

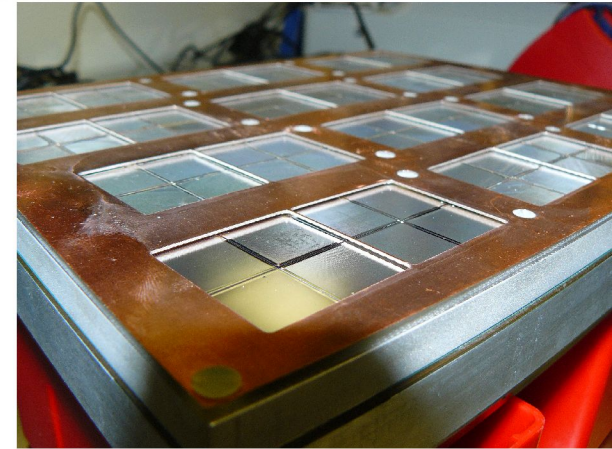
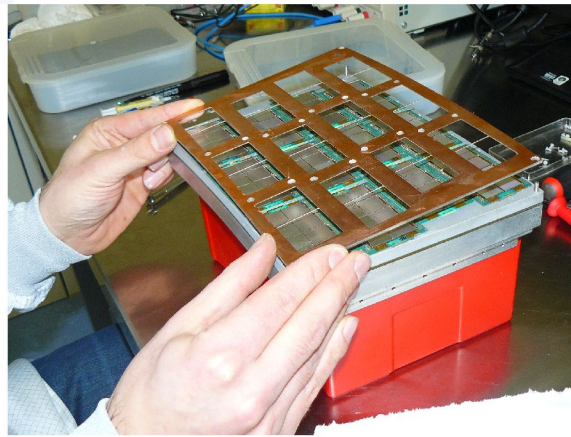
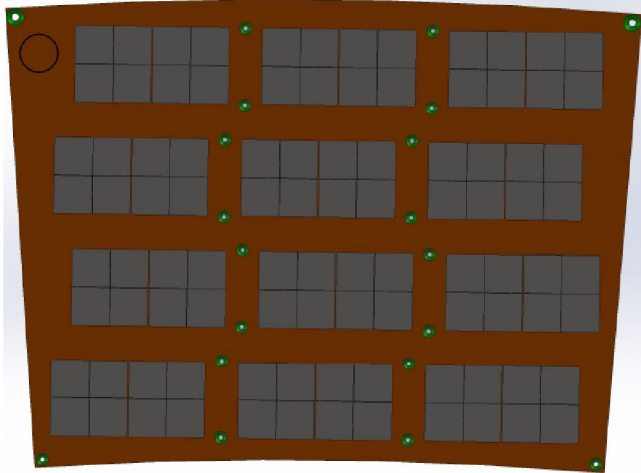
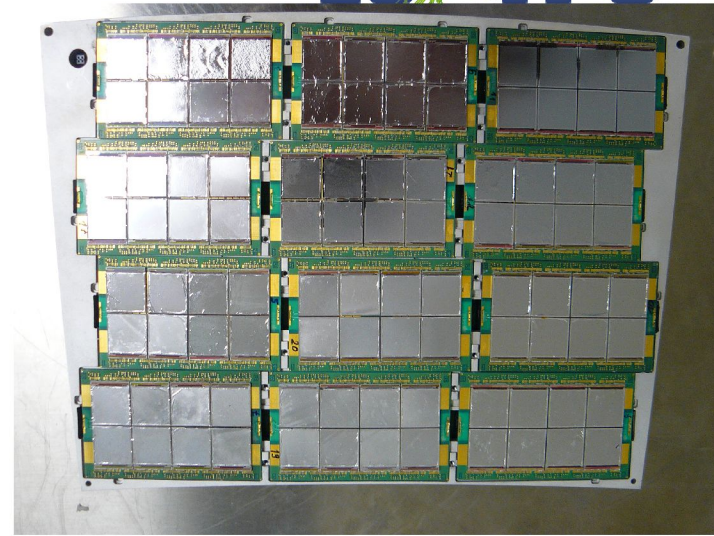
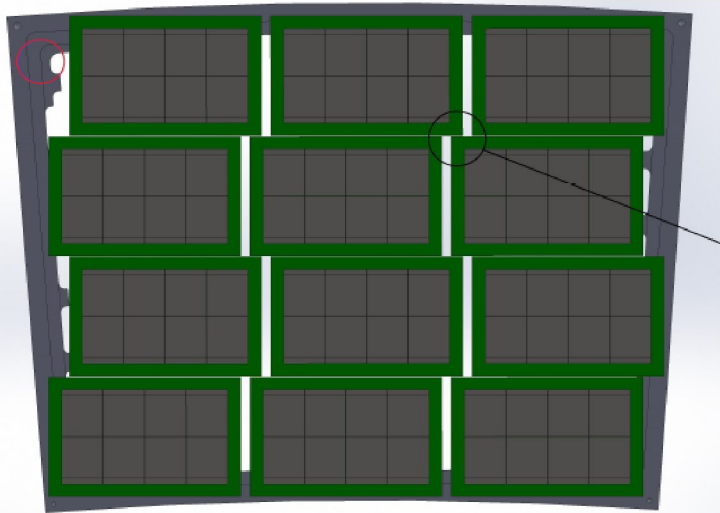
Preliminary results from the 160 InGrid test beam

Michael Lupberger
University of Bonn

LCTPC-WP Meeting 10.09.2015

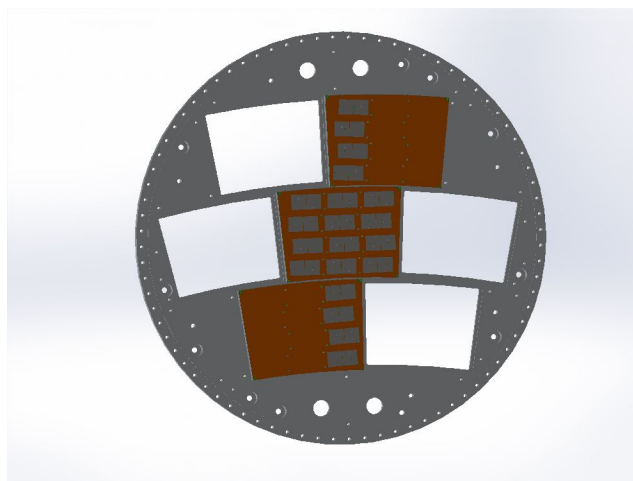
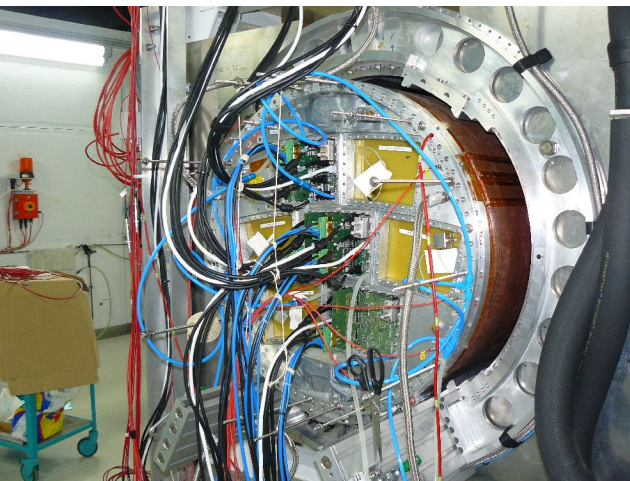
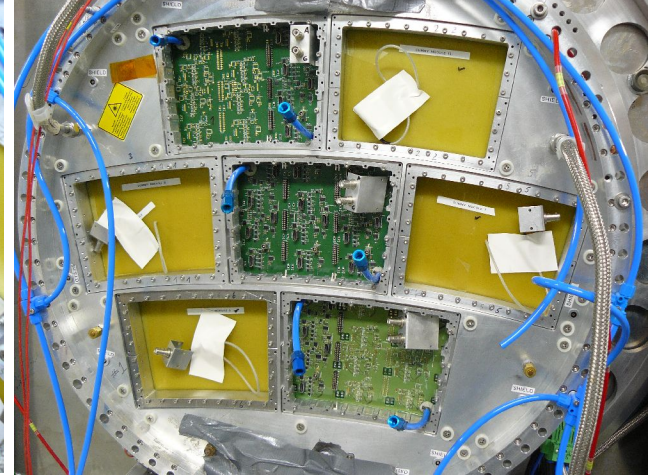
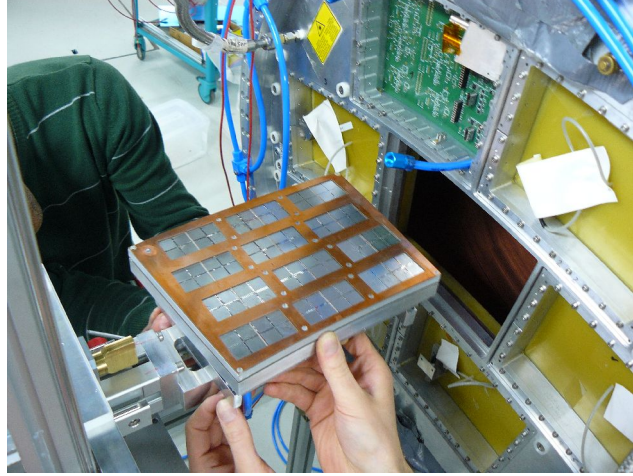
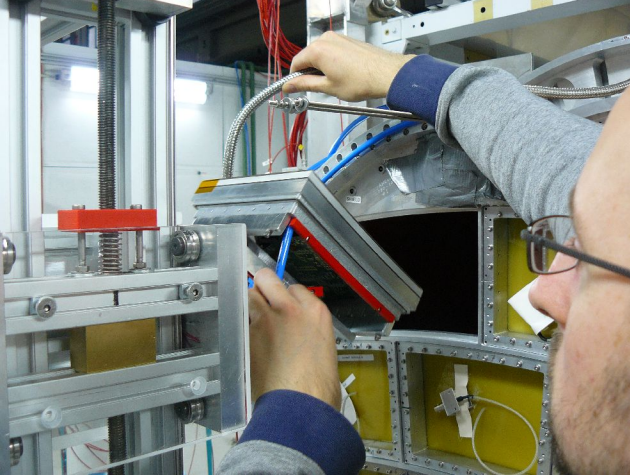
Setup

96 InGrid Module



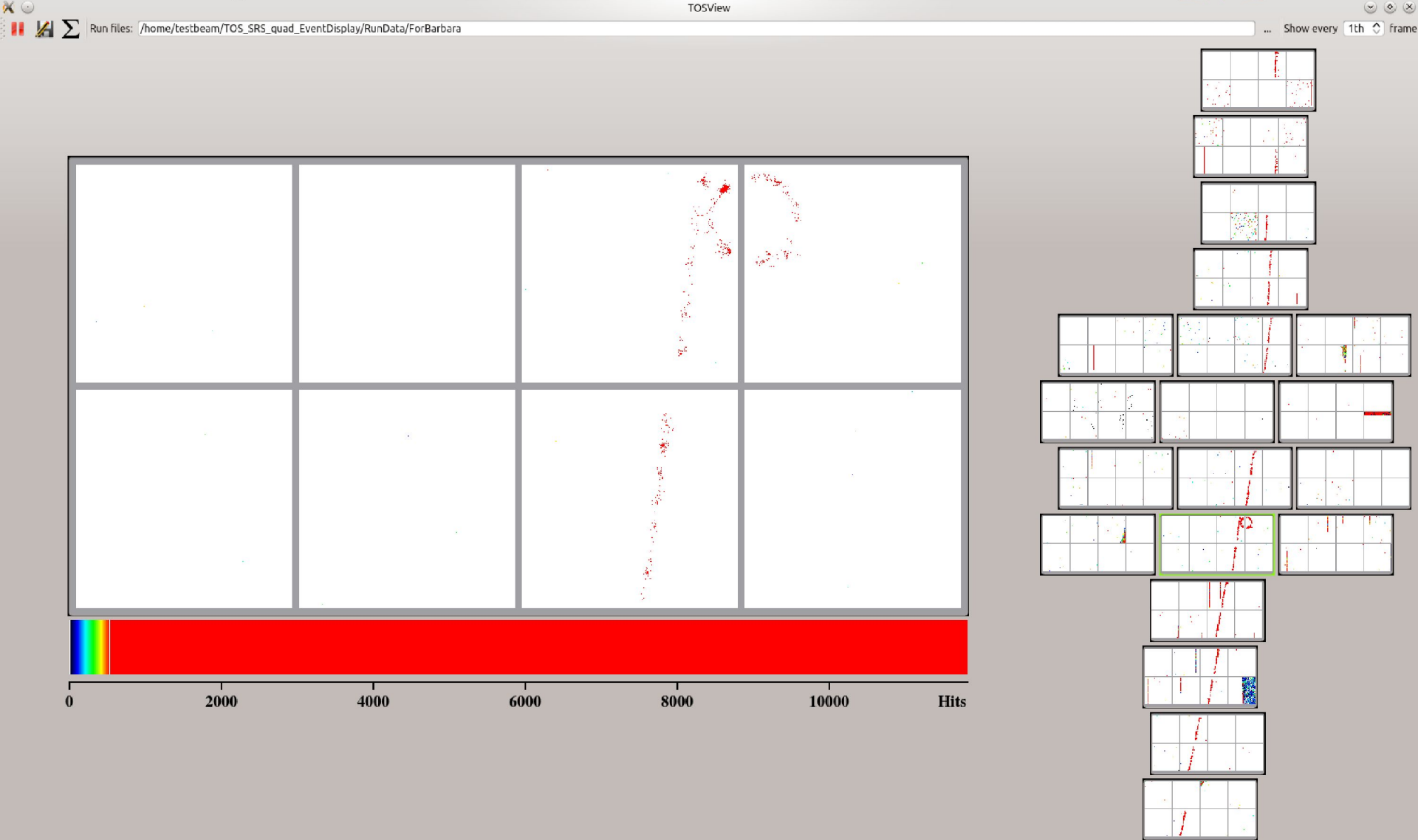
Setup

3 modules: 1x 96, 2x 24 InGrids



Event display

Not aligned



Event display

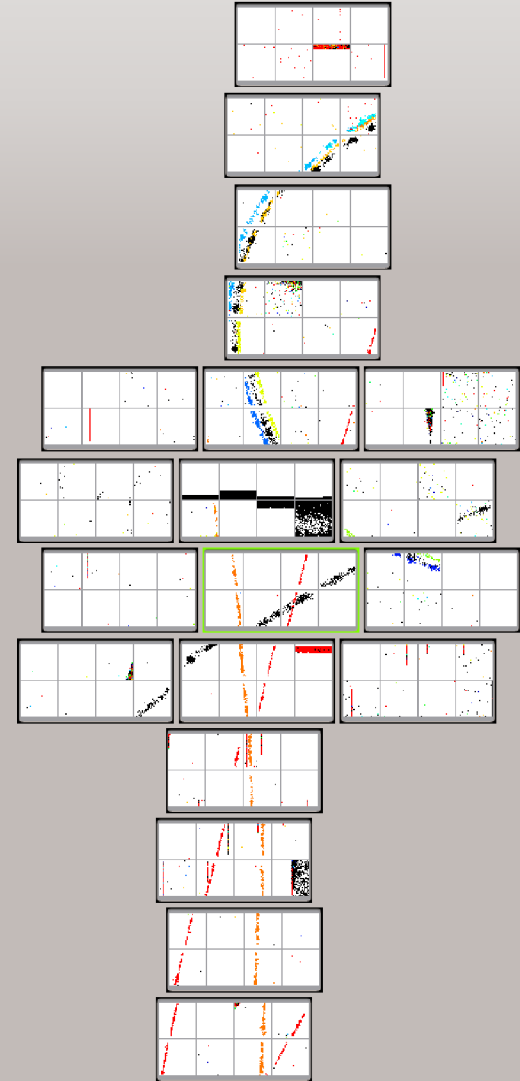
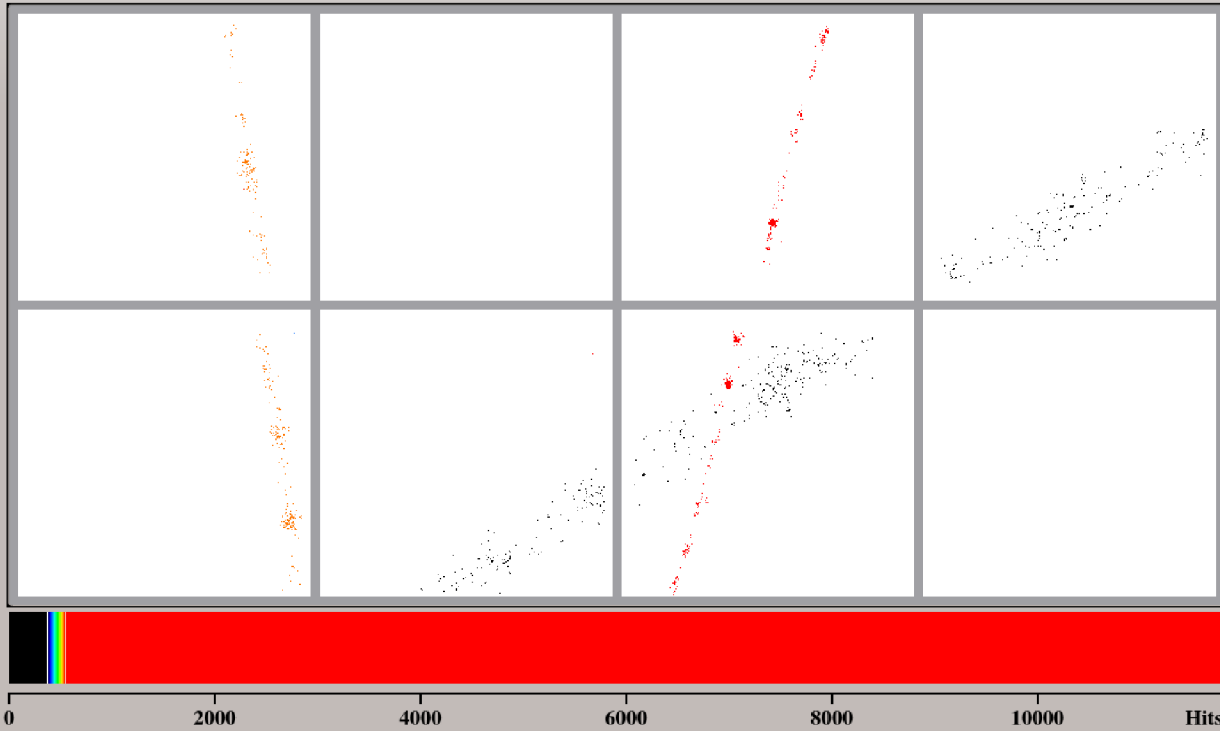


Not aligned

TOSView

Run Files: /home/michael/Run_000087_150401_23-15-42

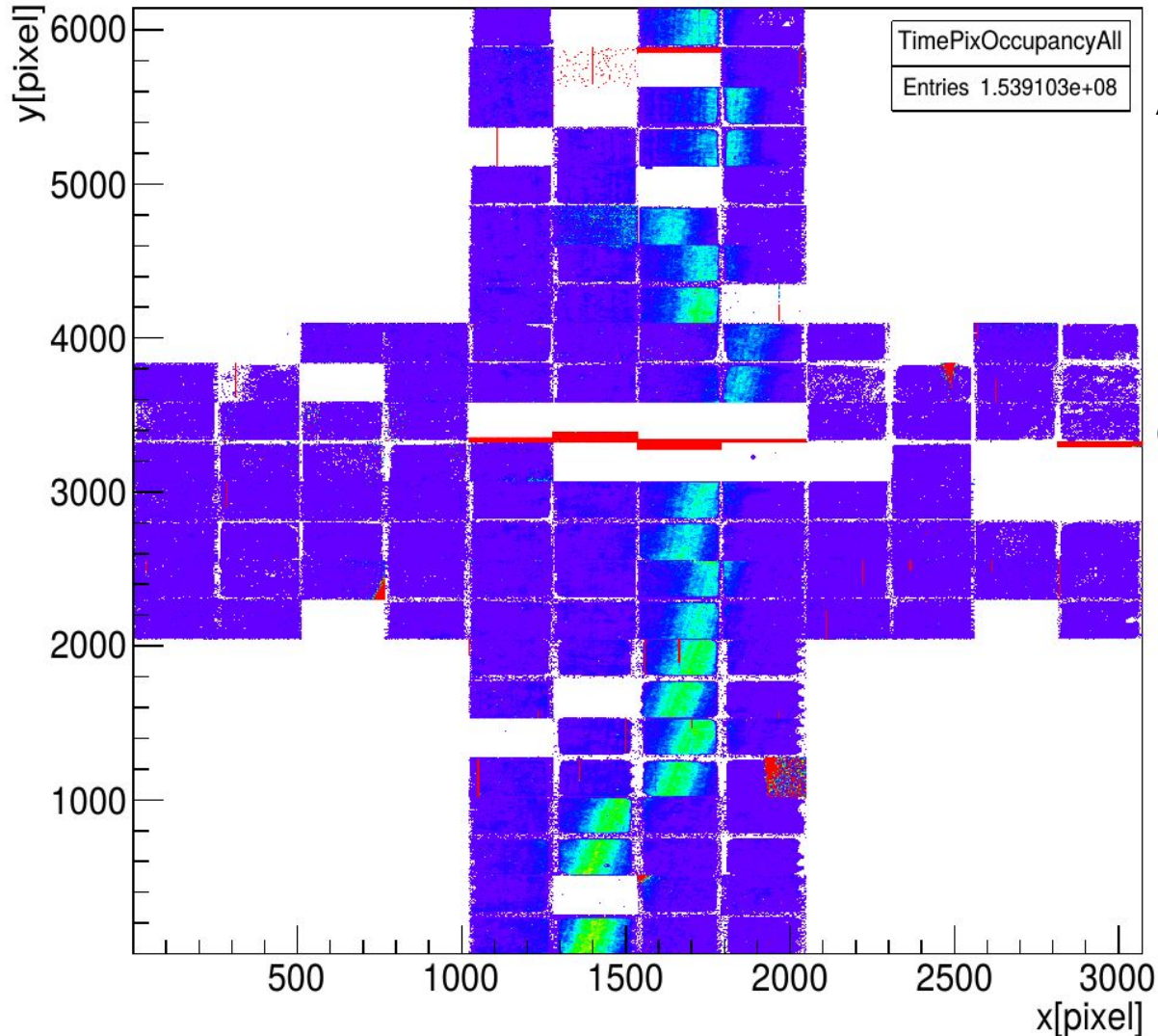
Show every 1th frame



Data cleaning



Dead chips, columns and pixel: occupancy plot



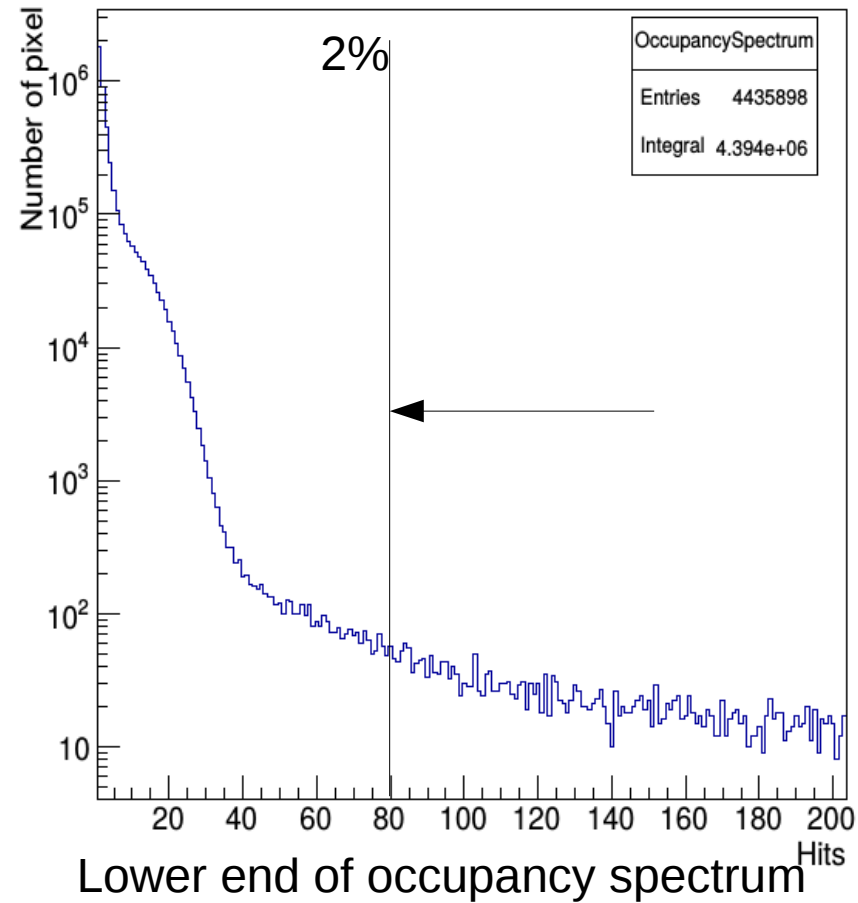
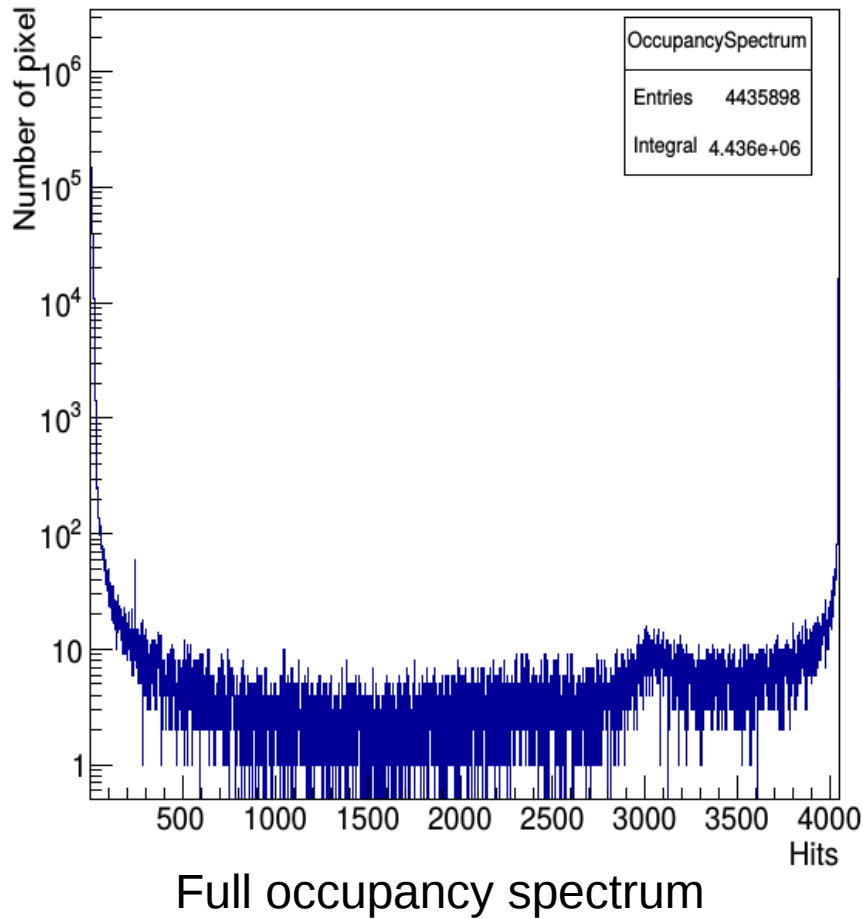
Approximation:

Pixel in beam gets hit in not more than 1 % of #events

Heat map: all red hit more often than 2 %:
Defect pixel/chips

Data cleaning

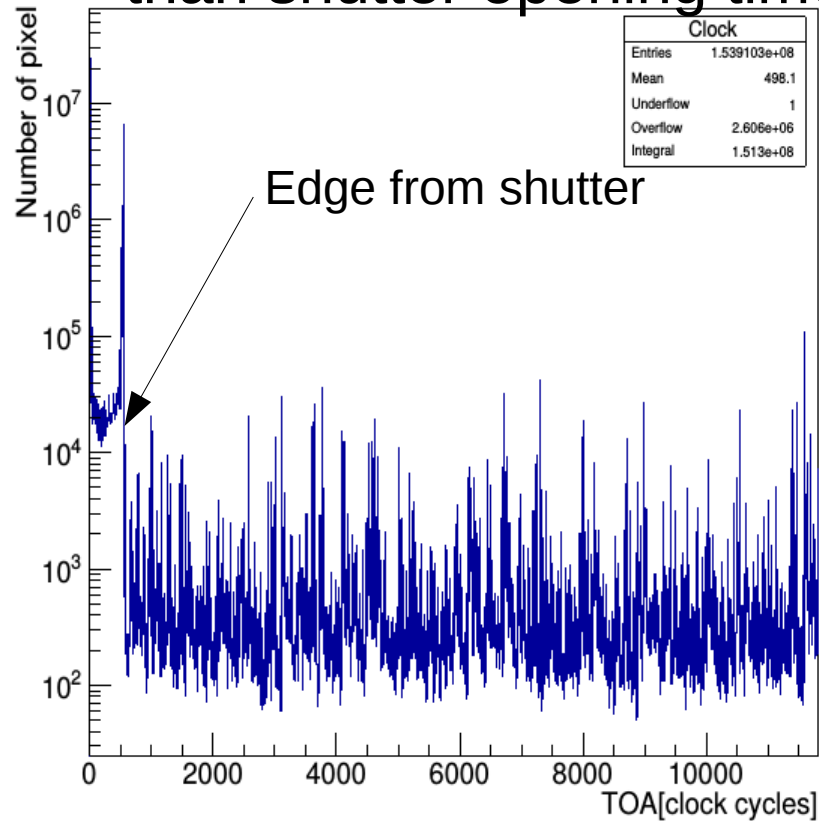
Cut in occupancy spectrum



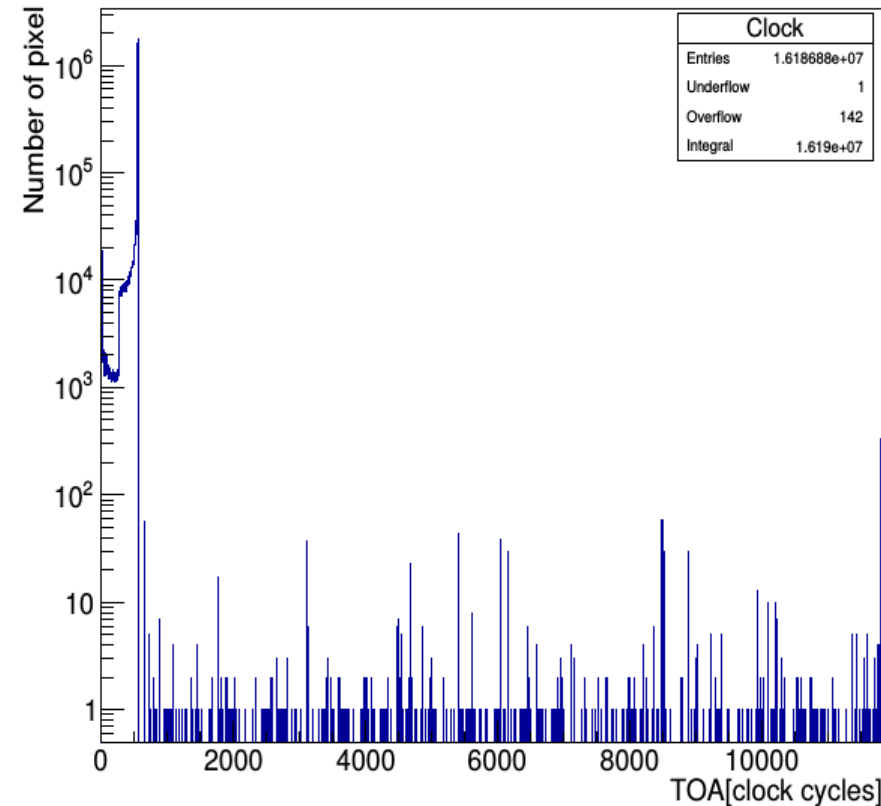
Data quality control



TOA spectrum: no pixel should count longer than shutter opening time



Raw TOA spectrum

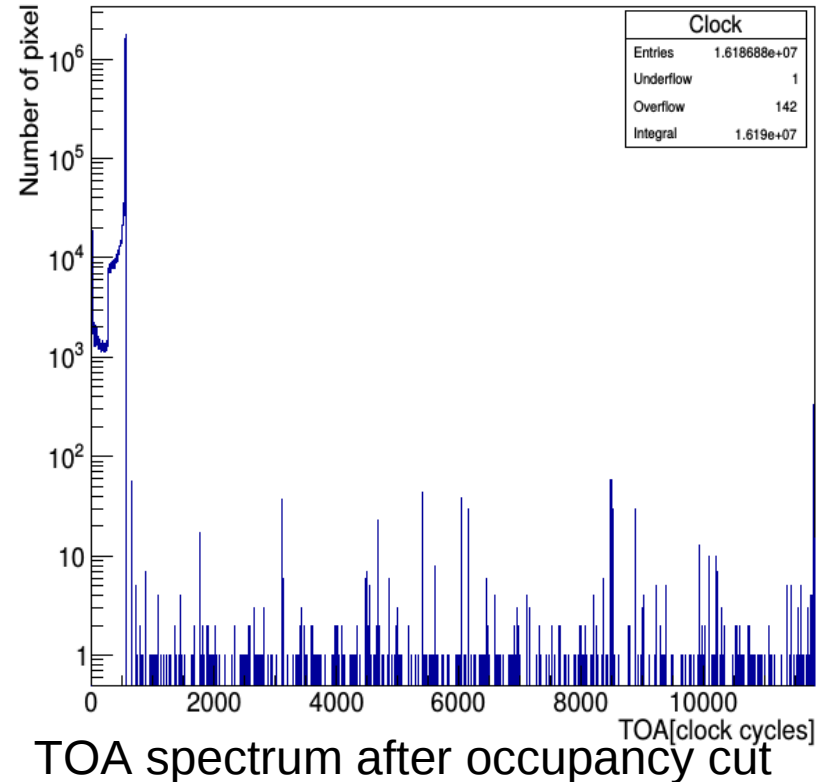
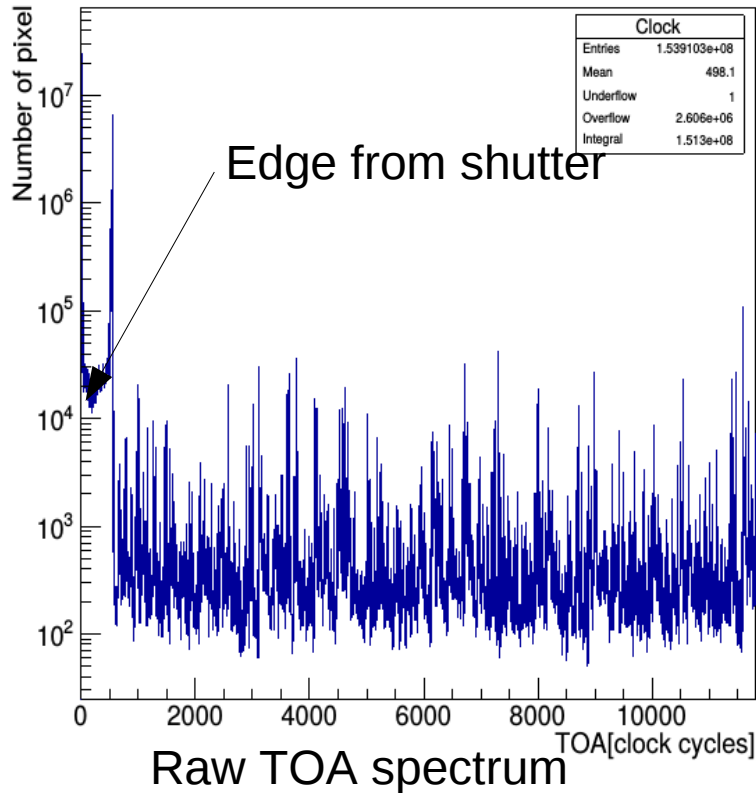


TOA spectrum after occupancy cut

Data quality control



TOA spectrum: no pixel should count longer than shutter opening time

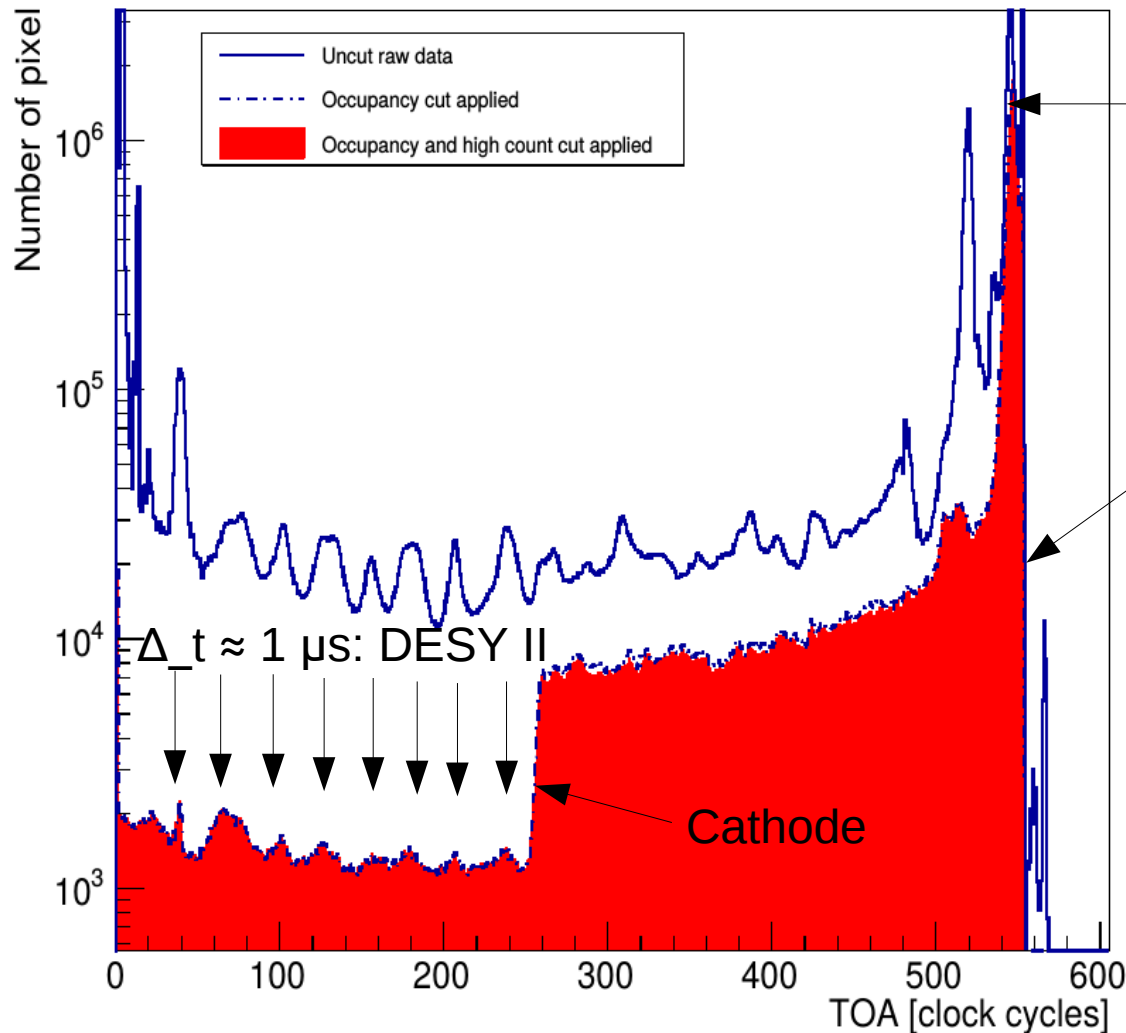


Investigate „high count hits“: almost all from 4 events
Few pixel, which give high counts in less than 2 % of events
→ reject events with too many „high count hits“, 1 % occupancy cut on high count hits

TOA spectrum



Effect of cuts



Beam position

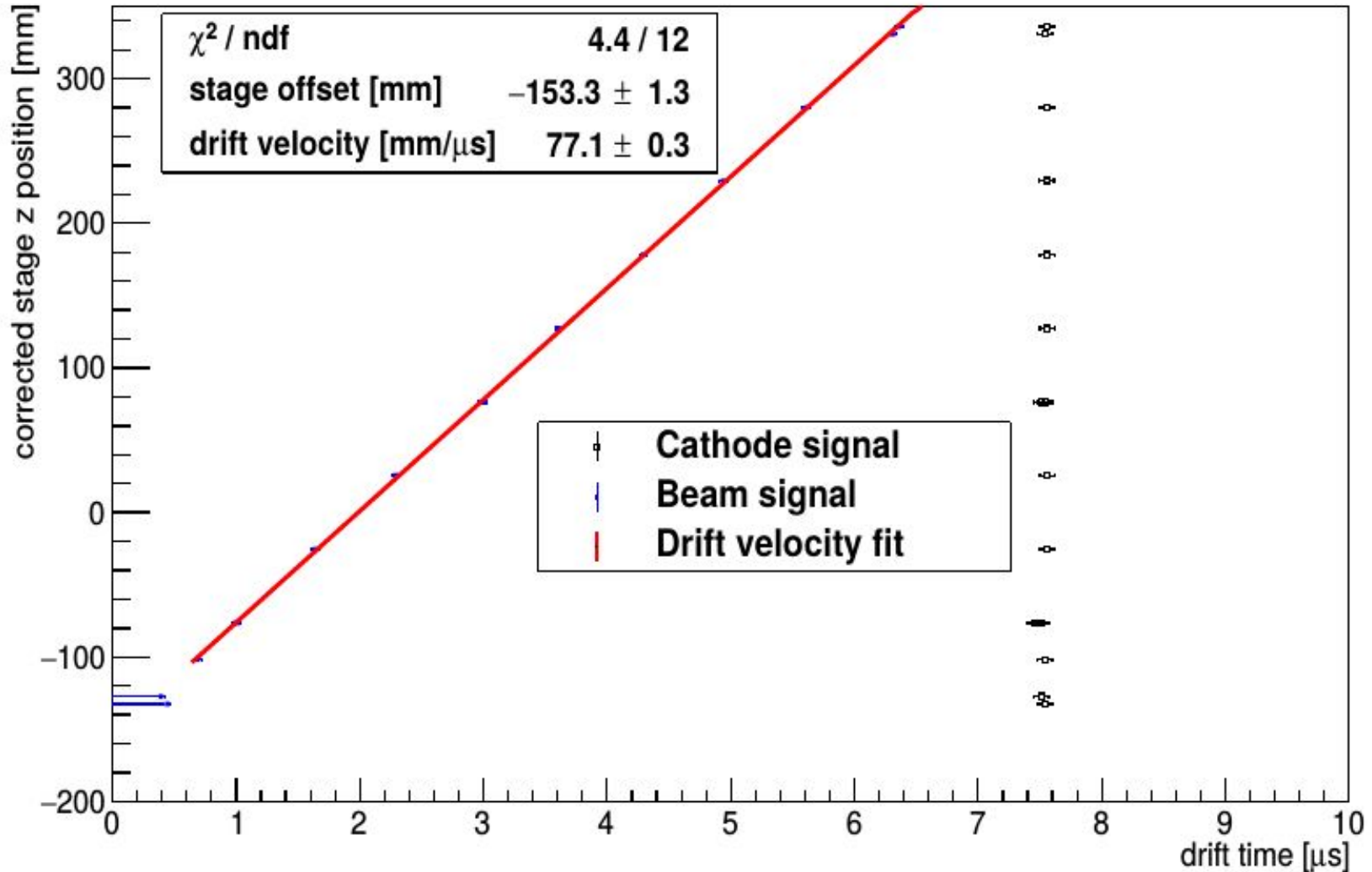
Shutter edge

- Drift velocity measurement:
- From time difference between cathode and shutter for each run
 - From beam position for a scan

Drift velocity



For a scan with corrected beam position



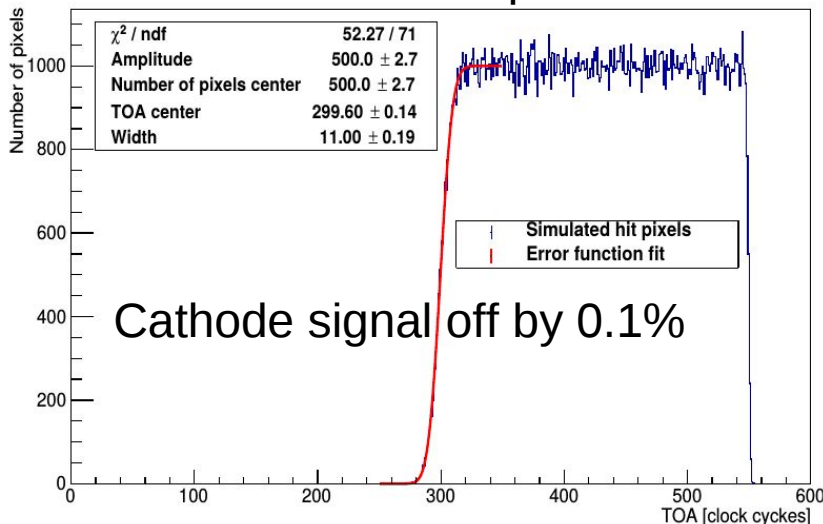
Drift velocity



Comparison to simulation

Run	B [T]	E_{drift} [V/cm]	Stage offset [mm]	$v_{d,meas}$ [mm/ μ s]	$\bar{v}_{d,cath}$ [mm/ μ s]	$v_{d,sim}$ [mm/ μ s]
51-59	0	230	-152.5 ± 2.0	76.7 ± 0.6	75.08 ± 0.34	76.50 ± 0.02
61-72	0	130	-151.2 ± 1.6	56.07 ± 0.2	54.80 ± 0.09	56.42 ± 0.01
76-89	1	230	-153.7 ± 1.8	76.9 ± 0.5	74.92 ± 0.16	76.39 ± 0.01
90-105	0	230	-153.3 ± 1.3	77.1 ± 0.4	75.3 ± 0.09	76.38 ± 0.01
121-135	1	130	-151.1 ± 1.3	52.49 ± 0.2	51.33 ± 0.33	53.23 ± 0.01

Simulated TOA spectrum

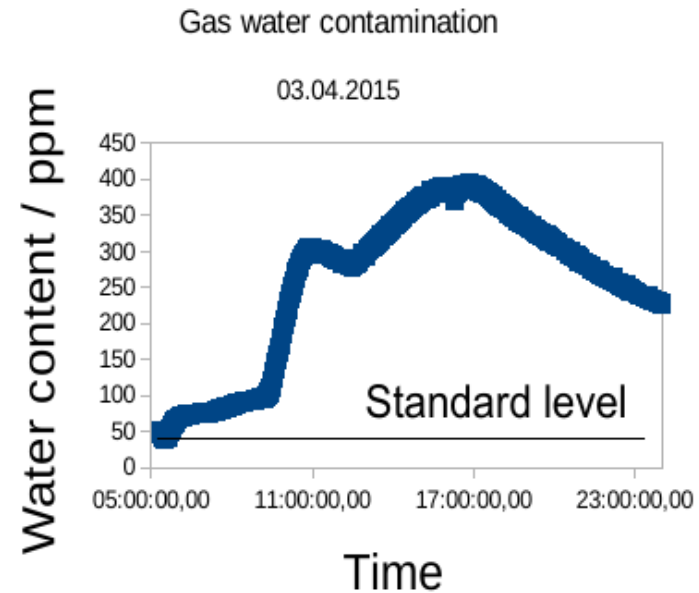
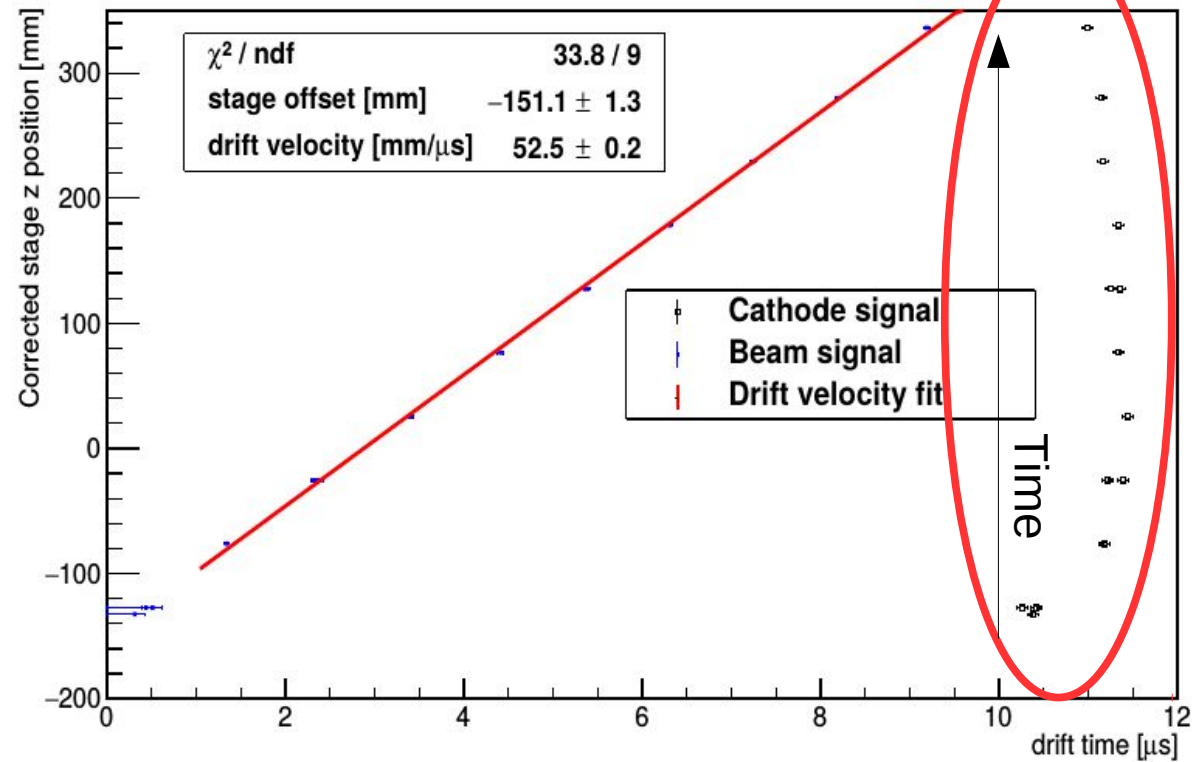


Systematically too small (1.2 %)
 From which effect „cathode signal“
 Is generated → needs further investigation

Drift velocity

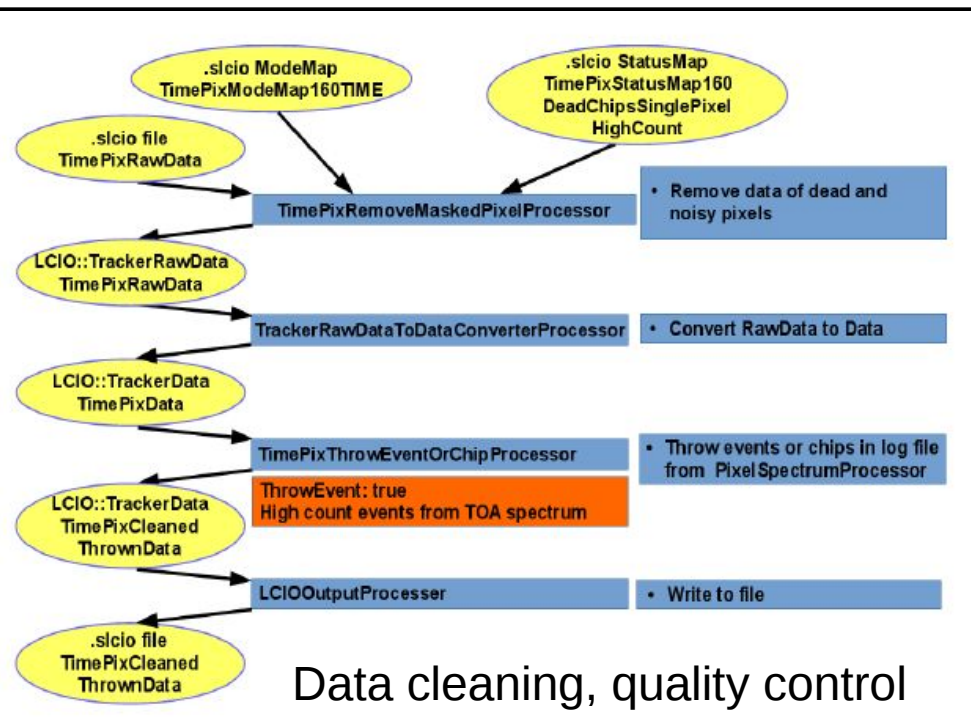
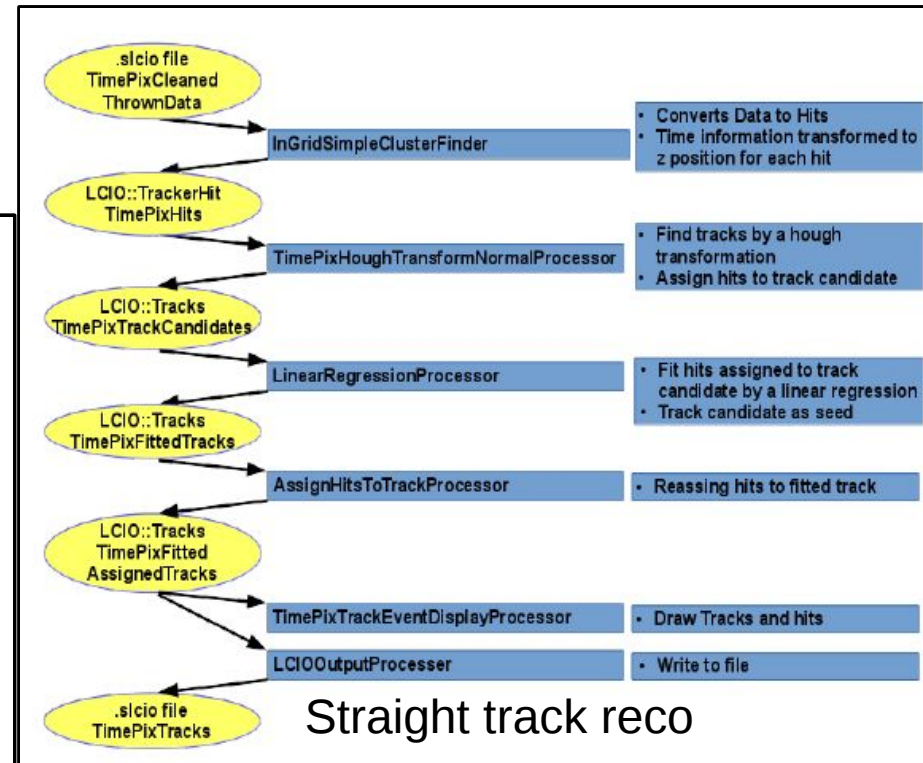
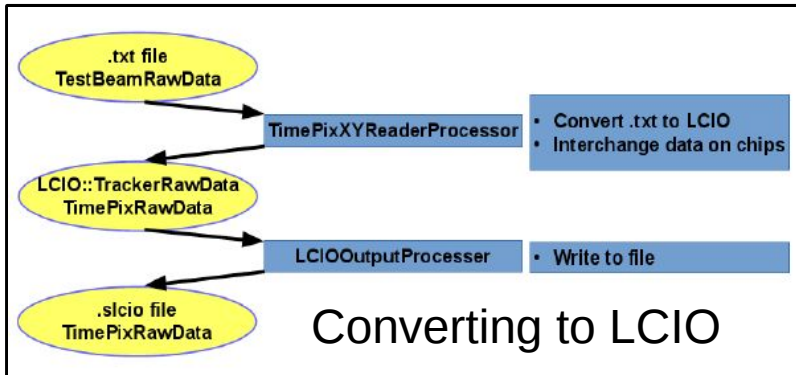


Effect of water contamination

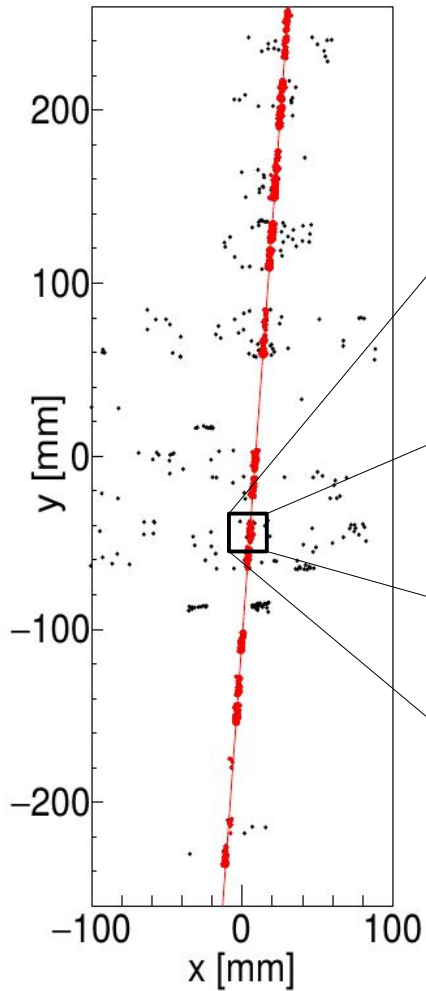


Run	Water contamination [ppm]	$v_{d,cath}$ [mm/ μs]	$v_{d,sim}$ [mm/ μs]
121	50	54.6 ± 0.6	55.84 ± 0.01
129	392	50.5 ± 0.5	51.03 ± 0.01
135	260	51.7 ± 0.5	52.82 ± 0.01

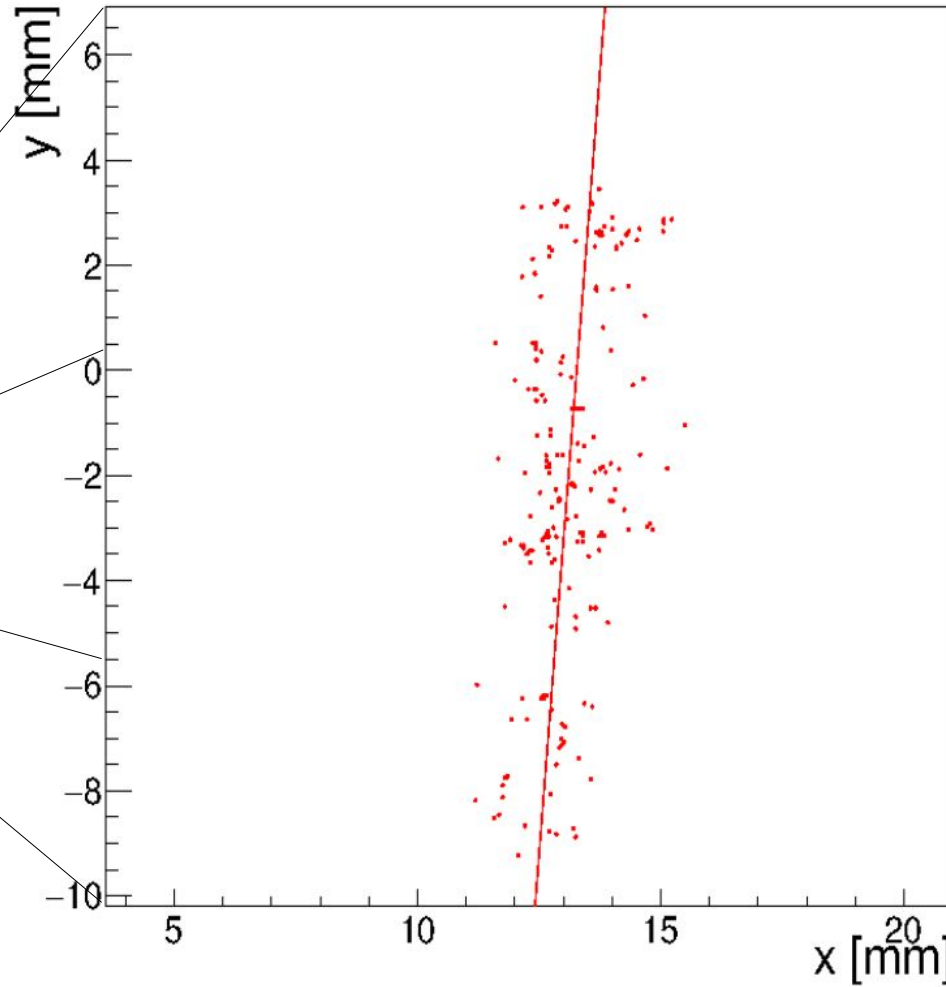
MarlinTPC processors



Reconstructed straight tracks

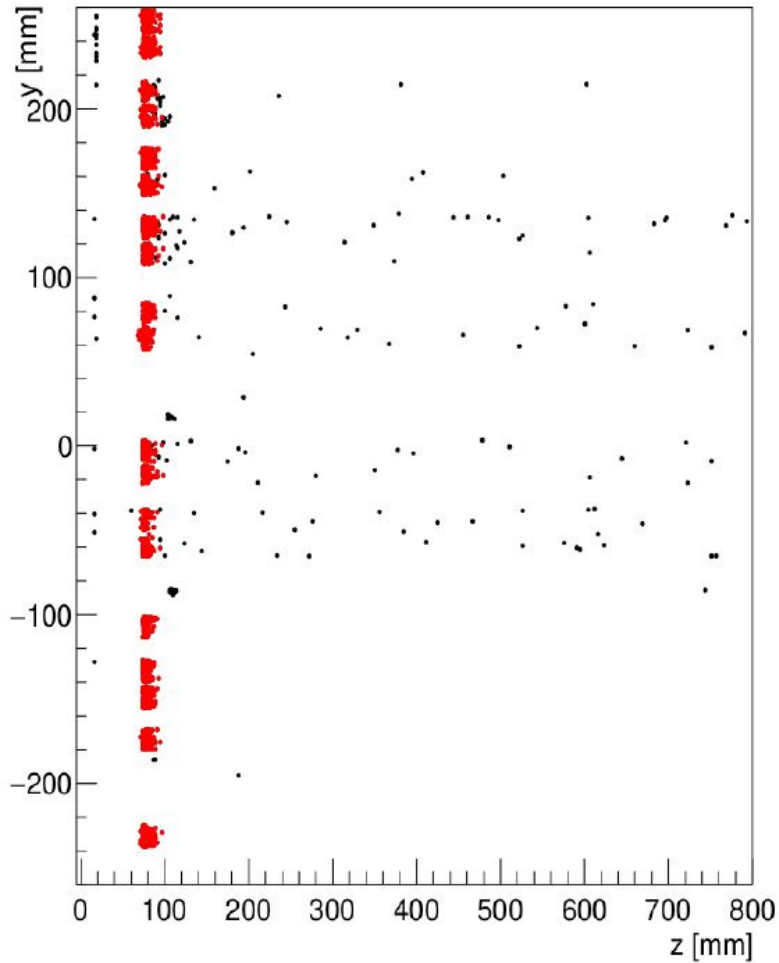


XY view, to scale

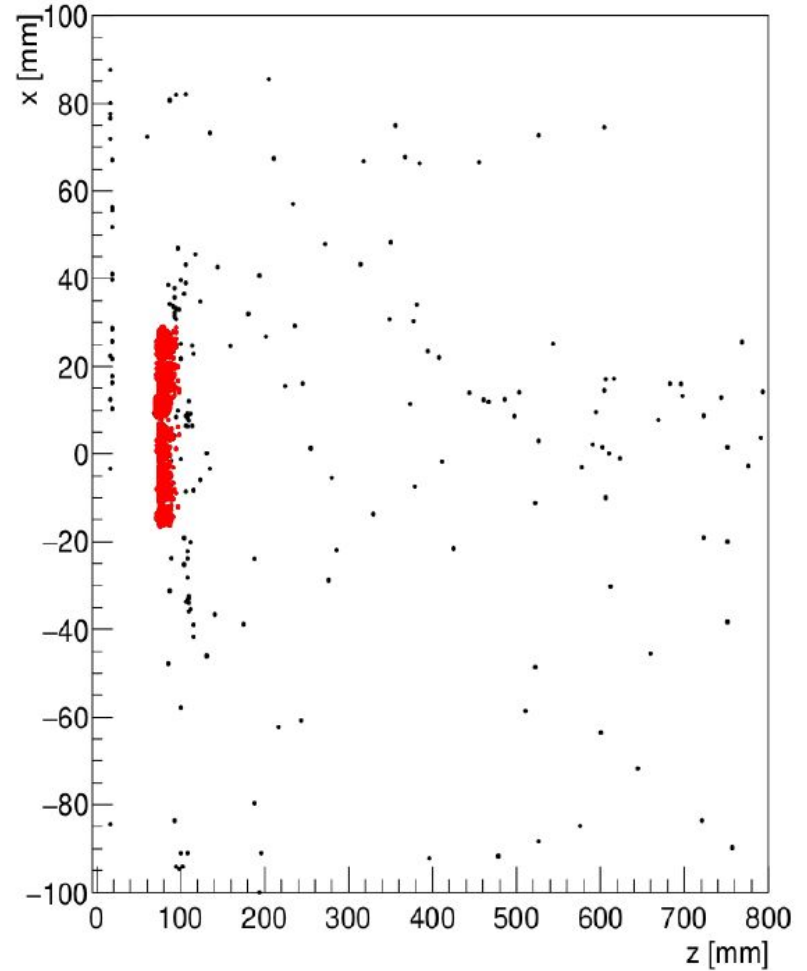


XY view, zoom

Reconstructed straight tracks

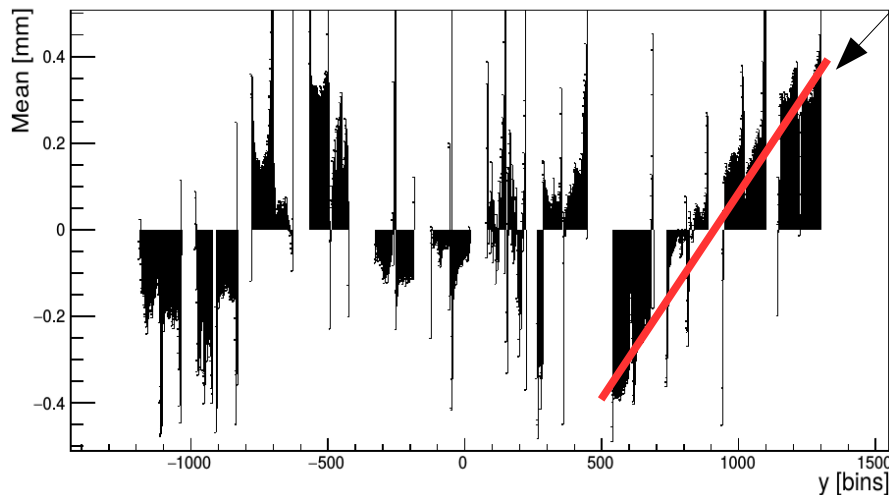
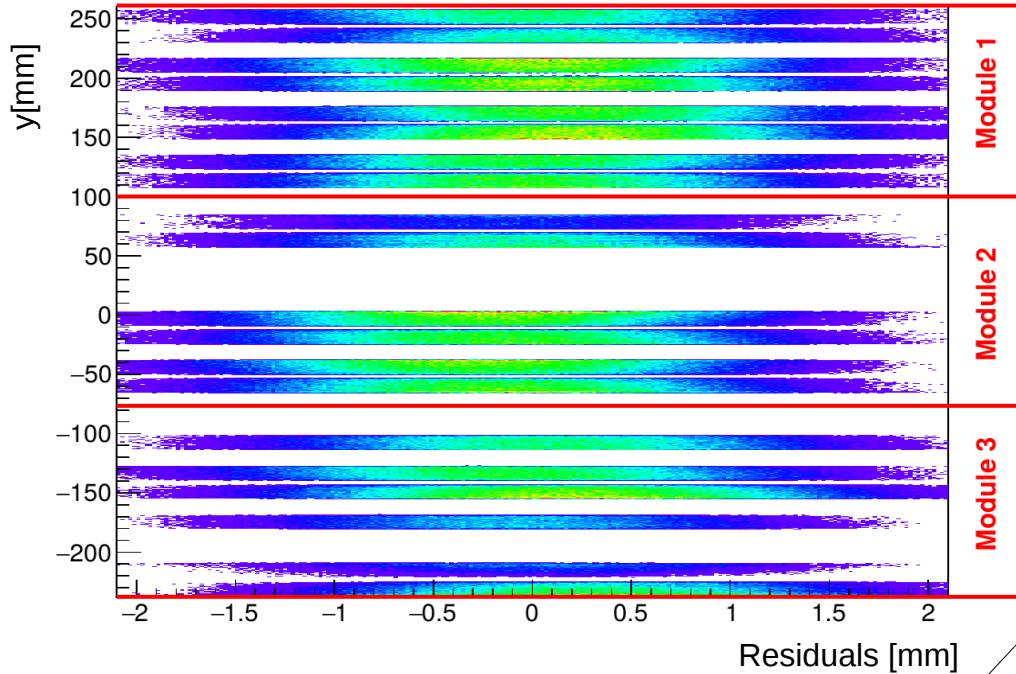


yZ view



XZ view

Residuals



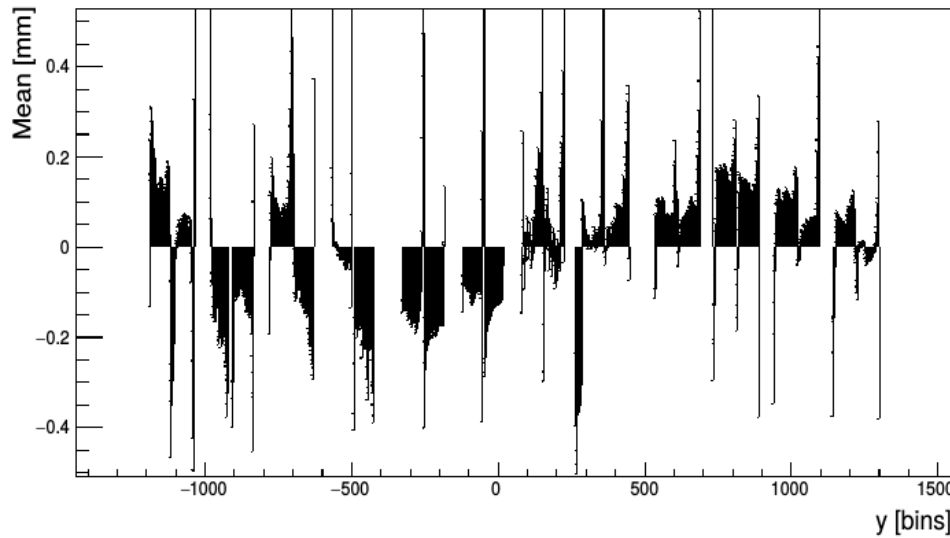
Systematic effect, expected

Modules aligned only as in CAD drawing!

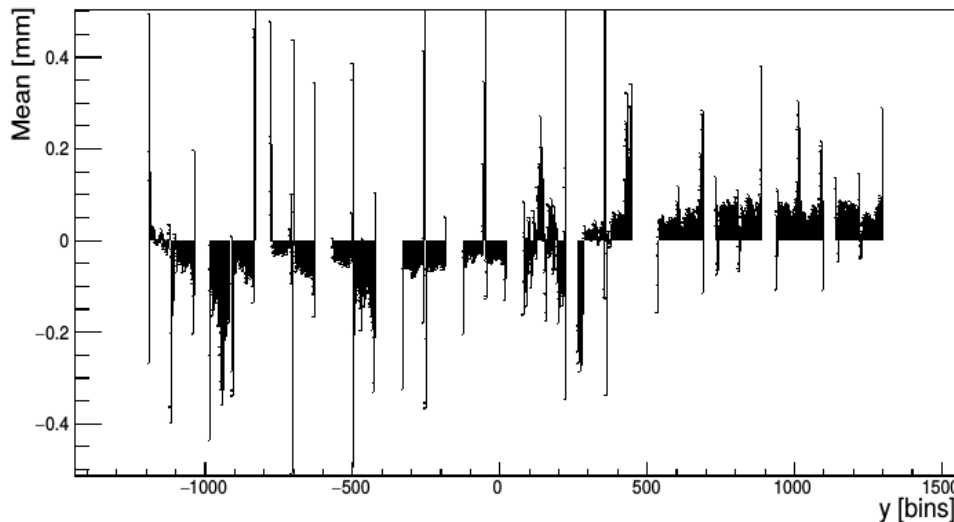
Chips on module: position precisely measured with microscope

→ try shifting/rotating modules

Residuals



Best result: both outer modules
Rotated by 0.92°

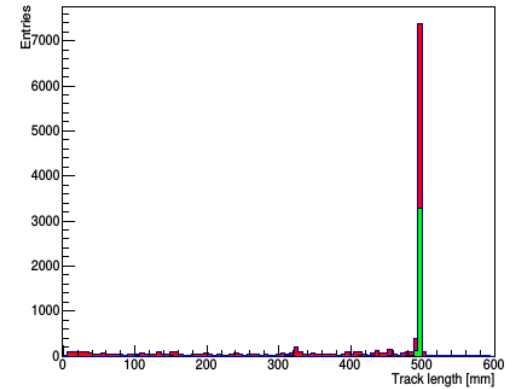
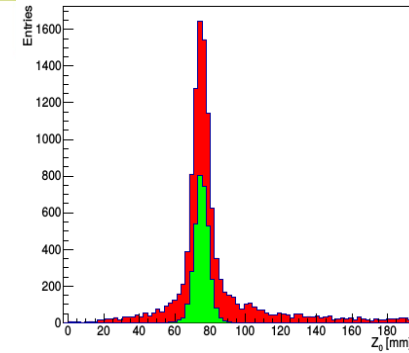
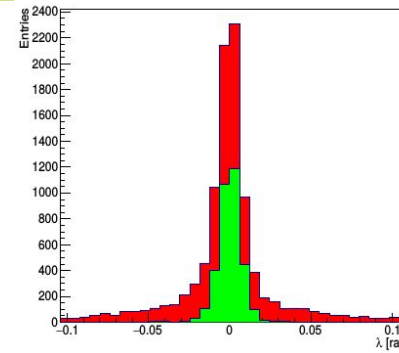
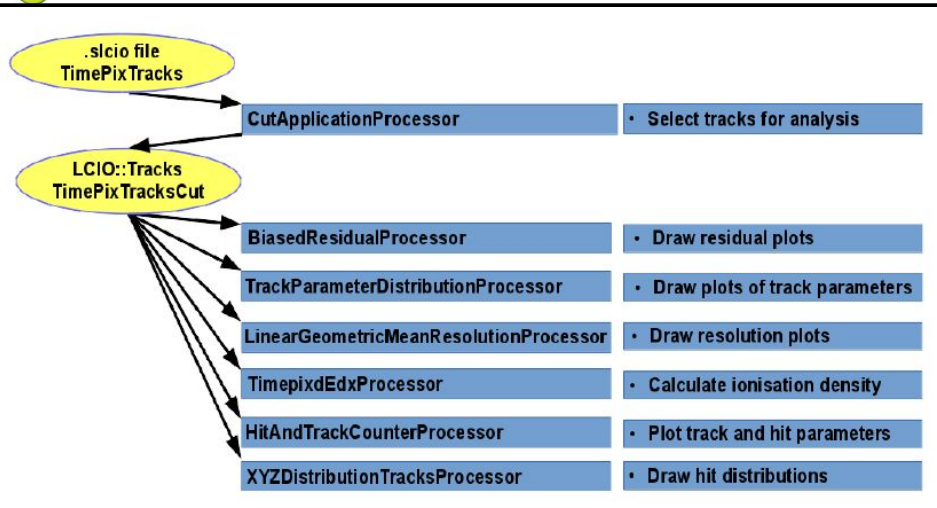


Try field correction:
Algorithm not suited, but gets a bit
▼ better

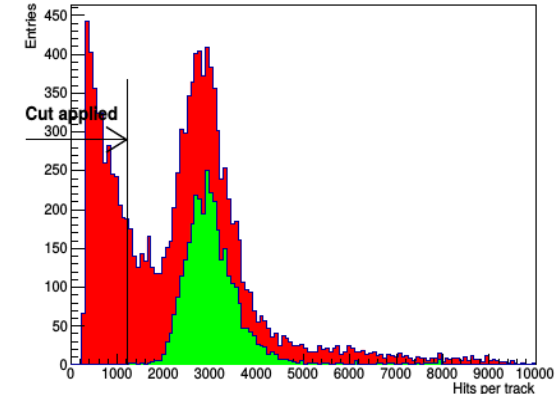
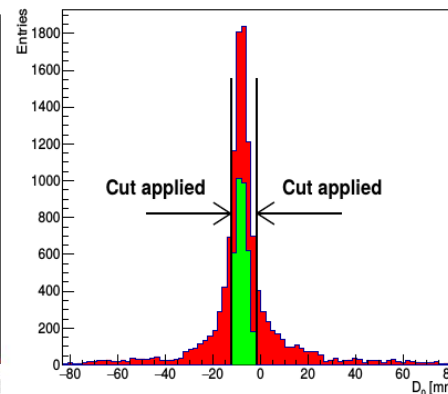
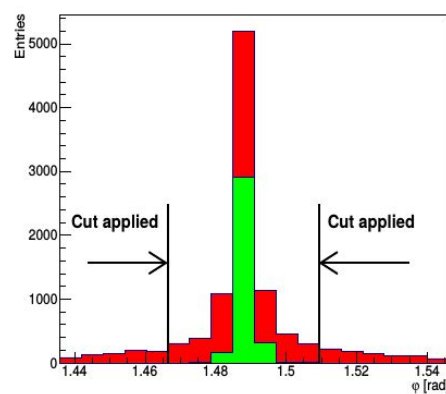
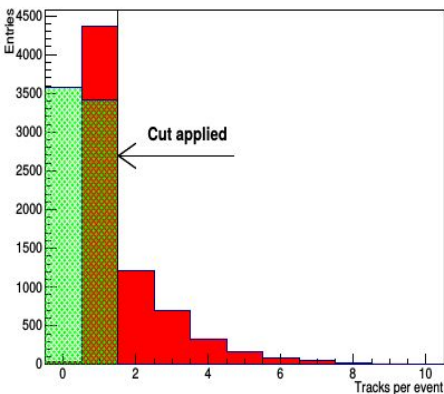
Problem: Algorithm for 2013 data,
where chips were in a row, beam along
chips \rightarrow correction only in one direction.
2015: staggered chips \rightarrow would need
2D map

To use algorithm at all: hard cut on D0
to restrict beam on small area

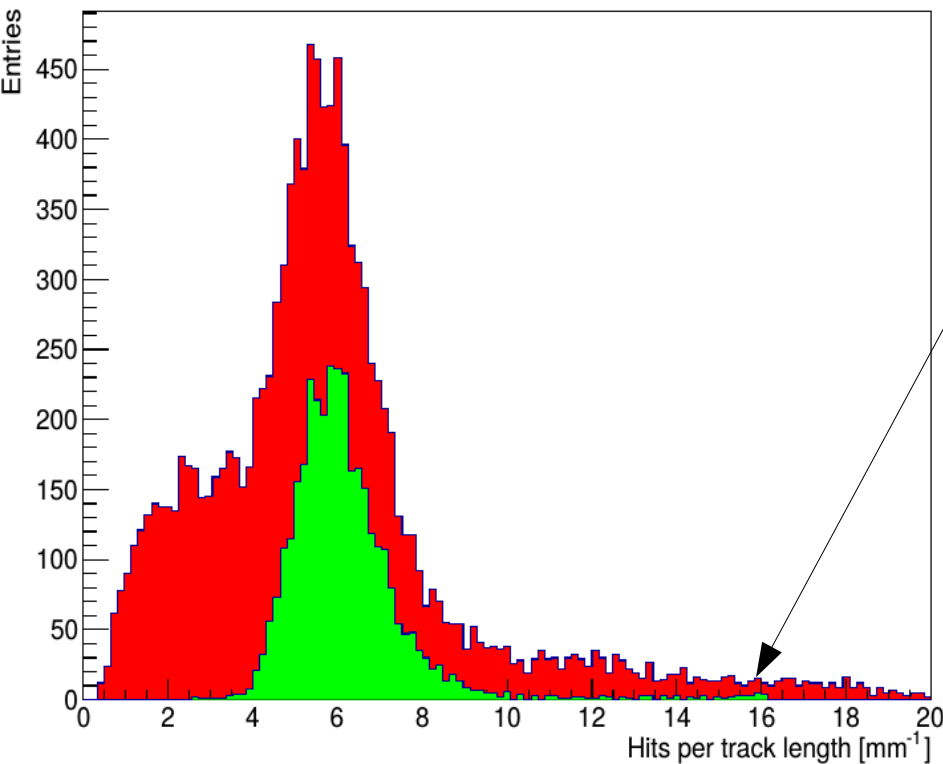
Analysis: Cuts



Cut	none	+ single tracks	+ ϕ	+ D_0	+ number of hits
Number of accepted tracks	12401	4322	4224	3419	3418
Accepted tracks [%]	100	35	34	28	28



Analysis: Energy loss



Unresolved double tracks

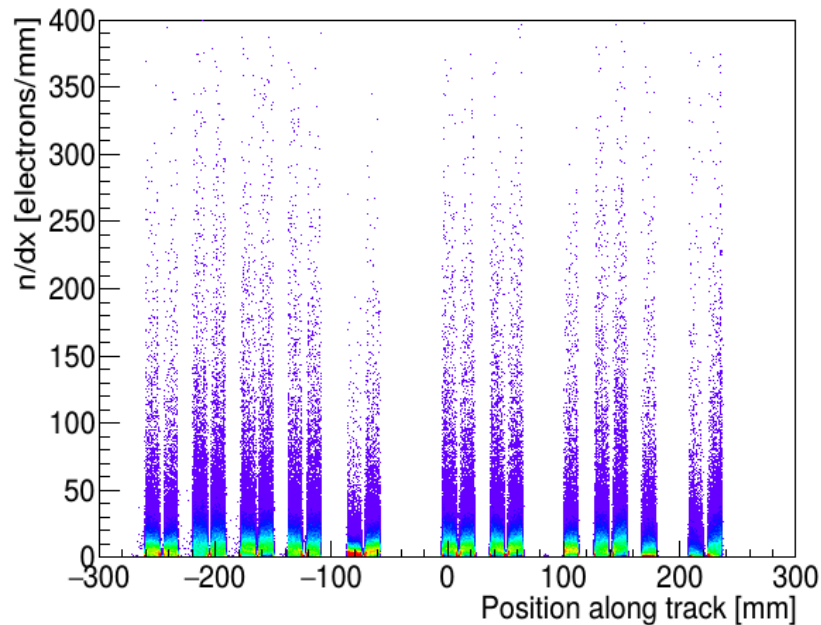
Resolution rms/mean: $(23.9 \pm 0.7) \%$
Resolution fit sigma/mean: $(15.4 \pm 0.7) \%$

Expected (Allison & Cobb): 14.06 %

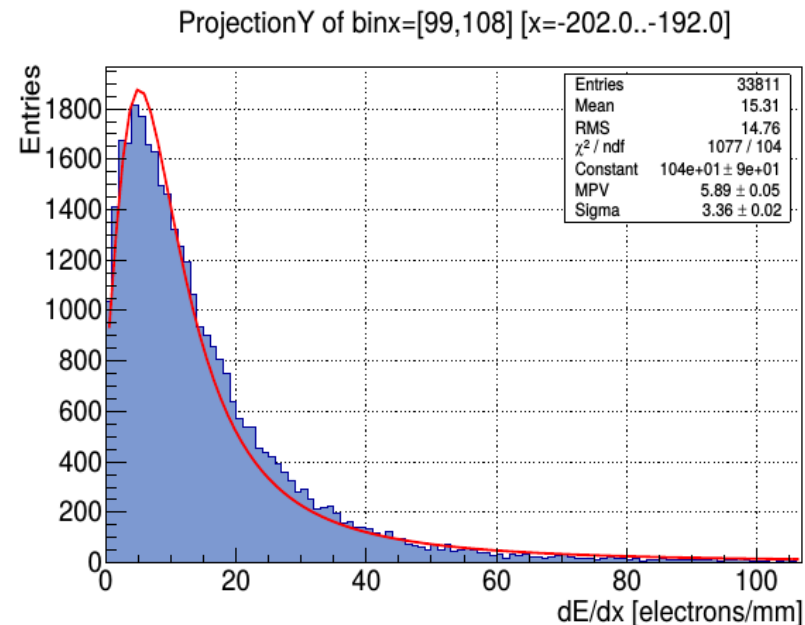
→ try to find better measure

Track length: 50 cm including dead chips, gaps
Corrected track length: 28.0 cm → ≈ 109 e/cm

Analysis: Energy loss



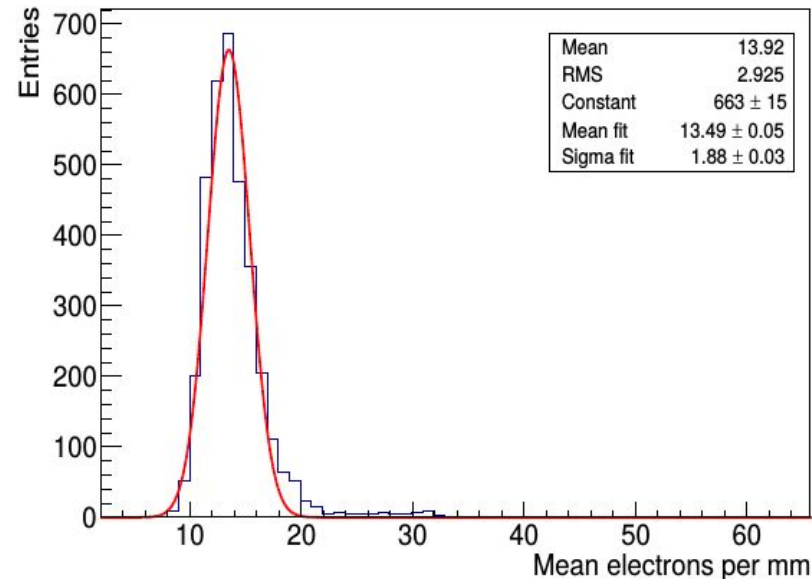
(a) Number of hits in slices along the track.



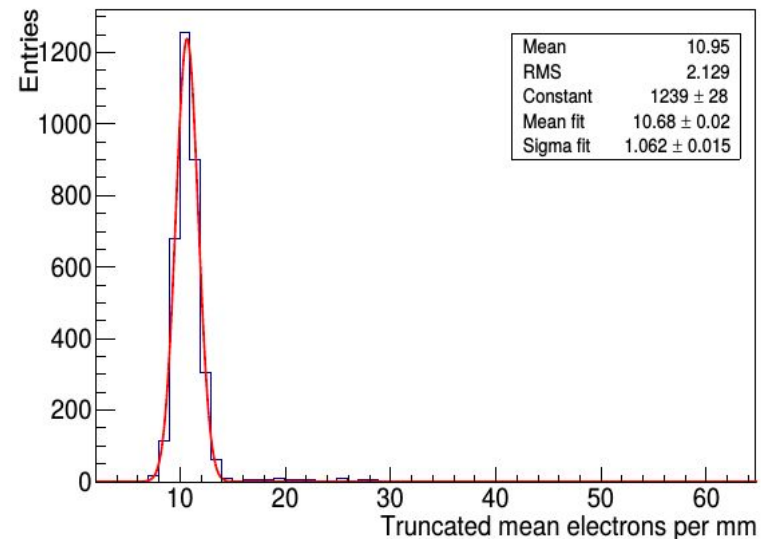
(b) Projection of Figure 8.29a on the n/dx axis for a 10 mm wide region in a chip center fitted by a Landau distribution.

Figure 8.29: Number of hits along the track in 1 mm slices along the track.

Analysis: Energy loss



Mean number of hits in intervals of 1 mm along the track with a resolution of (14.0 ± 0.3) % in the peak fitted by a Gaussian distribution.



Truncated mean (reject 5% highest, 5 % lowest means) number of hits in intervals of 1 mm along the track with a resolution of (9.9 ± 0.5) % in the peak fitted by a Gaussian distribution.

Expected: 7.57 % → 31 % off/room for improvement

Analysis: Energy loss



Extrapolation to ILD:

Allison & Cobb, 1mm intervals:

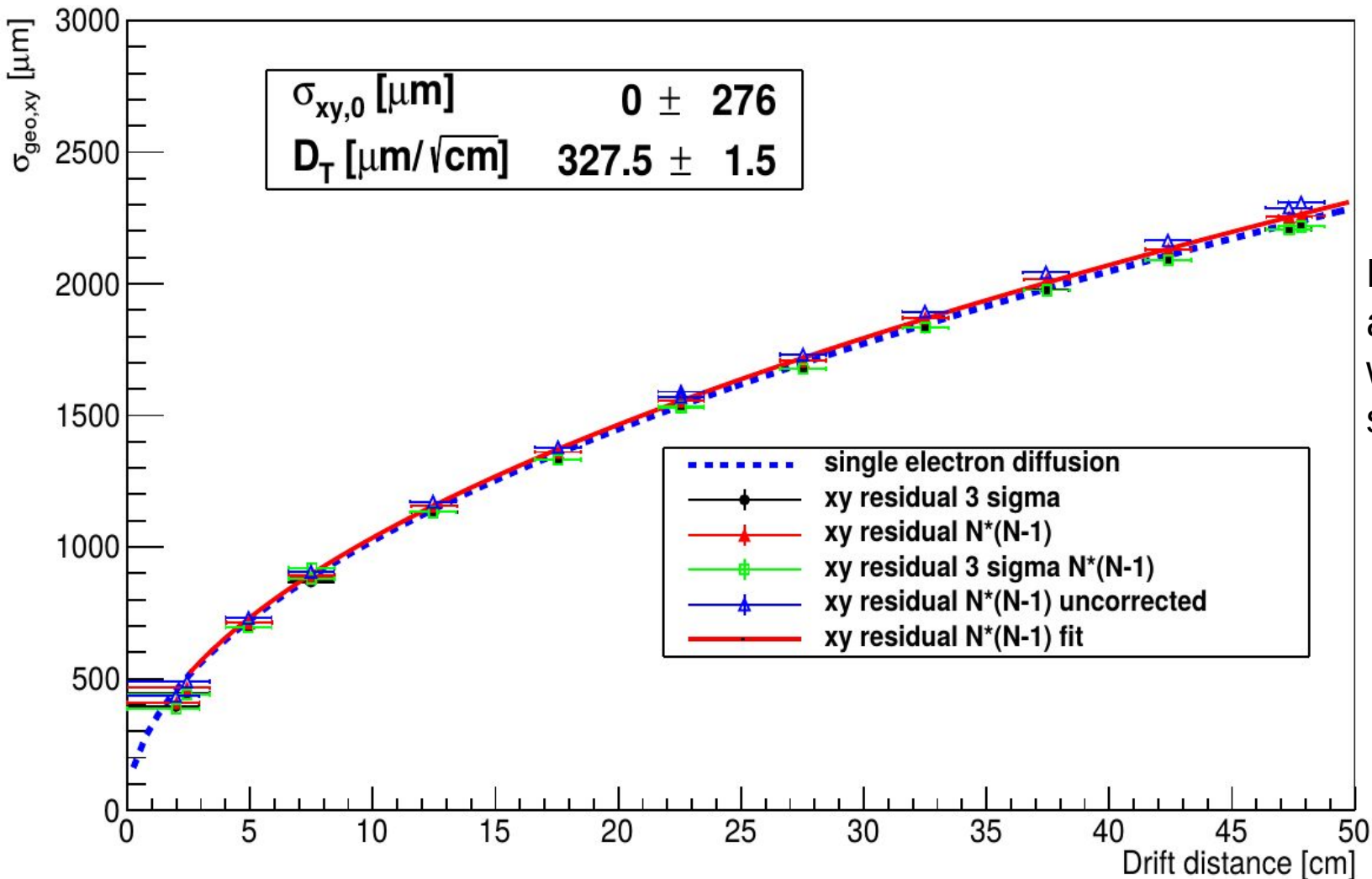
$L_{\text{total}} \approx 1.5 \text{ m}$ (full Pixel-TPC): 3.84 %

$L_{\text{pixel}} = 1.01 \text{ m}$ (current module layout Pixel-TPC): 4.36 %

With current 31 % inefficiency: 4.81 / 5.71 %

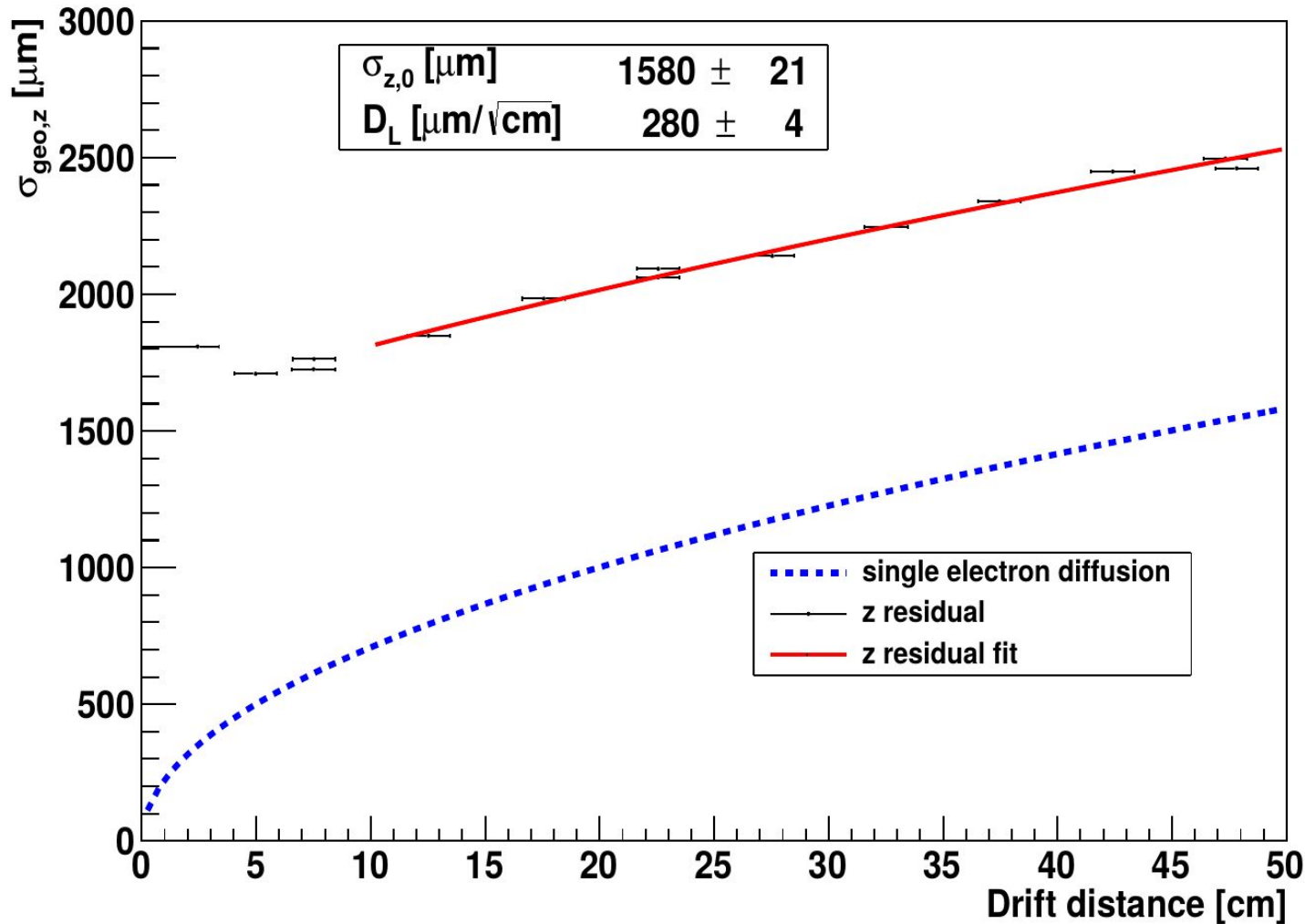
Improvement: search for better measure, e.g. only central chip areas, harder truncation...

Transverse spatial resolution



D_T in agreement with simulation

Longitudinal spatial resolution



Similar to 2013 result

Expected $\sigma_{z,0}$:
40 MHz clock:
750 μm

Diffusion not in agreement with simulation

- different effects
- field distortions in z

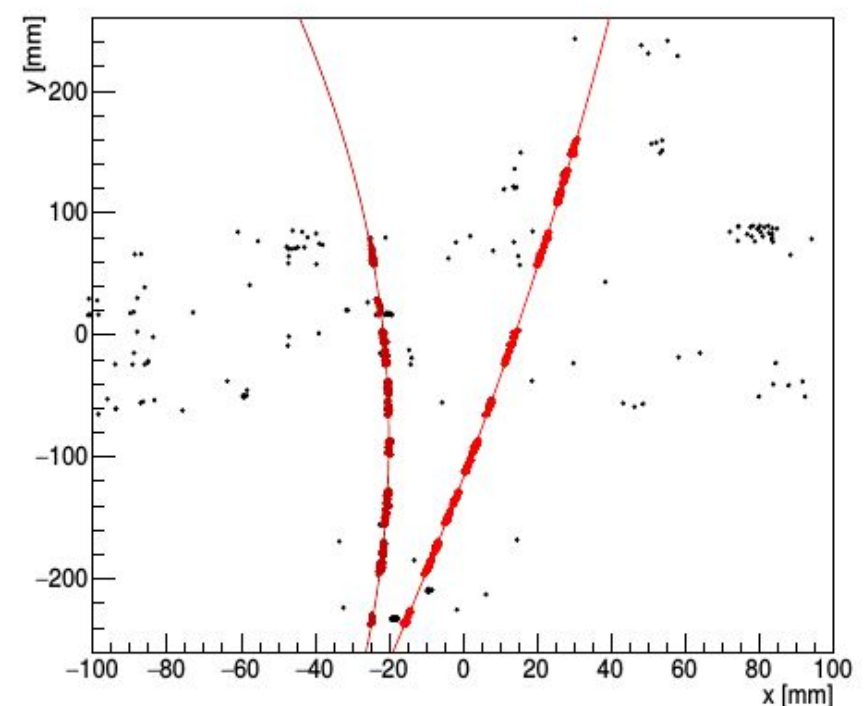
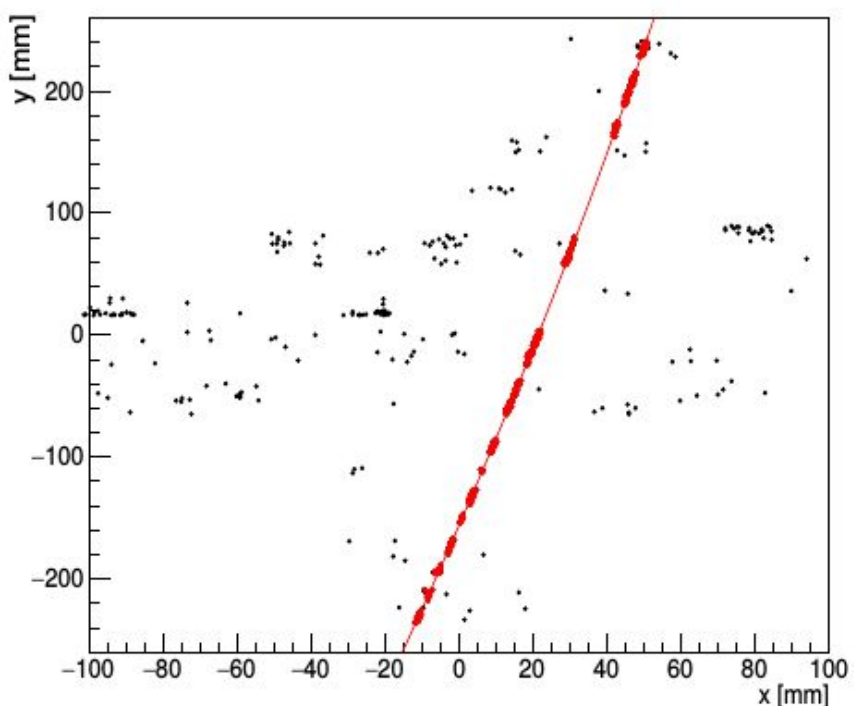
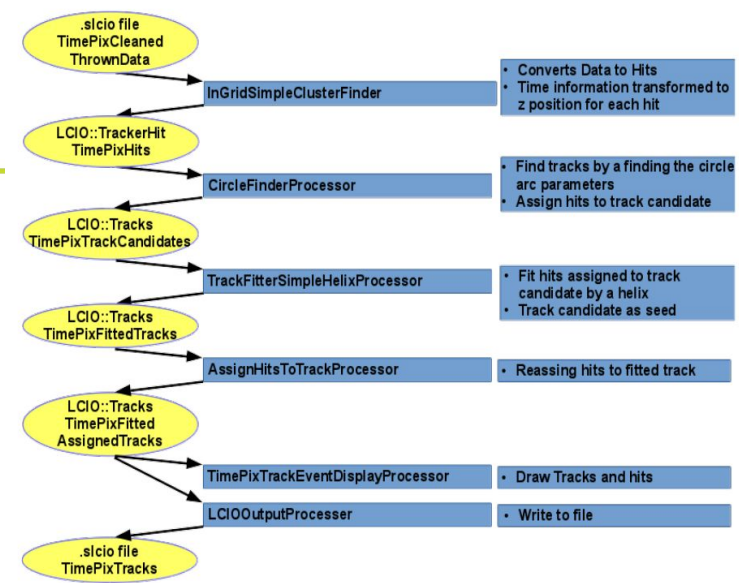
Curved track reco

New track finder: circle finder

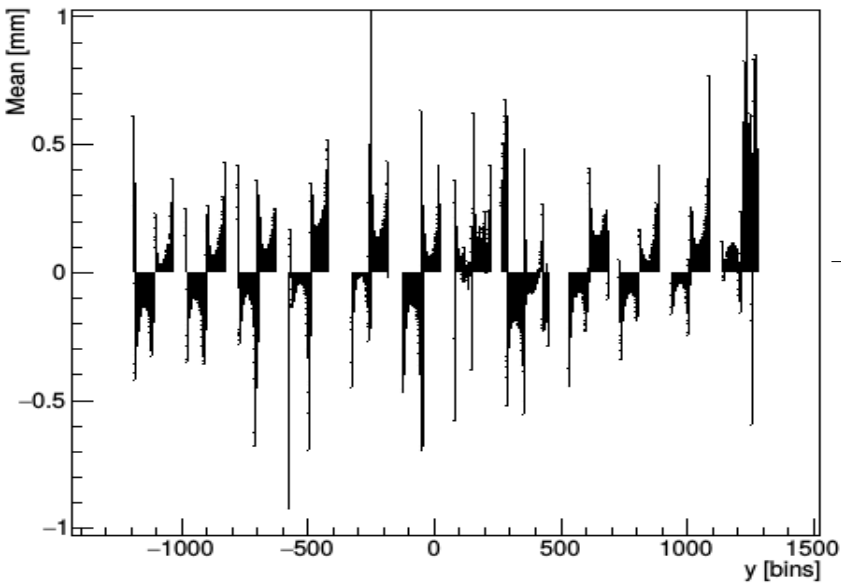
→ see LCTPC-Pixel Meeting 23.07.2015

Reason: no working finder for pixelised data,
checked: FHT, WindowedHT, HT+helix fit

Track finder method	Found	Partially found	Multiple found	Fake	Not found
Eye	109	0	0	0	0
CircleFinder	73	0	1	5	36
Hough transformation	54	31	15	11	9

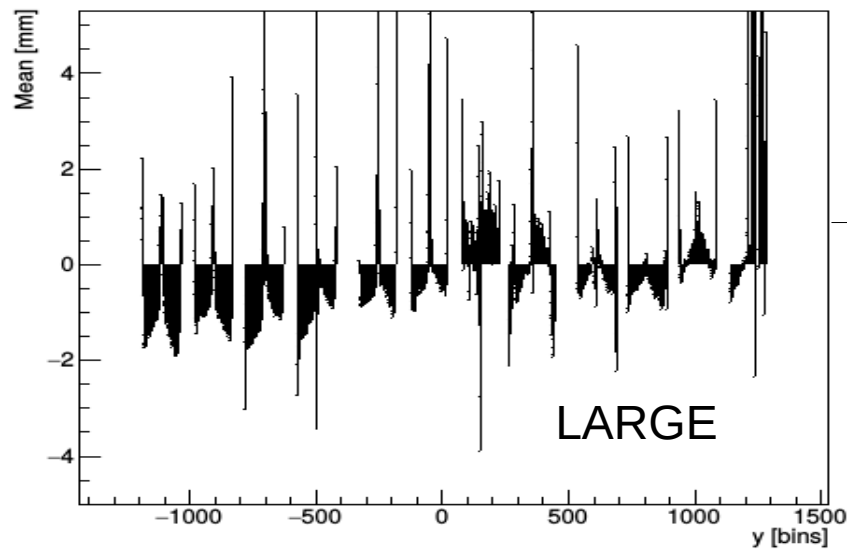
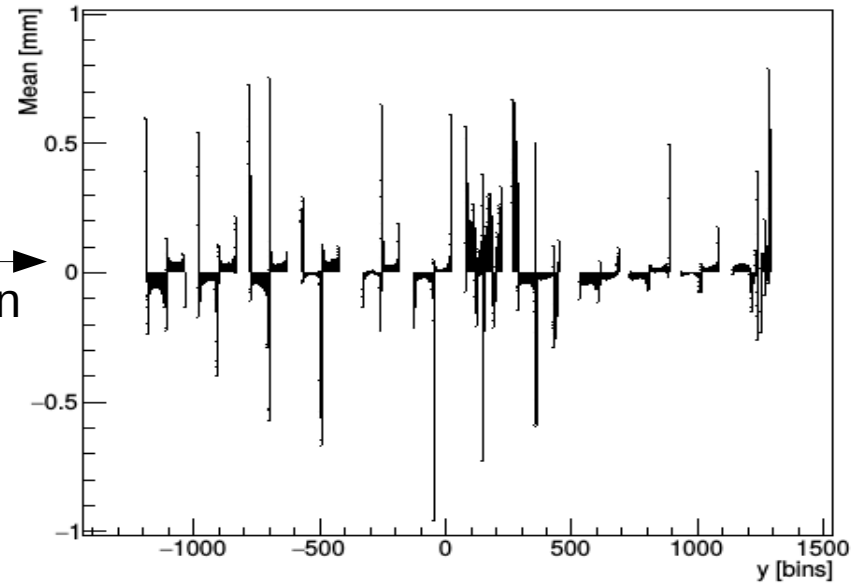


Field distortions



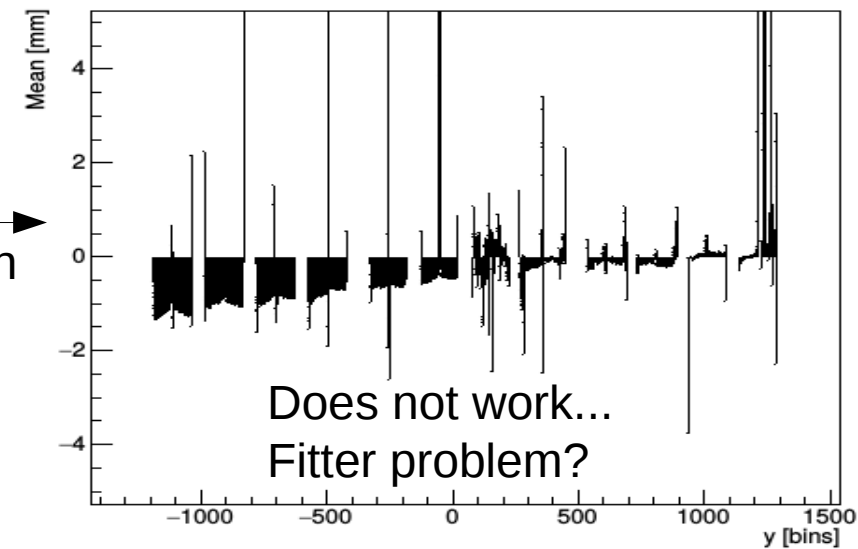
XY

Correction

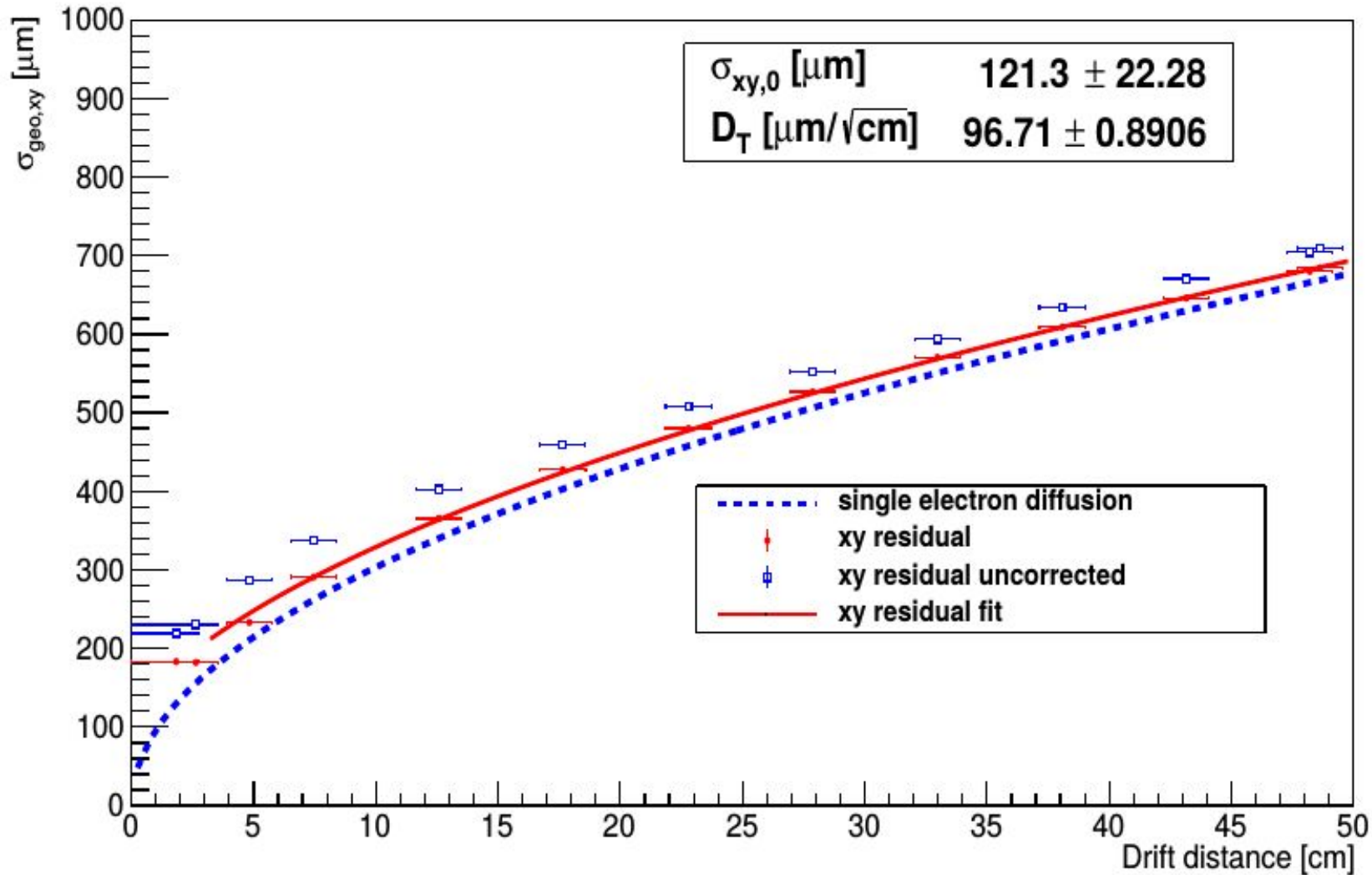


Z

Correction



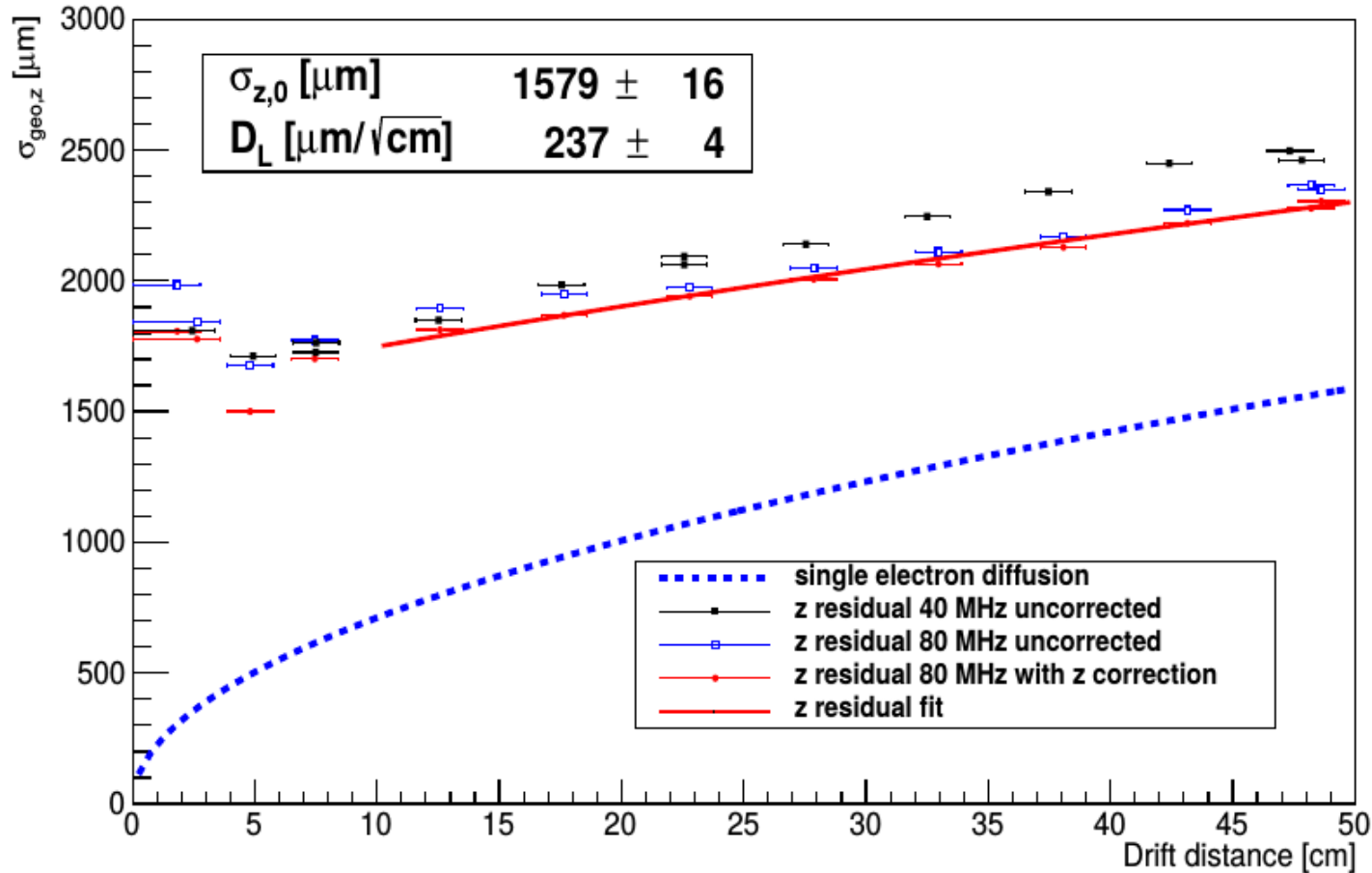
Transverse spatial resolution



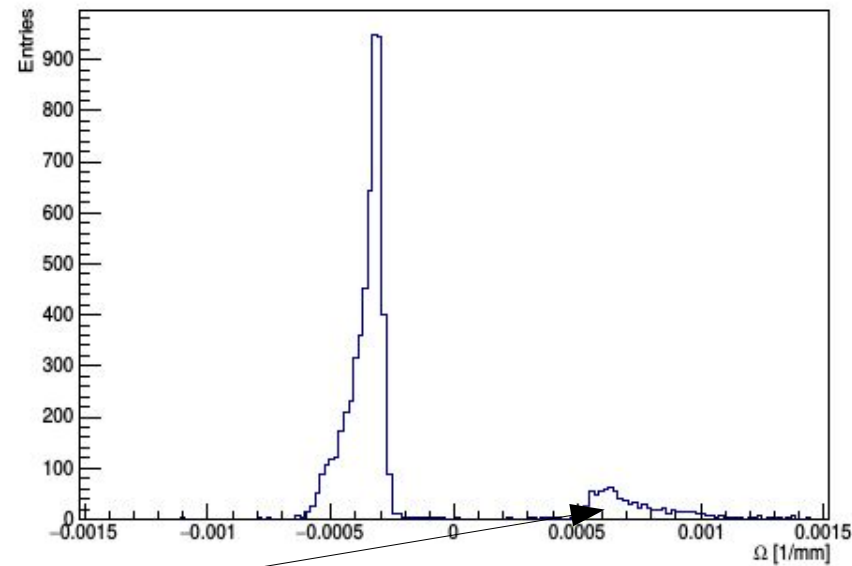
Longitudinal spatial resolution



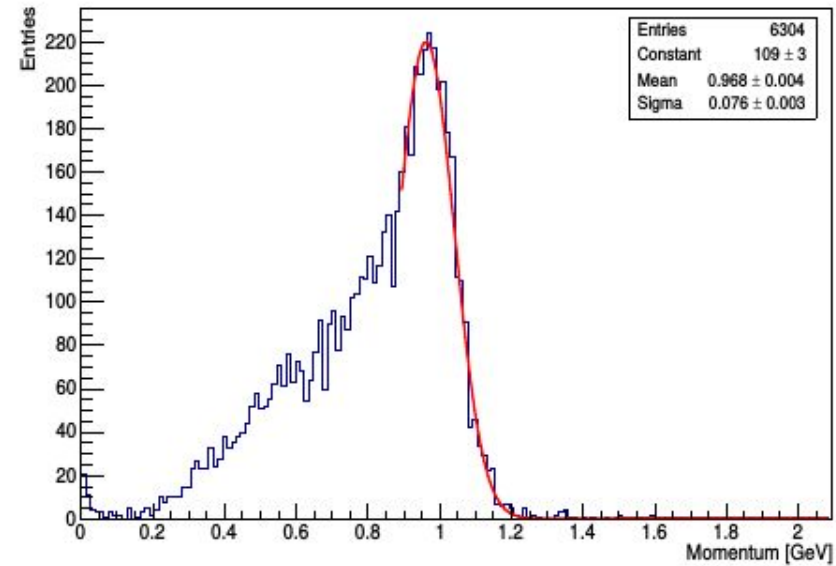
80 MHz sampling frequency used → should improve, does only bit Z field distortion dominate (?)



Momentum measurement



Antiparticles, lower momentum
→ pair produced (?)

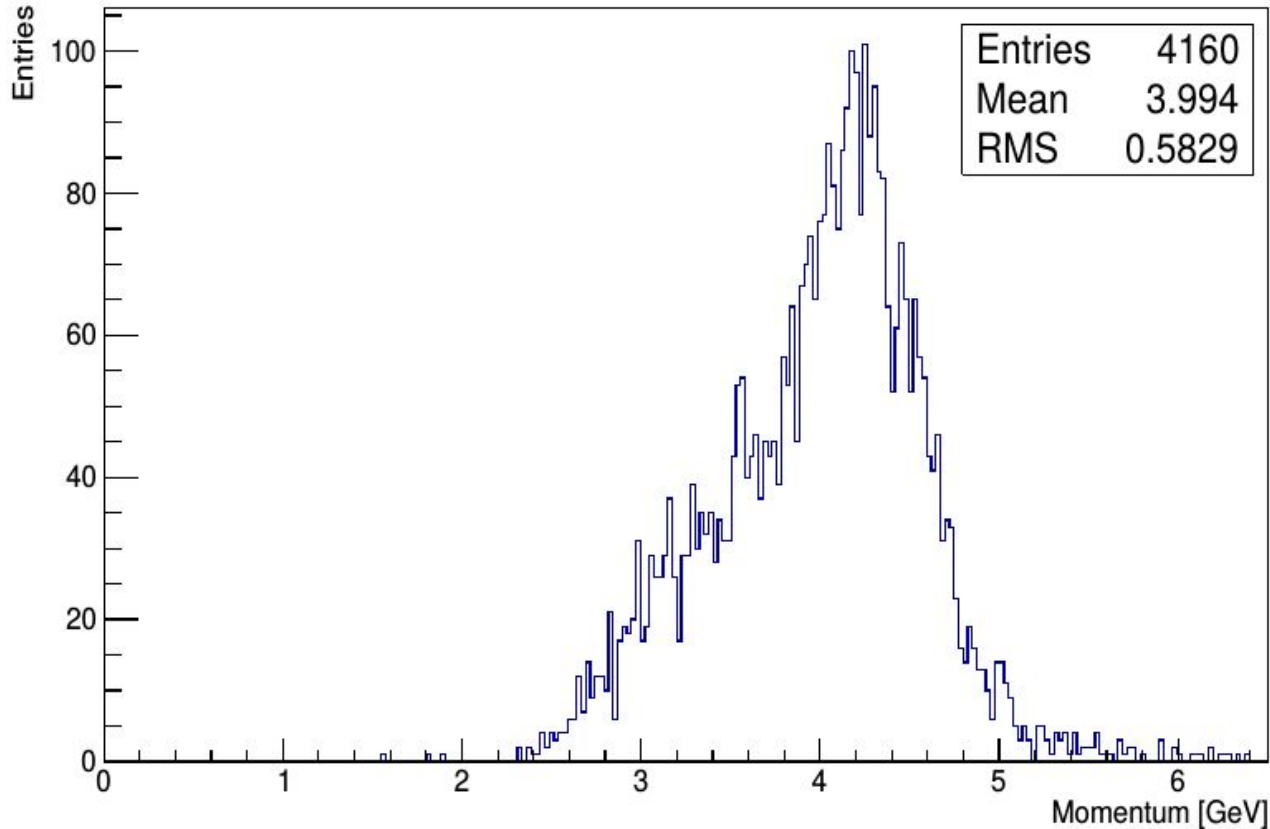


1 GeV run: resolution 8.07 %
Expected:
Gluckstern: 0.16 %
Multiple scattering: 0.73 %
Beam spread: 6.36 %

Momentum measurement



Higher momenta: not correctly reconstructed. Fitter problem? Alignment?



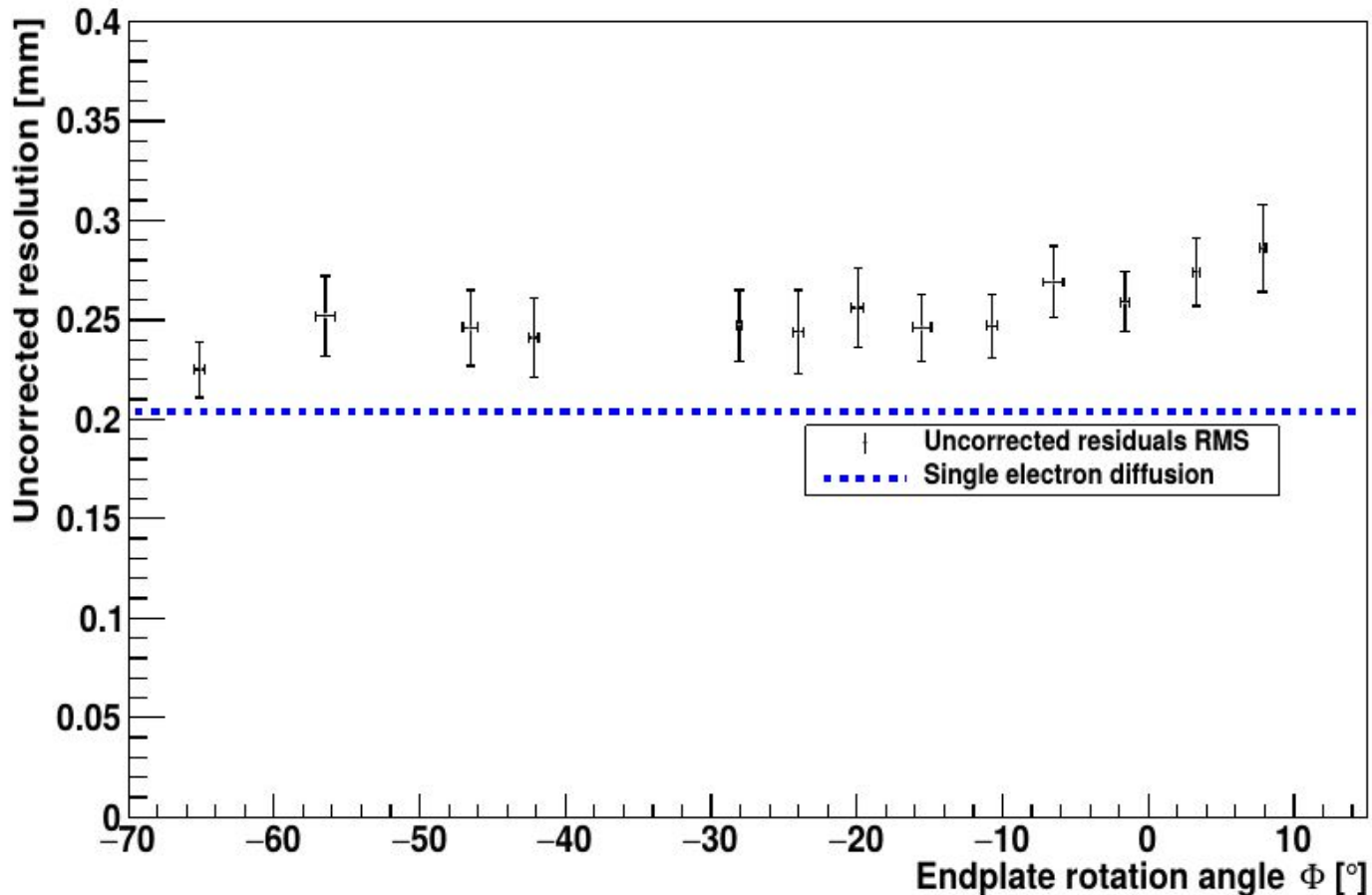
Transverse spatial resolution



For different track angles

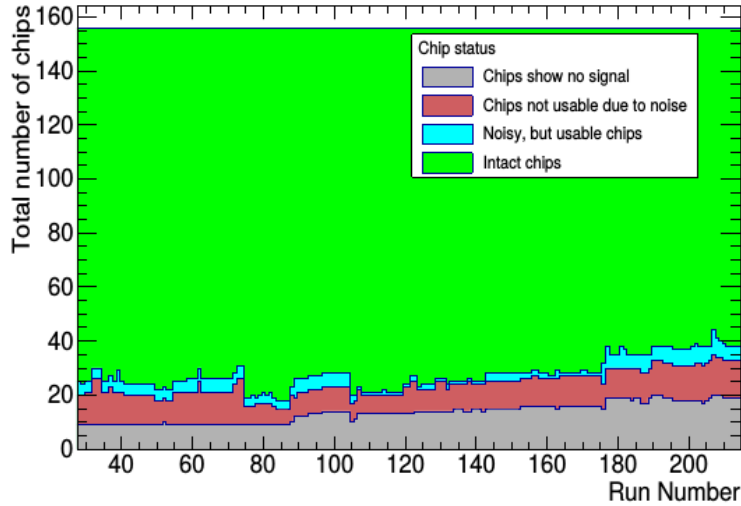
Error bars: not errors of residual rms (would be $<$ dots because of large number of hits)

Represent fluctuations of residuals for tracks

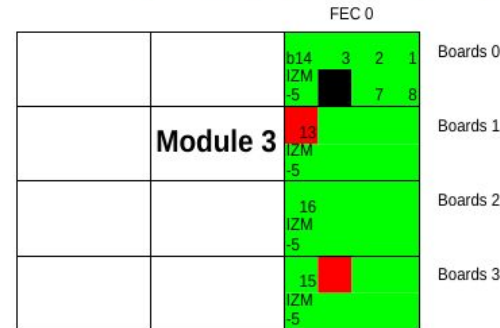
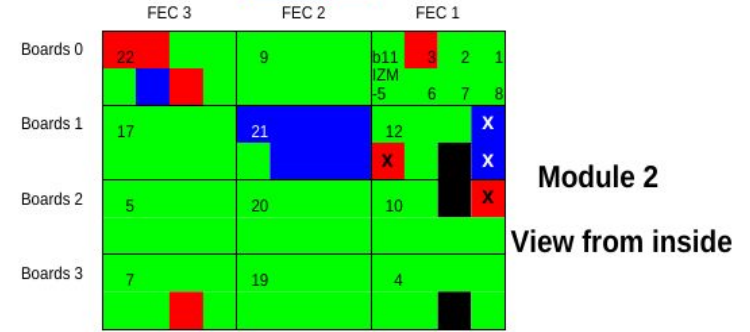
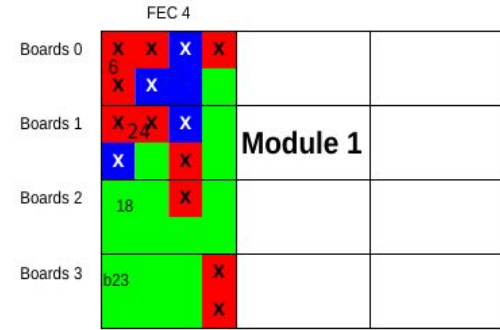
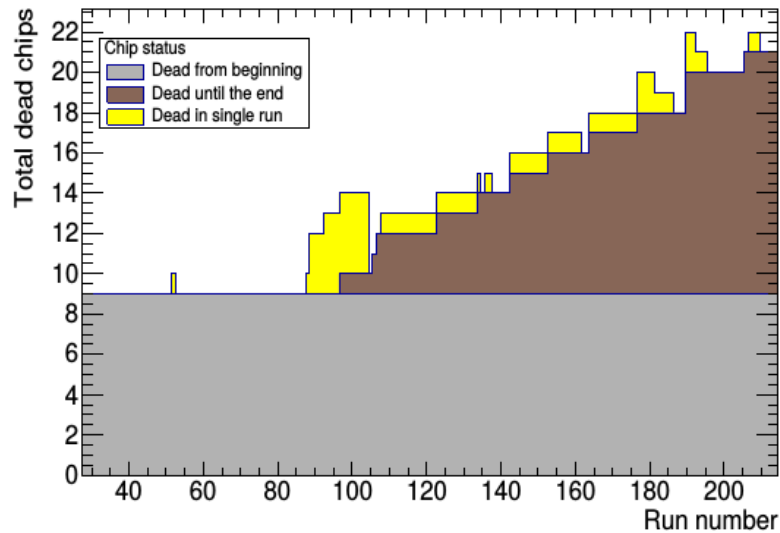


Died chips

Chips operational in the test beam



Categories of dead chips



Green: ok, red: dead, blue: noisy, black: unconnected
x: additionally after test beam

The end



Thanks to all of you!

