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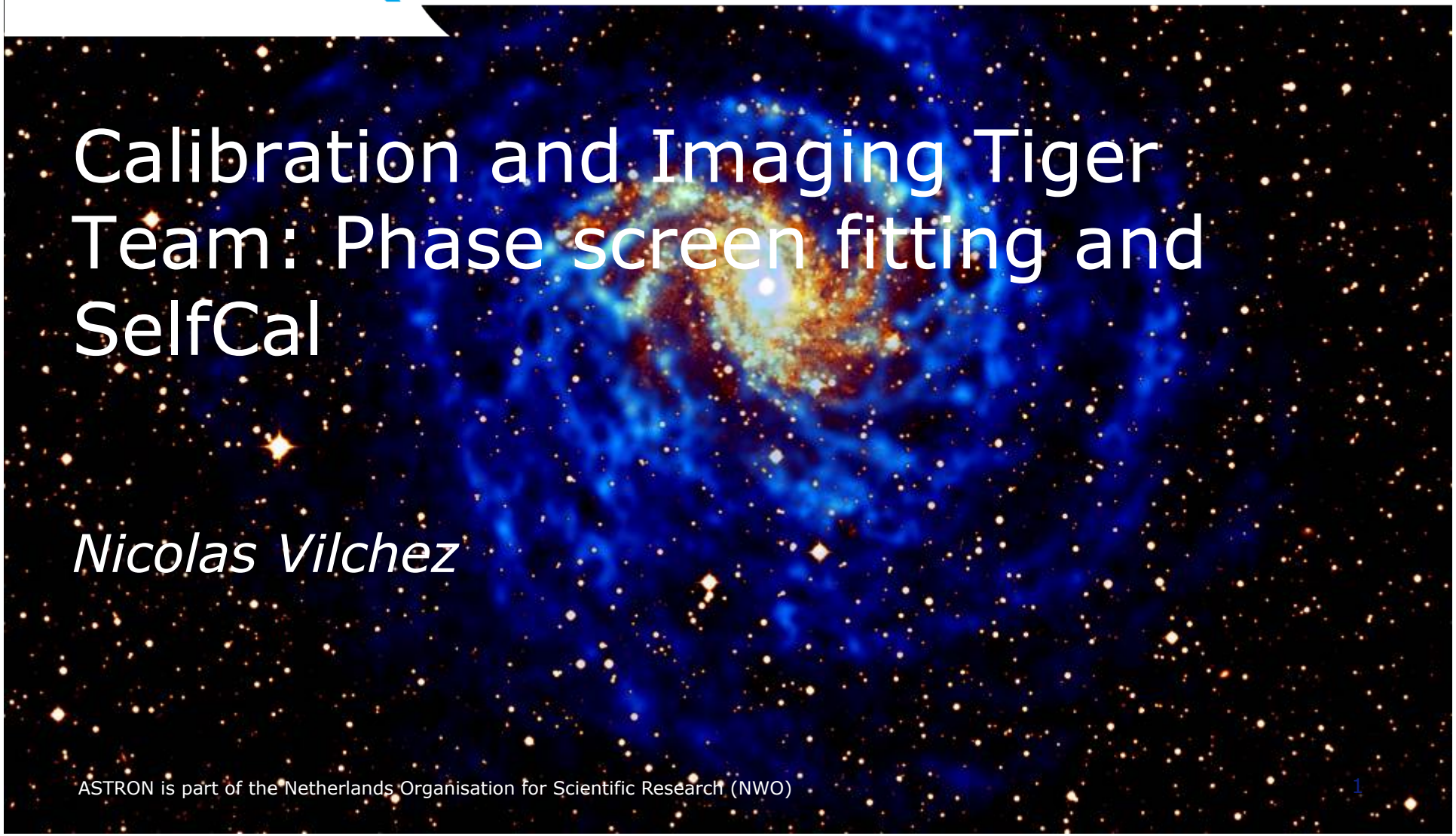
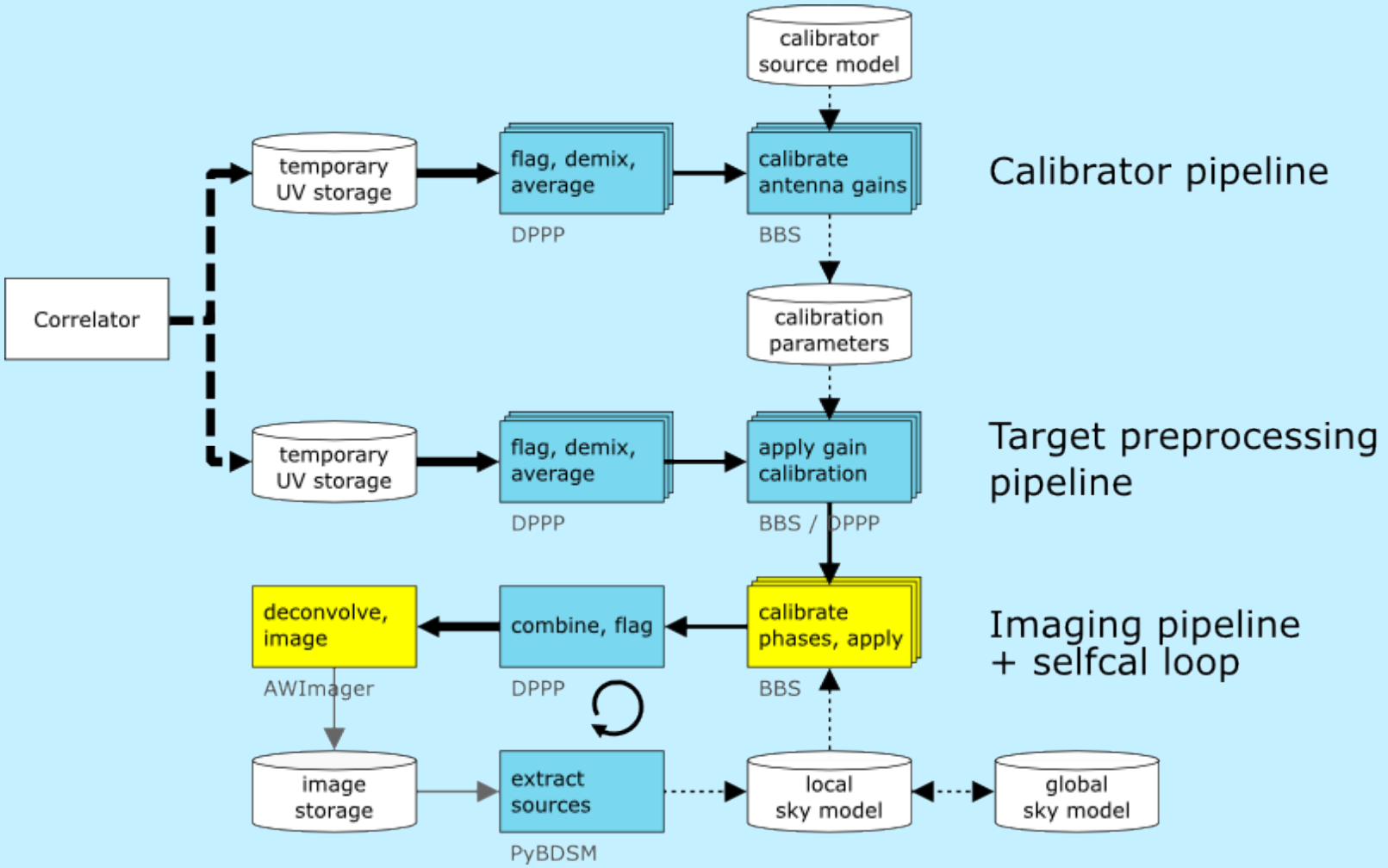
Netherlands Institute for Radio Astronomy



Calibration and Imaging Tiger Team: Phase screen fitting and SelfCal

Nicolas Vilchez

Direction Dependent Calibration: Overview



Direction Dependent Calibration: Motivations

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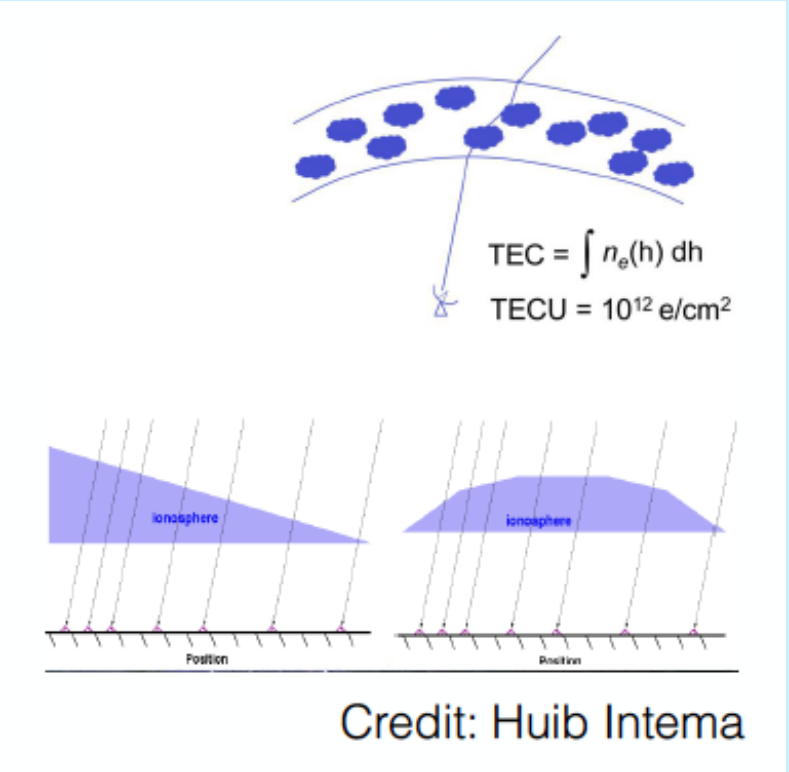
- The ionosphere can cause time- and position-dependent phase shifts

- 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 this has not been possible with LOFAR => Beam and ionosphere varying in time and frequency.



- One solution: use phase differences between sources

Direction Dependent Calibration: Strategy

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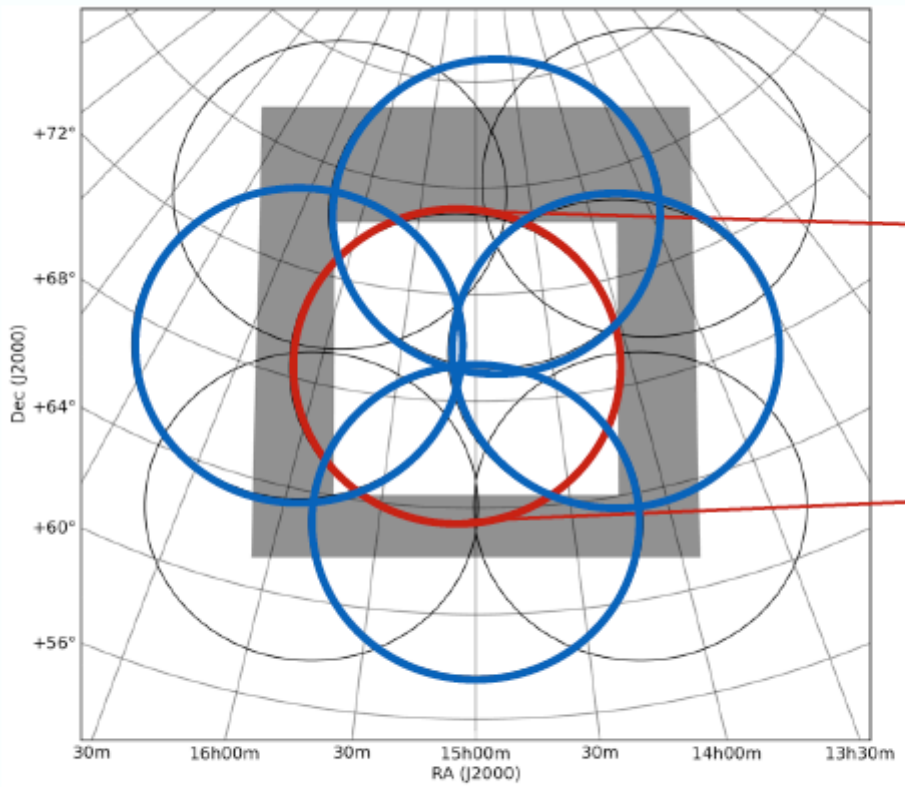
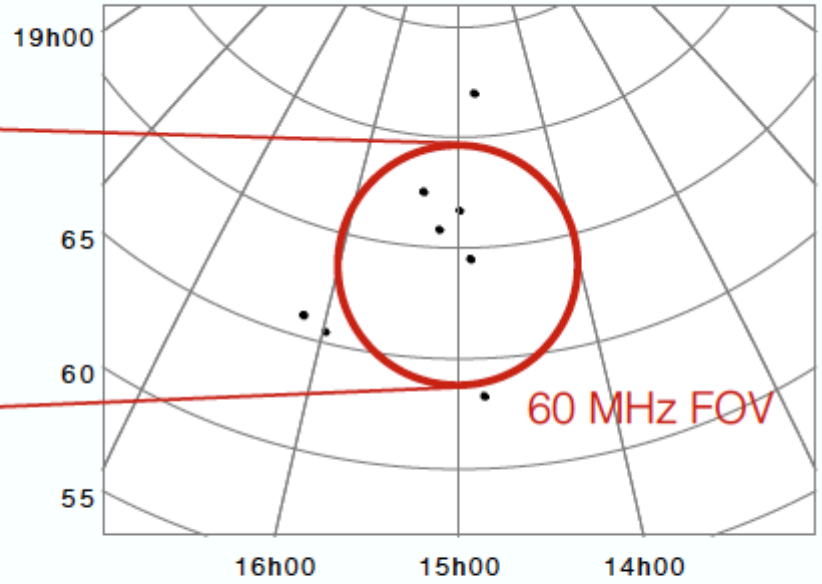
- Perform direction-dependent calibration for patches of sources
- Assume that instrumental effects are the same in all directions
- Subtracting phase solutions for two sources will result in purely ionospheric effects =>TEC screen generation.
- Test with MSSS (Multifrequency Snapshot Sky Survey), LBA data: 8 2-MHz bands, 9 11-minute snapshots (*Heald et al in prep)*

Direction Dependent Calibration: MSSS field of view



MSSS Verification Field layout



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

credits: David Rafferty

Direction Dependent Calibration: Example of TEC screen

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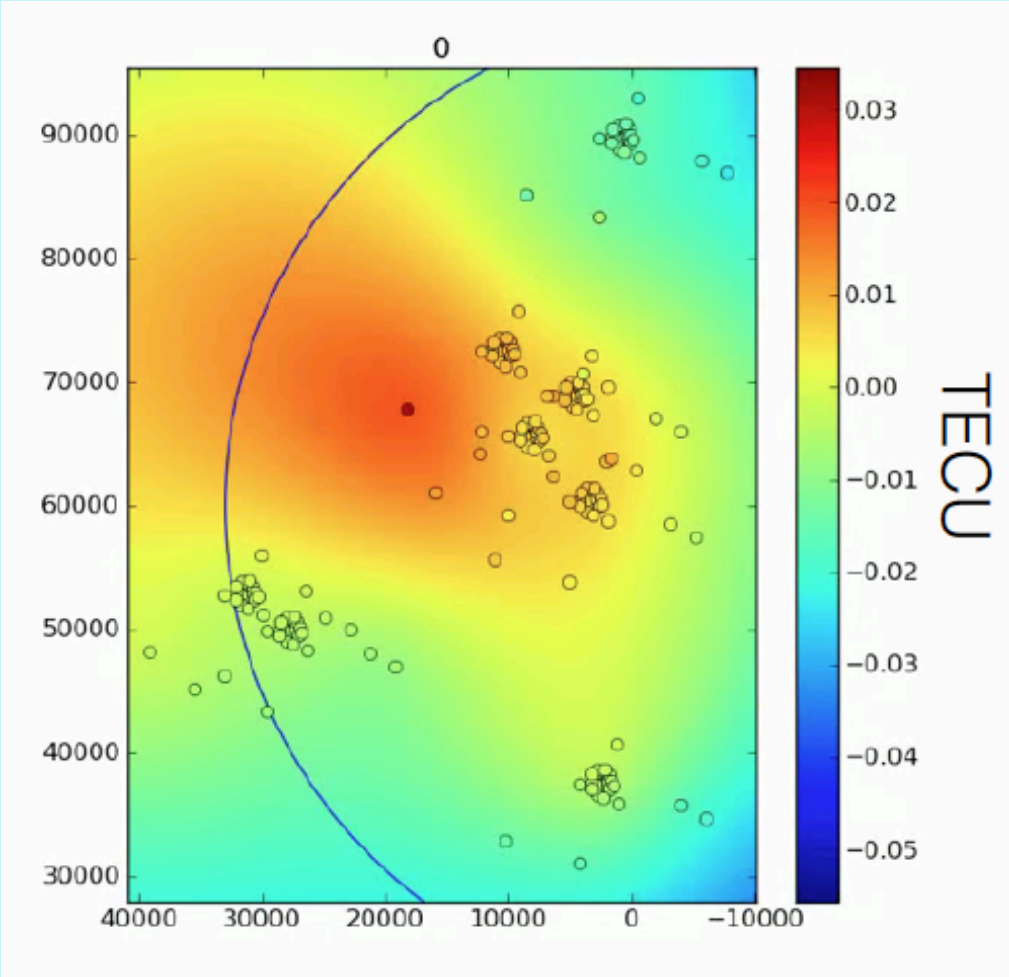
- TEC value was derived for each pierce point every 10 seconds using fit to phases across all 8 Bands

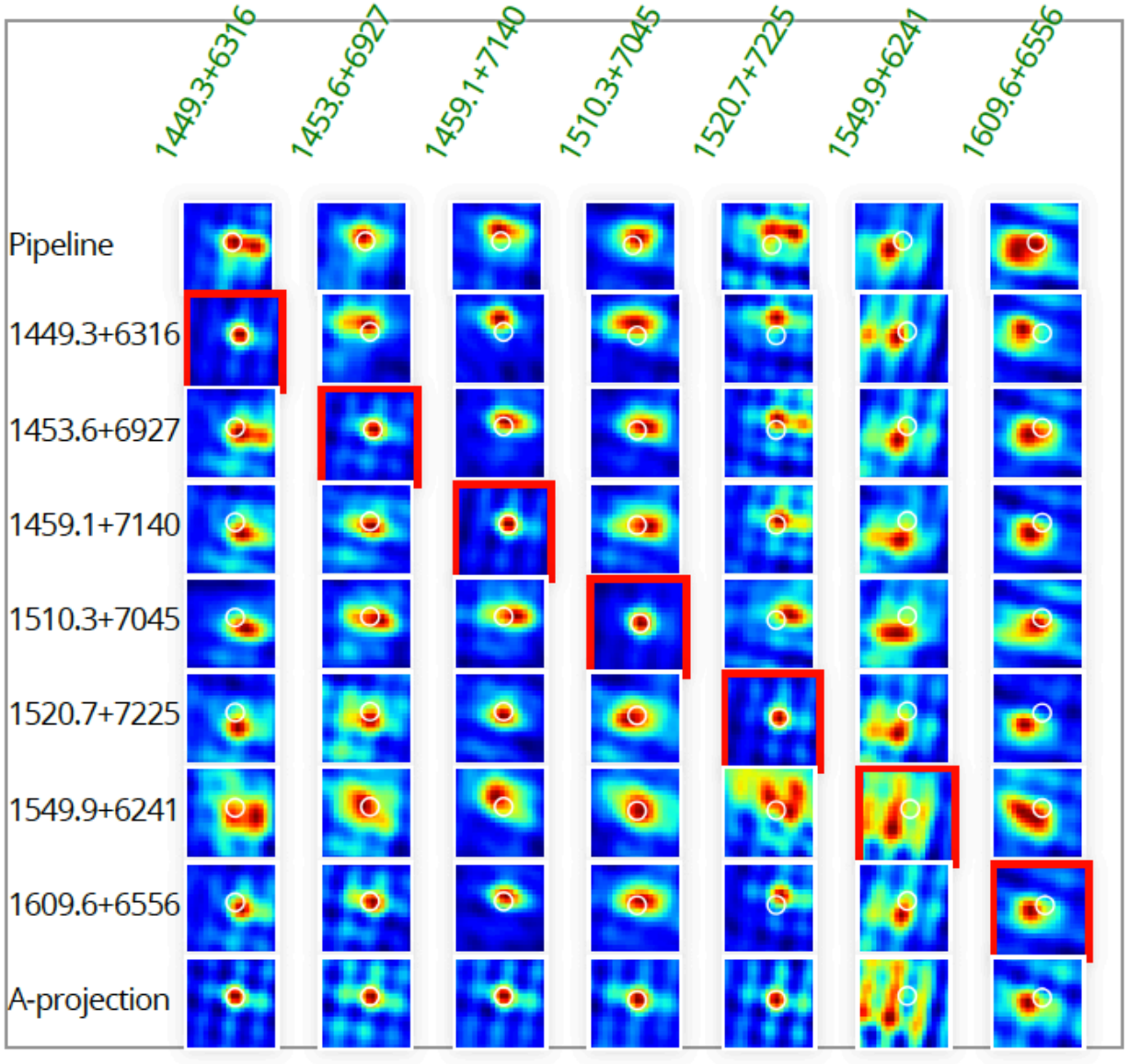
- All core stations + 5 remote stations were Used

- 7 11-minute snapshots were used (first two snapshots not used due to poor solutions)



credits: David Rafferty

Direction Dependent Calibration:
TEC screen used by the imager (AWimager)



credits:
Bas Van Der Tol

Direction Dependent Calibration: conclusion

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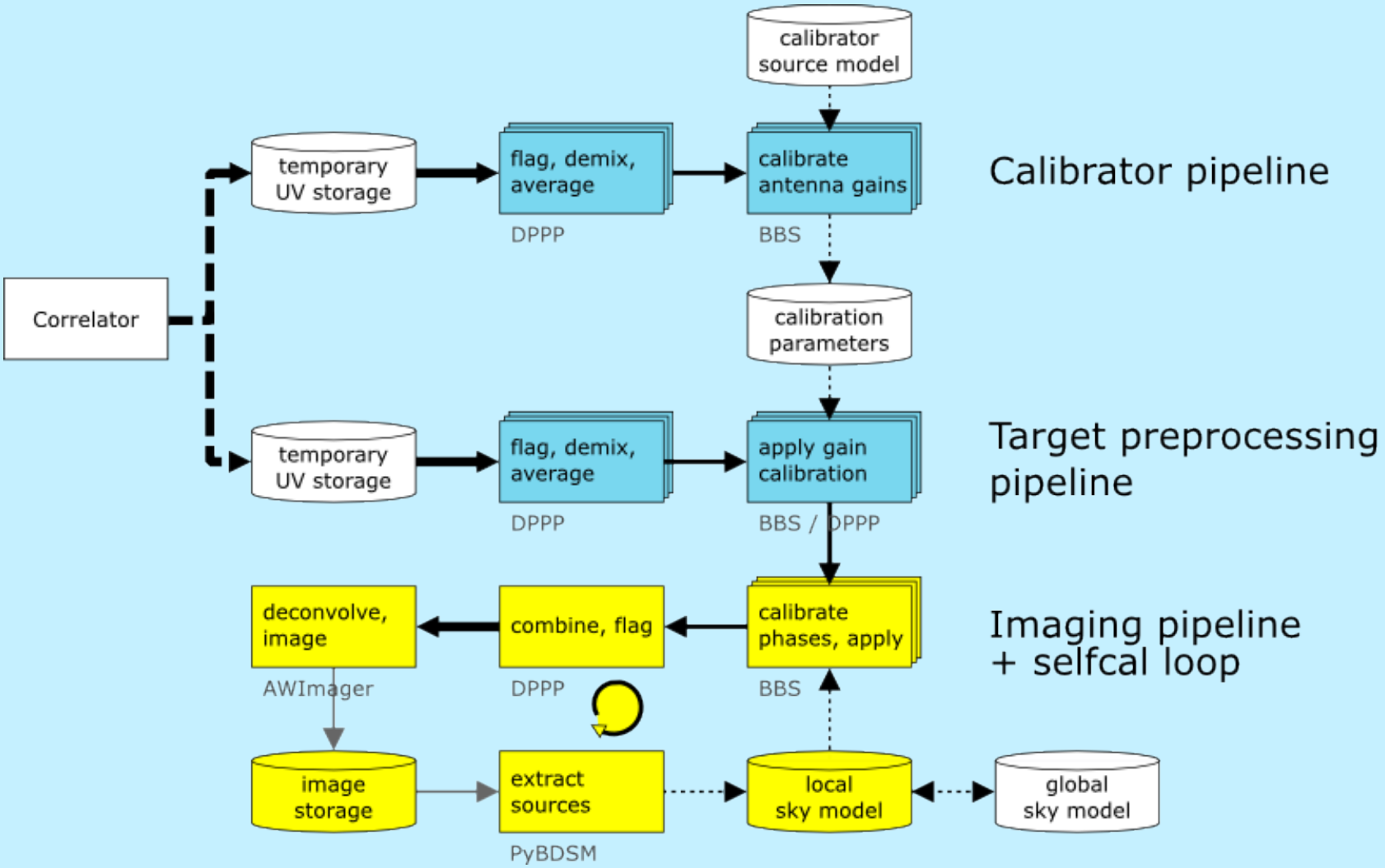
- Using TEC screen, 50% more sources are detected at 30 MHz, 30% more at 45 MHz

- Position of extracted sources is more accurate => beam FWHM 167”x133” => error on the position ~20x10” are removed thanks to phase screens.

⇒ **Conclusion**: Real improvements ! But …

⇒ **Performances**: generate TEC screen for 11 min snapshots every 10s Time computing ~ 20 hours ! Need more tests on different Data set and optimize time computing (also memory) …

Self-Calibration phase only direction independent: Overview



Self-Calibration phase only direction independent: Motivation

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- **Goal**: improve the phase solution and the final image quality using a generic tool (i.e black box tool, parameters are computed internally and automatically)

- **How to do**: Improve the Sky model as much as possible at highest possible resolution and calibrate data with this skymodel.

Self-Calibration phase only direction independent: Strategy

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- **Concept**:
    1. Using a starting sky model (VLSSr), calibrate data, image at 15 times the best resolution and extract a skymodel

    2. Calibrate with the extracted sky model and image at higher resolution that previously, extract a new skymodel.

    3. Loop this procedure until the best possible resolution of the observation (~longest baseline)

Self-Calibration phase only direction independent: Strategy

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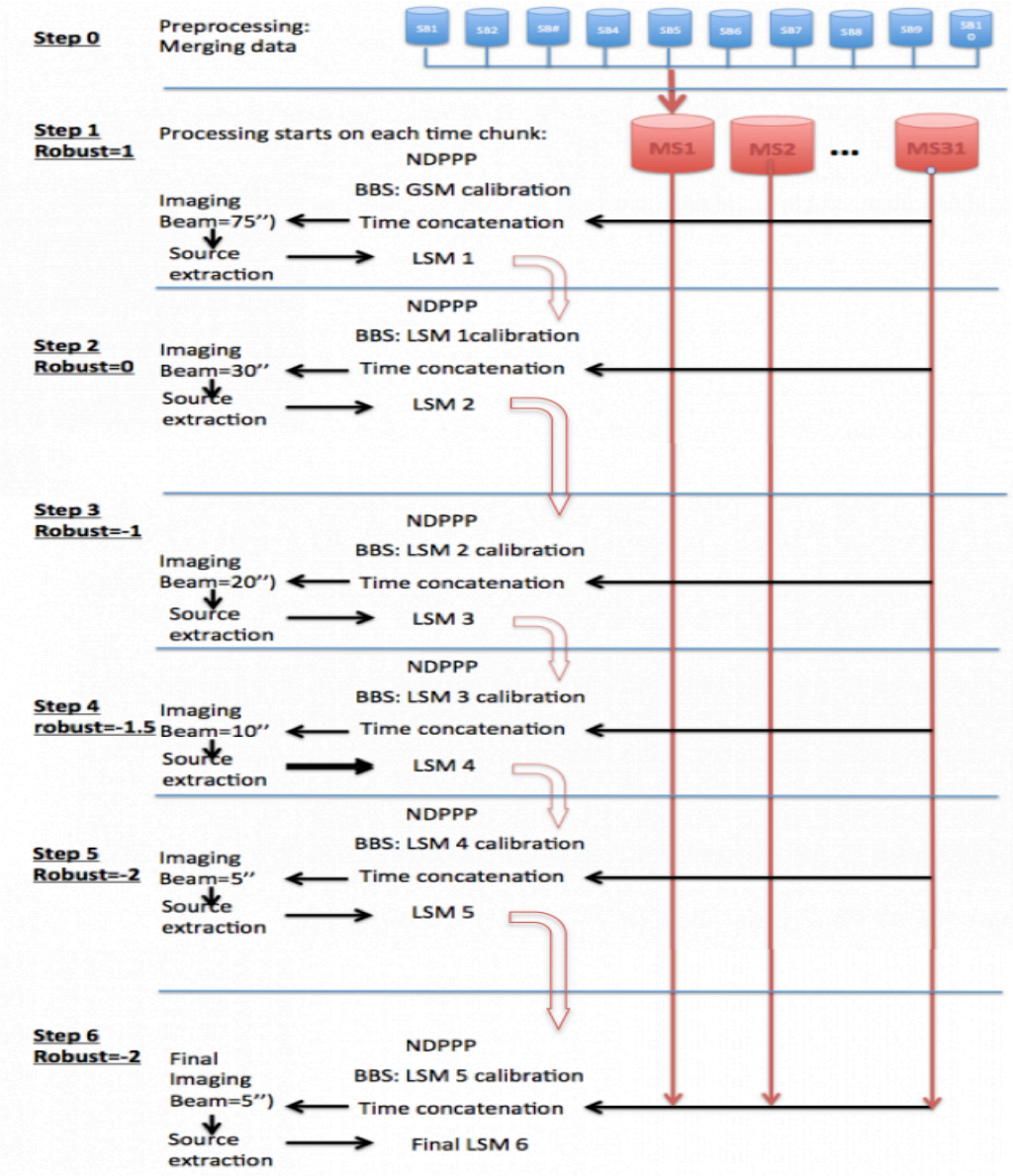
- **Consequences: A generic tool**

Increasing resolution implies to compute internally:

  - Image size at each cycle (nof pixel and pixel size)
  - UVmax and wmax cut at each cycle
  - Image threshold cleaning at each cycle
  - Robust parameter at each cycle (1 to -2)

Self-Calibration phase only direction independent: Example: scheme of selfcal



Self-Calibration phase only direction independent: Results on HBA data (~140 MHz)

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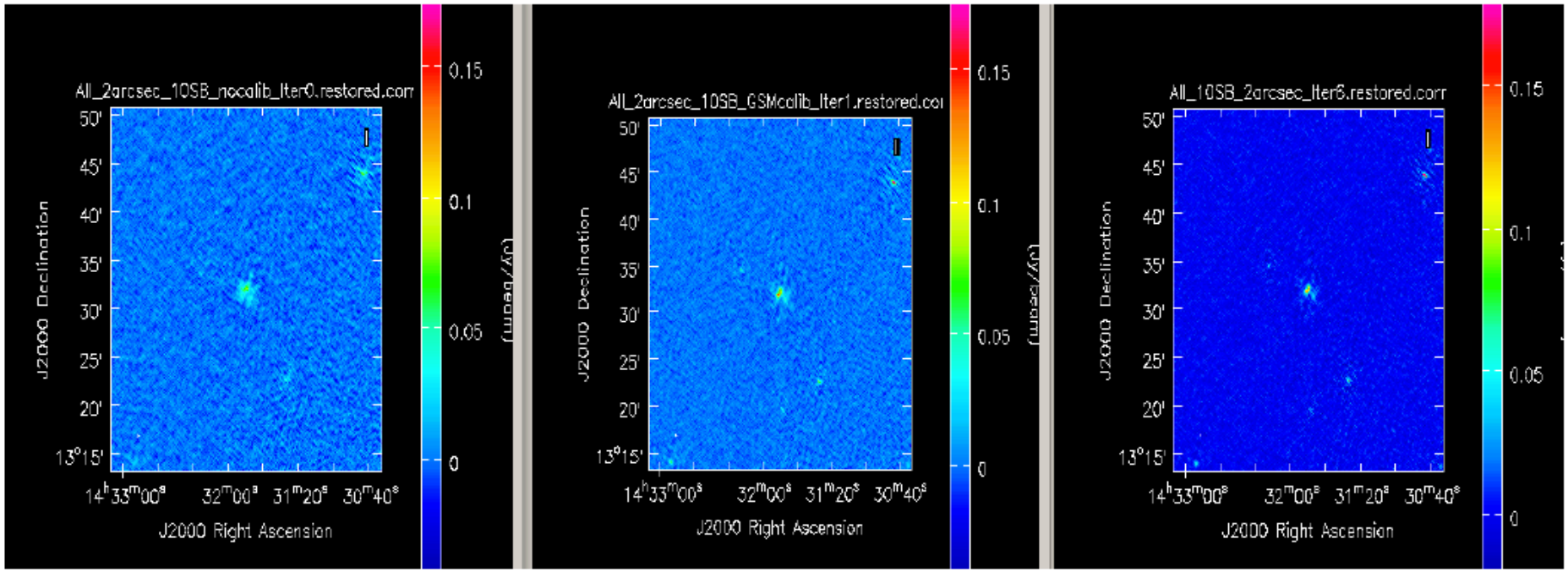
No phase Calibration | GSM Calibration | Self-Calibration



Rms~30mJy Rms~10mJy Rms~2mJy

Thermal noise ~ 0.7 mJy

Self-Calibration phase only direction independent: Results on High HBA data (~200 MHz)

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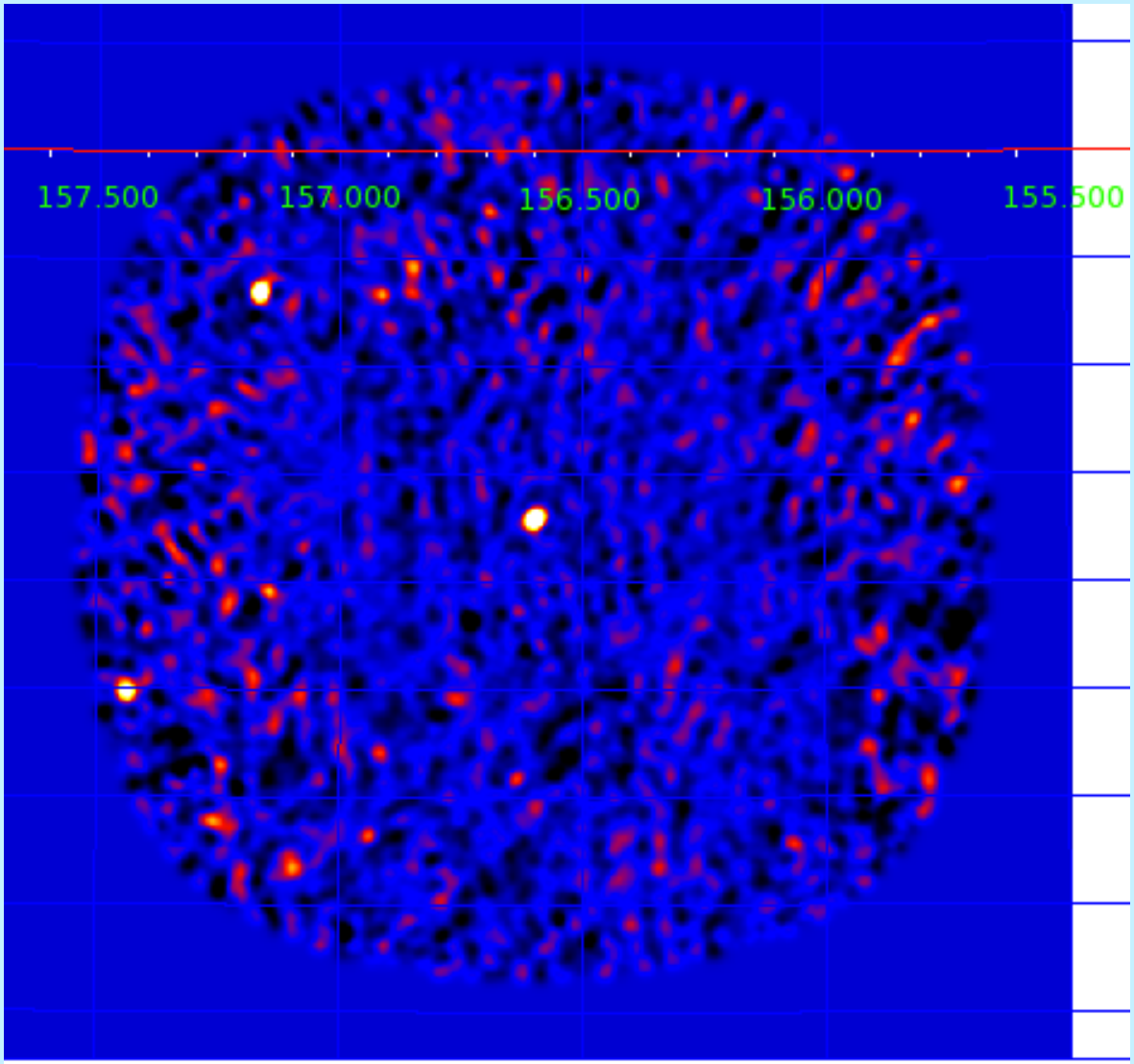
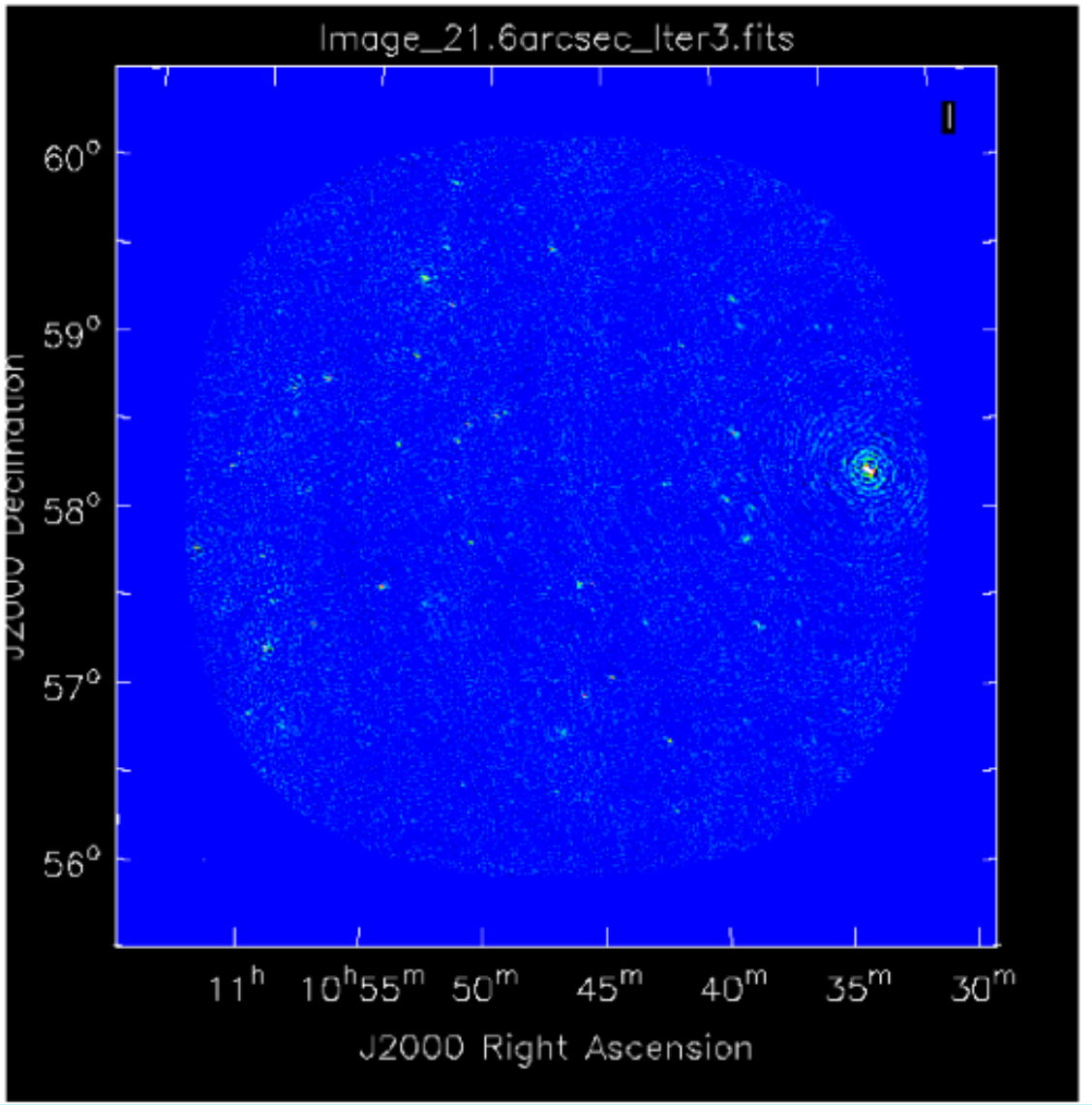


At 200 MHz,
The fov is tight:
2° instead 5°
at lower
frequency

credits: Raymond Oonk

Self-Calibration phase only direction independent: Results on LBA data (~60 MHz)



At 60 MHz,
Maximum useful
Baseline ~20km
Beam ~ 50”

Higher baselines,
Ionospheric
effects dominates !

credits: Ilse Bemmel

Self-Calibration phase only direction independent: Perspectives

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- Selfcal works on each LOFAR frequency bands
- Finish to validate the method:
  - Using mask and calibrate with dot model
    - Important time computing increase and memory consuption … need a compromise
- Final implementation in the imaging pipeline
- Implement direction dependant calibration (TEC screens)