精勤司天 诚信修文

ForkEoR: a new machine learning based cleaning and foreground removal method for CD/EoR imaging

Jiajun Zhang

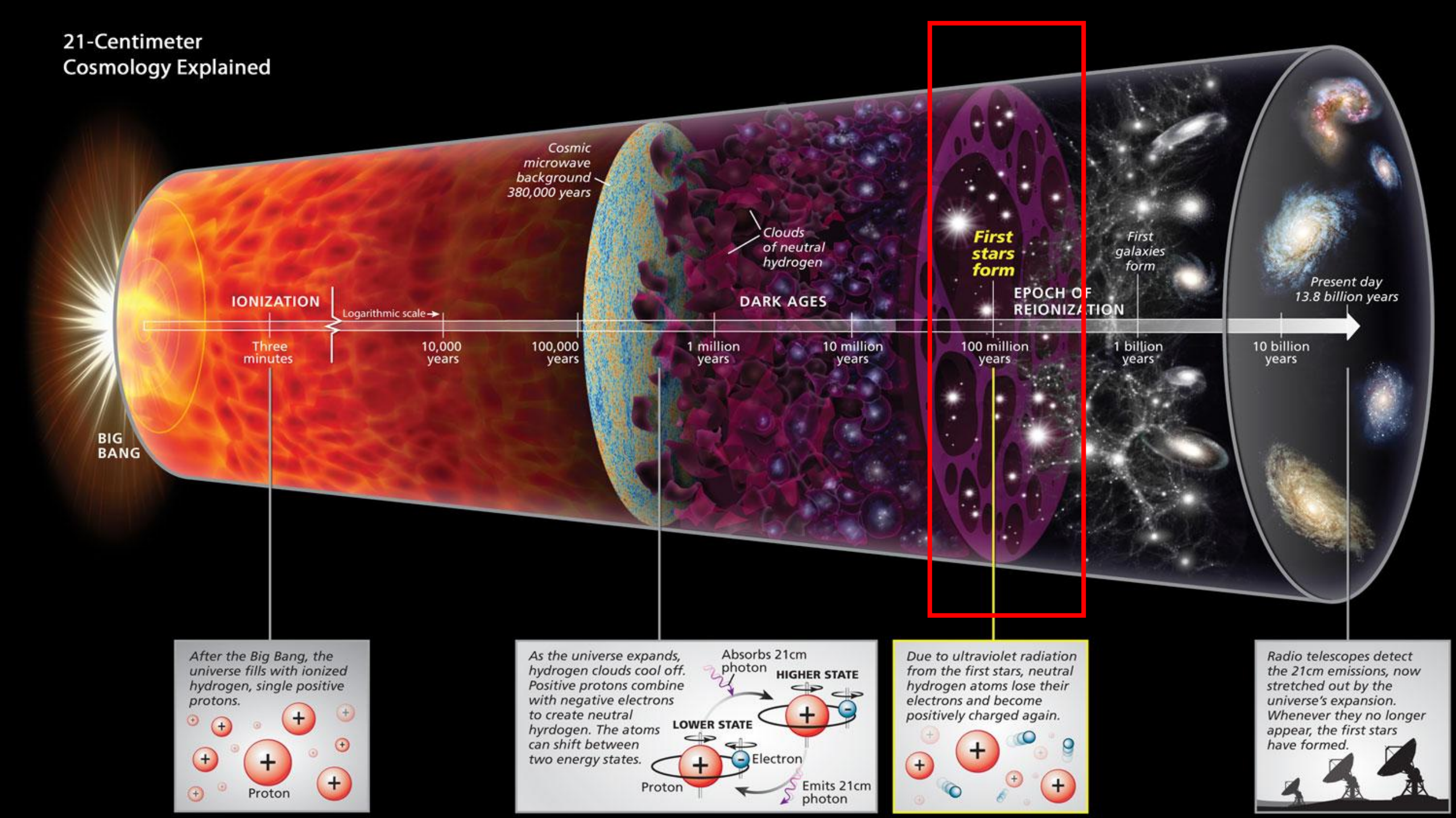
2024/July/19@Tsinghua

Collaborator: Ningyue Fan, Zhenghao Zhu and Huanyuan Shan

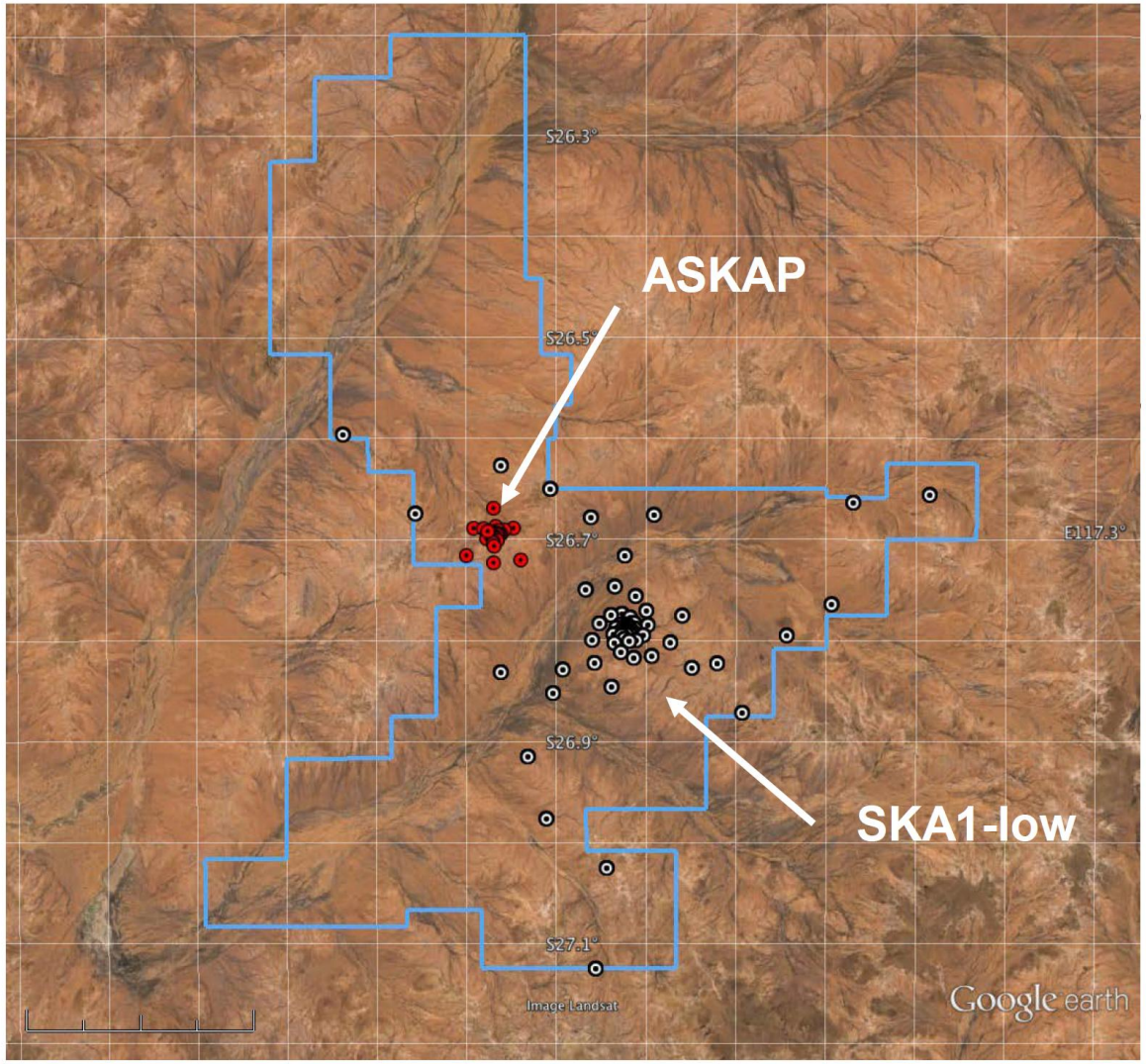
Outline

1. CD/EoR
2. End-to-End simulation
3. What is ForkEoR?
4. The performance of ForkEoR
5. What’s next?

21-Centimeter Cosmology Explained



SKA1-low Configuration (Boolardy, Aus.)



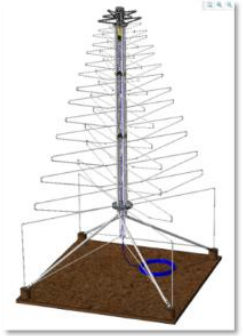
SKA1-low
the SKA's low-frequency instrument

Location: Australia

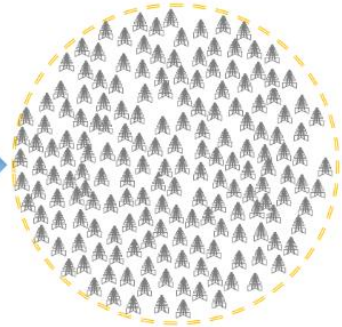
Frequency range:
50 MHz
to
350 MHz

~131,000
antennas spread between
512 stations

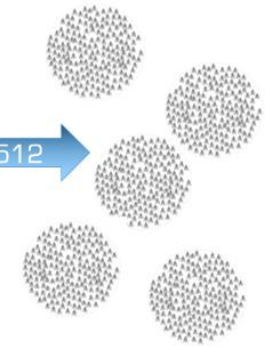
Maximum baseline:
~65km



256



512



SKA1-Low
Antenna/Receptor
Antenna Beam

SKA1-Low
"Station"
Station Beam

SKA1-Low
"Array"
Correlation and
Tied-array Beams

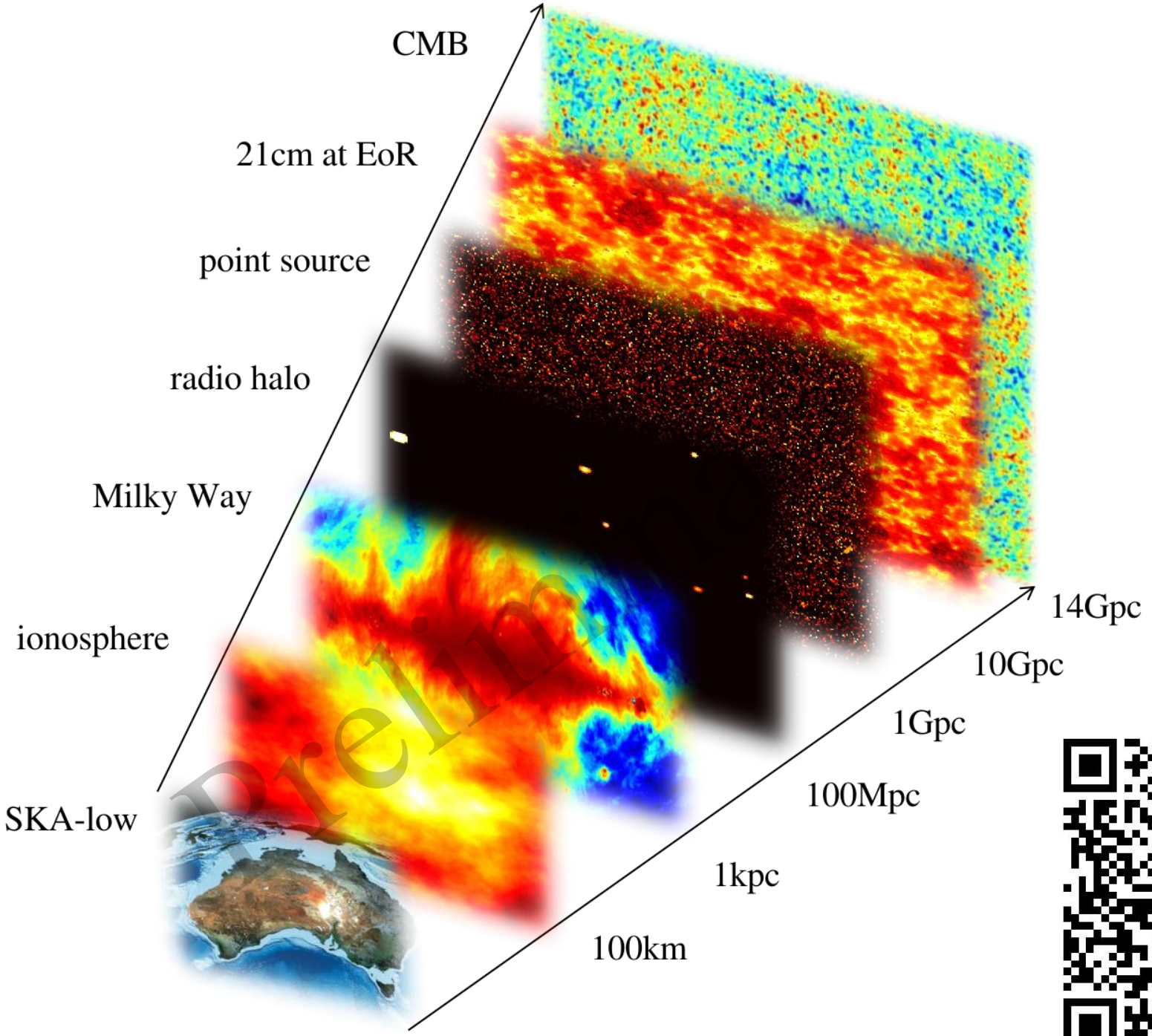
Exploring the Universe with the world's largest radio telescope

How to remove foreground?

1. Foreground is smooth in frequency

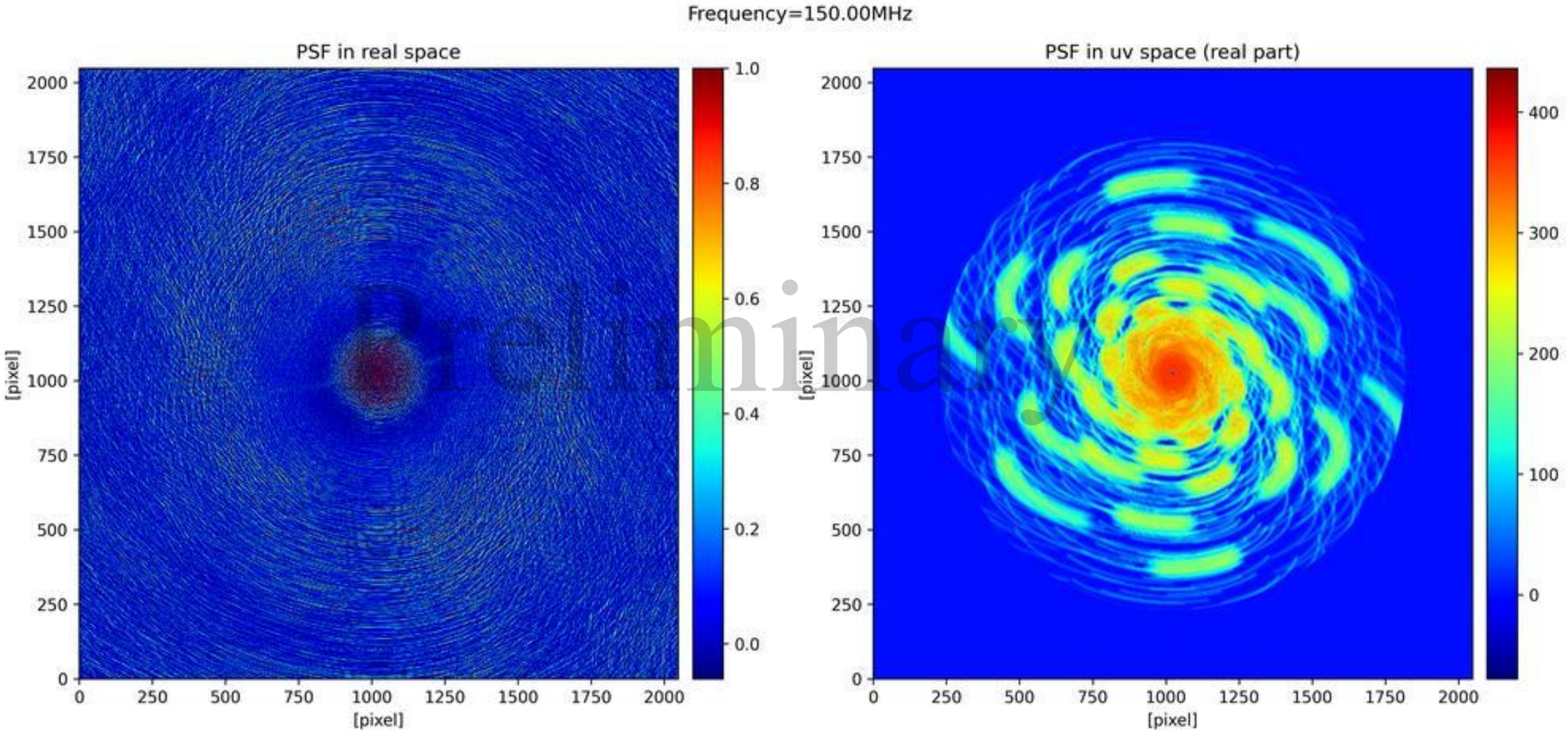
2. 21cm signal is fluctuating

3. Pick out the fluctuating signal from smooth signal



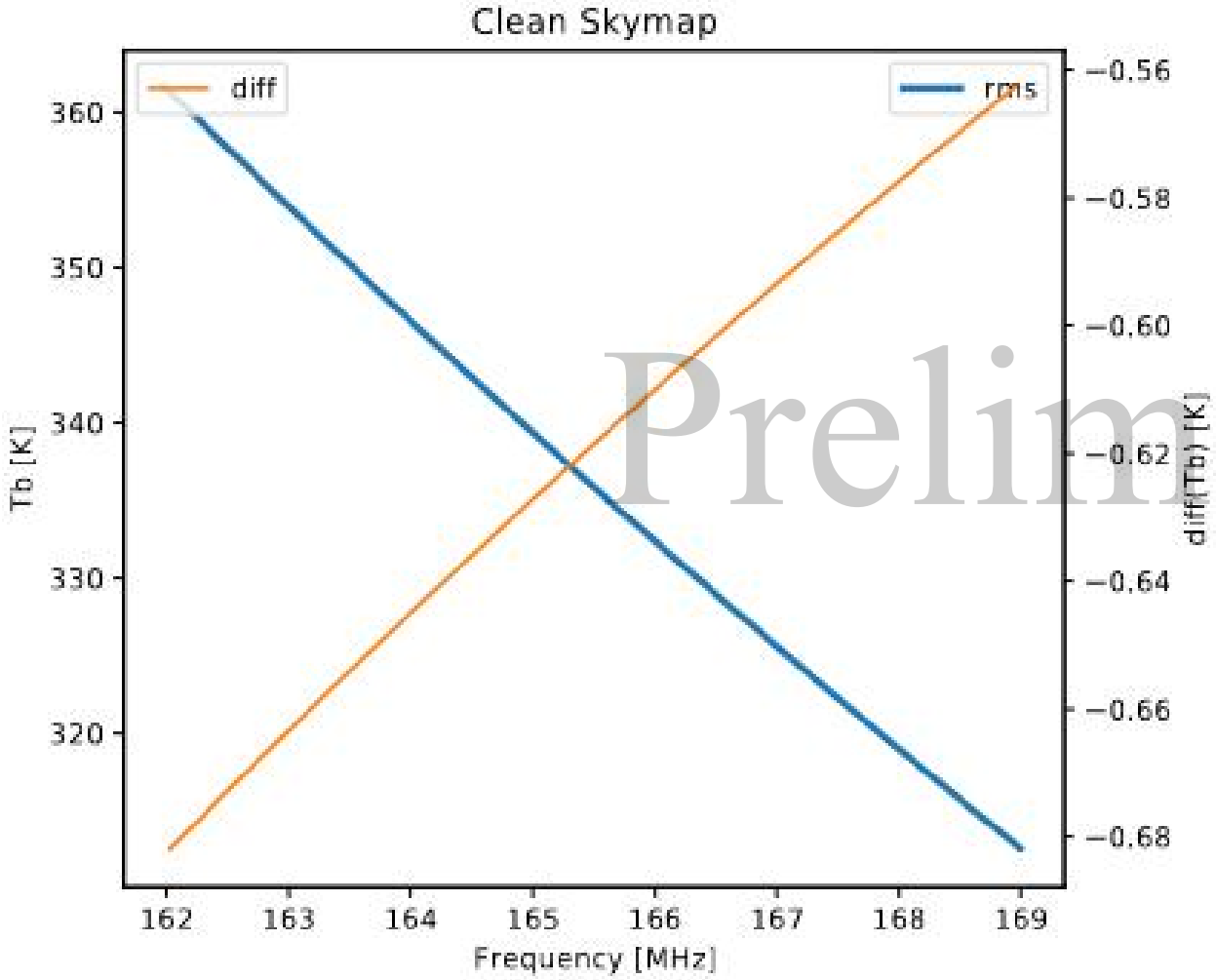
Preliminary

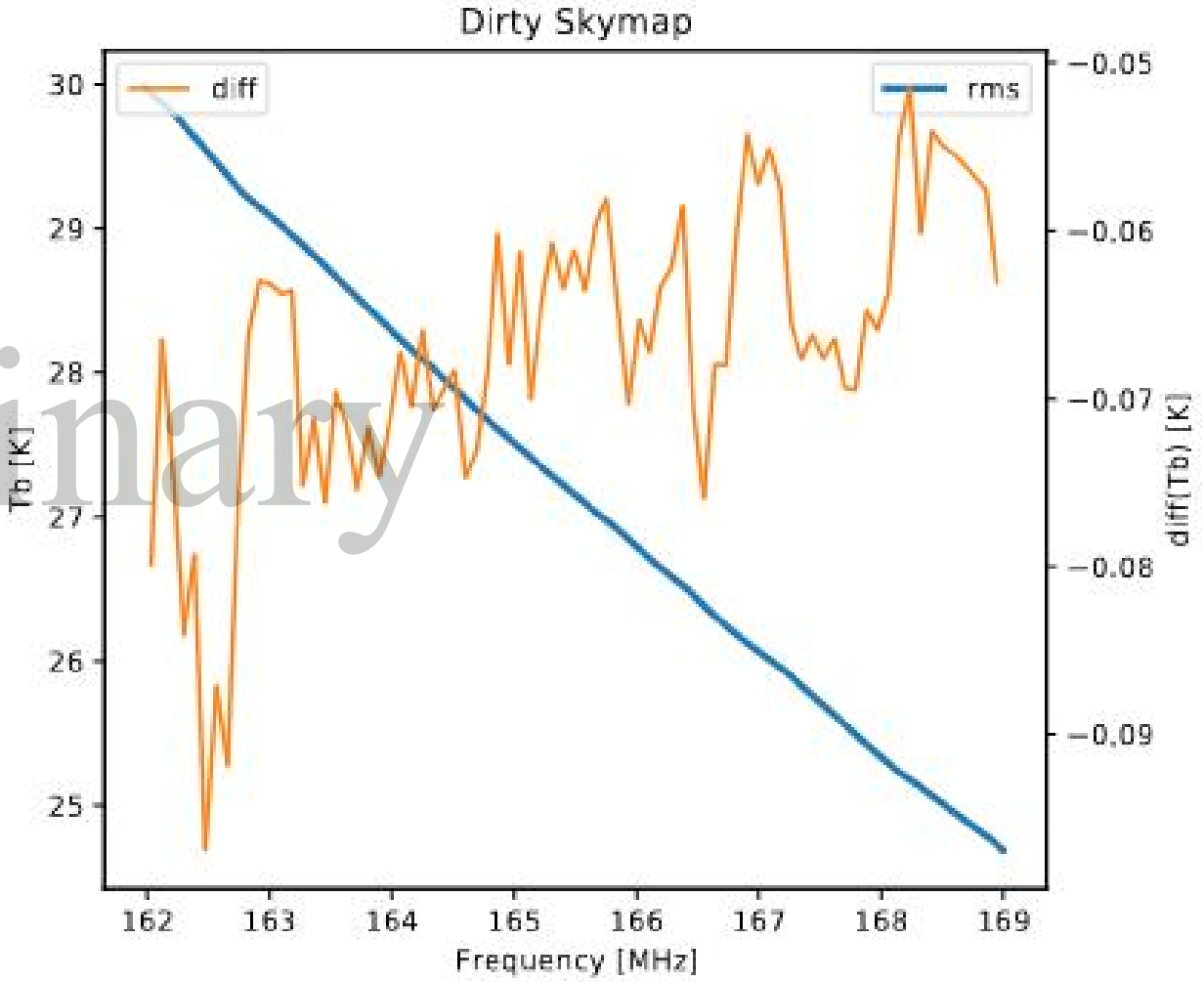
Complex PSF comes from the incomplete coverage in uv space



Preliminary

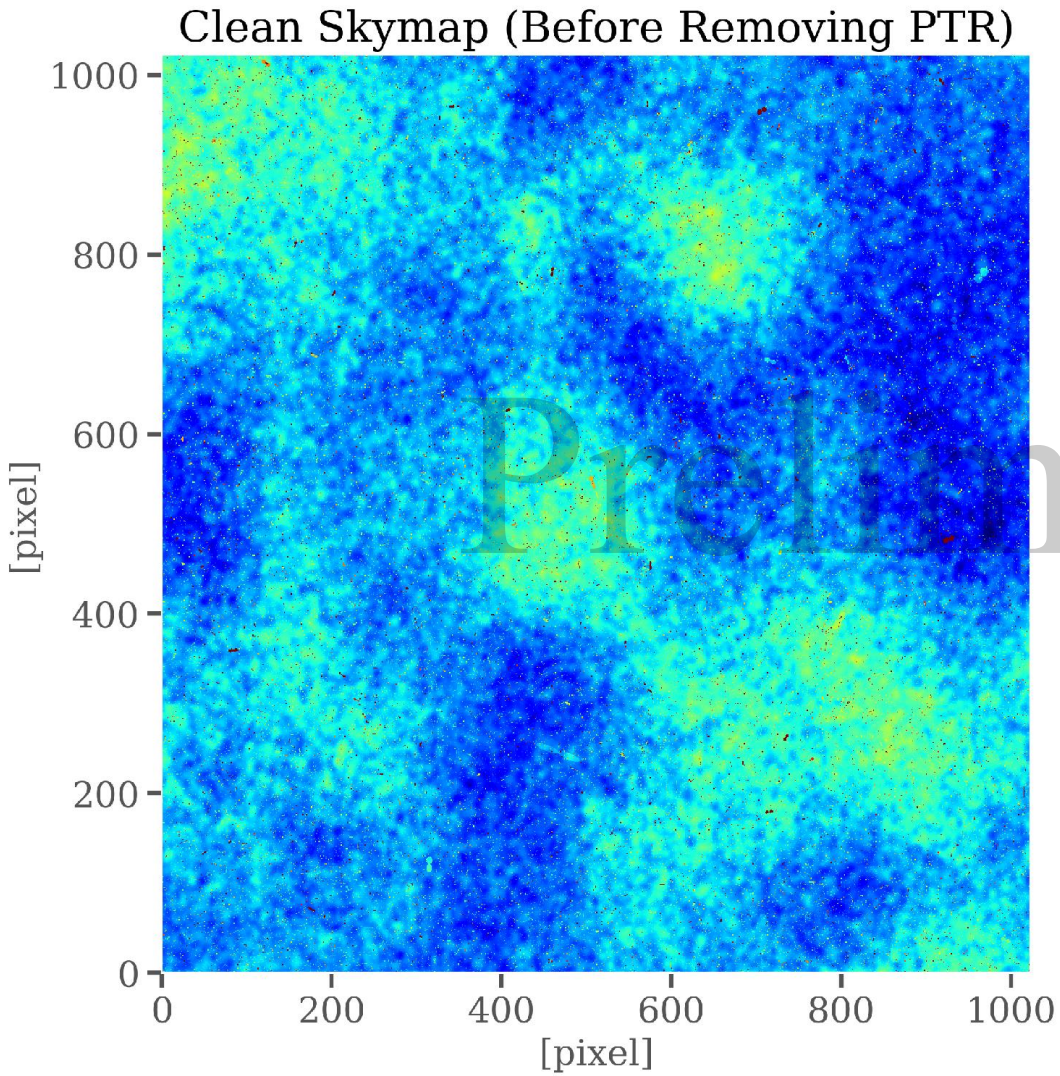
Skymap convolved by the PSF = non-smooth foreground

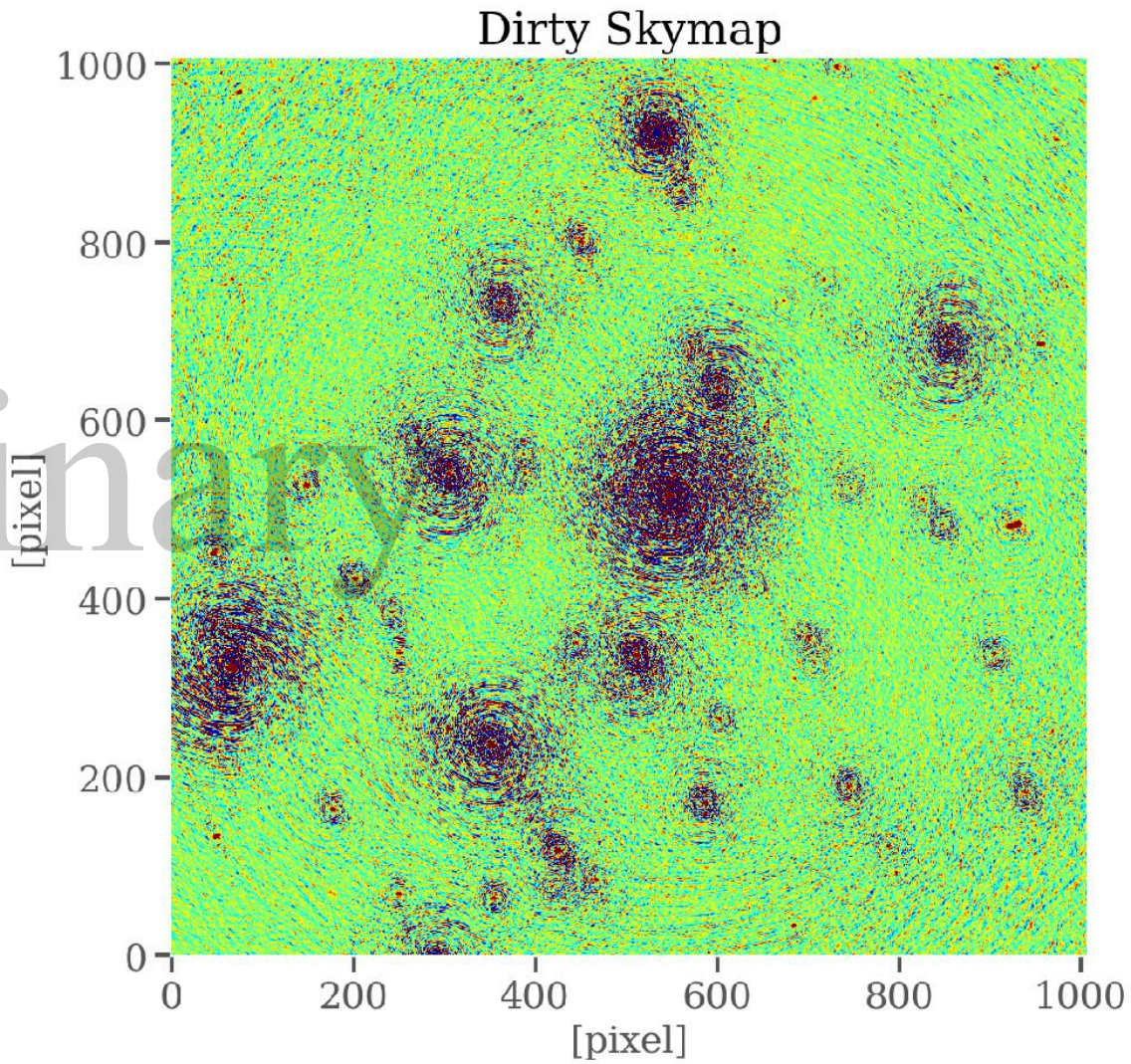




Preliminary

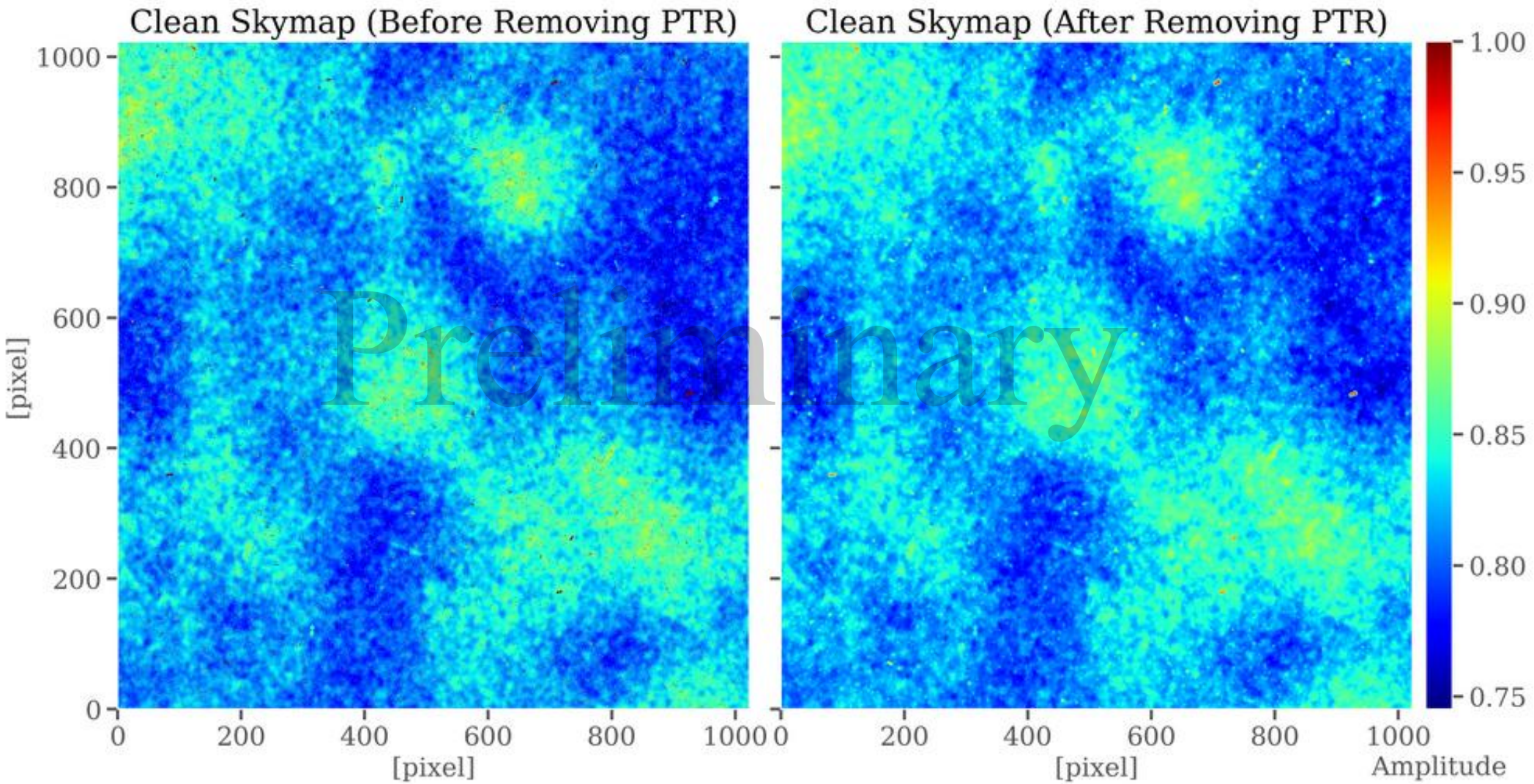
Bright point sources need to be treated before training

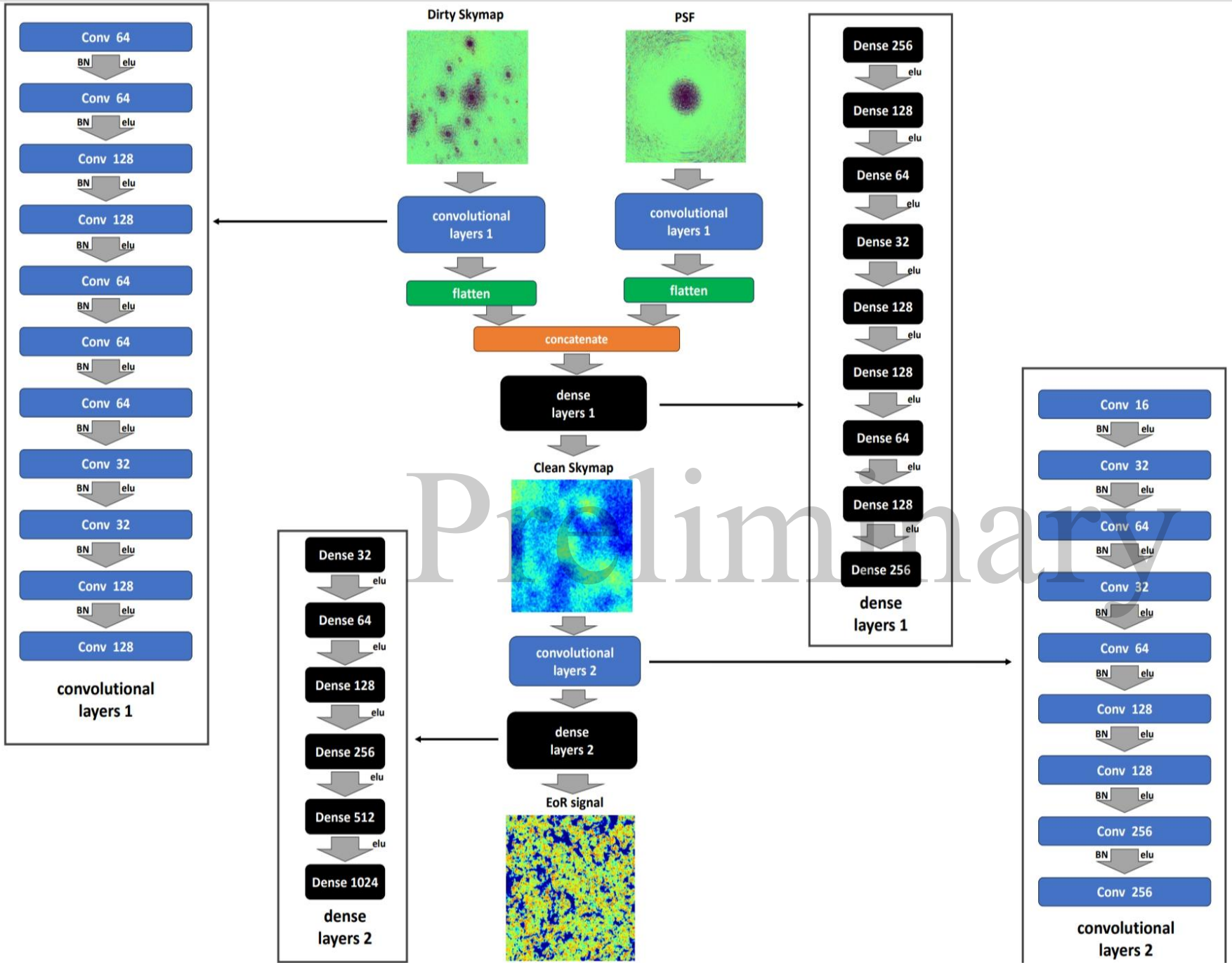




Preliminary

Remove top 1% bright pixels and gaussian smoothing





Preliminary

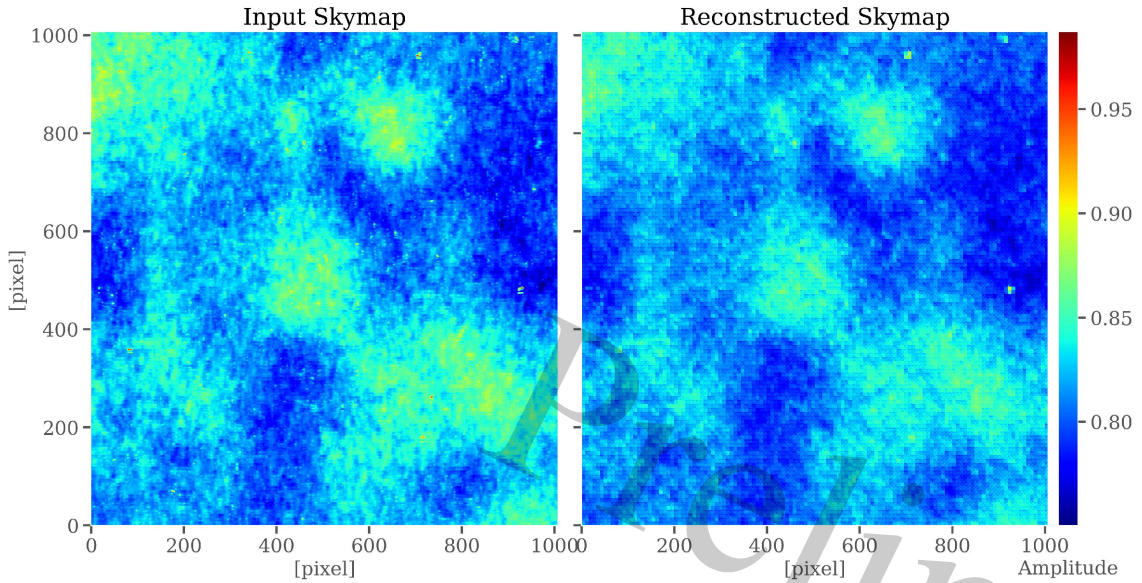
ForkEoR

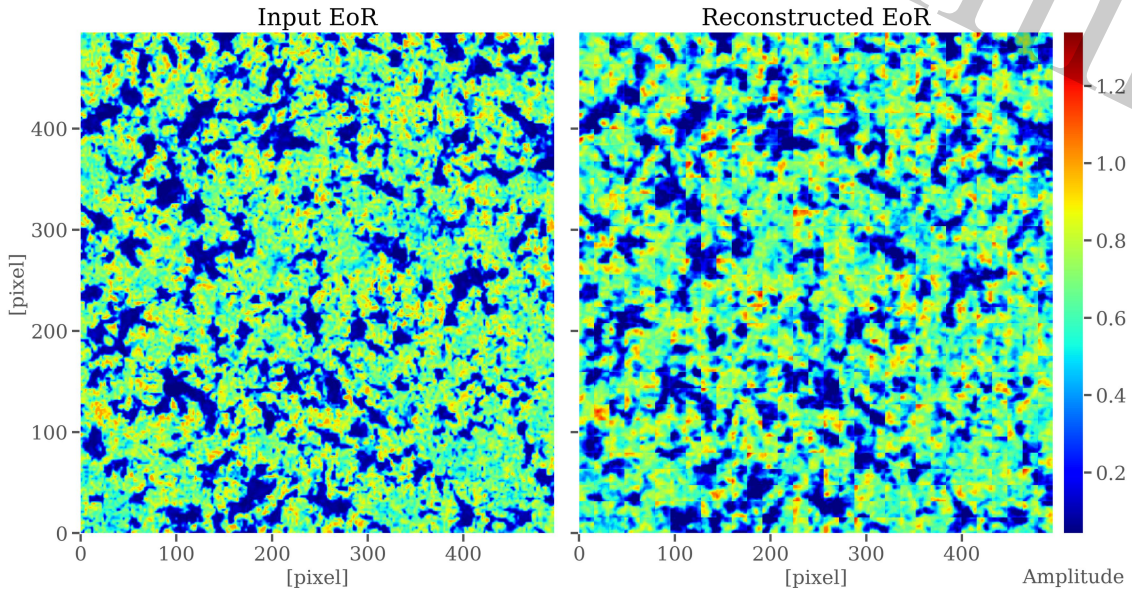
1. Fork like CNN

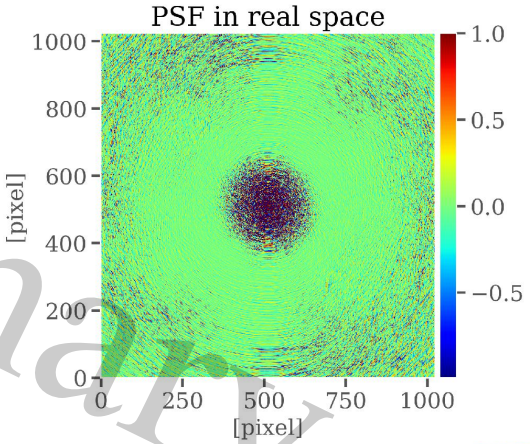
2. CNN foreground removal

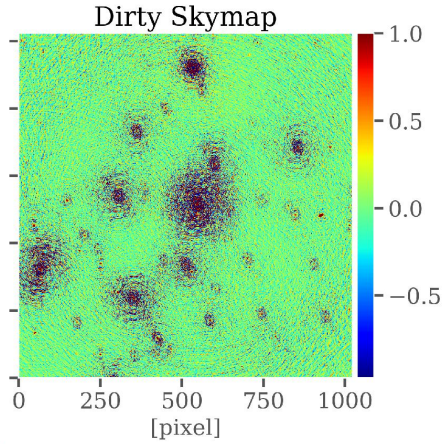
3. training and testing

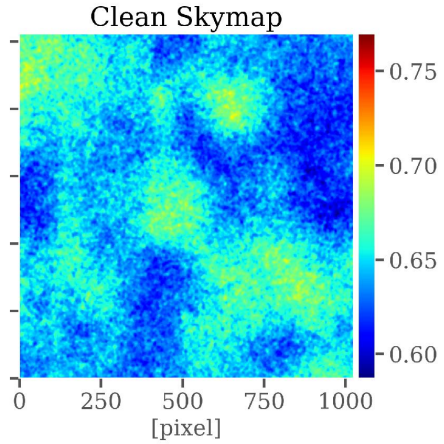
The performance of ForkEoR
Deconvolution: 97%
EoR Reconstruction: 92%



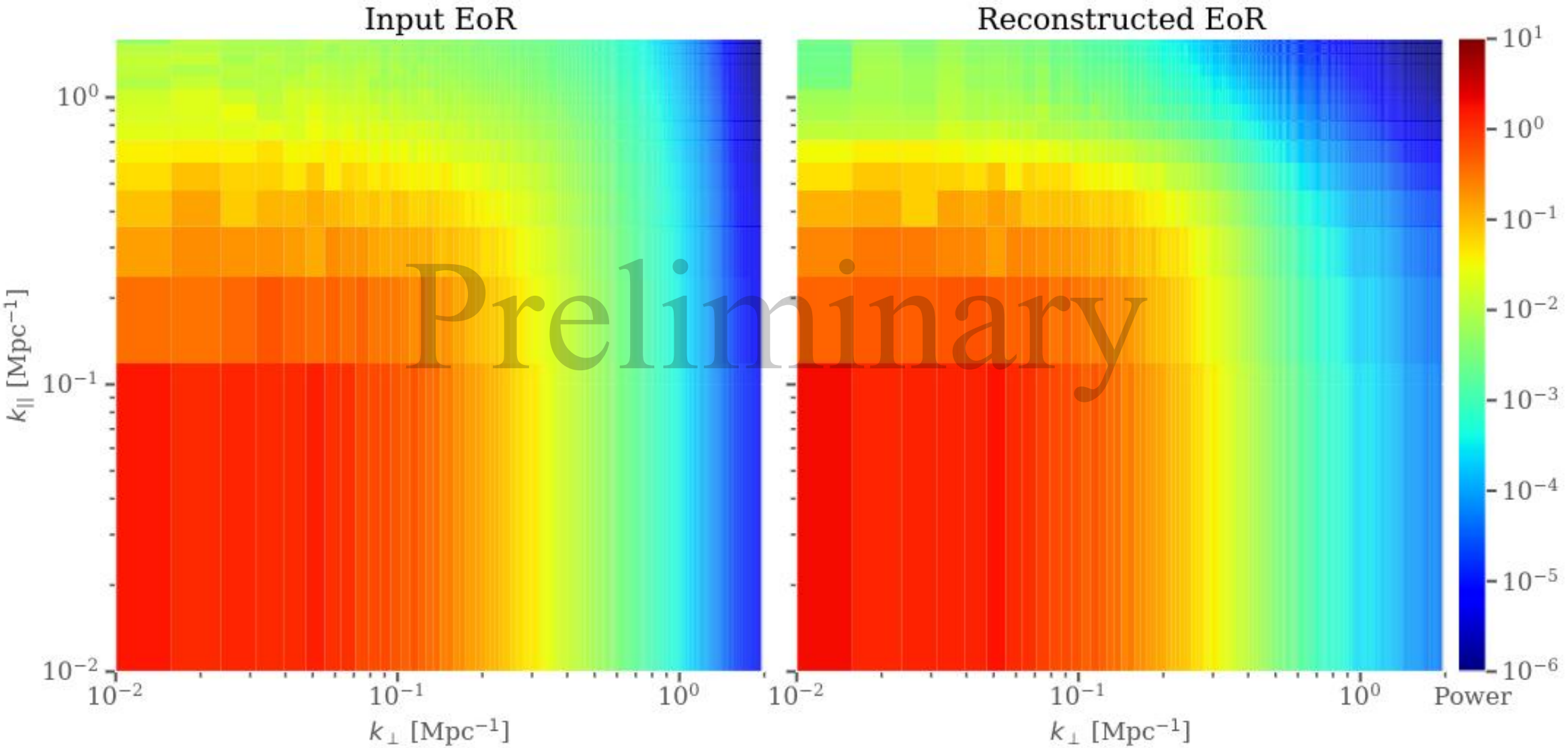








Preliminary


Input EoR
Reconstructed EoR
Preliminary
$k_{\parallel}$ [Mpc^{-1}]
$k_{\perp}$ [Mpc^{-1}]
$k_{\perp}$ [Mpc^{-1}]
Power
10^{0}
10^{-1}
10^{-2}
10^{1}
10^{-3}
10^{-4}
10^{-5}
10^{-6}

What's next?

1. check the overfitting possibility

2. more training, validating and testing sample

3. better End-to-End simulation

4. parallelize ForkEoR for faster training

5. further optimize the parameters of the structure

6. testing correctness by applying to SDC3a data and test robustness with multiple PSFs

What is AI's view of the universe?
This image generated by 文心一格