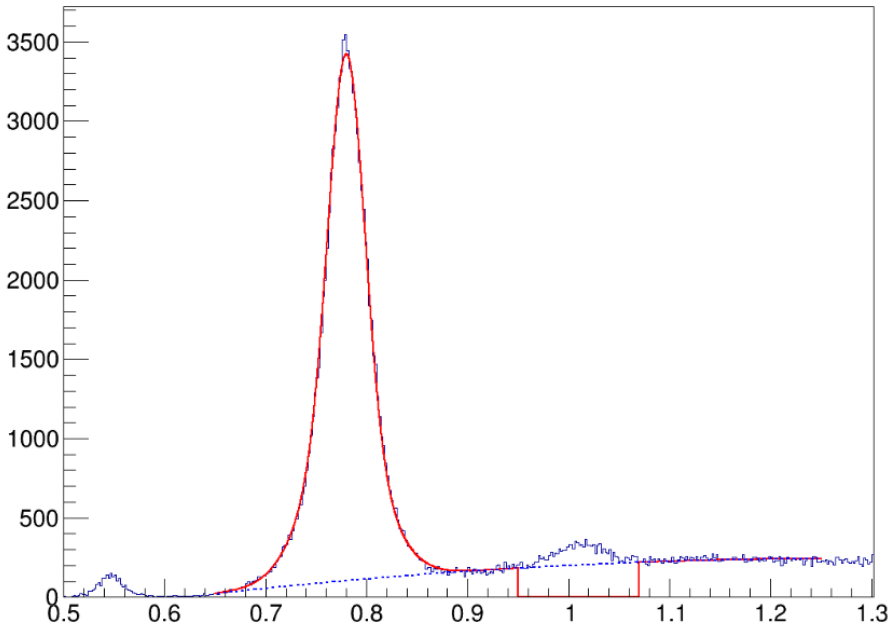


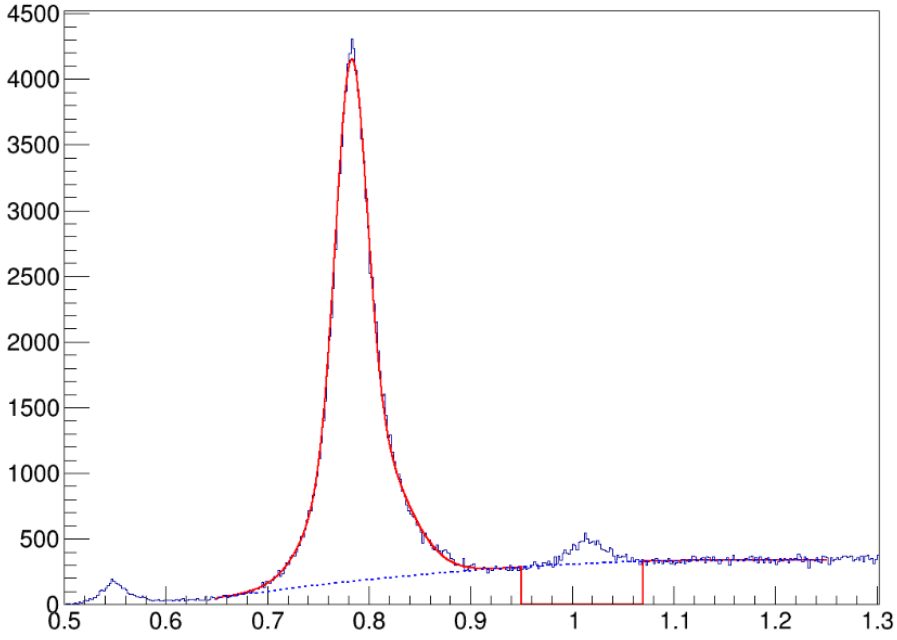
2017 Coherent Peak Data

Data Numerator (2 gaussian)



$\gamma\gamma\pi^+\pi^-$ inv. mass (GeV)

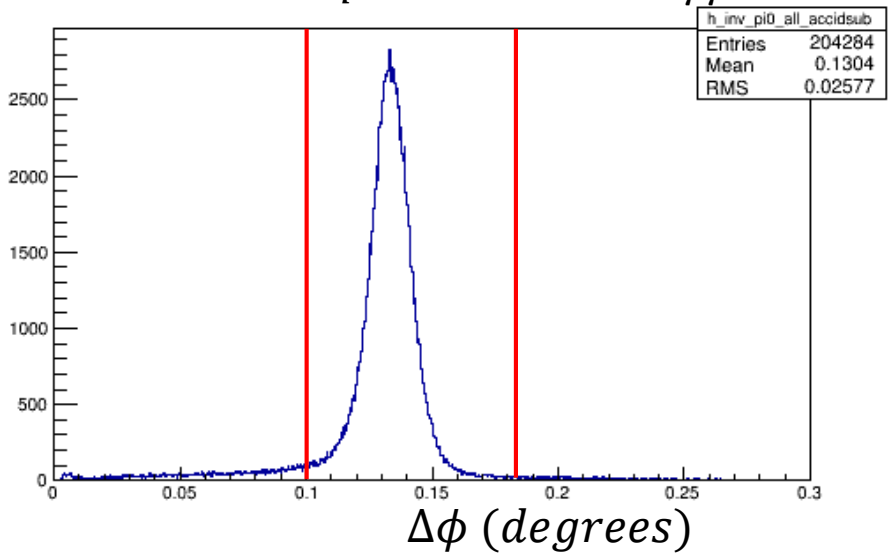
Data Denominator (3 gaussian)



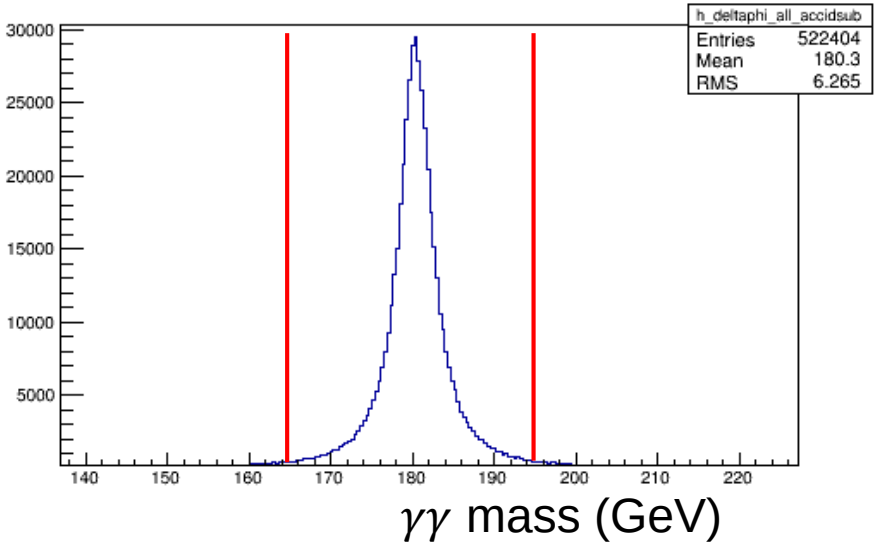
Recoil against proton mass (GeV)

Quality Cuts on ω Invariant Mass

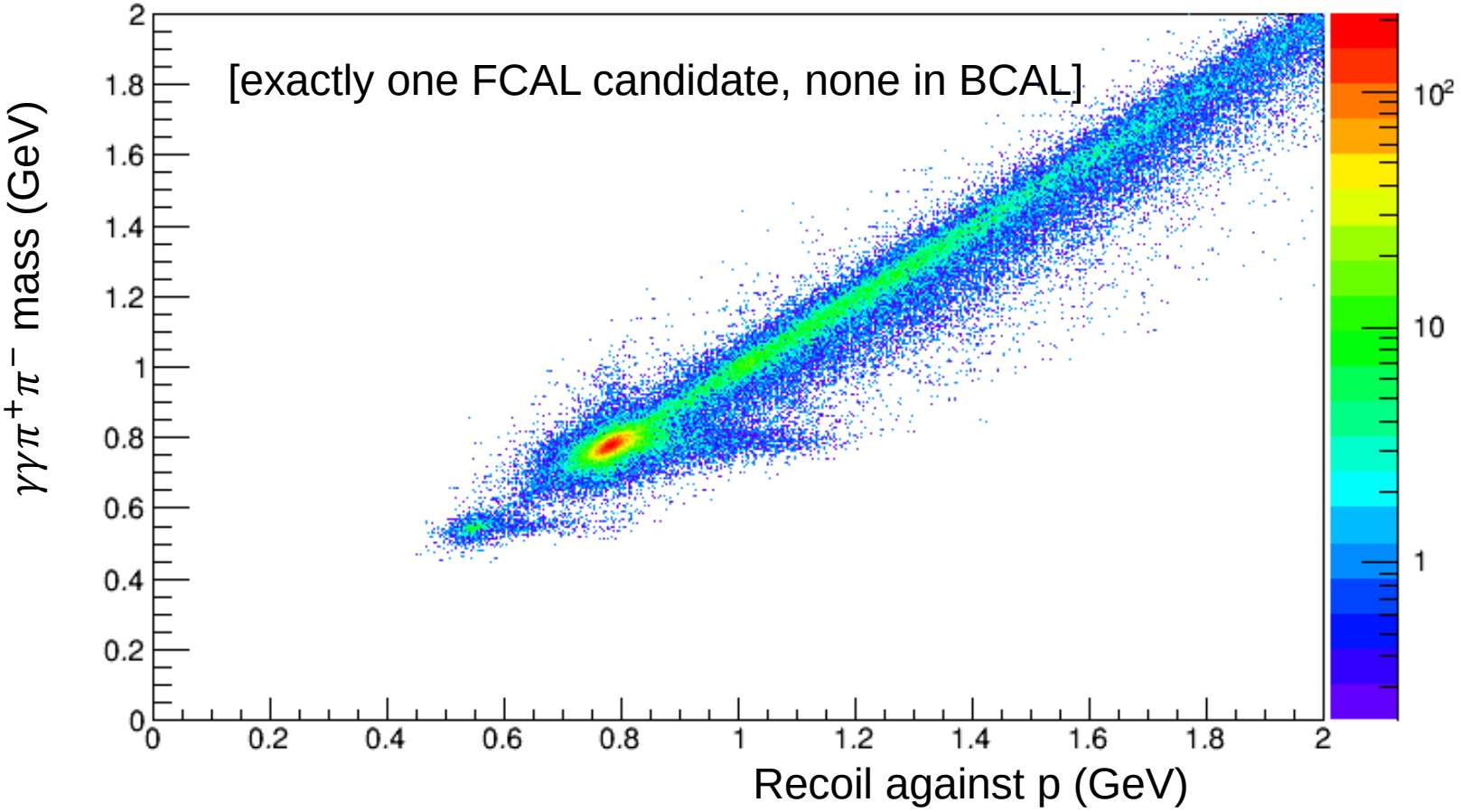
$\Delta\phi = \phi_{proton} - \phi_{\pi^+\pi^+\gamma\gamma}$



π^0 mass cut



2017 Data: 2D Plot



Long horizontal right tail??

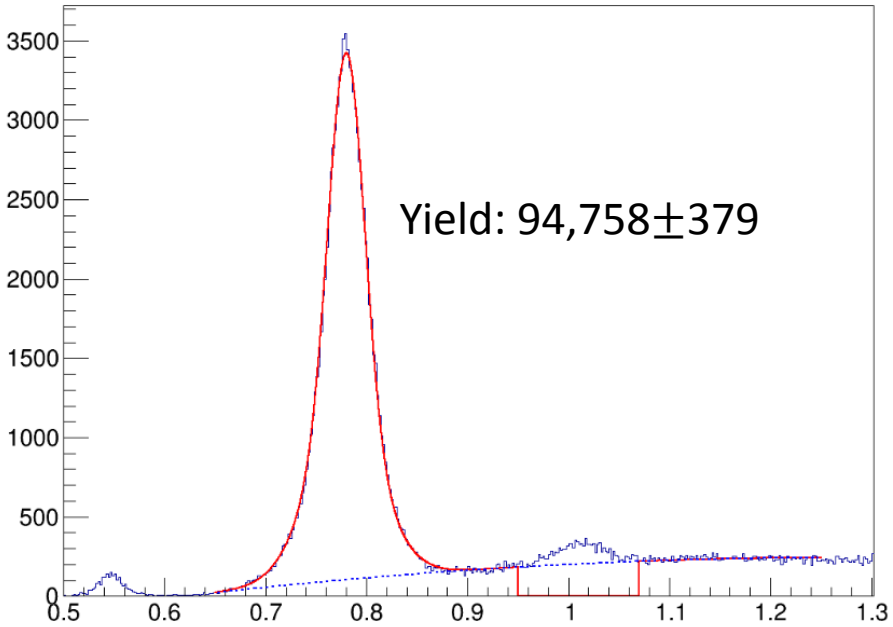
Are Data Yields Consistent?

Nope!

Interpretation: long right tail gets mis-sorted as background

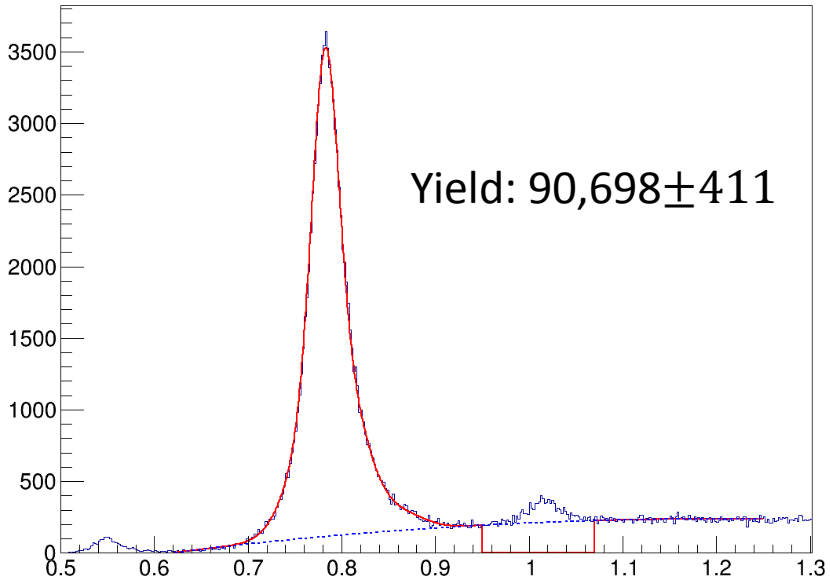
4% discrepancy here, would be dominant uncertainty

Simple MC Numerator (2 gaussian)



$\gamma\gamma\pi^+\pi^-$ inv. mass (GeV)

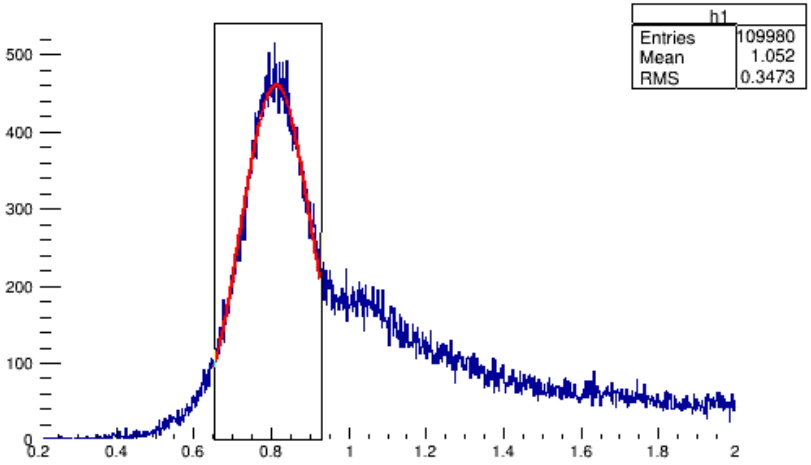
Simple MC Denominator (3 gaussian)



Recoil against proton mass (GeV)

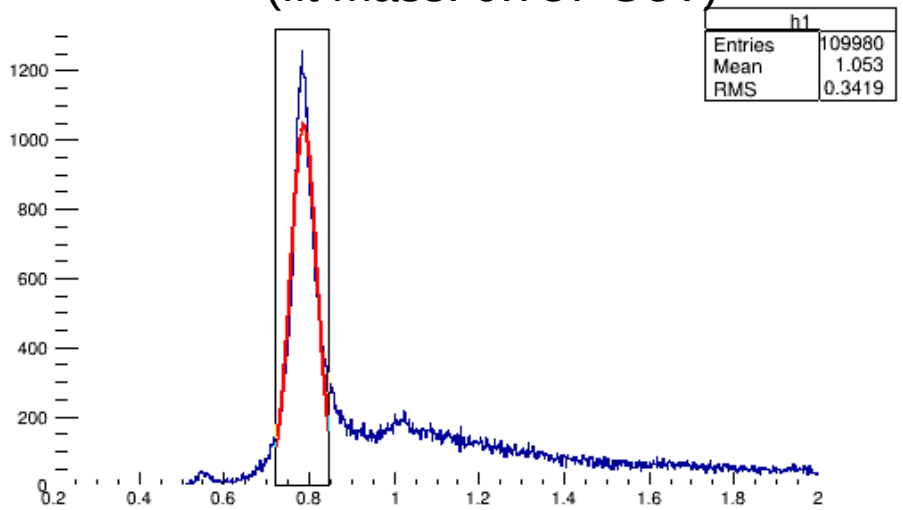
What's Going On With Those Protons?

Pre-kinfit
(fit mass: 0.812 GeV)



Recoil against proton mass (GeV)

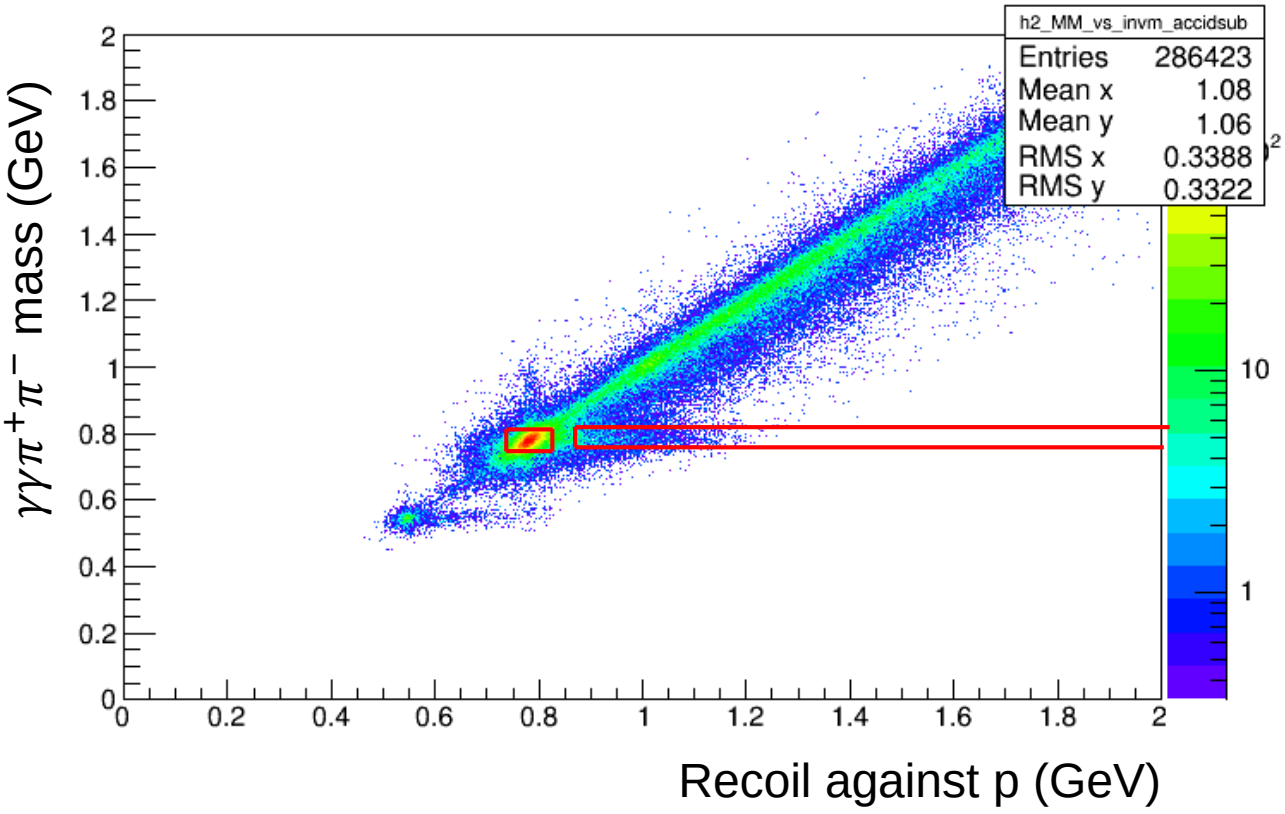
Post-kinfit
(fit mass: 0.787 GeV)



Recoil against proton mass (GeV)

Missing γ Energy – Found γ E

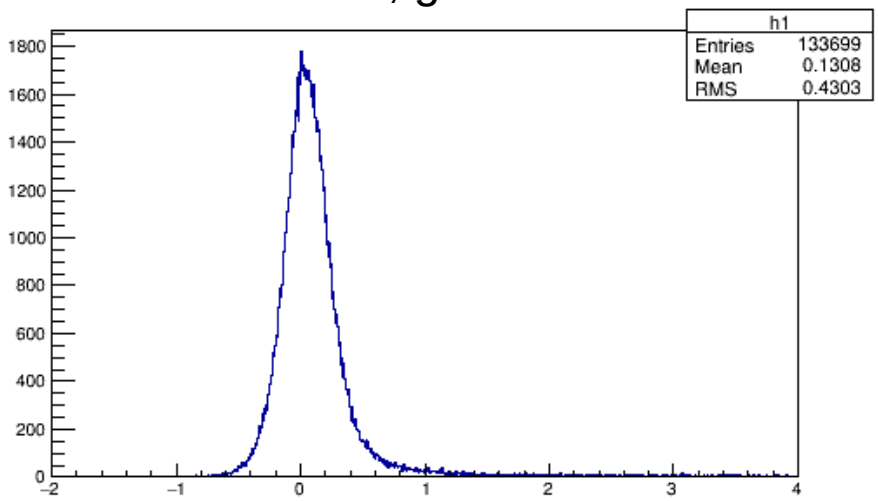
- Examine missing photon E – found photon E in red regions



MC: Missing γ Energy – Found γ E

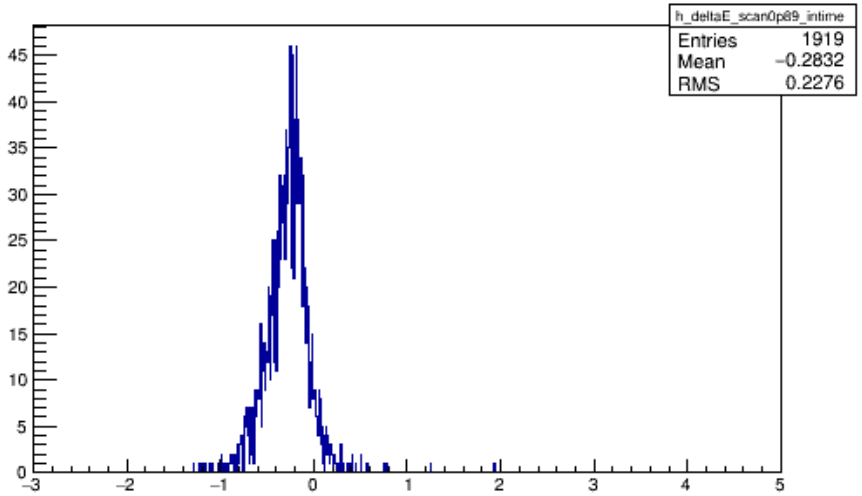
Same events as 2D plot shown

Good recoil mass, good invariant mass



Missing – found photon energy (GeV)

Good invariant mass, high recoil mass

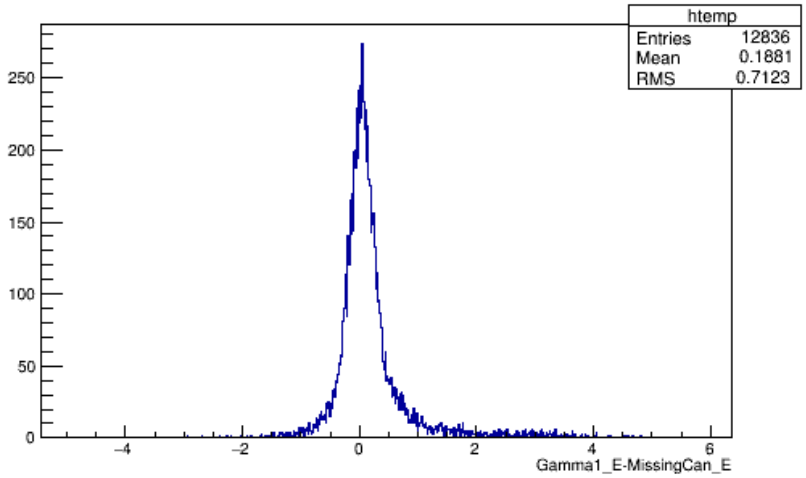


Missing – found photon energy (GeV)

Data: Missing γ Energy – Found γ E

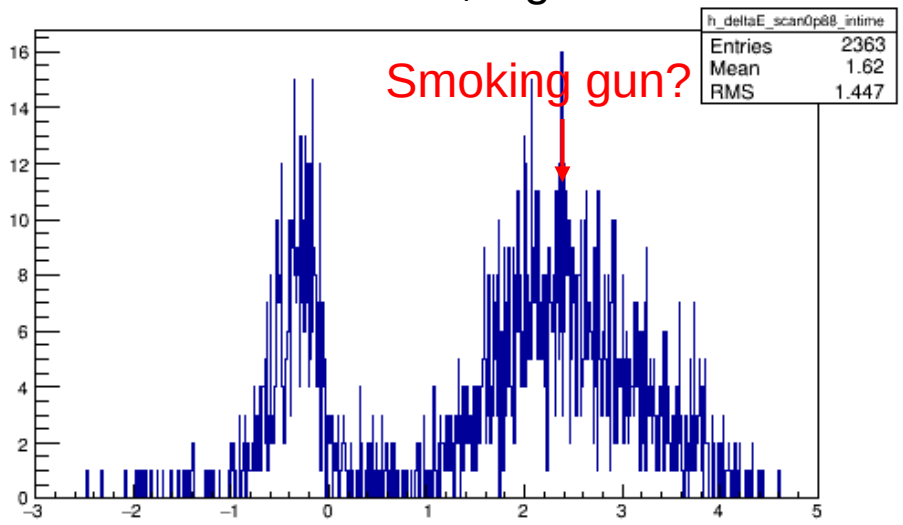
Same events as 2D plot shown

Good recoil mass, good invariant mass



Missing – found photon energy (GeV)

Good invariant mass, high recoil mass



Missing – found photon energy (GeV)

Can We Isolate/Cut the Tail? (reference)

Tried a lot of things, nothing so far

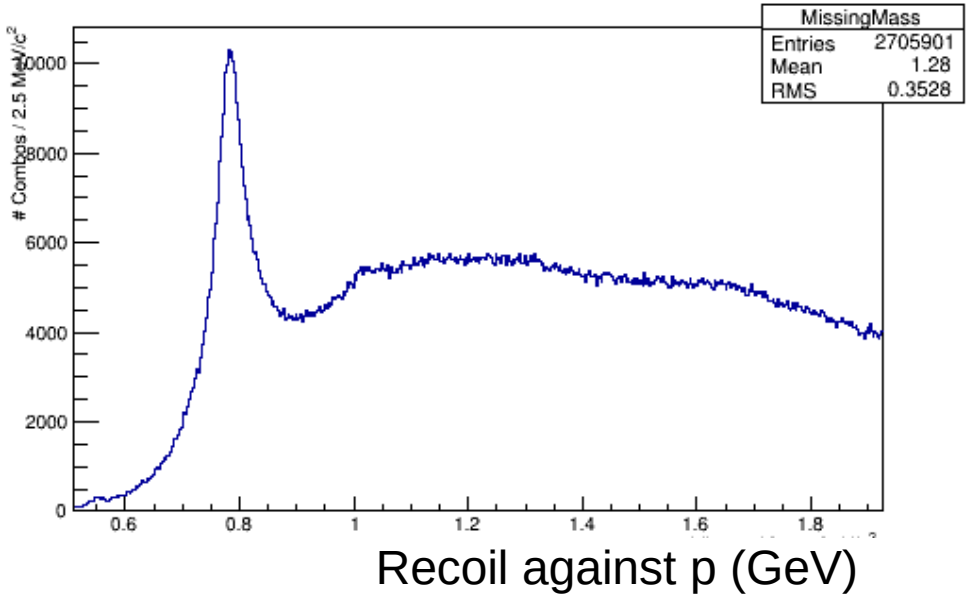
- 2016 data shows same issue
- Additional kinfit hypothesis (vertex and π^0 mass)
- Kinfit tight χ^2
- β cuts to better separate pions and protons
- Tight tracking χ^2 on all candidates
- Proton # hits

The Good News

If we can solve the issue of the tricky recoil mass distribution:

- Missing $\pi^{\pm}$ should be doable up to max θ as well!

(quality cuts not applied here, background reducible)



Summary

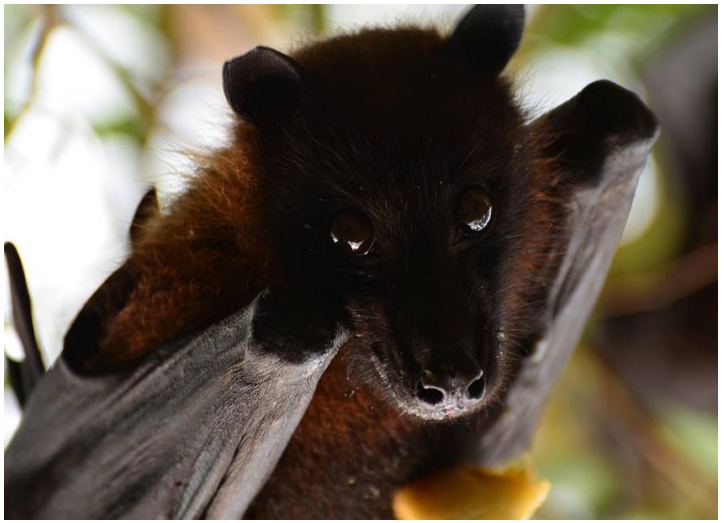
- Even a simple sounding study relies on lots of pieces:
  - Accidental subtraction
  - Kinematic fitting
  - Resolution (though we try to decouple)
- It takes a village! Let's see what we can accomplish

R&D: The Indian Flying Fox ?

BE BEST

BEBEST.gov

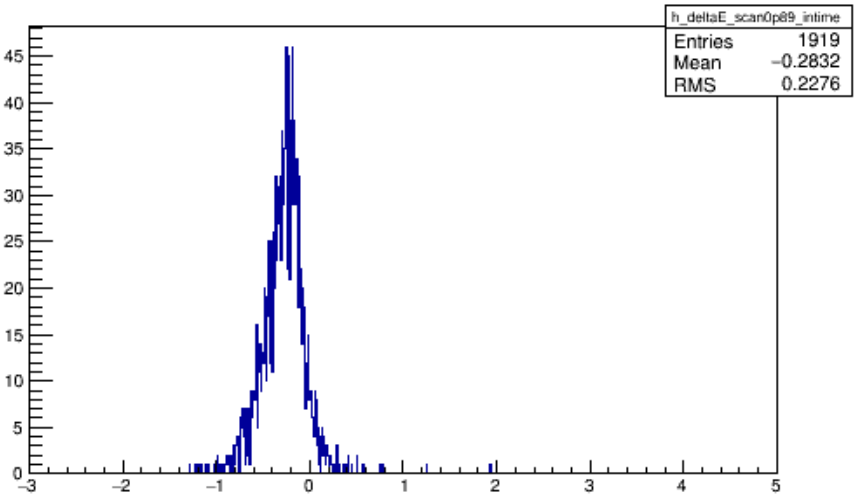
- Consumer of ripe fruit
- Important pollinator for external environment



Side-by-Side Energy Difference

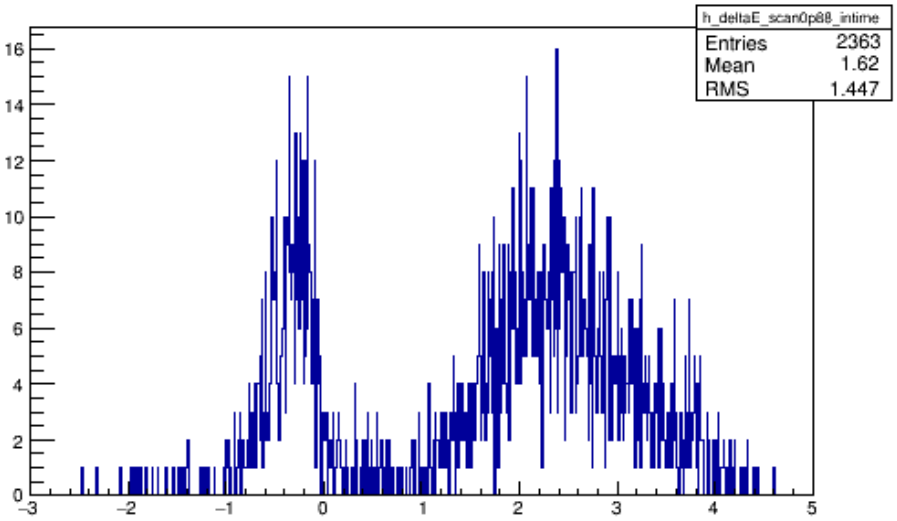
- 0.77<$\pi^+\pi^+$ $\gamma\gamma$ mass < 0.79 GeV
- Missing mass > 0.88 GeV

MC



Missing – found photon energy (GeV)

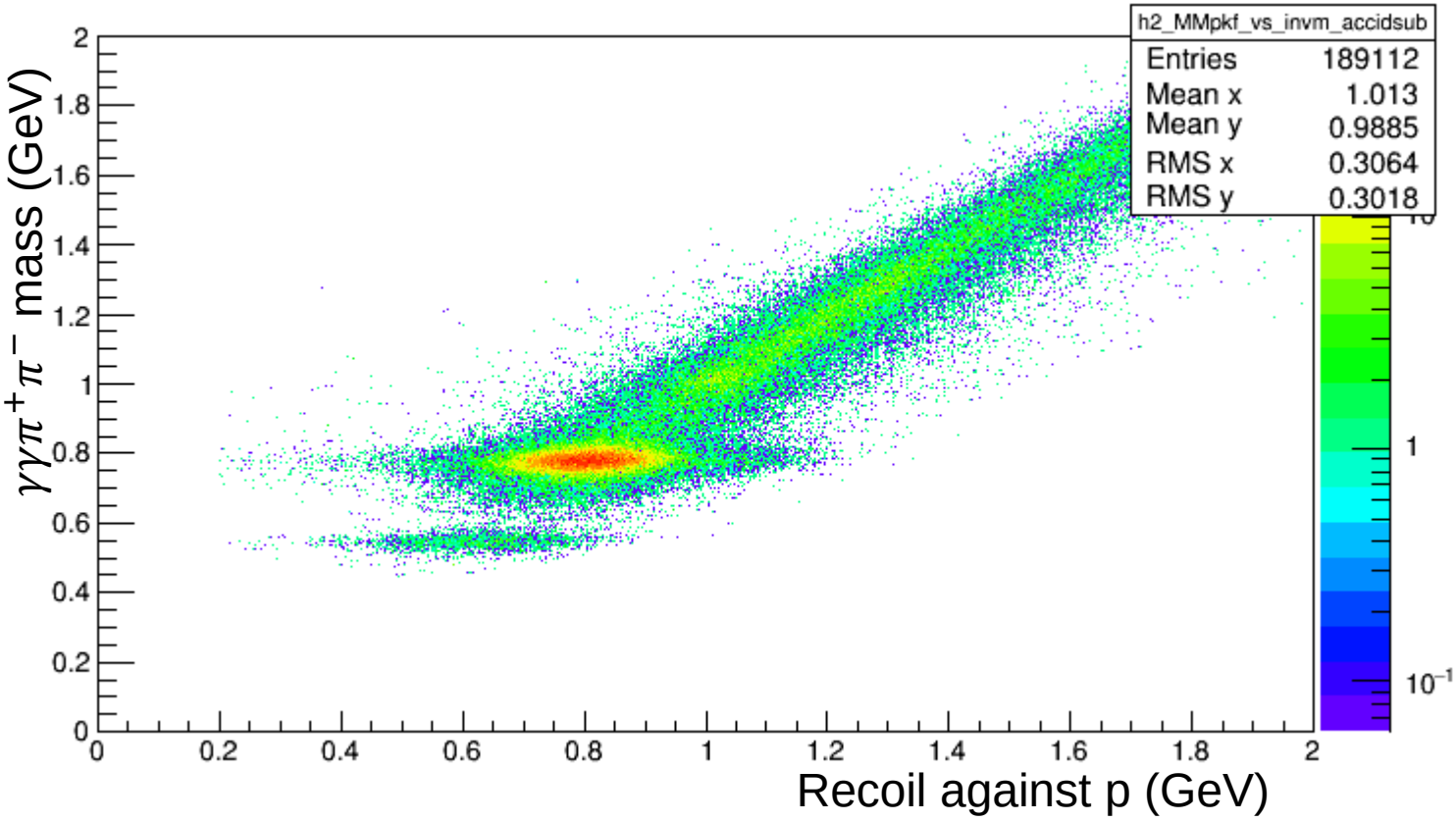
Data



Missing – found photon energy (GeV)

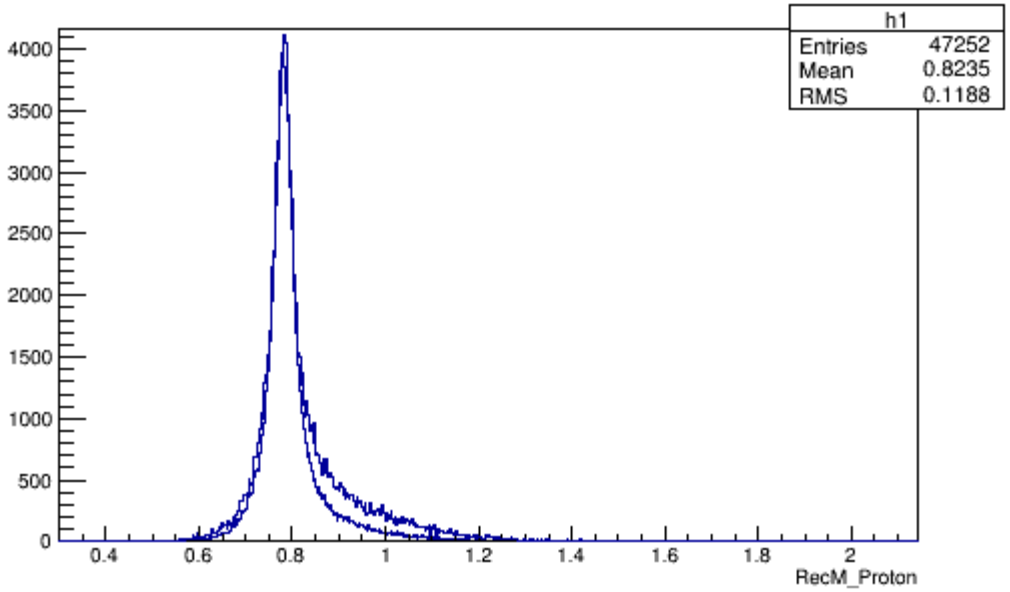
Recoiling Against $X \rightarrow \omega + stuff$?

- Post kinematic fit would have wrong hypothesis, would show up in pre-kinfit recoil mass maybe
- No clear sign of some



Long Right Tail In Data

- Doesn't look like we can just use 1 FCAL shower case to try to fix shape for 0 or 1 showers
- Cut tight on good inv. mass around ω
  - Narrower distribution: 0 BCAL showers, 1 FCAL shower
  - Wider distribution: 0 BCAL showers, 2 FCAL showers



Fractional Movement of Recoil Mass