



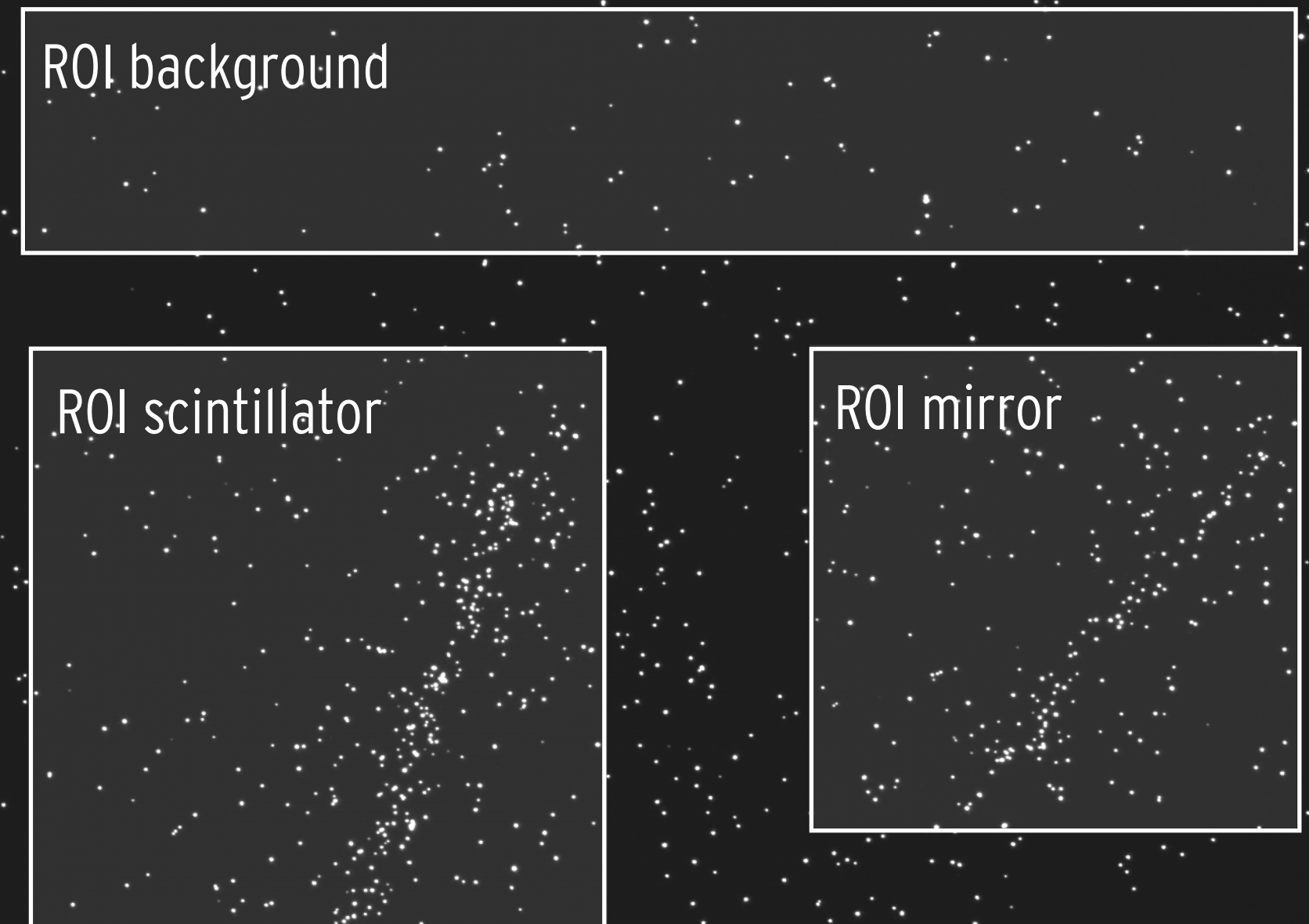
# The MIP tracks reconstruction

Samuele Lanzi - RIPTIDE meeting Dec 2025

# ROI extraction

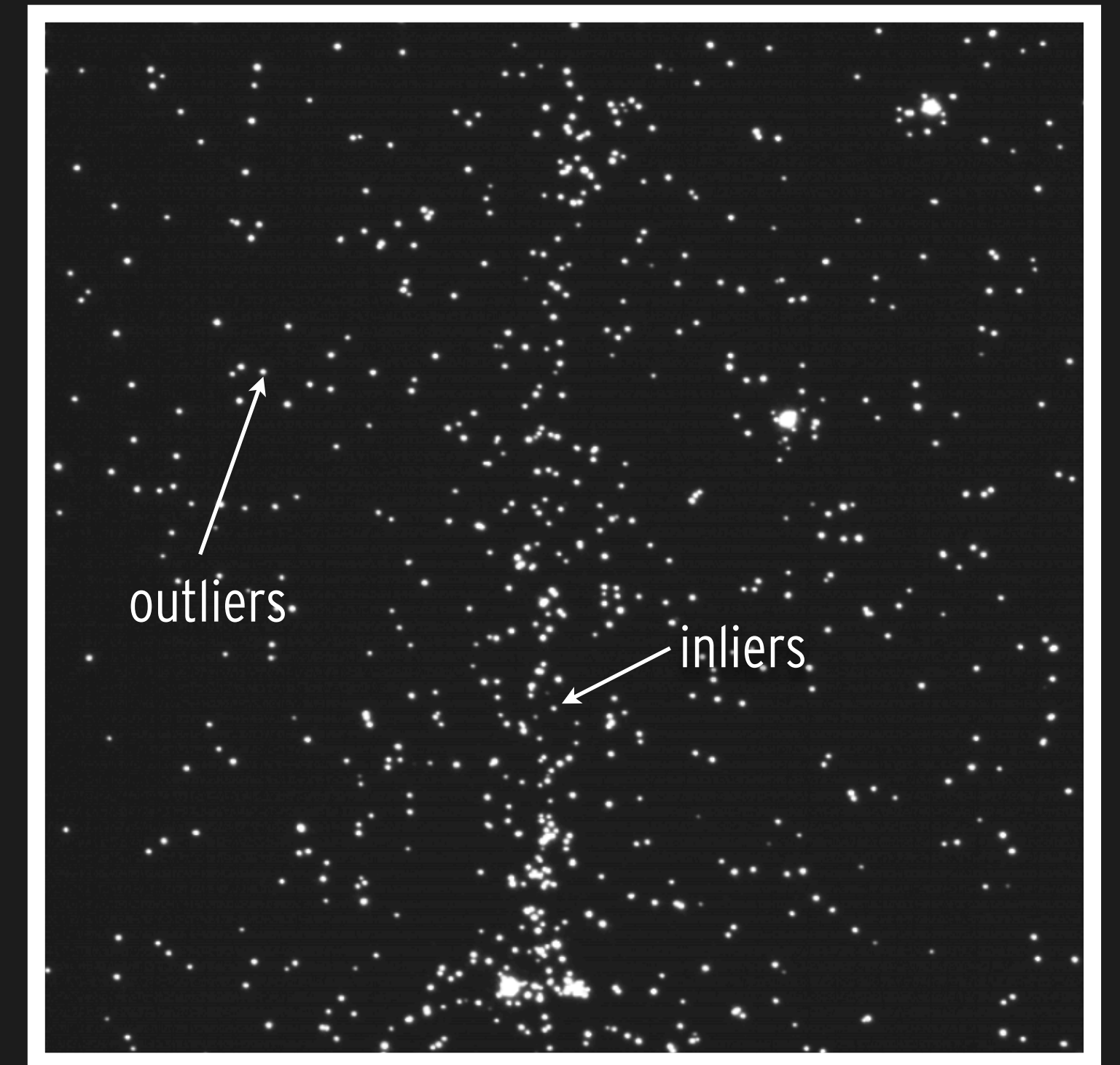
For each frame, extract the **mean** and **standard deviation** of the grey level distribution from 3 regions of interest (ROI):

- **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.

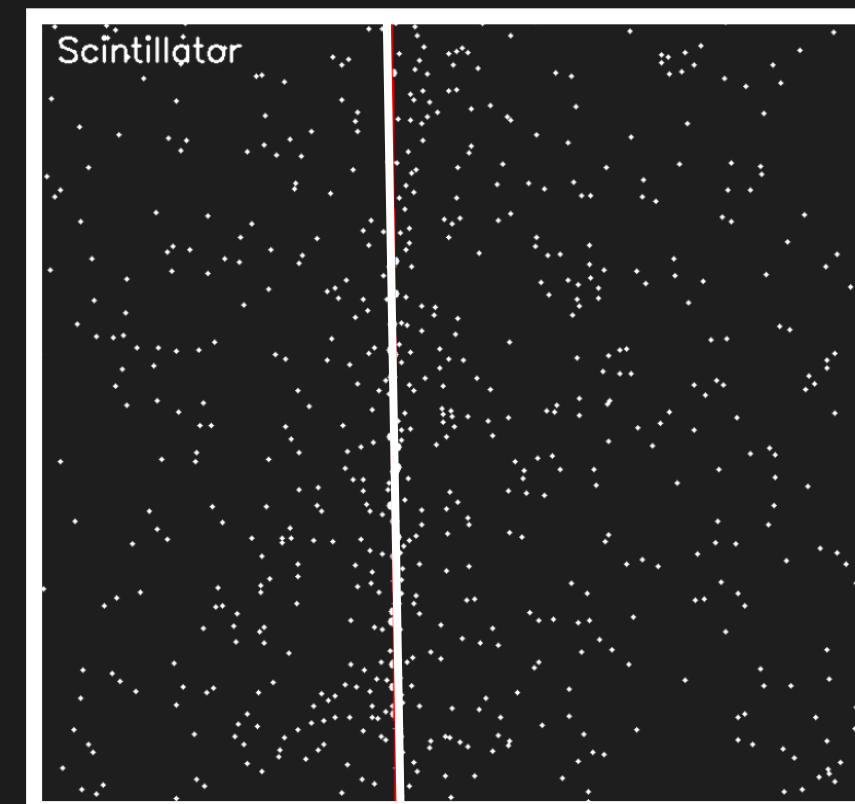
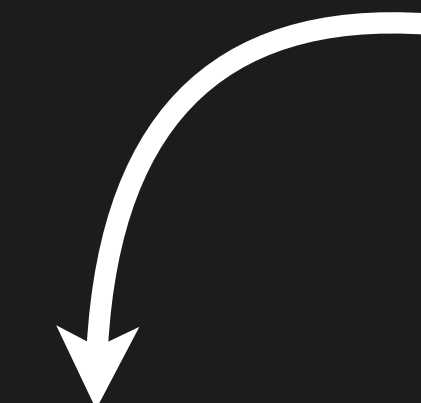
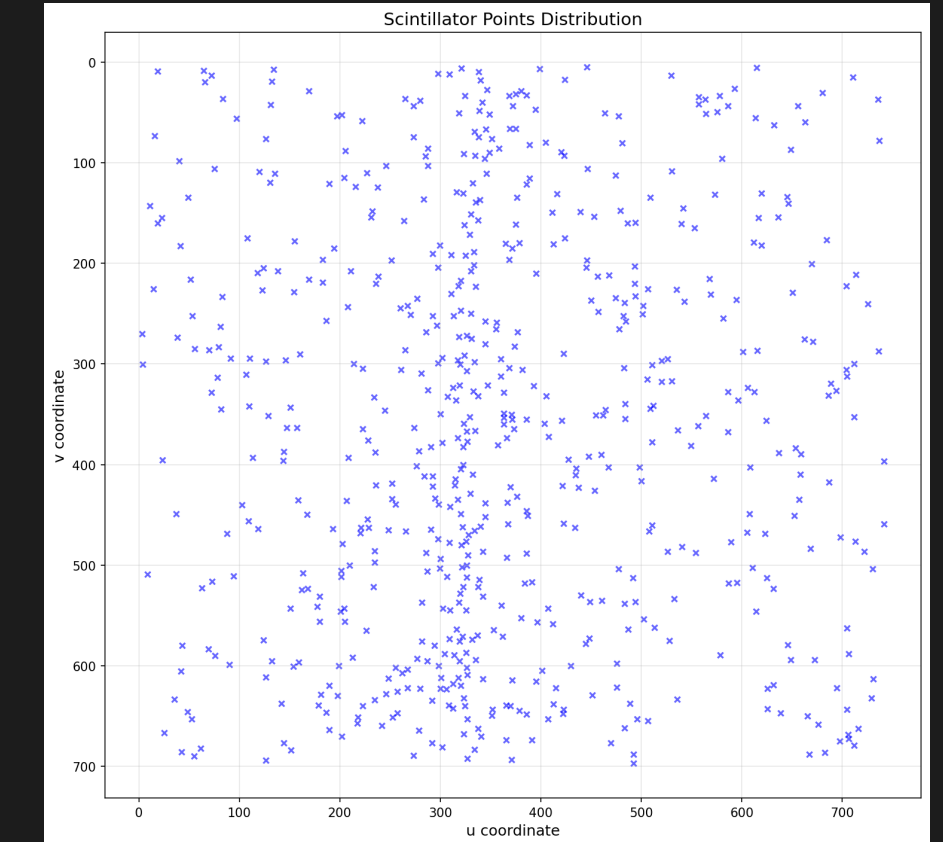
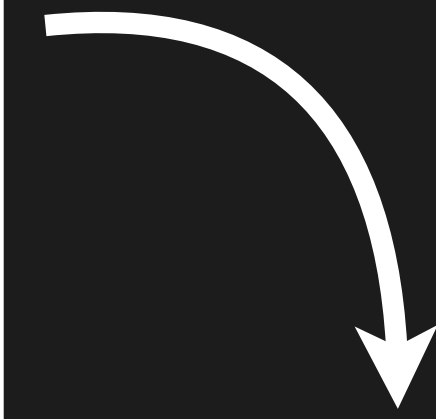
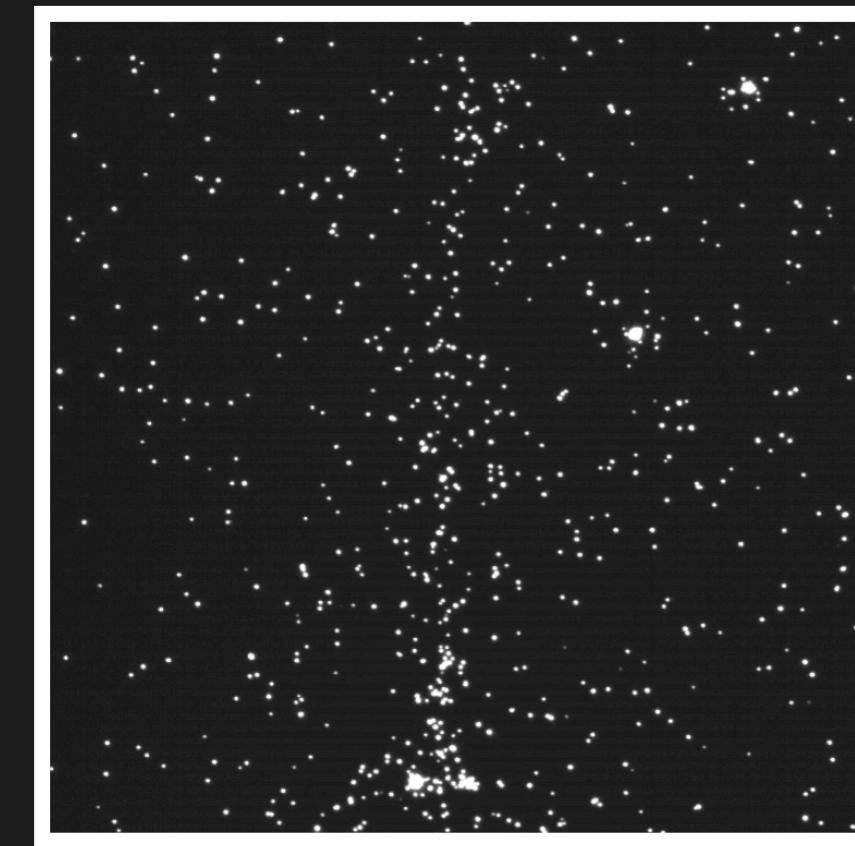


An example track in the scintillator ROI

# RANSAC

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

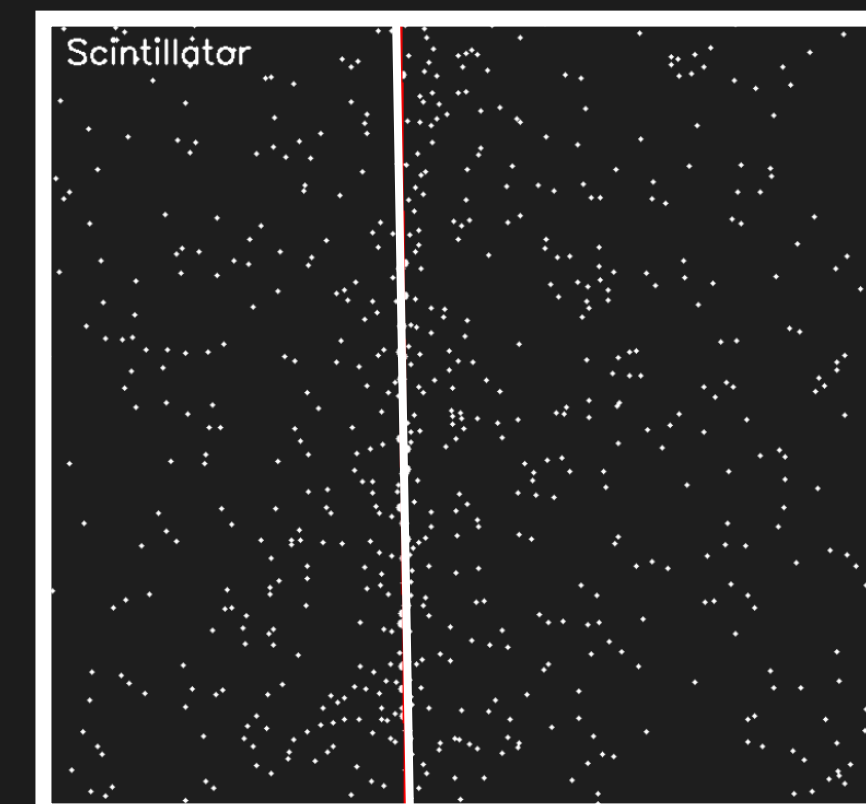
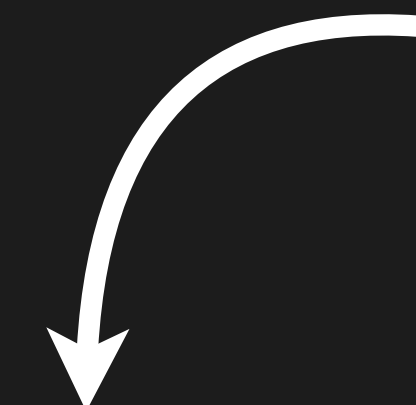
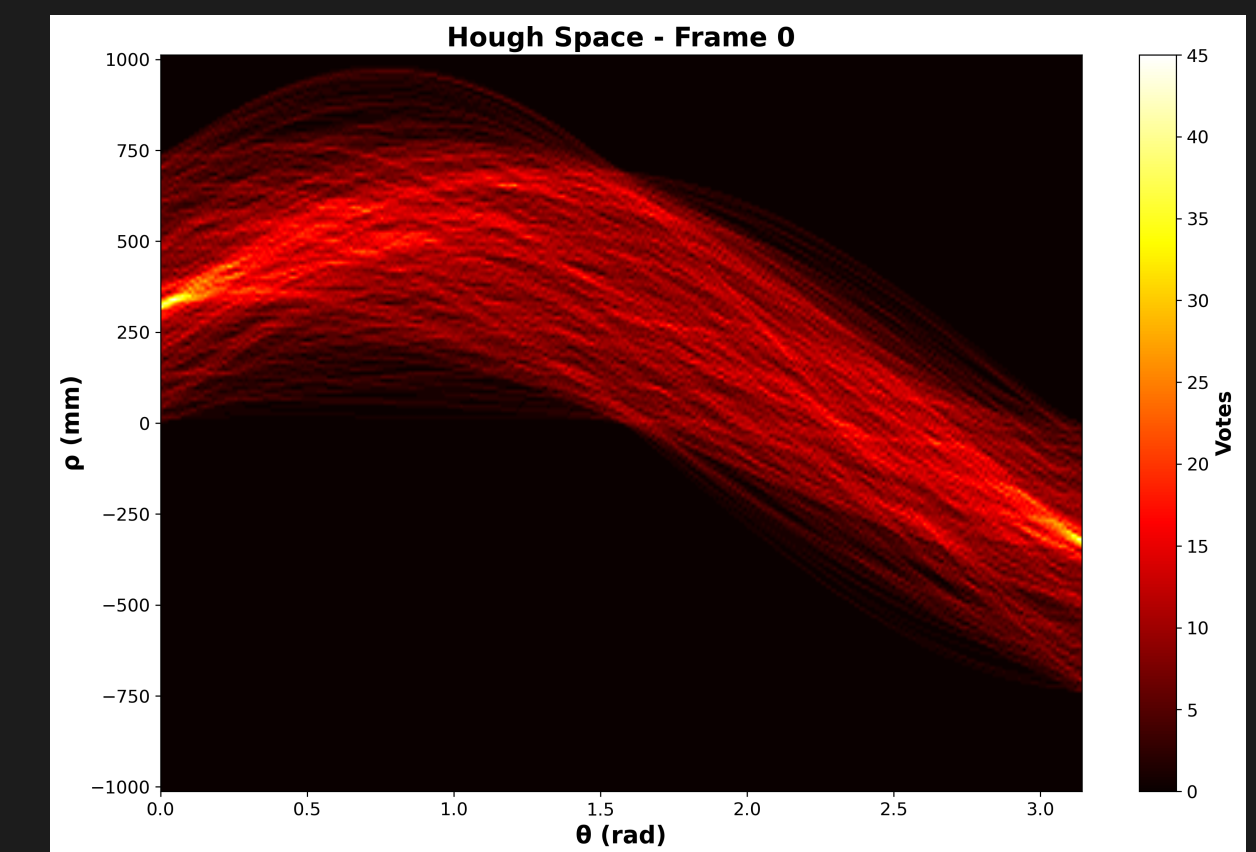
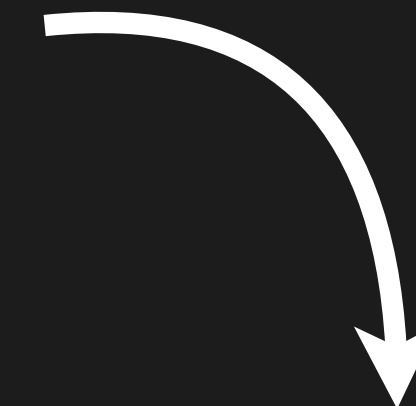
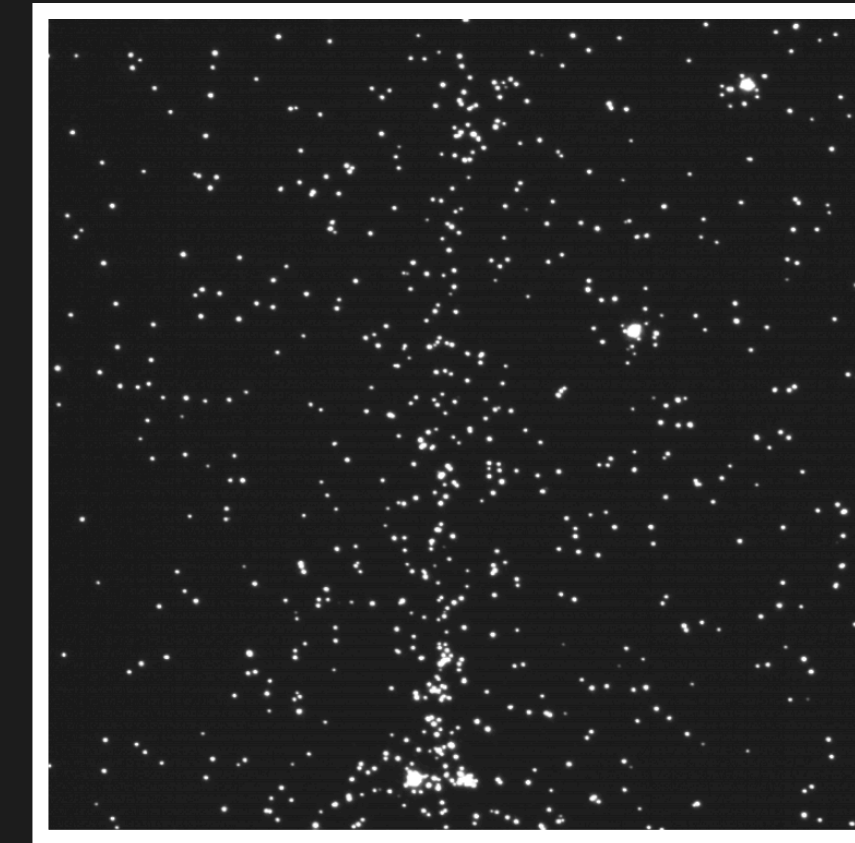
1. **Sample:** Randomly select 2 points (minimum distance 10 px).
2. **Compute:** Calculate the line passing through the 2 points ( $ax + by + c = 0$ ).
3. **Consensus:** Count inliers (points at a distance  $<$  threshold from the line).
4. **Repeat** until a model with enough inliers is found.
5. **Refine** 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  $\theta \in [-90^\circ, 90^\circ]$  (step =  $1^\circ$ )
2. **Find:** The most voted point in the Hough space that give the precisest value for  $\theta$  in the projection
3. **Calculate:** the corresponding angular coefficient of the line

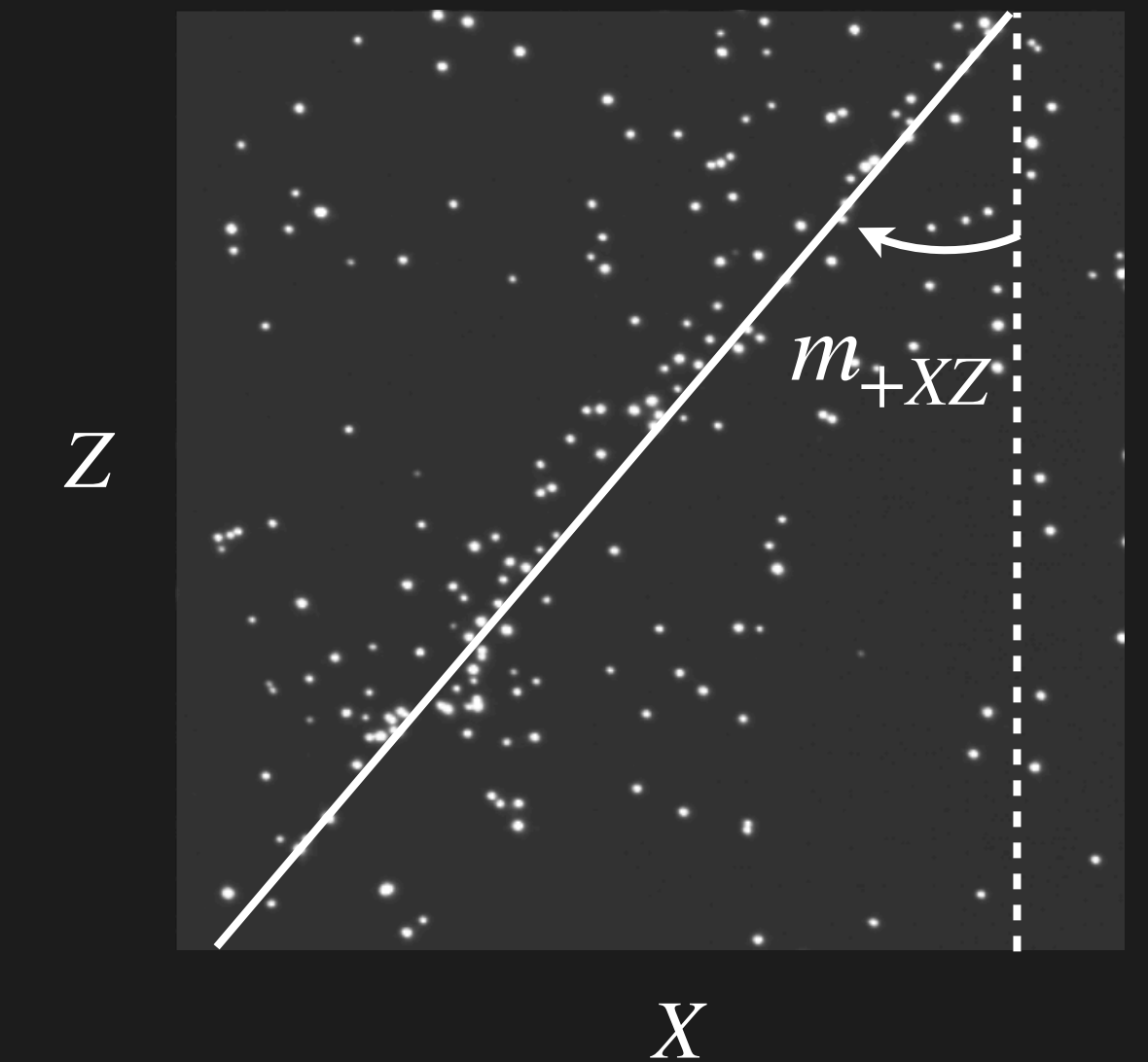
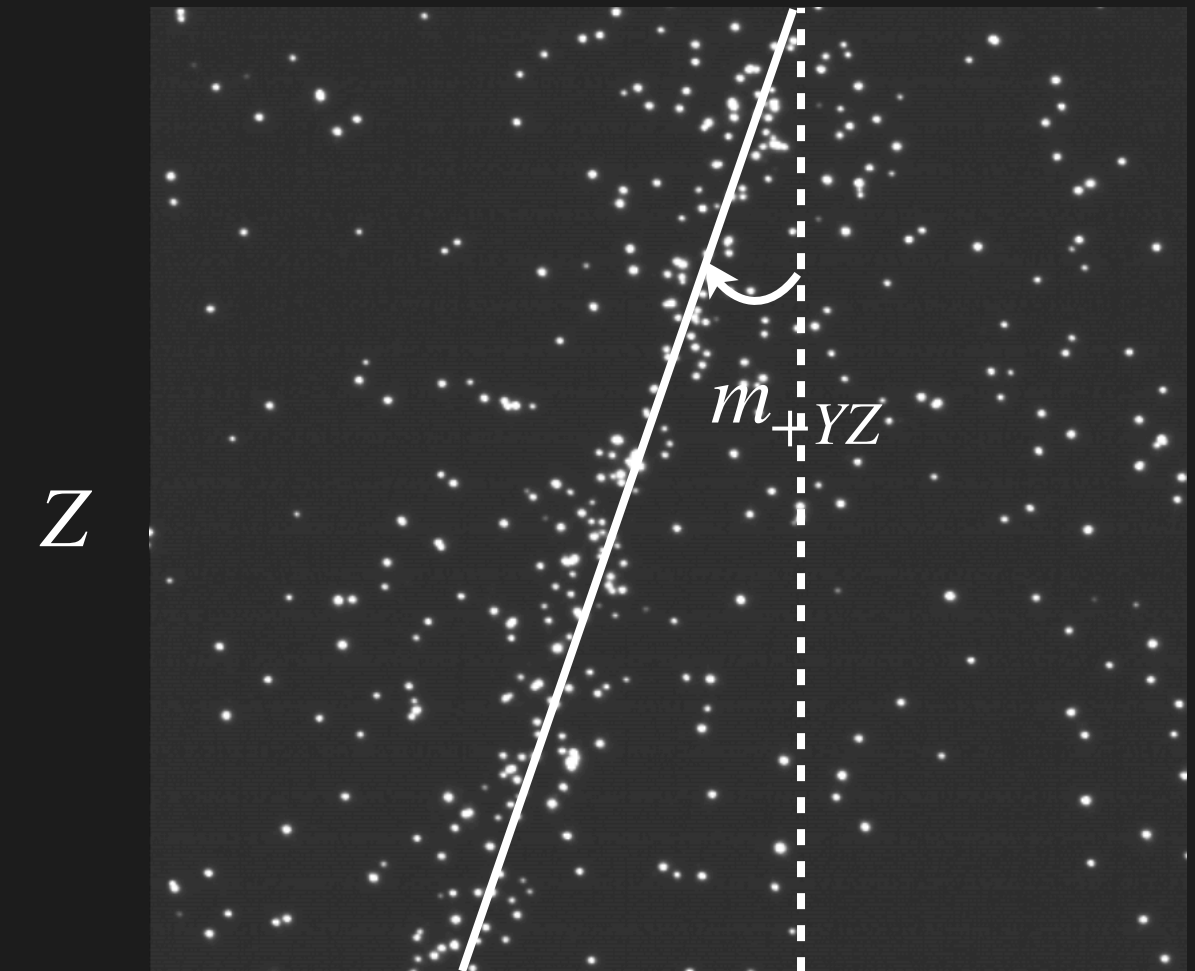


# FROM 2D TO 3D

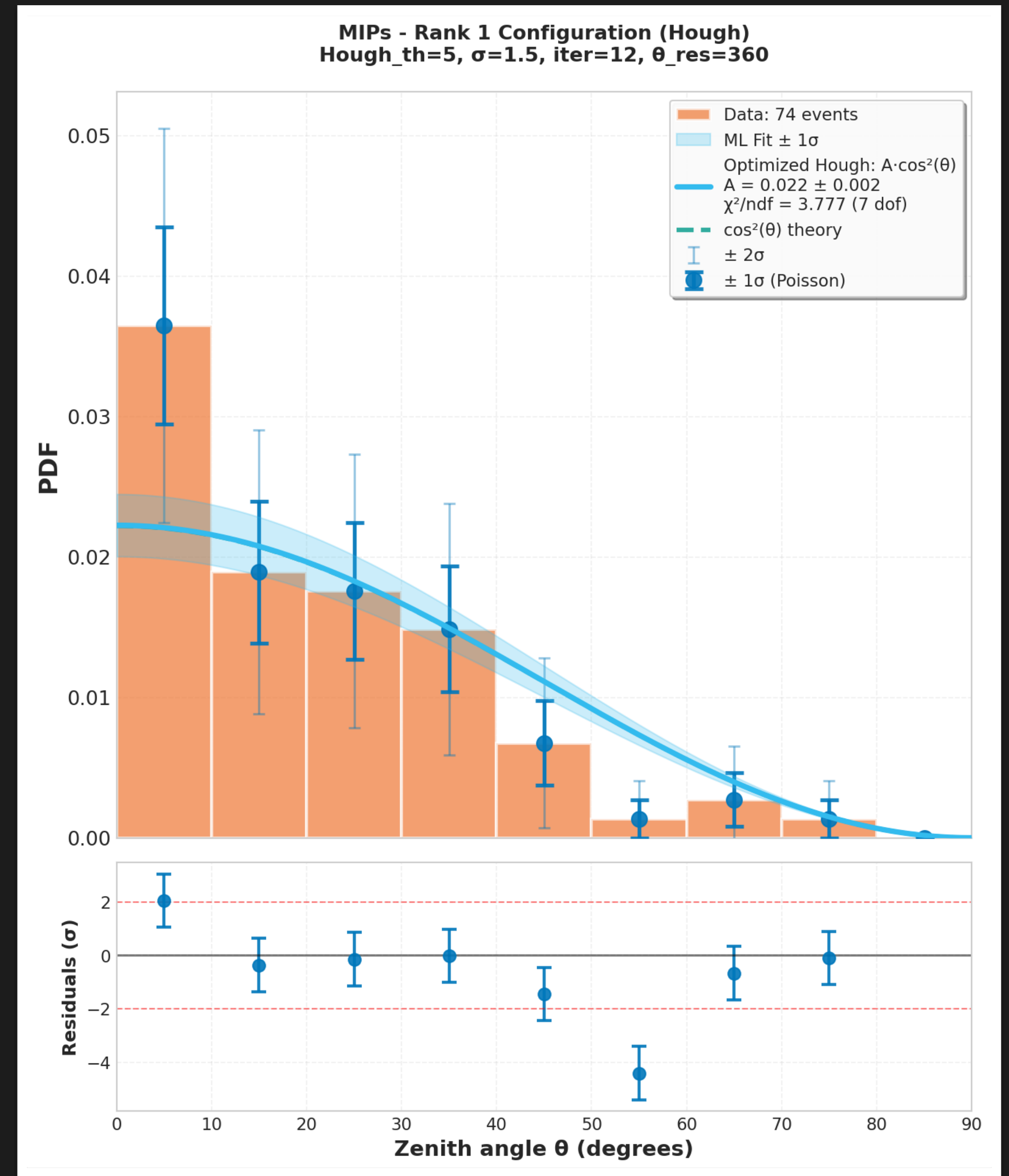
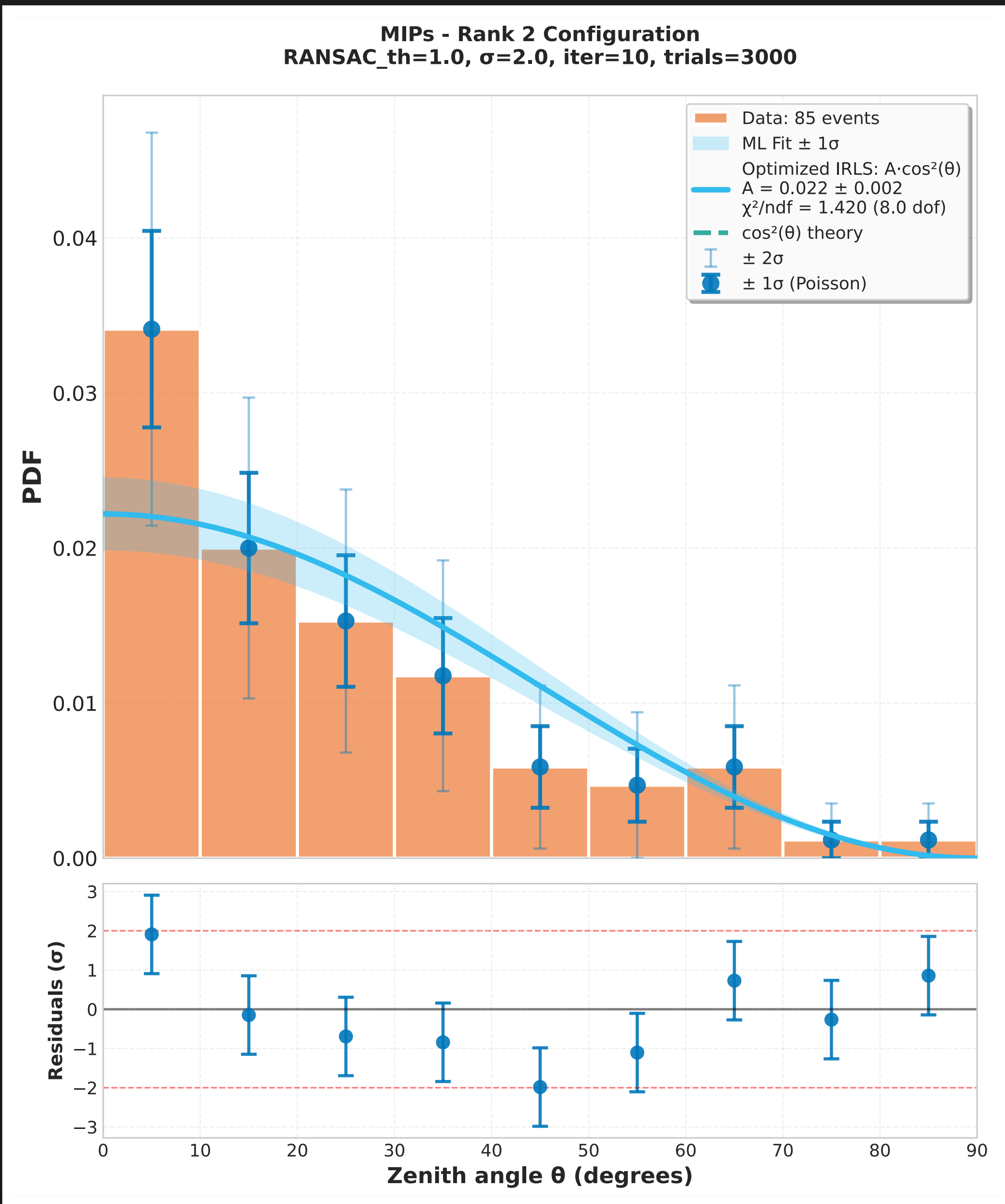
$$\begin{cases} m_{+YZ} = \tan \theta_{+YZ} = \Delta y / \Delta z \\ m_{+XZ} = \tan \theta_{+XZ} = \Delta x / \Delta z \end{cases}$$

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

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

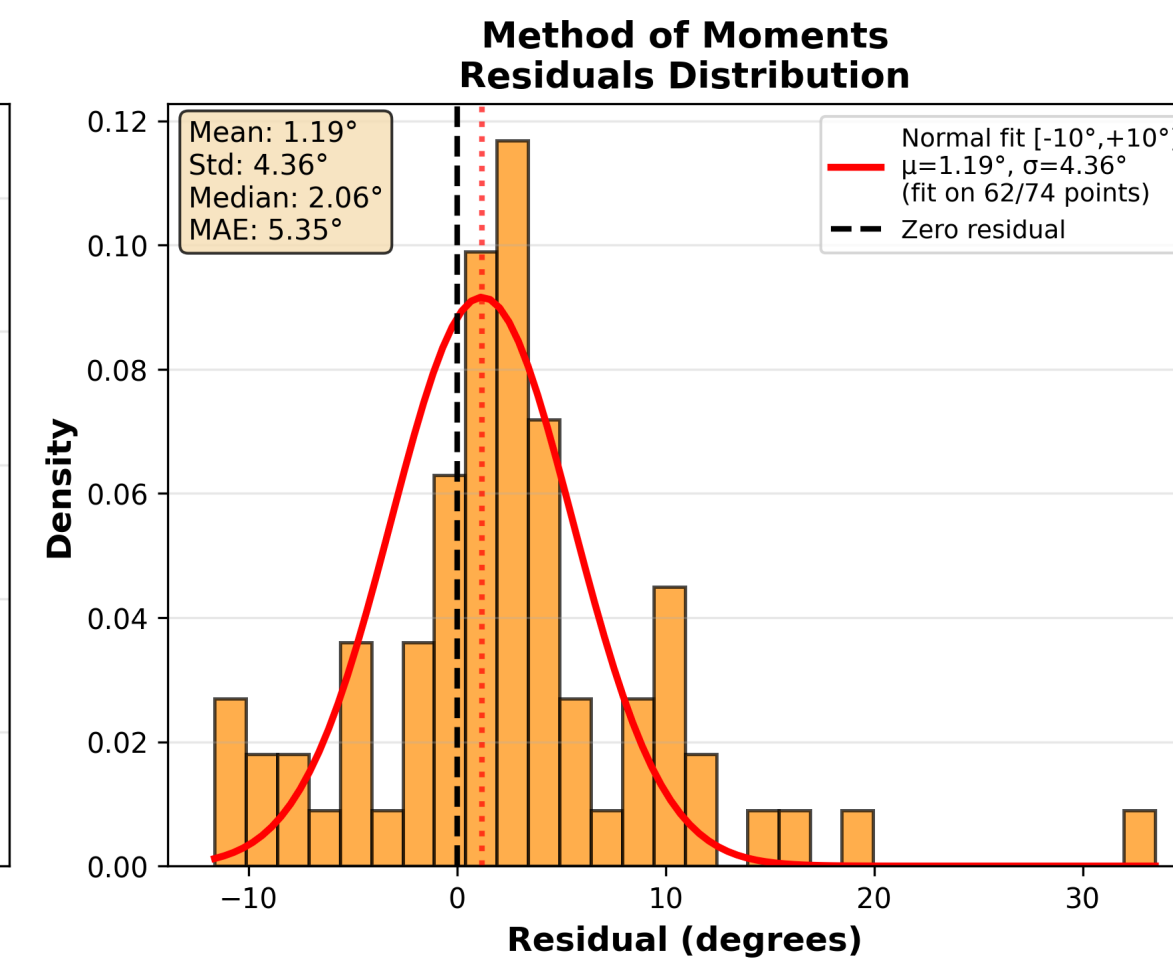
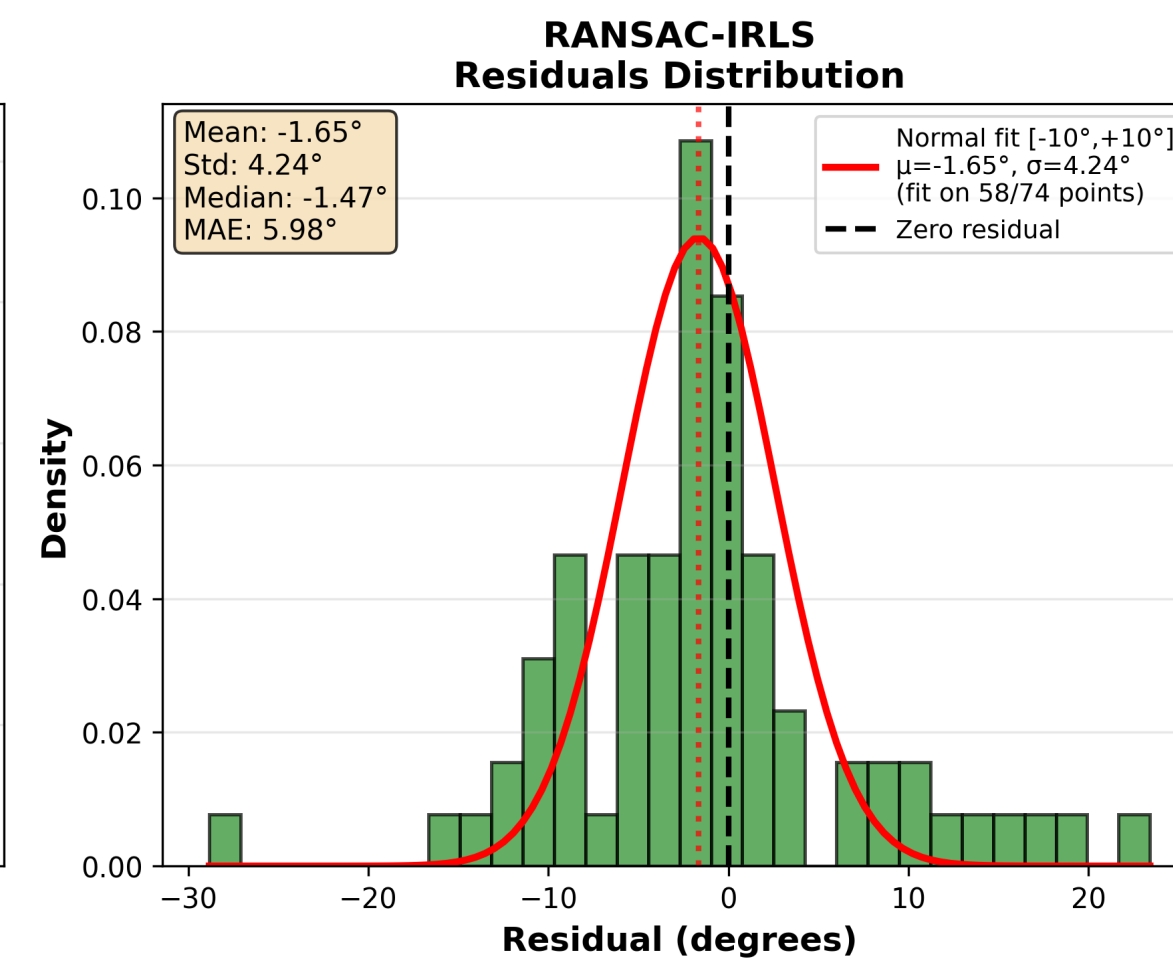
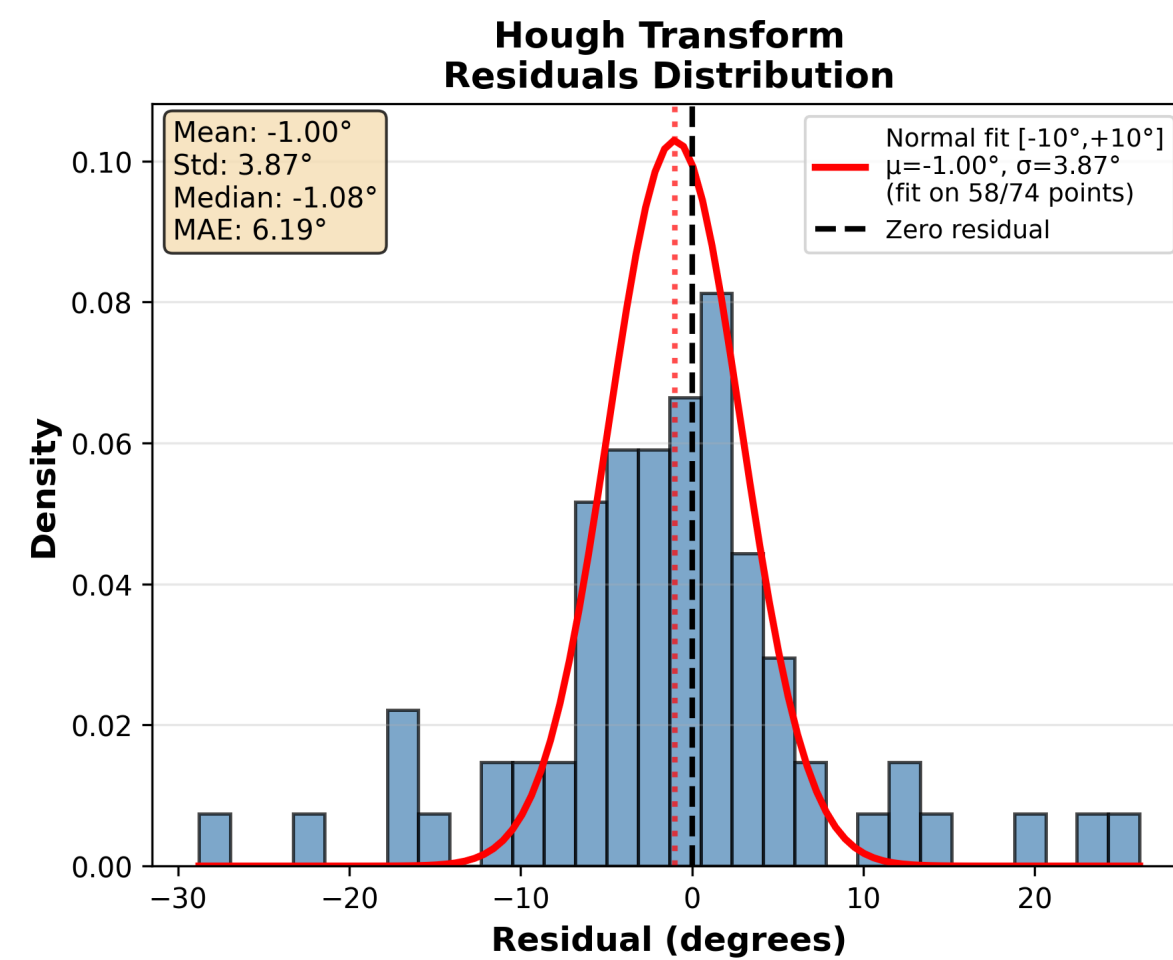
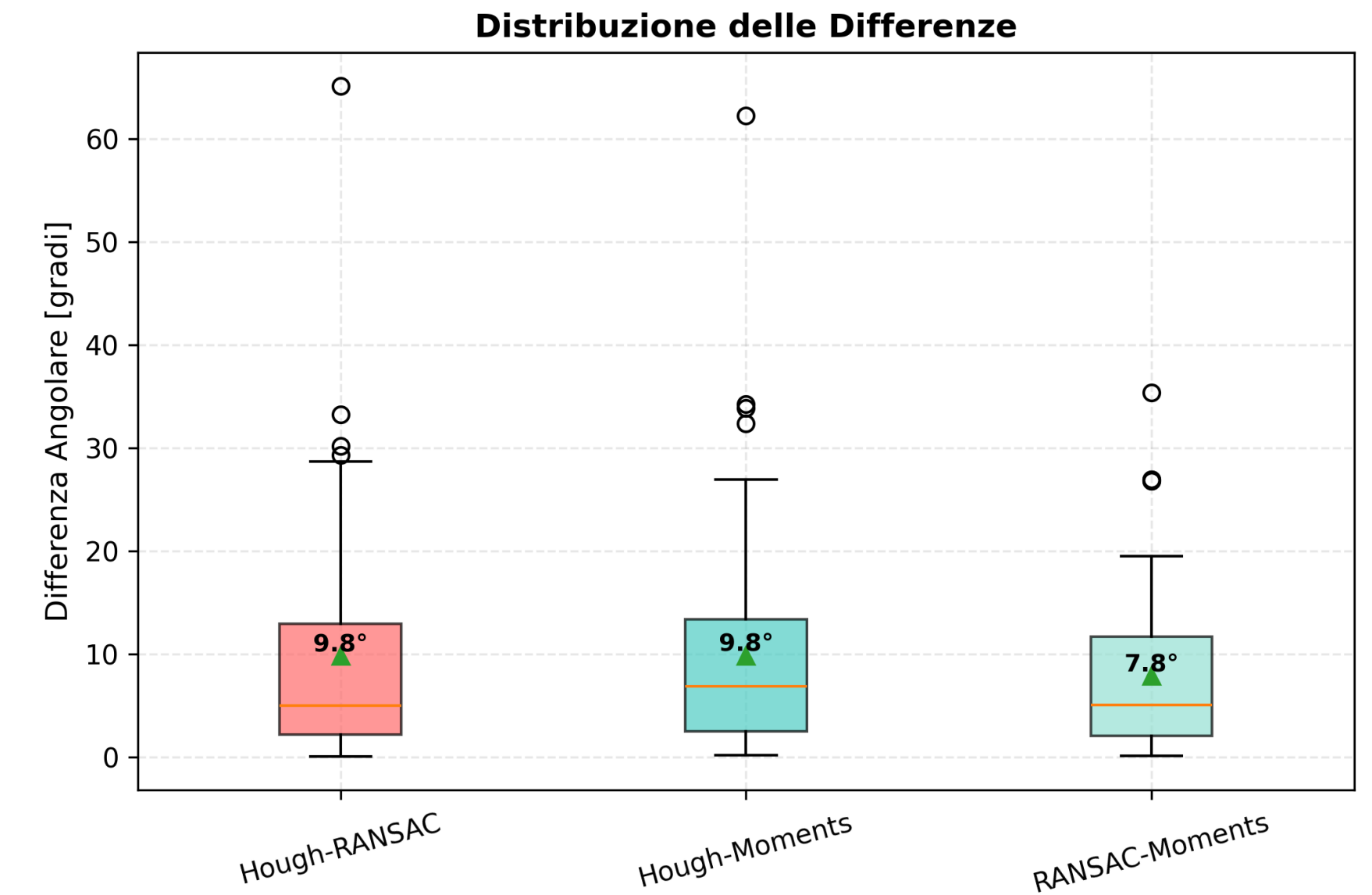


# ANGULAR DISTRIBUTION



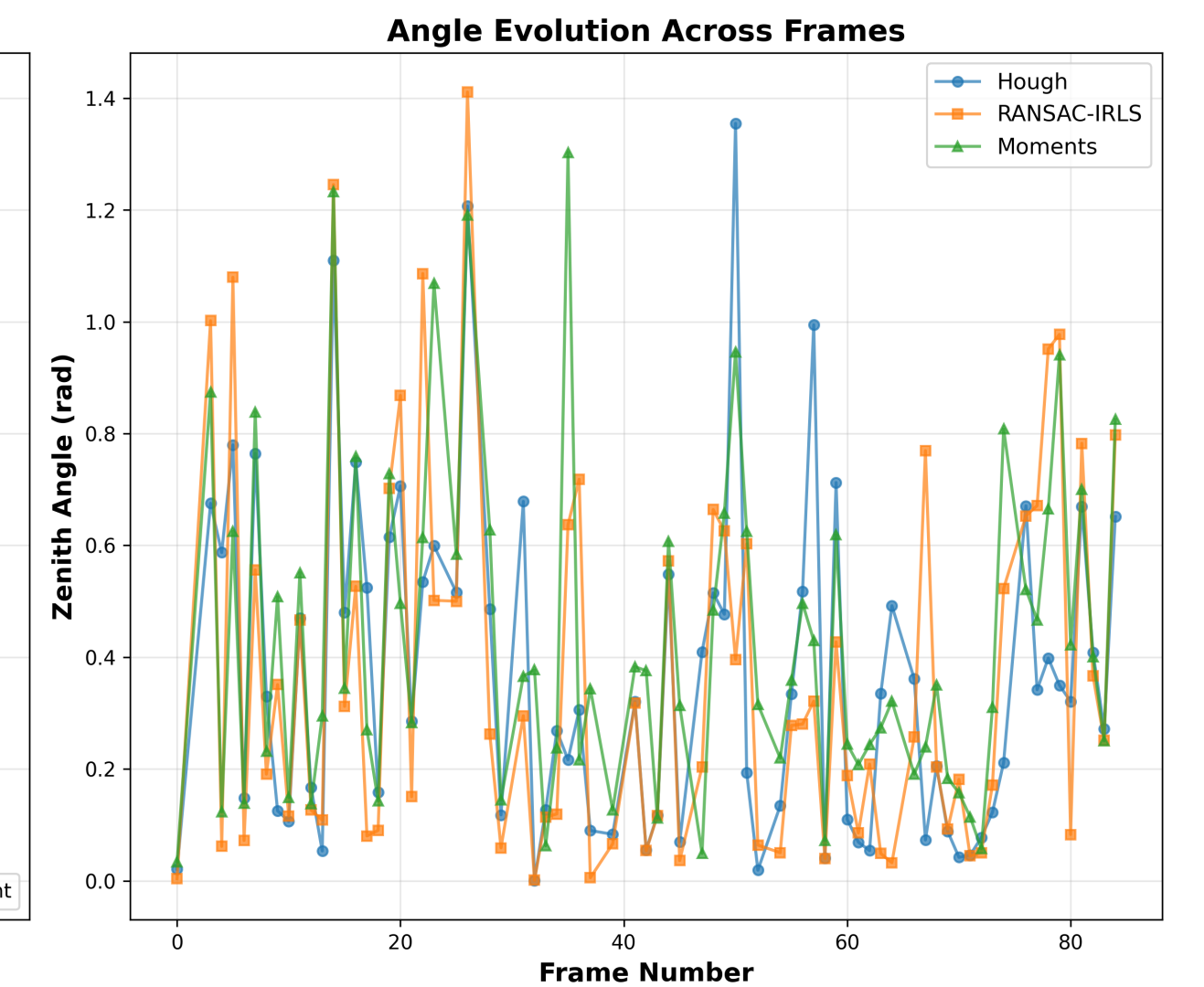
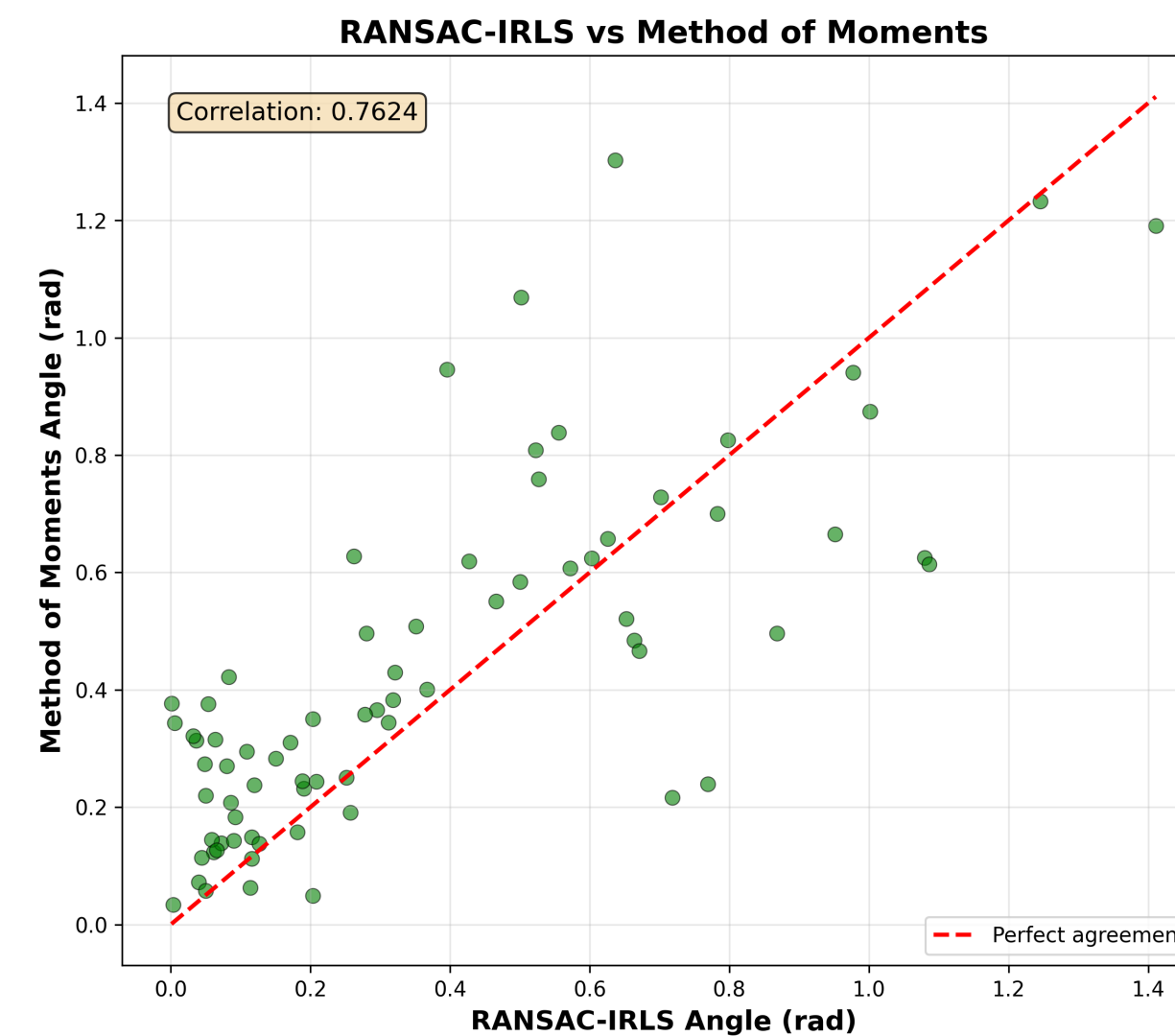
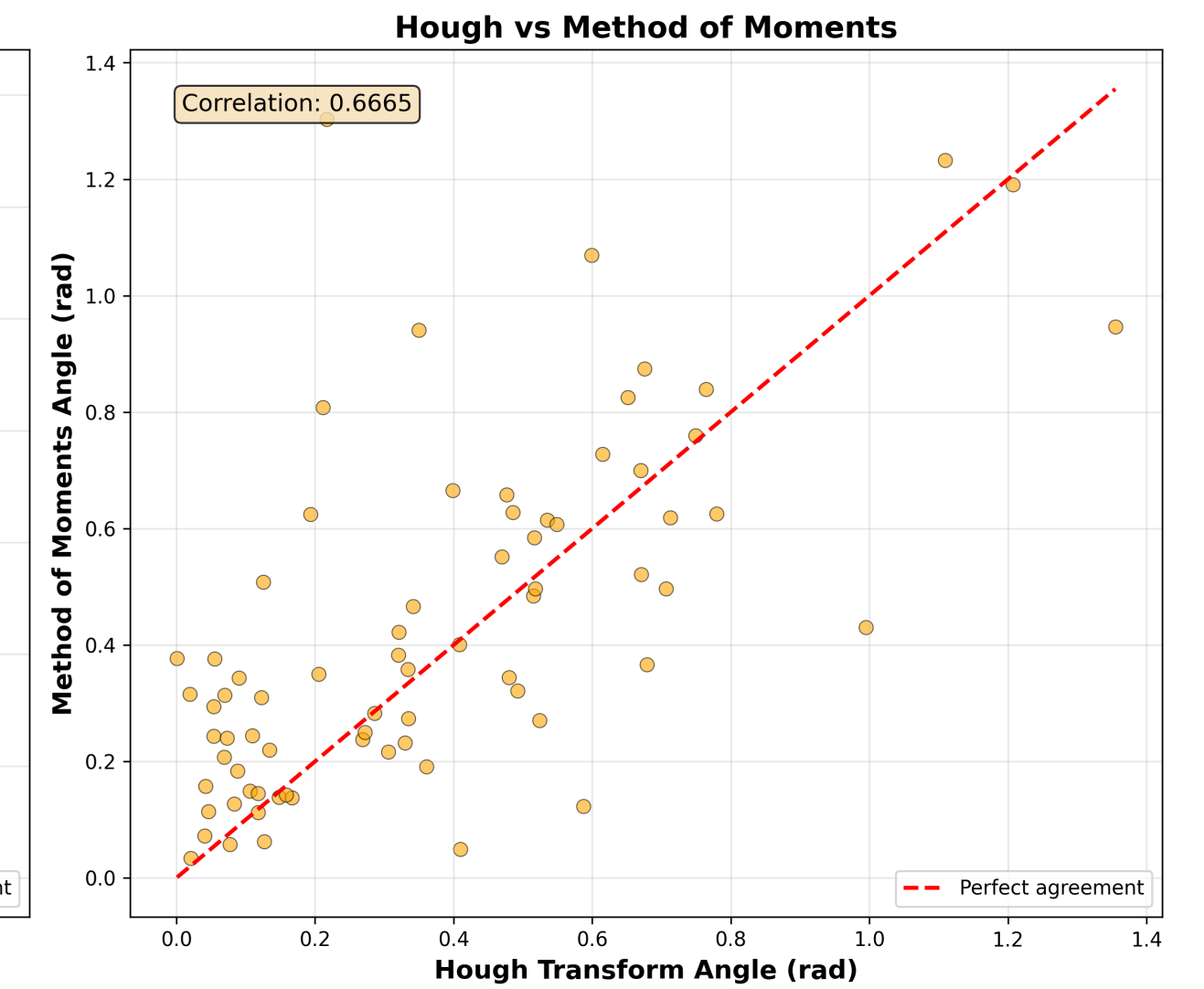
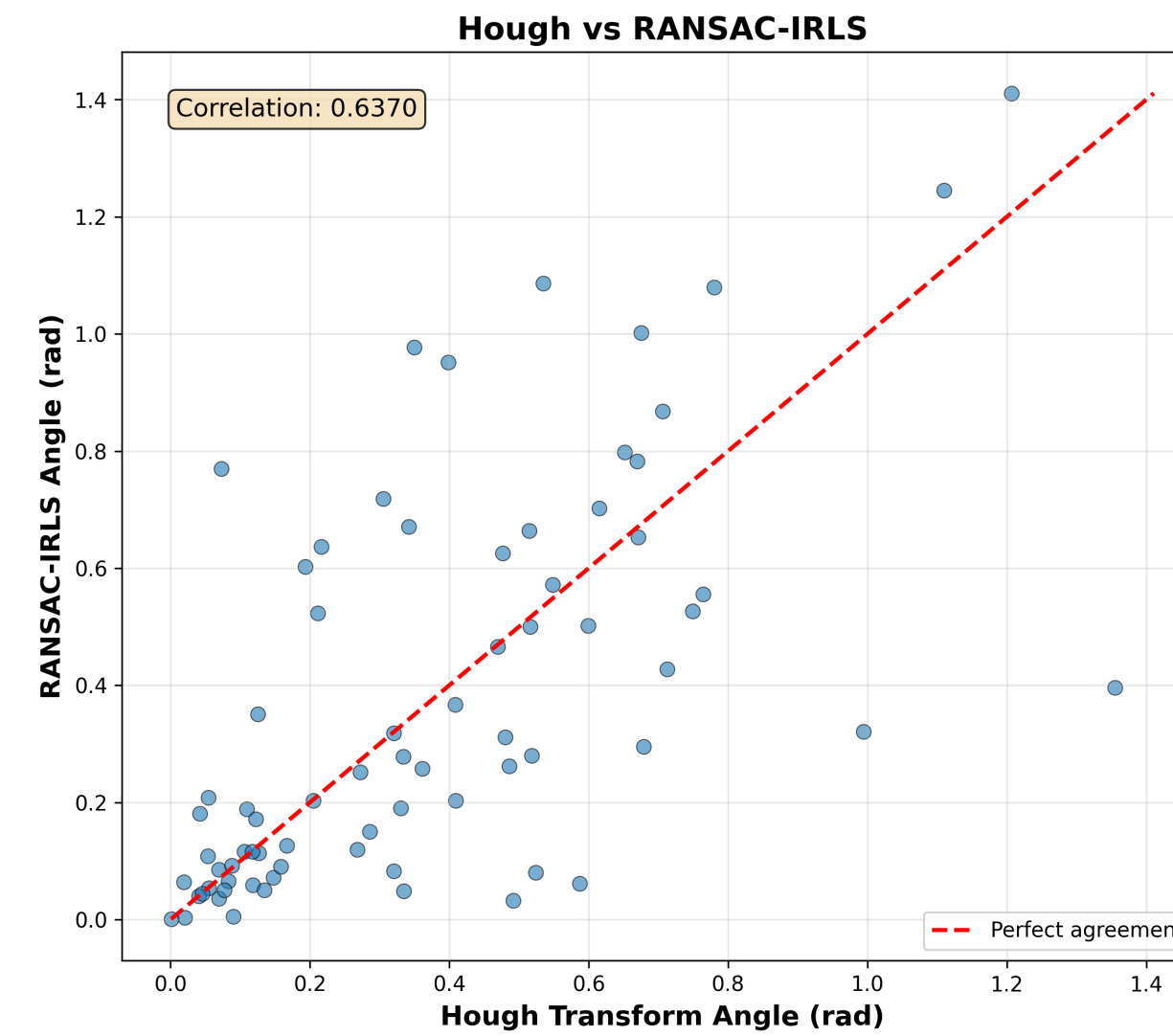
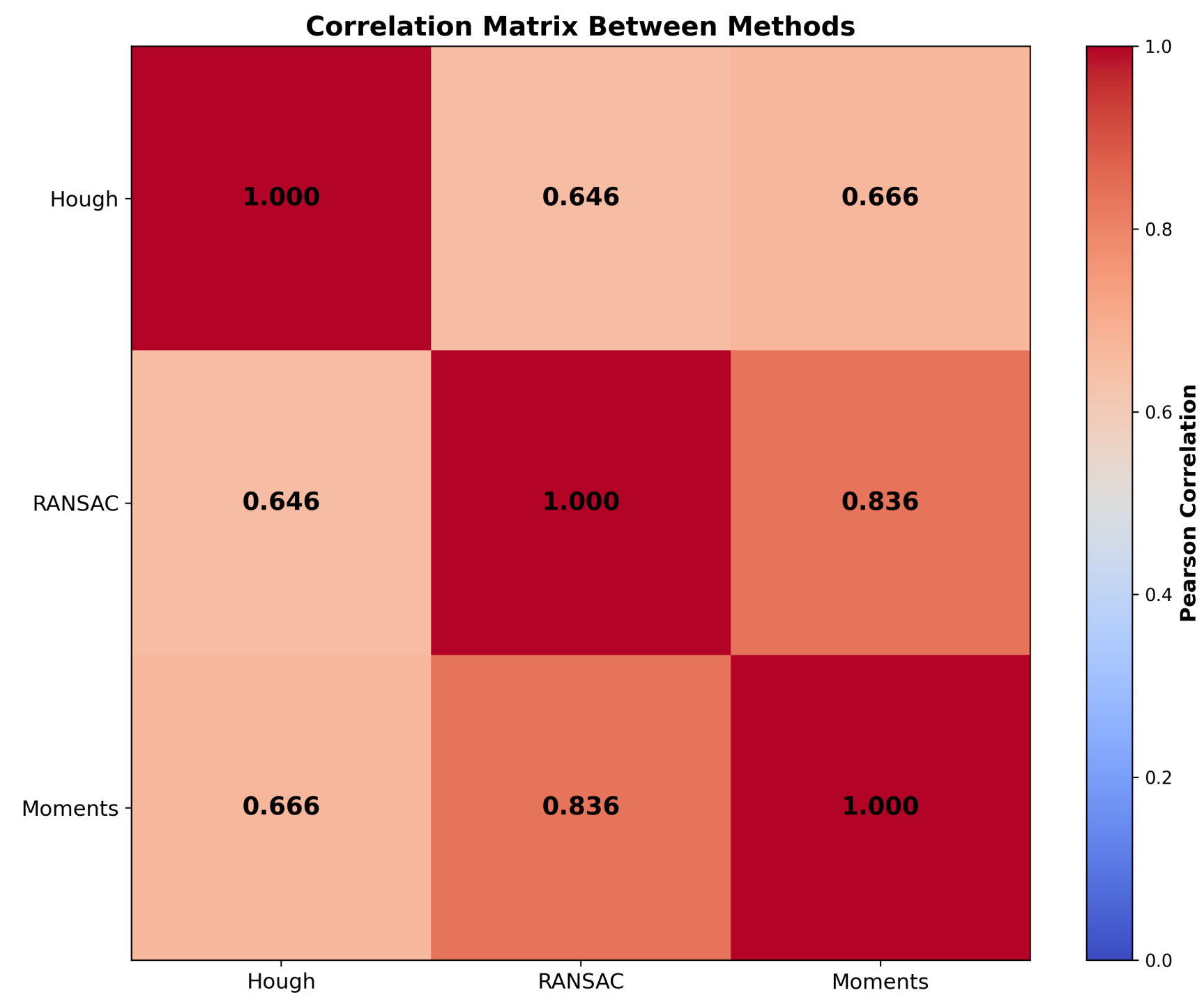
# METHODS COMPARISON

To assess the agreement between the methods, a **residual analysis** with respect to the fit curve and a comparison of the **angular differences** between the methods were conducted.



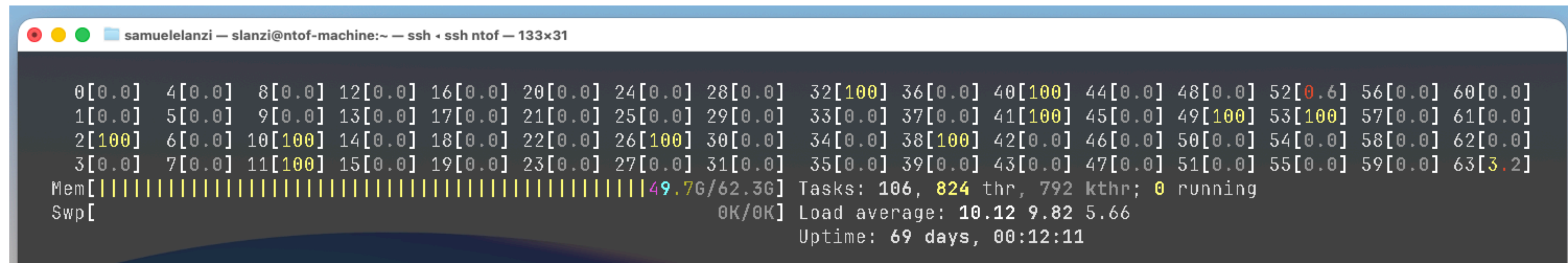
# METHODS COMPARISON

Correlation between methods:



# STATUS OF THE SIMULATION

- Memory saturation when CRY is used



```
0[0.0] 4[0.0] 8[0.0] 12[0.0] 16[0.0] 20[0.0] 24[0.0] 28[0.0] 32[100] 36[0.0] 40[100] 44[0.0] 48[0.0] 52[0.6] 56[0.0] 60[0.0]
1[0.0] 5[0.0] 9[0.0] 13[0.0] 17[0.0] 21[0.0] 25[0.0] 29[0.0] 33[0.0] 37[0.0] 41[100] 45[0.0] 49[100] 53[100] 57[0.0] 61[0.0]
2[100] 6[0.0] 10[100] 14[0.0] 18[0.0] 22[0.0] 26[100] 30[0.0] 34[0.0] 38[100] 42[0.0] 46[0.0] 50[0.0] 54[0.0] 58[0.0] 62[0.0]
3[0.0] 7[0.0] 11[100] 15[0.0] 19[0.0] 23[0.0] 27[0.0] 31[0.0] 35[0.0] 39[0.0] 43[0.0] 47[0.0] 51[0.0] 55[0.0] 59[0.0] 63[3.2]
Mem[|||||49.7G/62.3G] Tasks: 106, 824 thr, 792 kthr; 0 running
Swp[0K/0K] Load average: 10.12 9.82 5.66
Uptime: 69 days, 00:12:11
```

- If I generate particles with the `PrimaryGeneratorAction` and use `/gps` in the macro, this strange behavior does not occur.
- These days I am trying to solve the problem...

# 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  $\sim 10^\circ$
  - 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