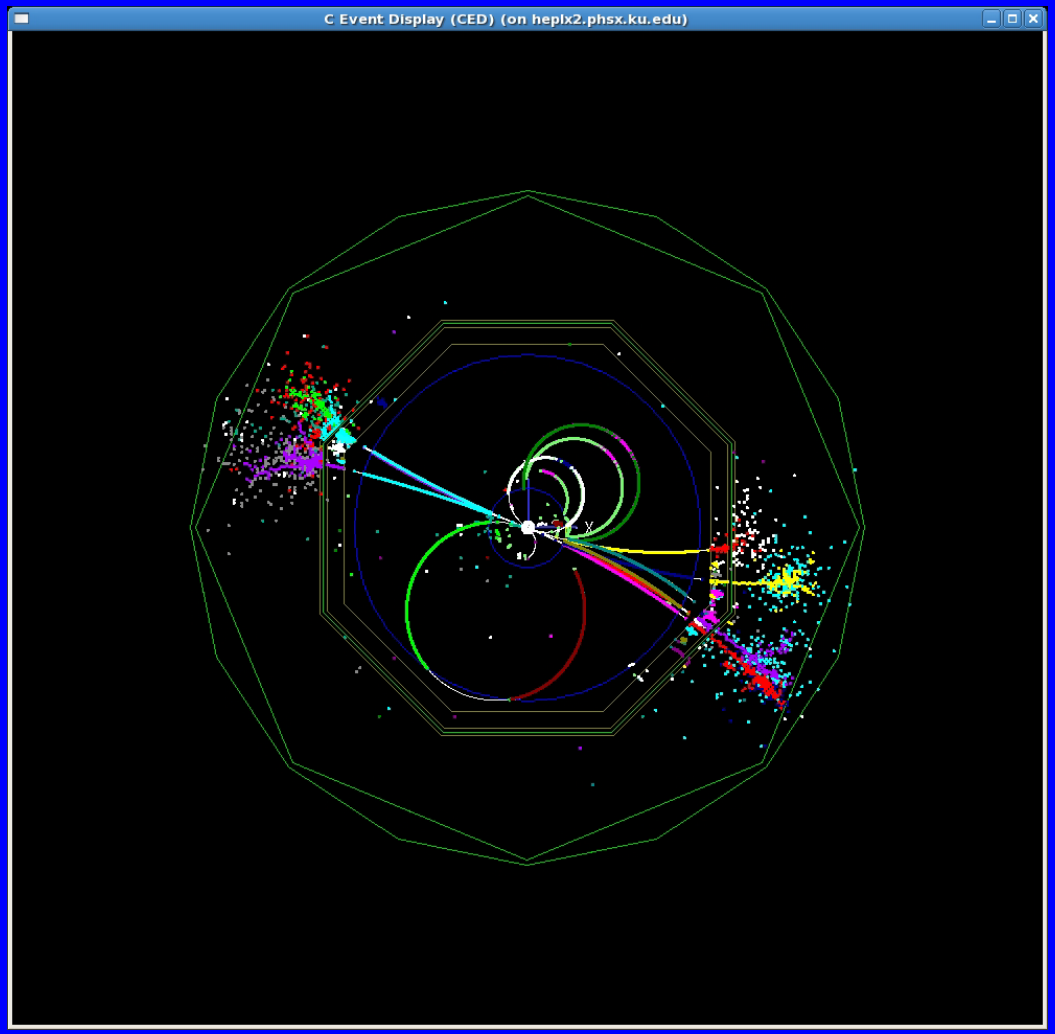
Investigating Various Reconstruction Issues



Graham W. Wilson, University of Kansas
ILD Optimization Meeting, Dec 1st 2010

Context

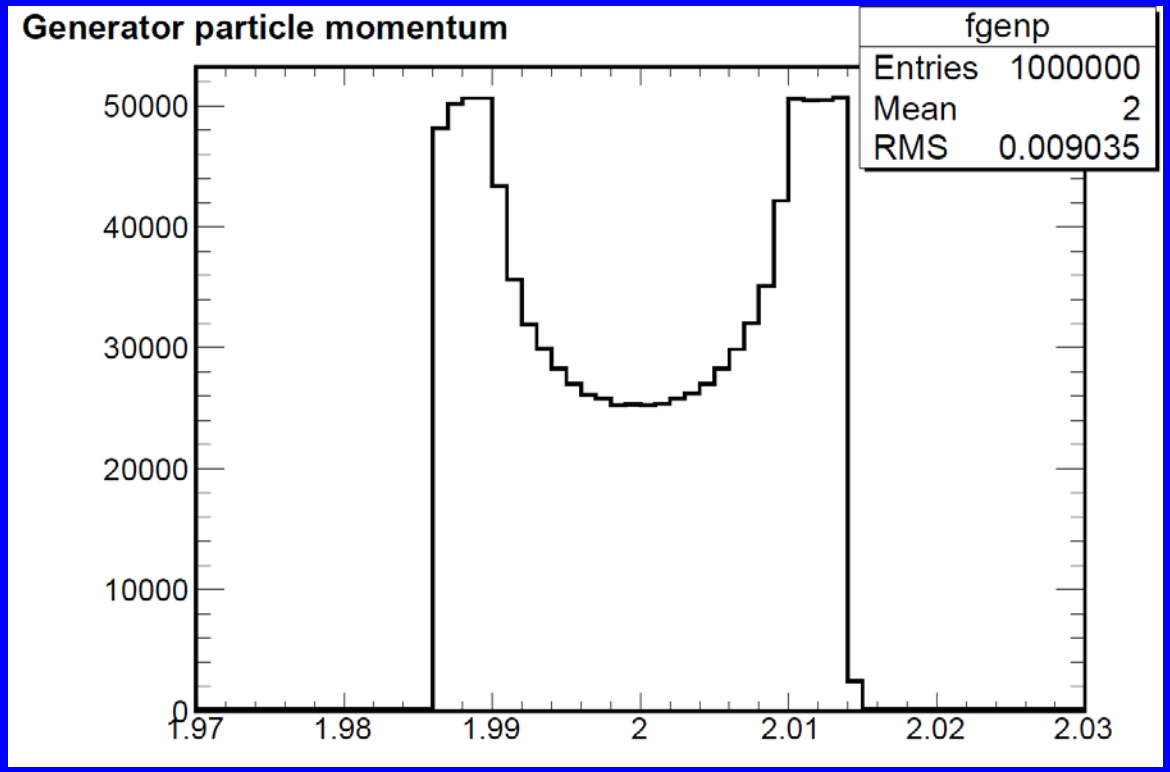
- At KU, we're working on two inter-related topics related to event reconstruction using the ILD00 model with an emphasis for now on low energy jets.
  - 1. Investigating mass-constrained fits to π^0 in hadronic events. (with Brian van Doren).
  - 2. Investigating event-specific hadronic event reconstruction.
    - See talk at IWLC2010. Conclusions:
    - Significant energy bias event-to-event. (x 0.85)
    - Significant variation in energy resolution event-to-event. (x 0.89)
- Today, I report on a number of reconstruction issues spotted/uncovered as a result of studies related to topics 1 and 2.
  - For π^0 : looking into photon angular resolution and photon conversion reconstruction.
  - For 2. General single-particle calibration issues.

Issue List

- 1. Apparent energy smearing from generator file → simulation.
- 2. Low reconstruction efficiency for photon conversions.
  - A) V0Finder efficiency is very low for 2 GeV converting photons (10%)
  - B) Very low LDCTrack tracking efficiency for photons converting in the TPC.
  - C) V0Finder calls lots of photons, K_short or Lambda.
- 3. Energy measurement in the looper regime.
  - Started looking at single electrons (and single muons) to understand elements of conversion reconstruction.
  - Observe significant biases in prompt electron and muon reconstruction.
    - Split tracks ?
    - Double counting ?
  - Tracking efficiency looks very good.
- 4. Photon cluster position reconstruction.
  - Now see very large position “quantization” in contrast to previous studies by Brian using old Pandora. Correct ? Do we want to stagger the wafers in ϕ ?

(lorentzTransformationAngle Feature)

Cautionary tale: Should turn off lorentzTransformationAngle in Mokka steering file when processing single particle events.

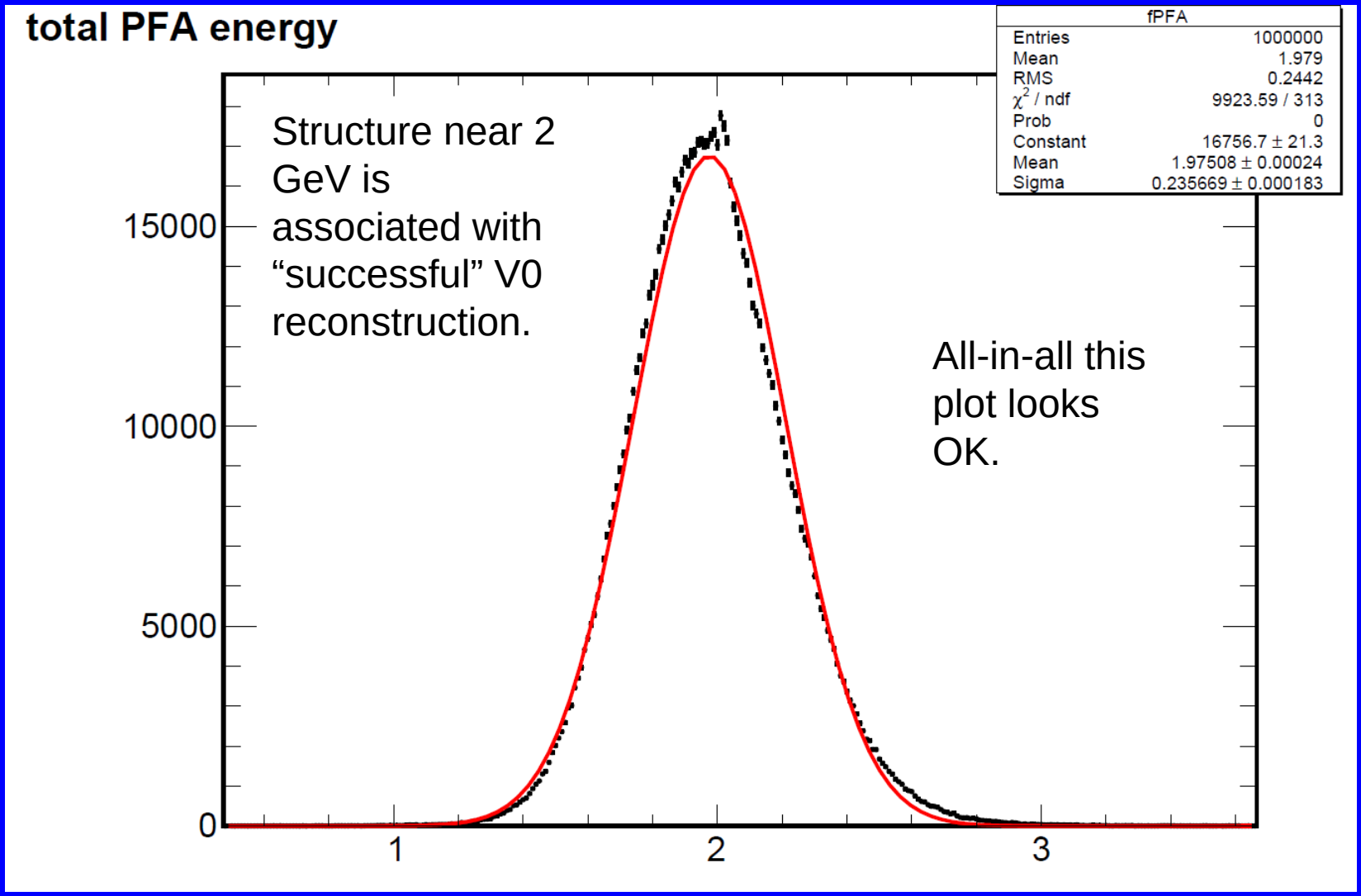


Here particles with 2 GeV momentum are smeared by the p_x boost associated with the ±7 mrad horizontal crossing angle. Not at all good for momentum resolution studies …

Photon Reconstruction Study

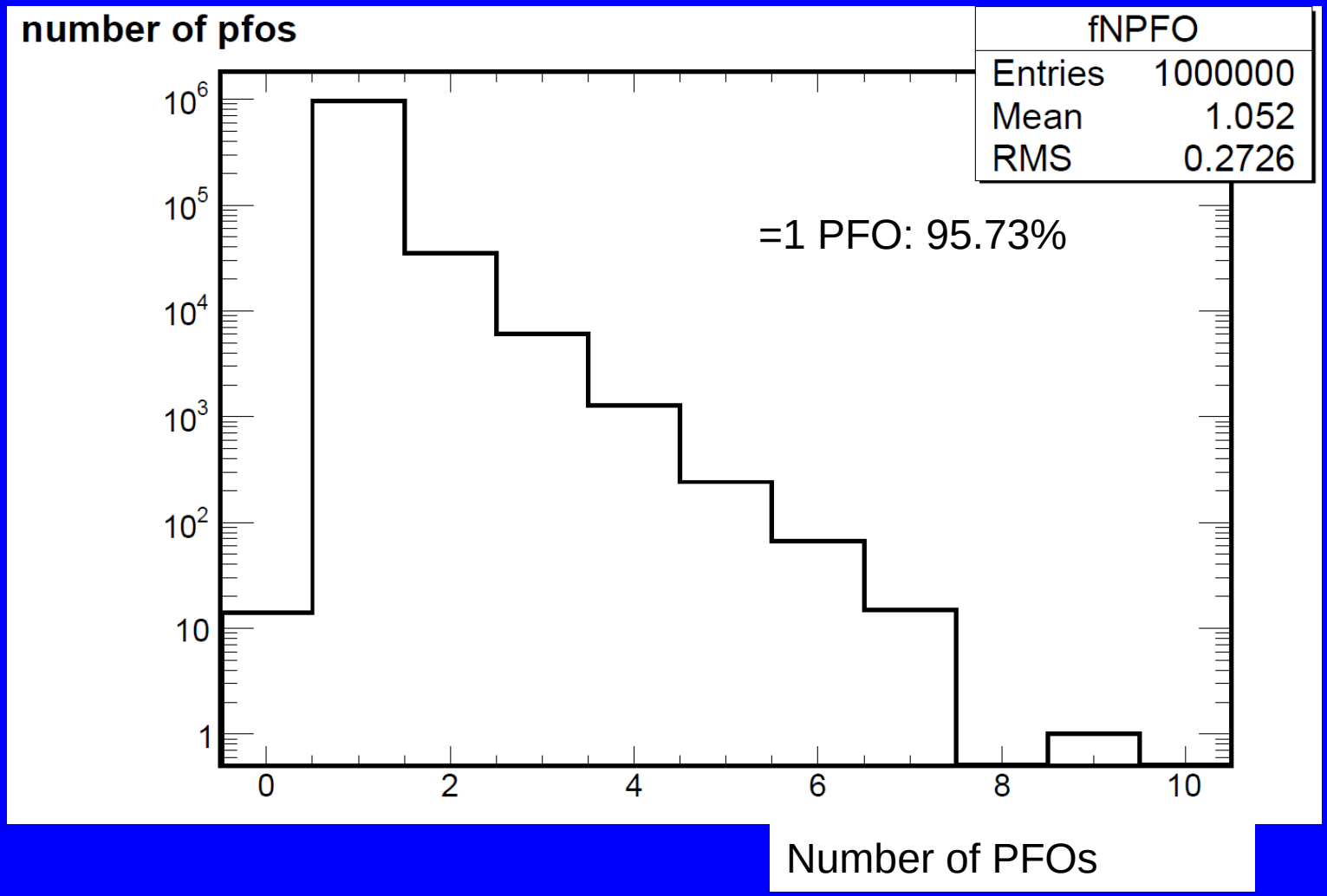
- For π^0 study, typical energy of interest 4 GeV
  - Many of Brian's studies done with 4 GeV pi0
  - So photon energies around 2 GeV
  - Conversion electron energies around 1 GeV.
- Studies indicated a very low reconstruction efficiency for photons with tracks.
- So decided to investigate 2 GeV photon reconstruction with high statistics (to get reasonable statistics for events with tracks).
  - 1 M single photon events with energy of 2 GeV with polar angle of $45° < \theta < 135°$

2 GeV photon sample

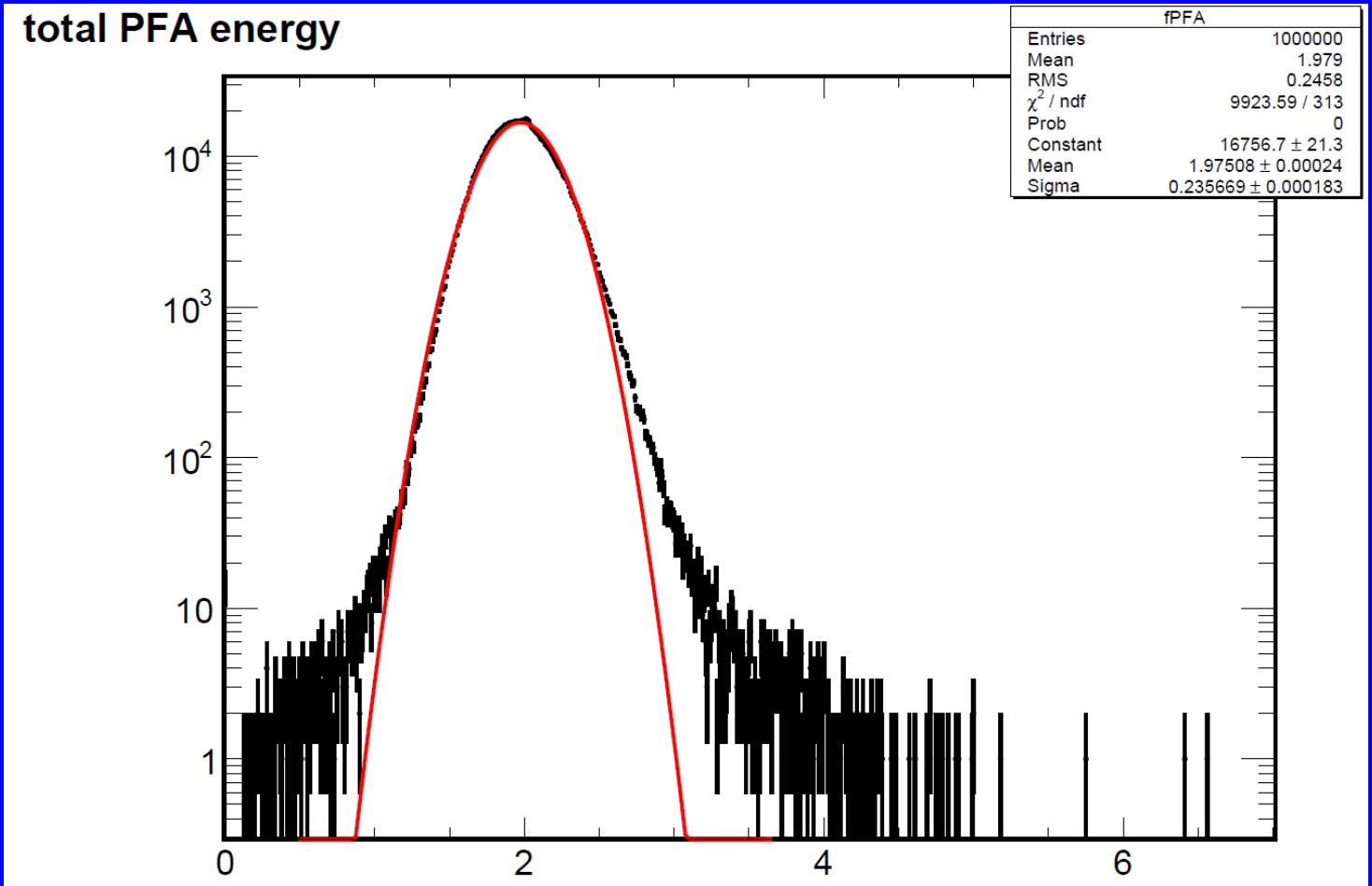


2 GeV photon sample

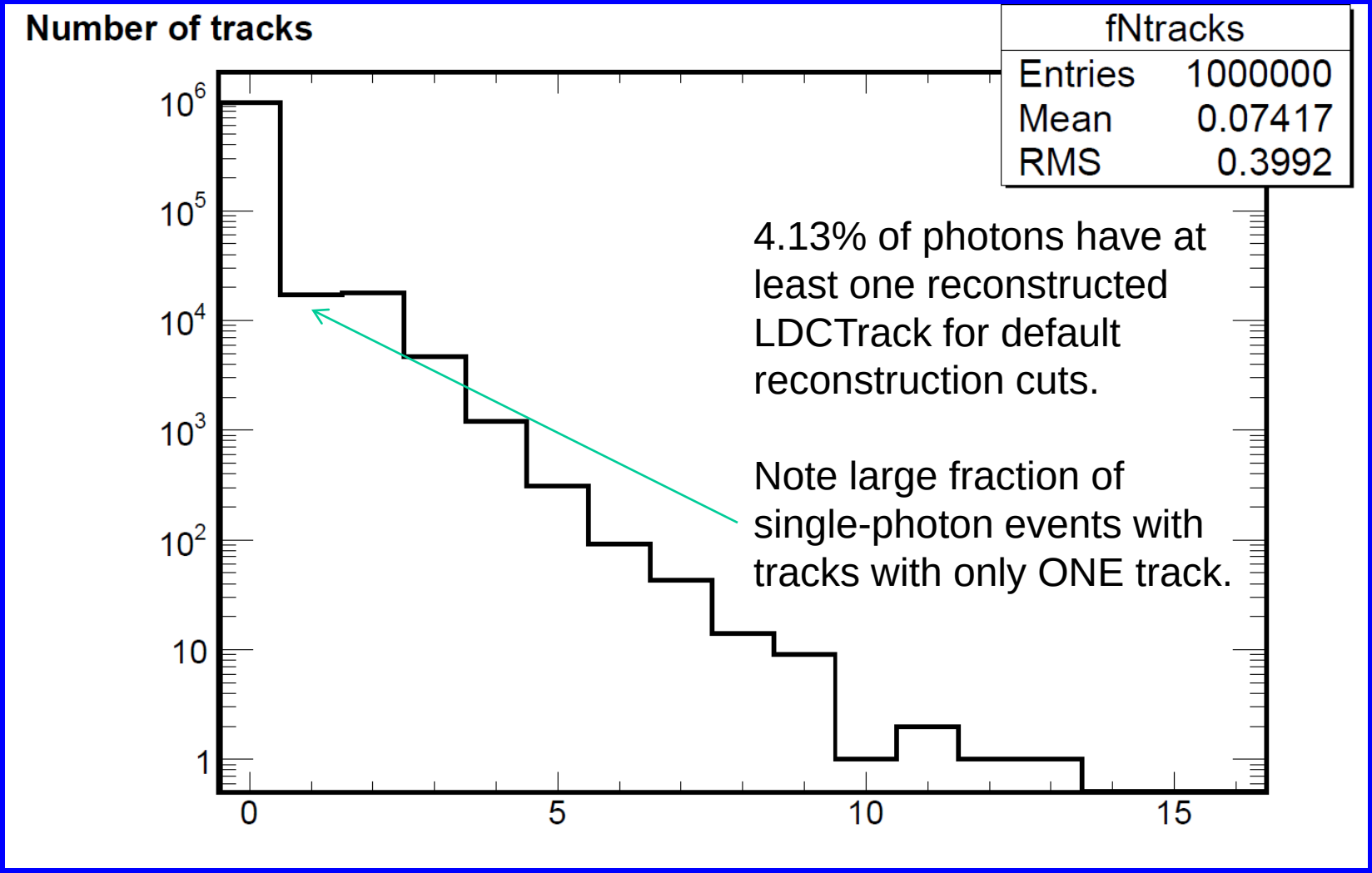
But sometimes there are many PFOs found (and the PFO may not be identified as a photon)



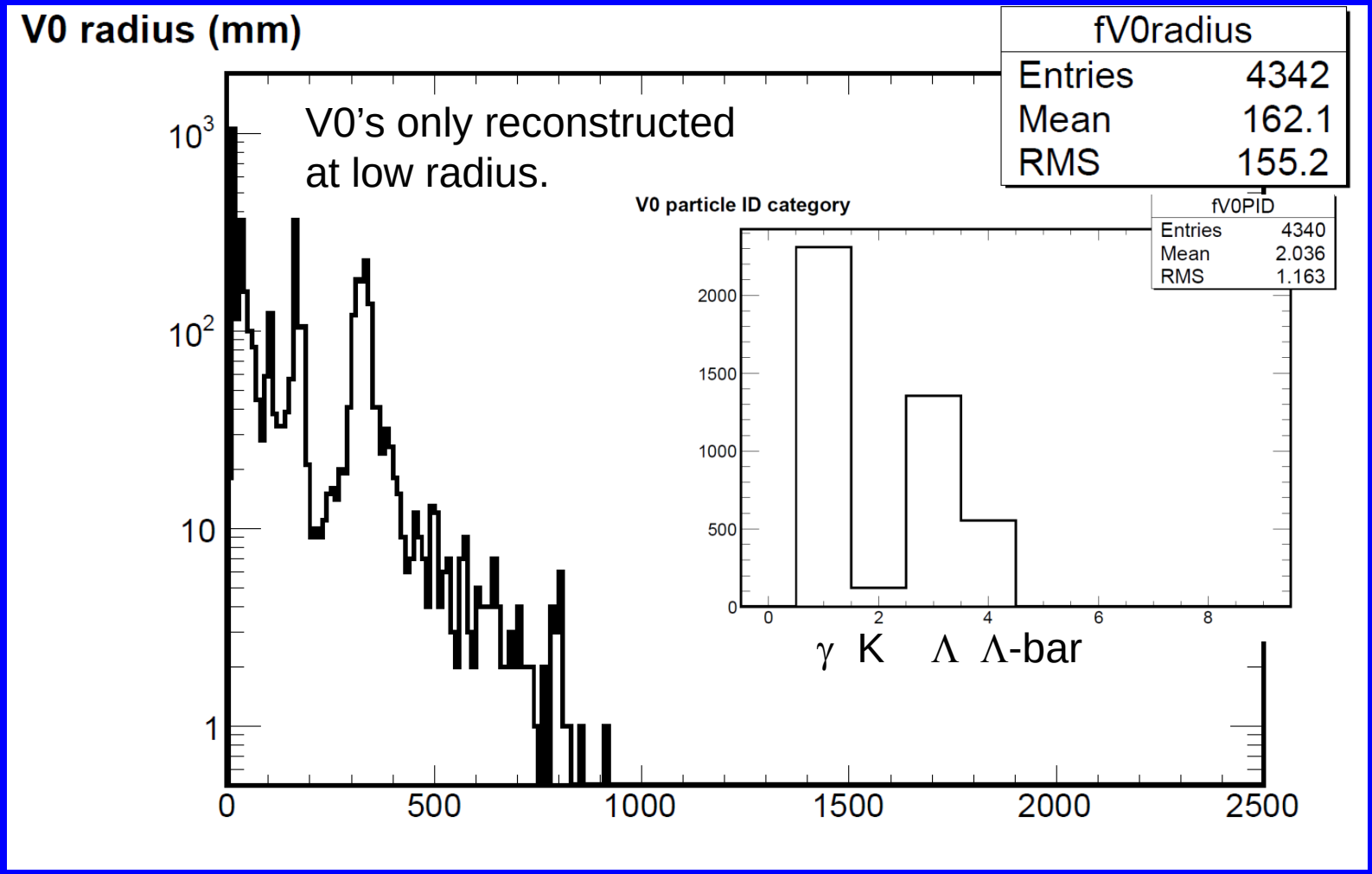
2 GeV photon sample



2 GeV photon sample

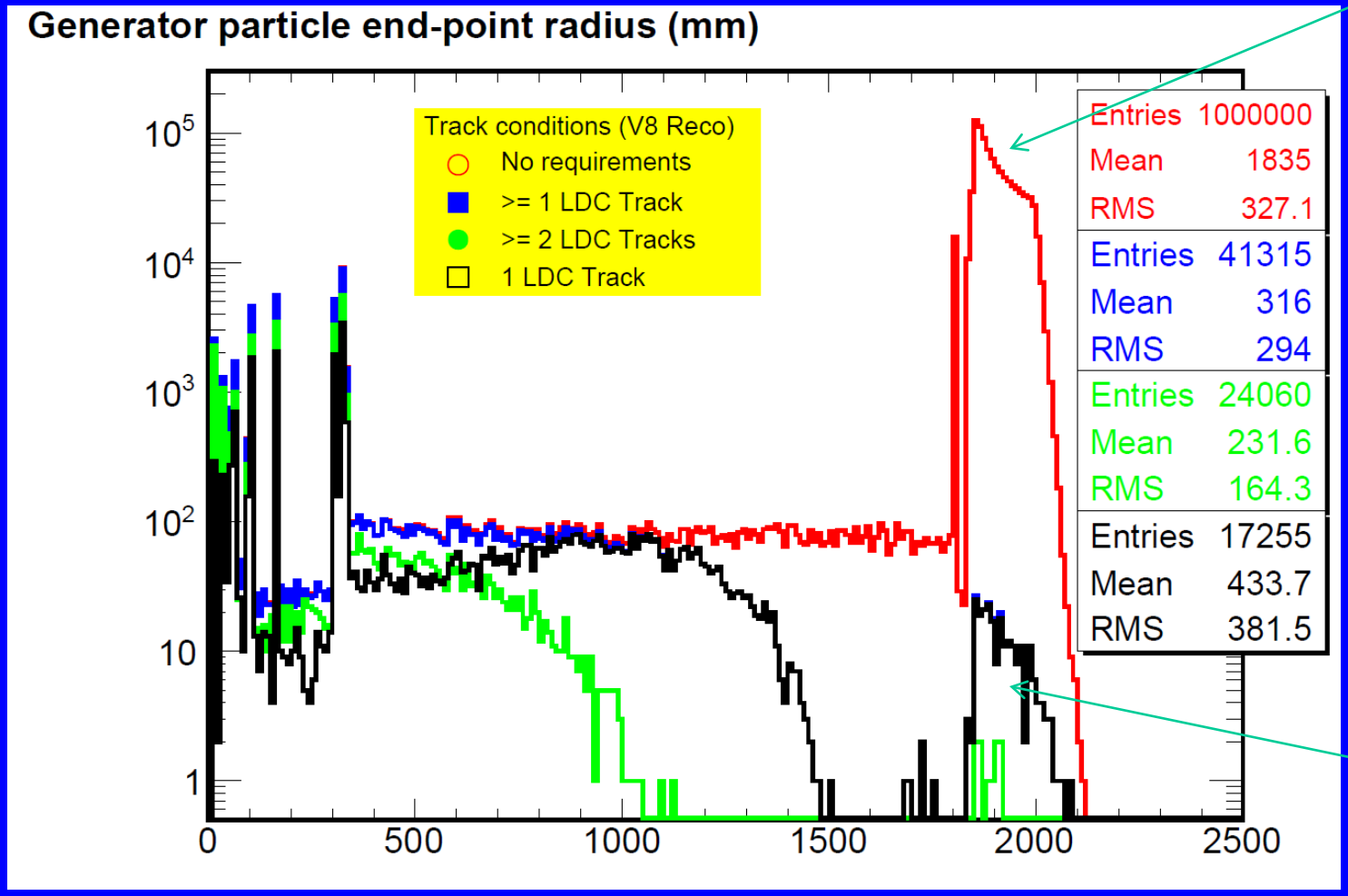


2 GeV photon sample



But only 0.43% of photons are reconstructed as V0's (and only 0.23% ID'd as photon)

2 GeV photon sample



Interact in ECAL

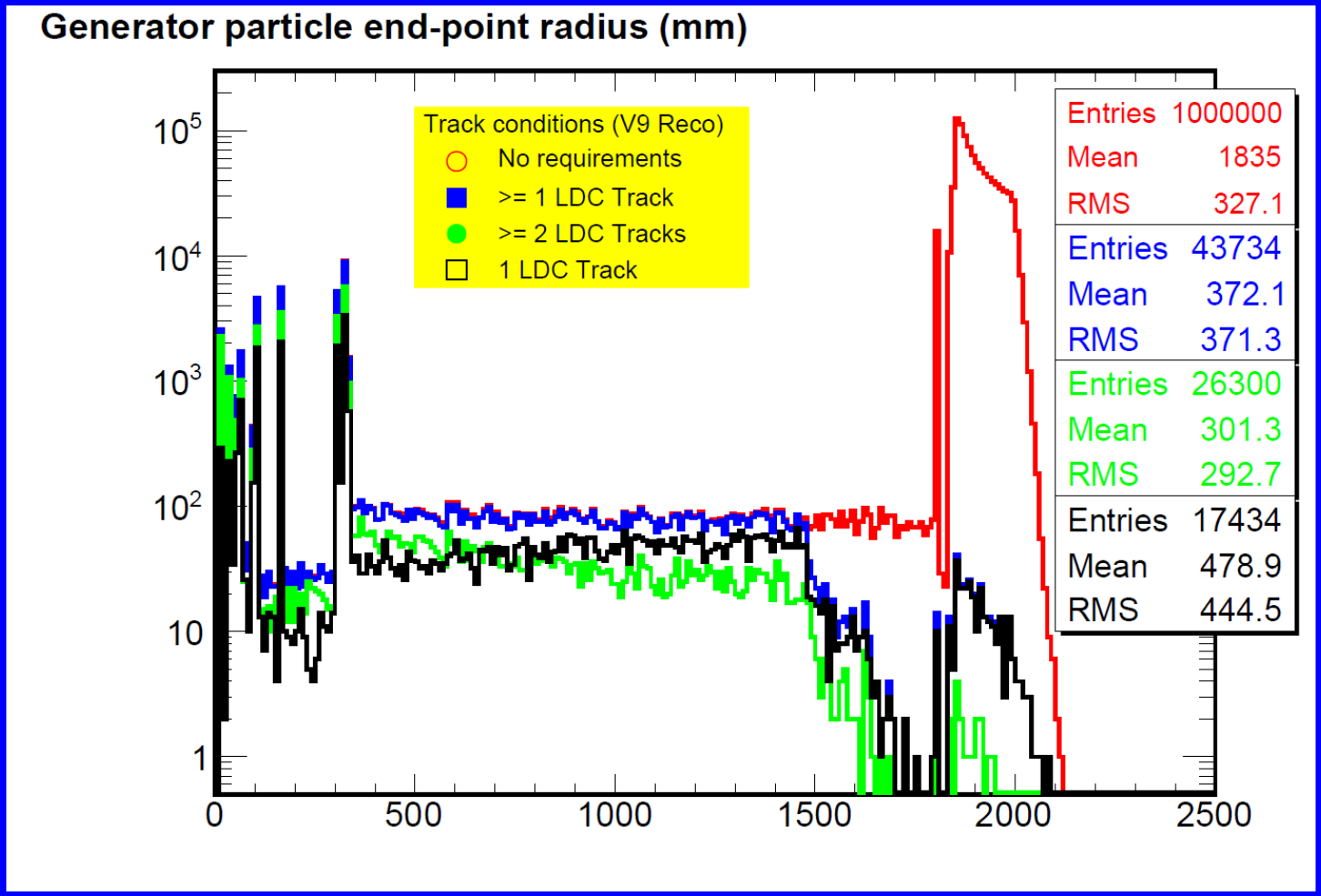
Back-scatter from ECAL

We saw that the V0finder algorithm performance is poor for photons. But one does not even find at least two tracks (green curve) very often for conversions at r > 40 cm (the TPC tracking volume).

Have explored changes to FullLDCTracking processor

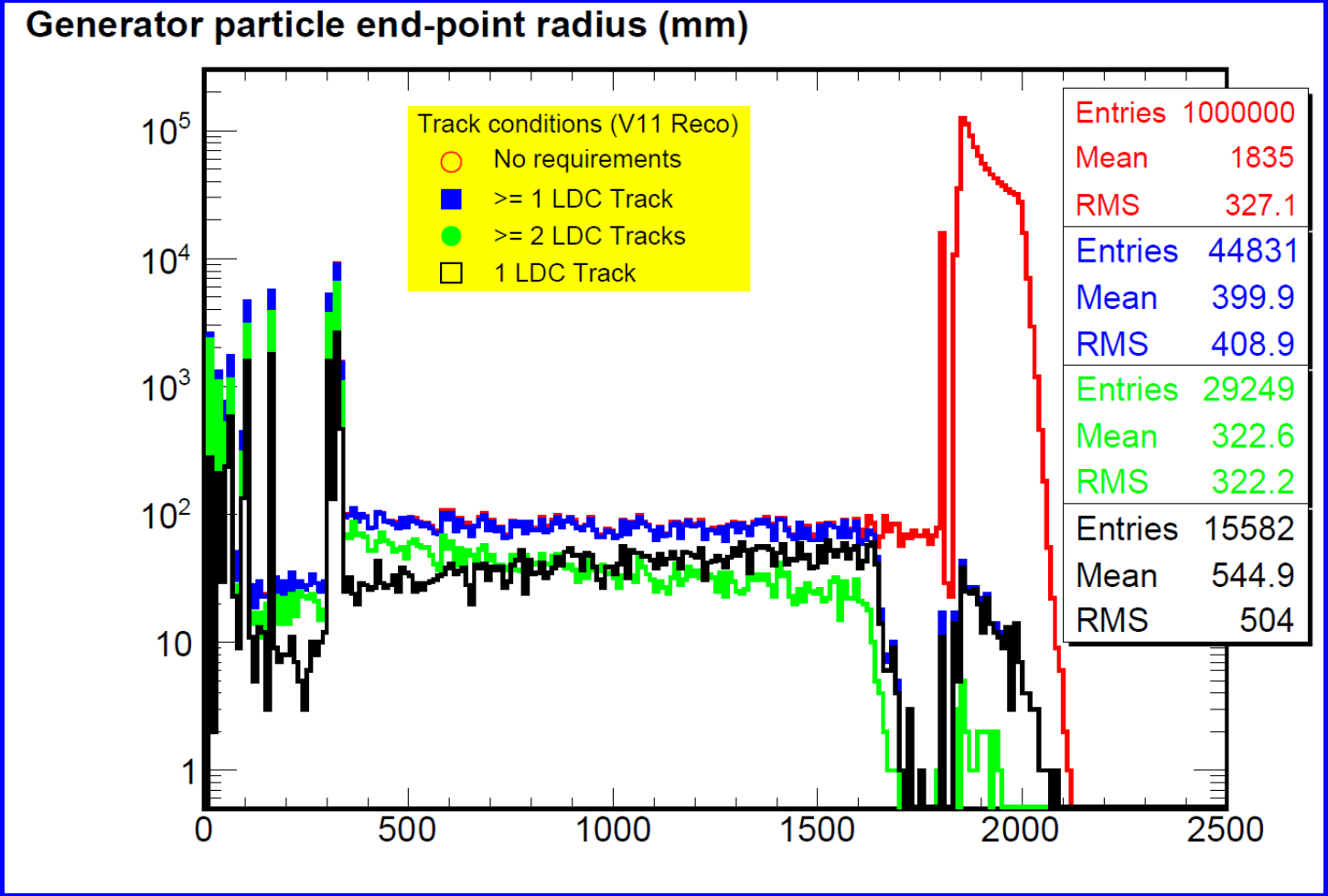
- V8: Standard cuts
- V9: Loosen D0 and Z0 cuts from 500 mm to 2000 mm
- V11: Loosen TPC only hit requirement from 35 to 15.

2 GeV photon sample (V9 Reco)



Extends 2-track efficiency to 1500 mm. Although still not so efficient.

2 GeV photon sample (V11 Reco)



Helps increase TPC fiducial length by another 12 cm or so (still useful in comparison to ECAL measurement for low energy photons).

Conversion summary

- V0finder efficiency for conversions very poor.
  - (Note: In OPAL we used dE/dx extensively in conversion finding.)
- LDCTrack efficiency for conversions could be improved substantially – but still not great.
  - Two hit resolution ?
- Did not find time yet to dig as much as planned into what is going on with V0 finding.

R<40 cm Efficiency	>=1 track	>=2 tracks
V8	99.50%	64.5%
V9	99.55%	64.8%
V11	99.66%	70.8%

40<R<160 cm Efficiency	>=1 track	>=2 tracks
V8	66.7%	17.3%
V9	89.7%	38.3%
V11	97.2%	46.4%

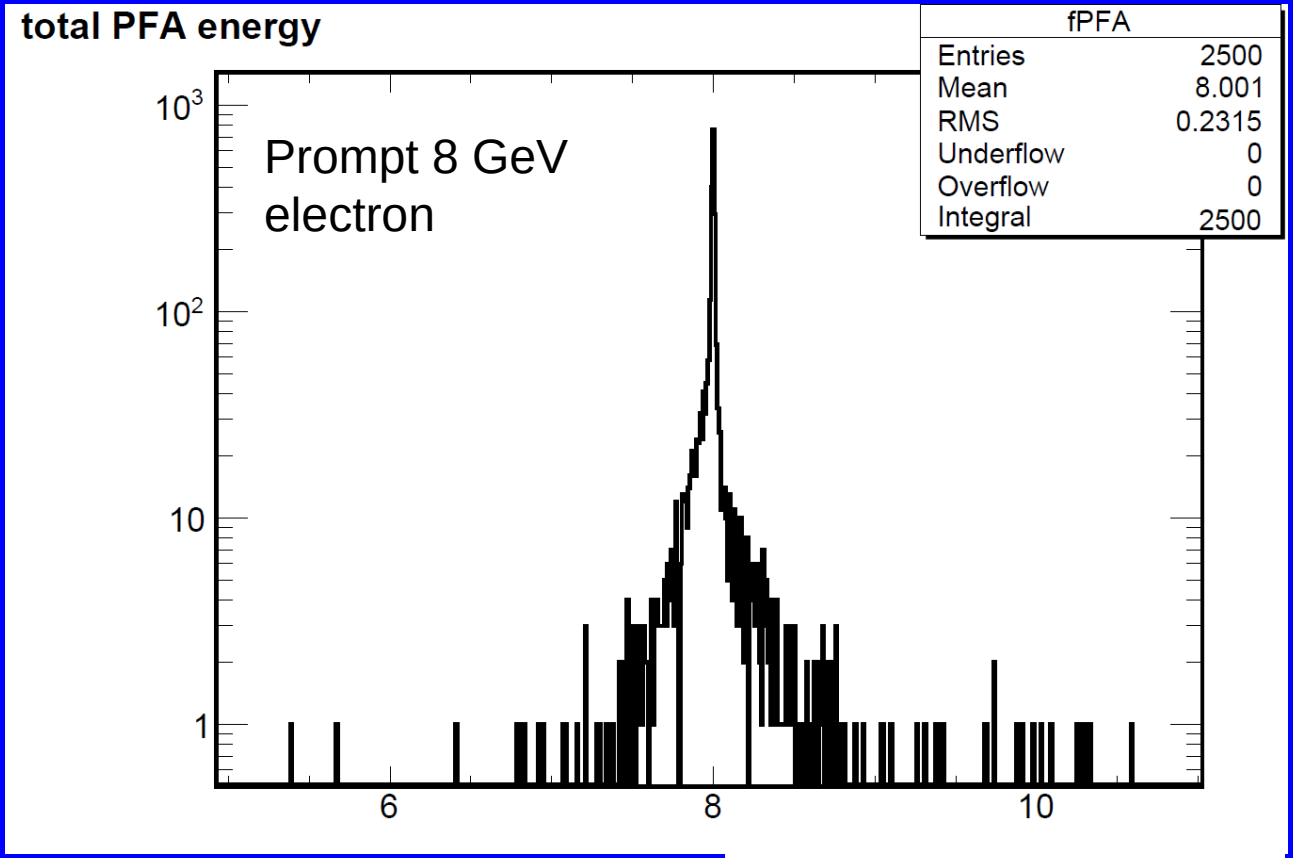
Is the problem tracking ?

- Clearly highly efficient tracking even for electrons for reasonable pT tracks coming from IP. (barrel)

Electron pT (GeV)	>=1 LDC track efficiency
2	99.98+-0.02%
1	99.97+-0.02%
0.5	99.96+-0.02%
0.25	99.91+-0.03%
0.125	97.0+-0.2%
0.0625	1.09+-0.10%

- Similar picture for mu-, mu+ and e+.
- Did not yet check for tracks with origin far from IP (did try … but not as trivial for me as I had expected … see later remarks).

Are there problems with charged particle energy reconstruction ?



Looks pretty good ! (but wait …)

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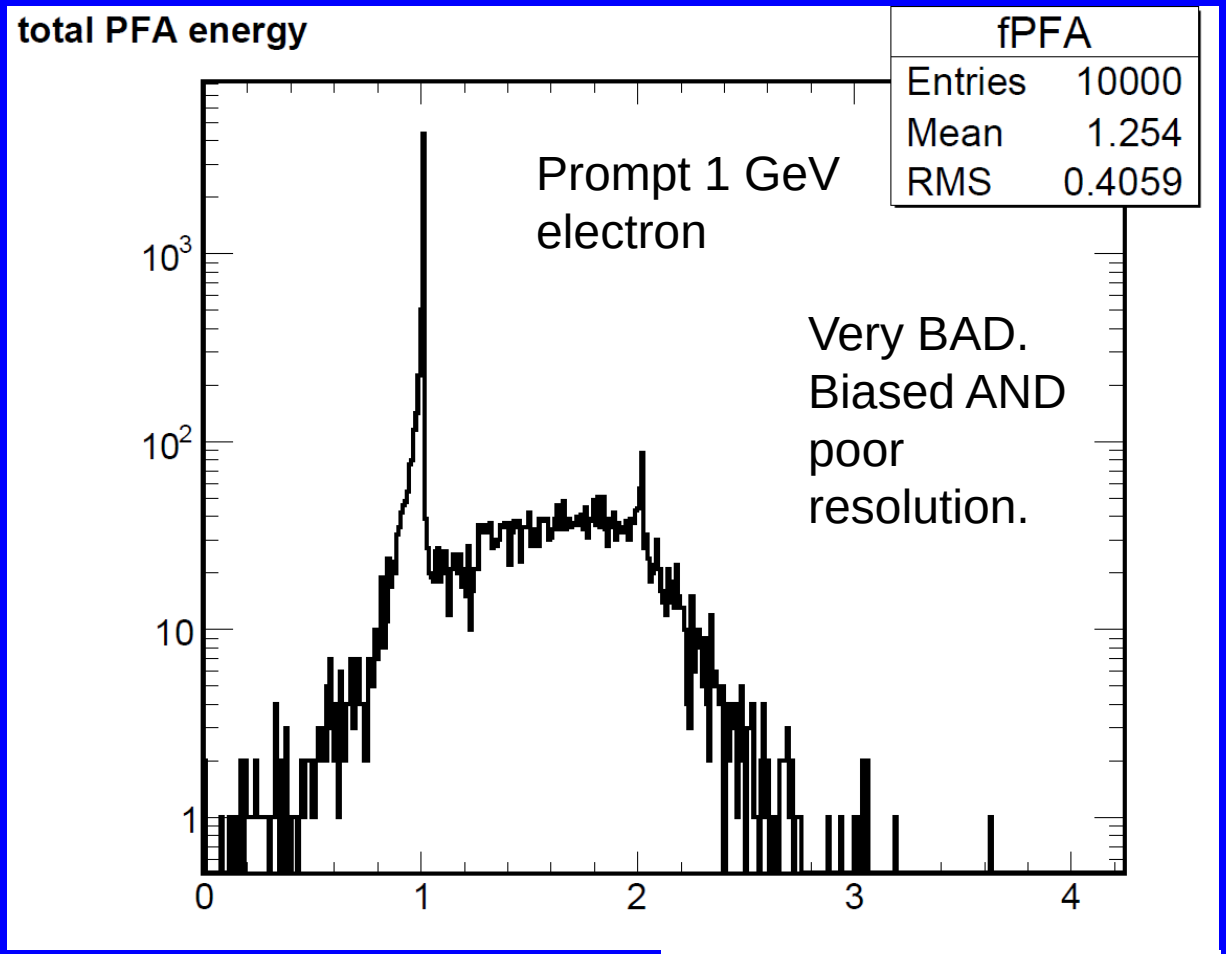

Looping pT is 0.91 GeV.

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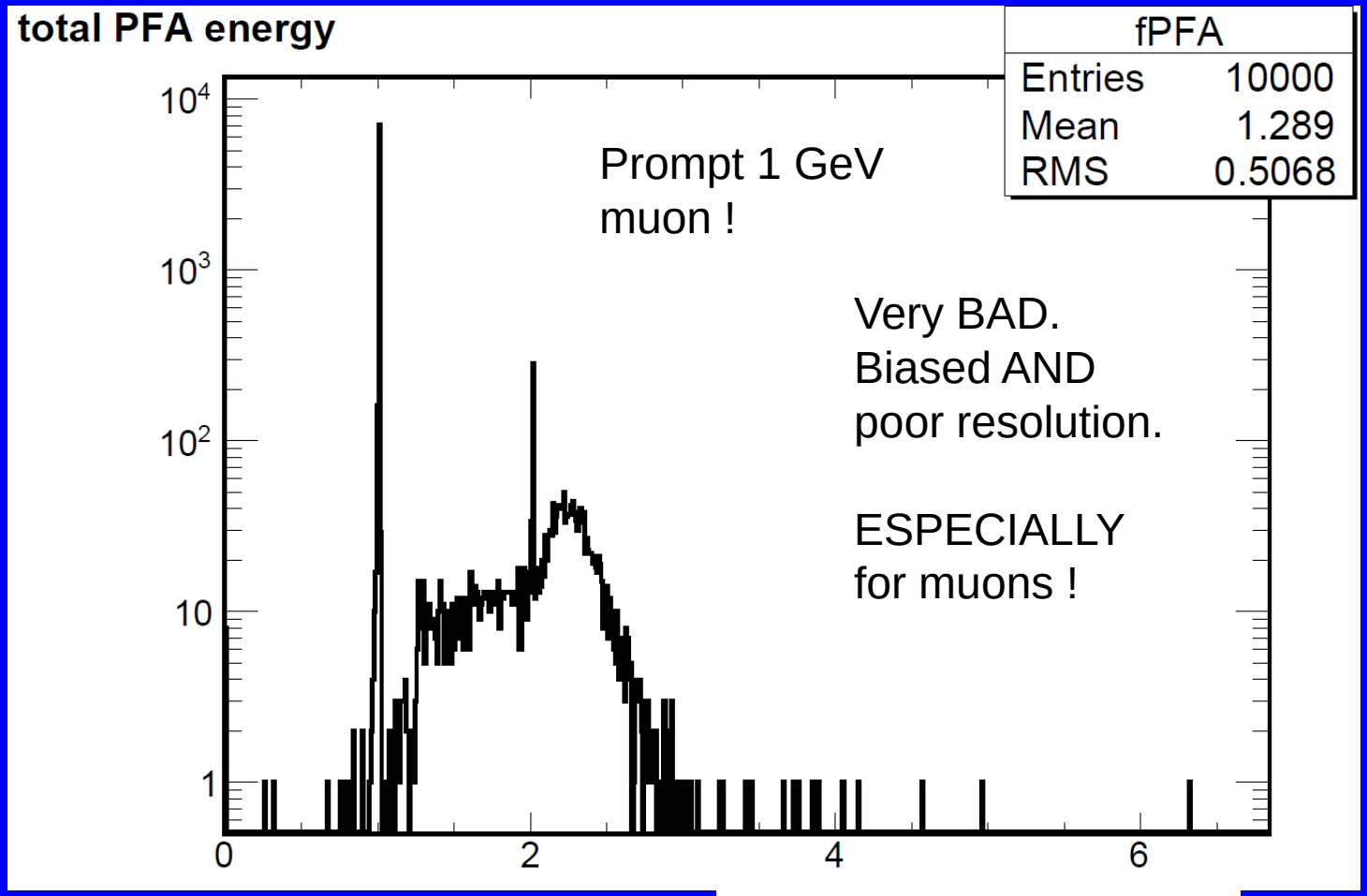

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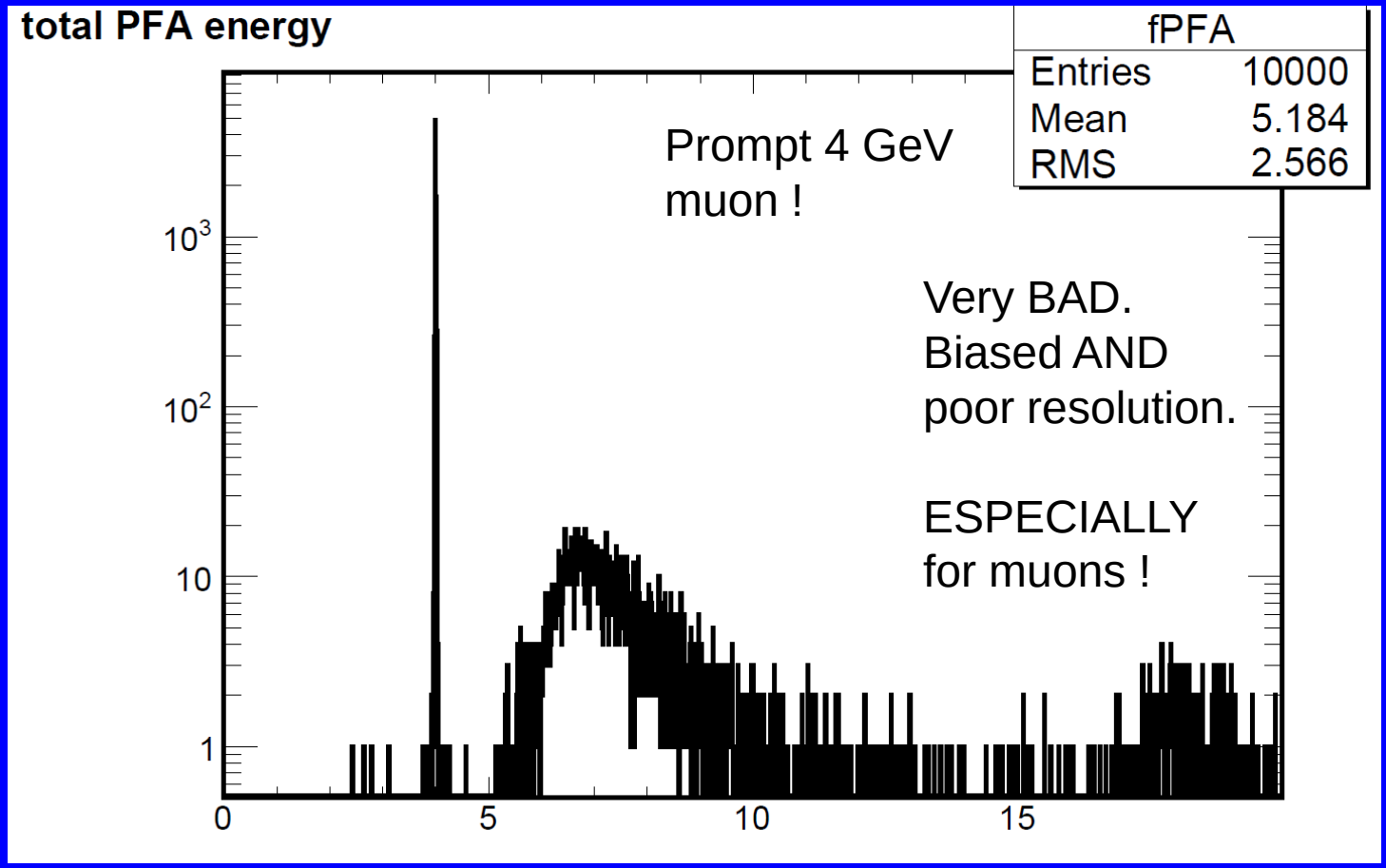
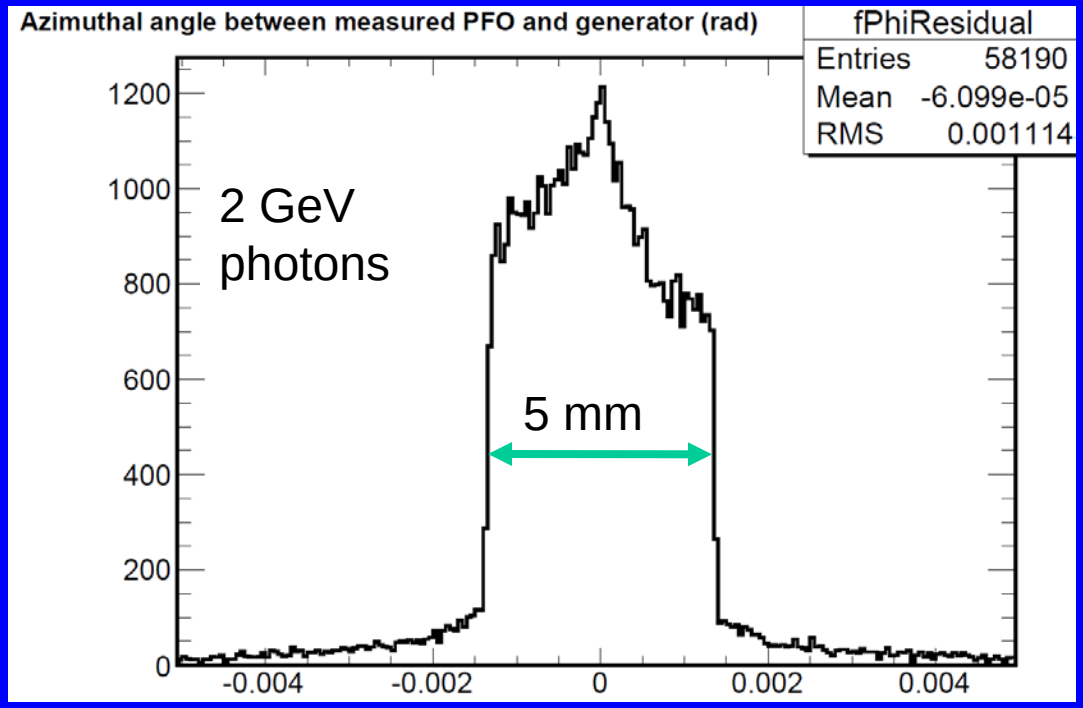


Particle Response Calibration

- I demonstrated how it is relatively straightforward to get something akin to “confusion” in single-particle events, particularly in the regime where charged particles loop.
  - I strongly suspect that (a multitude of) issues like seen here are behind our event-specific bias observations.
- I looked at low energy prompt electrons and muons since they seemed appropriate to understanding conversions – clearly for Particle-Flow other particles are usually of more interest.
- I think we need a systematic approach to characterizing the per-particle energy response calibration.
  - Need this for every detector model, physics list, simulation and reconstruction setting.
  - Ideally corrections would be applied in the reconstruction – or at least be available to the analyzer.

Photon Cluster Position Reconstruction

- pi0 mass-constraint depends on determining accurately the γ–γ opening angle.



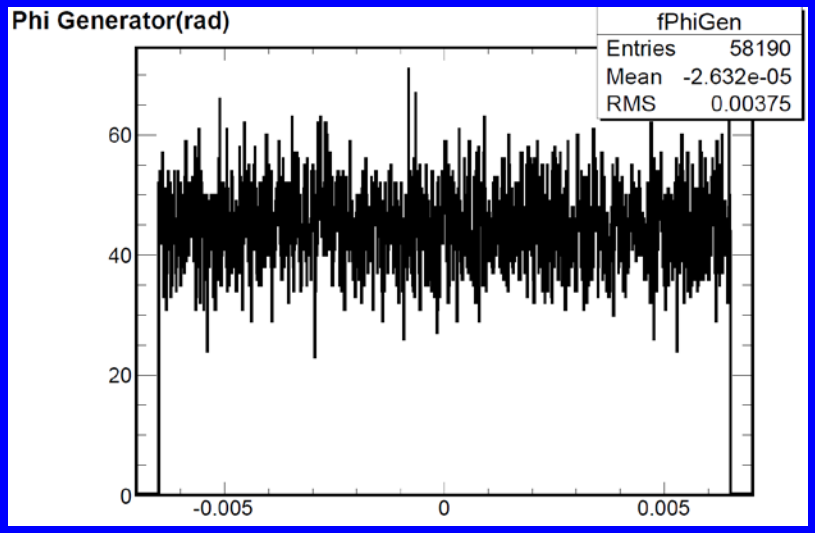
- Planning to investigate other algorithms with better resolution – depend on layers being staggered …

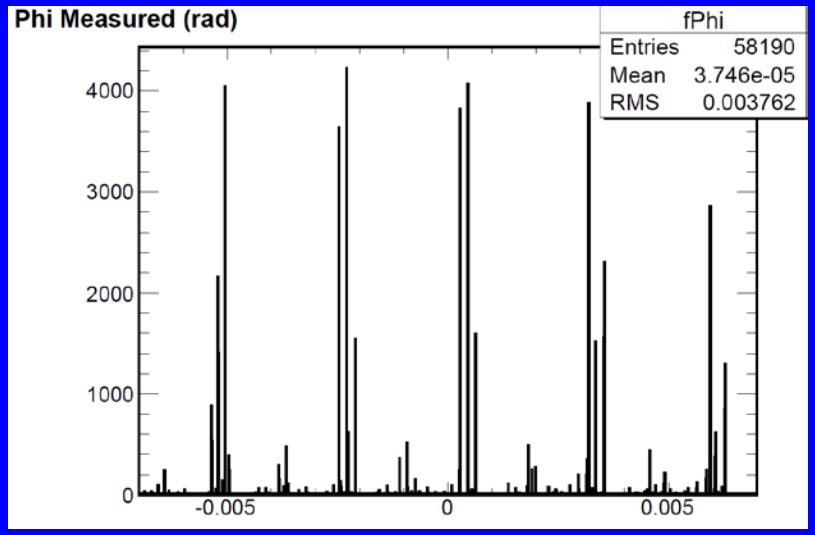
Find that the azimuth is VERY preferentially reconstructed inside the the 5mm * 5mm Si cell, with extremely sharp edges.
Here use PandoraPFANew photon PFO.
Previous study by Brian using PandoraPFA had a Gaussian response function.

Looks like for example the most energetic cell is taken as the position ??

Do we want to stagger the Si wafers ??

Photon Cluster Reconstruction



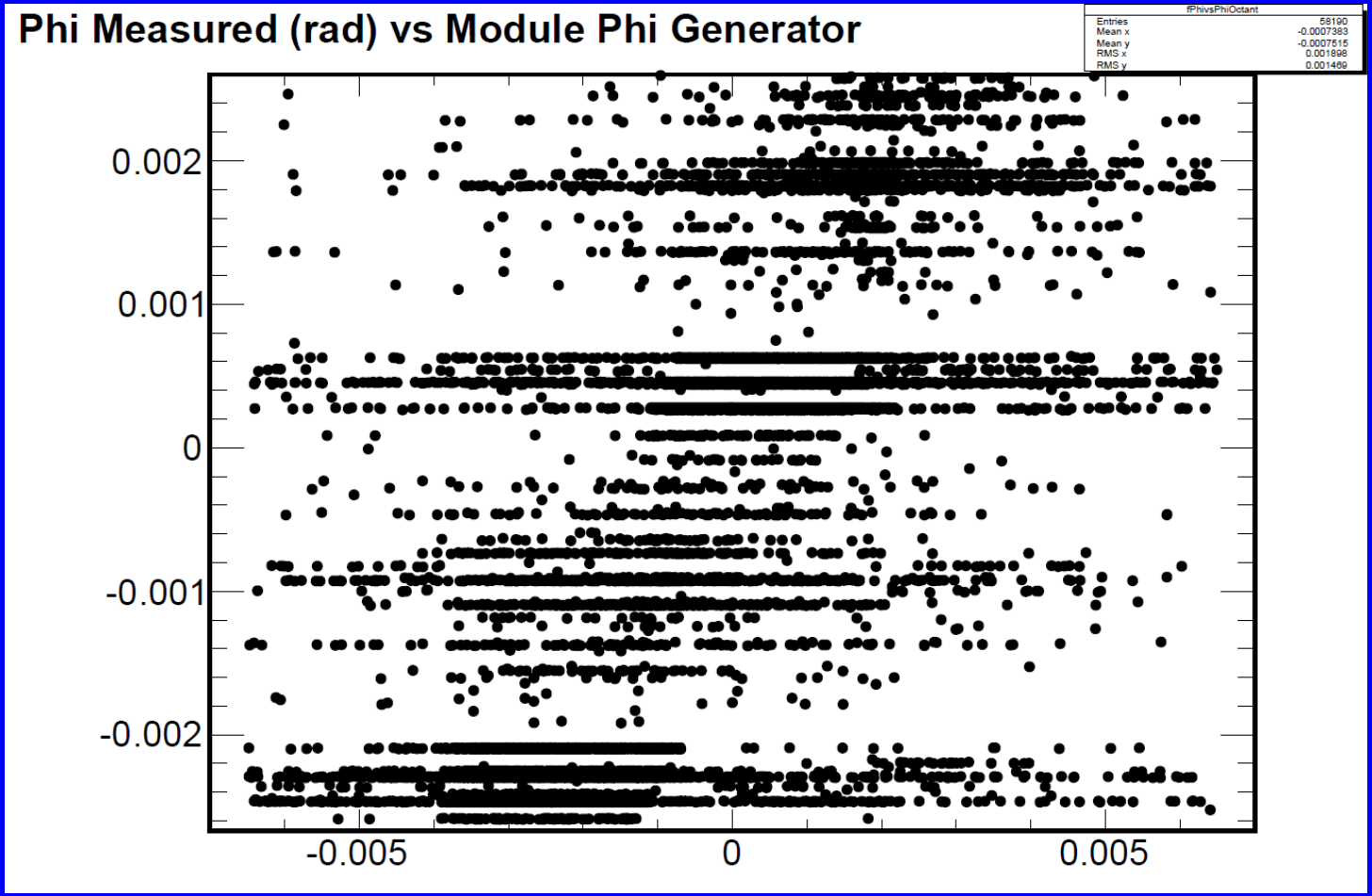


I first observed this issue with the usual barrel photons. Here another 2 GeV sample of photons is generated which have $0.05 < \cos\theta < 0.10$ and have phi very close to the center of a barrel module.

The reconstructed phi exhibits (to an extreme) the usual calorimeter pattern of reconstructing positions close to the center of the cell when using naïve estimators.

I strongly suspect staggered phi in the ECAL wafers would give better performance.
(Effects are less pronounced in θ – but still noticeable near $\cos\theta=0$)

What I thought would be an obvious “S-curve” plot



Study Summary

- Conversions are currently poorly understood.
  - And consequently not useful yet for π^0 study
- Suspect that there are quite a few problems associated with loopers.
- We need a systematic approach to the calibration of reconstructed particles.
- Interested in improving photon position reconstruction (old study demonstrated 300 μm for 1 GeV photon feasible)
  - Will likely need ability to offset different ECAL layers at the fraction of a cell-size to properly optimize.
  - Looks like photon reconstruction has changed considerably ?

Some more technical issues

- On Friday, the DESY AFS based ilcsoft v01-09 on slc4 32-bit was broken (changes to root 5.26.00b)
  - Not sure if it is now fixed – but managed to work-around by switching to the local copy that I had intended to use a while ago (I lost quite a bit of time on this …)
- I started some studies with displaced single particles to understand tracking efficiency vs vertex position using the stdhep generator that I had used for similar (old) studies with SLIC.
  - Mokka ignored the macro-scopic particle vertex position encoded in the stdhep files and stuck it at (0,0,0).
    - I guess a switch to force using the input vertex position would be helpful.
    - But also, more generally, don't we need to be able to specify beam-spot and beam-spread information ?? (especially in z).
- Reconstruction repeatability / reproducibility status ?
  - Related to (lack of) control of random numbers

Backup Slides

Versions used for single particle studies.

- Single particle stdhep files produced using java DiagnosticEventGenerator
- ilcsoft v01-09 Mokka, ILD00 detector
- reconstruction using the following tags
  - MarlinReco v00-18-03
  - PandoraPFANew tag-1.28
  - MarlinPandora tag-1.13