Direct Optimal Mapping for 21cm Cosmology

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Xu et al. 2022

21cm Cosmology

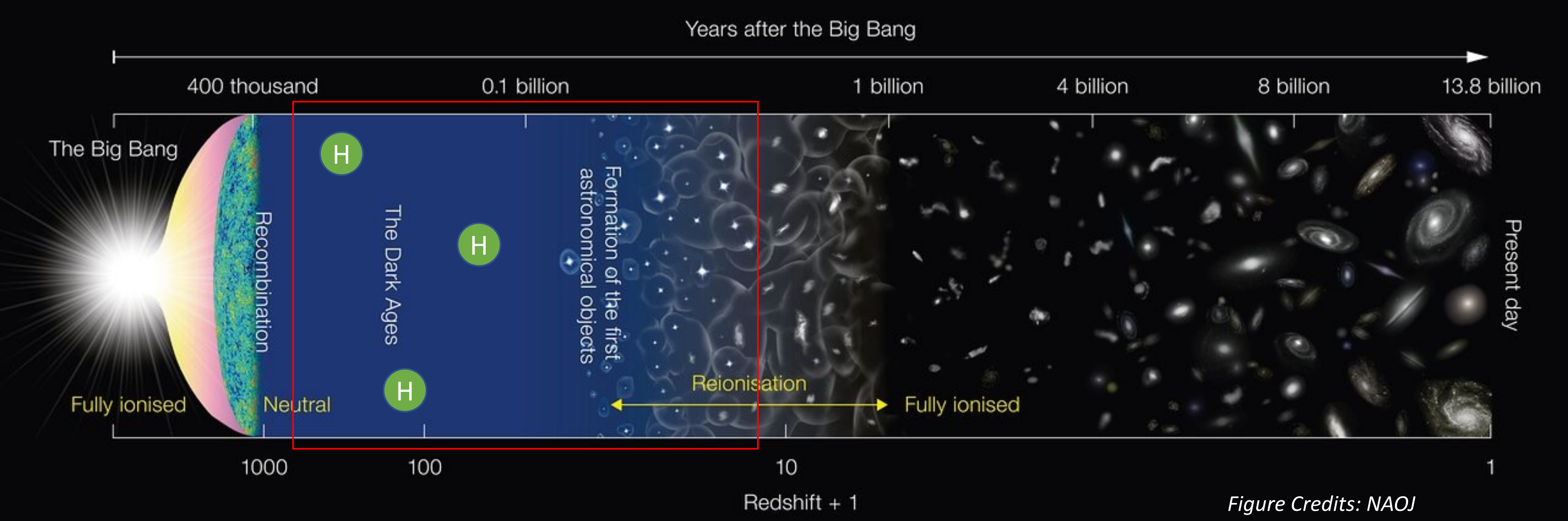
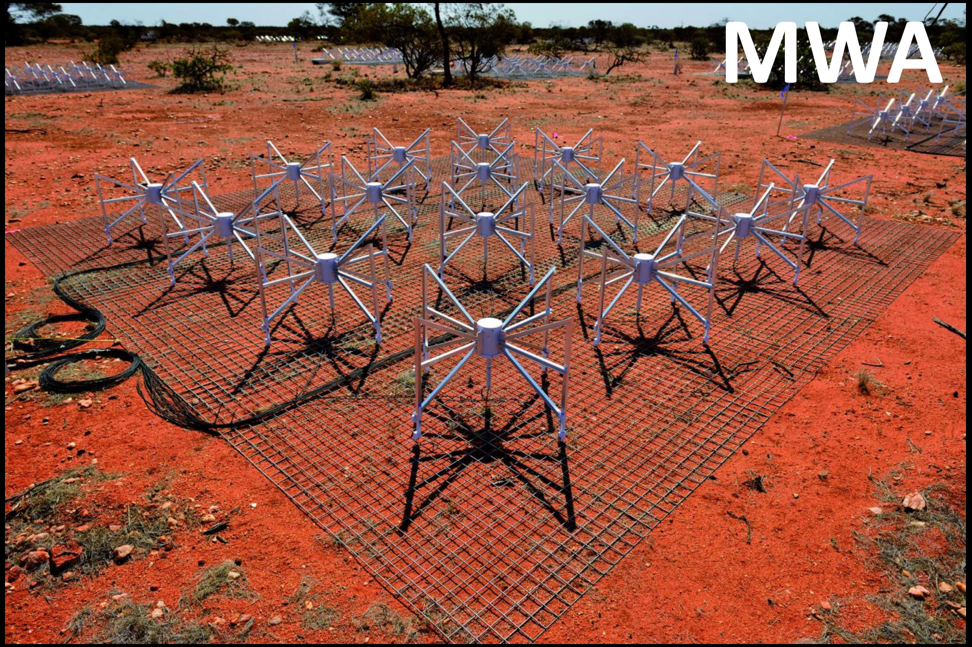


Figure Credits: NAOJ



Interferometers!

Hydrogen Epoch of Reionization Array (HERA)

- Interferometer
  - 14m dishes
  - 350 dishes are all built
  - 50-250 MHz $(z = 5 \sim 27)$

- Raw data measures the visibilities between antennas

- Mapping visibilities to sky maps

Figure credits: Google Map

Direct Optimal Mapping Formalism

Data model

$$d = A\,m + n$$

Noise matrix is defined as

$$N = < nn^\dagger >$$

It is proved that the map can be recovered via

$$\hat{m} = DA^\dagger N^{-1} d$$

without cosmological information loss.

D is a normalization matrix without a set form.

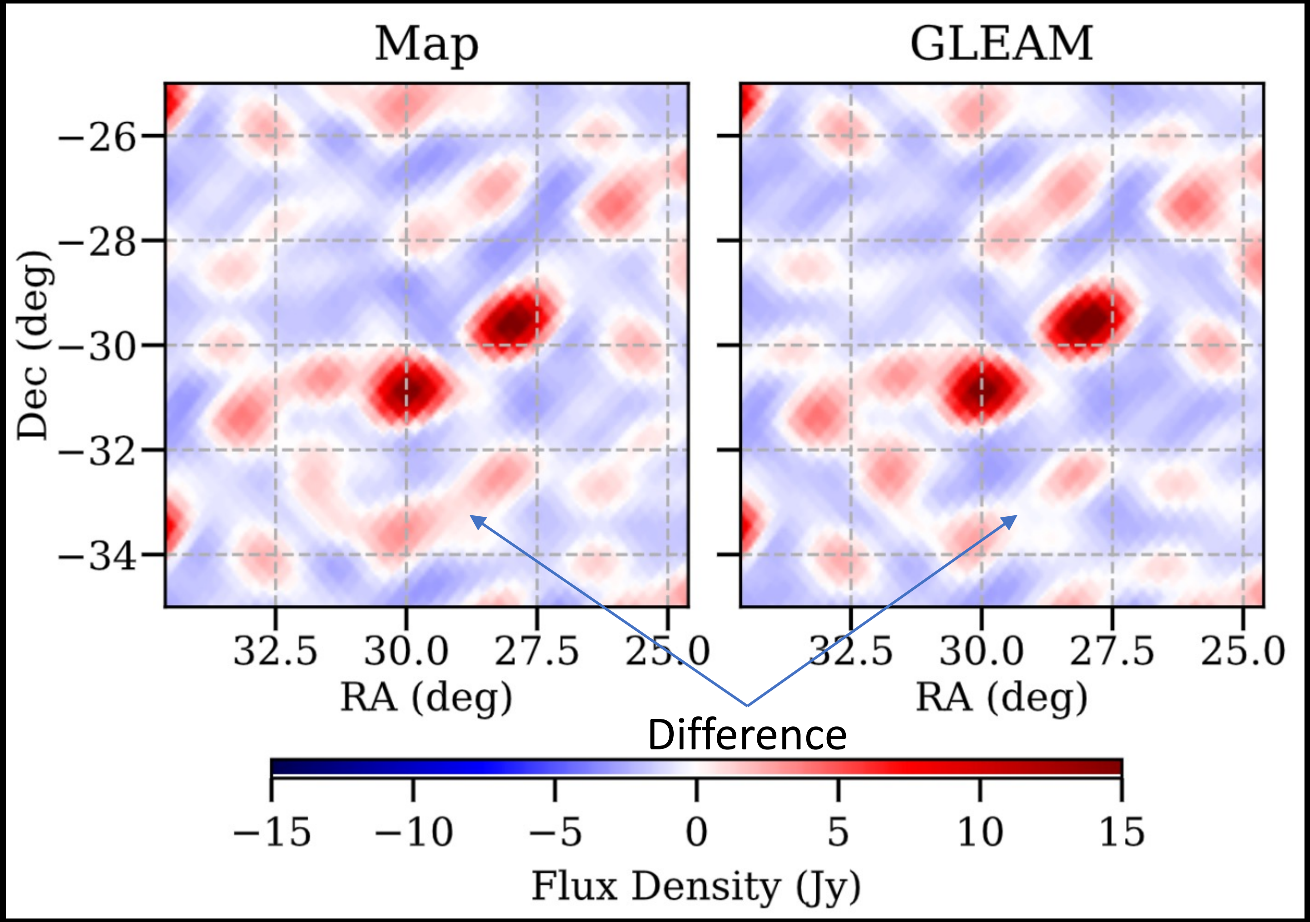
Dillon et al. 2015

Mapping HERA Data

- Comparing with sky models
  - GLEAM: radio point source catalog
  - GLEAM (convolved)

- GLEAM misses some diffuse emission

- Residual?



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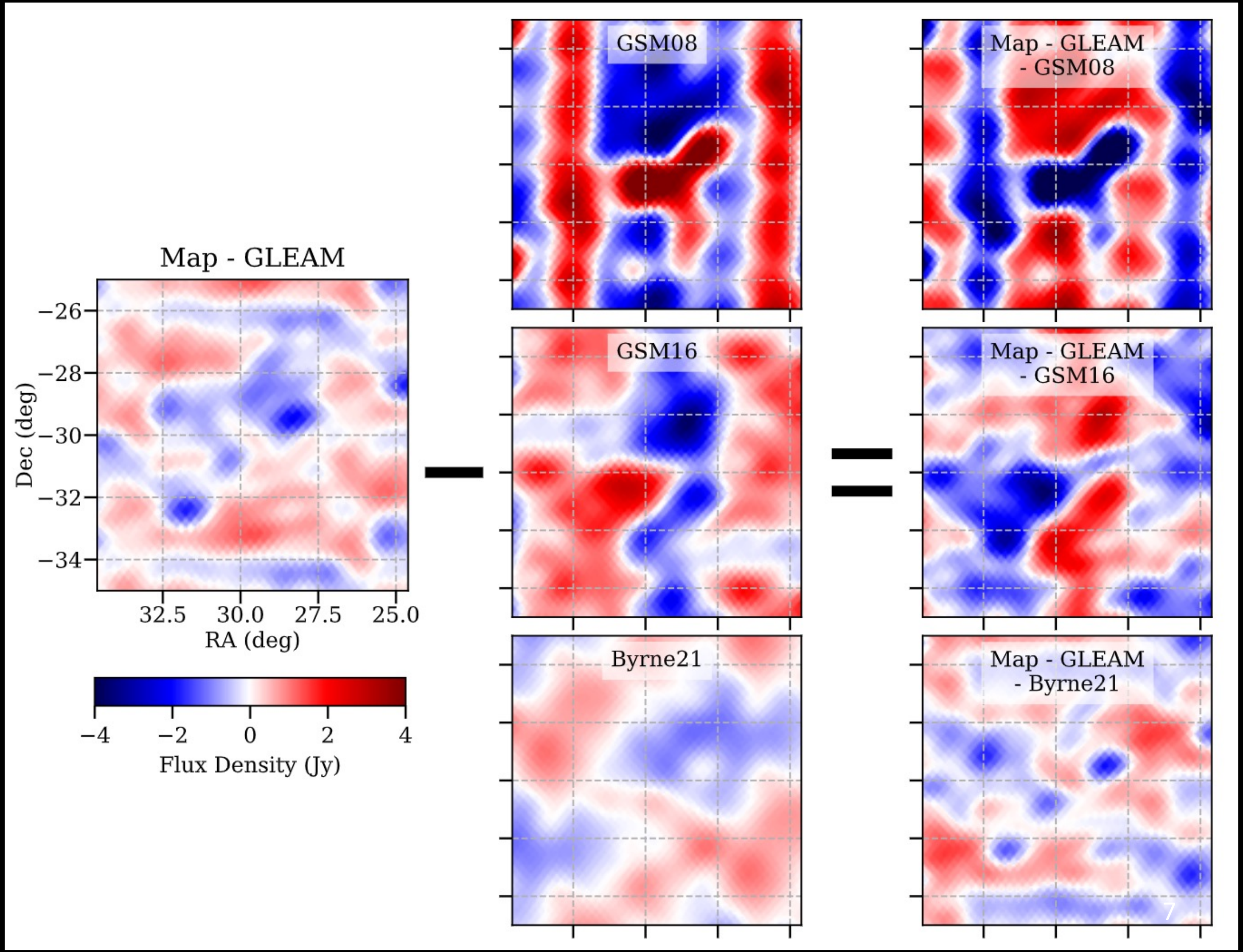
Continuum Sky Models

- 1/10 peak value after subtracting GLEAM
- Global Sky Model (GSM)
- GSM08 and GSM16 show inconsistent emission compared to the measurement
- Byrne21 map (measurement from MWA) is consistent in large angular scales



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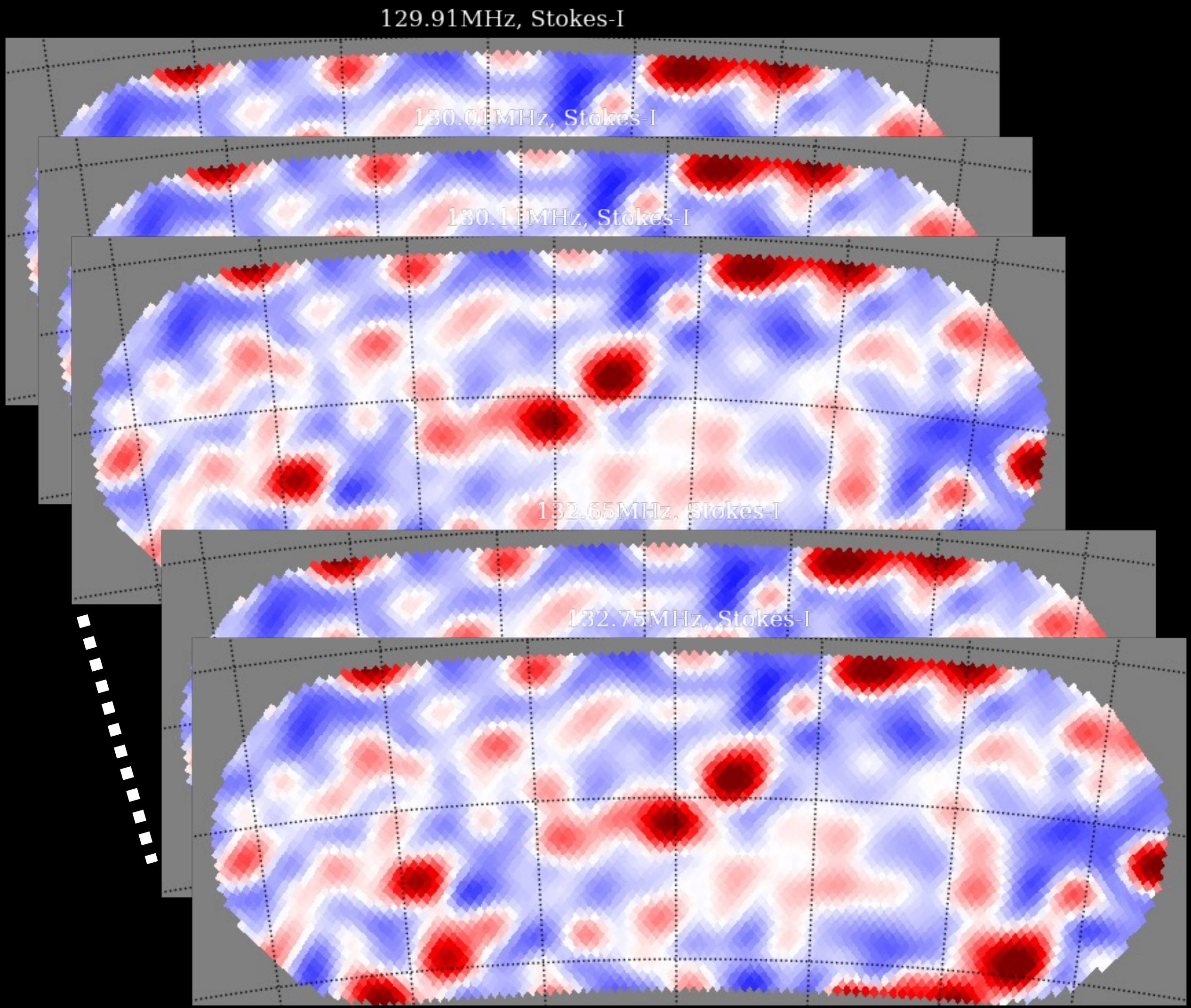
Widefield + Multi-frequency

- Mapping interferometric data with trackable statistics
- Maps
  - Full covariance matrix of the map pixels
  - Different frequency → different redshift
- Measuring image power spectrum
- Cross-correlating with other datasets
  - CMB lensing field
  - High-redshift quasars



Xu et al., 2022

Conclusion

- 21cm signals have the potential to dramatically increase the volume we can probe for cosmology.
- We have developed a mapping method, inspired by the CMB optimal mapping.
- The mapping method applied to the HERA data has already distinguished different sky models.
- We will measure the power spectrum around cosmic reionization and cross-correlate with other datasets.