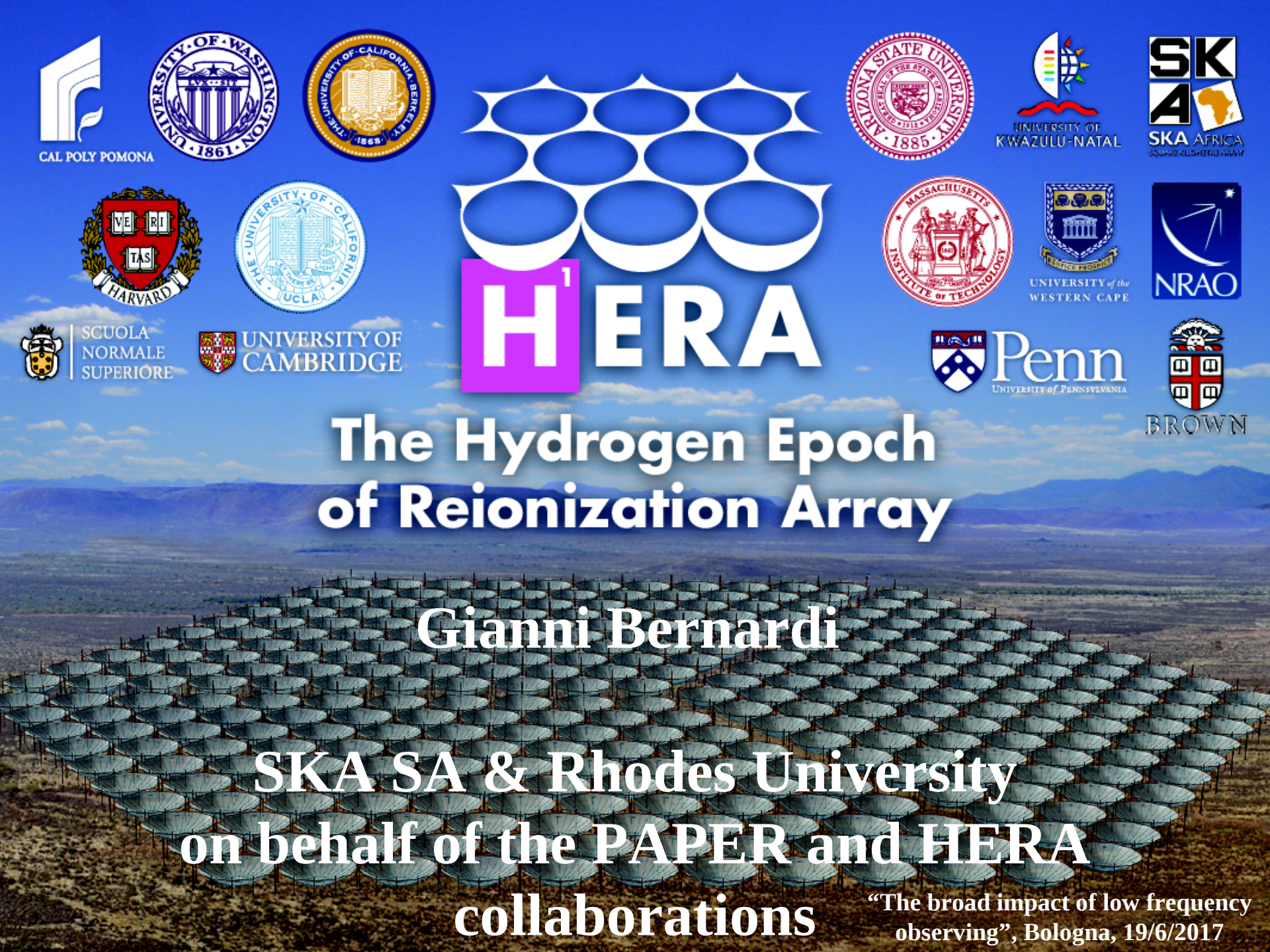


**Gianni Bernardi**

**SKA SA & Rhodes University**

**on behalf of the PAPER and HERA collaborations**

**"The broad impact of low frequency observing", Bologna, 19/6/2017**

# Before HERA: measuring the EoR with the Precision Array to Probe the Epoch of Reionization (PAPER)

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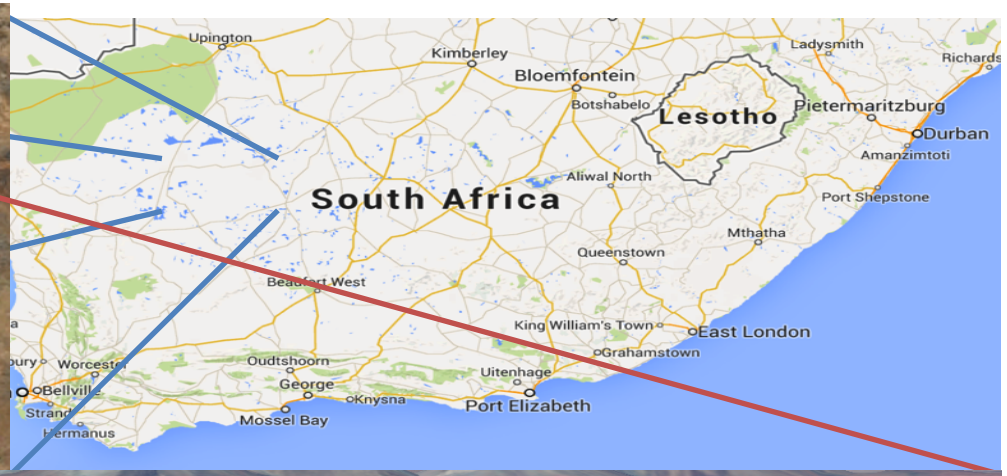
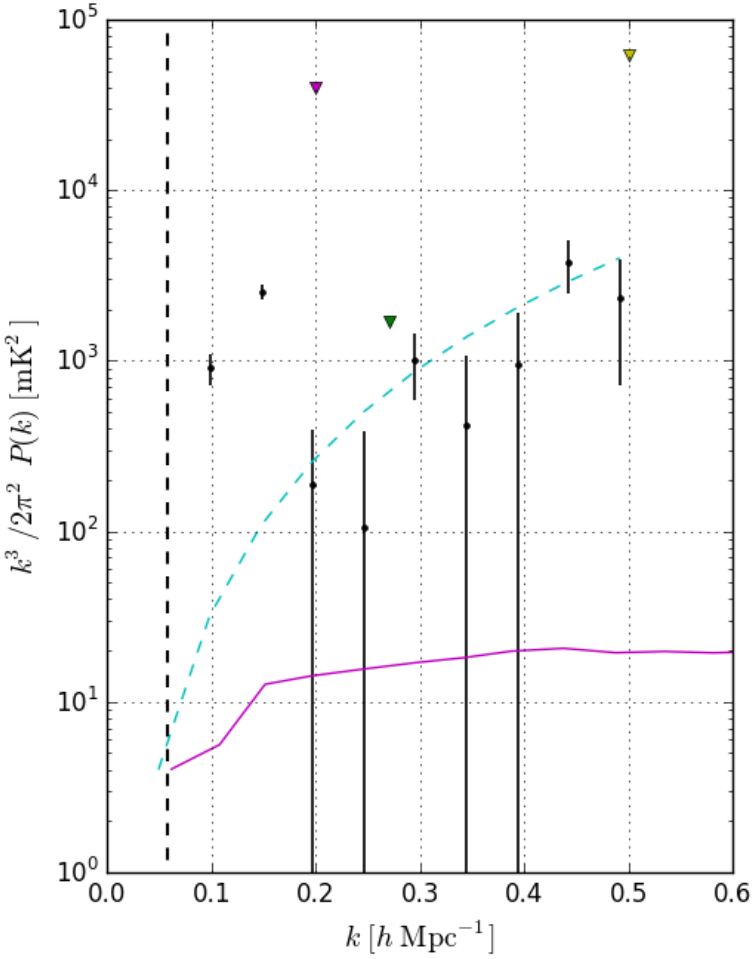


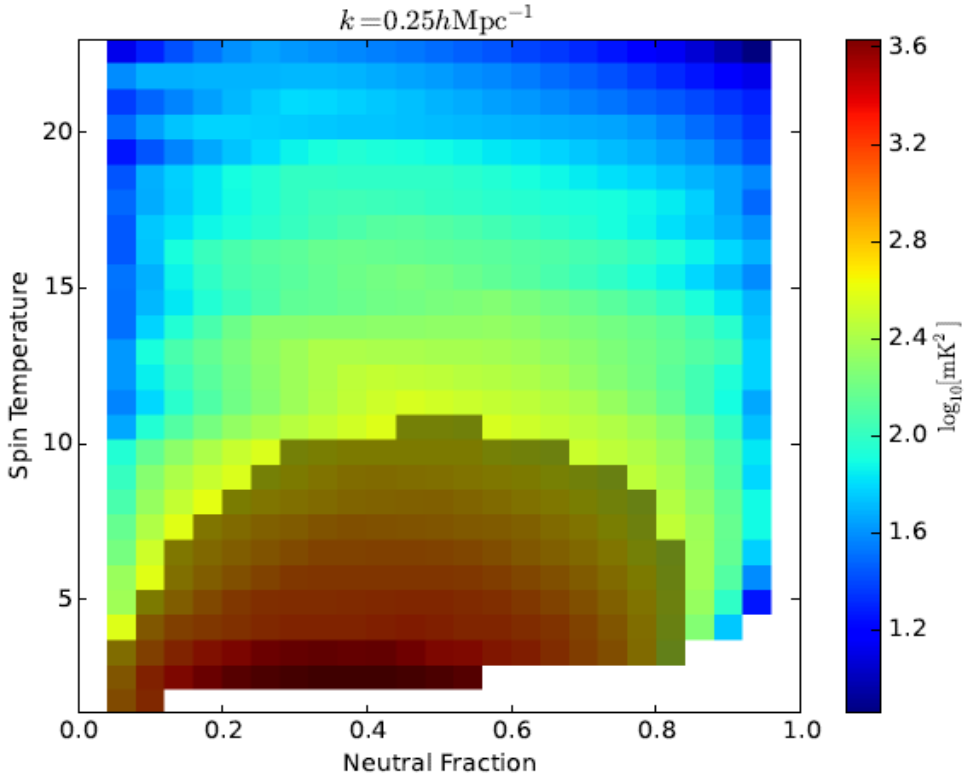

# Before HERA: measuring the EoR with the Precision Array to Probe the Epoch of Reionization (PAPER)


- Dual-polarization sleeved dipoles;
- 100-200 MHz;
- Staged deployment:
  - 32 dipoles (redundant and non redundant);
  - 64 dipoles (redundant);
  - 128 dipoles (redundant with outriggers)

# PAPER-32 and PAPER-64 results: evidence for heated IGM @ z > 8

## (Parsons et al. 2014, Jacobs et al. 2015, Ali et al. 2015, Pober et al. 2015)



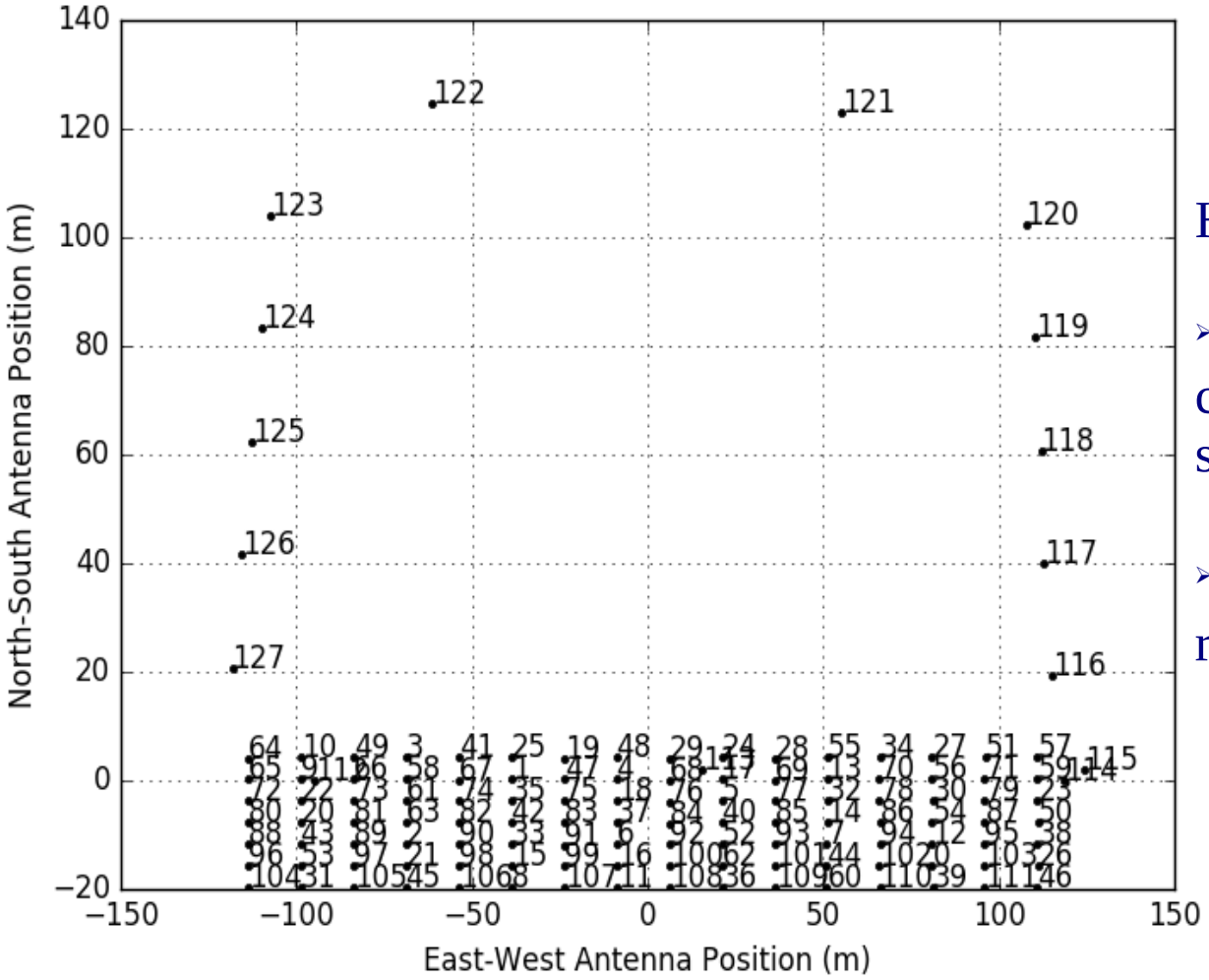




$$\delta T_b \propto 27 x_{HI}(1+\delta)\left(1-\frac{T_\gamma}{T_s}\right)\ \mathrm{mK}$$

$T_s = T_k > 10$ K @ z = 8.4 for $15\% < x_{HI} < 80\%$

Unheated IGM: $T_k \sim 1$ K @ z = 8.4

# PAPER-128 (final) results upcoming (work in progress):




Hybrid configuration:

- highly redundant configuration for power spectrum;
- outriggers for improved resolution and uv coverage

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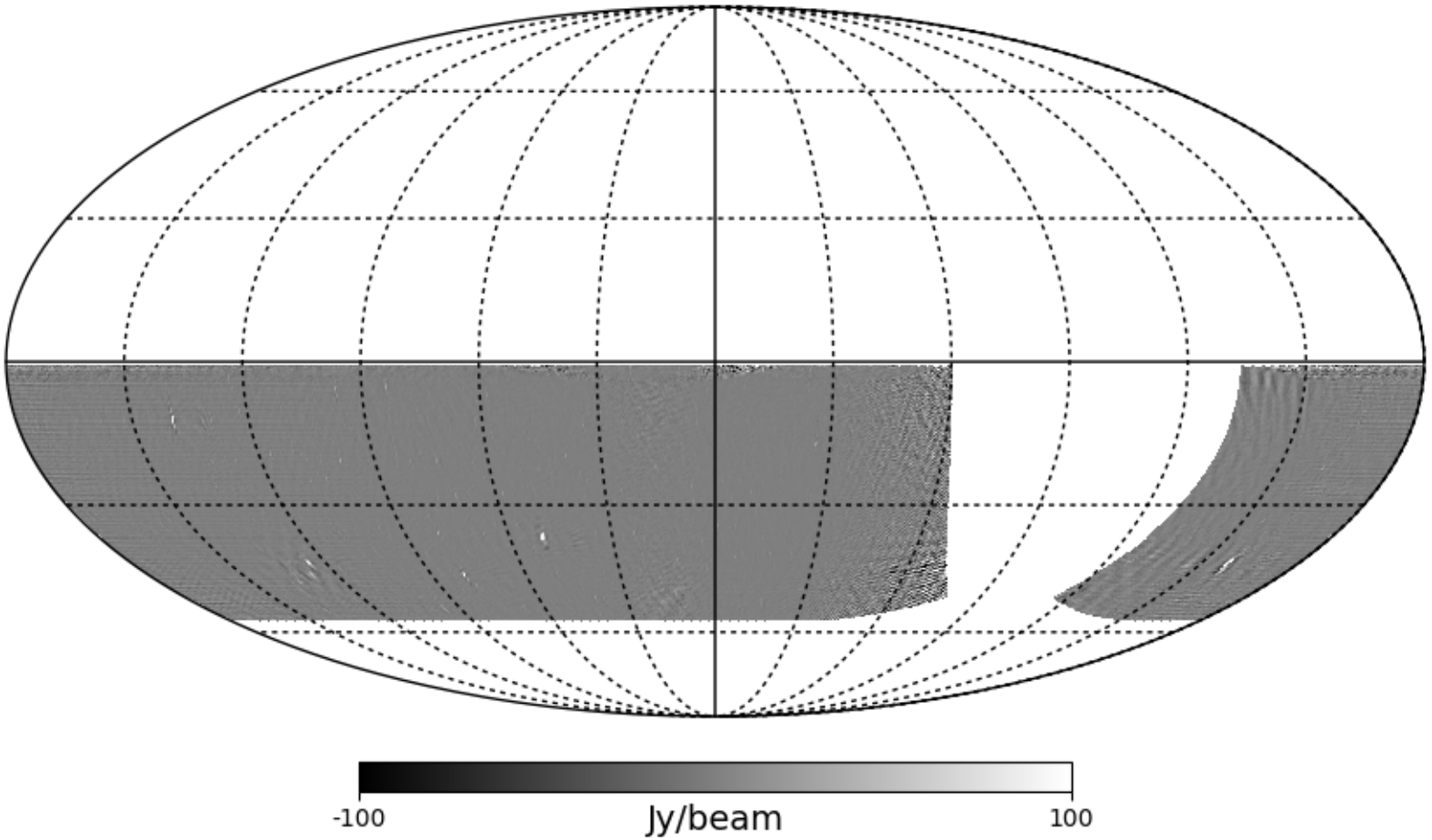

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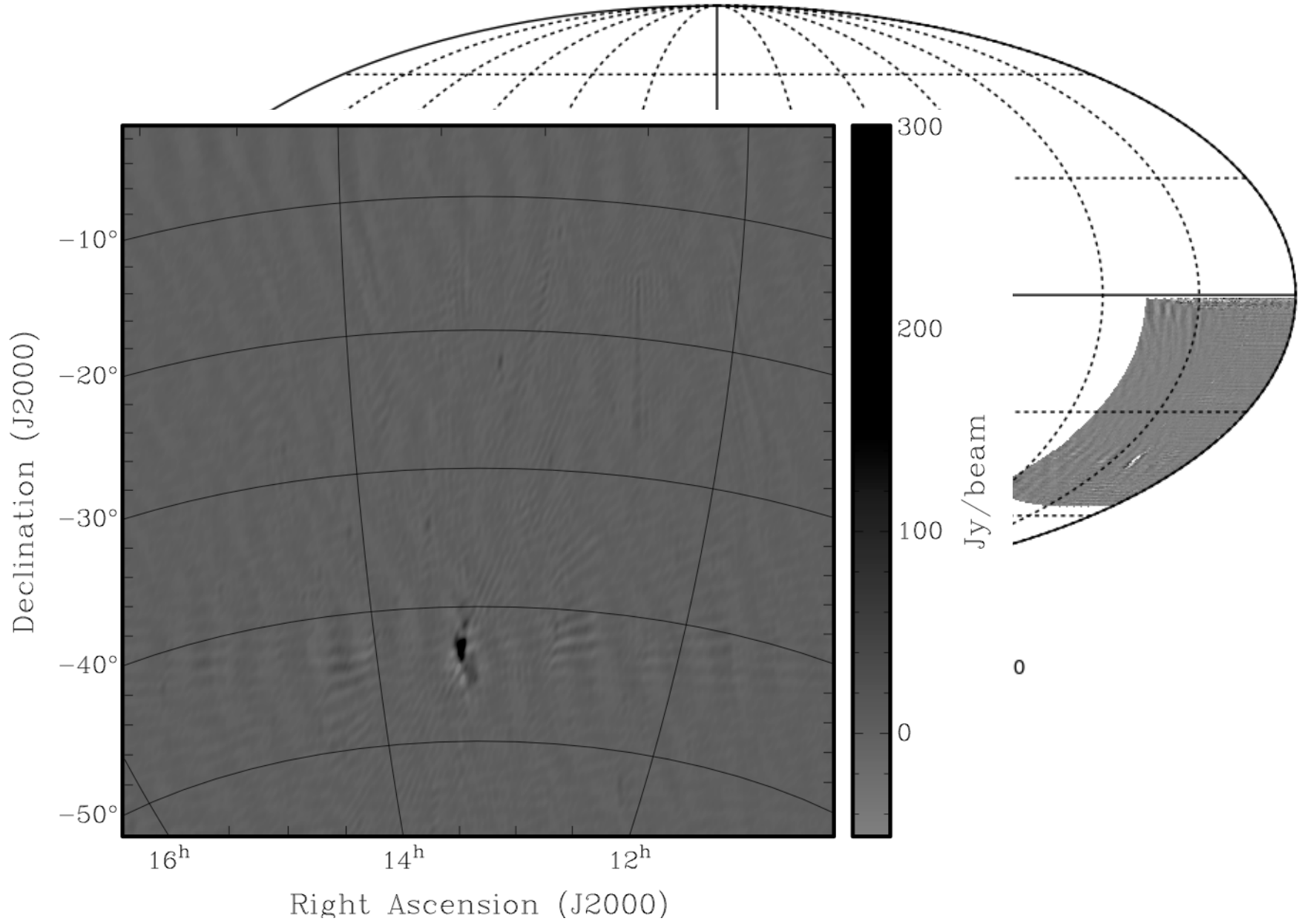

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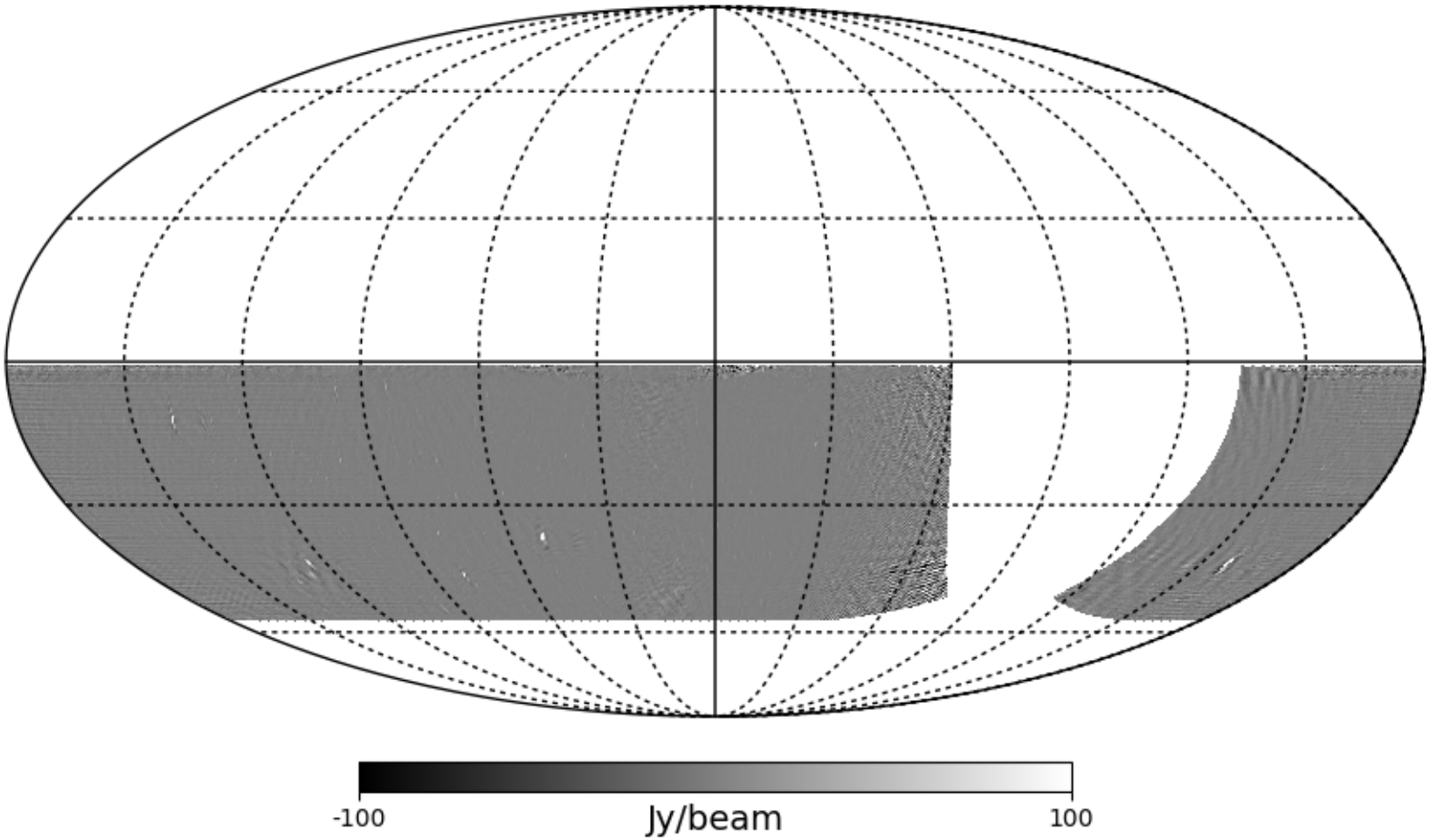

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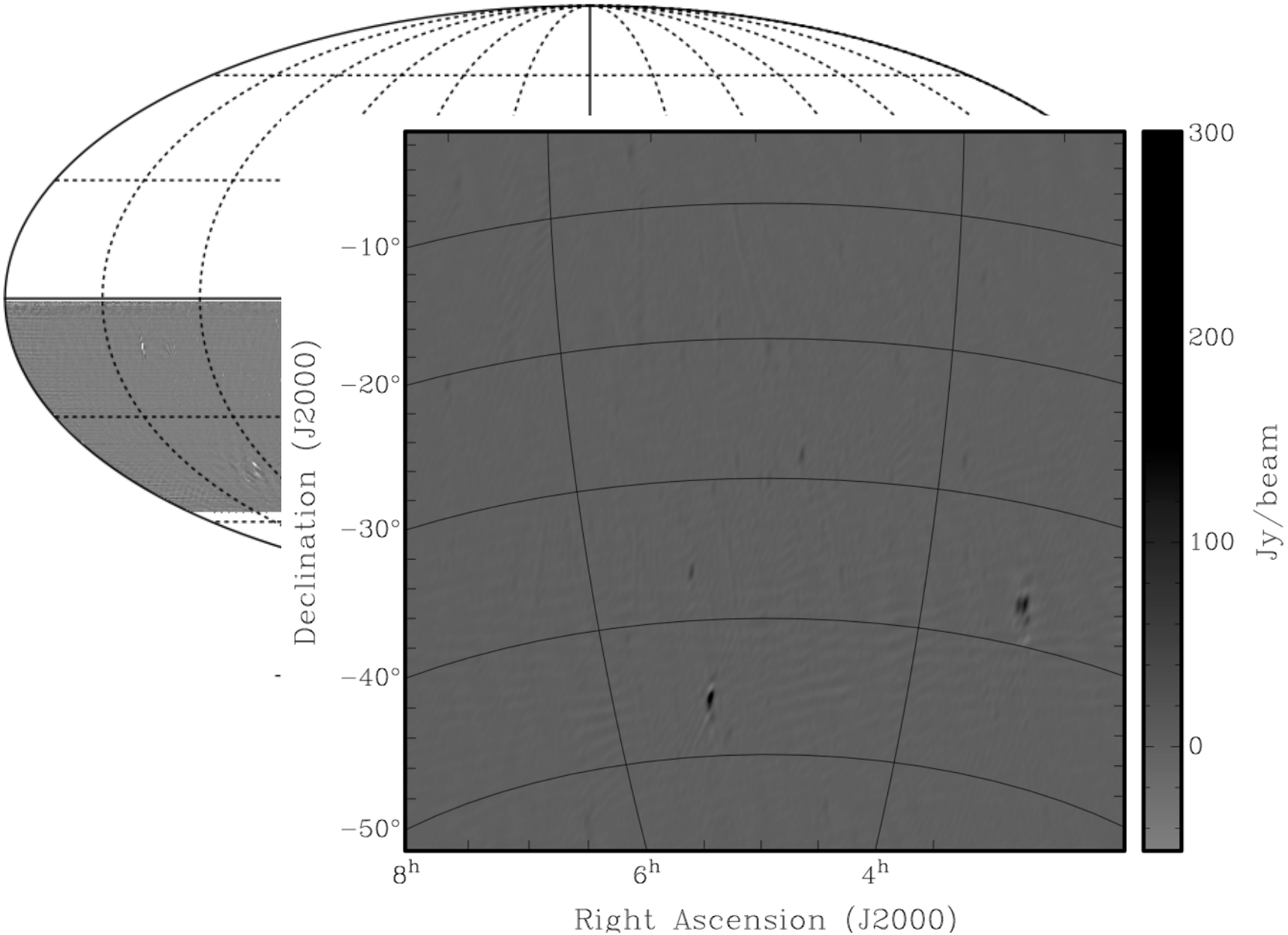

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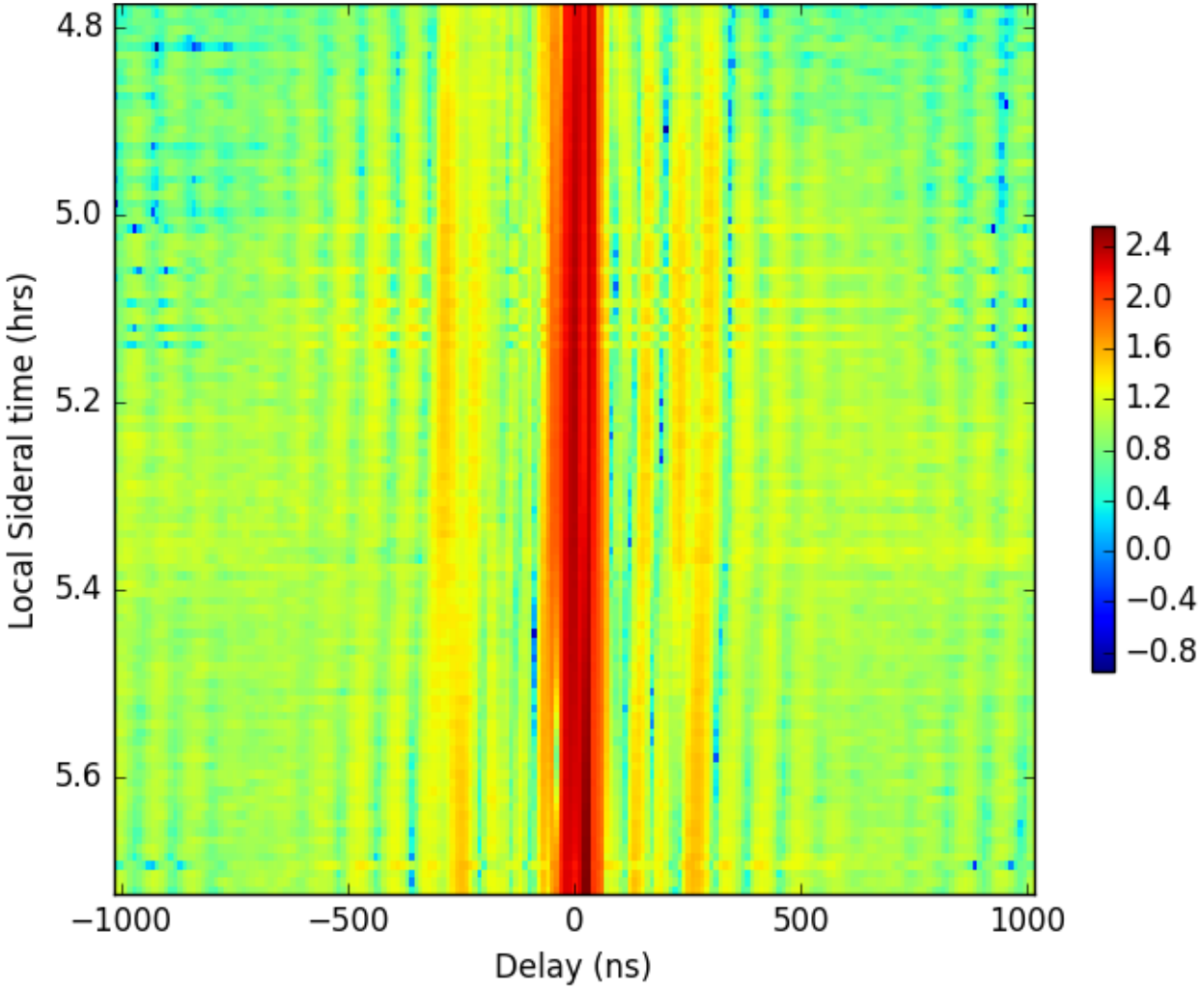


Example of delay transformed visibilities for a 15 m baseline integrated over 20 days

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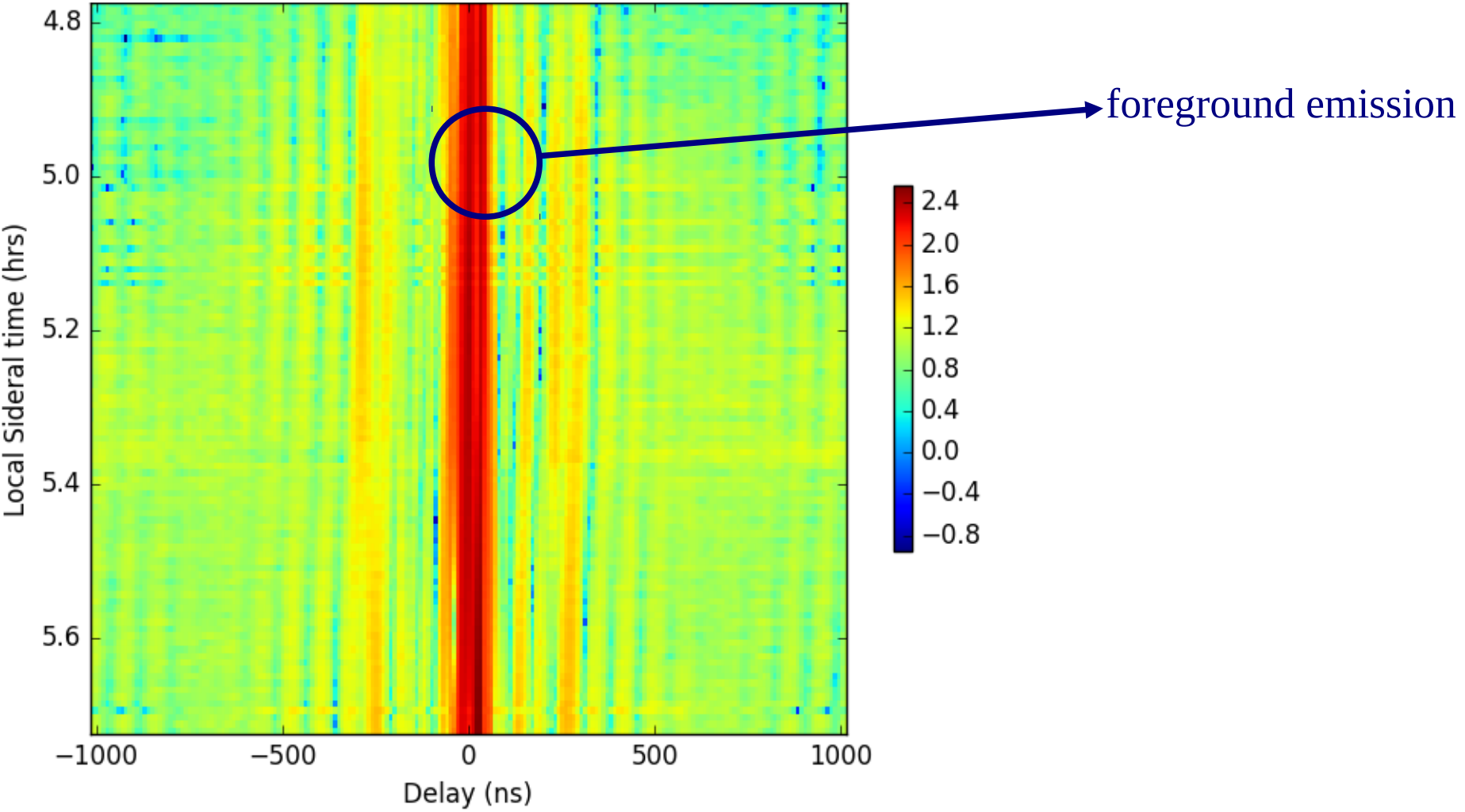


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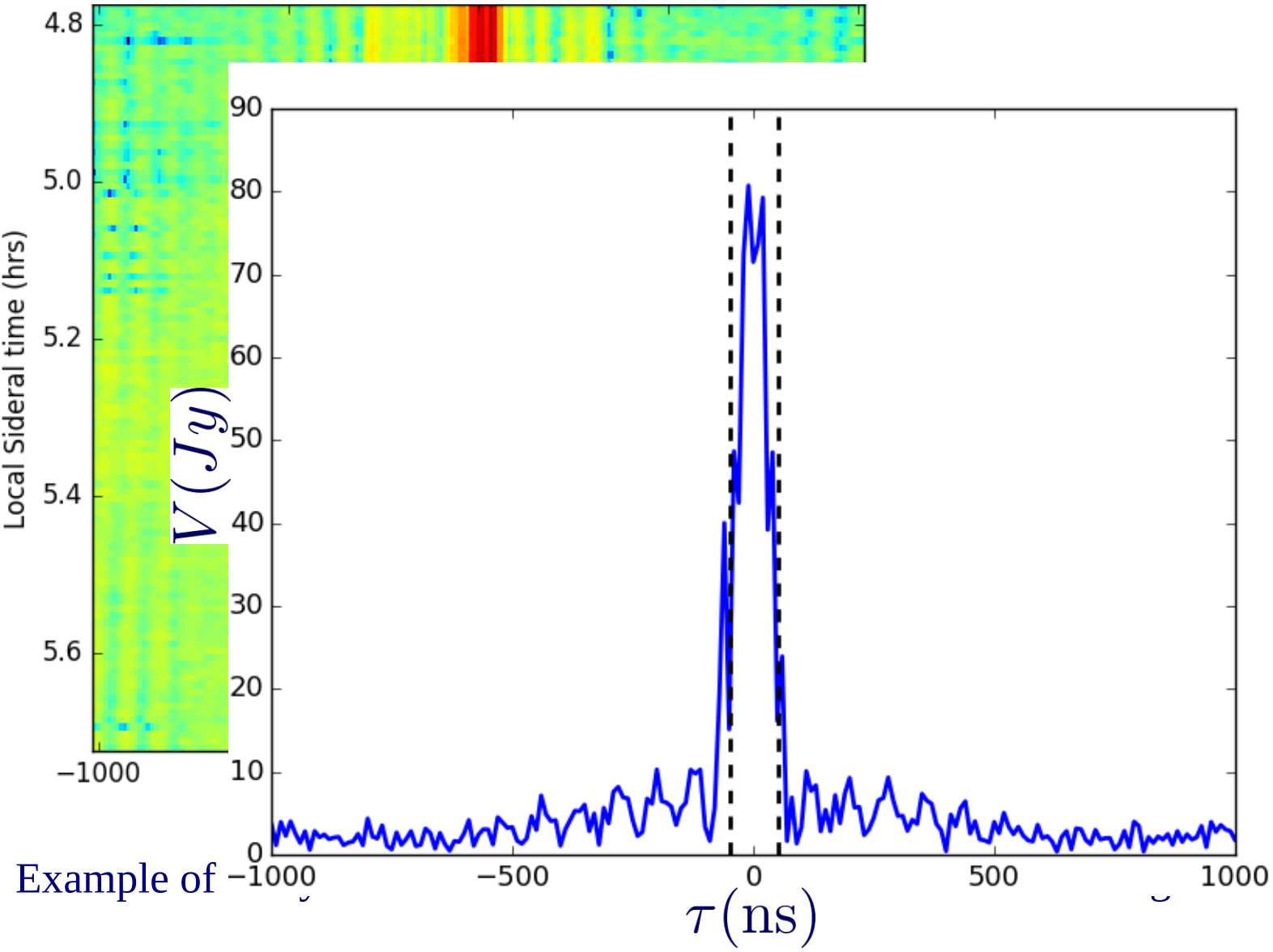



d emission

Example of ver 20 days

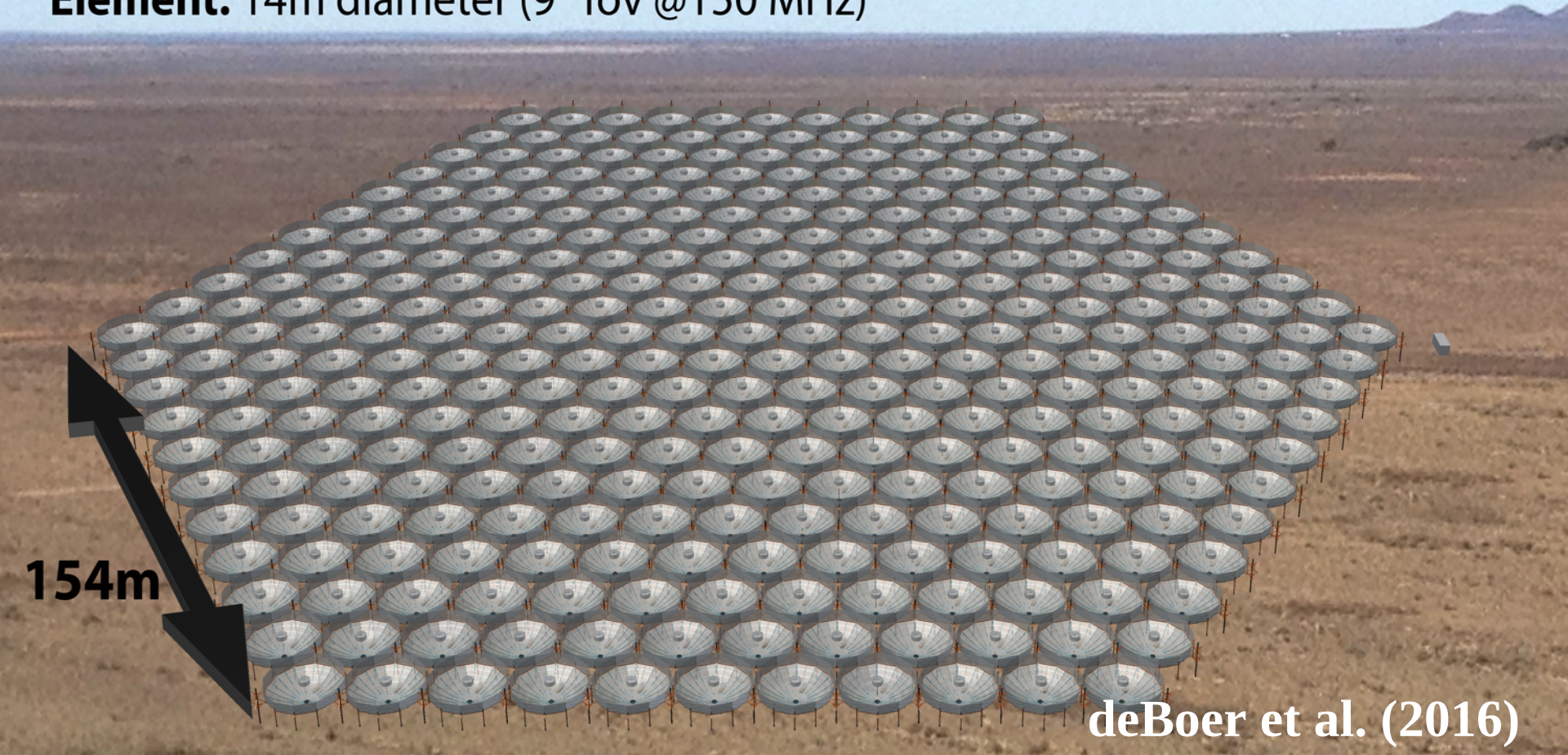
# HERA

**Location:** S30° 34′, E21° 25′ E (South Africa)
**Configuration:** 331 hex-pack, 21 outriggers
- **Min baseline:** 14.6m (7.8° scale)
- **Max baseline:** 1066m (9′ beam)

**Array core:** 310m diameter
**Element:** 14m diameter (9° fov @150 MHz)

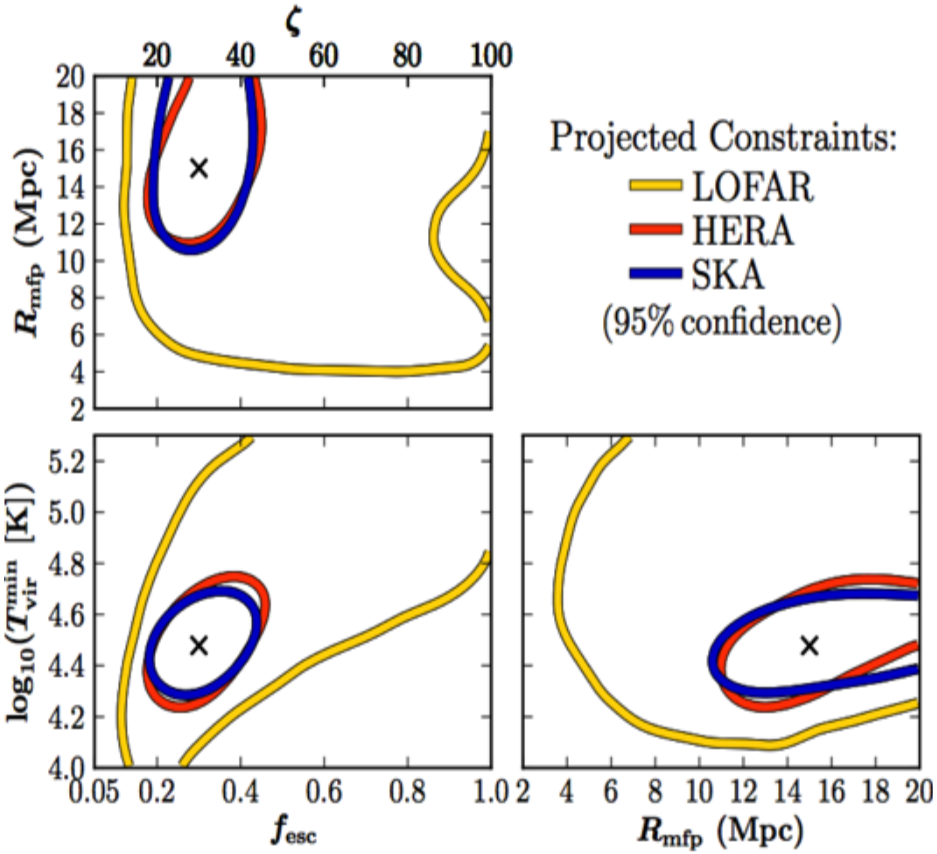
**Frequency**
- **Digitized:** 50 - 250 MHz
- **EOR band:** 100 - 200 MHz
- **Channel:** 97.7 kHz

$T_{sys} = 100 + T_{sky}$

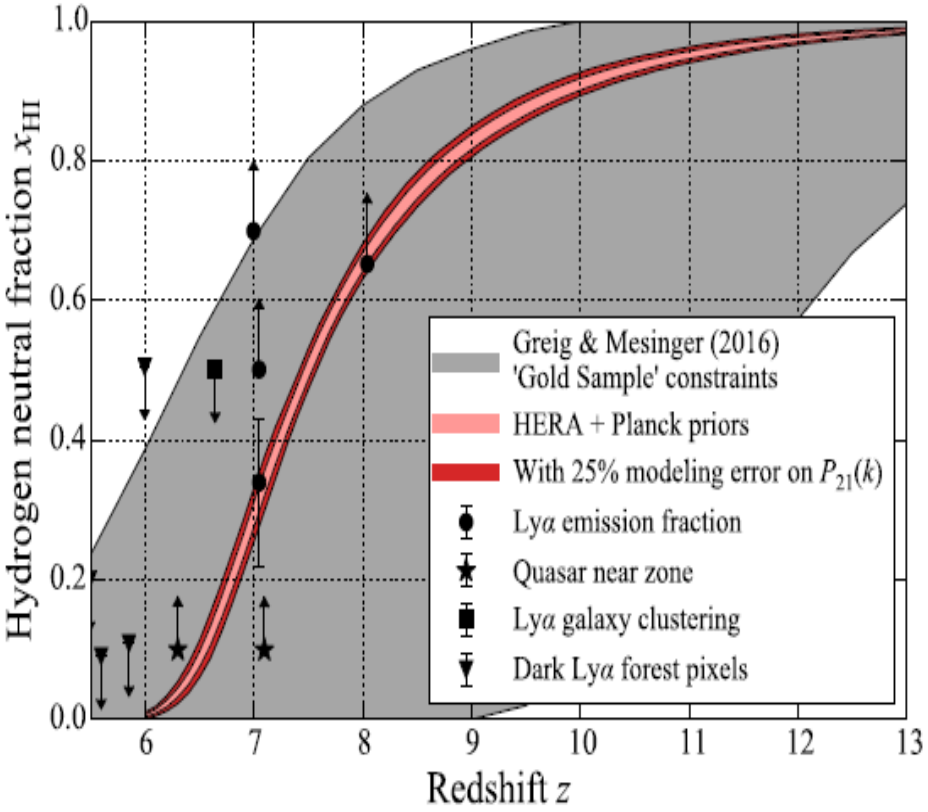



deBoer et al. (2016)

# HERA constraints on reionization

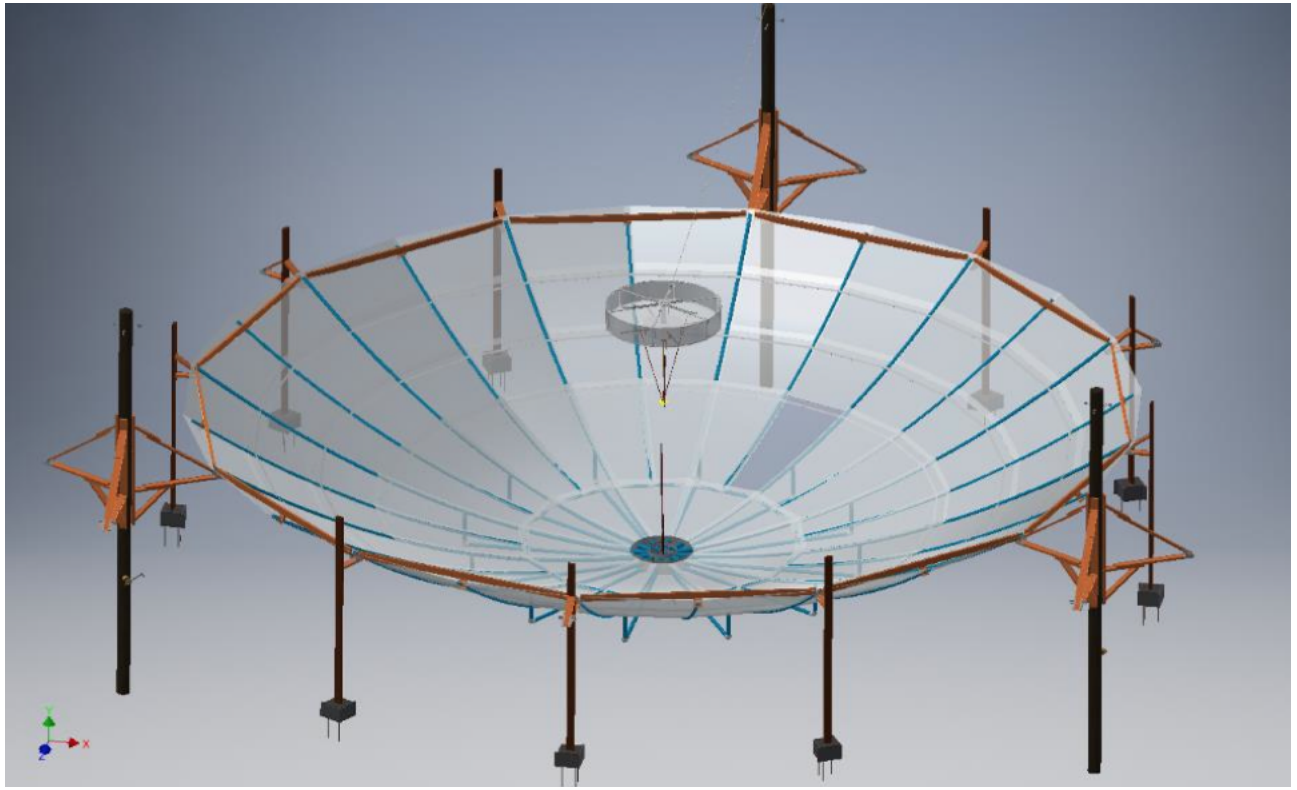



deBoer et al. (2016),
Greig & Mesinger (2016)




deBoer et al. (2016),
Liu & Parsons (2015)

# HERA status: 19 dishes, commissioning observations

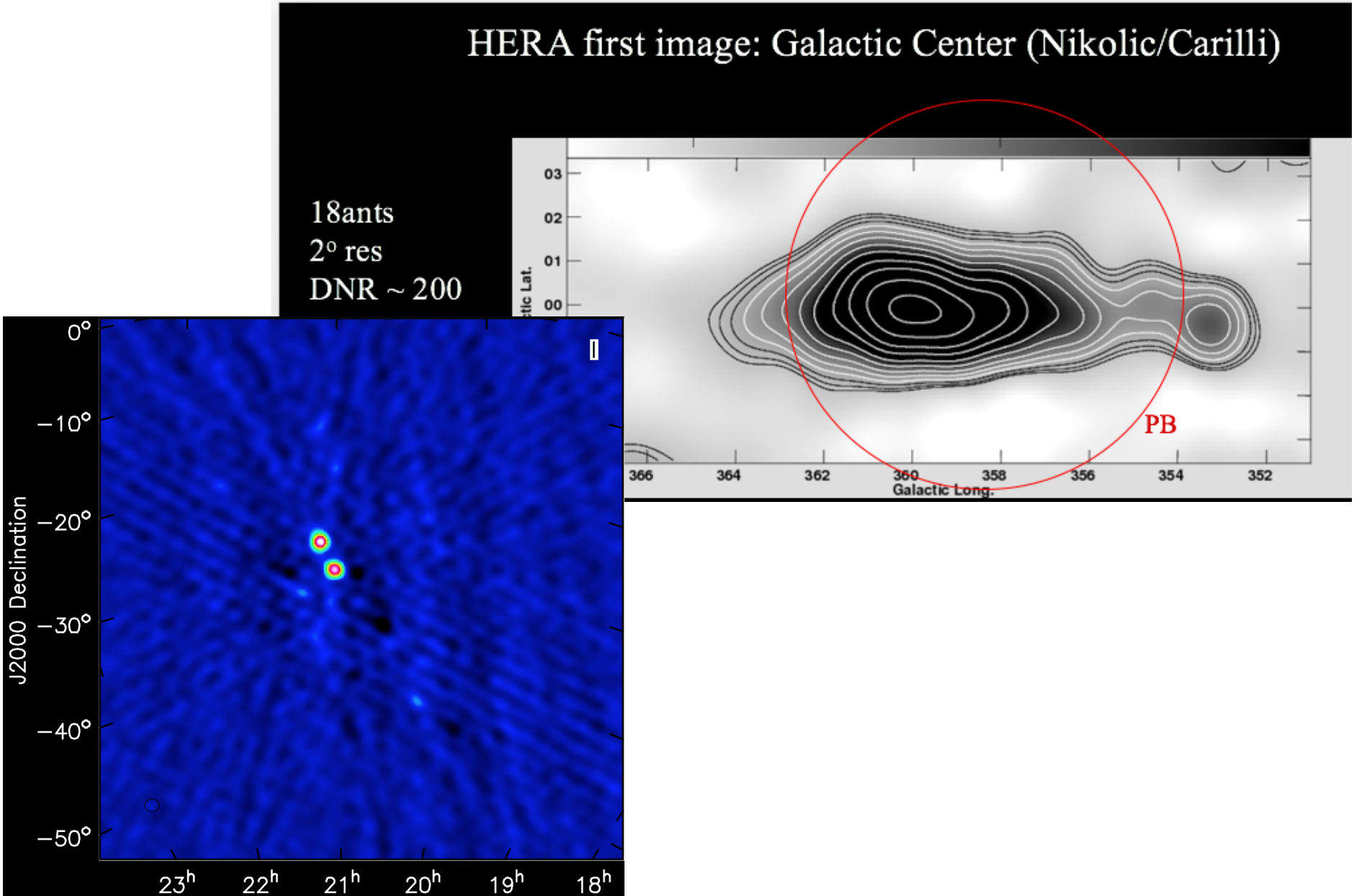


Ewall-Wice et al. (2016),
Neben et al. (2016),
Thyagarajan et al. (2016)

# HERA status: 19 dishes, commissioning observations

# The sky seen by HERA-19

## (see Grobler's poster!)



# The sky seen by HERA-19

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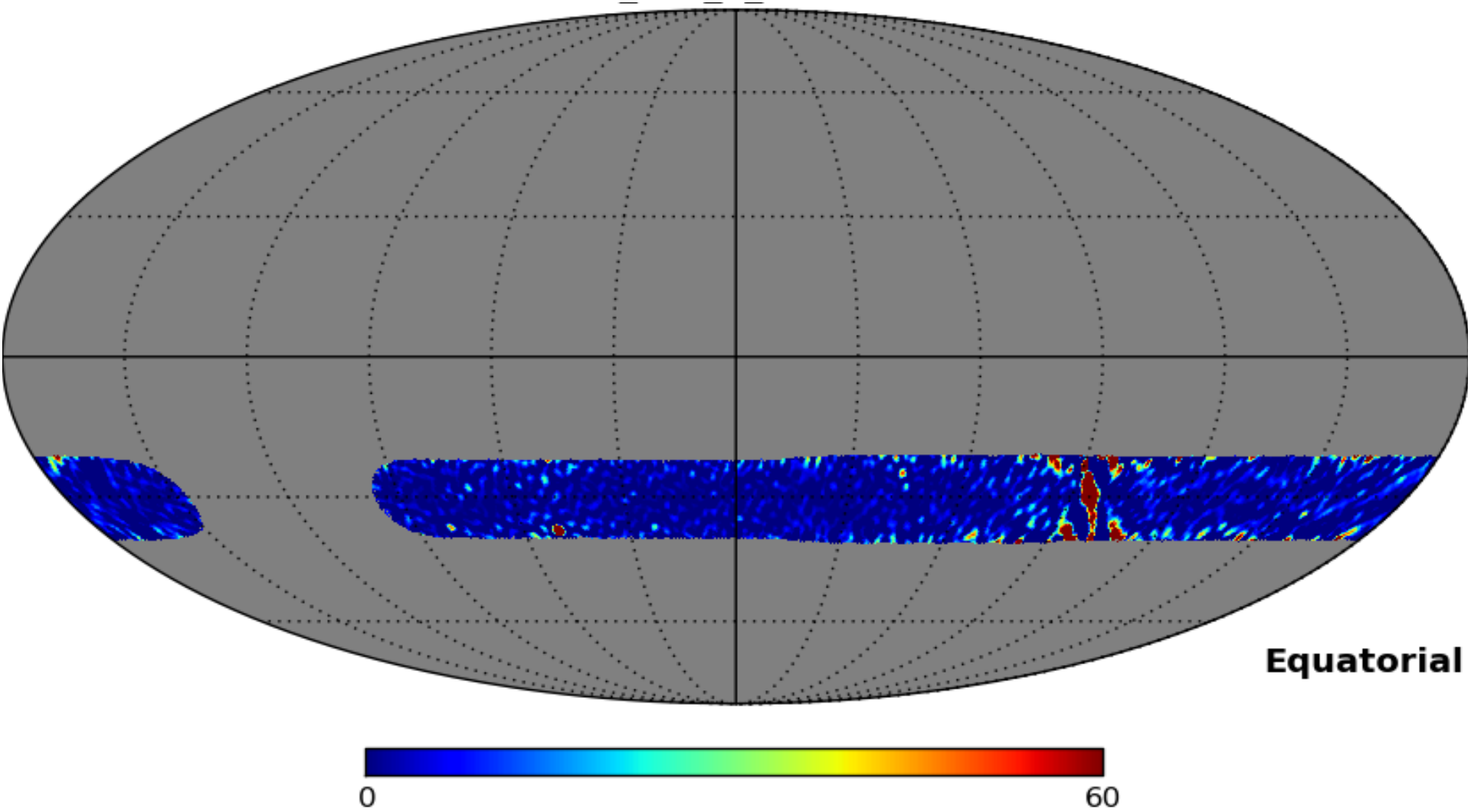
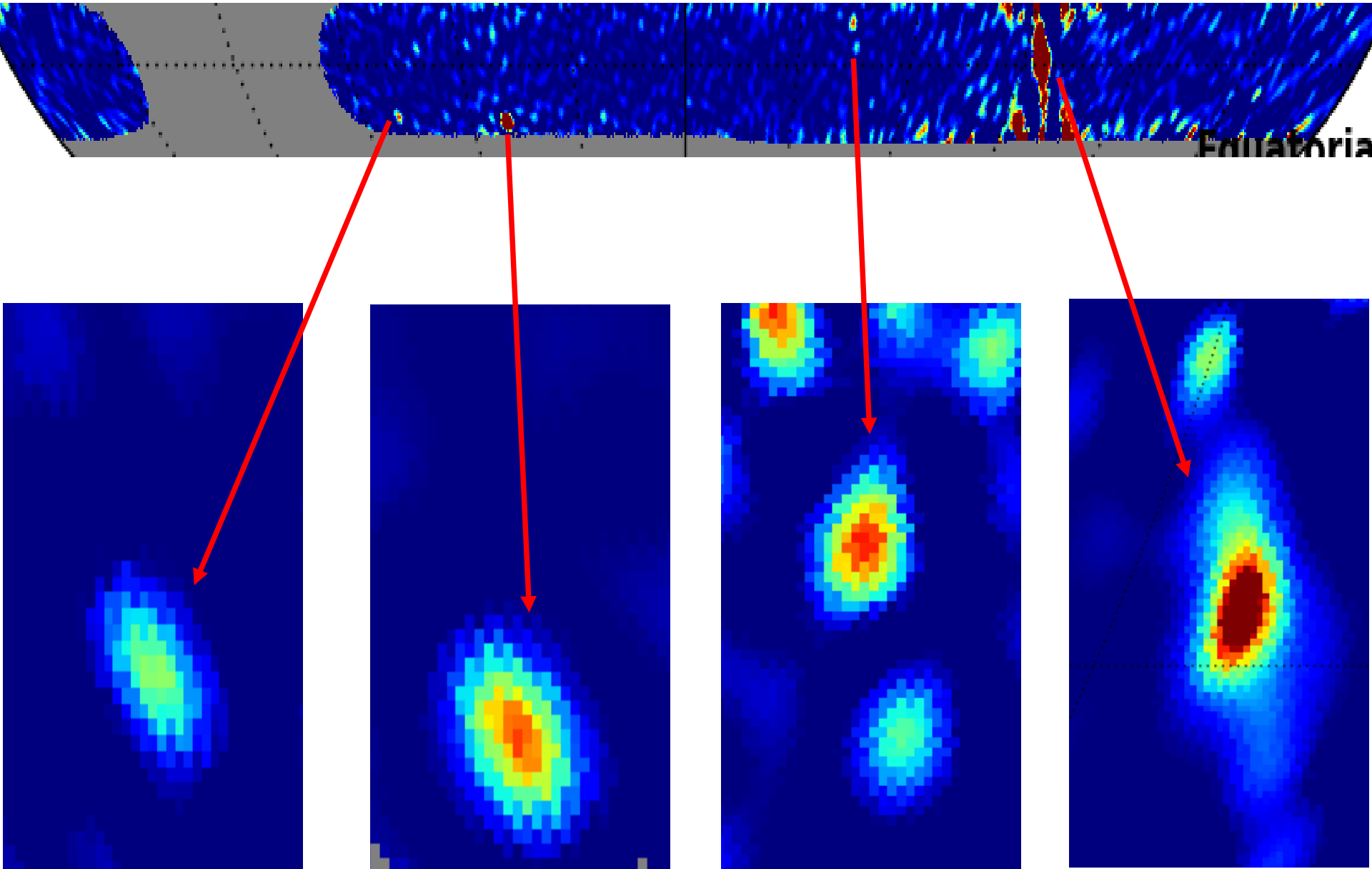


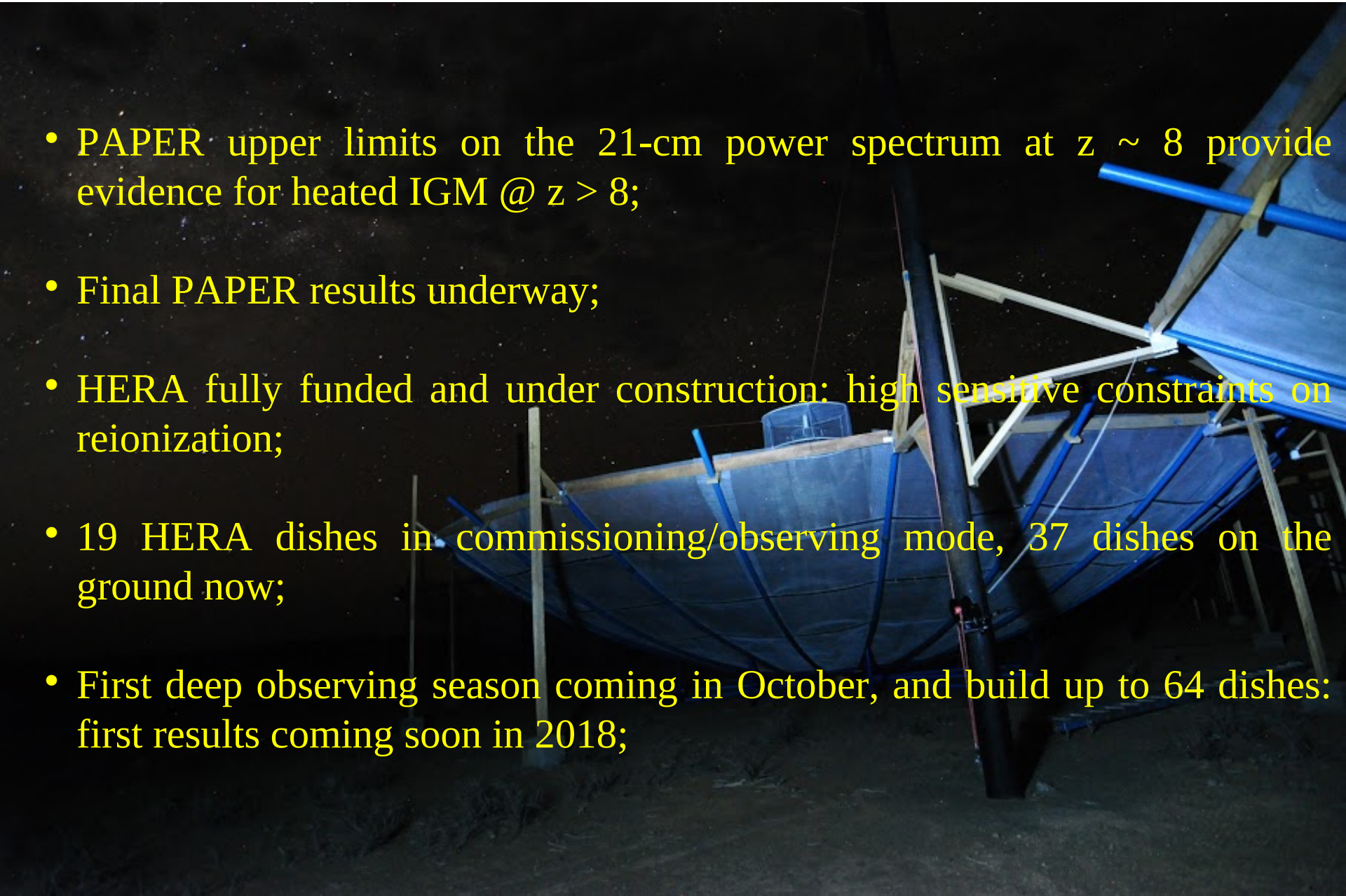

- three nights of drift scan observations resampled on the Healpix sphere;
- 2 degrees angular resolution;
- averaged over 60 MHz bandwidth;

# The sky seen by HERA-19

**(see Grobler's poster!)**



# Conclusions



- PAPER upper limits on the 21-cm power spectrum at z ~ 8 provide evidence for heated IGM @ z > 8;
- Final PAPER results underway;
- HERA fully funded and under construction: high sensitive constraints on reionization;
- 19 HERA dishes in commissioning/observing mode, 37 dishes on the ground now;
- First deep observing season coming in October, and build up to 64 dishes: first results coming soon in 2018;

# Conclusions