The COLIBRE model

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COLd Ism gas and Better REsolution

Project core members:

Benitez-Llambay, Alejandro
Chaikin, Evgenii
Correa, Camila
Frenk, Carlos
Husko, Filip
McGibbon, Rob
Ploeckinger, Sylvia
Richings, Alex
Schaller, Matthieu
Schaye, Joop
Trayford, James

1-slide project overview

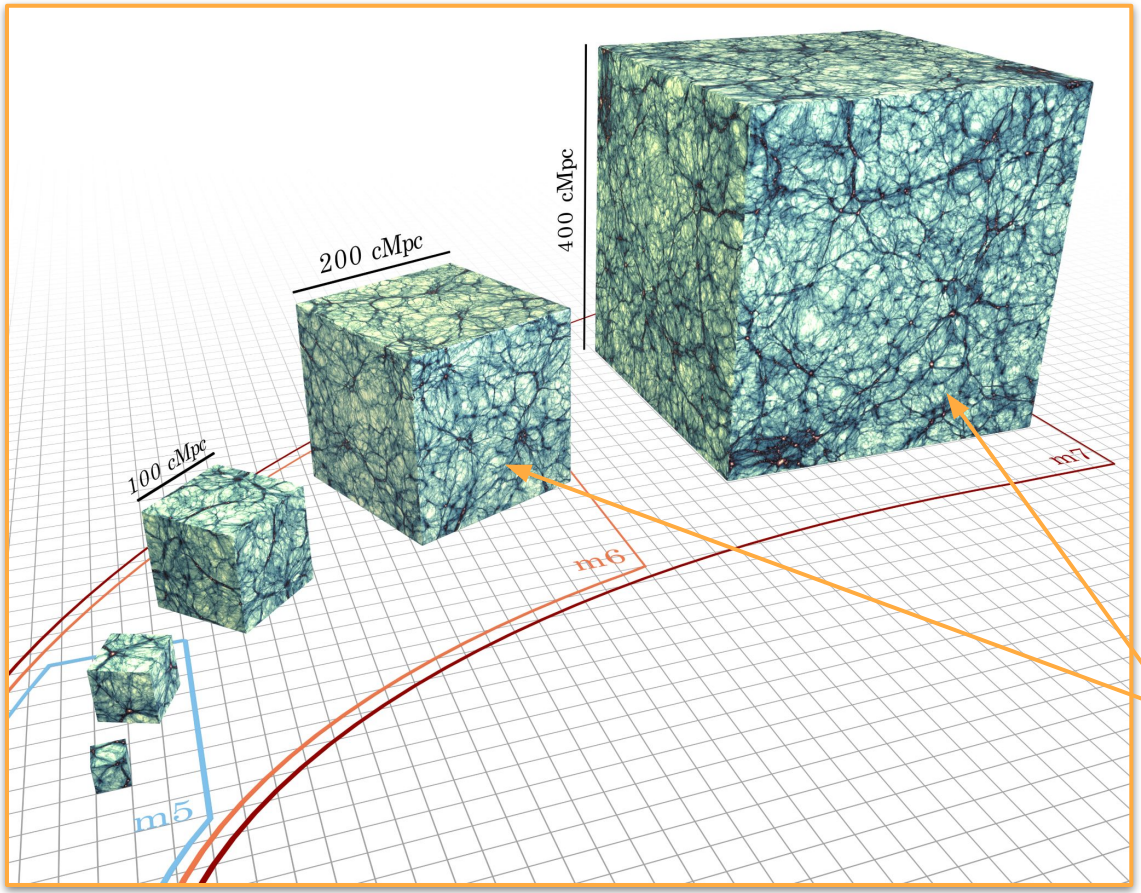
- Successor of the EAGLE project, run with the **SWIFT code** (SPH-based), (MS+24)
- **3 main resolutions** and simulation volumes (for now),
- **Cold ISM** physics with **non-equilibrium** (H+He) chemistry, **live dust,** (Richings+14, Ploeckinger+25) (Trayford+25)
  and updated **chemistry**, and various **early feedback channels**. (Correa in prep.) (Benitez-Llambay in prep.)
- Dark matter & baryon particles have same mass (size + dynamics effects), (Ludlow+19,20)
- Calibration of model using **ML techniques**, new **halo finder linking through time**, (Chaikin in prep.) (Forouhar-Moreno+25)
- **Globular cluster model** coupled to the solver, **jet-AGN** model. (Pfeffer in prep.) (Husko in prep.)

Simulation sizes

m5 → $m_{gas} \approx 10^5\ M_\odot$

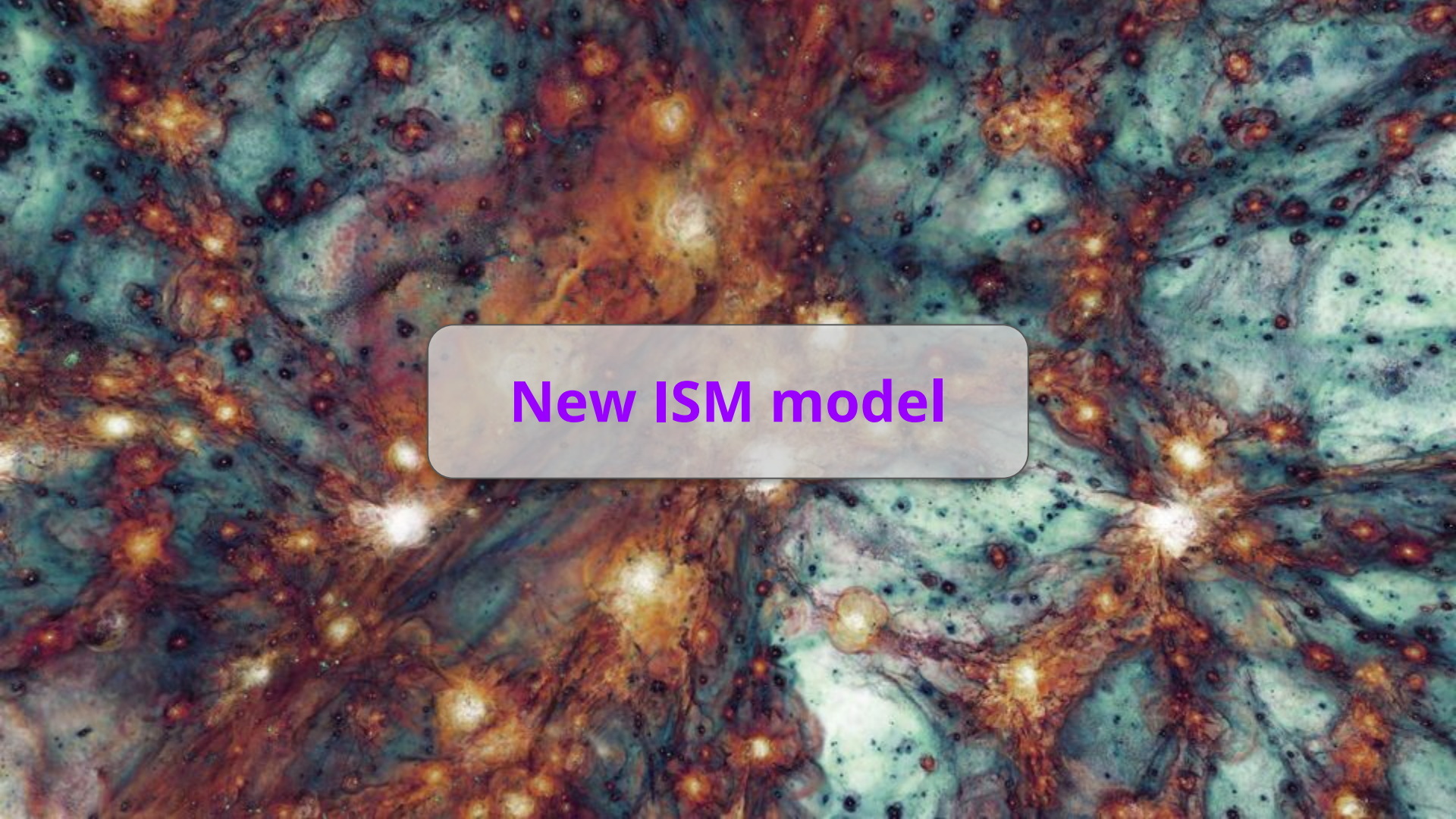
m6 → $m_{gas} \approx 10^6\ M_\odot$

m7 → $m_{gas} \approx 10^7\ M_\odot$



$N_{gas} = 3008^3$

$N_{tot} = 5140^3$


New ISM model

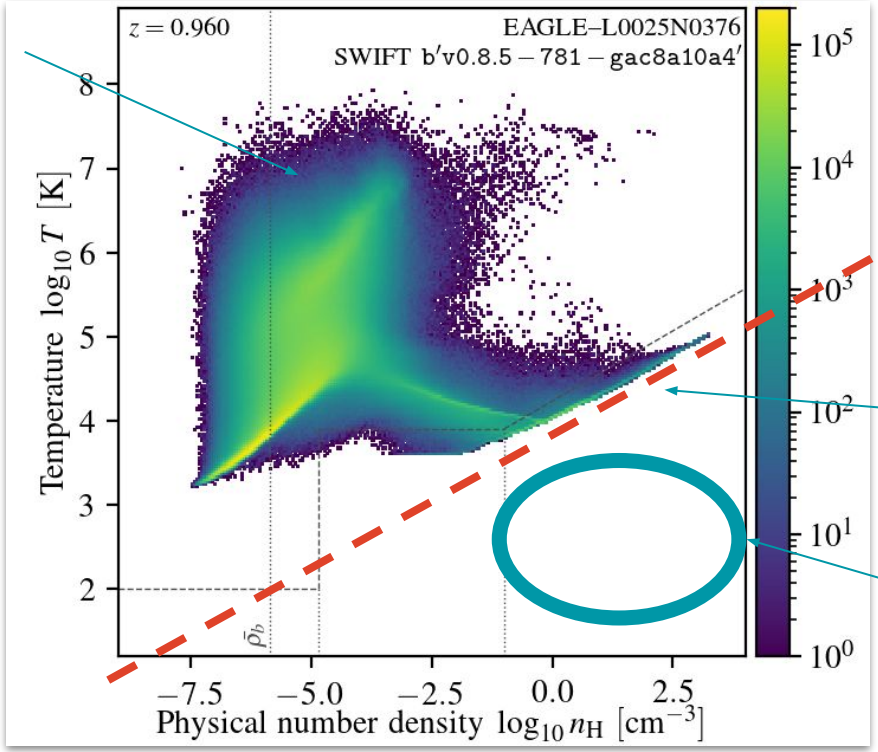
EAGLE-like phase-space

Typical resolution:

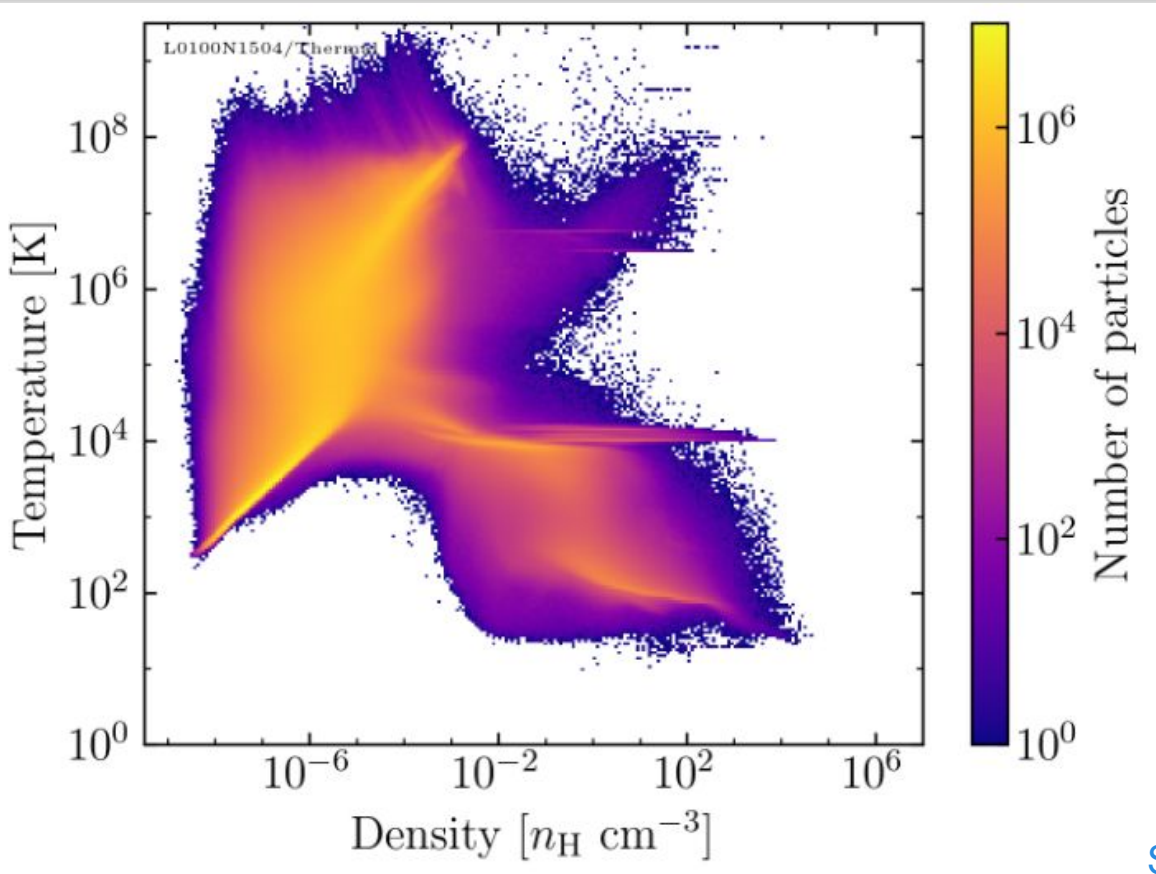
100 - 1000 pc

OR

10^4 - 10^8 $M_\odot$



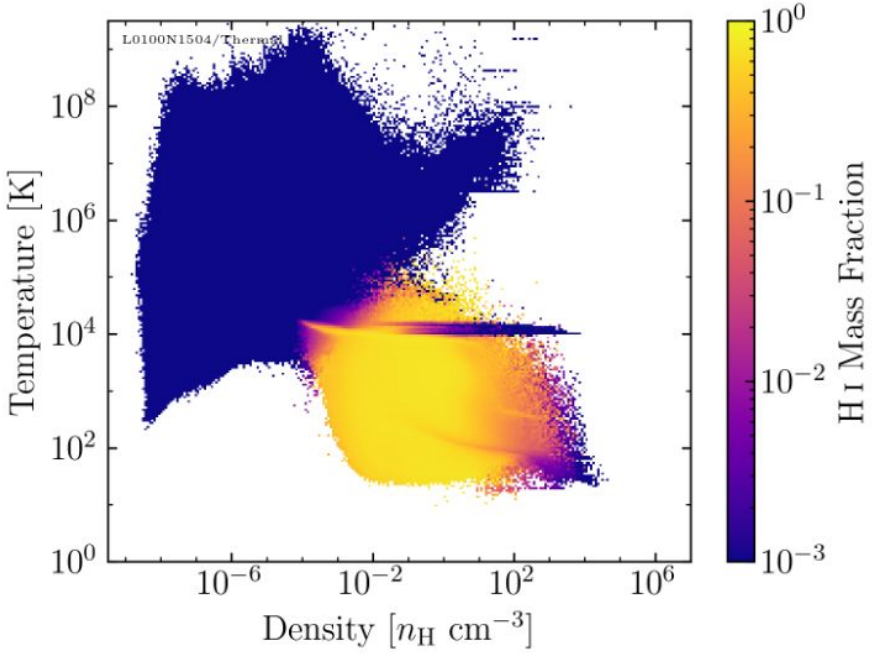
COLIBRE phase-space



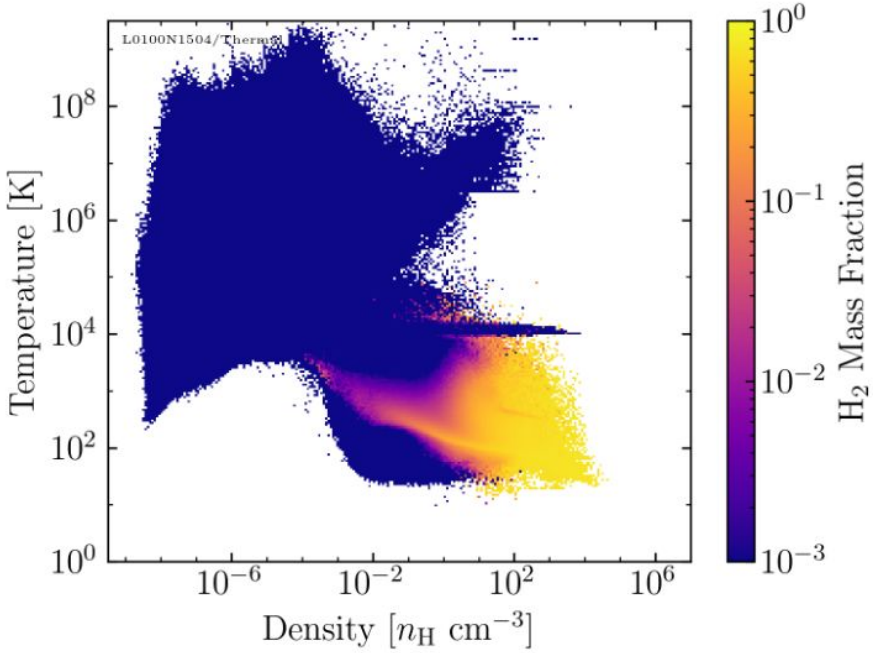
Schaye (in prep.)

Self-consistent H phases

HI



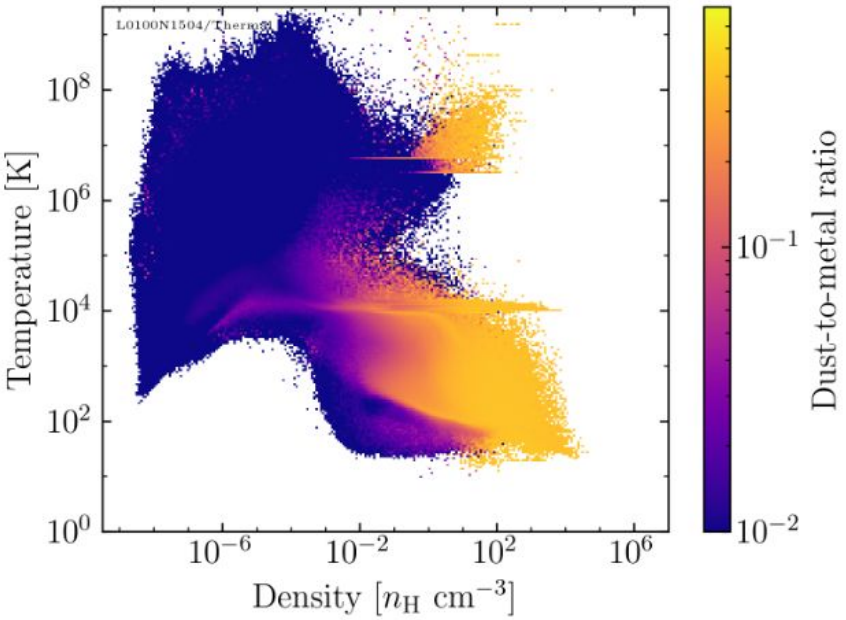
H_2



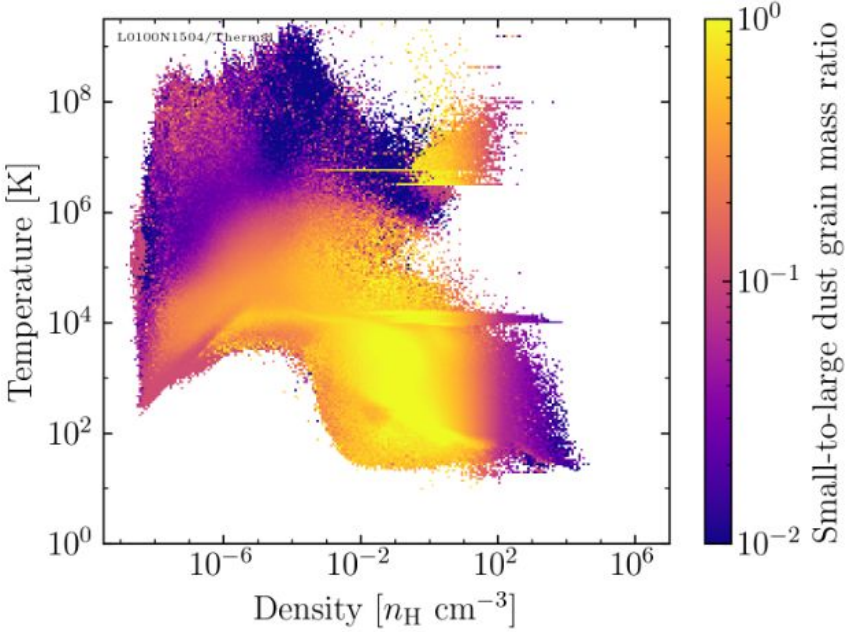
Schaye (in prep.)

Non-uniform D-to-M ratio

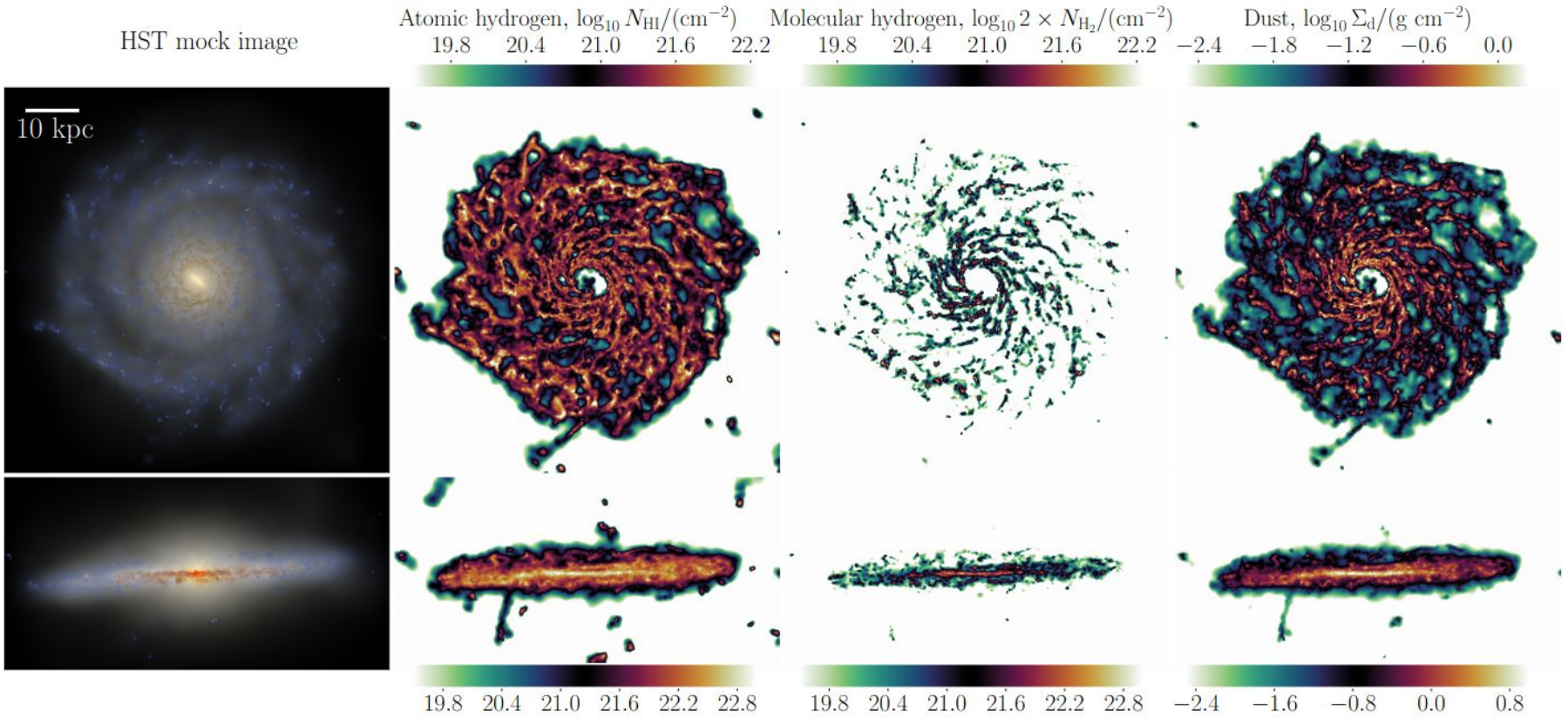
Dust to mass



Small to large grains



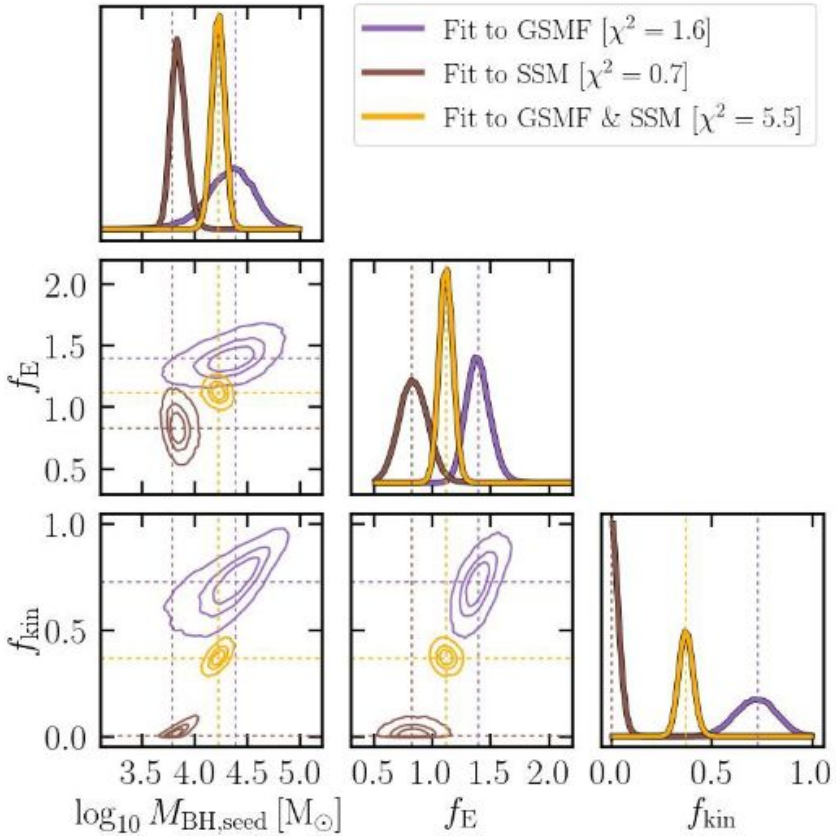
Self-consistent H phases



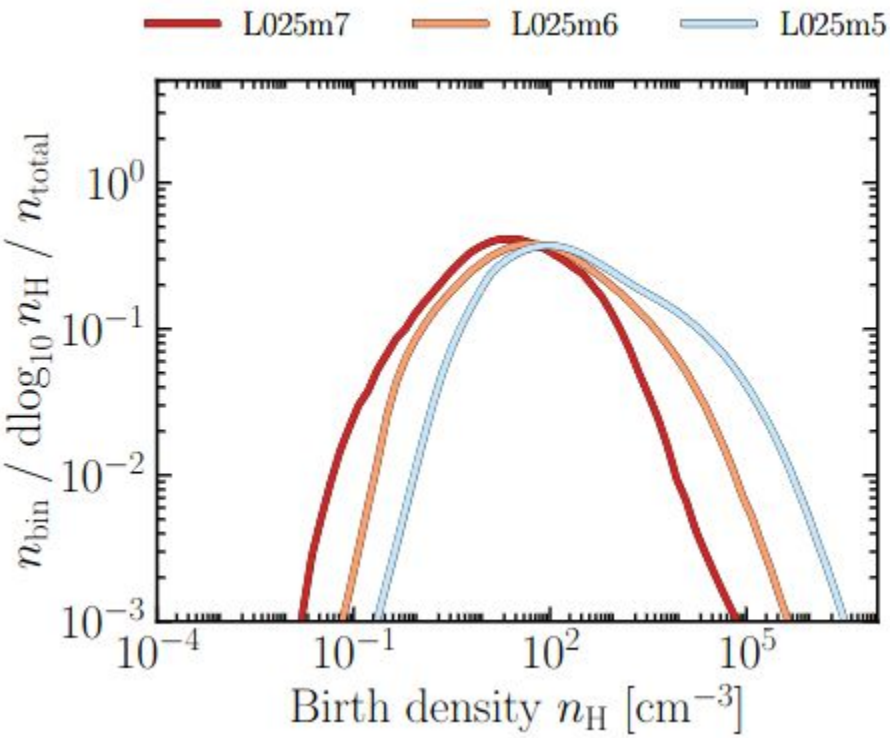

Feedback

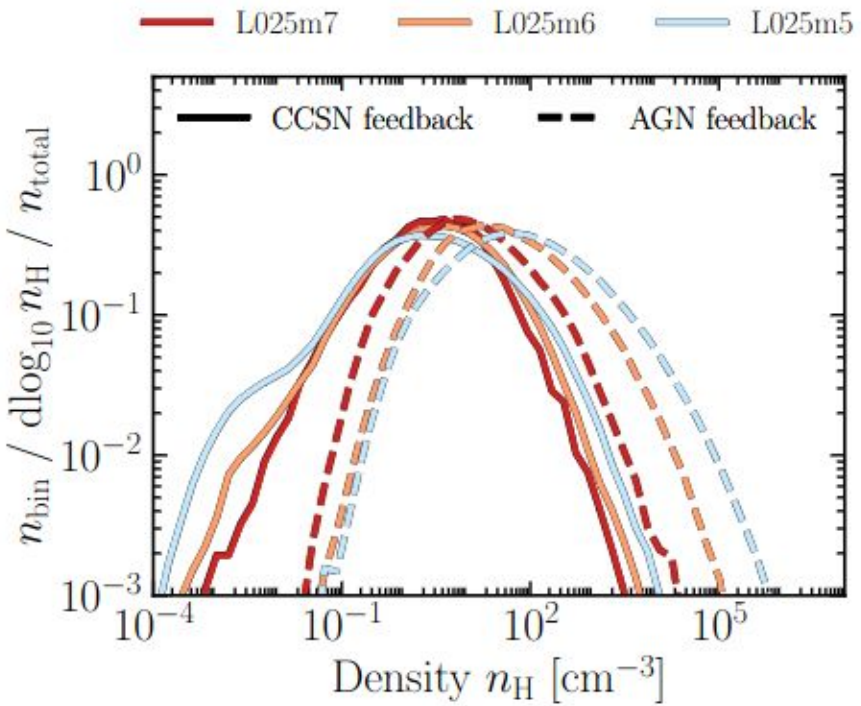
COLIBRE feedback

- Heating temperature is variable and set by DV&S 2012 criterion
- Total energy injected is a function (sigmoid) of local ***pressure***.
- Kinetic fraction is fixed to 10%. Kick velocity is 50km/s (fixed). (Chaikin+23)
- We choose the particles using an isotropic scheme. (Chaikin+22)
- Calibration using Gaussian process emulators (Chaikin in prep.)

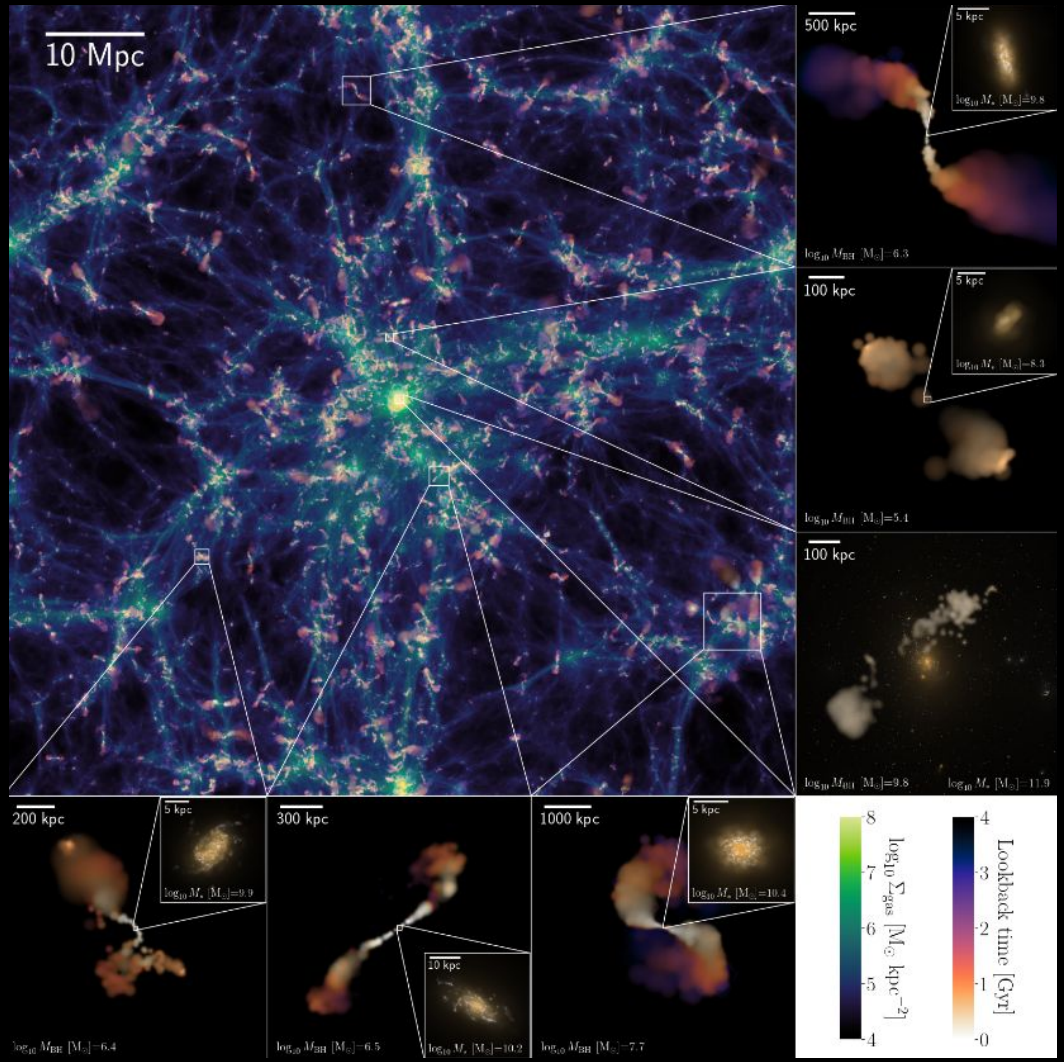


SF and feedback convergence





Schaye (in prep.)



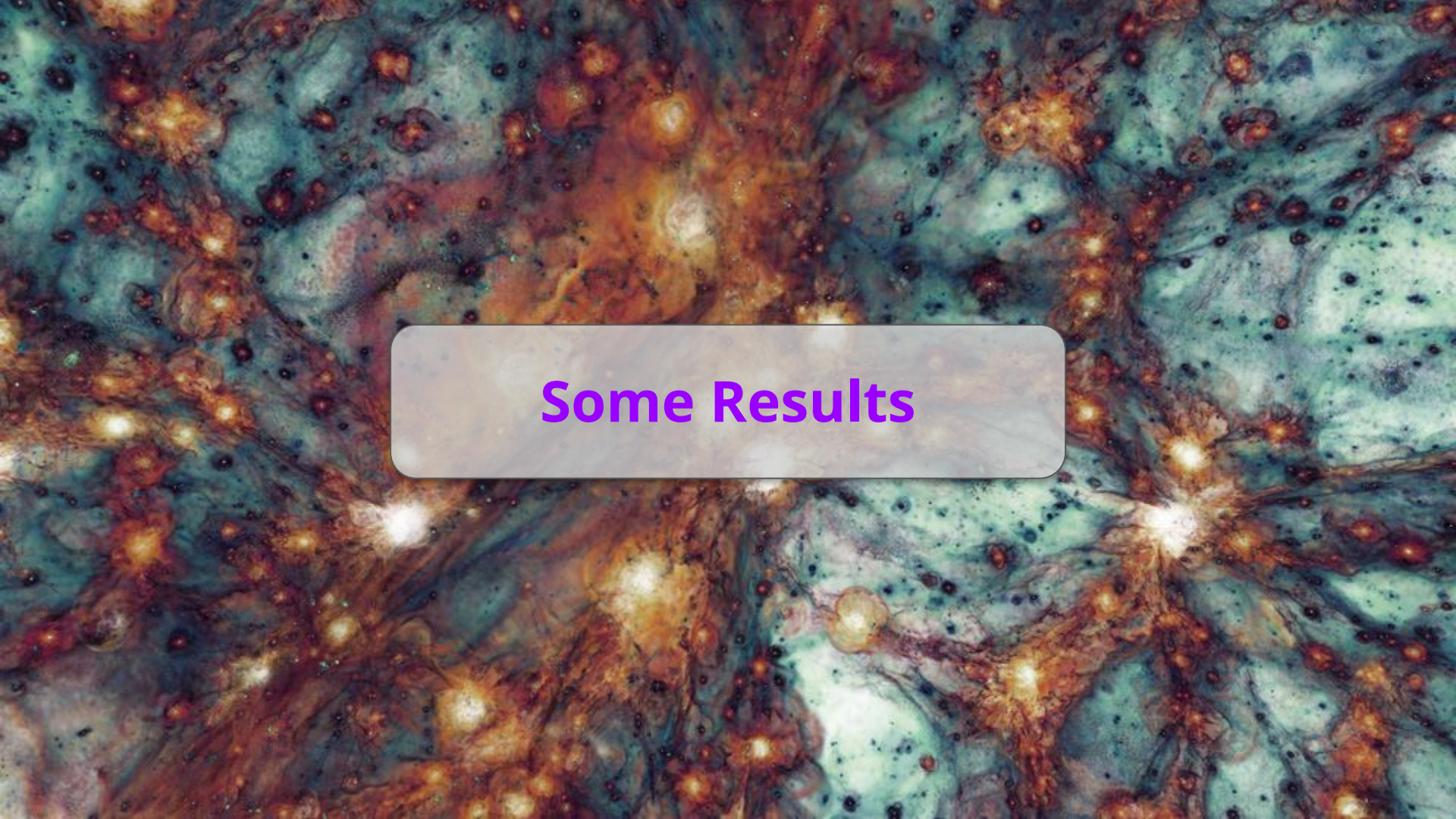
AGN feedback model

Jet at < 0.01x Eddingtoon and at > 1x Eddington

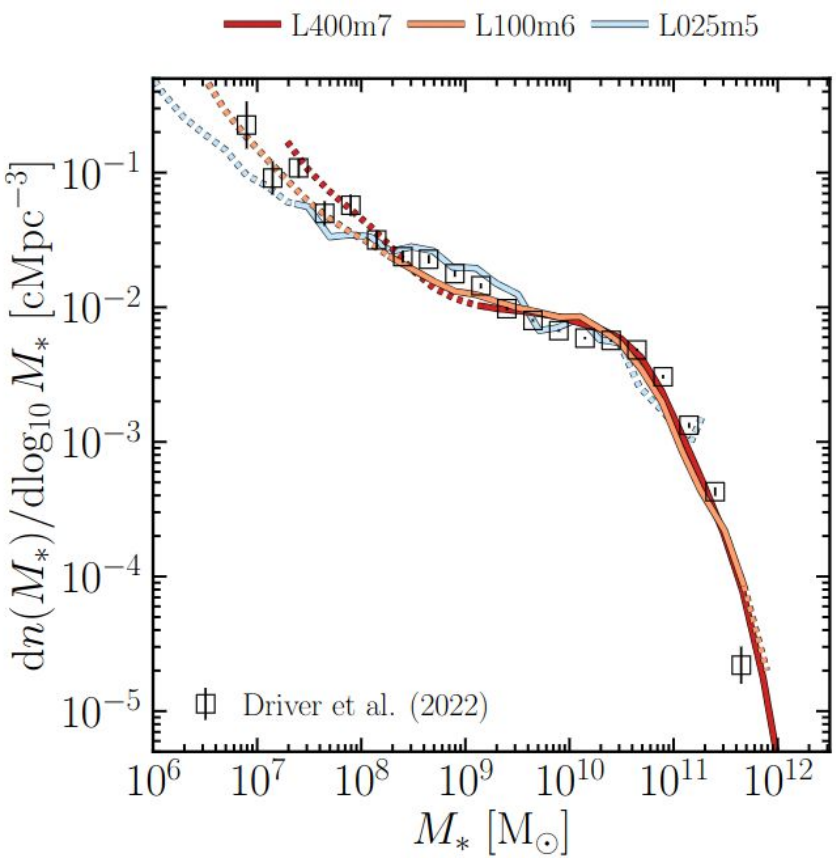
Thermal in between

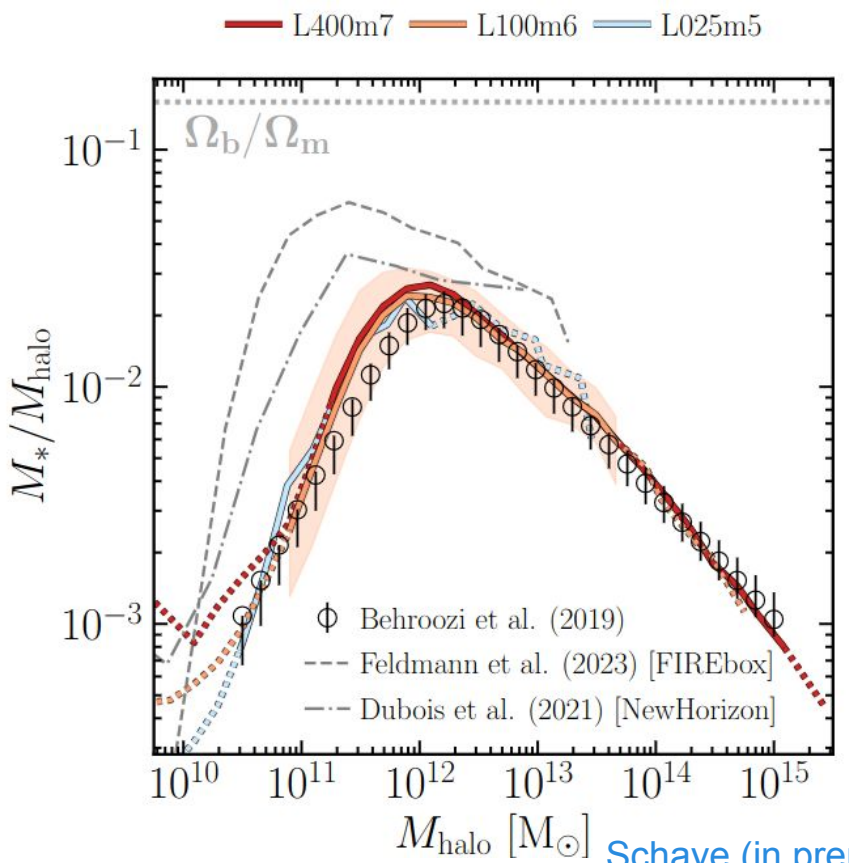
Bondi-Hoyle accretion with Krumholz turbulence correction

Spin evolution to direct the jets


Some Results

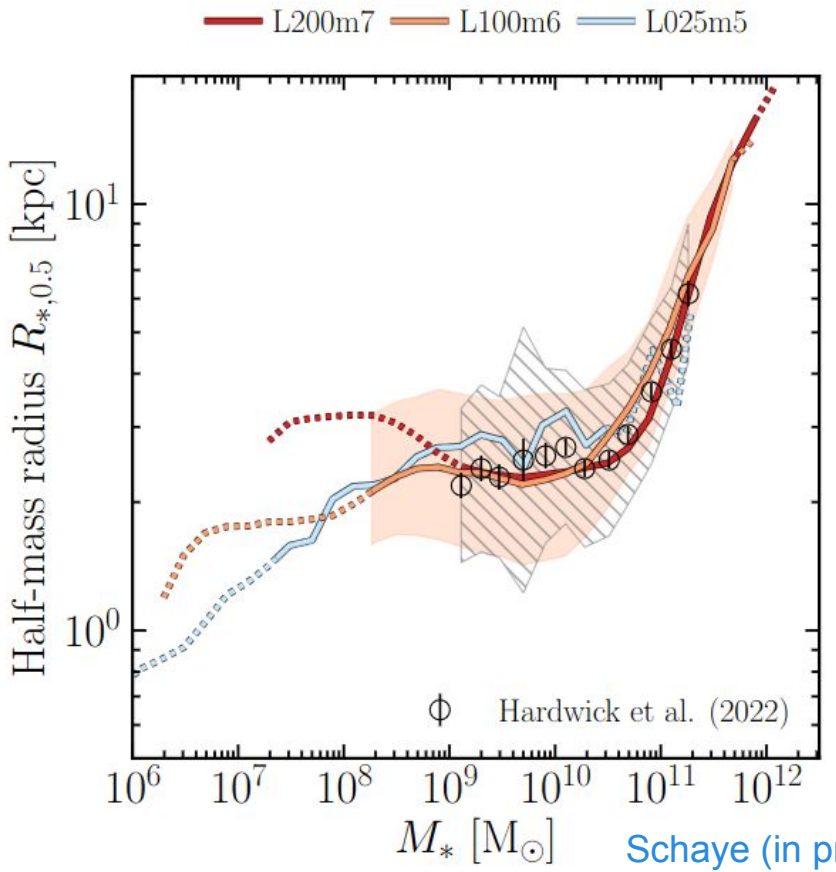
Calibration targets - Stellar masses



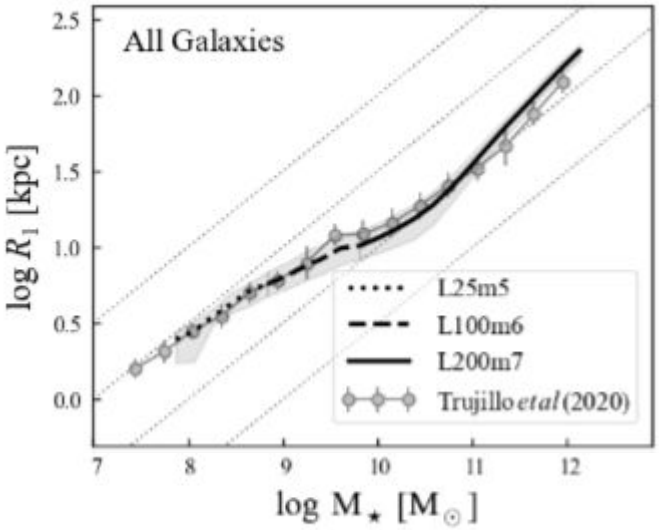


Schaye (in prep.)

Calibration targets - Stellar sizes

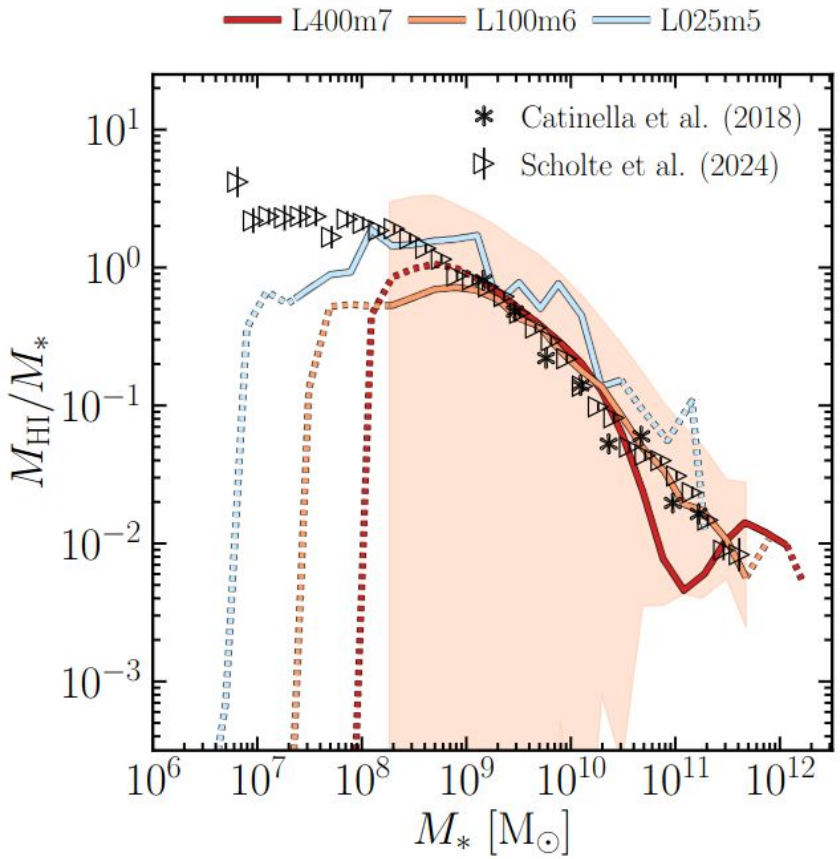


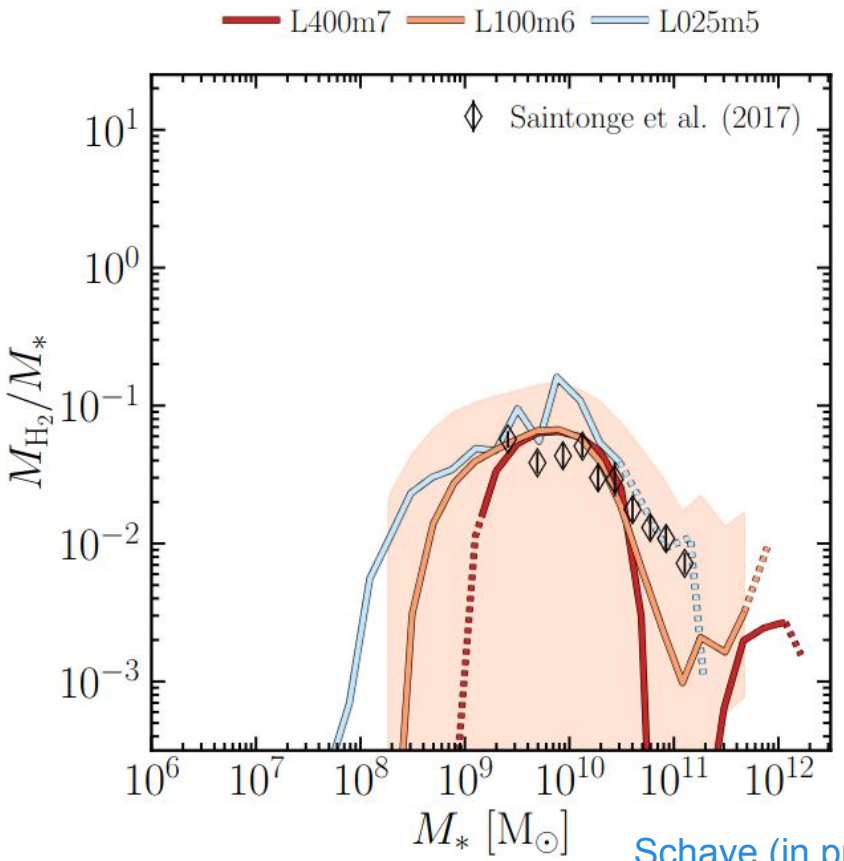
Schaye (in prep.)



Ludlow (in prep.)

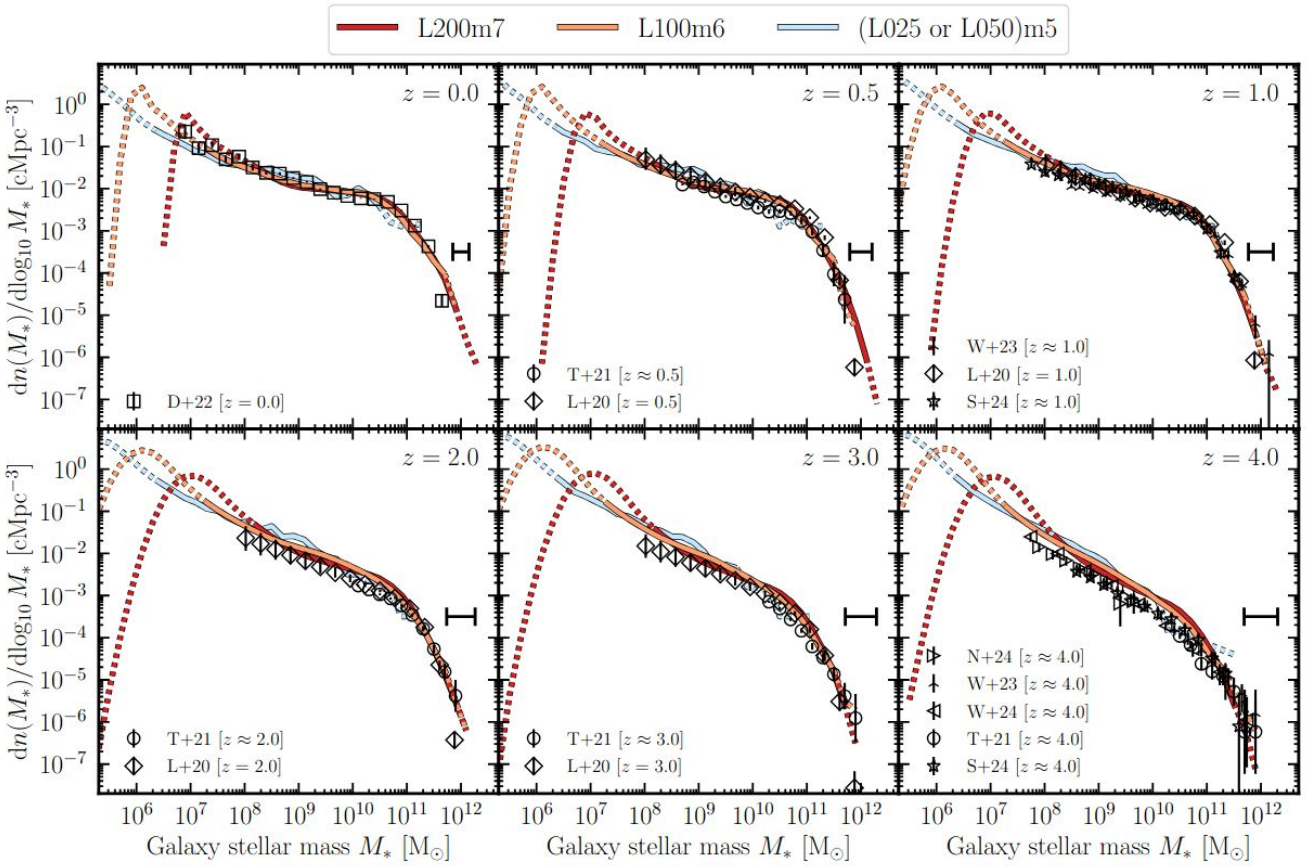
Gas content of galaxy





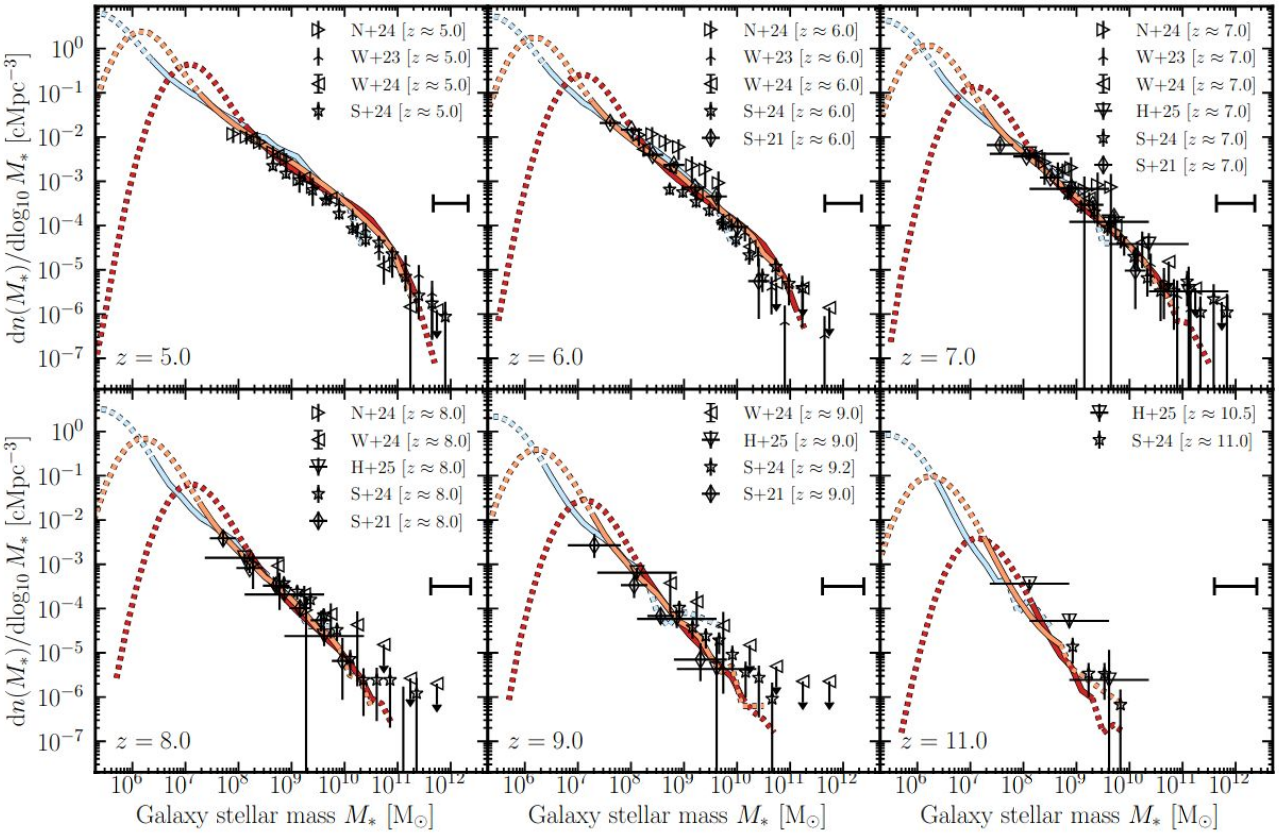
Schaye (in prep.)

High(er)-z results



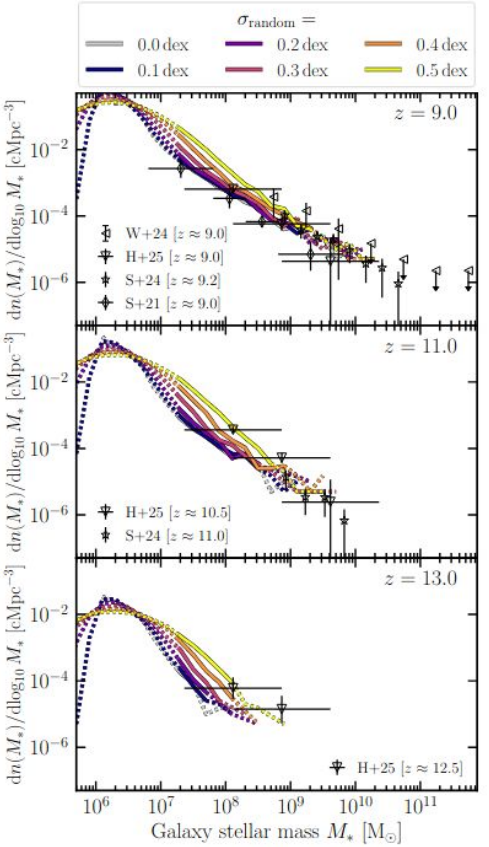
Chaikin (in prep.)

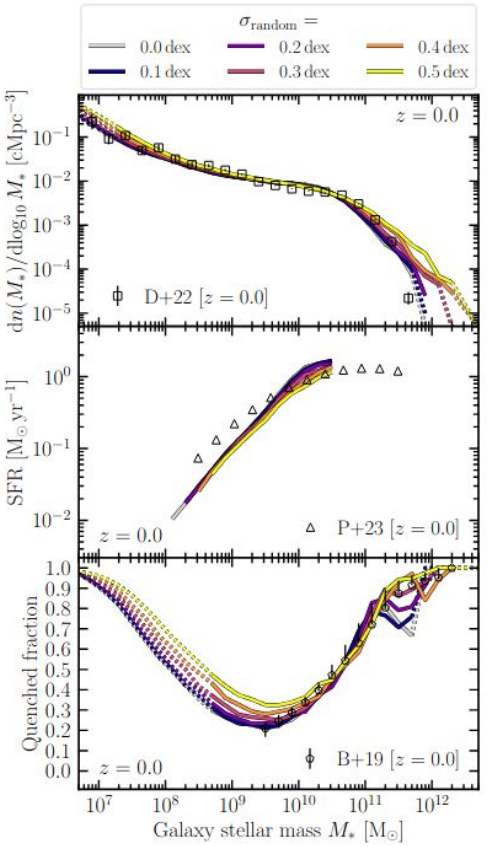
High(er)-z results



Chaikin (in prep.)

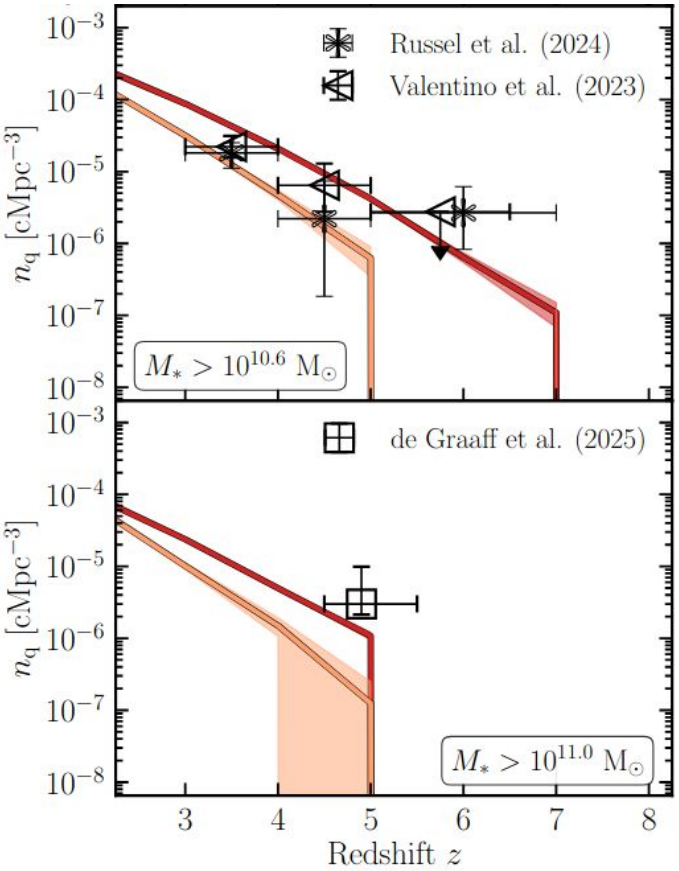
Effect of Eddington bias





Chaikin (in prep.)

Massive quenched objects



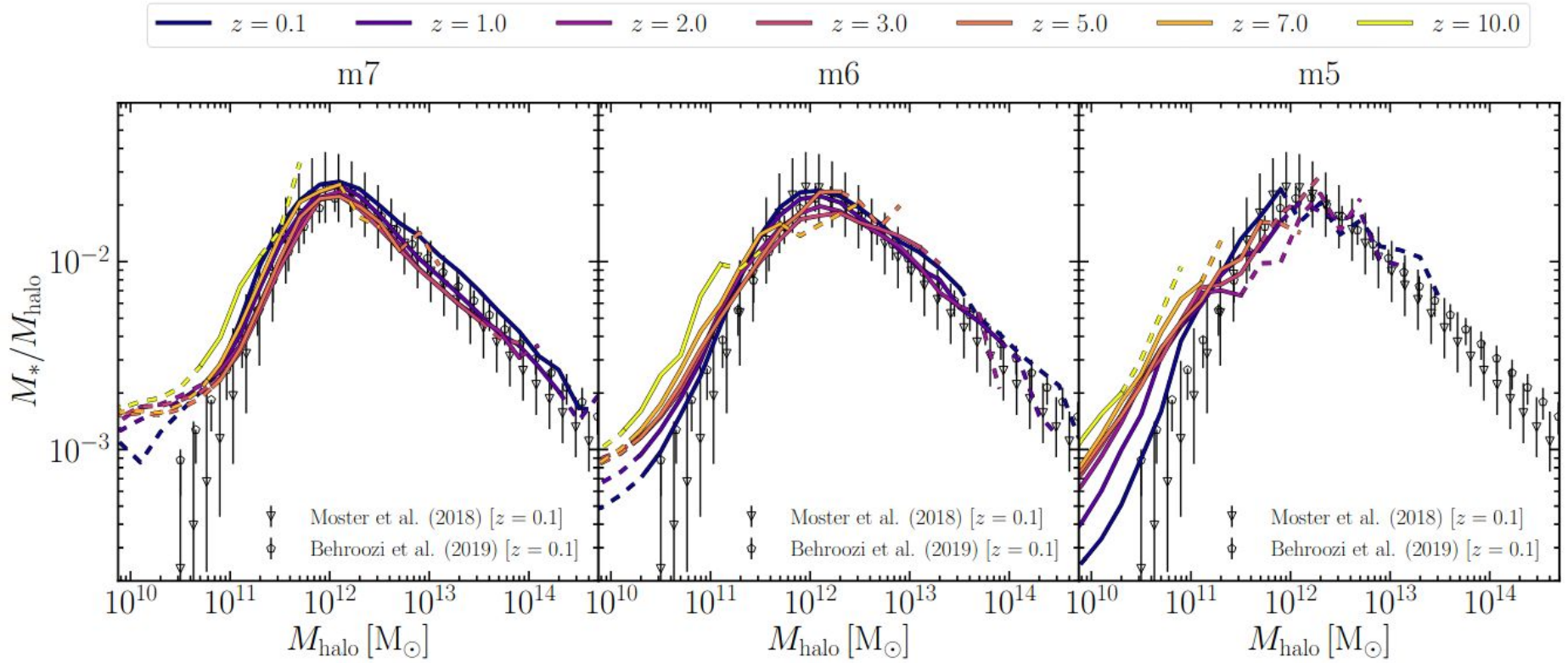
Quiescent Galaxy Selection: sSFR $< 10^{-10}\,\mathrm{yr}^{-1}$

L400m7 L200m6

Simulations are in good agreement with the data.

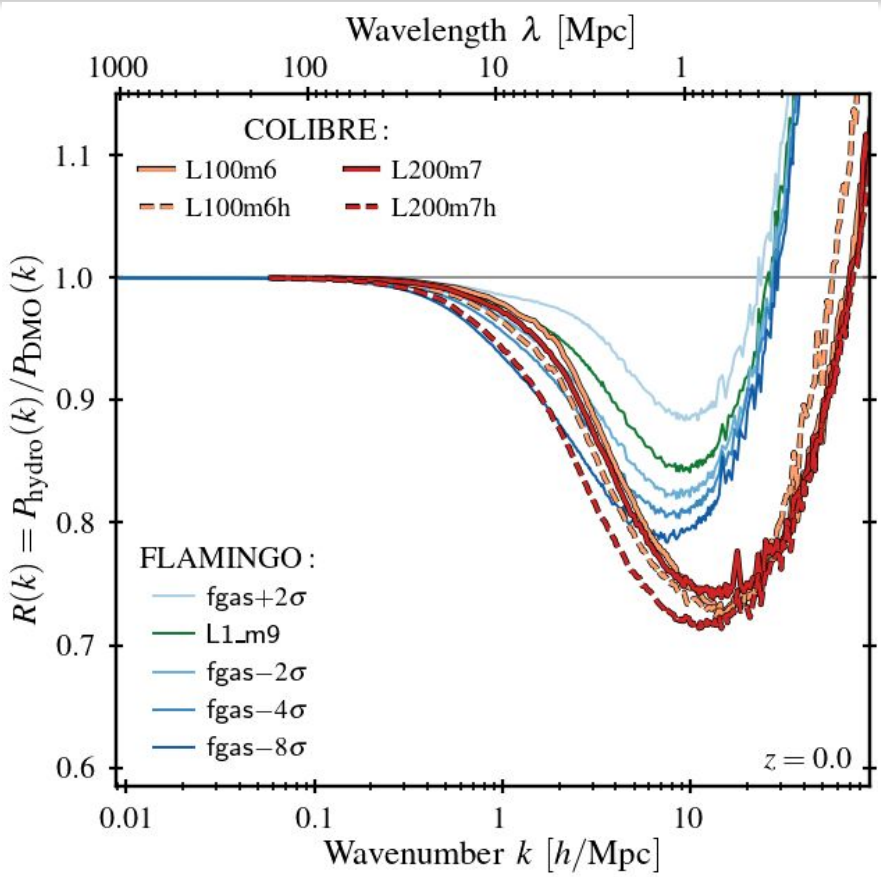
Large volume is necessary to beat down cosmic variance.

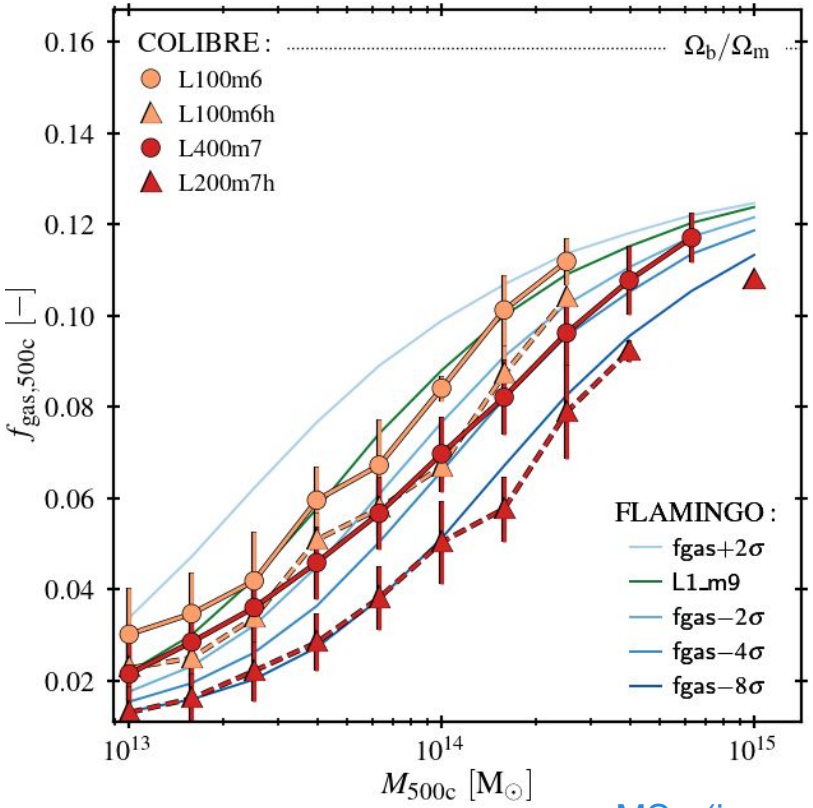
Galactic star formation efficiency



Chaikin (in prep.)

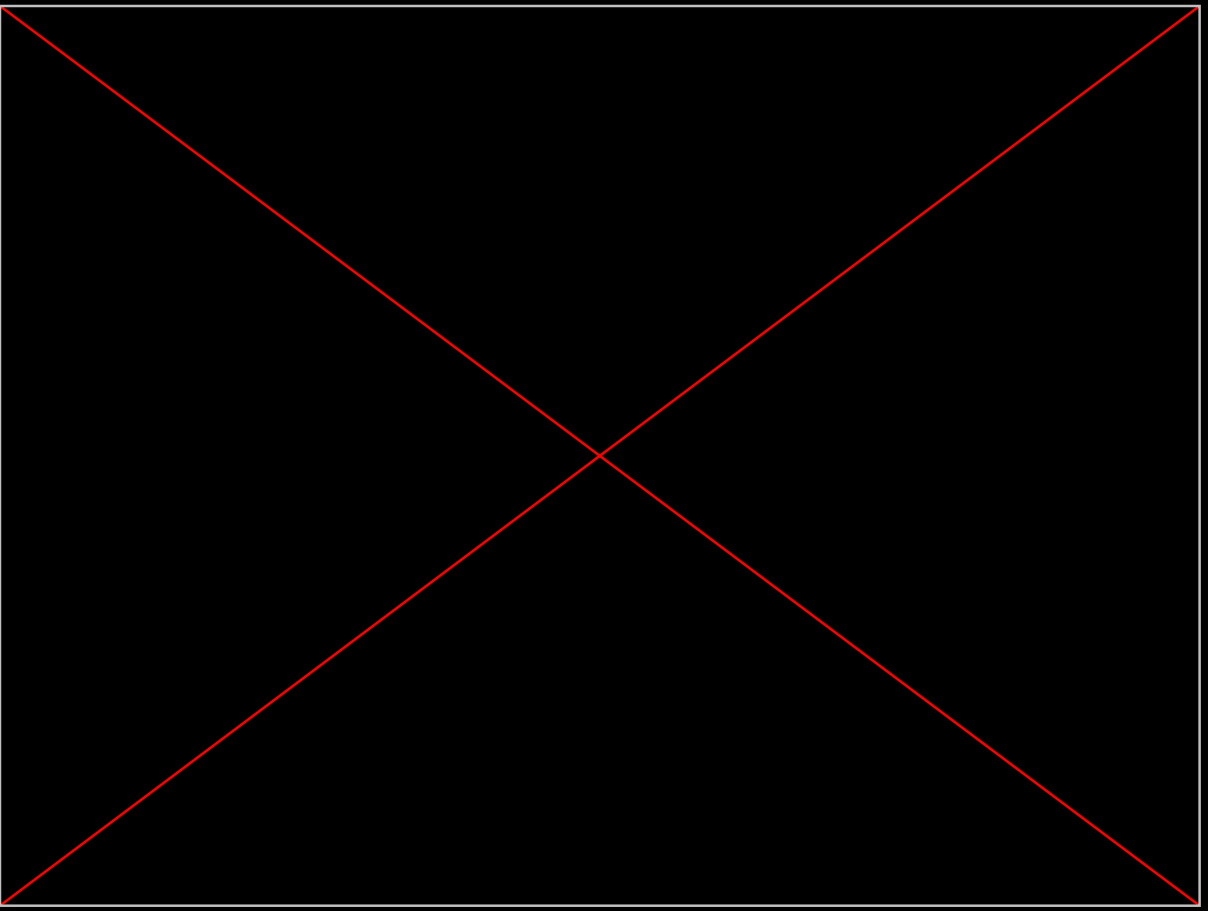
Feedback impact on cosmology





MS+ (in prep.)

COLd Ism gas and Better REsolution



- New generation of galaxy formation model in large volumes to z=0.
- Multiple resolutions, volumes, model variations.
- Cold ISM, non-eq. chemistry model, live-dust, self-consistent HI, H_2, AGN jet feedback.
- Good test bed for (and good match to) population-level galaxy properties.
- Invitation: Please come have a chat about what you'd like to see from the simulations or **you** would like to do with them!