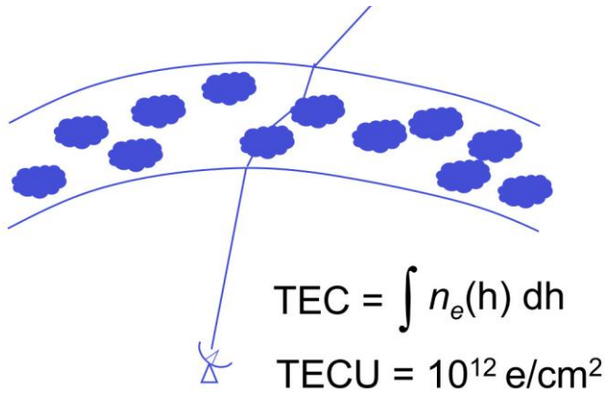
Fitting and Testing Ionospheric Phase Screens with MSSS Data

David Rafferty, Bas van der Tol, George Heald (+TT)

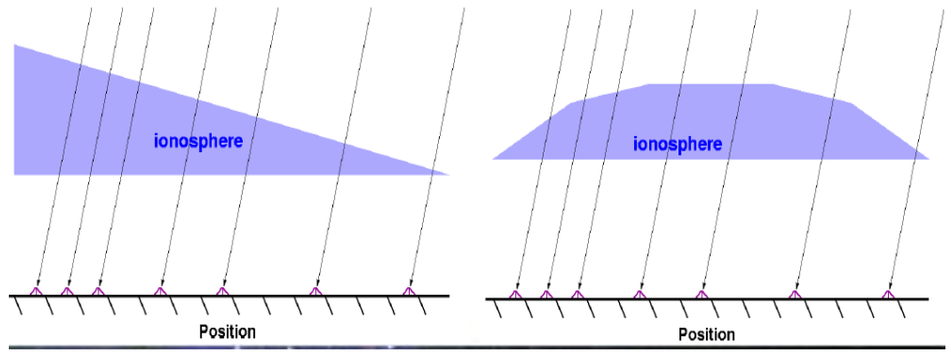
Introduction

- The ionosphere can cause time- and position-dependent phase shifts



- Using direction-dependent calibration, these shifts can be measured and corrected (e.g., with phase screens as in SPAM)

- The SPAM approach assumes that instrumental effects have been removed, but (so far) this has not been possible with LOFAR



Credit: Huib Intema

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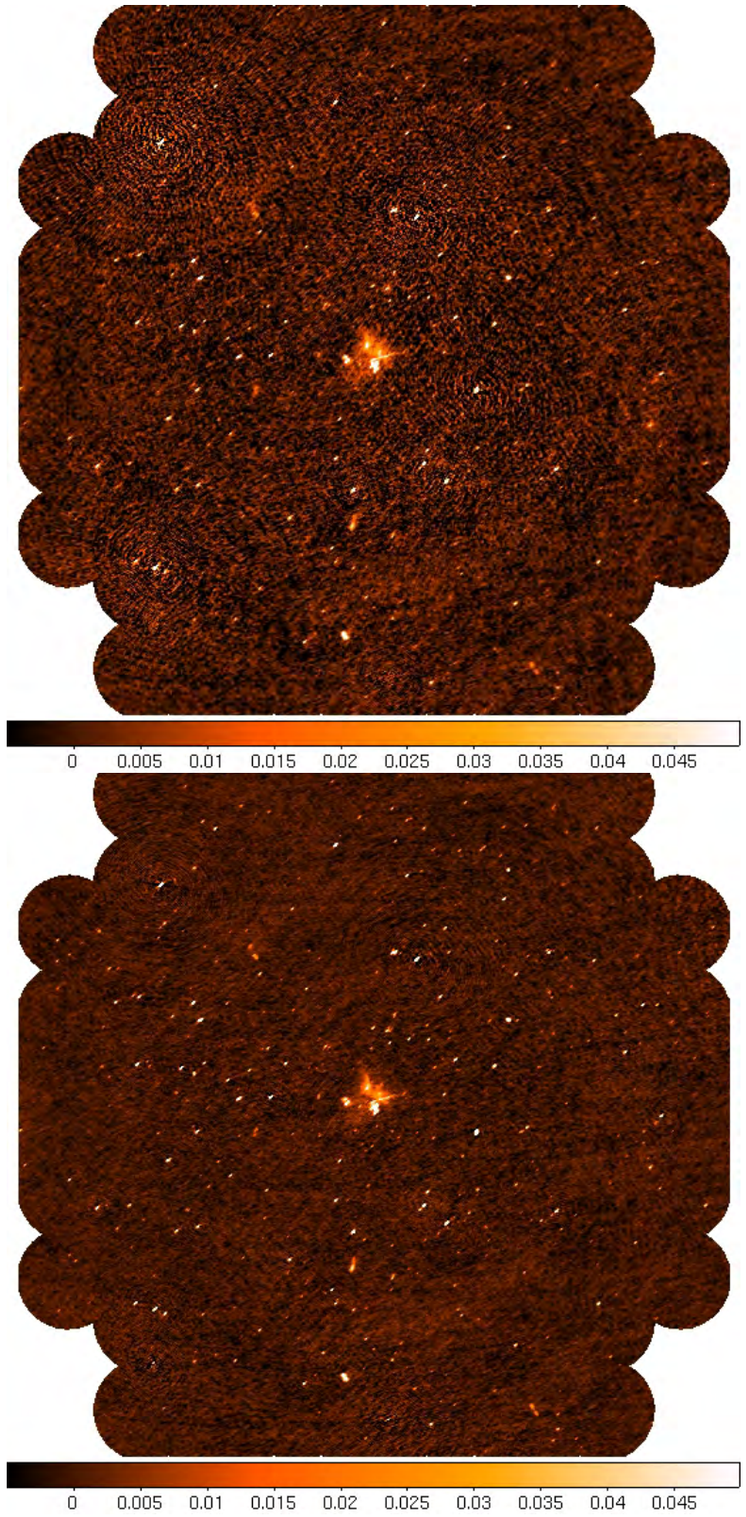
- One solution: use phase differences between sources



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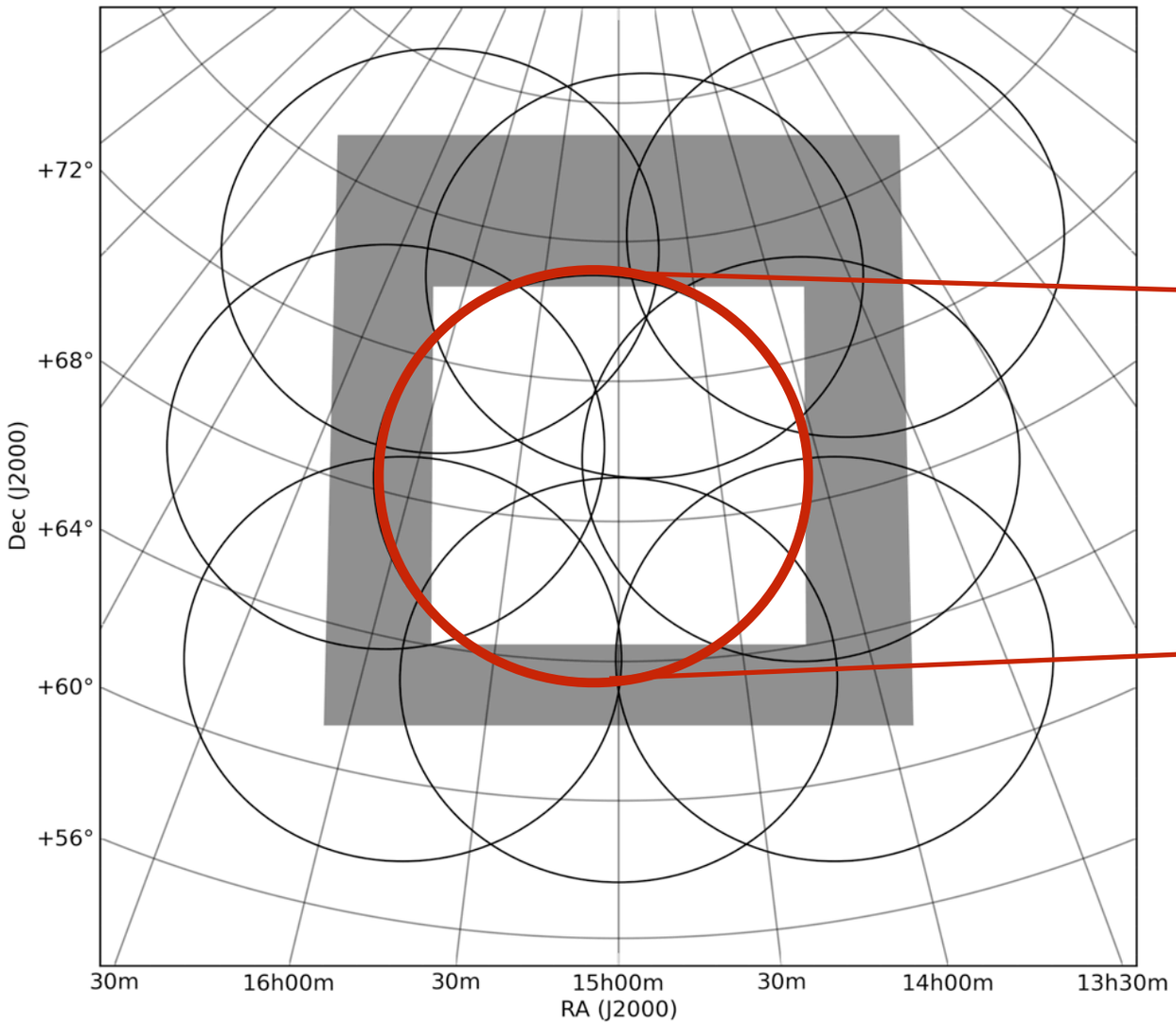
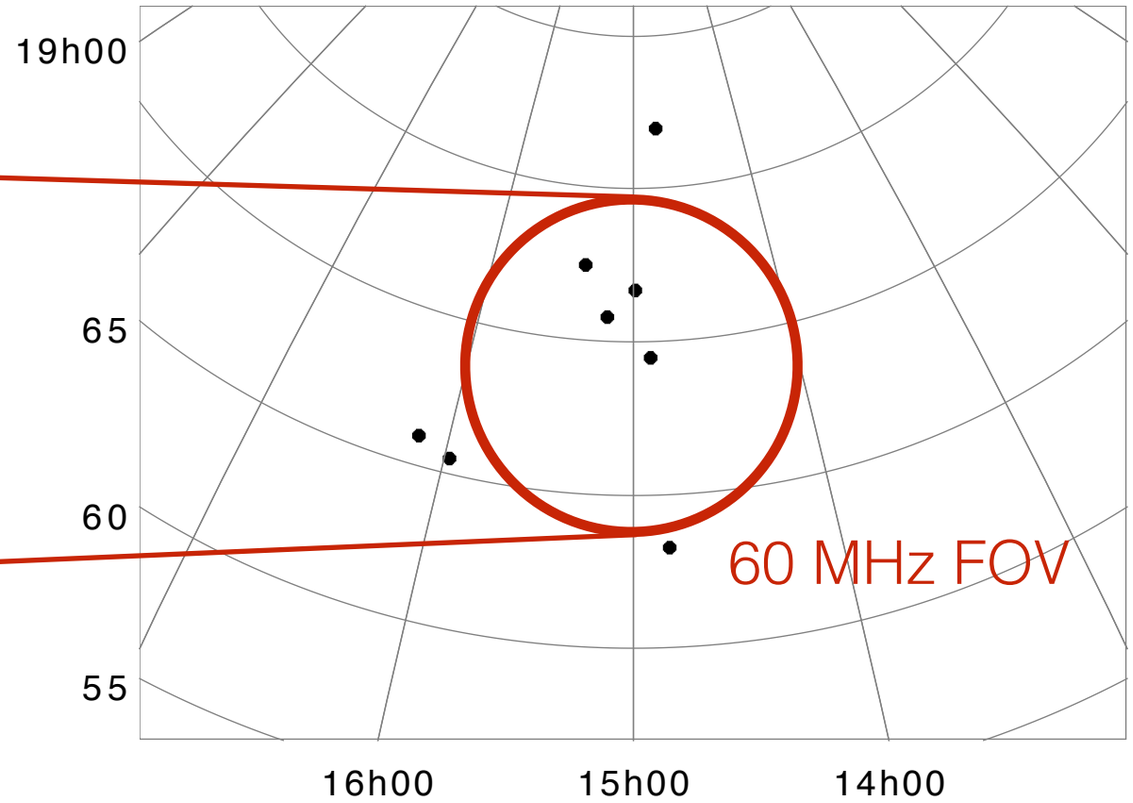
Source Differencing

- Perform direction-dependent calibration for bright sources
- Assume that instrumental effects are the same in all directions
- Subtracting phase solutions for two sources will result in purely direction-dependent (ionospheric) effects
- Test with MSSS (MVF) LBA data: 8 2-MHz bands, 9 11-minute snapshots

MSSS Verification Field



MSSS Verification Field layout



Phase-screen calibrators
(S_{60} > 10 Jy)

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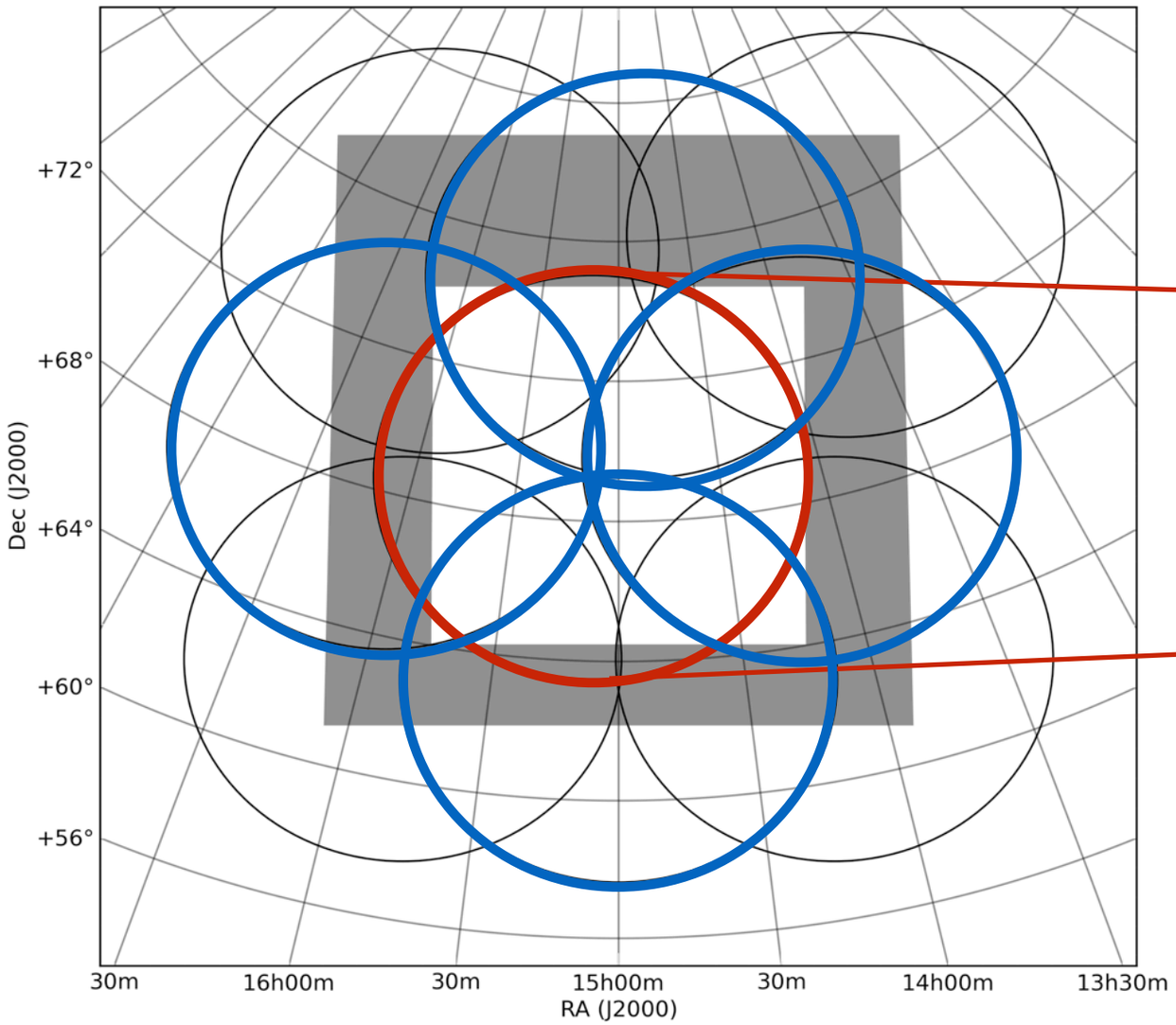

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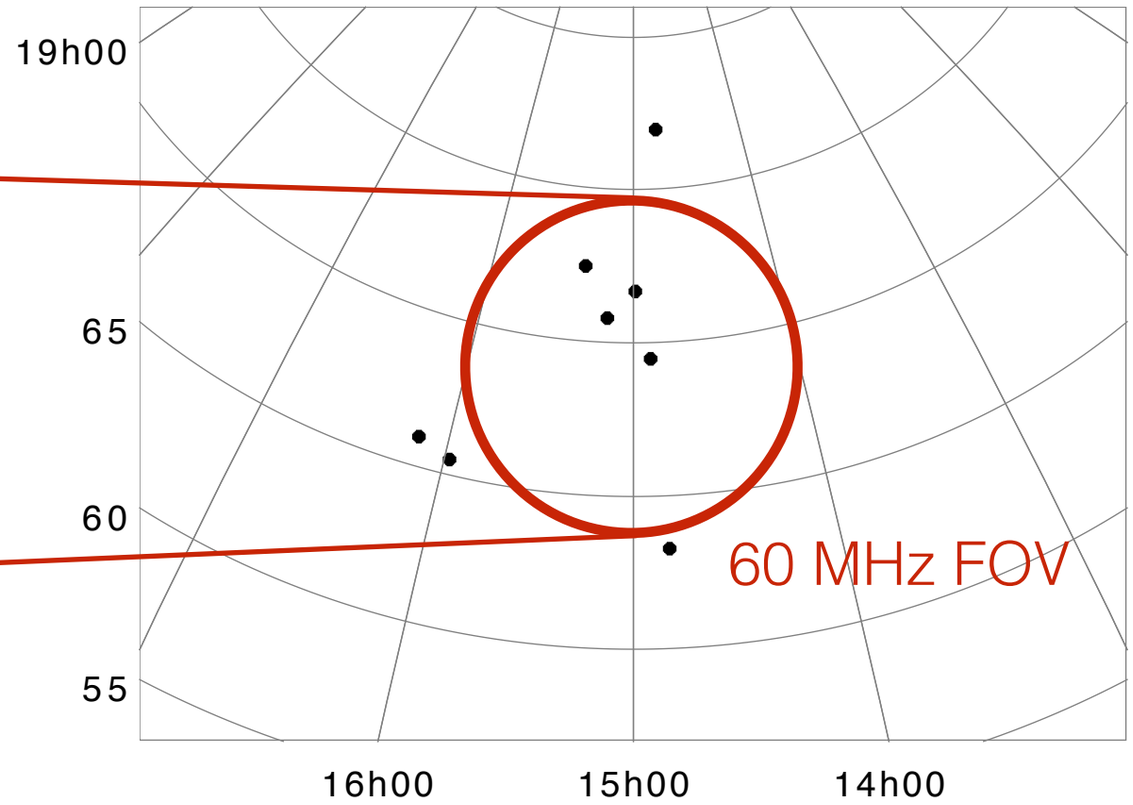

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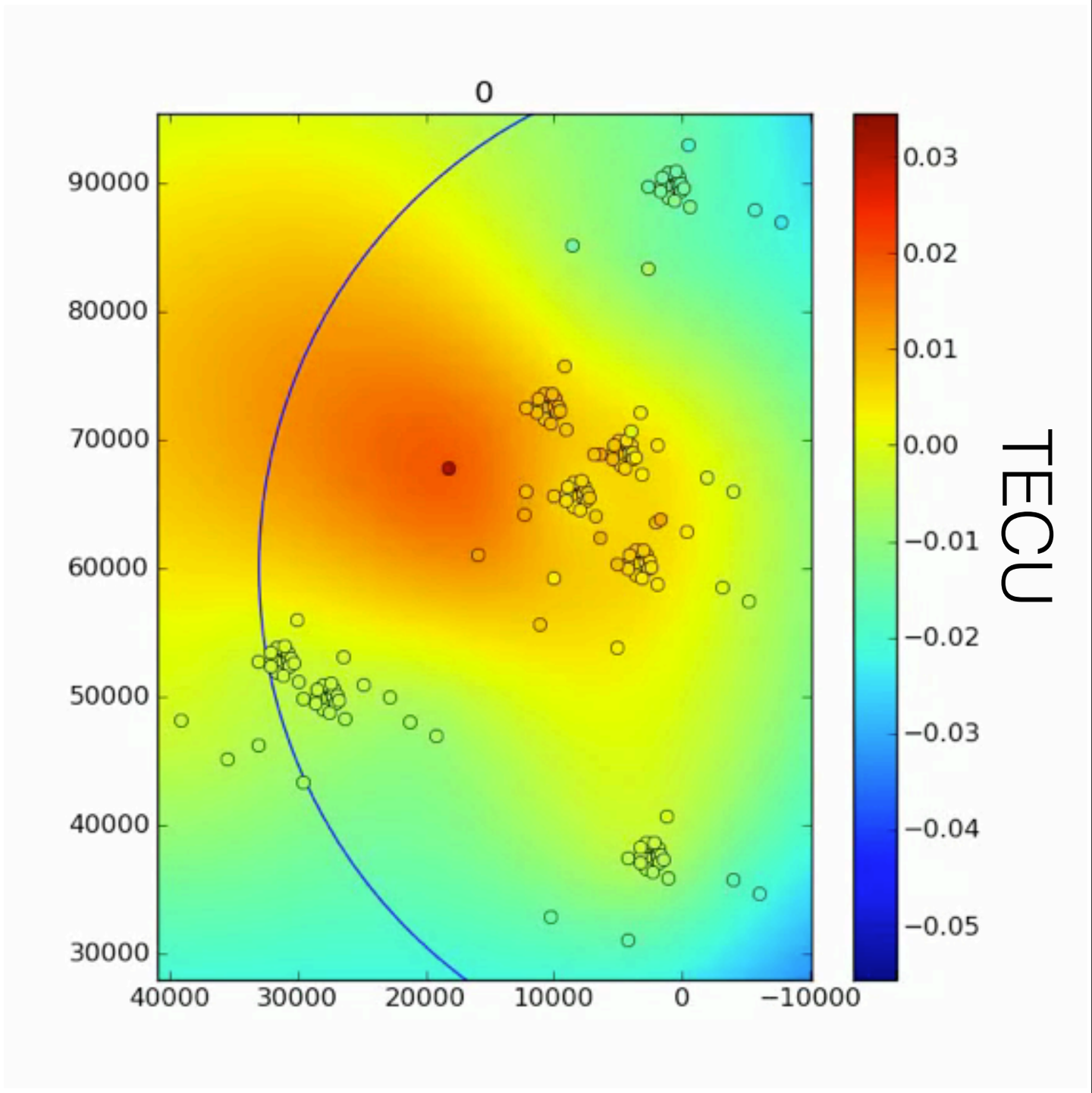
Example Phase Screen

- TEC value was derived for each pierce point every 10 seconds using fit to phases across all 8 bands
- All core stations + 5 remote stations were used
- 7 11-minute snapshots were used (first two snapshots not used due to poor solutions)



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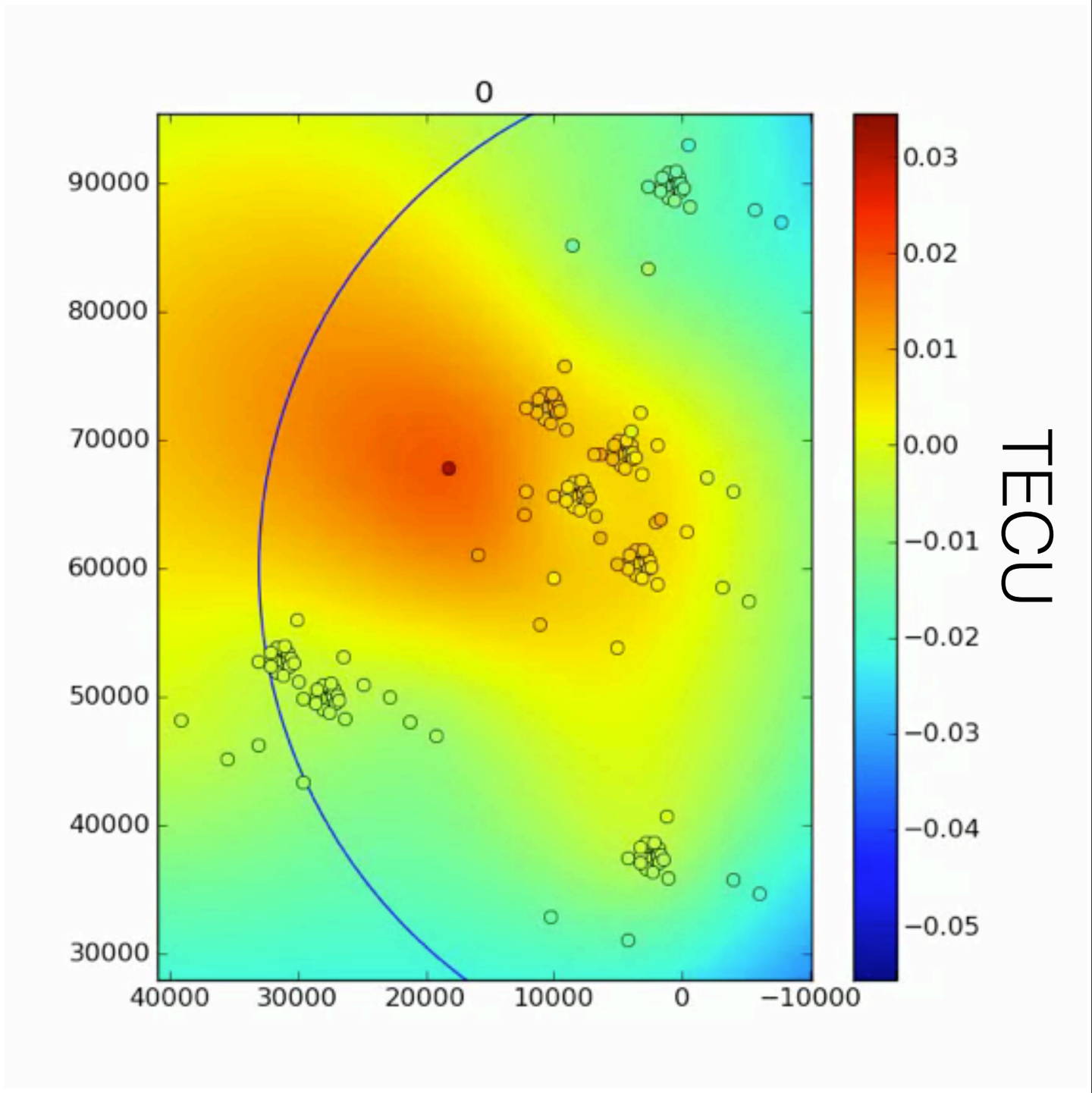
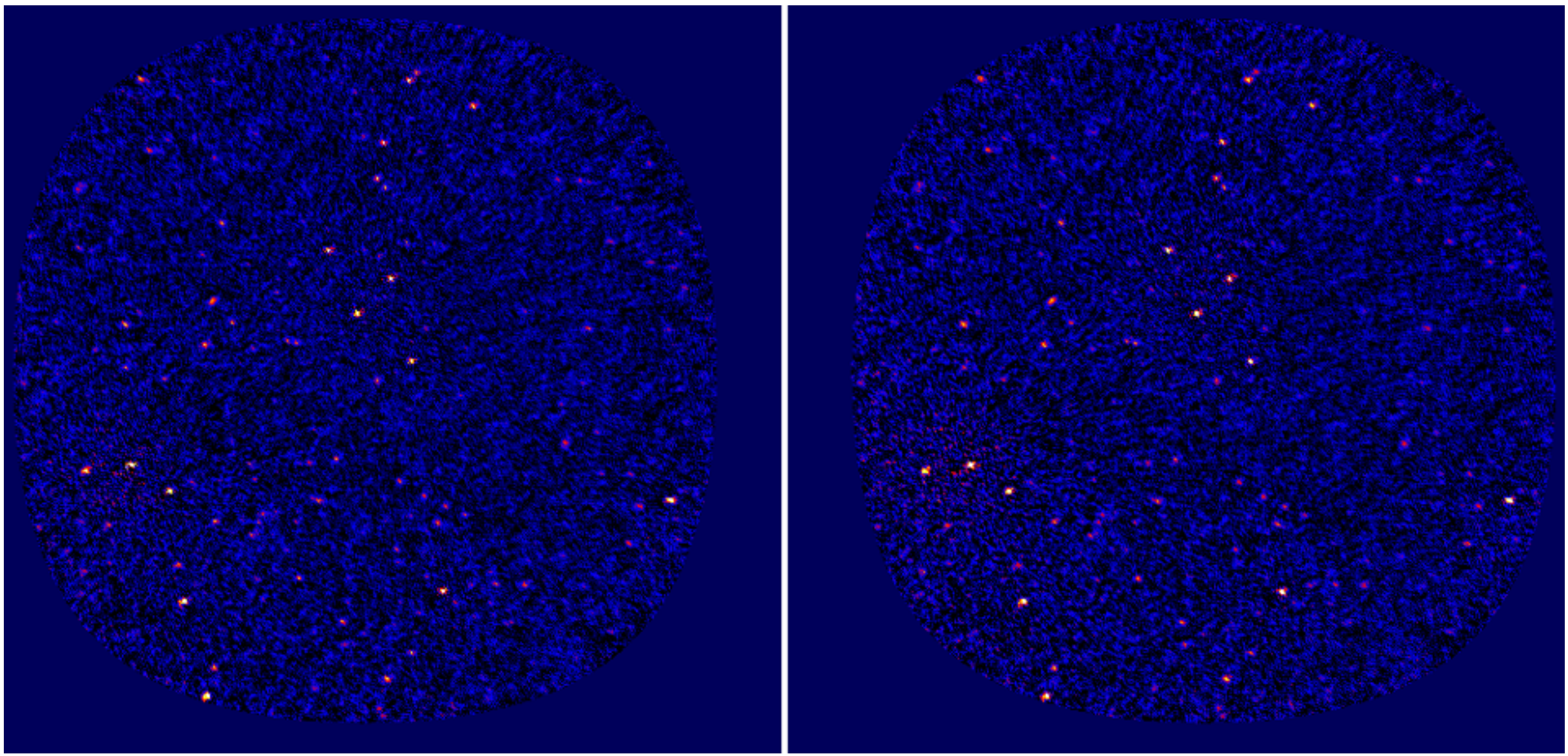


30 MHz Images



With phase screen

Without phase screen

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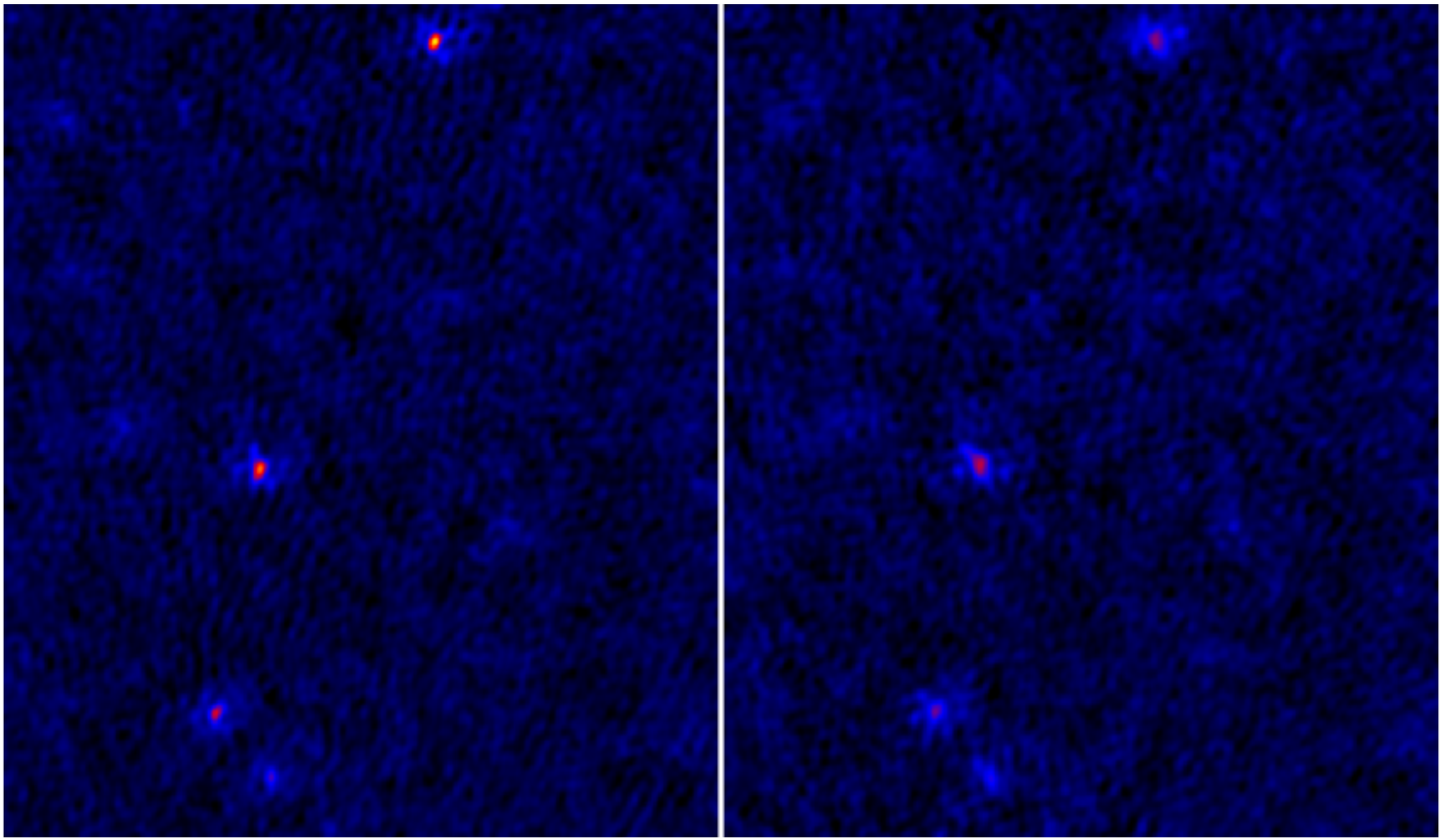
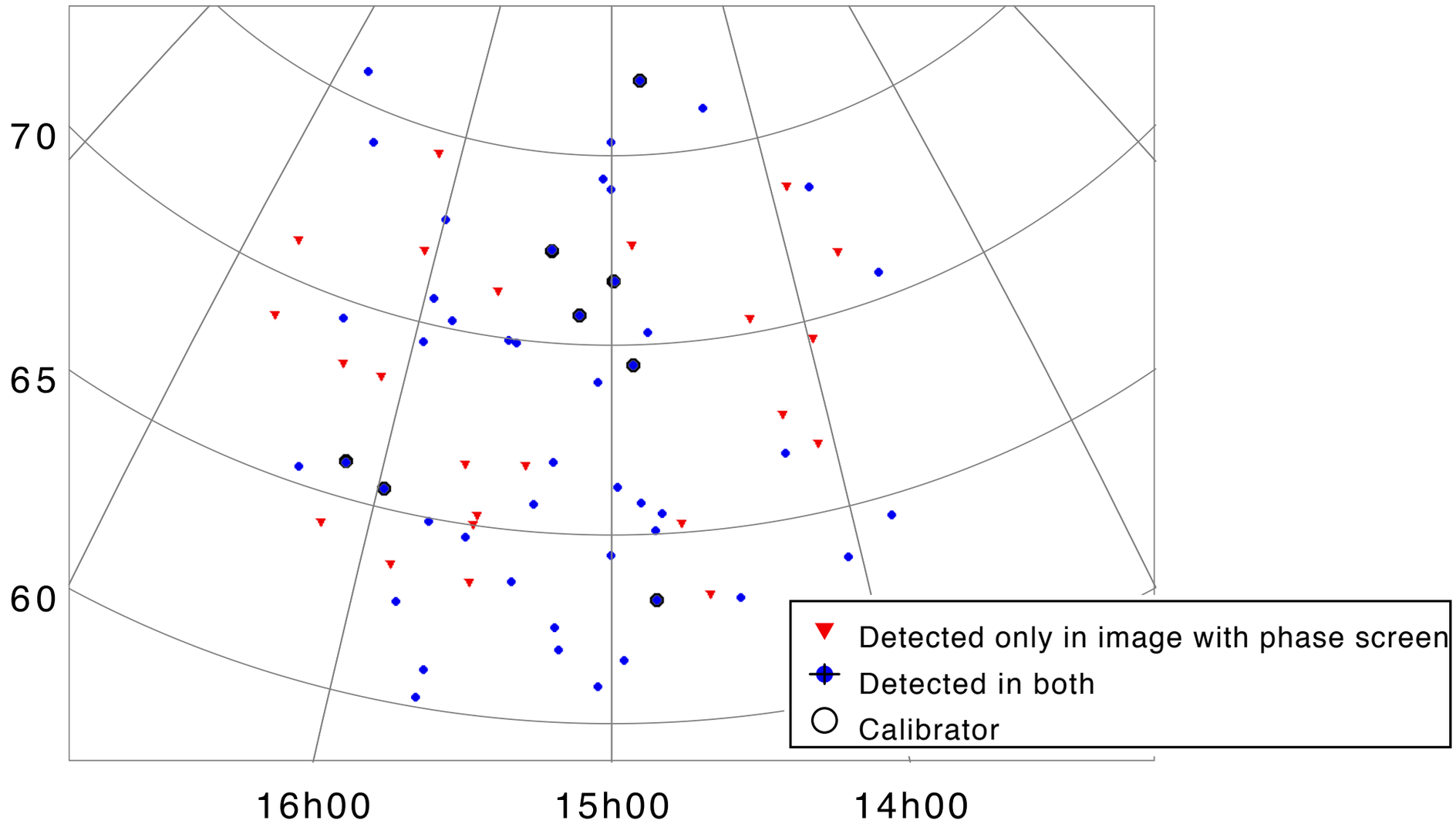


With phase screen

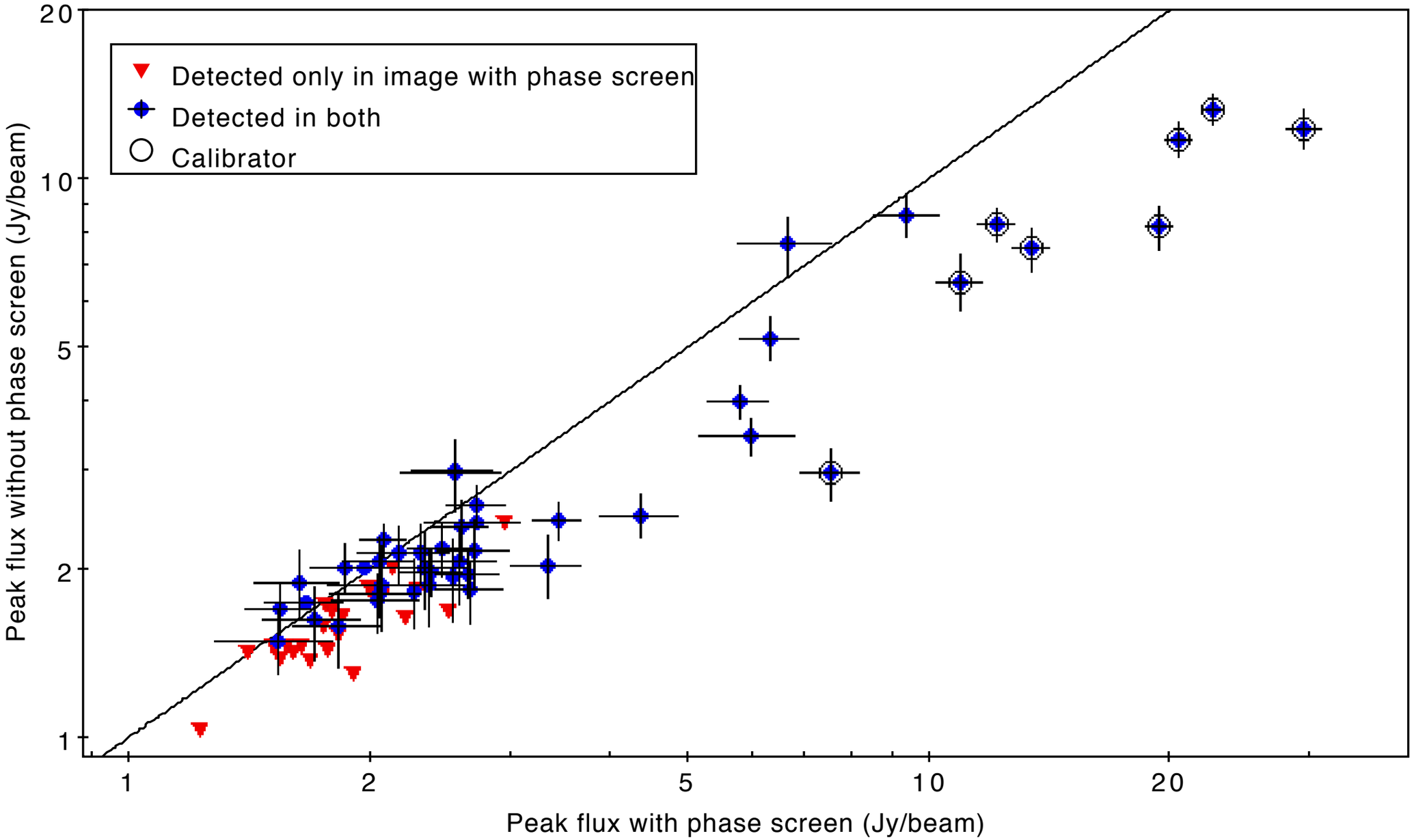
Without phase screen

Detected Sources at 30 MHz (>6σ peak flux)

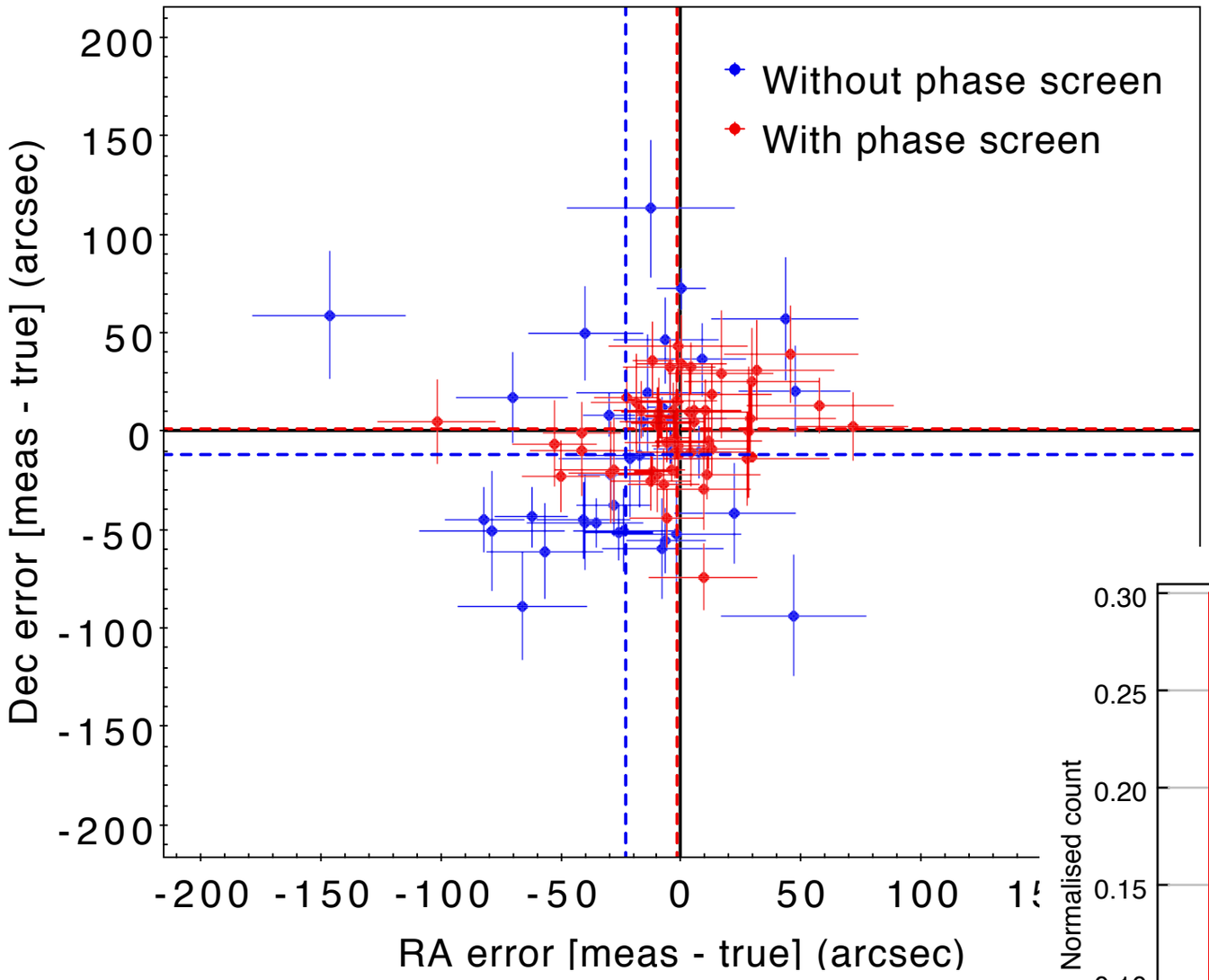


- At 30 MHz, ~ 50% more sources detected in image with phase screen (~30% more at 45 MHz)

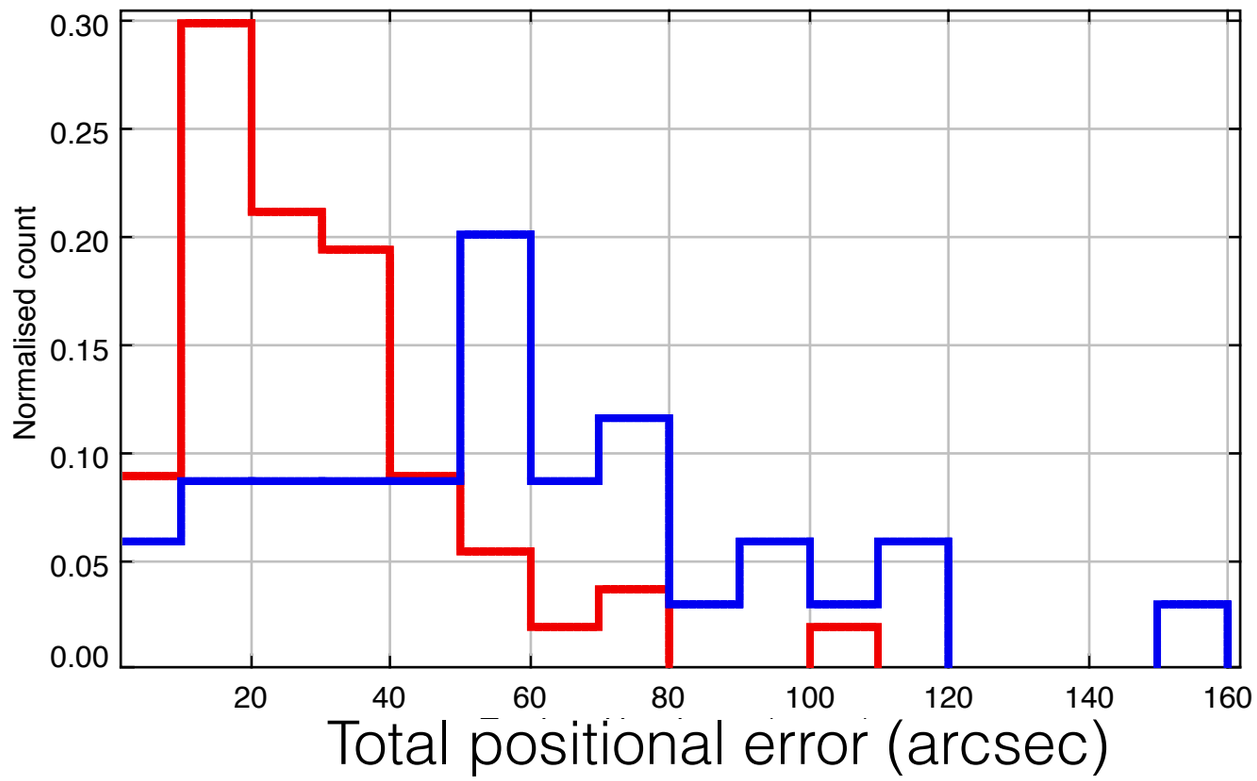
Peak Fluxes at 30 MHz



Positional Errors at 30 MHz



Beam FWHM:
167x133 arcsec



To-do and Application to Other LBA Observations

- Image all 8 bands and compare source detection to images without screen (Giulia)

- Try more sophisticated peeling strategies (varying solution intervals, use of patches, etc.)

- Investigate different screen heights and two layers

- Likely need simultaneous flanking field observations to obtain enough calibrators in all bands, so considerable bandwidth may be required

- Can require a lot of time: current approach for 8 bands, 11 minutes =10-100 hours