

The background of the slide is a Cosmic Microwave Background (CMB) fluctuation map, showing a complex pattern of temperature variations across the sky. The colors range from dark blue (cooler) to red and orange (warmer), with bright yellow and white spots indicating the highest temperatures. The pattern is highly detailed, showing the intricate structure of the early universe.

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
Ploekinger, Sylvia
Richings, Alex
Schaller, Matthieu
Schaye, Joop
Trayford, James



1-slide project overview

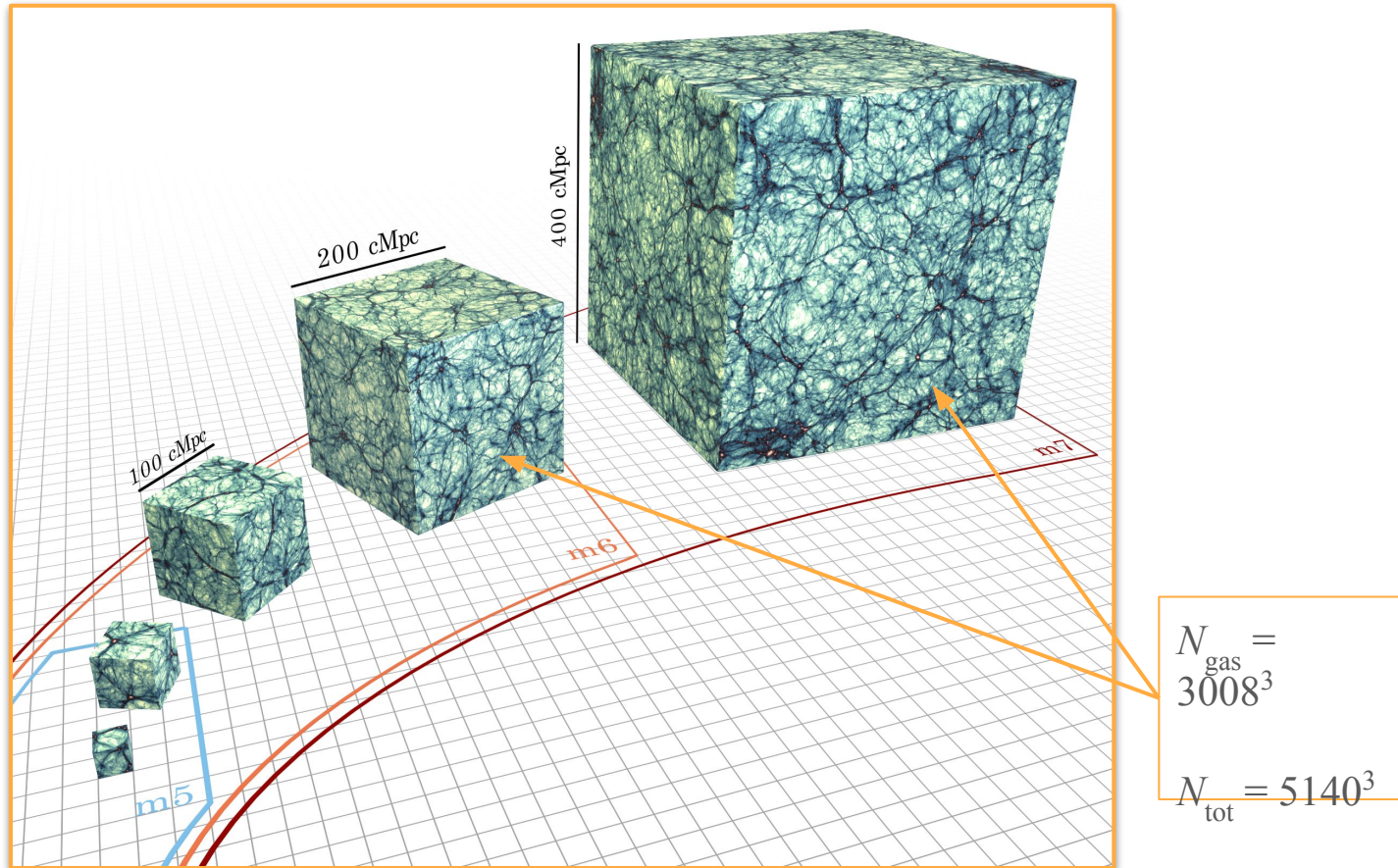
- Successor of the EAGLE project, run with the **SWIFT code** (SPH-based),
(MS+24)
- **3 main resolutions** and simulation volumes (for now),
- **Cold ISM** physics with **non-equilibrium** (H+He) chemistry, **live dust**,
(Richings+14, Ploeckinger+25) (Trayford+25)
and updated **chemistry**, and various **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**
(Chaikin in prep.) (Forouhar-Moreno+25)
through time,
- **Globular cluster model** coupled to the solver, **jet-AGN** model.
(Pfeffer in prep.) (Husko in prep.)

Simulation sizes

m5 $\rightarrow m_{\text{gas}} \approx 10^5 M_{\odot}$

m6 $\rightarrow m_{\text{gas}} \approx 10^6 M_{\odot}$

m7 $\rightarrow m_{\text{gas}} \approx 10^7 M_{\odot}$





New ISM model

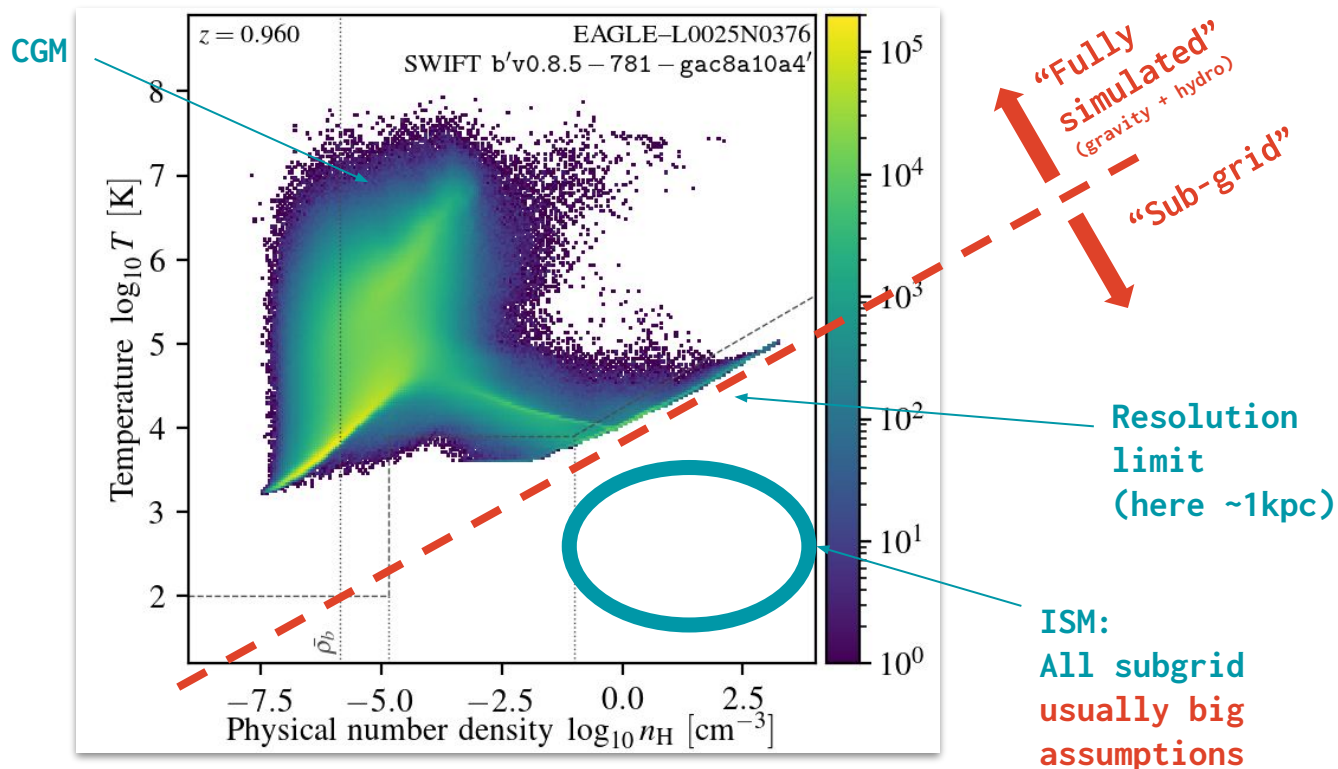
EAGLE-like phase-space

Typical resolution:

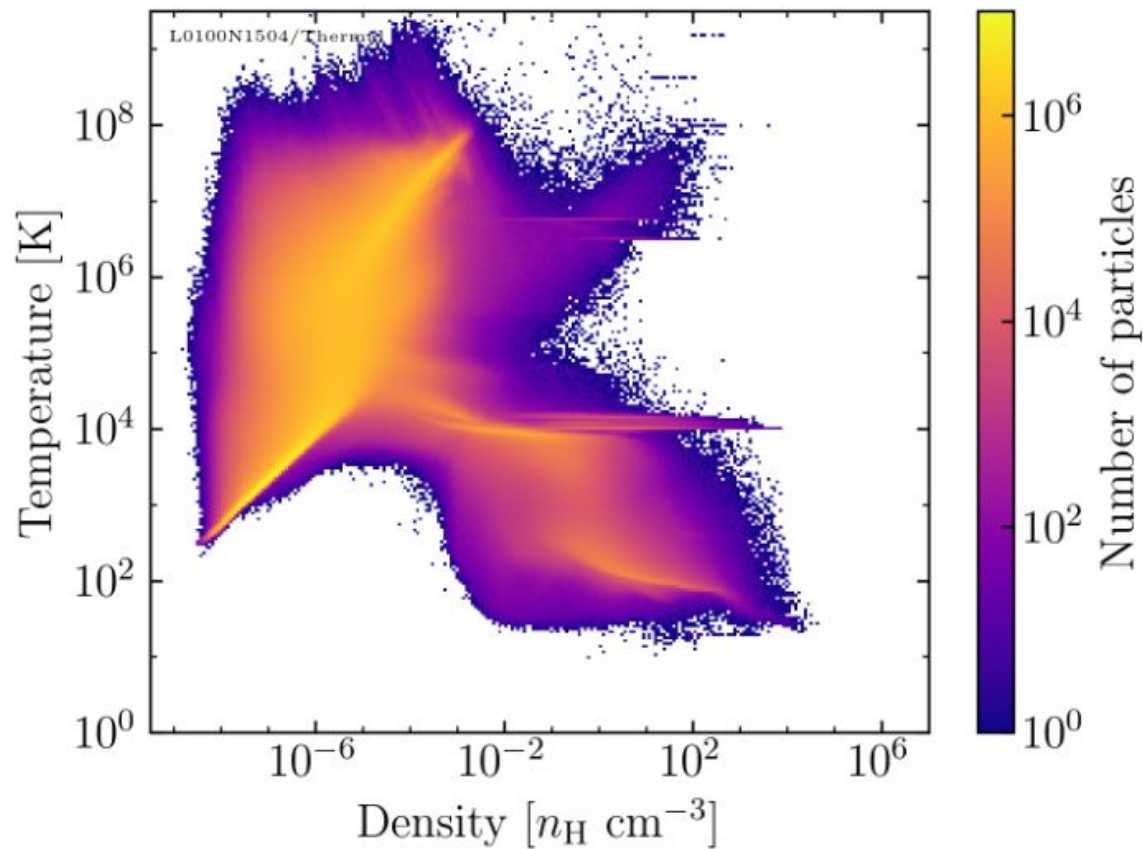
100 - 1000 pc

OR

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



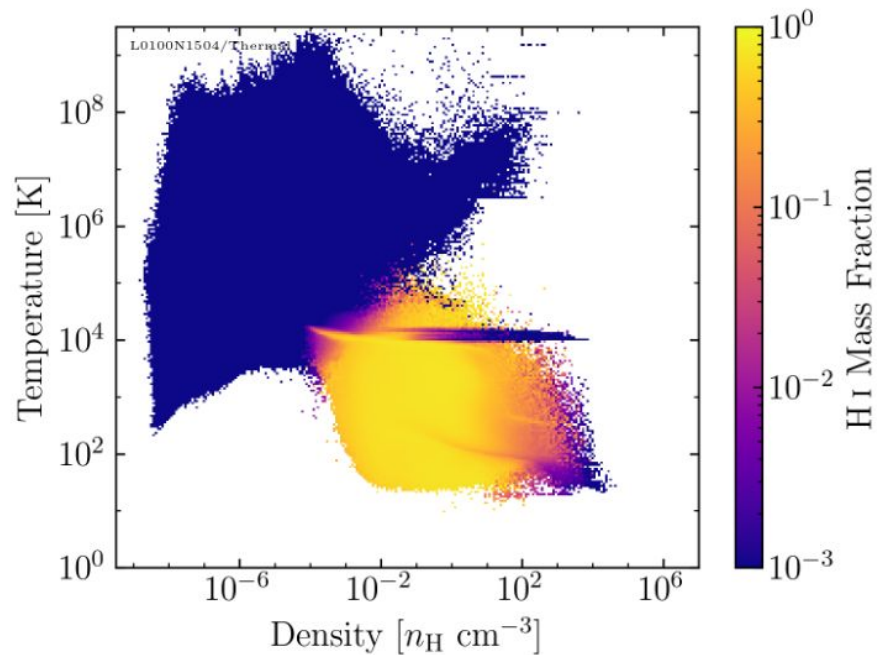
COLIBRE phase-space



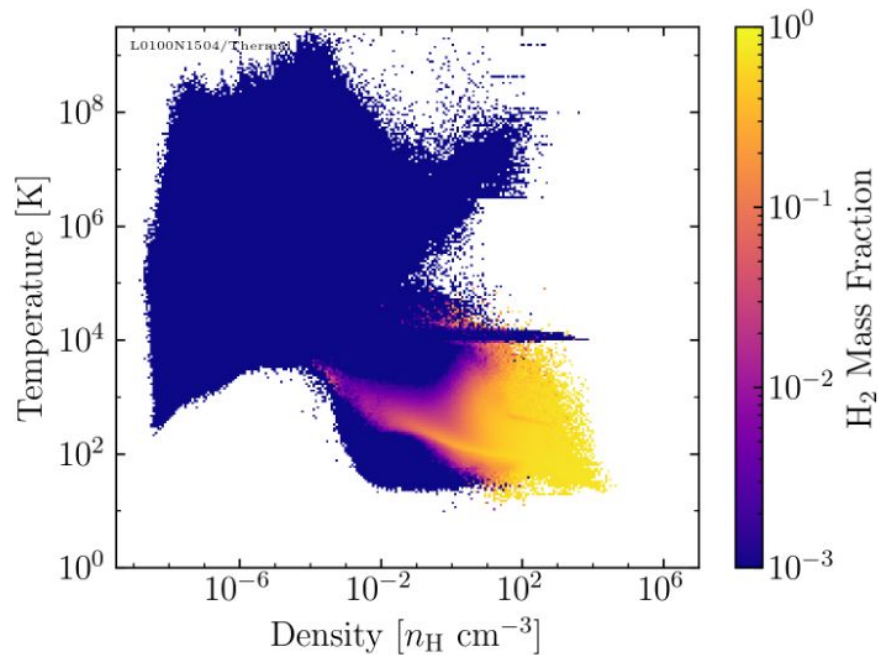
Schaye (in prep.)

Self-consistent H phases

HI



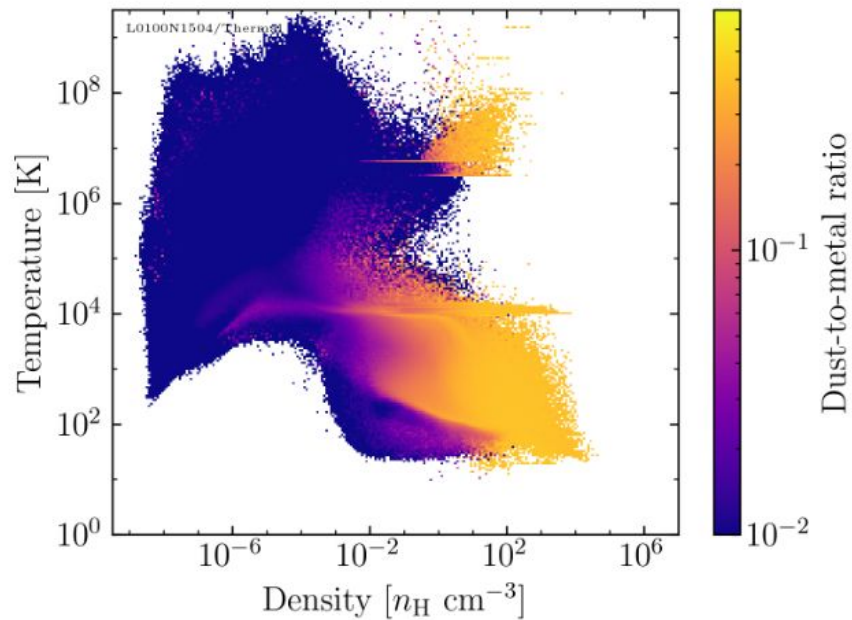
H₂



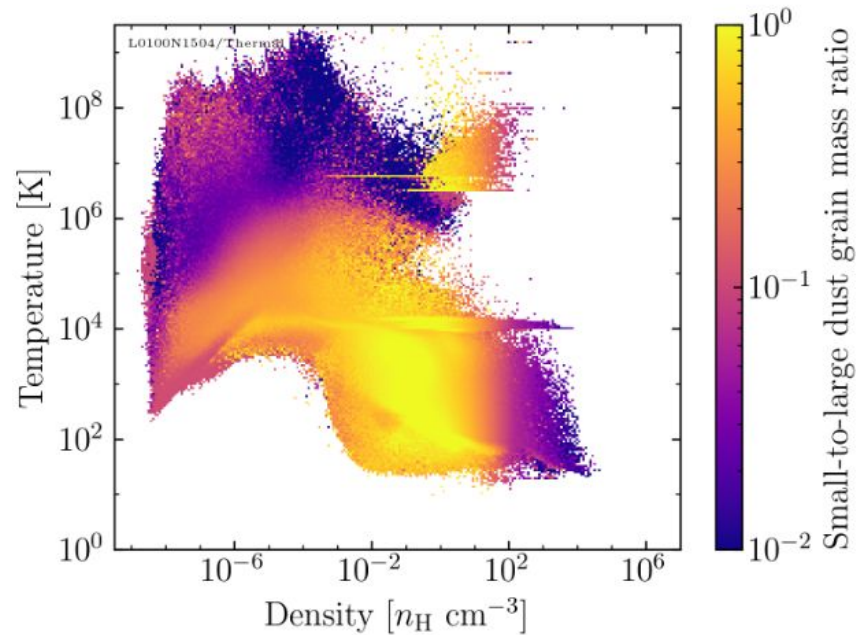
Schaye (in prep.)

Non-uniform D-to-M ratio

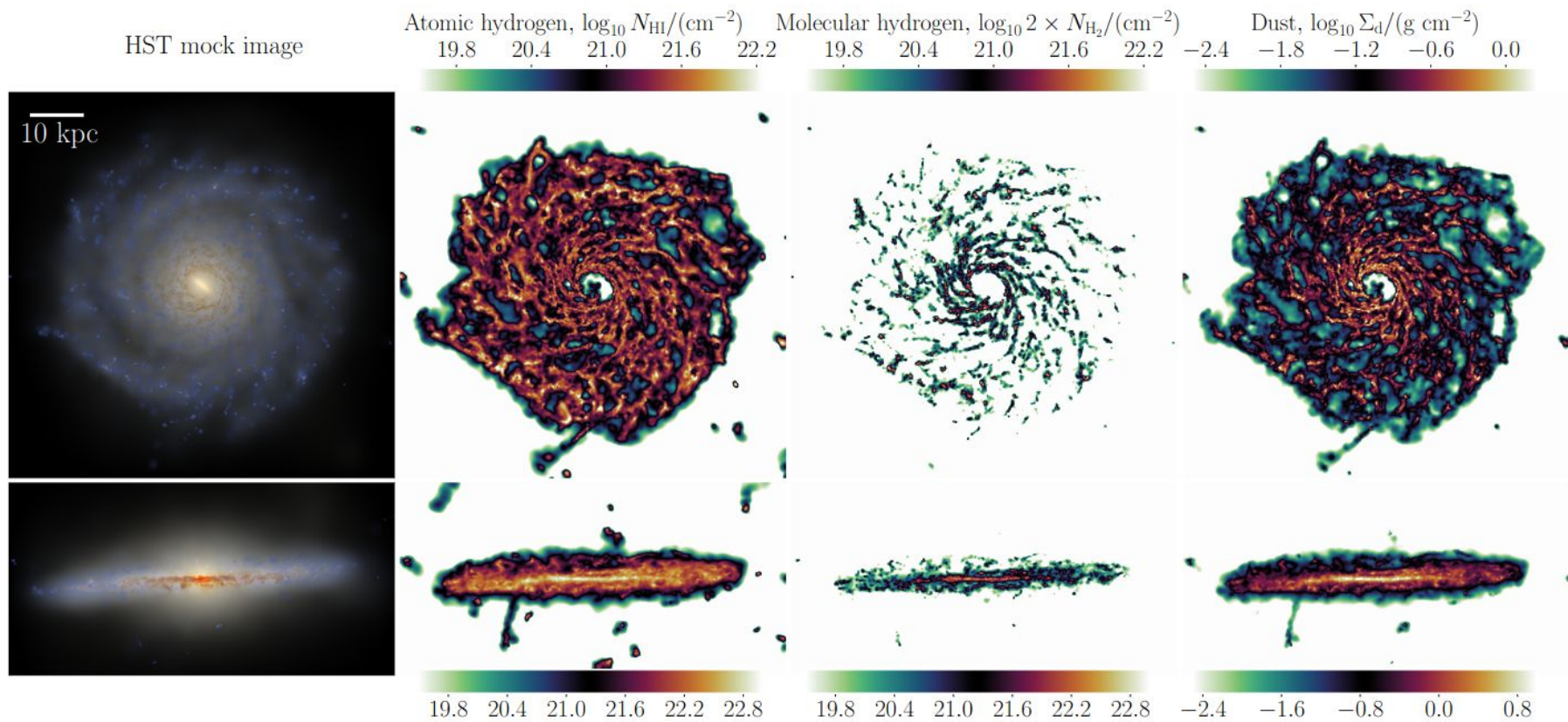
Dust to mass



Small to large grains



Self-consistent H phases

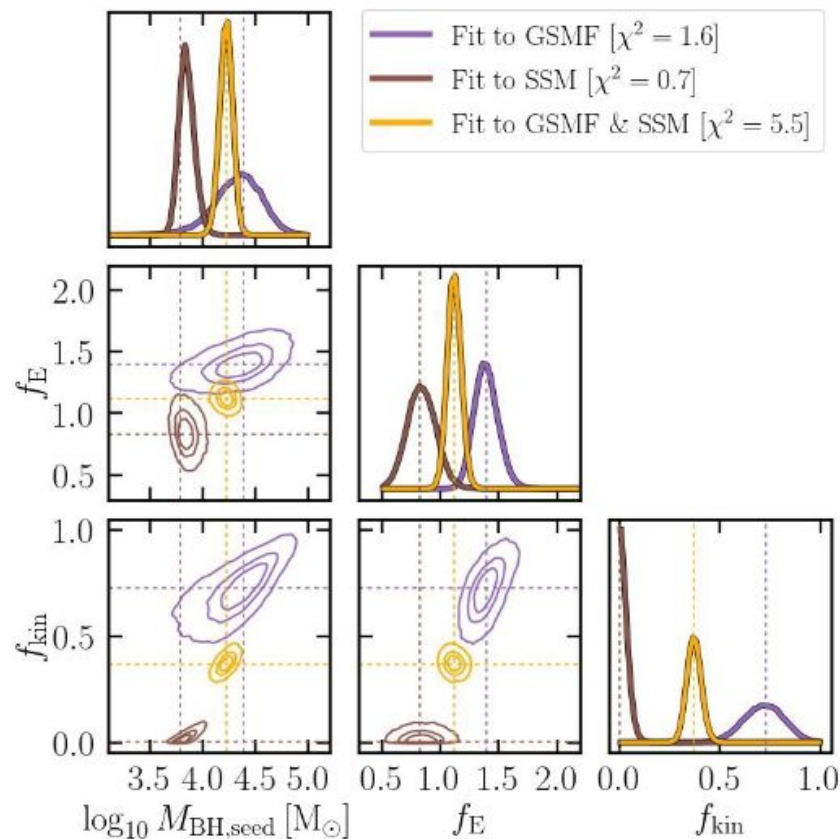


The background of the slide is a detailed Cosmic Microwave Background (CMB) fluctuation map. It displays a complex pattern of temperature variations across the sky, with colors ranging from deep blue (cooler regions) to bright yellow and orange (warmer regions). The map shows a network of filaments and voids, representing the large-scale structure of the universe. Numerous small, dark spots are scattered throughout, likely representing individual galaxies or clusters of galaxies.

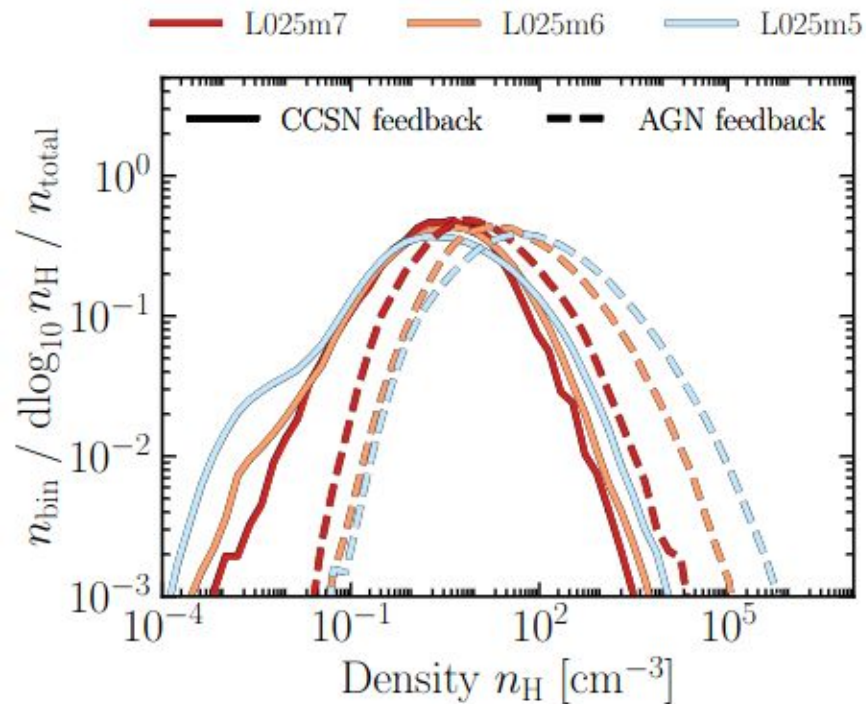
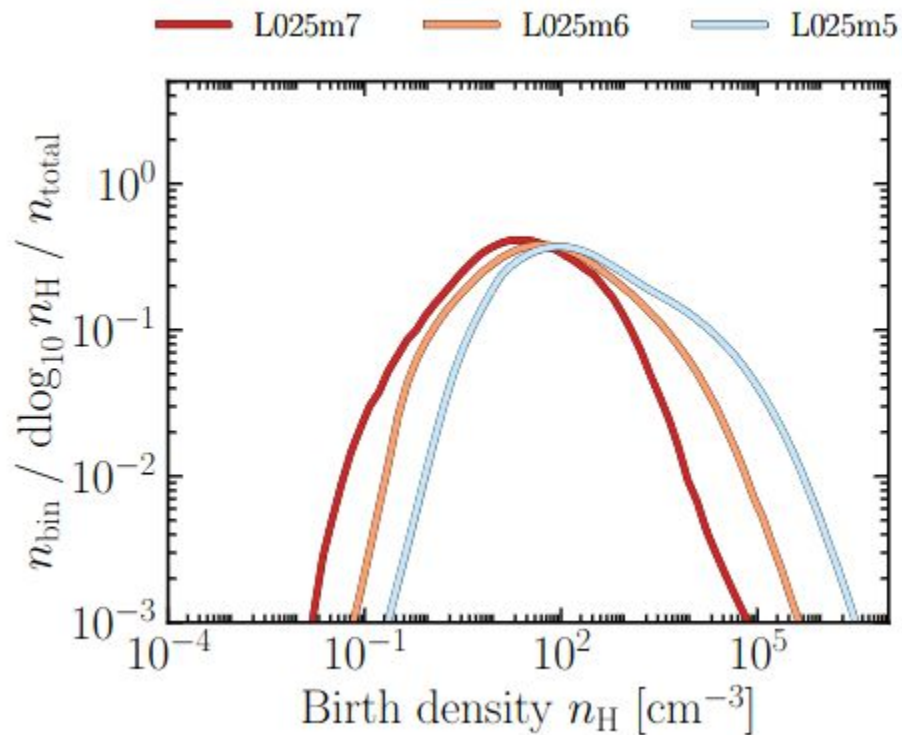
Feedback

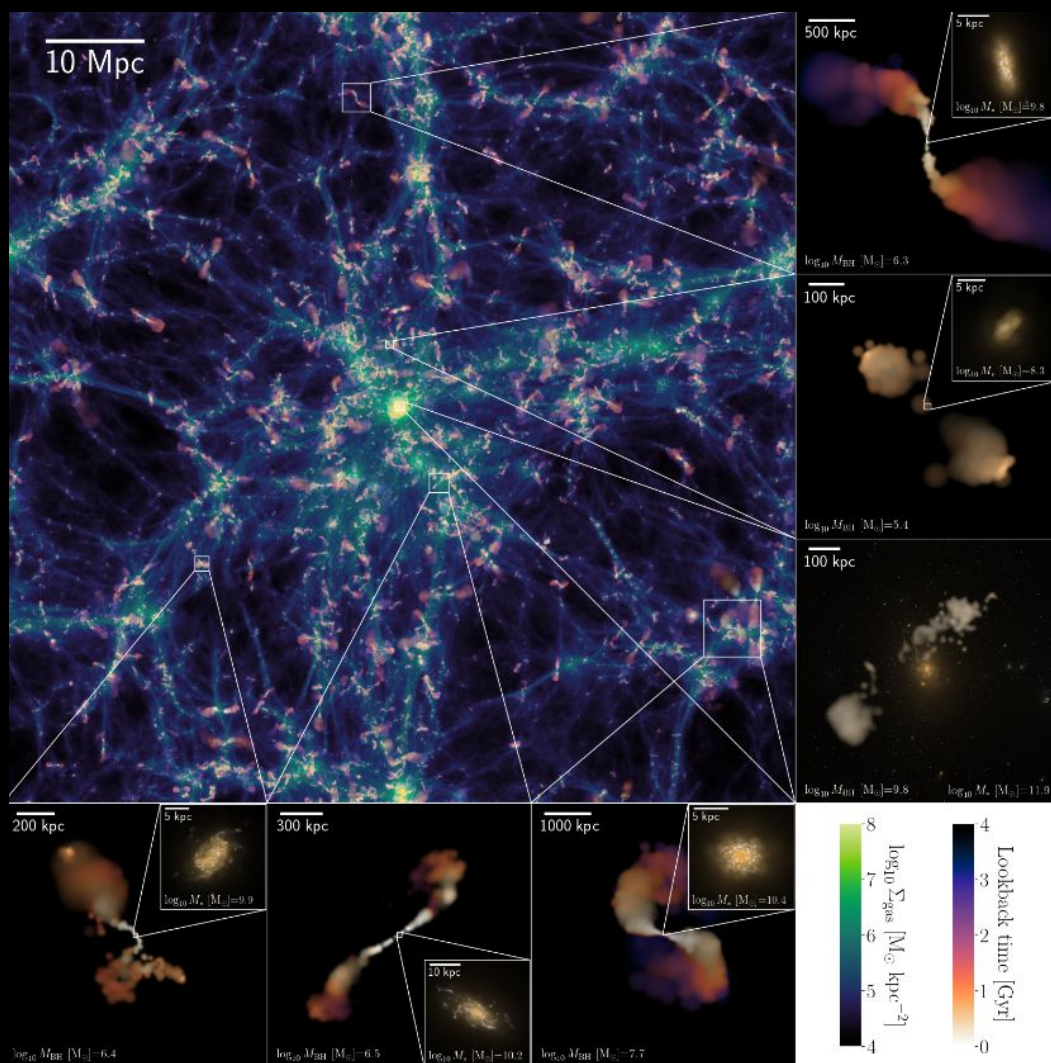
COLIBRE feedback

- 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





AGN feedback model

Jet at $< 0.01 \times$ Eddington
and at $> 1 \times$ Eddington

Thermal in between

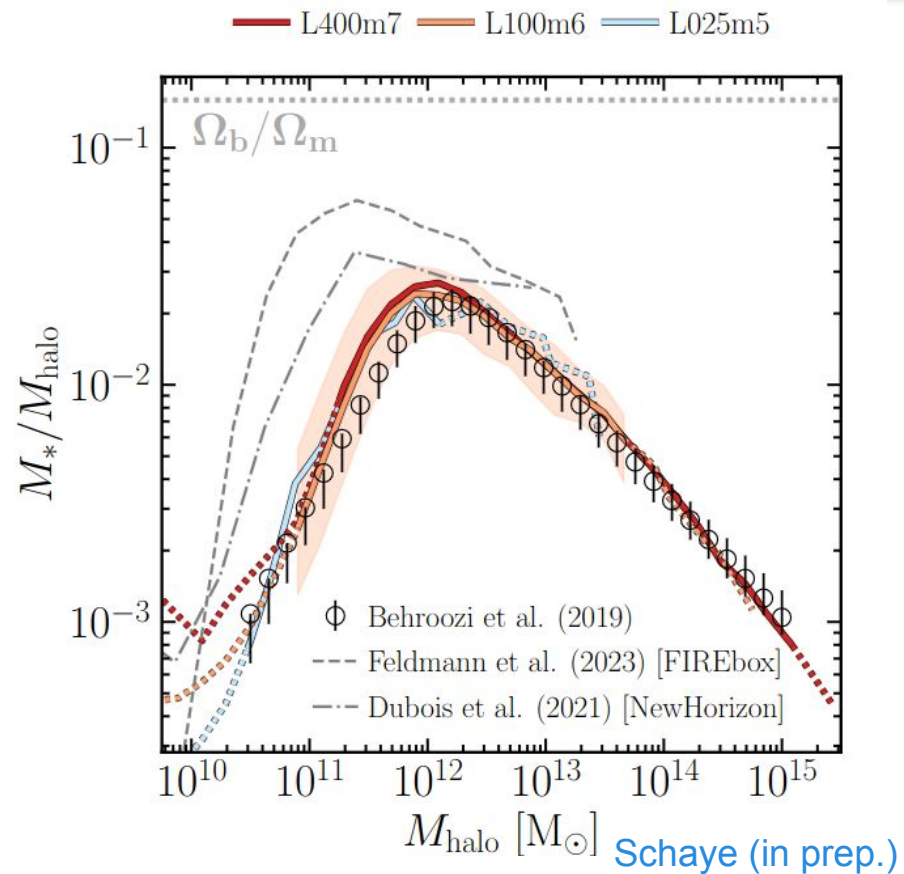
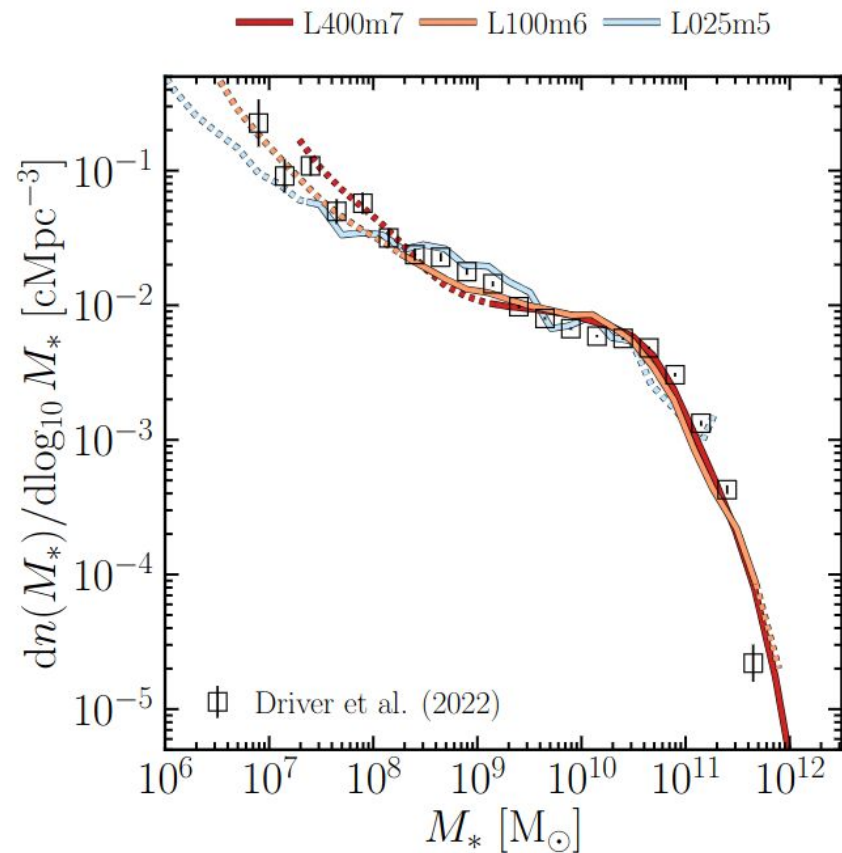
Bondi-Hoyle accretion
with Krumholz turbulence
correction

Spin evolution to direct
the jets

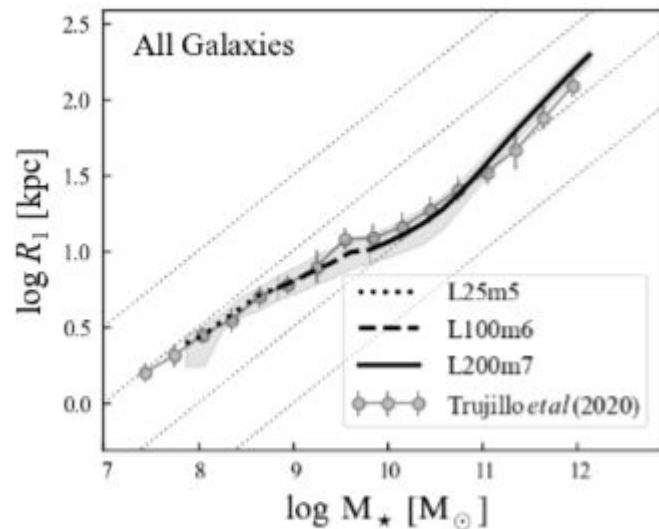
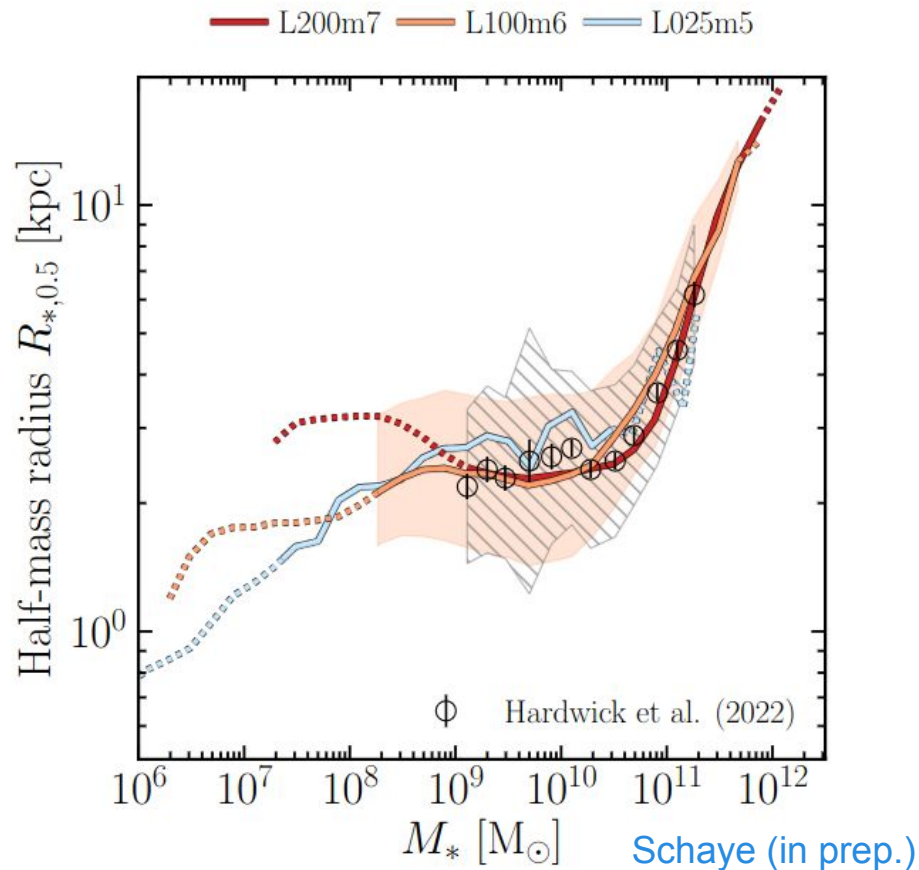
The background of the slide is a detailed Cosmic Microwave Background (CMB) fluctuation map. It displays a complex pattern of temperature variations across the sky, with colors ranging from deep blue (cooler regions) to bright yellow and orange (warmer regions). The map shows a network of filaments and voids, characteristic of the large-scale structure of the universe. Numerous small, dark spots are scattered throughout, representing individual galaxies or clusters of galaxies. The overall texture is grainy and intricate, reflecting the high-resolution data from satellite missions like COBE, WMAP, or Planck.

Some Results

Calibration targets - Stellar masses



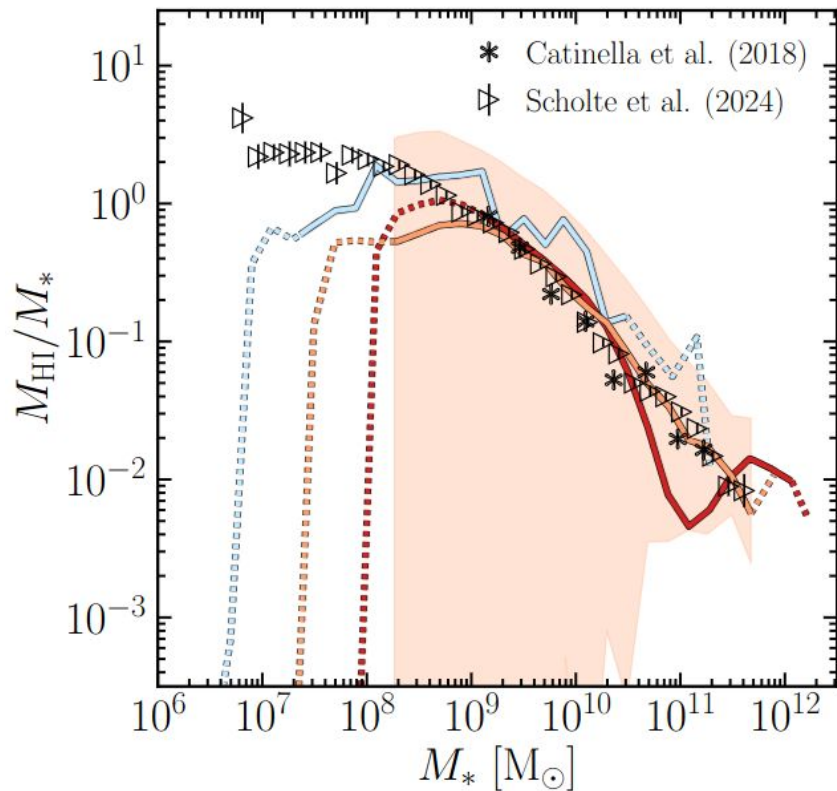
Calibration targets - Stellar sizes



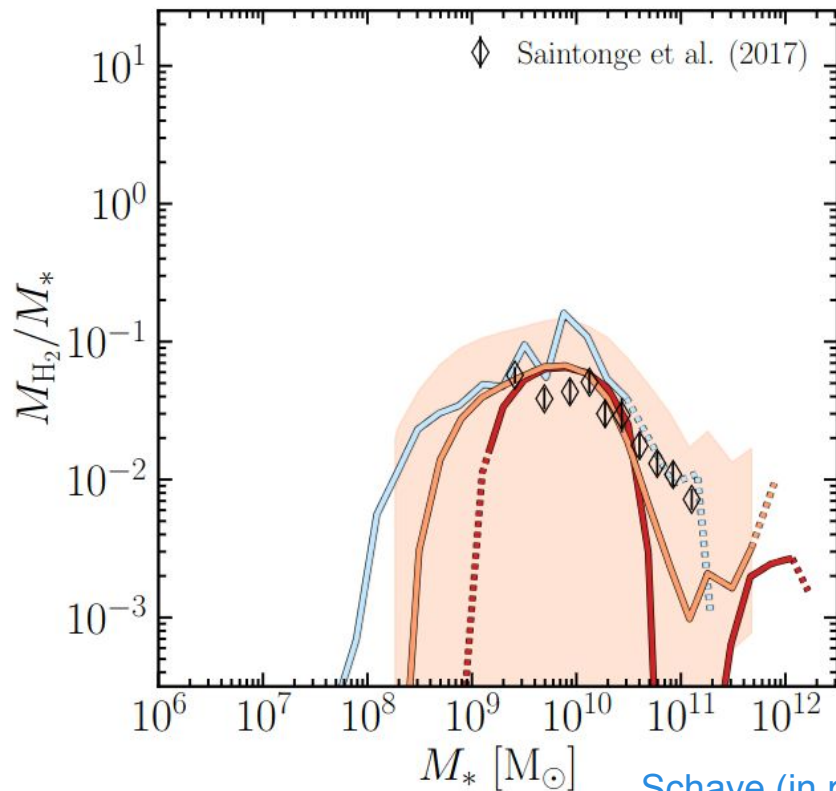
Ludlow (in prep.)

Gas content of galaxy

— L400m7 — L100m6 — L025m5

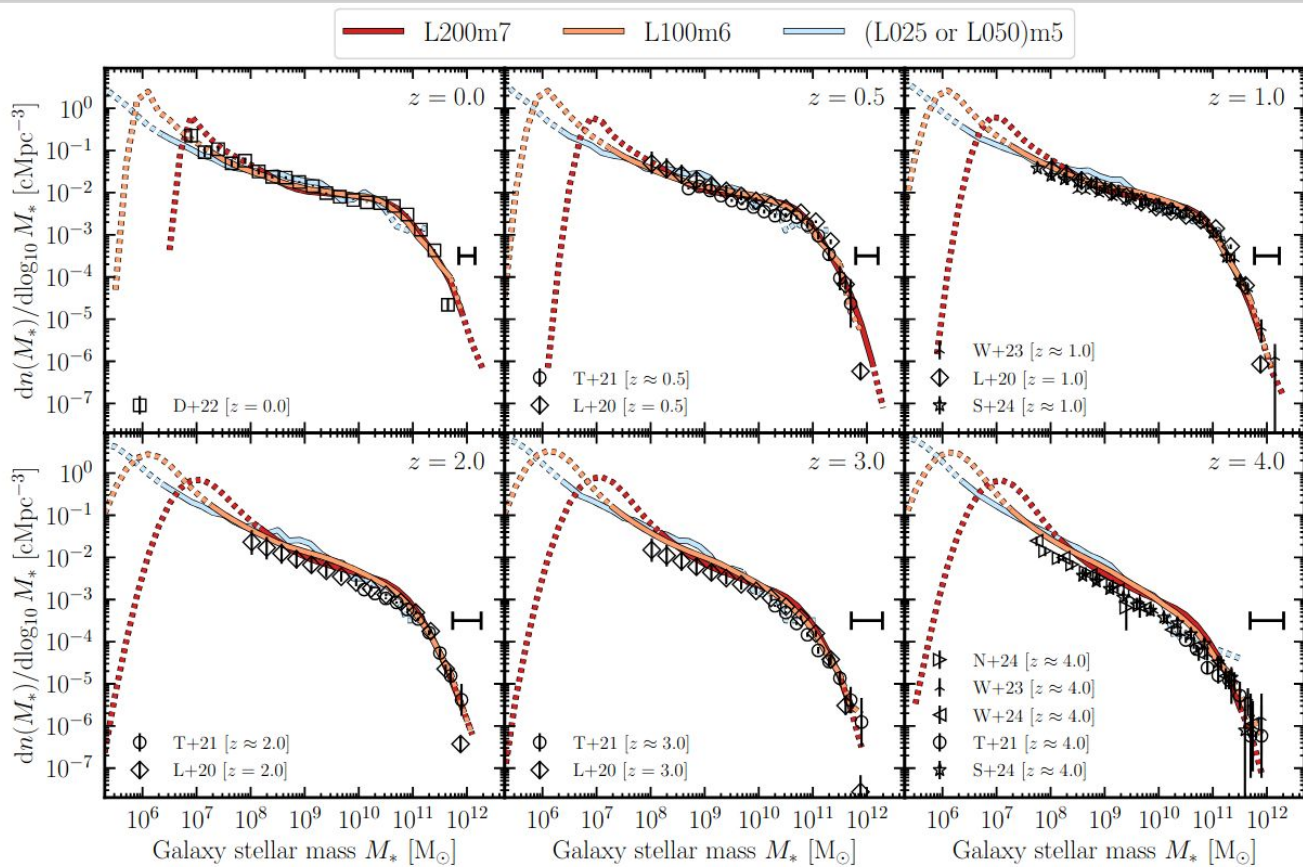


— L400m7 — L100m6 — L025m5

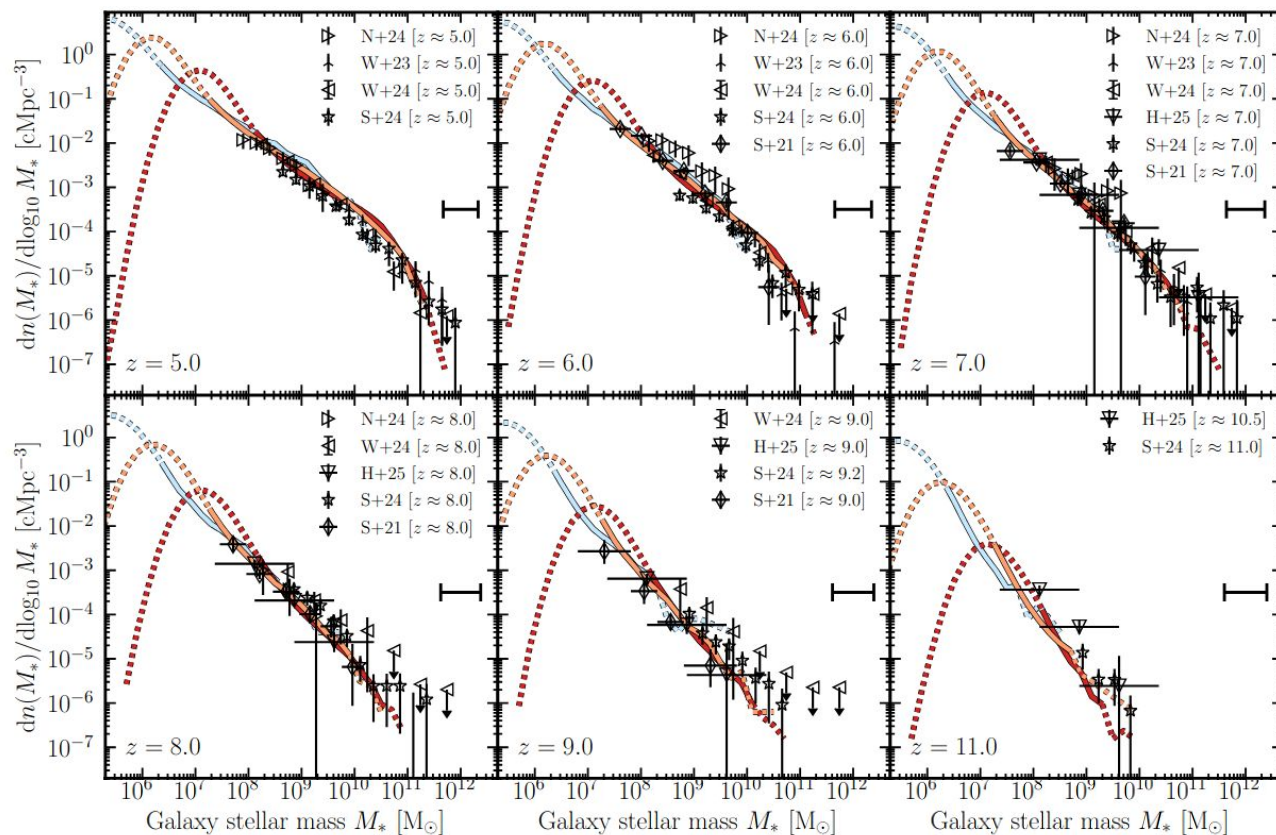


Schaye (in prep.)

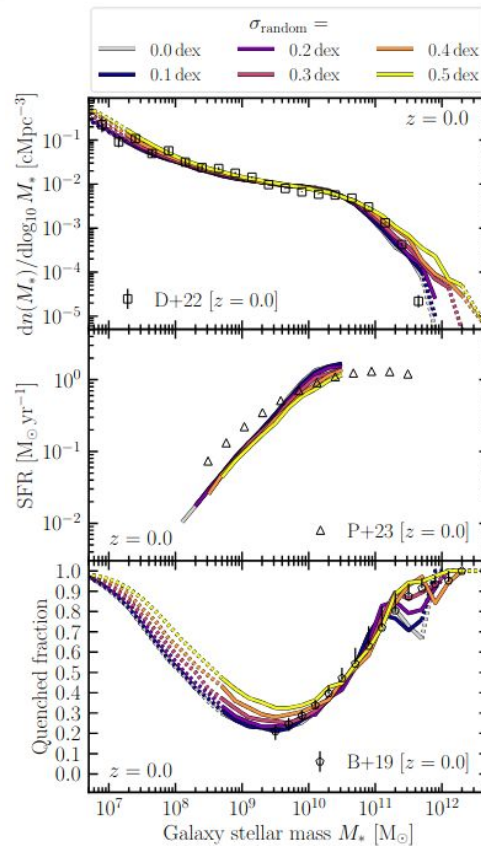
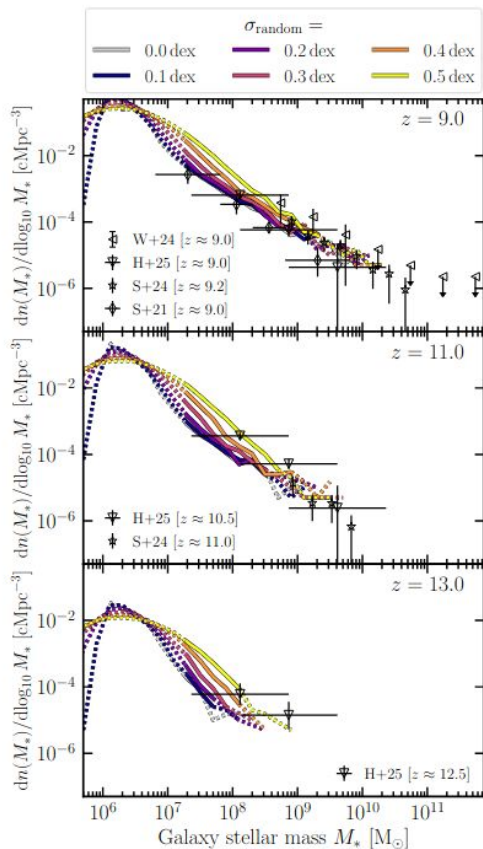
High(er)-z results



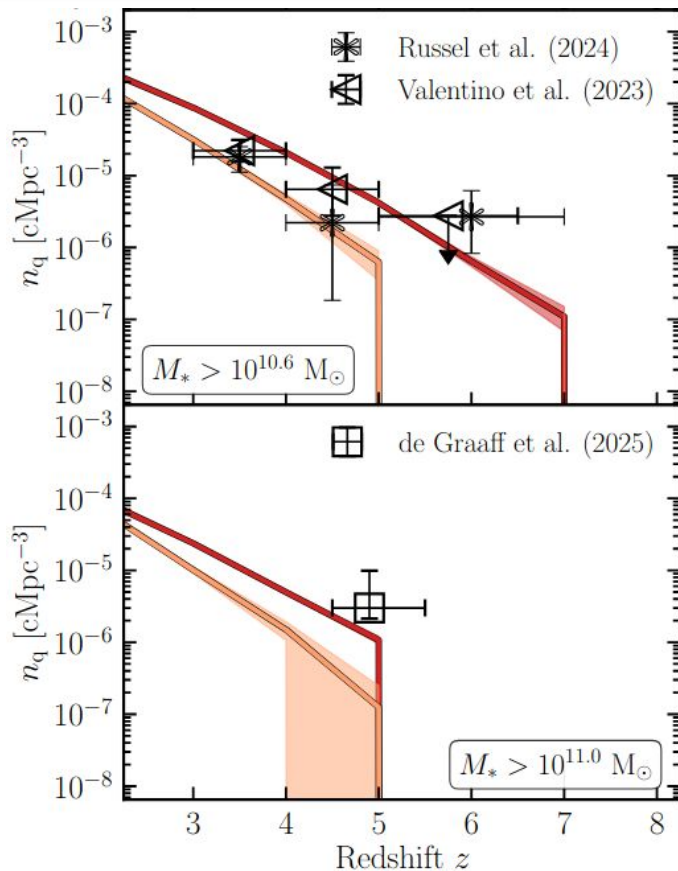
High(er)-z results



Effect of Eddington bias



Massive quenched objects



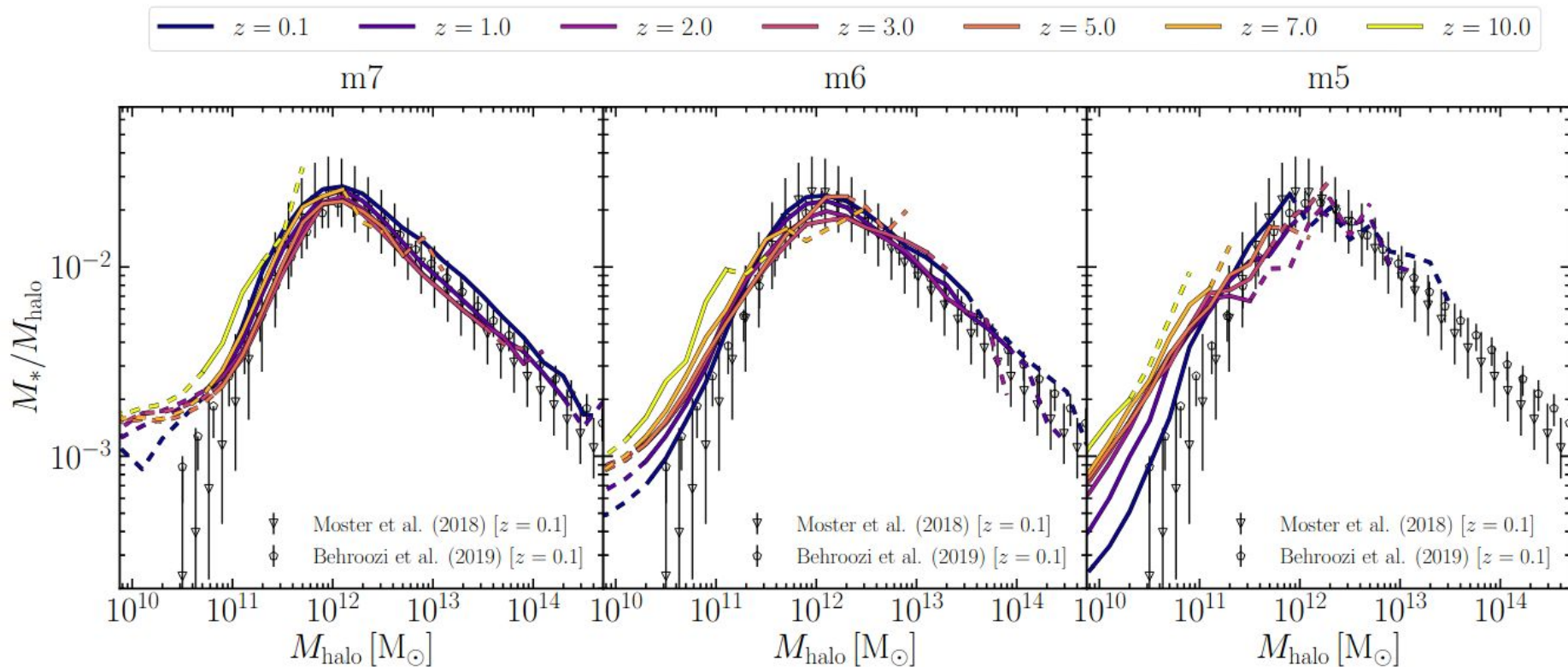
Quiescent Galaxy Selection: $\text{sSFR} < 10^{-10} \text{ yr}^{-1}$

L400m7 **L200m6**

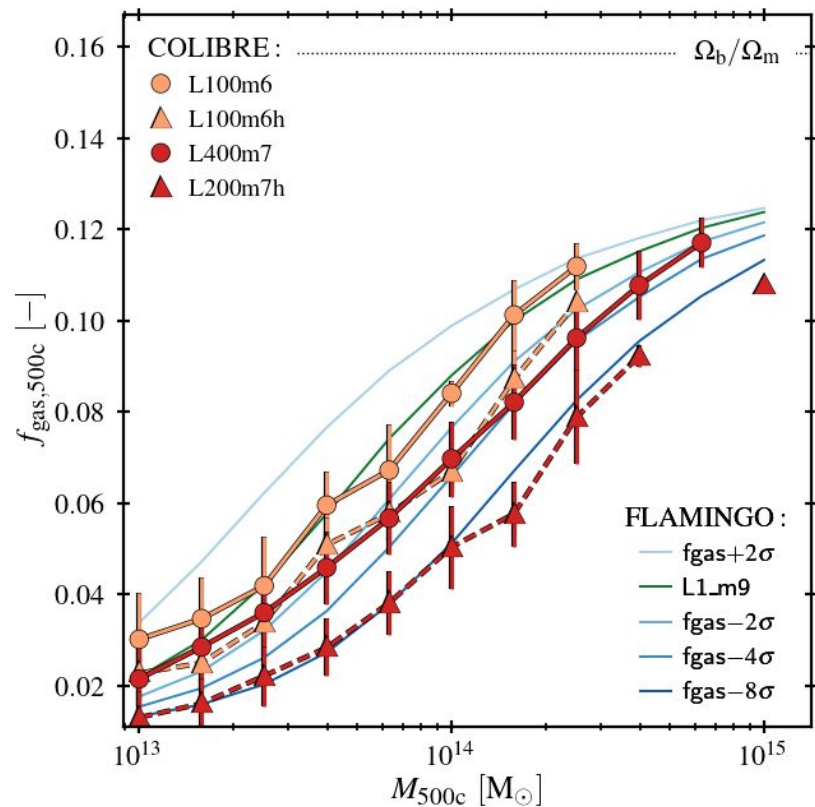
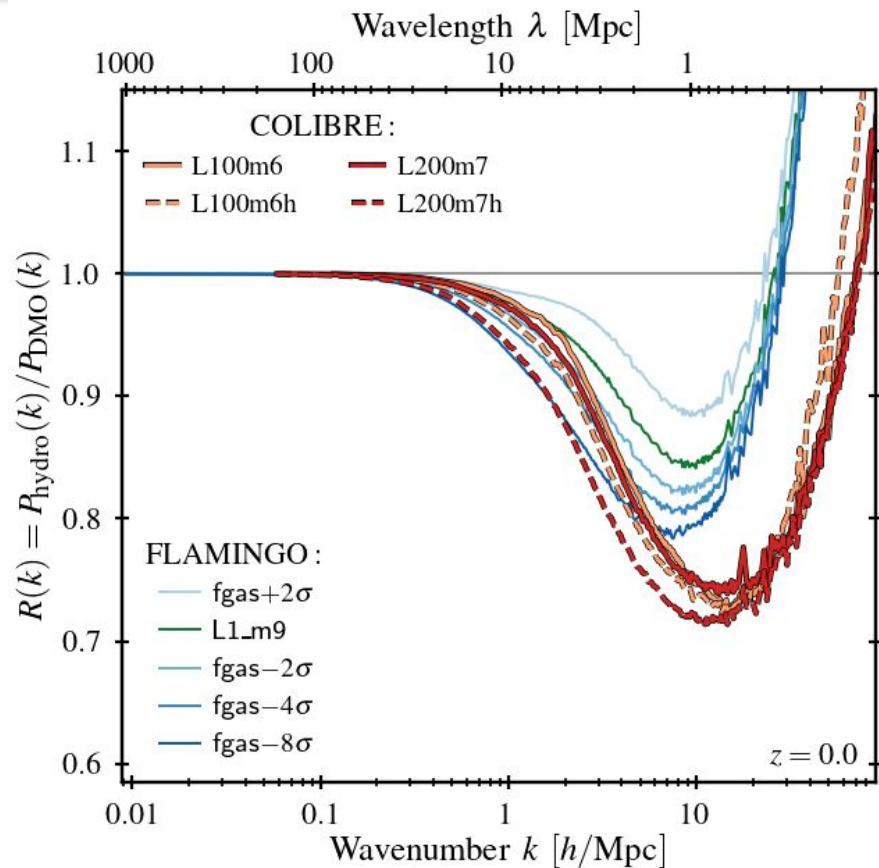
Simulations are in good agreement with the data.

Large volume is necessary to beat down cosmic variance.

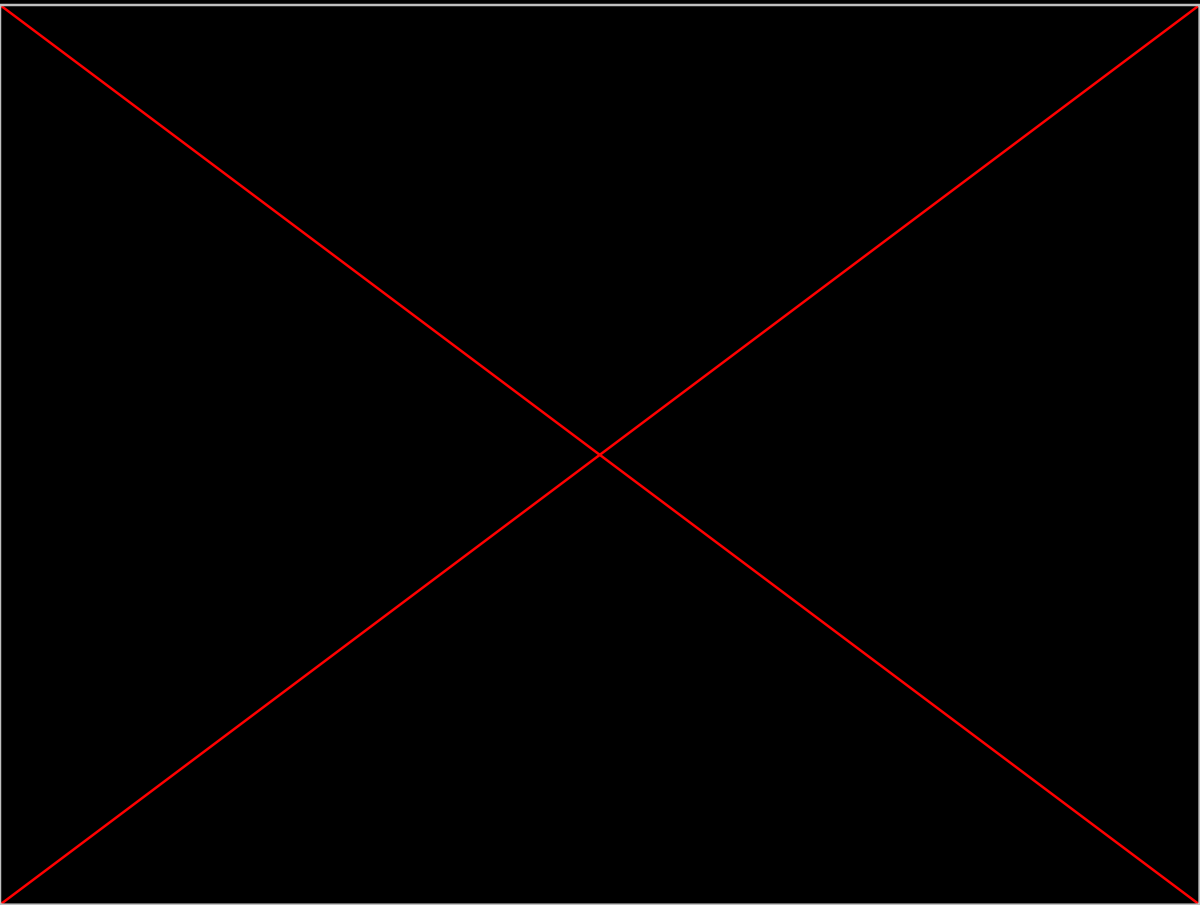
Galactic star formation efficiency



Feedback impact on cosmology



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, H₂, 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!