

Modeling Reionization Sources in the JWST Era

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The Flood Is Coming

- Astro2010:

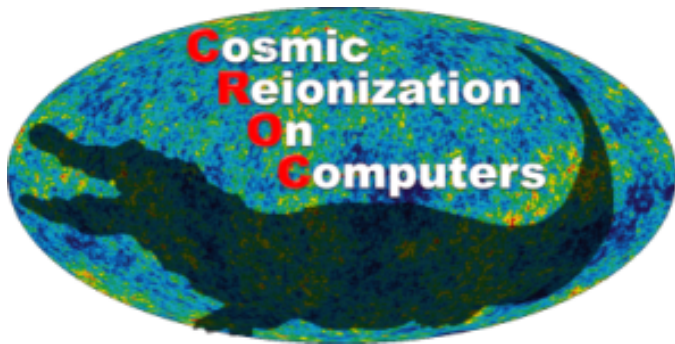
The priority science objectives chosen by the survey committee for the decade 2012-2021 are searching for the first stars, galaxies, and black holes;

- ALMA: 2014+
- **JWST: 2018**
- HERA: 2015-2020
- NGOT: 2021-2025
(GMT, TMT, E-ELT)



The Flood Is Coming

- It is clear that forthcoming observations will make all existing theoretical models obsolete.
- We are preparing for the flood:

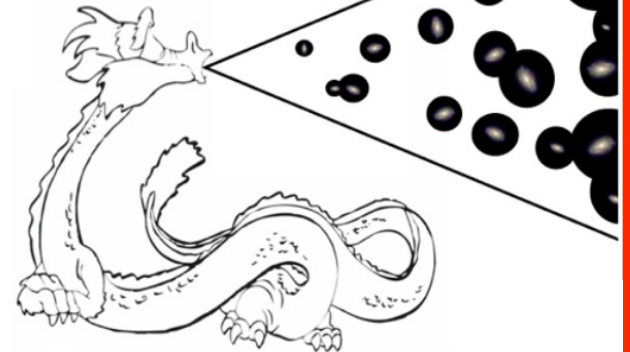


Cosmic Dawn

Emma

**Renaissance
Simulations**

DRAGONS

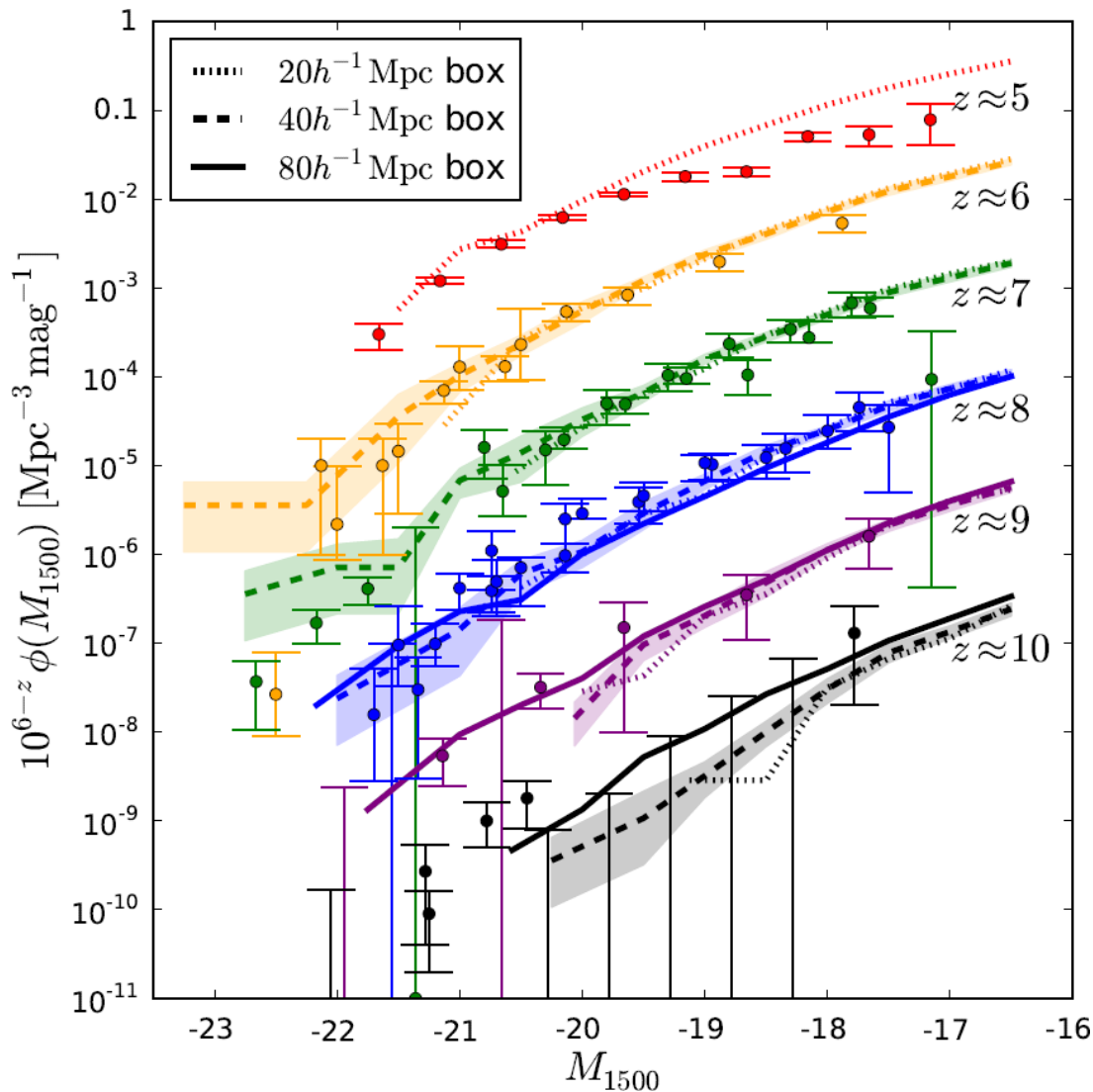
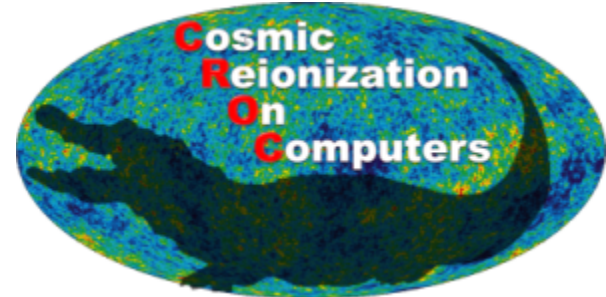


Covering The Gap

- With modern computing power we can run $(100 \text{ Mpc})^3$ volume simulations with 100 pc resolution and full physics.

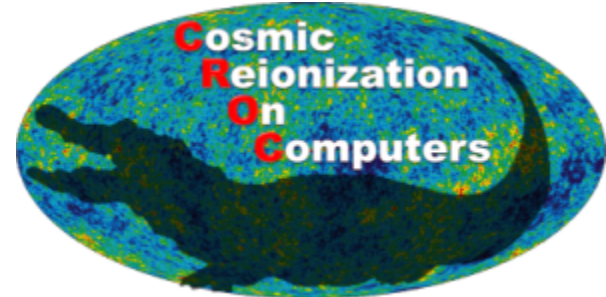
| | 2000-2010 | | 2015 |
|--------------------|-----------|------------|---------------------------|
| | Small box | Large box | |
| physics | full | incomplete | full (SFF+RT) |
| spatial resolution | high | low | high (100 pc) |
| mass resolution | high | high | high ($10^6 M_{\odot}$) |
| dynamic range | low | high | high ($>10^5$) |
| volume | small | large | large (100 Mpc) |

The CROC Project: Validation

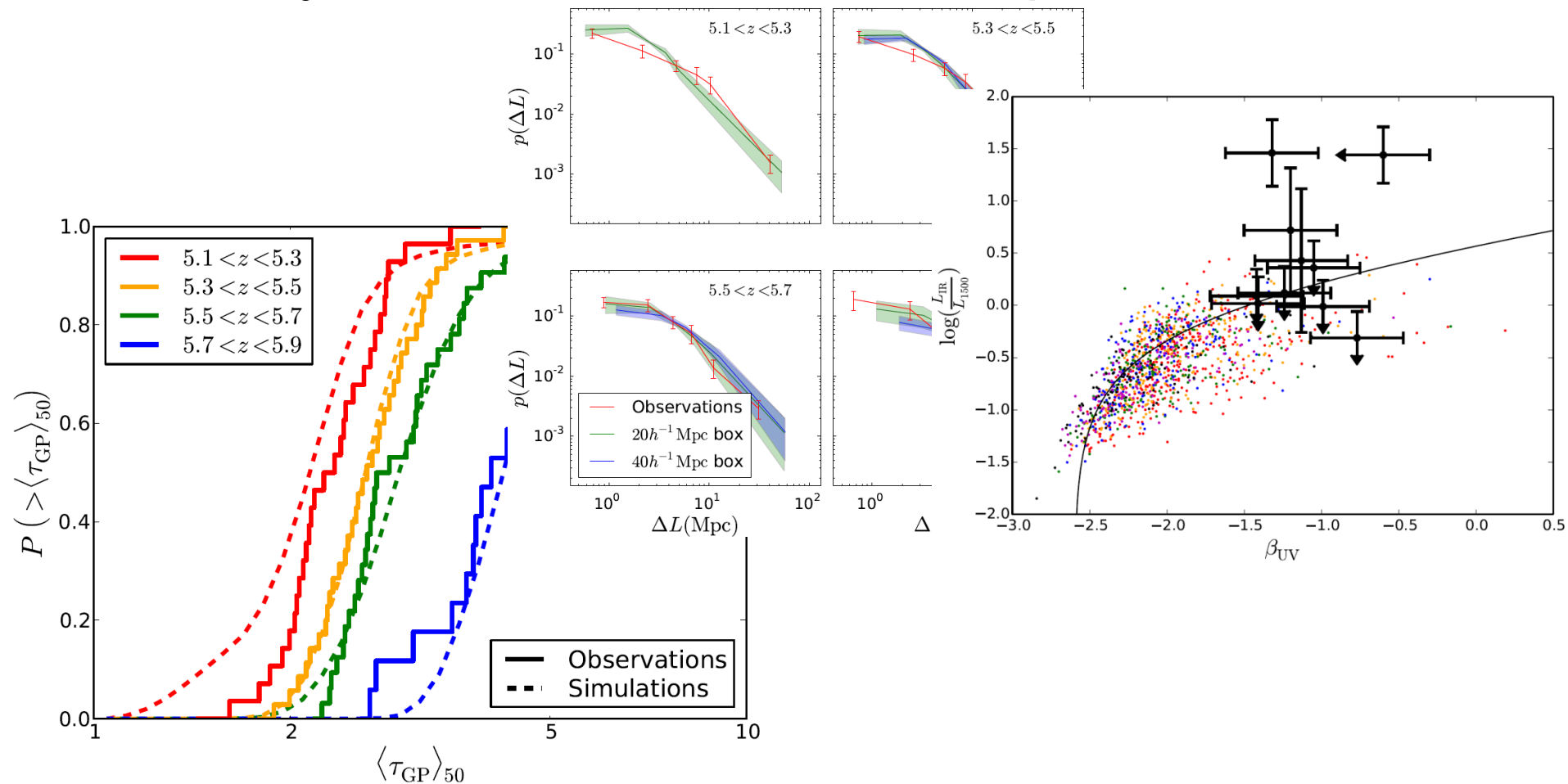


- Galaxies in right halos *all the time!*

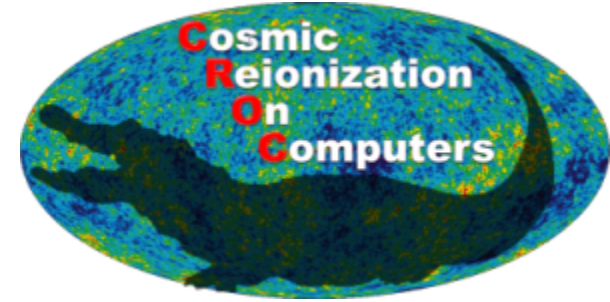
The CROC Project: Validation



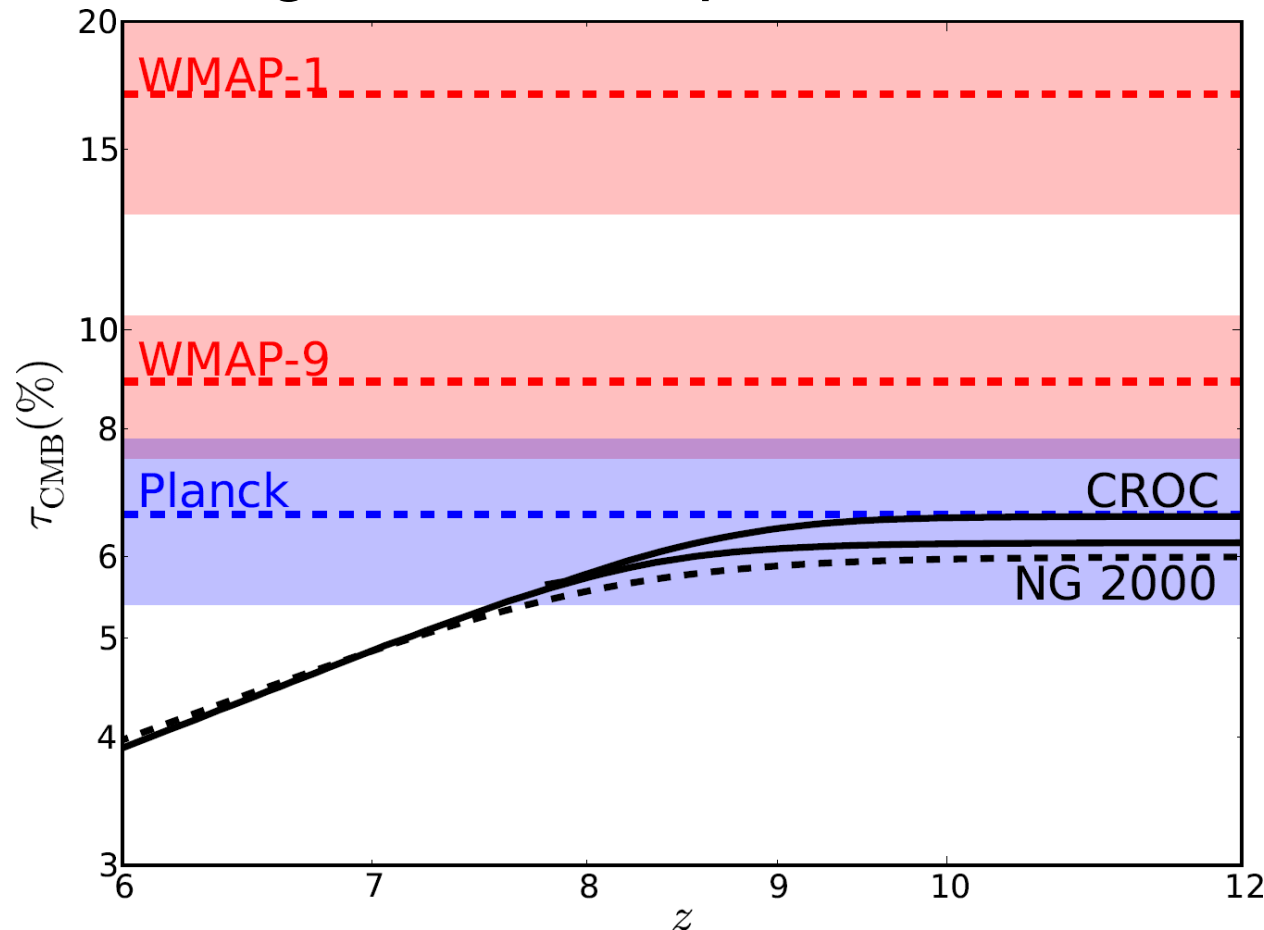
- Many other observations are reproduced too...



The CROC Project: Validation

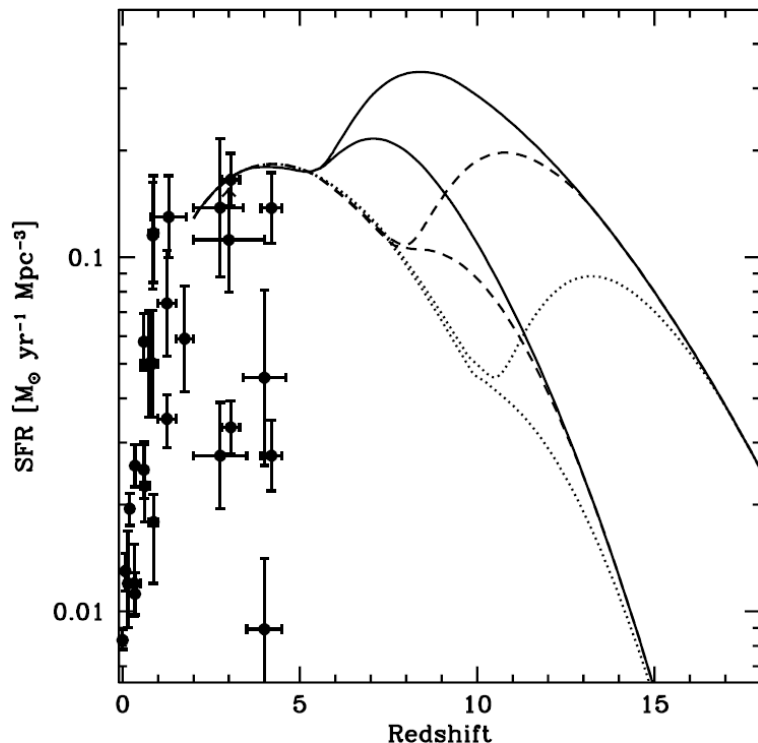


- Finally, CMB observations succeeded in matching theoretical predictions.



Lesson 1: Backreaction of Reionization on Galaxies

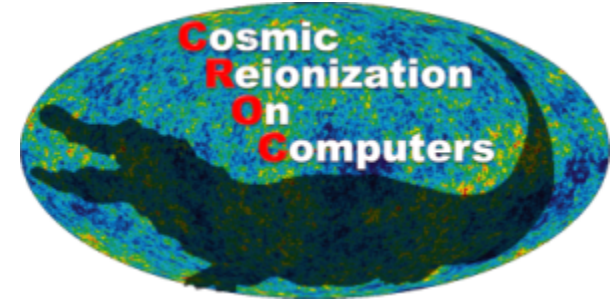
- Reionization suppresses gas accretion on low mass halos (“photoevaporation”).
- Reionization may affect global star formation rate (“Barkana & Loeb effect”).



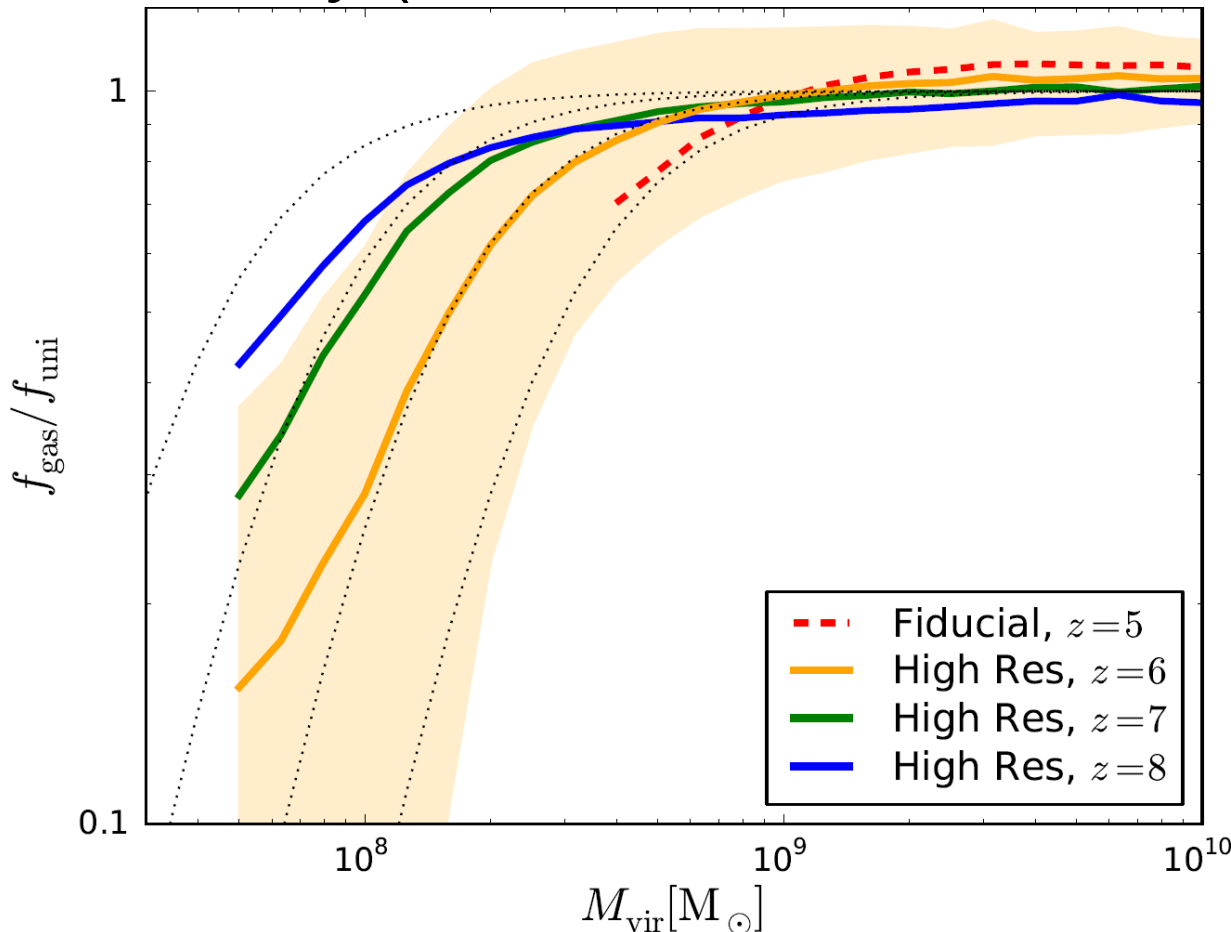
- One of JWST science goals.

(Barkana & Loeb 2000)

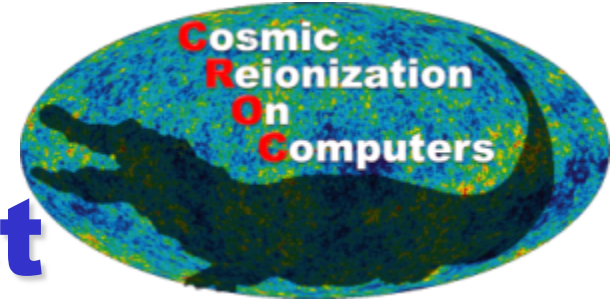
Backreaction: Gas Fractions



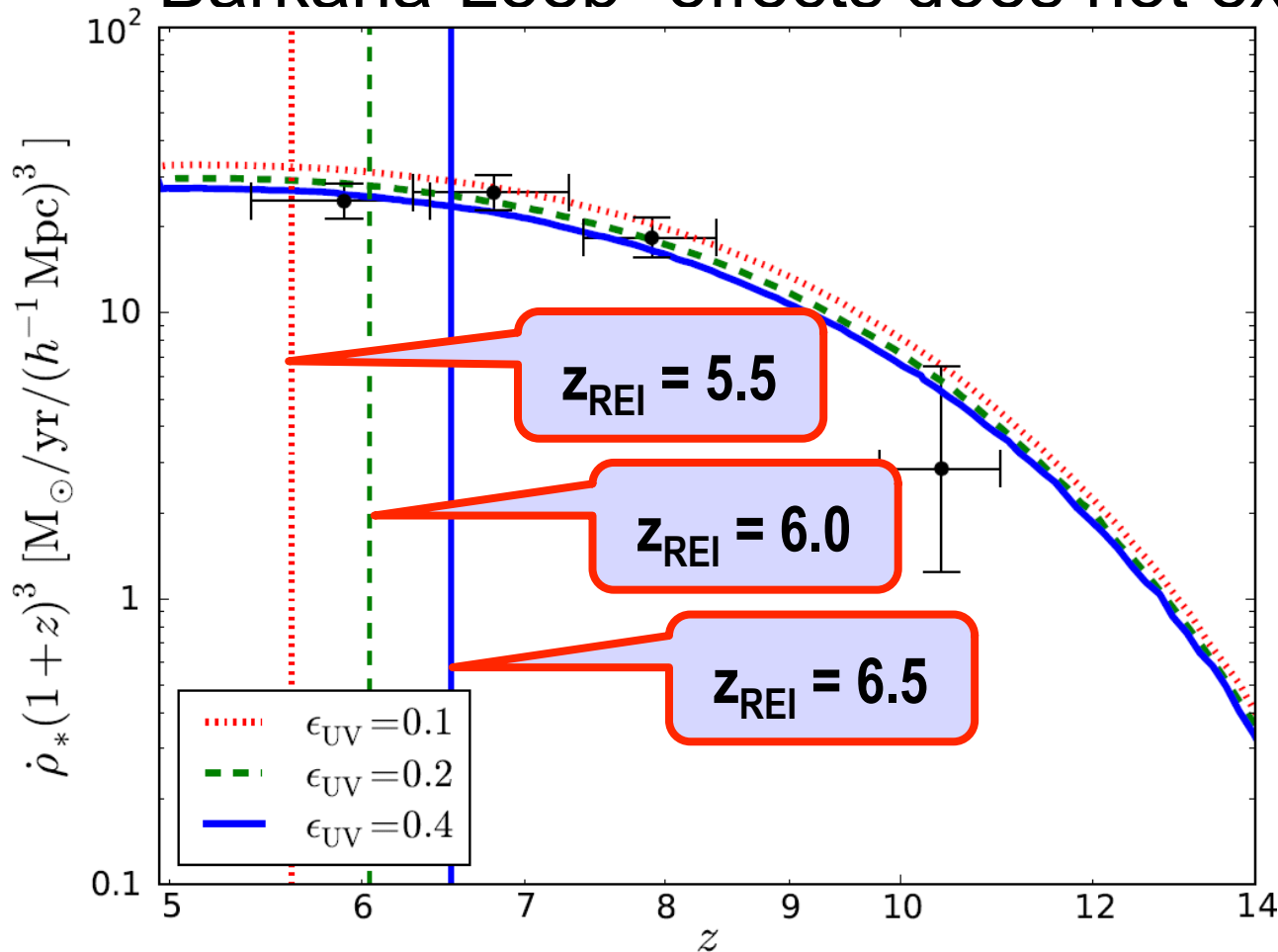
- Match Okamoto et al (2008) results *exactly* (after reionization, of course).



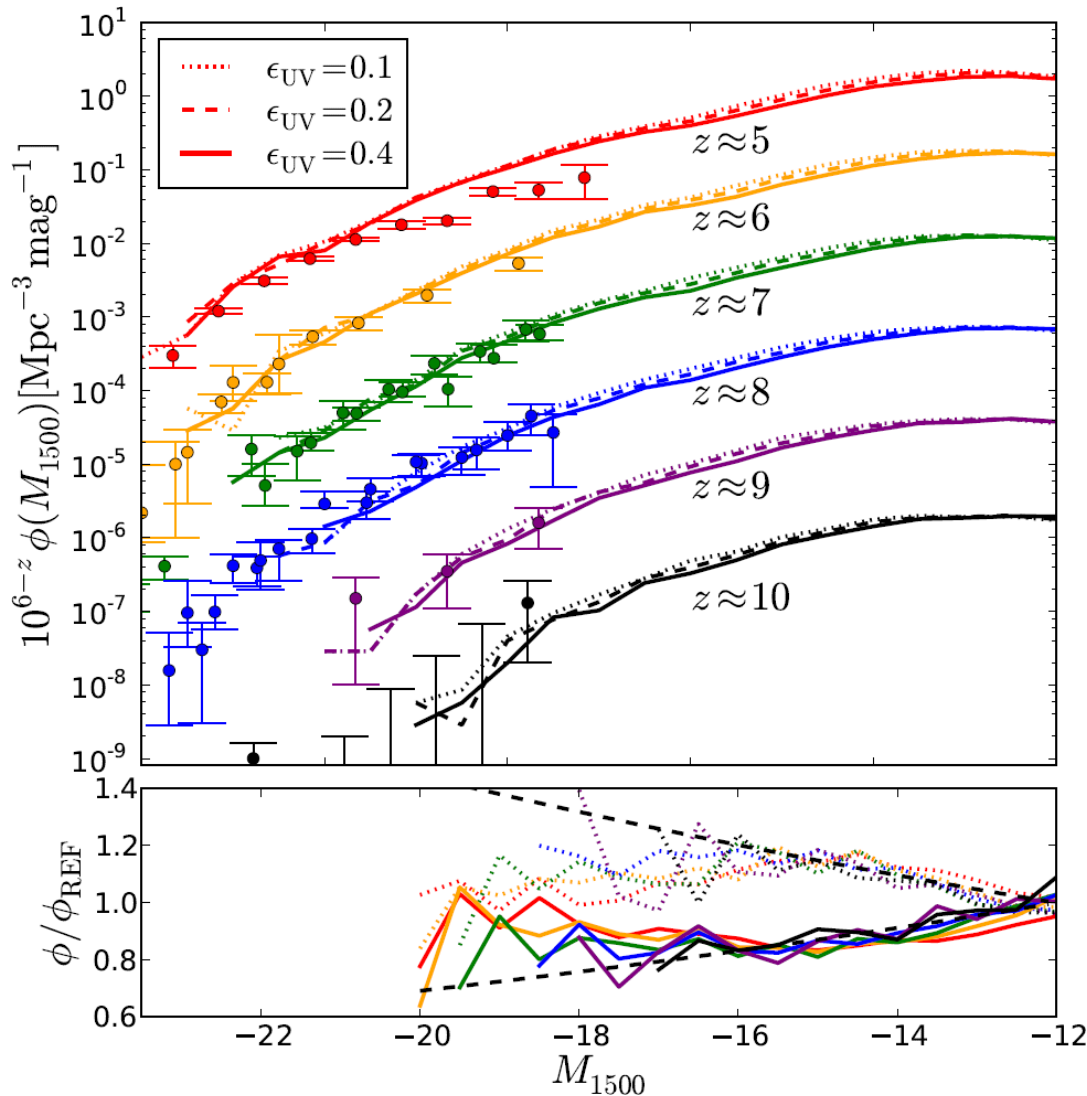
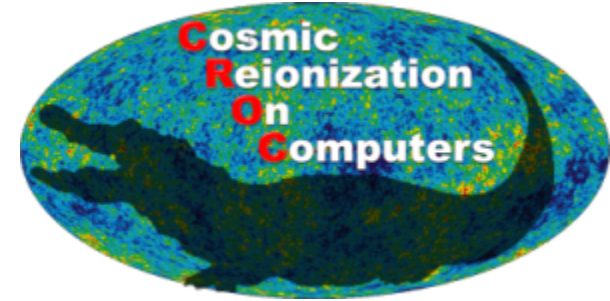
Backreaction: Barkana-Loeb Effect



- There is no feature at reionization:
“Barkana-Loeb” effects does not exist.

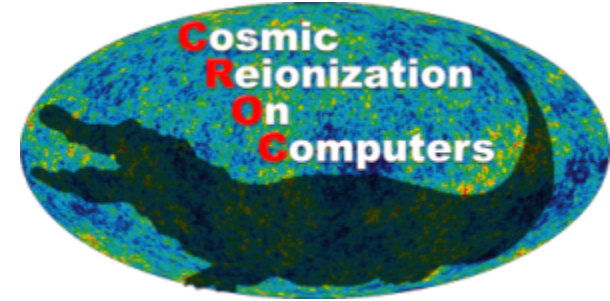


Backreaction: Faint-End Slope

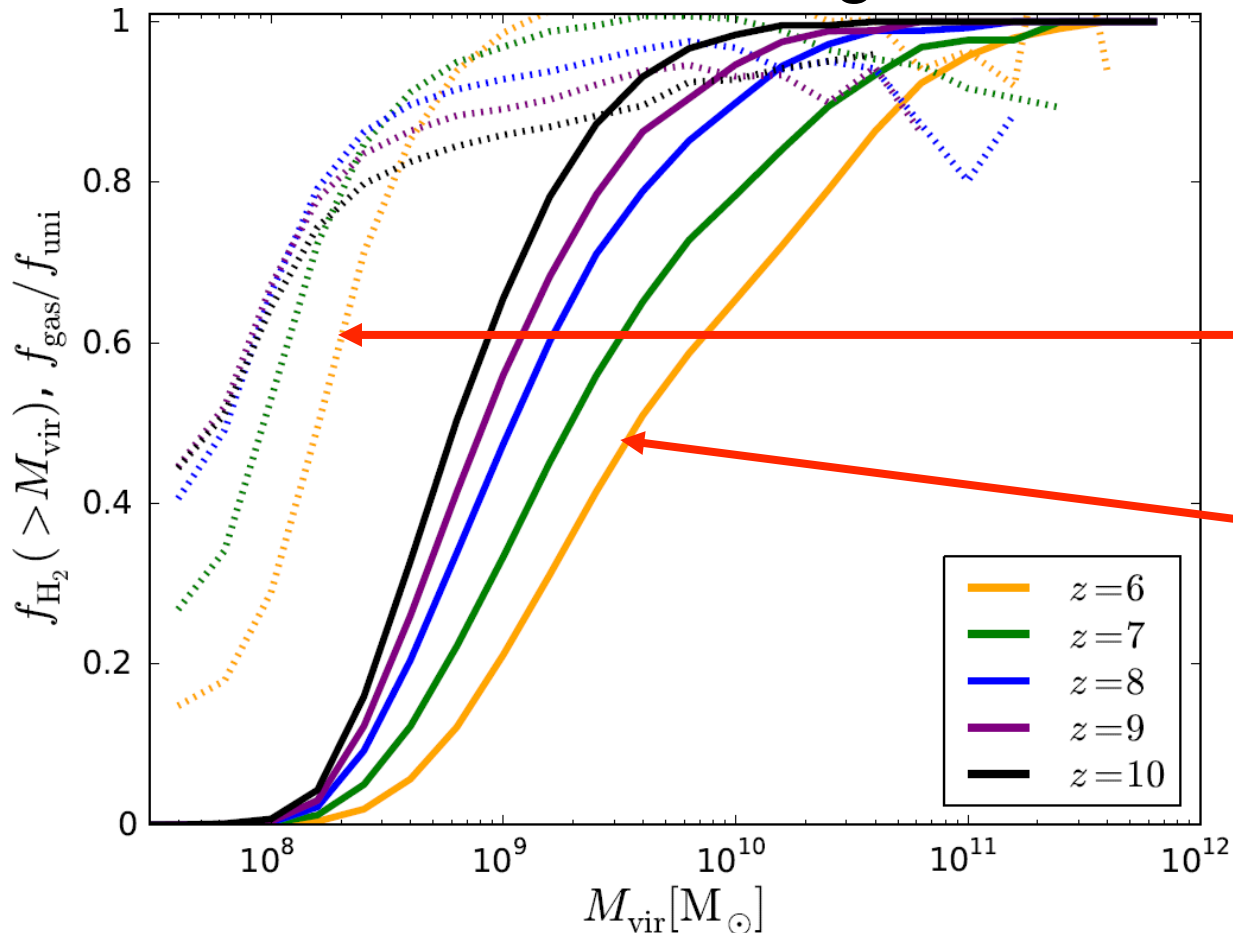


- The faint-end slope of UV luminosity function varies by $\Delta z = 1$ for $\epsilon_{\text{UV}} = 0.1$

Backreaction: Why?



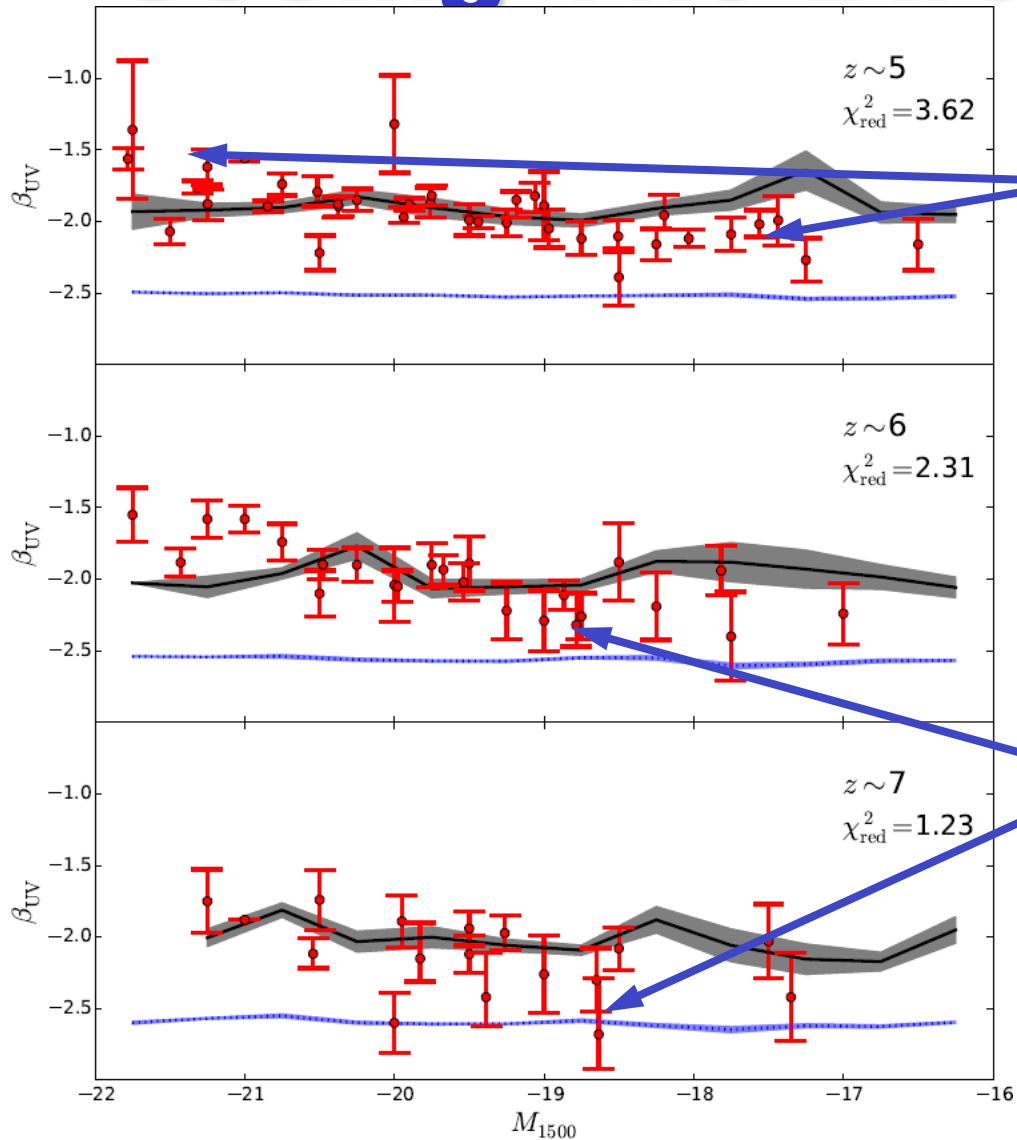
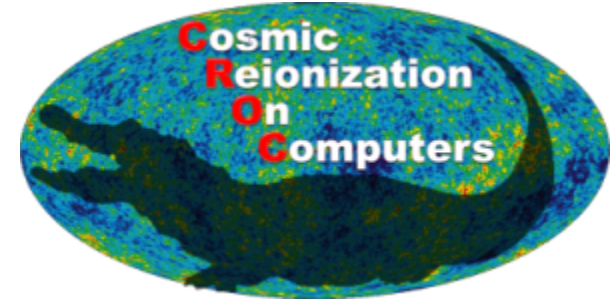
- Galaxies affected by photoionization contain no molecular gas.



Gas fractions

Molecular gas

Lesson 2: Are We Seeing The Birth of



Dust?

... slope is too flat

... scatter is too low

Conclusions

- Supercomputing power has passed the “petascale” mark. That power is just right for modeling cosmic reionization numerically.
- The first *realistic* simulations of reionization are currently being developed by several groups (CROC, DRAGONS, CosmicDawn, etc).
- We already learned new things (there is no backreaction, dust is a living beast, why blue galaxies are bright in FIR, ...).
- By the time JWST floods us with data, theorists’ Ark will be ready.