Cosmology and Astrophysics with EQUALS

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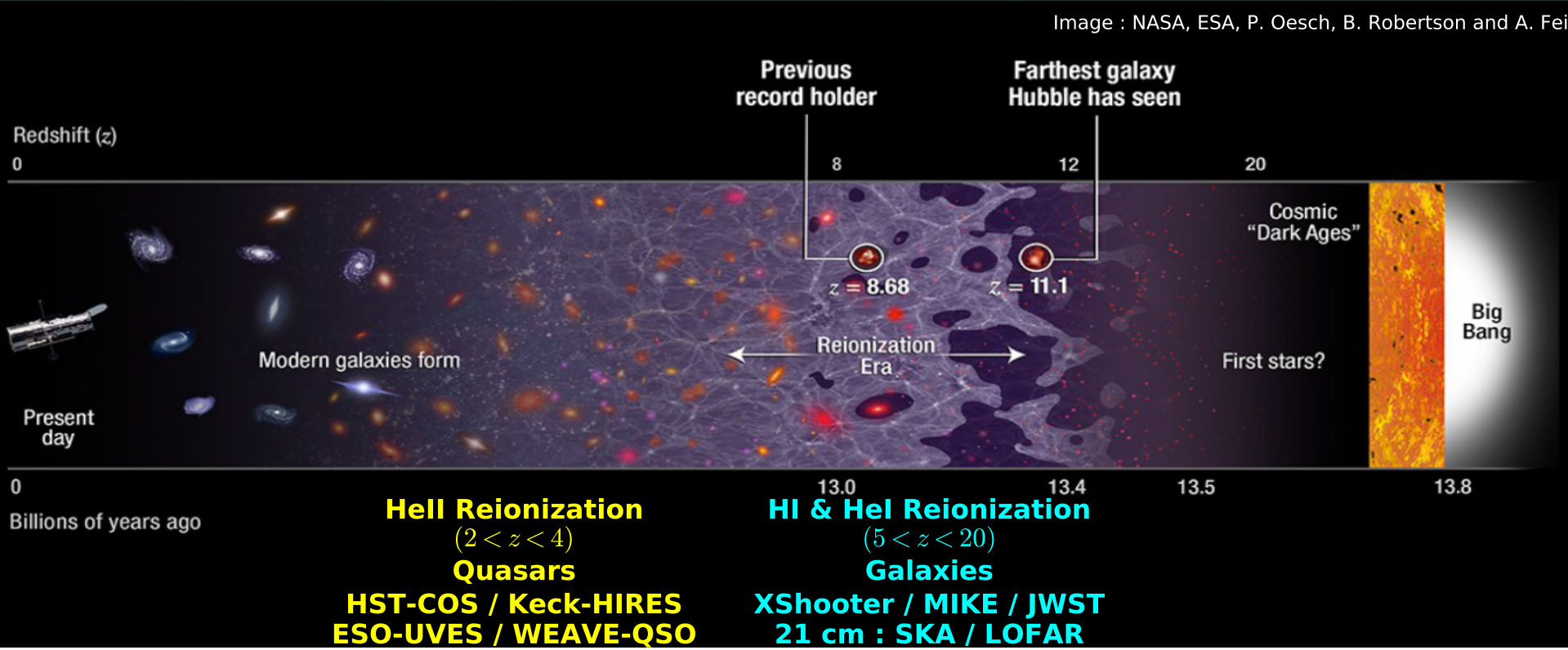
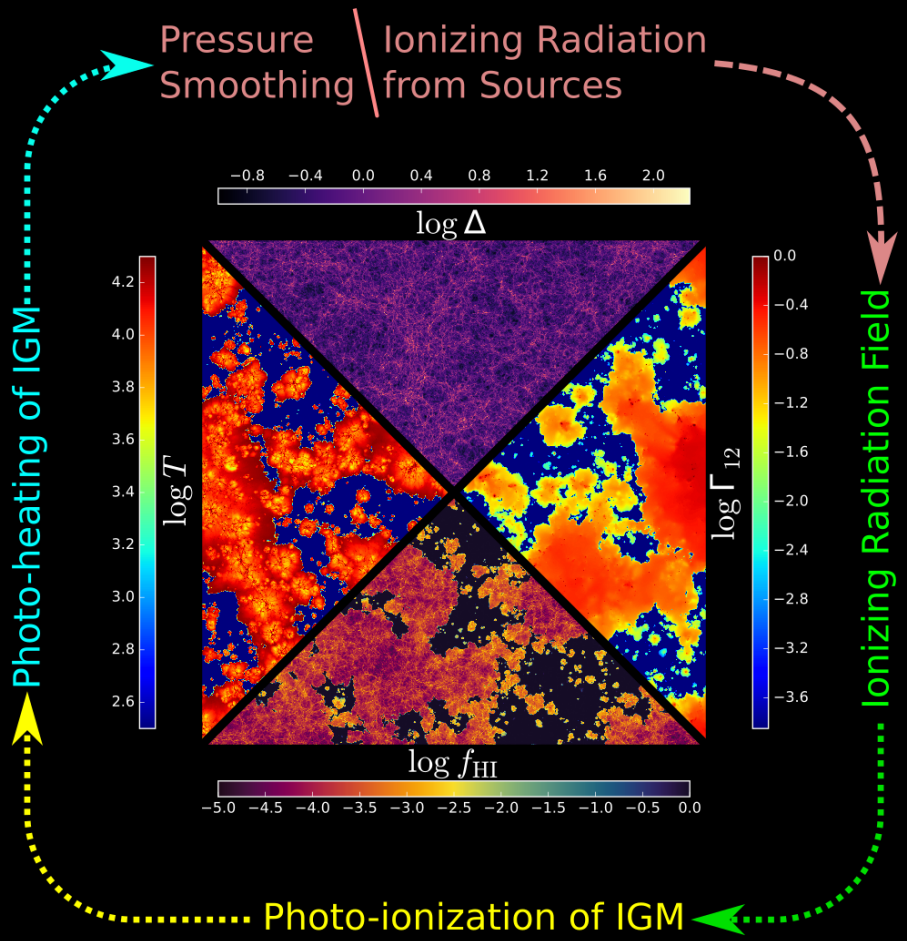
Introduction



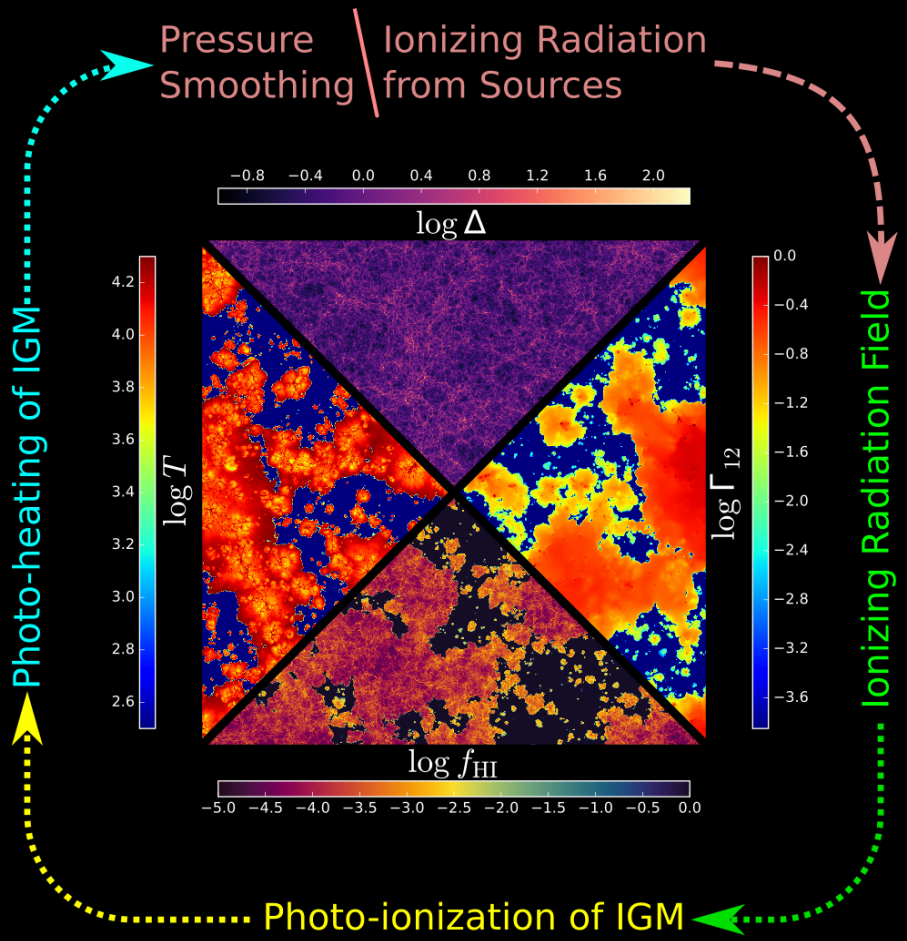
- 3 Important questions of reionization
- Timing of reionization? $\Rightarrow$ Early vs Late reionization
- Nature of reionization? $\Rightarrow$ Uniform vs Patchy
- Sources of reionization? $\Rightarrow$ Small or Large mass Galaxies, $f_{\rm esc}$?

Motivation



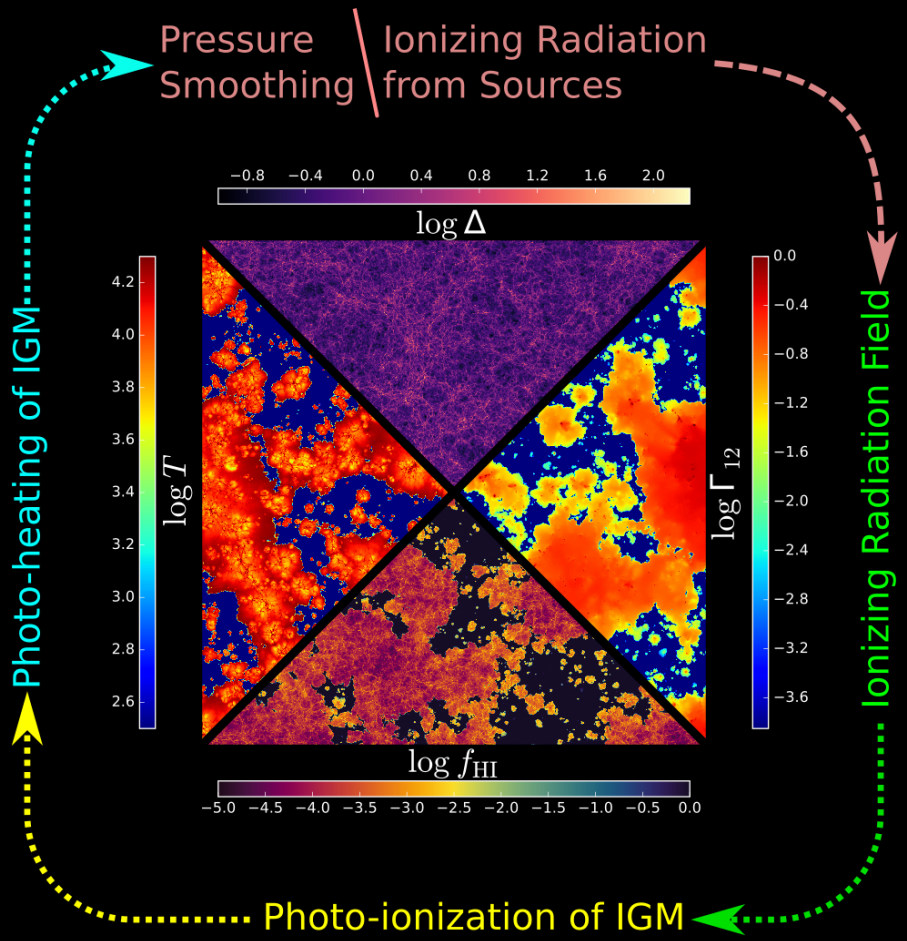
- 3 Important questions of reionization
- Timing of reionization?
- Nature of reionization?
- Sources of reionization?

Motivation



- Evolution of 3 IGM parameters to understand procees of reionization
- Timing of reionization? $\Rightarrow$ Neutral Fraction, Photo-Ionization Rate
- Nature of reionization? $\Rightarrow$ Mean Free Path of ionizing photons
- Sources of reionization? $\Rightarrow$ Temperature of IGM (SED of sources)

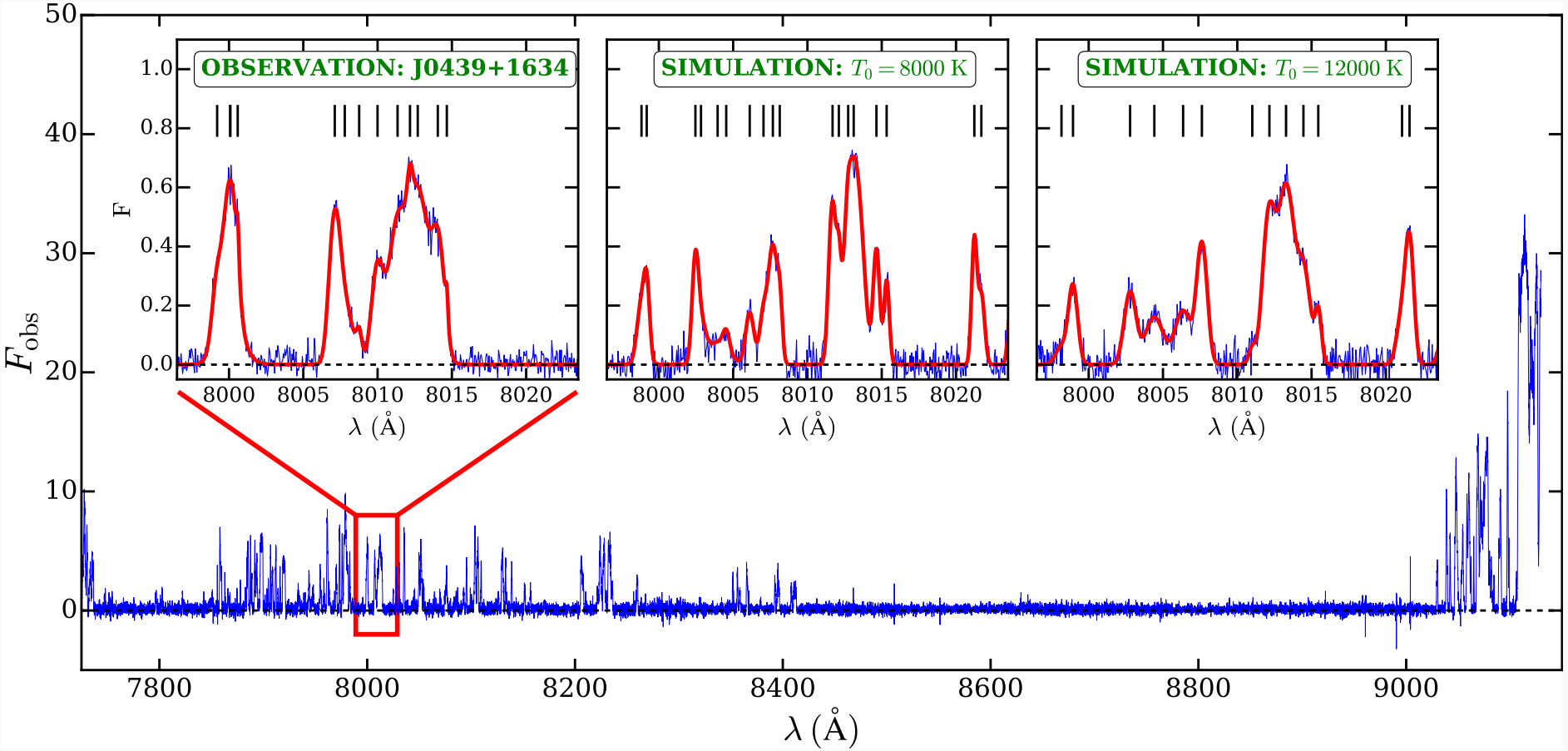
Motivation



- Previous Research was focused on measuring evolution of $\Gamma_{\rm HI}$, $f_{\rm HI}$, $\lambda_{\rm mfp}$, T_0
- Timing of reionization? $\Rightarrow$ Neutral Fraction, Photo-Ionization Rate
- Nature of reionization? $\Rightarrow$ Mean Free Path of ionizing photons
- Sources of reionization? $\Rightarrow$ Temperature of IGM (SED of sources)

Previous Research

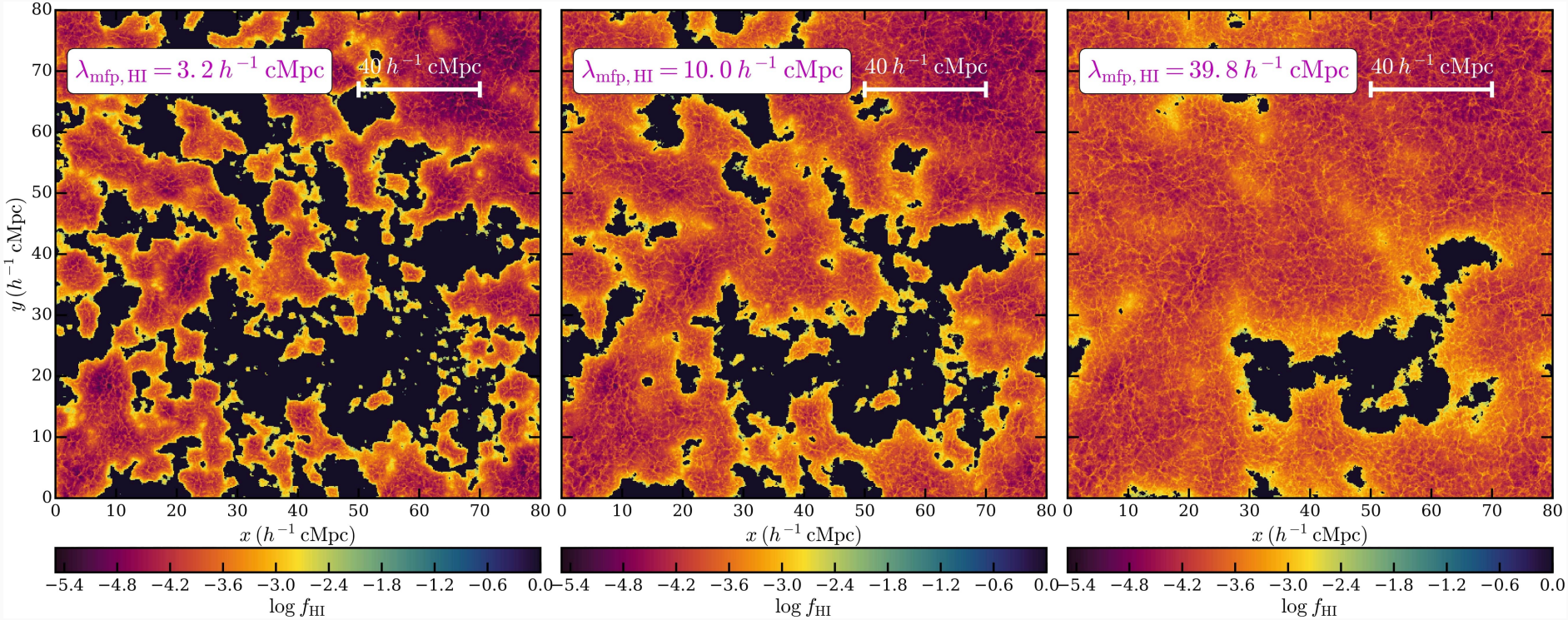
[Gaikwad+2020,2021,2023]



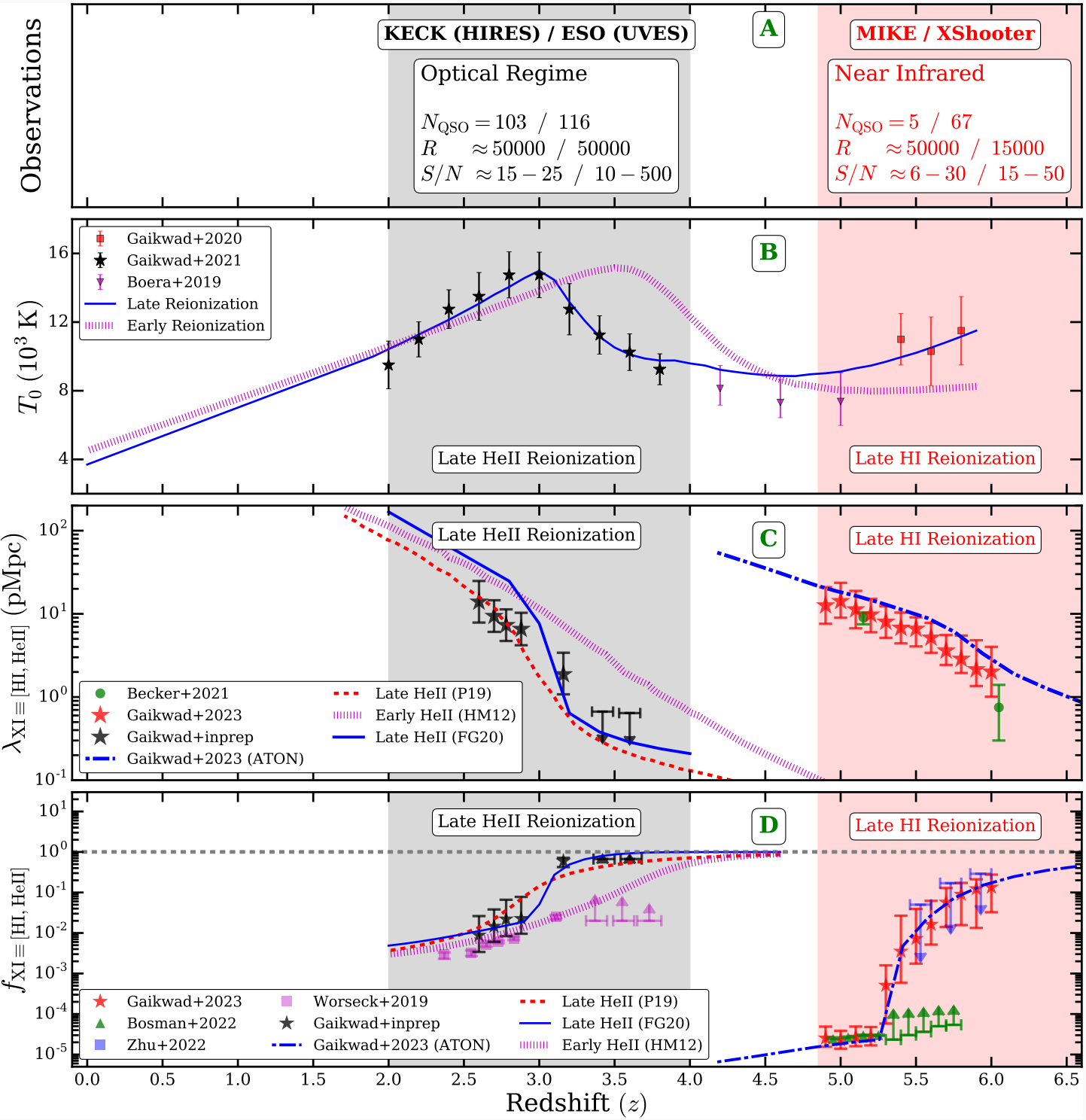
- How can we measure / constrain $f_{\rm HI}$, $\lambda_{\rm mfp,HI}$ and T_0?
- Comparing properties of observations with simulations.
- Observations: Quasar absorption spectra (Lyα forest)
- Simulations: Sherwood-Relics post-processed with EX-CITE or ATON

Previous Research

[Gaikwad+2020,2021,2023]



- I have developed codes to analyze QSO absorption spectra in observations and simulations
- EX-CITE, GLASS, WEAVEIFY, VIPER, SPECRED, HEART (Available on Bitbucket)
- SPECRED ⇒ To coadd spectra, fit continuum and mask metal lines (Gaikwad+2021)
- VIPER ⇒ To decompse Lyα forest in multi-component Voigt profiles (Gaikwad+2017)
- EX-CITE ⇒ To model patchy reionization (Gaikwad+2023)
- GLASS ⇒ To generate QSO absorption spectra in simulations (Gaikwad+2018)
- WEAVIFY ⇒ To add instrumental resolution, noise and continuum to simulated spectra



Previous Research

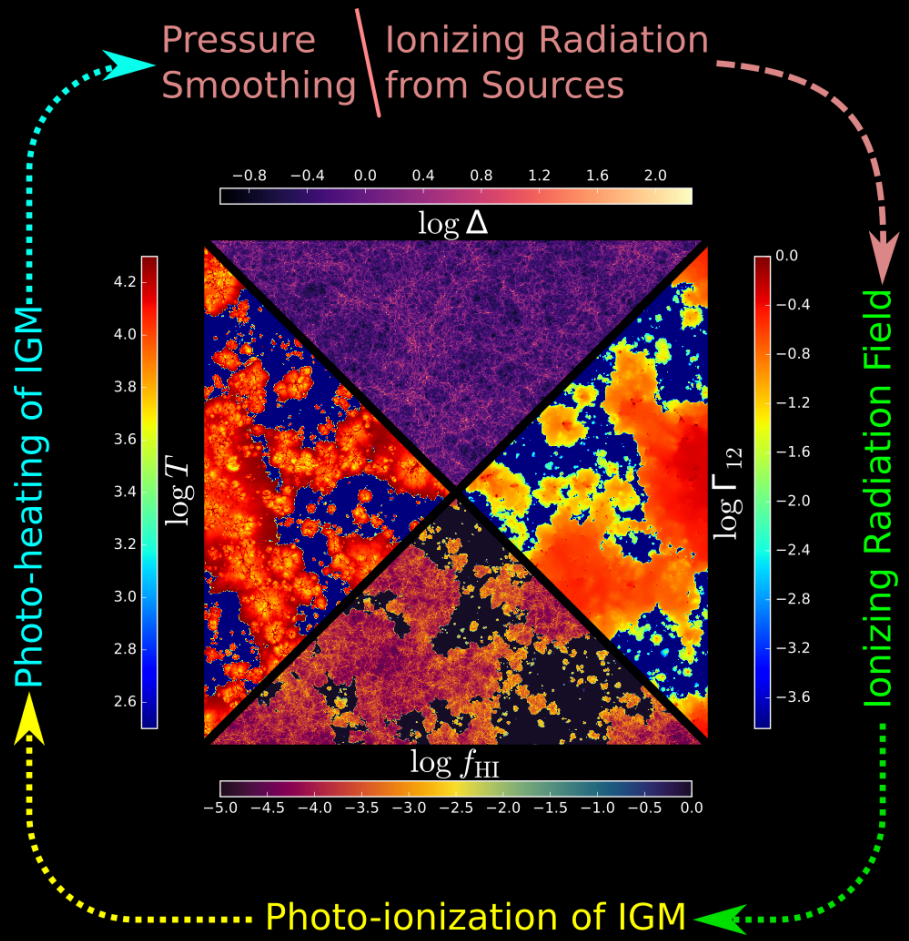
Parameters constrained from observations

- Temperature
- Mean free path
- Neutral fraction

The evolution of parameters suggest "late" H I ($5 < z < 6$) and He II ($2 < z < 4$) reionization

Postdoc Research Plan

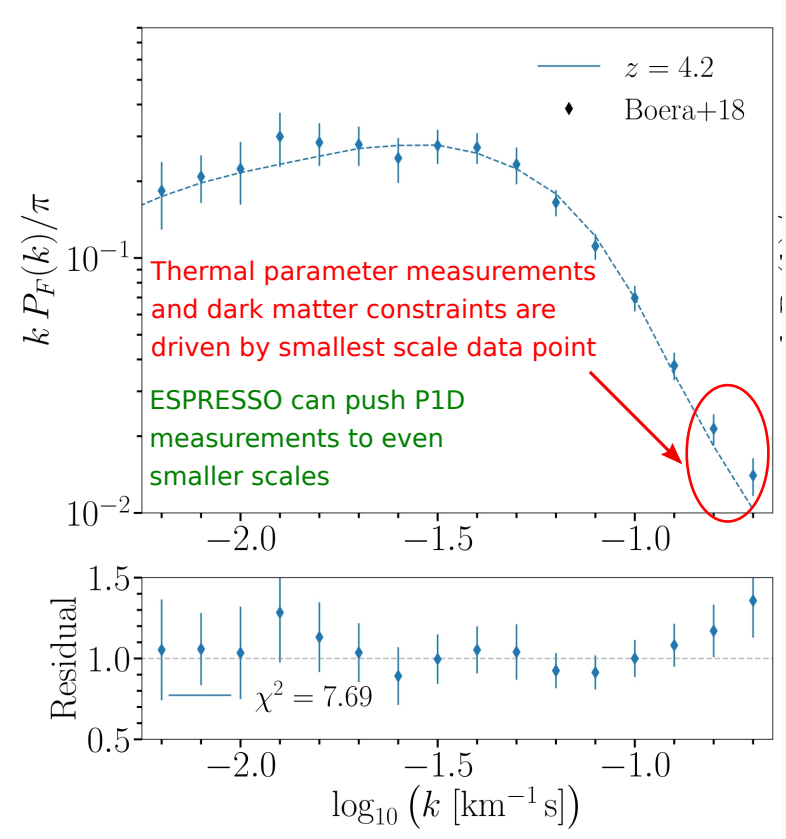
Astrophysics and Cosmology with ESPRESSO



- Broad overview of Postdoc research plan
- Timing of reionization? ⇒ Temperature Fluctuations
- Nature of reionization? ⇒ Pressure smoothing effects
- Sources of reionization? ⇒ Modeling of metals in IGM
- Nature of Dark Matter? ⇒ Constraints on mass of Warm Dark Matter

Measuring P1D with ESPRESSO

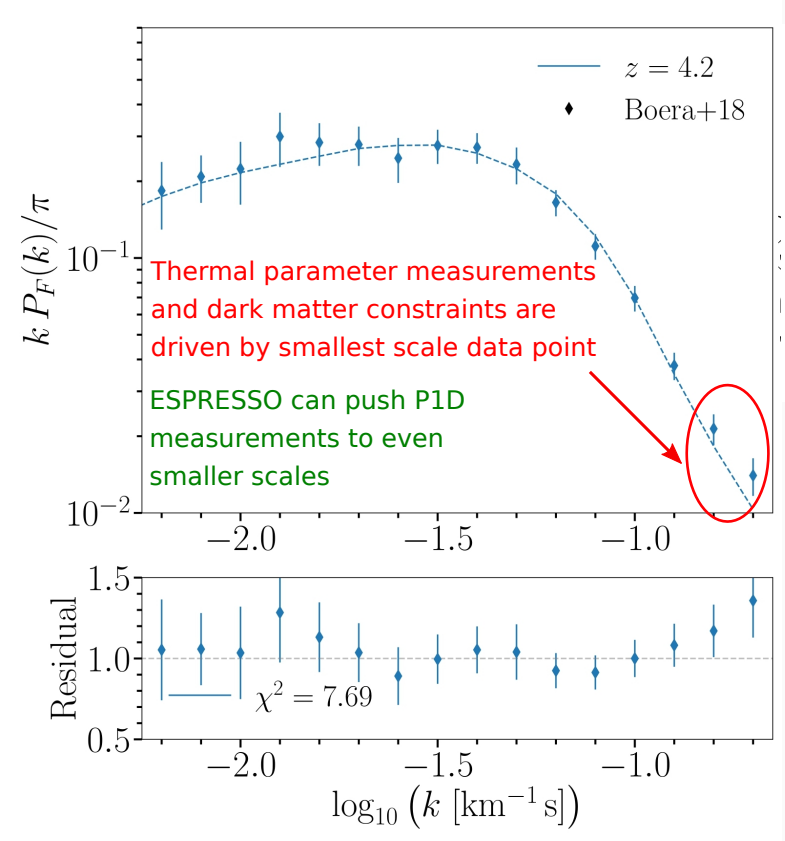
(Gaikwad+2021, Vilasenor+2022, Irsic+2023)

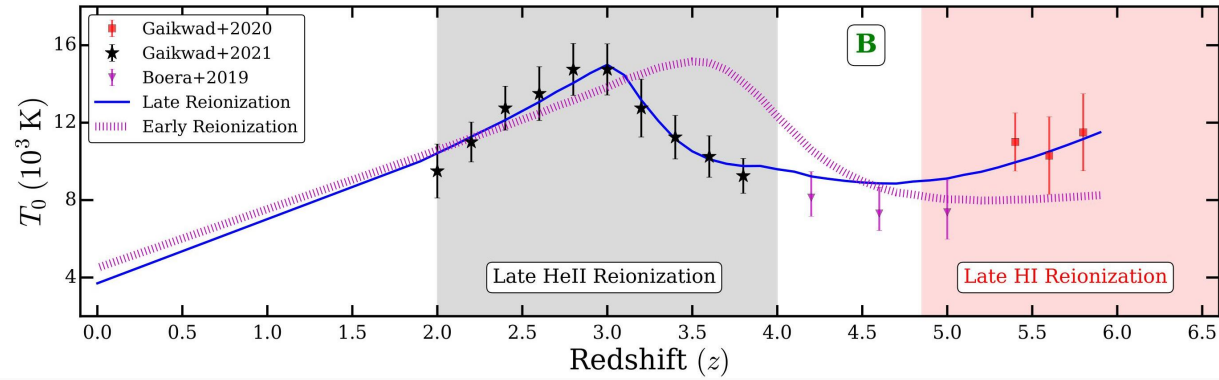


- Primary goal: To robustly measure P1D at $3.5 < z < 4.5$ on small scales
- ESPRESSO has unprecedented spectral resolution
- Understanding systematics (i) Noise, (ii) Metals and (iii) Continuum
- Why are P1D measurements so important?

Measuring P1D with ESPRESSO

(Gaikwad+2021, Vilasenor+2022, Irsic+2023)

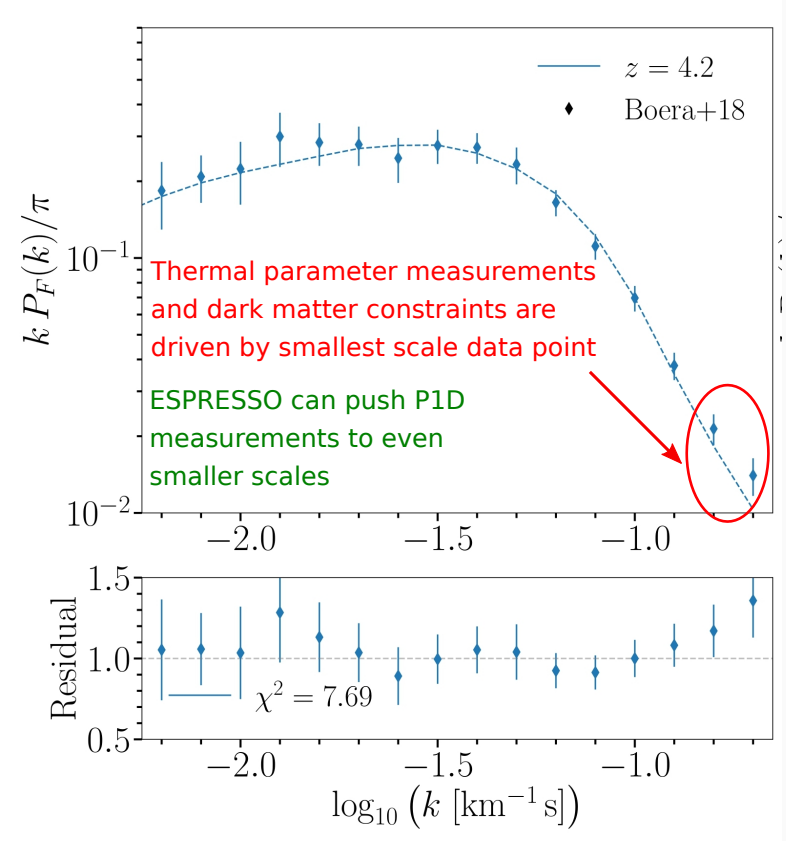


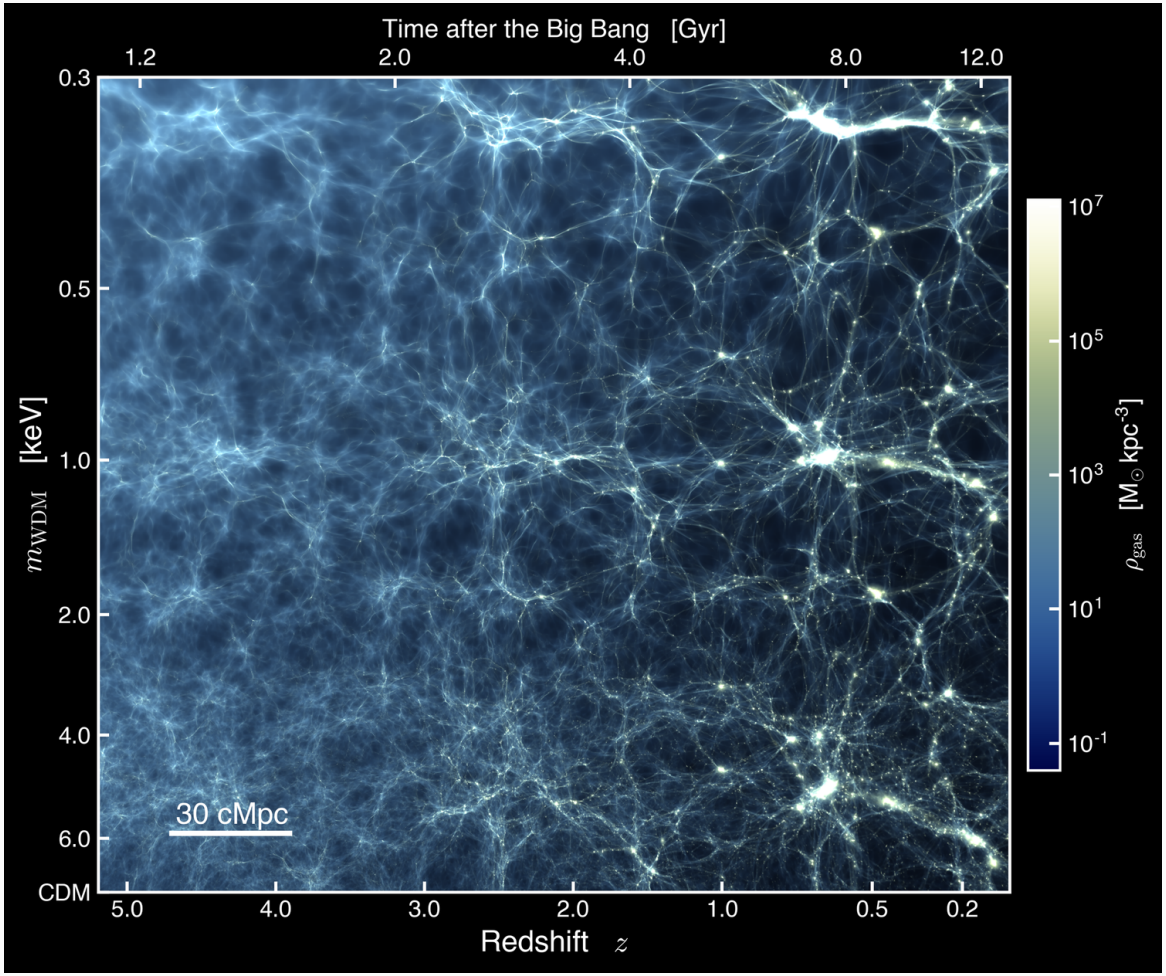


- Previous measurements could be biased by resolution correction and noise.
- Measured IGM Temperature is systematically lower than models
- The lower temperature in this work is driven by smallest scale power.
- A robust P1D measurements from ESPRESSO could resolve this discrepancy.

Measuring P1D with ESPRESSO

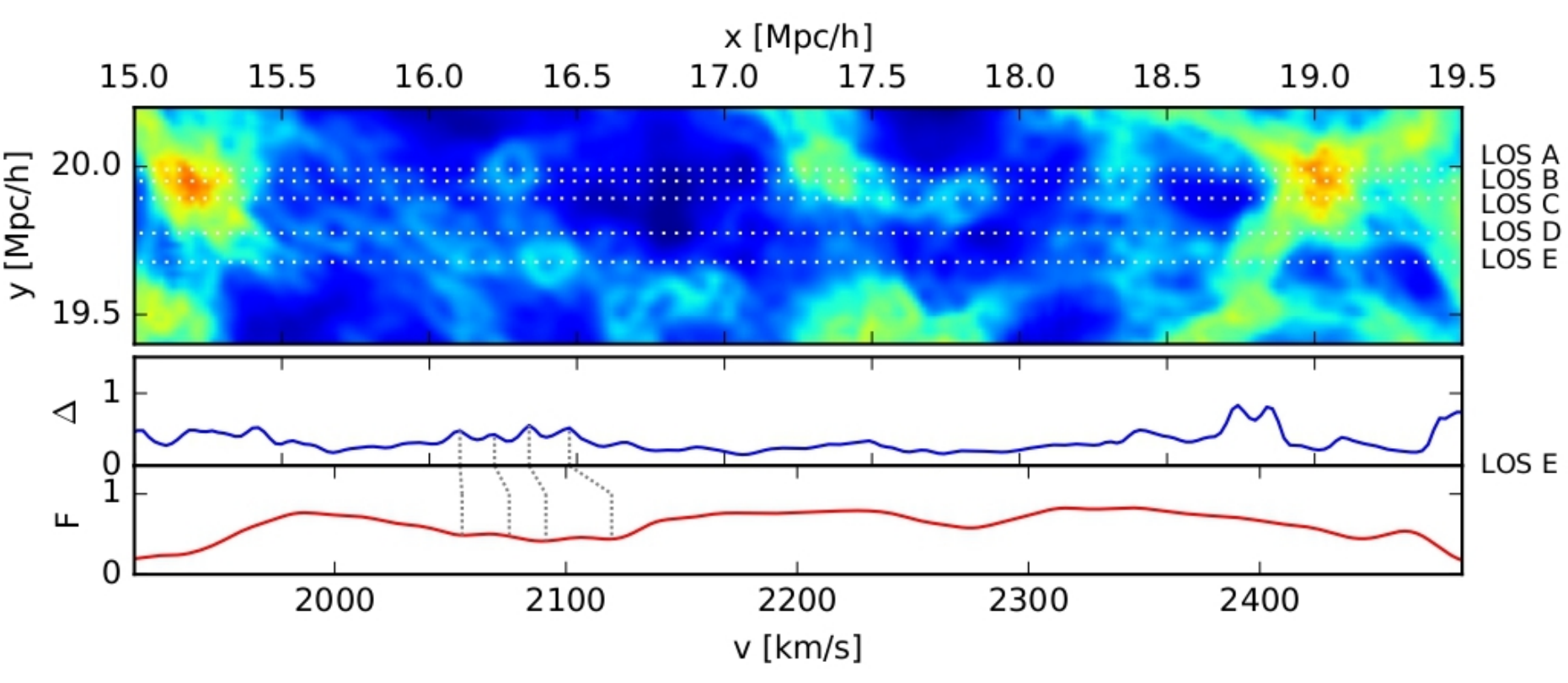
(Gaikwad+2021, Vilasenor+2022, Irsic+2023)





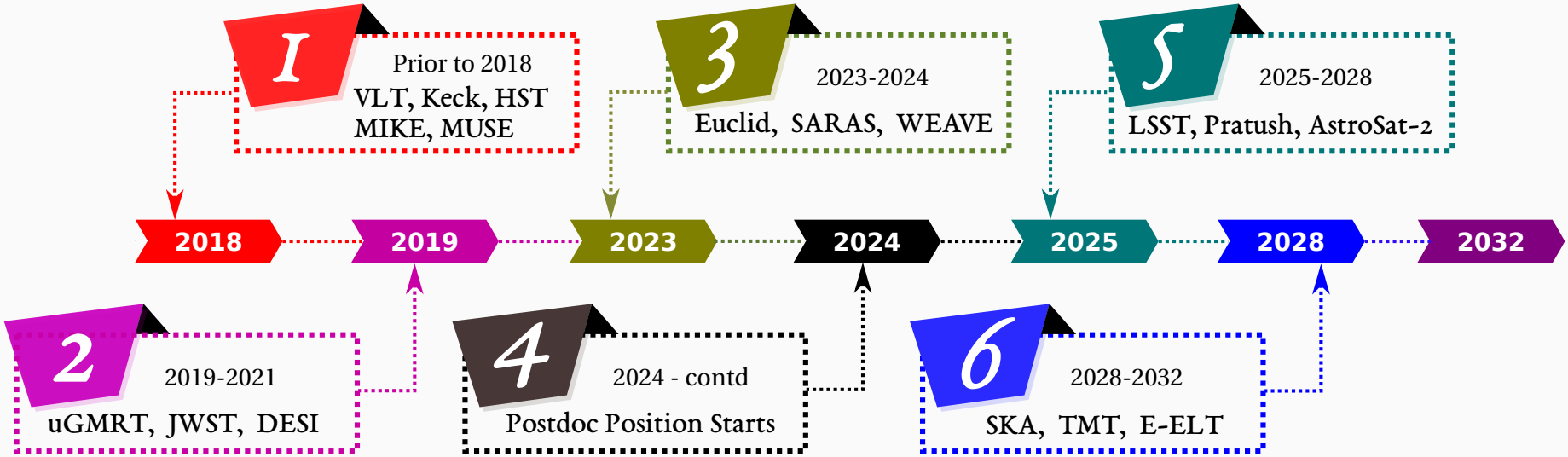
- Previous measurements could be biased by resolution correction and noise.
- One of the best constraints on WDM comes from small scale suppression in P1D
- A robust P1D measurements from ESPRESSO could help better constrain mass of WDM

Detecting pressure smoothing effects in ESPRESSO (Puchwein+2023)



- Delayed hydrodynamical response of the gas to photo-heating of IGM leads to ring like pressure smoothing effects at $4 < z < 5$
- Such density rings can be detected with high resolution spectra from ESPRESSO
- These rings are expanding at a rate of few m/s $\Rightarrow$ Possible to detect them in Sandage test experiment

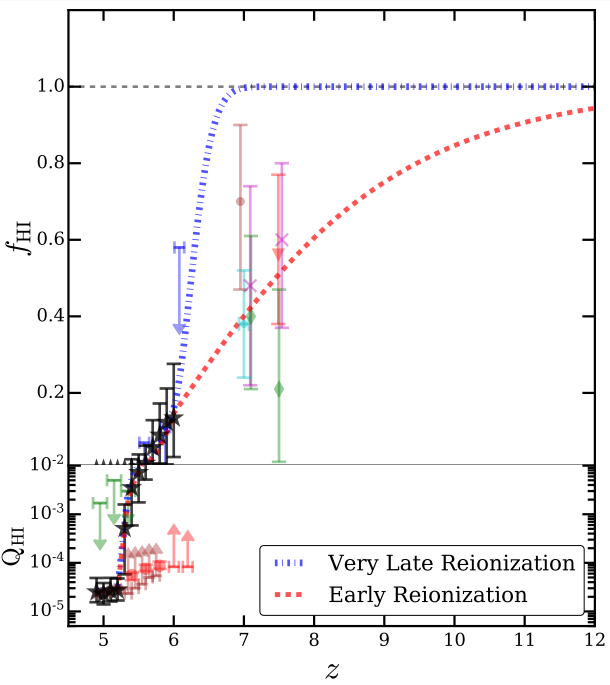
Summary

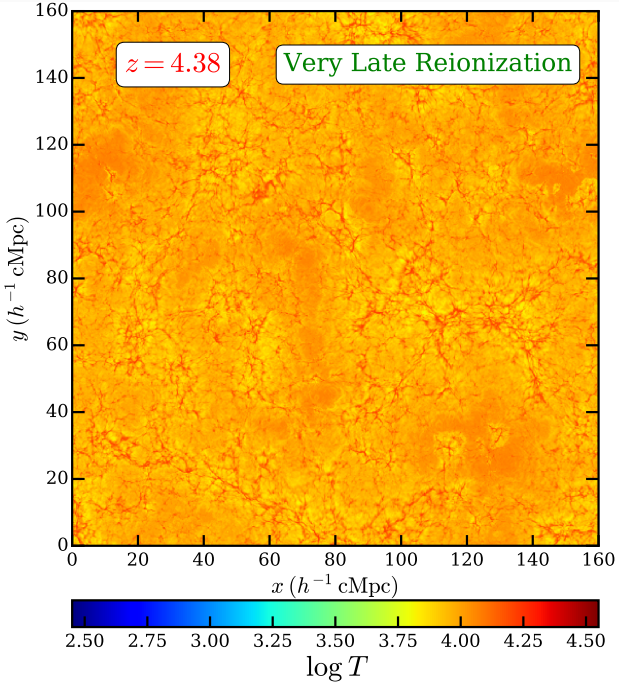


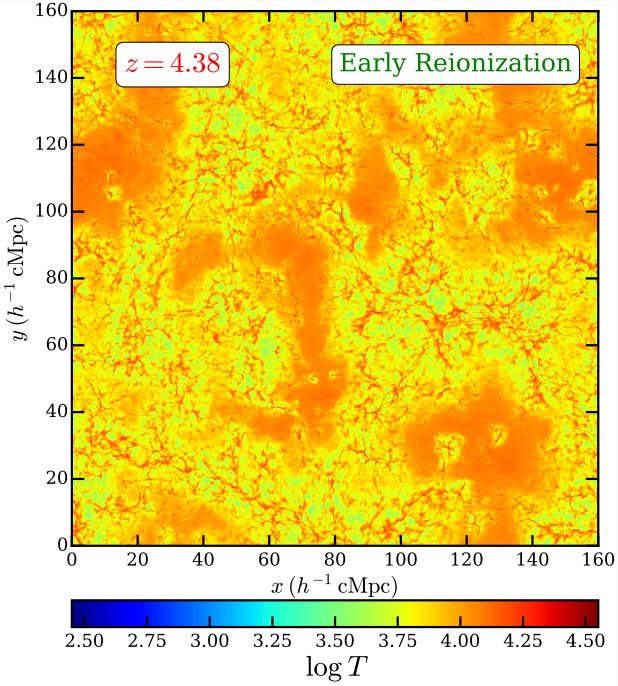
- My research interests aligned very well with the postdoc position
- Unprecedented quality ESPRESSO spectra provides unique opportunity to answer
- Timing of reionization? $\Rightarrow$ Temperature Fluctuations
- Nature of reionization? $\Rightarrow$ Pressure smoothing effects
- Sources of reionization? $\Rightarrow$ Modeling of metals in IGM
- Nature of Dark Matter? $\Rightarrow$ Constraints on mass of Warm Dark Matter
- ESPRESSO is a good test bed for E-ELT (ANDES)

Appendix

Detecting temperature fluctuations with ESPRESSO (Gaikwad+in prep)







- An early reionization model produces more fluctuations in the temperature
- The temperature fluctuations could be detected with bispectrum measurements and Voigt statistics
- A high resolution ESPRESSO spectra can measure the bispectrum.
- VoIgt profile Parameter Estimation Routine (VIPER)