



Detector alignment with muons

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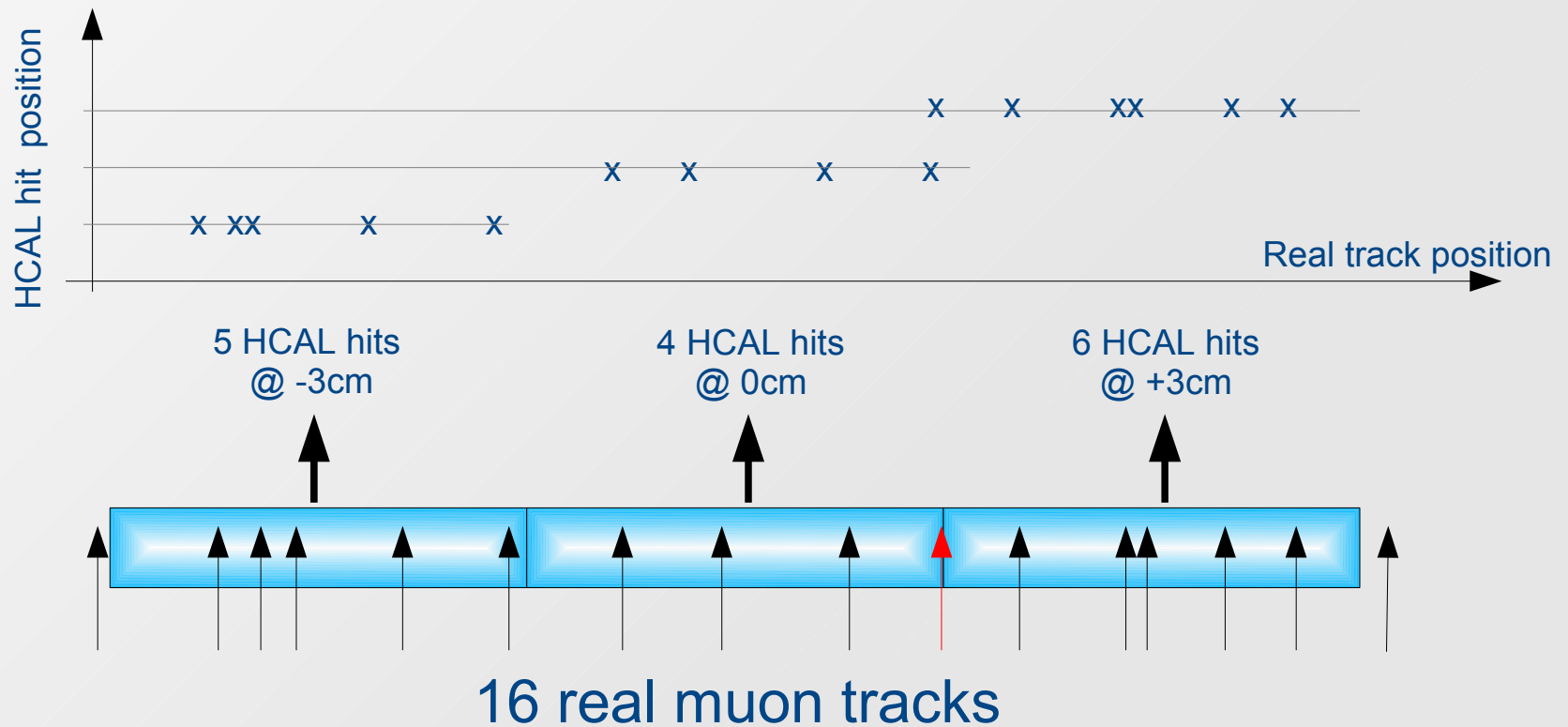
Based on idea of Niels Meyer

Alignment

- What is the precise position of the HCAL (layers)?
 - Take into account for *new Reconstruction software*
- Idea
 - Use muons
 - Tracks known from drift chamber tracker
 - Interpolate tracks to HCAL layer
 - Comparison interpolated position ↔ HCAL hit position gives offset
- In practice
 - Muon selector processor cutting on
 - *Number of hits in HCAL*
 - *Symmetry of hit positions*
 - Marlin processor to collect data / create histograms
 - Separate program for analysis
- Idea and procedure by Niels Meyer

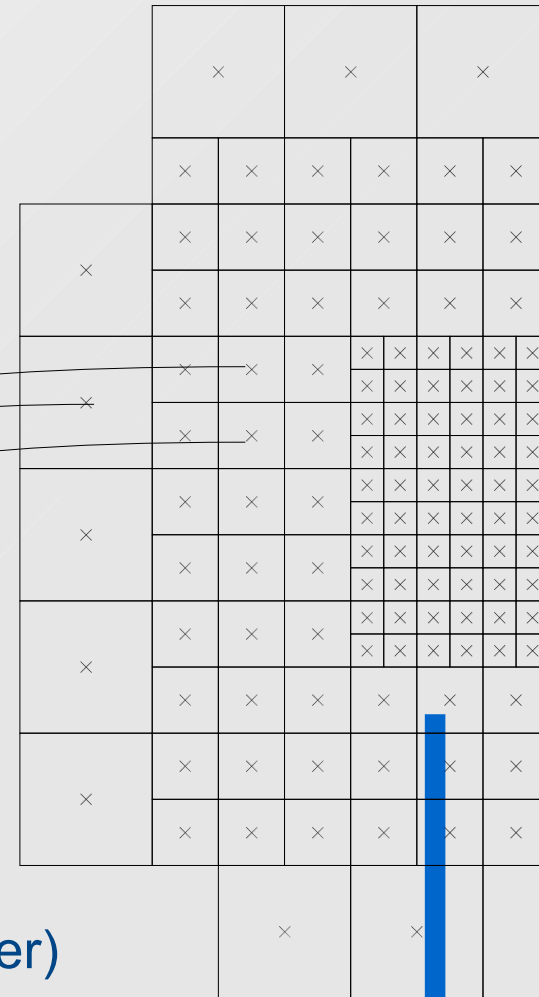
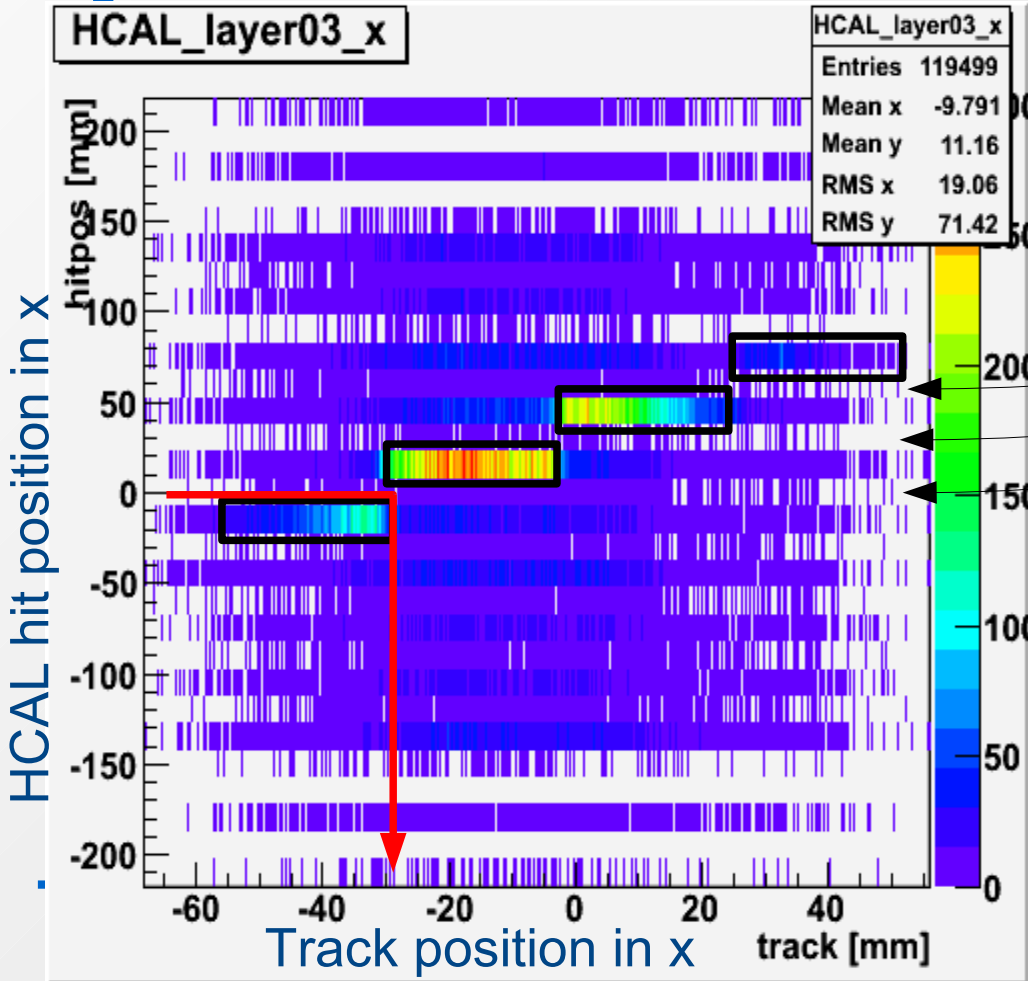
Expected data

- Look at projection of HCAL hits in x and y separately
- Tracker gives more or less “exact” positions
- HCAL gives discrete positions
- Correlation should show tiles as steps



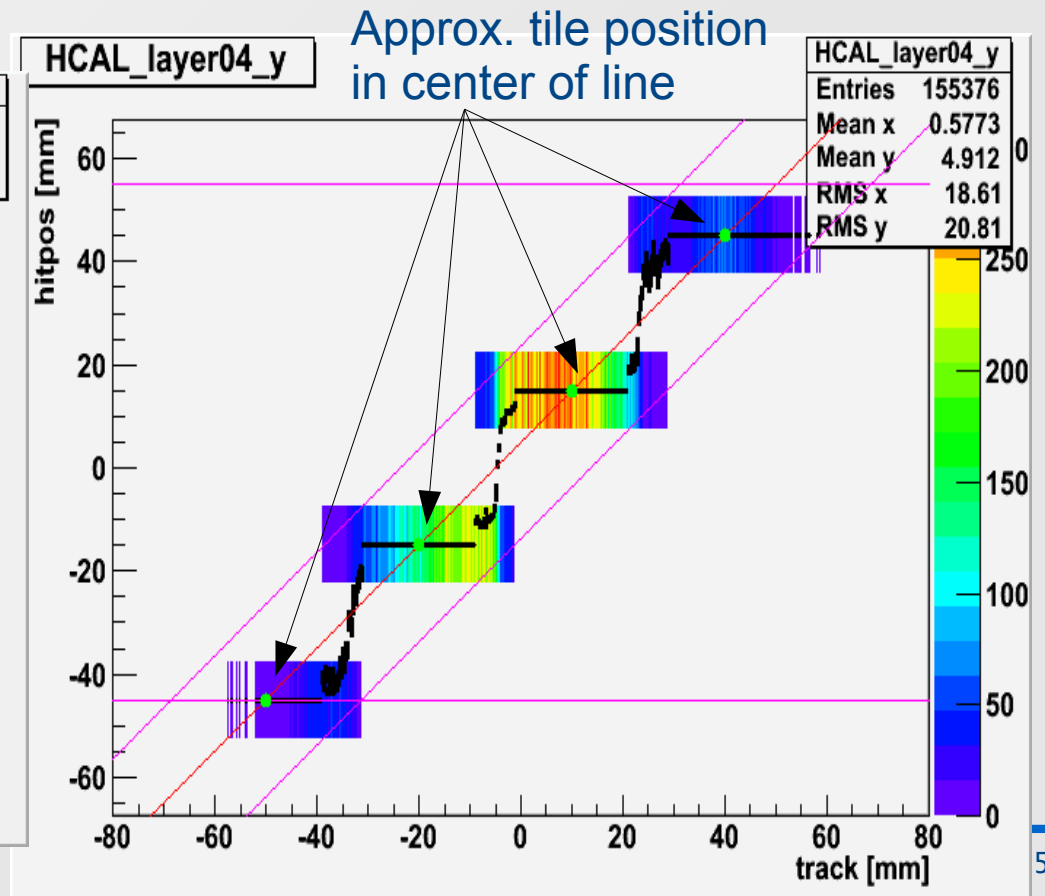
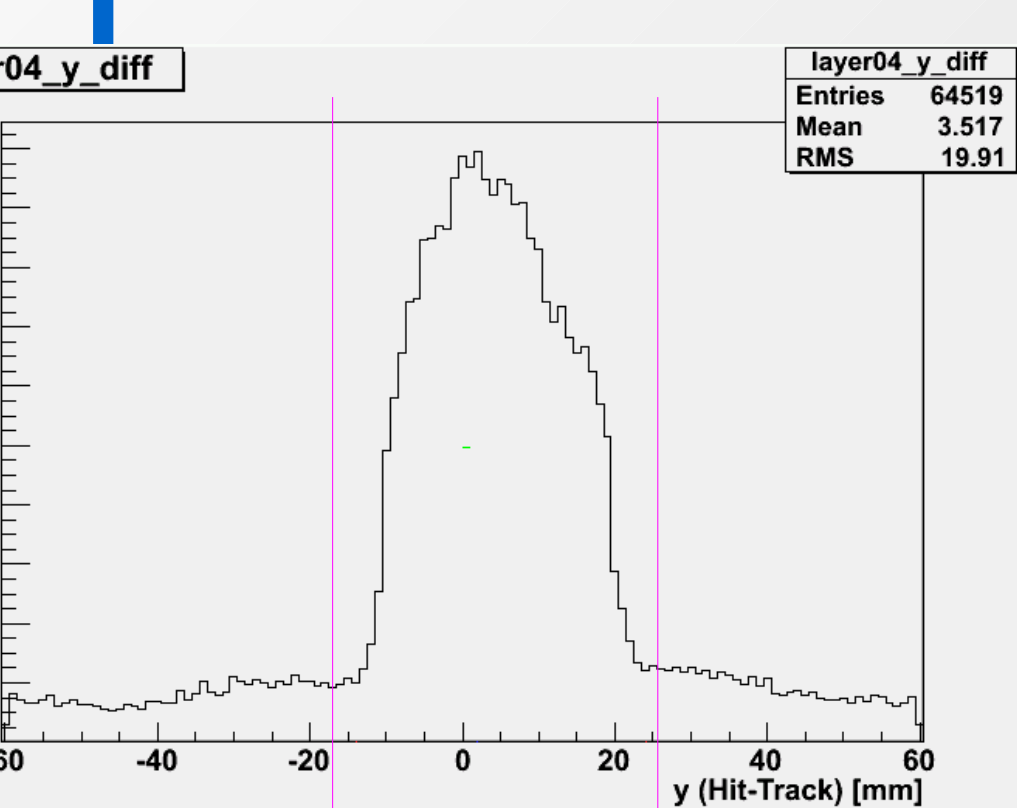
First look at data

- Tiles visible as regions with many hits
- Lots of noise hits i.e. hits over full track position range
- Also hits of coarse tiles in between
- What HCAL calls “0mm” is “-30mm” in reality



Cleanup

- Histogram of difference [hit position – track position] shows tile size and offset → Use for further cut
- Profile of correlation plot (black) is step function to be fitted
- Good start parameters for fit



Fit

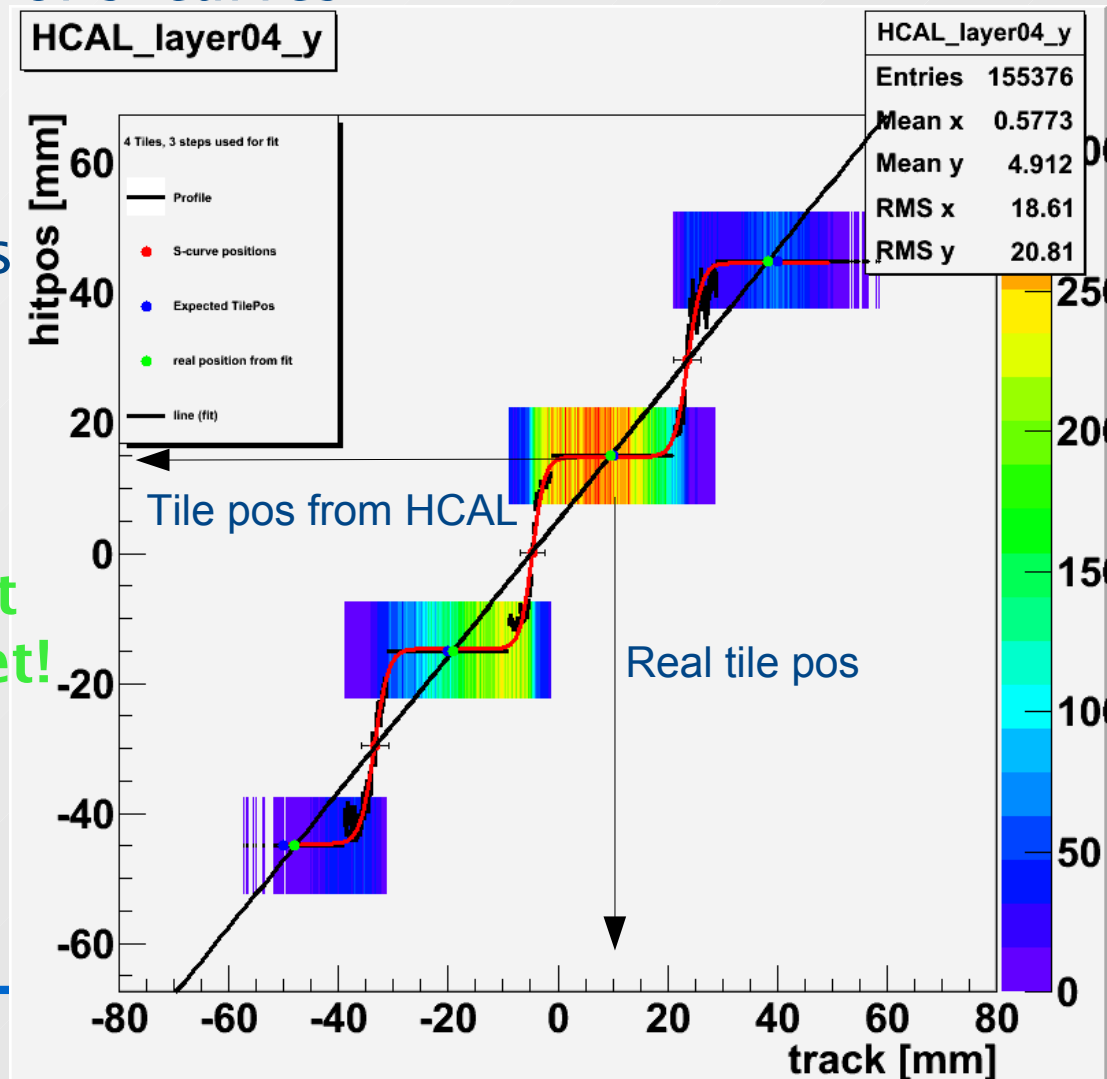
- Fit multi step function based on s-curve $f(x) = \frac{a}{1 + \exp[-s \cdot (x - o)]}$

Linear fit through centers of s-curves

- Crossing of linear function with plateaus gives real tile positions as x-value!

- Real position & HCAL hit position give layer offset!

- So repeat this for all layers in x and y!

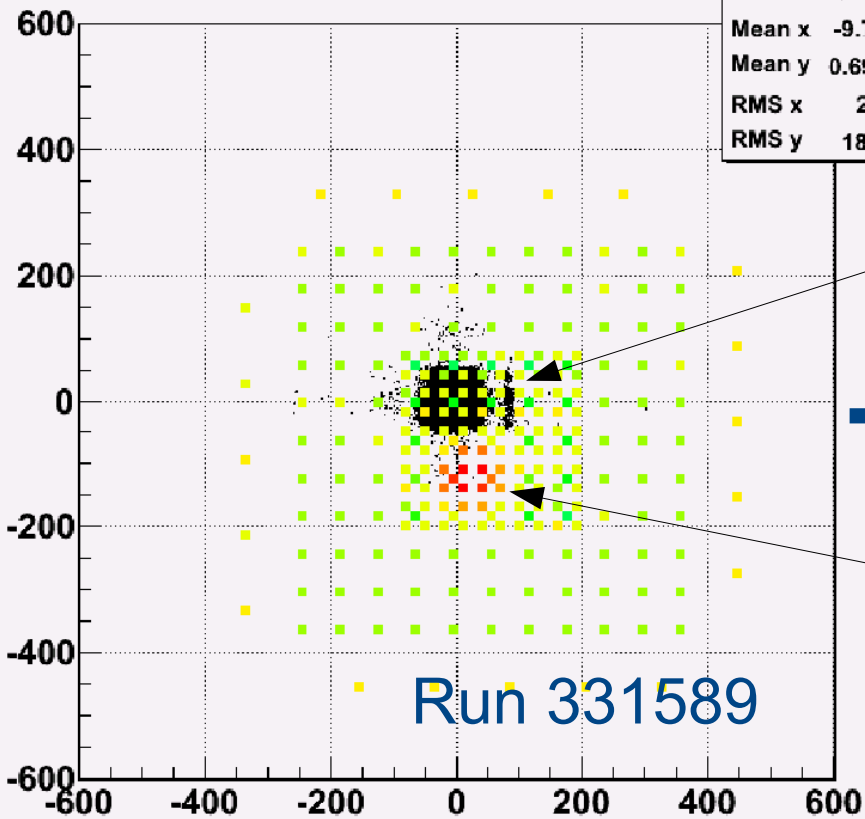


It works...

- Bug in reco software *did* cause large (calculated) offsets up to 230mm – fine for testing alignment software!
- Applying calculated offsets and re-calculation of offsets gives new offsets $<0.6\text{mm}$ in all layers in x and y

TrackXY intercept on front

TrackXY intercept on fro	
Entries	6236
Mean x	-9.72
Mean y	0.697
RMS x	20.
RMS y	18.4

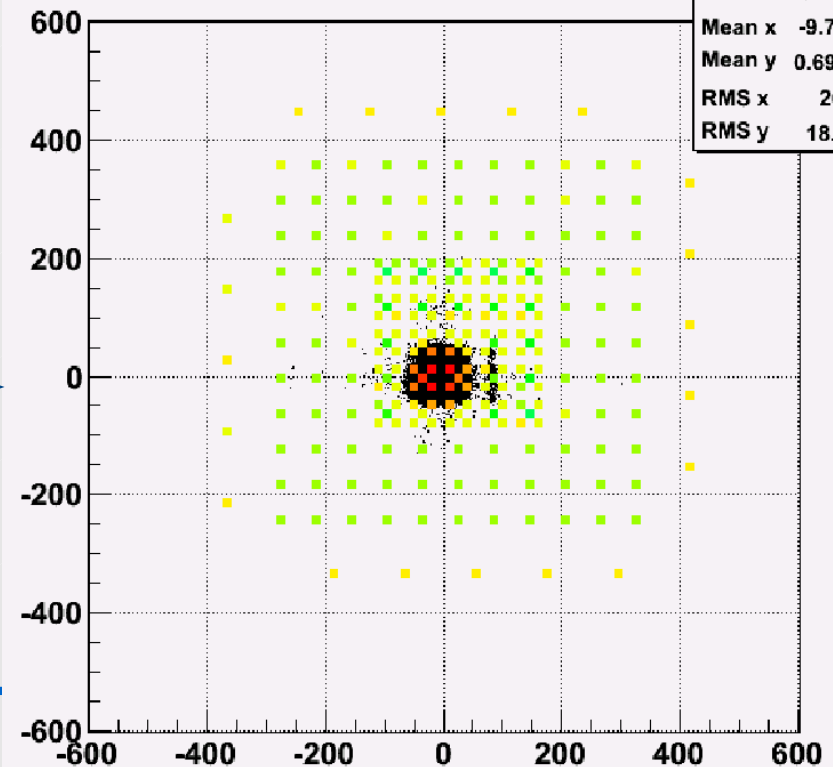


“real” beam spot

HCAL beam spot

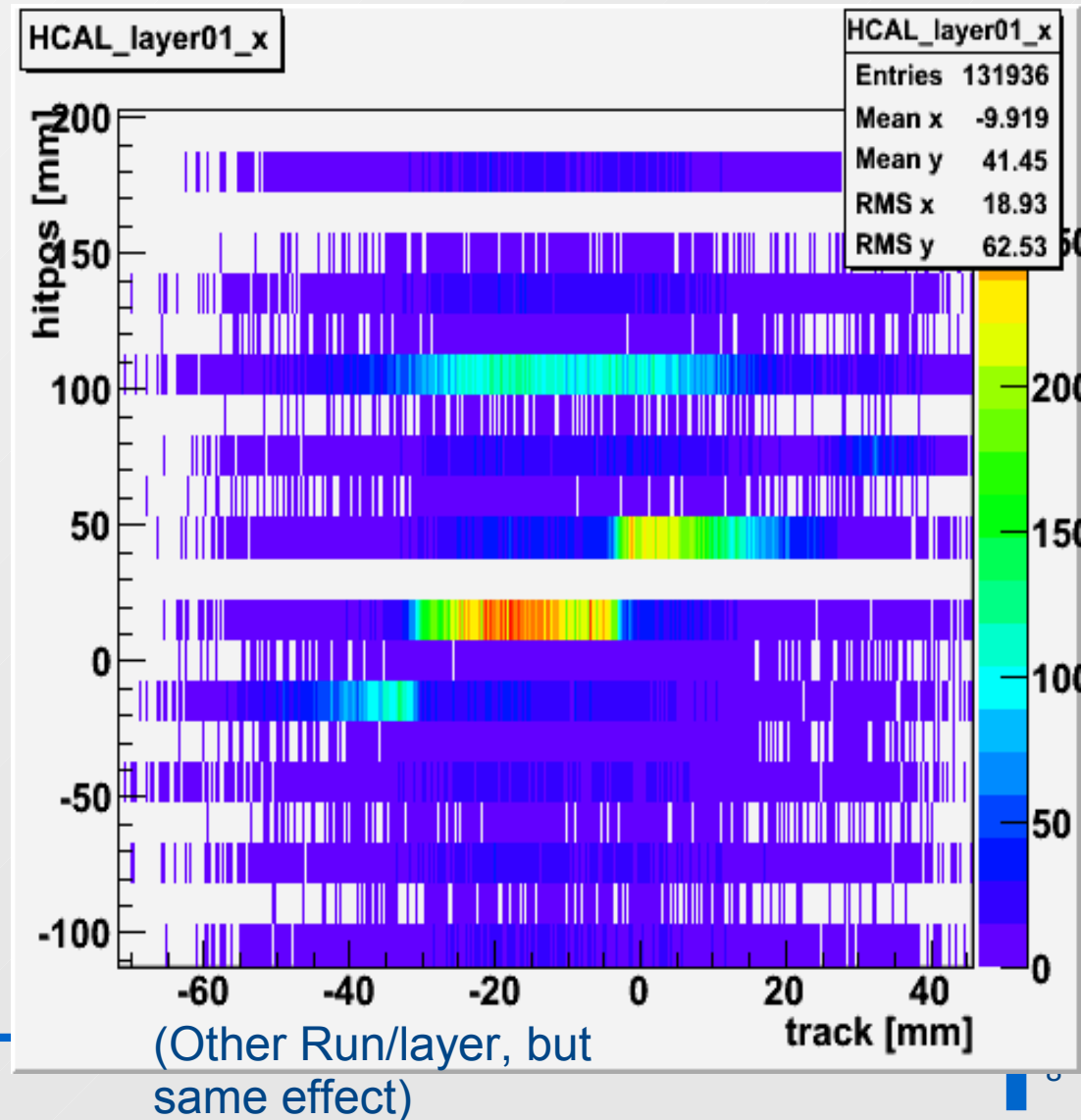
TrackXY intercept on front

TrackXY intercept on front	
Entries	62367
Mean x	-9.724
Mean y	0.6975
RMS x	20.2
RMS y	18.47

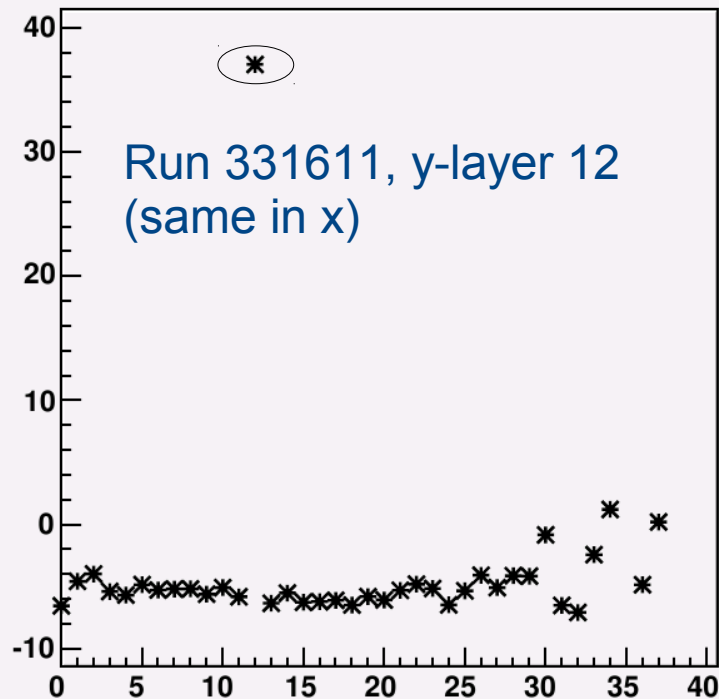


Problems on alignment: failing offset calculation

- Sometimes alignment fails due to
 - Low statistics
 - Noisy tiles

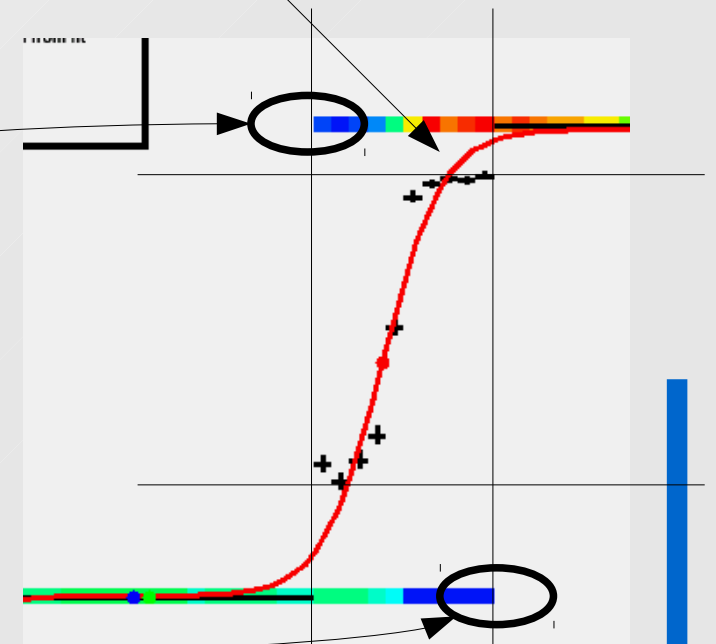
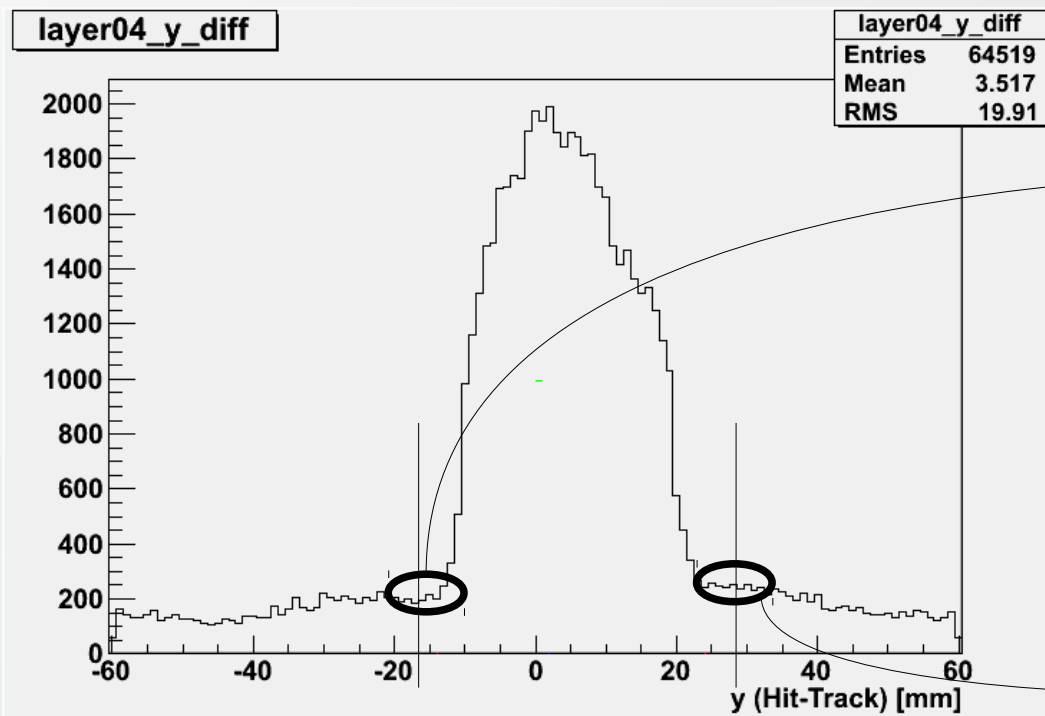


y offsets per layer [mm]



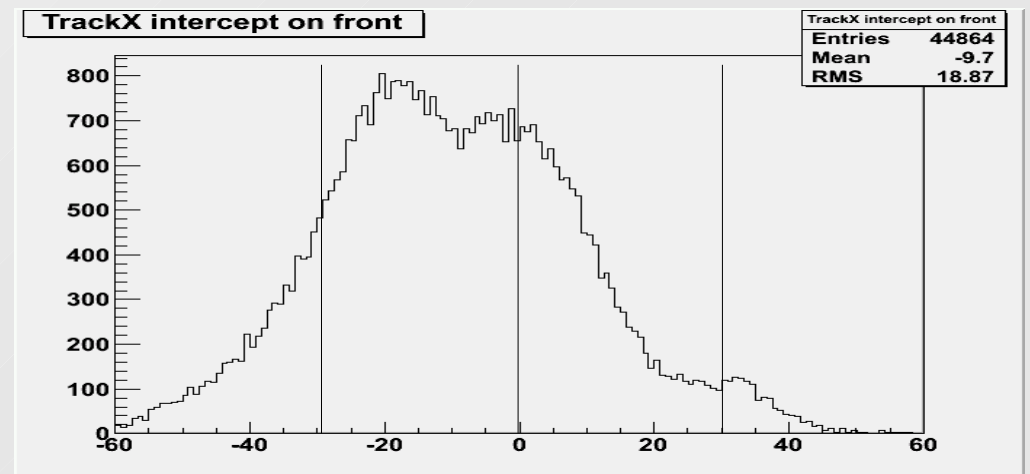
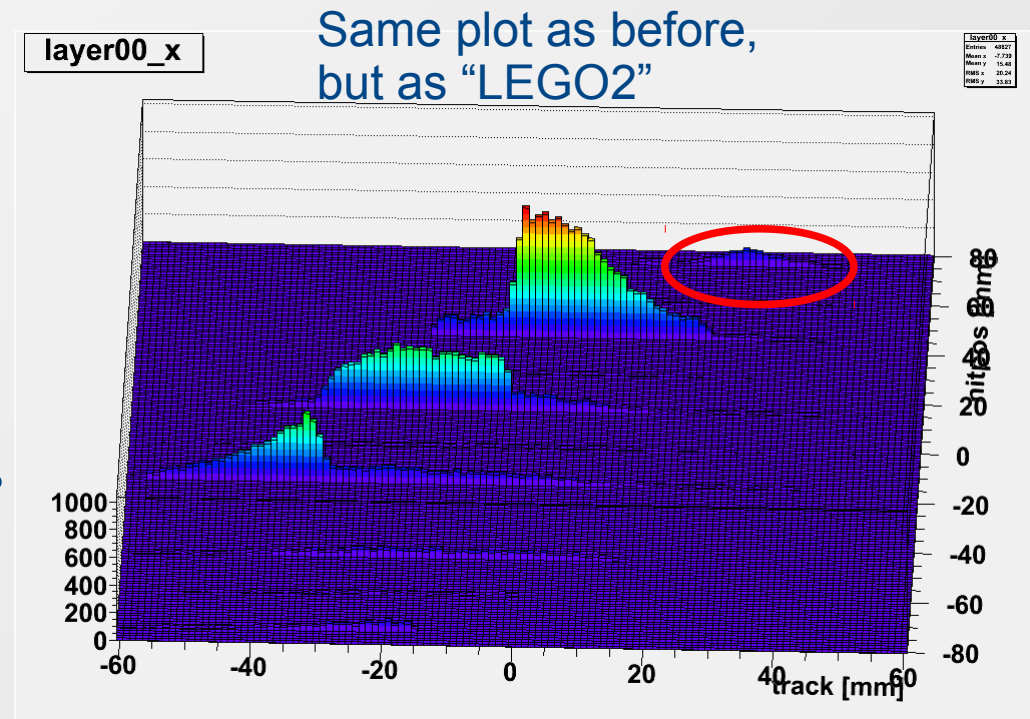
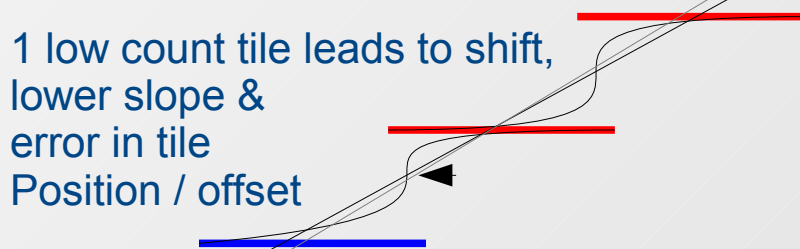
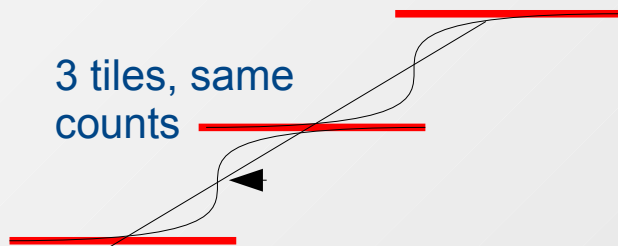
Problems on alignment: S-curve

- Noise: there are always uncorrelated HCAL hits
- S-curve does not converge to plateau
- Up to now no idea how to get rid of it
- Noise in most cases not as uniform as shown here



Beam profile

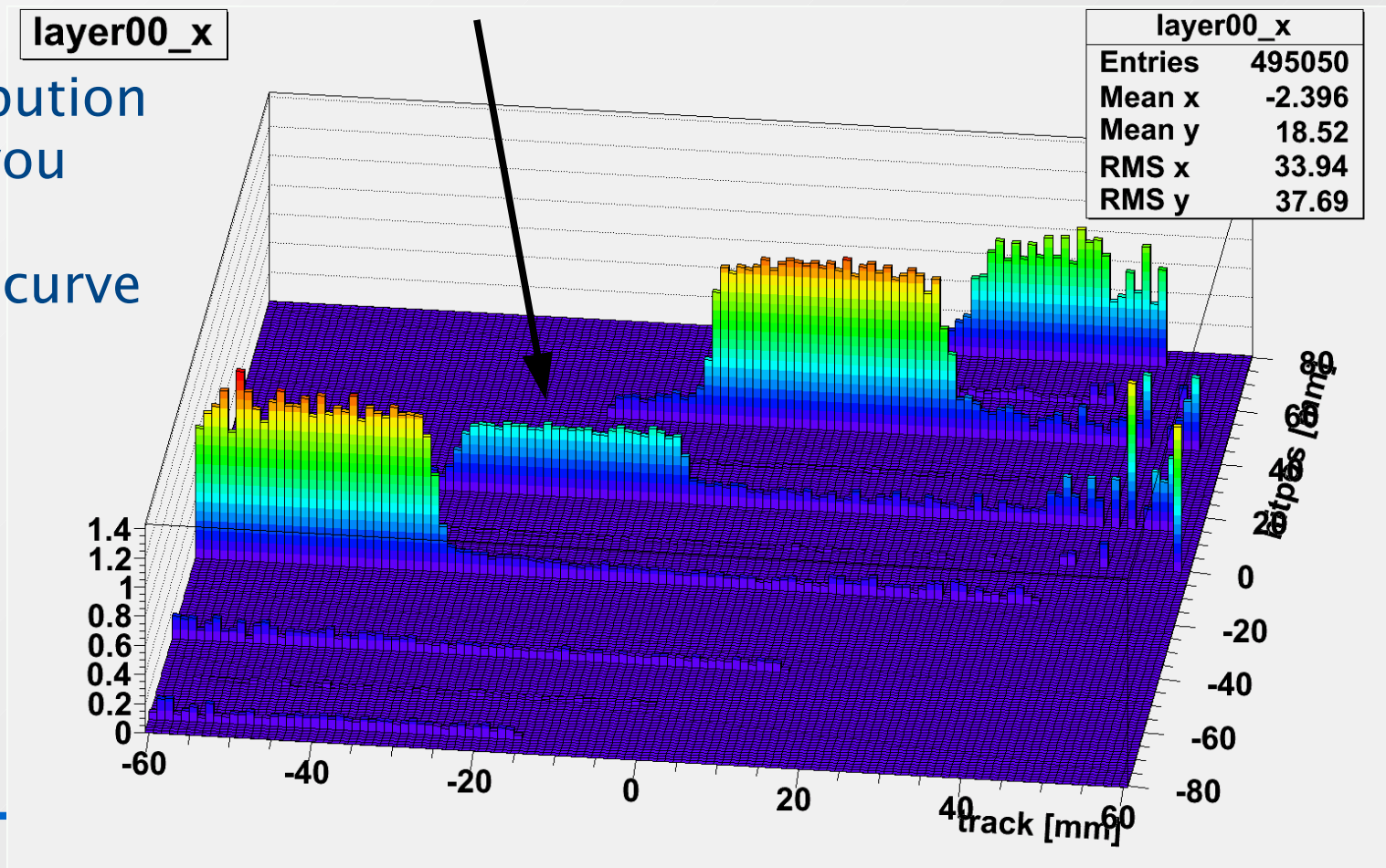
- Fine layers have 4 tiles in tracker range.
 - But can you thrust them?
 - Outer tiles have low hit counts due to beam profile
 - Shifts S-curve to other tiles



Beam profile

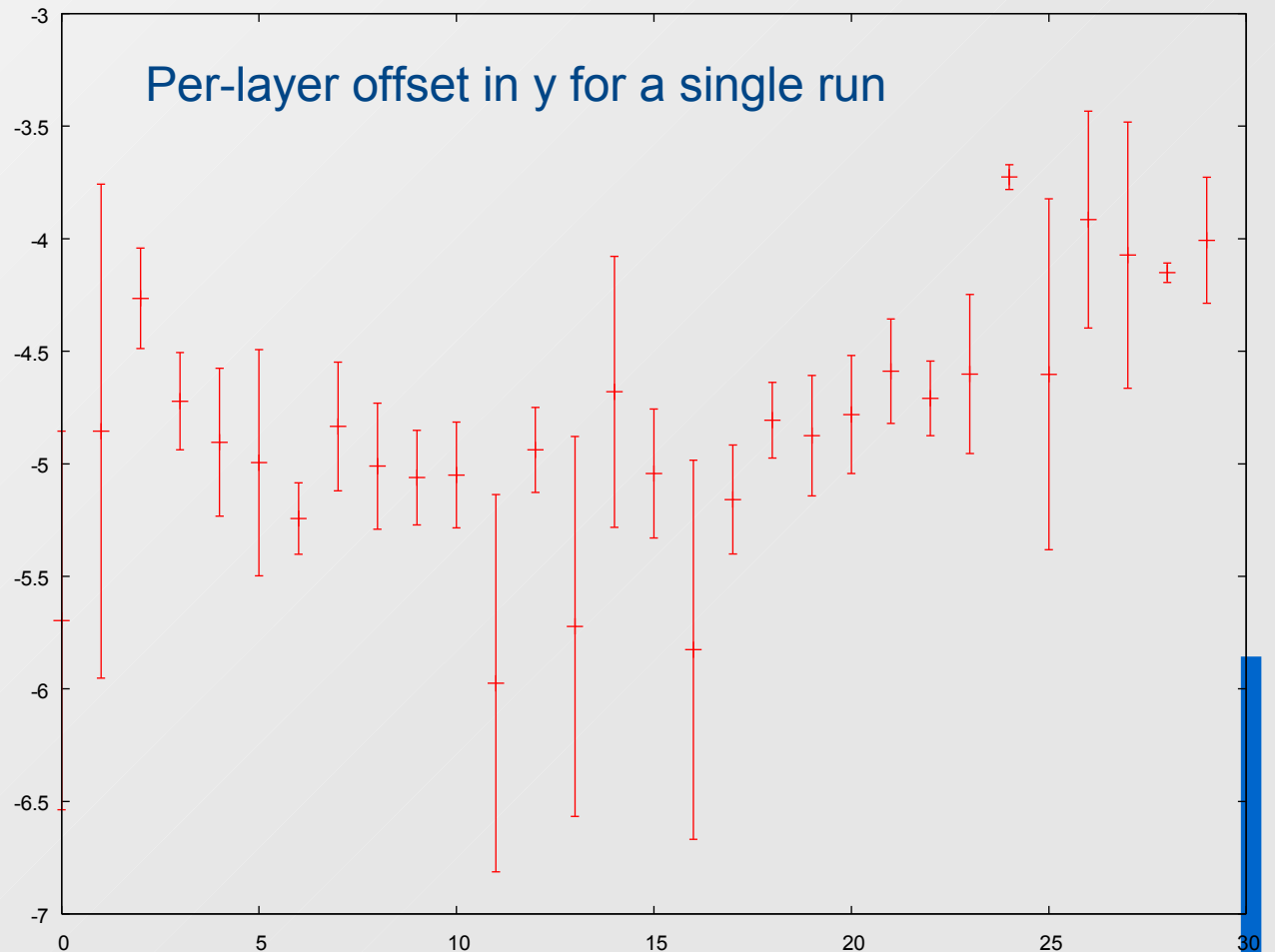
- Normalize histograms by beam profile, i.e. normalize all bins at given track position by #tracks at this position
 - Gives well shaped distribution
- Dead tiles give lower signal in sum
 - Normalize each row to 1

- → Distribution is what you expect
- Better S-curve fits



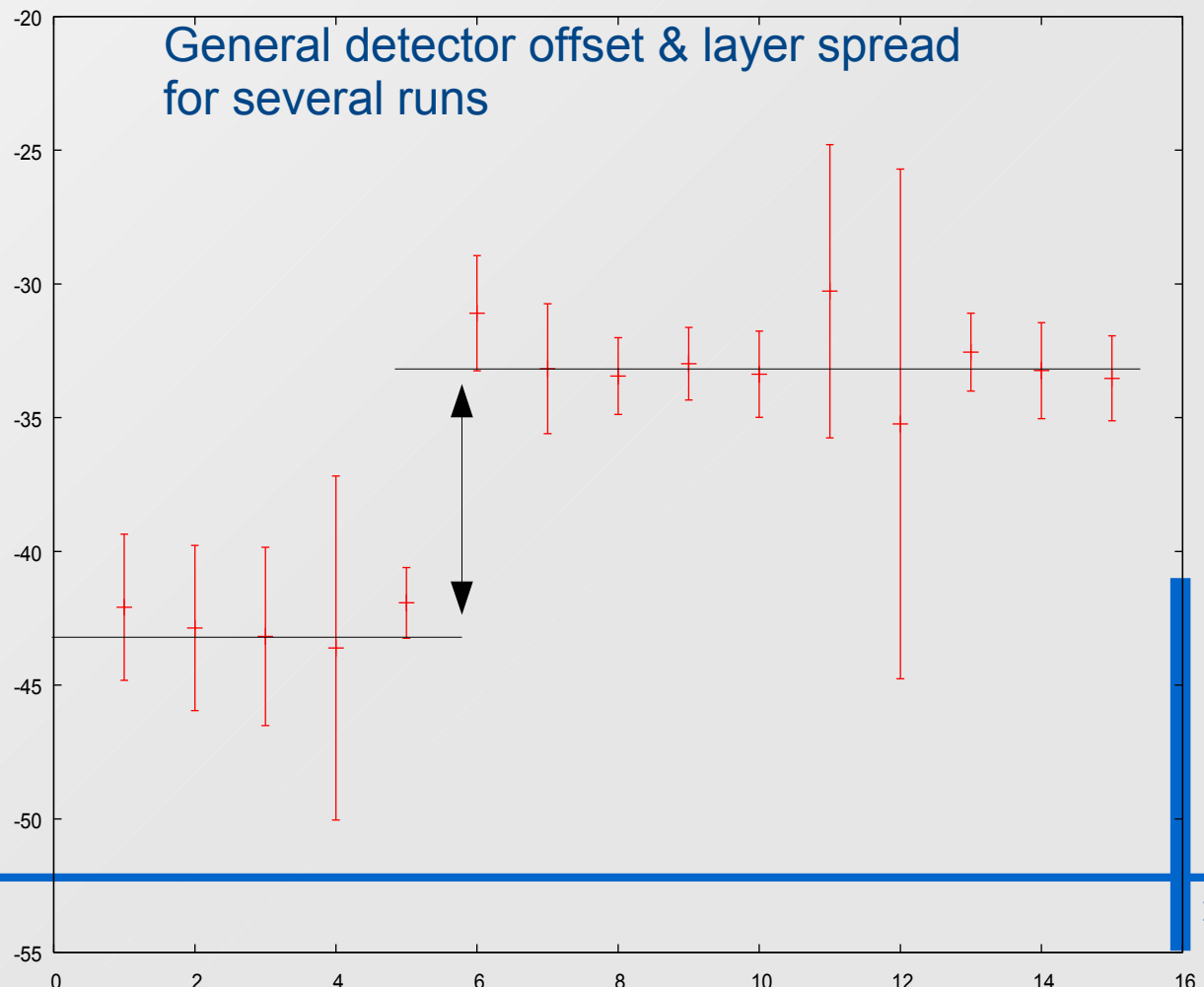
First result: HCAL per-layer offset

- Typical offsets for each layer is $\sim -33\text{mm}$ in x and $\sim -4\text{mm}$ in y
- Errors due to noise / low statistics



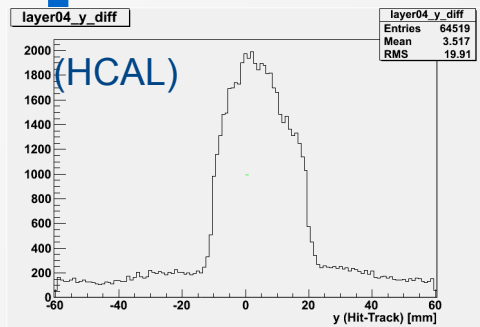
First result: HCAL general offset vs. run

- Analysis of several runs gives almost uniform offsets
- But something happened between Run330934 & 331587
 - Offset decreases from $\sim -43\text{mm}$ to $\sim -33\text{mm}$ in x-direction
 - Same in y
- Should check offsets over whole beam period
- Lack of muon runs
- *Need for using pion runs*



Other Detectors - ECAL

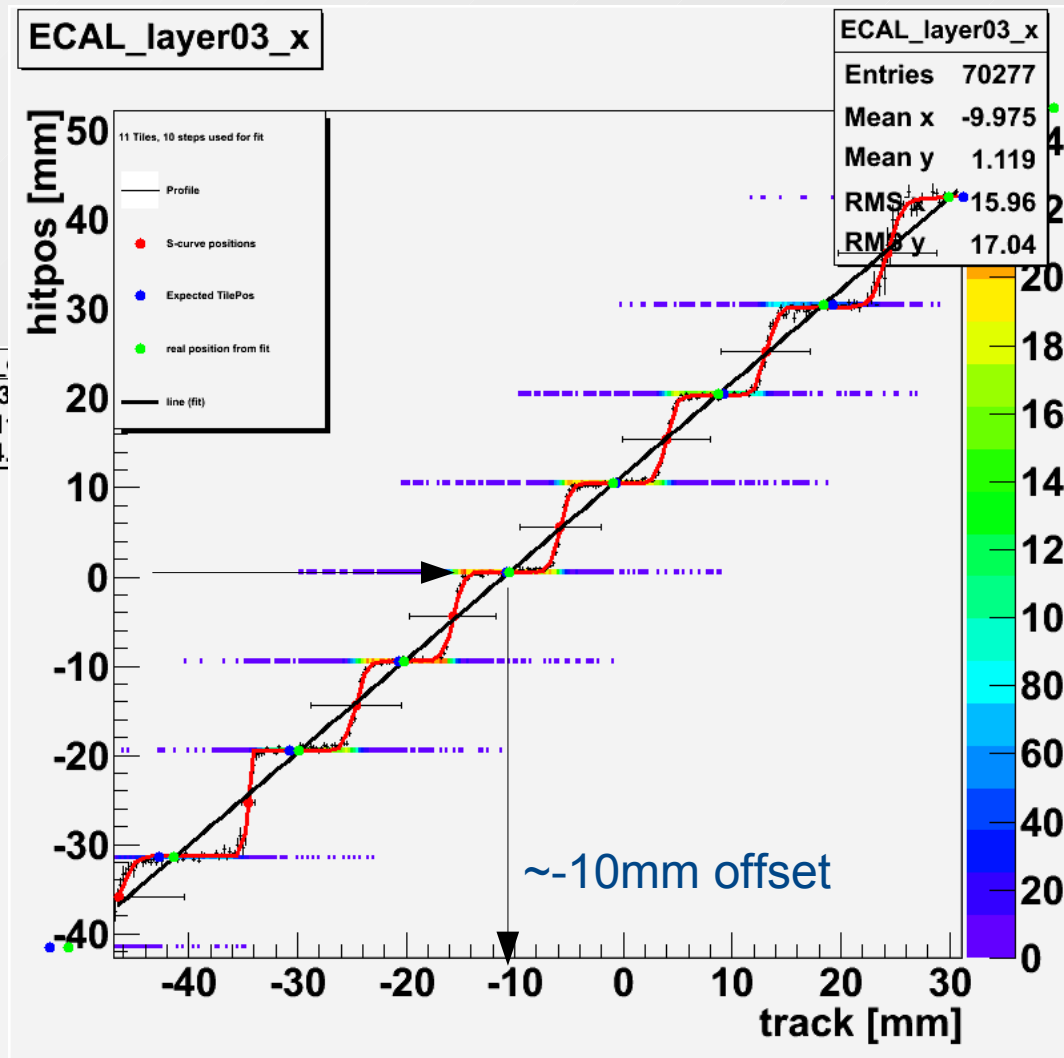
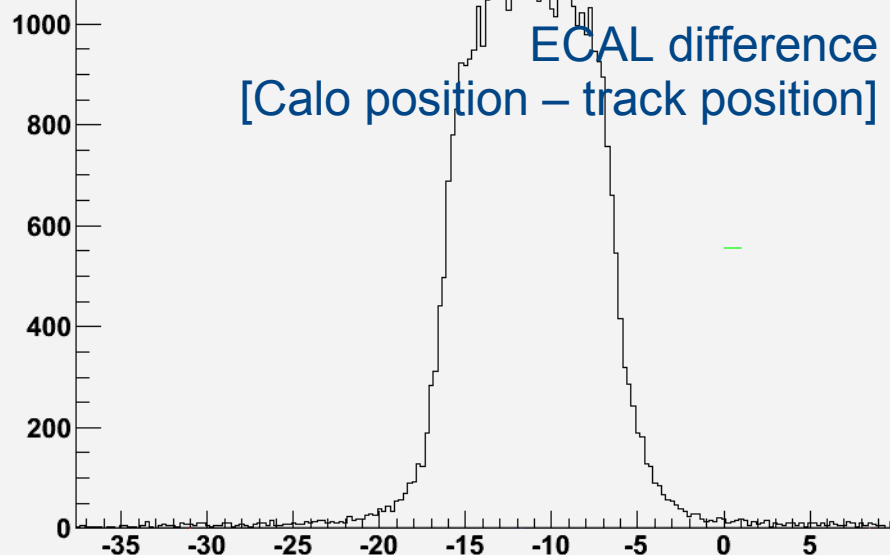
- Cell size of 1cm: lots of steps to fit
- In contrast to HCAL, almost no noisy cells, clean signal
 - Get perfect s-curves



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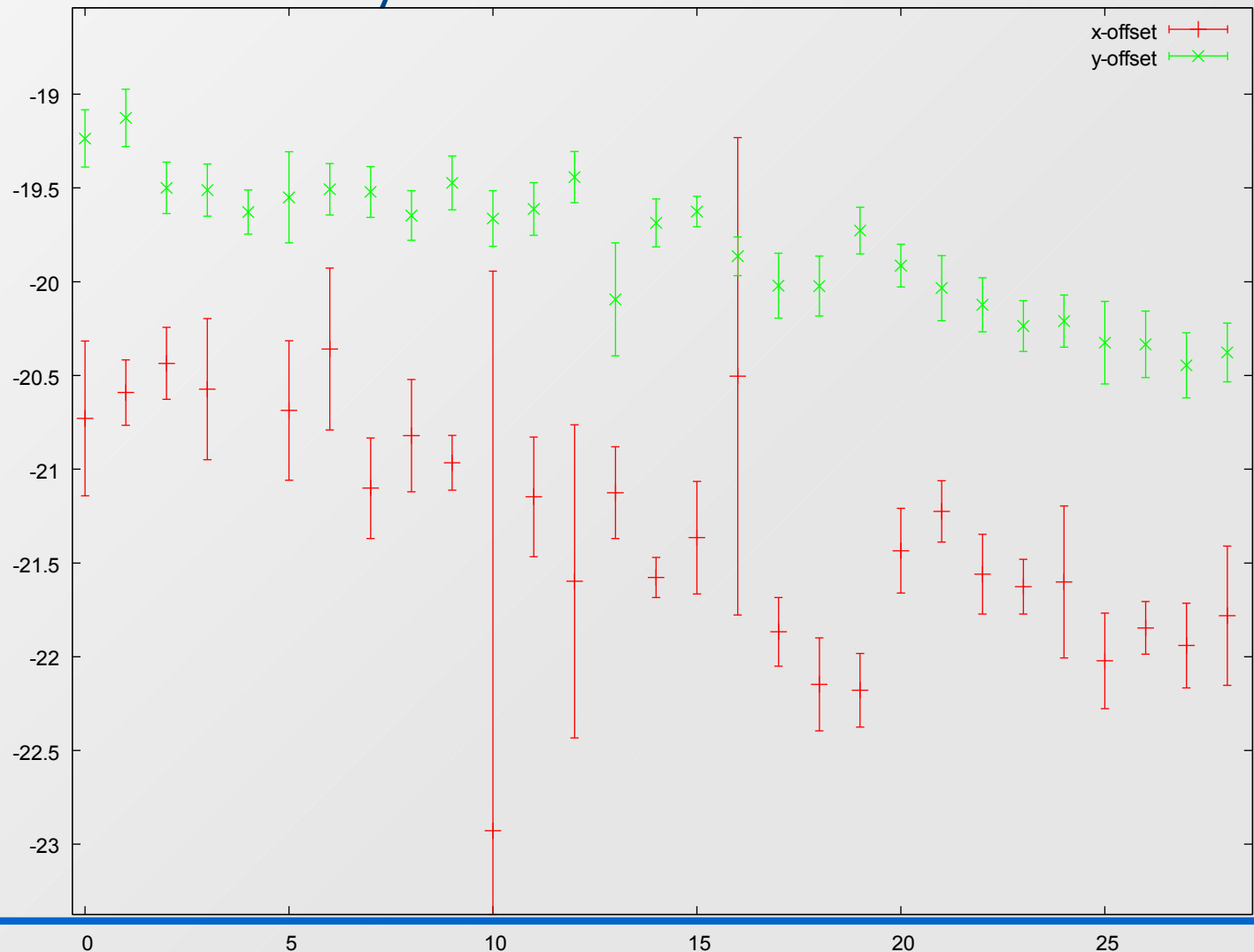
layer06_x	
Entries	3
Mean	-1
RMS	4

ECAL difference
[Calo position - track position]



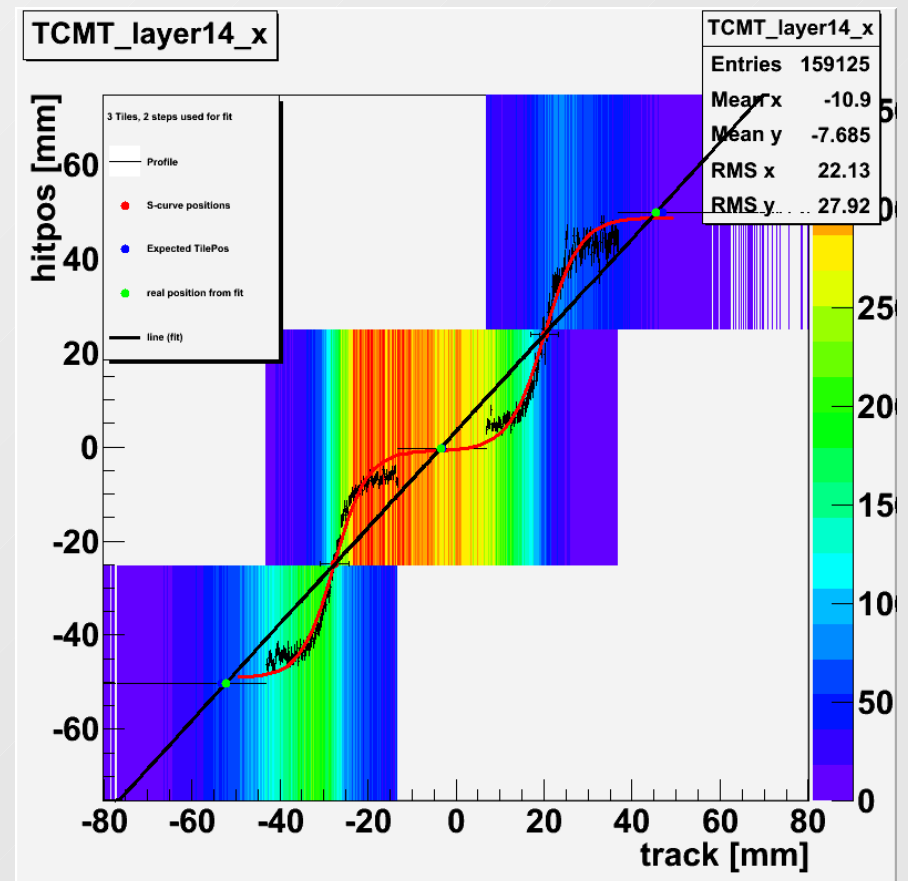
Other Detectors - ECAL per-layer offset

- ECAL shows general offset of $\sim 2\text{cm}$ in x and y
- 1–2mm spread between layers



Other detectors - TCMT

- In principle similar to HCAL – but simpler geometry
- Suffers from large Scintillator width (5cm, approx beam width)
- Proof of principle, but no real look into data yet...



Summary & Outlook

- In principle, alignment works
 - HCAL shows offsets of ~ 1 tile size
 - ECAL shows offsets of ~ 2 cell sizes
 - TCMT suffers from large cell size, not analyzed yet (needed?)
- Extend to muons of pion runs
 - Shift in offsets seen during testbeam
 - Needs improved muon selection
 - More statistics – combine data from several runs
- Other testbeam seasons like FNAL '08 and '09
- Offsets will be written to database and taken into account during reconstruction