# Digitizer vs. Testbeam

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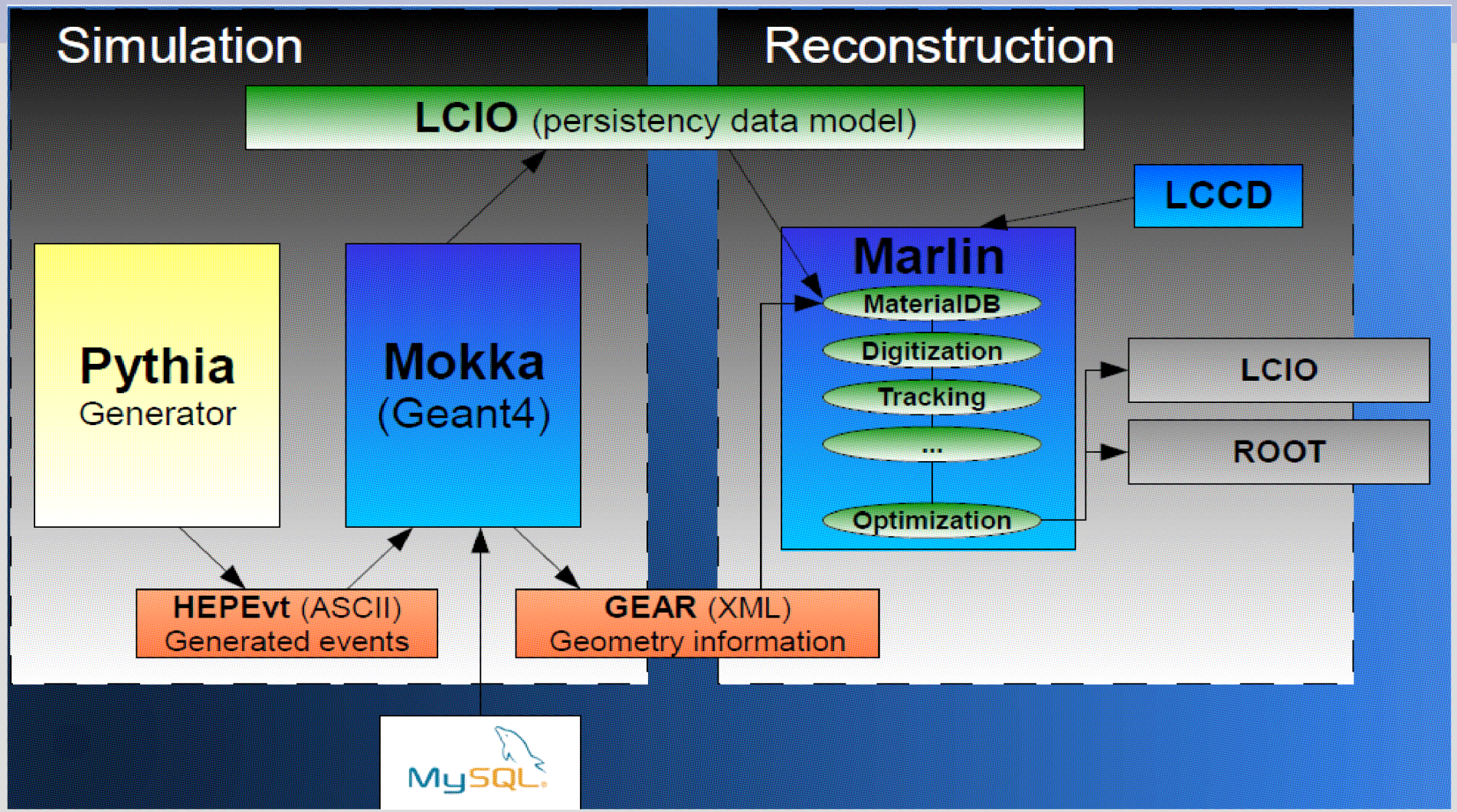
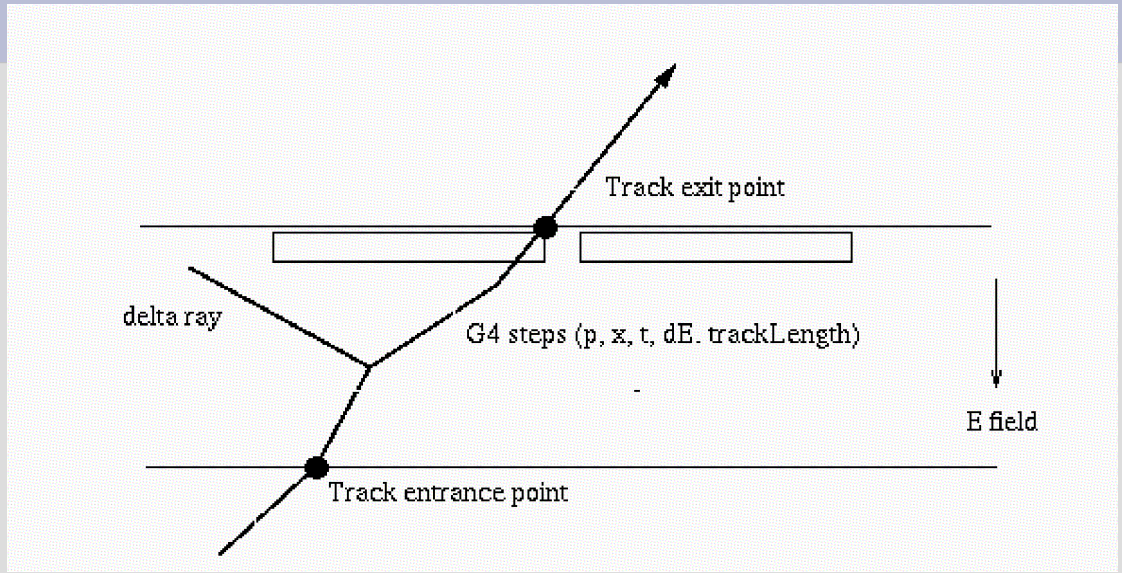
# Outline

- Overview of recent changes in the simulation algorithm.
- Estimation of digitizer parameters based on testbeam 2008 data.
- TB 2008 angular scan:  cluster charge, cluster size, charge sharing.
- Point resolution for 450 um DEPFET sensor for TB 2008.

# Reminder: Tool Chain



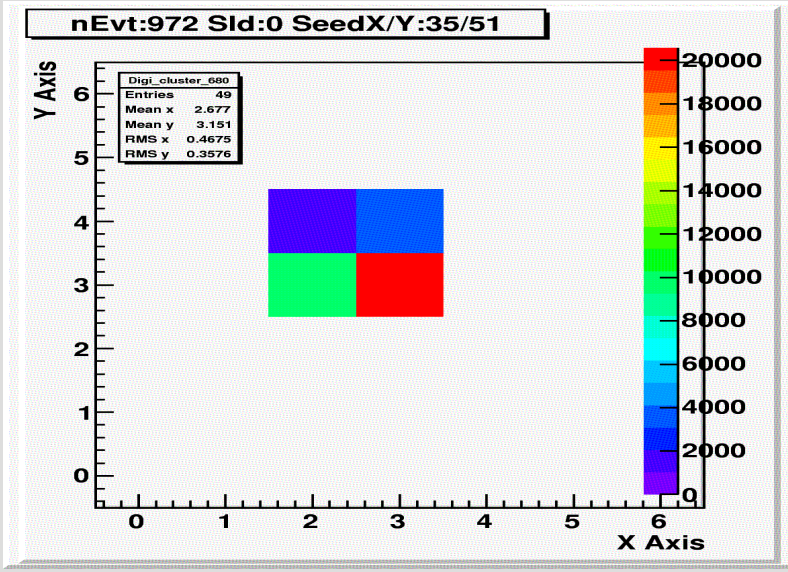
# Geant4/Mokka Simulations



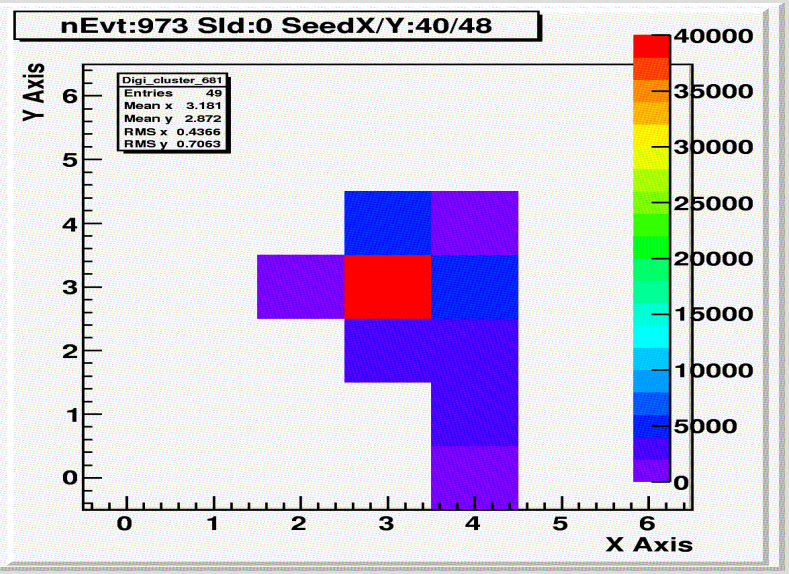

- Geant4 steps for primary and secondary particles are used as digitizer input.
- Standard EM models (QGSP_BERT physics list) with range cut of 0.5 um are used.
- Alternative EM models from Geant4 (PAI / LEP) could be tested.
- Not yet implemented: step limit for Geant4 steps for simulation of 50 um sensors.

# Digitization

(typical cluster, normal incidence)




(cluster with delta ray, normal incidence)




- Signal charges from all G4 steps (primary pion and secondary delta rays) are collected and digitized.
- Digitizer relies on Geant4 input: no additional energy redistribution ( „fluctuate“ ).
- Output option: digitizer forms NxM clusters compatible with TB data after preprocessing and clustering.

# Digitizer Paramters

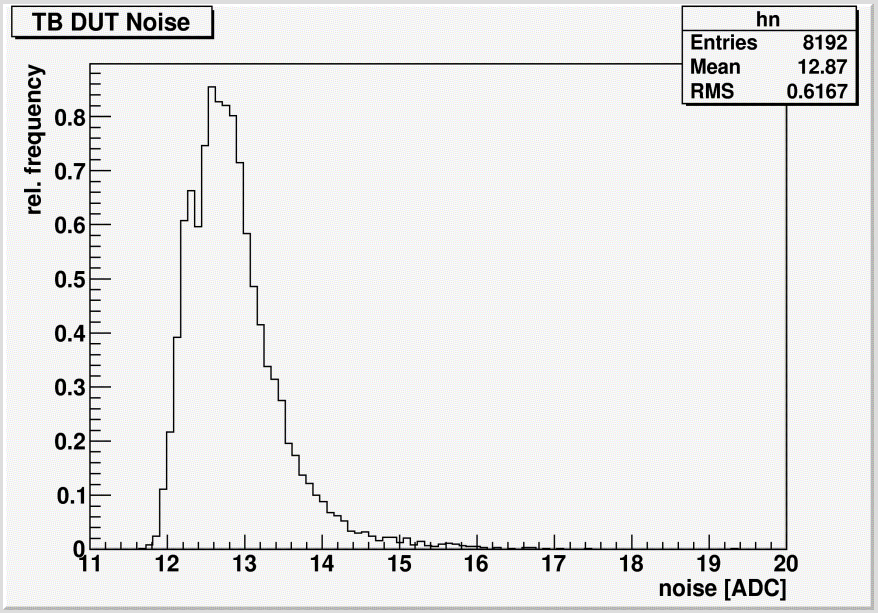
- DEPFET digitizer has 3 free (tuneable) parameters:
  - Electric noise: Gaussian noise is added to collected charge for each pixel.
  - Average electric field in depleted Si bulk: determines charge collection time.
    - Discussion with R. Richter: calculate electric field profile in Si bulk from realistic potentials at backplane contact and below IG.
  - Lorentz angle in magentic field (not tested in previous testbeams).
- Goal: use one set of digitizer parameters for different beam incidence angles.

# Data Processing

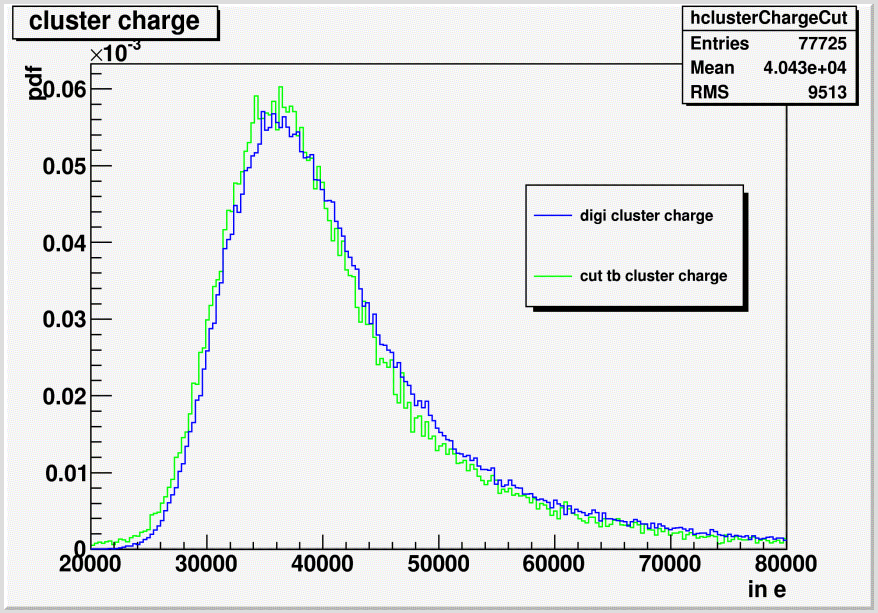
- Testbeam data (2008 campaign) from 24x24 $um^2$ DUT on rotation stage.
  - Low gain modulation -> no gain correction necessary.
- Marlin/Eutelescope based processing of Runs 1318 ( Θ = 0°), 1298 ( Θ=6°) and 1314 (Θ=12°).
- Fixed Frame Clusters with framesize adapted to rotation angle (3x3, 7x3 and 9x5).
  - Fixed Frame Clusters are a „relict“ of testbeam studies (and should be eliminated).
- Common Cluster Cuts for TB and Digitizer:
  - Seed Charge Cut: $5xN_{el}$
  - Neighbor Charge Cut: $2.6xN_{el}$
- Additional TB cuts: low sensor occupency (<3), border cuts (10 px), minimum seed charge.

# Noise estimation for TB 2008

DUT (24x24 $um^2$ ) on rotation stage



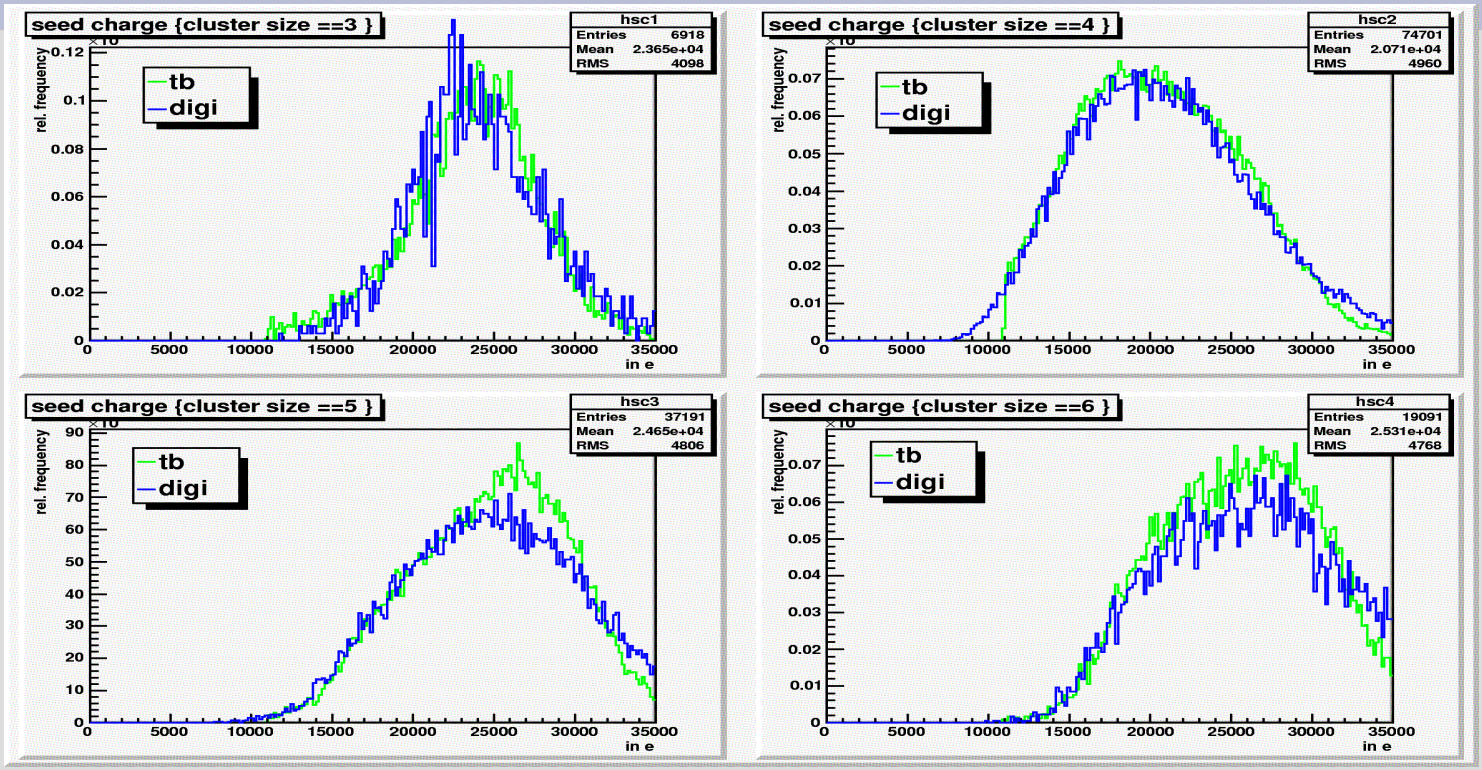

DUT cluster charge for rotation of 12°




- 1) TB noise distribution:
  - MPV noise: $N_{el}$ = 12.6 ADC
- 2) TB cluster charge:
  - Konversion: K = 22 e/ADC

- 3) Simulated noise:
  - $K*N_{el}$ = 280 ENC

# Seed Charge vs. Cluster Size



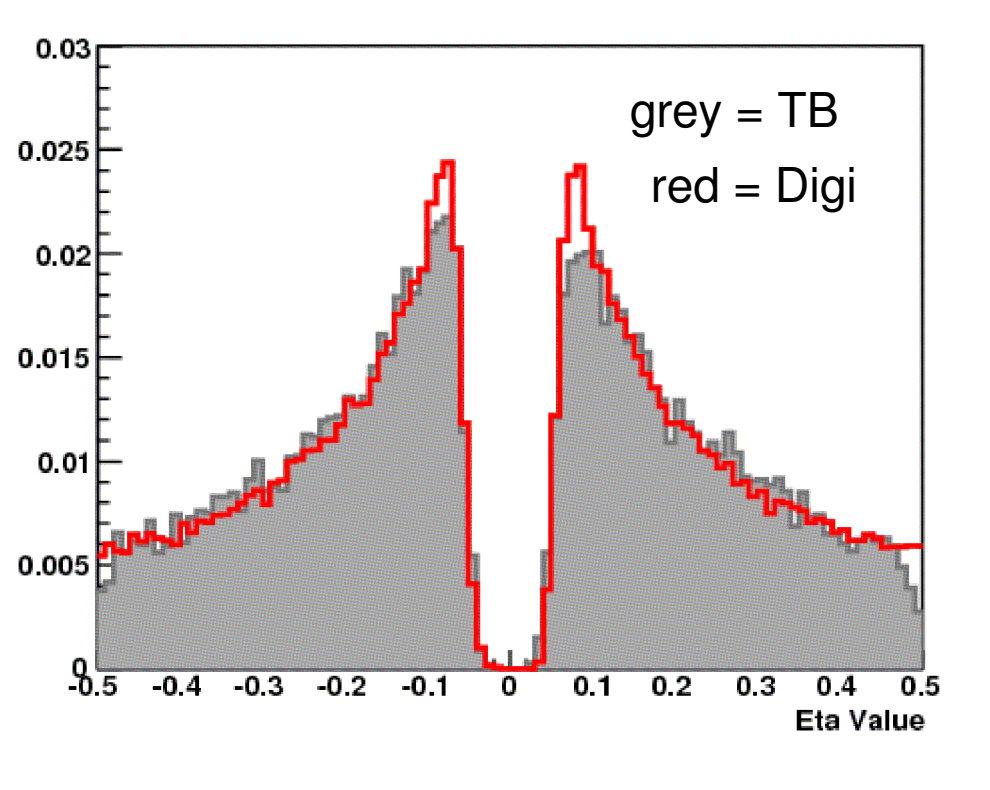

- Run 1318 ( Θ=0° ) seed charge distributions for fixed total cluster size.
- Test correlation between seed charge and cluster size for TB and Digitizer.
  - Probe for diffusive signal sharing between pixels.

# Eta Distribution
# Testbeam Data vs. Digitizer

Definition of Eta Distribution:

$$\eta = \frac{S_{left}}{S_{rigth} + S_{left}}$$

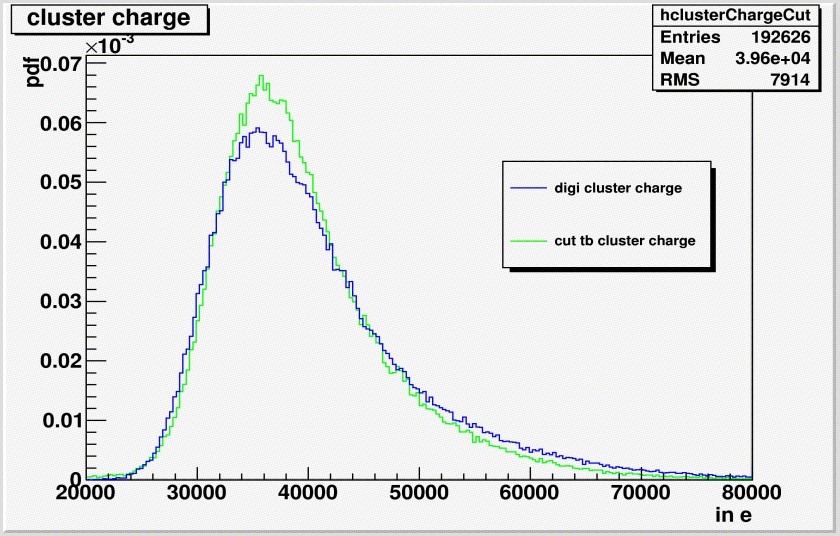
$$Z(\eta) = Z_{left} + pitch \star \int_0^{\eta} \rho(\eta')d\eta'$$



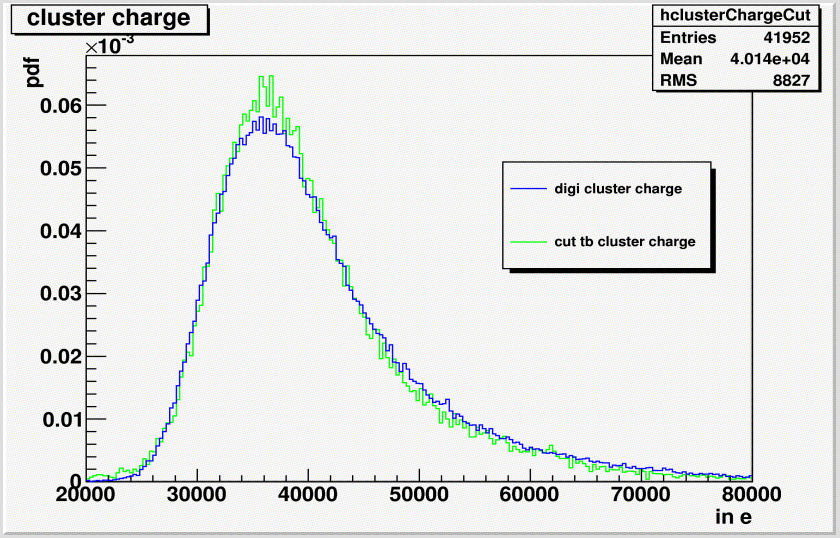

Eta distribution for normal incidence.

# Cluster Charge: Digitizer vs. TB

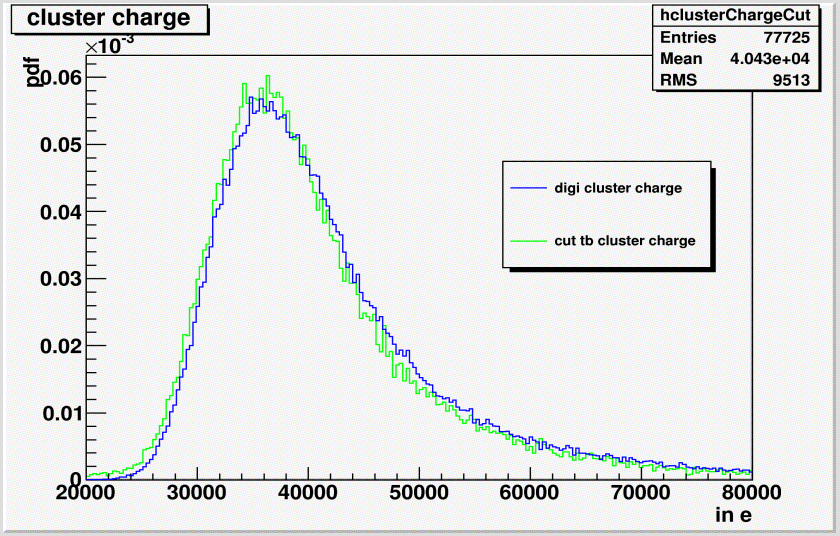
Θ = 0°




Θ = 6°



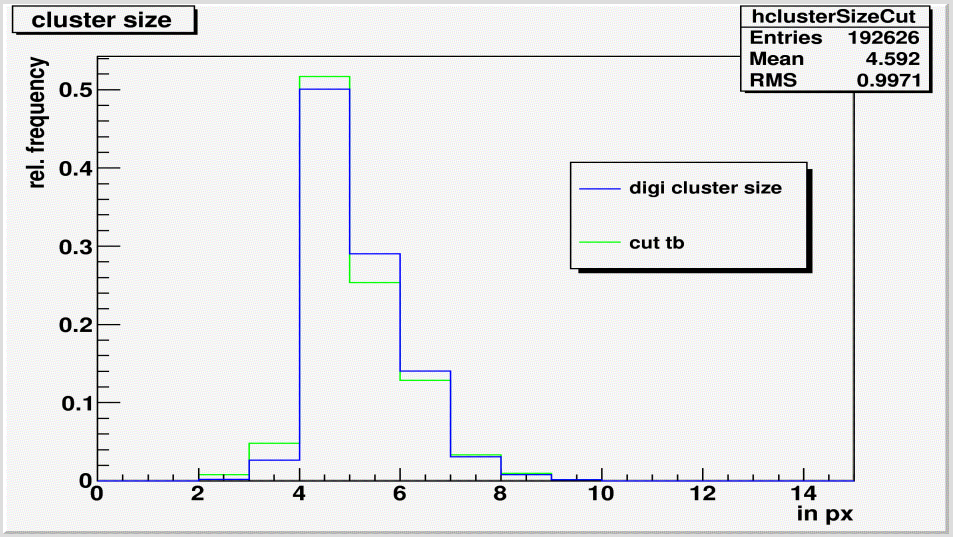

Θ = 12°



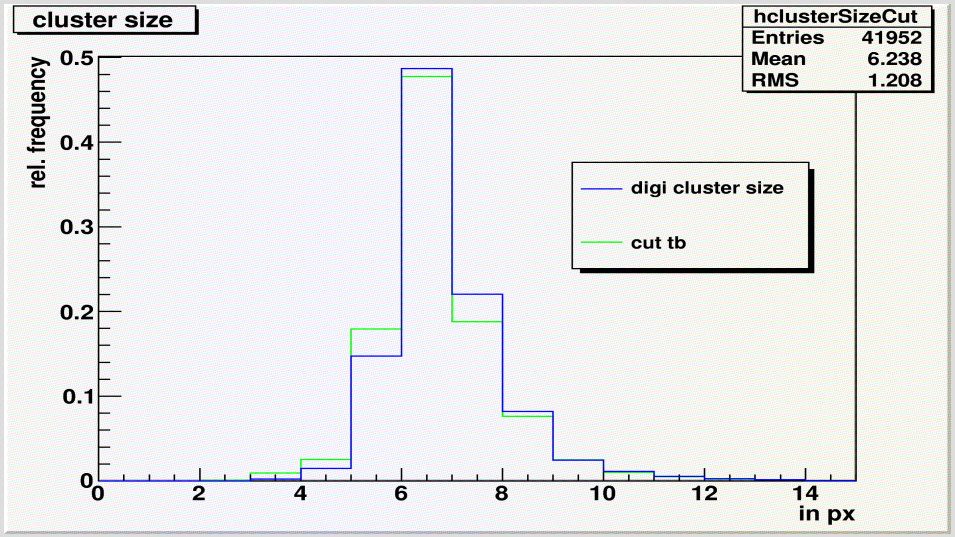

- Trend: agreement improves with increasing incidence angle.
- A possible explanation is internal gate saturation:
  - at Θ = 0: most signal charge deposited in seed pixel
  - at Θ = 12°: signal charge shared by ~9 pixels.

# Cluster size: Digitizer vs. TB

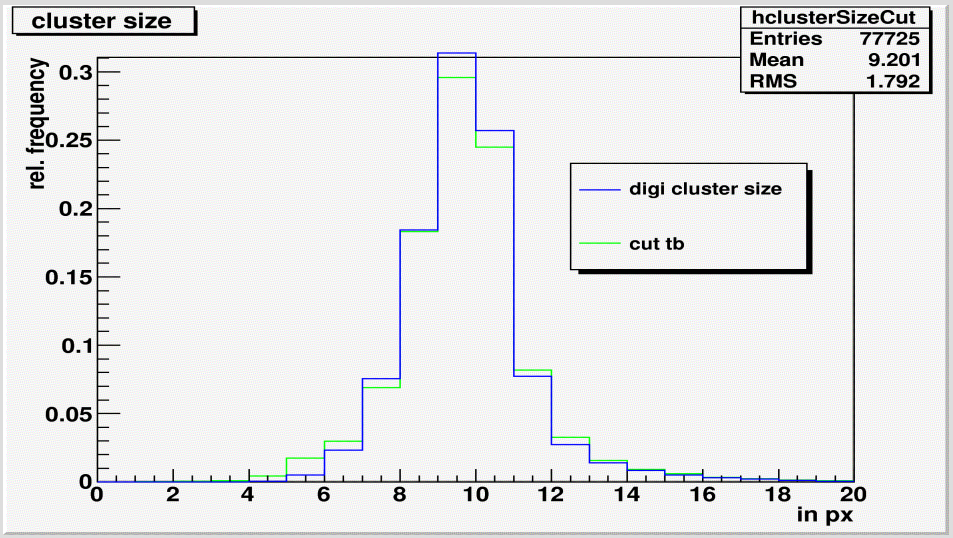
Θ = 0°




Θ = 6°




Θ = 12°



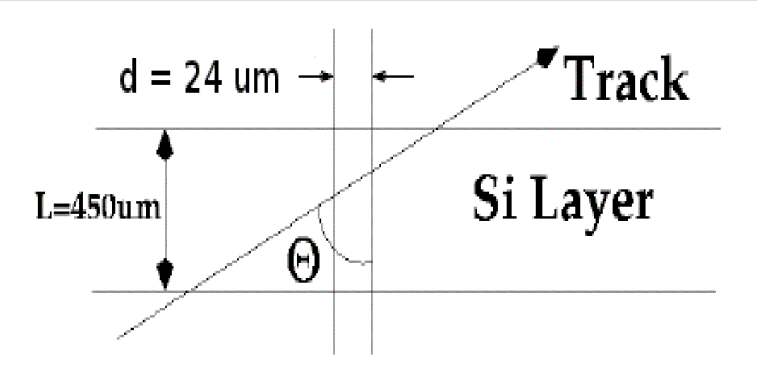

- Good agreement between TB and Digitizer:
  - Systematics < 5 %
- Problem in Barcelona analysis:
  - Fixed Frame Clusters too small.

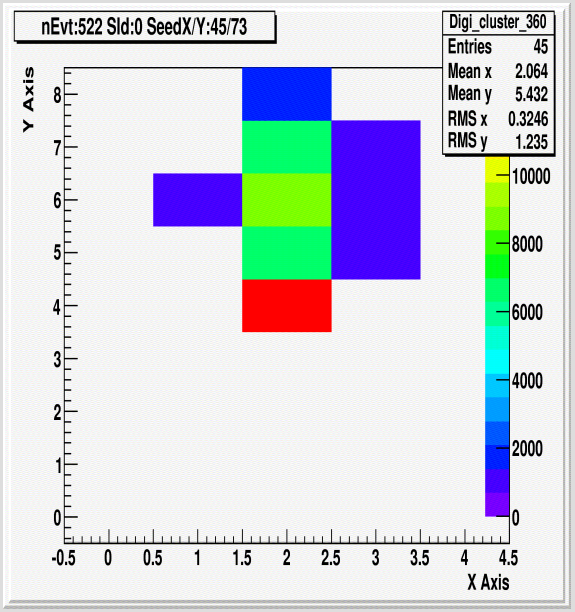
# Thin sensors

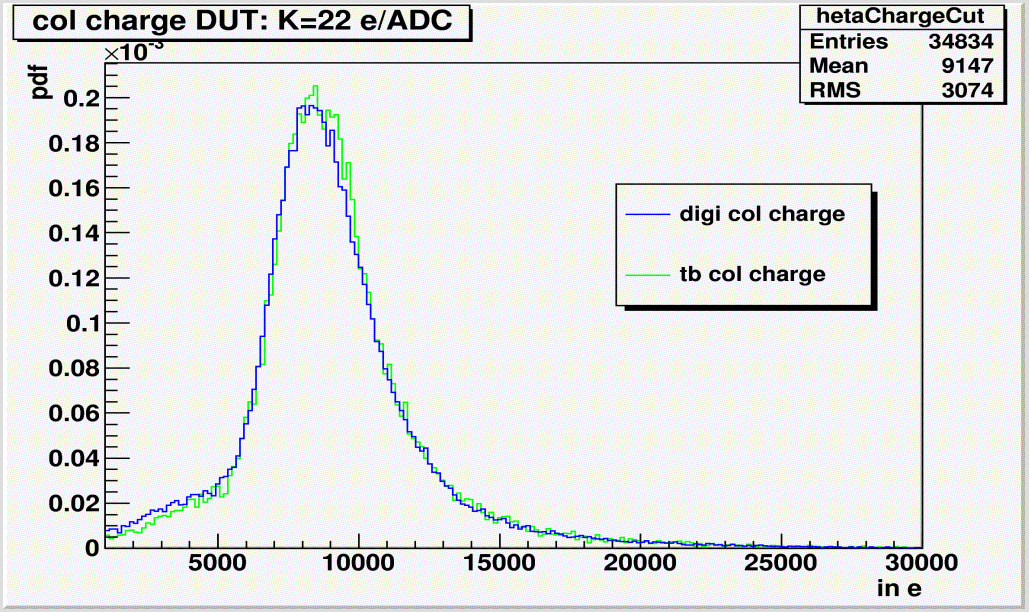
Test beam clusters at inclined angles can be used to probe energy loss in thin Si.

Track length per px vs. incident angle: l = d/sin(Θ)

Track length per pixel is ~115 um for 12° incidence.

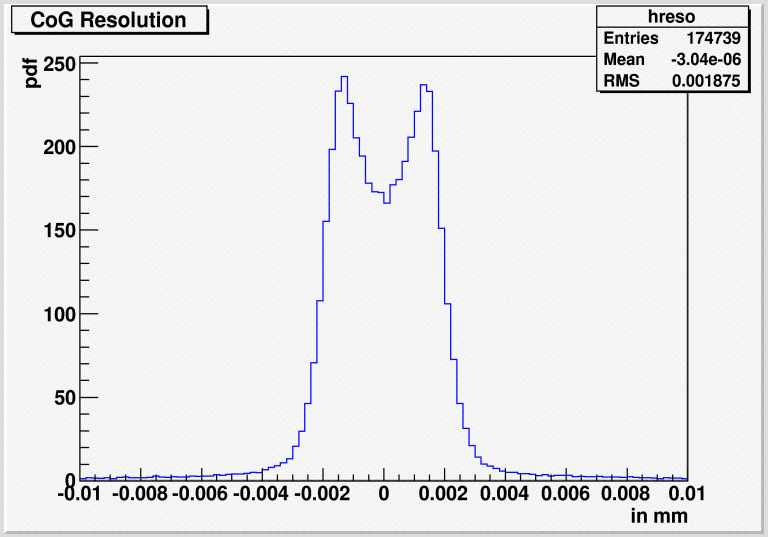


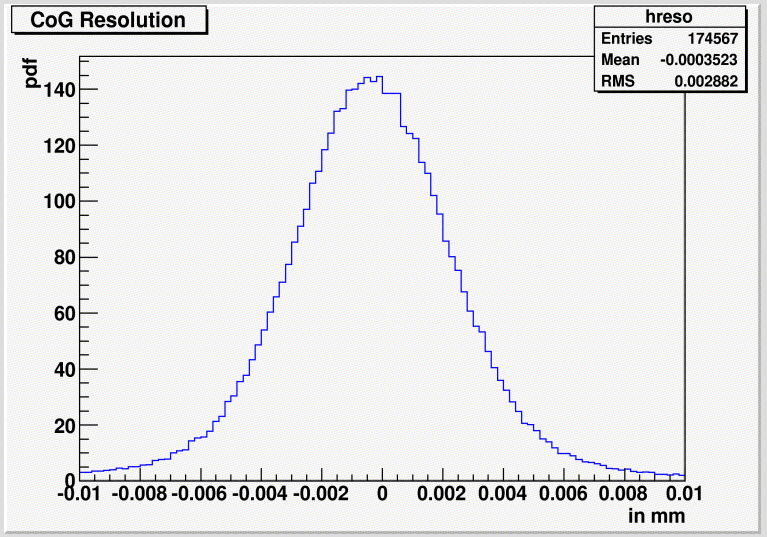



# Digitizer CoG Resolution

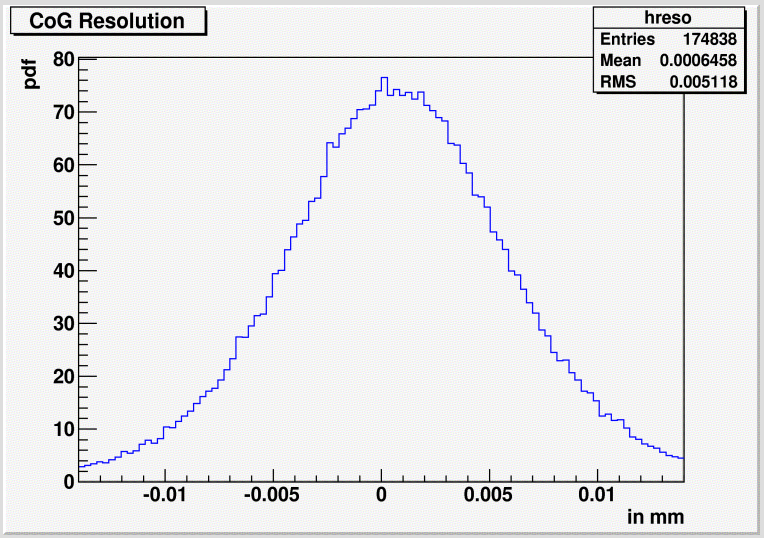
Θ = 0°




Θ = 6°




Θ = 12°



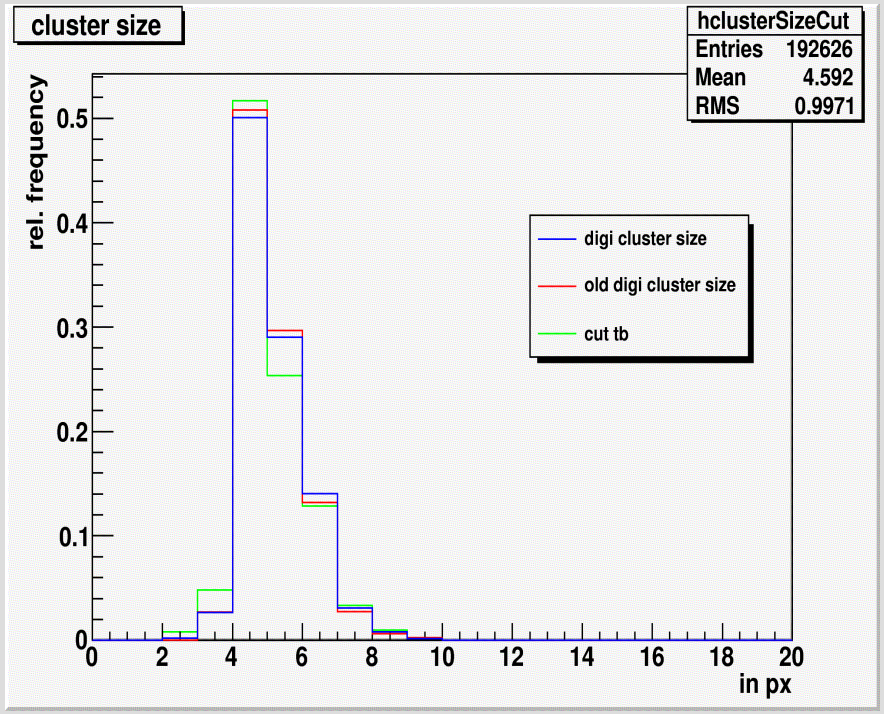

- Resolution = MC hit – CoG hit
- RMS values:
  - 0°: 1.8 um
  - 6°: 2.9 um
  - 12°: 5.1 um
- Double peak for normal incidence CoG.

# Outlook

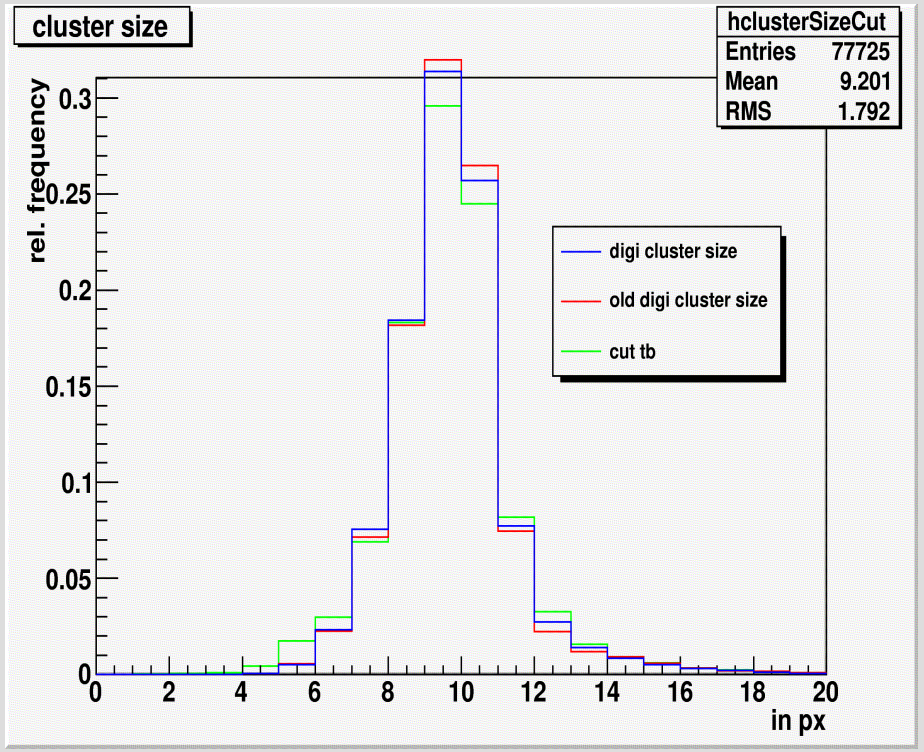
- In general: agreement is reasonable taking into account the simplicity of the Digitizer.
- Open issues:
  - Implement step size cuts in Geant4/Mokka.
  - Proper calculation of Electric field in Si bulk (drift time to sensor surface).
  - Analyse voltage scan data from TB's. (cluster size vs. Backplane voltage)
- Do something useful with the Digitizer.

# Cluster Size: Old Digitizer vs. New Digitizer

Θ= 0°

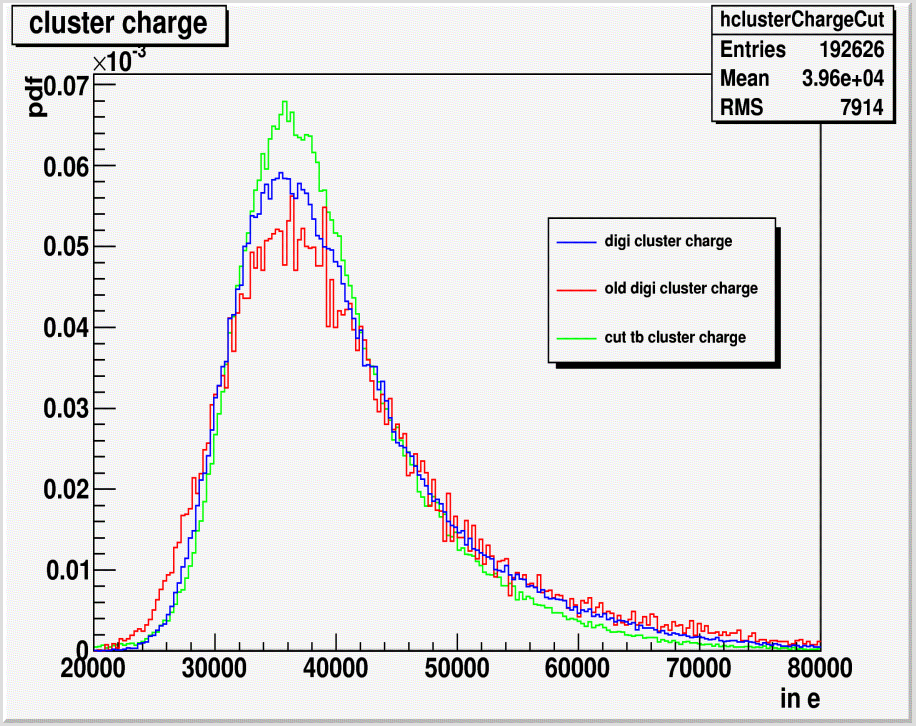



Θ= 12°



# Cluster Charge: Old Digitizer vs. New

Θ= 0°




Θ= 12°