MWA Observations of the EOR1 Field

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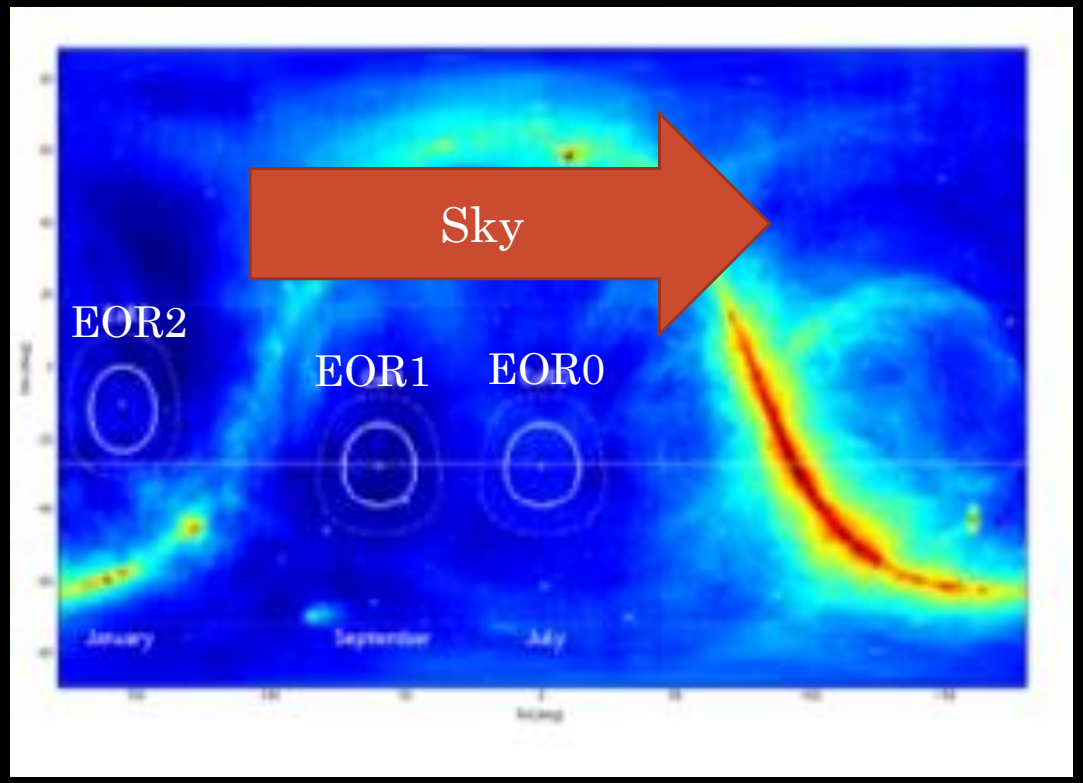
MWA EOR Experiment

Instantaneous *uv* of the Phase I MWA puts it in the 'imaging array' camp of EOR arrays

Location on the future site of SKA-LOW offers unique opportunities for informing the design of the telescope and experiments

Systematics which limit MWA EOR must also be dealt with to enable full SKA EOR Science

MWA EOR Observing



- Main MWA EOR Observing uses drift-n-shift on 2+1 southern fields
  - GOOD: Cold regions of the sky
  - GOOD: Improved sky model
  - BAD: Variable beams
- 2000+ hrs of EOR data
  - Sensitivity is not showstopper
  - Systematic floor appears < ~10hrs
- Many dangers lurk
  - Calibration
  - Ionosphere
  - RFI
  - Signal Chain

MWA EOR Calibration Modules

RTS (Mitchell 2008)

- Sky-Based
  - Catalogue Model
- Iterative Solver
  - 1000+ sources
- GPU-Accelerated
- PS from visibilities:CHIPS

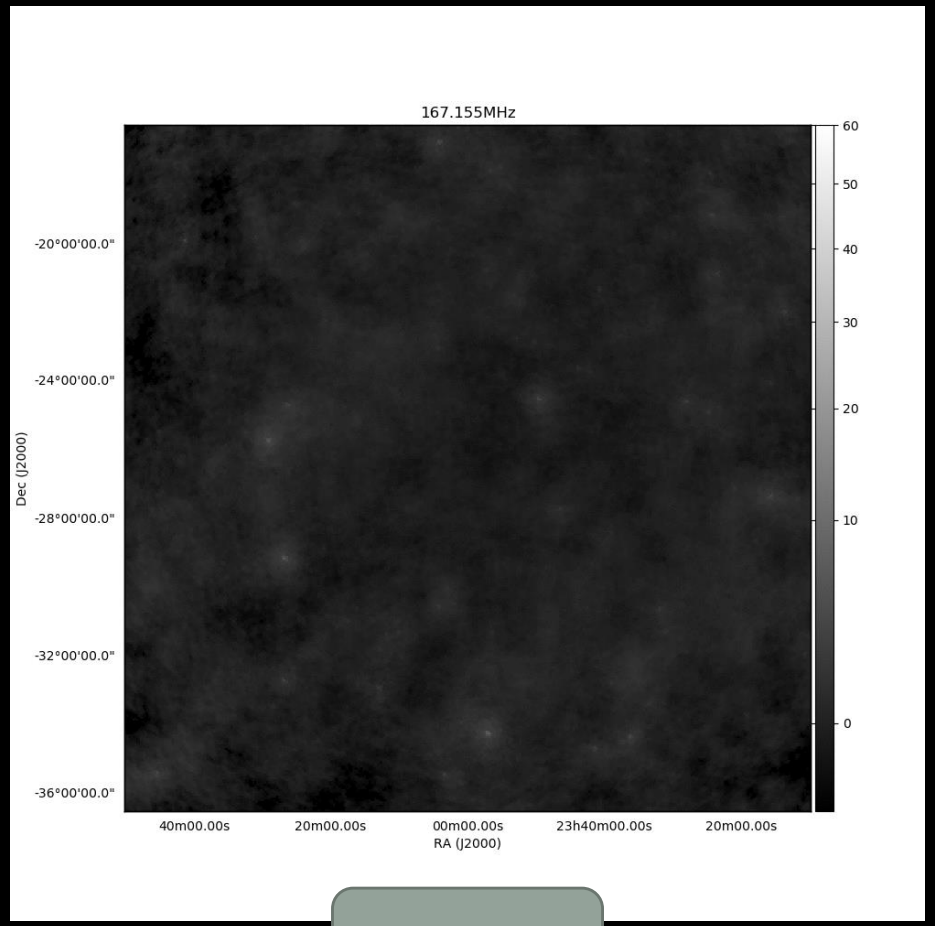
FHD (Sullivan 2012)

- Sky-Based
  - Self-Cal
- Simultaneous Solver
- AWS Accelerated!
- PS from Images (Eppsilon)

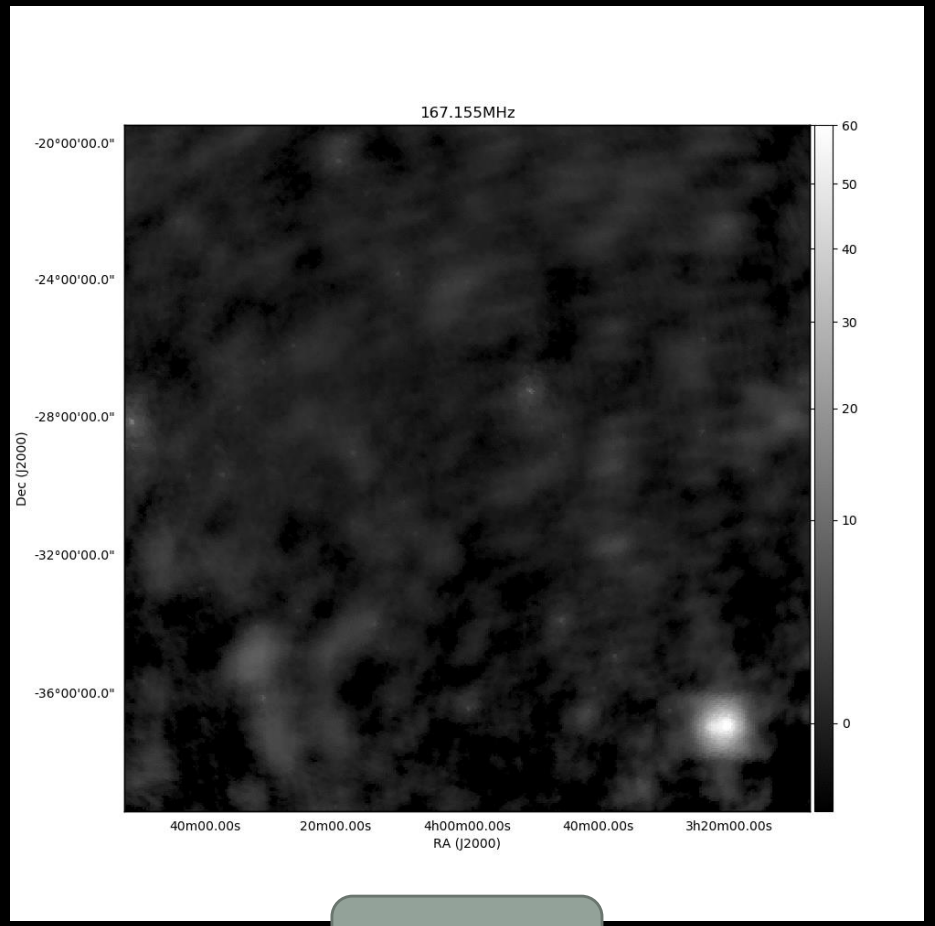
OMNICAL (Zheng 2014)

- Redundant Calibration
- Phase II Hexes
- Delay Transform PS

MWA EOR Field Comparison

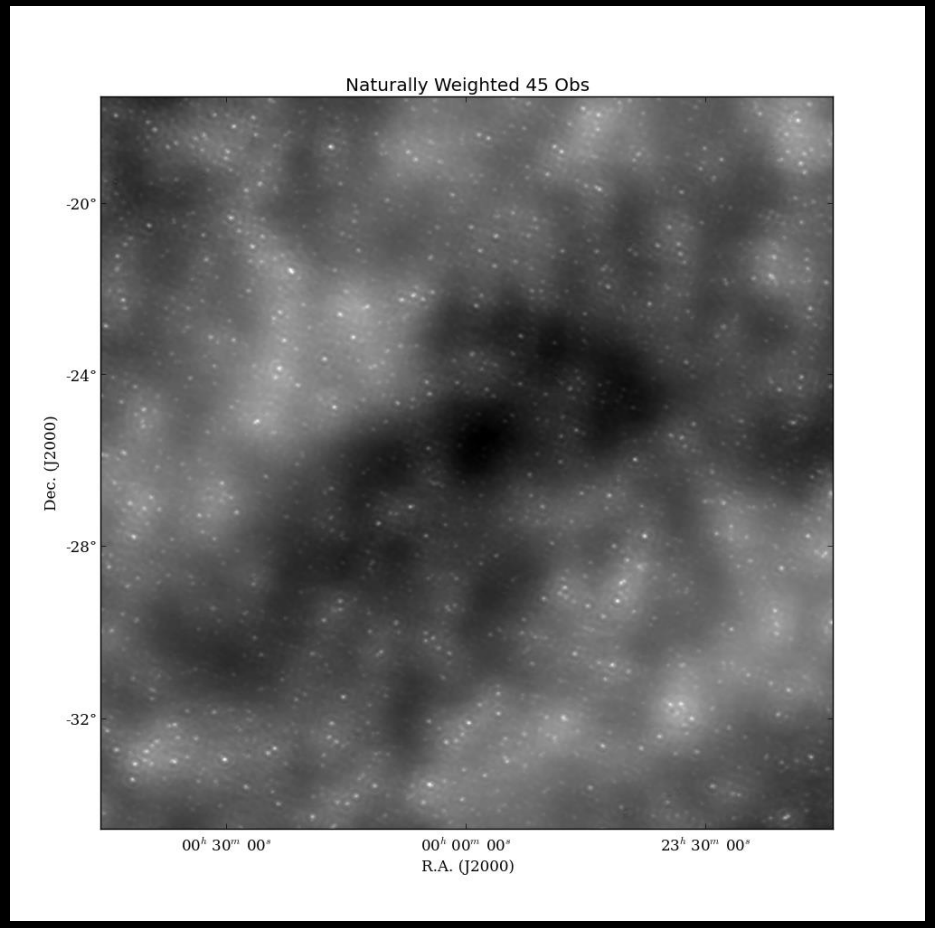


EOR0



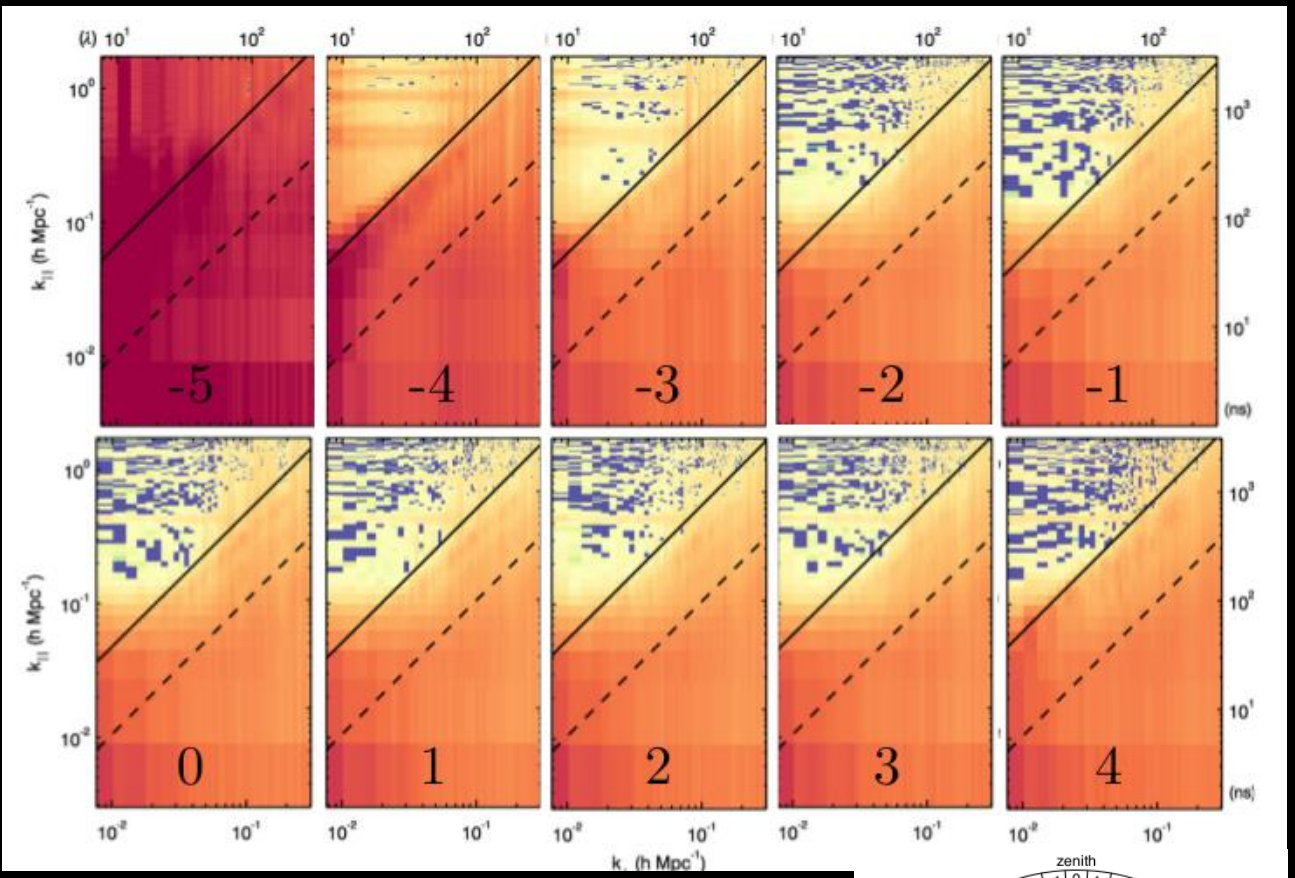
EOR1

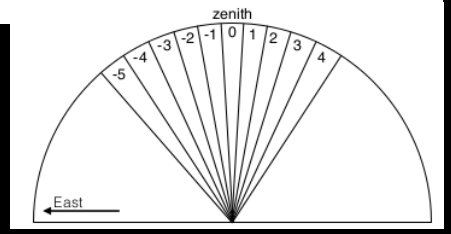
EOR0 – Widefield Foregrounds



- EOR0 has few bright / extended sources
  - Good for point source based calibration
  - Less residual FG power in the wedge
- Season 1 MWA EOR results reported in Beardsley et al (2016)
  - 30 hrs @ z~7

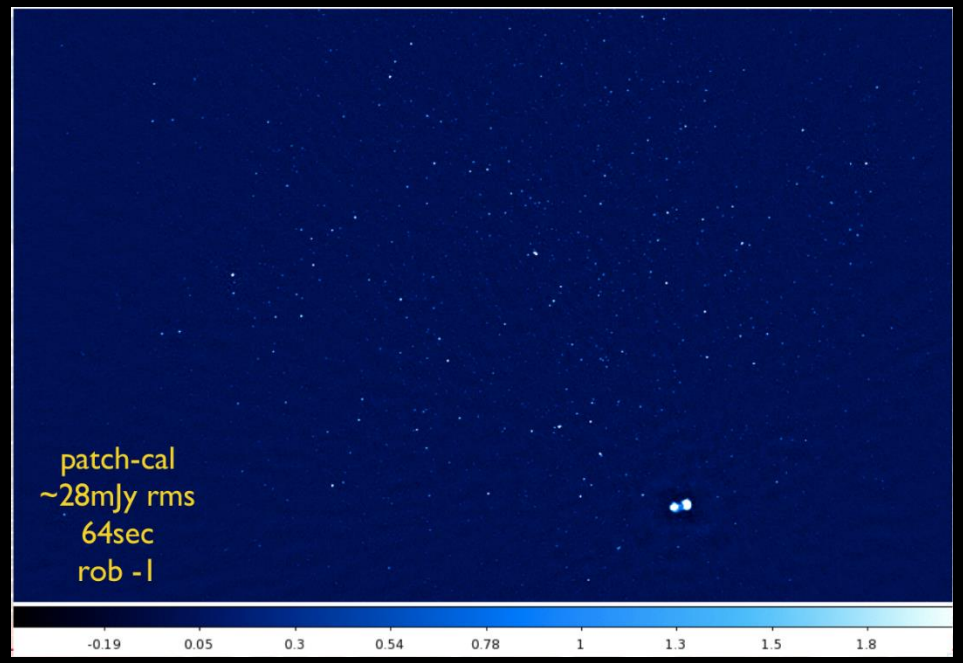
EOR0 – Widefield Foregrounds





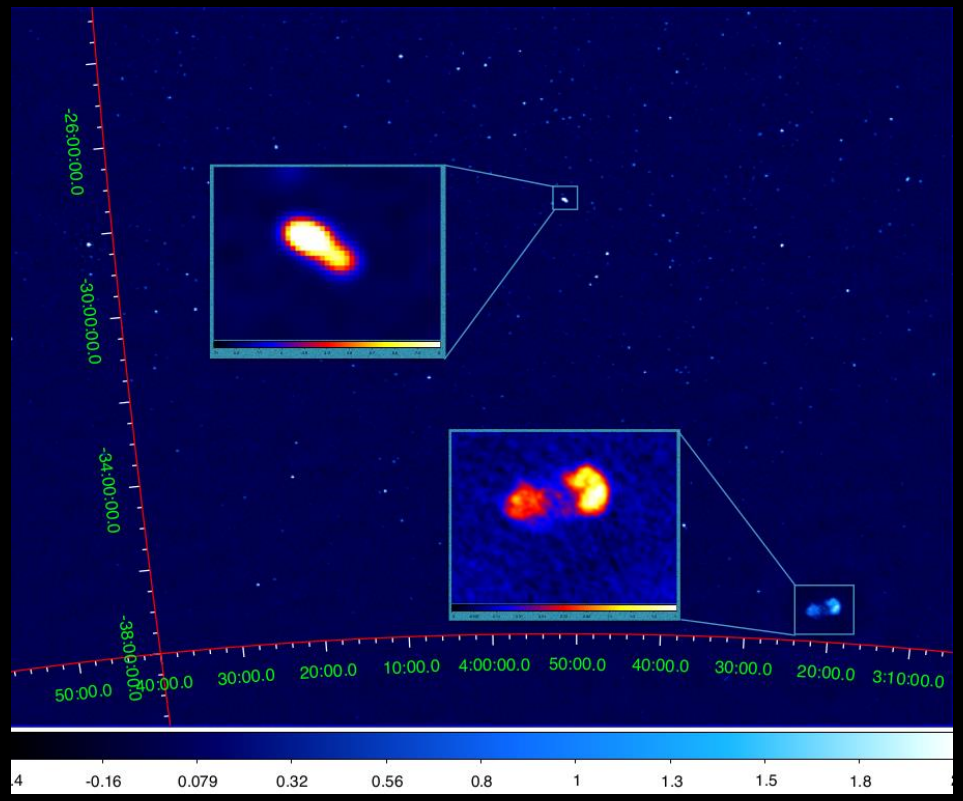
- EOR0 has few bright / extended sources
  - Good for point source based calibration
  - Less residual FG power in the wedge
- Season 1 MWA EOR results reported in Beardsley et al (2016)
  - 30hrs @ z~7
- However, as illustrated in Thayagarajan (2015), proximity to the Galactic Center increase widefield FGs
- GC ~10^4 Jy vs SKA-Low Sidelobes ~-45db

EOR1 – Processing

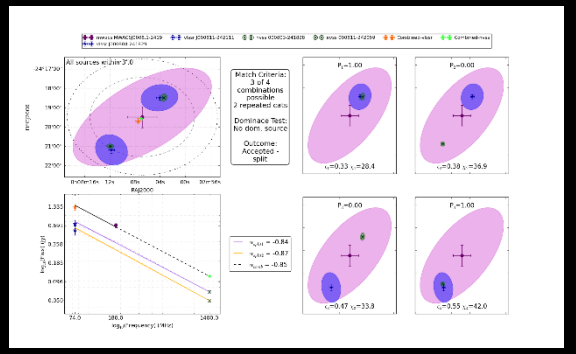


- Field centered at 4h, -30deg
- Processing through RTS + CHIPS
  - Two stage calibration
    - 1000 brightest sources in main lobe used to set DI calibration for each ~2min MWA obs
    - 1000 sources peeled every 8s to resolve ionospheric displacements
      - Ionospheric monitoring (Jordan 2017)
    - Residual visibilities passed to CHIPS (Trott 2016)
- Working towards processing a ‘Beardsley’ of EOR1 data to allow direct comparison (M. Rahimi)

EOR1 – Sky Model

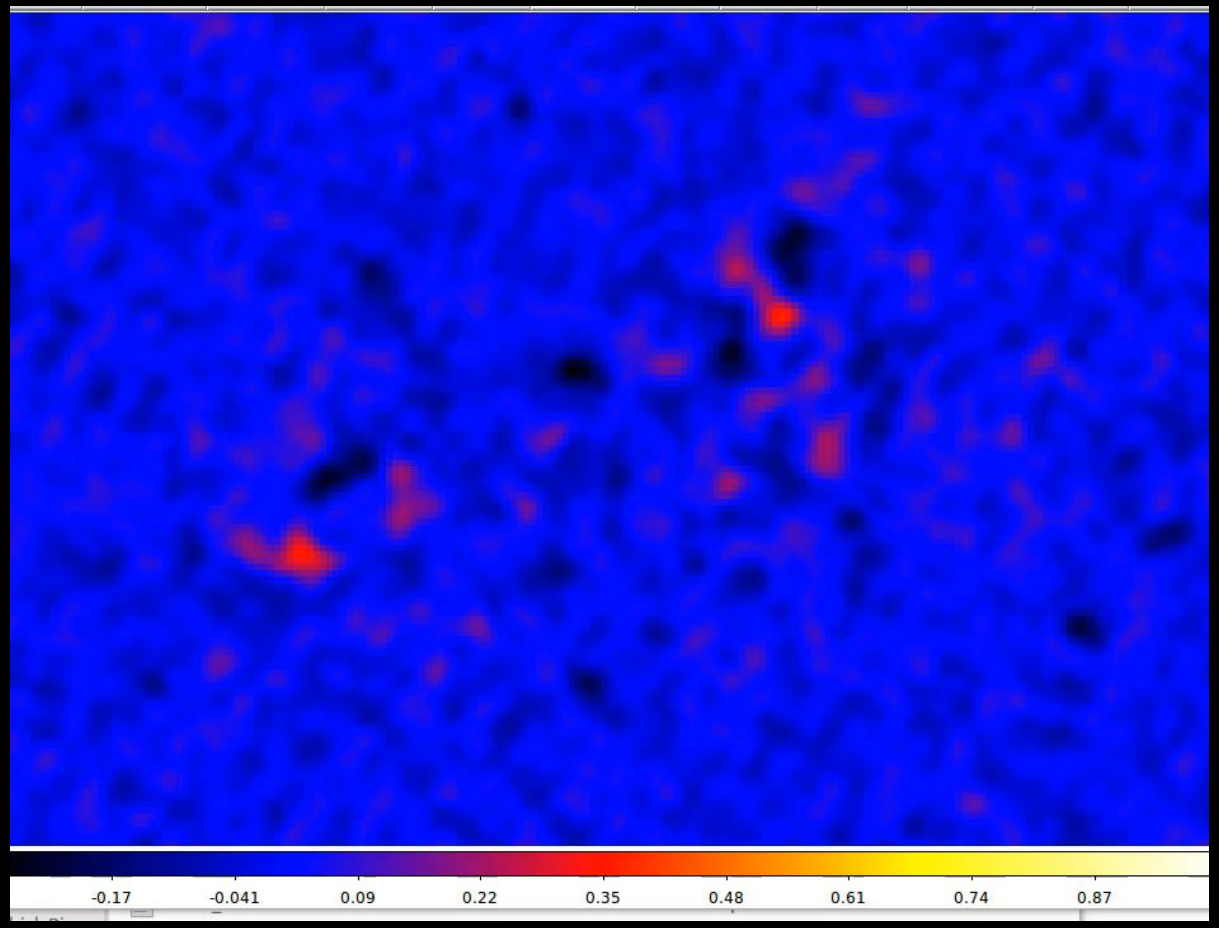


- Initial sky model constructed by PUMA (Line 2016)



- Shaplet-based model of Fornax A created by J. Riding
- Hi-Res TGSS images (courtesy H. Intema) used to model other bright extended and resolved sources in the FOV (P. Procopio)

EOR1 – Fornax A



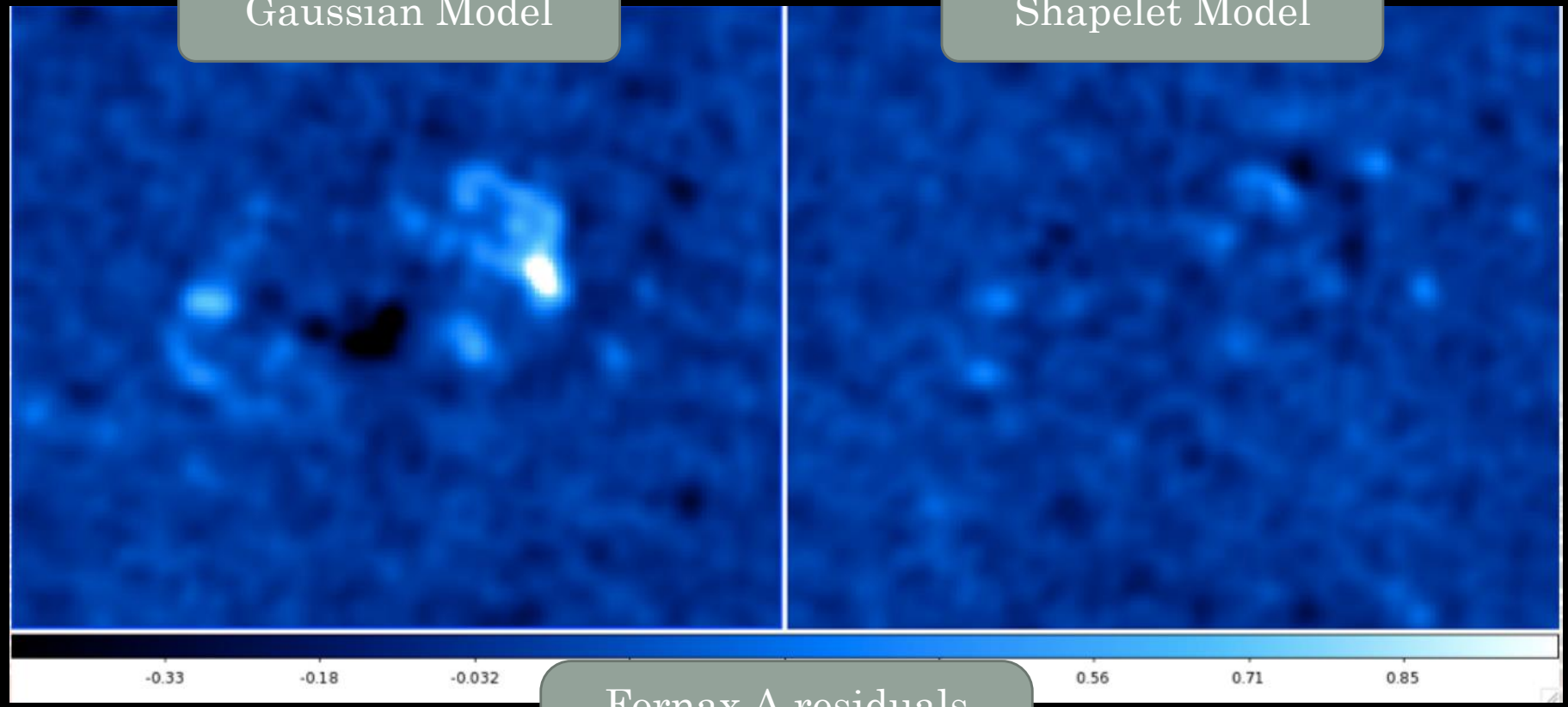
Dir-Dependent Calibration in 24 coarse channels

Shaplet coefficients remain fixed

EOR1 – Fornax A

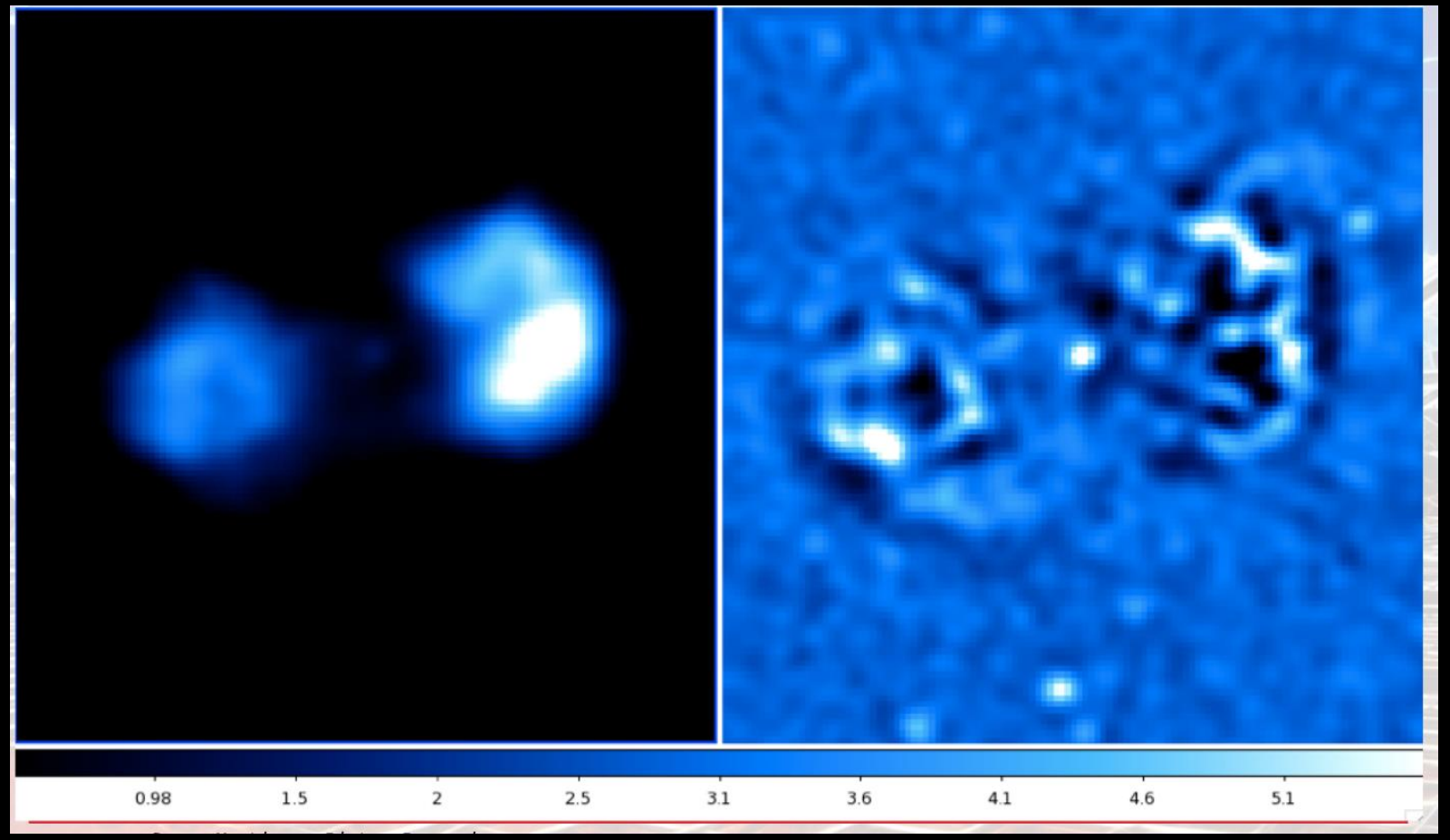
Gaussian Model

Shapelet Model



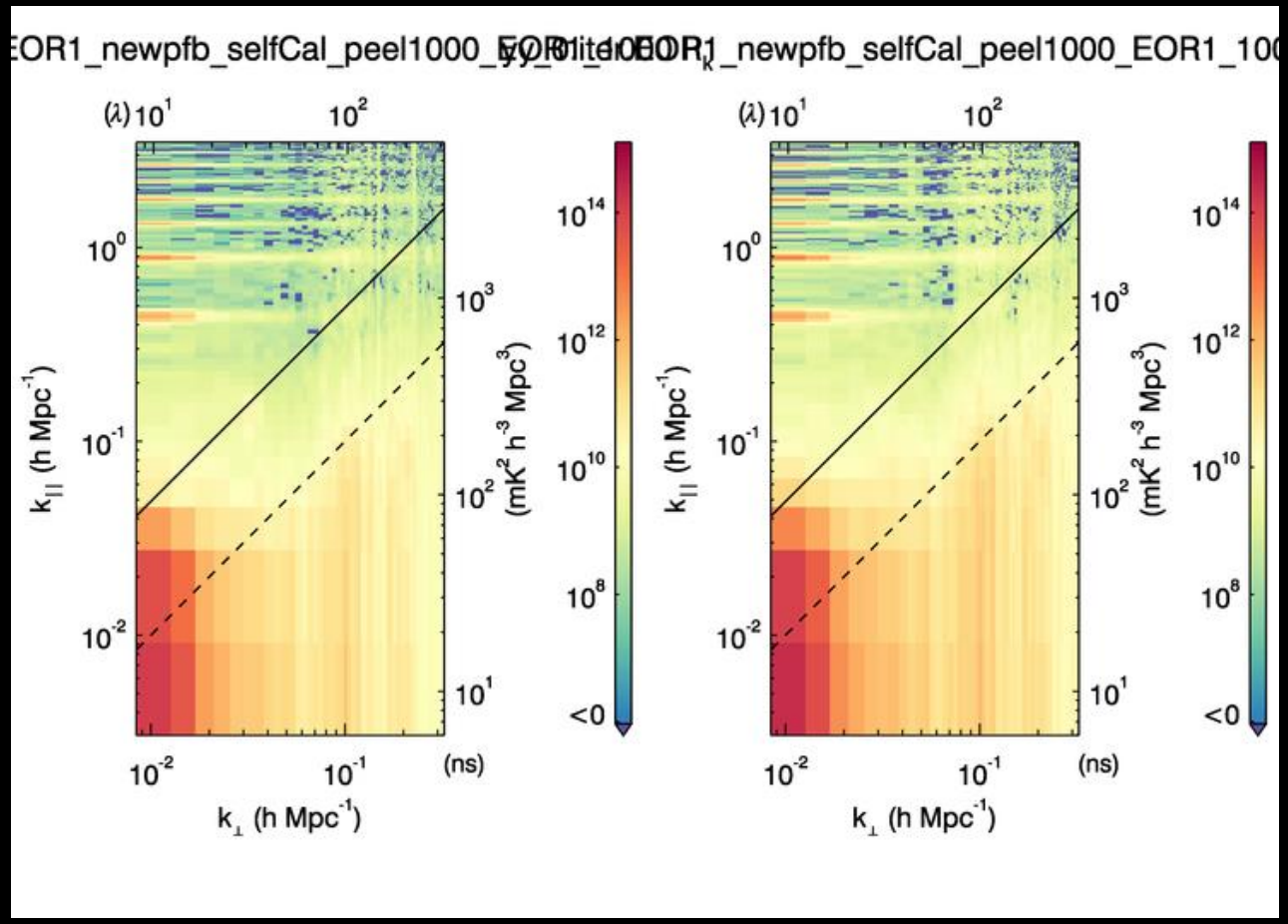
Fornax A residuals across single 1.28MHz coarse channel

EOR1-Fornax A



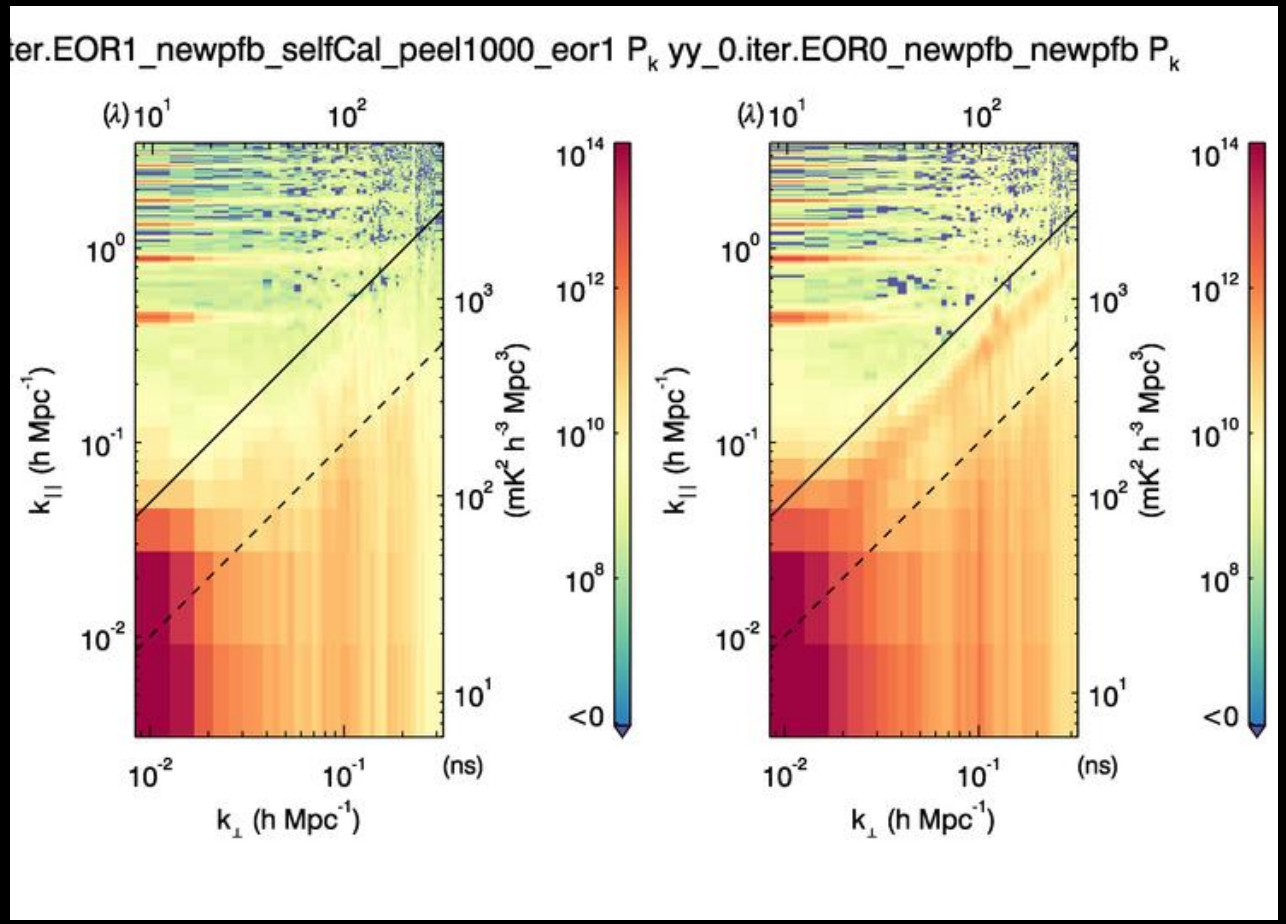
Fornax A residuals across the entire 30MHz band

EOR1 Power Spectra



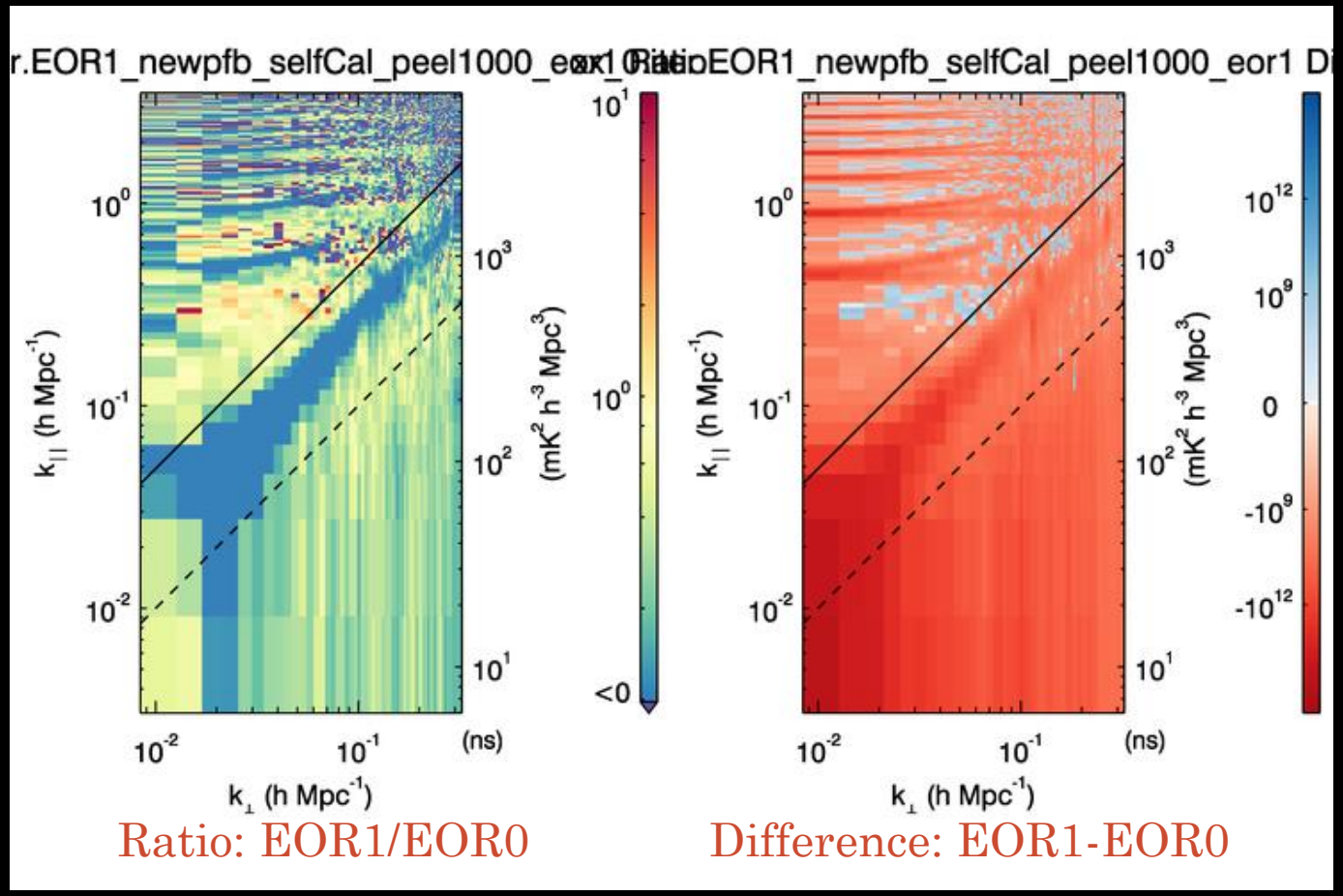
30 Minutes of zenith pointing data

EOR1 vs EOR0 Power Spectra



20 Minutes of zenith pointing data

EOR1 Power Spectra



Ratio: EOR1/EOR0

Difference: EOR1-EOR0

✅ Lower Widefield FGs

✅ Lower Sky Temperature

❓ More complex FGs

EOR1 – Lessons

We are progressing towards a z~7 MWA limit based on EOR1 observations for comparison to Beardsley (2016)

Observing different fields teaches different lessons about the sky, our techniques and our instrument

MWA Phase II will offer an additional dimension of comparison, interesting to both HERA and the SKA-LOW