Exploring Beyond Standard Cosmological Model during the Epoch of Reionization

Stockholm University

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NORDITA fellow

NORDITA

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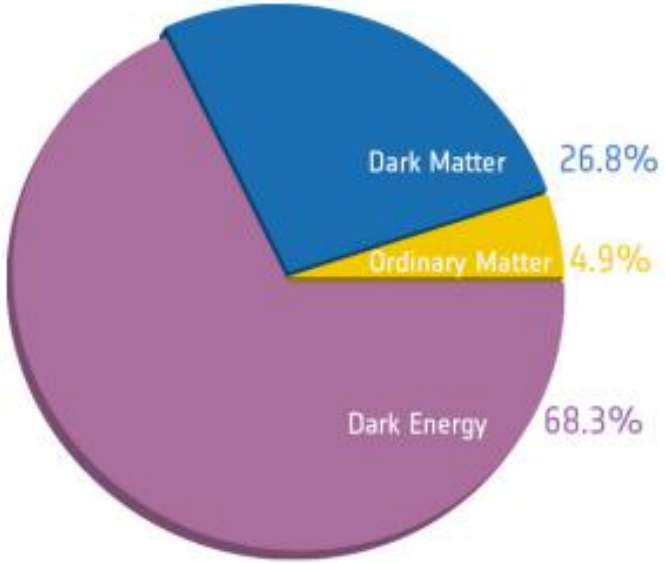
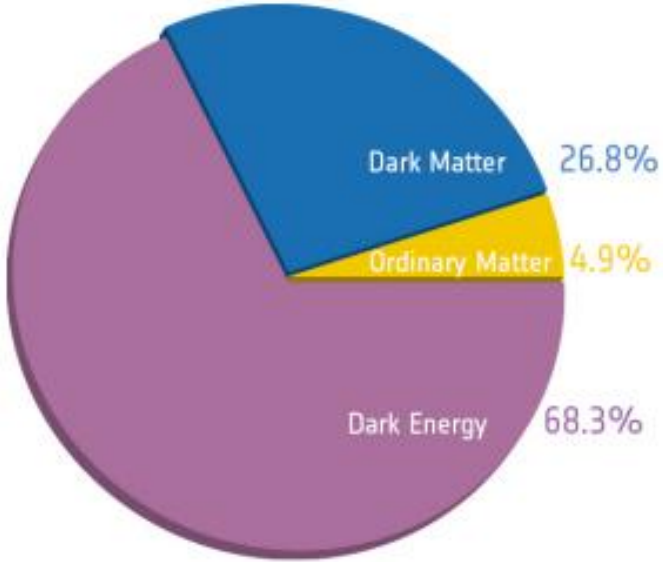
Content of our Universe today



Credits: ESA

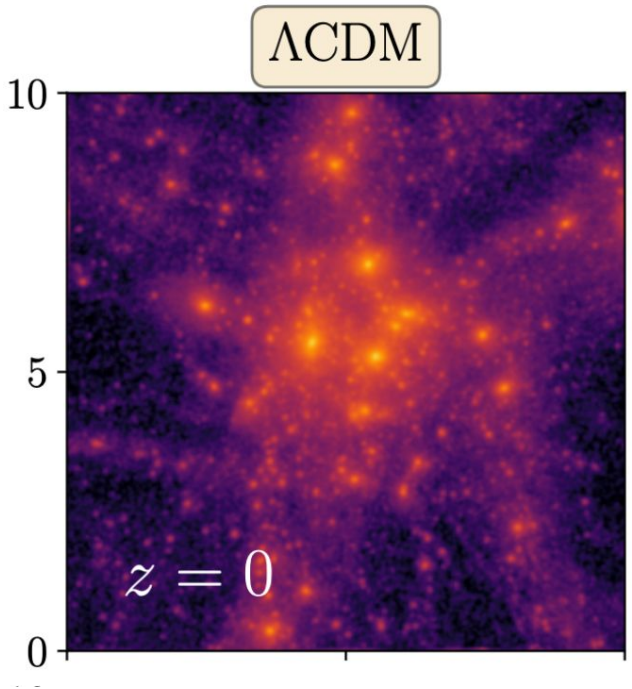
Content of my talk

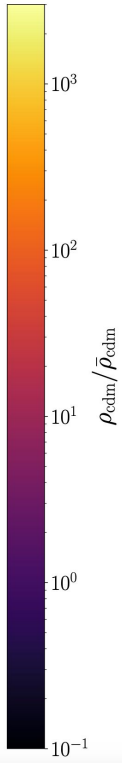


Credits: ESA

- Dark matter models
- Dark energy models

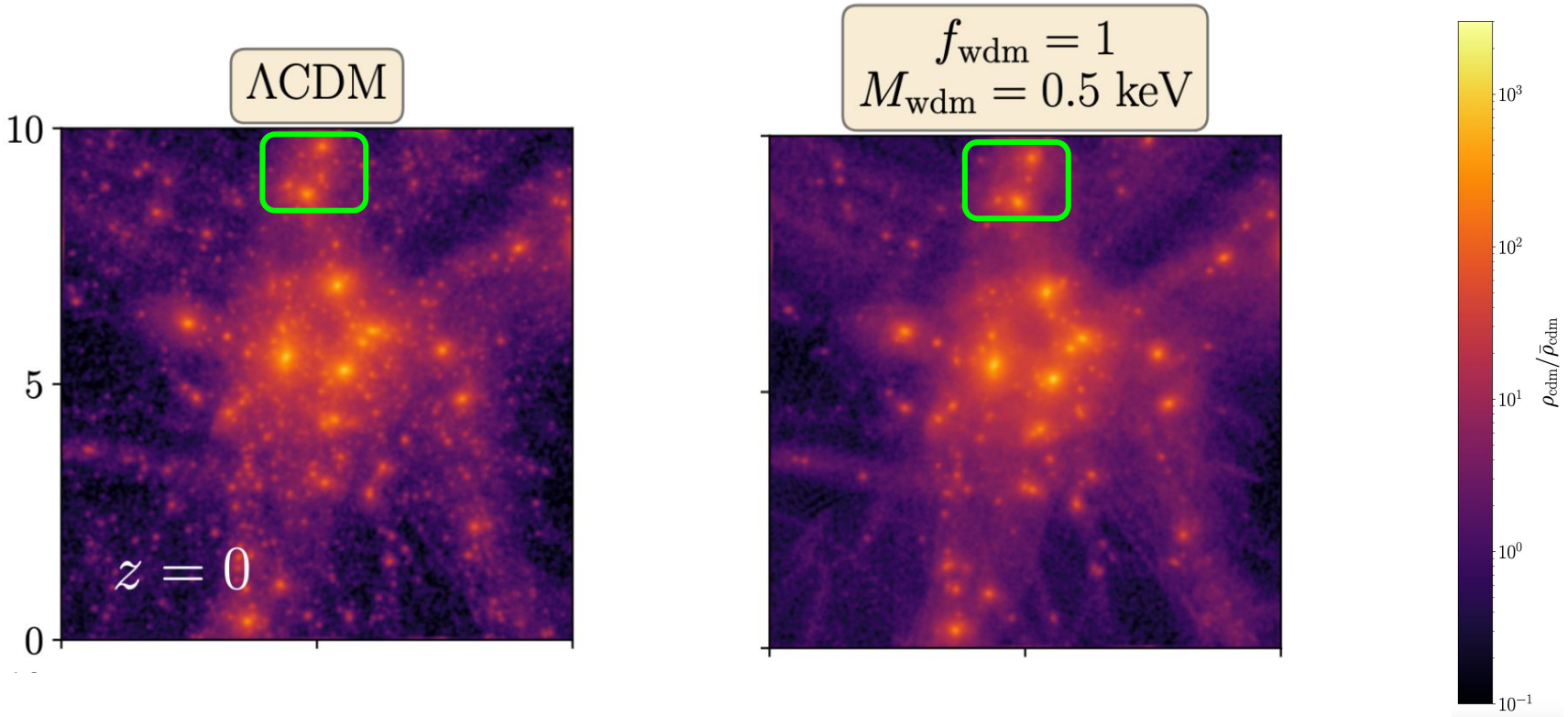
Dark matter driving structure formation





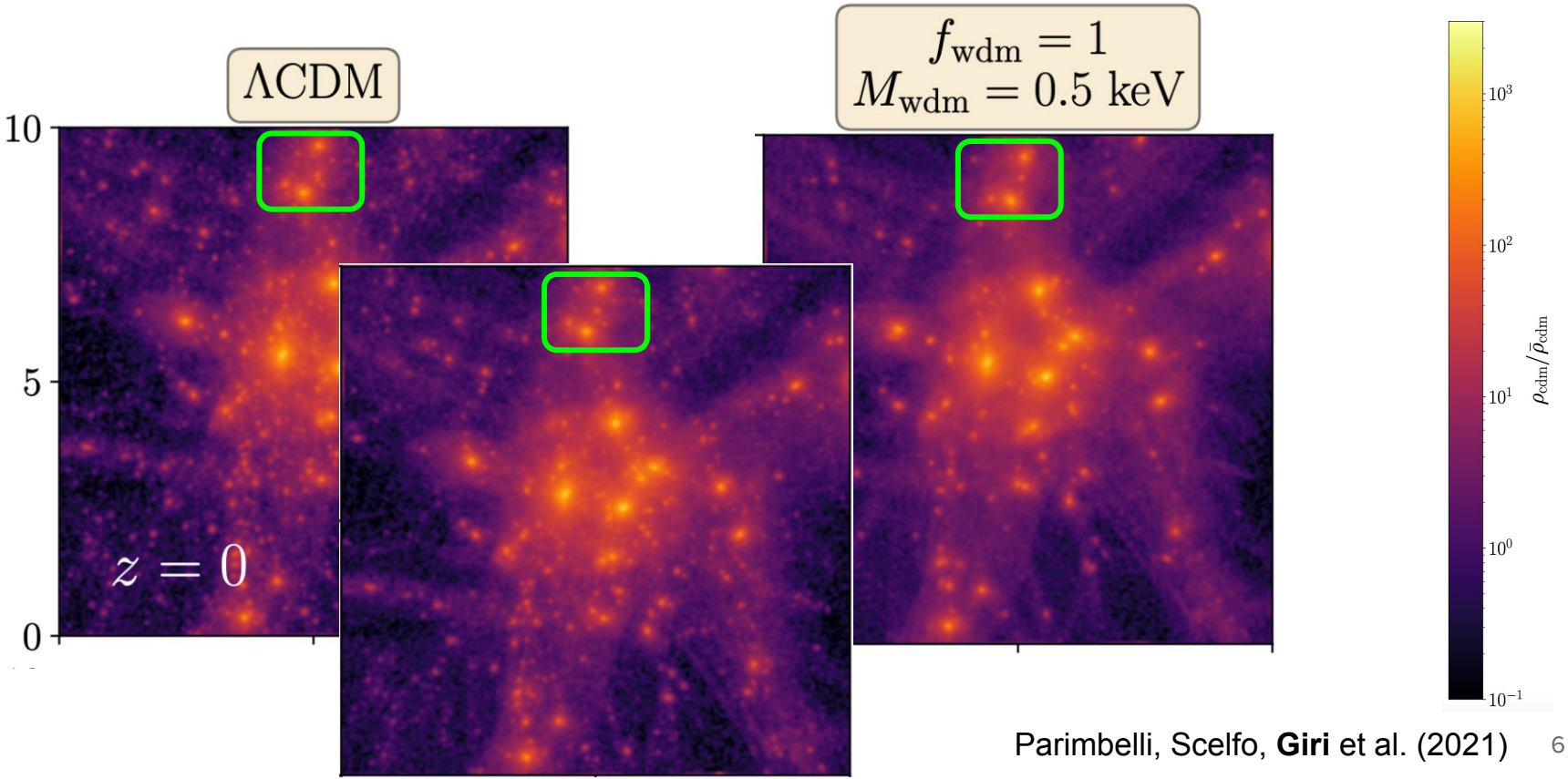
Parimbelli, Scelfo, **Giri** et al. (2021)

Non-cold dark matter models



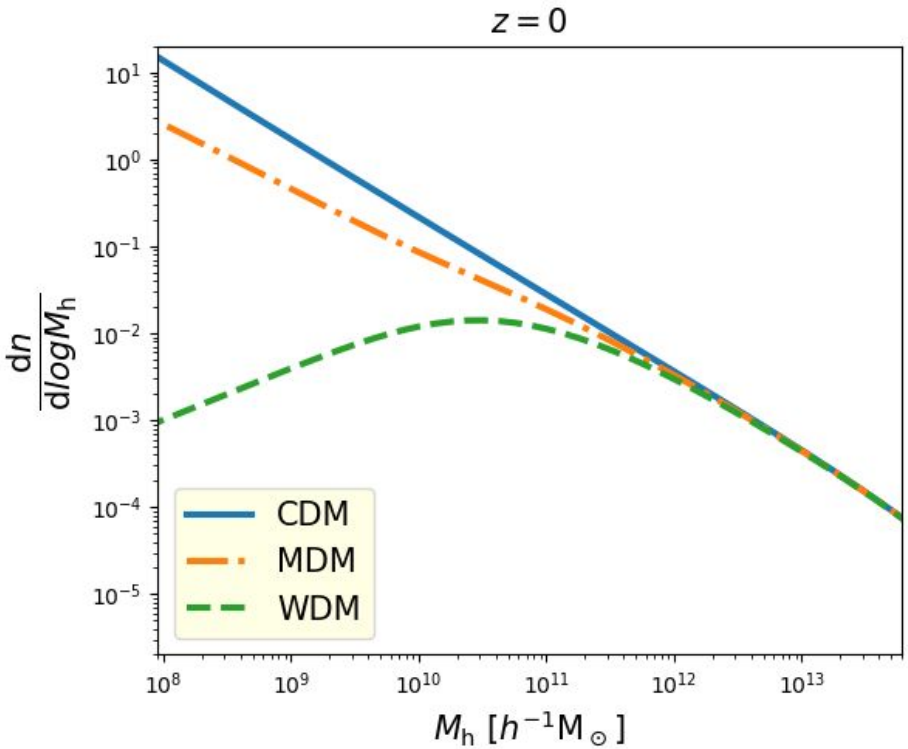
Parimbelli, Scelfo, **Giri** et al. (2021)

Mixture of cold and warm dark matter particles



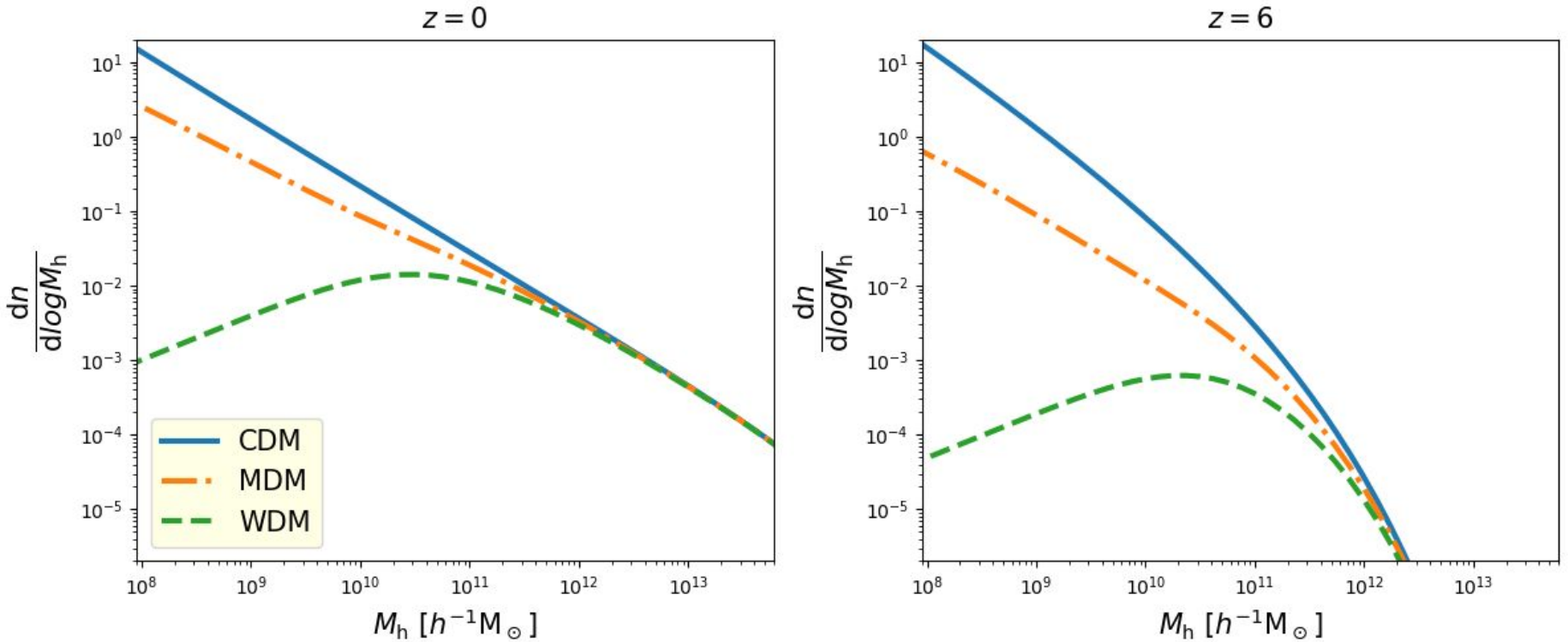
Parimbelli, Scelfo, **Giri** et al. (2021)

Halo Mass Function



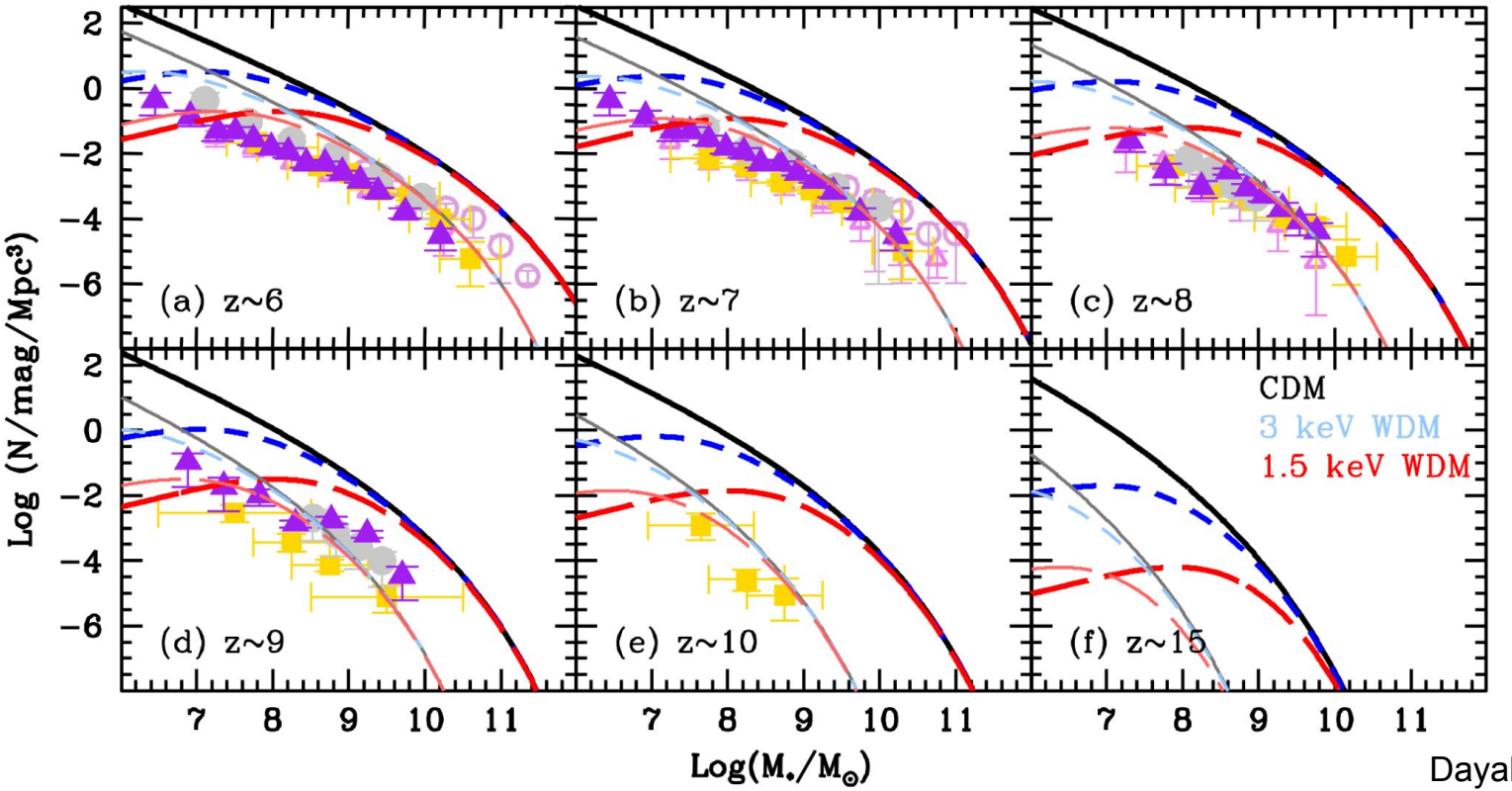
Giri & Schneider (2022)

Differences are more distinct at high redshift



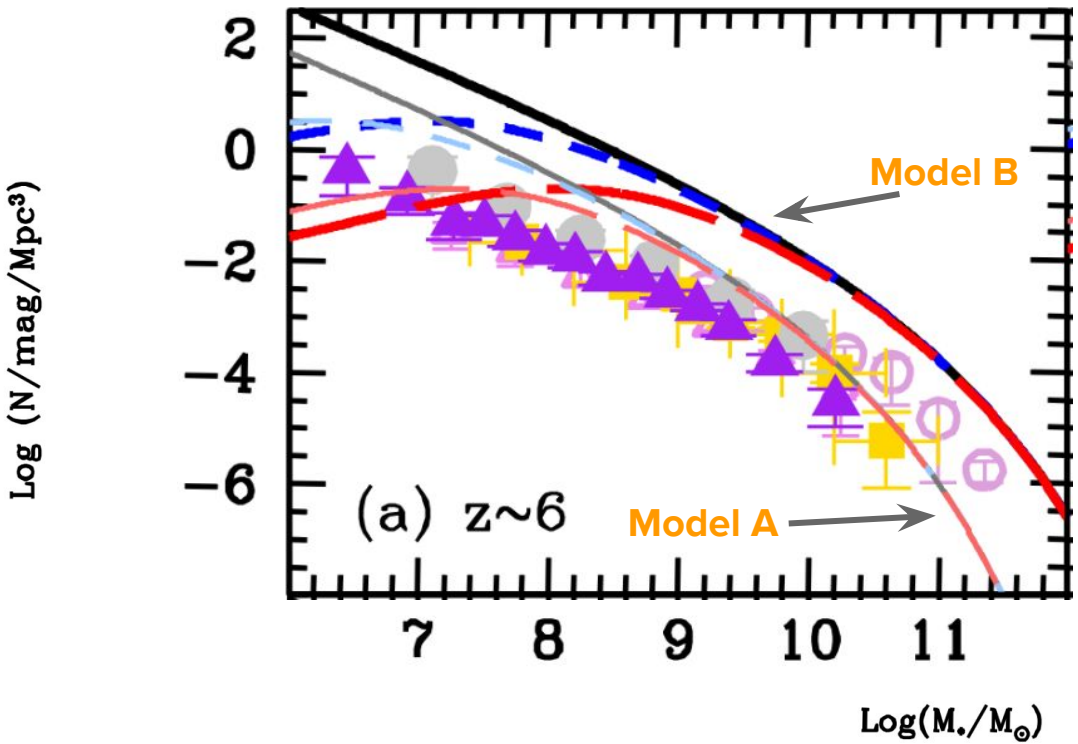
Giri & Schneider (2022)

Testing WDM models with JWST



Dayal & **Giri** (2024)

Stellar Mass Function at Redshift 6

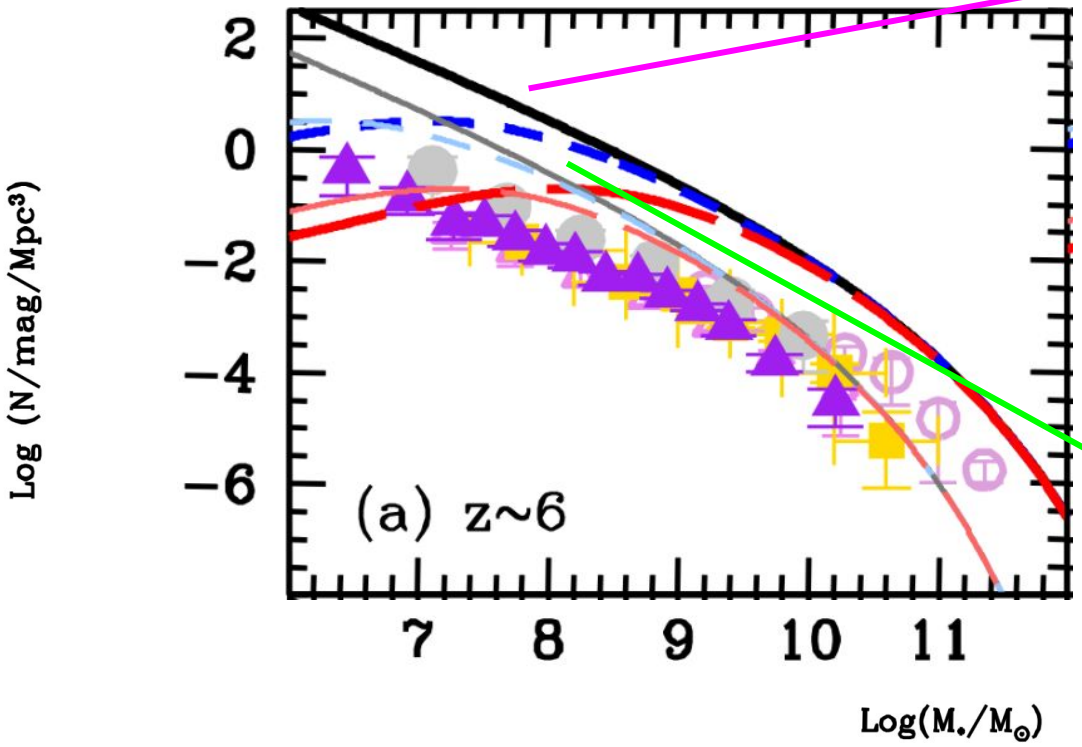


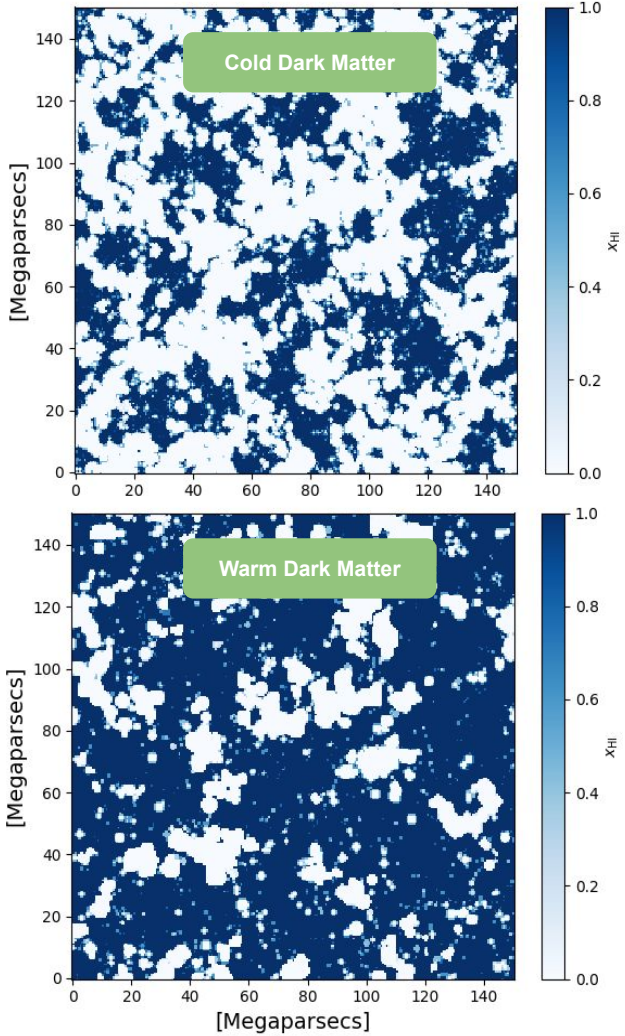
$$M_\star = \epsilon_\star(z) \left(\frac{\Omega_\mathrm{b}}{\Omega_\mathrm{m}}\right) M_\mathrm{h}$$

CDM
3 keV WDM
1.5 keV WDM

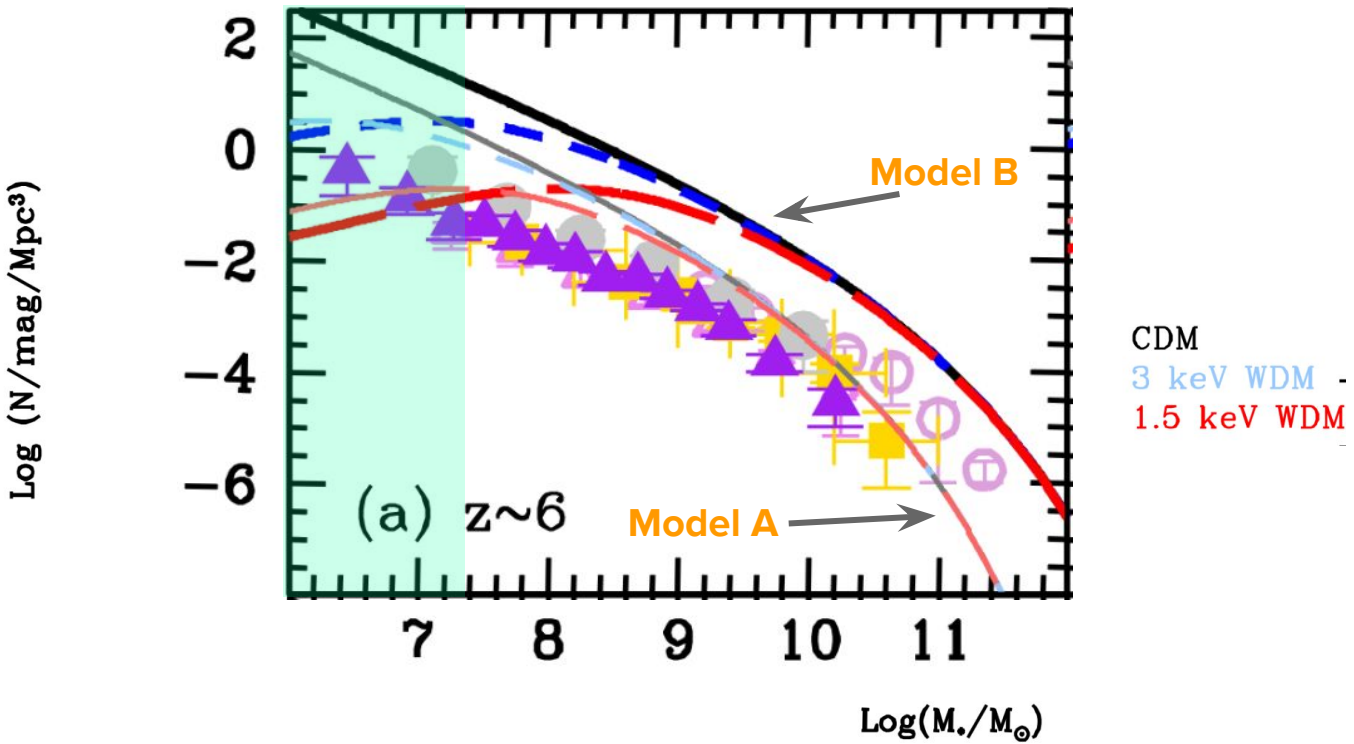
Dayal & **Giri** (2024)

Reionization is delayed in WDM



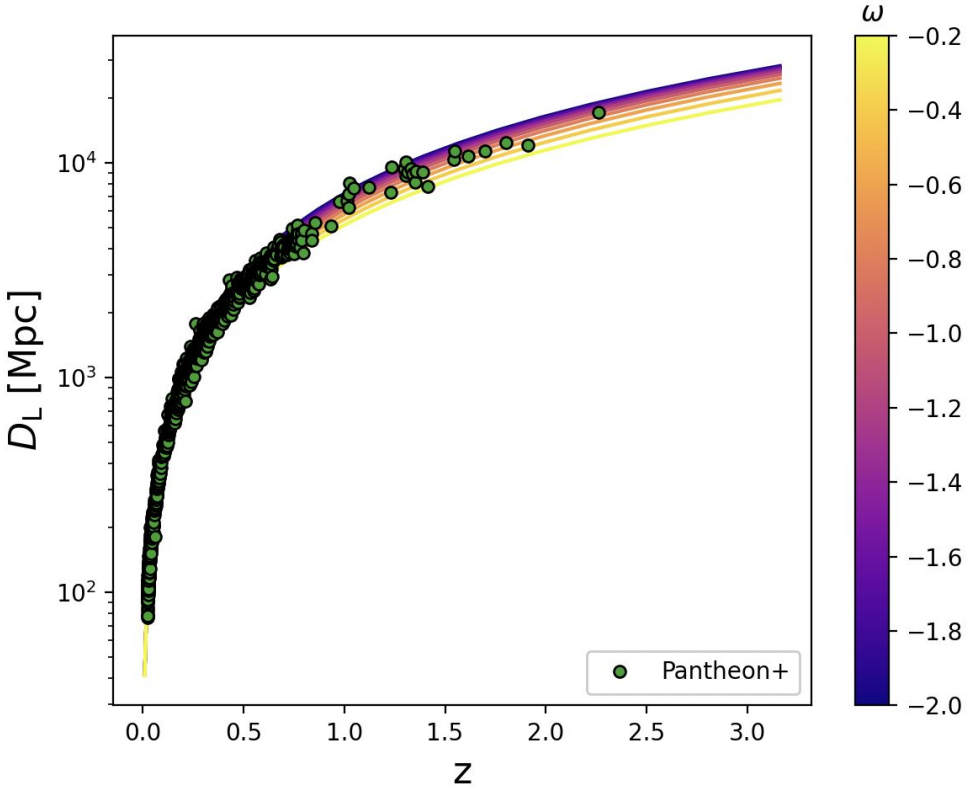


1.5 keV WDM can be ruled out



Dayal & **Giri** (2024)

Dark energy affects the rate of expansion



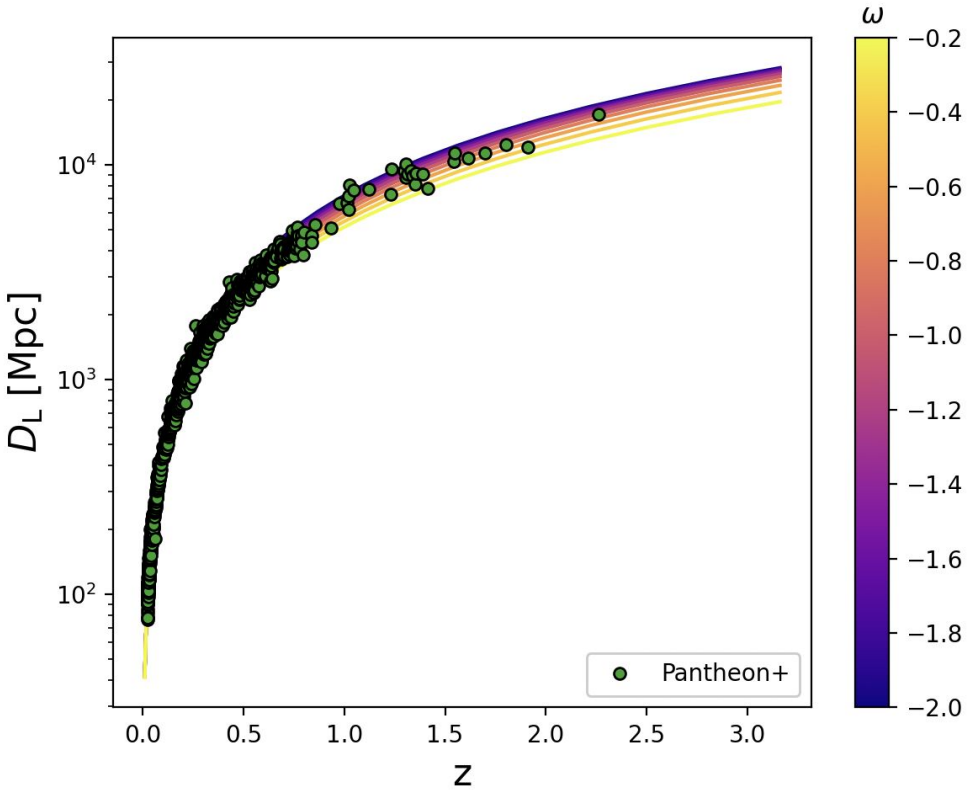
wCDM

$$\omega(z) = w$$

$$\left[\frac{H(z)}{H_0}\right]^2 = \Omega_m(1+z)^3 + \Omega_\Lambda(1+z)^{3(1+\omega)}$$

$$D_{\mathrm{L}}(z) = (1+z)\int_0^z \frac{c dz'}{H(z')}$$

wCDM cosmology

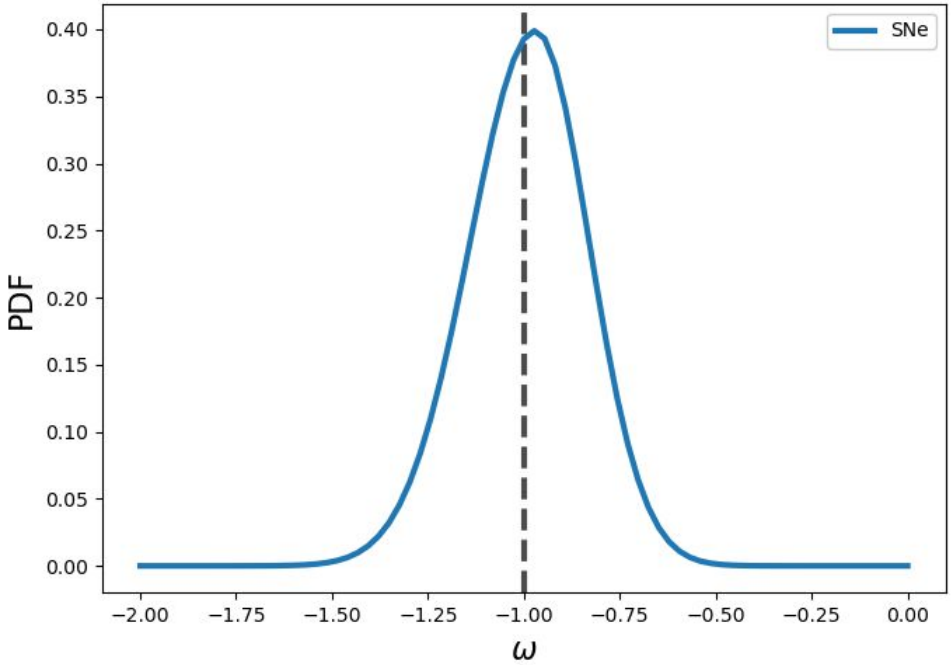


wCDM

$$\omega(z) = w$$

← **ΛCDM**

Constraint from SNe data (Pantheon+)

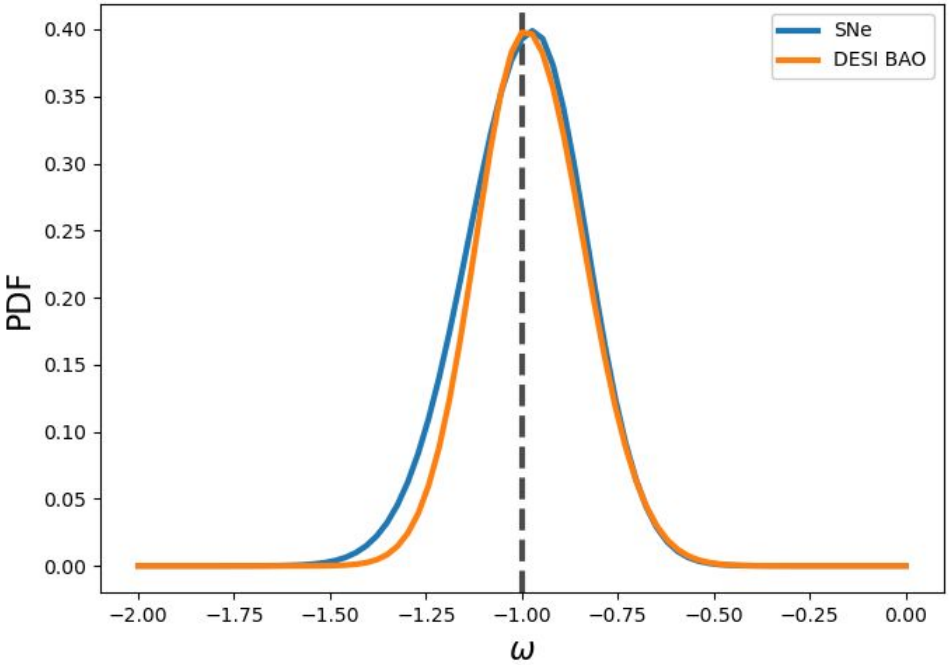


wCDM

$$\omega(z) = w$$

Giri+in prep

Constraint from DESI BAO

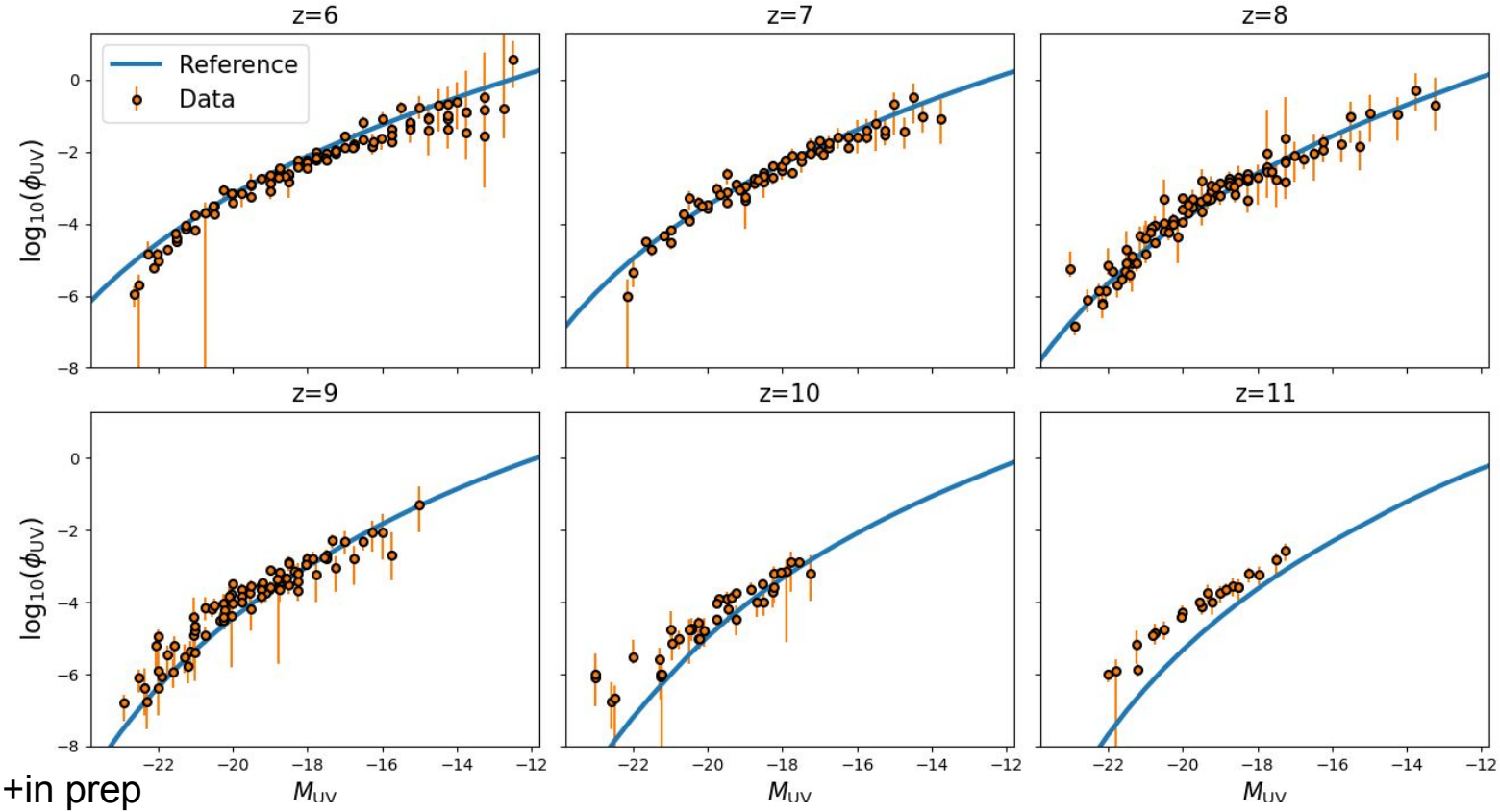


wCDM

$$\omega(z) = w$$

Giri+in prep

High-z Ultraviolet Luminosity Functions (UVLFs)



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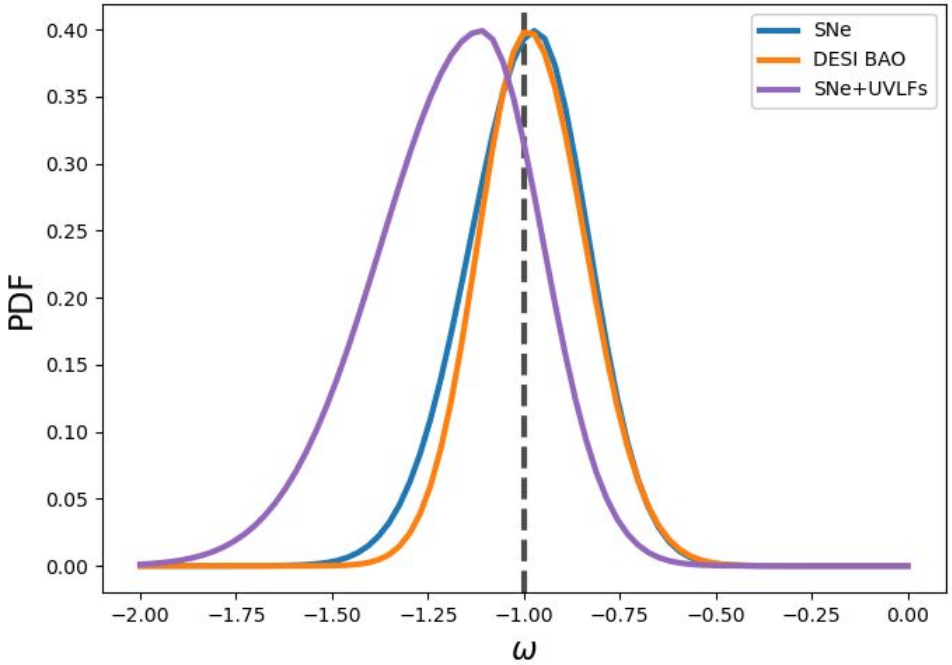
Constraint from SNe + high-z UVLFs



wCDM

$$\omega(z) = w$$

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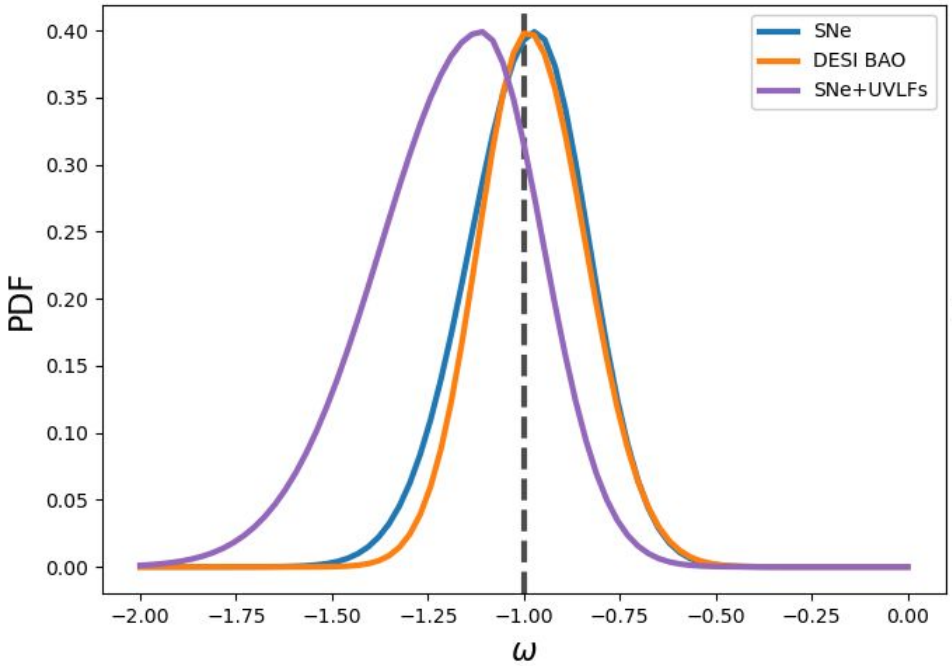
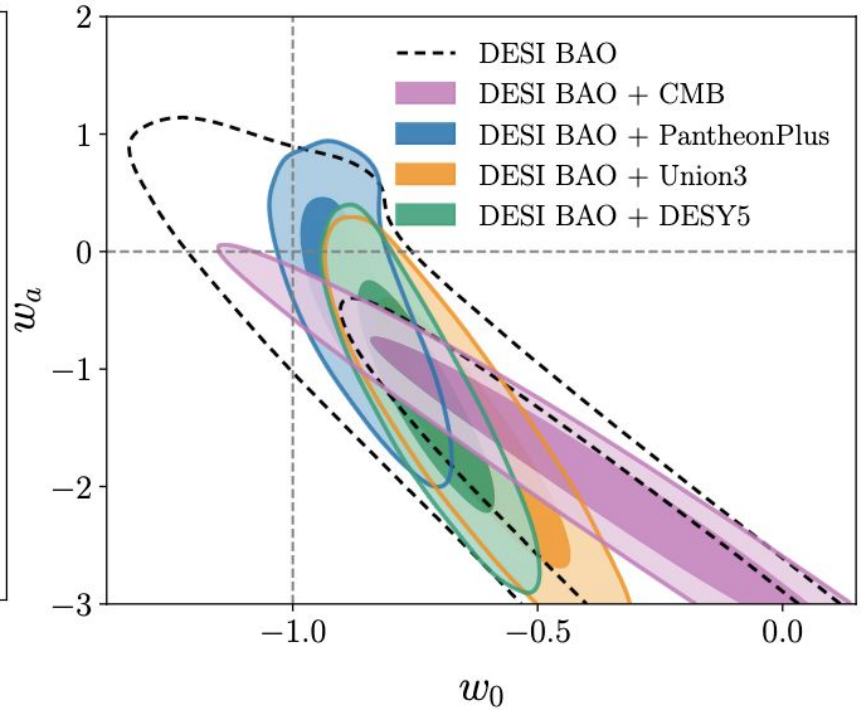
Mirage of Λ

w_0w_aCDM or CPL

$$\omega(z) = \omega_0 + \omega_a \frac{z}{1+z}$$





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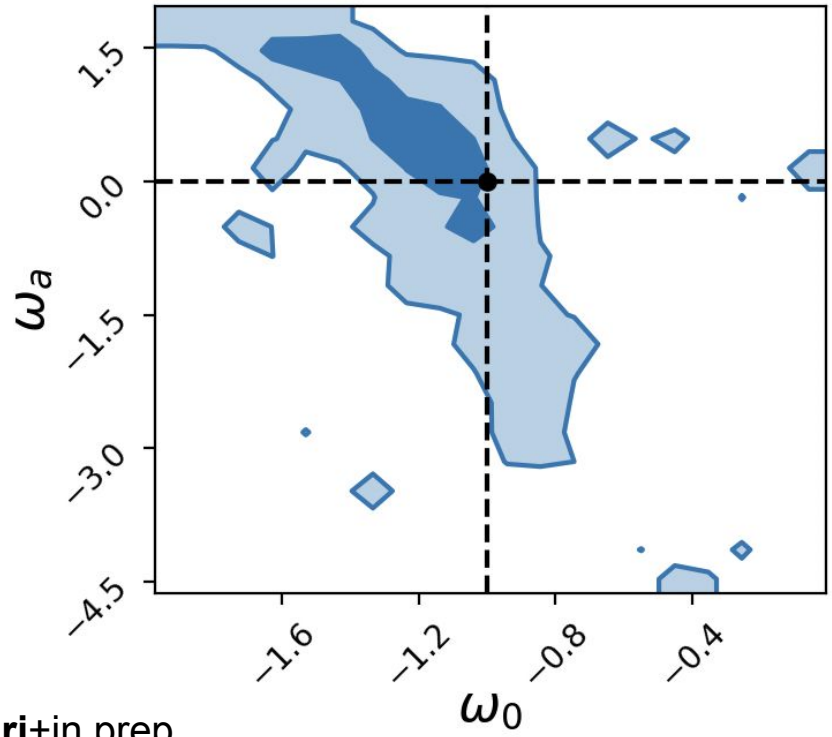
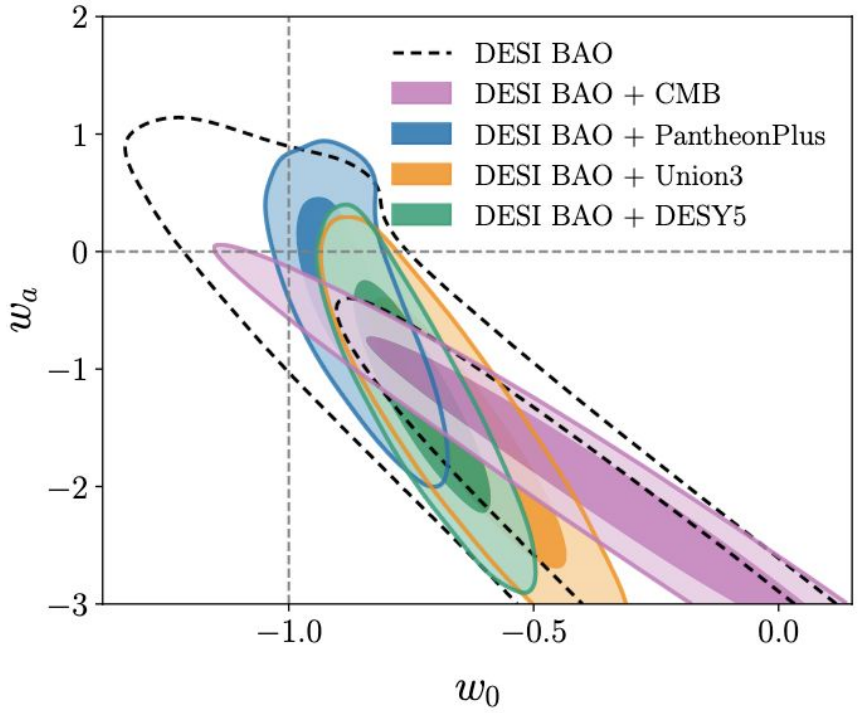
DESI Collaboration+(2024)

Dynamical Dark Energy

w_0w_aCDM or CPL

$$\omega(z) = \omega_0 + \omega_a \frac{z}{1+z}$$





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Summary

- Non-cold dark matter models (e.g. WDM & FDM) 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
- JWST data is already sensitive to rule out extreme dark matter models
  - **M_{WDM}>1.5 keV (current JWST data)**
- We can explore **dynamical dark energy** including high-z observations
  - Current data hinting towards a **deviation from a constant dark energy**