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TB2009 Analysis in Prague

Jan Brož, Zdeněk Doležal, Zbyněk Drásal, Peter Kodyš, Peter Kvasnička, Lukáš Malina, Christian Oswald, Jan Scheirich

Institute of Particle and Nuclear Physics, Faculty of Mathematics and Physics, Charles University in Prague

Whole report ~100 pages with many details now available on our wiki in direct link:

http://aldebaran.hll.mpg.de/twiki/pub/DepfetInternal/TBResults2009PraguePage/201004_TB2009PrgAnal_Rel1.pdf

or on wiki page:

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DEPFET Beam Test 2009 - Prague Analysis Report

Jan Brož, Zdeněk Doležal, Zbyněk Drásal, Peter Kodyš[1], Peter Kvasnička, Lukáš Malina, Ján Scheirich

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Internal report describing Prague analysis of the beam test 2009 at SPS CERN

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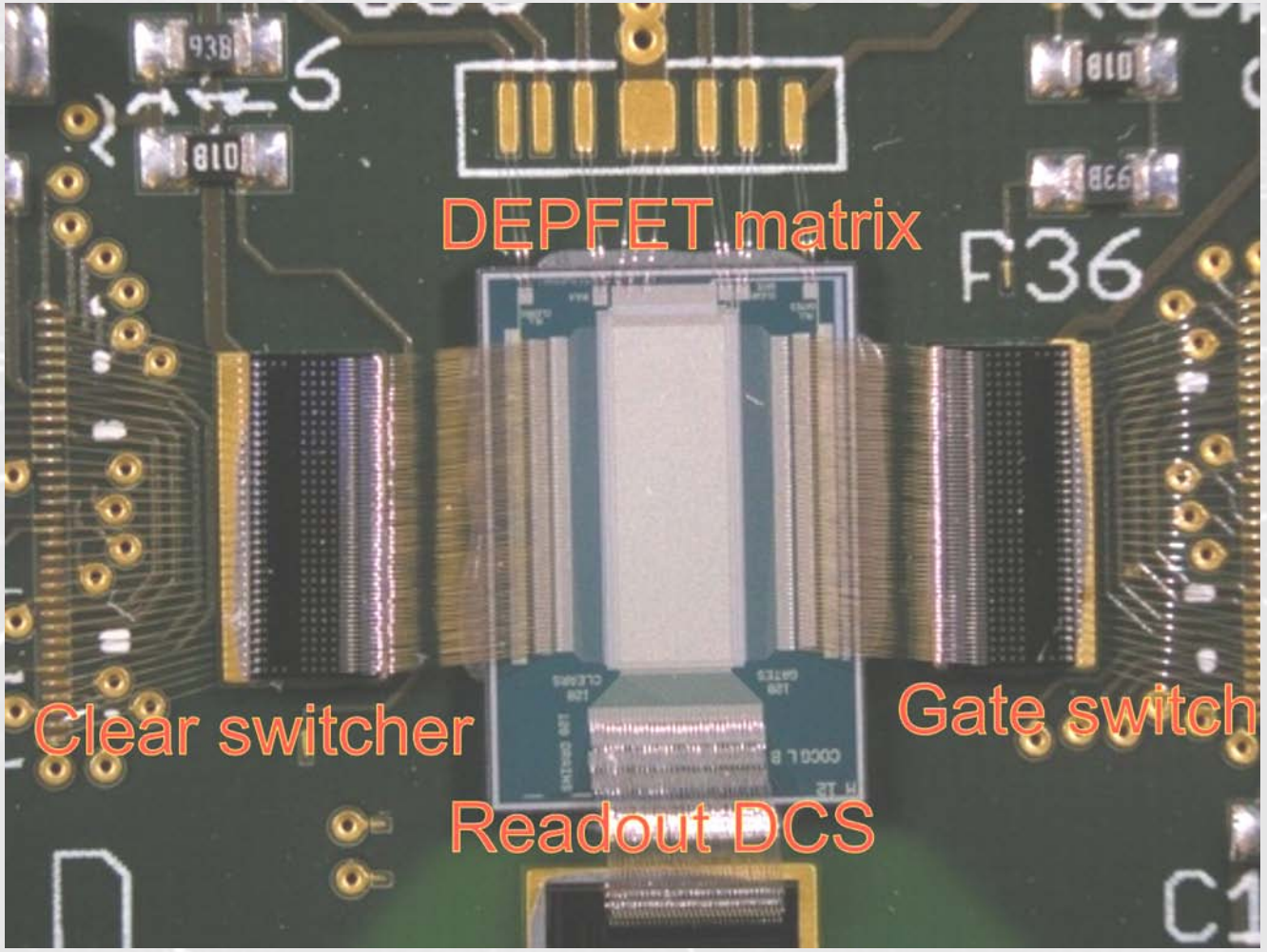
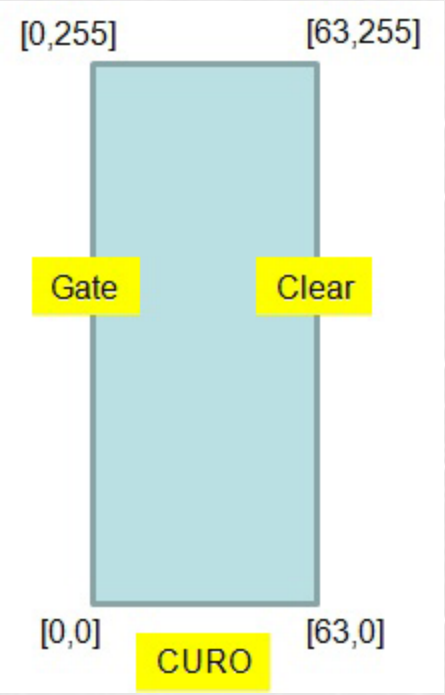
Description of analysis



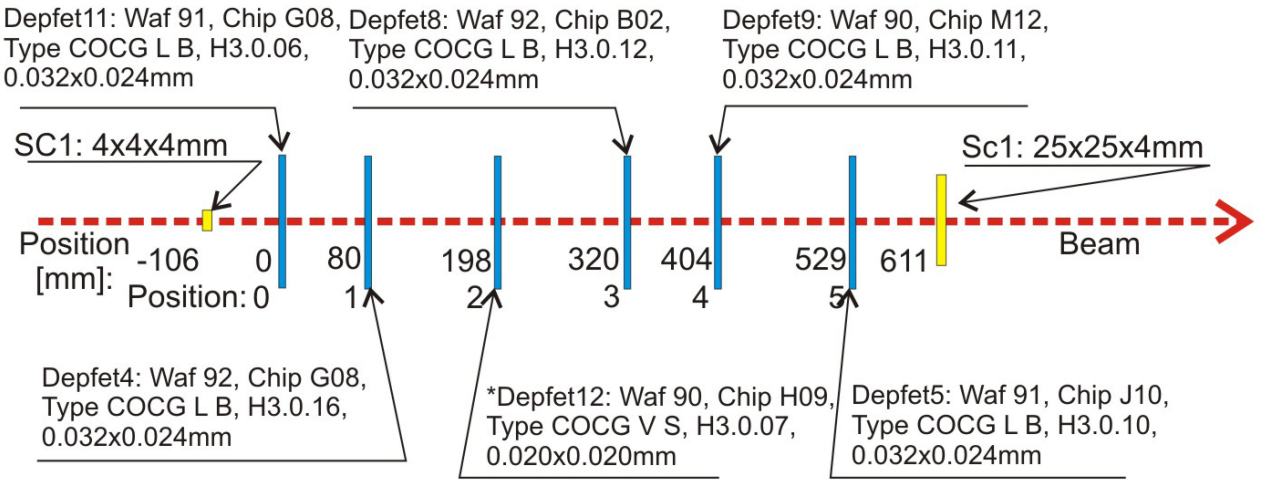


Description of analysis

Geometry of DEPFET TB, CERN - SPS, August 2009

Detector thickness: 0.45mm Si

Beam: 120 GeV/c hadrons: protons (67%), pions (29.4%), muons (about 1% of the pion flux), and few Kaons (about 3%)
The maximum delta_P of the beam line is 1.5%, depends on collimator settings (ref. by Ilias Efthymiopoulos), information is not confirmed.
There was additional setting of particle energy: 40, 60 and 80 GeV/c electrons, unknown detail structure of beam.



* - on position 2 alternate next two modules as DUT:
Depfet12(the same S3B board): Waf 92, Chip J12, Type C3G L A, H3.0.01, 0.032x0.024mm
Depfet7: Waf 90, Chip G11, Type COCG S E, H3.0.07, 0.024x0.024mm

Description of analysis

Scan test description	Acquired events	Hits	Hits per pixel
Whole dataset	7374599	110618985	6751.6
H.3.0.16	380595	5708925	348.4
H.3.0.07	933668	14005020	854.7
H.3.0.04	1012110	15181650	926.6
H.3.0.10	2074048	31110720	1898.8
H.3.0.11	945658	14184870	865.7
H.3.0.12	1027314	15409710	940.5
H.3.0.06	1001206	15018090	916.6

Table 2.1: Characterization scans performed at MPI with the summaries as obtained from Prague analysis

Scan test description	Acquired events	Events per pixel
Whole beam test	4288627	261.7
Bias scan	507275	30.9
Banch Mark PLL24MHz2 33ms frame	33671	2.0
Alignment scan	806887	49.2
Long scan 1	384885	23.4
Edge scans	643922	39.3
Long scan 2	234046	14.2
Biasscan	500295	30.5
High frame occupancy scan	63210	3.8
Energy scans (all)	533629	32.5
e - 60 GeV (1)	16735	1.0
e - 60 GeV (2)	239877	14.6
e - 40 GeV	158254	9.6
e - 80 GeV	55553	3.3

Table 2.2: Beam test scans with the summaries as obtained from Prague analysis

Description of analysis

The main program on TB2009:

- Bias scans 100-200 V
- Edge scan (to study edge effects)
- Alignment scan: shift of detector #2 at the level of a few microns was performed
- Beam energy scan (to test for the effects of multiple scattering): 40, 60, 80, 100, 120 GeV/c – electrons and pions

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Beam test analysis before tracking

Analysis of individual planes:

1. raw data inspection / frame display
2. "black" correction (pedestals, CMN, pixel noise)
3. "white" correction - pixel gain estimation
4. hit reconstruction (pixel COG and η - correction)
5. production of DST

Beam test analysis before tracking (one special comment)

Stability of CMN correction over measurement time

The plots show CMN for 2 coordinates.

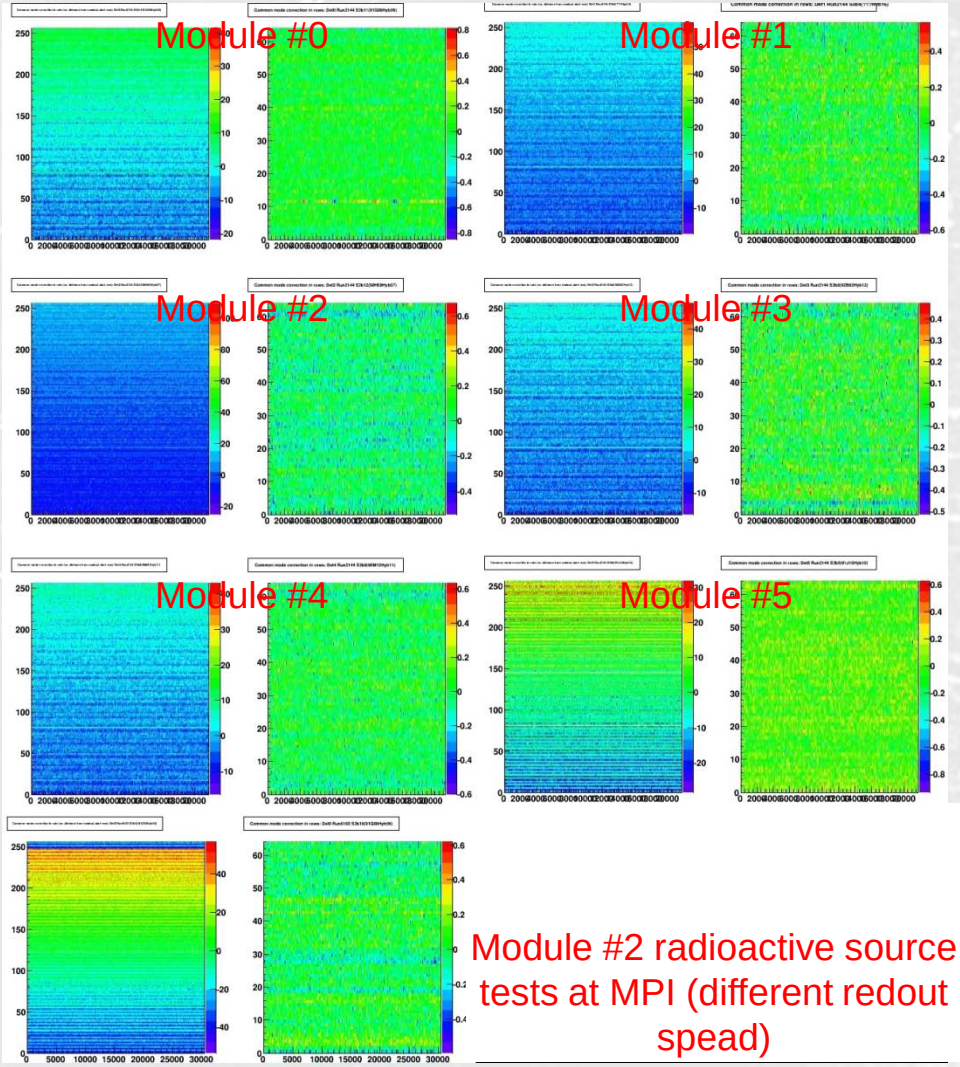
The first plot shows CMN correction for the first half-rows at a distance (y-axis) between 0 and 256 from the start readout row (data for the other half-rows are not shown).

The second plot shows CMN correction in the 64 columns of the sensor.

The horizontal axes show measurement time or event number and homogenity on x - direction confirm stable response over whole run.

Color scale is typically in range ±40 ADU or less.

There is first time to visualize this effect because we know position of start raw. There is no need to do any special analysis step base on this.



Module #2 radioactive source tests at MPI (different redout spead)

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Beam test analysis before tracking

Module #0

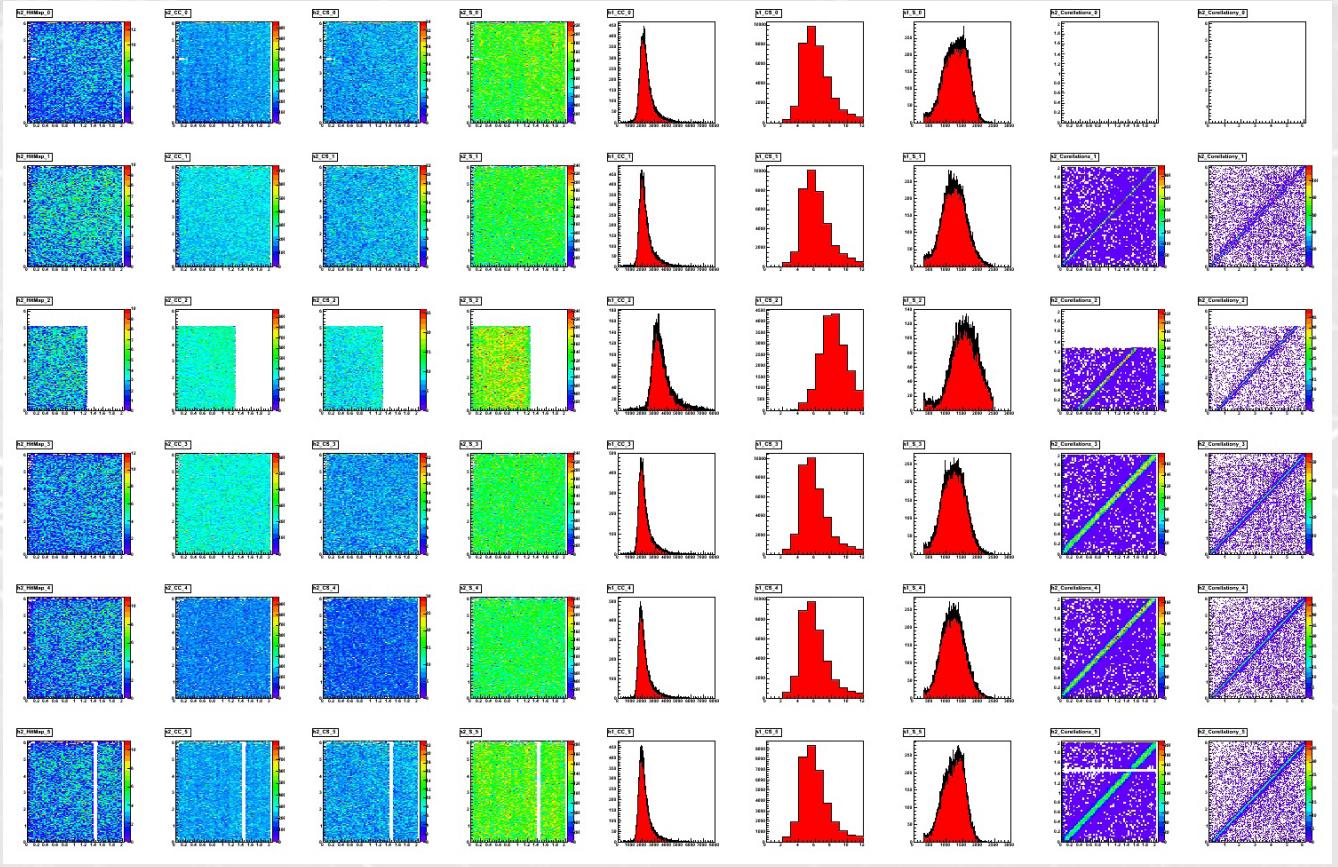
Module #1

Module #2

Module #3

Module #4

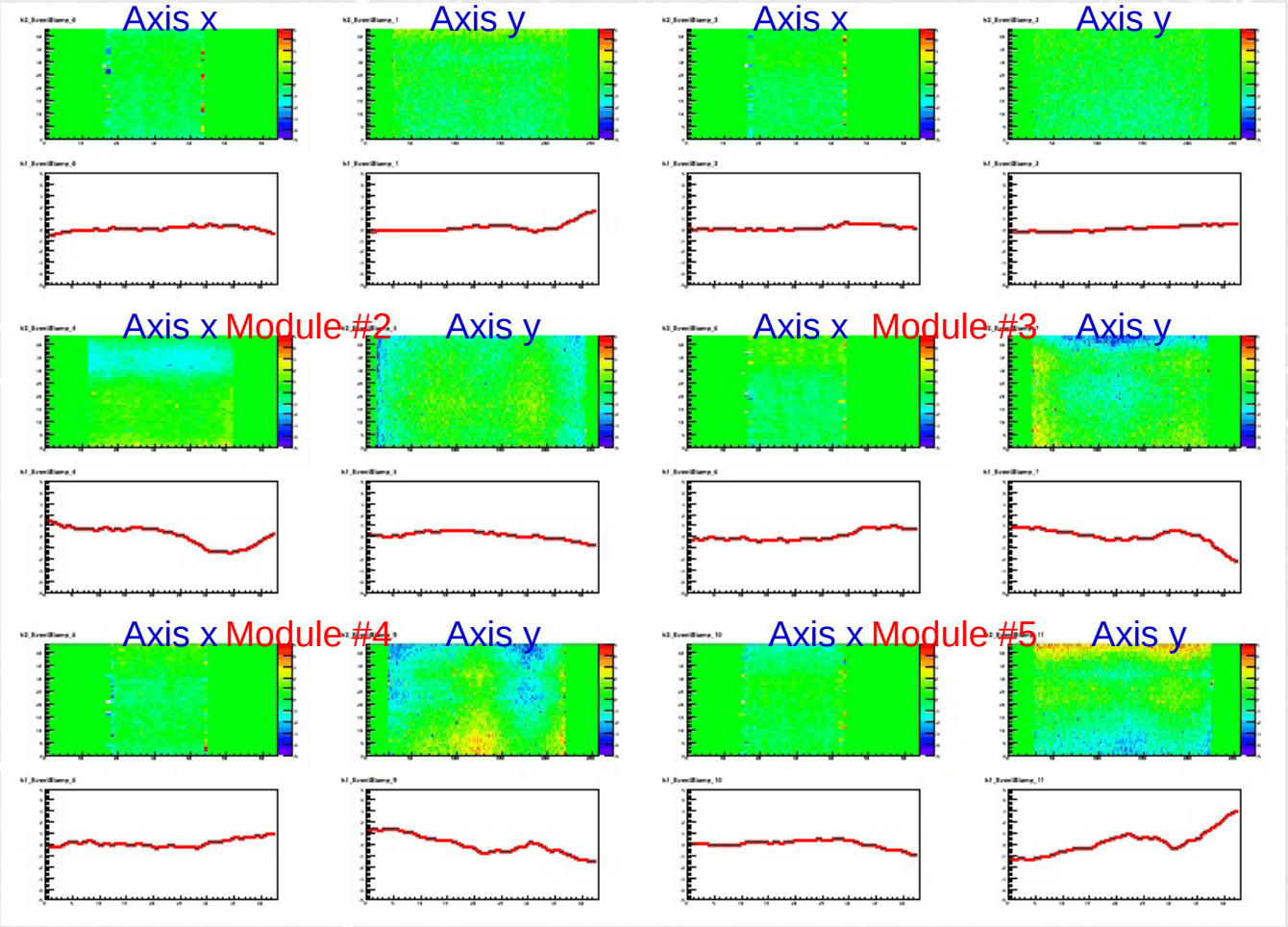
Module #5



A typical set of plots produced in DST creation for 120 GeV pions.

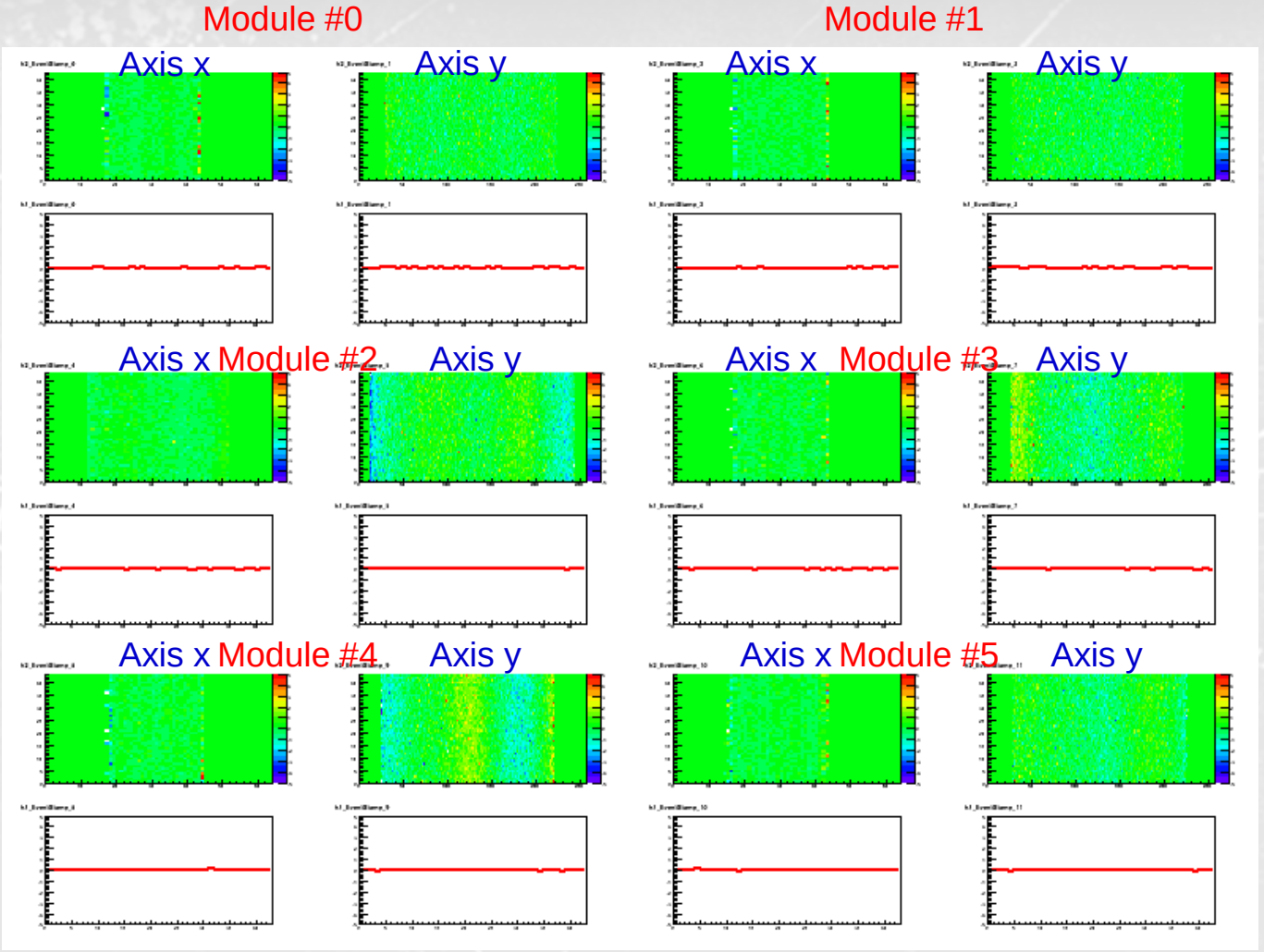
Hit map (1), map of cluster charge (2), cluster size (3), seed (4), cluster charge, cluster size and seed signal distributions (5-7) and hit correlations (8)

Mechanical stability of measurement



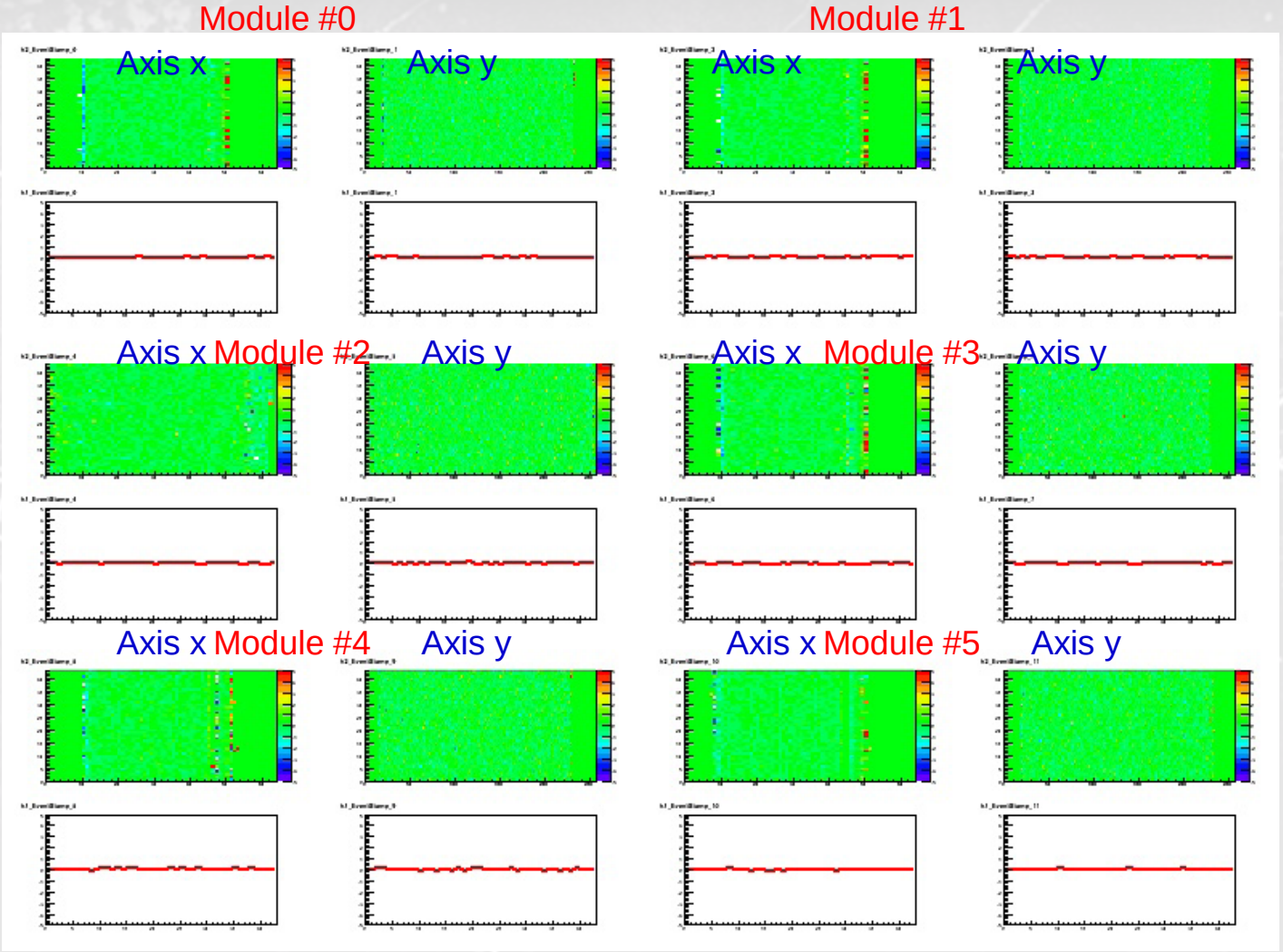
Upper plots horizontal axis shows LSR distribution in column or row, in vertical axis are sections of run (time or event distribution) and the color scale is in range ± 5 μm. The lower plot shows medians of LSR for each section and are corresponding with vertical axis of upper plot. The vertical scale is in range ±5 μm.

Mechanical stability of measurement



After mechanical corrections.

Mechanical stability of measurement



After LSR and mechanical corrections.

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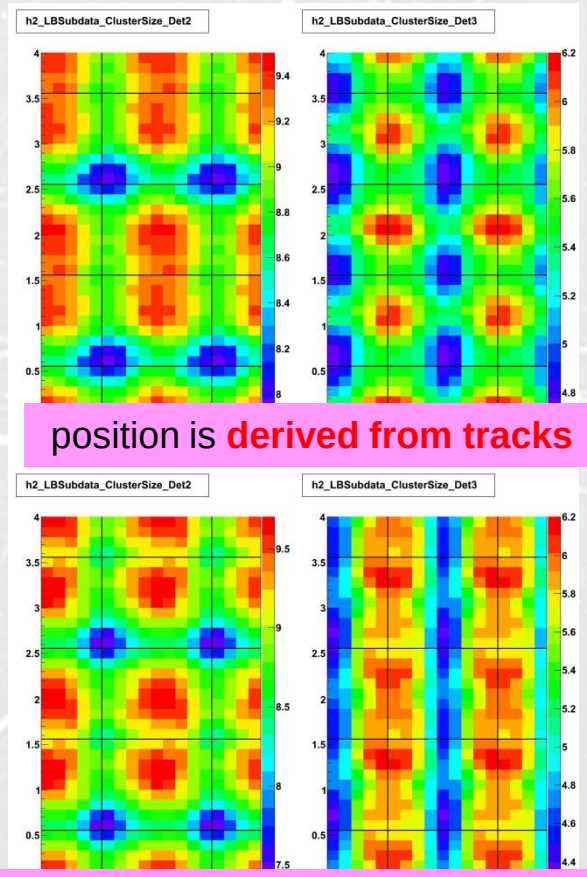
Sub-pixel analysis from the beam test

Cluster size

module #2 module #3

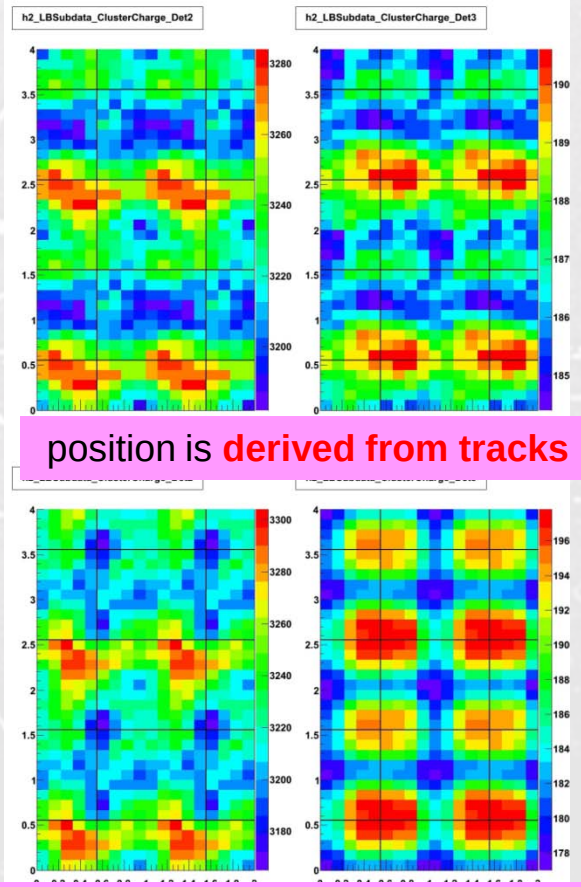


position is **derived from tracks**

COG + η – correction position
calculations (give worst information)

Cluster charge

module #2 module #3



position is **derived from tracks**

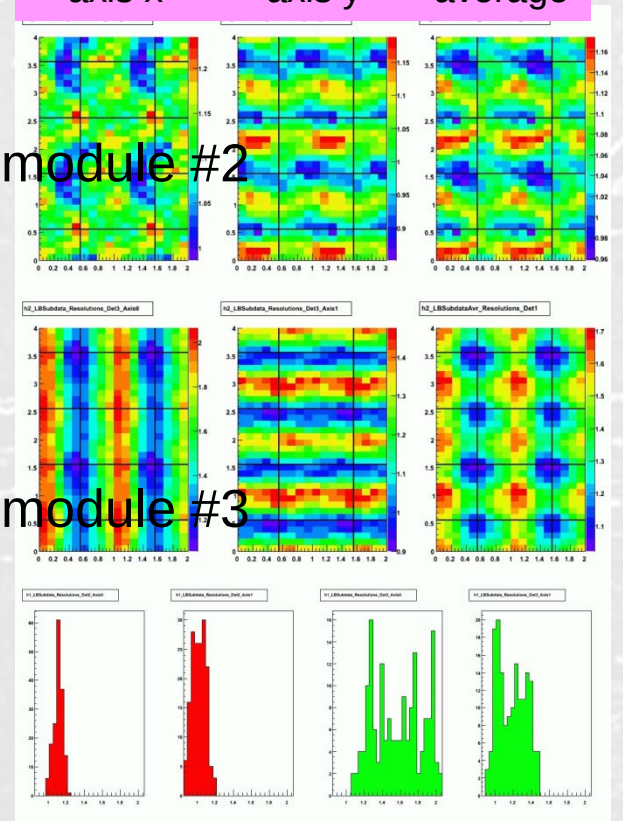
COG + η – correction position
calculations (give worst information)

Resolution

axis x | axis y | average

module #2

module #3



Distribution of values

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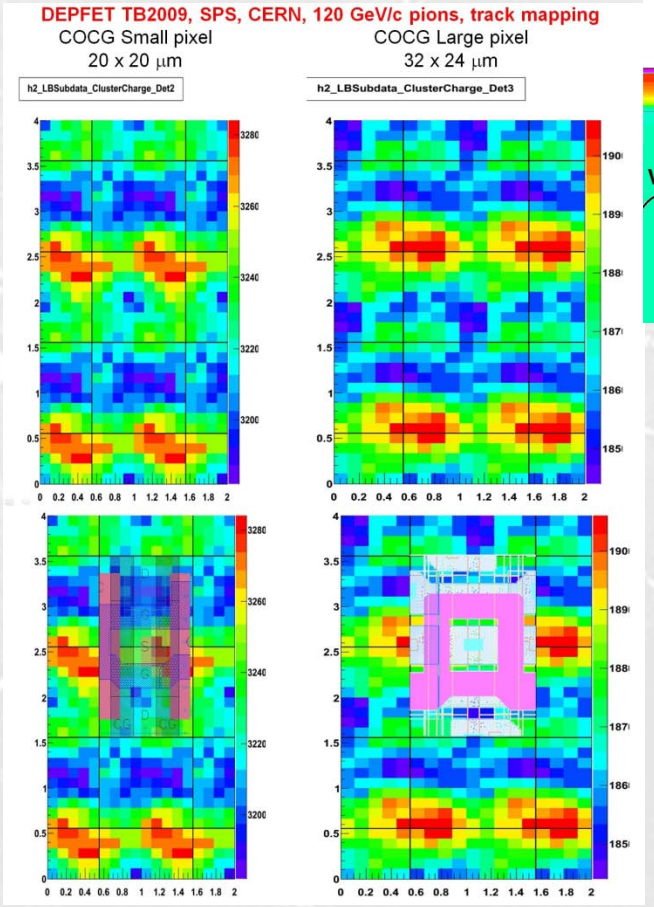
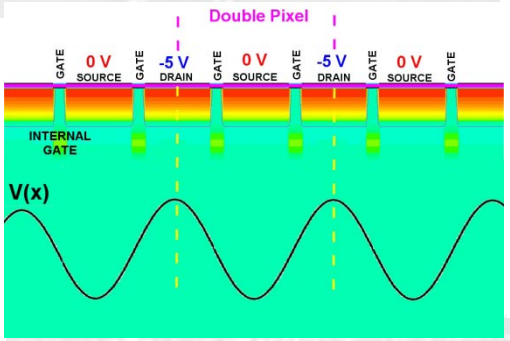
Sub-pixel analysis from the beam test

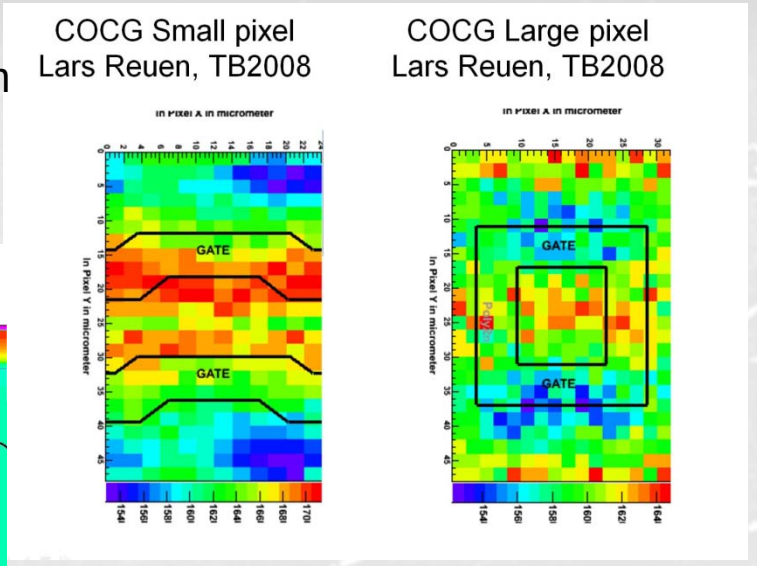
Lars Reuen
for the beam
test 2008

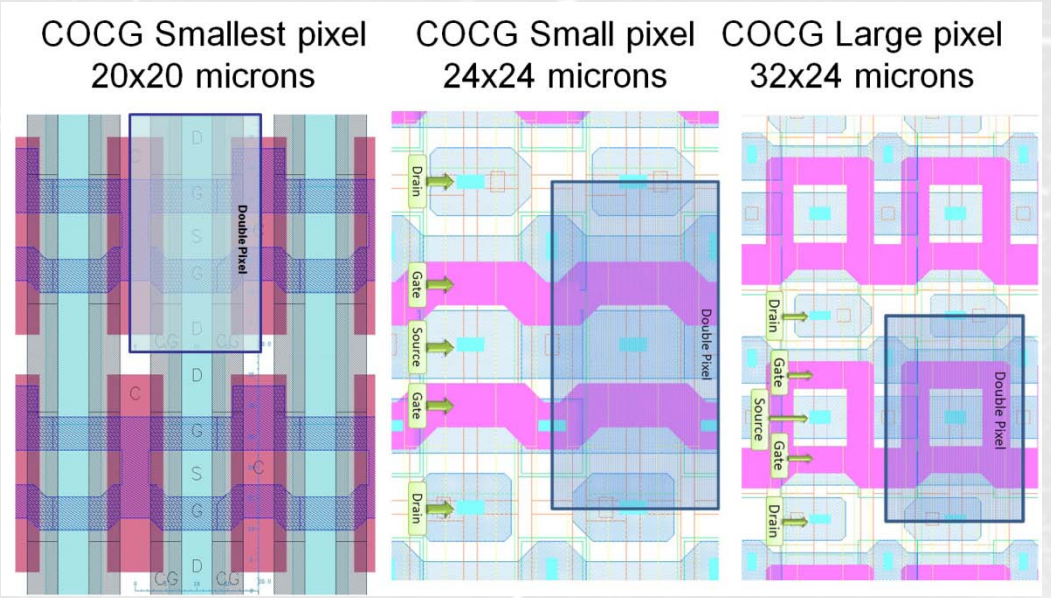
Cluster charge



Double pixel model







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Sub-pixel analysis from the beam test

Value	Module	axis x		axis y	
		Minimum	Maximum	Minimum	Maximum
Residuals in μm	2	1.4	1.6	1.2	1.5
	3	1.5	2.4	1.4	1.85
Resolutions in μm	2	1.0	1.2	0.8	1.2
	3	1.0	2.0	0.9	1.5

	Module	Minimum	Maximum
Cluster Charge in ADU	2	3180	3280
	3	1850	1900
Seed in ADU	2	1200	1900
	3	900	1600
Cluster Size	2	8.0	9.4
	3	4.8	6.2

Table 14.1: Measured minima and maxima for residuals, resolution, cluster charge, seed and cluster size.

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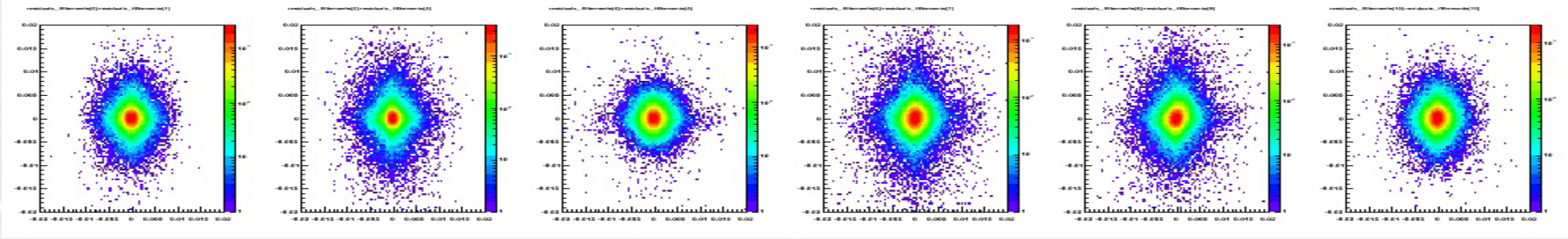
Residuals and resolution final results

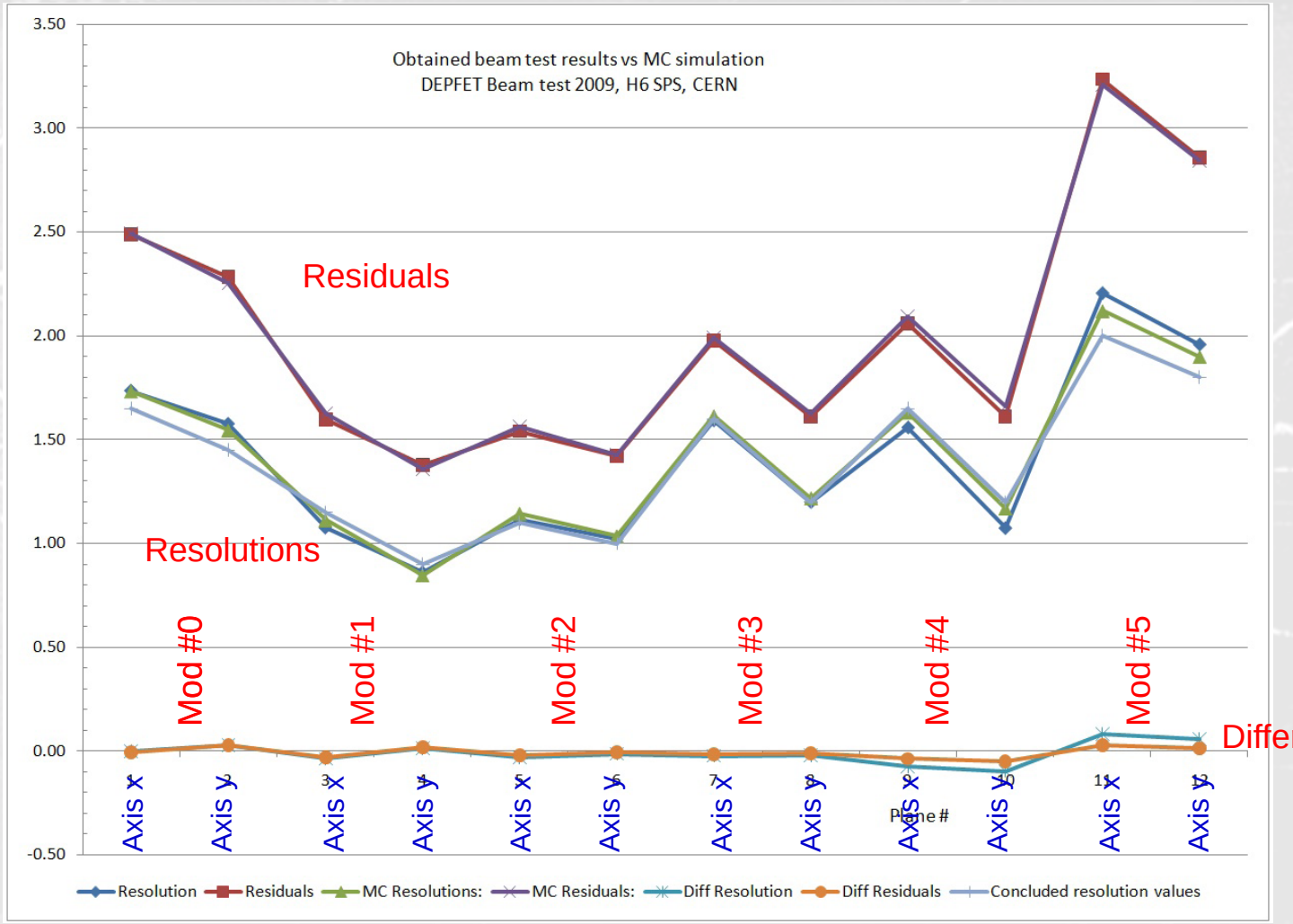
Residuals in [μm]	Module 0 H.3.0.06 COCG L B 32x24 μm		Module 1 H.3.0.16 COCG L B 32x24 μm		Module 2 H.3.0.07 COCG V S 20x20 μm		Module 3 H.3.0.12 COCG L B 32x24 μm		Module 4 H.3.0.11 COCG L B 32x24 μm		Module 5 H.3.0.10 COCG L B 32x24 μm	
	x	y	x	y	x	y	x	y	x	y	x	y
Truth residuals	2.49	2.28	1.60	1.38	1.54	1.42	1.98	1.61	2.06	1.61	3.24	2.86
MC Residuals	2.49	2.26	1.63	1.36	1.56	1.43	1.99	1.62	2.10	1.66	3.21	2.84
Diff Residuals	0.00	0.03	-0.03	0.02	-0.02	-0.01	-0.02	-0.01	-0.04	-0.05	0.03	0.02
NoTimeCor	1.68	1.55	1.09	0.92	1.66	1.13	1.69	1.30	1.54	1.18	2.37	3.23
Dif 2x2 (LSR)	0.10	0.04	0.07	0.04	0.23	0.10	0.05	0.05	0.09	0.13	0.05	0.04
Dif 3x3 (LSR)	0.05	0.02	0.04	0.03	0.15	0.09	0.04	0.04	0.08	0.13	0.04	0.03
Best 2x2+det#2 3x3	2.49	2.28	1.60	1.38	1.54	1.42	1.98	1.61	2.06	1.61	3.24	2.86
OnePixelEta	2.50	2.33	1.61	1.42	1.68	1.50	1.98	1.64	2.06	1.64	3.23	2.91
Diff OnePixel	-0.01	0.05	0.00	0.03	0.00	0.03	0.00	0.03	0.00	0.03	-0.01	0.05

Table 15.1: Residuals in x and y axes from Prague analysis for different cases of corrections or analysis ways, run 2144. Error of residuals can be estimated to 0.1 μm. 2x2 means COG calculation was done from highest 2x2 pixels arround seed, 3x3 means all neghbouring pixels used for COG position calculation.



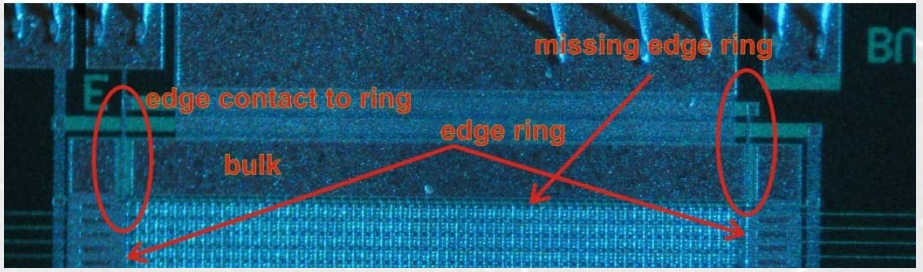
Typical residual 2D plots for all detectors, counts in color scale are in the logarithmic scale. Axes x and y are in range ±20 µm.

MC Simulations: Verification of the Analysis

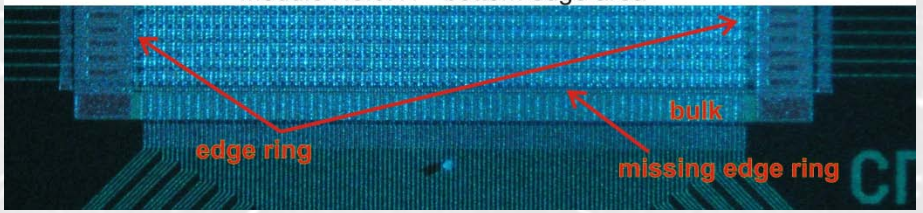


Edge scan

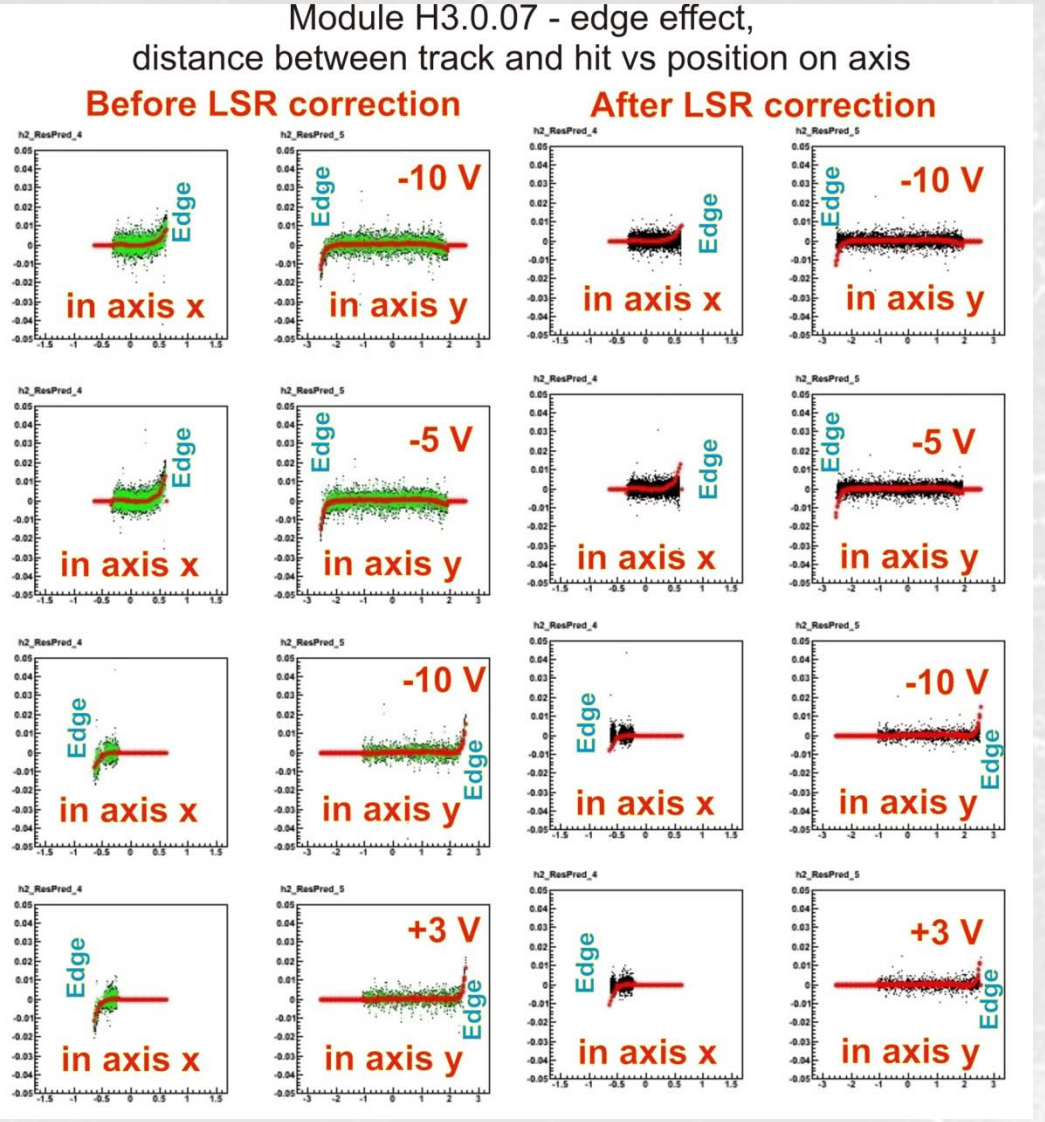
Module H3.0.11 - upper edge area



Module H3.0.11 - bottom edge area

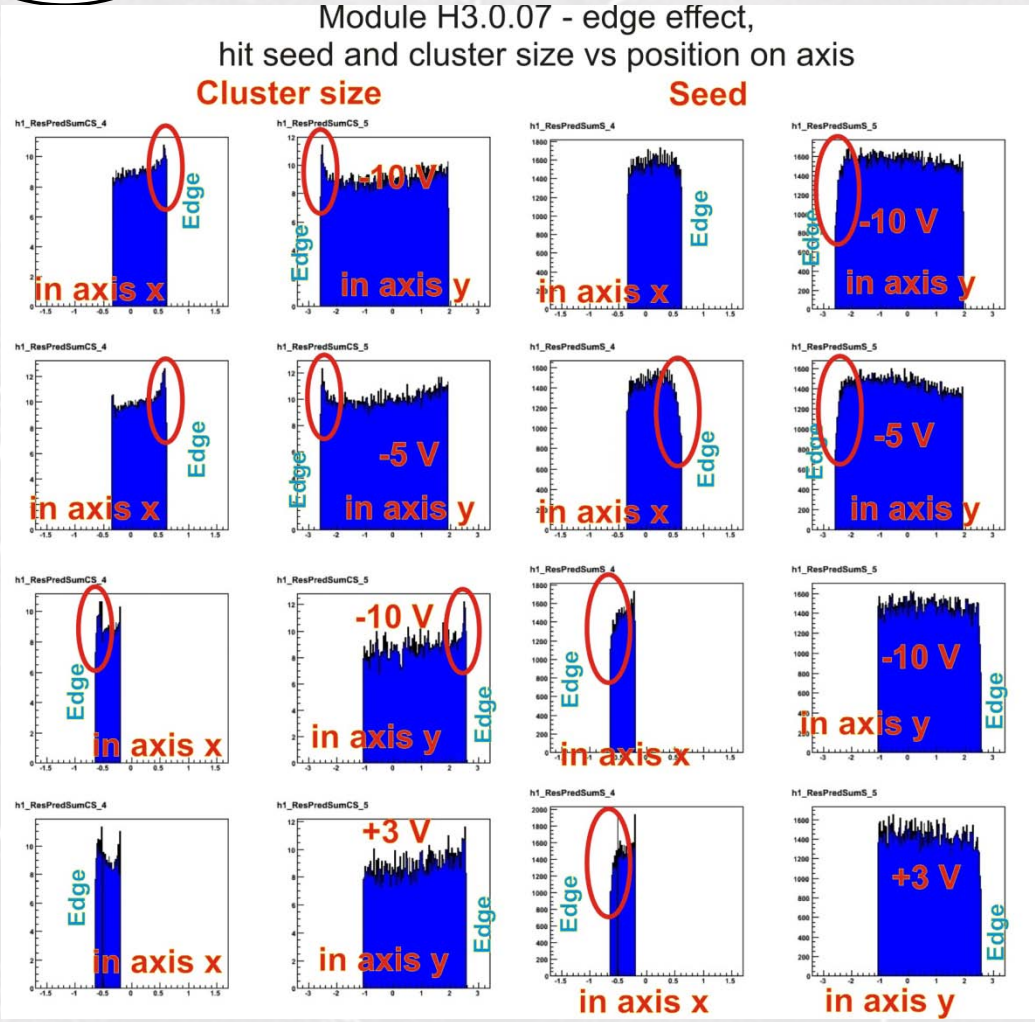


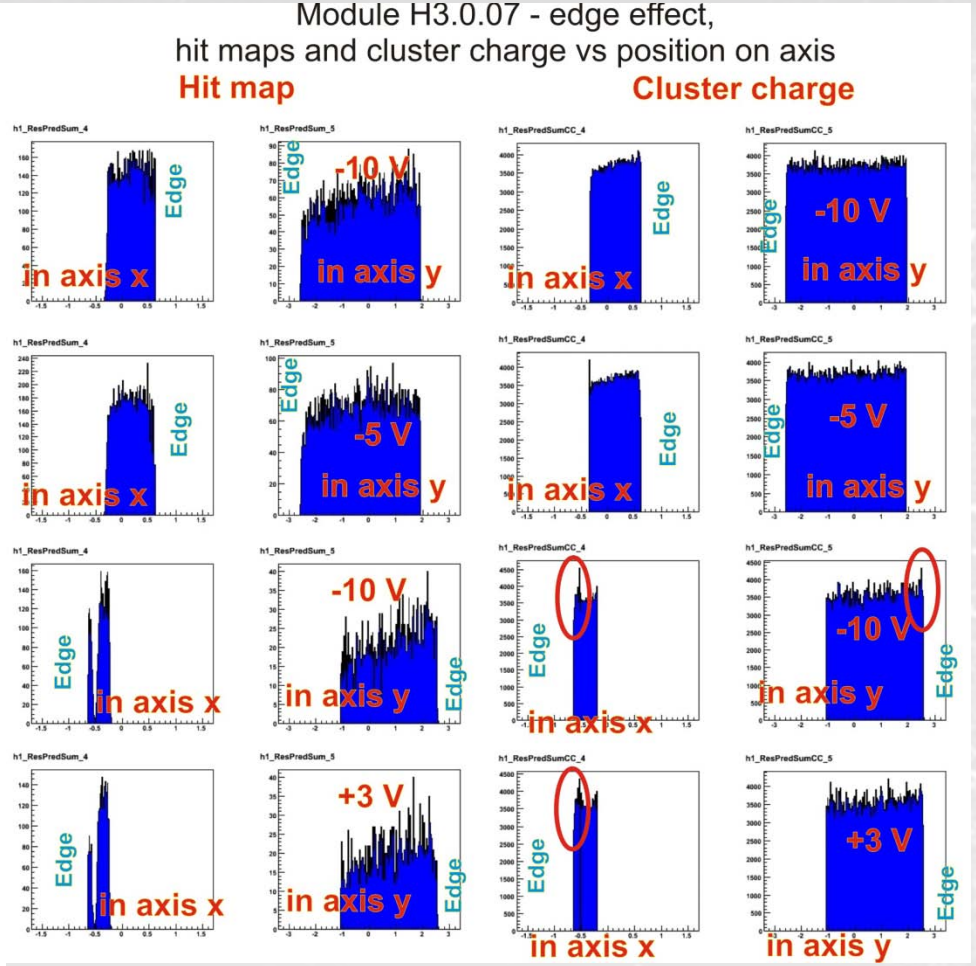
Module H3.0.07 - edge effect,
distance between track and hit vs position on axis



1. One module affects average residuals and resolutions on all others
2. Self-effect is about extra 0.04 µm
3. Other modules worsen by about extra 0.05 - 0.15 µm (affect alignment and tracking)
4. Affects average cluster charge and seed
5. Small influence on the cluster size

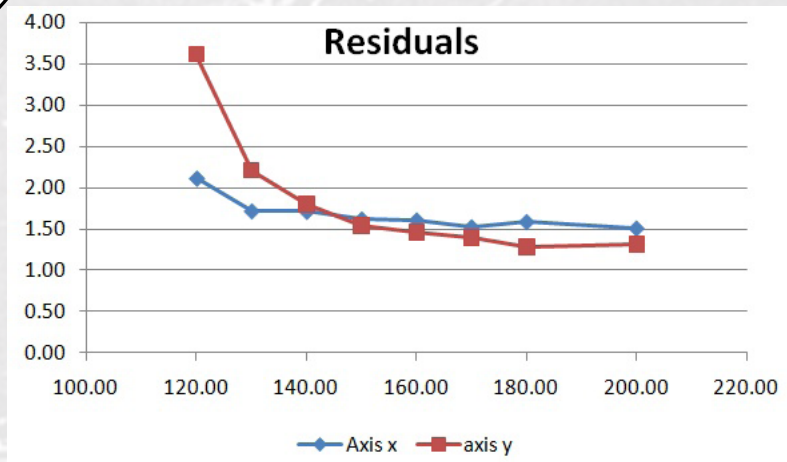
Edge scan

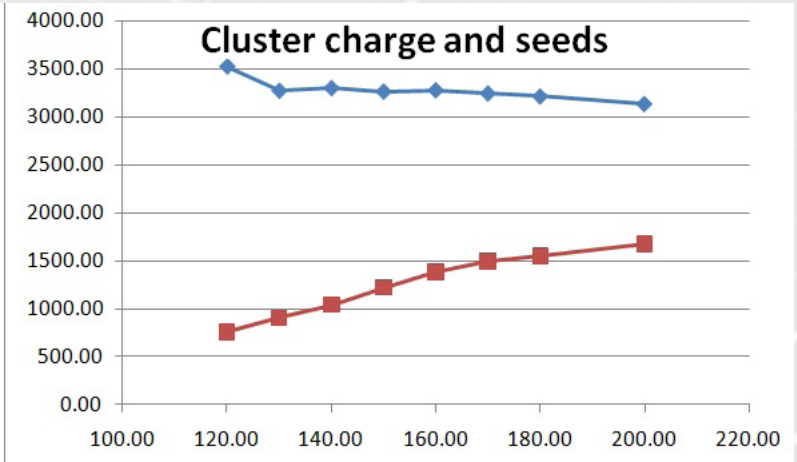


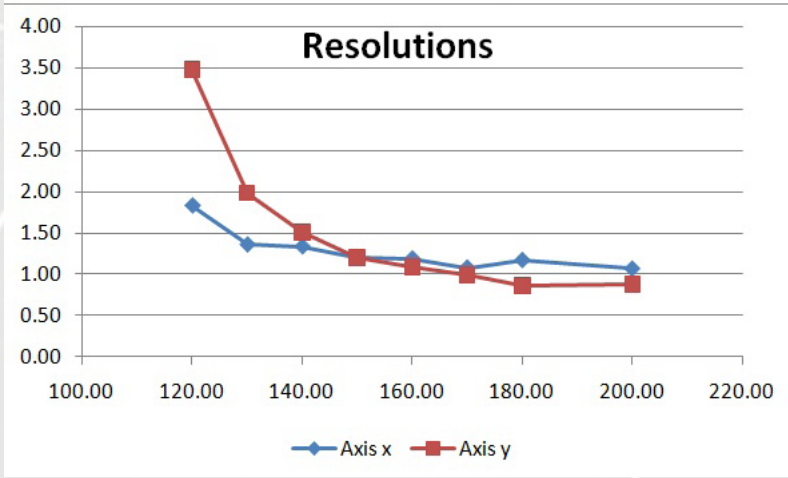


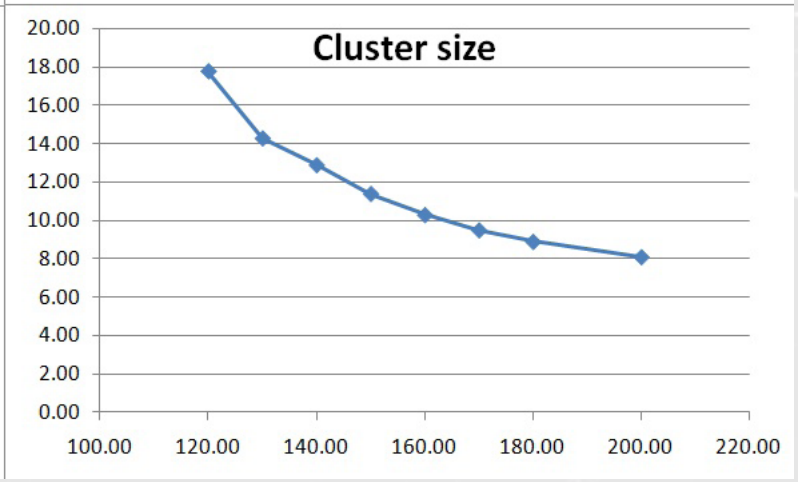
Irregular edge response is marked with circles

Bias scan









Possible problem is that there is no clear visible saturation on cluster charge over voltage ~160 V.

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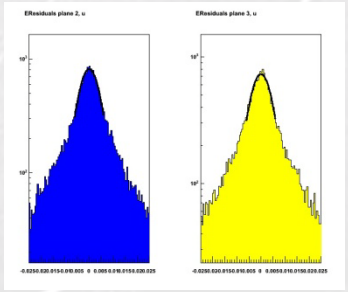
Alignment scan

Study of how the movement of a detector along one axis and corresponding changes in alignment shift. The comparison shows that alignment reproduces small movements of the detector with the precision of 0.14 ± 1.23 μm. Typical (RMS) variations of alignment shifts are in the range 0.33 - 1.10 μm.

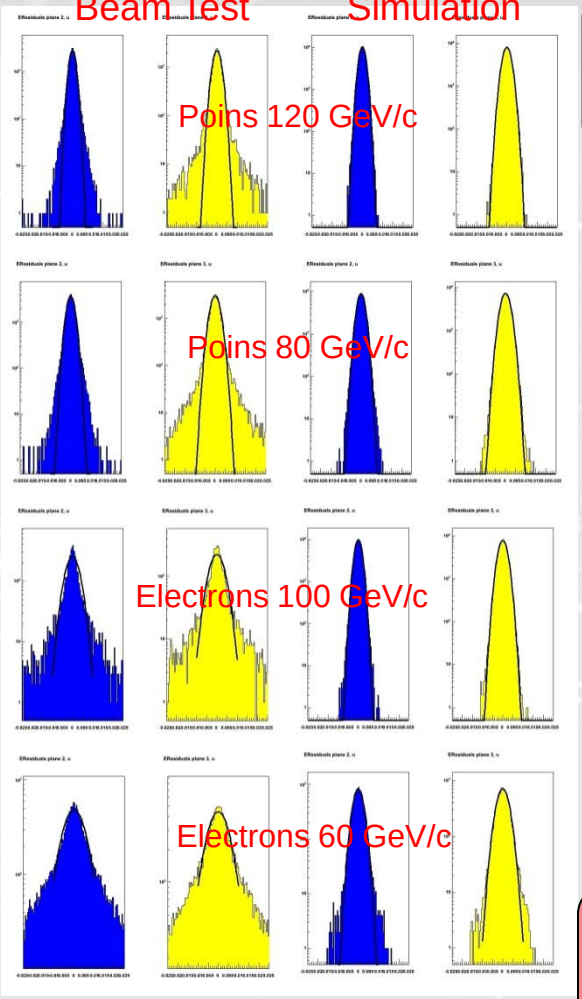
The corresponding variation in residuals and resolutions are in the range 0.02 - 0.06 μm, which is well below their typical variation (0.1 μm).

- Alignment scan is mechanically at the edge of abilities of the positioning tables.
- Additional mechanical forces come from thick cables and have long relaxation time
- The moves by several microns indeed have low repeatability, and the response of the positioning tables at such moves is not well defined.
- The mechanical setup is known to displace on micron scale during long experiments

Energy scan



Very special fit only for top hat for 100 GeV/c electrons



Energy scan: Residuals for module #2 (blue) and #3 (yellow), fit is not good for TB electrons

pions – good agreement between beam test data and simulations.

electrons – discrepancy between data and simulations on the level of 1.3 - 1.8 μm higher value for residuals from beam test.

For electrons: We cannot reproduce in simulations the scatter observed in TB data!

Possible explanations:

1. Too low rate of accepted tracks per hour which gives come problems in compensation of mechanical instabilities.
2. Contamination of beam with an additional fraction of particles with lower energy and different types (This message is coming from consultations), still under discussion…
3. Unexpected shift of energy to lower values about 10-15 GeV/c compared to the nominal energy

Comparison with other analyses would be vital.

At the lower energies of electrons a smaller rate of tracks per hour gives some problems in compensation of mechanical instabilities. Results are highly sensitive to this correction - changes on the level of 2 μm are possible

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Conclusion

- Analysis of DEPFET TB2009 in Prague is almost complete.
- Final results obtained are presented: individual detector resolutions (and corresponding residuals), resolution vs. sub-pixel position, edge scan, resolution vs. bias, alignment properties and energy scan.
- The analysis shows consistent behavior of tested DEPFET modules over the whole course of the beam test and some new mysteries: energy scan of electrons, from where it comes?
- **Main goal now is tune standard analysis based on Mokka/Marlins ILC framework**

Resolution in [μm]	Module 0 H.3.0.06 COCG L B 32x24 μm		Module 1 H.3.0.16 COCG L B 32x24 μm		Module 2 H.3.0.07 COCG V S 20x20 μm		Module 3 H.3.0.12 COCG L B 32x24 μm		Module 4 H.3.0.11 COCG L B 32x24 μm		Module 5 H.3.0.10 COCG L B 32x24 μm	
	x	y	x	y	x	y	x	y	x	y	x	y
Truth residuals	2.49	2.28	1.60	1.38	1.54	1.42	1.98	1.61	2.06	1.61	3.24	2.86
Truth resolutions	1.65	1.45	1.15	0.90	1.10	1.00	1.60	1.20	1.65	1.20	2.00	1.80

Table 20.1: Table of final residuals and resolutions in x and y axes from Prague analysis. Error of residuals and resolutions can be estimated to 0.1 μm

Whole report ~100 pages with many details now available on our wiki in direct link:

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