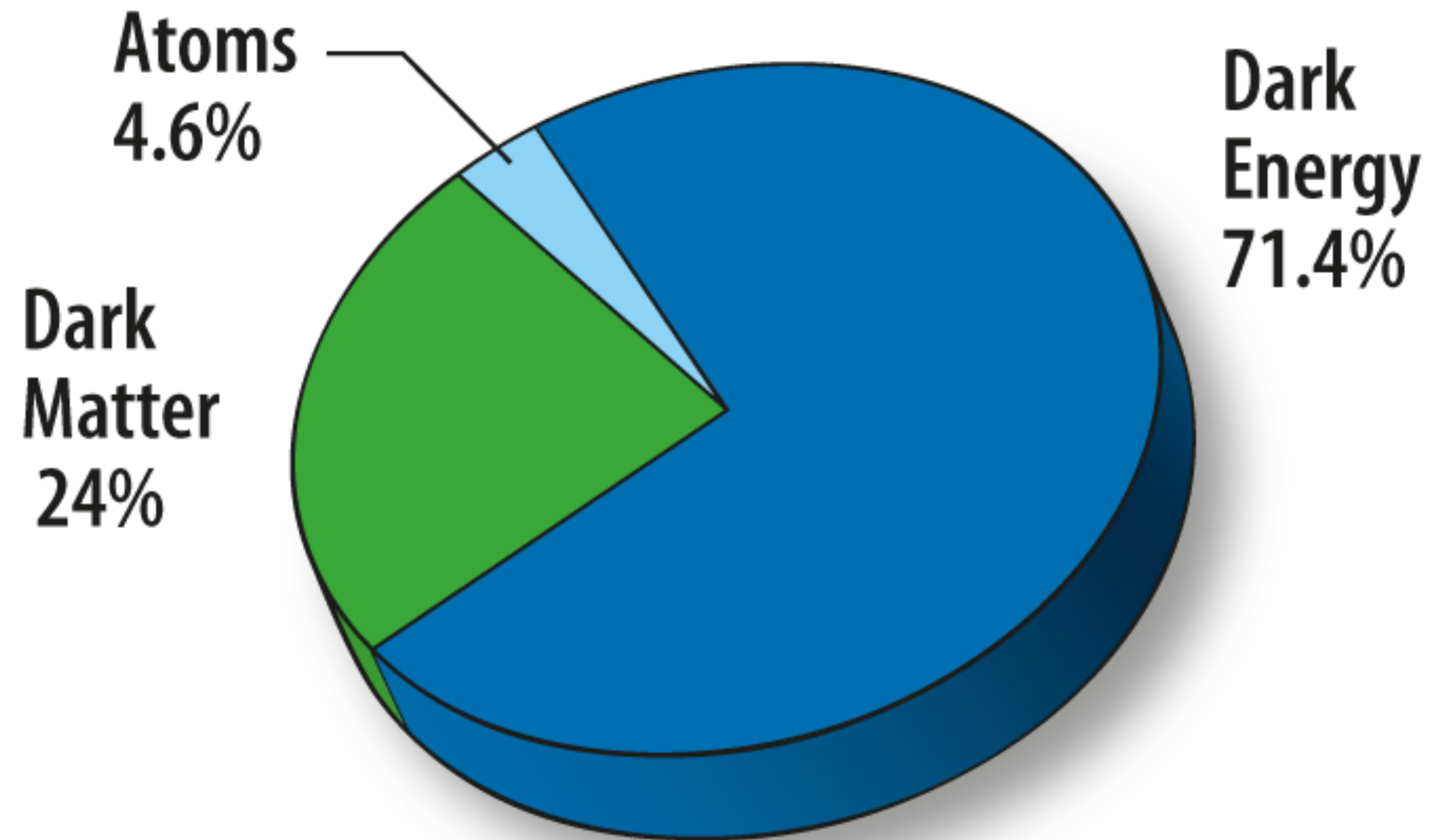


Impact of a w CDM cosmology on the tSZ power spectrum

Emma Ayçoberry (postdoc at CEA Paris-Saclay)

Standard Λ CDM model

- ▶ **Standard model** of cosmology
- ▶ Flat universe composed of:
 - Cosmological constant Λ
 - Cold dark matter
 - Baryonic matter

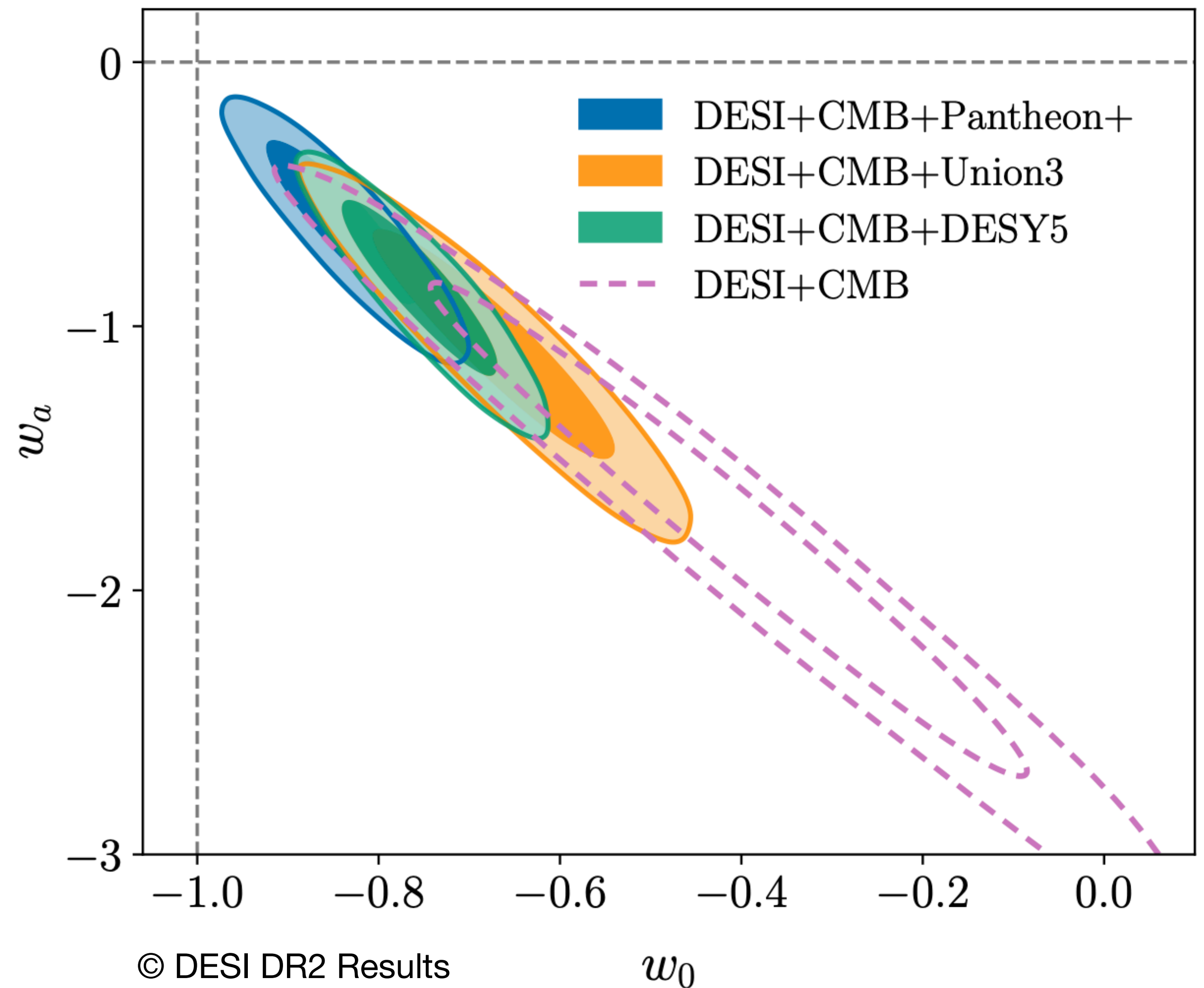


© WMAP

© nasa

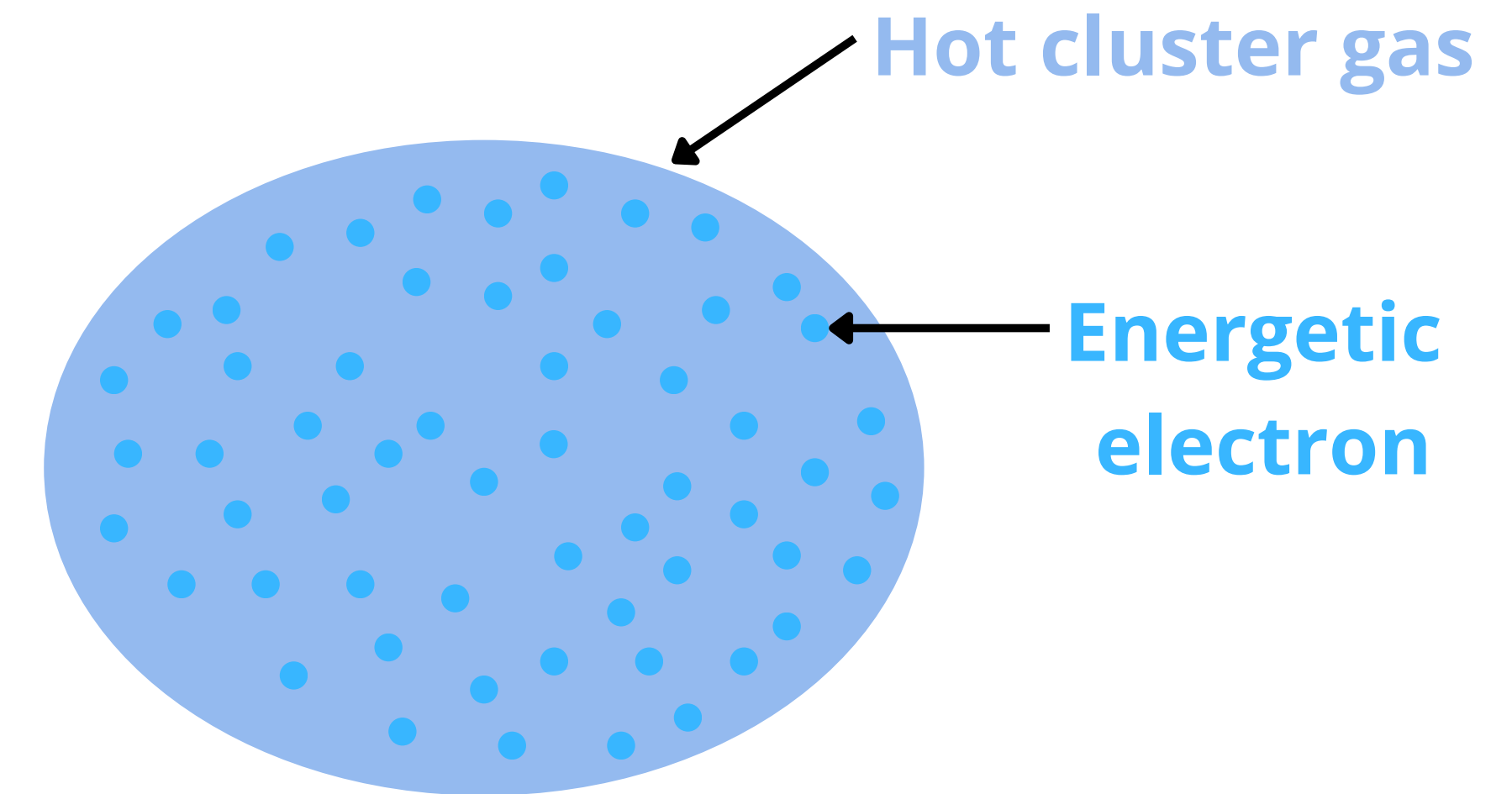
Beyond Λ CDM model

- ▶ **Nature of dark energy** is still unknown
- ▶ Λ CDM model \rightarrow tension between the different observables
- ▶ **Explore beyond Λ CDM models**
 - w CDM: constant DE where $P = w\rho$
 - w_0w_a CDM: evolving DE where $w(a) = w_0 + w_a(1 - a)$
 - ...



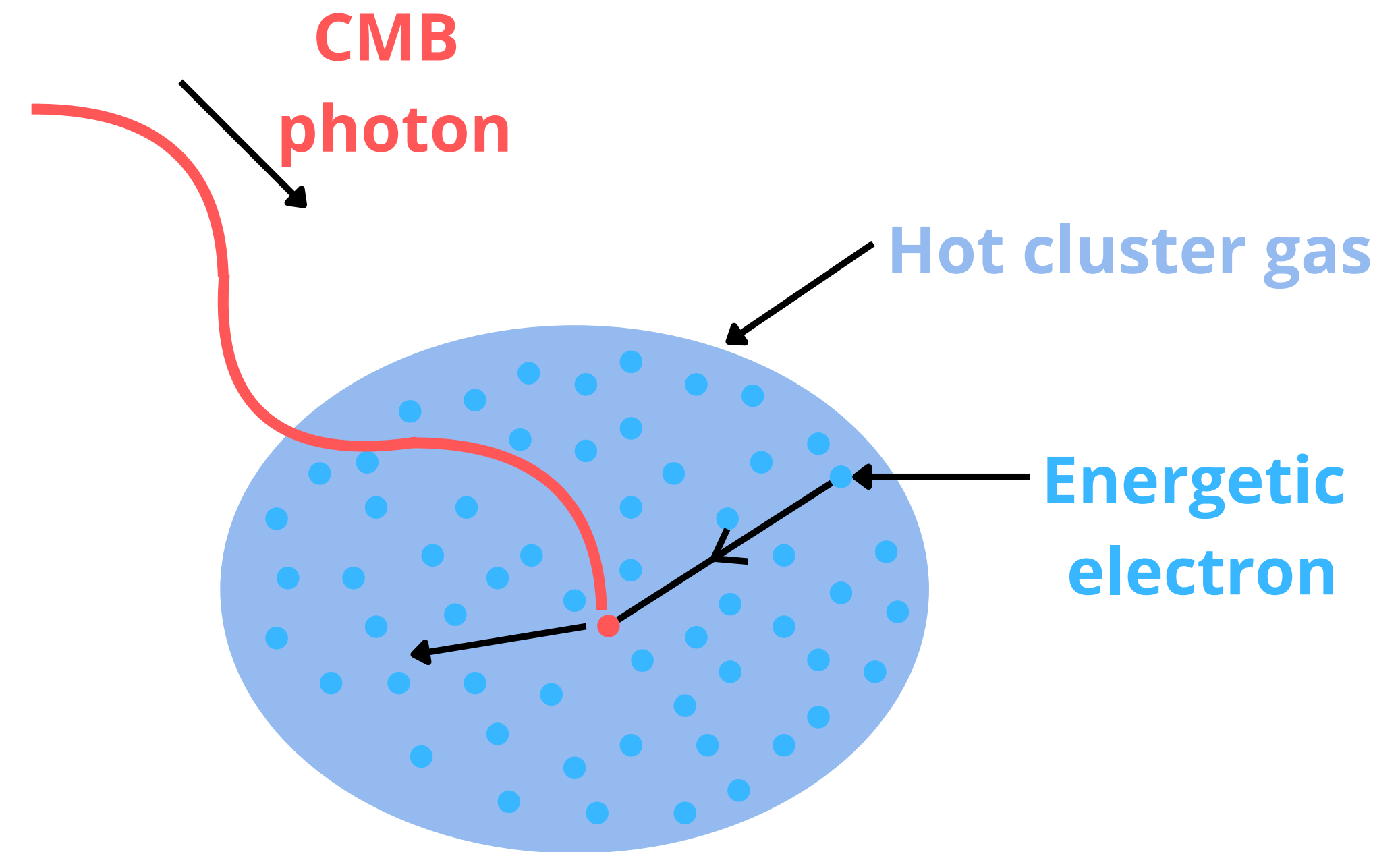
Thermal Sunyaev-Zel'dovich effect

- ▶ Comes from the **thermal electrons**, which reside mostly in **galaxy clusters**



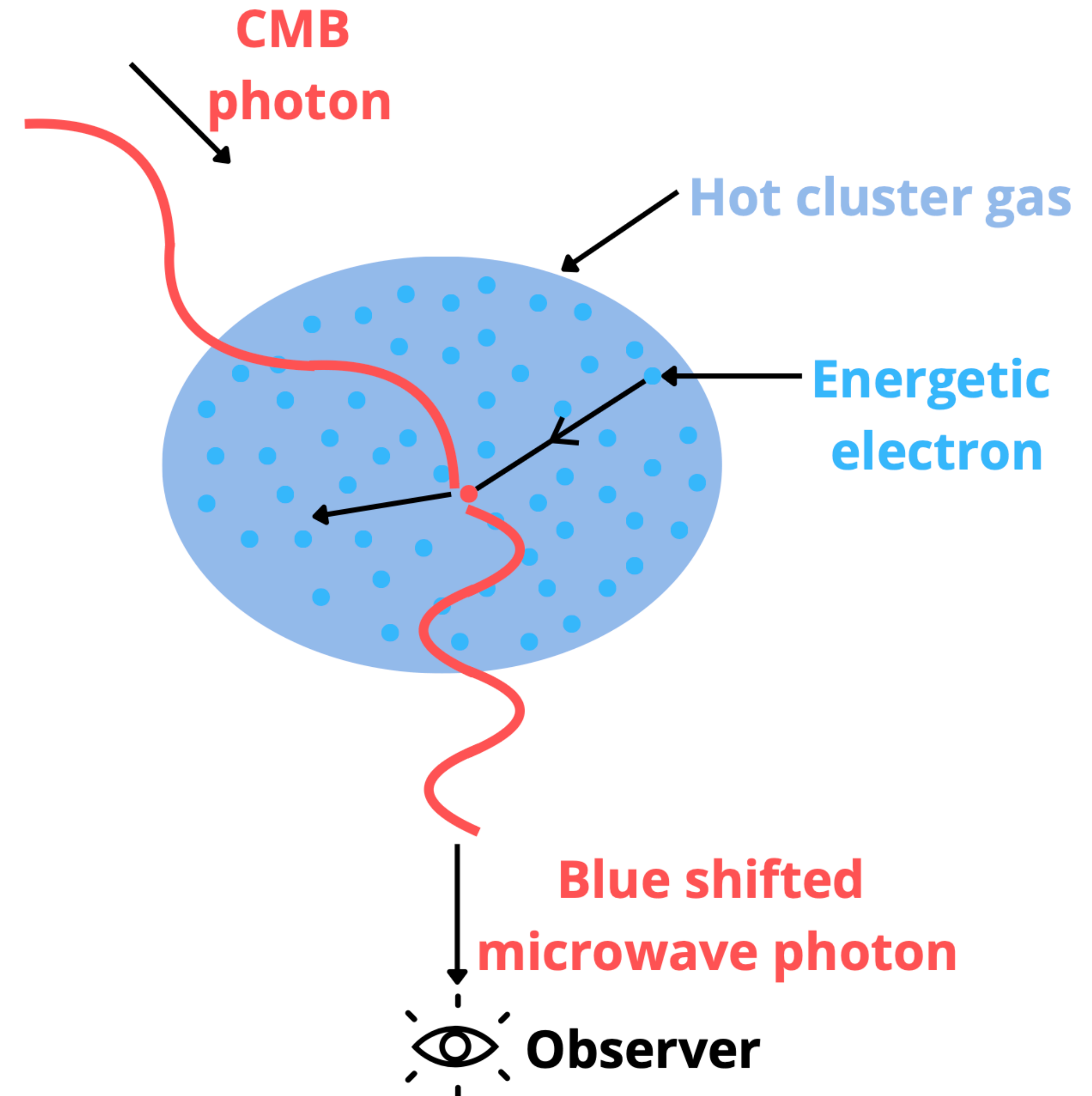
Thermal Sunyaev-Zel'dovich effect

- ▶ Comes from the **thermal electrons**, which reside mostly in **galaxy clusters**
- ▶ Energy is transferred from **hot electrons** to **CMB photons** through **inverse Compton scattering**

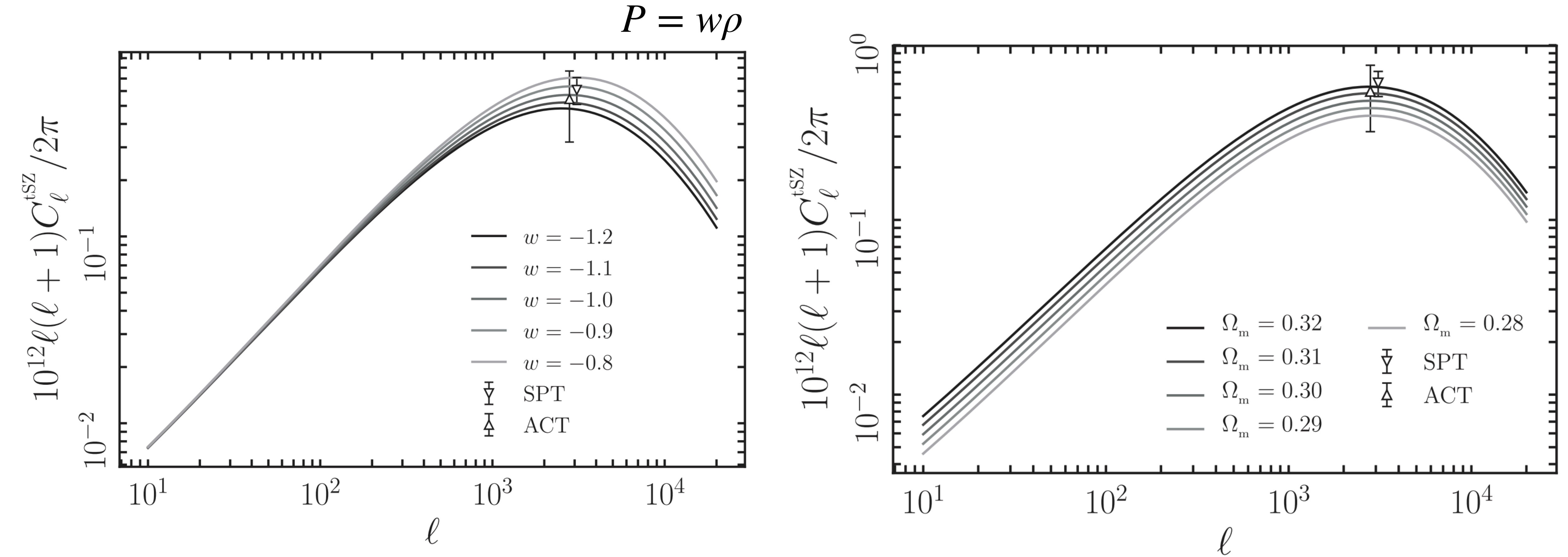


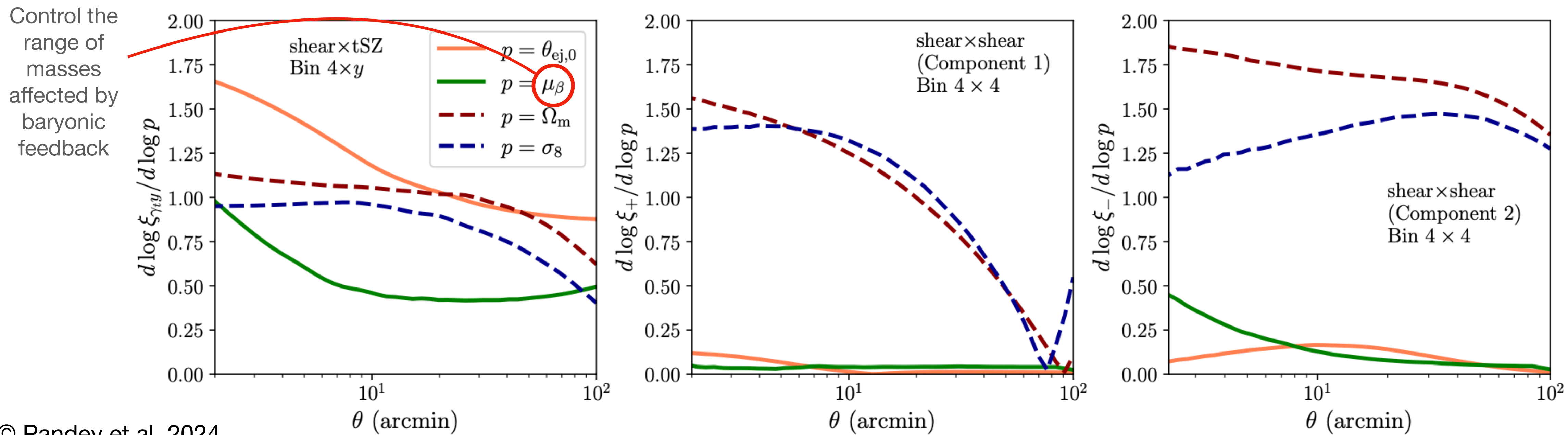
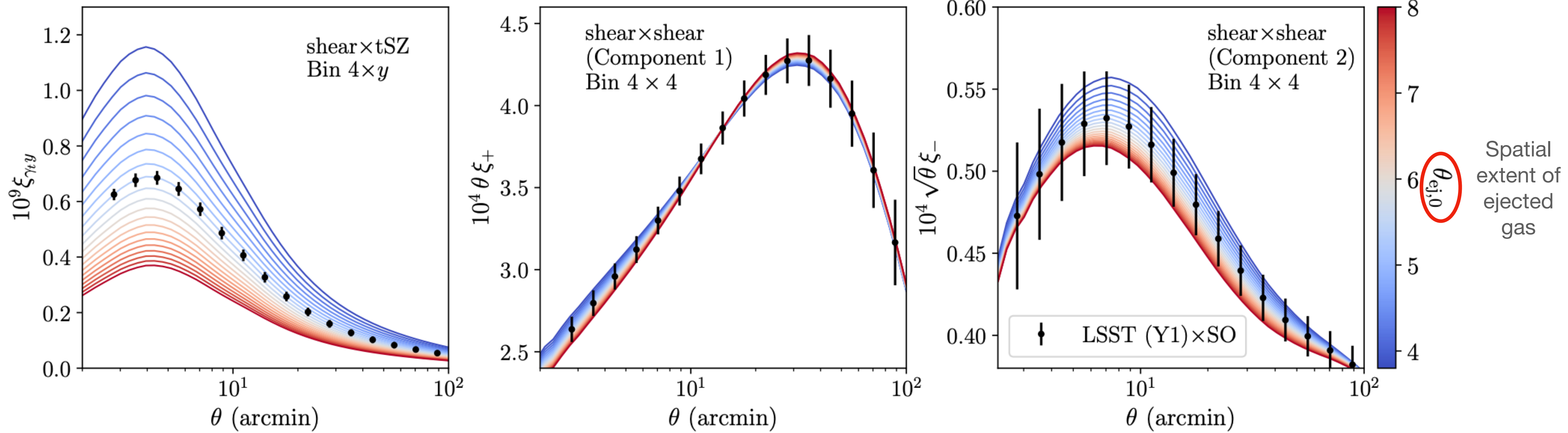
Thermal Sunyaev-Zel'dovich effect

- ▶ Shift in **energy**
- ▶ Information about the late time Universe
- ▶ Dependence: **gas density and temperature**
- ▶ Electron pressure along the line of sight



Thermal Sunyaev-Zel'dovich effect

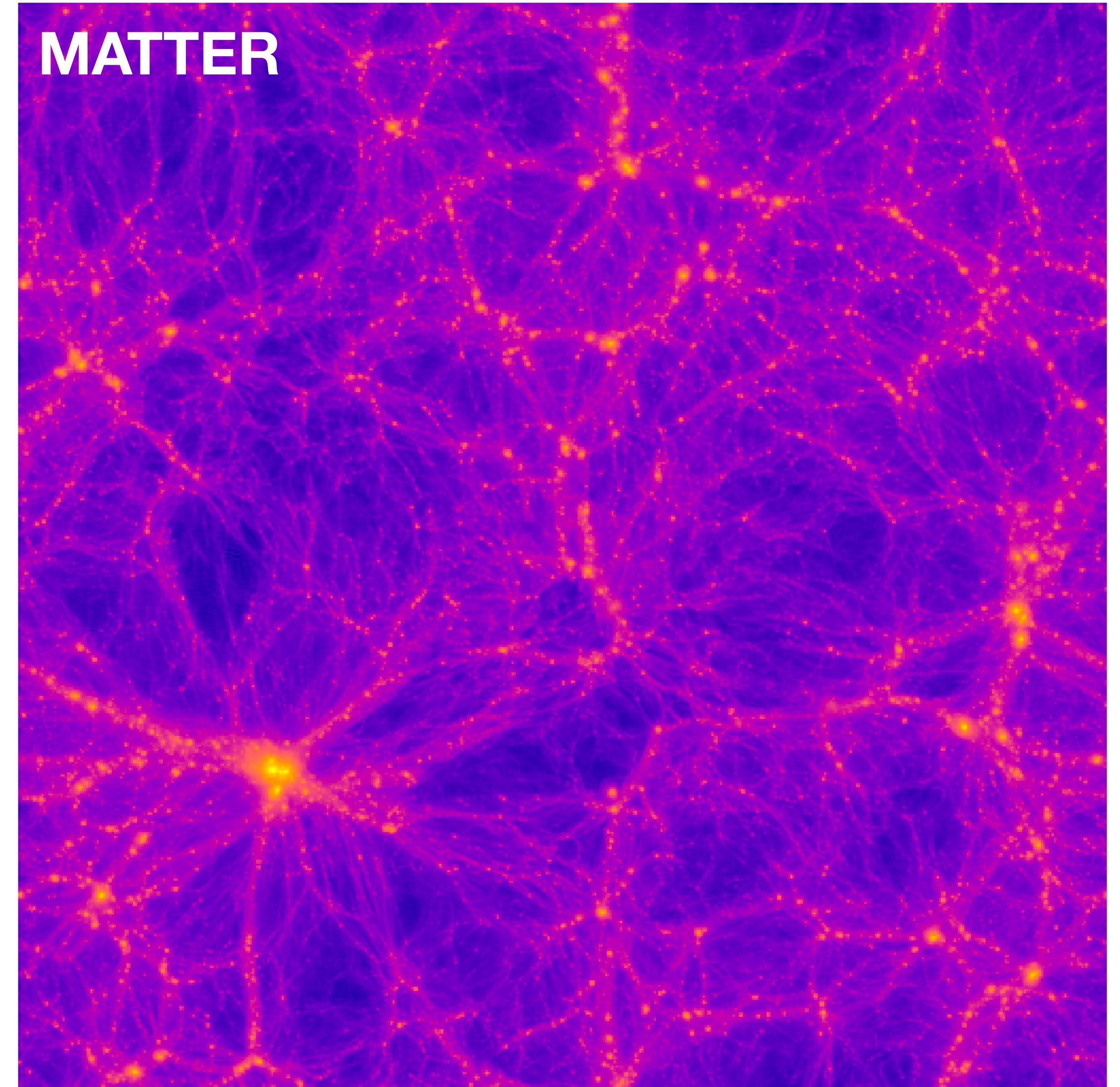
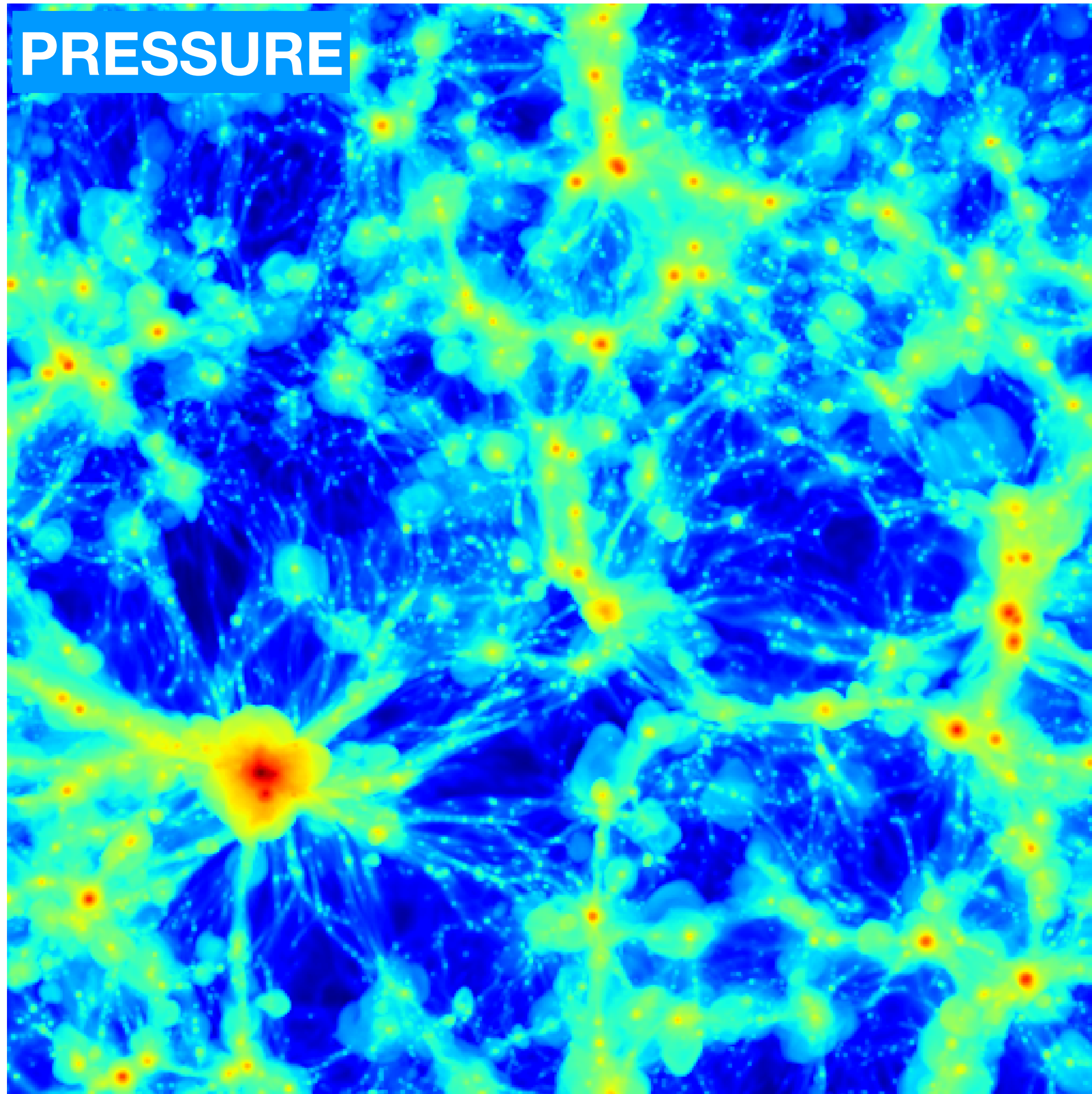




Thermal Sunyaev-Zel'dovich effect

- ▶ Sensitive to cosmology, including dark energy
 - ▶ Sensitive to baryonic physics
- Break the degeneracies between cosmology and astrophysics
- Test cosmological model beyond Λ CDM

Horizon-AGN

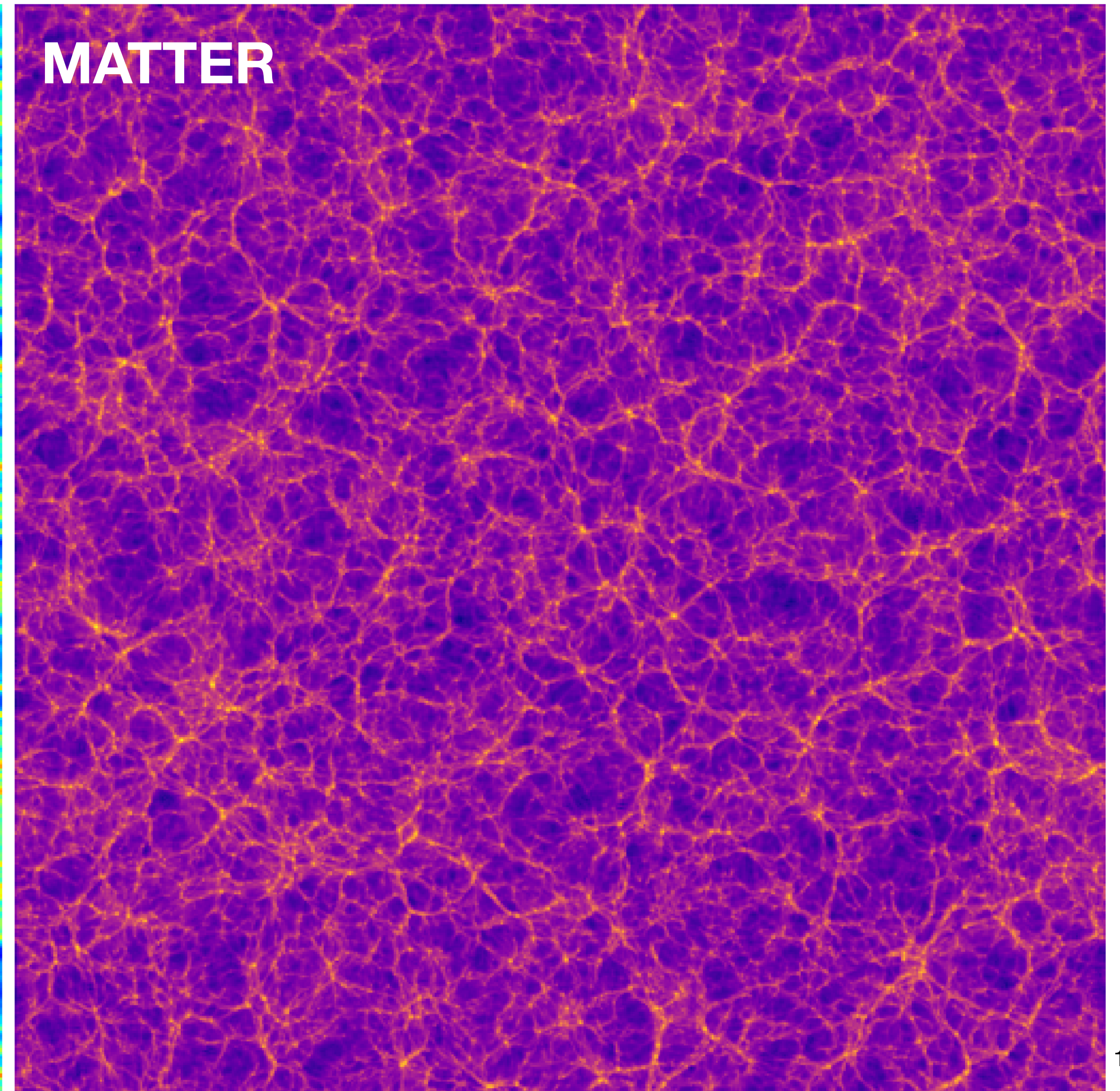
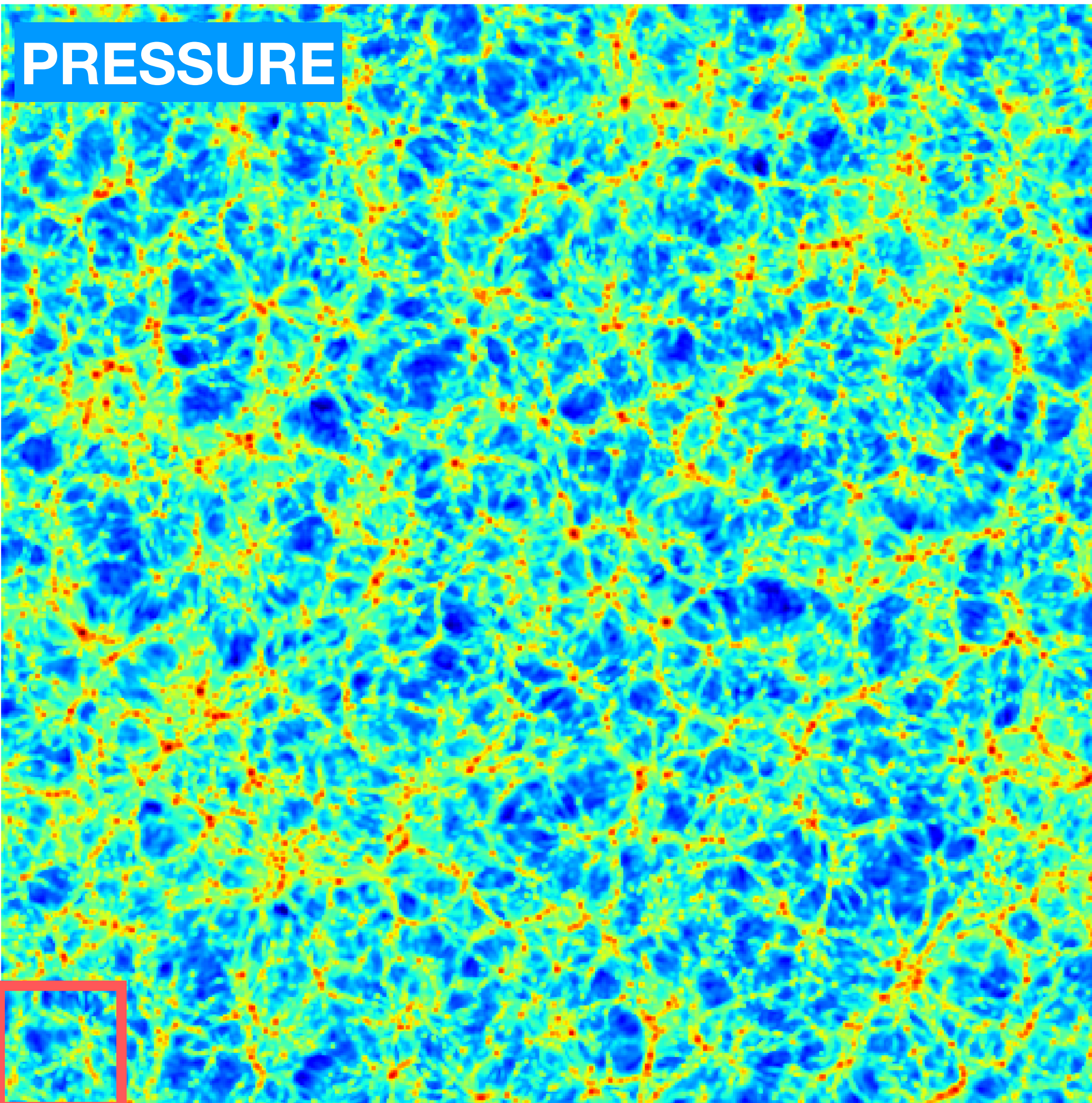


L896_wCDM simulations

- ▶ Cosmological hydrodynamical simulations
- ▶ $896 h^{-1}$ Mpc comoving volume, 1024^3 DM particle $\rightarrow M_{\text{DM,res}} = 6 \times 10^{10} M_{\odot}$
- ▶ Gas cooling and heating, no galactic physics
- ▶ Initial condition using 2LPT
- ▶ **Cosmology w CDM:** $P = w\rho$ with different w
 - $w(a) = w_0 + w_a(1 - a)$
 - $w = -0.8, w = -1, w = -1.2$

Equivalent to Λ CDM

L896_wCDM simulations

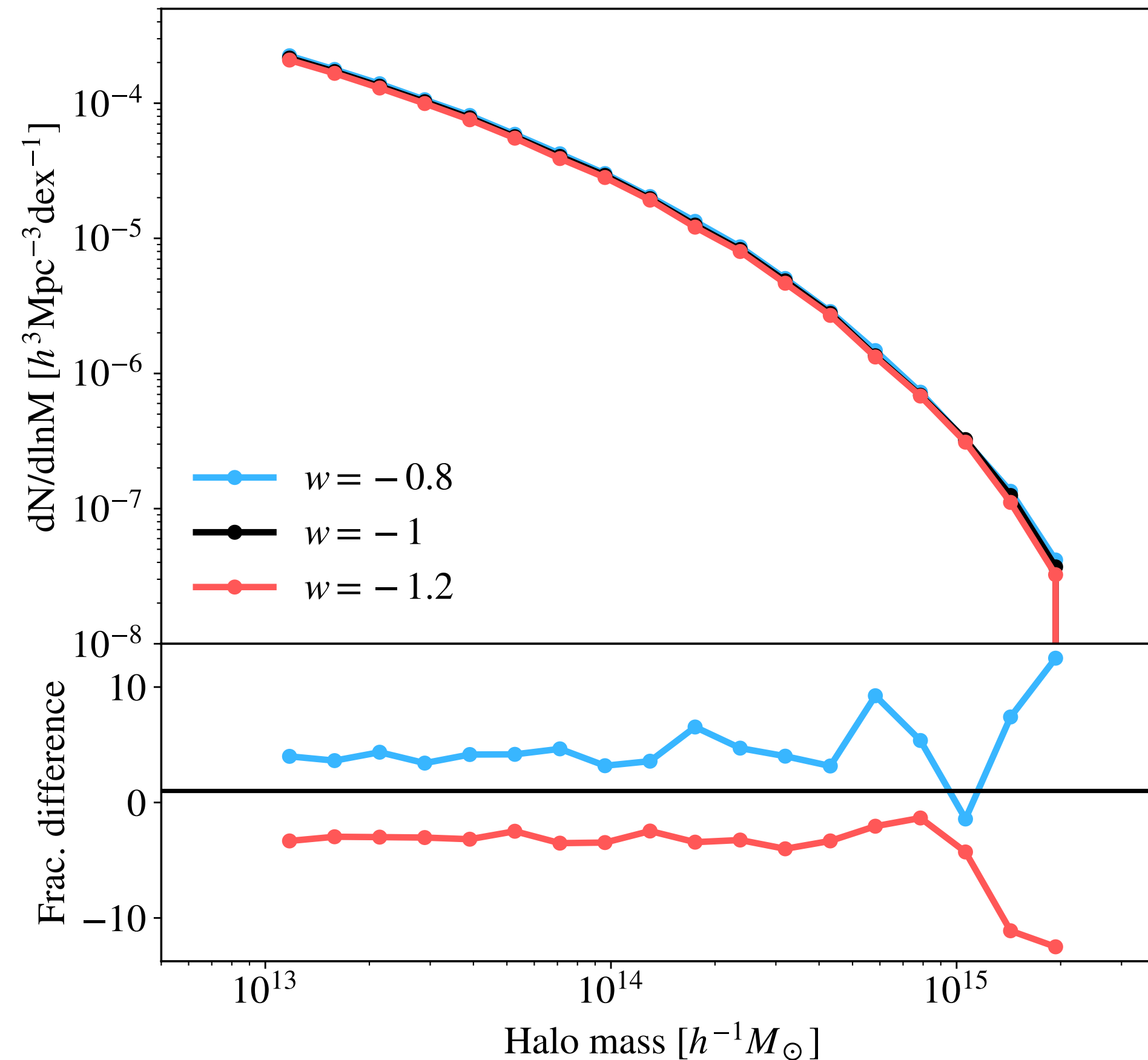


Size of Horizon-AGN

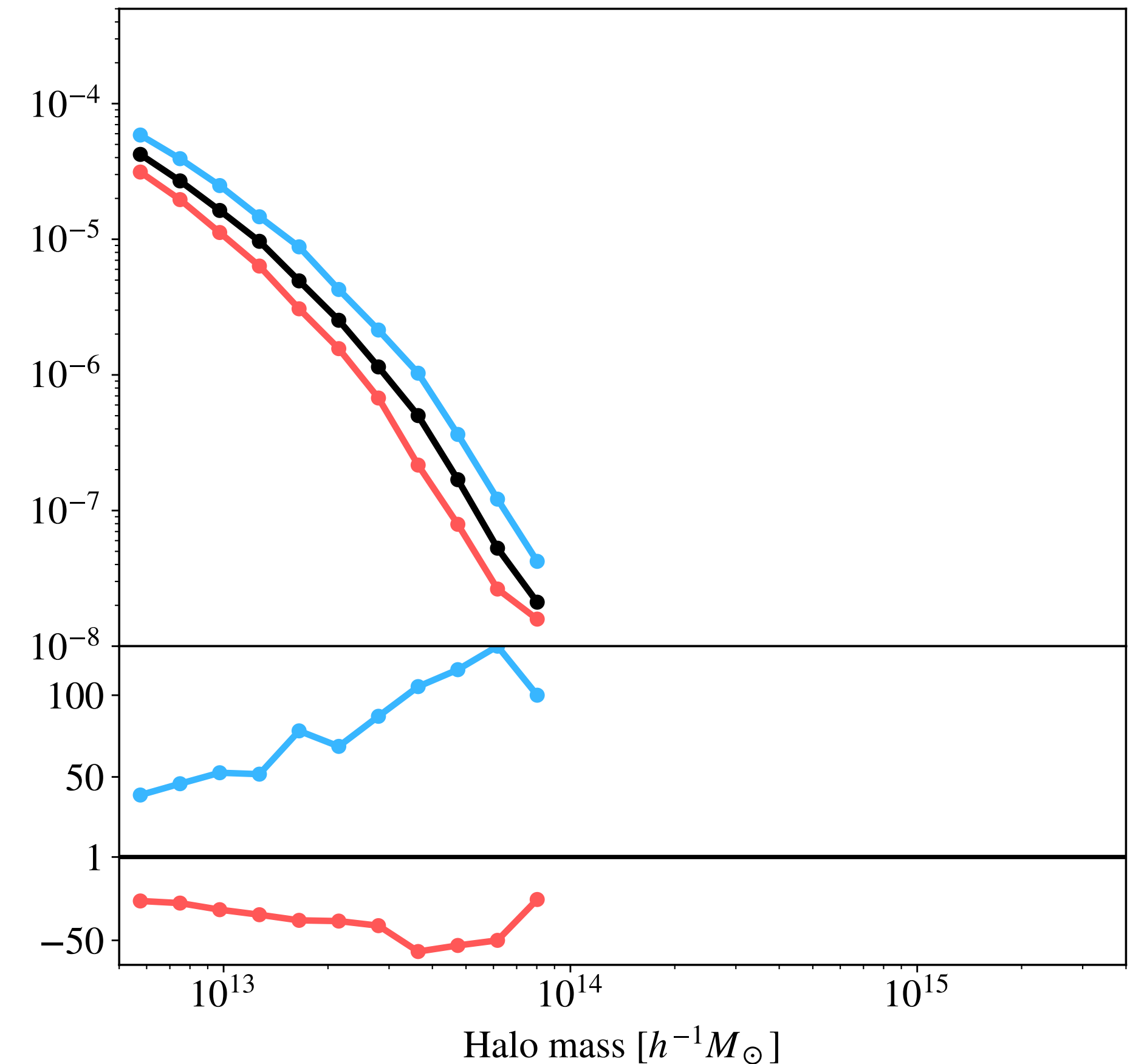
Halo mass function

- ▶ Dark energy impacts the growth of structures
- ▶ $P = w\rho$

$z = 0.02$

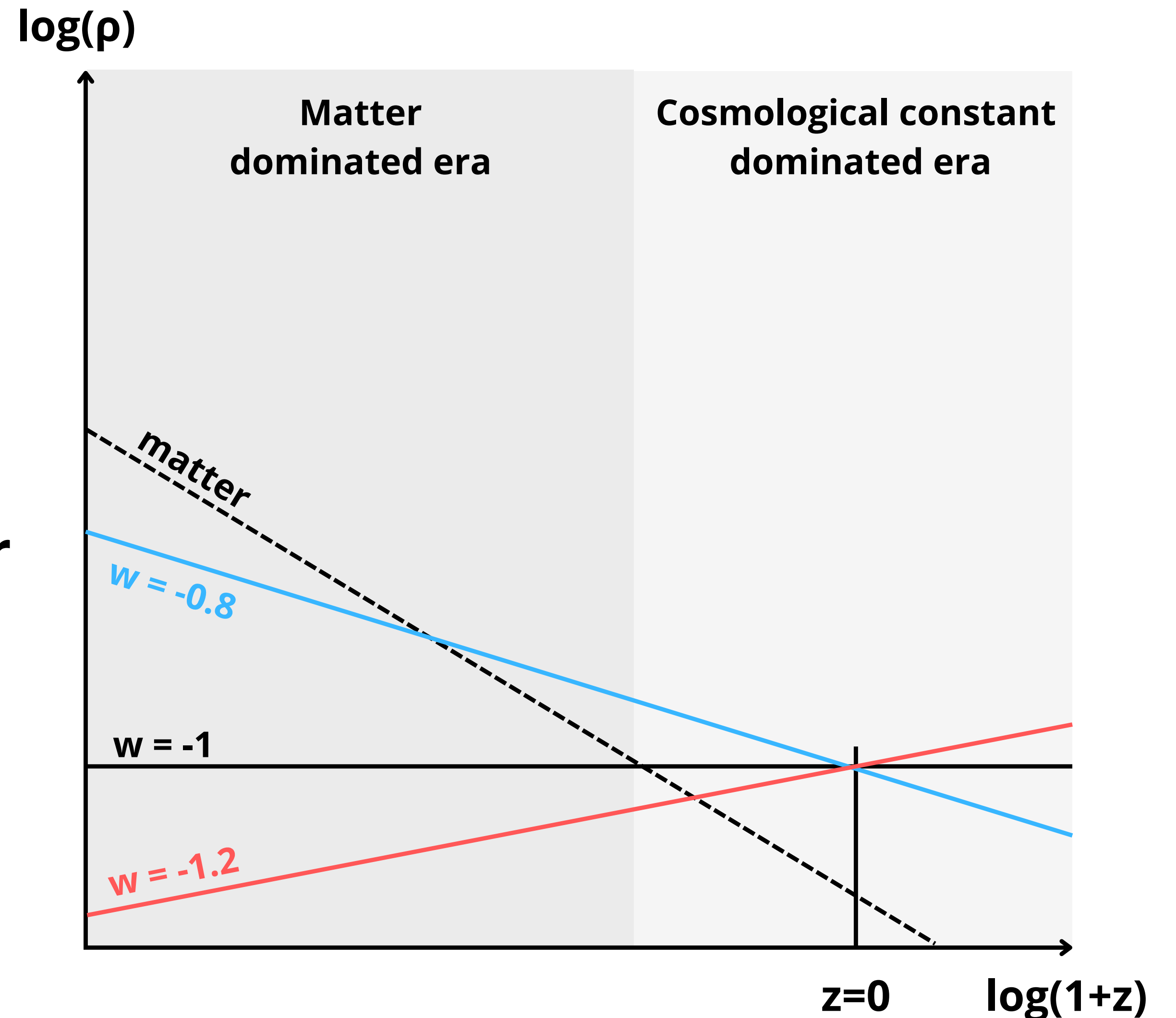


$z = 2.72$



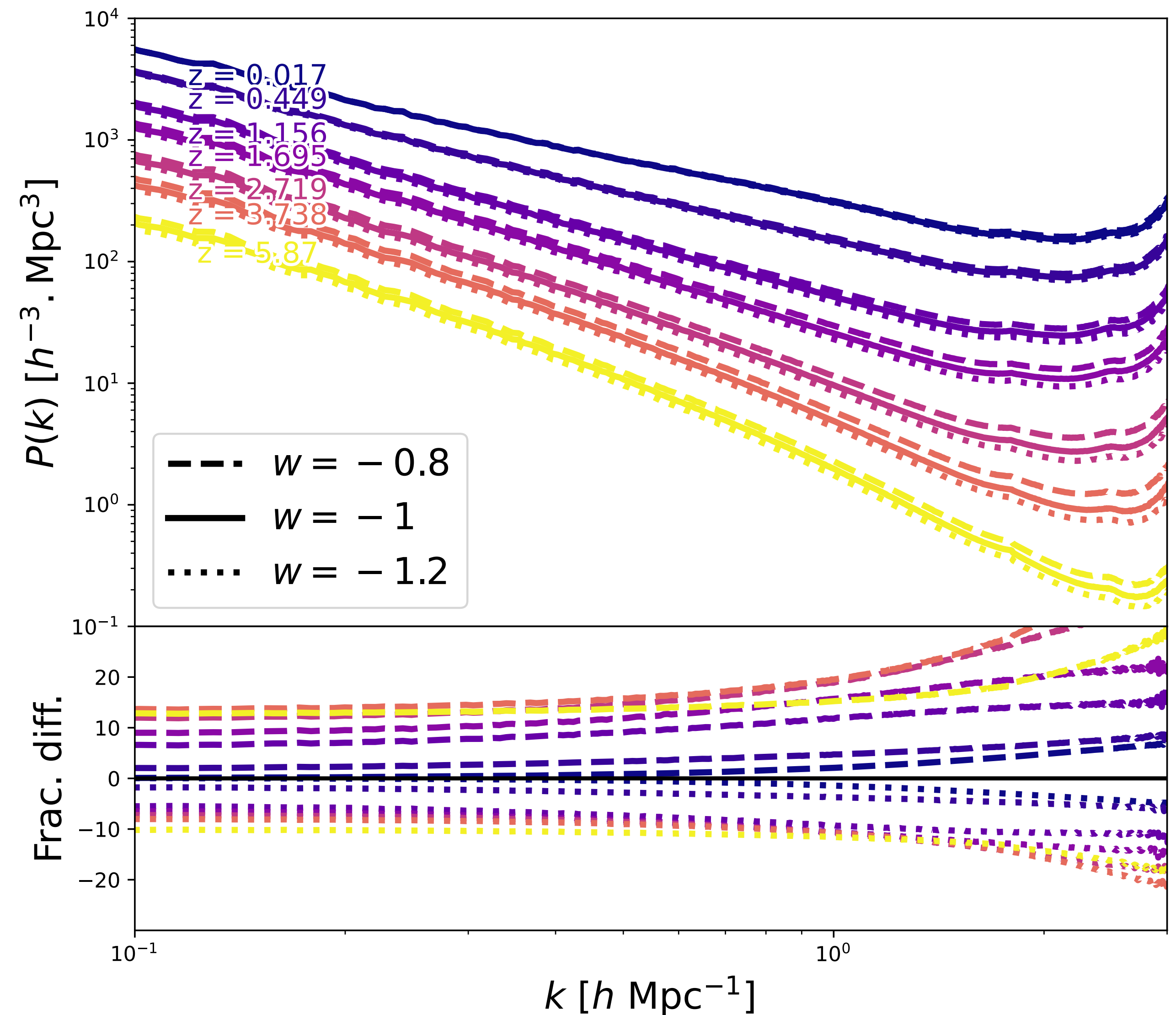
Growth of structures

- ▶ $w = -0.8$ accelerated expansion starts earlier
 - growth of structures is slower
 - **structure more developed earlier**
- ▶ Opposite trend for $w = -1.2$



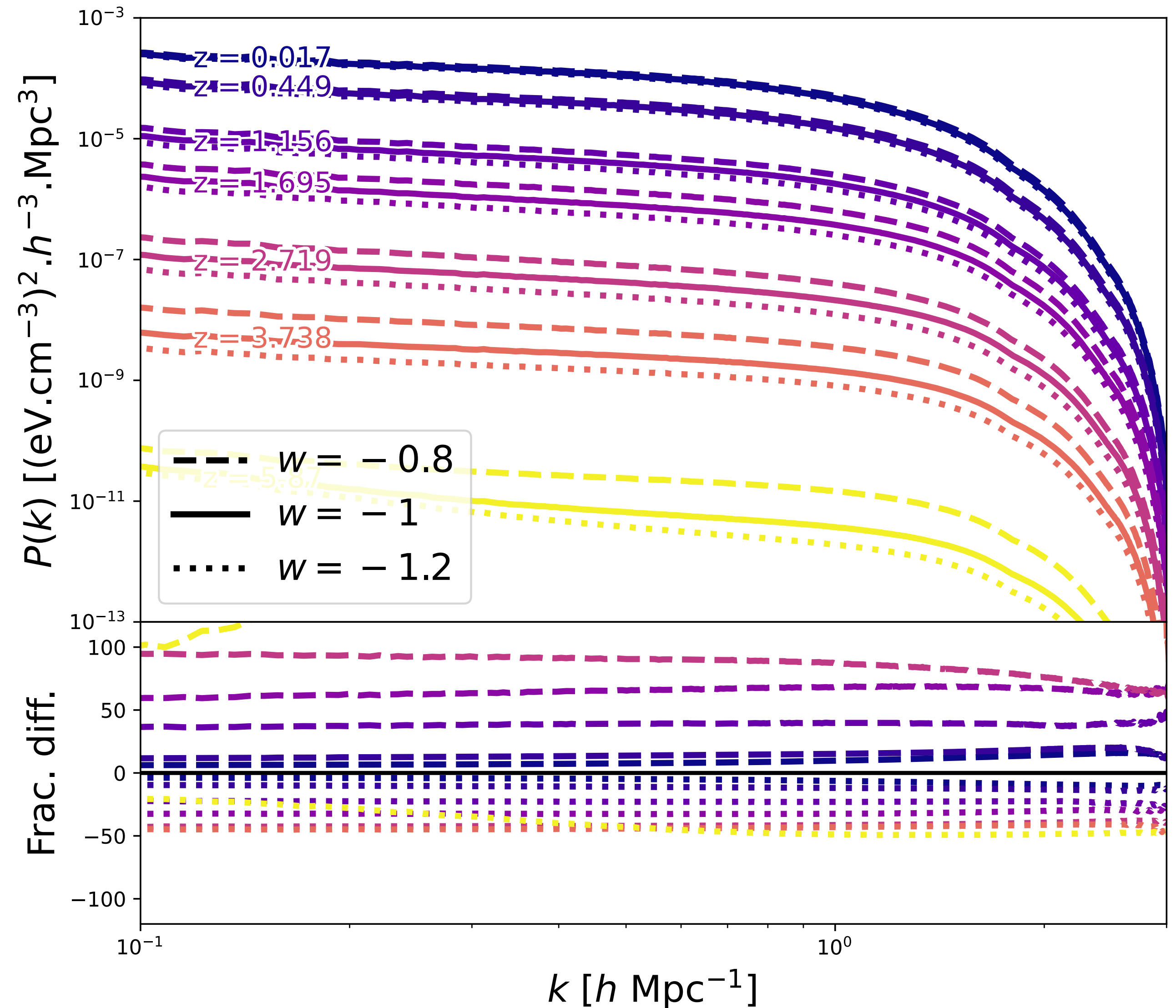
Matter power spectrum

- ▶ Power increases from $w = -0.8$ to $w = -1$ to $w = -1.2$
- ▶ **These trends are expected**



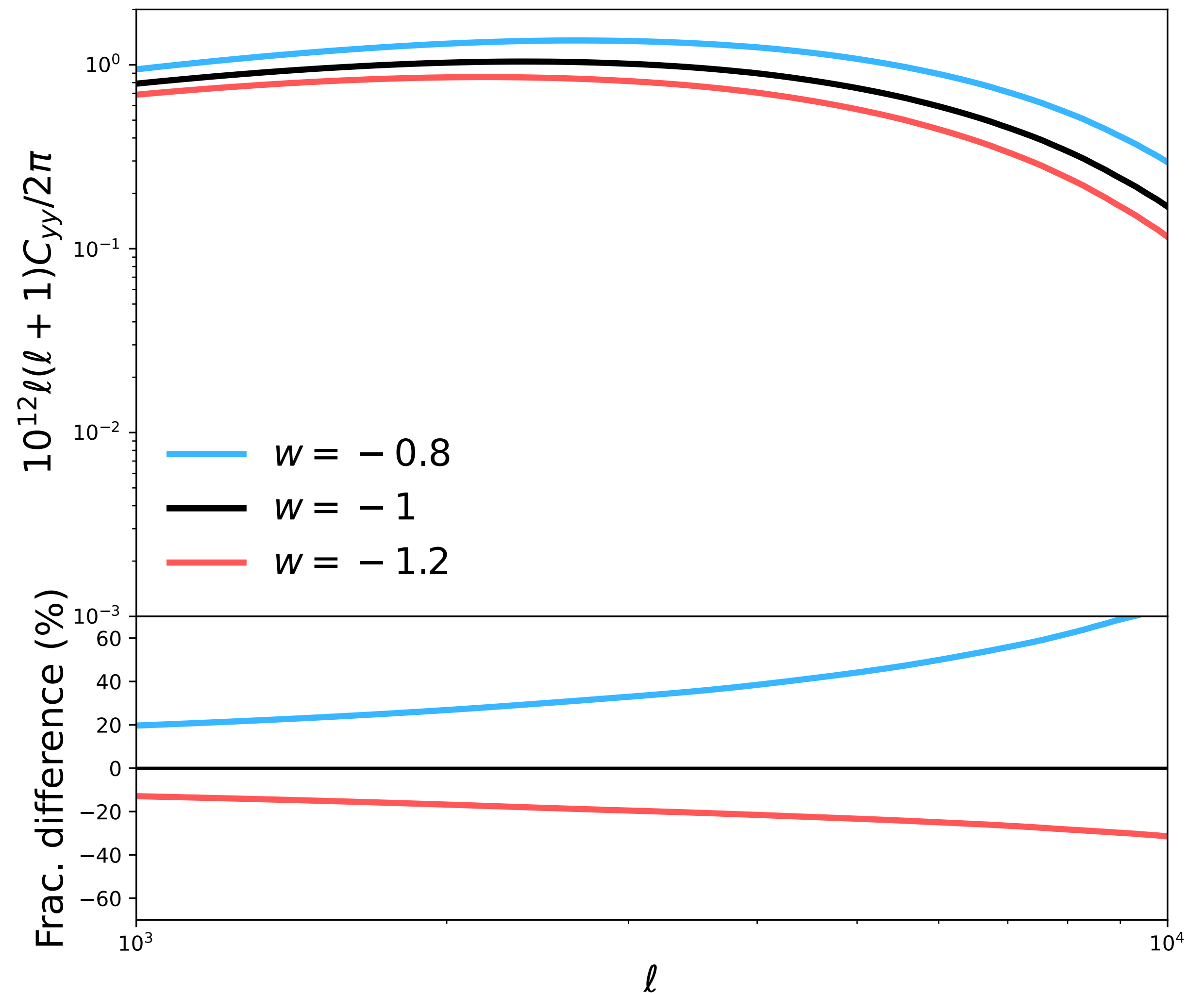
Pressure power spectrum

- ▶ Power increases from $w = -0.8$ to $w = -1$ to $w = -1.2$
- ▶ **These trends are expected**
- ▶ **Can it be predicted by simple quantity?**



Angular pressure power spectrum

- ▶ $w = -0.8$: 20% to 80% more power
- ▶ $w = -1.2$: 15% to 40% less power

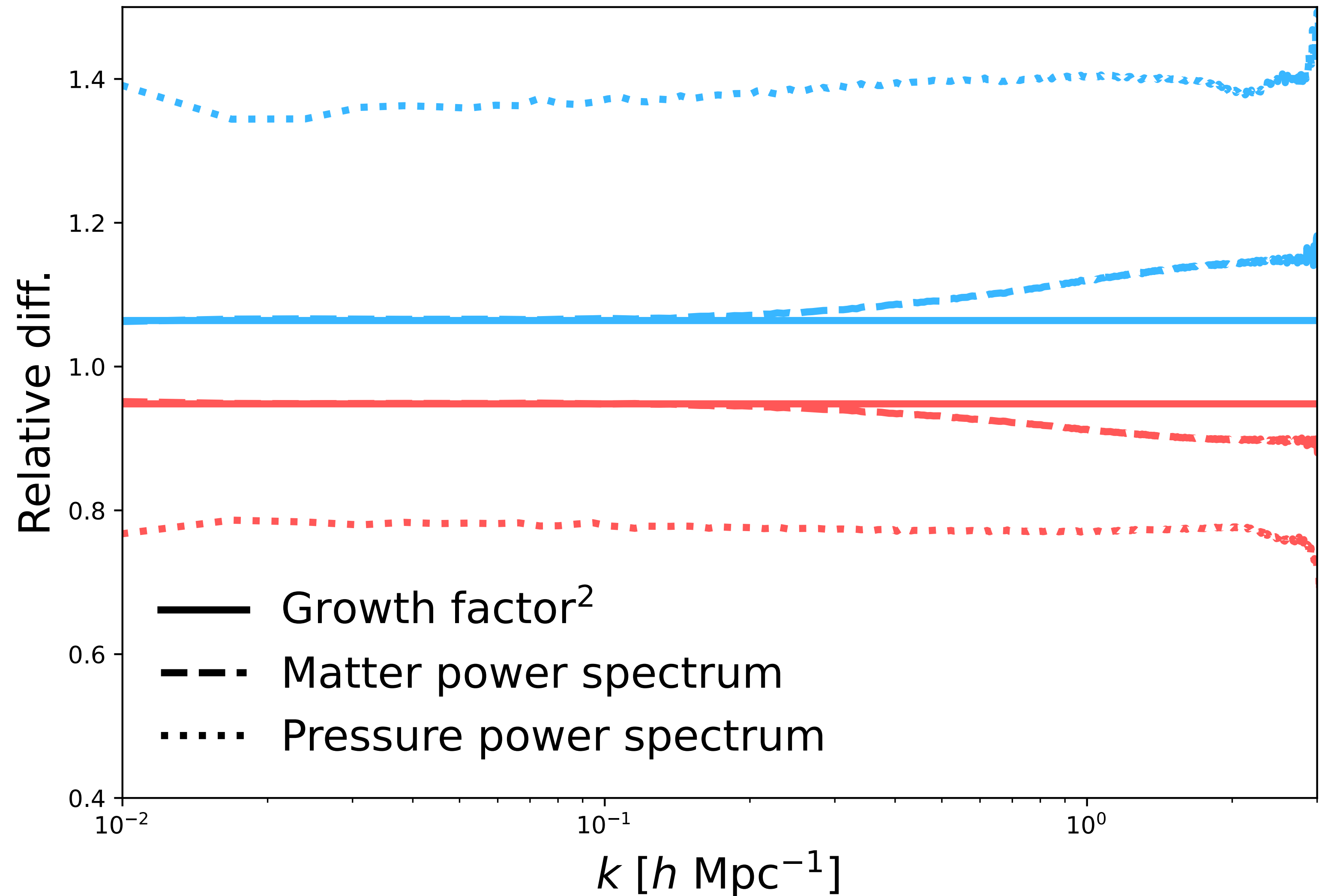


Predictability of the spectrum

$z = 1.156$

$$\frac{w = -0.8}{w = -1}$$

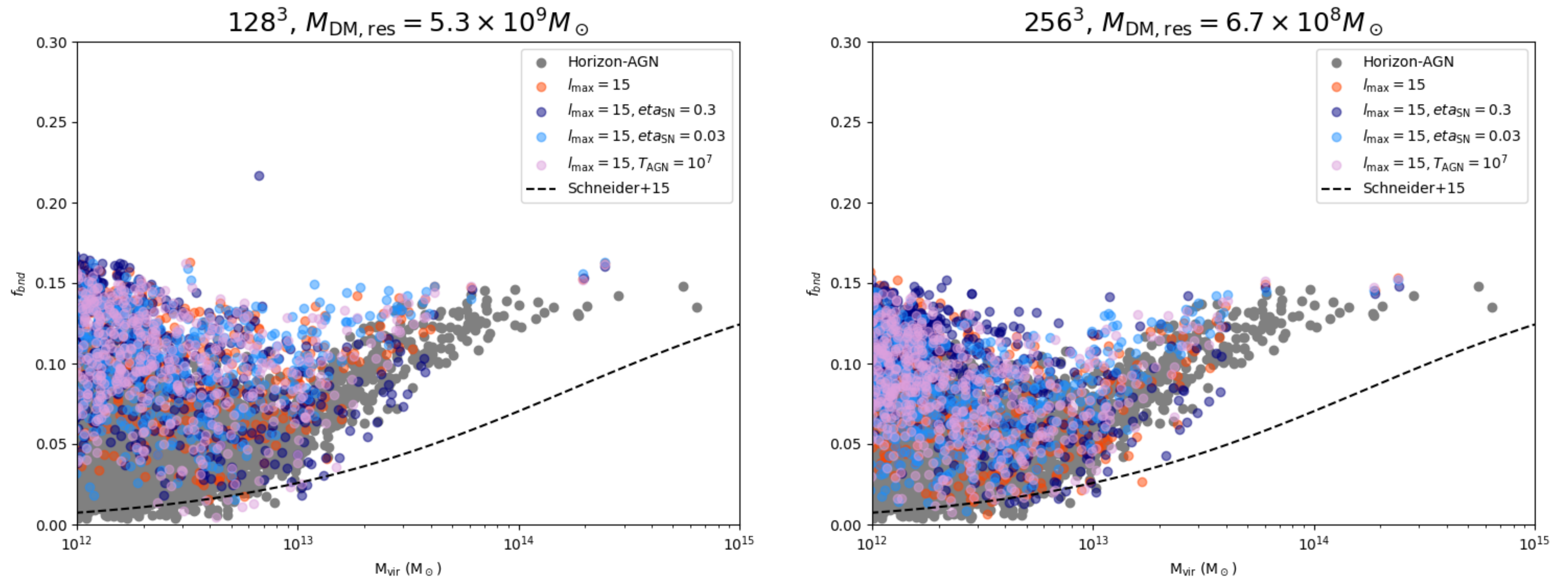
$$\frac{w = -1.2}{w = -1}$$



Full hydrodynamical simulations

- ▶ Use more realistic baryonic physics → **Horizon-AGN-like setup**
 - Which resolution & size?
 - $200 h^{-1}\text{Mpc}$, 1024^3 DM particles
 - $6.7 \times 10^8 M_{\odot}$
 - Calibration of the physics → test the impact of the AGN and SN feedback

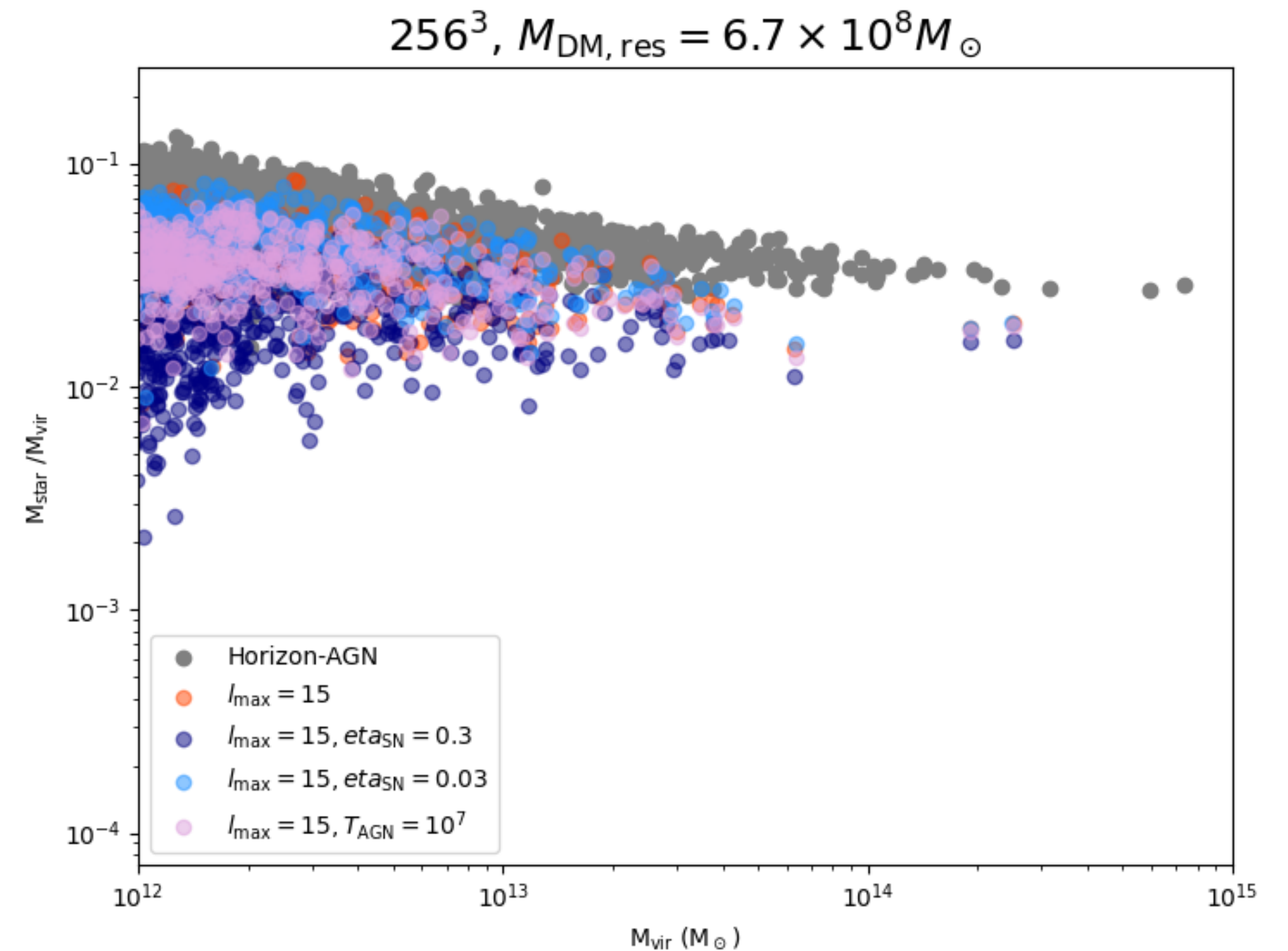
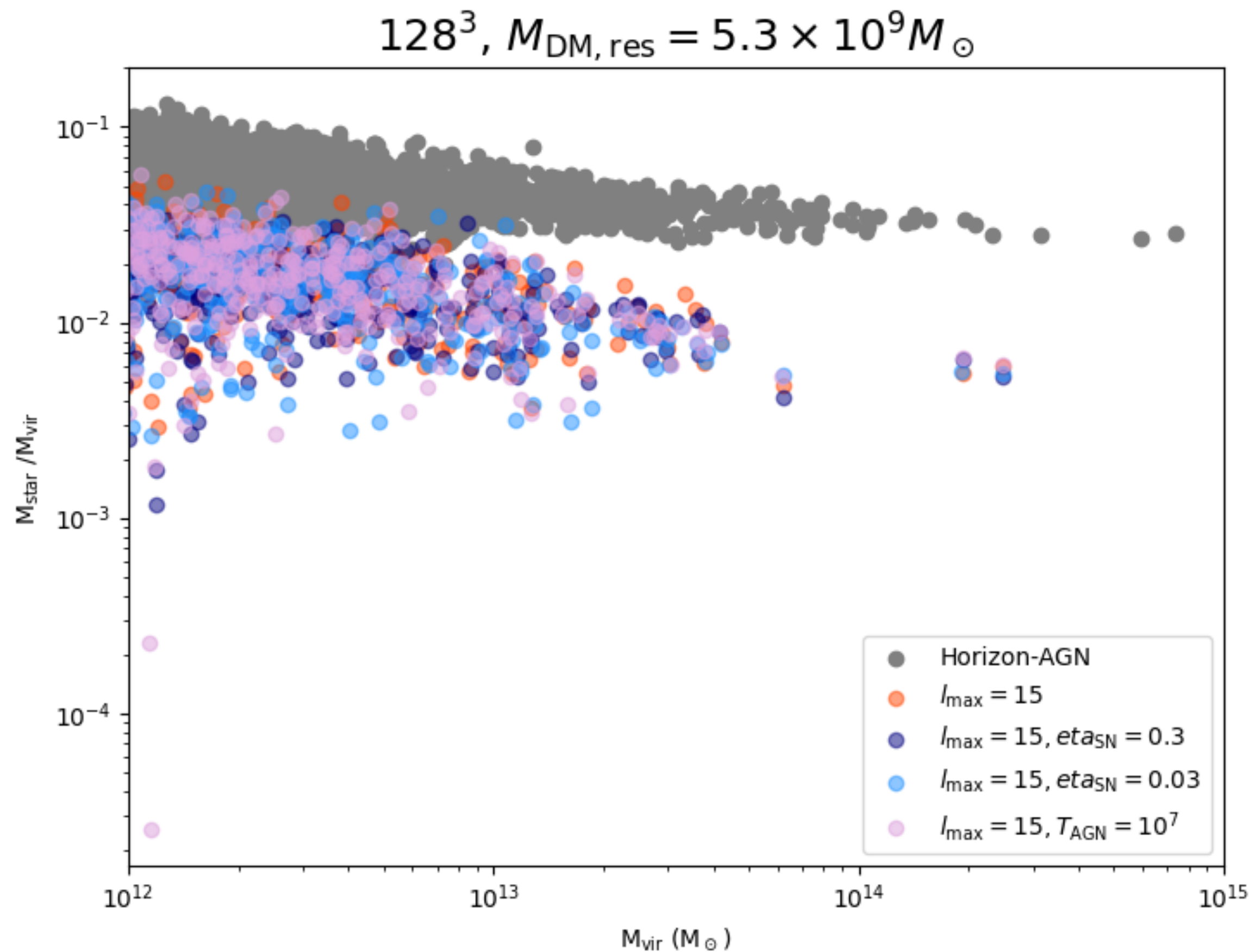
Full hydrodynamical simulations



$$f_{\text{bnd}} = \frac{M_{\text{gas}}}{M_{\text{gas}} + M_{\text{stars}} + M_{\text{DM}}}$$

Full hydrodynamical simulations

- ▶ Stellar to halo mass relation: to be updated with stellar mass of galaxies



Next steps

- ▶ Use more realistic baryonic physics → **Horizon-AGN-like setup**
 - What power are we loosing if we keep the simple physic?
- ▶ Go from w CDM to **$w_0 w_a$ CDM** cosmologies ($w(a) = w_0 + w_a(1 - a)$)
- ▶ Good balance between volume, resolution and physical processes included
 - → map the **$w_0 - w_a$ plane**
 - → **degeneracies between cosmological and astrophysical parameters** thanks to a few simulations that vary keys physical processes

Conclusions

- ▶ Impact of w on the halo mass function, matter and pressure power spectrum
 - $w = -0.8 \rightarrow$ more halos, more massive halos, more power (matter & pressure)
 - Growth factor alone is not enough to predict the trends
-

Perspectives

- ▶ Try to predict the trends
- ▶ New suite of simulations with a $w_0 w_a$ CDM cosmology
- ▶ Impact on other properties: profile, concentration,...