



Detector alignment
of the
HCAL for testbeam CERN 2007

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Content

- There is always some misalignment of
 - Detectors to reference coordinate system
 - Components of detector (HCAL Layers)
- Raw alignment
 - Simple algorithm to get detector offset relative to reference coordinate system for all runs
 - results on CERN 2007
- Muon alignment
 - „Inter-layer“ alignment for HCAL using muons
 - First very preliminary results for CERN2007

Raw detector alignment

- Wire chamber tracker next to beam pipe
 - Gives **reference coordinate system**
 - Beam is always at about (0; 0) in xy-plane
- HCAL
 - Located on a stage movable in x and y (+angle)
 - Stage position is written to database
 - **Should report beam spot on (0; 0) , regardless of stage position, too**
 - May not apply due to stage position precision, errors in database...

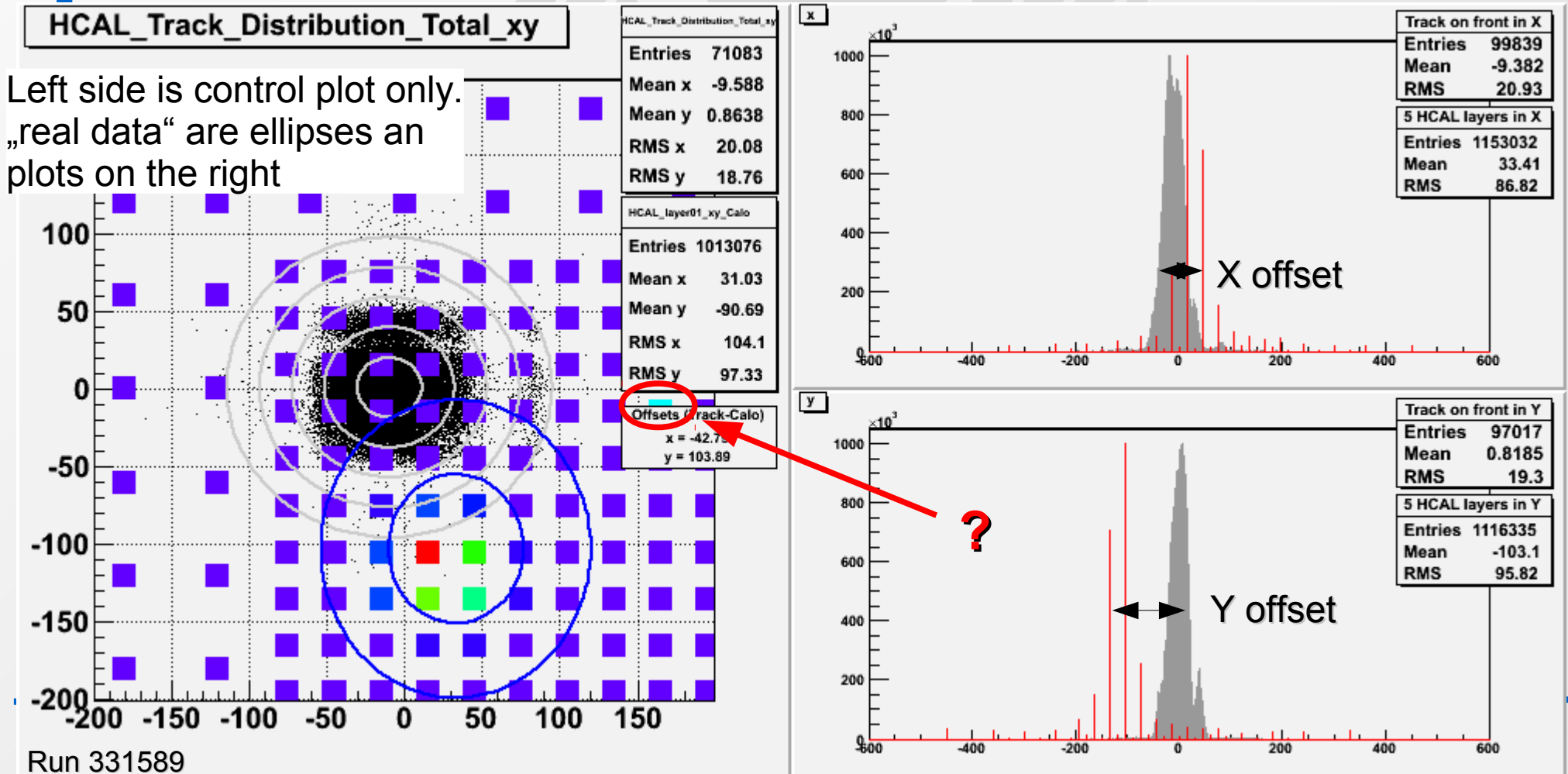
Raw detector alignment

- Idea (Angela):
 - Run reconstruction on test beam raw data
→ hit coordinates
 - (*Stage position is taken into account*)
 - Get COG of TRACK on HCAL front face
 - Get COG of HCAL hits ***in first 5 layers***
 - $\text{Offset} = (\text{COG}_{\text{TRACK}} - \text{COG}_{\text{HCAL}})$
 - Write offsets to database
 - Apply offsets to HCAL hist on future reconstruction (automatically)

- In principle no limitations in particle type / energy / ..., so works on any beamdata runs

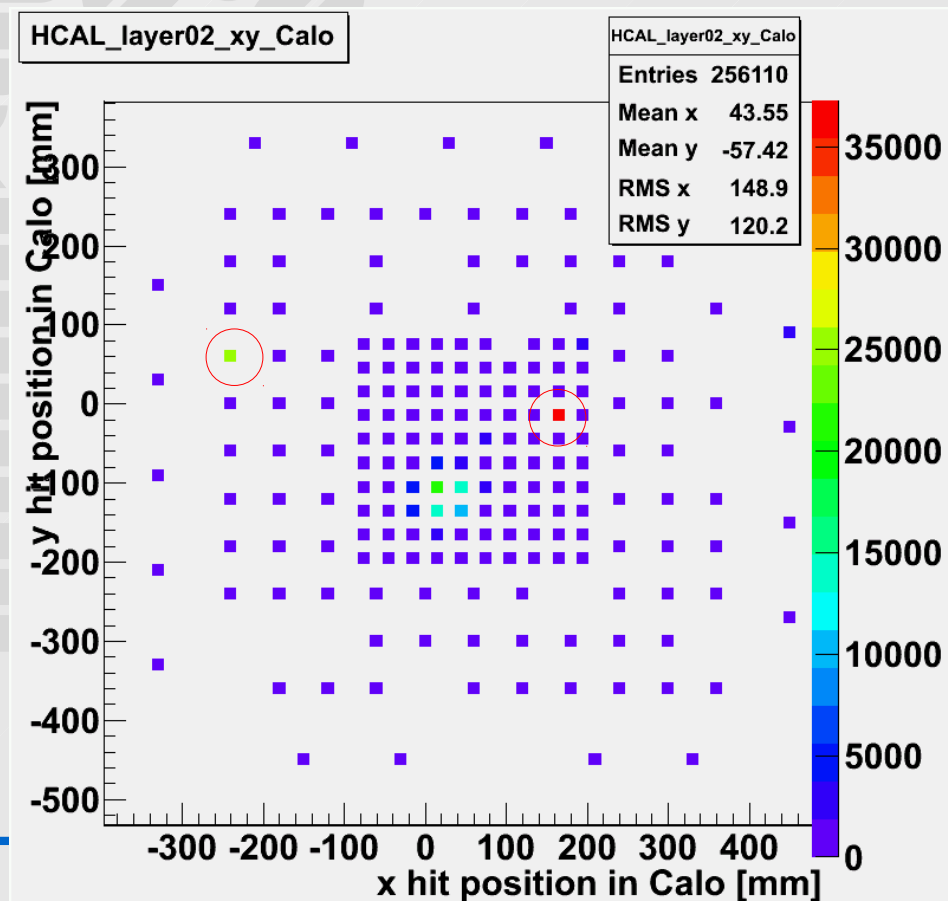
Raw detector alignment – Hits in first 5 layers

- Left: clipped control plot
 - 1 RMS steps (track)
 - 0.5 RMS steps (Hits)
- Right: projection in x, y
 - Track distribution
 - Hit distribution



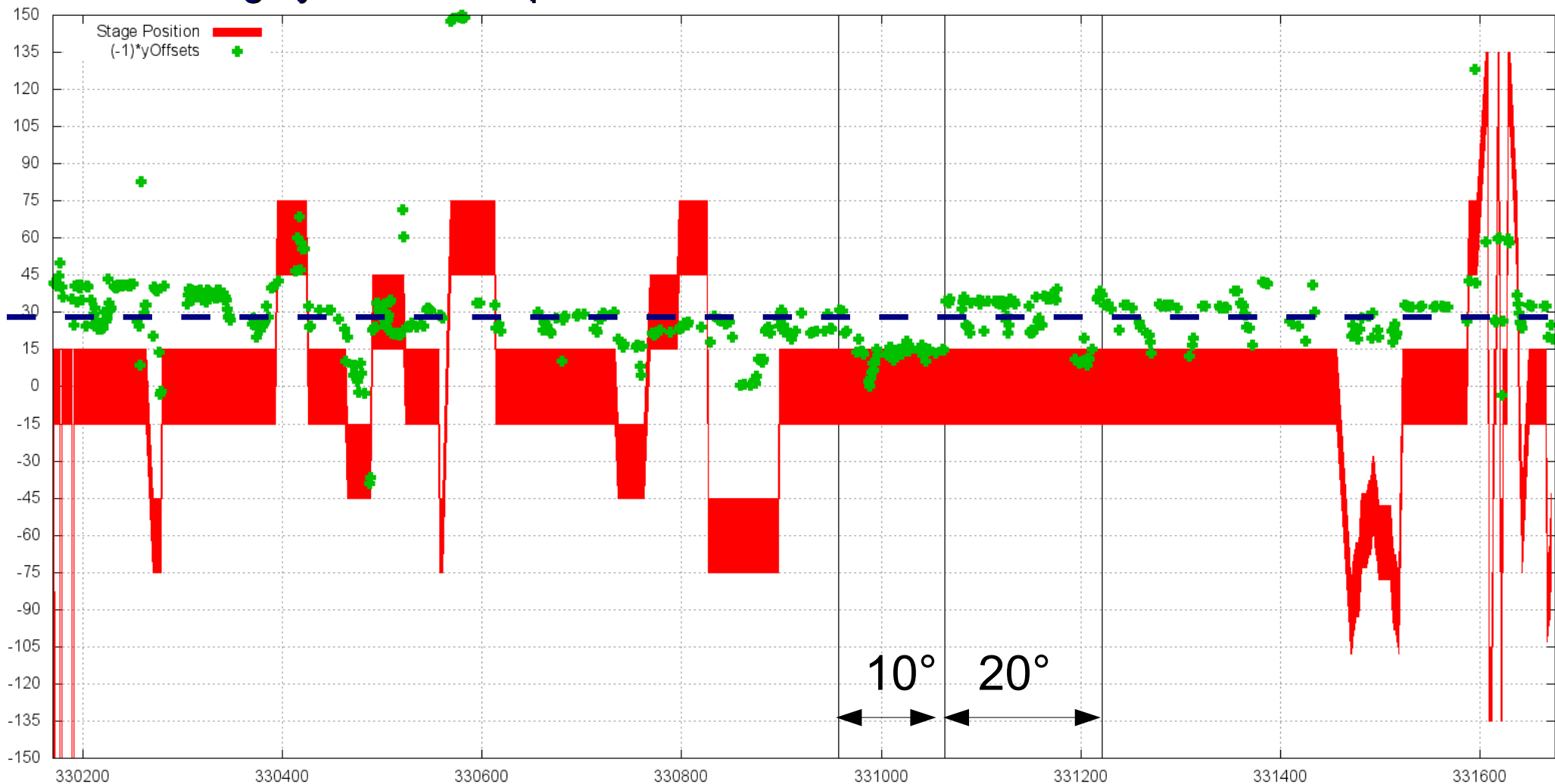
Raw detector alignment – noise

- One very noisy tile (and a second, less noisy one) in layer 2
- Influence depends on several parameters
 - Hits per event (here: 130GeV $\mu \rightarrow$ few, low ampli hits)
 - Distance beam spot \leftrightarrow tile
- We sum up over 5 layers
- Effect decreases
- But it's still there!
- Quick and dirty:
 - Ignore layer 2
 - Still enough statistics
 - (All events of Runs used)



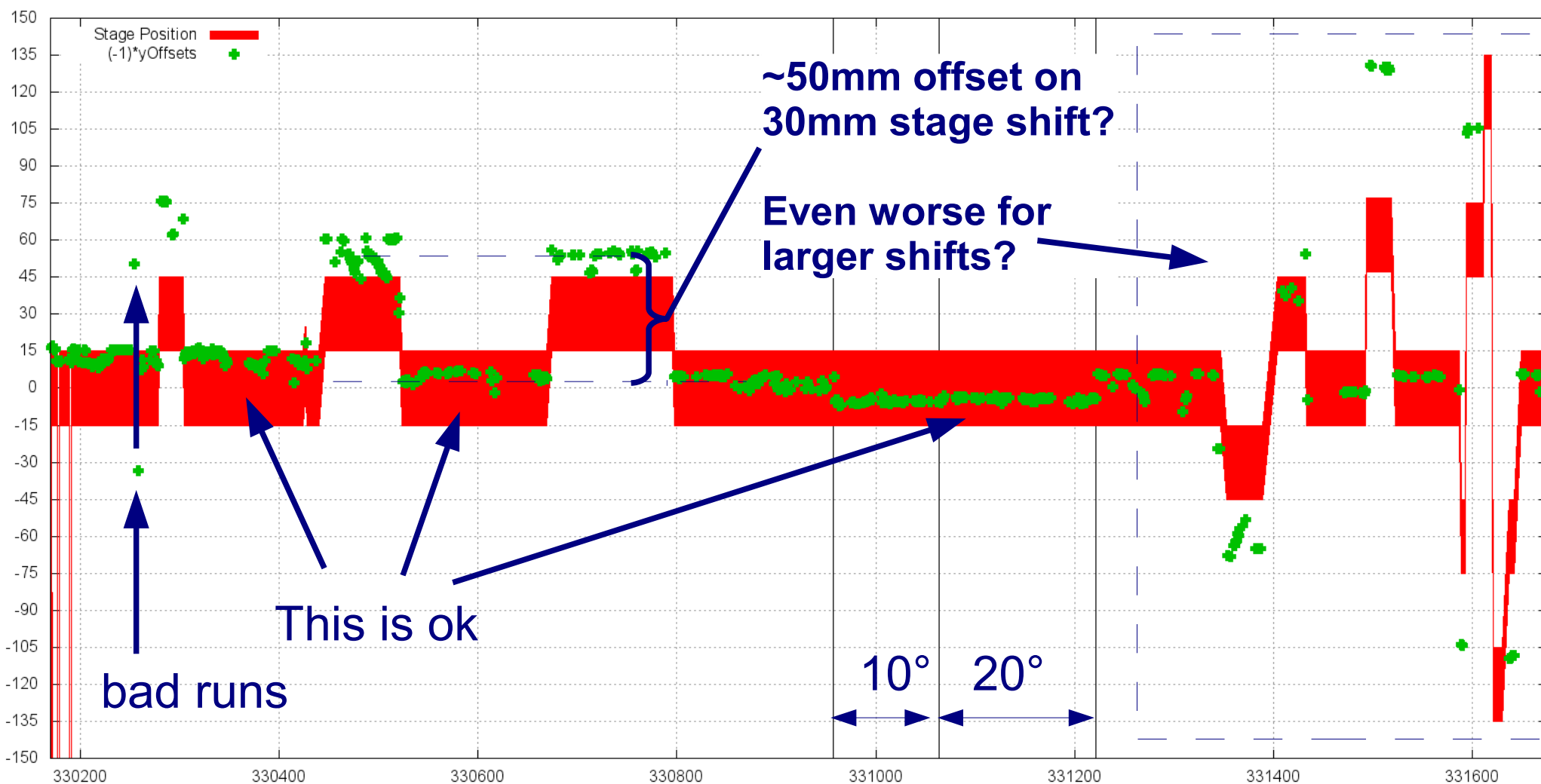
Raw detector alignment – X-offset of Run330xxx – 331xxx

- Stage position from db $\pm 15\text{mm}$ indicating tile size
- Calculated offset*(-1) to show correlation
- Generic offset $\sim 30\text{mm}$, large spread (not fully understood).
- Roughly what we expect. BUT...

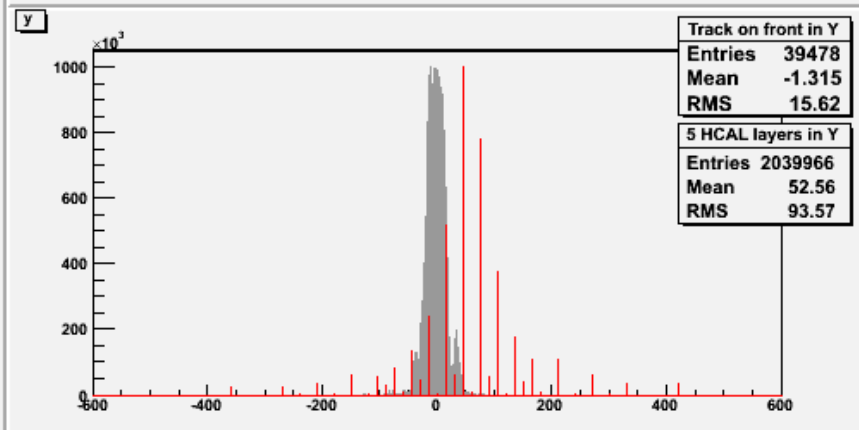
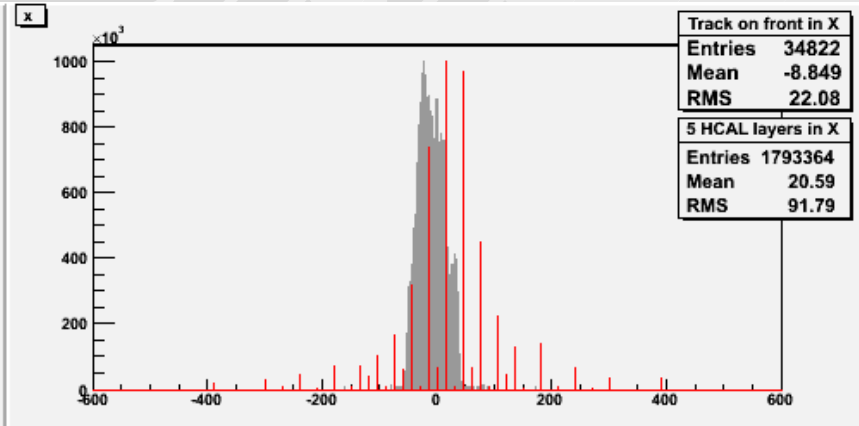
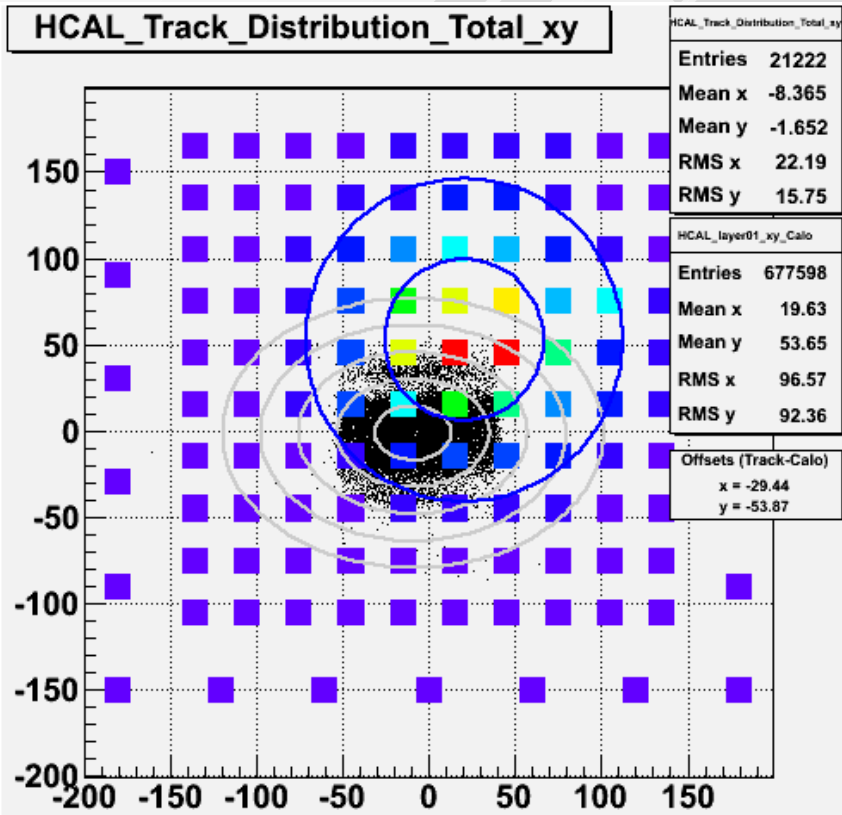
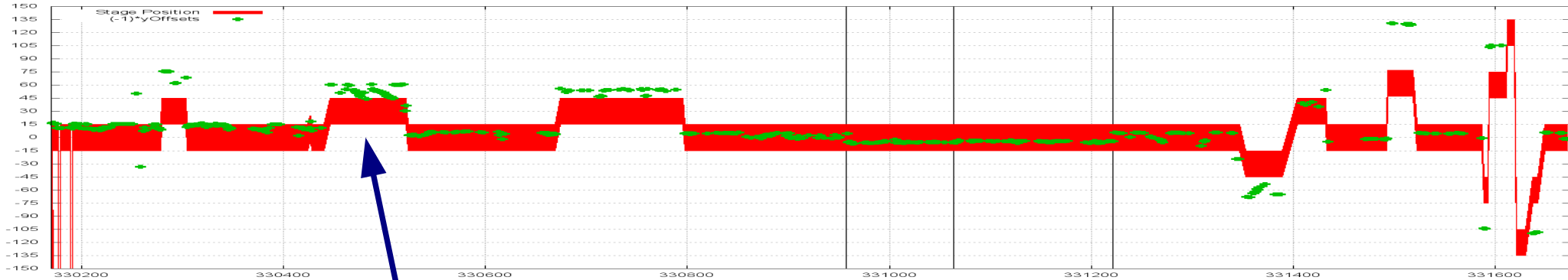


Raw detector alignment – Y-offset of Run330xxx – 331xxx

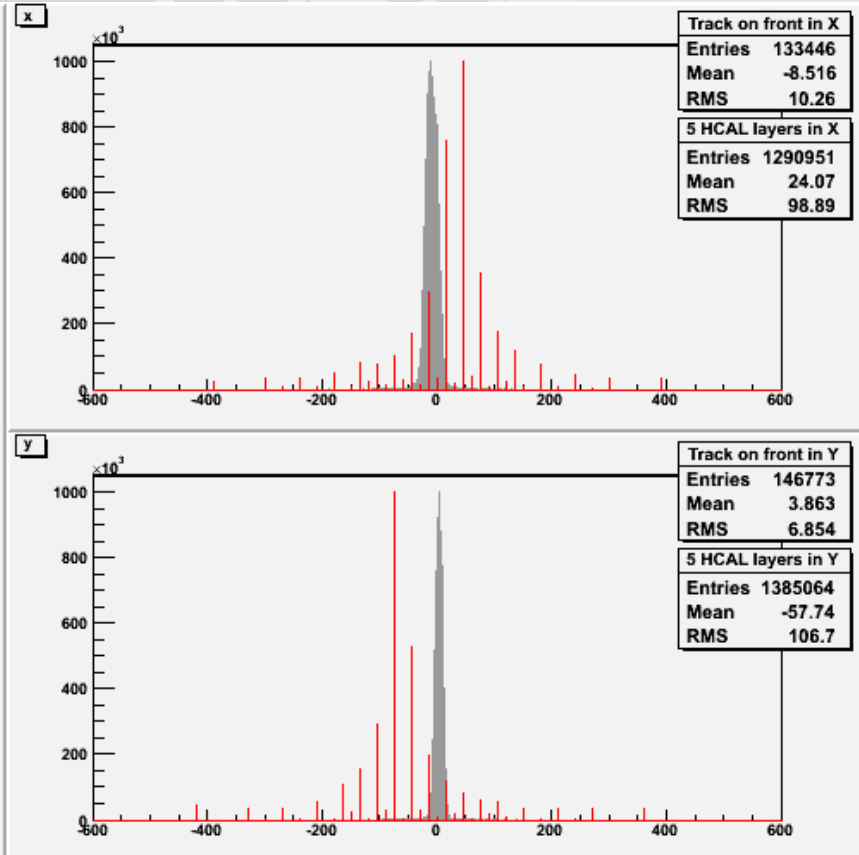
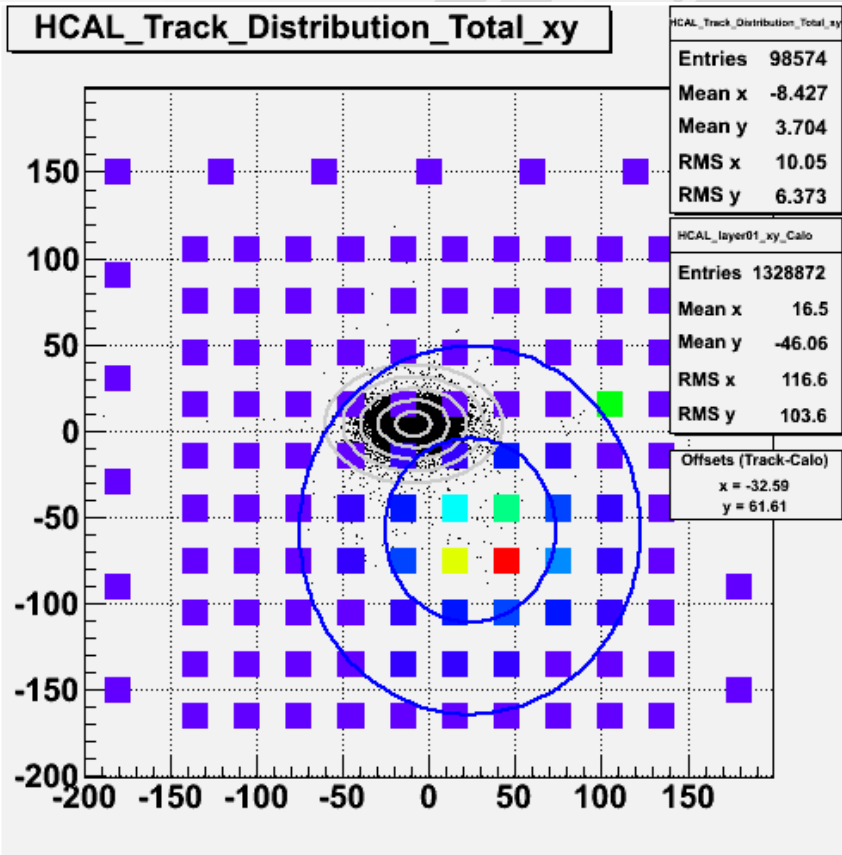
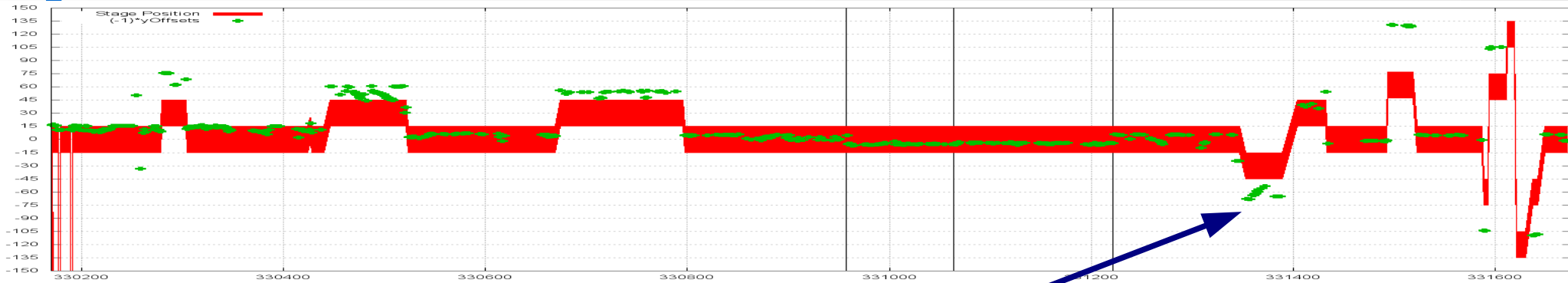
- Stage position from db $\pm 15\text{mm}$ indicating tile size
- Calculated offset*(-1) to show correlation
- Large offsets when moving stage!



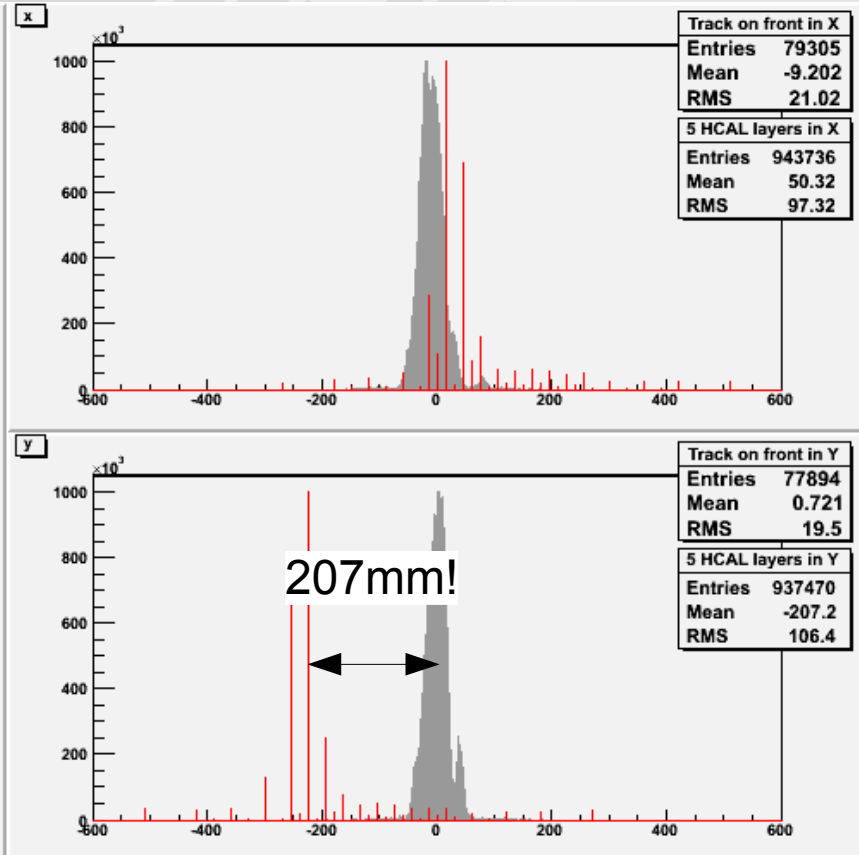
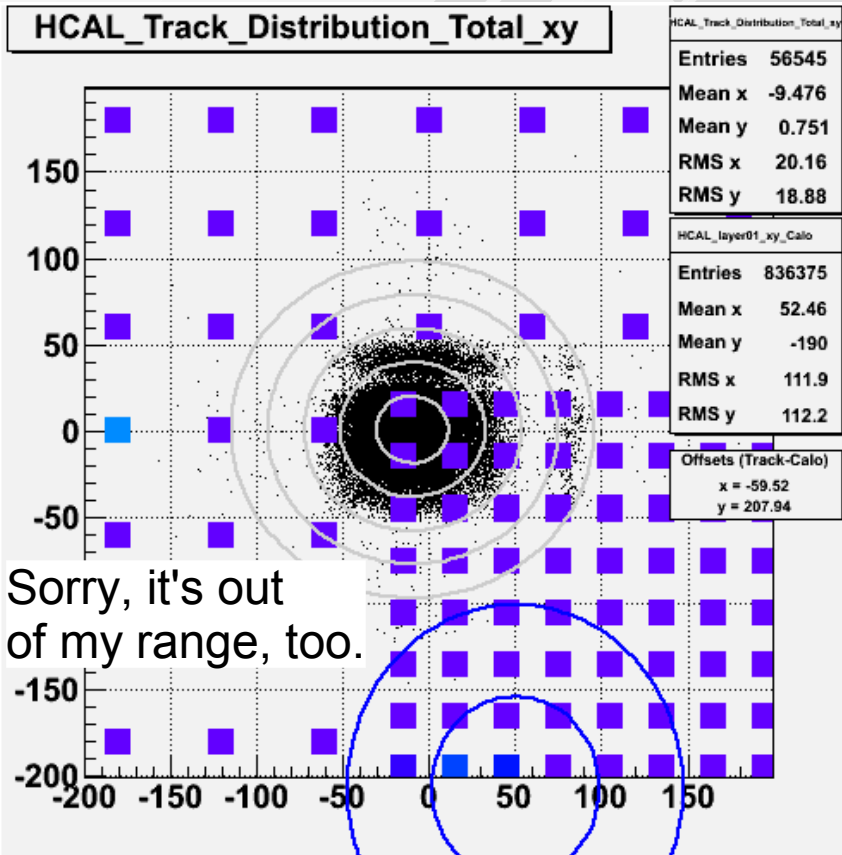
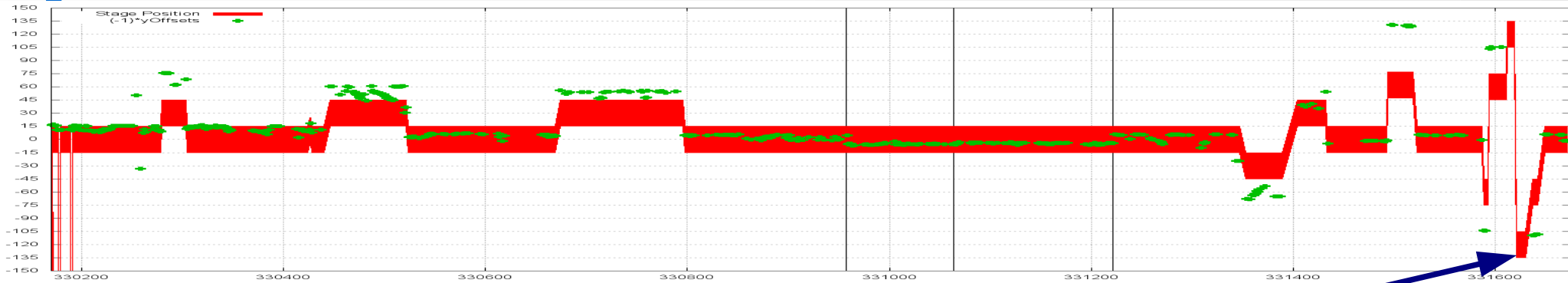
Raw detector alignment – control plots (Run330702)



Raw detector alignment – control plots (Run331363)



Raw detector alignment – control plots (Run 331628)

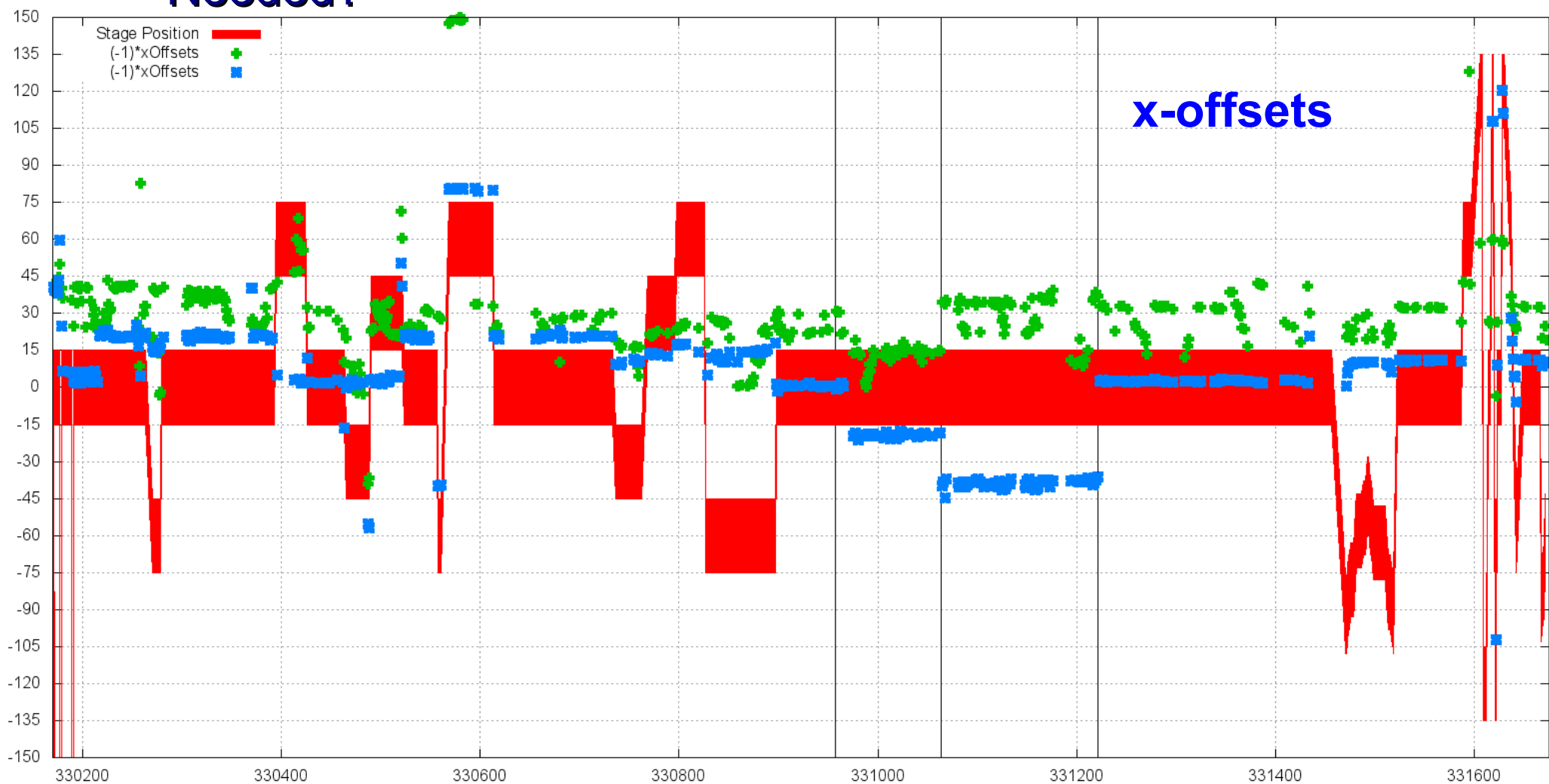


Raw detector alignment - conclusion

- Offsets in x need further check – but roughly as expected
- Offsets in y are large & correlated to stage position!
 - Seems to be a sign error in y stage position handling
- However, this is not an issue any more when this offsets are applied as it is just a shift in one direction
- Offsets are available for whole data taking period CERN07
 - All runs, even less important ones with few events etc.
- Would like to check data a bit more in detail
- Should be available in db / used in reconstruction soon

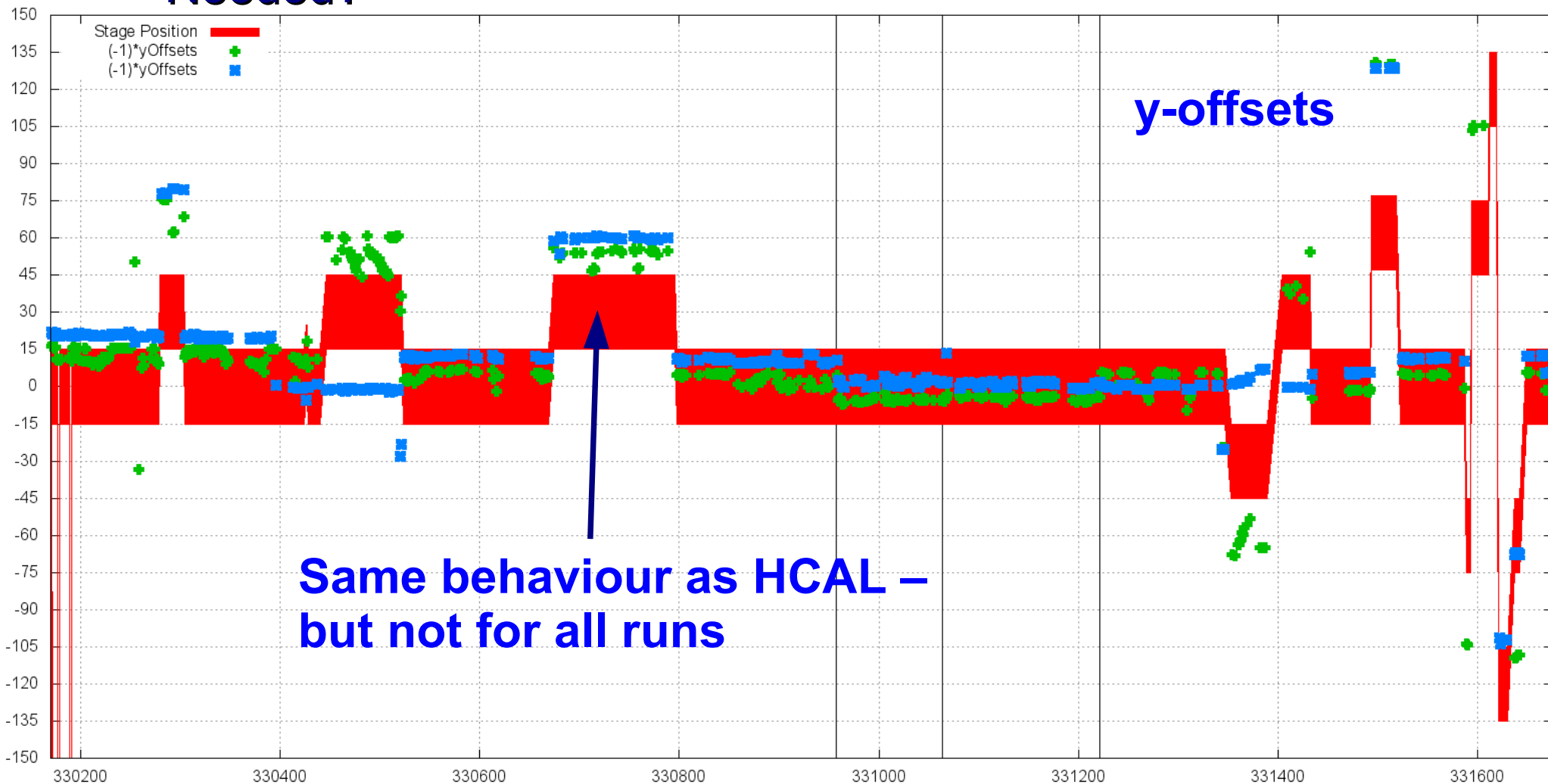
Raw detector alignment – Whats about ECAL?

- Code can handle ECAL in parallel to HCAL
- But this is the very first plot – So no comment!
- Needed?



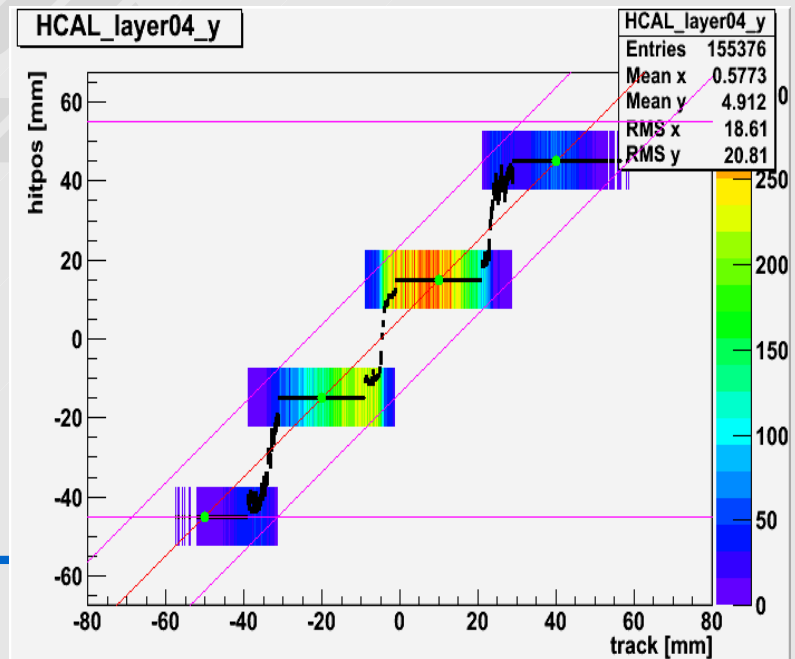
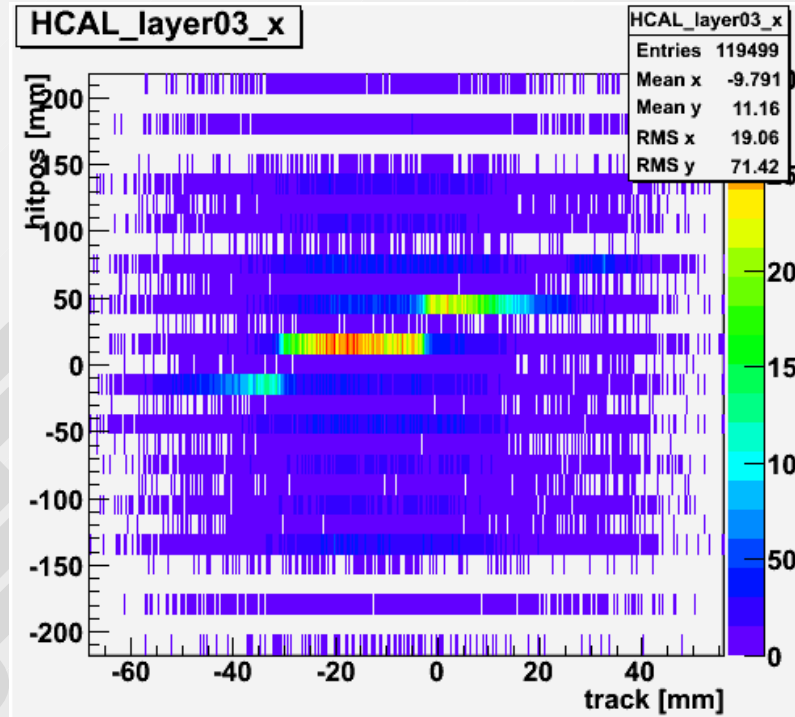
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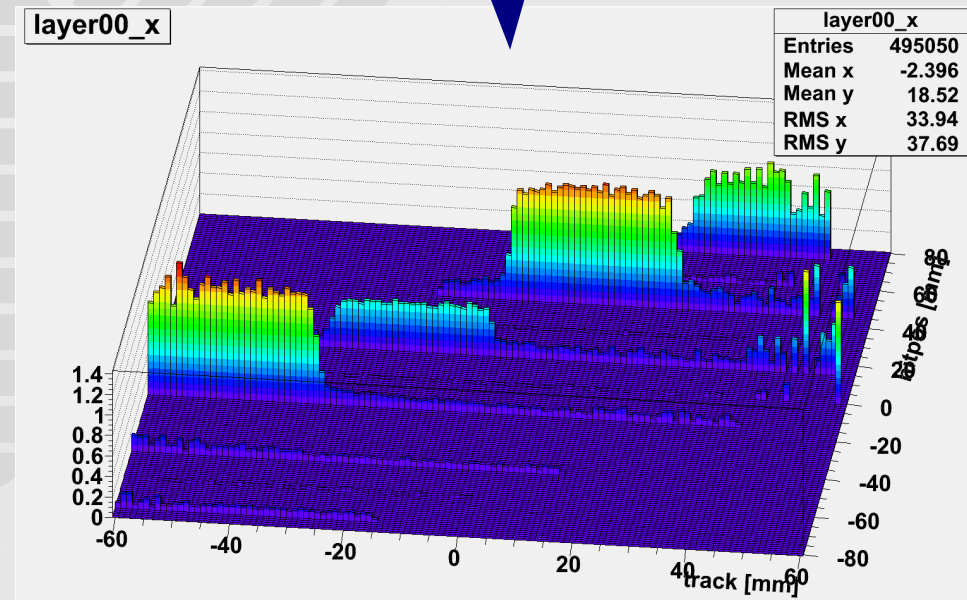
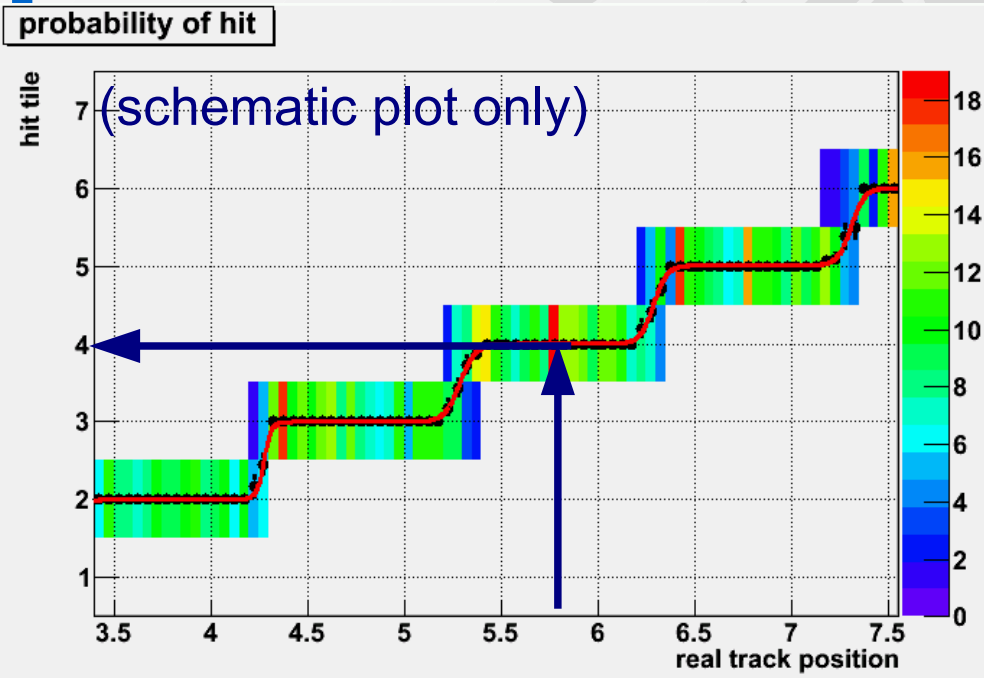
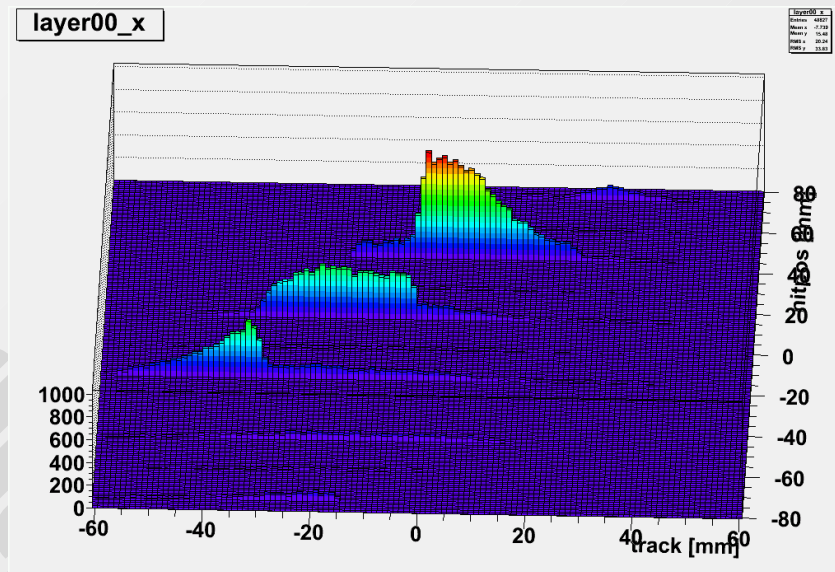
HCAL muon alignment

- Position of whole HCAL is clear now.
- There are still offsets (\sim mm) between HCAL layers
- Idea (Niels Meyer):
 - Muons give straight, clear tracks
 - Plot correlation of HCAL hit position to „real“ hit position(track)
 - *For x and y*
 - *For each layer*
- Clean up...



HCAL muon alignment

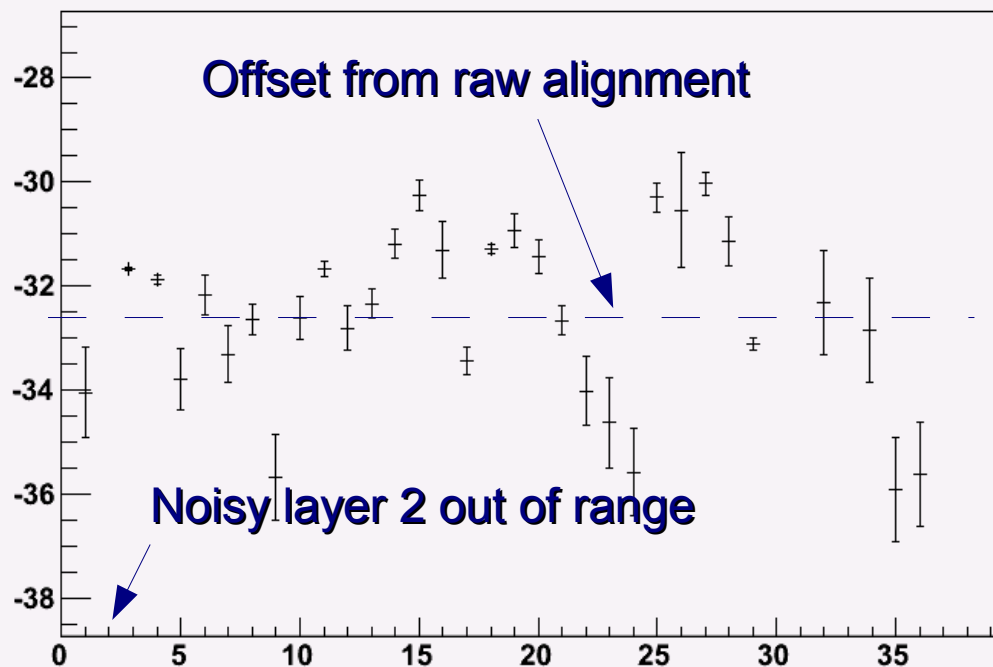
- Normalize
 - to beam profile
 - to hits in „row“
- Fit multi-step function
 - Steps are borders of tiles
 - Tile centers inbetween steps
→ Offsets!



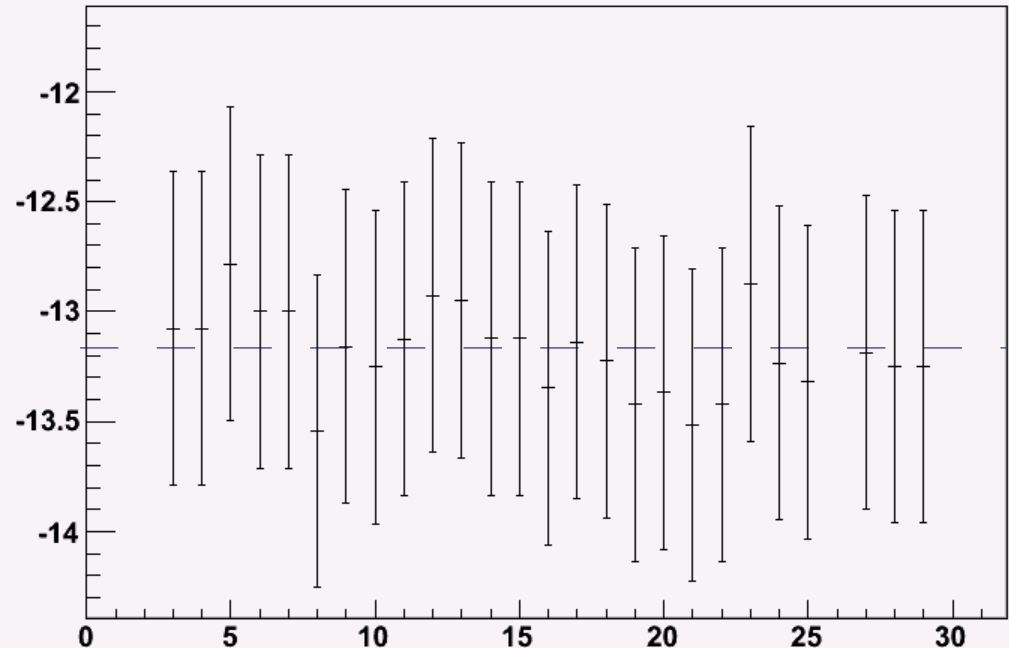
HCAL muon alignment – offsets in x and y (Run331565)

- Good vertical alignment (y) within 1mm (gravity?)
- ~5mm spread in horizontal alignment
 - May explain spread in raw alignment!
- General problem:
 - Offsets not constant for subsequent runs
 - But general shape stays equal
 - → Statistics problem in case of non-muon runs

x offsets per layer[mm]

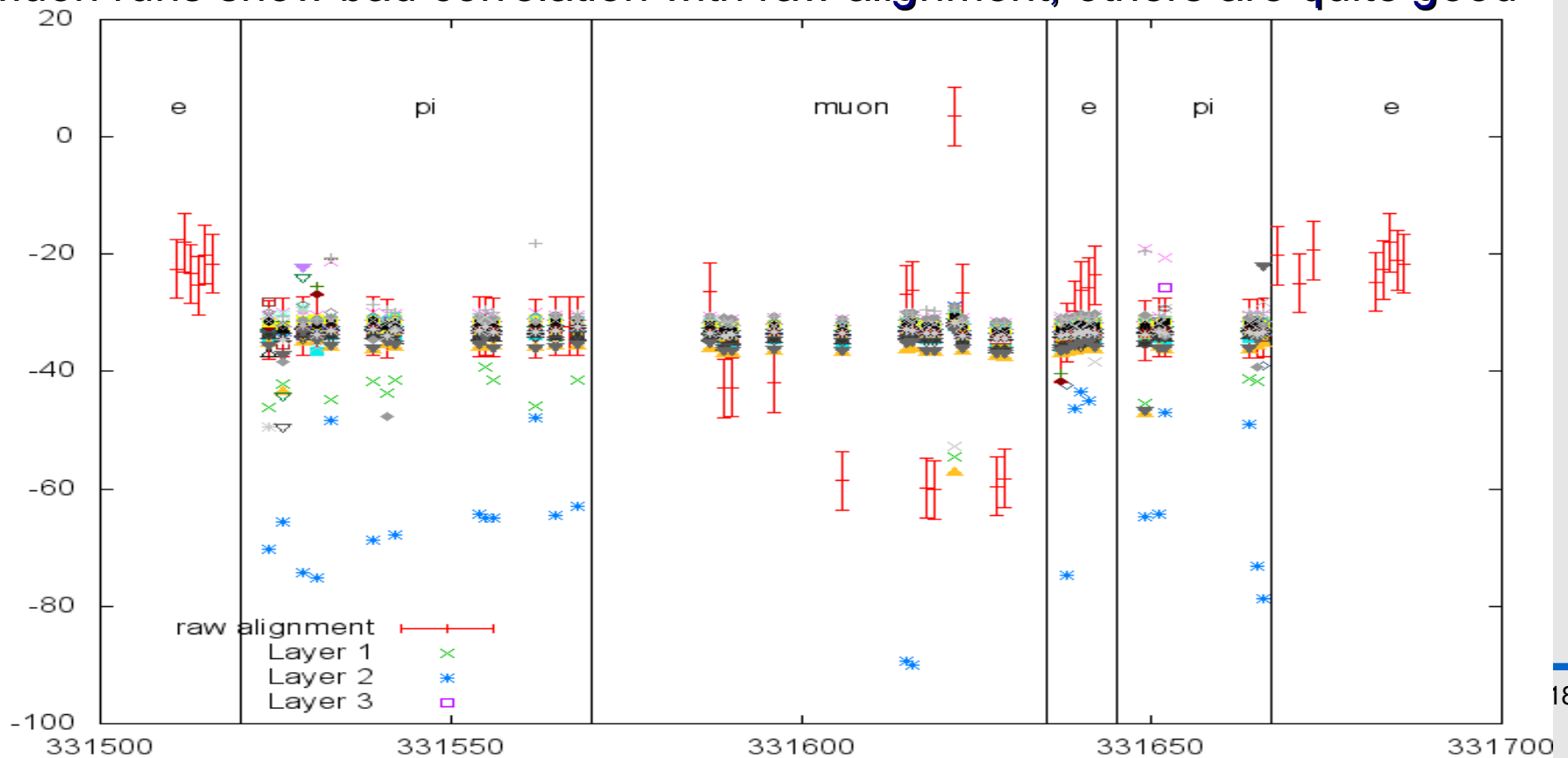


y offsets per layer[mm]



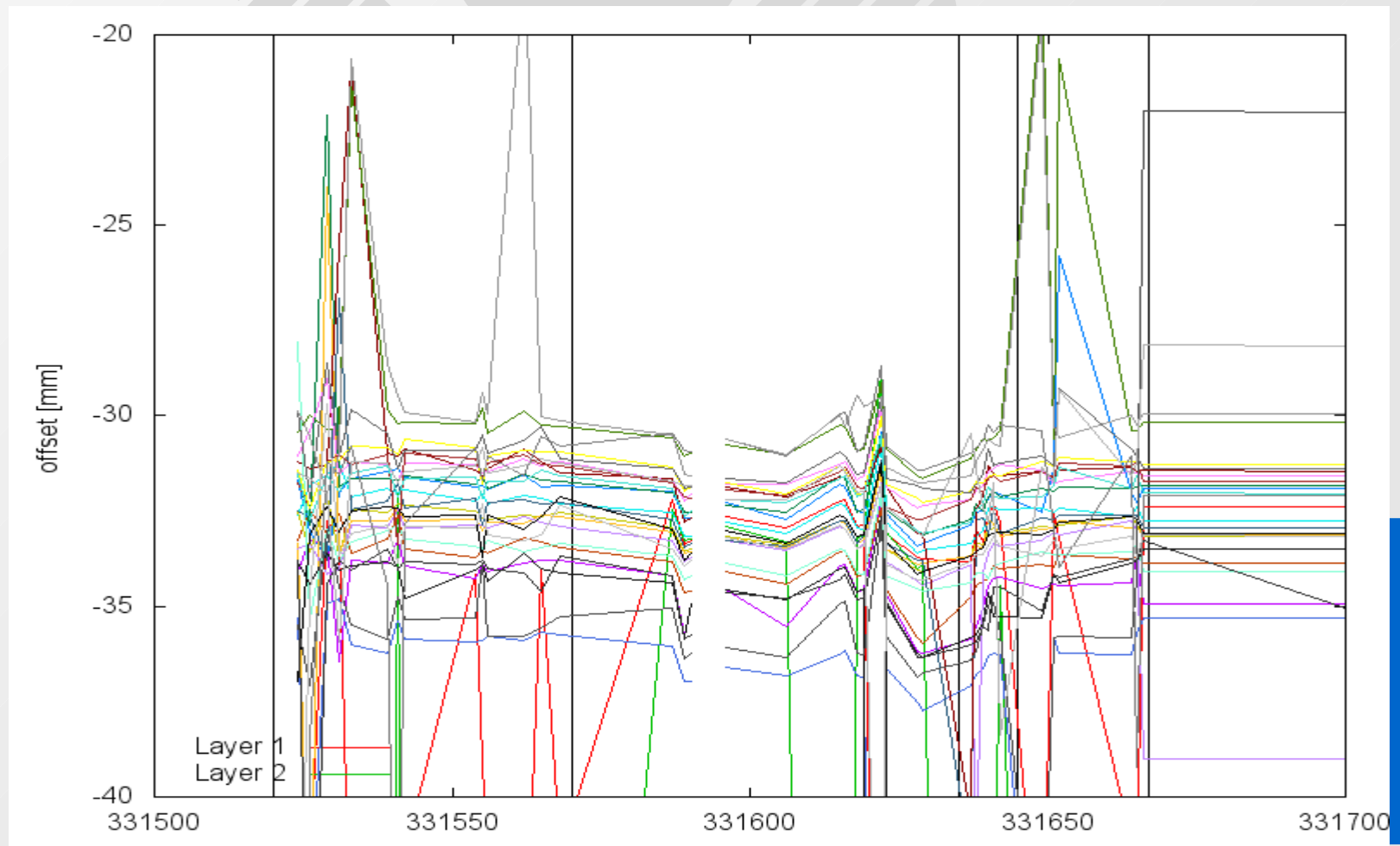
HCAL muon alignment – offsets in x for several runs

- In general, muon alignment works on runs with all „particle types“
 - Pion runs contain lots of muons
 - Some – but not all – electron runs too (?)
- Layer 1 & 2 show „noisy“ behaviour at some runs
- „Color pattern“ shows: offsets are roughly the same between layers, even when detector offset varies
- Muon runs show bad correlation with raw alignment, others are quite good



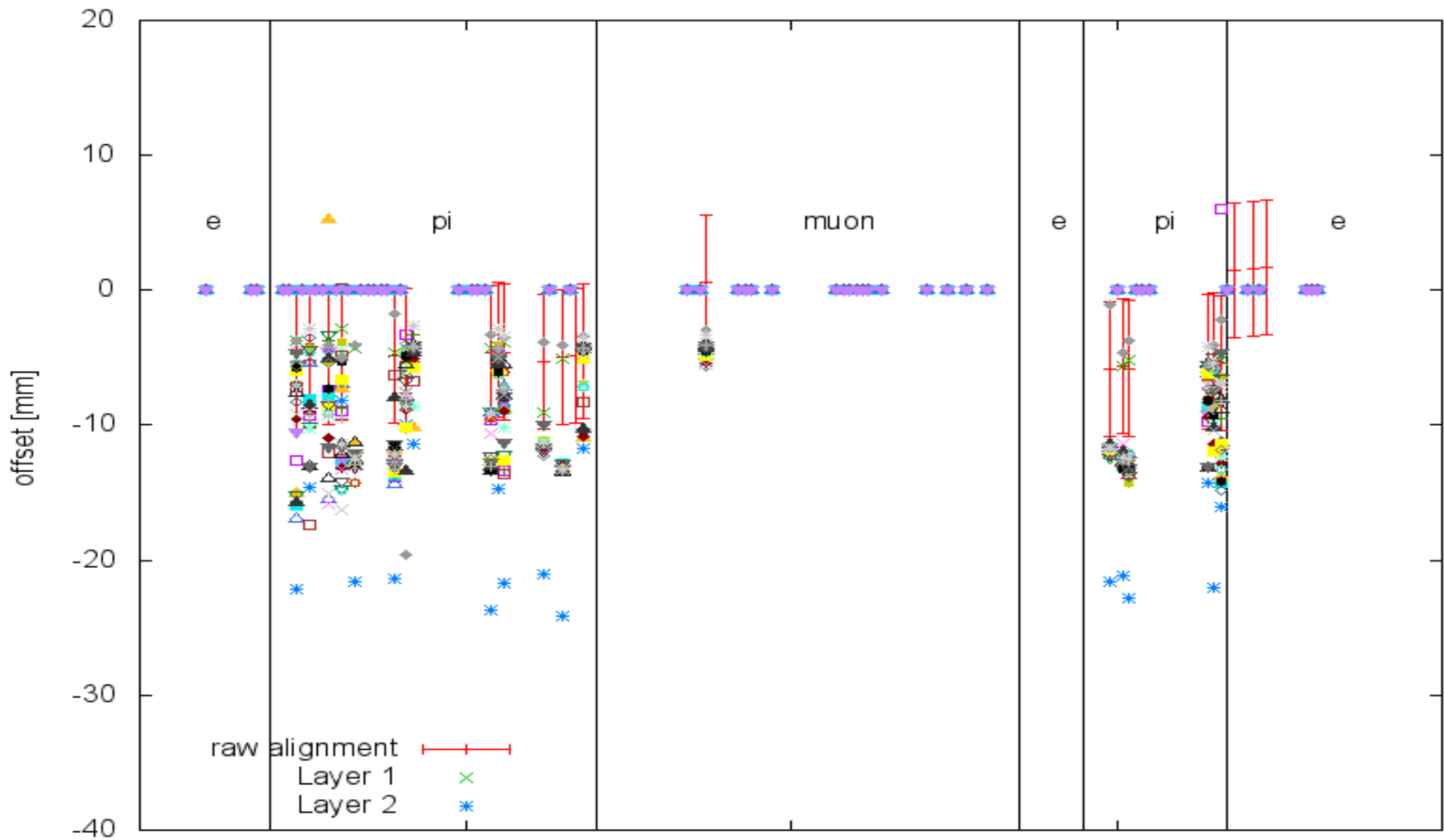
HCAL muon alignment – offsets in x for several runs – zoomed

- (some Runs with bad offset data in plot)
- „Inter layer“ offset stays roughly equal over runs
- Detector offset as general offset of all layers



HCAL muon alignment – offsets in y for several runs

- Calculation for x works in most cases
- Calculation for y usually fails

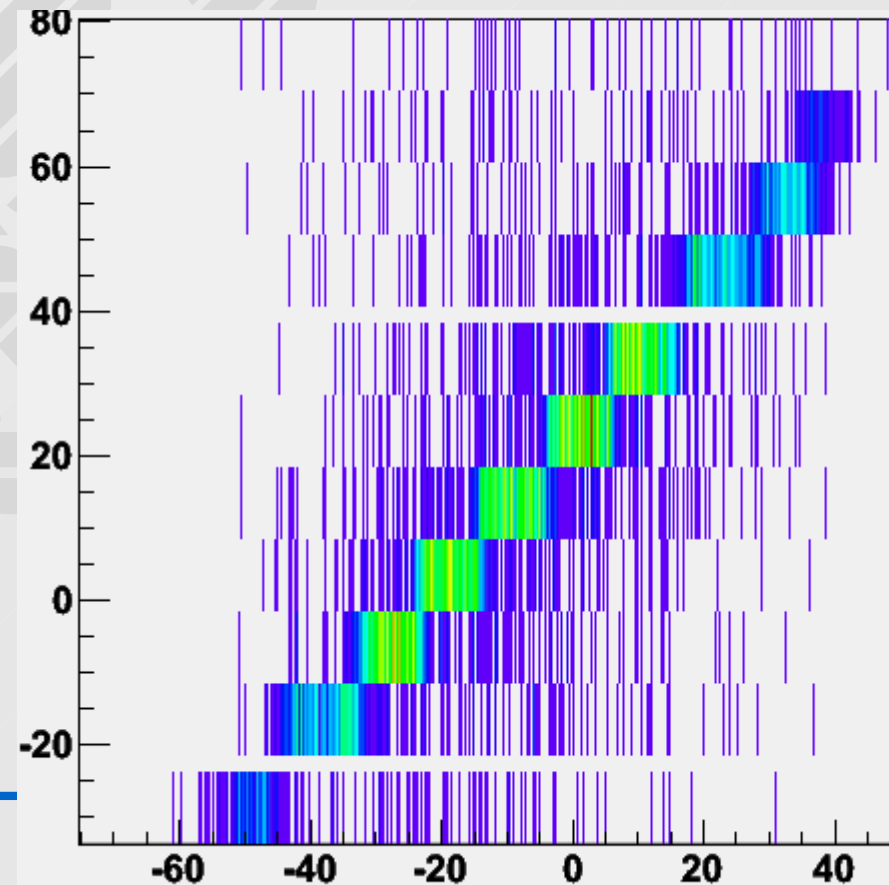


HCAL muon alignment – remarks

- In general, muon alignment is tricky
 - Number of tiles hit by beam depends on beam width
 - Narrow beam leads to few - sometimes just one - hit tile
 - *Bad statistics*
 - *Especially affects 60mm tiles in rear layers*
 - Some stage positions lead to beam spot in regions with fine and coarse tiles.
 - *Quite hard to implement*
 - *esp. if there's still a general detector offset – no clue which tiles (→ steps) are seen in data. Raw alignment might help*
 - *If you improve your code on one run, it may not work on the next*
- *Most non-muon runs lack on low muon event rate*
 - *Sum up several adjacent runs if you are sure, the HCAL didn't move*

Summary and outlook

- Raw alignment
 - There is some offset related to beam position
 - Quite simple algorithm
 - If data is correct (spread x?), it can be feed to db soon
 - *Test: apply offsets and recalculate them – should be zero thereafter!*
 - Other testbeam sites should be straight forward
- Muon alignment
 - Does only work for some runs really good.
 - Still needs work to get it running for all runs
 - *Data shown here was just produced these days*
 - Works on ECAL, too
 - *Nice steps due to 1cm pads*



ECAL muon alignment

- In principle, situation is much better:
 - 1cm pads give excellent steps to fit!
 - Not yet analyzed for many runs...

