

# Forecasting multi-tracer line-intensity mapping signals from the EoR using POLAR

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## POLAR

POLAR combines the semi-analytic galaxy formation model L-GALAXIES and 1-D radiative transfer simulation of cosmic reionization GRIZZLY to generate various predictions for the epoch of reionization (EoR) and for observables of line-intensity mapping (LIM) to probe EoR. Whereas frameworks such as THESAN are based on radiation-magnetohydrodynamical simulations, running them for large cosmological volumes is computationally expensive. On the other hand, tools such as LIMFAST rely on formalisms that obtain collapsed halos without resolving them in the simulations.

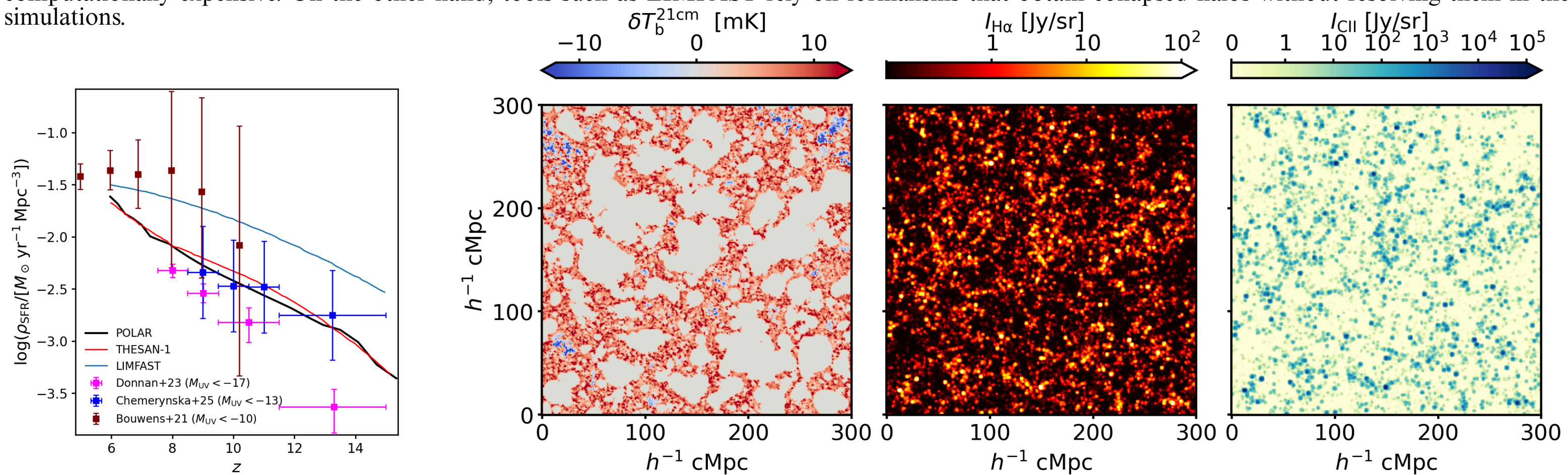
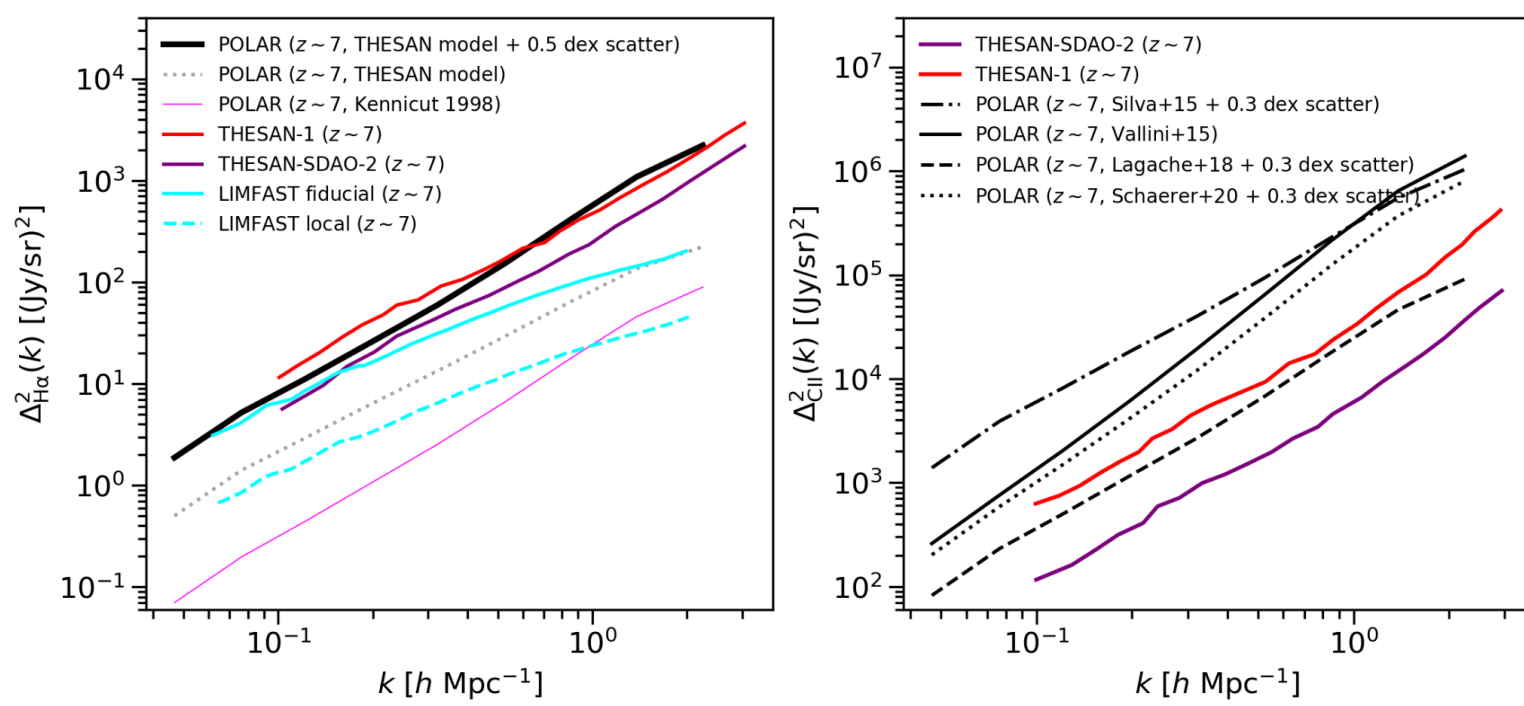


Fig.1 SFRD vs.  $z$

Fig.2 21cm, H-alpha and CII LIM maps from POLAR

POLAR combines a semi-analytic approach with a large volume ( $300 h^{-1} \text{ Mpc}$ )  $N$ -body simulation, achieving halo mass resolution of  $\sim 10^9 M_{\text{sun}}$ . This approach is comparatively less computationally expensive than frameworks such as THESAN, while providing consistent predictions such as the evolution of cosmic star-formation rate density (Fig. 1). Using scaling relations for SFR and line-luminosities (H-alpha and CII), LIM maps are generated from POLAR outputs as shown in Fig. 2.



## Summary statistics

Predictions for summary statistics (power spectrum, cross-power spectrum, etc.) are crucial to understand the EoR and for designing optimal survey parameters. Using POLAR, it is found that the prediction for the H-alpha power spectrum, assuming a scaling relation from THESAN and  $\sim 0.5$  dex  $L_{\text{line}}$ -SFR scatter at  $z \sim 7$ , is in good agreement with that from THESAN at a large range of  $k$ -modes, whereas it is close to the LIMFAST prediction at small  $k$ -modes. In the case of the CII power spectrum, the predictions from POLAR bracket that of the THESAN prediction, as shown in Fig. 3. Predictions for cross-power spectra are shown in Fig. 4.

Fig.3 Power spectra from POLAR

- POLAR ( $z \sim 7$ , Silva+15)
- POLAR ( $z \sim 7$ , Vallini+15)
- POLAR ( $z \sim 7$ , Lagache+18)
- POLAR ( $z \sim 7$ , Schaerer+20)

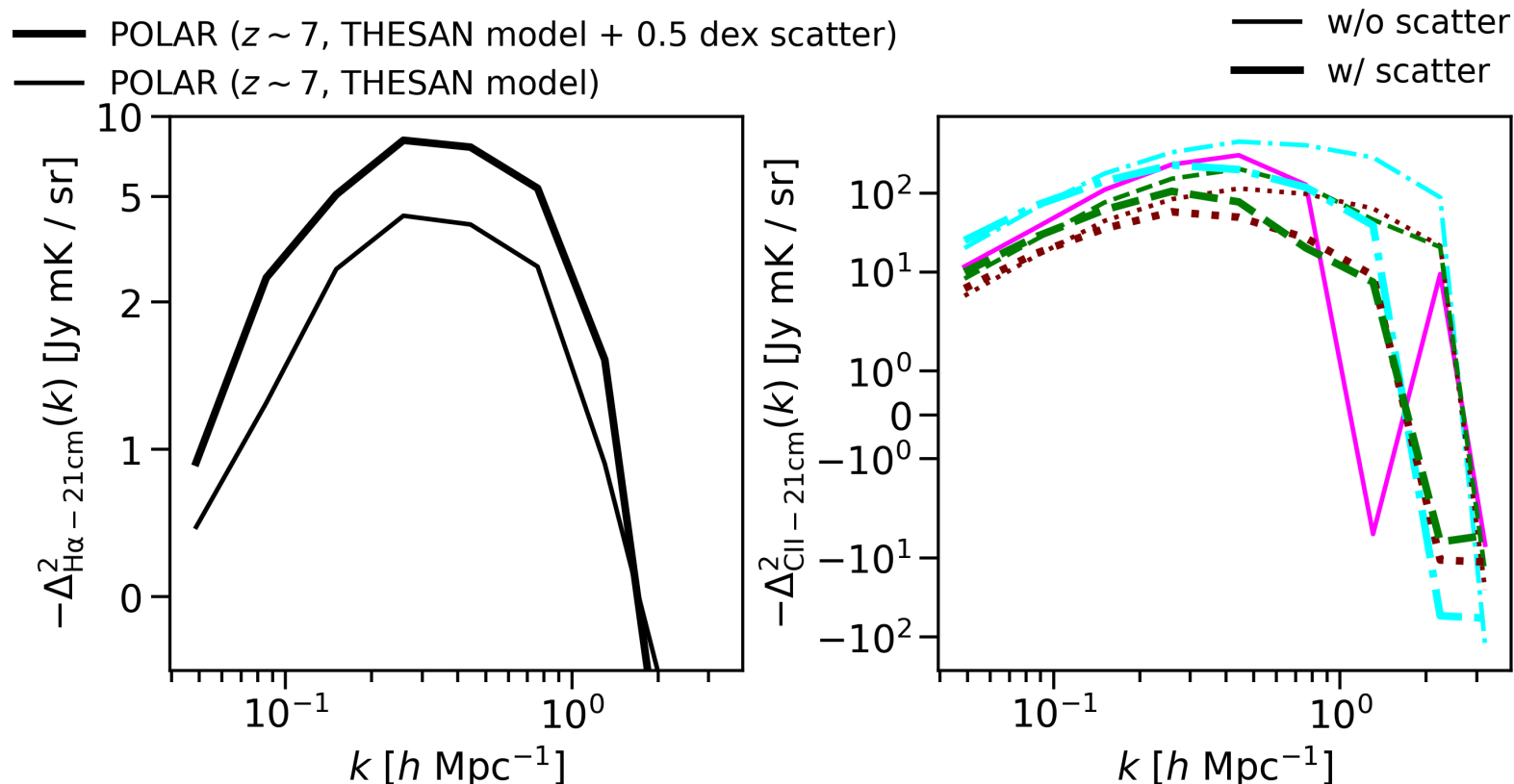


Fig.4 Cross-powerspectra from POLAR

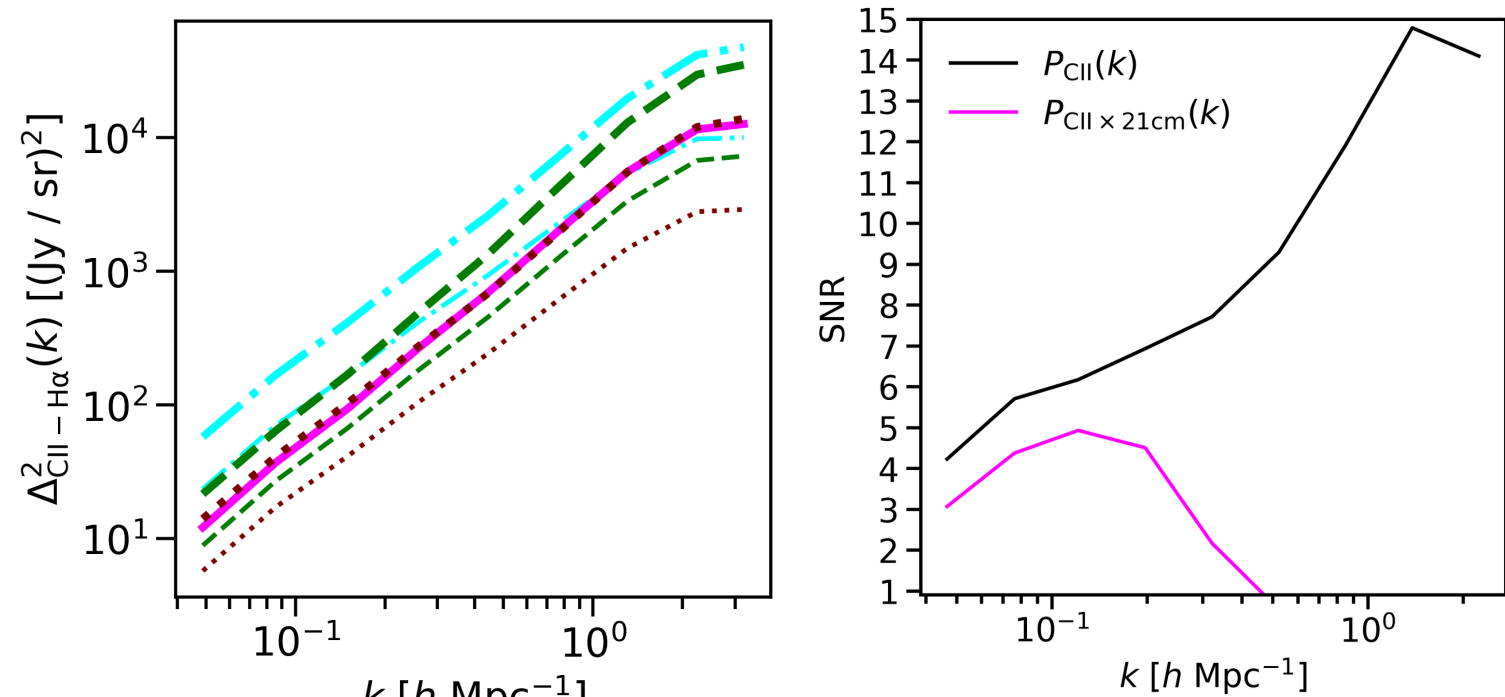


Fig.5 SNR vs.  $k$

## Signal-to-Noise

Surveys such as FYST will detect the CII LIM signal within the redshift range of  $3.5 < z < 8.05$ , covering the EoR. Using POLAR, predictions are made for the detectability of the CII power spectrum and CII x 21cm cross-power spectrum at  $z \sim 7$ . Using standard FYST survey parameters (4000 hrs,  $4 \text{ deg}^2$ ), and cross-correlation with 1000 hrs of SKA AA\* 21cm survey, our preliminary results suggest a detectability of  $> 3\sigma$  for these summary statistics at  $k \sim 0.1 h \text{ Mpc}^{-1}$ .

## Future scope

The analysis can be further extended to include line emissions like Ly-alpha, LIM light-cones, and also predictions for the angular power spectrum useful for the SPHEREx survey.

