Pixel Cosmic Note and Analysis Status

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for the Pixel System Test Group

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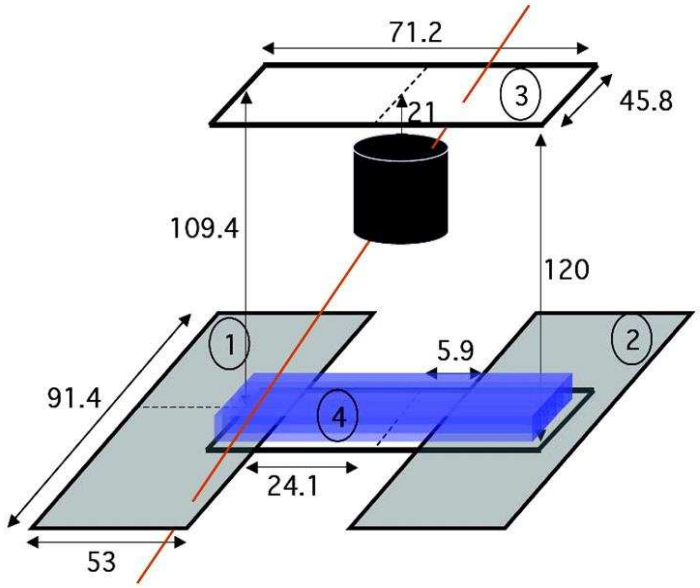
- Introduction (Attilio)
- Pixel EndCap A Cosmic Setup (Marian)
- Noise Studies (Ariel, Christoph, Georges)
- Tracking Studies (Weiming)
- Clustering and Efficiencies Studies (Weiming)
- Alignment Studies (Weiming/Marian)
- Lessons Learned and Future Improvements (Attilio)
- Conclusion
- The draft V2.0 is at http://www-cdf.lbl.gov/ weiming/cosmic/pixel_endcapA_cosmic_analysis_v2.pdf

Executive Summary

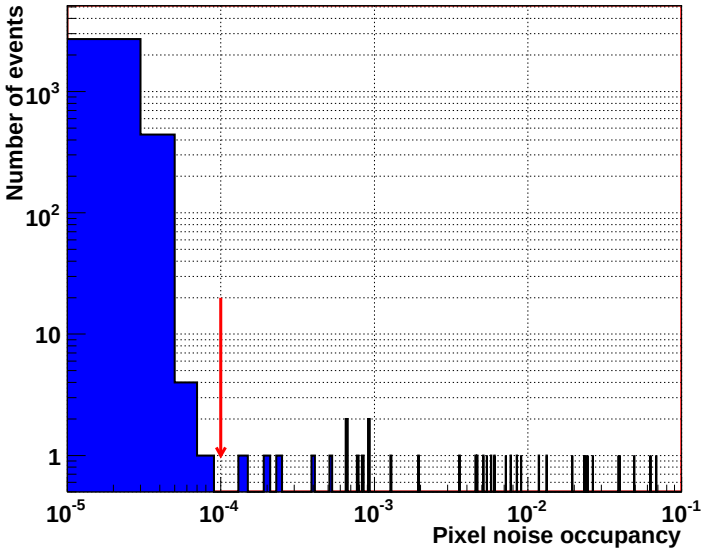
This document summarizes the results of the offline analysis for the pixel endcapA system test cosmic data. The setup consists of one pixel endcap of three disks, for a total of 144 modules and 6.6 million channels, about the 8% of the full detector with the goal of exercising the readout system, data taking and testing the offline reconstruction chain.

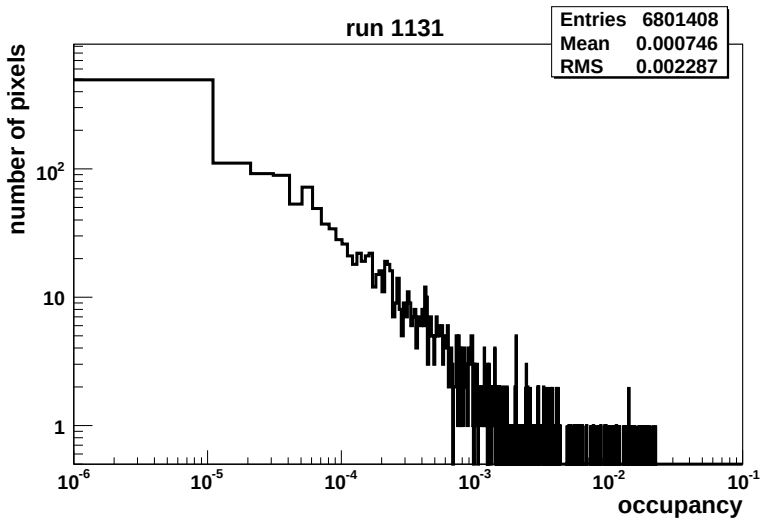
- The observed noise occupancy is found to be 10^{-9} after removing all the noisy pixels. Comparison with the detector characterization performed during the detector assembly shows that most of these noisy pixels were already flagged during the production test.
- The tracking studies, especially the ones related to particles passing in the overlap regions between adjacent modules, have been very useful in spotting problems in our geometry description and can be used for the relative alignment between the adjacent modules.
- The characteristic of pixel clustering in the data are checked and agree well with Monte Carlo simulation.
- The pixel cluster efficiency are also measured to be close to 100% using the hits in the module overlap regions.
- When using the geometry taken from the detector survey, an initial resolution of 21 μm is obtained. After a preliminary alignment this improves to 18 μm. The difference with the 16 μm expected from MC simulation are probably due to residual alignment uncertainties which are under investigation.

Pixel EndCap Setup



Pixel Occupancy

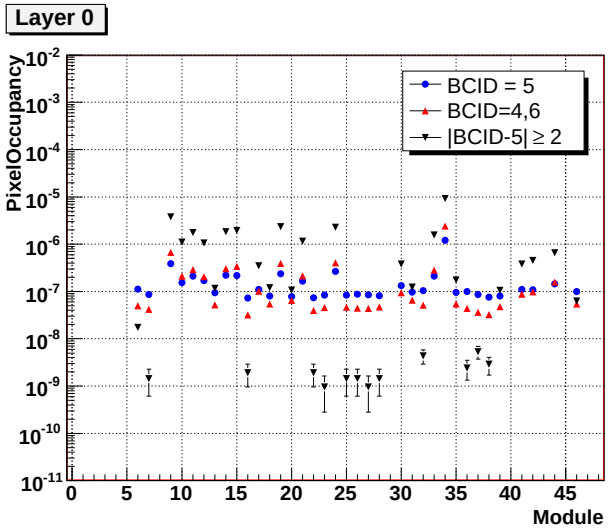


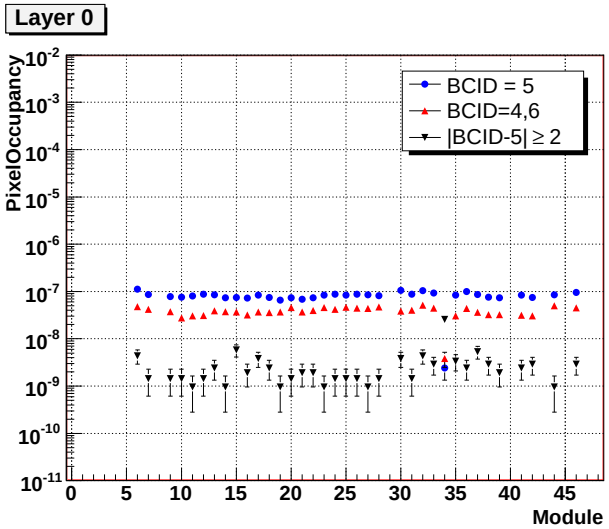


- Pixel occupancies in run 1125 cosmic data (left) and in run 1131 with random trigger (right)

- Requiring $> 10^{-4}$ as noise pixel cuts.

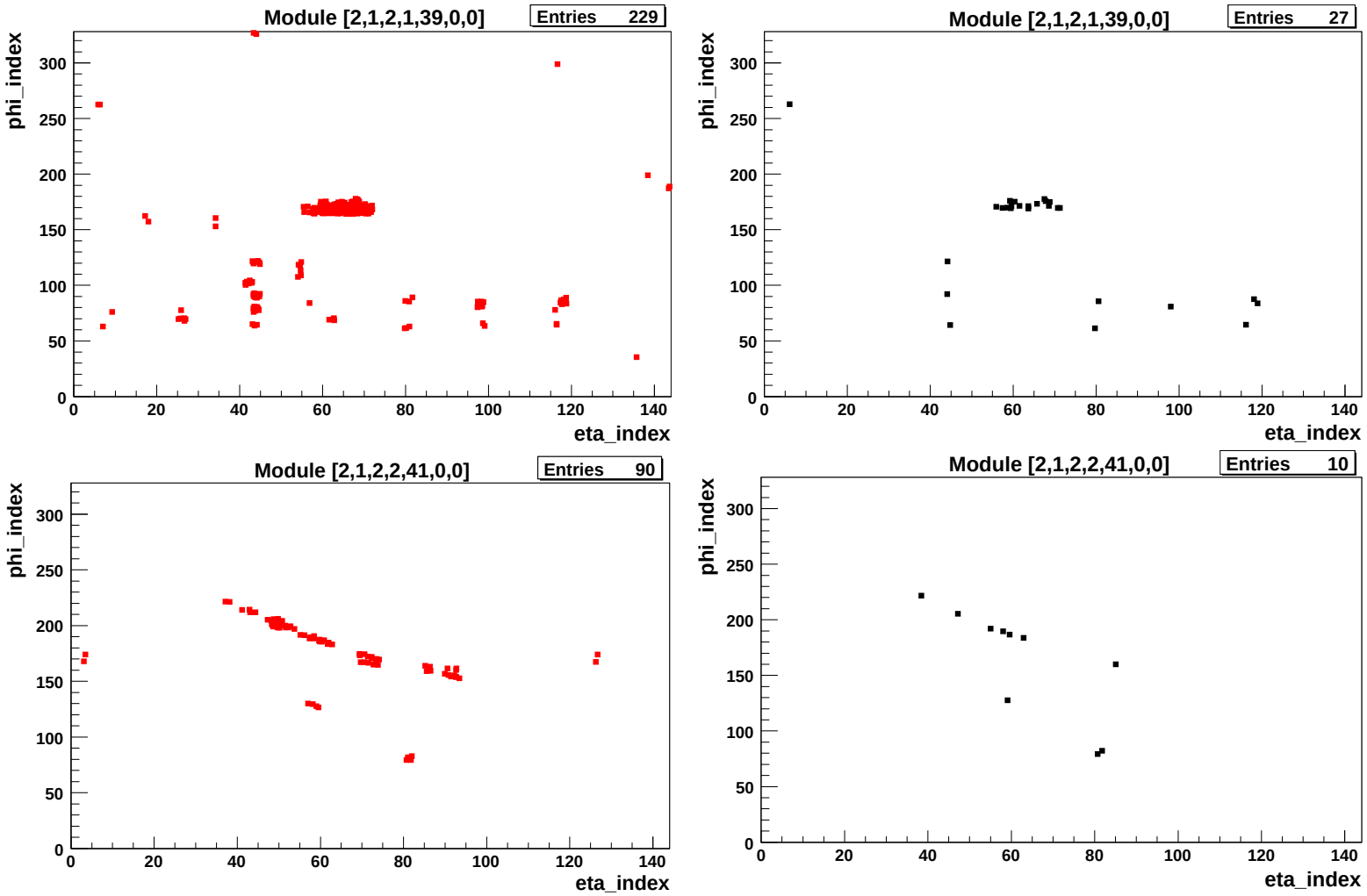
Noise from Run 1125 with Cosmic Trigger





- Module occupancy before and after removing hot pixels with occupancy $> 10^{-4}$.
- The noise level is at 10^{-9} for $|BCID - 5| > 2$ (out of time).

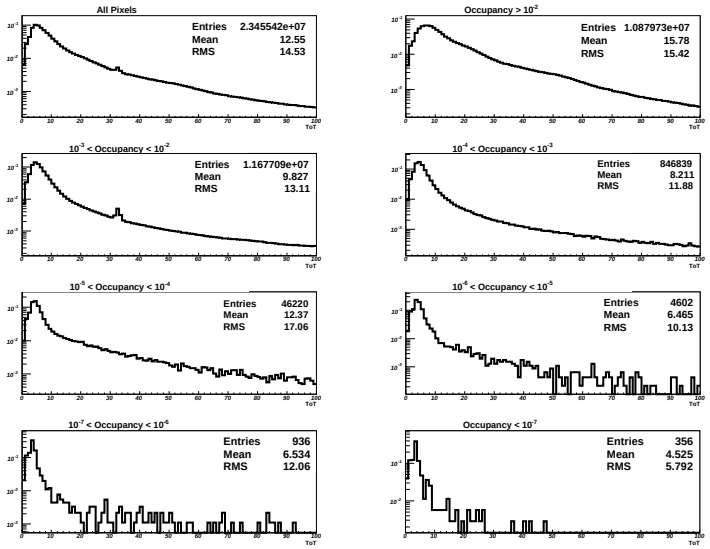
Noise from Run 1131 with Random Trigger

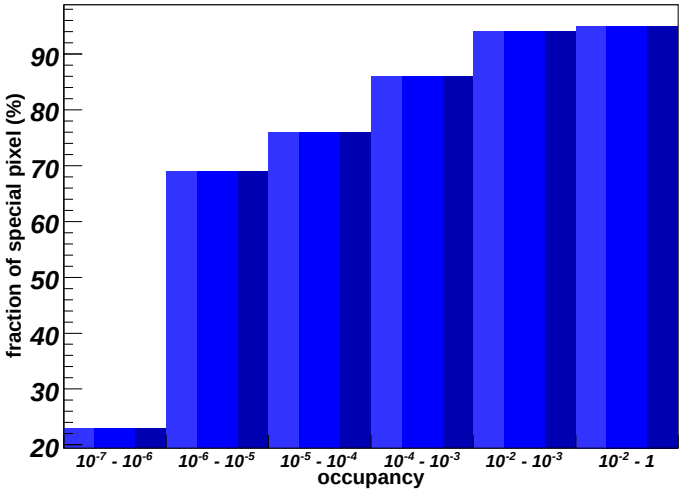


- Locations of special pixels defined with occupancy $> 10^{-4}$ shown in two noise modules

- Left is data and Right is production test data, seems strongly correlated

Tot and Noisy Pixels vs Occupancy

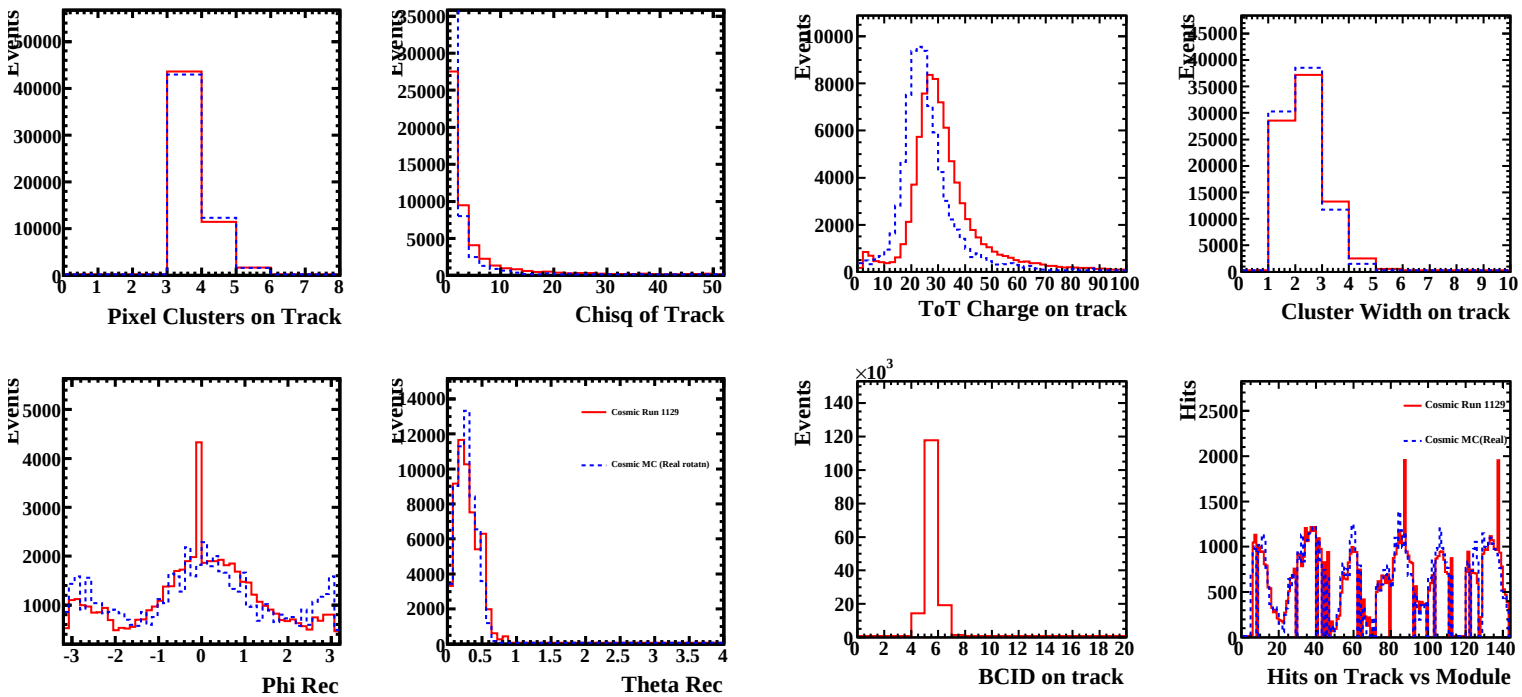




- Tot in different occupancy bins (left) and fraction of pixels flagged as the special pixel map (right)

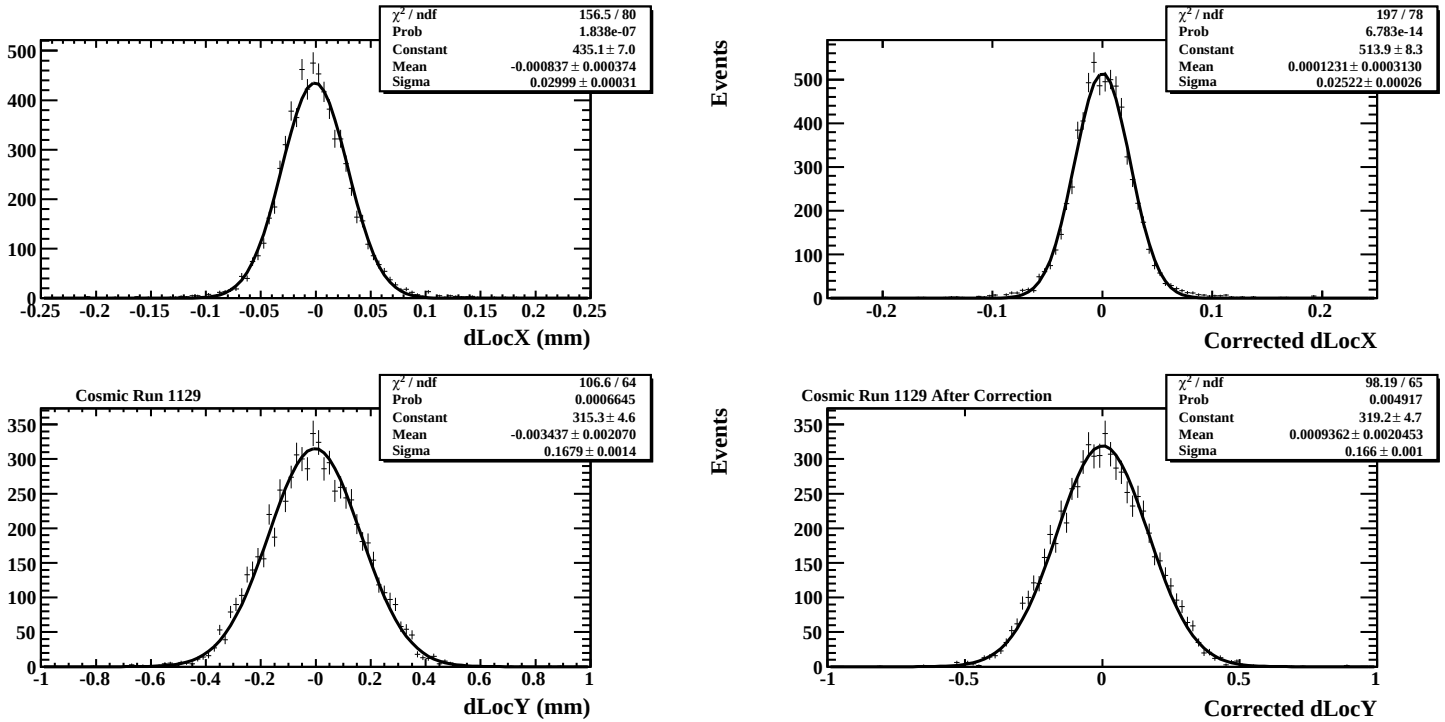
- The noisy pixels seem have a occupancy above 10^{-6}, instead of 10^{-4}.

Tracking Studies



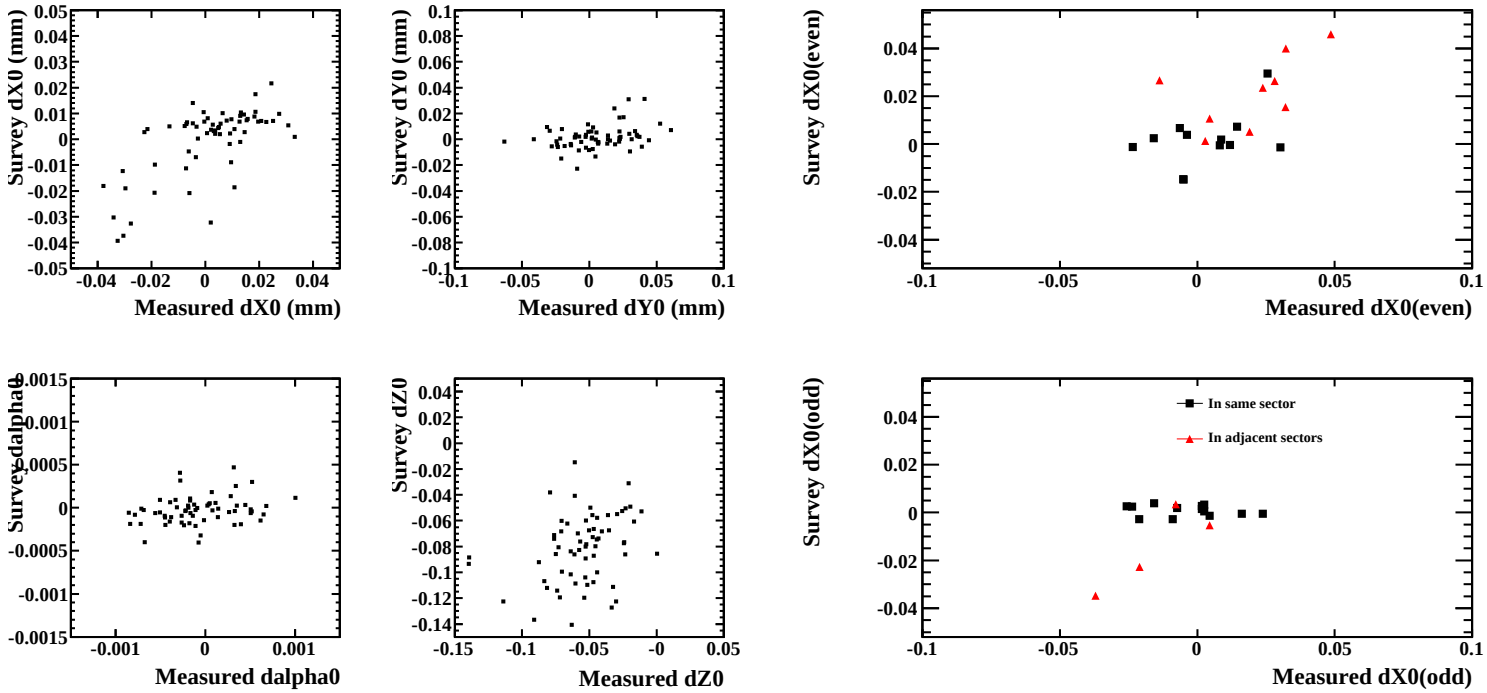
Data Sample	Tracking Rate (%)	Overlap Fraction (%)
Data	2.83 ± 0.01	23.4 ± 0.2
Ideal MC	≈ 6	≈ 28
Realistic MC(disable modules)	3.9 ± 0.1	24.6 ± 0.9

Residuals before and after Alignment (Overlap Residuals)



Resolution [μm]	Norminal+dz=4.25(mm)	After Alignment	MC
σ in dX	21	18	16
σ in dY	119	117	117

Alignment vs Survey

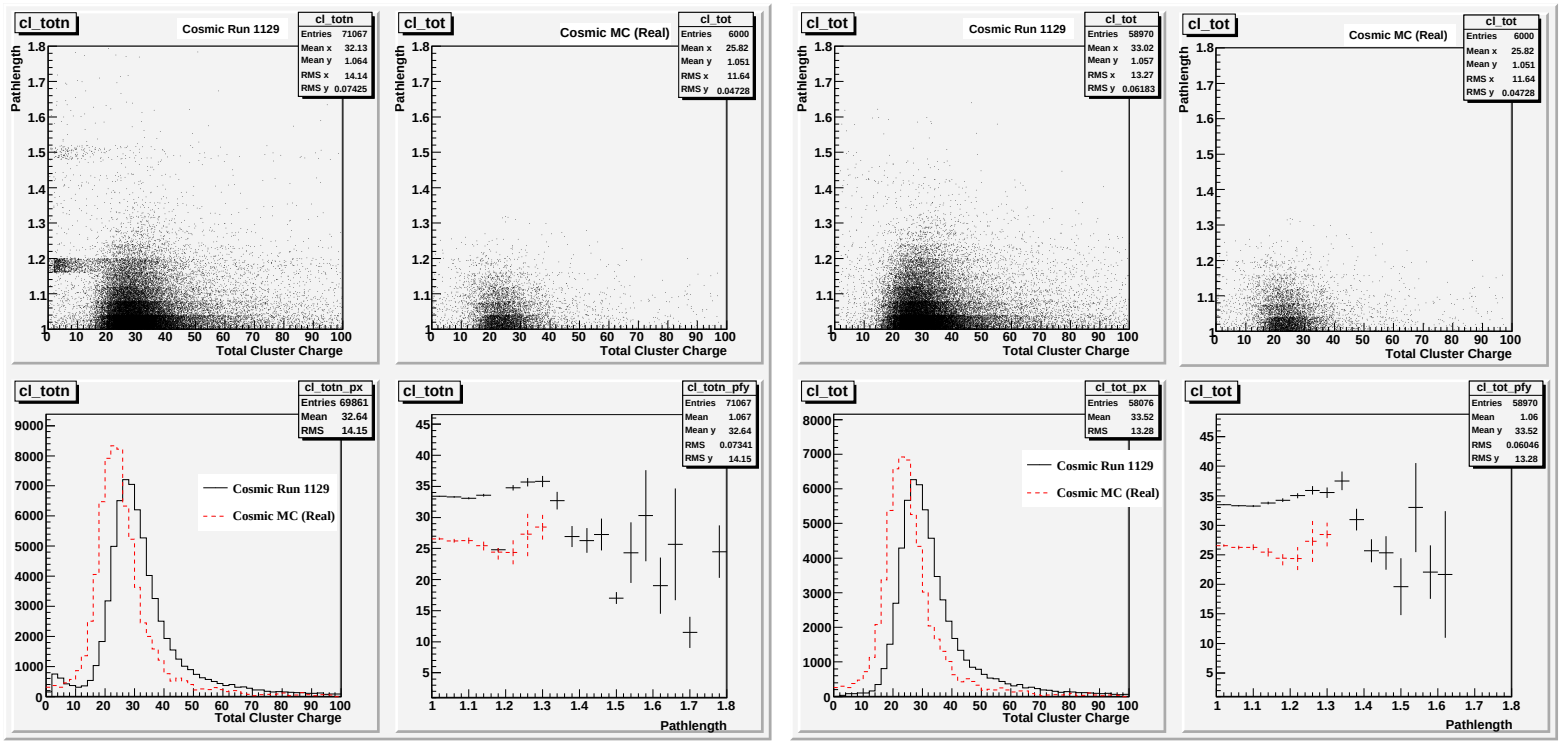


- Left: Relative alignment between overlap modules from cosmic data and survey.
- Right: Relative alignment between neighboring modules in the same side and in the same sector.

Ongoing Studies at LBNL

- Clustering and Efficiency studies with overlap hits
- Noise studies using run 1129 cosmic data
- Disk global alignment using cosmic tracks
- Module alignment and cluster resolution using overlap hits after noise clean up
- Alignment studies with pixels, instead of clusters (Marian)

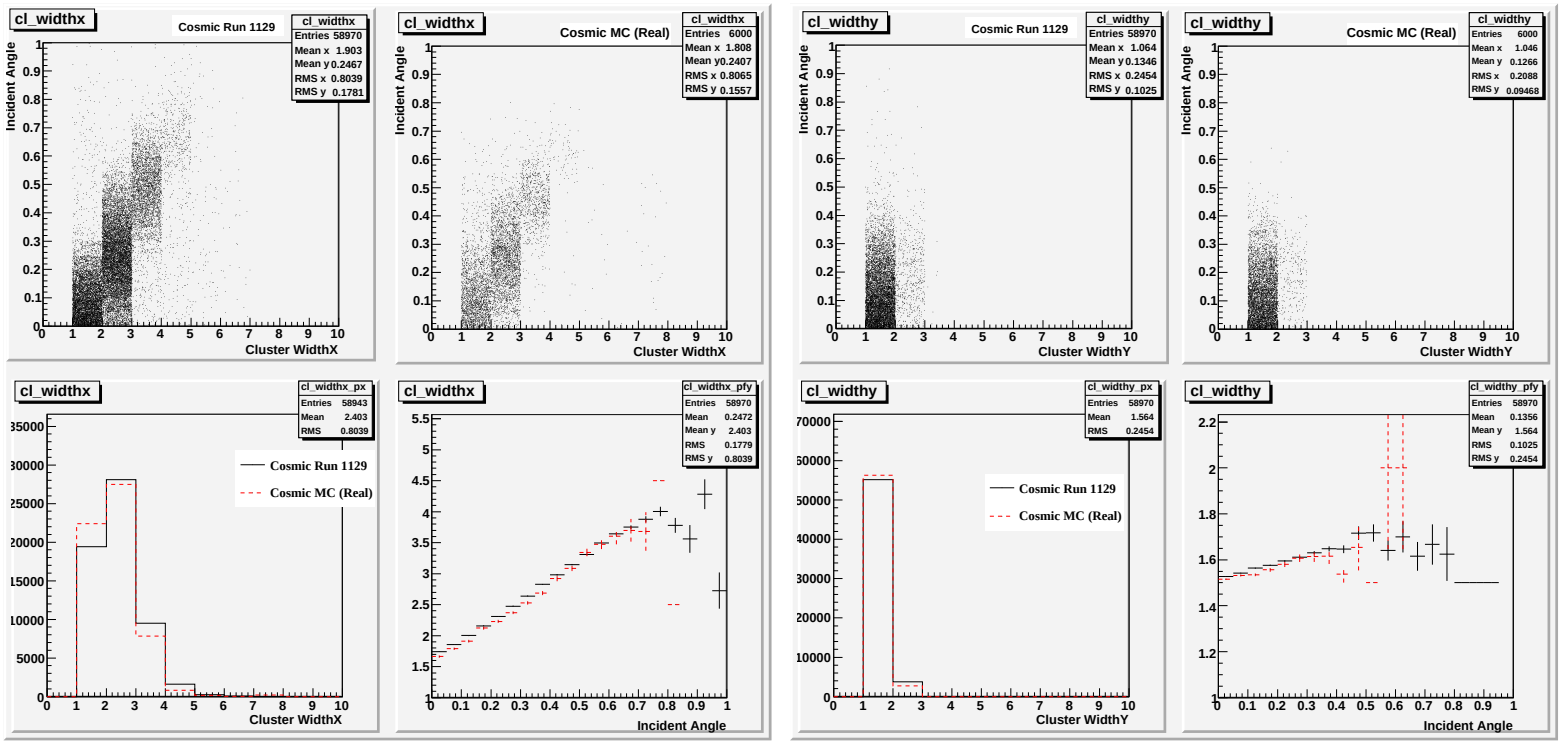
Clustering Studies



- Noise Modules identified: 0/15, 0/34, 1/39, 2/25, 2/41

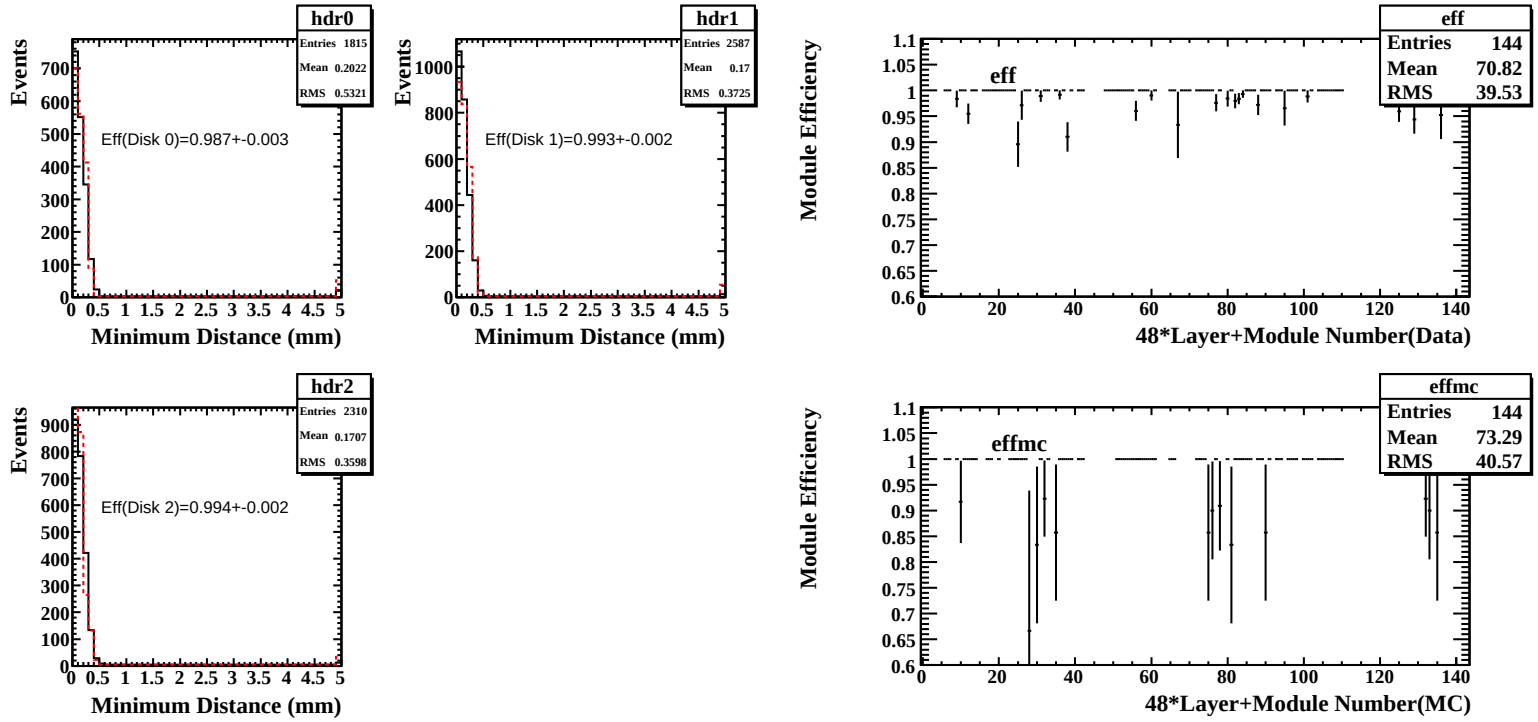
- After removal the noise modules (17% of tracks), the data and MC agree each other, except the tot is lower in MC due to wrong calibration used.

Cluster Width vs Incident Angle



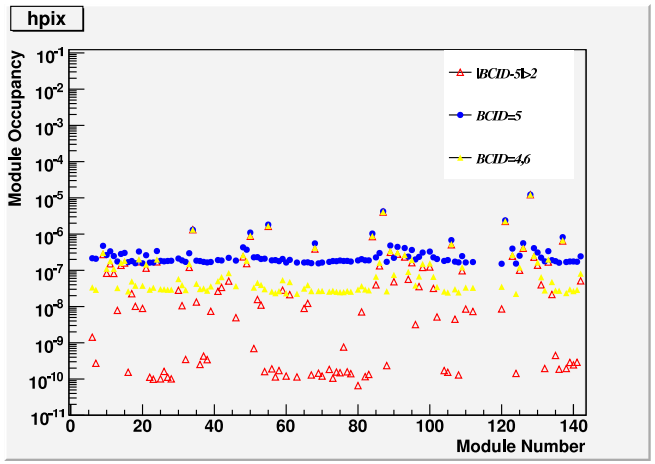
- Cluster width in local x (left) vs incident angle of track passing through disk
- Cluster width in local y (right) vs incident angle

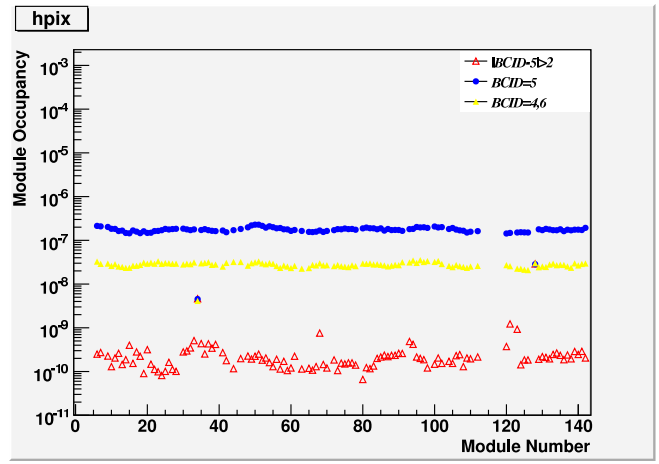
Efficiency in Overlap Regions



- Check hit efficiency in overlap regions by extrapolating a hit from one side of disk to other side.
- The residual distance between the real and expected hits consistent between data and MC (Red)
- The pixel efficiency is about 99%, flat vs module after removing the noise and disable modules

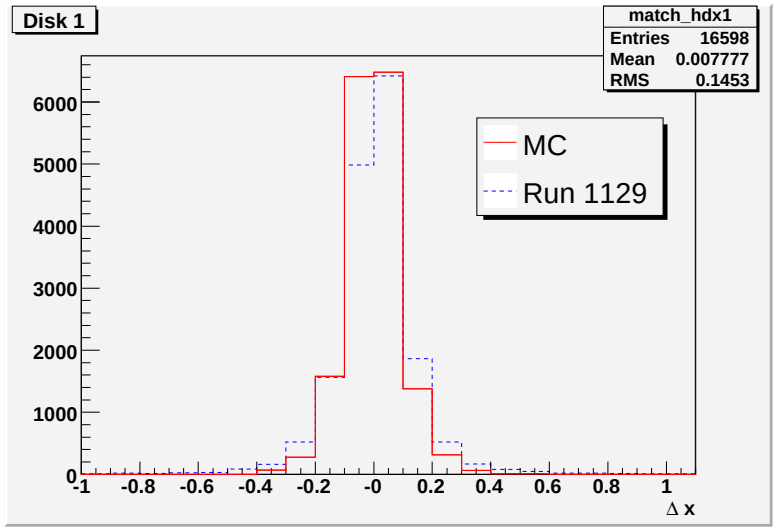
Noise Occupancy Studies for Run 1129

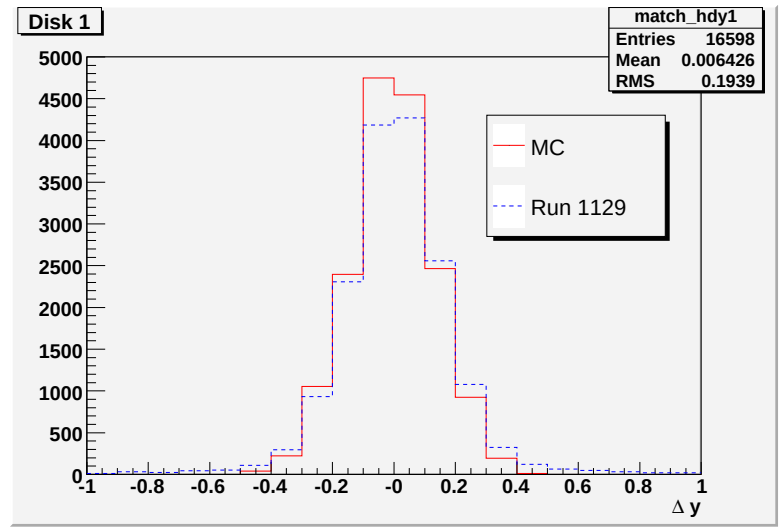




- The module occupancy before and after "hot pixel" removal, consistent with other noise studies.
- The noise occupancy is close to 10^{-10} per BCID.

Disk Global Alignment





- Fit a line to the hits from disk 0 and 2 and extrapolate it to the middle disk.
- The residuals in x and y seem agree well with the Monte Carlo predictions.

Conclusion

- The pixel cosmic note is in good shape with lots of help from many people.

- There have been presented a wide spectrum set of studies that provides significant insight about what to expect when the full detector in operation.
  - The observed noise occupancy is found to be 10^{-10} per BCID after removing all the noisy pixels and the hot pixels are strongly correlated with the special pixels in production test data.
  - The tracking studies in the overlap regions have been useful in spotting problems and for the alignment studies.
  - Using survey, an initial resolution of 21 μm is obtained. After a preliminary alignment this improves to 18 μm as 16 μm expected in prefect MC
  - Cluster data are in good agreement with MC simulation.
  - The pixel efficiencies measured to be close to 99% using overlap hits

- There are still some ongoing studies before releasing it to the collaboration