UNIVERSITY OF SURREY

Dark matter heats up in dwarf galaxies

Justin I. Read

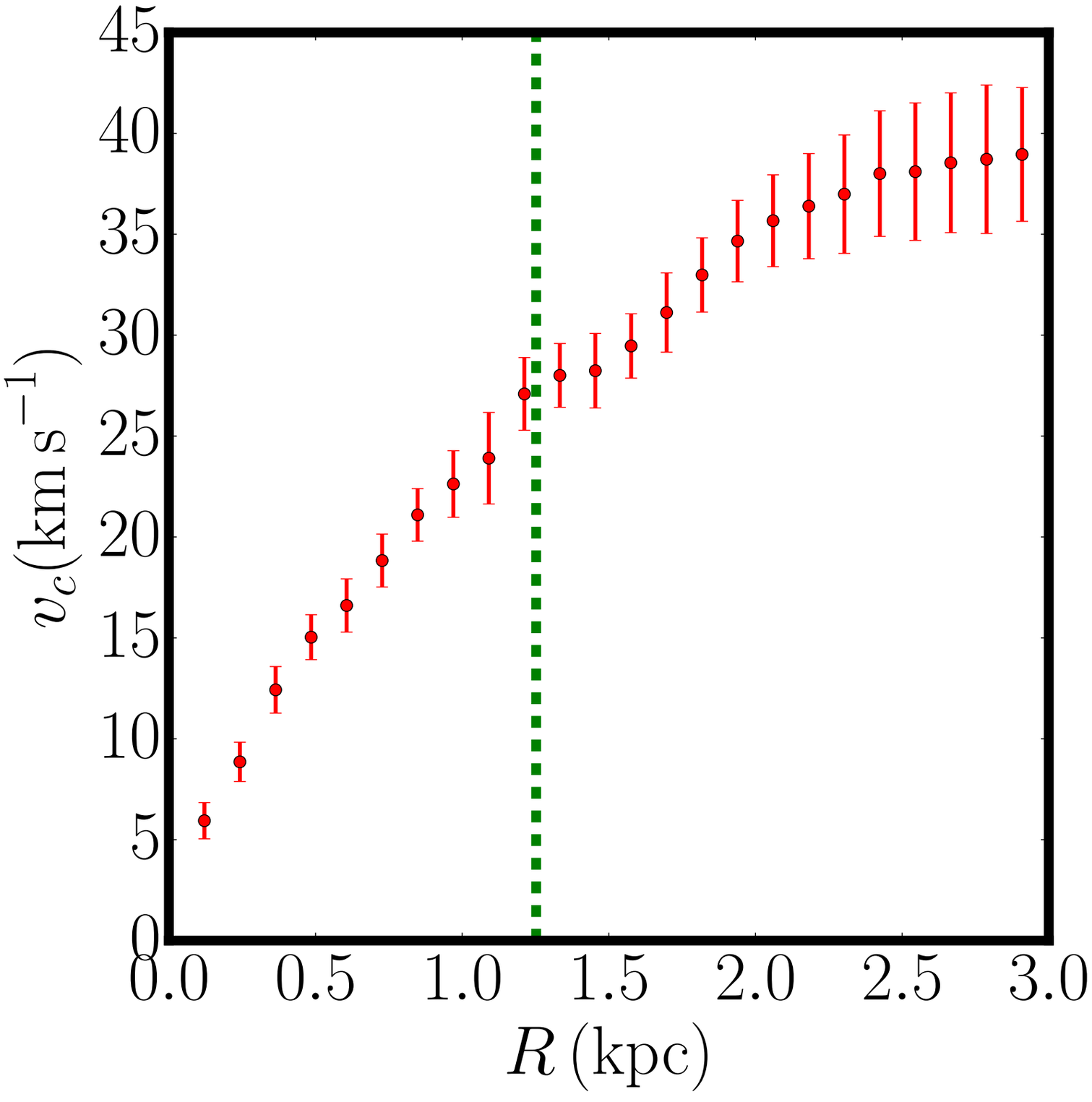
Matthew Walker, Pascal Steger, Oscar Agertz, Michelle Collins, Denis Erkal,
Giuliano Iorio, Filippo Fraternali, Alexandra Gregory,
Matthew Orkney, Andrew Pontzen, Martin Rey

The Cusp-Core Problem

The Cusp-Core Problem

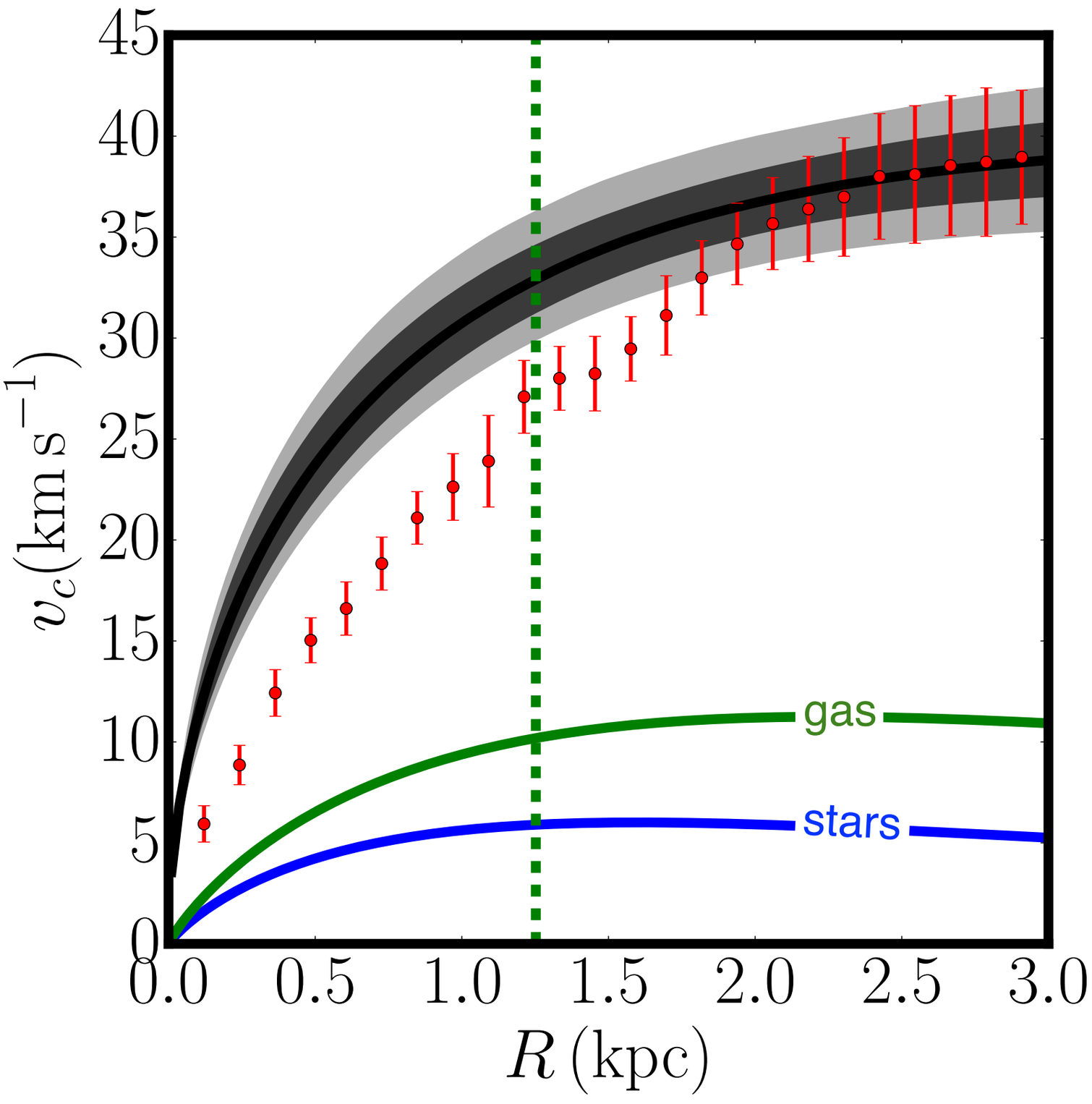
WLM; Leroy, Nature 2015

The Cusp-Core Problem



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

The Cusp-Core Problem



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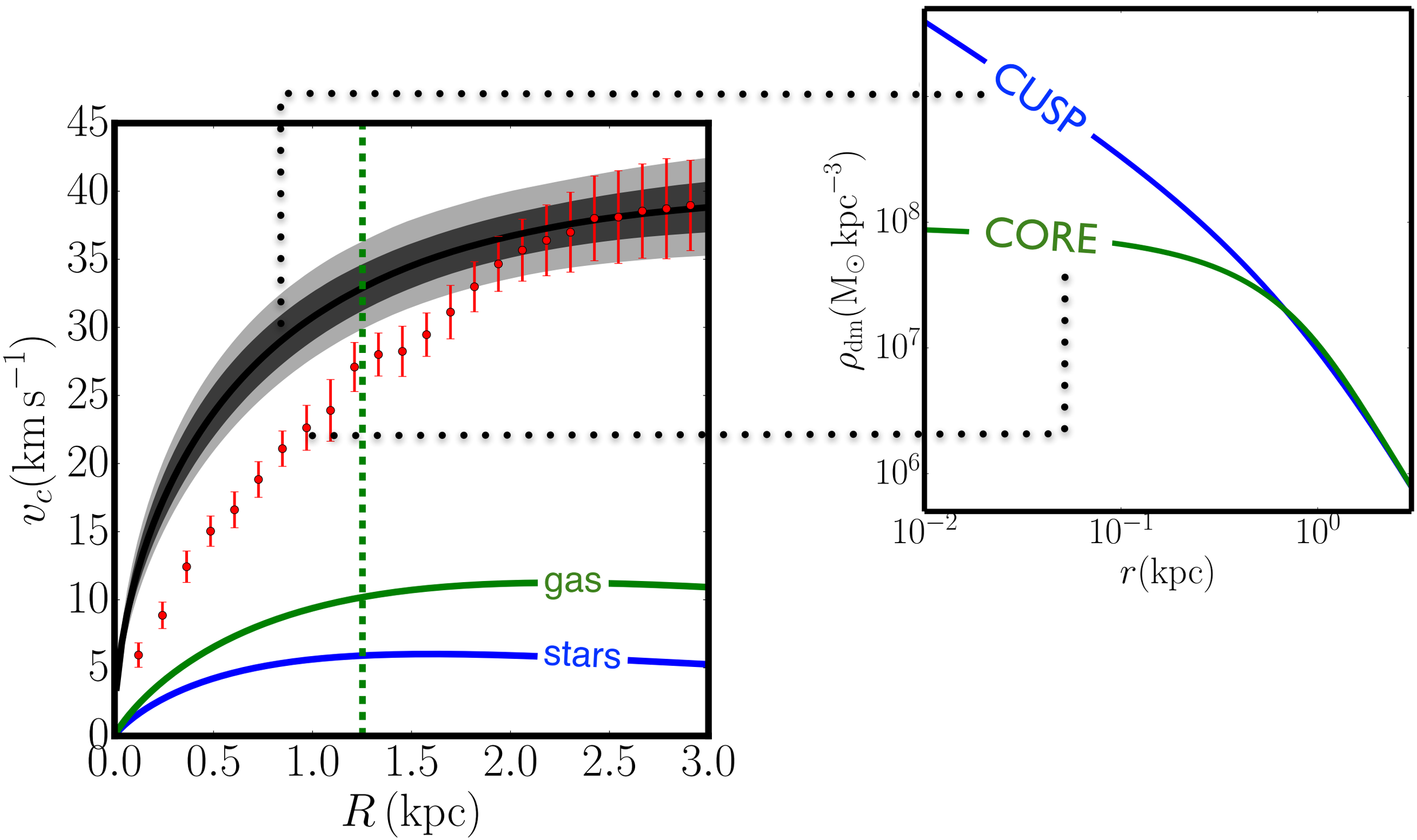
The Cusp-Core Problem



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

Dark Matter Heating

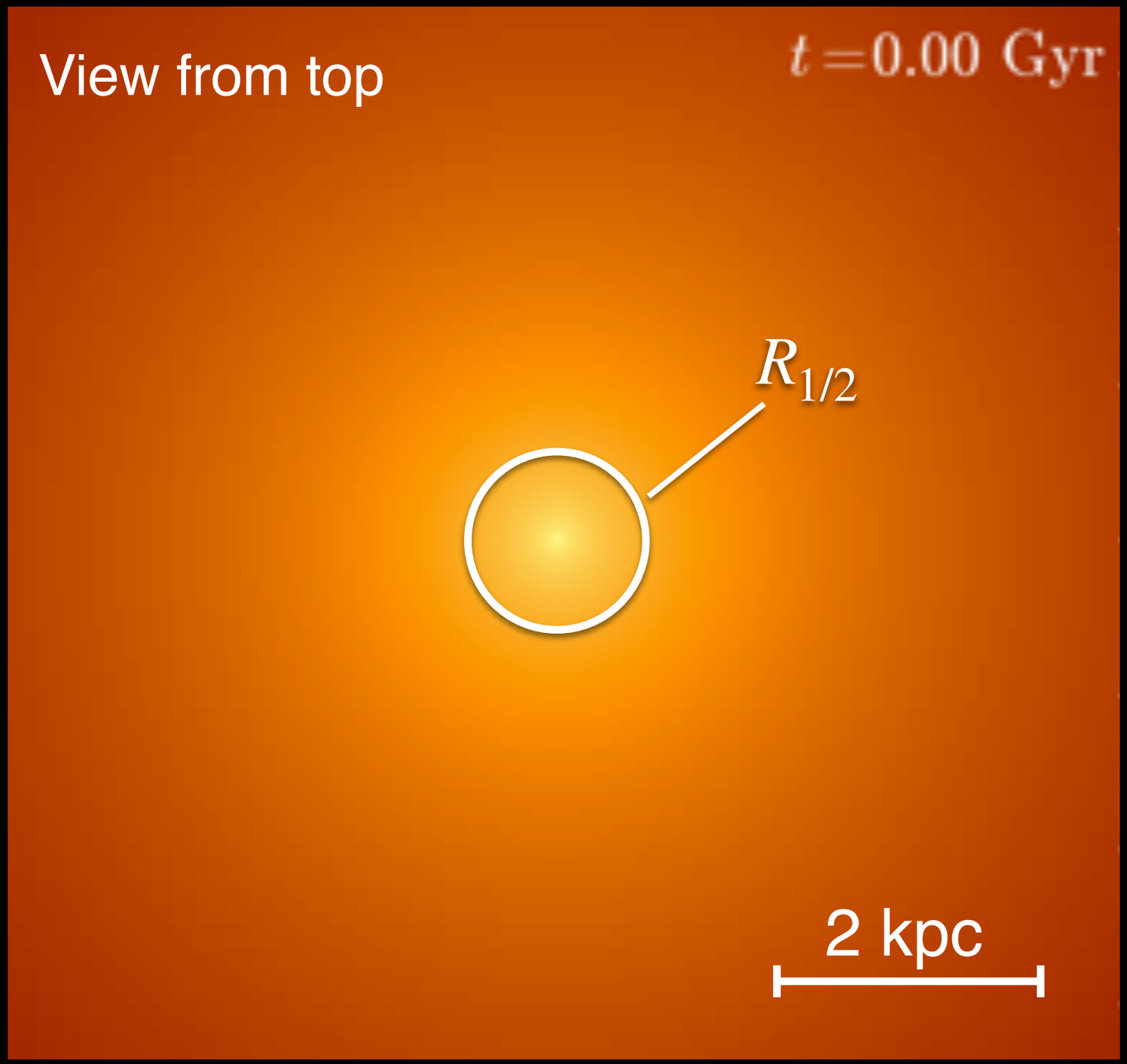
Dark matter heating

$\Delta x = 4\,\mathrm{pc}$

$M_{\mathrm{res}} = 300\,\mathrm{M}_{\odot}$

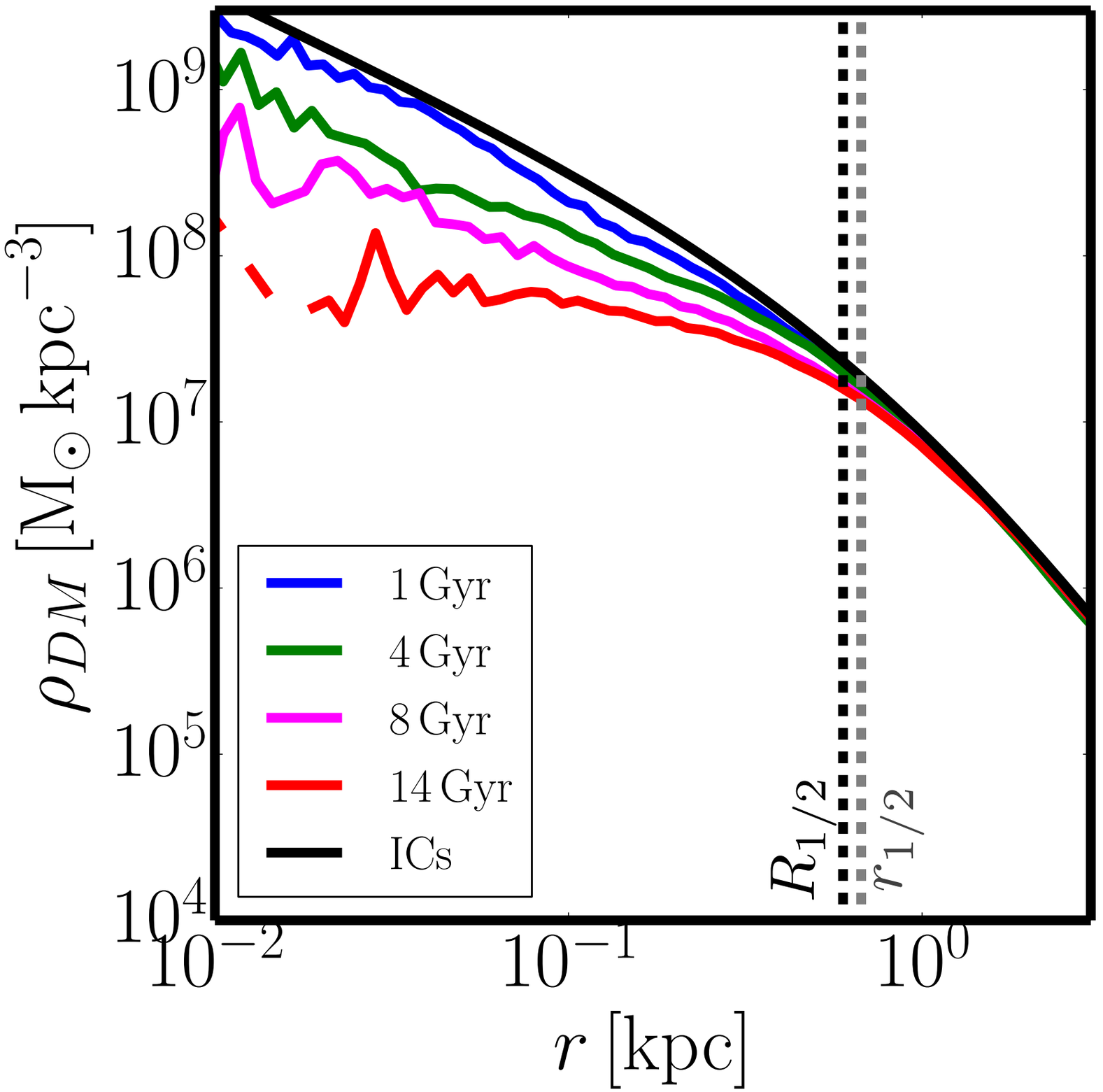
$\rho_{\mathrm{th}} = 300\,\mathrm{atoms/cc}$

$T_{\mathrm{gas,min}} = 10\,\mathrm{K}$



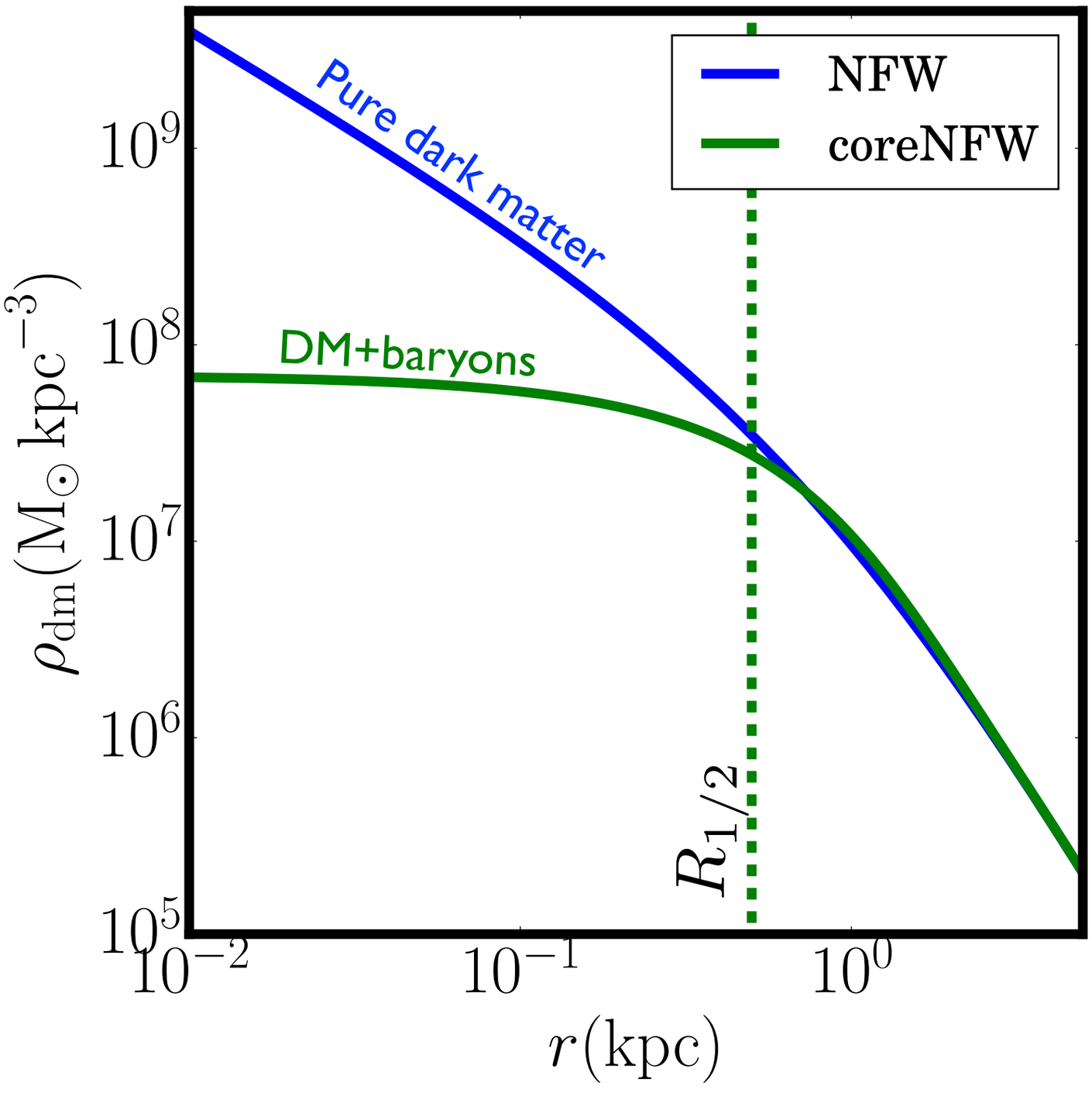
e.g. Navarro et al. 1996; Read & Gilmore 2005; Pontzen & Governato 2012; Read et al. 2016

Dark matter heating



Read et al. 2016

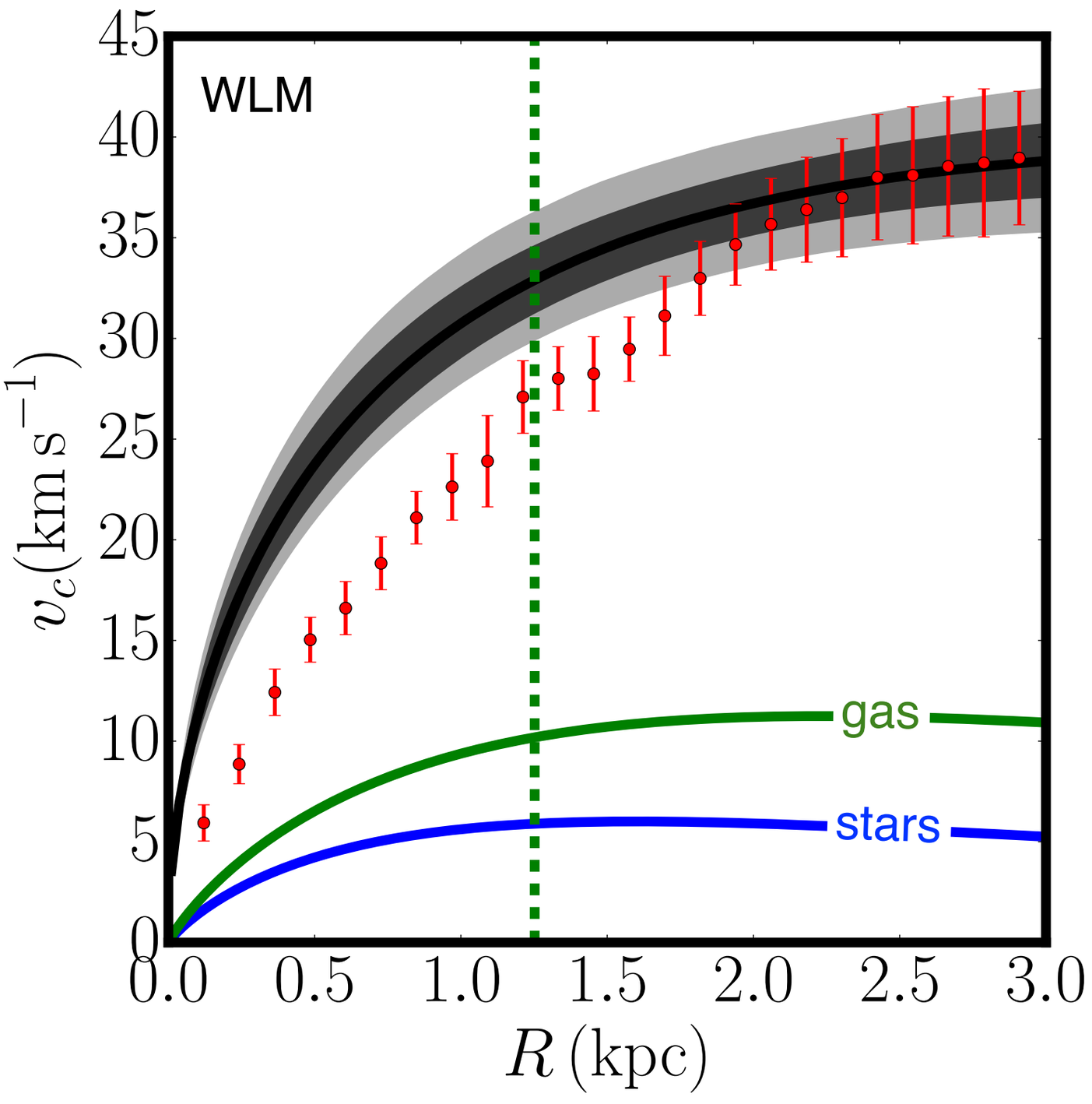
Dark matter heating



Read et al. 2016

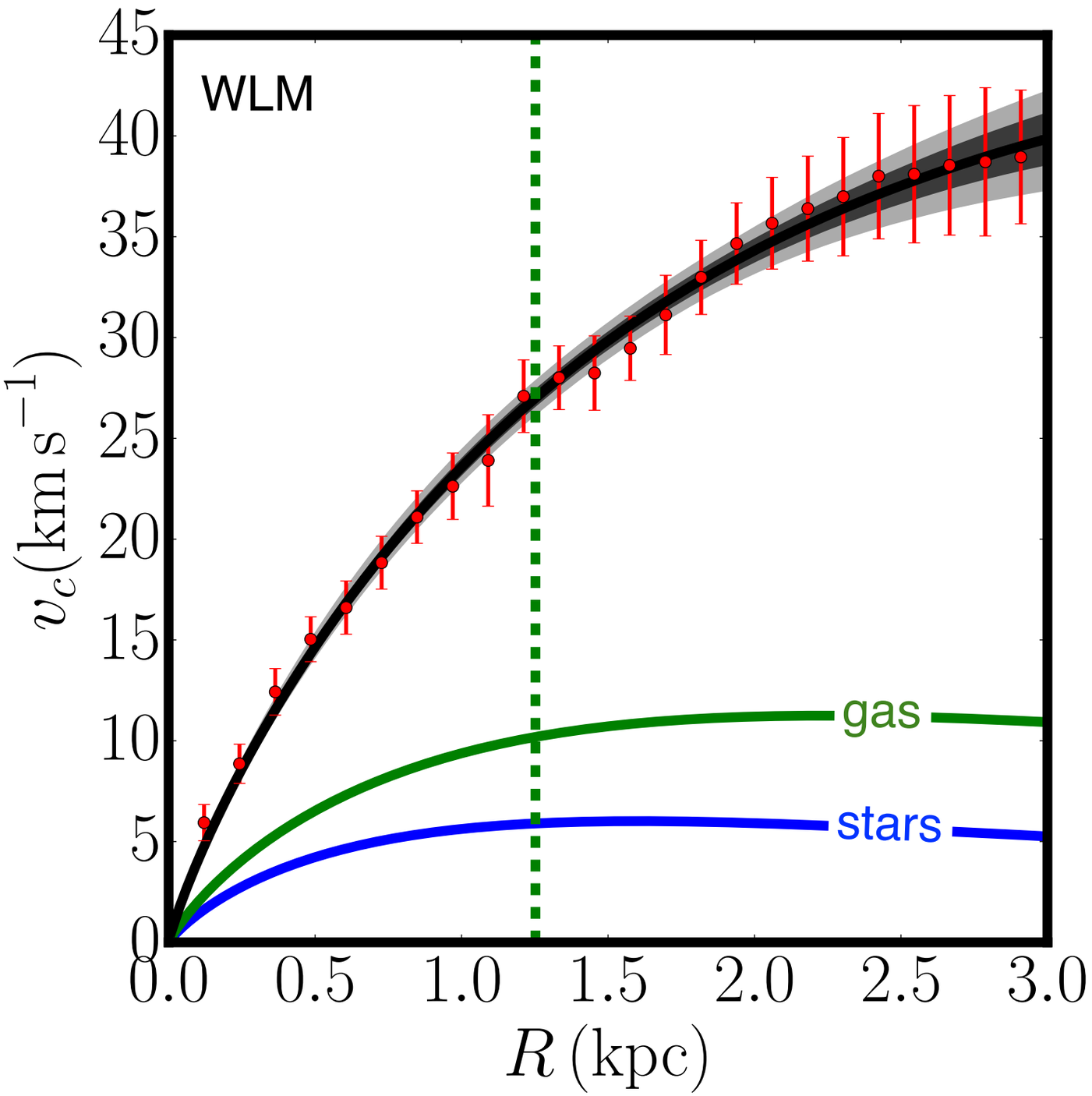
The Cusp-Core Problem Revisited

Measurement I Rotation cuves

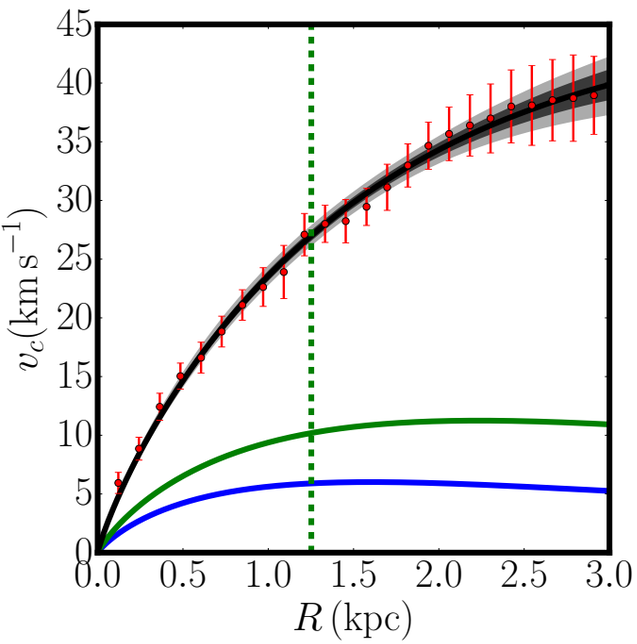


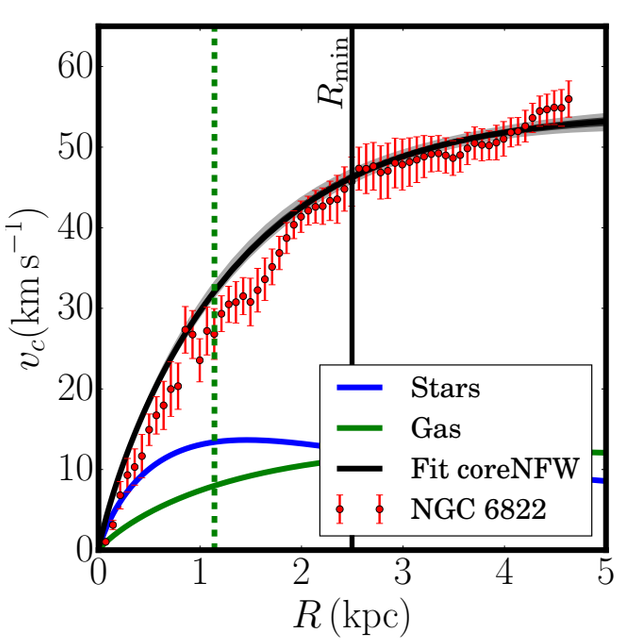
Read et al. 2016b,2017

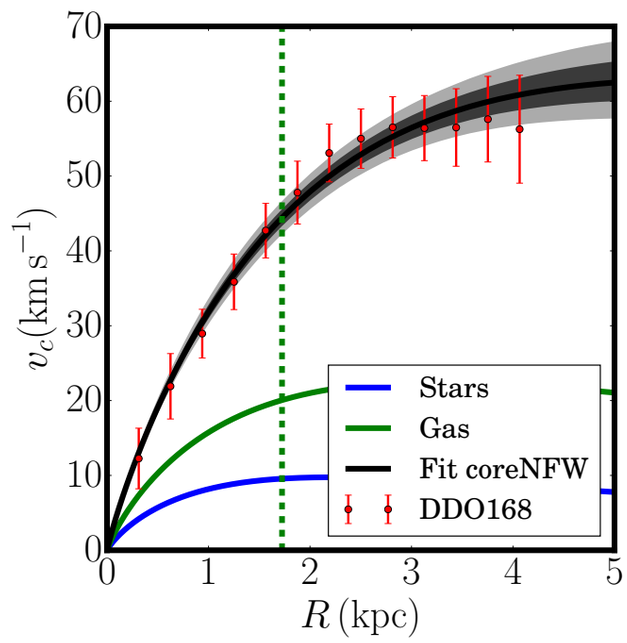
Measurement I Rotation cuves

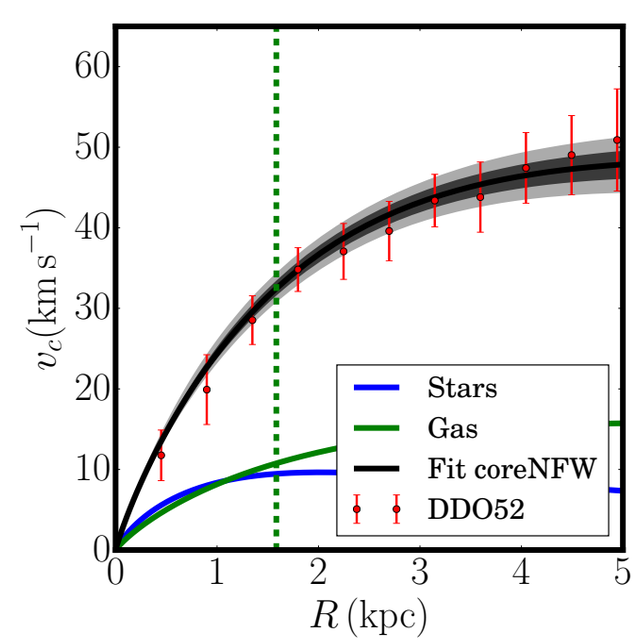


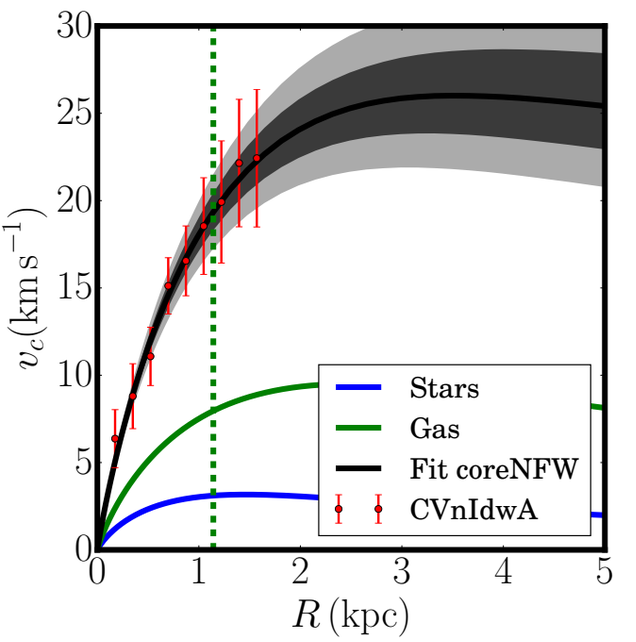
Read et al. 2016b,2017

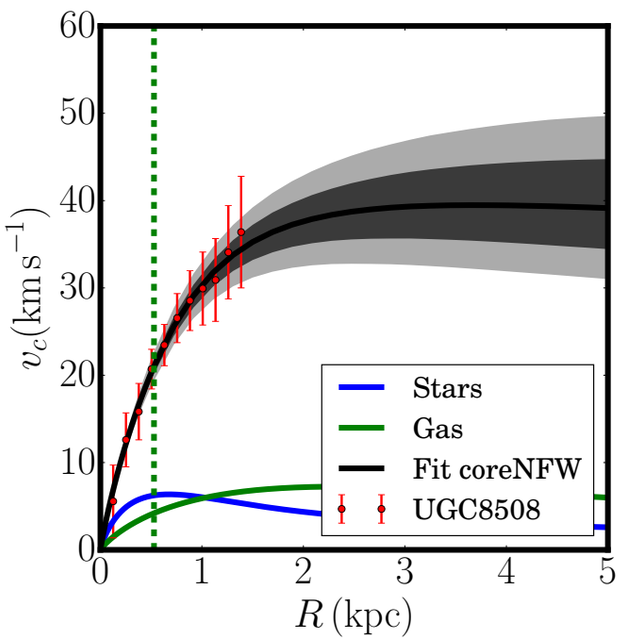

$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
Stars
Gas
Fit coreNFW
CVnIdwA

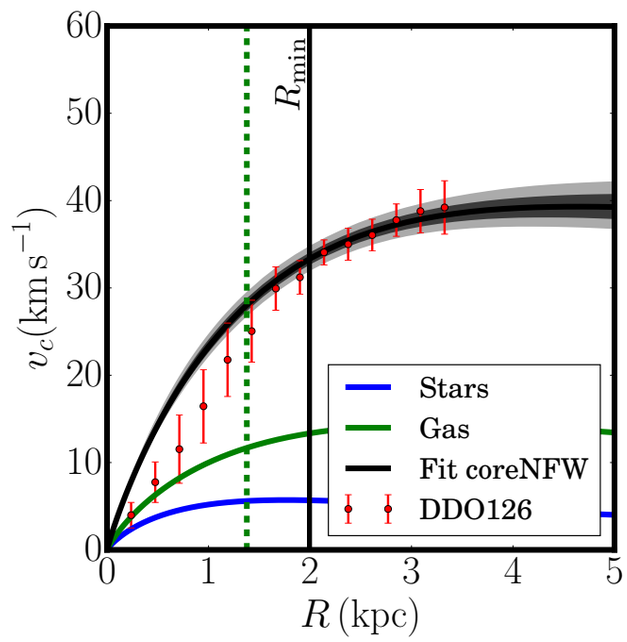

$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
R_{min}
Stars
Gas
Fit coreNFW
NGC 6822

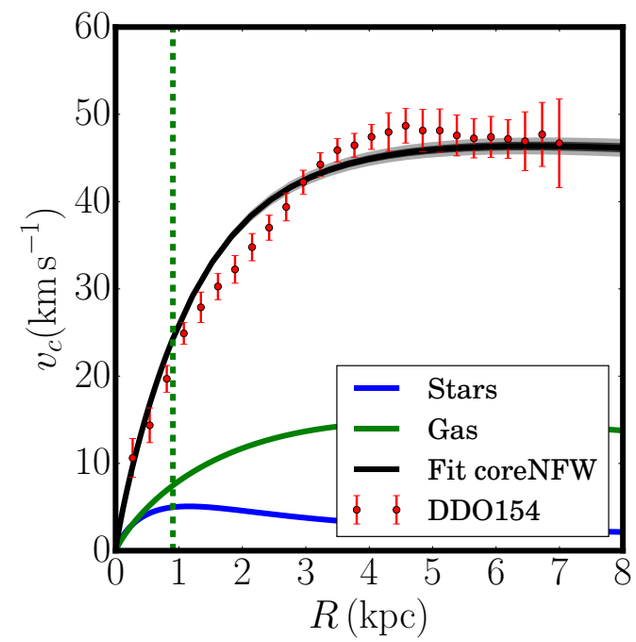

$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
Stars
Gas
Fit coreNFW
DDO168

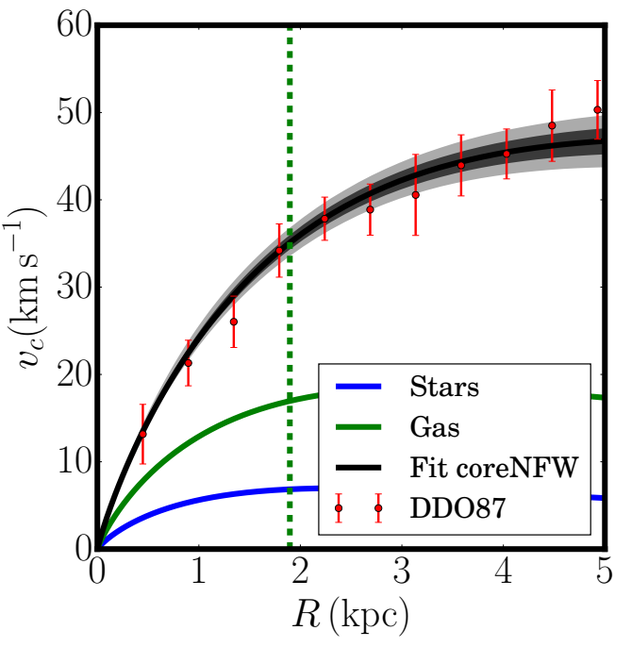

$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
Stars
Gas
Fit coreNFW
DDO52

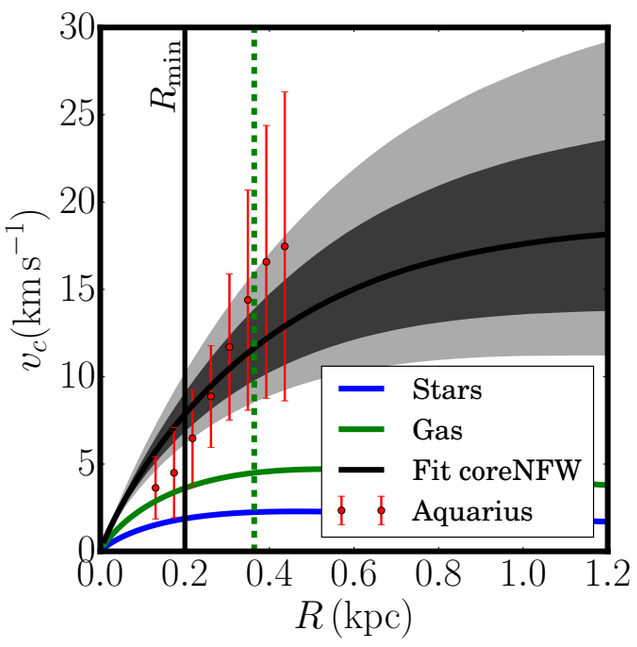

$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
Stars
Gas
Fit coreNFW
CVnIdwA

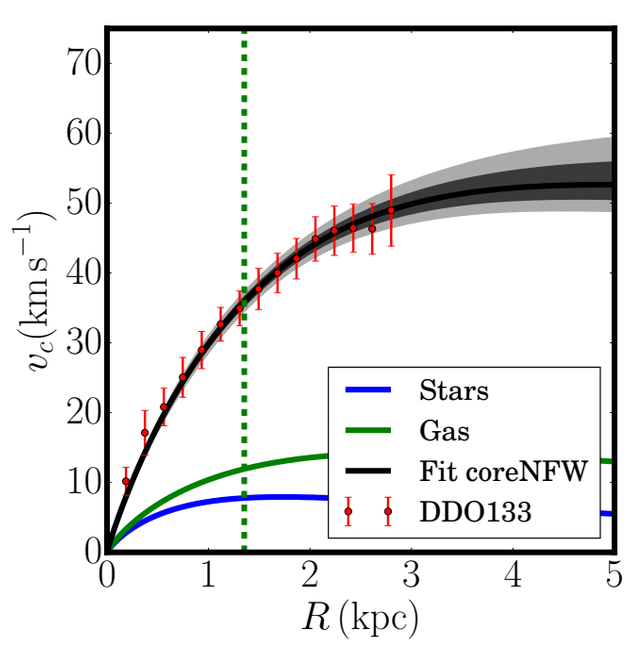

$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
Stars
Gas
Fit coreNFW
UGC8508

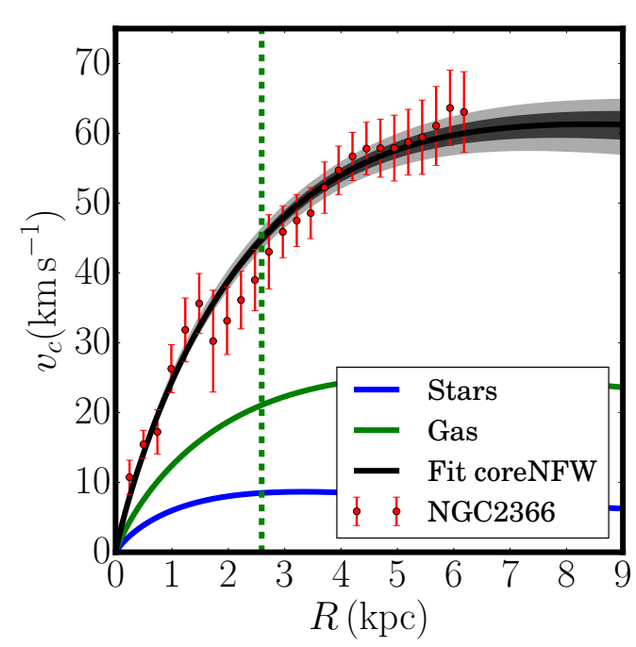

$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
R_{min}
Stars
Gas
Fit coreNFW
DDO126


$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
Stars
Gas
Fit coreNFW
DDO154


$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
Stars
Gas
Fit coreNFW
DDO87


$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
R_{min}
Stars
Gas
Fit coreNFW
Aquarius

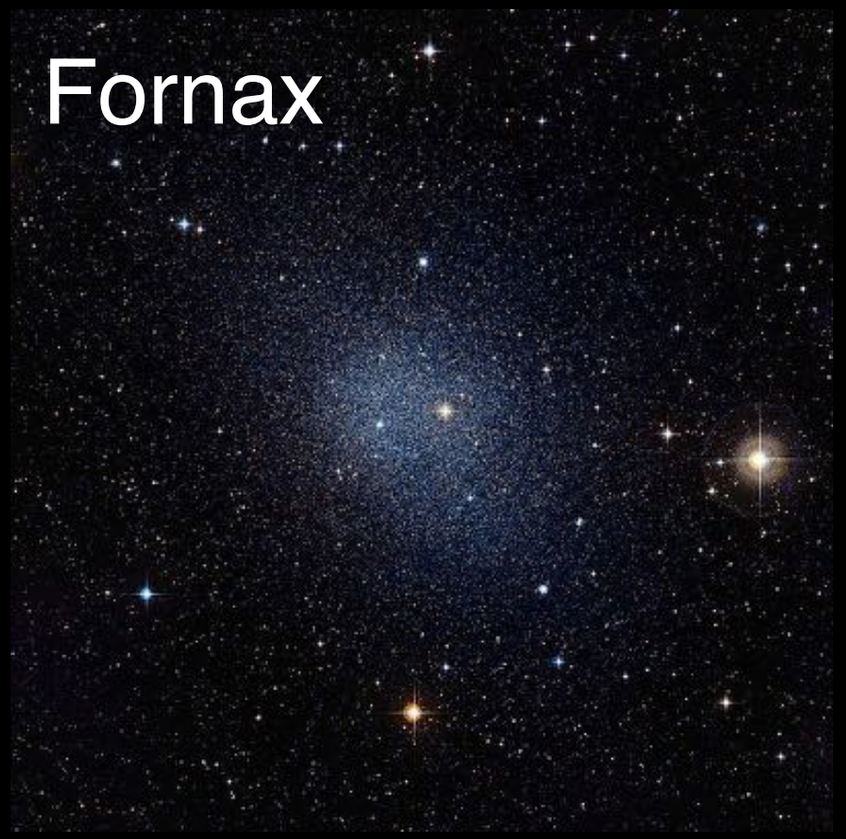

$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
Stars
Gas
Fit coreNFW
DDO133


$v_c(\mathrm{km\,s^{-1}})$
$R\,(\mathrm{kpc})$
Stars
Gas
Fit coreNFW
NGC2366

“Smoking gun” evidence for DM heating

Less star formation ⇒ more cusp

Leroy, Nature 2015



ESO/Digitized Sky Survey 2

Robert Lupton & SDSS

Decreasing star formation
⇒
More DM cusp!

Less star formation ⇒ more cusp

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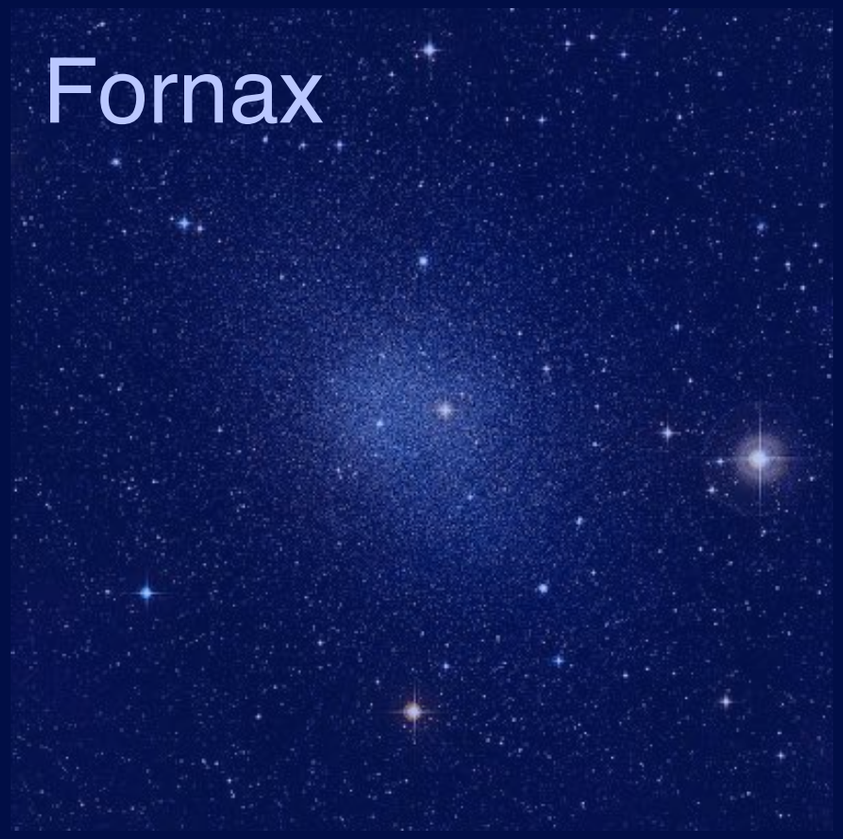
Leroy, Nature 2015



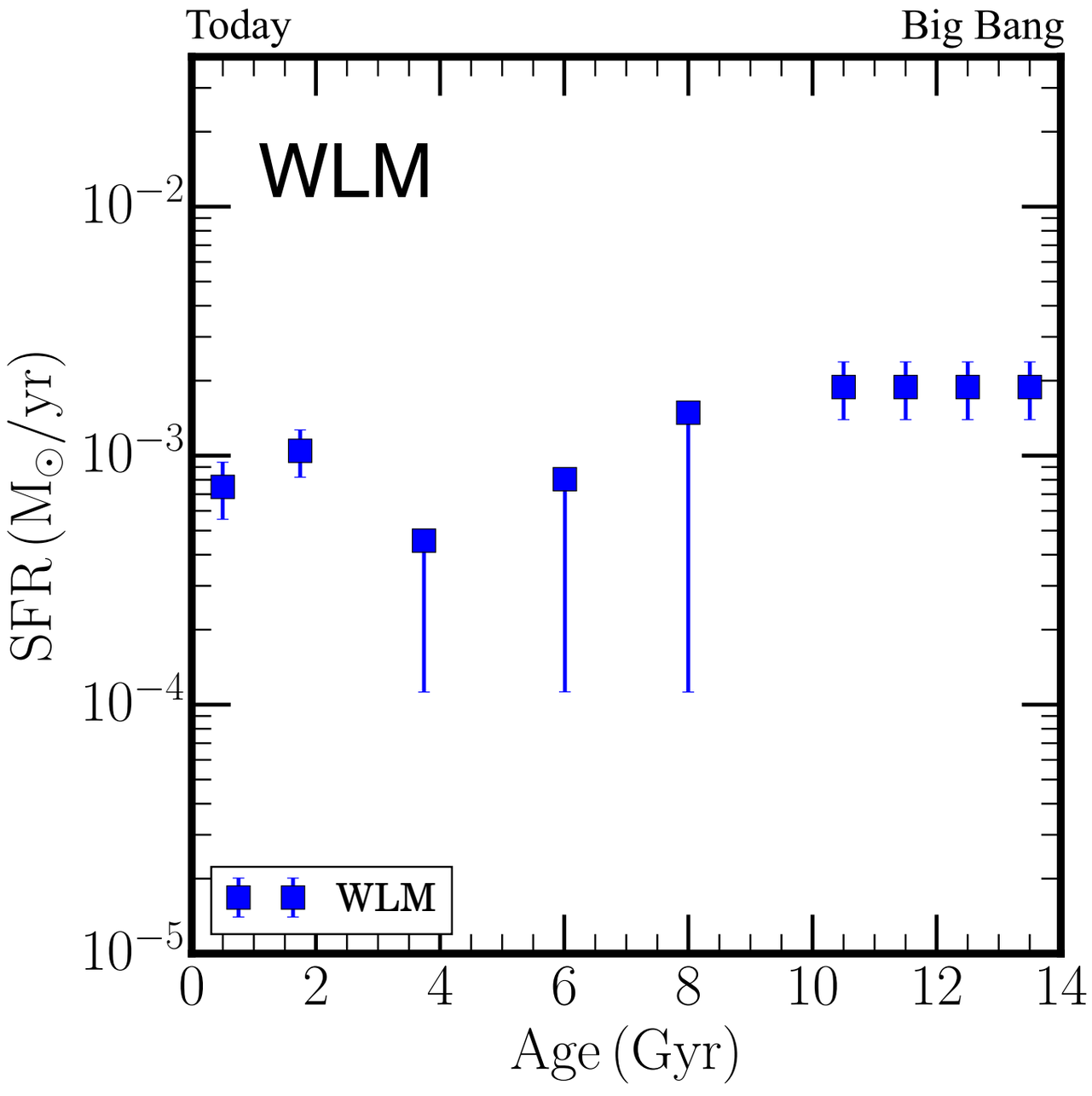
ESO/Digitized Sky Survey 2

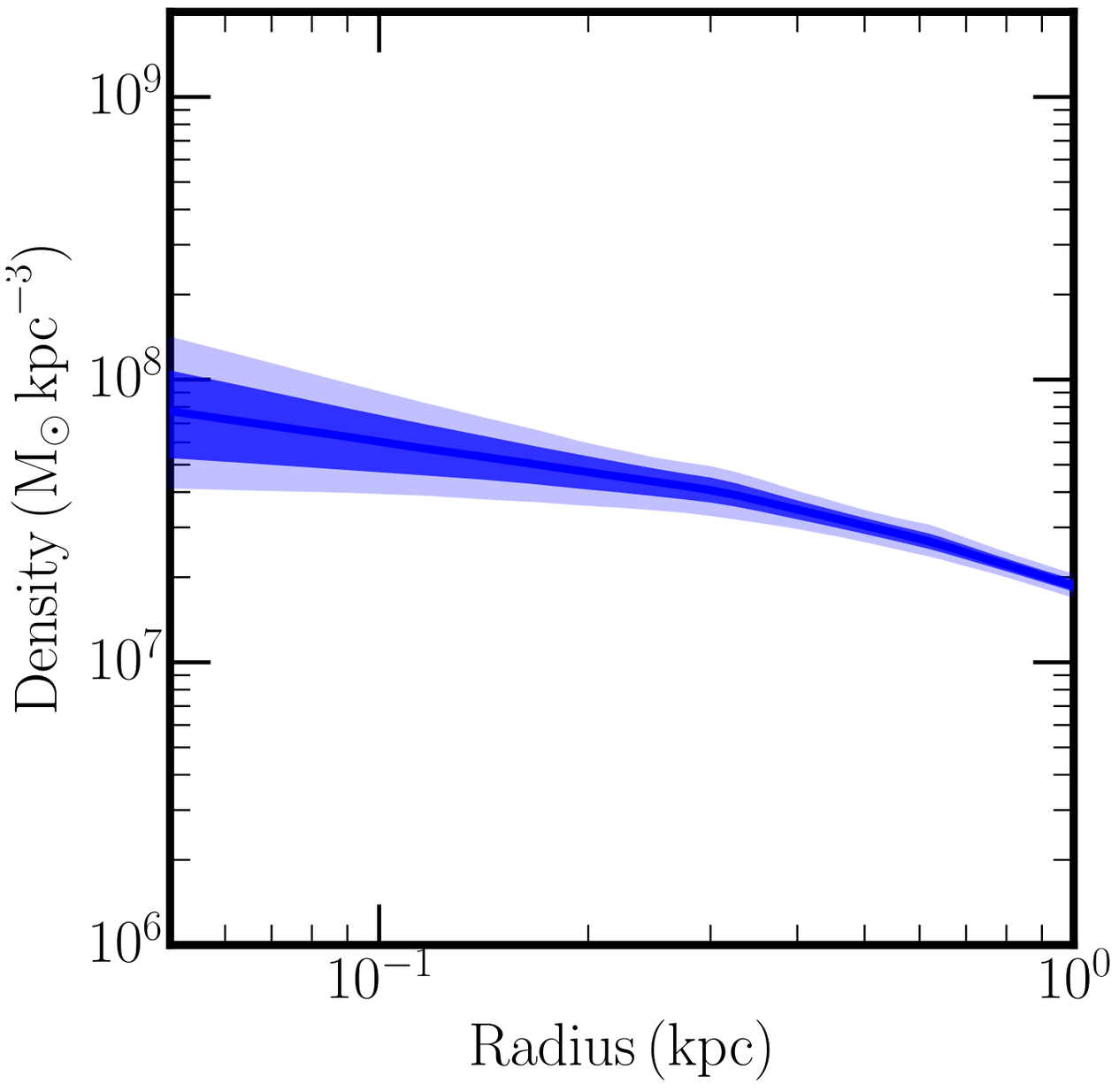
Robert Lupton & SDSS

Rotation curves

Stellar kinematics

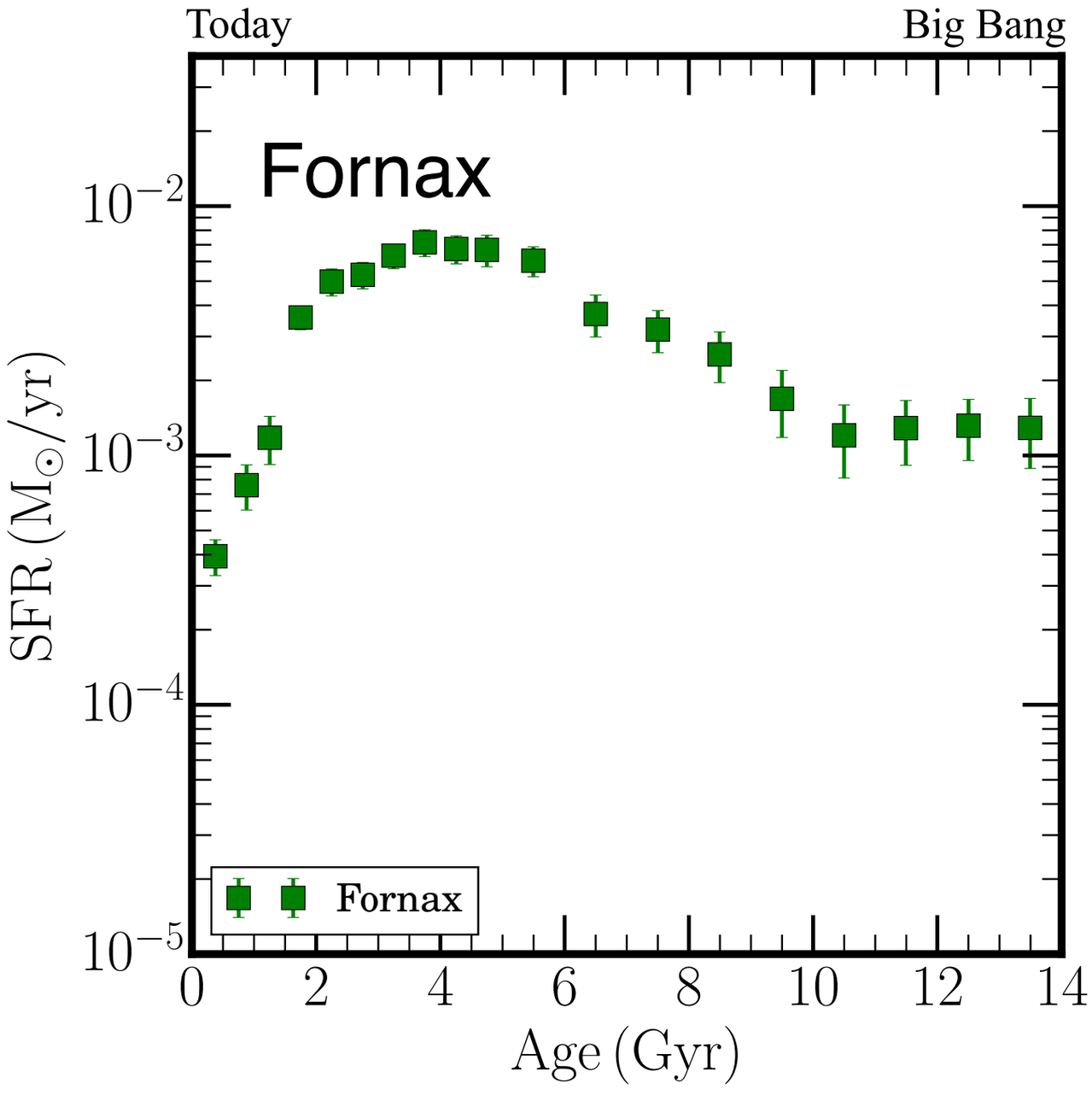
Less star formation ⇒ more cusp

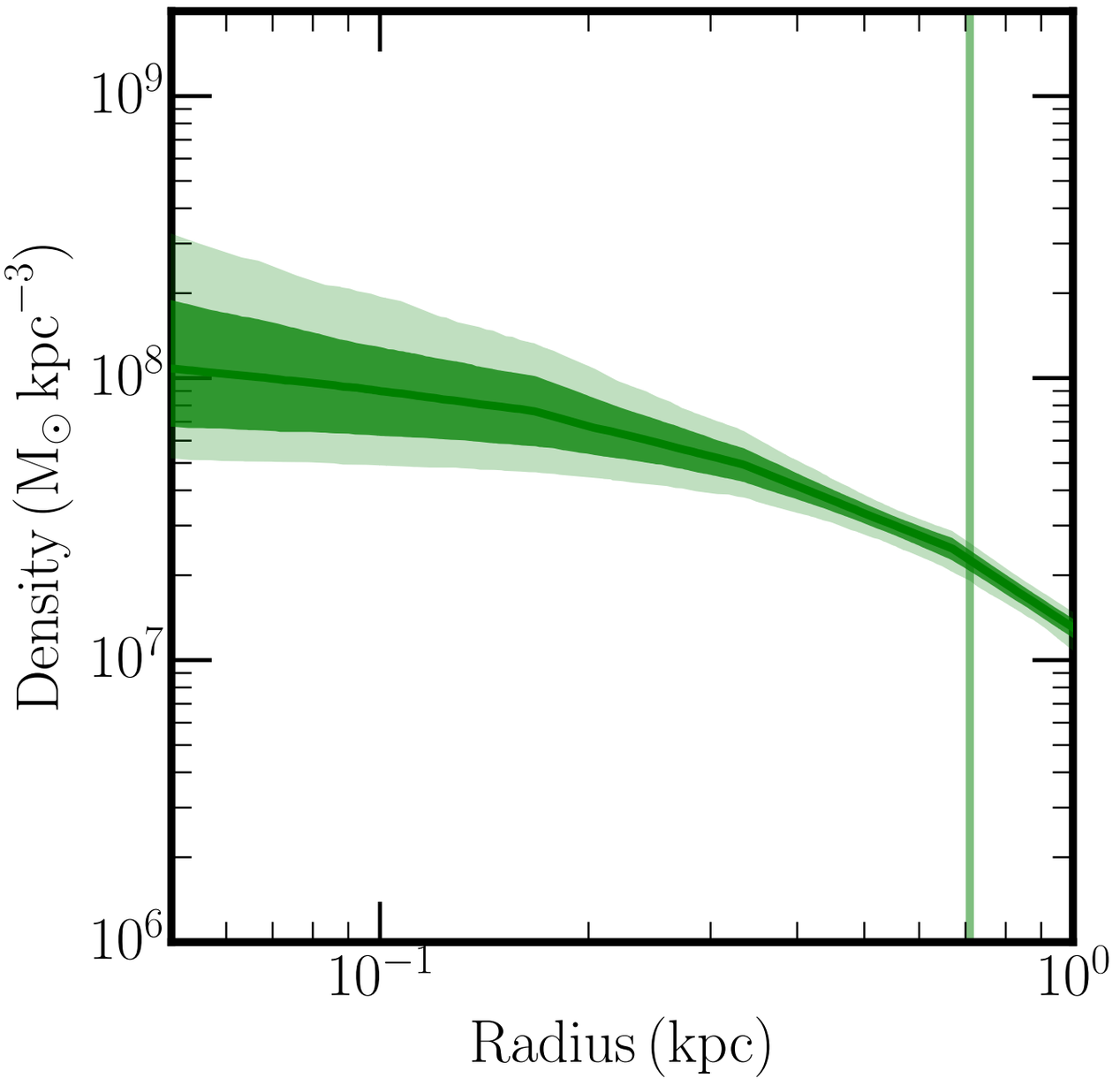




Read et al. 2018a,b,c: arXiv:1805.06934; arXiv:1807.07093; arXiv:1808.06634

Less star formation ⇒ more cusp





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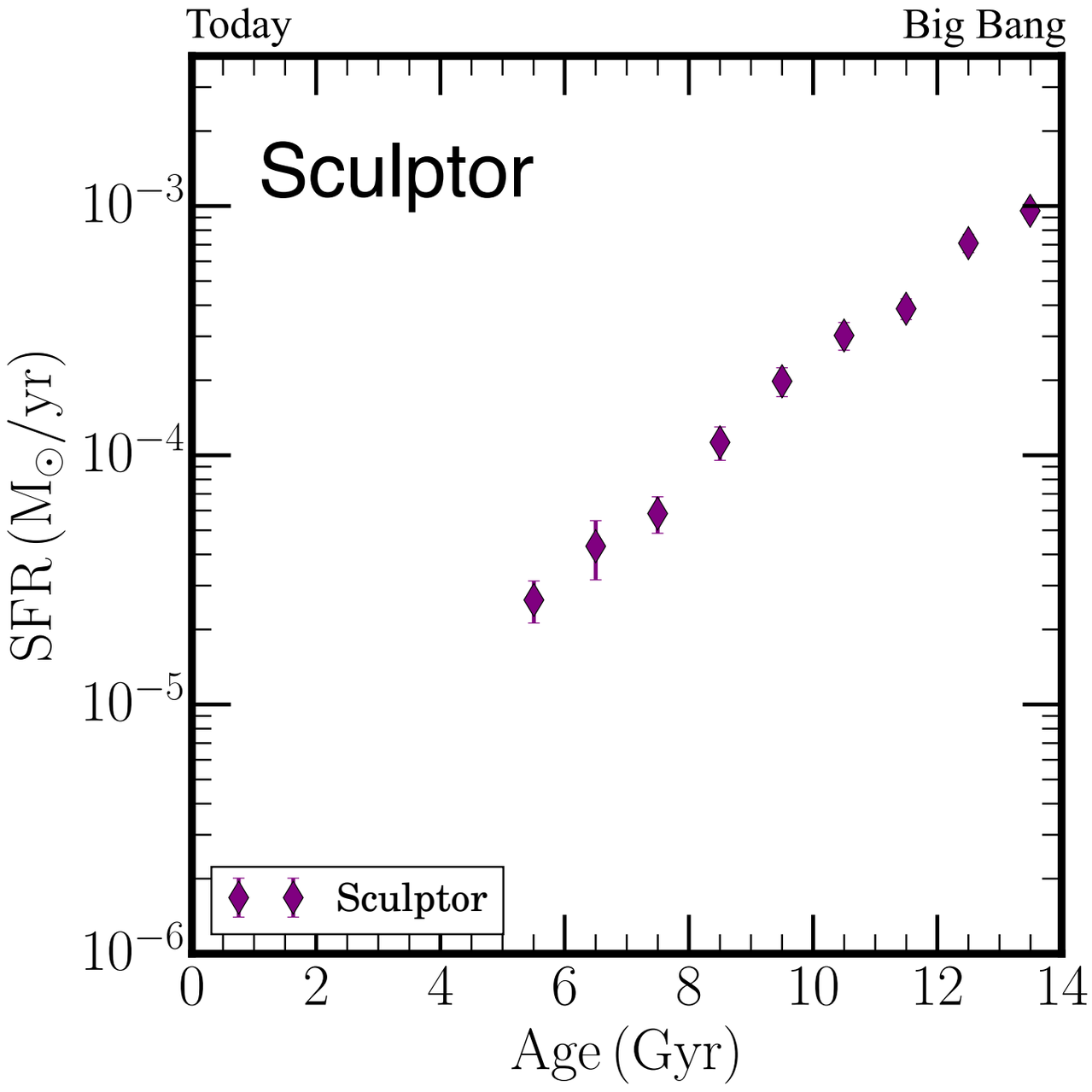

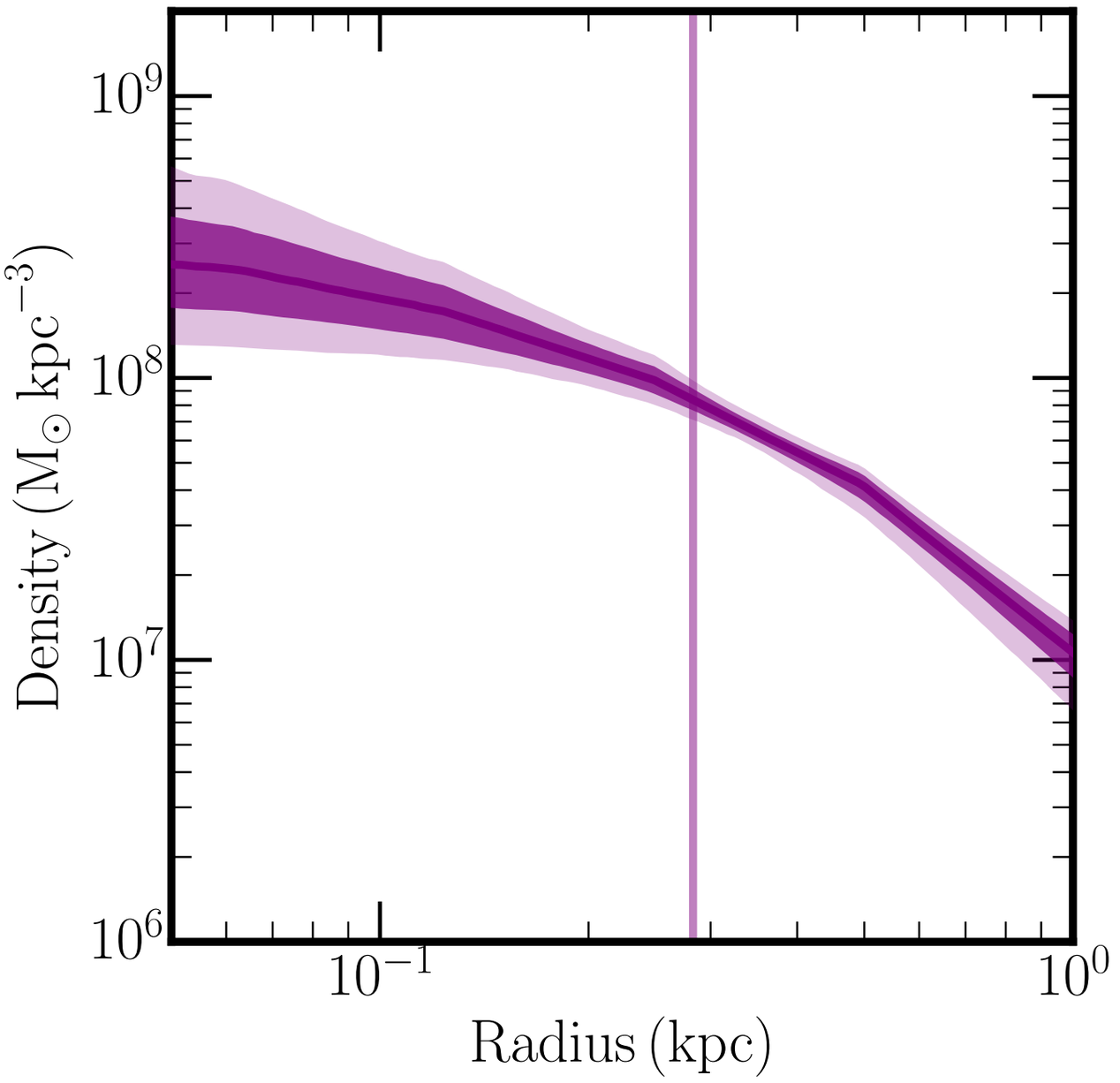

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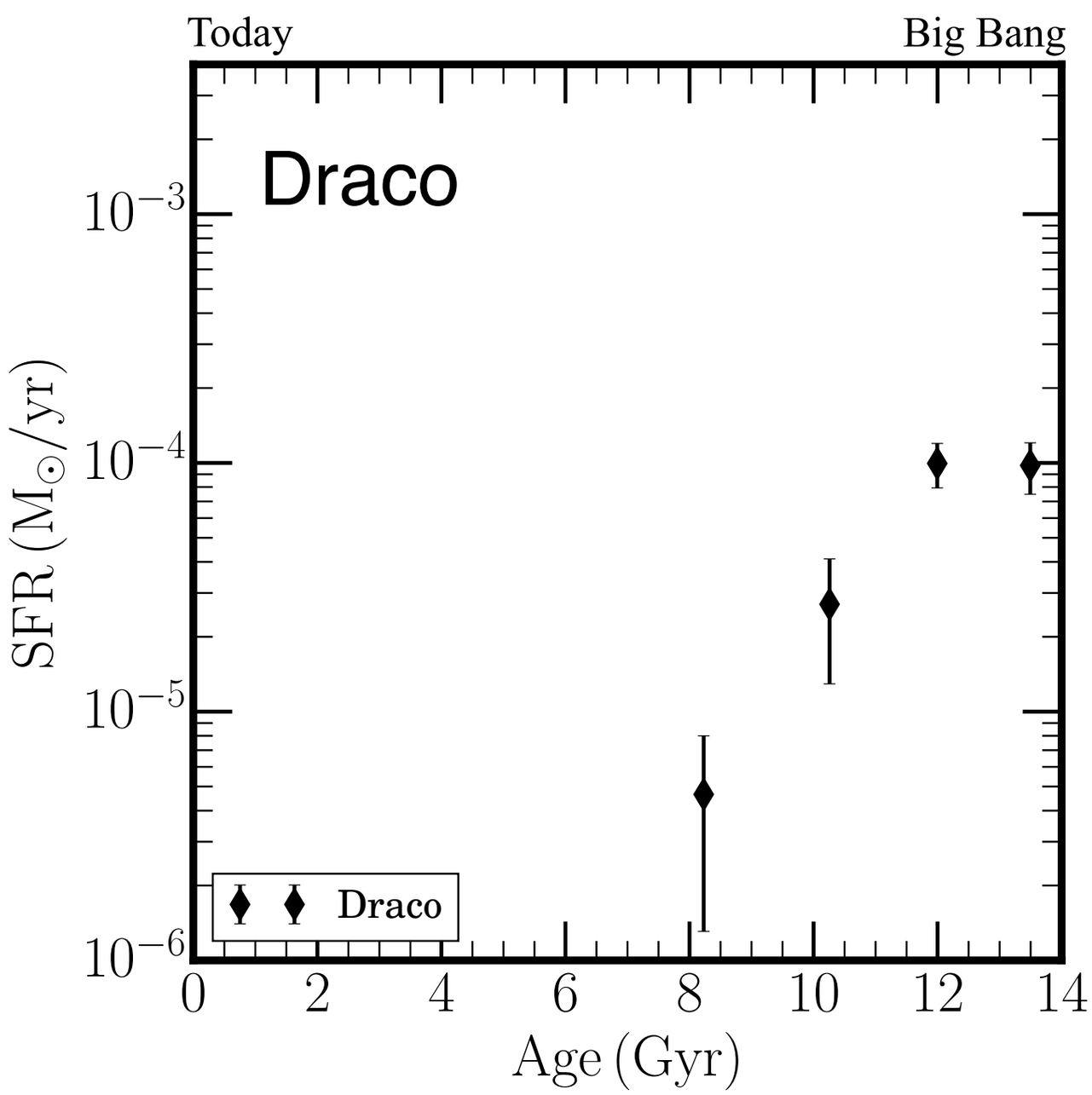

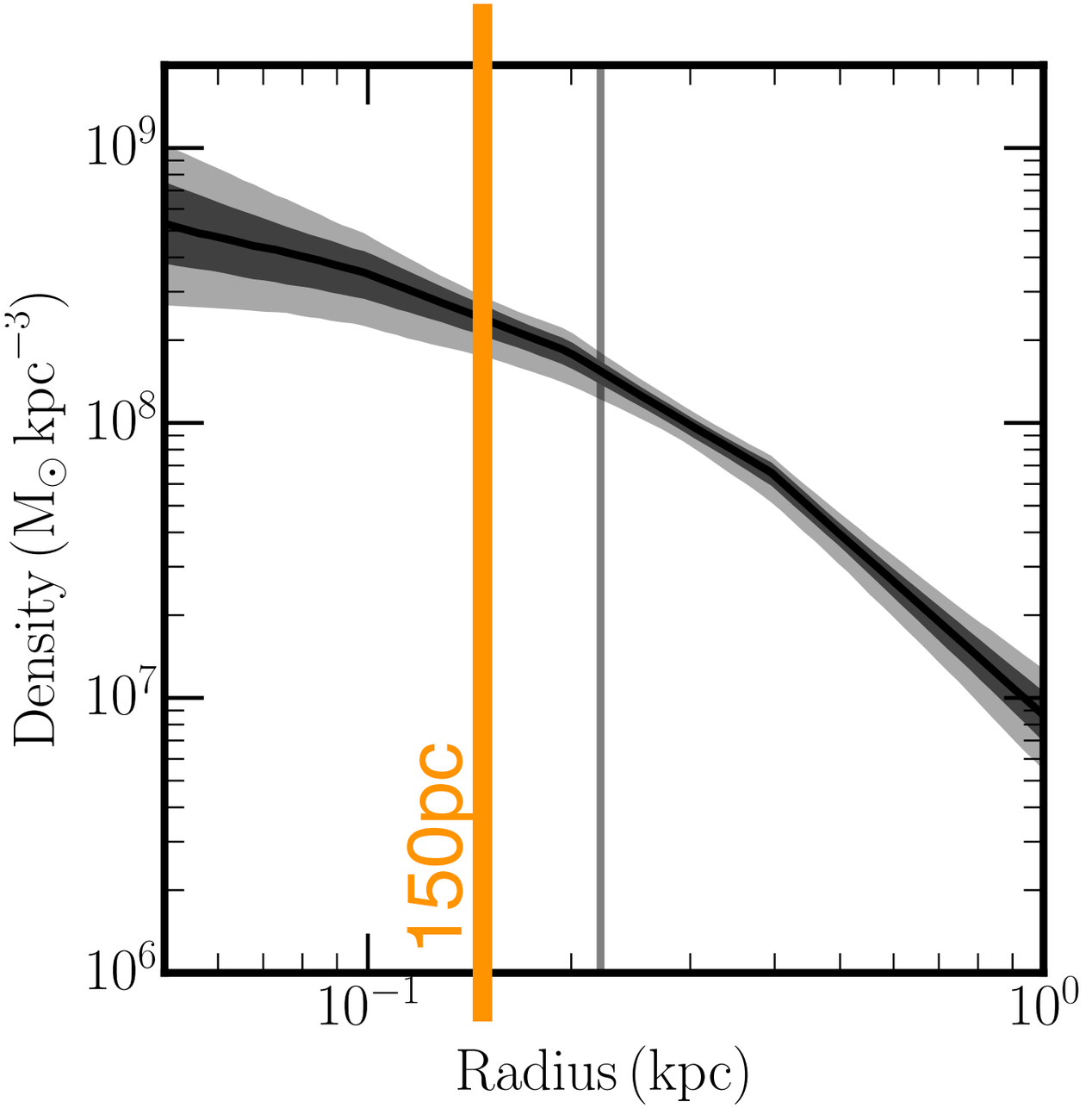

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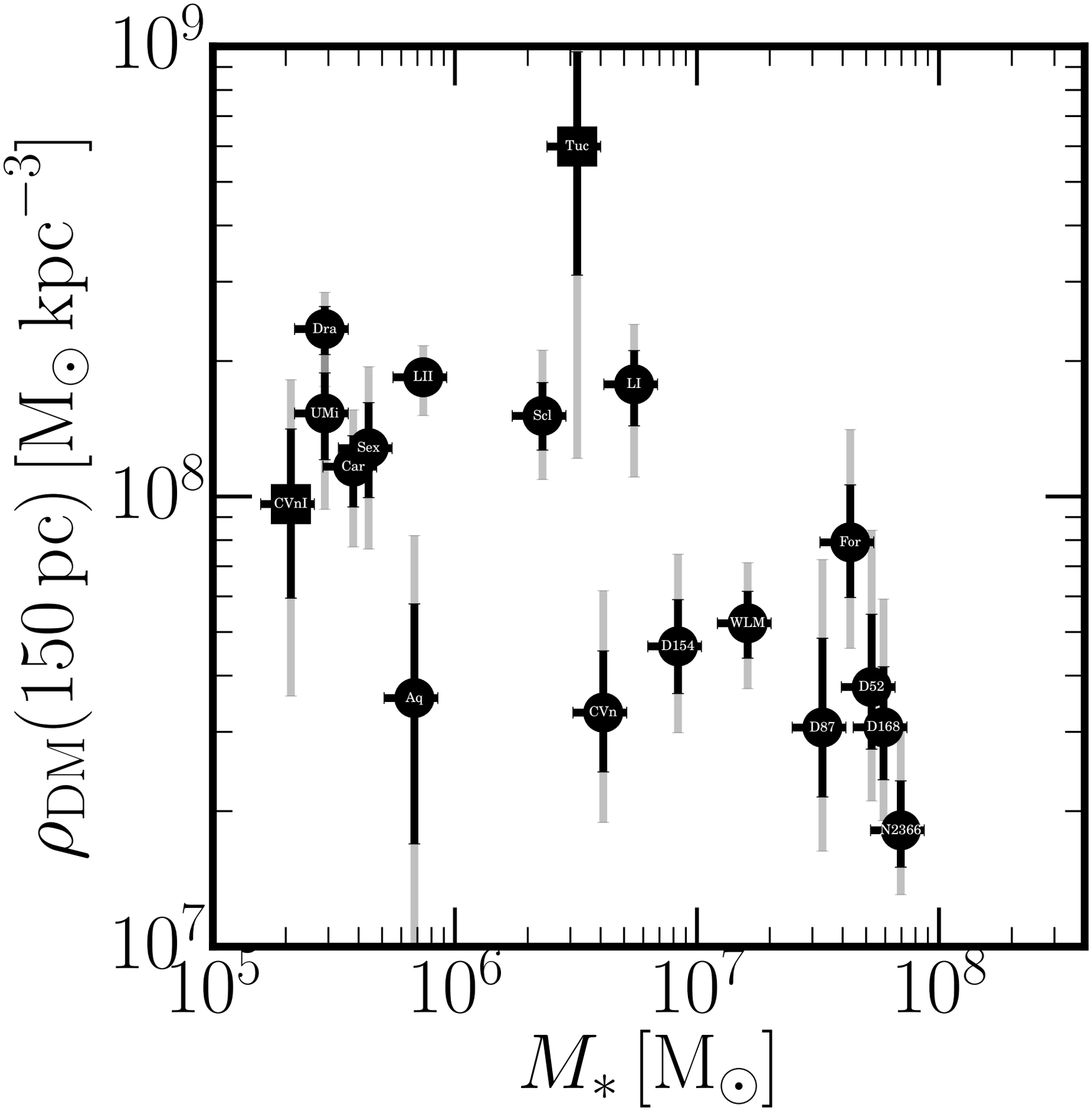

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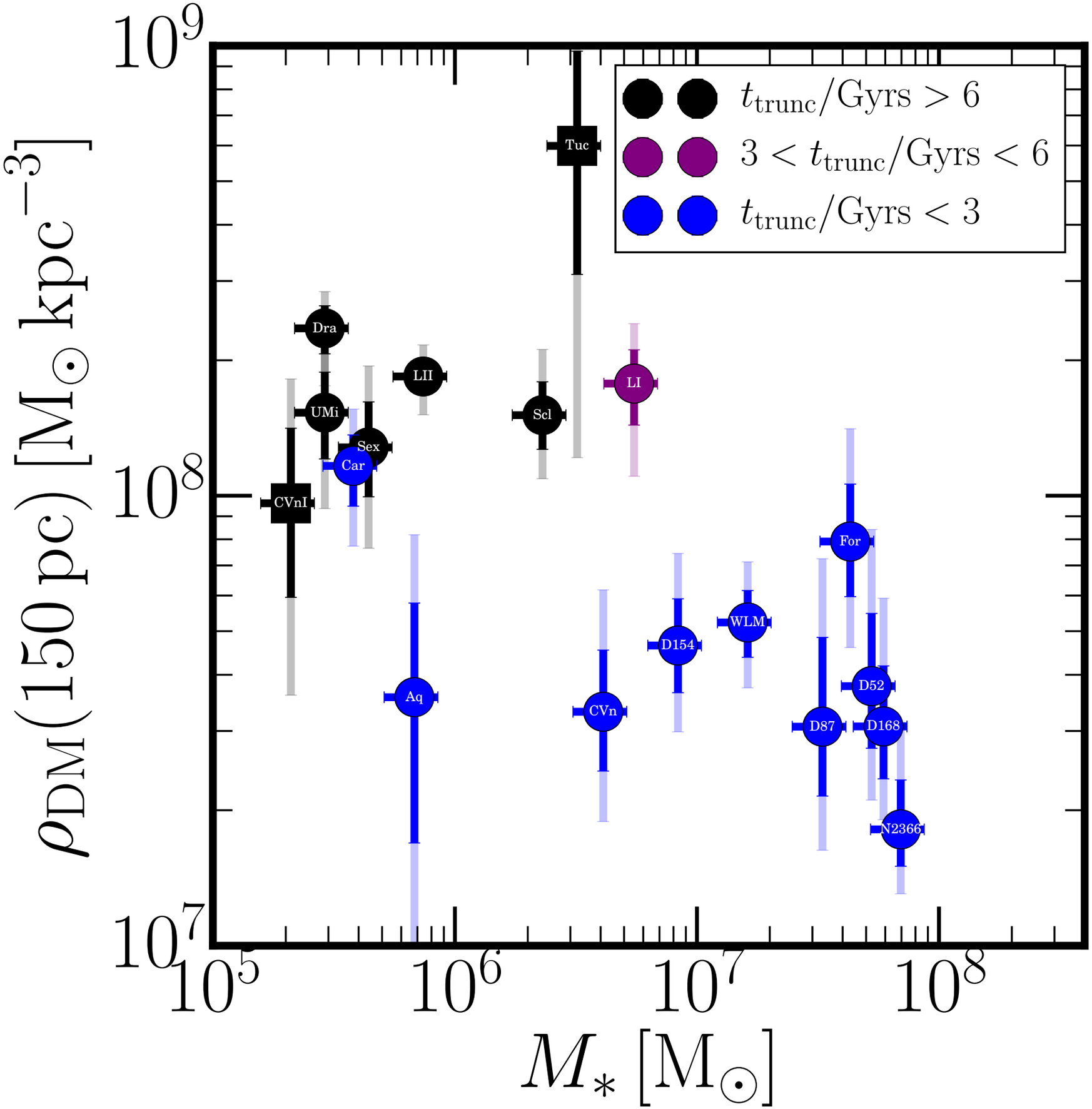

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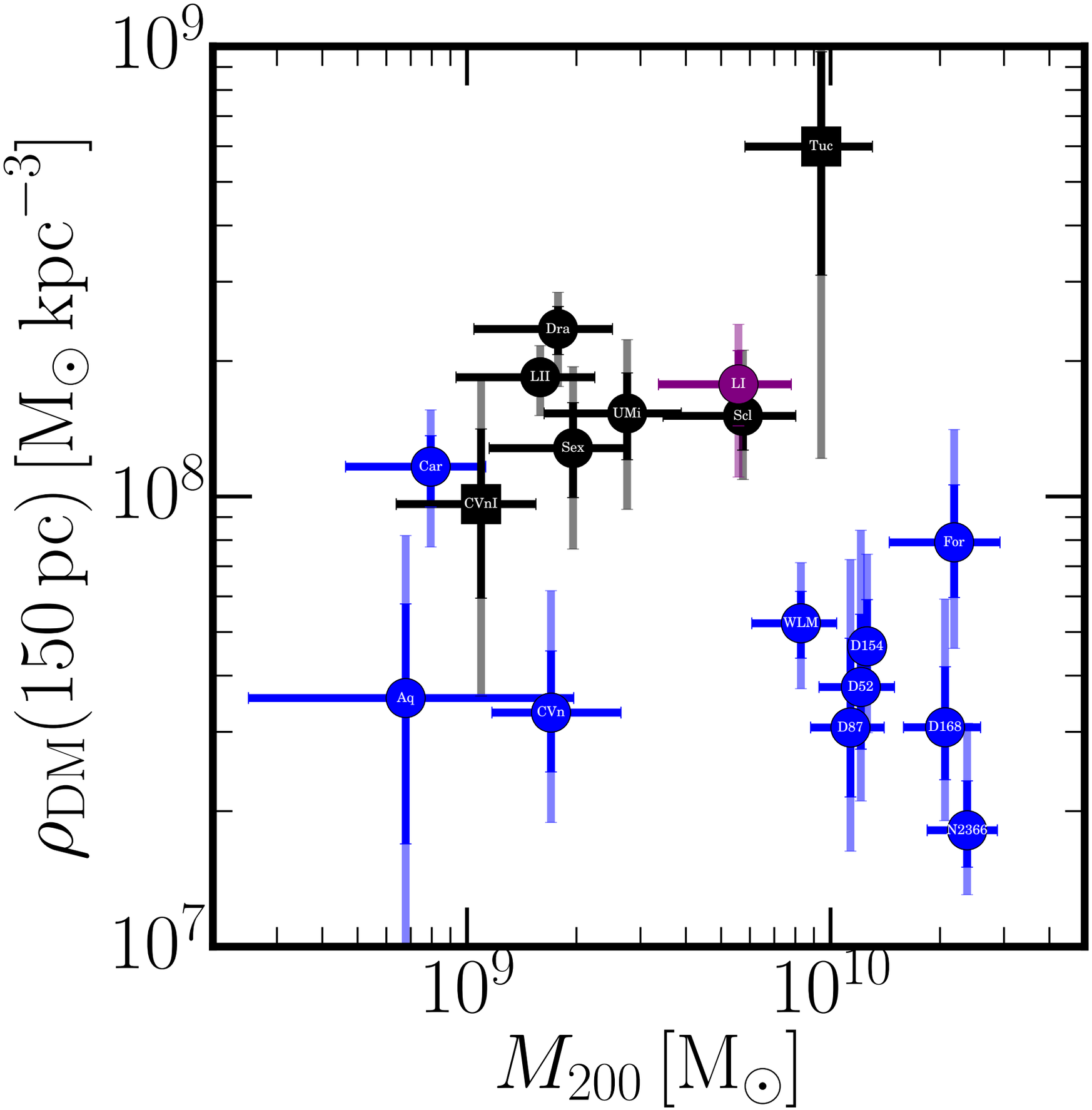

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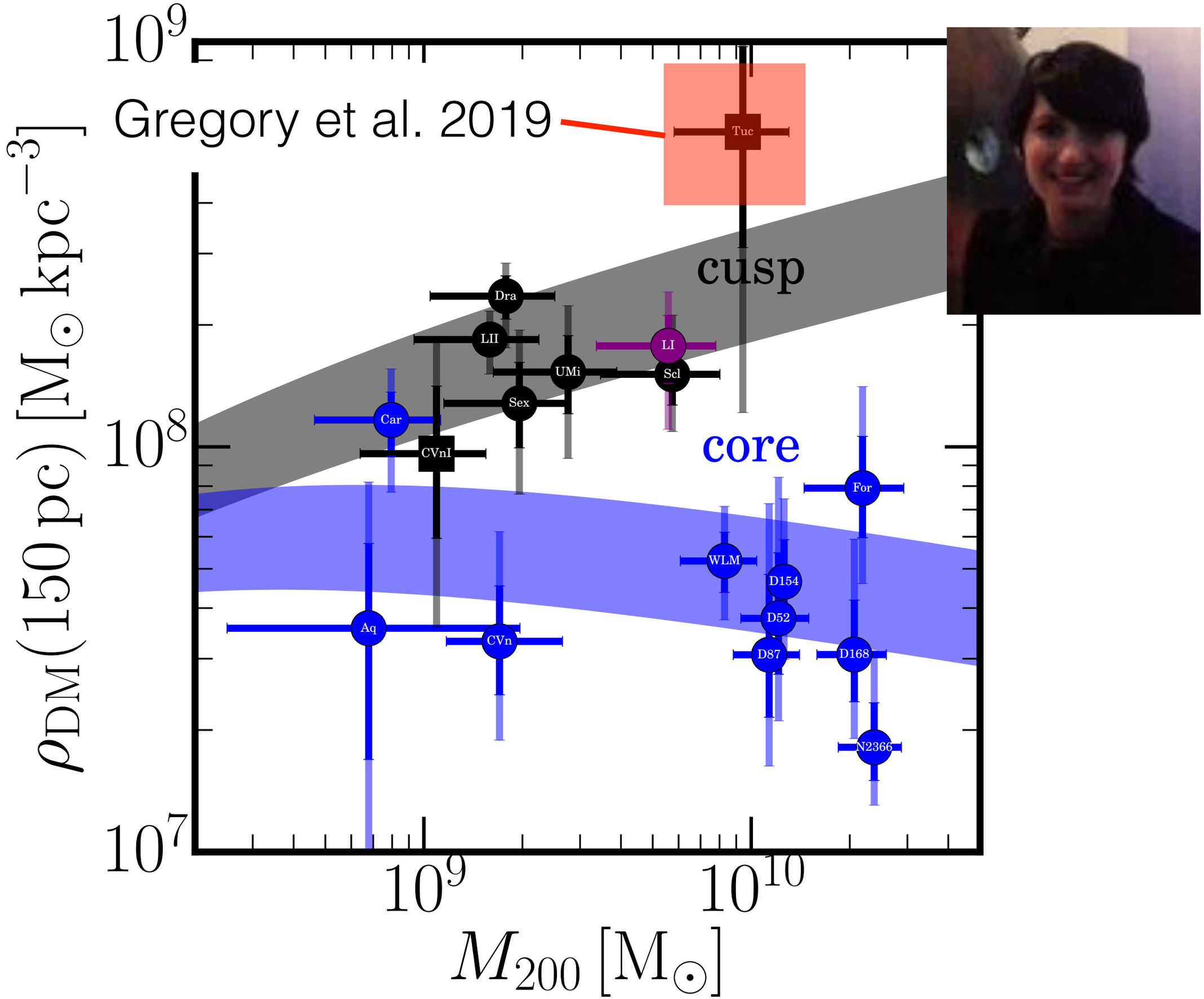

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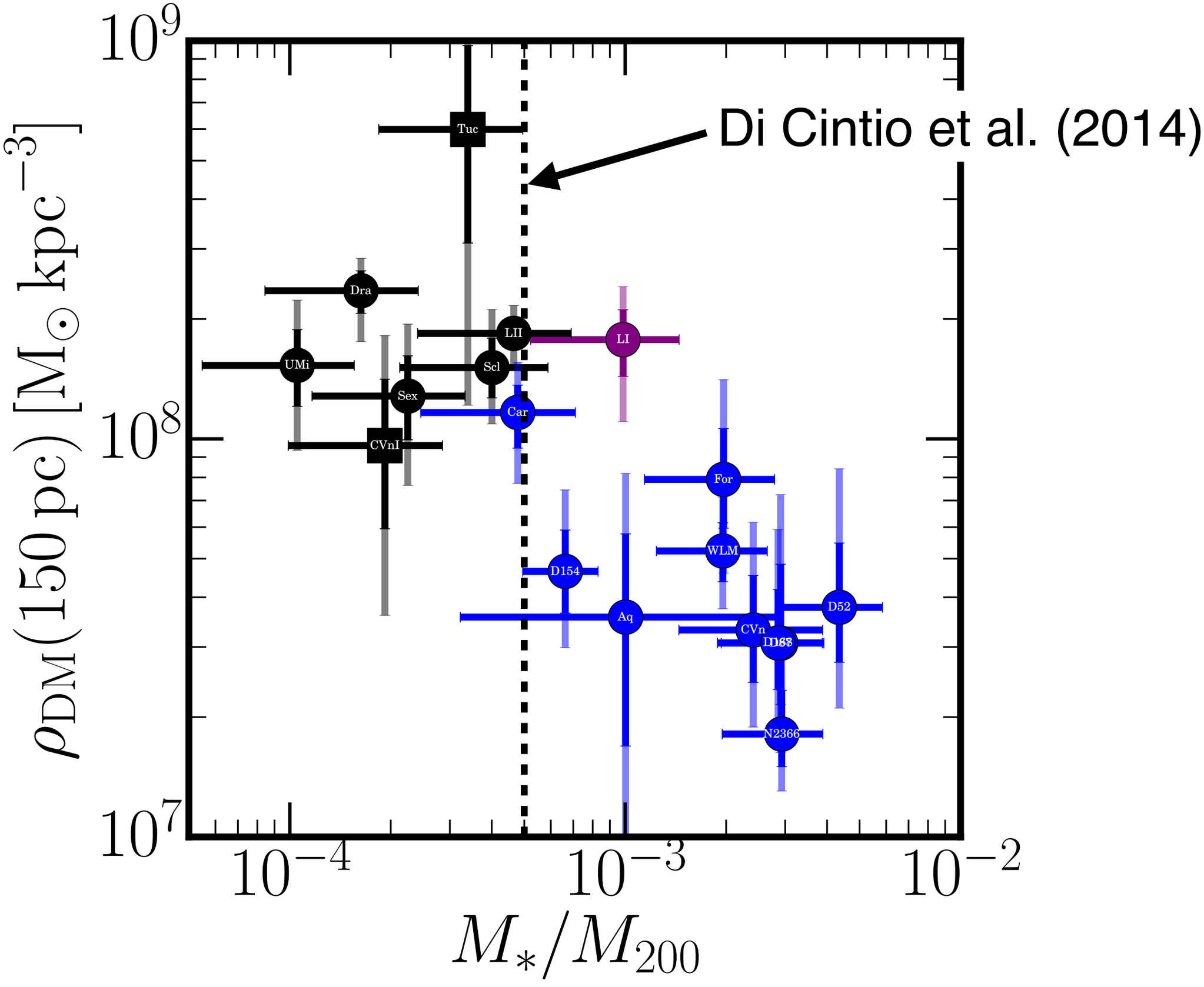


Read et al. 2018a,b,c: arXiv:1805.06934; arXiv:1807.07093; arXiv:1808.06634; Gregory et al. 2019

Implications

EDGE

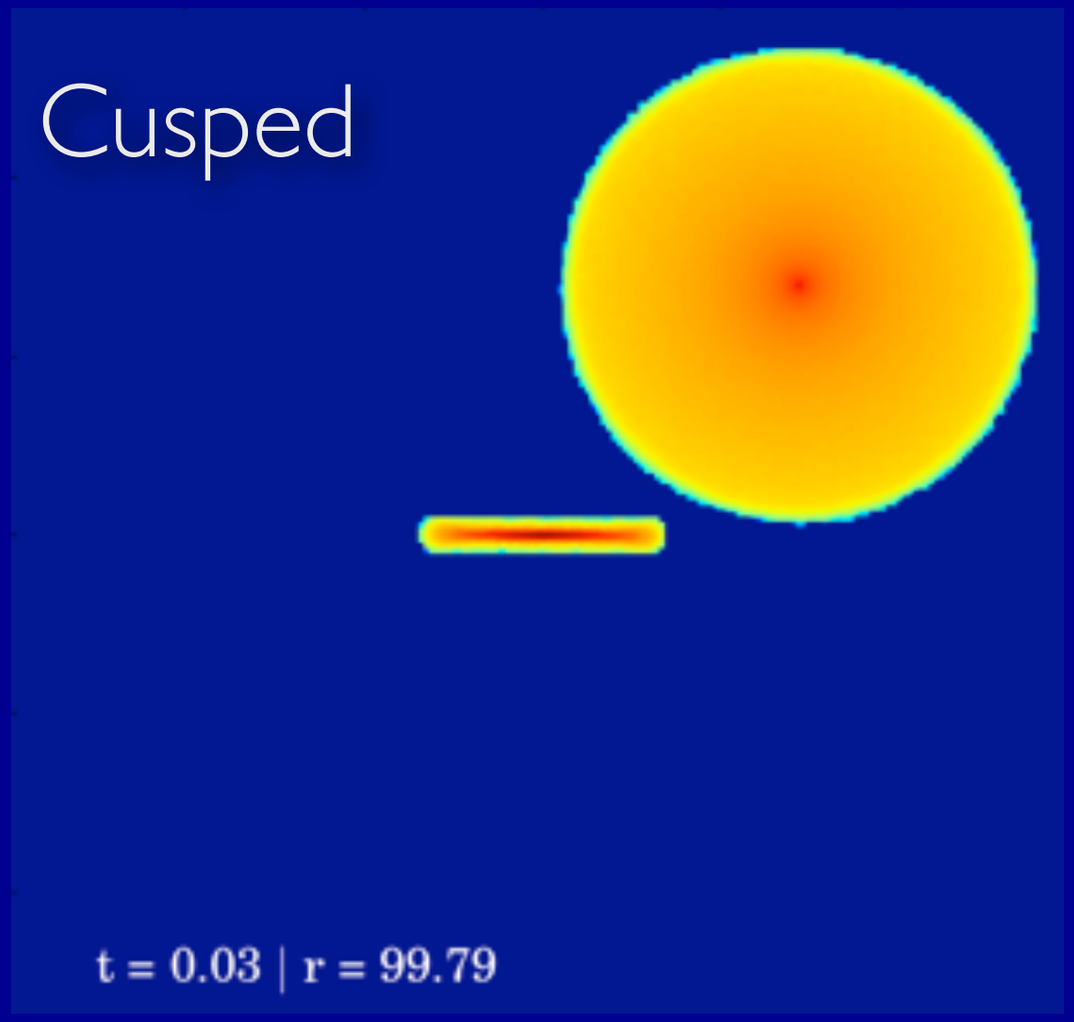
Lund University

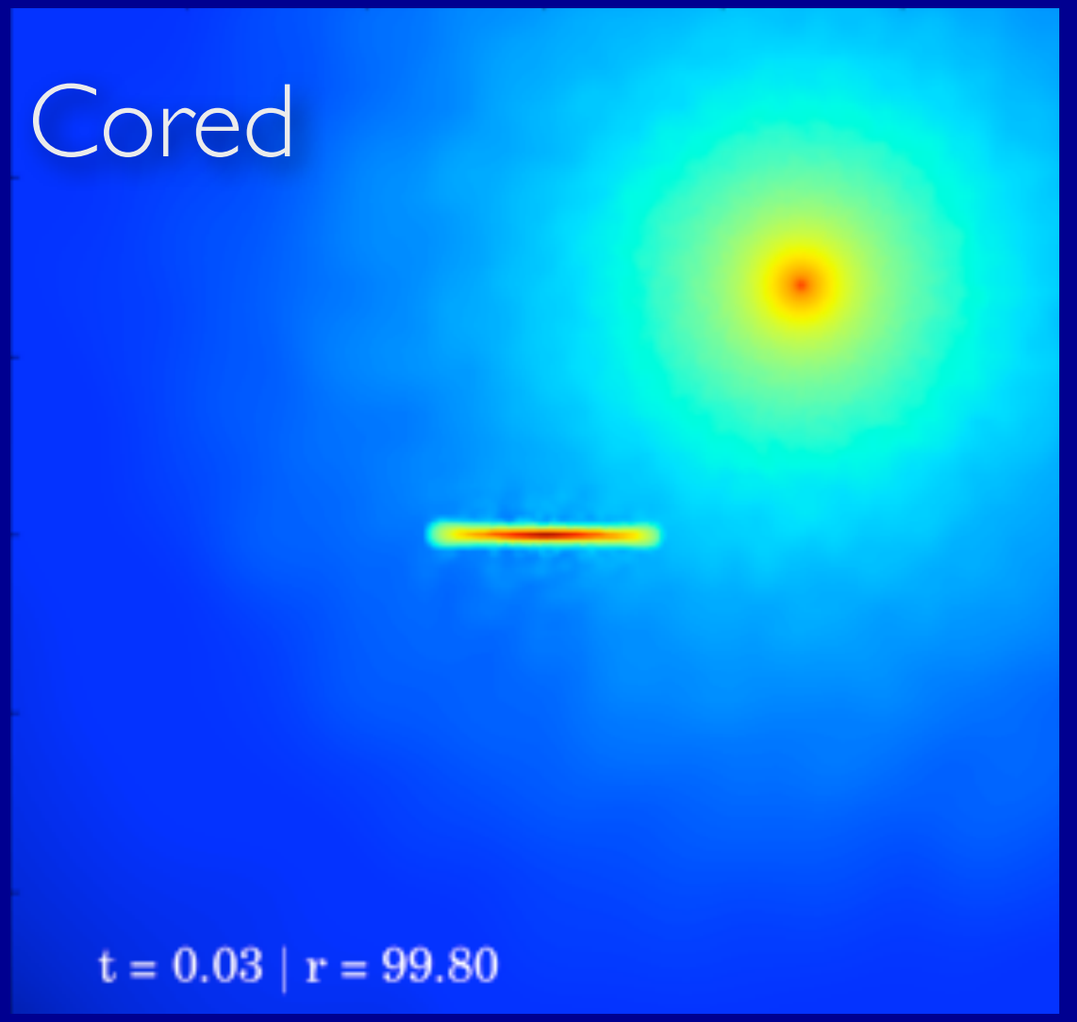
UCL

University of Surrey

Agertz et al. 2019 l arXiv:1904.02723

Implications I Tides





Read et al. 2006; Peñarrubia et al. 2010; Errani et al. 2019

Conclusions

Conclusions

- We have found evidence for “dark matter heating” in nearby dwarf galaxies.

- If correct, this solves the cusp-core problem (at least for the smallest dwarfs).

- Implications ⇒
  - Dark matter appears to be a cold, collisionless, fluid that can be heated up and moved around.
  - Densest dwarfs constrain “beyond-CDM” models.
  - Dark matter heating will impact galaxy formation from the “bottom up”. We are exploring this with EDGE.

Justin I. Read