

Deep widefield interferometry of the NCP

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ASTRON

Deep widefield interferometry

LOFAR challenges:

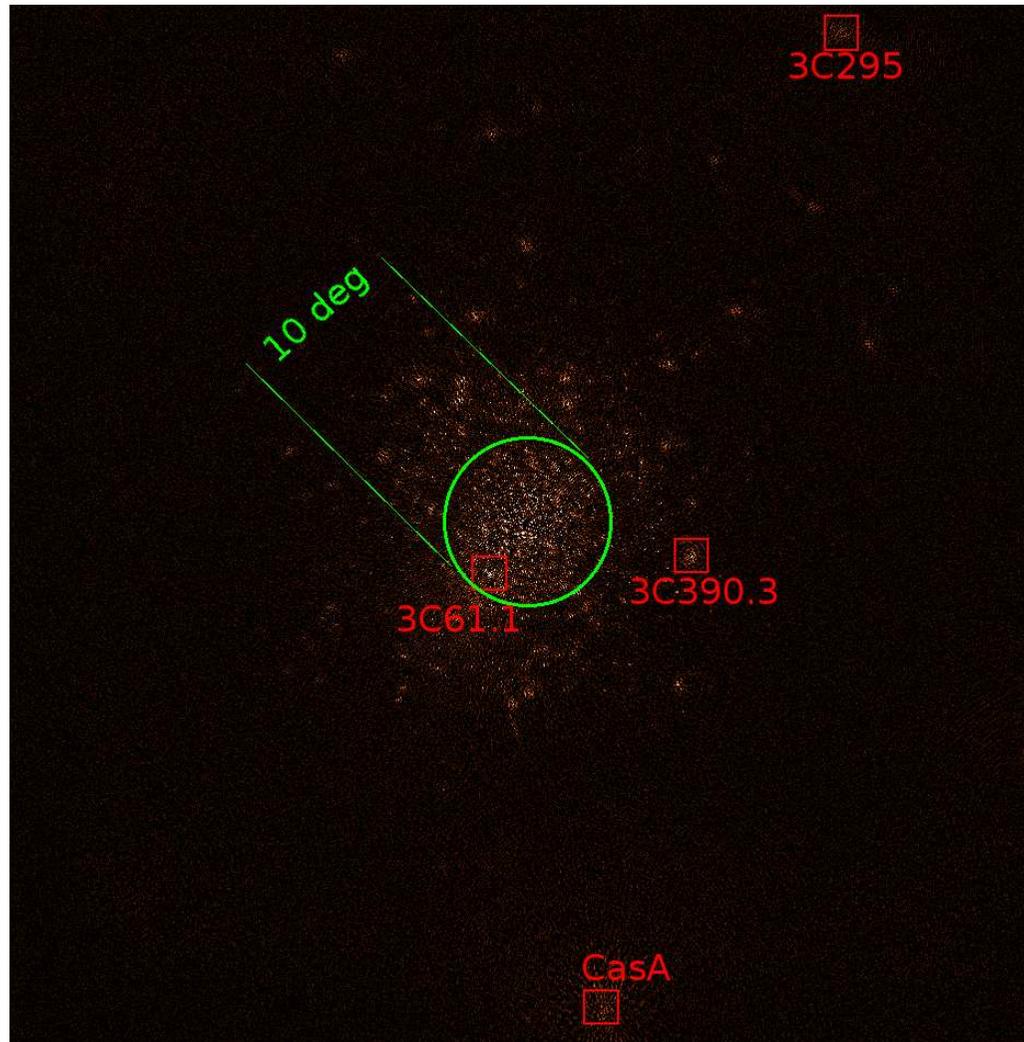
- Variable beam, ionosphere \Rightarrow errors that vary across the sky.
- Wide beams \Rightarrow thousands of sources.
- Many complex/extended sources.
- Calibration down to noise \Rightarrow good sky model, covering the full sky.
- Sky model construction \Rightarrow imaging a large field of view, with good enough resolution.
- Need to make billion pixel images (ExCon) \Rightarrow computational problems and aliasing problems need to be addressed.
- Widefield calibration is affordable (SAGECal). But need to minimize noise bias and flux loss.

Leading the way...



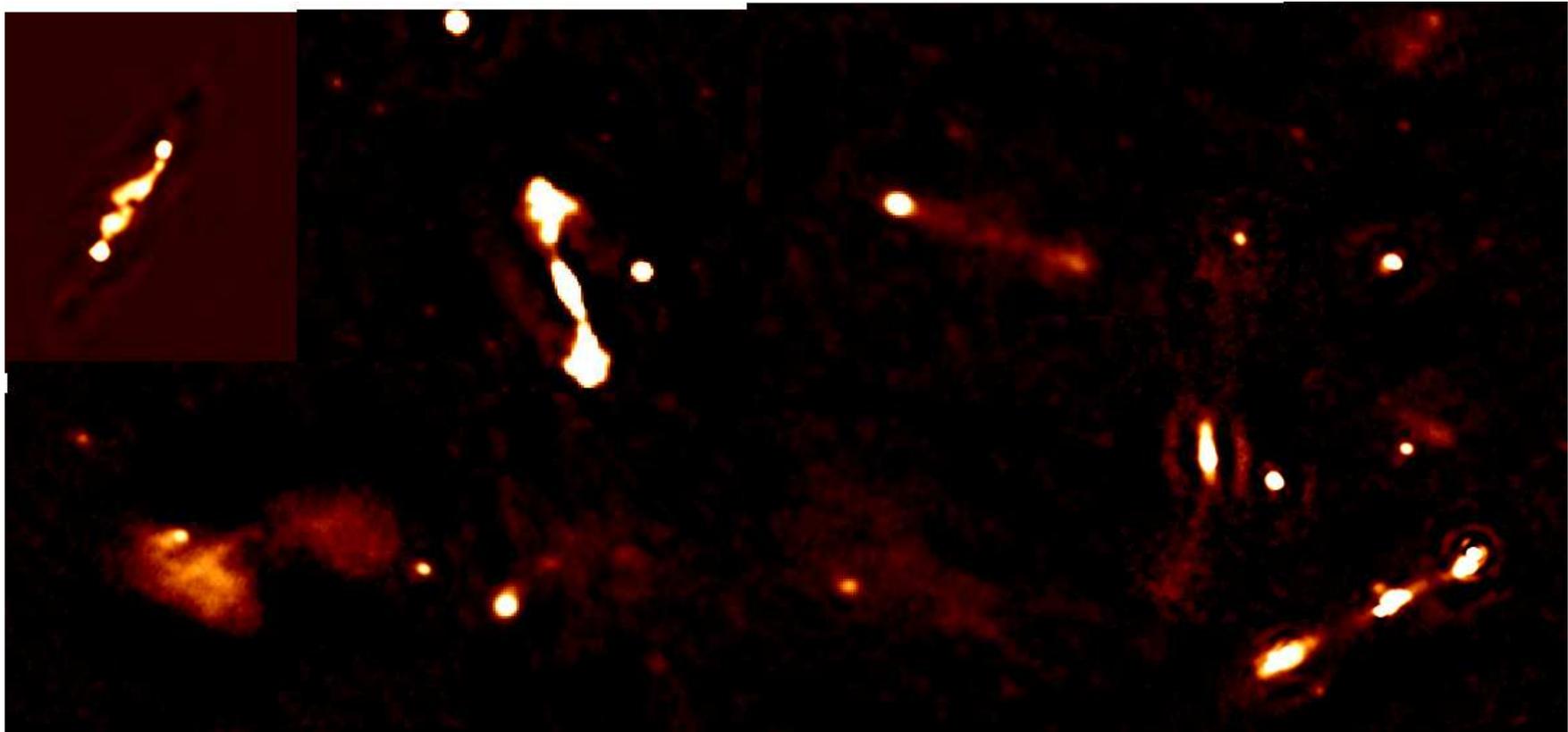
New challenges require new ways of looking at data
don't do this at home!

LOFAR NCP window



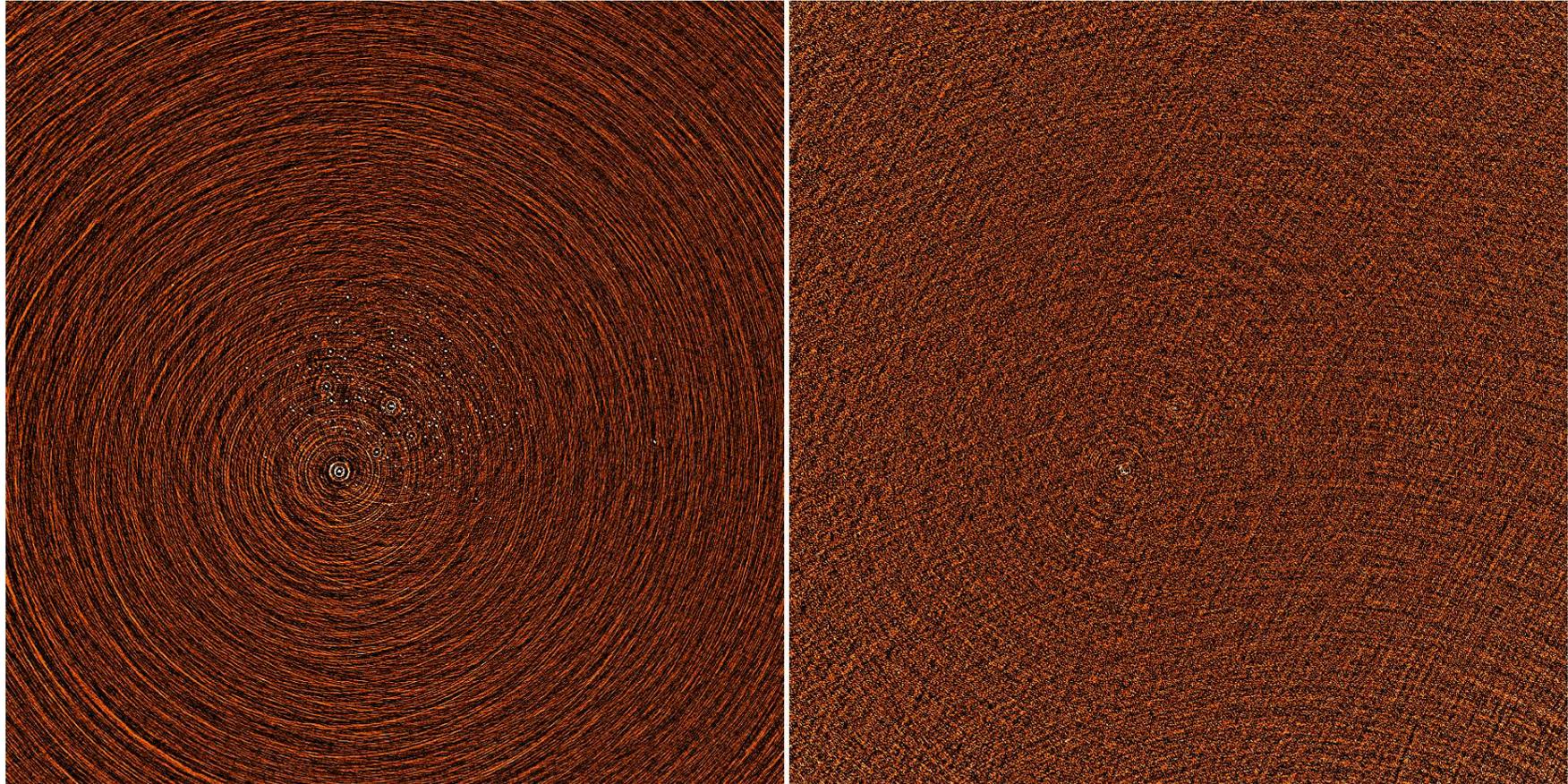
Core baselines < 3 km, 130 MHz, 62×62 sq. deg. image

Extended sources



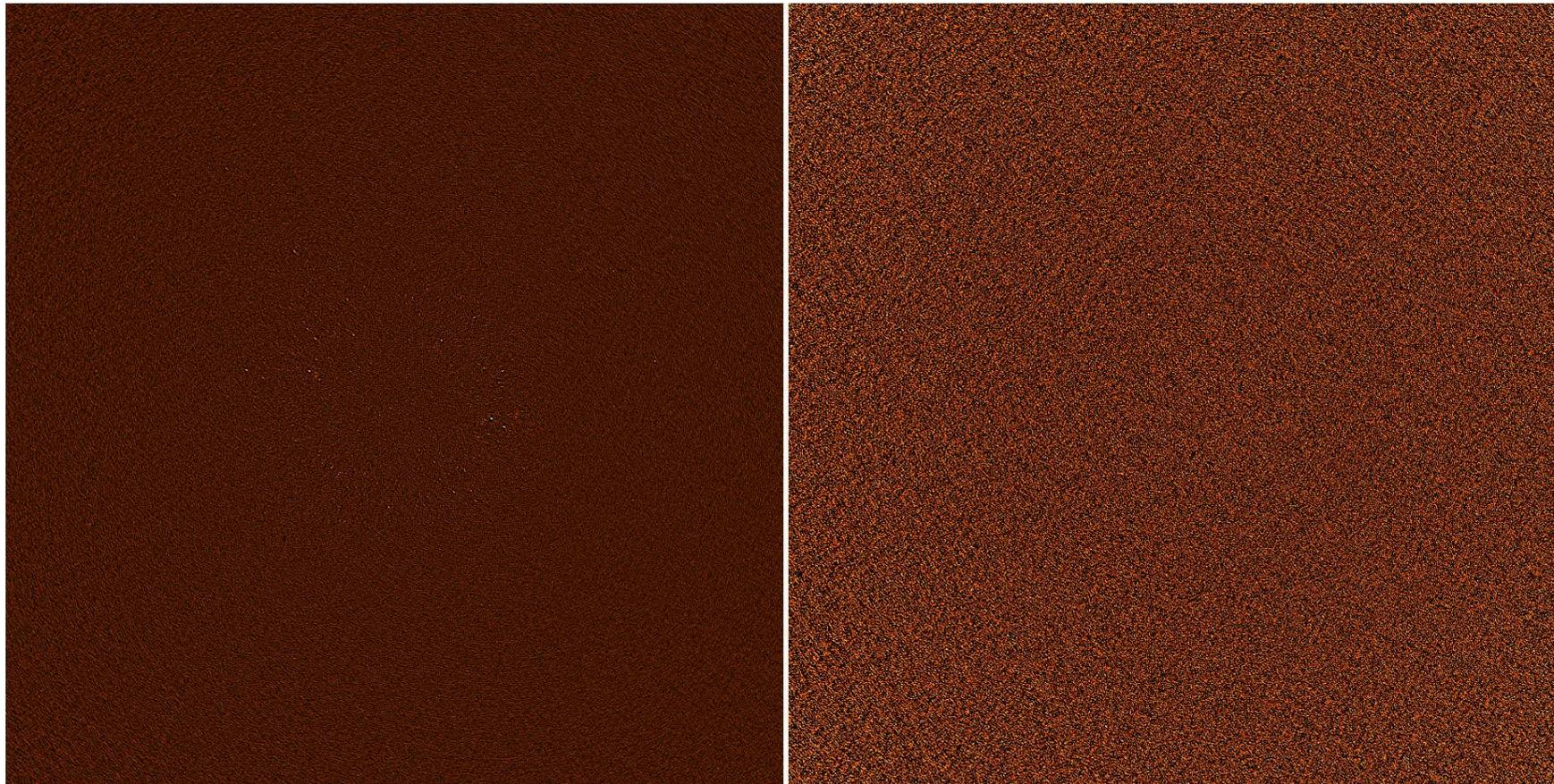
Some complex sources in the NCP FOV, (top left) 3C61.1

Before SAGECal



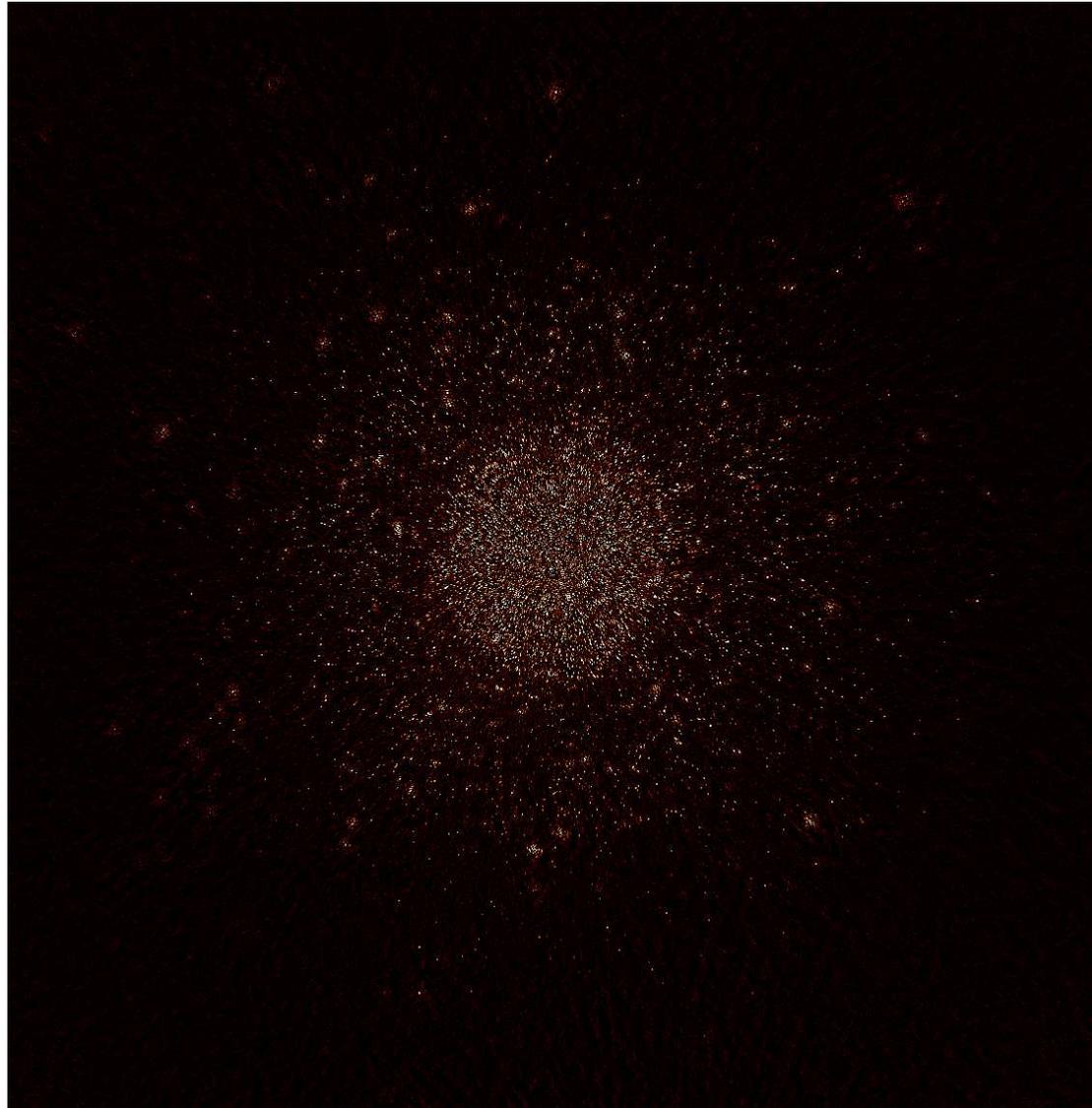
Stokes I (left) Stokes Q (right) showing sidelobes from CasA and CygA

After SAGECal



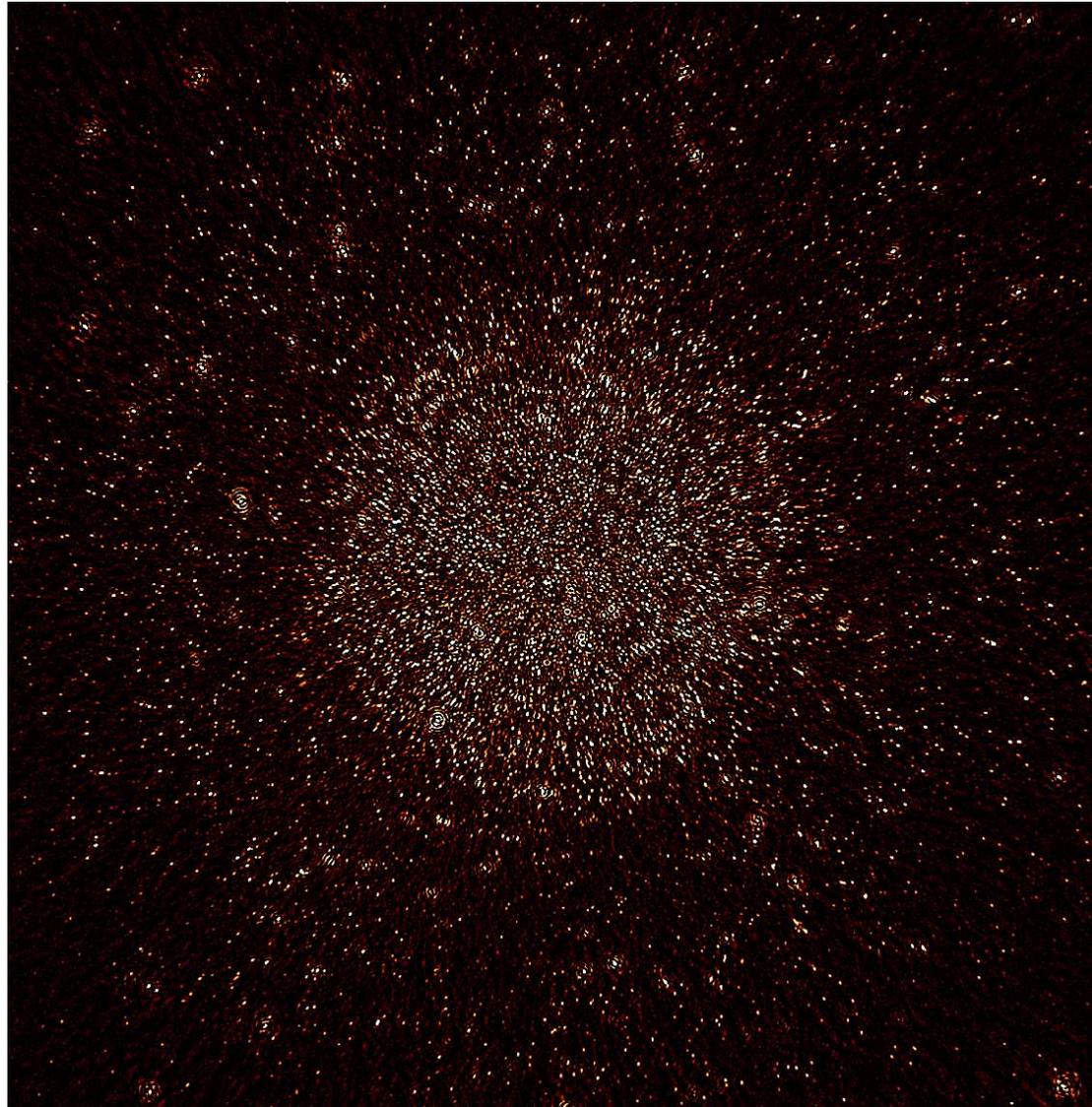
Stokes I (left) Stokes Q (right), after subtraction of 11,000 sources. Is this good enough?

NCP window (after calibration)



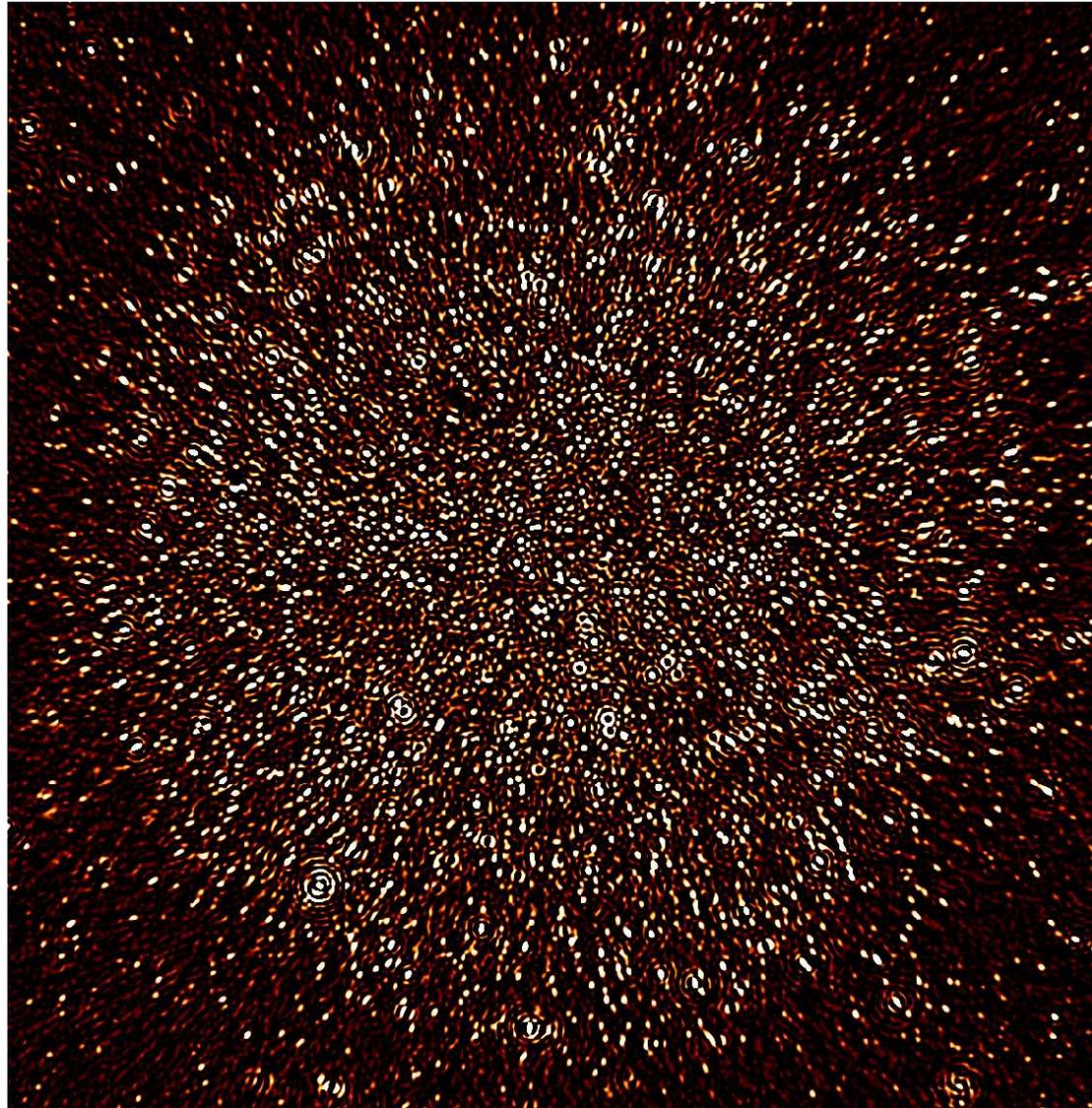
40×40 sq. deg. image, 30 – 1000 λ uniform weights, 3' PSF, 60 μ Jy

NCP window (after calibration)



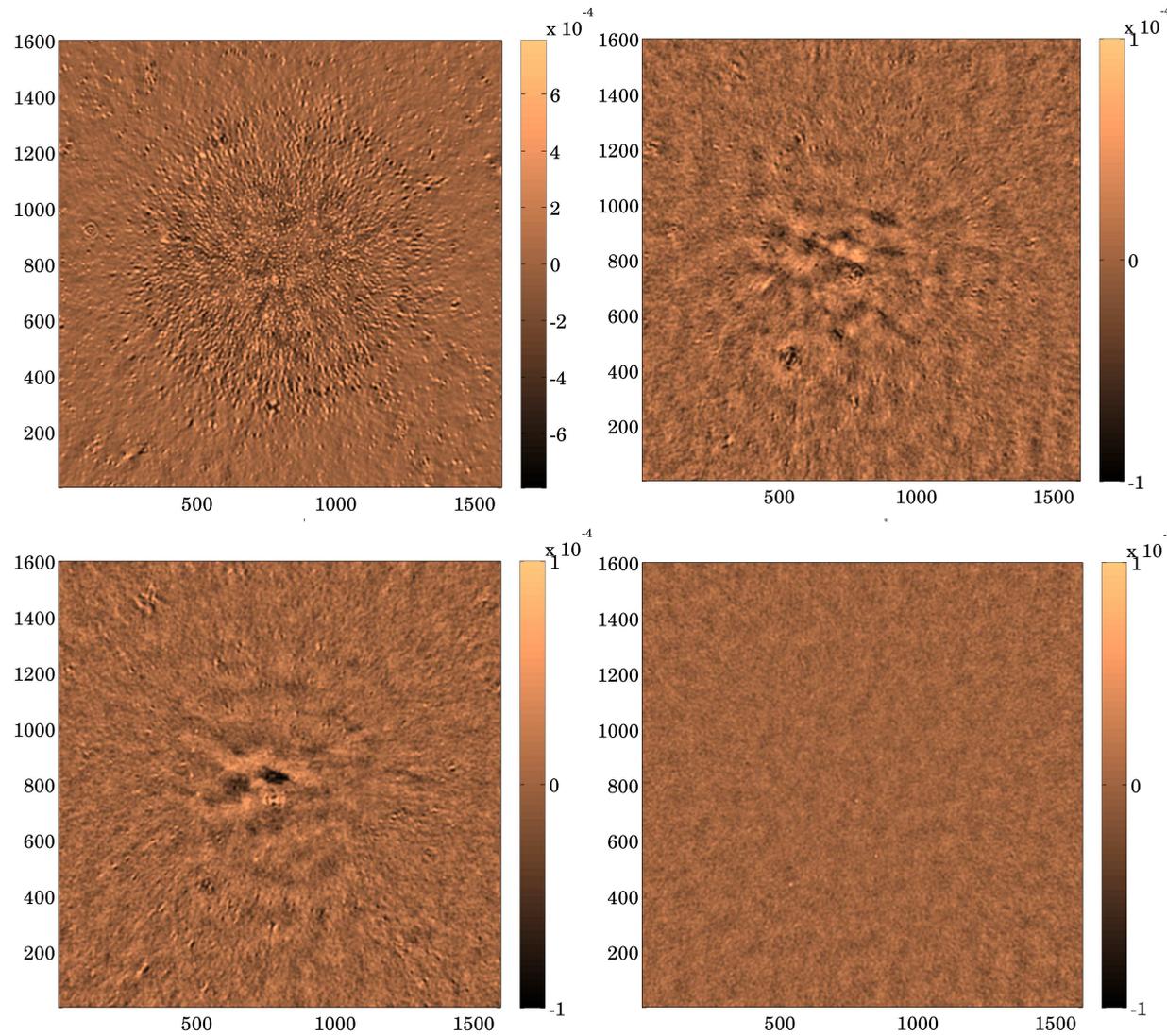
Confusion limited main lobe, peak values in $[-14, 30]$ mJy

NCP window (after calibration)



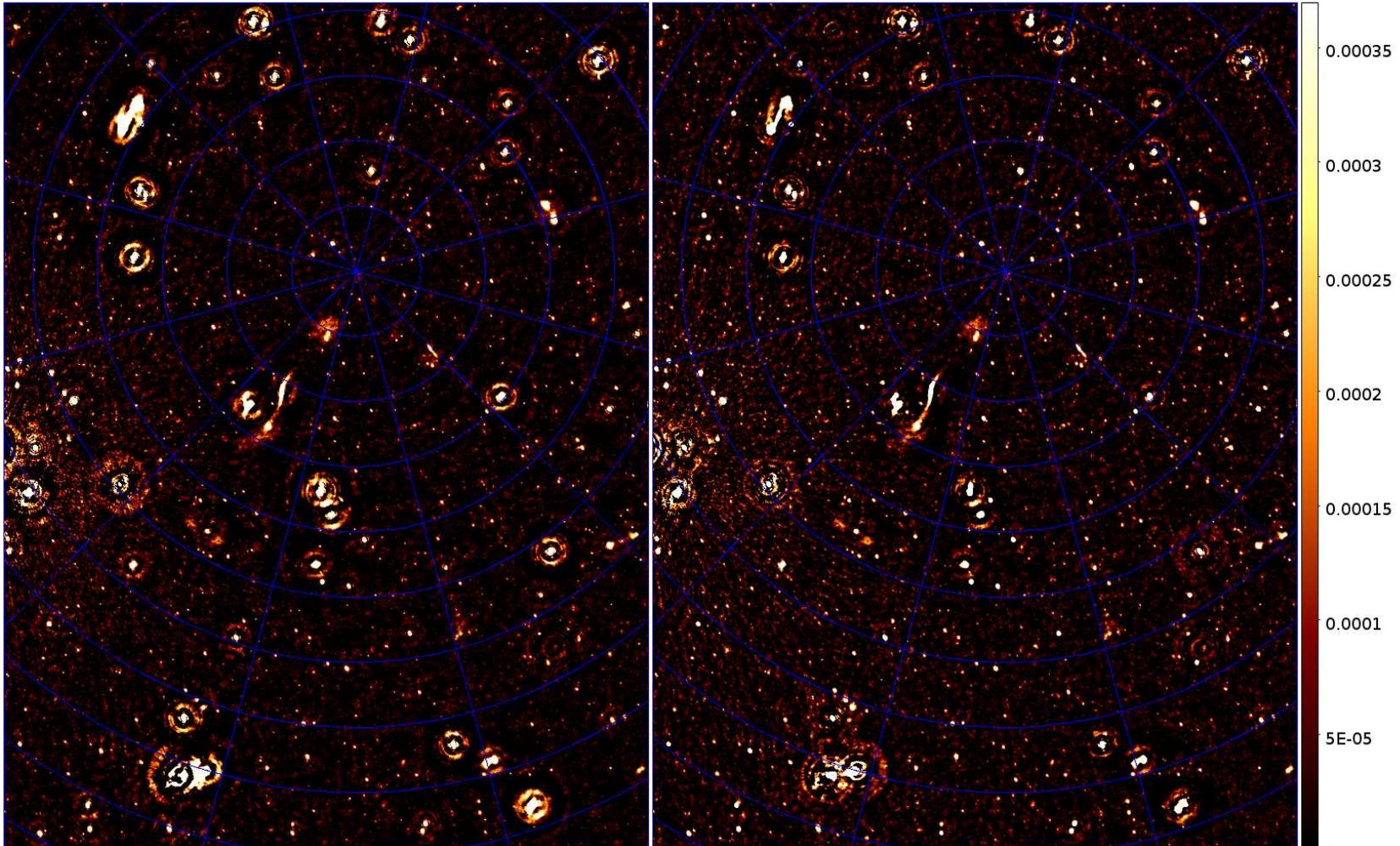
Confusion limited main lobe

Residual continuum images



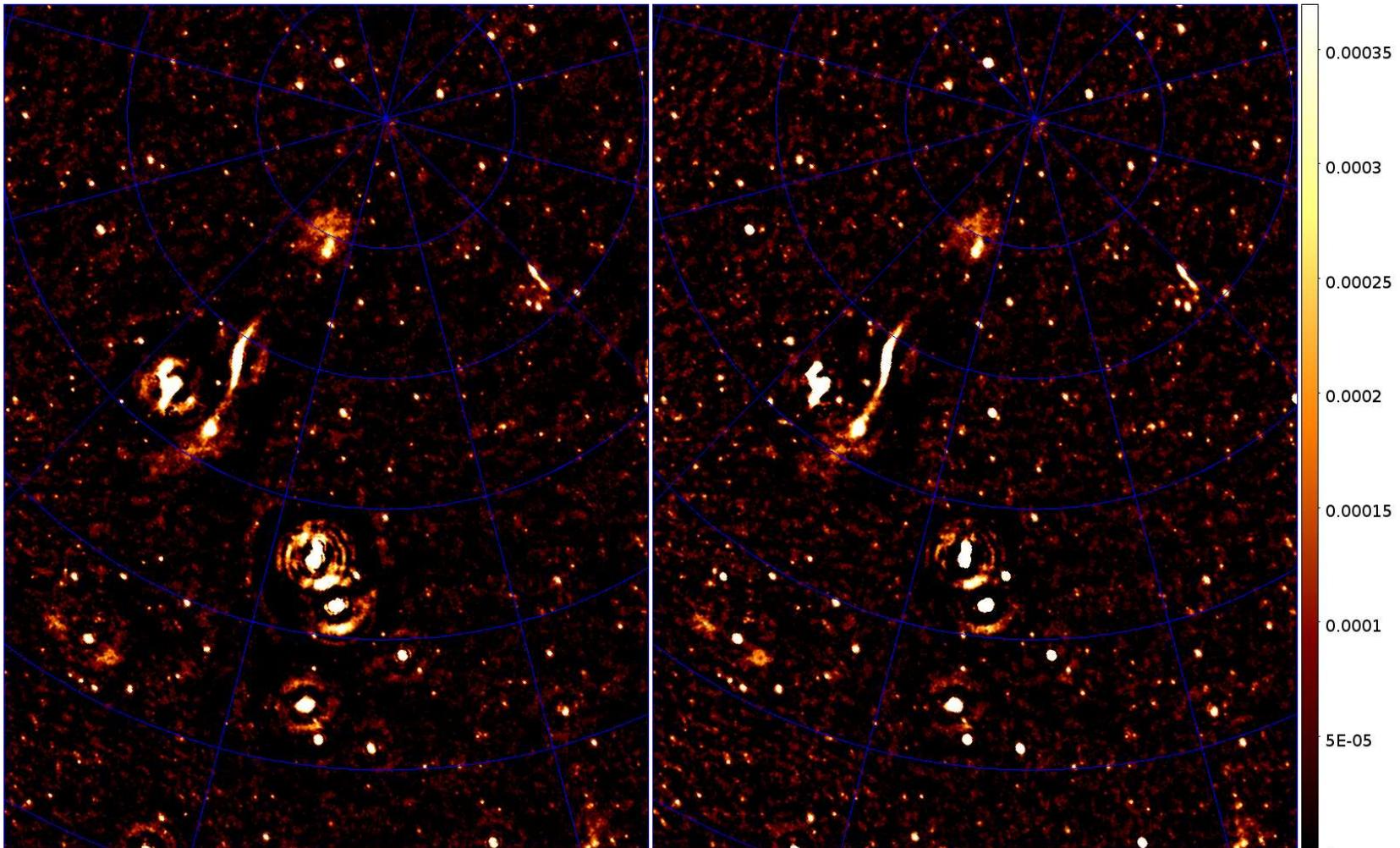
13×13 sq. deg., natural weight, $30 - 800\lambda$, $3'$ PSF, noise $I=55 \mu\text{Jy}$,
 $Q=U=V=15 \mu\text{Jy}$

Deep image of NCP



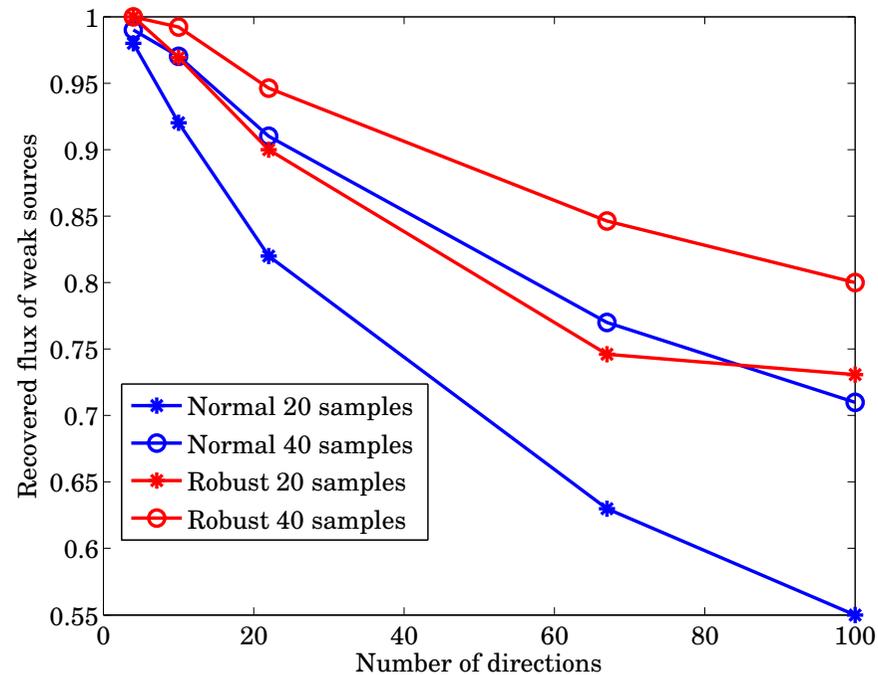
1 × 1.5 sq. deg. area, 6'' PSF (left) 170 hrs 35 μ Jy (right) 114 hrs 50 μ Jy

Deep image of NCP



(left) 170 hrs 35 μ Jy (right) 114 hrs 40 μ Jy, peak 5 Jy, dynamic range
> 100,000

Robust calibration



- Upper bound for flux loss $\sqrt{1 - 2 \frac{\#directions}{\#baselines_{orthogonal} \times \#samples}}$.
- Noise suppression reaches upper bound.
- Robust calibration [Kazemi & Yatawatta, 2013] does better, in preserving flux and minimizing artefacts.

Conclusions

- LOFAR EoR NCP data have produced the deepest images at 115-180 MHz.
- Only 110 hours processed so far, more to come. No unforeseen problems.
- More results from this data: from Saleem, Ajinkya, Abhik, Ger...tomorrow.