



Max-Planck-Institut
für
Radioastronomie

Lessons for SKA from LOFAR

Andreas Horneffer

(this time not speaking for anybody else)

- Digital radio interferometer for the frequency range of 10 - 270 MHz
- Array of 38+ Dutch and 8+ international stations of 48 to 96 simple antennas
- Low-Band antennas 10 – 90 MHz
- High-Band antennas 110 – 270 MHz
- Benefit from advance in computer technology
- “Do all the complicated stuff in digital computers”
→ “Software Telescope”



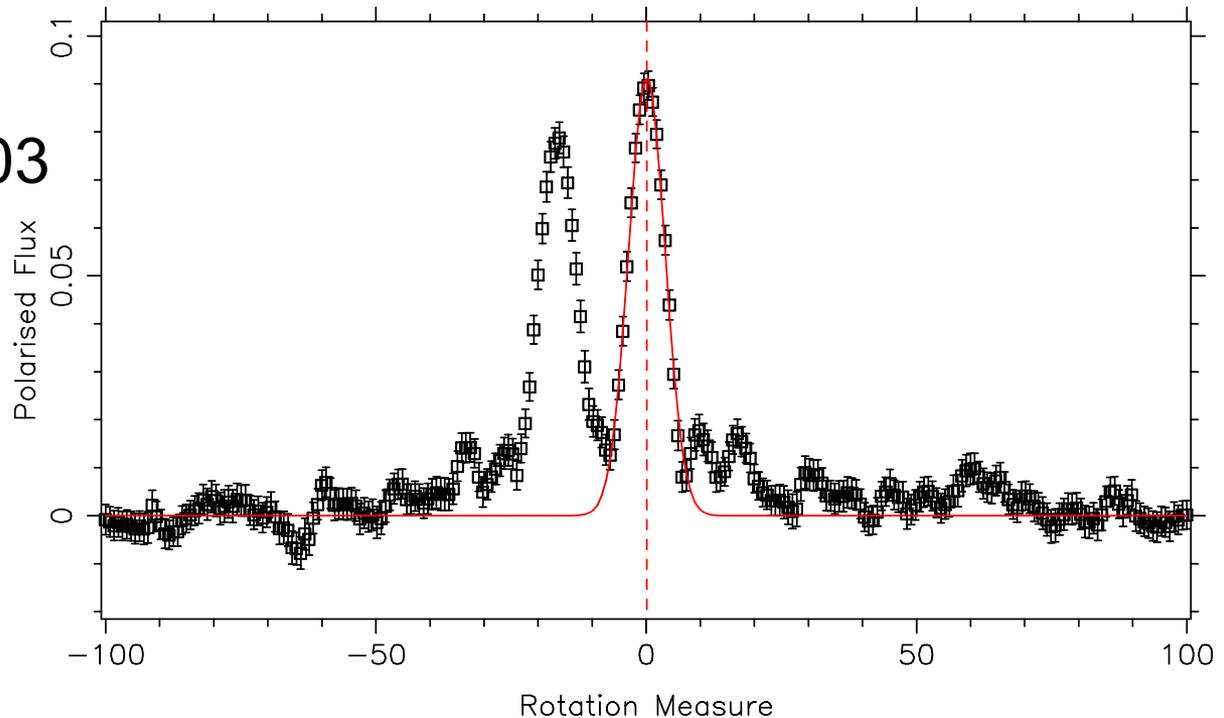
Calibration Challenges

- LOFAR has:
 - large field-of-view
 - direction (=time) and frequency variable station beams
 - linear feeds

- Thus we need:
 - good model of the polarization behavior of the feeds
 - good station beam model
 - direction dependent calibration

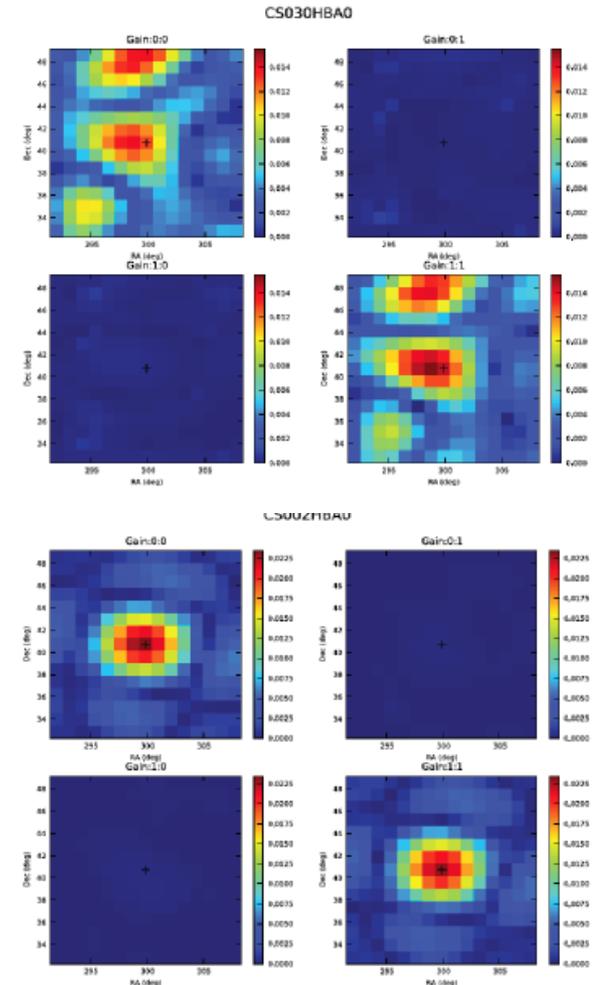
- Linear feeds lead to strong instrumental polarization.
- We haven't really solved the issue yet, but can deal with it through Faraday synthesis and RM-clean

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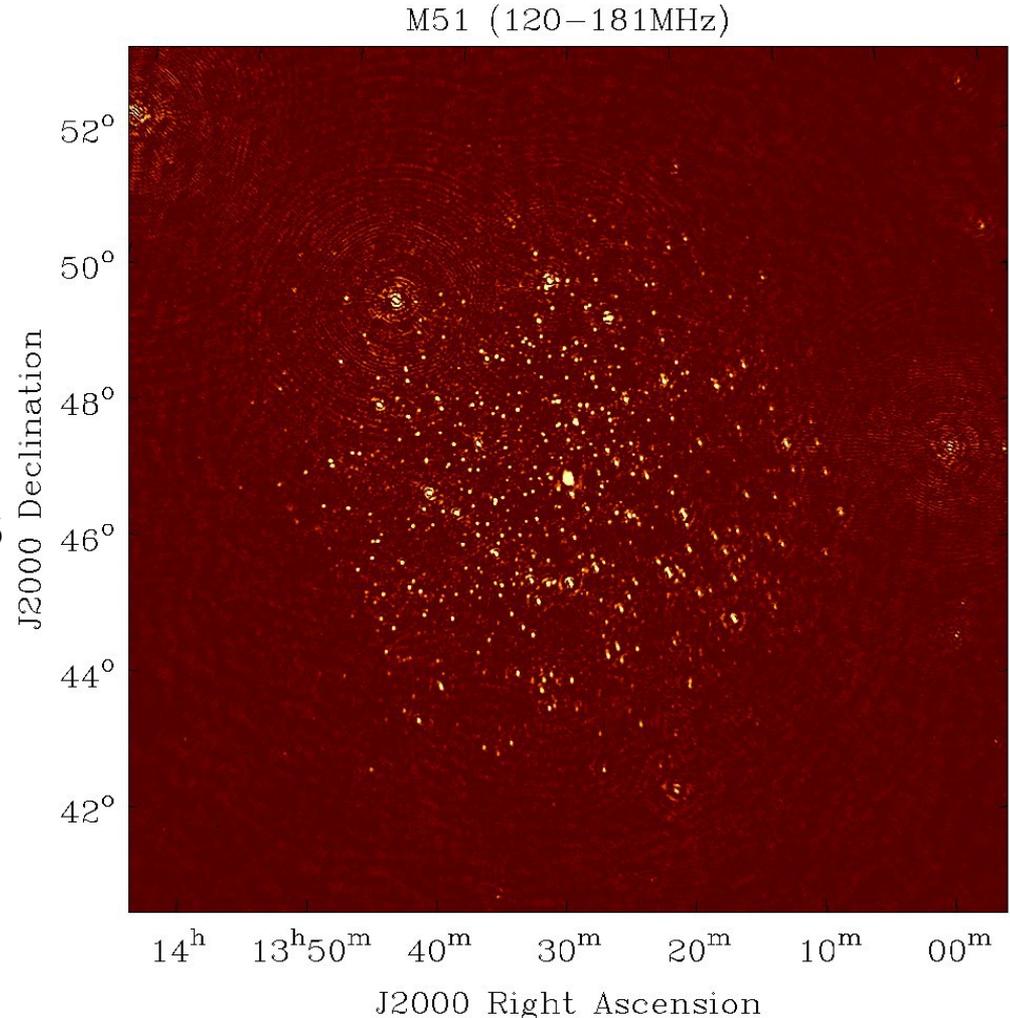


C. Sobey

- Need a good model of the station beam for:
 - prediction (subtraction) of sources (far) away from the field
 - prediction (subtraction) of sources within the field during calibration and imaging
- The effect of a bad beam (model) is lots of noise in the image where you don't know where it came from.
- This requires:
 - precise timing in the hardware
 - good station calibration (timing and position)
 - exact metadata in the datasets

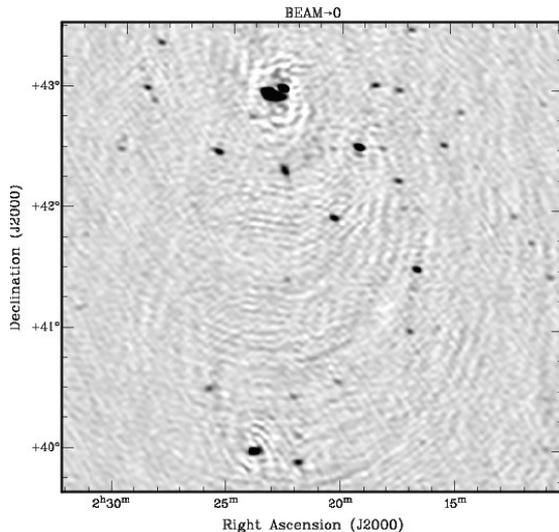


- Time and direction variable phase screen leads to artifacts
- These are the major noise contribution in typical LOFAR images
- Currently two ways to deal with that:
 - peeling
 - fitting a phase screen

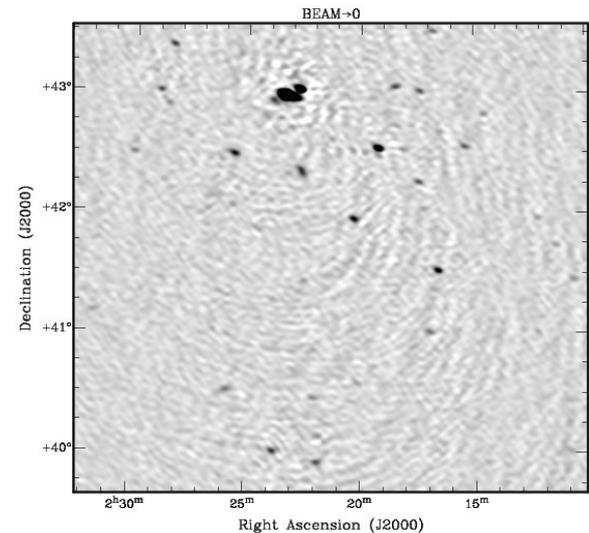


- Solve for different calibration values for different directions, then subtract the sources you are not interested in.
- Problem: sources/flux that is not in your model may be assigned to subtracted sources.

without
peeling

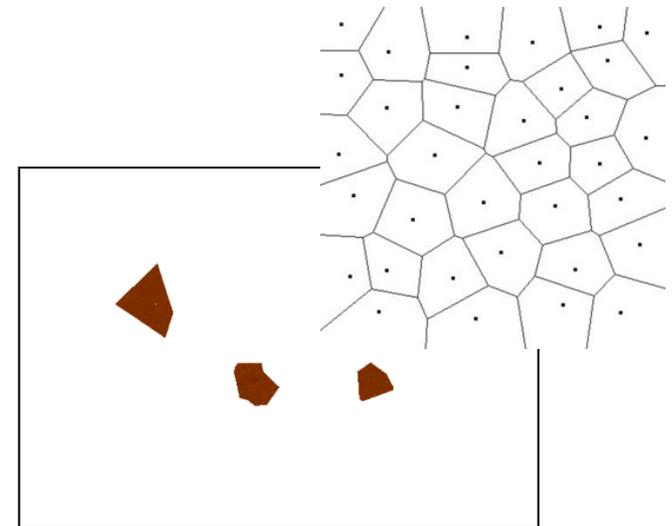
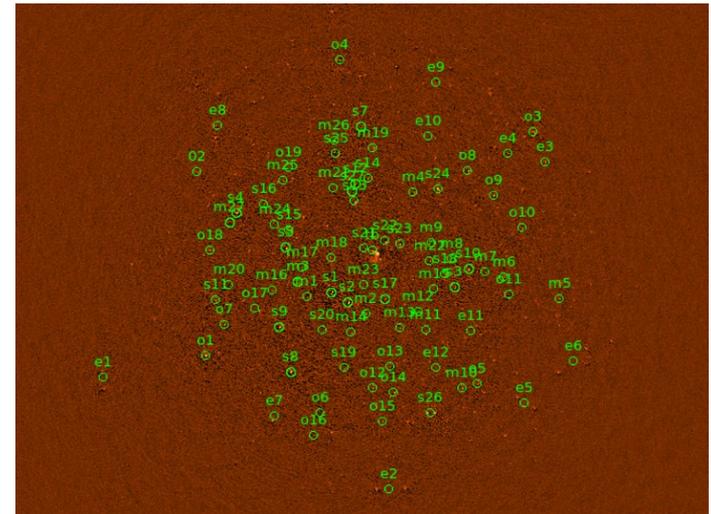


3C65
peeled

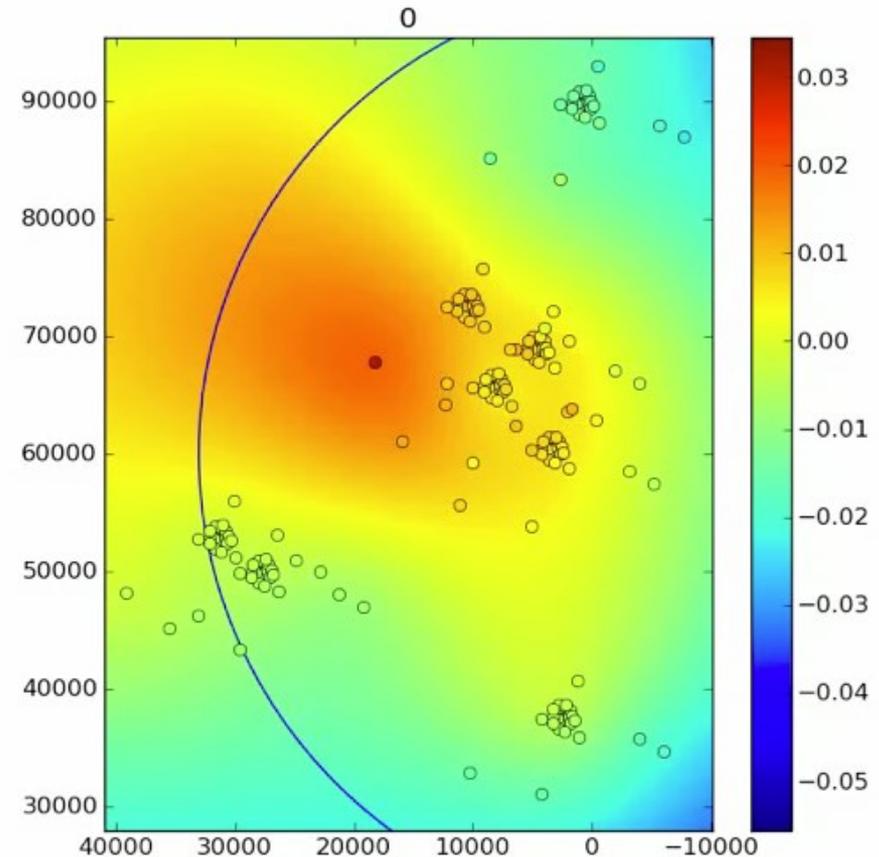




- Don't just solve for a few directions, solve for many (100 directions or so)
- Two ways:
 - “brute force” (sagecal)
 - iterating through calibrator sources
- “Missing flux” problem in first approach
- Huge effort (computing and manpower) needed for second.



- Assume a single phase screen between the telescope and the sky (the ionosphere)
- Solve for phase delay from different stations into different directions
- Apply phase screen by subtracting sources or during imaging



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- Polarization measurements with linear feeds need good understanding or calibration of the elements
 - All direction dependent calibration methods have in common:
 - they solve for many directions
 - limited by signal to noise for the directions
 - need lots of computing time
 - don't **really** work yet
 - More on that in the talk by B. Adebahr

Take Home Messages

- Any effort spend early to understand the instrument is well spent.
- Use circular feeds? Also for SKA-low?
- Half the work is in software and computing.
 - So start early. As hard as it is.
- The figure-of-merit for surveys
$$\text{FOV} * \text{sensitivity}$$
is only valid if you can calibrate the FOV.
- Don't expect to be done once the hardware is in the field. (That's when the fun part starts.)