First steps toward probing ultra-large-scales with the SKAO

Steve Cunnington - University of Manchester

A Cosmic Window to Fundamental Physics:
Primordial Non-Gaussianity and Beyond
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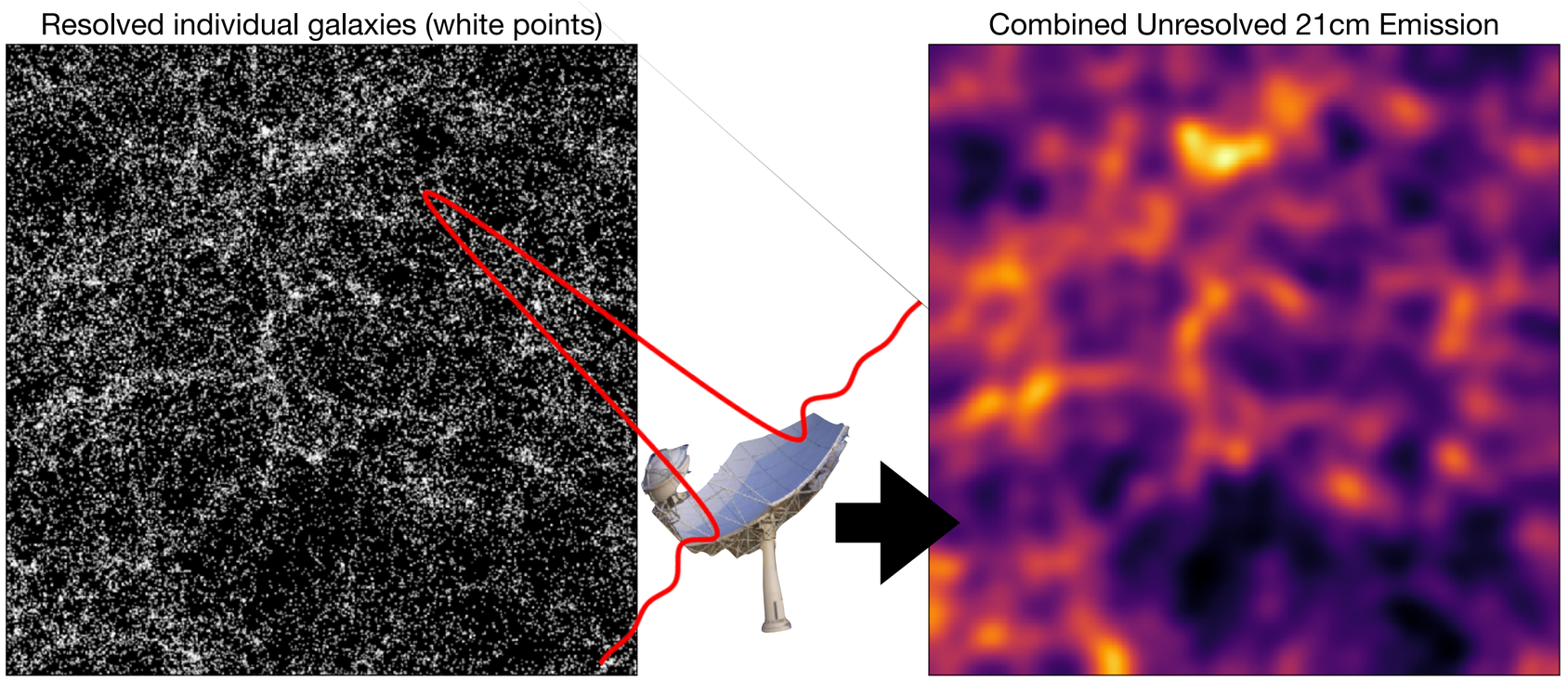
SKAO pathfinder MeerKAT, Karoo Desert, South Africa

Steve Cunnington [steven.cunnington@manchester.ac.uk]

Alternative ways to probe f_{NL} in large-scale structure?

- Record the combined and unresolved emission from all sources

This is known as … **intensity mapping**



Advantages:

- More efficient for mapping ultra-large-scales
- Provides excellent multi-tracer possibilities

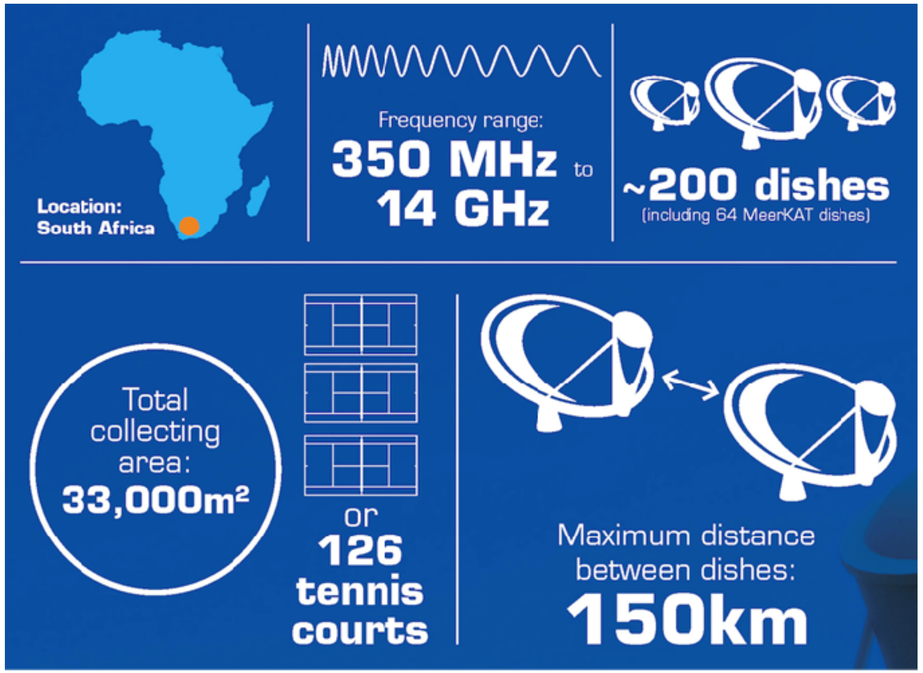
Challenges:

- Foreground contamination
- Radio Frequency Interference (RFI)

Steve Cunnington [steven.cunnington@manchester.ac.uk]

“SKA Observatory”

SKA1 - MID (South Africa)



Redshift range: $0 < z < 3$

Steve Cunnington [steven.cunnington@manchester.ac.uk]

SKAO Pathfinder: MeerKAT

- 64 dishes
- Will become part of SKA-MID
- $0.2 < z < 0.58$ (L-band)
- $0.4 < z < 1.45$ (UHF-band)
- ~4000 sq.deg surveys

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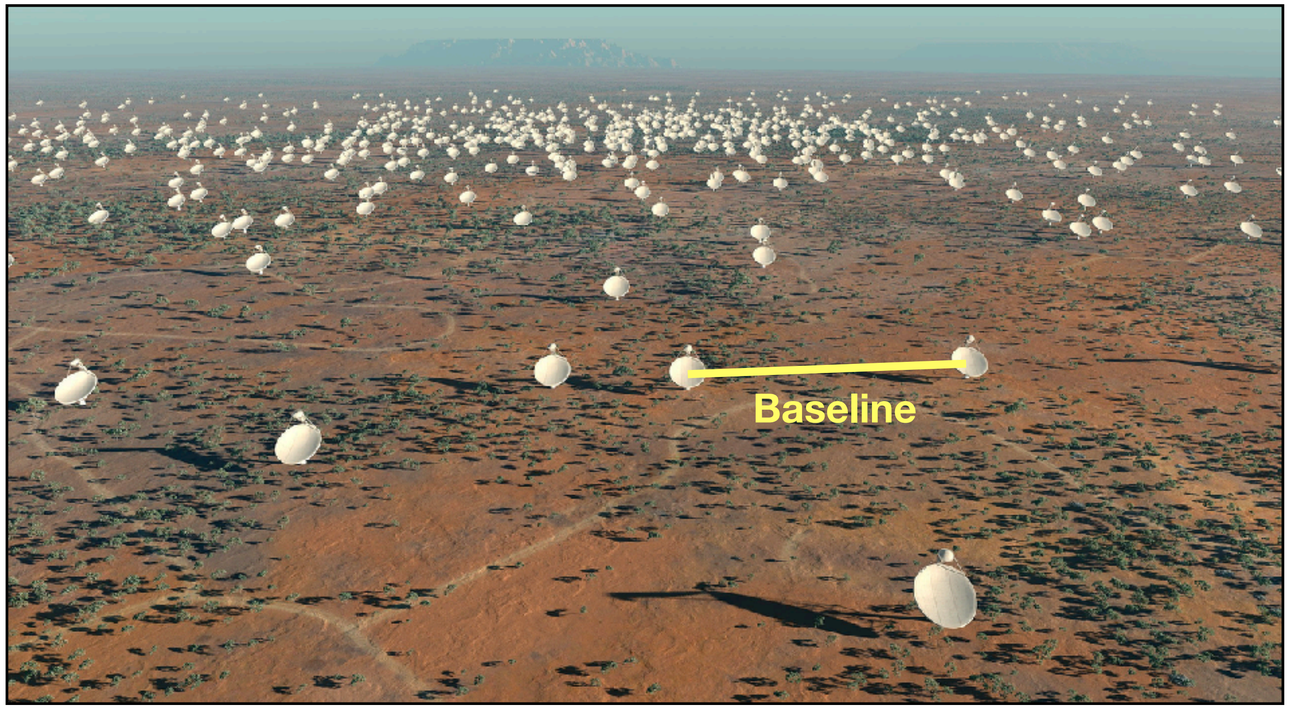
Interferometer has limitations for large-scale cosmology



Using SKAO as an **interferometer** means the largest scales we can probe are limited by how small the baselines are i.e. how *tightly-packed* the dishes are

Advantages achieved by using “single-dish mode”:

☑ Largest cosmological scales become accessible

☑ Increases observation time by a factor of N_{dish}

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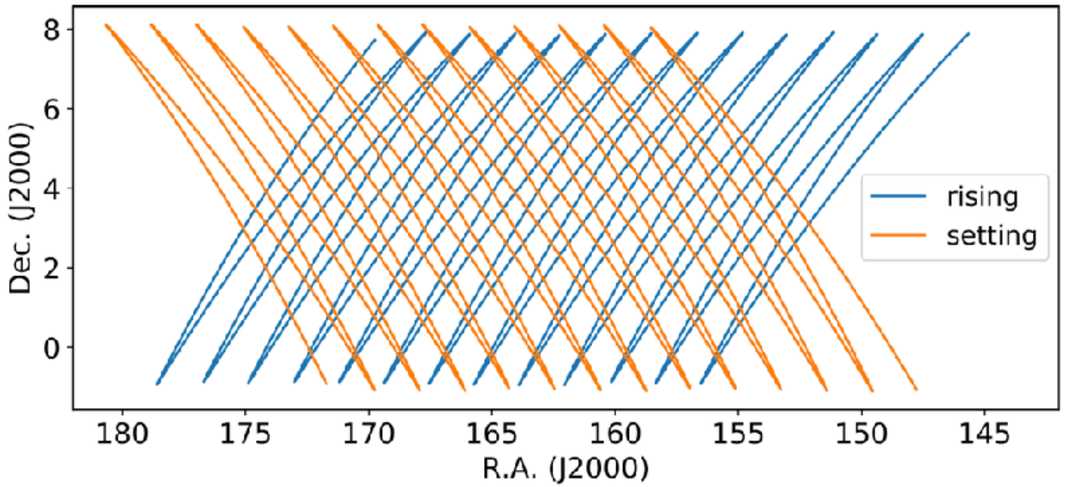
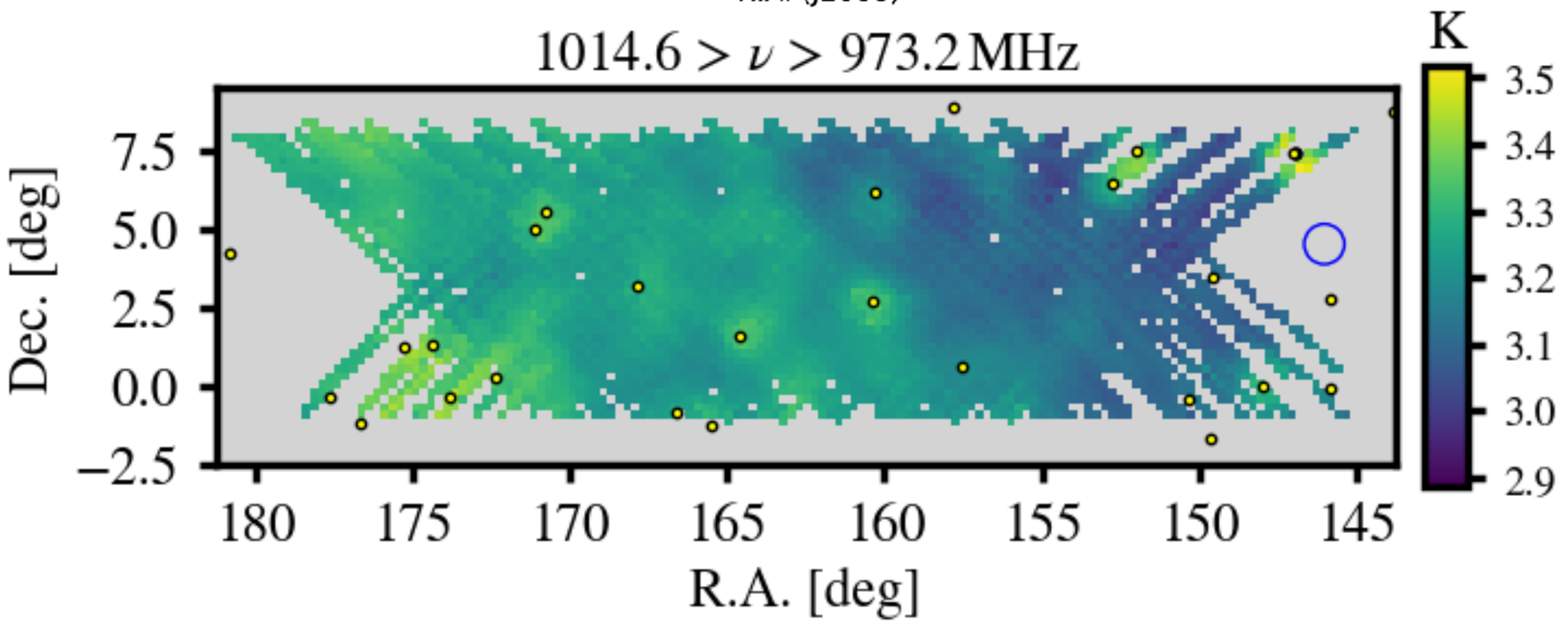
Conducting single-dish intensity mapping observations with MeerKAT

Pilot survey data:

- 10.5 hours of data from six nights of observations
- Overlapping with the WiggleZ11hr field (~200 deg^2)
- We use data in range 973-1015 MHz ($0.40 < z < 0.46$)

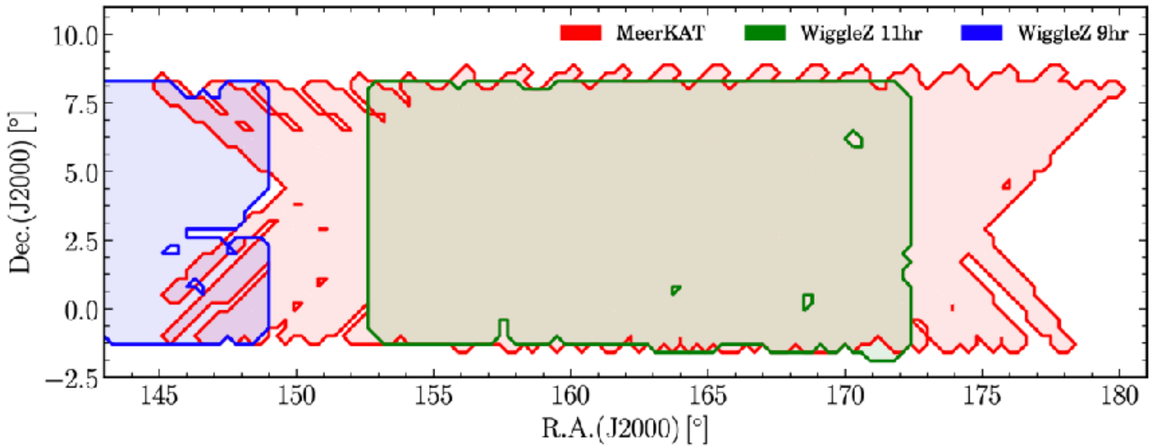
J.Wang, …, SC+21 [arXiv:2011.13789]



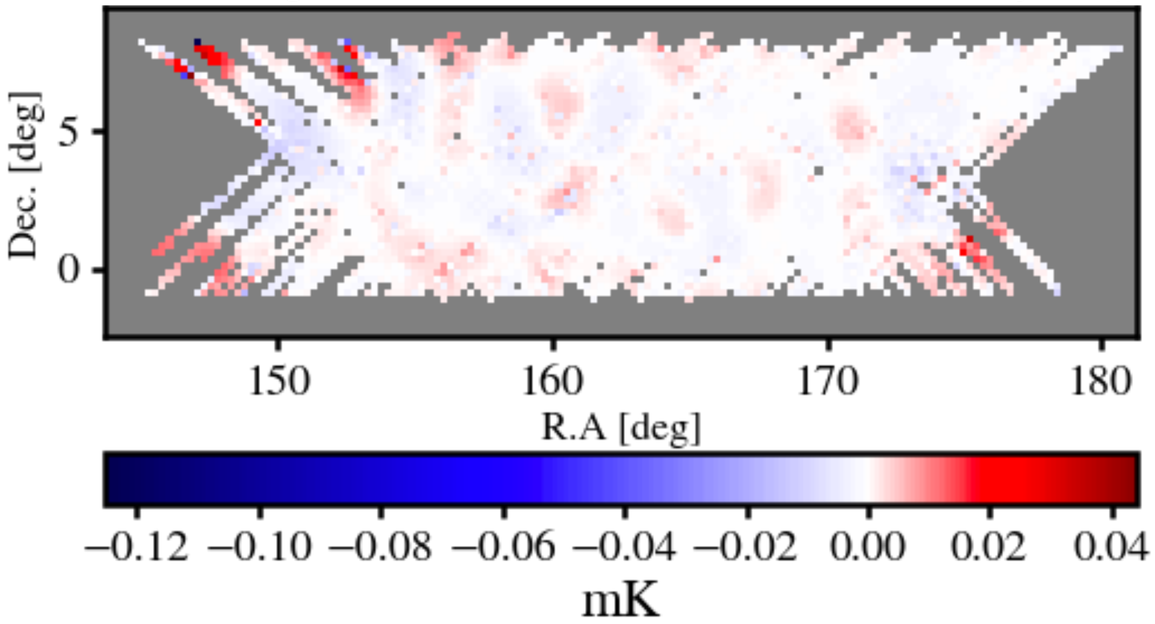


MeerKAT X Galaxies

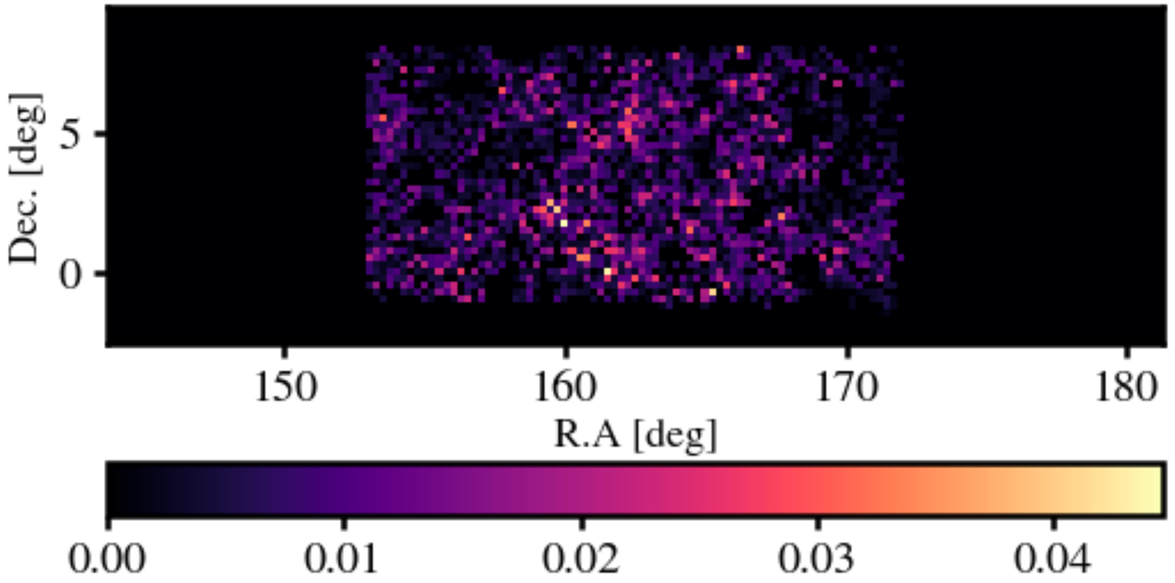
MeerKAT pilot observations conducted in WiggleZ 11hr field for the purpose of potential cross-correlations with a galaxy survey



Final foreground cleaned MeerKAT HI intensity map



WiggleZ Dark Energy Survey galaxies



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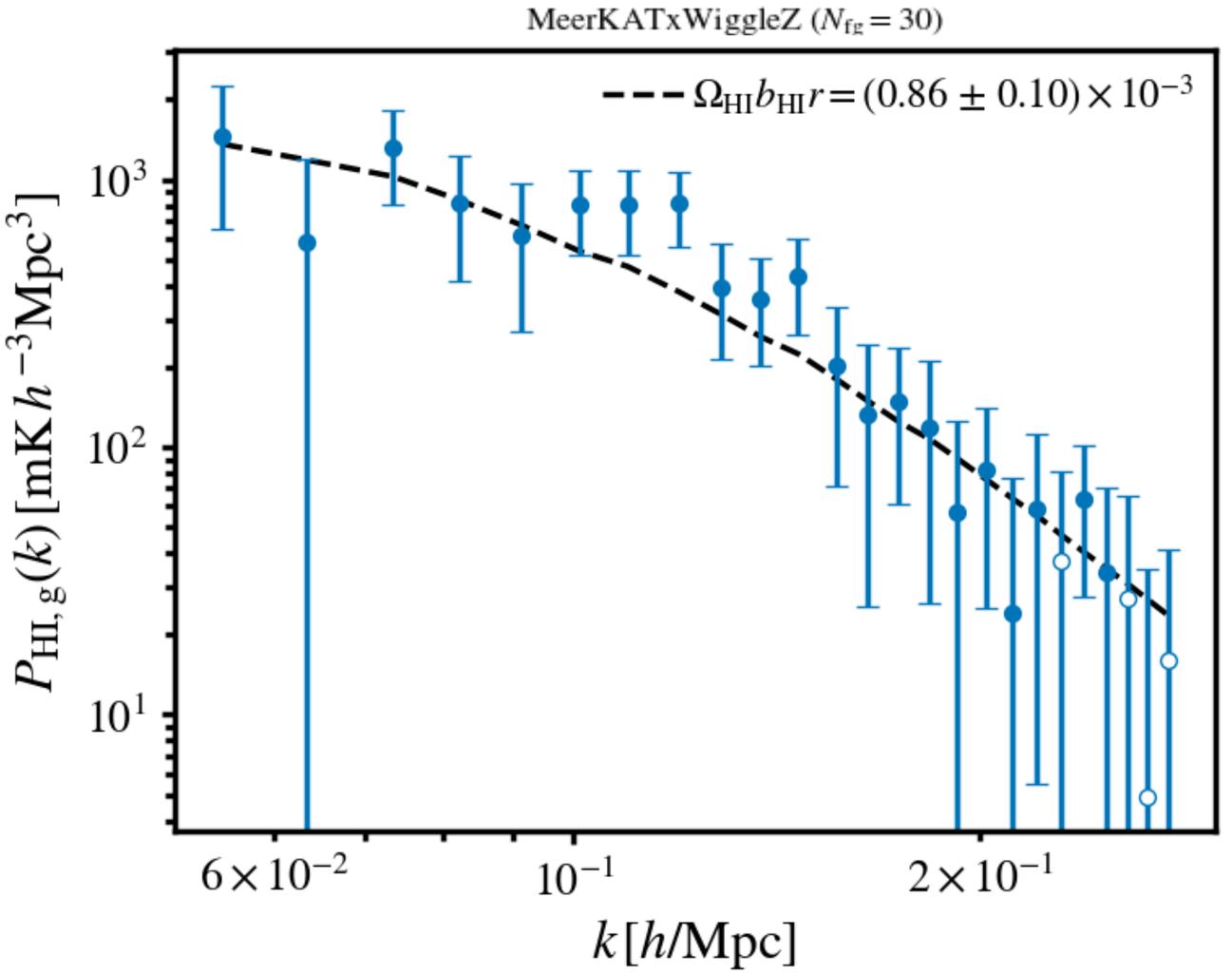
Detecting cosmological clustering with MeerKAT pilot intensity mapping survey

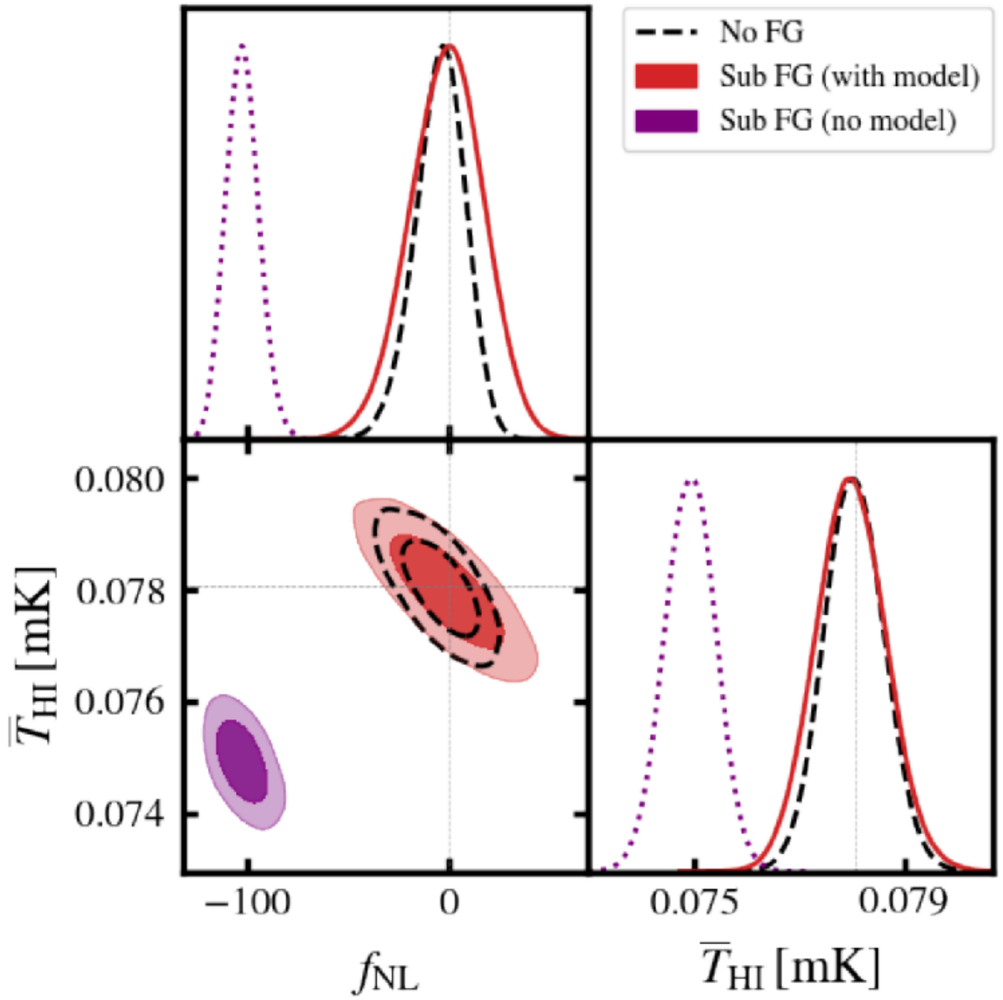
- Positive correlation (7.7σ) between galaxy survey and array of dishes in single-dish mode
- The first detection of its kind
- Important milestone for doing LSS cosmology with SKA intensity mapping



Looking to the future: PNG with 21cm intensity mapping

- MeerKAT pilot survey, 500 deg^2 in UHF band ($0.40 < z < 1.45$) will be observed in next few months
- Full MeerKAT 4000 deg^2 survey - first 21cm intensity mapping PNG constraints
- SKAO 20,000 deg^2 survey ($0 < z < 3$) - aim for $\sigma(f_{NL})\sim1$

Foreground removal effects will require attention



S.Cunnington+20 [arXiv:2007.12126]

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Summary…

- HI intensity mapping will observe unprecedented spectroscopic volumes to probe large scale structure
- The SKAO's pathfinder **MeerKAT** is now conducting intensity mapping
- **Detected a 7.7σ correlation** with overlapping WiggleZ galaxies
- Larger survey data with MeerKAT is arriving fast and will quickly become an important resource for PNG science

S.Cunnington+22 [arXiv:2206.01579]