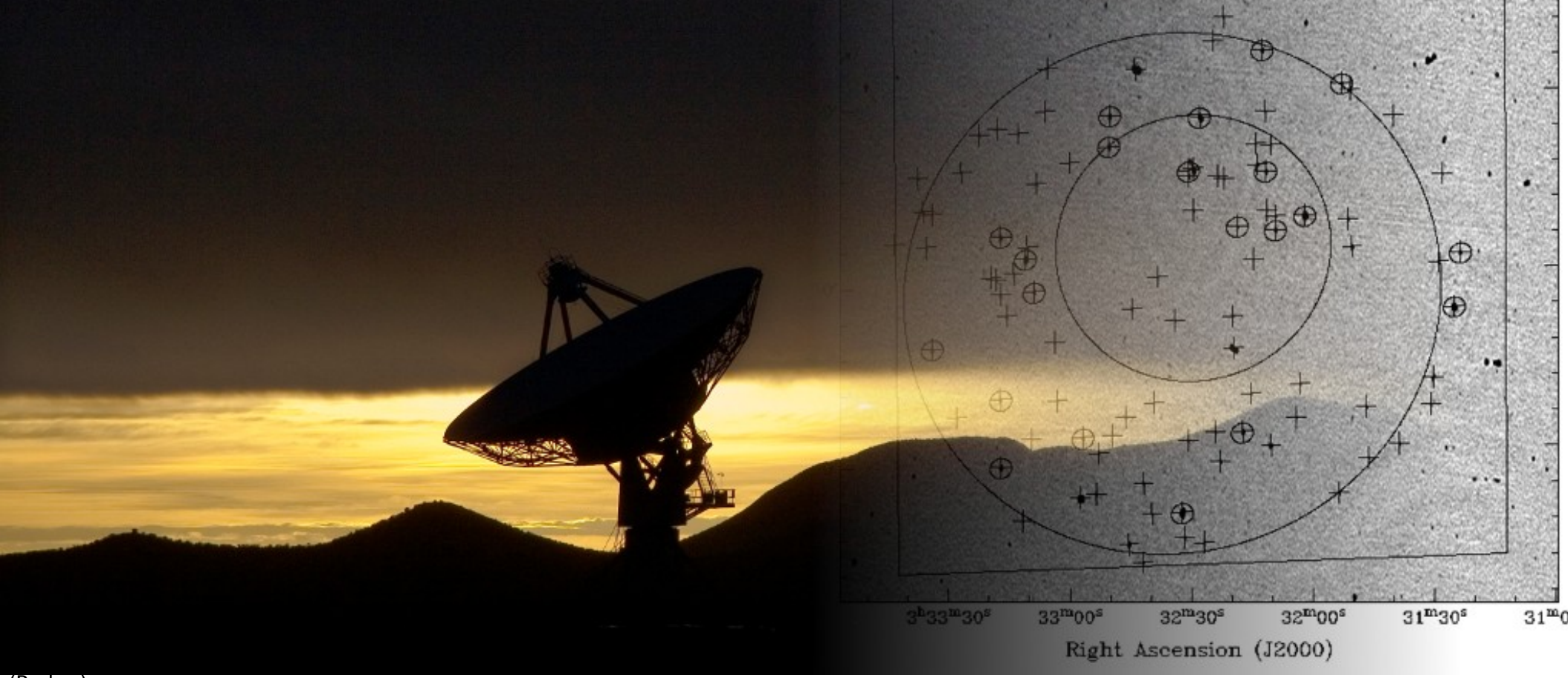

(Parker)

A new axis on the parameter space: Wide-field VLBI observations

First results from a new observational technique

05 October 2010

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Astronomisches Institut der Ruhr-Universität Bochum

RUB

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Wide-field radio observations

- Unobscured by dust
- Help identify SF/AGN
- Use in conjunction with IR/optical/Xray surveys
- Identify special sources: CSS/GPS/IFRS
- Radio/quasar mode dichotomy

- BUT: typical resolution > few arcsec
- No pc-scale morphology
- Can't separate SF/AGN in many cases

- SO: use VLBI surveys
- $T_B > 10^6$ K is great AGN filter (if z>~0.1)
- Unbiased study of pc-scale morphology

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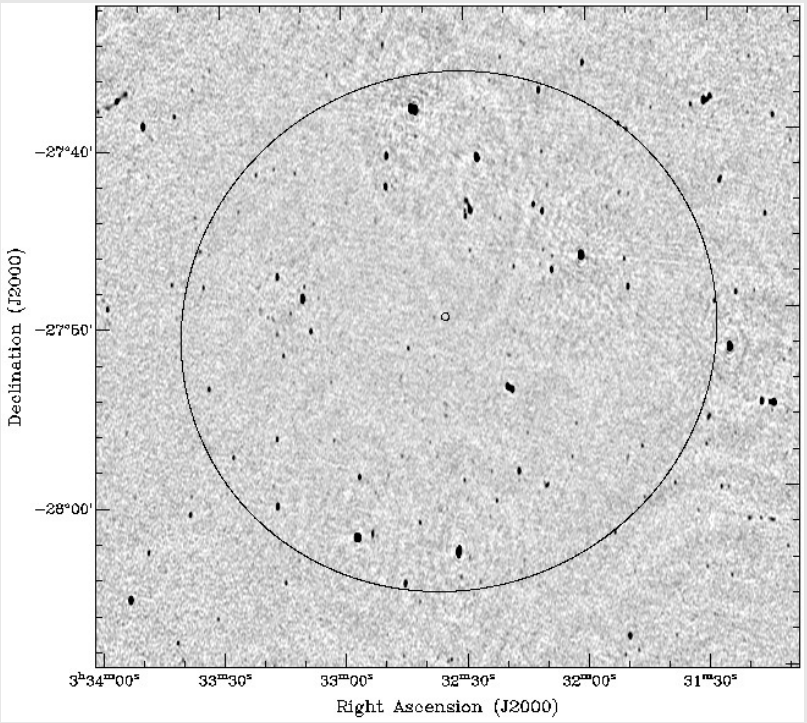
Wide-field VLBI observations

Applications and problems

- VLBI surveys are expensive
- Long baselines
  → high fringe rates
  → tiny FOV
  → no „blind“ surveys



Large circle: VLBA primary beams at 1.4GHz; small circle: VLBA FOV at 1.4GHz

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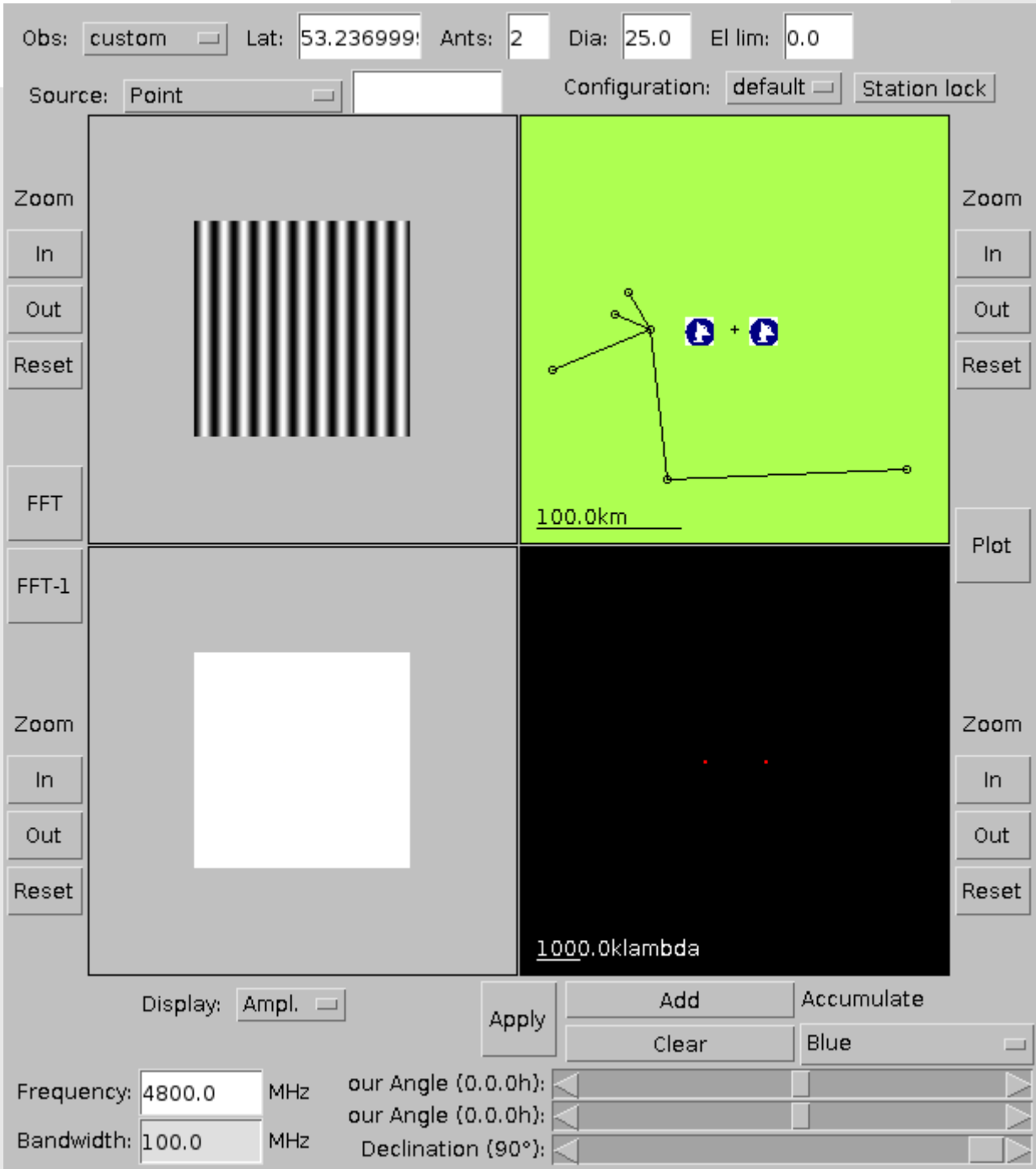
Applications and problems

- Two-element interferometer projects “sensitivity pattern” onto sky



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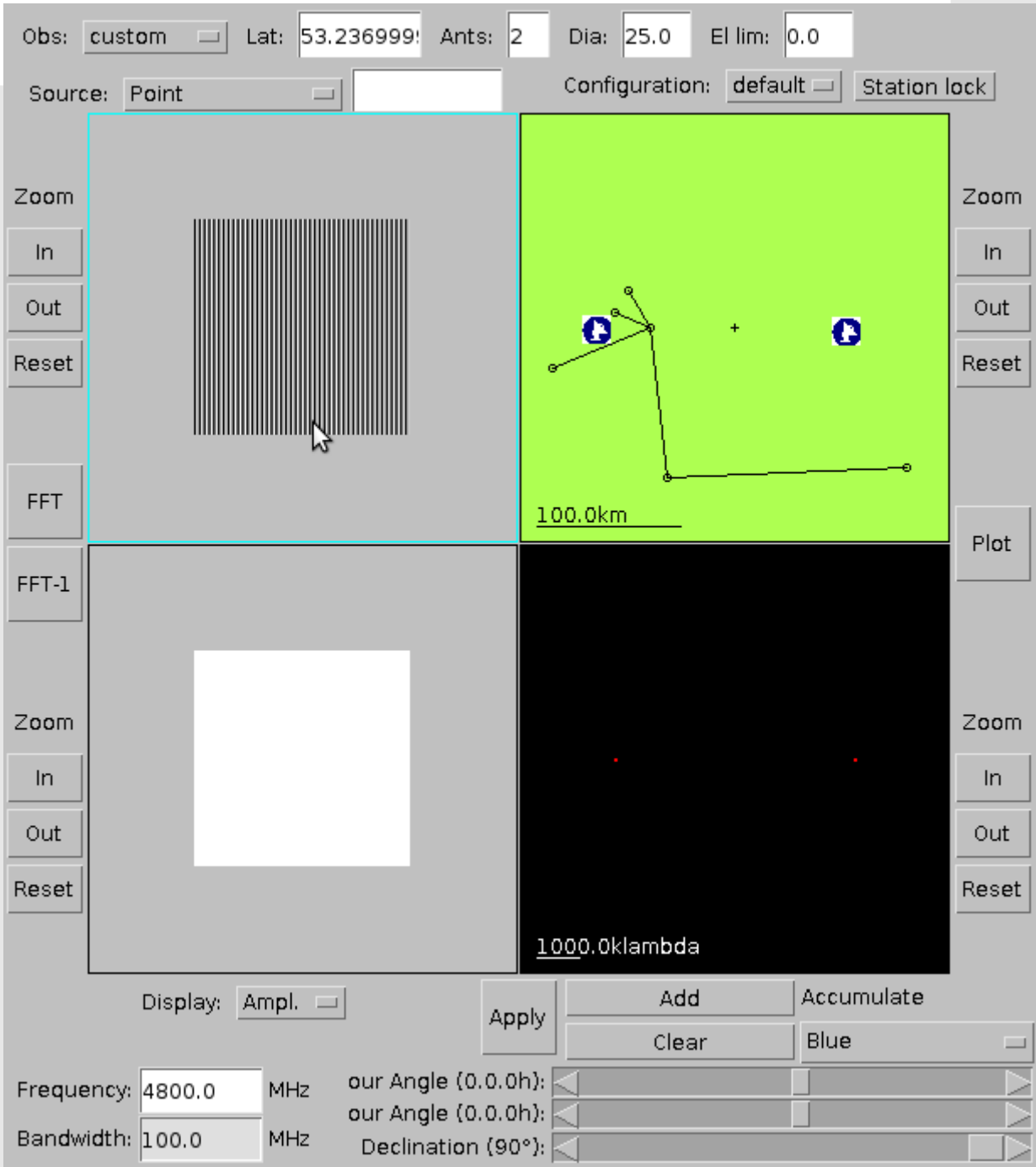
Applications and problems

- The longer the baseline, the narrower the fringes



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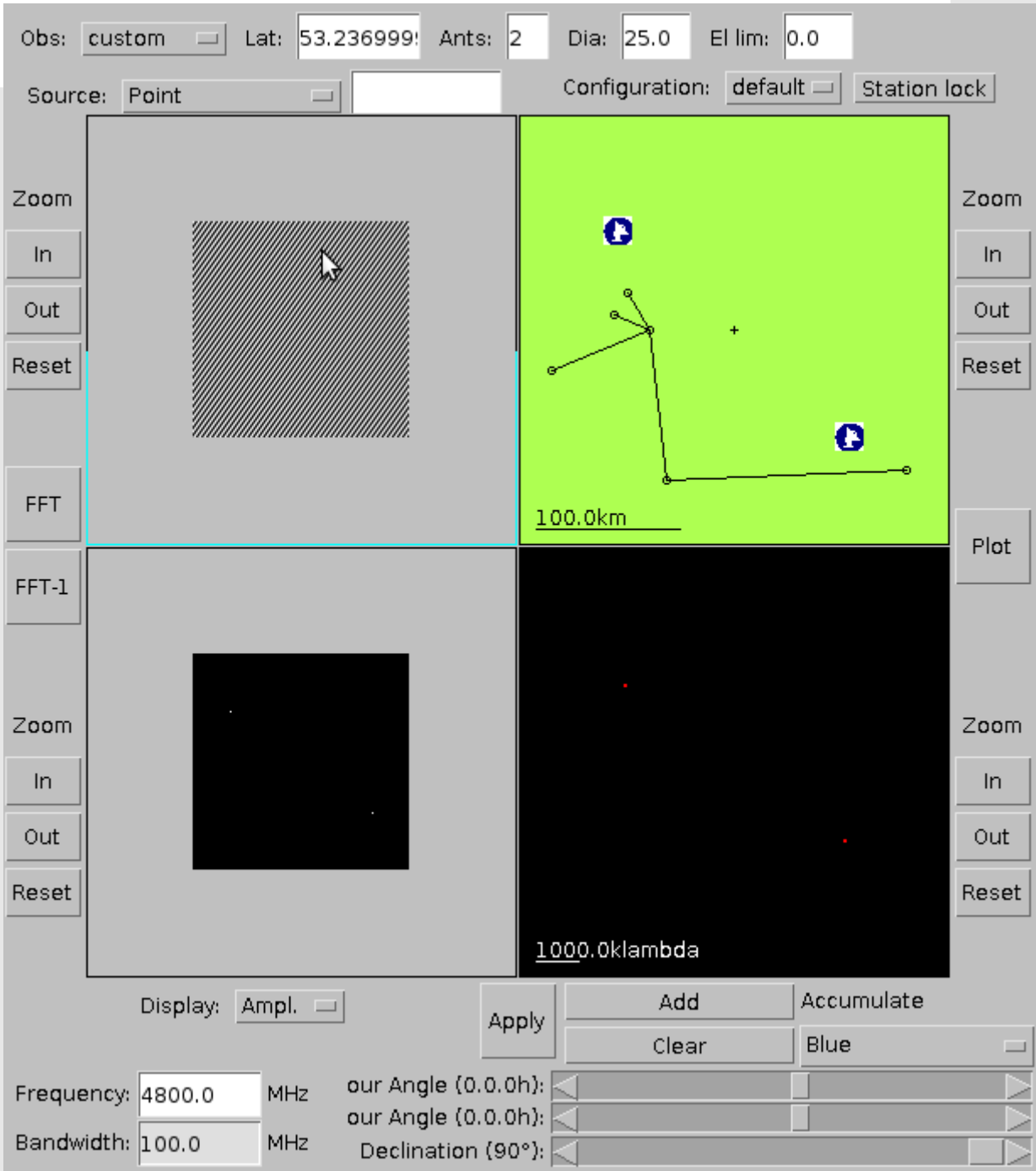
Applications and problems

- Fringe pattern rotates on sky as observations progress



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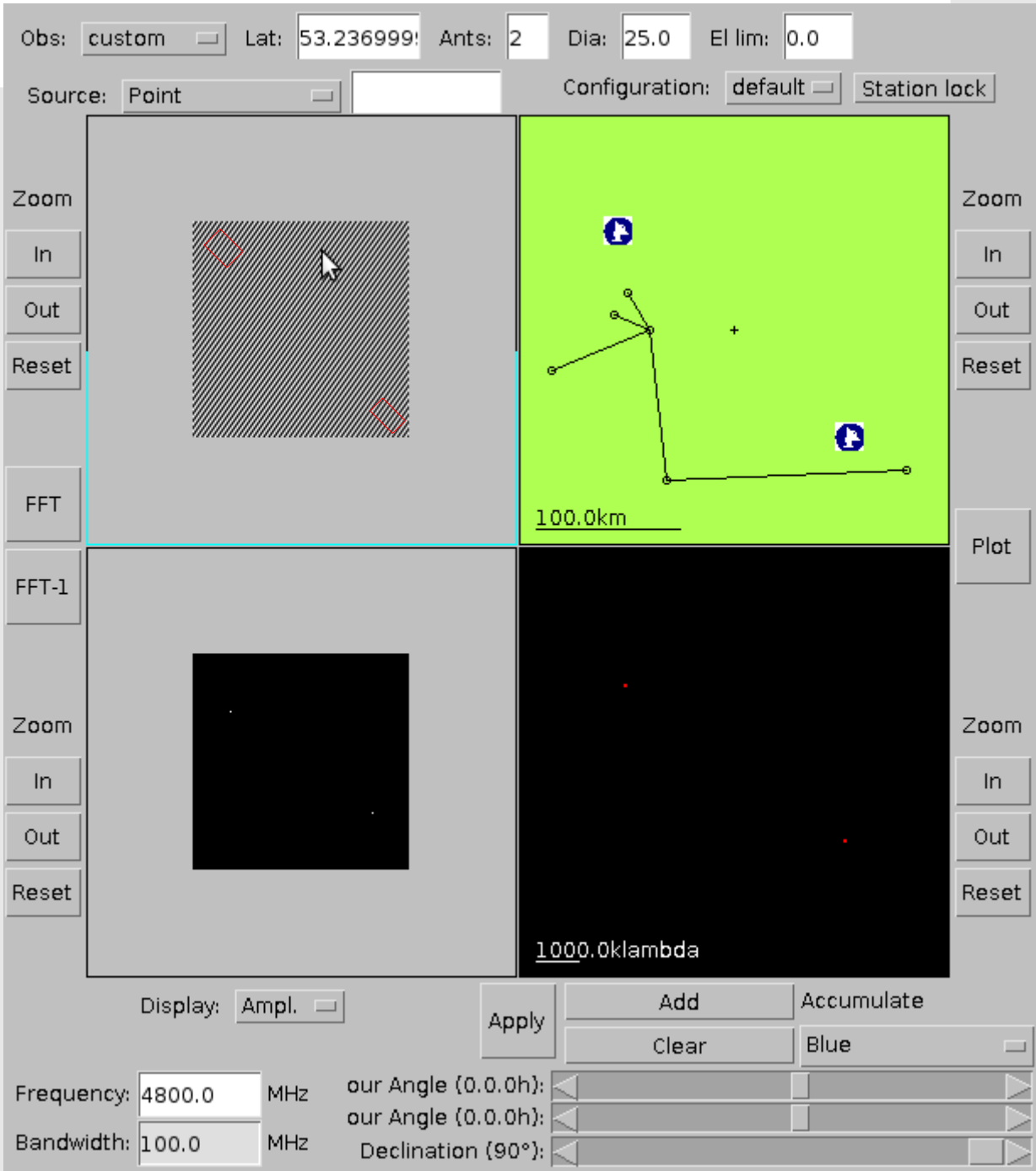
Applications and problems

- Visibility is measured over region in uv plane: $\Delta\nu/\nu$ * sqrt(l^2+m^2)
- And over time interval $\Delta\tau$
- If visibility changes in this region, you're in trouble

- Amplitude of source is degraded and „smeared“ across image

- Bandwidth smearing
- Time smearing



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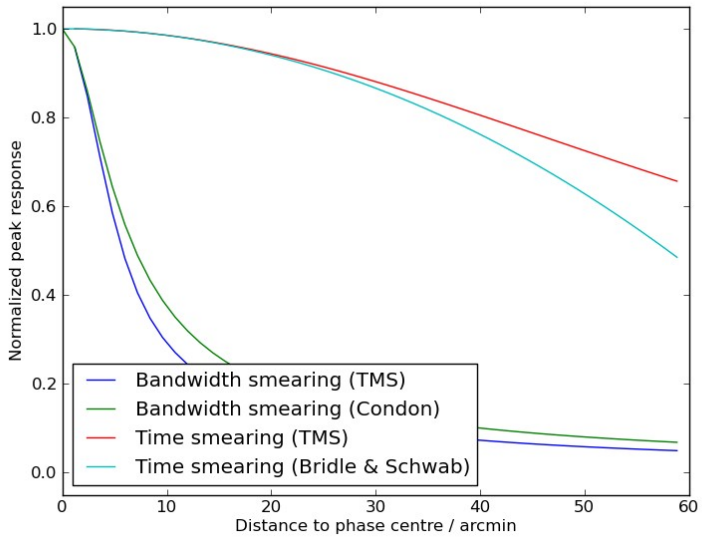
Wide-field VLBI observations

Applications and problems

- Does this affect you? HELL YES!

- Lofar: 1500km baselines, 240MHz, 250kHz channels, 1s integrations



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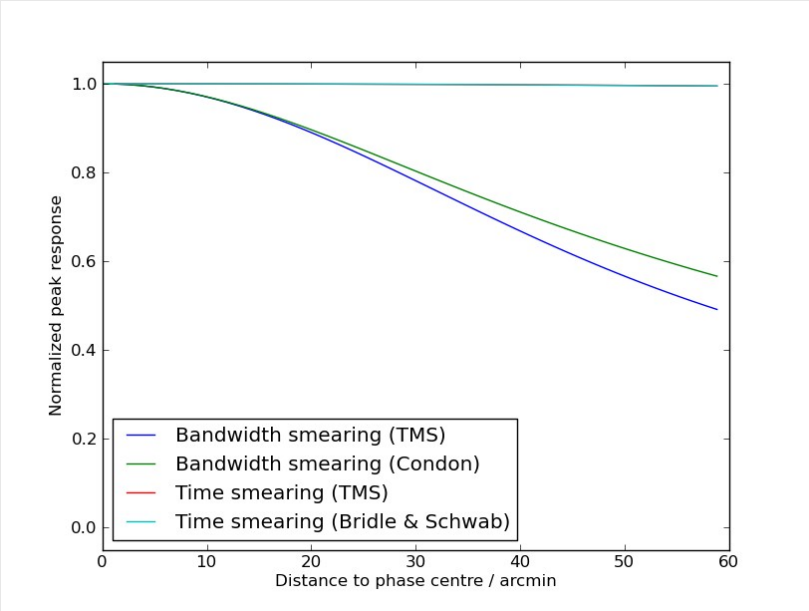
Wide-field VLBI observations

Applications and problems

- Does this affect you? HELL YES!

- Lofar: 1500km baselines, 240MHz, 25kHz channels, 0.1s integrations



- Lofar was build to have a LARGE field of view
- Imaging even small fractions of station beams with long baselines is going to hurt

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Wide-field VLBI observations

Applications and problems

- Workaround:
  high spectral/temporal resolution
  → large data volumes (order TB)
  → cumbersome/impossible

  (2TB for 12h VLBA run to map 2' FOV)

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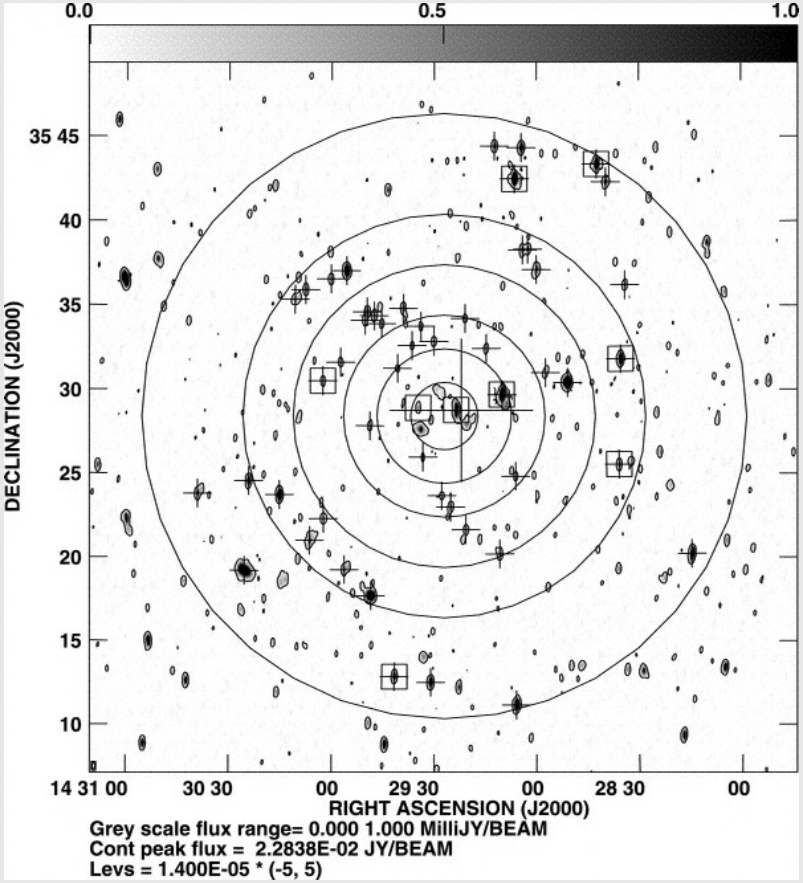
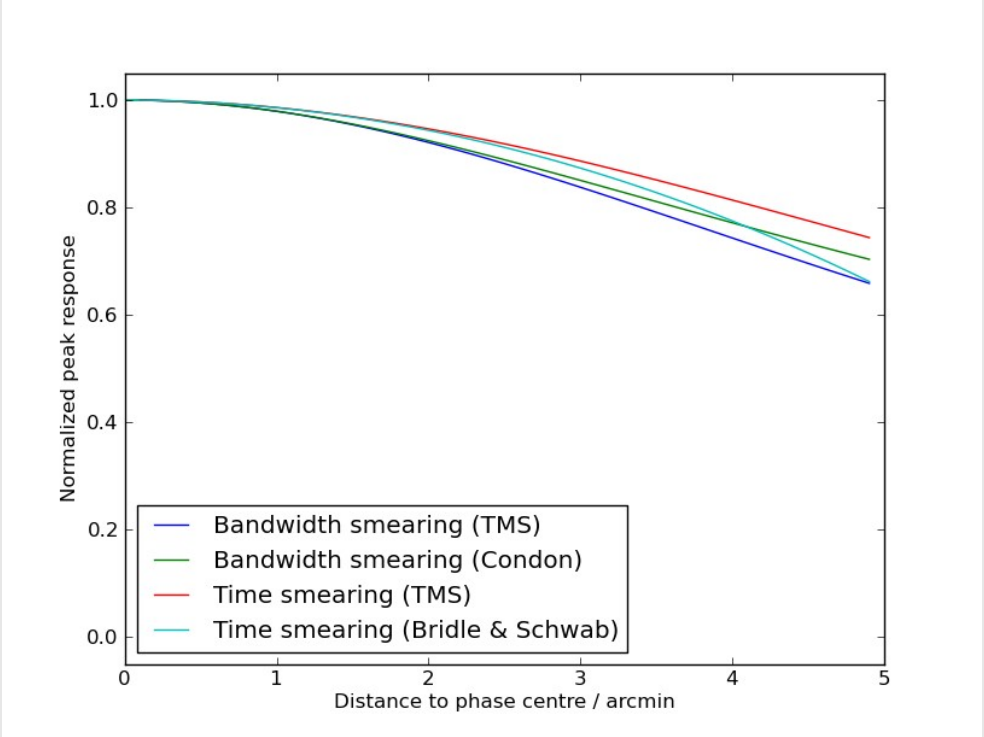
Wide-field VLBI observations

Applications and problems



Garrett+ 2005: 1024 channels, 0.5s integrations (120GB of data), FOV of few arcmin



Averaging losses on 5000km baseline with 64kHz channels and 0.5s integrations (as in Garrett+ 2005)

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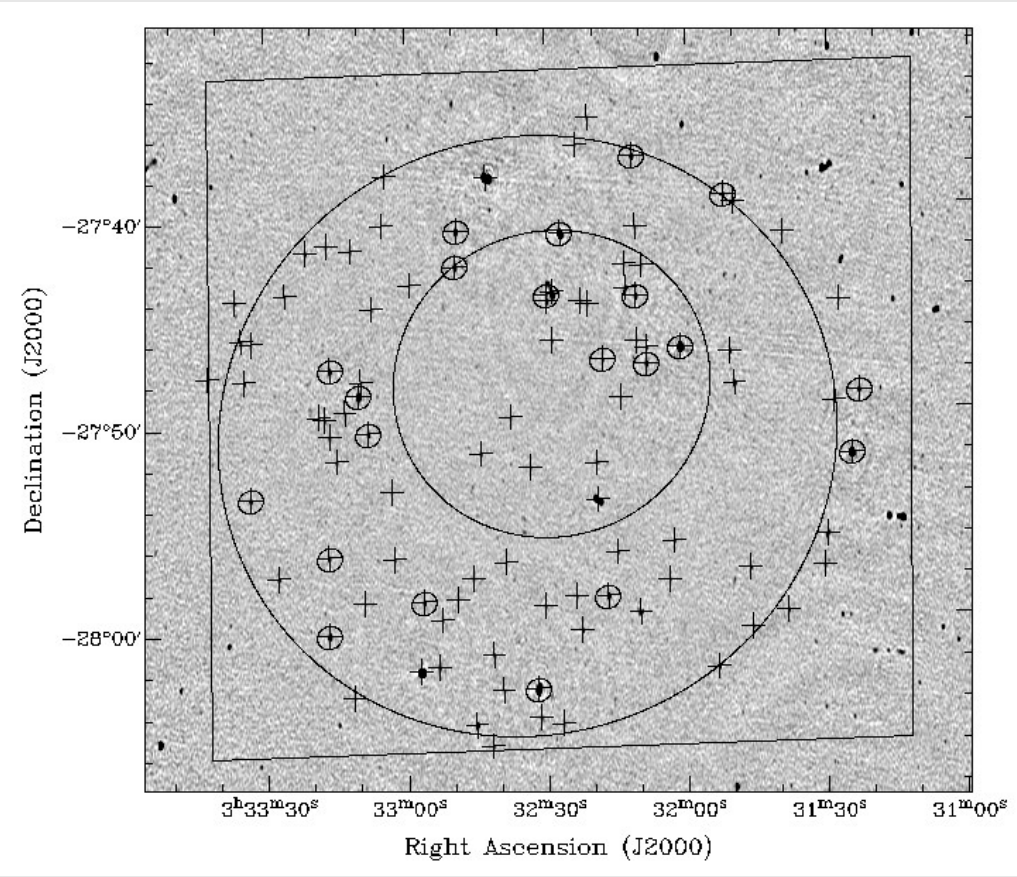
Wide-field VLBI observations

New methods: multiple phase centres in DiFX2

(Deller+ 2010, submitted)

In correlator

- Correlate with high resolution (τ=10ms, $\Delta\nu$=2kHz to 4 kHz)
- Calculate delay towards N phase centres
- Phase-rotate visibilities
- Average
- Result: N normal VLBI data sets



Radio sources from Norris+ (2006) indicated with pluses, large circle is VLBA FWHM at 1.4GHz, small circle is CDFS (Luo+ 2008), rectangle is ECDFS (Lehmer+ 2005)

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Wide-field VLBI observations

The pilot project – observations

(Middelberg+ 2010, submitted)

- CDFS observed at 1.4GHz in July 2007
- Expected sensitivity 50μJy – 100μJy
- Resolution: 29x9 mas^2 (natural weighting)
  21x6 mas^2 (uniform weighting)
- First project to use multi-phase centre capability of DiFX2, with N=96
- Primary beam correction scheme developed

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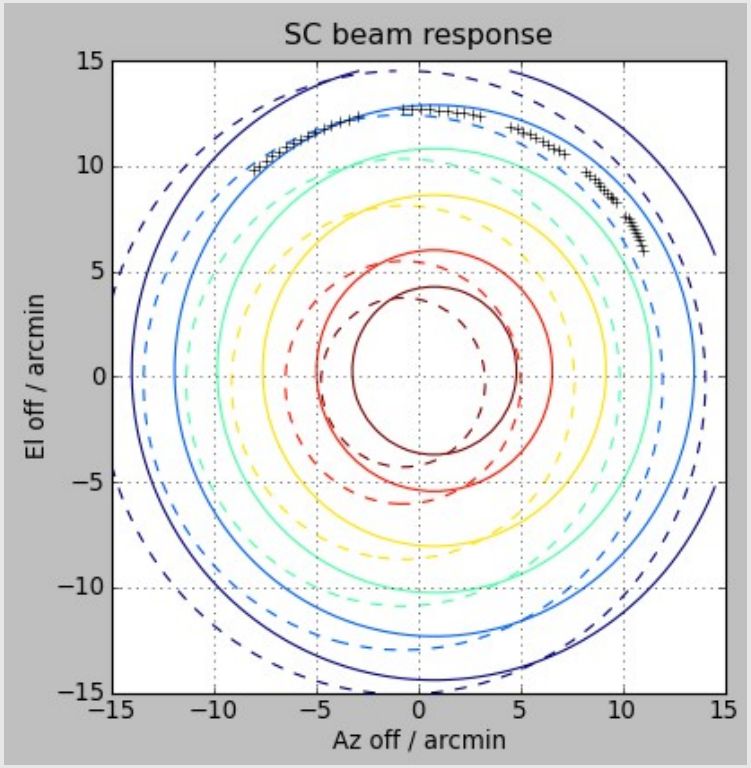

Contours: RCP and LCP beams of the VLBA antenna at St Croix; crosses: path of off-axis source during the observations

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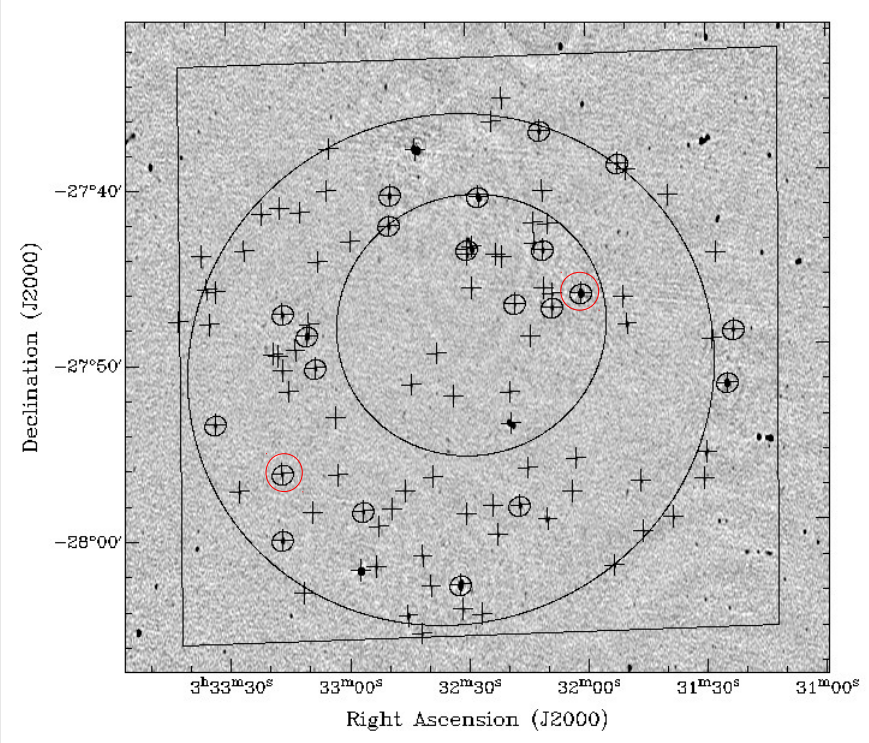
Wide-field VLBI observations

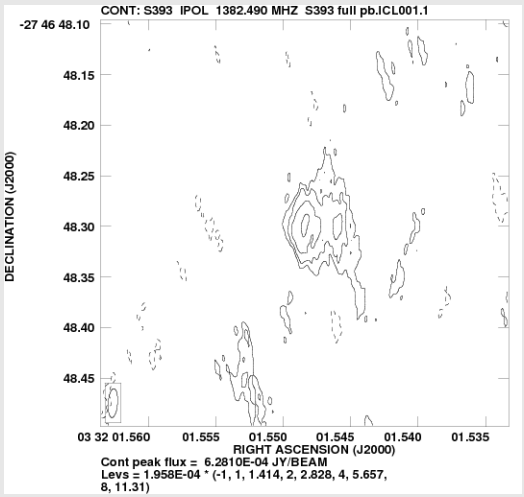
The pilot project – results

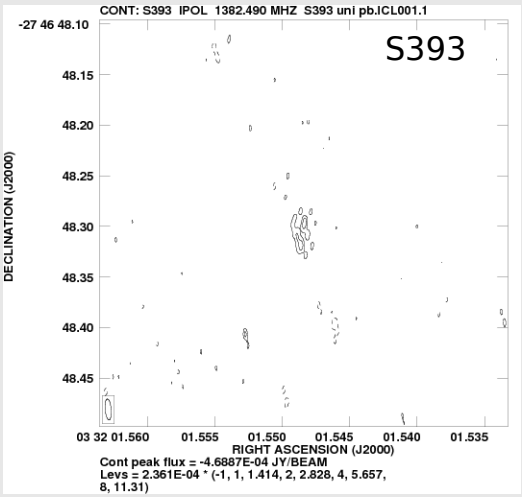
(Middelberg+ 2010, submitted)

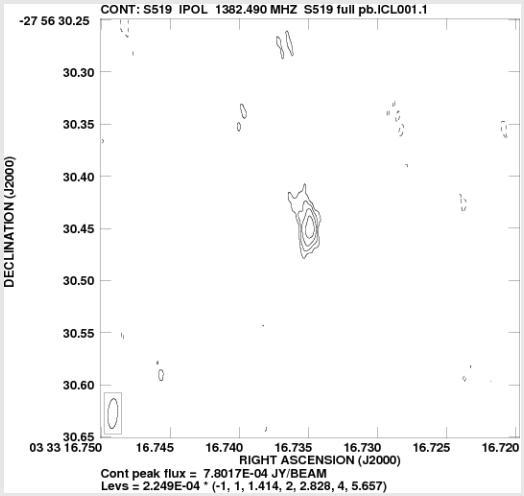


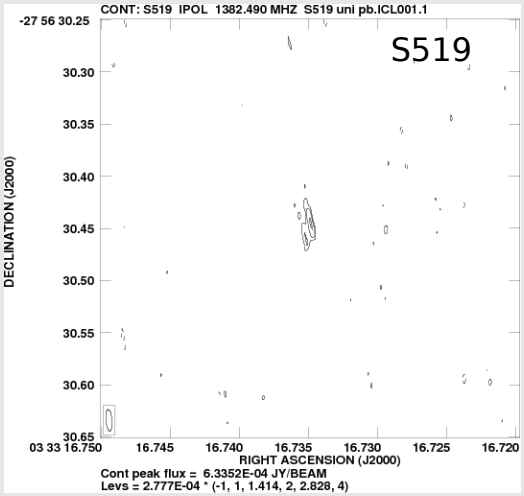
Target S393: z=1.07, S_{ATCA}=49.1mJy, S_{VLBI}=2.5mJy

Target S519: z=0.69, S_{ATCA}=0.9mJy, S_{VLBI}=1.1mJy









Left: natural weighting, right: uniform weighting

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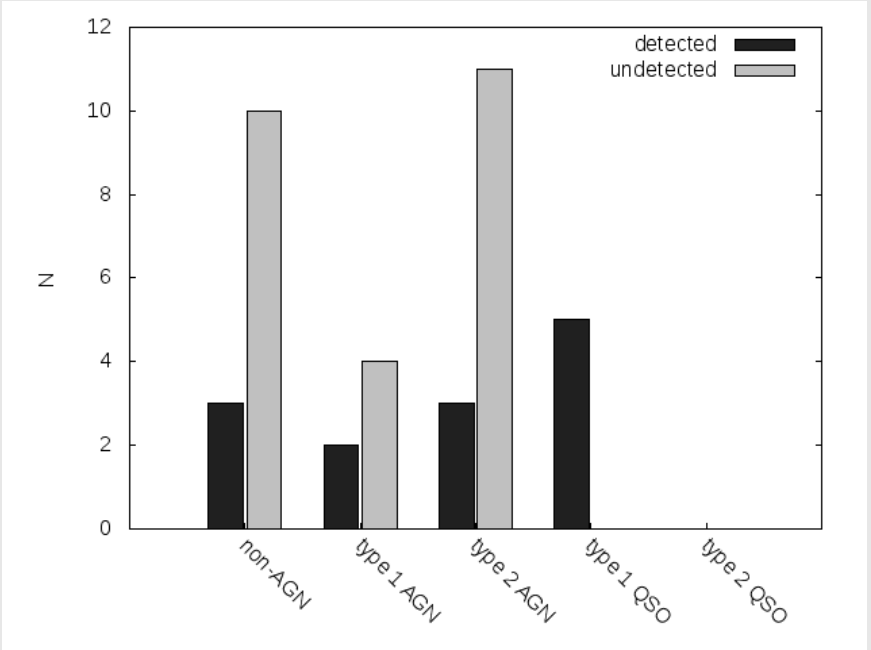
Wide-field VLBI observations

The pilot project – Summary

(Middelberg+ 2010, submitted)



- Detected 21% of sources (=AGN)
- Identified 8 previously unknown AGN
- Every X-ray type 1 QSO is detected
- 1 starburst/elliptical galaxy detected
- 1 potential radio SN
- Wide-field VLBI now practical and easy

  (but see Morgan+ 2010 for a different approach)
- Next step: Lockman Hole East (Ibar+ 2009), use mosaicing of three pointings

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Wide-field VLBI observations

The pilot project – Summary

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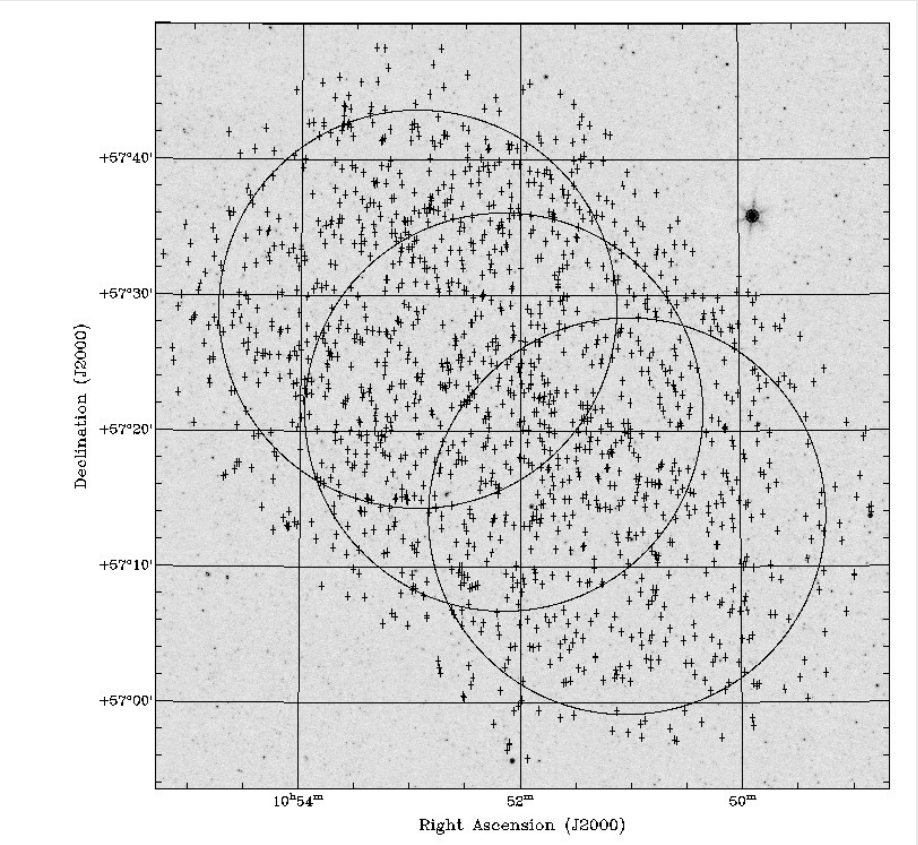

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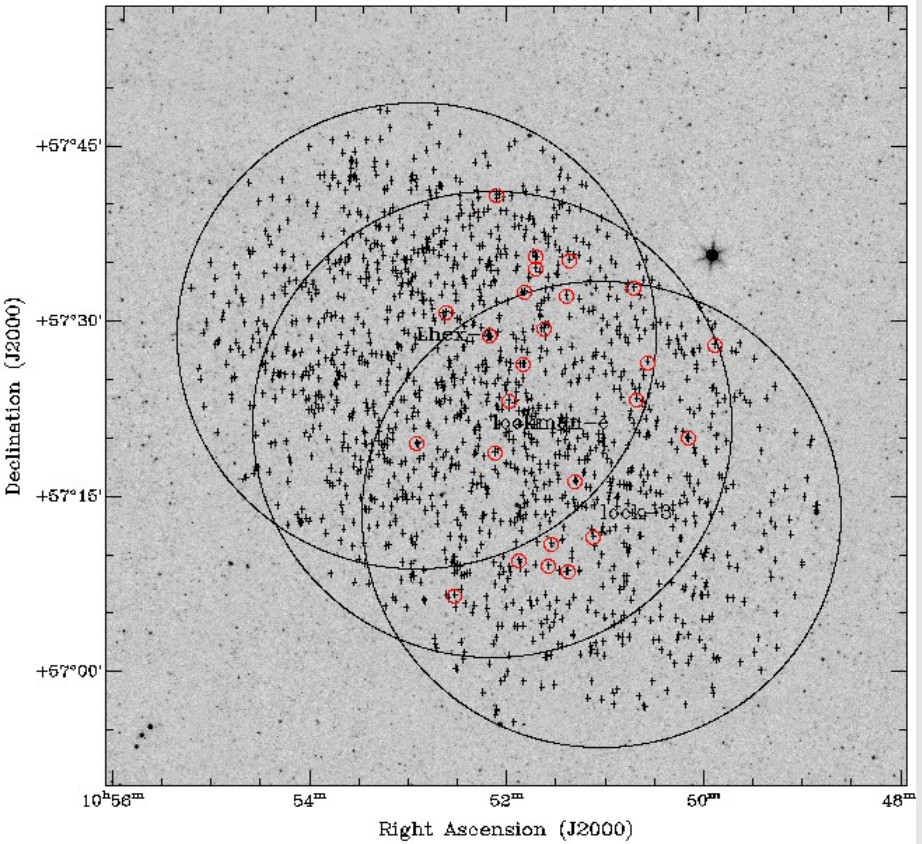
Wide-field VLBI observations

Last week's result: bm332b

(Middelberg+ 2010, not even in prep)

- bm332b: 12h @ 512Mbps
- 347 targets
- Phase-referencing only
- 28 targets with SNR>7
- Brightest has SNR=88



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