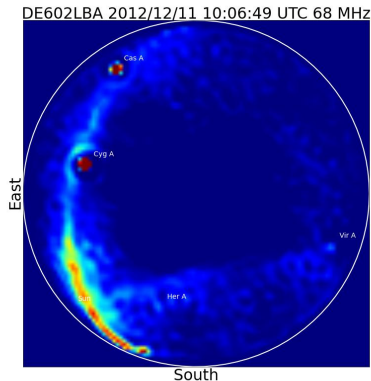


Aperture holography

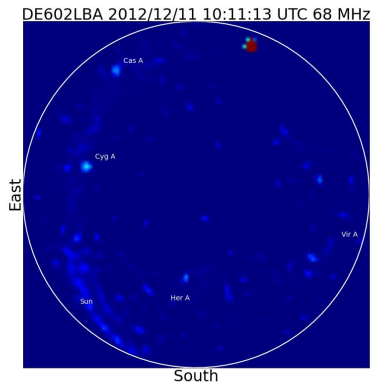
M.A. Brentjens and D. Bordenave

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ASTRON, Dwingeloo, The Netherlands
&
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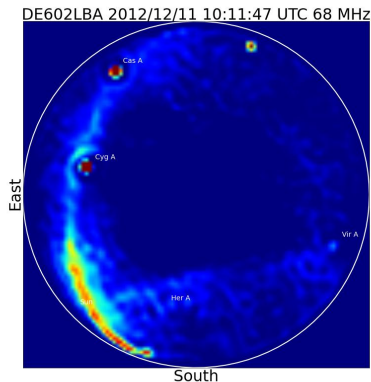
LOFAR status meeting 2015-09-16



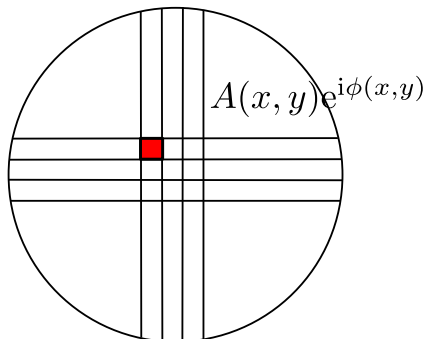
- All-sky imaging/calibration
- Multi-source sky model
- Sensitive to local RFI
- Must average over model errors (24h)
- Expensive data reduction



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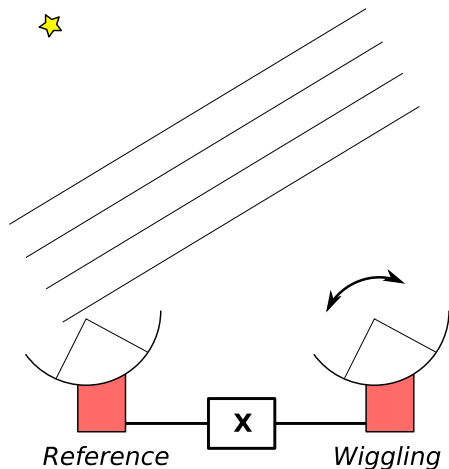
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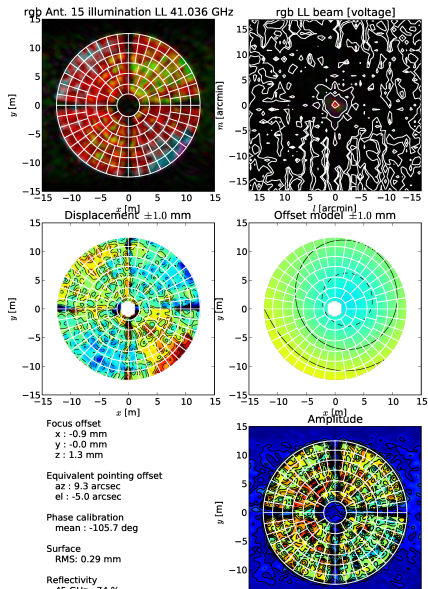
- Each element reflects radiation to focus
- All paths same length
- Add in phase at focus

$$G(l, m) = \int_{xy} a(x, y) e^{2\pi i(xl + ym)\nu/c}$$

$$a(x, y) = A(x, y) e^{i\phi(x, y)}$$



- Measure voltage beam pattern
- Dishes: scan target dish across cal source
- Dishes: correlate with reference station pointing at cal source
- Aperture arrays: use simultaneous multi-beaming
- Fourier transform voltage beam: aperture map!



- Extreme precision
- “Big” distortion on lower right side
- Distortion can be removed by moving panels
- Moving panels = station calibration

- Only calibrates *digital* beam former gains
- Two station sets: target & reference
- Reference: point at source
- Target: multi-beam at and around source (436 beams)
- Swap target and reference sets & repeat
- Select next sub band & repeat
- LBA: 2 min scans, HBA: 30 sec scans

Calibration

$$\mathbf{V}_c = \mathbf{J}_{ic} \mathbf{E}_{ij} \mathbf{J}_{jc}^\dagger$$

$$\mathbf{V}_k = \mathbf{J}_{ik} \mathbf{E}_{ij} \mathbf{J}_{jc}^\dagger$$

$$\tilde{\mathbf{V}}_k = \mathbf{V}_k \mathbf{V}_c^{-1}$$

$$\tilde{\mathbf{V}}_k = \mathbf{J}_{ik} \mathbf{E}_{ij} \mathbf{J}_{jc}^\dagger \left(\mathbf{J}_{ic} \mathbf{E}_{ij} \mathbf{J}_{jc}^\dagger \right)^{-1}$$

$$\tilde{\mathbf{V}}_k = \mathbf{J}_{ik} \mathbf{E}_{ij} \mathbf{J}_{jc}^\dagger \mathbf{J}_{jc}^{-1} \mathbf{E}_{ij}^{-1} \mathbf{J}_{ic}^{-1}$$

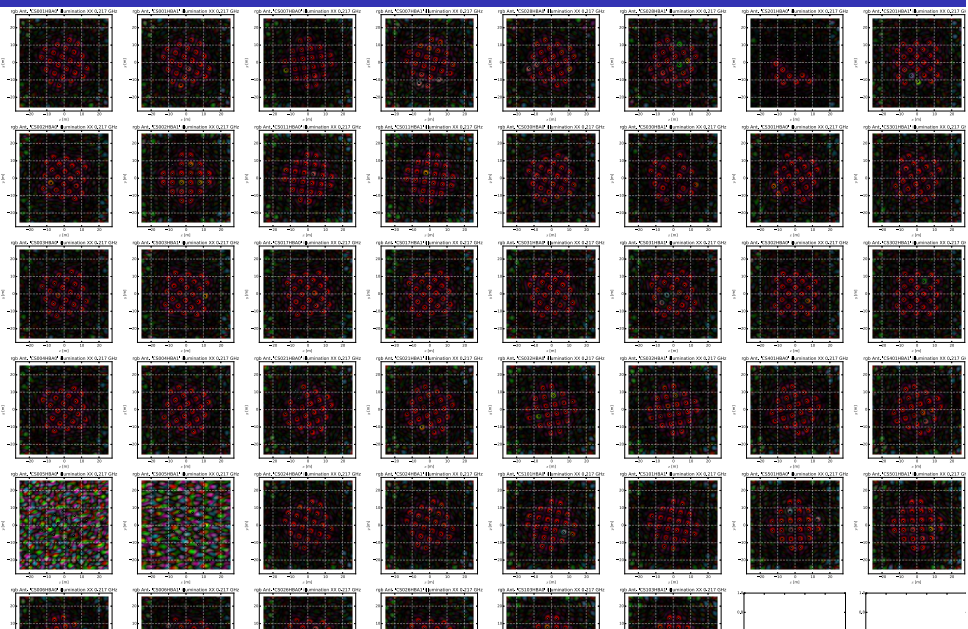
$$\tilde{\mathbf{V}}_k = \mathbf{J}_{ik} \mathbf{J}_{ic}^{-1}$$

Gain fitting

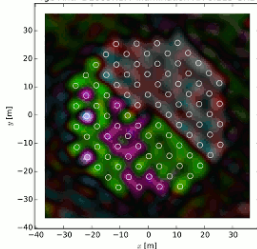
- Average per reference station (and determine σ_m)
- Weighted avg over reference stations
-

$$\mathbf{WB} = \mathbf{WFa}$$

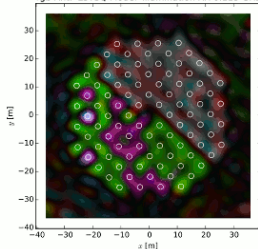
- Simple weighted linear problem
- Allows determination of (co)variances of parameters



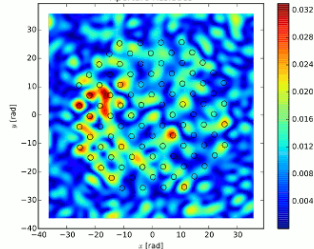
rgb Ant. 'DE609HBA' illumination XX 0.115 GHz



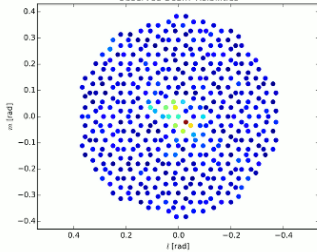
rgb Ant. 'LSTSQ Model' illumination XX 0.115 GHz



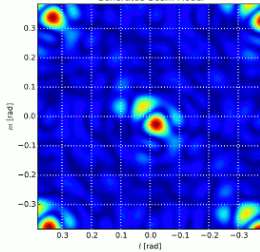
Aperture Residues



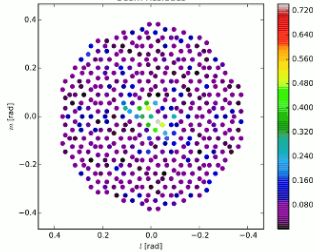
Observed Beam Visibilities



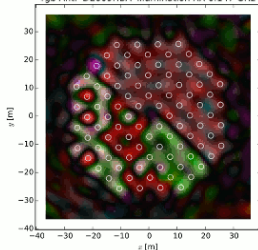
Generated Beam Model



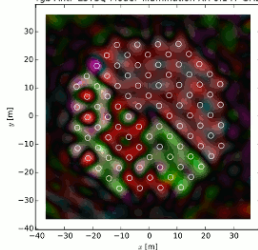
Beam Residues



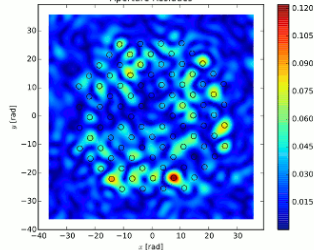
rgb Ant. 'DE609HBA' illumination XX 0.147 GHz



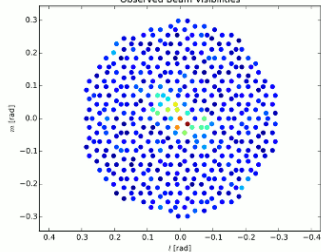
rgb Ant. 'LST5Q Model' illumination XX 0.147 GHz



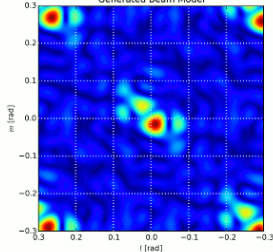
Aperture Residues



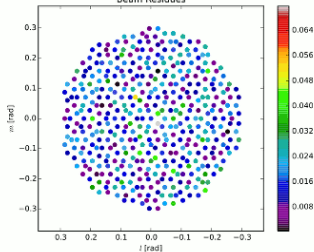
Observed Beam Visibilities



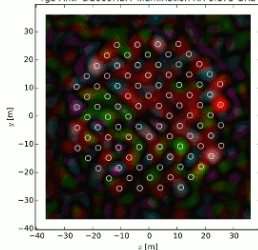
Generated Beam Model



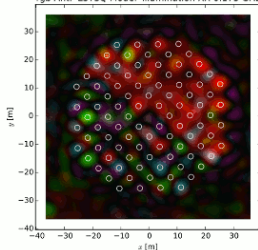
Beam Residues



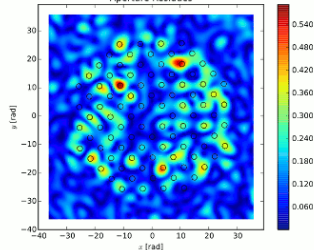
rgb Ant. 'DE609HBA' illumination XX 0.173 GHz



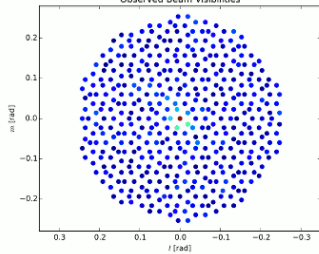
rgb Ant. 'LSTSQ Model' illumination XX 0.173 GHz



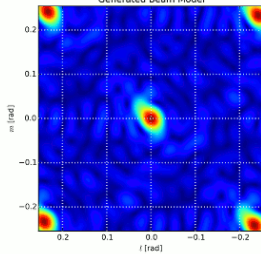
Aperture Residues



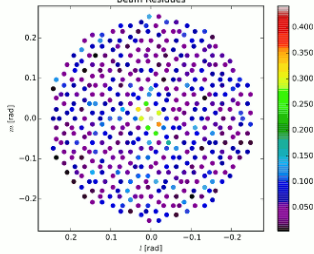
Observed Beam Visibilities



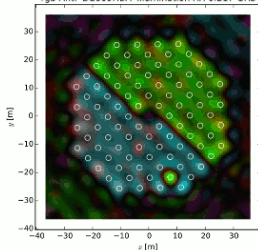
Generated Beam Model



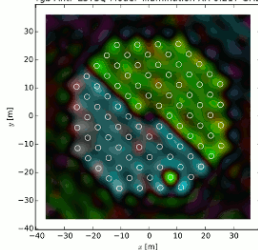
Beam Residues



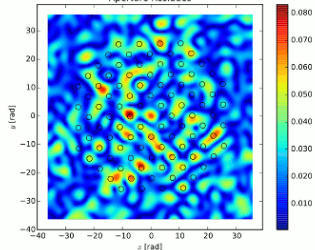
rgb Ant. 'DE609HBA' illumination XX 0.217 GHz



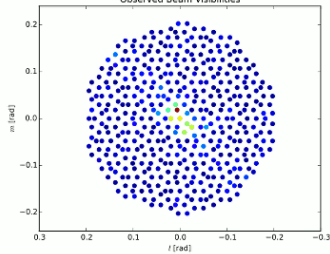
rgb Ant. 'LST5Q Model' illumination XX 0.217 GHz



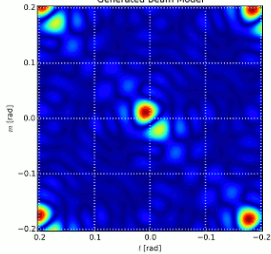
Aperture Residues



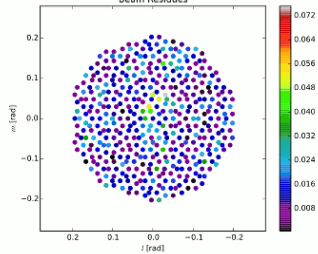
Observed Beam Visibilities



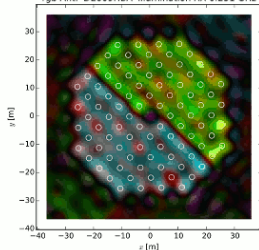
Generated Beam Model



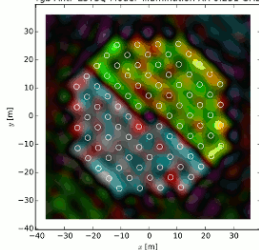
Beam Residues



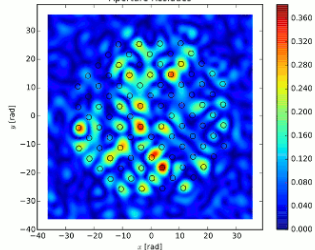
rgb Ant. 'DE609HBA' illumination XX 0.231 GHz



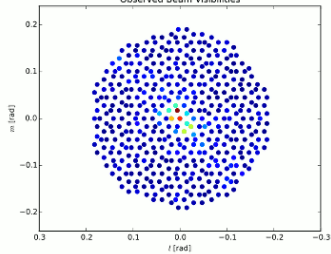
rgb Ant. 'LST5Q Model' illumination XX 0.231 GHz



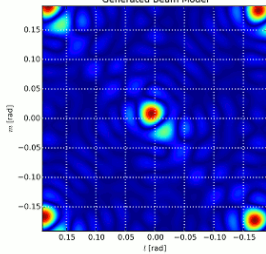
Aperture Residues



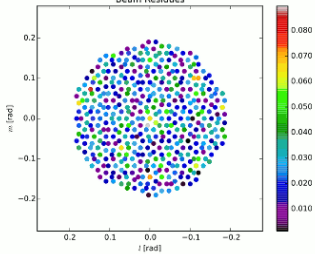
Observed Beam Visibilities



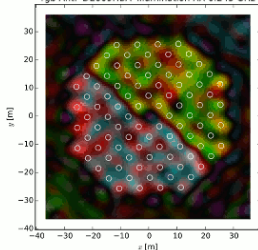
Generated Beam Model



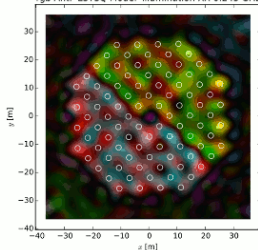
Beam Residues



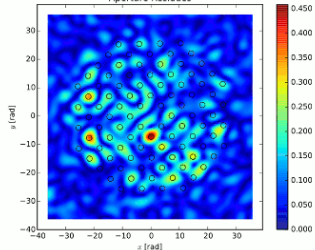
rgb Ant. 'DE609HBA' illumination XX 0.245 GHz



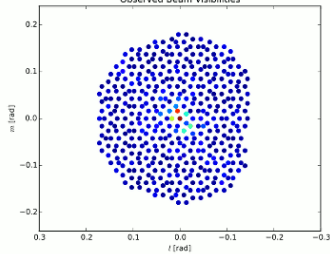
rgb Ant. 'LST5Q Model' illumination XX 0.245 GHz



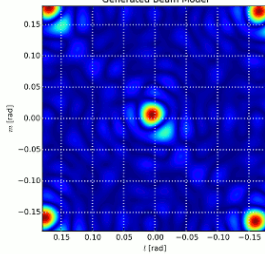
Aperture Residues



Observed Beam Visibilities



Generated Beam Model



Beam Residues

