Detecting Beyond Standard Model Cosmology through Epoch of Reionization Observations

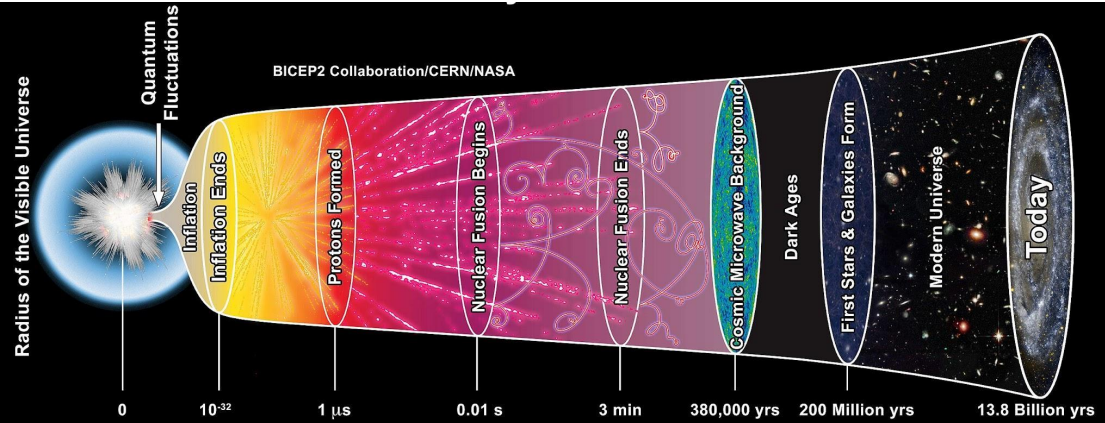
Sambit Giri

NORDITA fellow

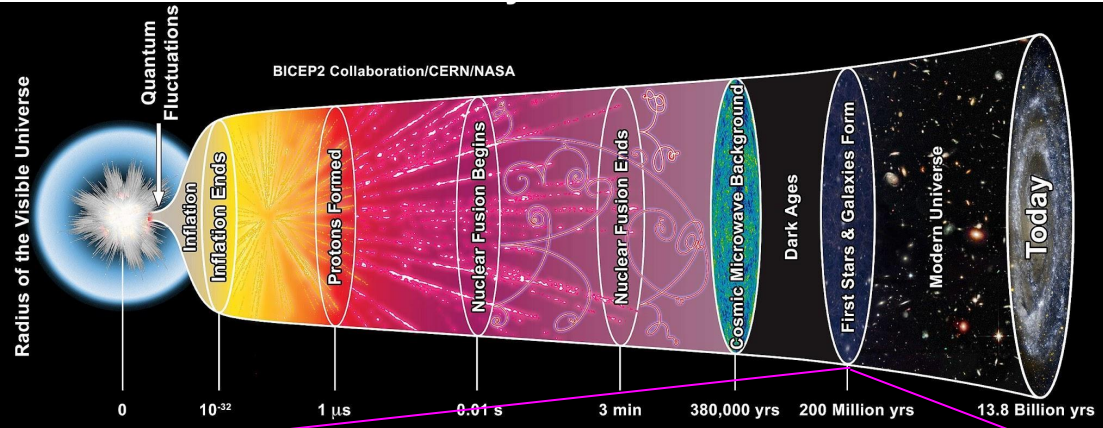
Collaborators

- Aurel Schneider (University of Zurich)
- Timothée Schaeffer (University of Zurich)
- Pratika Dayal (University of Groningen)
- Jordan Mirocha (JPL, Caltech)

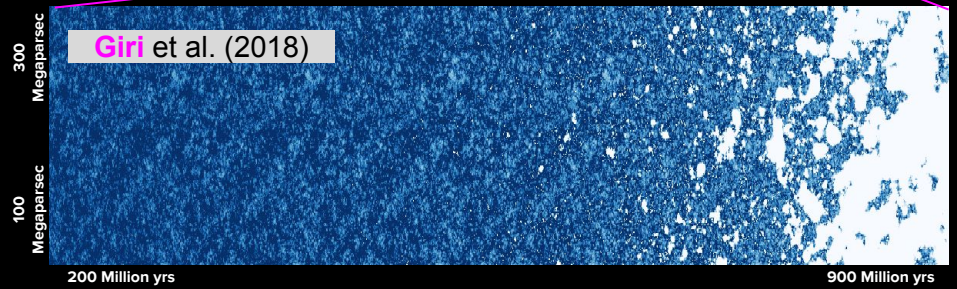
History of our Universe



History of our Universe



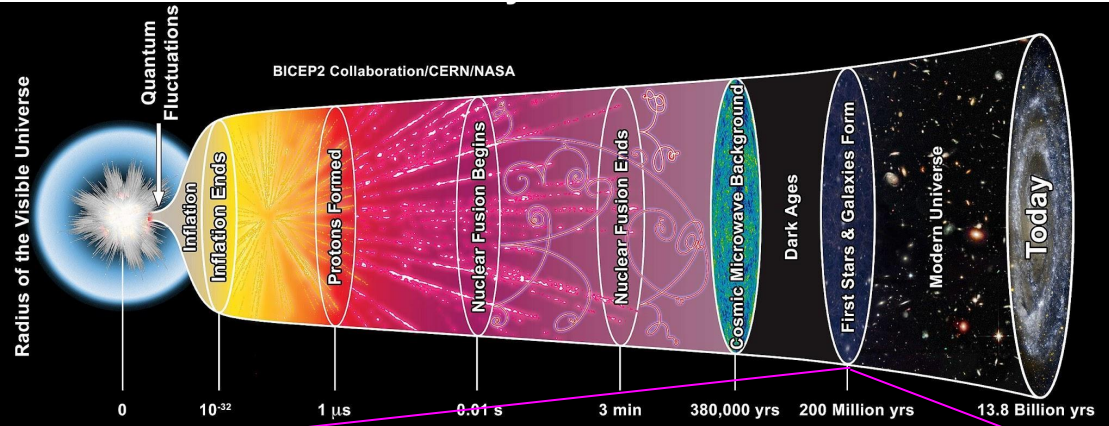
Intergalactic neutral hydrogen gas

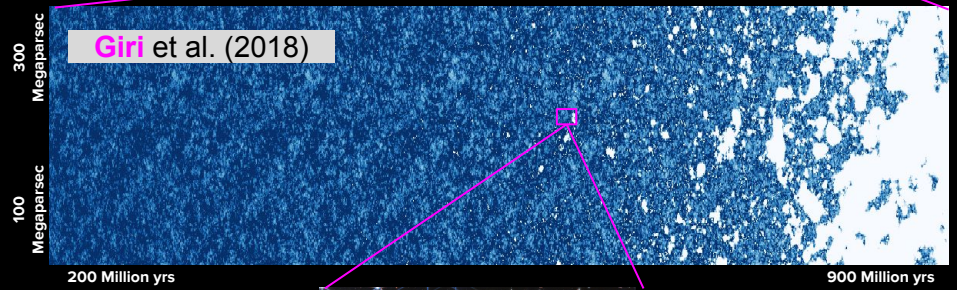


History of our Universe

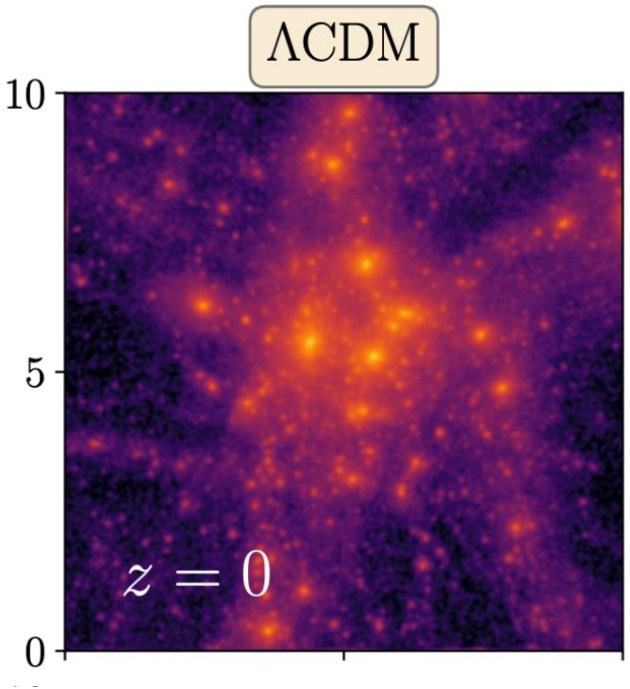
Intergalactic neutral hydrogen gas

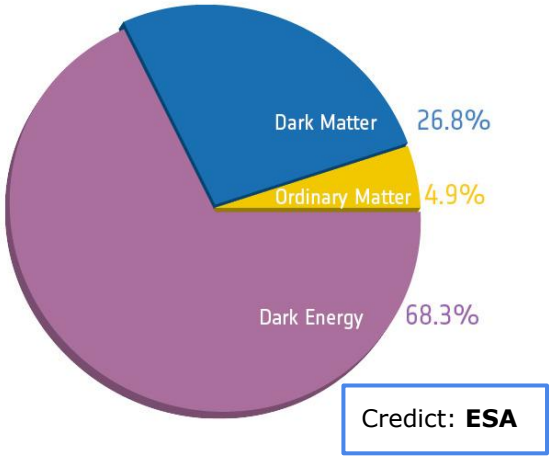
First generation of galaxies

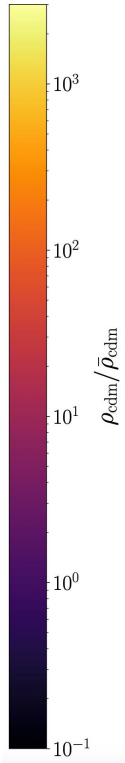




Cosmic structure formation

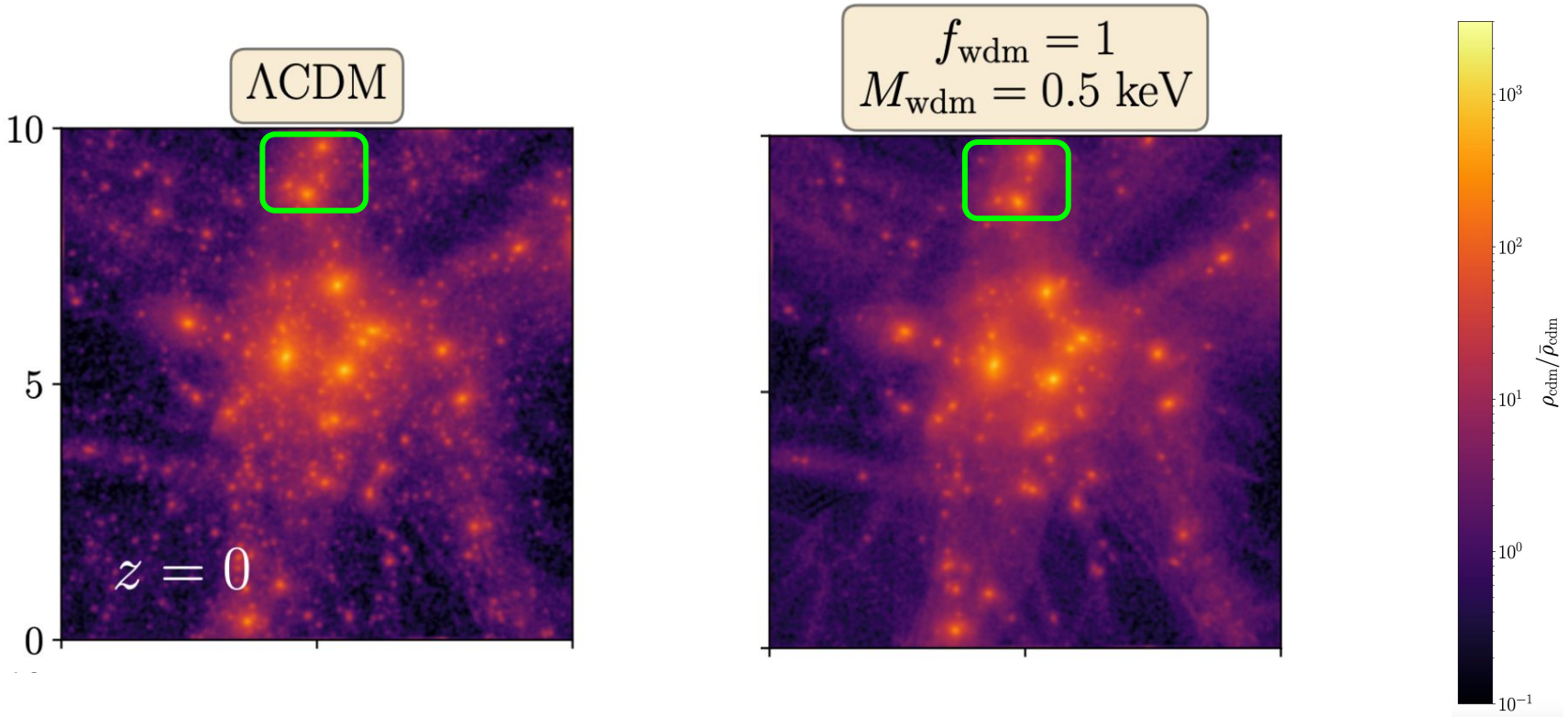






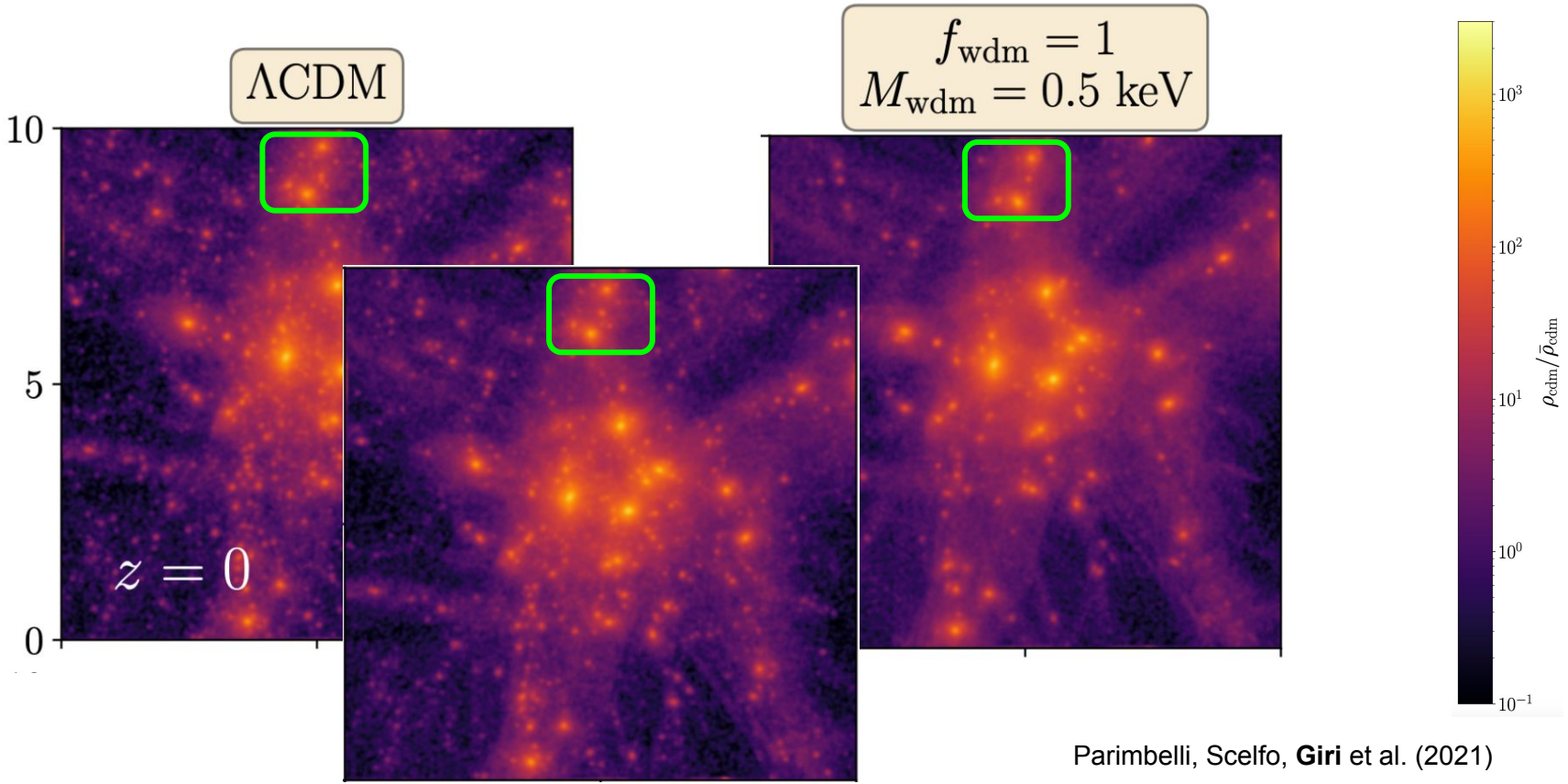
Parimbelli, Scelfo, **Giri** et al. (2021)

Non-standard dark matter models



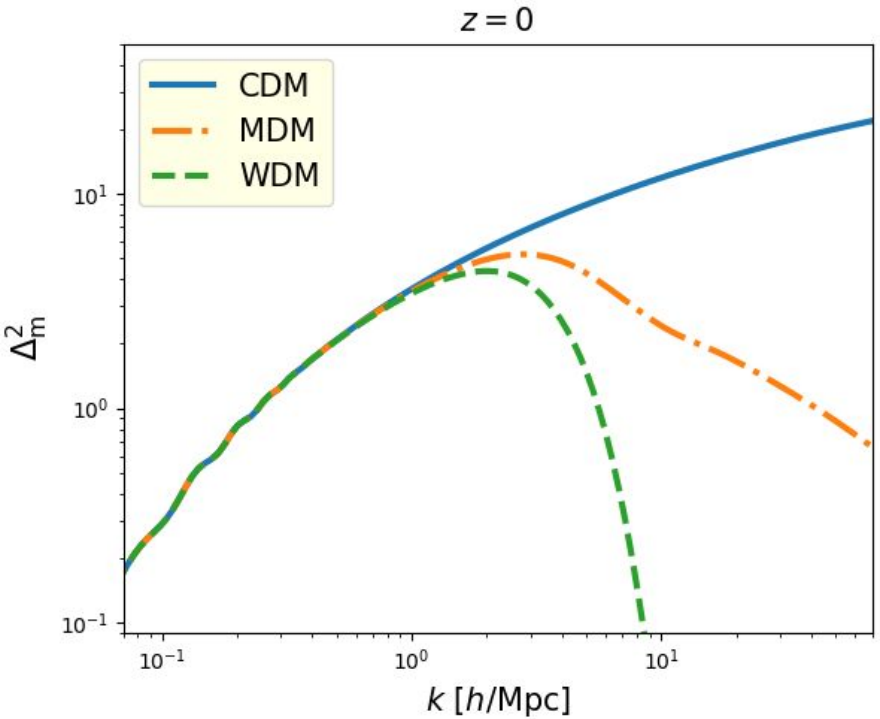
Parimbelli, Scelfo, **Giri** et al. (2021)

Mixture of cold and warm dark matter particles



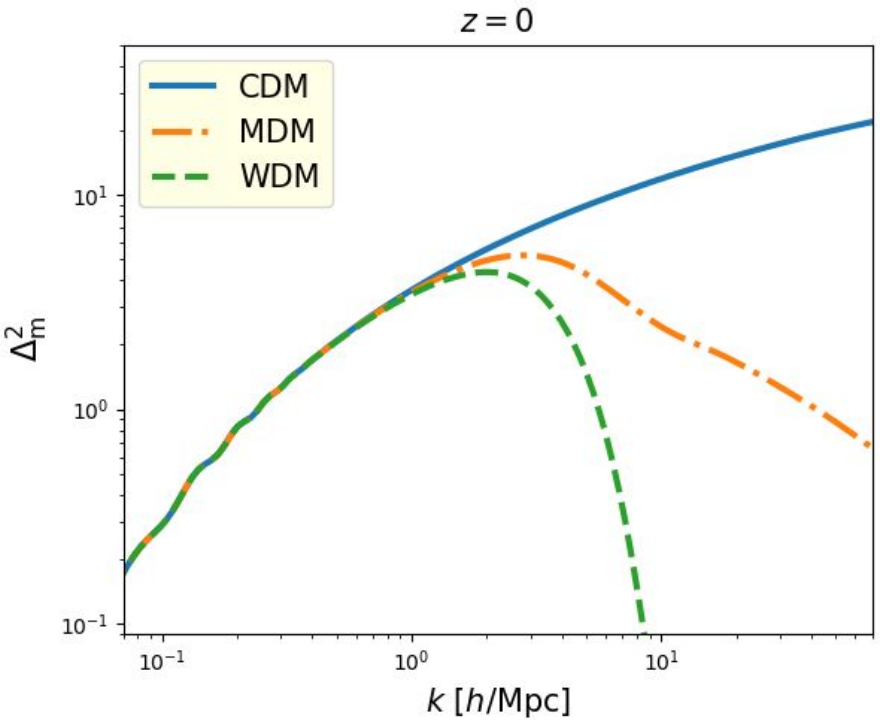
Parimbelli, Scelfo, **Giri** et al. (2021)

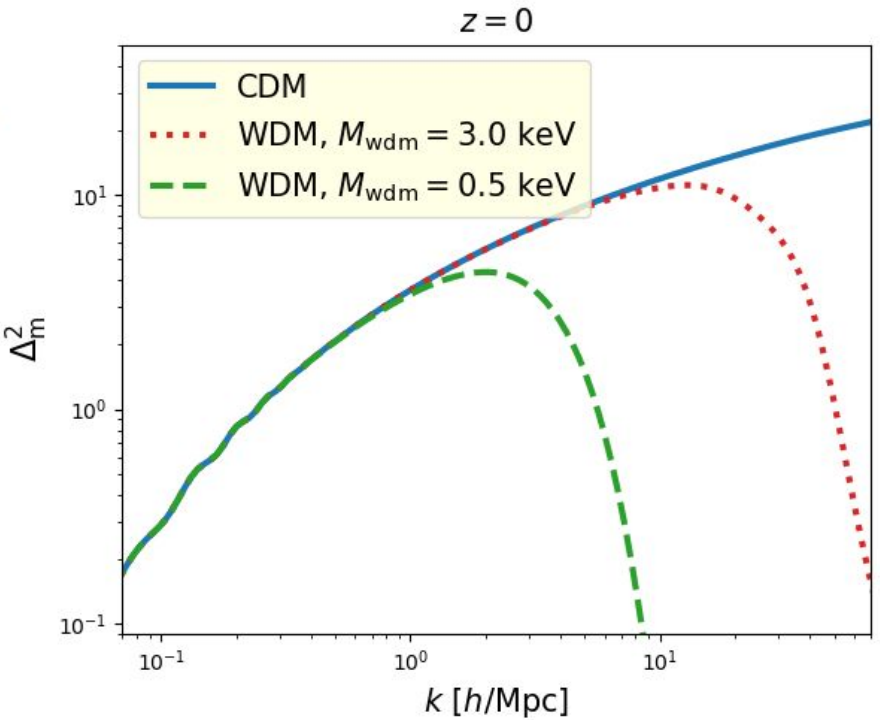
Matter power spectrum



Giri & Schneider (2022)

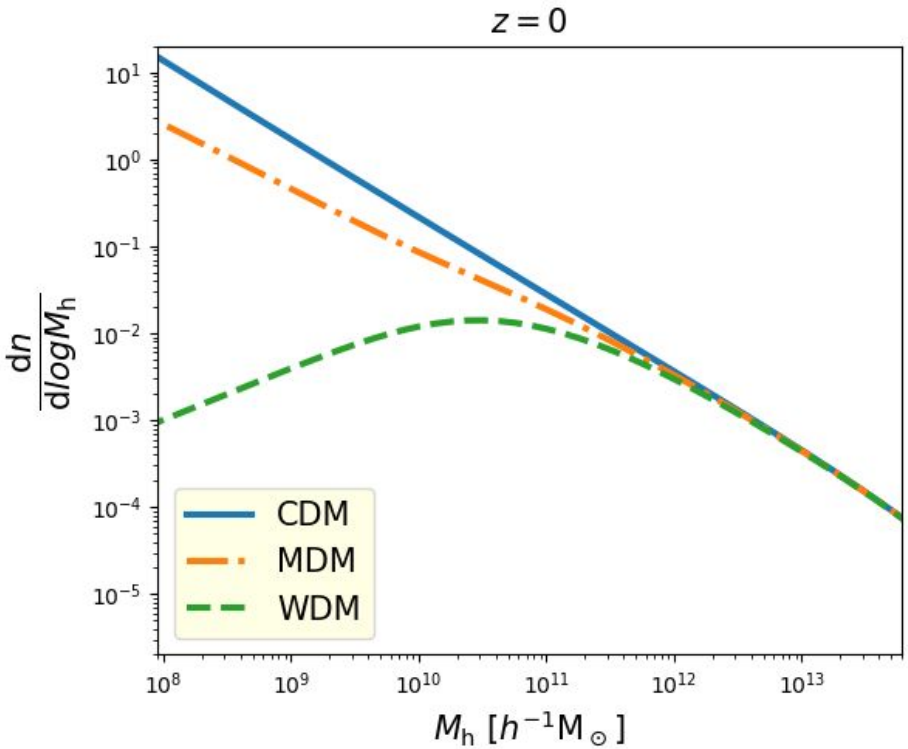
Dark matter mass decides the suppression scale





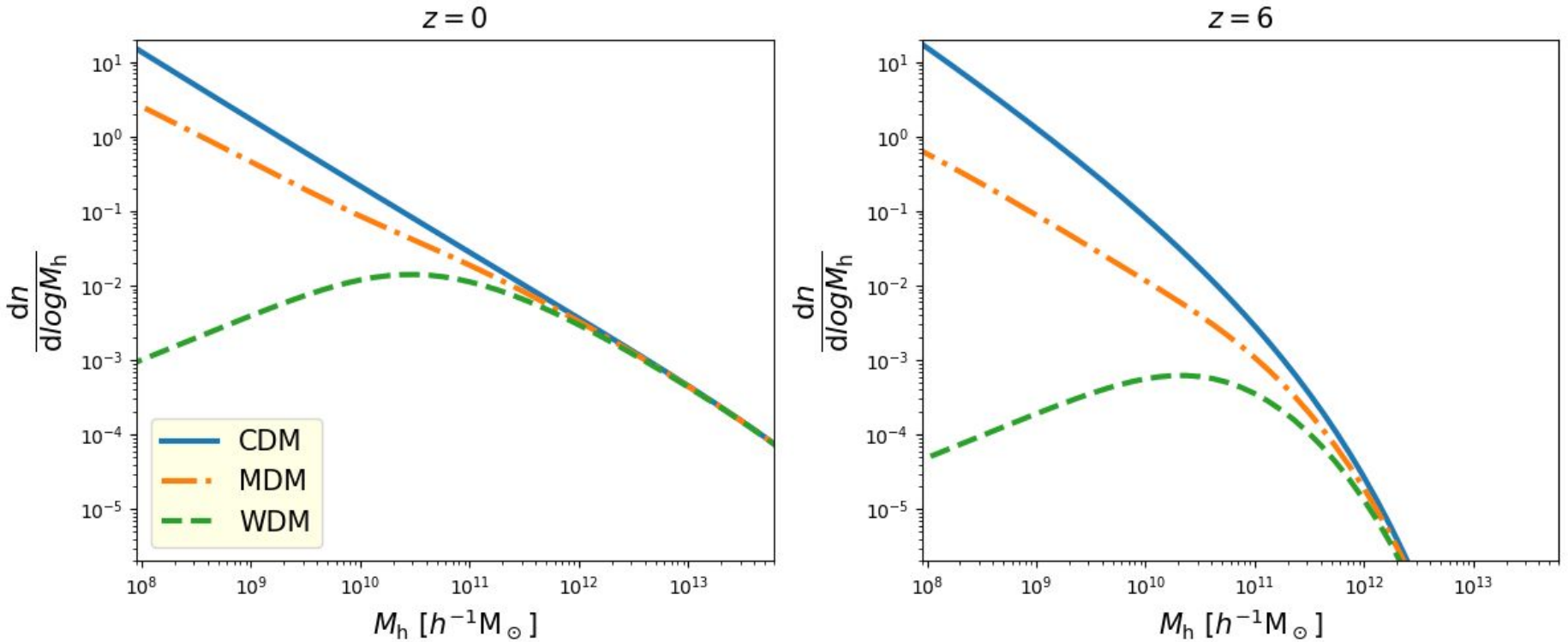
Giri & Schneider (2022)

Halo Mass Function



Giri & Schneider (2022)

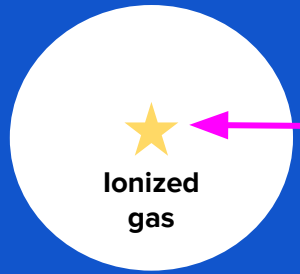
Differences are more distinct at high redshift

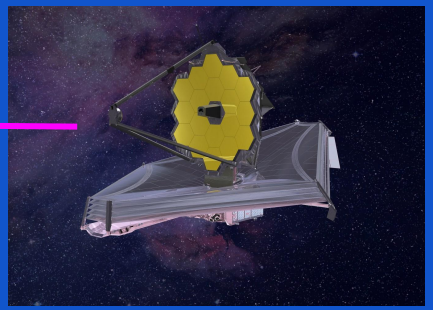


Giri & Schneider (2022)

Epoch of Reionization

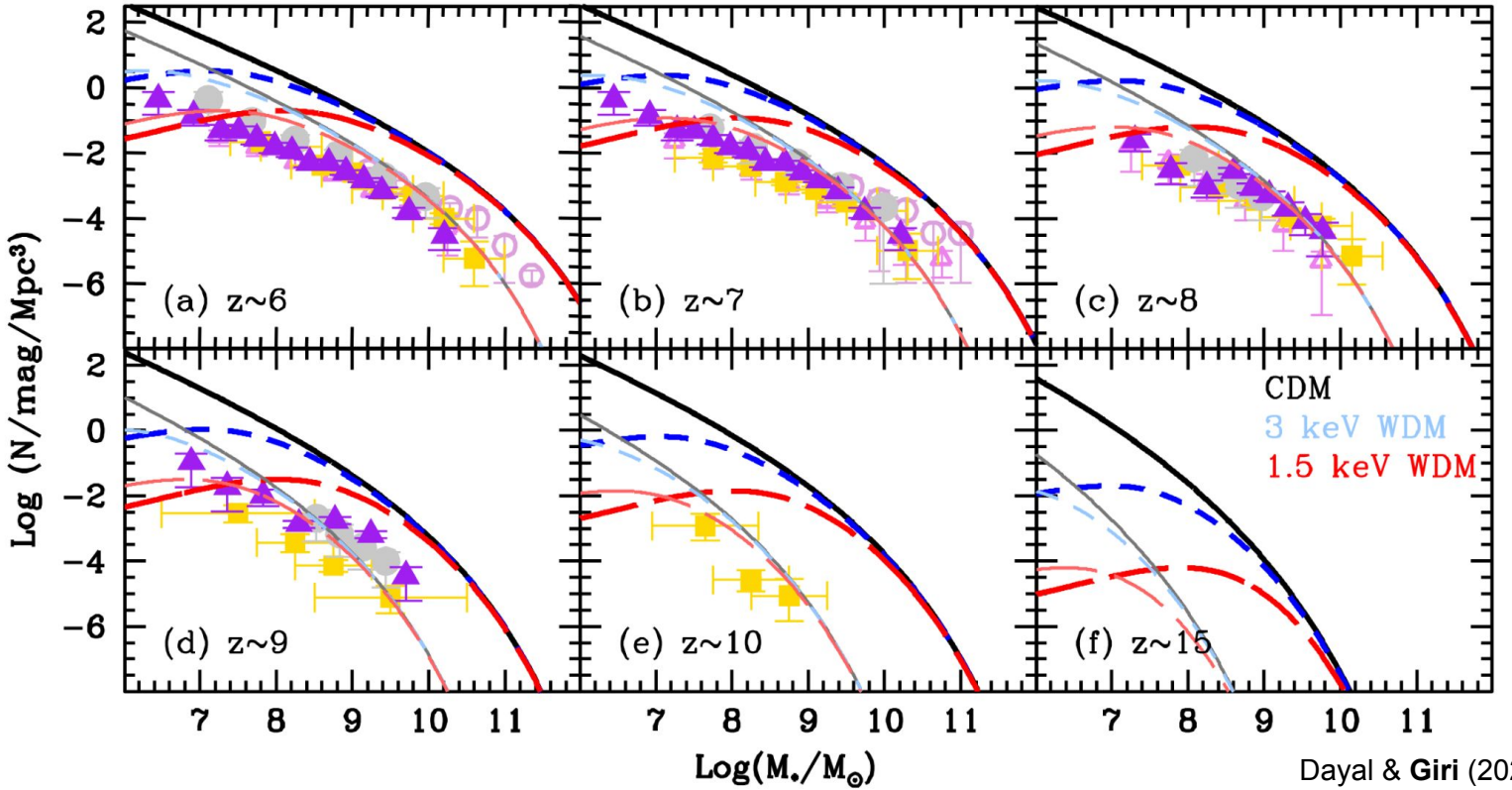
Observing Galaxies during Reionization





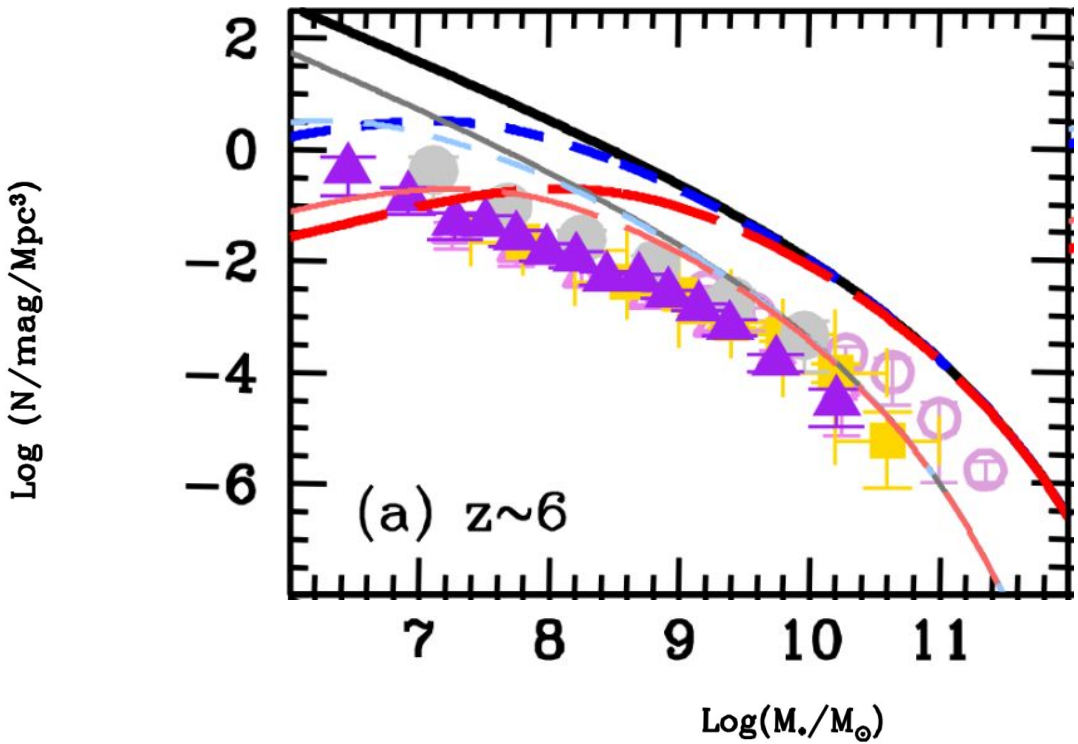
James Webb Space Telescope
(JWST)

Testing models with JWST



Dayal & **Giri** (2023)

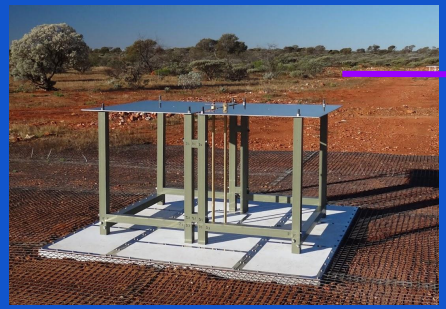
Stellar Mass Function at Redshift 6



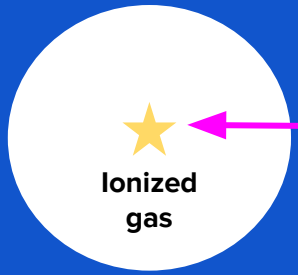
CDM
3 keV WDM
1.5 keV WDM

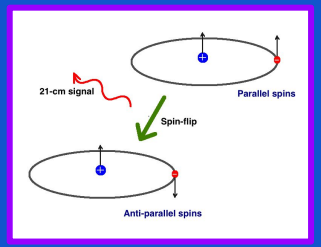
Observing the impact of Early Galaxies

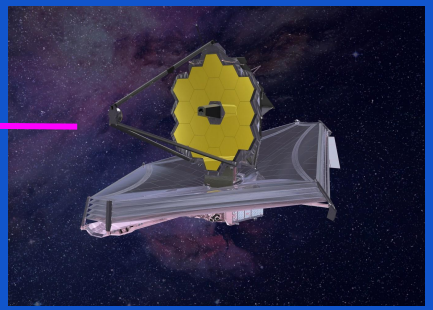
Square Kilometre Array (SKA)



Experiment to Detect the Global EoR Signature (EDGES)

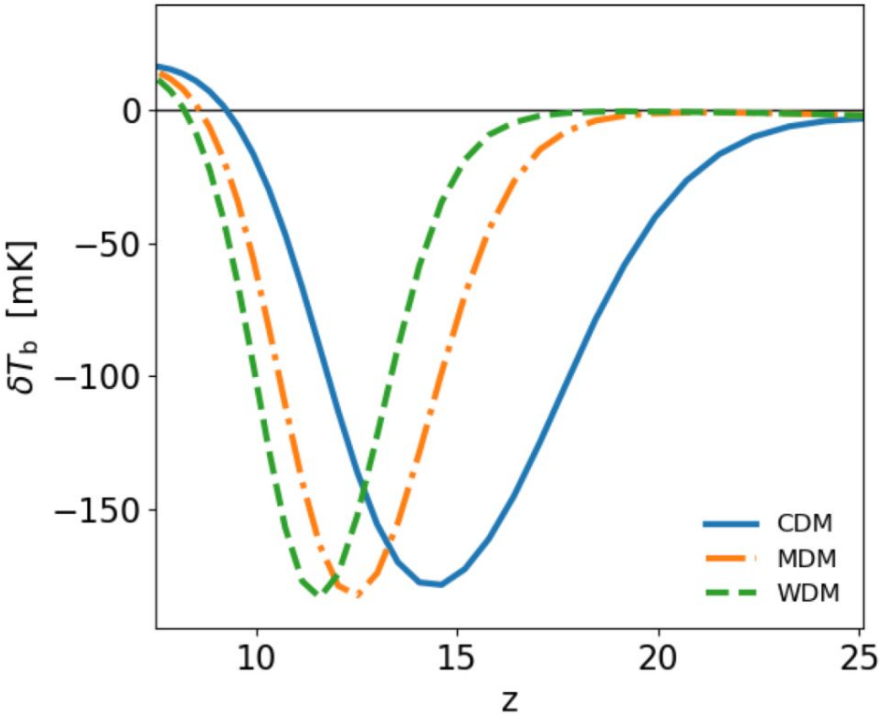






James Webb Space Telescope (JWST)

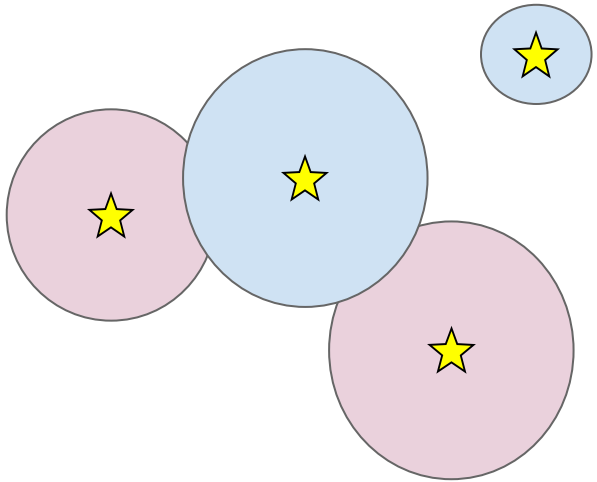
Global 21-cm signal



Giri & Schneider (2022)

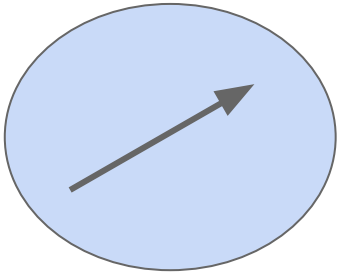
Halo model approach for 21-cm signal distribution

Seljak (2000)
Cooray & Sheth (2002)
...

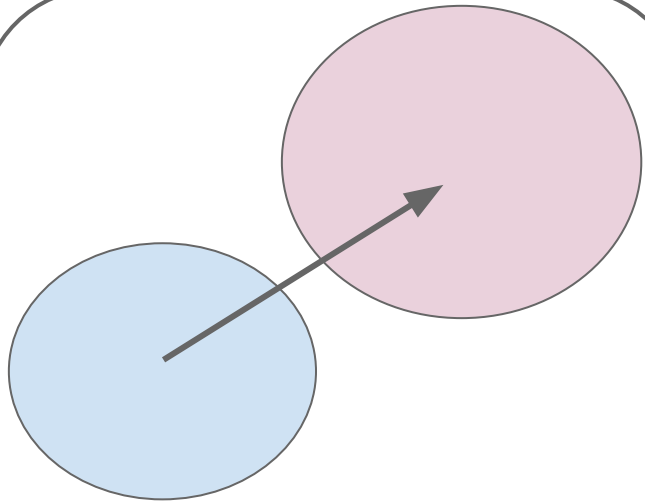


Schneider, **Giri** & Mirocha (2021)

Halo model approach for 21-cm Power spectrum



$$P_{XY}^{1\,\mathrm{h}}(k,z) = \frac{\beta_X \beta_Y}{(\bar{\rho} f_{\mathrm{coll}})^2} \int dM \frac{dn}{dM} \tilde{f}_*^2 M^2 |u_X||u_Y|,$$

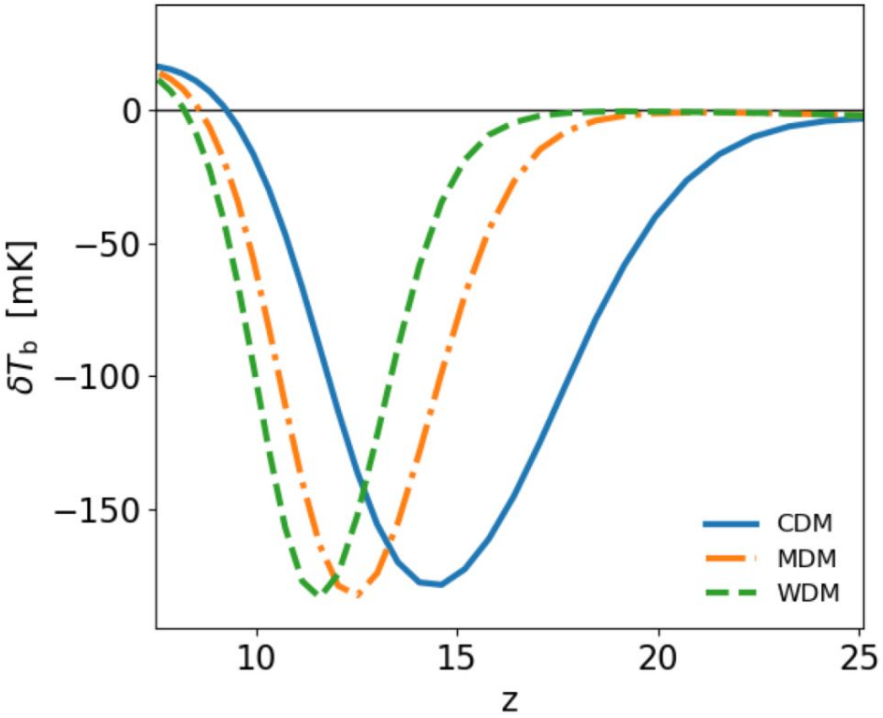


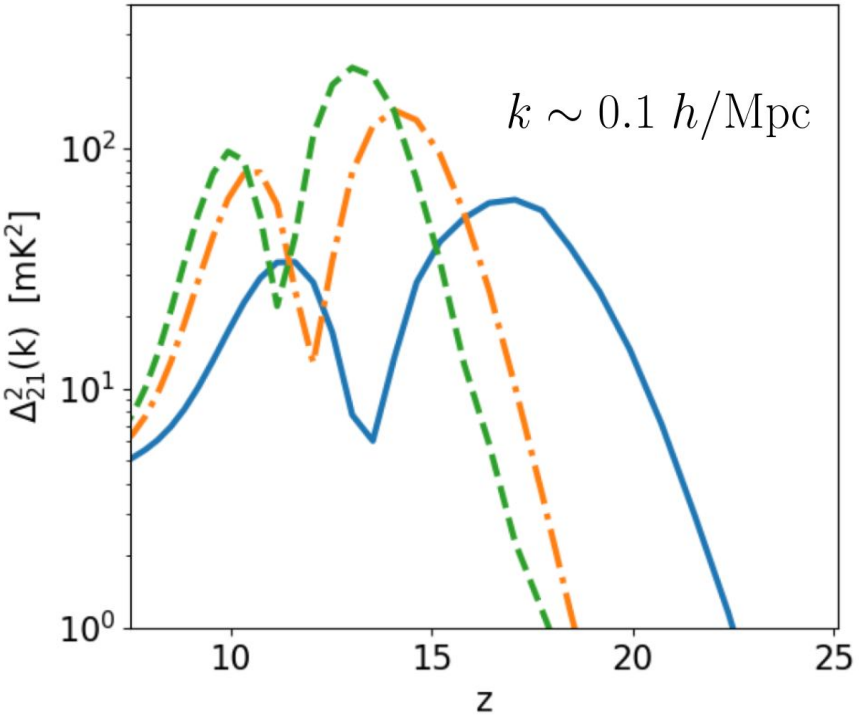
$$P_{XY}^{2\,\mathrm{h}}(k,z) = \frac{\beta_X}{(\bar{\rho} f_{\mathrm{coll}})} \int dM \frac{dn}{dM} \tilde{f}_* M |u_X| b_X \times \frac{\beta_Y}{(\bar{\rho} f_{\mathrm{coll}})} \int dM \frac{dn}{dM} \tilde{f}_* M |u_Y| b_Y \times P_{\mathrm{lin}}$$

$$P_{XY}(k,z) = P_{XY}^{1\,\mathrm{h}}(k,z) + P_{XY}^{2\,\mathrm{h}}(k,z),$$

Schneider, **Giri** & Mirocha (2021)

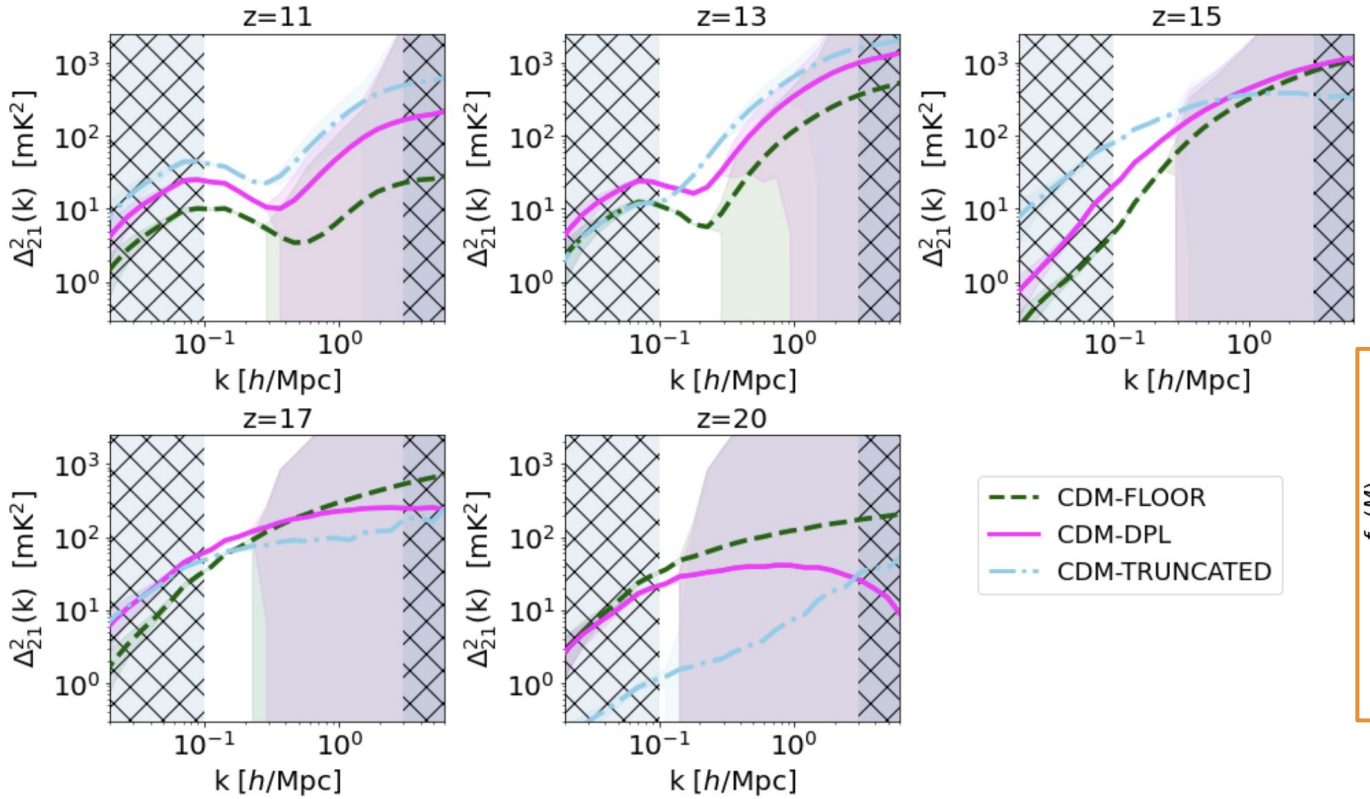
Global 21-cm signal & Power Spectrum

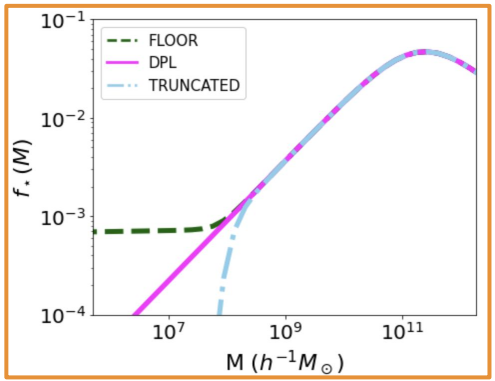




Giri & Schneider (2022)

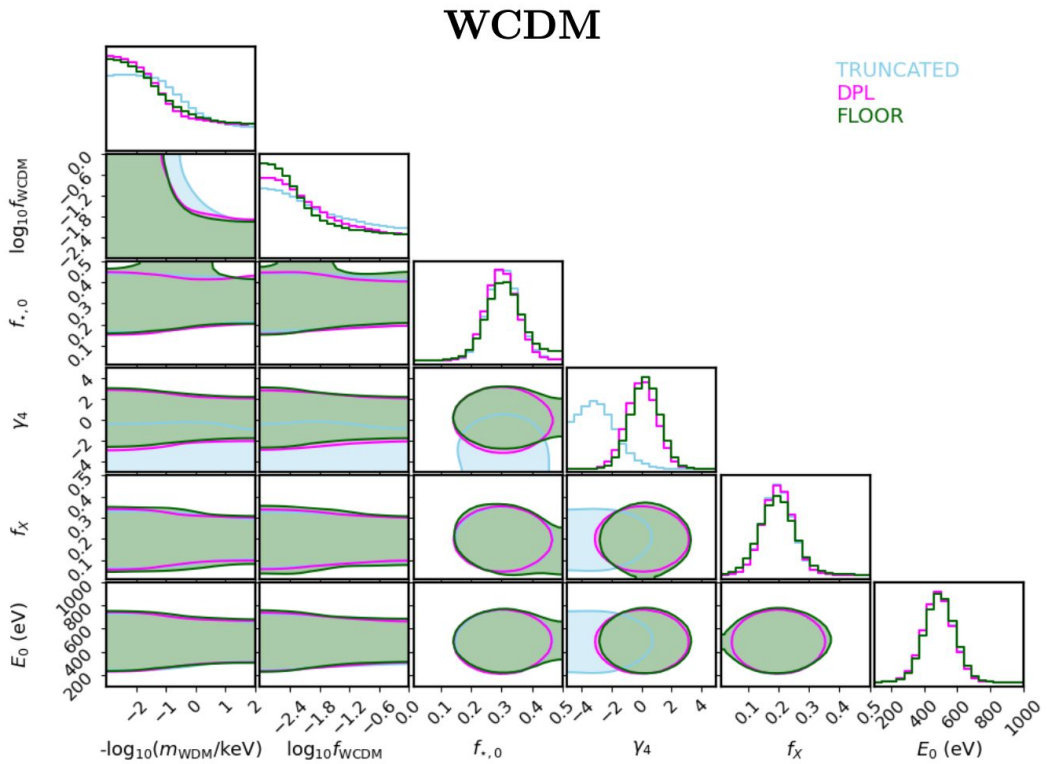
Expected SKA Power Spectra





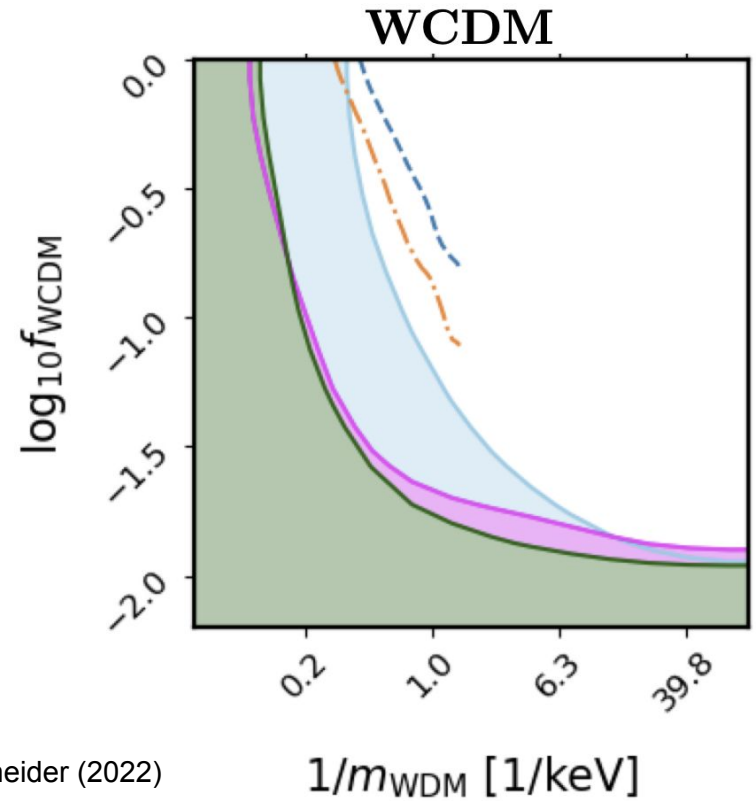
Giri & Schneider (2022)

Forecast study with SKA Power Spectra



Giri & Schneider (2022)

Constraints on warm+cold dark matter (WCDM)

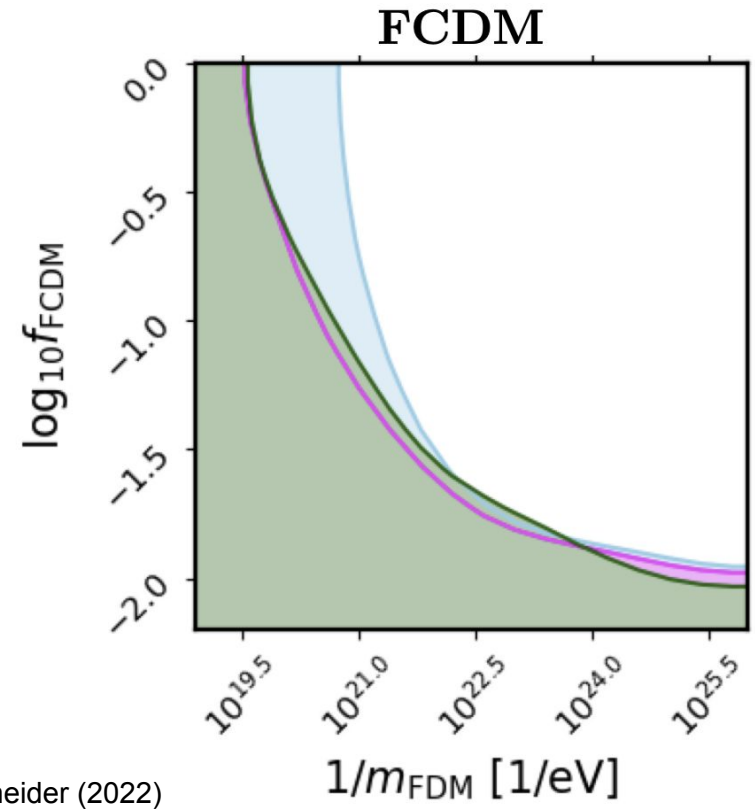


$$f \sim 1 : m_{\rm WDM} \gtrsim 15 \text{ keV (FLOOR, DPL)},$$
$$\gtrsim 4 \text{ keV (TRUNCATED)}$$
$$\text{CDM + hot relic} : f \lesssim 1\% \text{ (FLOOR, DPL, TRUNCATED)}$$

TRUNCATED
DPL
FLOOR
SDSS (Baur+2017)
SDSS+XQ+HR (Baur+2017)

Giri & Schneider (2022)

Constraints on fuzzy+cold dark matter (FCDM)



$$f \sim 1 : m_{\rm FDM} \gtrsim 2 \times 10^{-20}\ {\rm eV}\ ({\rm FLOOR, DPL}),$$
$$\gtrsim 2 \times 10^{-21}\ {\rm eV}\ ({\rm TRUNCATED})$$
$${\rm CDM + hot\ relic} : f \lesssim 1\%\ ({\rm FLOOR, DPL, TRUNCATED})$$

TRUNCATED
DPL
FLOOR

Giri & Schneider (2022)

Summary

- Non-cold dark matter models show **greater distinctions in earlier times**
- **Cosmic reionization is delayed** due to formation of less number of small mass light sources in non-cold dark matter scenarios
- Reionization epoch observations can **improve upon the constraints on the dark matter models**