



Redshifted 21cm Emission and the Reionization History

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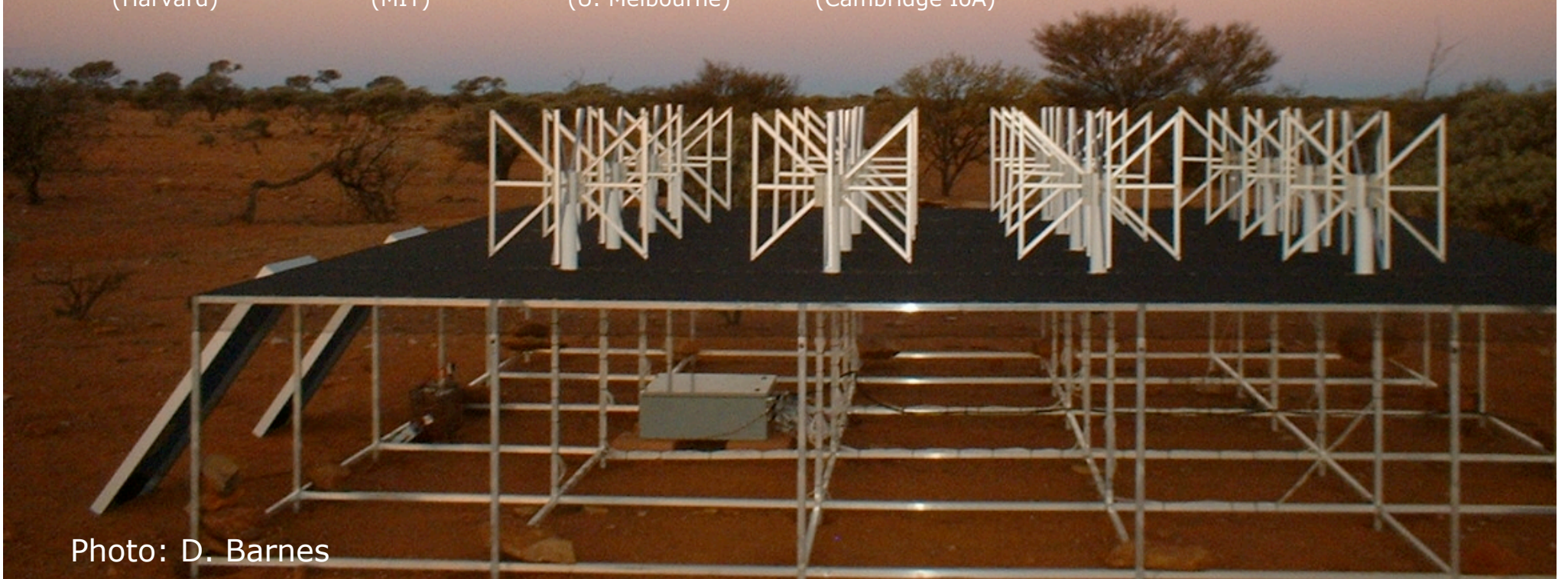
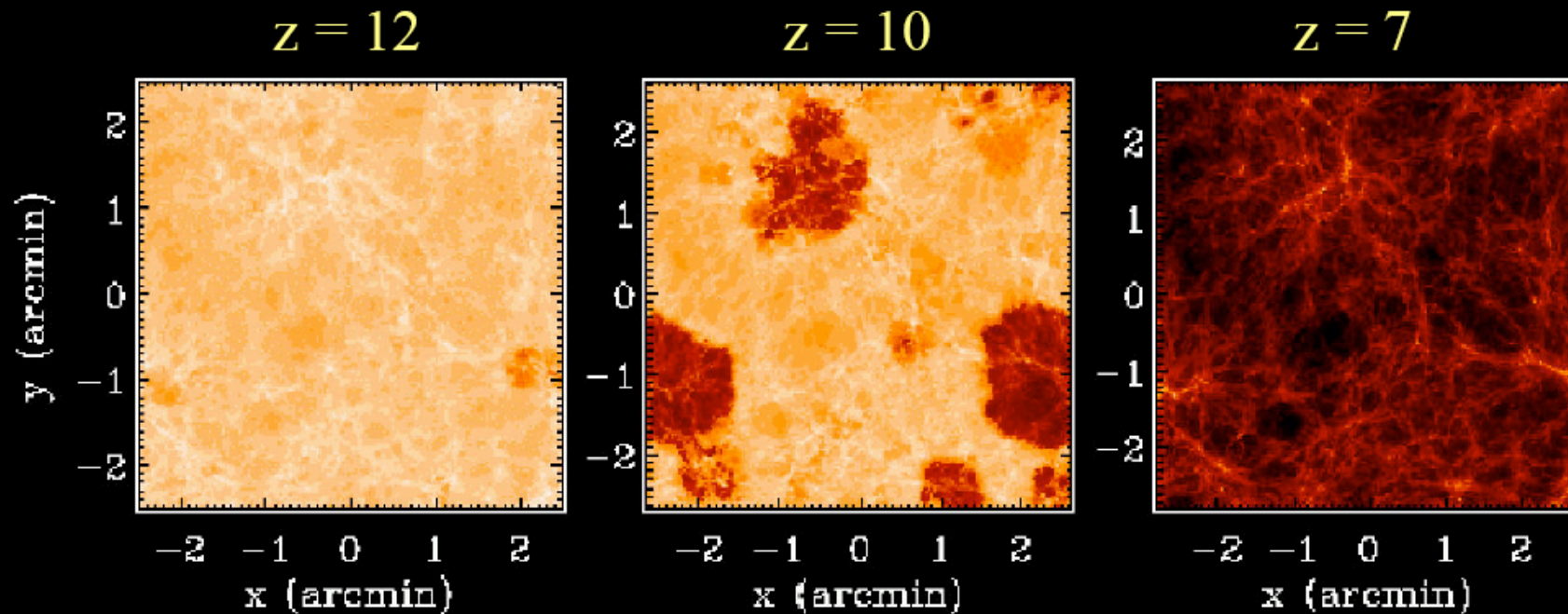


Photo: D. Barnes

Redshifted 21cm Emission



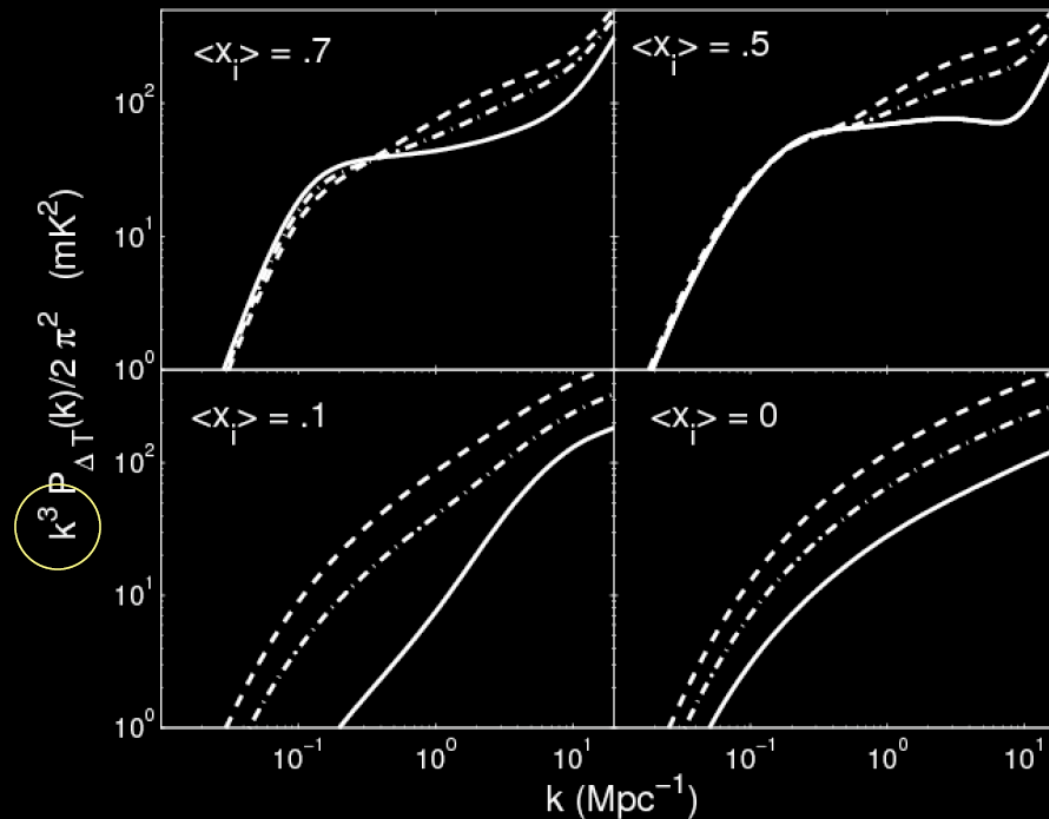
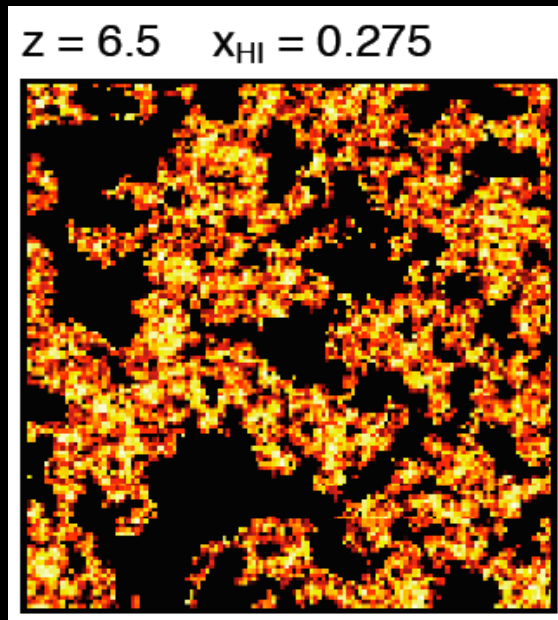
Zaldarriaga, Furlanetto, & Hernquist (2004)

- Neutral hydrogen at $z \sim 6$ could be detected at frequencies near 200MHz
- The evolution of neutral hydrogen traces the appearance and evolution of early galaxies

Galaxy Bias and Fluctuations in Redshifted 21cm Emission

Quasar HII regions and
Redshifted 21cm Imaging

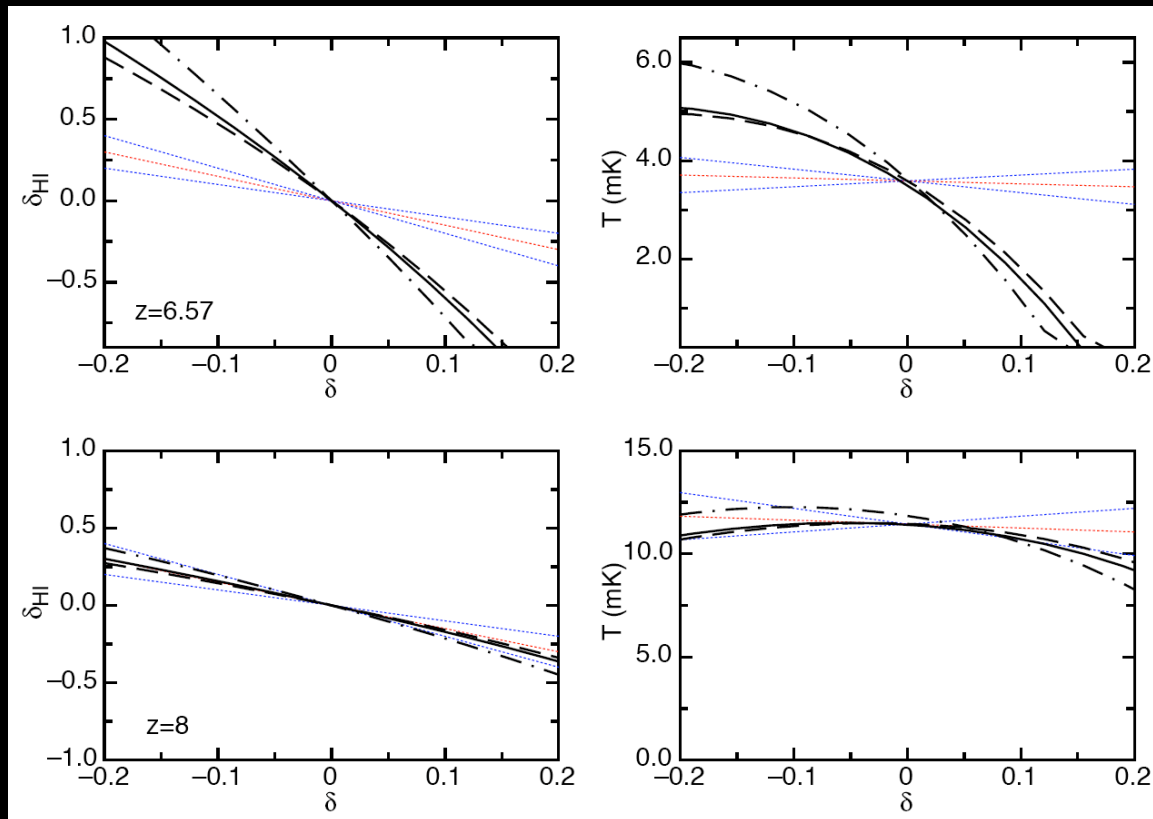
Topology of Reionization is Encoded in the Power-Spectrum of 21cm Intensity



McQuinn, Zahn, Hernquist, & Furlanetto (2006)

- Reionization should leave a distinct mark on the power-spectrum of spatial fluctuations in 21cm emission

Galaxy Bias & Patchy Reionization



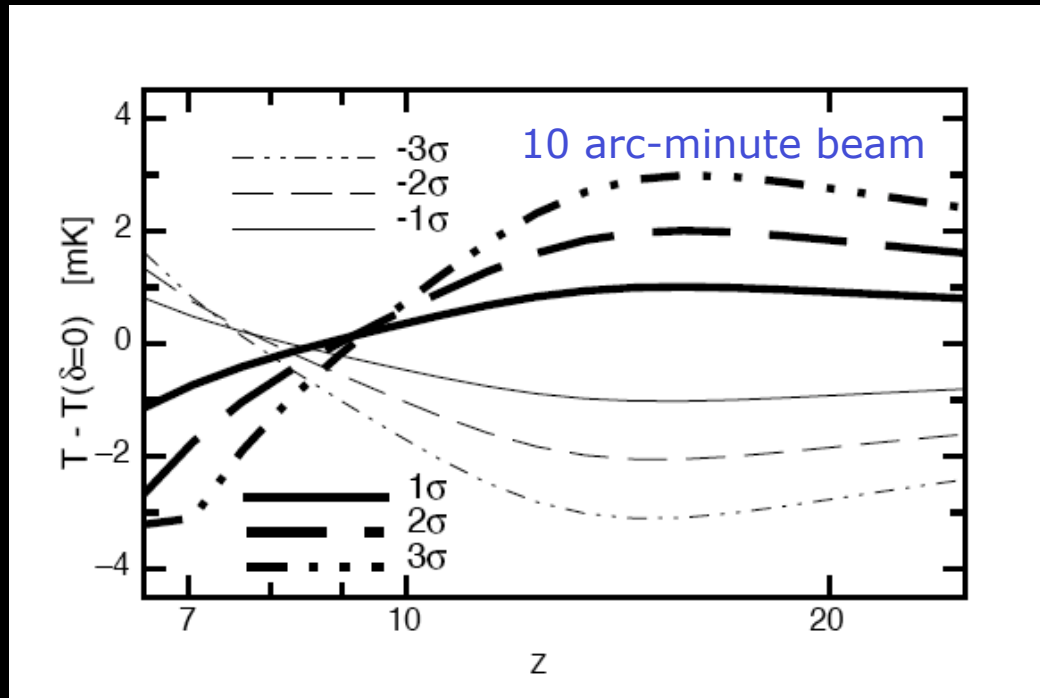
Intensity not
very sensitive
to overdensity.

Standard
Expression has δ
=0 and $R=\infty$.

Wyithe & Loeb (2007)

$$\begin{aligned} \frac{dQ_{\delta,R}}{dt} = & \frac{N_{\text{ion}}}{0.76} \left[Q_{\delta,R} \frac{dF_{\text{col}}(\delta, R, z, M_{\text{ion}})}{dt} \right. \\ & \left. + (1 - Q_{\delta,R}) \frac{dF_{\text{col}}(\delta, R, z, M_{\text{min}})}{dt} \right] \\ & - \alpha_B C n_{\text{H}}^0 \left(1 + \delta \frac{D(z)}{D(z_{\text{obs}})} \right) (1+z)^3 Q_{\delta,R}, \end{aligned}$$

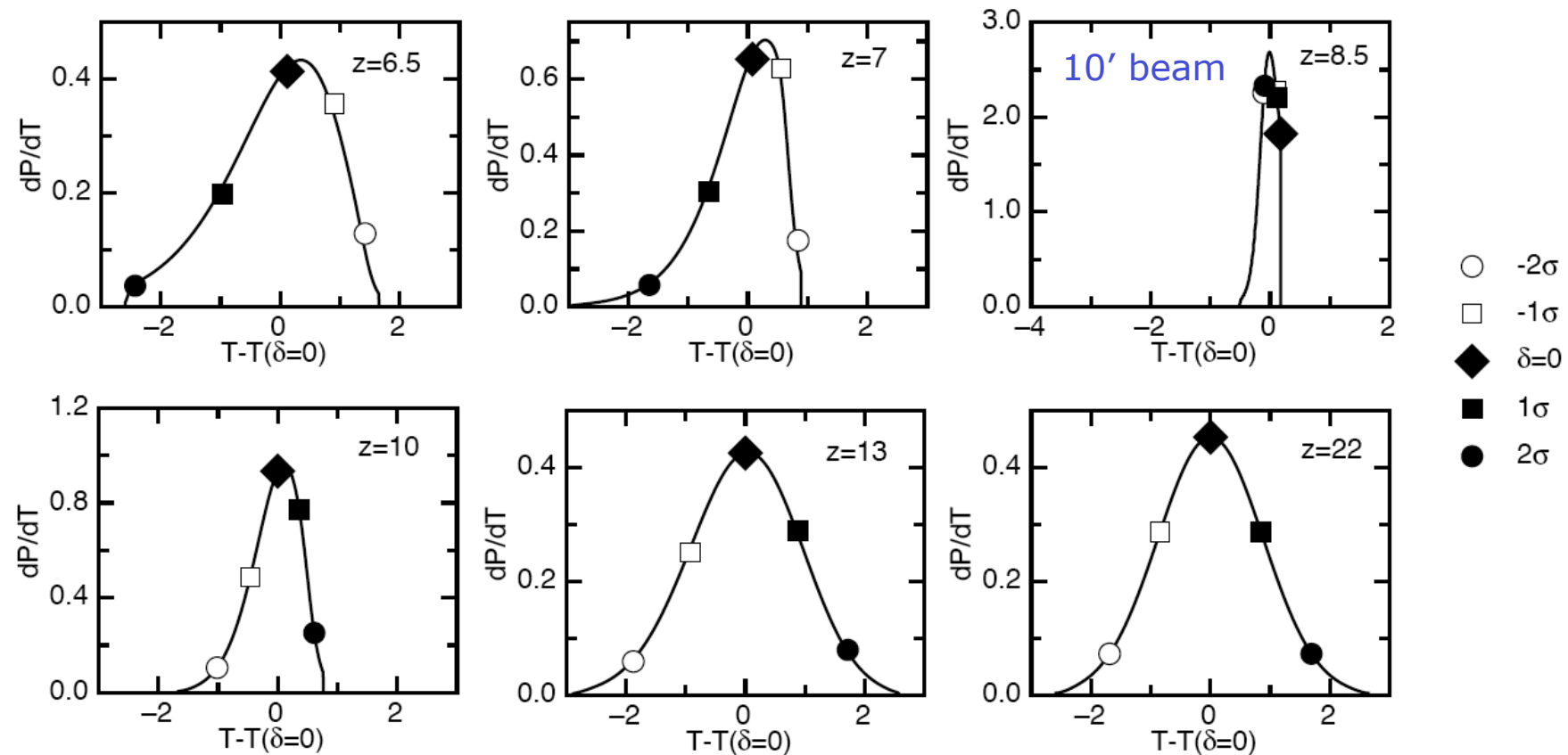
Galaxy Bias & Patchy Reionization



Wyithe & Morales (2007)

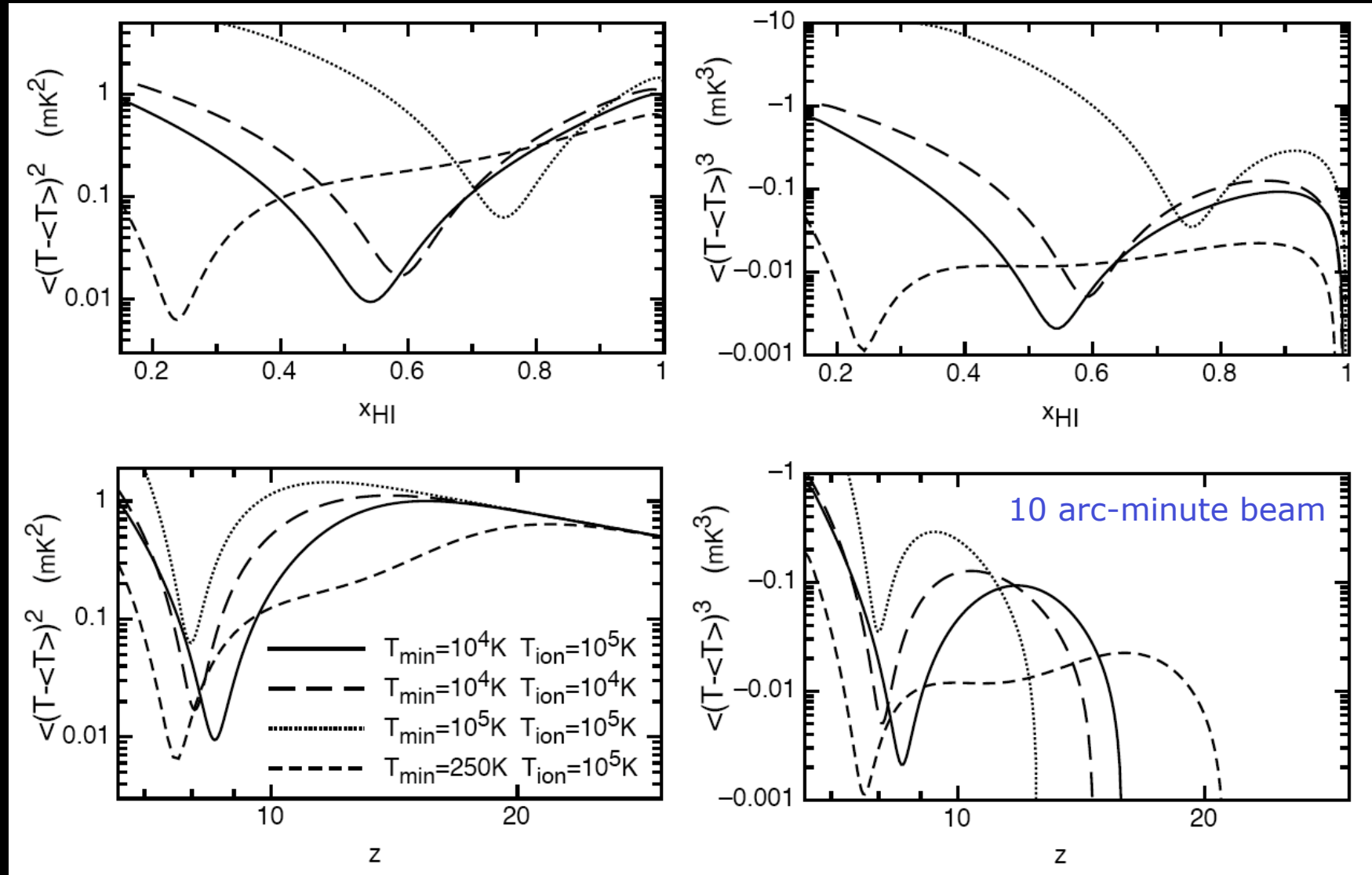
- Galaxy bias leads to a transition of excess 21cm intensity from over-dense to under-dense regions, and hence to a redshift where the fluctuation amplitude has a local minimum

Non-Gaussian 21cm Fluctuations

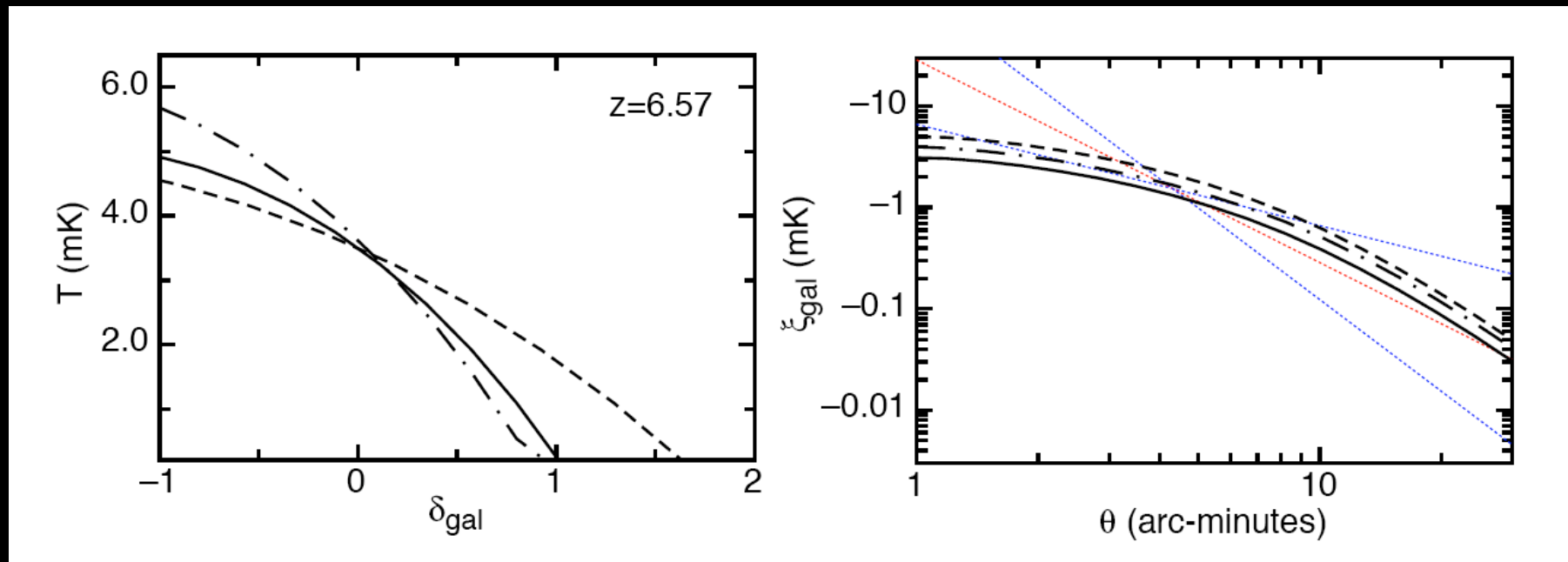


- Galaxy bias leads to a non-Gaussian distribution of intensity fluctuations

Second and Third Moments of 21cm Fluctuations Probe Galaxy Formation



Cross-Correlation of Fluctuations With Galaxies Directly Probes the Sources of Reionization



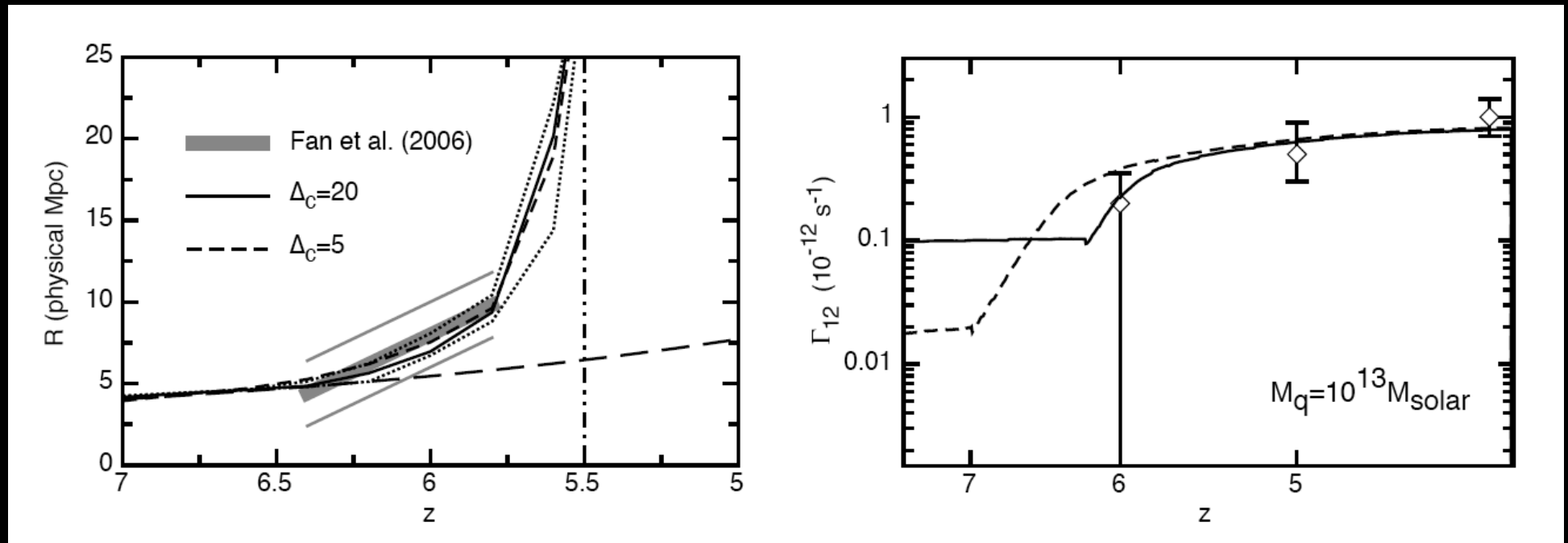
(Wyithe & Loeb 2007; Furlanetto & Lidz 2007)

- Galaxy bias correlates galaxies & ionization with dense regions => negative cross-correlation

Galaxy Bias and Fluctuations in Redshifted 21cm Emission

Quasar HII regions and
Redshifted 21cm Imaging

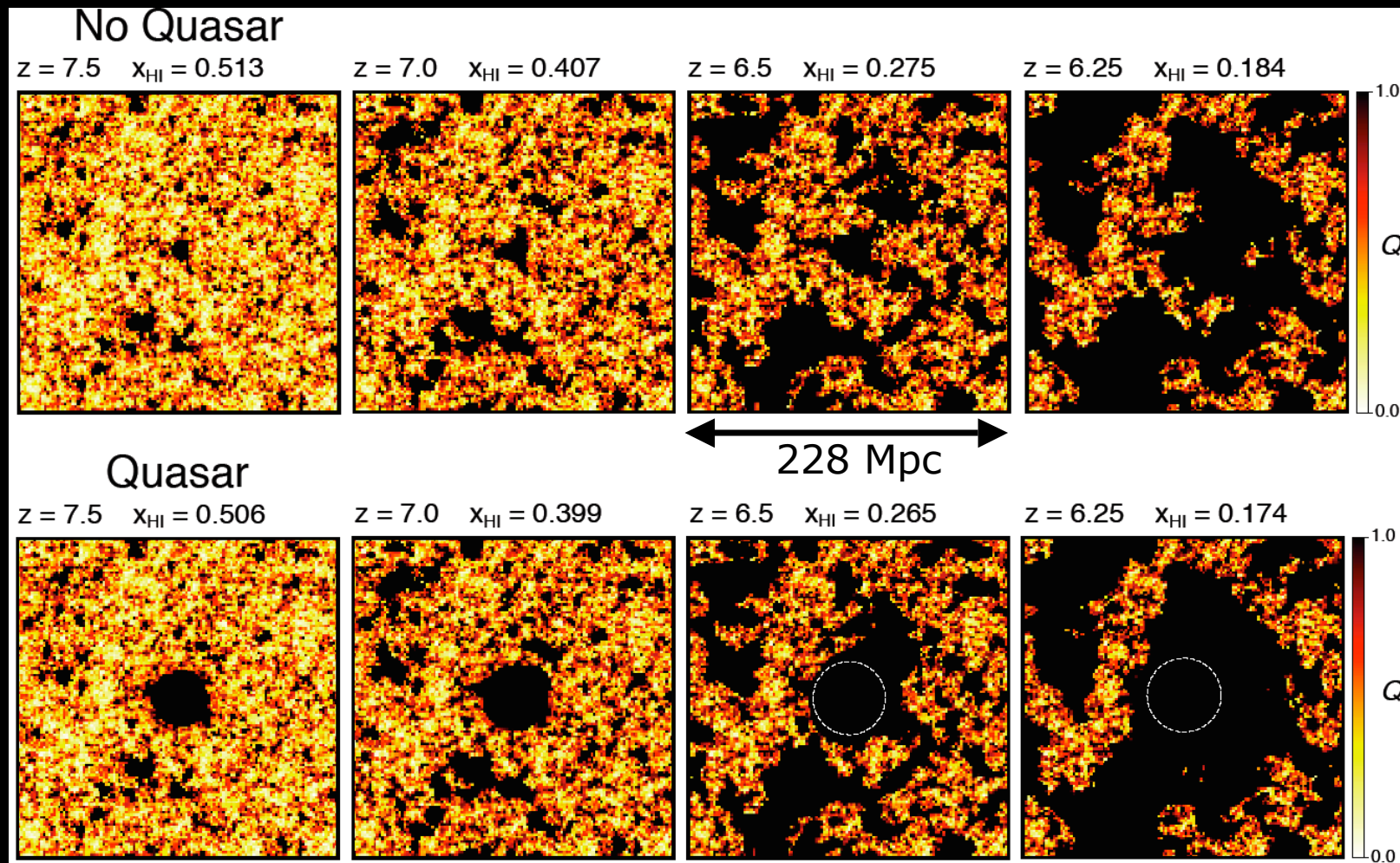
Quasar Near Zones and Overlap



Wyithe & Haehnelt, in prep

- Near-zone defined as radius where $T=10\%$ (Fan et al.)
- Rapid evolution of near-zone size implies a rapidly increasing ionizing background, and hence an overlapping IGM at $z \sim 6-7$

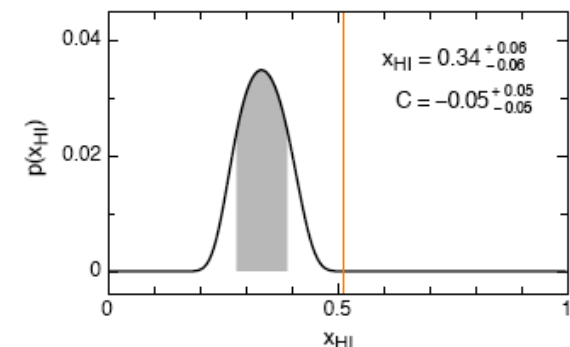
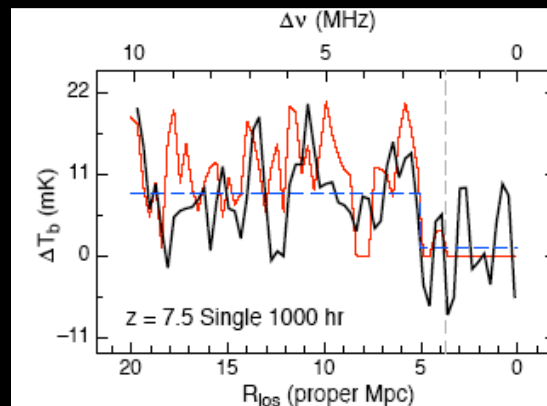
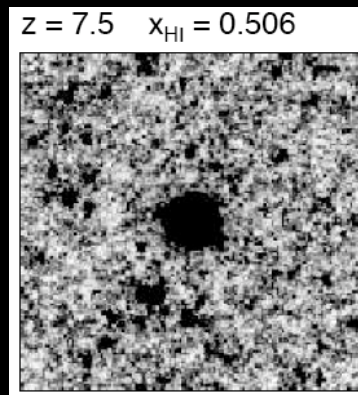
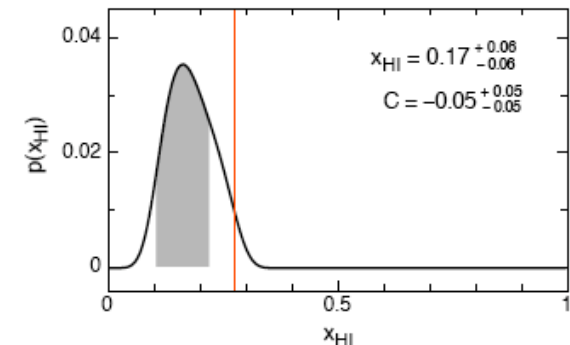
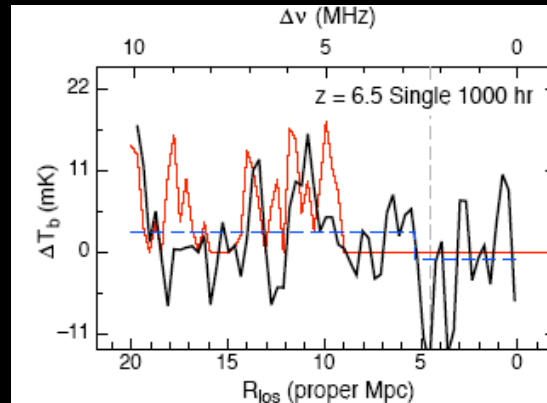
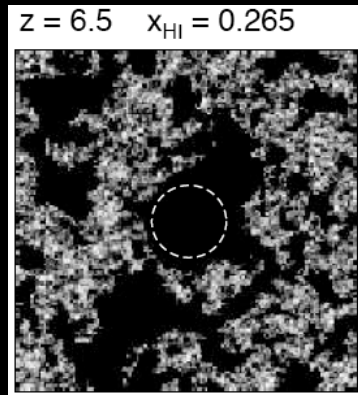
Quasar HII Regions



- Observations towards known quasars could allow a-posteriori detection of the IGM prior to reionization

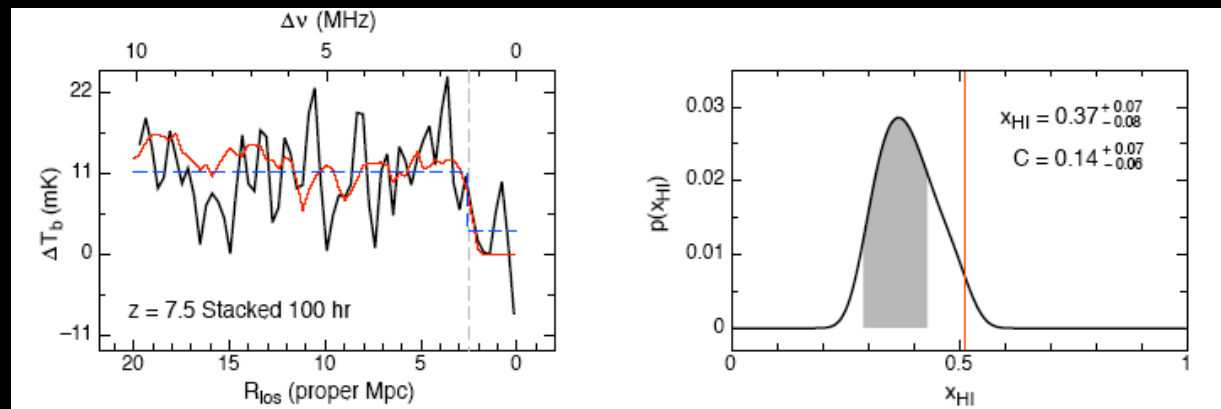
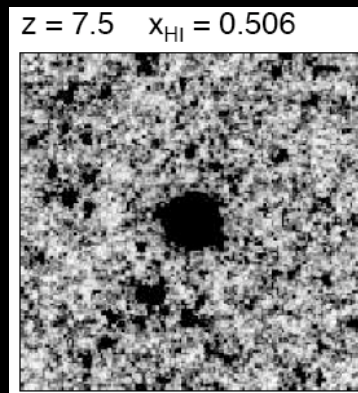
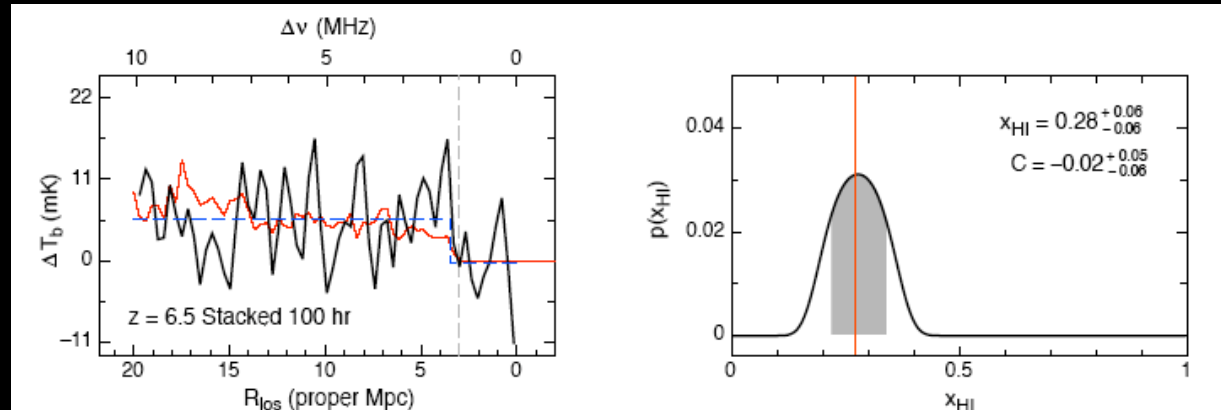
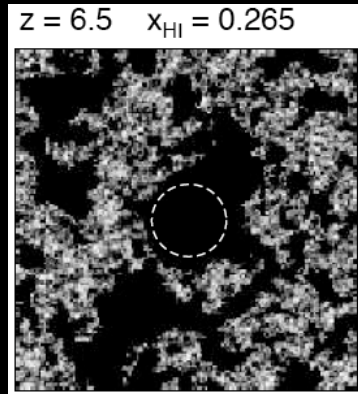
Paul Geil, in prep

Detectability of Quasar HII Regions



- Detection of a single 5-10Mpc HII region will be possible using the MWA with a 1000 hour integration at global neutral fractions as low as 25%

Detectability of Quasar HII Regions



- Detection of 10 stacked 3-5Mpc HII regions will be possible using the MWA with only 100 hours of integration. The radius could also measured

Conclusions

- The evolution of the fluctuation statistics in redshifted 21cm emission provides a wealth of information on the formation of galaxies that reionized the IGM
- The Mileura Widefield Array will have sufficient sensitivity to detect the HII regions surrounding high redshift quasars late in the reionization era



Photo: D. Barnes