Tracker Studies

Presentation of Tracking Benefits: Bill Schmidke

This is a follow-up study to Bill's regarding:

- Tracker technology choice?
- Number of tracking layers needed?
- E_γ, X_γ,Y_γ resolution estimates?

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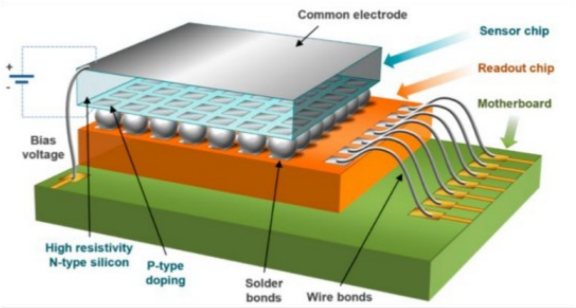
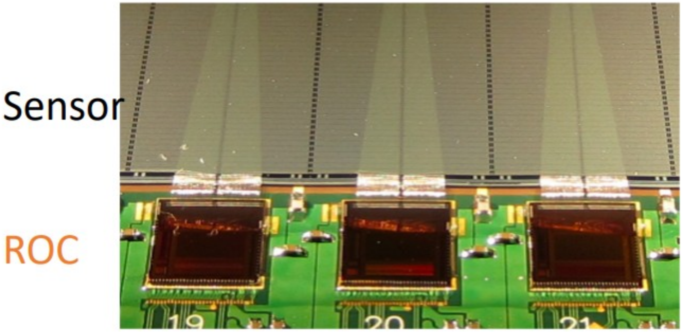
Oct 10th 2023

Tracker Technology --- AC-LGAD



AC-LGAD pixels



AC-LGAD strips

Very rough cost estimate:
$250k

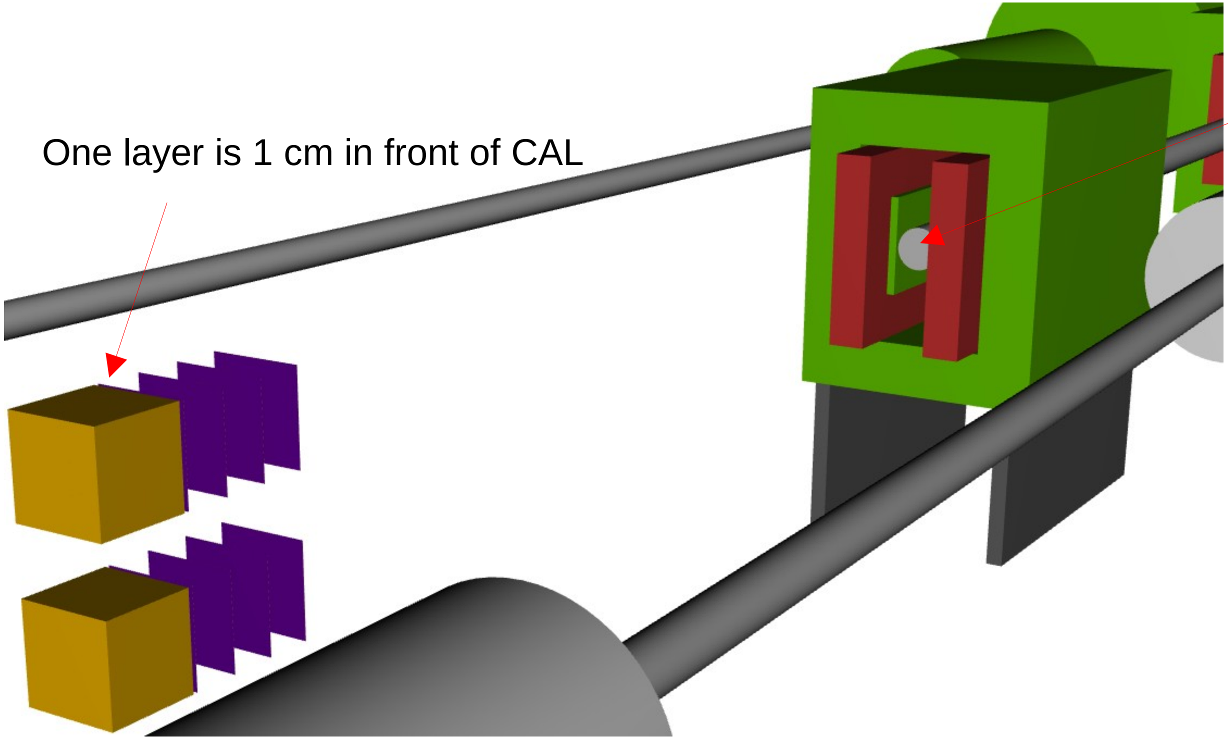
scaled BTOF cost by ratio of coverage areas, 2 tracking layers on top and bottom.

Scintillating fiber trackers might also be an option but engineering costs might not be worth it.
AC-LGAD + ASIC already a developed(ing) technology for ePIC.

Strip type sensors ~1-2 cm long might be suitable (fewer readout channels than pixels):

- Strip pitch = 500 um
- Position resolution perp to strip should be ~ 30 um, with charge sharing and the “1/sqrt(12)” effects. **Much better than what I used in previous studies.**
- Position resolution parallel to strips needs to be quantified but could be good enough, strips read out on both sides.

Simulation Settings

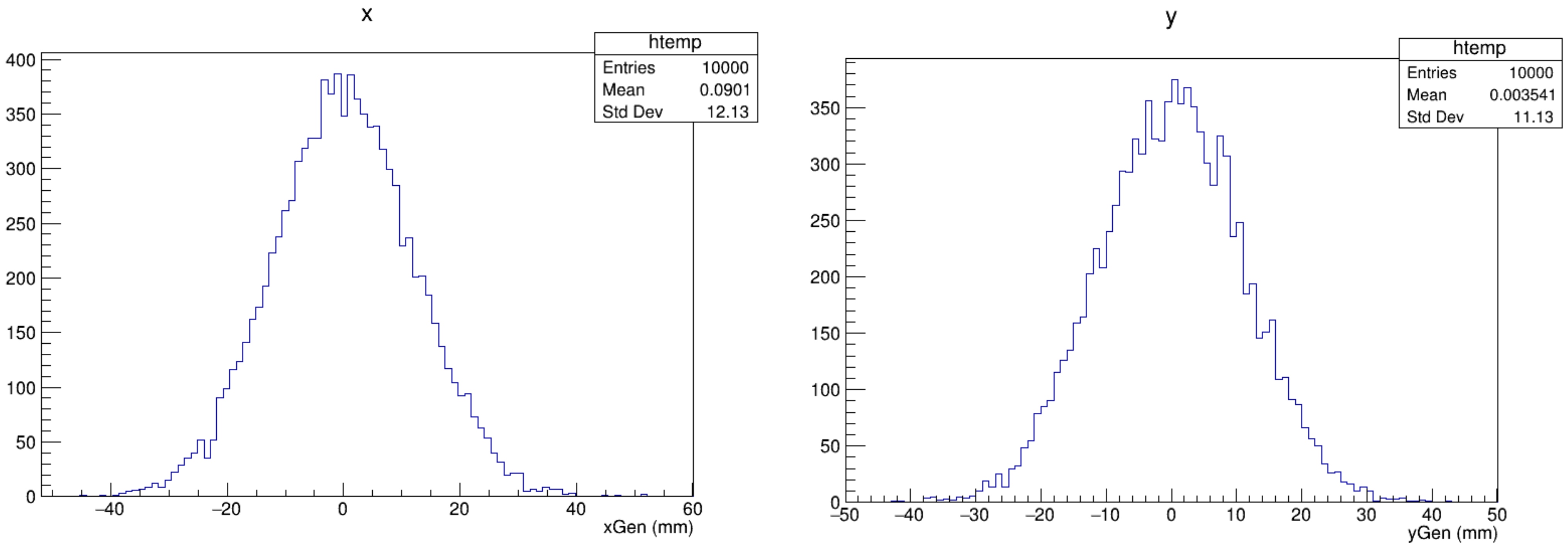


One layer is 1 cm in front of CAL

Exit Cap of vacuum chamber taken as 5 mm of Beryllium
Igor Korover's Studies

- Simulations done using 4, 3, or 2 AC-LGAD tracking layers.
- Material Budget: 0.3 mm thick Si sensor + chips/services/cooling (~1.2% X0).
- 18 GeV photons converting just before analyzer magnet (ideal 1 T*m B field).
- Beam effects turned ON (angular divergence, crabbing, beam energy spread, Vtx smear)

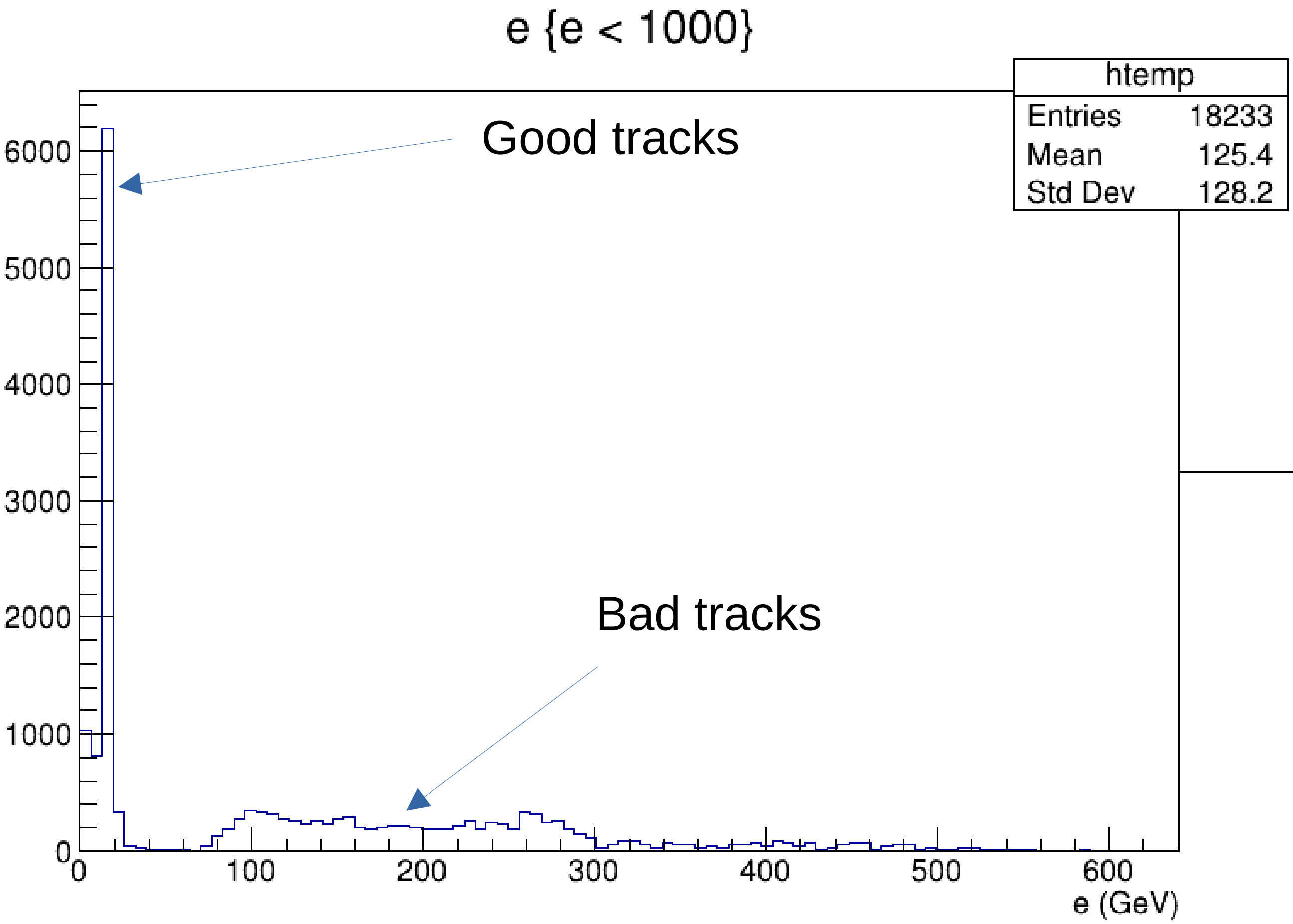
Generated Xᵧ and Yᵧ at entrance of analyzer magnet



- True photon position at IP is X=Y=0.
- Beam effects cause a significant smearing of photon position near the lumi detectors.

2 tracking layers.
Generated
E_γ = 18 GeV

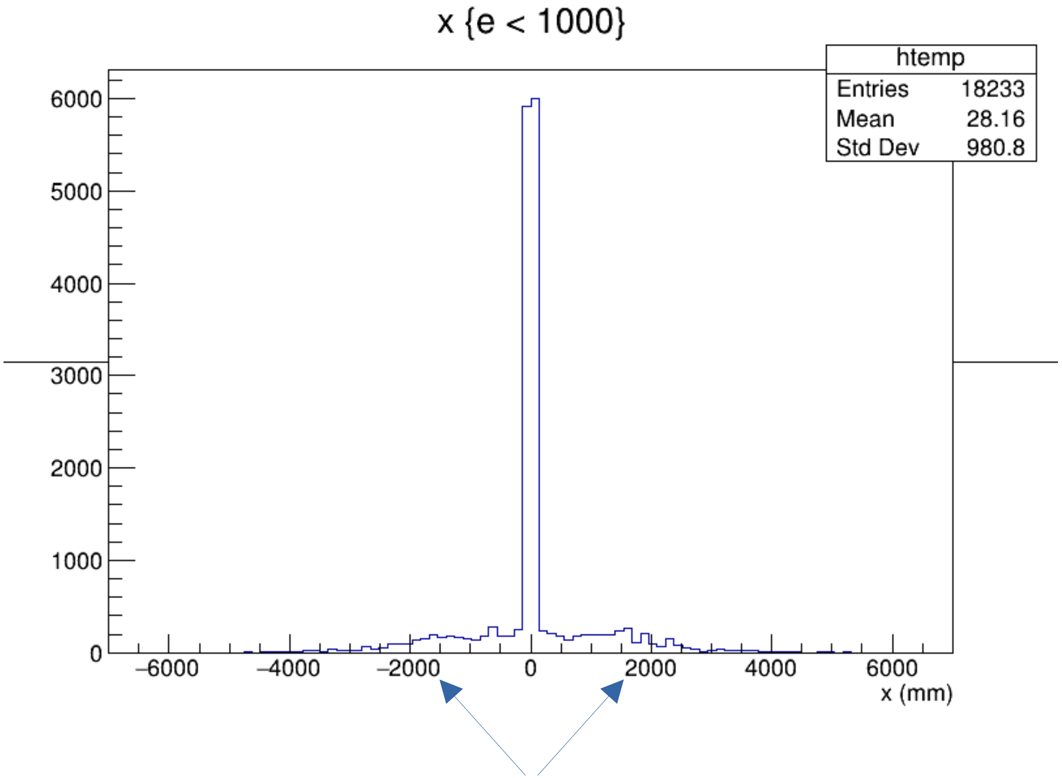
Reconstructed E_γ
No cuts

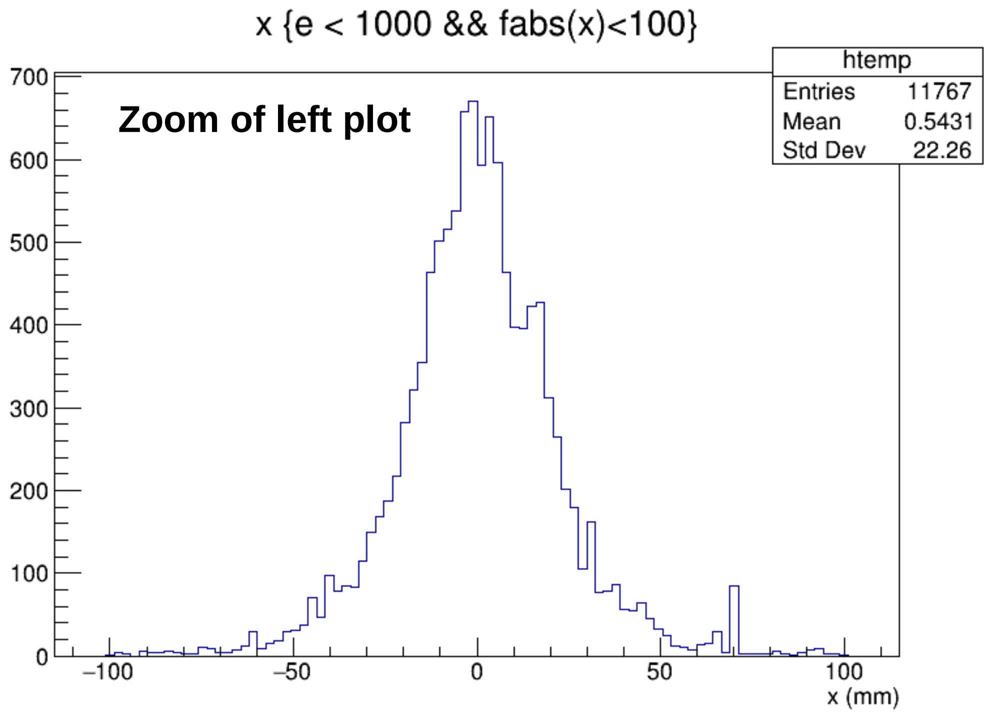


$$E_{rec} = \frac{p_T}{\sin\theta_y}$$

- p_T = 0.3 GeV for a 1 T*m dipole field.
- Need some cuts to isolate the good tracks.
- Clear unphysical energies from shallow angle tracks.
- Secondaries and multiple scattering in trackers/air/exit cap can cause bad tracks

X_γ reconstructed



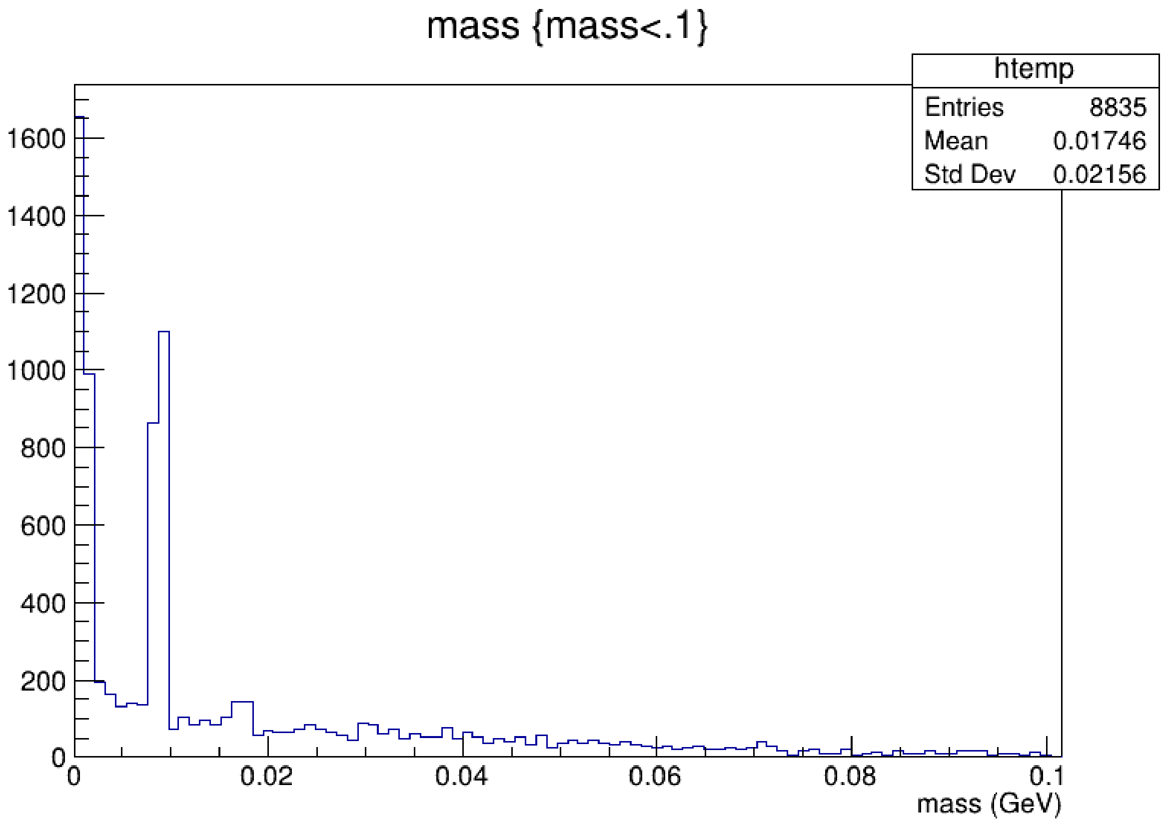


Some tracks clearly way out of range.

Core of distribution looks reasonable.
- Cut-variable candidate.

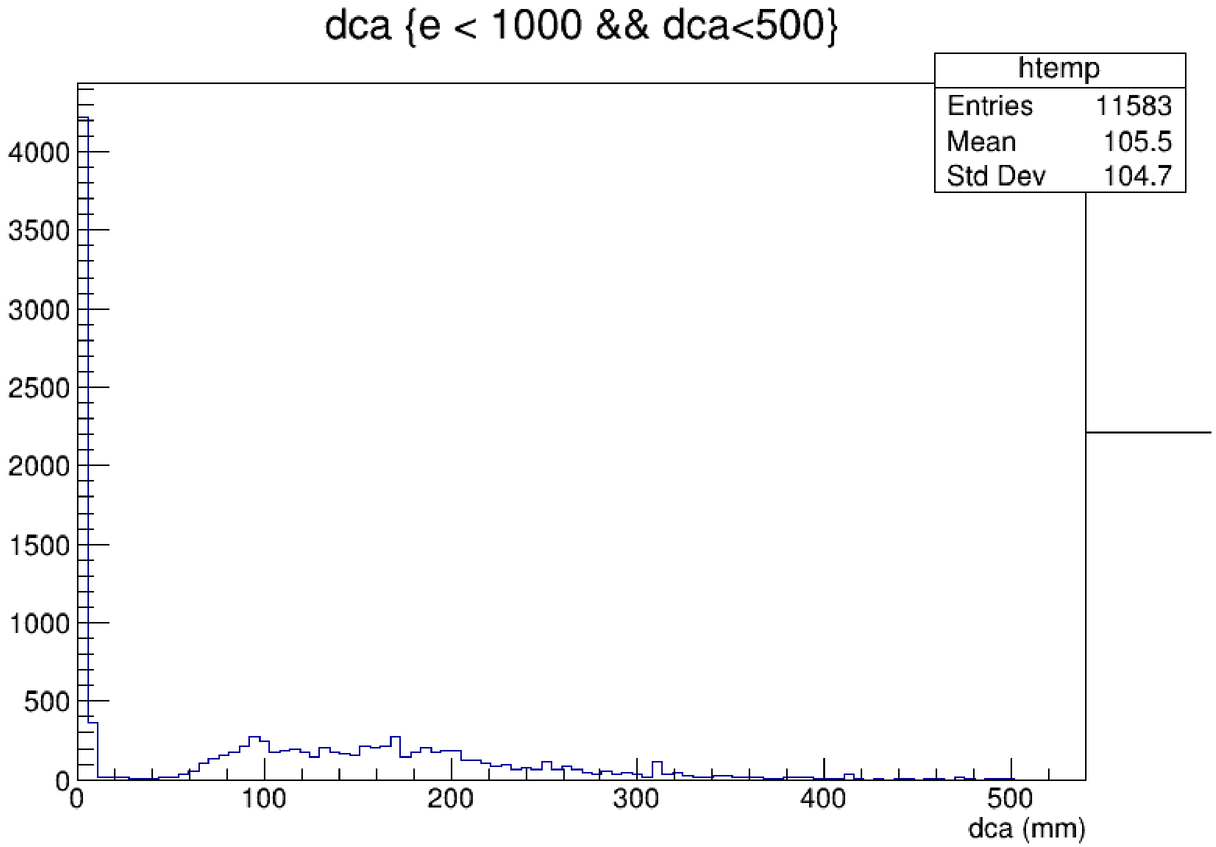
2 tracking layers.
Generated
E_γ = 18 GeV

Invariant mass of e+e- pair



Two peaks at low mass. Both correspond to “good” tracks (pixel discretization effect)
- Good cut-variable candidate.

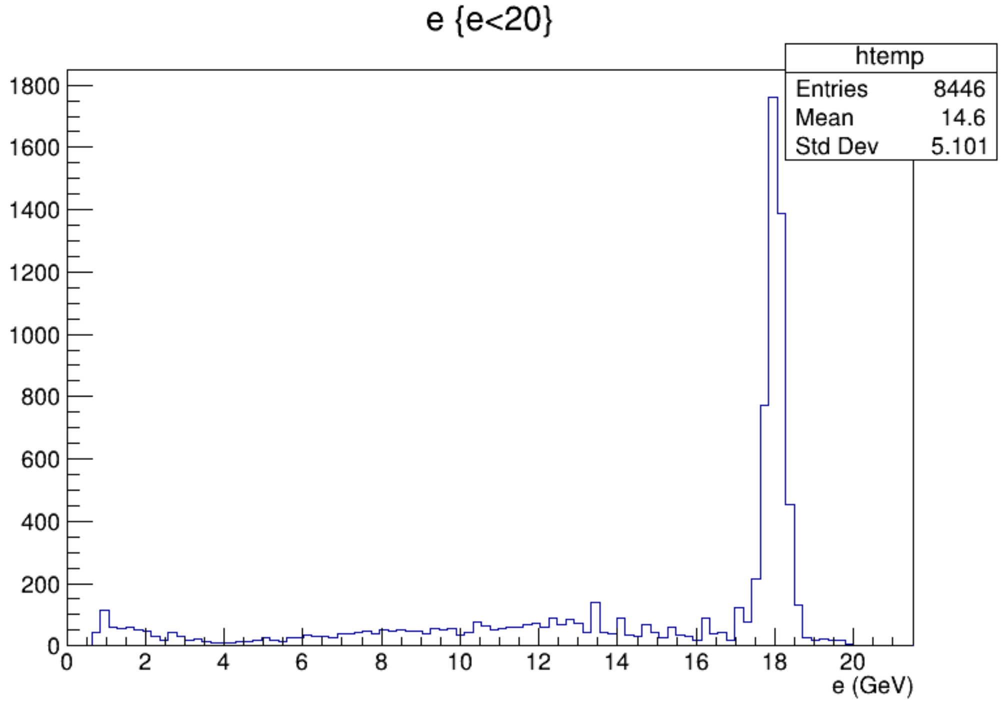
DCA of e+e- pair

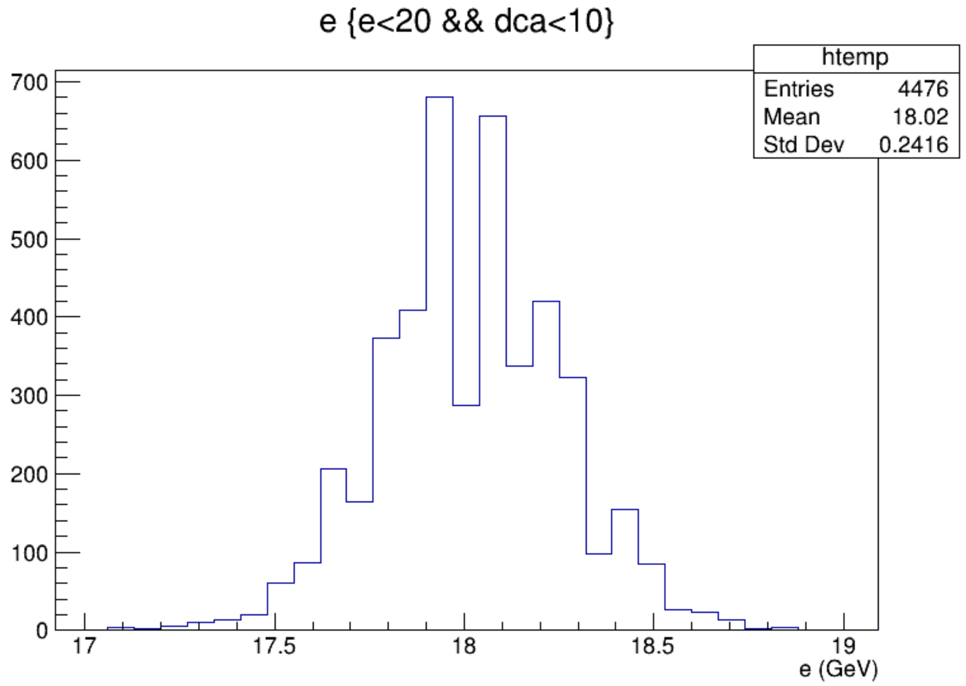


Main peak **is** well separated from the noise.

- **Good cut-variable candidate**

Reconstructed Eγ

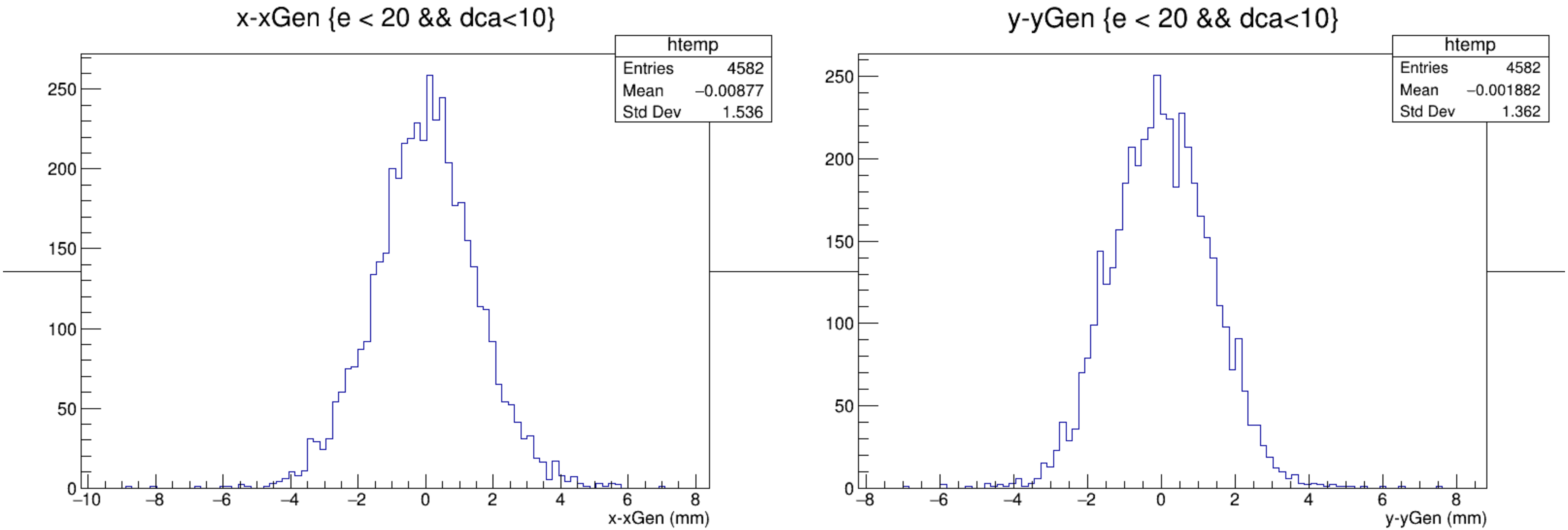




- With an energy and DCA cut, we get a narrow peak.
- $\delta E/E \sim 1\%$
- Should be the same or better resolution at lower energies.

Reconstructed X_γ and Y_γ at entrance of analyzer magnet

2 tracking layers.
Generated
E_γ = 18 GeV



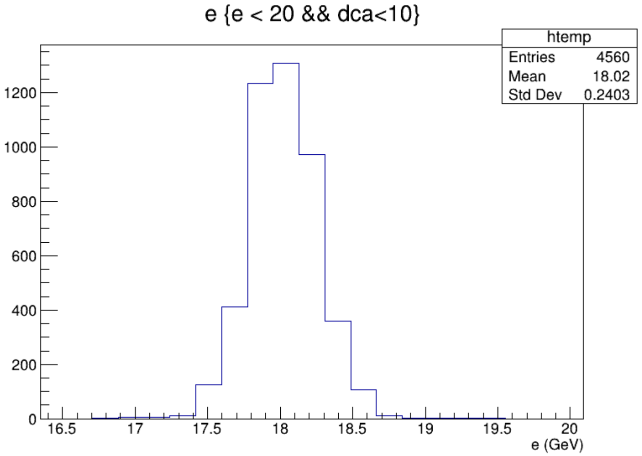
- X_γ and Y_γ position resolutions are ~1.5 mm each.

Reconstructed E_γ for 2,3,4 tracking layers

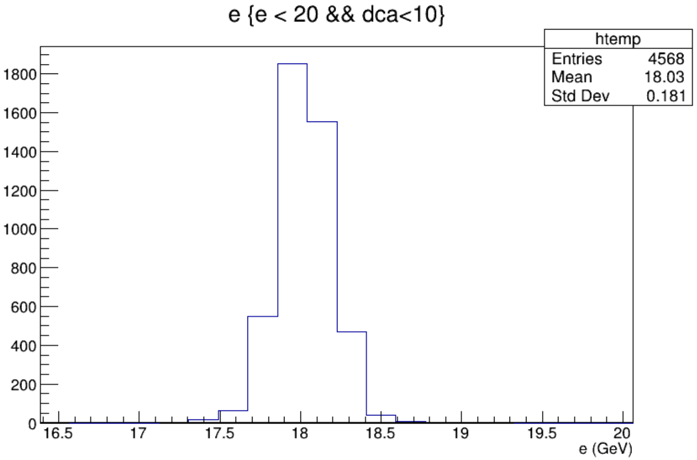
E_γ = 18 GeV

Without Beam Effects

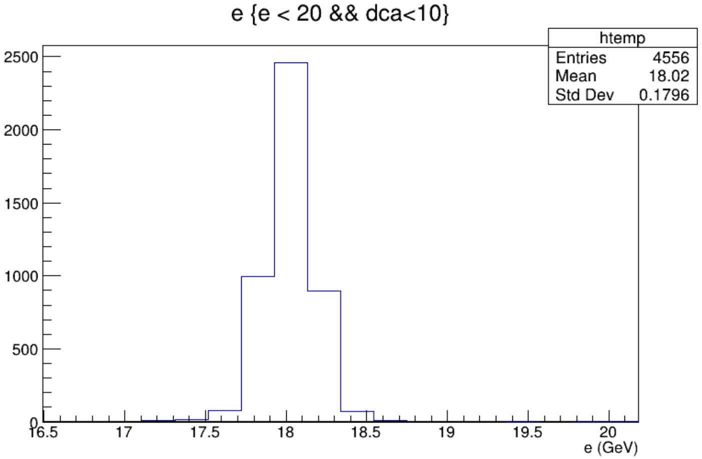
2 layers



3 layers



4 layers



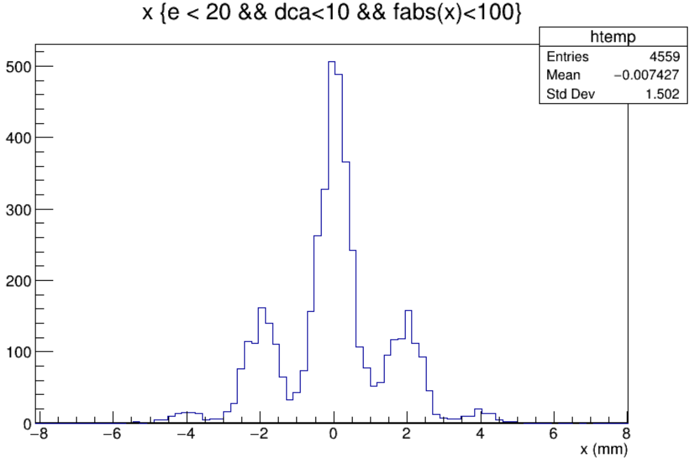
- Only a slight improvement in E resolution with more tracking planes

Reconstructed X_γ for 2,3,4 tracking layers

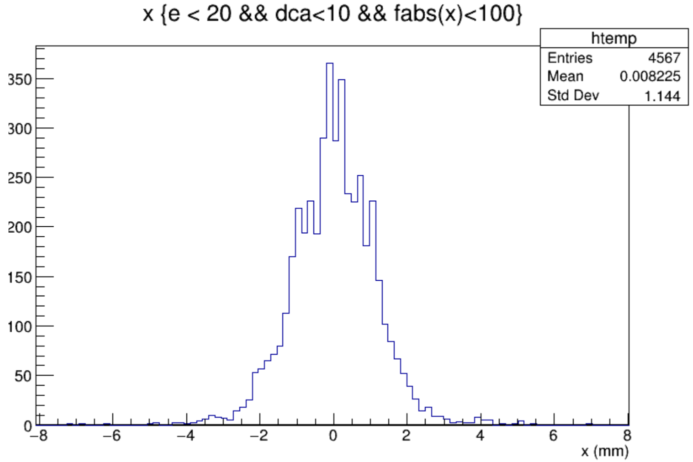
E_γ = 18 GeV

Without Beam Effects

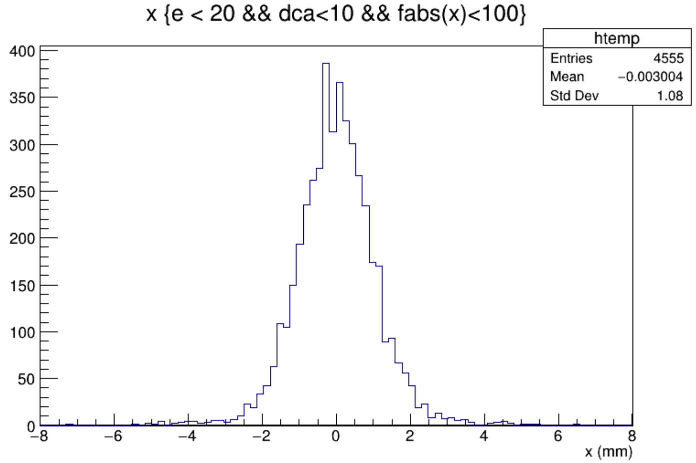
2 layers



3 layers



4 layers



Structures due to
discretization effects
500um strip pitch

- Only a slight improvement in position resolution with more tracking planes.

Summary

- AC-LGAD is a suitable technology for the PS trackers.
- 2 tracking layers should be enough. More layers don't significantly increase energy nor position resolution of photons.
- Energy resolution of photons is ~1-2% (mostly independent of E).
- Position resolution of photons is ~1.5 mm for X_γ and Y_γ. At ZEUS, it was 2.7 mm for X and 7.3 mm for Y (using slit collimator). Fig 16 and 17: Nucl Inst Meth A 565 (2006) 572
  Better measure of photon beam profile with trackers → needed to correct for loss outside aperture.

Side Remarks

- Tracking efficiency of 2 AC-LGAD layers is expected to be ~> 95%. The particular dead strips/ASIC channels can be incorporated in our simulations
  (modified acceptance function).
- Tracking is trivial with only 2 layers.
- AC-LGADs also provide very precise time resolution. Additional good-track isolation cut.