Polarized foregrounds for EoR measurements: lessons from PAPER

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PAPER and HERA collaborations

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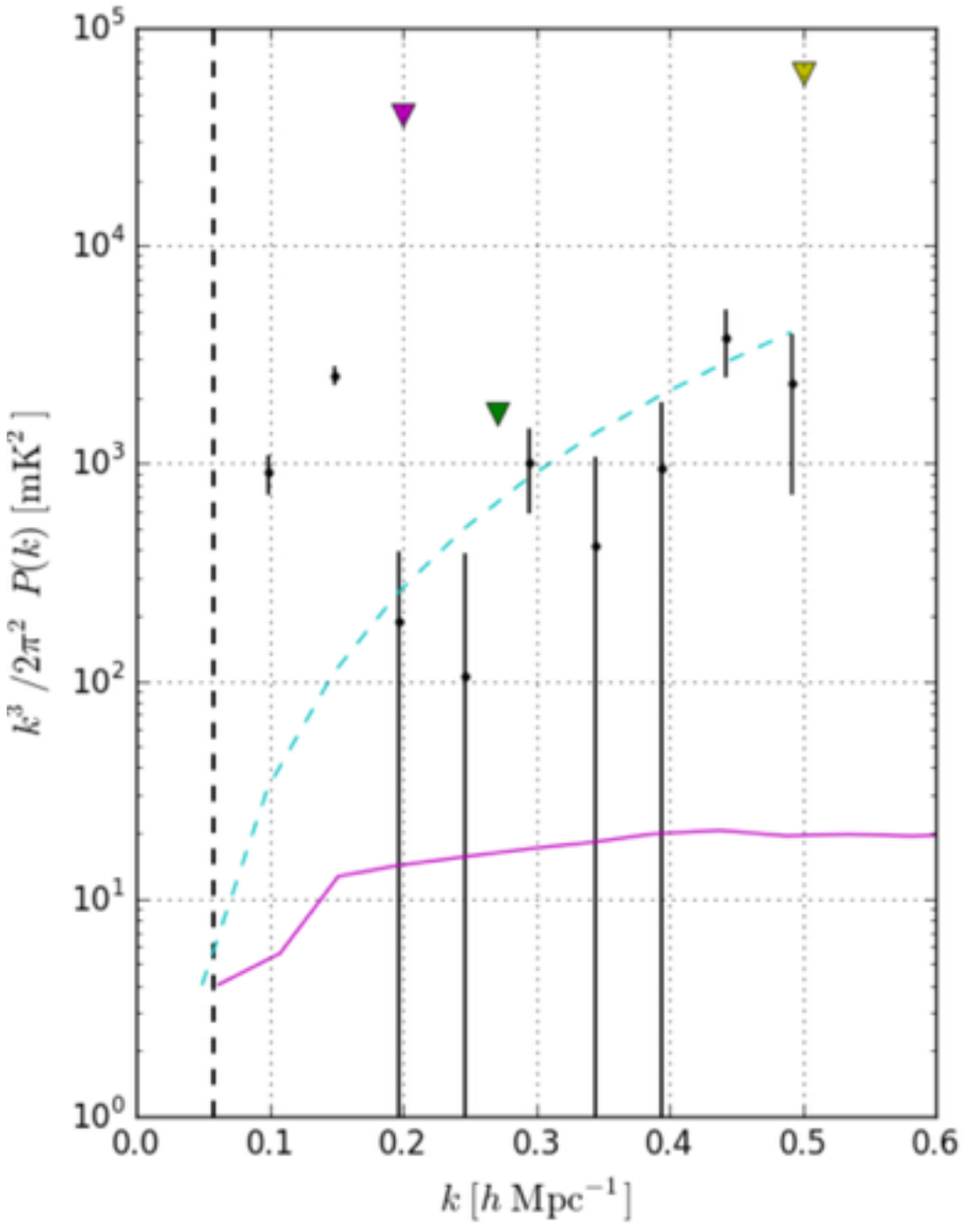
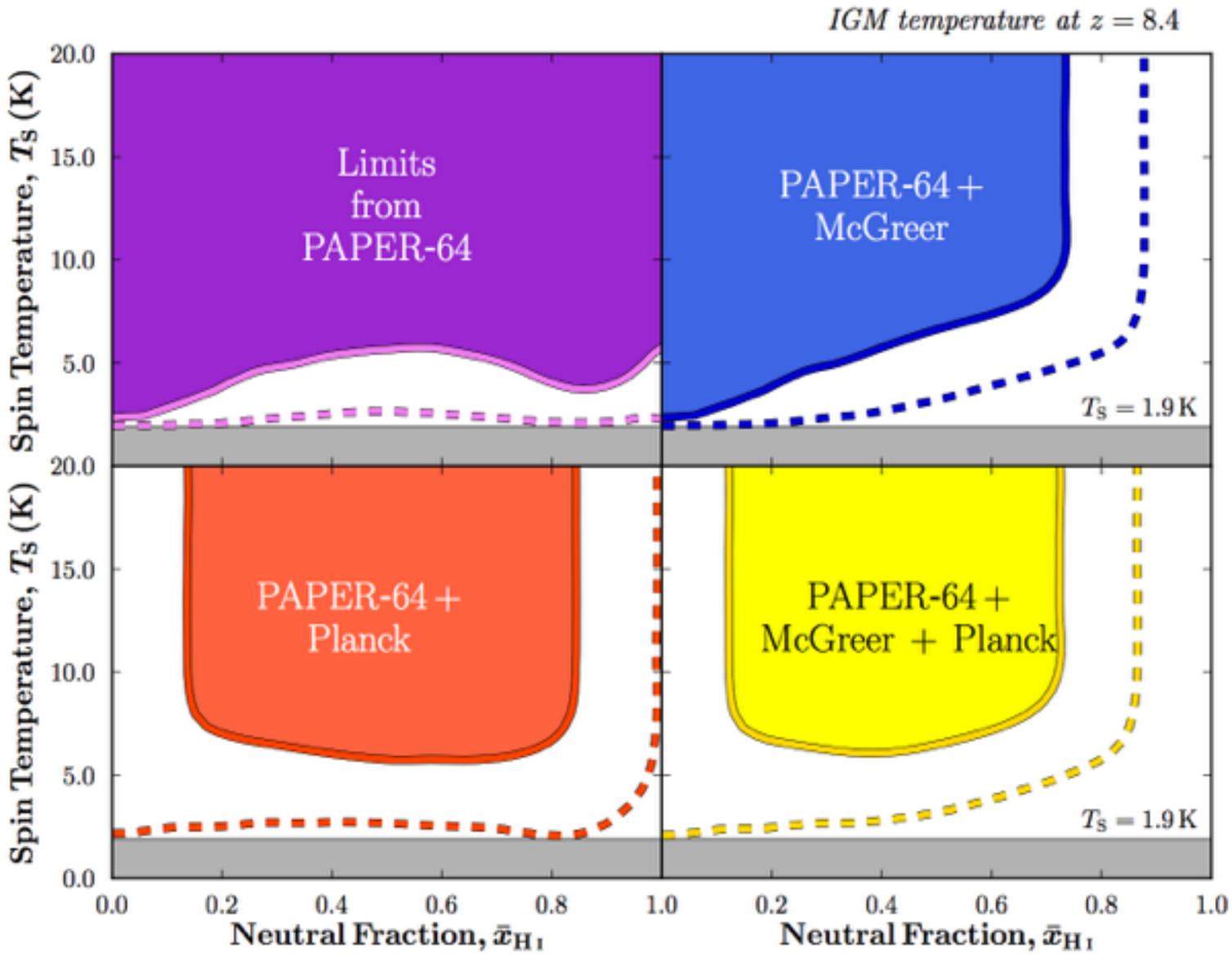
The **PAPER** P.S. pipe

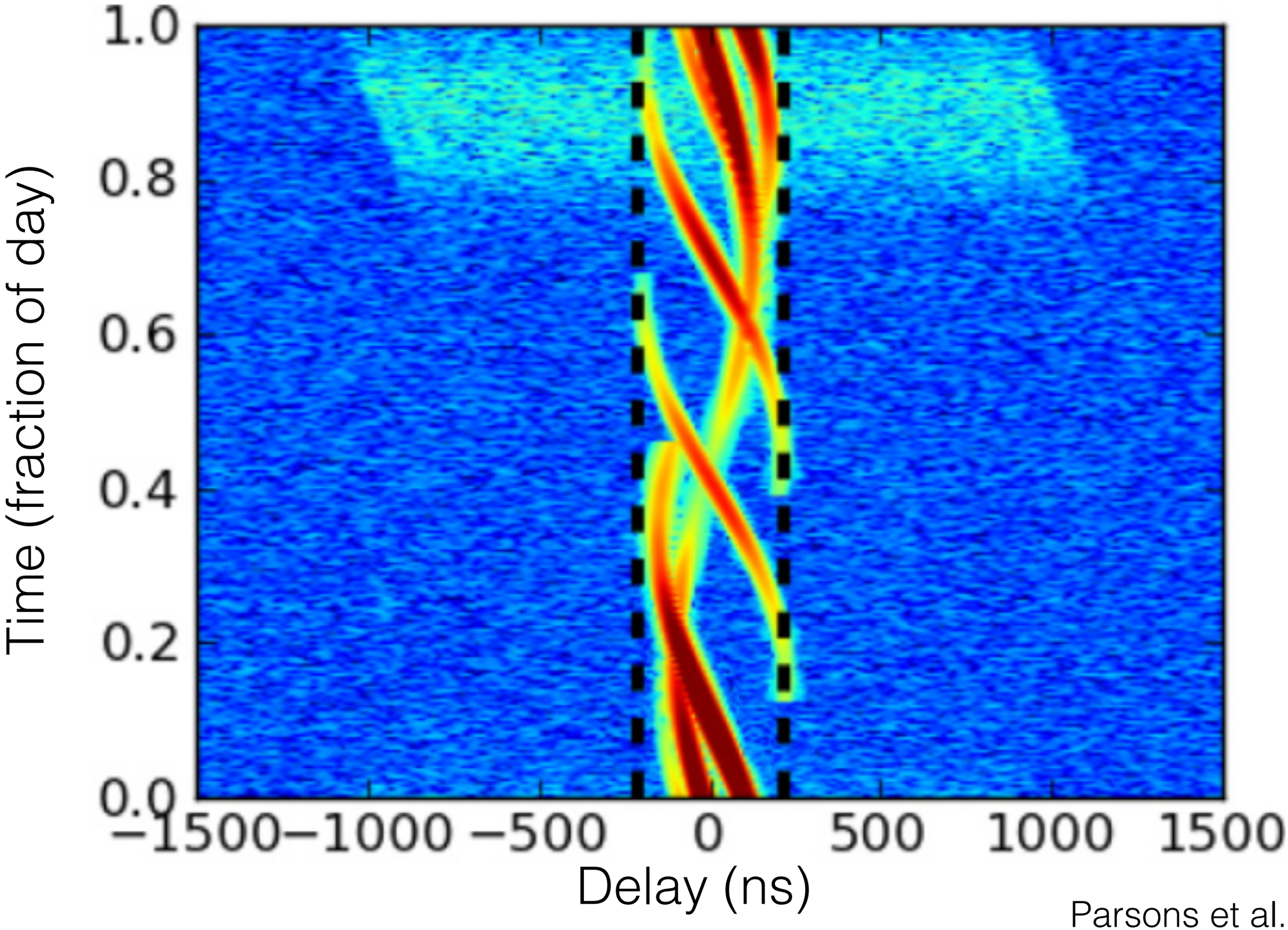
- Data are recorded, RFI flagged and compressed
- Crosstalk removal and OMNICALibration (Zheng et al. 2014)
- Delay-filtering for foreground-subtraction (Parsons et al. 2012a)
- LST-binning
- Fringe-rate filtering (Parsons et al. 2015)
- Hand-off to power spectrum estimation pipeline (Ali et al. 2015)
  (Delay transform; Covariance estimation & weighting; bootstrap errors)



Ali et al. 2015



Greig, Mesinger & Pober 2015



Parsons et al. 2012a

What sort of polarization systematics do we have to contend with?

- High-RM galactic foregrounds introduce spectral structure that can scatter outside of the delay filter
- Wide-field interferometers move diffuse emission to the edge of the delay filter (e.g. Thyagarajan et al. 2015a)
- The ionosphere can introduce additional RMs
- Wide-field beam effects can leak Q and U into I
- Direction-independent mixing between feed arms

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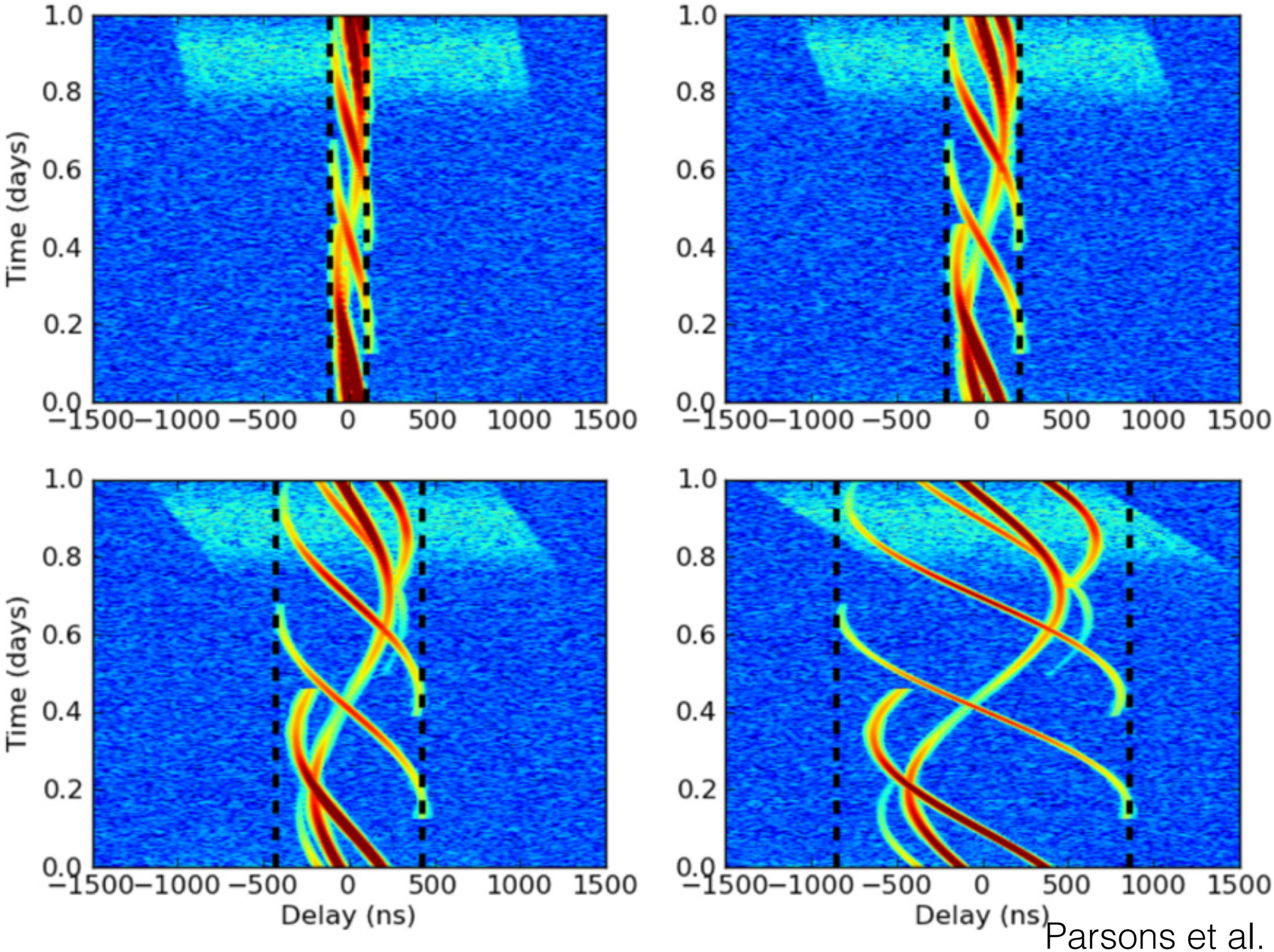

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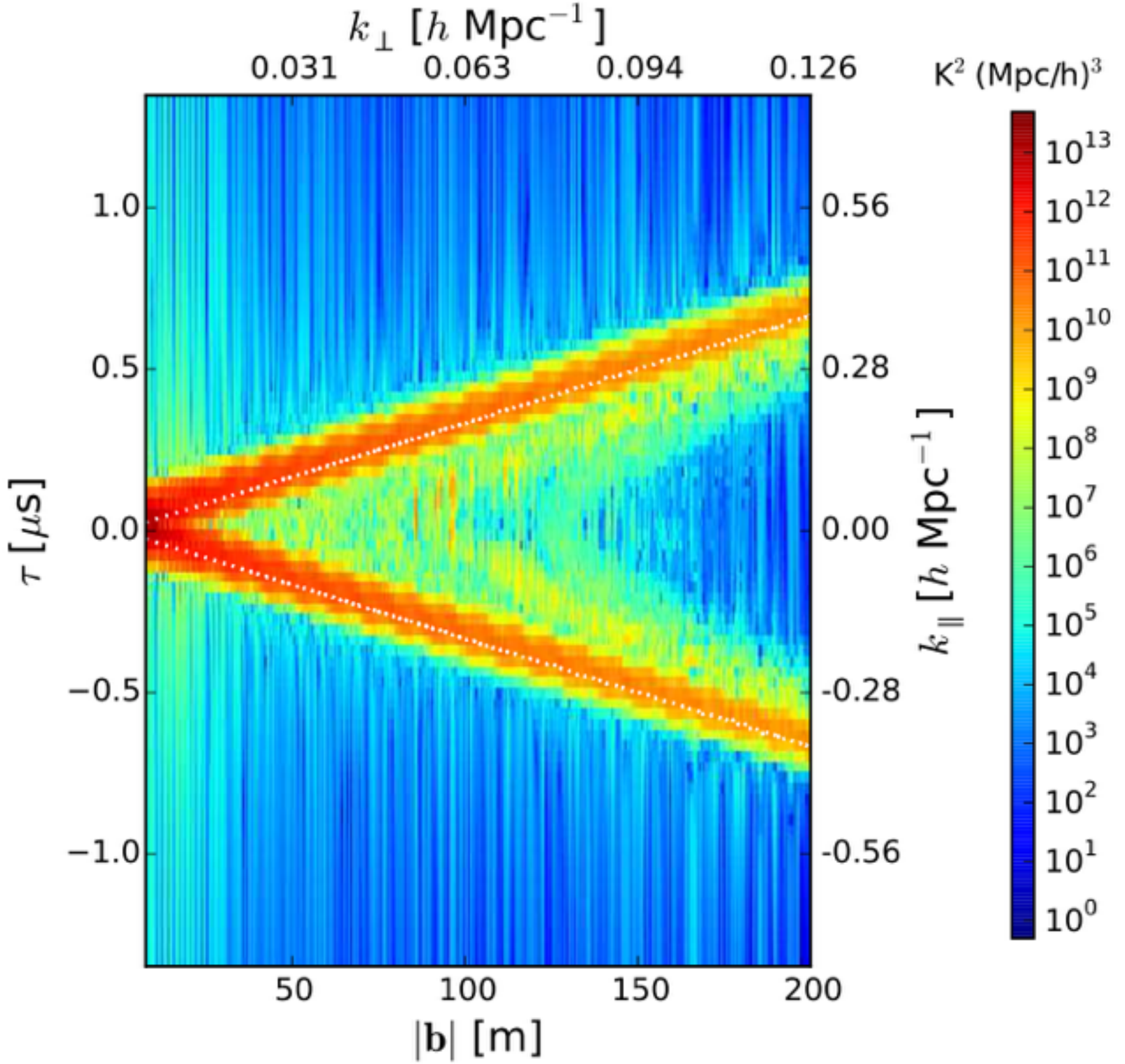
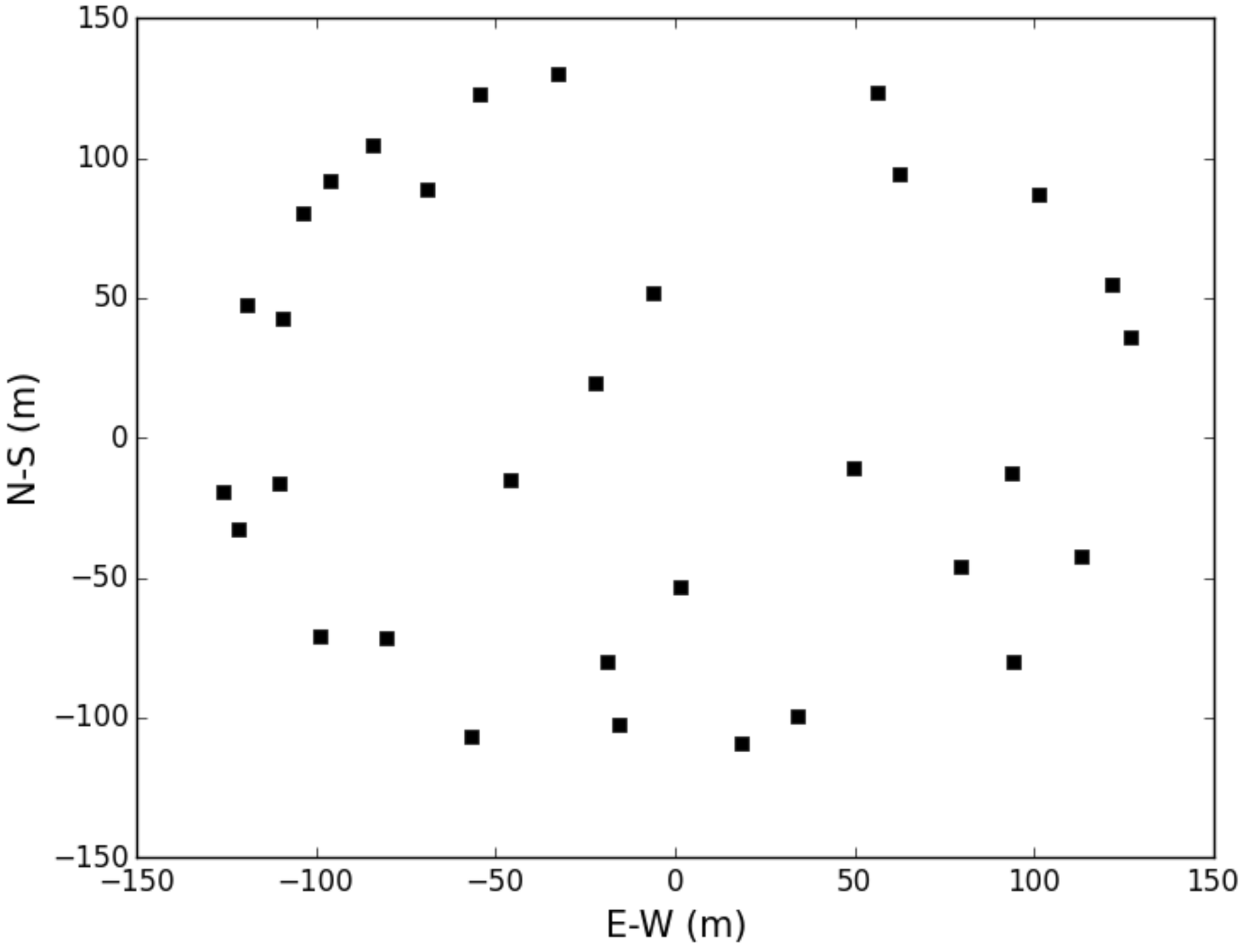


Thyagarajan et al. 2015a

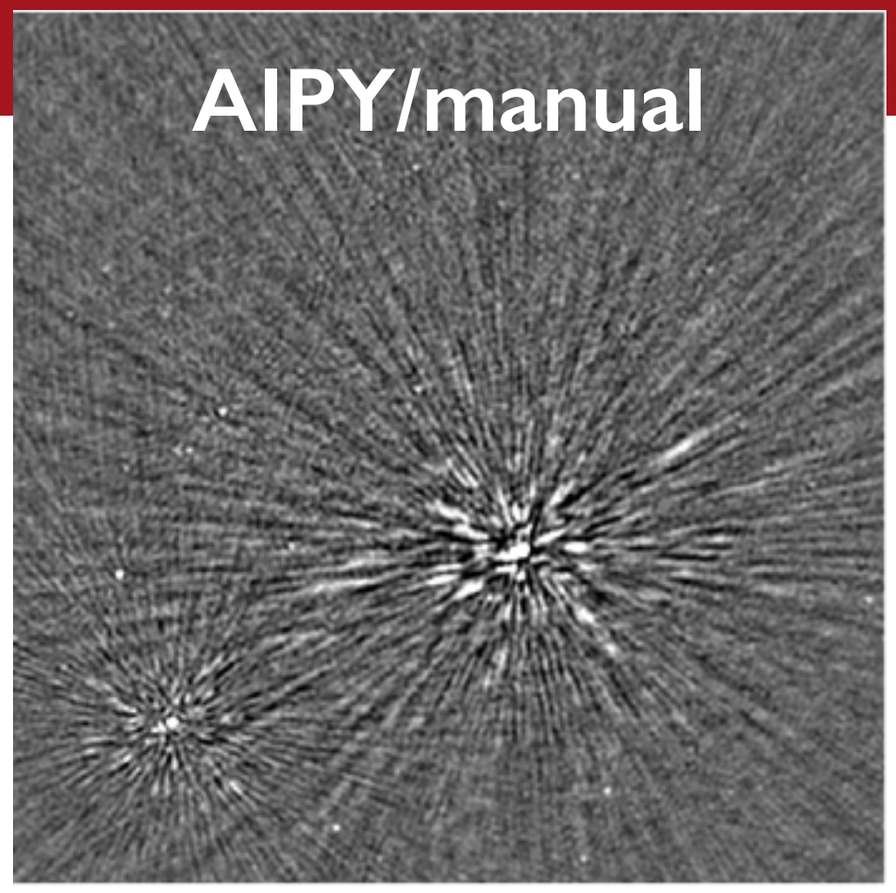
PSA-32 polarization imaging array (2011)



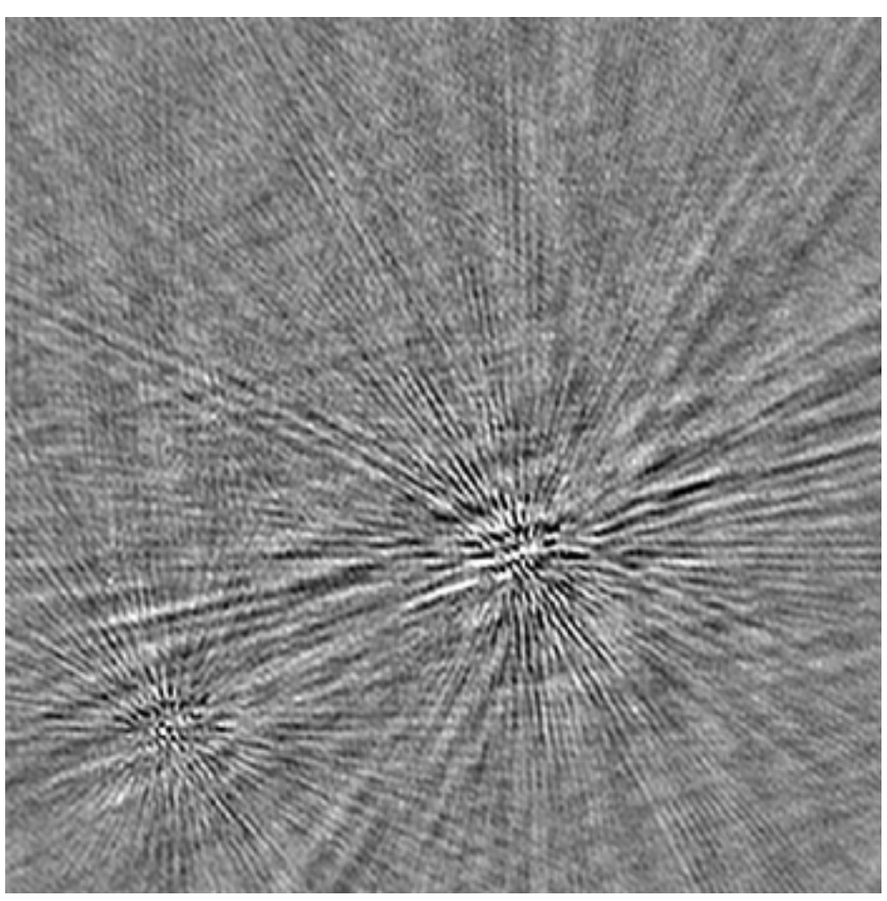
AIPY/manual

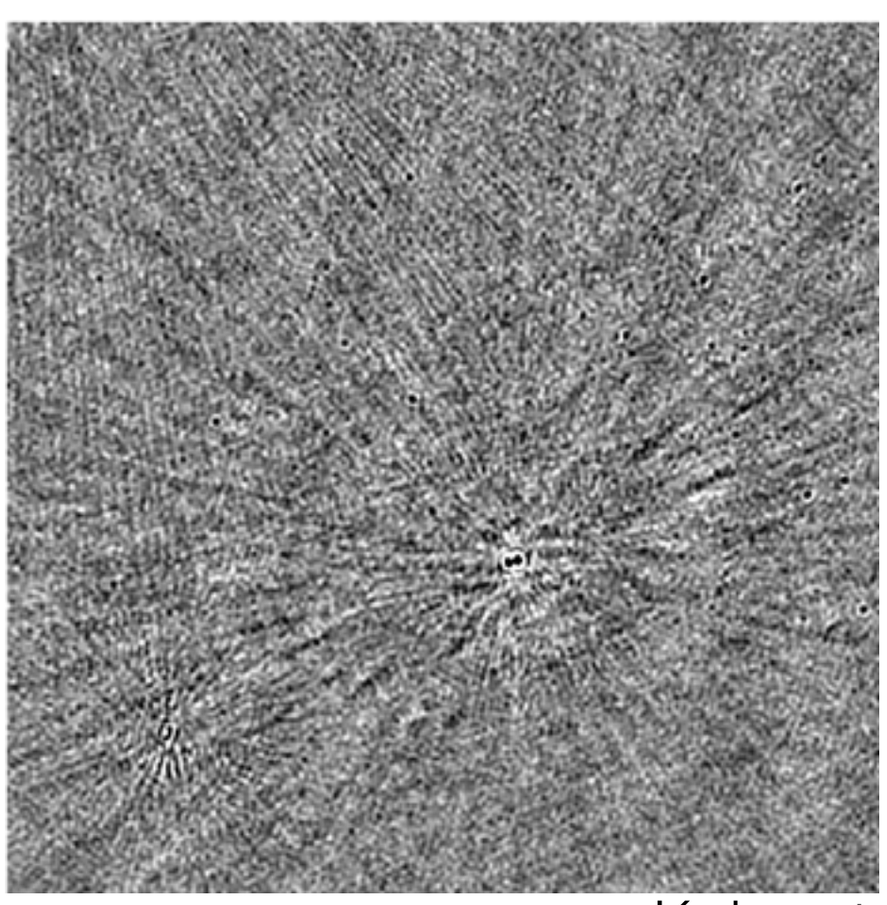
CASA

I



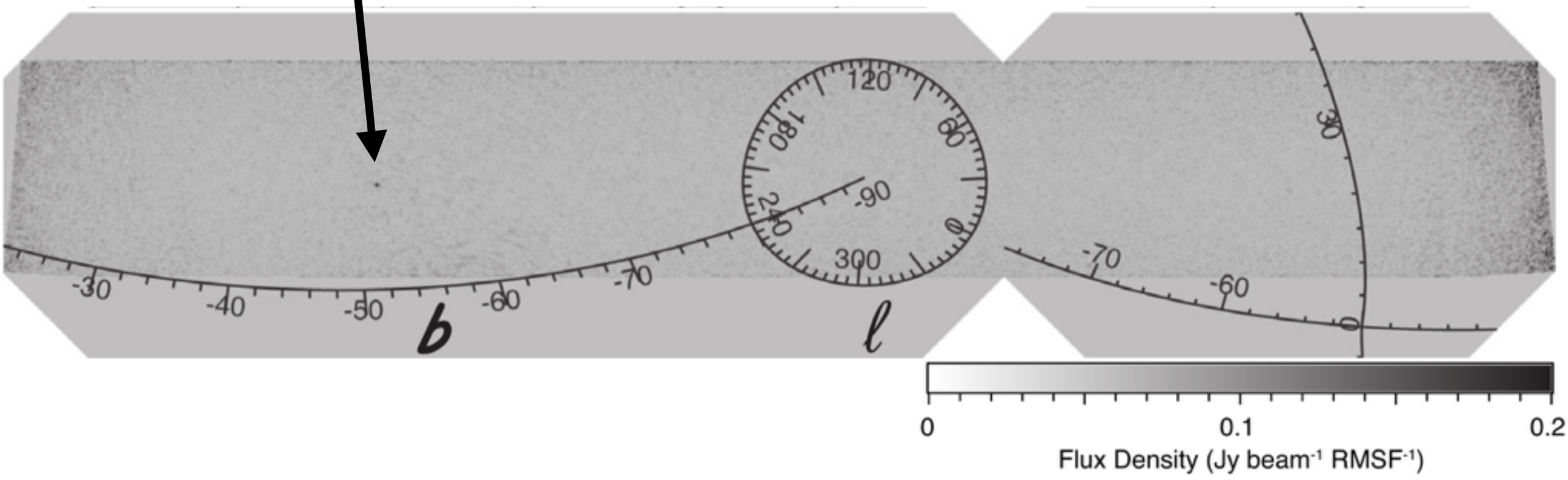
Q





Kohn et al. in prep

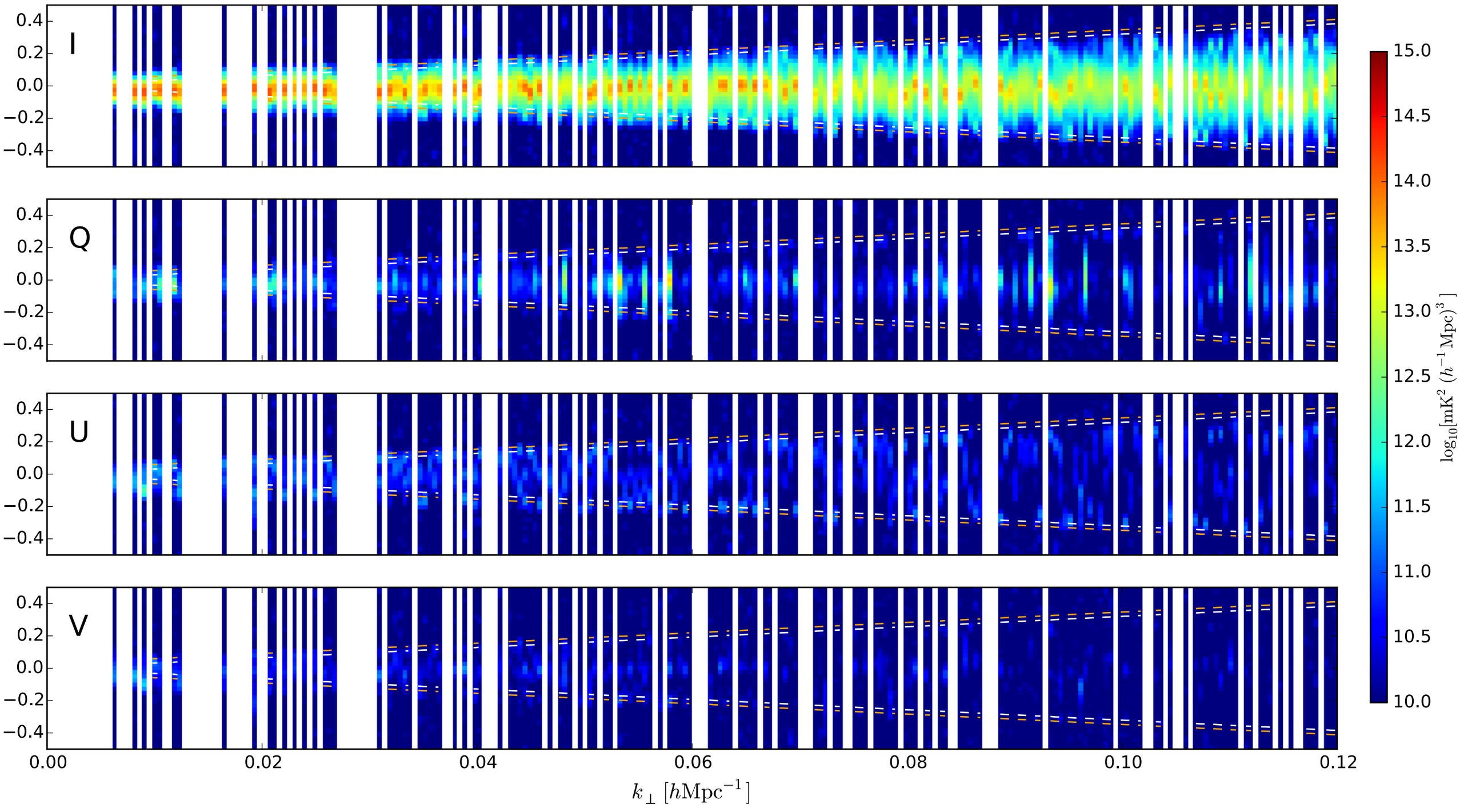
PMN J0351-2744 (RM = +34±2 rad/m^2)



Bernardi et al. 2013

Penn

Kohn et al. in prep



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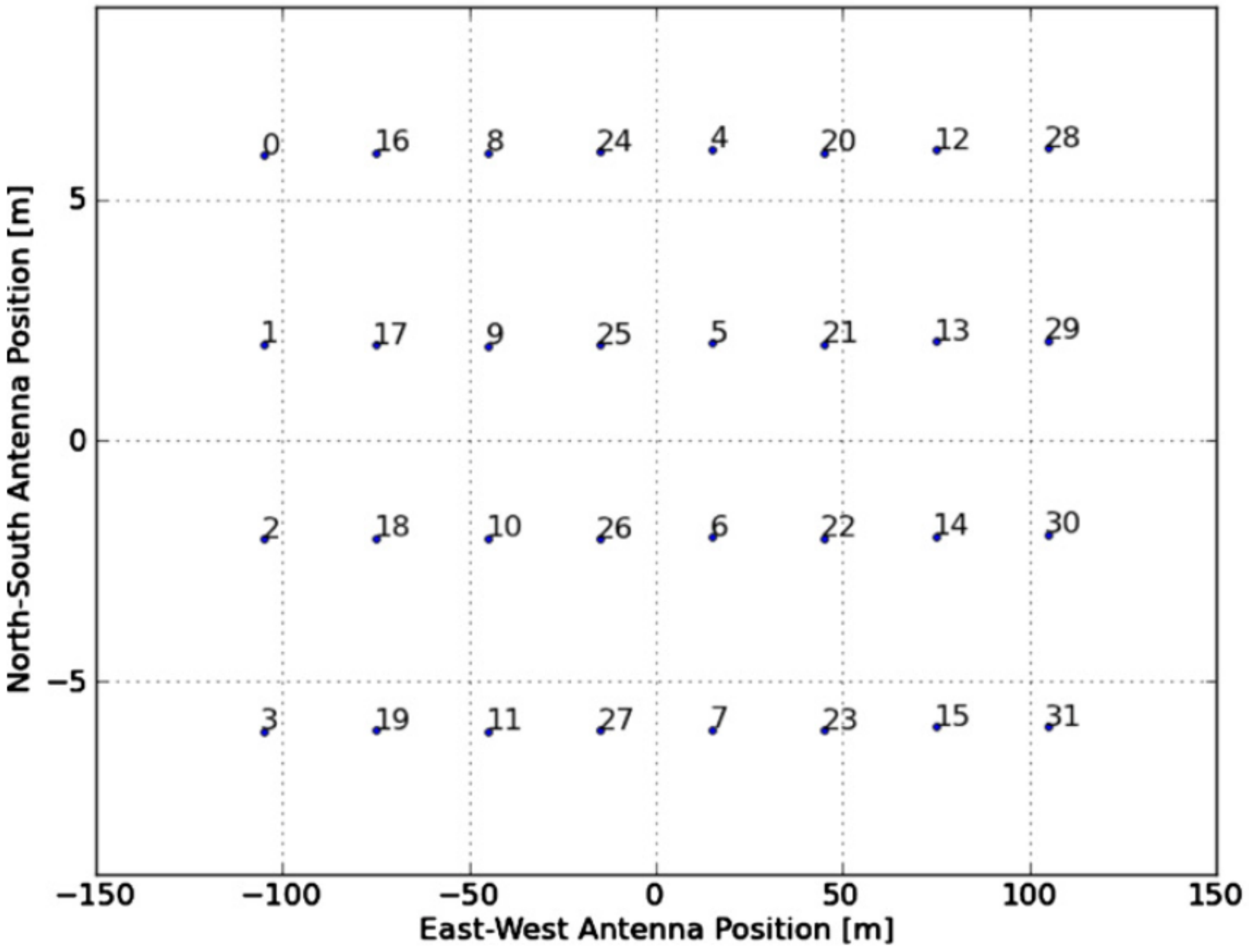
0
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11
27
7
23
15
31
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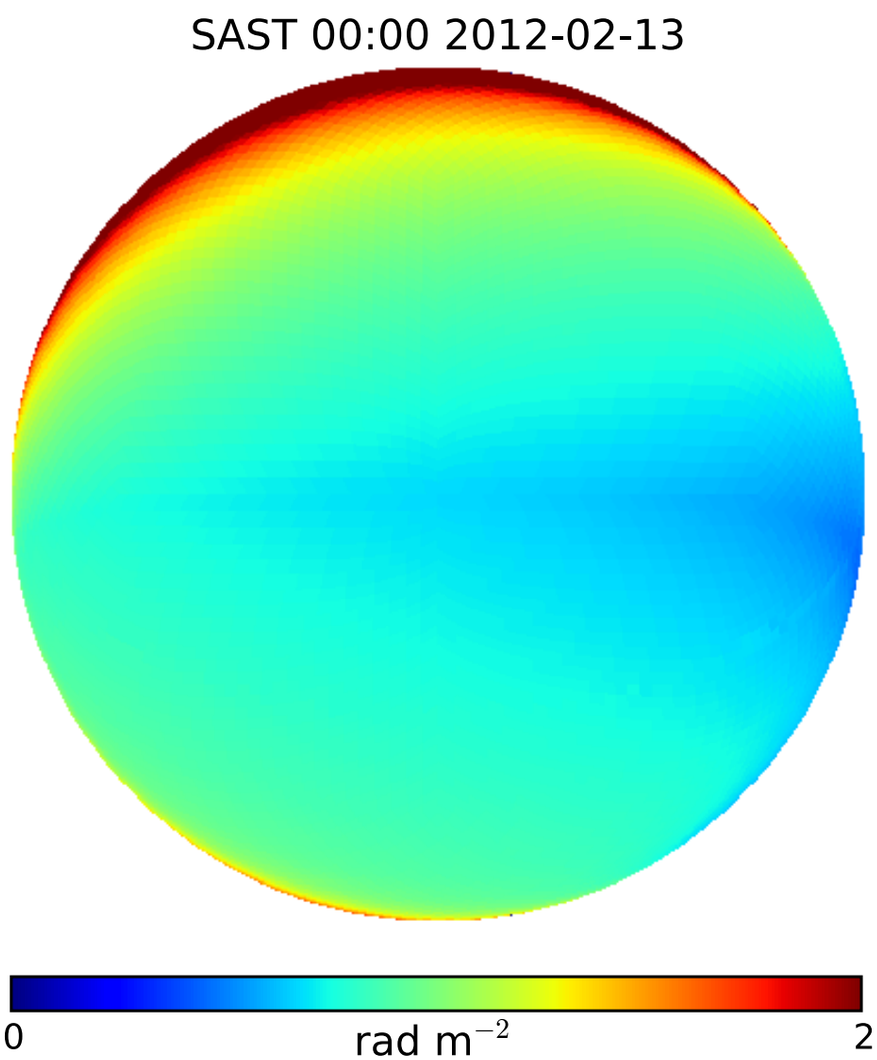
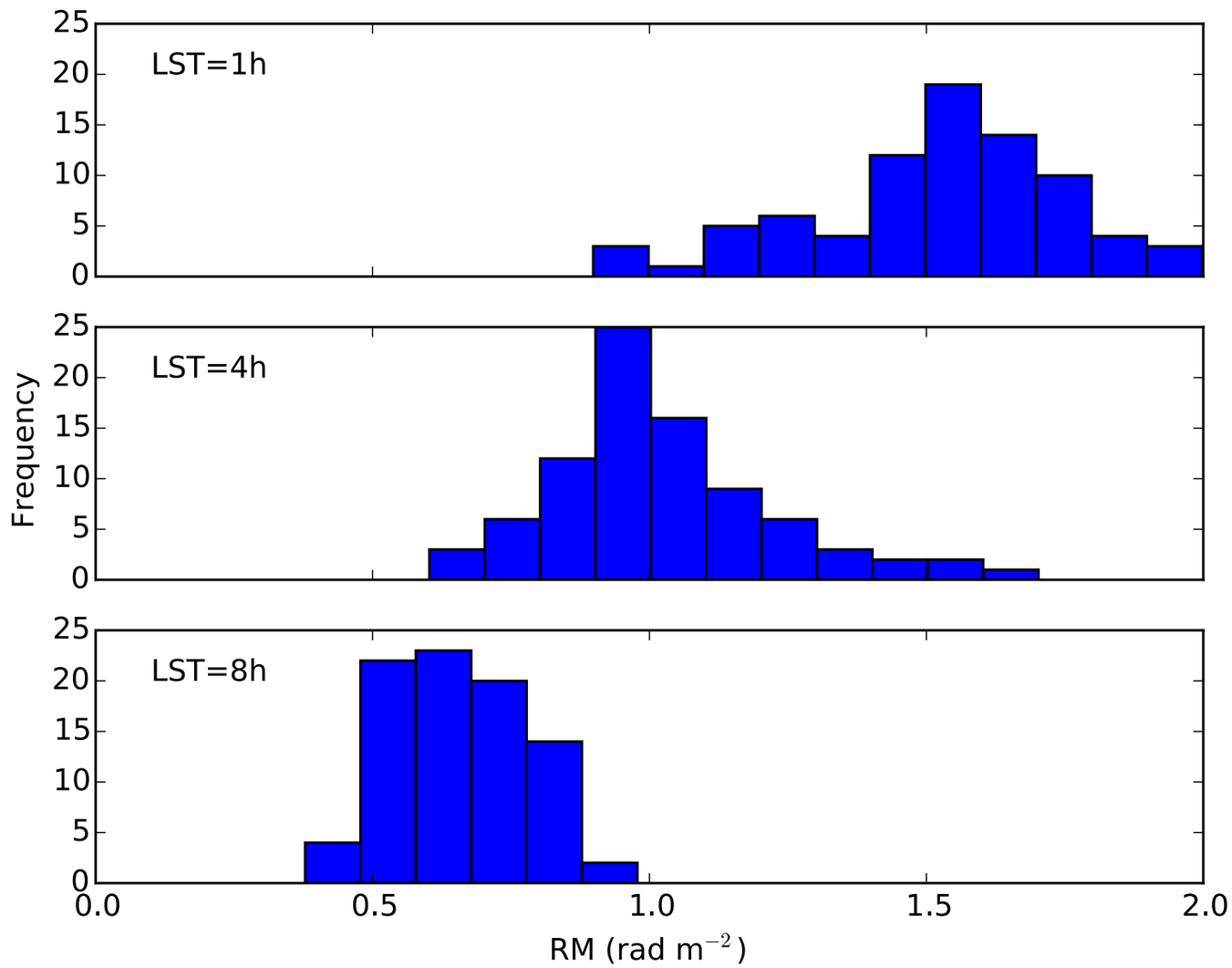
0
−5
−150
−100
−50
0
50
100
150
North-South Antenna Position [m]
East-West Antenna Position [m]

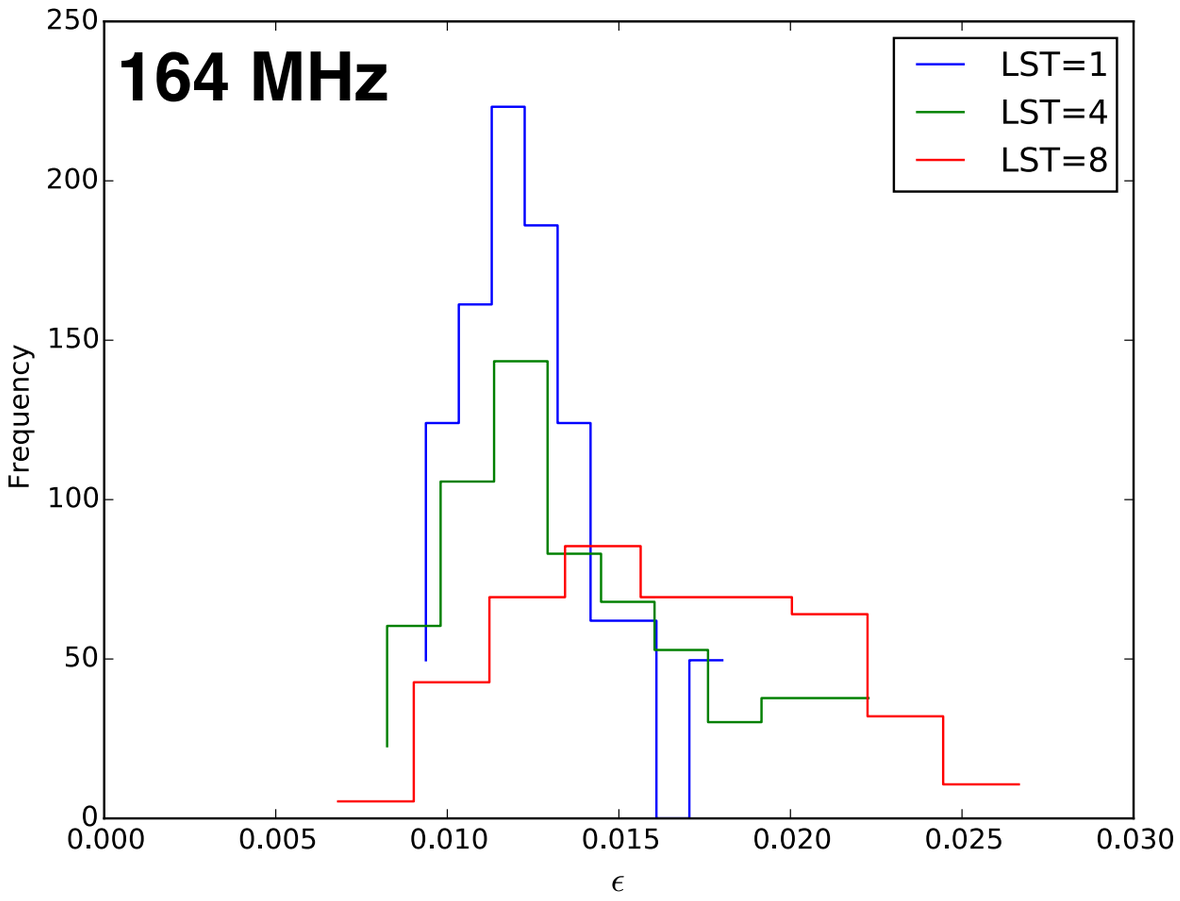


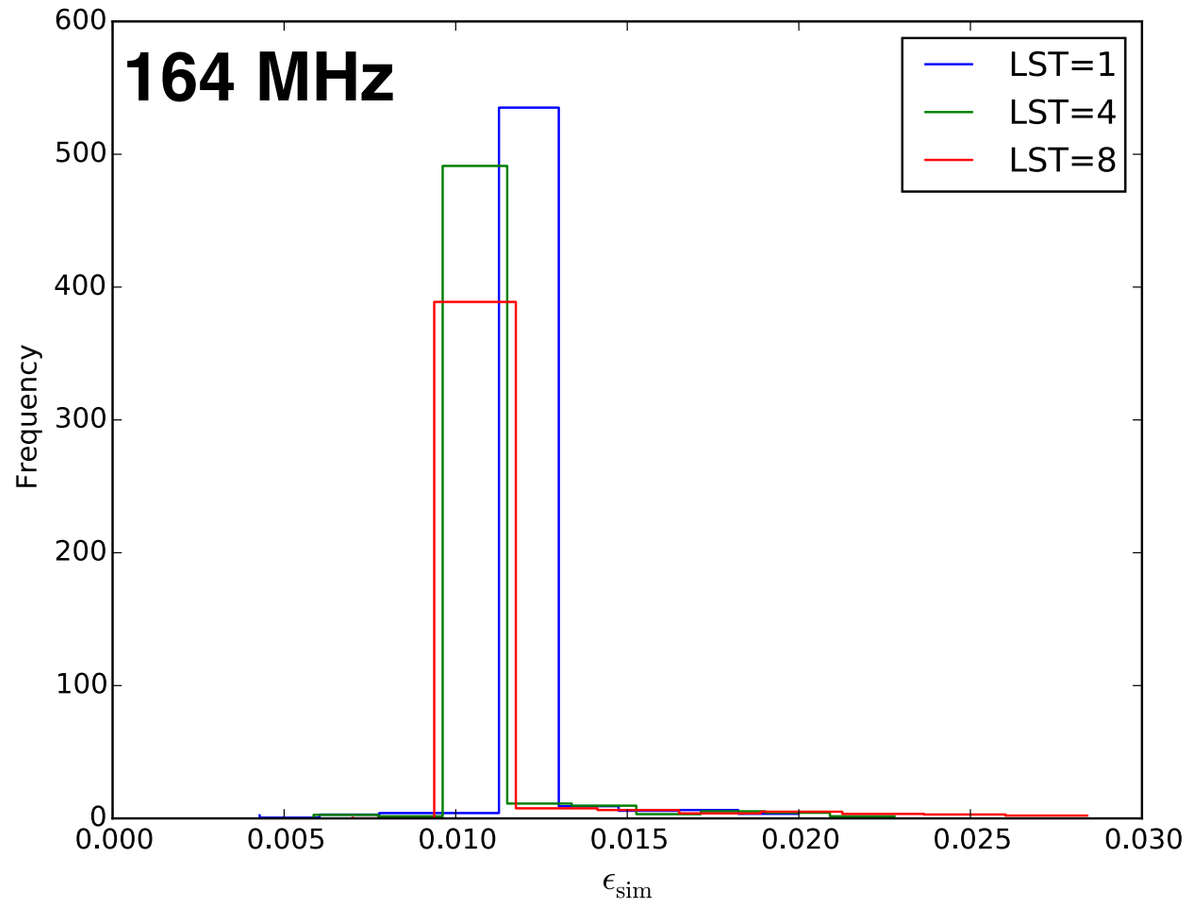


Using modded version of IonFR by
Sotomayor-Beltran et al. 2013
(beta = https://github.com/jaguirre/radionopy)

Moore et al. in prep.

Aguirre et al. in prep.





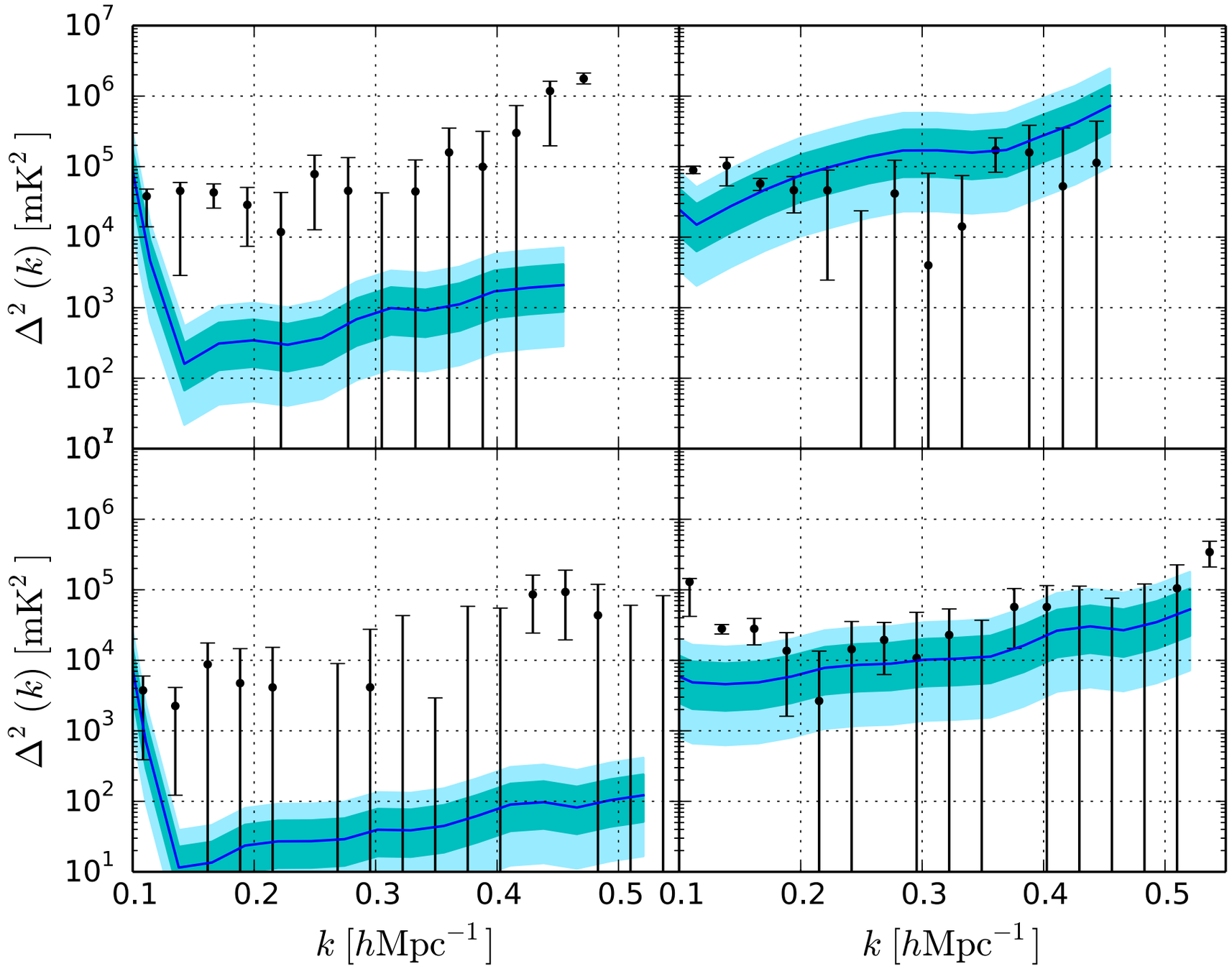
$$\widehat{P} \propto |\widehat{V}|^2 = \frac{1}{N^2}\left(\sum_{i,j} e^{-2i(\Phi_i - \Phi_j)\lambda^2}\right)|V|^2 \equiv \varepsilon|V|^2$$

Moore et al. in prep.

effective pol frac ~ 0.002

126 MHz

164 MHz



Moore et al. in prep.
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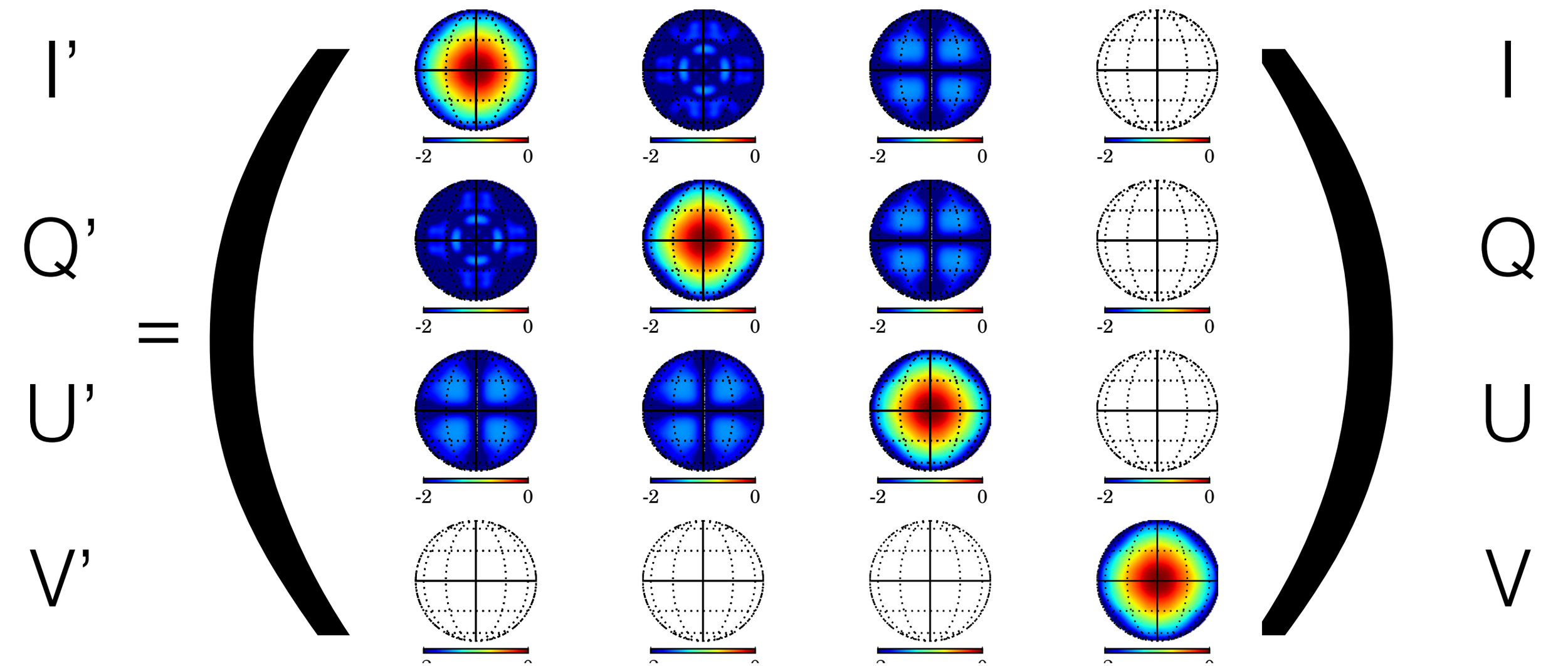


Aguirre et al. in prep

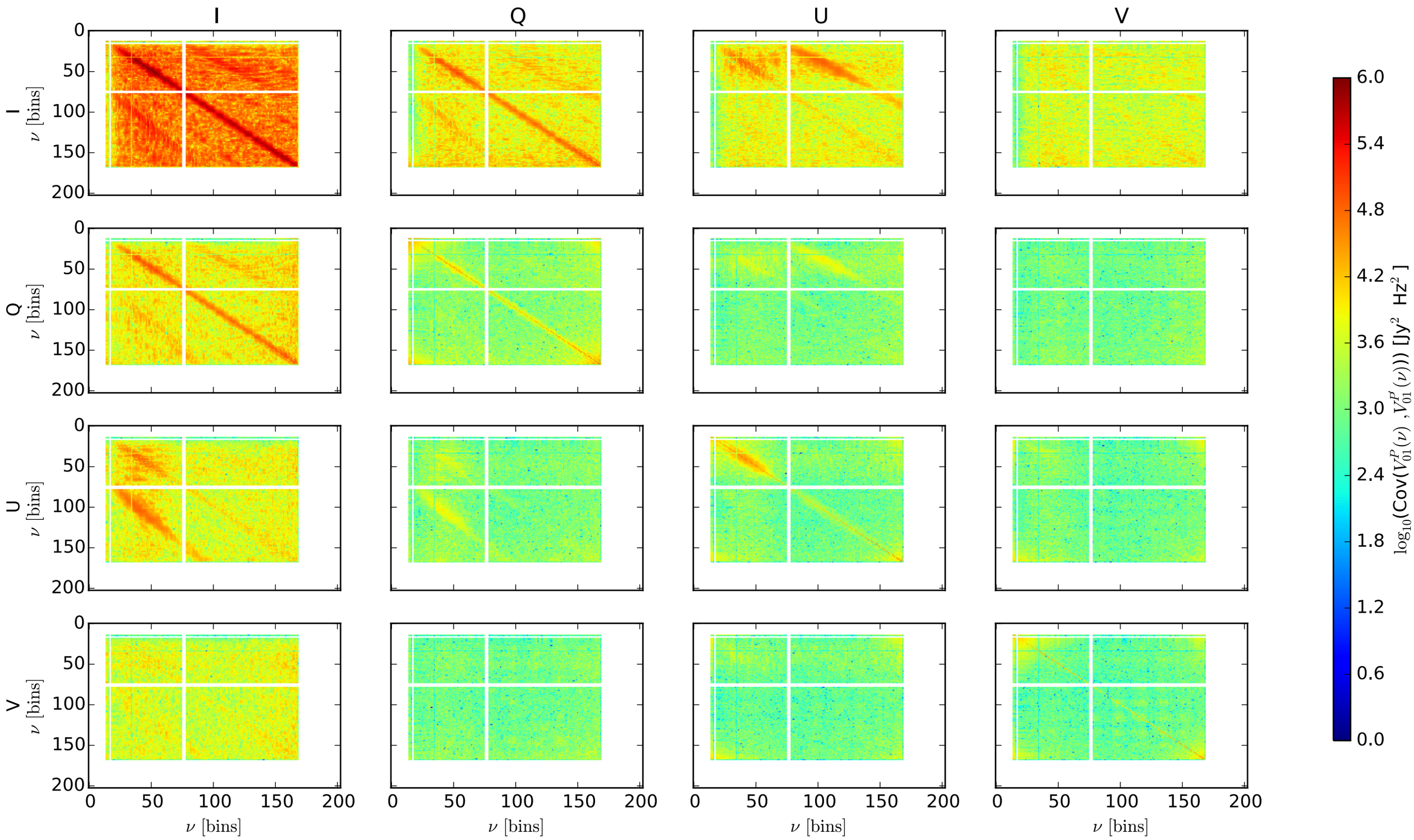
- Instrumental, terrestrial and astrophysical polarized foregrounds risk contamination of the EoR window

- On a nights-worth of data, this contamination only appears to occur close to the horizon at low *k*-values

- Ionospheric polarization can decohere any existing leakage, and heavily suppress it during LST-binning

- Instrumental polarization via widefield beam effects is an active area of research (ECHO, ORBCOMM, CST, FEKO, etc.)

- By transitioning into high S/N spaces for polarization, we are rapidly putting to rest these systematics for PAPER and HERA!



Kohn et al. in prep