Use of the HEXABOARD geometry for a coarse 3D readout of GEM-TPCs

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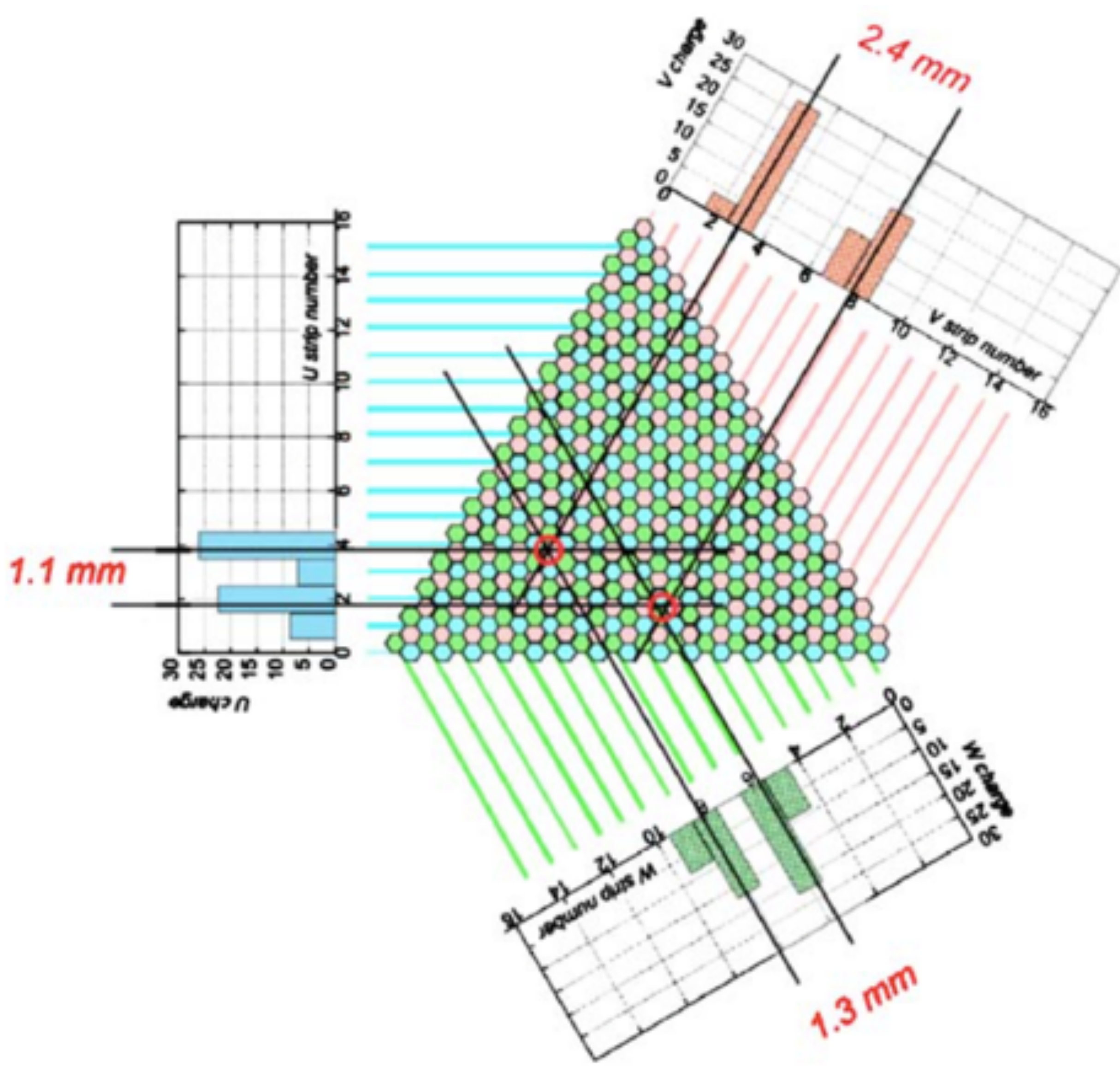
3D electronic readout

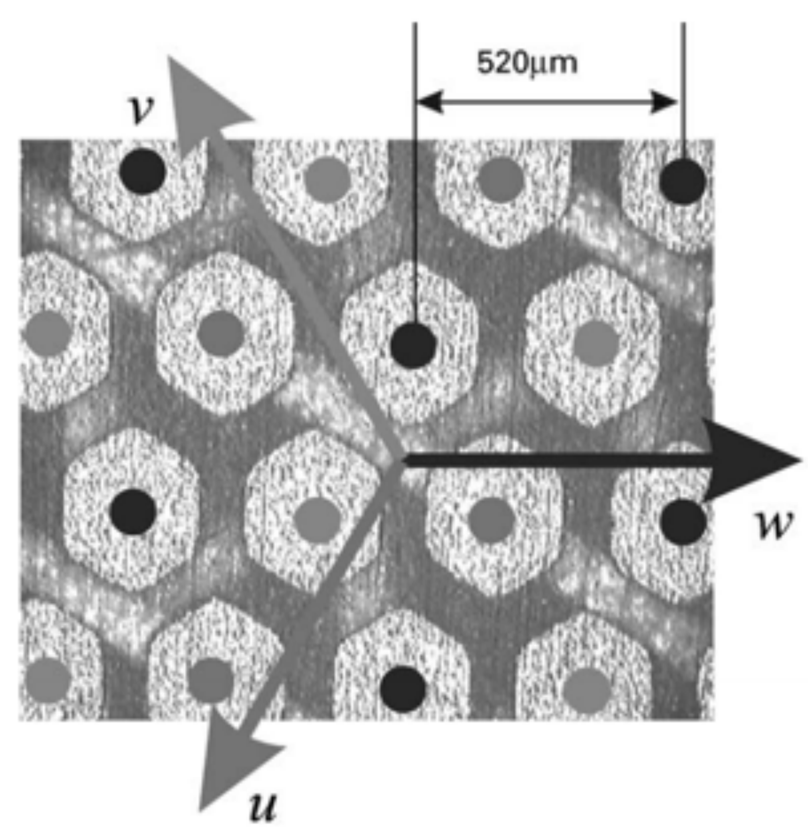
- Pixels:
  - very good 3D reconstruction (2D image + time projection)
  - large number of readout channels (>> $1M/m^2$ for sub-mm pixelization)
- 2D Strips:
  - manageable readout multiplicity ($20k/m^2$ for 100 μm pitch)
  - XYZ directionality with techniques similar to the ones developed in DRIFT for the wire readout
- HEXABOARD:
  - improved XYZ directionality with still manageable readout multiplicity

Hexaboard

- GEM readout with **hexagonal pads** alternatively readout by strips in **3 directions**
- Suitable for readout with SRS electronics



Nucl.Instrum.Meth. A478 (2002) 104-108



Recoil direction

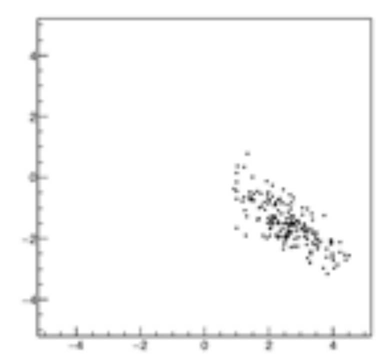
- We think that the hexaboard desing can provide an easy and powerful technique for 3D directionality

- Benchmark scenario:

  - 3D gaussian ionization cluster ($\sigma_{||}$ ~ 1 mm, $\sigma_{\perp}$ ~ 0.3 mm)

  - ~ 200 ionization pairs

  - ~ 10^3 gain, exponential distribution



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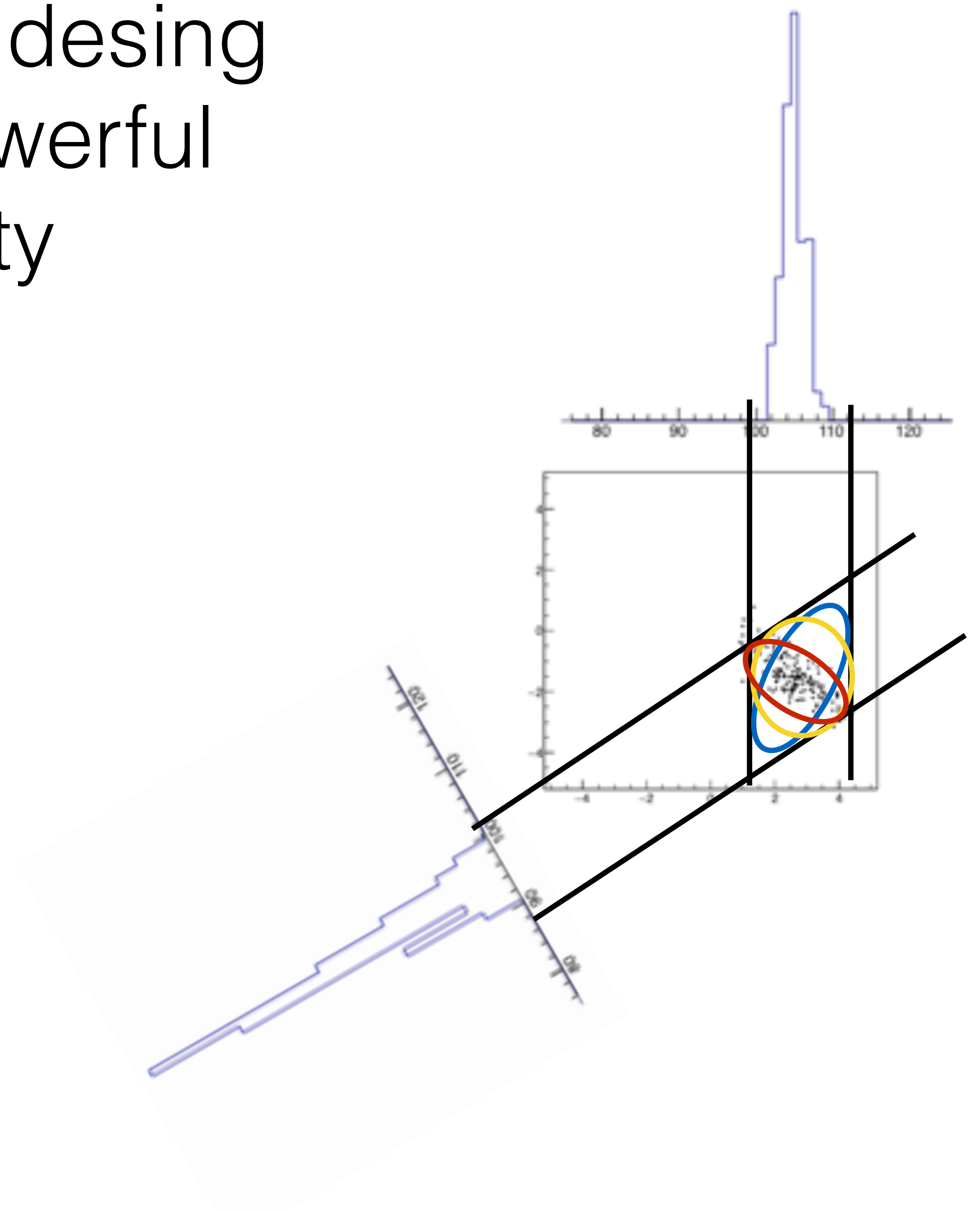

- *Using only the charge distribution, with 2 strip orientations there is a ∞-fold ambiguity in the XY plane*

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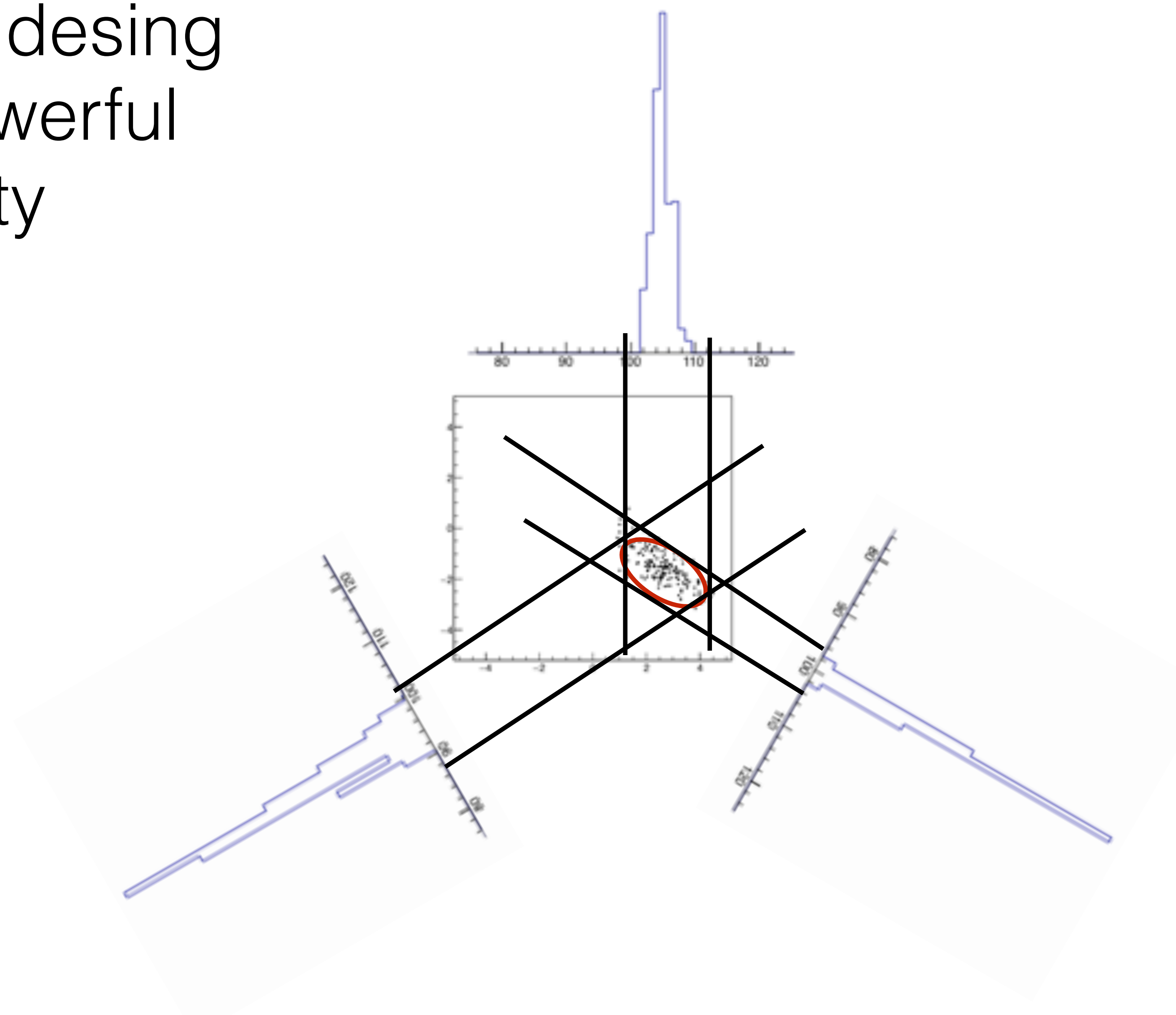


- *With 3 strip orientations, the charge distribution alone provides an* ***analytical estimate*** *of the cluster direction in the XY plane*

Some mathematics

- The benchmark cluster in the XY plane is described by a 2D covariance matrix

$$\Sigma = \begin{pmatrix} \sigma_x^2 & \rho\sigma_x\sigma_y \\ \rho\sigma_x\sigma_y & \sigma_y^2 \end{pmatrix}$$

- 3 parameters, 3 observables (σ_u, σ_v, σ_w)

- The first eigenvector of the covariance matrix gives the cluster direction

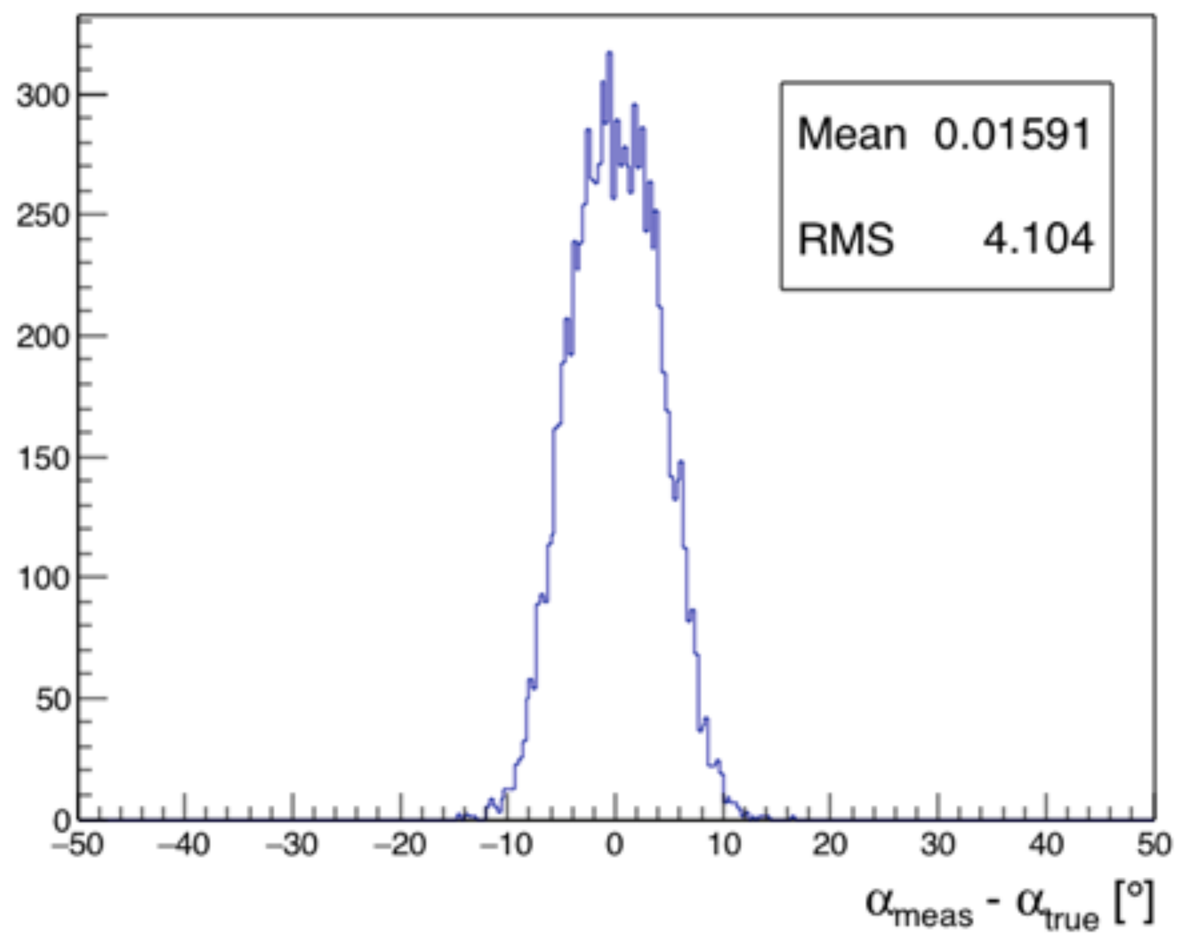
$$\sigma_x = \sigma_u$$

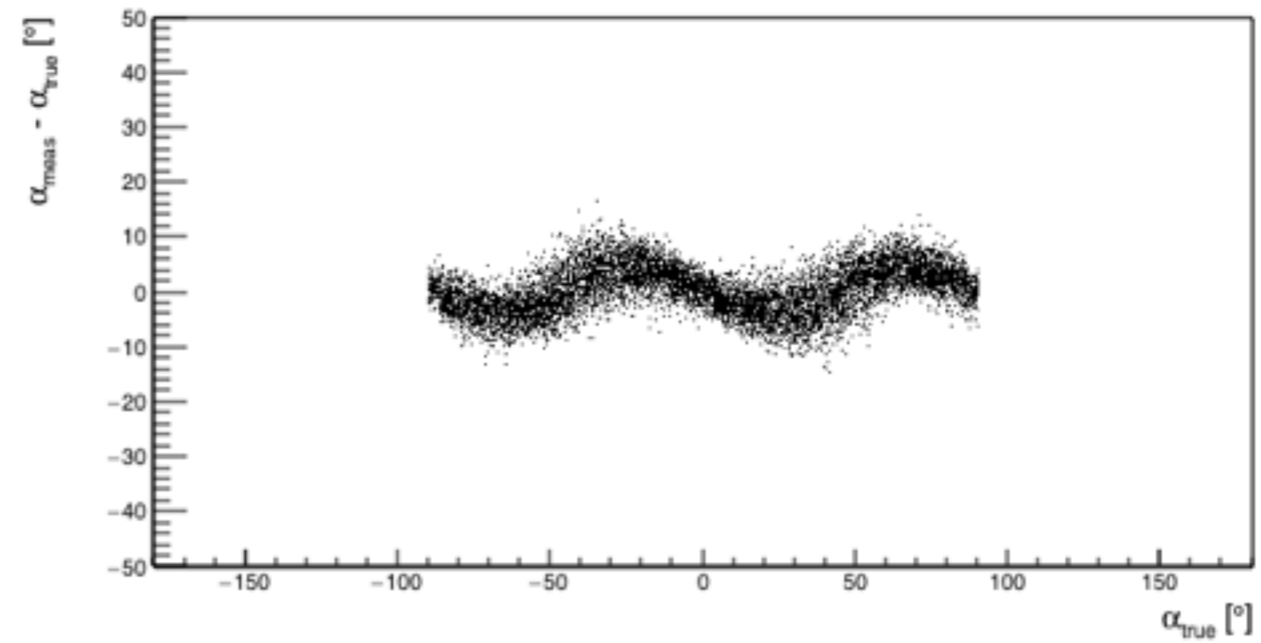
$$\sigma_y = \sigma_x \sqrt{\frac{2}{3}\left(\frac{\sigma_v^2}{\sigma_u^2} + \frac{\sigma_w^2}{\sigma_u^2}\right) - \frac{1}{3}}$$

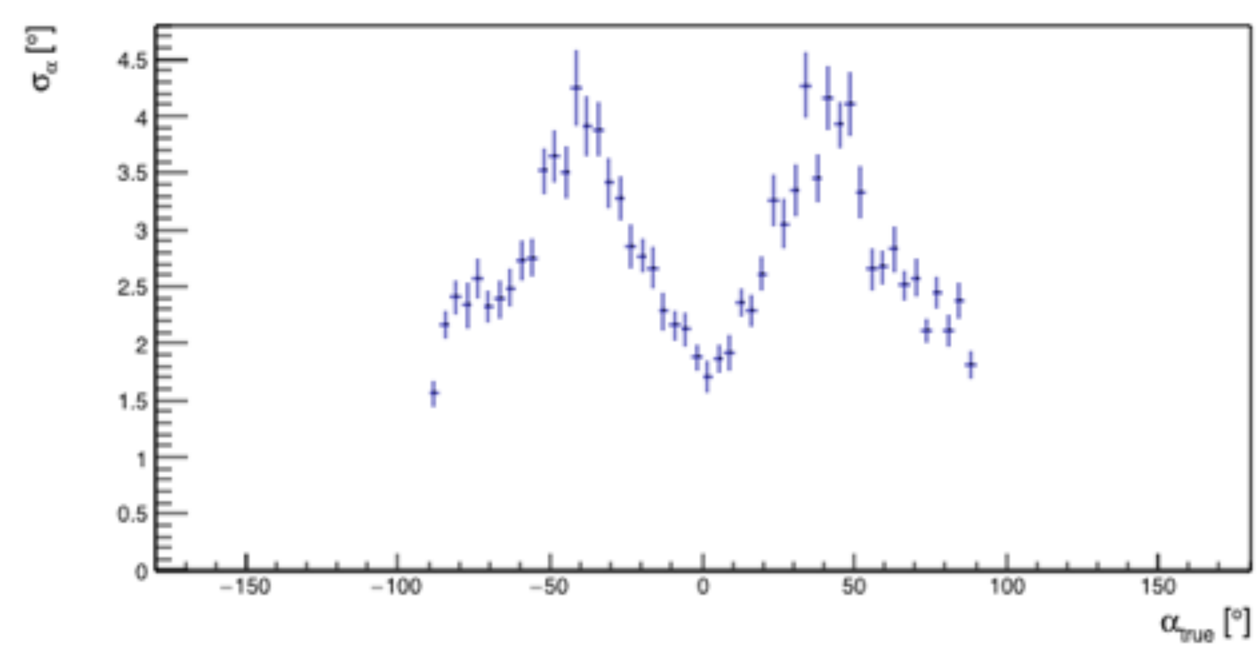
$$\rho = \frac{\sqrt{3}}{4}\left(\frac{\sigma_v^2}{\sigma_u^2} + \frac{\sigma_w^2}{\sigma_u^2}\right)\frac{\sigma_x}{\sigma_y}$$

Simulation

- Benchmark scenario + 520 µm strip pitch







From 2D to 3D

- From 3 to 6 parameters (or 4 assuming that the cluster is symmetric around the main axis)
- From 3 to ≥ 6 observables:
    - σ_u, σ_v, σ_w
    - σ of the charge-weighted time distribution over all strips (σ_z)
    - Profile of drift time vs. strip index in u, v, w

Discussion

- Reality will be significantly different:
    - non-gaussian clusters
    - head-tail asymmetries
    - noise
    - strip cross-talk
    - …
- Nonetheless, we think that the technique is very promising