Photon conversion study using Combined Test Beam data and future plans

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Contents

- **Reminder :**
  1. Now I am half-way through my contract.
  2. have worked for development of photon conversion finder with authors (of new tracking (Back-tracking) for secondary particles and vertex finder)

- **Results shown today :**
  -- Data and MC comparison for photon conversion in ATLAS combined test-beam (CTB)
  -- How can be this extrapolated to ATLAS ?
  -- Photon conversion tools now mature for ATLAS with dual validation strategy.

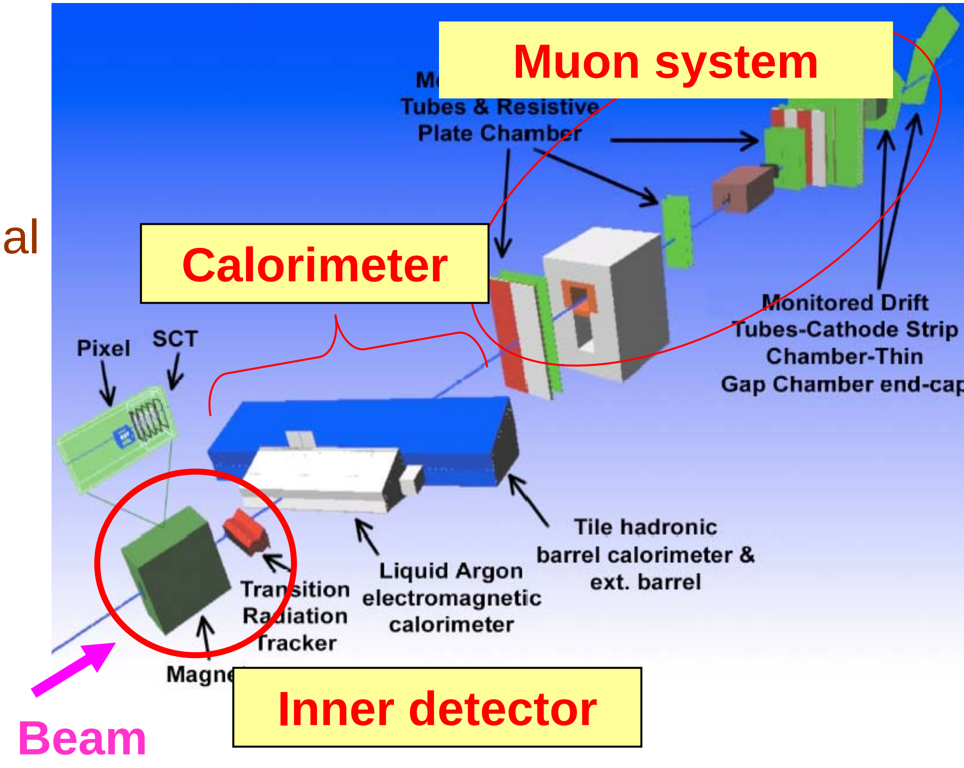
- **Plans for 2008 -2009**
  -- publish CTB photon paper (3 - 4months ?)
  -- prepare for ATLAS physics :
  1. build on work and expertise gained in e/gamma studies.
  2. early physics

Combined Test Beam (CTB)

-- Main purposes of CTB
  1. Test of the combined detector performance

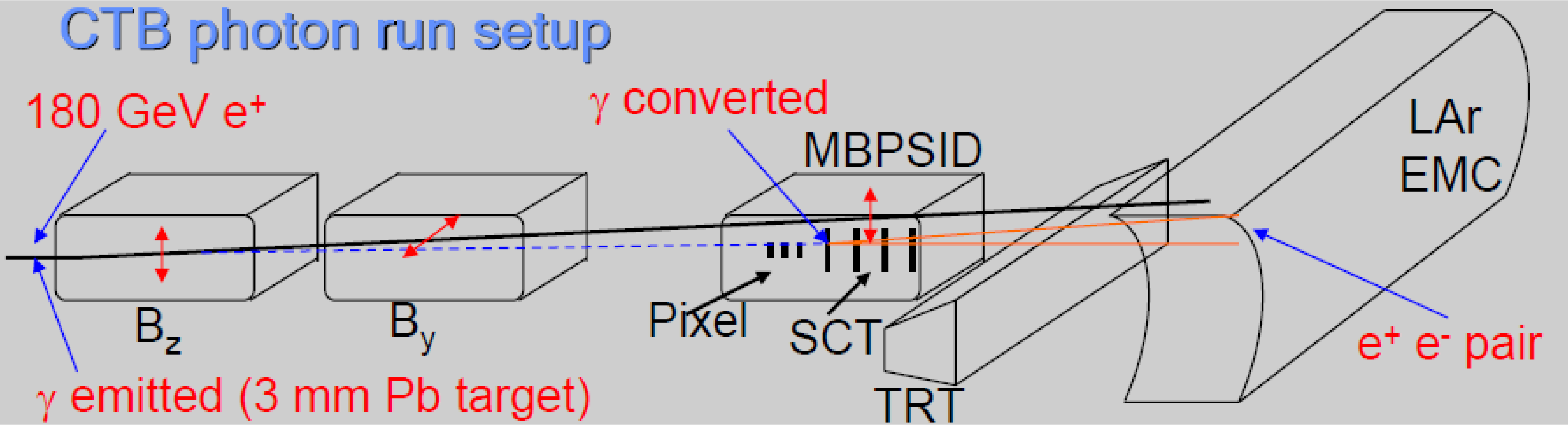
  2. Validation of the MC simulation of the detector response.

  3. Development and validation of additional functionality in offline software. (calibration, alignment)



-- The detector configuration is similar to
   ATLAS detector.
   1. Muon system
   2. Calorimeters
   （LAr Calorimeter、Tile Calorimeter）
   3. Inner detector (tracking system)
   → TRT was located outside of magnetic field.

Setup of photon run



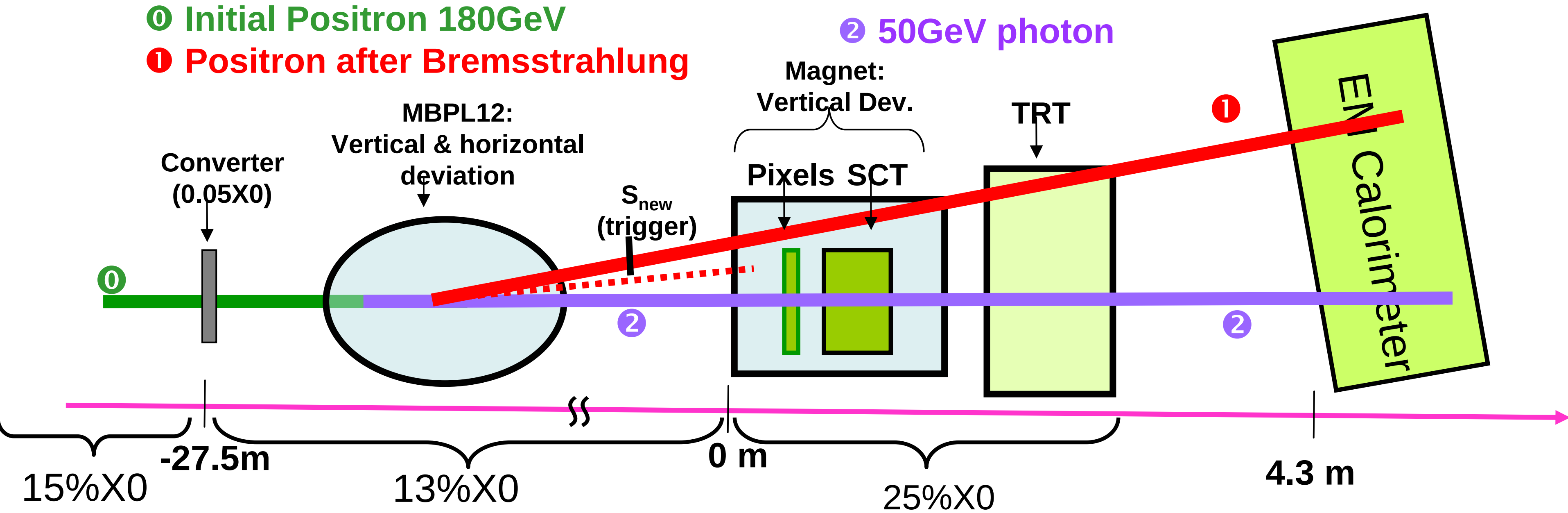
-- Outgoing primary positron was separated using two magnets.
-- Photon energy spectrum ~ 50GeV
-- Basically only photons passed through Silicon detectors.

Study on photon events

-- photon conversion reconstruction (reconstructed tracks and vertex)

-- Extrapolate tracks from ID to EM Calorimeter.

1. Comparison of real and predicted cluster position from ID.
2. Cluster energy spectrum
3. Photon energy scale determination



- Unlike standard charged particle beams, photon beam difficult to determine in terms of parameters;

  -- photon energy not well know a priori (trigger complicated)

  -- photon beam profile not well know a priori

  -- Alignment has to be assumed from other runs.

- Significant effort was required :

  -- Tune all parameters and compare data to MC

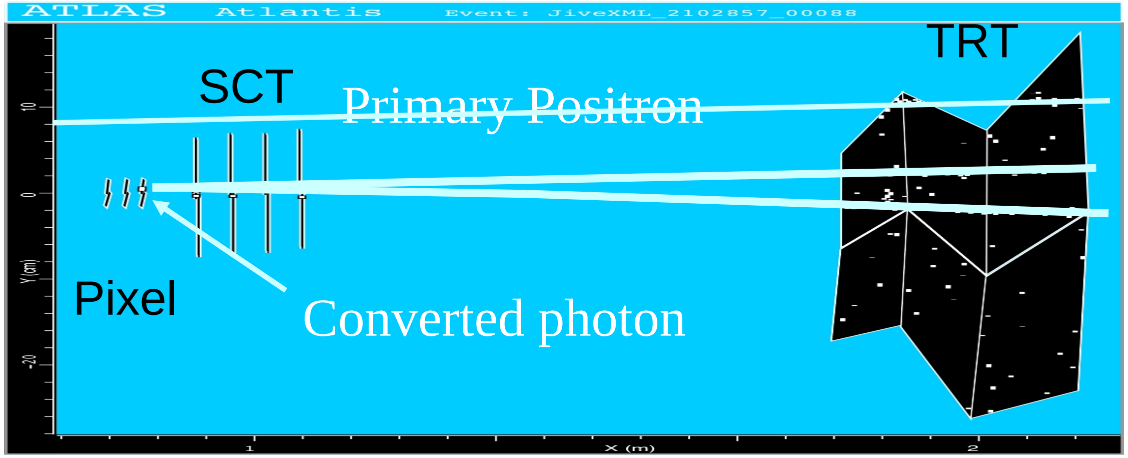
  -- validate simulation (material)

  1. In front of ID : ~15%X0 seen by primary e+ in beam line before emitting a photon

     : ~13%X0 in front of ID → photons may convert

  2. In ID : ~25%X0 in silicon and TRT → photons may convert

Track reconstruction



1. Standard pattern reconstruction strategy (Forward –Tracking : inside → outside)

-- Track candidate finding in Pixel and SCT (→ extend to TRT)

→ efficient for early conversion events (conversion happen at Pixel)

2. TRT seeded reconstruction (Back-Tracking : outside → inside : Si hit at least 1) New

-- dedicated tracking for secondary particles

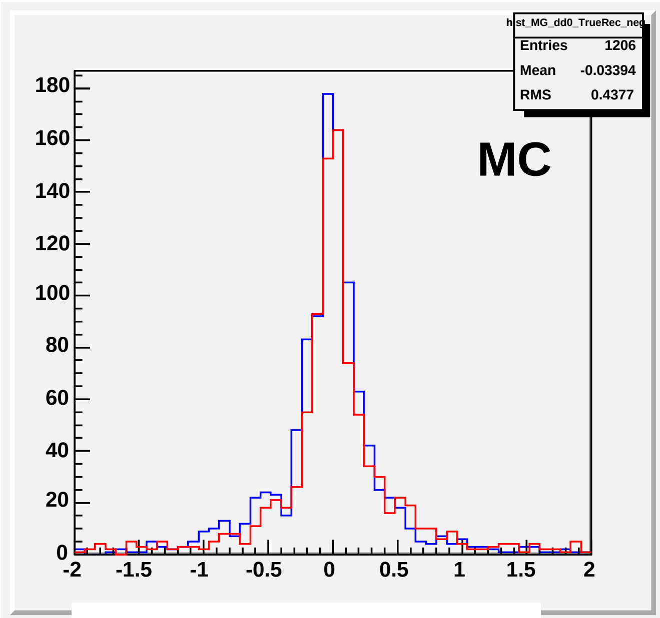
→ efficient for late conversion events (conversion happen at SCT) also.

3. Merged the above two track-collection (Forward + Back-tracking : remove overlapped tracks)

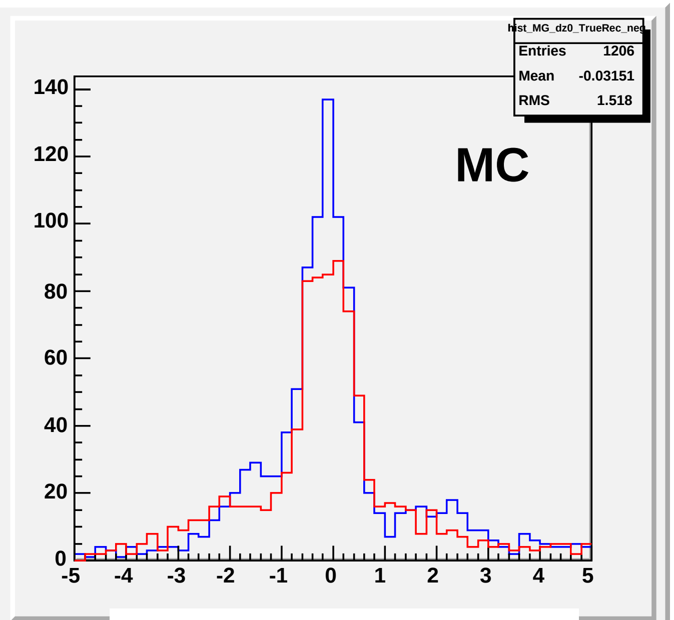
→ use this collection for this study

→ If have more than 2 tracks, choose a combination with the minimum approach between two tracks.

Impact point & Momentum (Rec V.S. True)



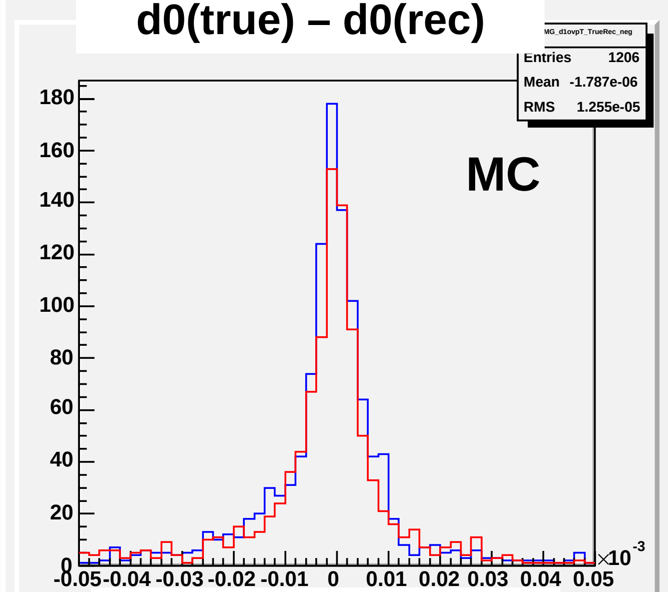
d0(true) – d0(rec)



z0(true) – z0(rec)

+charge

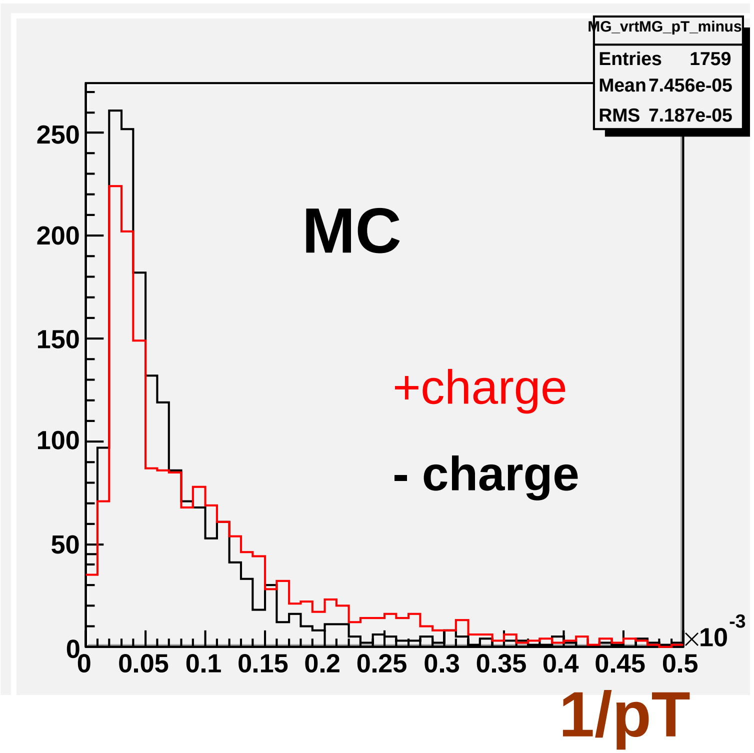
- charge

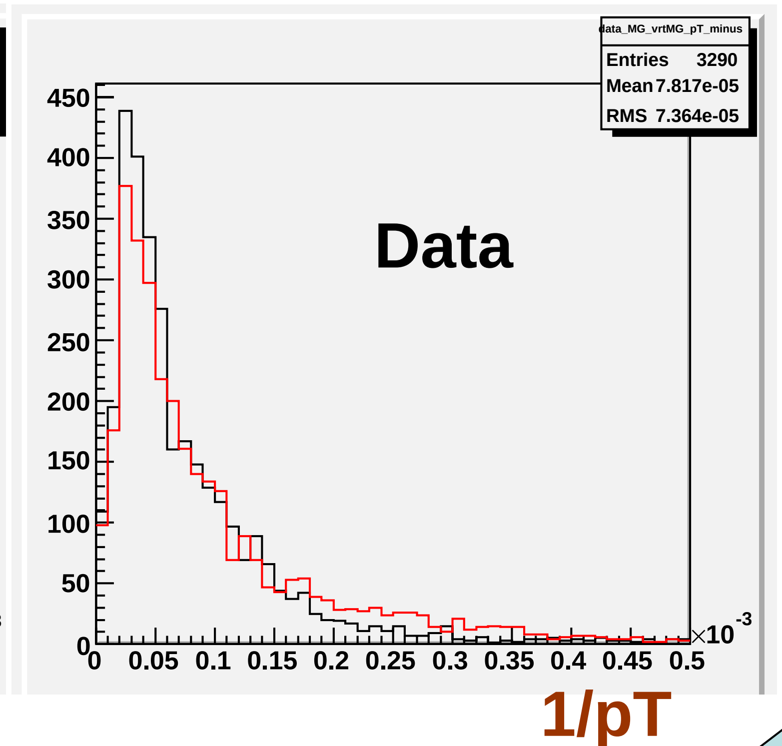


1/pT(true) – 1/pT(rec)

Tracks are reconstructed well.

1/p_T comparison (MC and Data)

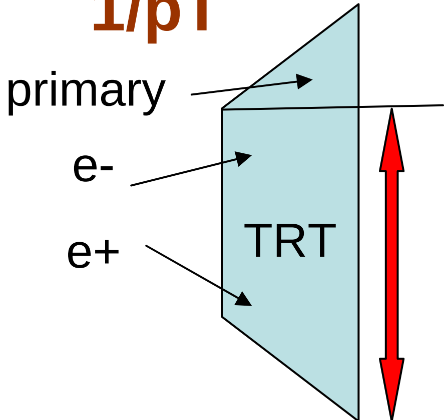




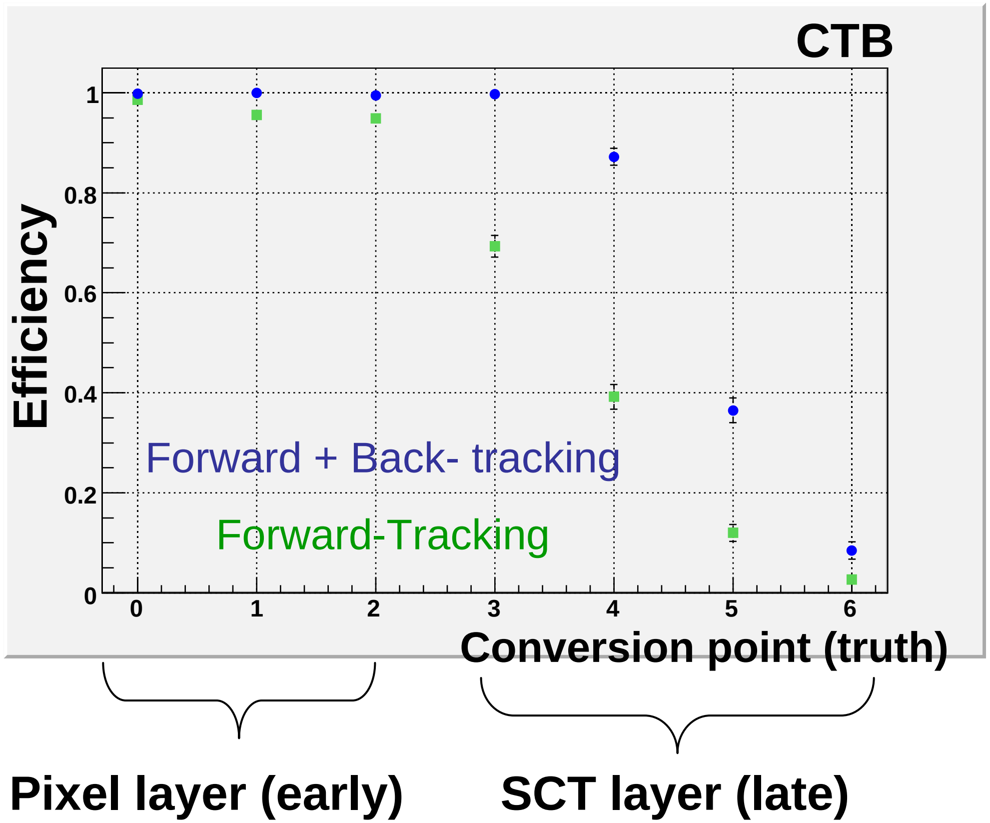
-- Tracks on real data can be reconstructed like on MC.

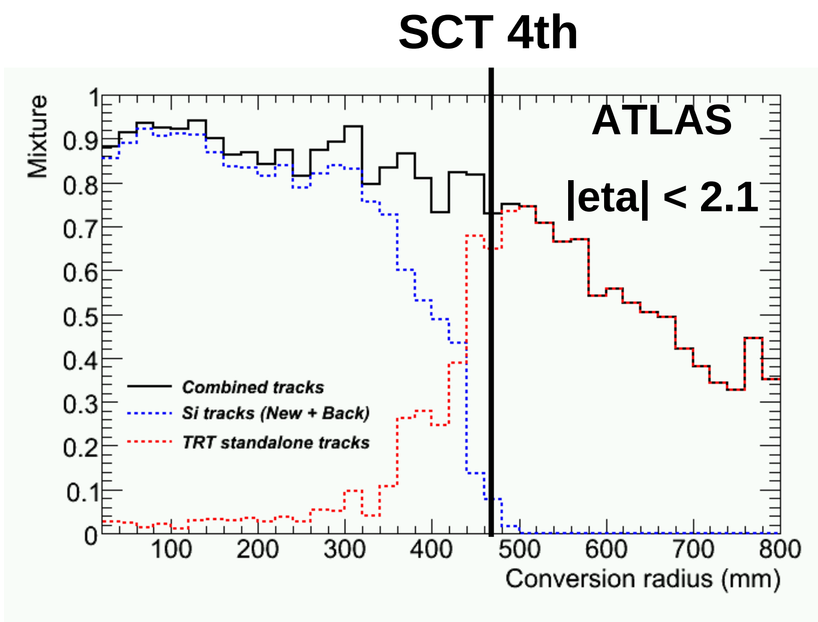
-- Acceptance difference between negative and positive charges seen in both data and MC.

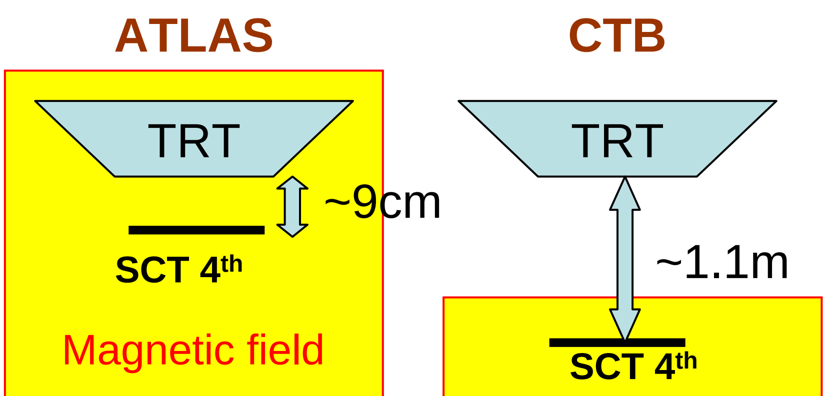
(due to fiducial removal of primary e^+ in TRT)



Tracking efficiency







-- Tracking efficiency is good for early conversion event.

-- Tracking efficiency become worse for late conversion events because number of hits is small.

→ If use TRT standalone tracking, it can be recovered for ATLAS detector more. (difficult for CTB because of no magnetic field in TRT and a large distance from SCT to TRT)

Vertex position (y and z) and resolution

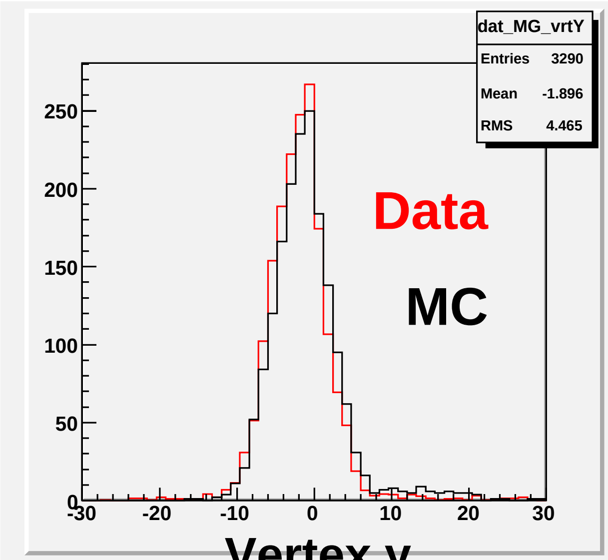
-- Vertex reconstruction using vertex finder tool based on Kalman Filter

1. suitable for any vertex reconstruction, secondary also.
2. Mass constraint

-- MC described Data well.

-- vertex resolution is estimated to be 8mm.

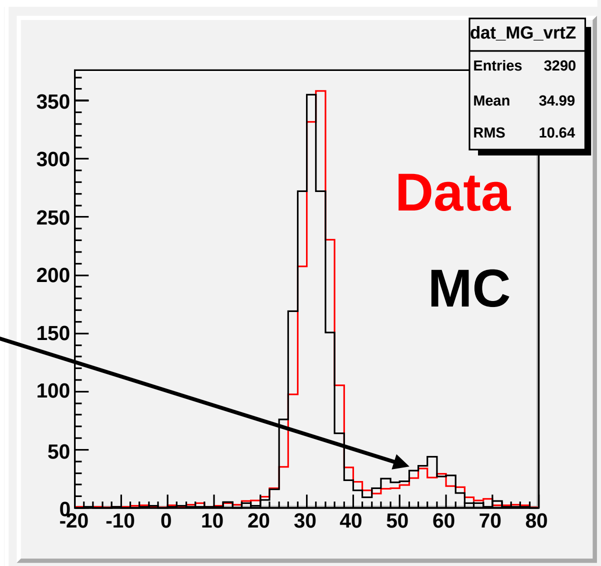
(ref. ATLAS detector $\sigma = 5$mm)



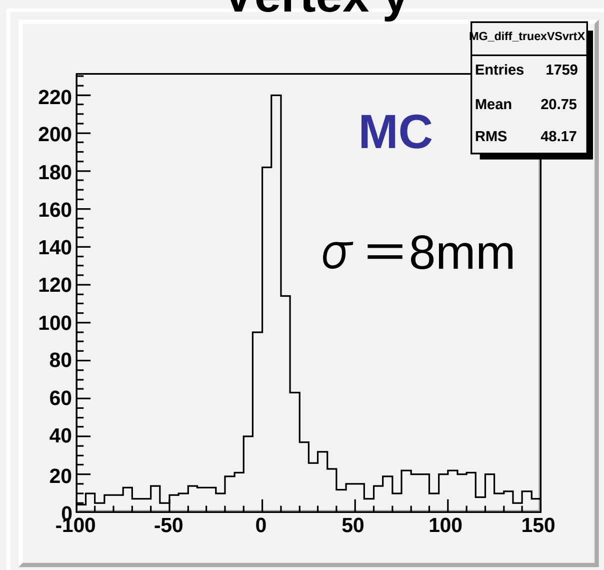
Vertex y

Spurious photons

from primary e^+

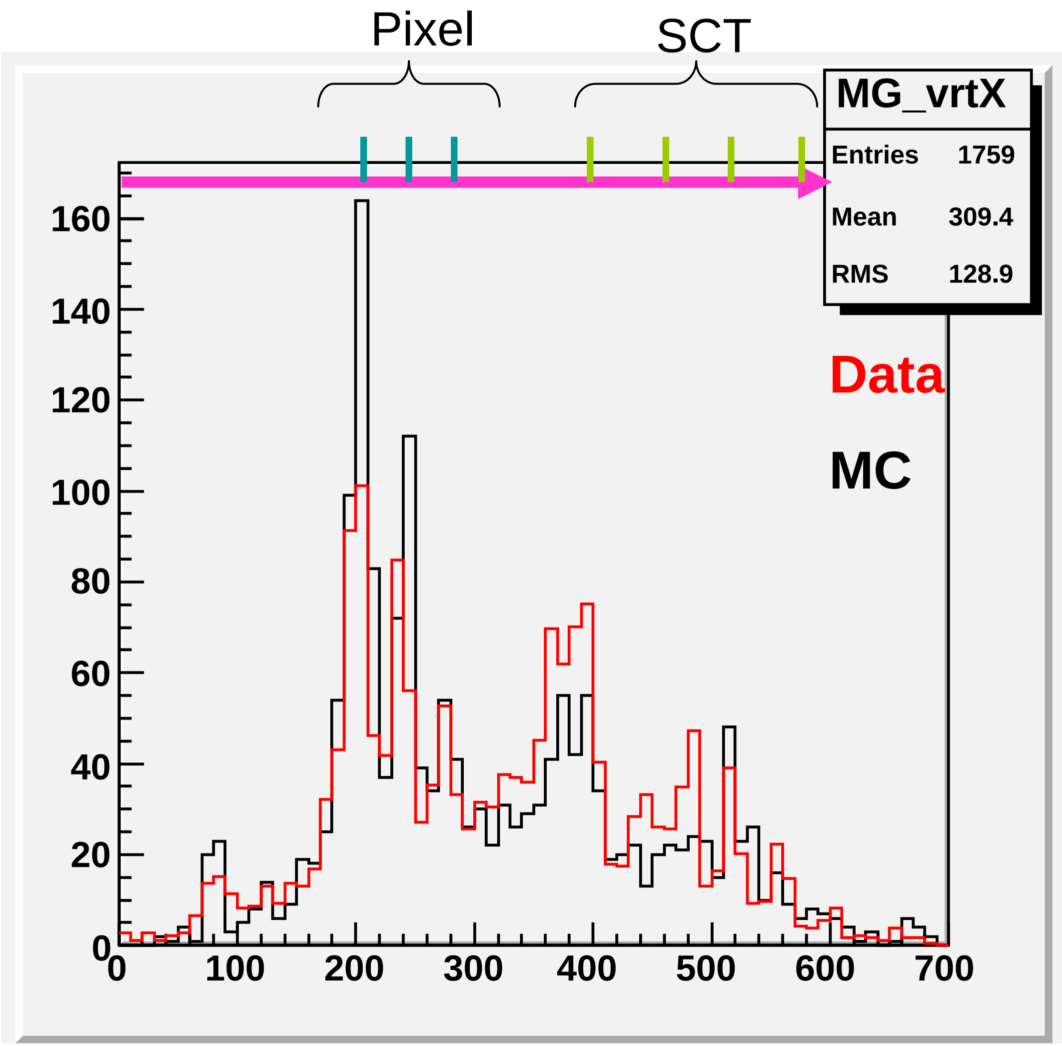


Vertex z



x(rec) –x(true)

Vertex x position

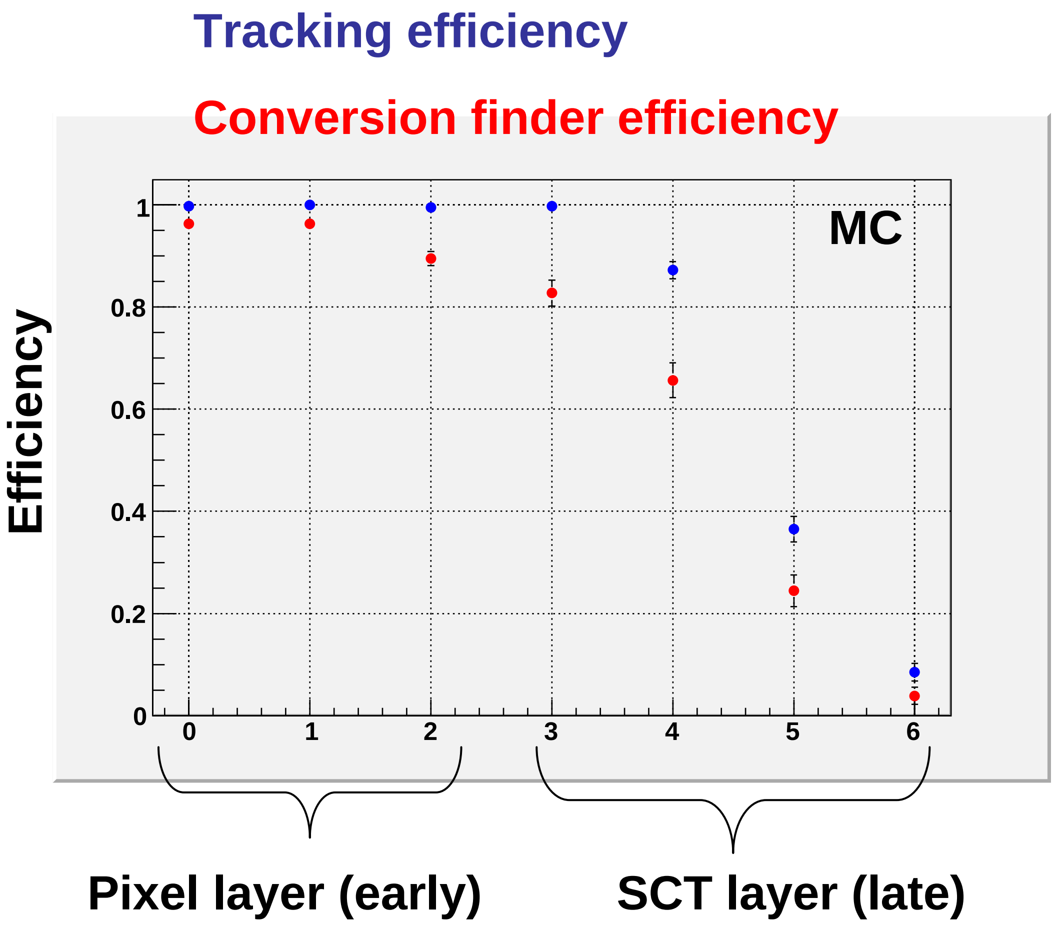


-- Detector structure can be seen in vertex_x distribution

-- not clear for last 2 layer of SCT due to low tracking efficiency.

-- Possible improvement: Mass constraint → angular constraint.

Conversion finder efficiency



1. definition of Conversion finder :

choose only tracks combination with the minimum approach <25 mm

2. Early conversion events in Pixel are reconstructed very well.

3. The efficiency can be recovered for late conversion events using TRT standalone tracking method.

Established Conversion finder

Extrapolate to Calorimeter

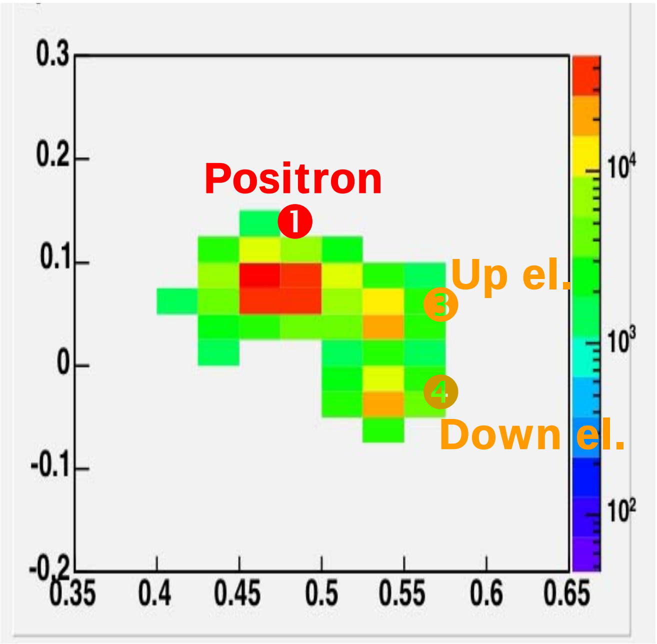
-- EM showers for electron pair are reconstructed using calorimeter cell-clustering

-- Use Topological clustering

1. to minimize noise
2. can reconstruct two narrow clusters.

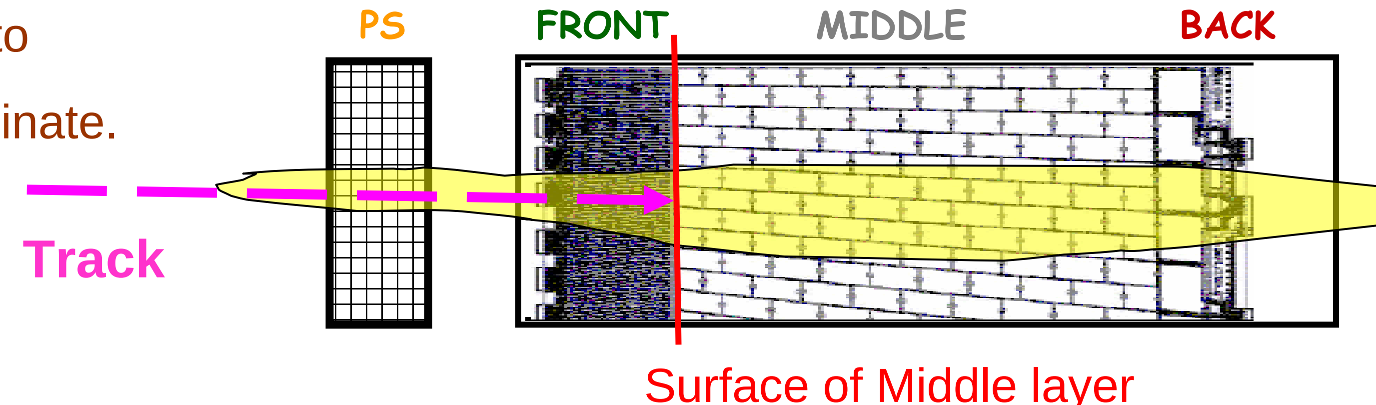
-- reconstructed 3 objects in EM calorimeter

1. primary e+ : ~ 125GeV
2. e+e- from photon

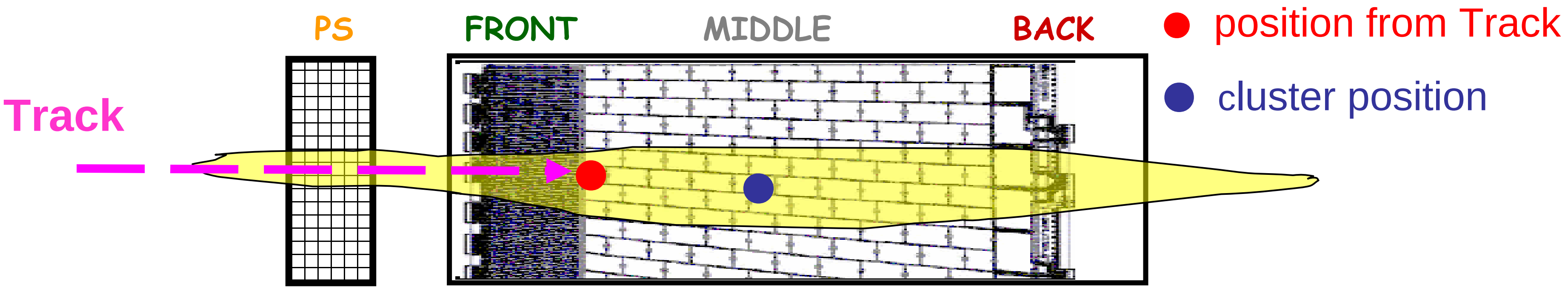


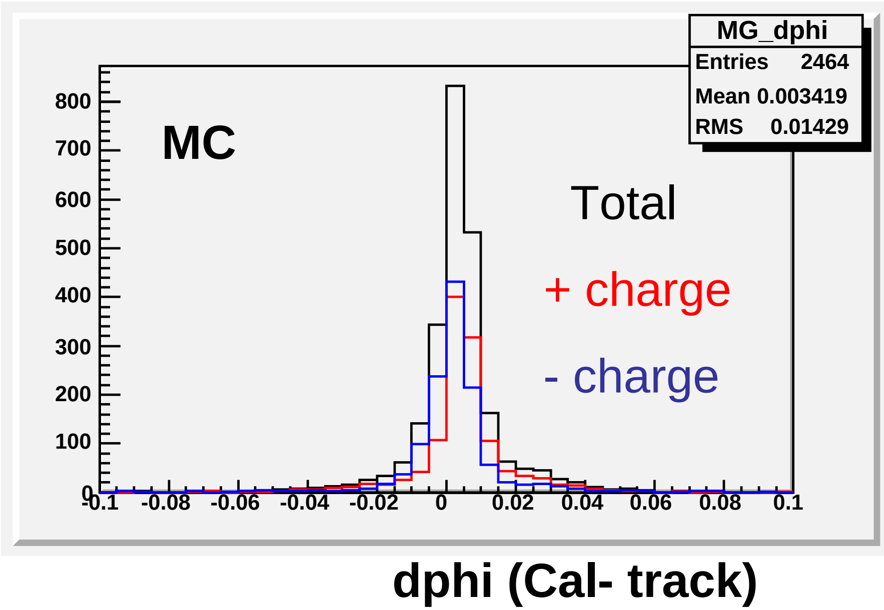
-- Tracks are extrapolated from ID to the surface of middle layer in CAL.

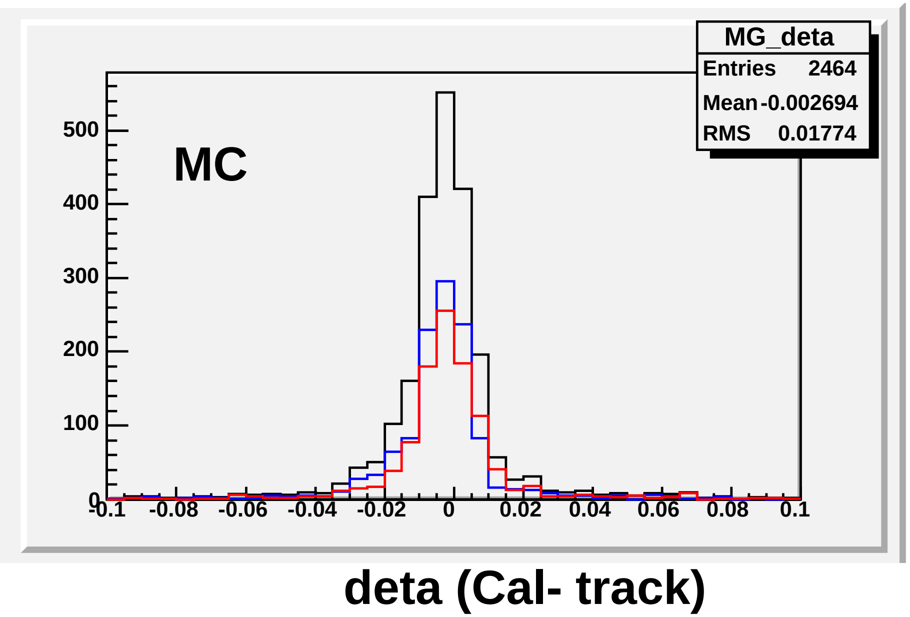
→ find closest cluster to track in local CAL coordinate.



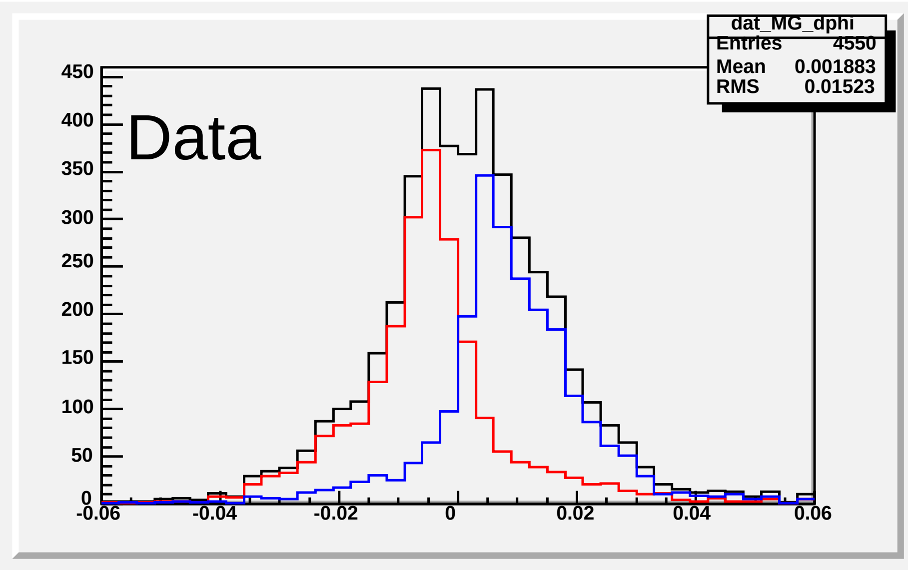
Comparison of positions between CAL cluster and track hit (1)



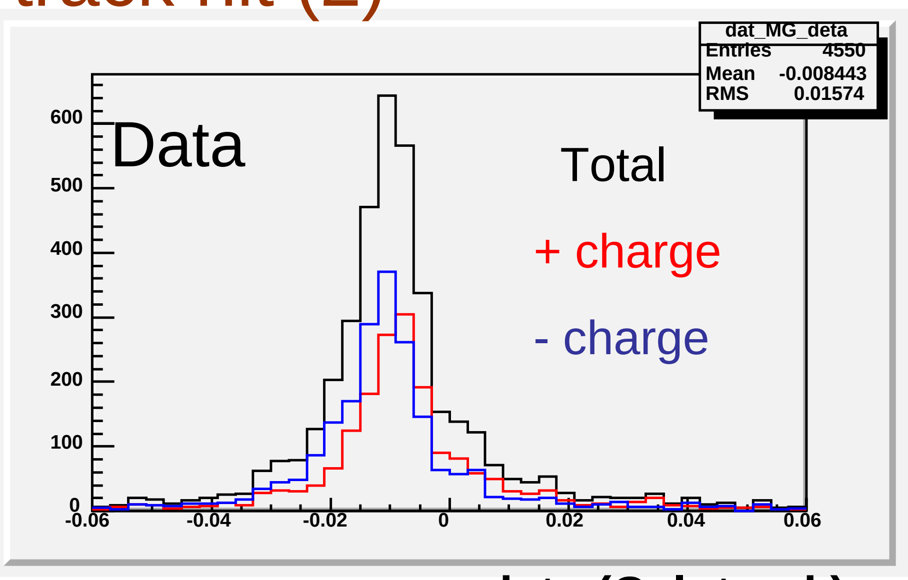




Comparison of positions between CAL cluster and track hit (2)



dphi (Cal- track)

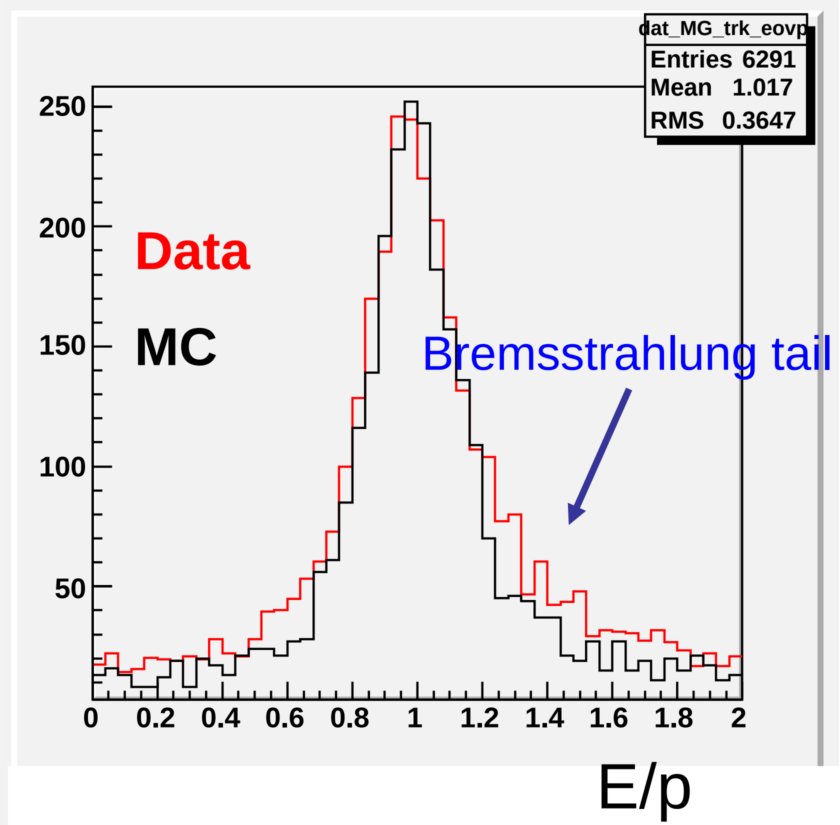


deta (Cal- track)

-- shifted by about 8 mrad for phi and about 10mrad for eta.

→ Now on discussion.. probably due to mis-alignment between ID and CAL.

E_{CAL}/p_{ID} distribution



-- E/p distribution for reconstructed $\gamma \rightarrow e^+e^-$ looks nice.

-- Data : 0.982 +- 0.152

MC : 0.983 +- 0.151

Possible improvement

-- Energy calibration for the topological clustering.

-- Alignment between ID and CAL.

-- Bremsstrahlung recovery

Summary & Future Plans

-- Photon conversion study on the combined test-beam data is almost done for ID side.

→ 1. TRT seeded tracking became ready for ATLAS physics analysis.
2. Established conversion finder
3. Started to check the combined performance of ID and CAL.

-- Future plan :Photon conversion ($\gamma \rightarrow e^+ e^-$) in the ATLAS at initial physics run:

1. γ/π^0 separation : to measure cross section of direct photon production (pp → γ +jet) and extract it from background (pp→jet +jet with jet→π^0).

One method using the converted photons

γ (→e^+e^-) → E_{CAL}/p_{ID} ~ 1.0

π^0(→$\gamma\gamma$ →γ e^+e^-) →E_{CAL}/p_{ID} >1.0

We sent this plot to ATLAS paper…

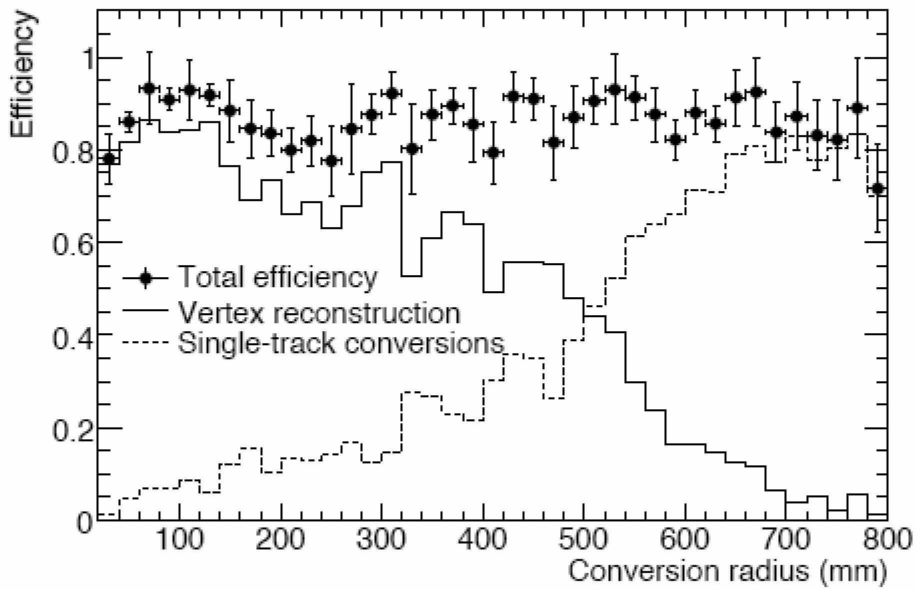


Figure 220. Efficiency to identify conversions of photons with $p_T = 20$ GeV and $|\eta| < 2.1$, as a function of the conversion radius. The overall efficiency is a combination of the efficiency to reconstruct the conversion vertex, as shown also in Fig. 219, and of that to identify single-track conversions (see text). The errors are statistical.

Conversion finder efficiency is ~ 85%