HI intensity mapping overview

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Australian Government
Australian Research Council

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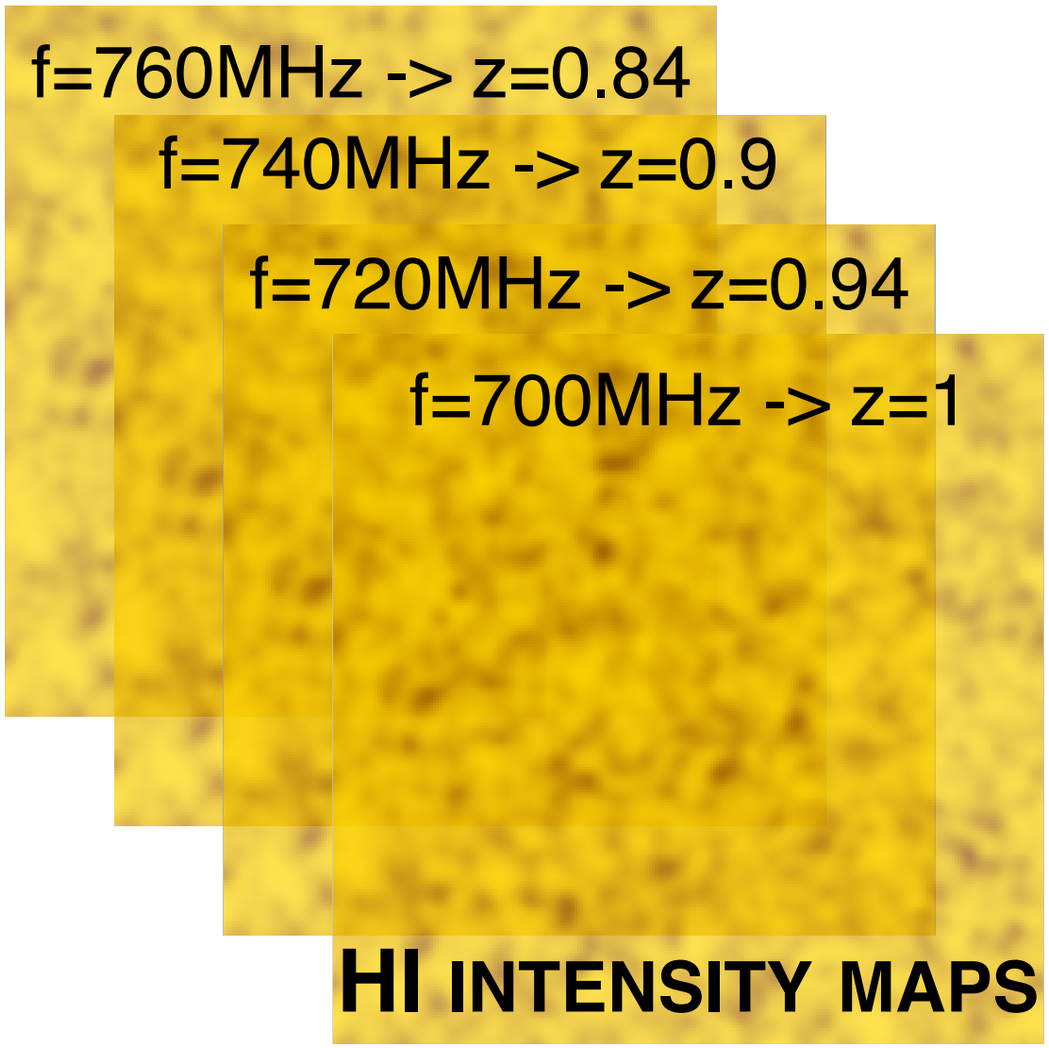
ASTROPHYSICS


CAASTRO
ASTROPHYSICS

HI Intensity Mapping



- Integrated line flux over **entire HI mass function**
- Tomographic maps of the Universe for **0<z<6**
- Observe **large cosmological volumes** for wide redshifts with high z- and low spatial-resolution
- Measurement of Large Scale Structure

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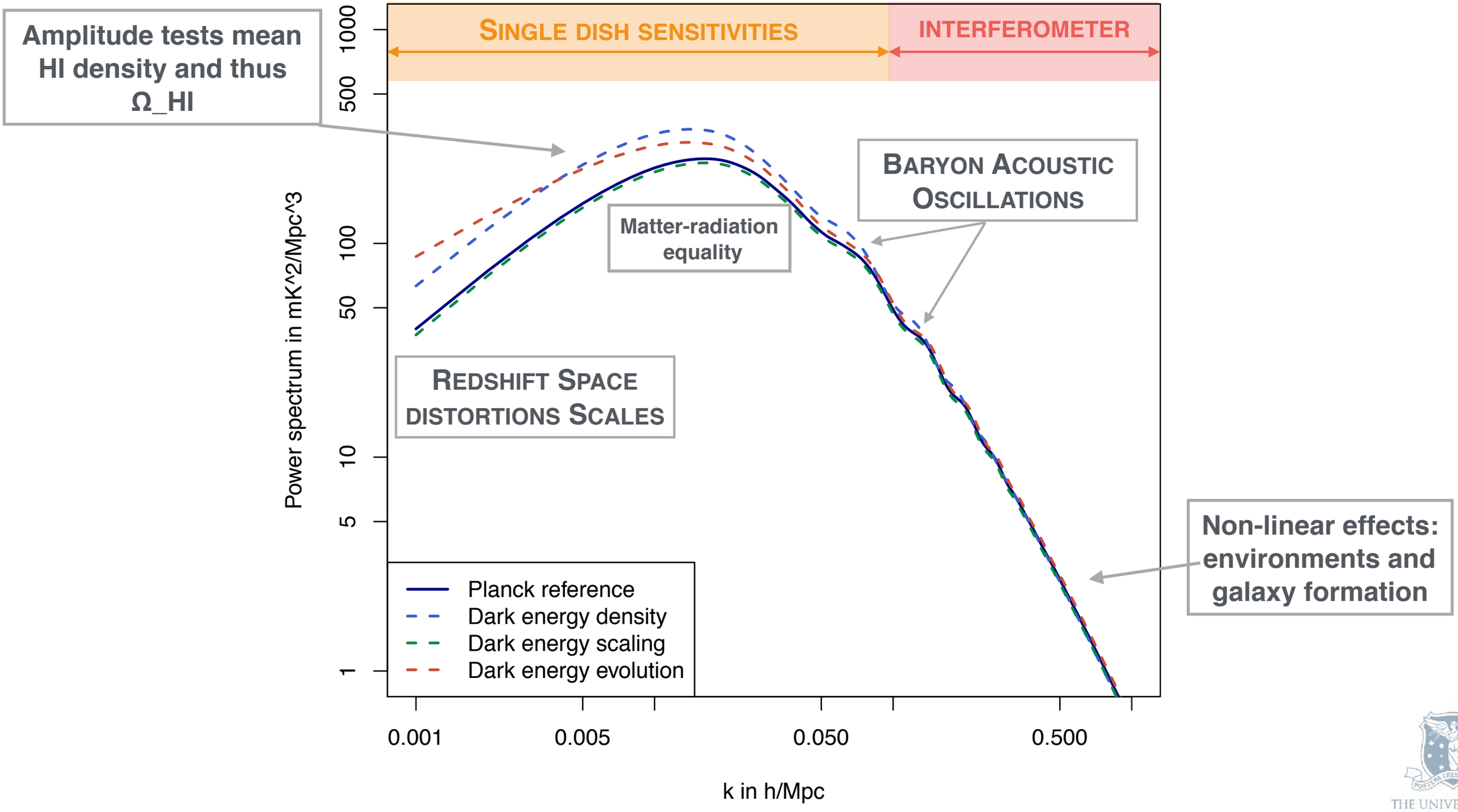
Temperature power spectrum



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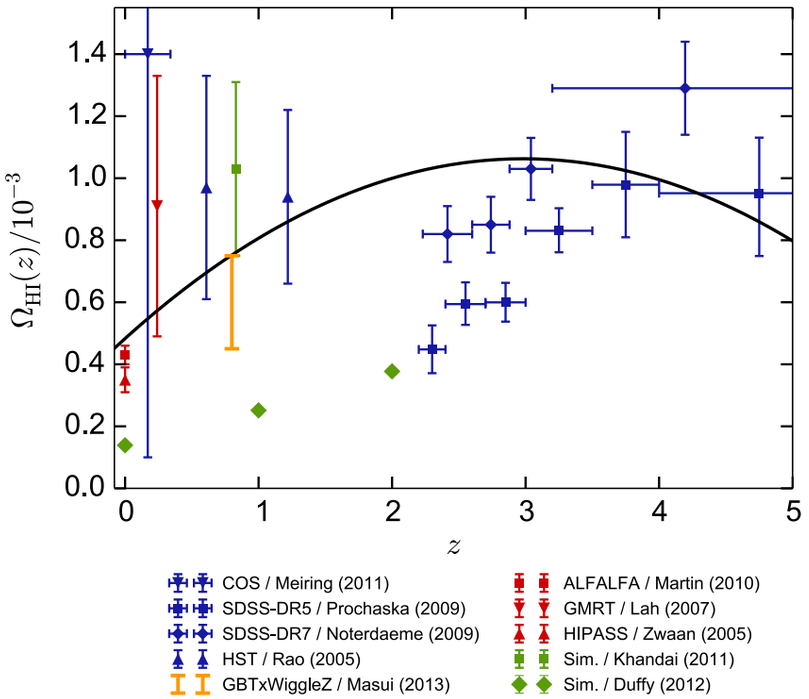
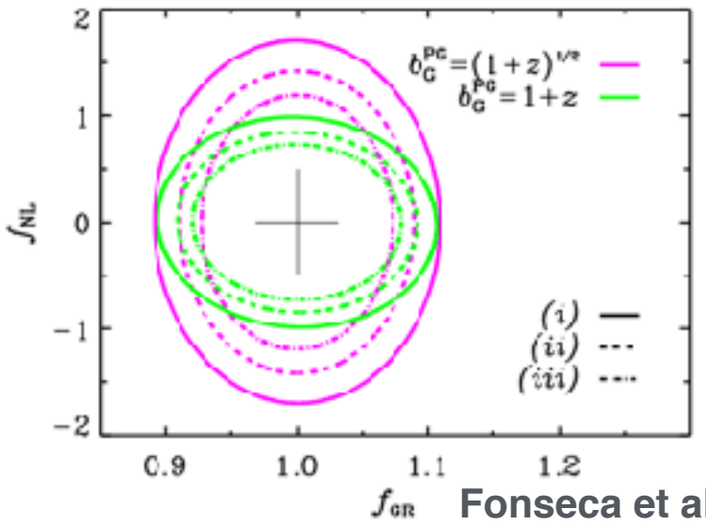
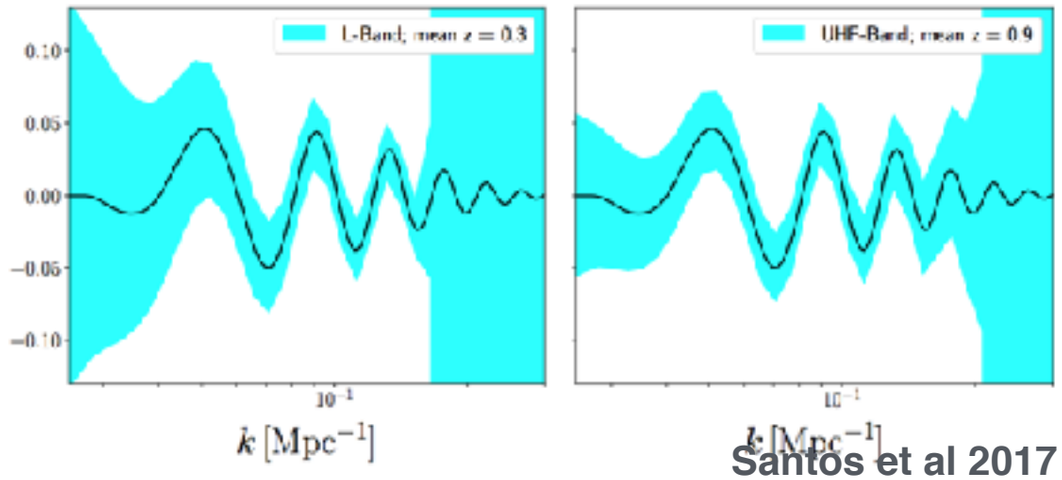


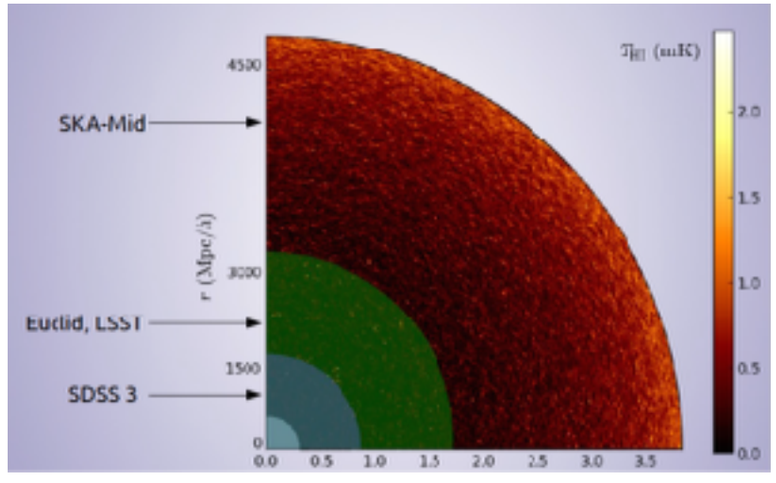
Santos et al 2015

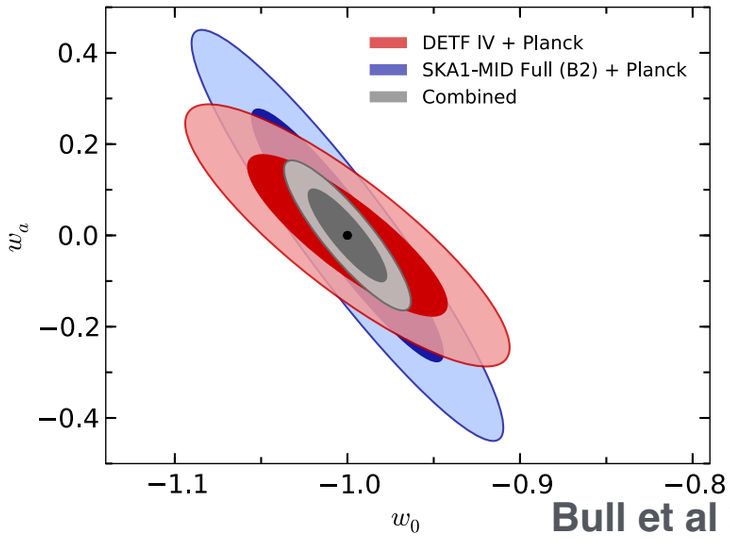


Fonseca et al 2015



Santos et al 2017





Bull et al 2015

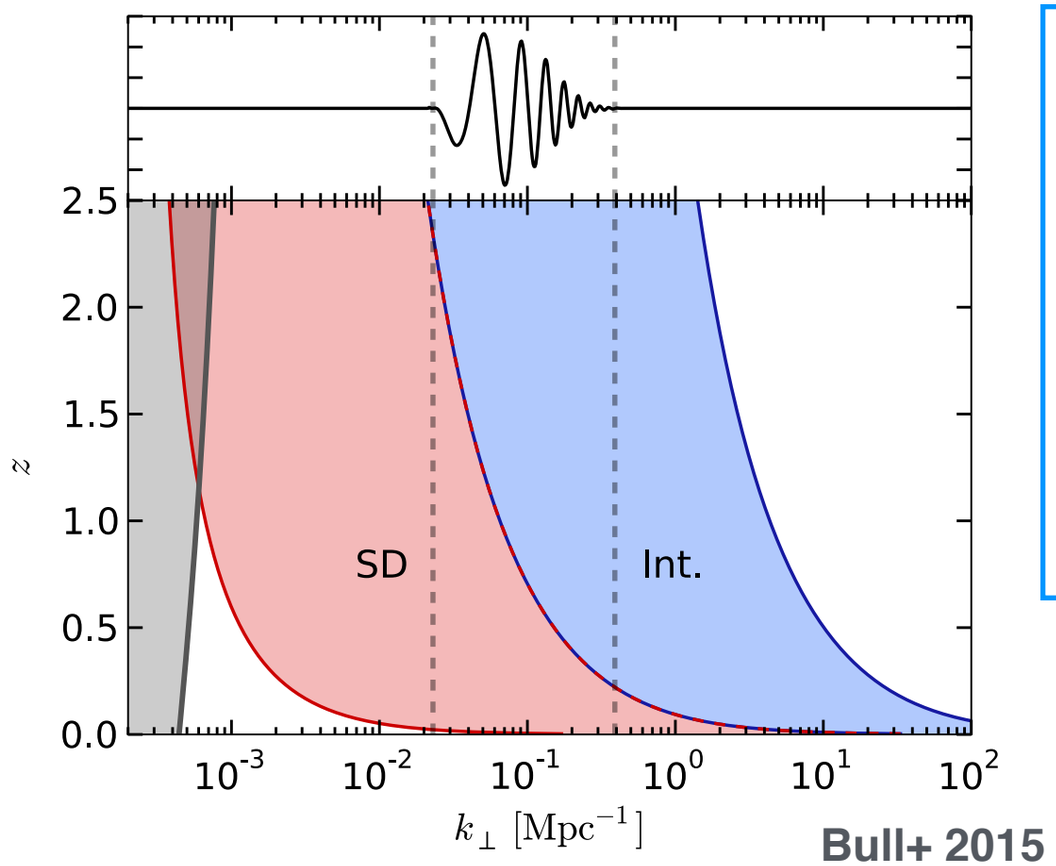
Experiments

Green Bank Telescope

Masui et al, Switzer et al13

Parkes Telescope

Anderson et al 17



Bull+ 2015

CHIME

Canada

Square Kilometre Array

SKA MID (South Africa)

ASKAP

Australia

plus Tianlai, MeerKAT, BINGO and more

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Challenges

- **Receiver Noise** amplitude comparable to signal -> isotropic, manageable in power spectrum space

- **Instrumental errors** calibration uncertainties, beam and pointing errors, polarization leakage -> simulations of instrument response

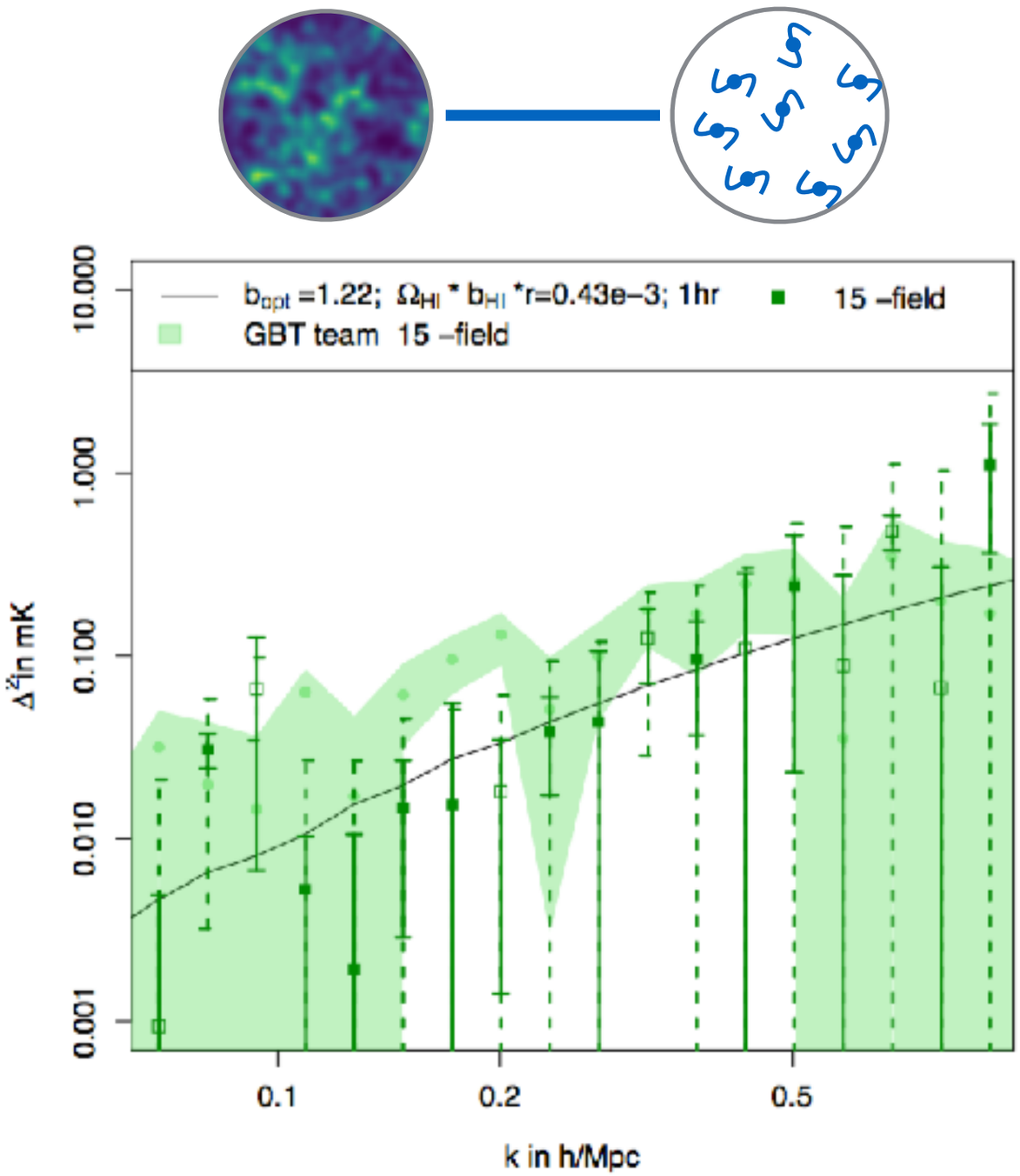
- **RFI** contaminates in spatial and frequency space -> go to the desert

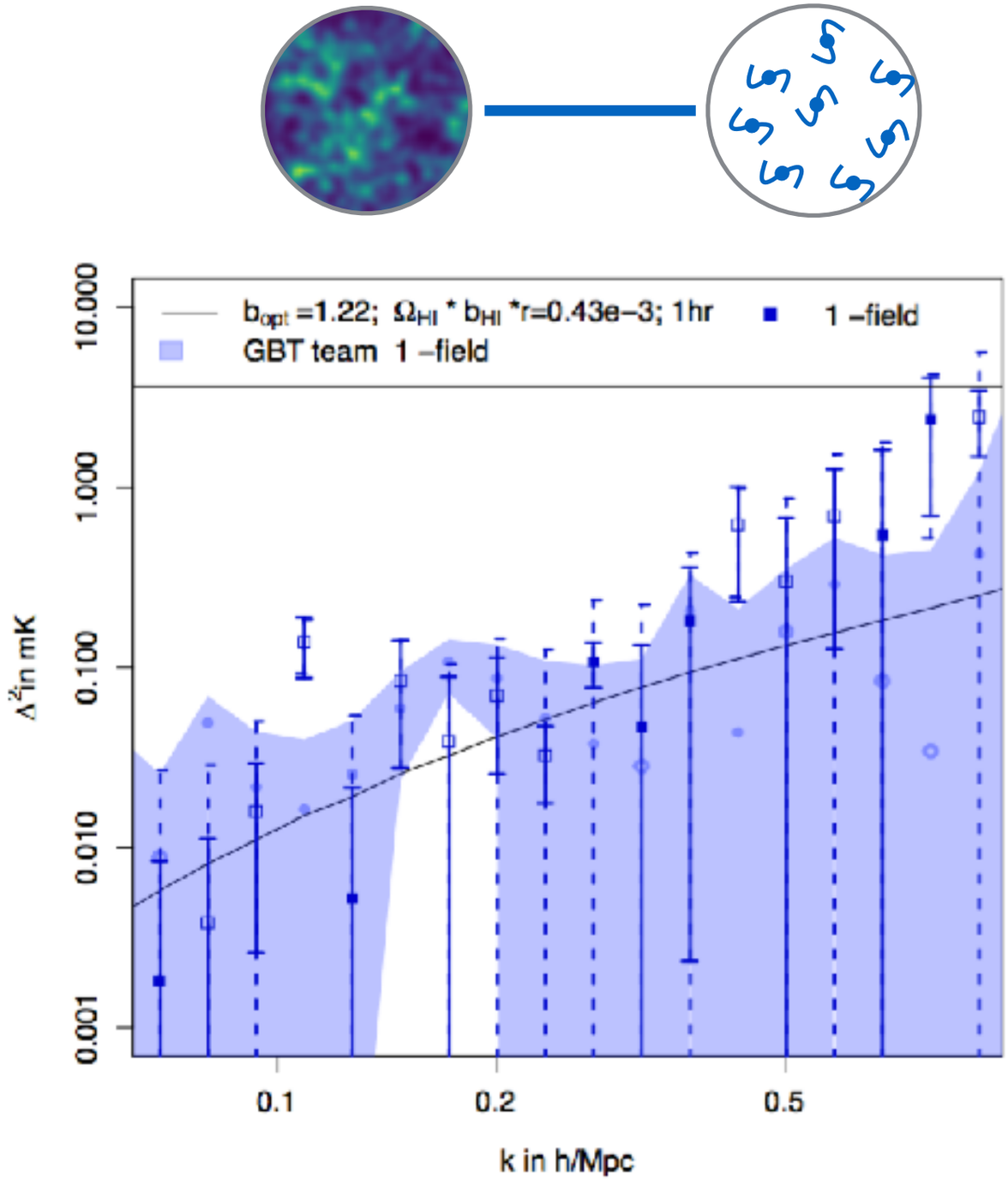
- **Foreground contaminations** Galactic emission and extra-Galactic point sources -> avoidance and removal strategies

Observations

Masui et al, 2013, Wolz et al 2017

$$\Omega_{HI} b_{HI} = [0.62^{+0.23}] \times 10^{-3}$$





GBT x WiggleZ - 40sqdeg - z~0.8

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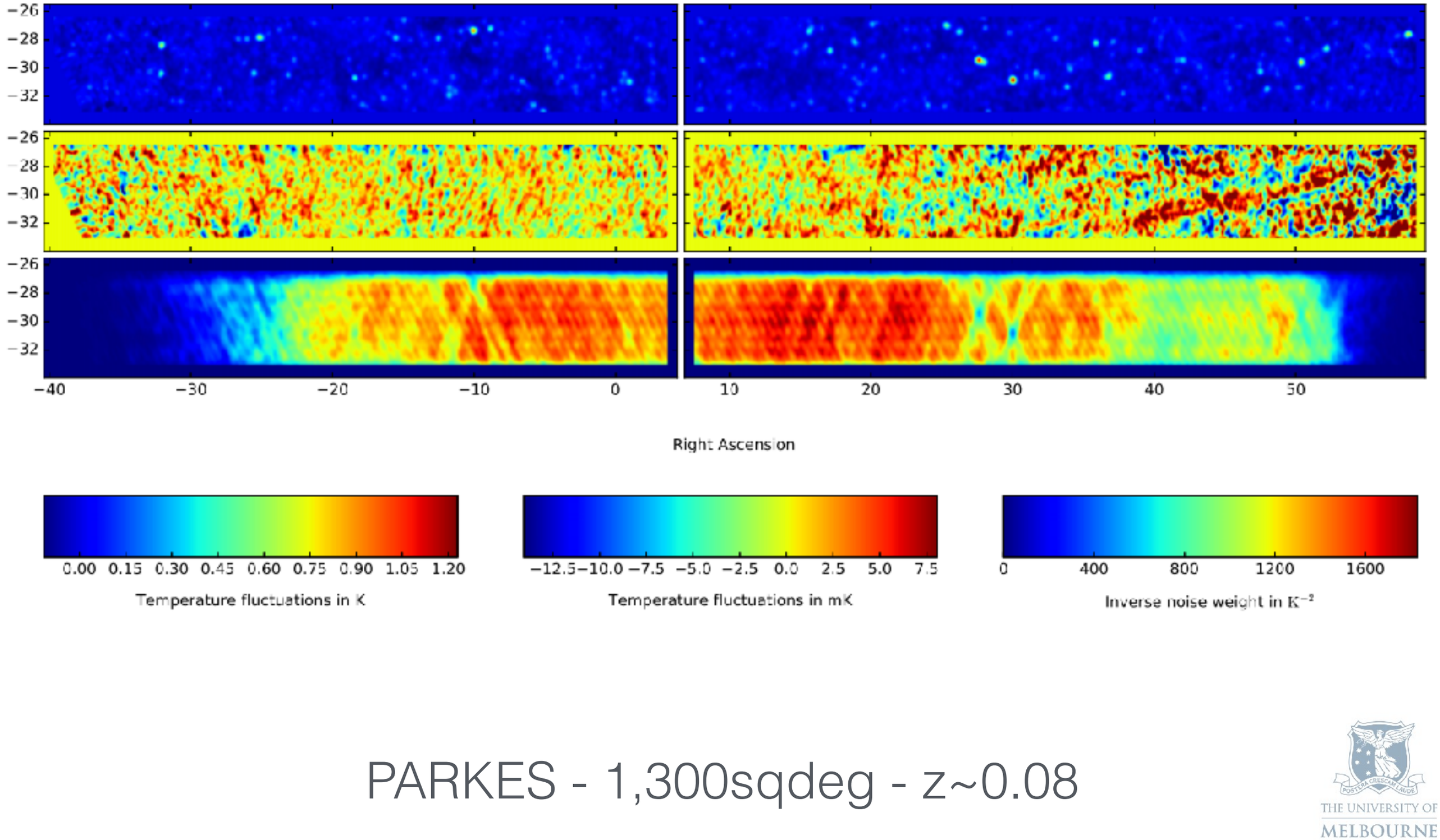
Observations

Anderson et al, 2017, 1710.00424



PARKES - 1,300sqdeg - z~0.08

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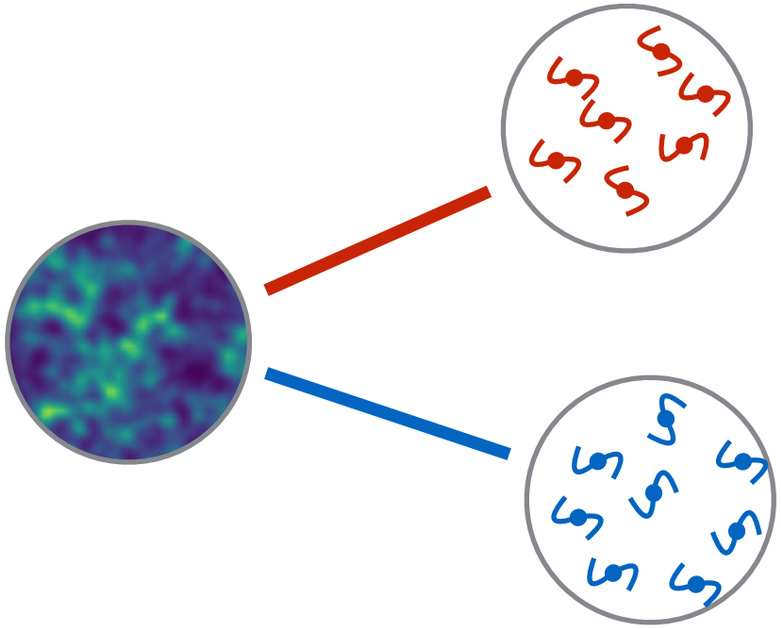
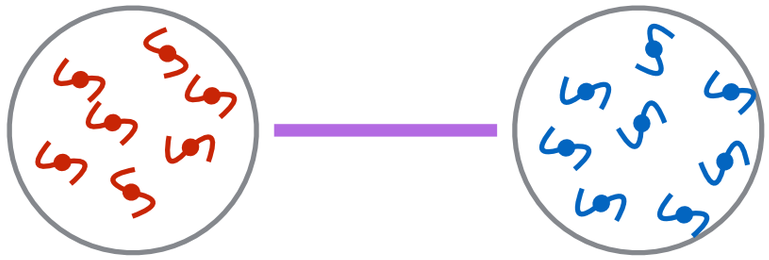
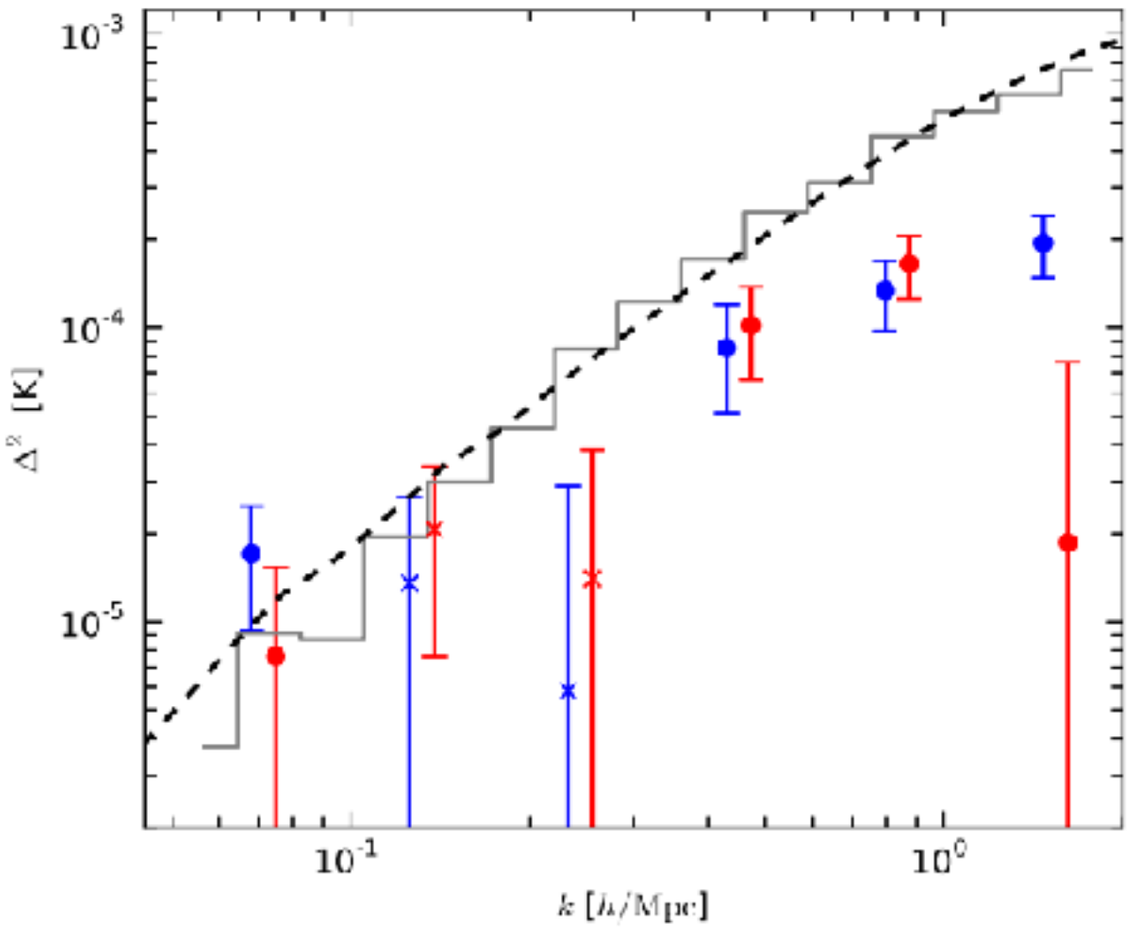
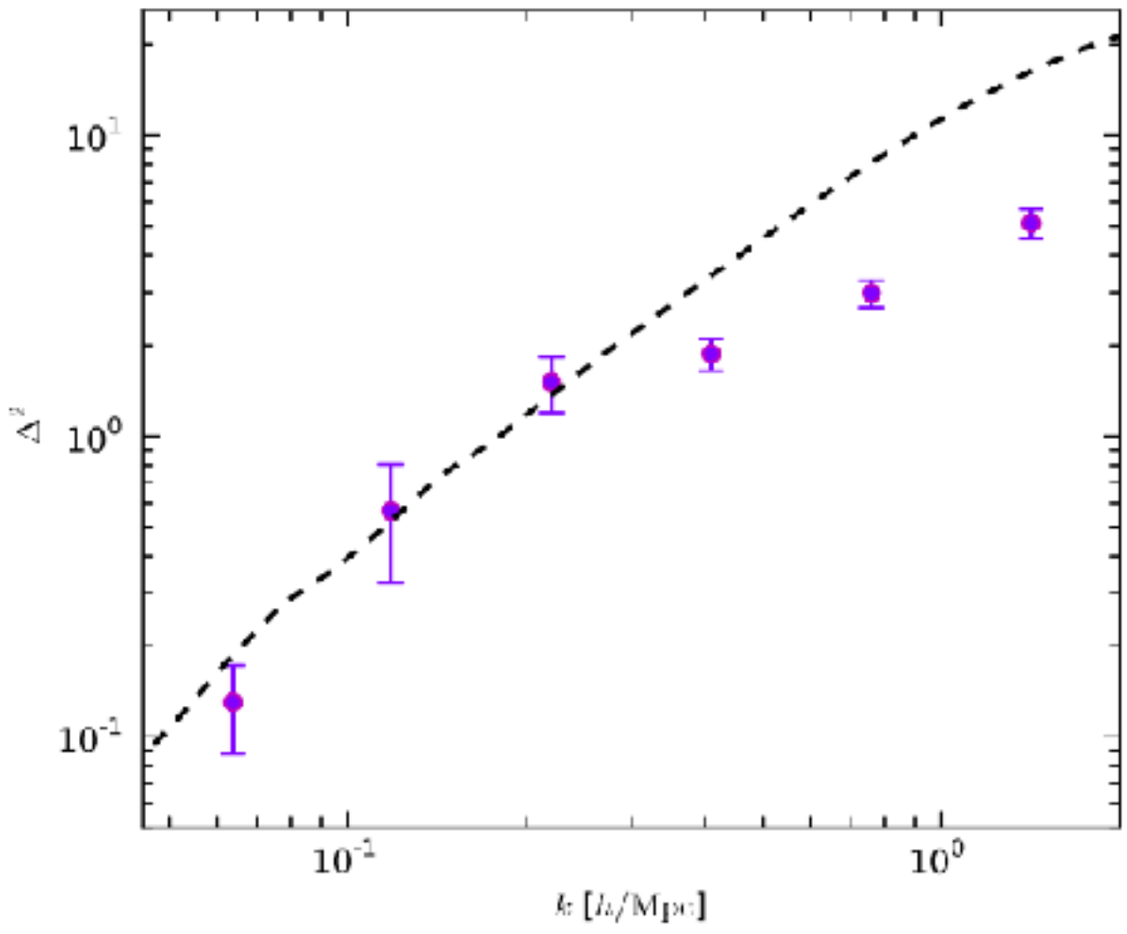
Observations

Anderson et al, 2017, 1710.00424









PARKES x 2dF - 1,300sqdeg - z~0.08

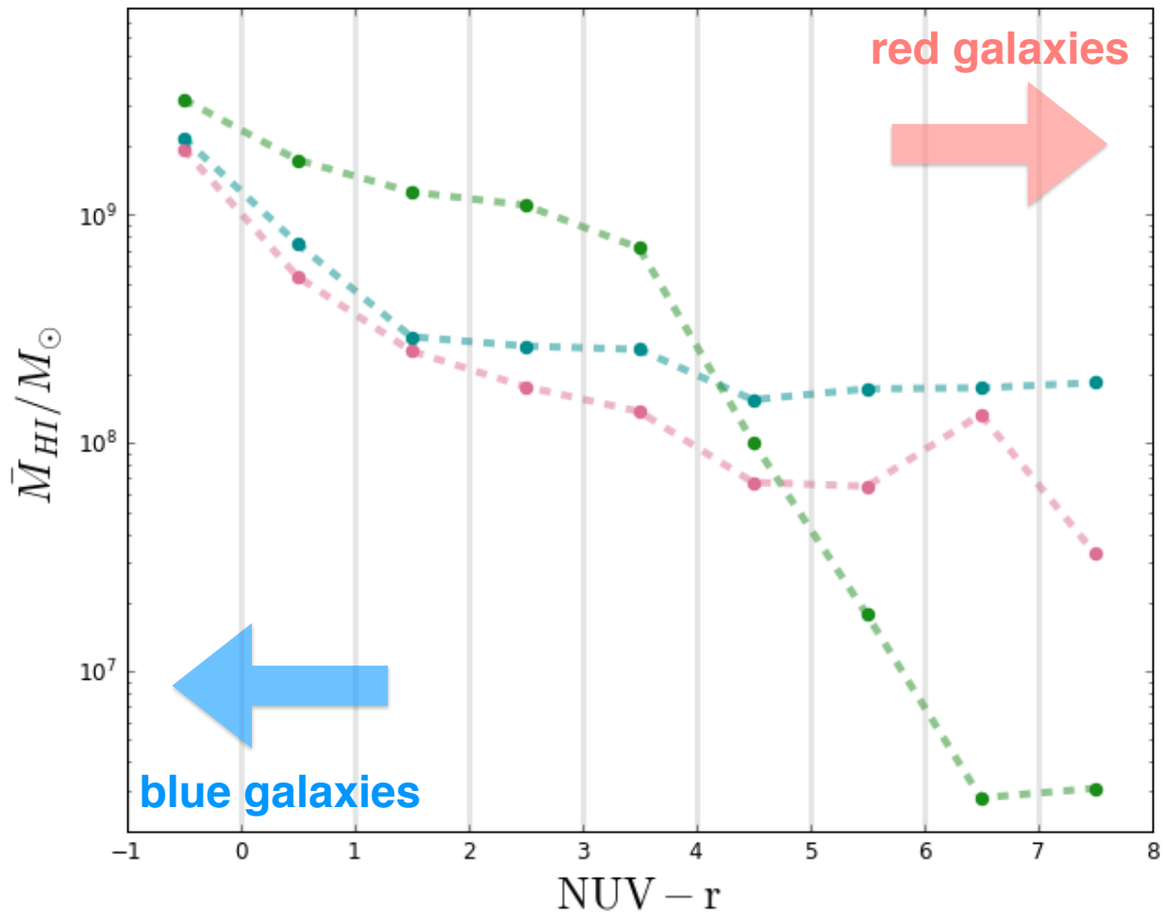
Galaxy evolution with HI intensity mapping cross-correlations

- HI intensity maps are **complete** ➡ global HI density

- HI-galaxy cross-correlations sensitive to galaxy properties

- **Cross shot noise** measures HI contents in galaxy samples

- **Scaling relations** of HI to star-formation activity



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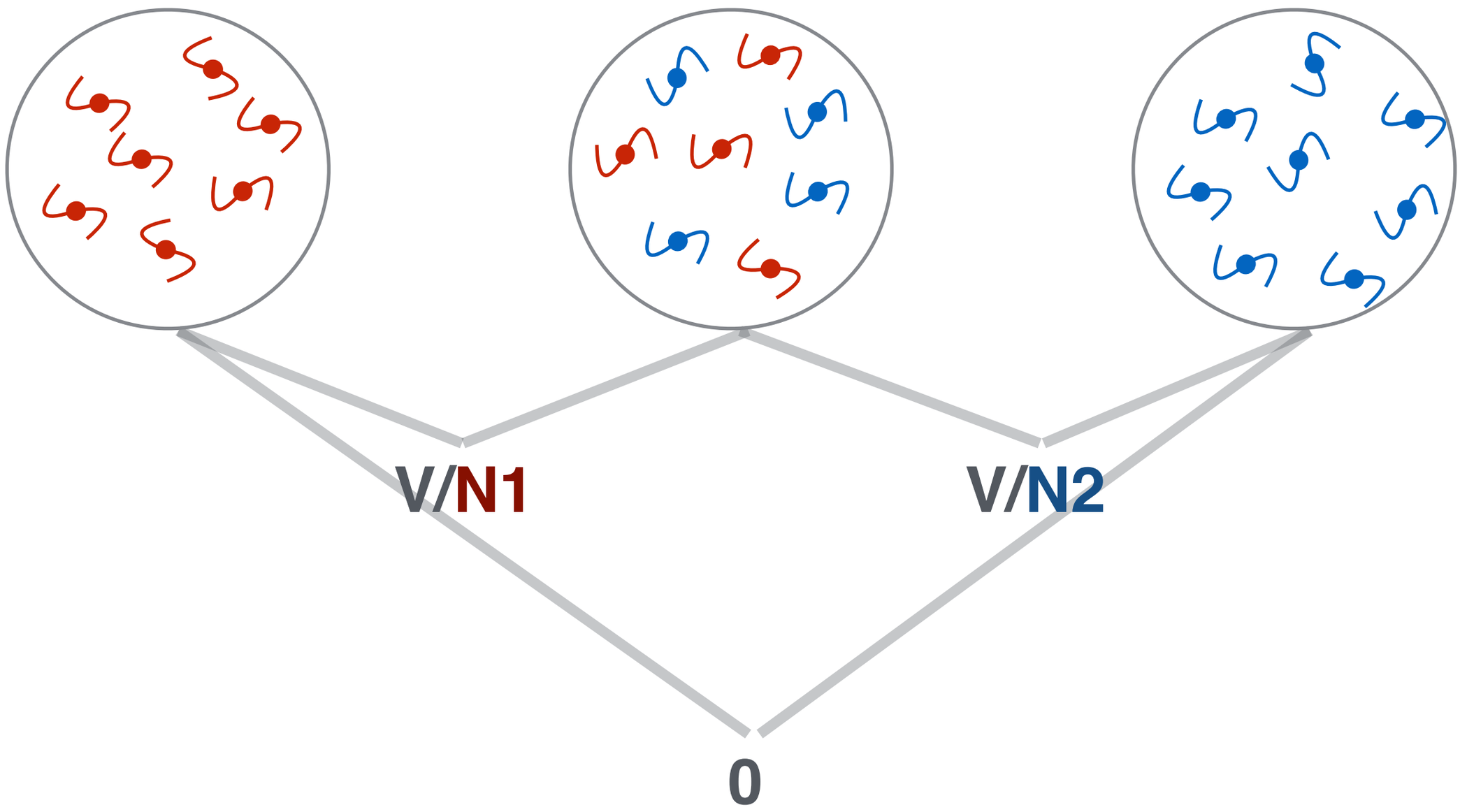
Galaxy auto power spectrum shot noise: **SN = 1/n = V/N**

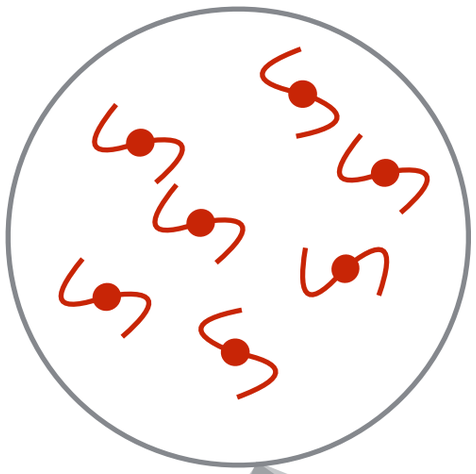
Galaxy cross power spectrum shot noise: **SN = V/(N1∩N2)**



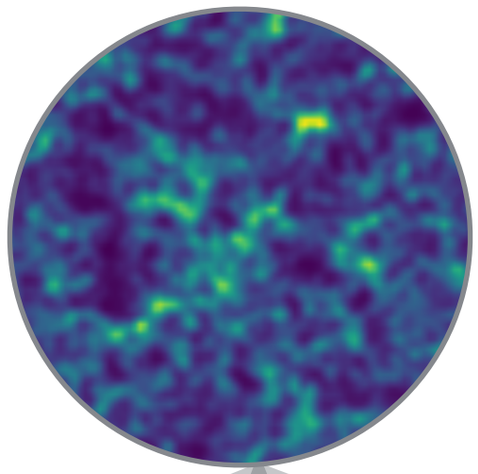
HI auto power spectrum shot noise: **SN = T/n = T*V/(N+N+M)**

HI-galaxy cross power spectrum shot noise: **SN = TV/N**

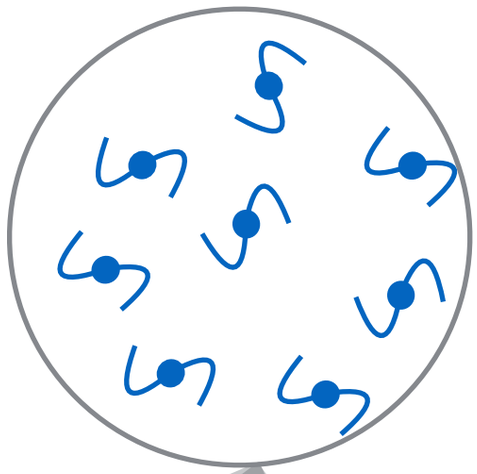
N red



N+N+M



N blue



TV/N

TV/N

0

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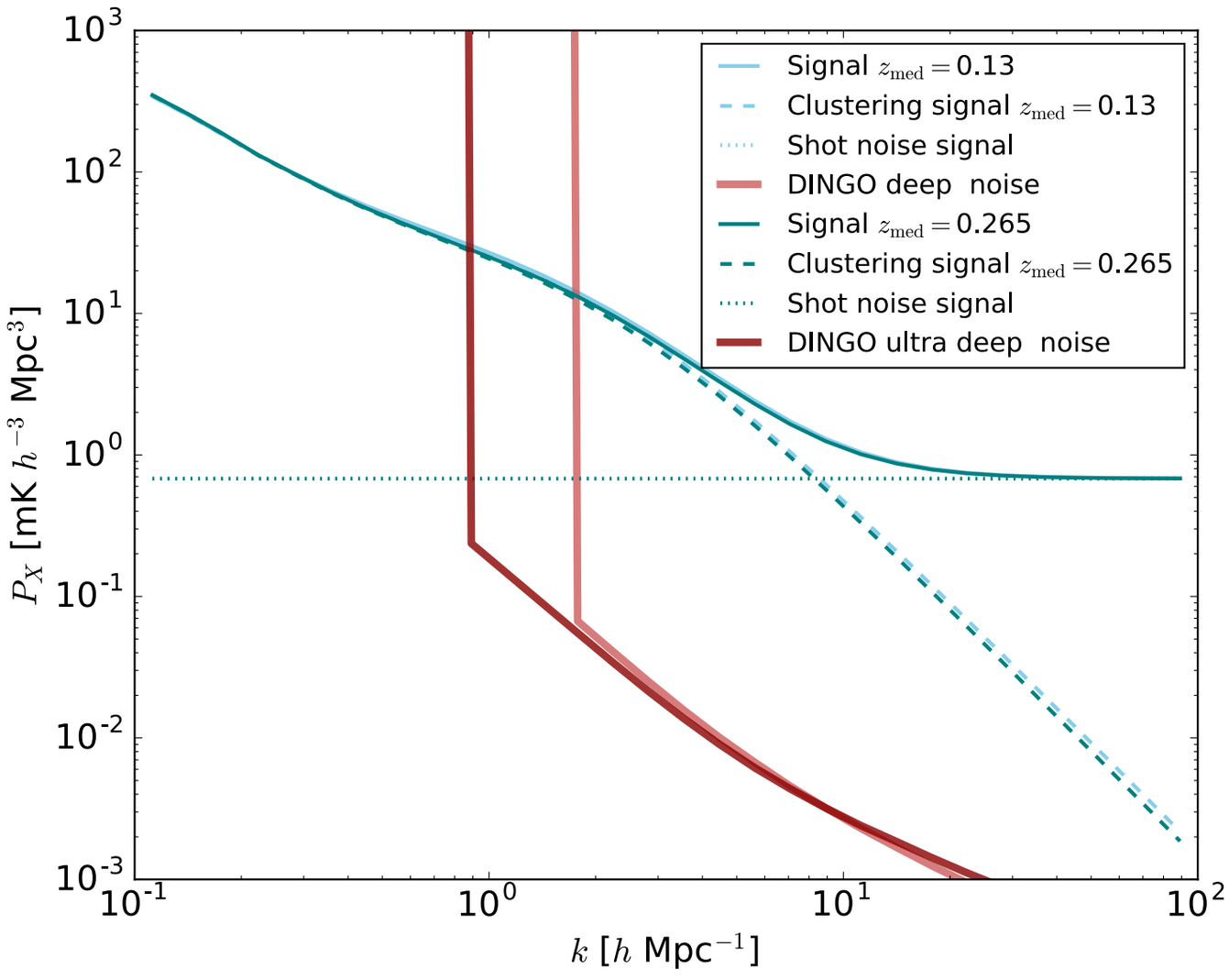
Forecast

LW et al 2017; 1703.08268

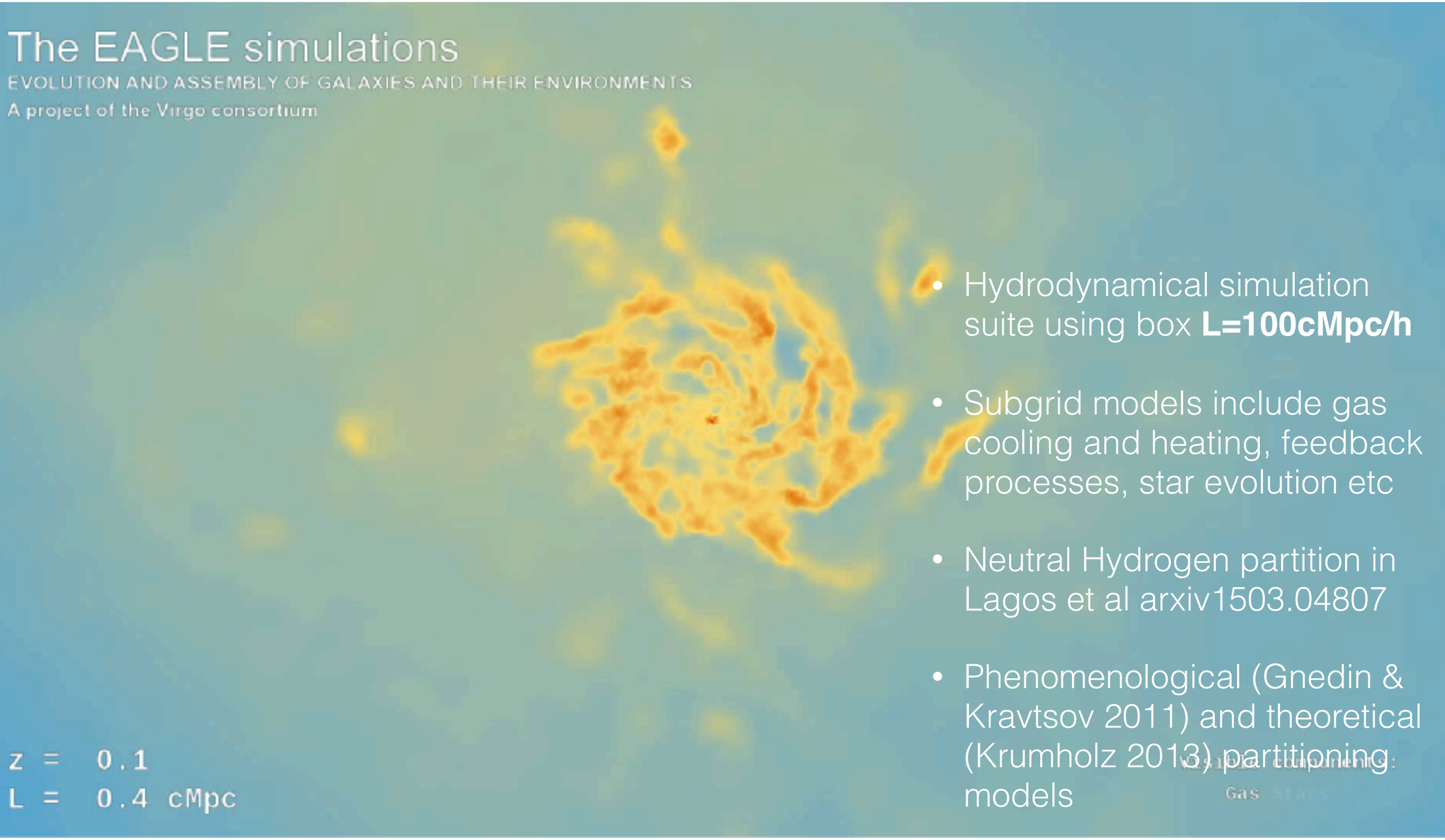
Poisson noise scales as **HI brightness temperature of the optical galaxy sample**

$$\mathrm{SN} = \frac{\overline{T}_{\mathrm{HI},g}}{n_g}$$



ASKAP DINGO forecast

Hydro-simulations



- Hydrodynamical simulation suite using box **L=100cMpc/h**
- Subgrid models include gas cooling and heating, feedback processes, star evolution etc
- Neutral Hydrogen partition in Lagos et al arxiv1503.04807
- Phenomenological (Gnedin & Kravtsov 2011) and theoretical (Krumholz 2013) partitioning models

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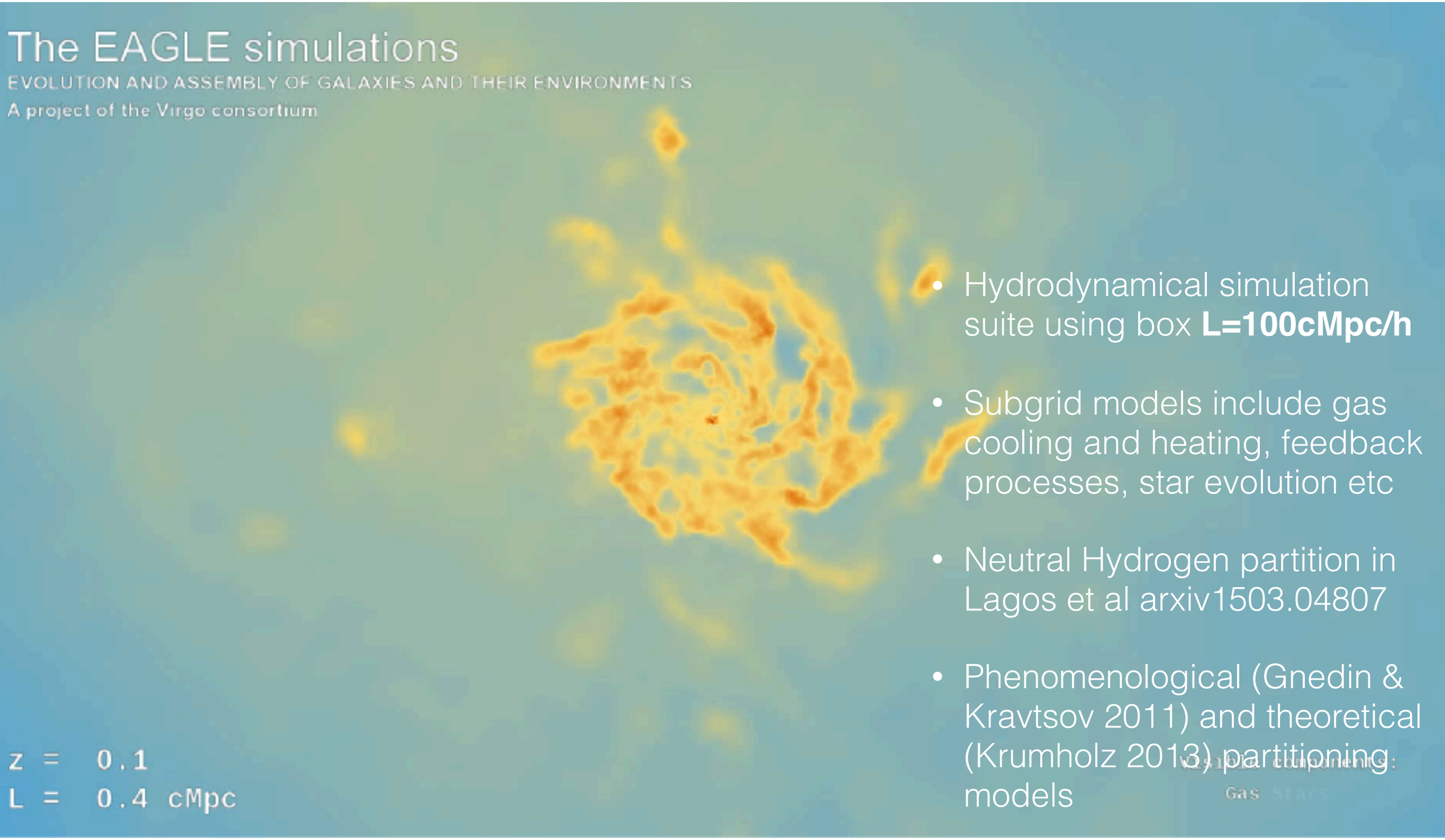

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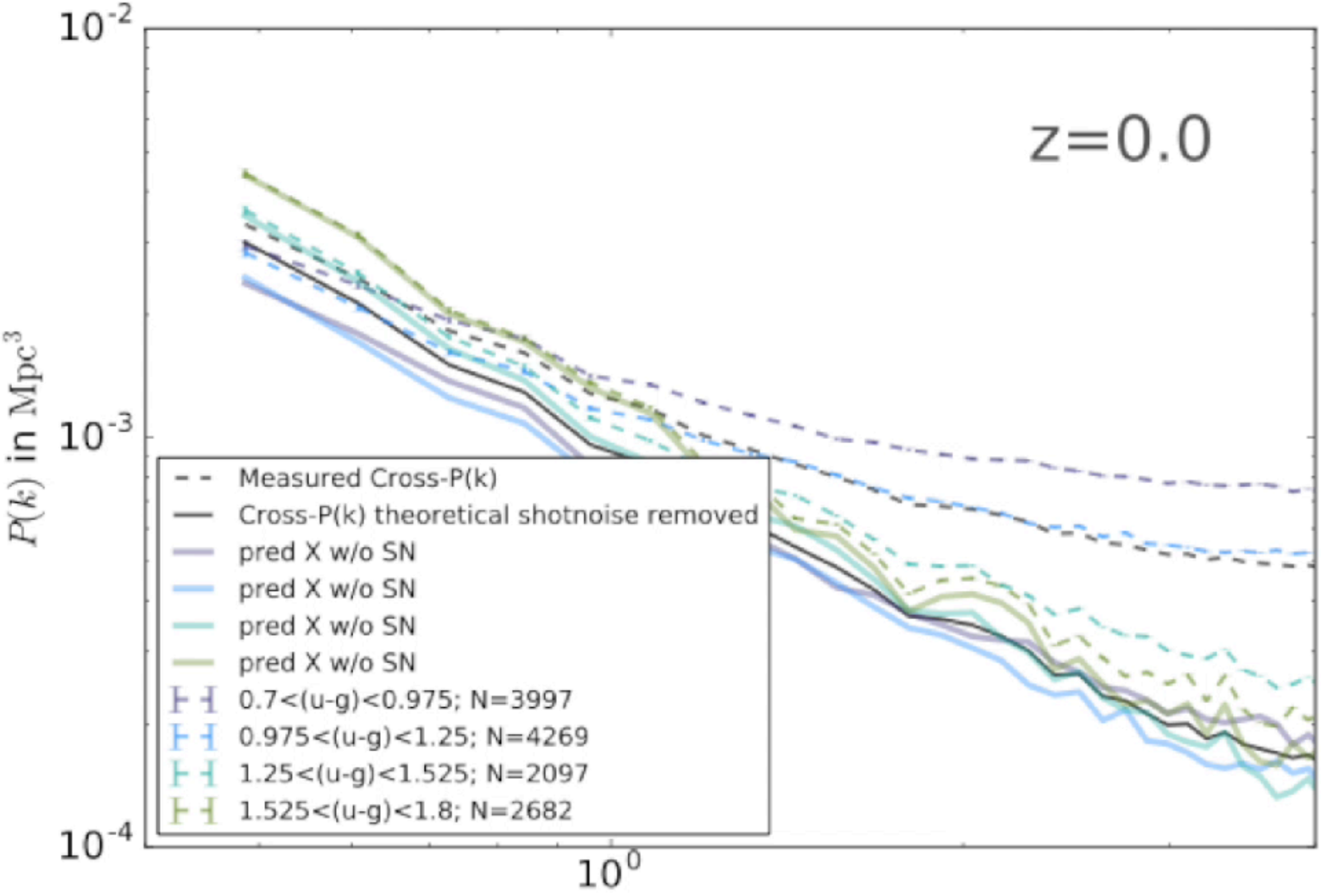

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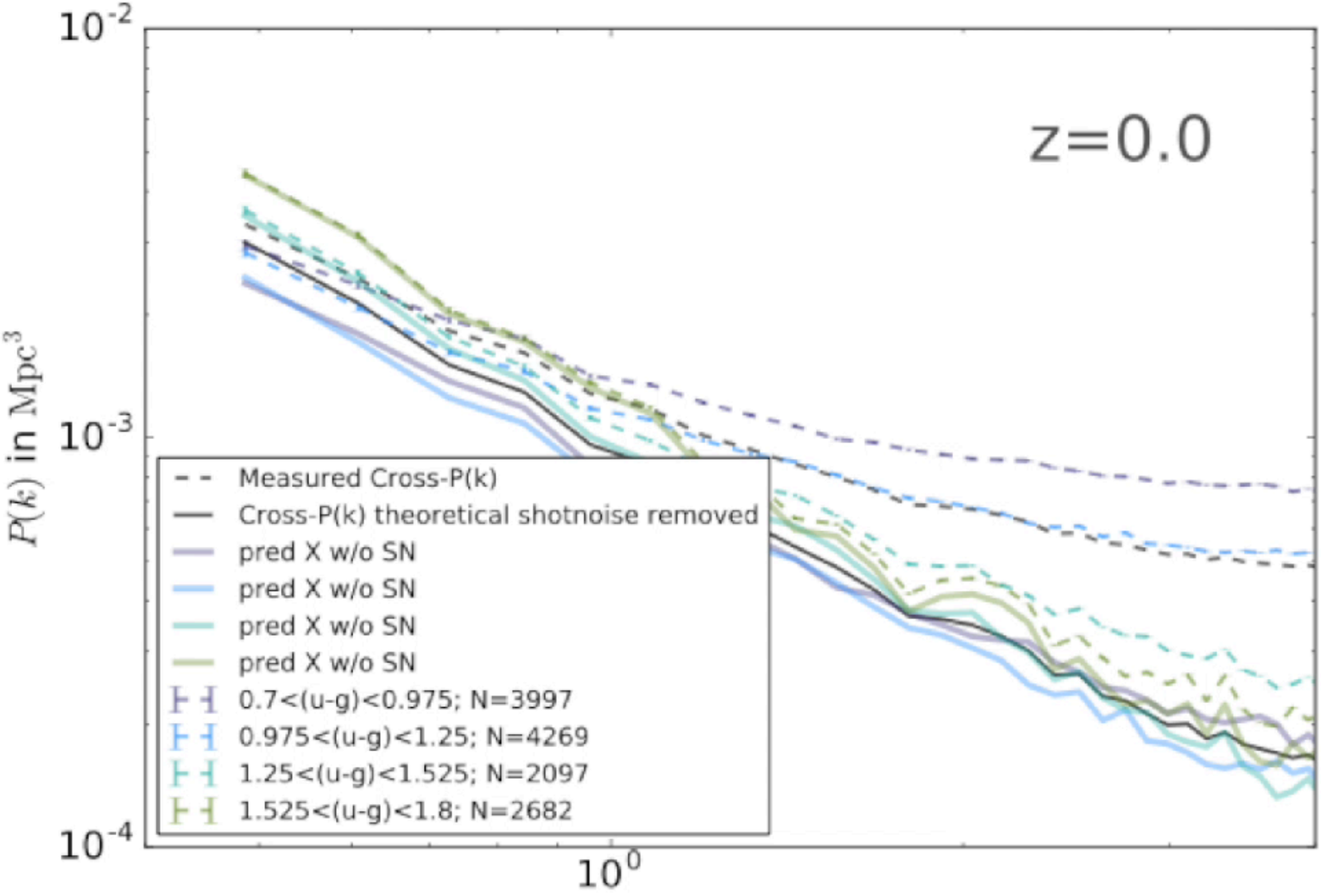
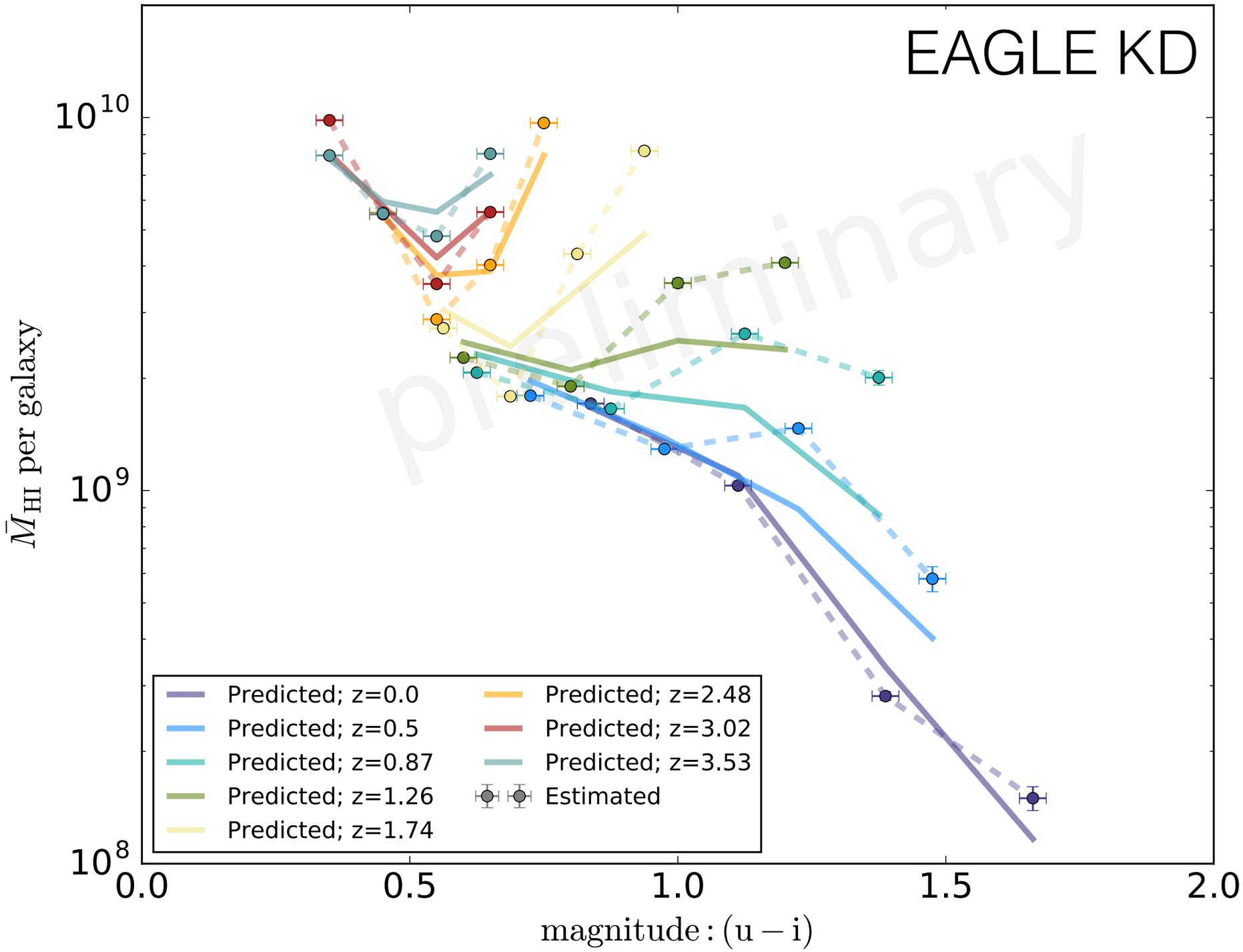


Hydro-simulations

Based on LW et al 2017; 1703.08268



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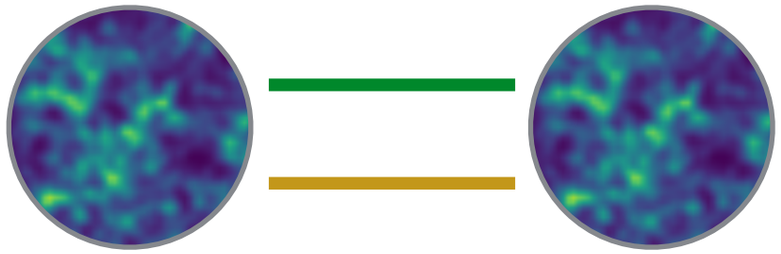
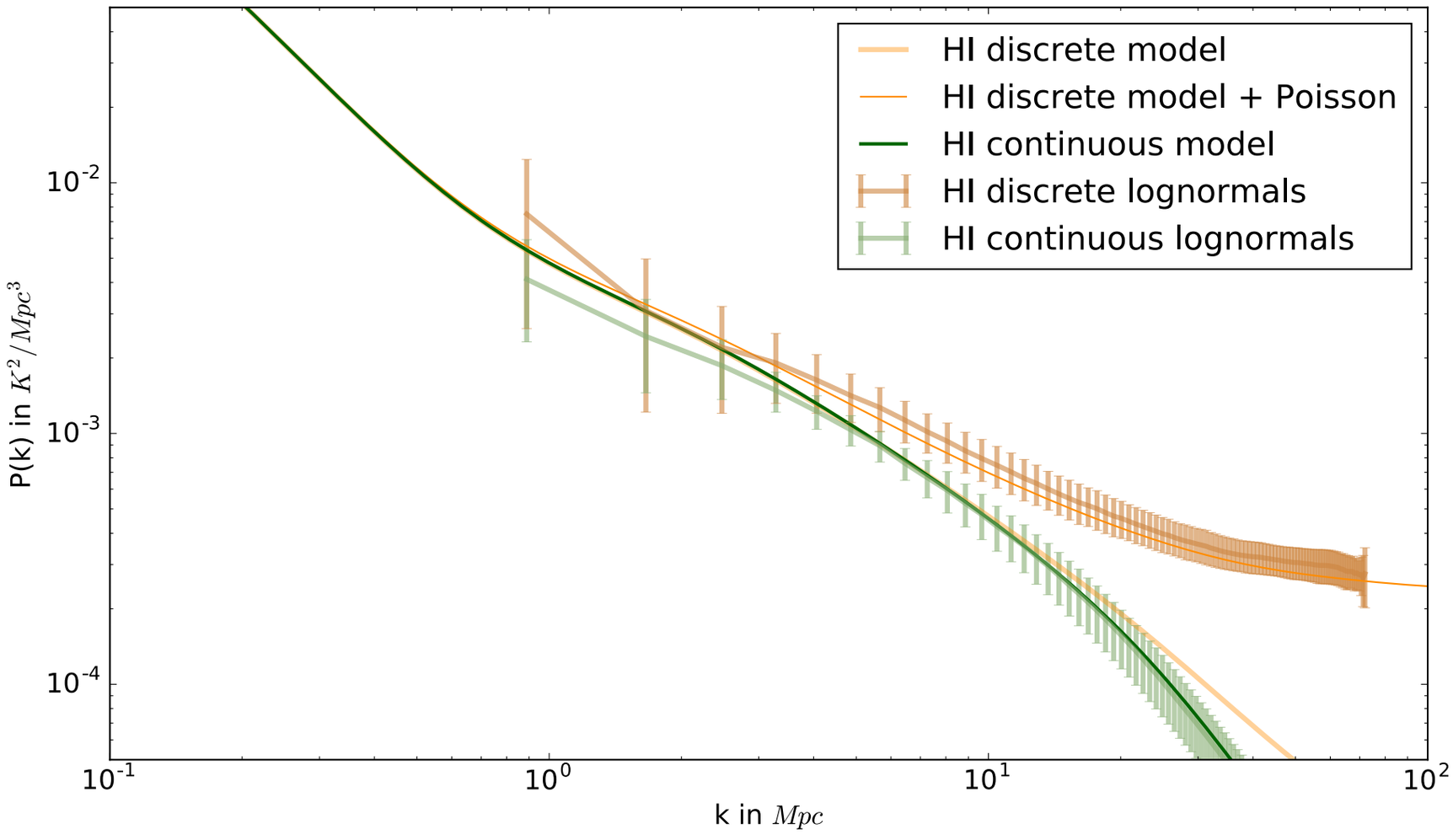
Analytic models

with Steven Murray; Wolz et al in prep

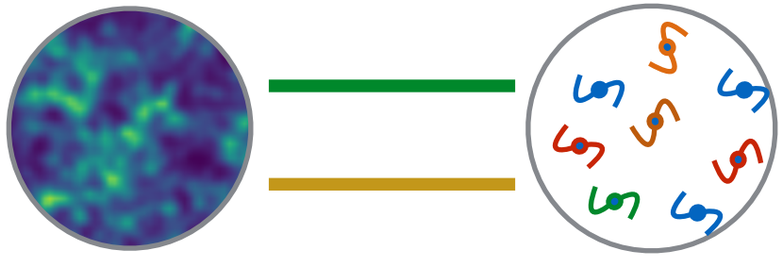


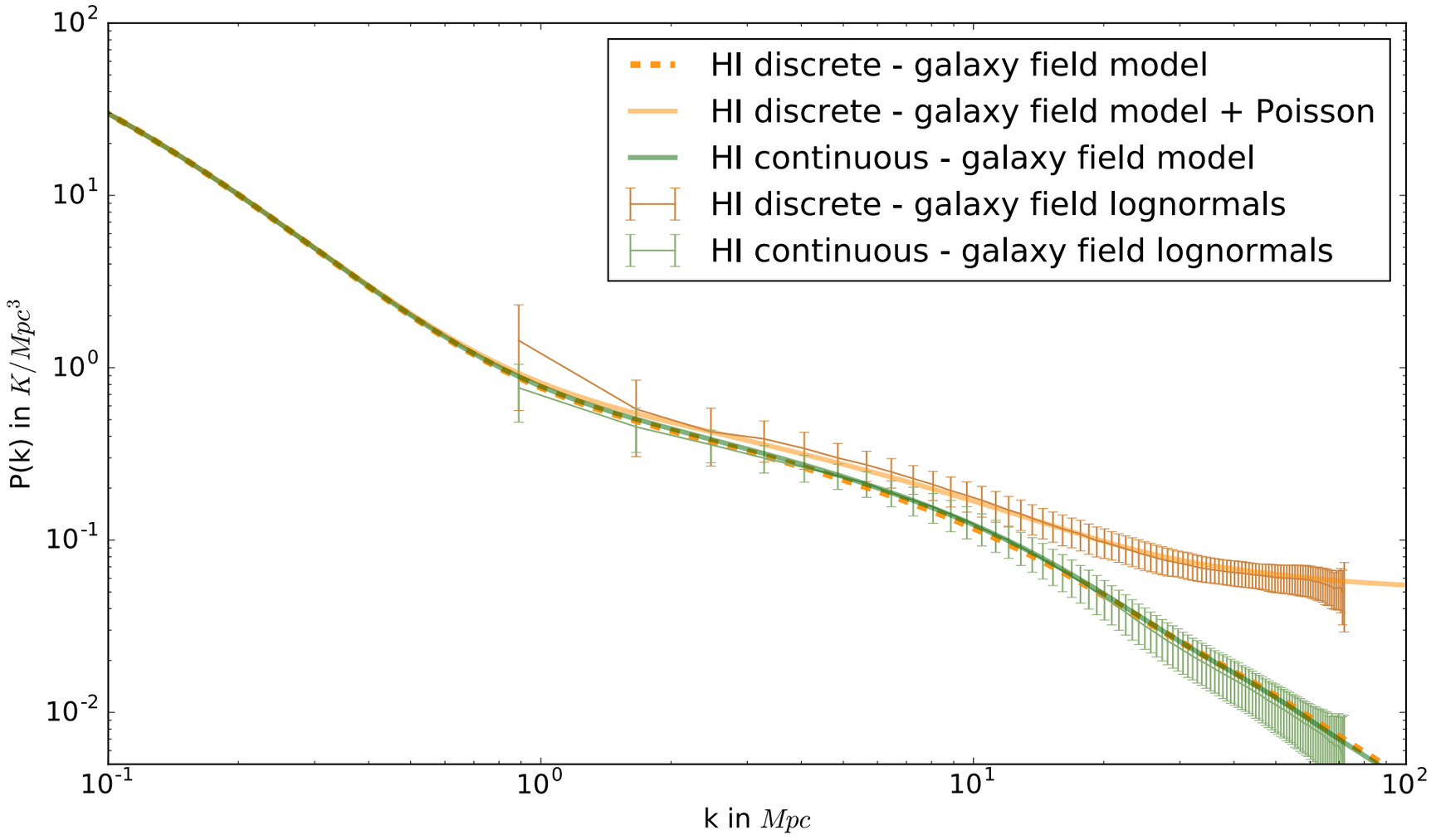


Halomodel - early/late-type HI distribution

Analytic models

with Steven Murray; Wolz et al in prep





Halomodel - early/late-type HI distribution

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SKA cosmology working group

- Focus Group on *Intensity Mapping* (Santos, Wolz)
  - Simulation pipelines (Manchester)
- Focus Group on *Cosmology with SKA-low* (Pritchard, Pourtsidou)
  - Simulations for Intensity Mapping with SKA-low 3<z<6
- Meeting at QMUL in London from 18.12. to 20.12. and SKA-Euclid day on 21.12.
- Red Book on SKA cosmology to be released

Interest - email lwolz@unimelb.edu.au

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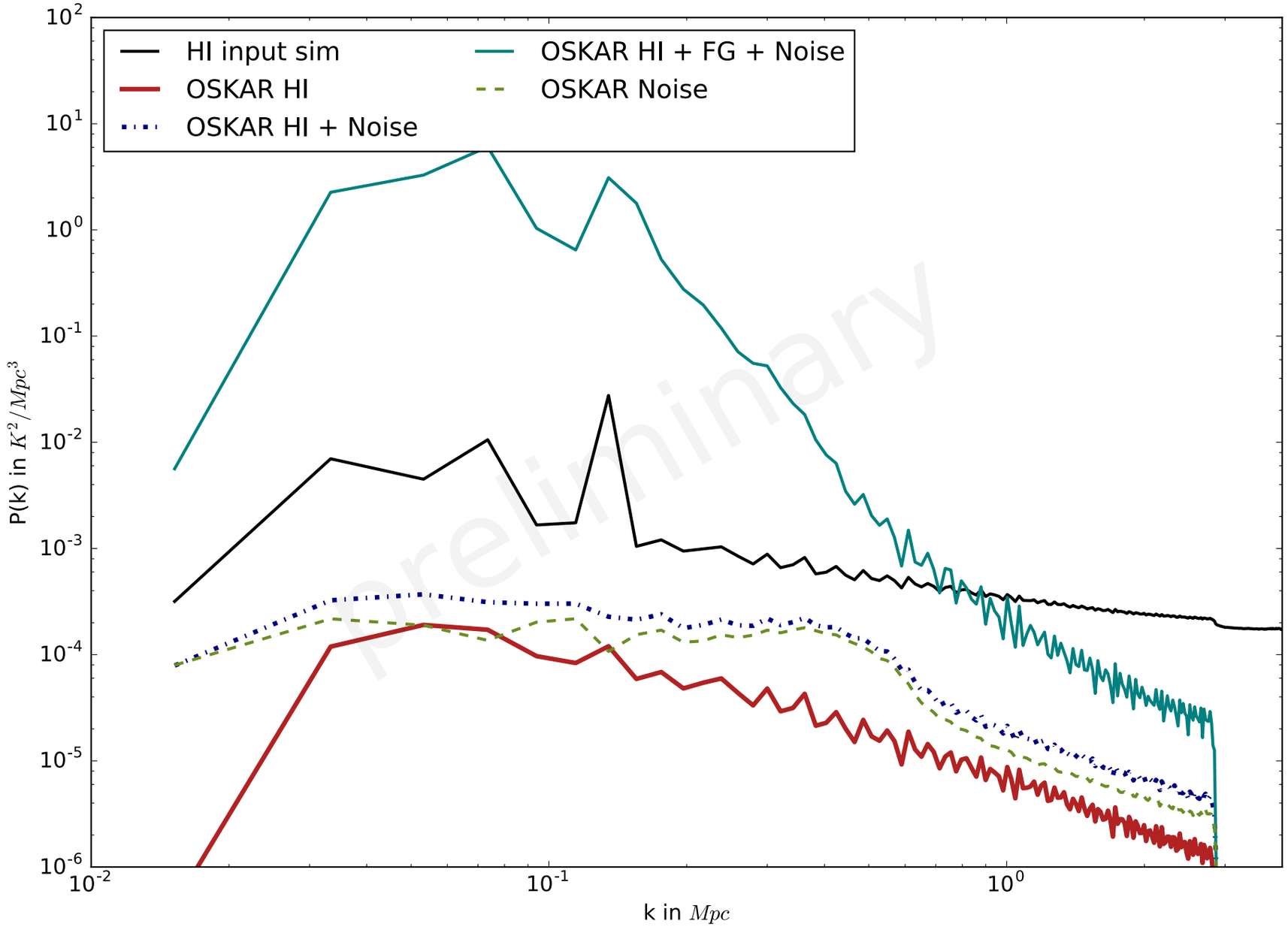
Mock data

Cosmology SKA-low Focus Group:
E. Chapman, J. Pritchard, F. Villascuesa-Navarro,
A. Pourtsidou, A. Weltmann, L. Wolz



SKA-low core - HI light cone 3<z<6 - Radius 3 deg

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Summary

- Intensity Mapping complimentary way to observe the large-scale structure
- Omega_HI measurements for all redshifts
- Intensity mapping cross-correlation robust way to test cosmology and galaxy evolution
- Preparations for intensity mapping with SKA Mid and SKA Low