

Imaging the 21-cm Signal from the Cosmic Dawn & Epoch of Reionization and the Connection with the Global Signal

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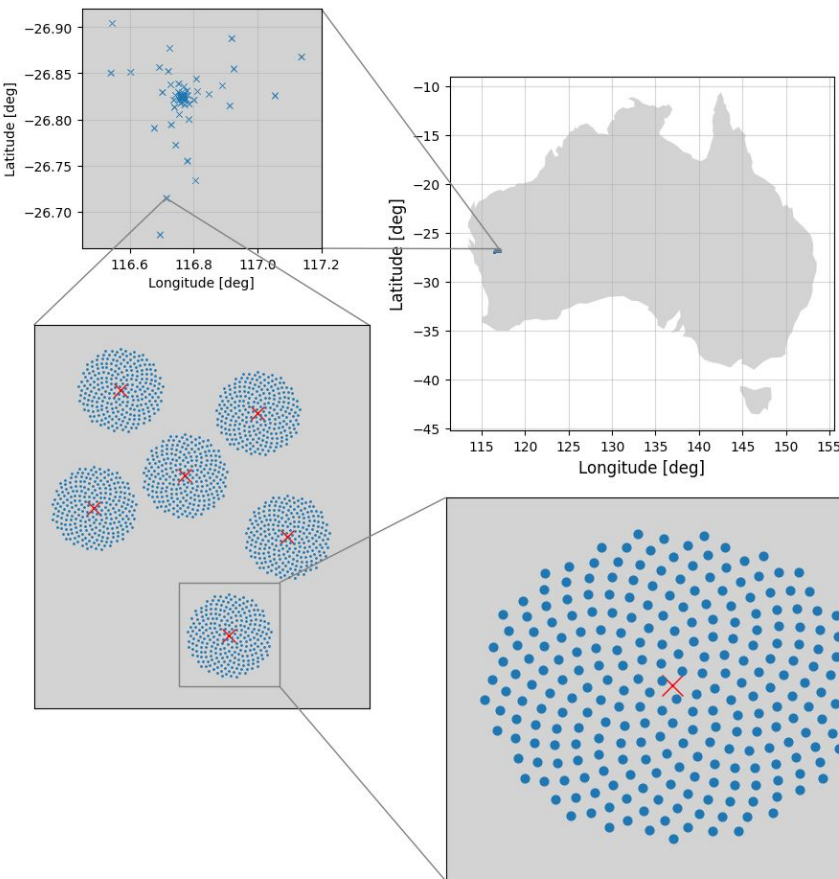
Imaging the 21-cm Signal from the Cosmic Dawn & Epoch of Reionization and the Connection with the Global Signal

Satadru Bag^{1,2}, Michele Bianco^{3,4}, Samir Choudhuri⁵, Saswata Dasgupta⁶,
Abhirup Datta⁷, Kanan K. Datta⁸, Ivelin Georgiev^{9,10}, Sambit K. Giri^{9,11}, Ian
Hothi¹², Akanksha Kapahtia¹³, Suman Majumdar⁷, Garrelt Mellema¹⁰, Arnab
Mishra⁸, Samit Kumar Pal⁷ and Feiyu Zhao¹⁴

Goal of the paper:

- Review of the imaging capabilities of SKA-Low
- Description of the variety of methods for quantitatively analysing image data
- Connection between image data and other observables

SKA-Low AA4 Layout

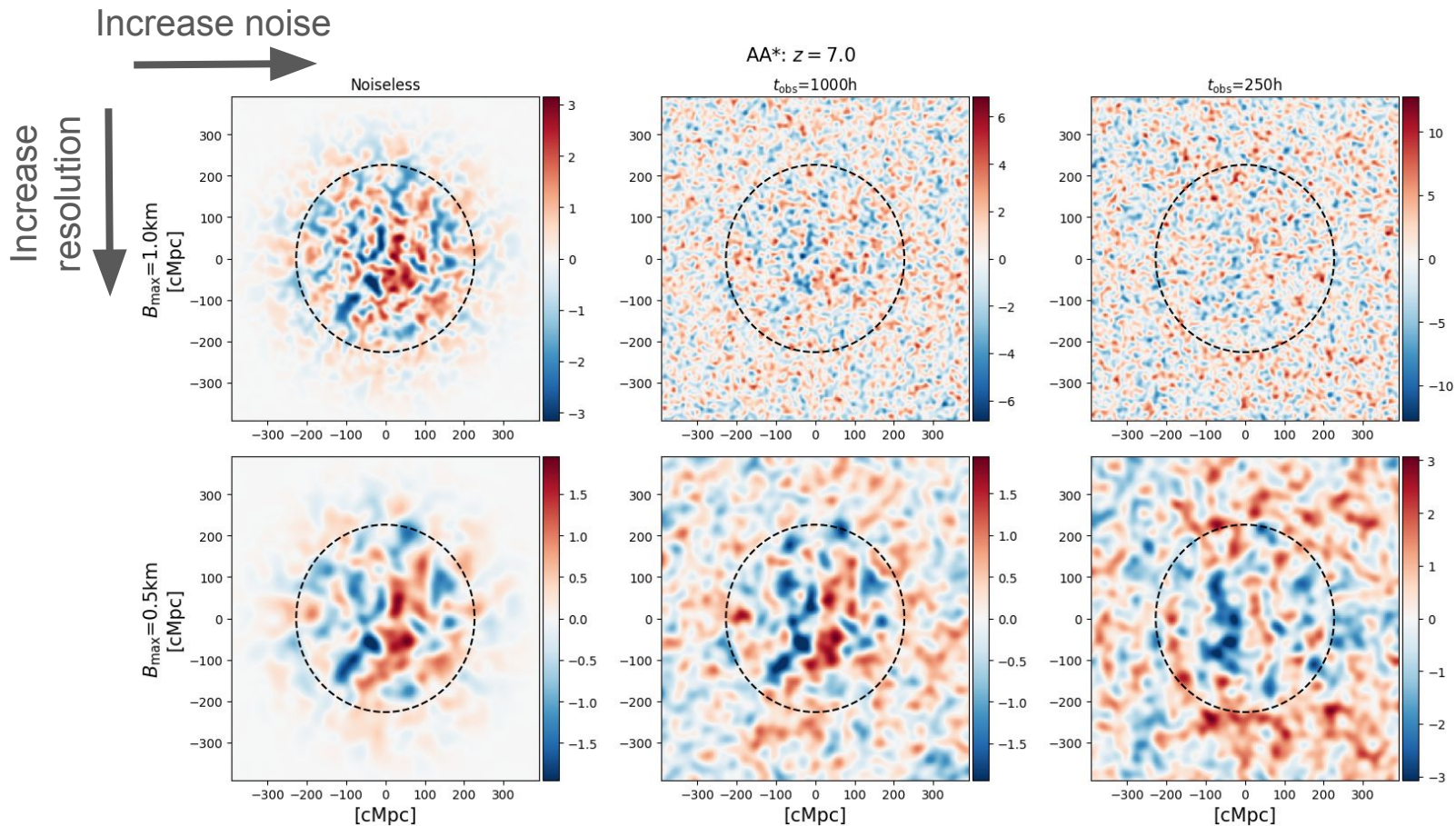


Final layout of the SKA-Low stations:

- 512 stations, each with 128 antennas
- Max baseline ~65 km, station diameter 35 m
- **FoV of 10 deg with 16 arcsec resolution**
- **Frequency range between 50 to 350 MHz**
- Cumulative observation length > 1000 h



Imaging Capabilities of SKA-Low

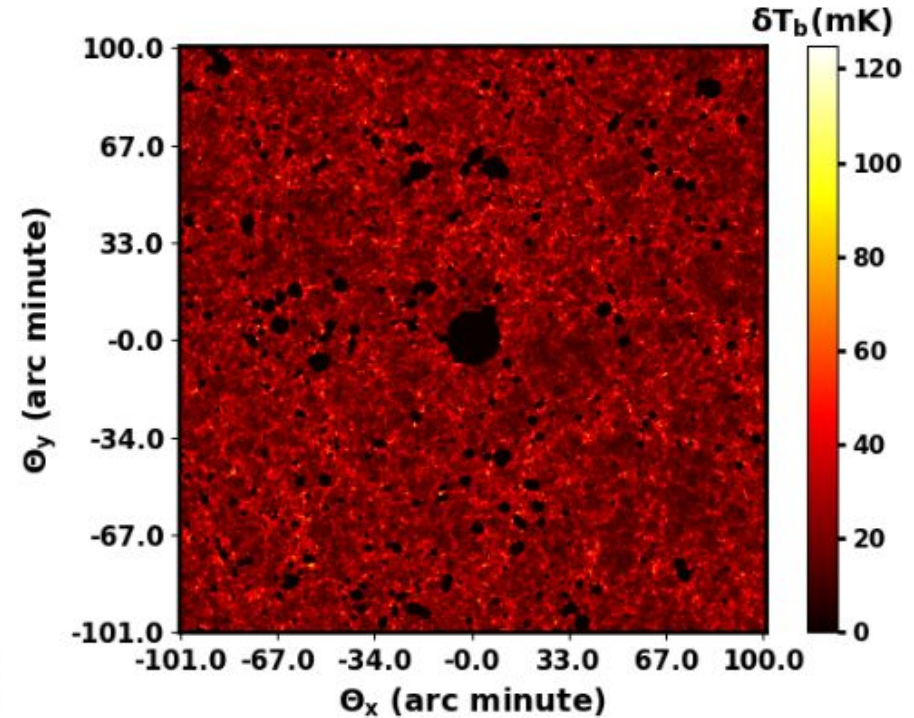
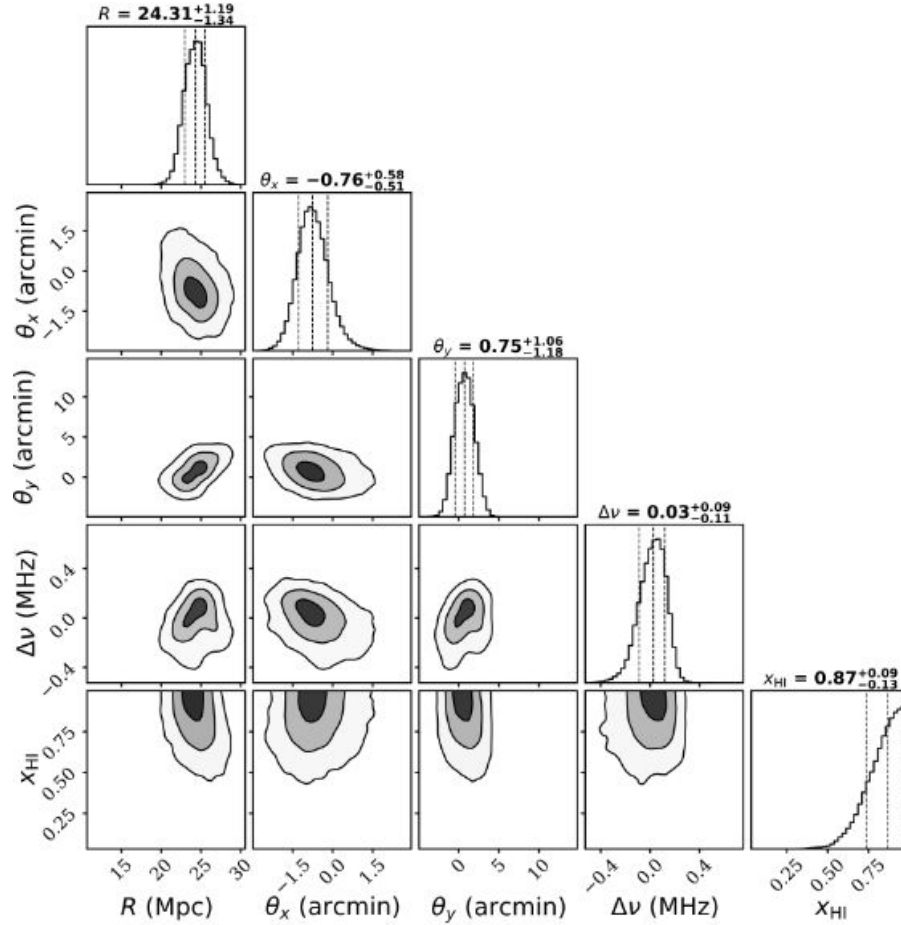


Identifying & Analysing Structures in Images

Most of the techniques applied on tomographic data are based on analysing structures in the images by **identifying ionized and neutral regions**.

- **Structures from image data:**
e.g. K-means clustering algorithm, gradient-descent method, Linear Iterative Clustering method, segmentation by ML.
- **Structures from visibility data:**
If it is known what kind of structure you are looking for, it is possible to look for its signature in the visibility data, without the need to construct image.

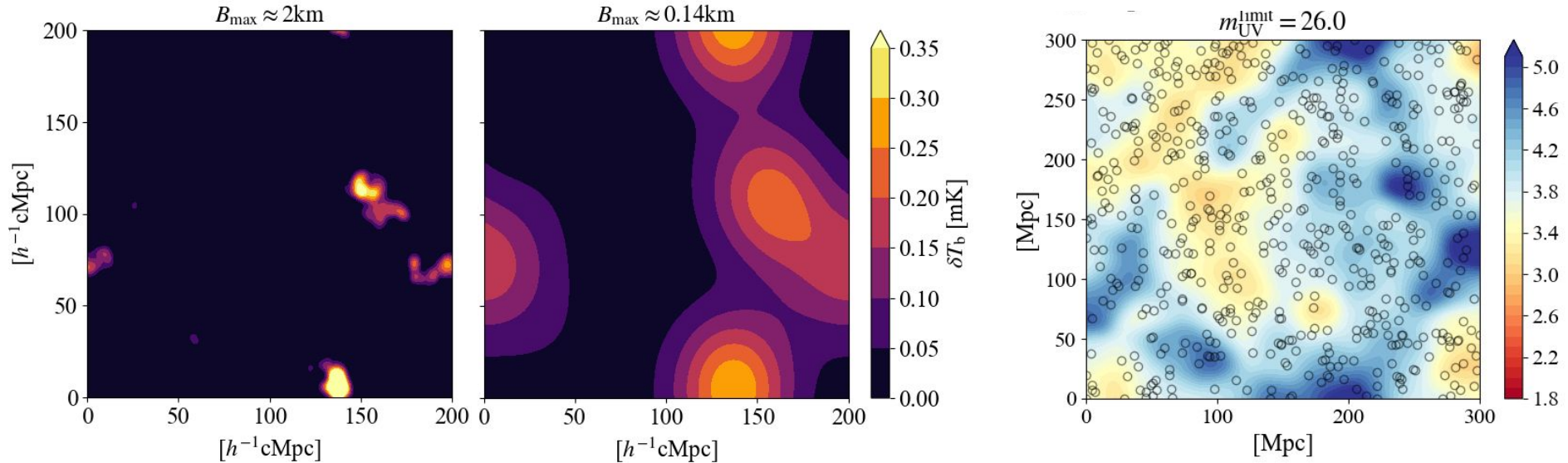
Identifying & Analysing Structures in Images



from [Mishra et al. \(2025\)](#)

Combining Image Data with Other Observables

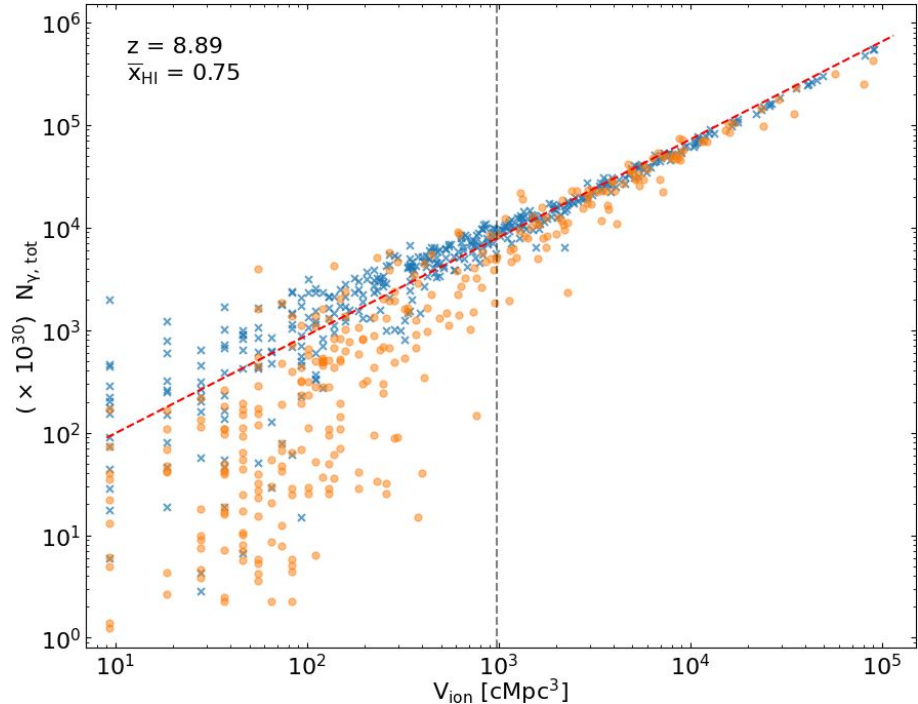
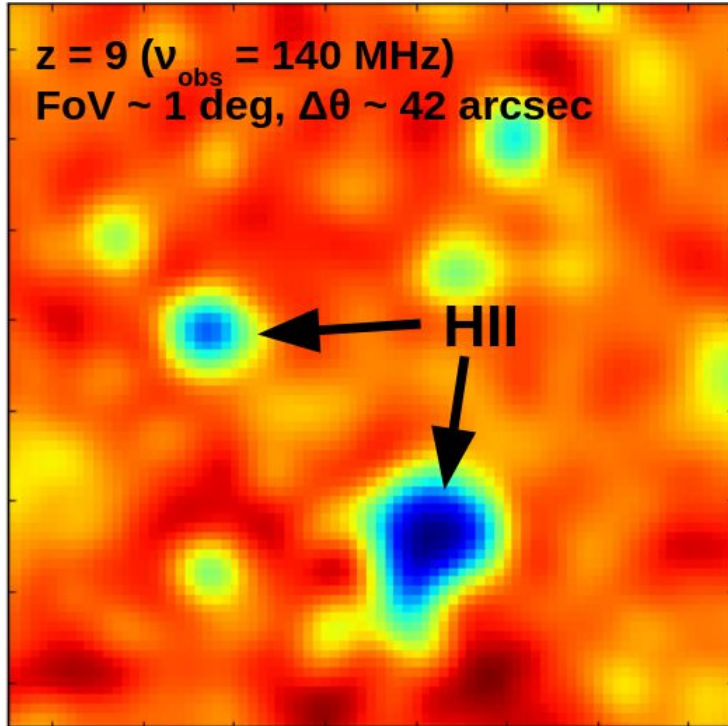
21-cm image data allows combination with other observables (e.g Ly- α forest, individual ionized bubbles to UV source)



from [Giri, Bianco et al. \(2025\)](#)

Combining Image Data with Other Observables

21-cm image data allows combination with other observables (e.g Ly- α forest, individual ionized bubbles to UV source)



from [Bianco et al. \(2023\)](#)

Conclusion and Summary

- Image capability of SKA-Low final AA4 layout (512 stations)
 - Respect science goal requirement set by the CD/EoR community
 - Possible need of longer integrated observational time (>1000 hours)
- Current analysis techniques focuses on identifying and analysing ionised and neutral regions from 21-cm observations.
 - Structure from image data or directly visibility data.
- Cross-correlation of 21-cm images from SKA-Low with other observables
 - Subaru/Hyper-Suprime Cam (i.e.: Ly- α forest)
 - JWST (i.e. individual source and ionised bubble)