The need of space VLBI for the space geodesy program

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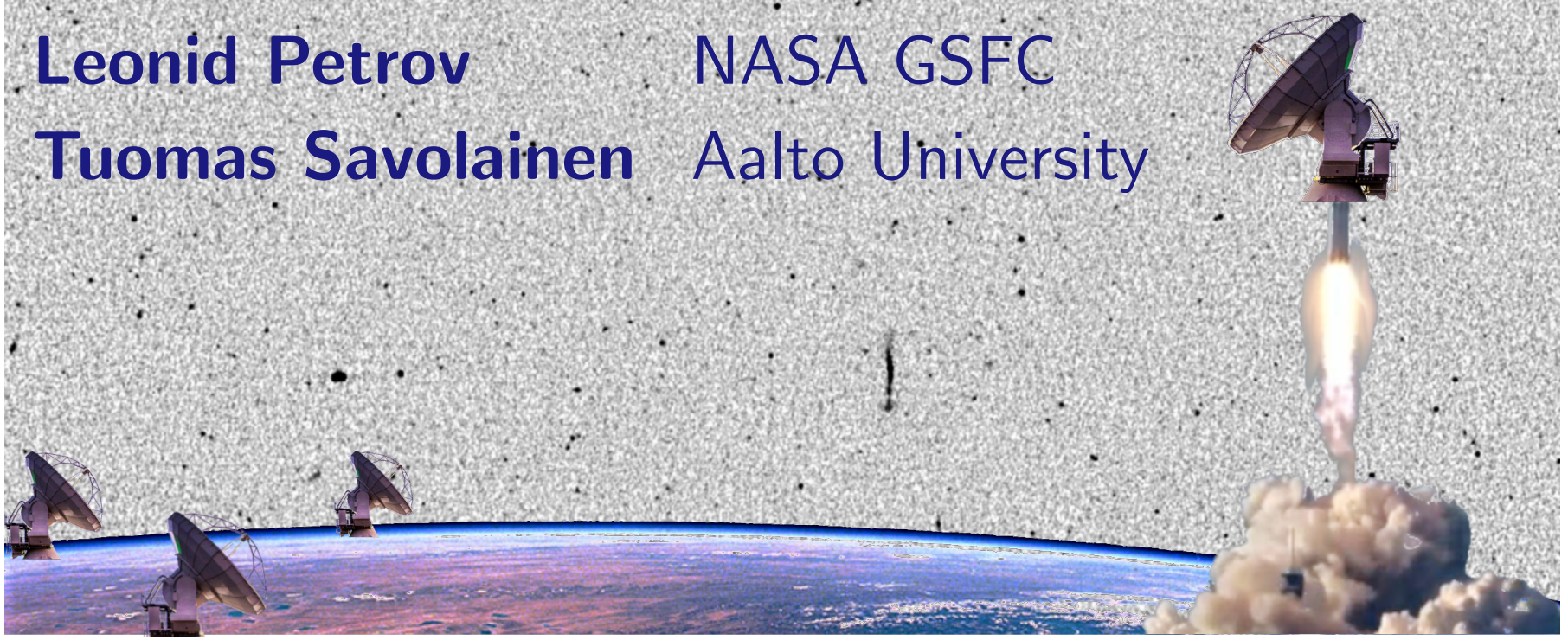
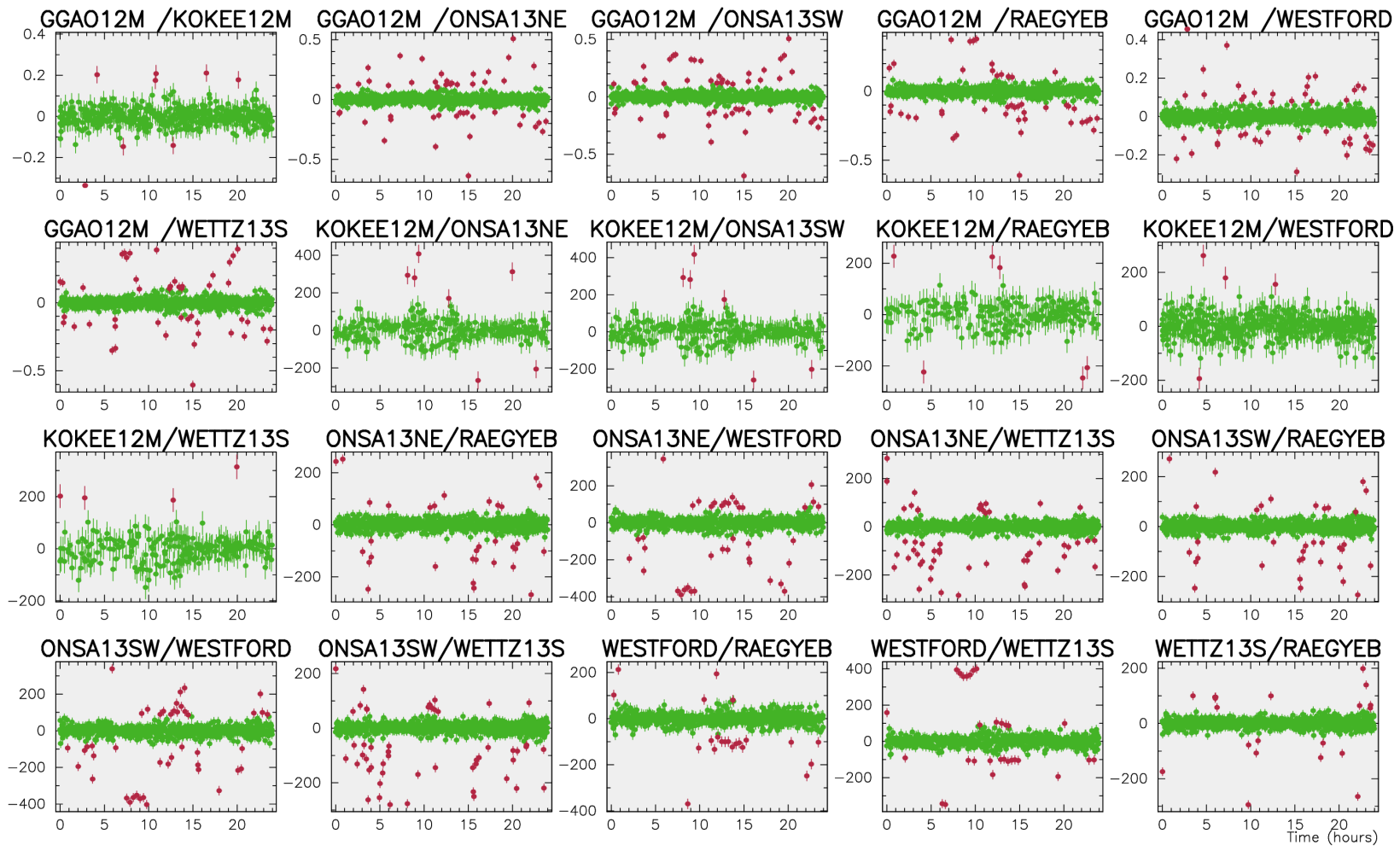
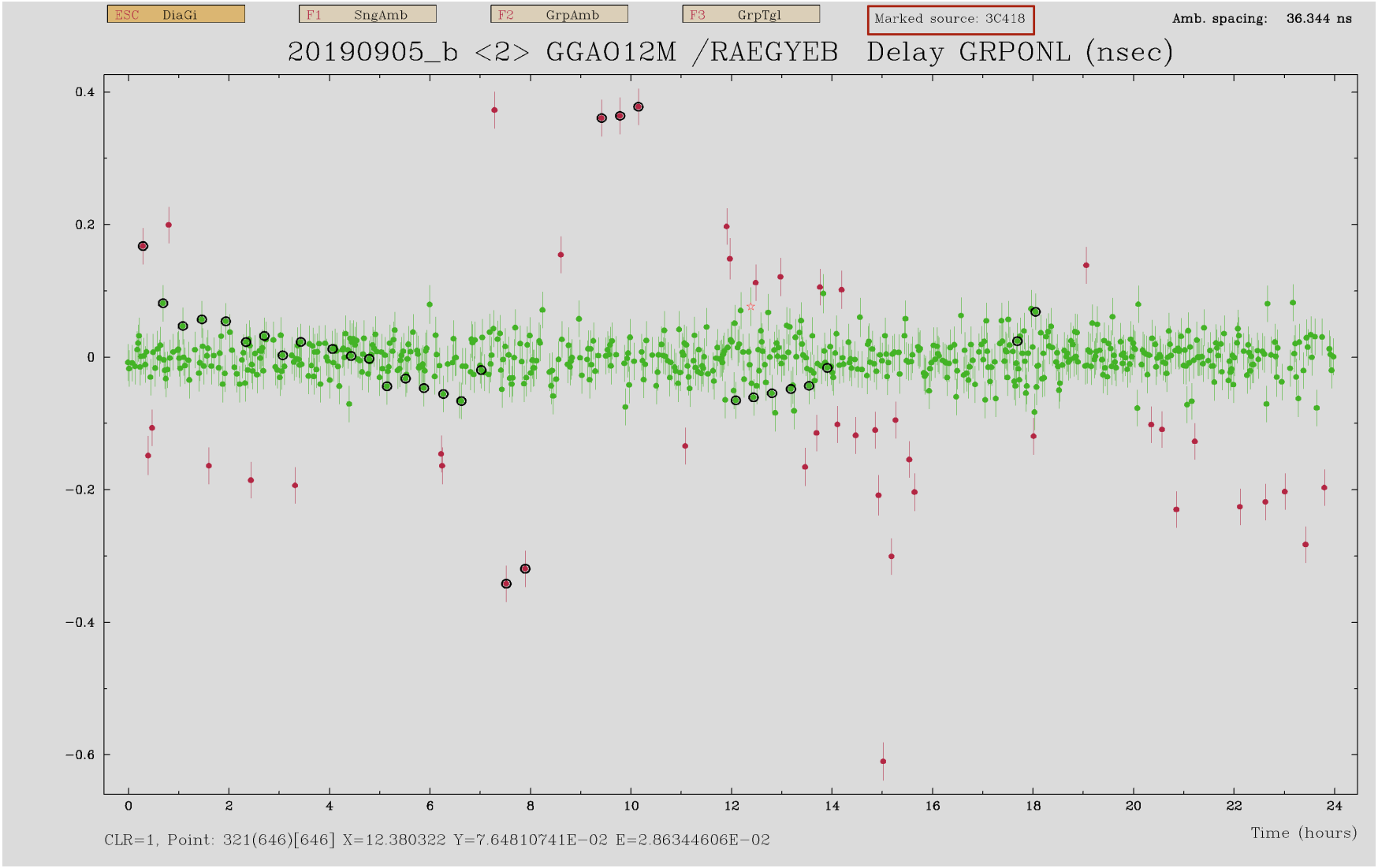


Postfit residuals of a VGOS VLBI experiment

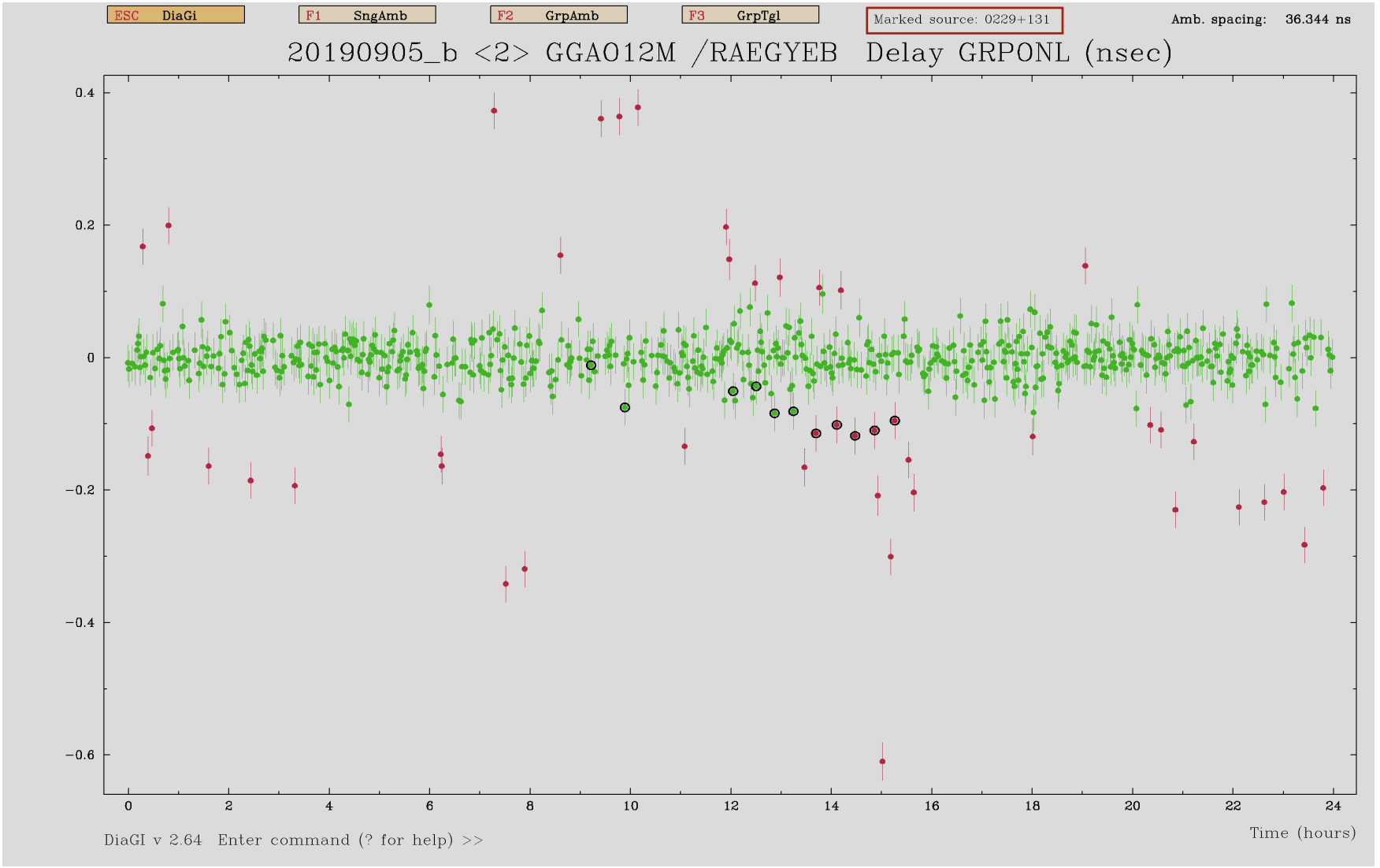


Red points (outliers) are mainly due to unaccounted source structure contribution.

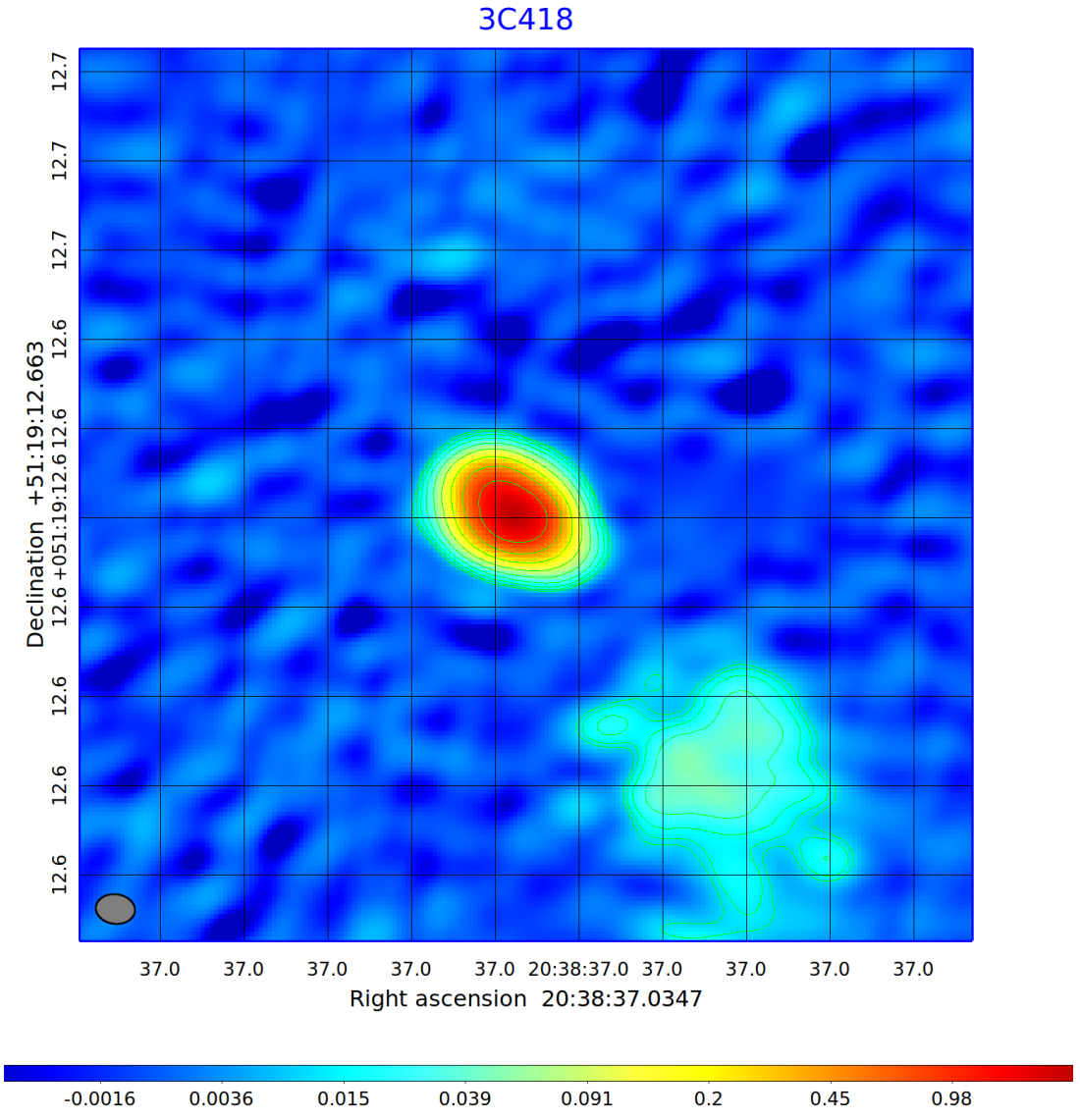
Residuals of 3C418



Residuals of 0219+131

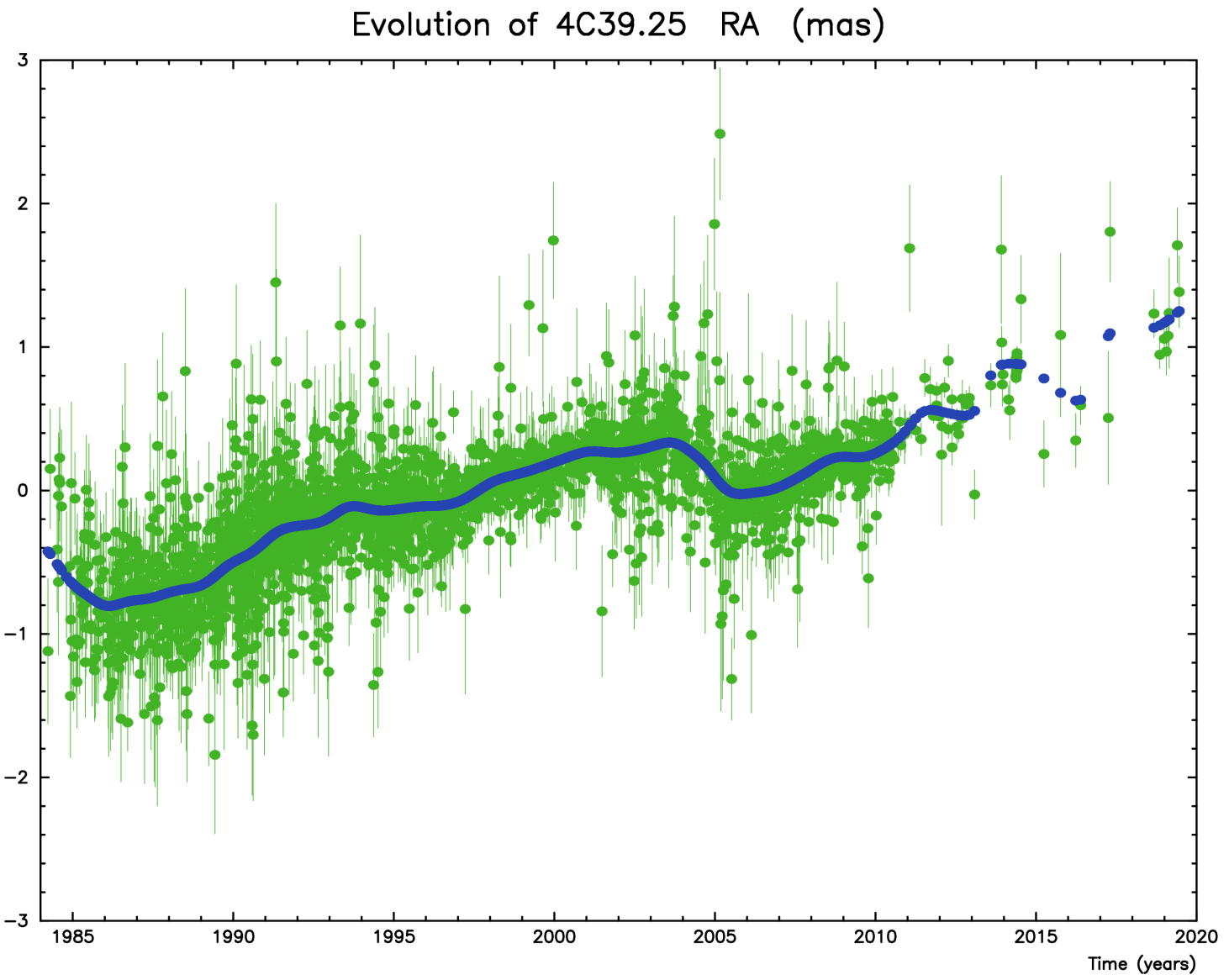


3C418 X-band image

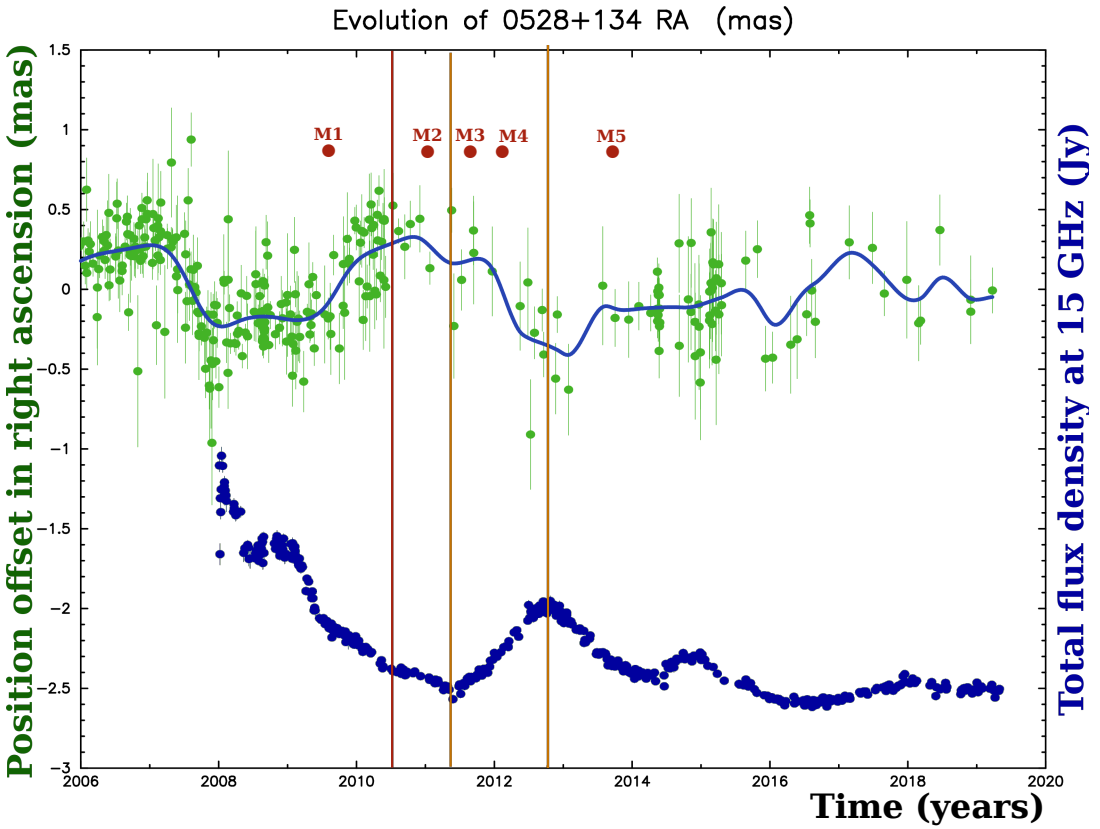


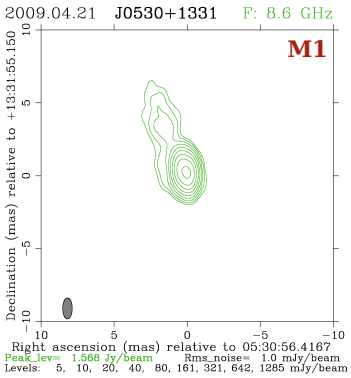
8.6 GHz, VLBA, rv124, 2017.07.17

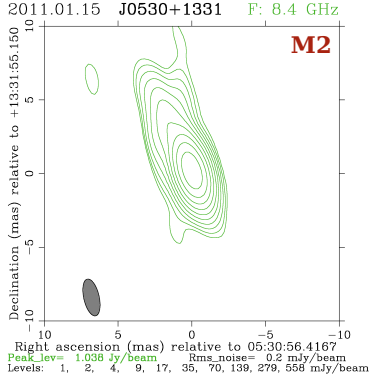
Time series of source positions from the space geodesy program

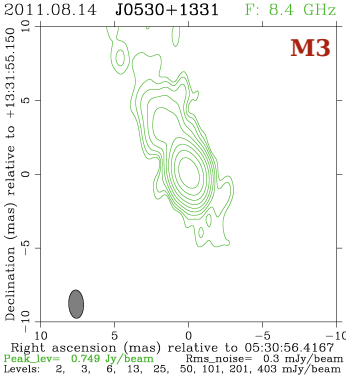


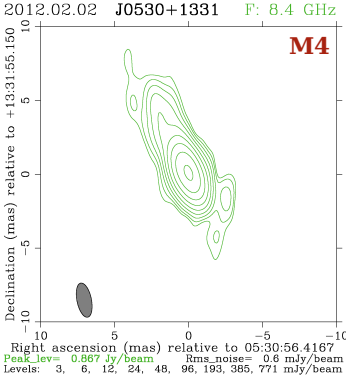
Time series of source positions from the space geodesy program

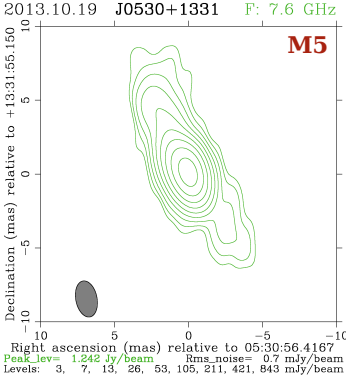








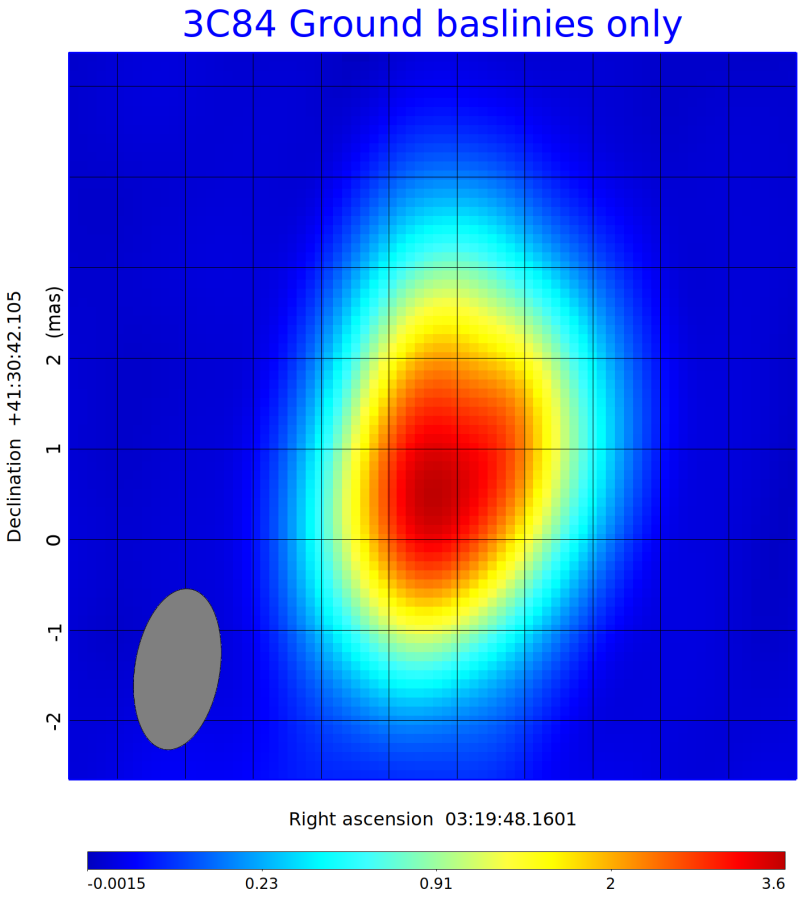


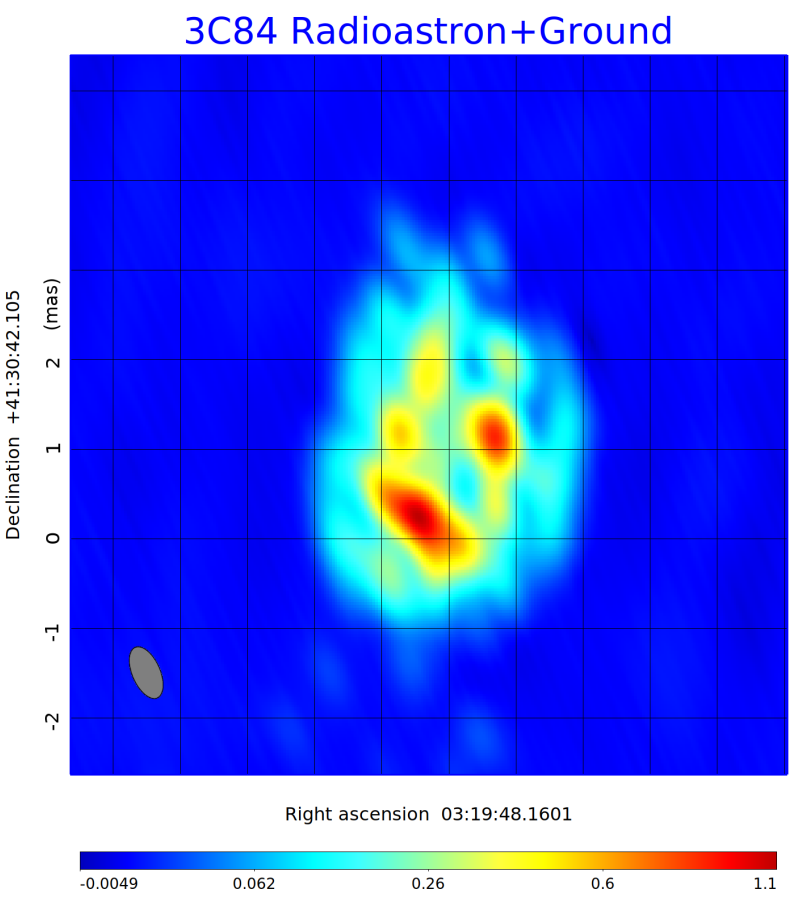


Difficulties in modeling source structure

- Need to get images
- Delay contribution stability
- Contribution of the image random noise to delay
- Contribution of the image systematic errors to delay
- Contribution of the spectral index to delay
- Contribution of polarization to delay
- How to identify the stable point (SMBH)?
- Contribution of the core-shift to delay
- ?

3C84 C-band image

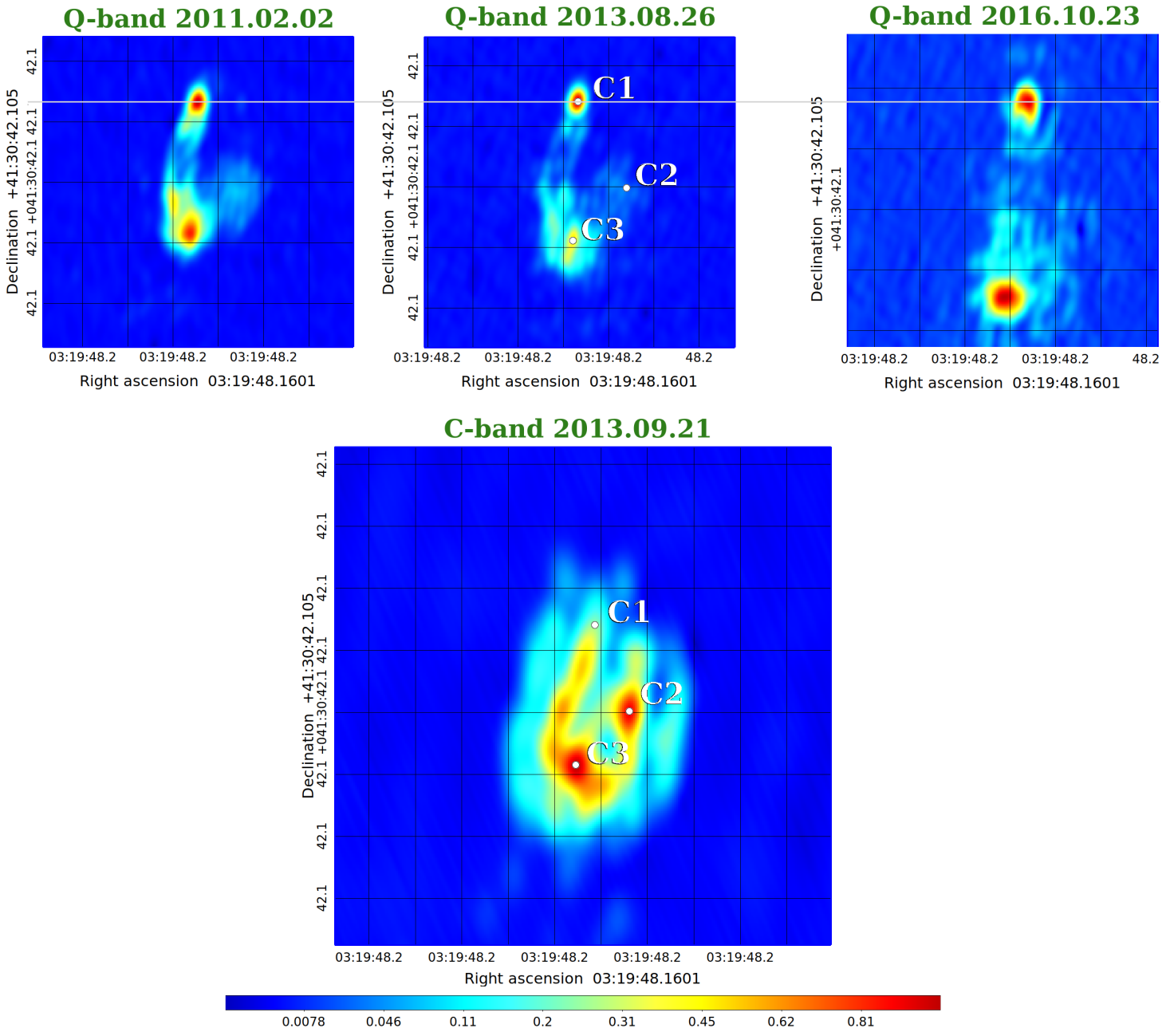




FWHM 1.8×0.9 mas

FWHM 0.60×0.3 mas

The “core” reveals rich structure!

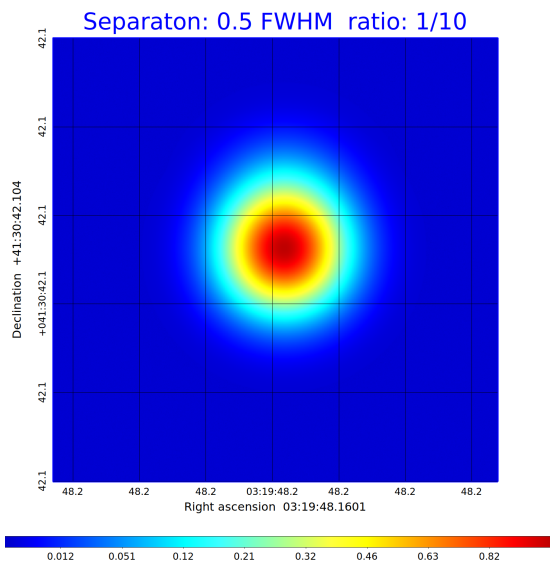


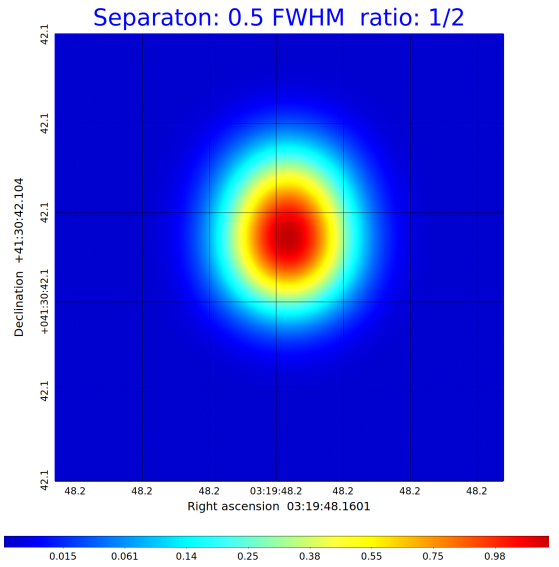
Credit for Q-band images: S. Jorstad and A. Marscher

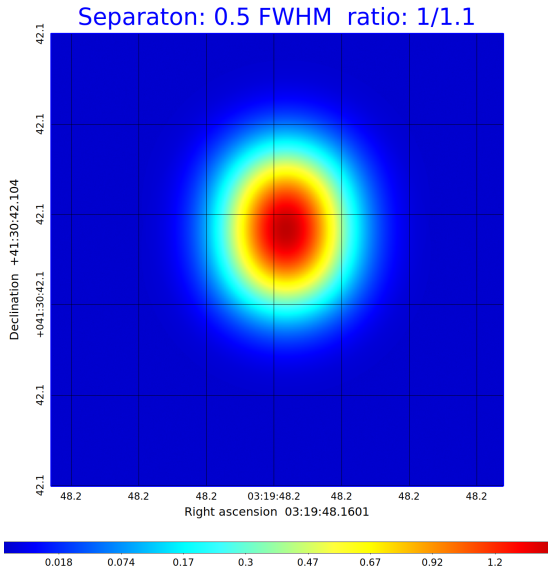
How source structure at scales less FWHM affects source position?

Approach:

- Data: MOJAVE-5 experiment BL229AT that observed 3C84 (and 28 other sources);
- Compute the contribution of path delay for different two-components Gaussian **tight** models;
- Compute difference in source position estimates.

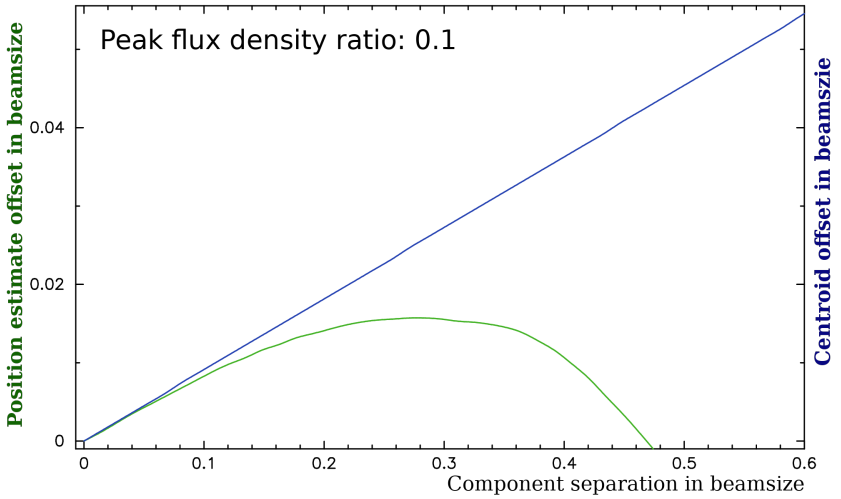


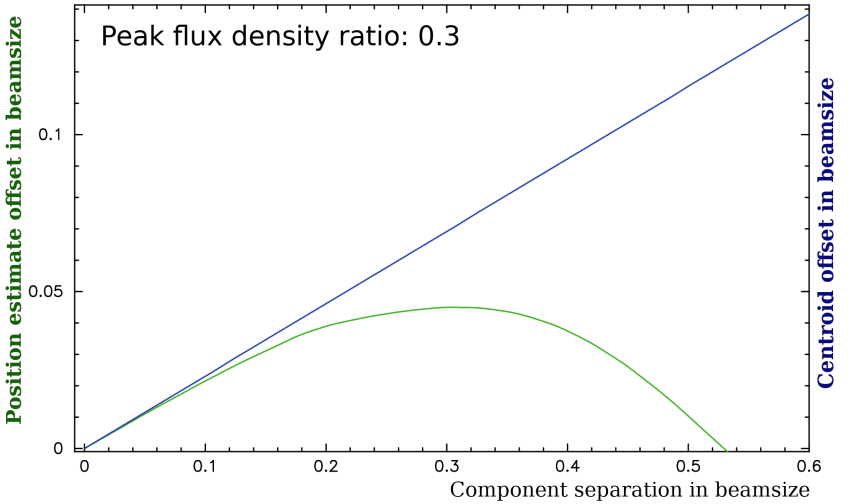


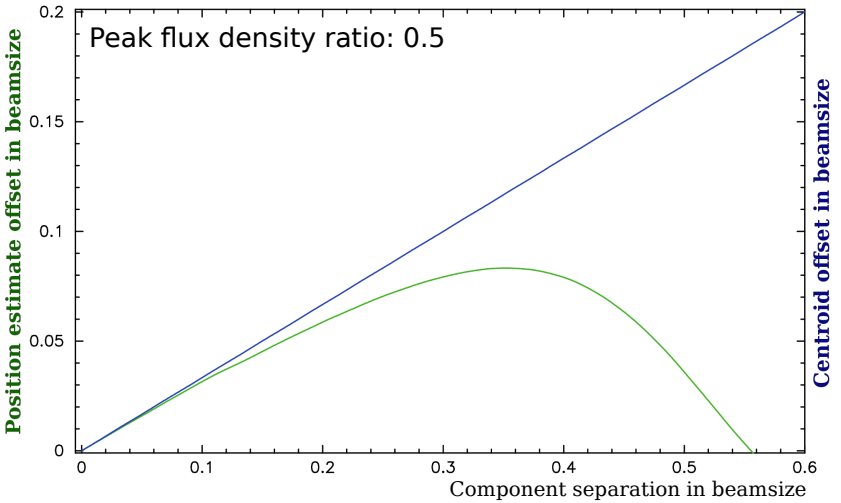


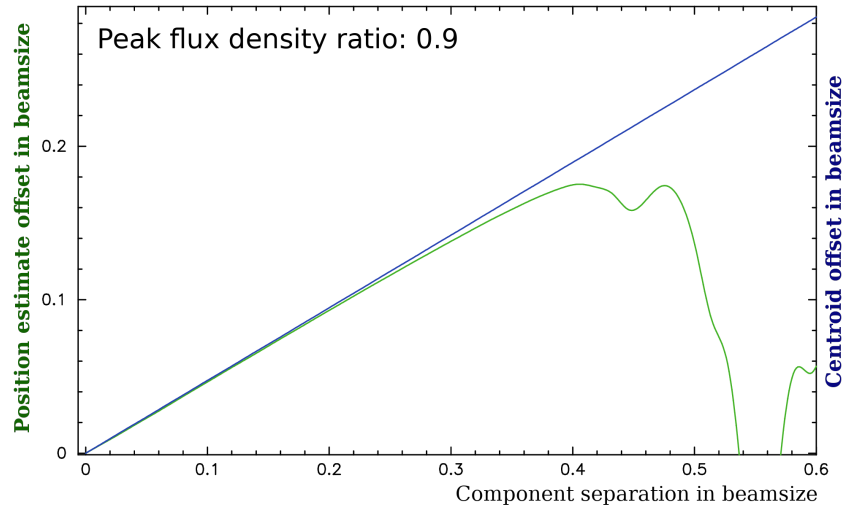
I. Simulation results for a two-component model

Position estimate offset as a function of component separation for a given ratio of component peak flux density.



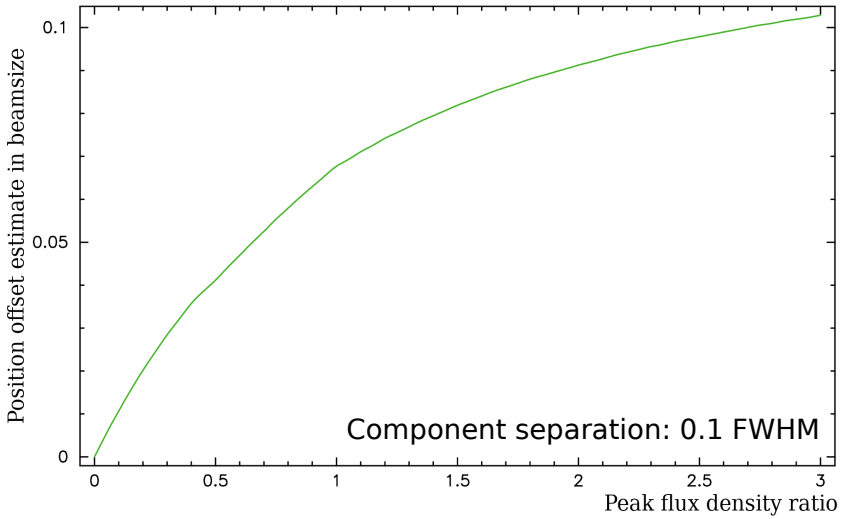


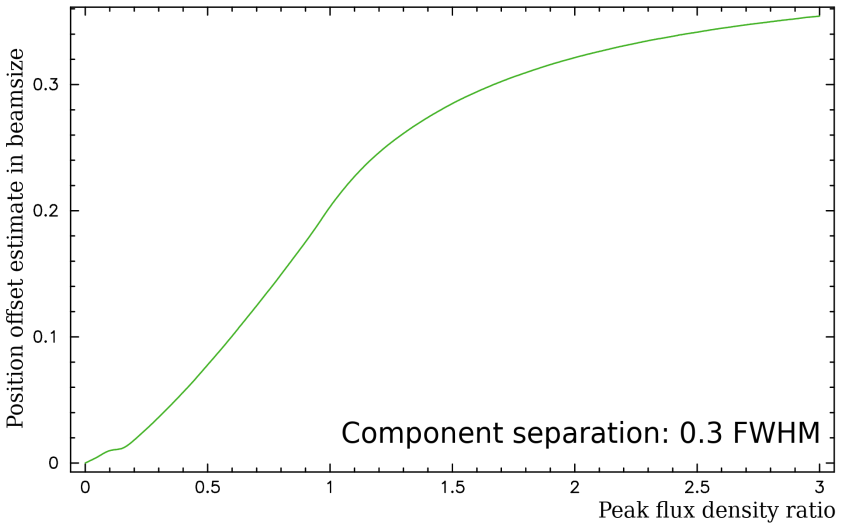


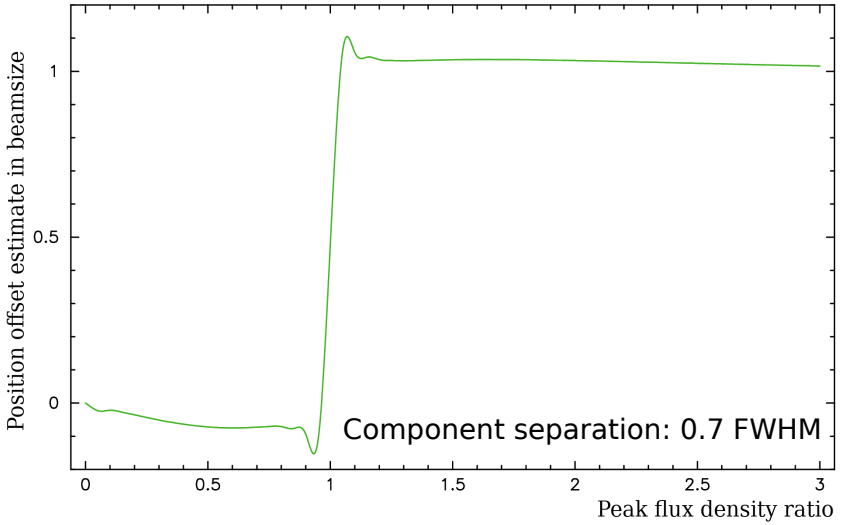


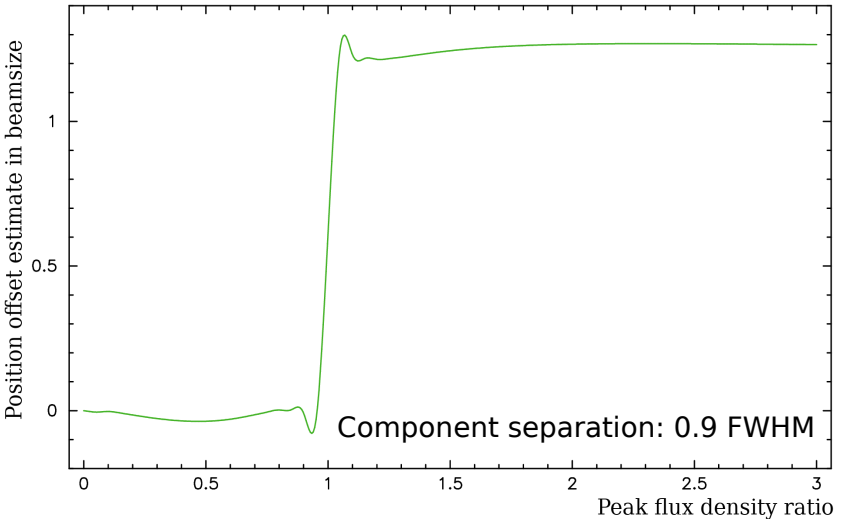
II. Simulation results for a two-component model

Position estimate offset as a function of the ratio of component flux density for a given component separation.









Contribution of C-band 3C84 source structure to the source position wrt SMBH in BL229AT:

Using Radioastron+Ground image

$$\begin{aligned} \Delta\alpha\cos\delta: &\quad -0.61 \pm 0.10 \text{ mas} \\ \Delta\delta: &\quad -1.83 \pm 0.07 \text{ mas} \end{aligned}$$

Ground-only image and the SMBH position from Radioastron

$$\begin{aligned} \Delta\alpha\cos\delta: &\quad -0.51 \pm 0.10 \text{ mas} \\ \Delta\delta: &\quad -1.69 \pm 0.07 \text{ mas} \end{aligned}$$

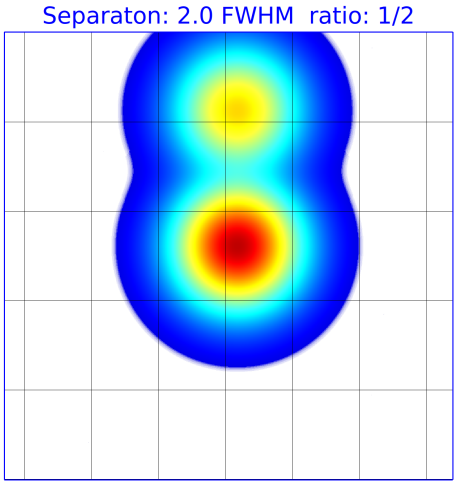
Ground-only image and the SMBH positoin at the phase center

$$\begin{aligned} \Delta\alpha\cos\delta: &\quad -0.19 \pm 0.10 \text{ mas} \\ \Delta\delta: &\quad 0.51 \pm 0.07 \text{ mas} \end{aligned}$$

Two regimes of source structure contribution

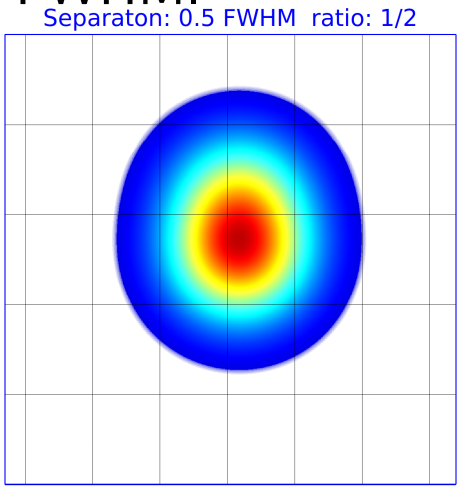
1. **strong regime**

   Ground-based image **shows** structure. Structure has scales greater than FWHM;



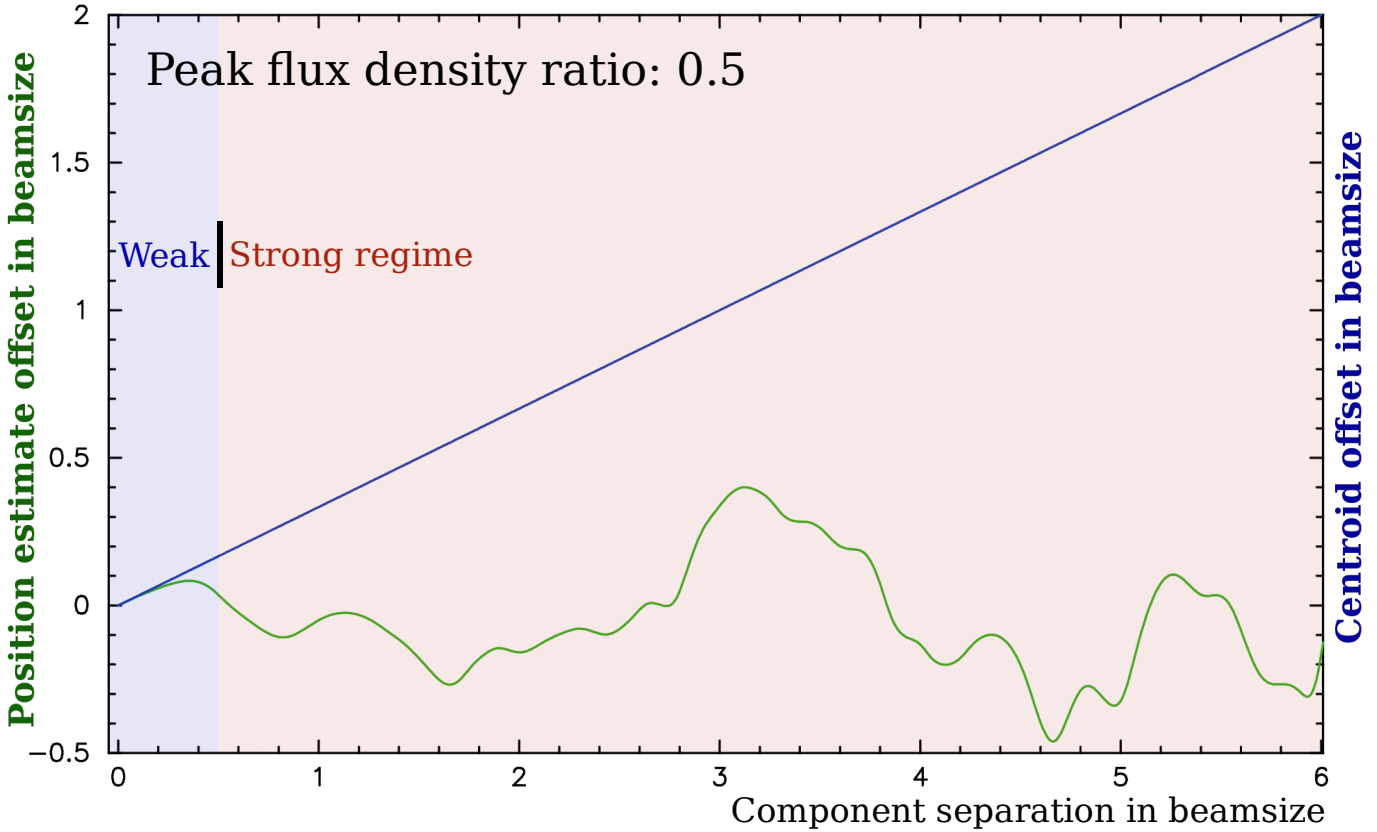
2. **weak regime**

   Ground-based image **does not show** structure that contributes.
   But space-ground does. Structure has scales less than FWHM.



Strong regime of source structure contribution

1. Contribution to source position is bounded
2. Strongly deviates from the centroid position
3. Strongly depends on “geometry” of the observation
4. Can be solved (or mitigated) using ground-based images



Weak regime of source structure contribution

1. Contribution to source position is bounded
2. Weakly deviates from the centroid position
3. Weakly depends on "geometry" of observations
4. Cannot be mitigated using ground-based images
5. Requires source monitoring at space-based baselines

Conclusions:

Radioastron results highlight the following:

- A strong evidence was obtained that the source contribution in the weak regime can be significant
- We explained why a source position offset may precede an appearance of a new image component on a ground-based image
- An additional science case emerged: geodetic sources need to be monitored at 2–14 GHz using space-ground baselines