Tracking test bench for the GEM TPC

First results of data analysis

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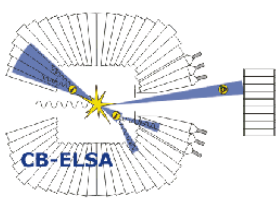

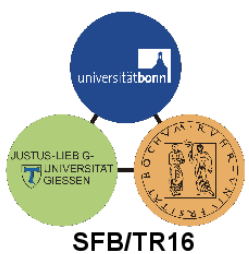

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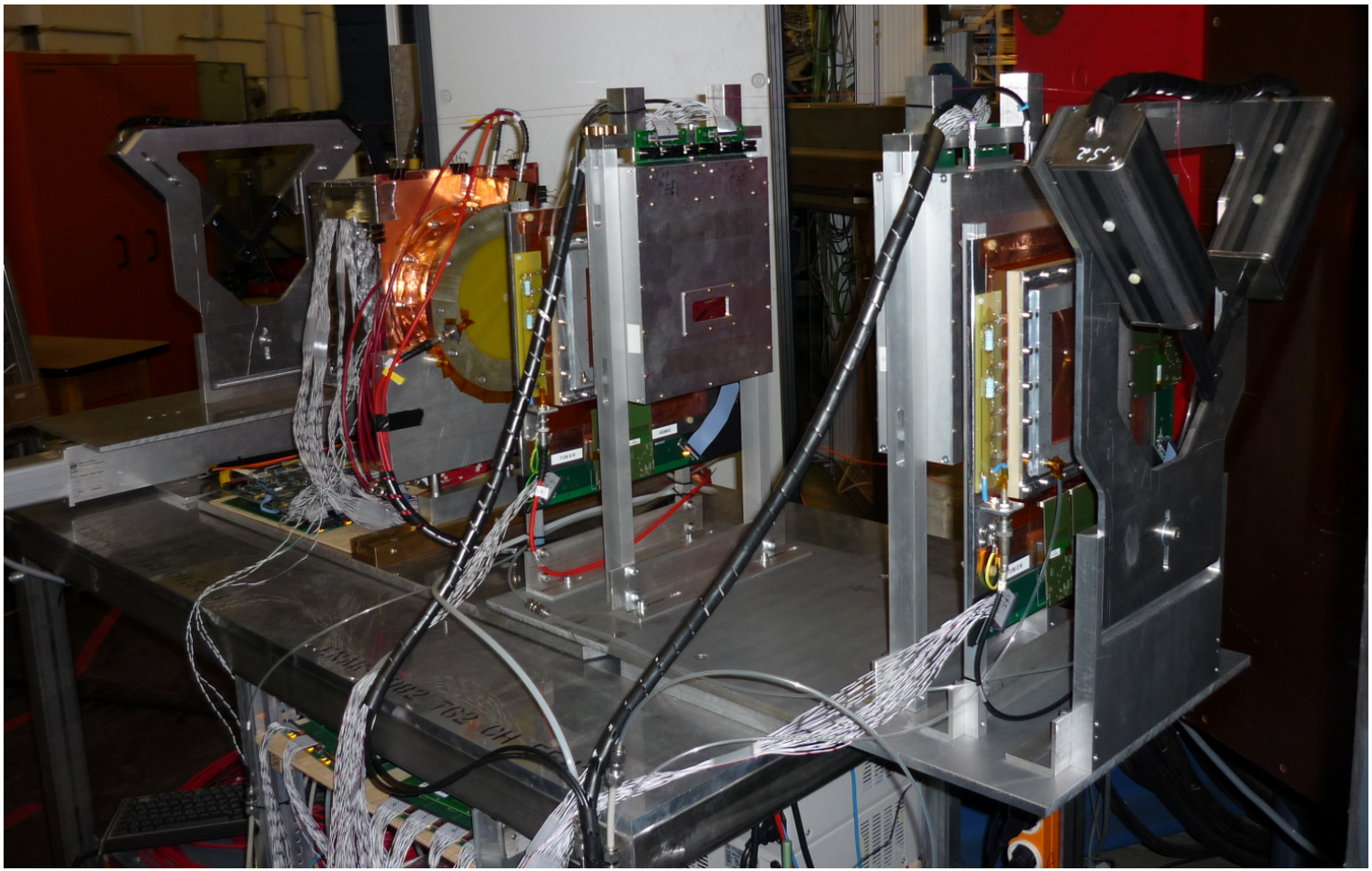
Aim of the tracking test bench

Aims and goals of the tracking test bench

- Test performance of a GEM TPC
- Investigate TPC components like FEE
- Develop and apply analysis software to real data
- Achieve experience in commissioning and operation of a TPC

Tracking test bench at ELSA in Bonn



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Analysis of beam telescope data

Data processing chain

- Raw data decoding, error detection, data mapping

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Analysis of beam telescope data

explora
extended plugable objectoriented root analysis

Data processing chain

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- Clustering in 1 dimension

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Analysis of beam telescope data

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- Generation of 2D hits per detector

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- Determination of 3D offsets ($\rightarrow$ 3D hits)

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Data processing chain

- Raw data decoding, error detection, data mapping
- Clustering in 1 dimension
- Generation of 2D hits per detector
- Determination of 3D offsets ($\longrightarrow$ 3D hits)
- Track fitting, calculating residuals

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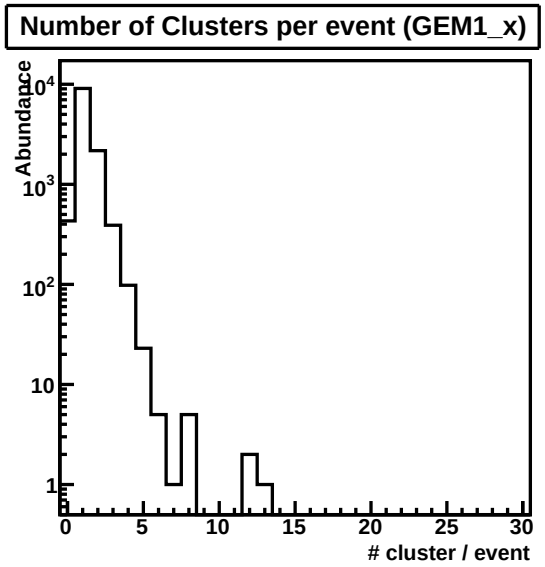
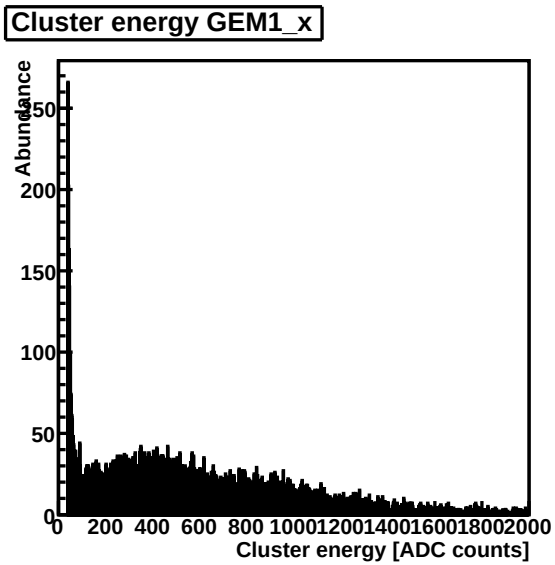
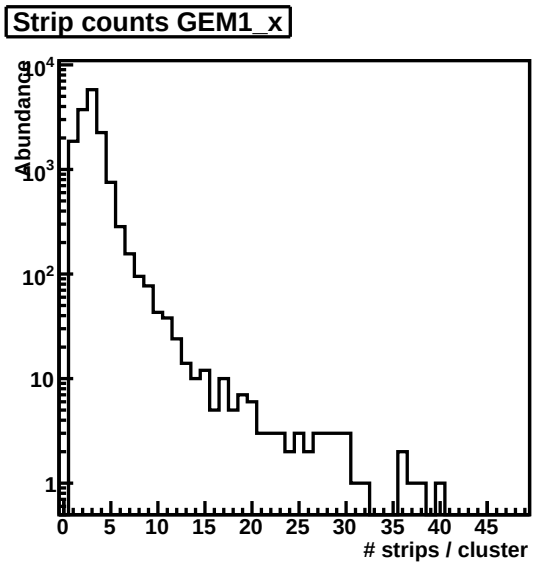
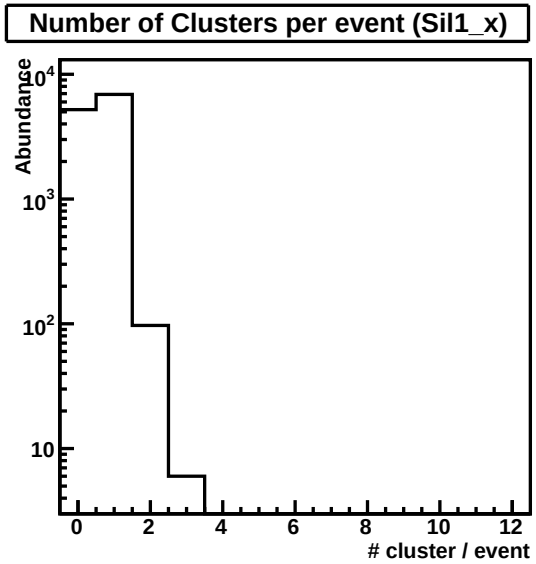
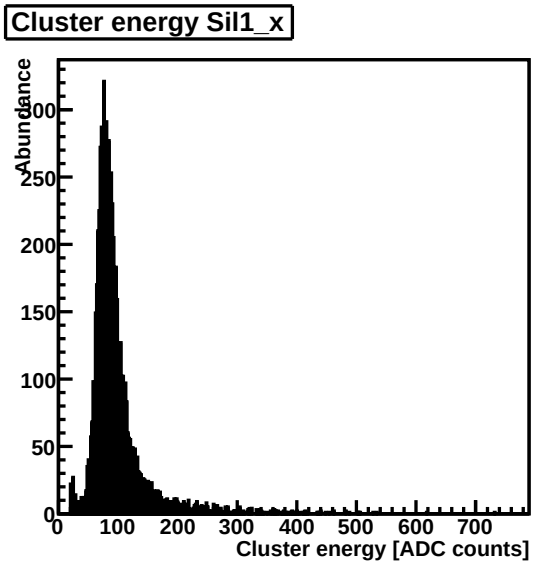
1D Clustering

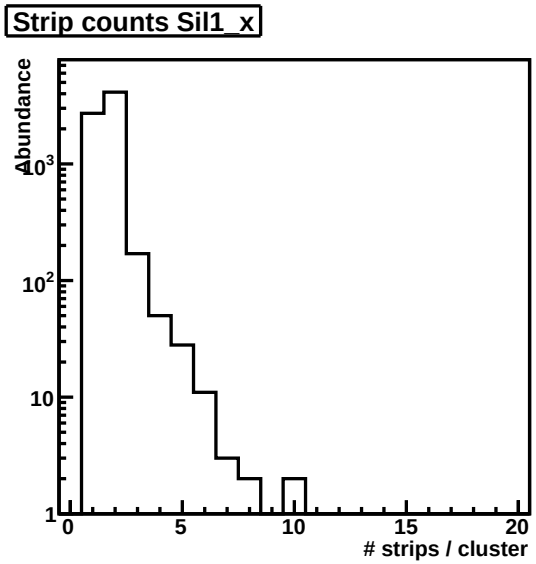




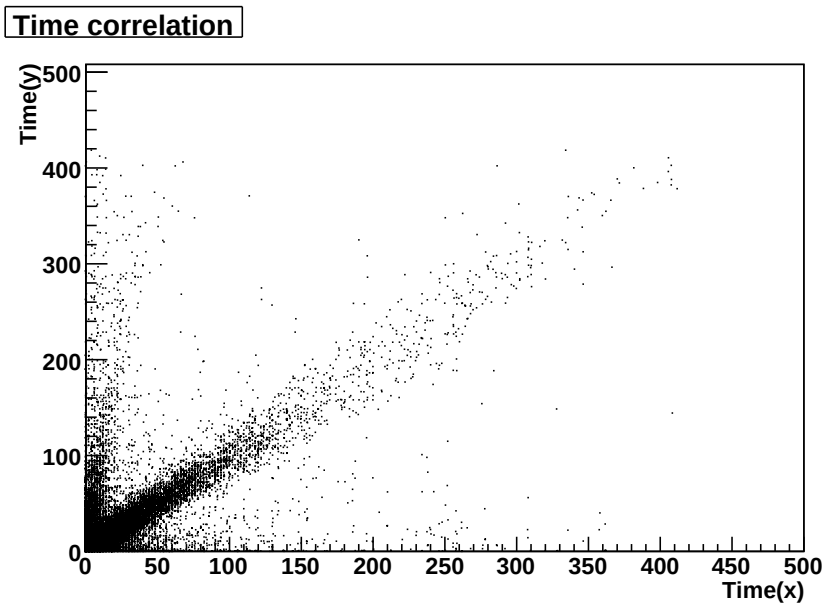


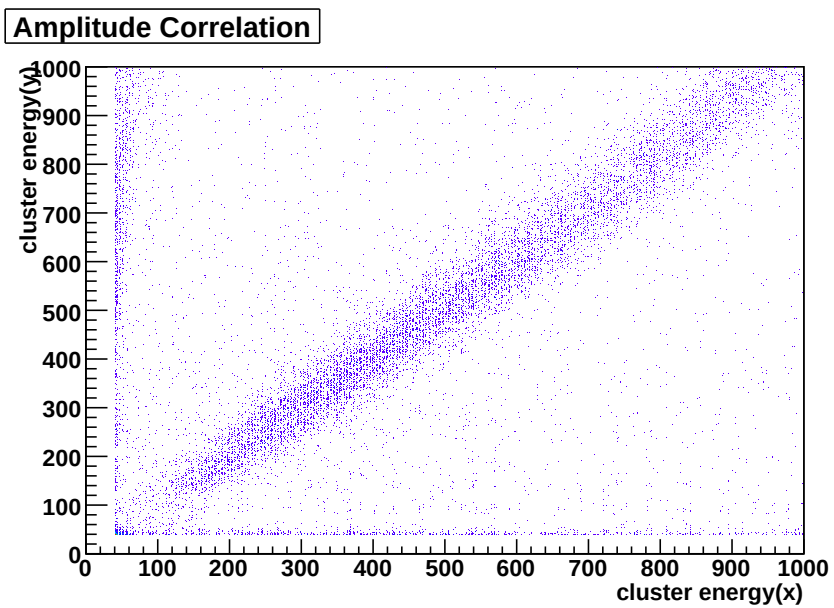






2D hit matching





Matching methods:

- Combinatorial
- Amplitude (GEM)
- Time (GEM & Sil)

Goals:

- Get rid of noise
- Find real hits

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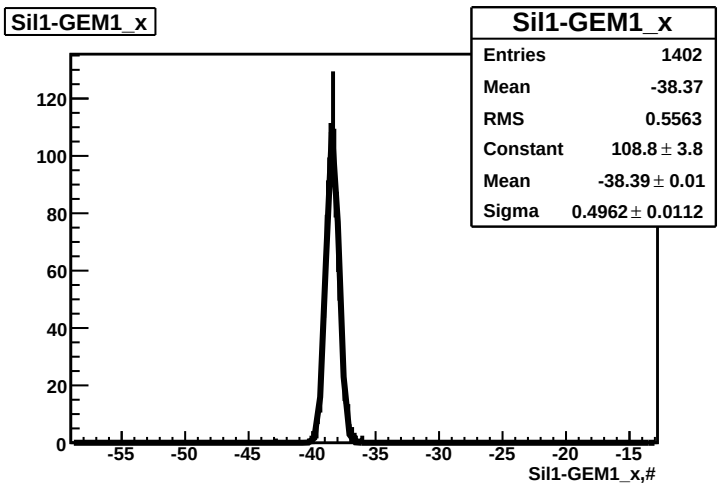
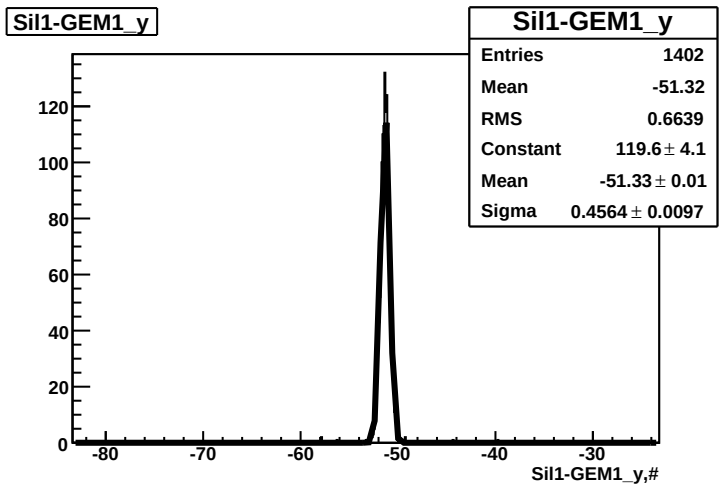
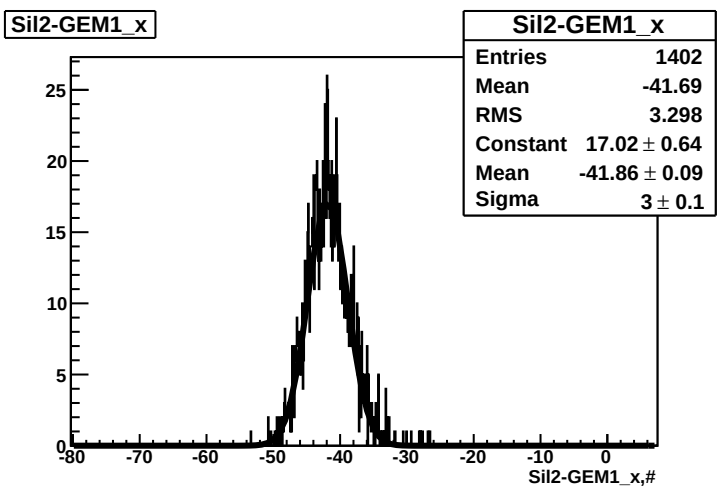
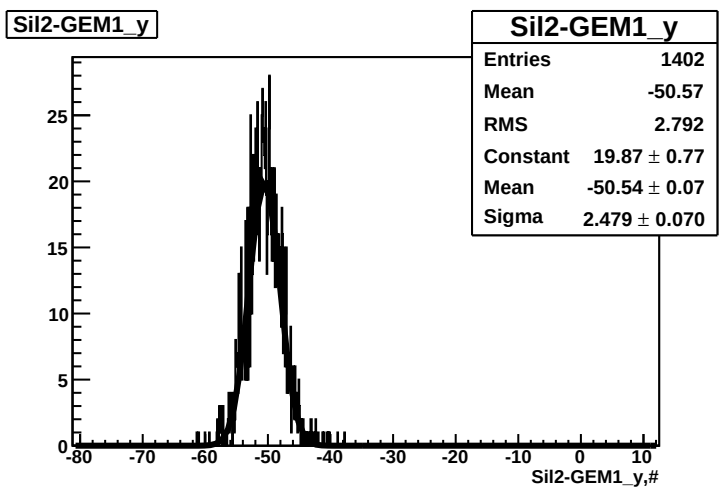
3D detector offsets

Determine x and y offsets by plotting det1_x - det2_x ...









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3D detector offsets

Determined Offsets

	x coordinate	y coordinate	$\langle z \rangle$ coordinate
GEM1	0.0 mm	0.0 mm	0.0 mm
GEM2	22.09 ± 0.01 mm	0.50 ± 0.09 mm	618.5 ± 0.5 mm
Sil1	38.39 ± 0.01 mm	51.33 ± 0.01 mm	85.4 ± 1.5 mm
Sil2	41.86 ± 0.09 mm	50.54 ± 0.07 mm	528.1 ± 1.5 mm

Inputs

- GEM1 is fixed as origin
- x and y offsets from delta plots
- z coordinates from photometry

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Track fitting

Track model

- Straight tracks
- Neglect scattering
- Take all 4 detectors

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χ^2 Minimization

$$\chi^2 = N \sum_i |(\vec{f}(z_i) - \vec{\xi}_i)/\epsilon_i|^2,$$

with ϵ_i = detector pitch (error), $N = \sum_i \epsilon_i^2$, $f(z_i)$ calc. position, $\vec{\xi}_i$ measured position.

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Residuals

Distance between track and detector hit:

$$r_i^x = \vec{f}(z_i) \cdot \hat{e}_x - \vec{\xi}_i \cdot \hat{e}_x$$

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Biased residuals

4 det. tracking $\longrightarrow$ Too good
3 det. tracking $\longrightarrow$ Too bad
Take the geometric mean
$\approx$ unbiased residuals
$\rightsquigarrow$ detector resolution

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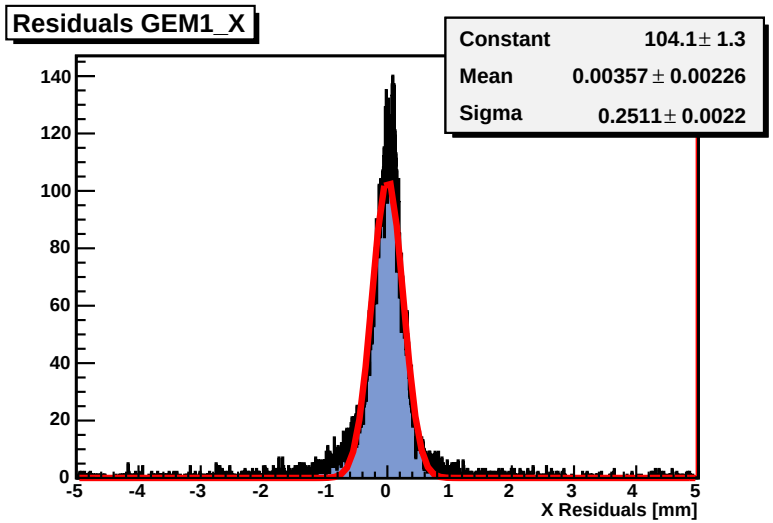
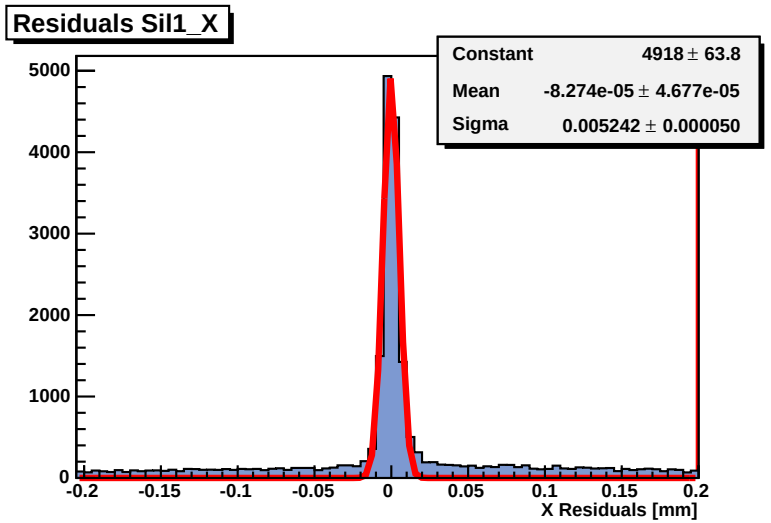
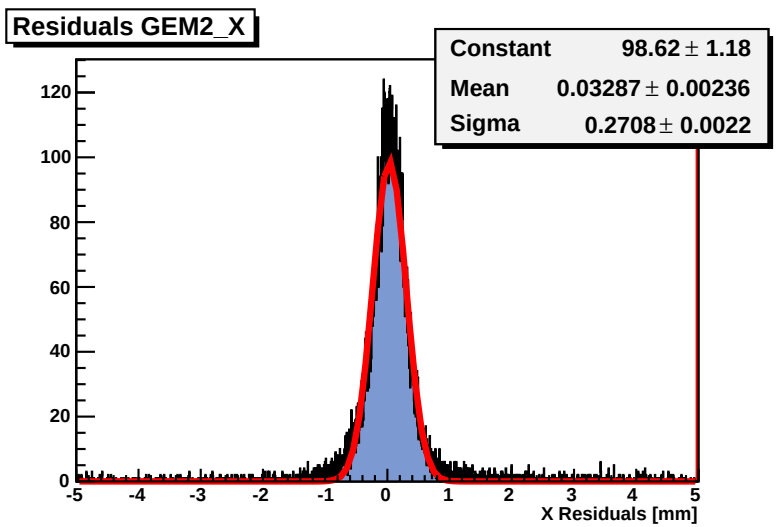
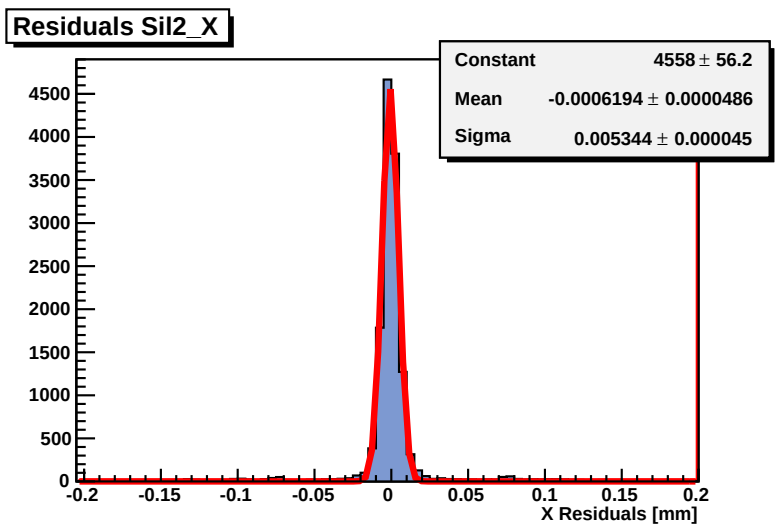
Biased residuals









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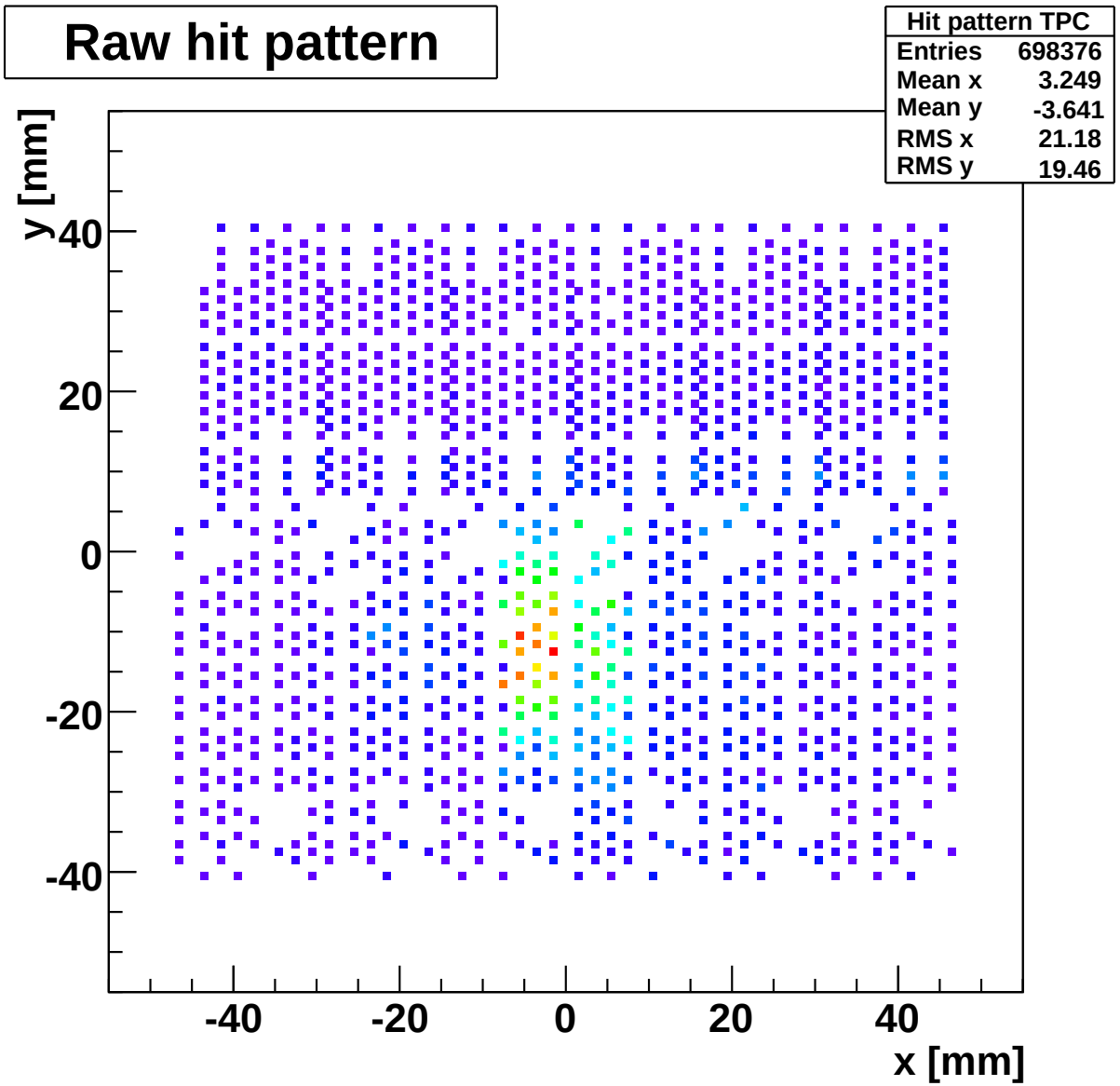
Hit pattern



Number of hits above a 5σ threshold.

Triggered beam spot visible.

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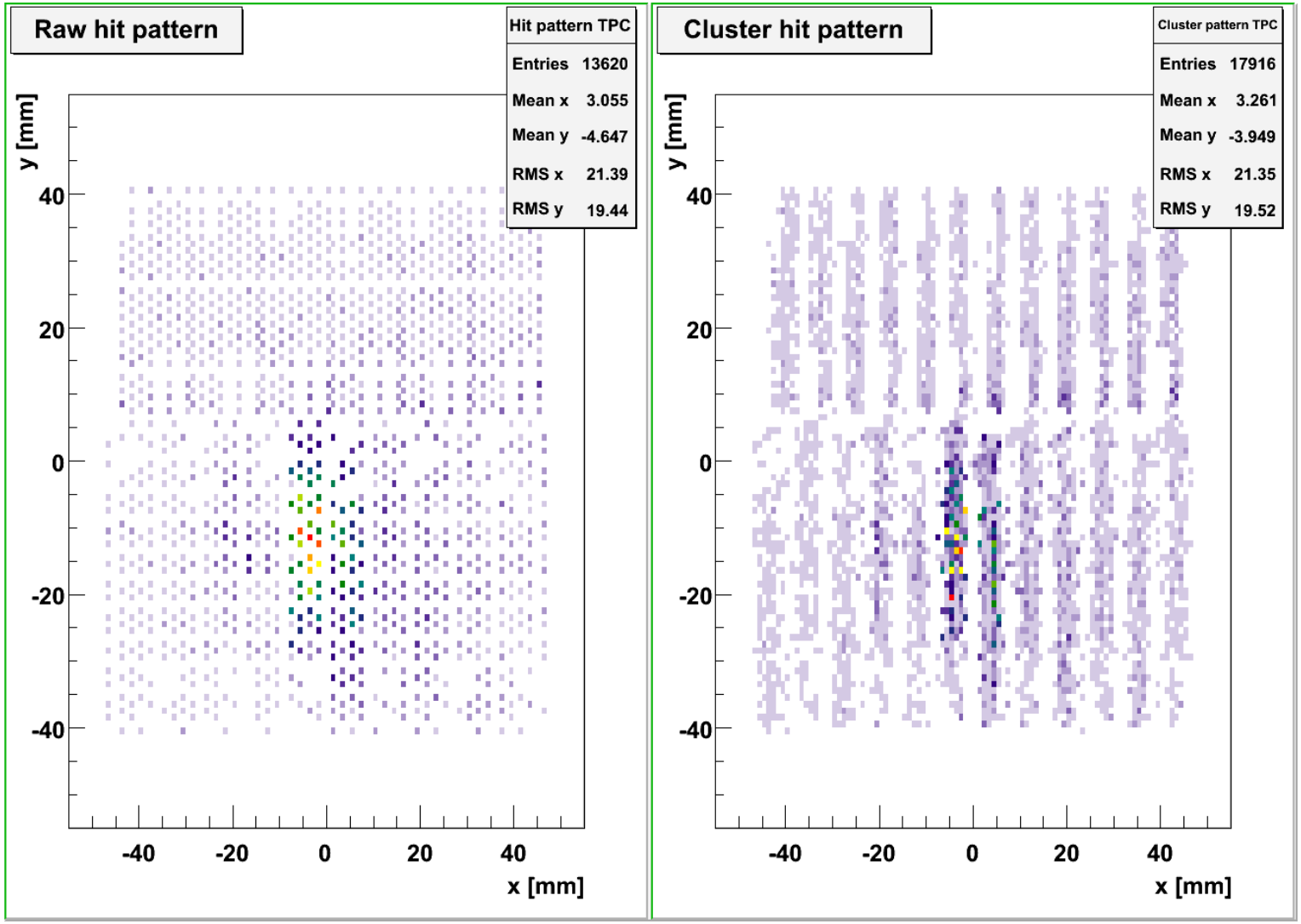
2D Clustering



Analysis of test TPC data

Done

- 2D clustering of hexagonal shapes
- Detector offsets determination
- TPC included in track fitting
- Generation of residual distributions

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Todo

- Investigate chip structure in cluster hit pattern
- Filter for correlated tracks
- Determine unbiased residual distribution

Summary

- Successful commissioning of beam telescope
- Development and application of tracking software
- Determination of biased residual distributions
- First results from test TPC obtained

Outlook

- Elaborate unbiased residuals
- Improve TPC clustering and residuals