GalFRESCA 2022

The Impact of Strong Dark Matter Self-Interactions on Dark Matter Halos Within and Surrounding the Milky Way

Daneng Yang (UCR)

Ethan Nadler (Carnegie Observatories and USC)

Hai-Bo Yu (UCR)

To appear soon…

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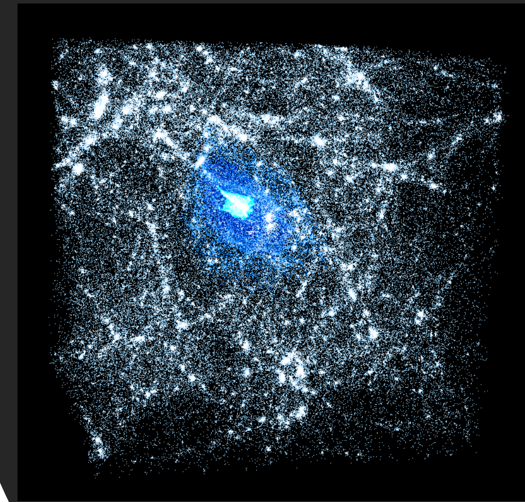
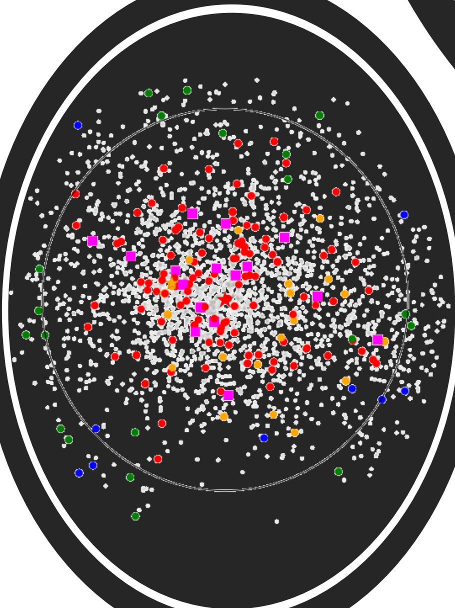
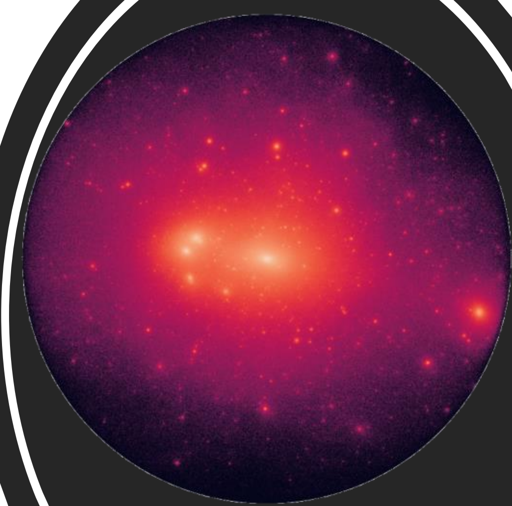
OUTLINE

- SIDM modelling
- Halo catalogs
- Core-collapsed halos
- Simulation results
  - $V_{\max} - R_{\max}$ distribution
  - $V_{\max} - V_{\text{fid}}$ distribution
  - Circular velocities
  - Inner density-pericenter







We perform cosmological zoom-in simulation of a Milky Way analog system.

Particle mass: $5.7 \times 10^4 \mathrm{M}_\odot$

MW mass: $1.6 \times 10^{12} \mathrm{M}_\odot$

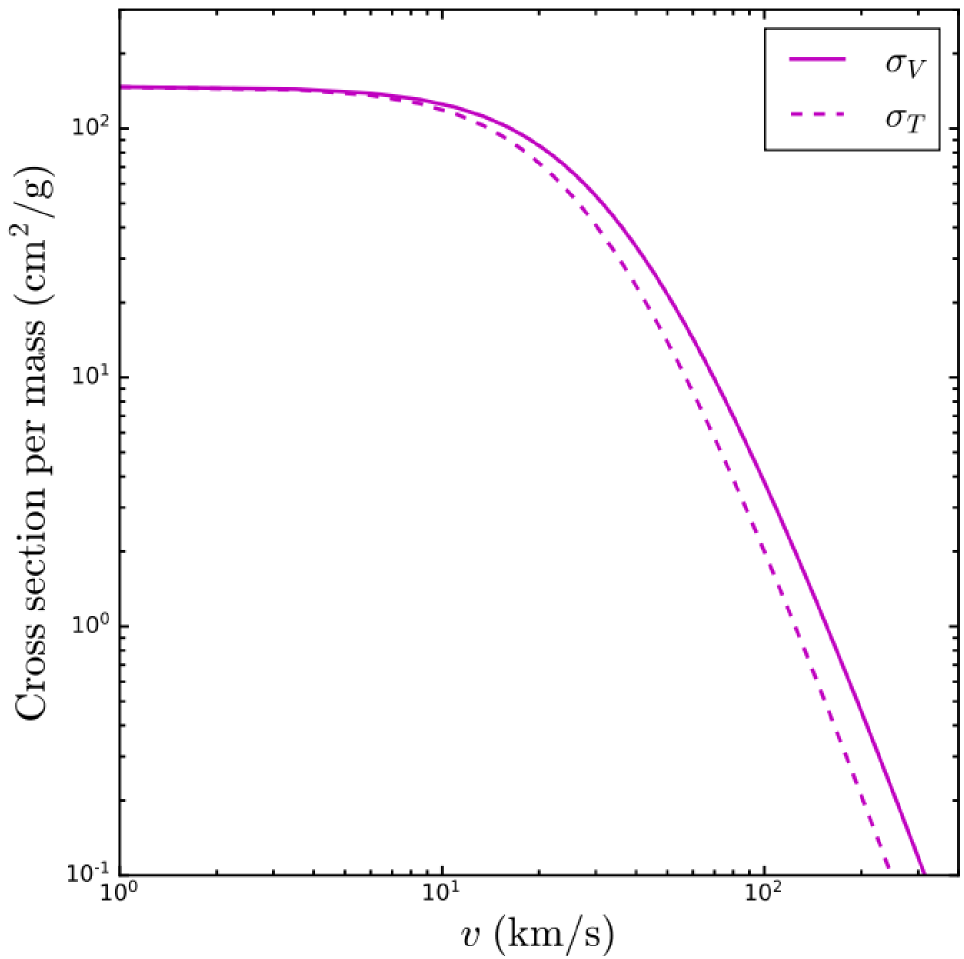
LMC mass: $1.8 \times 10^{11} \mathrm{M}_\odot$

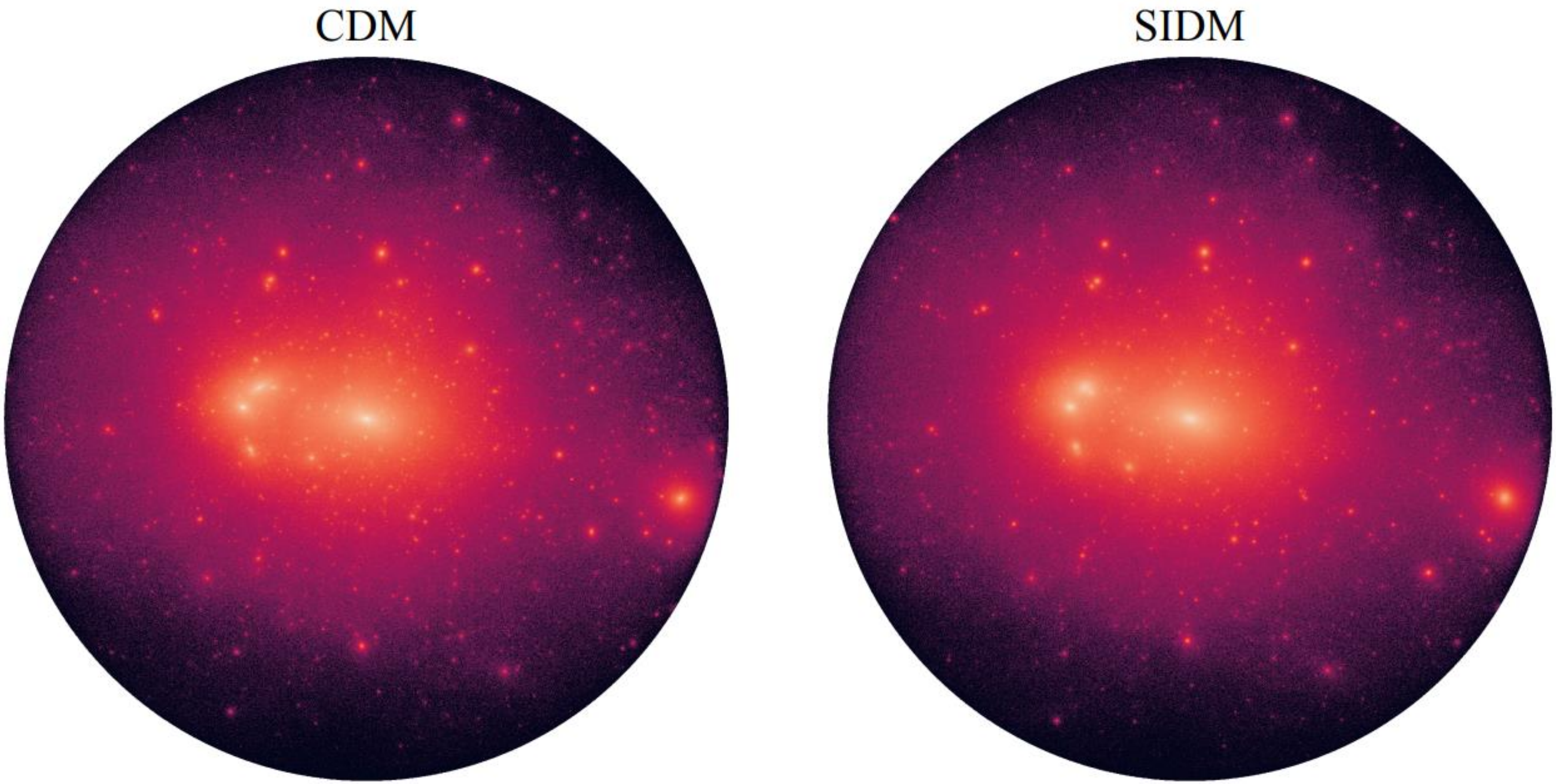
Rutherford-like scattering: (angular- and velocity-dependent)

$$\frac{d\sigma}{d\cos\theta} = \frac{\sigma_0 w^4}{2\left[w^2 + v^2 \sin^2(\theta/2)\right]^2}$$

$\sigma_0 = 147.1\ \mathrm{cm}^2/\mathrm{g}$, $w = 24.33\ \mathrm{km/s}$

$\sigma_T/m = 100\ \mathrm{cm}^2/\mathrm{g}$ at $v = 14\ \mathrm{km/s}$ and $\sigma_T/m = 2\ \mathrm{cm}^2/\mathrm{g}$ at $v = 100\ \mathrm{km/s}$

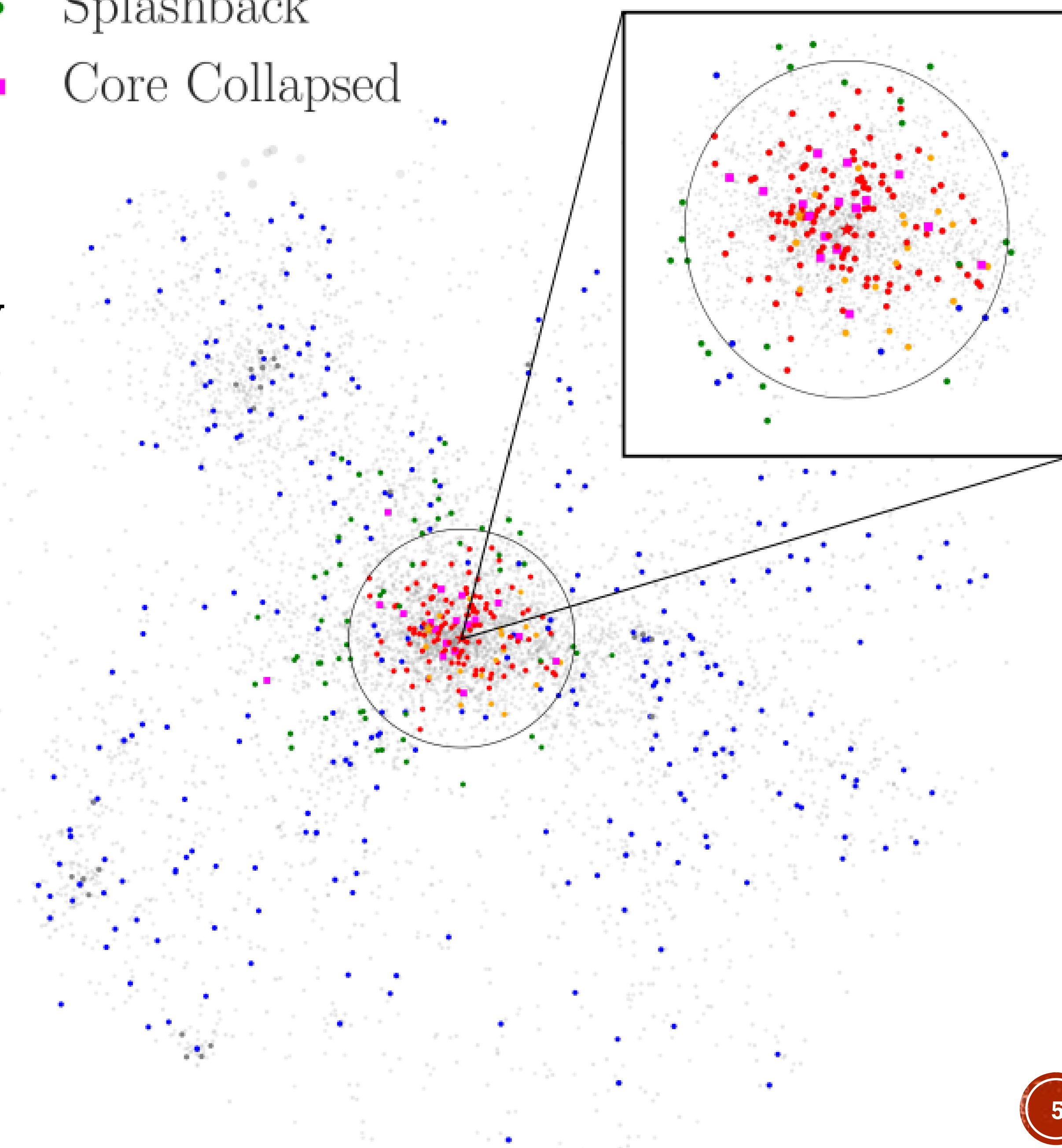




Similar number of resolved halos with masses higher than $10^8 M_\odot/h$

Core-collapsing halos look brighter (lower mass, smaller points)

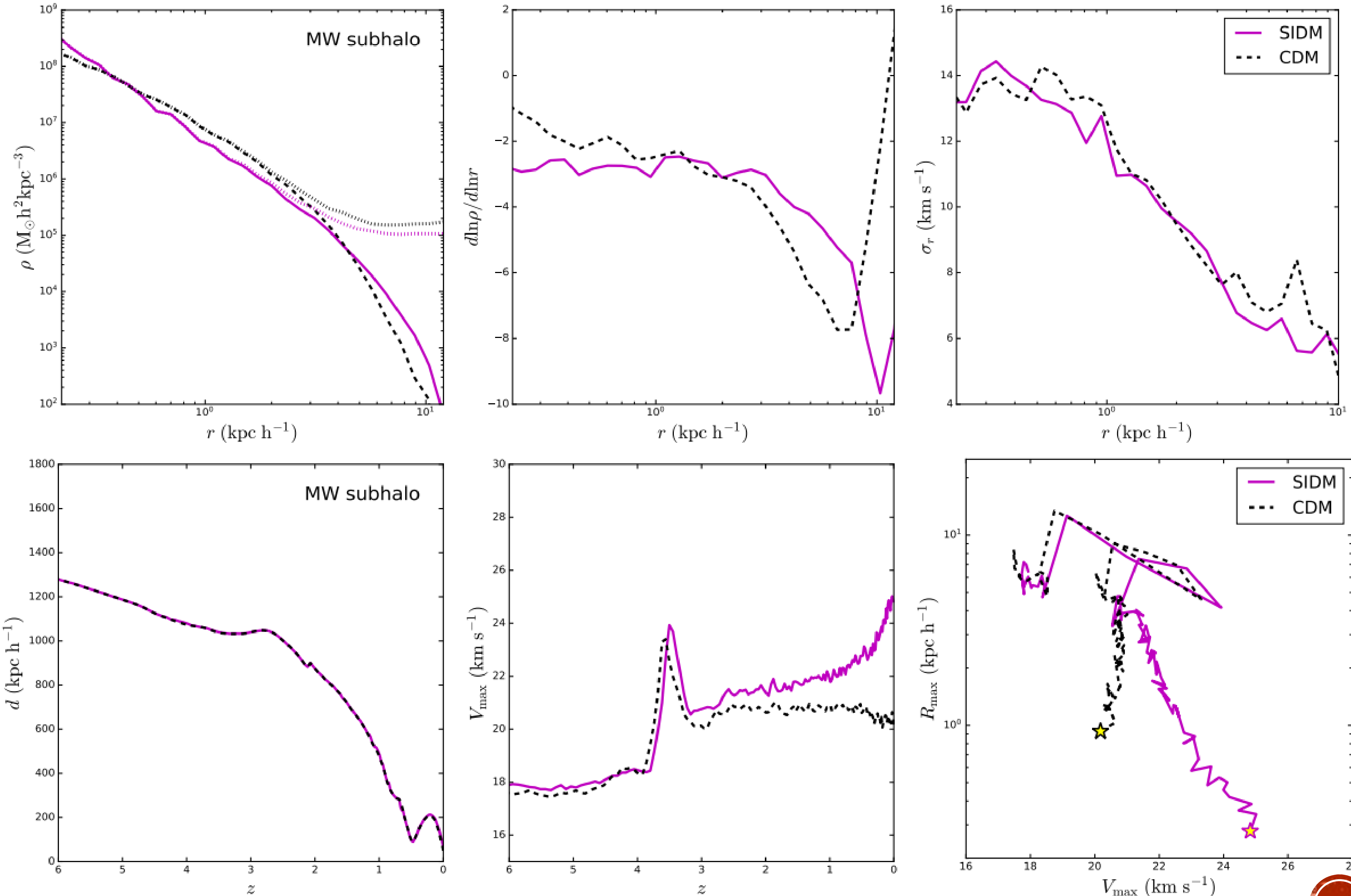
Core-forming halos look dimmer in the inner region (larger points)



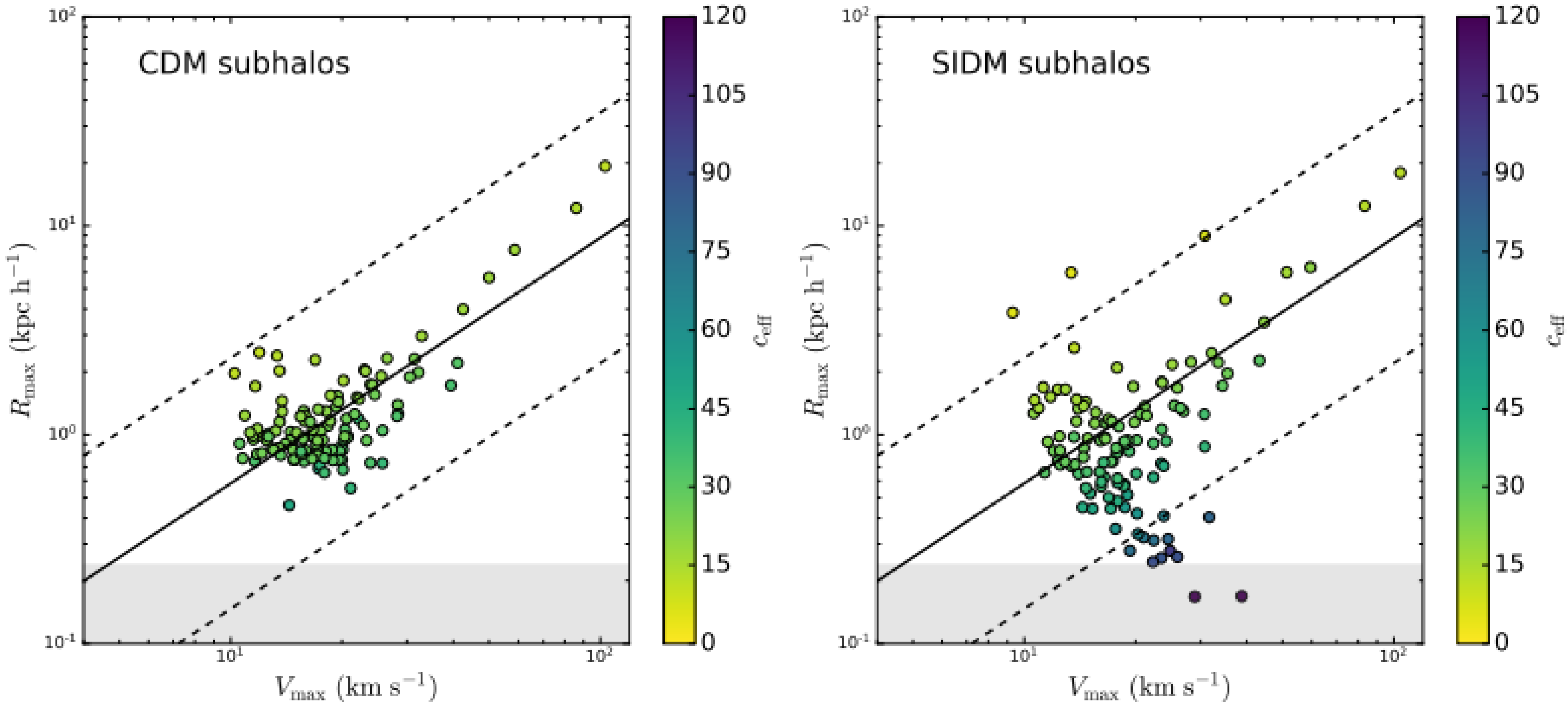
We select some clearly core-collapsed halos considering -0.6 dex below the best fit $\log_{10} V_{\max} - \log_{10} R_{\max}$ relation

- MW subs: 12
- LMC subs: 1
- Isolated: 46
- Splashback: 2

Benchmark core-collapsed **subhalo**

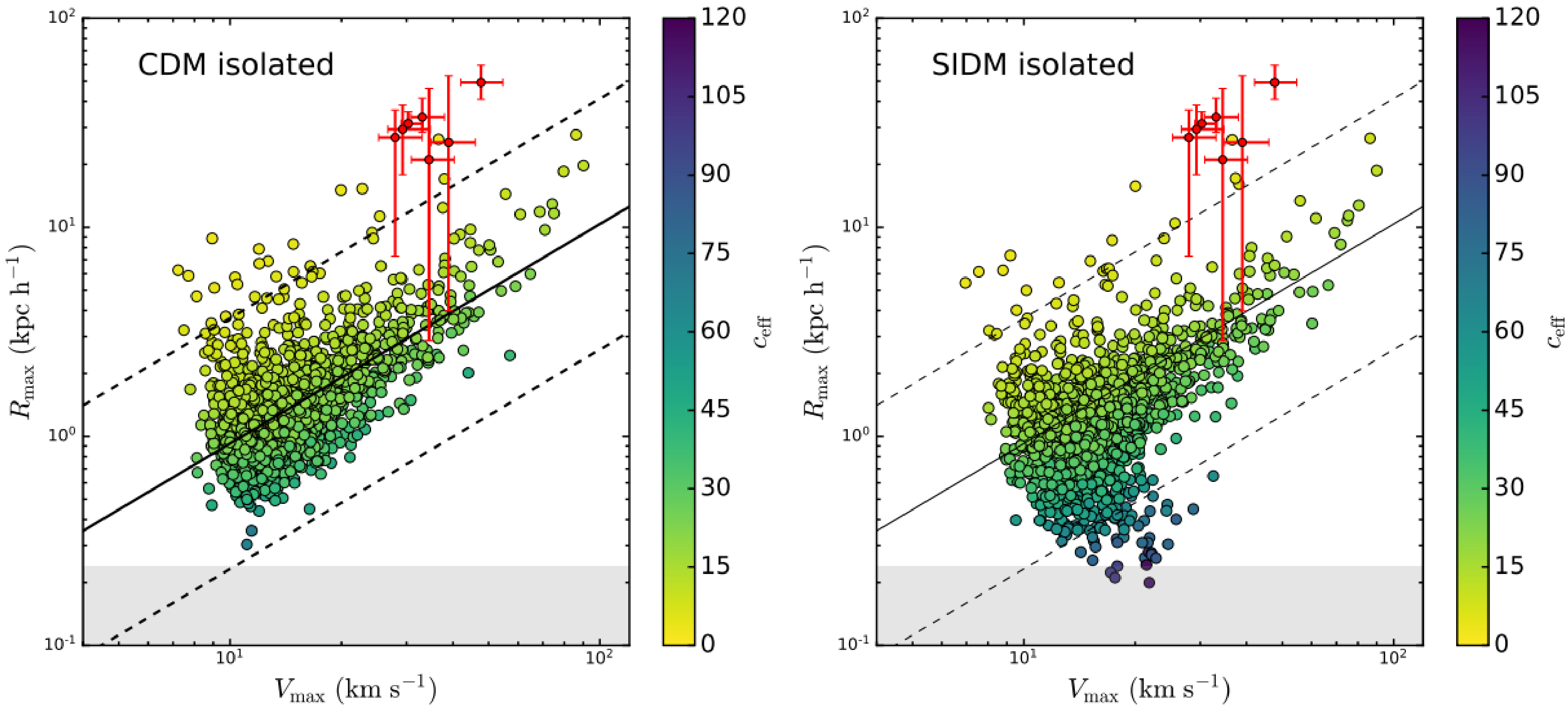


MW subhalos



In SIDM, the $V_{max} - R_{max}$ distribution has more spread:

- Some (deeply) core-collapsed halos are below -0.6 dex
- Some (ultra) low-concentration halos are above +0.6 dex

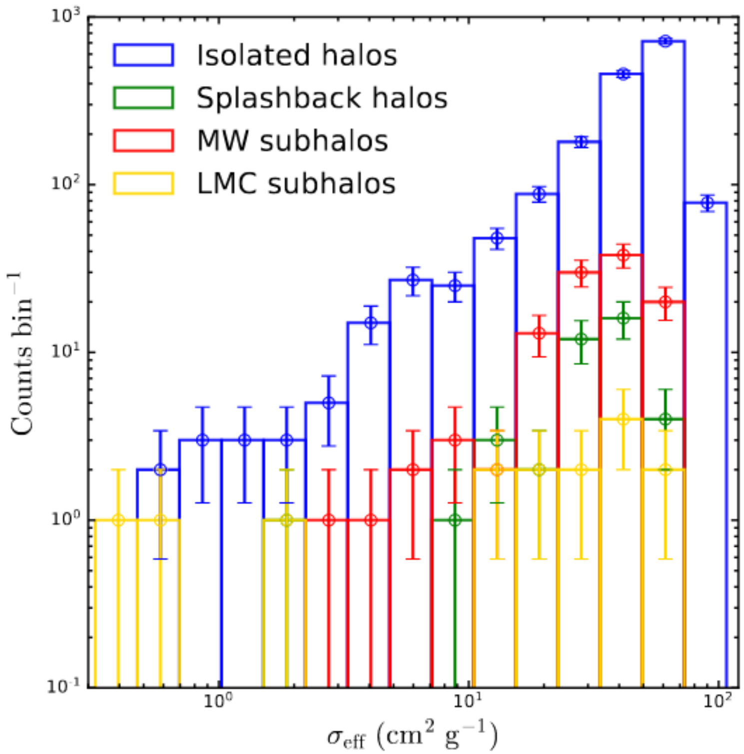


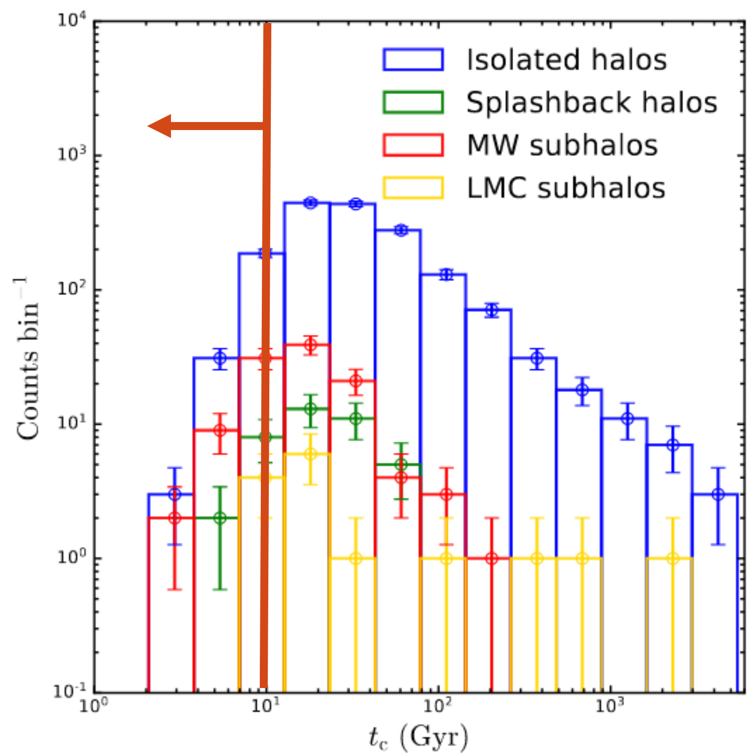
The spread can be described using an effective concentration, which reduces the usual definition for an NFW profile

UDGs from Kong et al. (2022)

$$c_{\rm eff} = \frac{R_{\rm vir}}{R_{\rm max}/2.1626}$$

Our selection condition is conservative





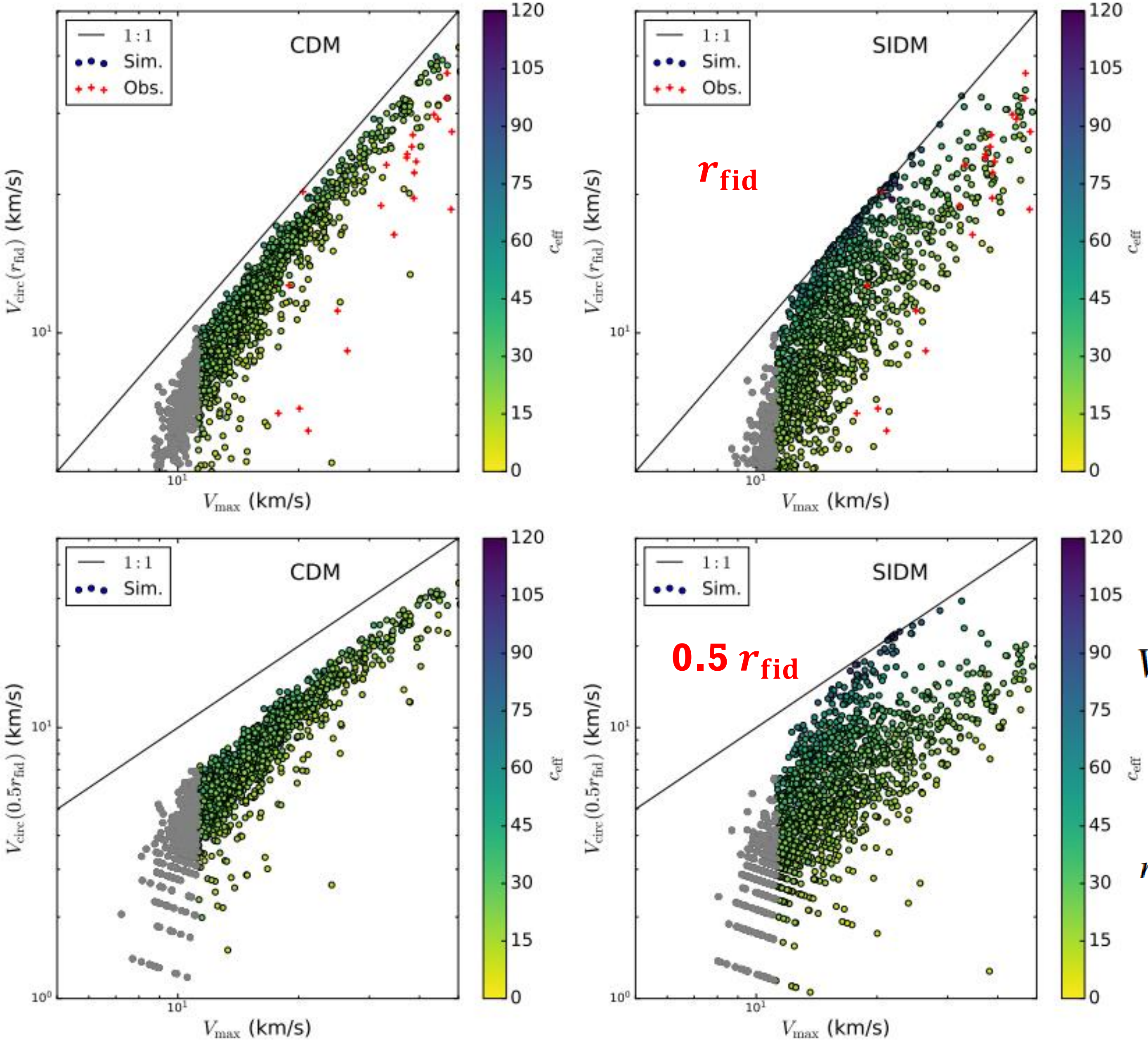
$$t_c = \frac{150}{\beta} \frac{1}{(\sigma_{\rm eff}/m)\rho_{\rm eff} r_{\rm eff}} \frac{1}{\sqrt{4\pi G \rho_{\rm eff}}}$$

$$\sigma_{\rm eff} = \frac{2\int v^2 dv d\cos\theta \frac{d\sigma}{d\cos\theta} \sin^2\theta v^5 \exp\left[-\frac{v^2}{4\nu_{\rm eff}^2}\right]}{\int v^2 dv d\cos\theta \sin^2\theta v^5 \exp\left[-\frac{v^2}{4\nu_{\rm eff}^2}\right]}$$

$$r_{\rm eff} = R_{\rm max}/2.1626$$

$$\rho_{\rm eff} = (V_{\rm max}/(1.648 r_{\rm eff}))^2/G$$

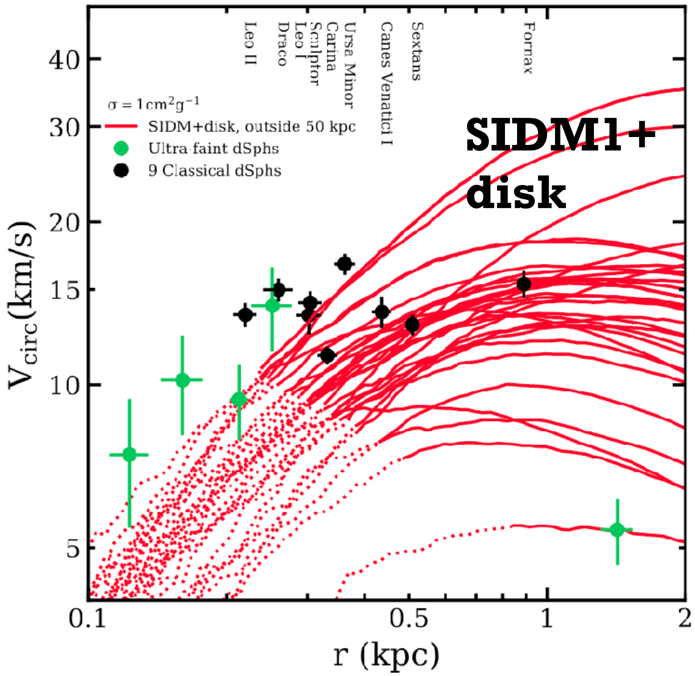
$$\nu_{\rm eff} = 0.64 V_{\rm max,NFW} \approx 1.05 r_{\rm eff}\sqrt{G\rho_{\rm eff}}$$

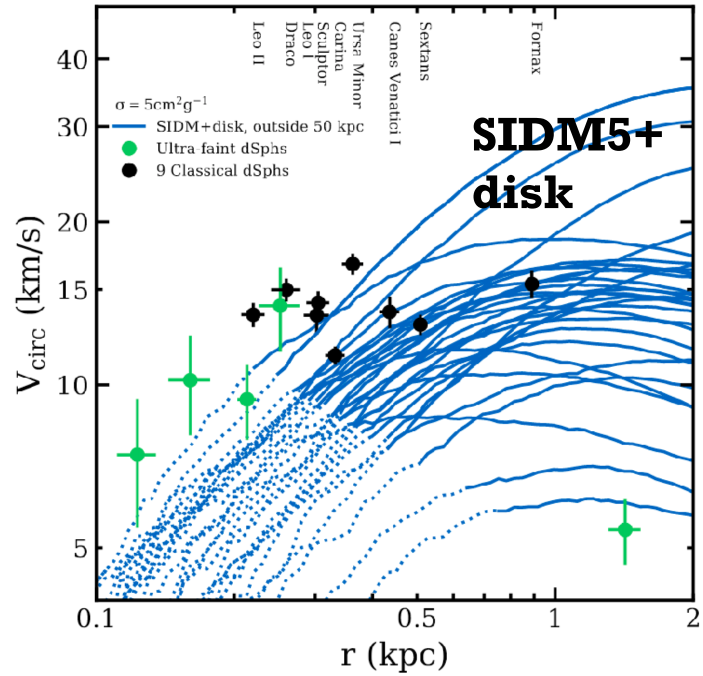


Core-forming halos have lower concentration and spread towards lower-right in SIDM

$$V_{\rm circ}(r_{\rm fid}) = \sqrt{\frac{GM(r<r_{\rm fid})}{r_{\rm fid}}}$$

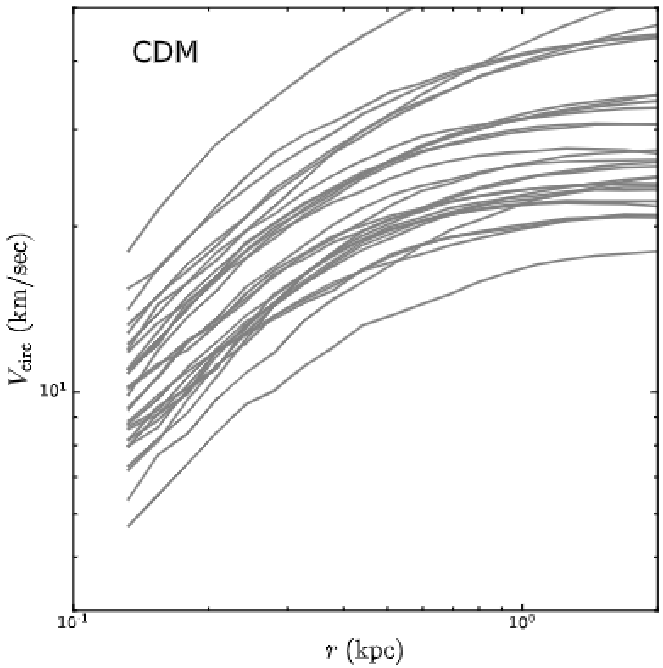
$$r_{\rm fid} = 2V_{\rm max}/(70\ {\rm km/s})\ {\rm kpc}$$

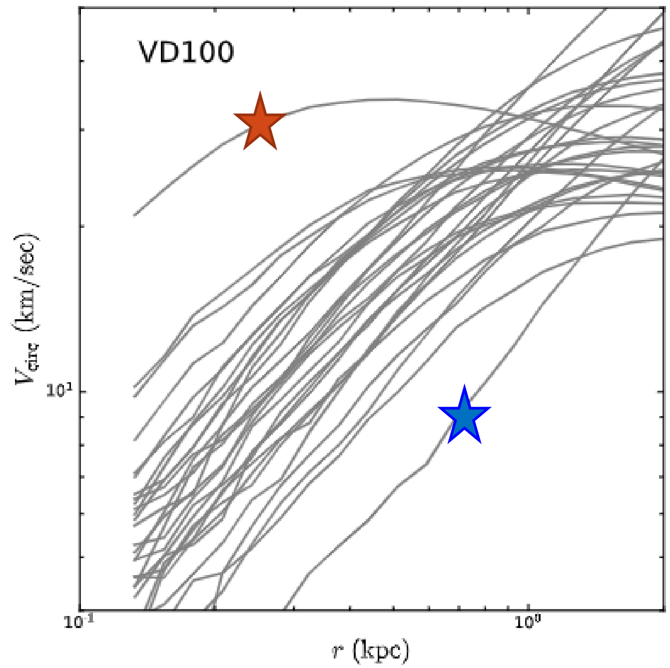




Silverman et al. 2022

Data points for MW **ultra-faint** and **classical** dSphs (30 kpc<r<Rvir)



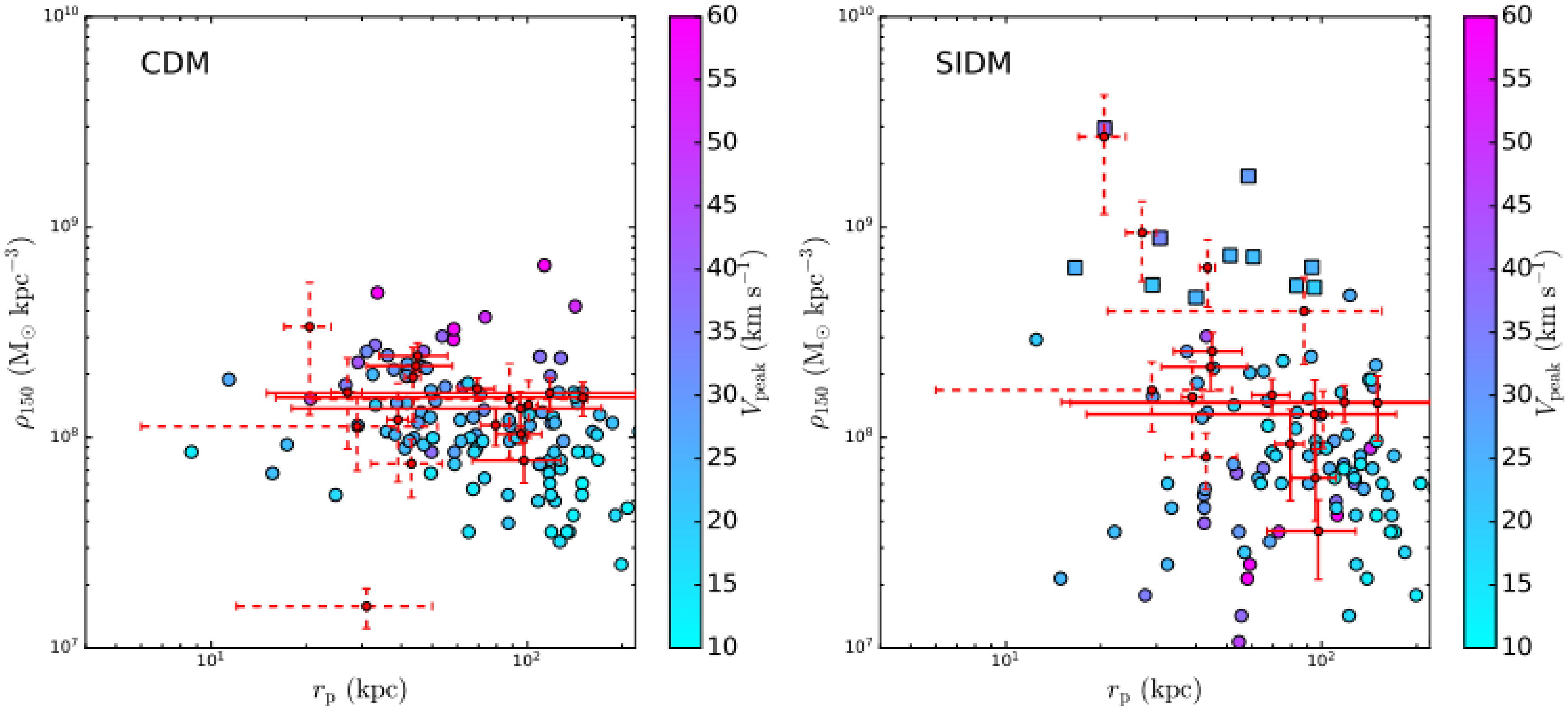


Core-collapsing

Core-forming

30 most massive subhalos

MW subhalos of masses > $10^8 M_\odot/h$

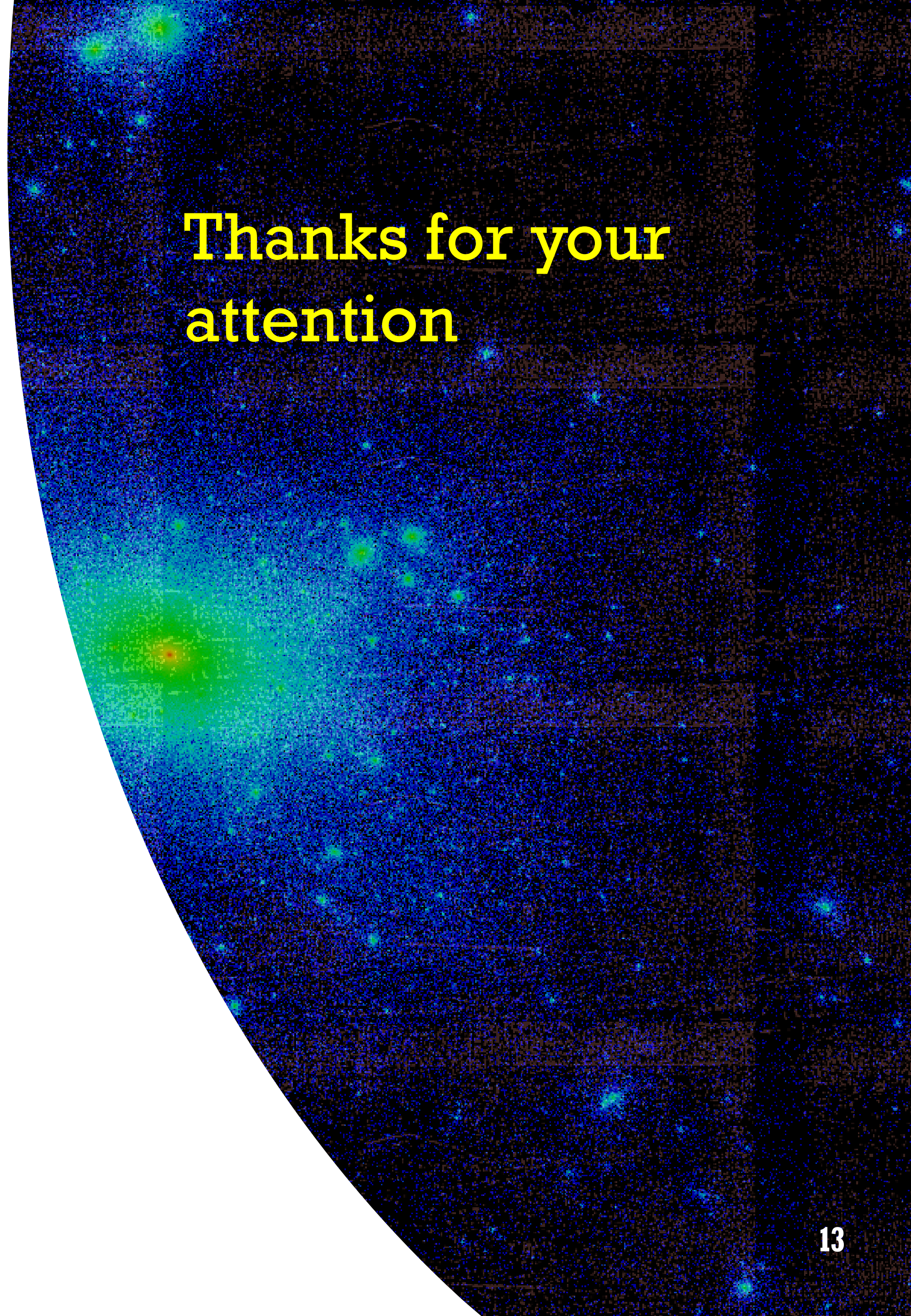


Classical dwarfs (solid) and ultra-faint dwarfs (dashed) from Kaplinghat, Valli and Yu, 2019

Inner density extrapolated assuming NFW profile (left panel) and cored-isothermal profile (right panel)

SUMMARY

- We simulated a MW-like system with strong dark matter self-interactions.
- We identified core-collapsed halos in all the categories.
- Our SIDM scenario predicts the existence of core-collapsed isolated and satellite halos hosting ultra-faint dwarf galaxies.
- For more realistic results, one should incorporate baryon effects especially the disk potential (on-going).



14 BACKUP

Benchmark core-collapsed **isolated** halo