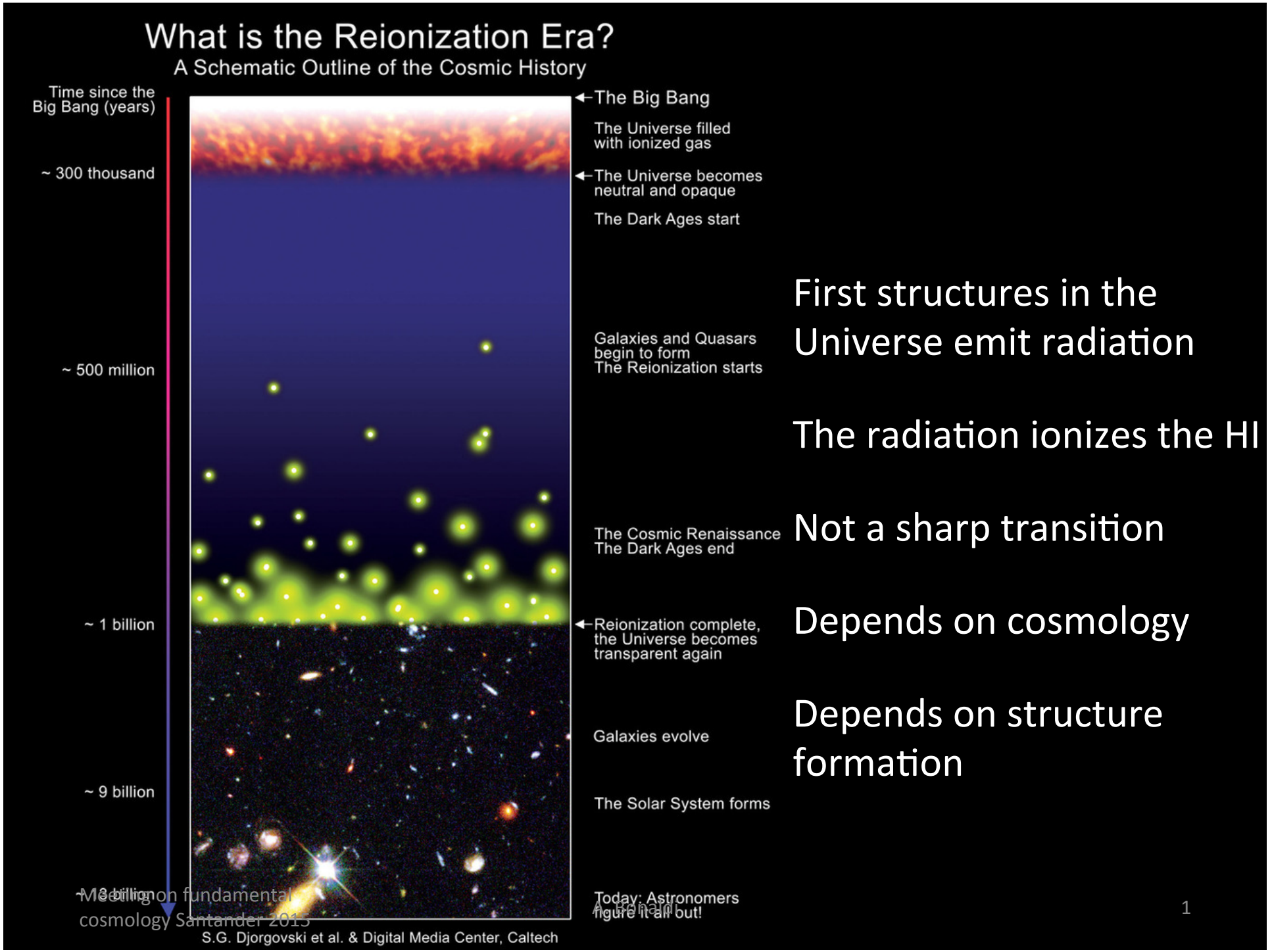
Forecast of foreground removal in SKA

Anna Bonaldi

Jodrell Bank centre for astrophysics



First structures in the Universe emit radiation

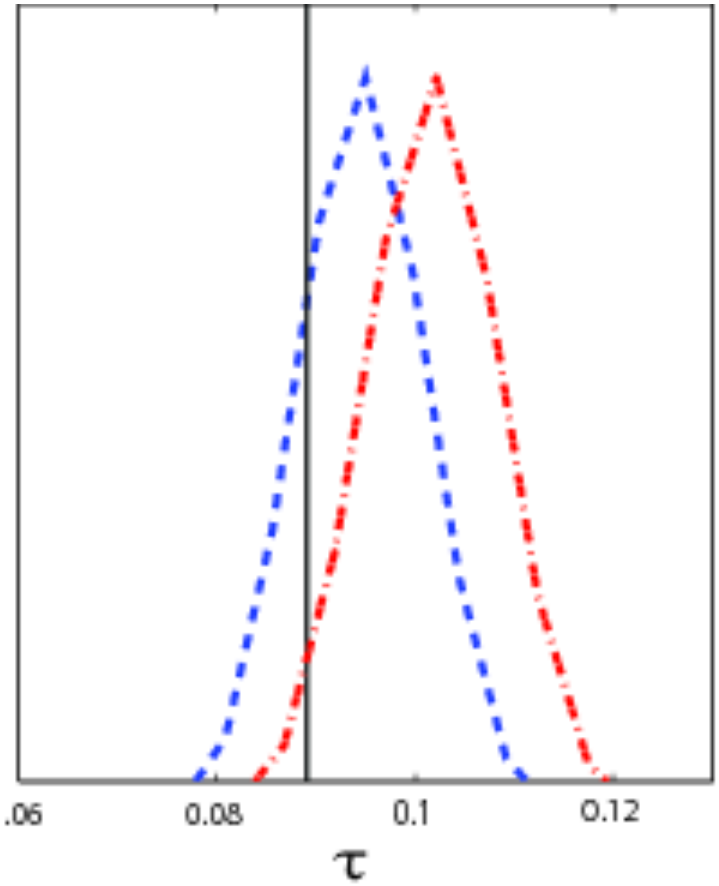
The radiation ionizes the HI

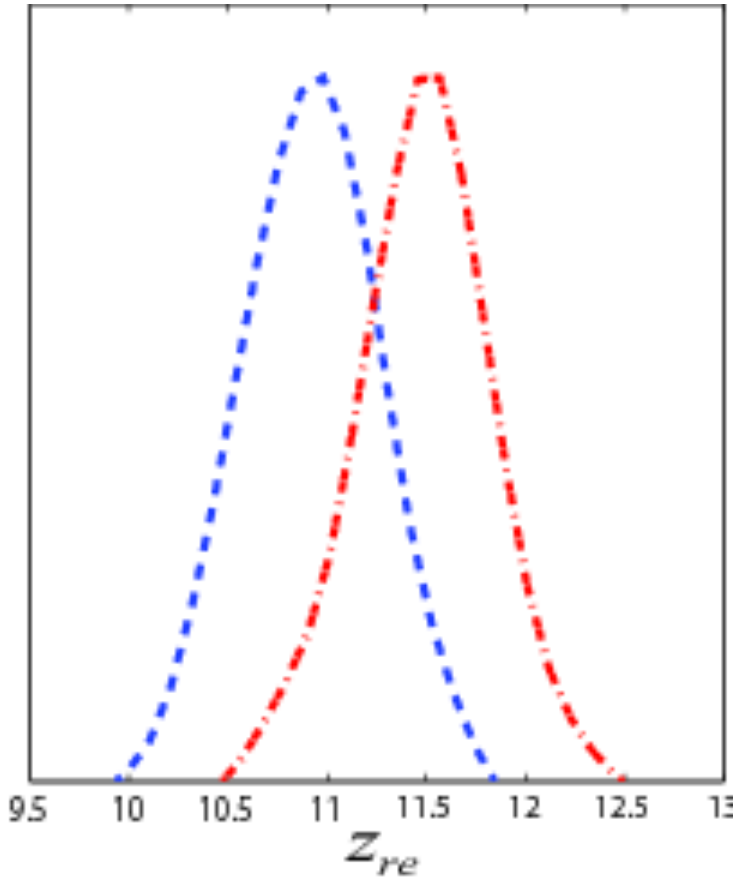
Not a sharp transition

Depends on cosmology

Depends on structure formation

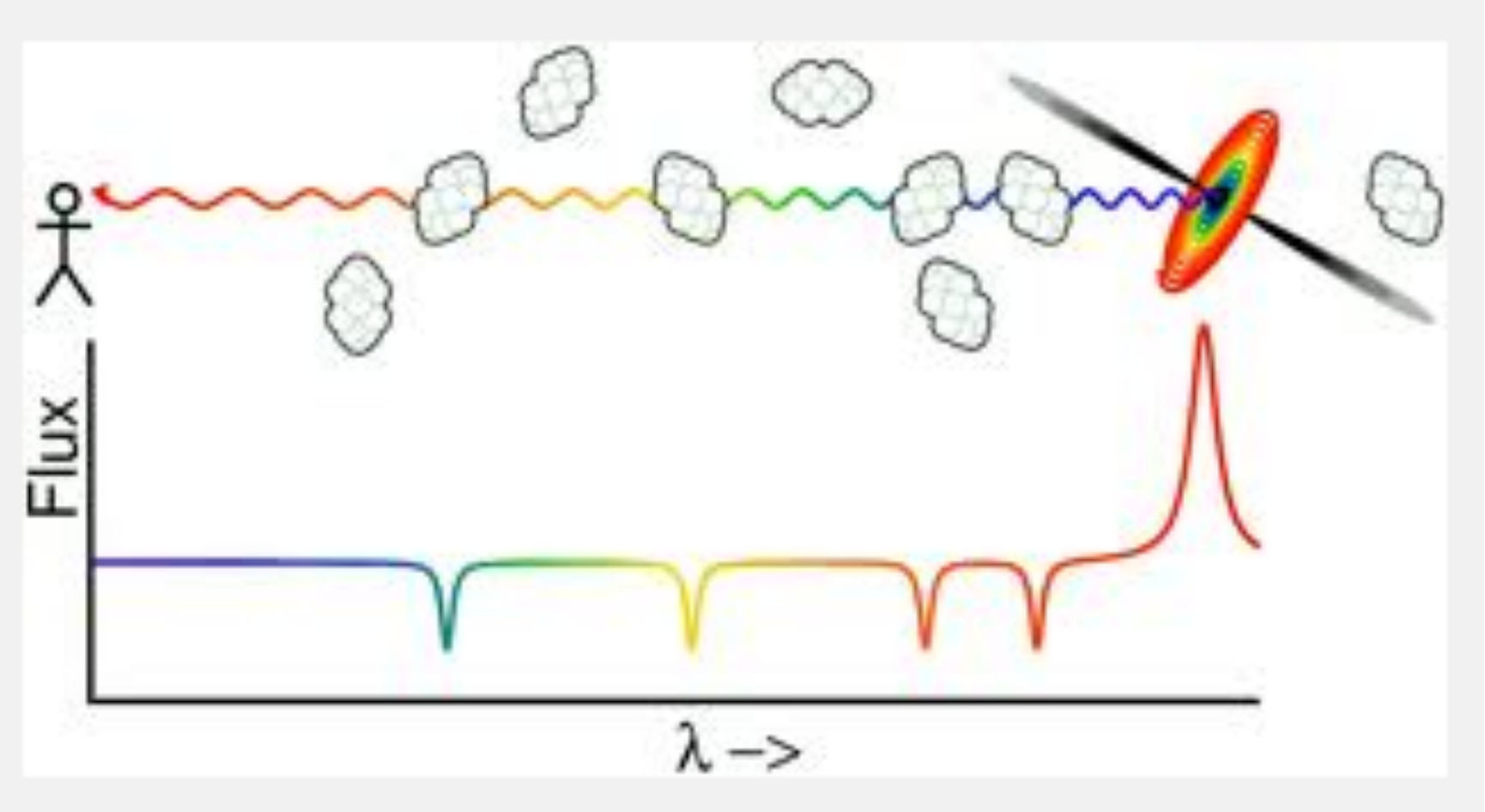
EoR probe 1: CMB





Integral constraint -> no information on history

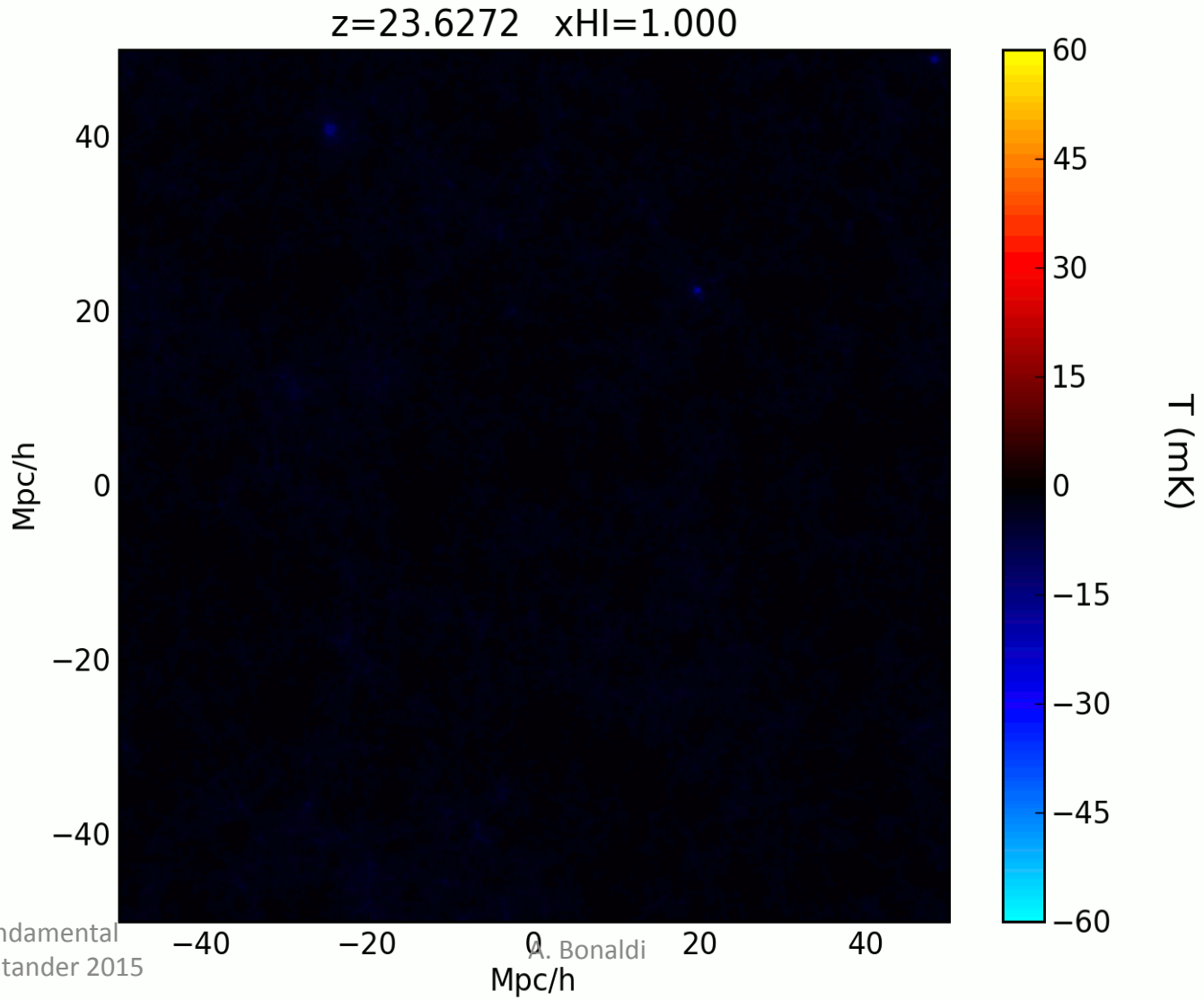
EoR probe2: Ly-a

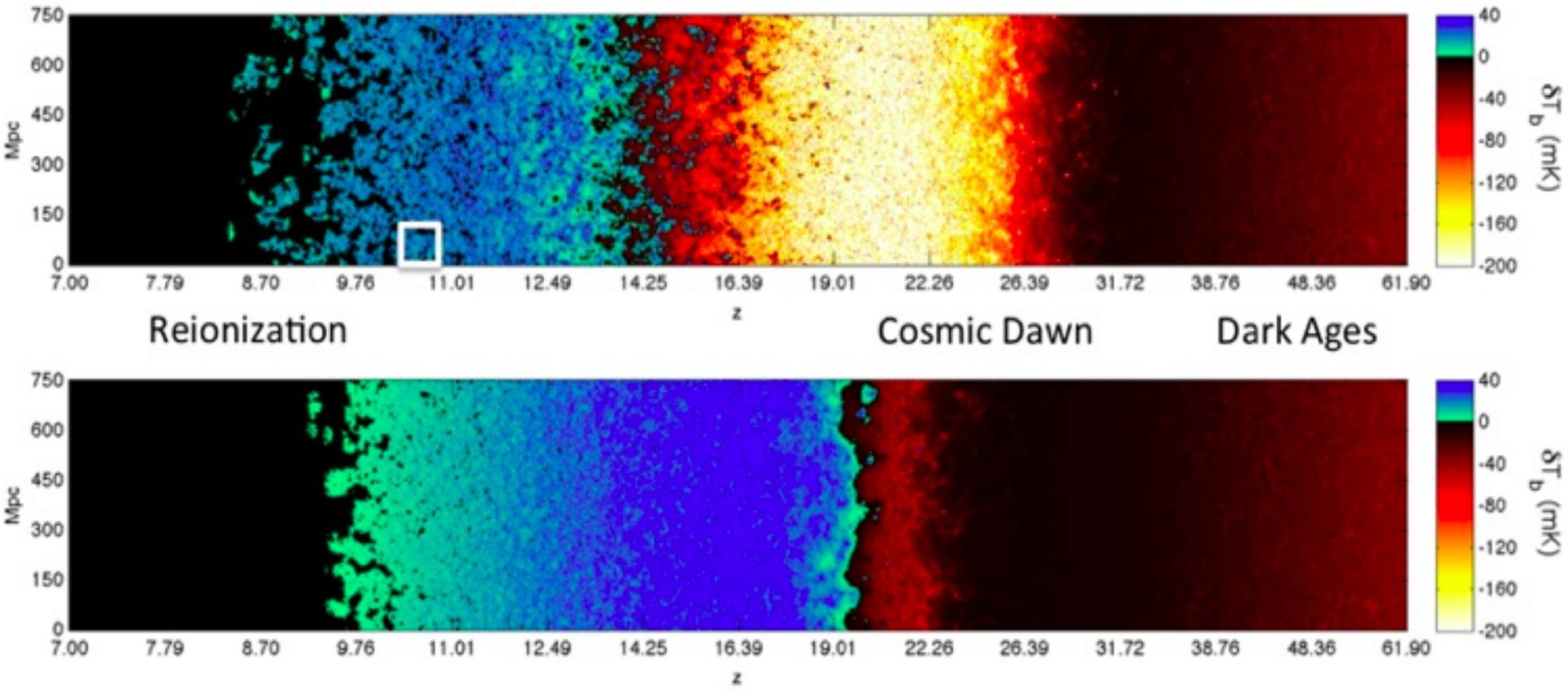


Needs a population of background sources, probes later reionization stages

21cm signal

Redshift maps to frequency! 100-200 MHz for z=13-6




750
600
450
300
150
0
Mpc
7.00
7.79
8.70
9.76
11.01
12.49
14.25
16.39
19.01
22.26
26.39
31.72
38.76
48.36
61.90
z
40
0
-40
-80
-120
-160
-200
δT_b (mK)
Reionization
Cosmic Dawn
Dark Ages

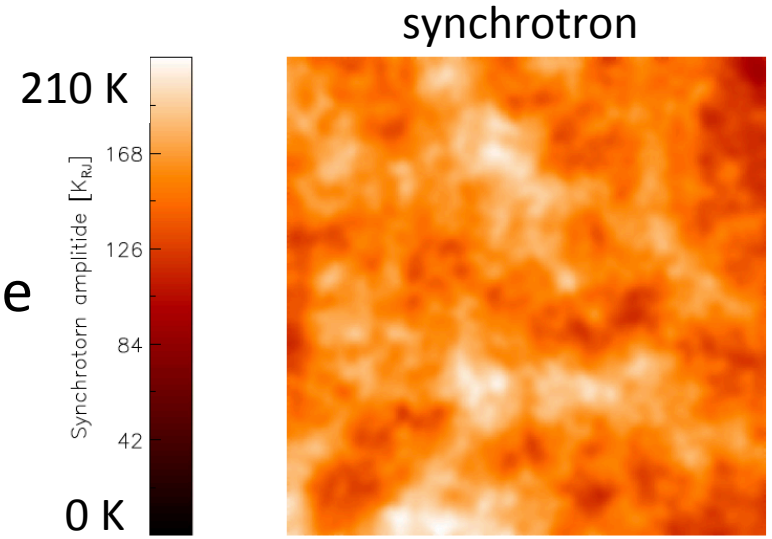
21cm challenges

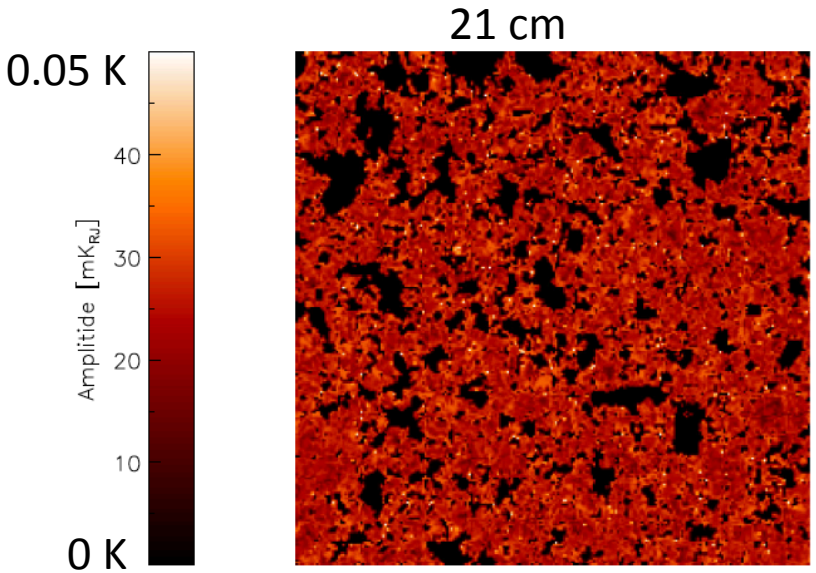
- 21 cm signal rms ~10 mK -> SKA sensitivity
- Radio sky is very bright:
  - diffuse emission
    - Synchrotron – 4 orders of magnitude stronger
    - Free-free – still stronger than HI
  - extragalactic radio sources
    - resolved: point-like
    - unresolved: background

Diffuse foreground removal

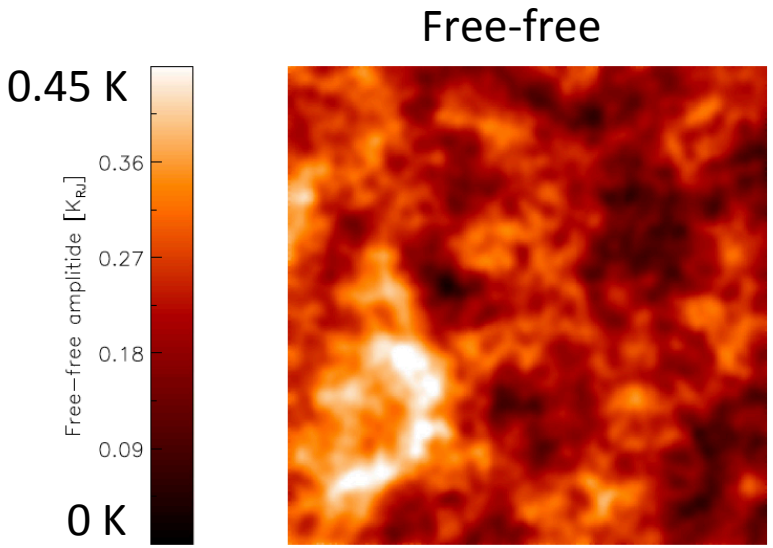
Bonaldi & Brown 2015 MNRAS

- SKA simulation
- HI + diffuse synchrotron and free-free

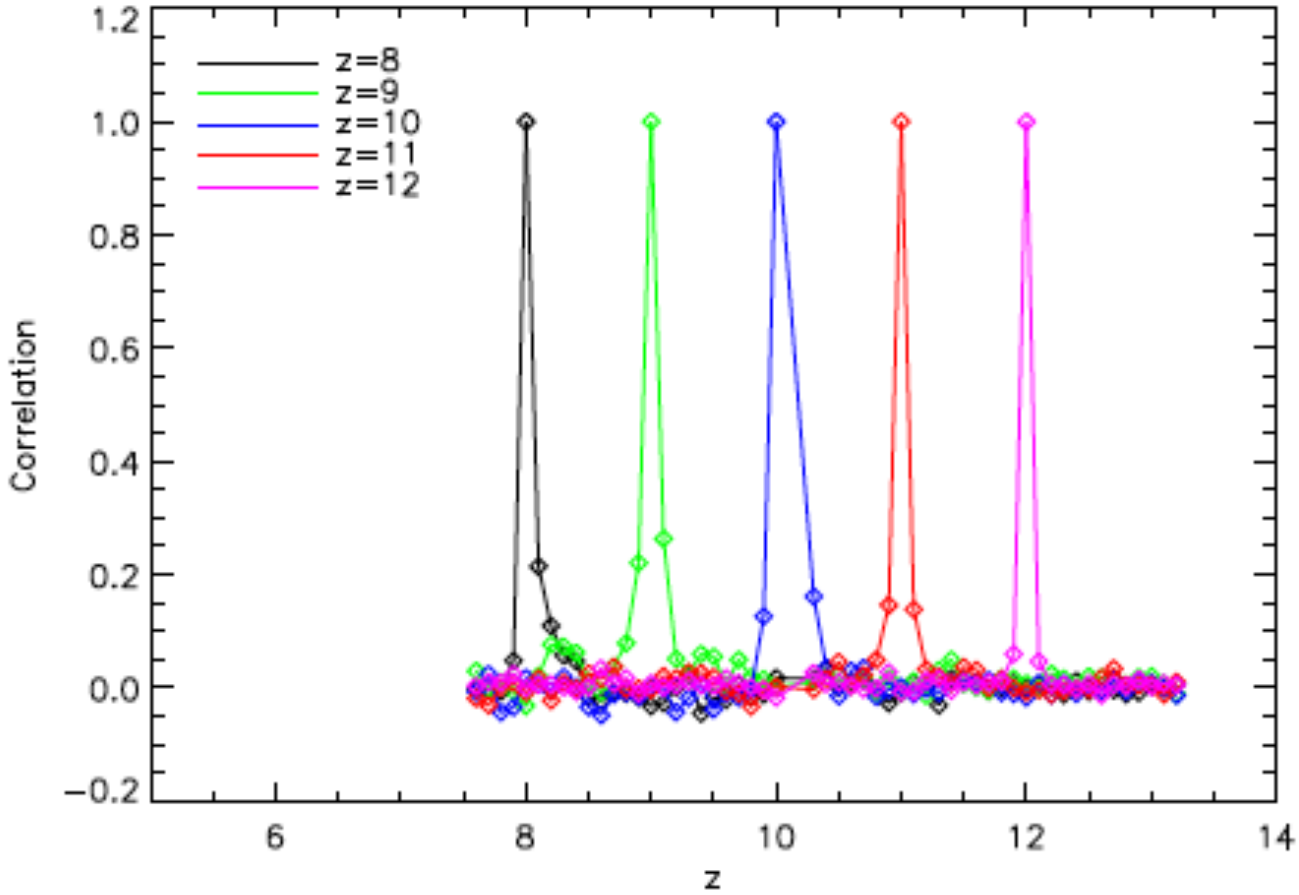




. Bonaldi

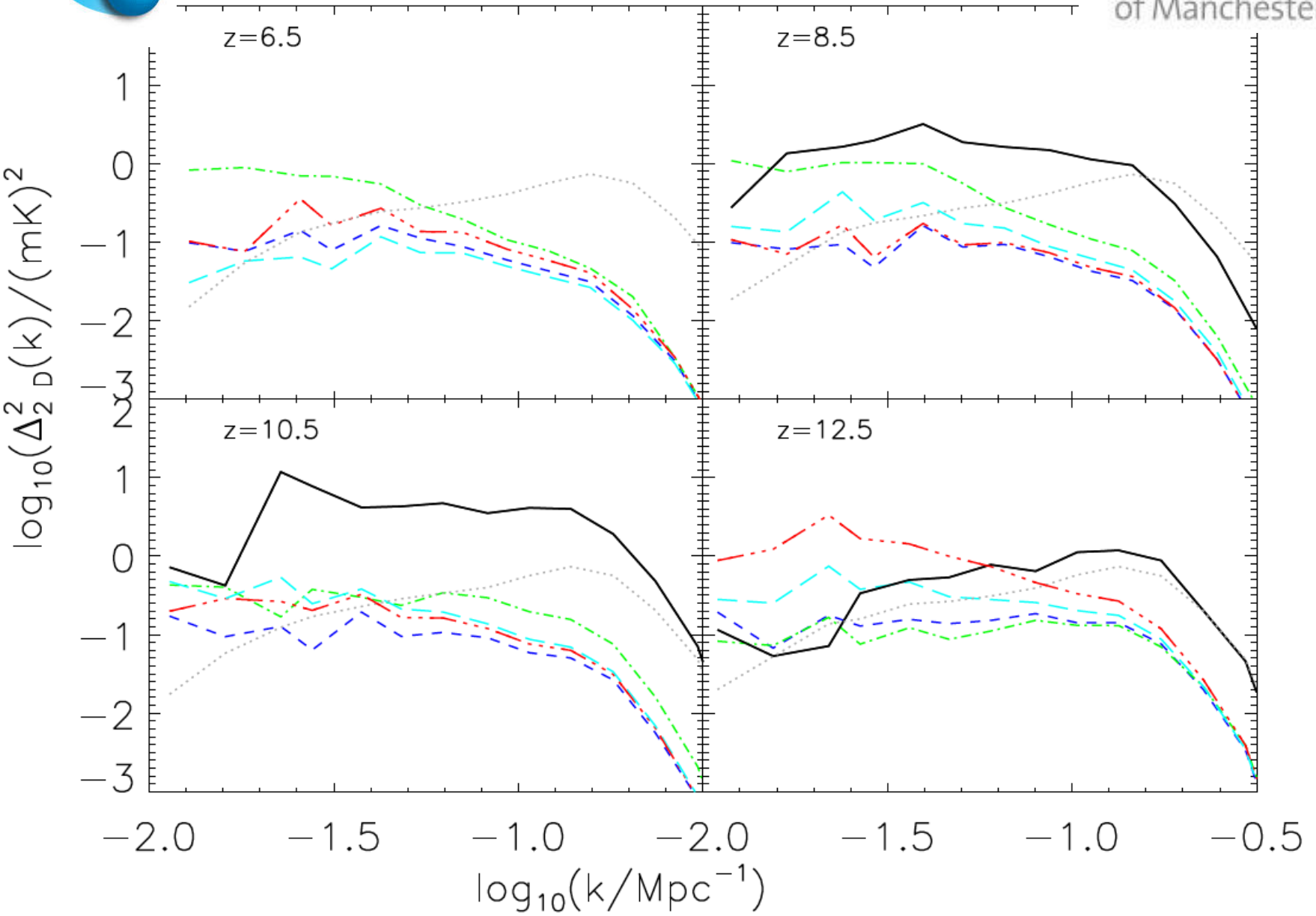


Bonaldi & Brown 2015 MNRAS

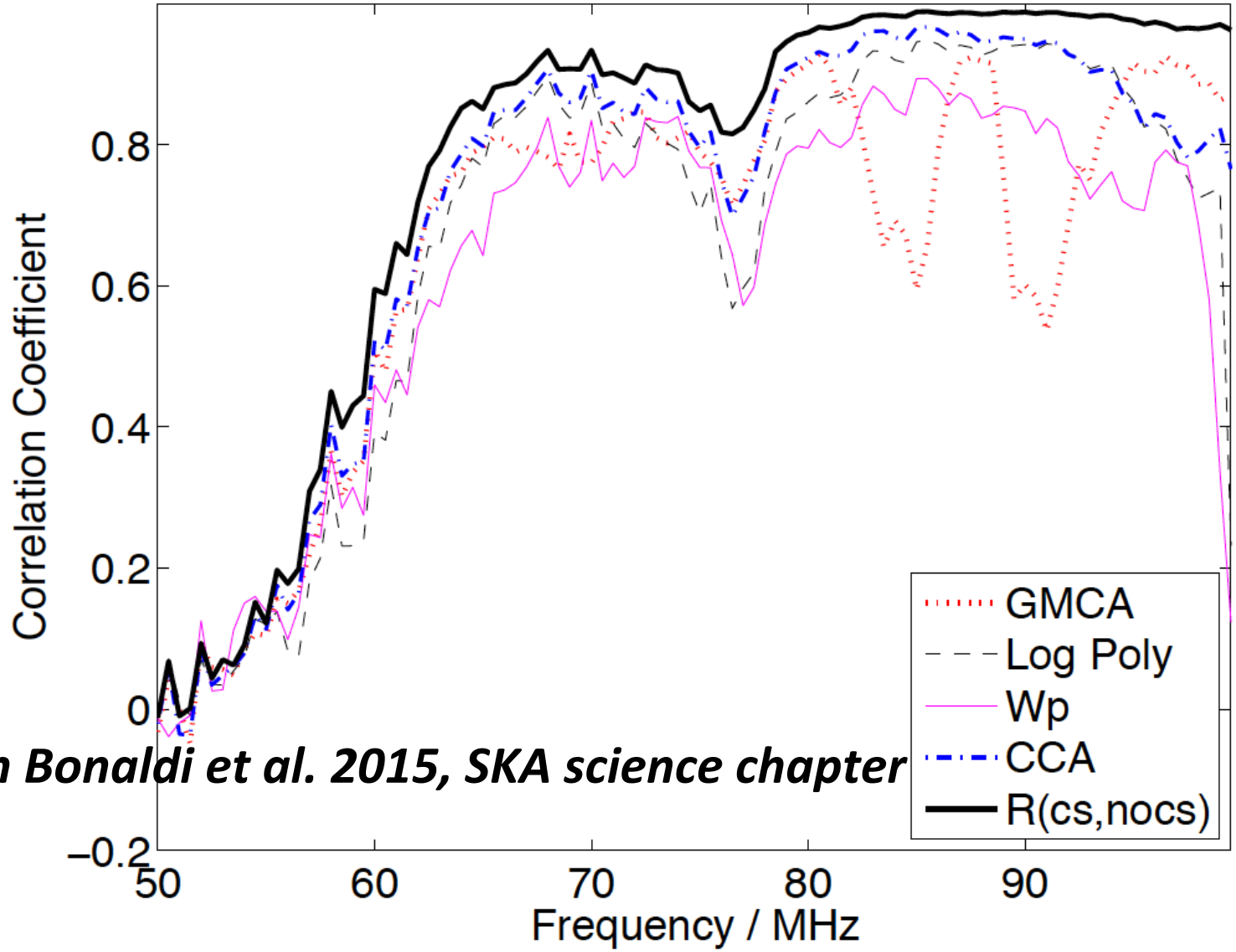


- Correlated Component Analysis (CCA) component separation method
- Estimate frequency spectrum of foregrounds
- Reconstruct foreground maps
- Subtract foregrounds

Cleaning performance



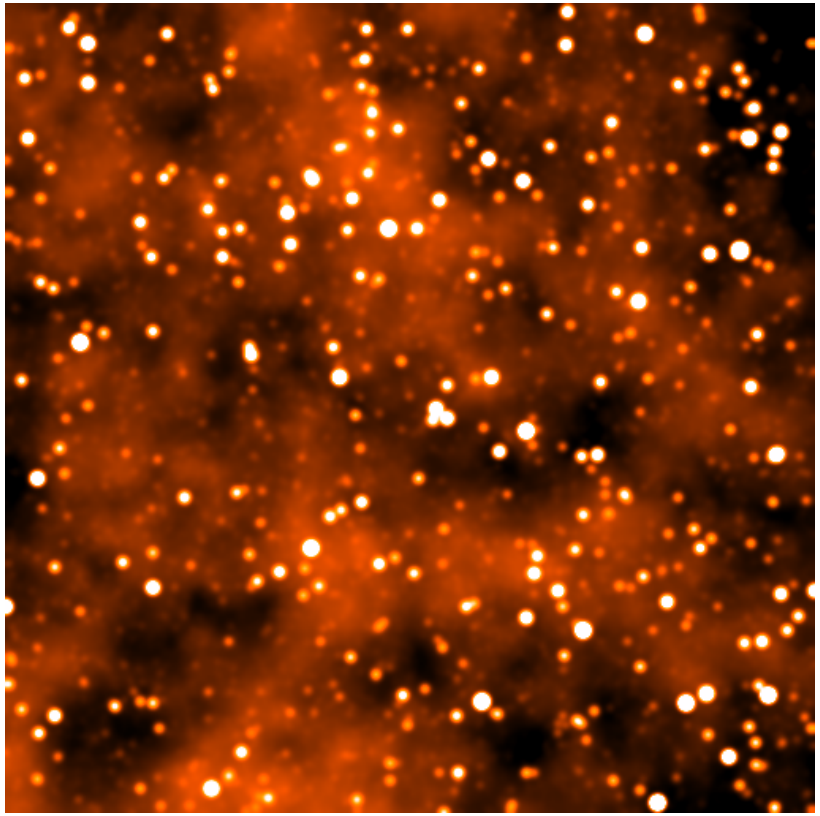
Cleaning performance

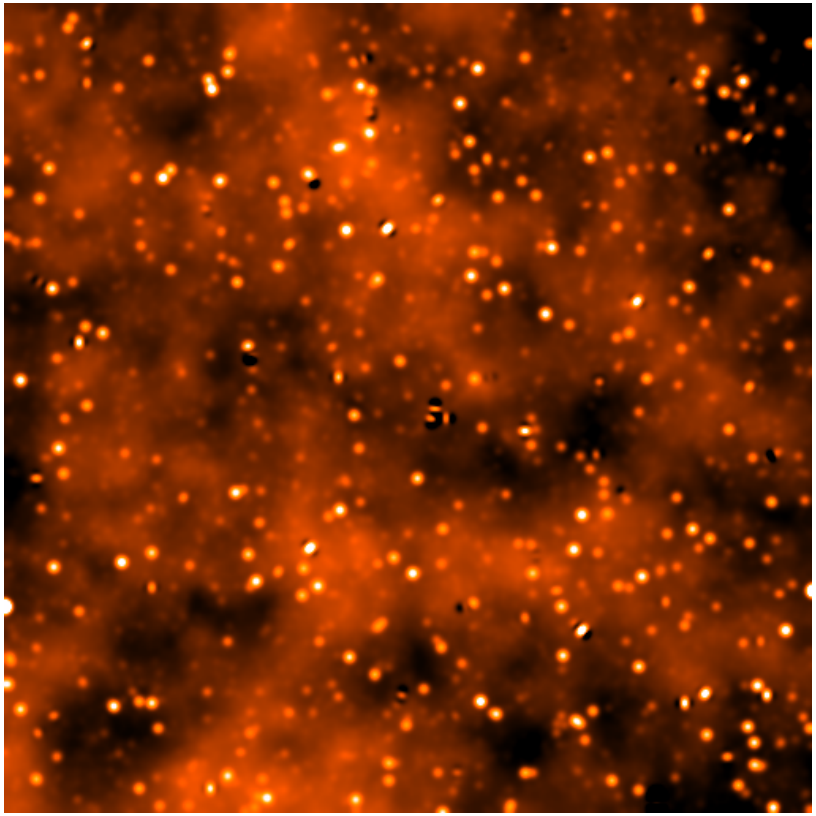


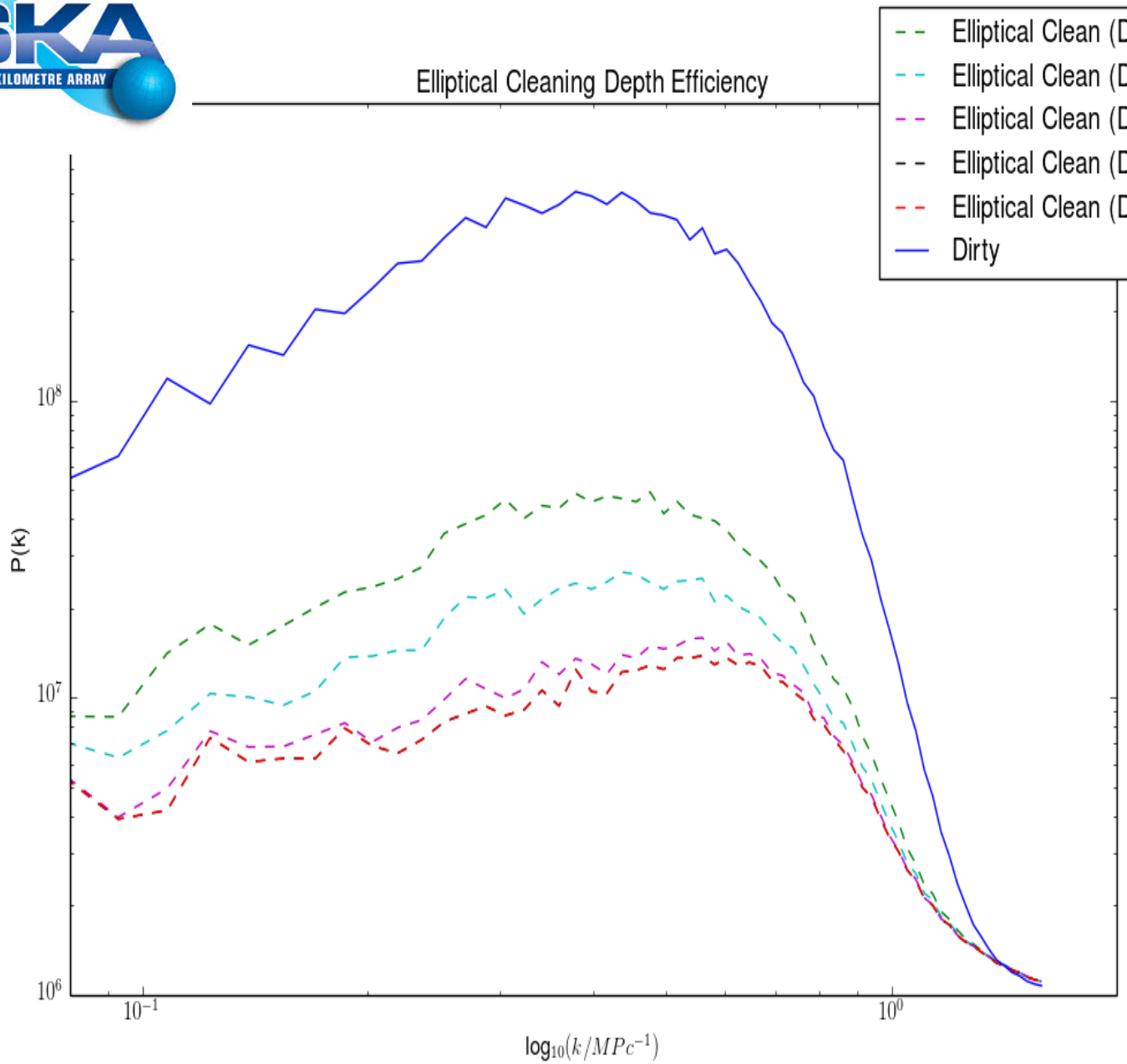
Chapman Bonaldi et al. 2015, SKA science chapter

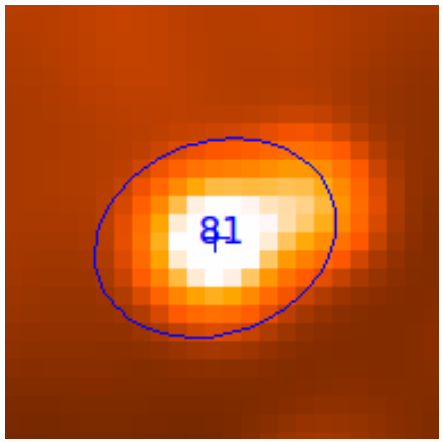
Removal of bright point sources

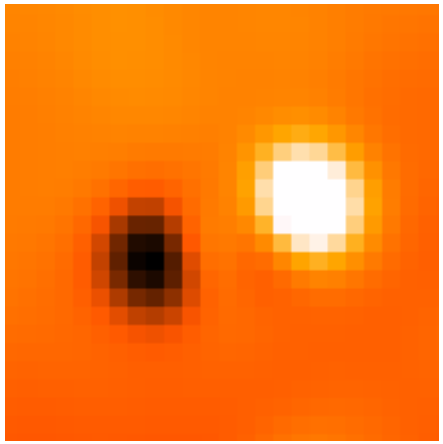
Eames, Bonaldi et al. work in progress






Elliptical Cleaning Depth Efficiency
Elliptical Clean (Depth 20)
Elliptical Clean (Depth 50)
Elliptical Clean (Depth 100)
Elliptical Clean (Depth 200)
Elliptical Clean (Depth 350)
Dirty
P(k)
10^8
10^7
10^6
10^{-1}
10^0
$\log_{10}(k/MPc^{-1})$


81



Conclusions

- SKA allows accurate detection and imaging of 21cm reionization signal
- Subtraction of diffuse and point-like radio foregrounds is crucial
- Developing a full pipeline:
  - Diffuse foreground removal: among the best methods developed so far
  - Subtraction of bright point sources: work in progress