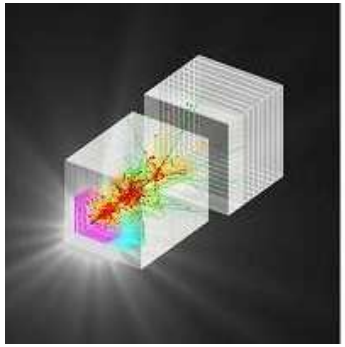
Investigation of the Transverse Hadronic Profile in the HCAL



Riccardo Fabbri & Angela Lucaci

DESY, 11 December 2008

Very preliminary results are shown and discussed

Current Analysis Procedure

- **Calculate impinging-track trajectory through the calorimeter**

  $\Longrightarrow$ **use tracking from chambers**

- **For correct track projection through calo, align chambers with HCAL**

  $\Longrightarrow$ **use hadronic shower COG in HCAL to align HCAL to Chambers**

  $\Longrightarrow$ **other methods under investigation (see next slides)**

- **Radial development of shower energy deposition along HCAL calculated wrt reconstructed track trajectory**

  ☞ **$\forall$ cell i calculate:**

  – **deposited energy** E_i

  – **radial coordinate wrt reconstr. track** t

  $$\rho_i = \sqrt{(x_i - x_t)^2 + (y_i - y_t)^2}$$

  ☞ **investigate transverse profile of deposited energy**

  – $E(\rho) = \sum_i E_i(\rho_i)$ – **longit. scan (E_{layer}), beam energy dependence**

- **Comparison of MC simulations with the data**

Data Selection

- π^+ beam data from CERN 2007 data taking period
  - use of 'old' tracking code (for comparison with official code see next slides)
  - discard events with signal in DC from multiple tracks
- NO ECAL before the HCAL: Runs 350381/3/4, 350390/1 (20/15/10/12/8 GeV; HCAL 30° tilted)
- Events selected with triggers
  - BEAM (SPILL + Scintillator coincidence) & SPILL data:

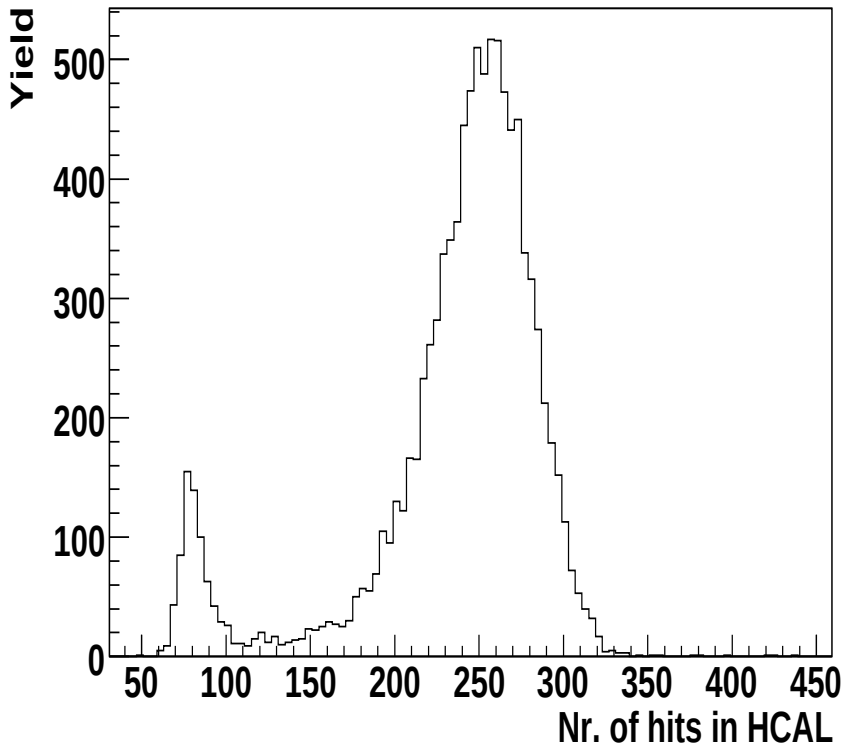
    (EventTrigger & 0x2002) == 0x2002
  - SKIP calibration data: if ((EventTrigger & 0x0010) == 0x0010) SKIP ...
  - SKIP Pedestal data: if ((EventTrigger & 0x0004) == 0x0004) SKIP ...
- HCAL energy cut: $E > 0.5$ MIP
- Discard events with Nr. of firing SiPM < 150 (see next slide)

  $\Longrightarrow$ get rid of MIPs visible in TMC as well
- Discard events with Nr. of firing SiPMs per layer < 15

  $\Longrightarrow$ clean structures from tracks starting showering deeper in the calo

MIP Contamination

- Nr. of Hits in HCAL per event



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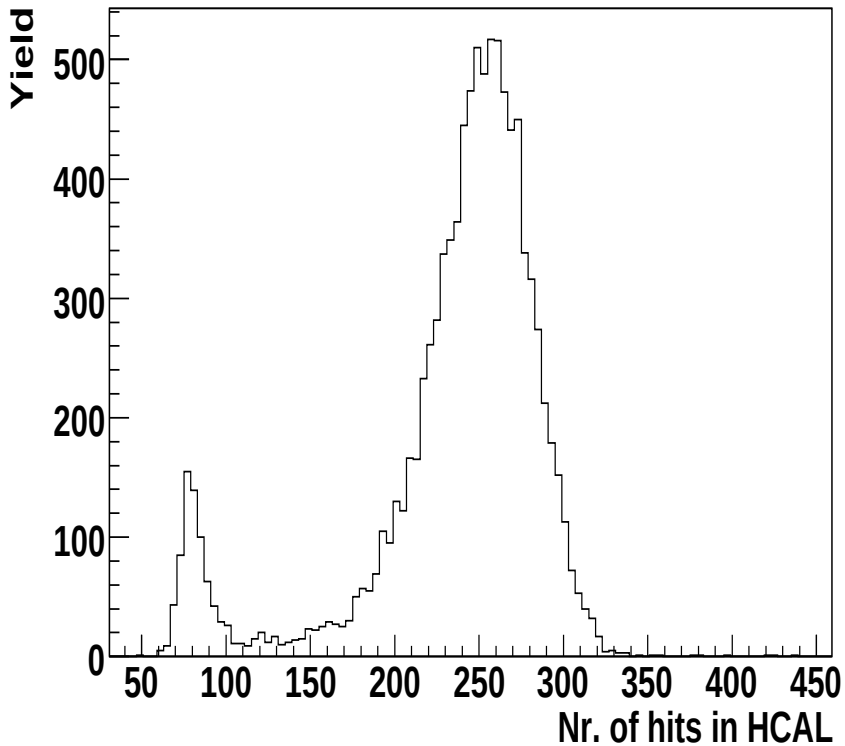
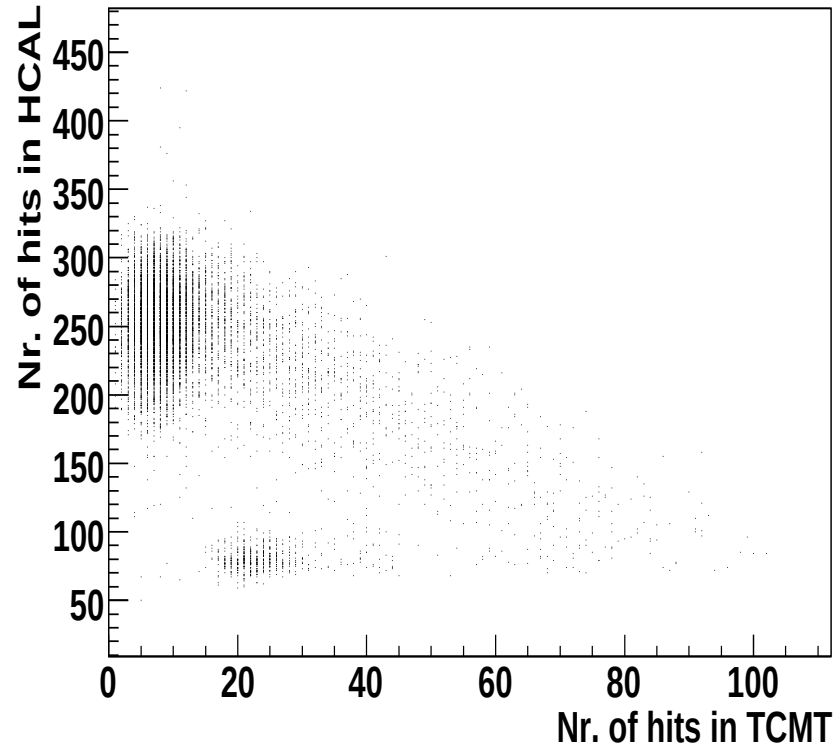


- Correlation plot:

HCAL vs TCMT hits per event:



Cut 'Nr. of hits in HCAL' < 150 should get rid of MIP like tracks

Misalignment Correction

Misalignment calculation:

- performed at track level
- calculate x_{proj} from tracking
- calculate COG_x as

$$COG_x = \frac{\sum_i E_i \star x_i}{\sum_i E_i}$$

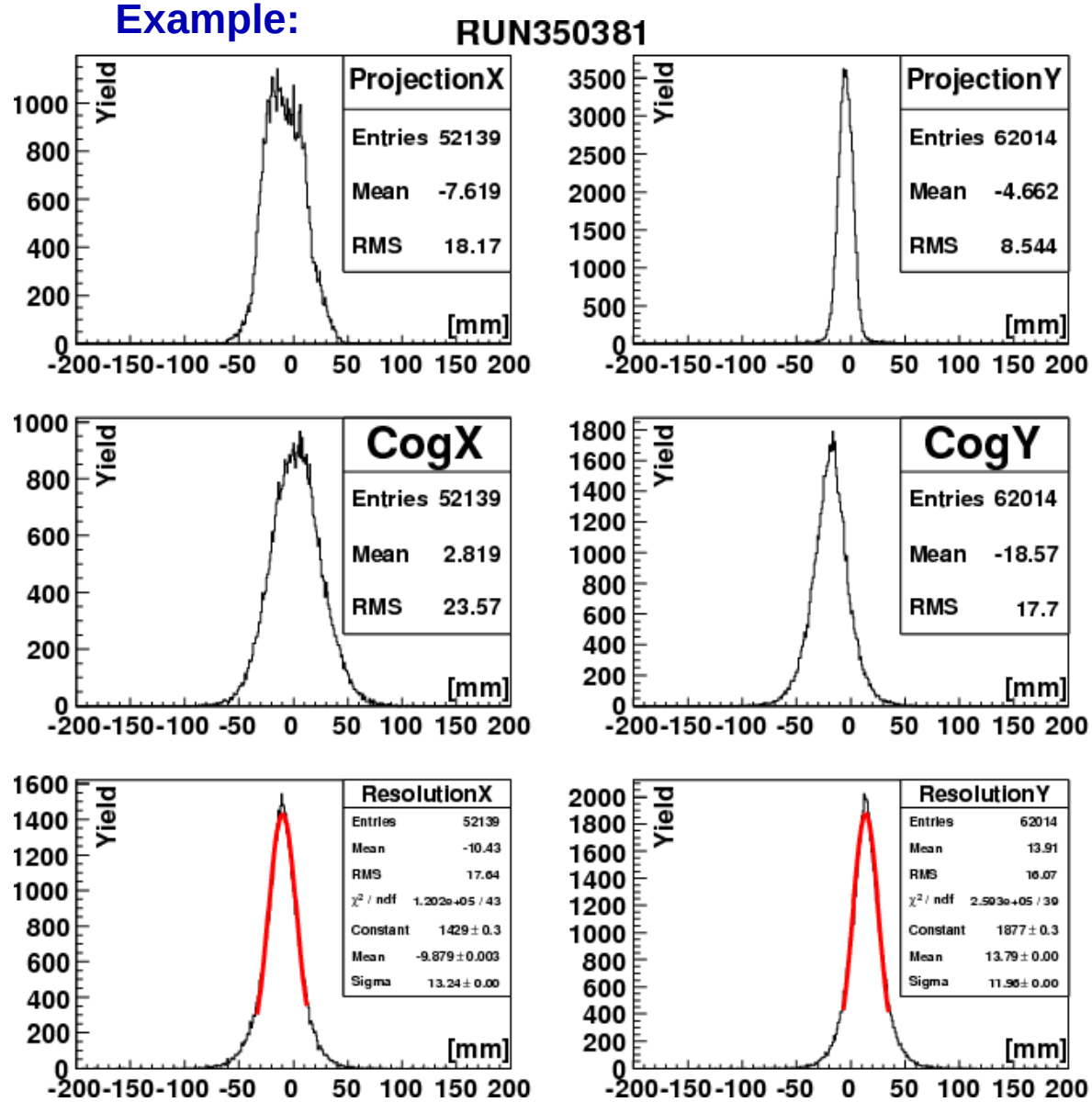
- fit $x_{proj} - COG_x$

  $\Rightarrow Mean \equiv$ misalign.

  $\Rightarrow \sigma \equiv$ resolution

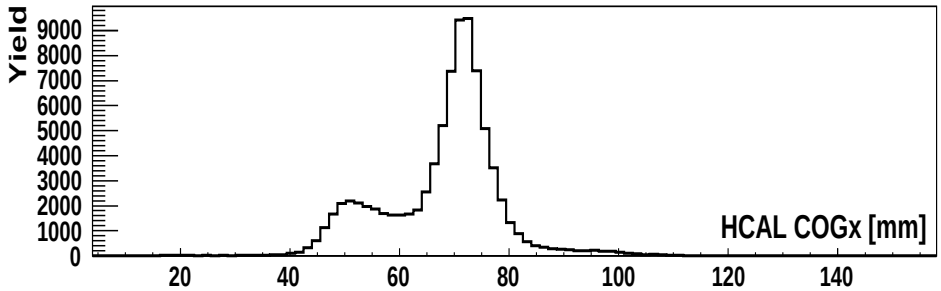
- similarely for y coord.

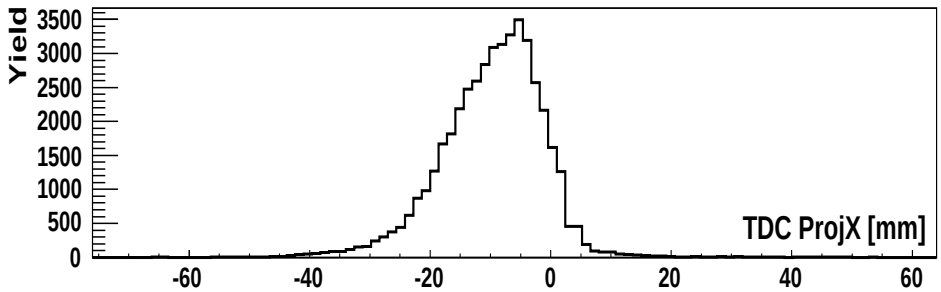
Example:

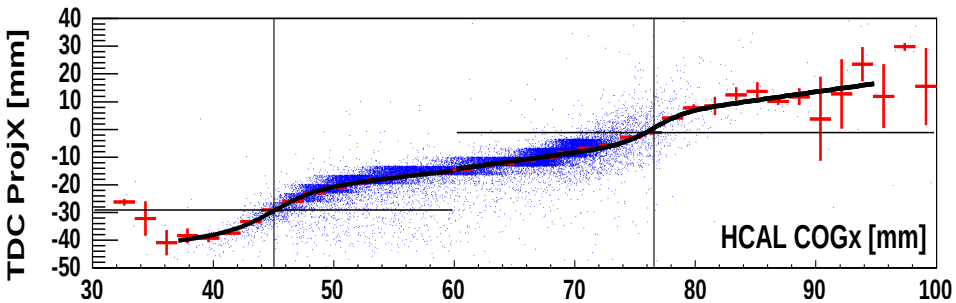


Comparison of Different Alignment Procedures

- Use Projection-COG correlation for electron data (Run 350110)







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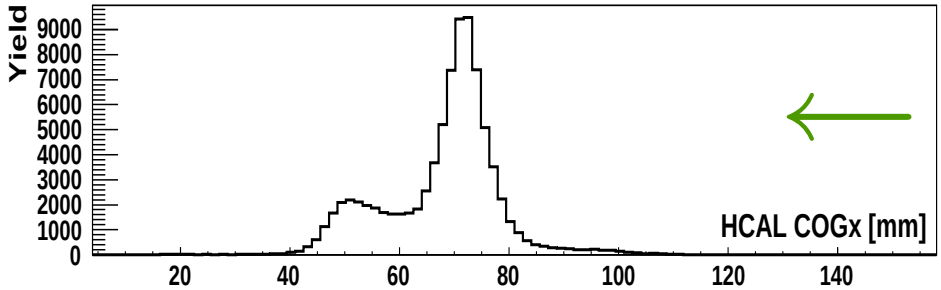
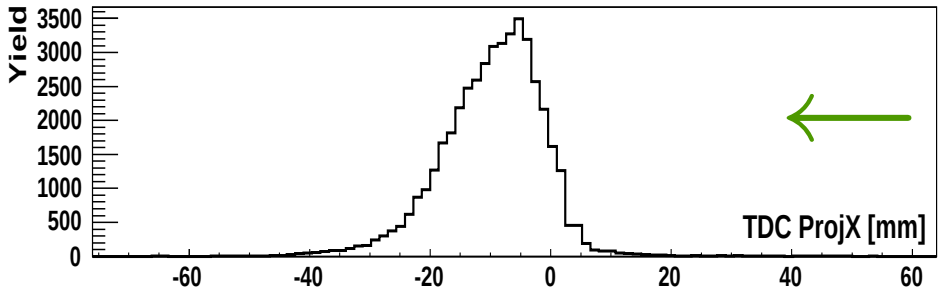


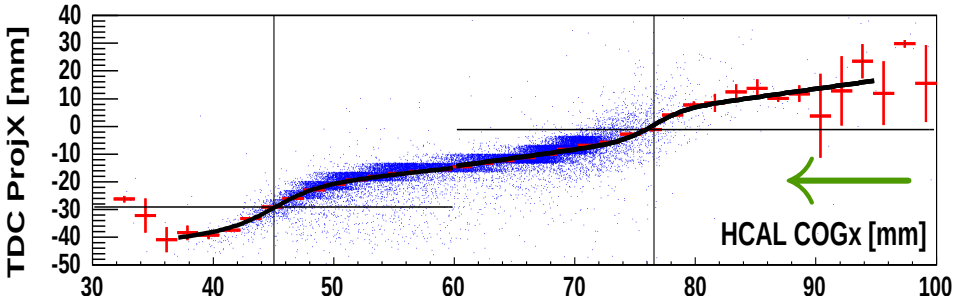
Dip in COG distribution possibly understood as generating by tile side effects

$\Rightarrow$ smearing out



Asymmetry in Proj distribution from χ^2 cut

$\Rightarrow \chi^2 < 2$



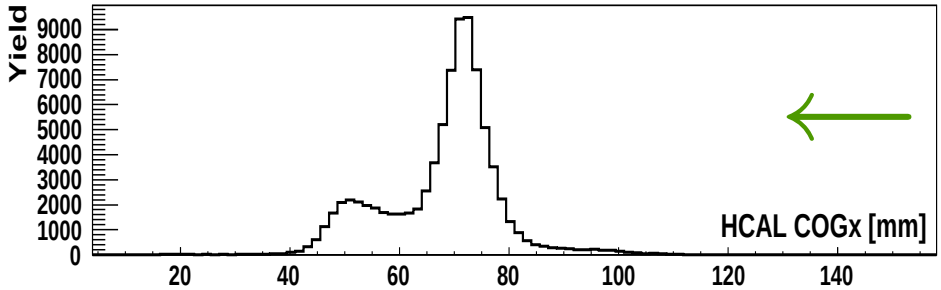
Fit correlation (2-D histo projected on x-axis) using 5-parameters function

$$f(x) = \frac{1}{e^{-\frac{x-a}{b}}+1} \cdot c + d + e \cdot x$$

NOTE: fit done separately for left and right side of projection

Comparison of Different Alignment Procedures

- Use Projection-COG correlation for electron data (Run 350110)



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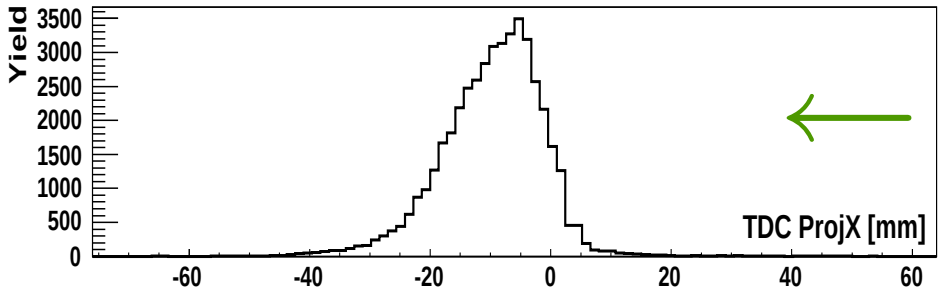

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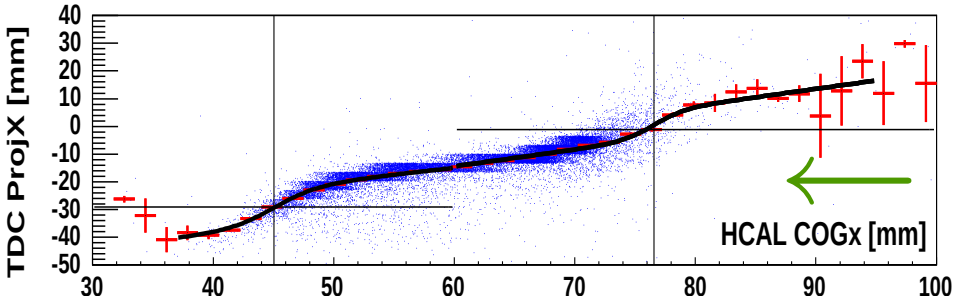

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$$f(x) = \frac{1}{e^{-\frac{x-a}{b}}+1} \cdot c + d + e \cdot x$$

NOTE: fit done separately for left and right side of projection

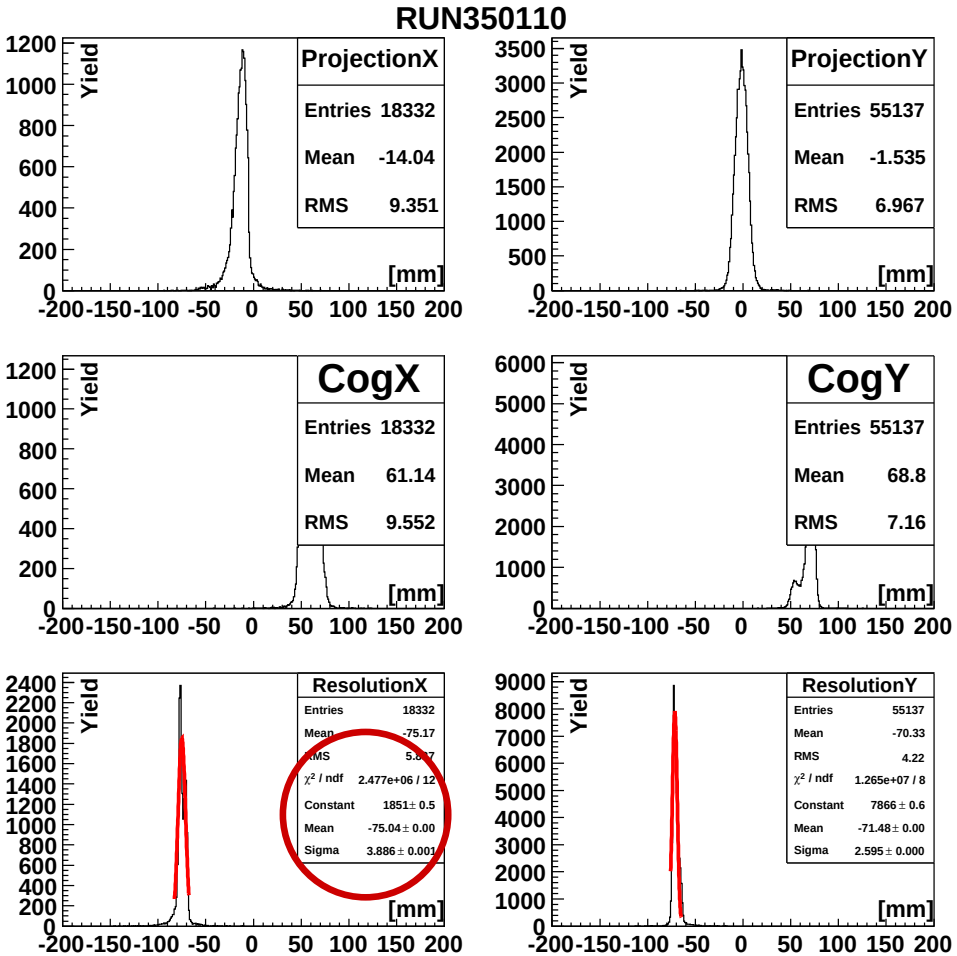
Misalignment calculation:

$\downarrow$ -74.40 mm

$\downarrow$ -76.06 mm

Comparison of Different Alignment Procedures

- Calculate at track level Projection-COG difference for same electron data

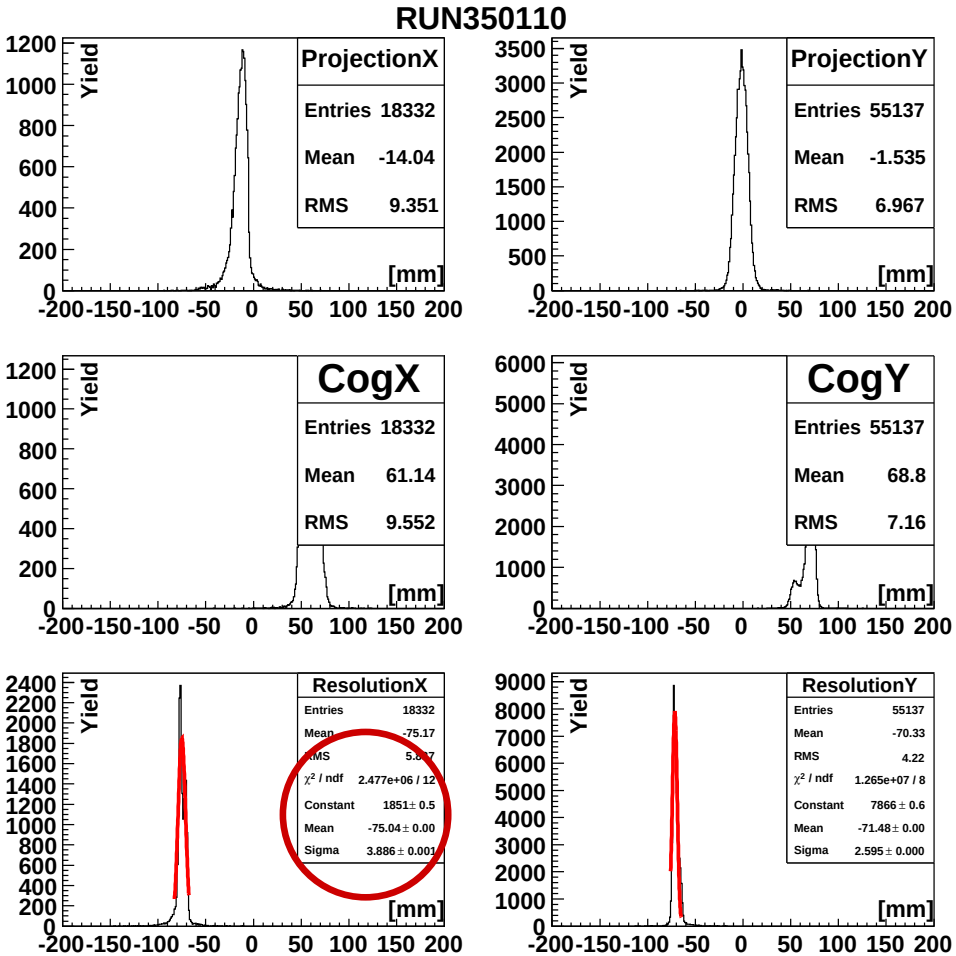


Misalignment measurement:

-75.0 mm vs -74.4/-76.1 mm

Comparison of Different Alignment Procedures

- Calculate at track level Projection-COG difference for same electron data



Misalignment measurement:

-75.0 mm vs -74.4/-76.1 mm

- ✔ qualitative agreement
- ✔ uncertainty not considered yet
- ✔ fitting needs user feedback

  ⇒ track-level difference more flexible

- ✔ alignment need for hadron runs as well

  ⇒ here correlation harder to get

- ✔ use track-level method

  ⇒ results to be compared with electron beam data taken in similar data taking conditions

Tracking Code Comparison

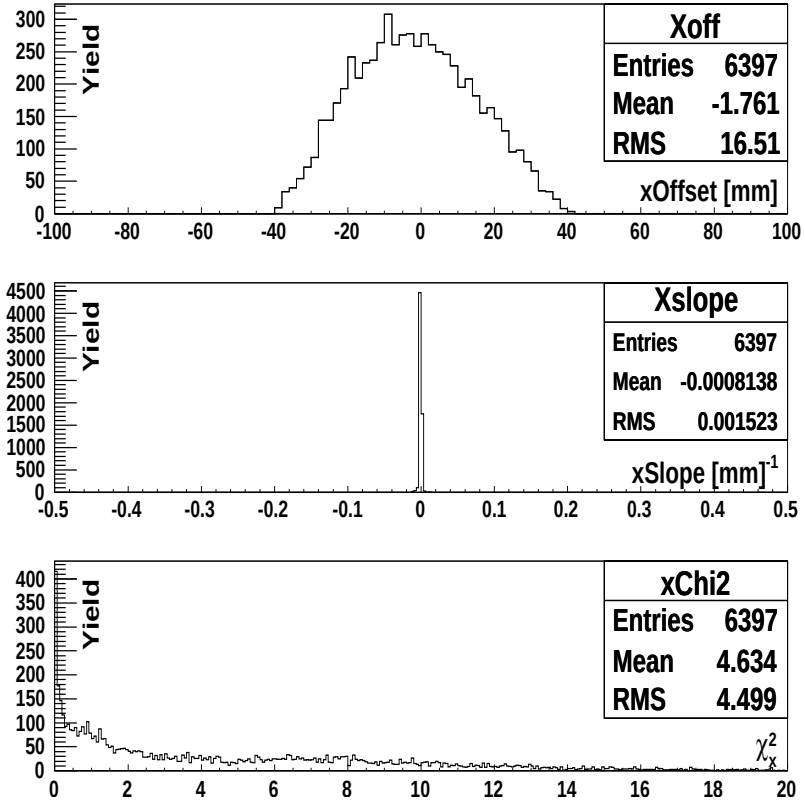
Old code:

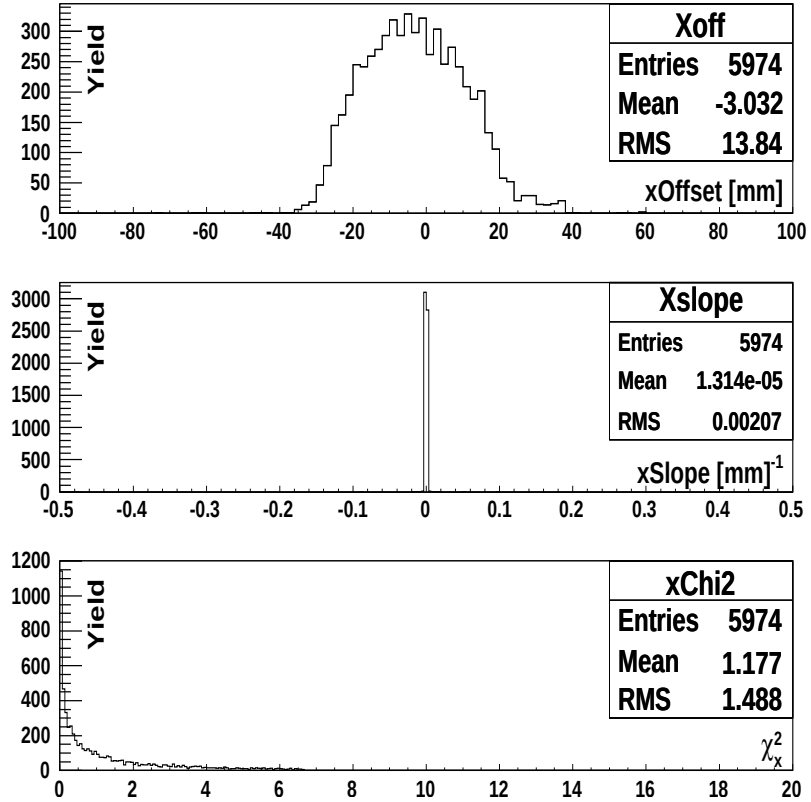
- calibration values hardcoded:
- values from data analysis/surveys

Official code:

- calibration values from database:
- values stored from?
- more complete data treatment

Run 350381



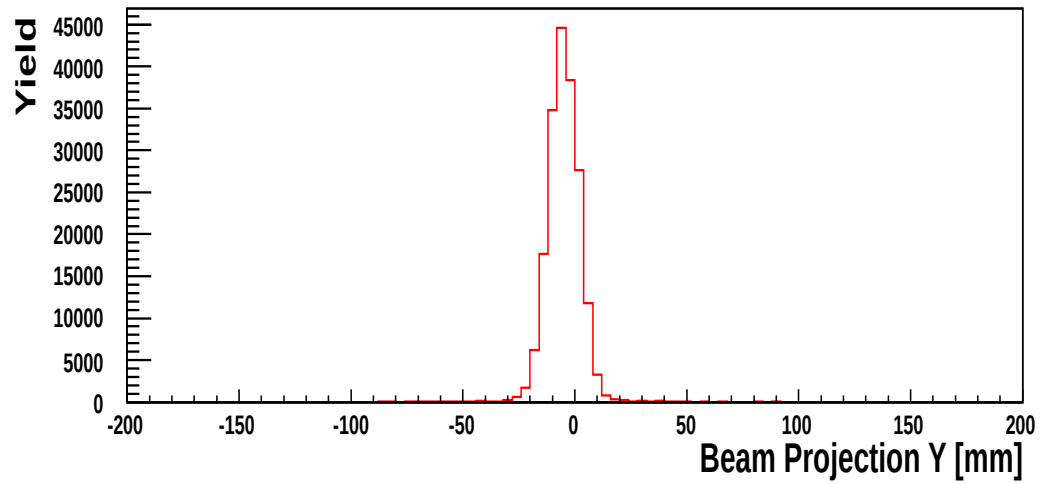


- **Results in disagreement:**
  - calibration constants mismatch? Investigation next week
  - problems in the reconstruction algorithm?

Effects from Finite Tile Size

- **Run 350381:**

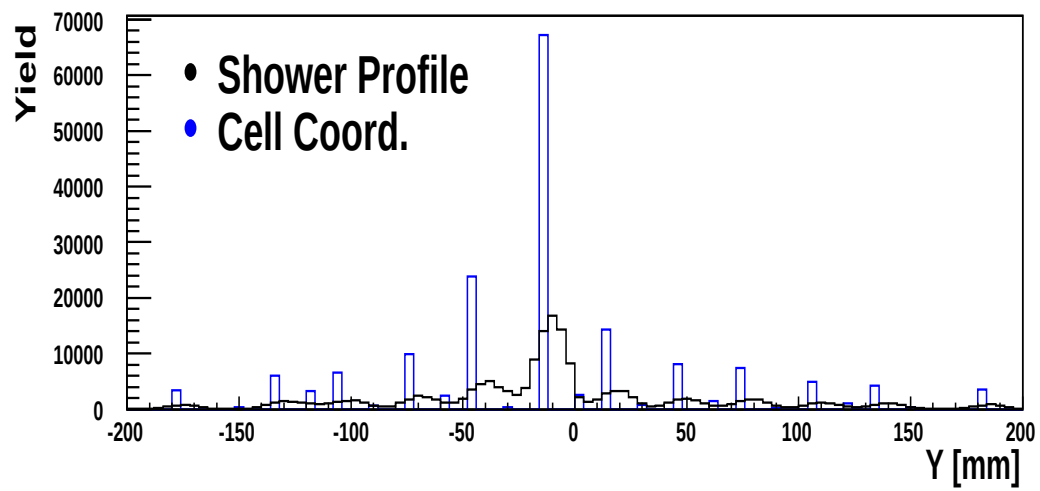
y-Coordinate



☞ **Small and non-uniform beam profile SHOULD bias the tile distance from track axis** $x_{proj} - COG_x$

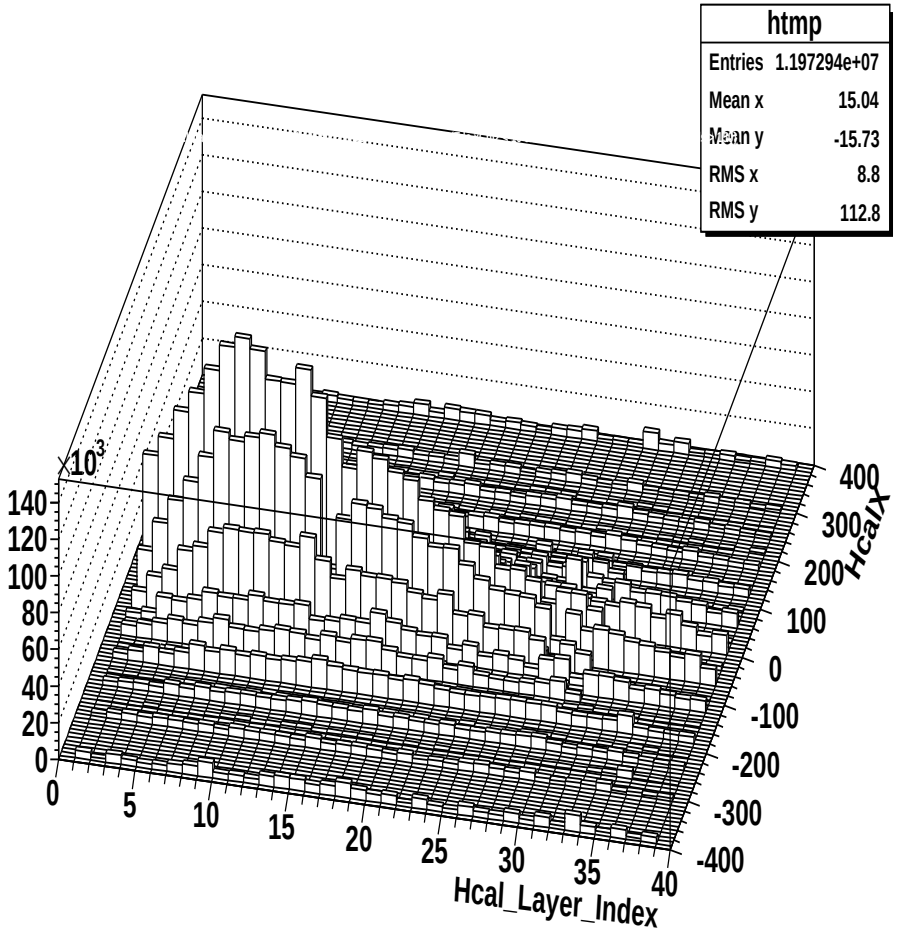
☞ **The effect expected for yield distributions**

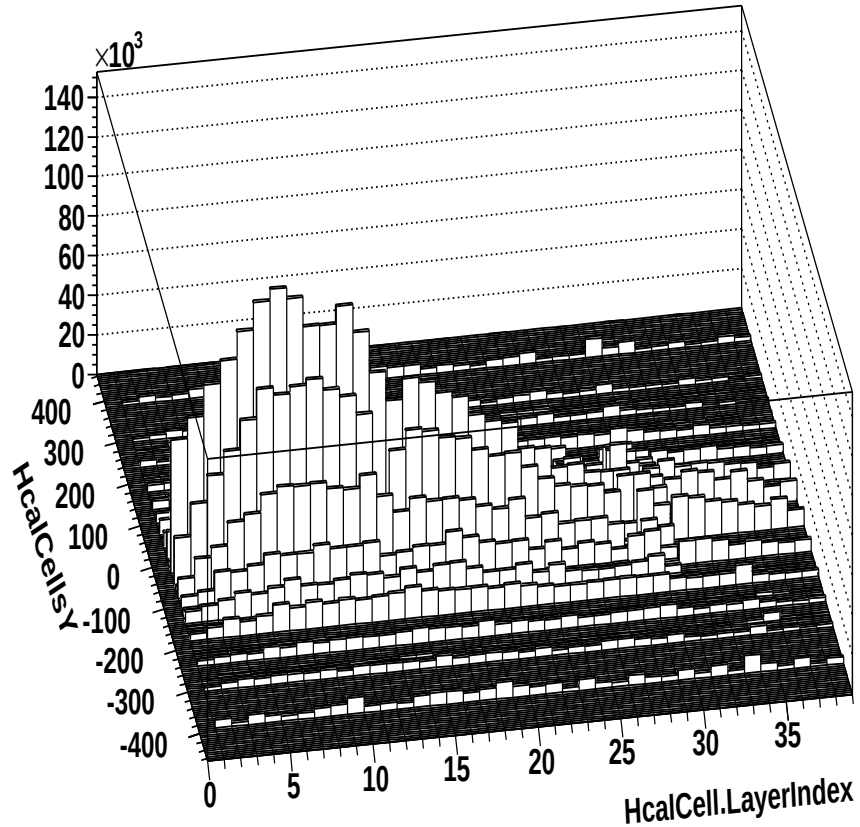
$\Longrightarrow$ **less pronounced when calculating mean values (as mean energy per hit)**



Snapshots

Run 350381: Yield distributions





☞ **Note the yield deficit in layer** 14

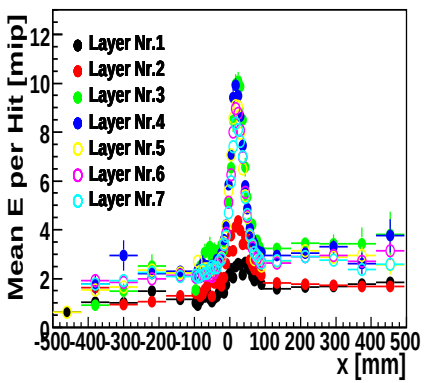
Mean Energy per Hit

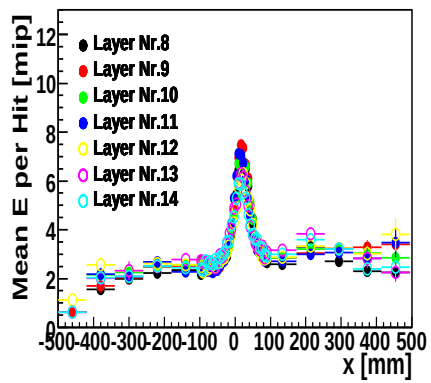
- **Run 350381:** **X (Y) profiles while integrating in Y (X)**

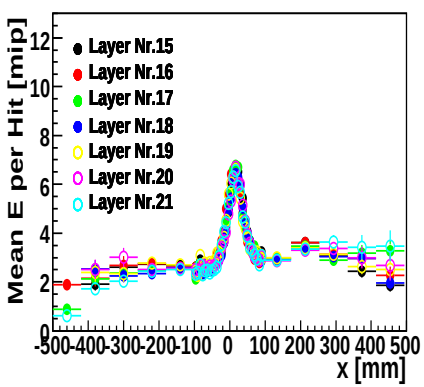
Mean Energy per Hit

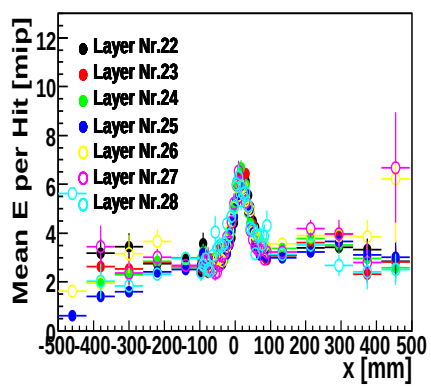
- **Run 350381:** X (Y) profiles while integrating in Y (X)

X-Profile

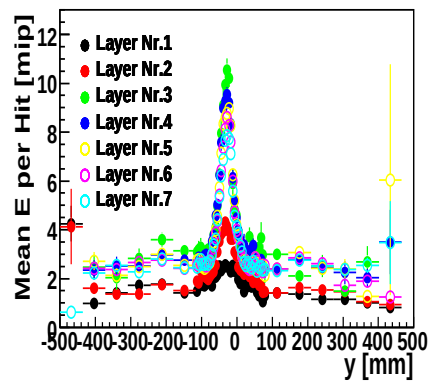


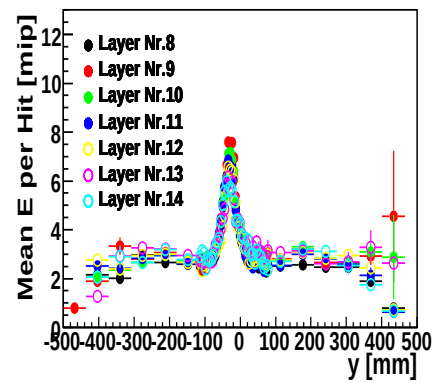


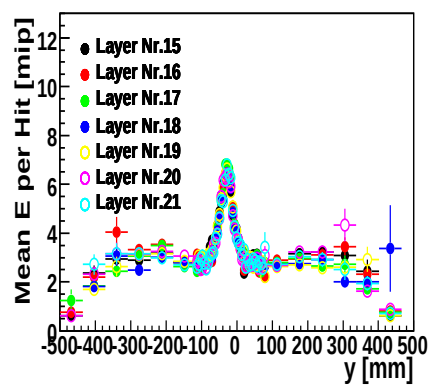


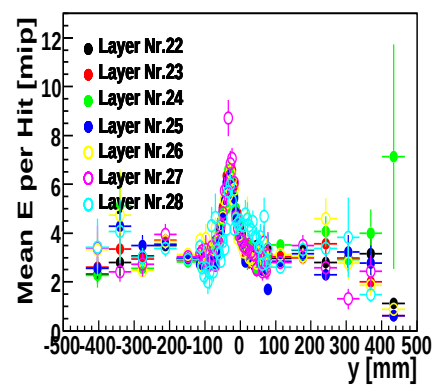


Y-Profile





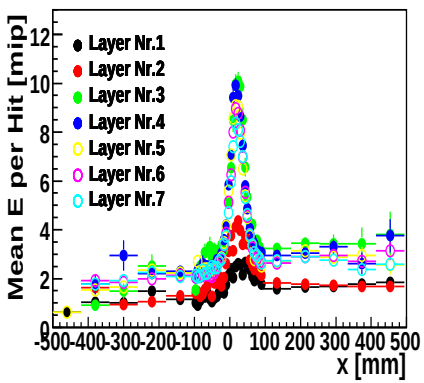


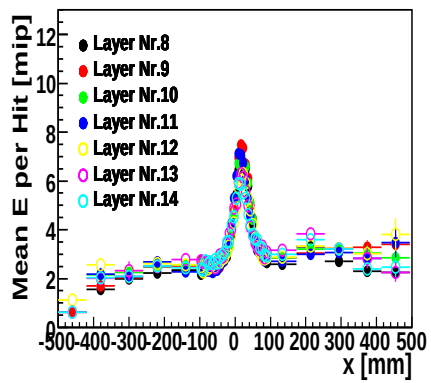


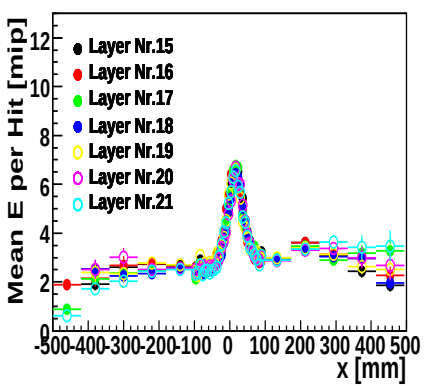
Mean Energy per Hit

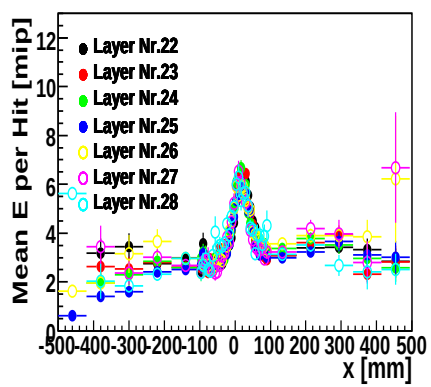
- **Run 350381:** X (Y) profiles while integrating in Y (X)

X-Profile

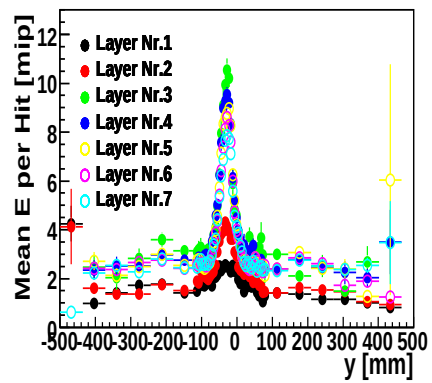


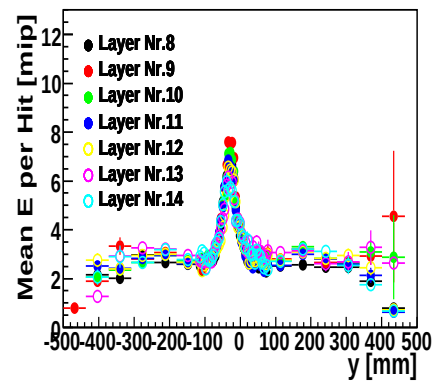


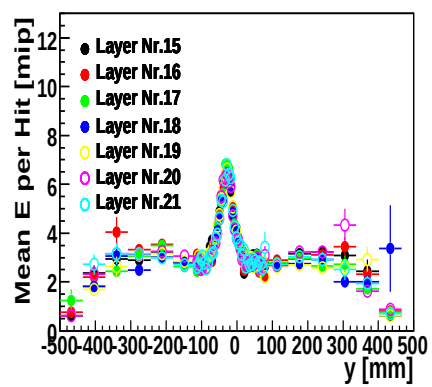


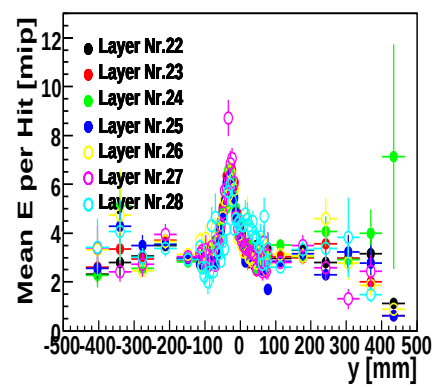


Y-Profile







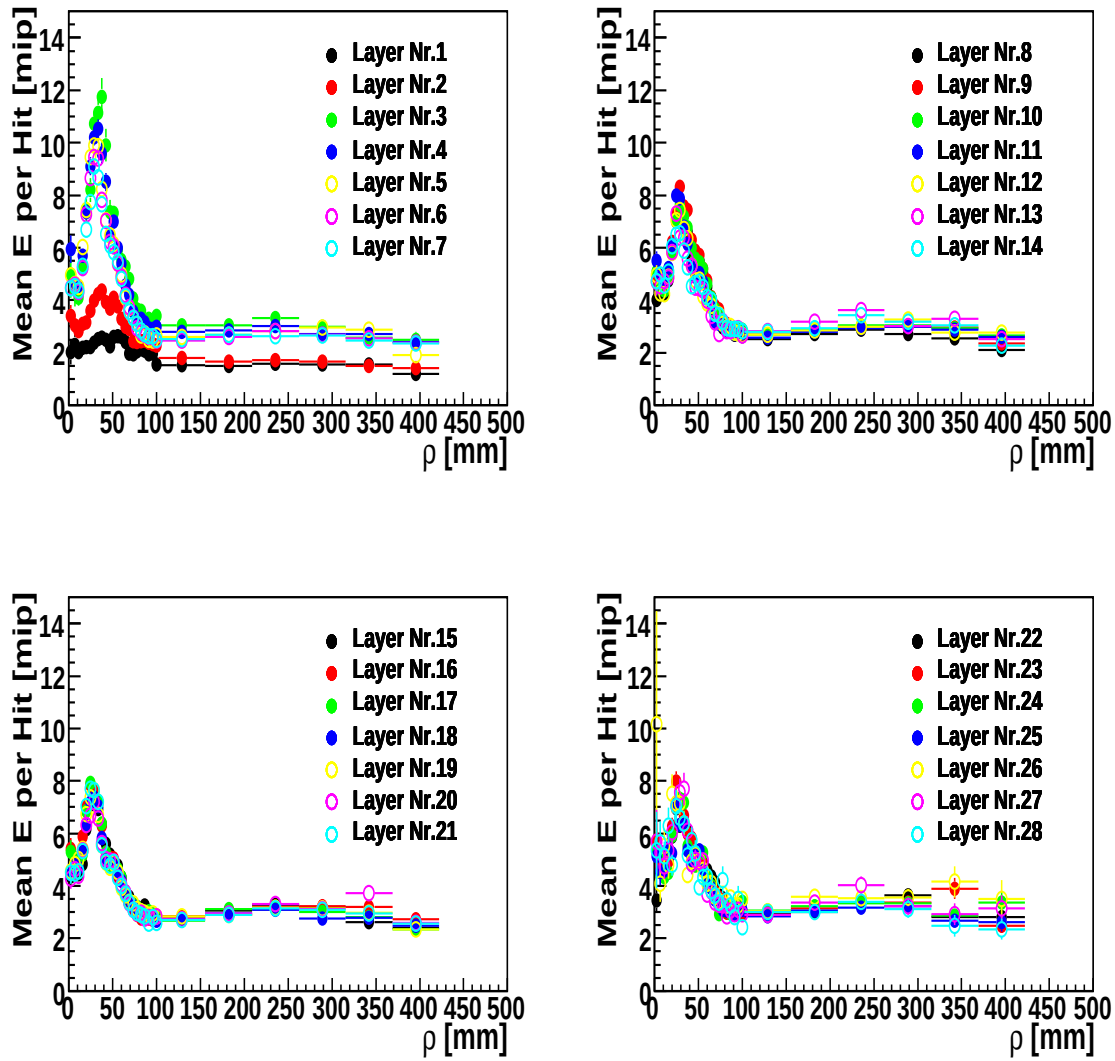


- ☞ profiles scale with layer distance
- ☞ shoulder present (in X)
- ☞ profiles not symmetric around zero (track axis)

Mean Energy per Hit

- **Run 350381:**

Radial ρ-Profile



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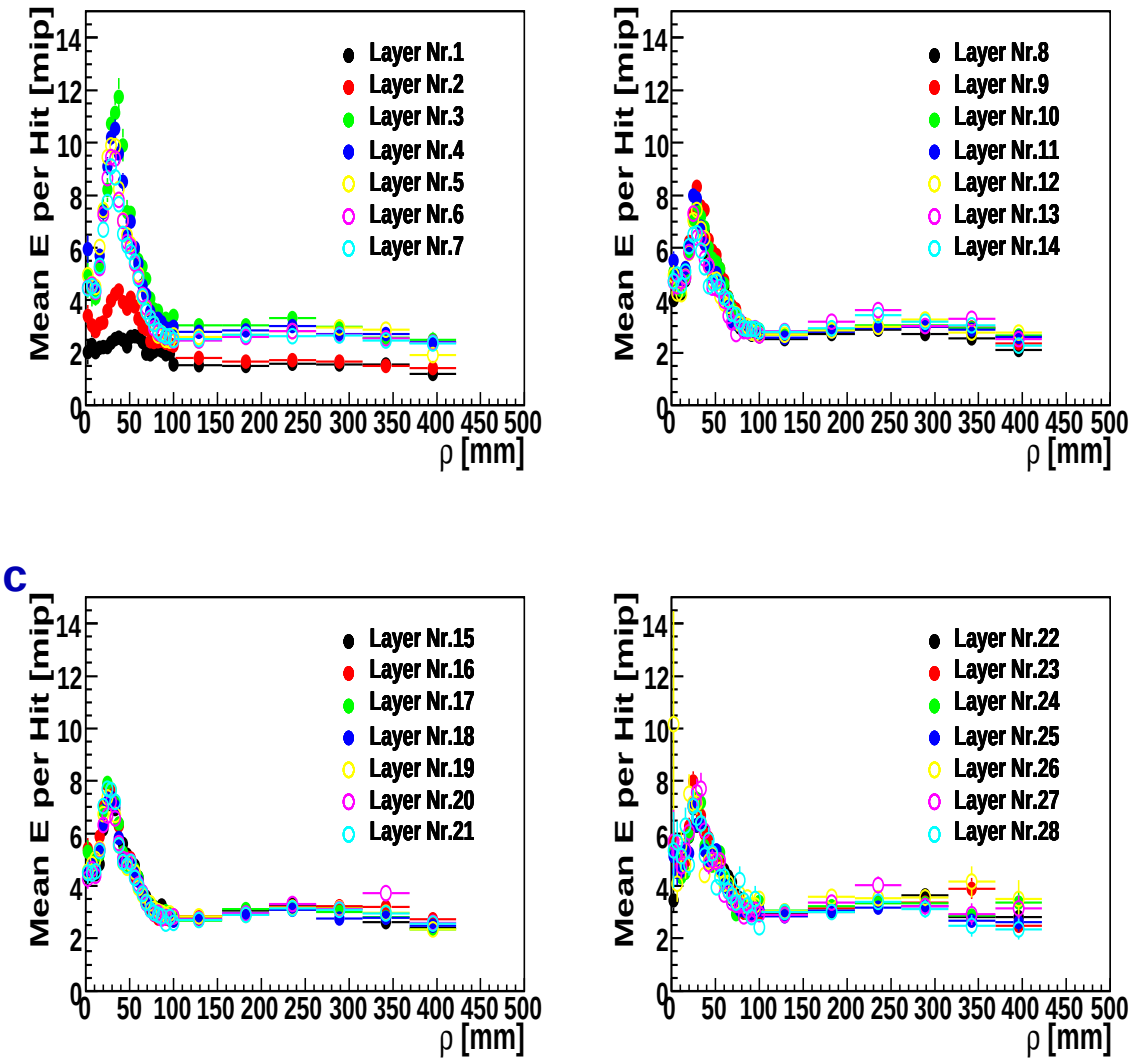


- ☞ profiles scale with the layer distance
- ☞ shoulder present
- ☞ Energy deposited not symmetric around zero (track axis)
  - ⇒ possibly due to a wrong misalignent correction

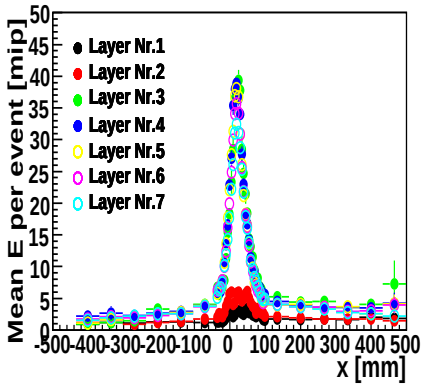
Mean Energy per Event

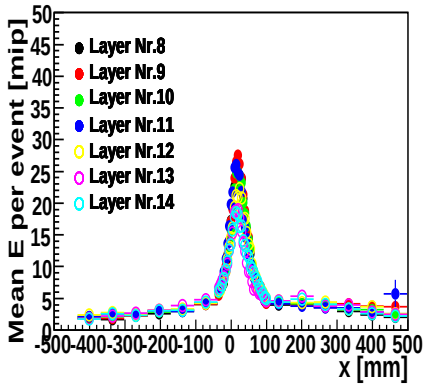
- **Run 350381:** **X (Y) profiles while integrating in Y (X)**

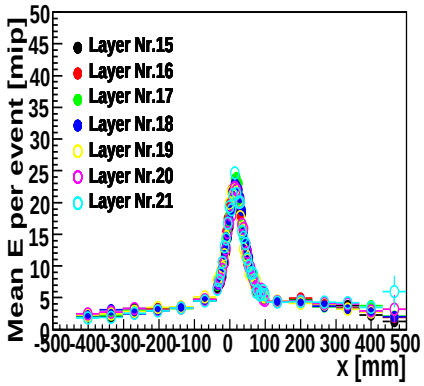
Mean Energy per Event

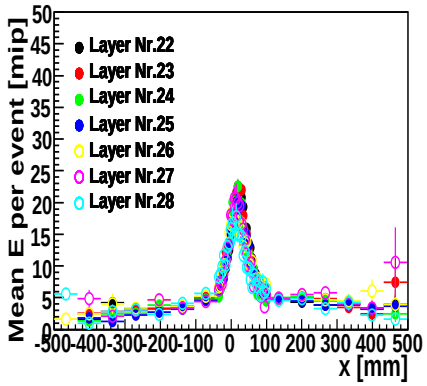
- **Run 350381:** X (Y) profiles while integrating in Y (X)

X-Profile

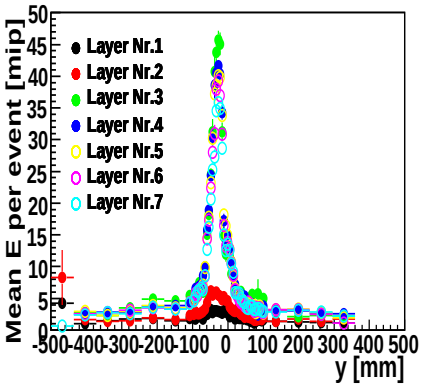


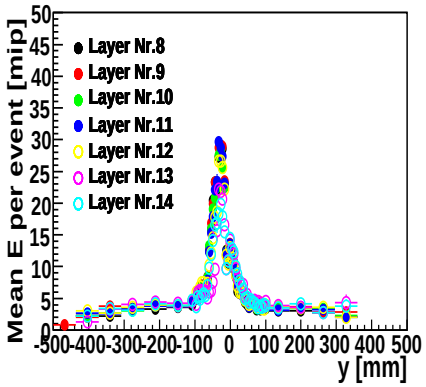


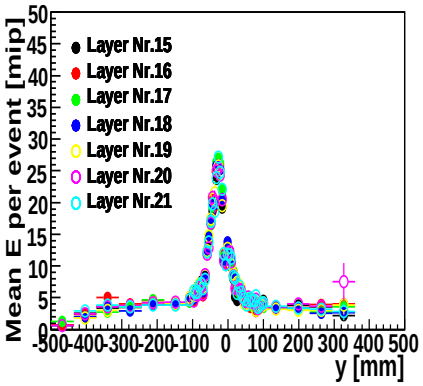


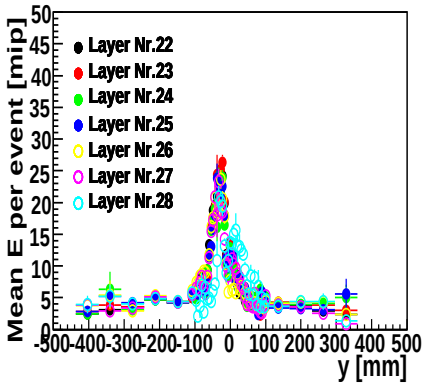


Y-Profile





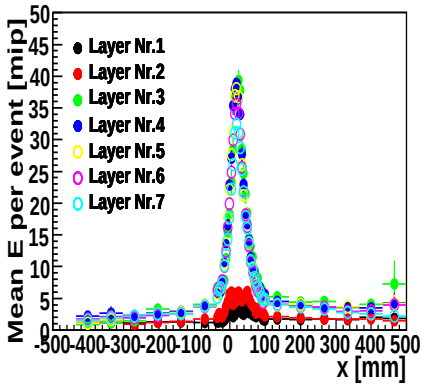


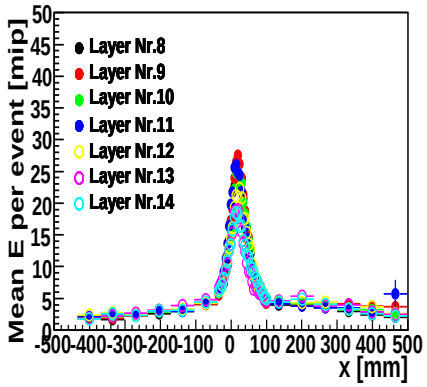


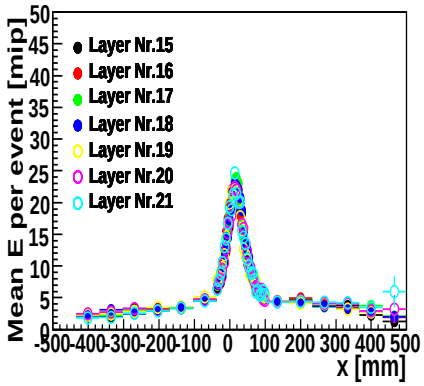
Mean Energy per Event

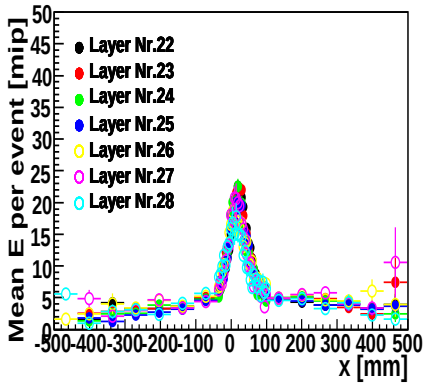
- **Run 350381:** X (Y) profiles while integrating in Y (X)

X-Profile

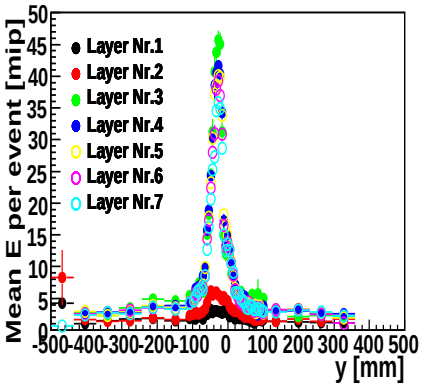


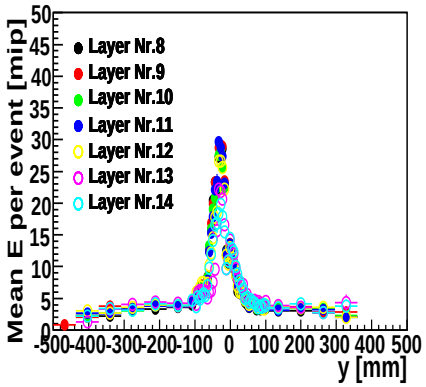


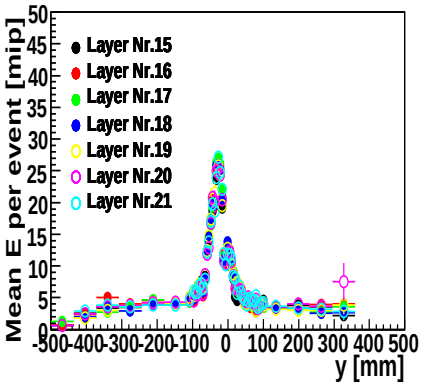


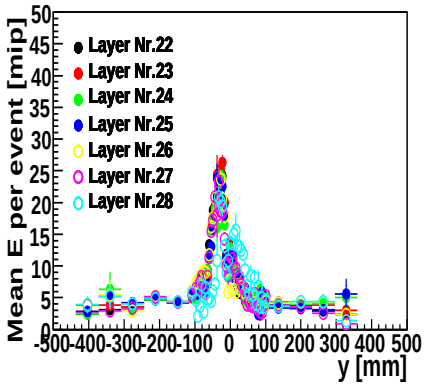


Y-Profile







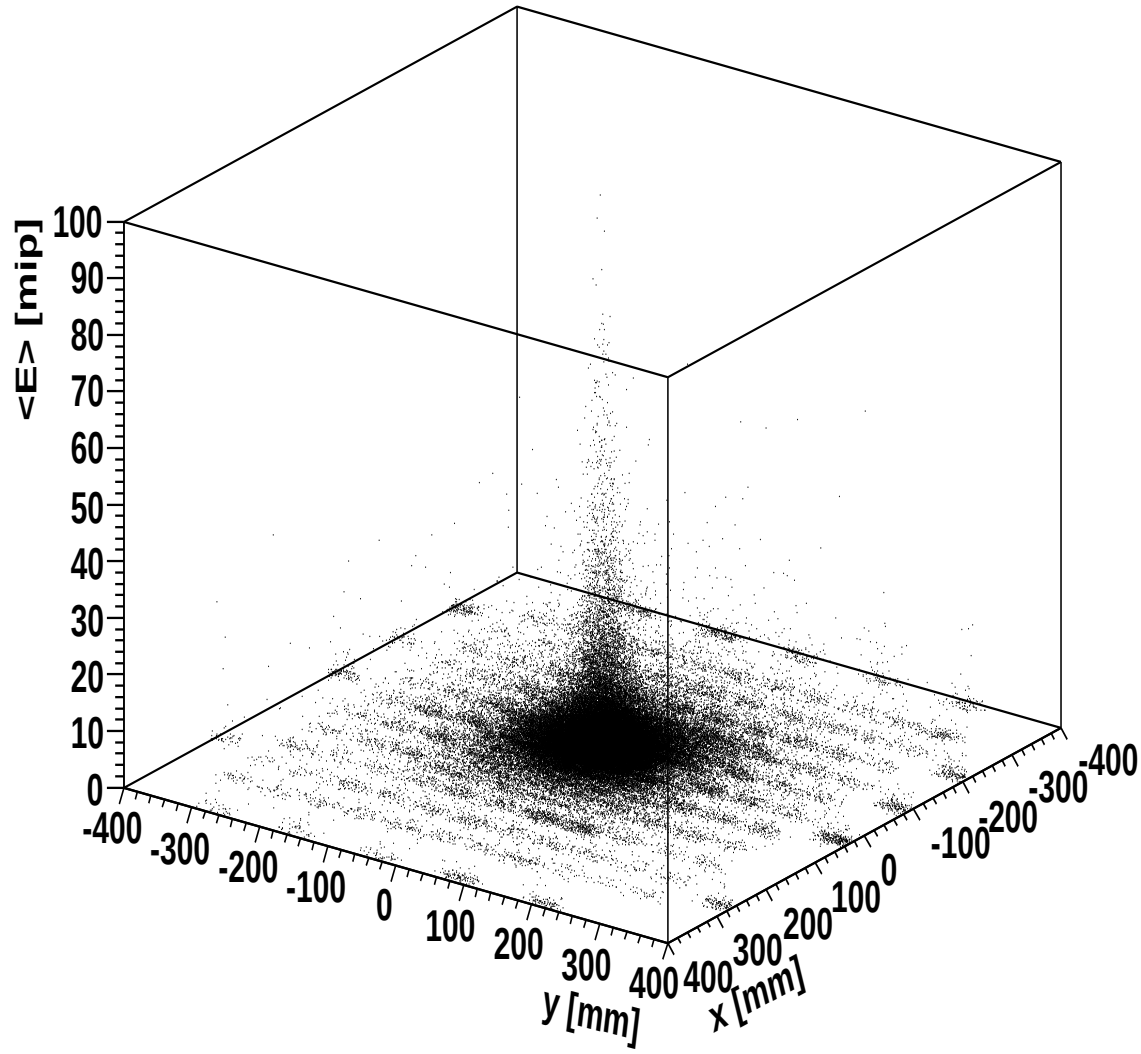


- ☞ **profiles scale with layer distance**
- ☞ **profiles not symmetric around zero (track axis)**

Mean Energy per Event

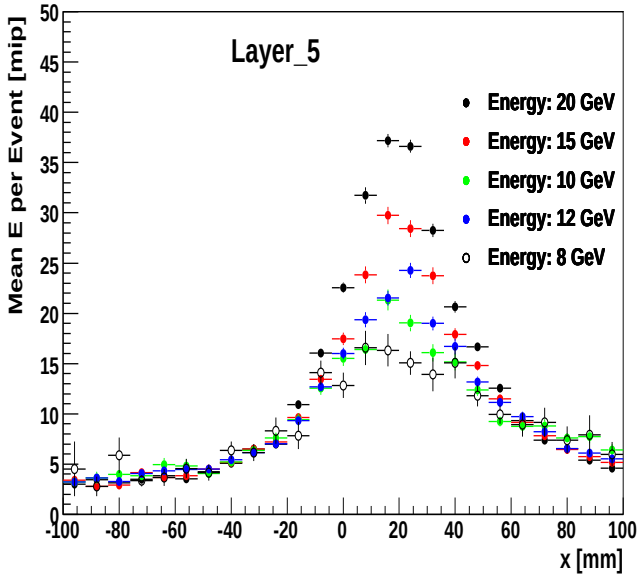
- **Run 350381:**

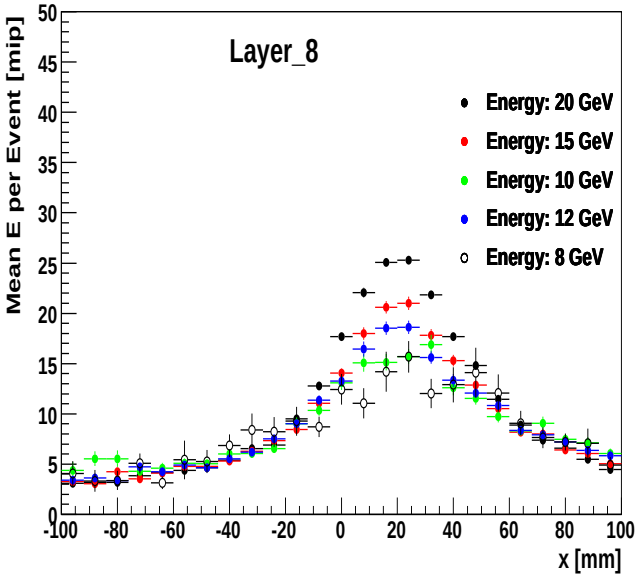
3-dim histo

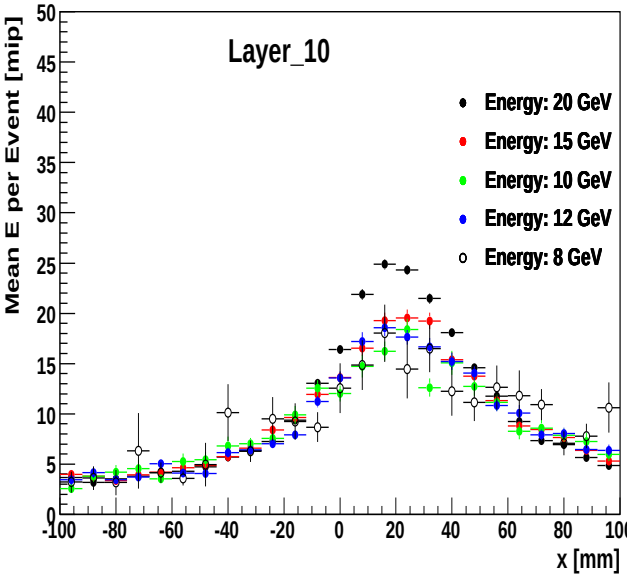


- ☞ **NOTE: very early stage plot**
- ☞ **layer at mid-detector**

Energy Dependence

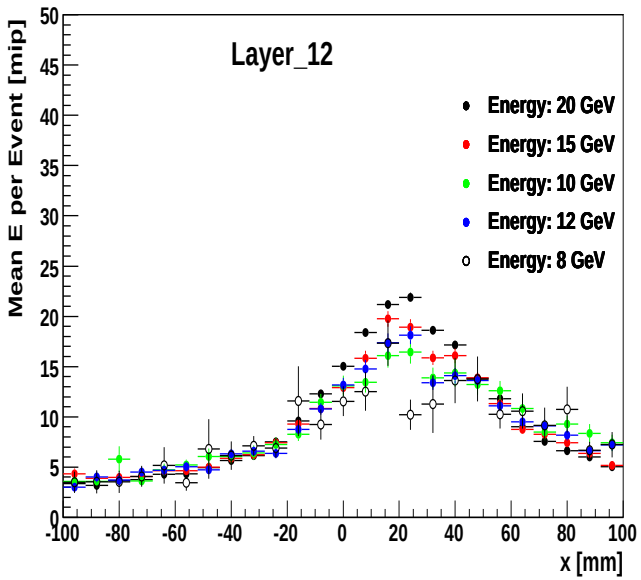


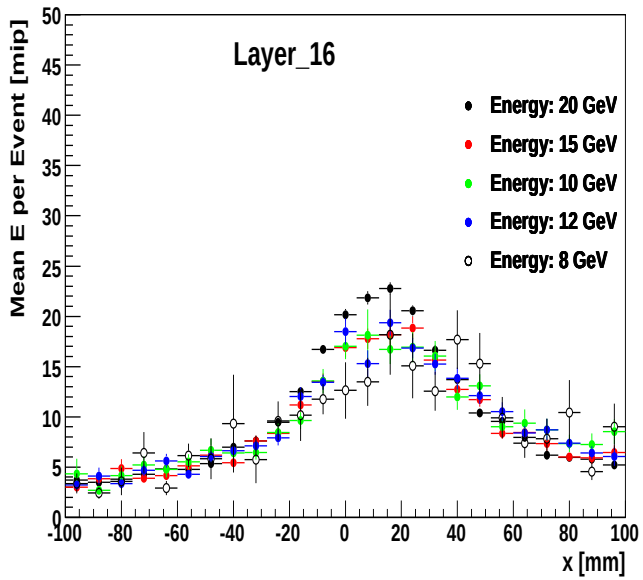


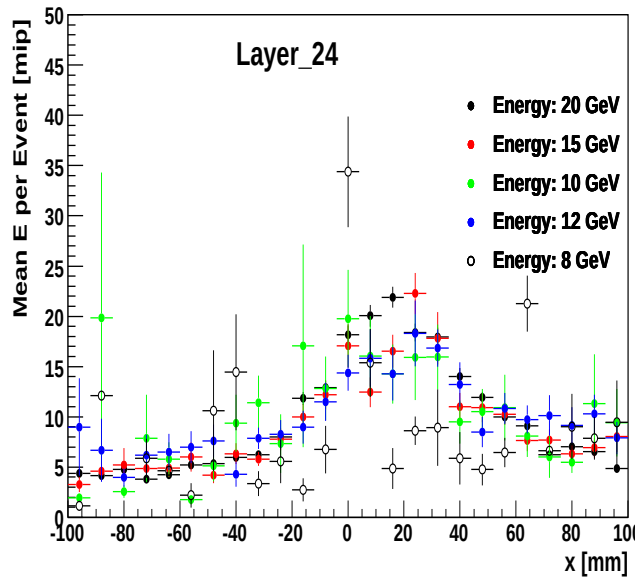


☞ **Clear profile dependence on beam energy**

Energy Dependence







- ☞ **Profile dependence on beam energy less pronounced with increasing radiation length**
- ☞ **Distance from shower start should also be considered**

Monte Carlo Simulation

- MC simulation can be used to compare model predictions with the data
- MC can help in disentangling detector effects from shower physics

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$\Longrightarrow$ it handles generated hits in DC when defined in same collection structure for all chambers

$\Longrightarrow$ some MOKKA models instead dumps hits for different chambers into separate collections

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— indexing of chambers in MC made now consistent with Tracking code

$\Longrightarrow$ it was: index 0-3 (0-2) for 2006,2008 (2007) running periods

$\Longrightarrow$ fixed by Fabrizio: now is 0-3 (1-3)

NOTE: NOT in the officialy released MOKKA yet

ONLY in the latest checked-in version (the so-called HEAD)

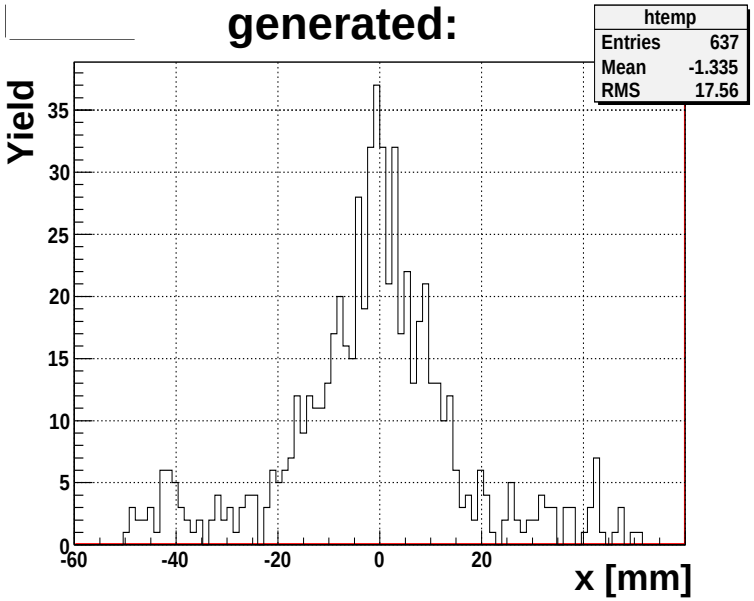
Thanks to Fabrizio S., Niels M., Paul D. for helping moving forward

Monte Carlo Simulation

- Some not-understood features still present MC output

Impact x-point at HCAL front face

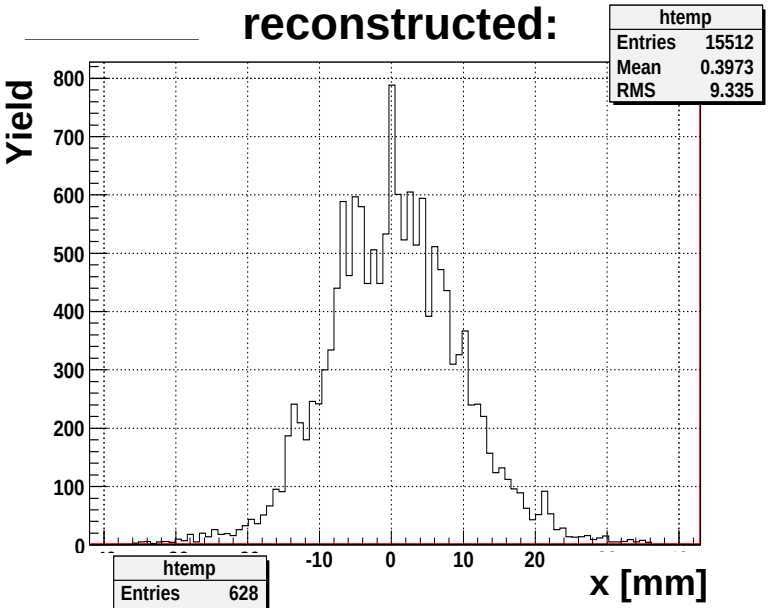
generated:

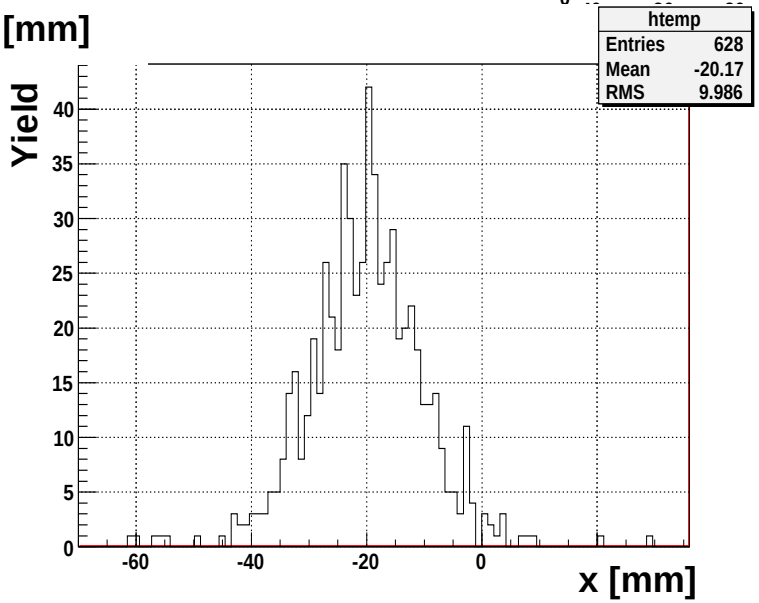


OK in 2008

⟷

reconstructed:





2007:

reconstructed beam profile

wrt generated profile

Wrong calib. constants?

Investigation ongoing

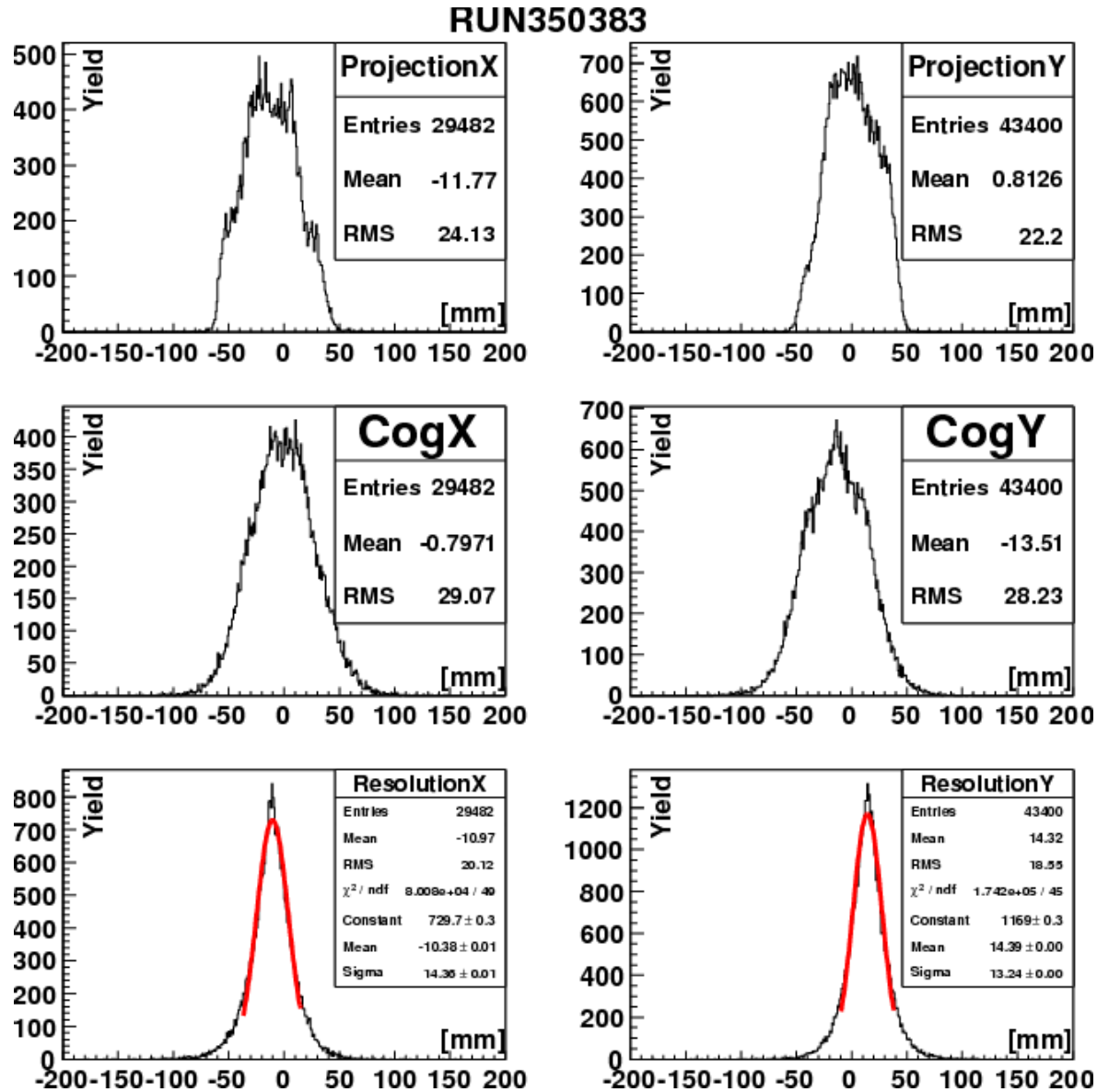
Summary and Outlook

- Data analysis on lateral hadronic showers ongoing:
  - ☞ Mean E per Hit / per Event investigated
  - ☞ Possible sources of measurement bias spotted
    - — MIP contamination $\Longrightarrow$ OK
    - — Later shower starts $\Longrightarrow$ OK
    - — Finite tile size effects $\Longrightarrow$?
    - — Yield deficit in layer 14 $\Longrightarrow$?
    - — Not proper alignment $\Longrightarrow$?
  - ☞ Analysis on MC data started
    - — Unespected problems found using the tracking code
- As next steps:
  - ☞ Improve the cleaning of the data sample
  - ☞ Understand/solve open issues found in preliminary results
  - ☞ Extract the differential energy profile dE/dA Analysis wrt shower starting point
  - ☞ Man power on tracking code needed

Backup Slides

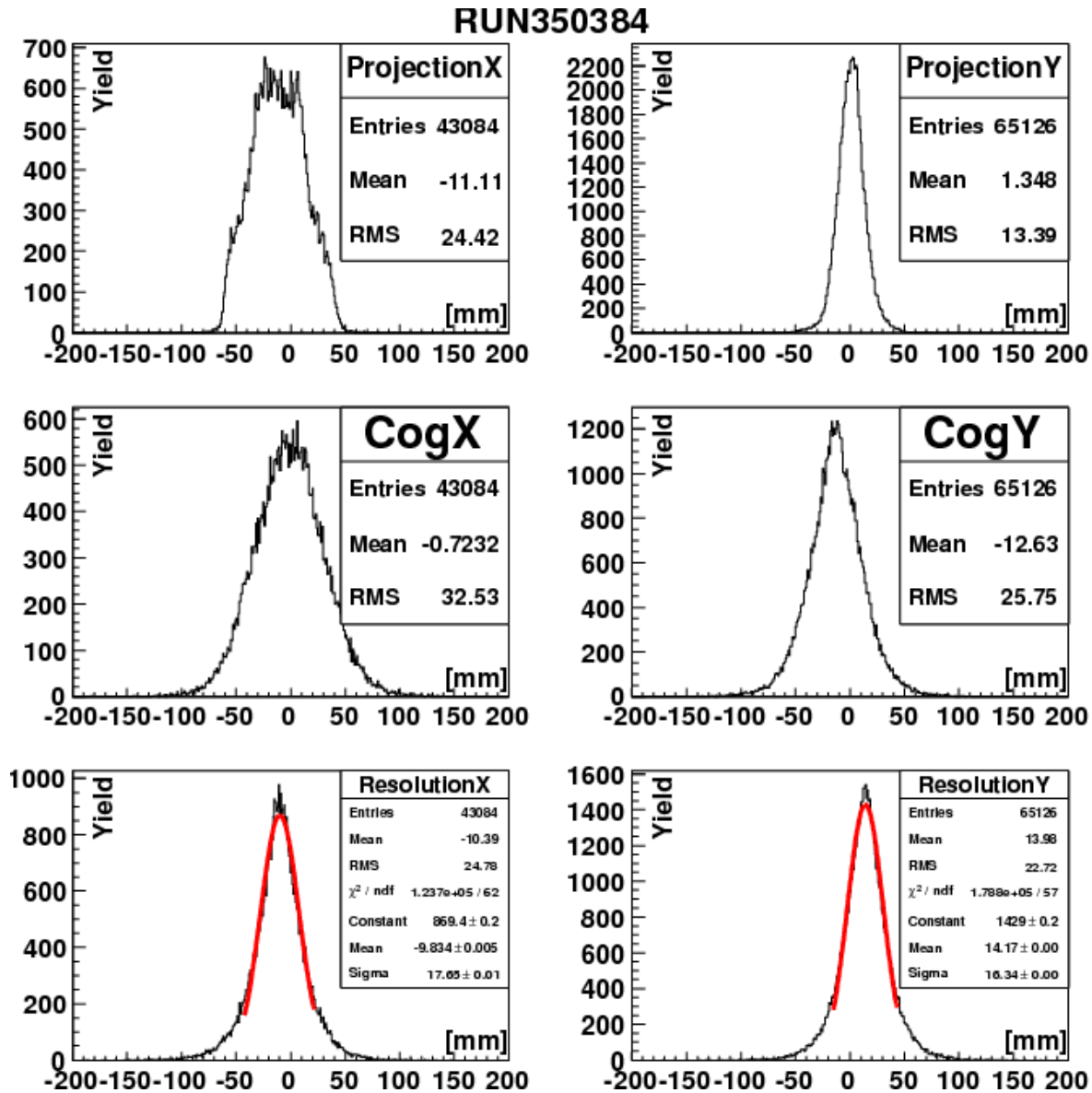
Alignment Plots

- 15 **GeV:**



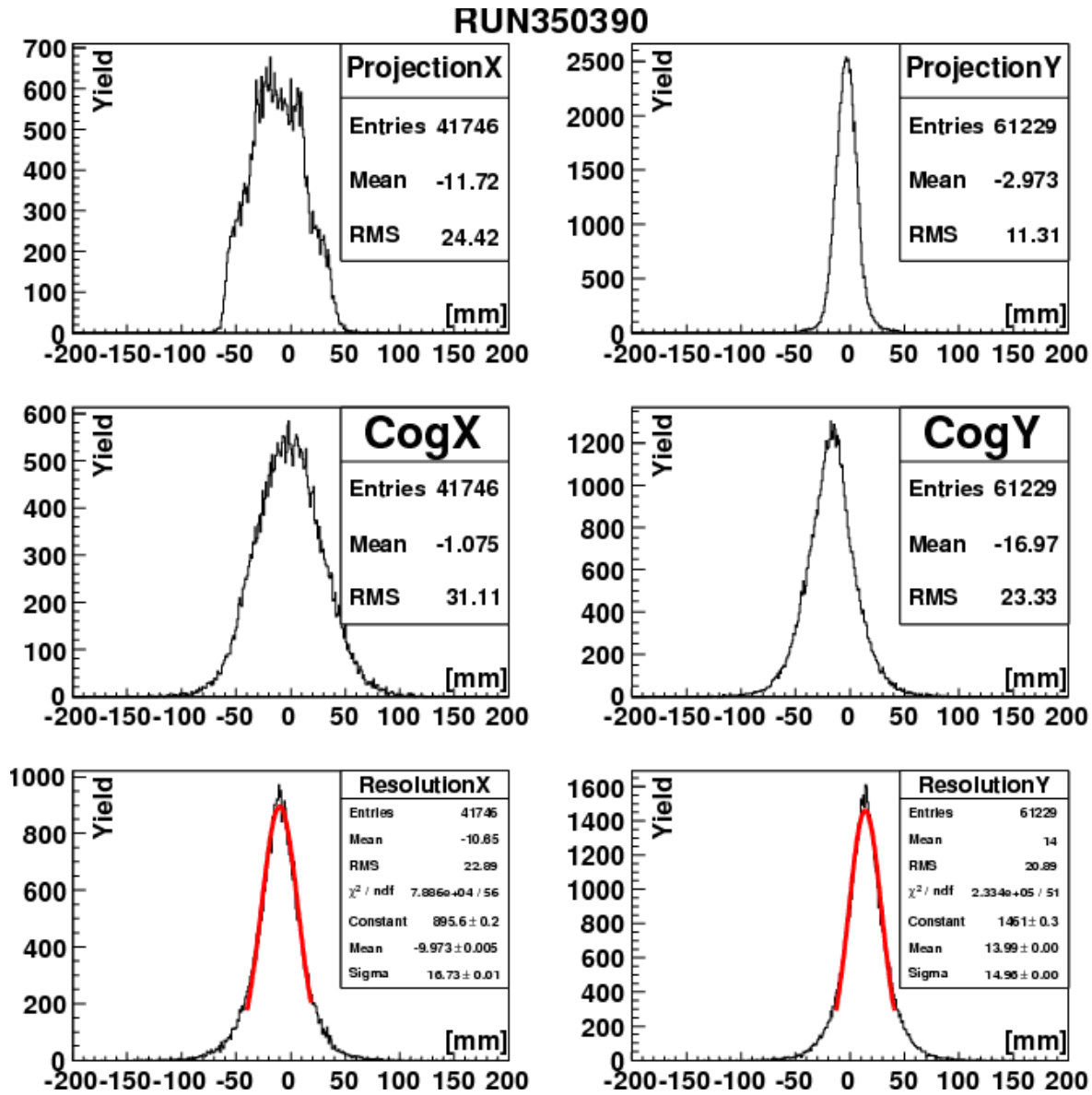
Alignment Plots

- 10 **GeV:**



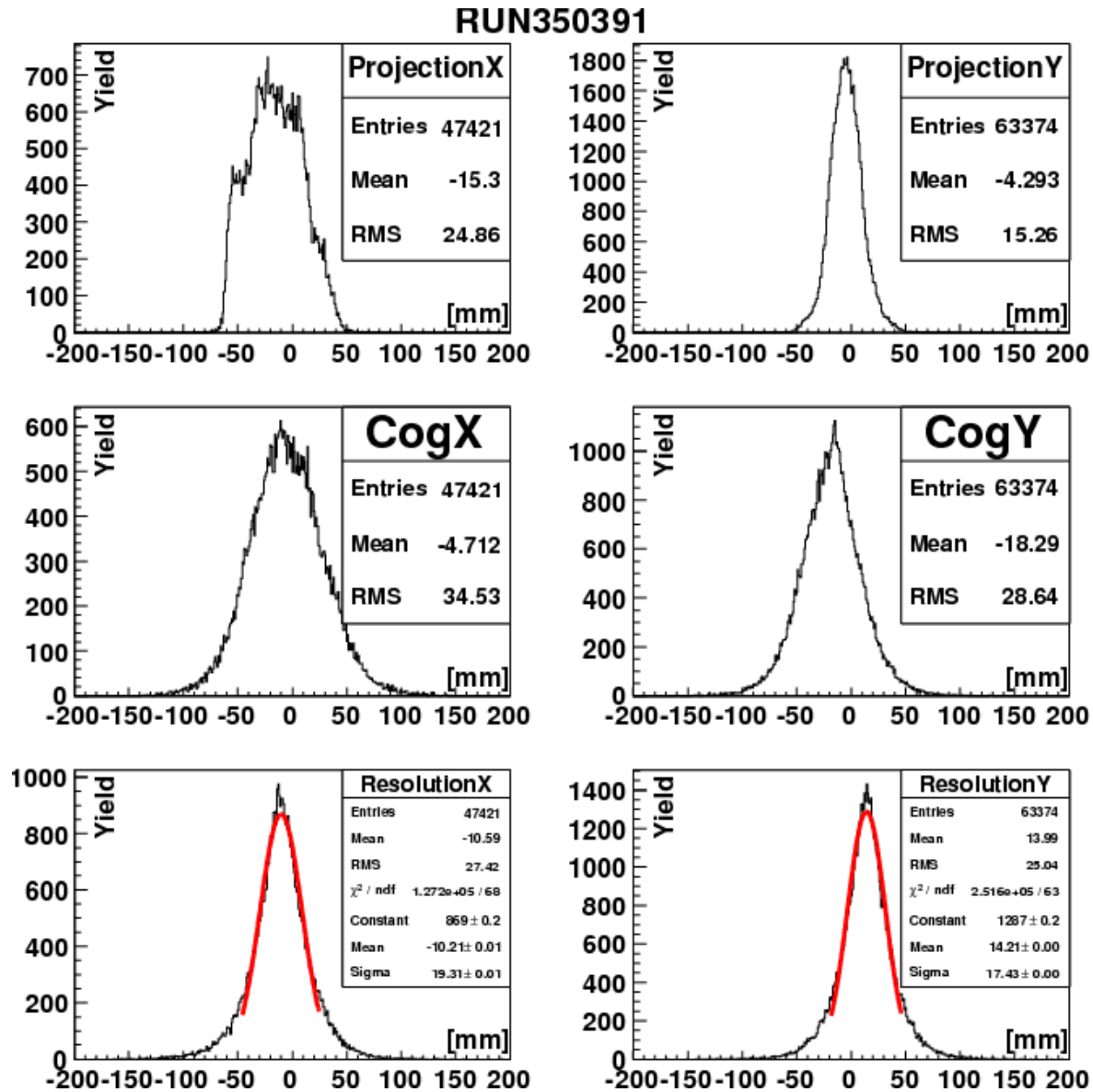
Alignment Plots

- 12 **GeV:**



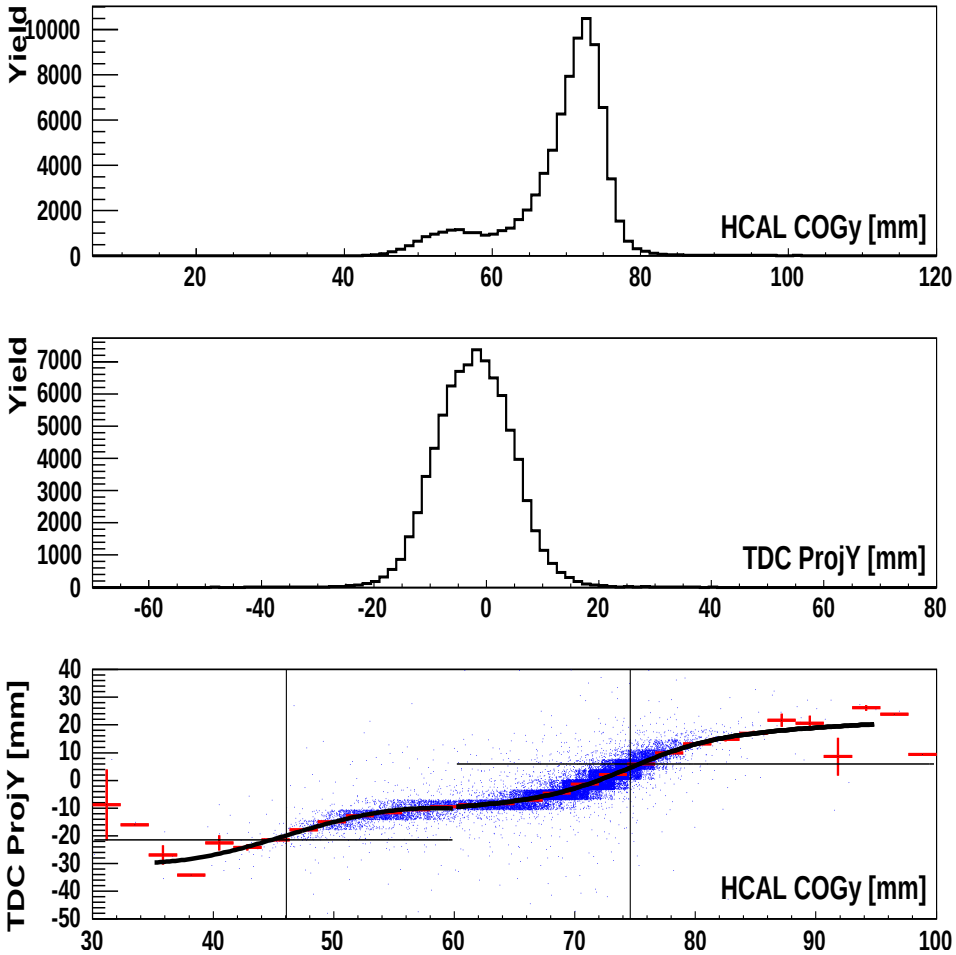
Alignment Plots

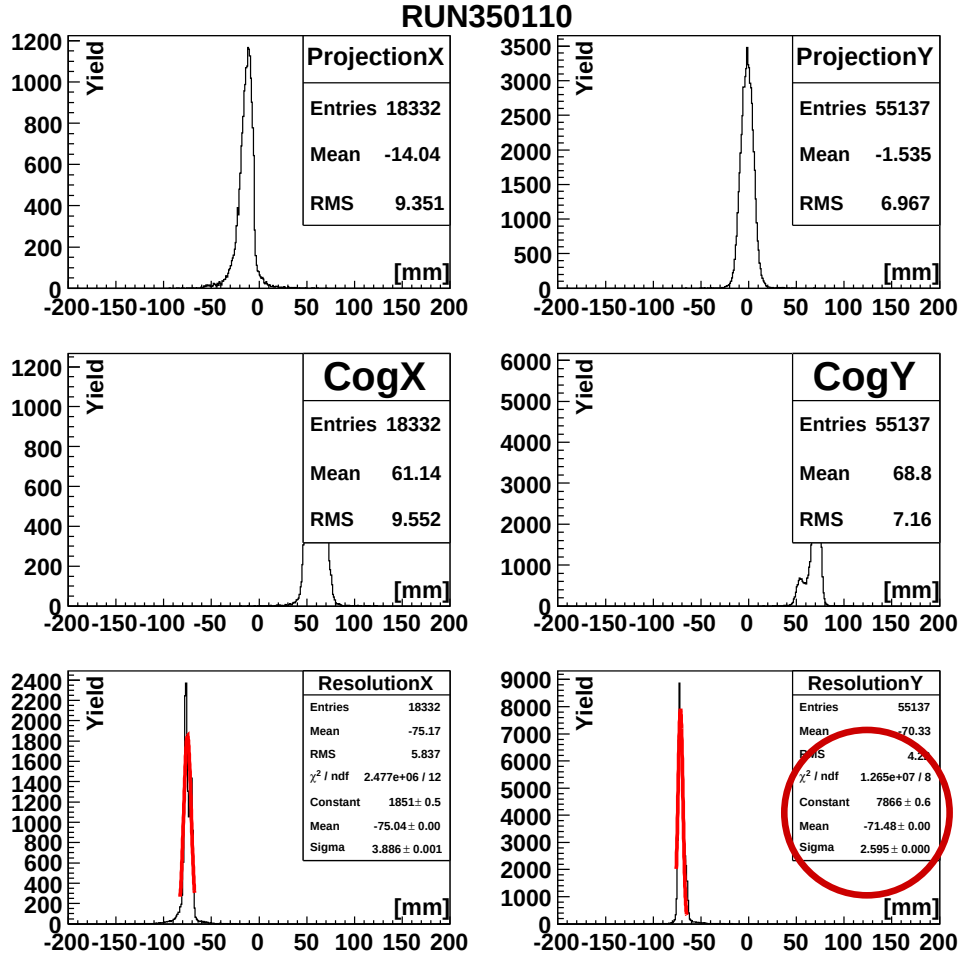
- 8 GeV:



Comparison of Different Alignment Procedures

- **Projection vs COG** **Correlation:** **Track-level difference:**





Misalignment calculation:

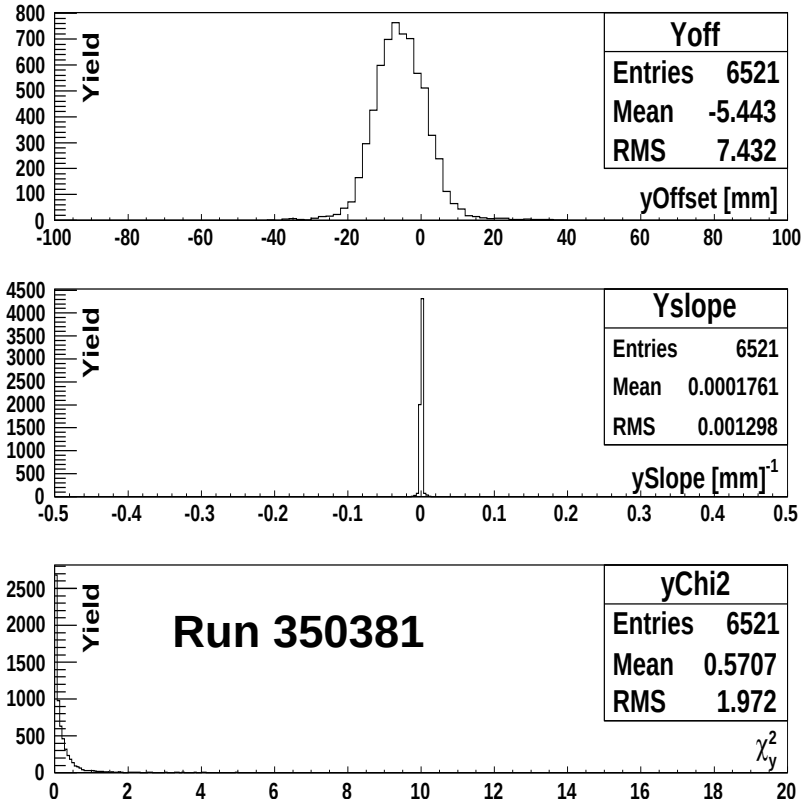
↓ **-65.95 mm** ↓ **-70.02 mm**

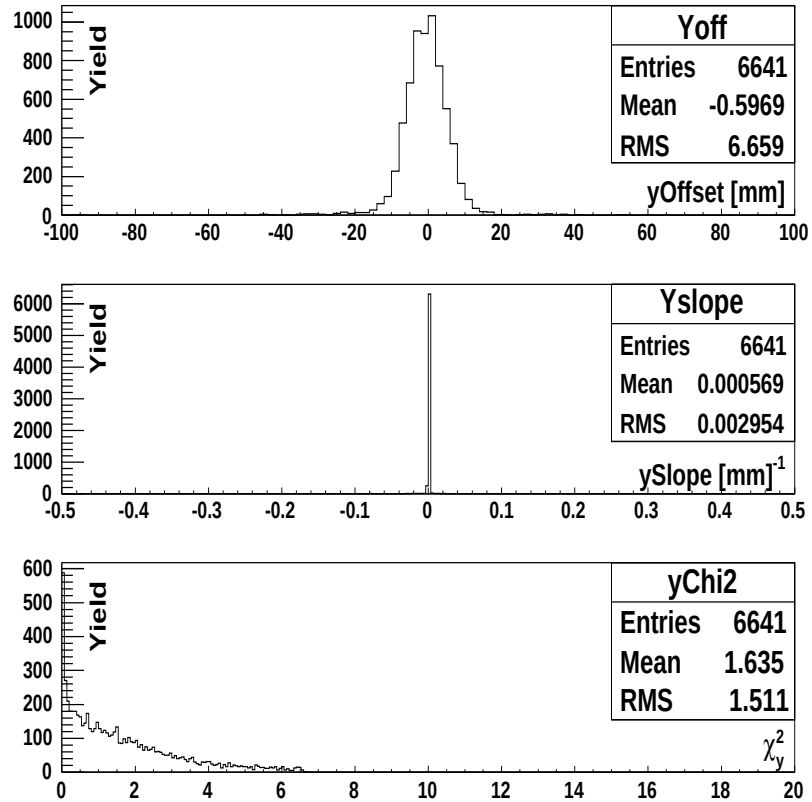
Misalignment measurement:

-71.48 mm

Tracking Code Comparison

Old code: y**-coordinate** **Official code:**

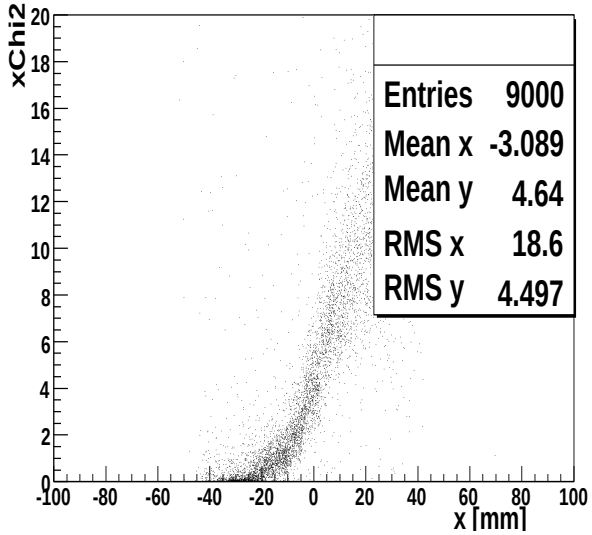


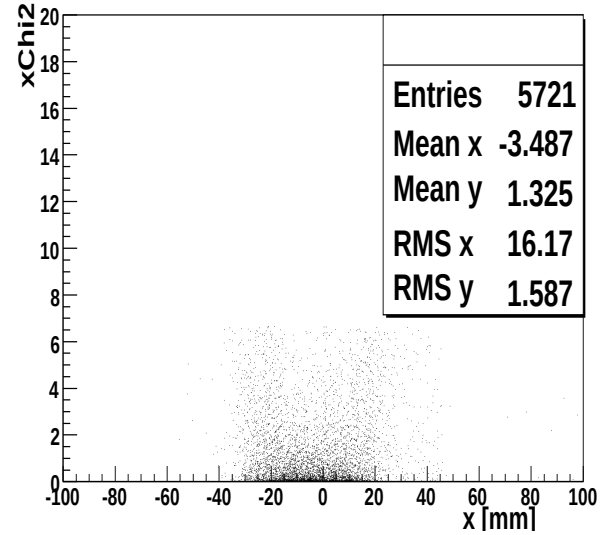


- **Results in disagreement:**
  - **calibration constants mismatch? Investigation next week**
  - **problems in the reconstruction algorithm?**

Tracking Code Comparison

Old code: **Run 350381** **Official code:**





Results in disagreement