The MIP tracks reconstruction

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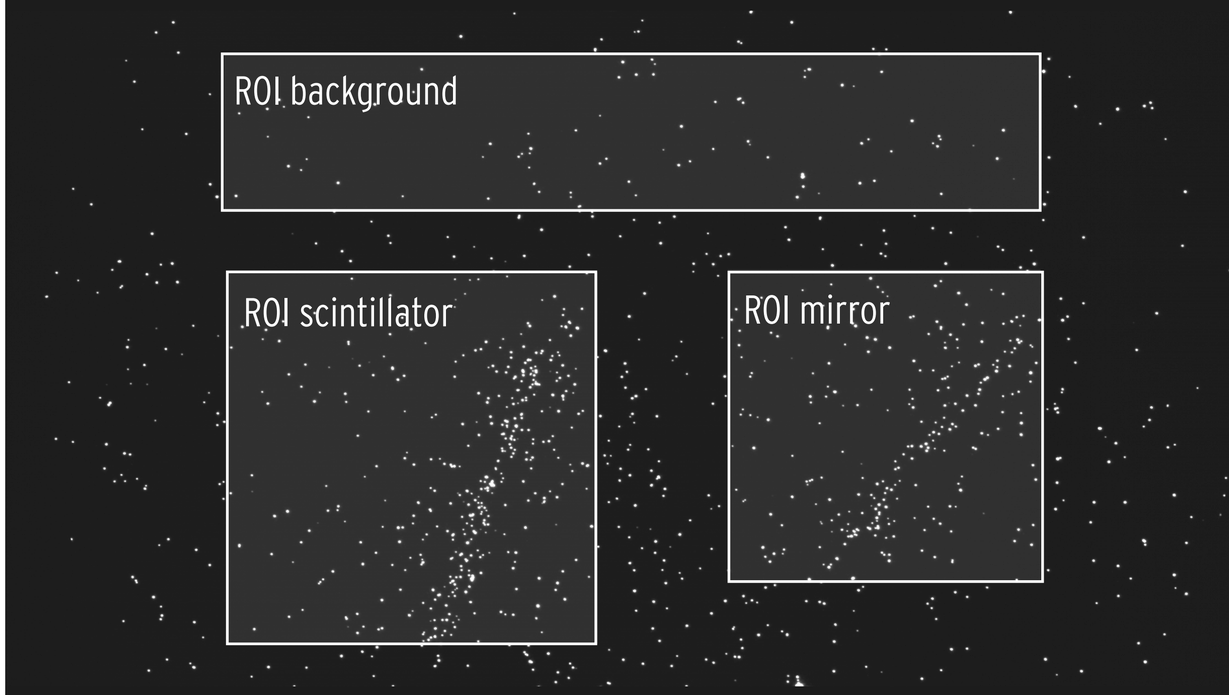
ROI extraction

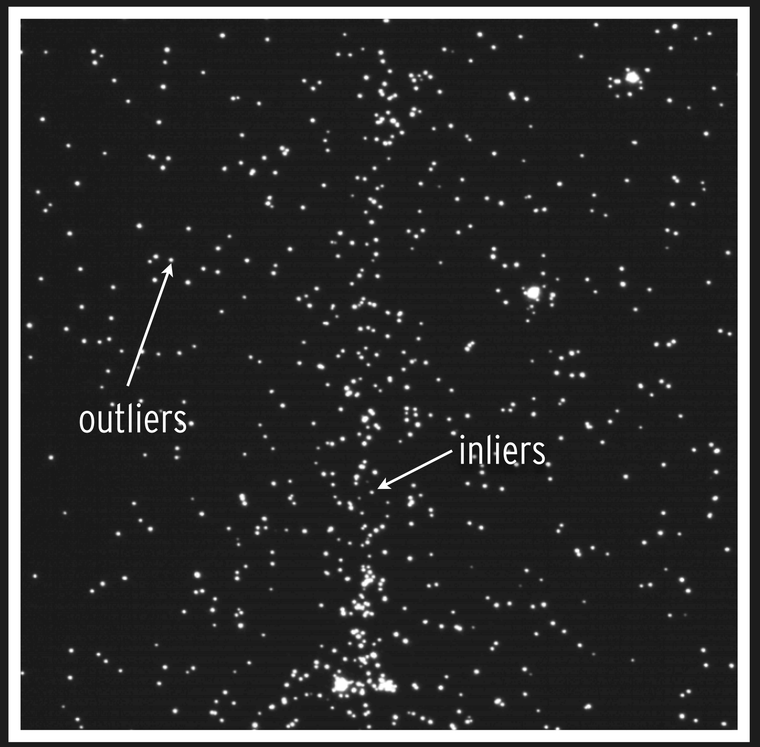
For each frame, extract the **mean** and **standard deviation** of the grey level distribution from 3 regions of interest (ROI):

- **Scintillator**
- **Mirror**
- **Background**



RANSAC

- **Main challenge**: inclusion of outliers/inliers in the fit procedure.
- **RANSAC** is an iterative algorithm for robust model estimation in the presence of outliers.
- **Idea**: repeatedly sample minimal subsets, fit the model, evaluate consensus.

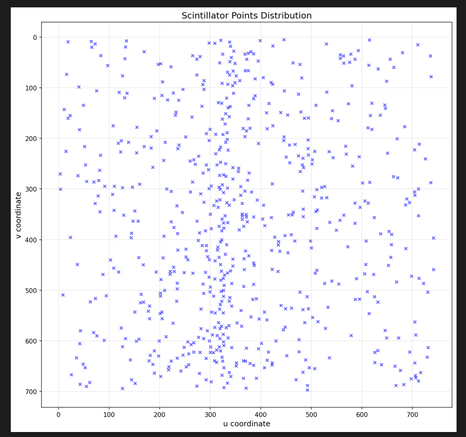


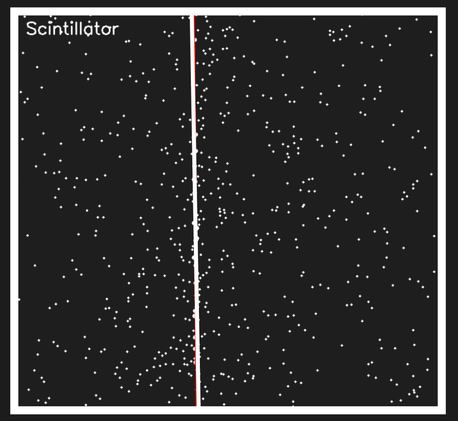
An example track in the scintillator ROI

RANSAC

From the image, **centroids** are extracted.

1. **Sample**: Randomly select 2 points (minimum distance 10 px).
2. **Compute**: Calculate the line passing through the 2 points ($ax + by + c = 0$).
3. **Consensus**: Count inliers (points at a distance < threshold from the line).
4. **Repeat** until a model with enough inliers is found.
5. **Refine** the best line using least squares on all inliers.





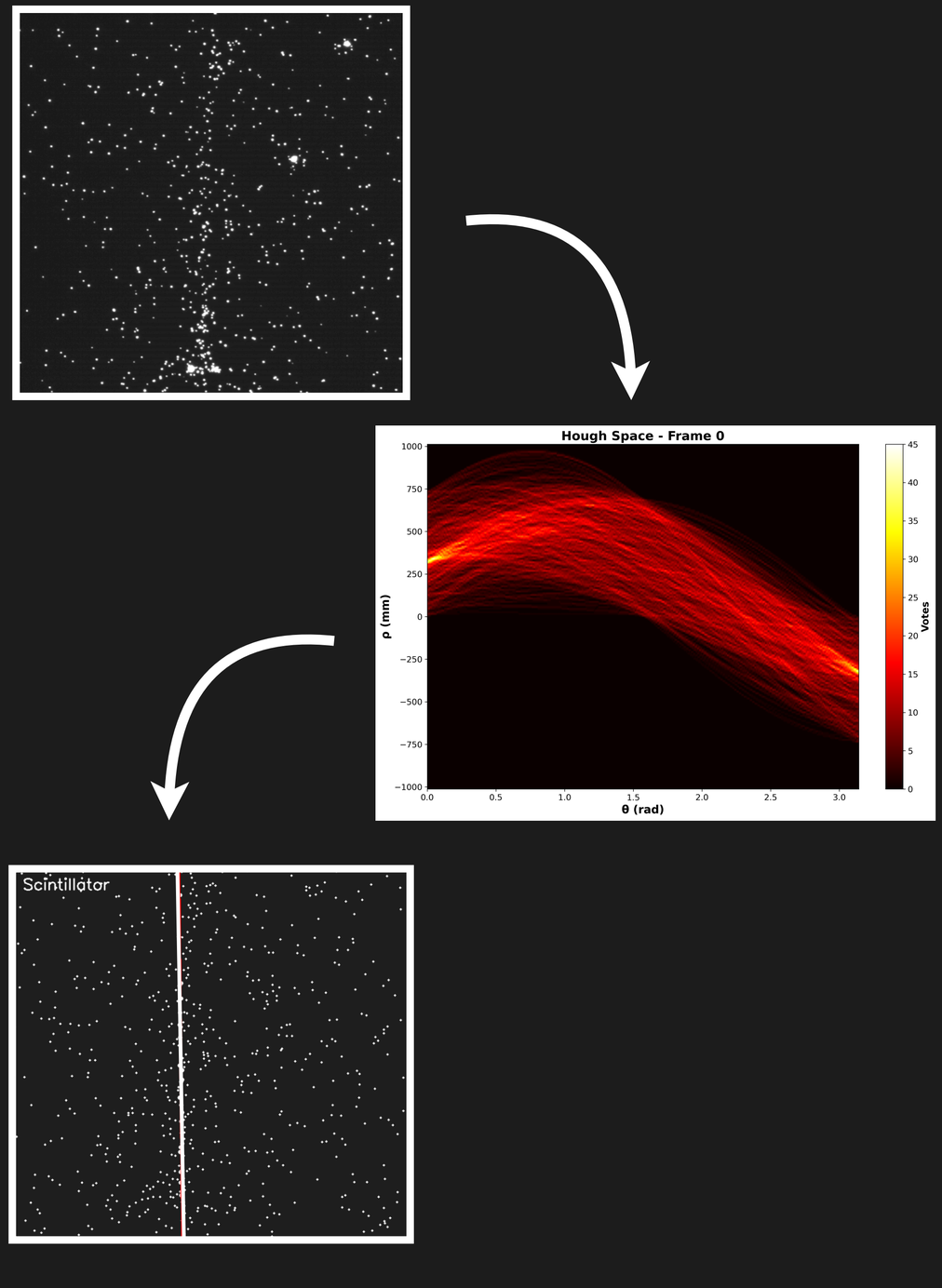
HOUGH

From the image, weighted **centroids** are extracted.

1. **Transformation**: Each point in the image space is transformed using $\rho = x \sin\theta + y \cos\theta$ where $\theta \in [-90°, 90°]$ (step = 1°)

2. **Find**: The most voted point in the Hough space that give the precisest value for θ in the projection

3. **Calculate**: the corresponding angular coefficient of the line

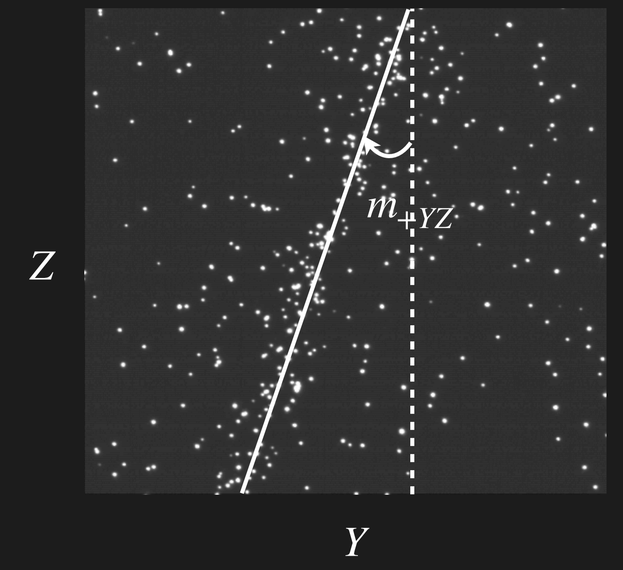


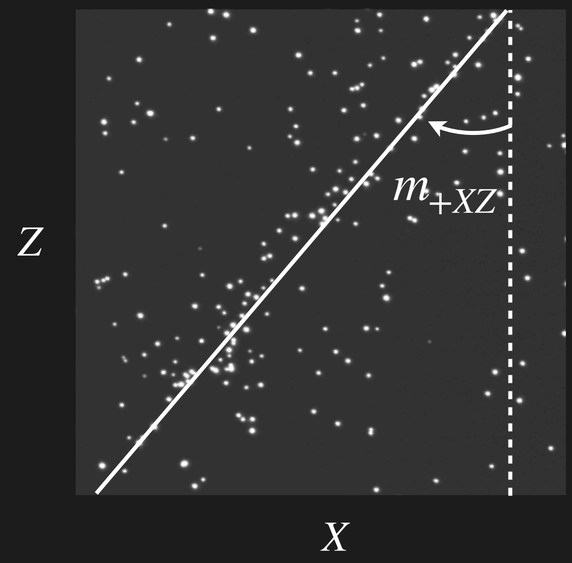
FROM 2D TO 3D

$$\begin{cases} m_{+YZ} = \tan\theta_{+YZ} = \Delta y/\Delta z \\ m_{+XZ} = \tan\theta_{+XZ} = \Delta x/\Delta z \end{cases}$$

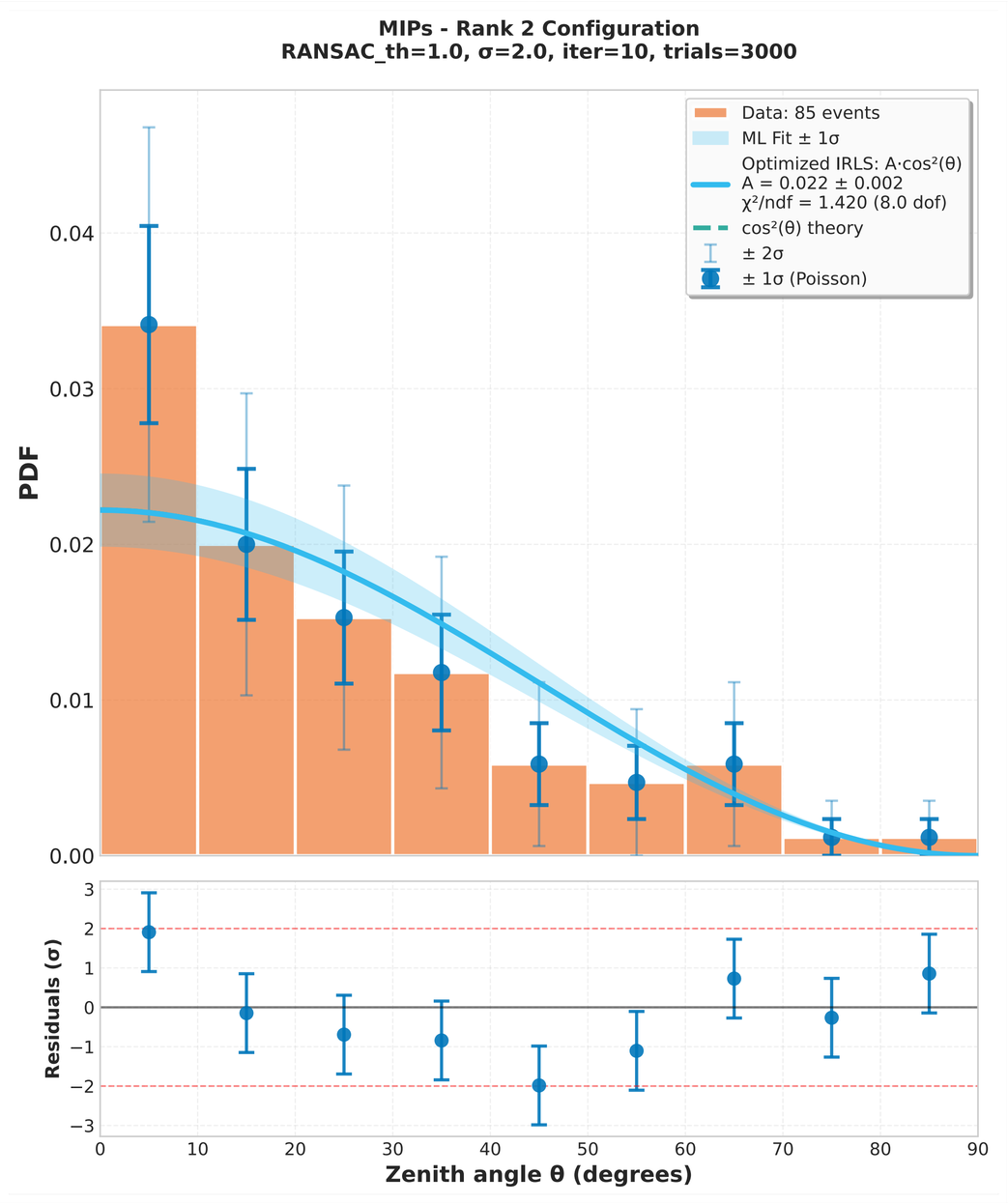
$$\tan\theta_{zenith} = \frac{\sqrt{\Delta x^2 + \Delta y^2}}{\Delta z}$$

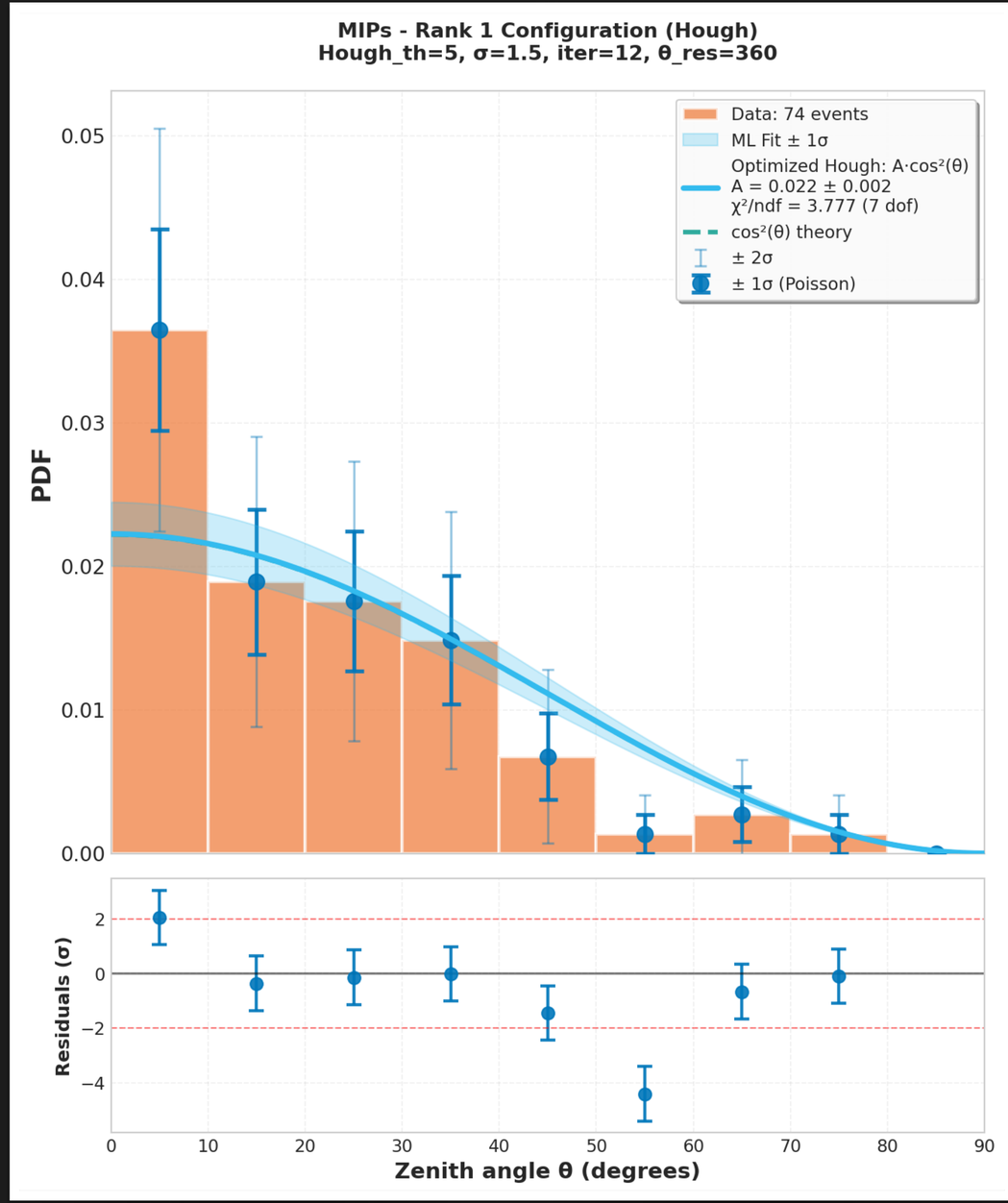
$$\theta_{zenith} = \arctan\sqrt{m_{+YZ}^2 + m_{+YZ}^2}$$





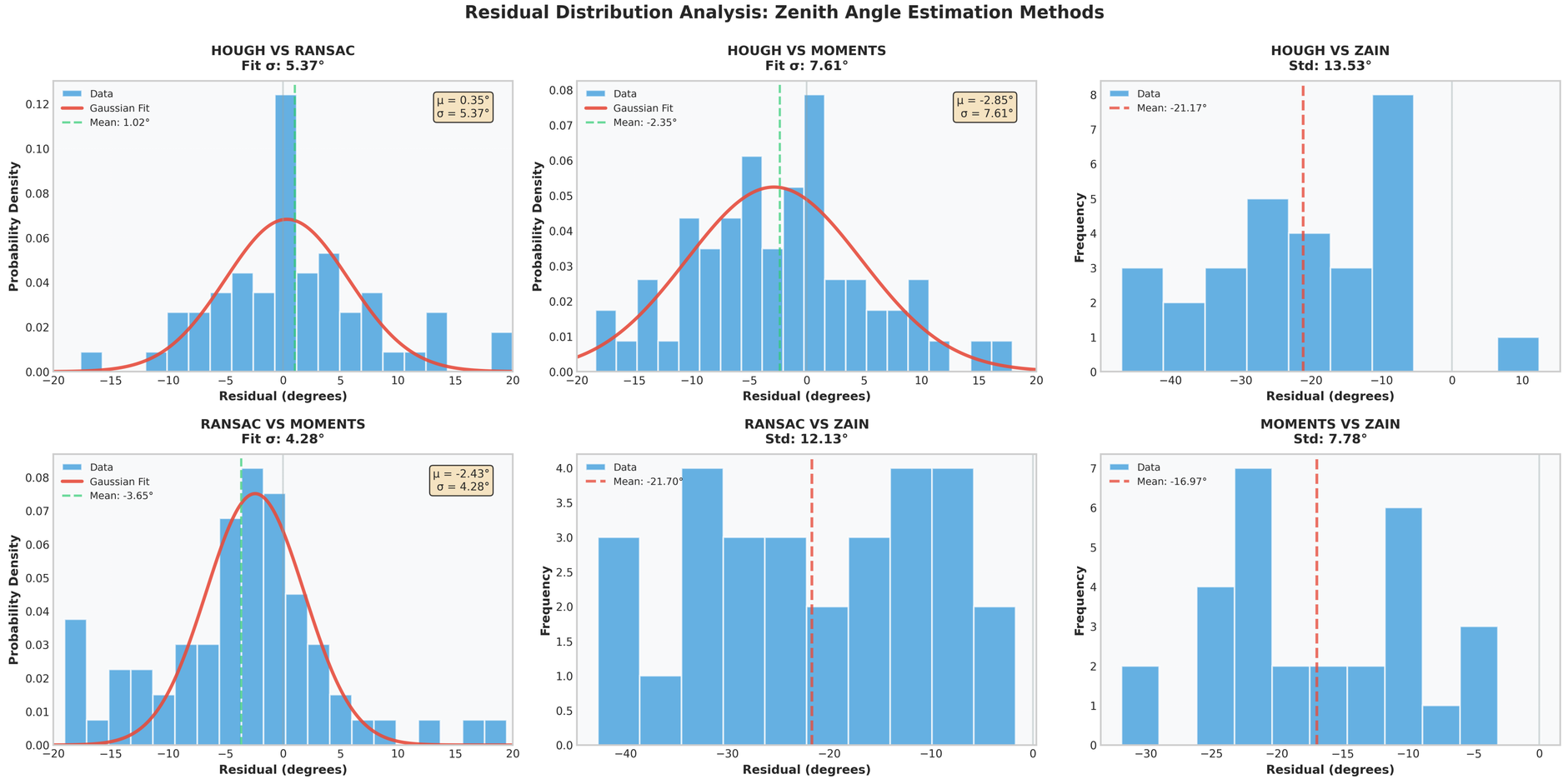
ANGULAR DISTRIBUTION





METHODS COMPARISON

To assess the agreement between the methods, a **residual analysis between zenith angles from various methods**



CONCLUSIONS

- **Track reconstruction** successfully implemented using two methods:
  - RANSAC
  - Hough Transform

- **3D zenith angle reconstruction** from 2D projections validated:

- **Methods comparison** demonstrates:
  - Good correlation between all three approaches
  - Angular differences typically ~10°
  - All methods suitable for MIP track analysis

- **Next steps**:
  - Resolve memory saturation issue with CRY generator
  - Optimize reconstruction usando parameters per valutare precisione e risoluzione dei vari metodi di ricostruzione