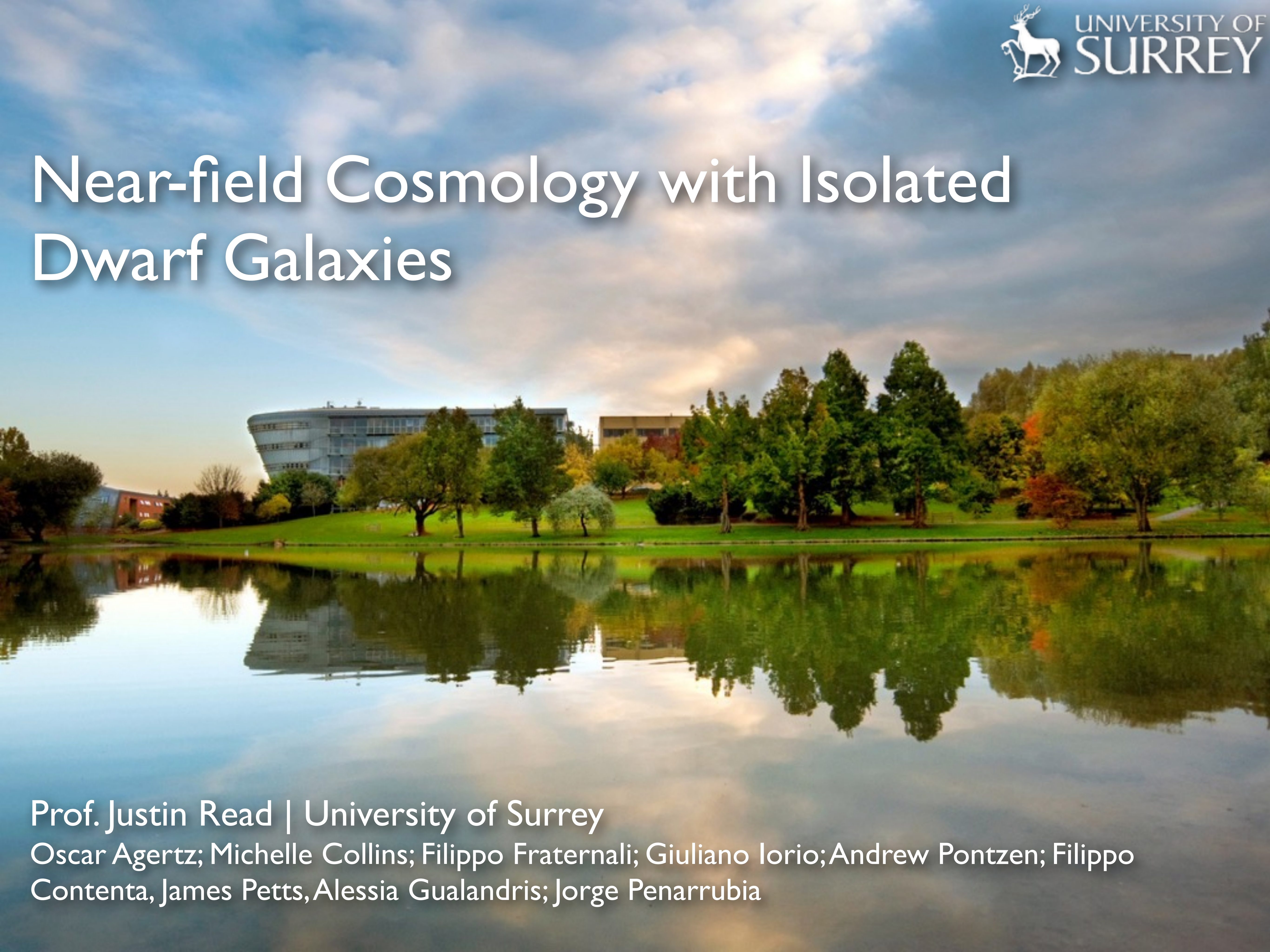


UNIVERSITY OF SURREY

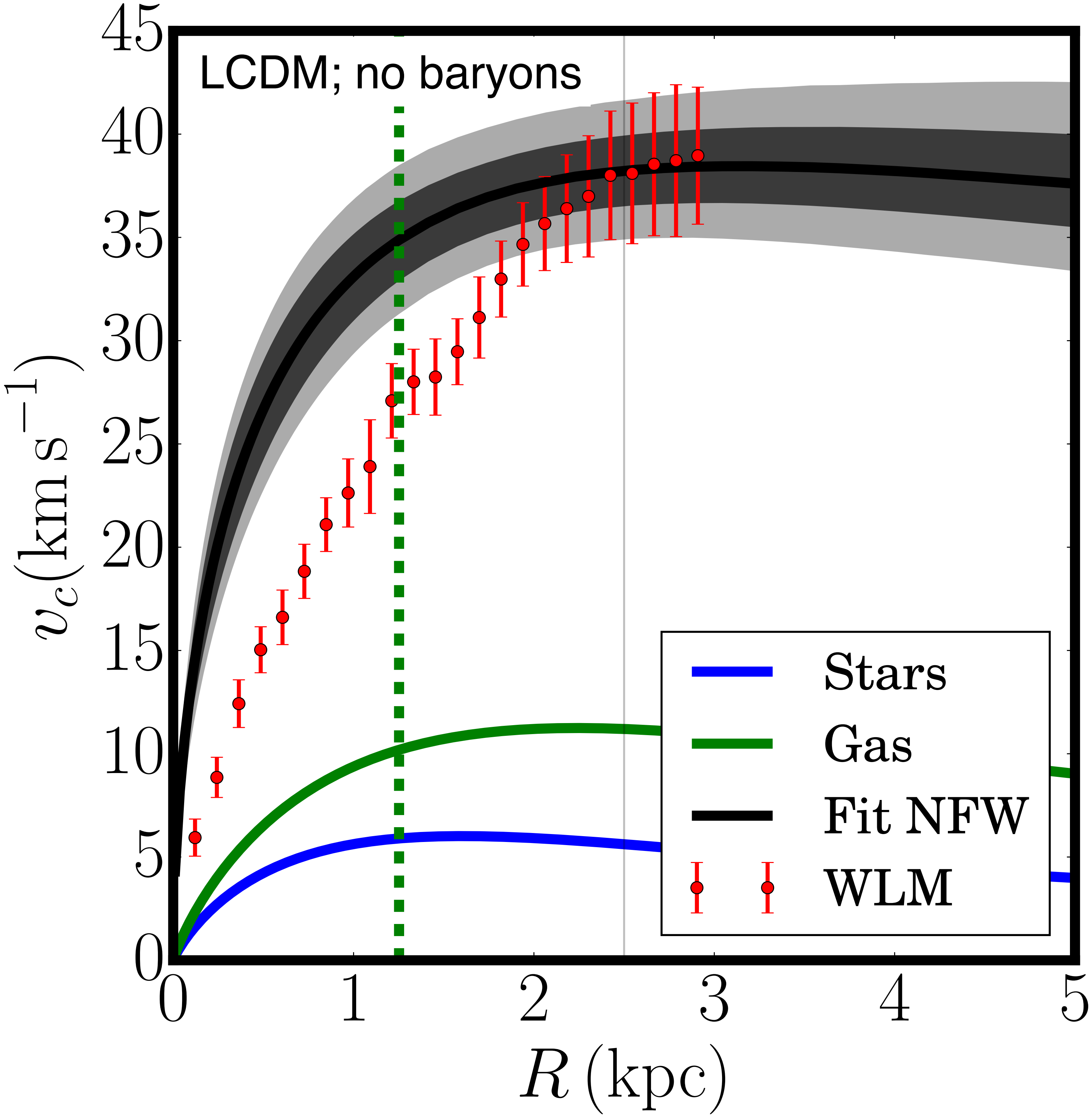
Near-field Cosmology with Isolated Dwarf Galaxies

Prof. Justin Read | University of Surrey
Oscar Agertz; Michelle Collins; Filippo Fraternali; Giuliano Iorio; Andrew Pontzen; Filippo Contenta, James Petts, Alessia Gualandris; Jorge Penarrubia

Background

[LCDM, successes, small scale puzzles]

Background | The 'cusp-core' problem



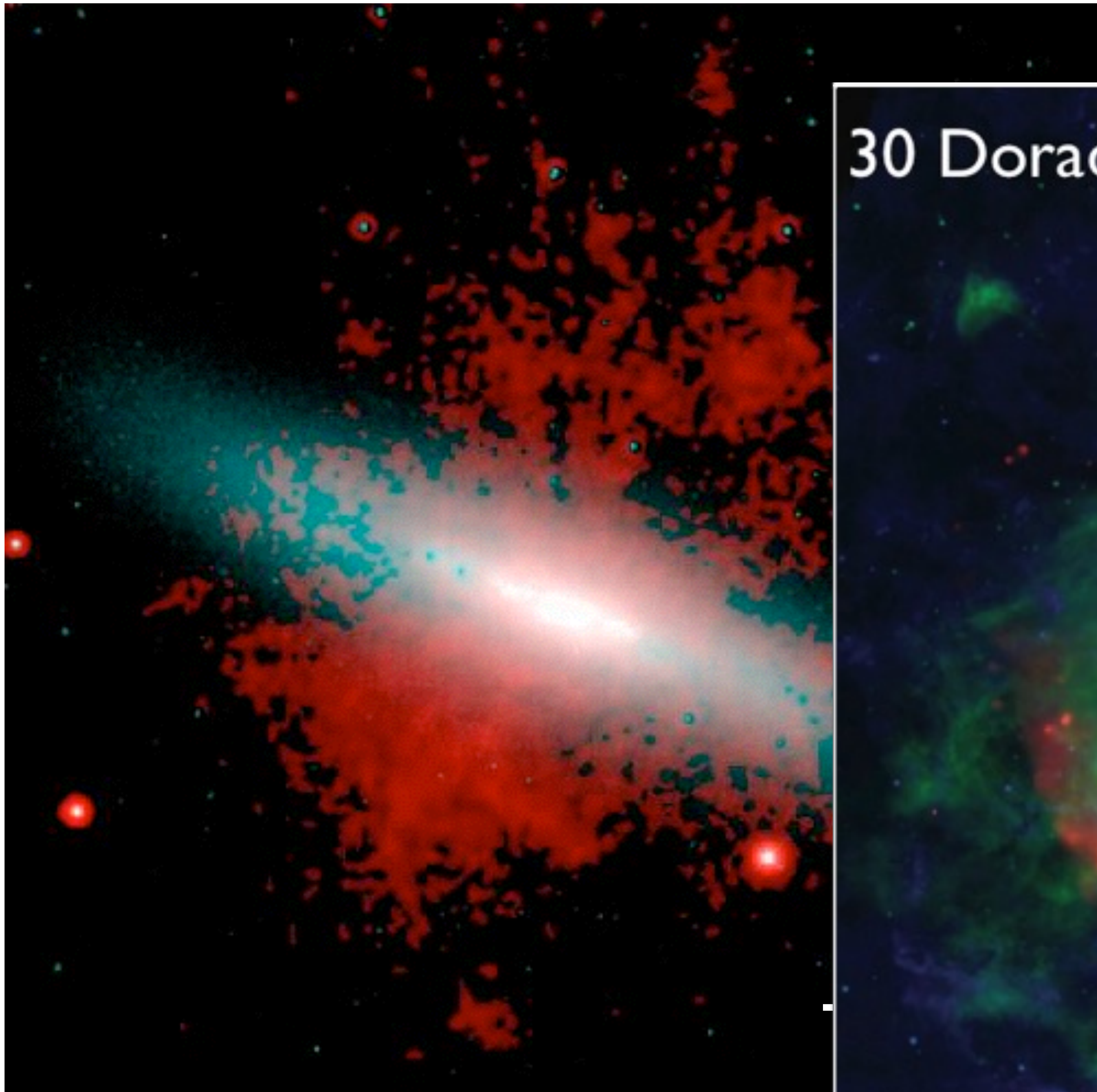
Flores & Primack 1994; Moore 1994; Read et al. 2017

Pure Dark Matter → Observed Universe

Predictive Simulations with baryons

[Getting feedback right for one isolated dwarf]

Simulations | Resolving feedback



Warm H2 in the M82 Galactic wind | Veilleux e

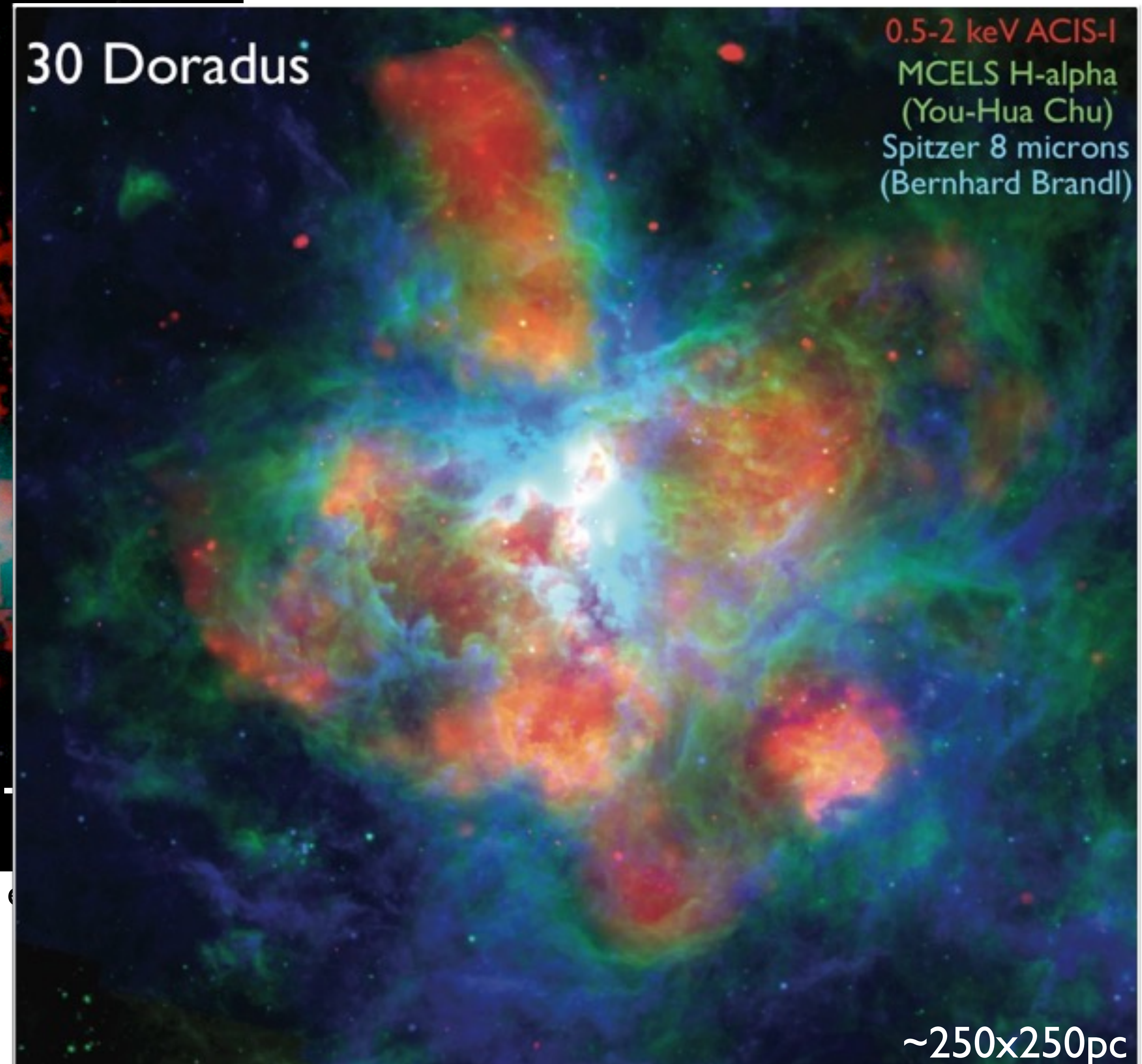


Image composite credit: Leisa Townsley

Simulations | Resolving feedback

$$E_c = 10^{51}\,\mathrm{ergs}$$

$$L = 100\,\mathrm{pc}$$

$$n = 10\,\mathrm{atoms/cc}$$

$$\Rightarrow T_c = 1.7 \times 10^4\,\mathrm{K}$$

$$T_c = \frac{2}{3k_b}\frac{E_c}{nL^3}$$

Agertz et al. 2013; Dalla Vecchia & Schaye 2008

Simulations | Resolving feedback

$$E_c = 10^{51}\,\mathrm{ergs}$$

$L = 100\,\mathrm{pc}$

$n = 10\,\mathrm{atoms/cc}$

$$\Rightarrow T_c = 1.7 \times 10^4\,\mathrm{K}$$

$L = 10\,\mathrm{pc}$

$n = 100\,\mathrm{atoms/cc}$

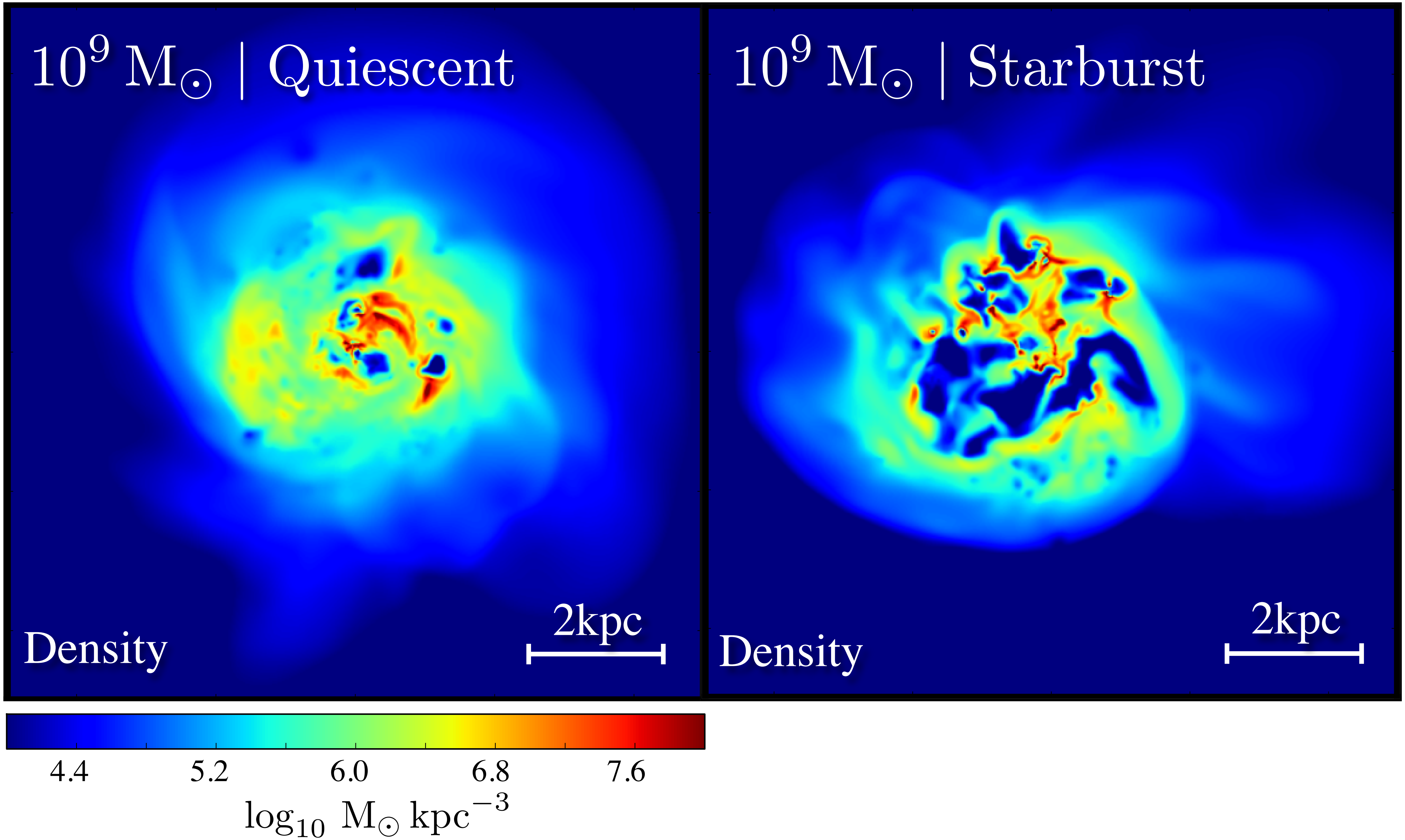
$$\Rightarrow T_c = 1.7 \times 10^6\,\mathrm{K}$$

$$T_c = \frac{2}{3k_b}\frac{E_c}{nL^3}$$

Agertz et al. 2013; Dalla Vecchia & Schaye 2008

Simulations | Resolving feedback

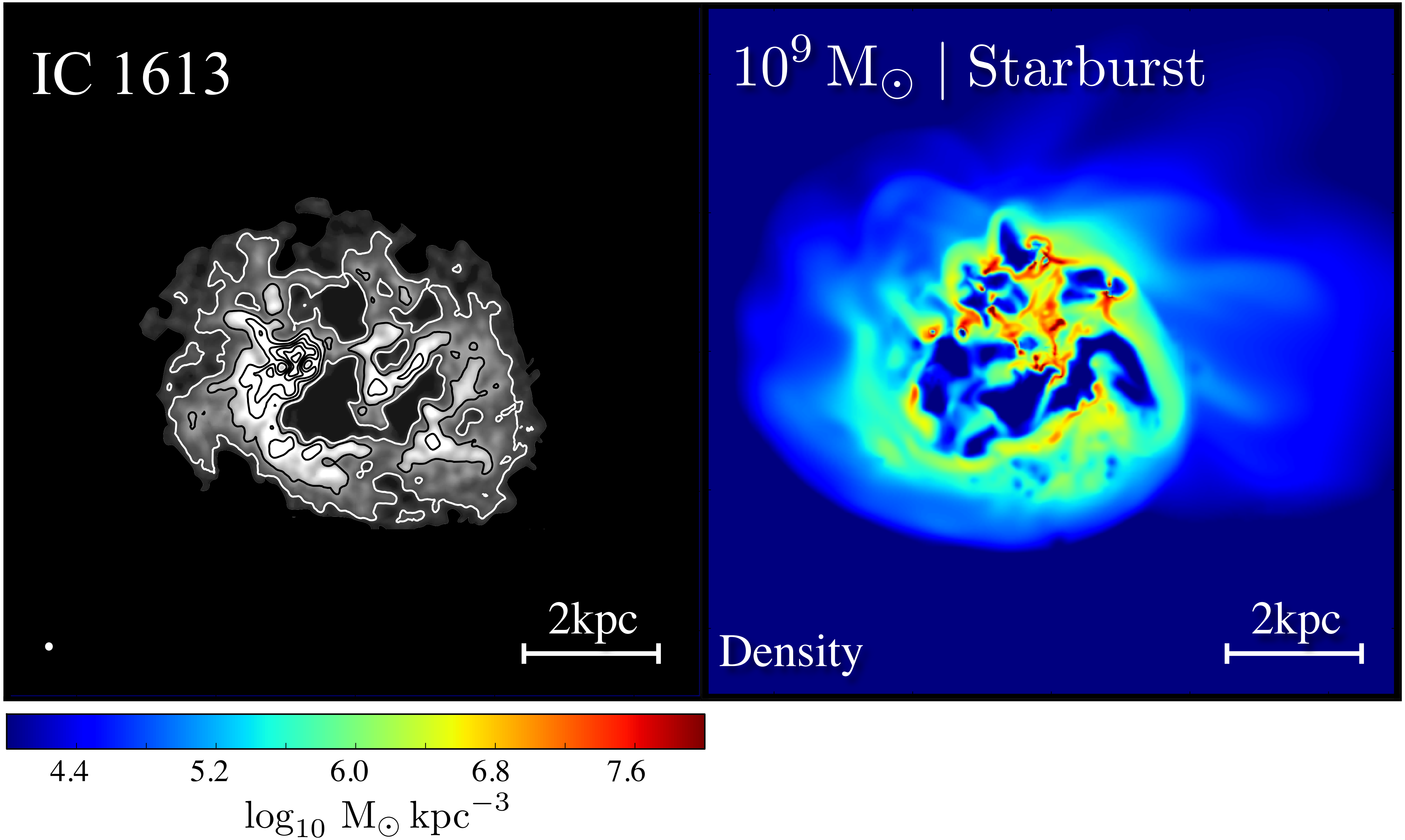
Read et al. 2016a,b



$$\Delta x = 4\,\mathrm{pc} \mid M_* \sim 300\,\mathrm{M}_\odot \mid M_{dm} = 250\,\mathrm{M}_\odot \mid n_{\mathrm{th}} = 300\,\mathrm{atoms\,cm}^{-3}$$

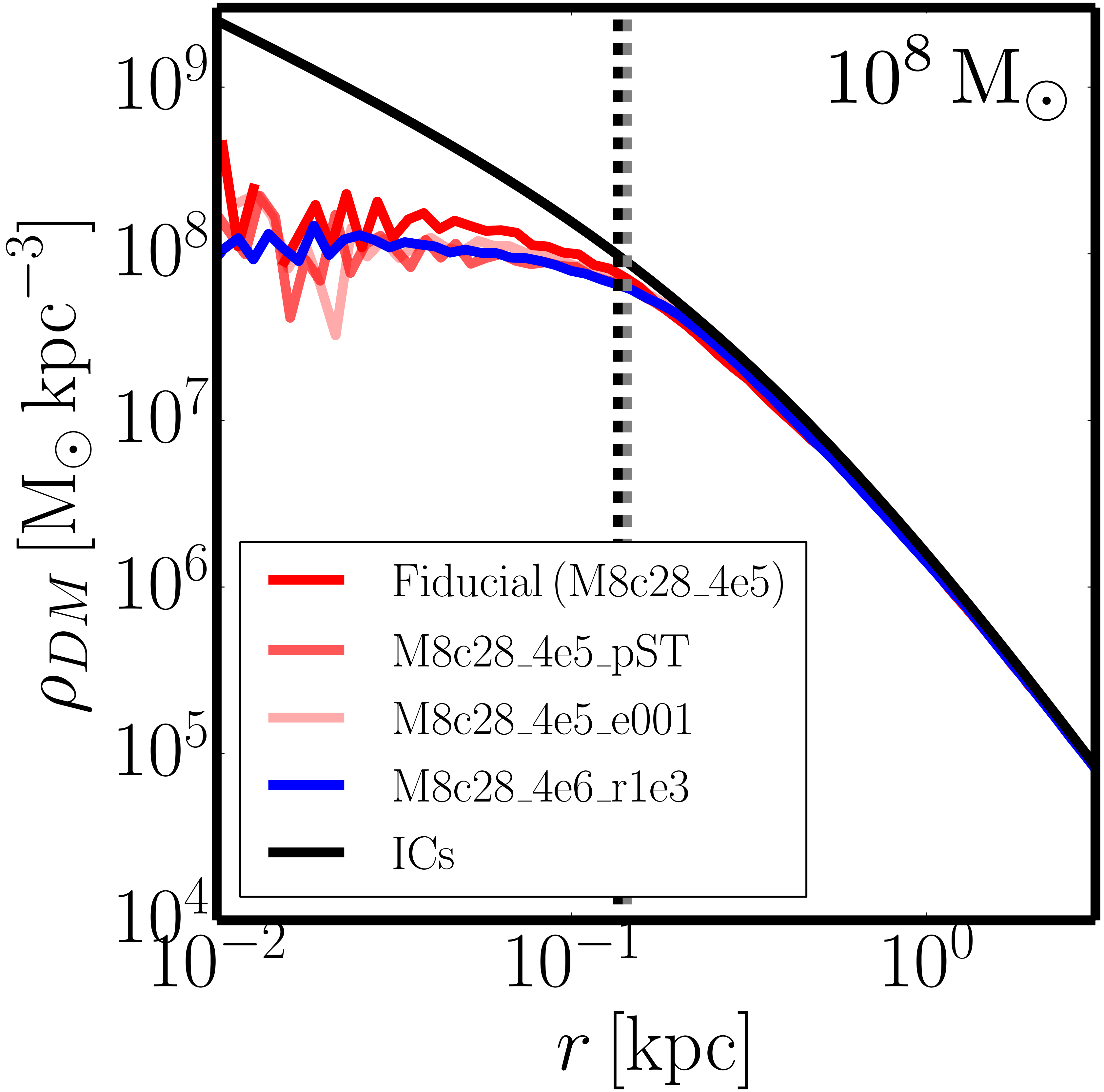
Simulations | Resolving feedback

Read et al. 2016a,b



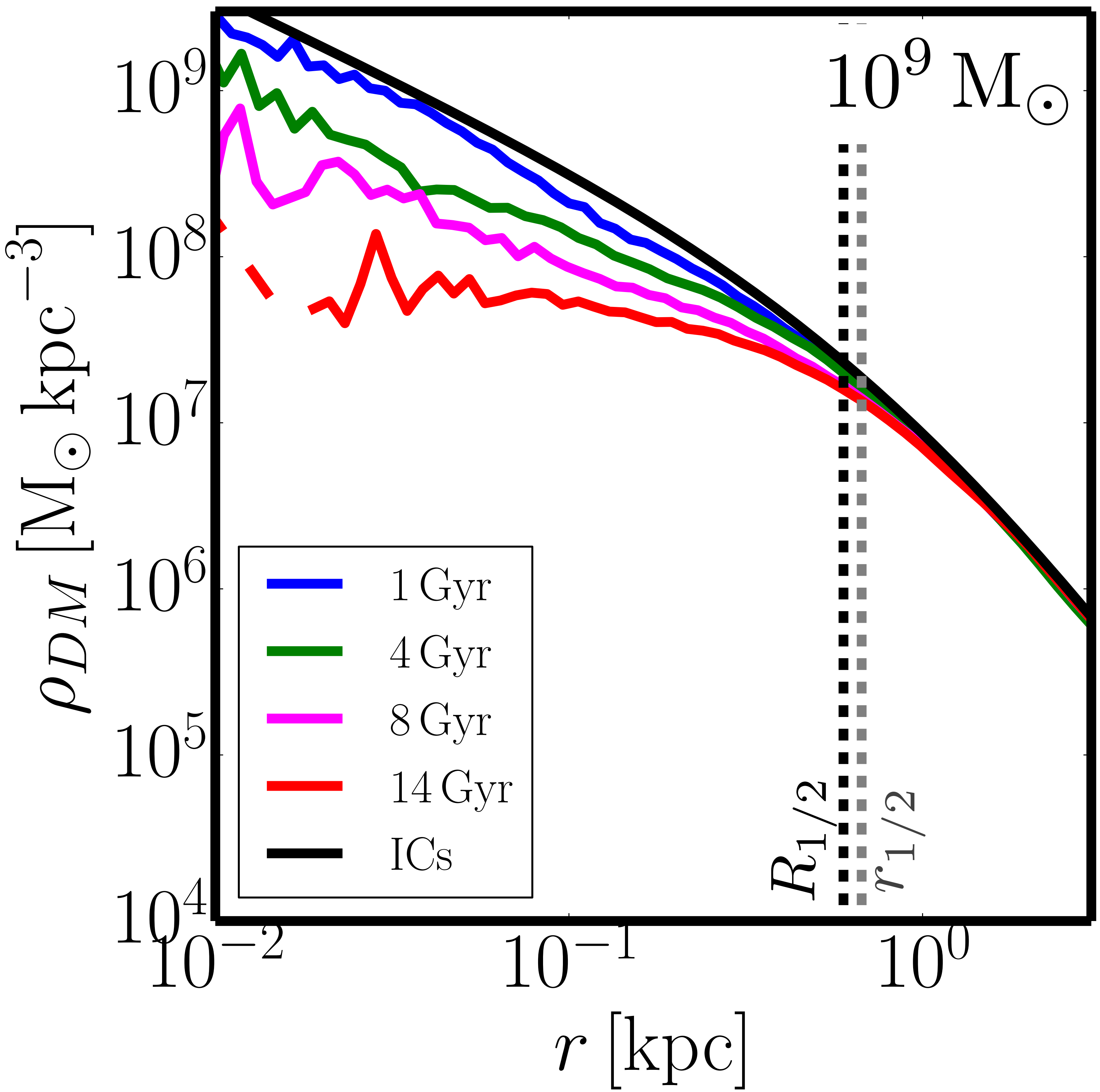
$$\Delta x = 4\,\mathrm{pc} \mid M_* \sim 300\,\mathrm{M}_\odot \mid M_{dm} = 250\,\mathrm{M}_\odot \mid n_{\rm th} = 300\,\mathrm{atoms\,cm}^{-3}$$

Simulations | Cusp-core transformations



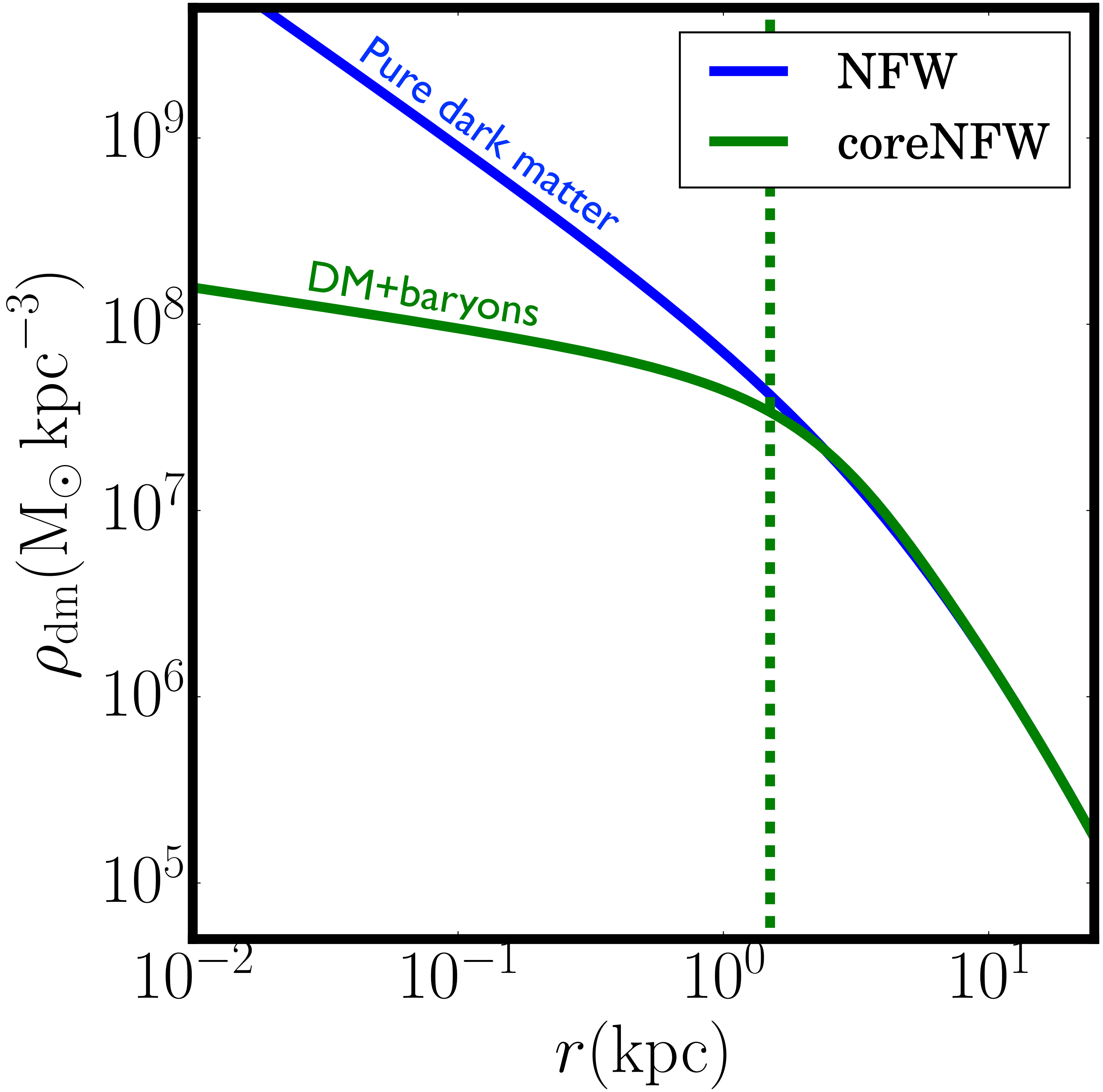
Read et al. 2016

Simulations | Cusp-core transformations



Read et al. 2016; and see Navarro 1996; Read & Gilmore 2005; Pontzen & Governato 2012

Simulations | Cusp-core transformations

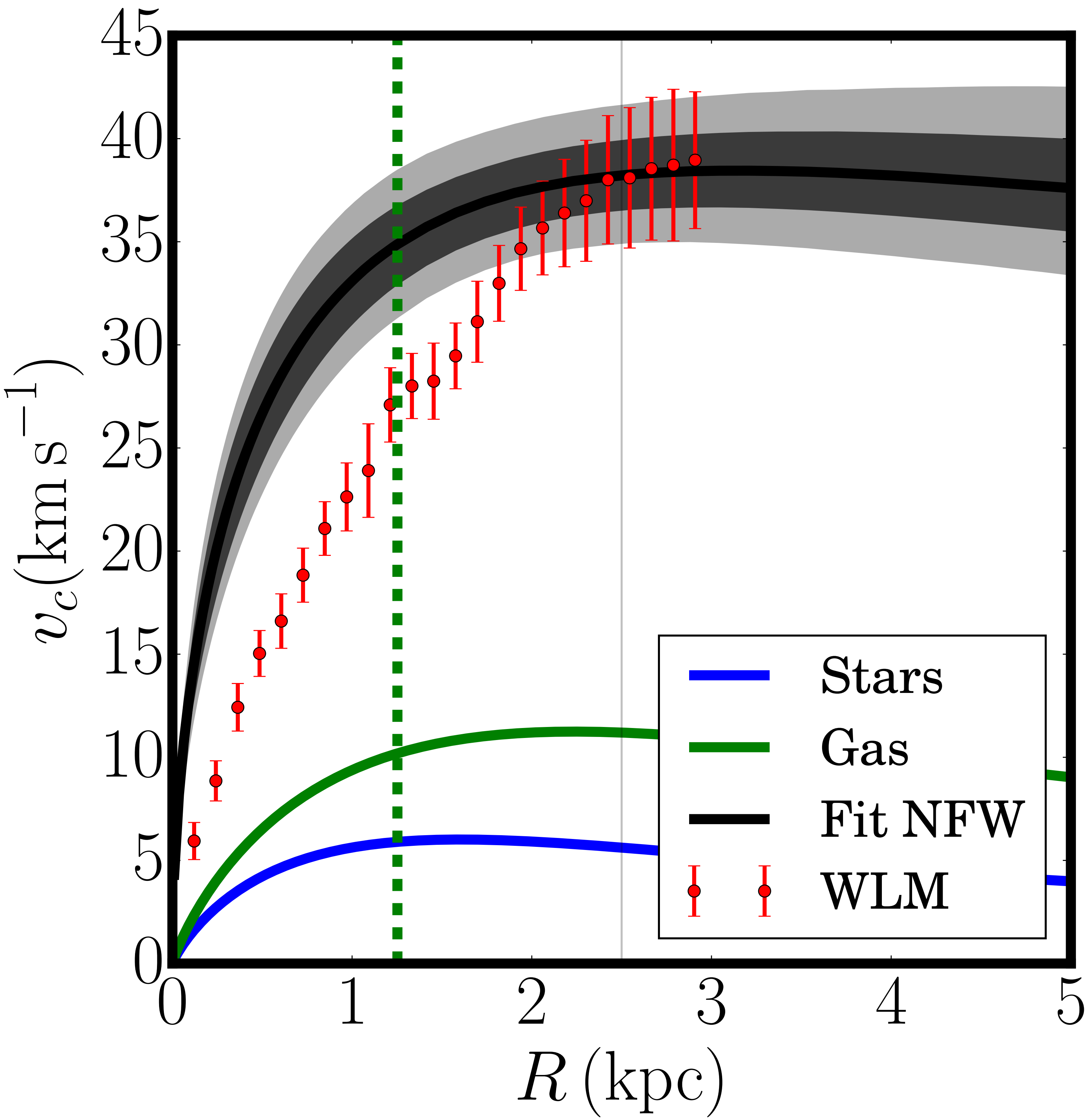


Read et al. 2016; and see di Cintio et al. 2014; Onorbe et al. 2015; Munshi et al. 2017

Isolated dwarfs

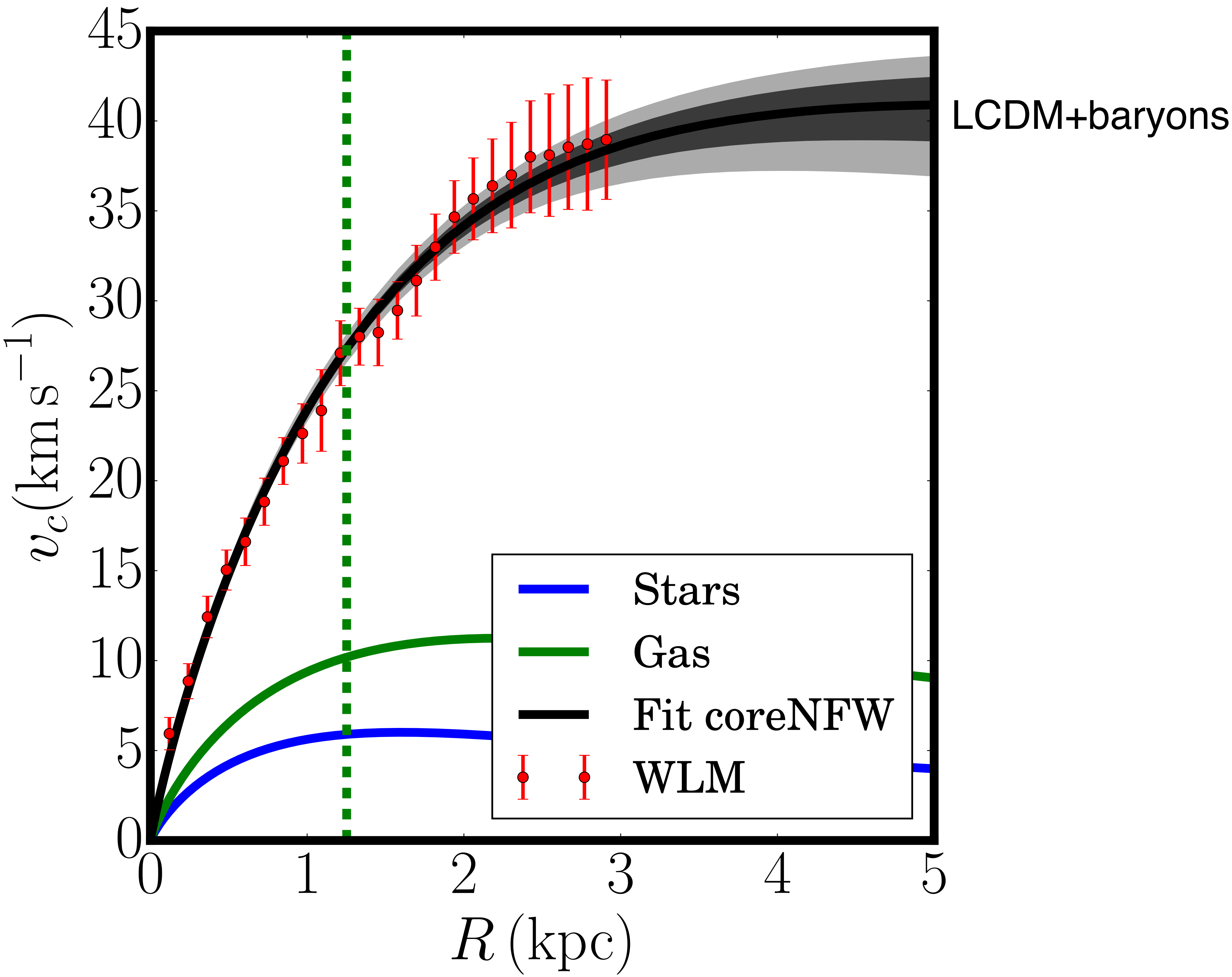
[rotation curves + abundance matching]

Measurement | Rotation curves

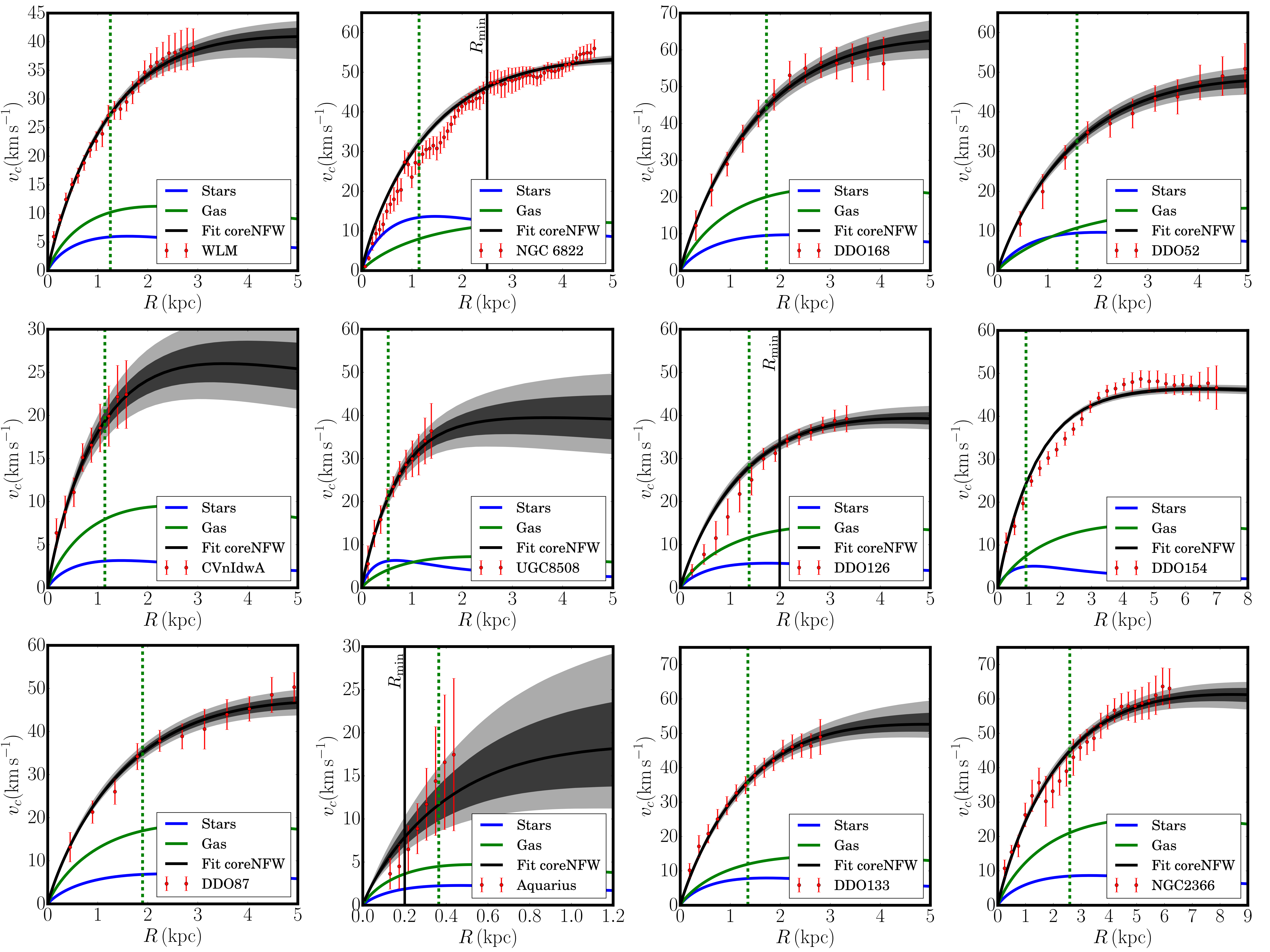


Read et al. 2016a,b; Read et al. 2017

Measurement | Rotation curves



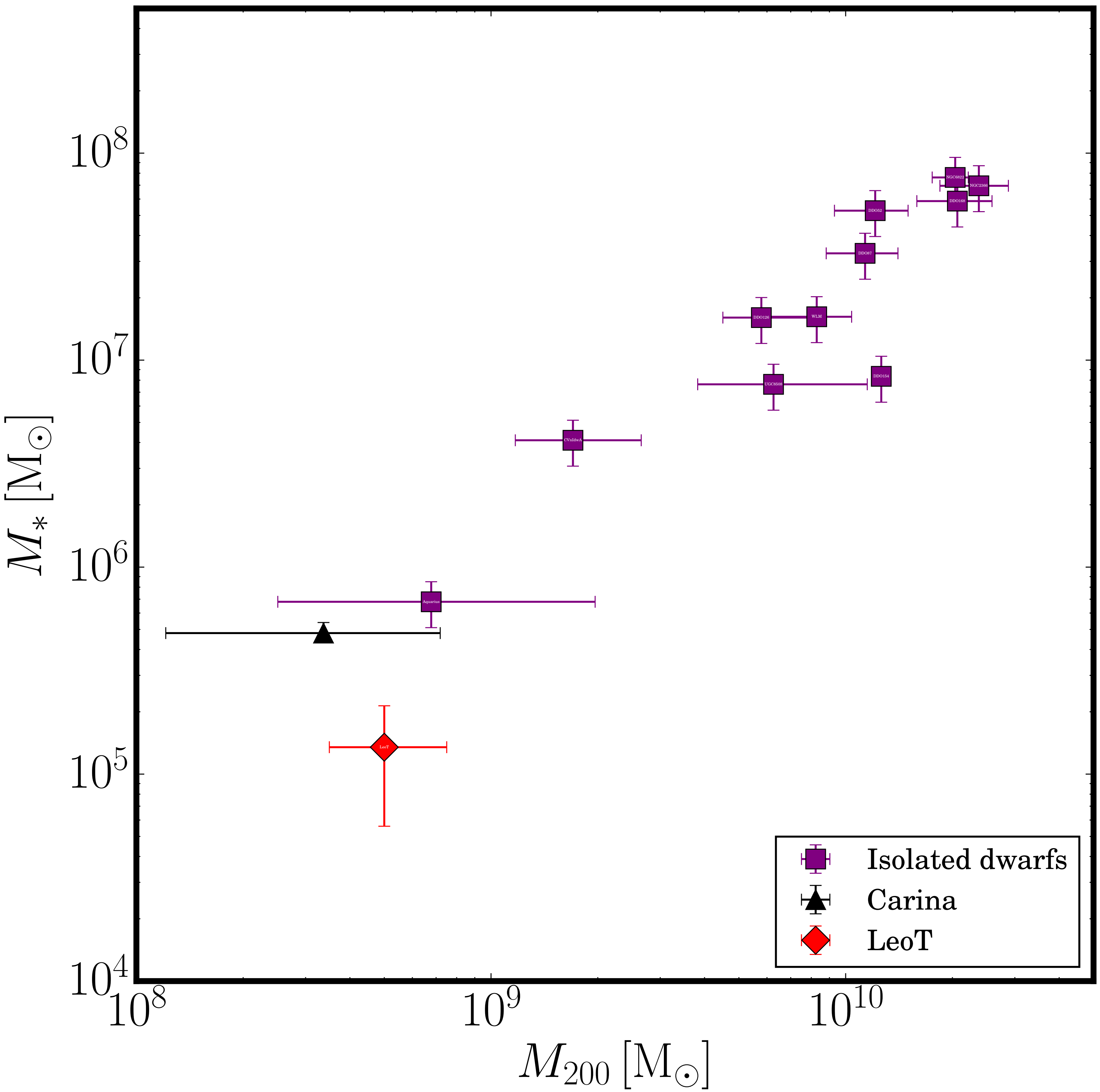
Read et al. 2016a,b; Read et al. 2017



WLM
NGC 6822
DDO168
DDO52
CVnIdwA
UGC8508
DDO126
DDO154
DDO87
Aquarius
DDO133
NGC2366
Stars
Gas
Fit coreNFW
$R_{\rm min}$
$v_c\,(\rm km\,s^{-1})$
$R\,(\rm kpc)$

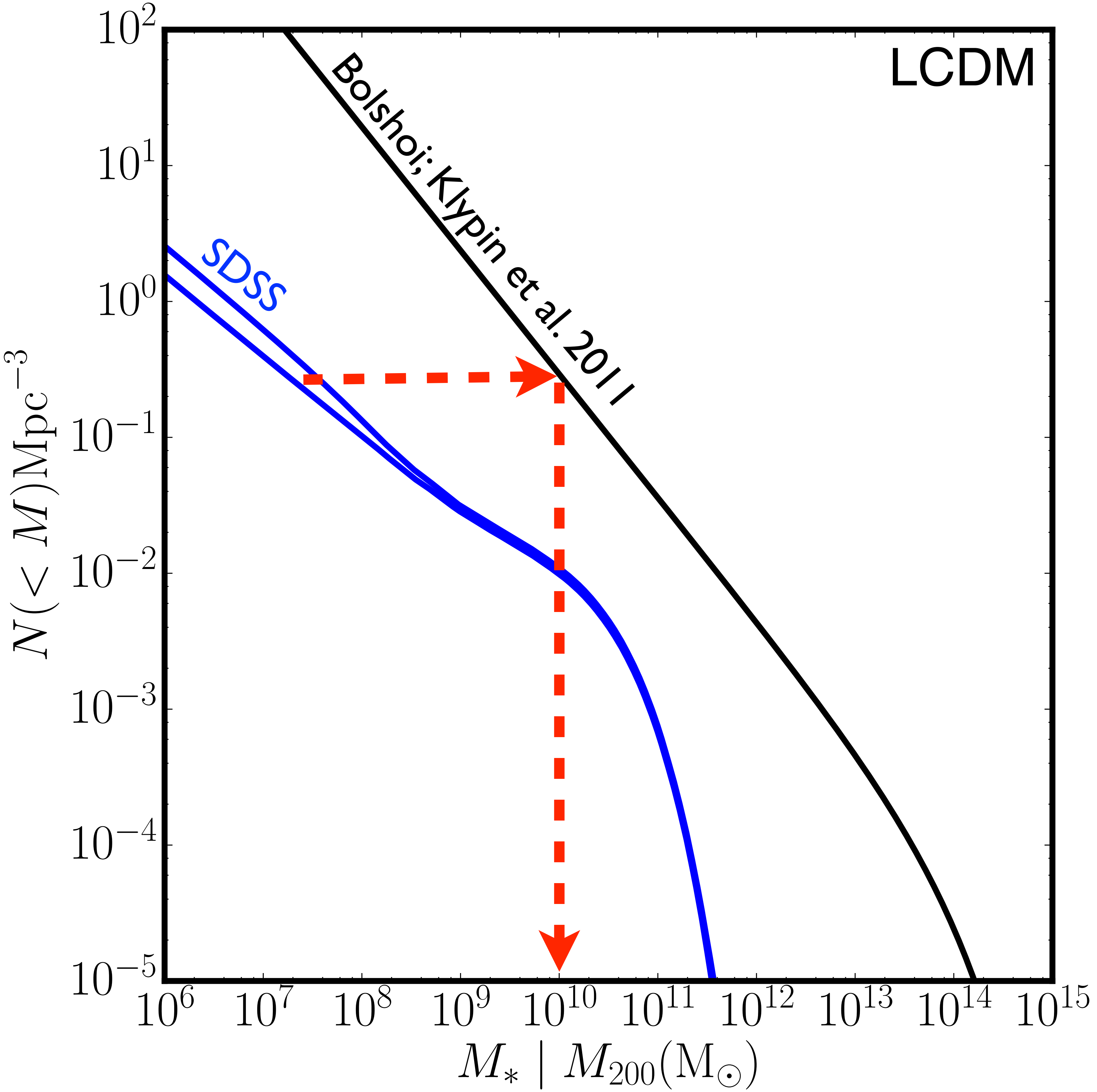
The stellar mass-halo mass relation

Measurement | The stellar mass-halo mass relation



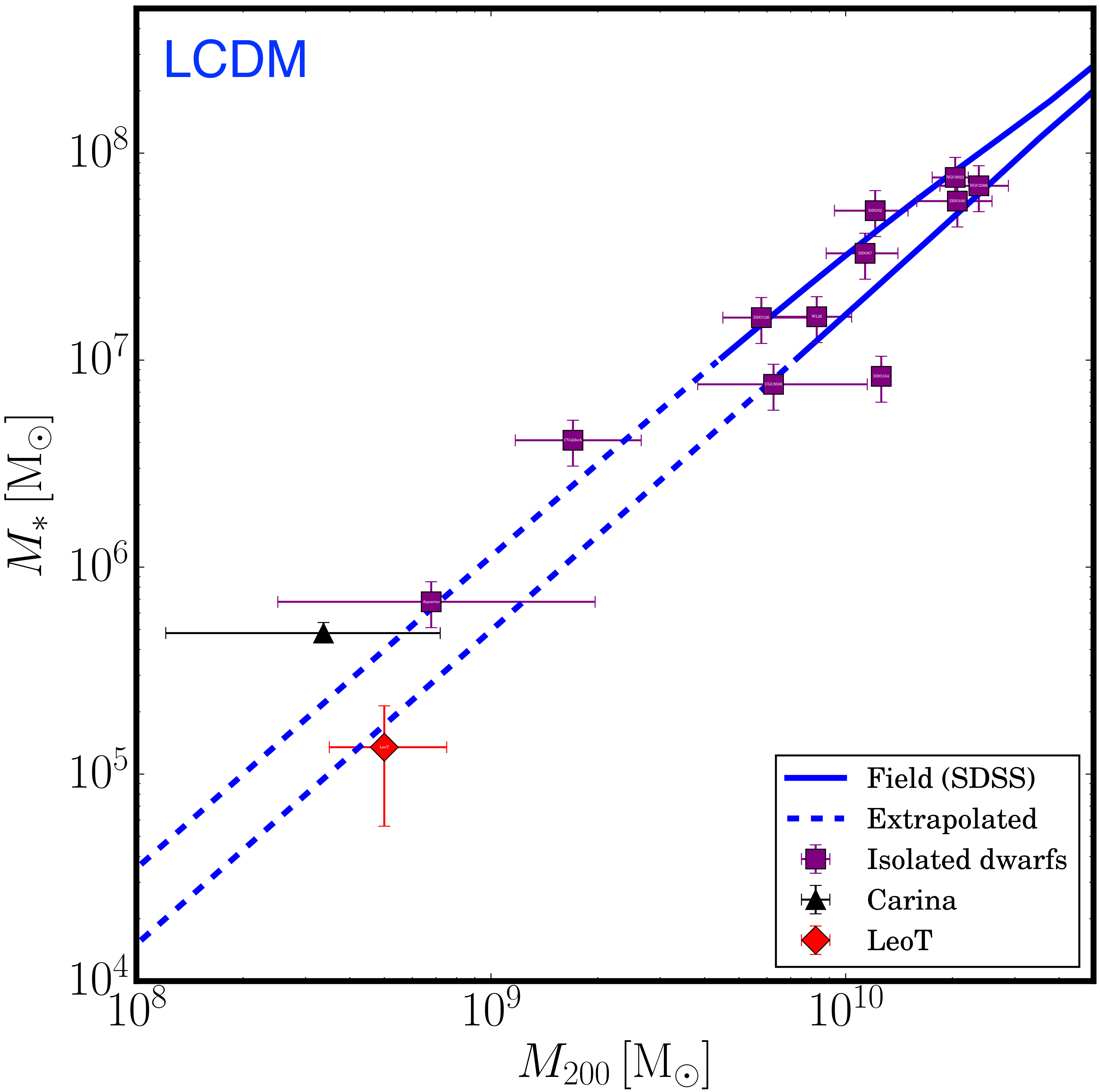
Read et al. 2016a,b; Read et al. 2017

Measurement | The stellar mass-halo mass relation



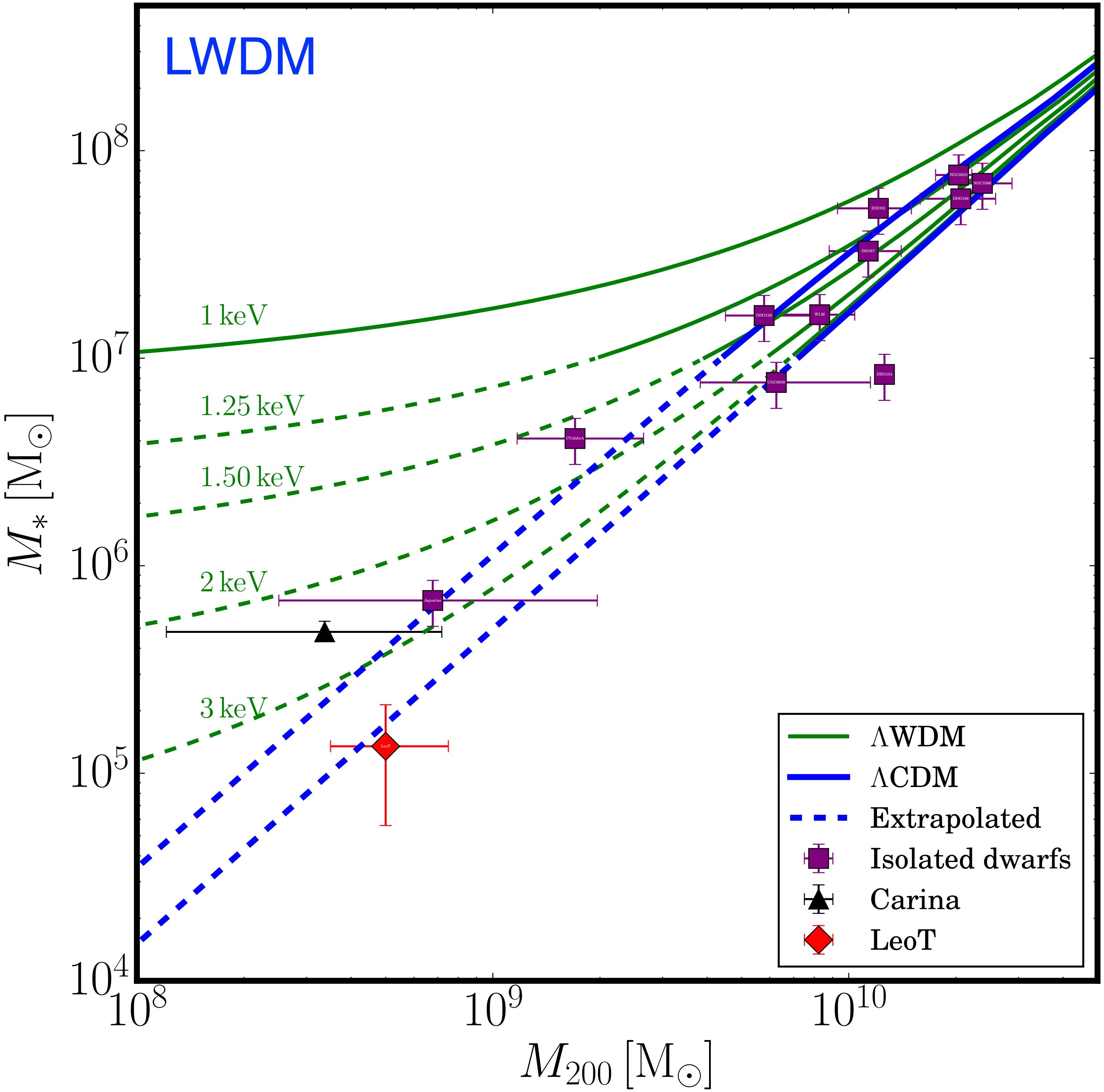
Read et al. 2016a,b; Read et al. 2017

Measurement | The stellar mass-halo mass relation



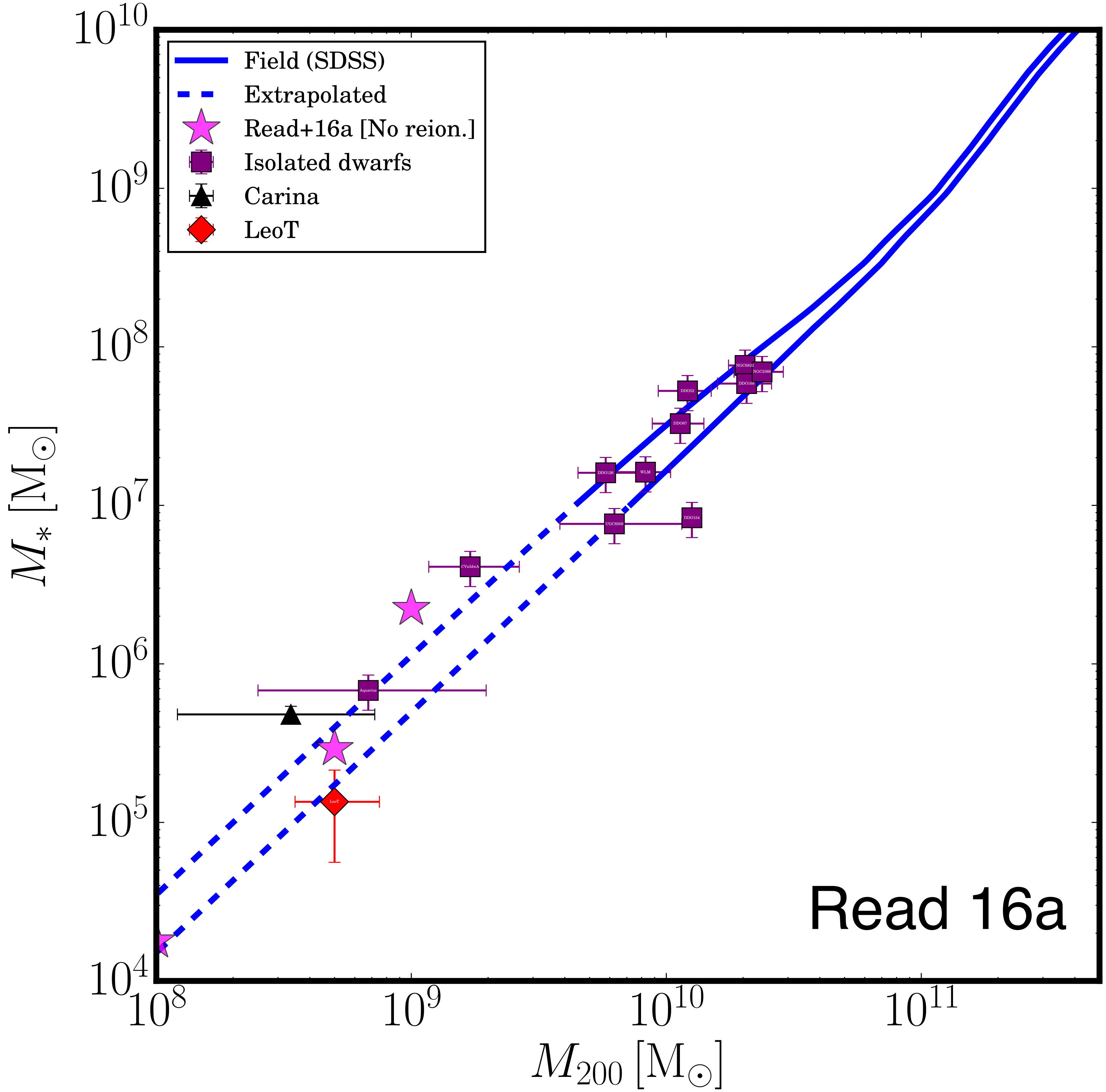
Read et al. 2016a,b; Read et al. 2017

Measurement | The stellar mass-halo mass relation



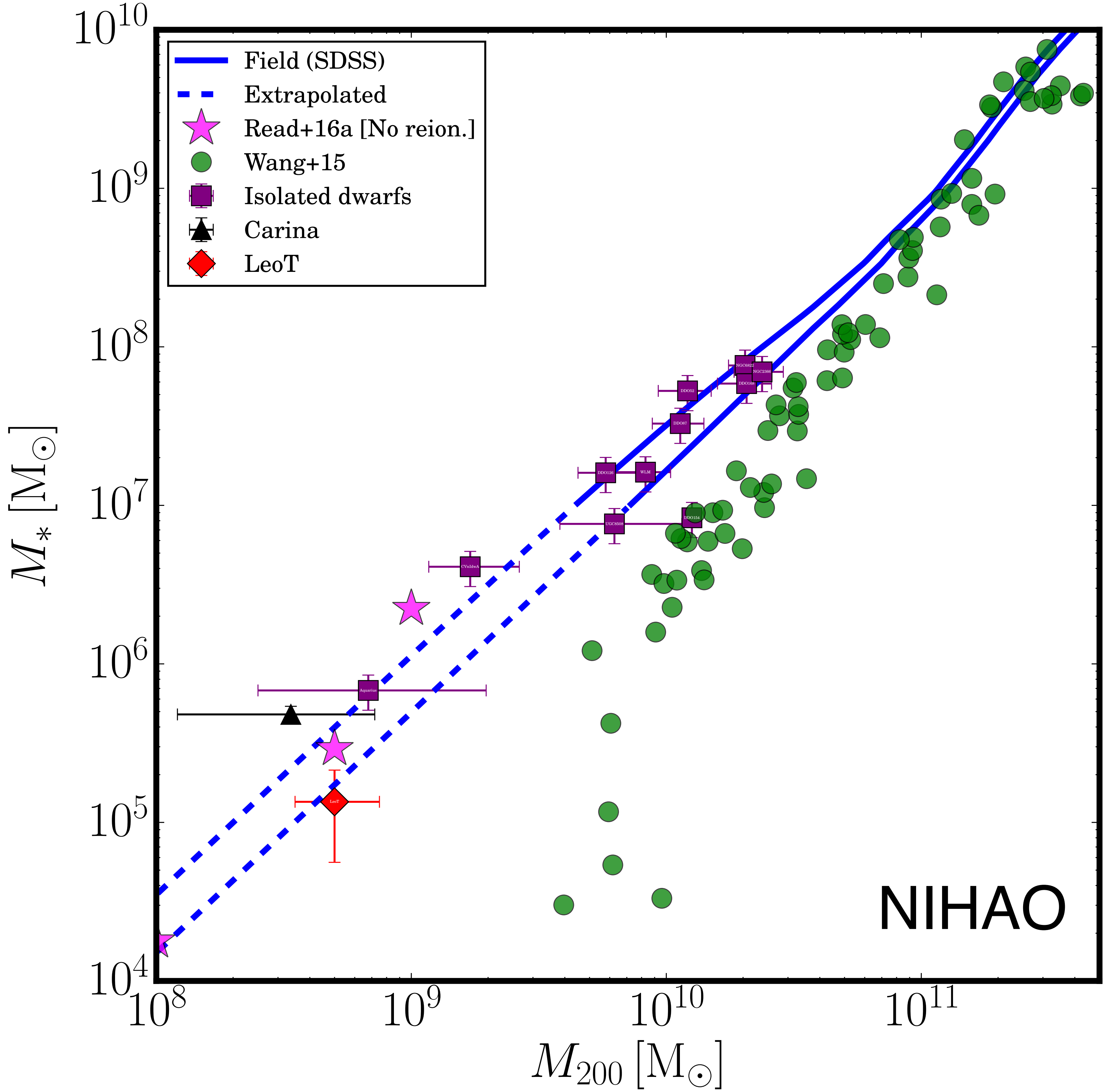
Read et al. 2016a,b; Read et al. 2017

Measurement | The stellar mass-halo mass relation



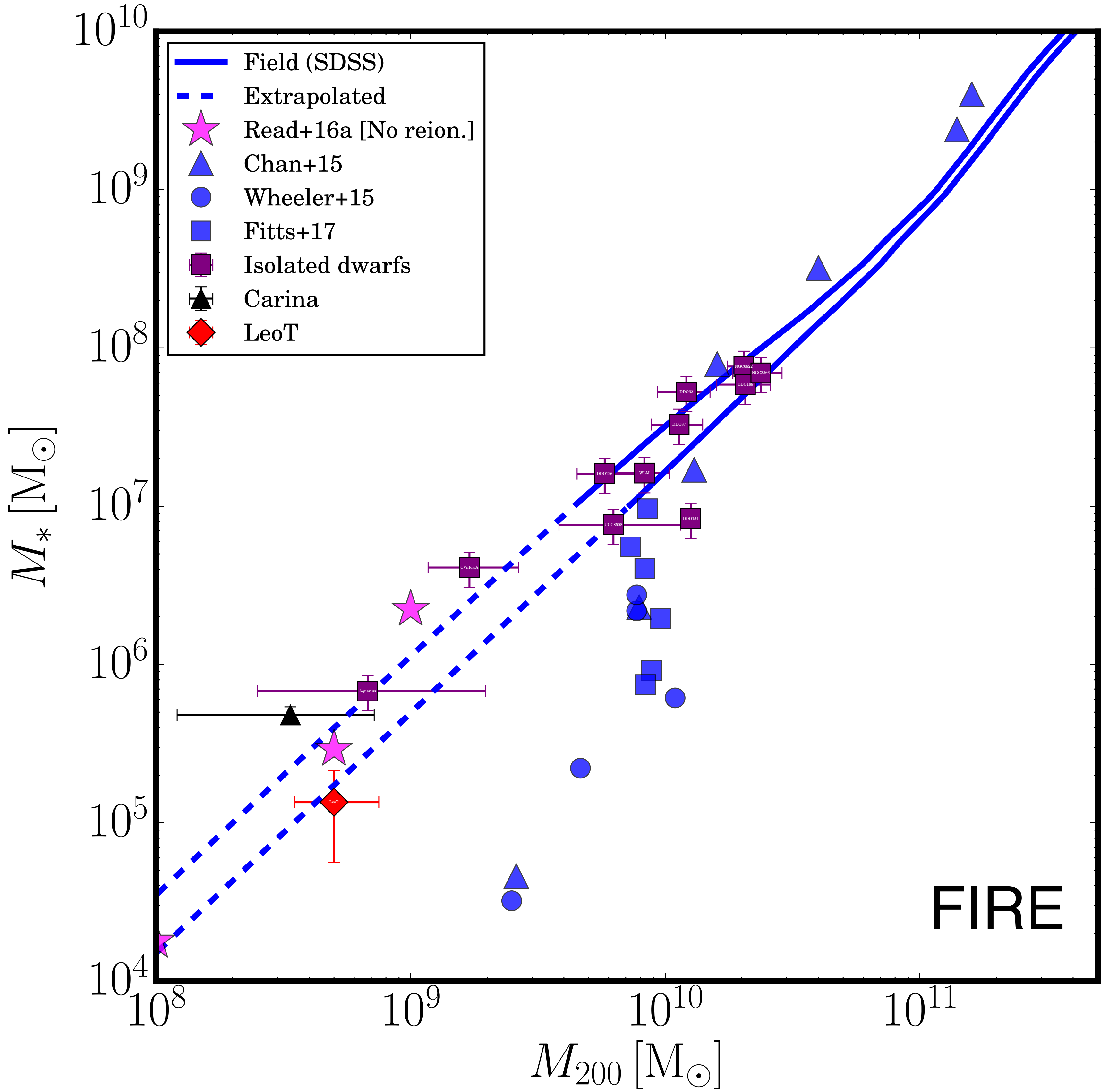
Contenta et al. 2017

Measurement | The stellar mass-halo mass relation



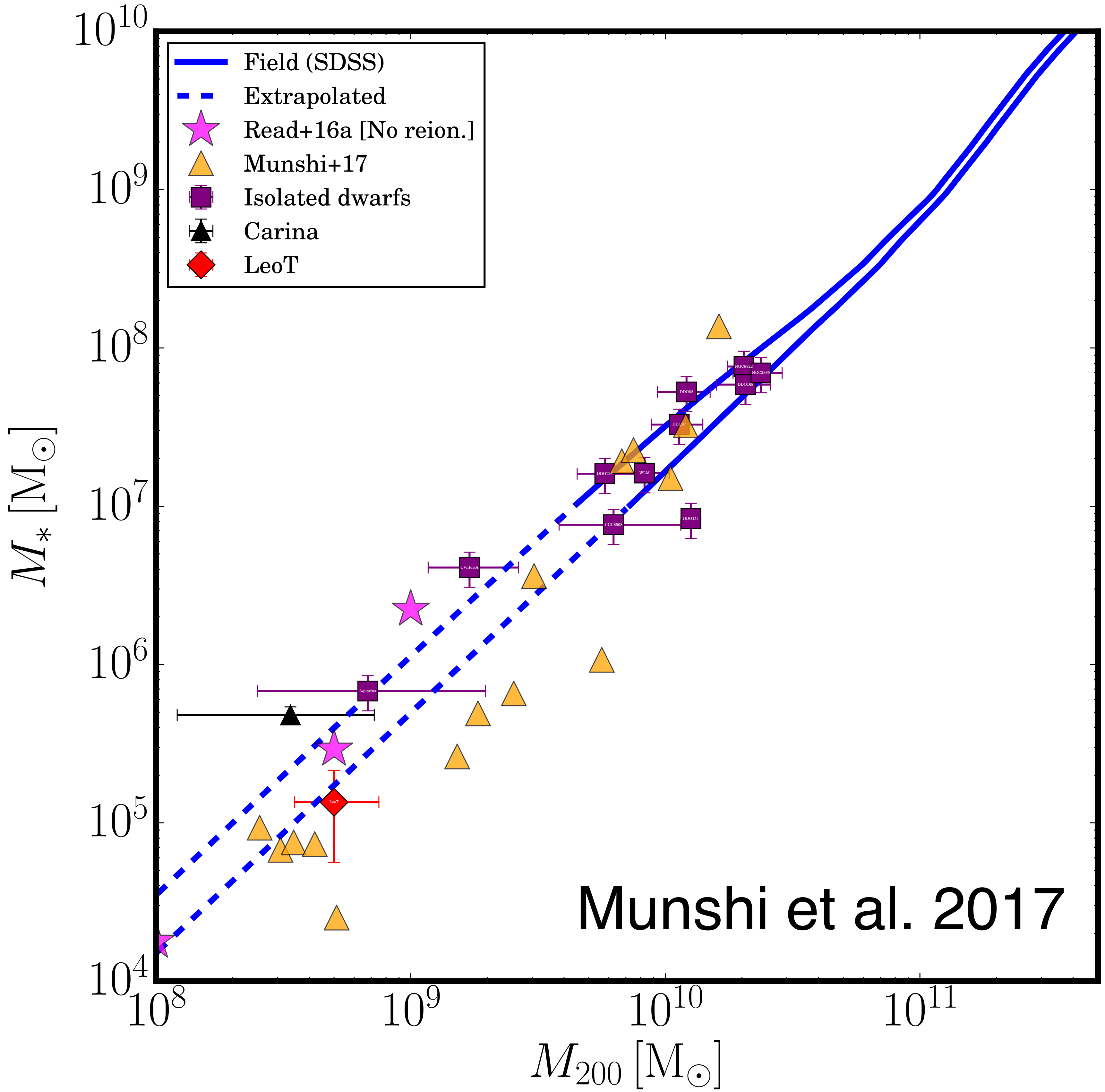
Contenta et al. 2017

Measurement | The stellar mass-halo mass relation



Contenta et al. 2017

Measurement | The stellar mass-halo mass relation

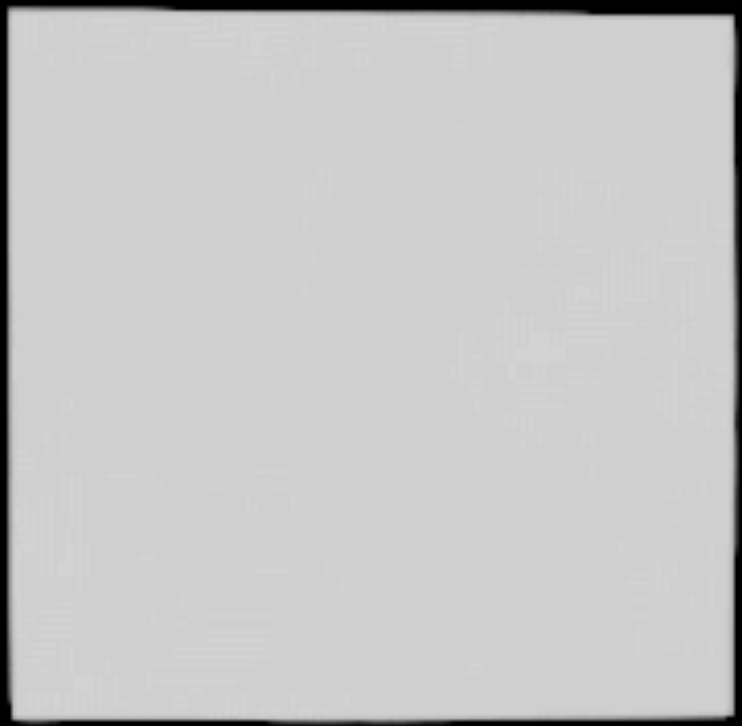


Contenta et al. 2017

Cosmological simulations

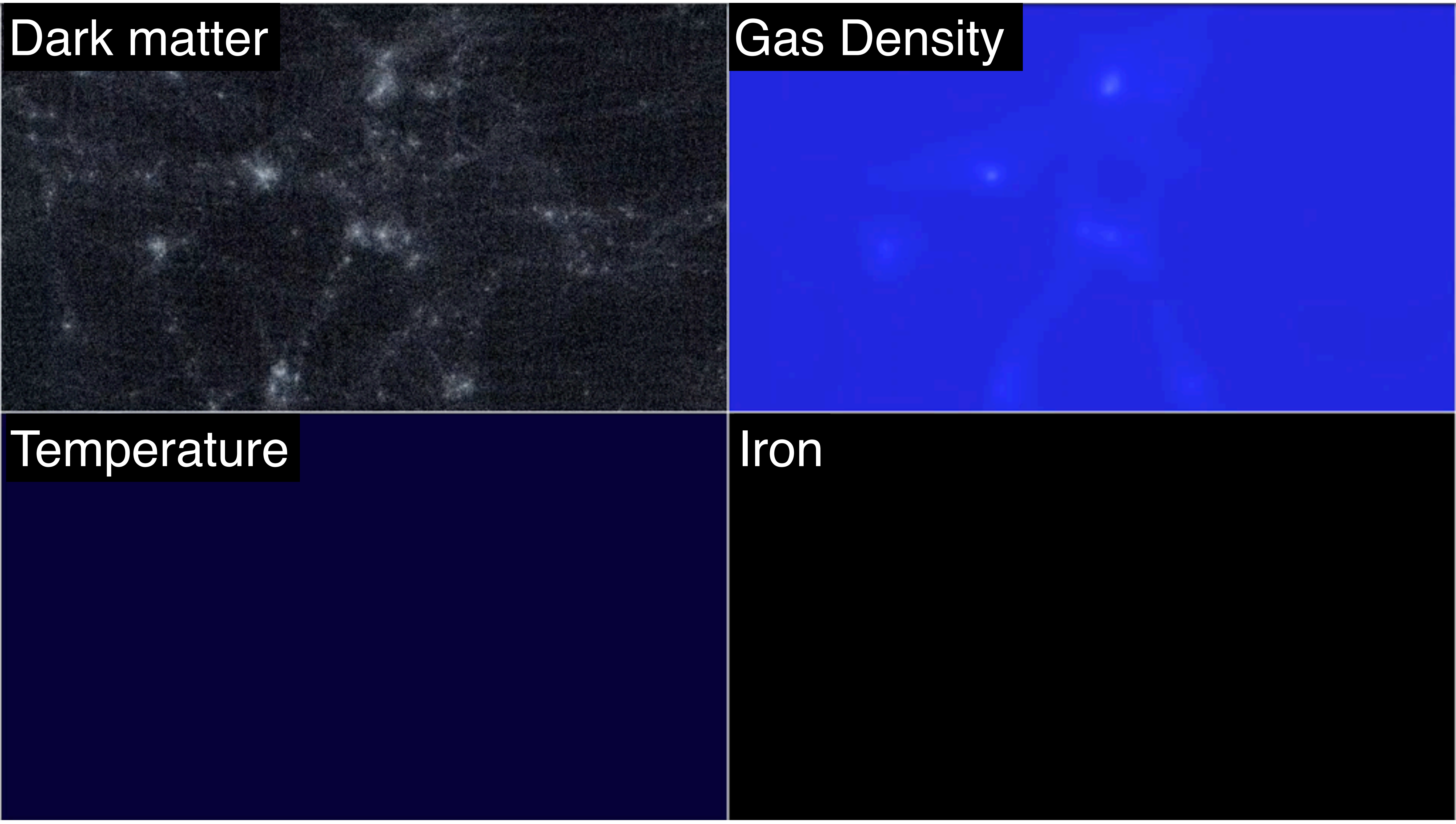
E.D.G.E.

Engineering **D**warfs at **G**alaxy formation's **E**dge



Oscar Agertz
Andrew Pontzen
Justin Read

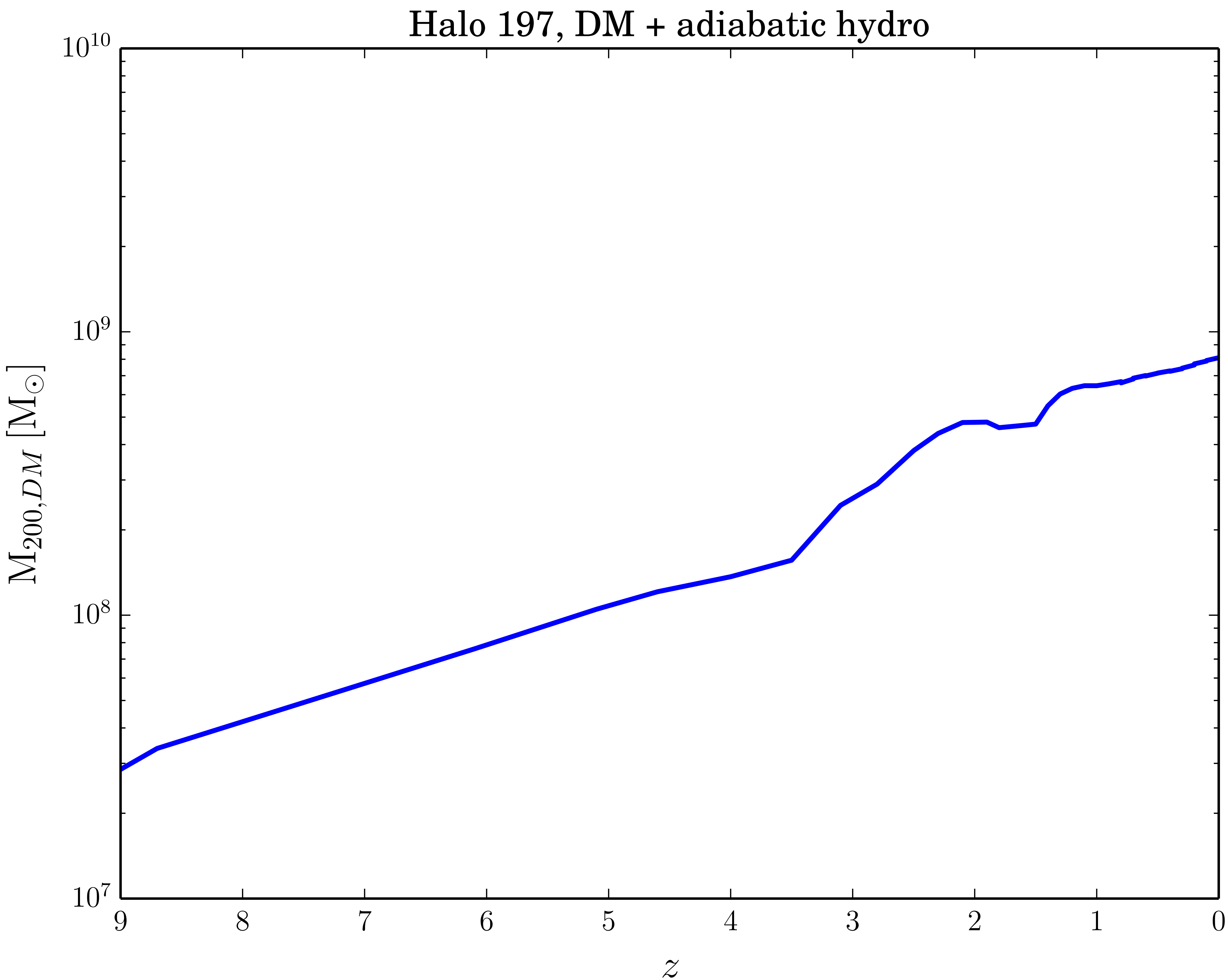
Cosmological simulations | E.D.G.E.



$M_{\rm DM} = 960\,{\rm M}_\odot$ (fiducial), $120\,{\rm M}_\odot$ (high) | $M_{\rm bar} = 160\,{\rm M}_\odot$

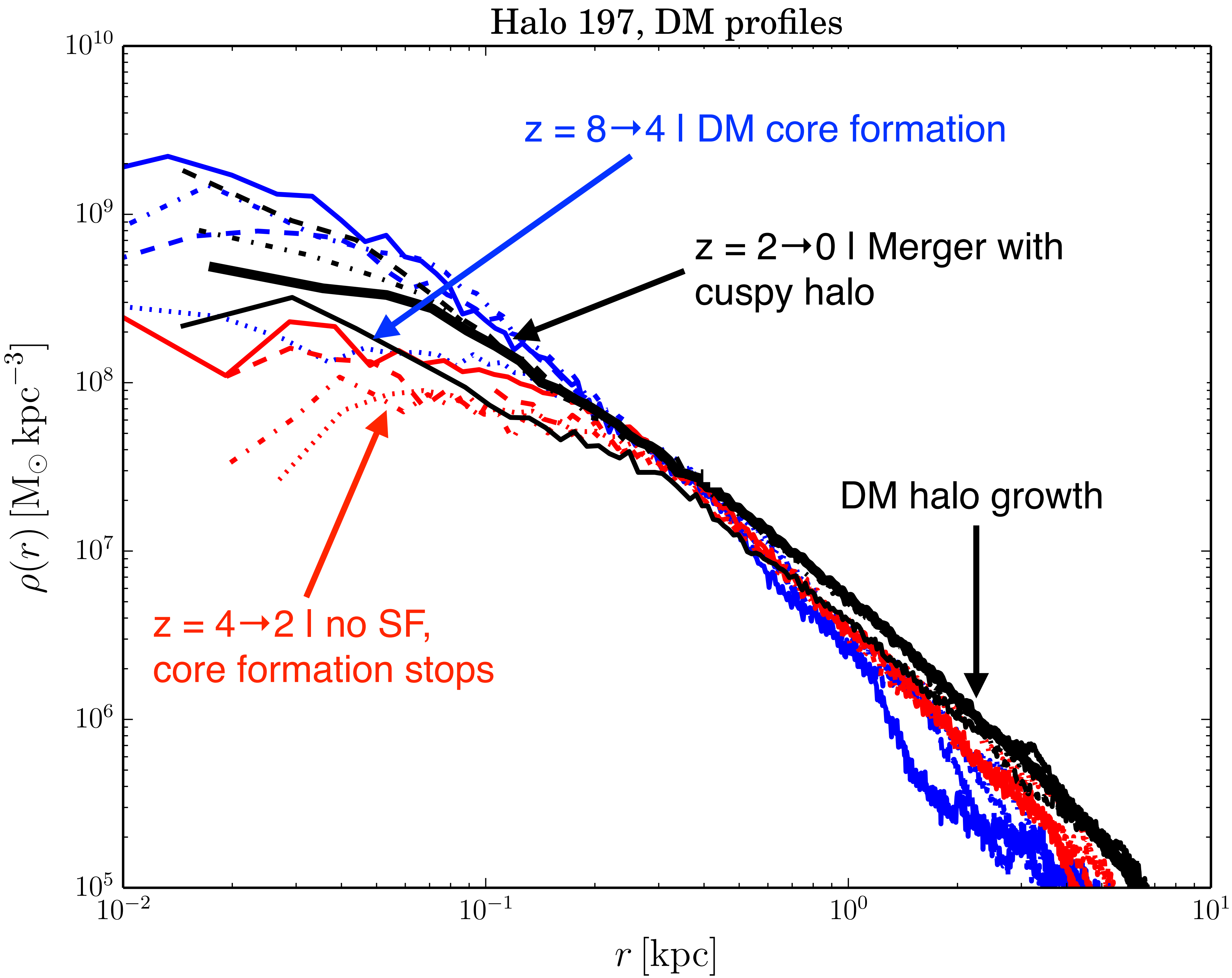
Agertz, Pontzen & Read in prep. 2017

Cosmological simulations | Cores & cusps in an ultra-faint



Agertz, Pontzen & Read in prep. 2017

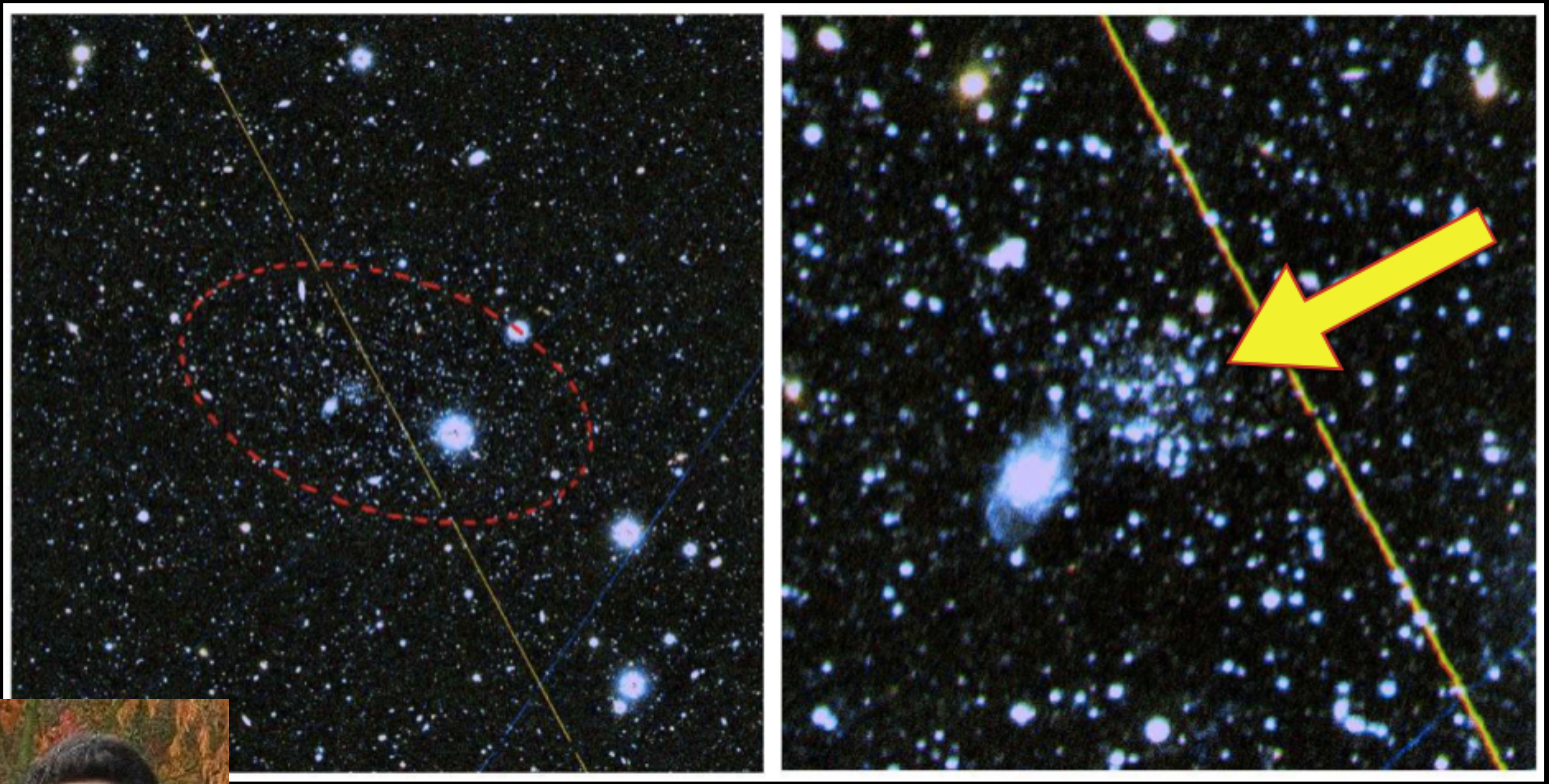
Cosmological simulations | Cores & cusps in an ultra-faint



Agertz, Pontzen & Read in prep. 2017; and see Laporte & Penarrubia 2014; Onorbe et al. 2015

A DM core in the ultra-faint dwarf Eridanus II

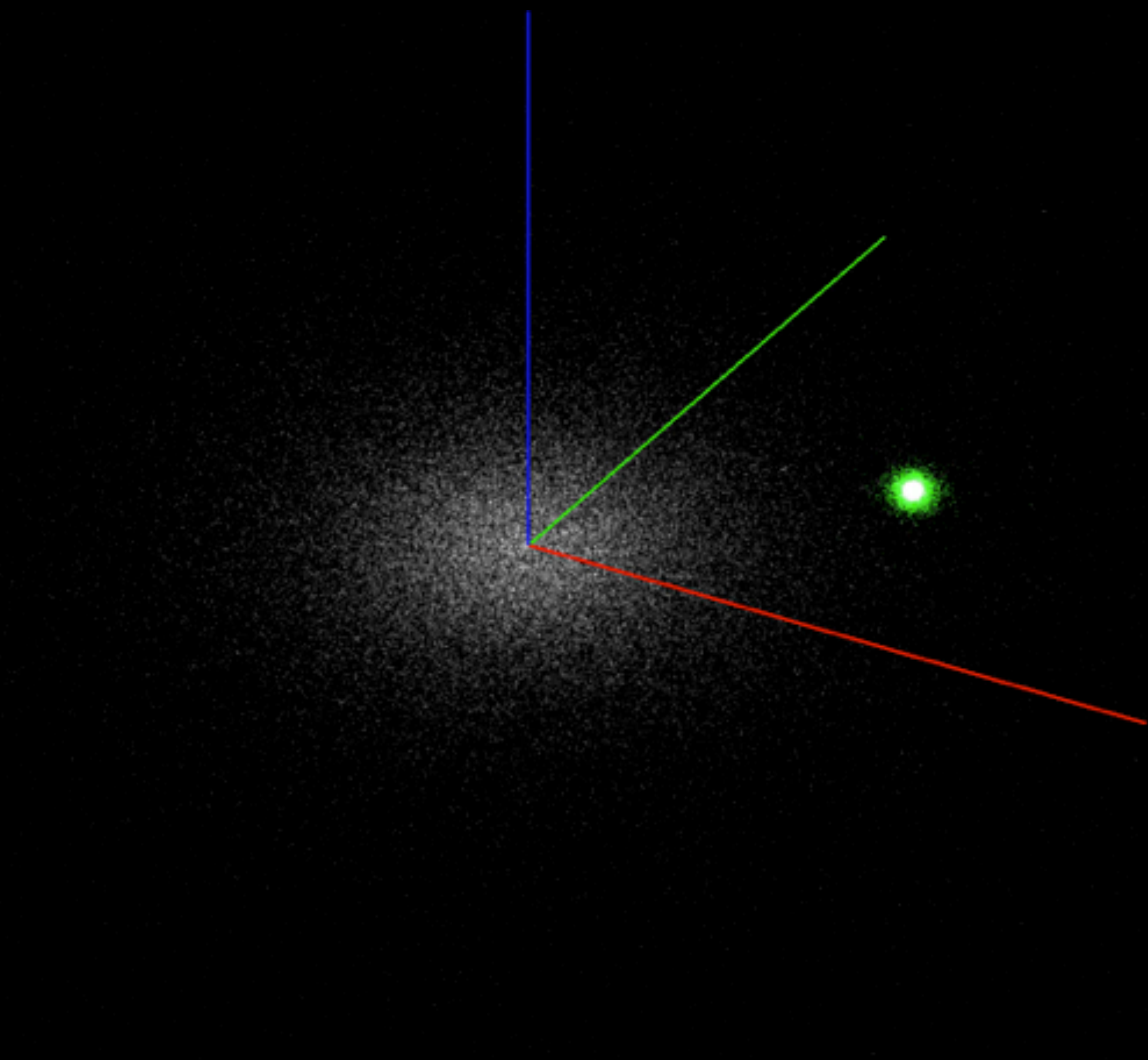
A DM core in an ultra faint | Eridanus II and its lone cluster

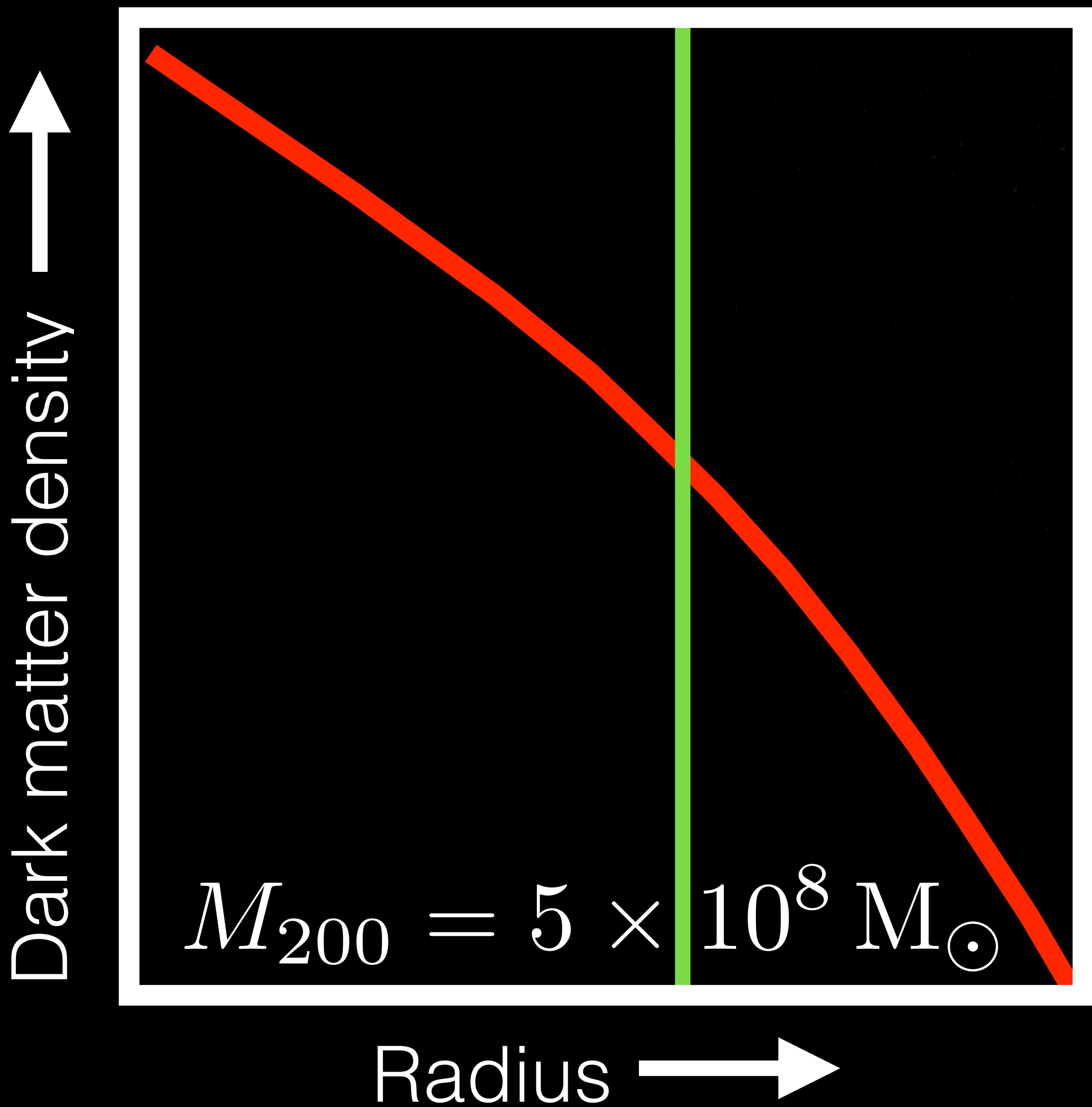


Contenta et al. 2017; Koposov et al. 2015; Crnojevic et al. 2016; Amorisco 2017

A DM core in an ultra faint | Cusped models

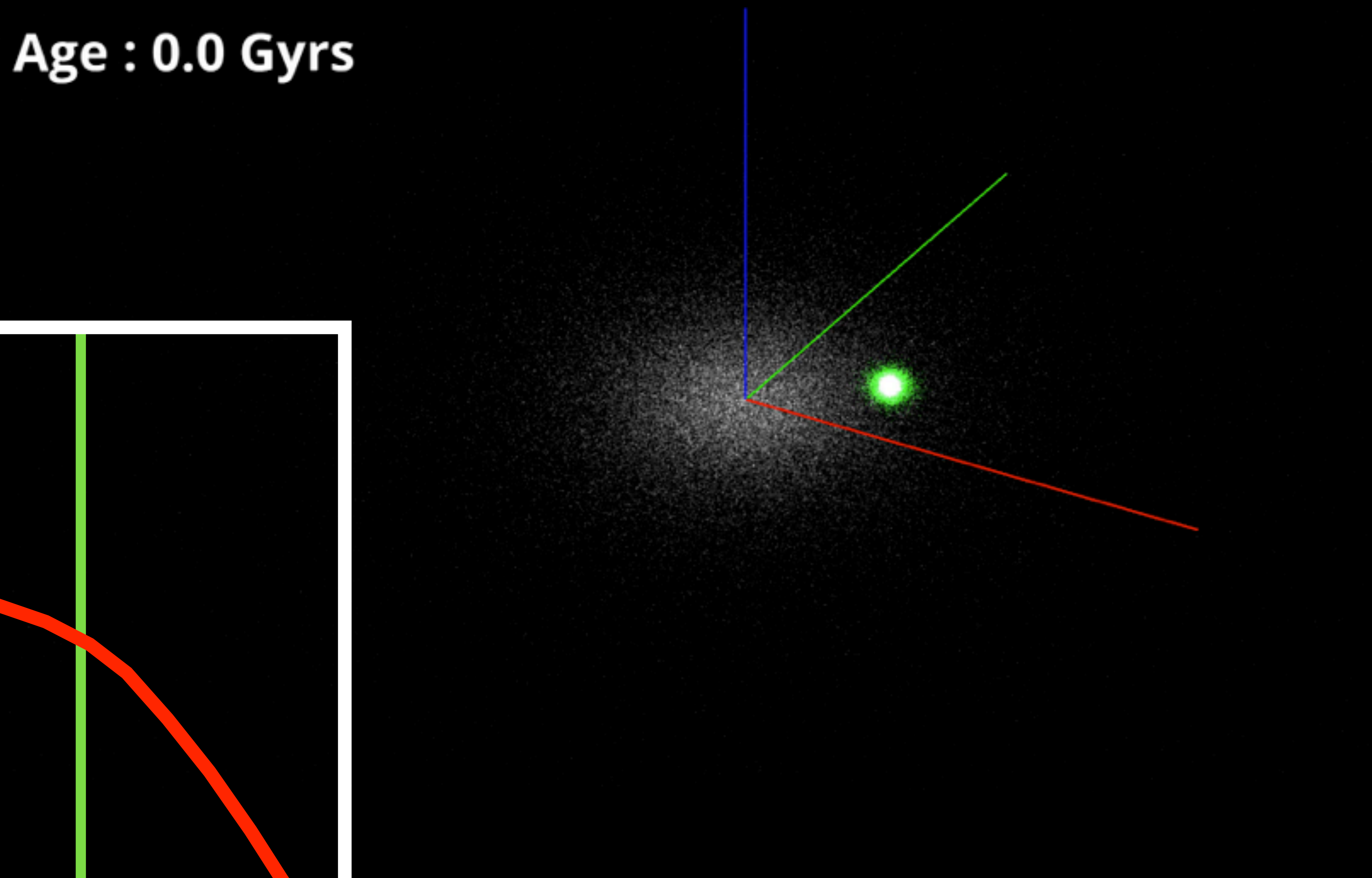
Age : 0.0 Gyrs

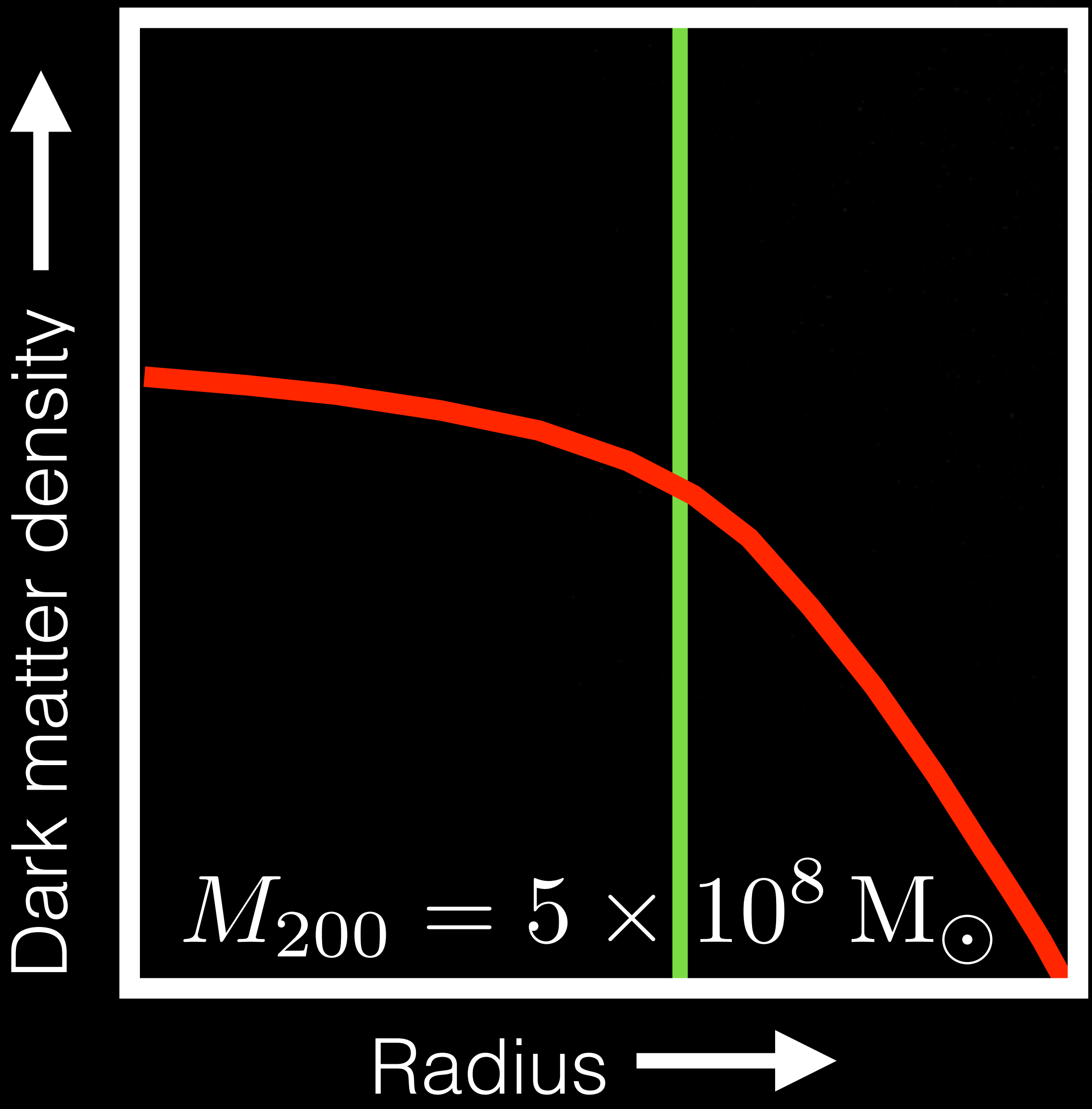




Contenta et al. 2017

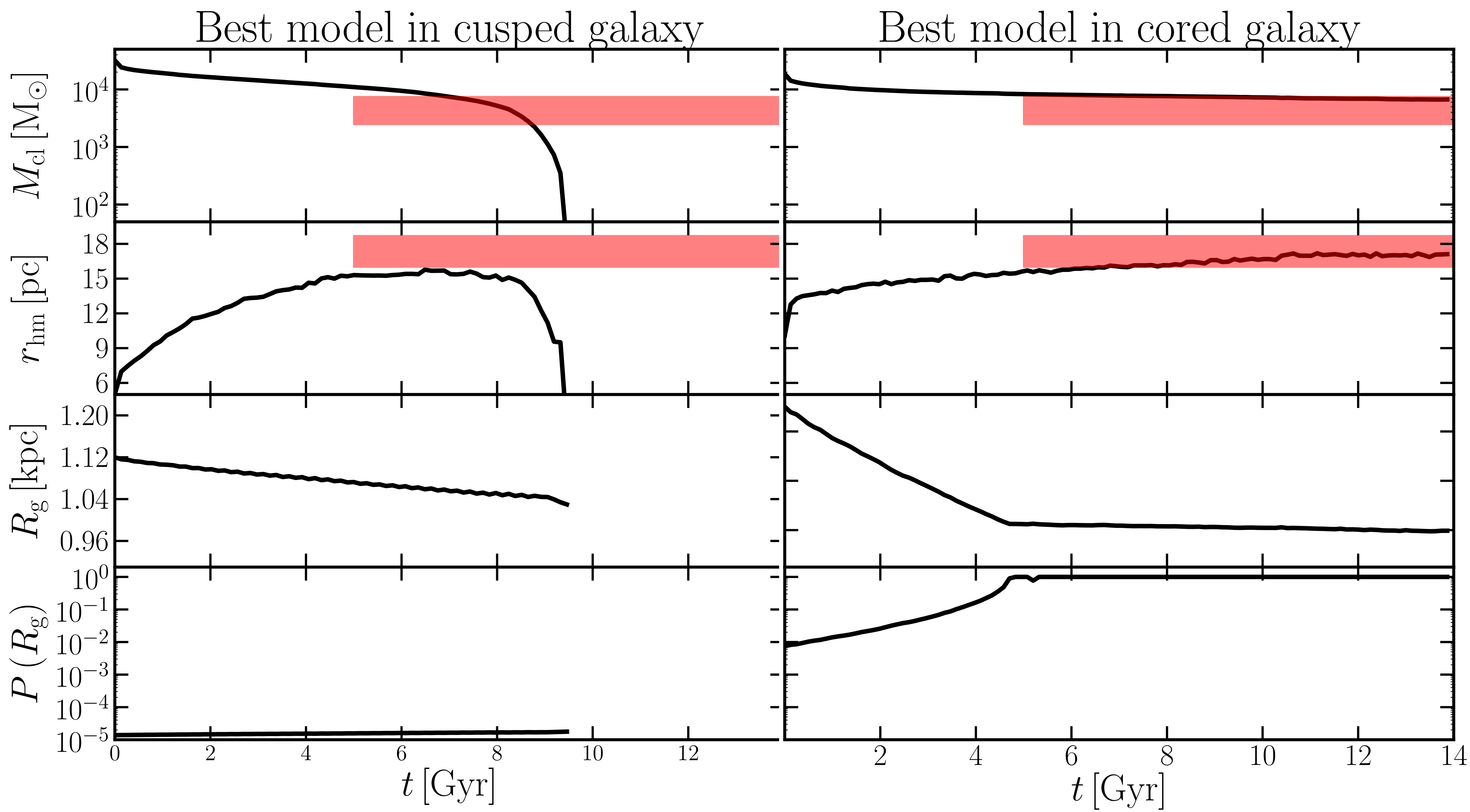
A DM core in an ultra faint | Cored models





Contenta et al. 2017

A DM core in an ultra faint | Results



Contenta et al. 2017

Conclusions

- Isolated dwarf simulations at ~4pc resolution predict **dark matter cores** of size ~$R_{1/2}$, **if SF not truncated**
- Abundance matching isolated dwarfs → $m_{\rm dm} > 2\,{\rm keV}$
- Even 'ultra-faints' can form DM cores; evidence for one in Eridanus II.
- Evidence for a dark matter cusp in Draco → evidence for "dark matter heating"; SIDM → $\sigma/m < 1\,{\rm cm}^2/{\rm g}$
- Dark matter likely a **cold(ish) & collisionless particle**