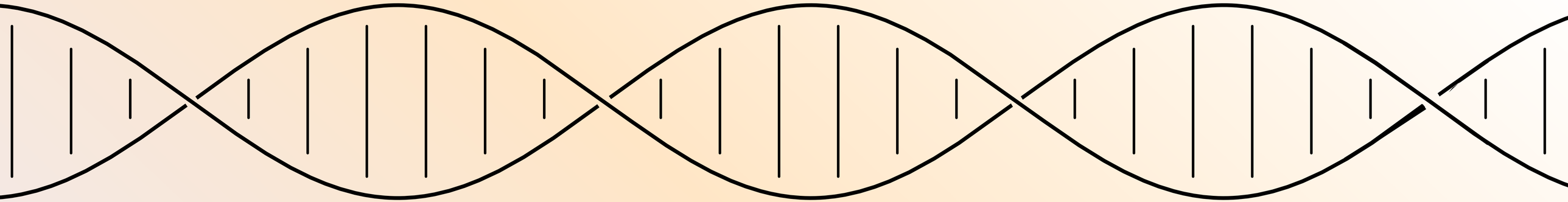


The interplay between feedback and history

Andrew Pontzen

gmgalaxies.org

University College London (until Summer 2024)

Durham University (from September 2024)

GMGalaxies

History **Environment**

‘nature’ / initial conditions

Feedback

‘nurture’

Some GMGalaxies projects

EDGE

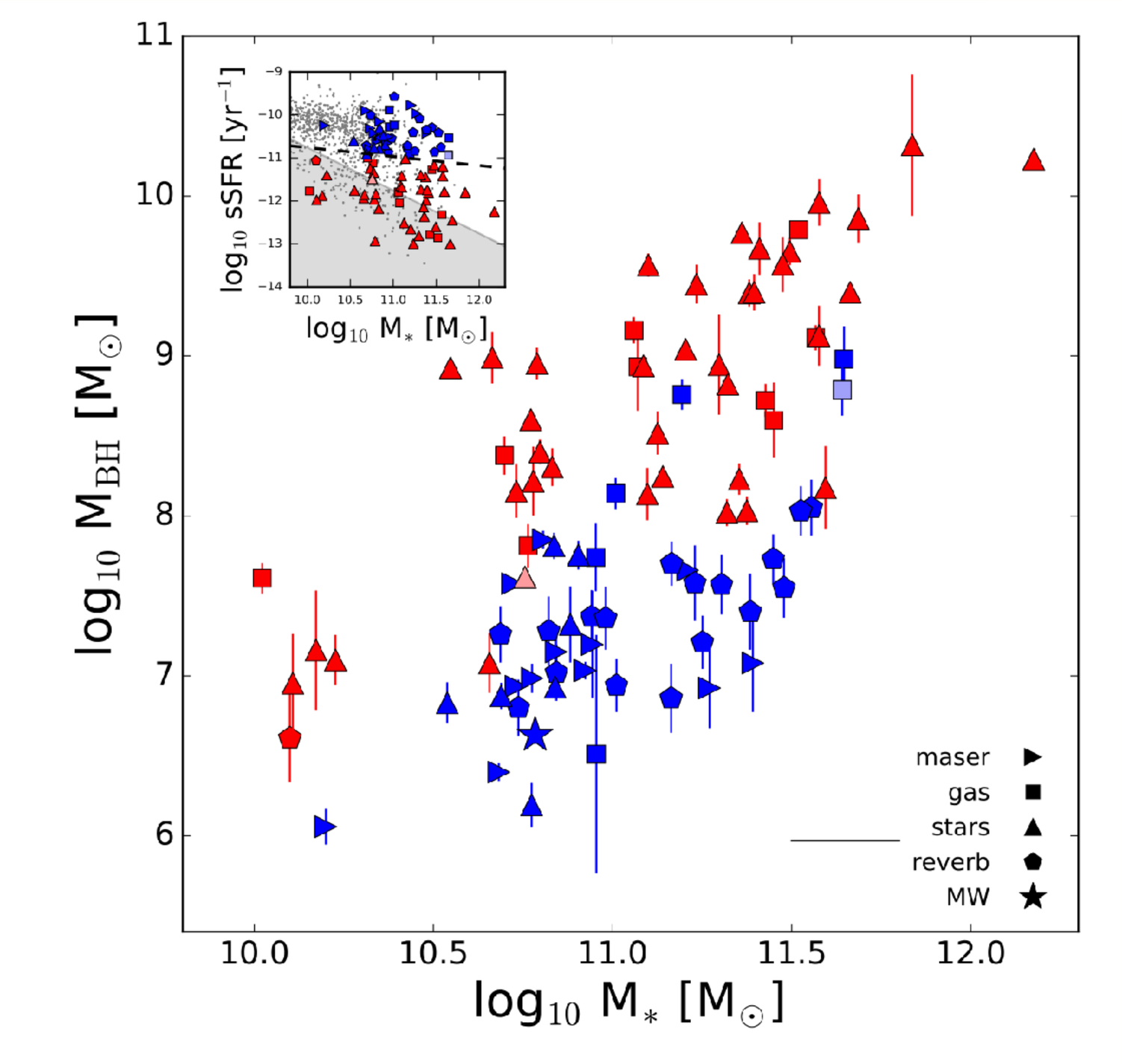
e.g. Eric Andersson,
Ethan Taylor,
Izzy Gray

Vintergatan-GM
Vintergatan-TNG

e.g. Gandhali Joshi

...and others...

e.g. Corentin Cadiou +
this talk

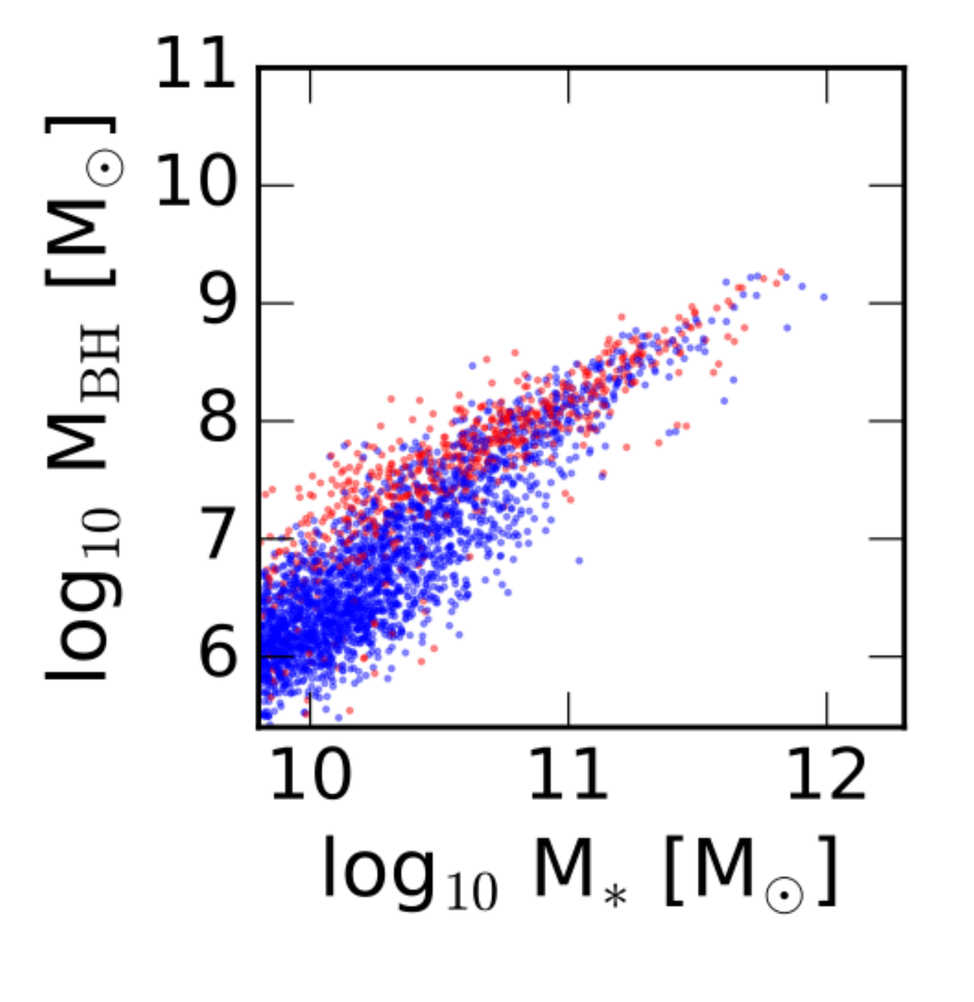


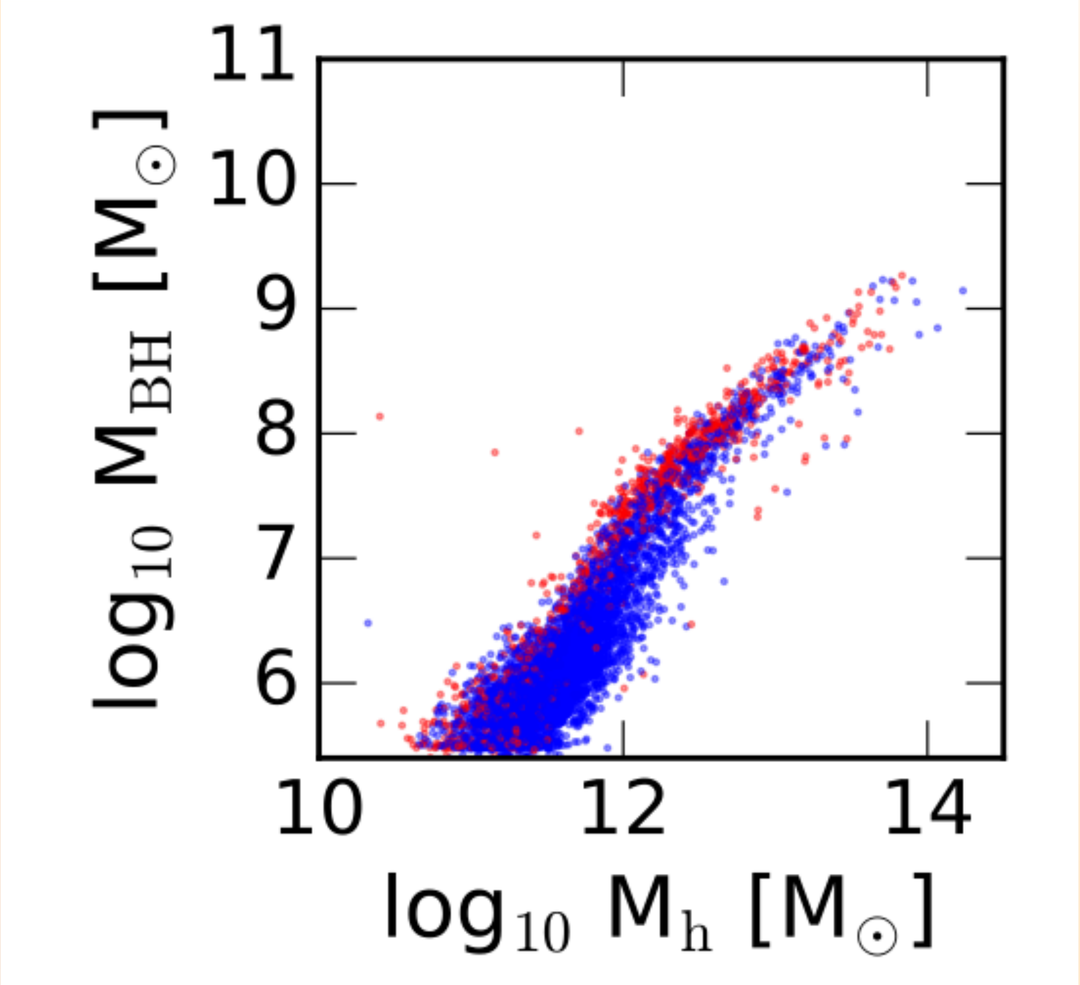
quiescent

star-forming

Terrazas+ 2016

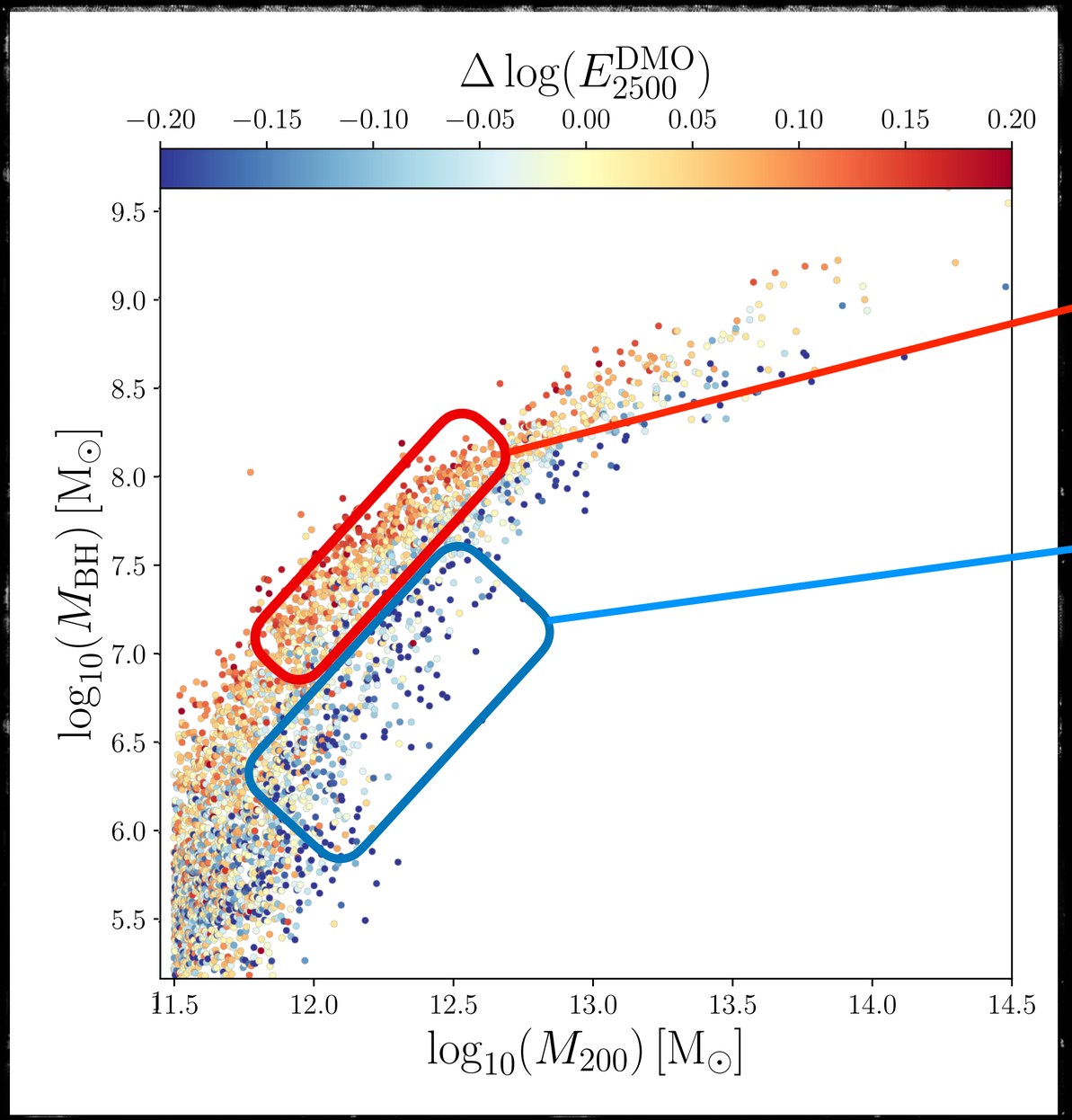
Eagle simulation





Terrazas+ 2017

Why the M_{BH} scatter at fixed M_{200}? (EAGLE)



Tightly bound
"Early former"?

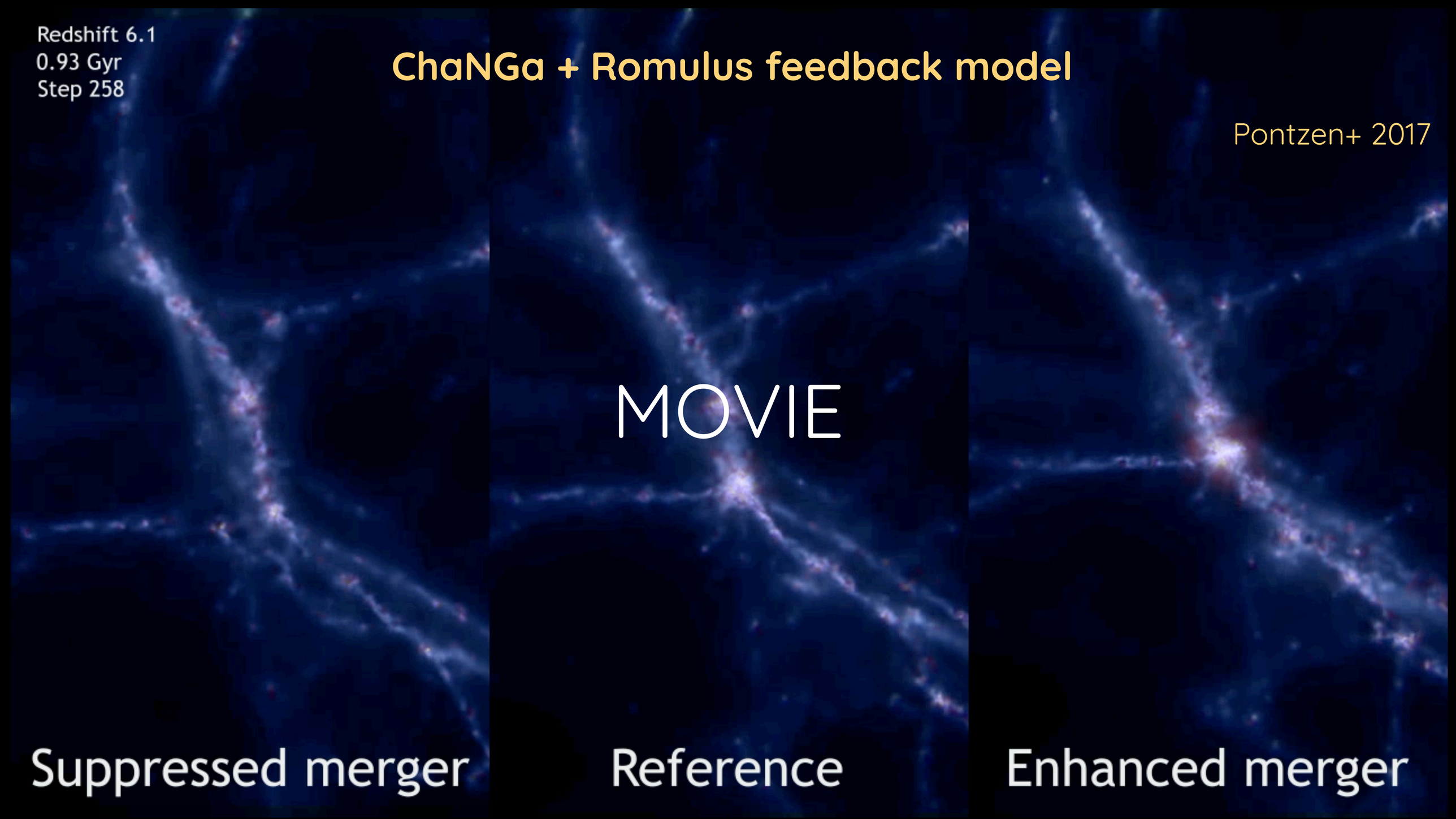
Loosely bound
"Late former"?

Davies+ 2020

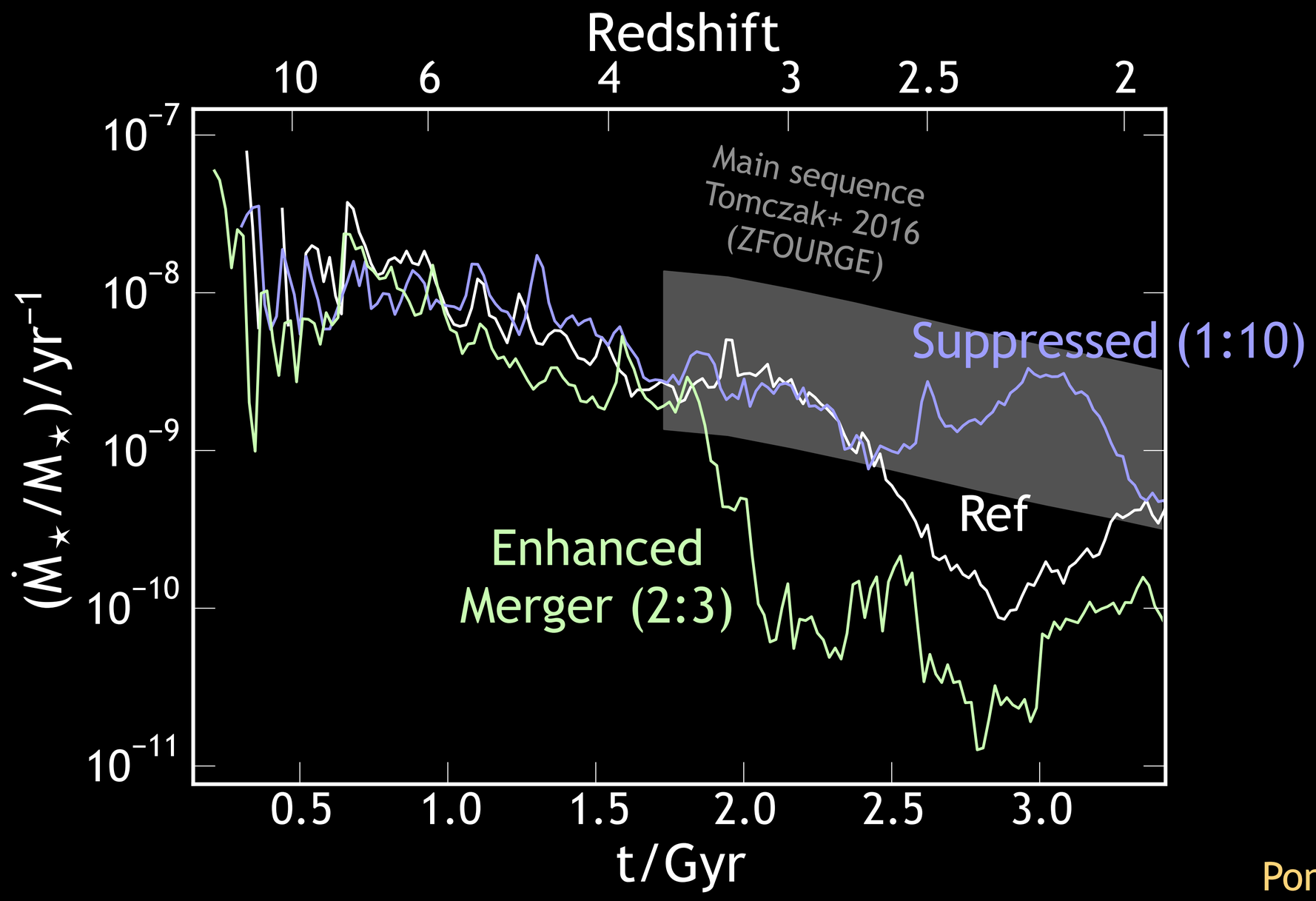
cf Booth & Schaye 2010

ChaNGa + Romulus feedback model

Pontzen+ 2017



ChaNGa + Romulus feedback model



Pontzen+ 2017

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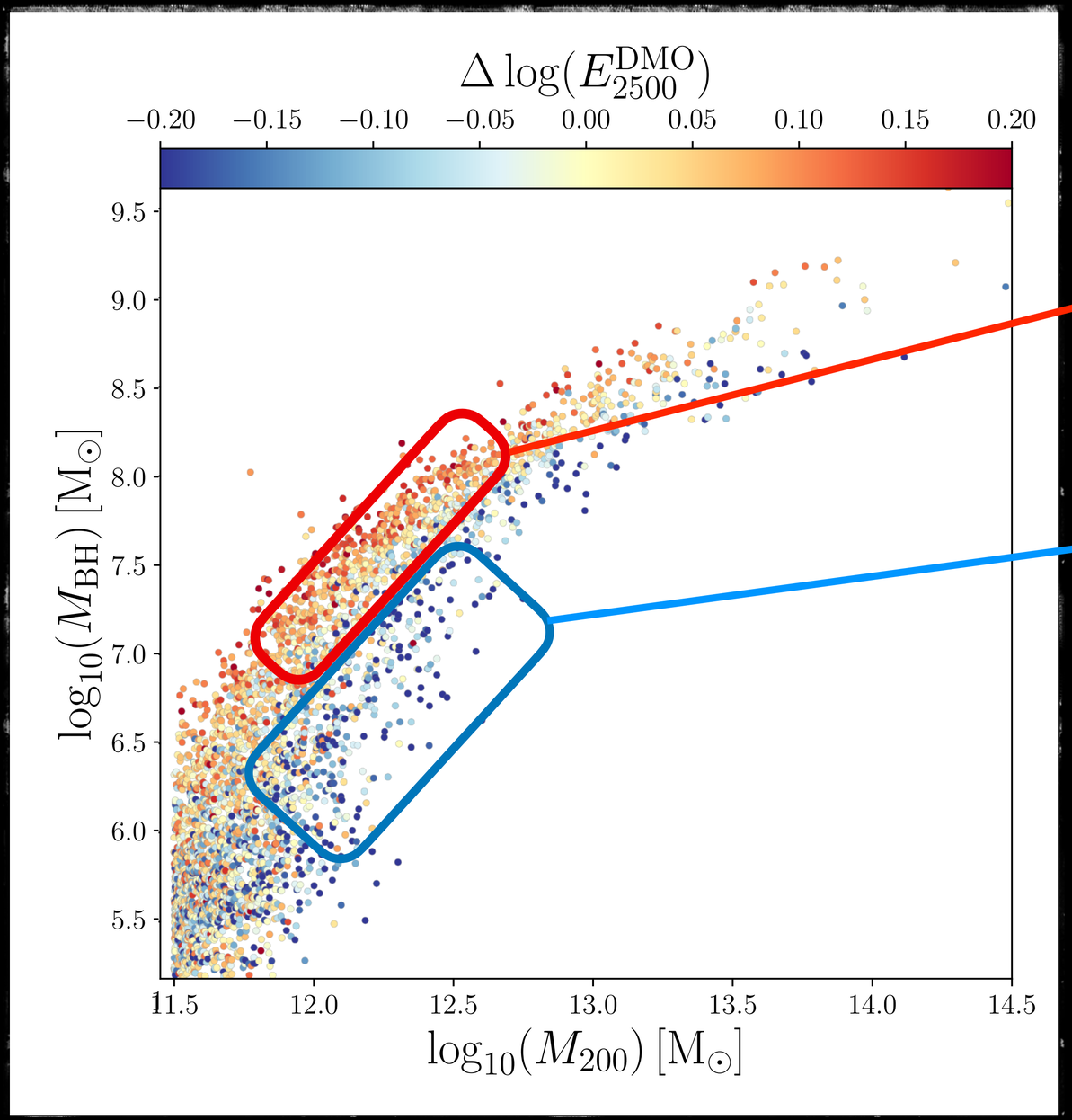

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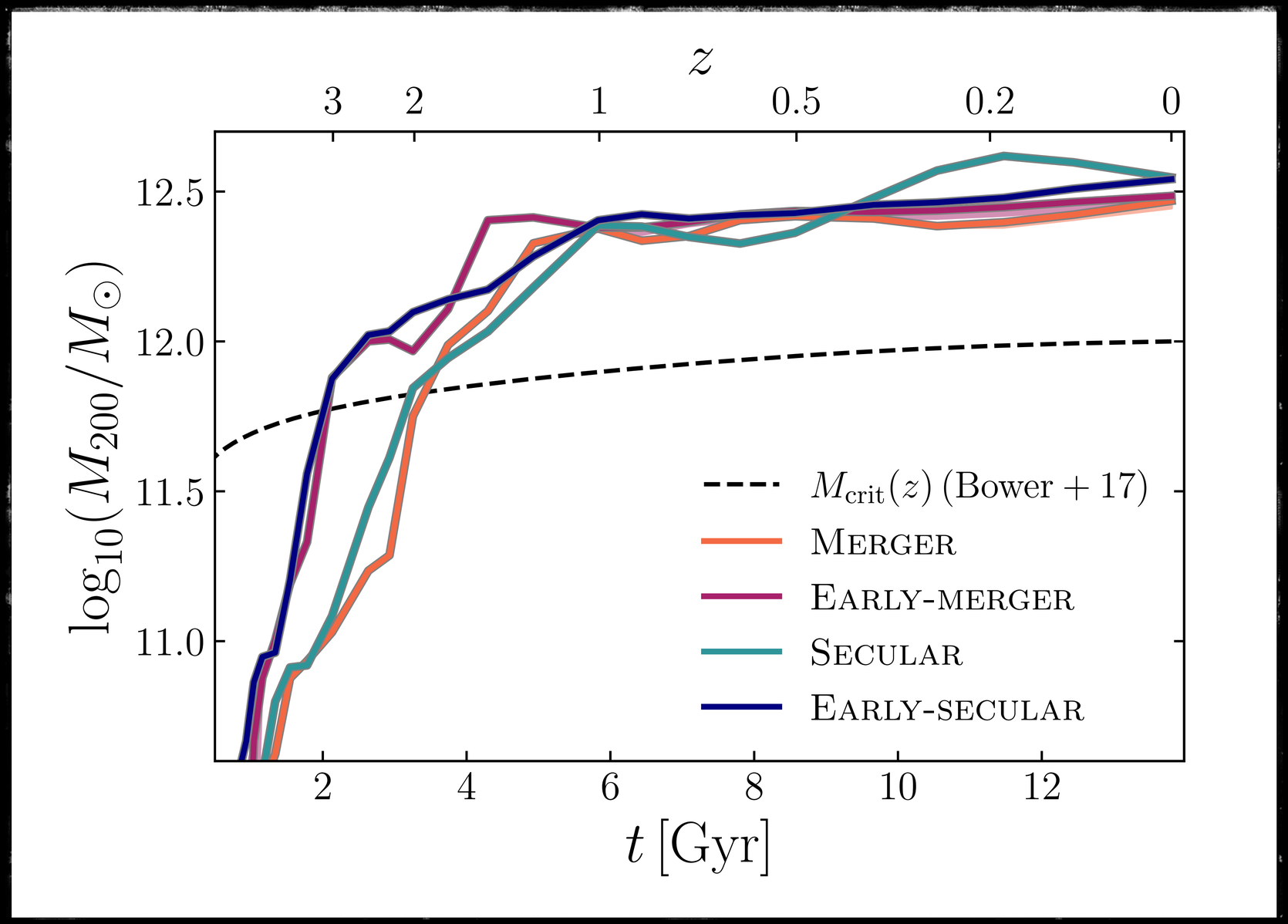
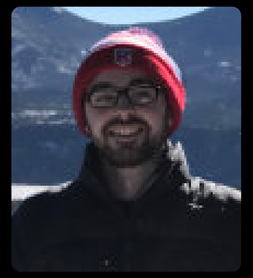
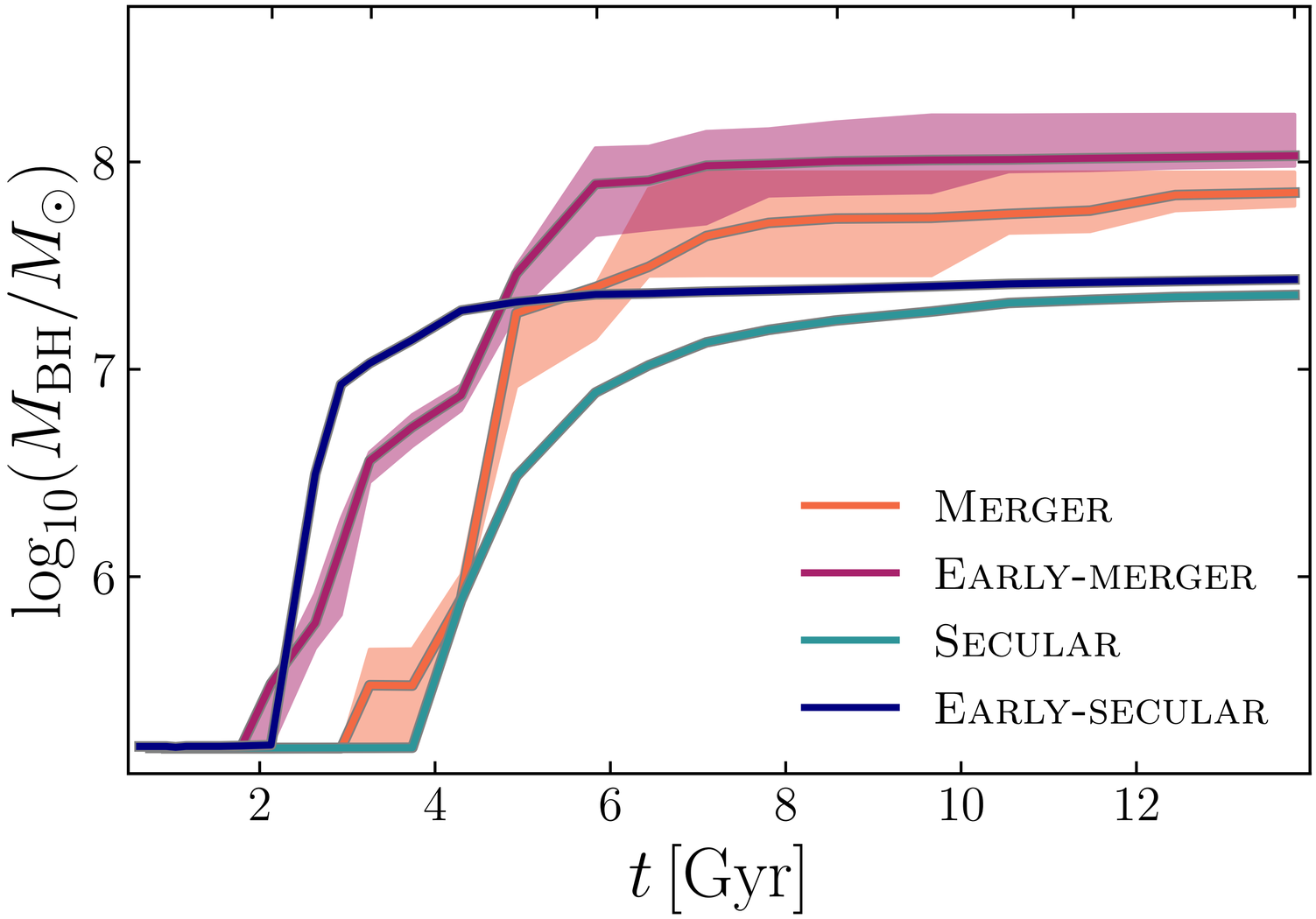
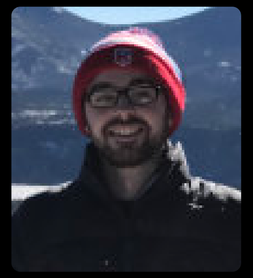

z
3
2
1
0.5
0.2
0
12.5
12.0
11.5
11.0
$\log_{10}(M_{200}/M_\odot)$
$M_{\rm crit}(z)$ (Bower + 17)
Merger
Early-merger
Secular
Early-secular
2
4
6
8
10
12
t [Gyr]

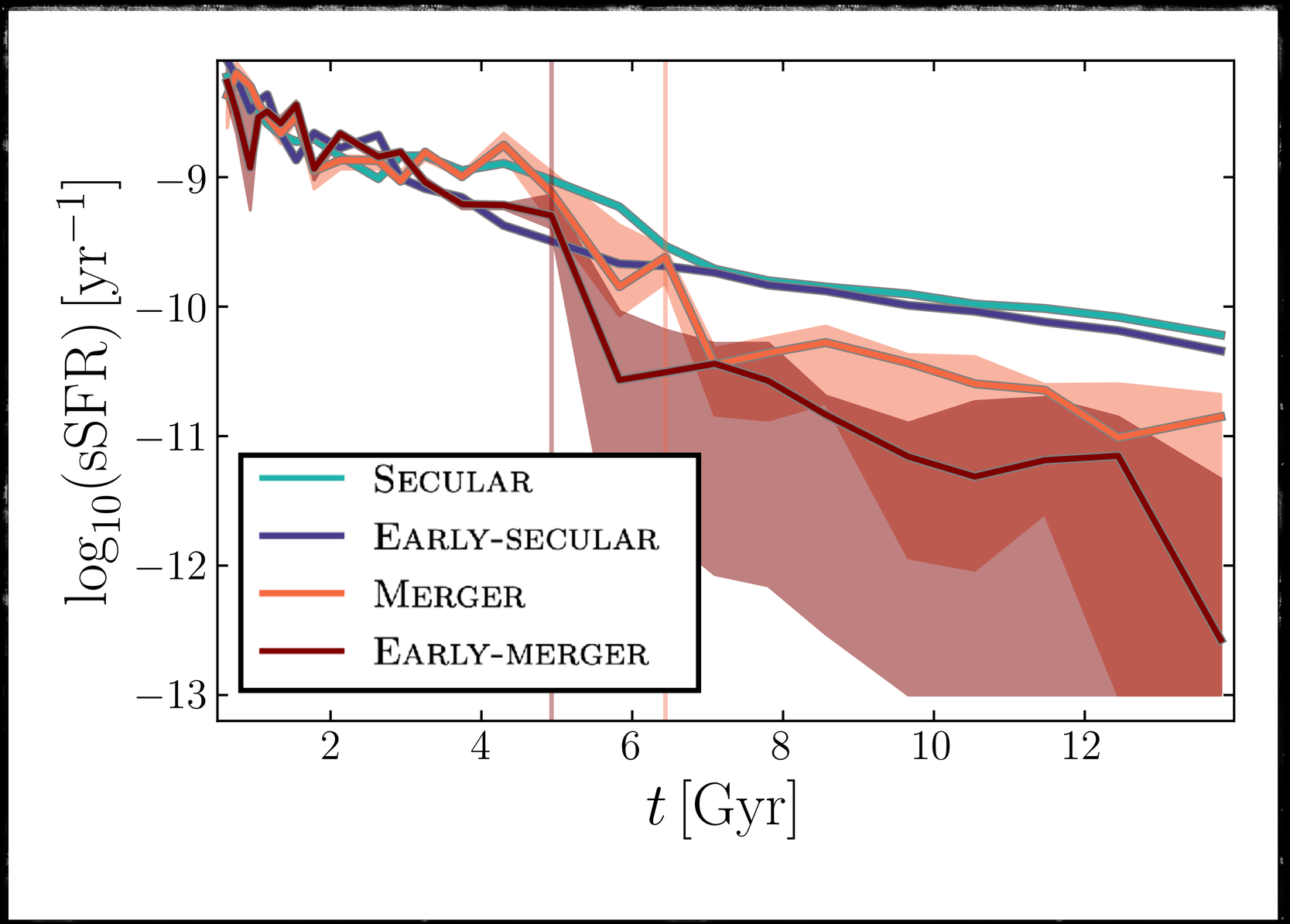


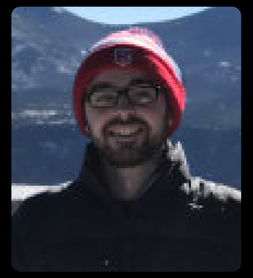
Davies+ 2024


$\log_{10}(M_{\rm BH}/M_\odot)$
8
7
6
2
4
6
8
10
12
t [Gyr]
Merger
Early-merger
Secular
Early-secular

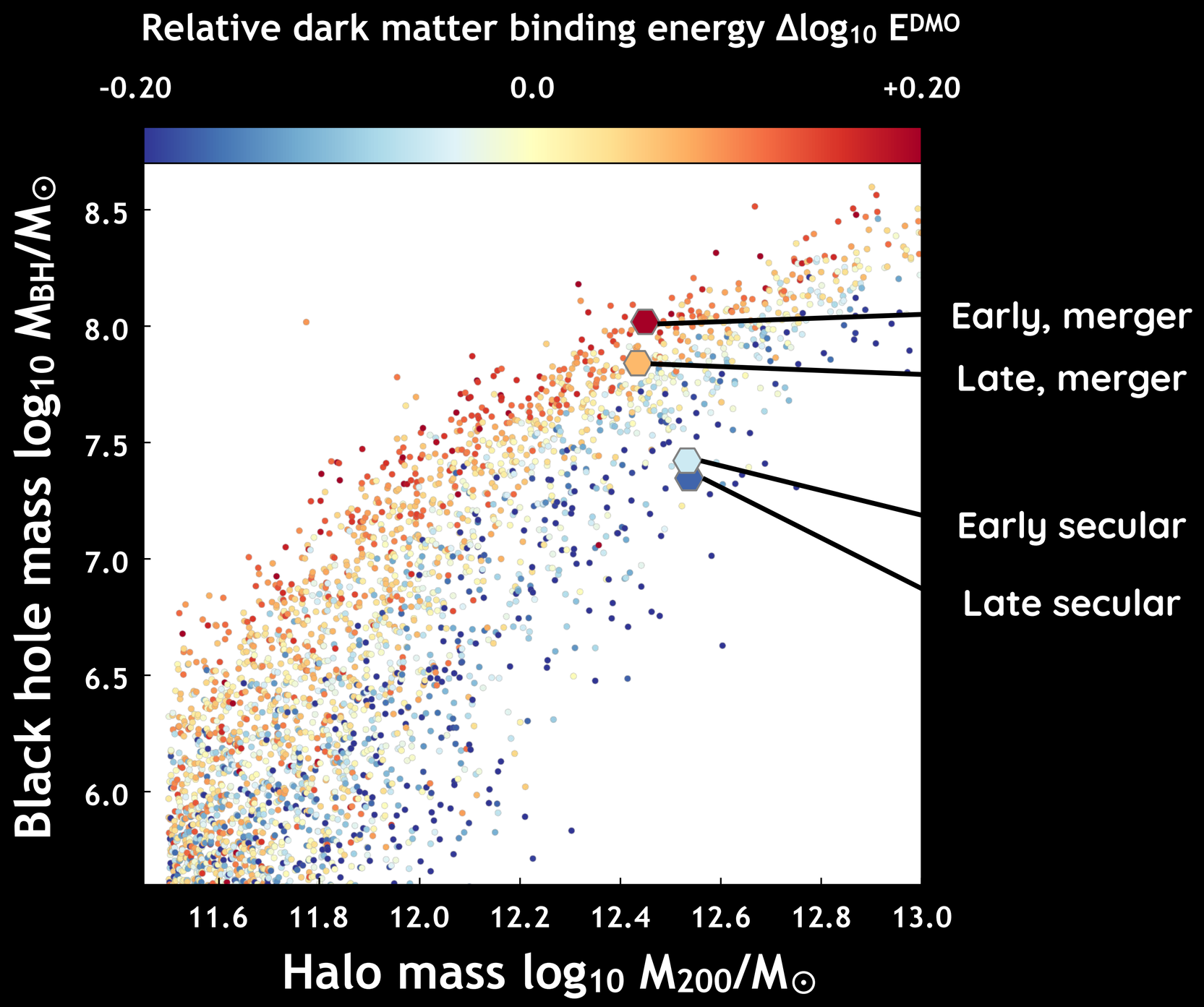


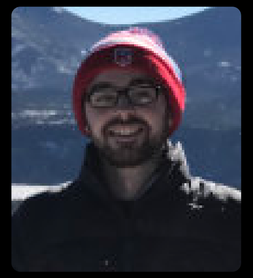
Davies+ 2024


$\log_{10}(\mathrm{sSFR})\ [\mathrm{yr}^{-1}]$
−9
−10
−11
−12
−13
2
4
6
8
10
12
t [Gyr]
Secular
Early-secular
Merger
Early-merger

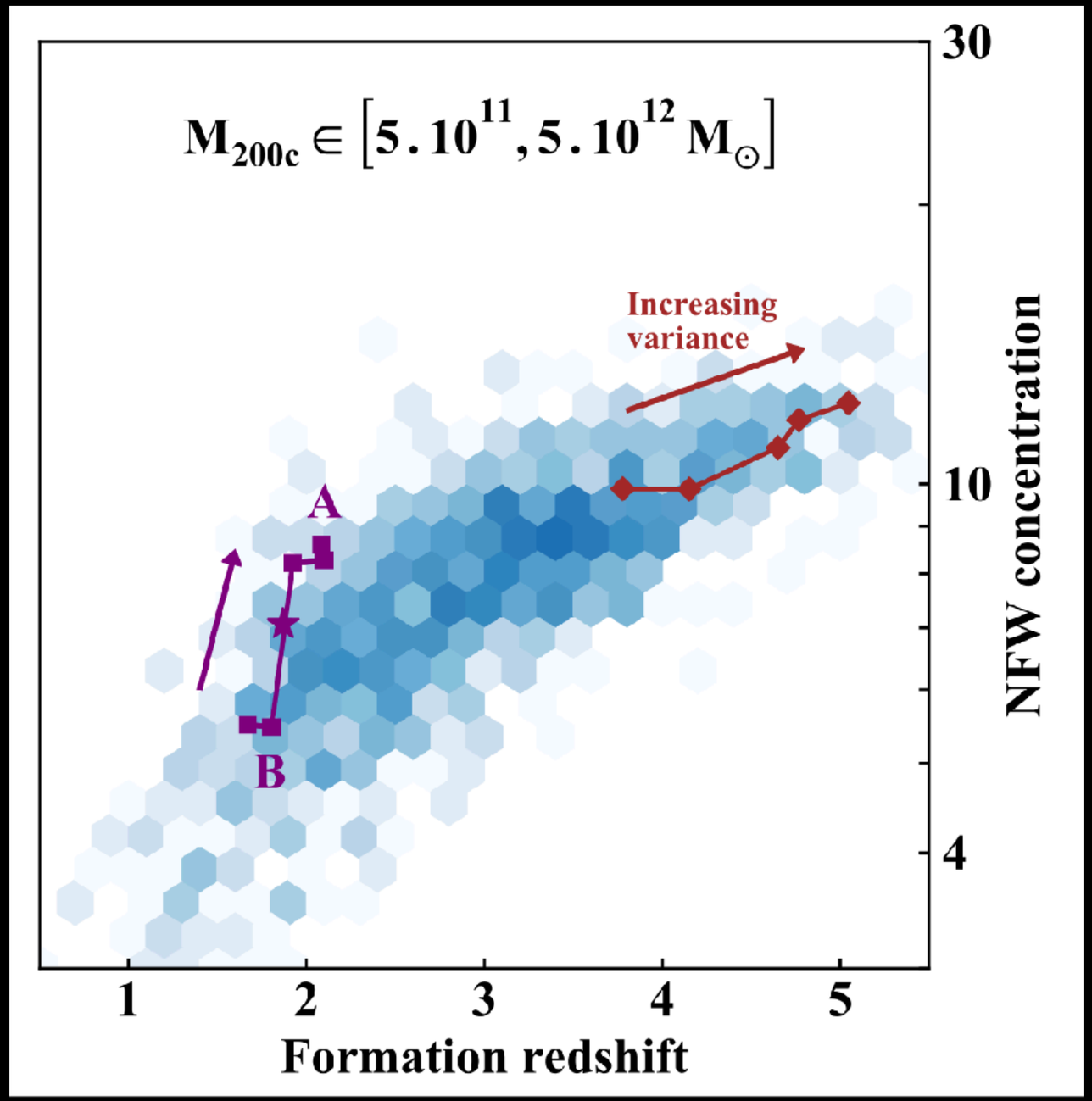


Davies+ 2024


Relative dark matter binding energy Δlog10 E^DMO
-0.20
0.0
+0.20
Black hole mass log10 MBH/M⊙
8.5
8.0
7.5
7.0
6.5
6.0
11.6
11.8
12.0
12.2
12.4
12.6
12.8
13.0
Halo mass log10 M200/M⊙
Early, merger
Late, merger
Early secular
Late secular



Davies+ 2024


$M_{200c} \in [5.10^{11}, 5.10^{12} M_\odot]$
Increasing variance
A
B
30
10
4
NFW concentration
1
2
3
4
5
Formation redshift

Rey+ 2019

What's the causal origin of diversity? (in EAGLE)

Collapse time / binding energy? ✗

Disruptive mergers ✓

(correlating with collapse time / binding energy)

Davies, Pontzen & Crain 2024

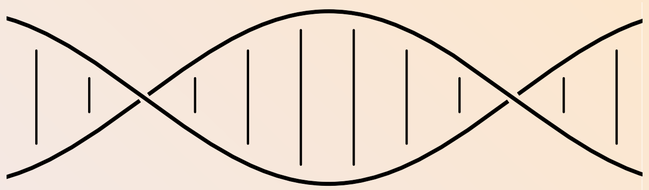
More broadly:

Big cosmological volumes tell you ‘**what**’

Genetically modified zooms tell you ‘**why**’

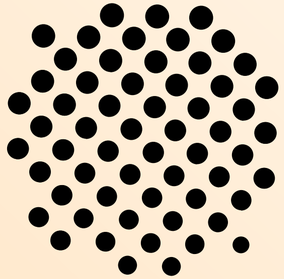
See also talks on EDGE, Vintergatan-GM

gmgalaxies.org/#code



genetIC

Initial conditions generator/modifier

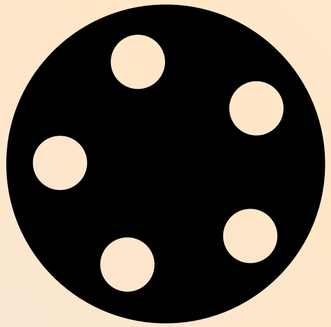


pynbody

Simulation analysis

tangos

Database creation and exploration



topsy

Interactive simulation visualization