Dark Matter Heating

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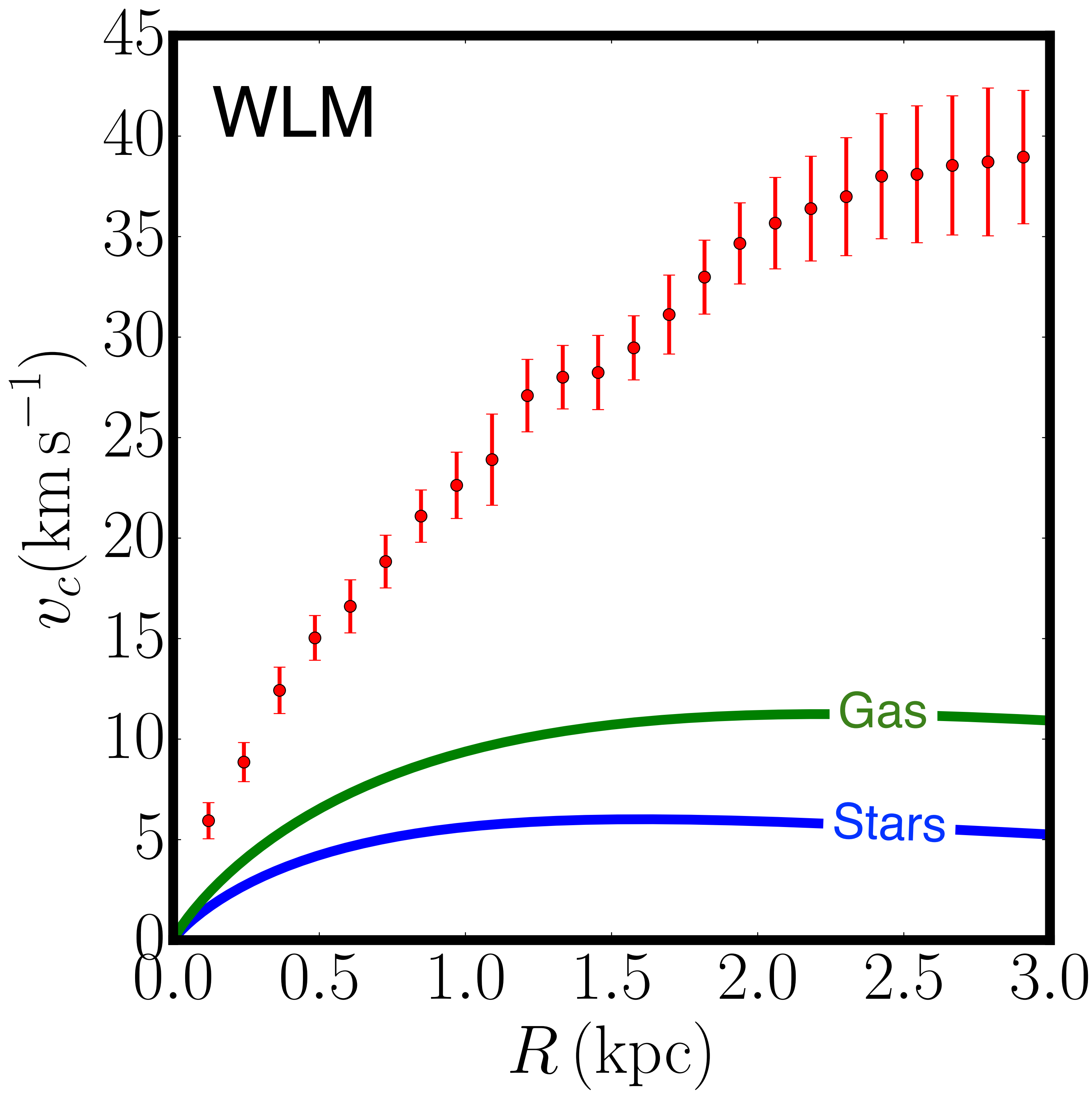
The Cusp-Core Problem

The cusp-core problem

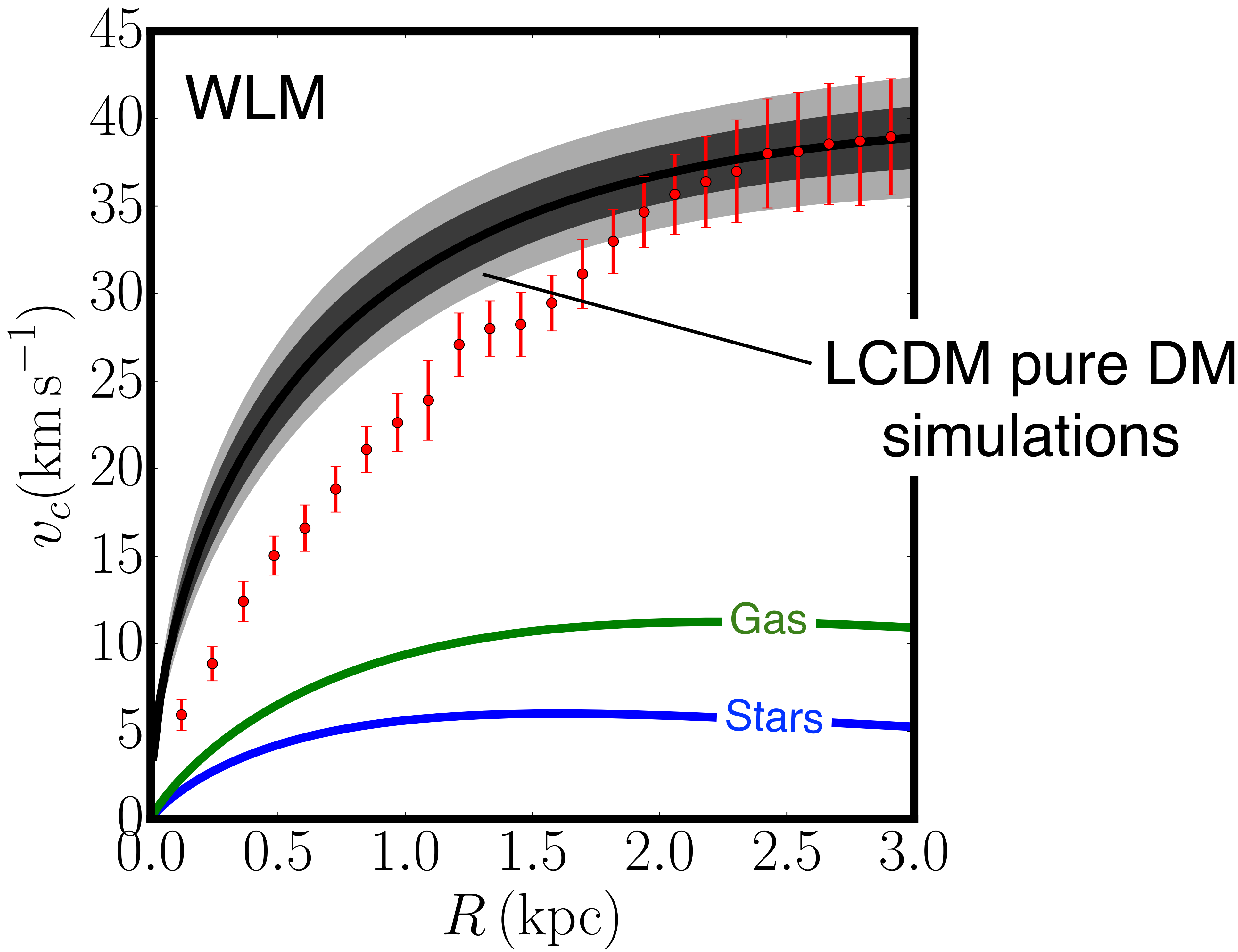
WLM | Leroy, Nature 2015

The cusp-core problem



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

The cusp-core problem



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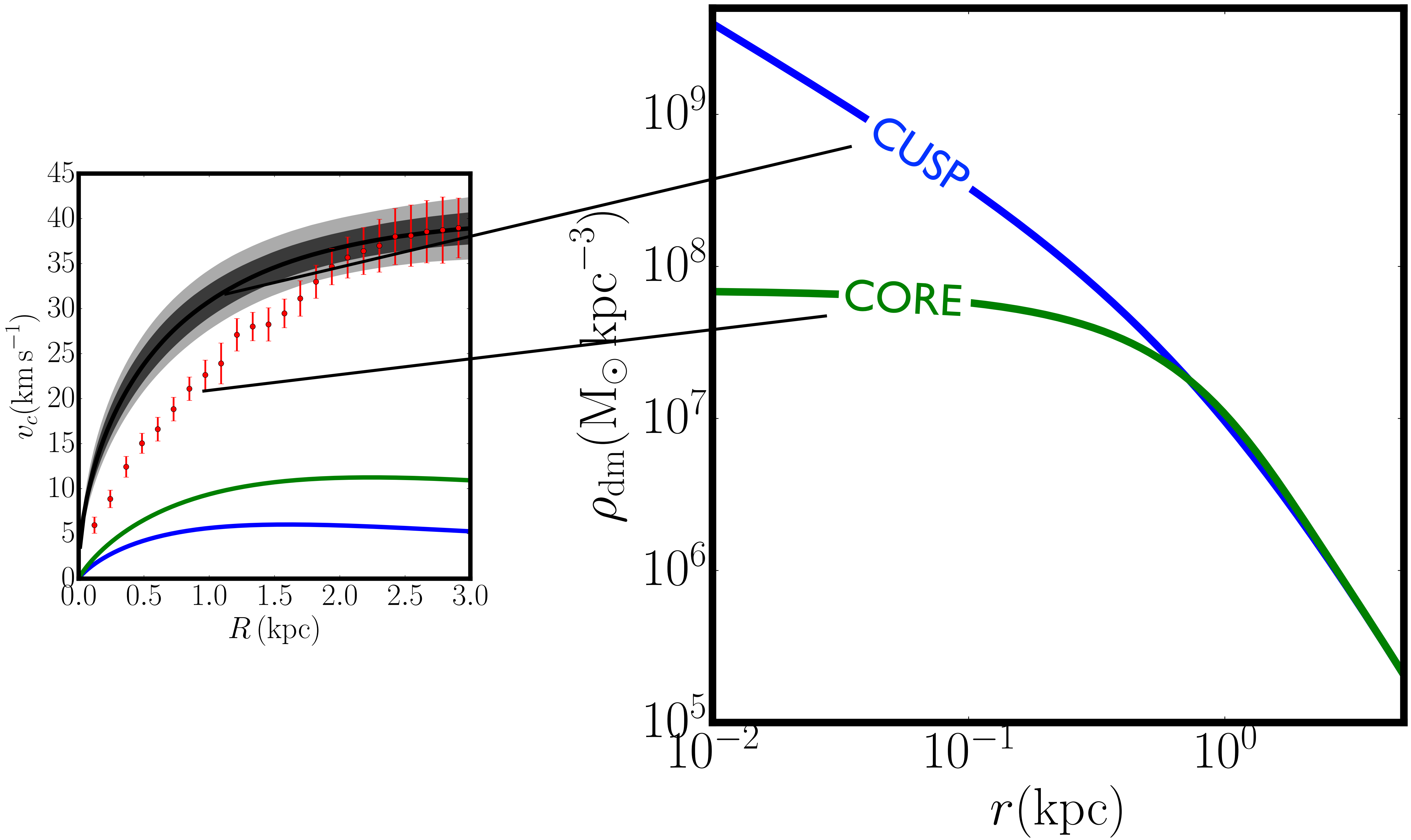


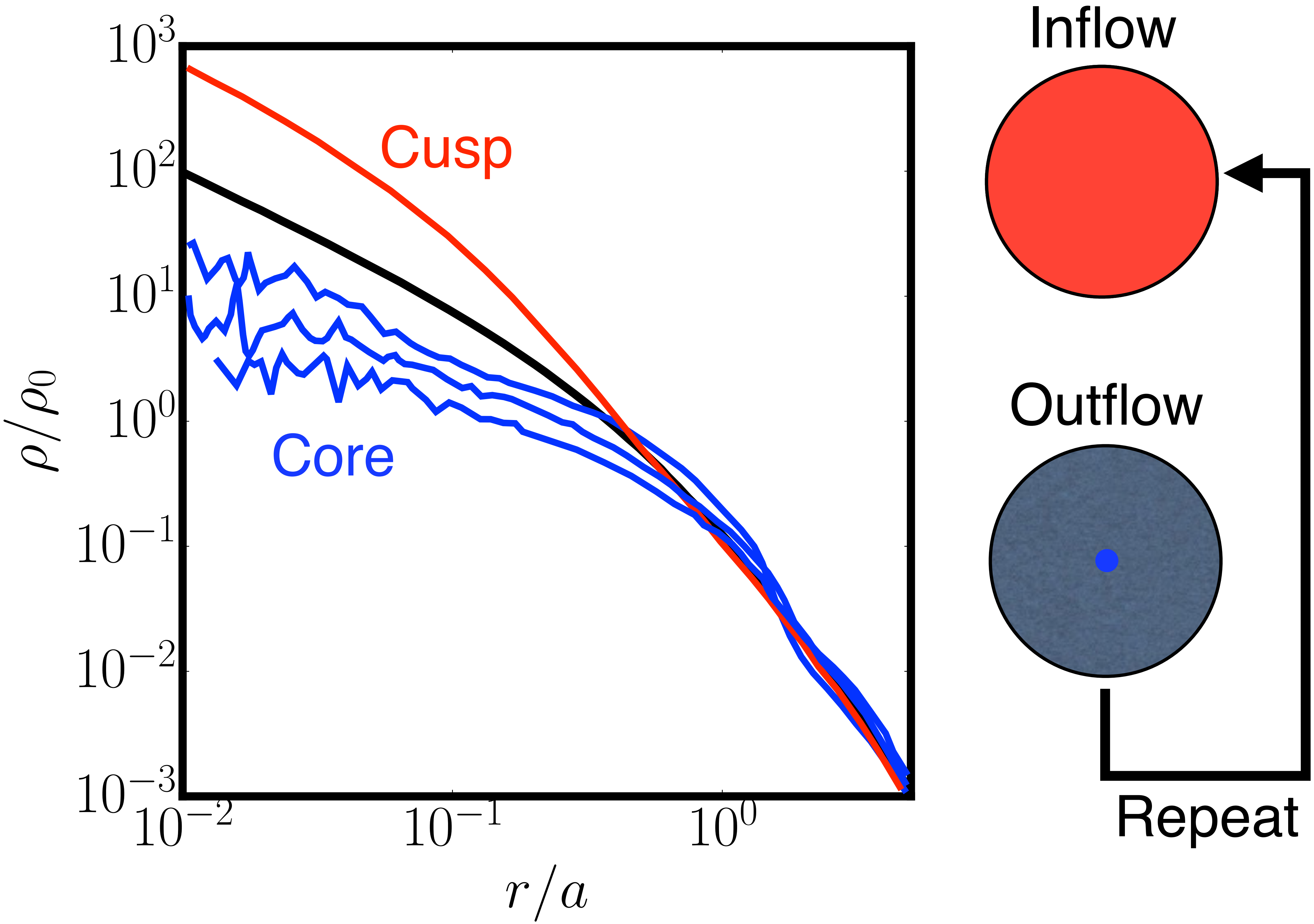
Dubinski & Carlberg 1991; Navarro et al. 1996

Pure Dark Matter Simulations

Observed Universe

Dark Matter Heating

The physics of dark matter heating



Navarro et al. 1996; Gnedin & Zhao 2002; Read & Gilmore 2005 Pontzen & Governato 2012

Stellar Feedback

Stellar feedback & galactic winds

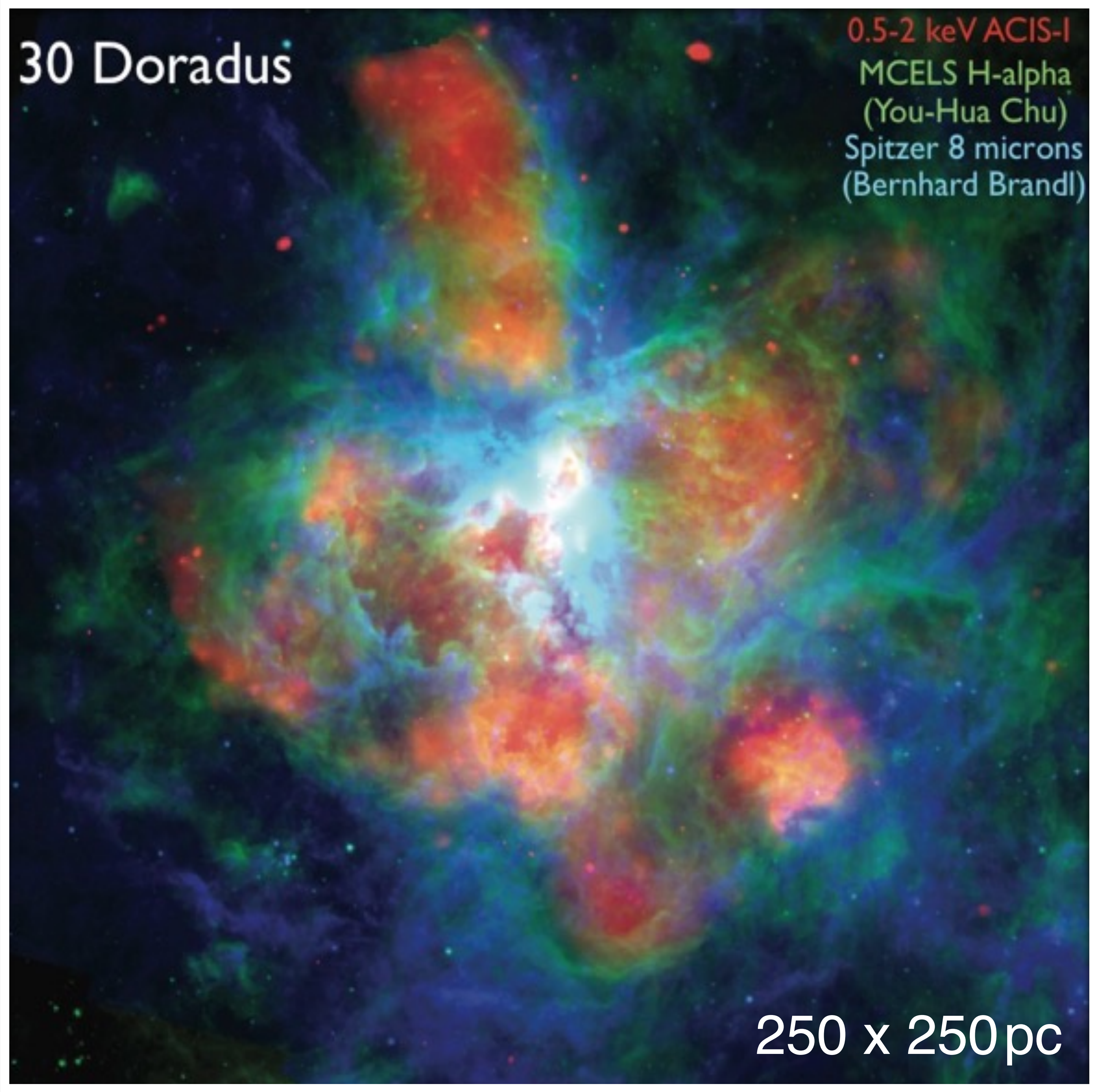
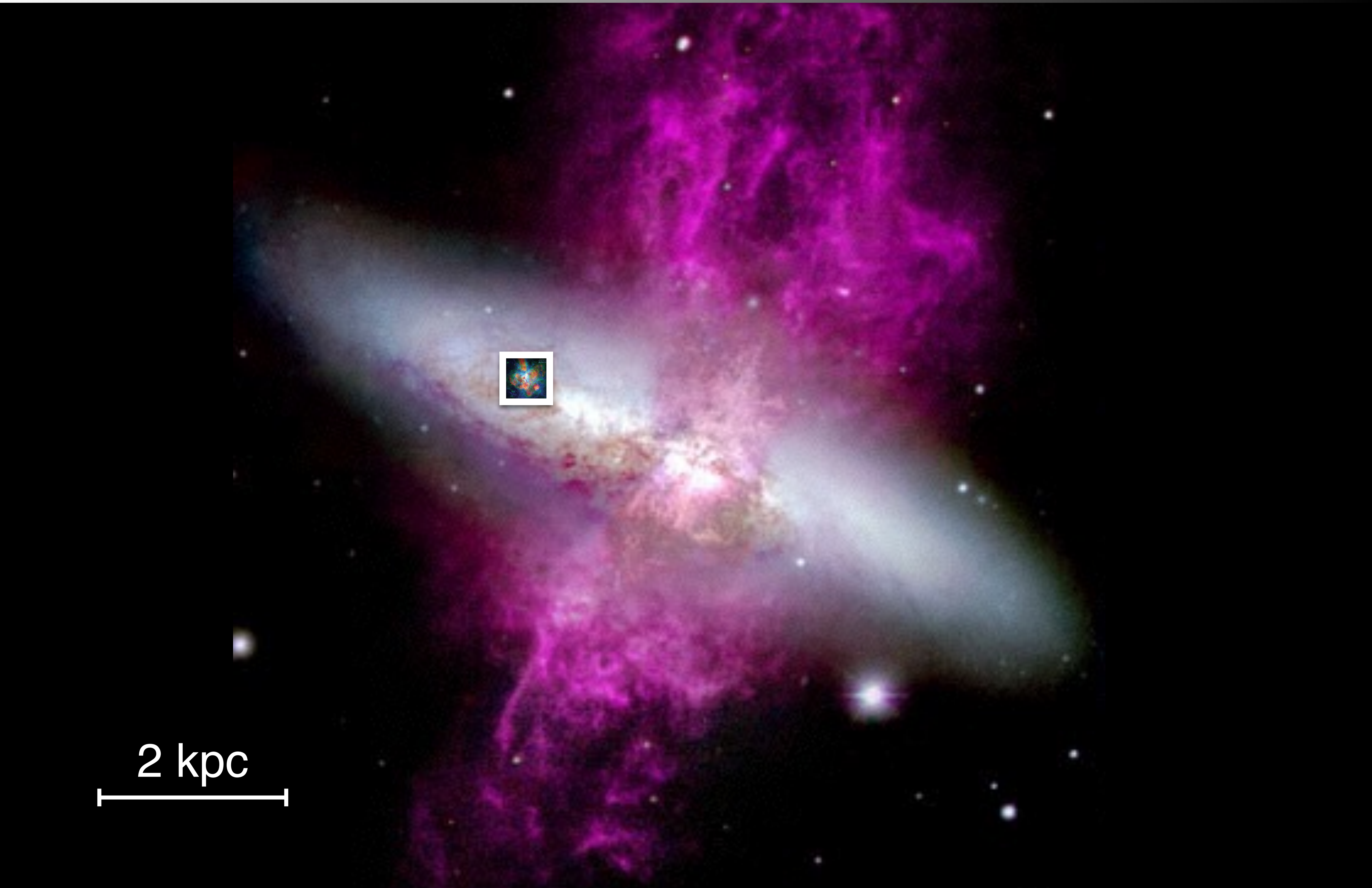


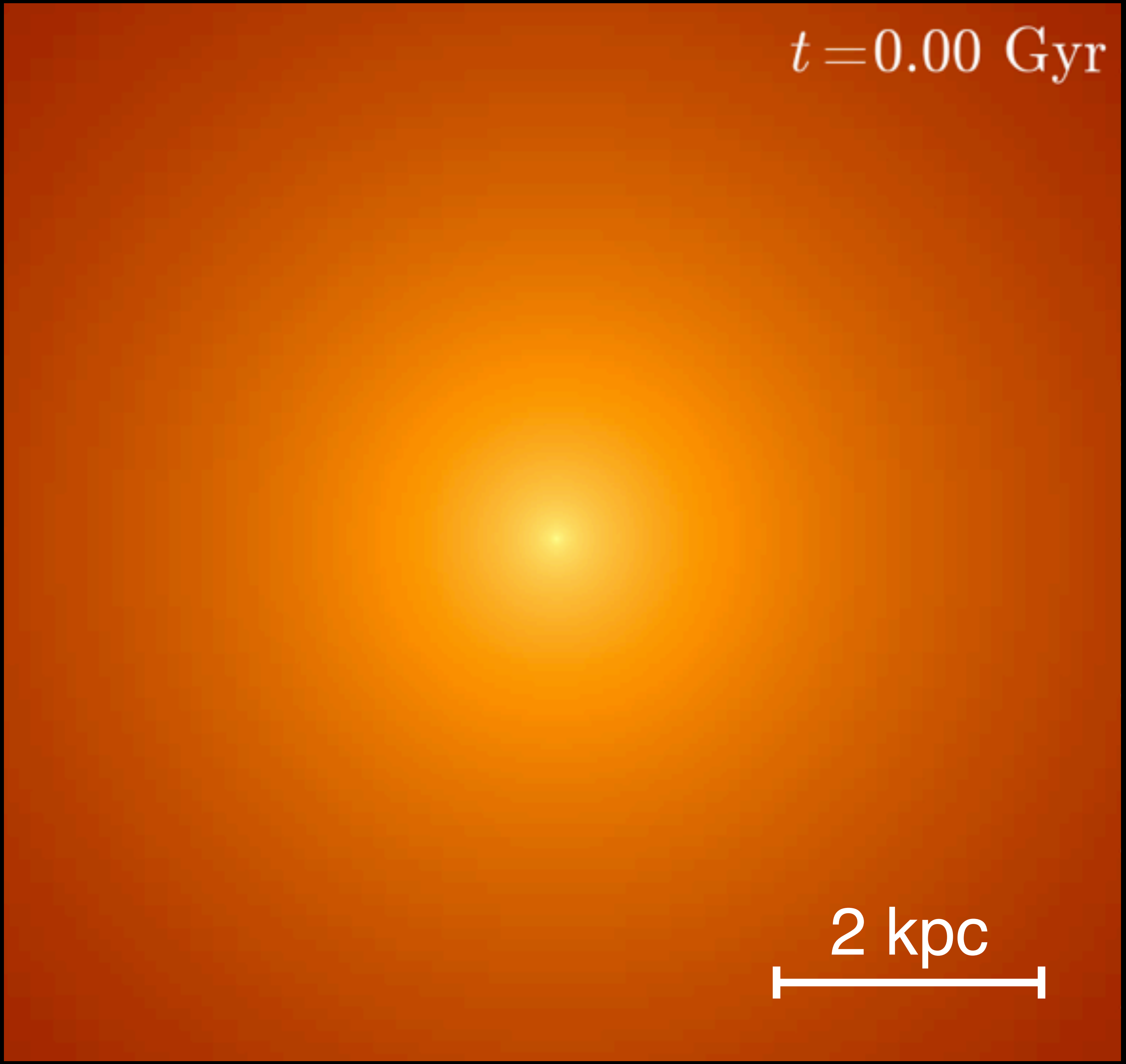
Image composite credit: Leisa Townsley et al. 2006

Stellar feedback & galactic winds



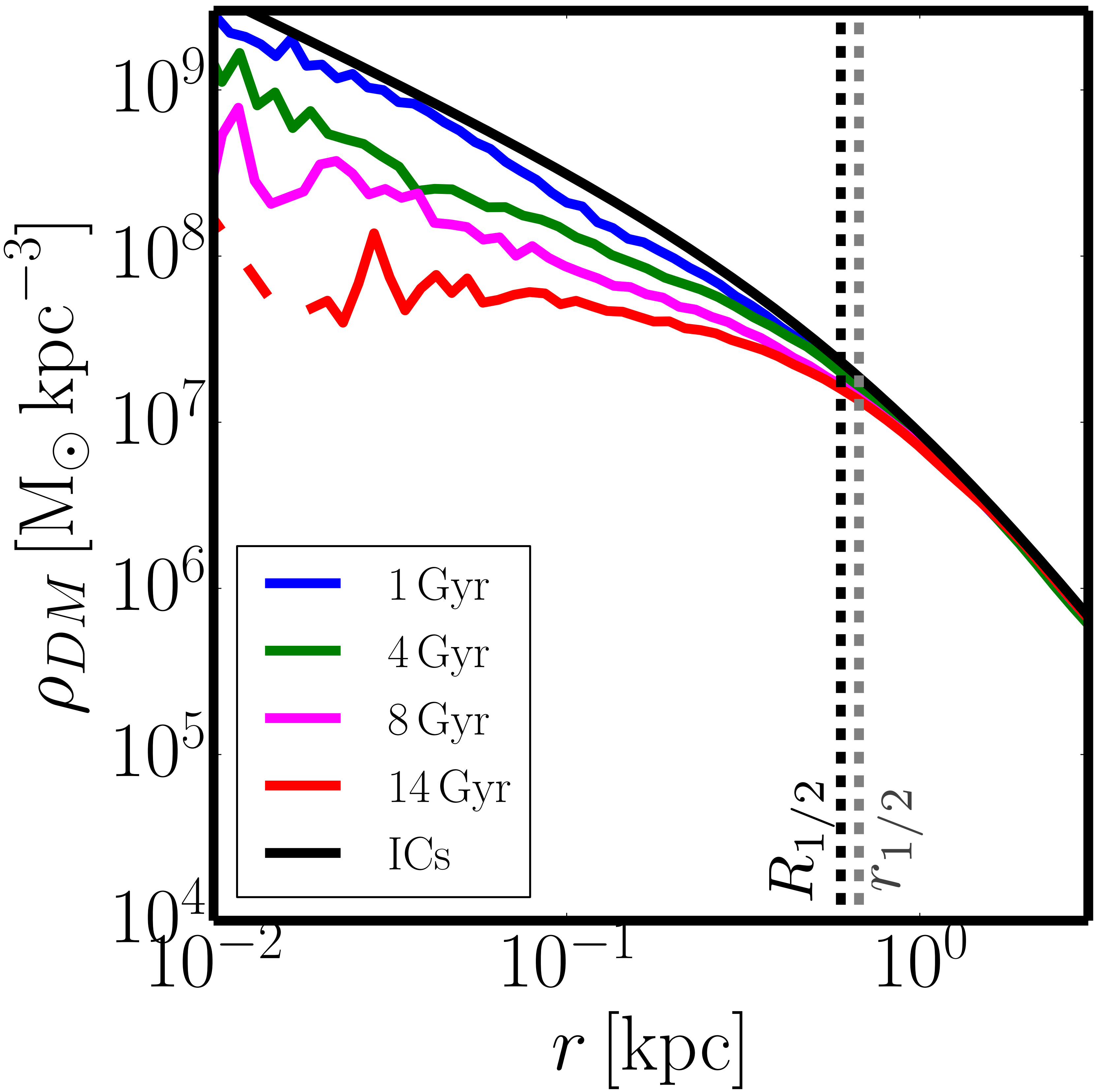
Westmoquette et al. 2009; and see Strickland & Heckman 2009; McQuinn et al. 2018

Simulations | Resolving stellar feedback



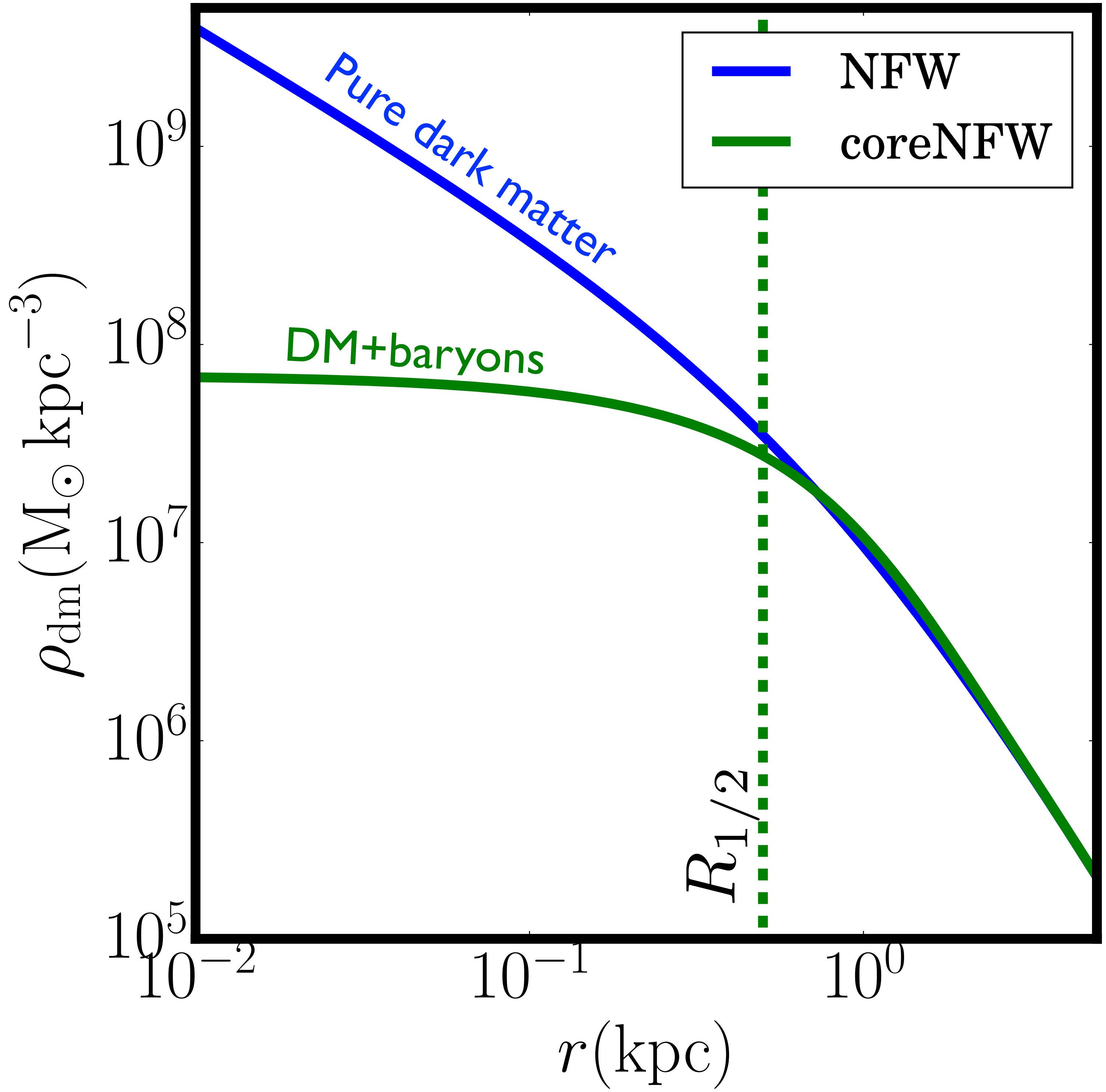
Read et al. 2016 | Spatial resolution 4pc; mass resolution 300M$_\odot$

Simulations | Cusp-core transformations



Read et al. 2016

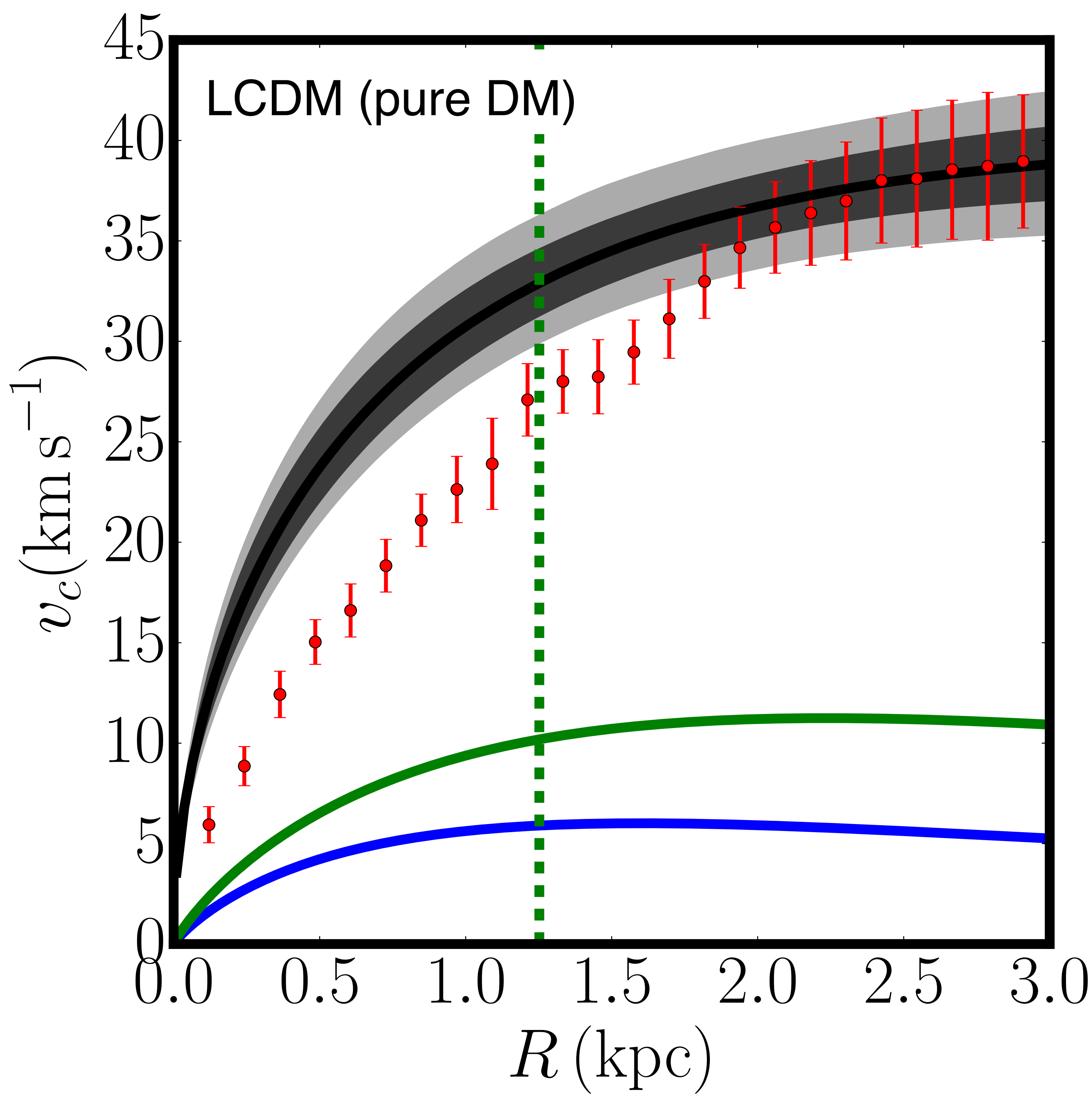
Simulations | Cusp-core transformations



Read et al. 2016

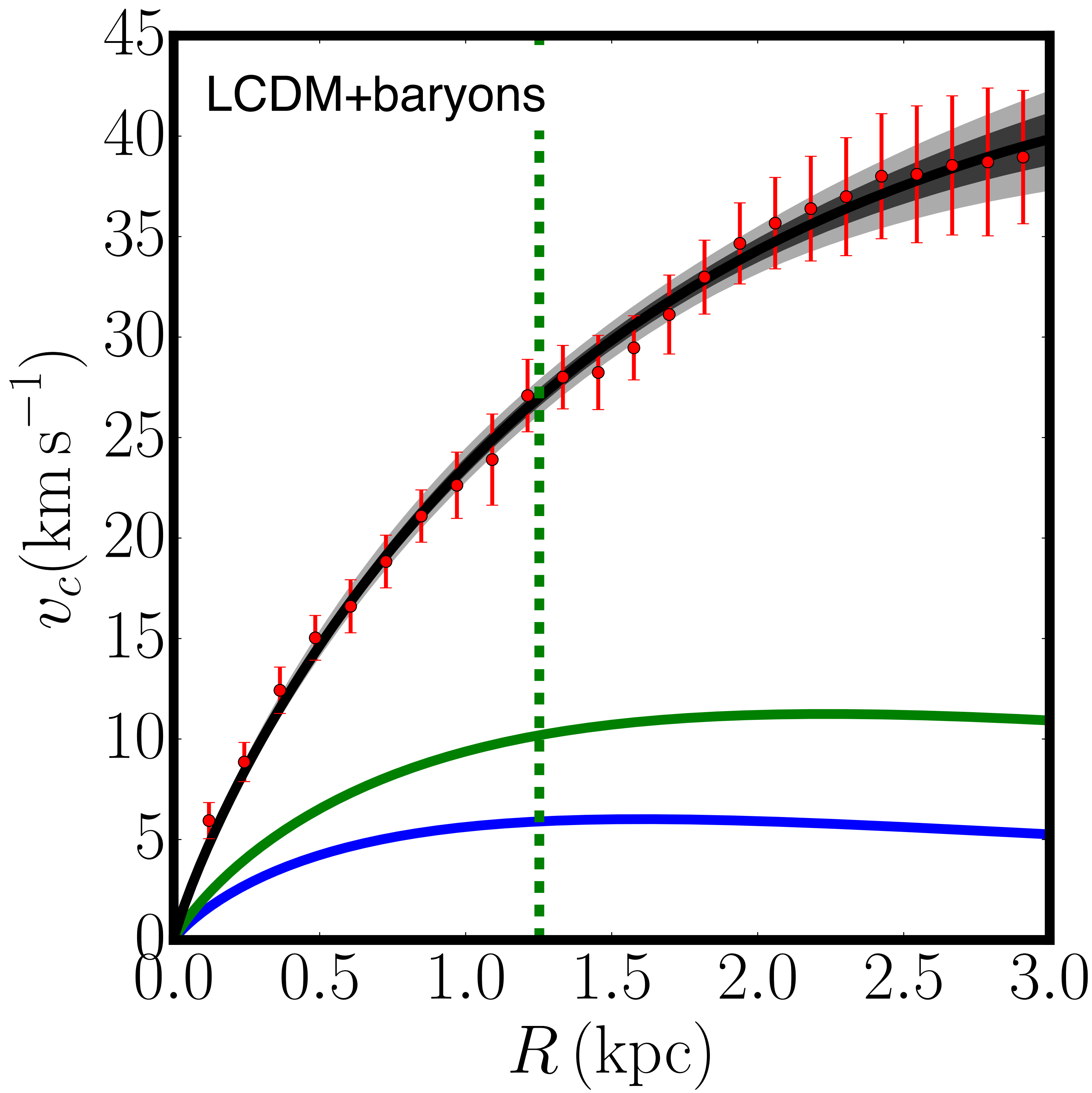
The Cusp-Core Problem Revisited

Measurement | Rotation cuves

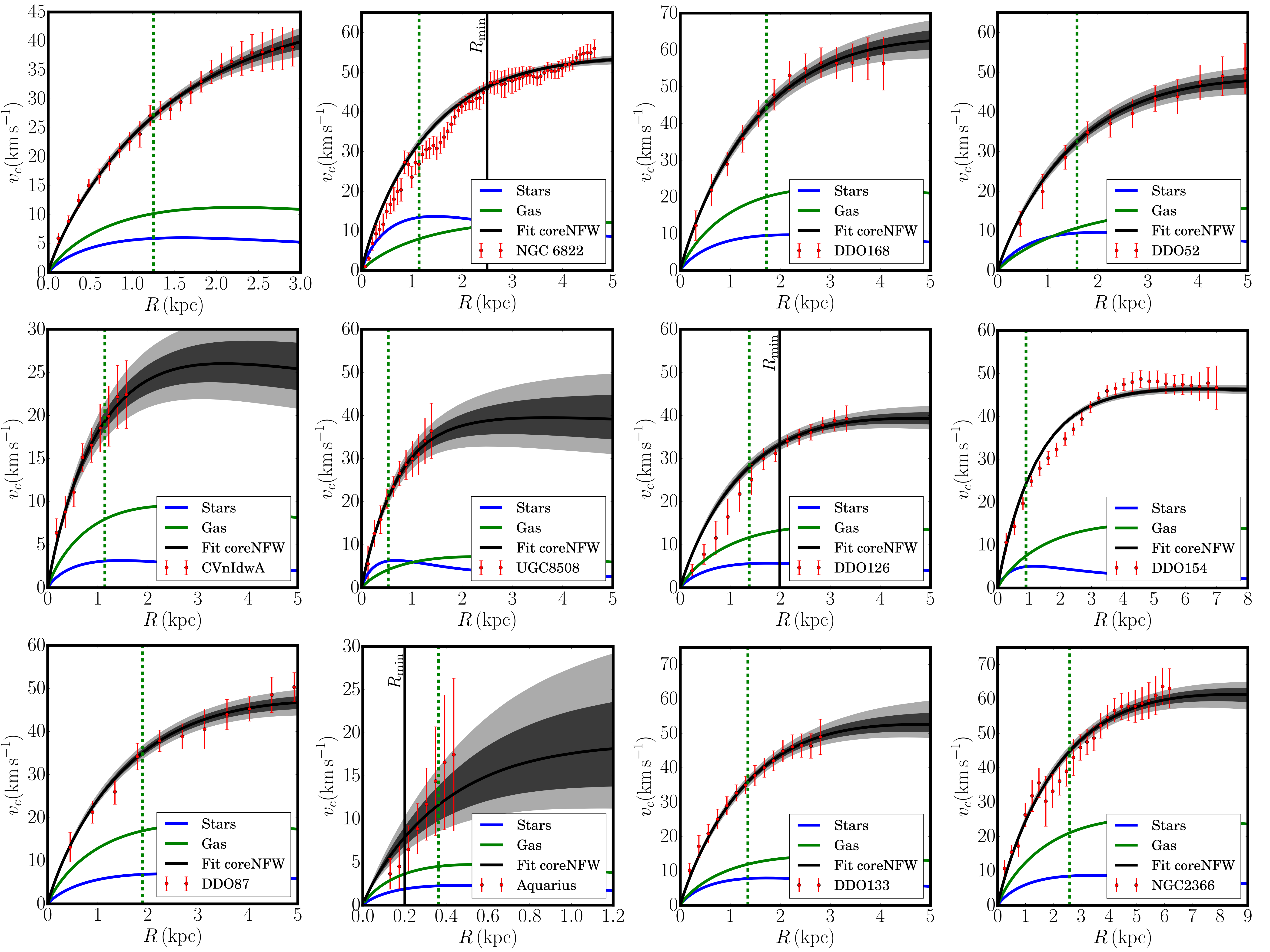


Read et al. 2016b,2017

Measurement | Rotation cuves



Read et al. 2016b,2017



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

Testing Predictions from DM Heating Models

Predictions

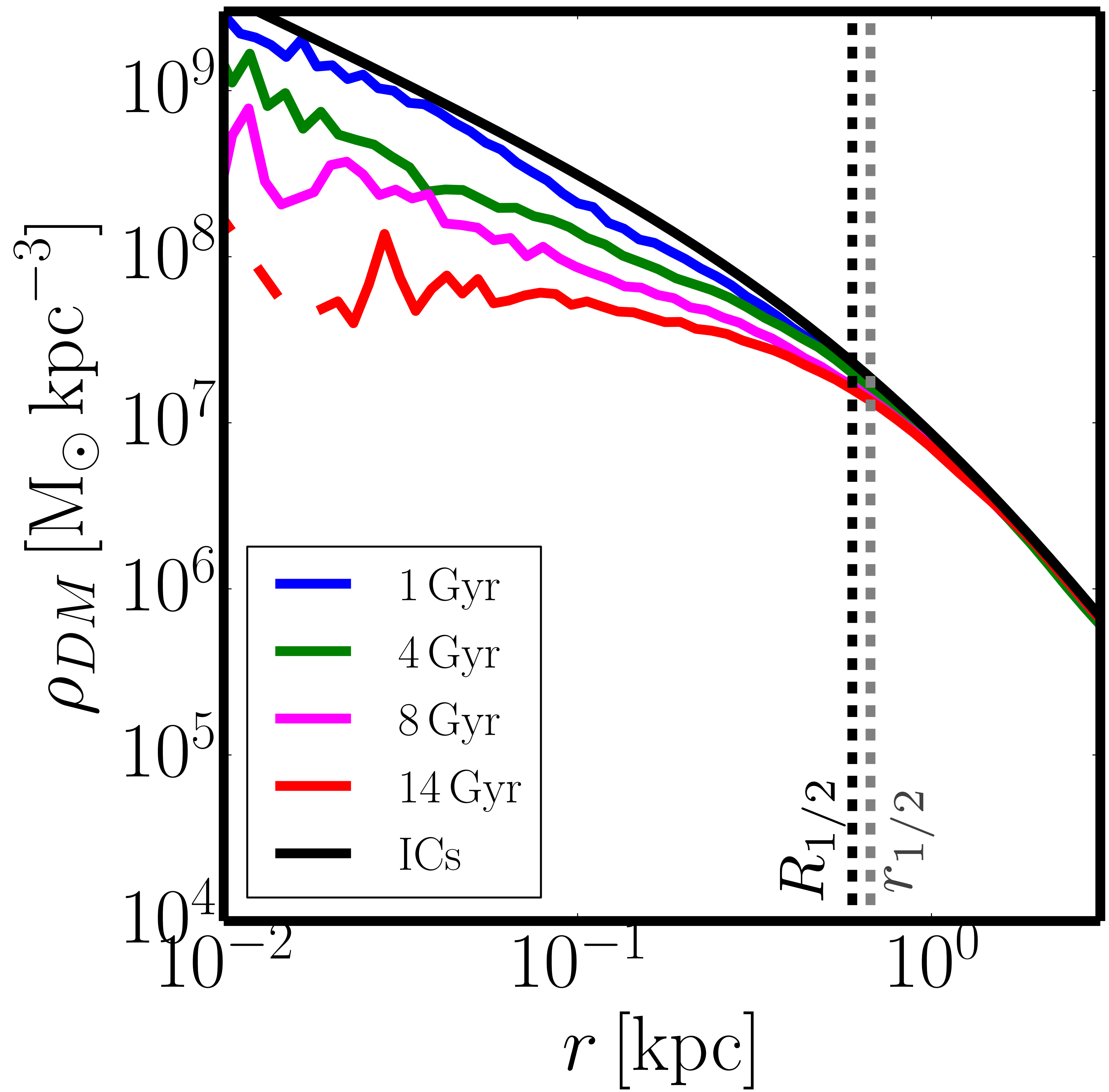
- Bursty star formation.
  [Teyssier et al. 2013; Kauffmann 2014; Sparre et al. 2017]

- Stars kinematically “heated” along with the dark matter ⇒ $v/\sigma < 1$.
  [Read & Gilmore 2005; Teyssier et al. 2013; Leaman et al. 2012; Wheeler et al. 2017]

- Radial migration of stars ⇒ age gradients.
  [El-Badry et al. 2016; Zhang et al. 2012]

“Smoking gun” evidence for DM heating

Less star formation ⇒ more cusp



Read et al. 2016

Less star formation ⇒ more cusp

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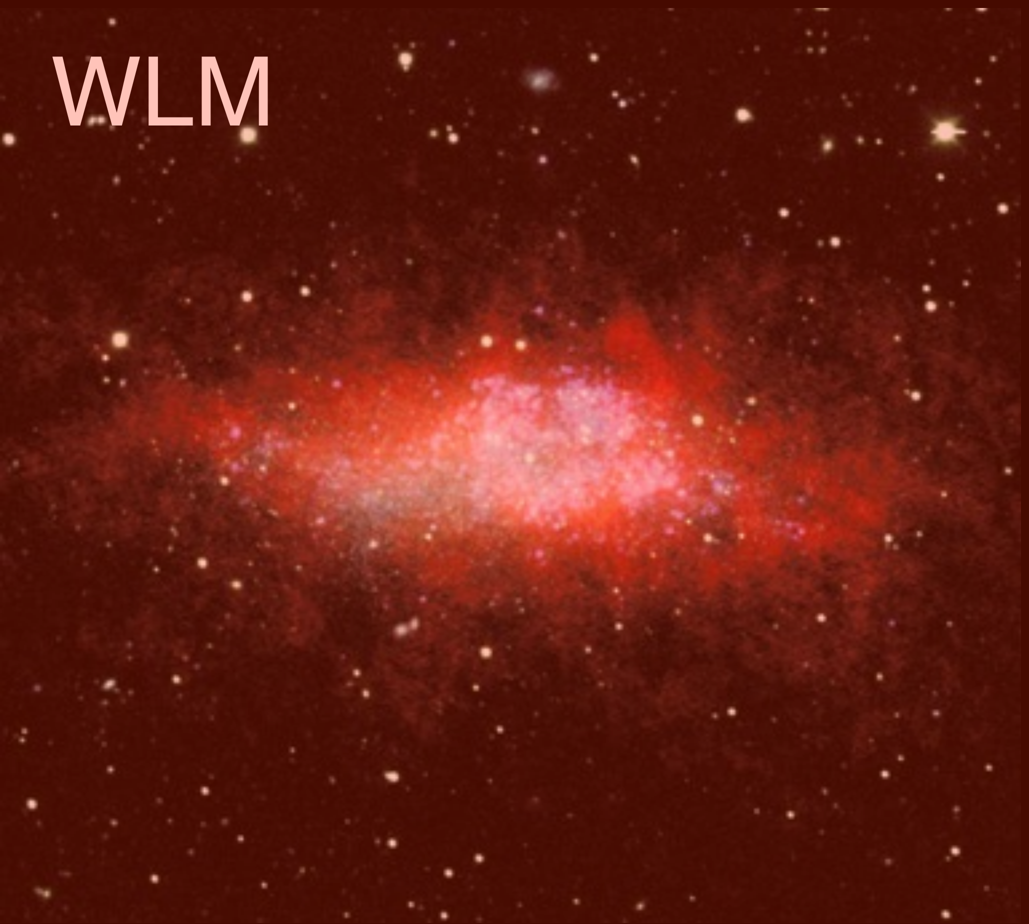
Leroy, Nature 2015

ESO/Digitized Sky Survey 2

Robert Lupton & SDSS

Decreasing star formation
⇒
More DM cusp!

Less star formation ⇒ more cusp



Leroy, Nature 2015

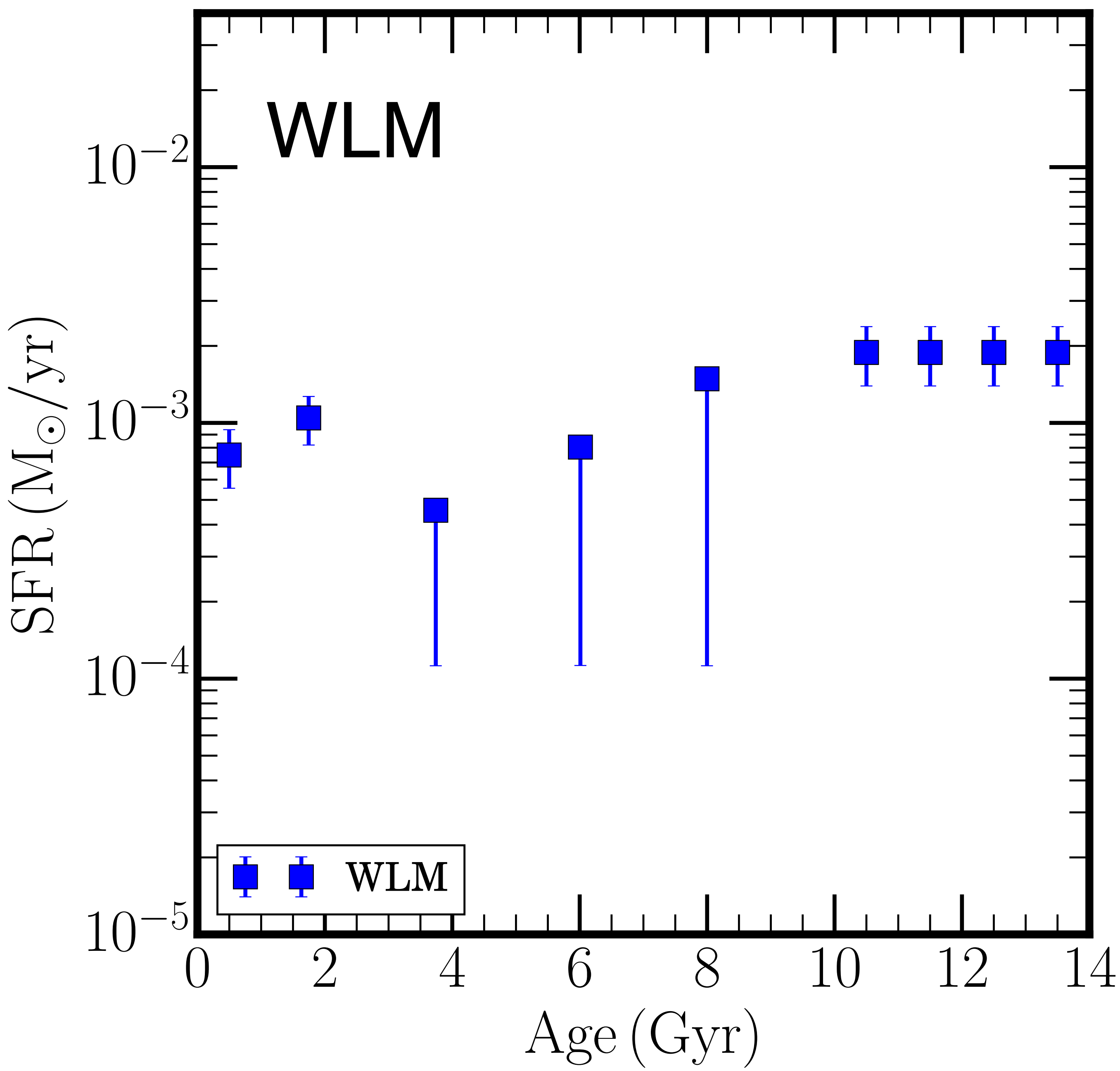
ESO/Digitized Sky Survey 2

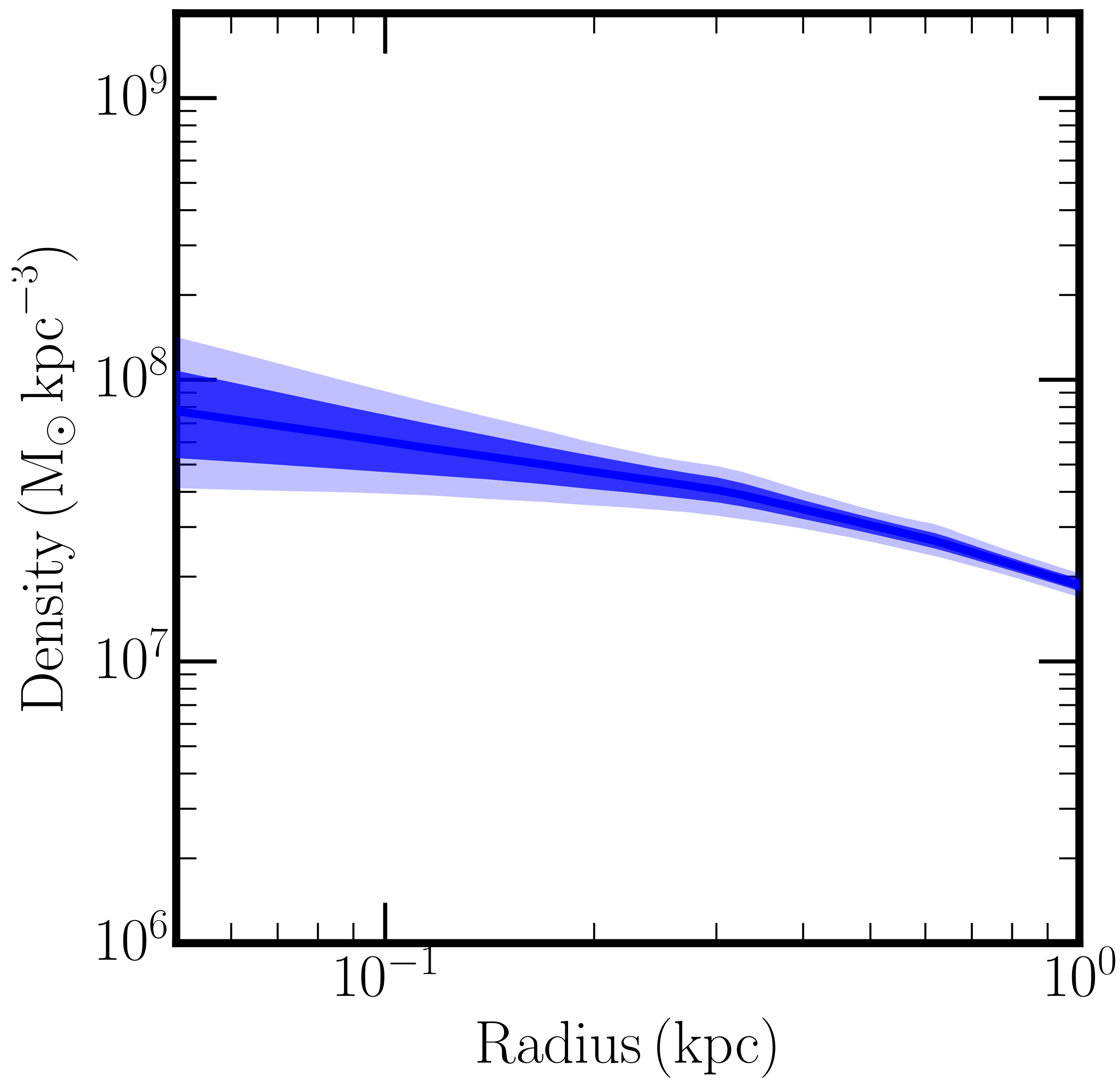
Robert Lupton & SDSS

Rotation curves

Stellar kinematics

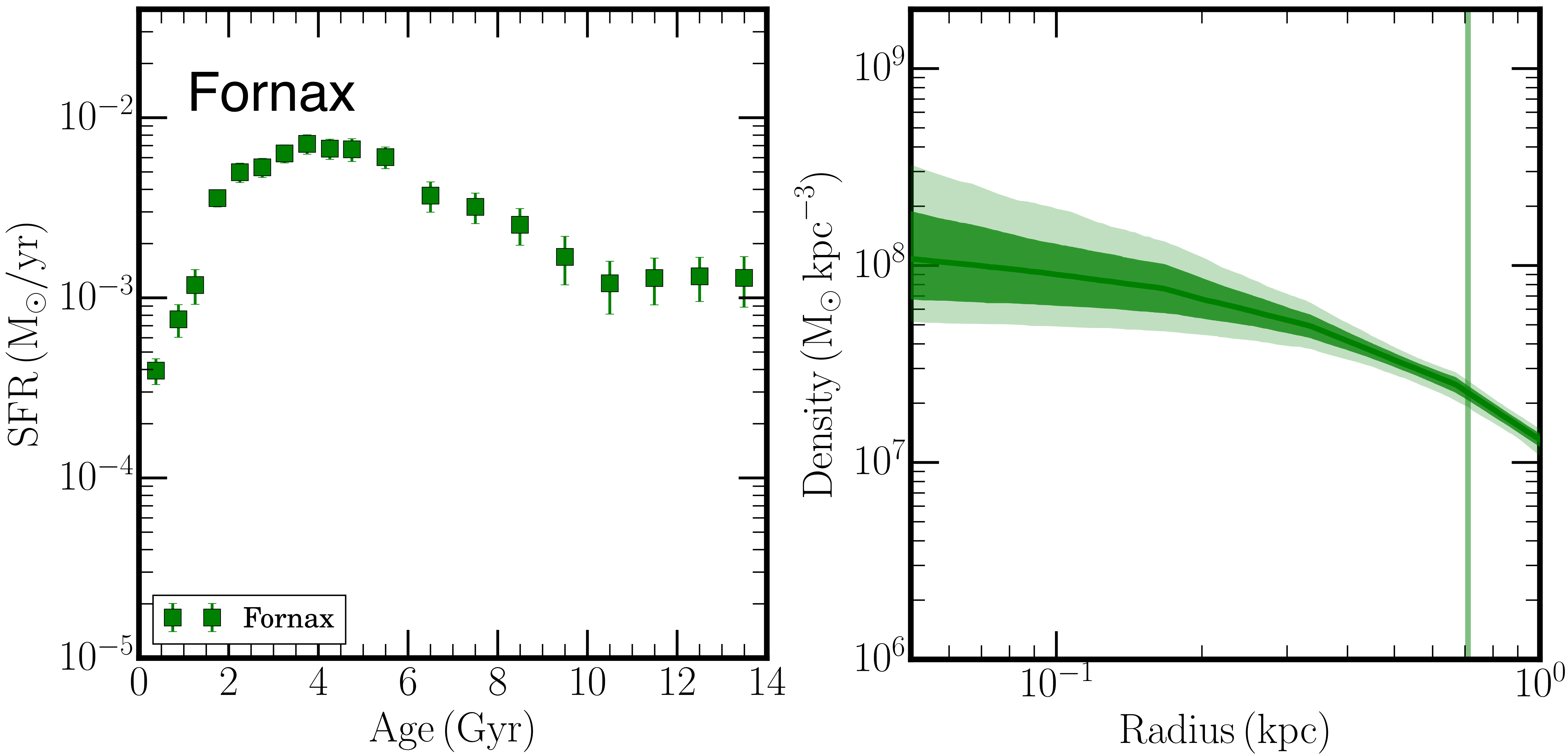
Less star formation ⇒ more cusp





Read et al. 2018a (arXiv:1805.06934),b,c in prep.

Less star formation ⇒ more cusp



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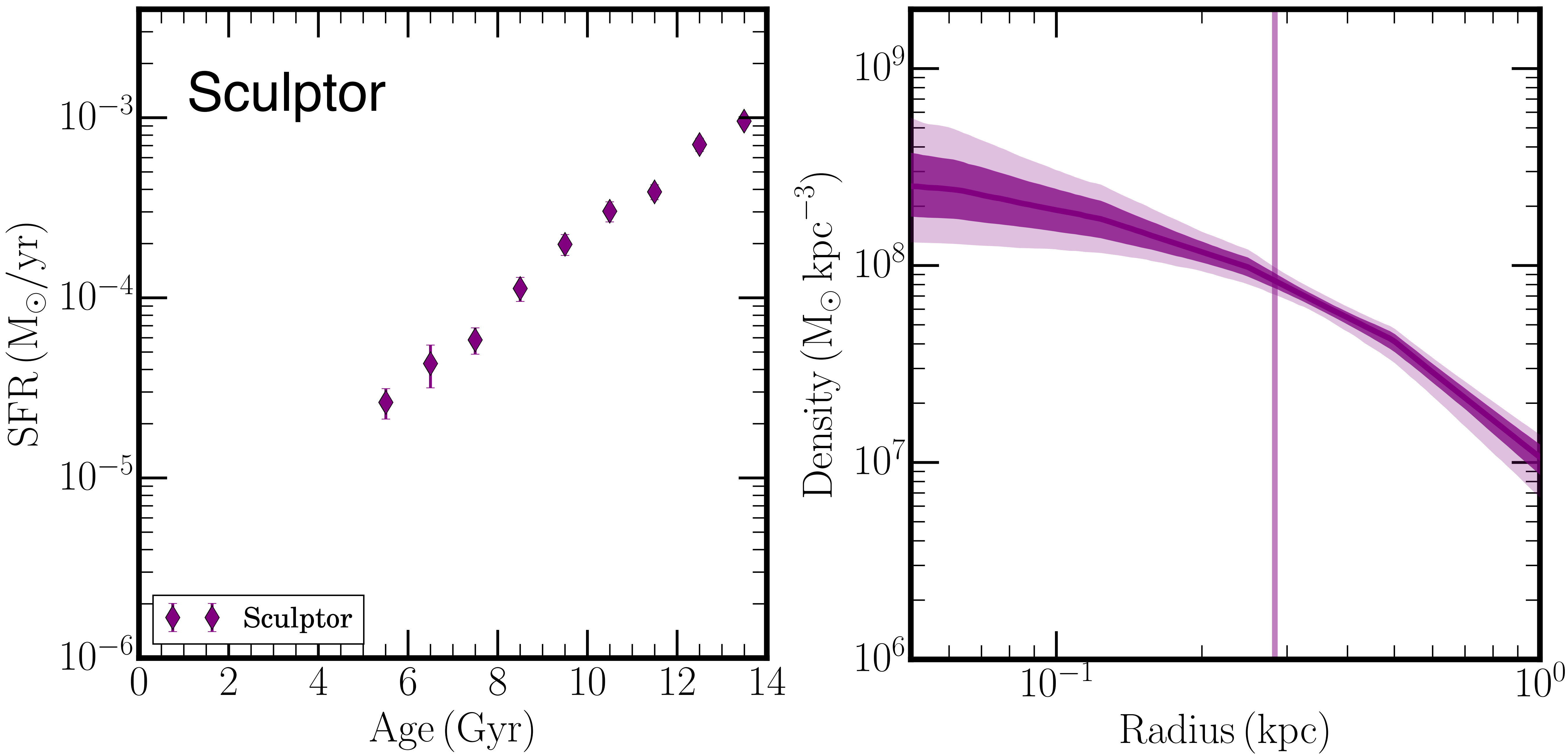

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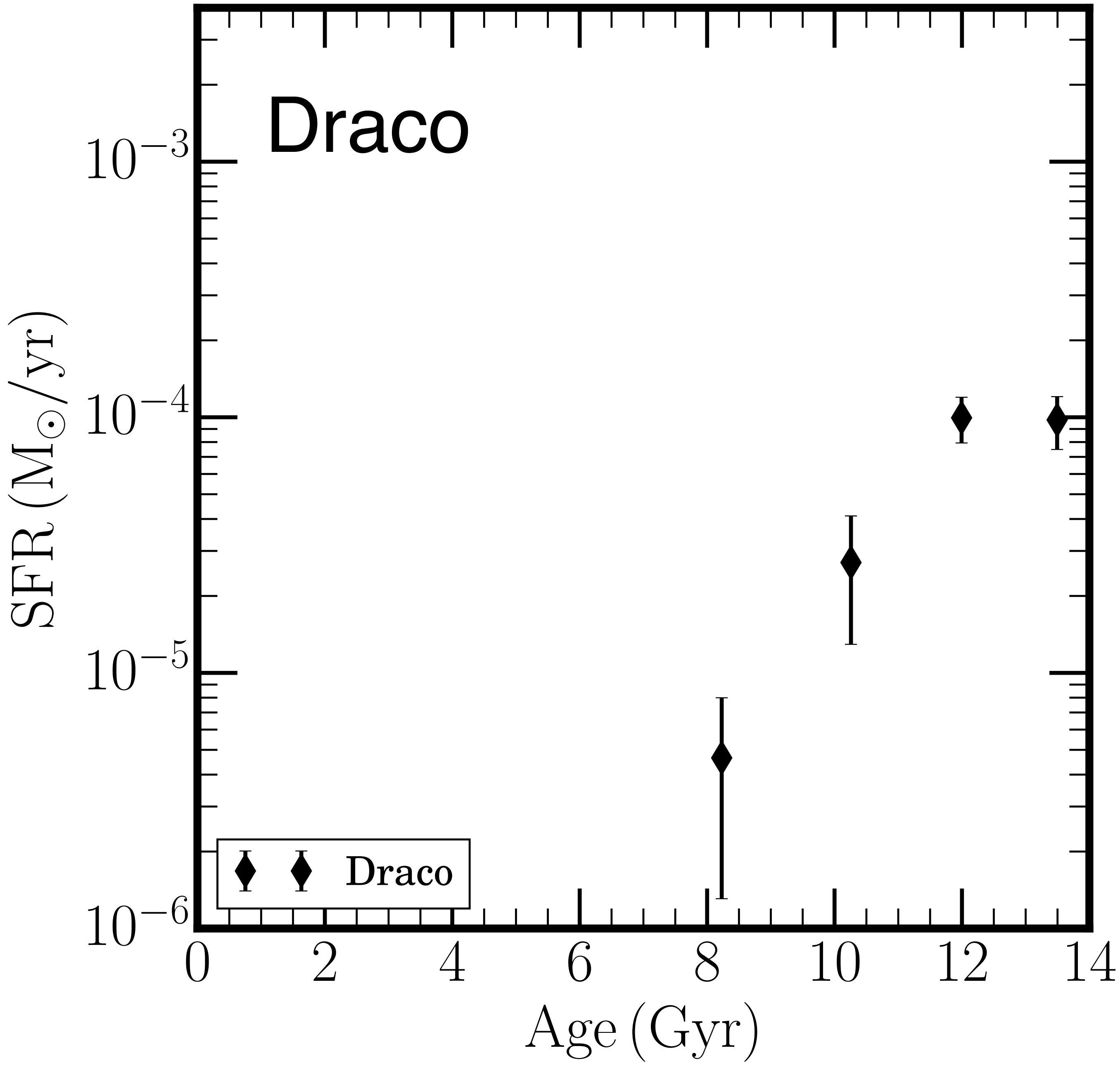

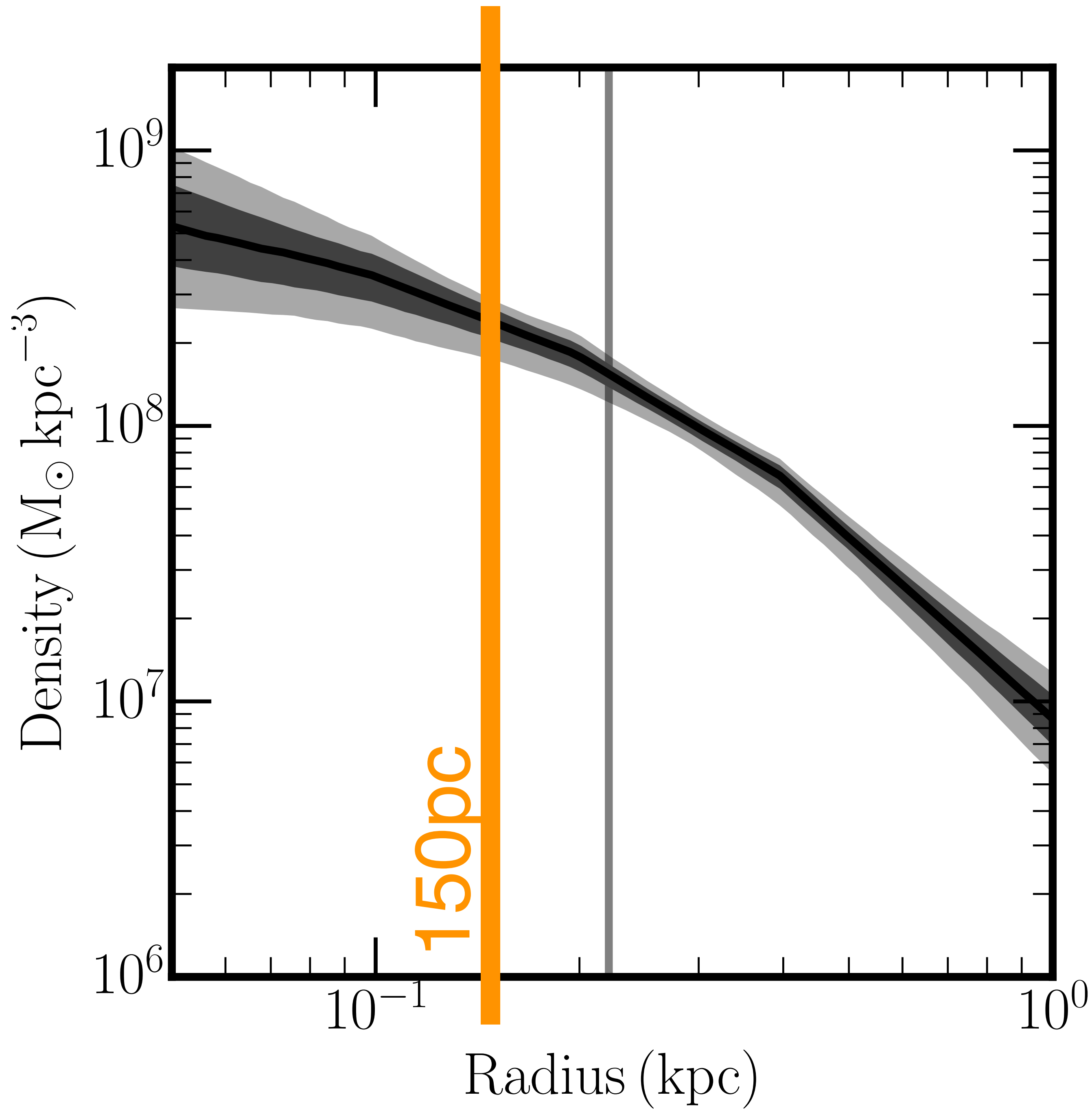

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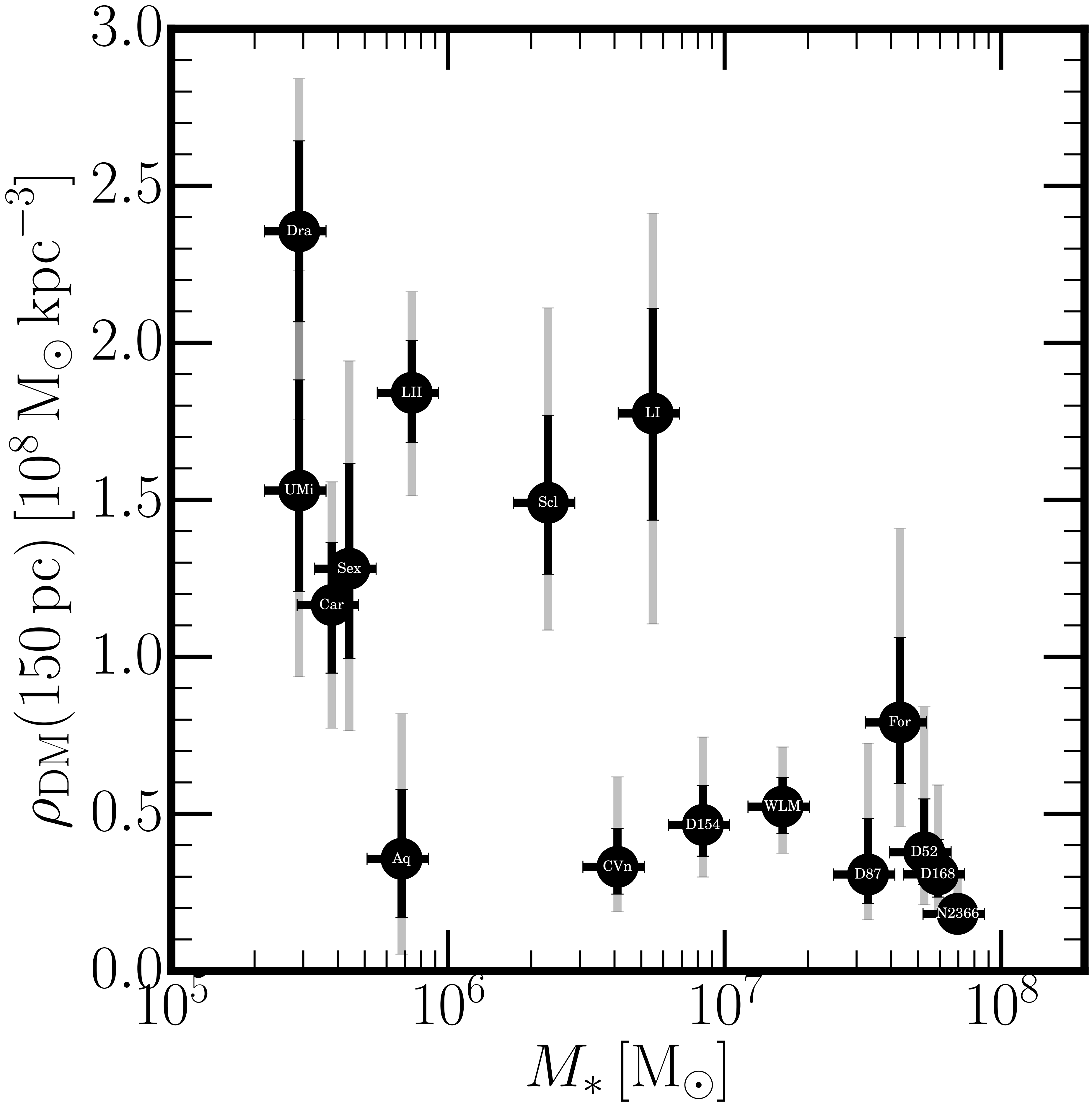

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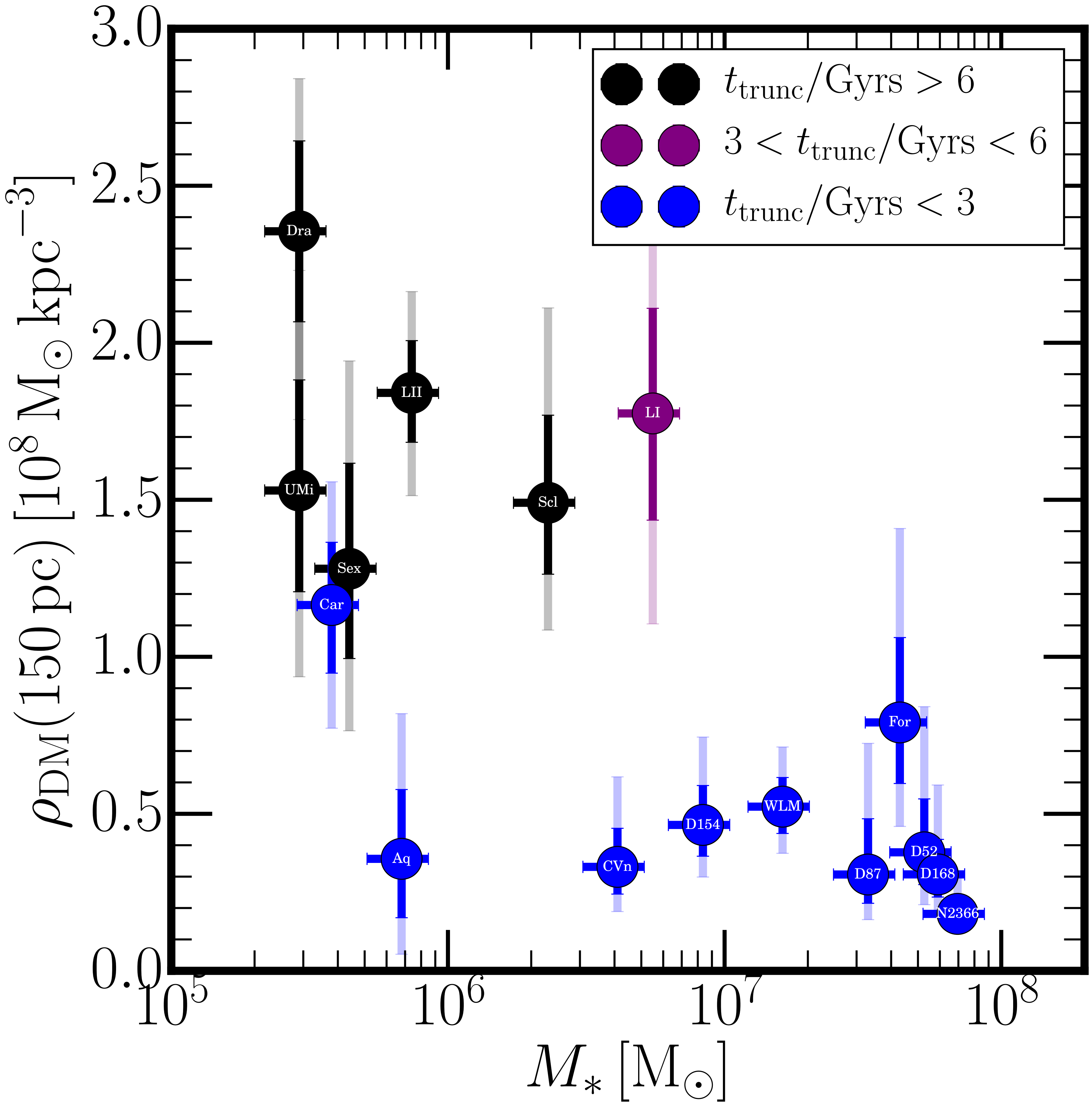

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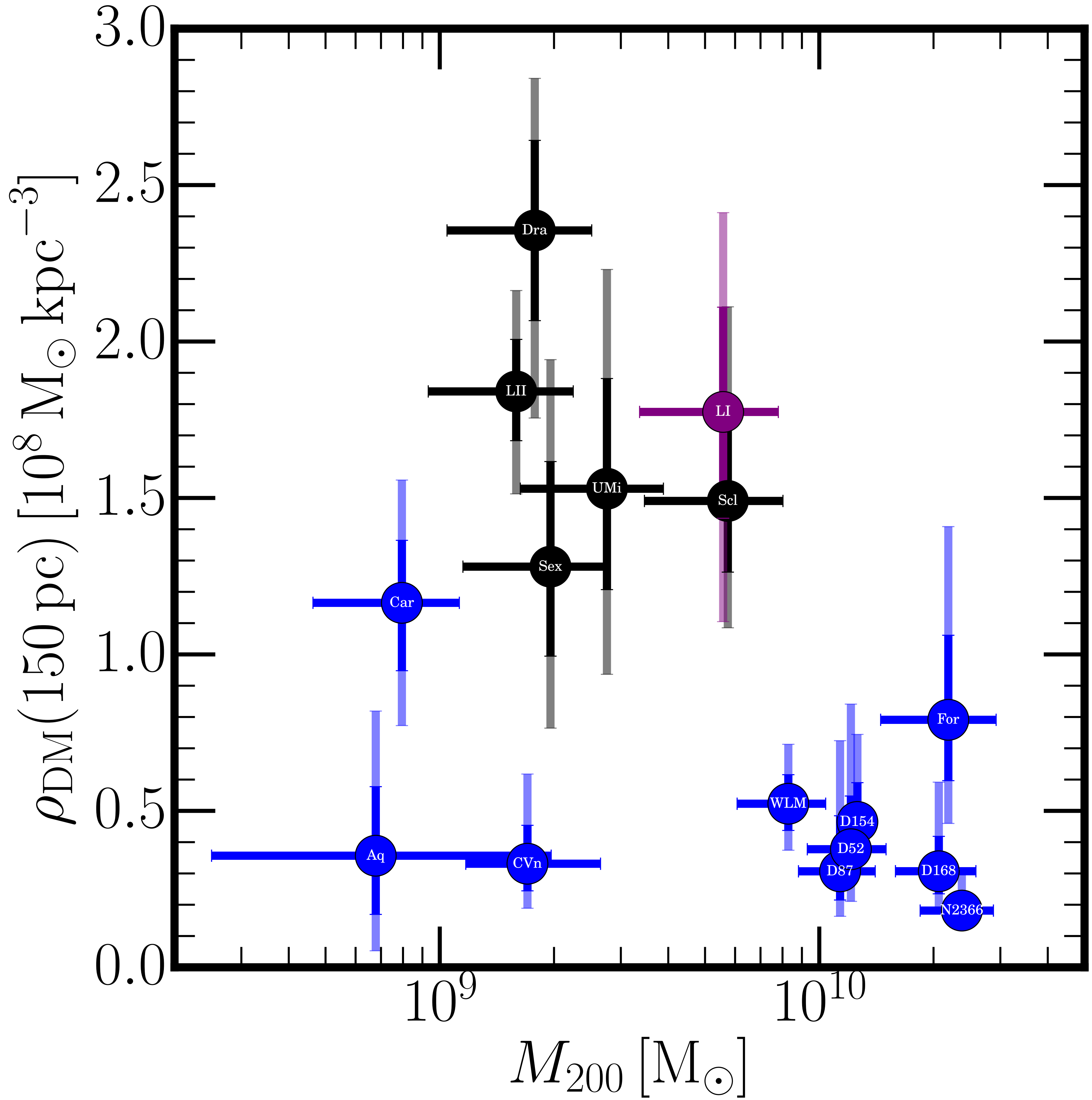

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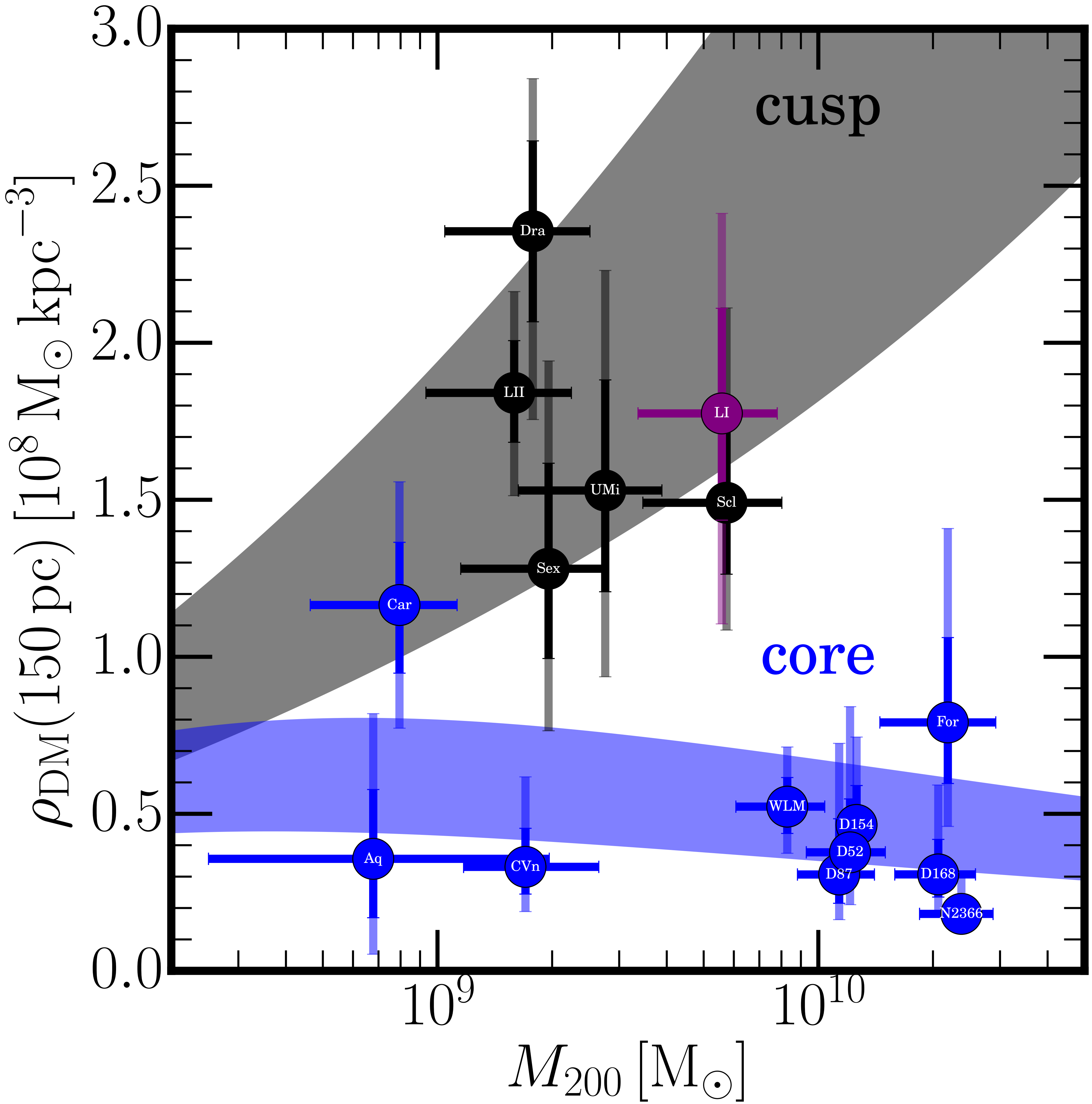

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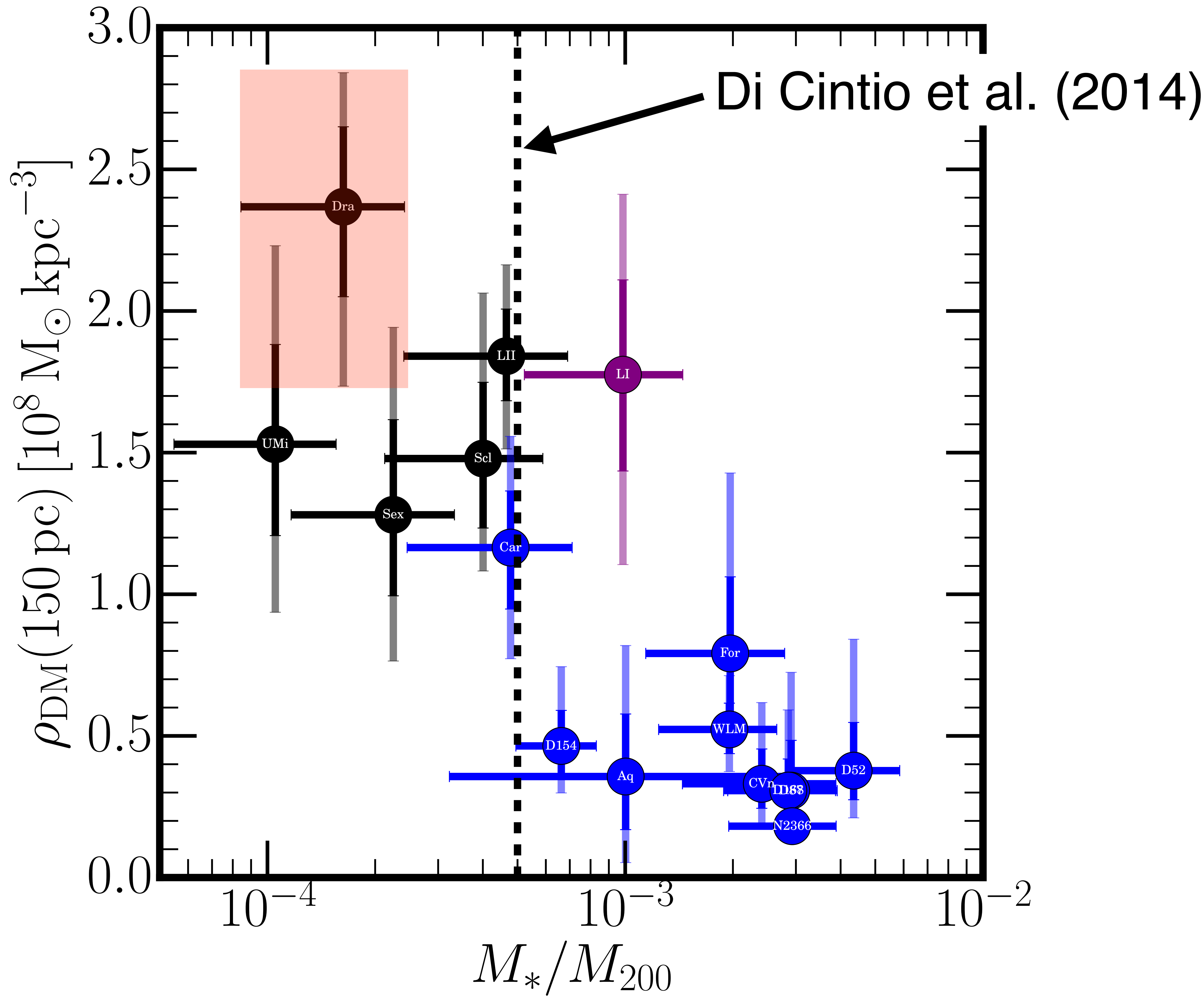

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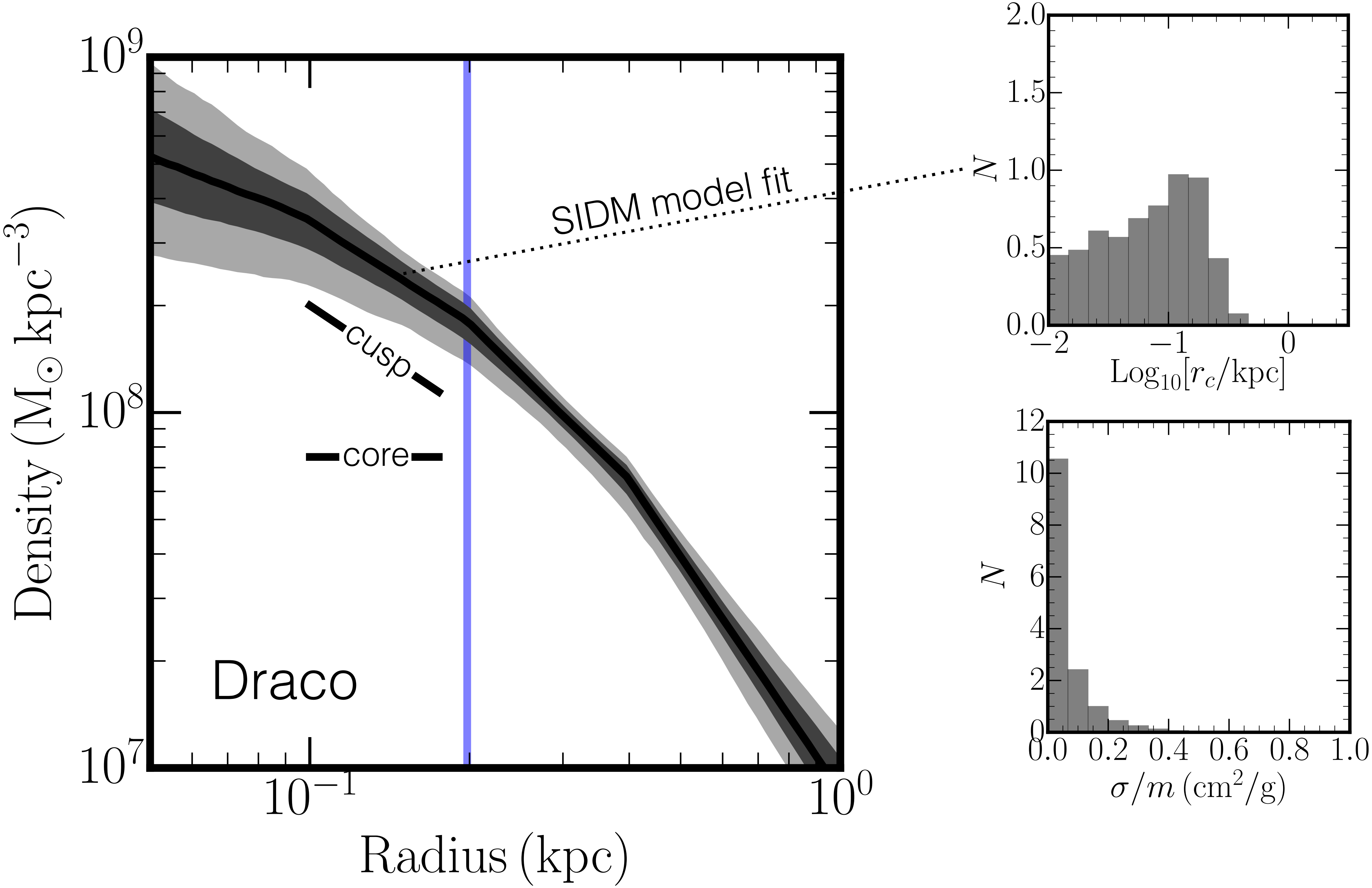

$$\sigma/m \;<\; 0.57\,\mathrm{cm}^2\,\mathrm{g}^{-1} \;\text{ at }\; 99\% \;\text{ confidence.}$$

Read et al. 2018 (arXiv:1805.06934)

Conclusions

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- Dwarf galaxies with more star formation have lower central dark matter densities.
- This suggests that dark matter in dwarf galaxies is "heated up" by baryonic processes.
- If so, this solves the cusp-core problem for dwarf galaxies in LCDM.
- Draco gives us a new constraint on the SIDM cross section: $\sigma/m < 0.57$ cm^2/g at 99% confidence.

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