



# An Emulator-based forecasting of the reionization epoch cosmology with 21 cm estimators

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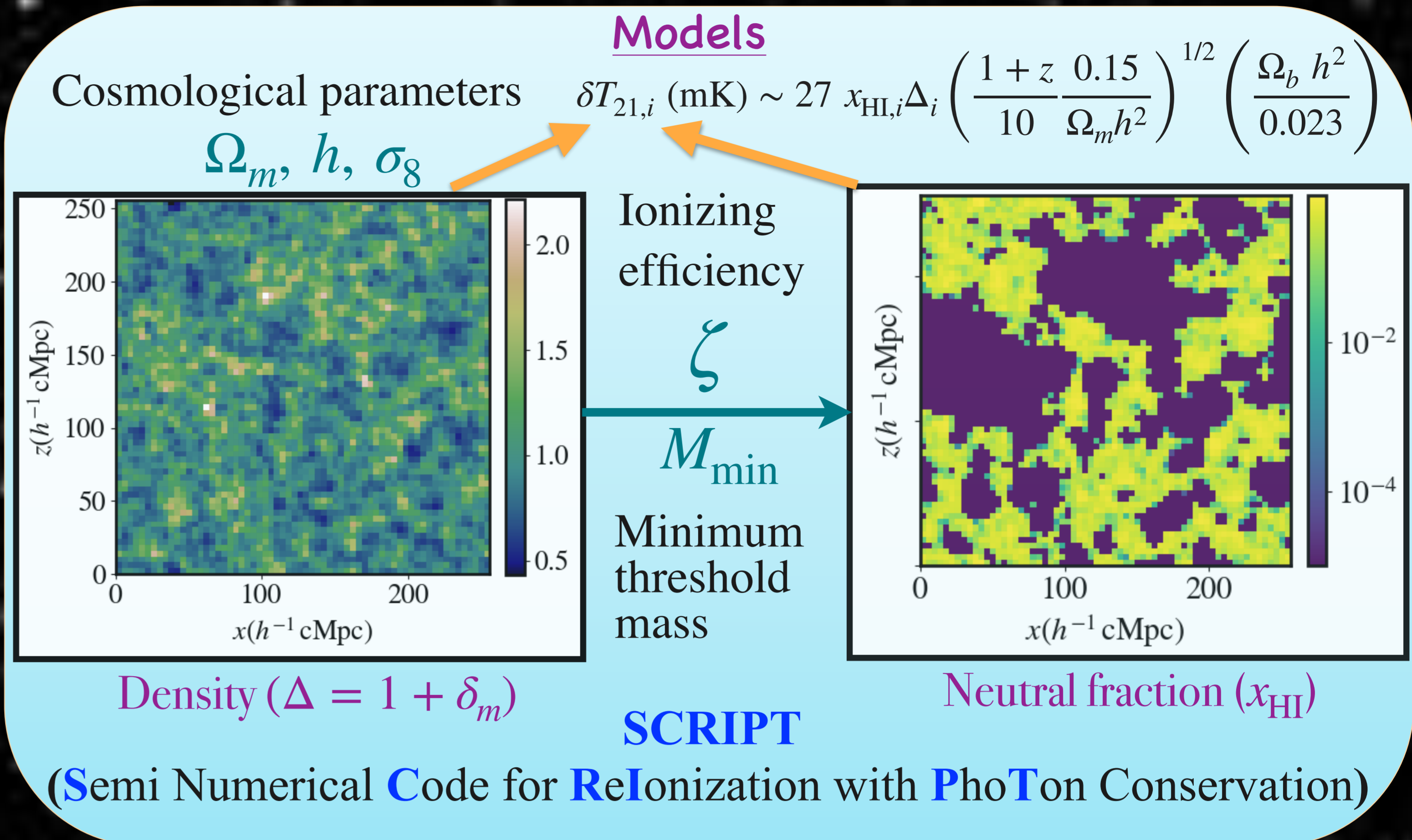
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## Epoch of Reionization (EoR)

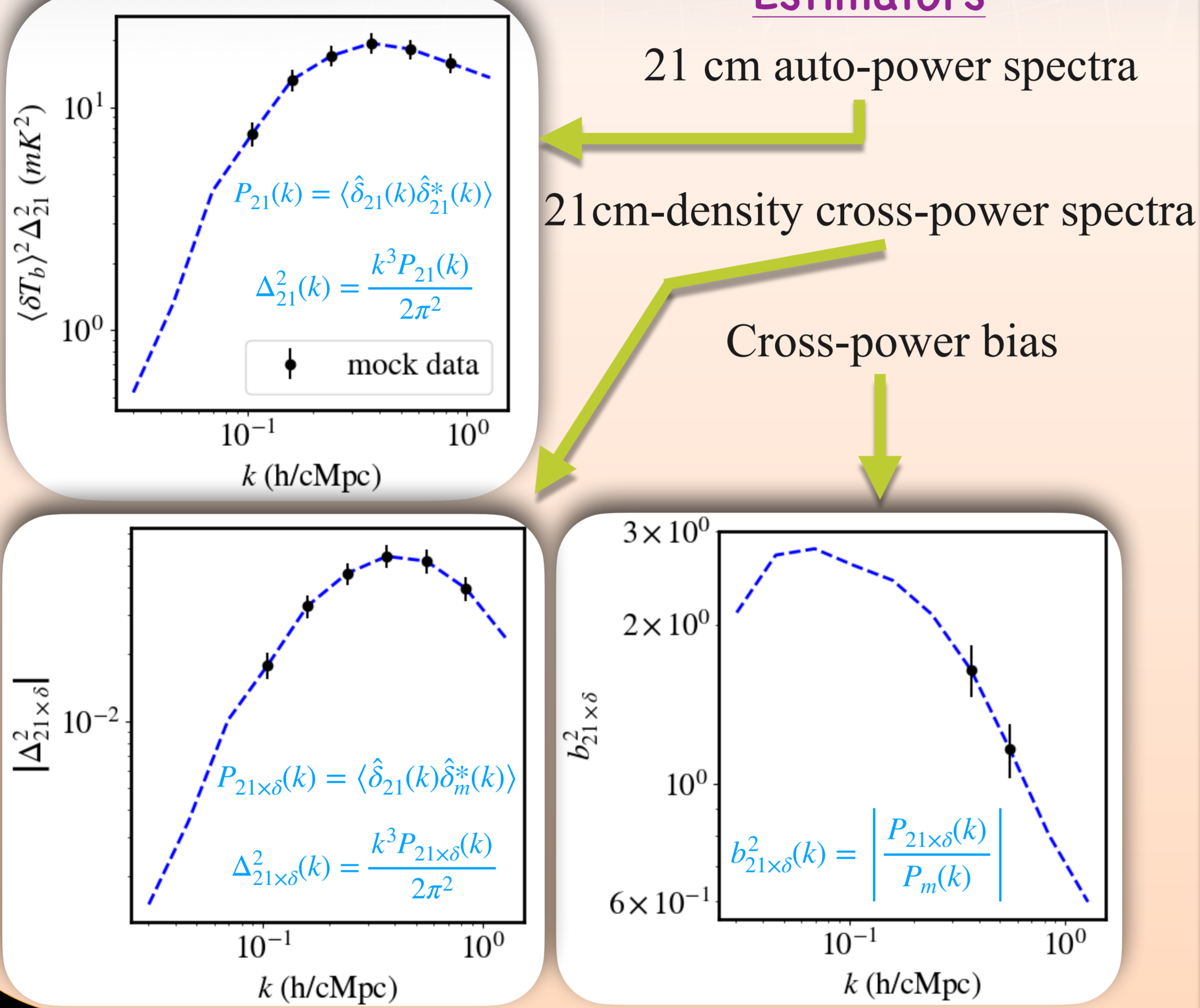
The epoch marks the transition of the Universe from a neutral/cold state to an ionized/hot state, by the photons coming from the very first luminous sources in the Universe. It is one of the least understood phases in the cosmic history.

### Motivations behind the work:

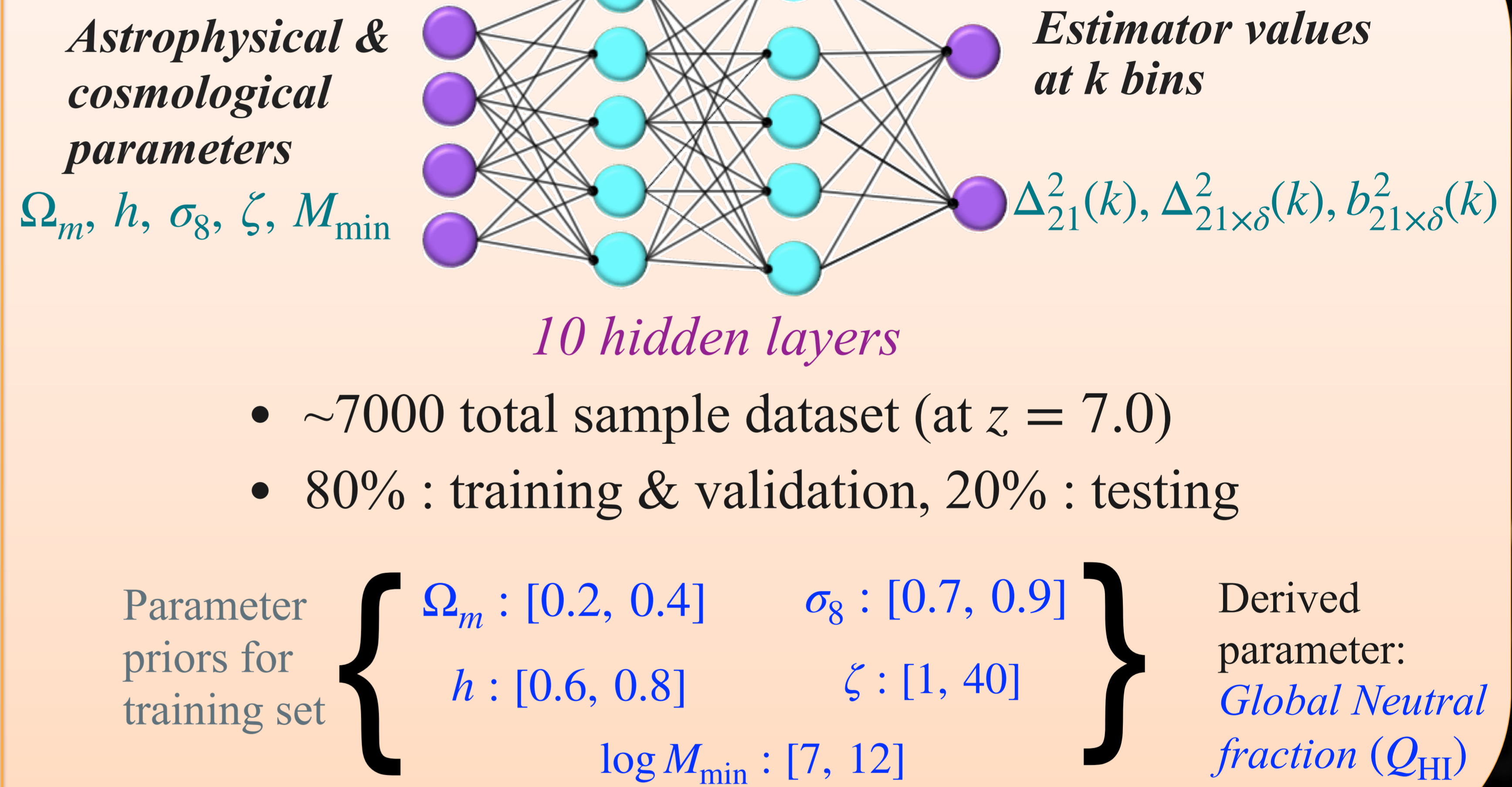
- Investigate the prospects of simultaneously constraining astrophysical and cosmological parameters using 21 cm observations during the EoR.
- Exploit 21-cm  $\times$  density field cross-correlations (probed by a variety of tracers including galaxy surveys, line intensity mapping).
- The observational prospects are very bright. The era can be explored with multi-wavelength synergies using available and upcoming facilities (such as JWST, NGRST, SKA, etc.).



## Estimators



## Artificial Neural Network (ANN) Emulator

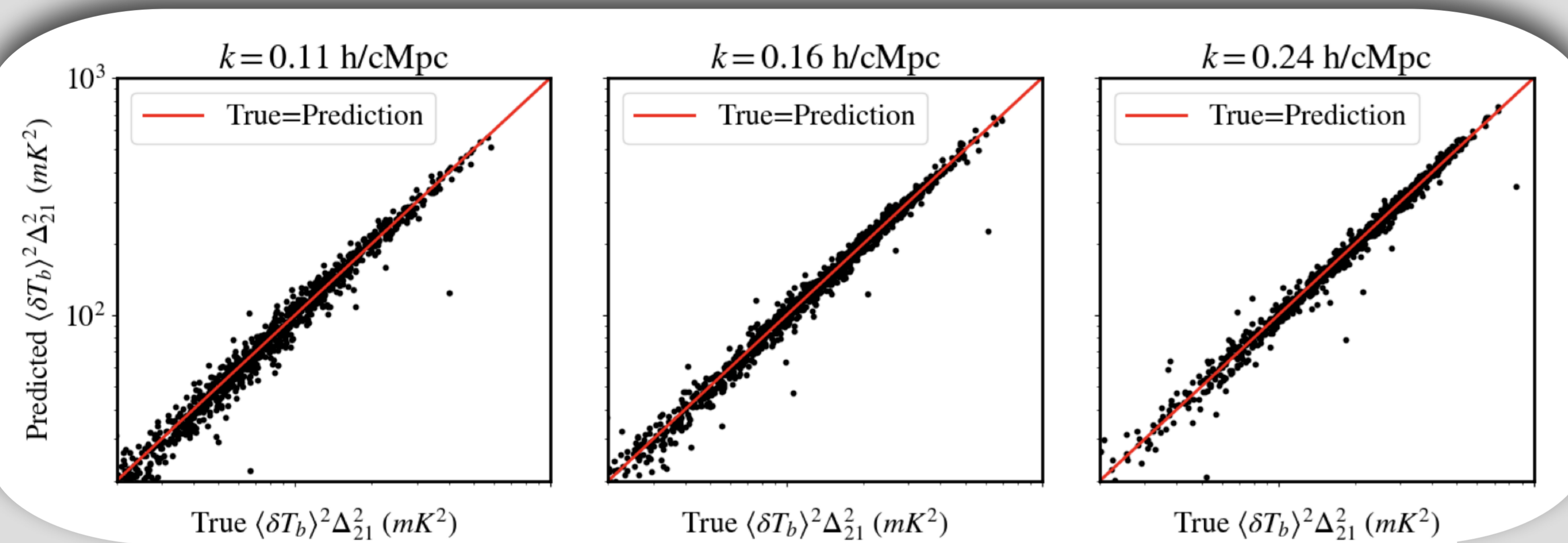


## Emulator performance

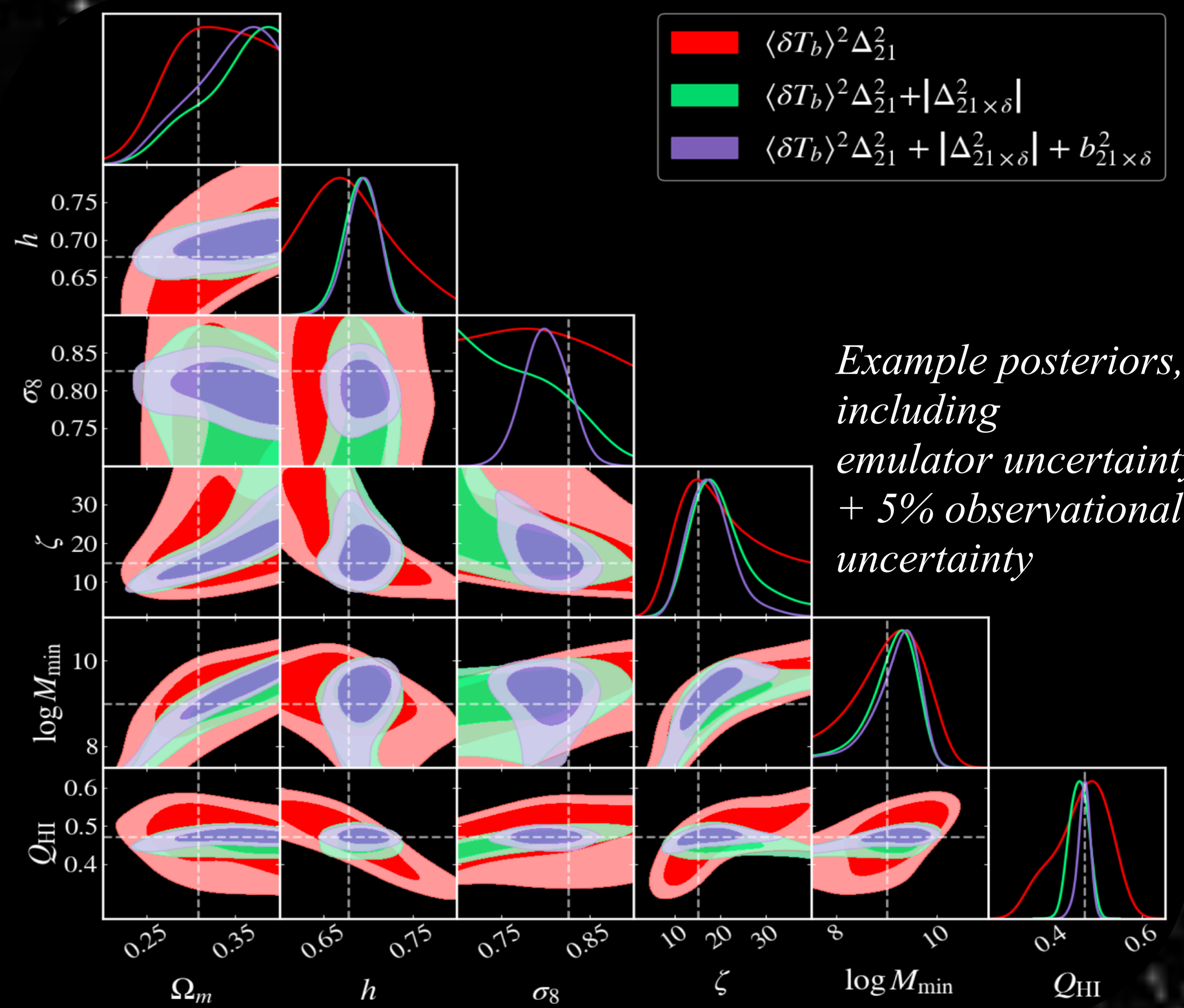
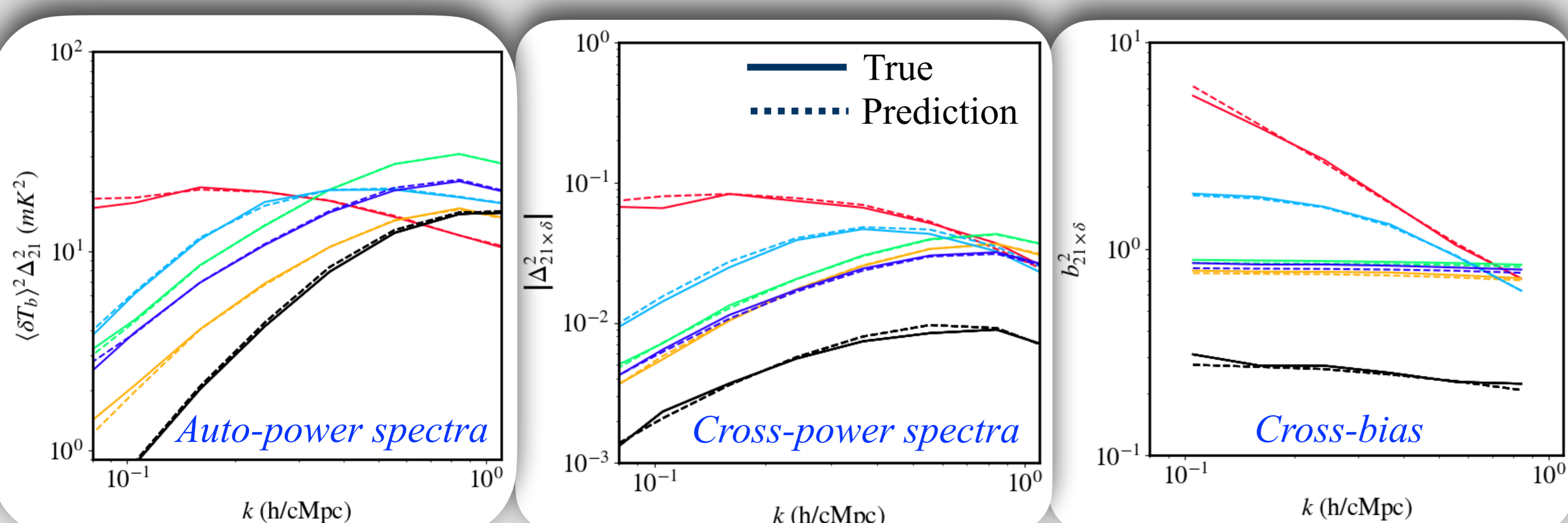
$$R^2 = 1 - \frac{\sum (y_{\text{true}} - y_{\text{predict}})^2}{\sum (y_{\text{true}} - \langle y_{\text{true}} \rangle)^2}$$

Auto-power spectra ( $R^2 = 0.98$ )    Cross-power spectra ( $R^2 = 0.99$ )    Cross-bias ( $R^2 = 0.92$ )

### Example comparison for 21 cm auto-power spectra



### A few random models from test set

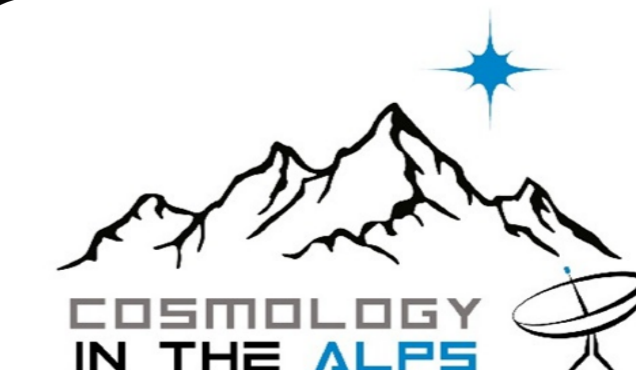


## Conclusions

- We built emulators of the 21 cm estimators (auto-power spectra, cross-power spectra with density & cross-bias) for exploring the epoch of reionization.
- We explored the parameter spaces varying both astrophysical and cosmological parameters, utilizing mock estimators.
- 21 cm power auto-power spectra combined with cross-correlation information can provide independent probes on cosmological parameters, such as  $h, \sigma_8$ .

Reference:

Maity, 2025, Astronomy & Astrophysics, Volume 703, A174



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