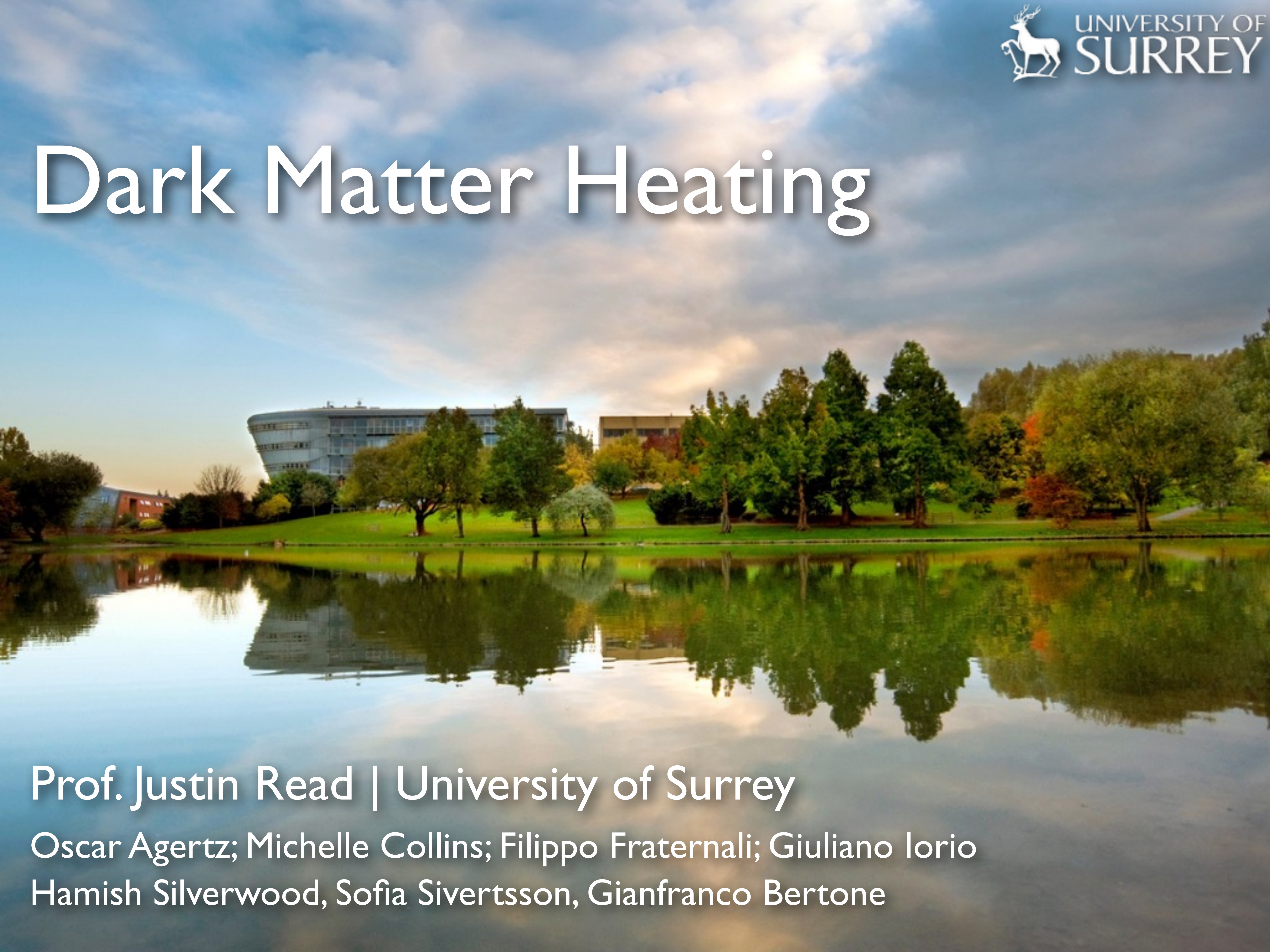


Dark Matter Heating

Prof. Justin Read | University of Surrey

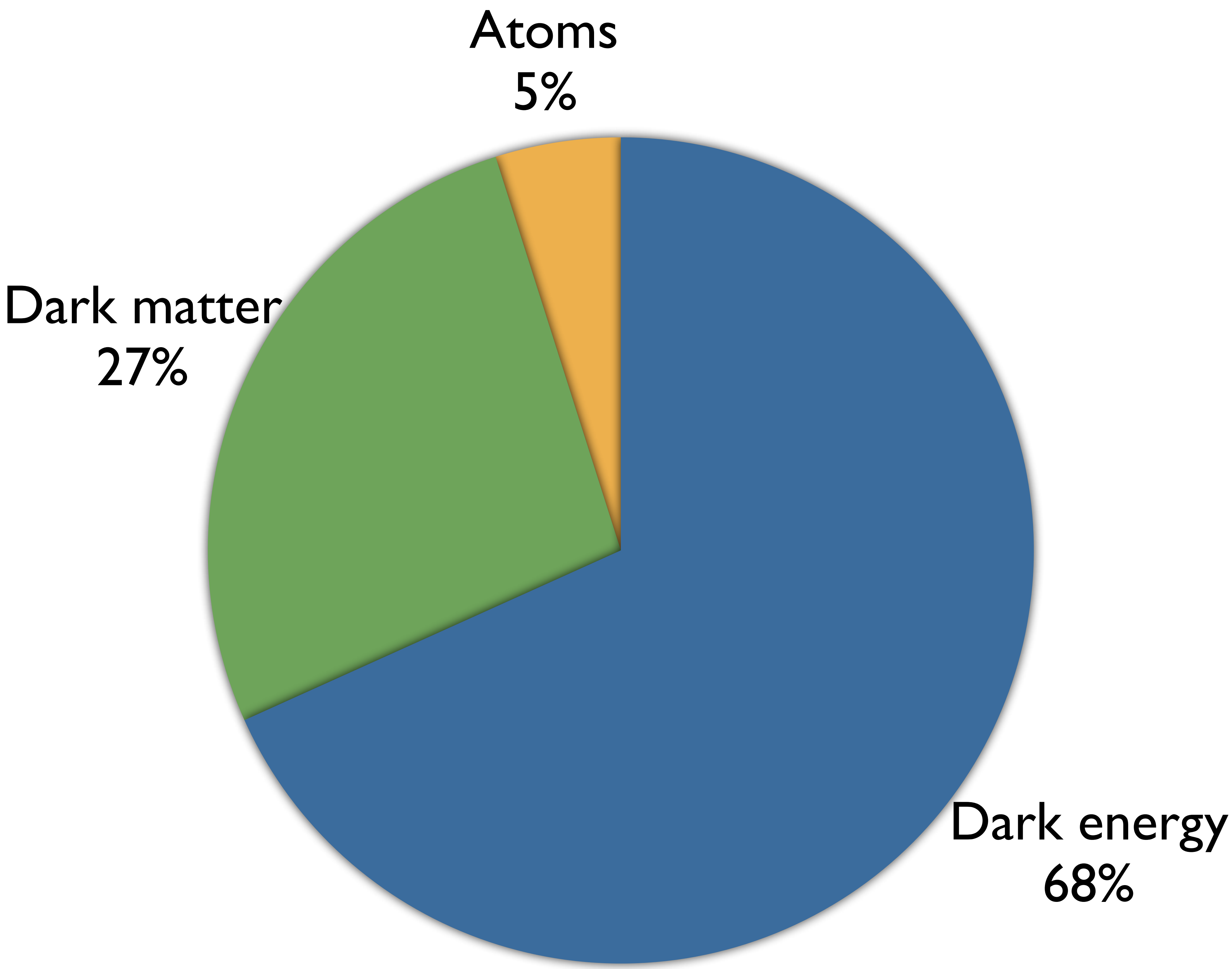
Oscar Agertz; Michelle Collins; Filippo Fraternali; Giuliano Iorio

Hamish Silverwood, Sofia Sivertsson, Gianfranco Bertone

Background

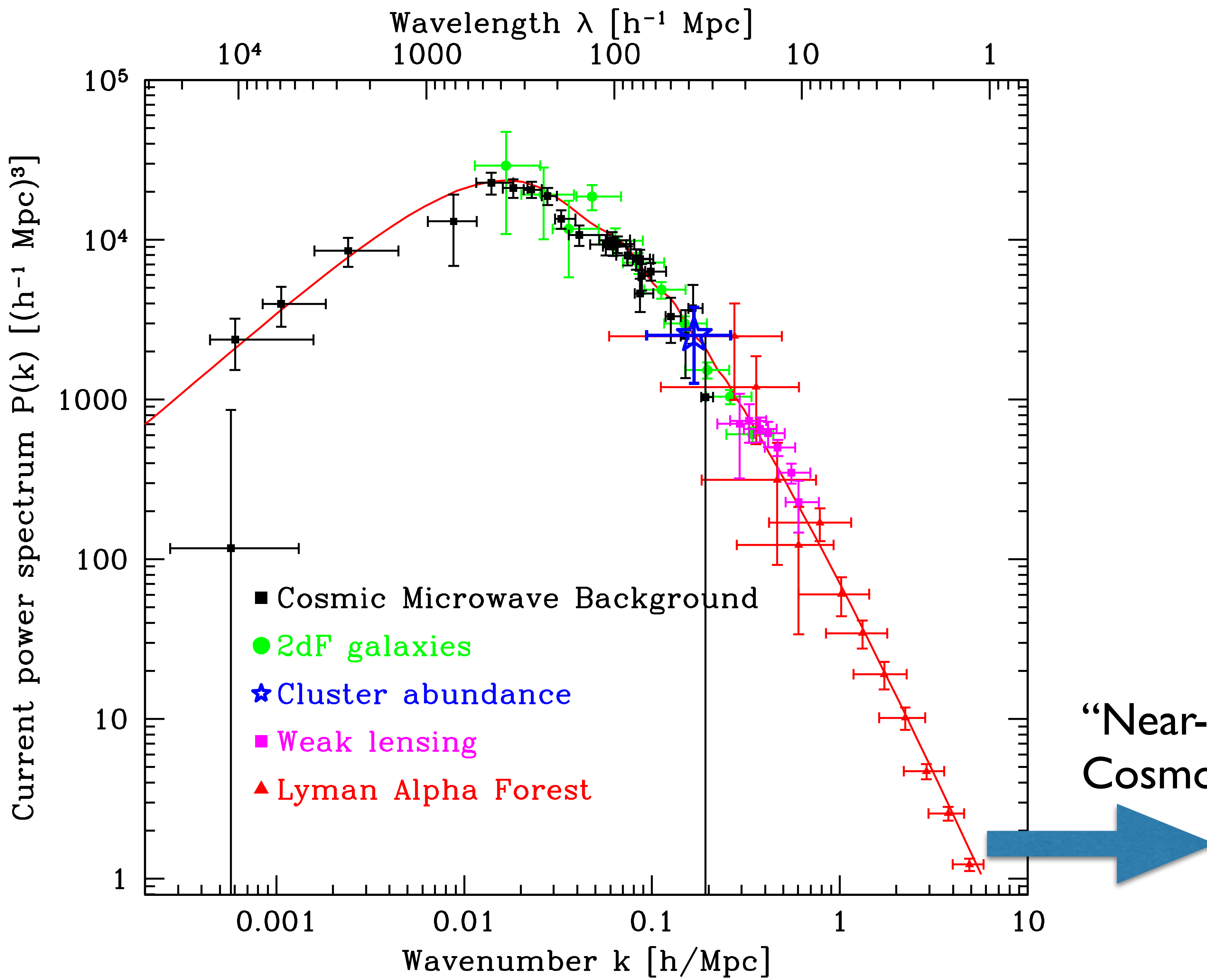
[LCDM, successes, small scale puzzles]

Background | The standard cosmological model LCDM



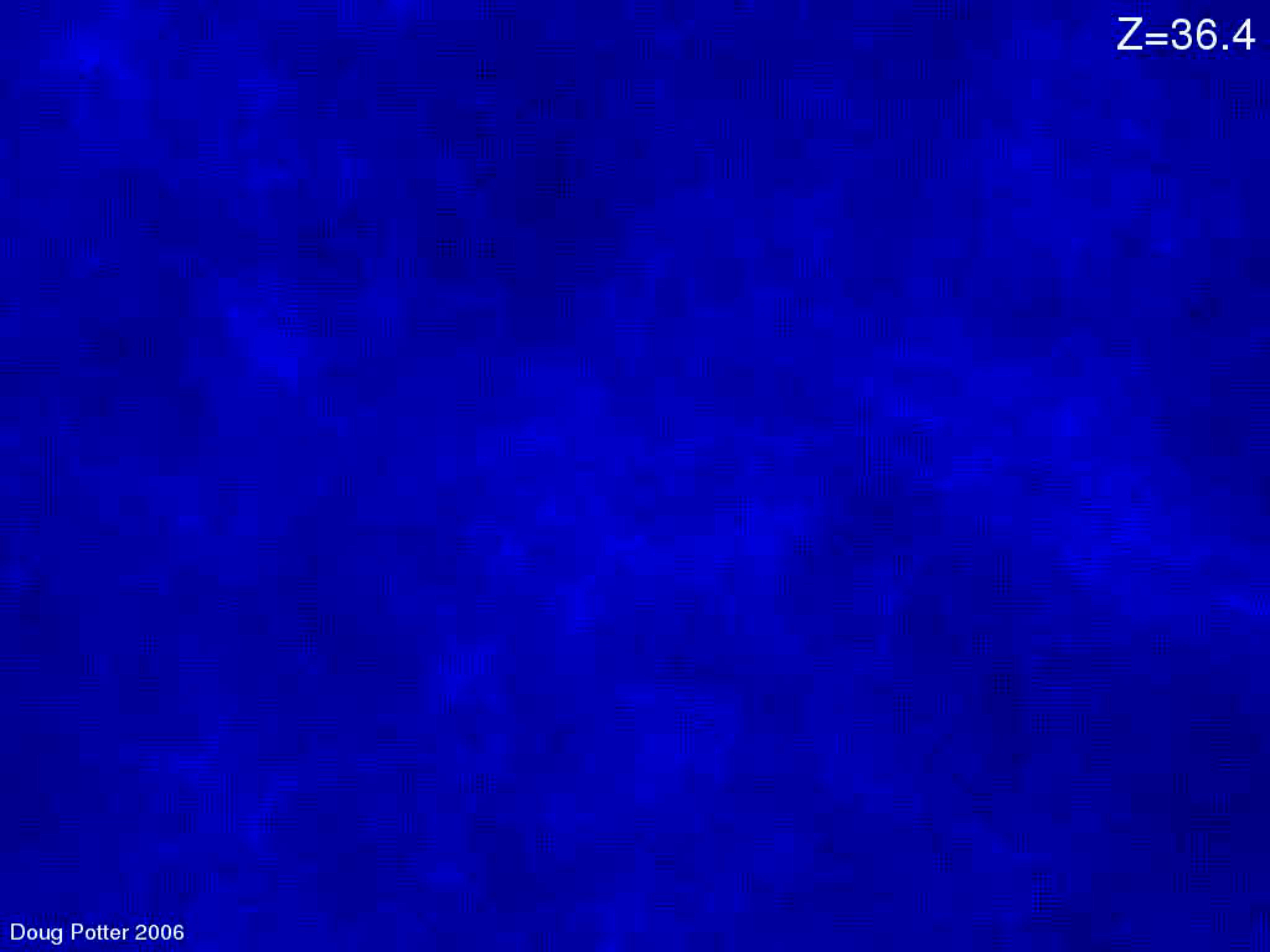
Planck 2015

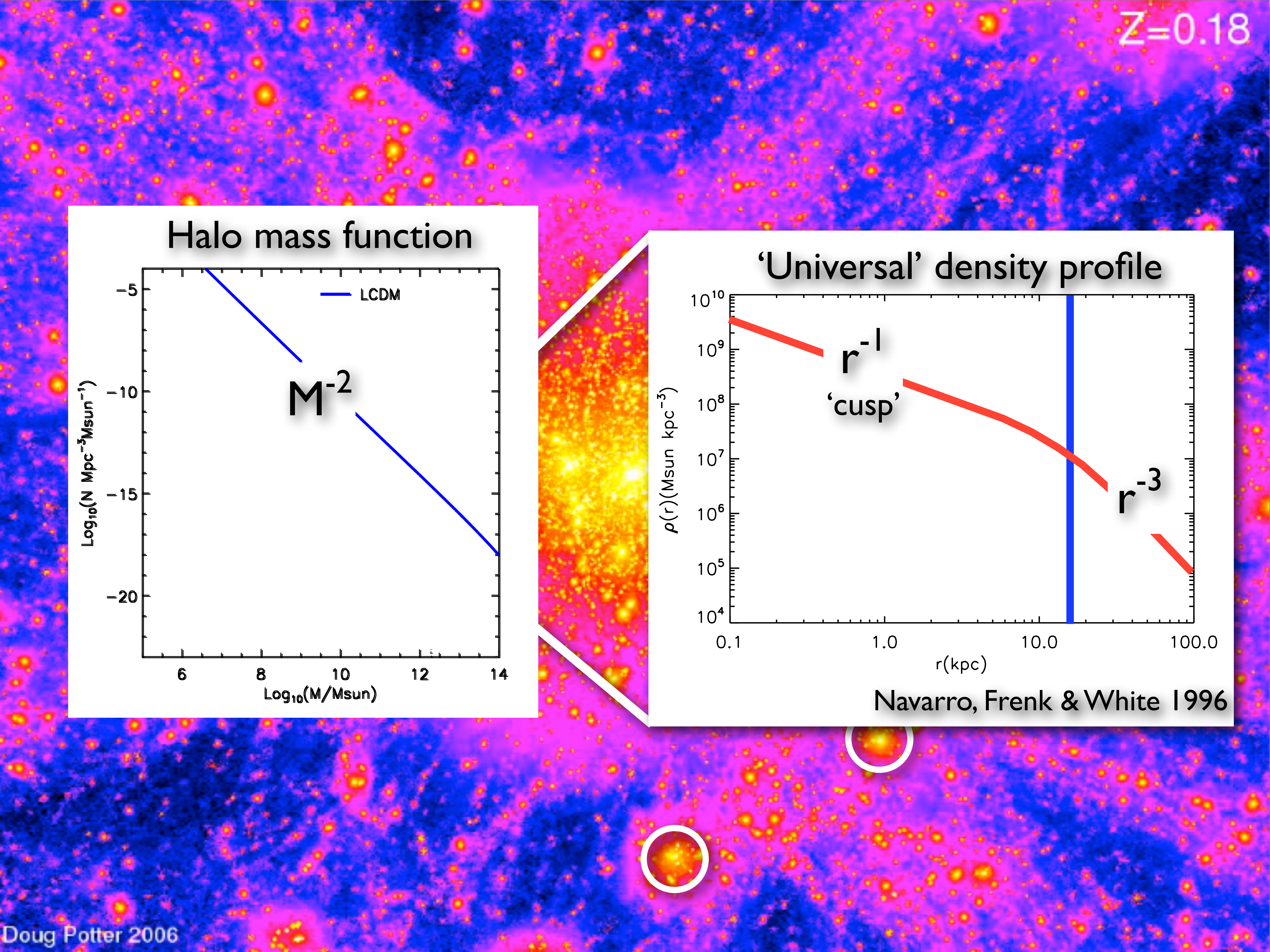
Background | The standard cosmological model LCDM

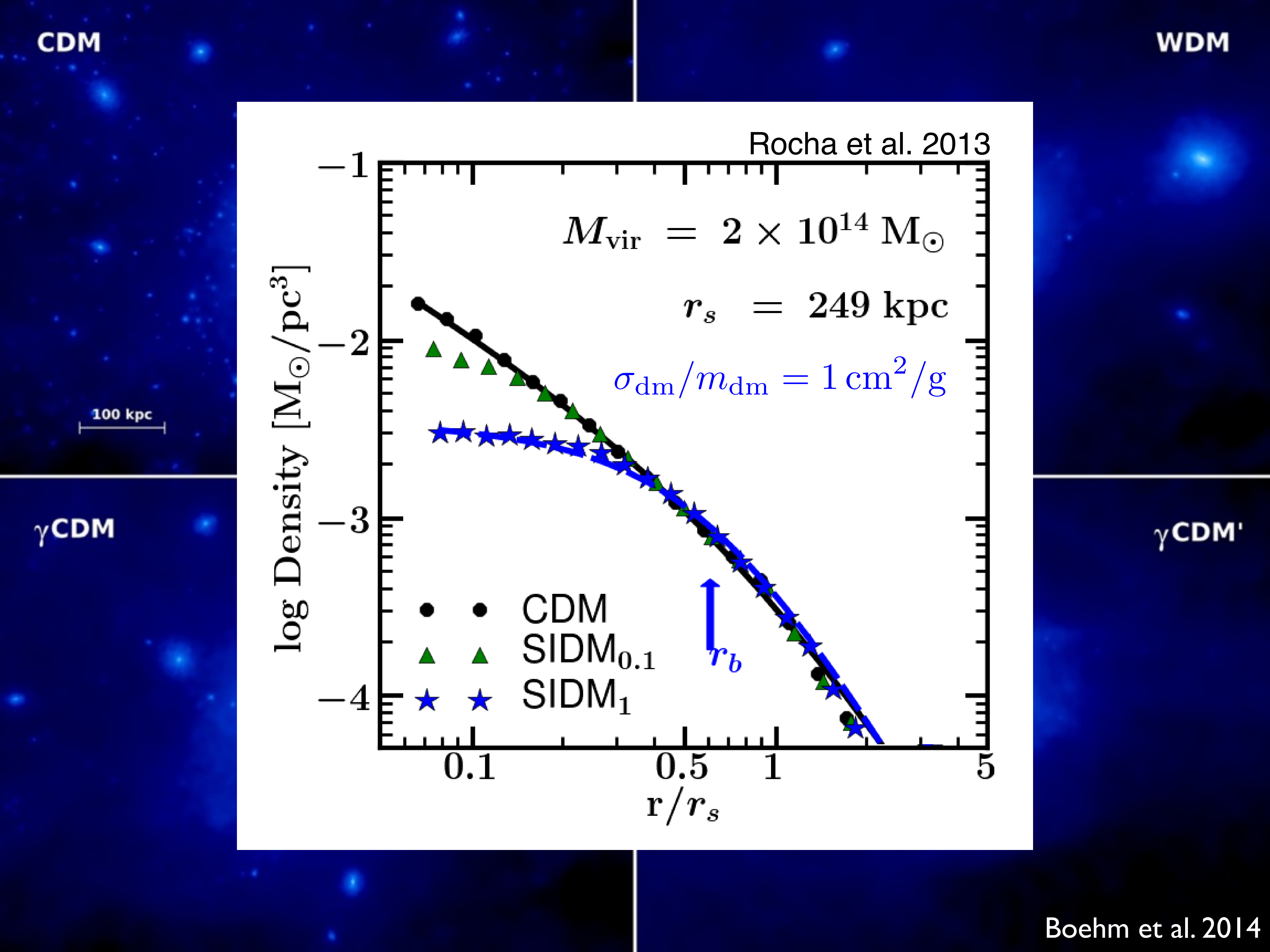


"Near-field" Cosmology

Tegmark & Zaldarriaga 2002

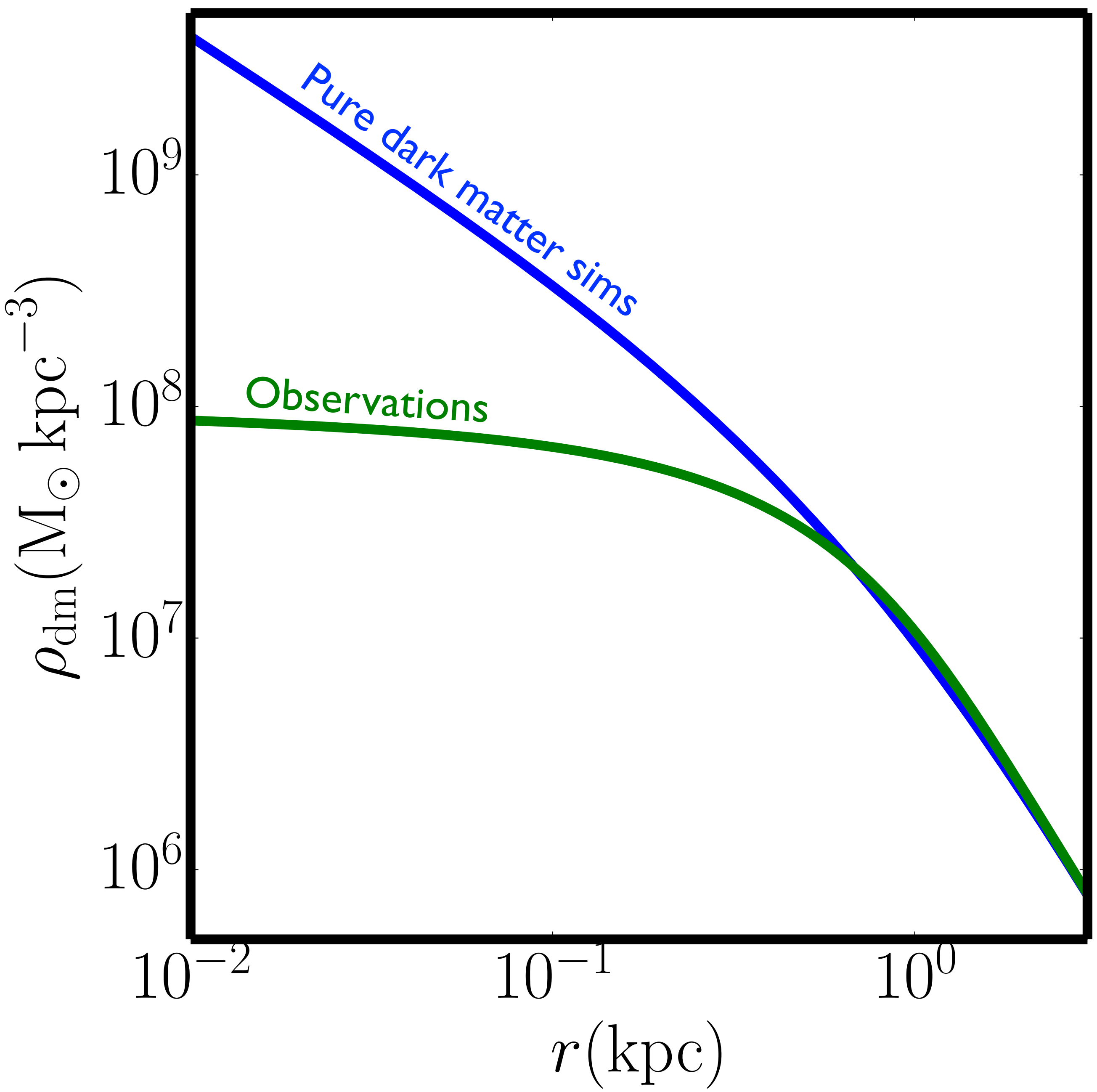

Z=36.4
Doug Potter 2006

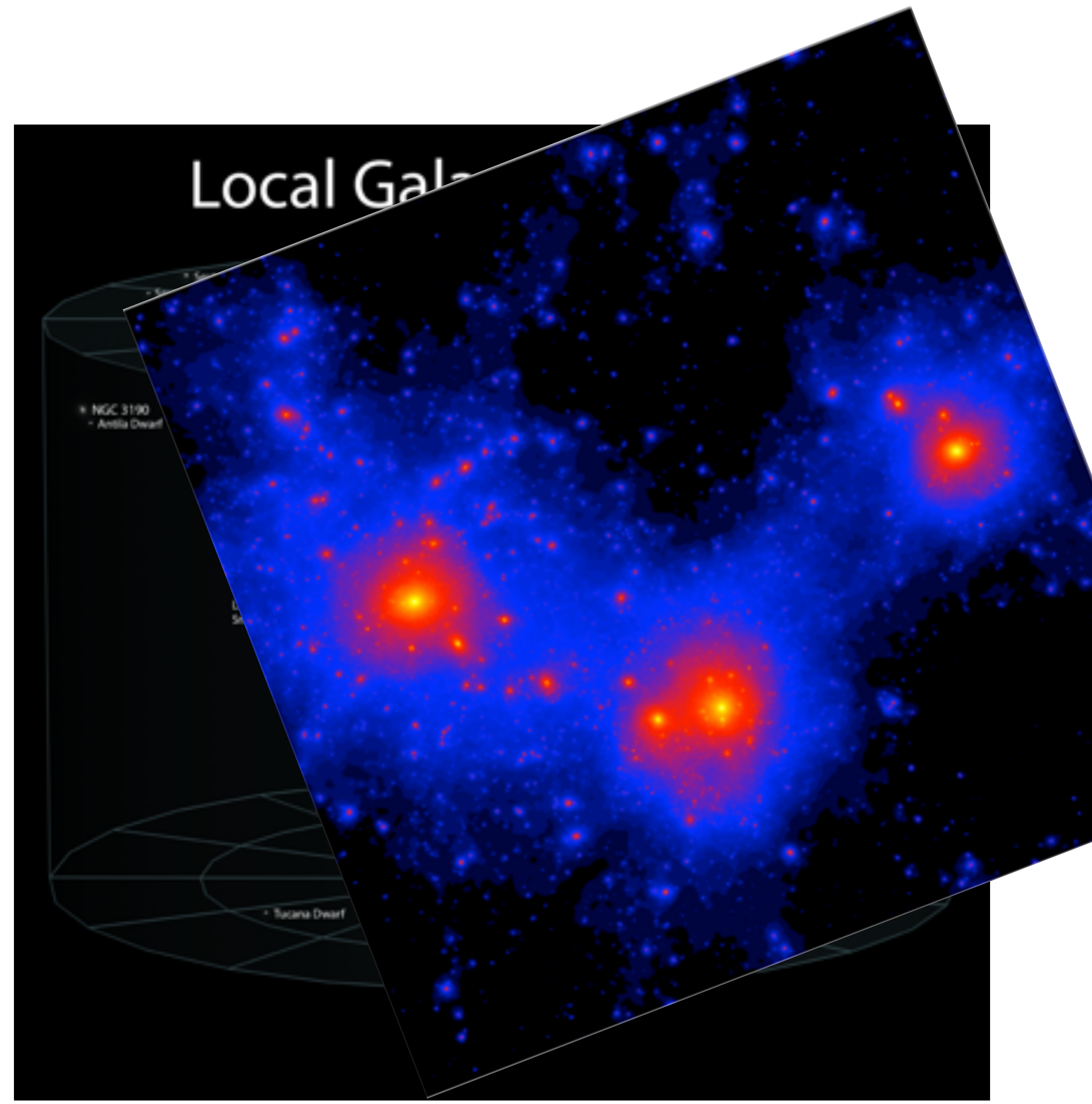

Z=0.18
Halo mass function
LCDM
M-2
Log10(N Mpc-3Msun-1)
Log10(M/Msun)
'Universal' density profile
r-1
'cusp'
r-3
ρ(r)(Msun kpc-3)
r(kpc)
Navarro, Frenk & White 1996
Doug Potter 2006



CDM
WDM
γCDM
γCDM'
100 kpc
Rocha et al. 2013
$M_{\rm vir} = 2 \times 10^{14}\ M_\odot$
$r_s = 249$ kpc
$\sigma_{\rm dm}/m_{\rm dm} = 1\,{\rm cm}^2/{\rm g}$
log Density $[M_\odot/{\rm pc}^3]$
−1
−2
−3
−4
0.1
0.5
1
5
r/r_s
r_b
CDM
$\mathrm{SIDM}_{0.1}$
SIDM_1
Boehm et al. 2014

Puzzles | 'Cusp-core' & missing satellites

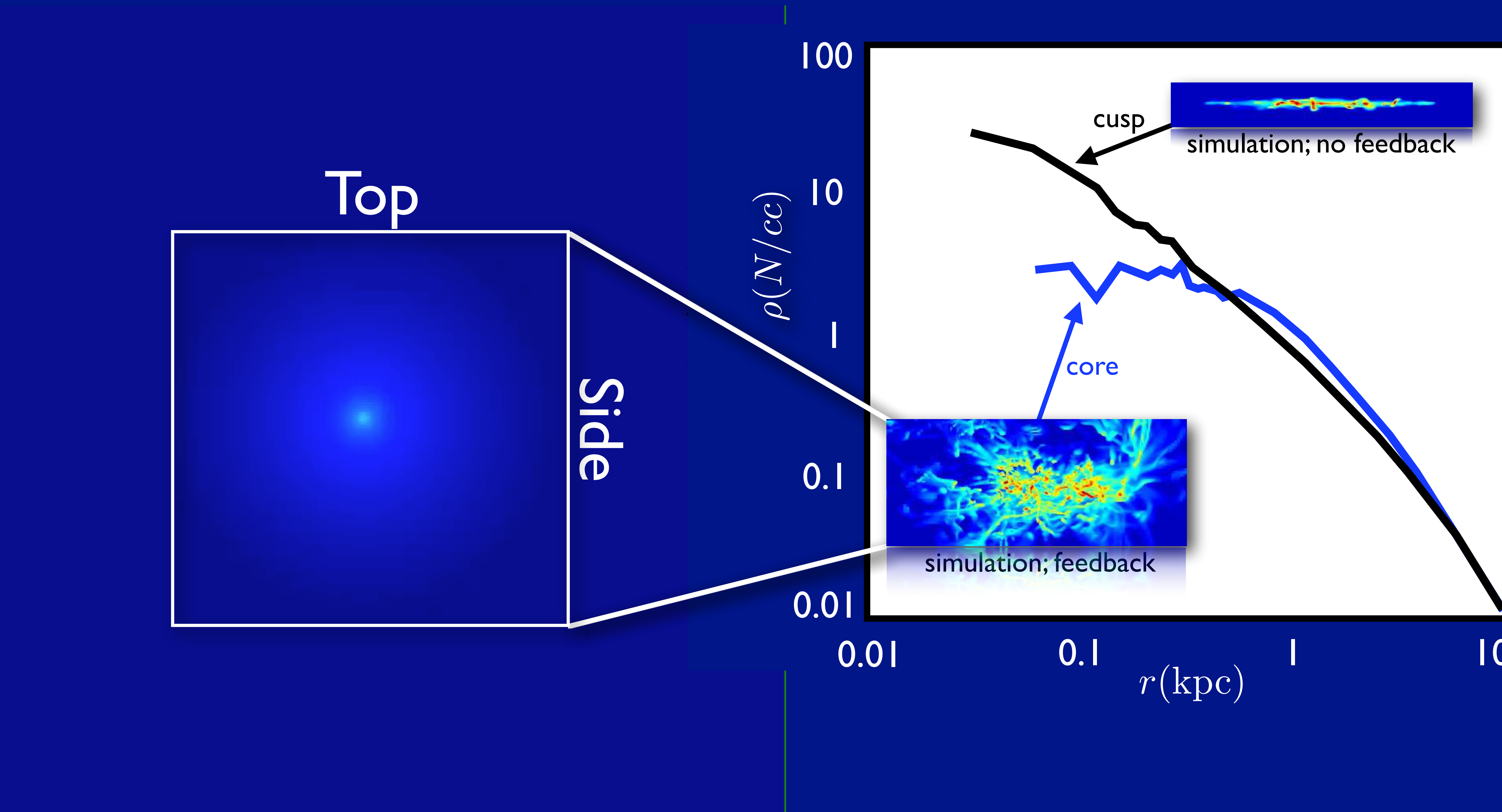




Moore 1994; Flores & Primack 1994; Klypin et al. 1999; Moore et al. 1999

Pure Dark Matter → Observed Universe

Stellar feedback → Cusp/core transforms

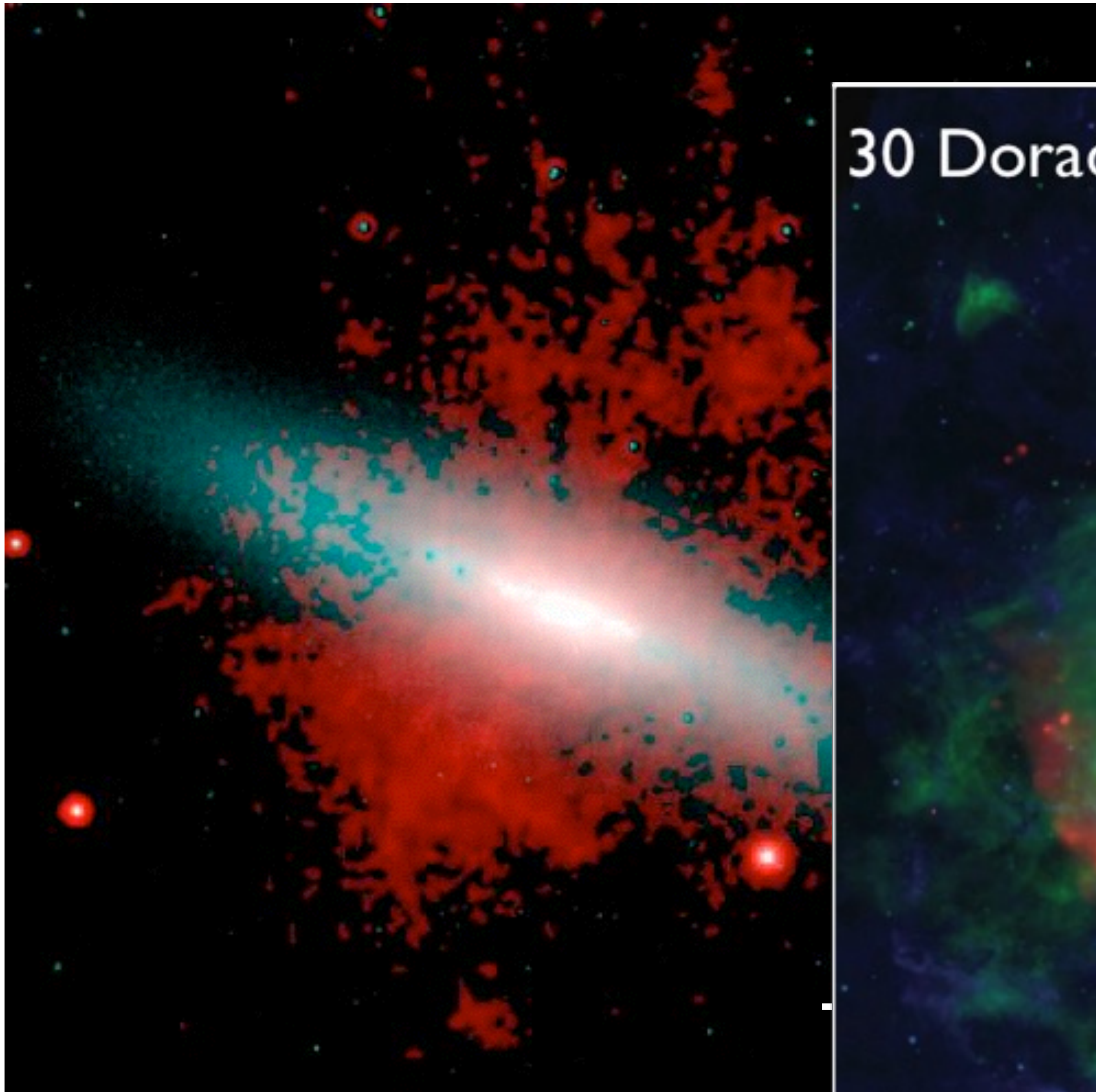


Navarro et al. 1996; Read & Gilmore 2005; Pontzen & Governato 2012/14; Teyssier et al. 2013

Predictive Simulations with baryons

[Getting feedback right for one isolated dwarf]

Simulations | Resolving feedback



Warm H2 in the M82 Galactic wind | Veilleux e

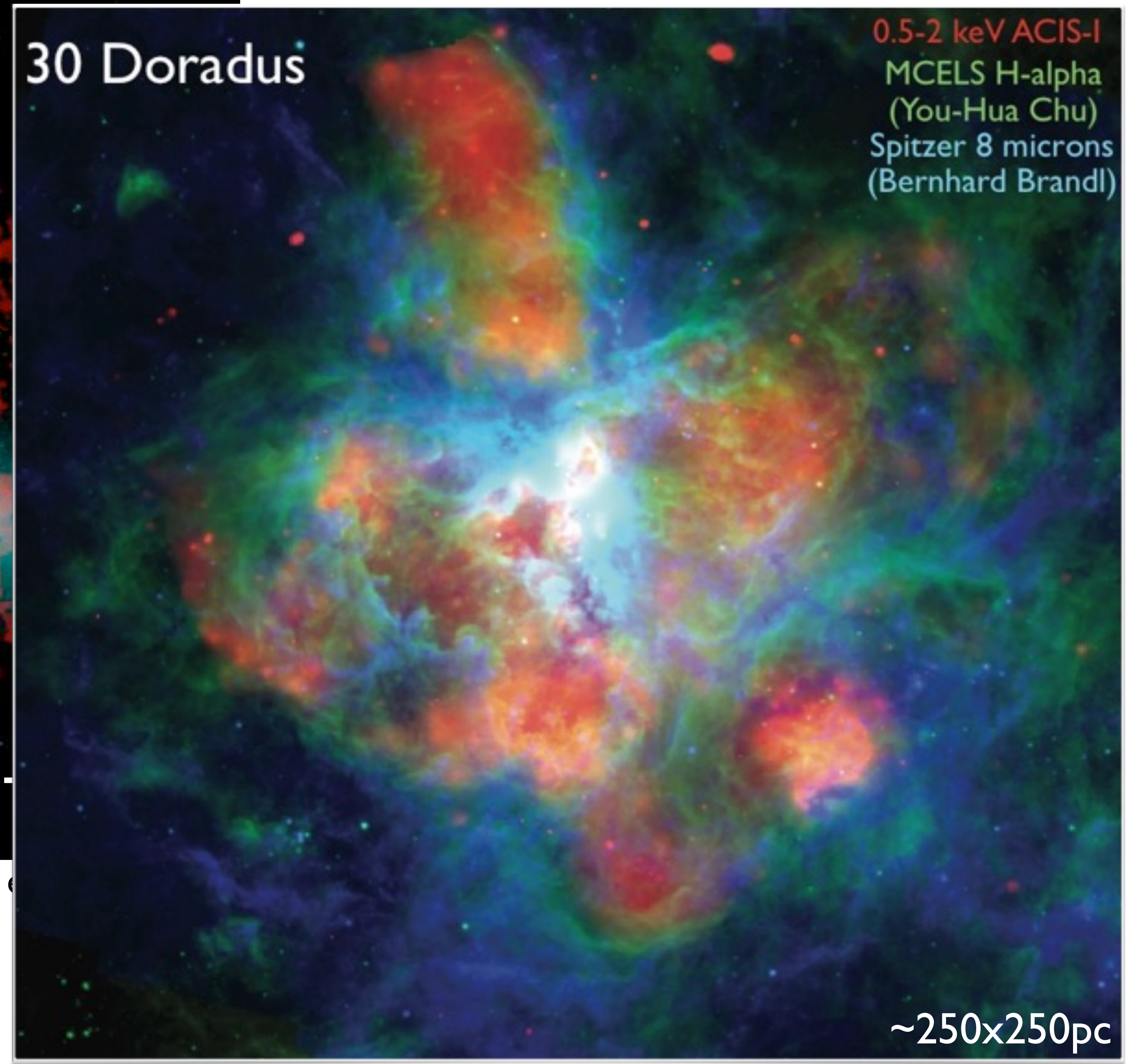
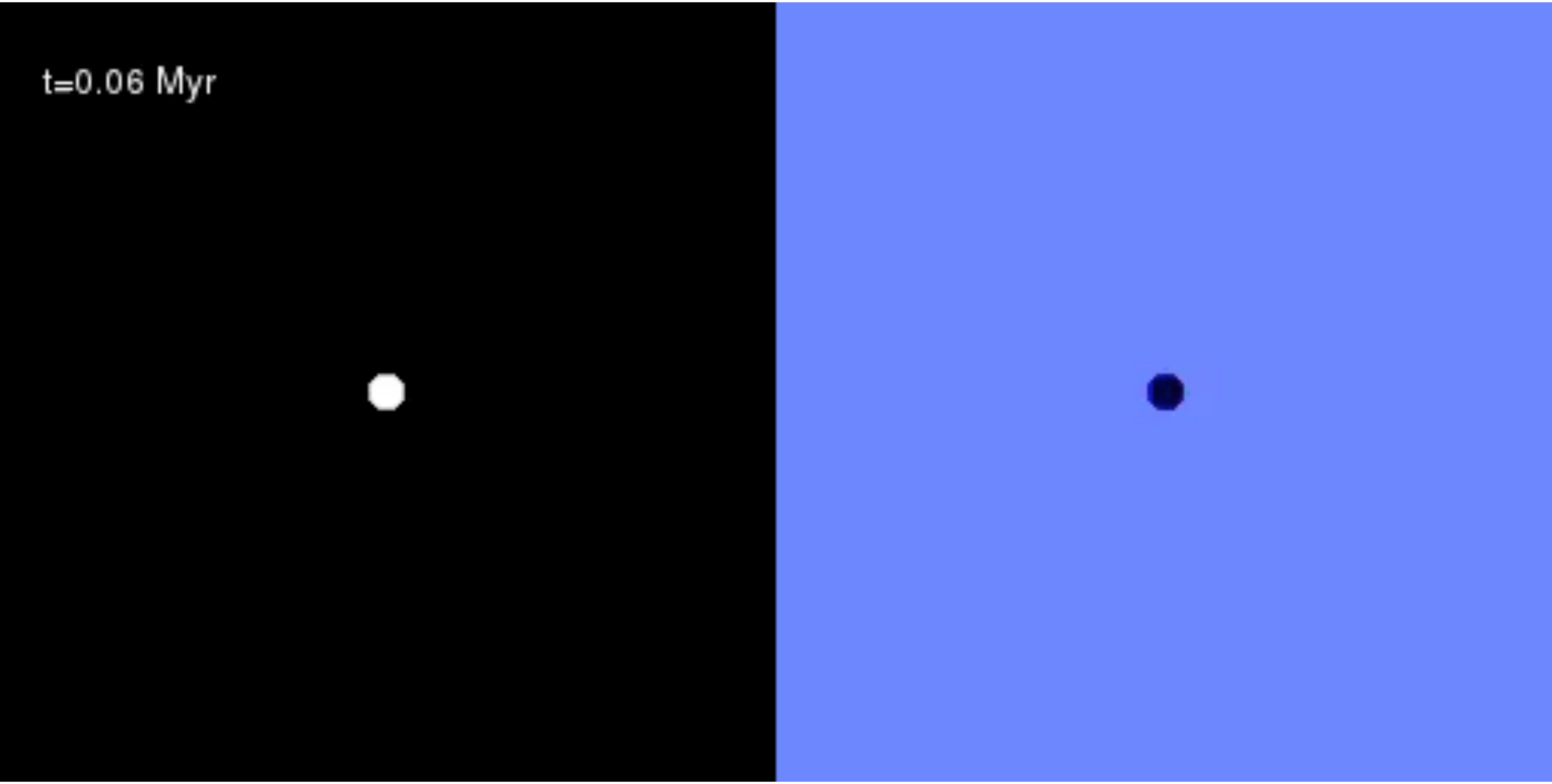


Image composite credit: Leisa Townsley

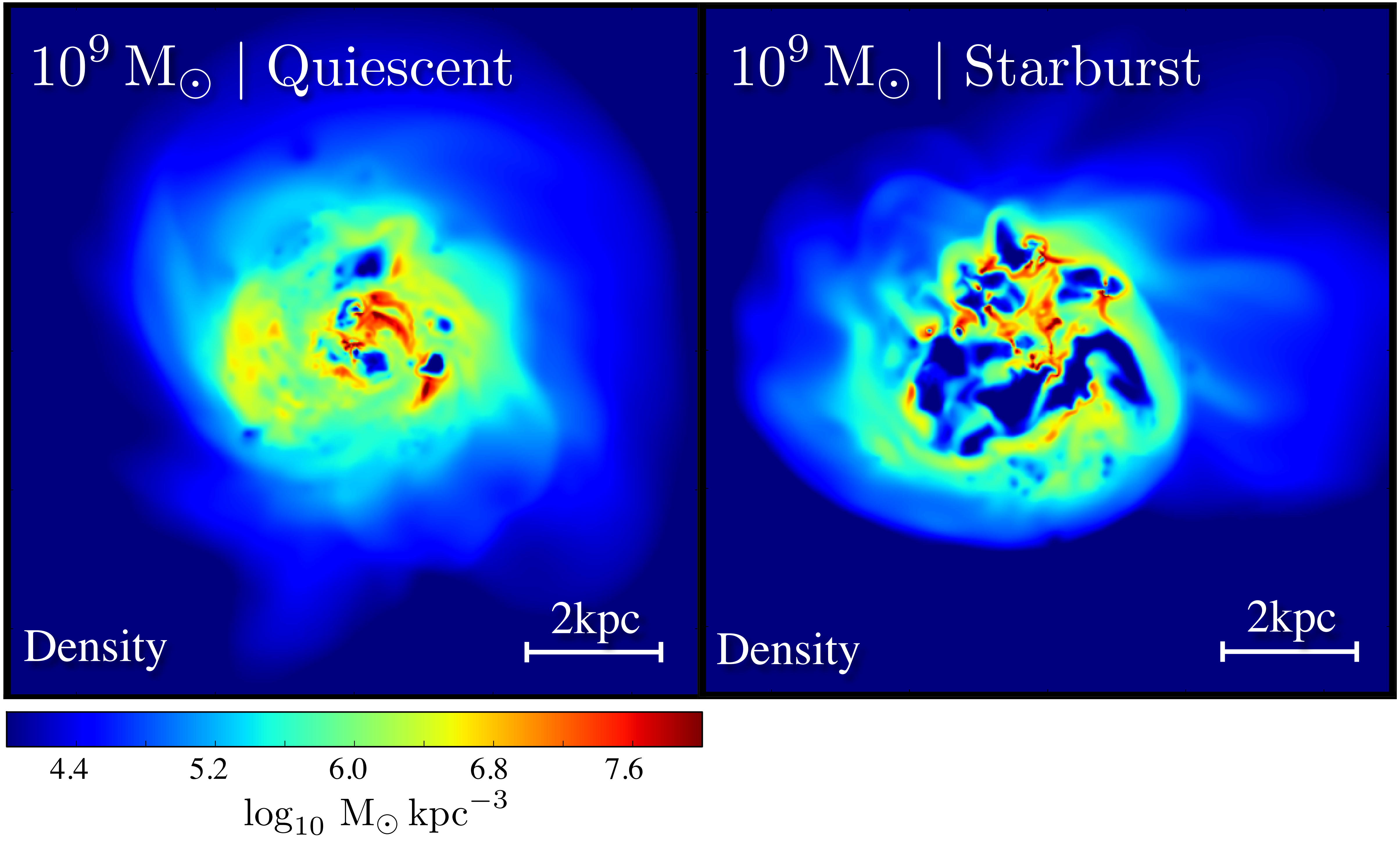
Simulations | Resolving feedback



Read et al. 2016

Simulations | Resolving feedback

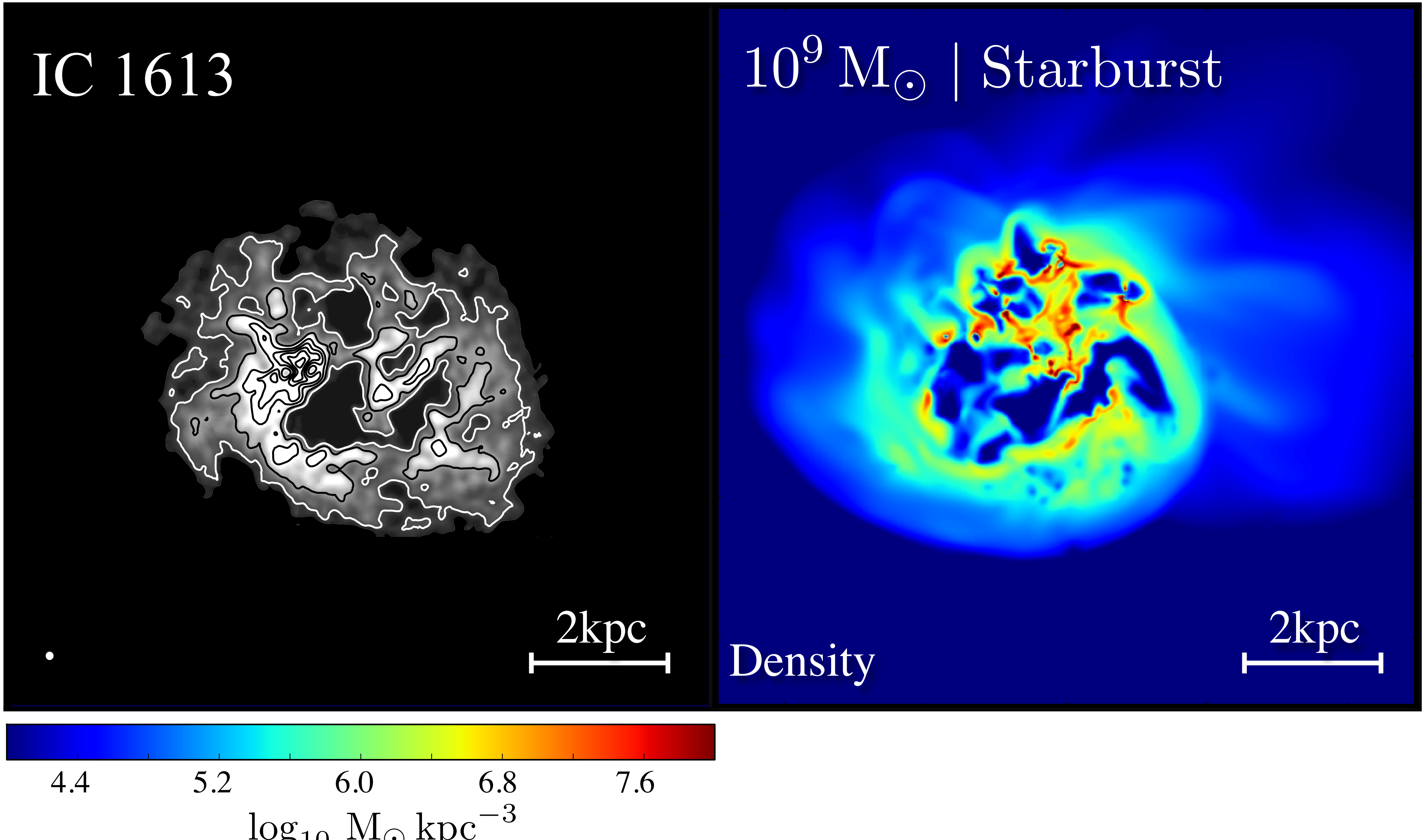
Read et al. 2016a,b



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

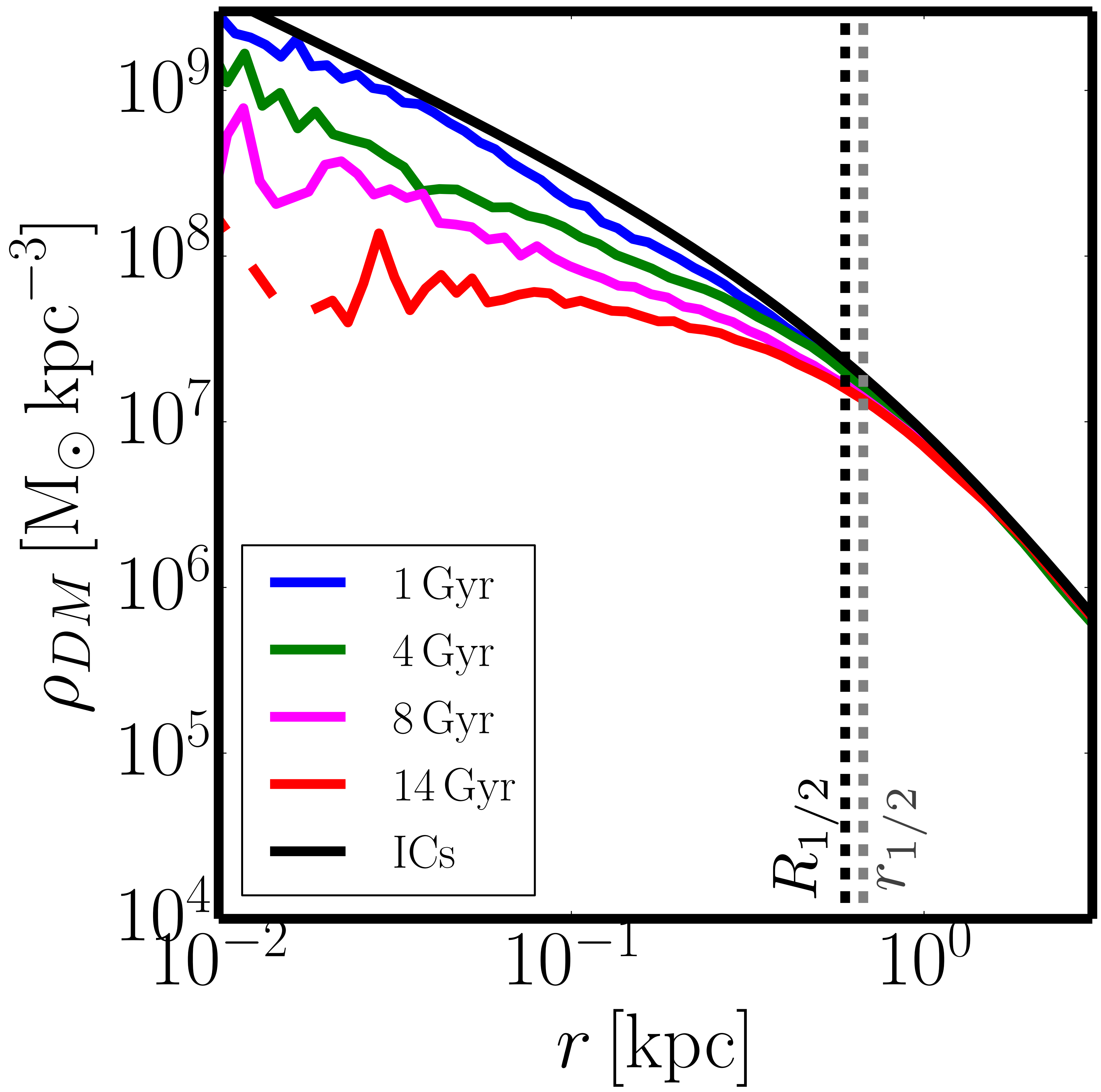
Simulations | Resolving feedback

Read et al. 2016a,b



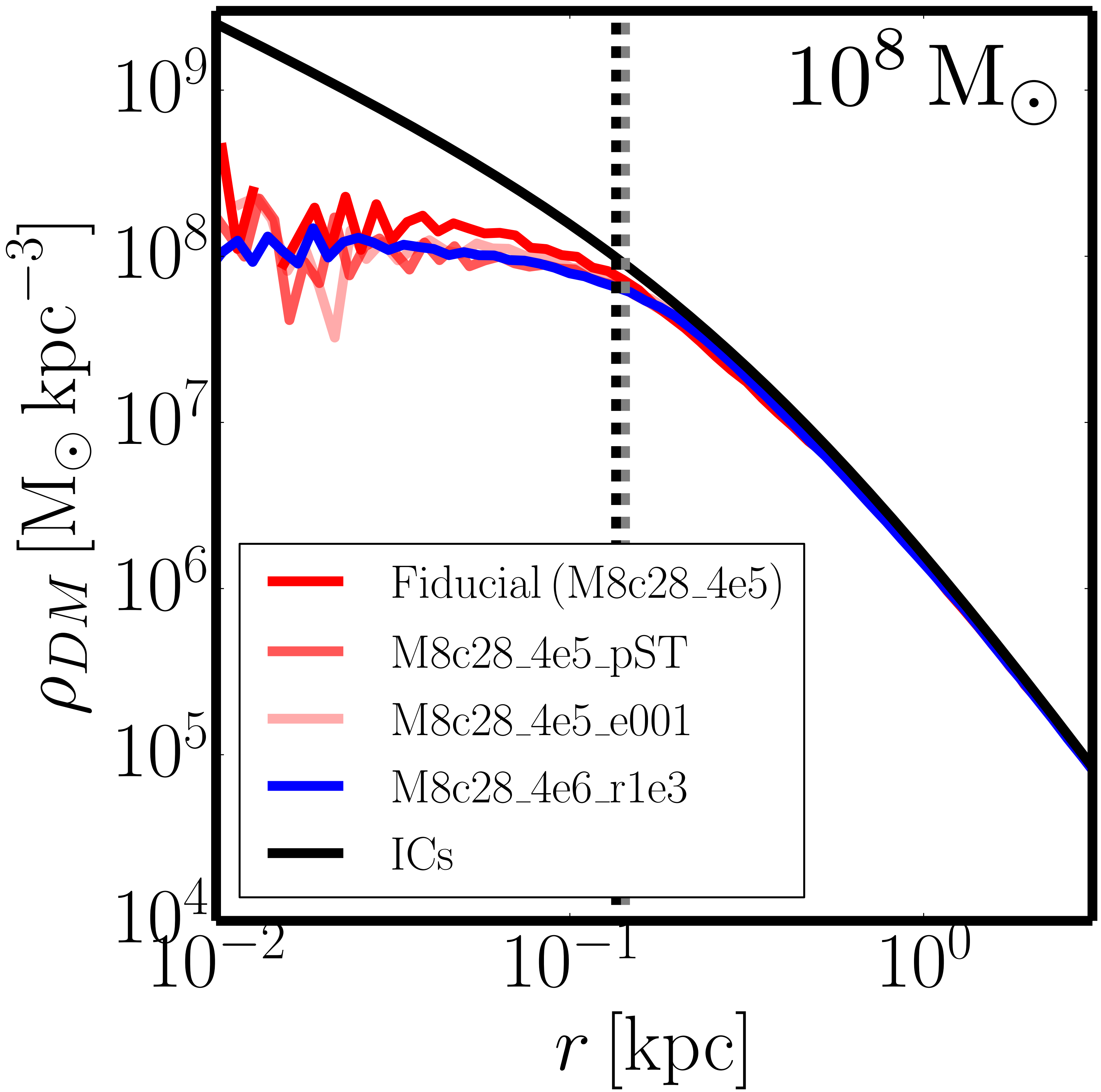
$$\Delta x = 4\,\mathrm{pc} \mid M_* \sim 300\,\mathrm{M}_\odot \mid M_{dm} = 250\,\mathrm{M}_\odot \mid n_{\rm th} = 300\,\mathrm{atoms\,cm}^{-3}$$

Simulations | Cusp-core transformations



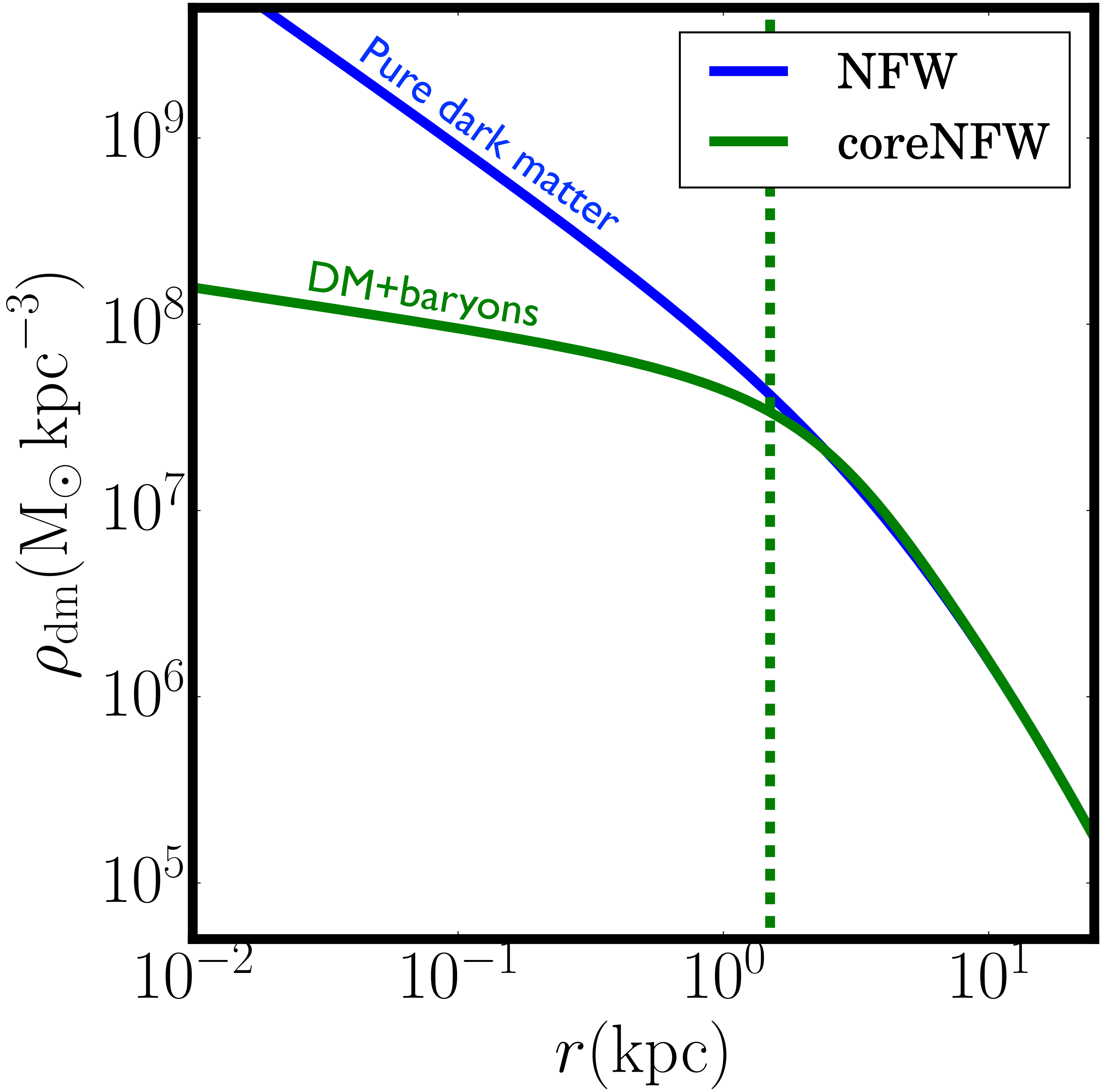
Read et al. 2016

Simulations | Cusp-core transformations



Read et al. 2016

Simulations | Cusp-core transformations



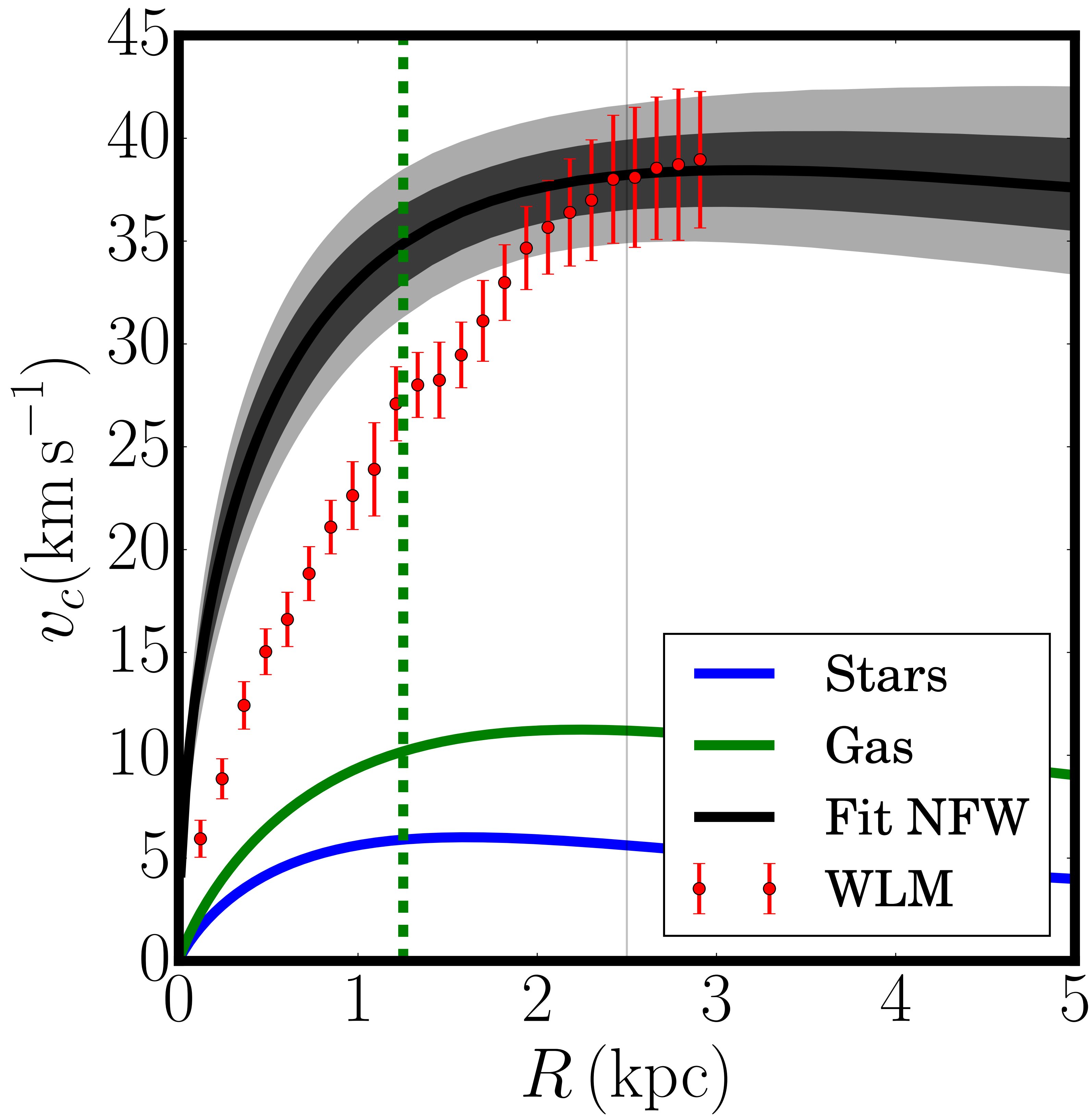
Read et al. 2016

Isolated dwarfs

[rotation curves + abundance matching]

WLM | Leroy et al. 2015 [UV (blue); optical (green); HI (red)]

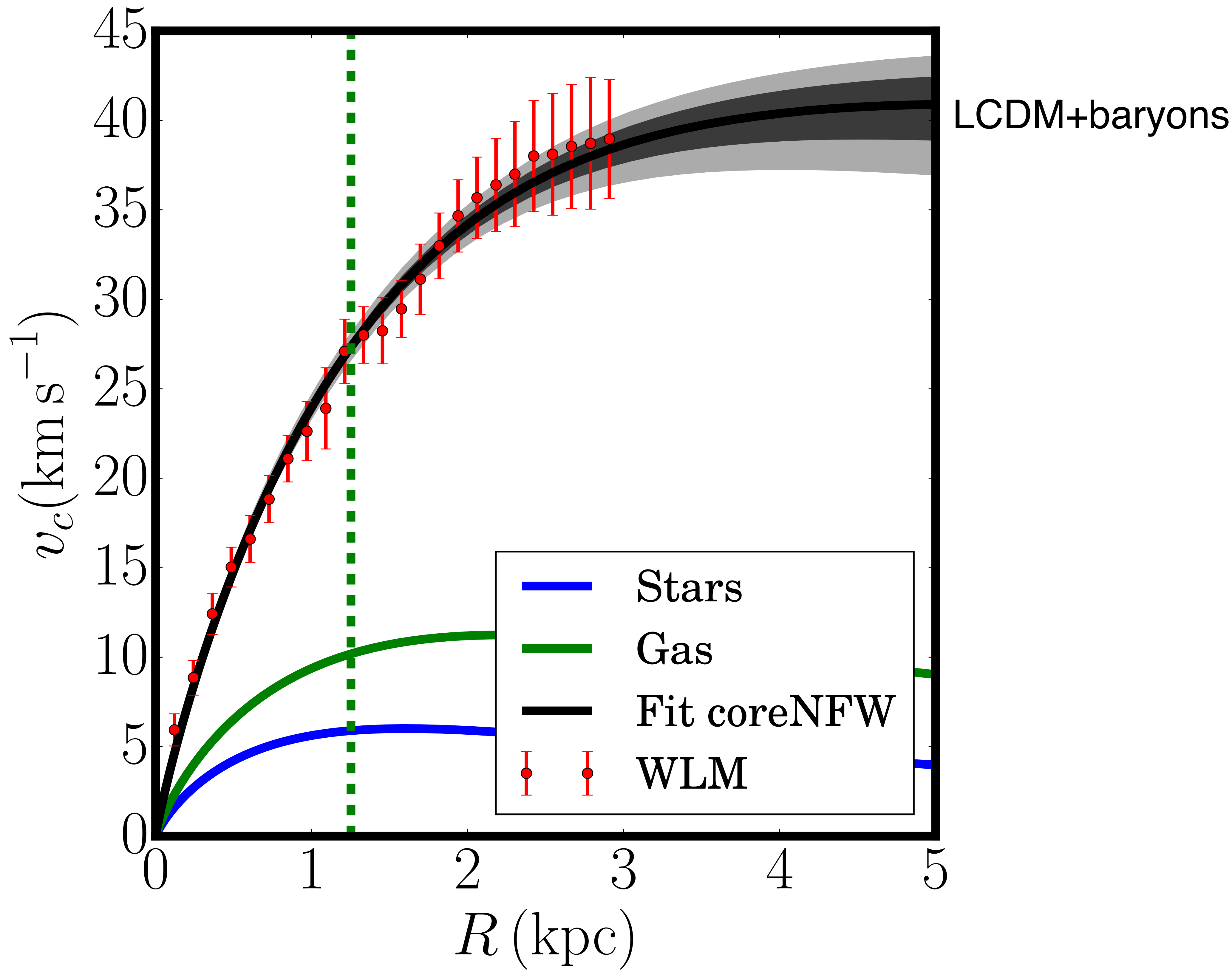
Measurement | Rotation curves



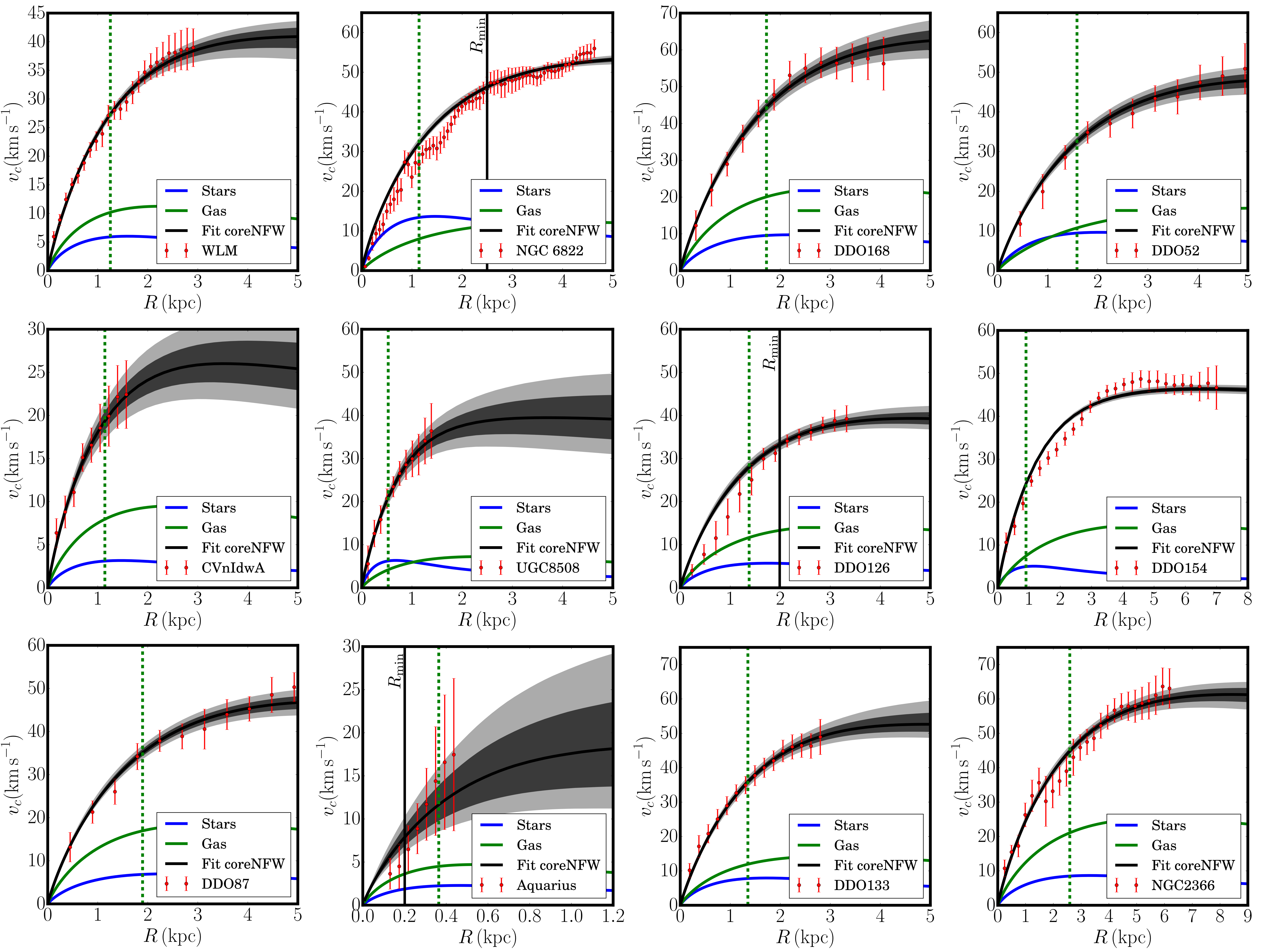
LCDM; no baryons

Read et al. 2016a,b,c

Measurement | Rotation curves

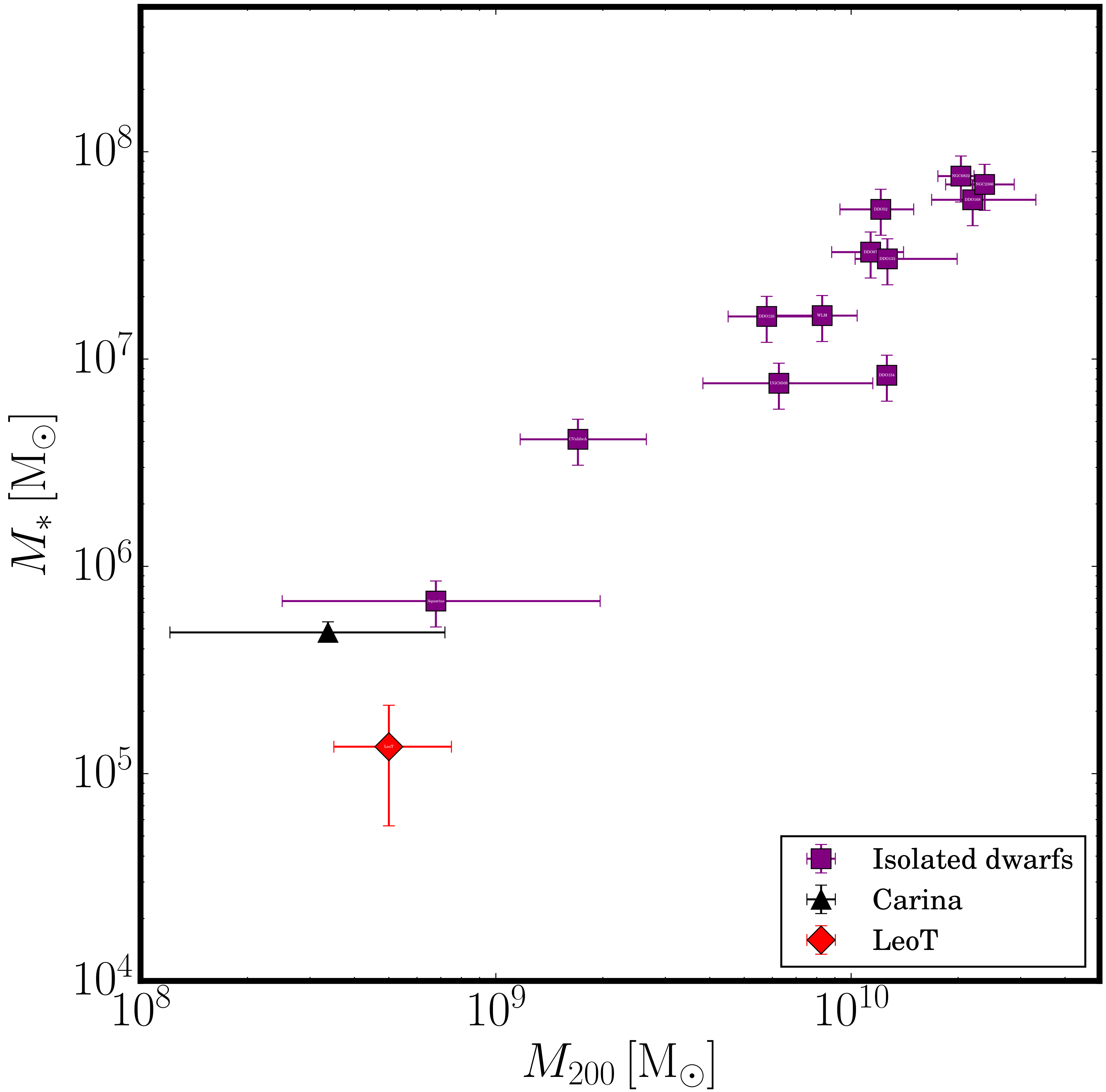


Read et al. 2016a,b,c



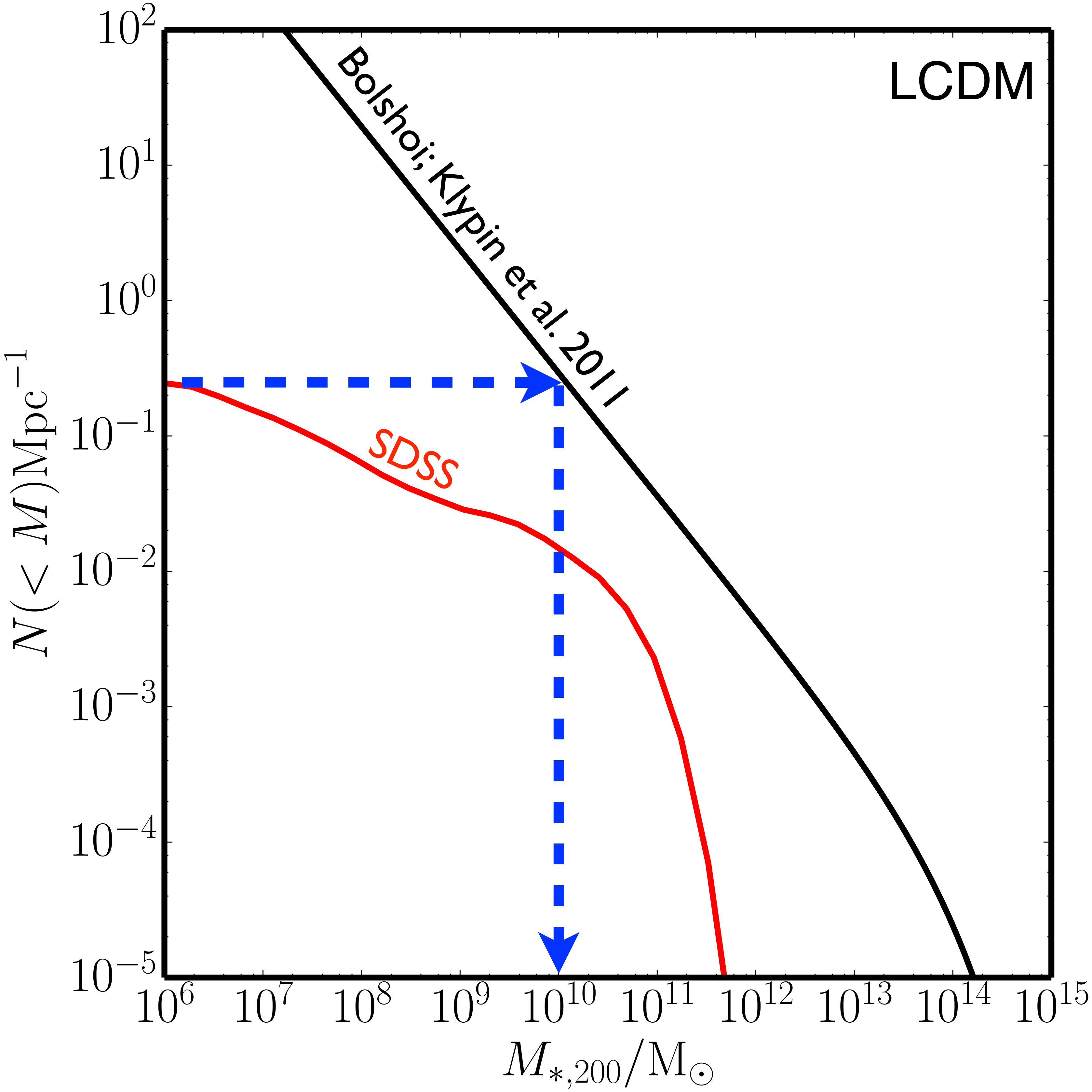
v_c(km s^{-1})
R (kpc)
$R_{\rm min}$
Stars
Gas
Fit coreNFW
WLM
NGC 6822
DDO168
DDO52
CVnIdwA
UGC8508
DDO126
DDO154
DDO87
Aquarius
DDO133
NGC2366

Measurement | The stellar mass-halo mass relation



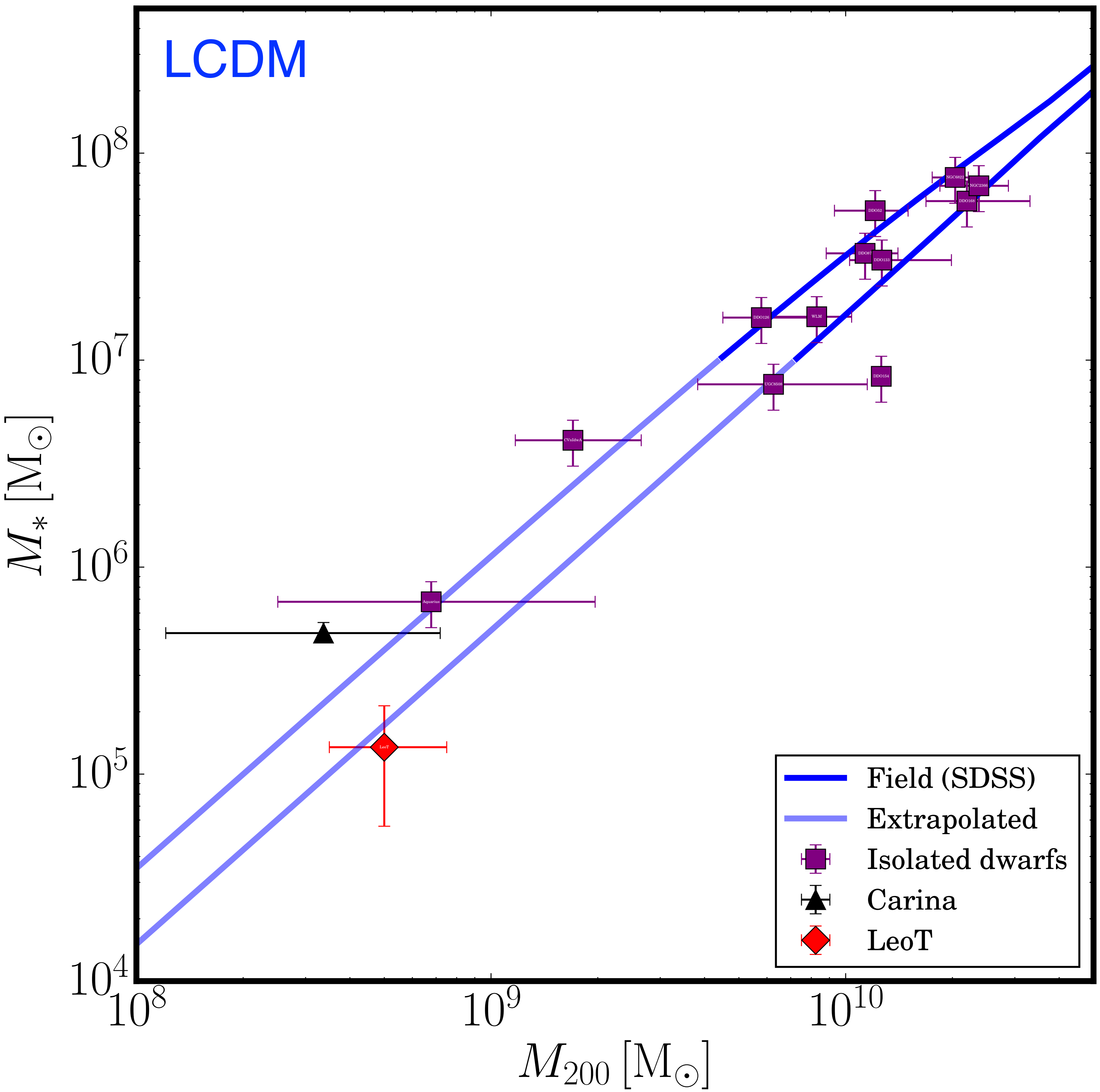
Read et al. 2016a,b,c

Measurement | The stellar mass-halo mass relation



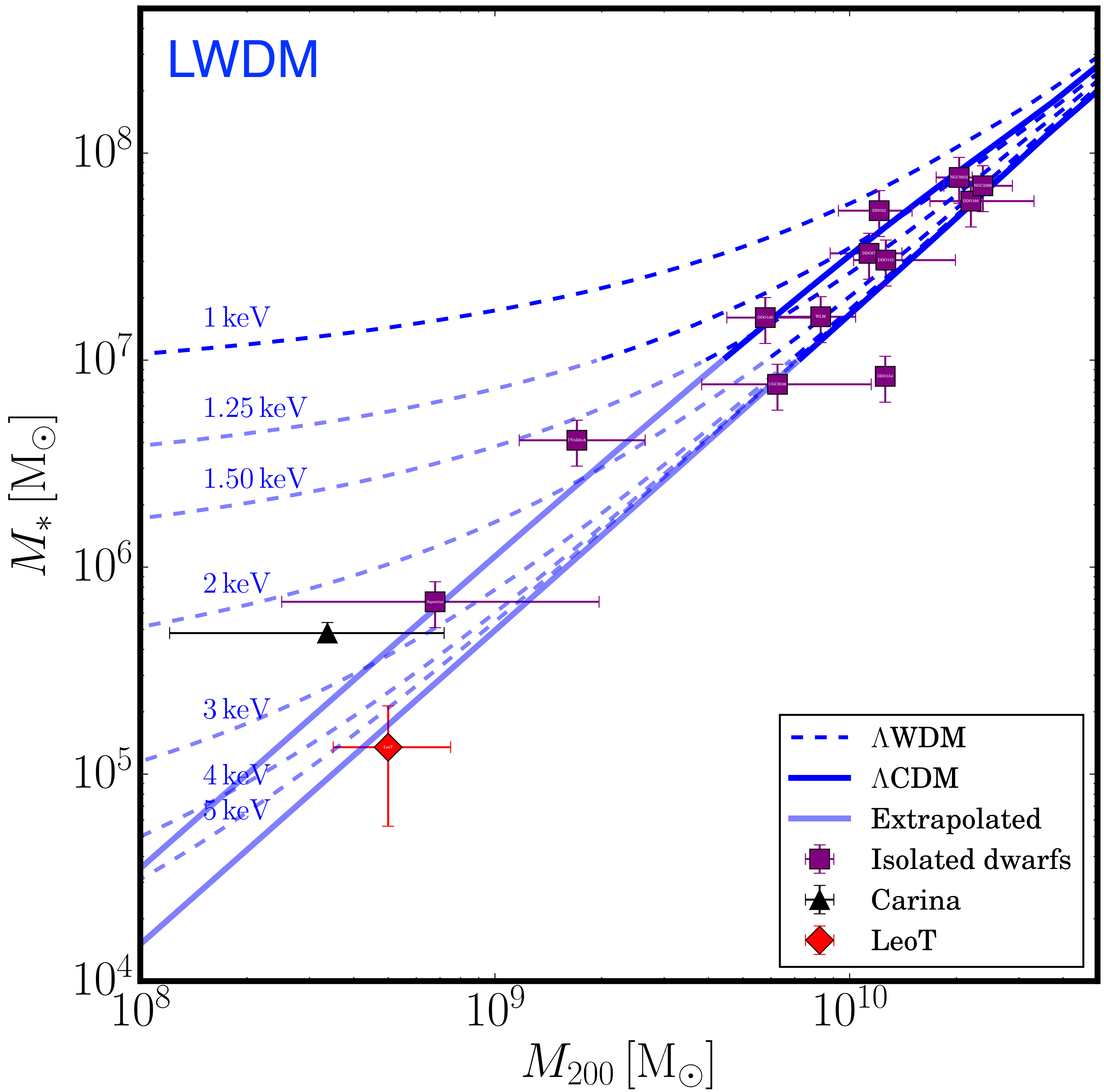
Read et al. 2016a,b,c

Measurement | The stellar mass-halo mass relation

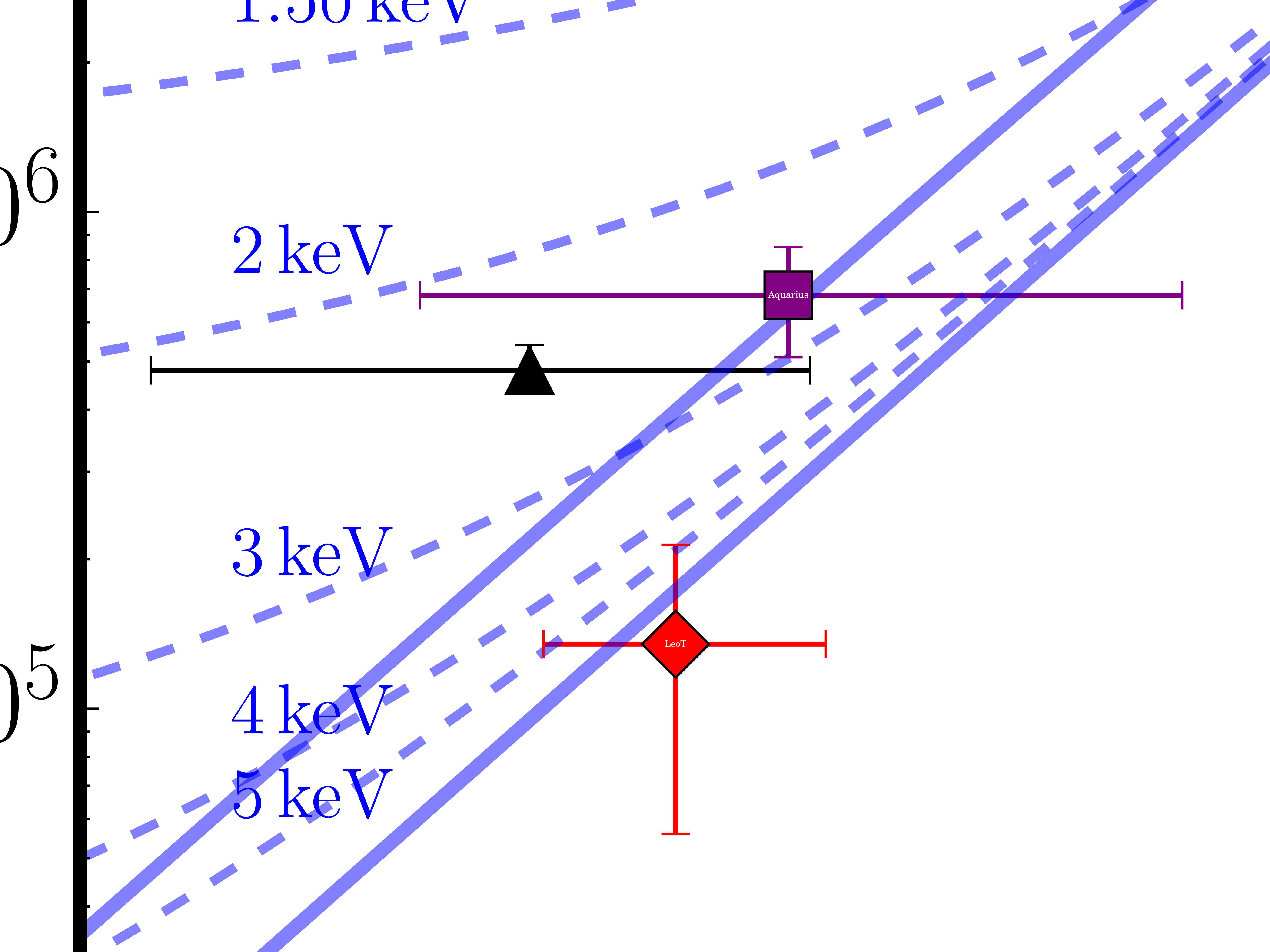


Read et al. 2016a,b,c

Measurement | The stellar mass-halo mass relation



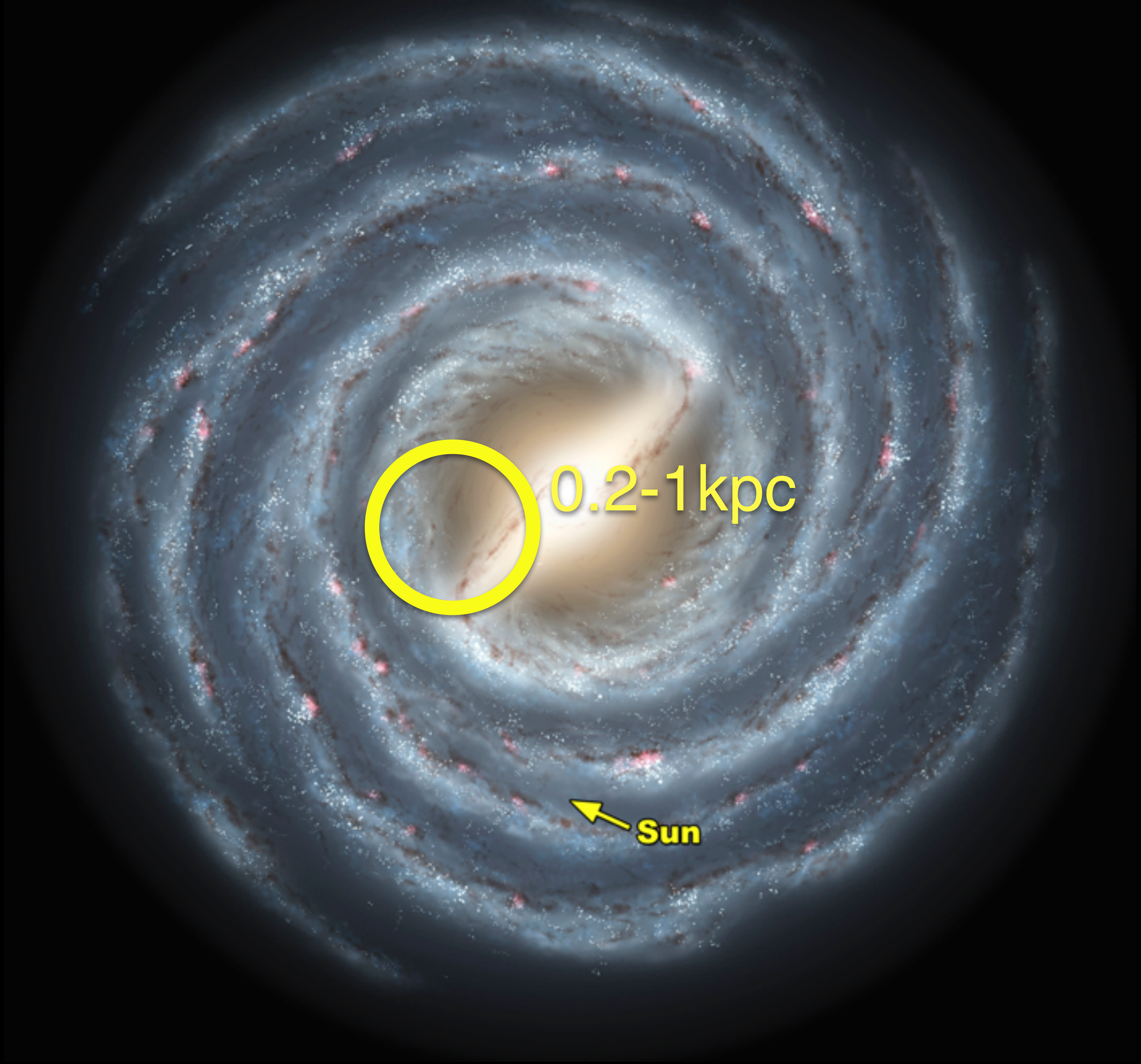
Read et al. 2016a,b,c



1.50 keV
10^6
2 keV
Aquarius
3 keV
10^5
4 keV
5 keV
LeoT

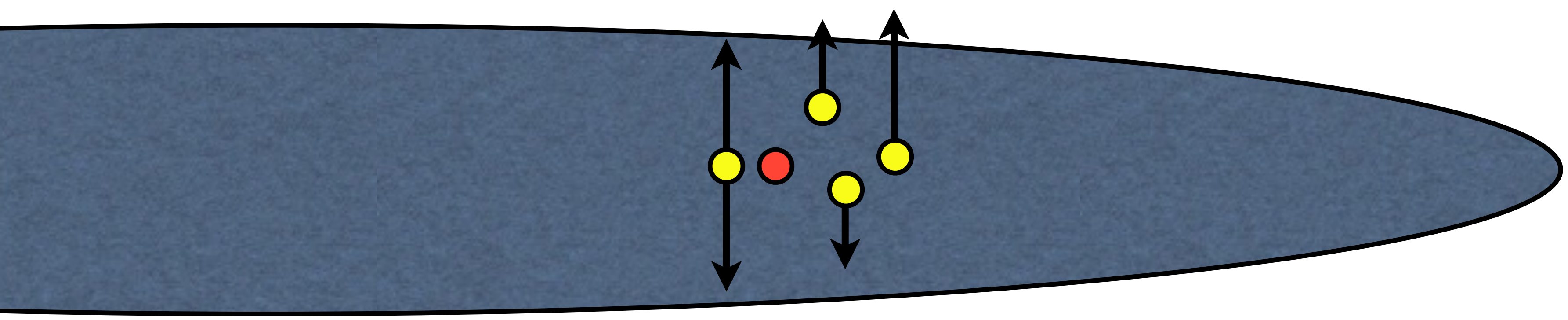
Local Dark Matter Density

Background | What is the local dark matter density?



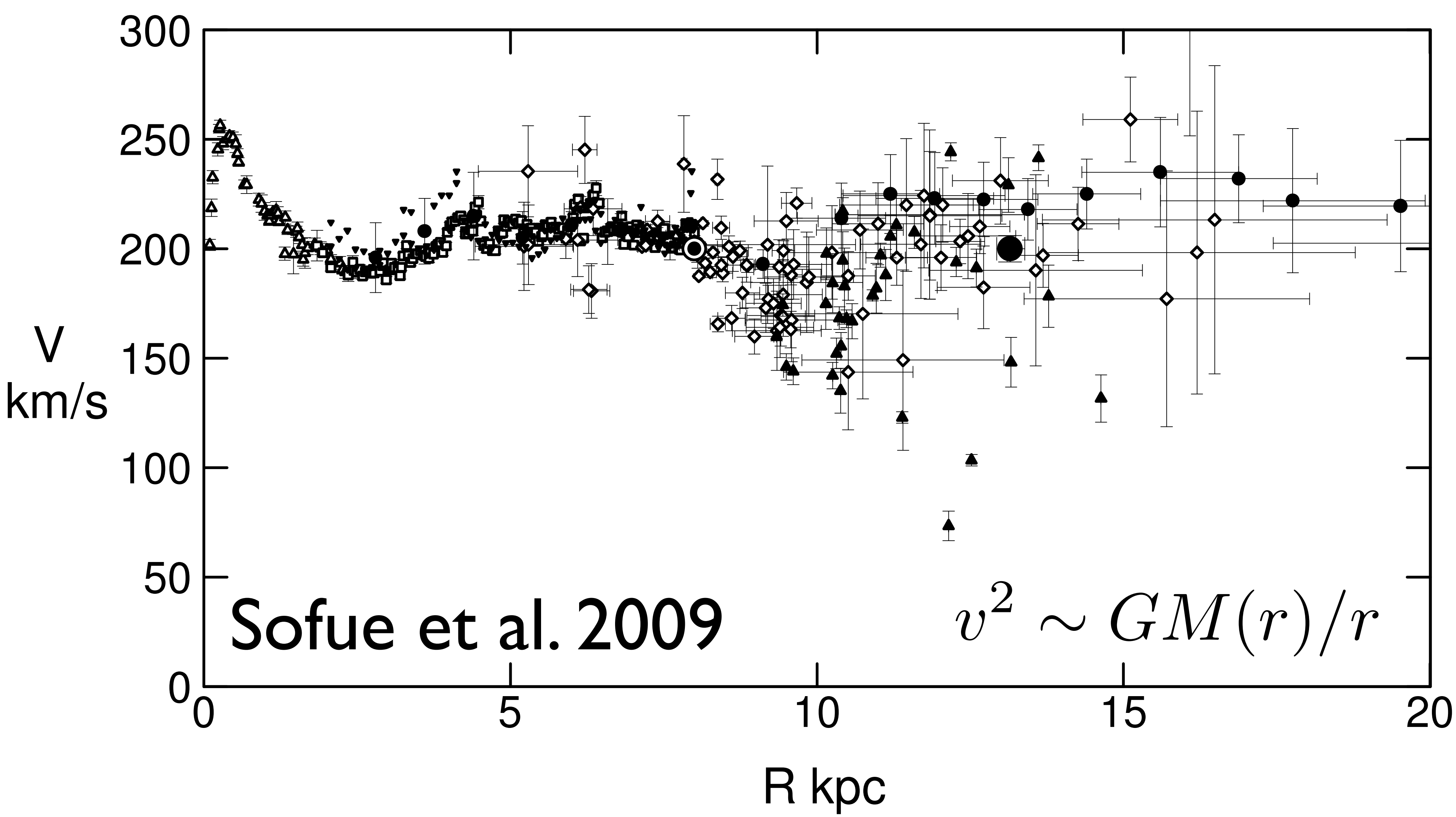
Background | How can we measure the local DM density?

1. Local measure:

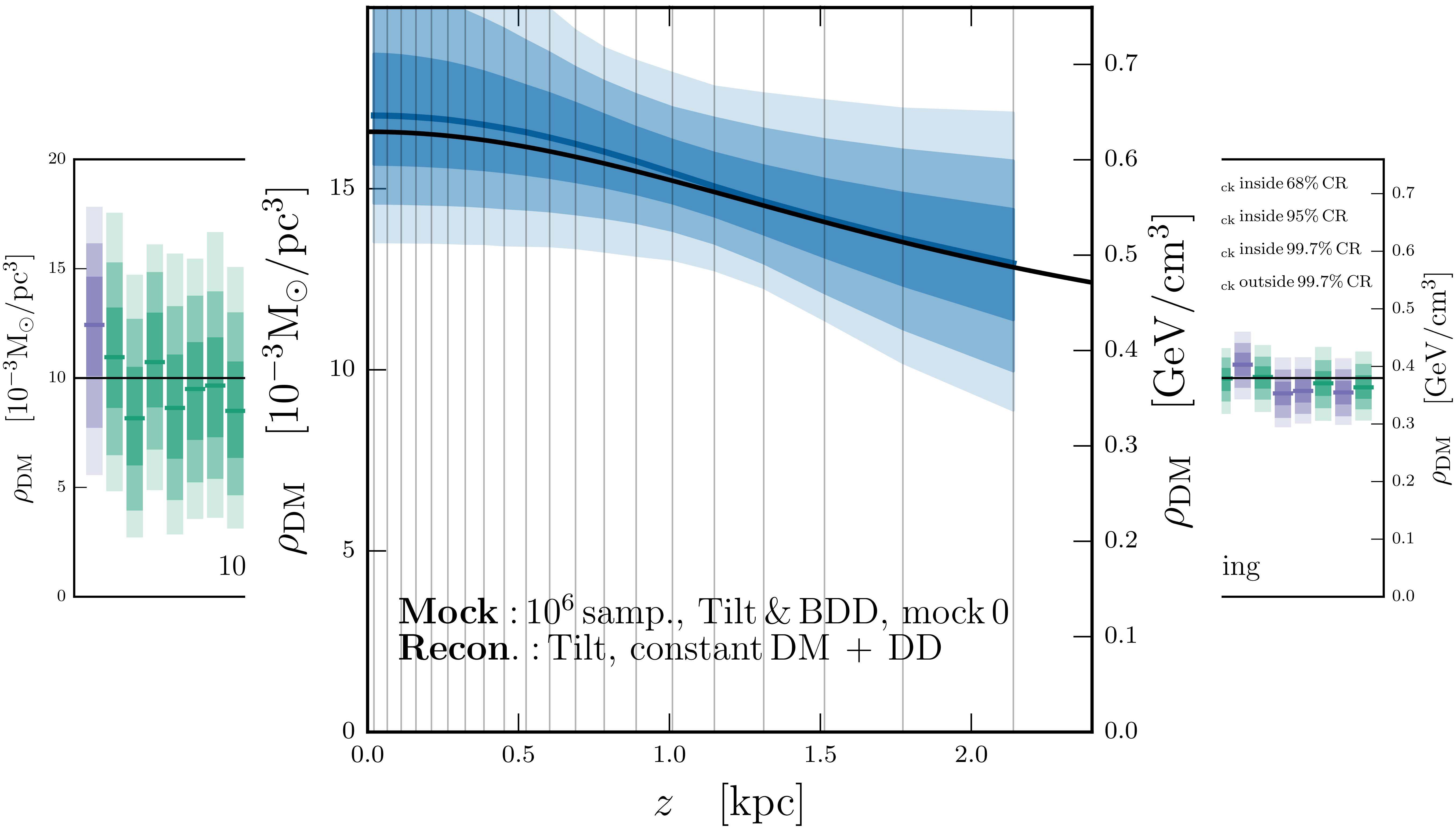


$\rho_{\rm dm}$

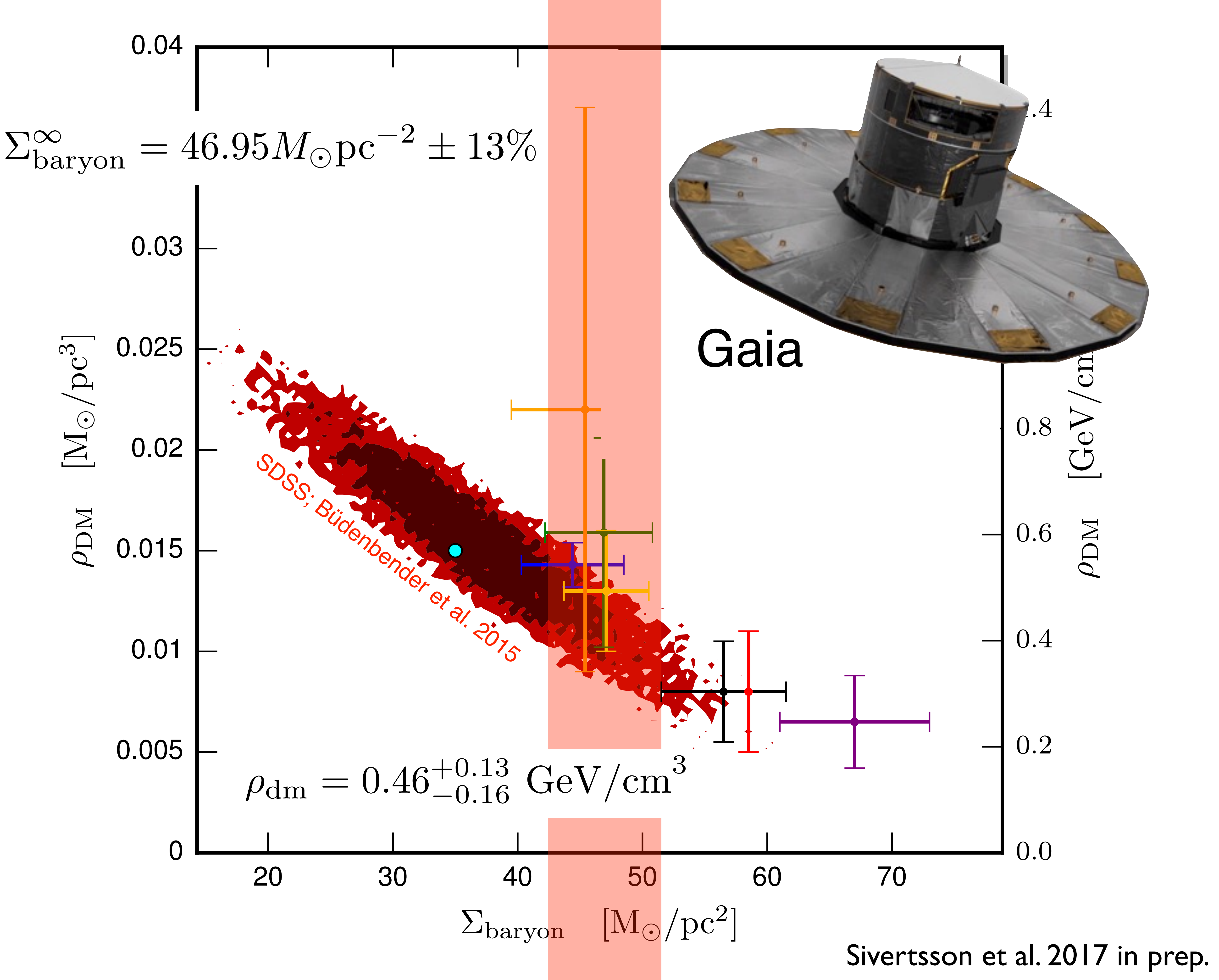
2. Glc



The Local Dark Matter Density | A new method



Silverwood et al. 2015



Sivertsson et al. 2017 in prep.

Conclusions

- Isolated dwarf simulations at ~4pc resolution predict **dark matter cores** of size ~$R_{1/2}$, **if SF not truncated**
- Abundance matching isolated dwarfs → $m_{\rm dm} > 2\,{\rm keV}$
- Dark matter likely a **cold(ish) & collisionsless particle**
- The local DM density is: $\rho_{\rm dm} = 0.46^{+0.13}_{-0.16}\,{\rm GeV/cm^3}$
- Improved accuracy will be **hard**. Is it needed?