The Experimental Challenge of 21 cm Observations

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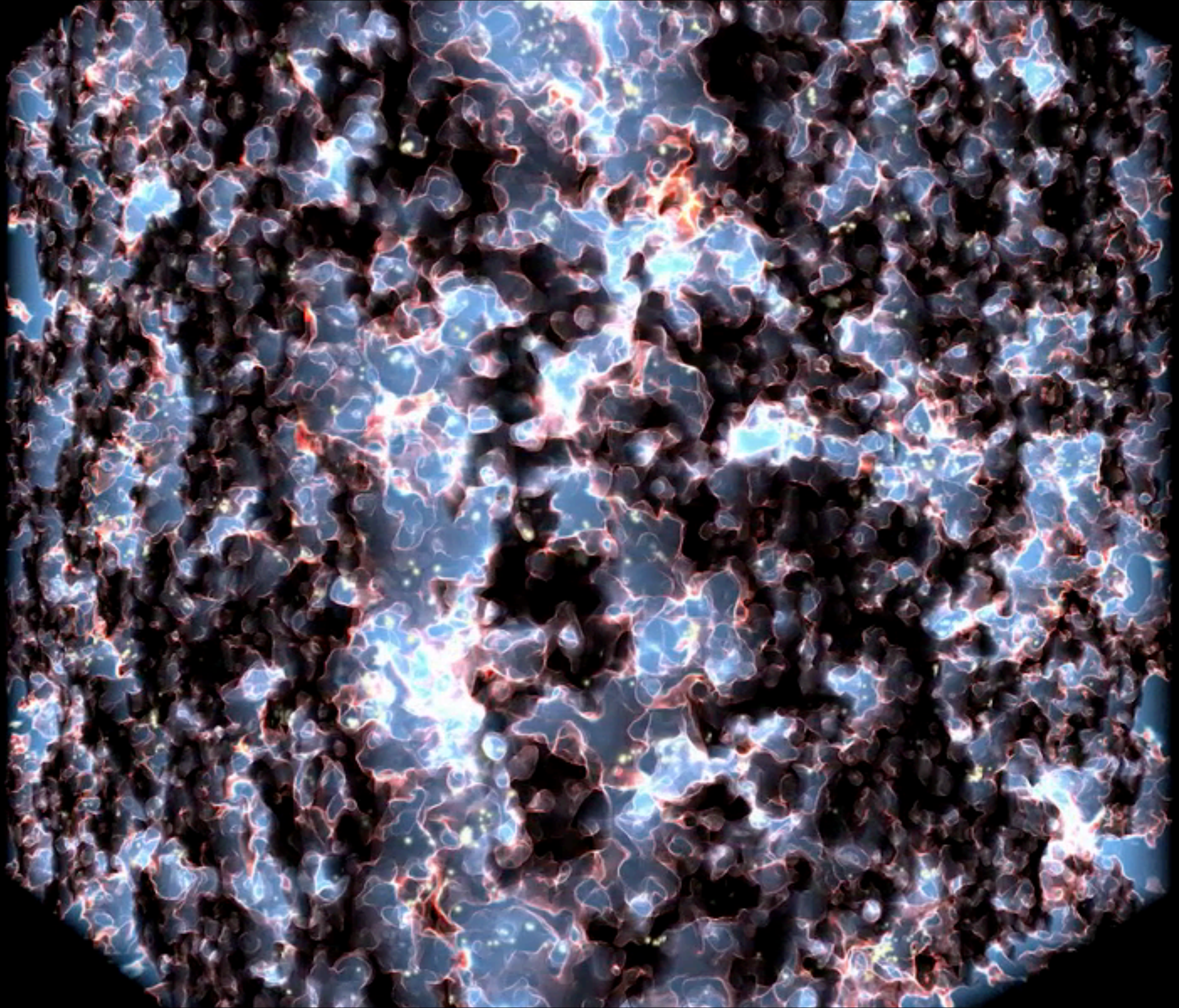
EoR: PAPER, LOFAR, MWA, HERA

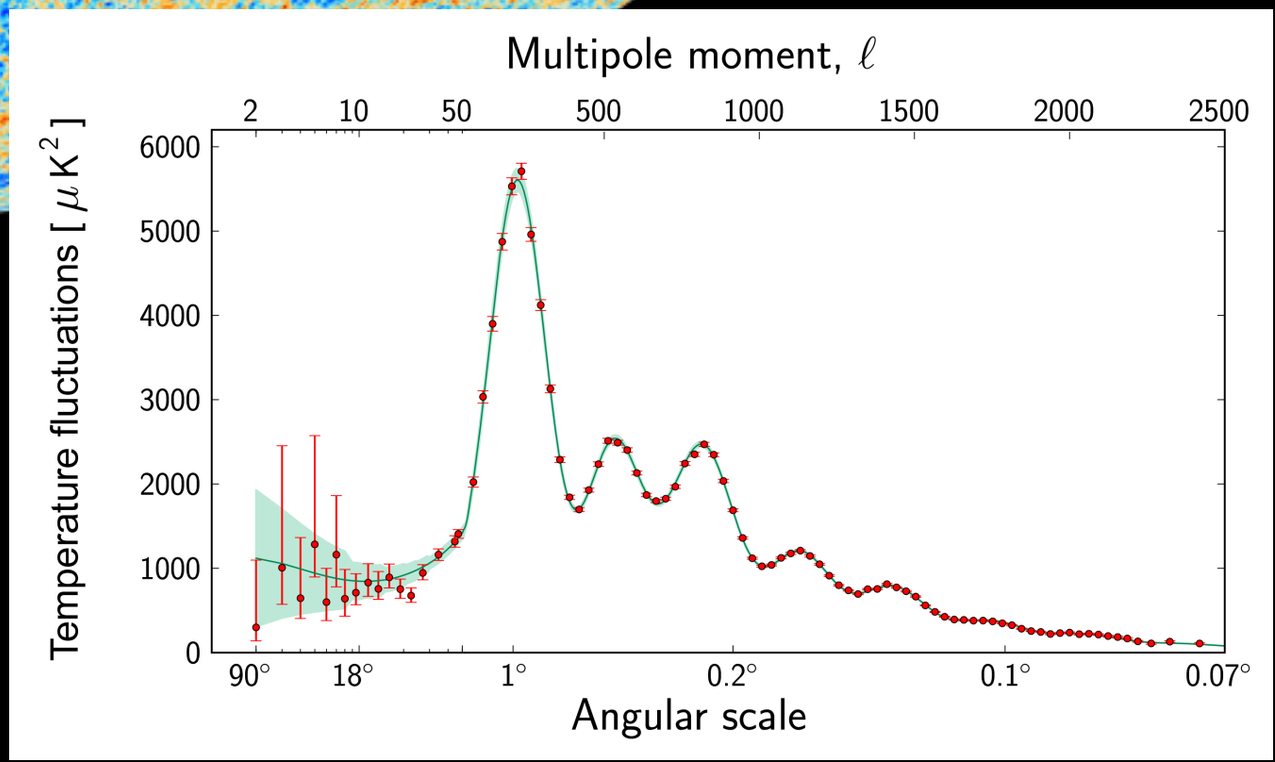
Dark Energy: CHIME, HIRAX

COMAP

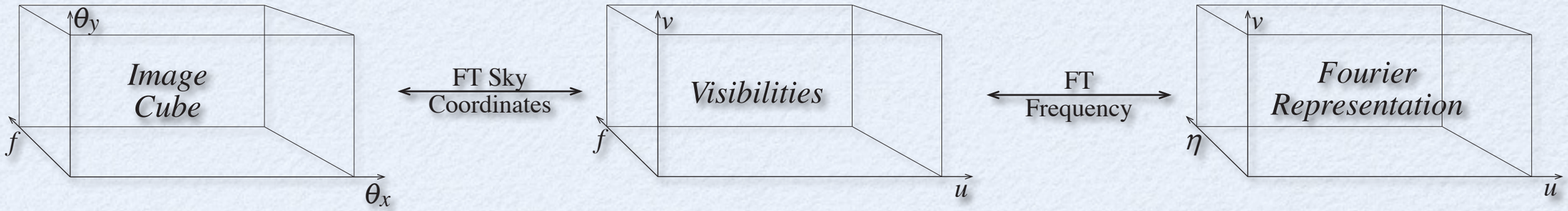
Carbon Monoxide intensity mapping to study star formation at z= 2.4-2.8 and reionization



CMB

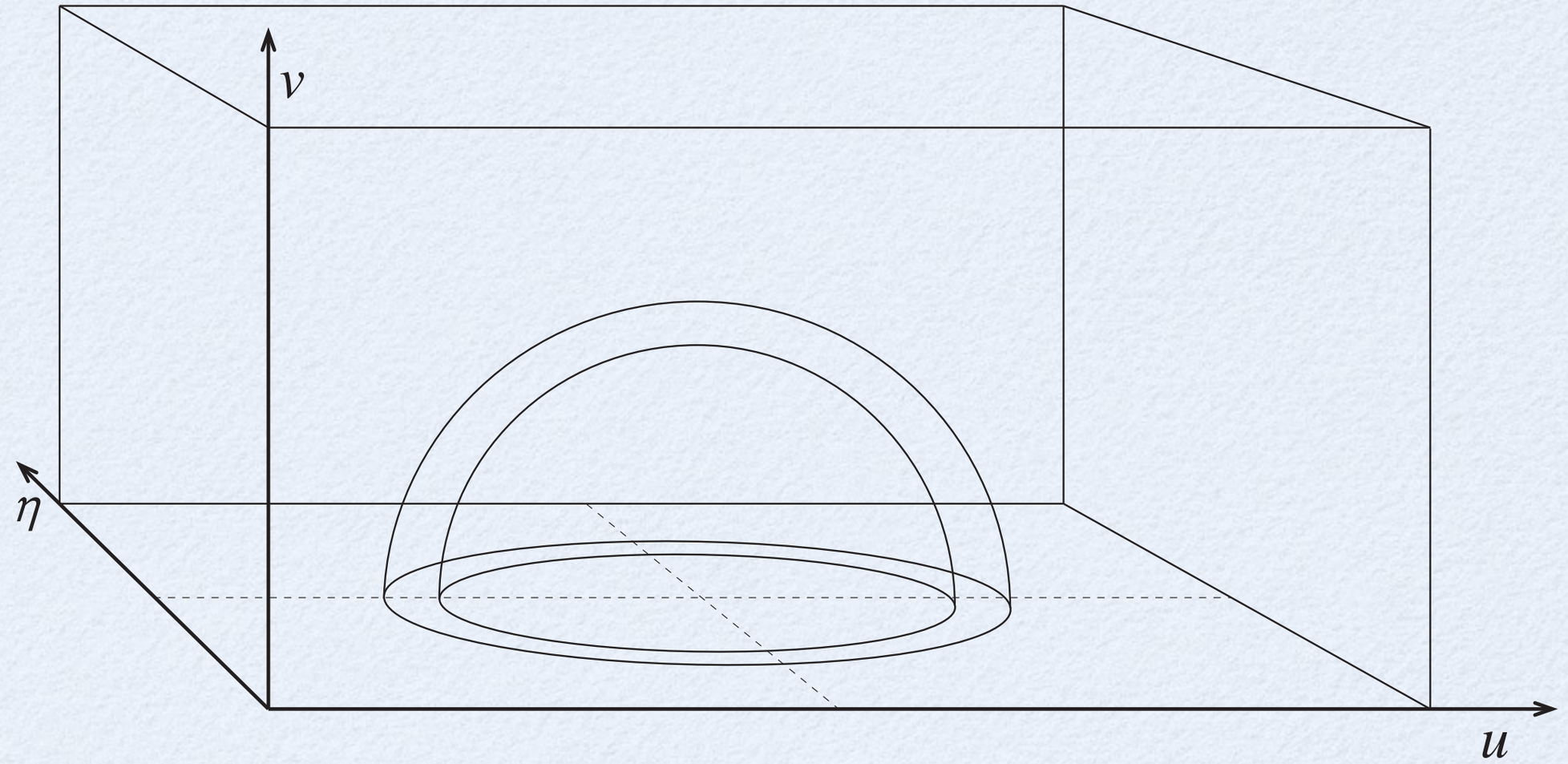

Multipole moment, ℓ
2
10
50
500
1000
1500
2000
2500
Temperature fluctuations [μ K^2]
6000
5000
4000
3000
2000
1000
0
90°
18°
1°
0.2°
0.1°
0.07°
Angular scale

Statistical EoR detection



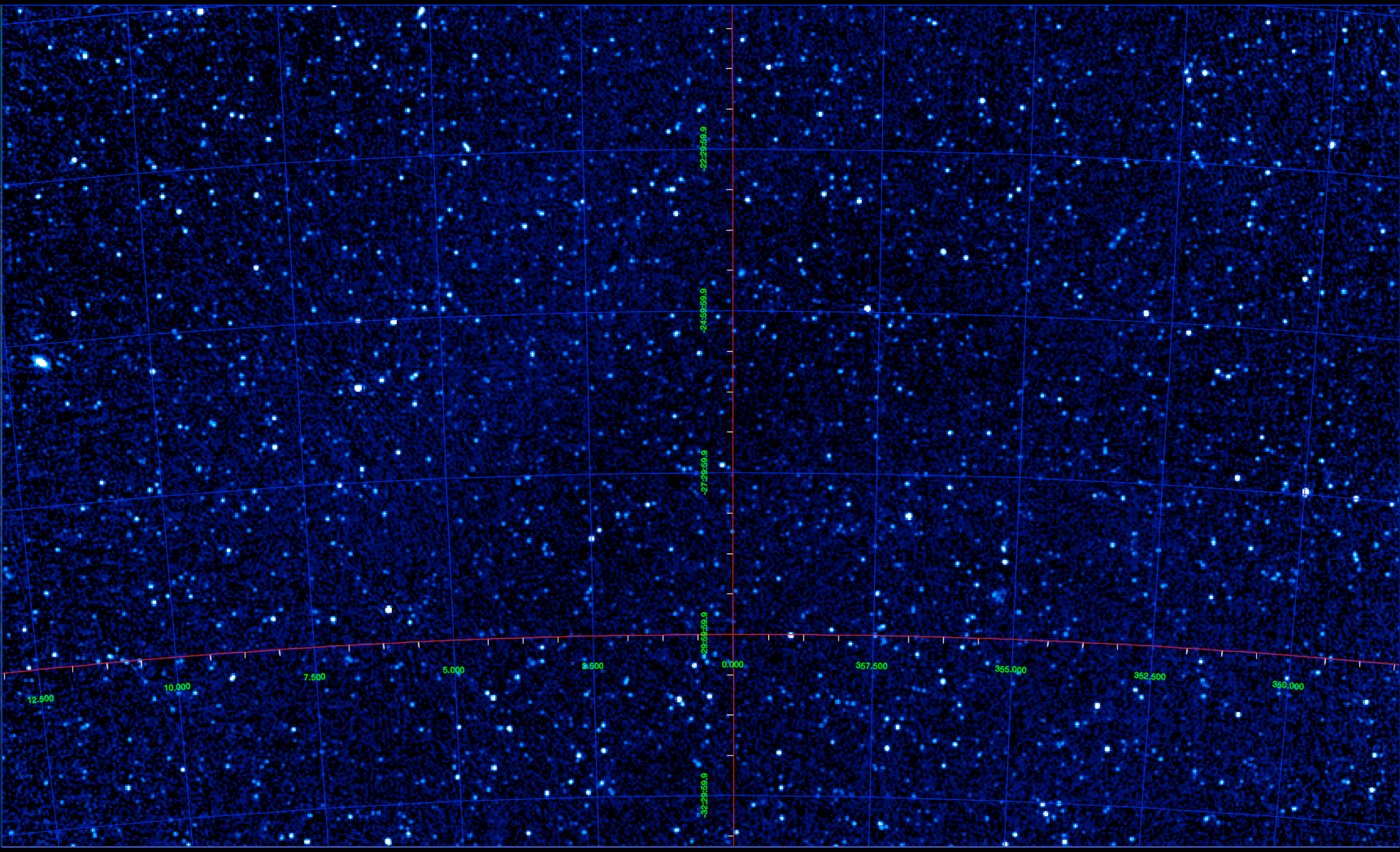
Morales & Hewitt (2004)

Spherical symmetry



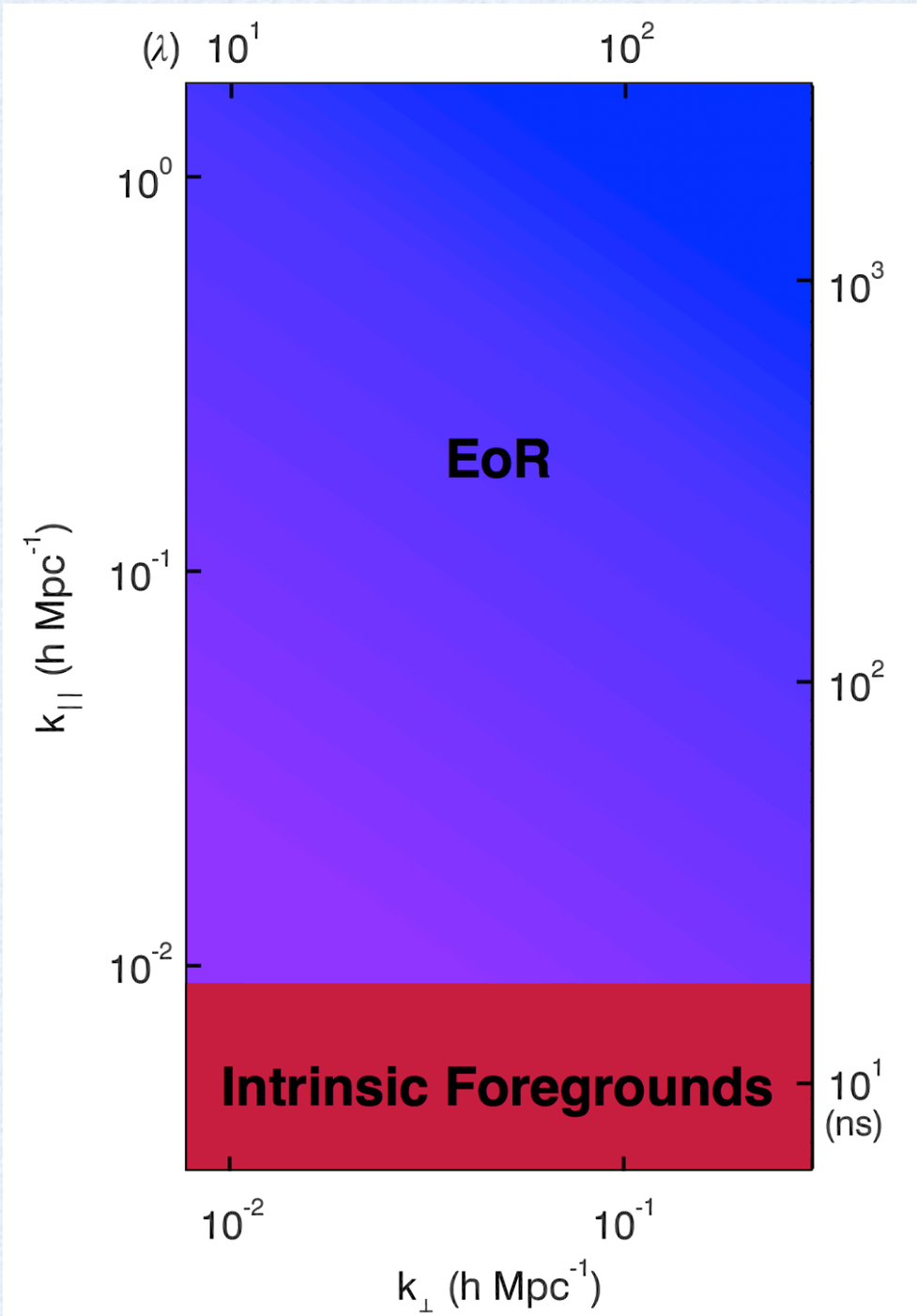
Morales & Hewitt (2004)

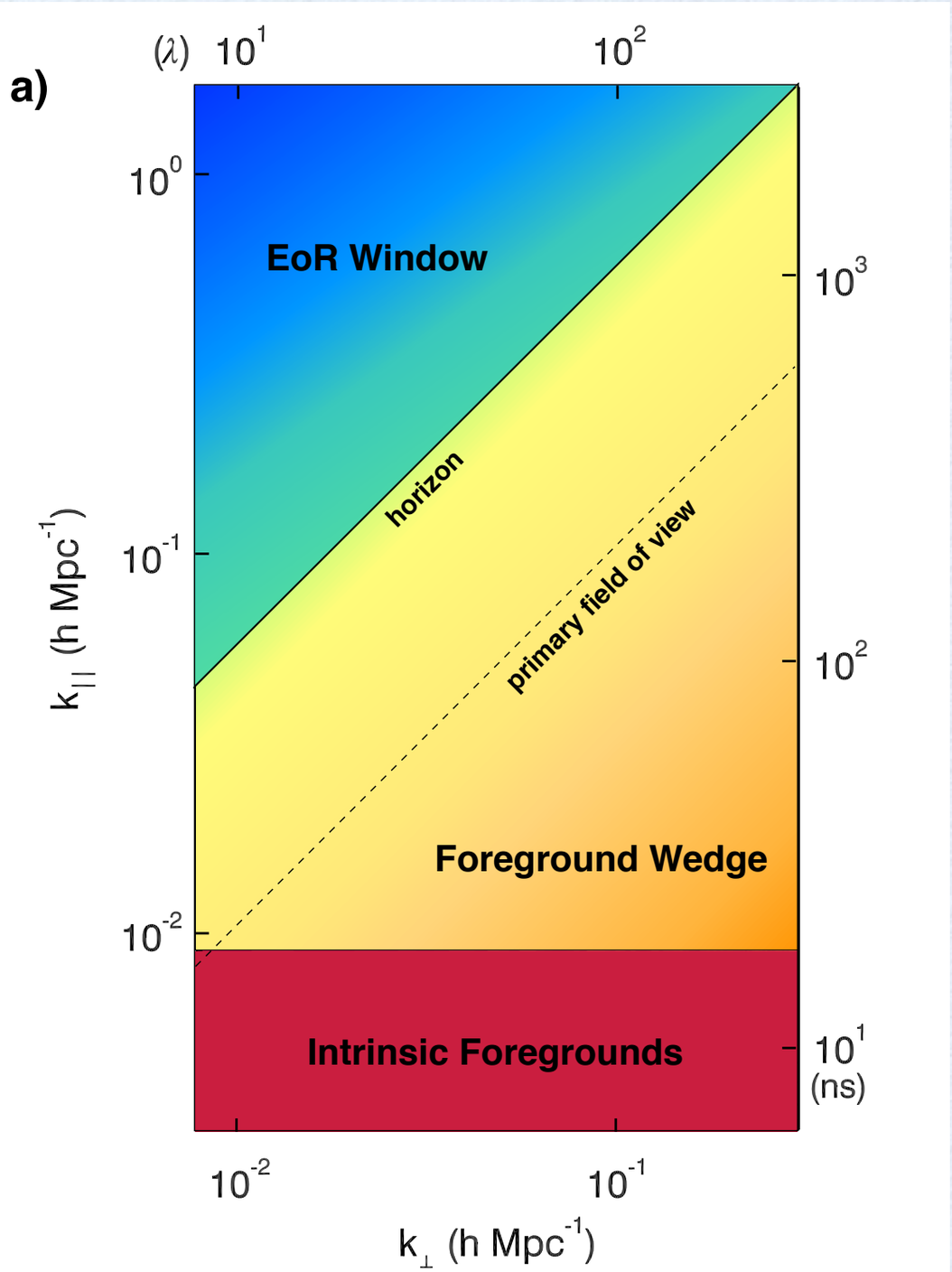
Moon to scale 



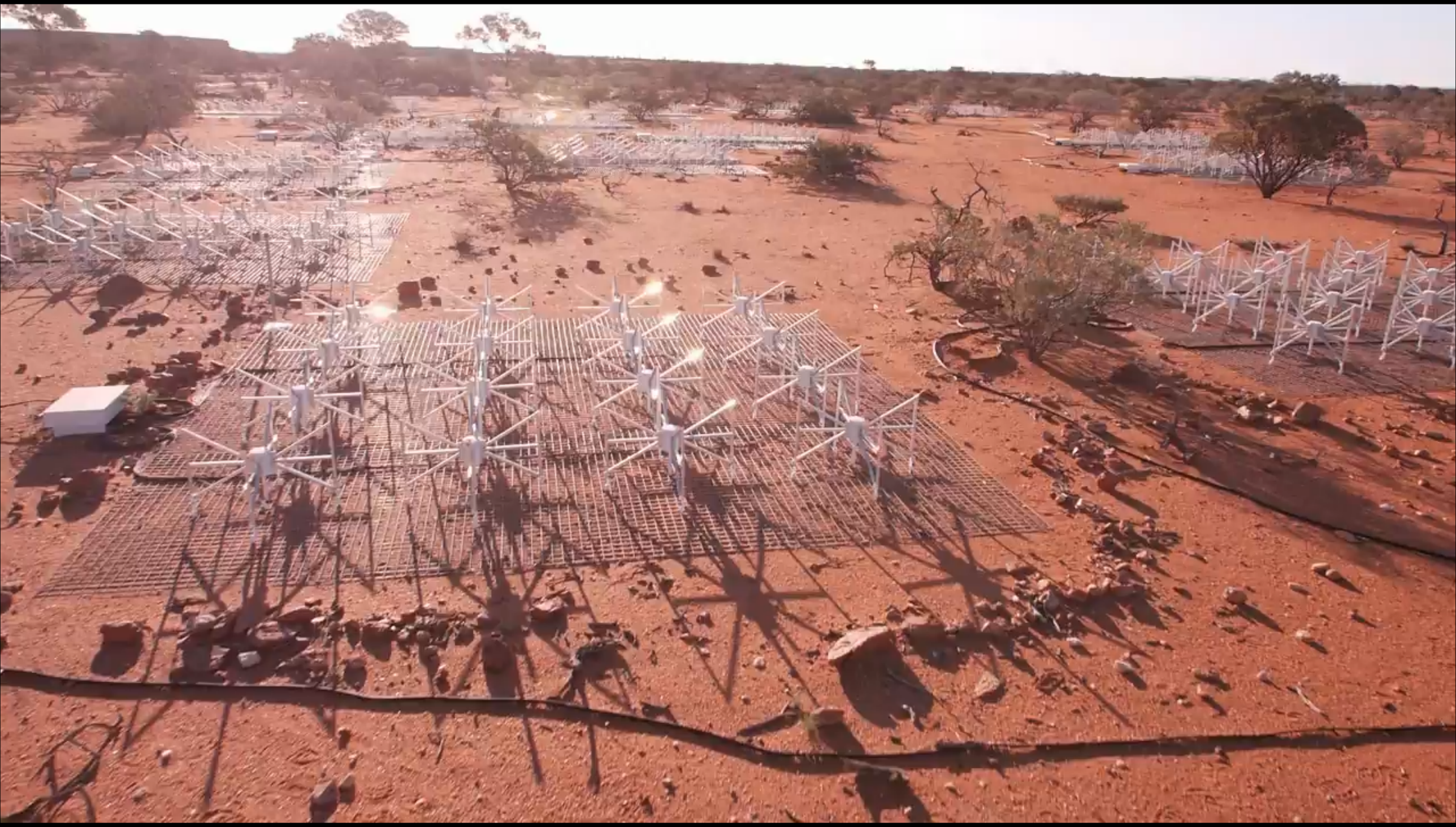
2 minutes of data, dark field, signal dominated

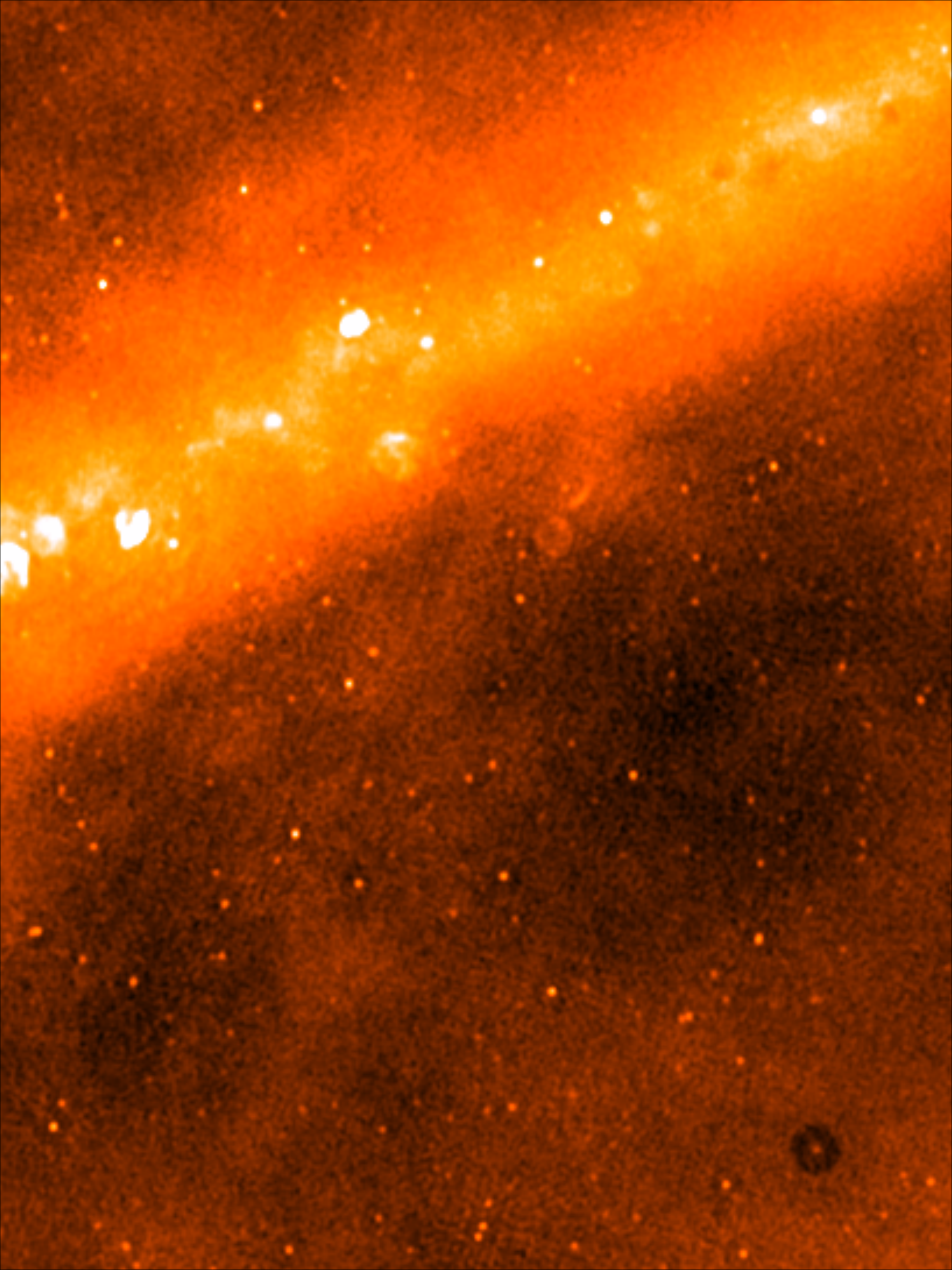
21 cm window


(λ)
10^1
10^2
10^0
10^3
10^-1
10^2
10^-2
10^1
(ns)
EoR
Intrinsic Foregrounds
k_|| (h Mpc^-1)
10^-2
10^-1
k_⊥ (h Mpc^-1)

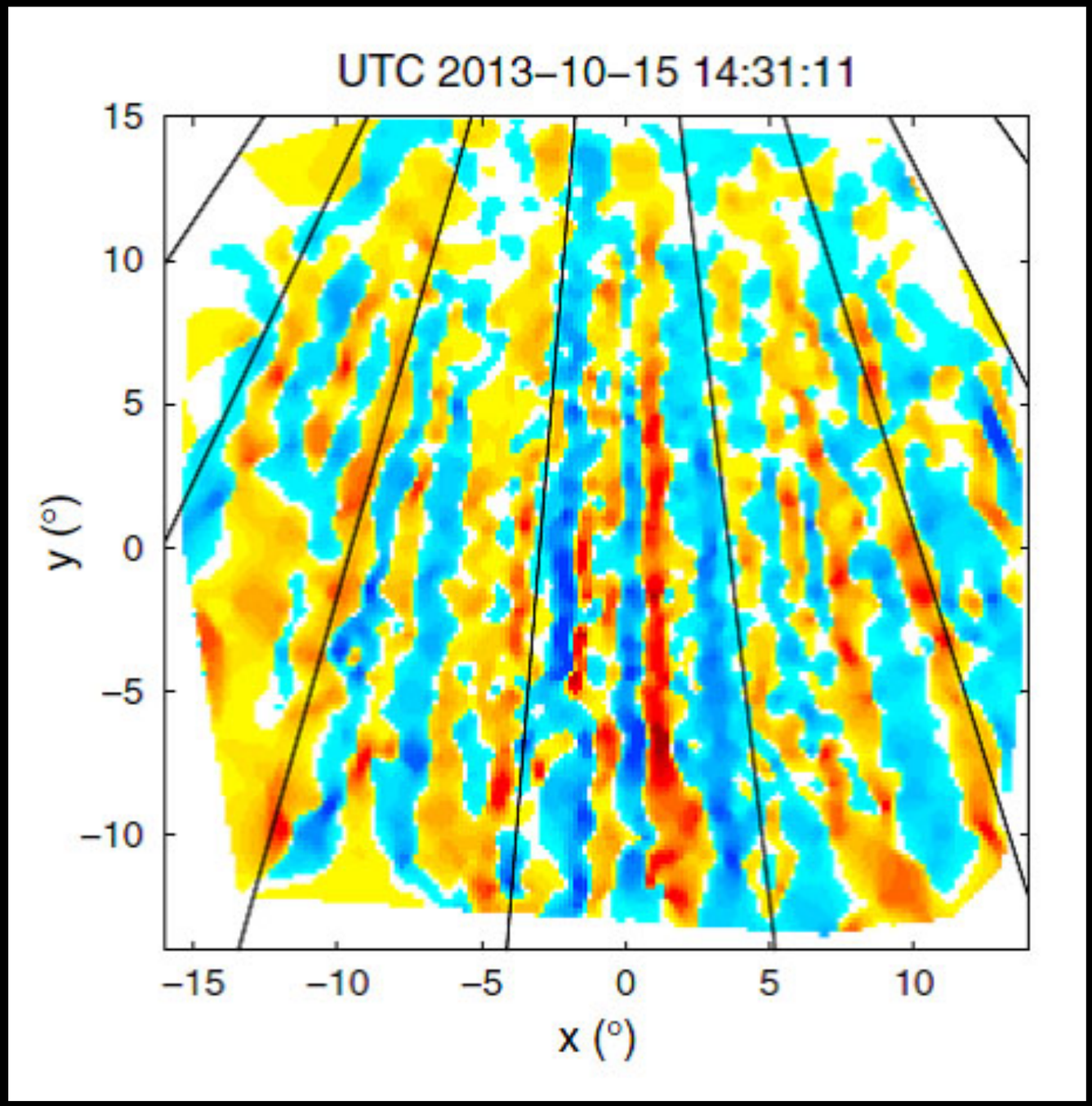

a)
(λ)
10^1
10^2
10^0
10^3
10^-1
10^2
10^-2
10^1
(ns)
EoR Window
horizon
primary field of view
Foreground Wedge
Intrinsic Foregrounds
k_|| (h Mpc^-1)
10^-2
10^-1
k_⊥ (h Mpc^-1)

Looking at the data…



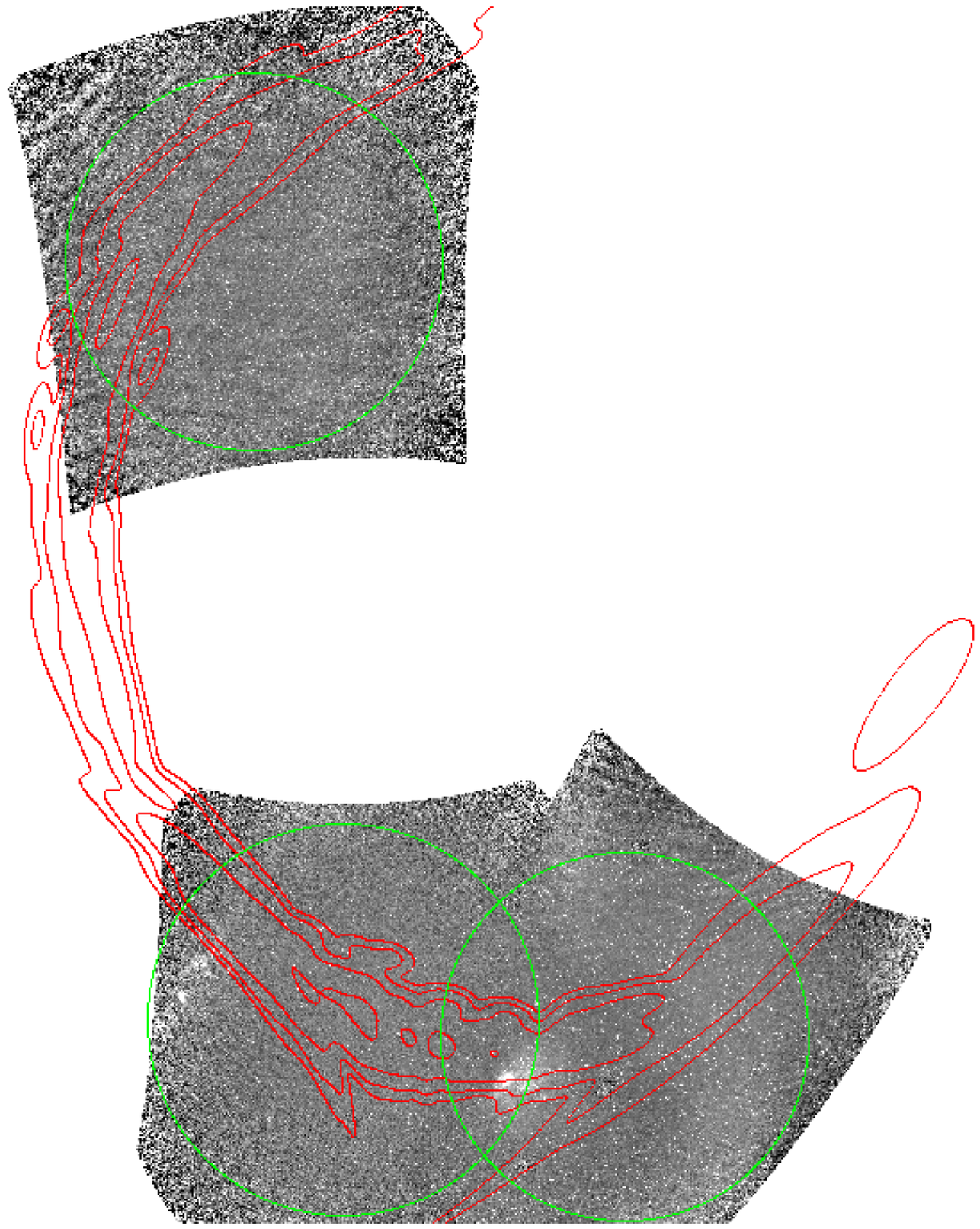


Ionosphere & Plasmasphere



Loi et al. 2015

Variable sky (LIGO follow up)




EXIT
EXIT
EXIT

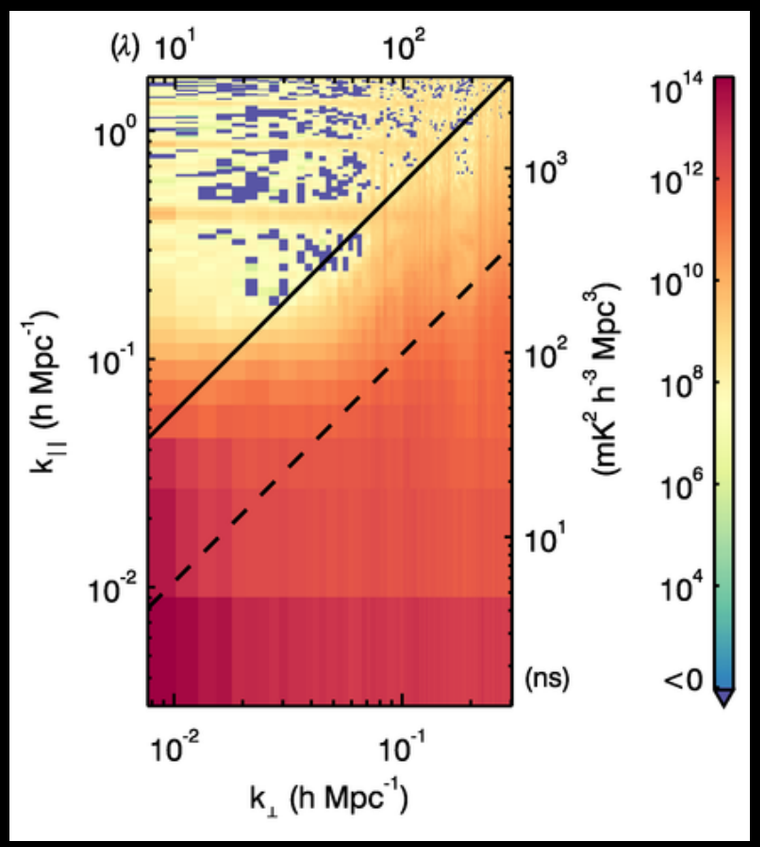

NERD

KATALOGSS

Precision foreground catalog

Carroll et al. 2016

KATALOGSS



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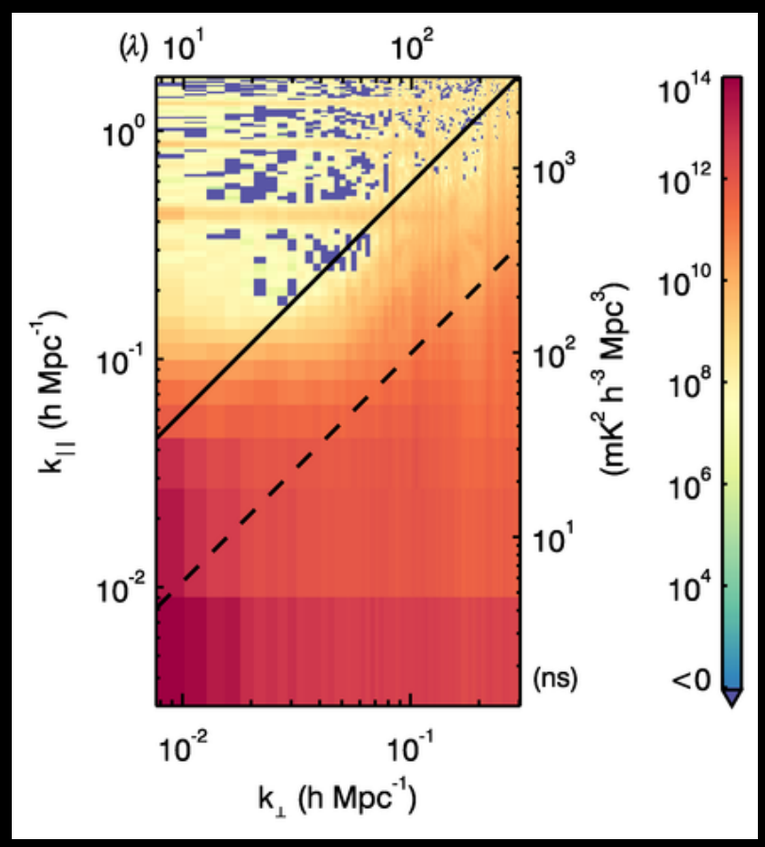

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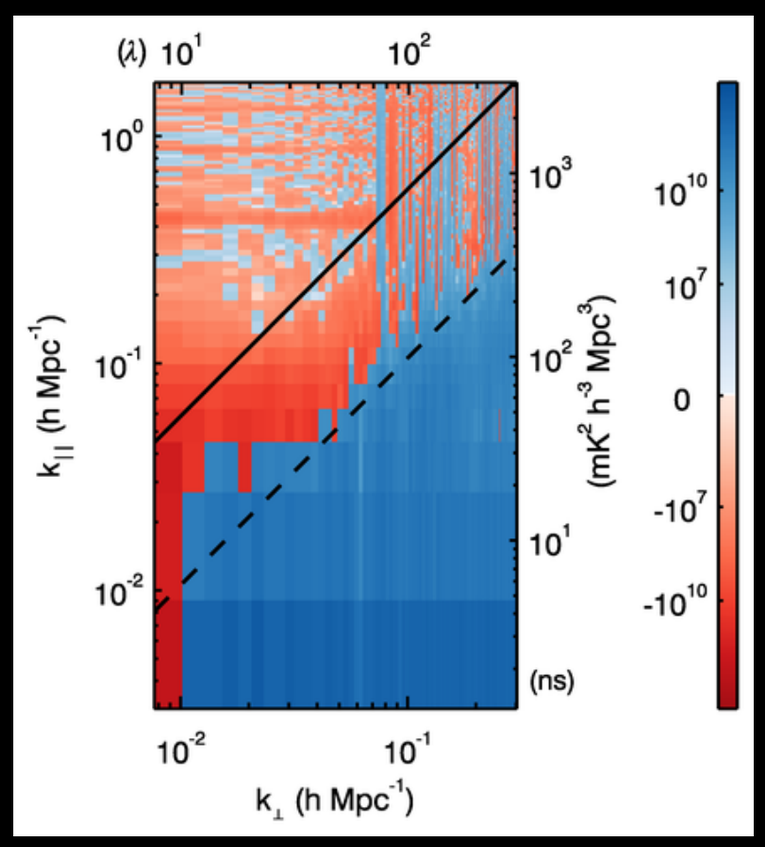
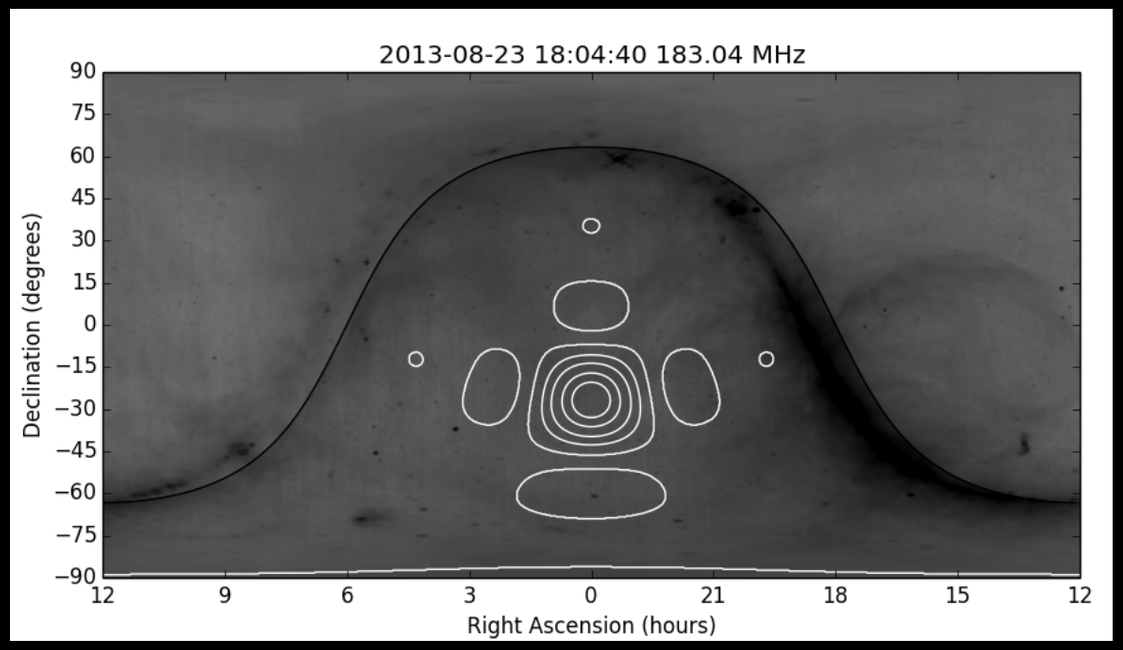
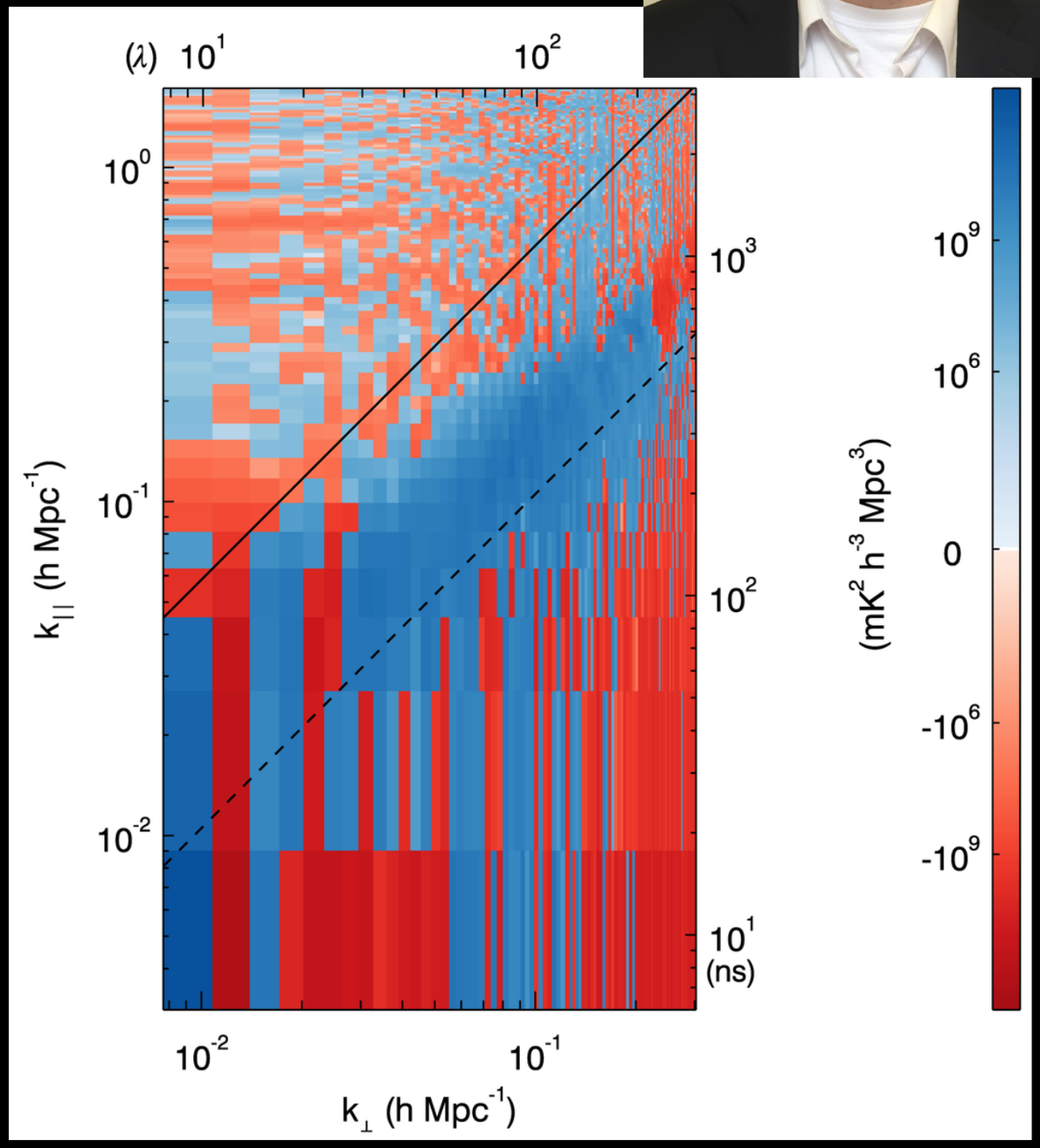


Carroll et al. 2016

Sidelobe Sources

- Sidelobe sources bleed higher in $k_{||}$
- Most critical for opening the EoR window

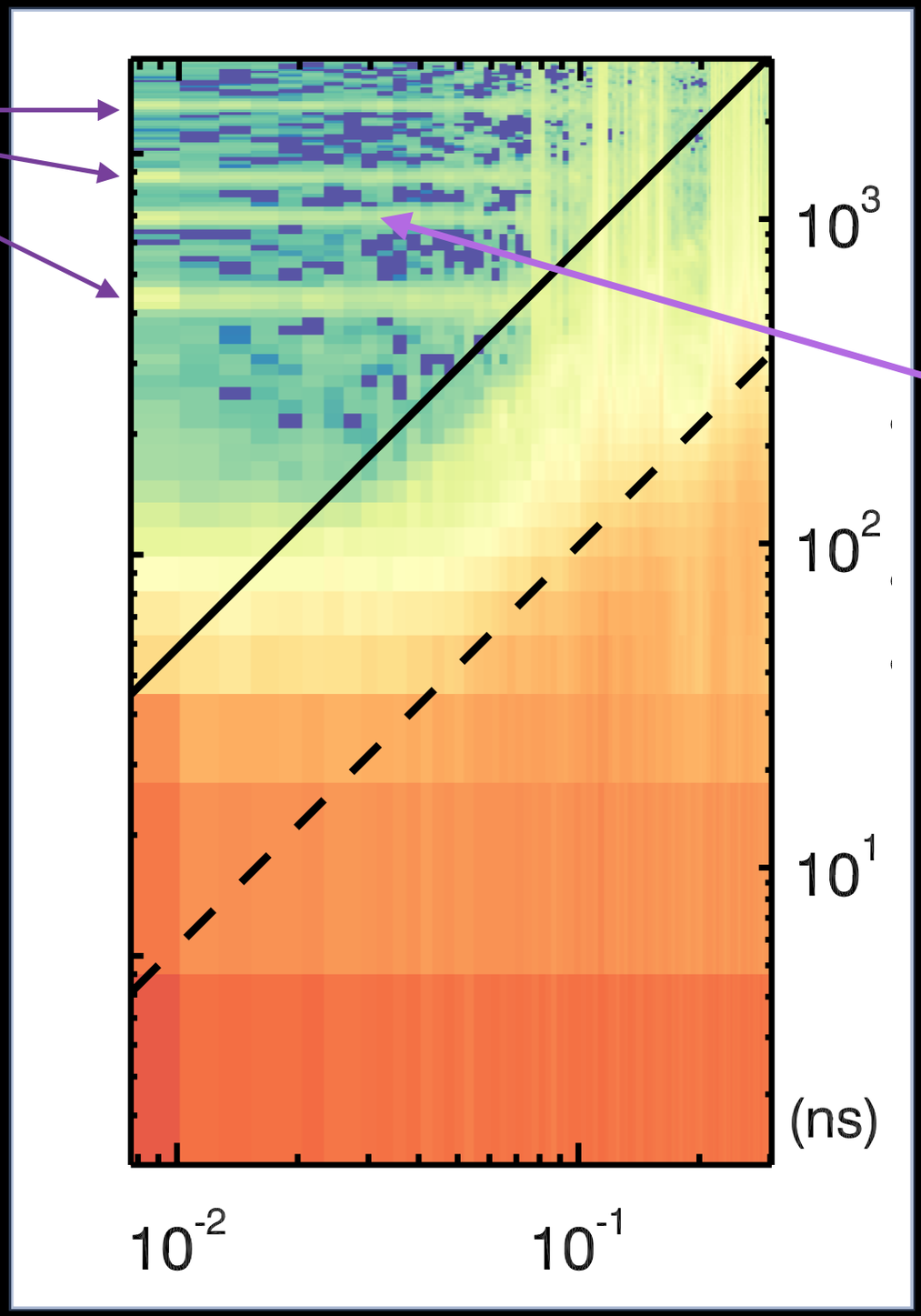




Pober et al. 2016

Precision Calibration

Frequency gaps

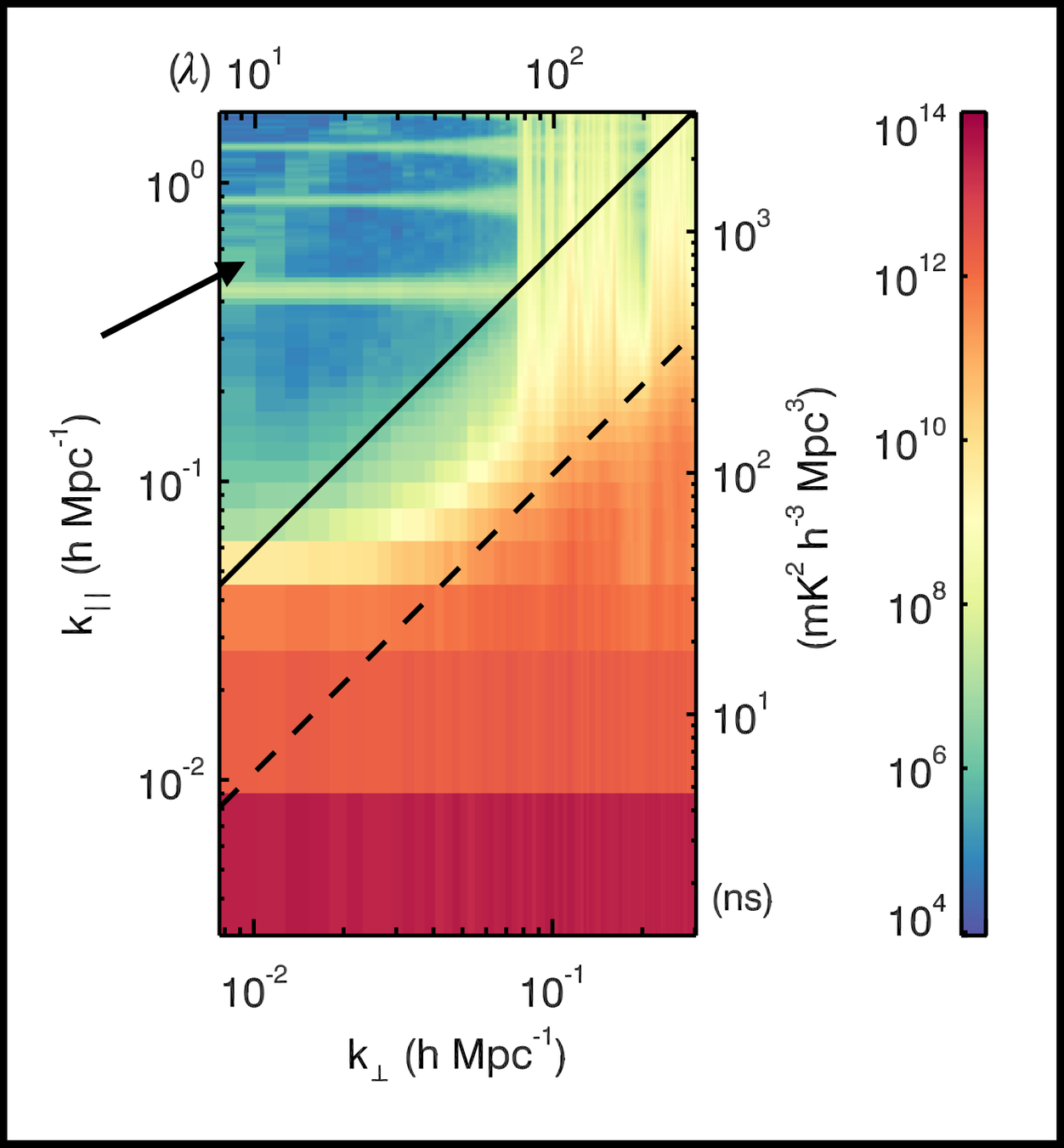


150 m cable reflection

Beardsley et al. 2016

Barry et al. 2016

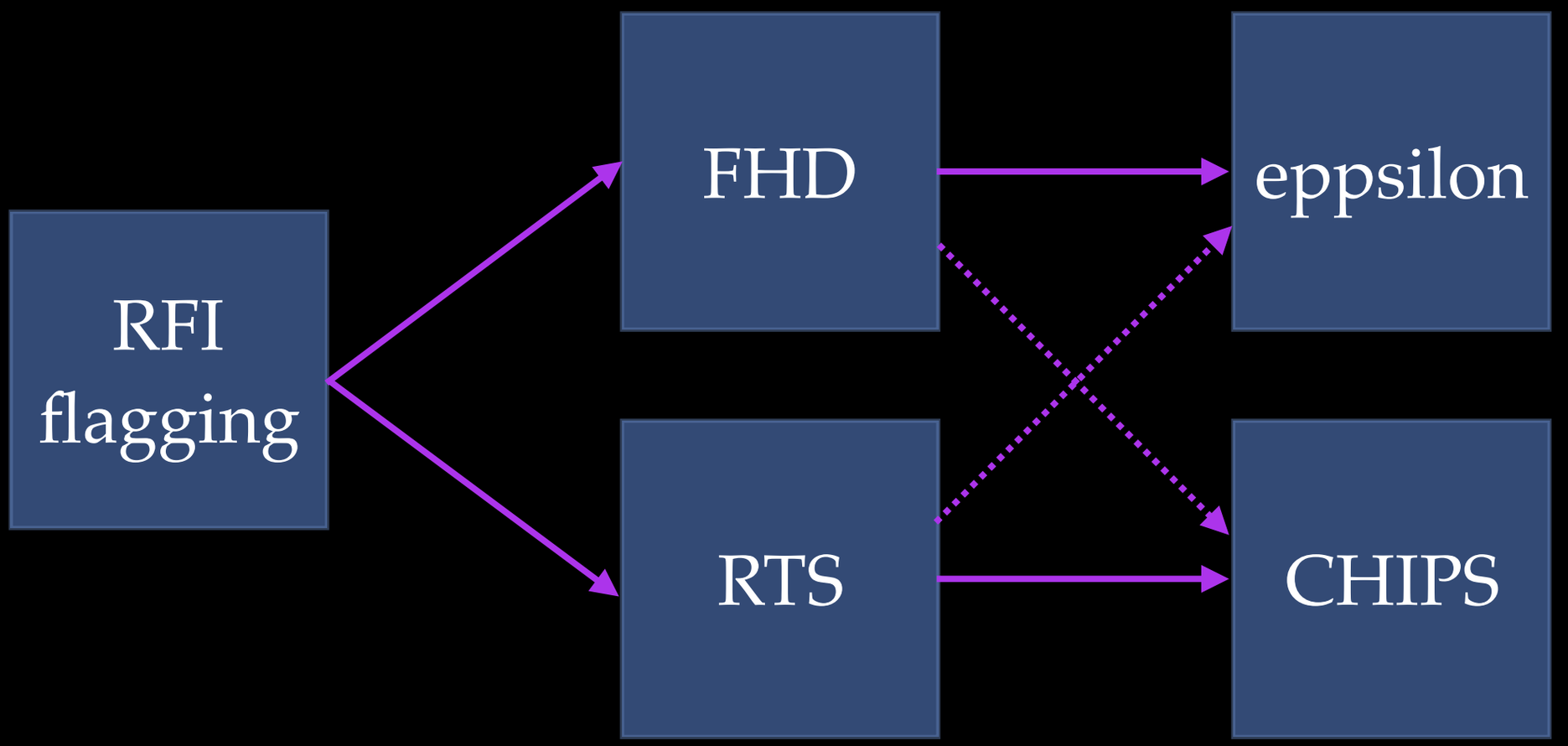
Precision Analysis



- Antenna gridding kernels must be calculated to better than 1/7000 wavelength

Beardsley et al. 2016

MWA Community comparison framework



Jacobs et al. 2016

Power Spectrum Method

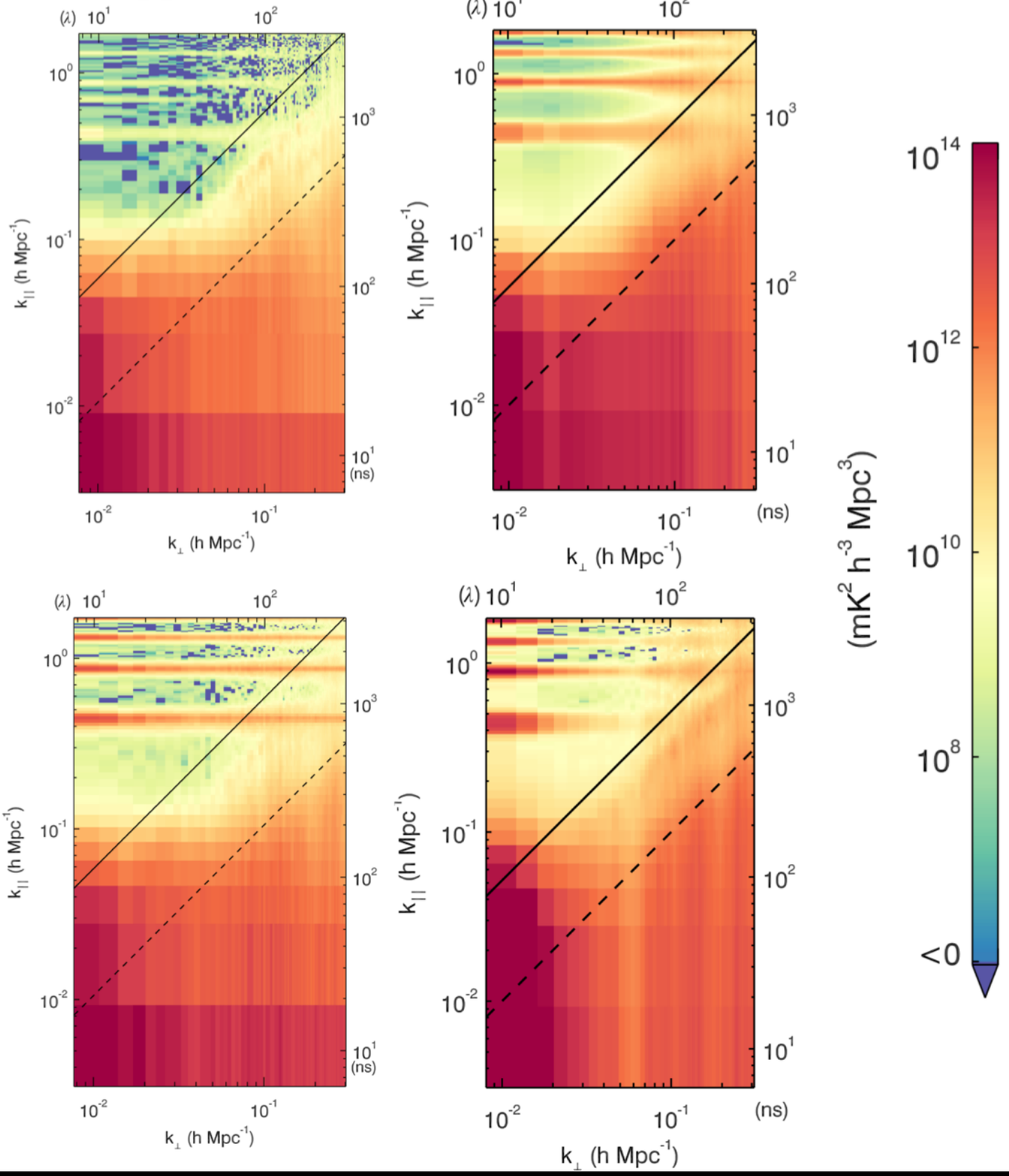
Foreground Removal

FHD

RTS

εppsilon

CHIPS



Jacobs et al. 2016

Where are we going…

- MWA phase II commissioning
- HERA funded and being built


08/03/2016


35

Conclusion

- Radio is a natural place for a physicist
- Many large telescopes and precursors under construction
- Intersection of big data and precision analysis