Modelling stellar cluster populations alongside their host galaxies: the EMP-Pathfinder view

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Introducing EMP-*Pathfinder*: modelling the simultaneous formation and evolution of stellar clusters in their host galaxies

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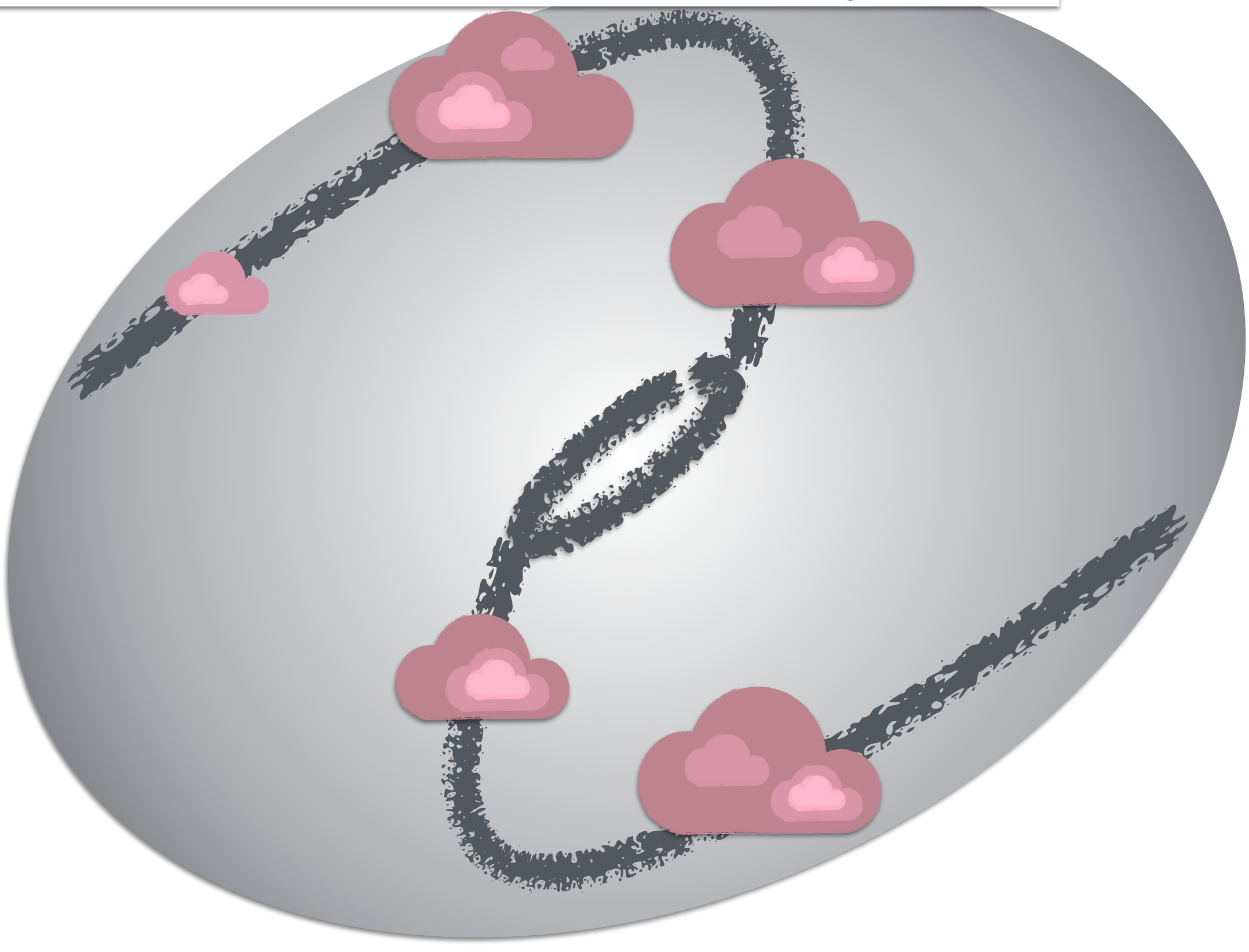
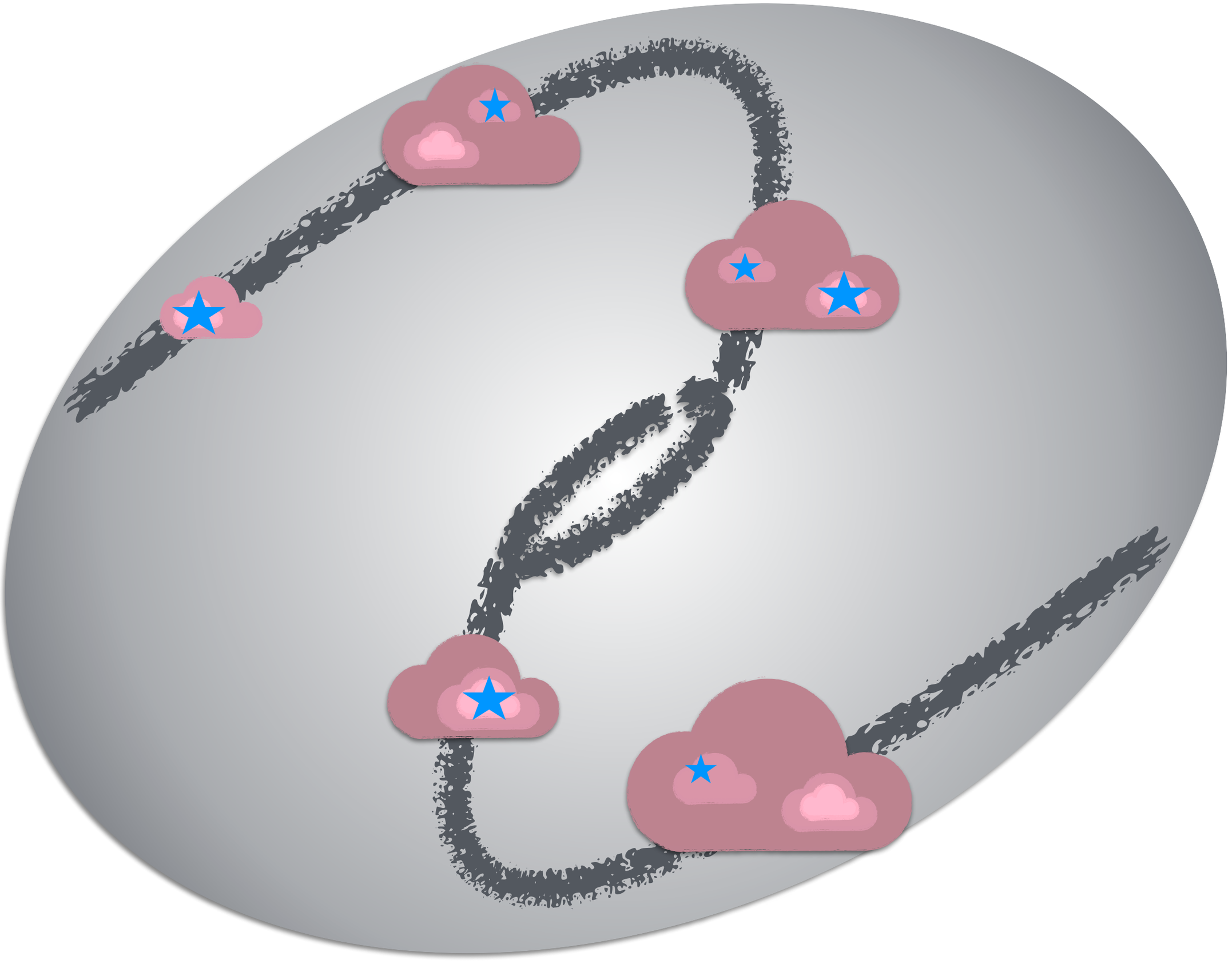
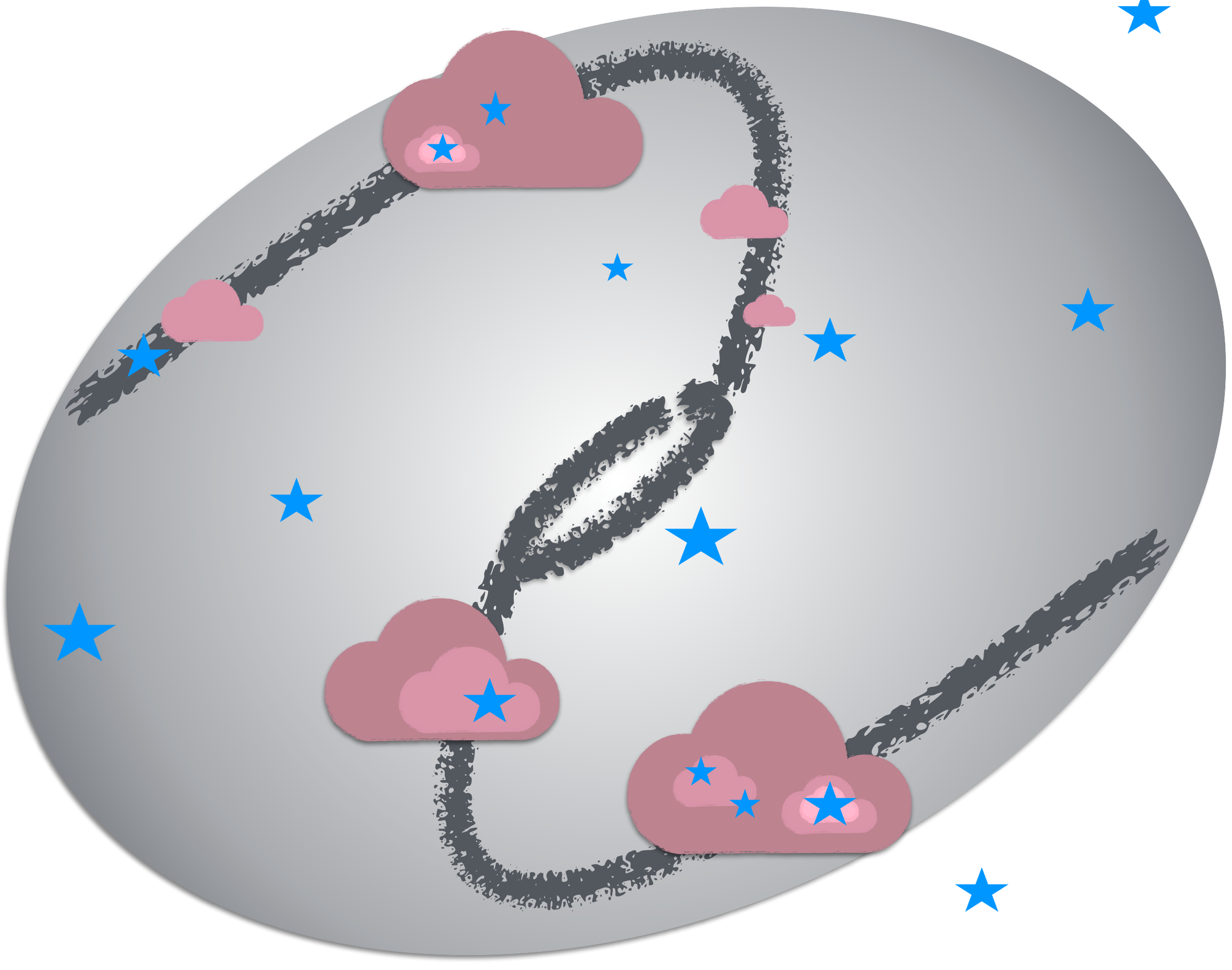
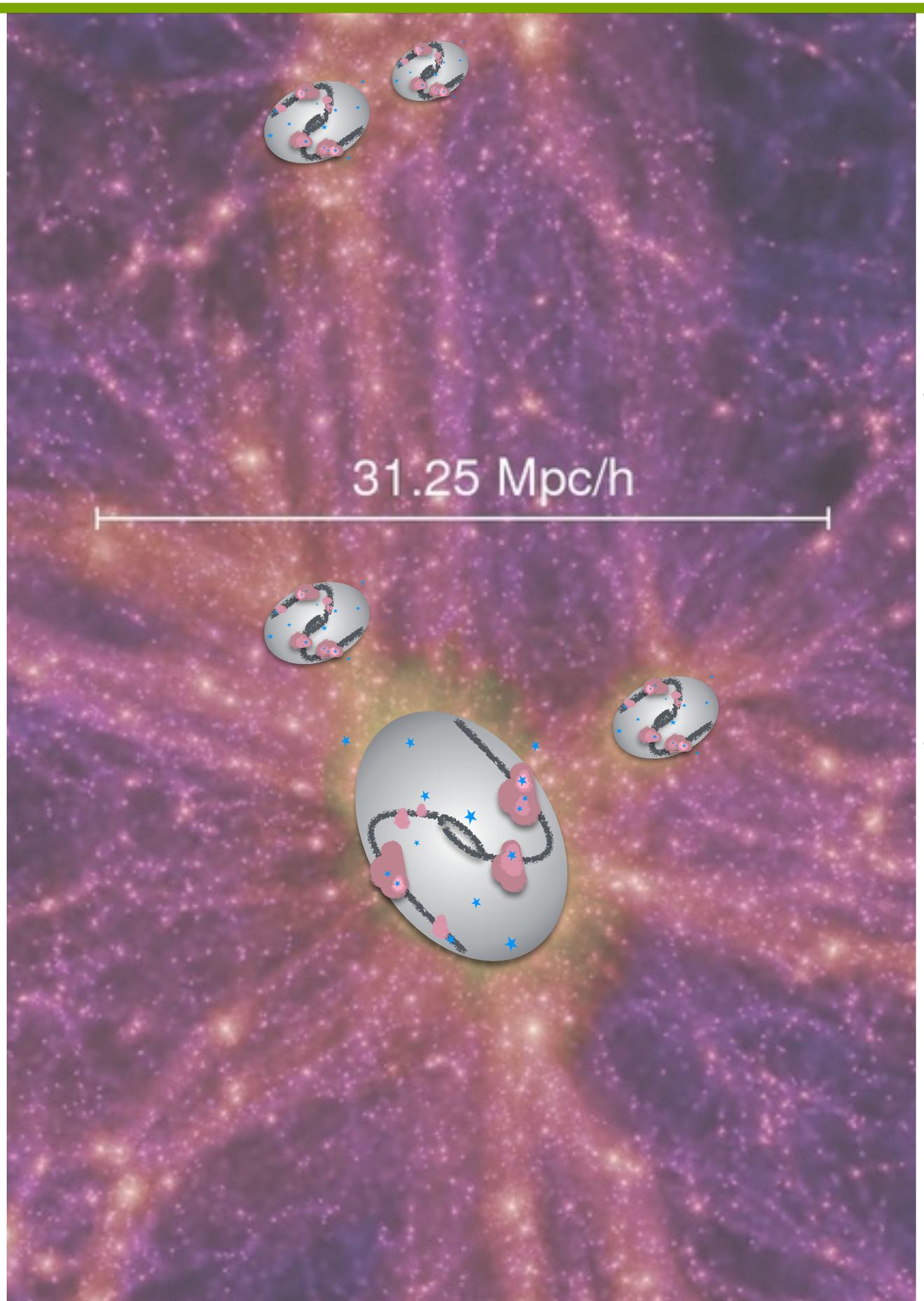
Reina-Campos+ (subm. to MNRAS, arXiv:2202.06961)

Once upon a time when the Universe was young...









Millenium Simulations (Credit: Volker Springel)

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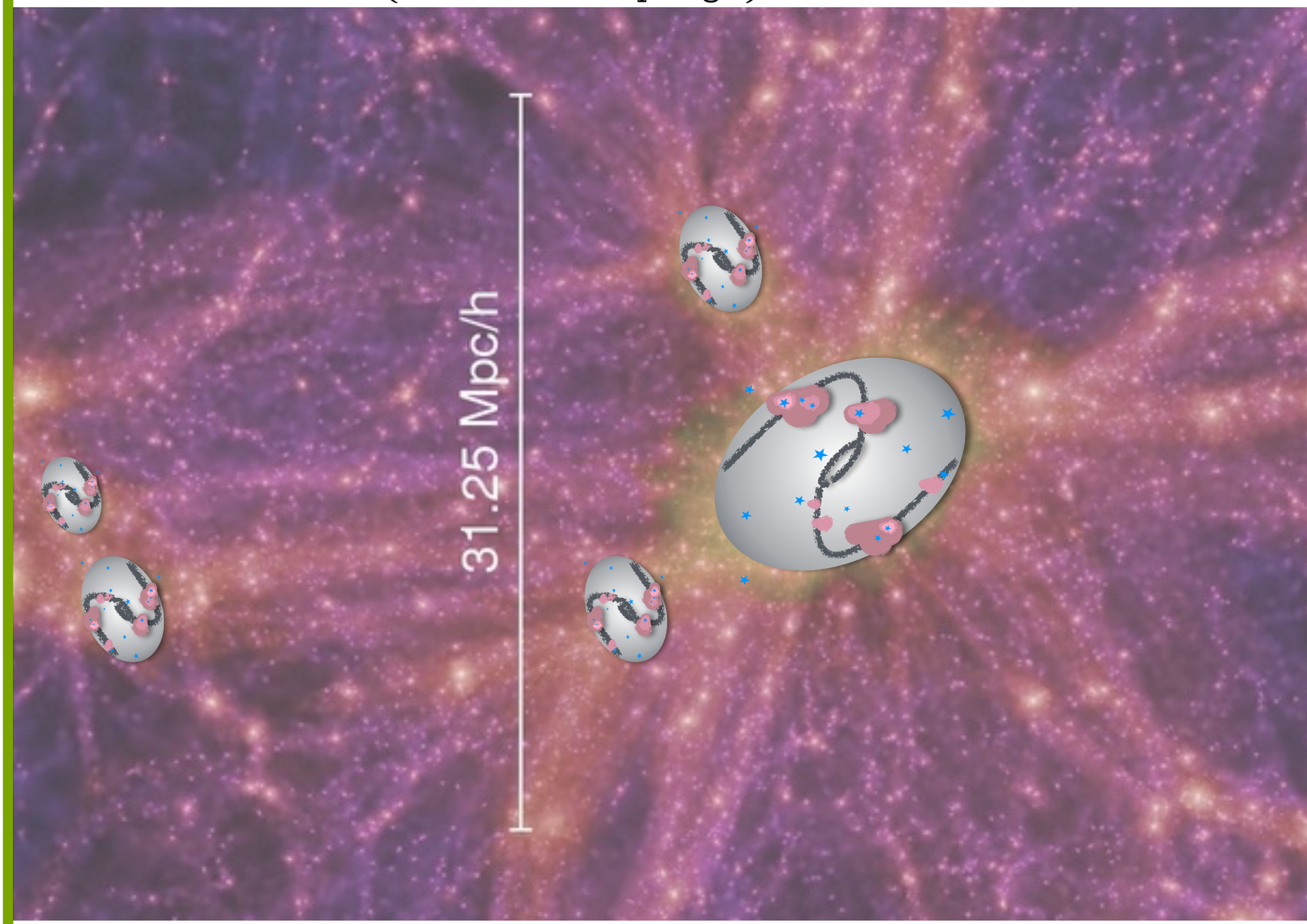
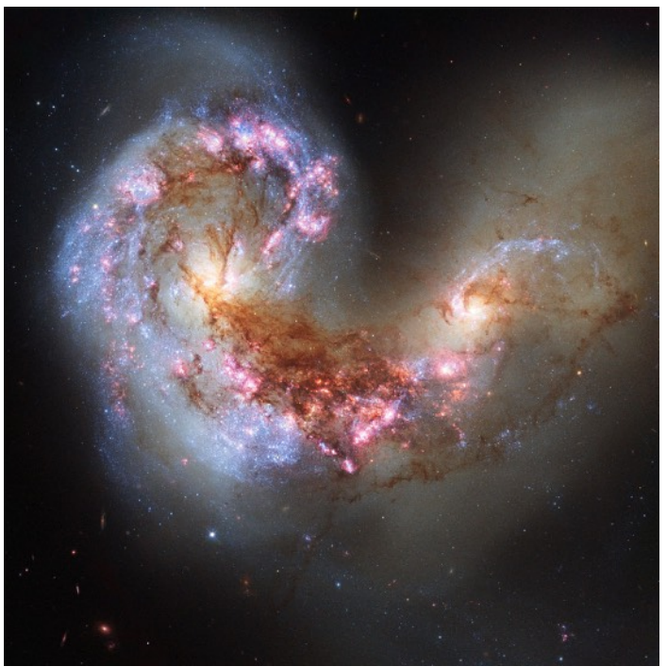


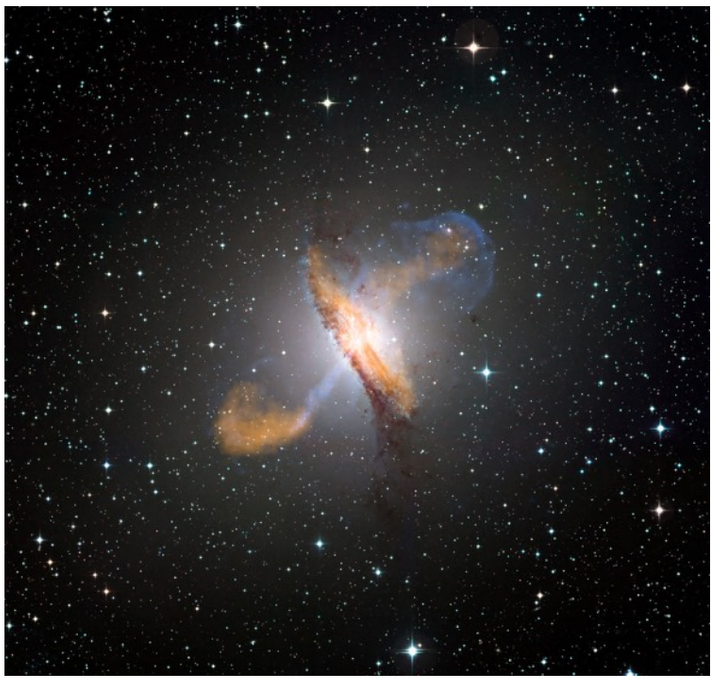
Antennae galaxies

Credit: NASA / HST



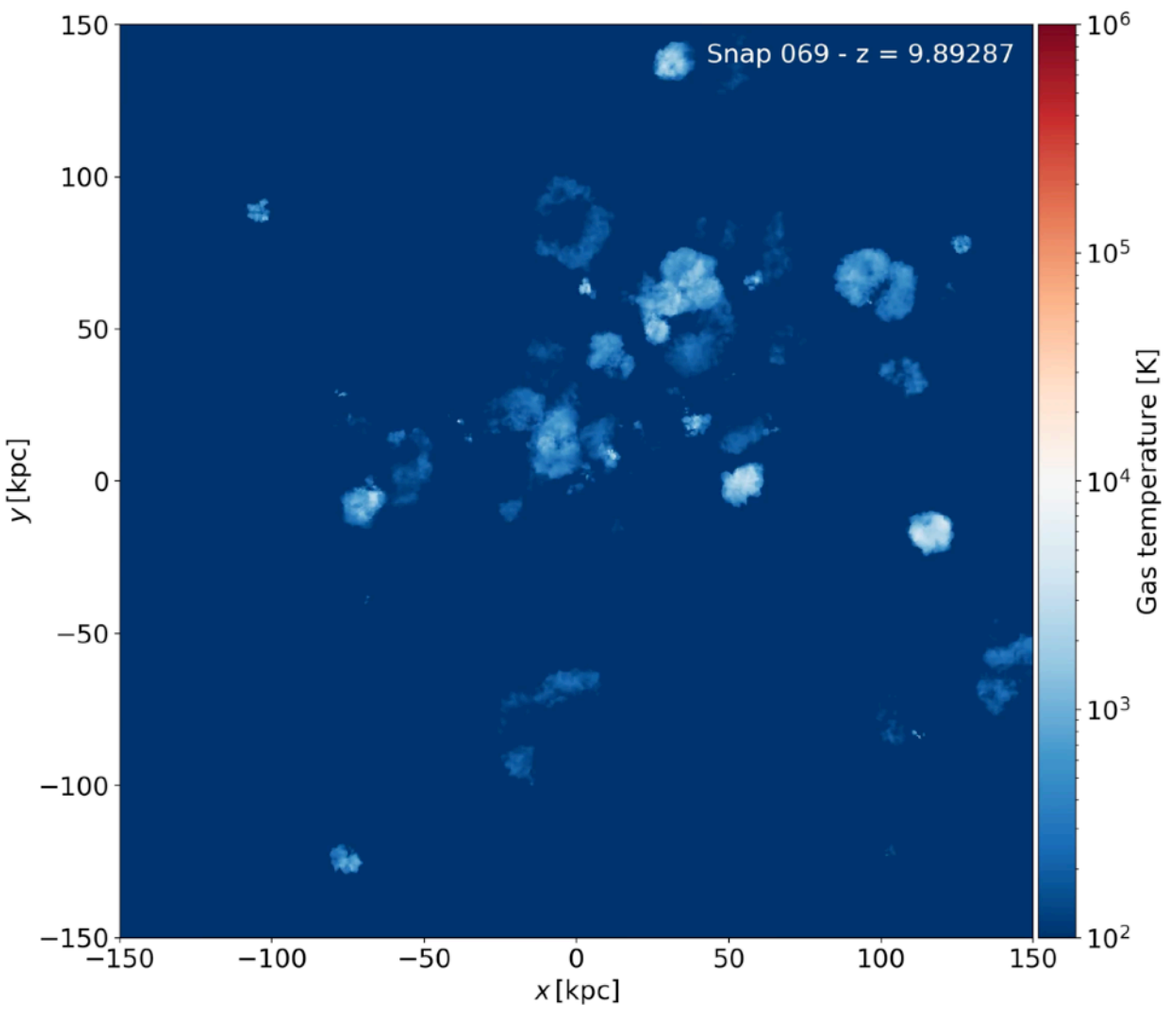
Cen A

Credit: ESO/WFI
MPIfR/ESO/APEX/A.Weiss et al.
NASA/CXC/CfA/R. Kraft et al.



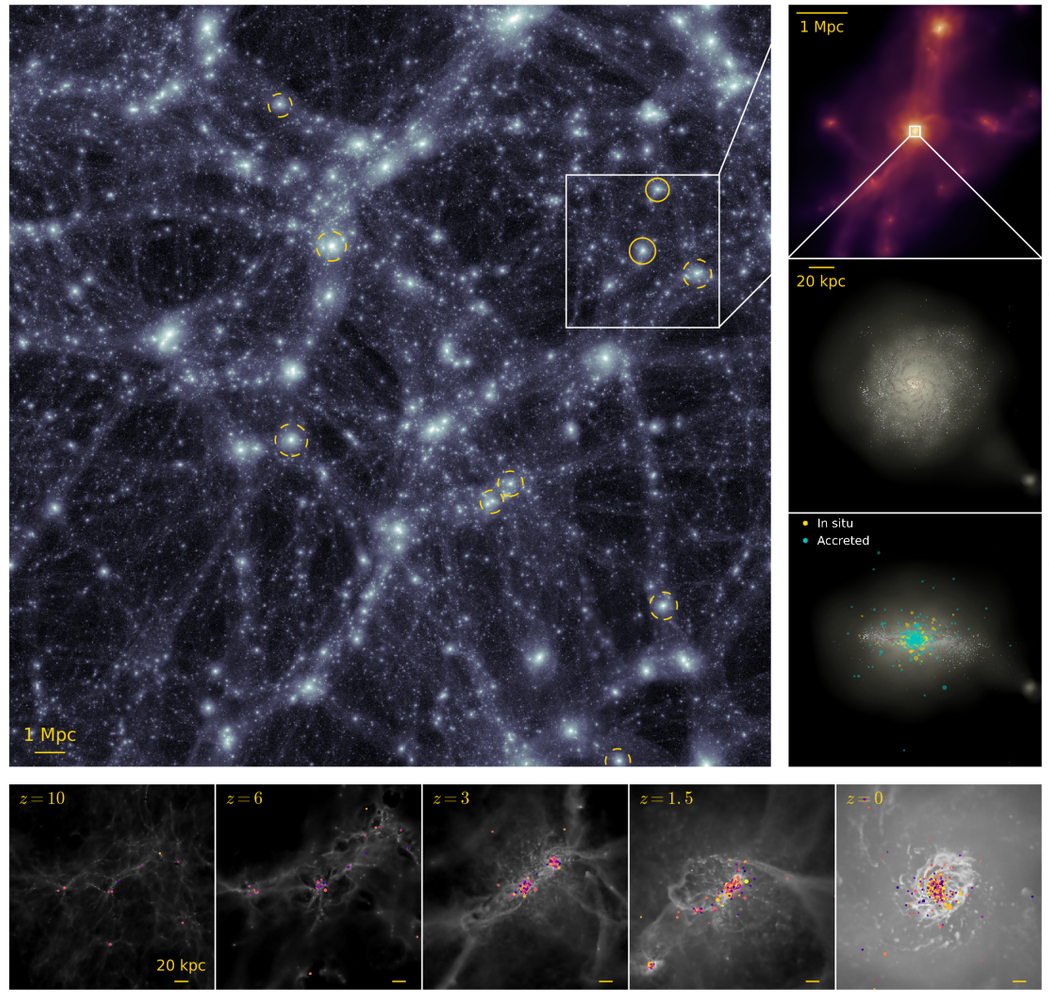
EMP-Pathfinder

EMP-Pathfinder is a new galaxy formation model that includes the physics of the multiphase nature of the ISM in AREPO, and it is coupled to a sub-grid model for stellar cluster formation and evolution



Assembly of a MW-mass galaxy from z =10 to z = 0

The E-MOSAICS project



Pfeffer+ (2018), Kruijssen+ (2019)

Main difference: warm ISM

EMP-Pathfinder

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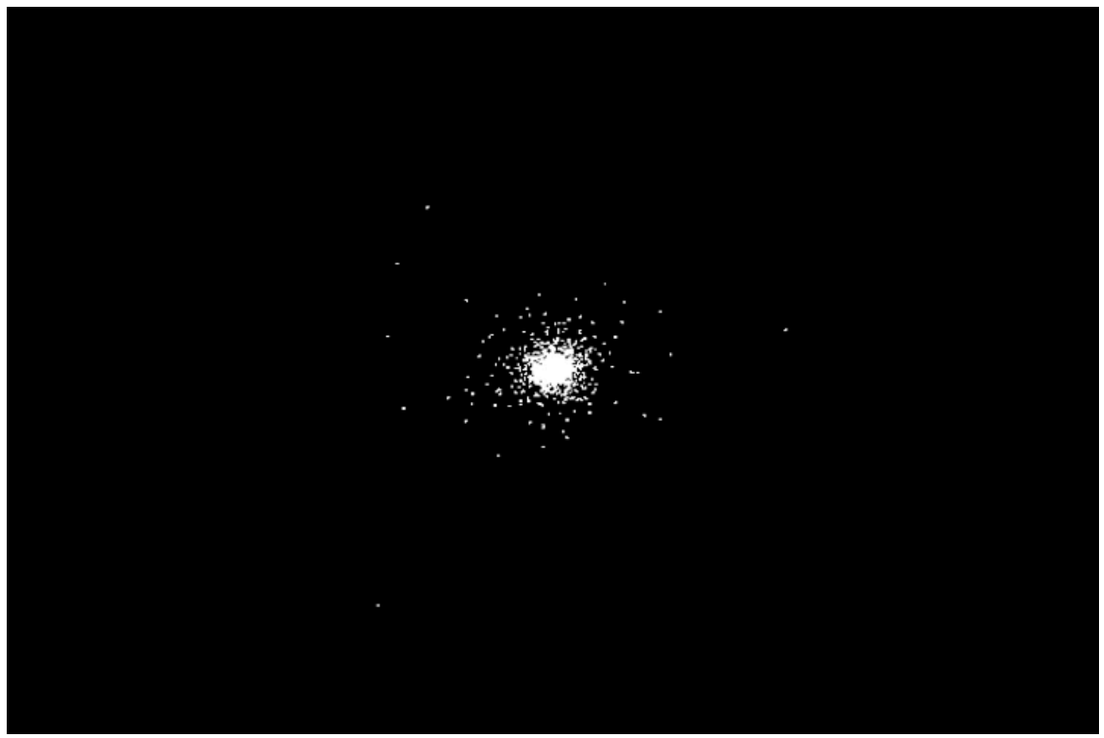
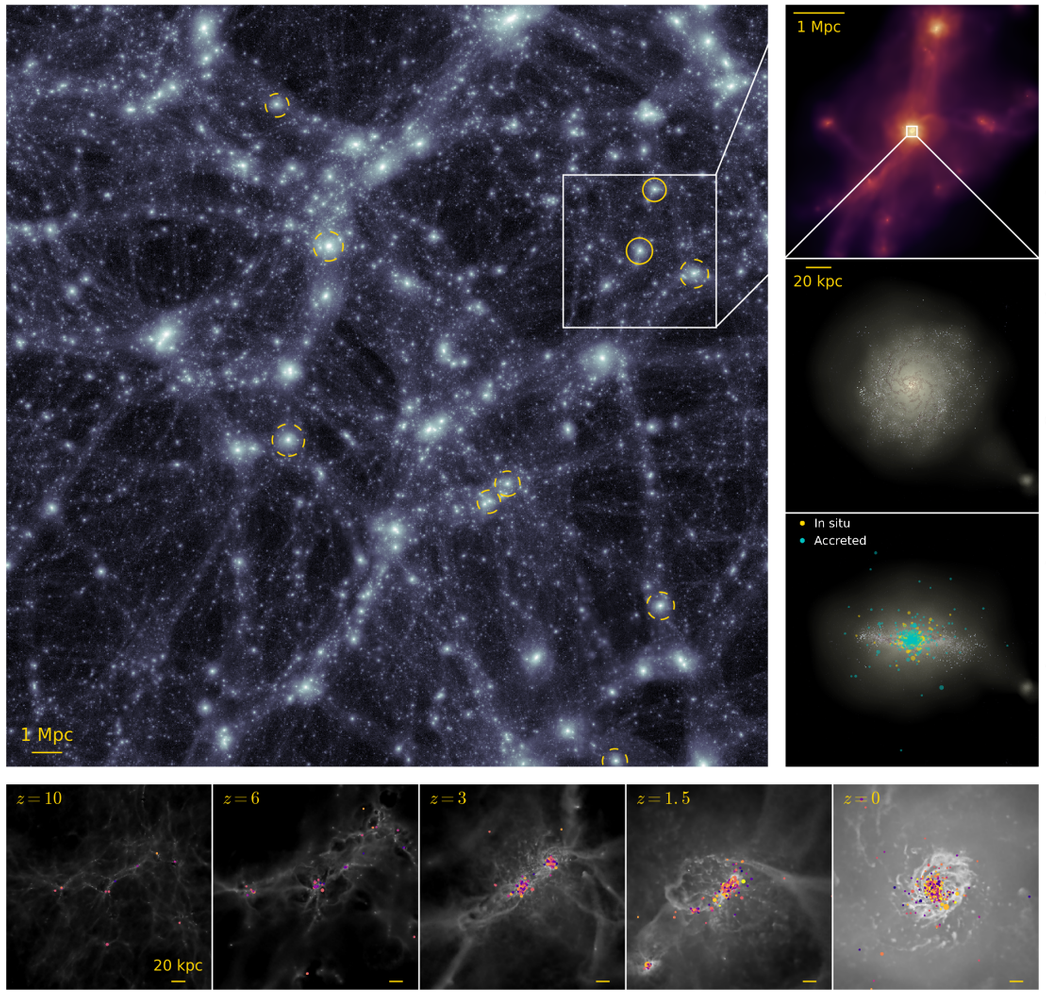
Dominant cluster disruption mechanism is tidal shocking by dense gas

Lamers & Gieles (2006), Kruijssen+ (2011)



Gieles+ (2006)

The E-MOSAICS project



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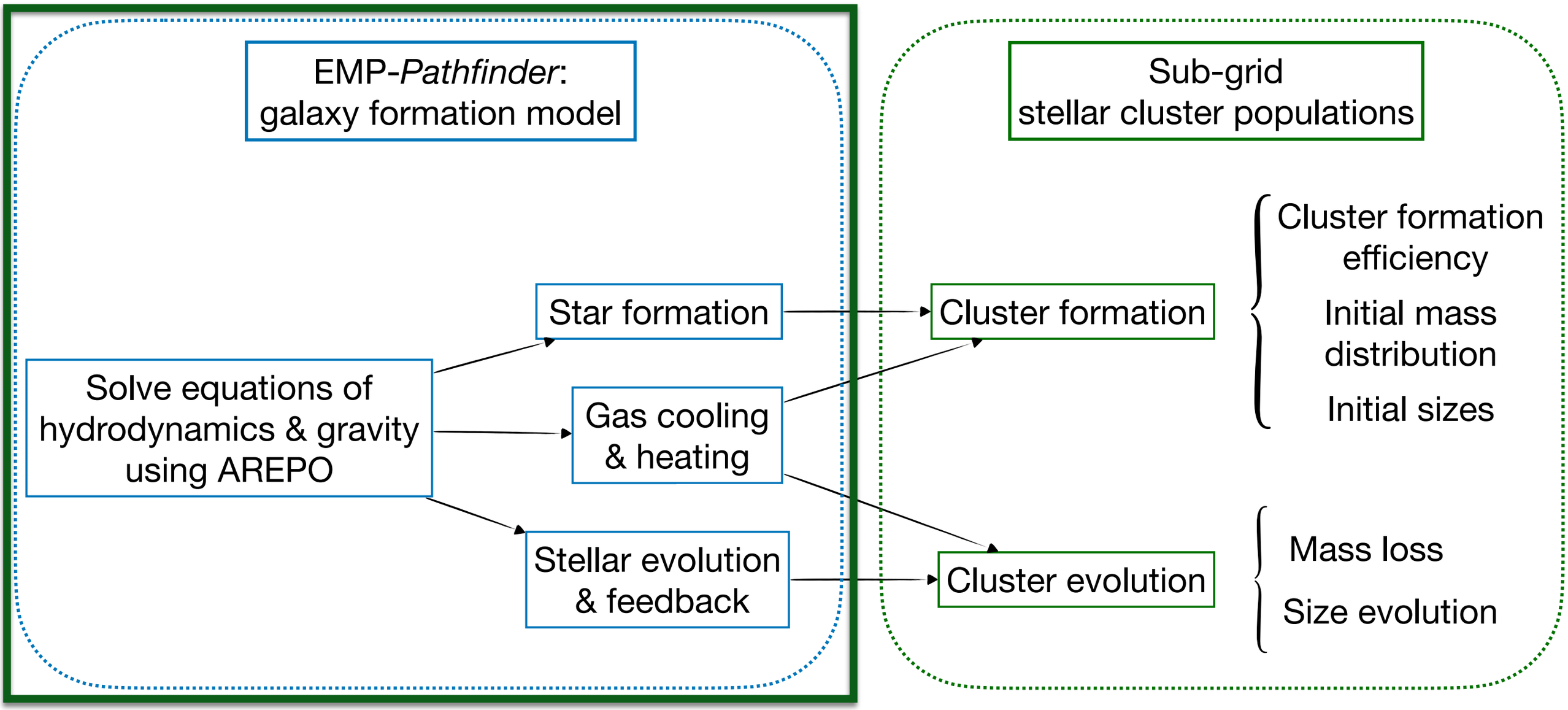
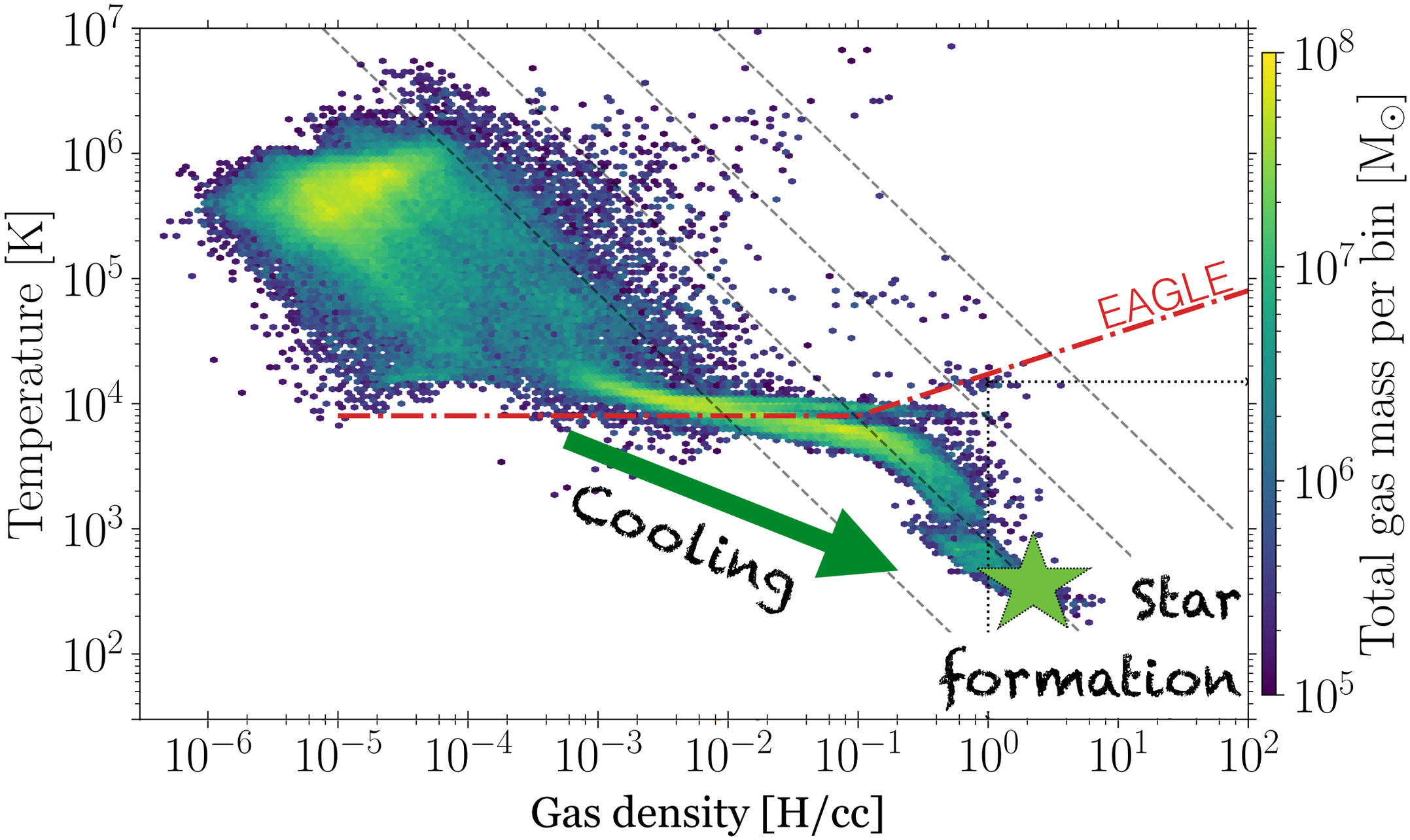


EMP-Pathfinder

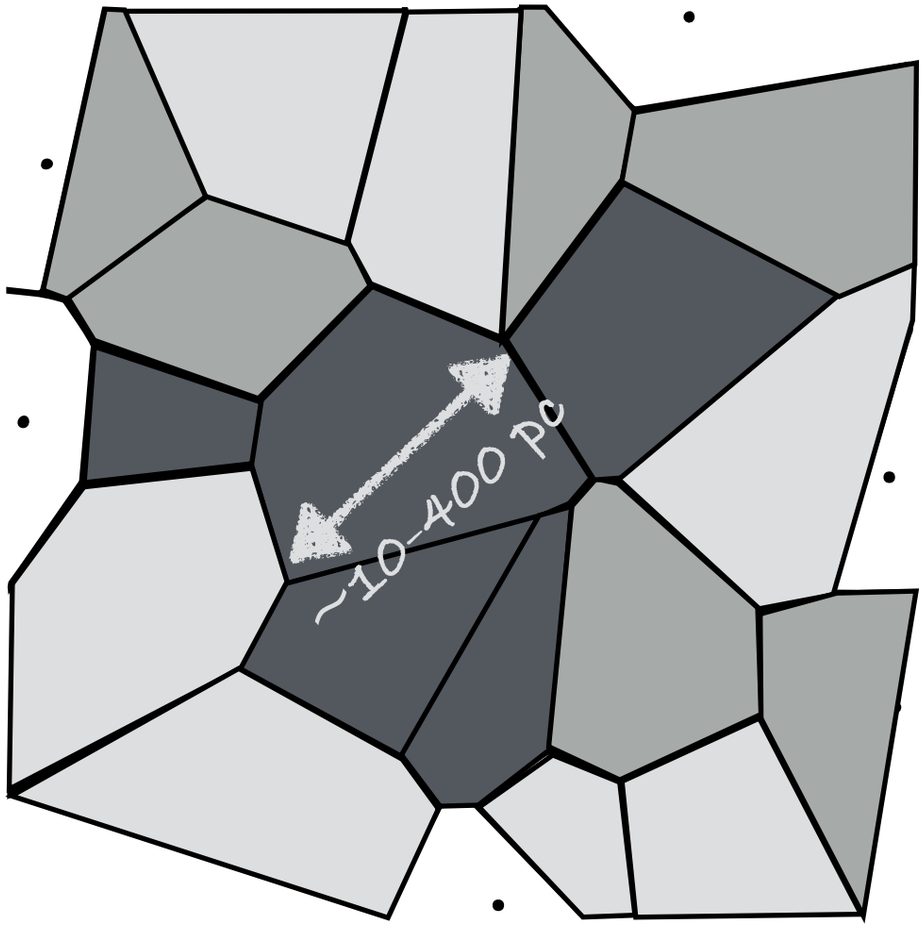
Baryonic physics



Gas bound to a Milky Way-mass galaxy at z=0

EMP-Pathfinder

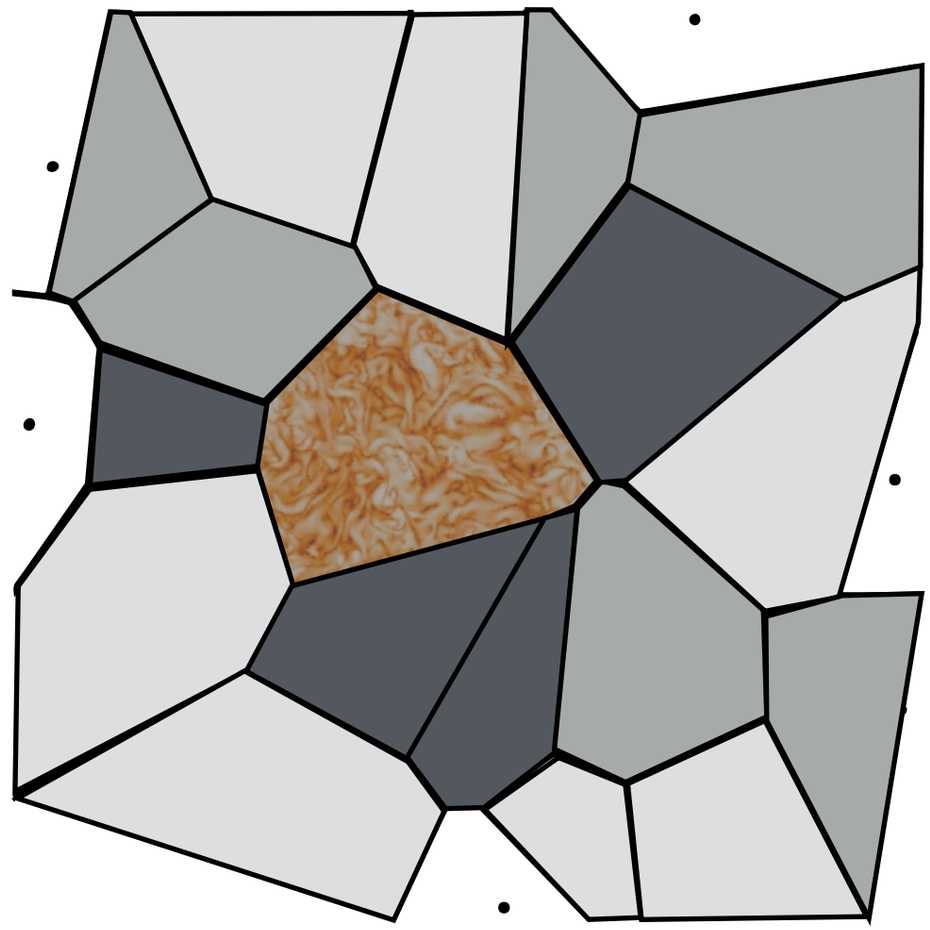
Star formation prescriptions



Cen & Ostriker (1992), Katz (1992)

Constant SFE:

gas density
<u>regulates</u> star formation



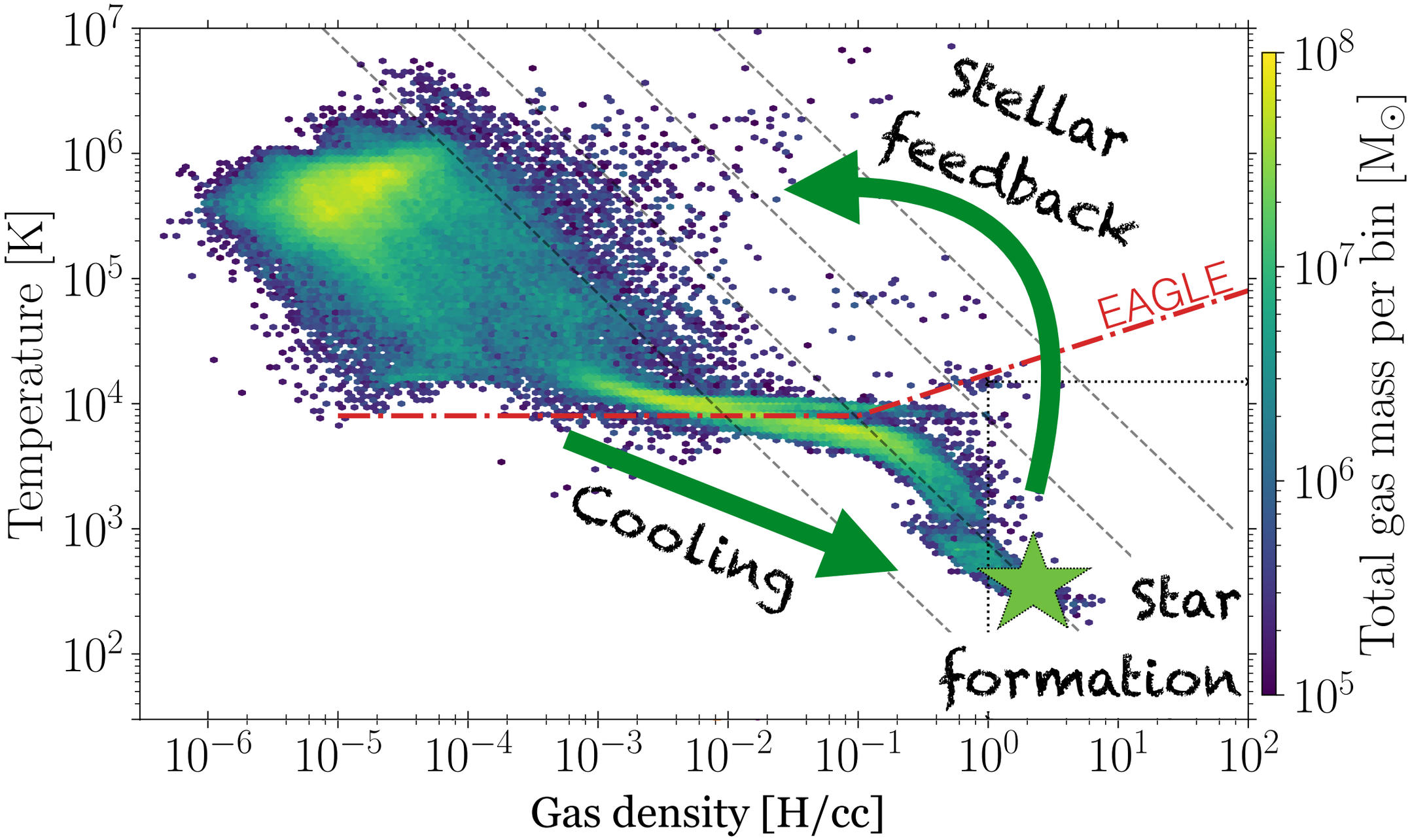
Federrath & Klessen (2012), Kretschmer & Teyssier (2020)

Multi free-fall SFE:

turbulent state of the gas can
<u>suppress or enhance</u> star formation

EMP-Pathfinder

Baryonic physics



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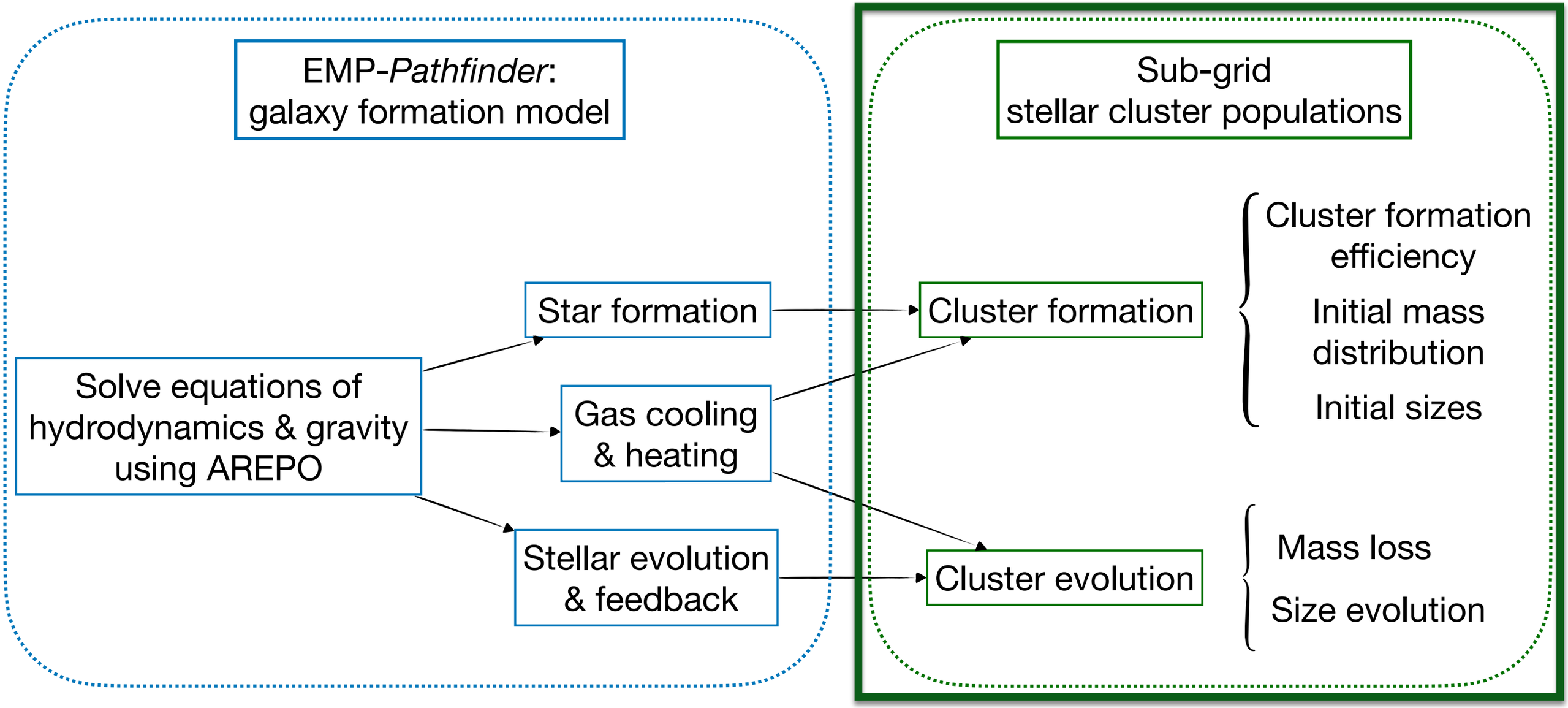
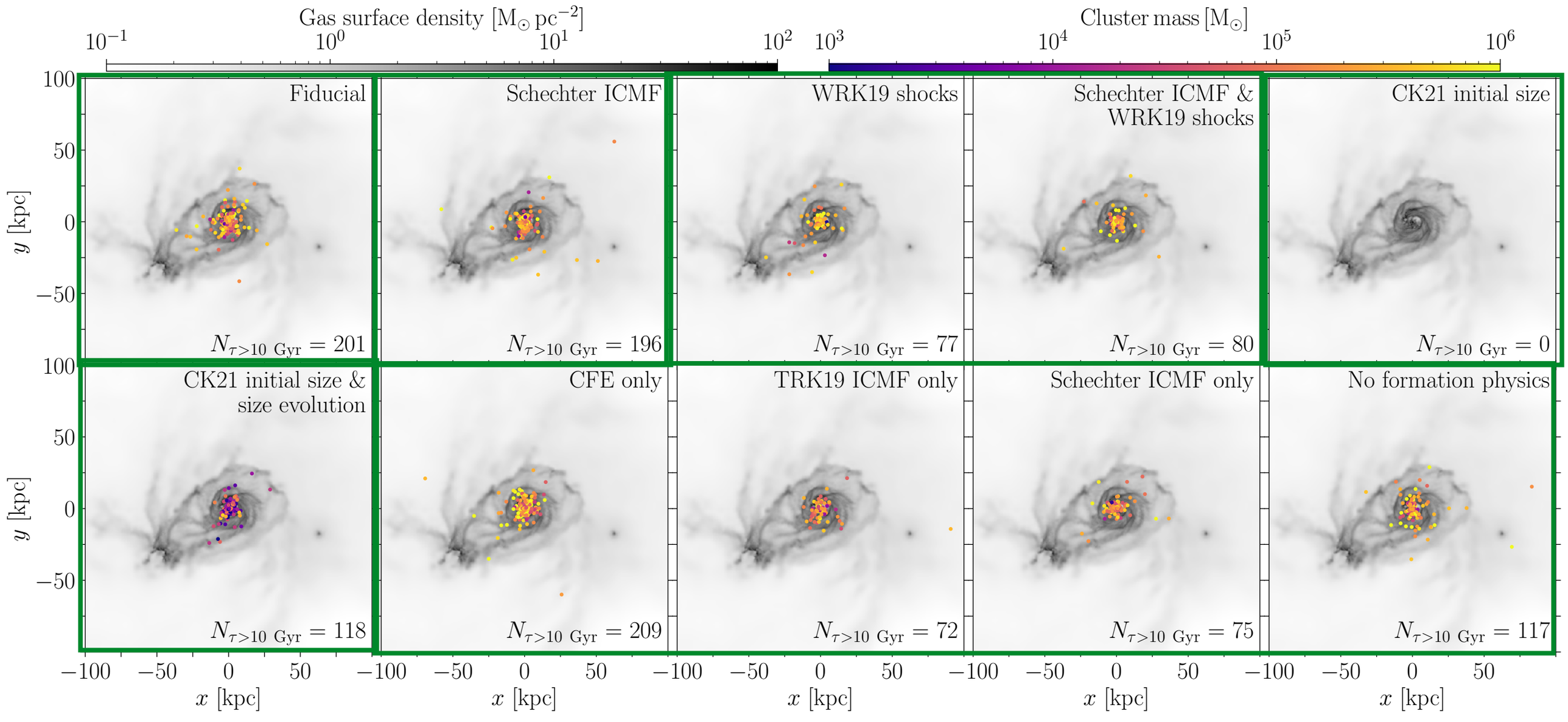


EMP-Pathfinder

Sub-grid stellar cluster populations:

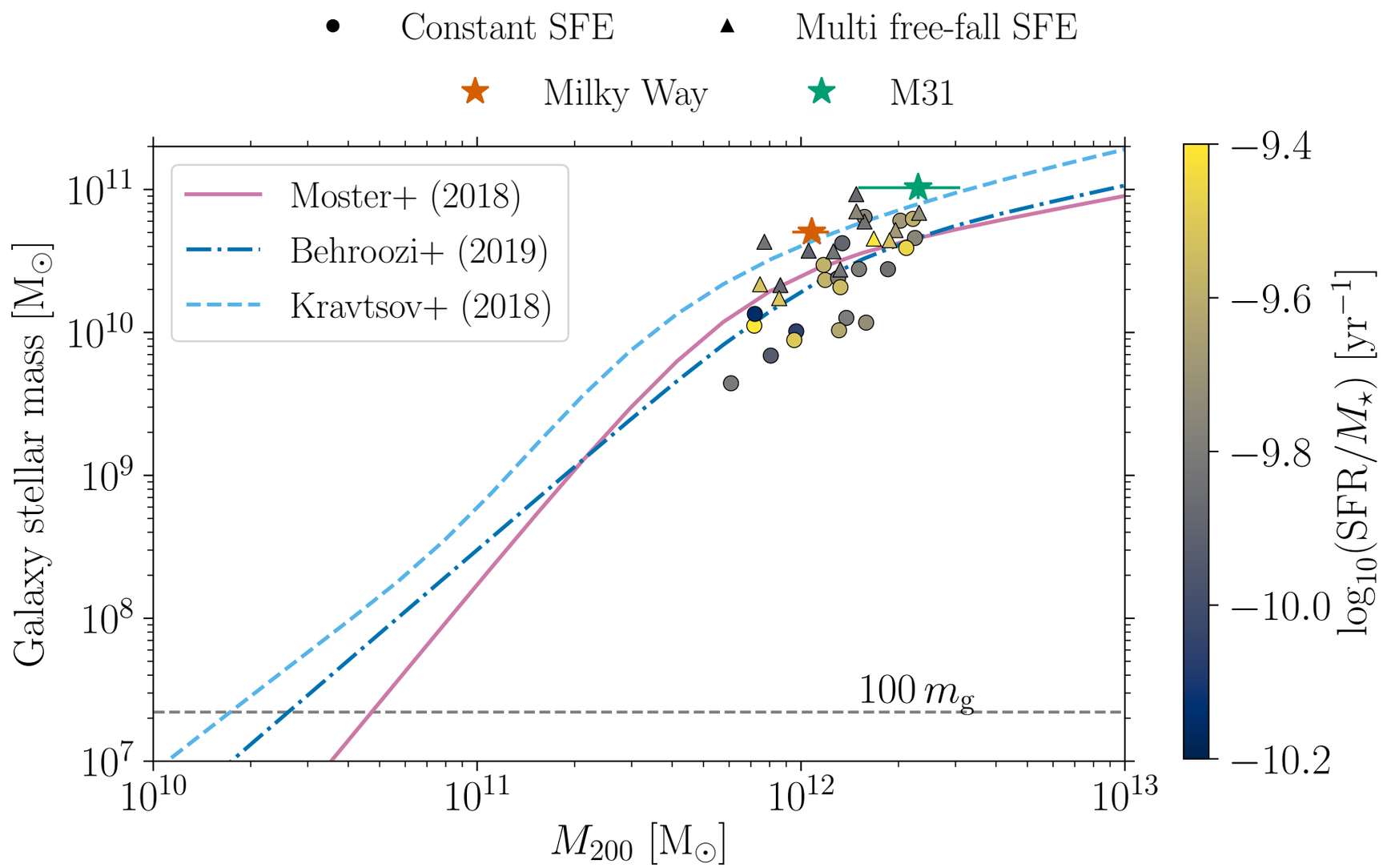
up to 10 parallel cluster populations at once!



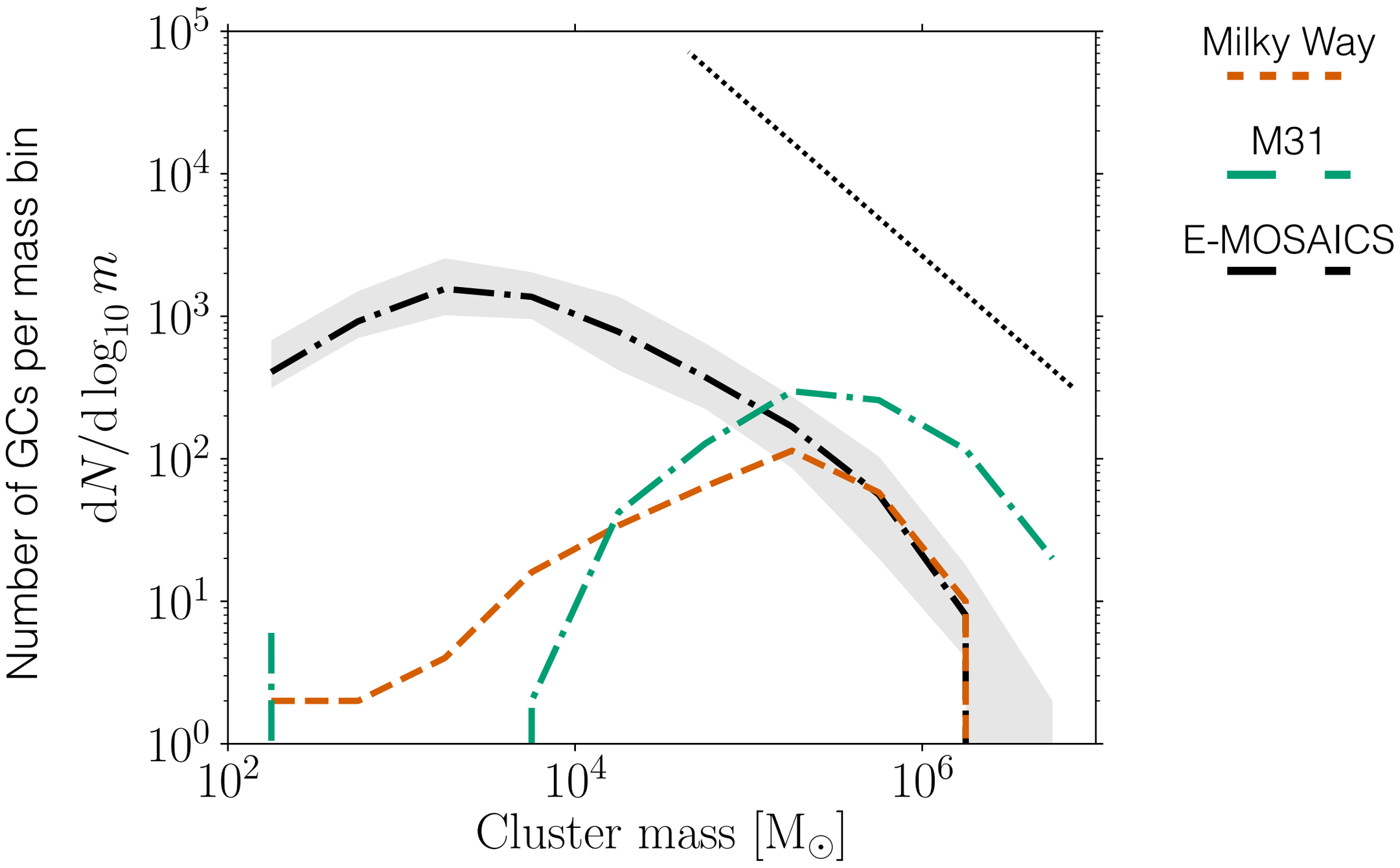
EMP-Pathfinder

Simulations:

suite of cosmological zoom-in Milky Way-mass simulations:
21 with the constant SFE and 14 with the multi-ff SF recipe
at a mass resolution of ~2.2e5MSun
and a minimum gravitational softening for the gas of 80 pc

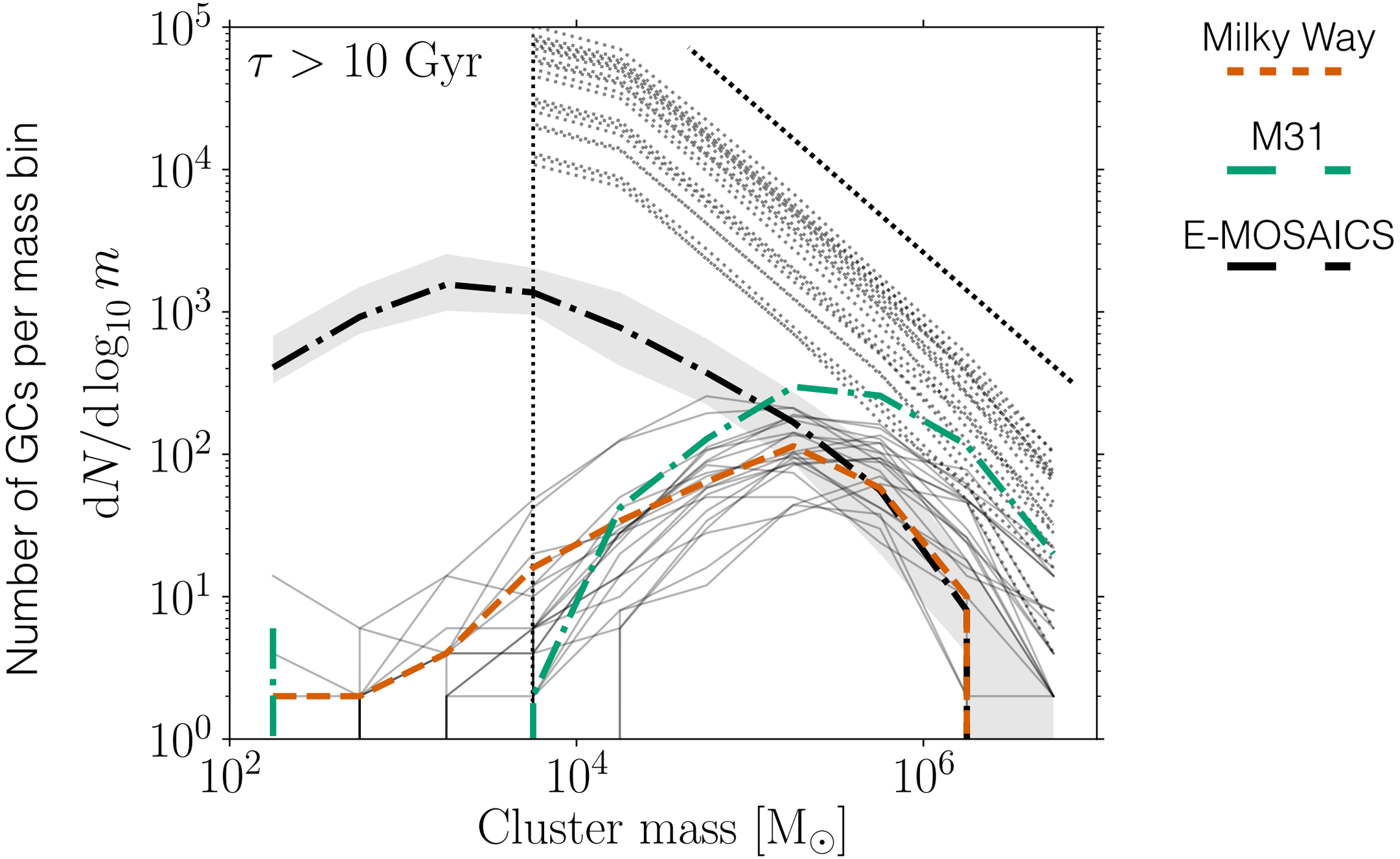


Old (> 10 Gyr) stellar clusters



Old (> 10 Gyr) stellar clusters

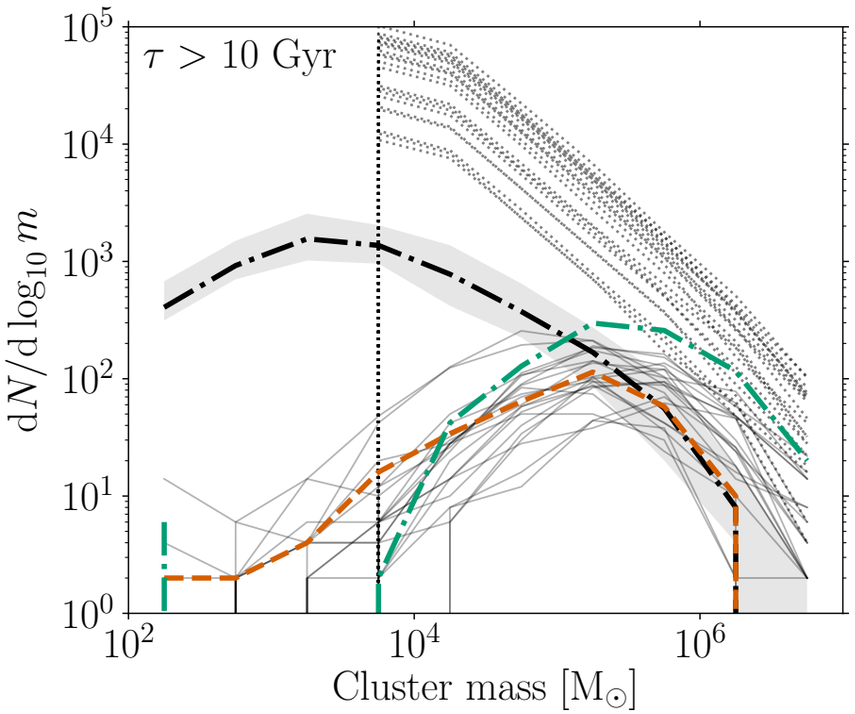
Old stellar clusters (>10 Gyr) evolved in a cold ISM reproduce the mass distribution of GCs in the Milky Way and M31



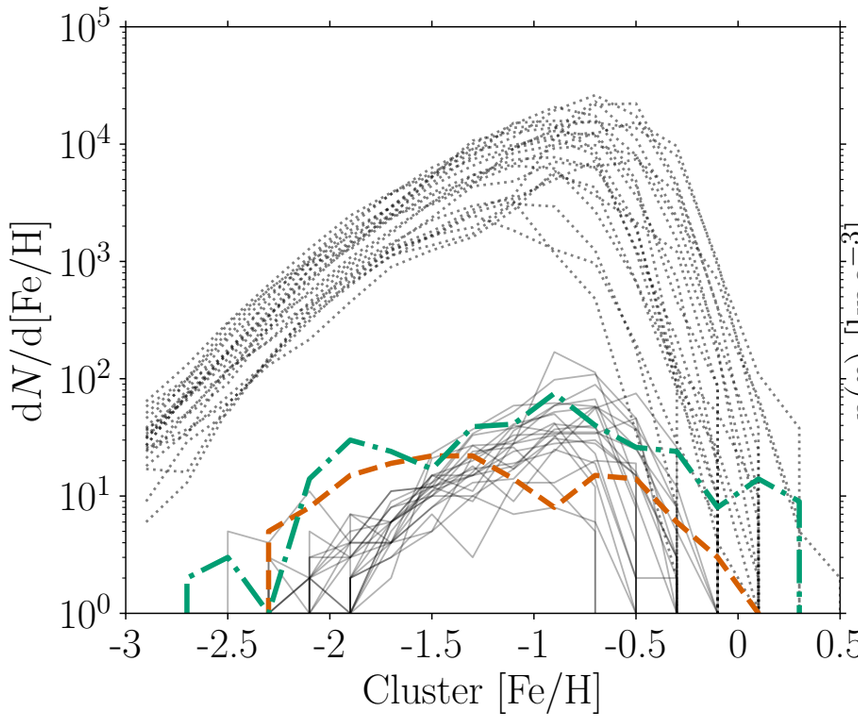
Old (> 10 Gyr) stellar clusters

Old stellar clusters (>10 Gyr) evolved in a cold ISM reproduce the properties of GCs in the Milky Way and M31

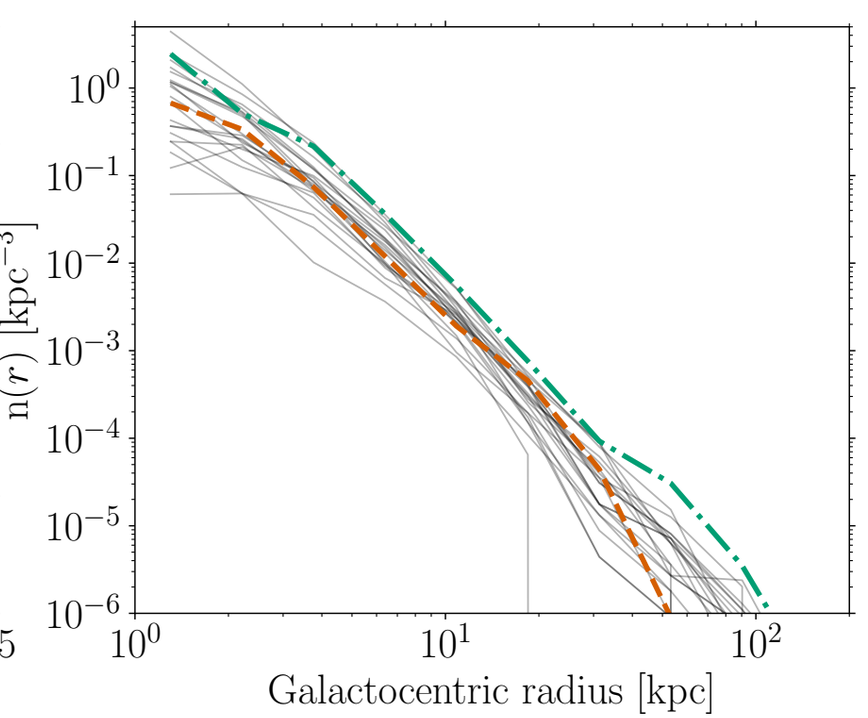
Milky Way M31 E-MOSAICS



Mass function



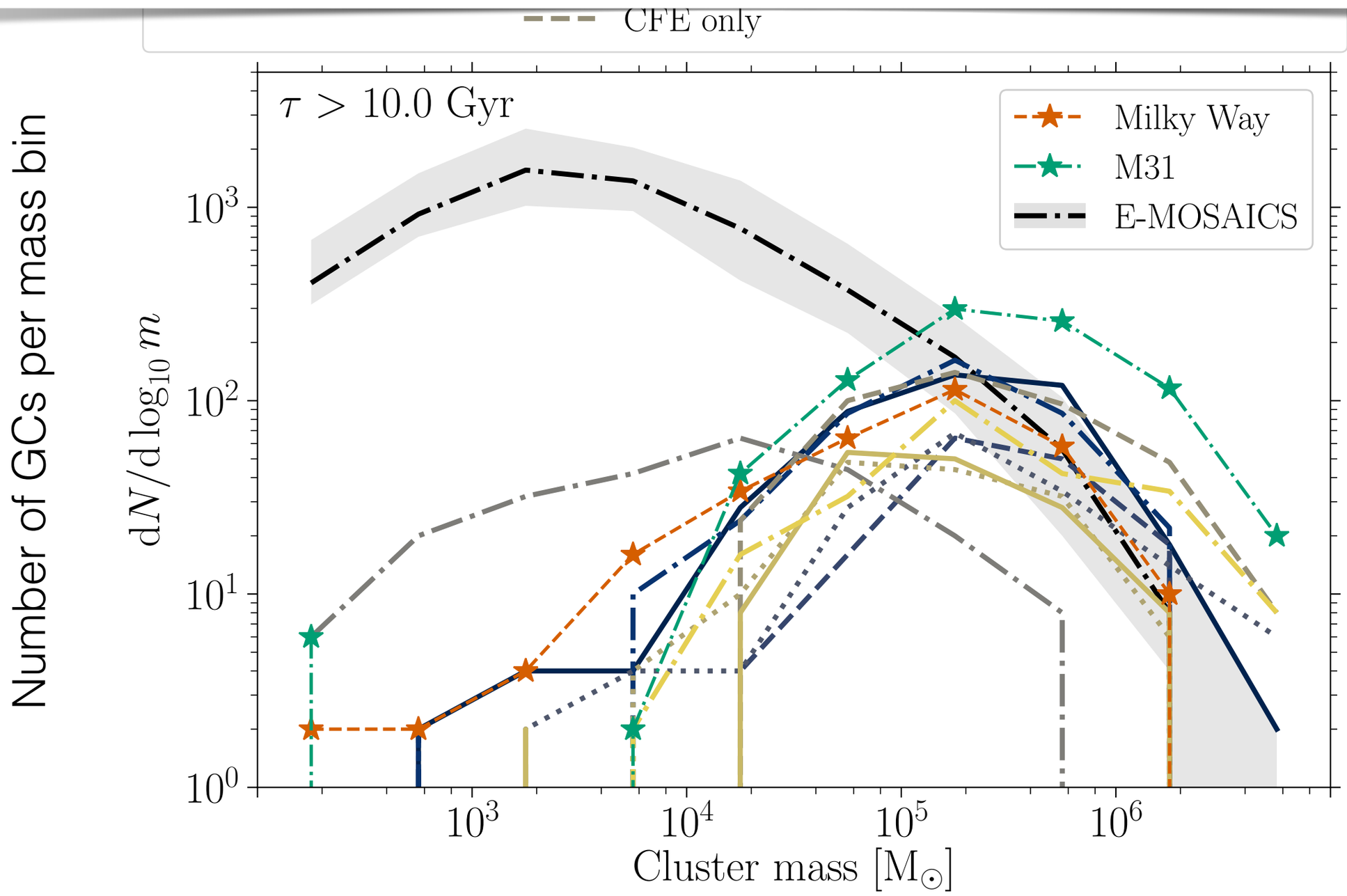
Metallicity distribution



Number density radial profile

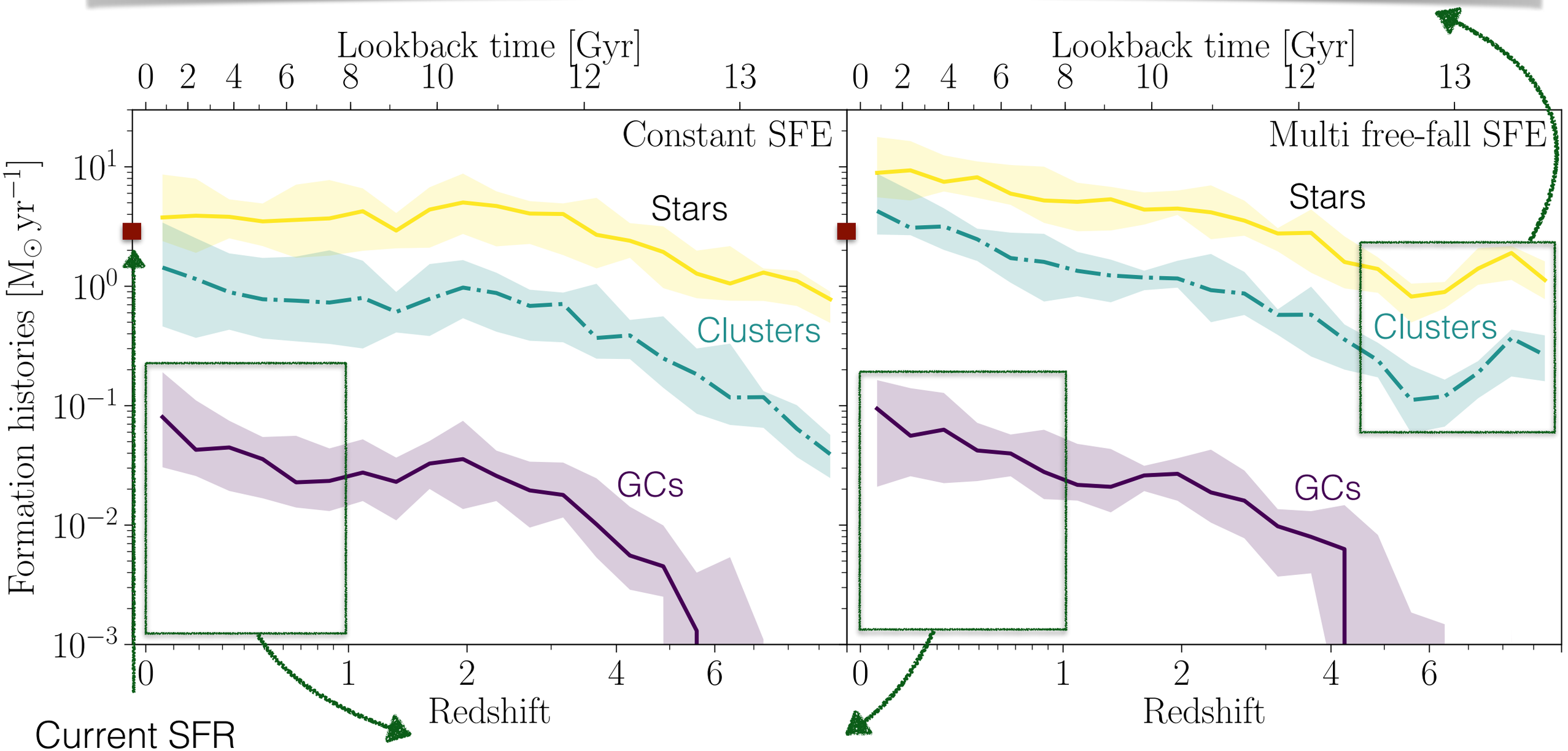
Parallel old (> 10 Gyr) stellar clusters

Emergence of GC populations takes place relatively independently of the specific choice of cluster formation and evolution model



Formation histories of stars and GCs

Cluster formation is very sensitive to the adopted baryonic physics that modify the cold, gas reservoir within galaxies



Current SFR in the Milky Way

e.g. Licquia&Newman (2015)

Unexpected - related to star formation

Also see Appendix E in Pfeffer+ (2018)

Take-home messages

EMP-Pathfinder: modelling the concurrent formation of stellar clusters and their host galaxies with a cold, dense ISM.

After a Hubble time of evolution in a cold ISM,
old stellar clusters (>10 Gyr) are in excellent agreement
with observed GCs in the Milky Way and M31

Stellar clusters can be diagnostic tools for
upcoming simulations that include the cold phase of the ISM

Reina-Campos+ (subm. to MNRAS, arXiv:2202.06961)