Progress presentation

Algorithm development for the segmentation of astronomical images with unique features

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Space Debris

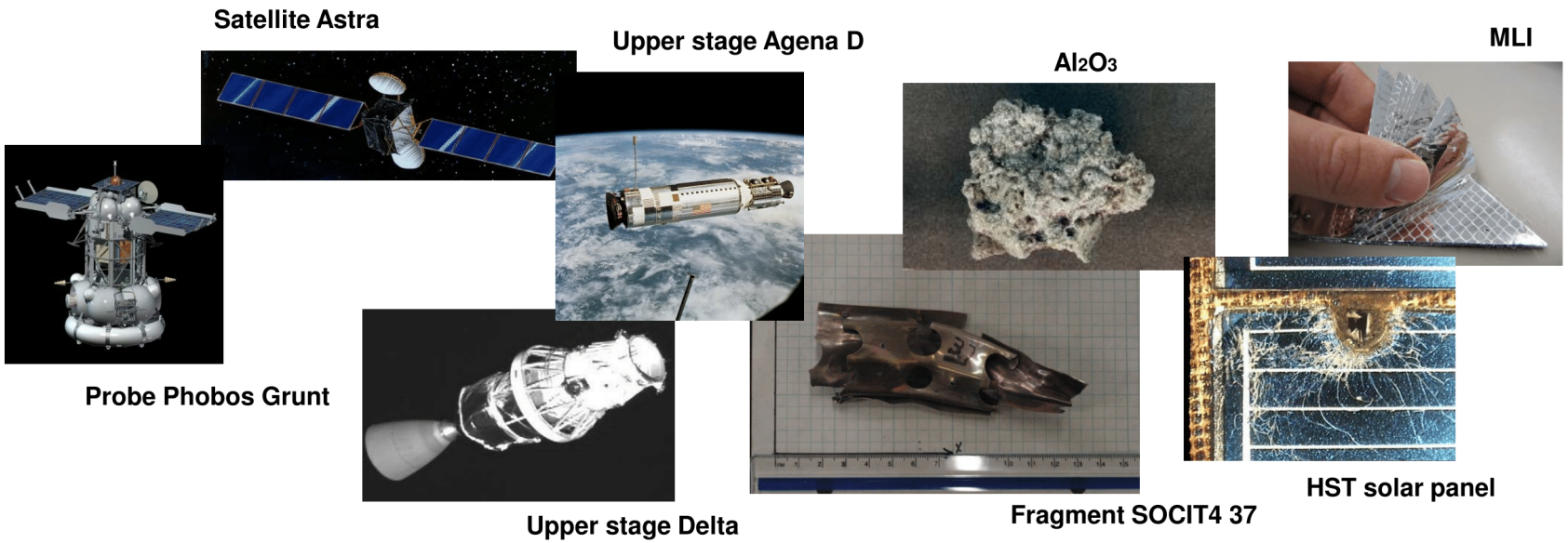

Figure 1: Space debris sources

Space View

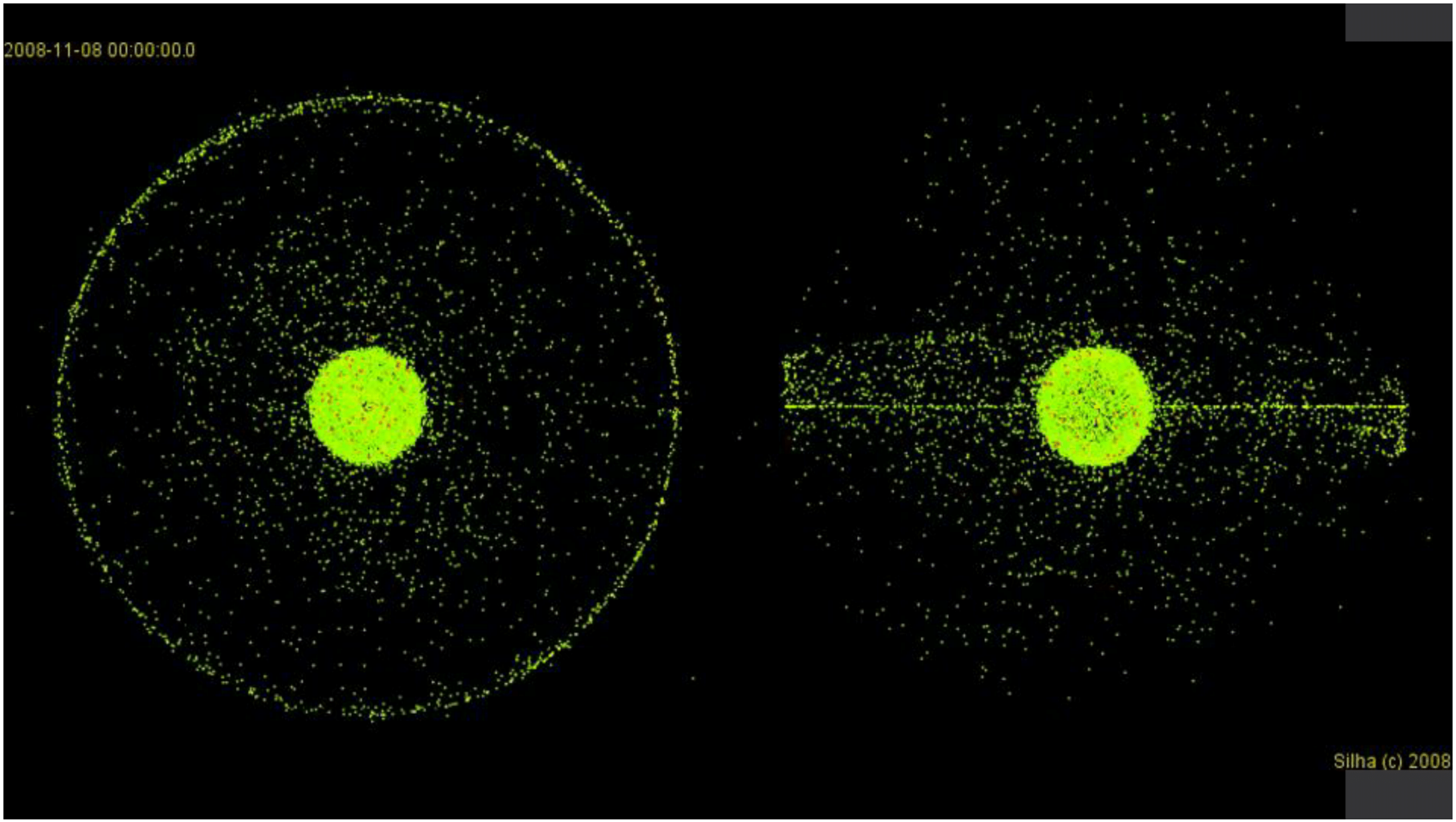

Figure 2: Debris clusters (GEO, LEO)

GEO/LEO

There are multiple orbital layers

- LEO (Low Earth Orbit)
- GEO (Geosynchronous Earth Orbit)
- GNSS, GTO, Molniya

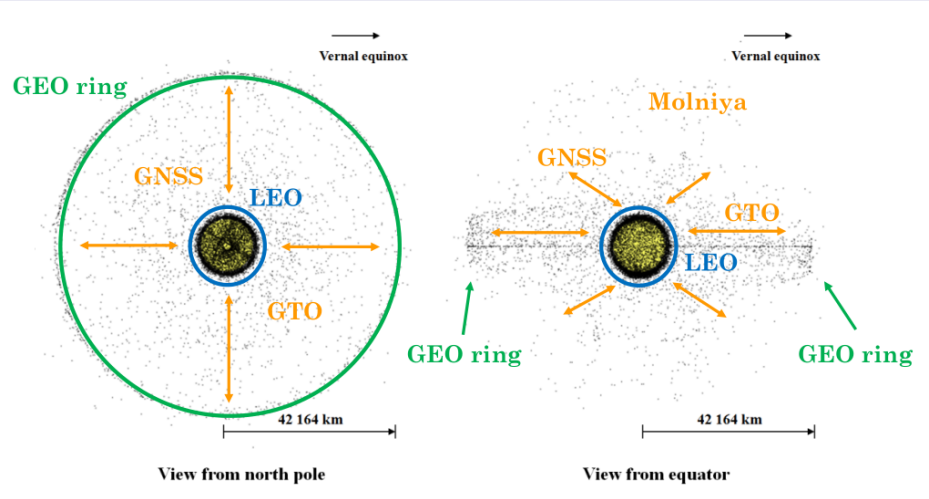

Figure 3: Orbital layers

Change over time

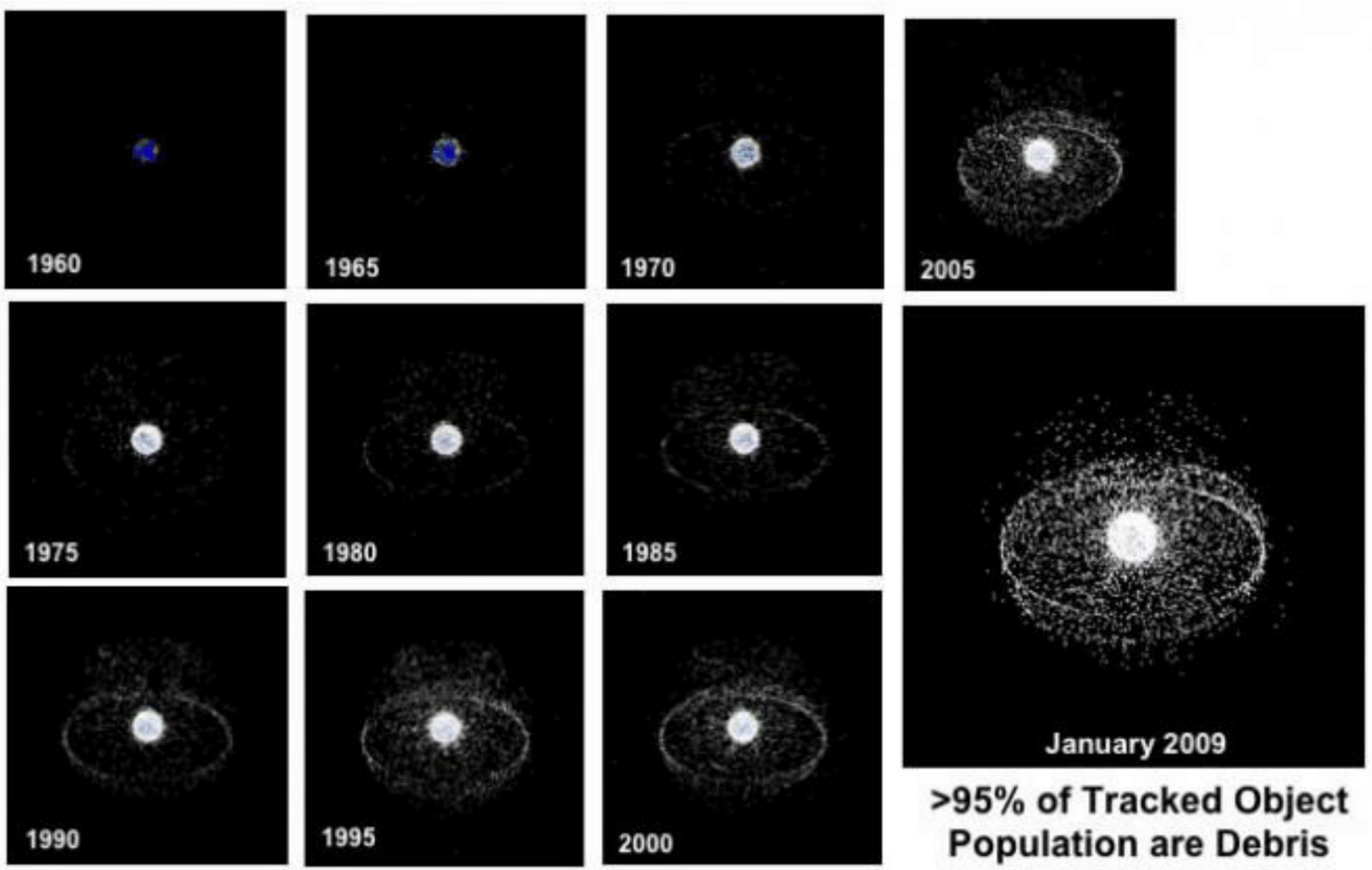

Figure 4: Amount of debris through time milestones

AGO 70cm

AGO 70 programs

- Astrometry, surveys
- Photometry, light curves
- Photometry, colors

Figure 5: AGO 70cm installation(left), mount(middle), primary mirror(right)

Pipeline

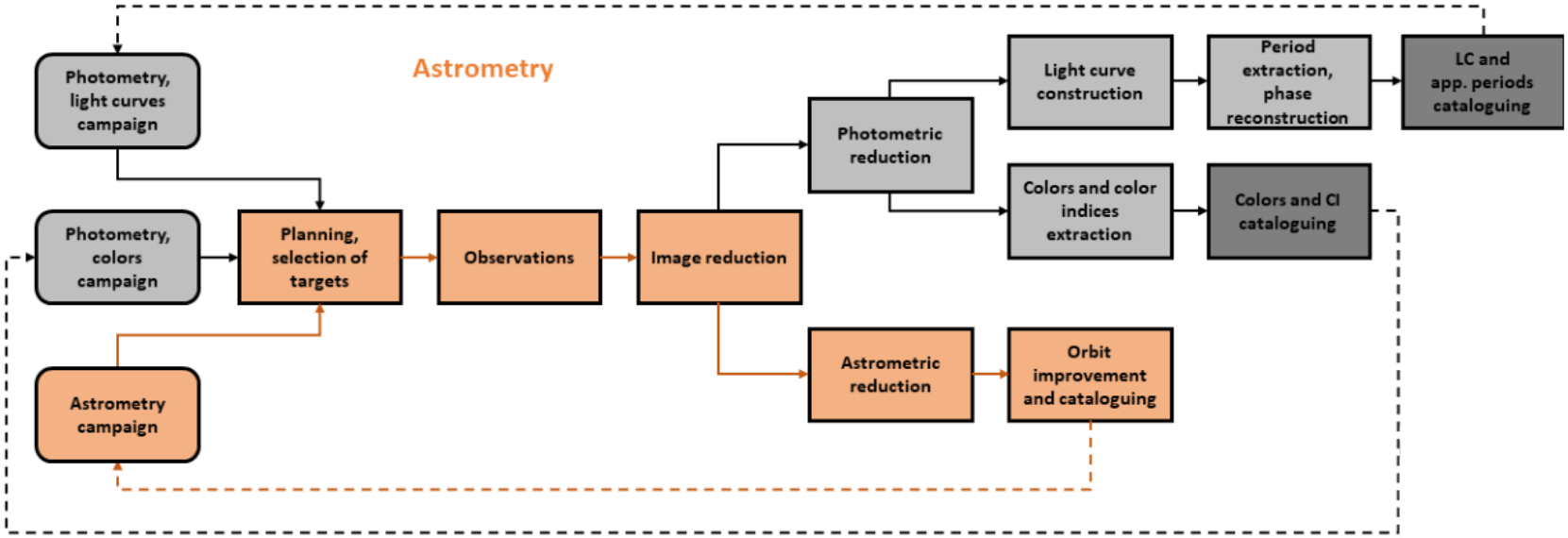

Figure 6: Astrometry pipeline

Tracking

There are 2 types of tracking

- Sidereal tracking
- Object tracking

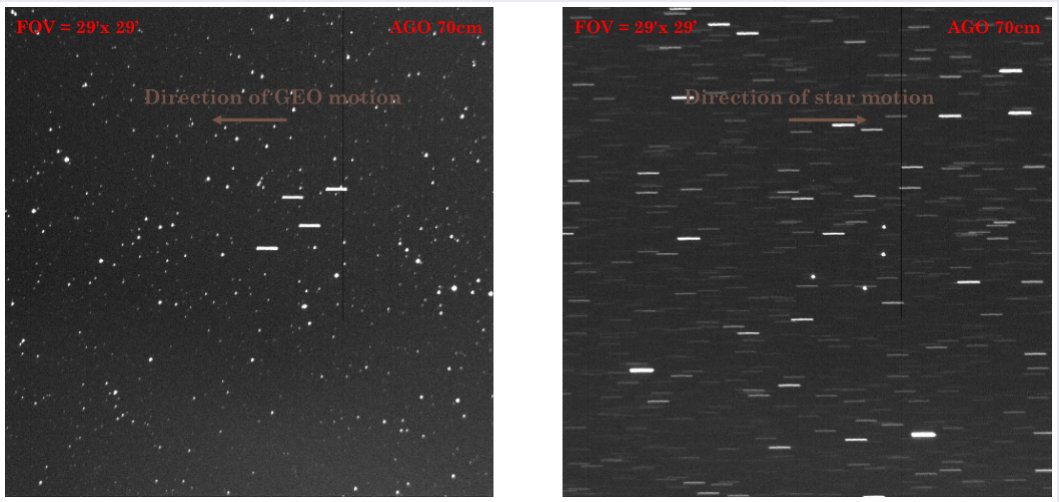

Figure 7: Posible tracking methods, Sidereal tracking(left), Object tracking(right)

Steps

- Image capture
- Image reduction
- Sky background estimation
- Sky background extraction
- Star object identification and extraction (image segmentation)
- Astrometric reduction
- Star masking
- Object identification, Image segmentation
- Tracklet building
- Tracklet conversion, tracklet the final product

Sky background estimation/subtraction

Reasons/Causes

- Moon light (global linear gradient)
- Stars, Nebulas, Galaxies (local nonlinear gradients)
- Hardware related reflexions

Methods

- Convolution with large median kernel (at least 25% of the size of image)
- Sigma clipping

Sky background estimation/subtraction

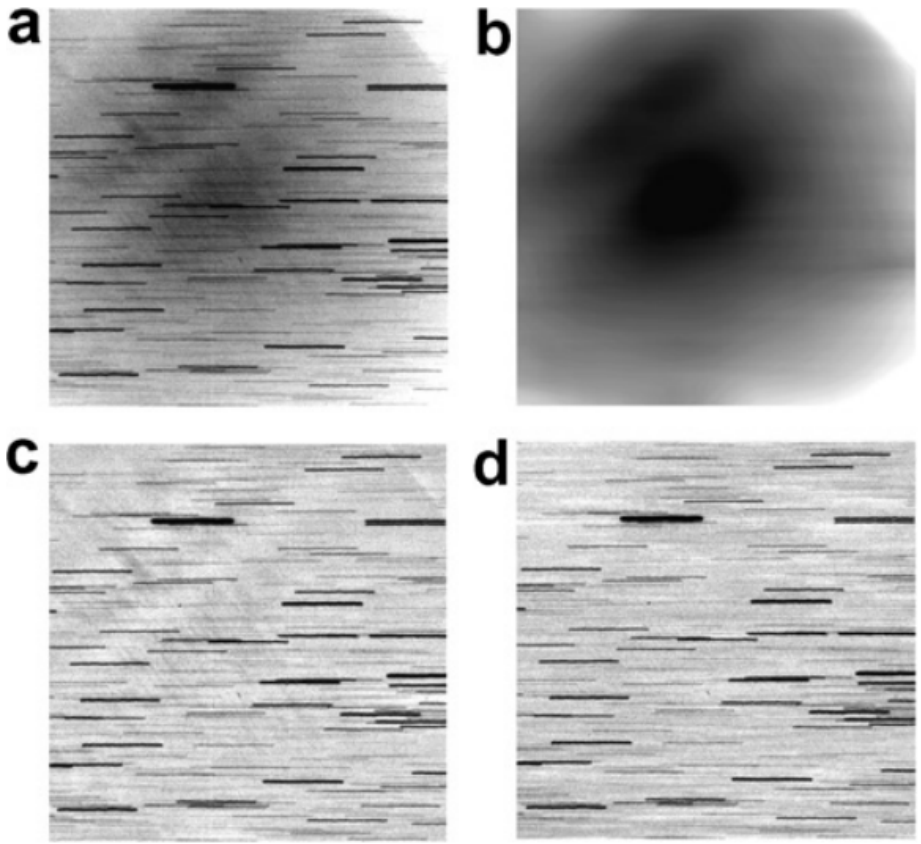

Figure 8: original image(a), background(b), result median filtering(c), sigma clipping(d)

Sky background estimation/subtraction

Figure 9: Dumbell nebula M27, AGO 70cm telescope

Sky background estimation results

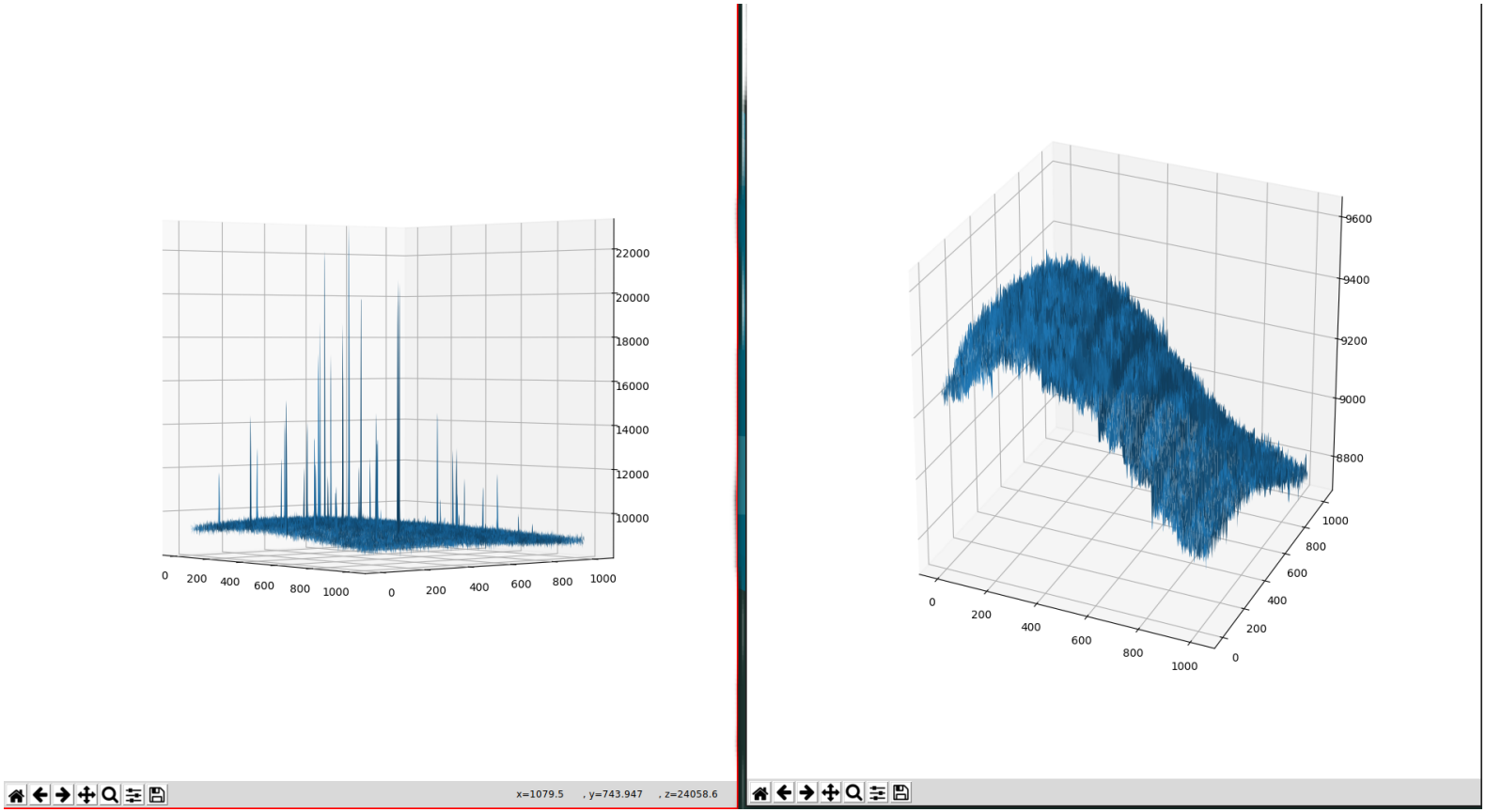

Figure 10: original image(left), estimated background(right)

Object identification

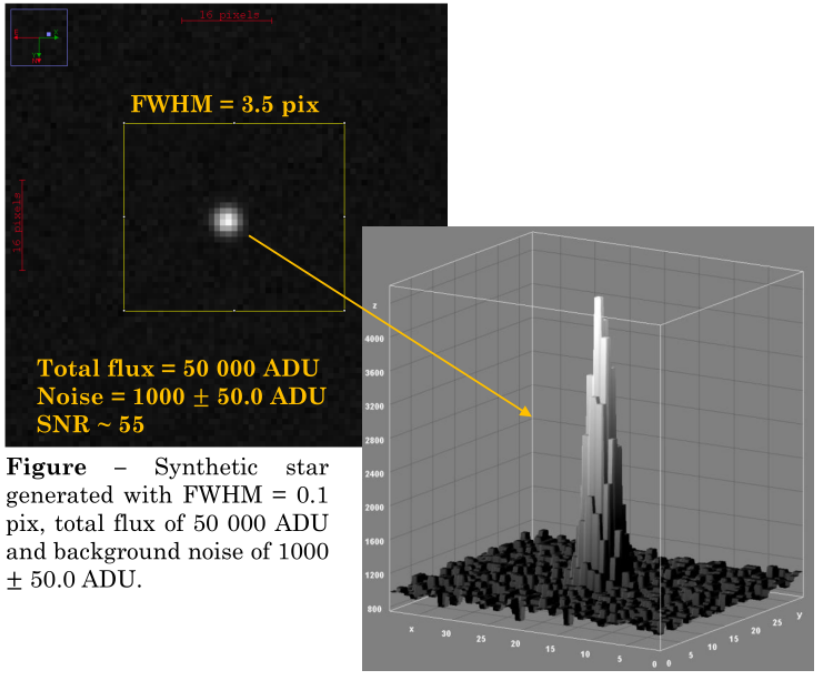

Figure – Synthetic star generated with FWHM = 0.1 pix, total flux of 50 000 ADU and background noise of 1000 ± 50.0 ADU.

Figure – 3D profile of synthetic star.

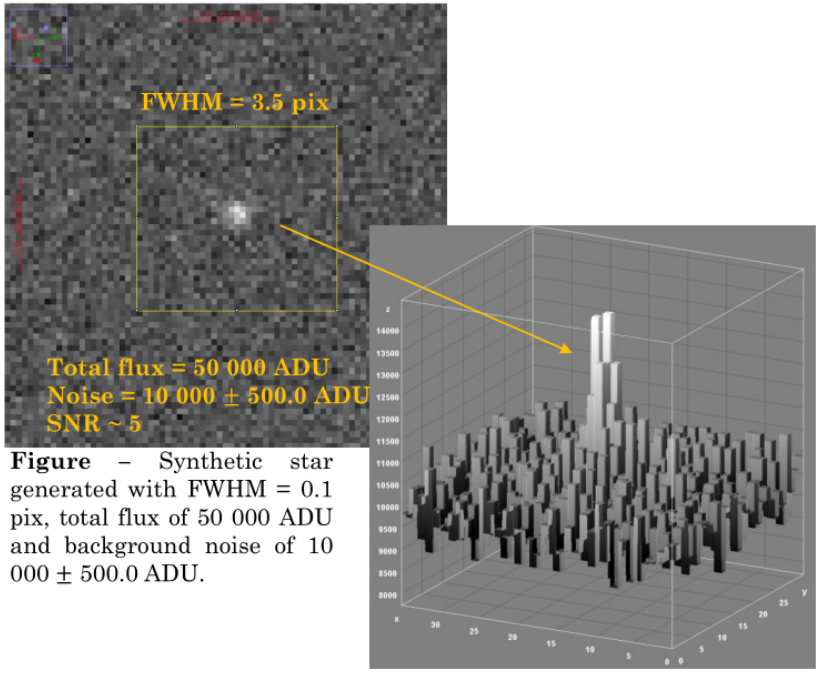

Figure – Synthetic star generated with FWHM = 0.1 pix, total flux of 50 000 ADU and background noise of 10 000 ± 500.0 ADU.

Figure – 3D profile of synthetic star.

Object identification

Methods

- Barycenter positions
- PSF fitting
- Edge detection

PSF fitting - trail

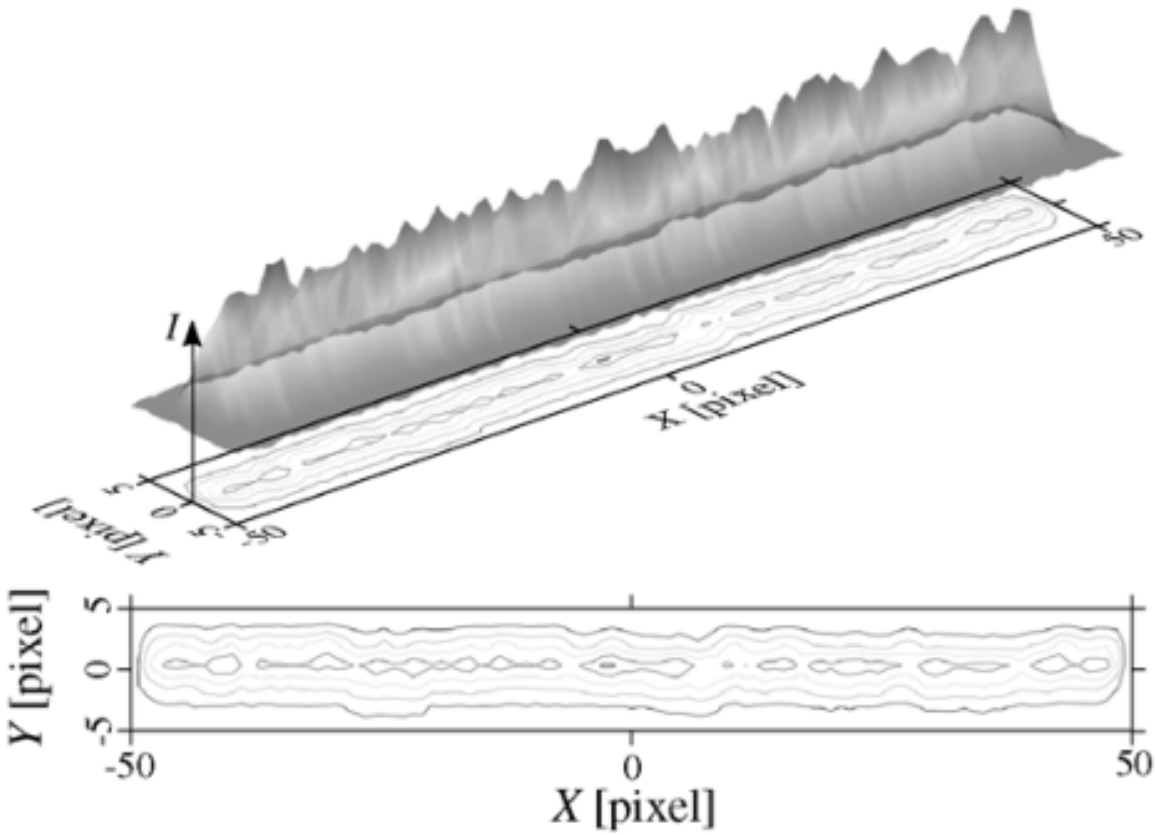

Figure 11: Trail shown from 3d perspective

PSF fitting

$$f_{\text{point}}(r; A, w) = A \exp\left(-\frac{r^2}{w^2} \cdot 4 \ln 2\right)$$

$$f_{\text{trail}}(x, y; A, w, l) = f_{\text{point}}\left(\sqrt{[s(|x| - l/2)]^2 + y^2}; A, w\right)$$

Figure 12: PSF fitting equations

Tools

Python

- Numpy
- Astropy (fits files)
- Scipy (convolve, fitting)
- Matplotlib
- Plotly

AstroImageJ

Workflow

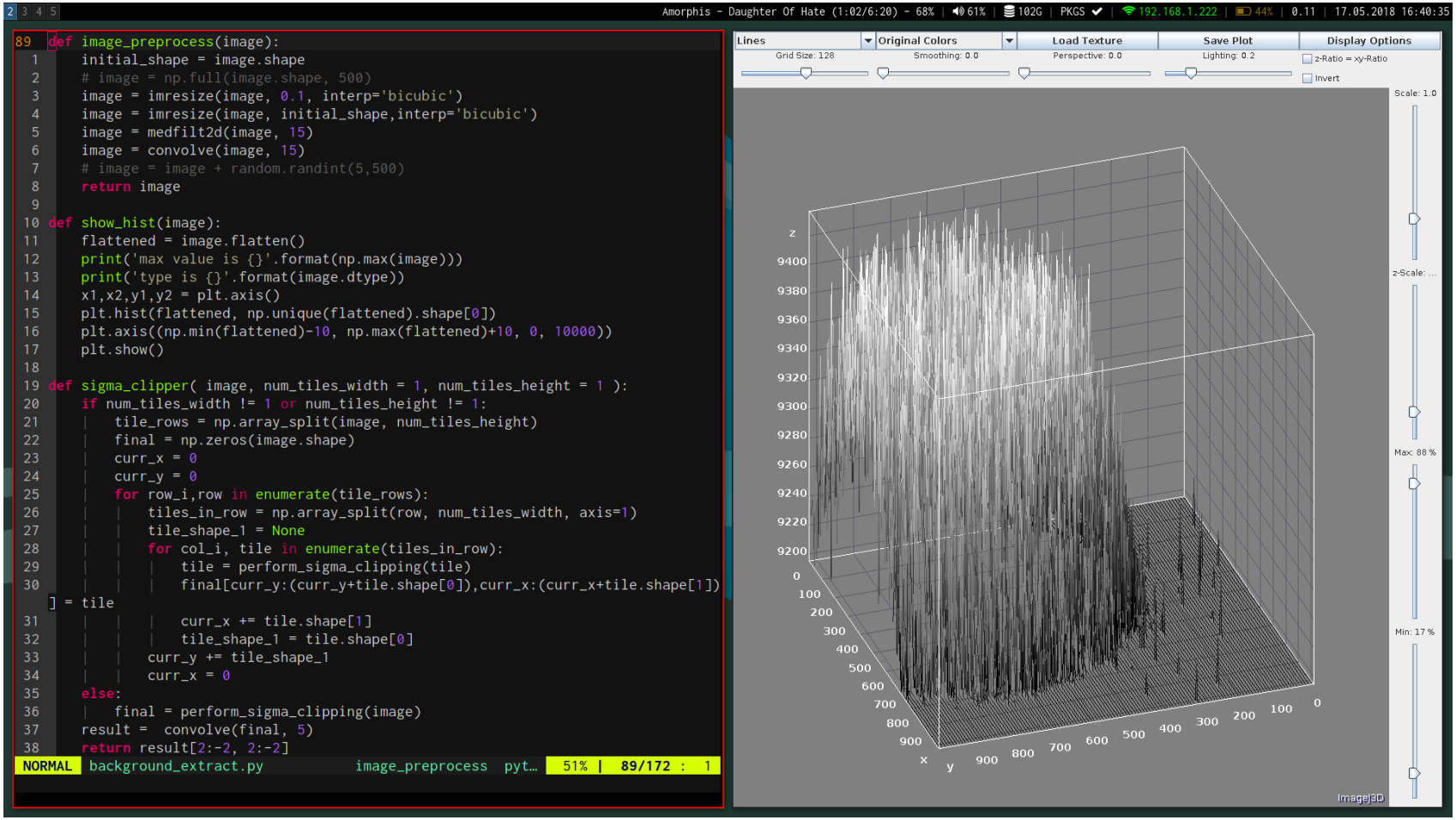

Figure 13: Python + AstroImageJ

Credits

- V. Kouprianov, Distinguishing features of CCD astrometry of faint GEO objects
  Advances in Space Research, Volume 41, Issue 7, 2008,
  Pages 1029-1038, ISSN 0273-1177
  http://www.sciencedirect.com/science/article/pii/S027311770700369
- Jiří Šilha, PhD. Division of Astronomy and Astrophysics
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The End

Thank you for your attention