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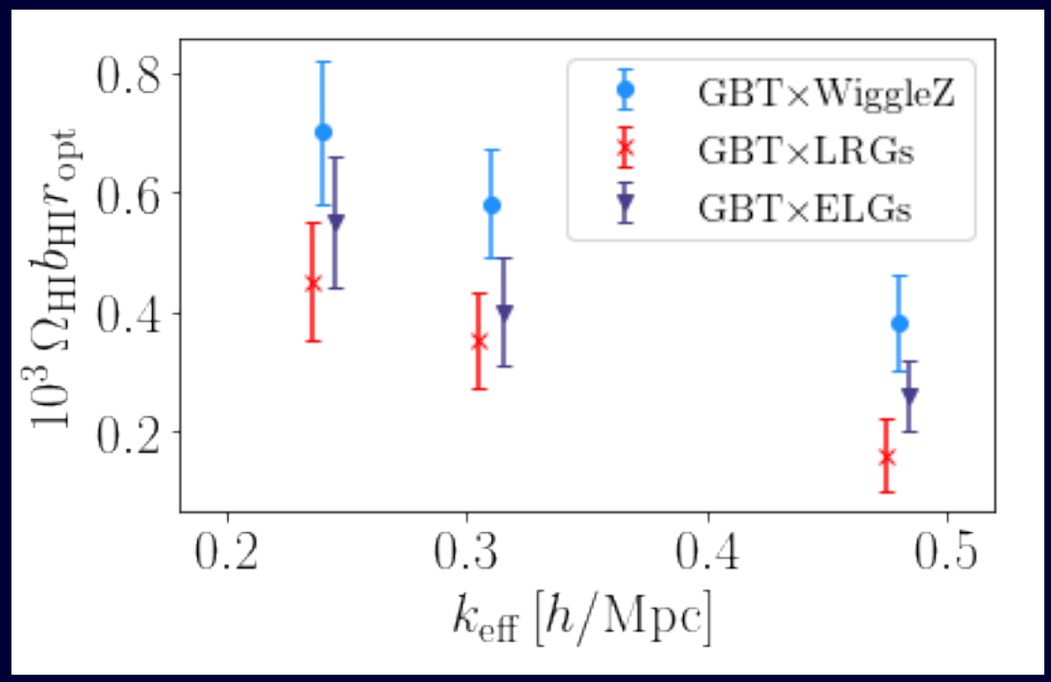
Dr Laura Wolz - UKRI Future Leader Fellow
University of Manchester

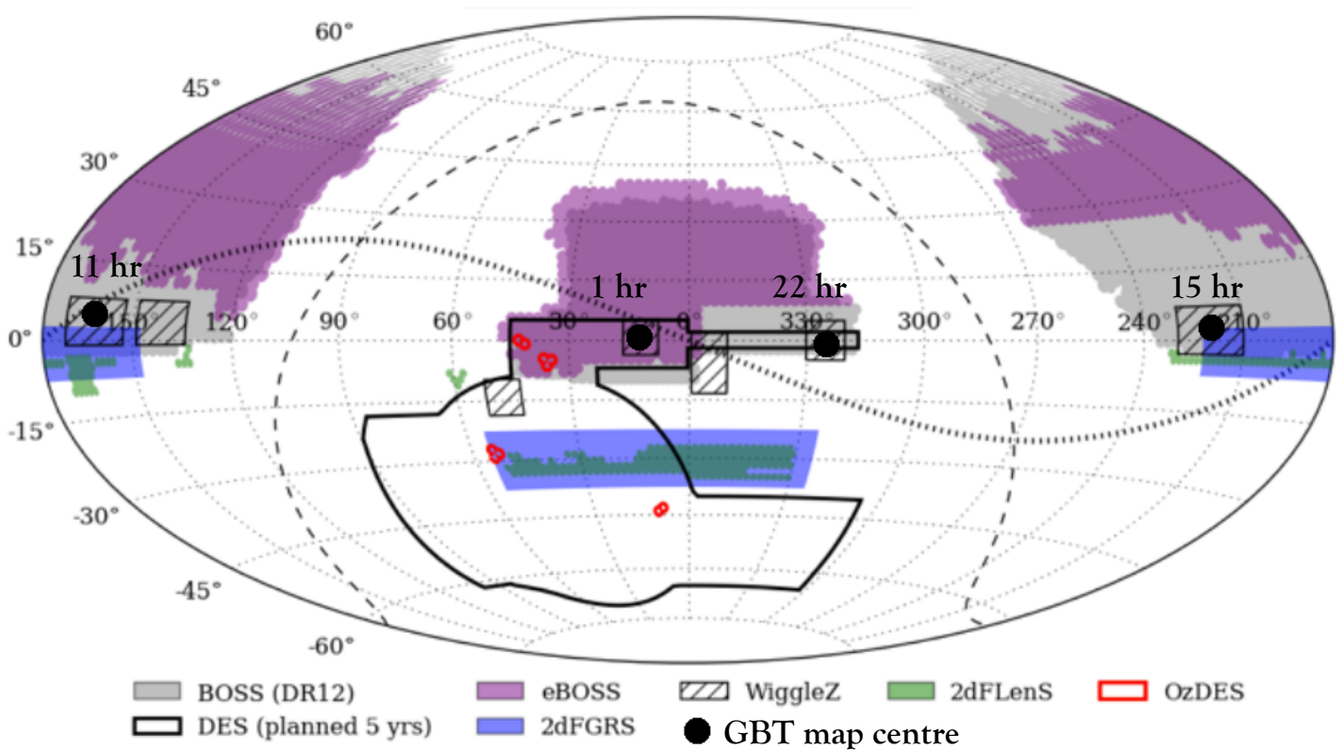


HI constraints from cross-correlation of eBOSS galaxies and GBT intensity maps

31.08.2022 - 21CM COSMOLOGY WORKSHOP 2022

Green Bank Telescope data

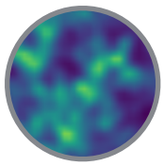
- 🎧 **700<f<900MHz** ⏱️ **100hrs** ✨ **~100sqdeg** 🔭 **FWHM~0.44deg**
- Data divided in 4 sub-season
- Masked around edges and frequency 0.62<z<0.95



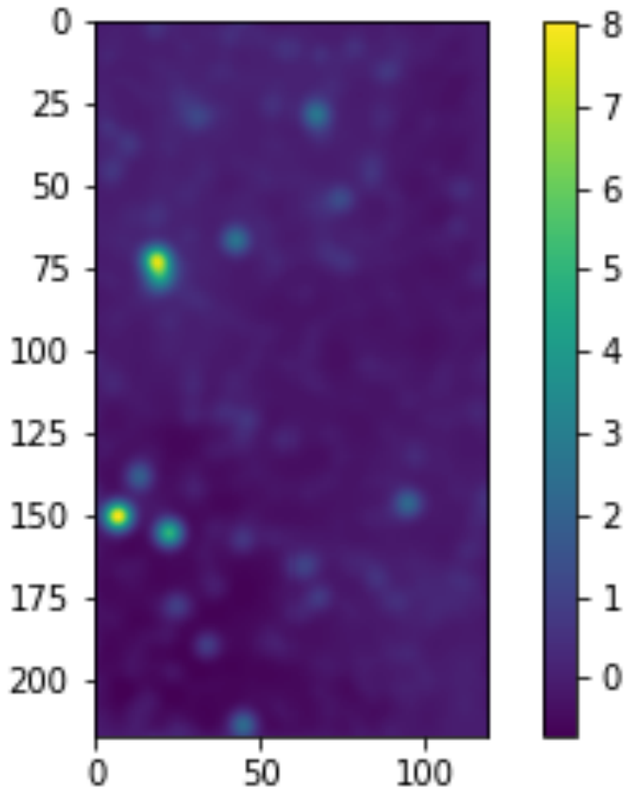
See Switzer et al 2013, Masui et al 2013 for previous data and Wolz et al 2016 for analysis pipeline

Analysis Pipeline

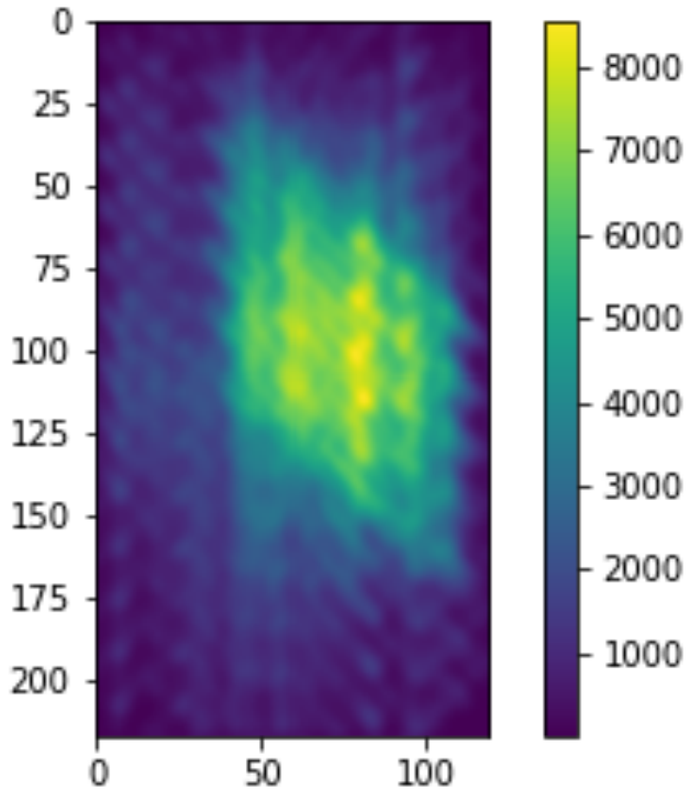
- Start with GBT data after map-making (pixel~0.067deg)
- Convolve to same angular resolution 1.4*max beam->FWHM~0.44 deg
- Mask out the edges of the 2d-maps (15pix per side)
- Apply fastICA (using N_IC=2 ...32)
- Estimate power spectrum using inverse noise variance weighting
- Correct for signal loss with transfer function
- Estimate error bars
- Average over all sub-sections (A,B,C,D)



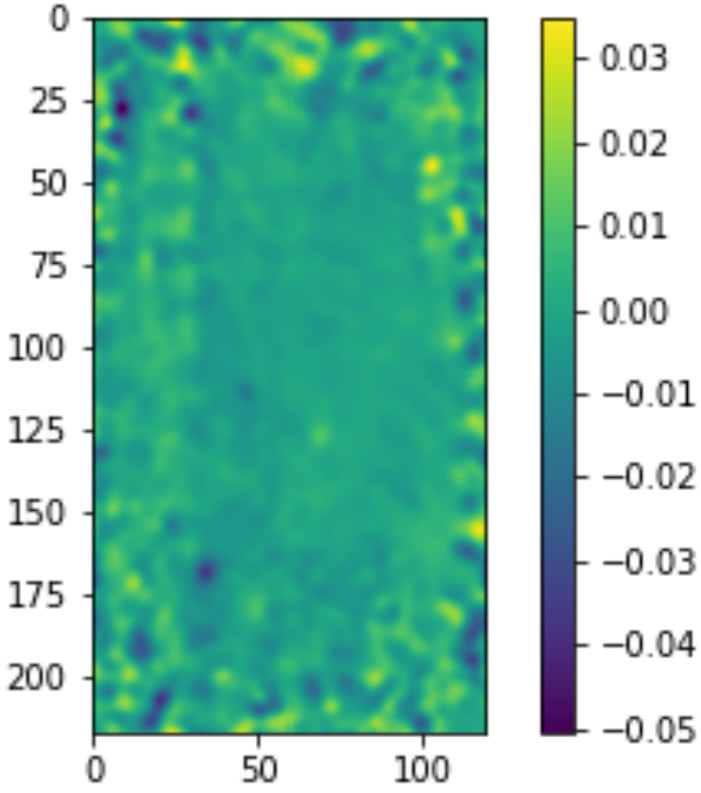
Data



Inverse noise



Cleaned



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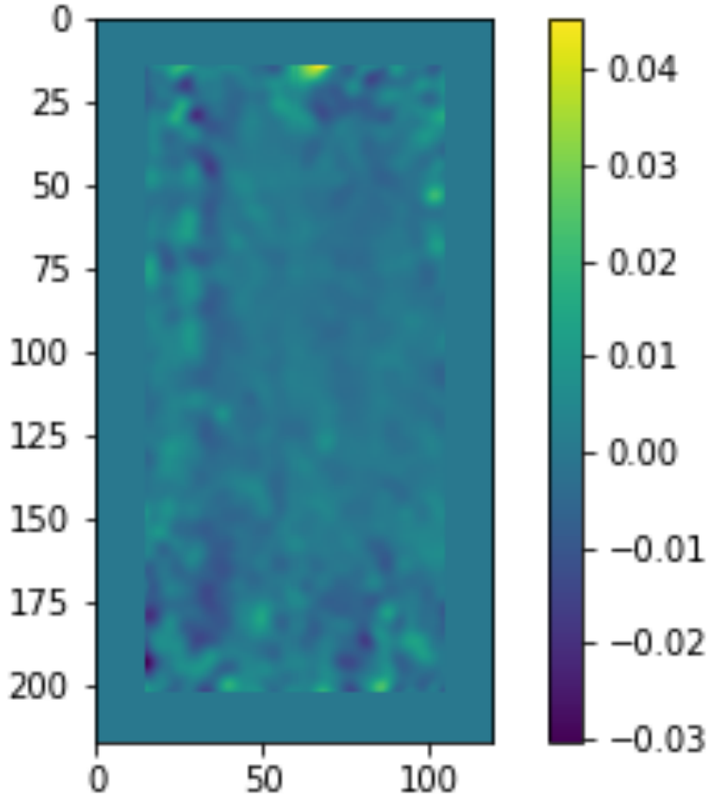
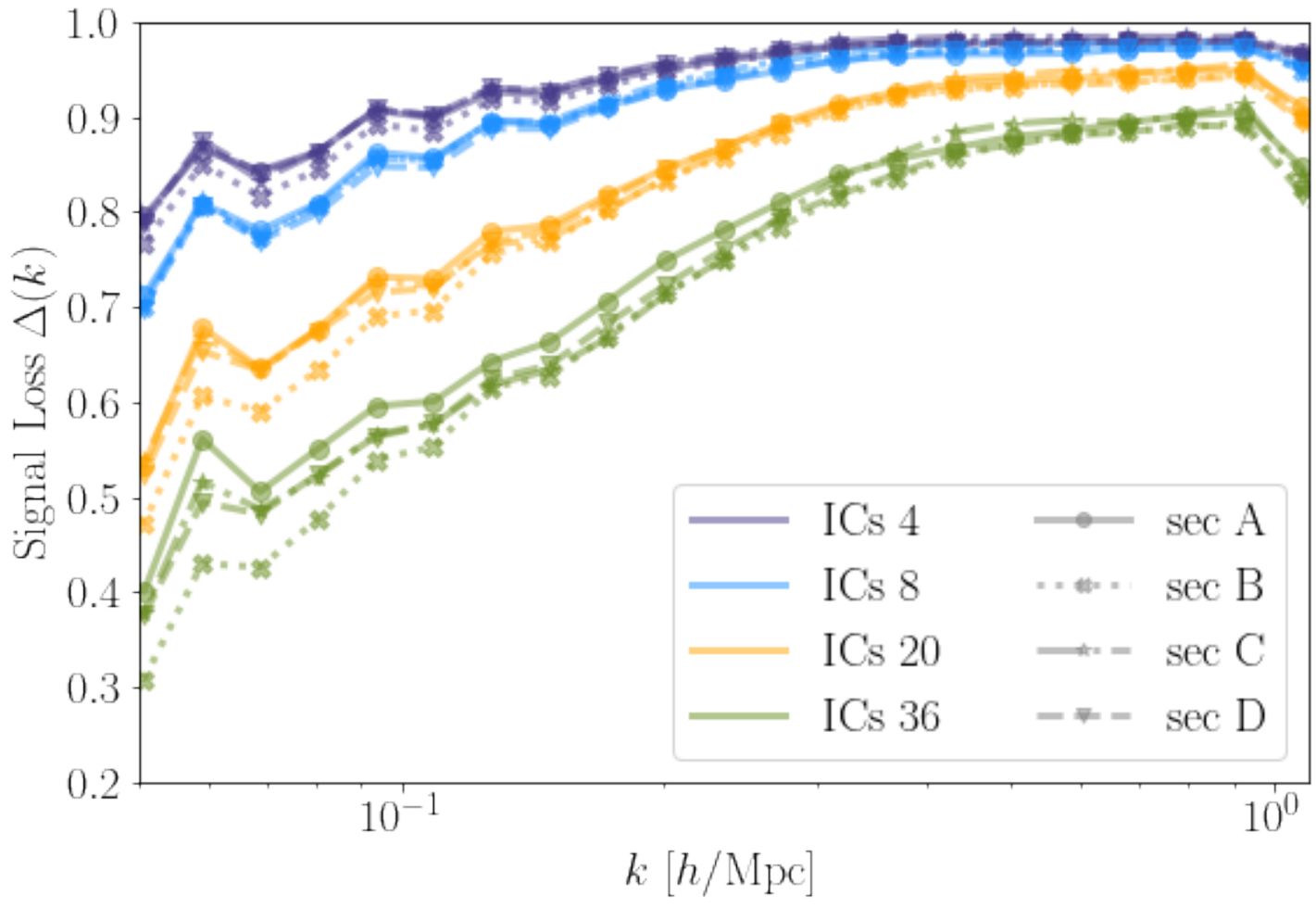


Foreground Subtraction Transfer Function to correct for HI signal loss



Based 100 mock realisations added to the data pre-fastICA and run through our analysis pipeline

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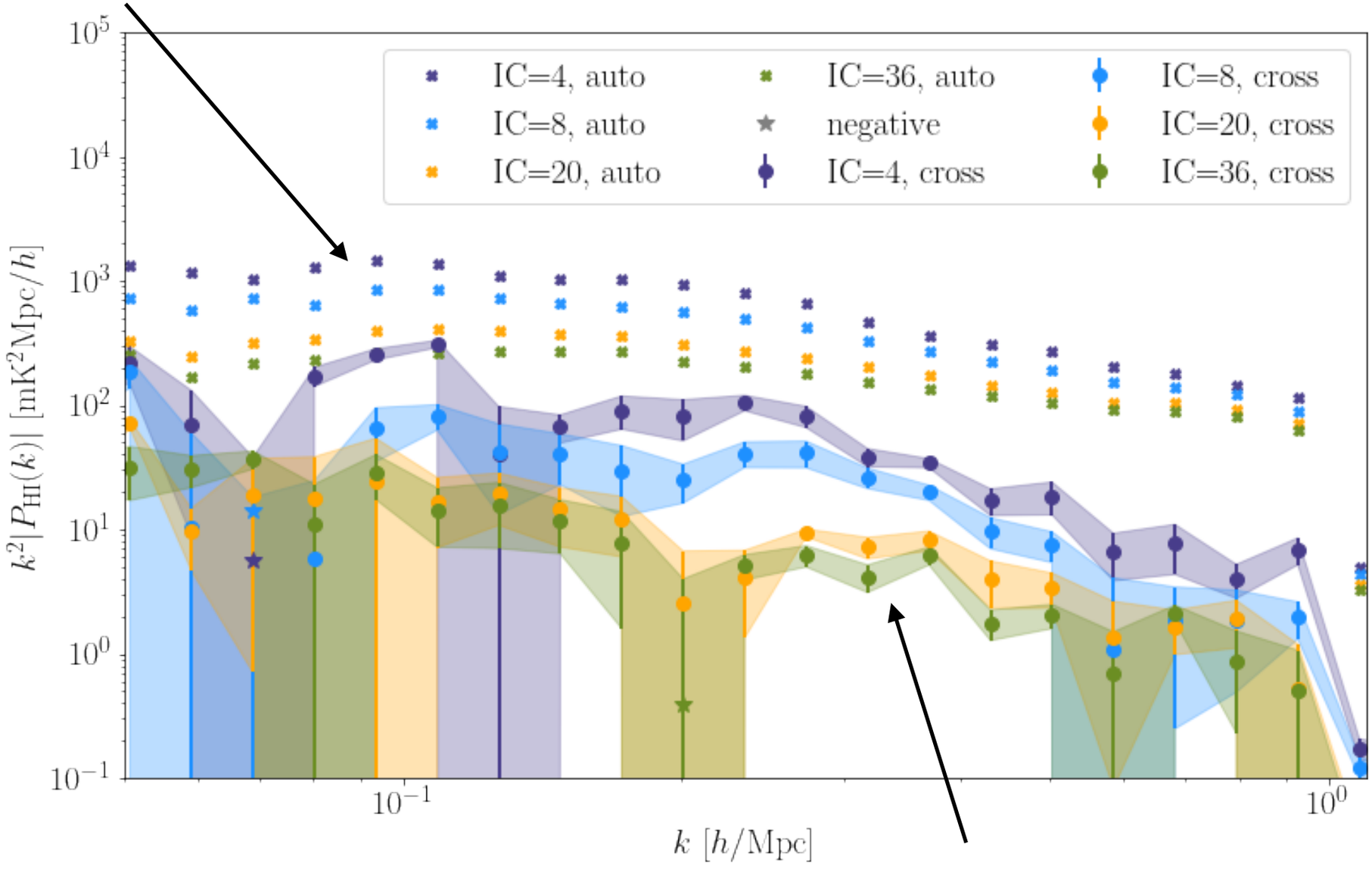
GBT HI intensity mapping power spectrum

Auto-season -> noise dominated



Cross-season -> upper limit of HI intensity mapping

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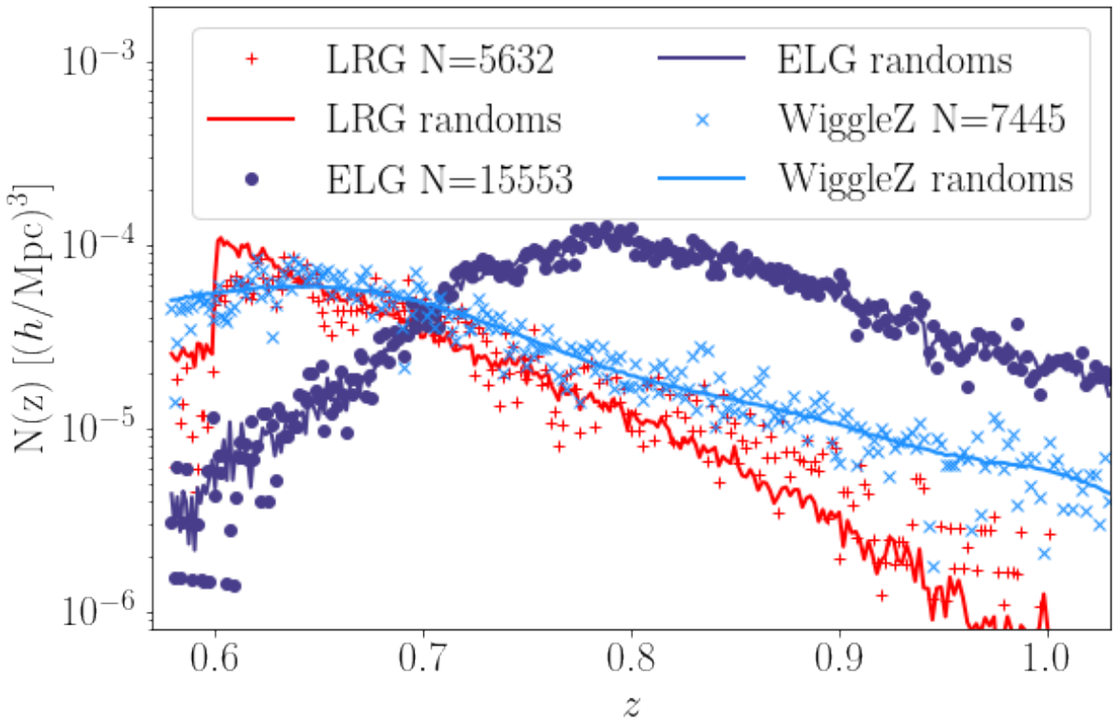
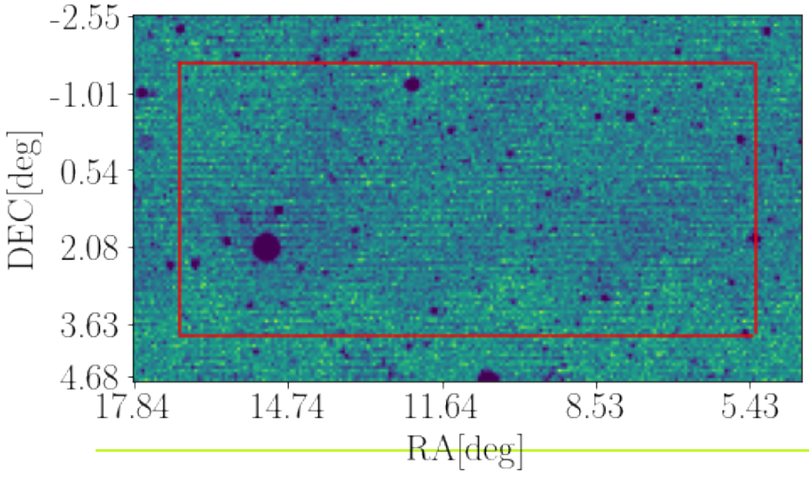
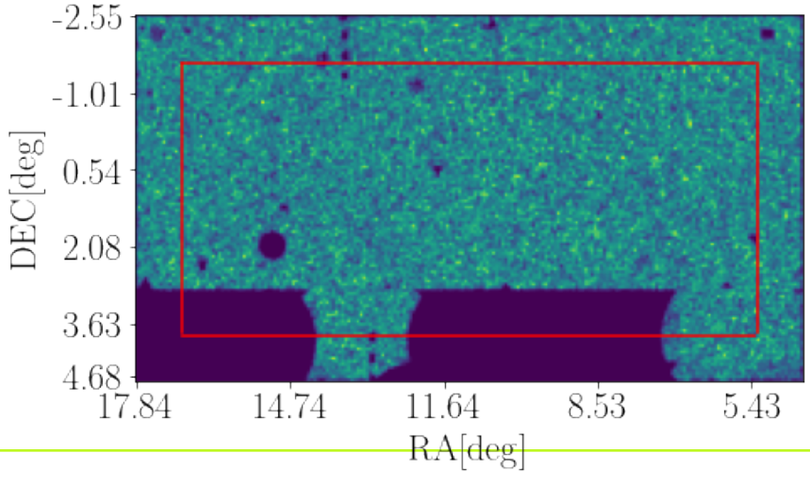
Galaxy samples



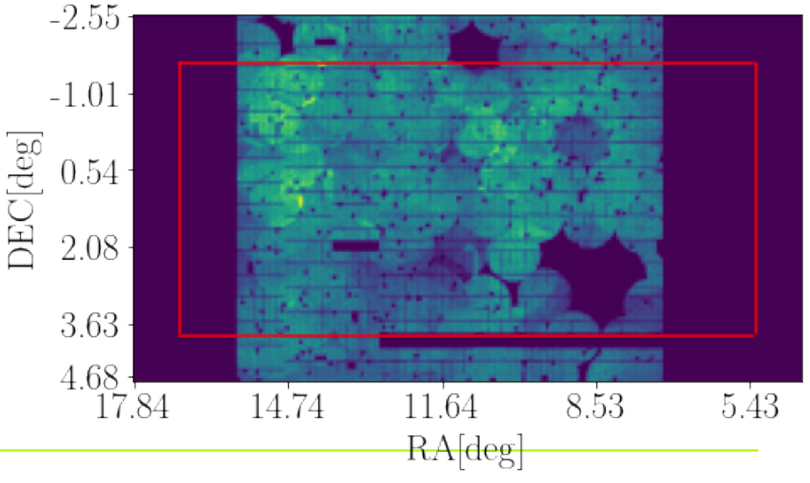
ELG



LRG



WiggleZ



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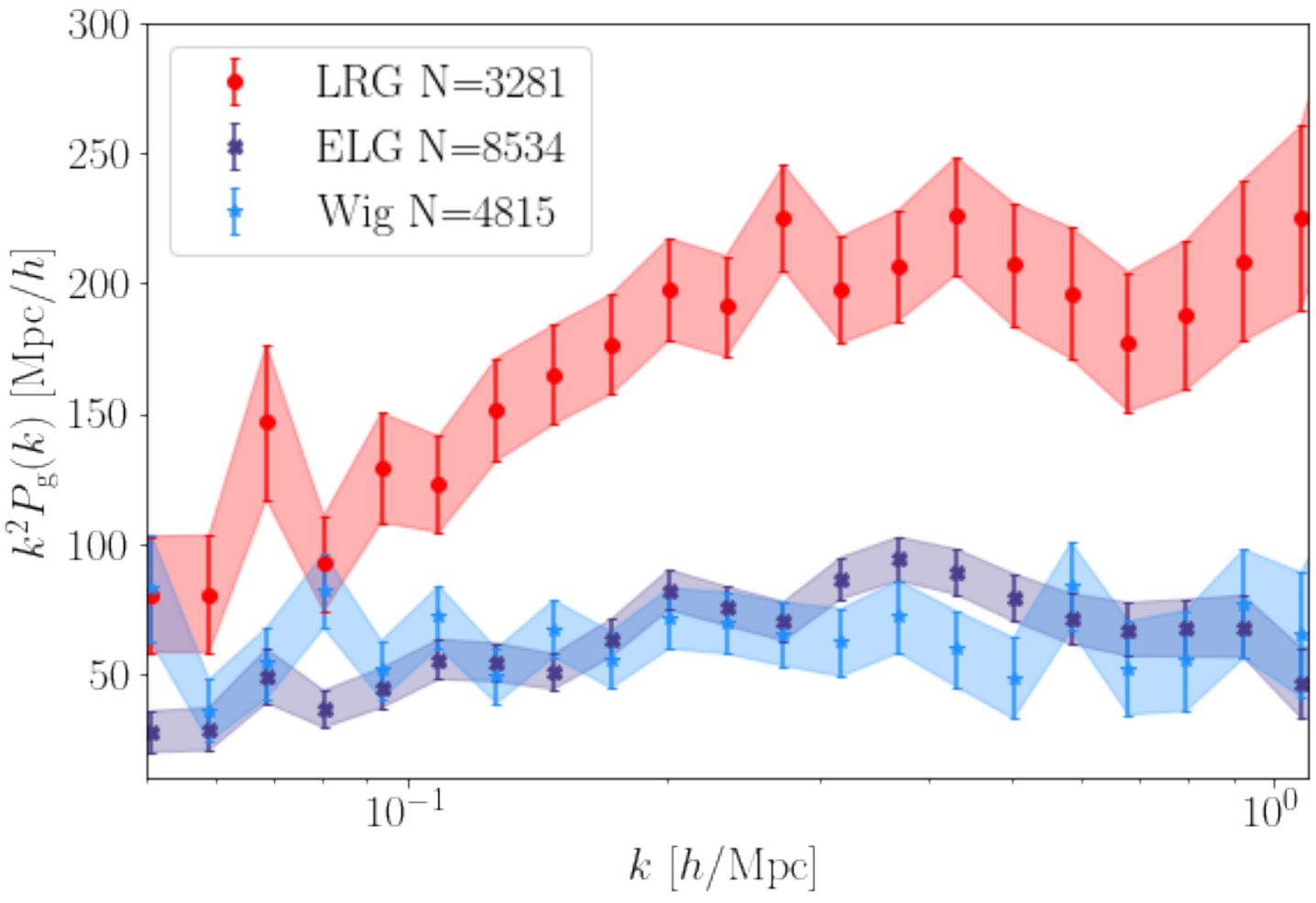
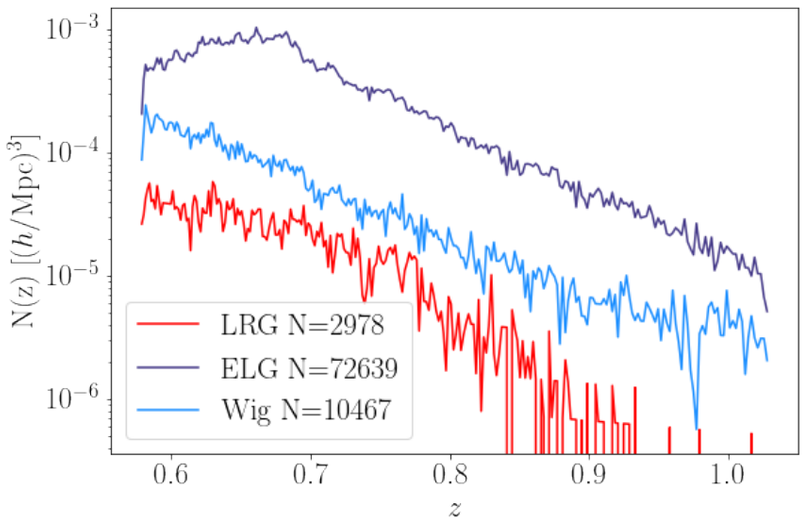
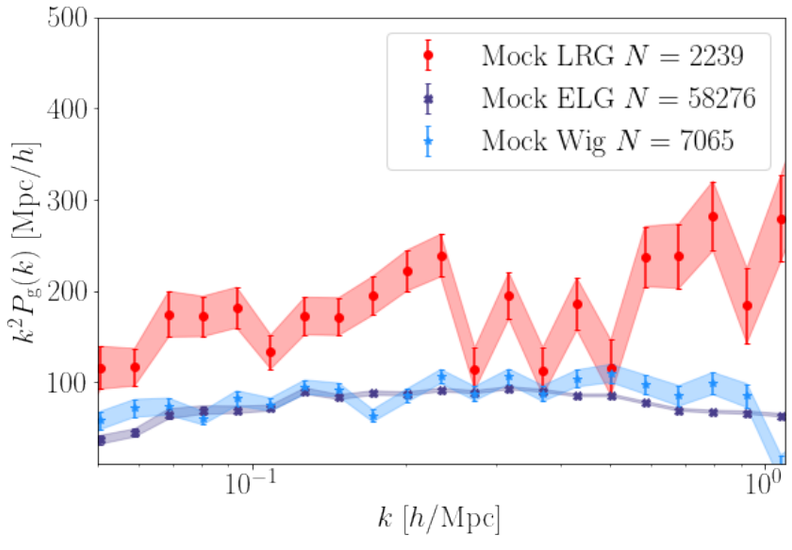
Galaxy power spectrum



SIMULATION





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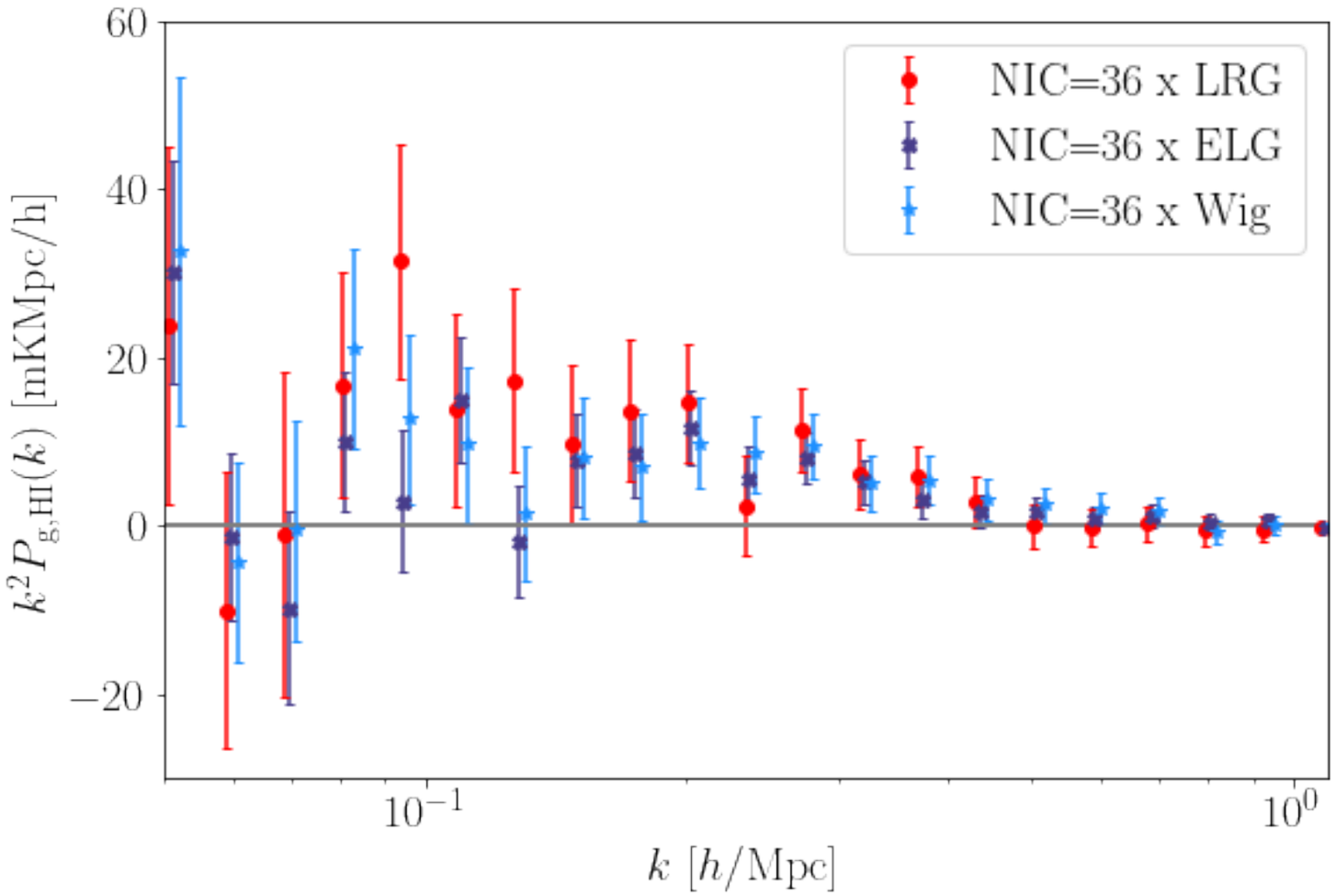
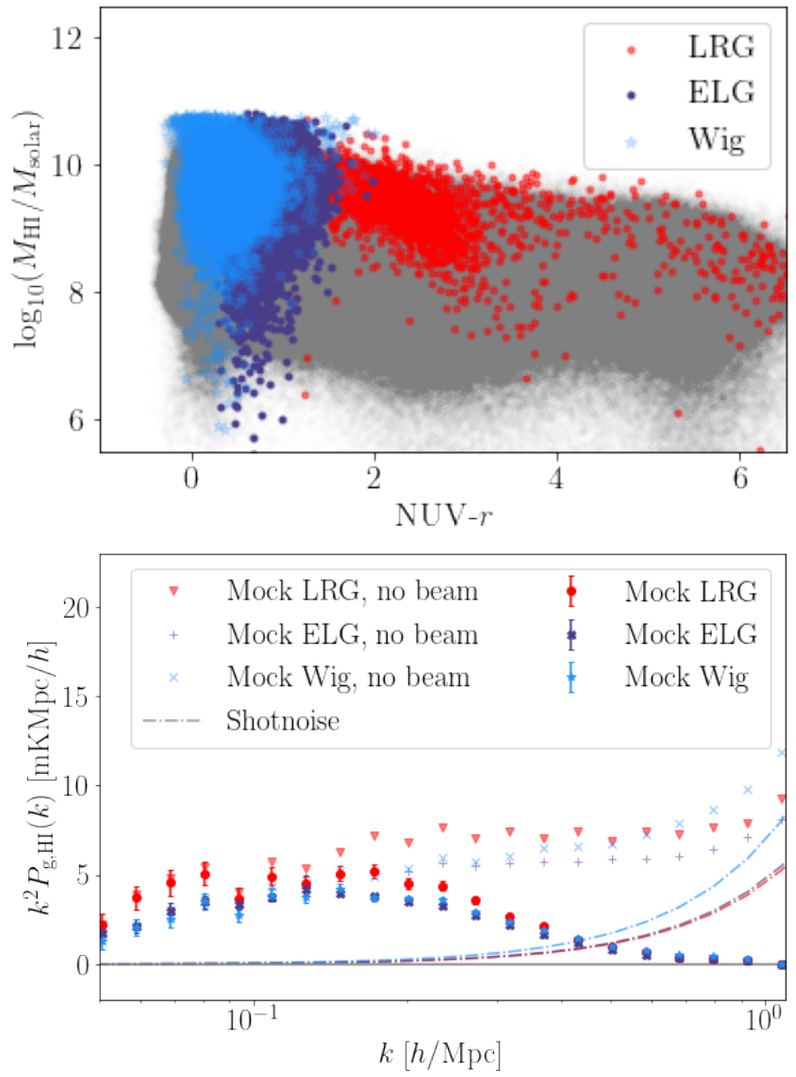
GBT-galaxy cross-power spectrum



SIMULATION



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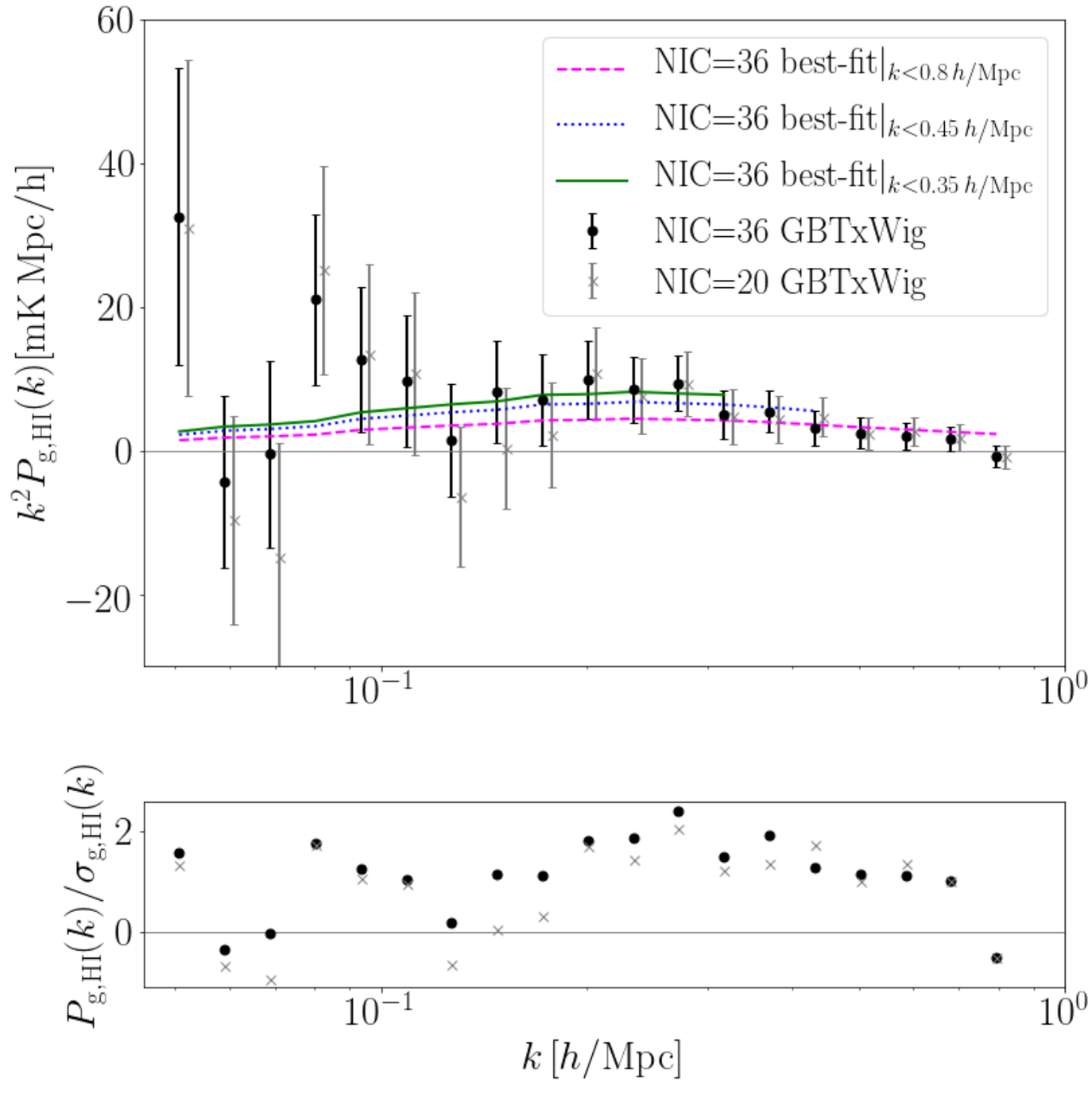
Model choice for constraints

- Empirical model CAMB-HALOFIT incl Kaiser dark matter RSD
- $$P_{\mathrm{HIg}}(k) = T_{\mathrm{HI}} b_{\mathrm{HI}} b_{\mathrm{g}} r P_{\delta\delta}(k)$$
- Assume cosmology and galaxy bias
- Scale-independent constraints on $\Omega_{\mathrm{HI}} b_{\mathrm{HI}} r$
- Constraints on different scales to investigate scale-dependence

Power spectra and detection significance



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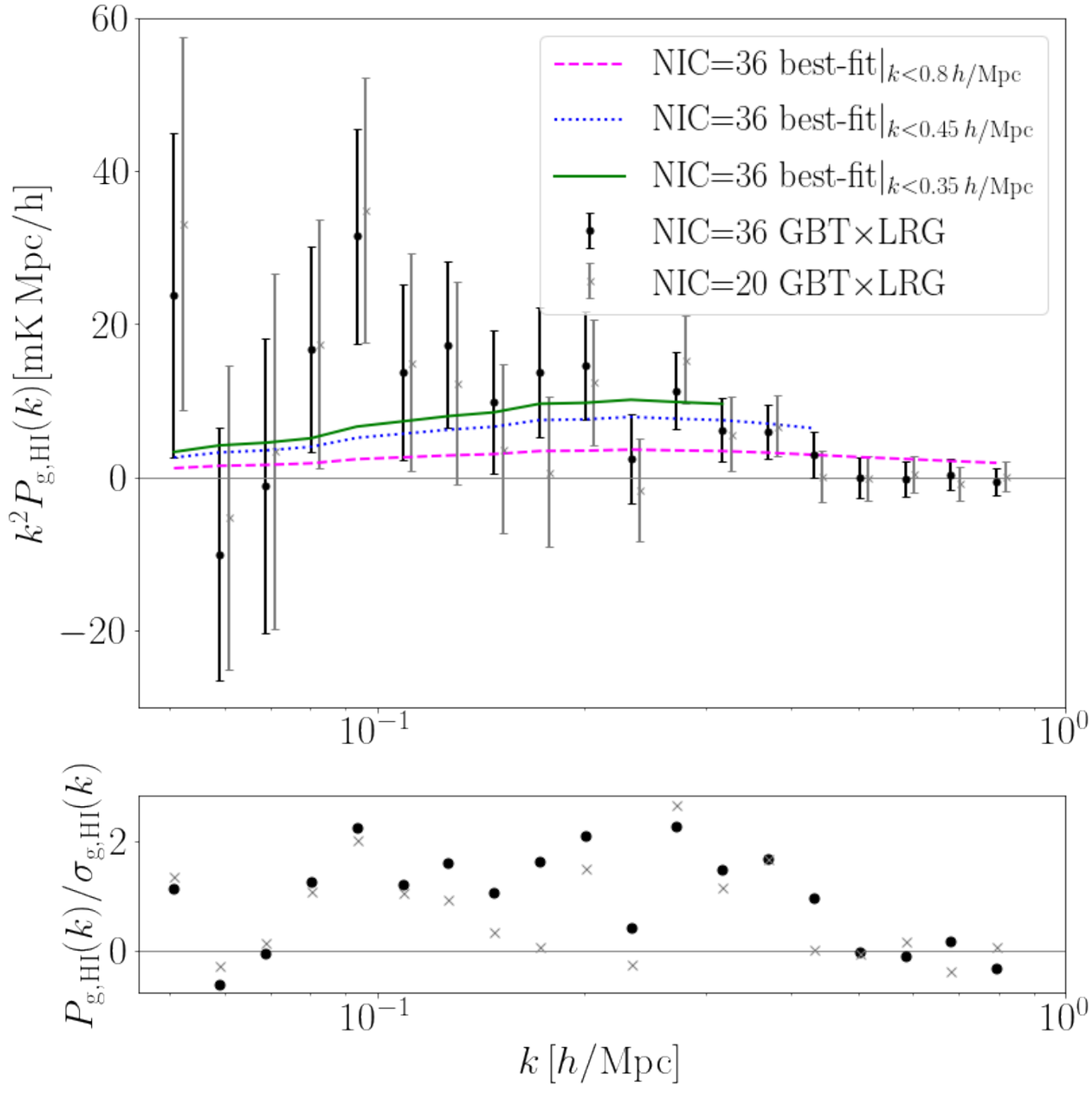
Power spectra and detection significance



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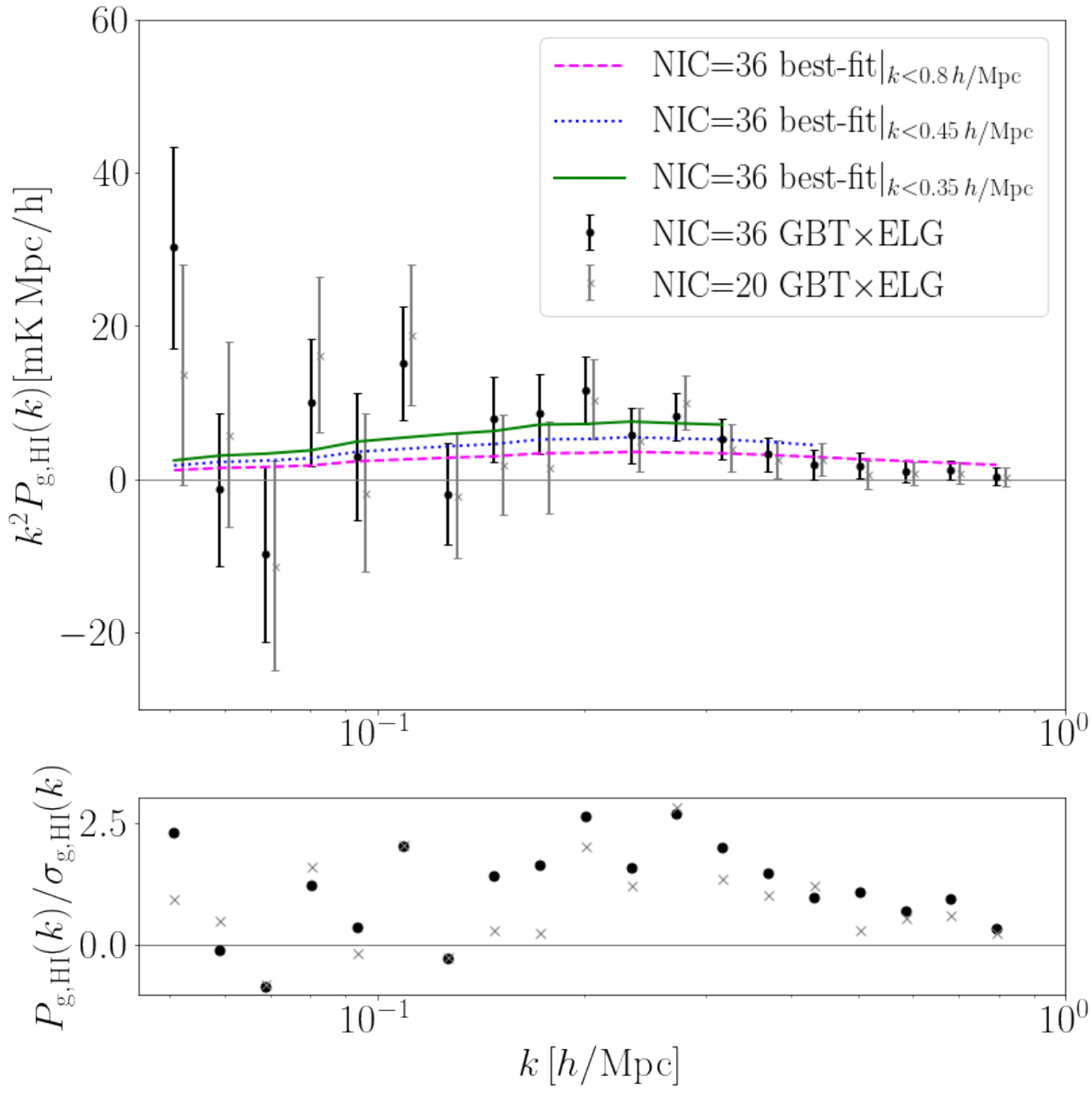
Power spectra and detection significance



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Constrain HI density via $\Omega_{\rm HI} b_{\rm HI} r_{\rm HI-gal}$

	GBTxWiggleZ	GBTxELGs	GBTxLRGs	$k_{\rm eff}\,[h/{\rm Mpc}]$
Case I [$k < 0.8\,h/{\rm Mpc}$]				
NIC=20:	0.35 ± 0.09	0.20 ± 0.06	0.12 ± 0.06	-
NIC=36:	$0.38 \pm 0.08\ (4.4\sigma)$	$0.26 \pm 0.06\ (4.5\sigma)$	$0.16 \pm 0.06\ (2.9\sigma)$	0.48
Case II [$k < 0.45\,h/{\rm Mpc}$]				
NIC=20:	0.53 ± 0.12	0.36 ± 0.09	0.28 ± 0.09	-
NIC=36:	$0.58 \pm 0.09\ (4.8\sigma)$	$0.40 \pm 0.09\ (4.9\sigma)$	$0.35 \pm 0.08\ (4.4\sigma)$	0.31
Case III [$k < 0.35\,h/{\rm Mpc}$]				
NIC=20:	0.58 ± 0.17	0.48 ± 0.12	0.38 ± 0.12	-
NIC=36:	$0.70 \pm 0.12\ (4.4\sigma)$	$0.55 \pm 0.11\ (5\sigma)$	$0.45 \pm 0.10\ (4.2\sigma)$	0.24

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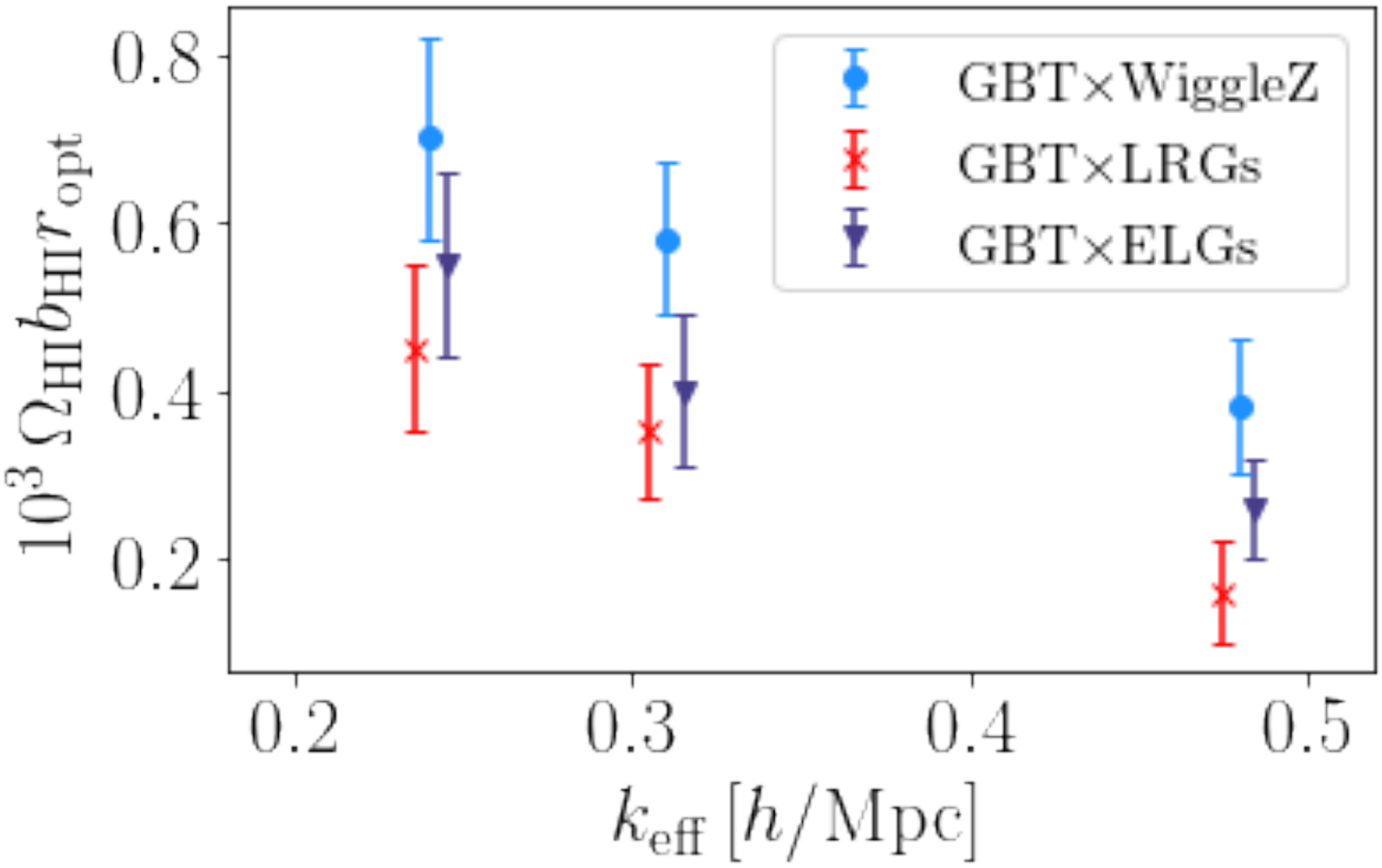
Constrain HI density via $\Omega_{\rm HI} b_{\rm HI} r_{\rm HI-gal}$



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HI energy density constraints

Further Assumptions:

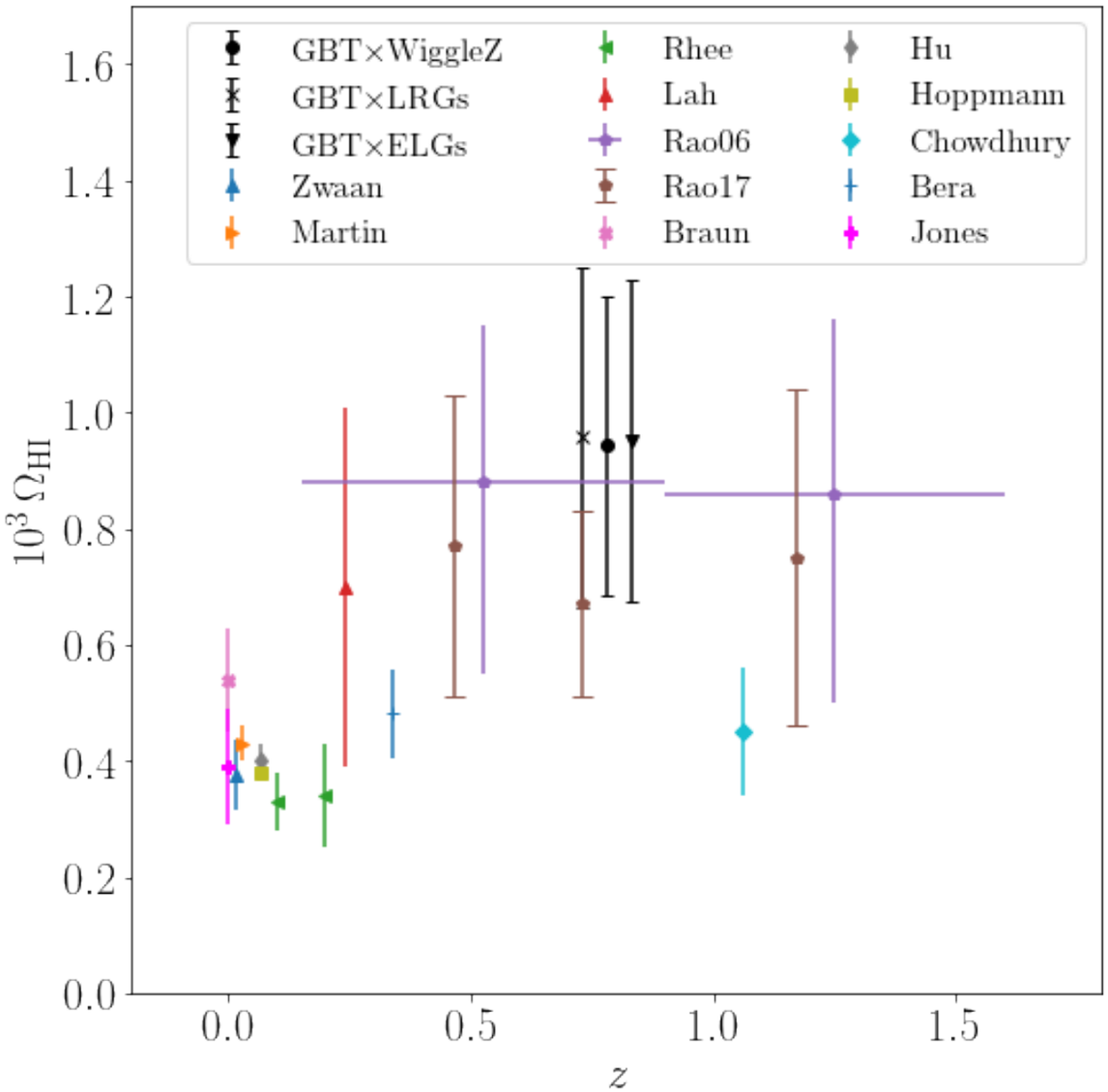
$b_{\rm HI} = 0.825$

Cross-correlation factor for WiggleZ

$r_{\rm HI,Wig} = 0.9$

Use this as benchmark and derive ELG and LRG r from our simulations

$r_{\rm HI,ELG} = 0.7$ and $r_{\rm HI,LRG} = 0.6$



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Summary

- Successful detection of cross-correlation signal with three spectroscopic galaxy surveys
- Consistent HI constraints from all three probes
- Indications for scale-dependent coefficient due to differing HI content of galaxies in samples
- Open challenges: more detailed transfer function study, impact of beam-re-convolution, impact of different RFI removal

LAURA.WOLZ@MANCHESTER.AC.UK