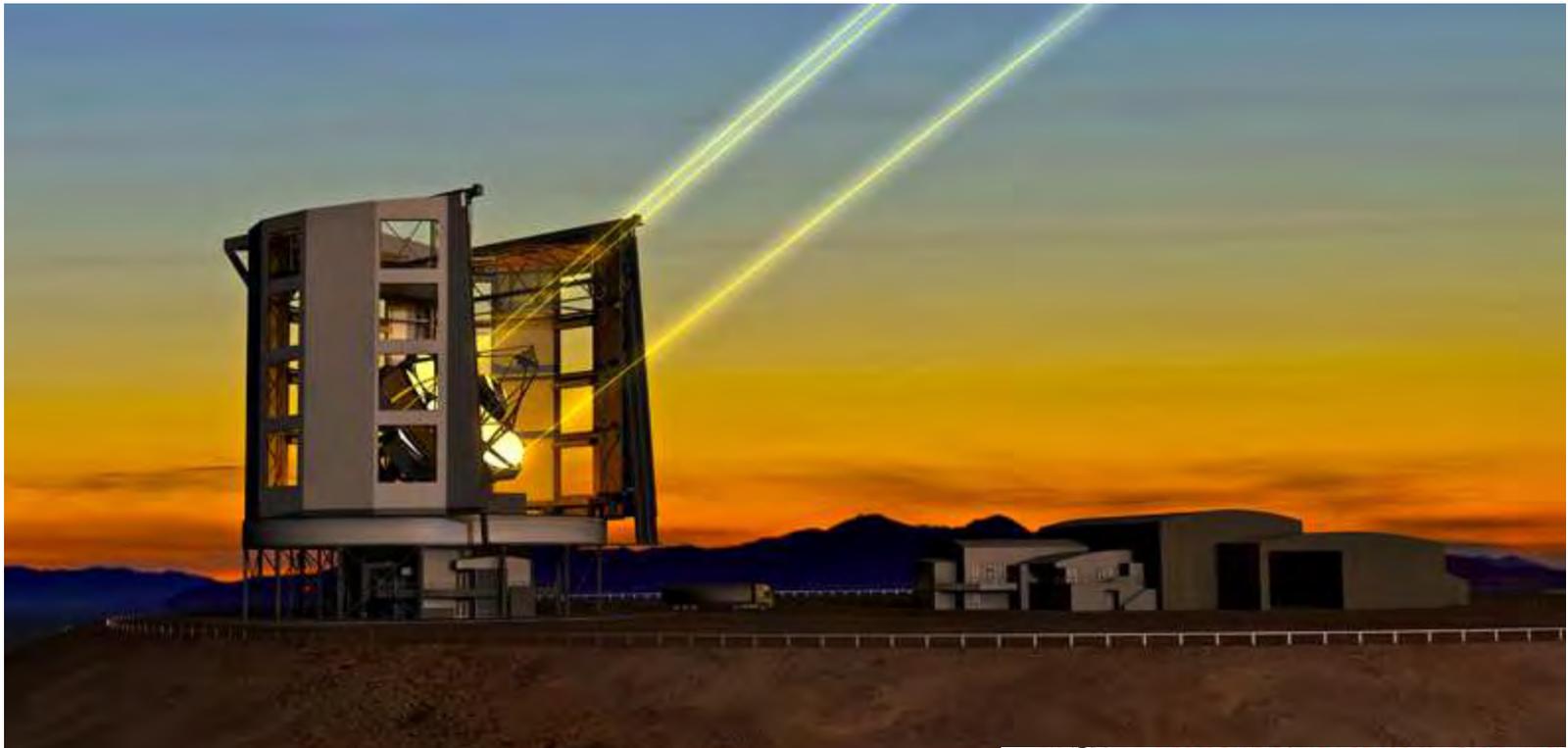




First Light And Reionization

Nick Gnedin



Reionization and 5-Year Plans

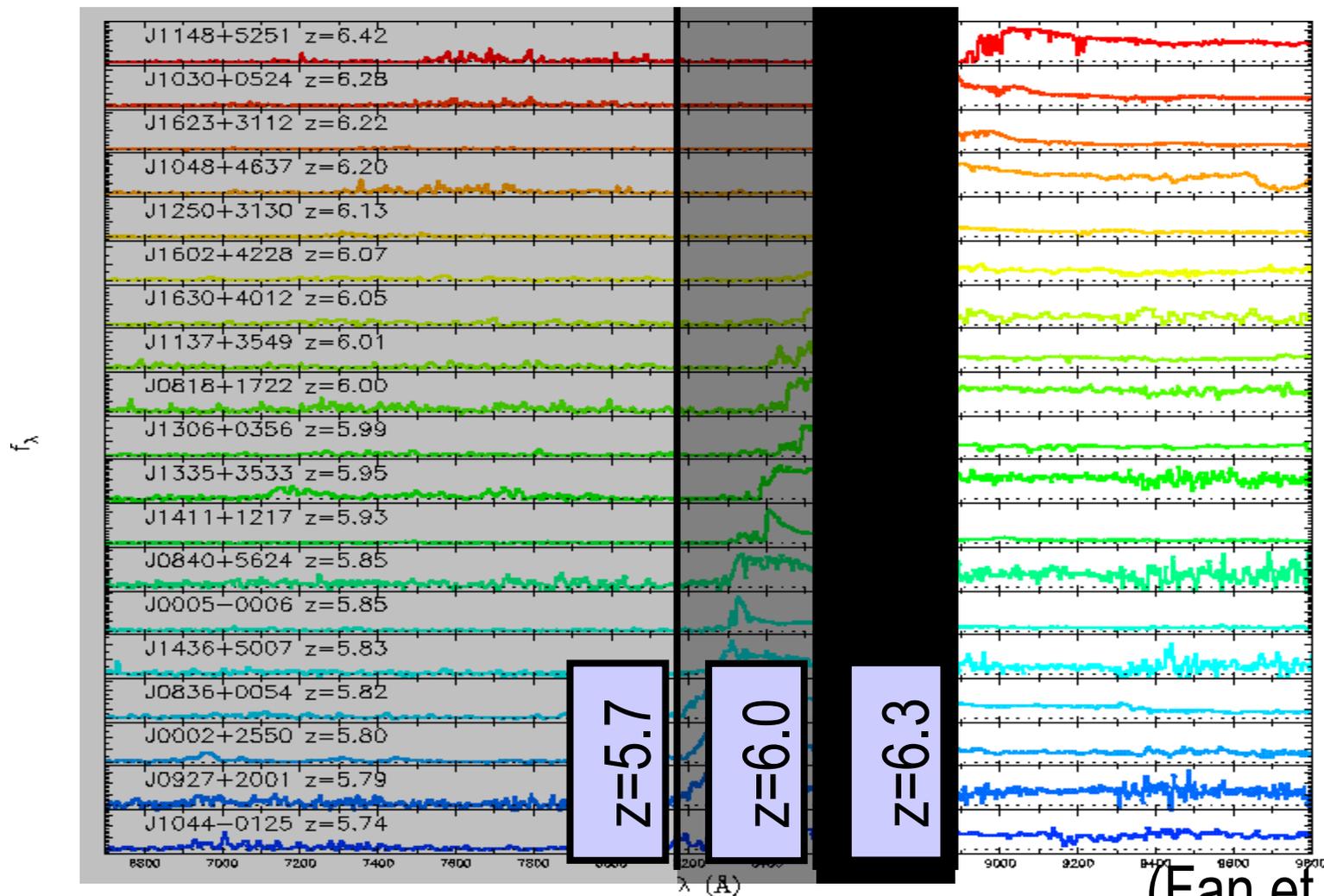


- Sovier leaders would love reionization – it is a field where every 5 years something interesting happens.





SDSS Quasars ~ 2005

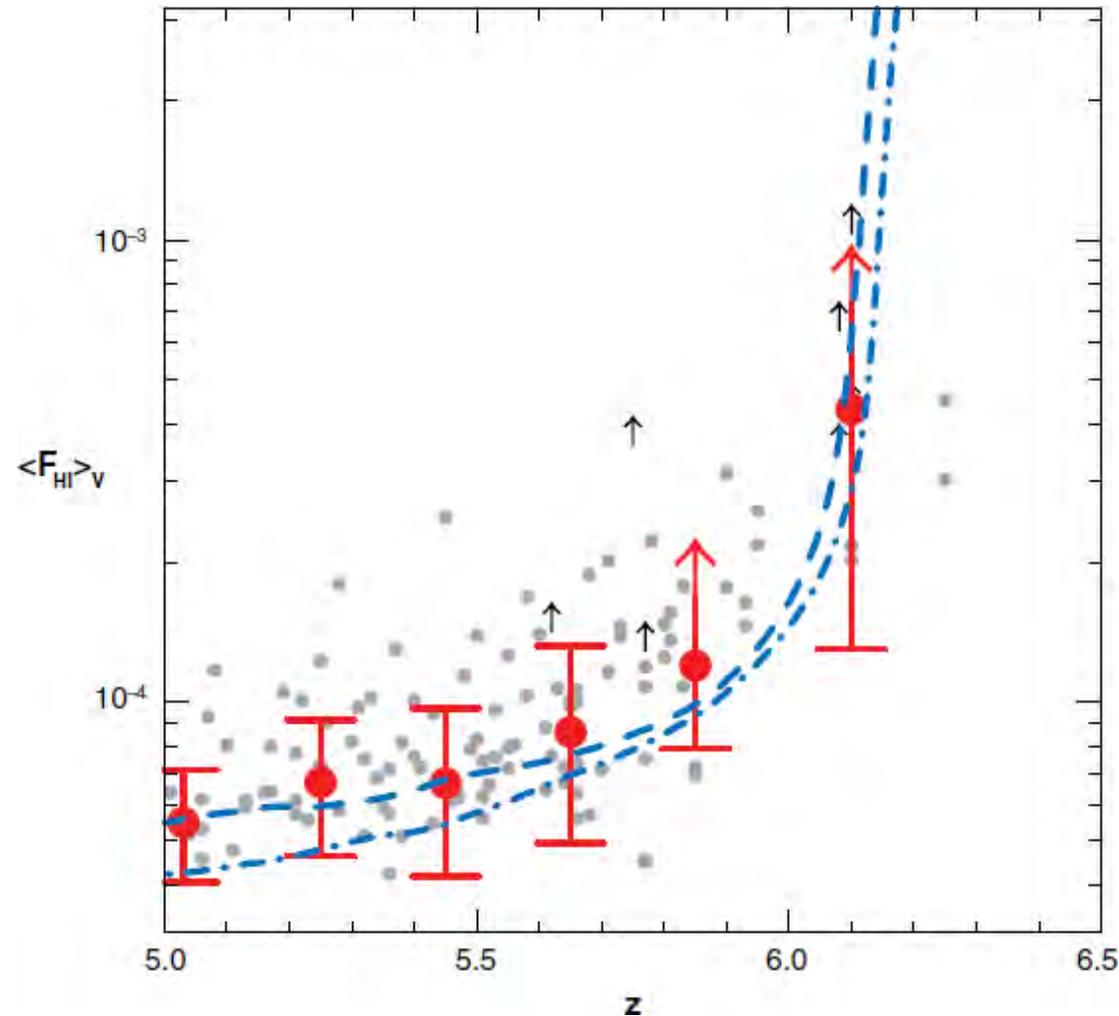


(Fan et al 2005)



SDSS Quasars ~ 2005

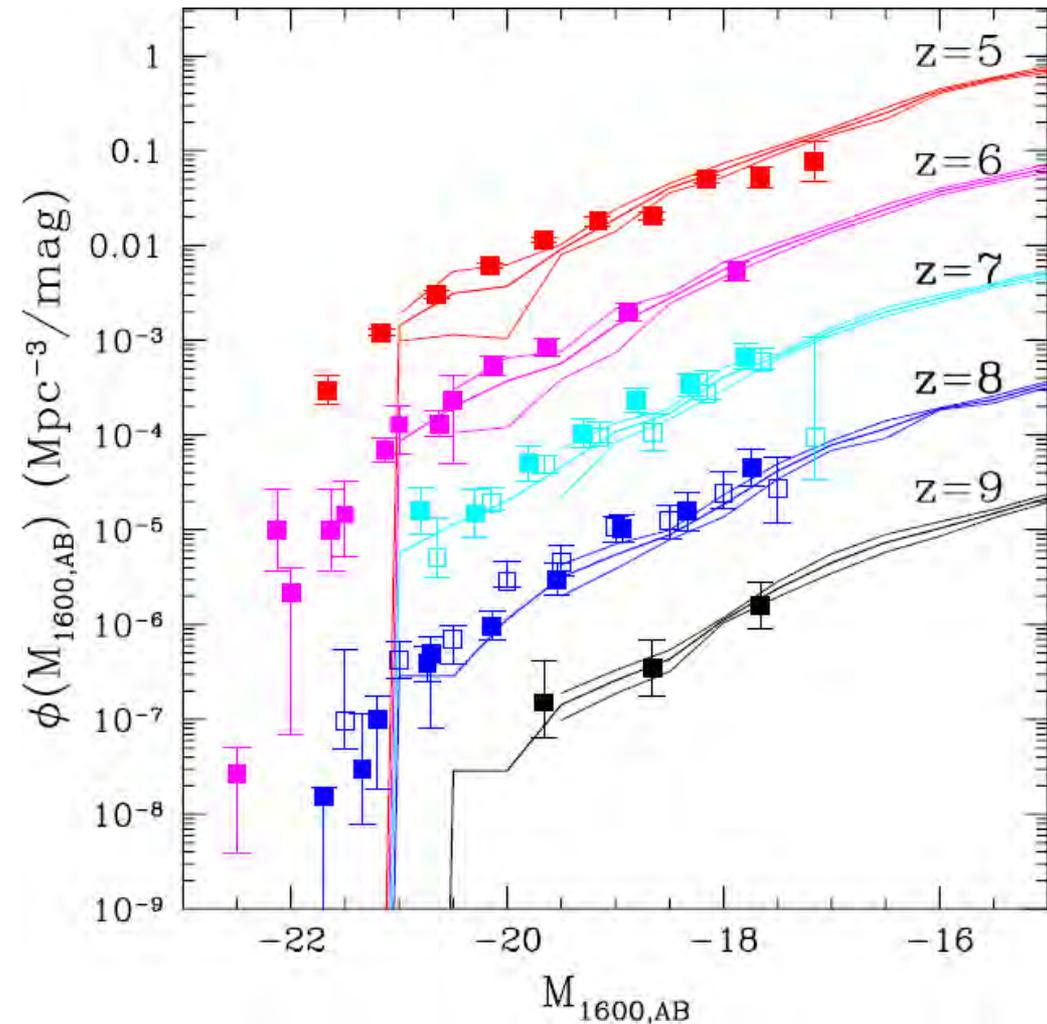
- SDSS quasars are unambiguous – reionization ended at $z \approx 6$.





Hubble WFC3 ~ 2010

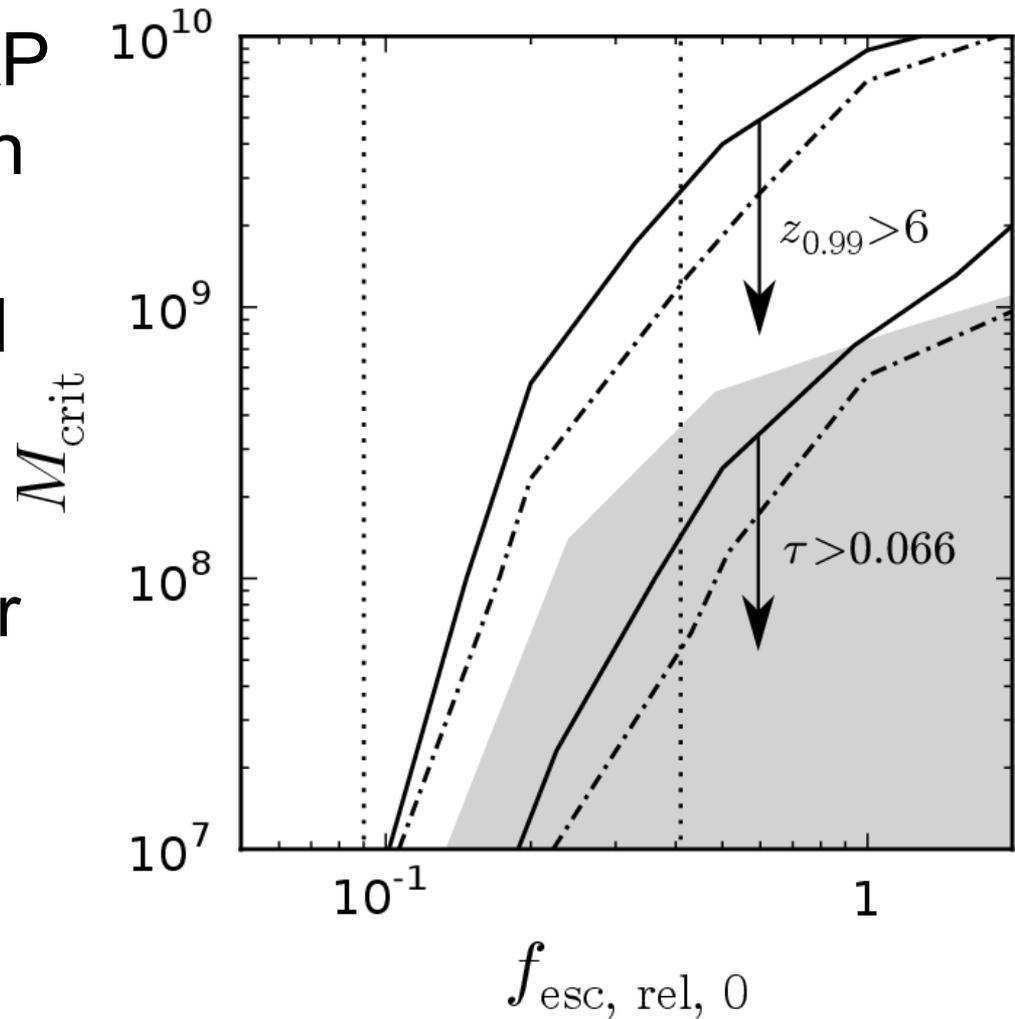
- UV luminosity functions are measured all the way to $z \sim 9$.





CMB ~ 2015

- Tension between WMAP Thompson optical depth measurement and observed UV LFs is still with us.
- Depending on the Planck results, it may or may not remain after ~2015...





Redshifted 21 cm ~ 2015



- Precision Array for Probing the Epoch of Reionization (PAPER)
- Murchison Widefield Array (MWA)
- ...



Redshifted 21 cm ~ 2015

arXiv.org > astro-ph > arXiv:1304.4229

Search or Article

Astrophysics > Cosmology and Extragalactic Astrophysics

Overcoming real-world obstacles in 21 cm power spectrum estimation: A method demonstration and results from early Murchison Widefield Array data

Joshua S. Dillon, Adrian Liu, Christopher L. Williams, Jacqueline N. Hewitt, Max Tegmark, Edward H. Morgan, Alan M. Levine, Miguel F. Morales, Steven J. Tingay, Gianni Bernardi, Judd D. Bowman, Frank H. Briggs, David Emrich, Daniel A. Mitchell, Divya Oberoi, Thiagaraj Prabu, Randall Wayth, Rachel L. Webster

arXiv.org > astro-ph > arXiv:1304.4991

Search or Article

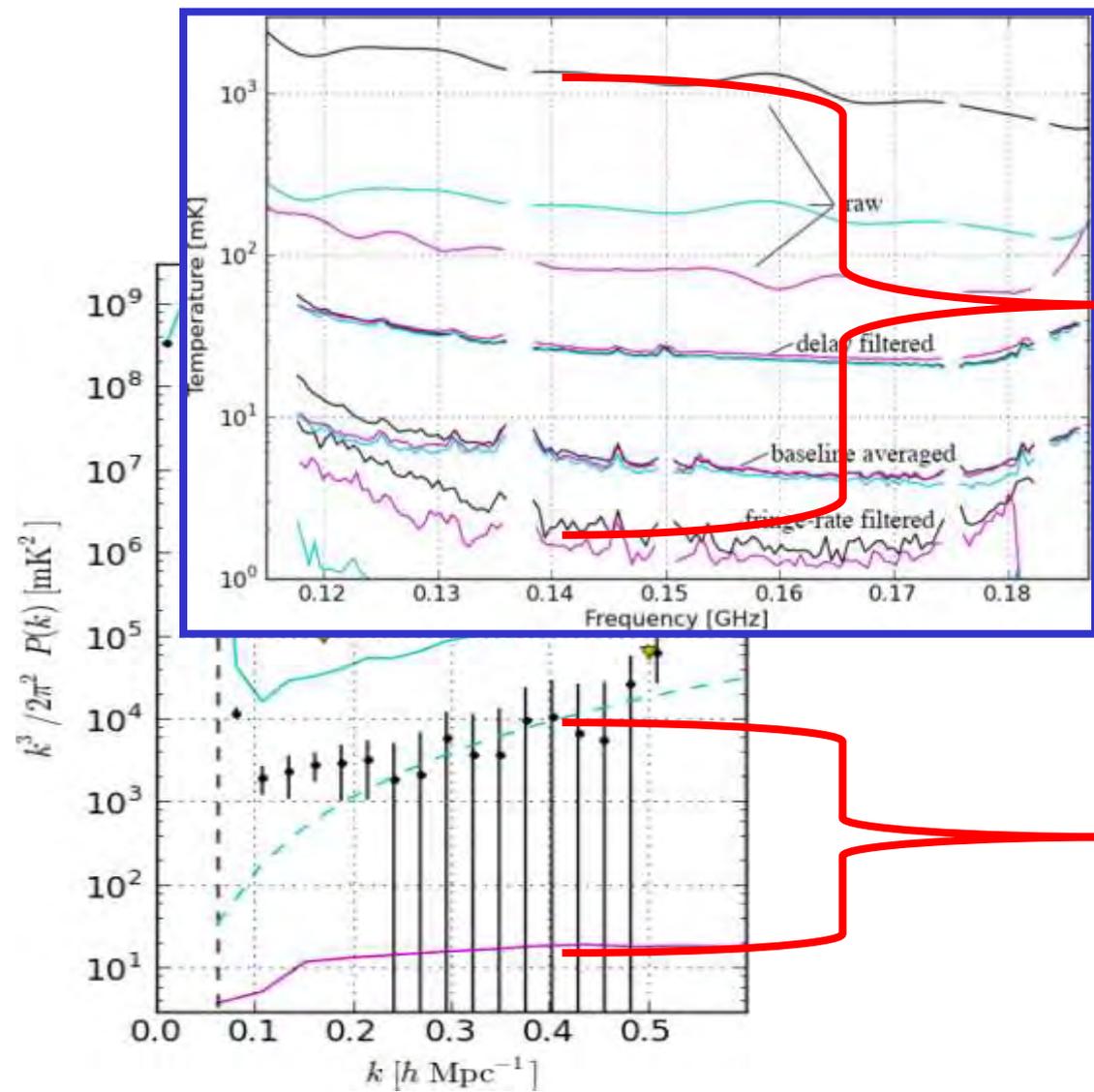
Astrophysics > Cosmology and Extragalactic Astrophysics

New Limits on 21cm EoR From PAPER-32 Consistent with an X-Ray Heated IGM at $z=7.7$

Aaron R. Parsons, Adrian Liu, James E. Aguirre, Zaki S. Ali, Richard F. Bradley, Chris L. Carilli, David R. DeBoer, Matthew R. Dexter, Nicole E. Gugliucci, Daniel C. Jacobs, Pat Klima, David H. E. MacMahon, Jason R. Manley, David F. Moore, Jonathan C. Pober, Irina I. Stefan, William P. Walbrugh



Redshifted 21 cm ~ 2015



3 orders of magnitude passed.

1 to go...

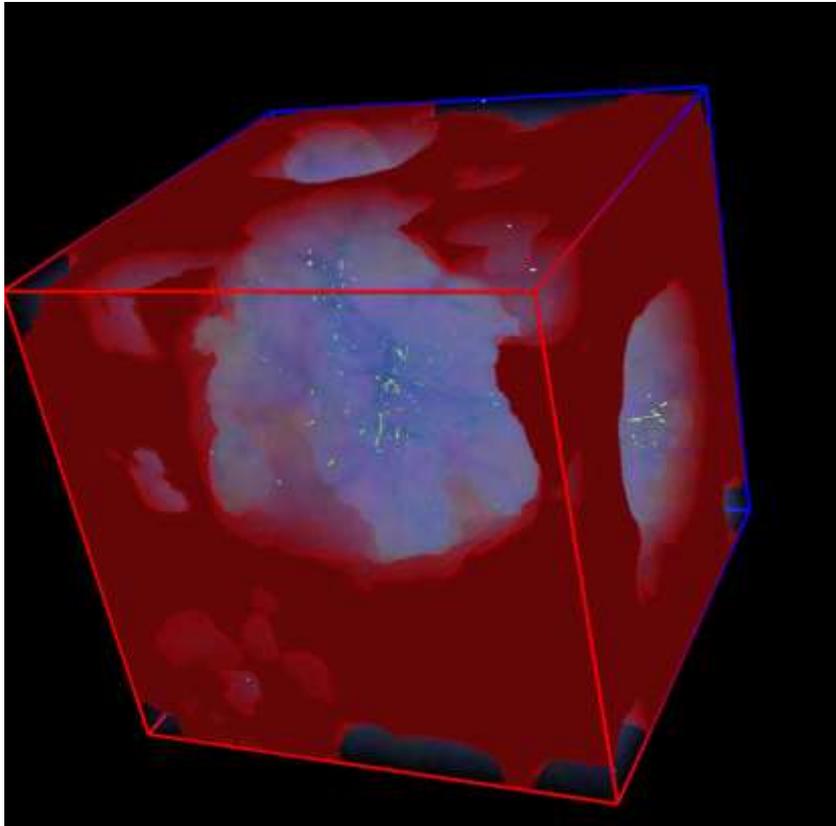


Redshifted 21 cm ~ 2015

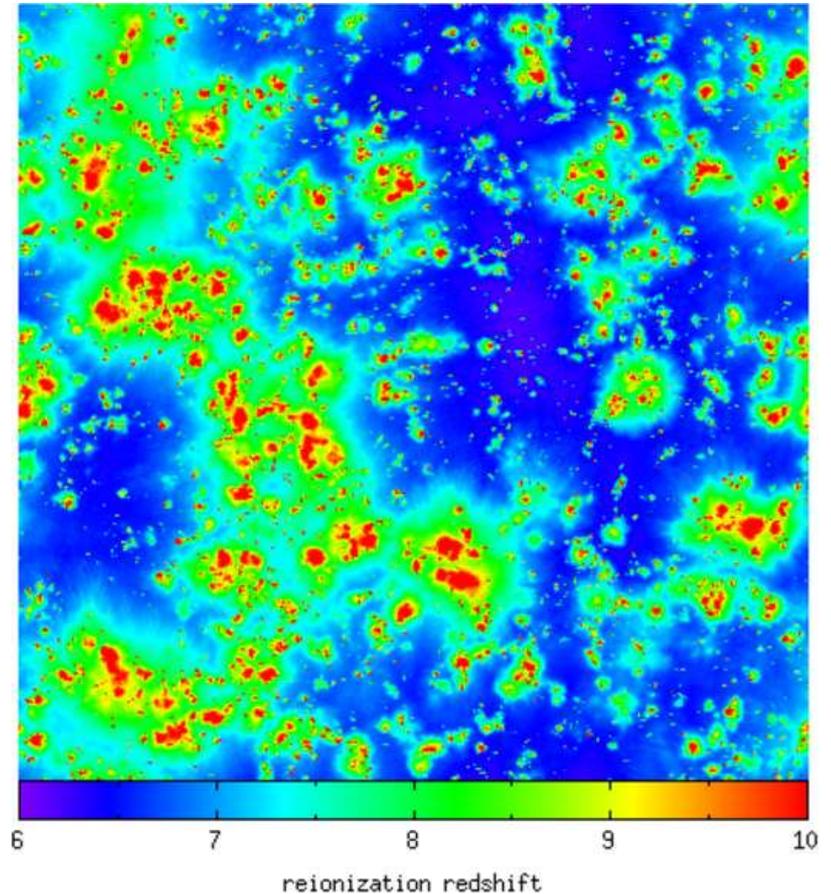
- Progress in measuring the redshifted 21 cm is mind-blowing.
- $\frac{3}{4}$ of the way already passed with ~50% reduced funding.
- The actual detection by ~2015 is likely.



Theory ~ 2005



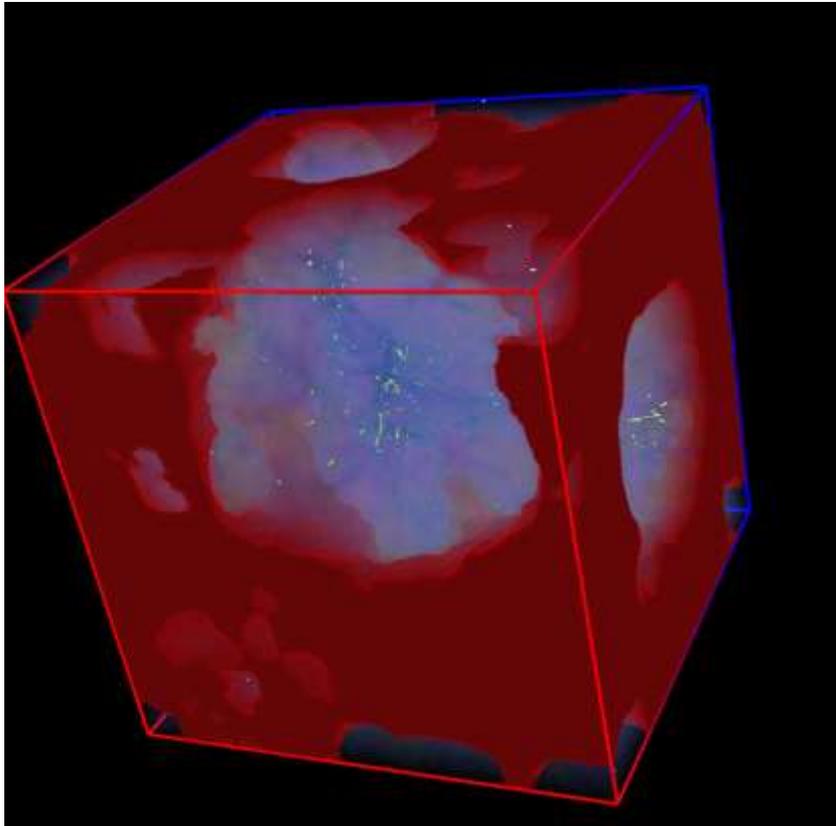
- Small boxes
- Hydrodynamics
- Self-consistent RT



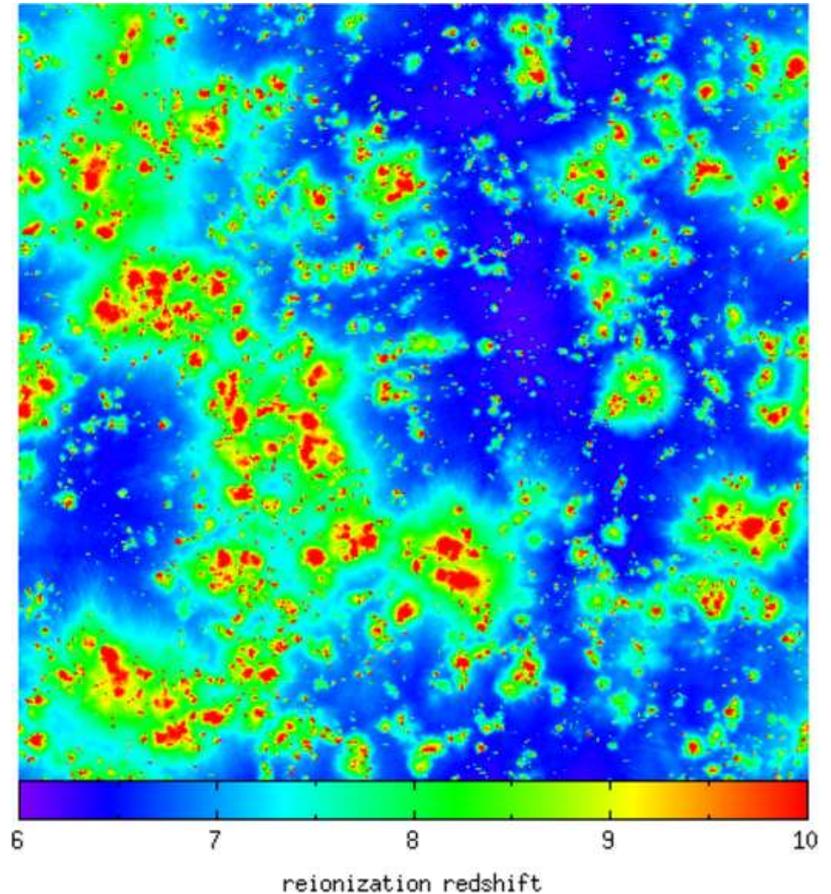
- Large boxes
- N-body
- RT in post-processing



Theory ~ 2010



- Small boxes
- Hydrodynamics
- Self-consistent RT

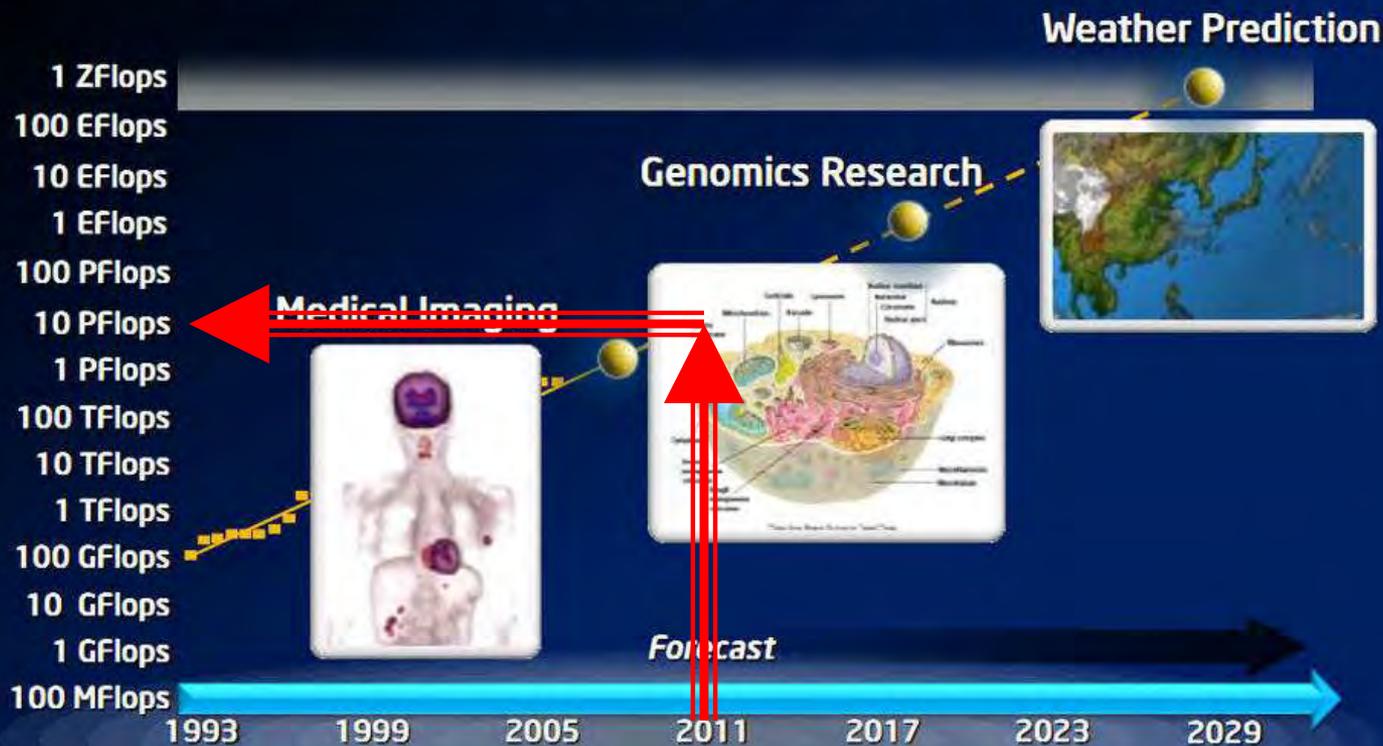


- Large boxes
- N-body
- RT in post-processing



Theory ~ 2015

An Insatiable Need For Computing

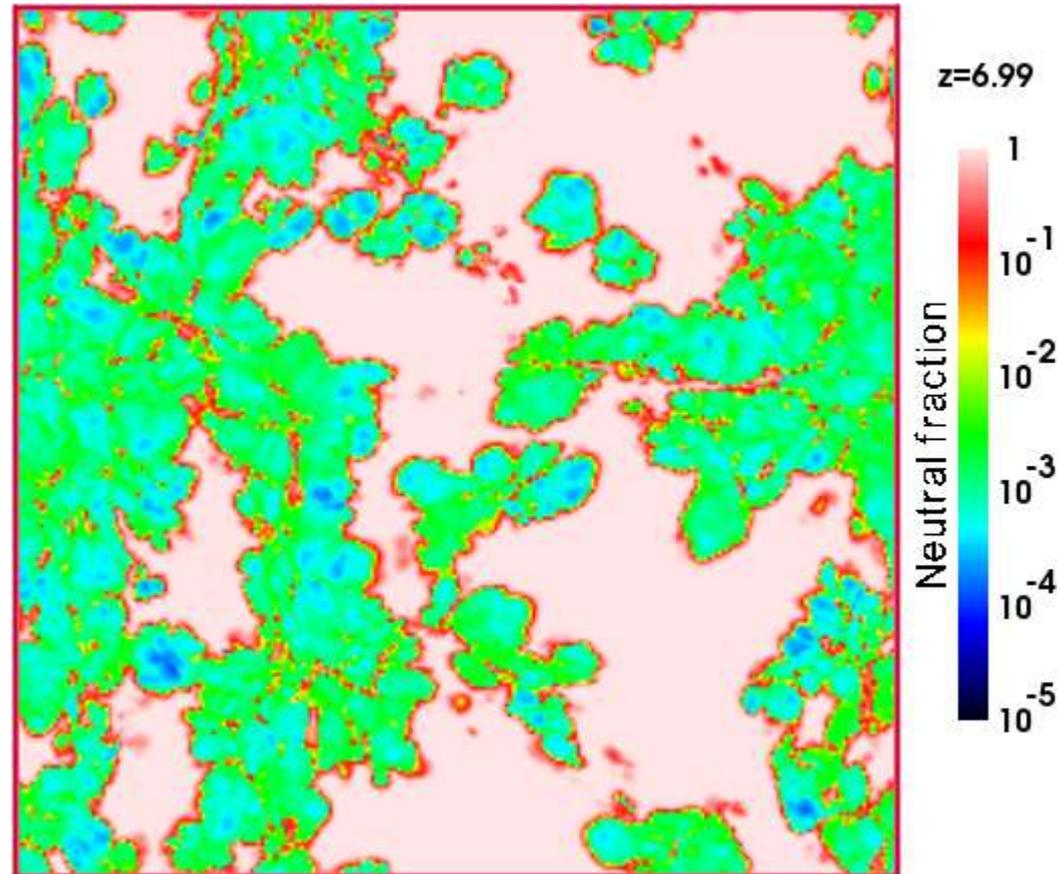


Exascale Problems Cannot Be Solved Using the Computing Power Available Today

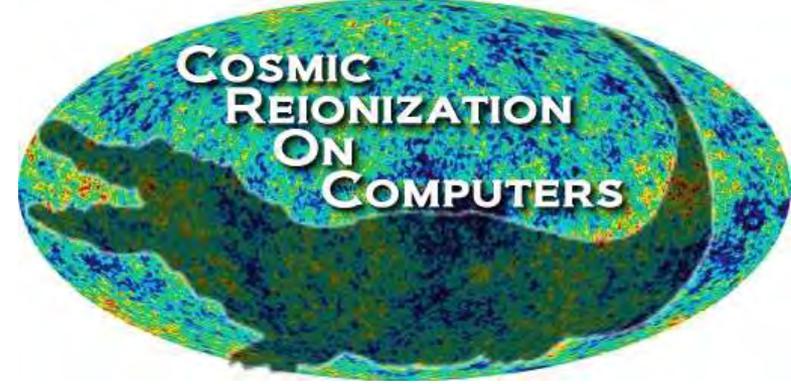


Theory ~ 2015

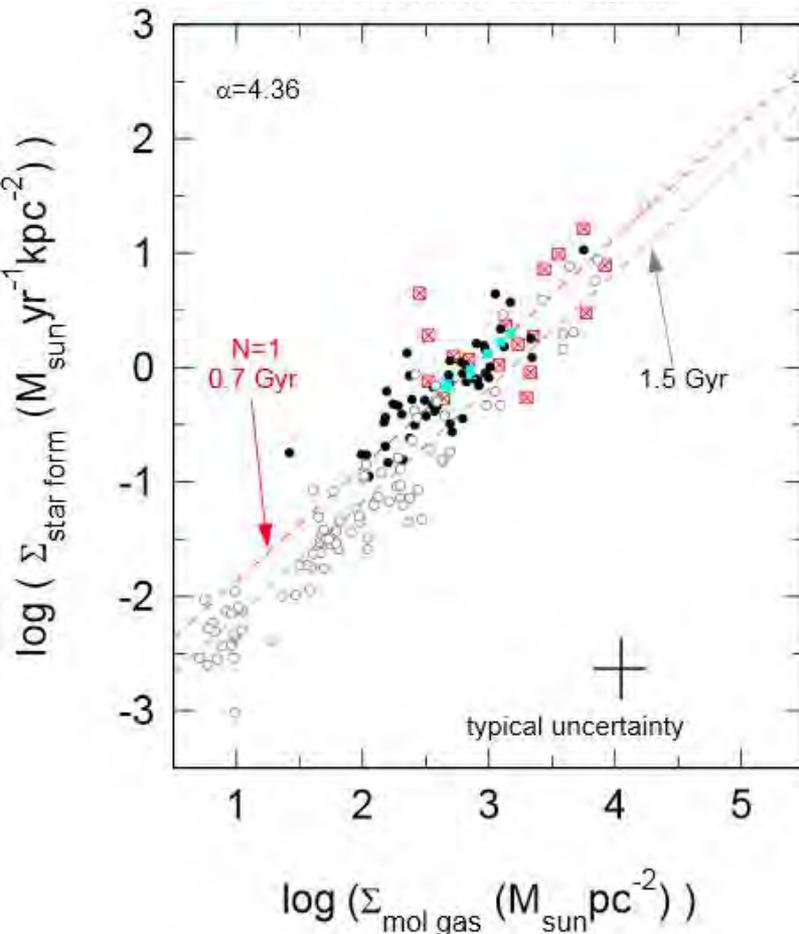
- Sustained peta-scale computing is what needed to jump-start the reionization theory.
- With such computing power, one can run hydro simulations with the fully self-consistent RT in 100 Mpc boxes.



CROC Project

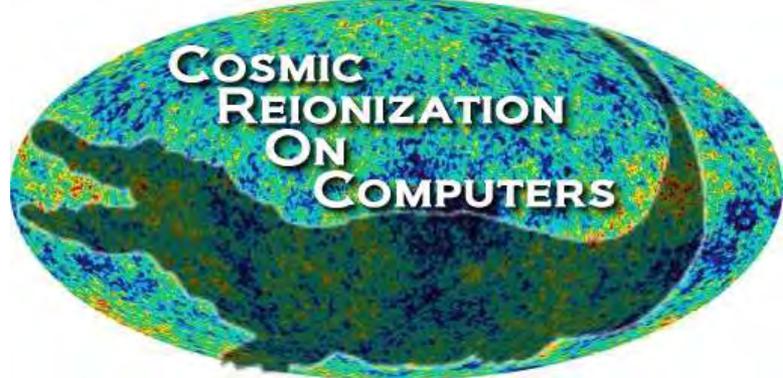


(Tacconi et al 2013)

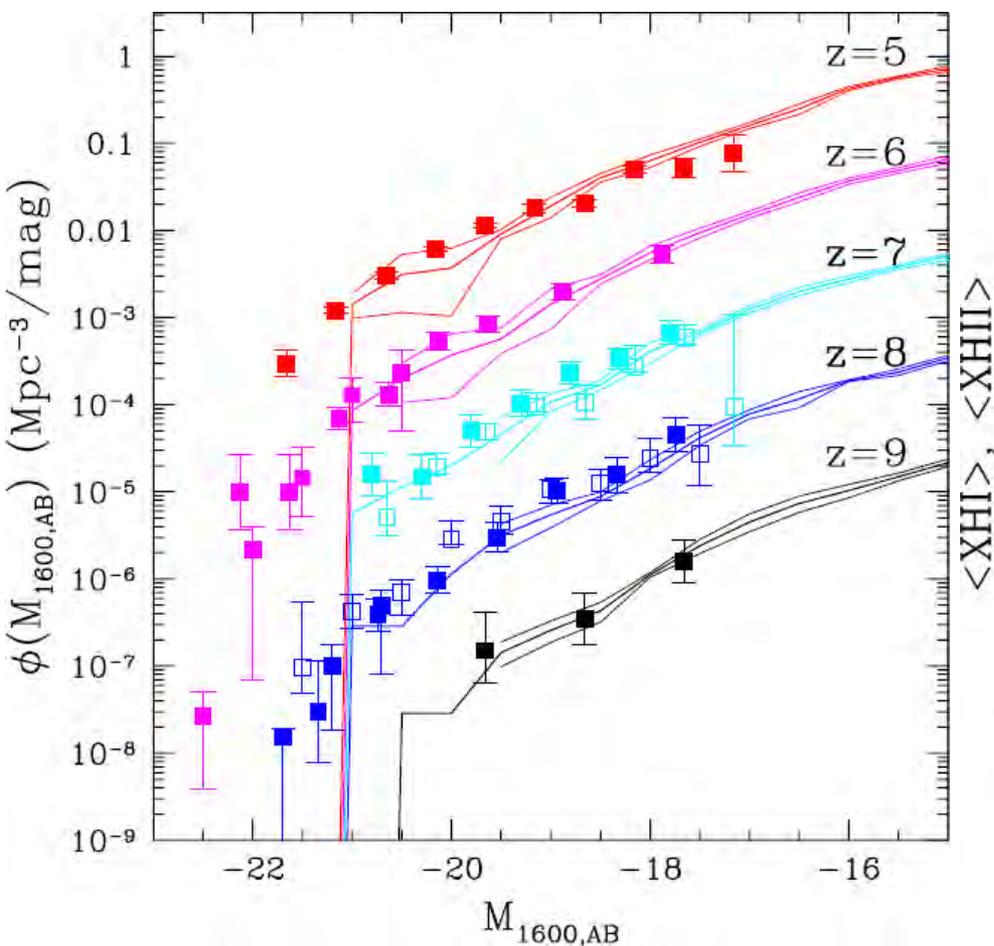


- Star formation based on the observed molecular Kennicutt-Schmidt relation.
- Standard (“blastwave”) feedback model.
- Up to 200,000 dynamic range with AMR.
- Fully self-consistent RT.

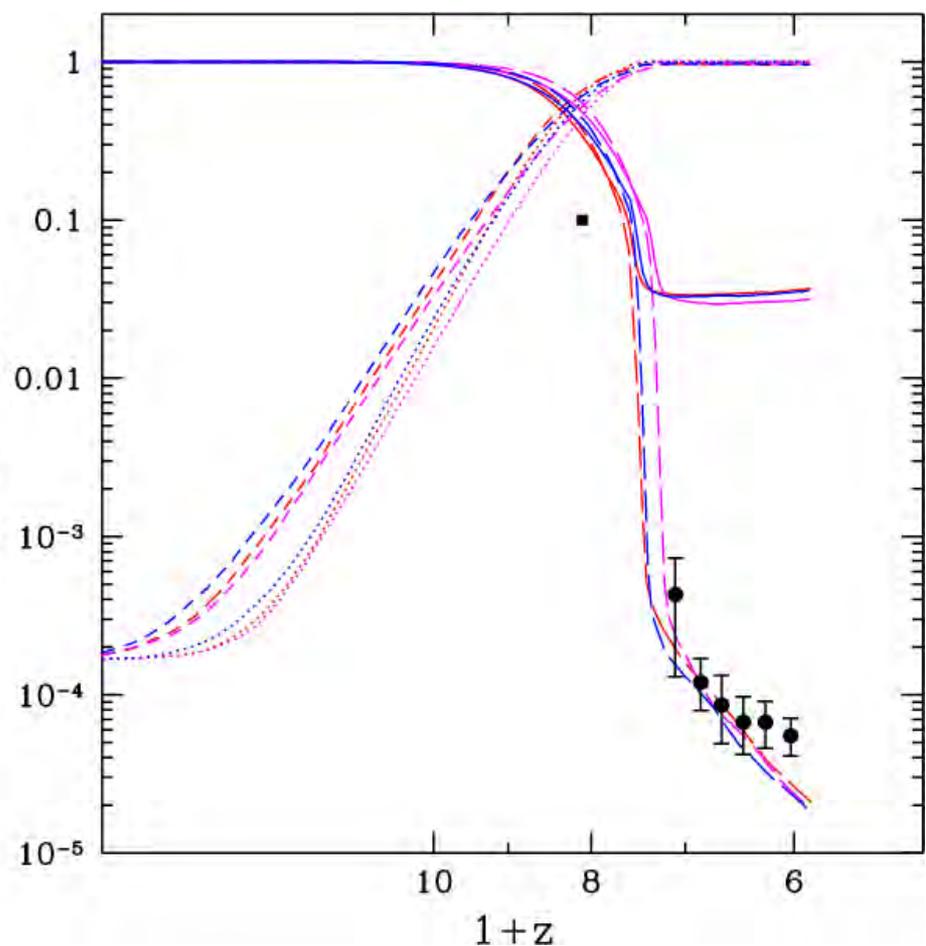
CROC Project



✓ UV luminosity functions



✓ IGM opacity





Playing Field ~ 2020

- Two big guys on the block: JWST and GMT.
- By ~2020 we should have:
 - Detection of 21 cm signal and the measurement of the 21 cm power spectrum over ~ 1 dex in wavenumber; perhaps, images of a few large HII regions around brightest quasars.
 - Detailed numerical simulations that model ~100 Mpc boxes with ~10 pc resolution, resolving galactic disks and the escape of ionizing radiation from star-forming regions.



Let's Dream! ~ 2020

- “21 cm tomography” – matching HII regions to their source galaxies (and yes, hemisphere does matter, MWA & PAPER are in the south):
 - relative escape fractions
 - with proper modeling – clustering of galaxies and gas
 - possibly, in large enough HII regions, constraints on the non-stellar/non-AGN ionizing sources (like DM annihilation)



Let's Dream! ~ 2020

- Spectroscopy: detailed studies of proximity zones around large quasars:
 - properties of host halos of quasars
 - properties of surrounding IGM (albeit a highly biased part of the universe)
- Spectroscopy: constraining the evolution of the (bright end of the QSO) luminosity function:
 - time-scales for supermassive black hole growth
 - perhaps, constraints on seed masses



Let's Dream! ~ 2020

- Spectroscopy: metal pollution in the IGM
- Evolution and clustering of Lyman- α emitters:
 - dust abundance in first galaxies (the only place where dust formation/destruction timescales matter)
 - extra clustering of Lyman- α emitters due to foreground absorption (?)
- Other cool stuff someone smart will come with...



Conclusions

- Reionization studies are like Roman legions: steady and unstoppable.
- The rest of this decade will see it becoming multi-wavelength (with multi = 2) – there is little doubt that redshifted 21 cm signal will be detected in the next 2-3 years (barring some major economic crisis).
- GMT and, to a lesser extent, JWST will be instrumental in complimenting radio (gas) with studies of infrared (stars).

The End

