Sunyaev-Zeldovich Signals from L^* Galaxies

and Thermal Properties of the CGM

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Yakov Faerman, Shy Genel

mm Universe, June 25 2025

The Circumgalactic Medium

Diffuse gas surrounding galaxies out to large distances

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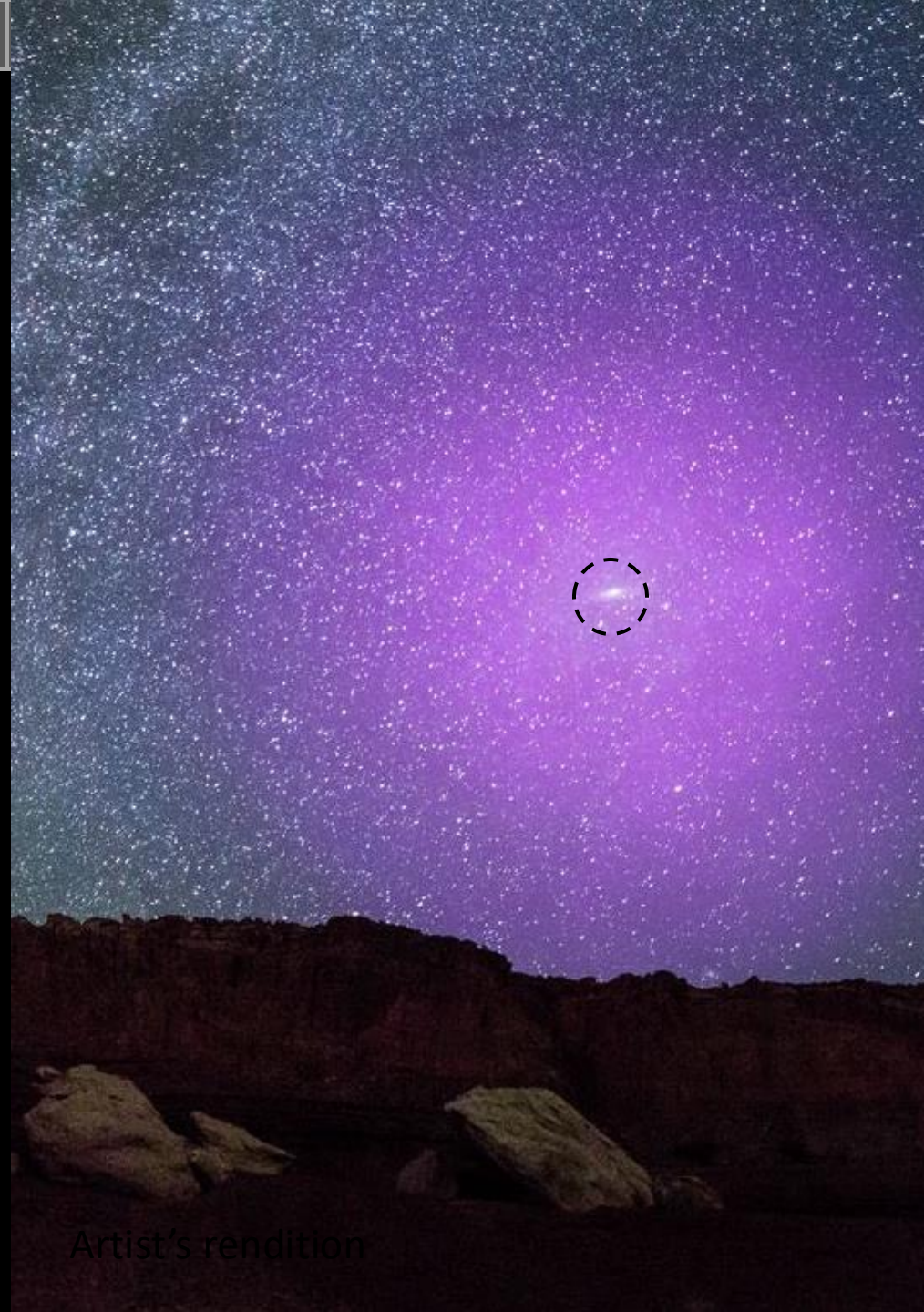

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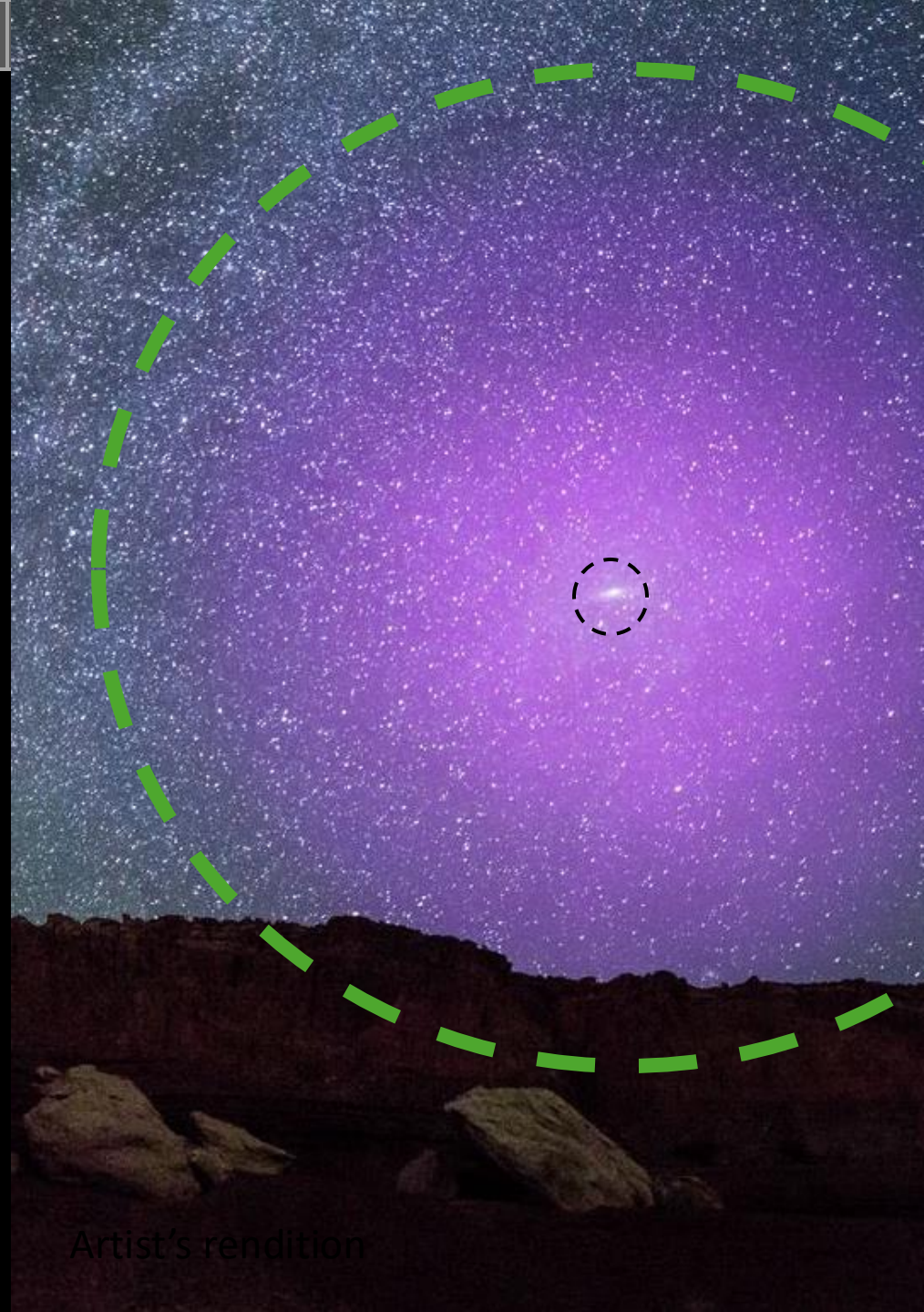
Diffuse gas surrounding galaxies out to large distances



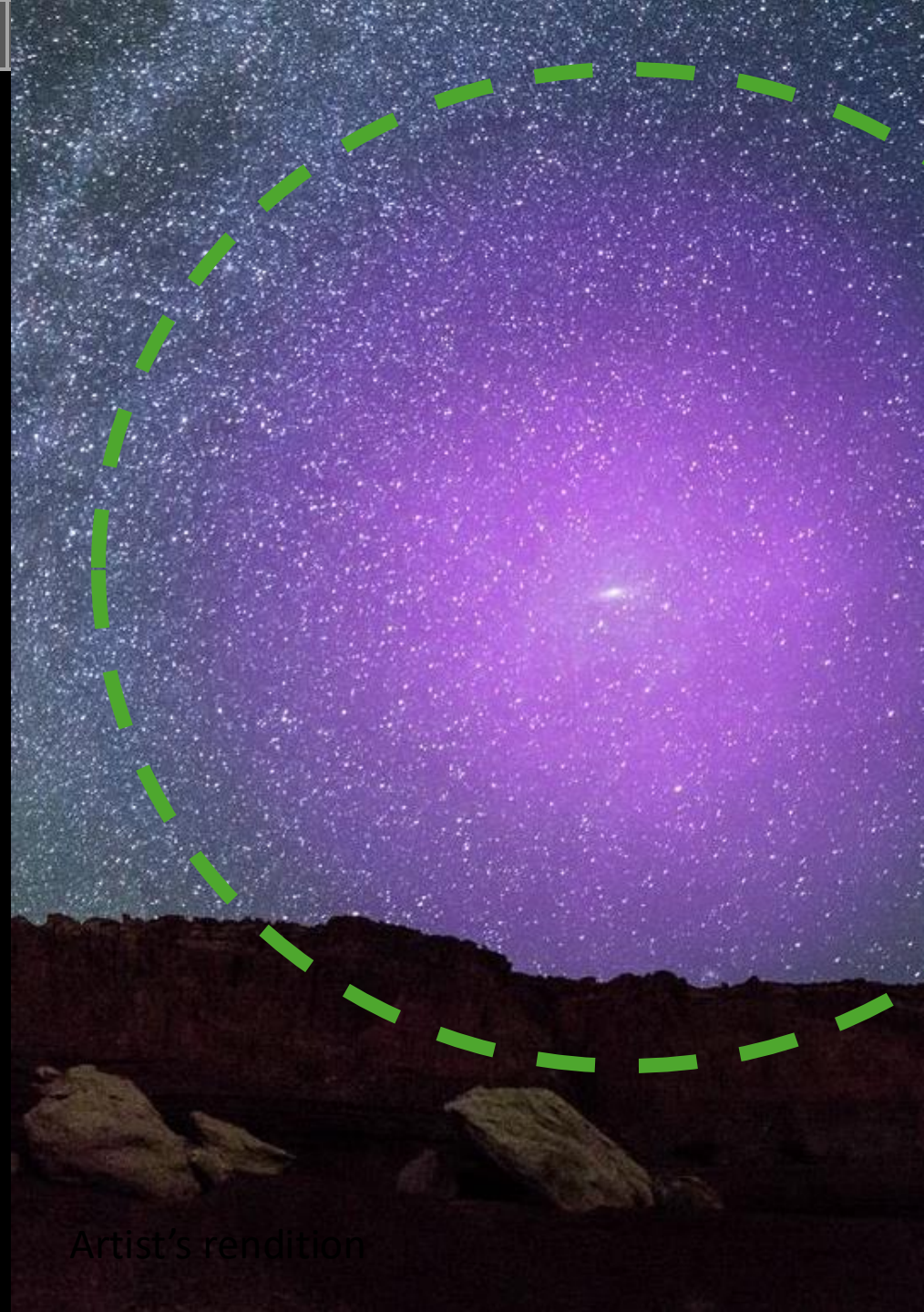
The Circumgalactic Medium

Diffuse gas surrounding galaxies out to large distances

An expected structure

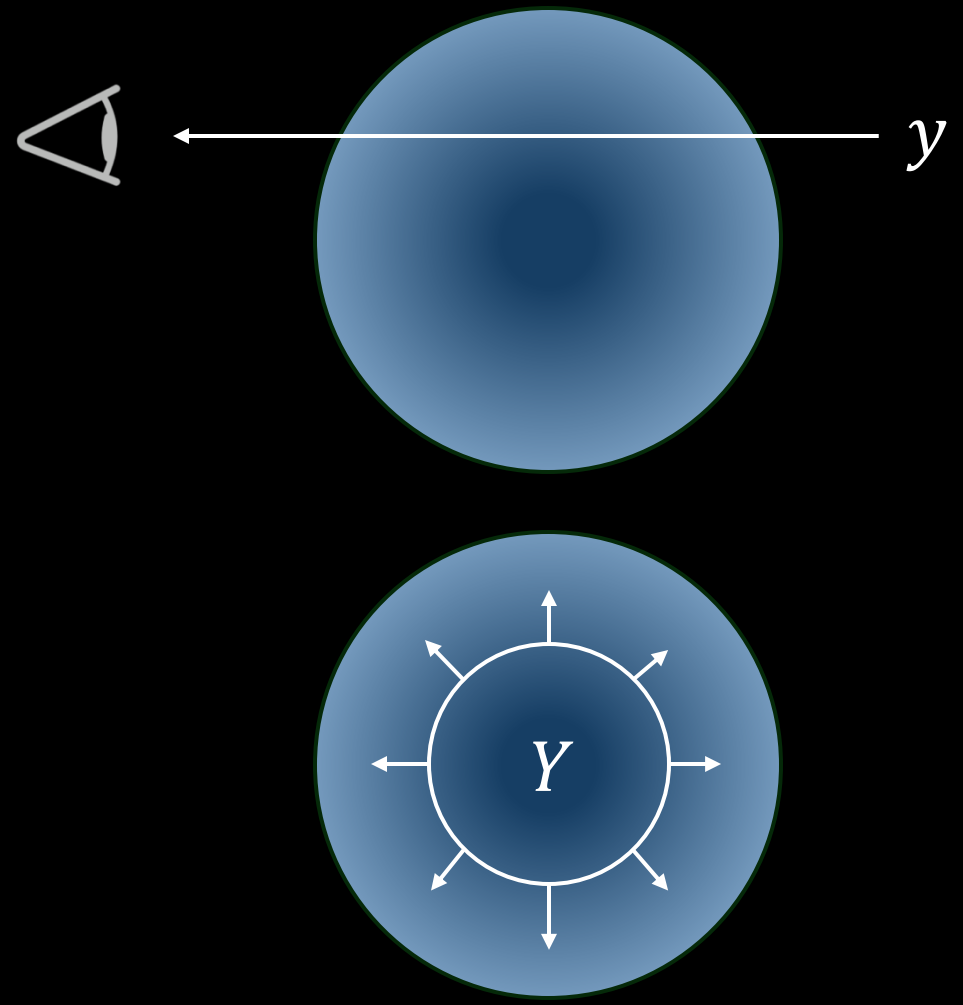
Multiphase

Plays a critical role in galaxy evolution



Thermal Sunyaev Zeldovich Effect

- Proportional to the CGM thermal pressure:
  - $\frac{\Delta T}{T} \propto y \propto \int p_e dz$
  - $Y \propto \int p_e dV$



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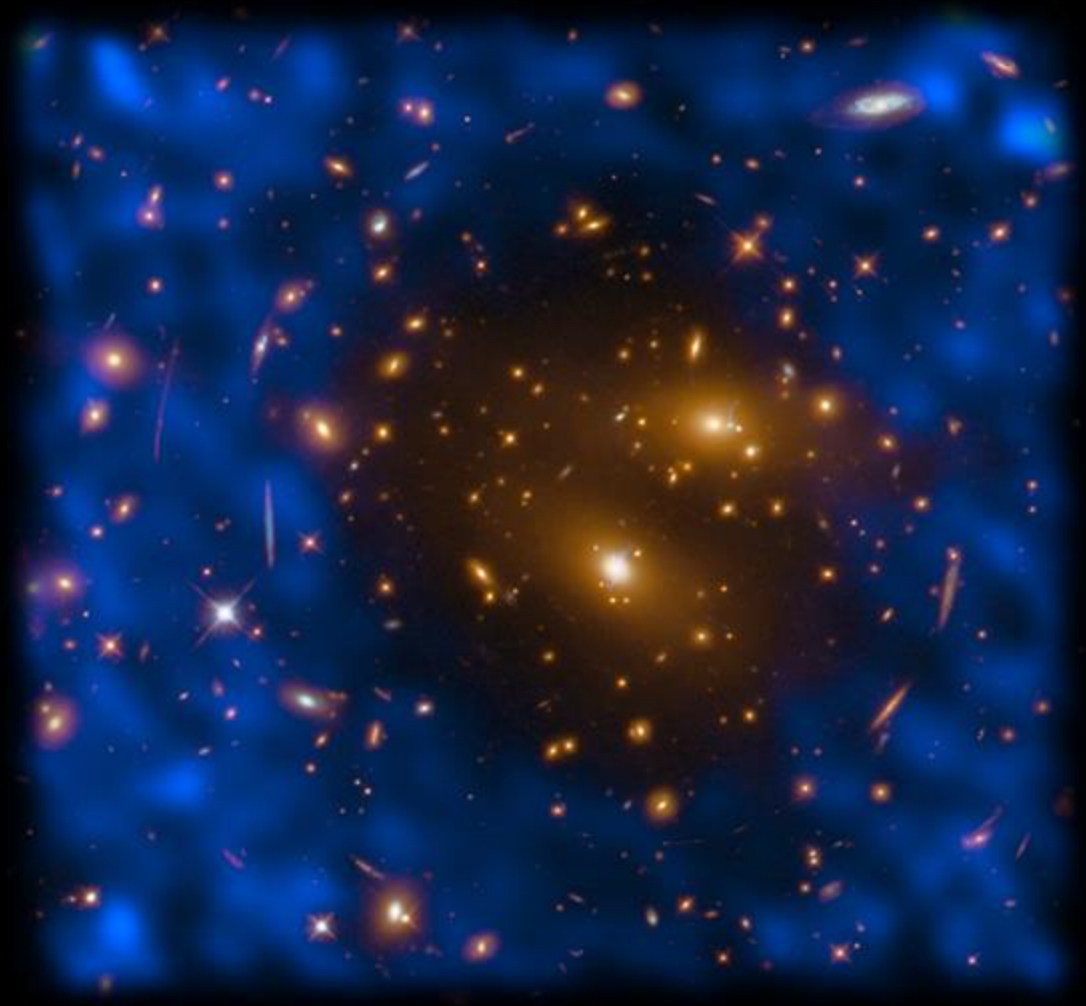
- Usually observed in massive clusters



Bregman et al. 2022

- Stacked 11 nearby L* galaxies
  - $d < 10\ Mpc$
  - $\langle M_* \rangle = 6.8 \times 10^{10}\ M_\odot$
  - $M_{vir} = 2.75 \times 10^{12}\ M_\odot$

NGC 5194 (M51)

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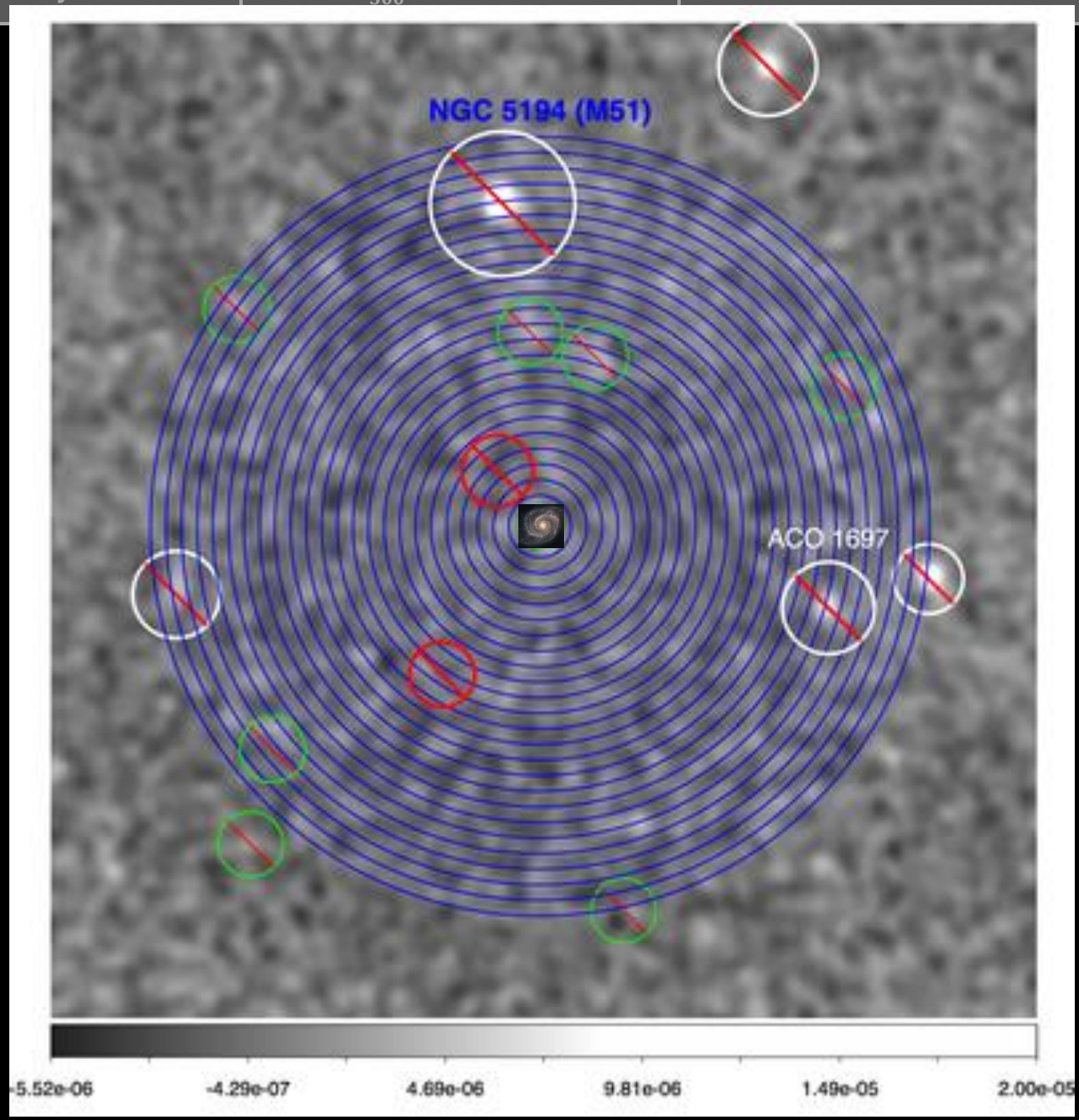

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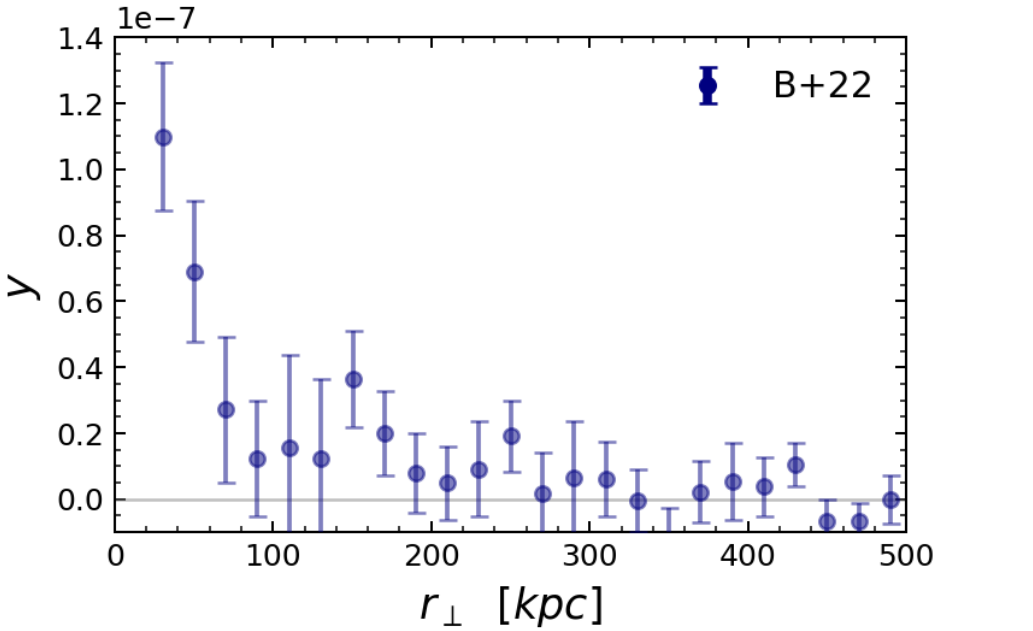
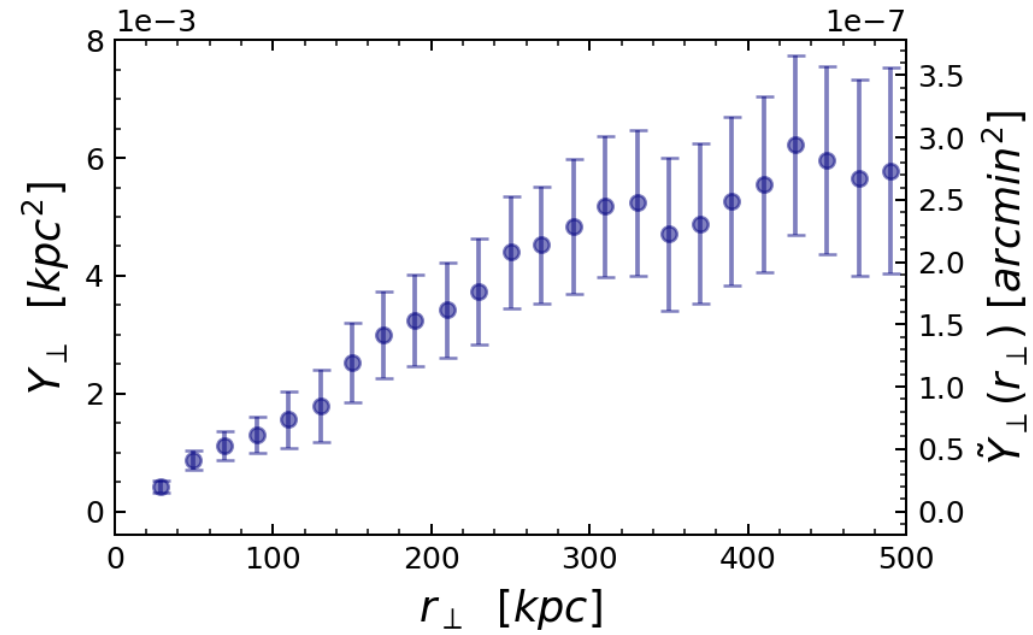
- Using mcmc, we find:
  - $a_{P,th} = 2.03$
  - $\phi_T^* = 2.39$





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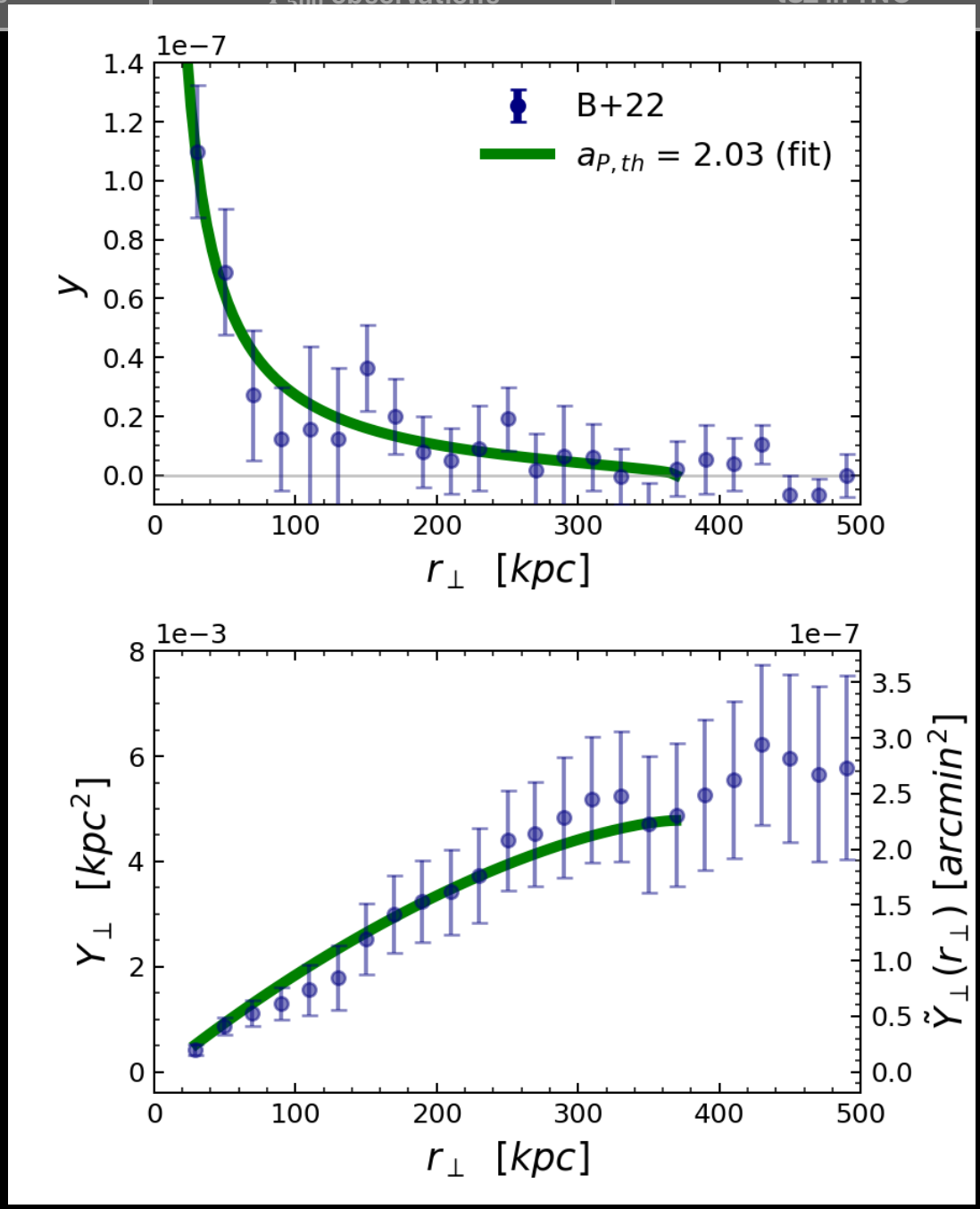
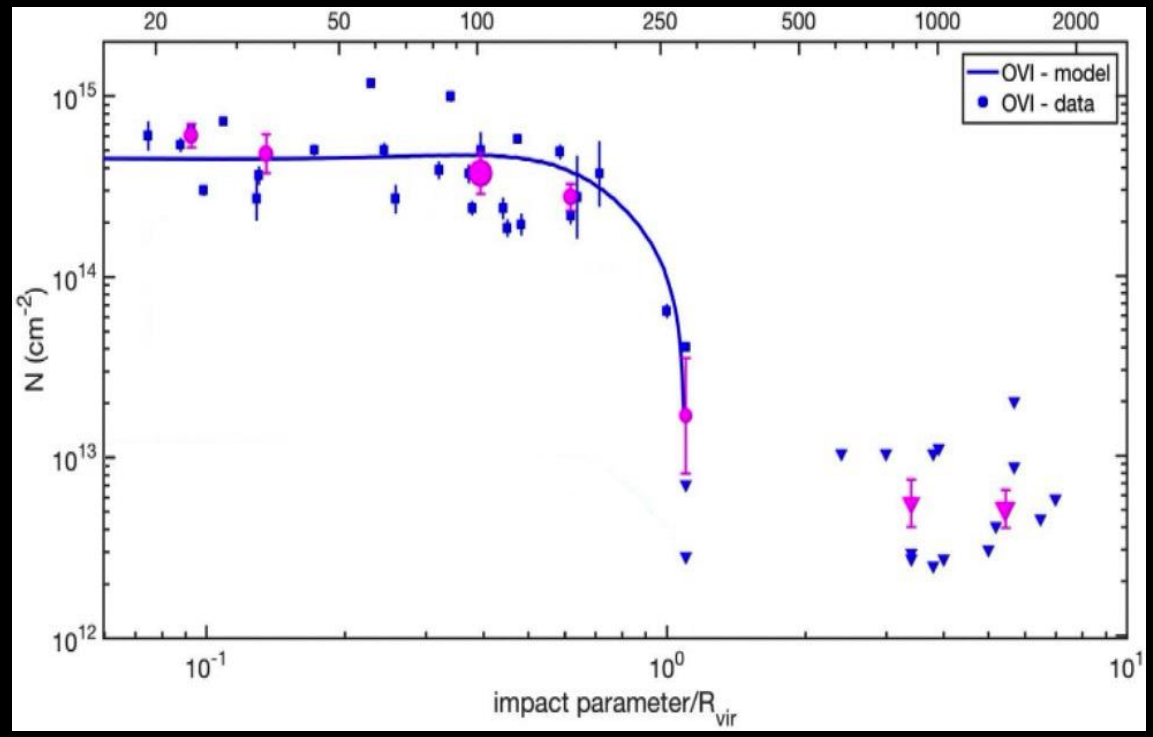


Faerman, Sternberg and McKee (2017, 2020)

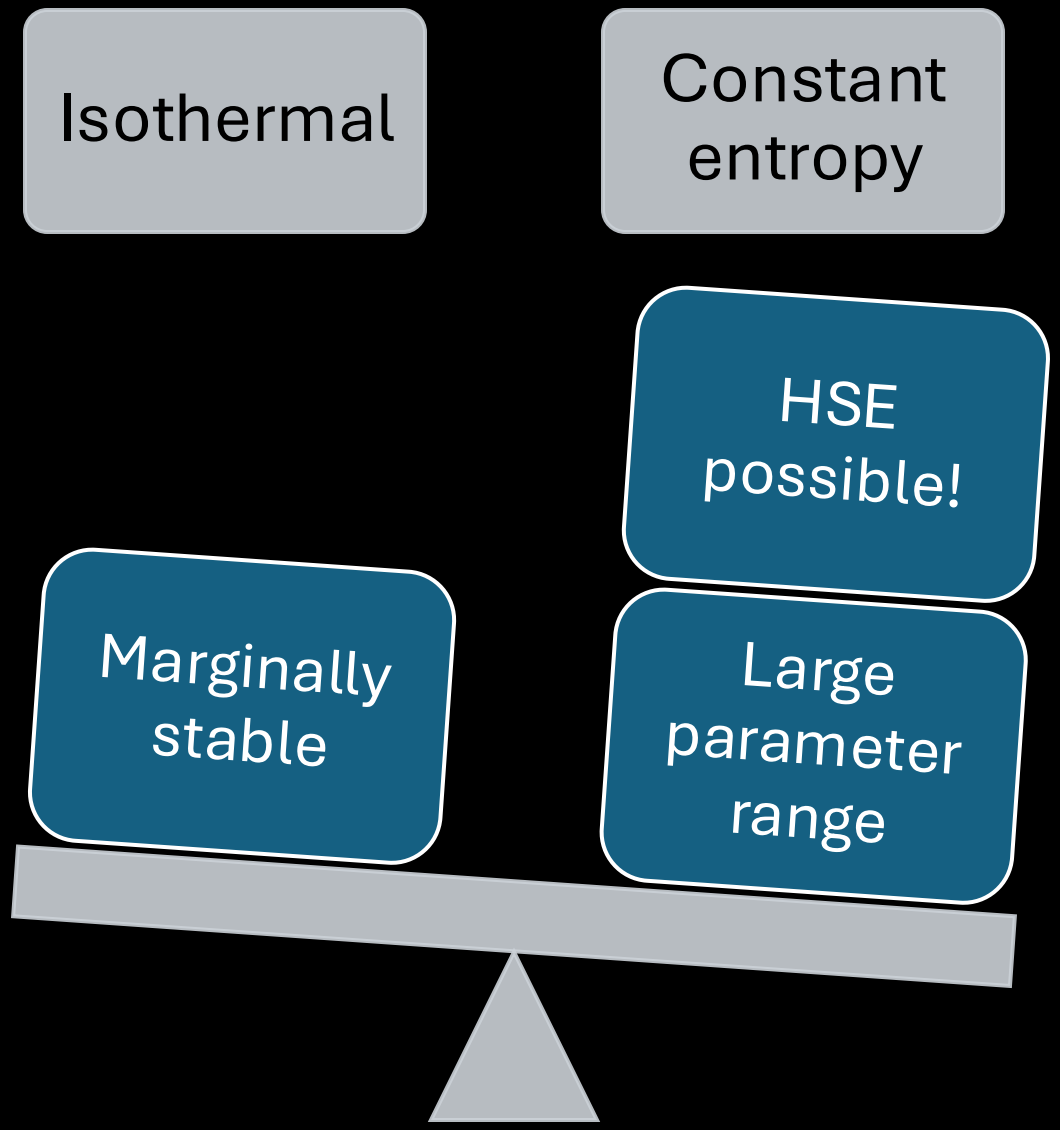
- HSE solutions for MW-like CGM
- Recreates O VI, O VII, and O VIII absorption
- Resulting $p_e(r)$ well represented by power laws



Faerman+2020 *ApJ* **893** 32

Bregman et al. 2022

- From the power Law:
  - $p_e \propto r^{-a_{P,th}}$
- Can it be in HSE?
  - Under what E.o.S?
- Cosmological baryon constraints



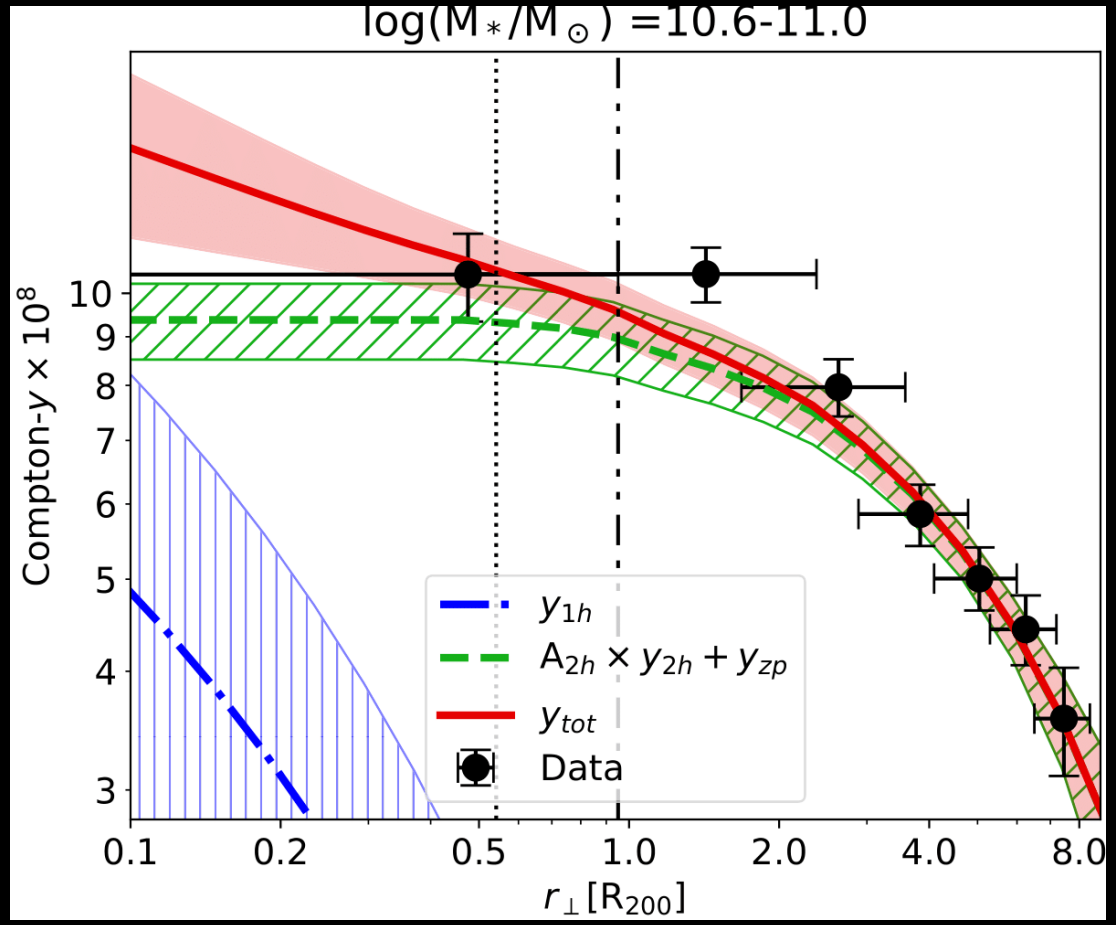
Das et al. 2023

Stacking >640,000 galaxies ($z < 0.5$)

ACT + WISExSuperCOSMOS

Fit similar $y(r)$ profiles for all stacks

⇒ We only analyze Y_{500}



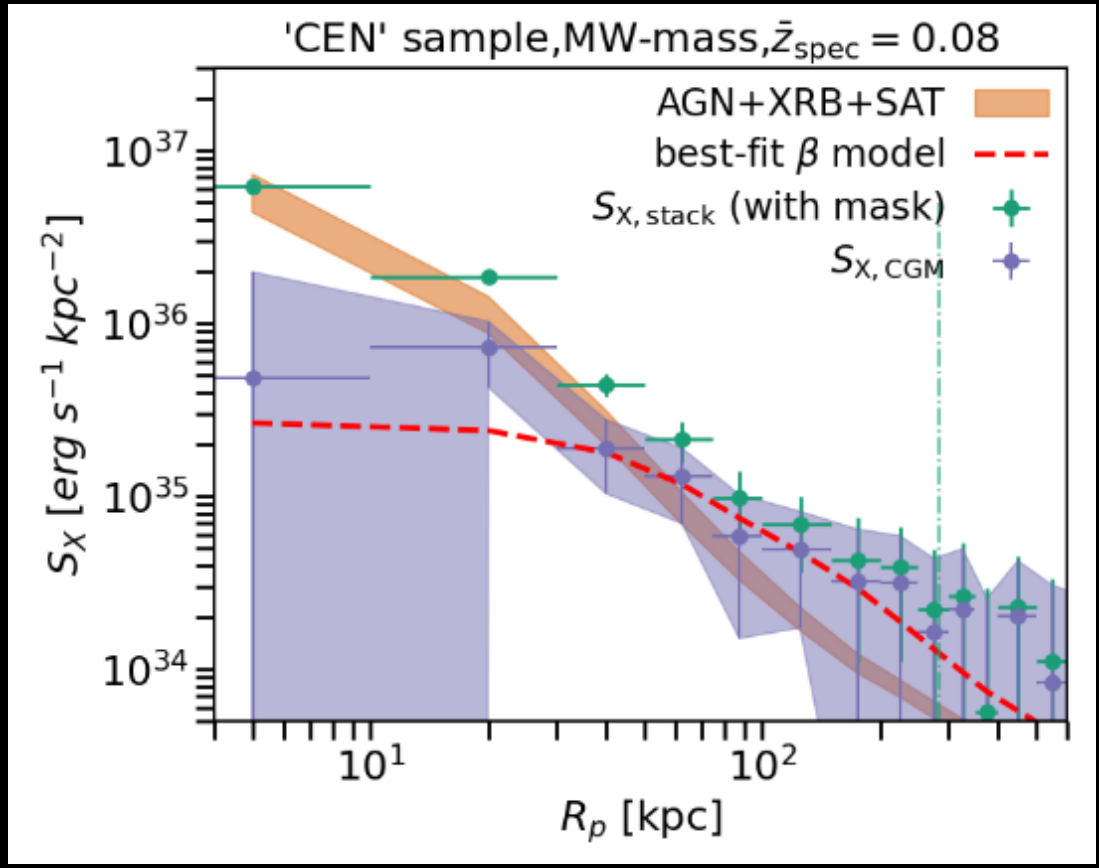
Zhang et al. 2024

Stacked eROSITA detections

MW-like halos

Fit S_X to obtain CGM parameters

Apply PLM to get Y_{500}



Illustris TNG100

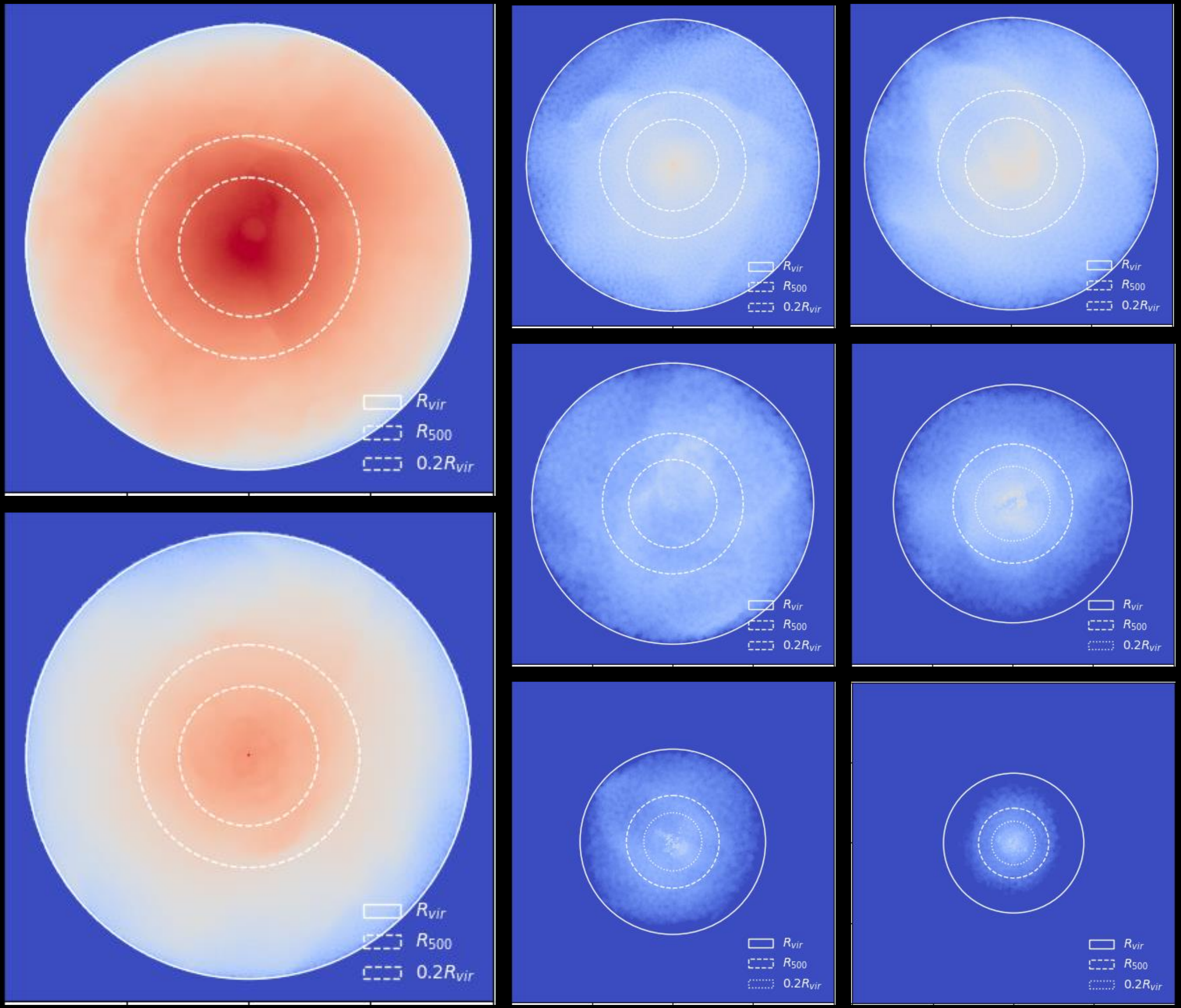
Pillepich et al. 2017
Springel et al. 2017
Nelson et al. 2018
Naiman et al. 2018
Marinacci et al. 2018

TNG50

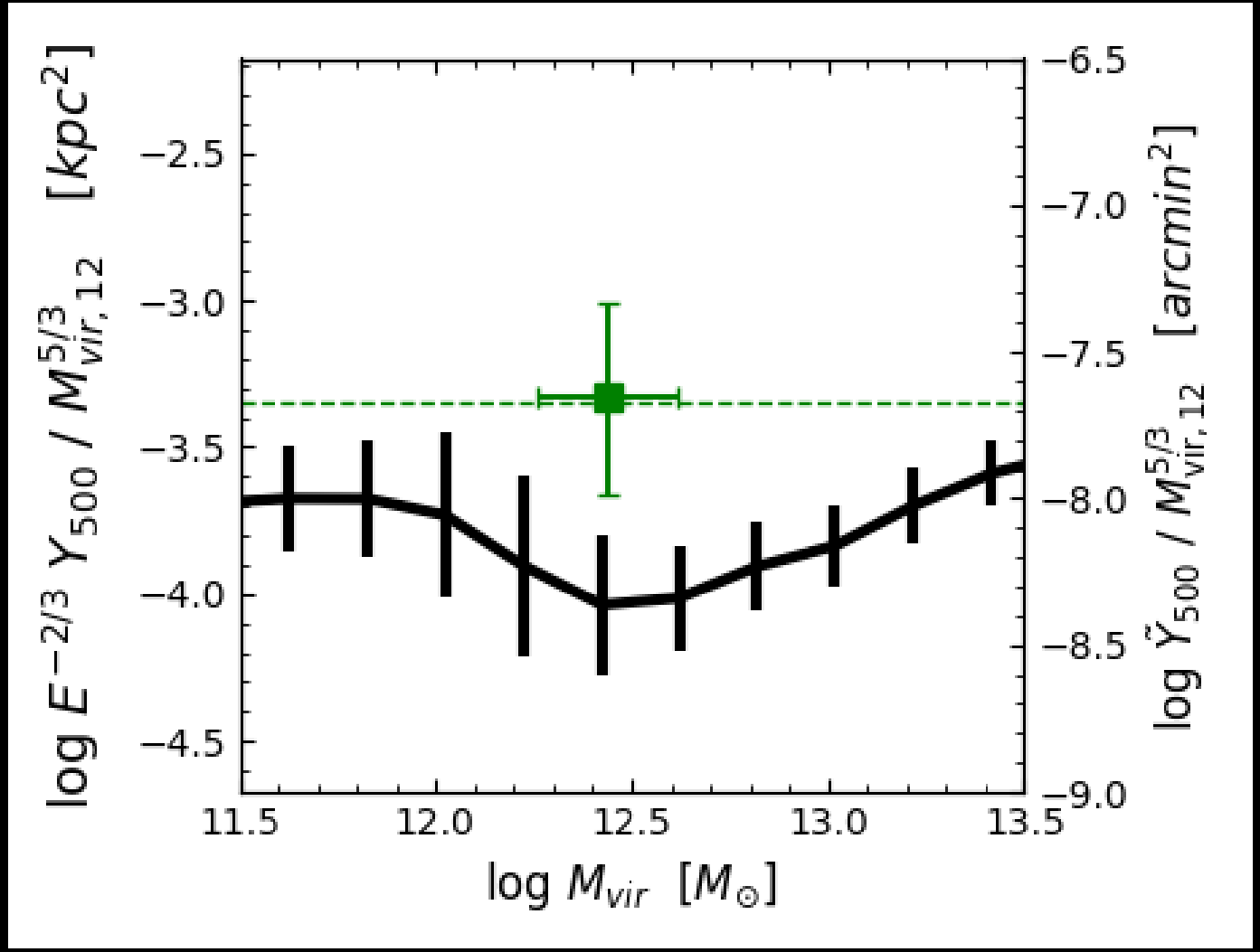
Oren+ 2024

- y Maps for 648 halos
  - $11.5 < \log\left(\frac{M_{vir}}{M_{\odot}}\right) < 14.5$
  - Well described by a power law distributions

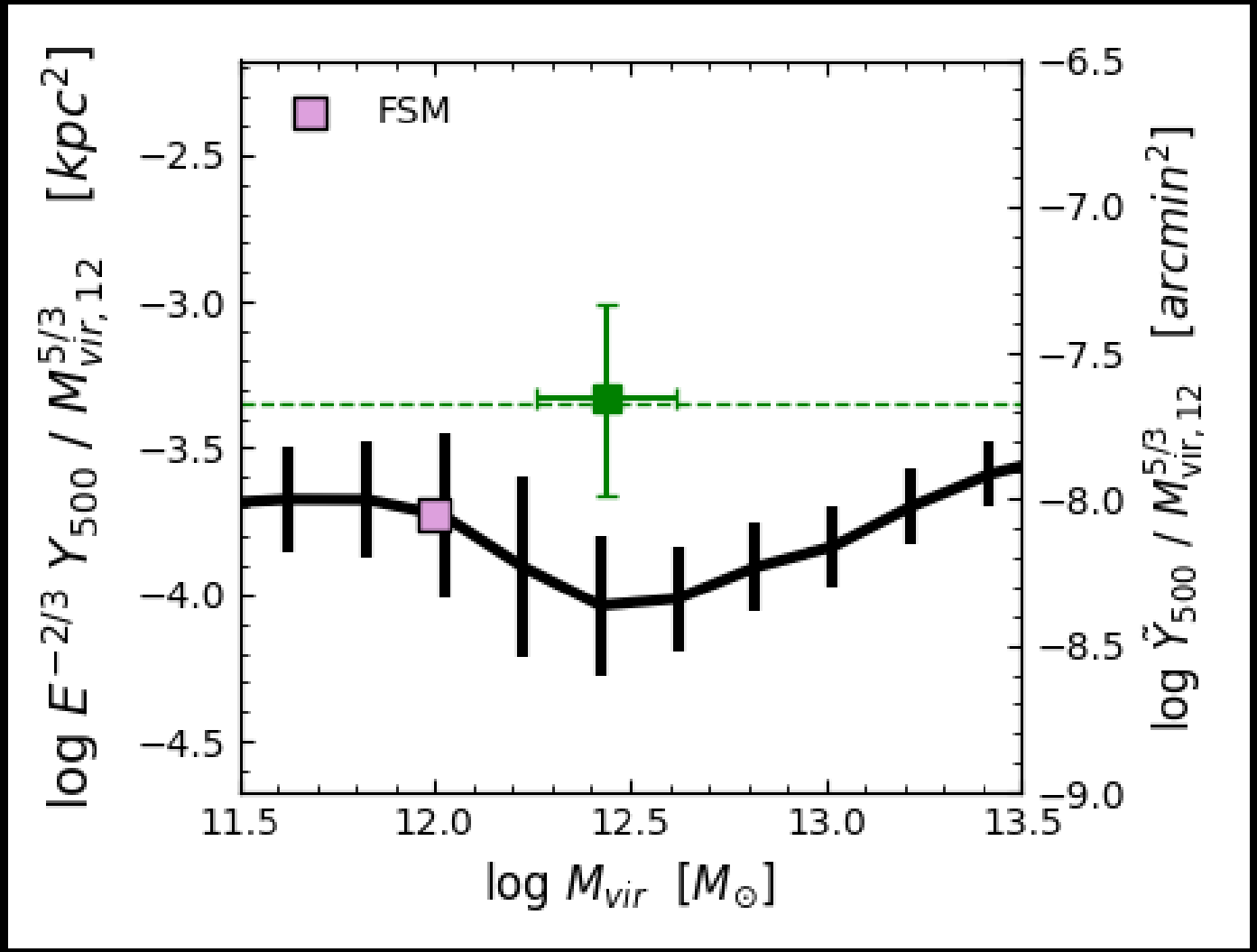
- Y for 10,000 halos
  - $\log\left(\frac{M_{vir}}{M_{\odot}}\right) > 11.5$



Oren+ 2024


log $E^{-2/3}$ Y_{500} / $M_{vir,12}^{5/3}$ [kpc^2]
log $\tilde{Y}_{500}$ / $M_{vir,12}^{5/3}$ [$arcmin^2$]
log M_{vir} [$M_\odot$]
−2.5
−3.0
−3.5
−4.0
−4.5
−6.5
−7.0
−7.5
−8.0
−8.5
−9.0
11.5
12.0
12.5
13.0
13.5

Oren+ 2024


FSM
log $E^{-2/3}$ Y_{500} / $M_{vir,12}^{5/3}$ [kpc^2]
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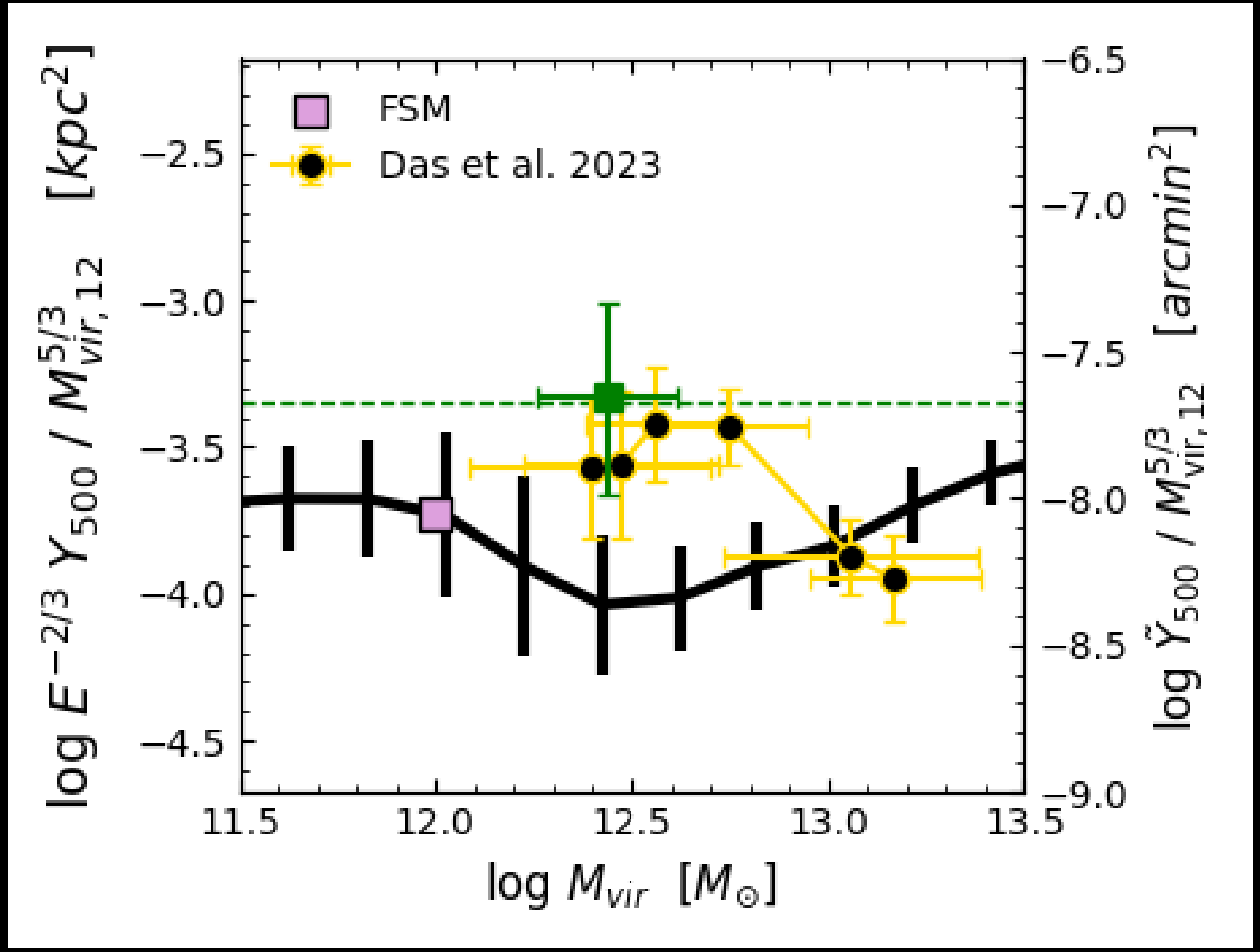
12.5
13.0
13.5

Oren+ 2024


FSM
Das et al. 2023
log $E^{-2/3}$ Y_{500} / $M^{5/3}_{vir,12}$ [kpc^2]
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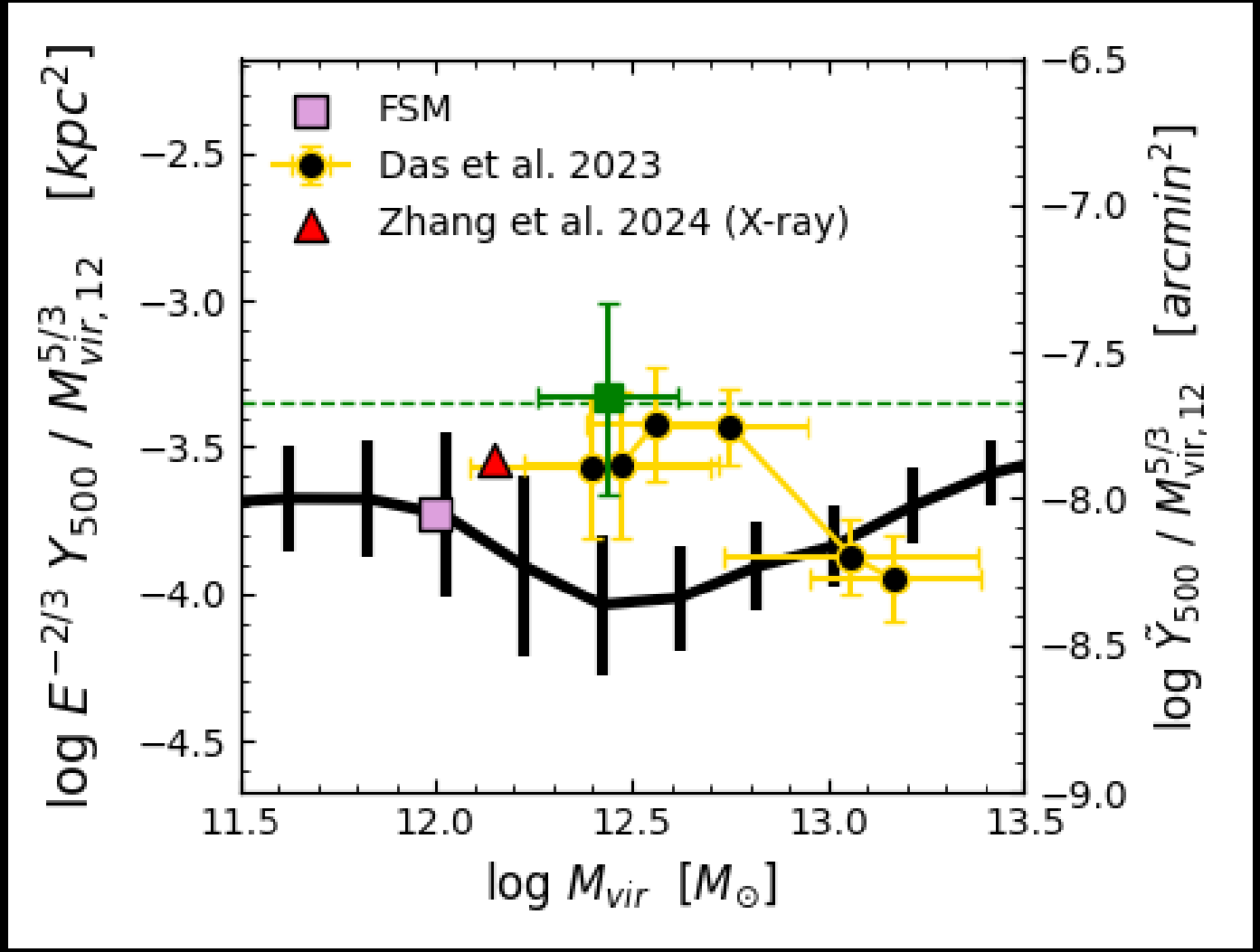
FSM
Das et al. 2023
Zhang et al. 2024 (X-ray)
log $E^{-2/3}$ Y_{500} / $M_{vir,12}^{5/3}$ [kpc^2]
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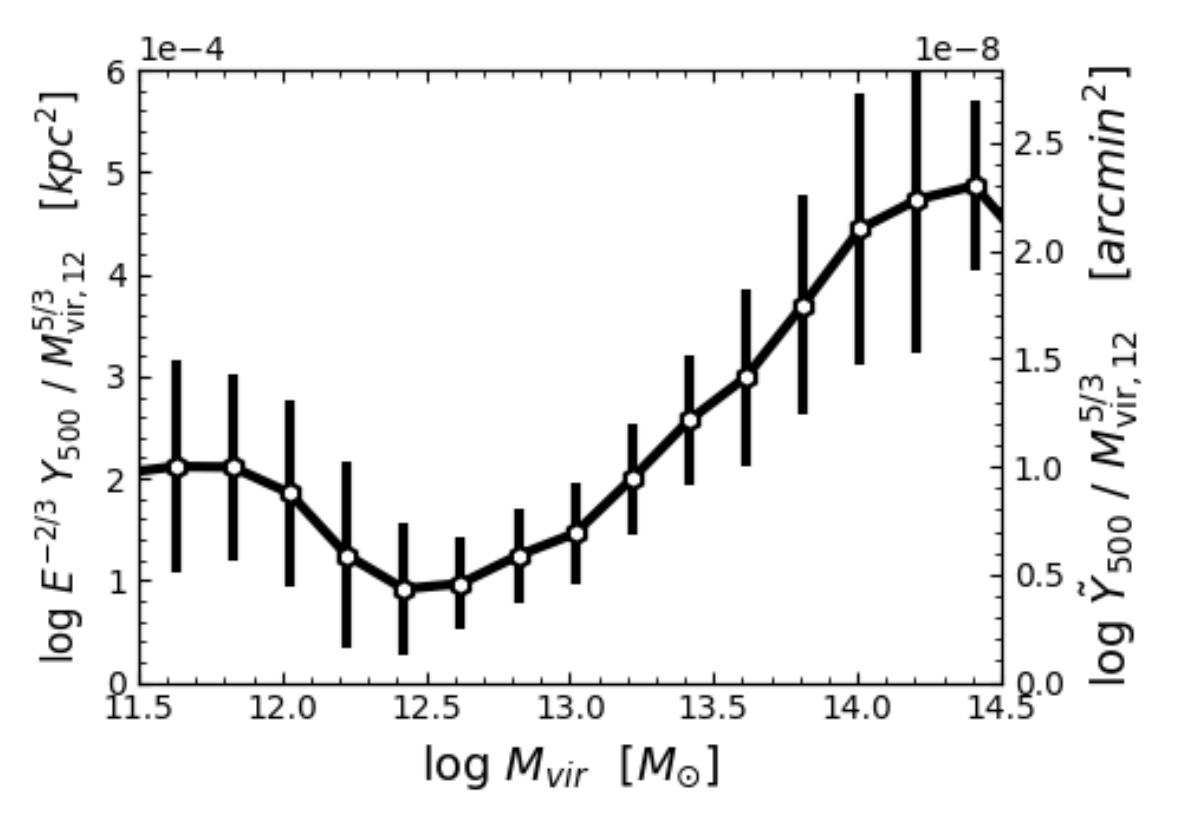
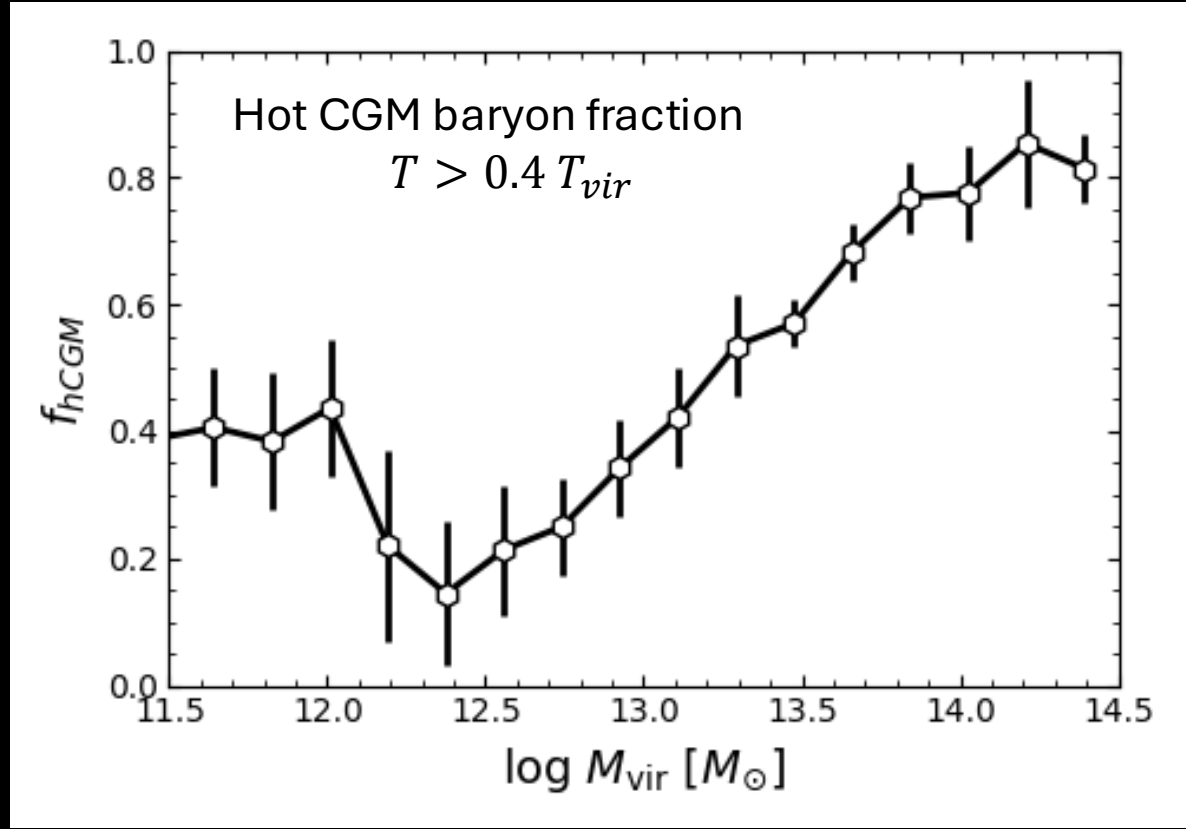
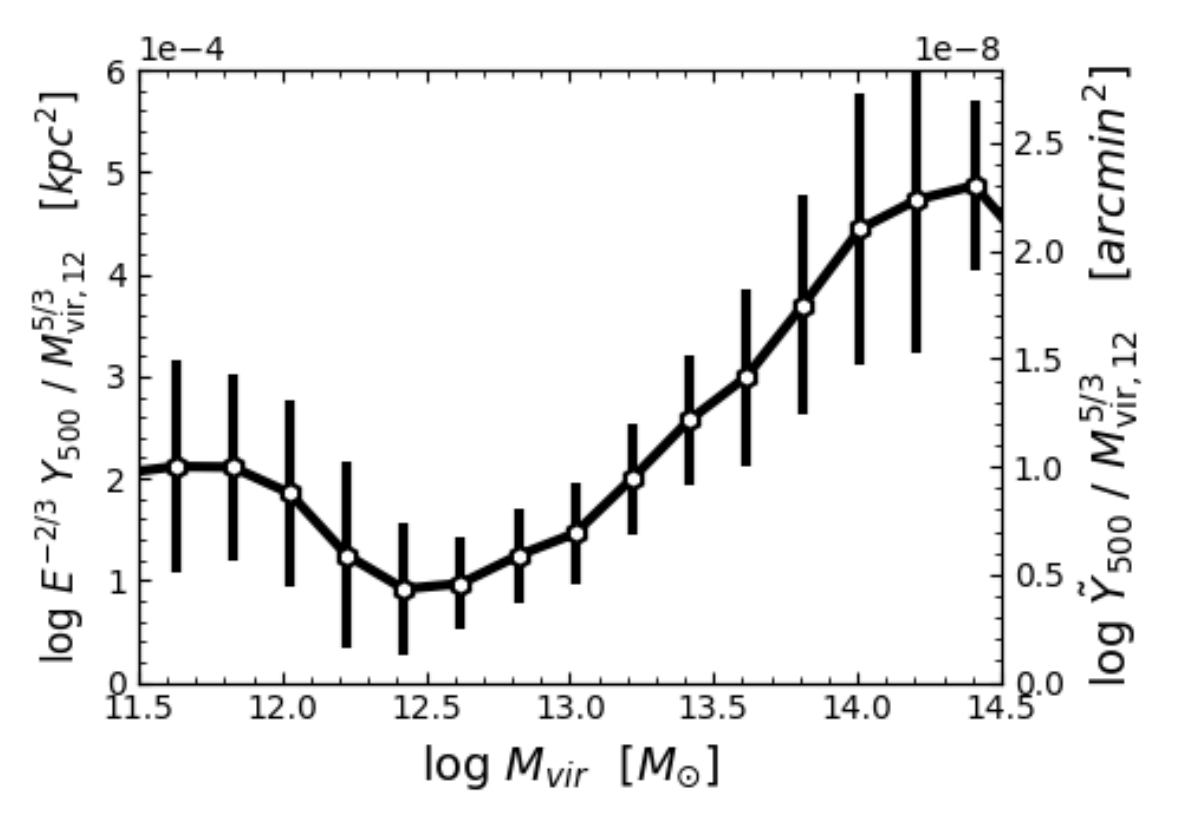
13.5

Oren+ 2024


1e−4
1e−8
log $E^{-2/3}$ Y_{500} / $M_{vir,12}^{5/3}$ [kpc^2]
log $\tilde{Y}_{500}$ / $M_{vir,12}^{5/3}$ [$arcmin^2$]
log M_{vir} [$M_\odot$]


Hot CGM baryon fraction
$T > 0.4\,T_{vir}$
f_{hCGM}
log M_{vir} [$M_\odot$]

Oren+ 2024


1e−4
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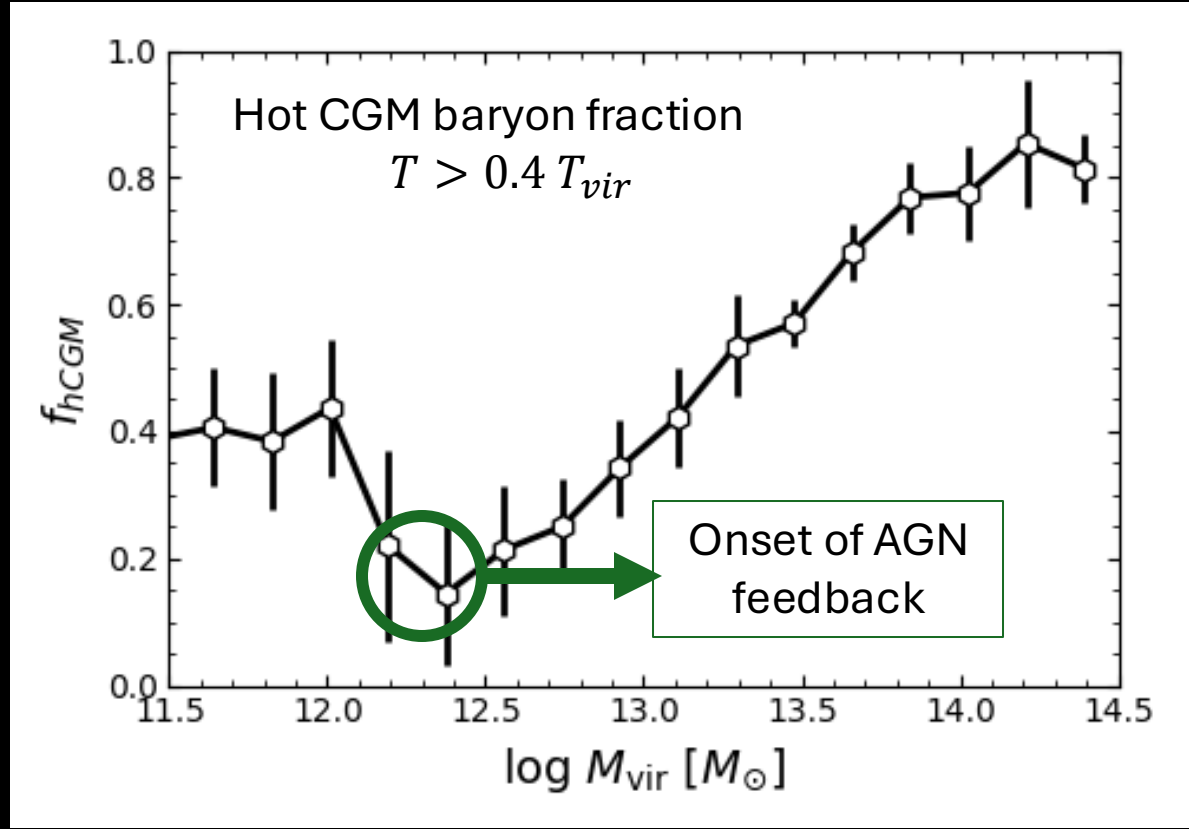
Hot CGM baryon fraction
$T > 0.4\,T_{vir}$
f_{hCGM}
Onset of AGN feedback
log M_{vir} [$M_\odot$]

Summary

- The B+22 stack of 11 nearby L* galaxies:
  - Has a steep pressure slope ($a_{P,th} = 2$)
  - If isothermal, marginally stable
  - If isentropic, can be in HSE

- B+22 and D+23 results are consistent with each other and with recent (0.5-2 keV) CGM X-ray observations
  - For $1 < M_{12} < 3 \quad 2.5 \times 10^{-4} < Y_{500} < 5.0 \times 10^{-4}\ kpc^2$

- Strong feedback in TNG100 leads to reduced CGM baryon fractions and lower tSZ