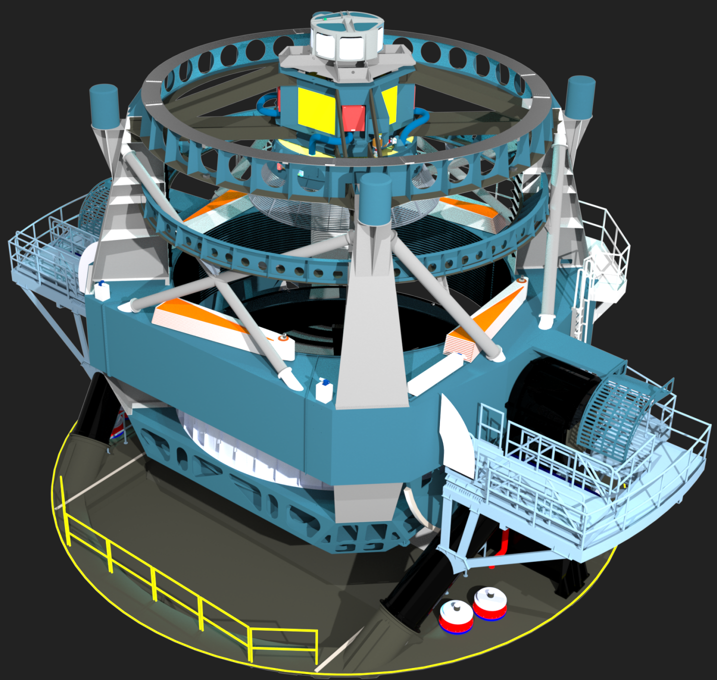
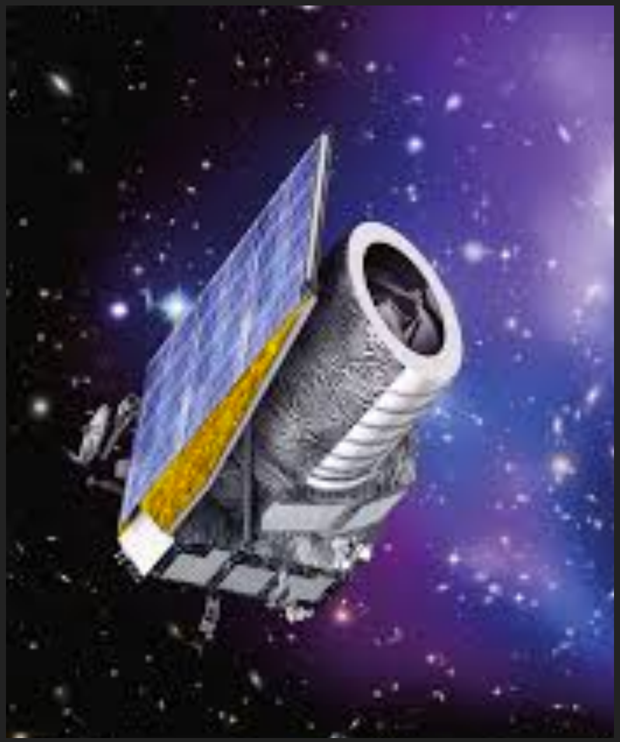
CoSyne: Cosmological Synergies in the upcoming decade
11/12/19

Using Radio 21cm Intensity Maps to Calibrate Photometric Redshifts

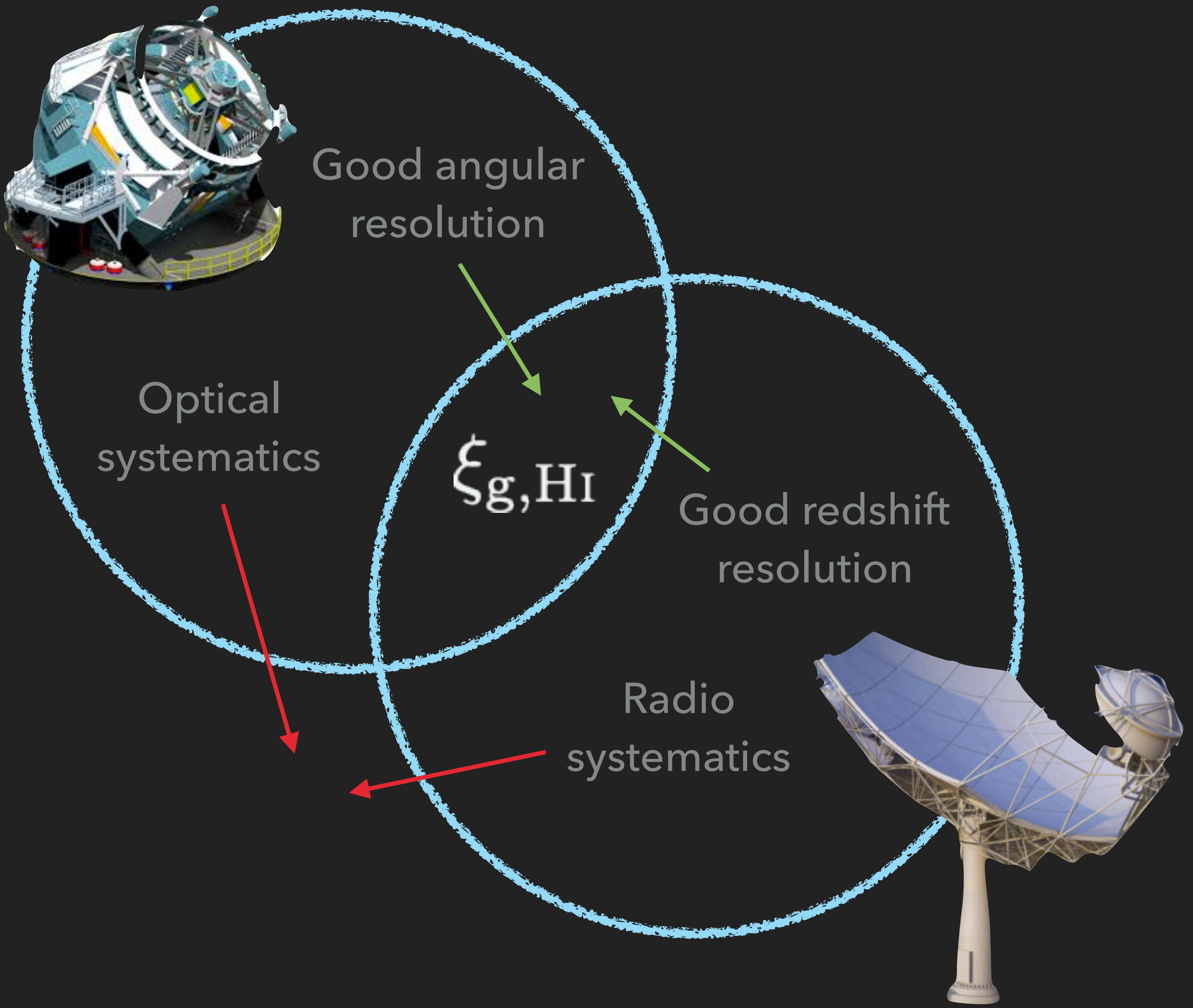
Steve Cunnington
(with Ian Harrison, Laura Wolz, Alkistis Pourtsidou, David Bacon)

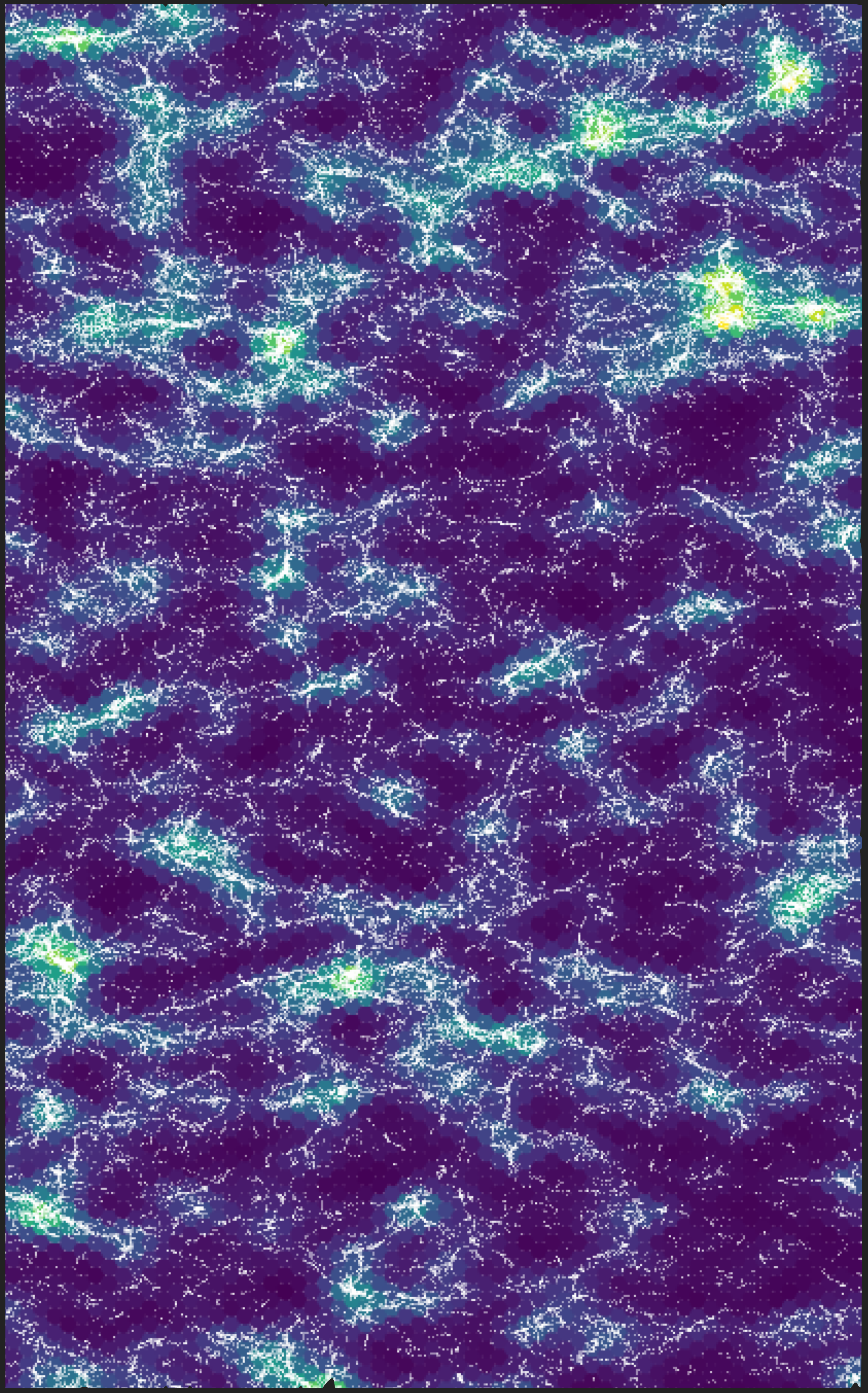




s.cunnington@qmul.ac.uk

OPTICAL AND RADIO SYNERGIES

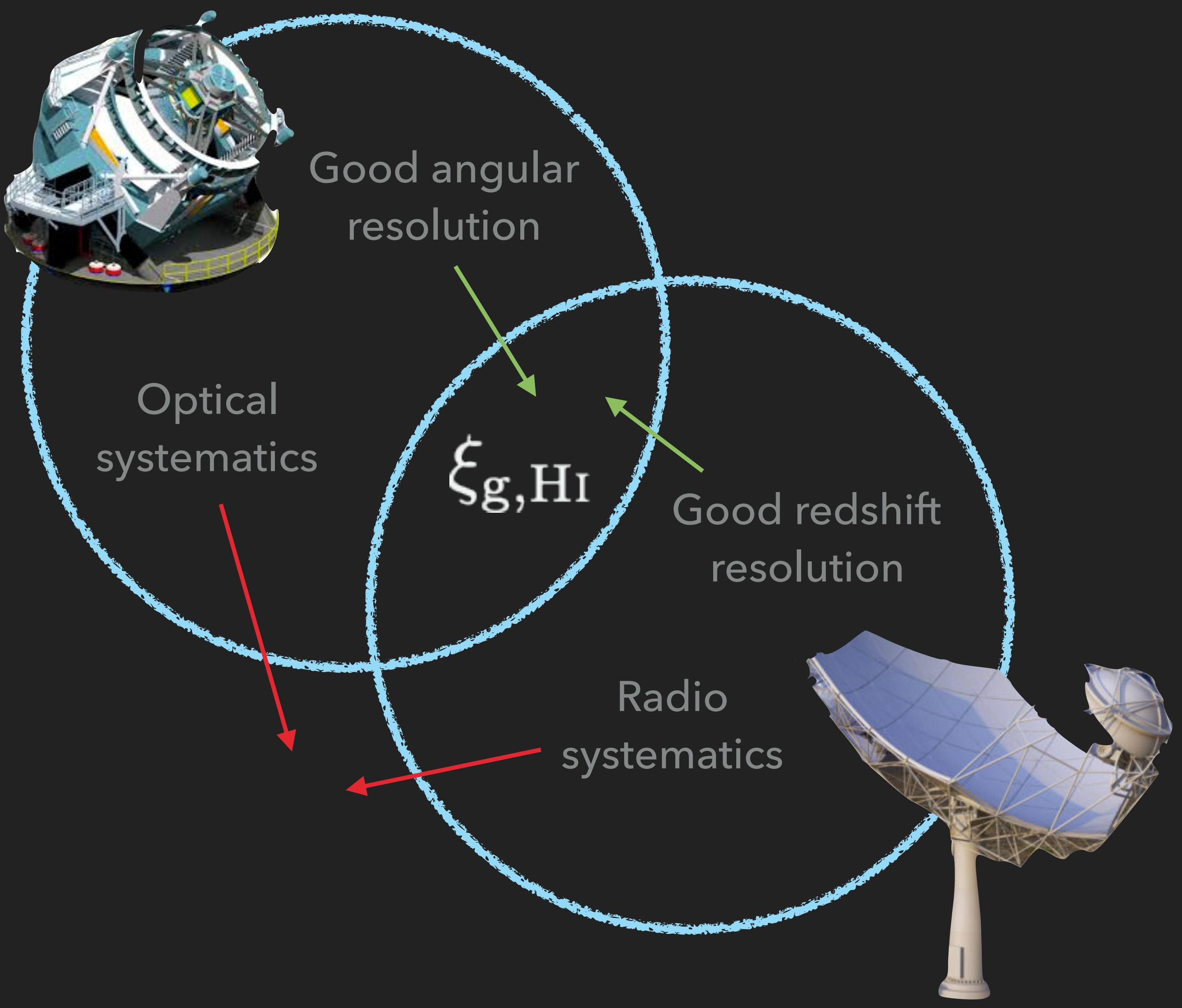




Credit: Julian Bautista

s.cunnington@qmul.ac.uk

OPTICAL AND RADIO SYNERGIES



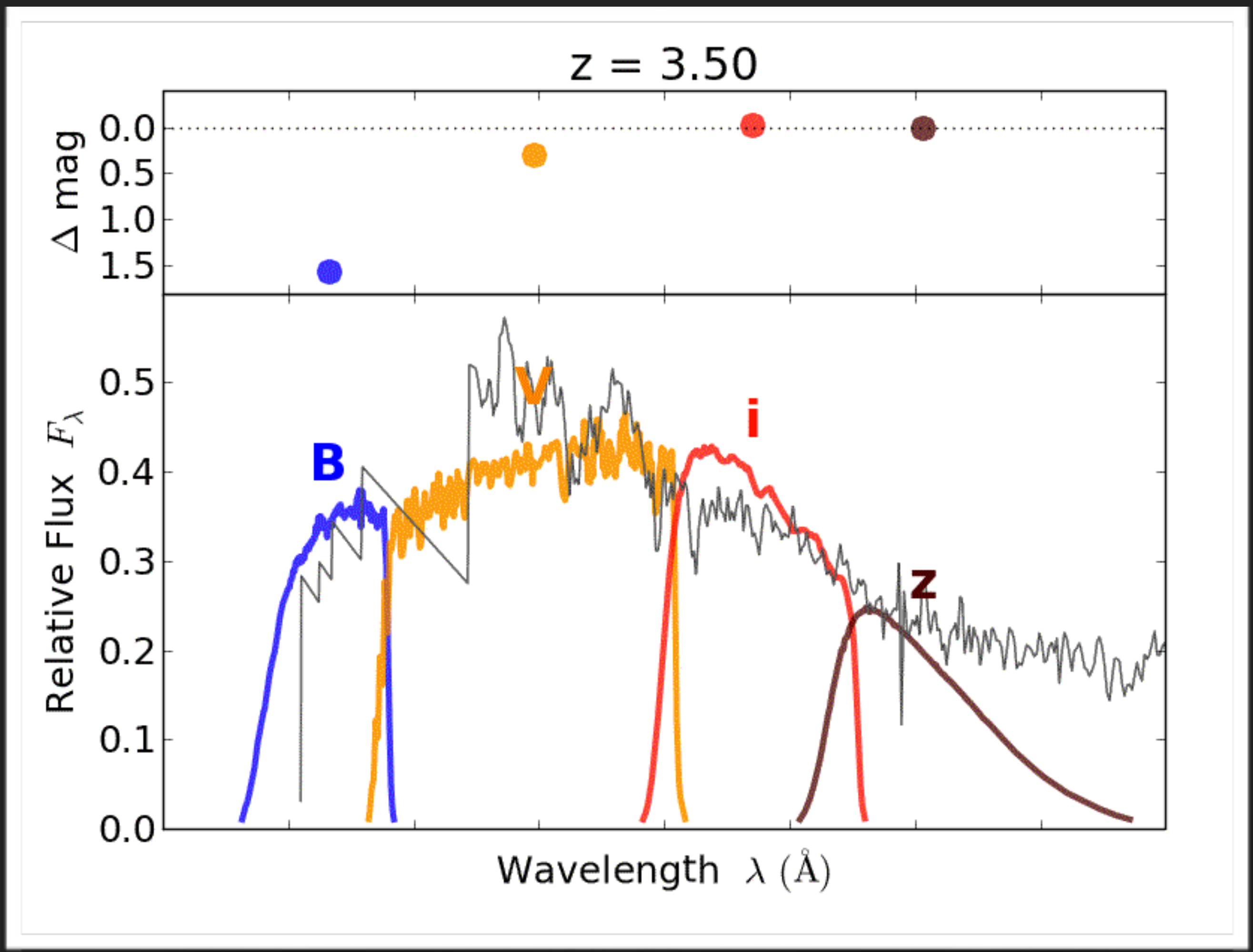
- Currently all HI intensity mapping detections have relied on cross-correlation with an overlapping optical survey e.g.:
- GBT x WiggleZ

- Parkes x 2dF

s.cunnington@qmul.ac.uk

RADIO INTENSITY MAPPING CAN BENEFIT OPTICAL SURVEYS TOO

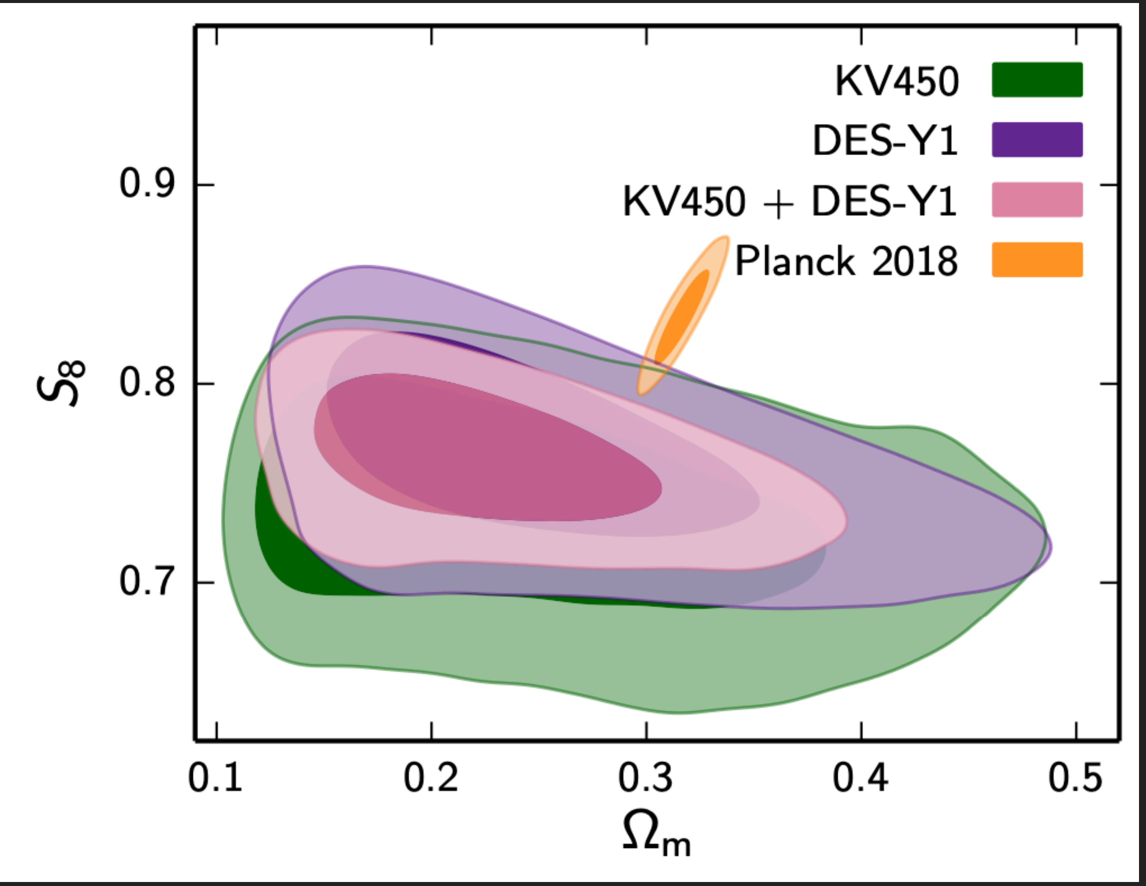
… by calibrating photometric redshifts (photo-z)



- Optical photometry surveys have large uncertainty in the redshifts they measure

- Photometric redshifts use magnitudes within broad colour filters to estimate spectral features and infer a redshift

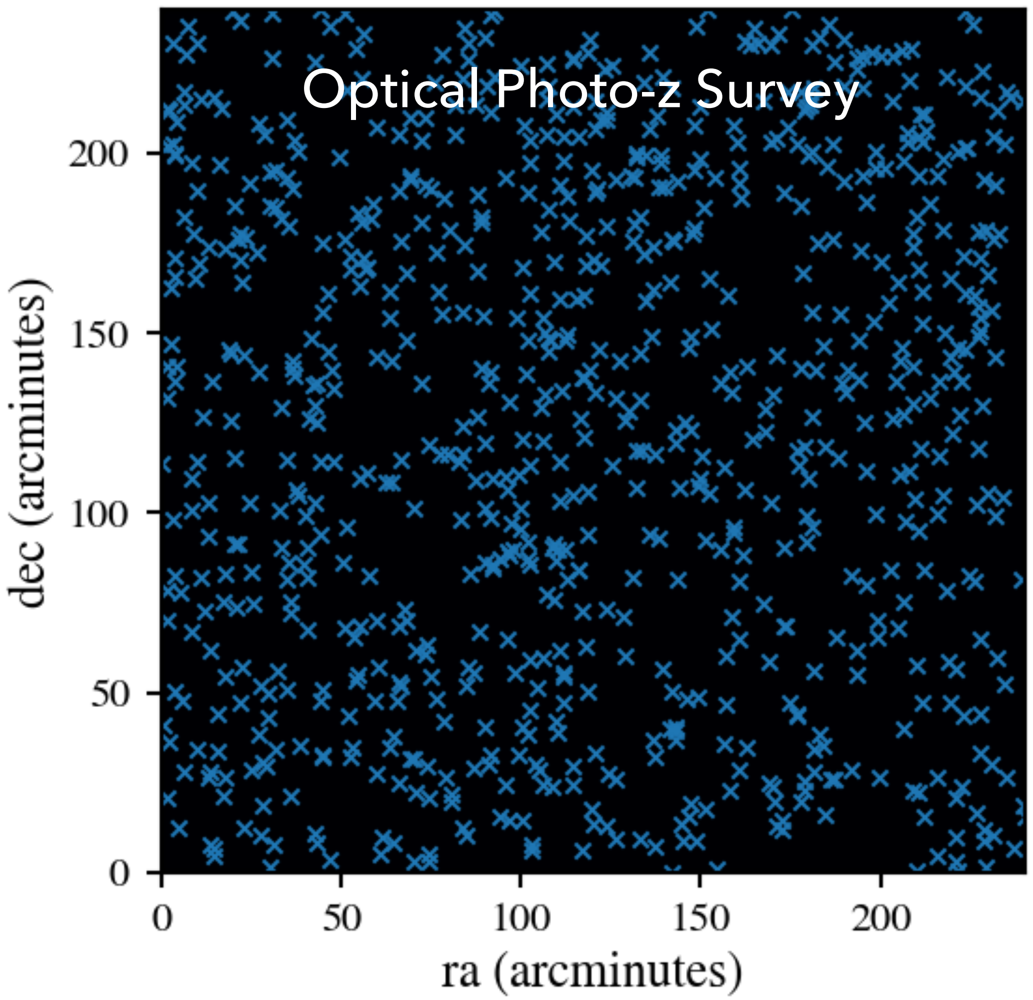
- Photo-z errors are often cited as a potential leading contributor to the Sigma_8 tension

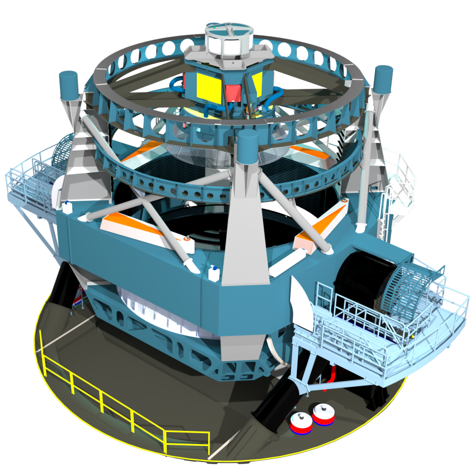


Credit: Jouaki et al. 22019 (1906.09262)

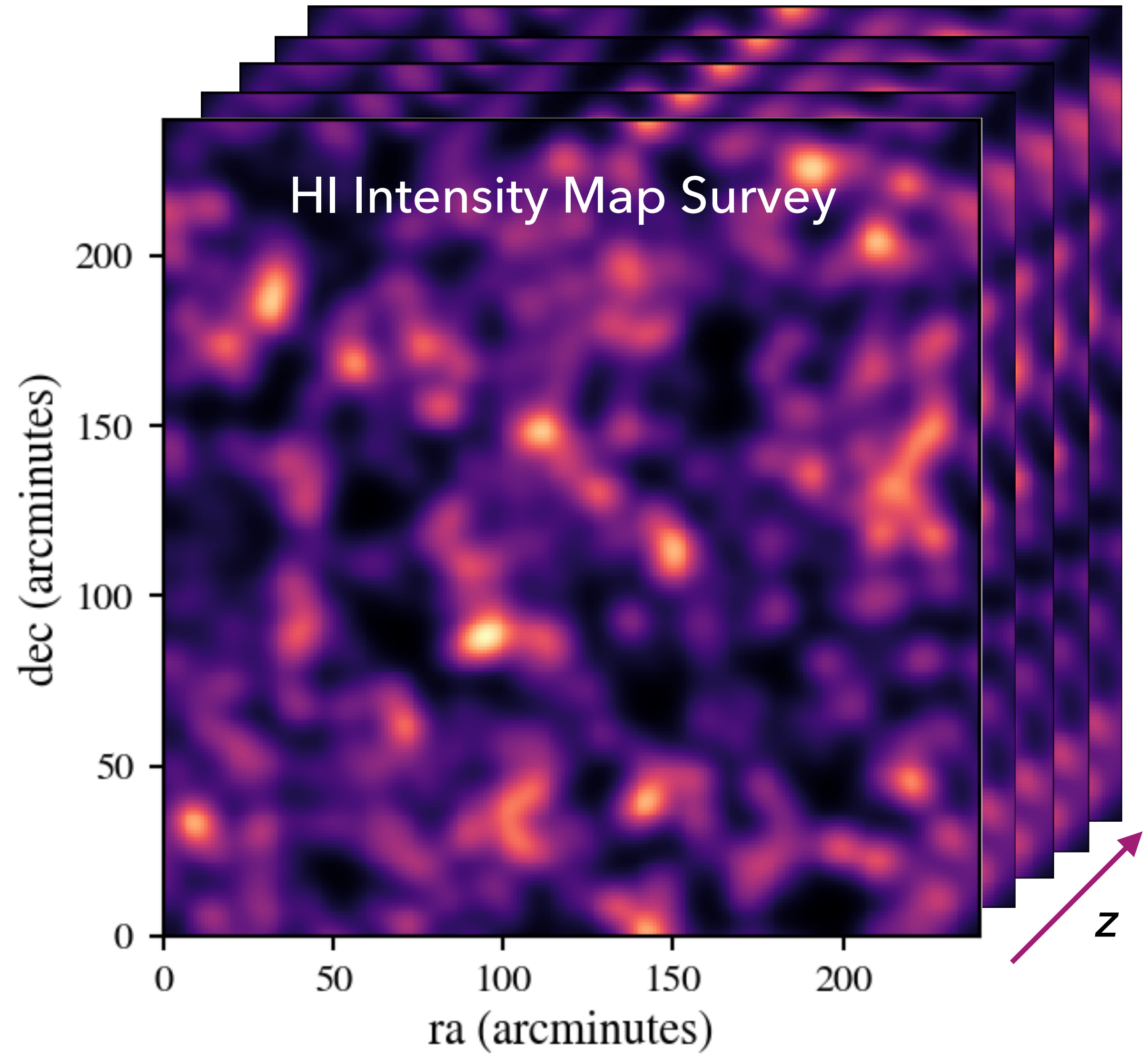
s.cunnington@qmul.ac.uk

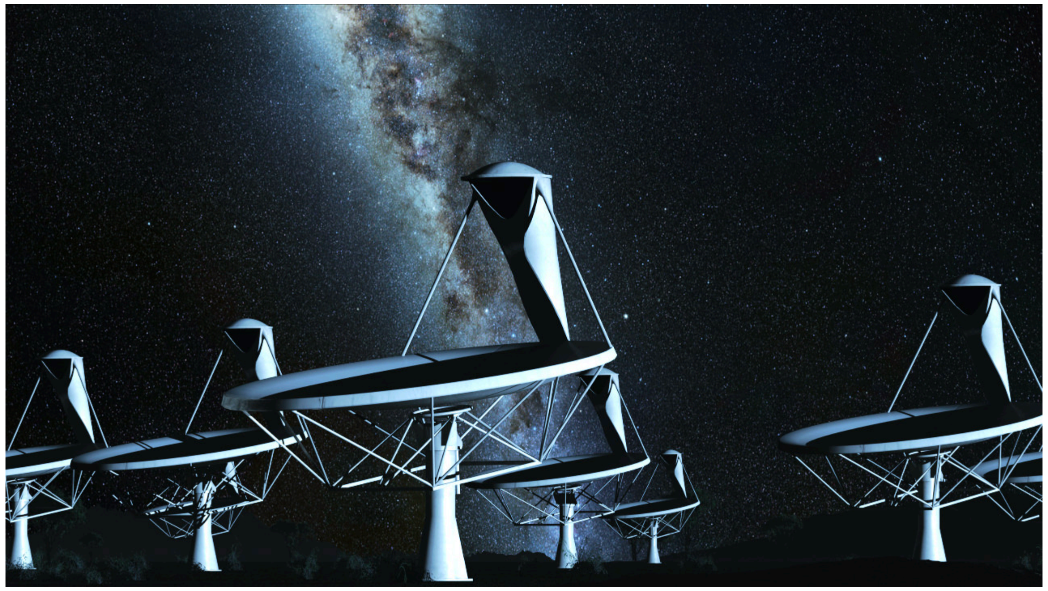
CLUSTERING-BASED REDSHIFT ESTIMATION





Unconstrained Redshifts





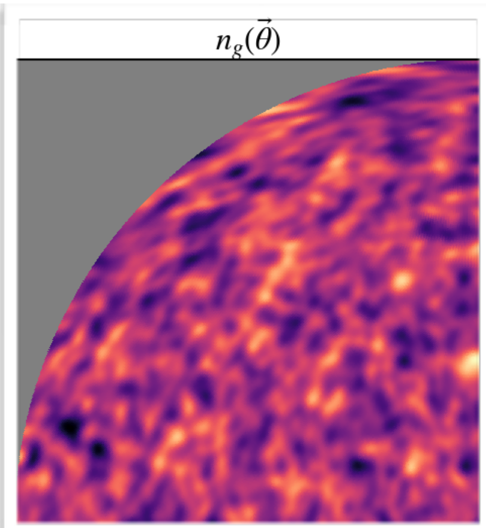
Excellent Redshift [use as reference sample]

s.cunnington@qmul.ac.uk

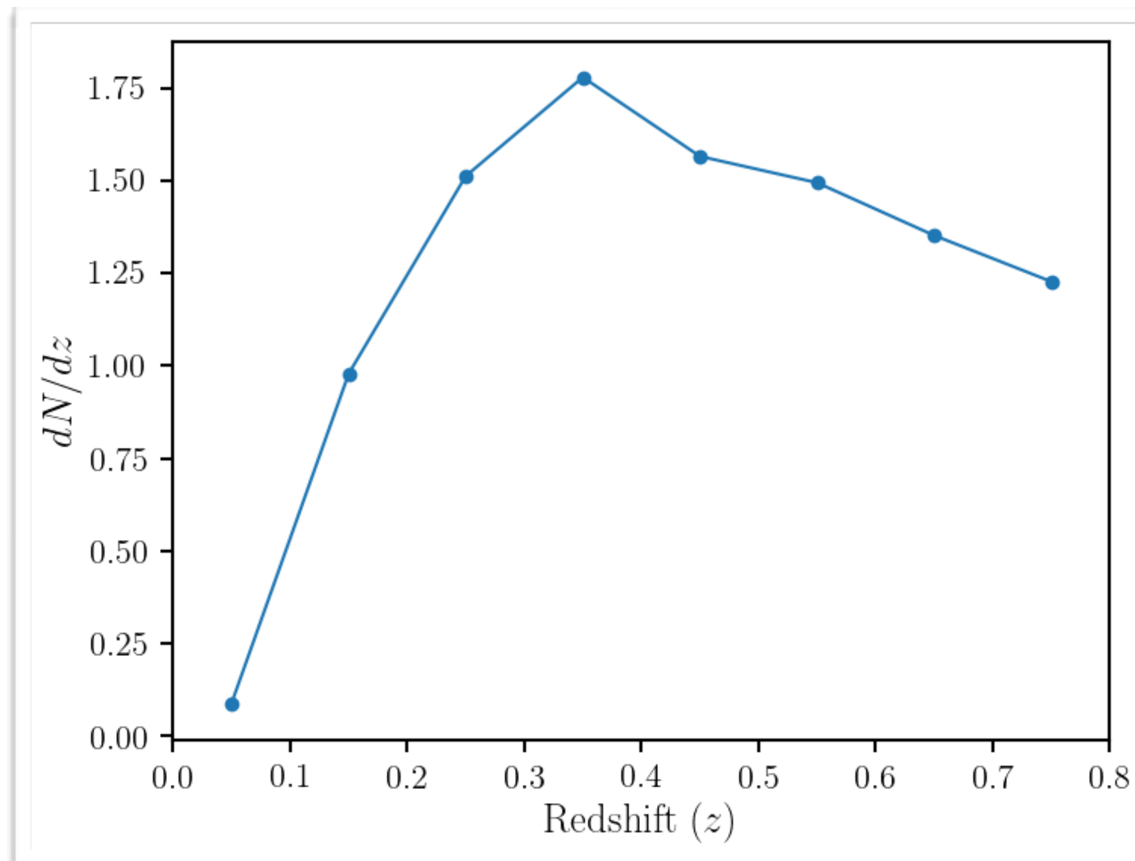
CLUSTERING-BASED REDSHIFT ESTIMATION

Use angular clustering between two surveys to constrain the redshift distribution for the photo-z sample

Bin all optical galaxies and look at angular cross-correlation with each slice of HI intensity map

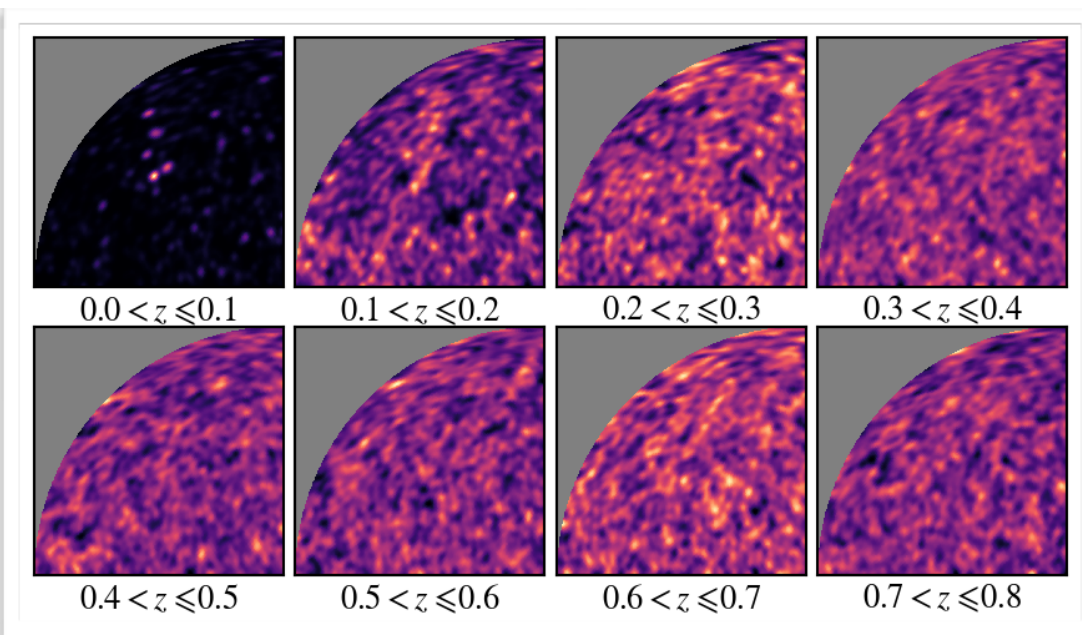


$$\frac{dN_{\mathrm{g}}}{dz}(z) = \frac{w_{\mathrm{g,HI}}(z)}{w_{\mathrm{HI,HI}}(z)}\bar{T}_{\mathrm{HI}}(z)\frac{b_{\mathrm{HI}}(z)}{b_{\mathrm{g}}(z)}\frac{1}{\Delta z}$$



MOCK EXAMPLE

Reference 21cm Sample



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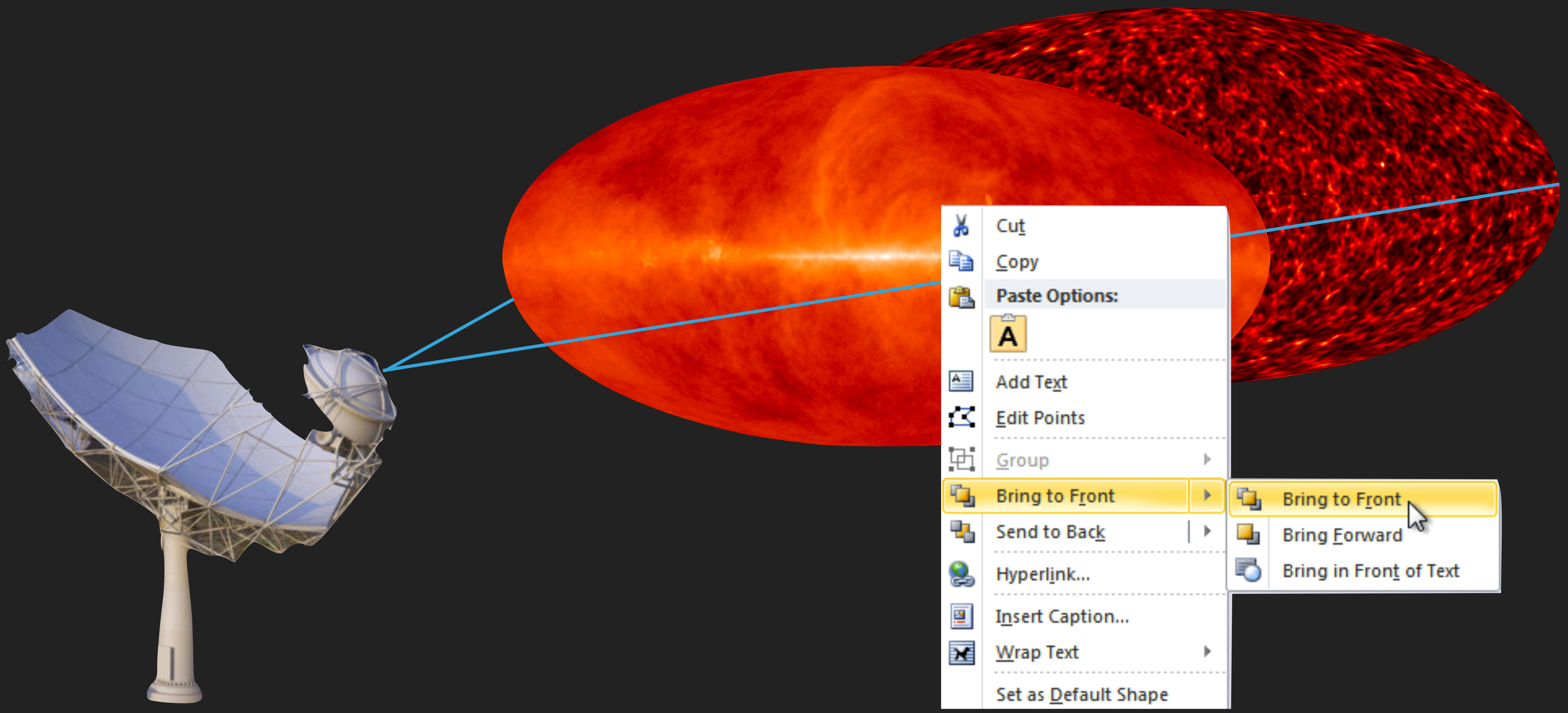
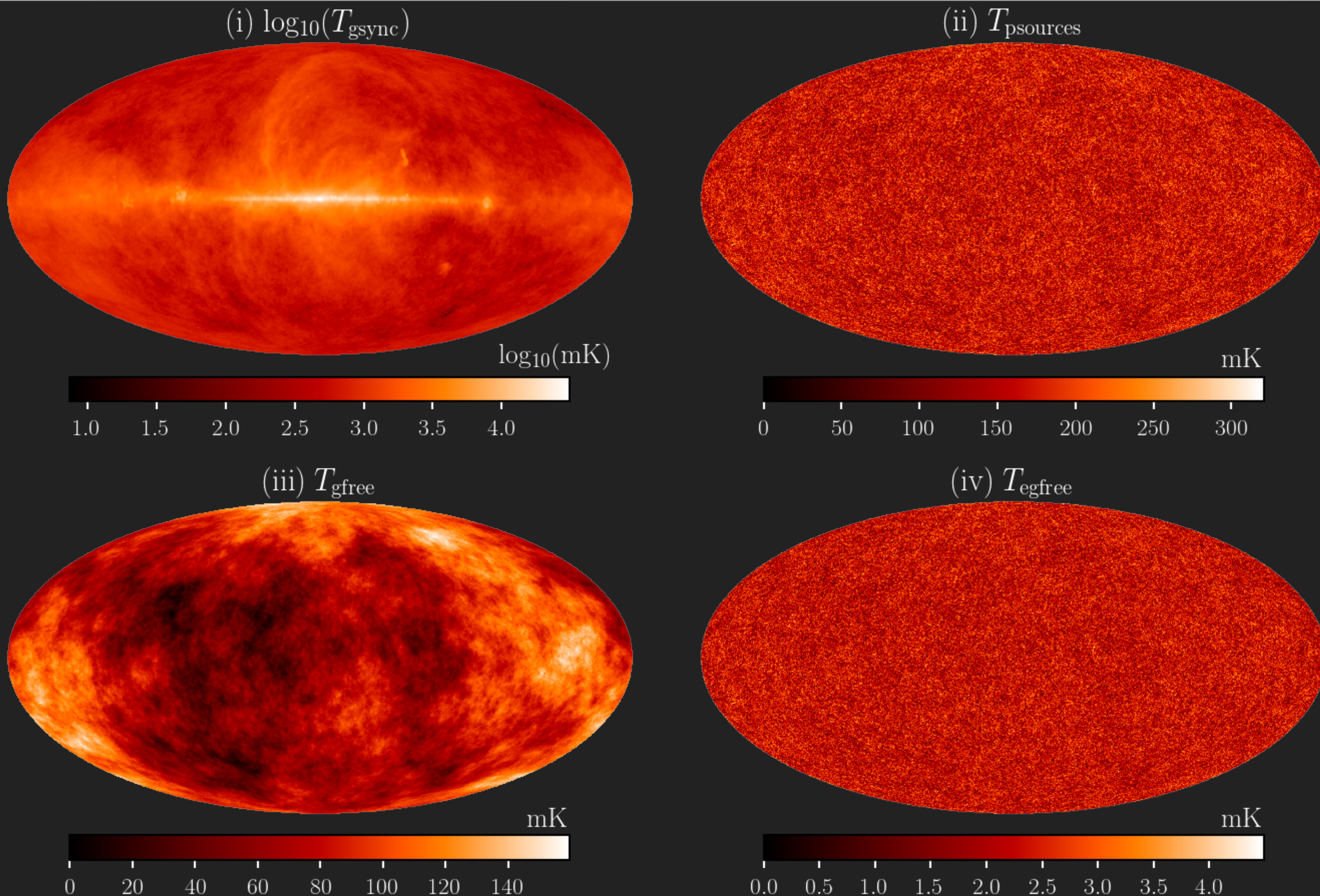
CHALLENGES FOR USING 21CM INTENSITY MAPS TO CALIBRATE PHOTO-Z

FOREGROUNDS!



s.cunnington@qmul.ac.uk

21CM FOREGROUNDS



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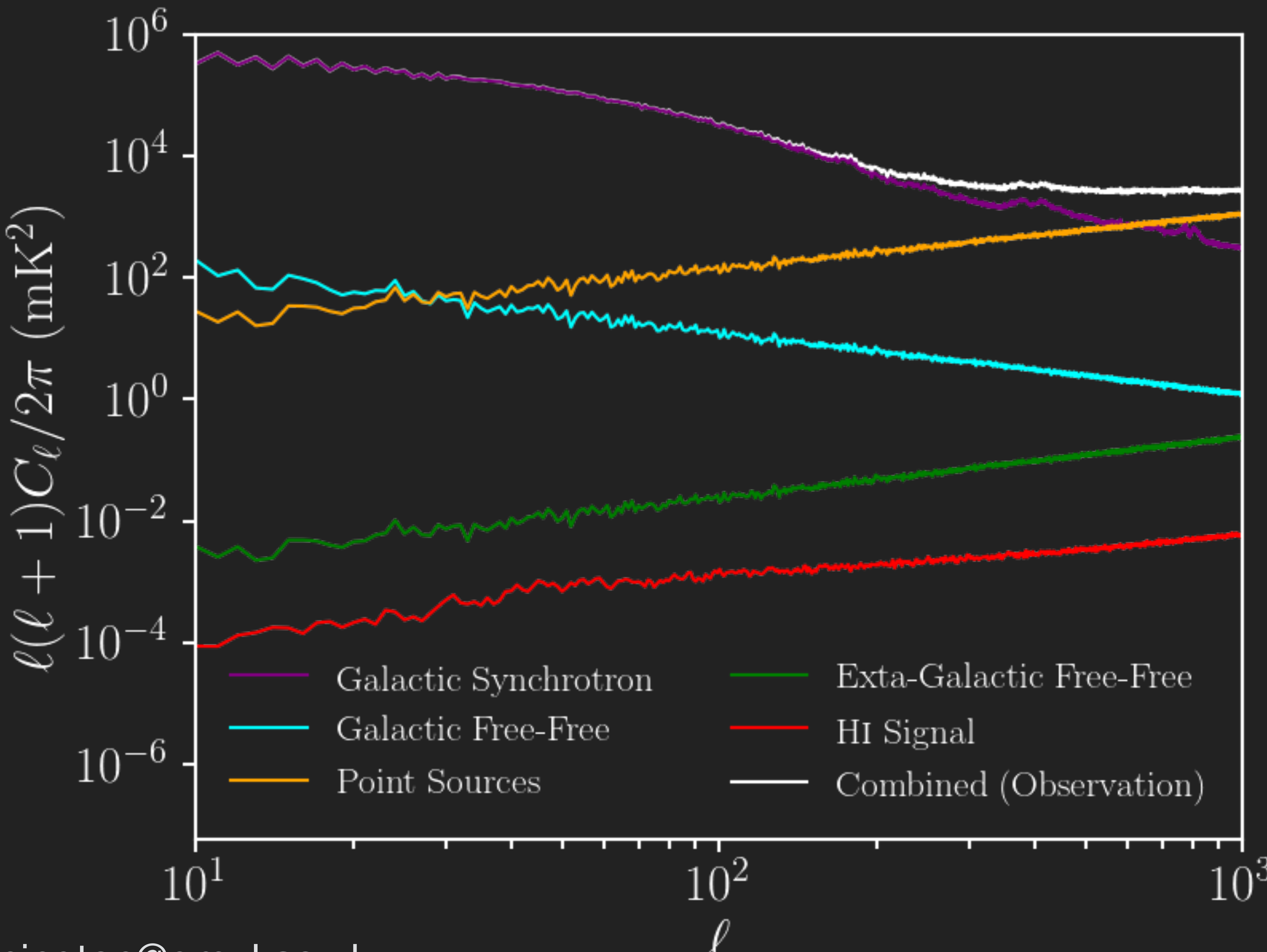
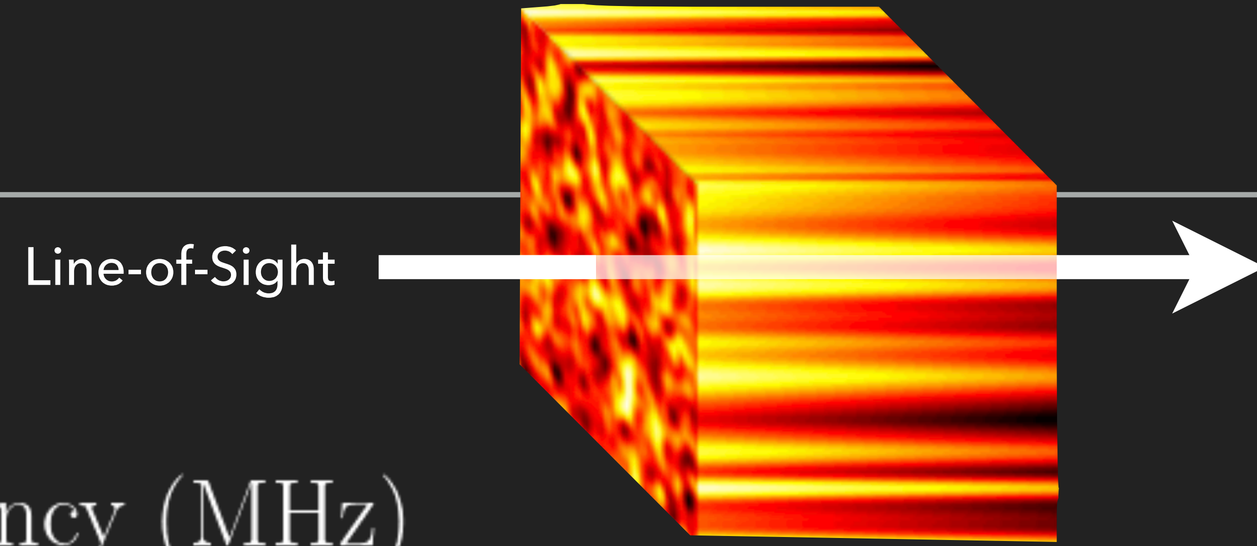
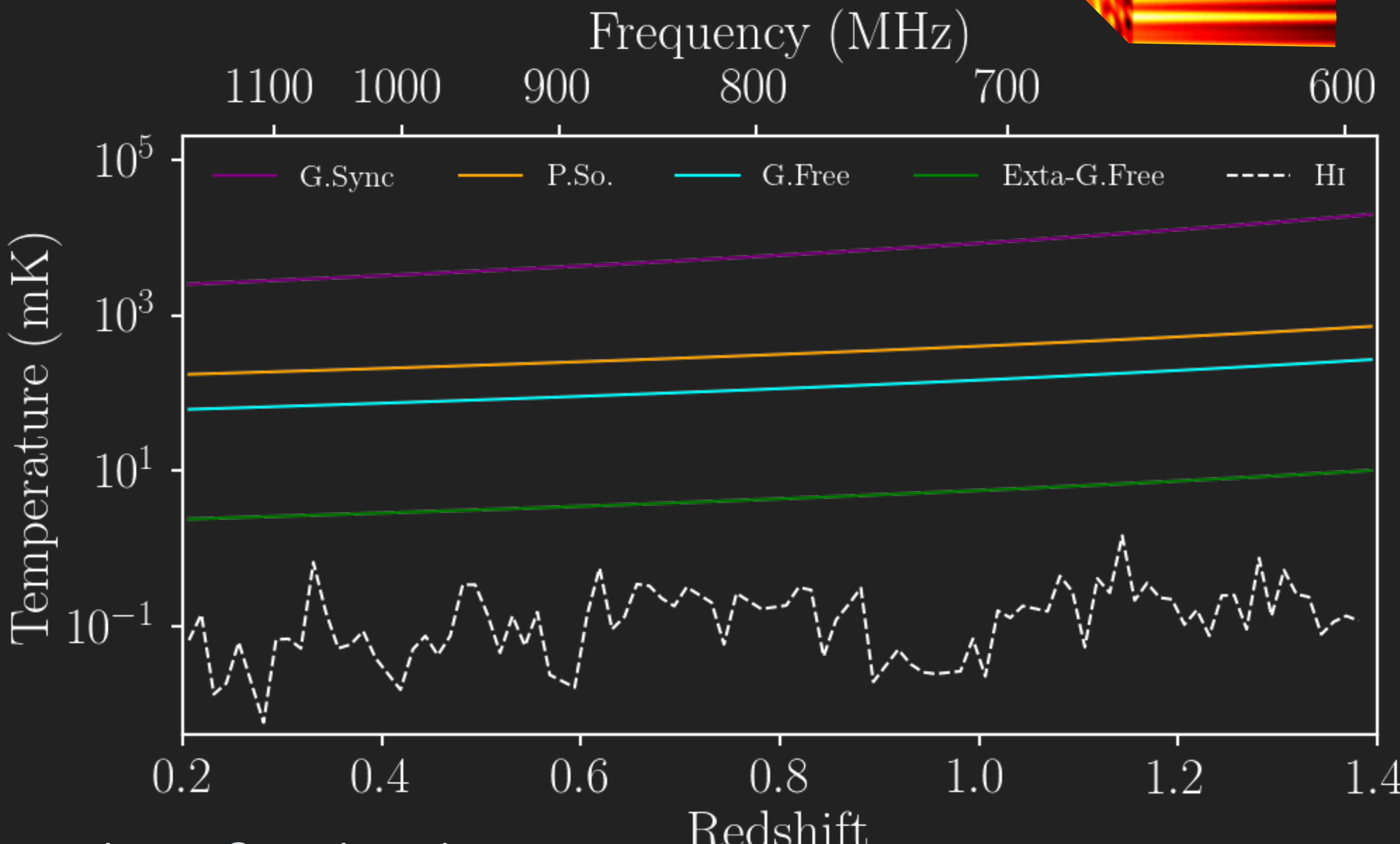


s.cunnington@qmul.ac.uk

21CM FOREGROUNDS





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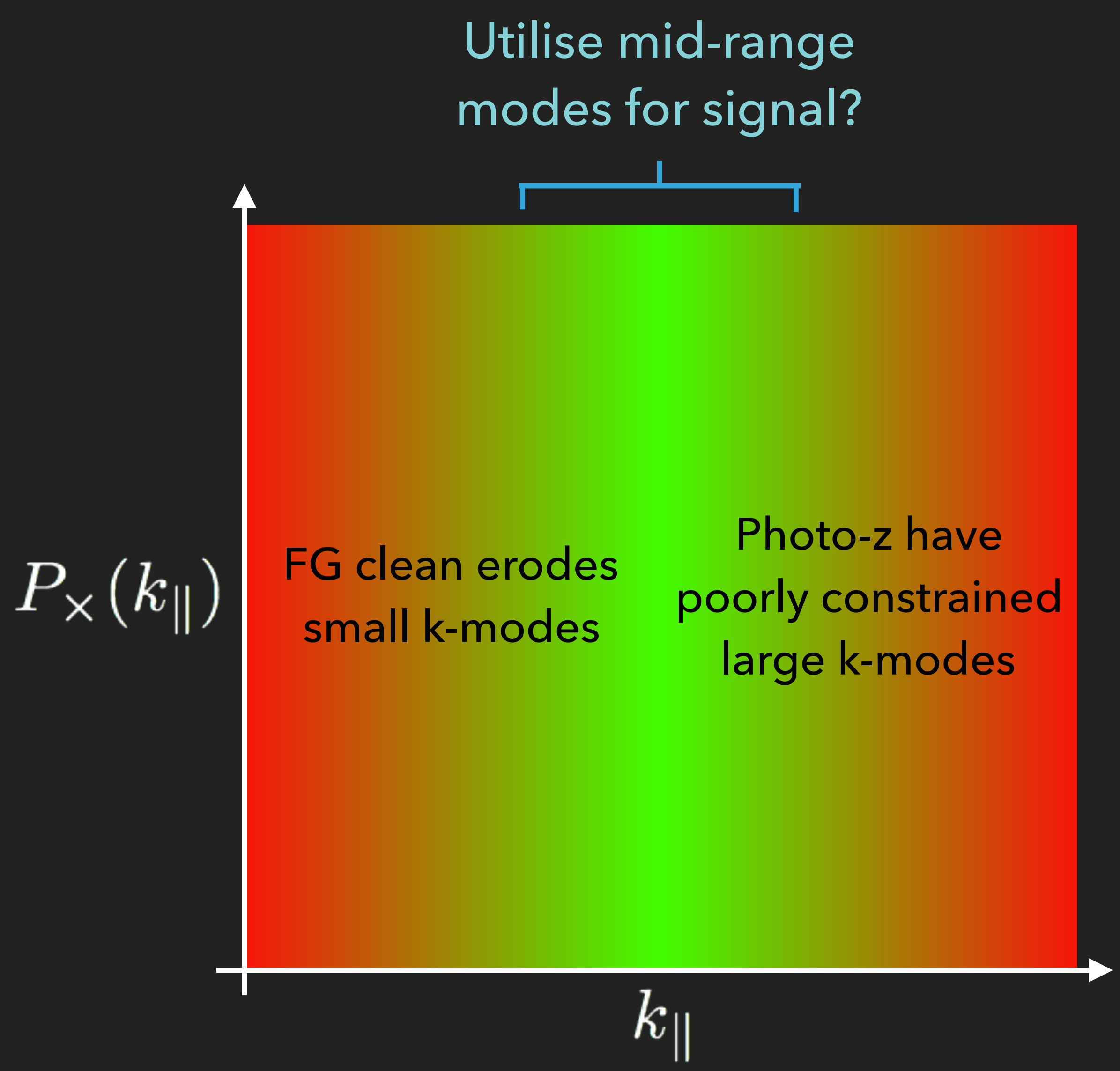
Can clean foregrounds by removing modes which are smooth along line-of-sight

- Foreground removal erodes **large radial modes (low k_para scales)**
- Need to cross-correlate these cleaned maps with optical photo-z surveys which will have poor constraints on **small radial modes (high k_para scales)**

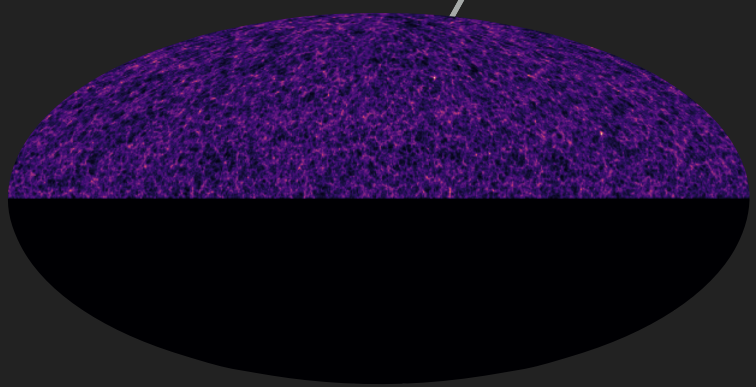


DOES ENOUGH INFORMATION REMAIN FOR CLUSTERING-Z ?

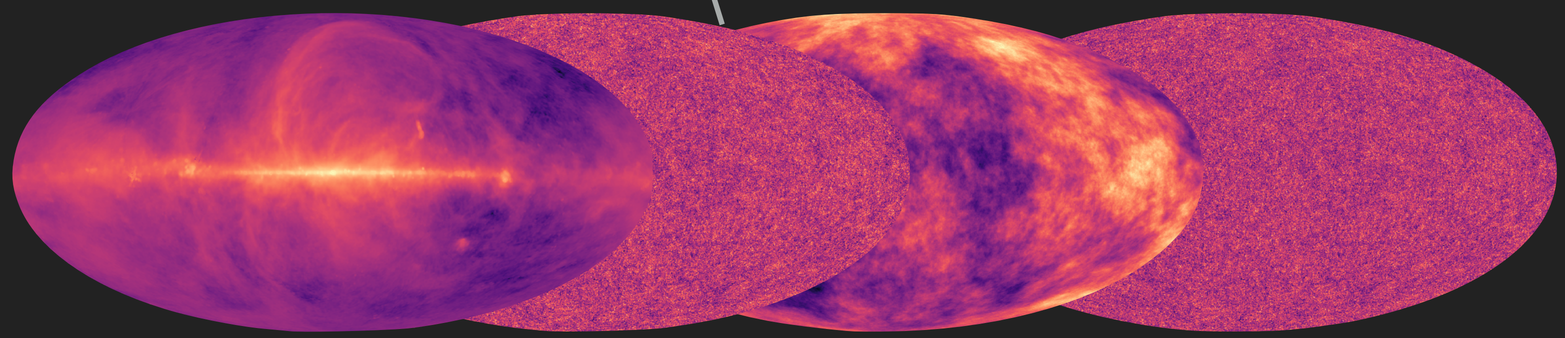
s.cunnington@qmul.ac.uk

SIMULATION PIPELINE

$$\delta T_{\rm obs}(z) = \delta T_{\rm HI}(z) + \delta T_{\rm noise}(z) + \sum_i \delta T_i^{\rm FG}(z)$$



Example HI intensity map
GAEA semi-analytic model
(Zoldan et al. 2017)



- Foreground clean the simulated observed maps

$$\delta T_{\rm clean}(z) \;\; \mathbf{x} \;\; \delta_{\rm g}(z_{\rm photo})$$

- From same galaxy catalogue, can also extract an optical sample with some simulated photo-z error

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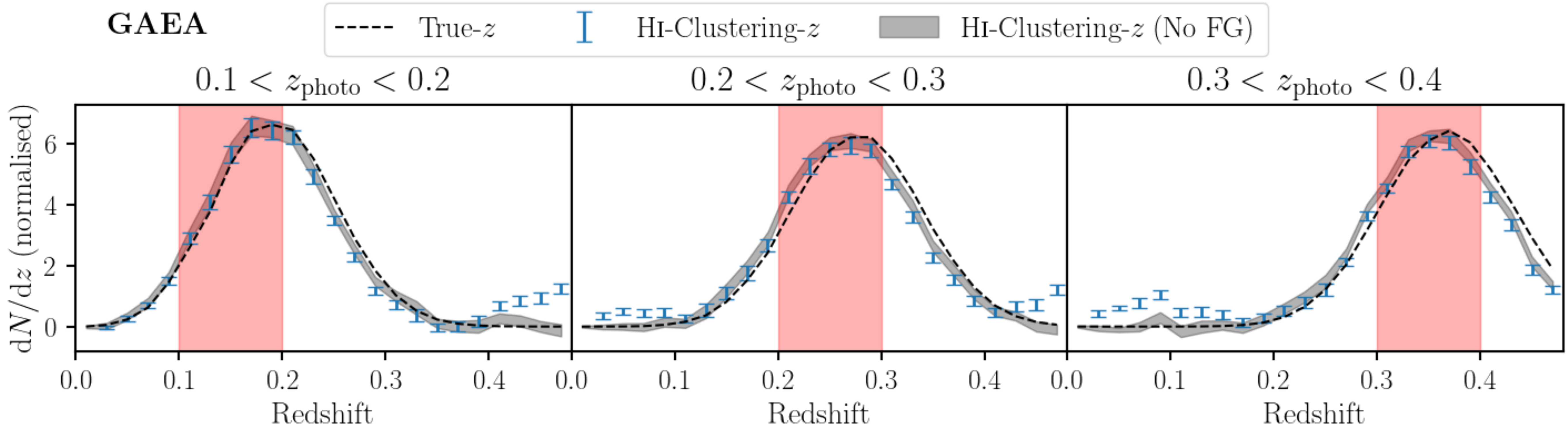
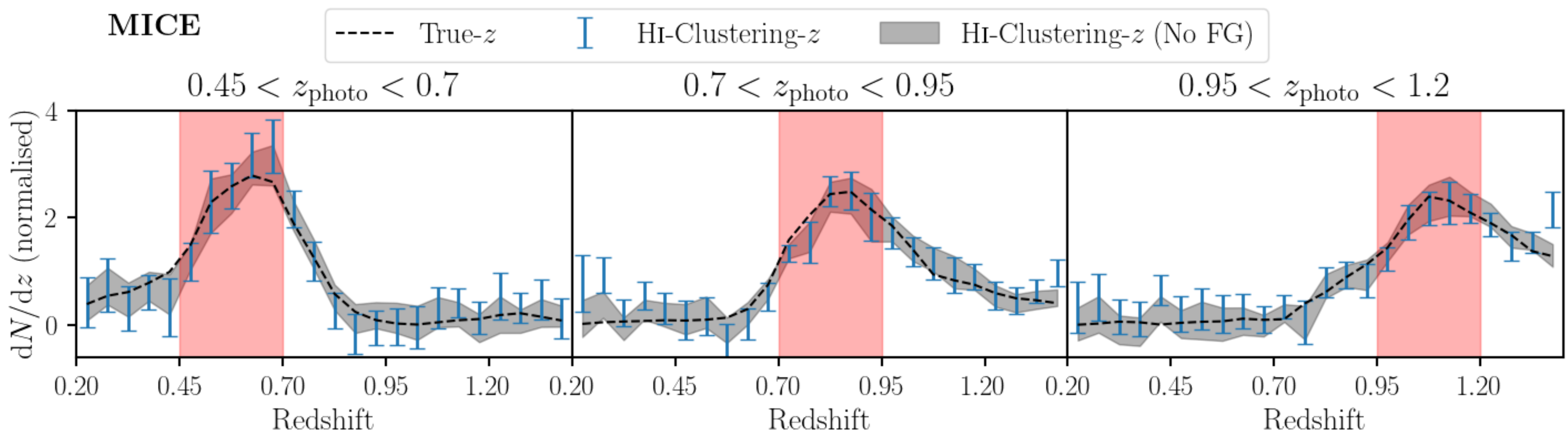
CLUSTERING-BASED REDSHIFT ESTIMATION WITH HI INTENSITY MAPS



Using GAEA (Zoldan et al. 2017)



Using MICECATv2.0 (Crocce et al. 2013)

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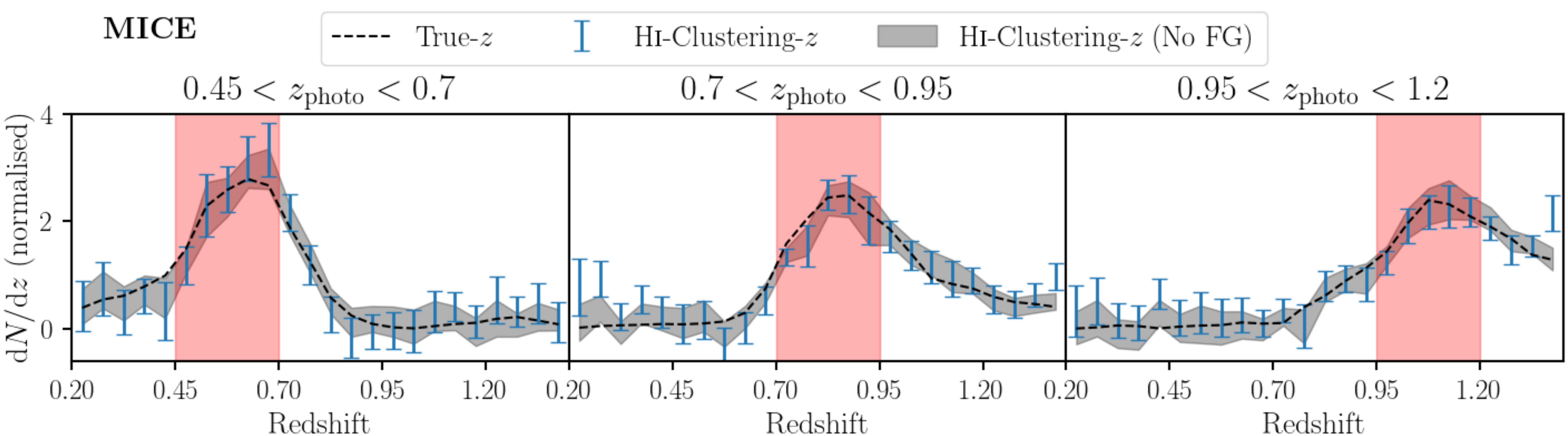
SUMMARY

- Success has already been achieved in cross-correlating HI intensity maps with optical galaxy surveys to show potential for future synergies - **provided first intensity mapping detections**
- In future, HI intensity mapping surveys will be able to **limit systematics** in optical surveys
- One example of this is using intensity maps as a reference sample and utilising shared clustering to **calibrate photo-z** for an overlapping, optical imaging survey
- **HI foregrounds remove small k-parallel modes** and photo-z data has poor constraints on k-perpendicular modes so not trivial that the two will have enough S/N to cross-correlate
- However, we have shown that **HI clustering-based redshift estimation is possible** and can provide excellent information for e.g. weak lensing probes (**solution to sigma-8 tension?**)



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