

Single dish intensity mapping progress with MeerKLASS

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SKA Cosmology SWG Meeting

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MANCHESTER
1824

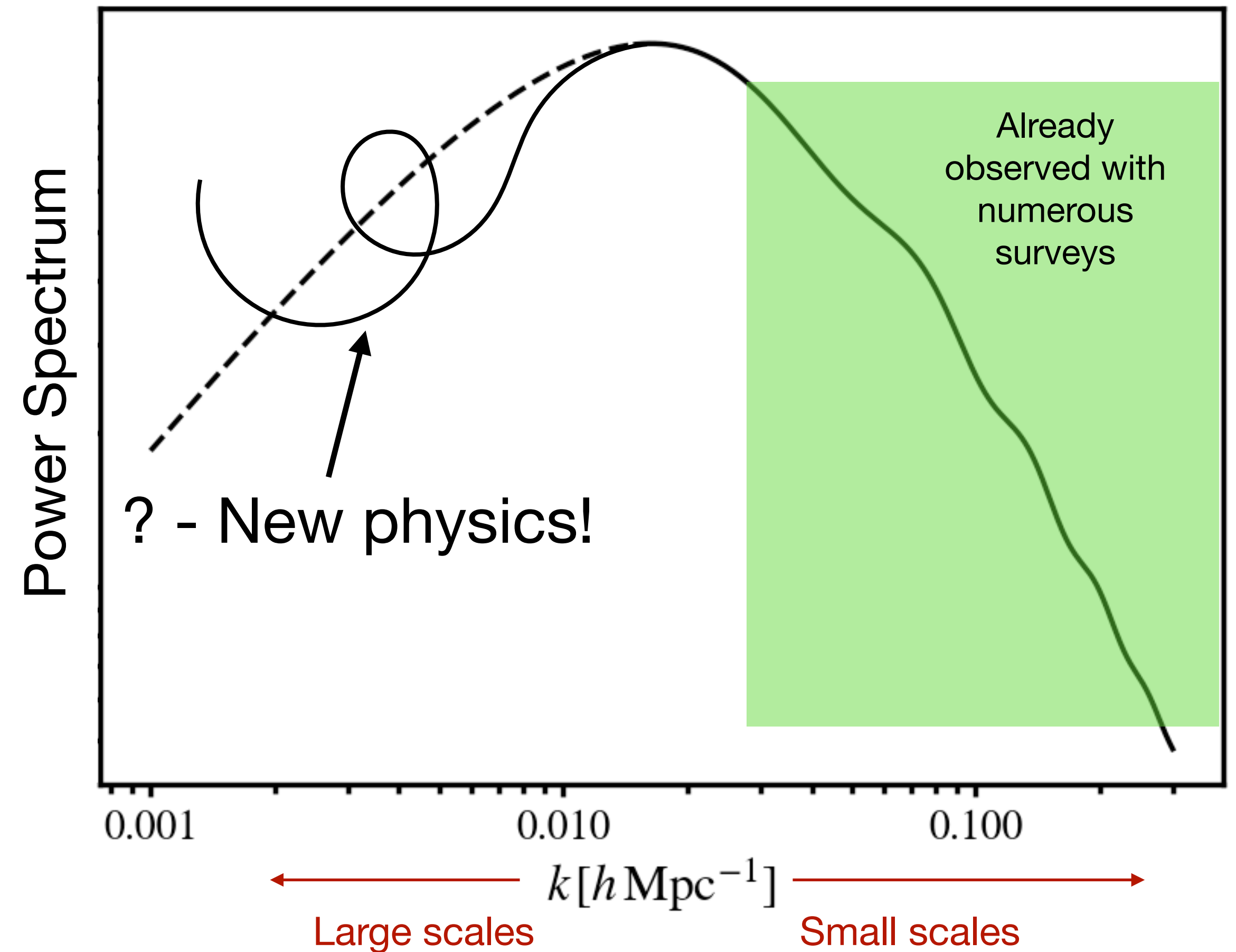
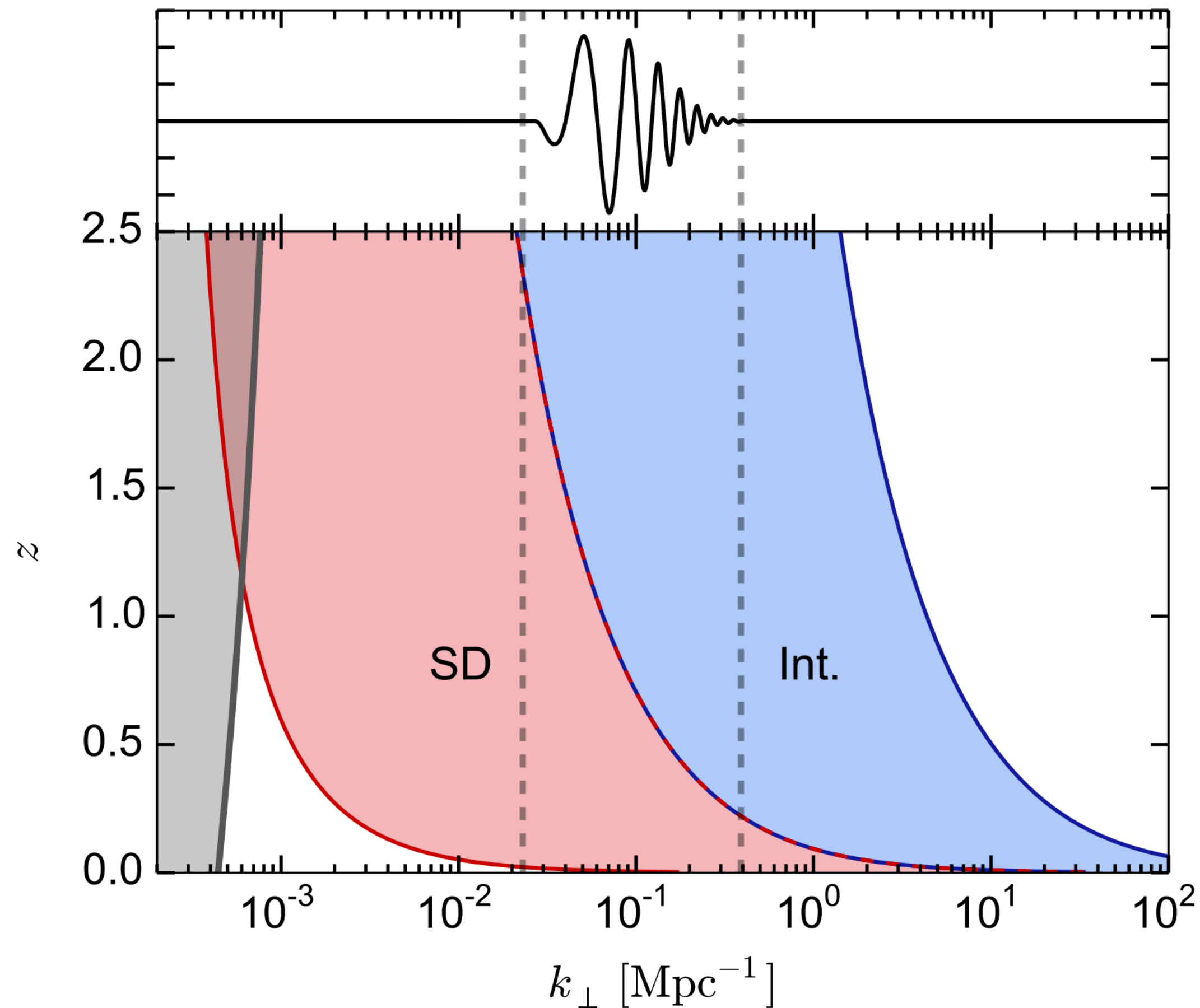
The University of Manchester



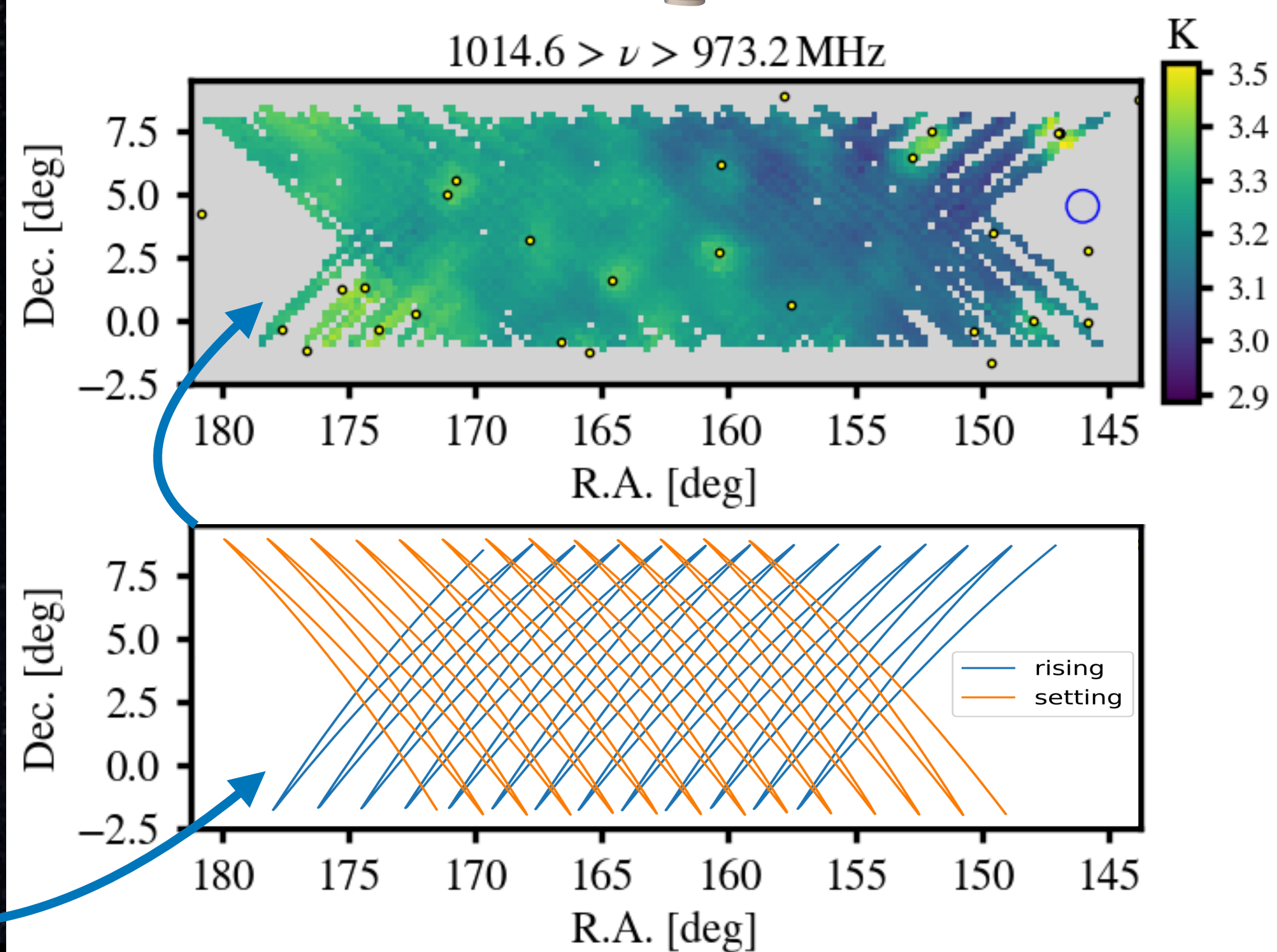
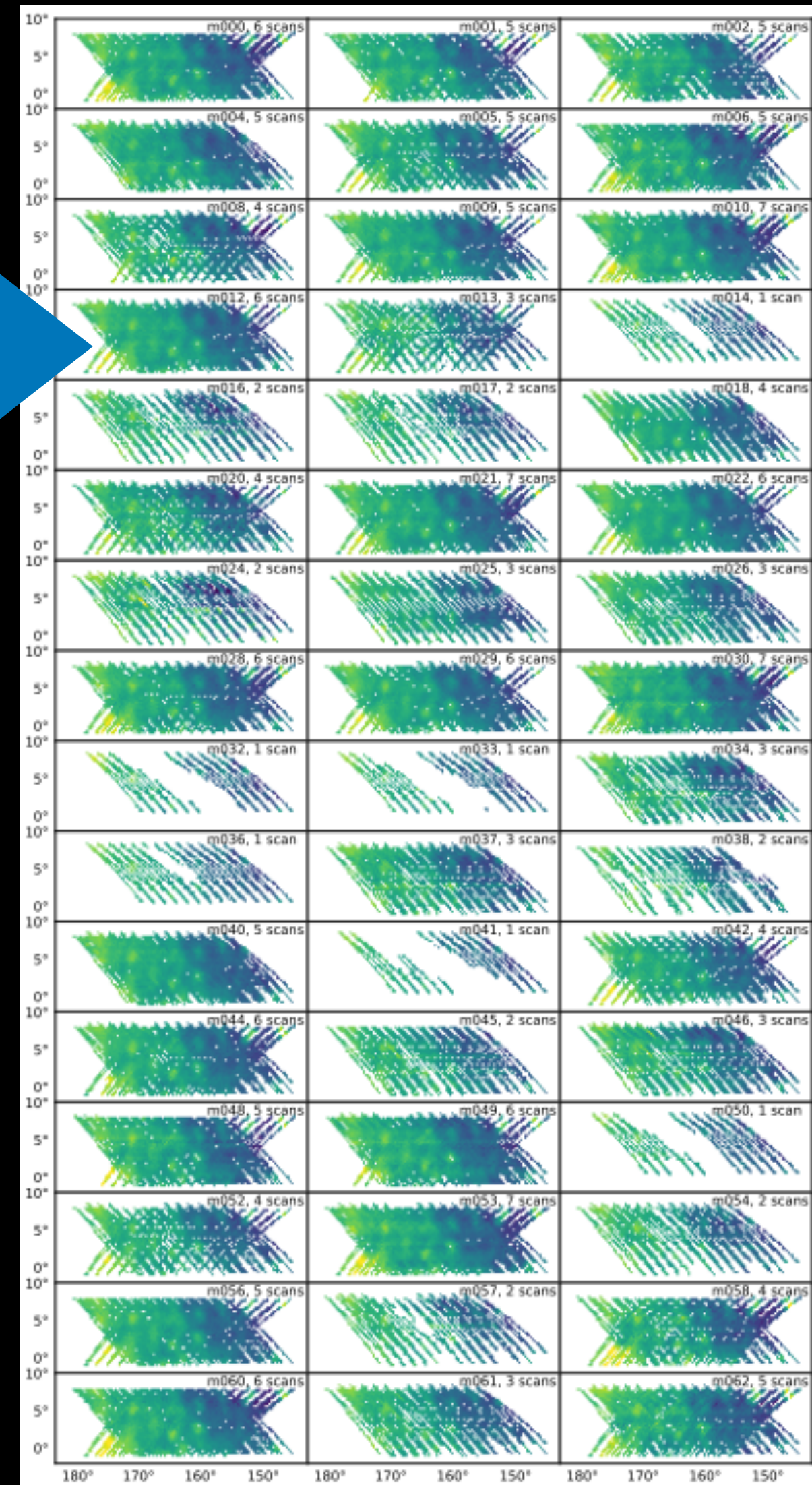
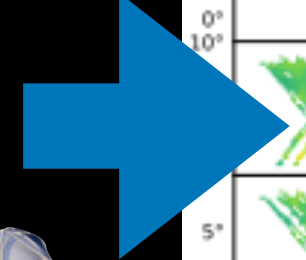
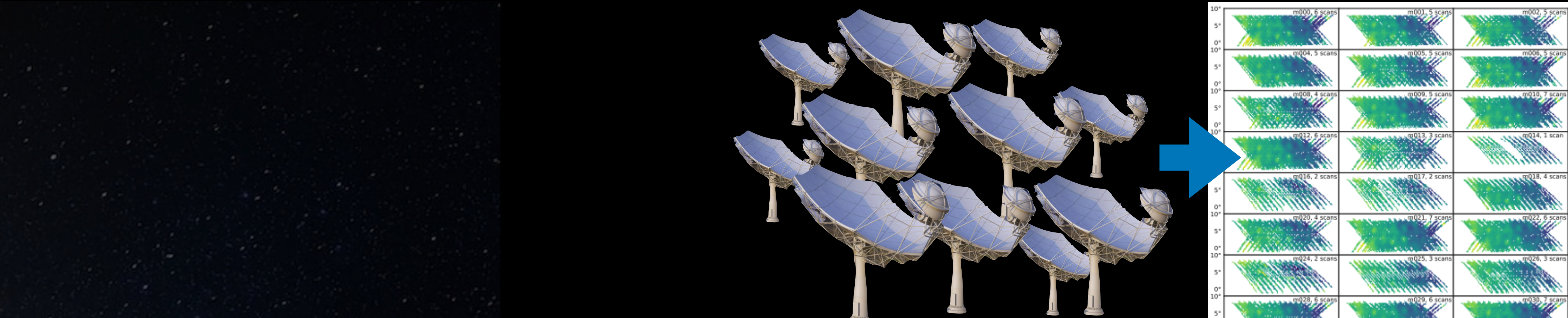
UK Research
and Innovation

Why single-dish (largest cosmological scales)?

P.Bull+15 [arXiv:1405.1452]

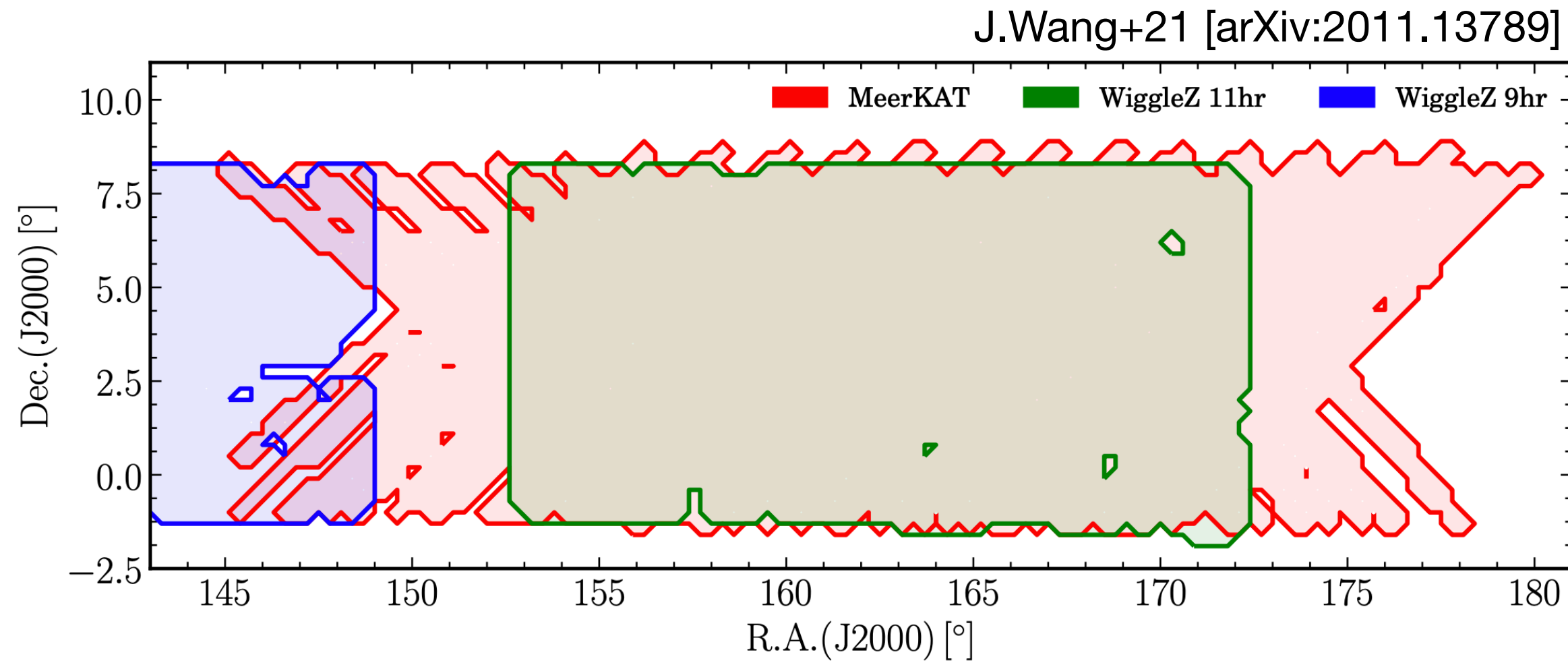


- Probe primordial inflation
- New test of general relativity
- Access to *linear* scales

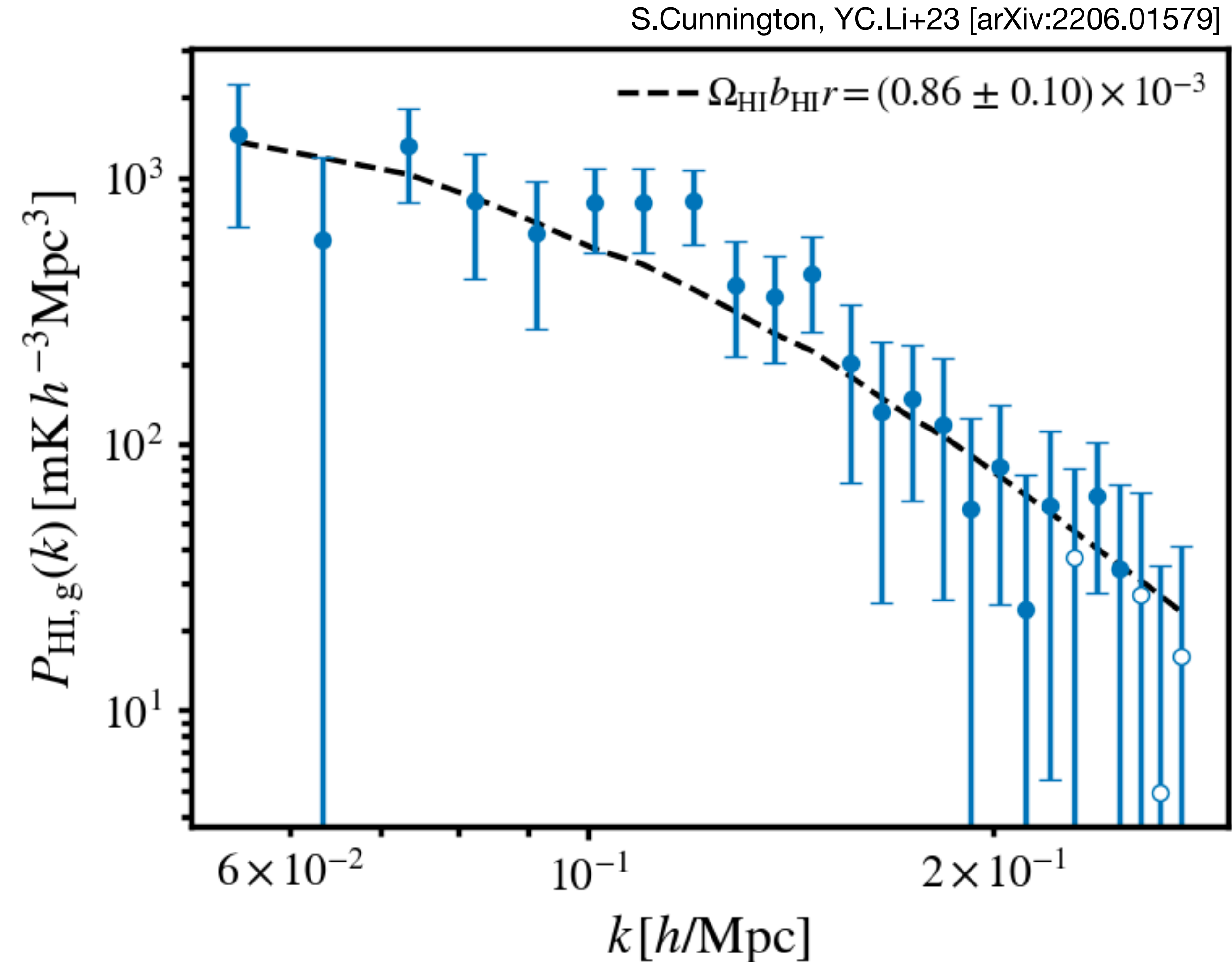


J.Wang+21 [arXiv:2011.13789]

Detecting cosmological clustering with MeerKLASS pilot intensity mapping survey



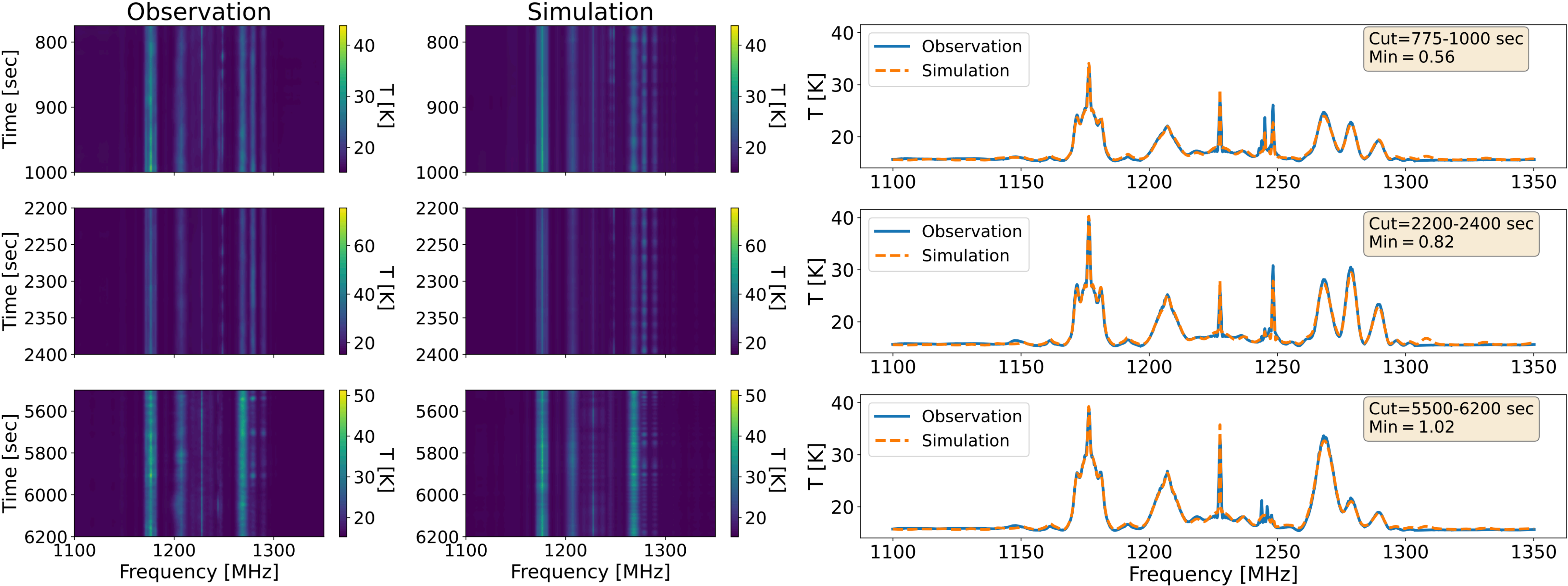
- Just **10.5 hours of observations**
- Positive correlation (**7.7σ**) between galaxy survey and array of dishes in single-dish mode
- The first detection of its kind
- Important milestone for doing LSS cosmology with **SKA intensity mapping**



Challenges and lessons learnt with MeerKLASS

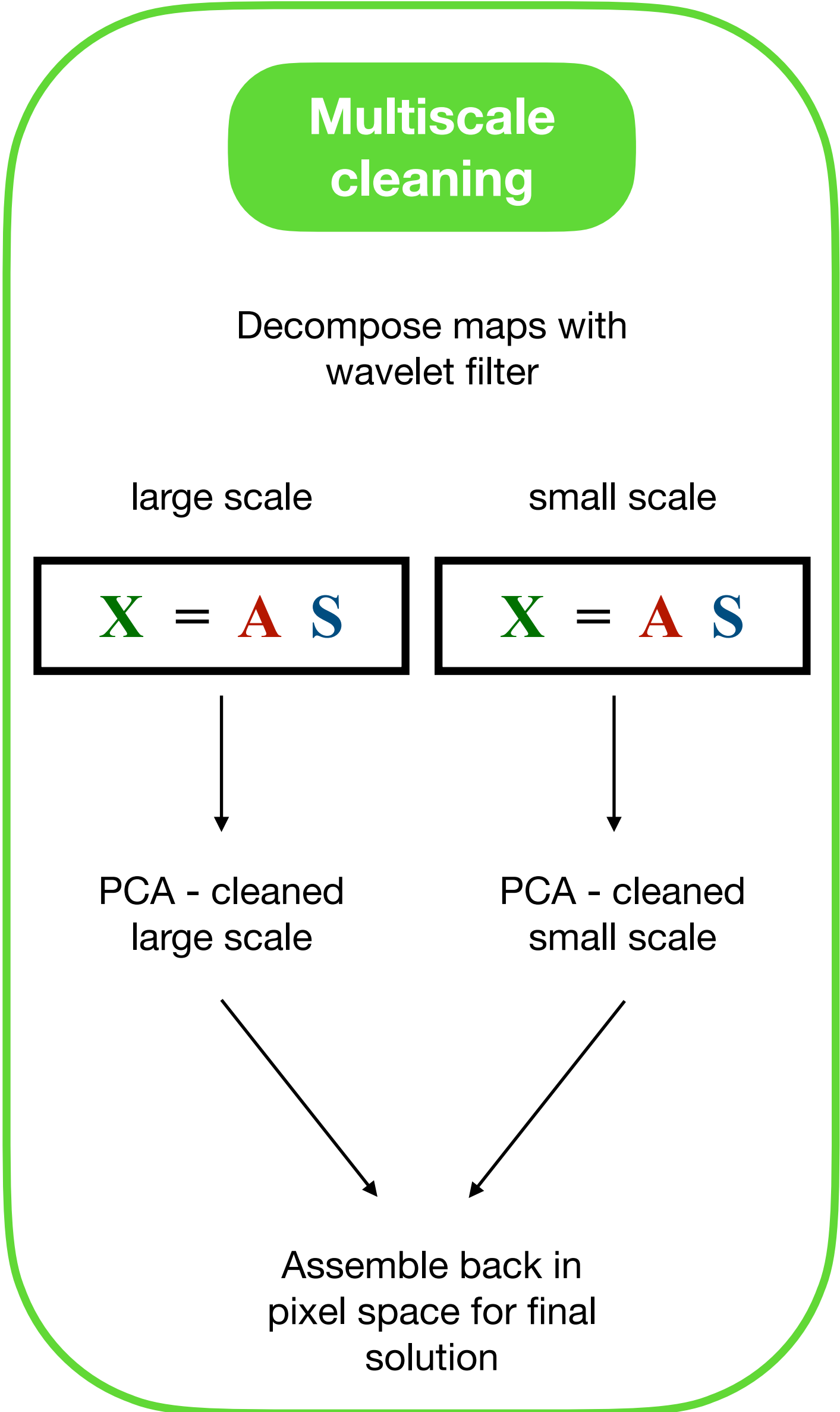


Understanding RFI contamination

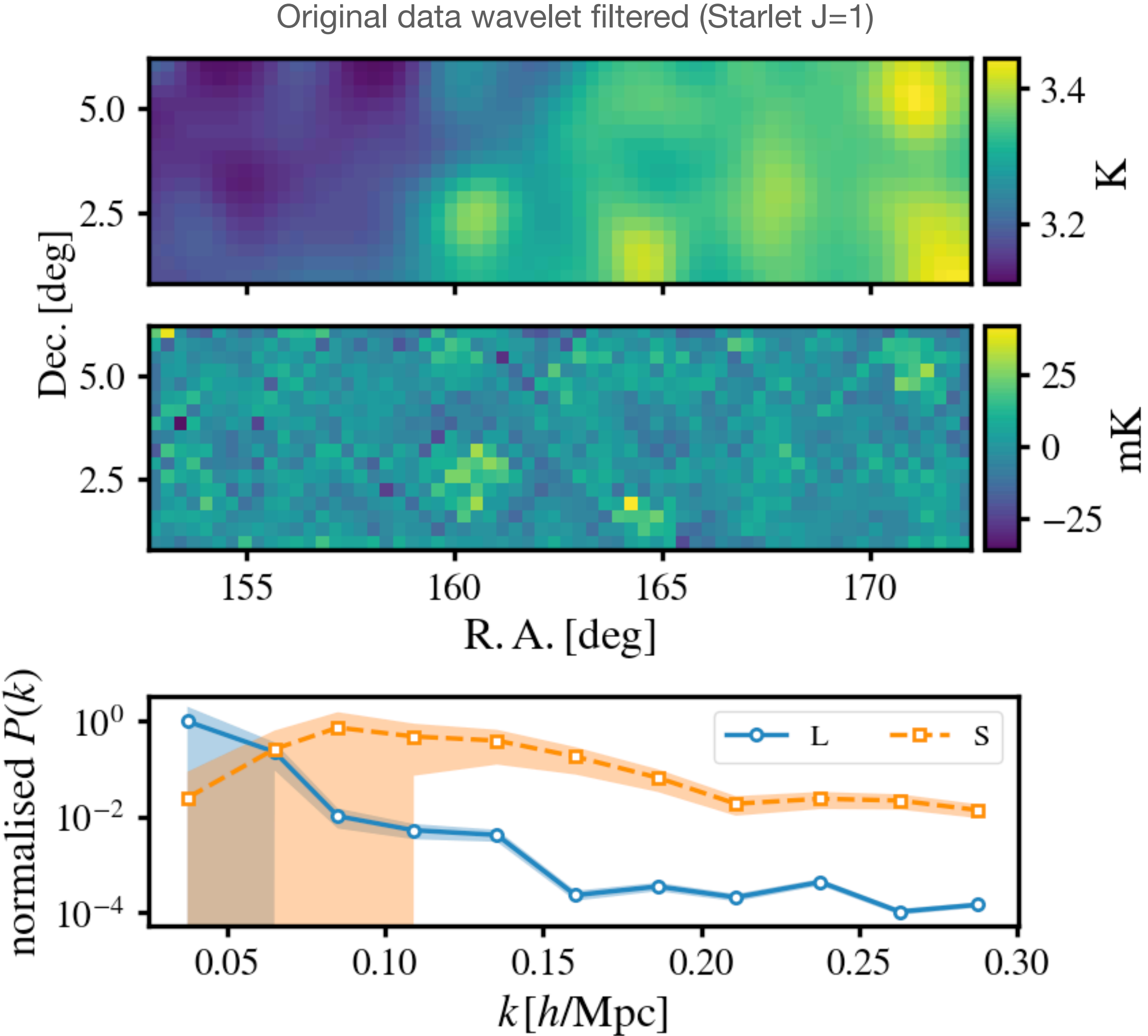


New approach to foreground cleaning

Slide credit:
Isabella Carucci

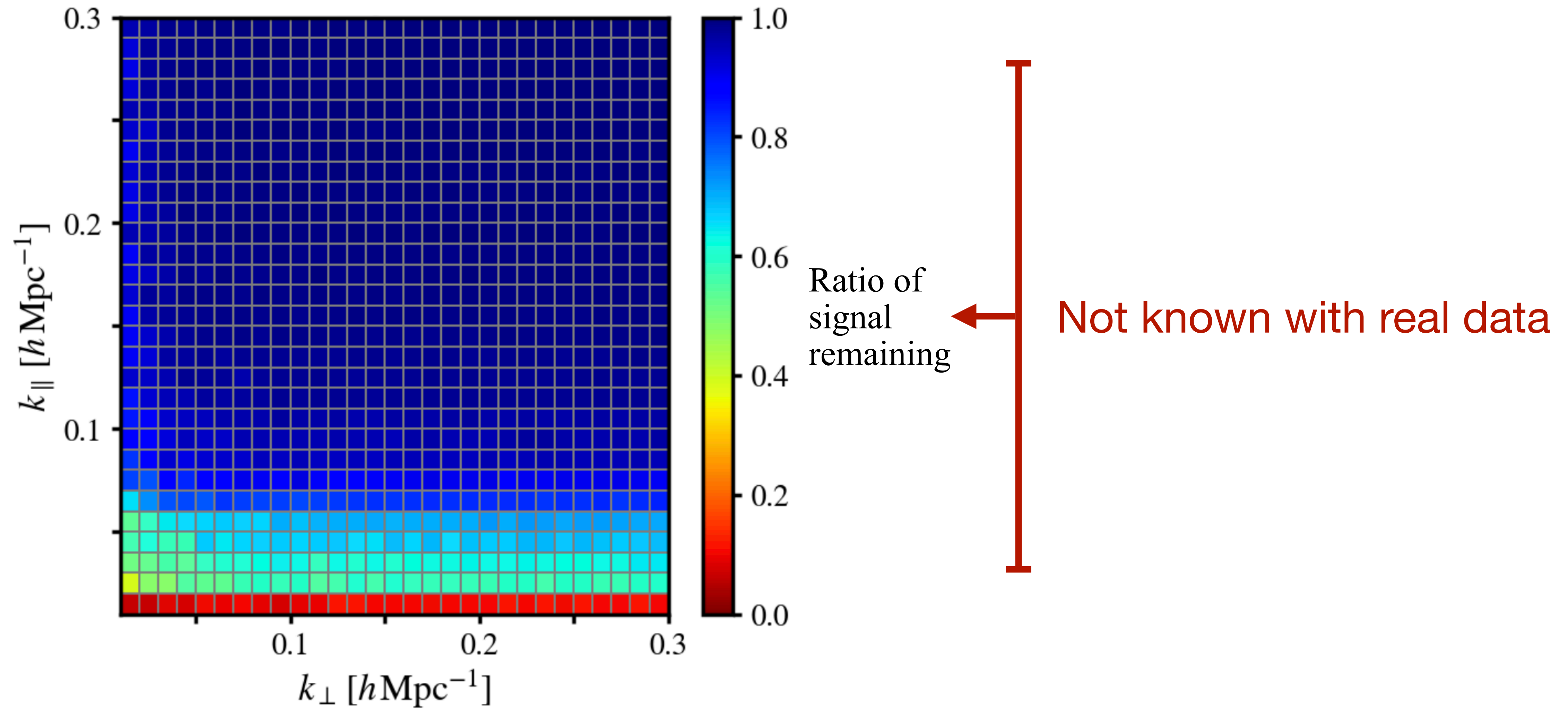


multiscale



Carucci, + in prep.

How much (HI) signal is lost in foreground cleaning?



Testing signal loss reconstruction with simulations

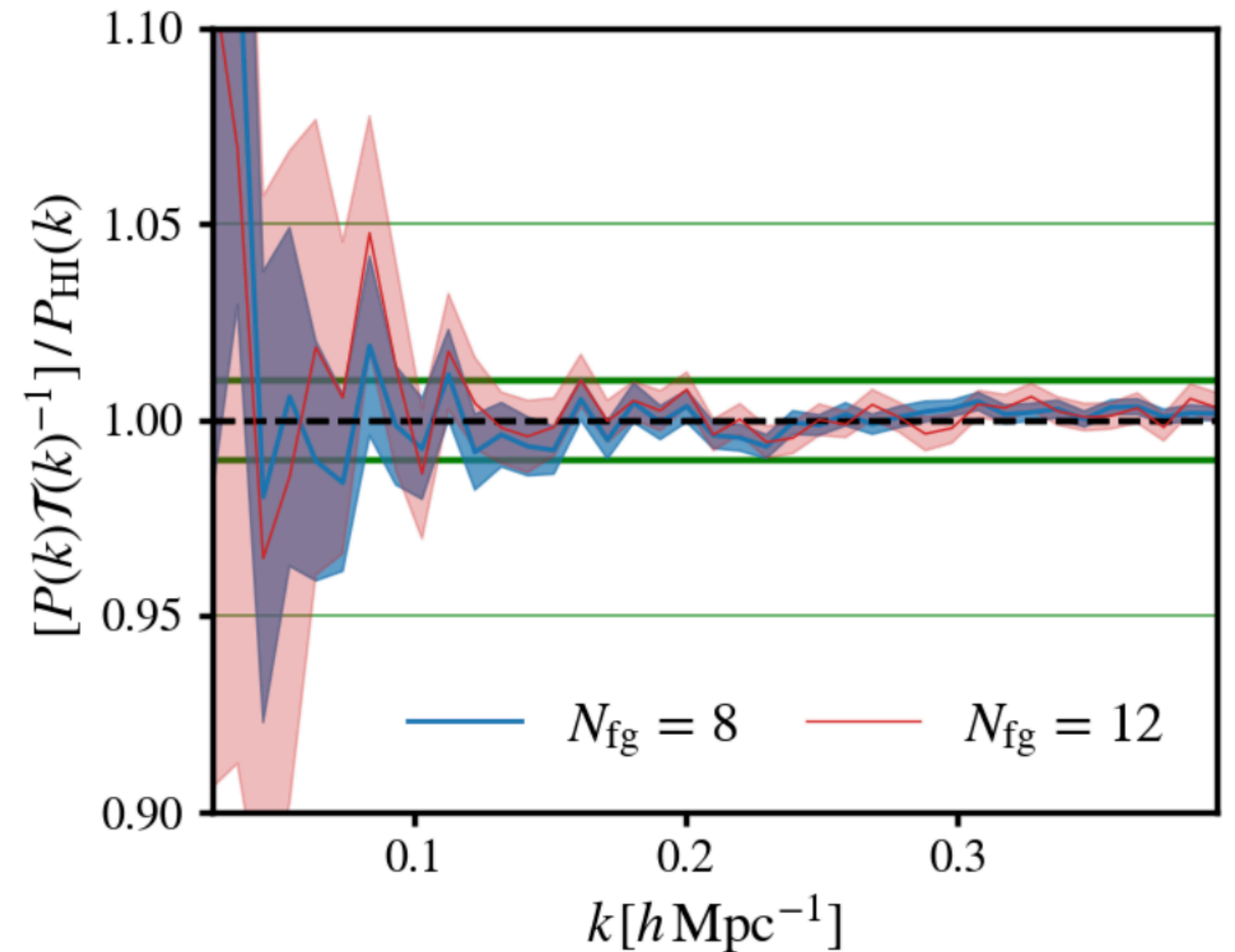
Constructing a foreground cleaning transfer function for signal reconstruction:

Inject mocks into real observational data and clean

$$\mathcal{T}(k) = \left\langle \frac{\mathcal{P}(\mathbf{X}_{\text{clean}}^m, \mathbf{X}_m)}{\mathcal{P}(\mathbf{X}_m, \mathbf{X}_m)} \right\rangle$$

Uncleaned (original) mock

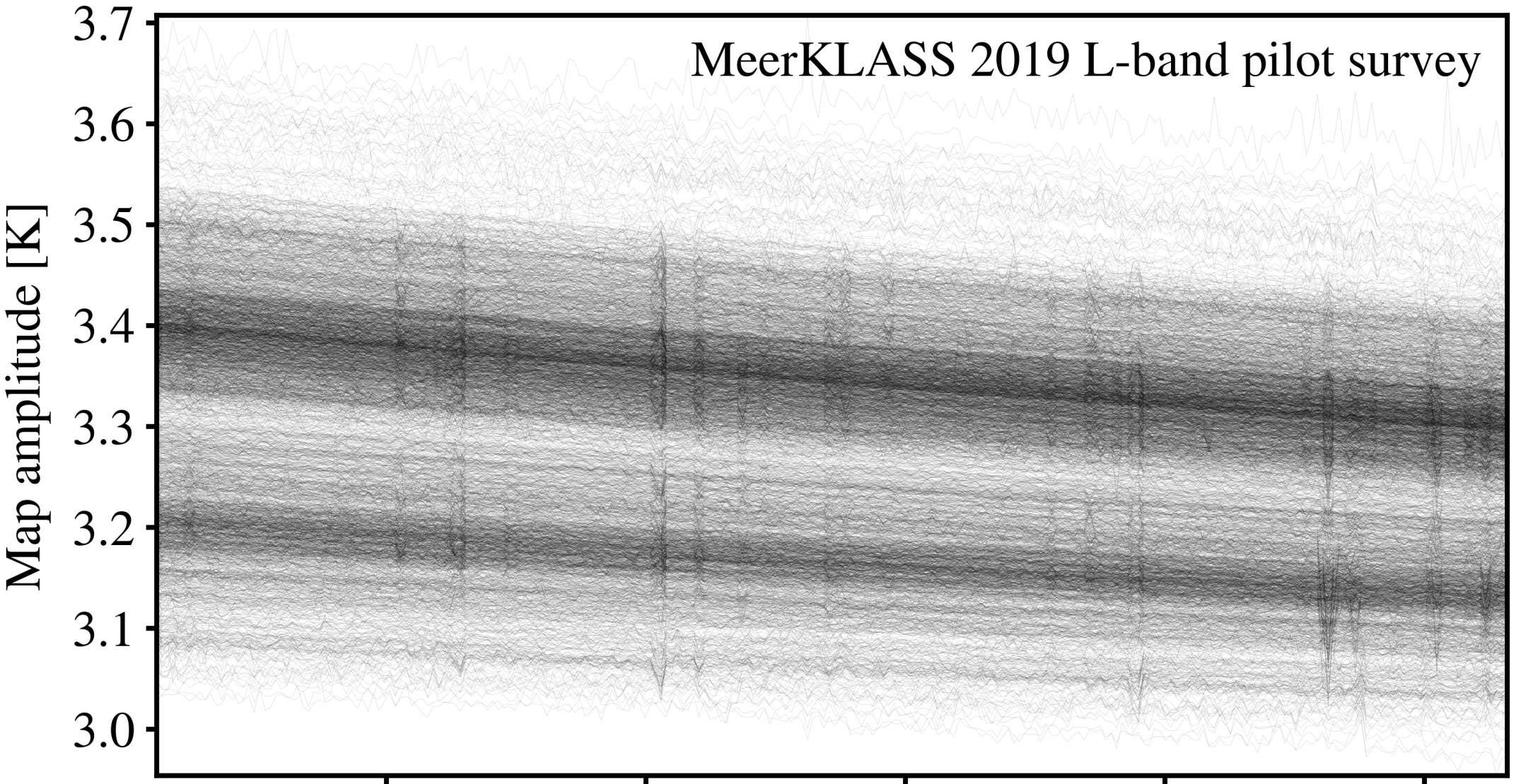
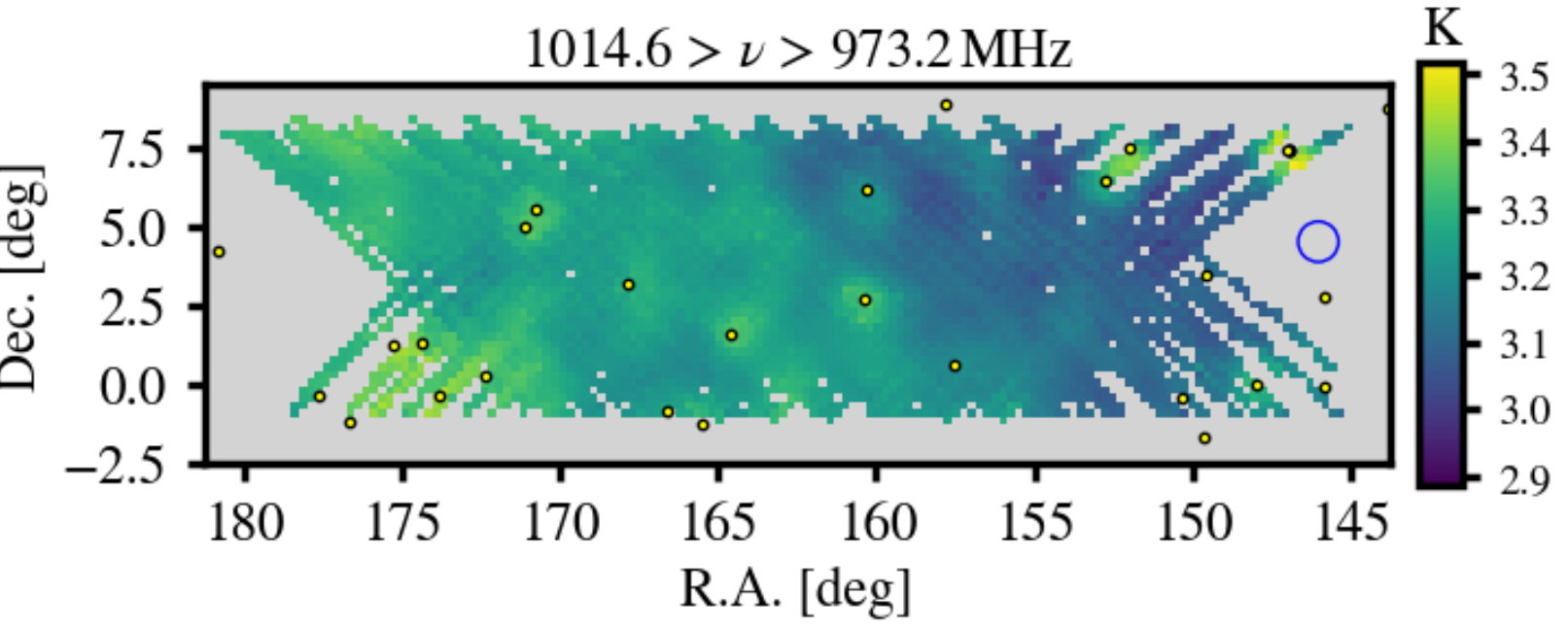
$$P_{\text{corrected}}(k) = P_{\text{cleaned}}(k) / \mathcal{T}(k)$$



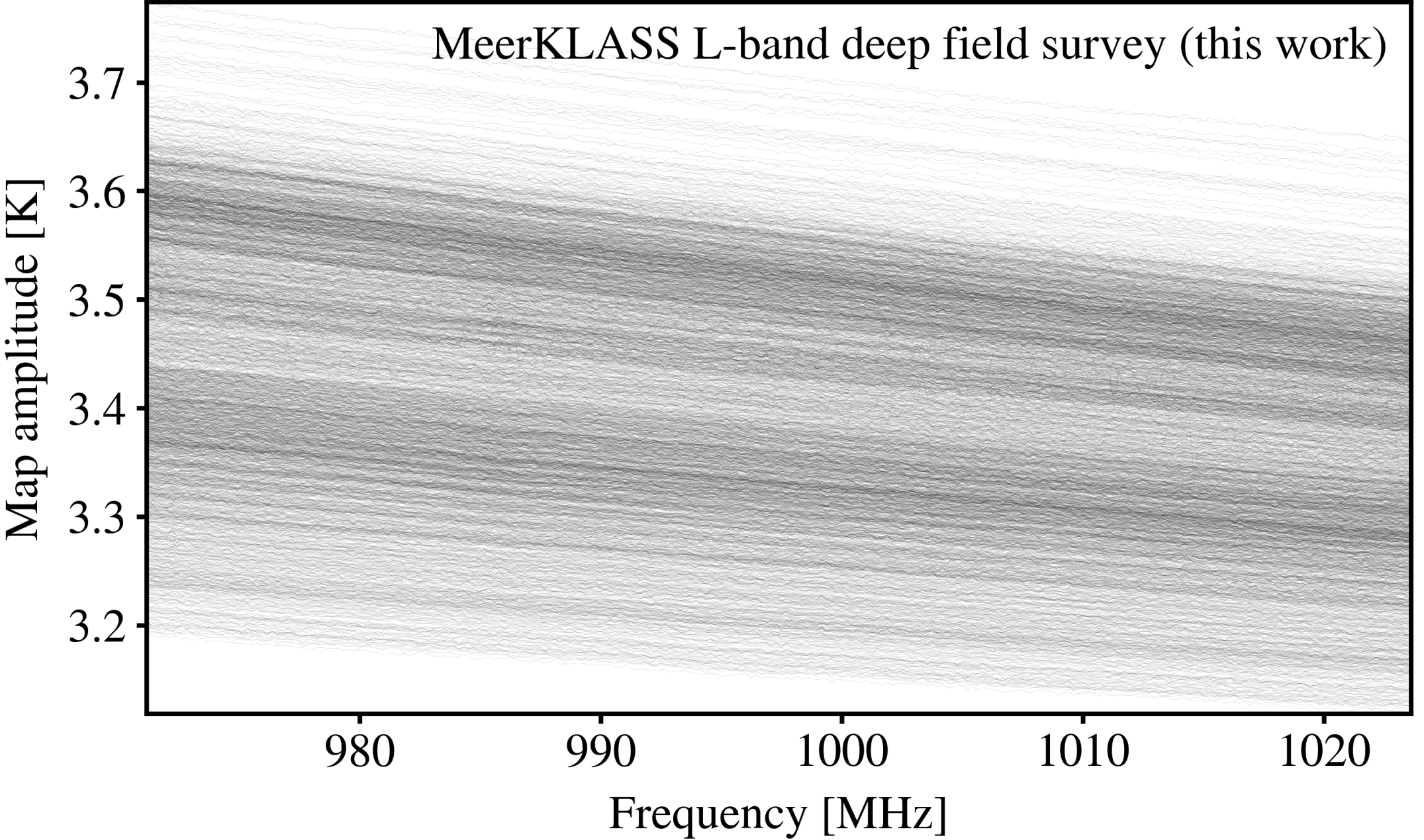
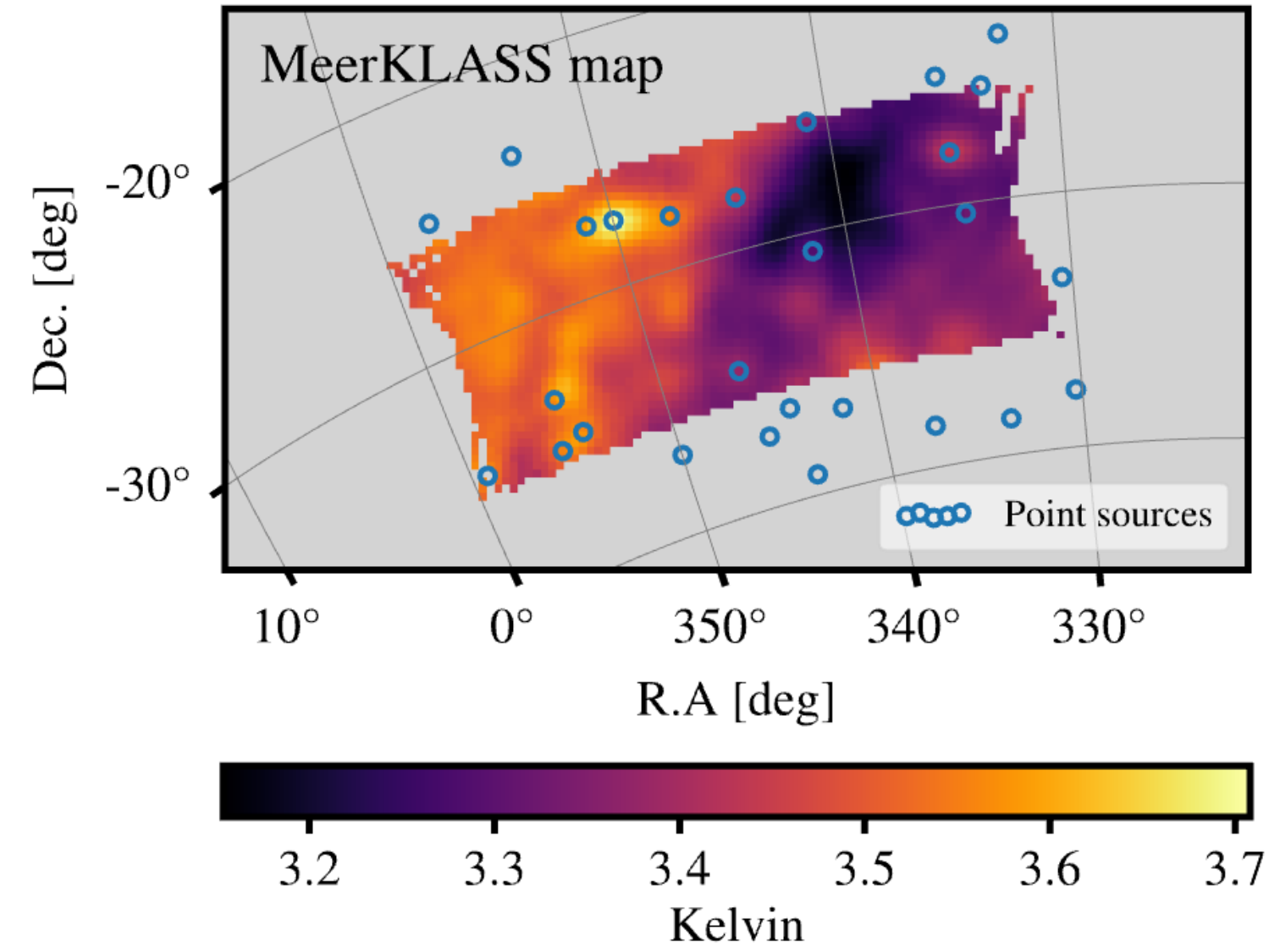
Progress and results with MeerKLASS



Deeper L-band observations



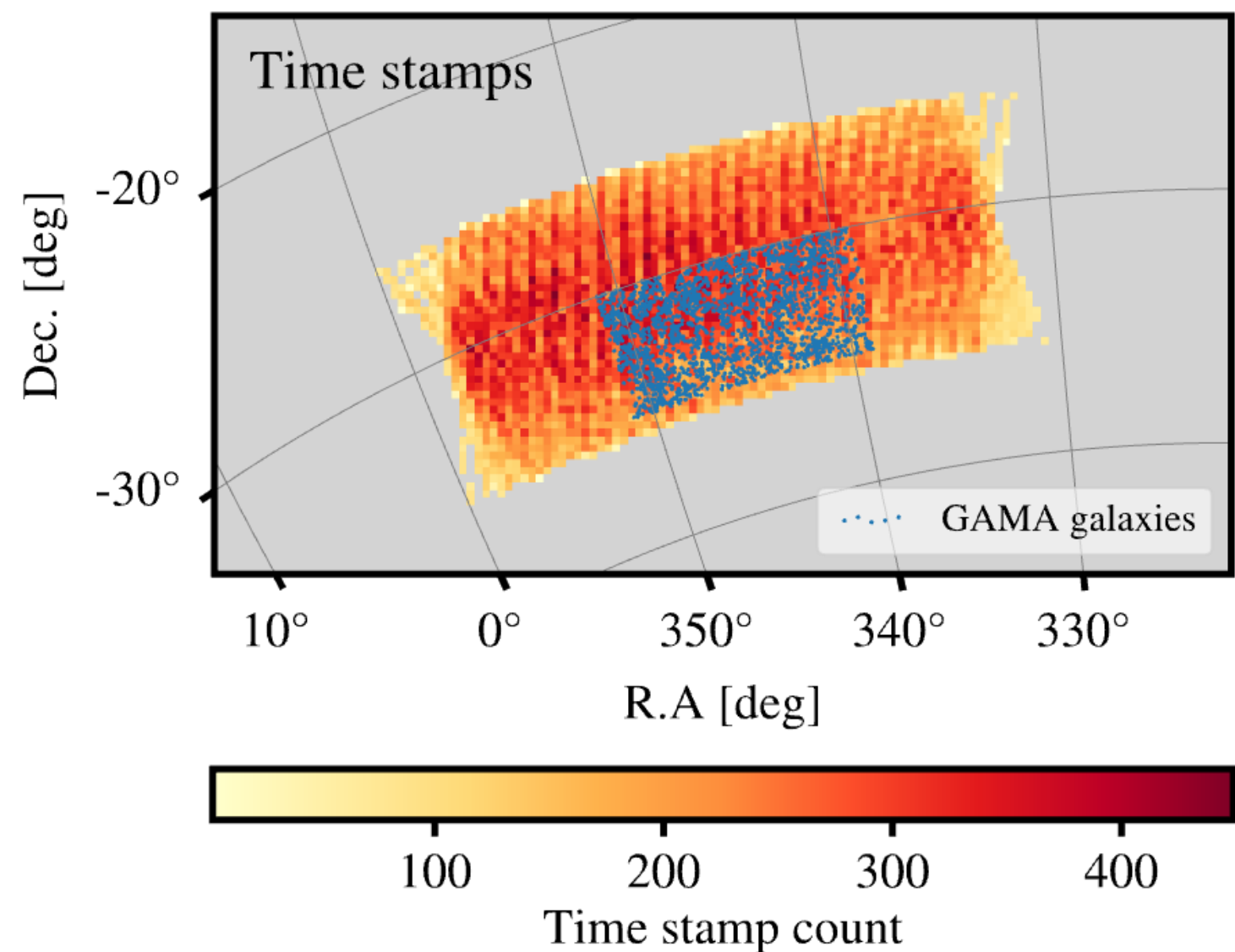
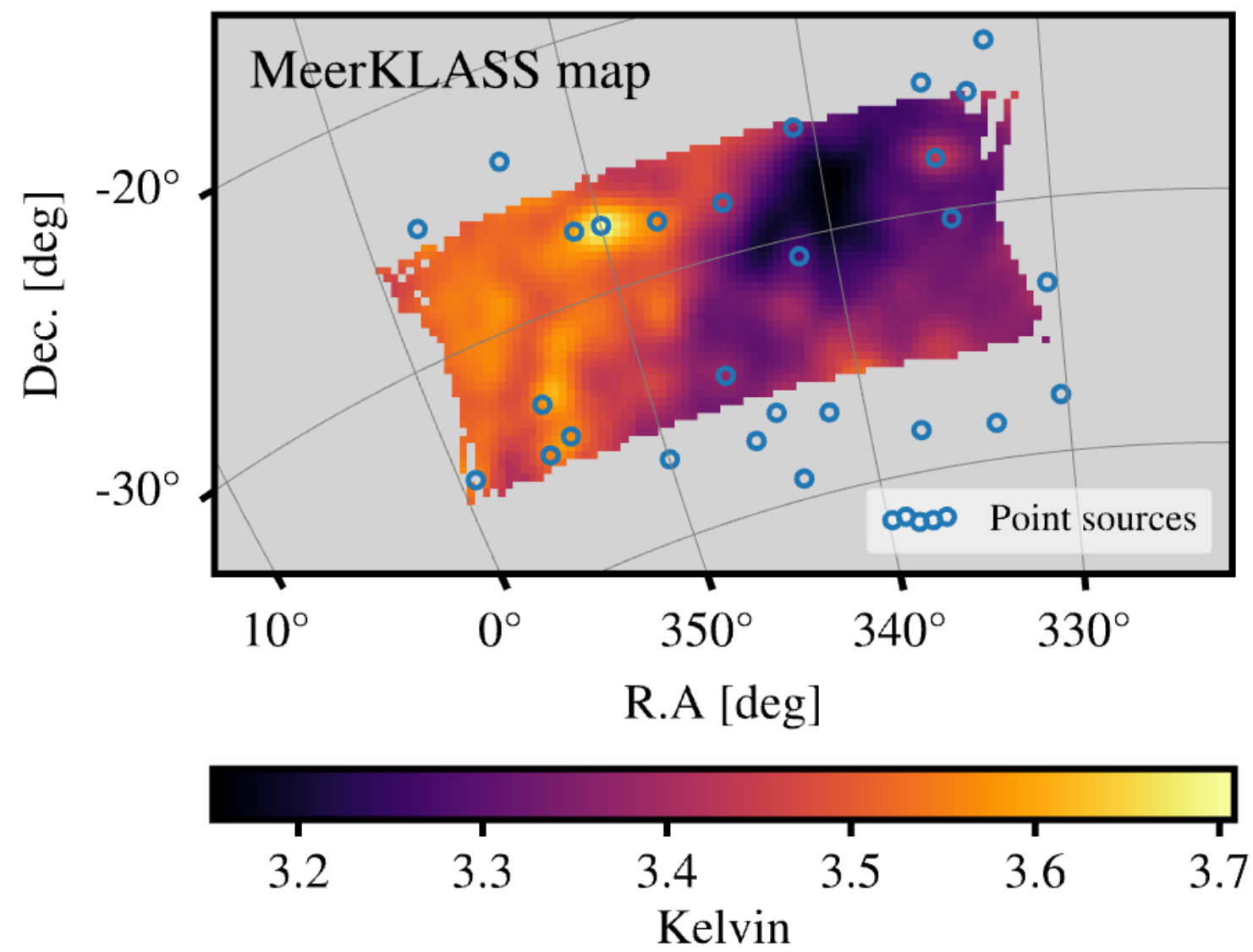
7 repeated scans
(~10.5 hrs observation)



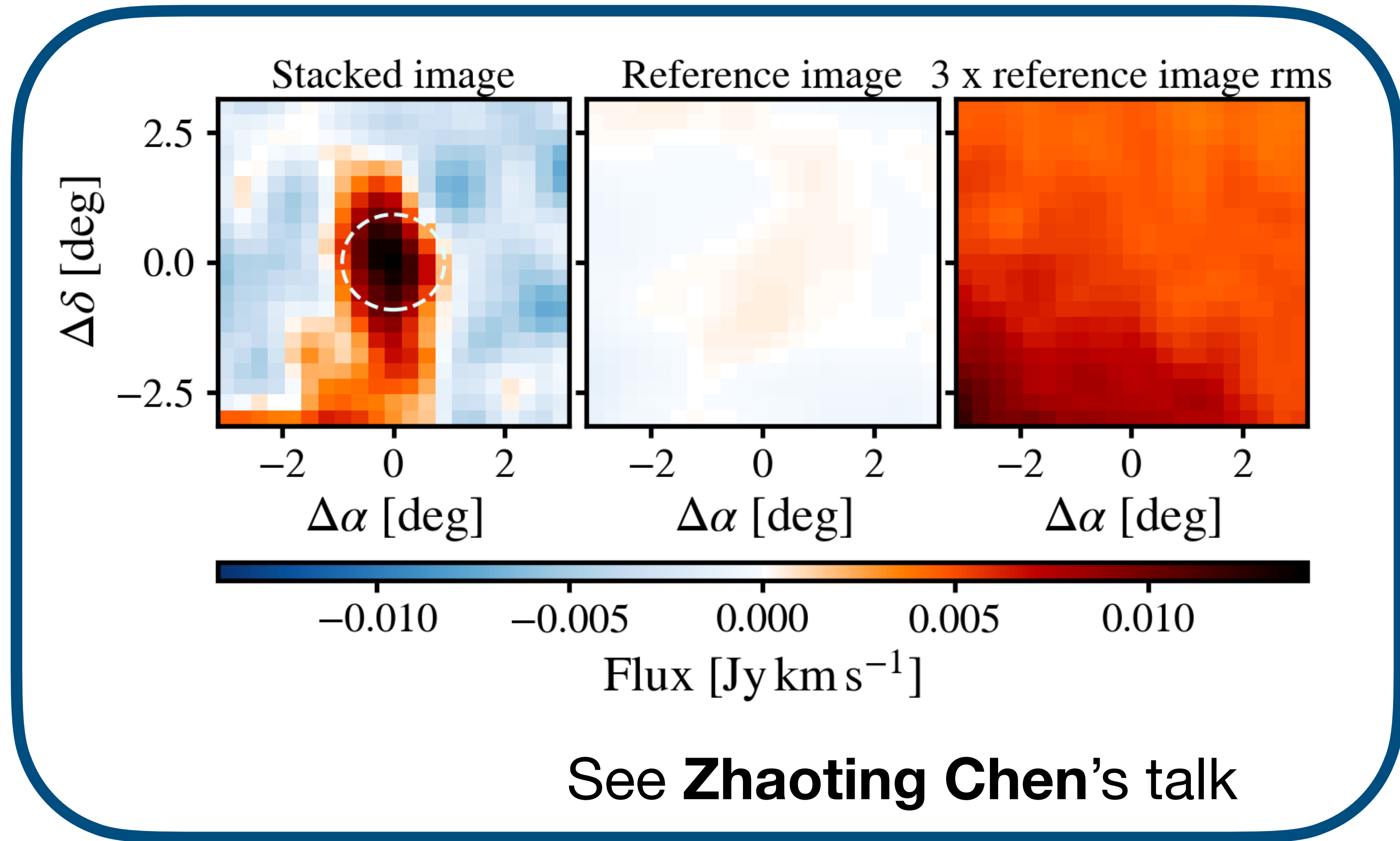
27 repeated scans*
(~40 hrs observation)

*41 observed [14 flagged]

Results from MeerKLASS deep-field



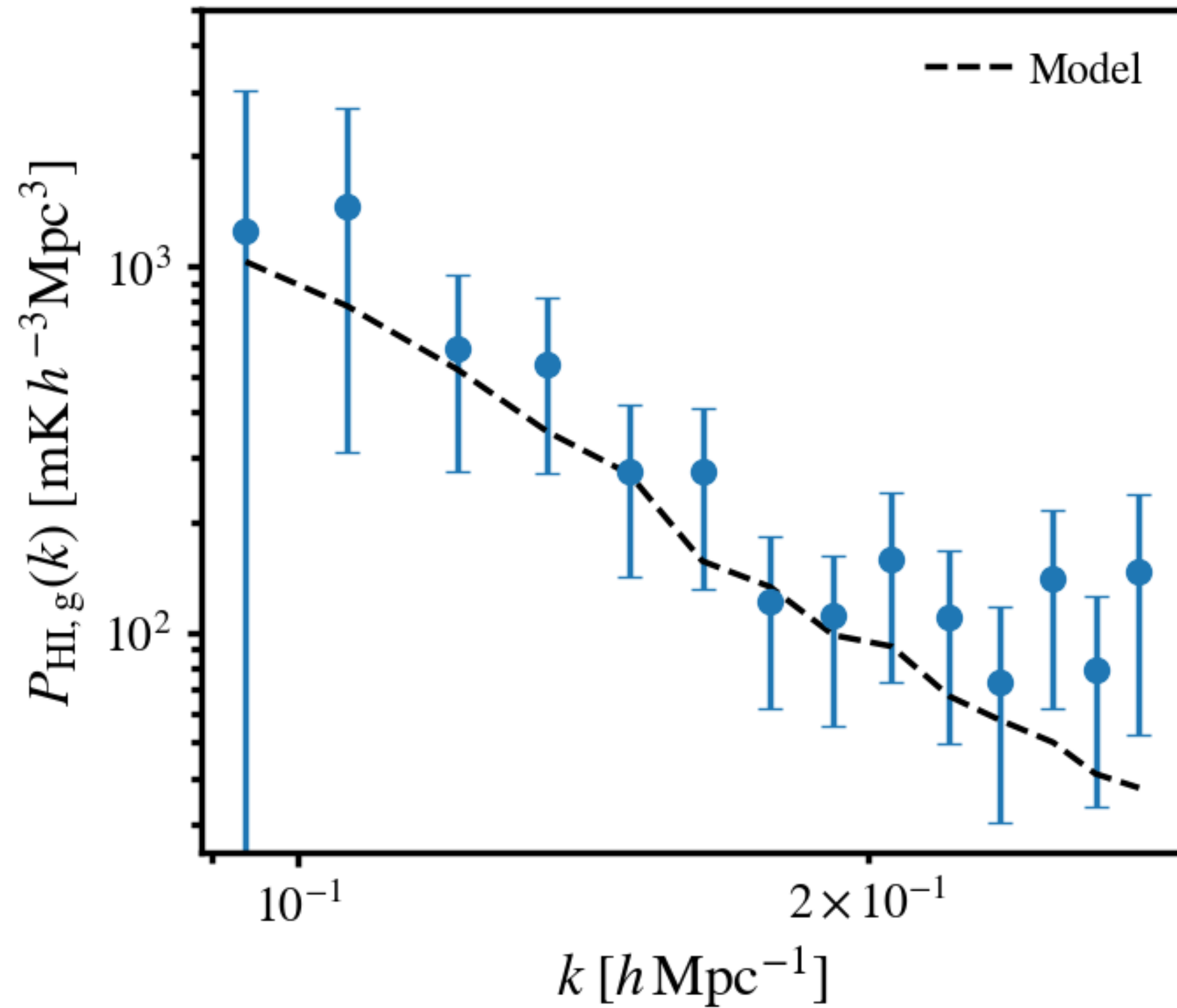
Cross-correlation with small field of GAMA galaxies



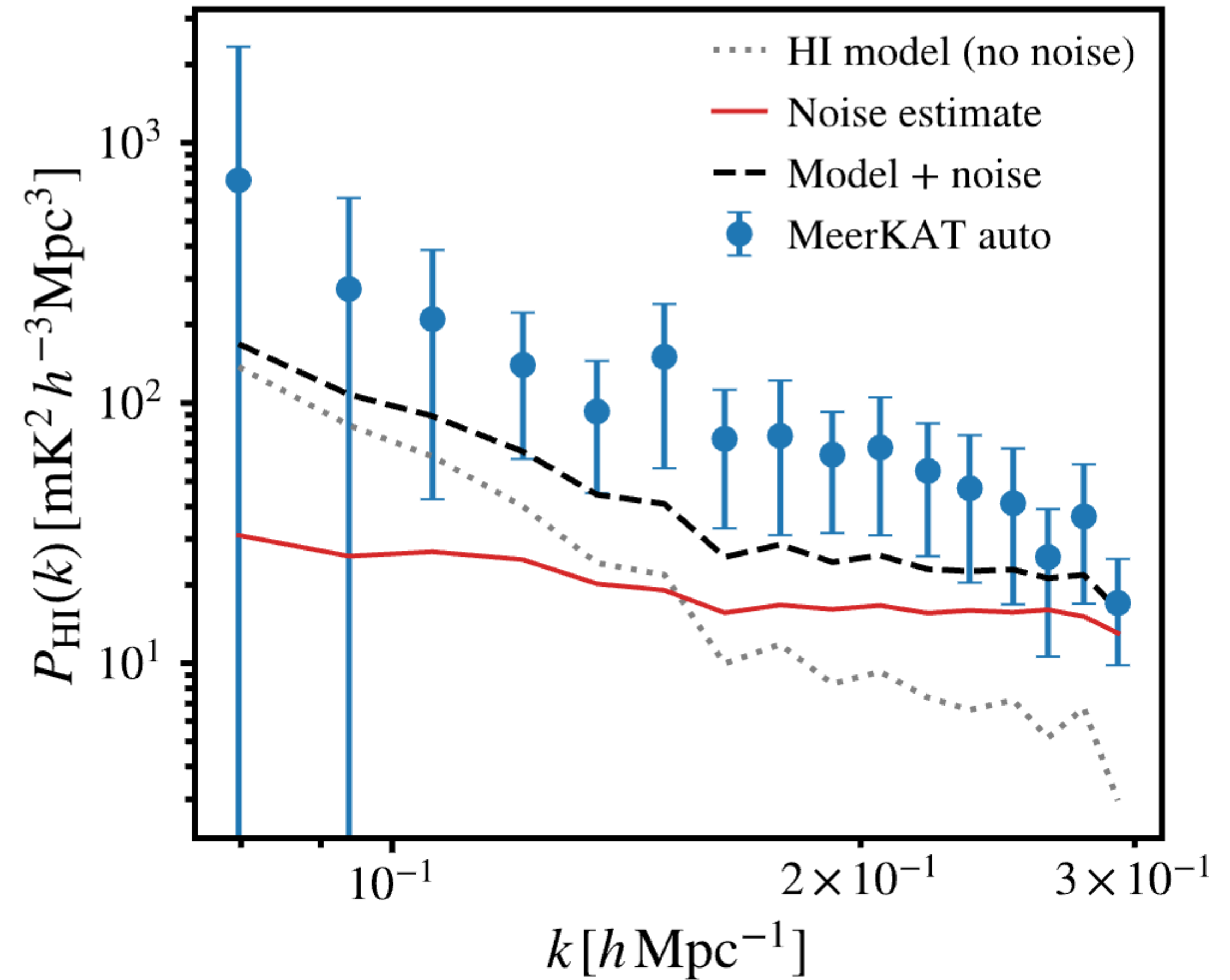
See **Zhaoting Chen's** talk

Results from MeerKLASS deep-field

Cross-correlation with GAMA galaxies



HI auto power spectrum “lowest upper-limit” ...

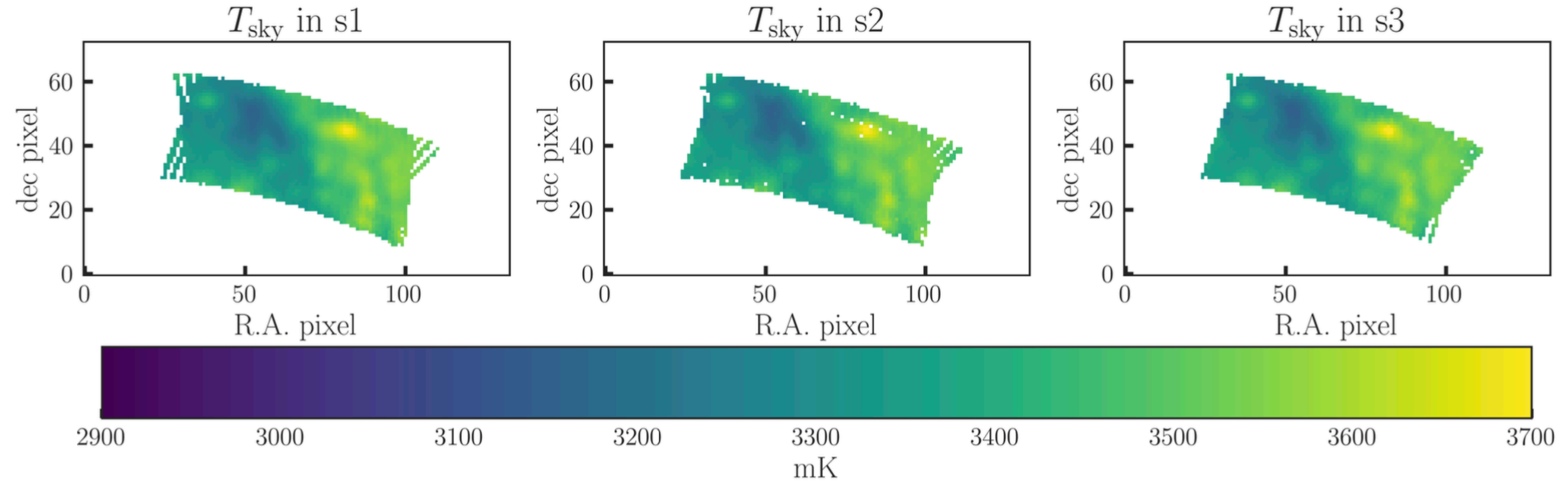


Slide credit: Isabella Carucci

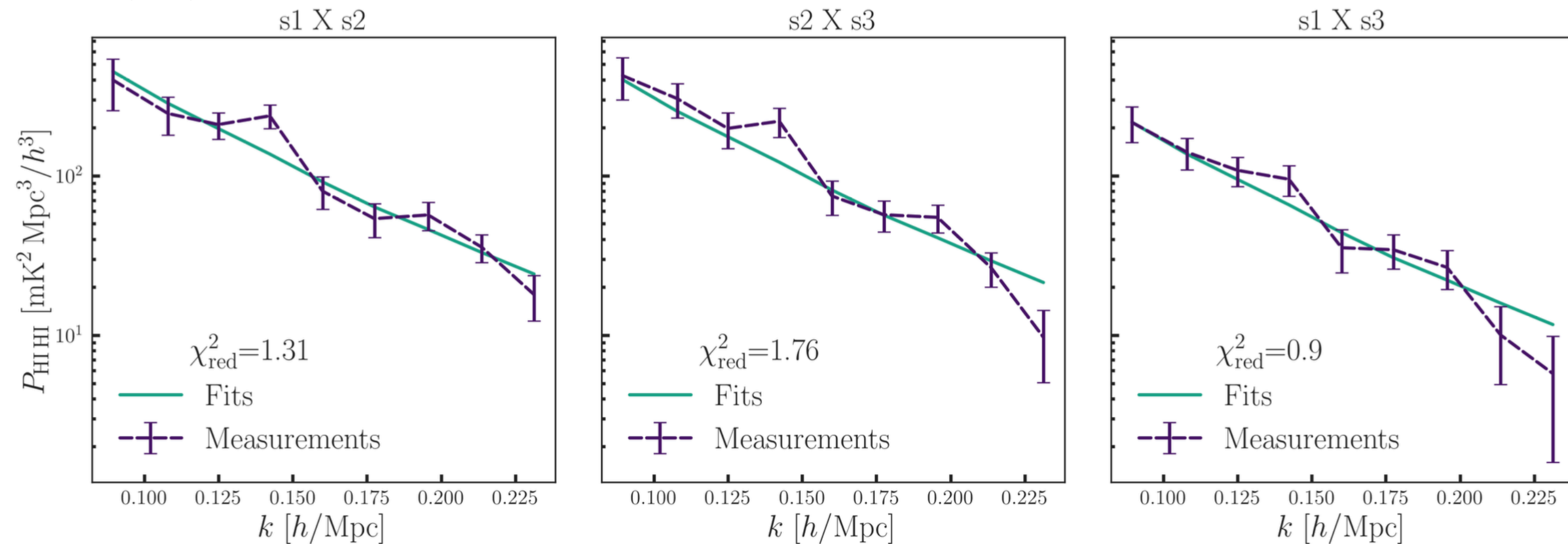
Very Preliminary

Are we ready to move forward without the galaxies?

Internal cross-correlations

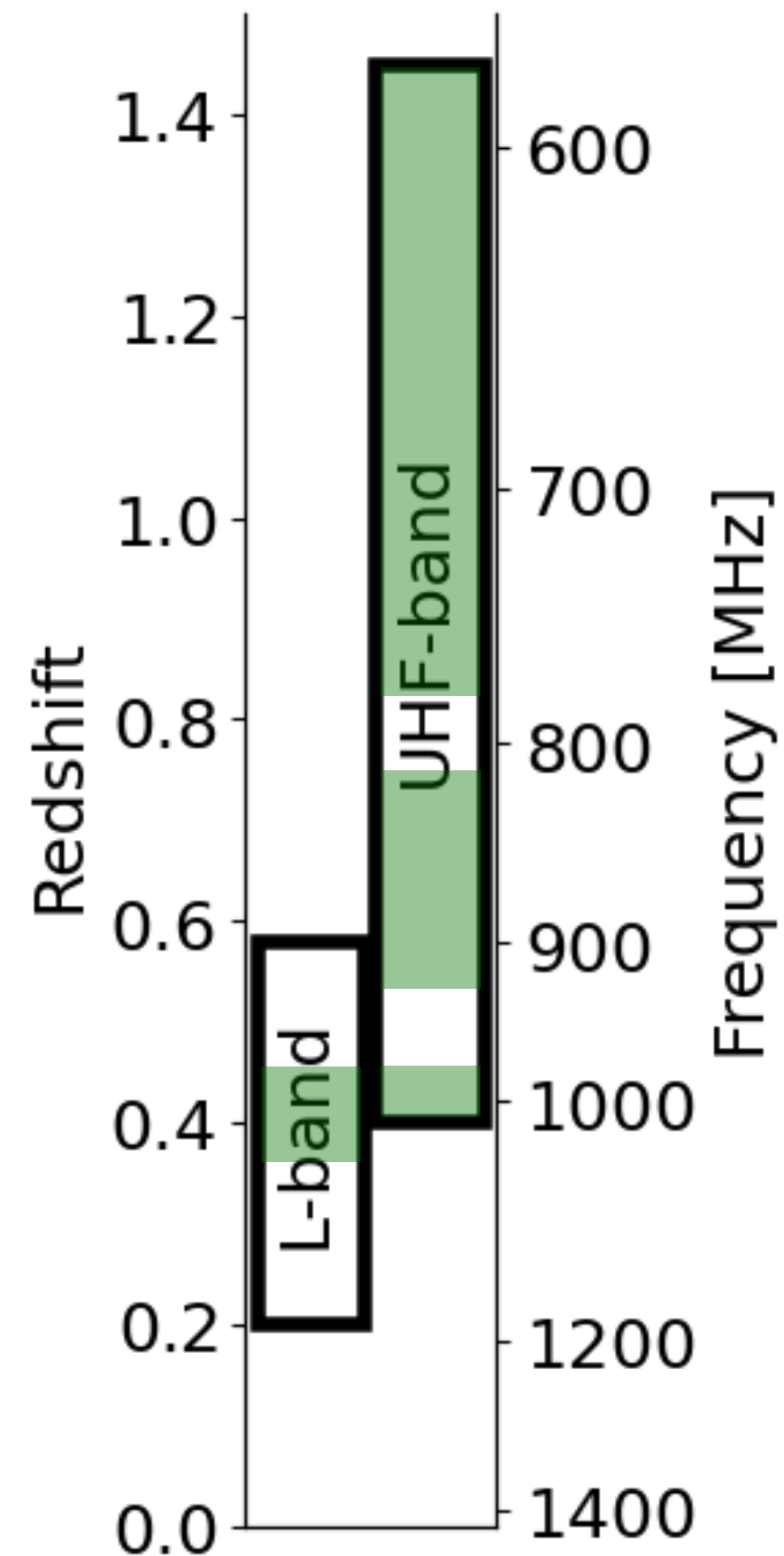
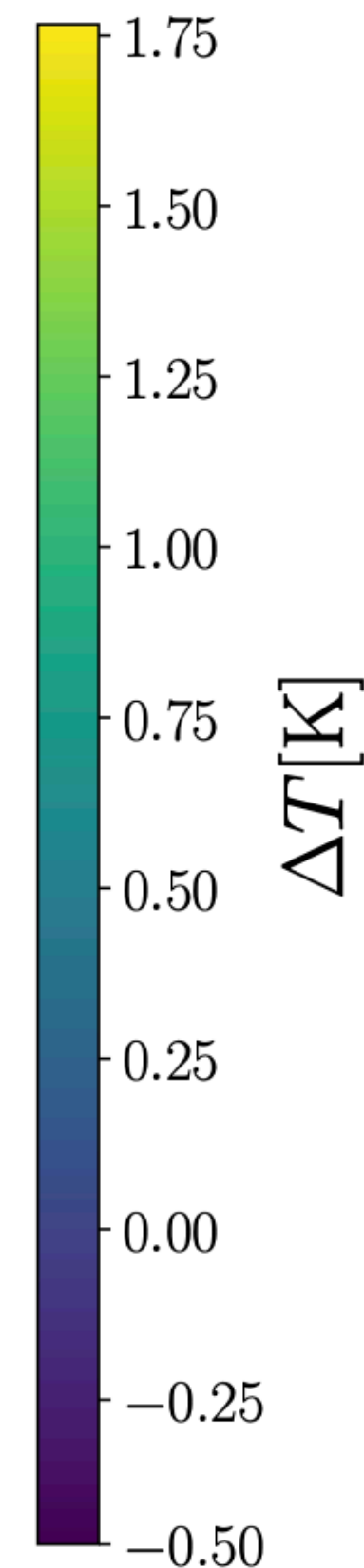
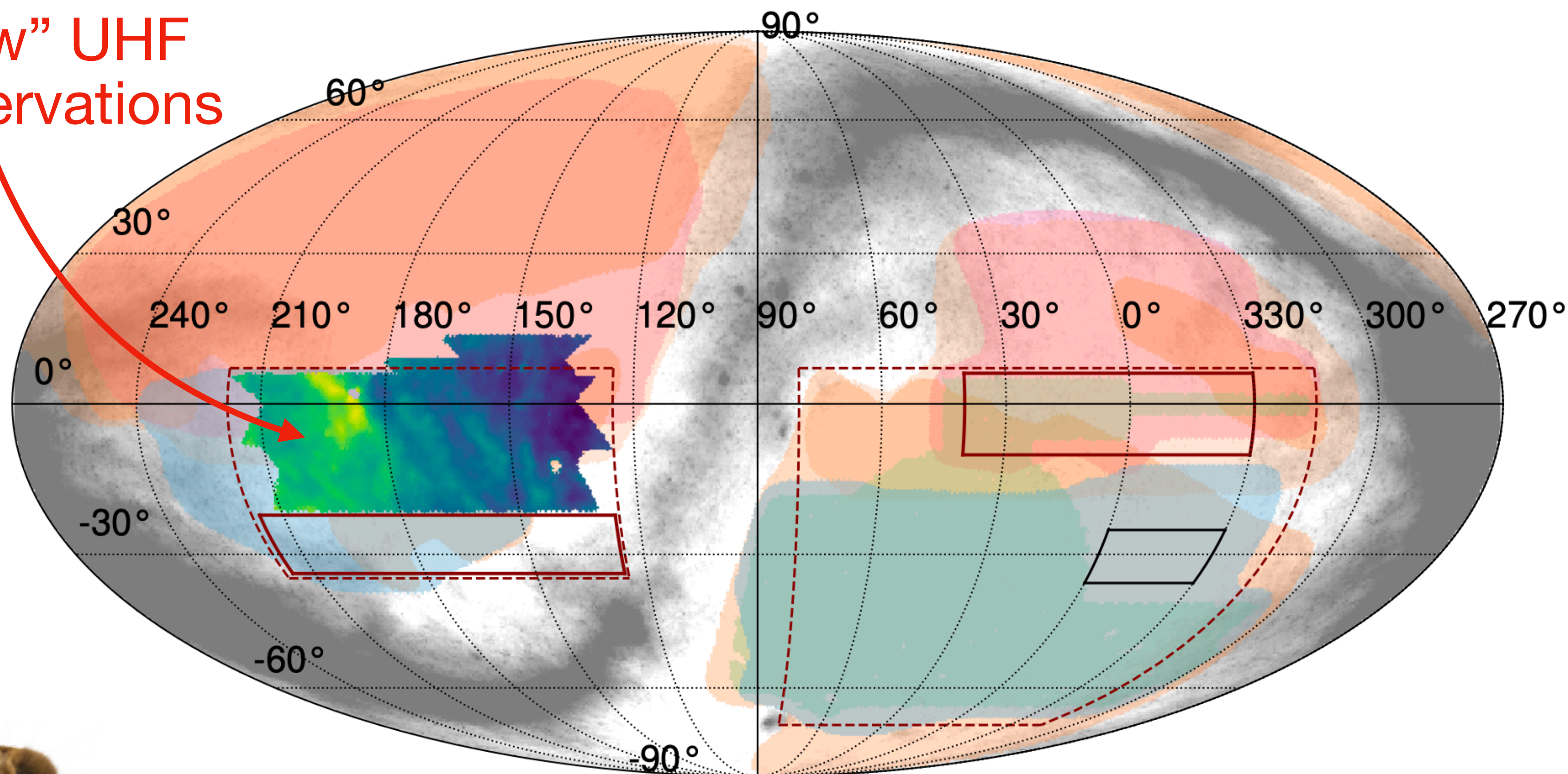


Work led by Matilde Barberi Squarotti



Calibrating UHF maps and future observations with MeerKLASS

“New” UHF observations



- | | | | |
|------|--------|-------------|---------------------|
| SDSS | Euclid | 4MOST | MeerKLASS 2024-2025 |
| DES | DESI | L-band 2021 | MeerKLASS 2023-2028 |



How does this fit into the SKA Science Book

HI Intensity Mapping Focus Group chapter “sub-section”

- ***Observational frontiers in HI intensity mapping***

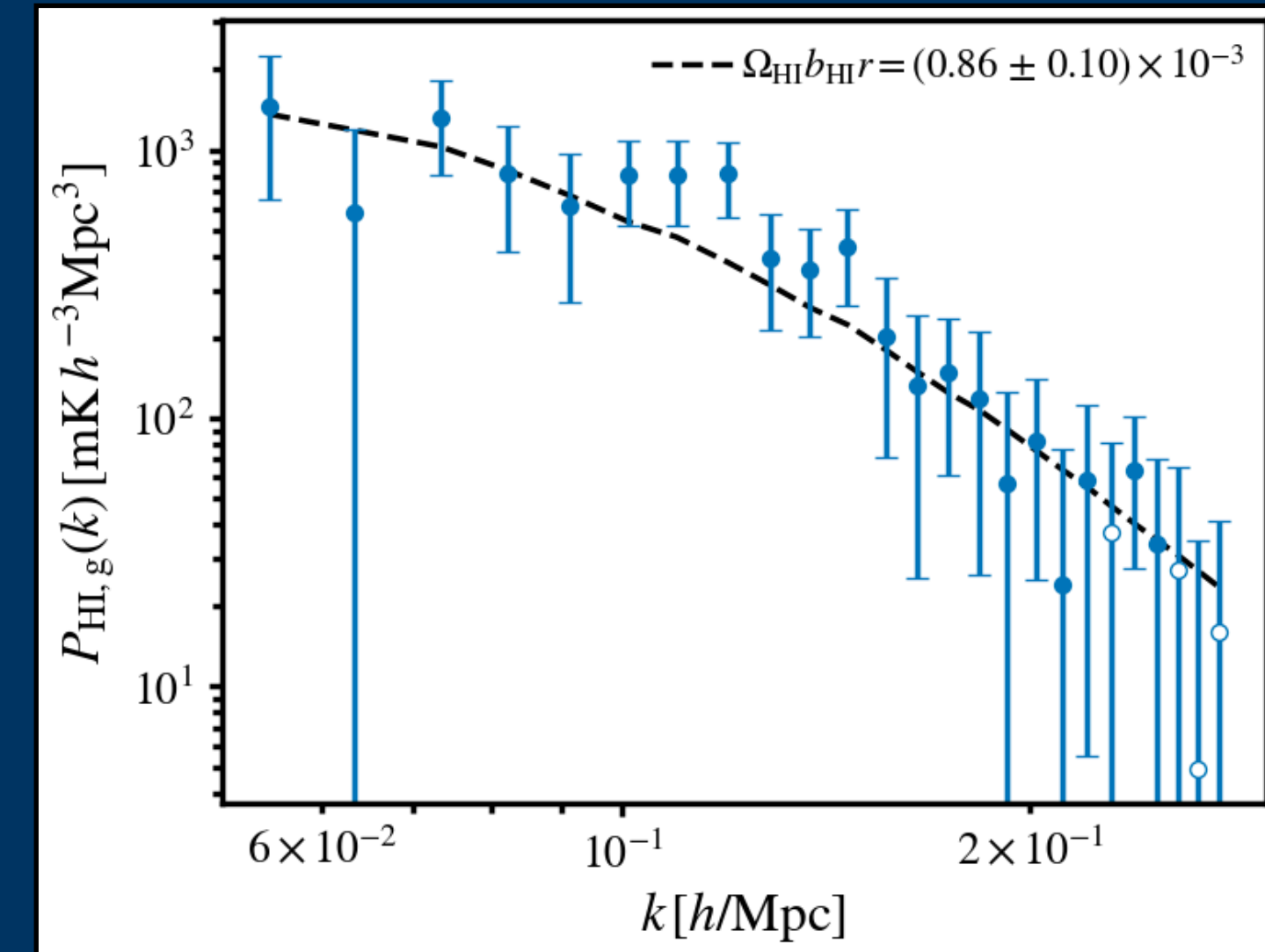
- ➔ will include references to other SKAO pathfinders (CHIME, uGMRT, FAST etc. - leaders please interact...)

MeerKLASS results do not directly forecast SKAO AA4 but they are *reducing the risk-profile* of single-dish IM with SKA-Mid

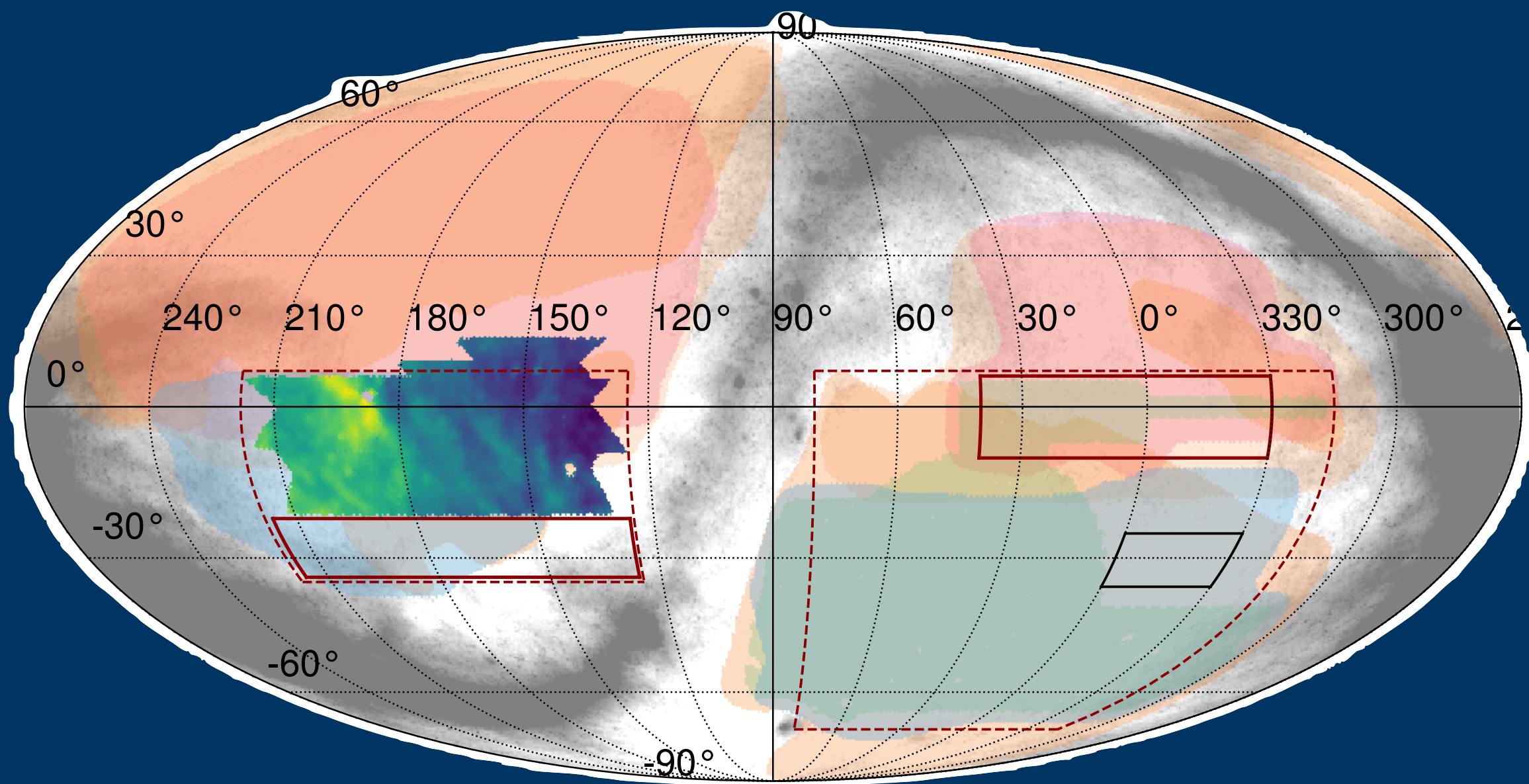
In Summary...

- Probing **ultra-large scales** with SKAO will need single-dish intensity mapping
- Pilot surveys with **MeerKLASS** have demonstrated the **single-dish** intensity mapping method →
- **RFI**, **regridding** techniques, **foreground cleaning** and reconstruction of **signal loss** from foreground cleaning are being investigated/validated

[arXiv:2404.17908, arXiv:2312.07289 & 2302.07034]



[arXiv:2206.01579]



- Calibrated observations for a **10,000 deg²** ($0.4 < z < 1.4$) MeerKLASS survey are now arriving...

Merci!