Prompt Cusps

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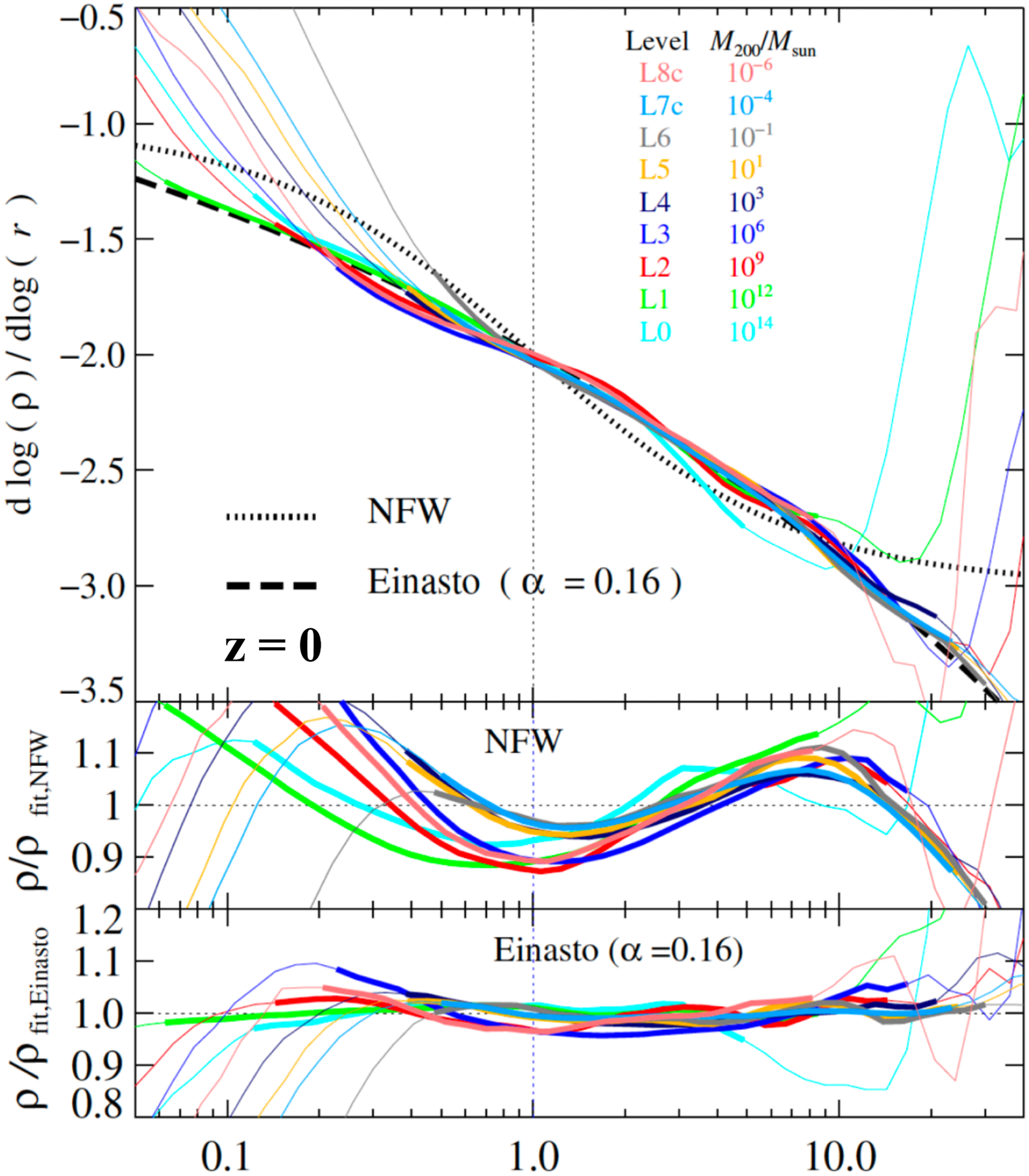
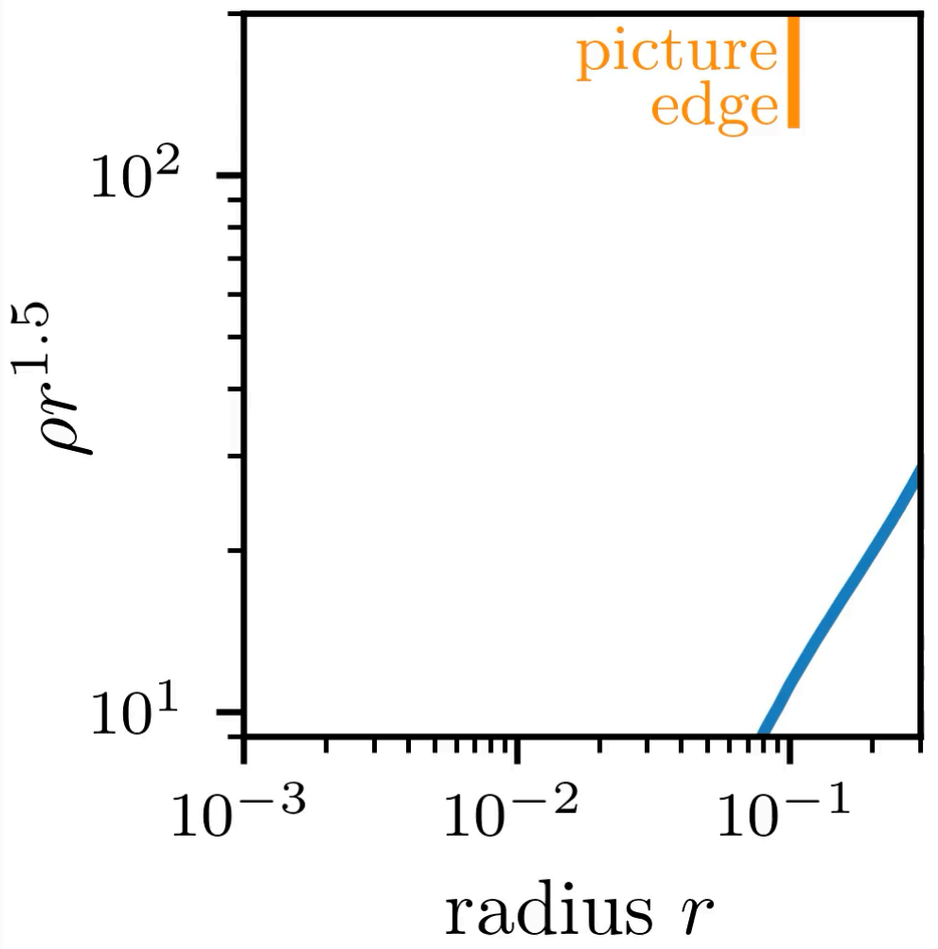


Density profile shapes

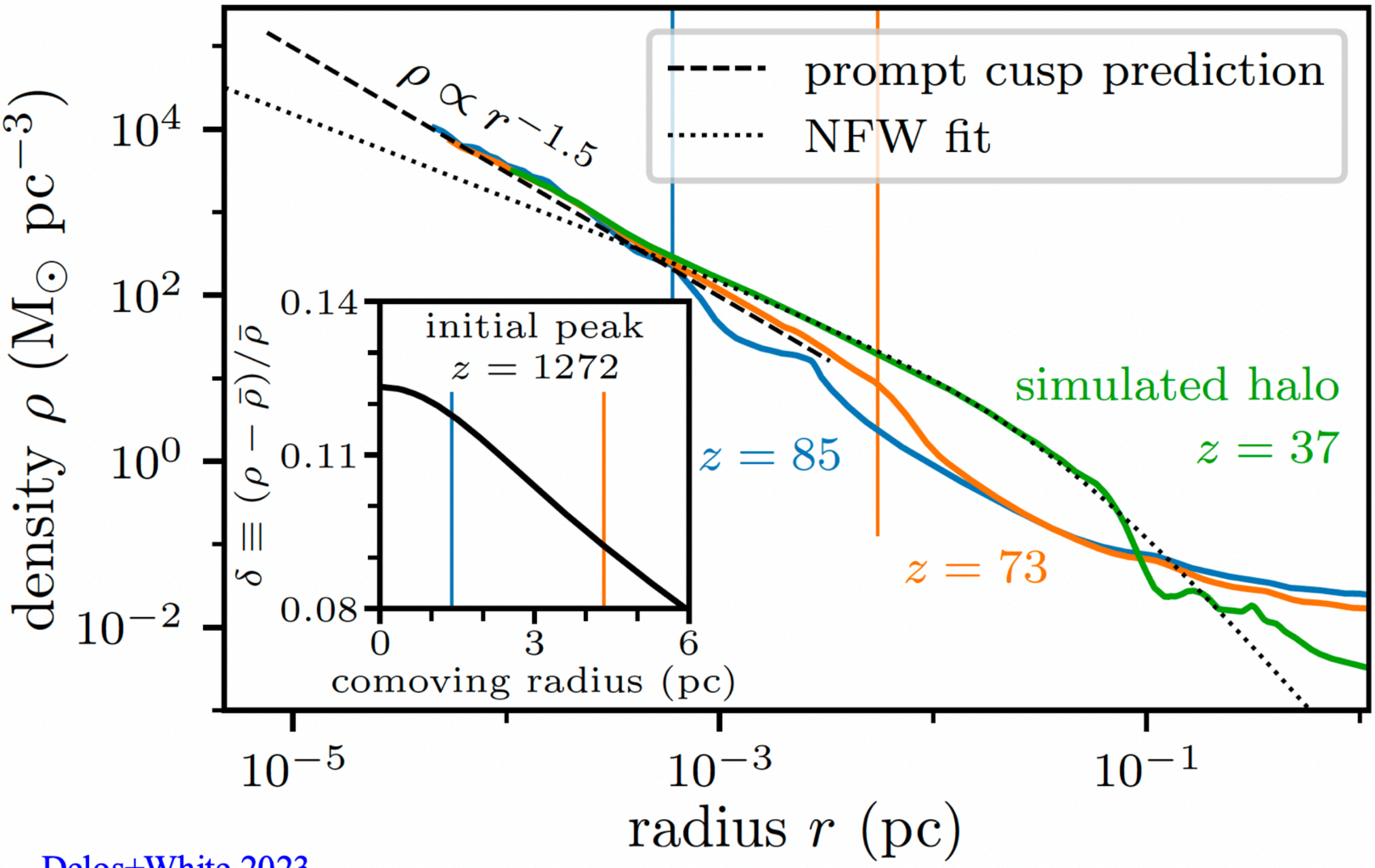
Over 19 orders of magnitude in halo mass and 4 orders of magnitude in density, the mean density profiles of halos are fit by NFW to within 20% and by Einasto (with α = 0.16) to within 7%

Wang, Bose et al 2020

$t/t_c = 0.58$



Prompt cusp and subsequent halo growth for a peak with $z_{coll} = 87$



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Prompt Cusps

- ...are relevant whenever P(k) is sharply truncated at high k
- ...form promptly as each initial density peak collapses
- ...have density profiles, $\rho(r) \approx 24\,\bar{\rho}\,(r / R)^{-1.5}$, where $\bar{\rho}$ is the mean cosmic DM density and $R = a_c(\delta / \nabla^2\delta)^{1/2}$ is the size of the linear overdensity peak (both measured at t_c, the time of peak collapse)
- ...have, by 1.2 t_c, mass, $M_{cusp} \sim 7\,R^3\,\bar{\rho}$, and size, $r_{cusp} \sim 0.1\,R$
- ...have an inner core radius set by phase-space constraints, thus dependent on the nature and cosmological origin of the DM
- ...suffer late-time tidal disruption only in star-dominated regions of galaxies (through encounters with individual stars)
- ...dominate the dark matter annihilation signal in all but the very densest regions of galaxies

Delos+White 2022

H1 $a = 0.73$ 0.61 0.51
H2 $a = 0.78$ 0.66 0.55
H3 $a = 0.56$ 0.47 0.39
W1 $a = 0.48$ 0.40 0.34
W2 $a = 0.49$ 0.41 0.34
W3 $a = 0.56$ 0.47 0.39
W4 $a = 0.48$ 0.40 0.34
W5 $a = 0.69$ 0.58 0.48
C1 $a = 0.57$ 0.48 0.40
C2 $a = 0.55$ 0.46 0.39
C3 $a = 0.57$ 0.48 0.40
C4 $a = 0.75$ 0.63 0.53

$\rho r^{3/2}$

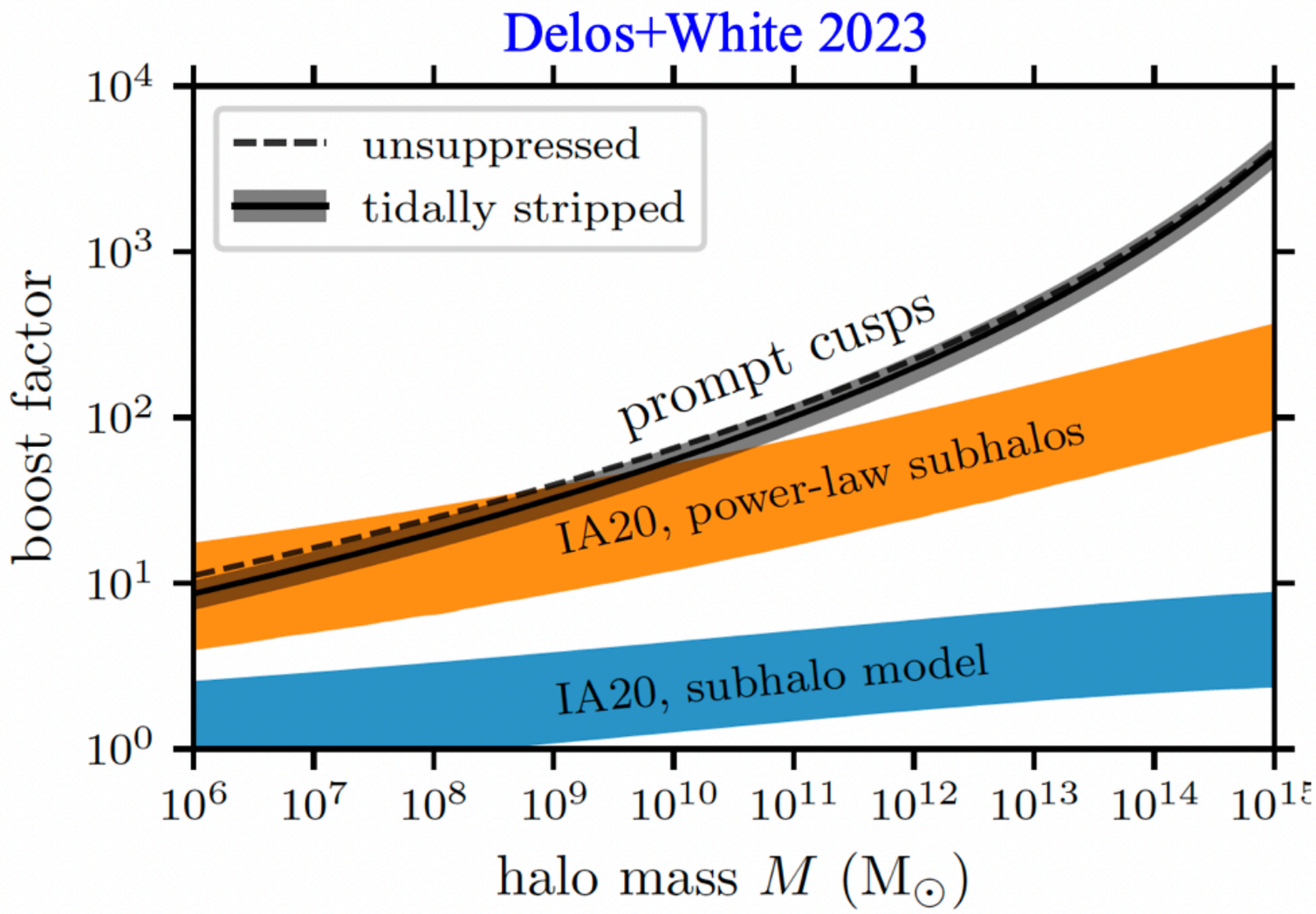
10^2

10^1

10^{-3} 10^{-2} 10^{-1}

r

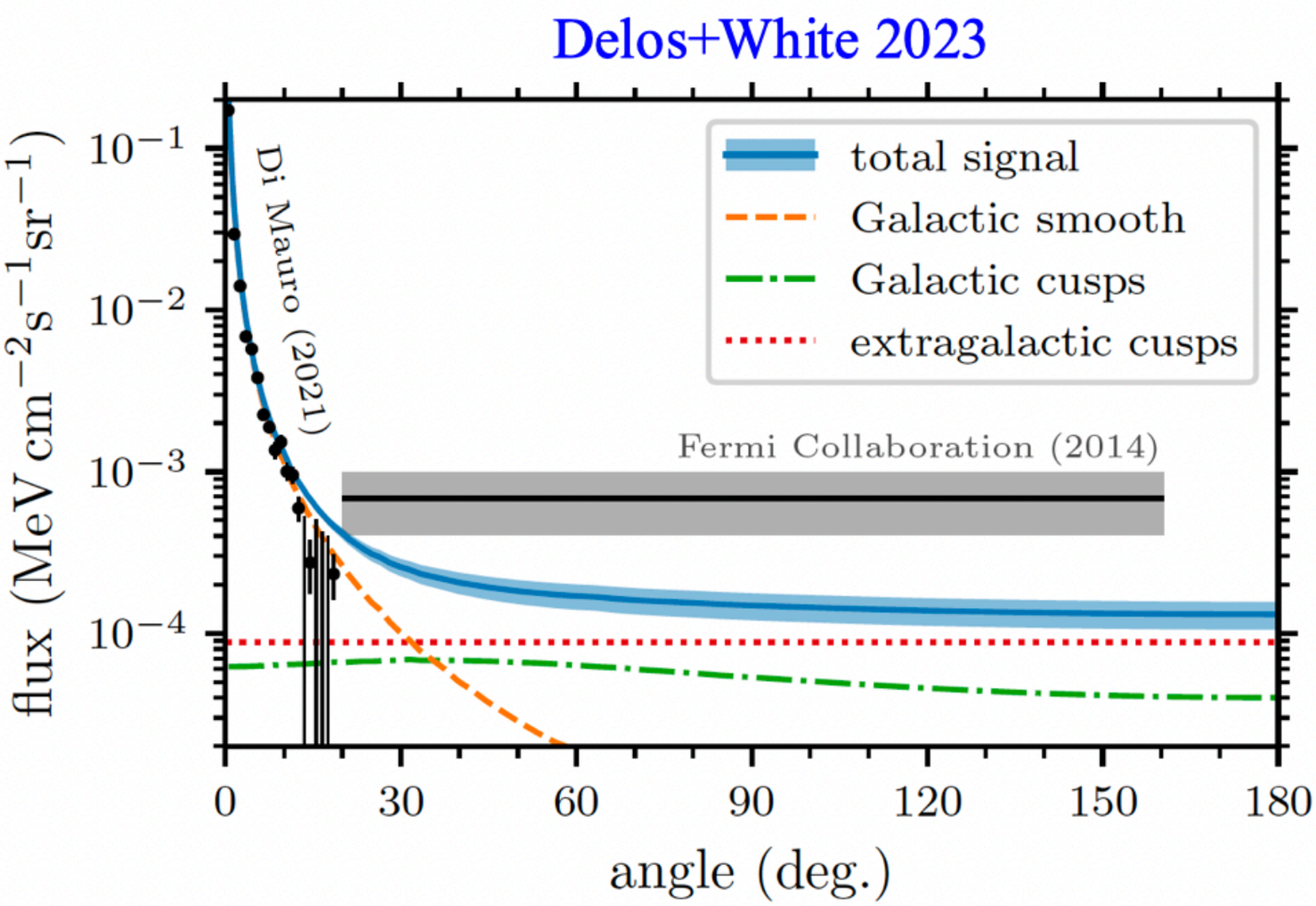
Annihilation radiation boosts in field halos...



Prompt cusps boost the emission from distant halos by factors ~20 (small dwarfs) ~200 (MW-like galaxies) and ~2000 (rich clusters)

These are much larger than recent estimates of the boost due to substructure made by extrapolating results of high-resolution halo simulations .

….and in the Milky Way



The profile due to cusps is much shallower than that due to the smoothly distributed dark matter

Cusp emission dominates at >20° from the Galactic Centre.

The mean surface brightness coming from the MW's halo is comparable to that from the halos of external galaxies

Prompt cusps do not affect the Fermi Galactic Centre Excess, but if this is due to annihilation then they contribute much of the 1 – 10 GeV background

Prompt cusps

- The formation mechanism and structure of prompt cusps differ from those of "normal" halos

- For a m = 100 GeV, Tkd = 30 GeV WIMP, prompt cusps have Earth mass and are a million times more abundant than Earth-mass planets in the Milky Way, accounting for a percent or two of all dark matter

- In the Milky Way they are significantly disrupted both by tides and (particularly) by stellar encounters within ~20 kpc

- They have no observable dynamical or gravitational lensing effects

- They dominate the dark matter annihilation signal from the outer halo of the Milky Way and from all extragalactic objects, leading to a local luminosity density that is proportional to $\bar{\rho}_{dm}$ rather than $\bar{\rho}_{dm}^{2}$