What determines the extent of baryon-induced dark matter core creation in dwarfs?

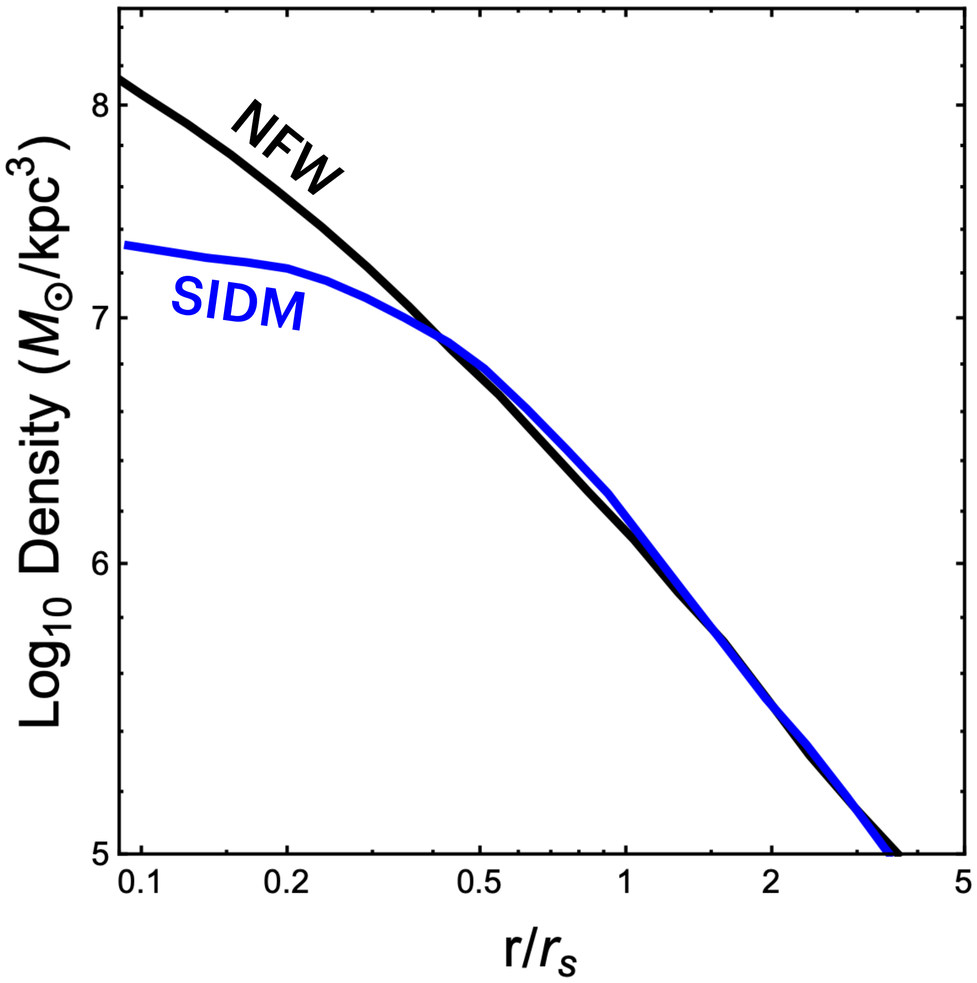
Claudia Muni

w/ Andrew Pontzen, Justin I. Read, Oscar Agertz, Martin P. Rey, Ethan Taylor, Stacy Y. Kim, Emily I. Gray

National Astronomy Meeting, Durham University - July 2025

Dark matter density profiles as probes of dark matter

The “cusp - core problem”



Tulin & Yu (2017)

Dark matter density profiles as probes of dark matter

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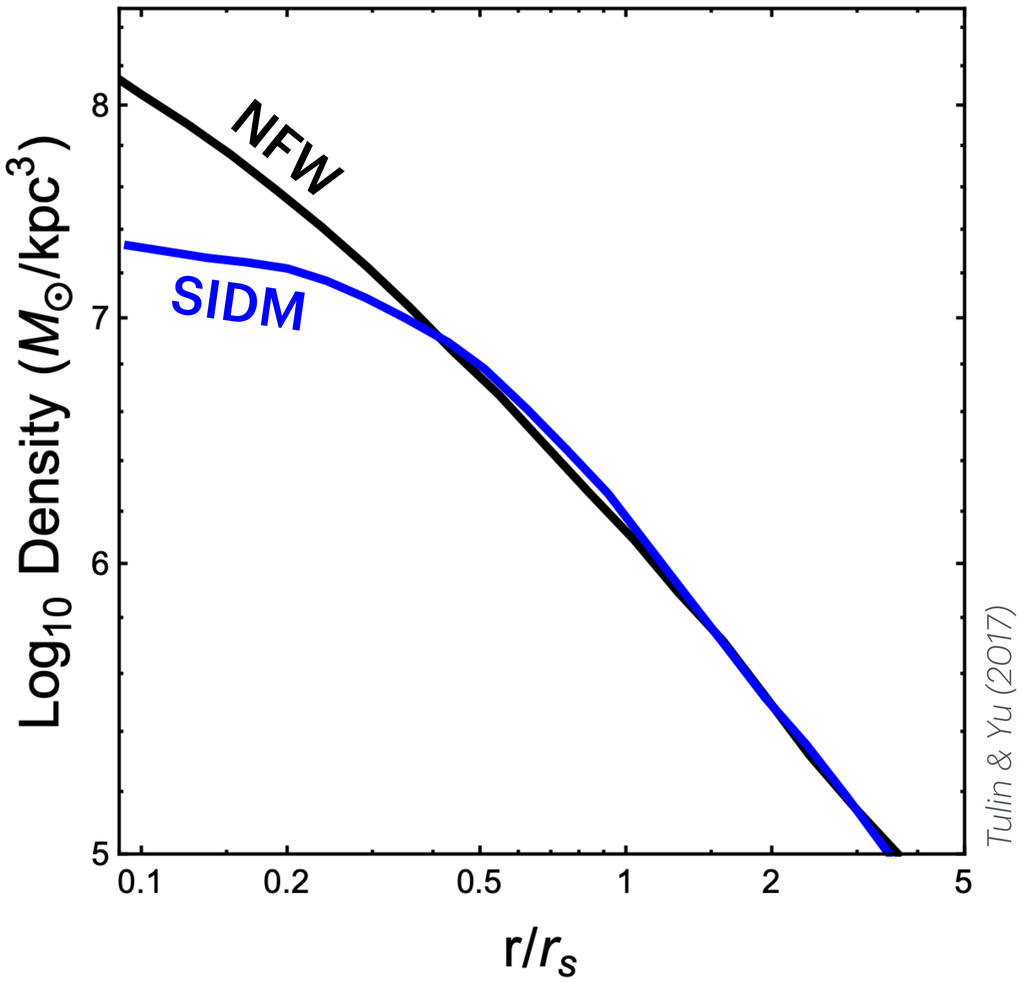
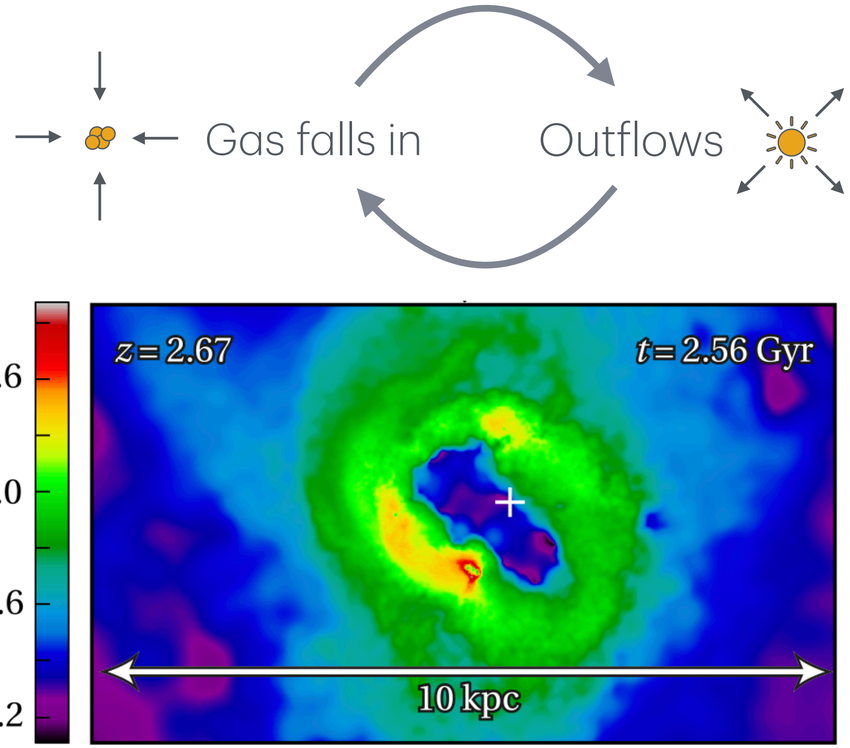


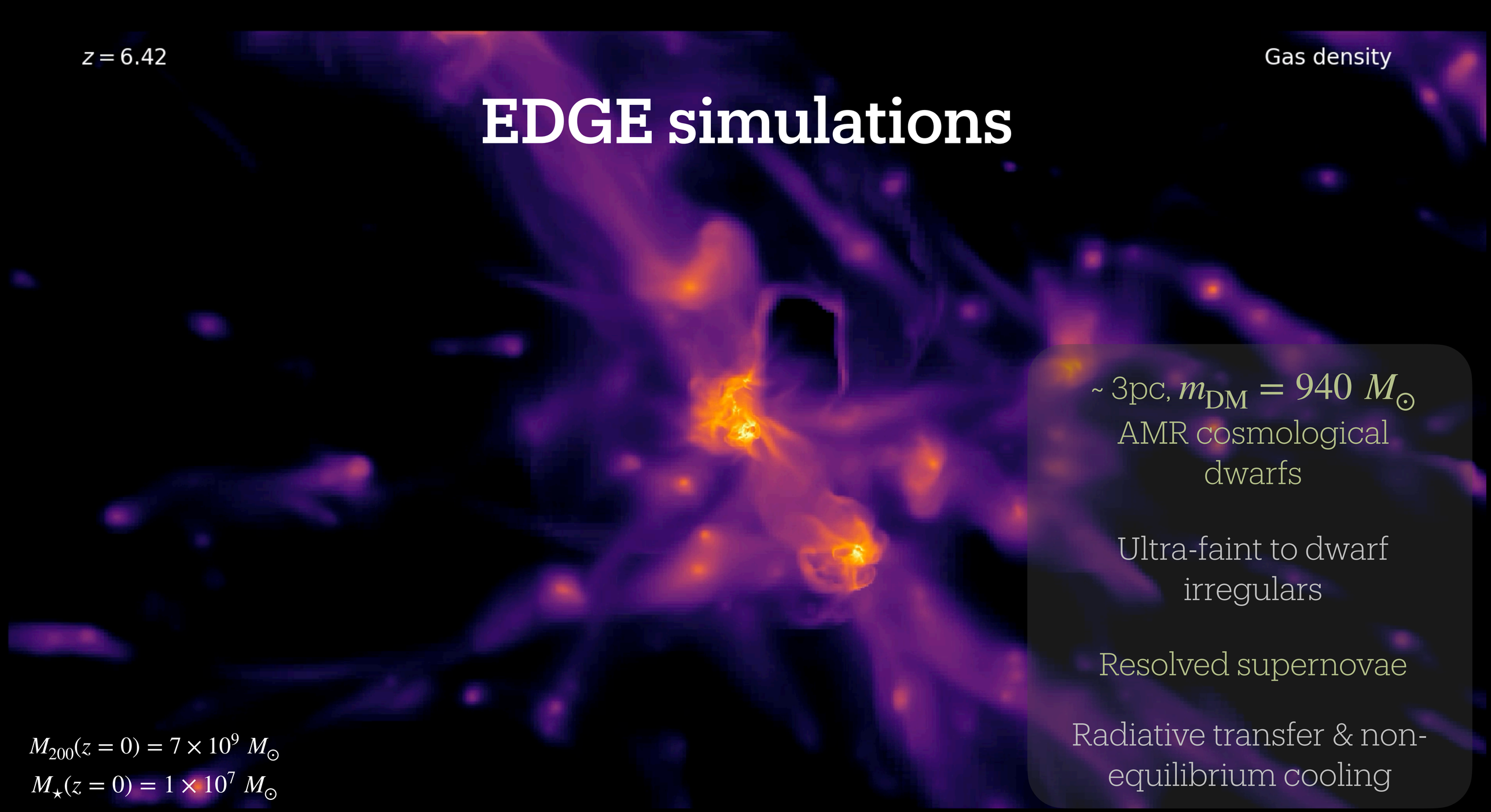
Tulin & Yu (2017)

BUT galaxies re-sculpt dark matter (**within CDM!**)

e.g. Navarro et al. (1996), Read et al (2005), Pontzen et al. (2012)



Pontzen & Governato (2012)



EDGE simulations

~ 3pc, $m_{\mathrm{DM}} = 940\ M_\odot$
AMR cosmological dwarfs

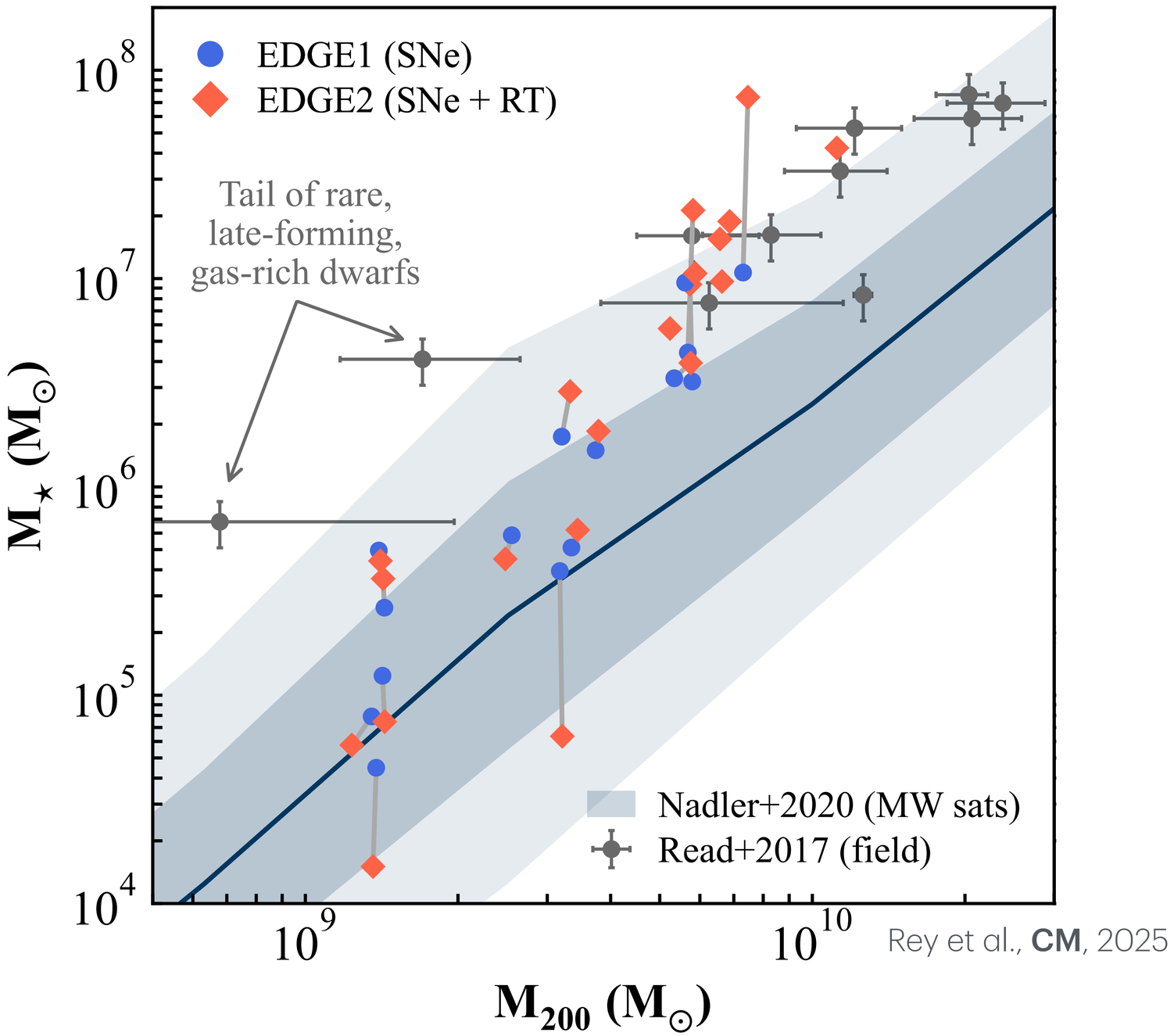
Ultra-faint to dwarf irregulars

Resolved supernovae

Radiative transfer & non-equilibrium cooling

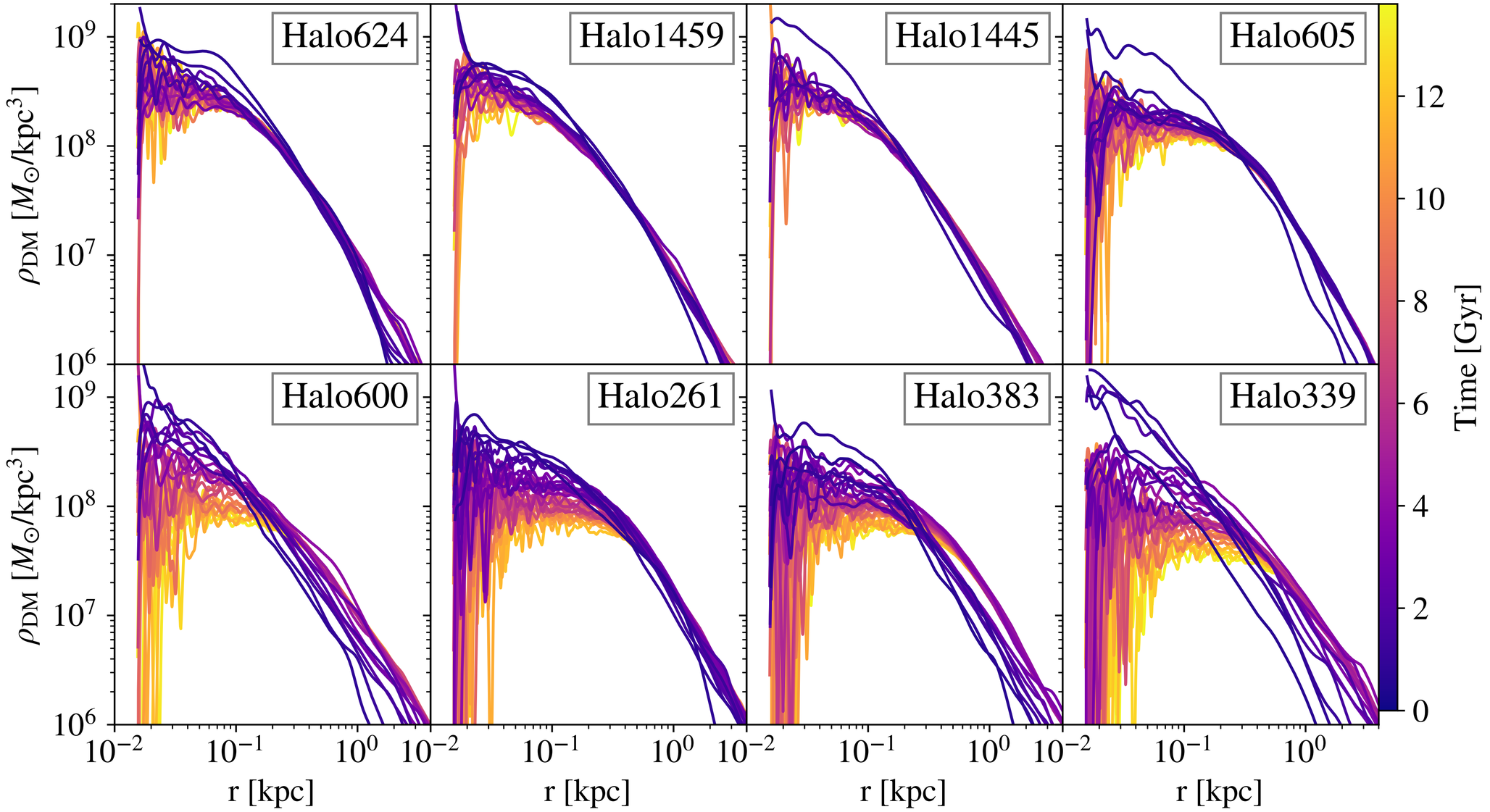
$M_{200}(z = 0) = 7 \times 10^9\ M_\odot$
$M_\star(z = 0) = 1 \times 10^7\ M_\odot$

EDGE and data



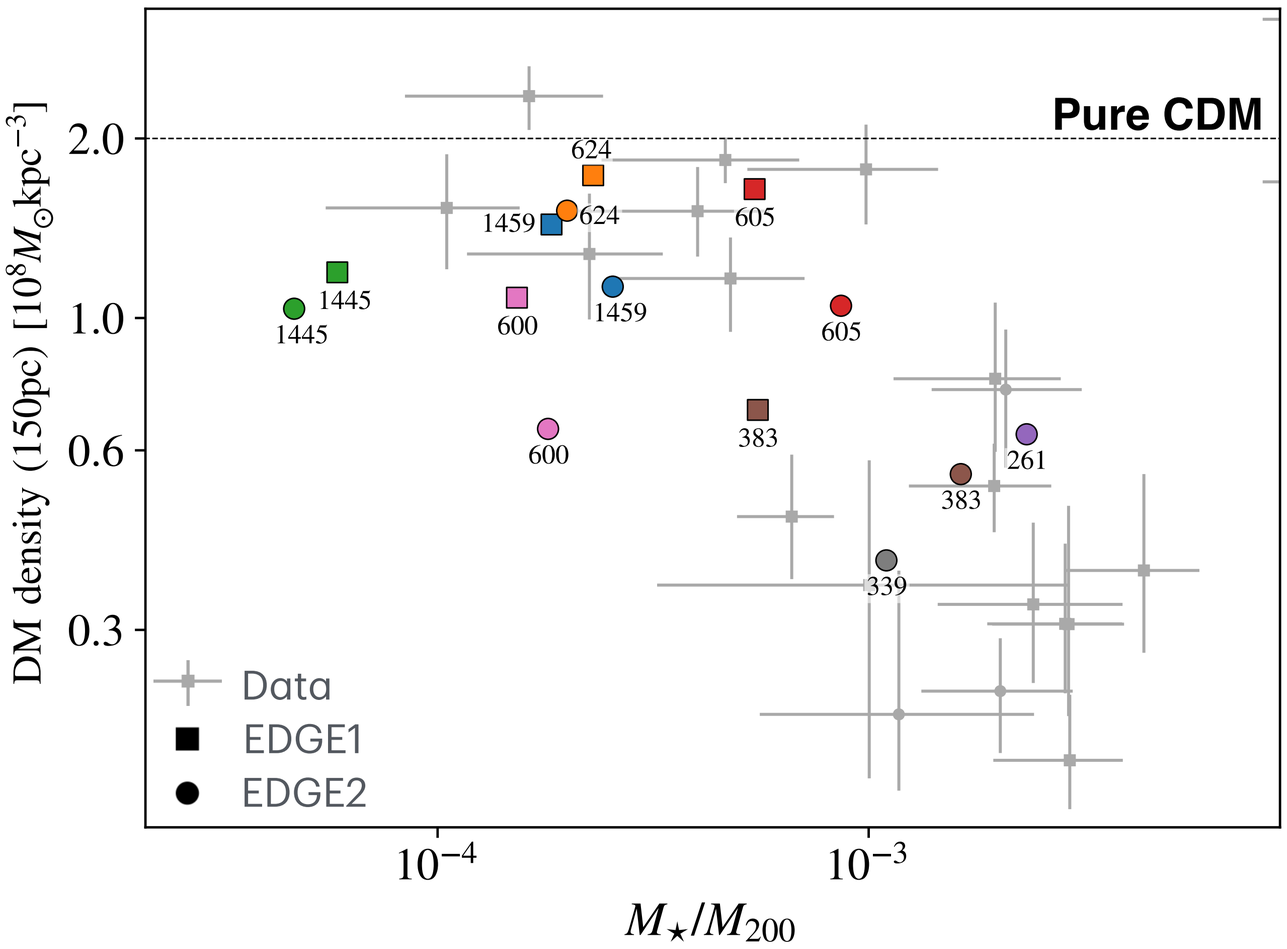
Rey et al., **CM**, 2025

Do we see core formation in EDGE? - **Yes!**



Cusp-core transformation in EDGE

Muni+2025



Energy injection

(cf Penarrubia, Pontzen, Walker 2013)

Cusp-core transformation in EDGE

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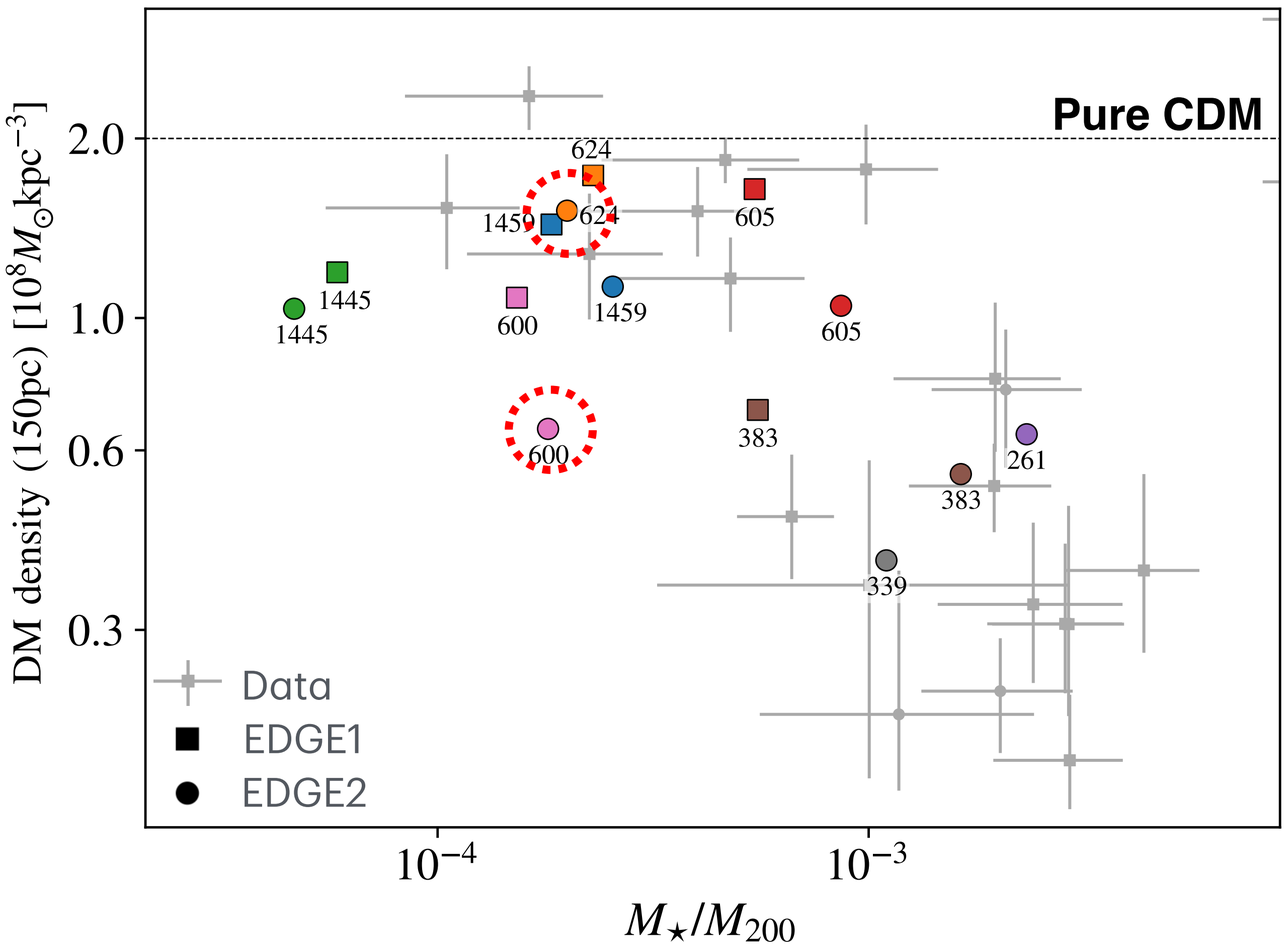

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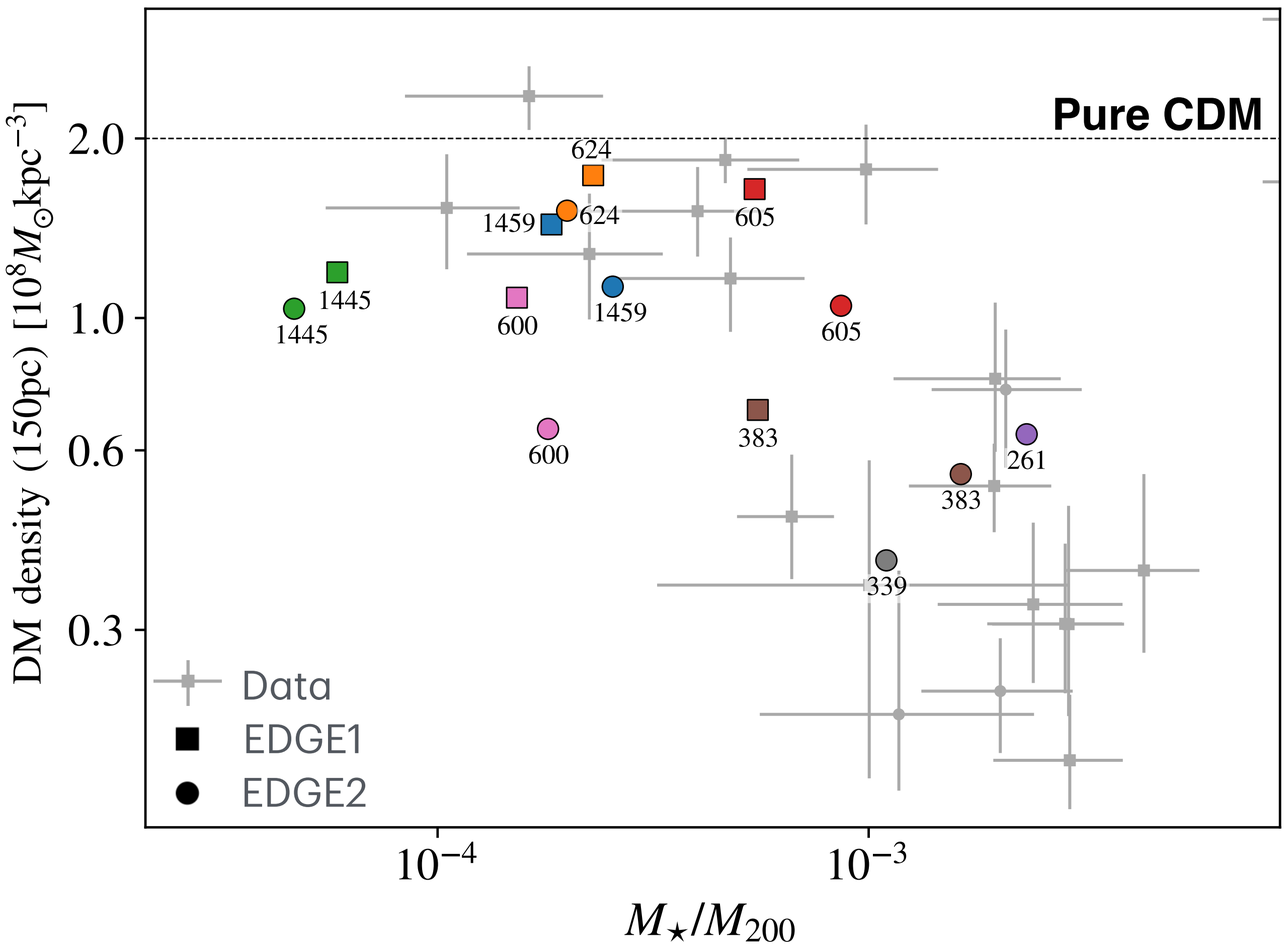

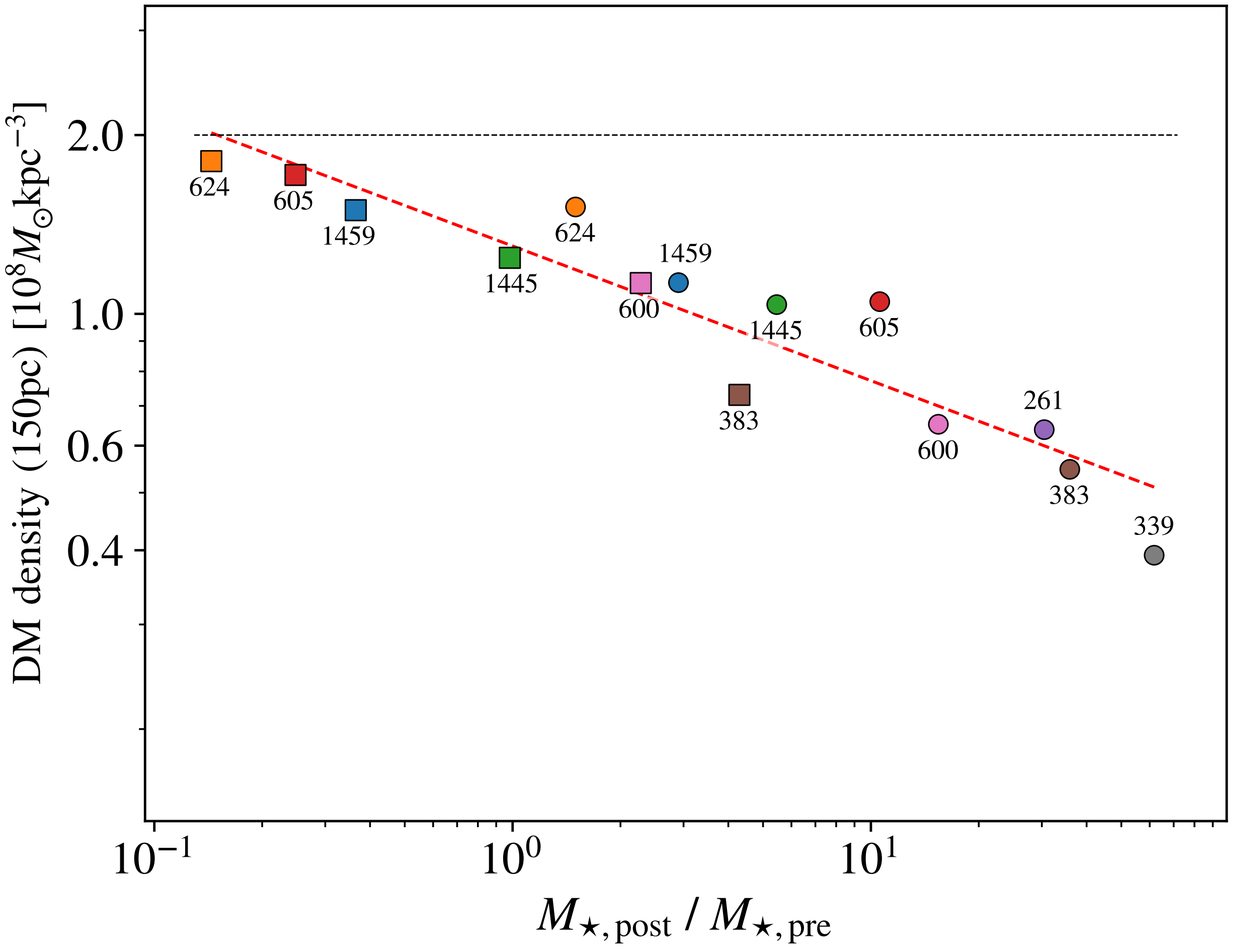

Energy injection
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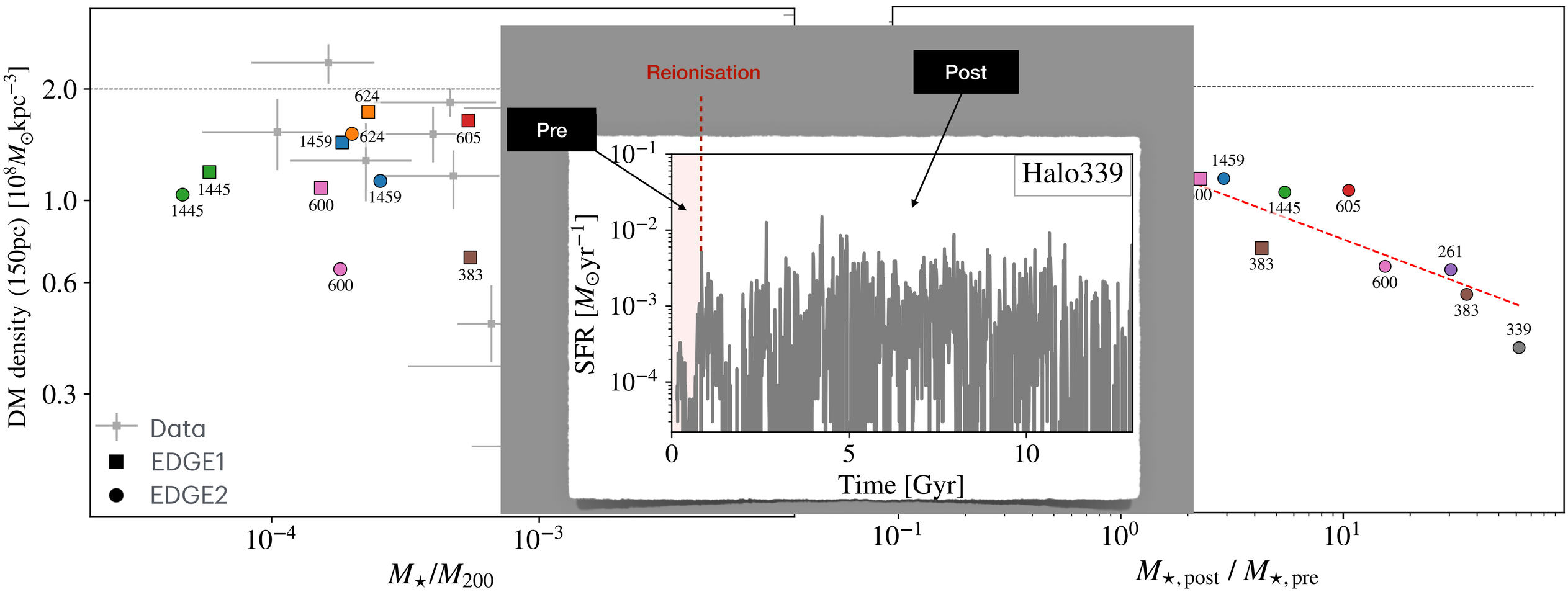
Sustained energy injection

Cusp-core transformation in EDGE

Muni+2025



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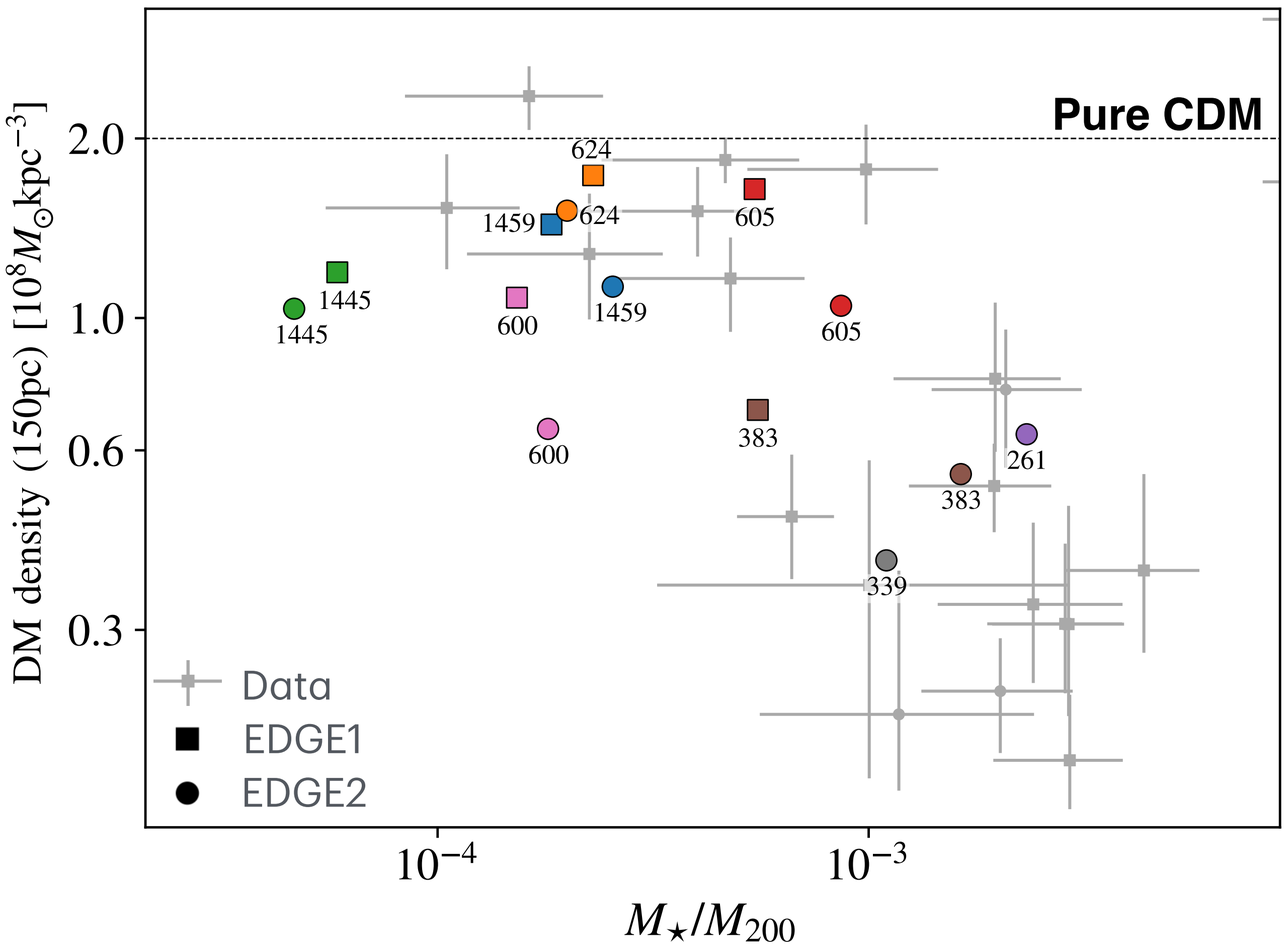

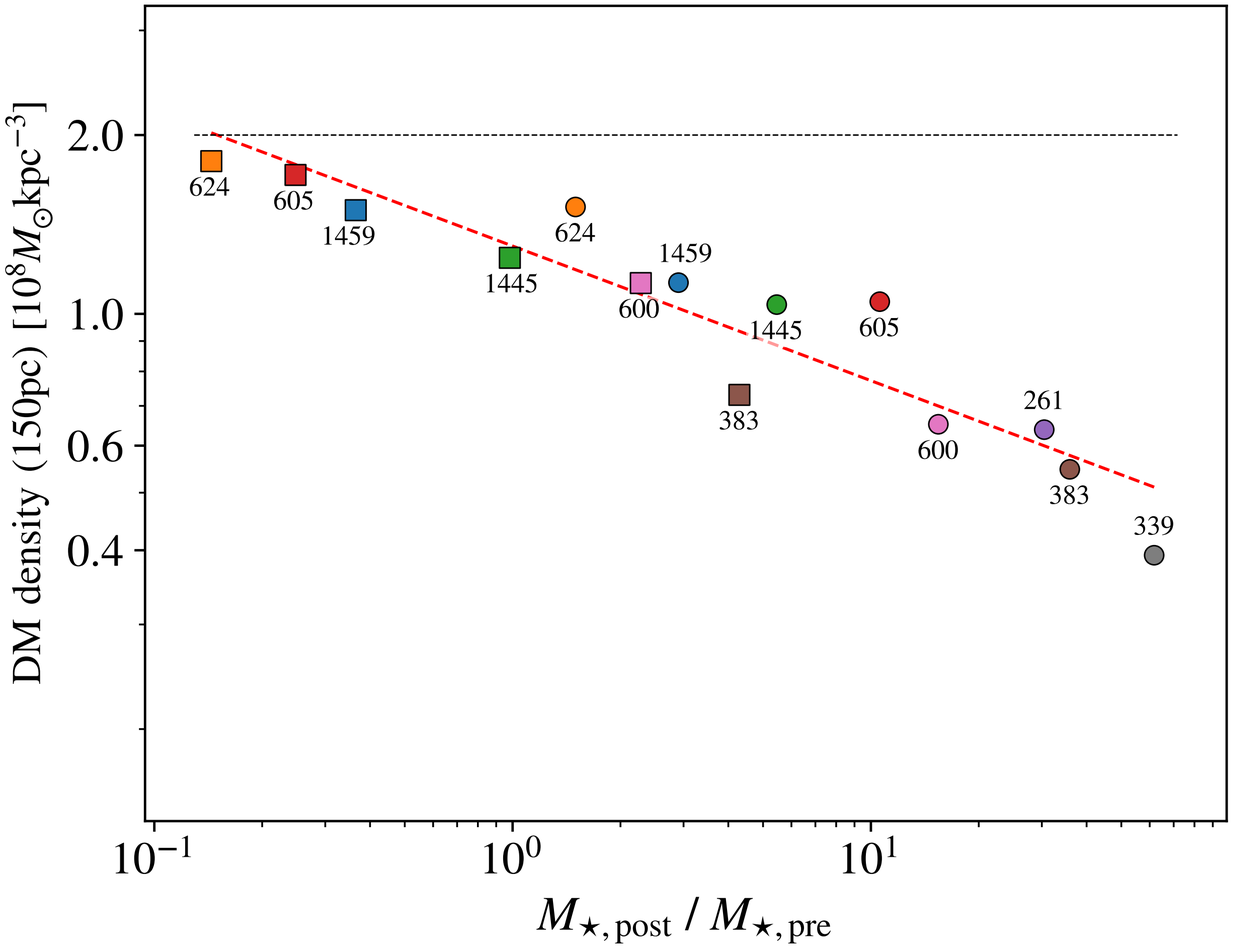

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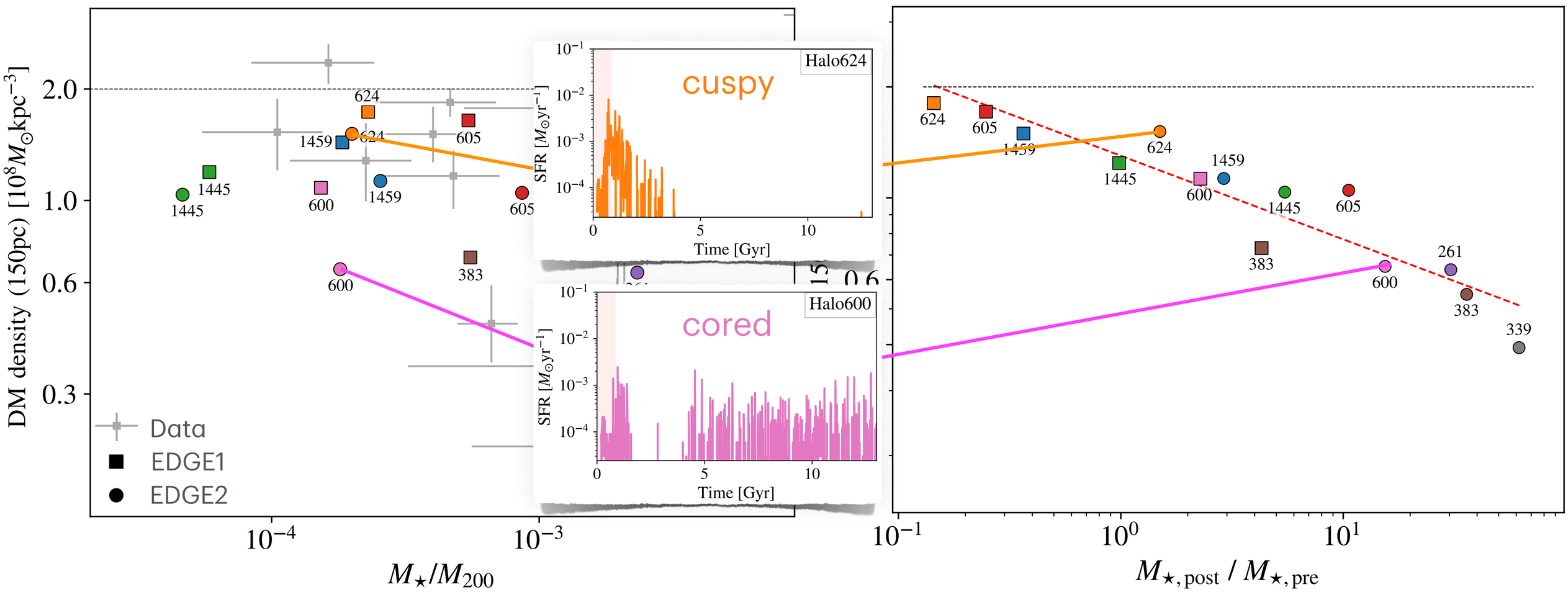

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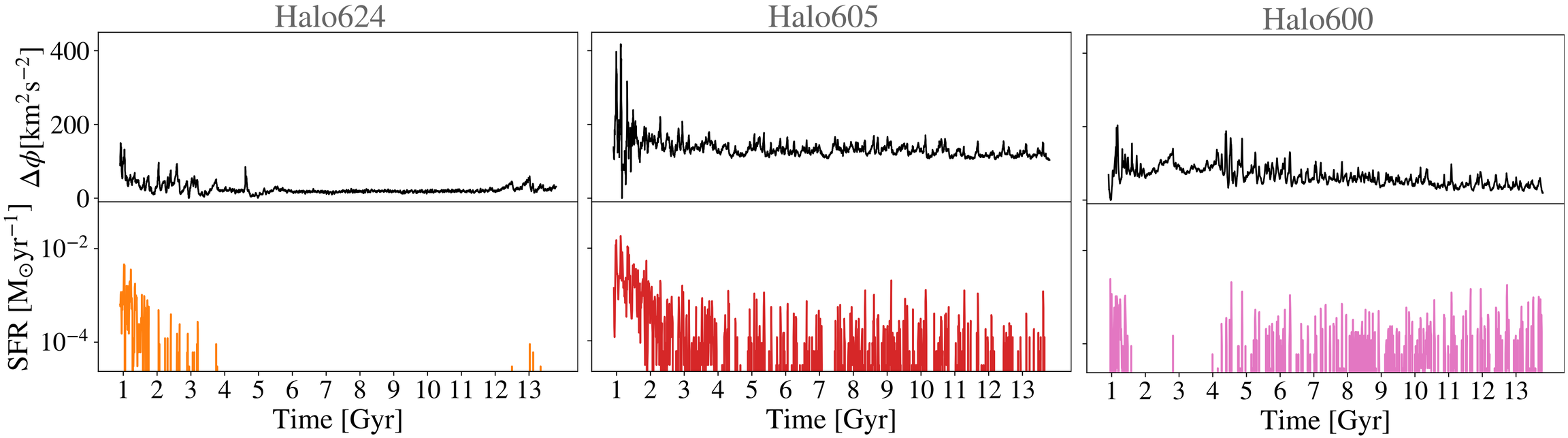
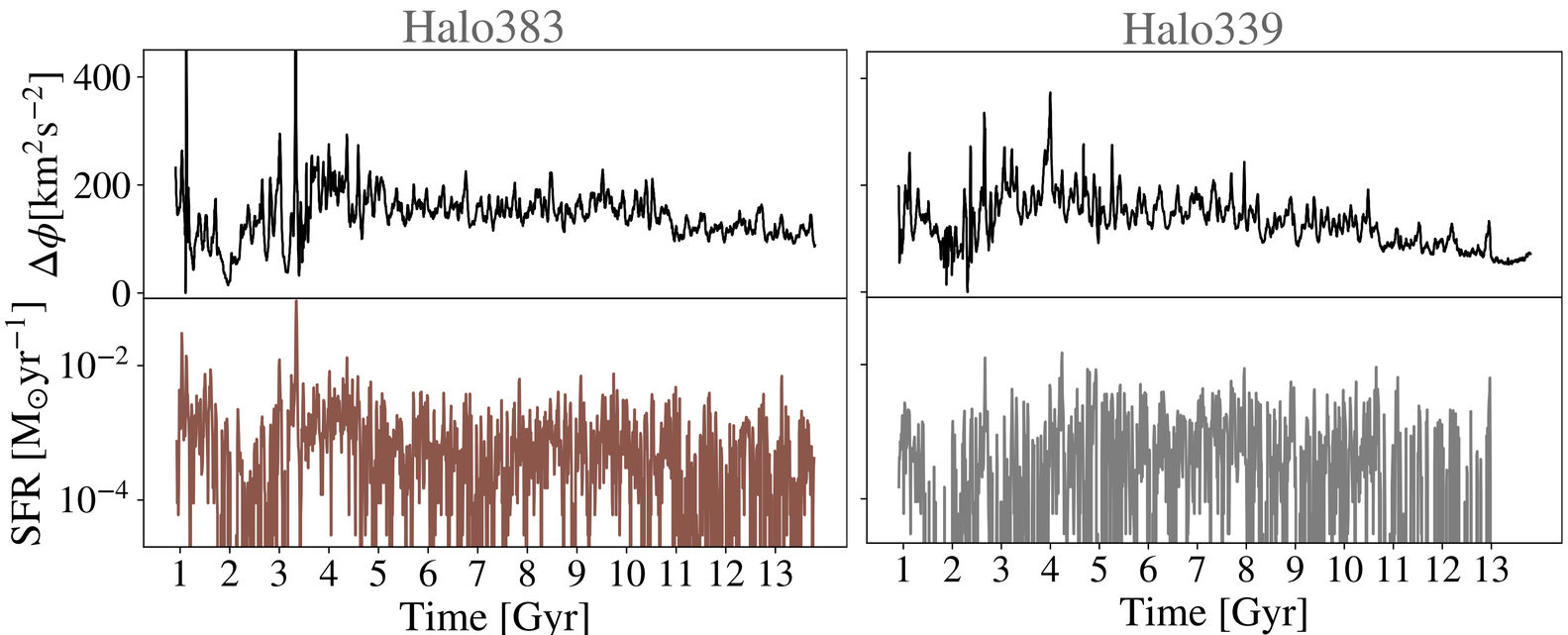
Sustained energy injection

Gravitational potential fluctuations in EDGE

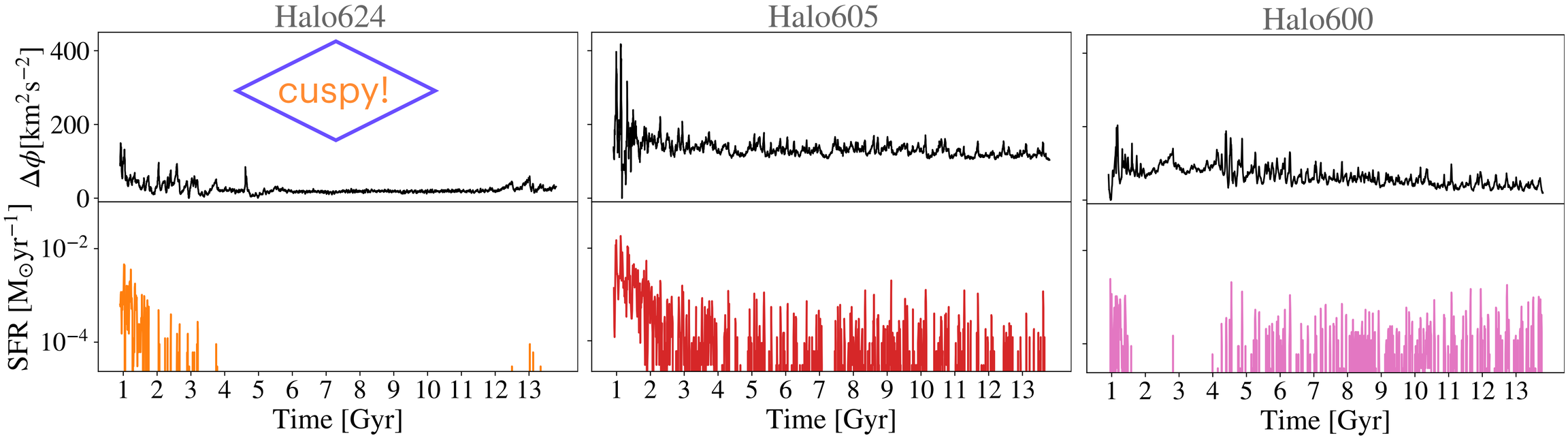


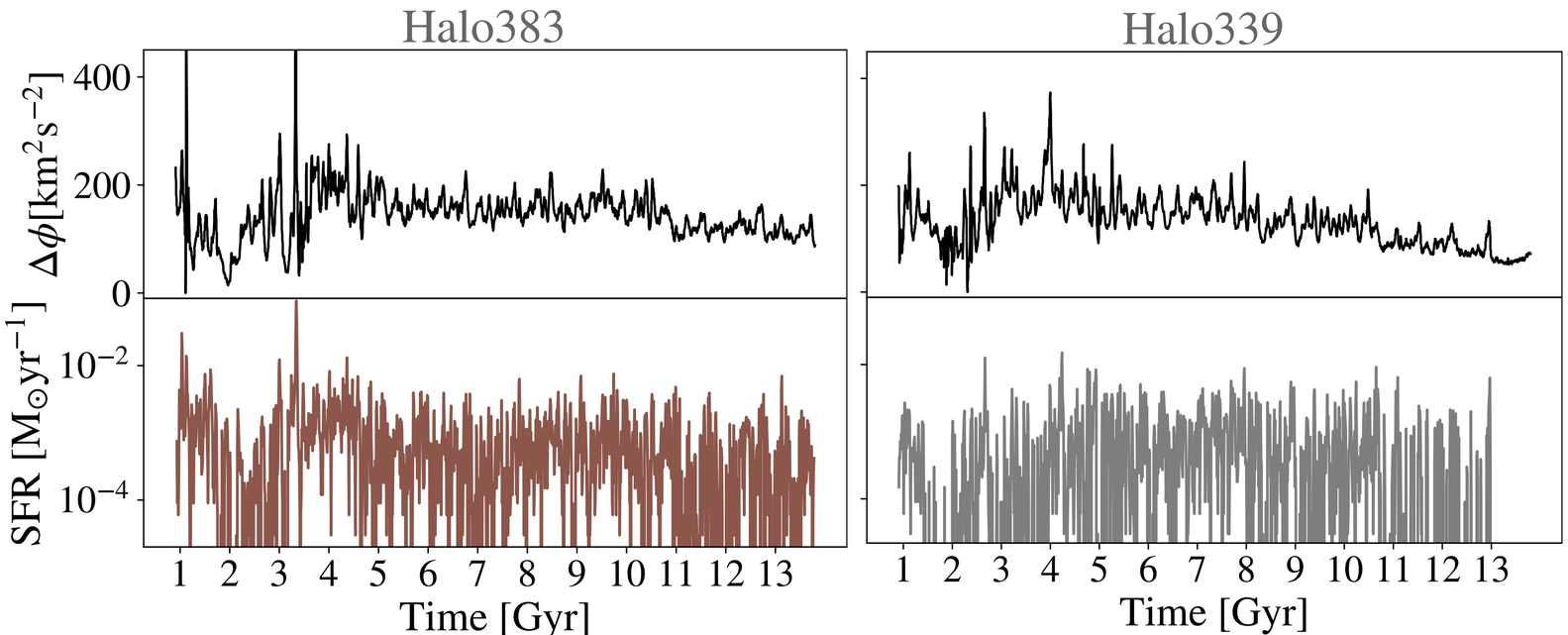


Measured on timescales <5 Myr

Work in progress!

Gravitational potential fluctuations in EDGE





Measured on timescales <5 Myr

Work in progress!

Conclusions

Q: **How** are dark matter density profiles in dwarf galaxies affected by baryons?

- Analysed the dark matter density profiles in EDGE suite
- $M_\star$ / M_{200} — density at z=0 has a lot of scatter
- $M_{\star,\mathrm{post}}$ / $M_{\star,\mathrm{pre}}$ correlates very well with dark matter density
- Independent of some variations to sub-grid and formation history
- Gravitational potential fluctuations in EDGE caused by SNe feedback

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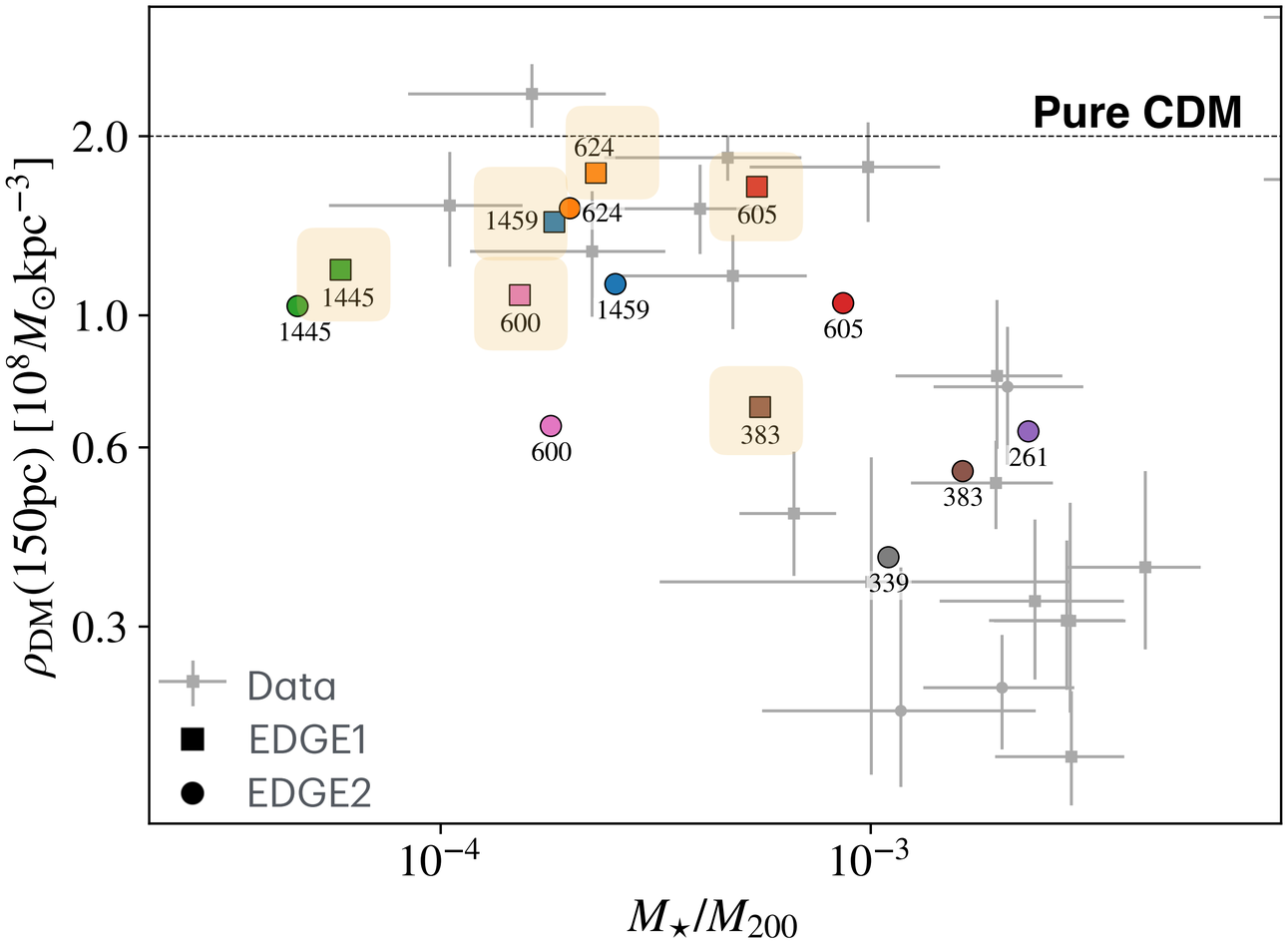
Additional slides

Cusp-core transformation in EDGE

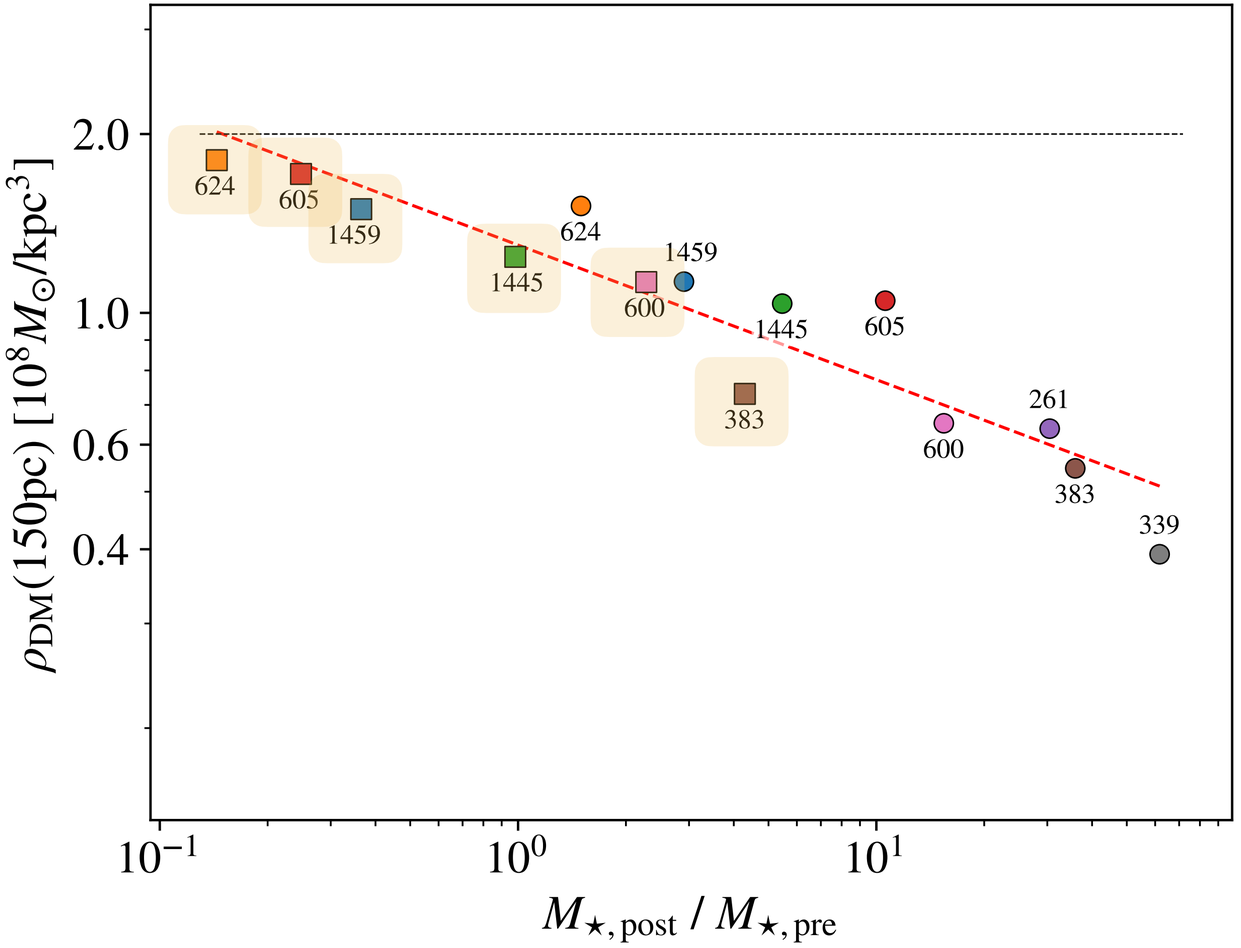
changes to sub-grid

Muni+2025

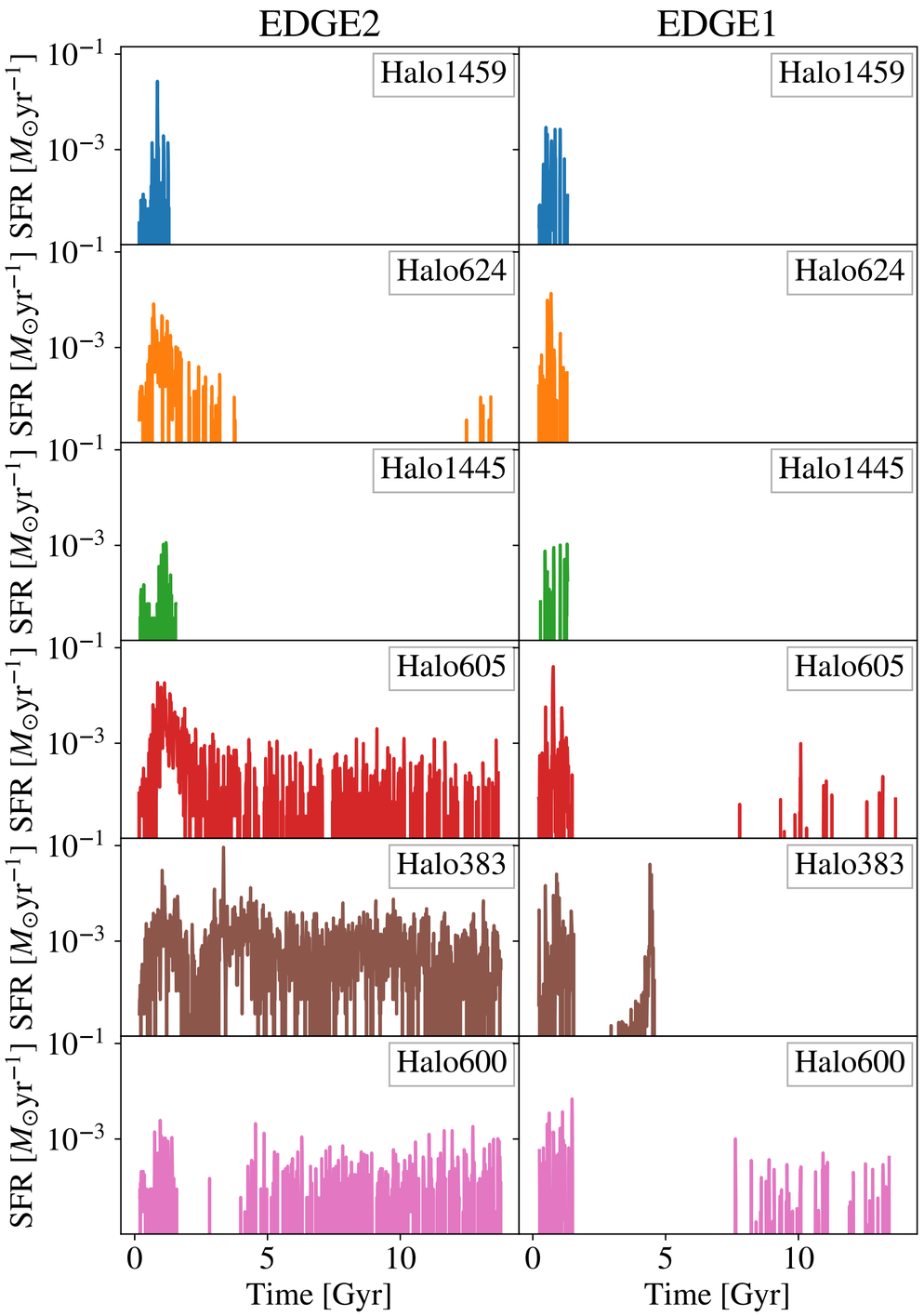


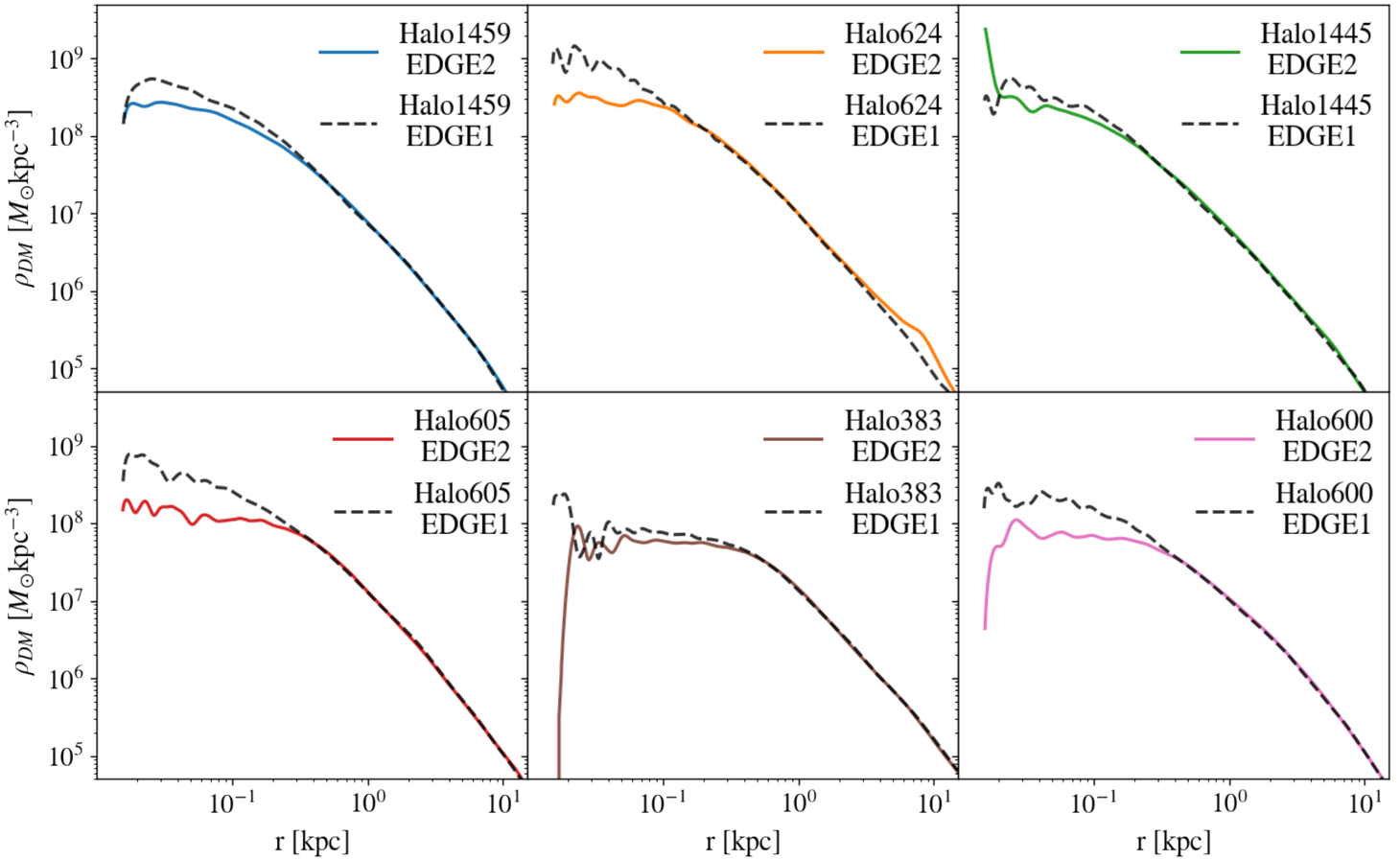
Energy injection

(cf Penarrubia, Pontzen, Walker 2013)

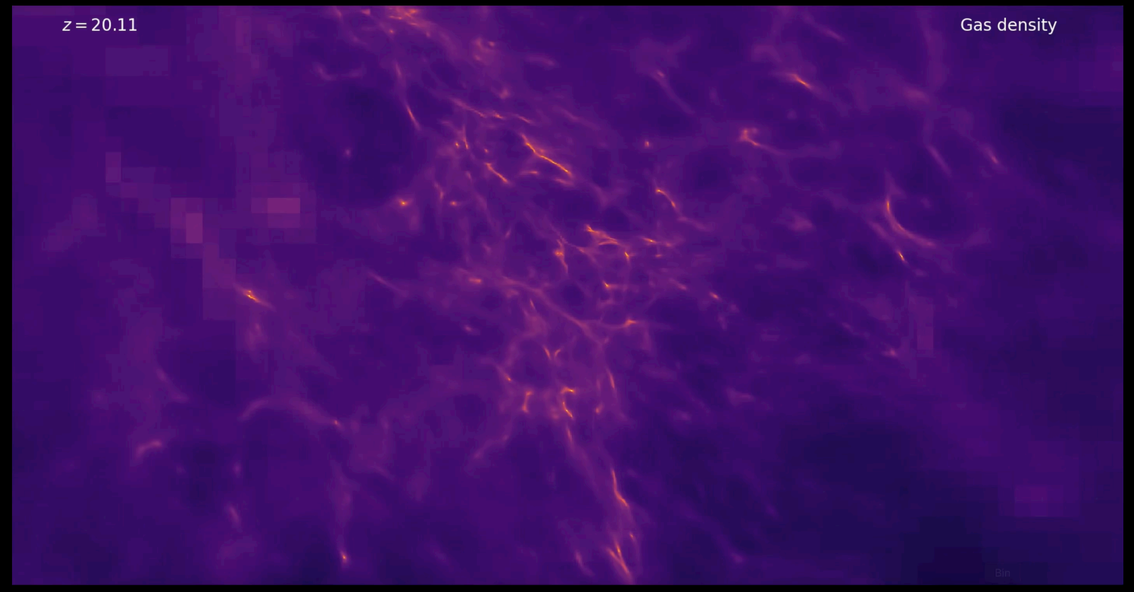


<u>Sustained</u> energy injection


EDGE2
EDGE1
Halo1459
Halo624
Halo1445
Halo605
Halo383
Halo600
SFR [$M_\odot$yr^{-1}]
Time [Gyr]

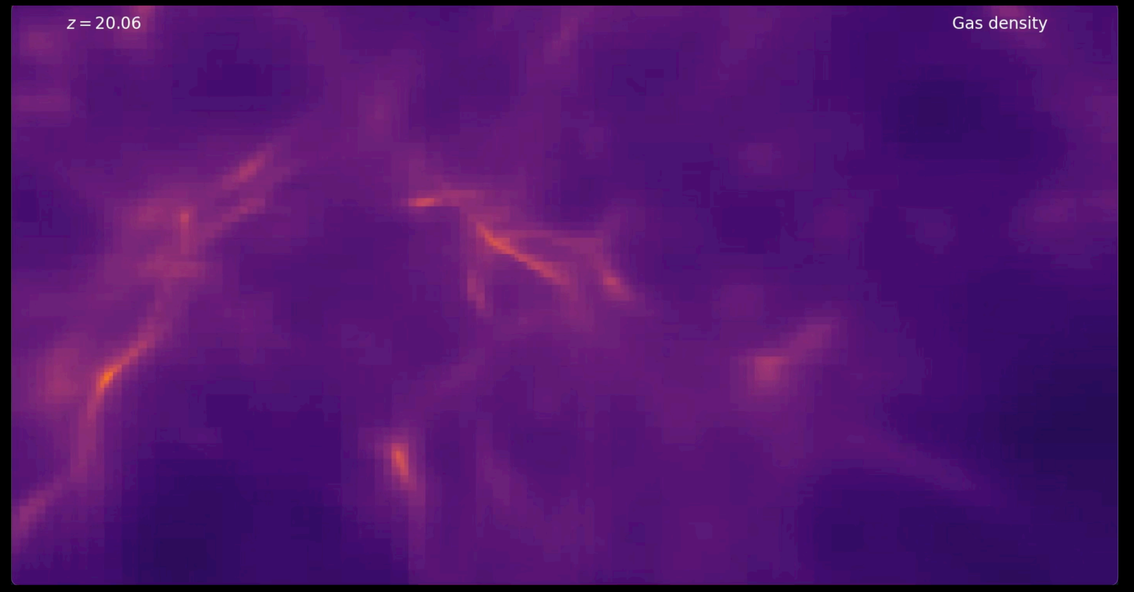

Halo1459 EDGE2
Halo1459 EDGE1
Halo624 EDGE2
Halo624 EDGE1
Halo1445 EDGE2
Halo1445 EDGE1
Halo605 EDGE2
Halo605 EDGE1
Halo383 EDGE2
Halo383 EDGE1
Halo600 EDGE2
Halo600 EDGE1
ρ_{DM} [$M_\odot$kpc^{-3}]
r [kpc]

The importance of reionisation in dwarfs



More massive

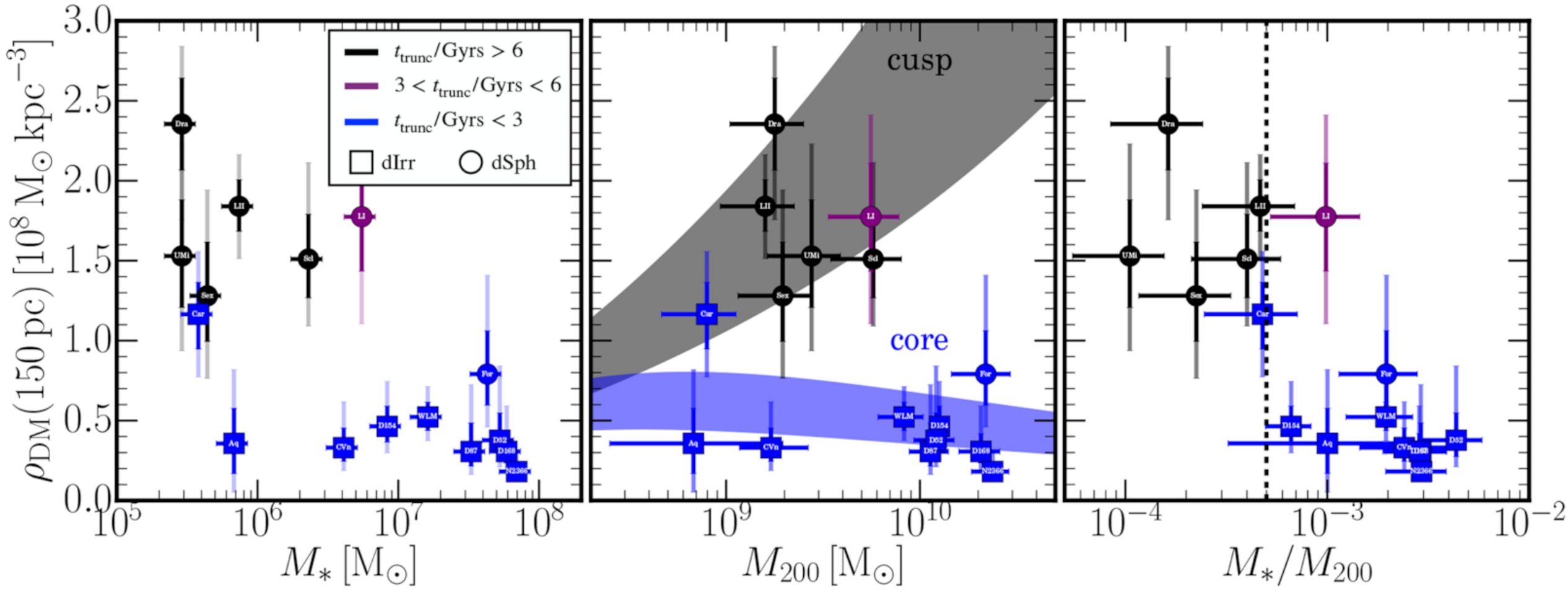
$$M_{200}(z=0) = 7 \times 10^9\ M_\odot$$
$$M_\star(z=0) = 1 \times 10^7\ M_\odot$$



Less massive

$$M_{200}(z=0) = 1 \times 10^9\ M_\odot$$
$$M_\star(z=0) = 6 \times 10^4\ M_\odot$$

Observations of real dwarfs



[Read+2019]