Alignment of silicon strip detectors on a micrometer scale

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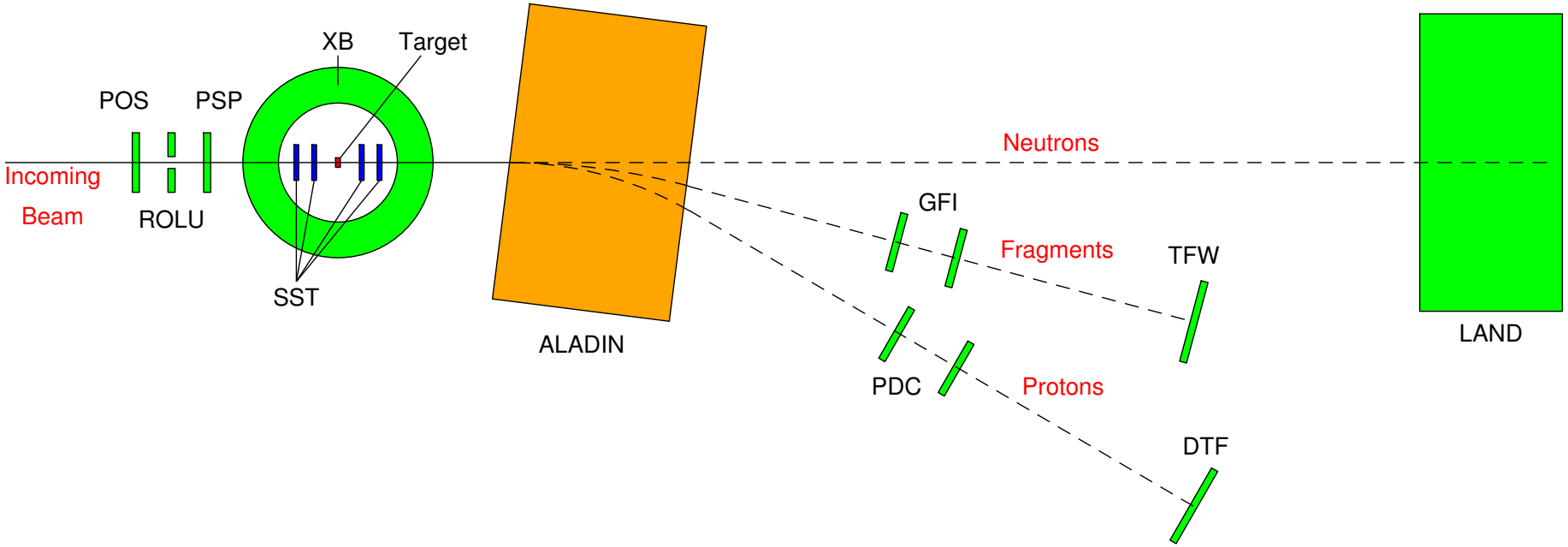
Outline

- The Land-setup and the SST-detectors
- Aligning the detectors
- Results
- Calibrate position sensitive PIN diodes
- Summary

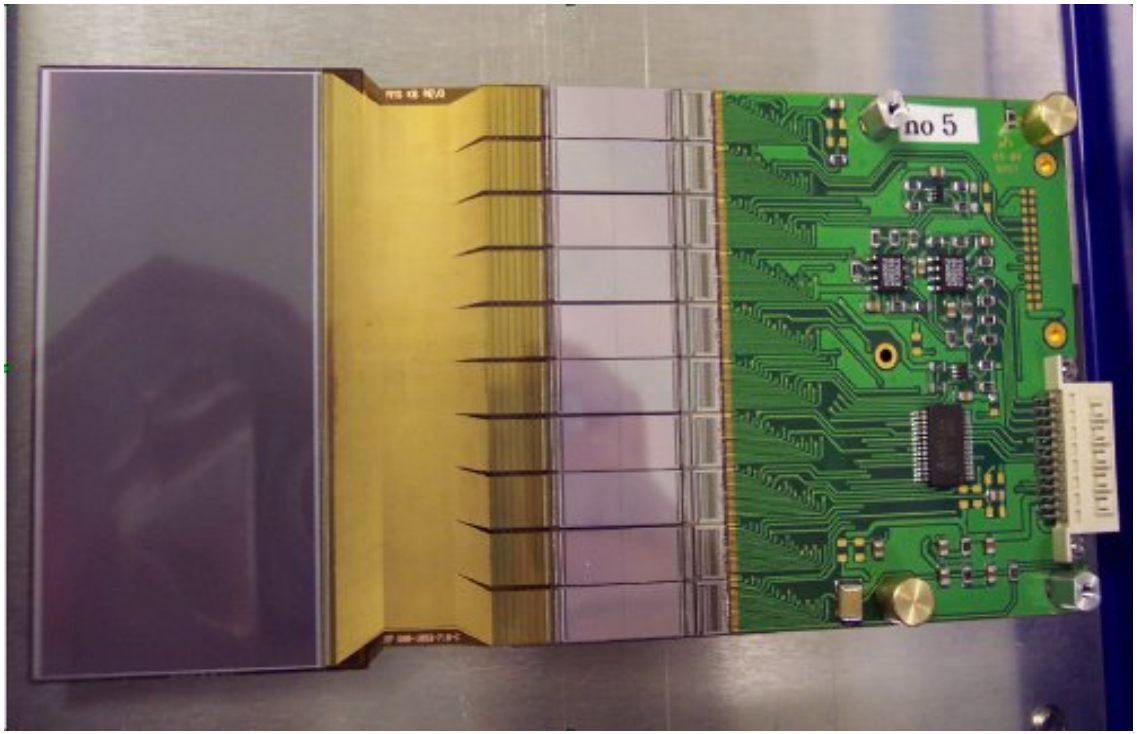
LAND-setup

System of detectors for kinematically complete measurements of reactions with relativistic radioactive beams at GSI/FAIR.



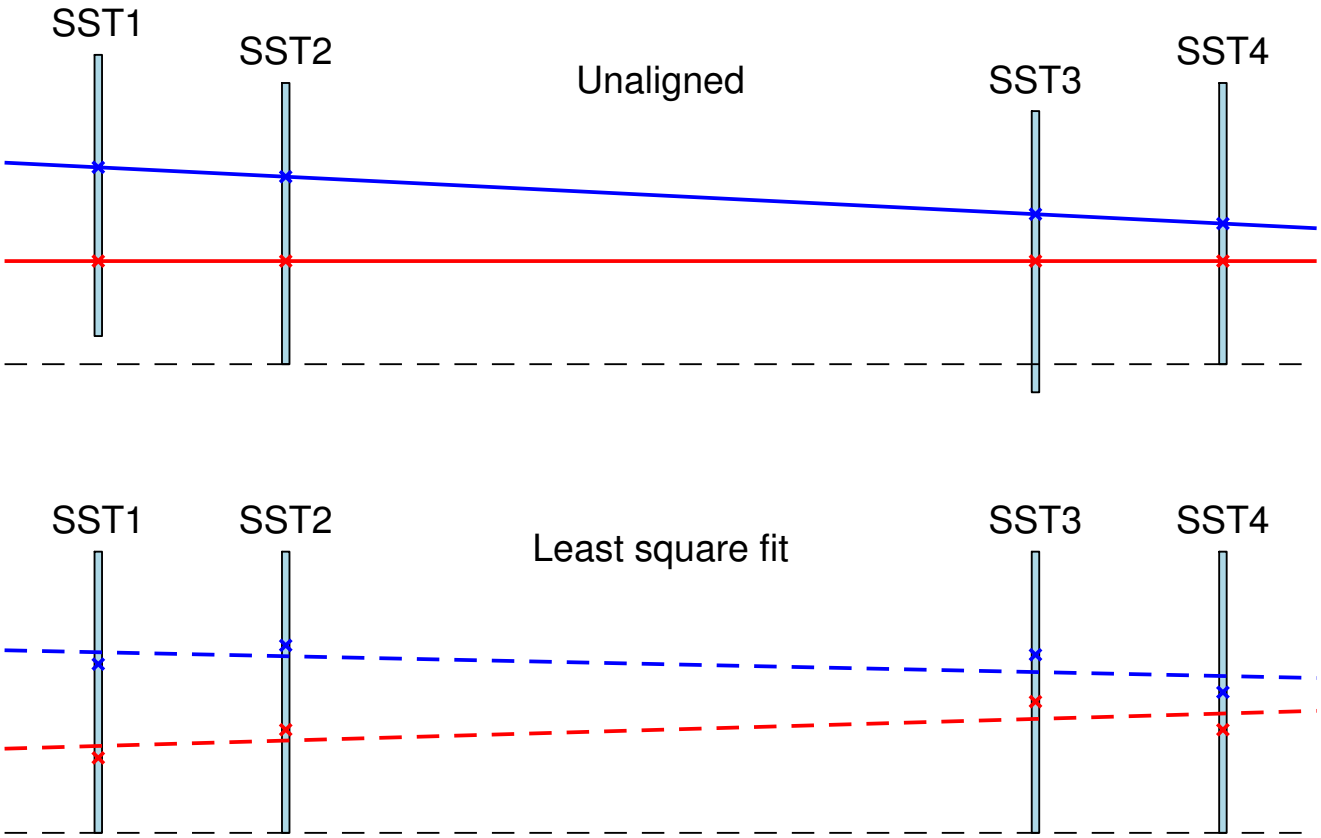
SST-detectors

- $72 \times 40\ \mathrm{mm}^2$ Silicon strip detectors
- $640 + 384$ Read-out channels
- Energy and Position
- Spatial resolution $\sim 10\ \mu\mathrm{m}$
  $\rightarrow$ **problem: mechanical alignment with sufficient precision.**



Idea of the alignment procedure

- Assume that the tracks are straight lines
- Make a least square fit from the hit positions
- "Move" the detectors to minimise the residuals



Millepede II [1]

- Millepede is developed to solve alignment problems
- Divide the variables into
  - **Local** – change for each track
  - **Global** – same for all tracks

[1] V. Blobel, "Software alignment for tracking detectors" *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, vol. 566, no. 1, pp. 5 – 13, 2006.

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- Use corrections of the form

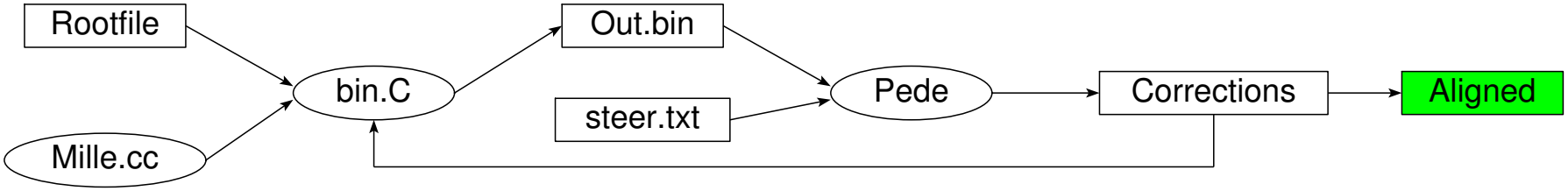
$$x_{\mathrm{c}} = (x_{\mathrm{m}} - \Delta x_{\mathrm{i}}) \cdot \cos(\omega_{\mathrm{i}}) + (y_{\mathrm{m}} - \Delta y_{\mathrm{i}}) \cdot \sin(\omega_{\mathrm{i}})$$
$$y_{\mathrm{c}} = (y_{\mathrm{m}} - \Delta y_{\mathrm{i}}) \cdot \cos(\omega_{\mathrm{i}}) - (x_{\mathrm{m}} - \Delta x_{\mathrm{i}}) \cdot \sin(\omega_{\mathrm{i}})$$

- Provide Millepede with
  - The residuals
  - The derivatives for each variable
  - The detector resolutions

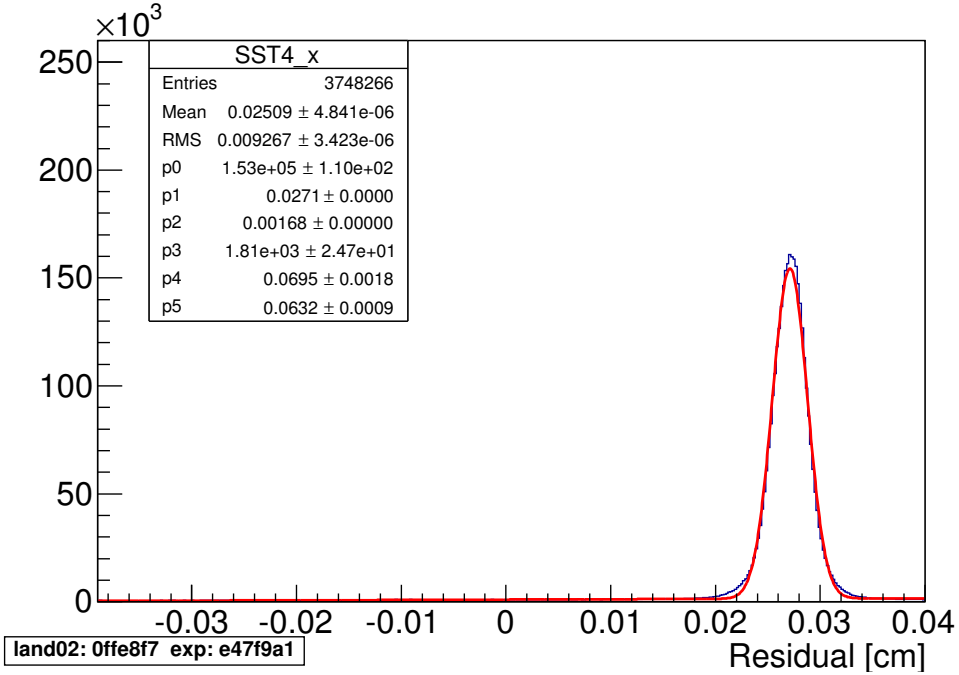
[1] V. Blobel, "Software alignment for tracking detectors" *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, vol. 566, no. 1, pp. 5 – 13, 2006.

Obtaining the corrections

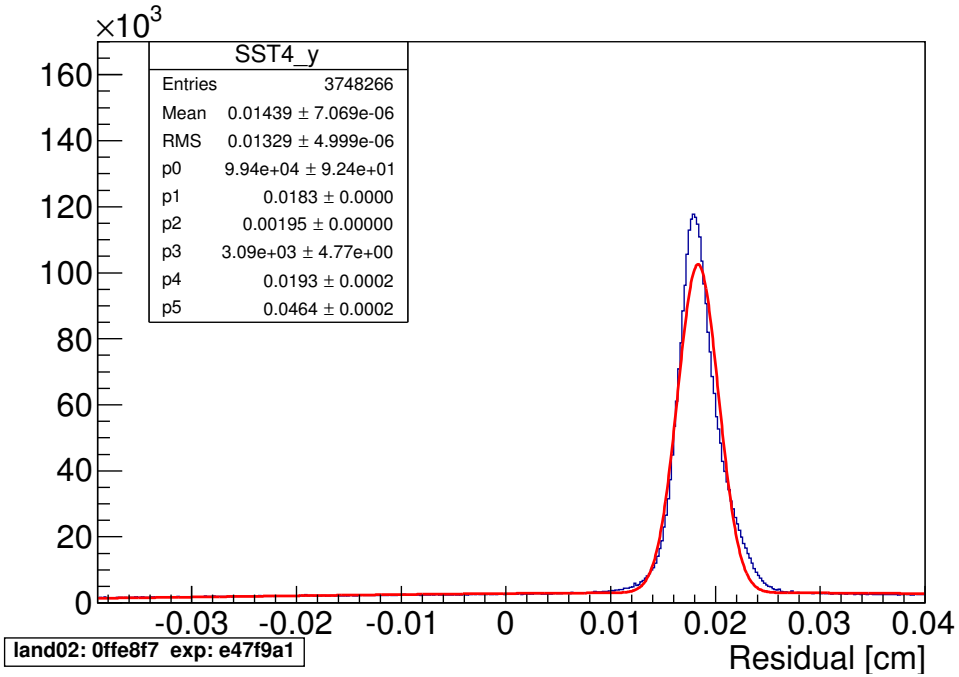
- Millepede = Mille.cc + Pede
- Mille.cc is used to create a binary file
- Binary file is used by Pede to calculate corrections



Before alignment

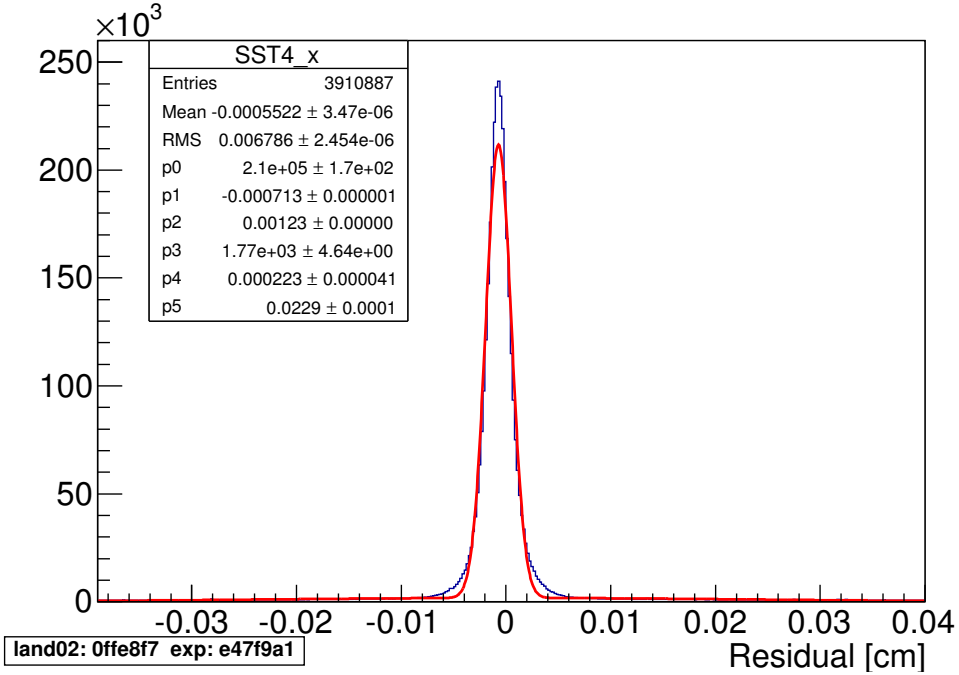


- Peak: 271 μm
- Sigma: 16.8 μm

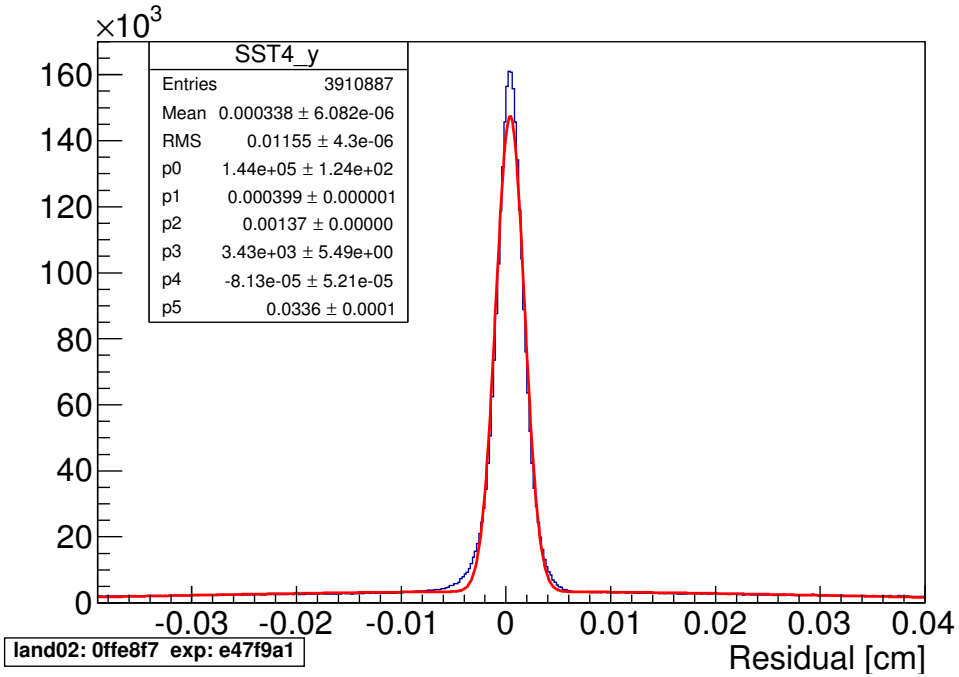


- Peak: 193 μm
- Sigma: 19.5 μm

After alignment



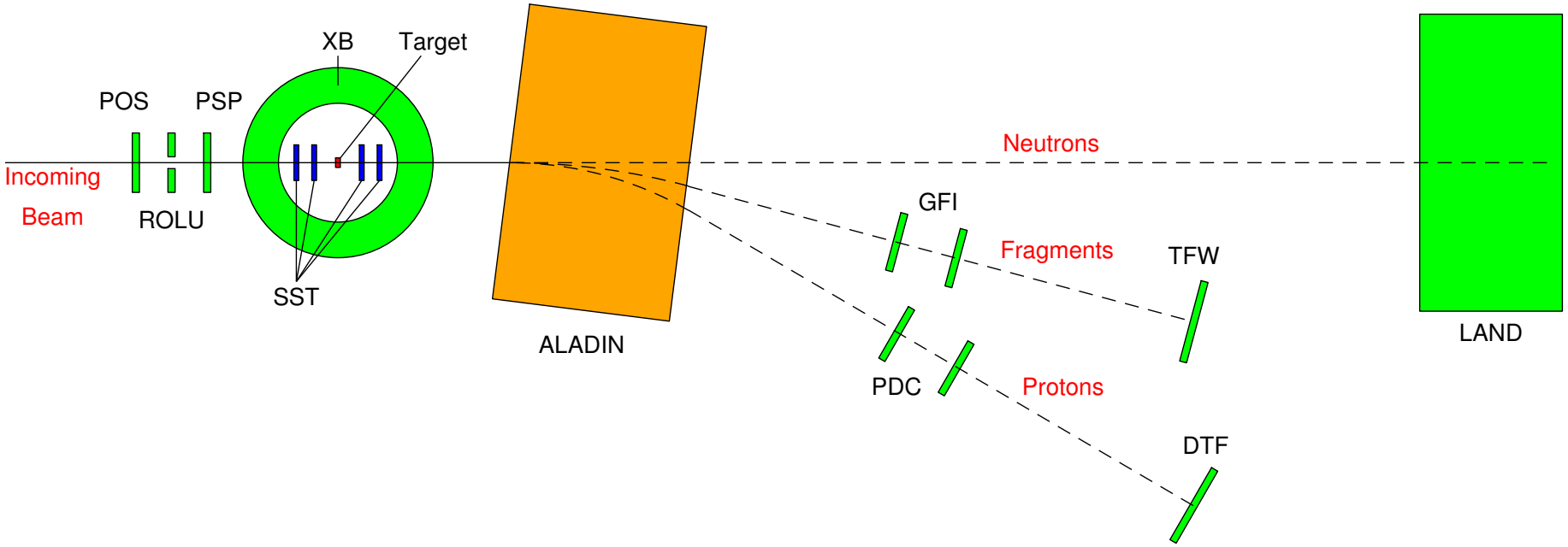
- Peak: 7.1 μm
- Sigma: 12.3 μm



- Peak: 4.0 μm
- Sigma: 13.7 μm

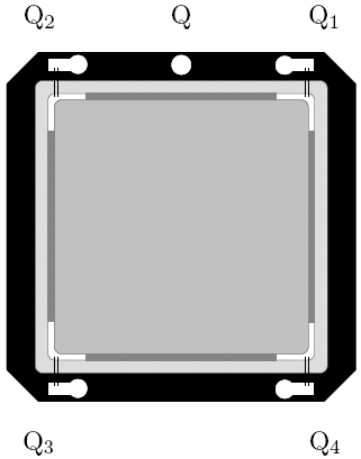
Using the SST:s to calibrate the PSP

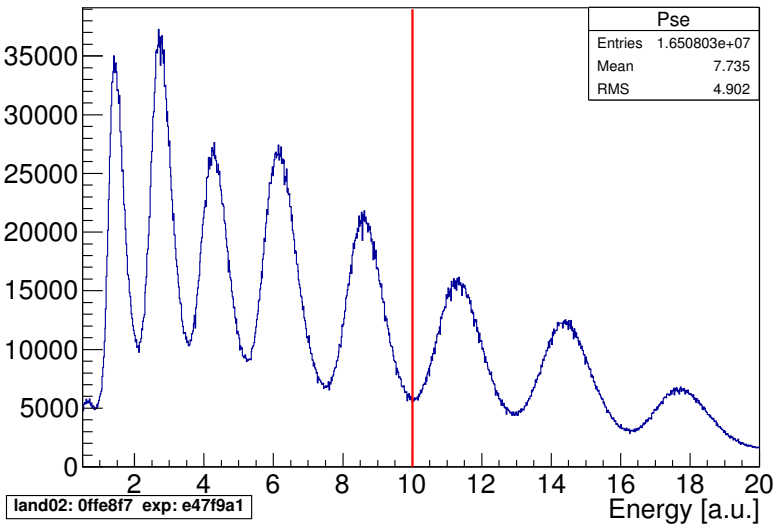
- PSP - Position Sensitive silicon PIN diode
- Calibration by extrapolating hit position from SST:s



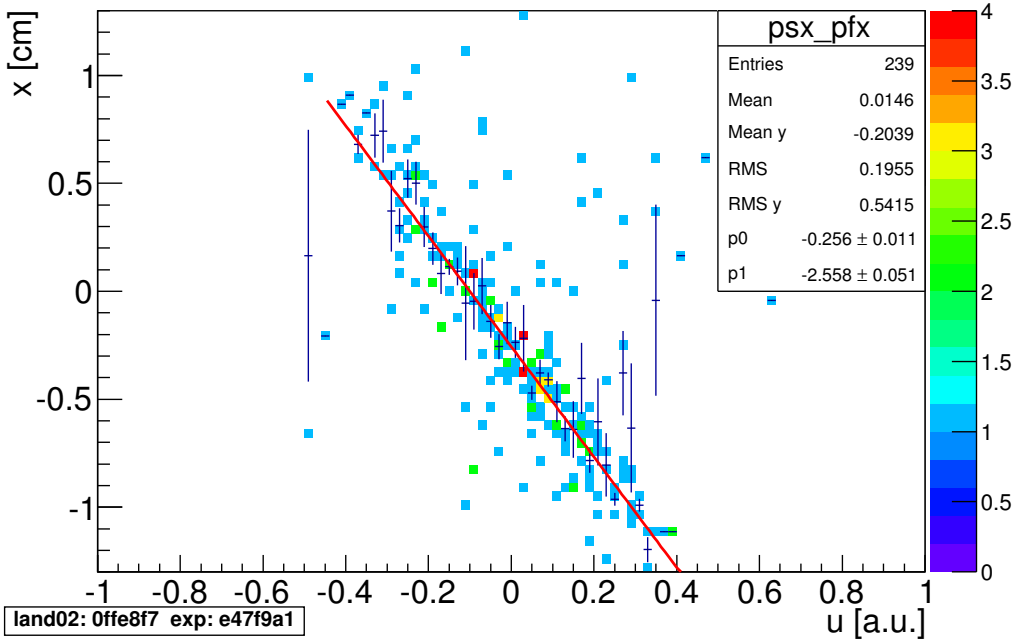
Convert internal coordinates to global coordinate system

- Linear relation between internal and global coordinates
  $x = k_{\mathrm{x}} \cdot u + m_{\mathrm{x}}$
  $y = k_{\mathrm{v}} \cdot v + m_{\mathrm{v}}$
- Resolution strongly dependent on Z
- Limit to tracks with small total residual

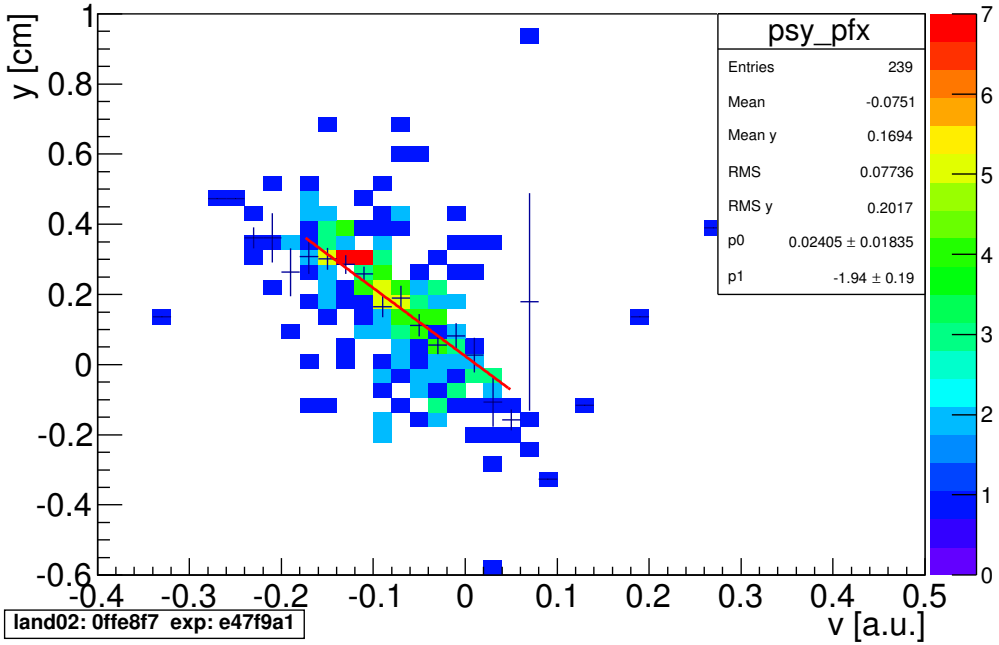




Linear fits

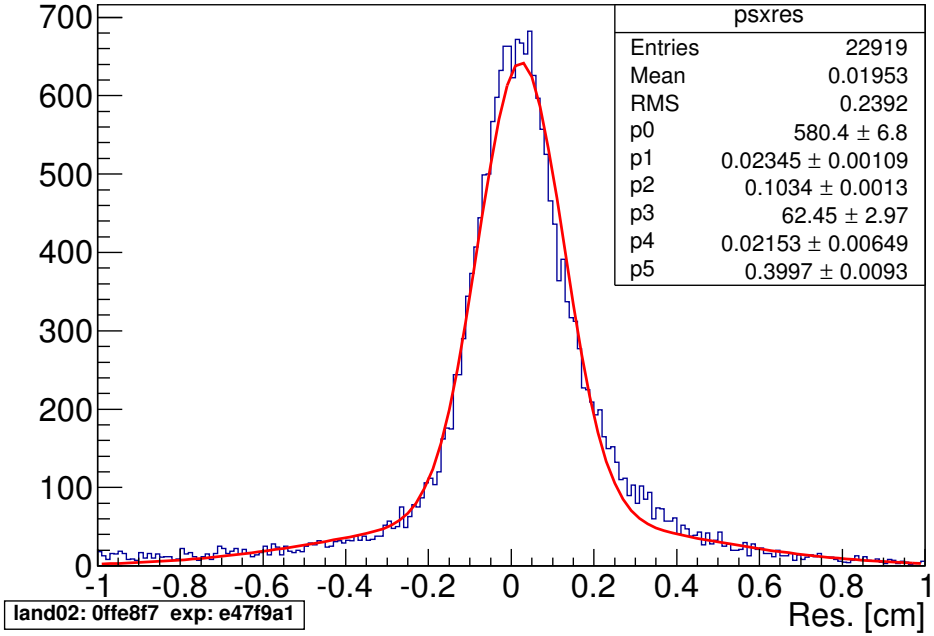


- $k_{\mathrm{x}} = -2.56$
- $m_{\mathrm{x}} = -0.26$

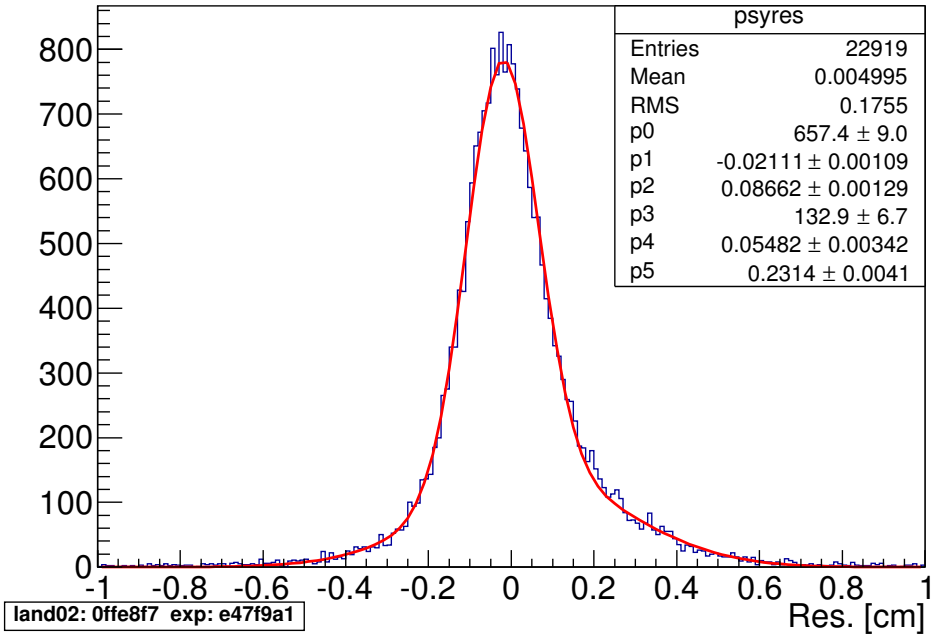


- $k_{\mathrm{y}} = -1.94$
- $m_{\mathrm{y}} = 0.02$

PSP residuals



- Peak 0.23 mm
- Sigma 1.0 mm



- Peak -0.21 mm
- Sigma 0.9 mm

Summary

- Hard to align detectors with micrometer precision
- One solution is to use Millepede to virtually move the detectors
- Position resolution improved approximately 25%
- The PSP detector can be calibrated with the SST detectors

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Thank you for your attention