A New Simulation Tool for EUDET JRA1

A.F.Żarnecki, L.Maczewski, P.Nieżurawski
Warsaw University

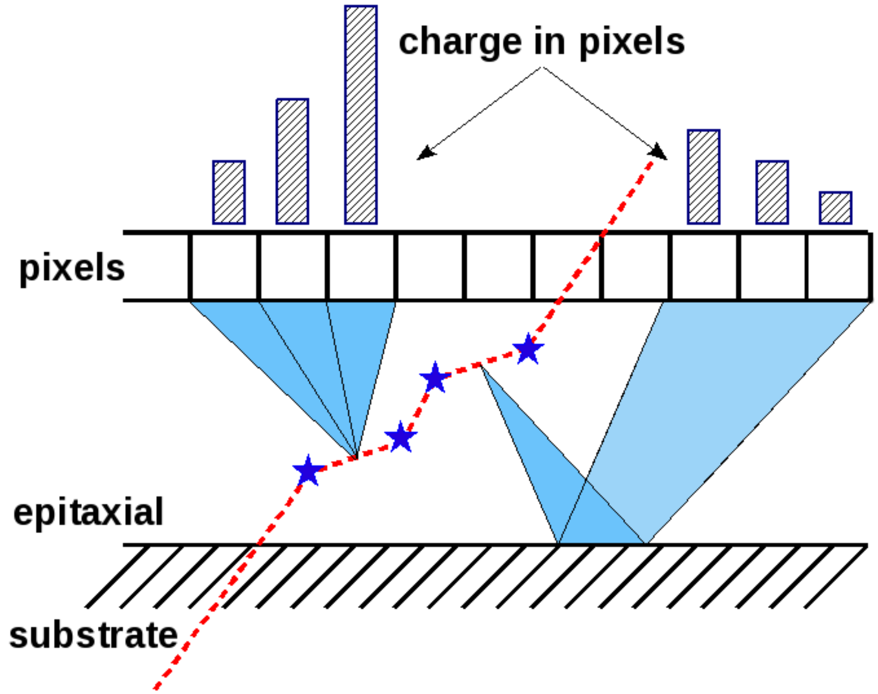
Outline

- Model
- TDSPixelsChargeMap
- EUTelMAPSdigi
- Results

Model

Model describing MAPS response assumes that three processes dominate charge distribution:

- isotropic diffusion in epitaxial layer
- charge reflection at the substrate boundary
- charge attenuation in epitaxial layer



Only 2 parameters (attenuation length and reflection coefficient)

+ parameters describing sensor readout (gain, noise)

For details see presentation of L.Maczewski

TDSPixelsChargeMap

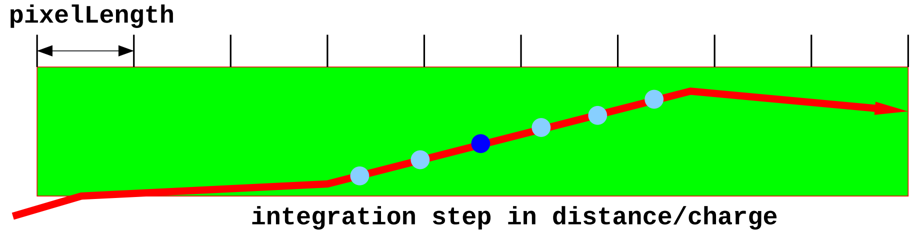
New class for charge distribution calculations

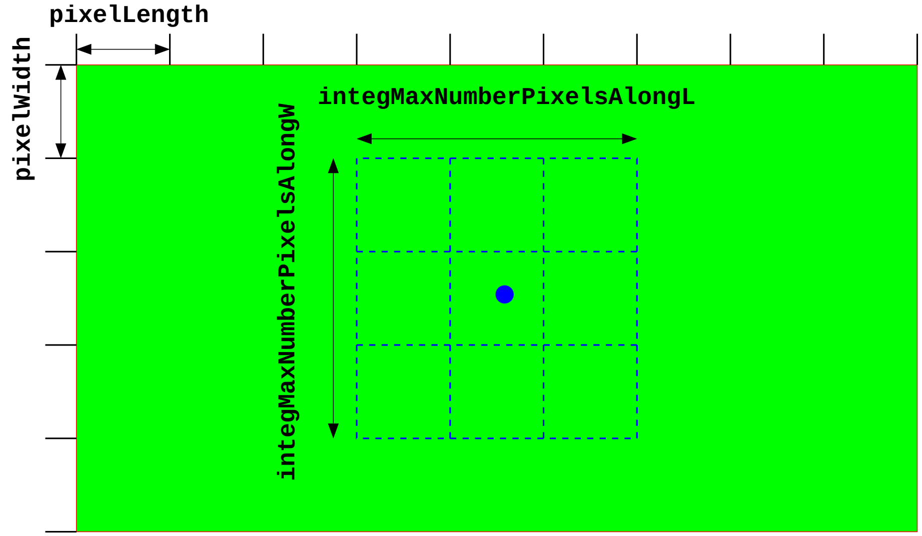
TDSPixelsChargeMap

Deposit of Geant/Mokka hit is distributed in many steps along particle path.

Charge collected in each pixel is calculated by numerical integration of charge diffusion formula.

Integration results stored in a grid, so simulation is very fast (except for first 100 hits)



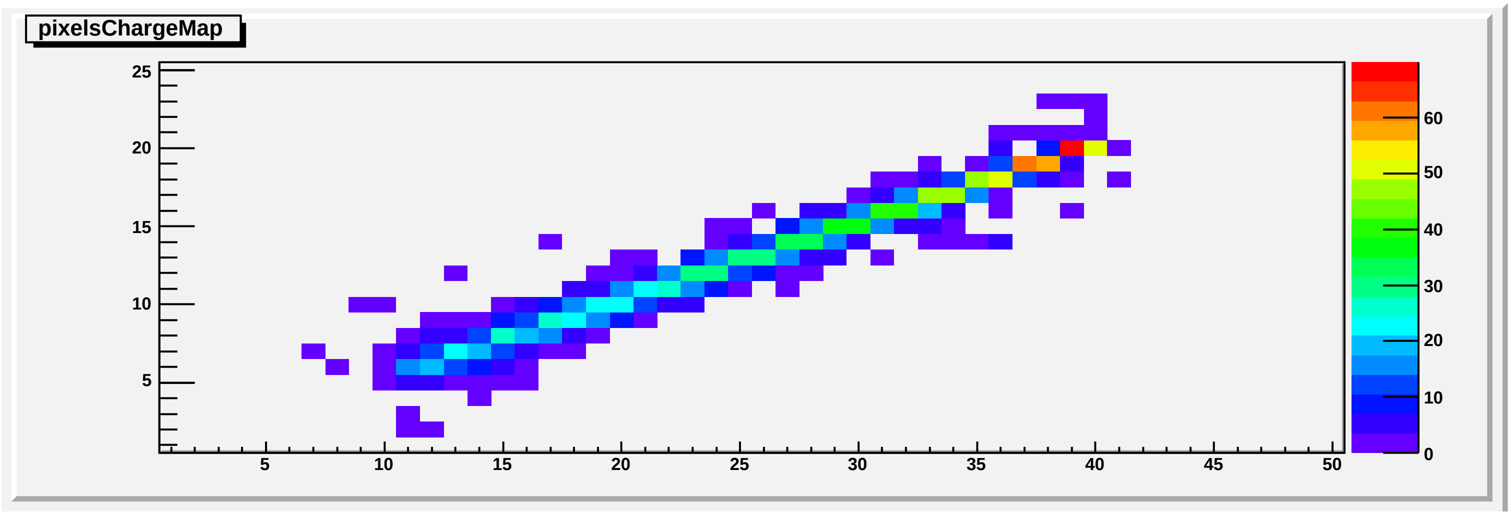


Dedicated option implemented in Mokka forces it to store separate Geant steps:

/Mokka/init/detailedHitsStoring VXD

TDSPixelsChargeMap

Simulated cluster shape for particle crossing at $\theta \approx 89^\circ$



TDSPixelsChargeMap has been included in the Eutelescope repository

Work is in progress to optimize the package for the VXD detector simulation.

MAPSdigi

EUTelMAPSdigi

New Marlin processor, based on TDSPixelsChargeMap

- defines sensor geometry and integration storage for TDSPixelsChargeMap based on GEAR geometry description
- reads SimTrackerHit hit collection (output from Mokka)
  Eutelescope geometry driver thanks to Tatsiana Klimkovich
- transforms hit coordinates to the local (sensor) reference frame
- applies TDSPixelsChargeMap methods to divide ionization charge (as given by Mokka) between pixels
- applies digitization (gain, noise, threshold)
- stores output as TrackerData (as Zero Suppressed data)
  many thanks to Antonio Bulgheroni for implementing this part!

MAPSdigi

EUTelMAPSdigi

Main parameters:

- IonizationEnergy - Ionization energy in silicon [eV] (3.6)
- ChargeAttenuationLength - Charge attenuation length in diffusion [mm] (0.050)
- ChargeReflectedContribution - Charge reflection coefficient (1.)
- IntegMaxNumberPixelsAlongL(W) - integration range in pixels, along length (width)
- DepositedChargeScaling - Scaling of the deposited charge
- ApplyPoissonSmearing - flag for Poisson smearing of the collected charge
- AdcGain - ADC gain in ADC counts per unit charge
- AdcGainVariation - ADC gain variation
- AdcNoise - ADC noise in ADC counts
- AdcOffset - Constant pedestal value in ADC counts
- ZeroSuppressionThreshold - Threshold (in ADC counts) for removing empty pixels

MAPSdigi

EUTelMAPSdigi

Whole chain can be run in single Marlin job:

```
<execute>
   <processor name="AIDA"/>
   <processor name="MAPSdigi"/>
   <processor name="MyEUTelAutoPedestalNoiseProcessor"/>
   <processor name="Clustering"/>
   <processor name="LoadEta"/>
   <processor name="HitMaker"/>
   <processor name="TestFitter"/>
   <processor name="FitHistograms"/>
   <!--processor name="FitViewer"/-->
   <processor name="Save"/>
</execute>
```

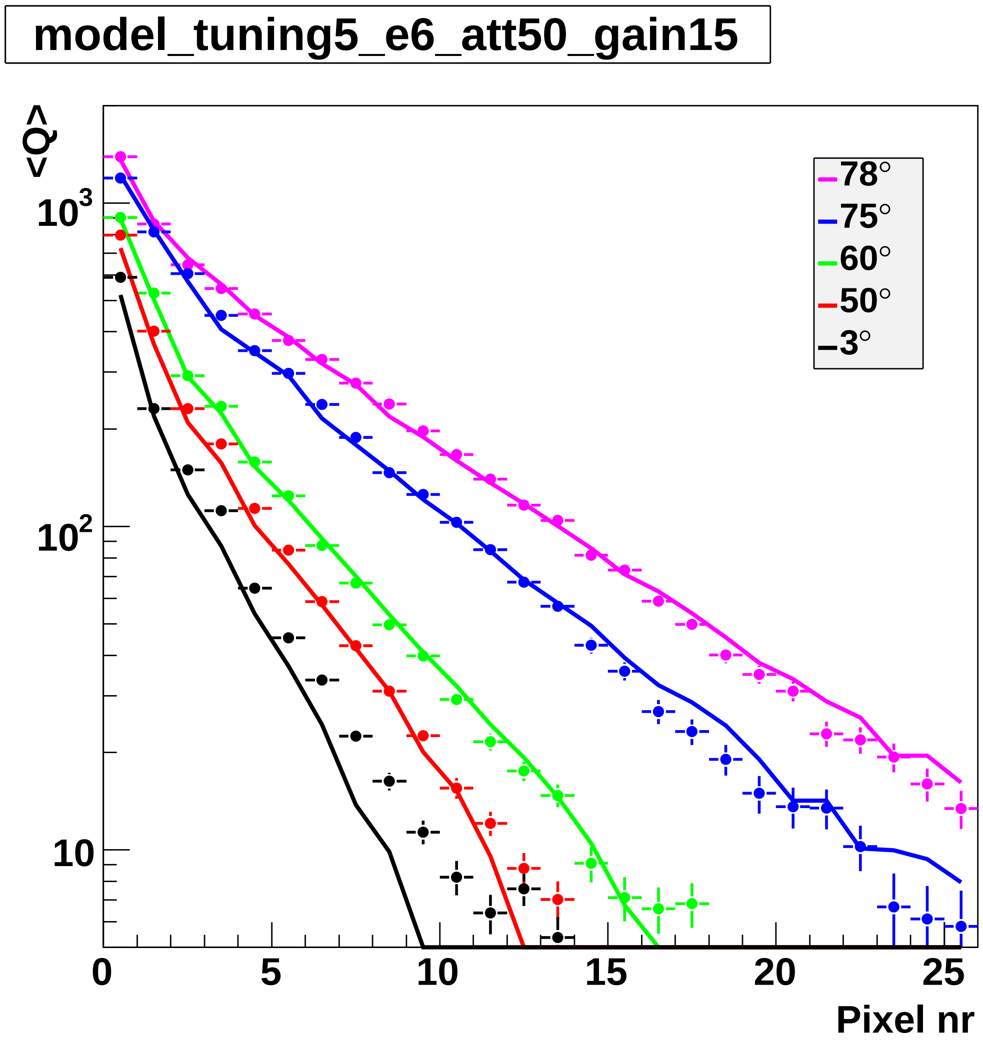
MAPSdigi

Attenuation length was fitted to the charge profiles obtained for electrons at large angles (data from L.Maczewski)

$$\lambda \;=\; 50 \pm 5\mu m$$

Reflection coefficient set to 100%

Gain and noise taken from data

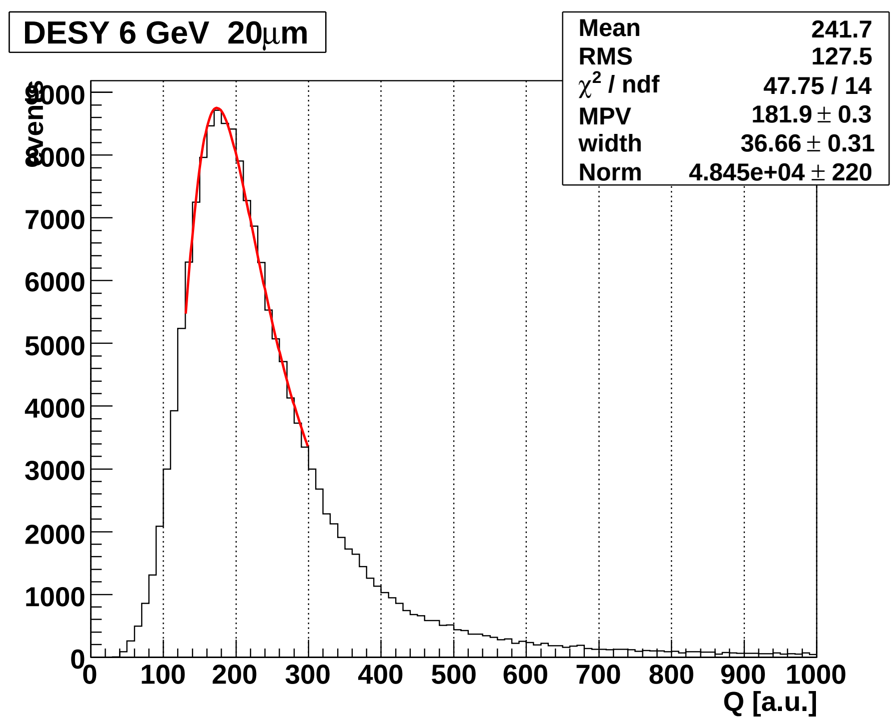


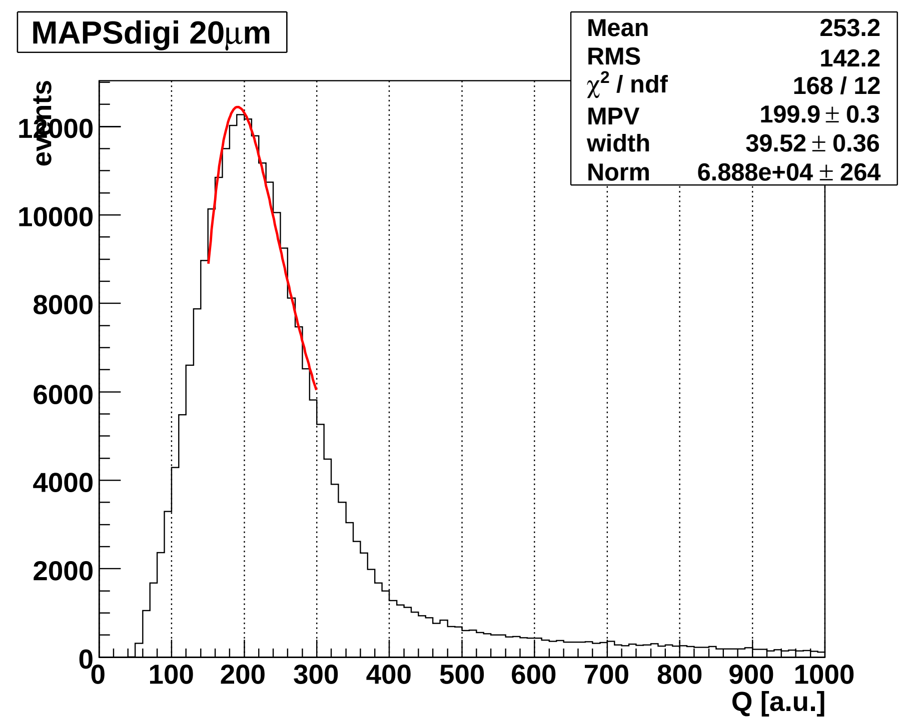
Results

Comparison of MAPSdigi simulation with DESY 2007 test data, 6 GeV electrons

Signal distribution

Cluster signal (in ADC units) for middle plane



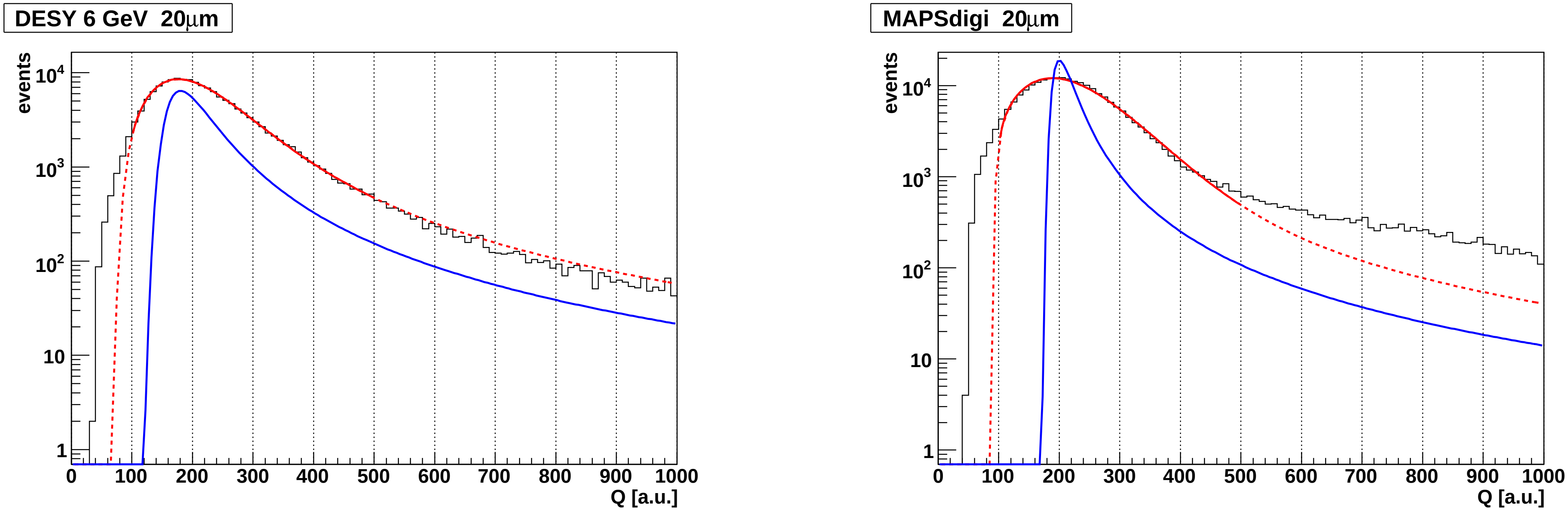


Results

Signal distribution

Cluster signal (in ADC units) for middle plane

Fitted with Landau ⊕ Gamma distribution (blue: Landau contribution)



Simulation results in wider distribution with higher tail

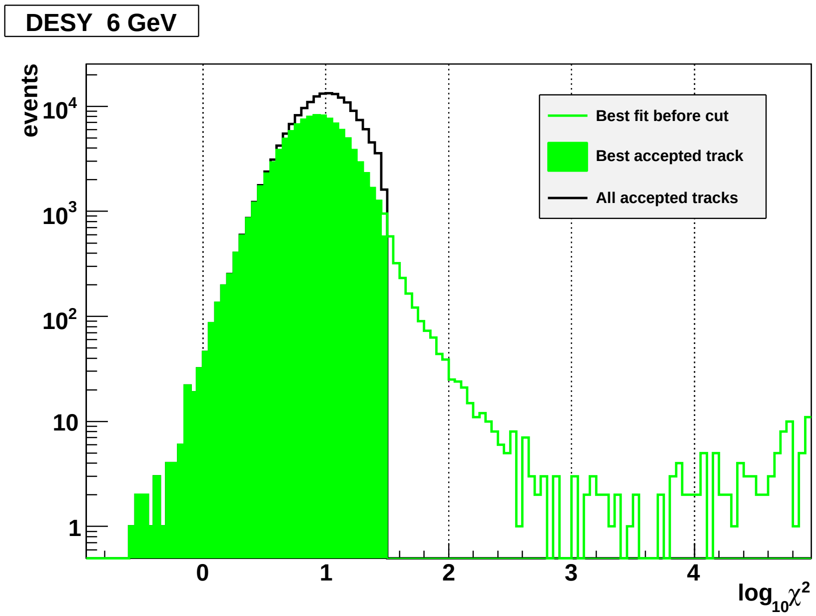
tracking in very thin layers not detailed enough in Geant?

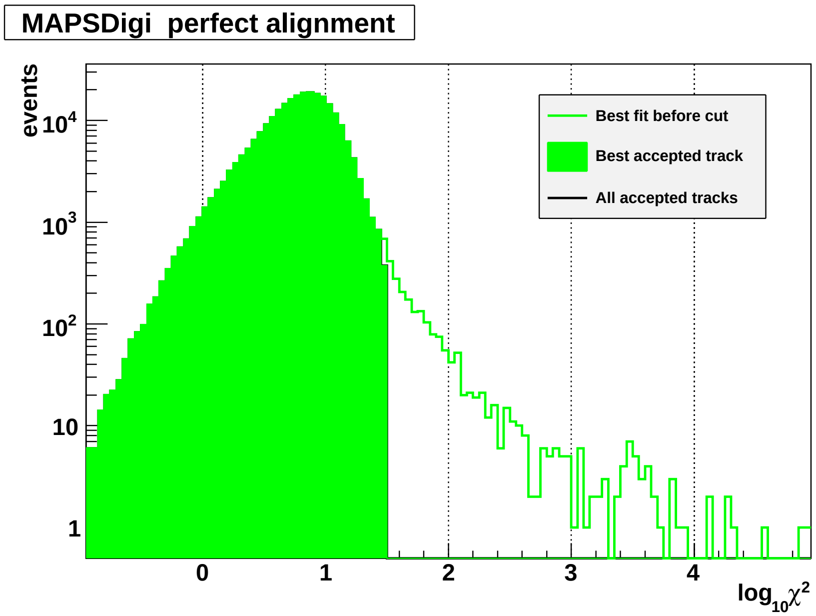
Results

Fit quality

χ^2 distribution for tracks fitted to all sensor layers

Ideal telescope geometry used in MAPSdigi (perfect alignment)





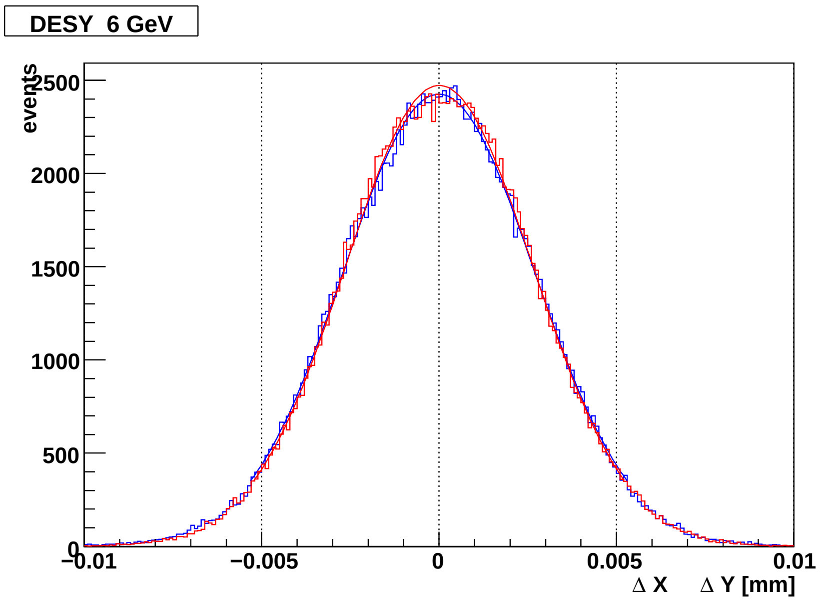
Fits to simulated data are often “too good” !?

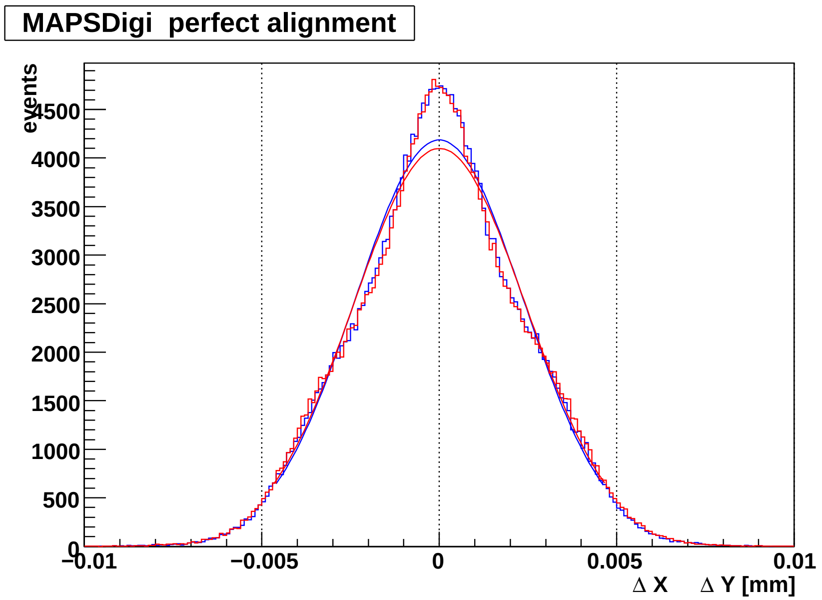
Results

Residuals

Fit residua distribution for middle layer.

Perfect telescope alignment



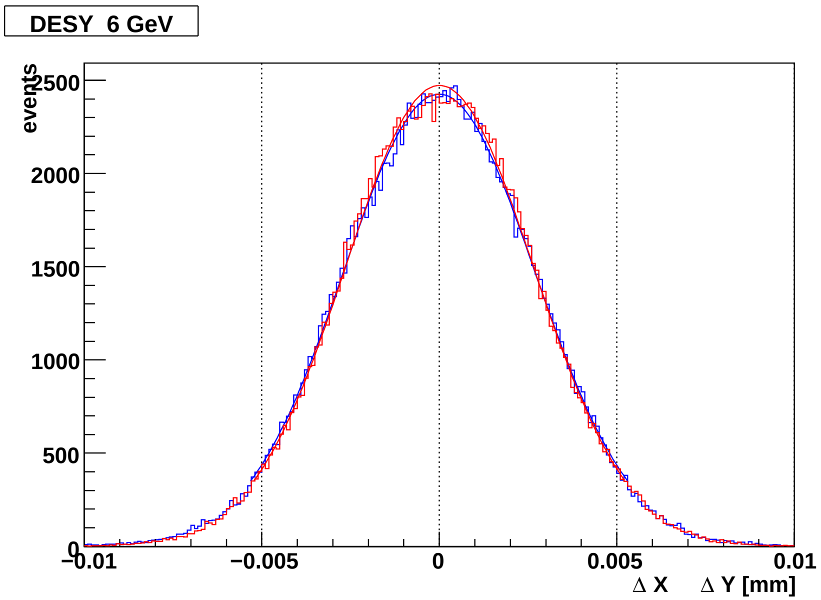


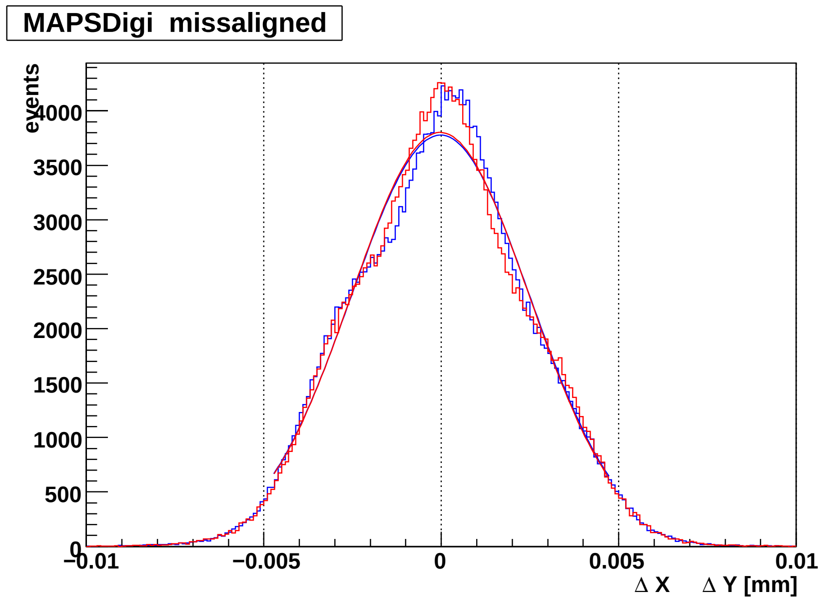
Results

Residuals

Fit residua distribution for middle layer.

Plane shifts included



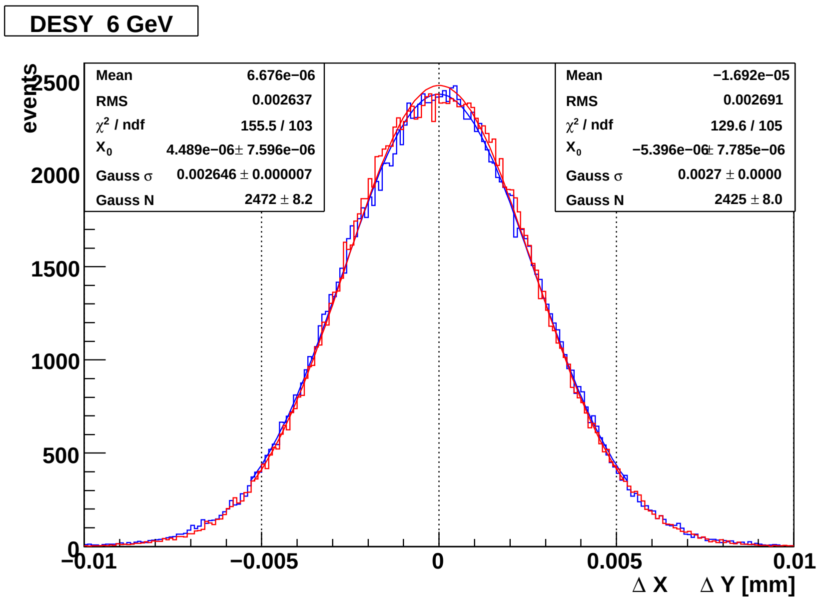


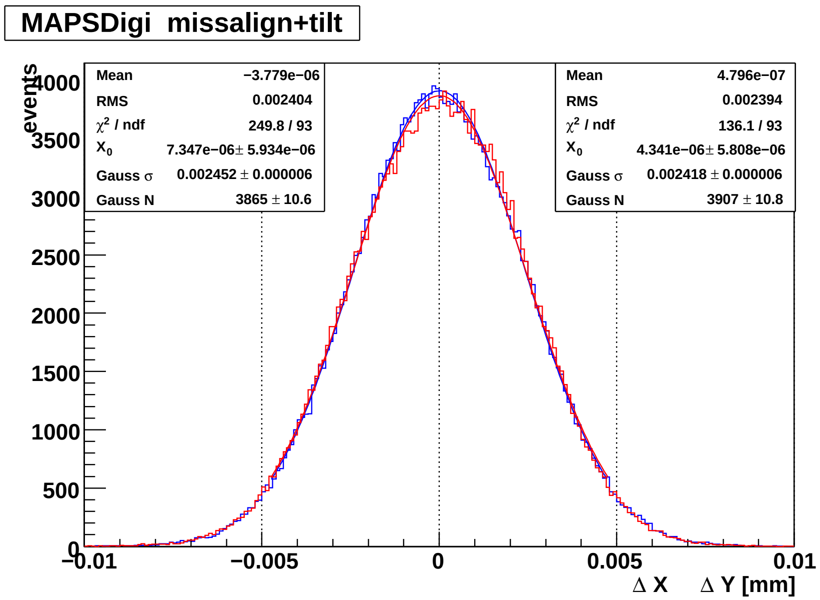
Results

Residuals

Fit residua distribution for middle layer.

Plane shifts and rotations included





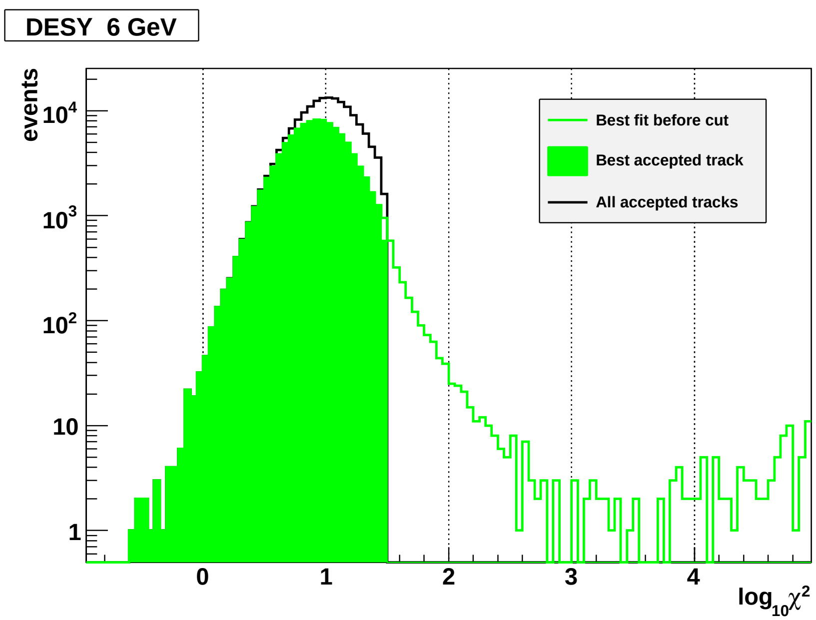
Realistic geometry description is crucial!

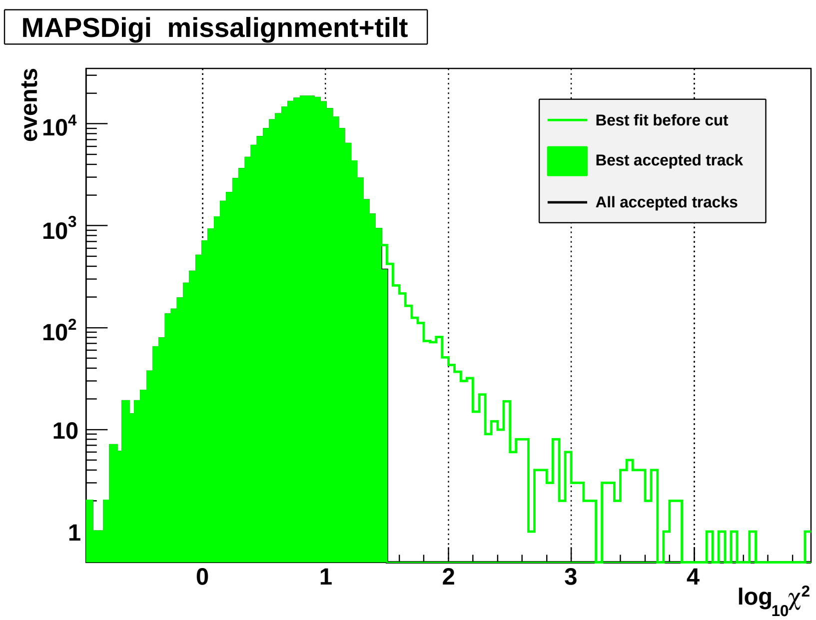
Results

Fit quality

χ^2 distribution for tracks fitted to all sensor layers

Plane shifts and rotations included





Realistic geometry description is crucial!

Best track (out of $\langle\rangle \sim 3$) shown for data, single particle events in simulation

Results

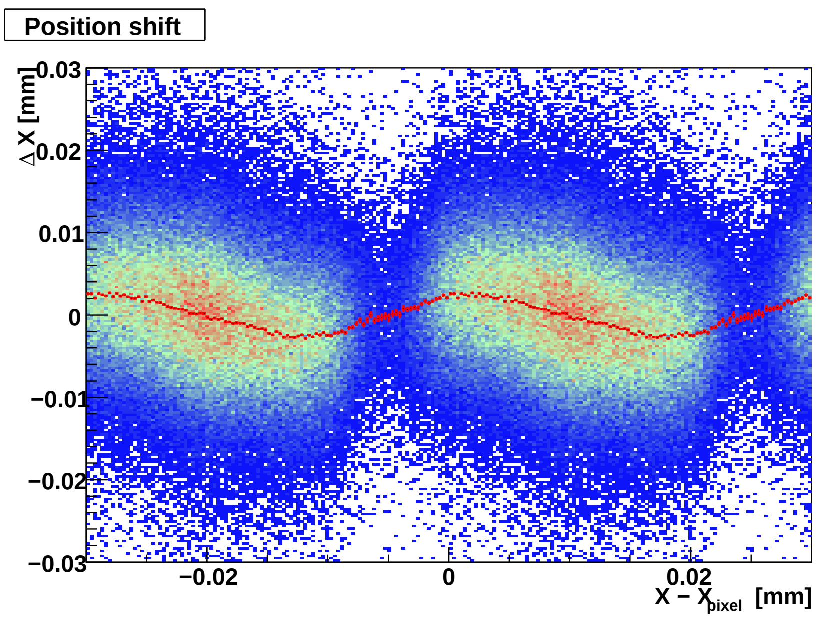
Eta correction

Results presented so far: without eta correction

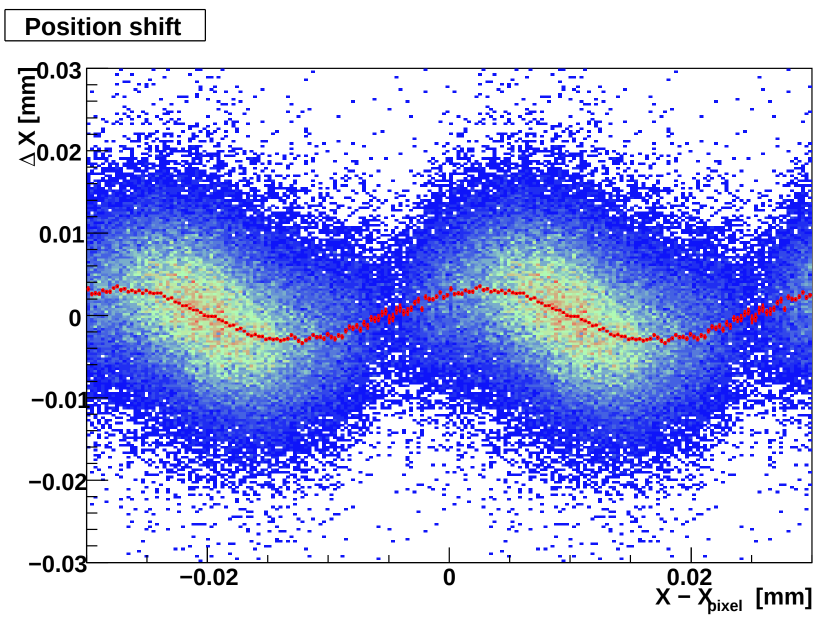
First plane used as DUT, fit to remaining four layers

Position shift in first layer, as a function of CoG position w.r.t. pixel center:

Data



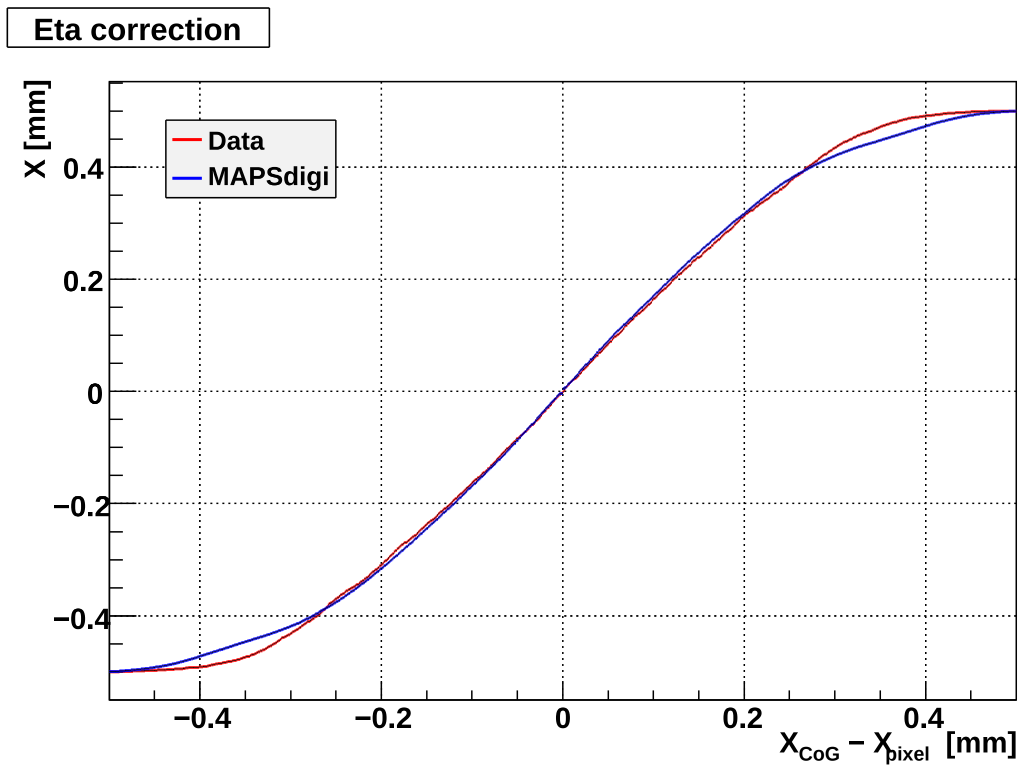
MAPSdigi



Results

Eta correction

Eta correction as calculated by EUTelCalculateEtaProcessor



Proper slope in the middle. Discrepancies near the edge of the pixel.

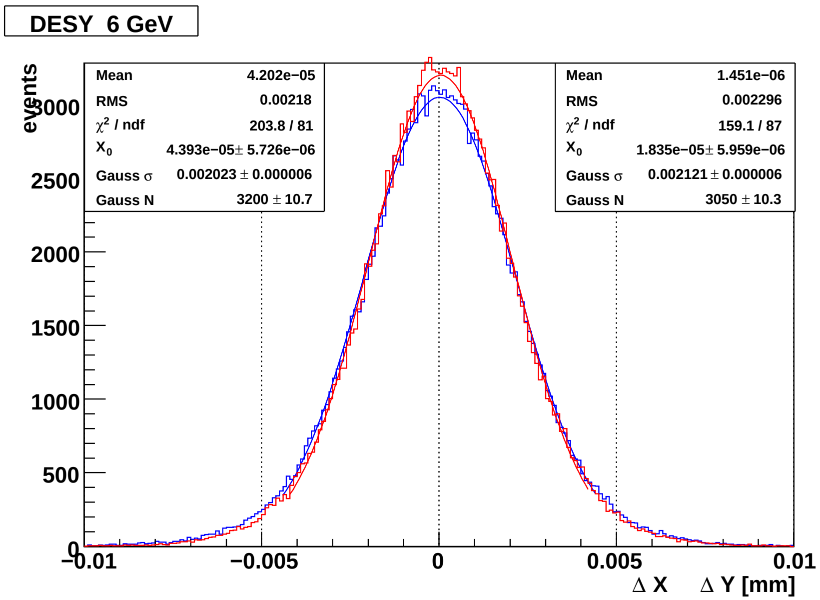
Simulation assumes uniform response over pixel surface and no gaps between pixels...

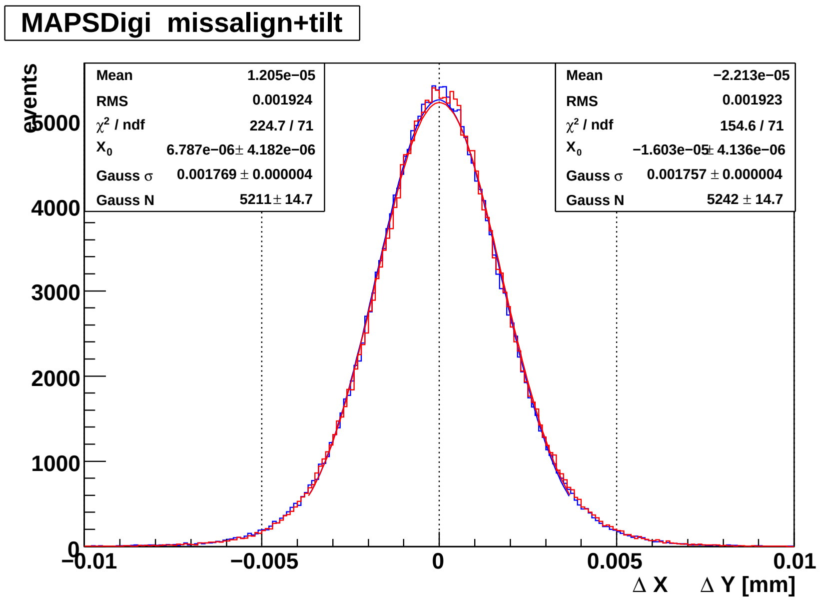
Results

Residuals

Fit residua distribution for middle layer. Eta correction included.

With plane shifts and rotations



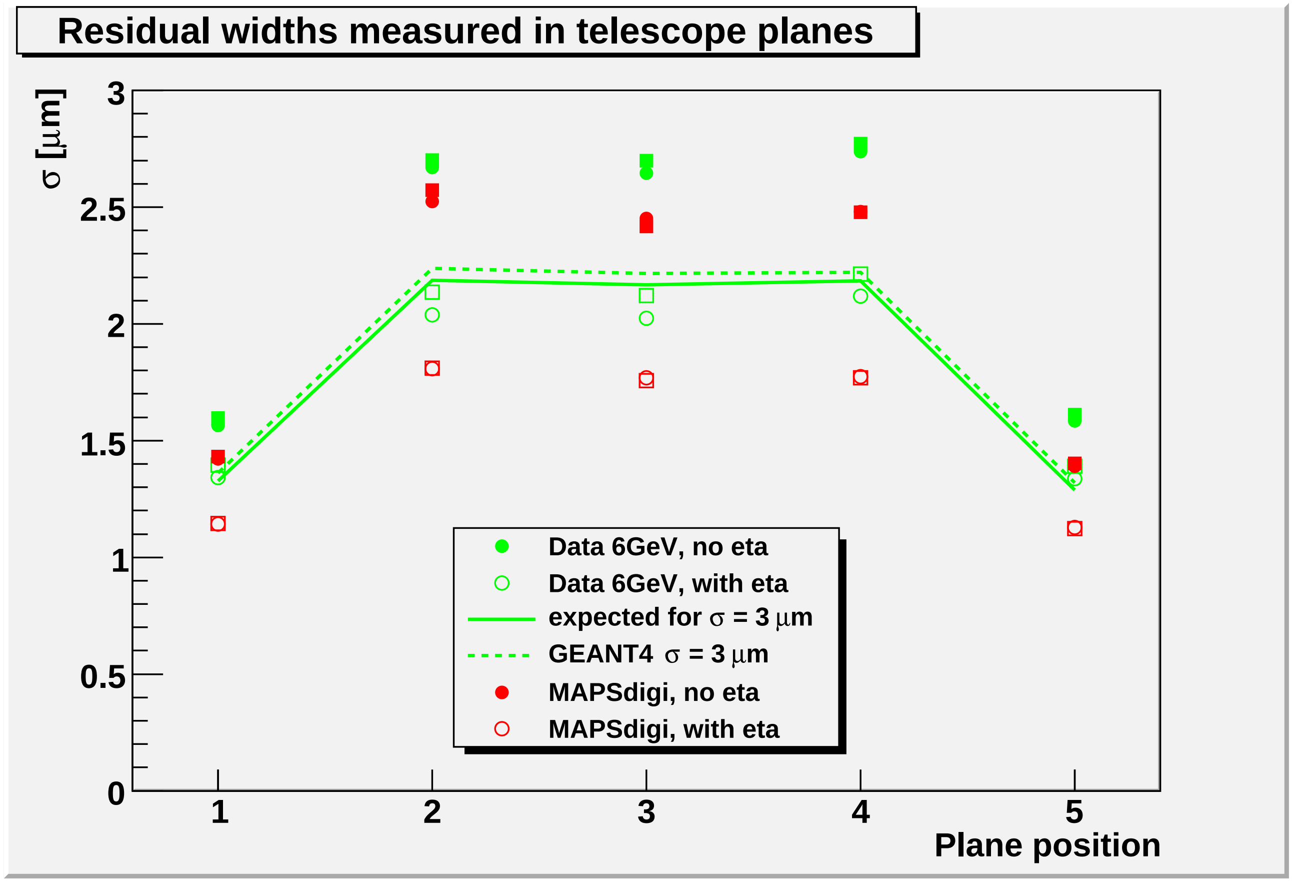


Simulation results in slightly narrower distribution

Results

Residuals

Residua width from fit of Gaussian distribution (within $\pm 2\sigma$)



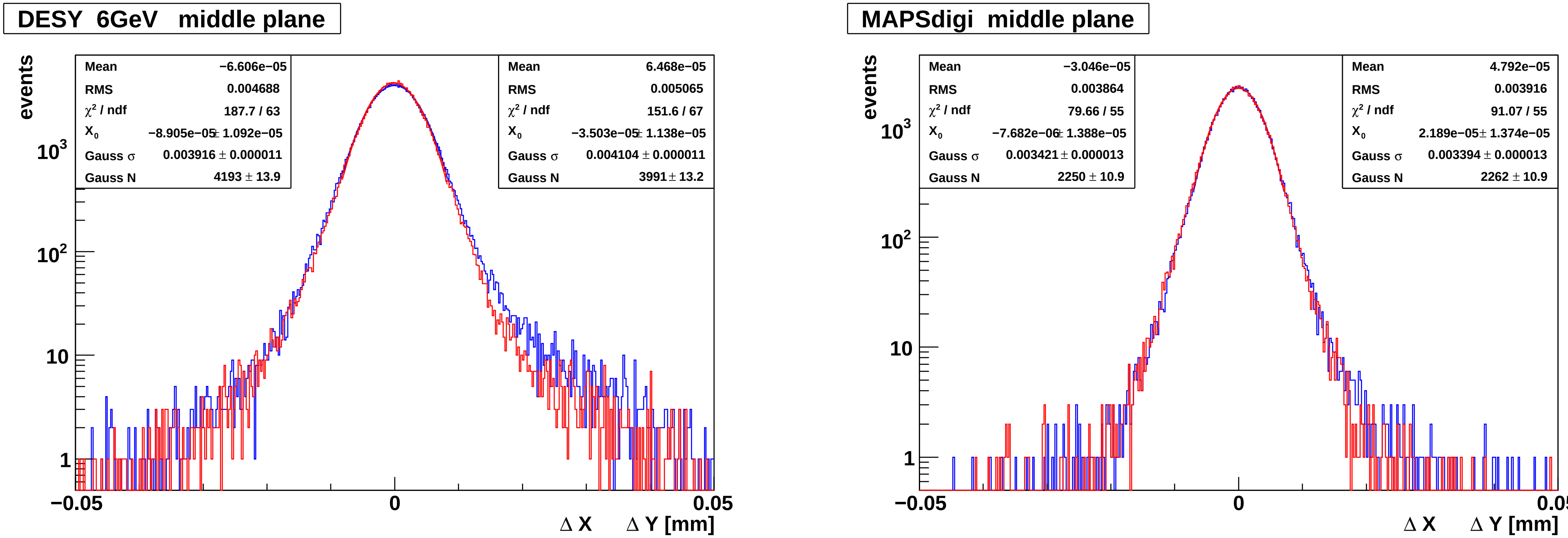
Similar behaviour. Similar effect of eta correction. Simulation slightly too optimistic?

Results

DUT simulation

Middle plane used as DUT, fit to remaining four layers

Measured - expected position in the DUT plane

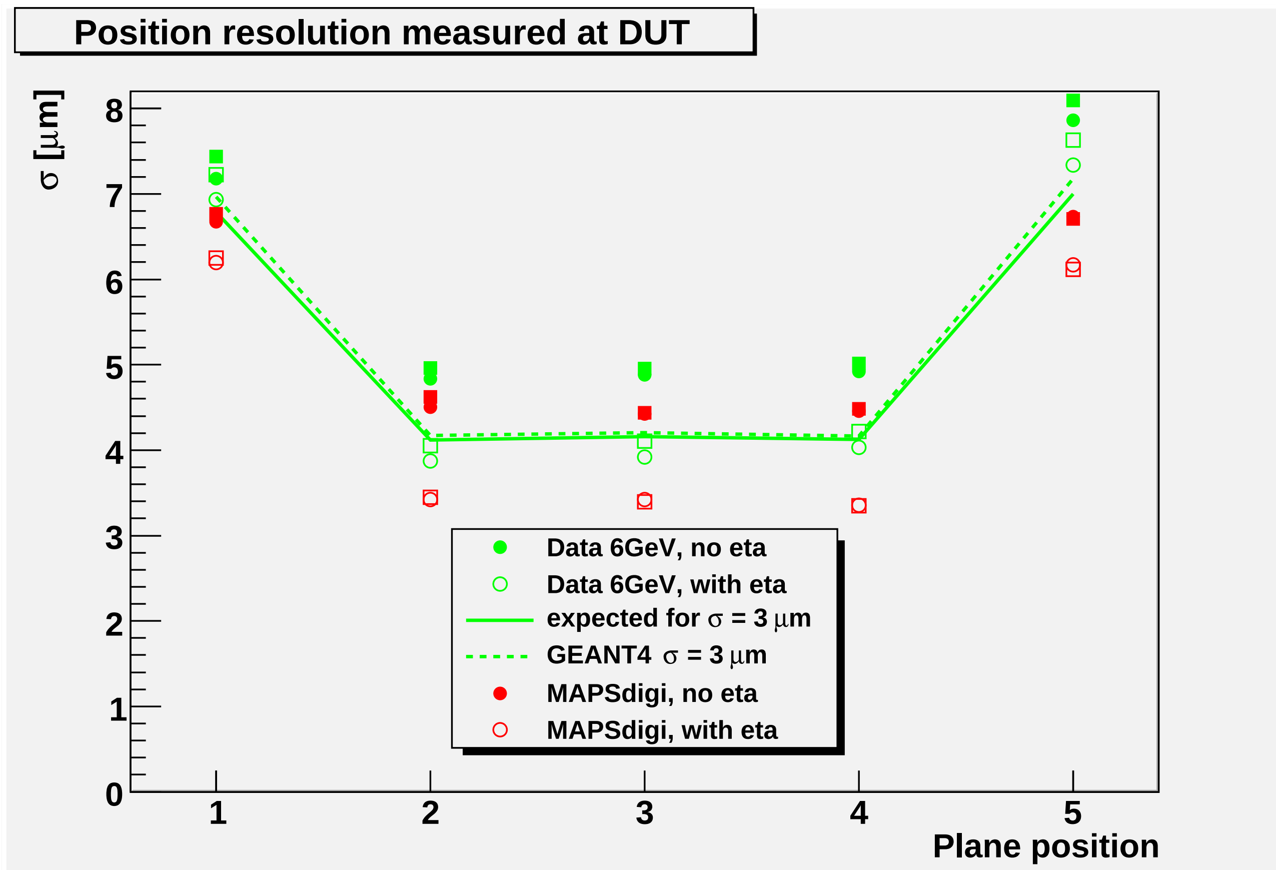


∼ 3 times more events in data sample...

Results

DUT simulation

DUT resolution from fit of Gaussian distribution (within $\pm 2\sigma$)



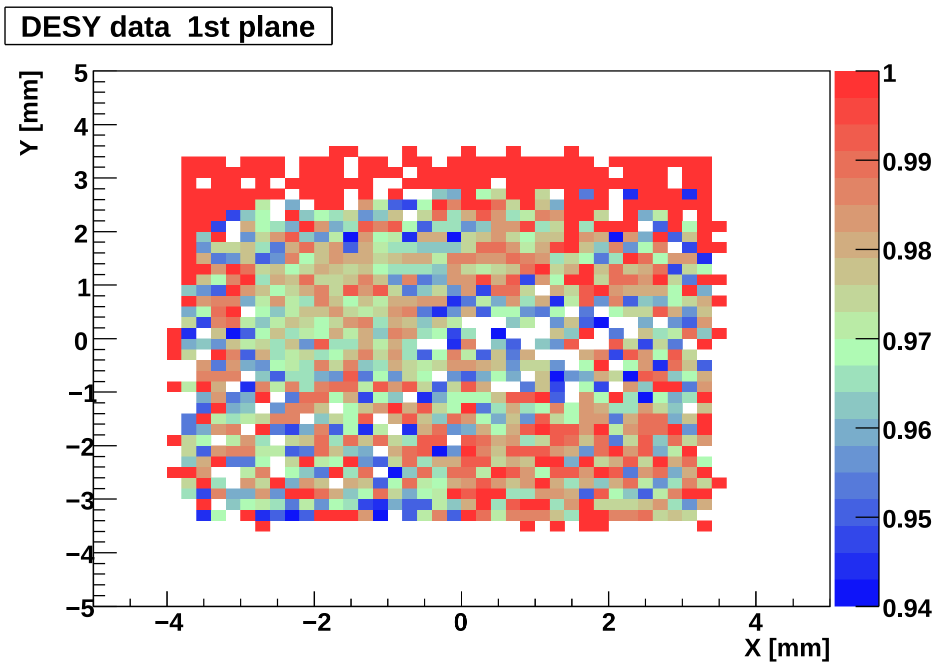
Similar effect of DUT eta correction. Simulation slightly too optimistic again...

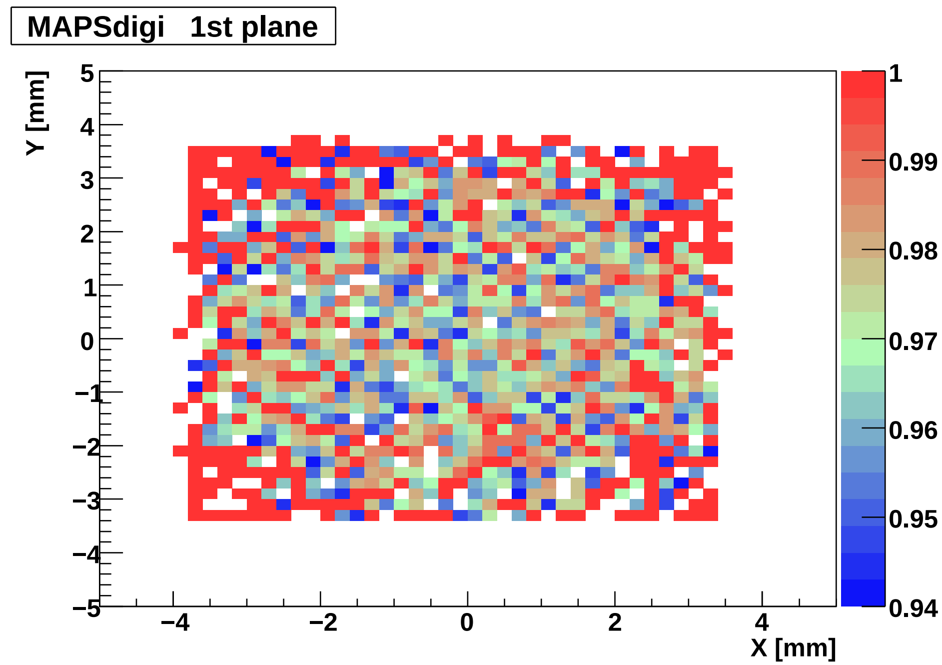
Results

Efficiency

First plane used as DUT, fit to remaining four layers

Efficiency of finding DUT hit within $50\mu m$ from the track





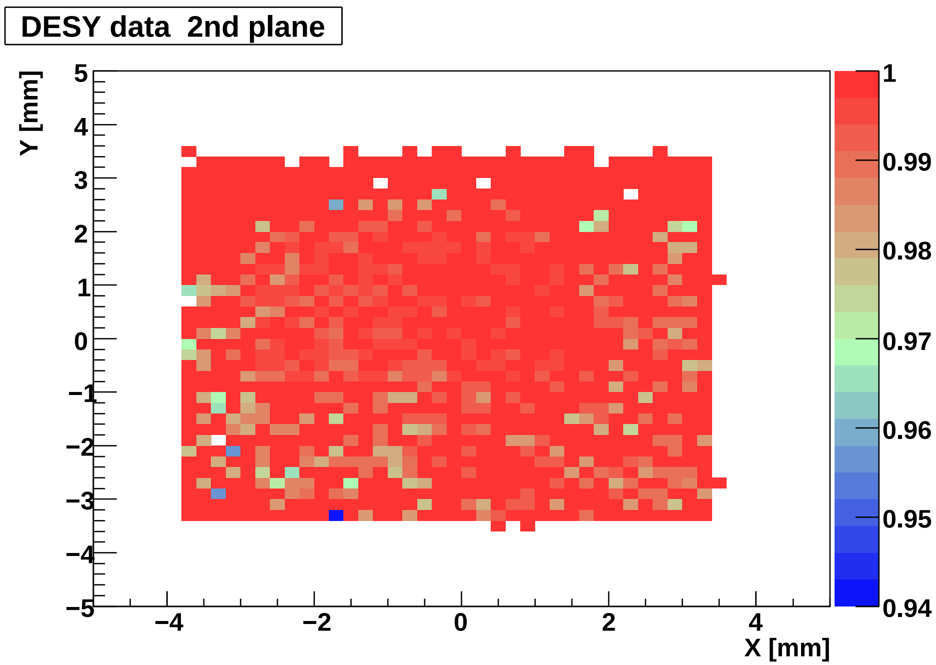
Surprising similarity !

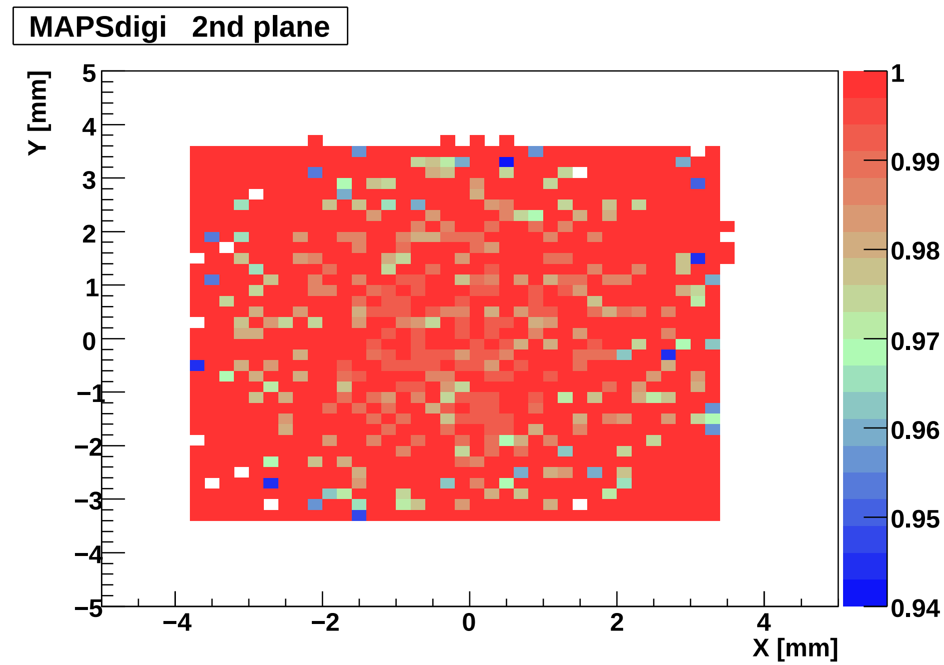
Results

Efficiency

Second plane used as DUT, fit to remaining four layers

Efficiency of finding DUT hit within $50\mu m$ from the track





Surprising similarity ! Probably dominated by multiple scattering...

Conclusions

Simulation processor for EUDET telescope ready.

Results compared with telescope test data from DESY
⇒ good description of all features of the test data

MAPS description probably too simplified
⇒ detector performance slightly better than observed in data

Sensor geometry description can be improved
(e.g. epitaxial layer thickness, gaps between pixels, pixel response function)

Future plans

VXD simulation

The main goal of TDS development is to simulate VXD performance at ILC.

First results for VXD05 configuration (3×2 layers), ILD_00fw detector model

Guinea Pig pair background, nominal machine parameters

Occupancy - fraction of pixels above threshold, per 1 BX (perpendicular MIP $\sim$ 1000 e)