CONSTRAINING THE NATURE OF DARK MATTER WITH SUBSTRUCTURE LENSING: PREDICTIONS FROM THEORY AND SIMULATIONS

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MPA - Garching

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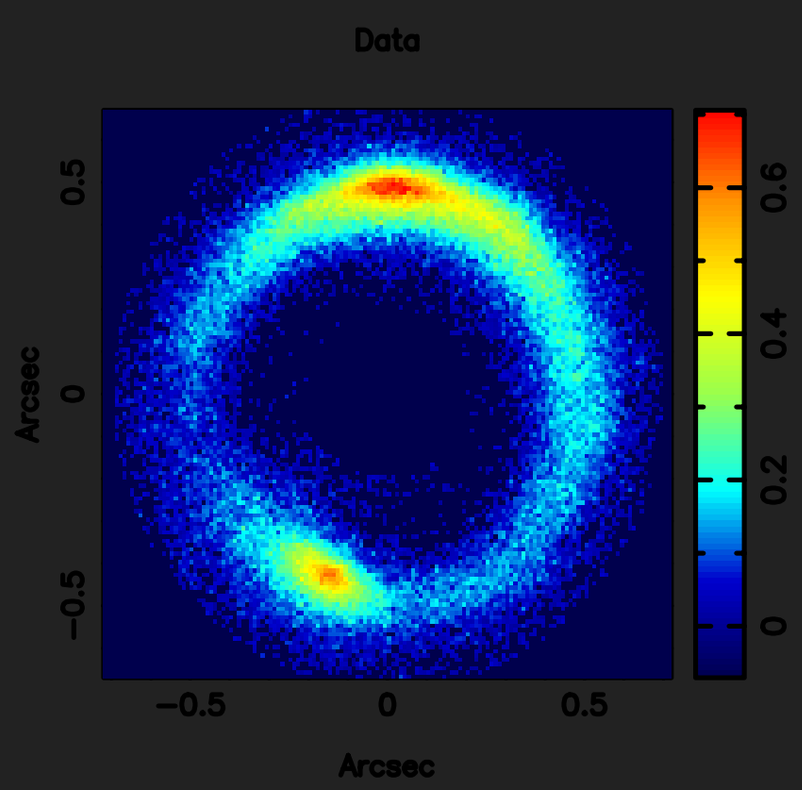

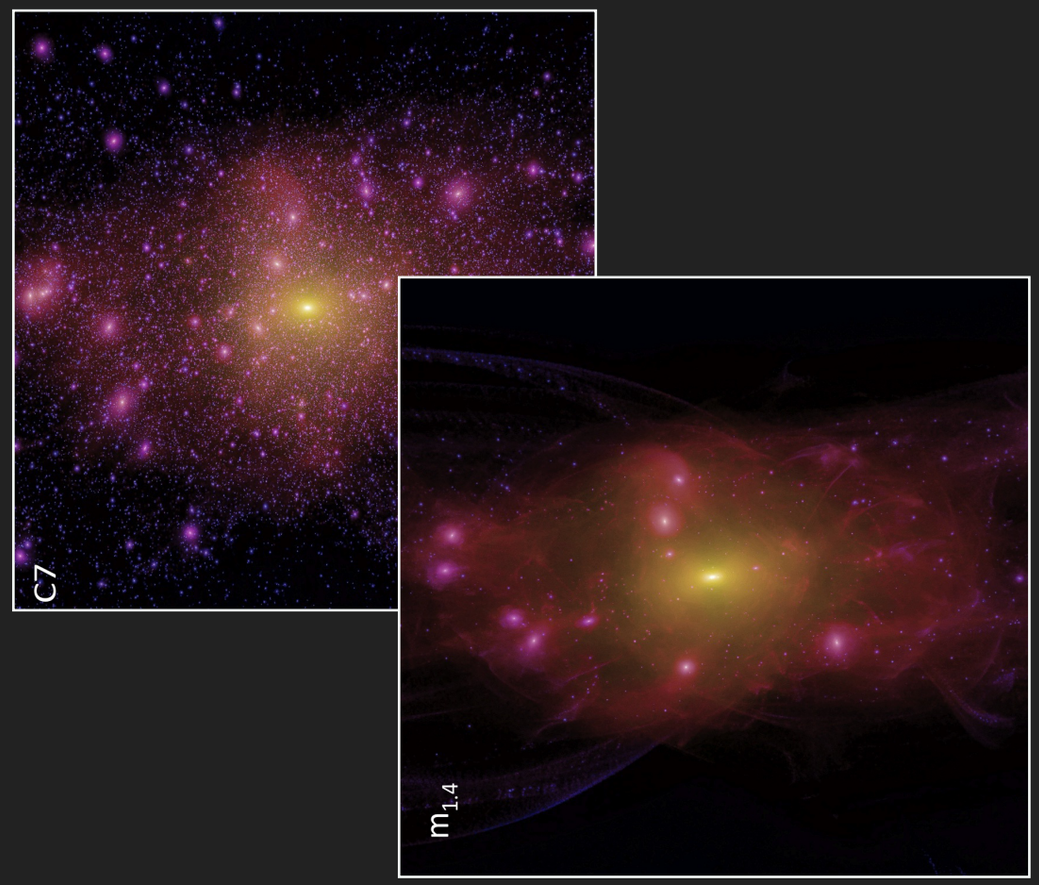

Miramare 02.07.2018

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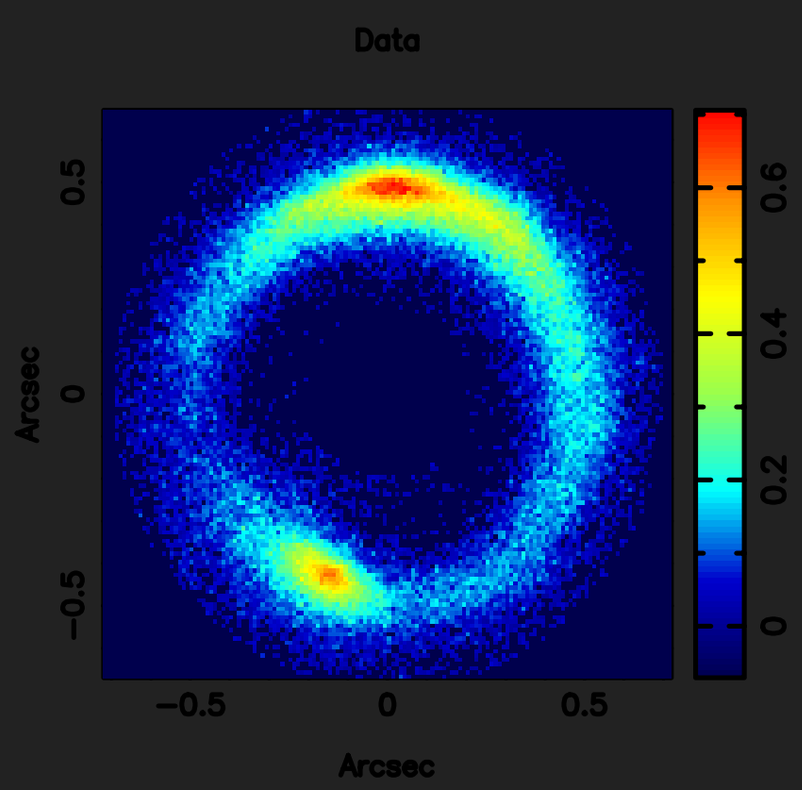

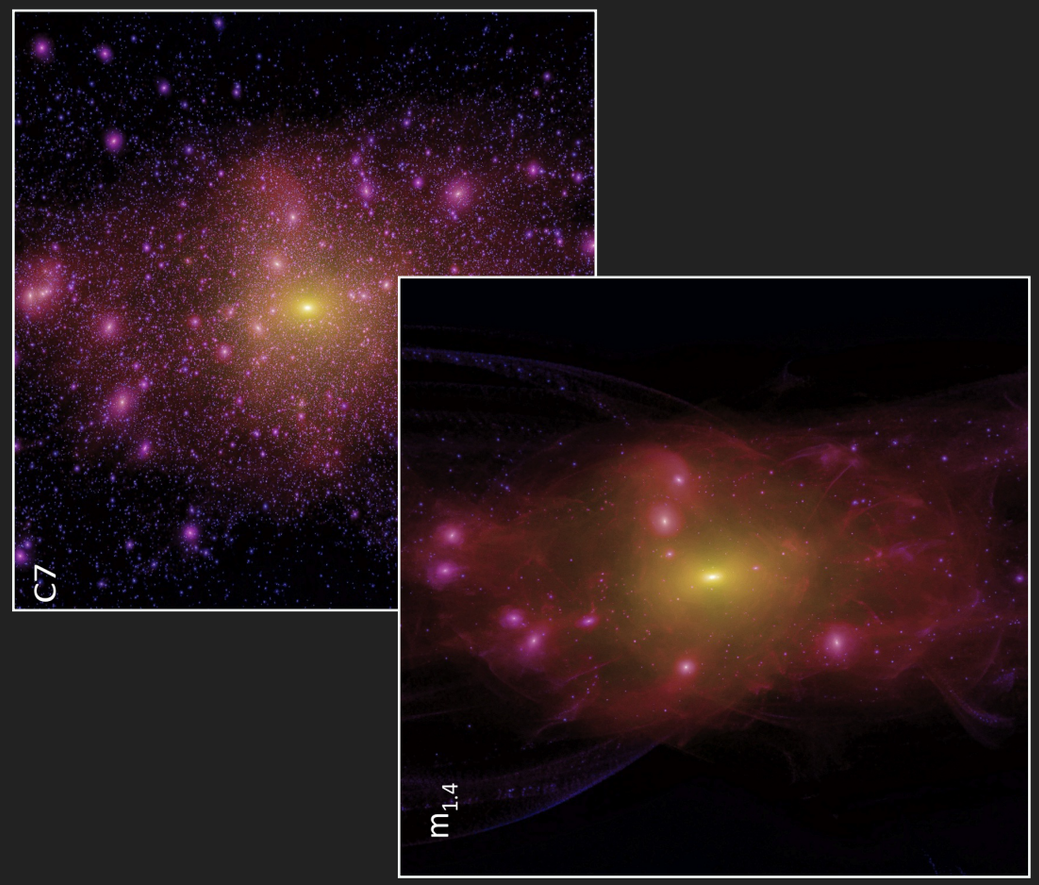

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PREDICTIONS & NUMERICAL SIMULATIONS

LINE-OF-SIGHT CONTRIBUTION

(Despali et al. 2018)

- how many LOS haloes we expect vs substructures in the main lens
- predictions for CDM vs WDM

...see Elisa's talk!

SIDM

(Despali, Sparre, Vogelsberger, Zavala, Vegetti et al in prep.)

- impact of SIDM on the main halo properties
- different distribution of Einstein rings?
- subhalo counts and profiles

STERILE NEUTRINOS

(Despali, Lovell, Vegetti et al. in prep.)

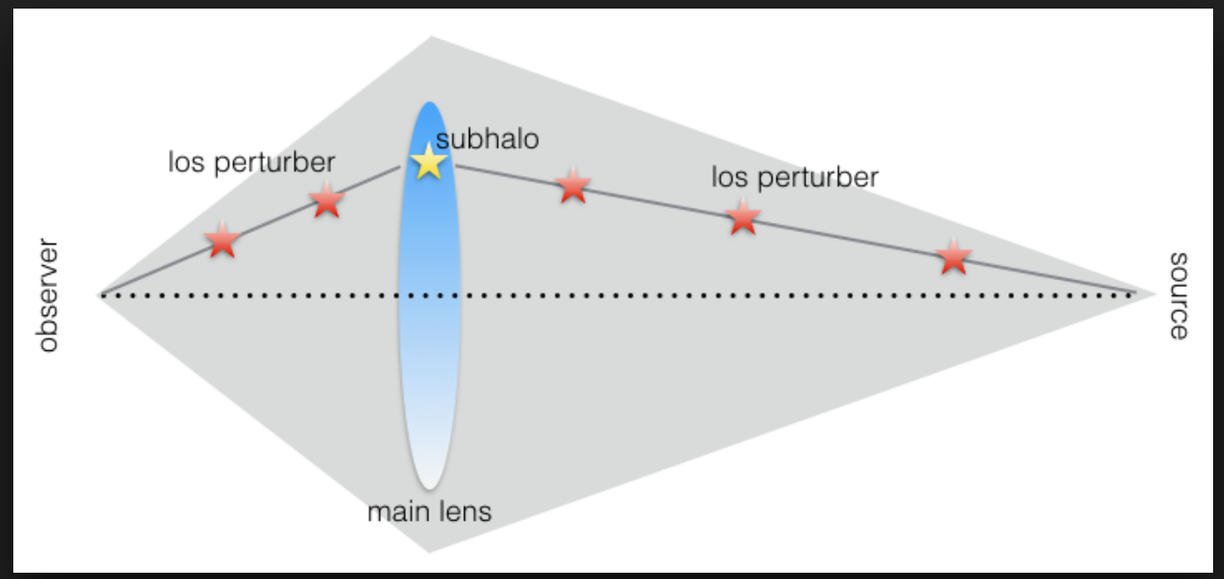
- subhalo counts from sterile neutrino WDM zoom simulations
- subhalo profiles, distribution and lensing power spectrum

LINE-OF-SIGHT CONTRIBUTION

(Despali et al. 2018)

lensing is sensitive to the whole mass distribution between the observer and the source

$$N_{LOS} = \int_0^{z_S} \int_{M_{LOW}(z)}^{M_{max}} n(m,z) dm \frac{dV}{dz} dz$$



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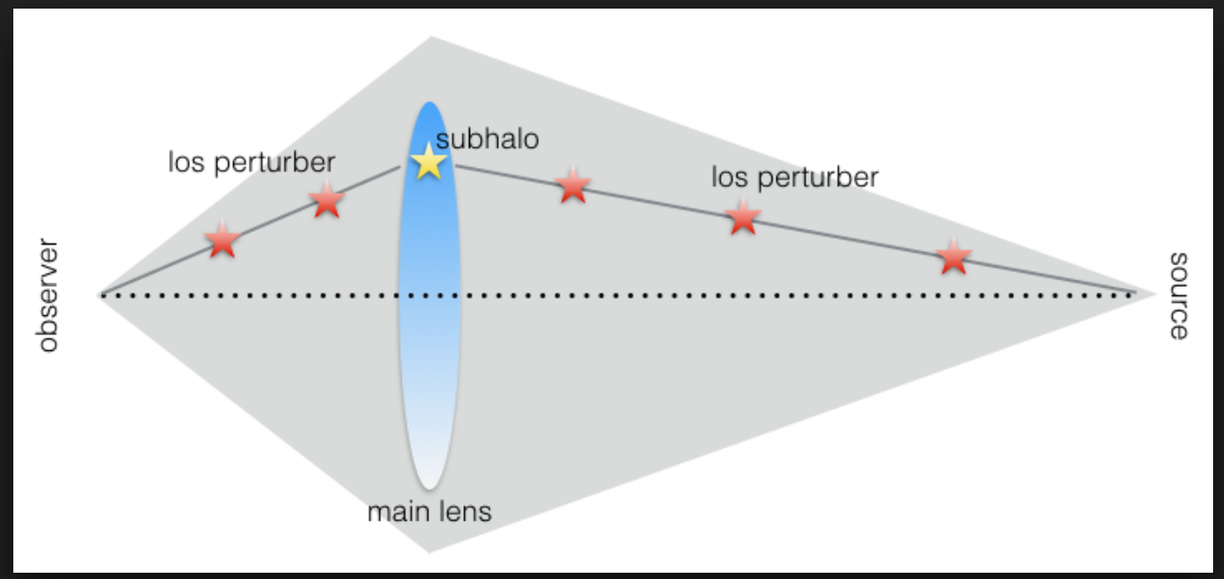
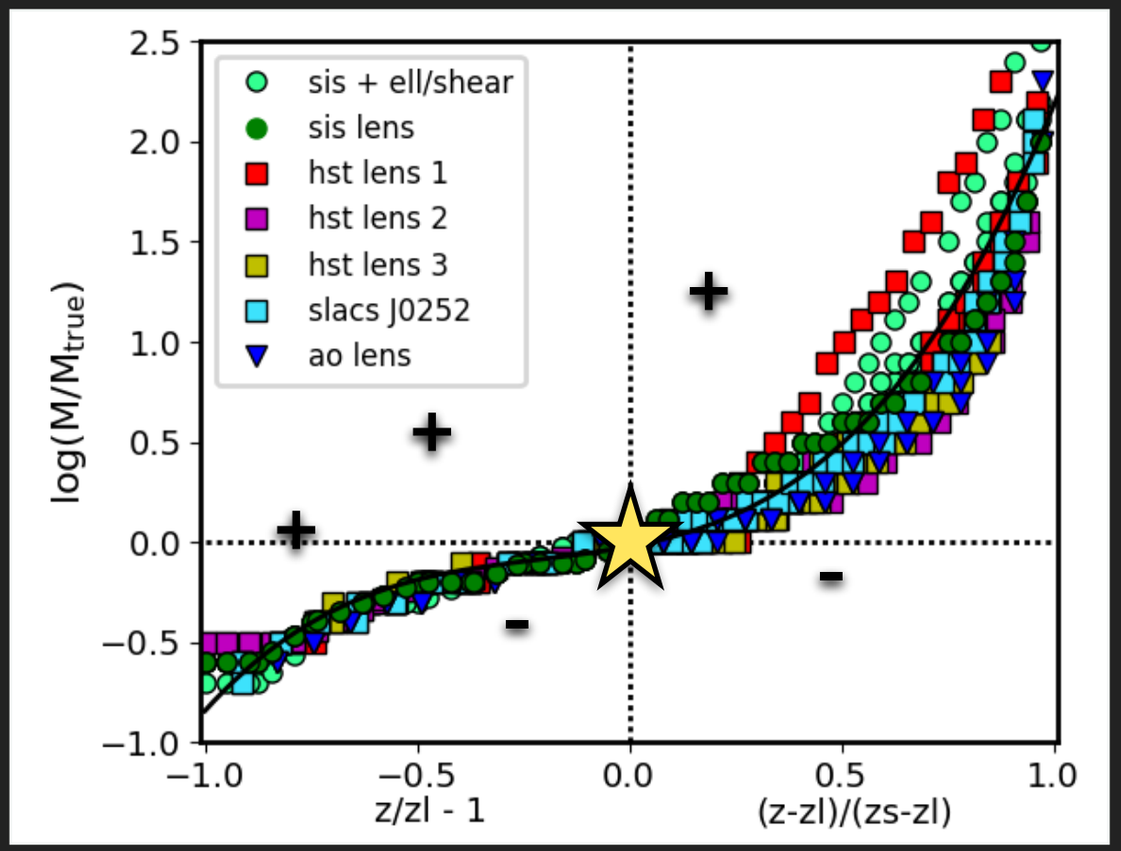


"EQUIVALENT LINE-OF-SIGHT"



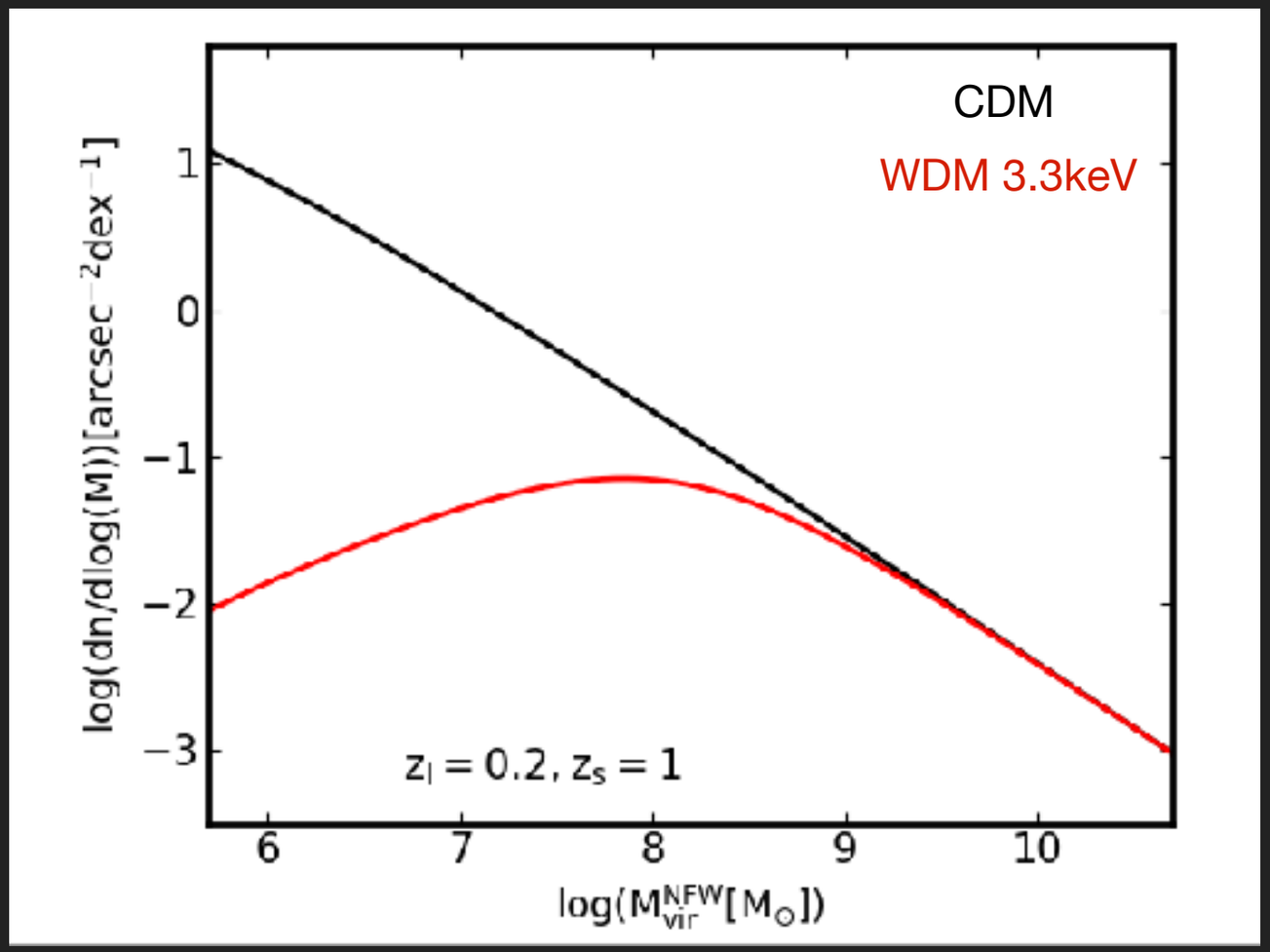
> used to rescale the sensitivity function at $z \neq z_L$

$$\log M_{vir}(z) = (0.41x + 0.57x^2 + 0.9x^3)$$

LINE-OF-SIGHT CONTRIBUTION

(Despali et al. 2018)

$$\frac{n_{WDM}}{n_{CDM}} = (1 + \gamma M_{hm} M^{-1})^{\beta}$$



LINE-OF-SIGHT CONTRIBUTION

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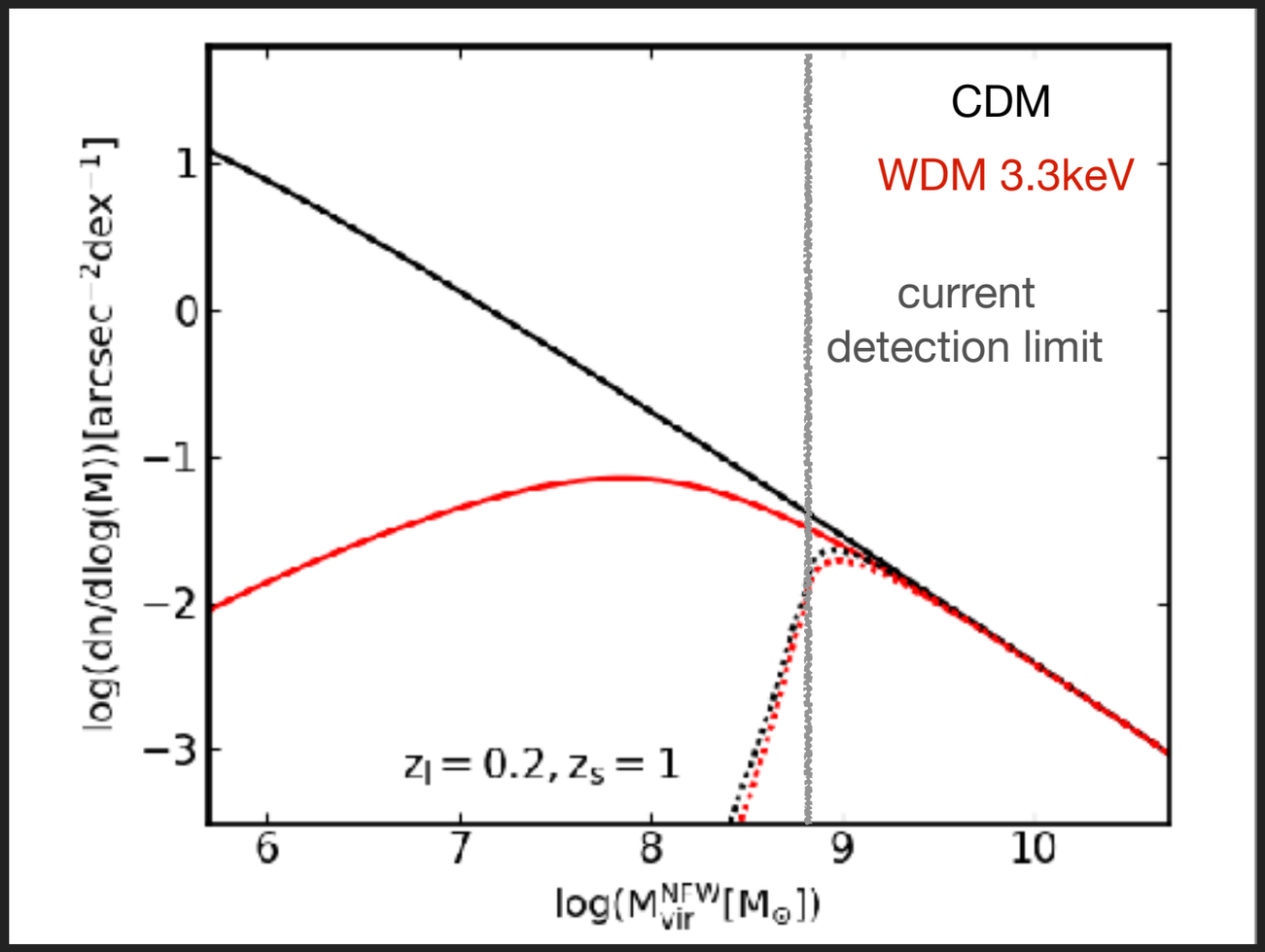

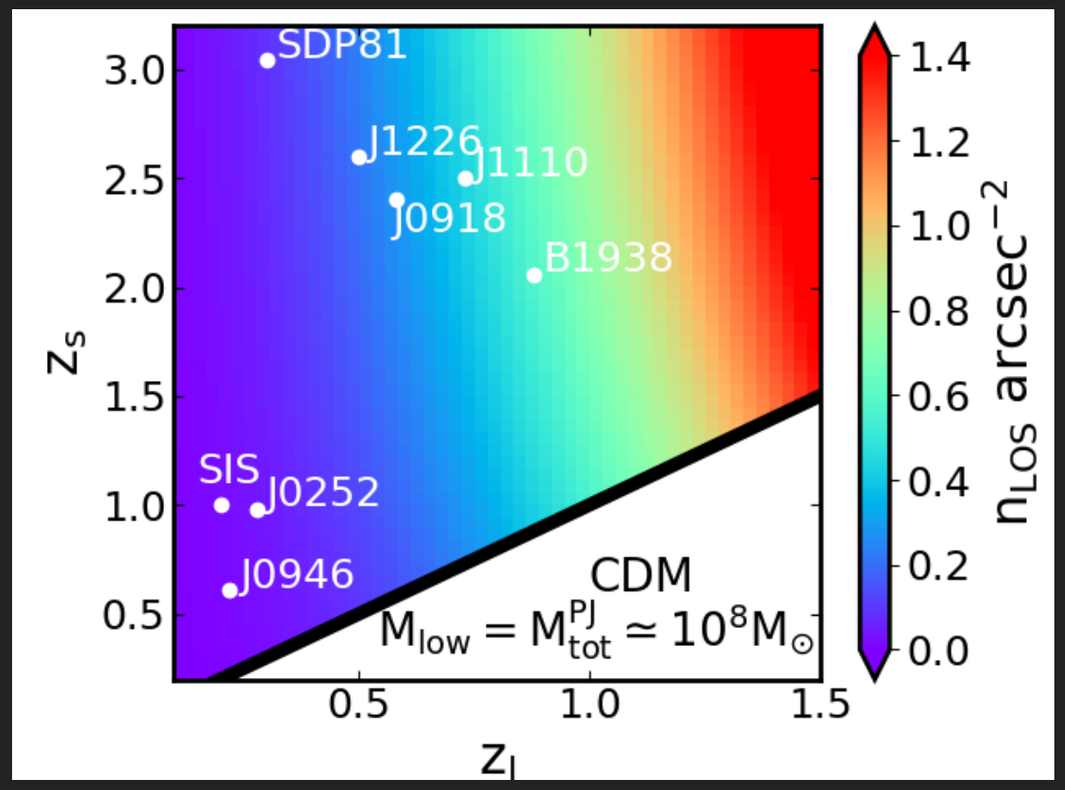

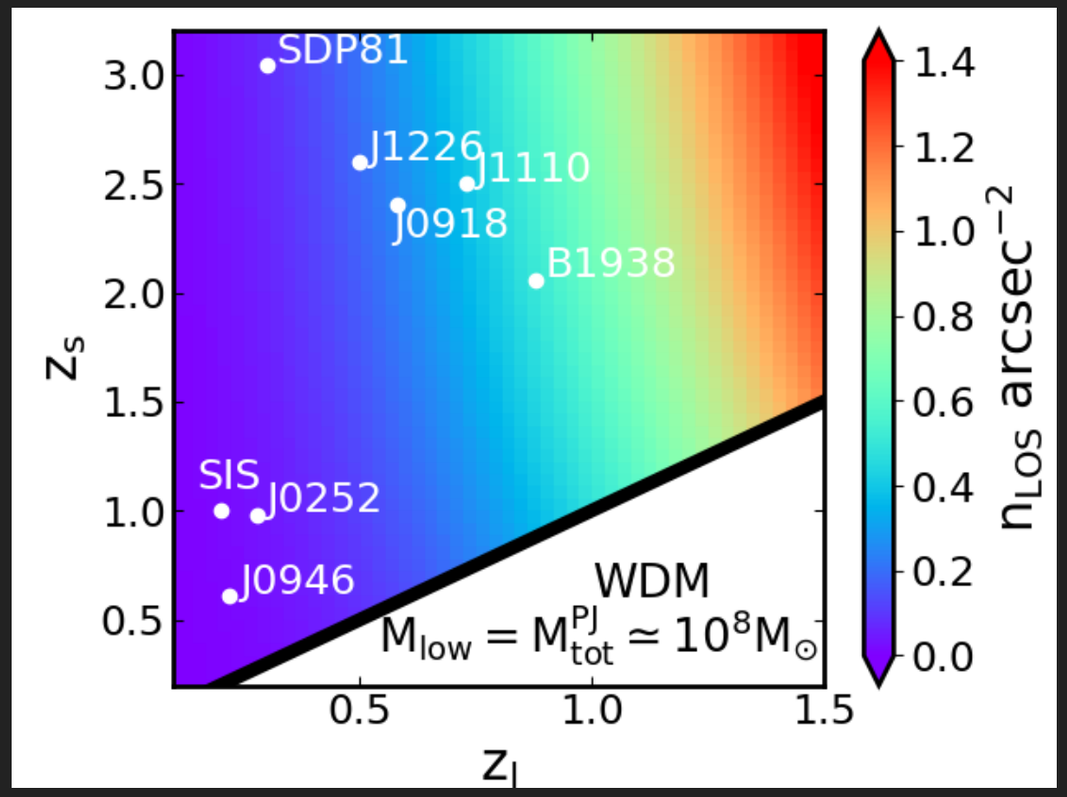

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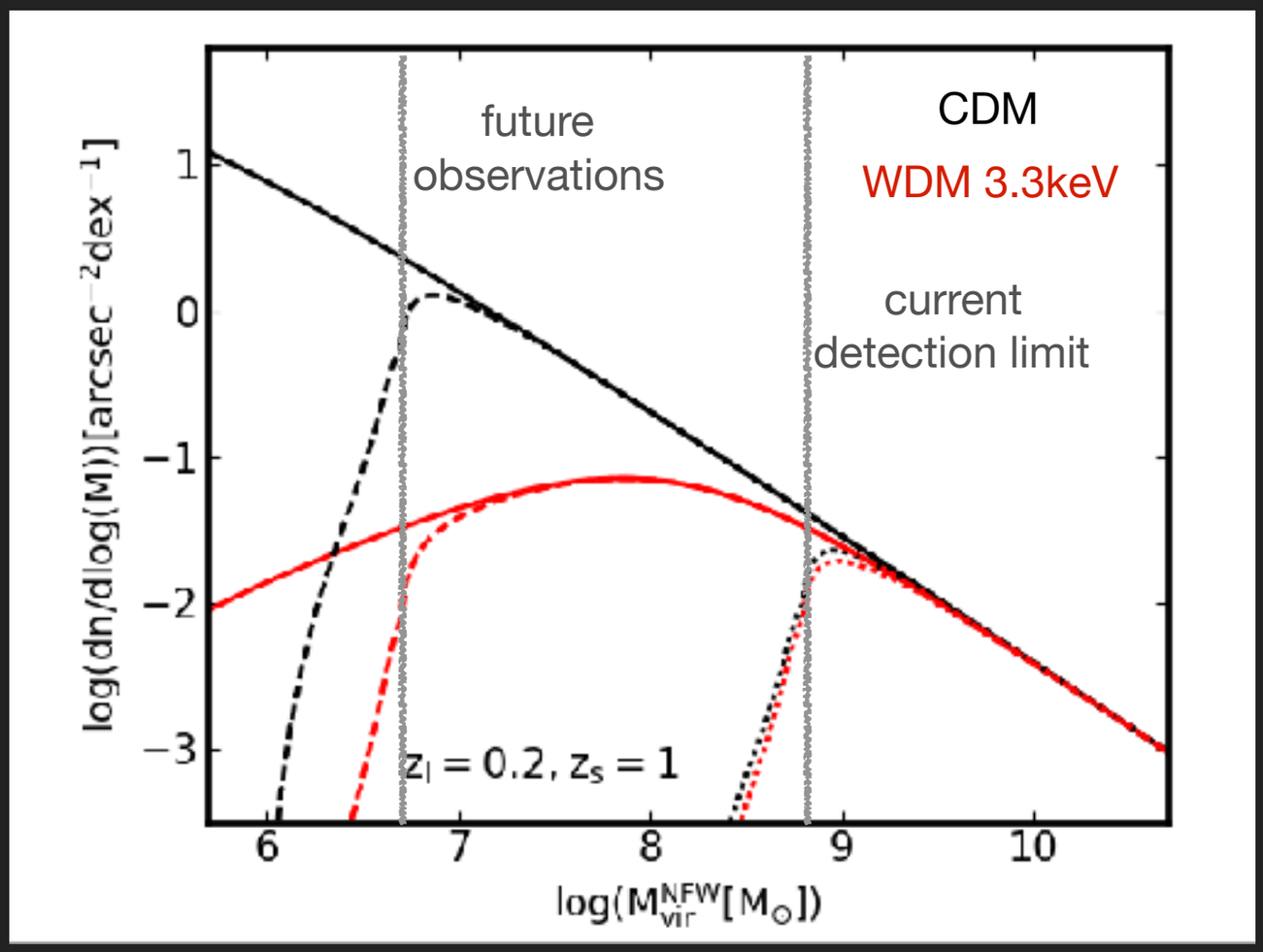

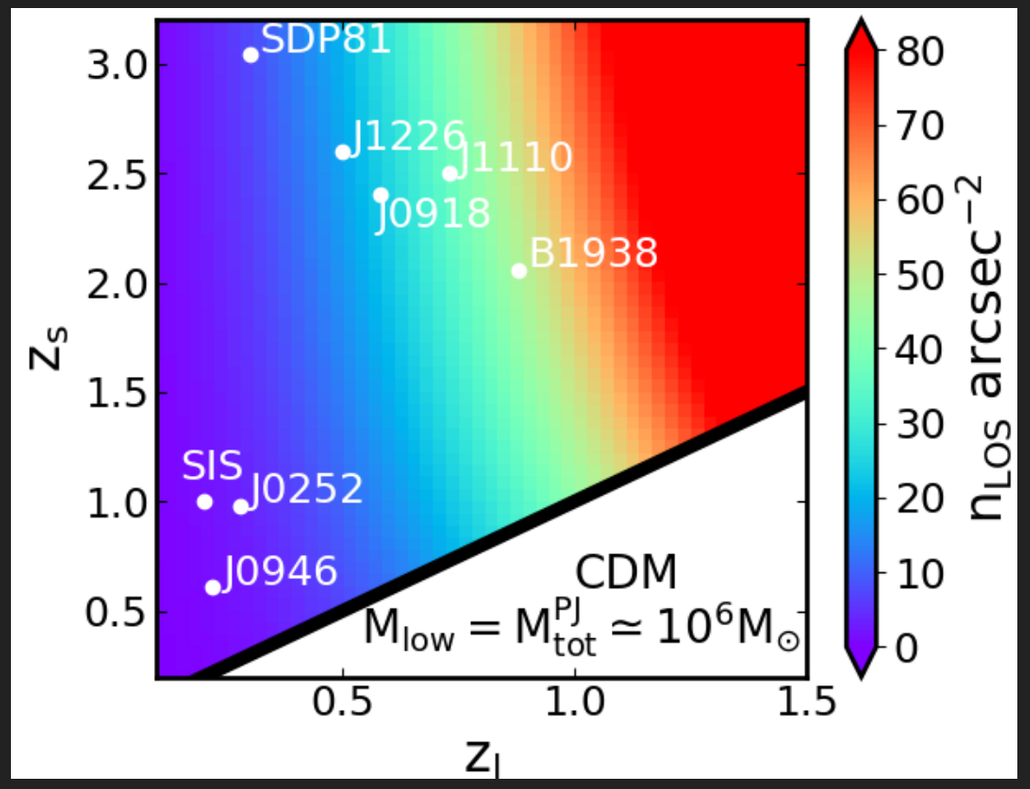

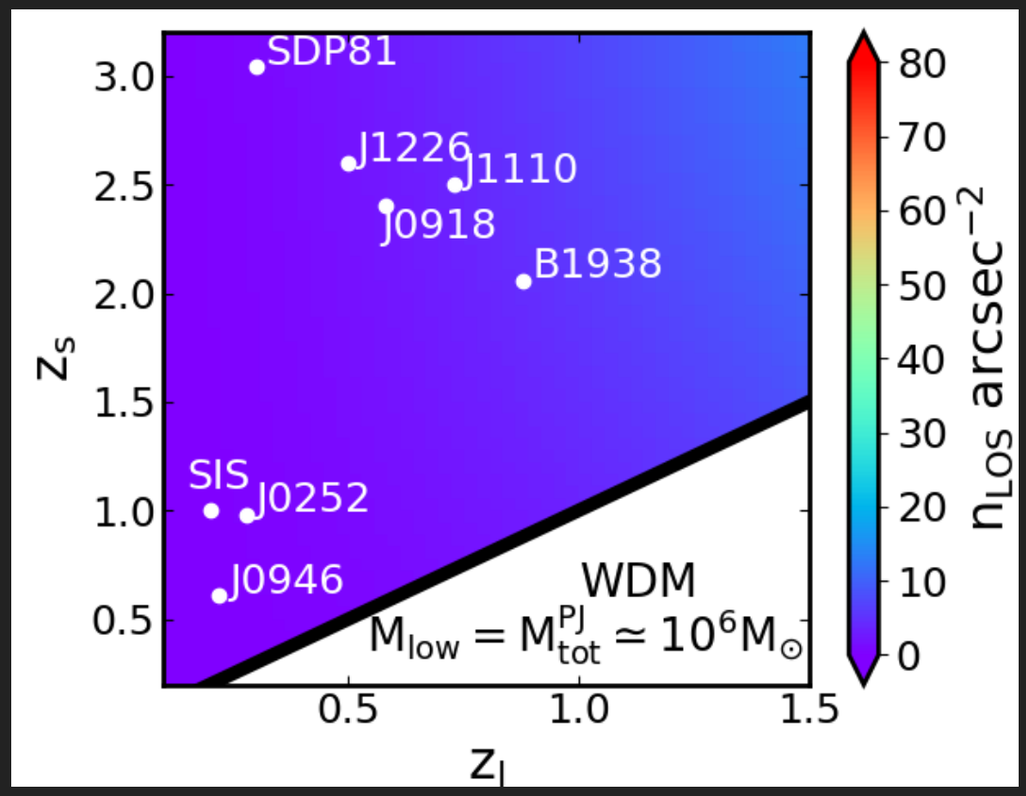

LINE-OF-SIGHT CONTRIBUTION

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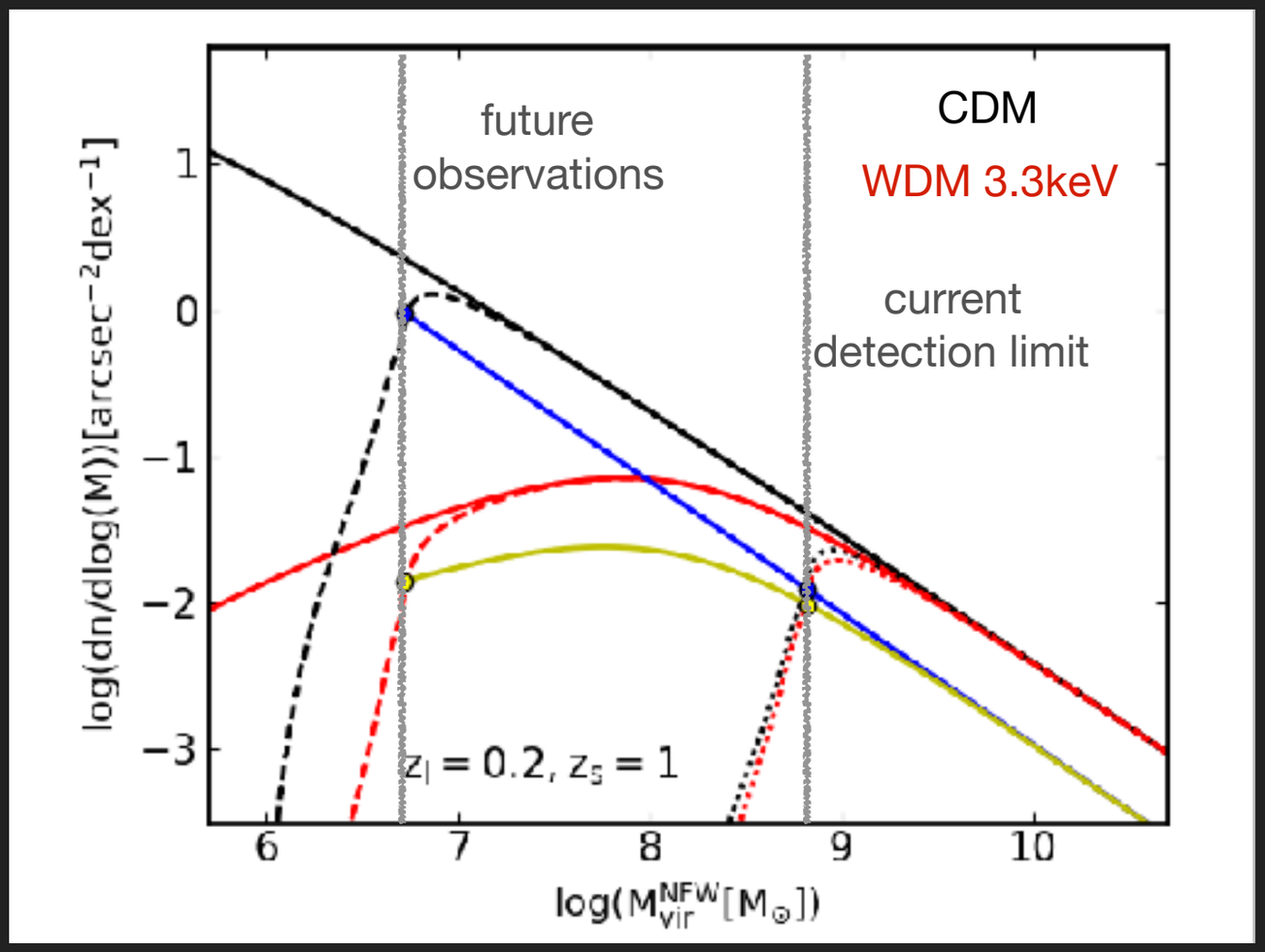
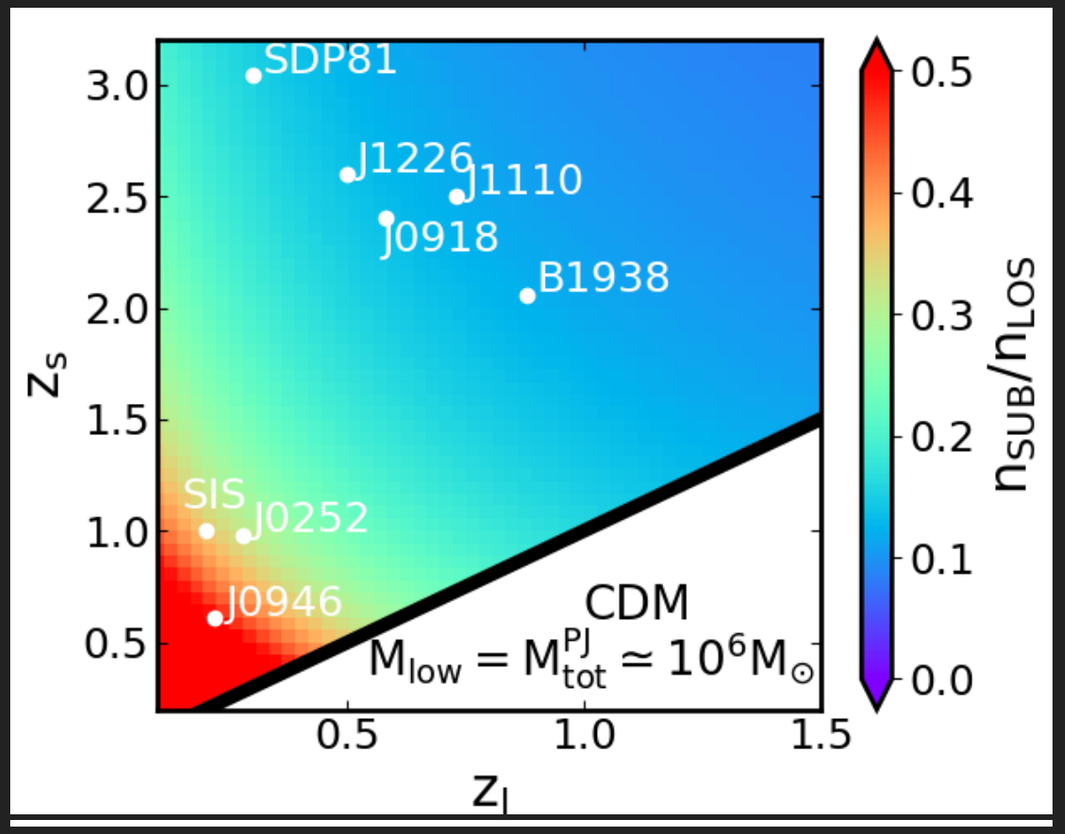


ratio subhaloes/line-of-sight



> the line-of-sight population dominates

PREDICTIONS & NUMERICAL SIMULATIONS

SUMMARY

LINE-OF-SIGHT CONTRIBUTION

- the LOS population **dominates** and provides **cleaner constrains**
- with better sensitivities we'll be able to discriminate CDM/WDM
- we need to be careful with mass definitions

SIDM

STERILE NEUTRINOS

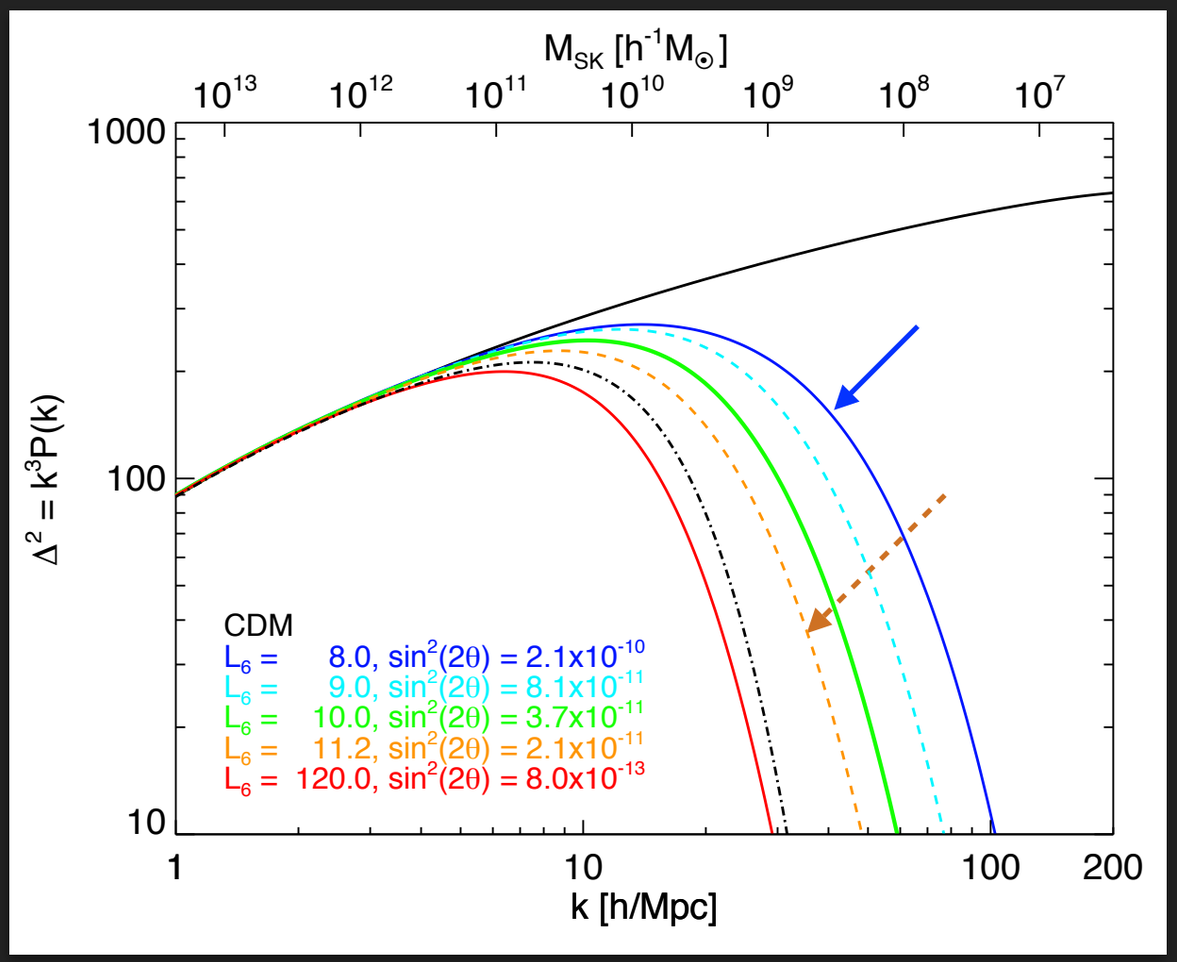
STERILE NEUTRINO DM

(Despali, Lovell et al. in prep.)

- 4 ETG-analogues selected from the Eagle simulation

$2 \times 10^{13}\ M_\odot$
$1 \times 6\ 10^{12}\ M_\odot$
$1 \times 4\ 10^{12}\ M_\odot$

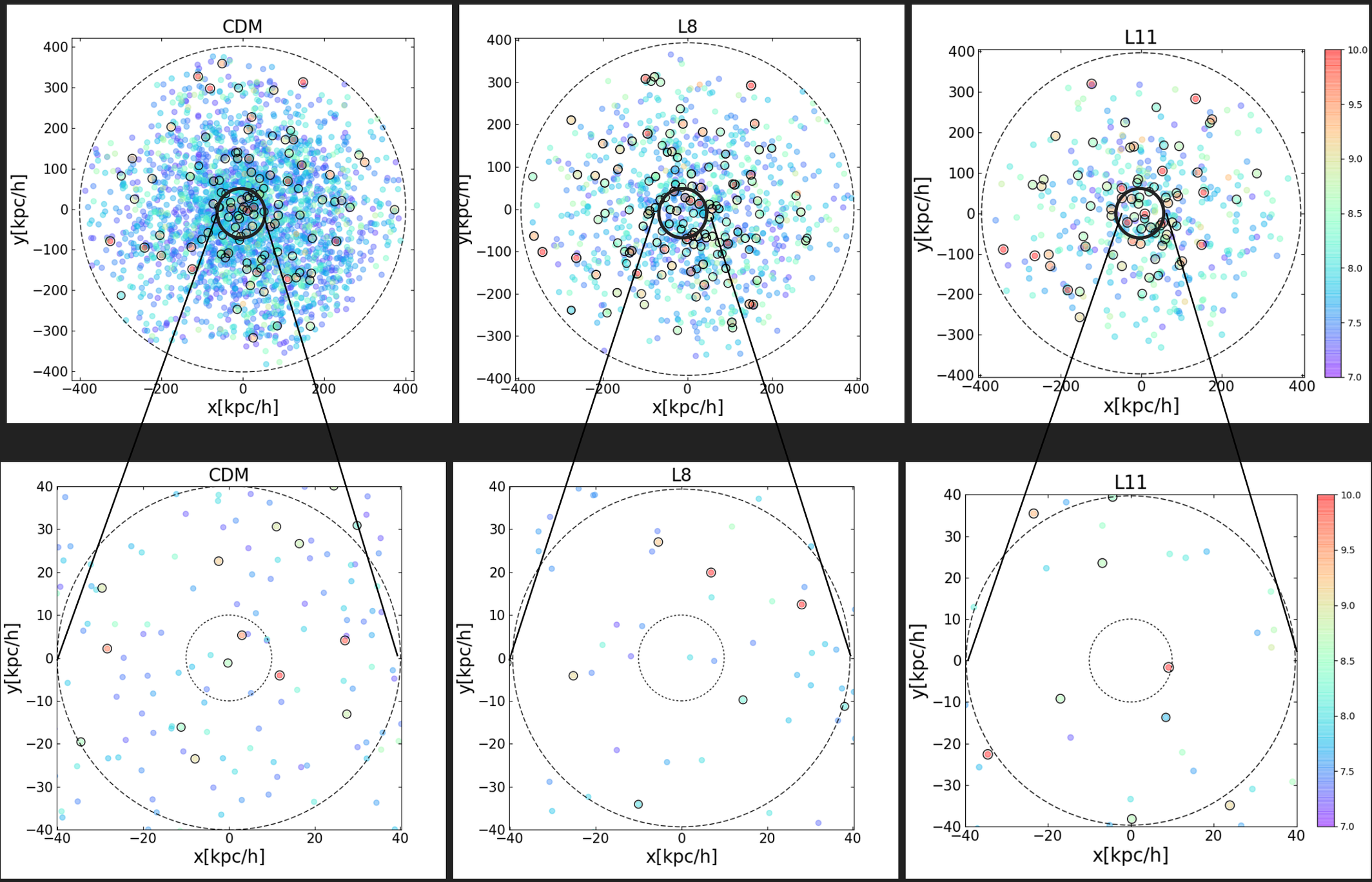
- re-simulated with 2 models of **7.1 keV sterile neutrino**: $L_6 = 8, 11.2$
- DMO and **hydro versions**



STERILE NEUTRINO DM

(Despali, Lovell et al. in prep.)

- same number of “luminous” satellites - as in Lovell+16
- difference in the “dark” population



STERILE NEUTRINO DM

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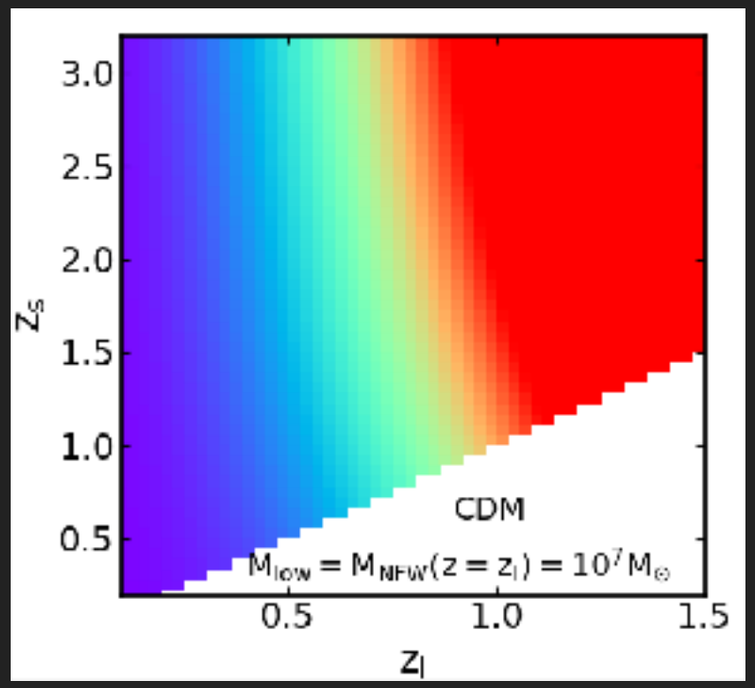

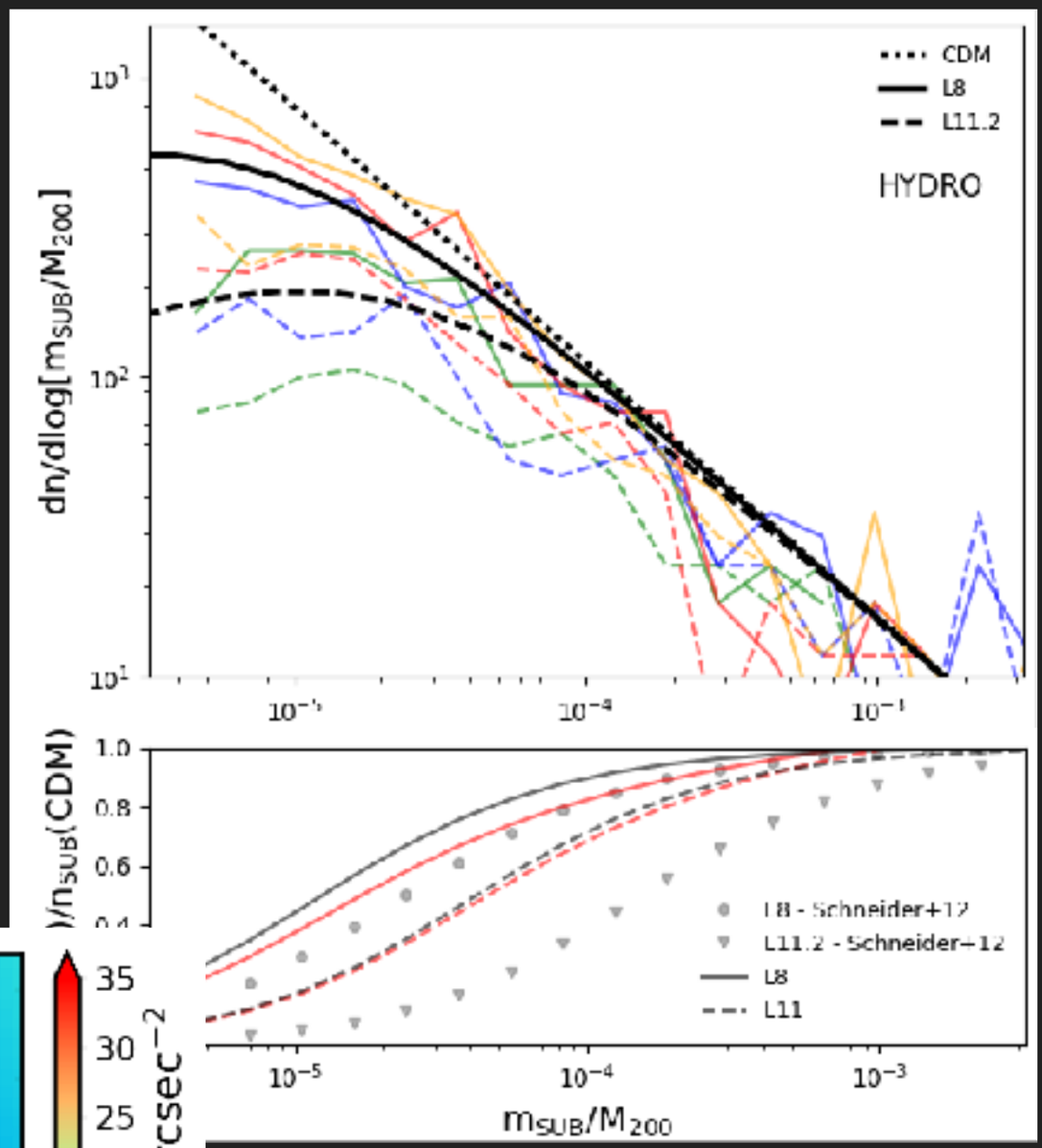

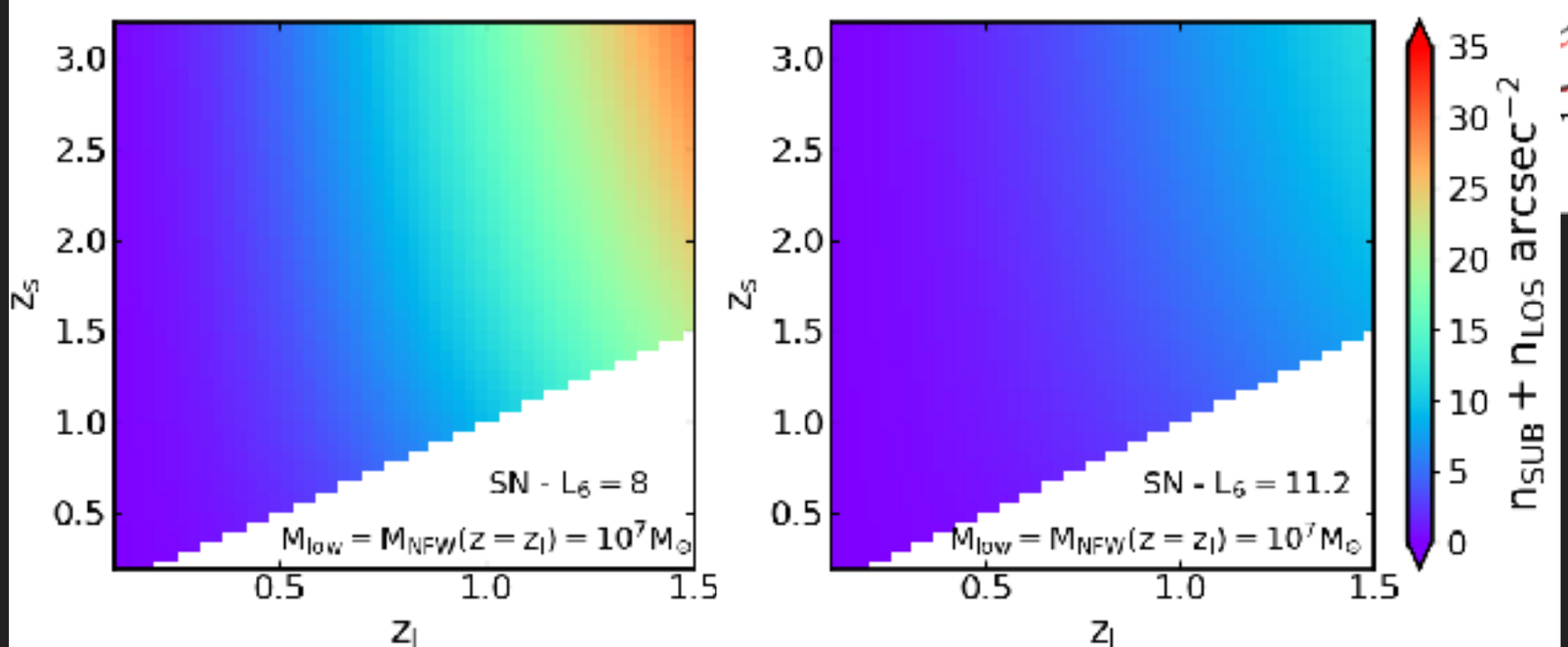

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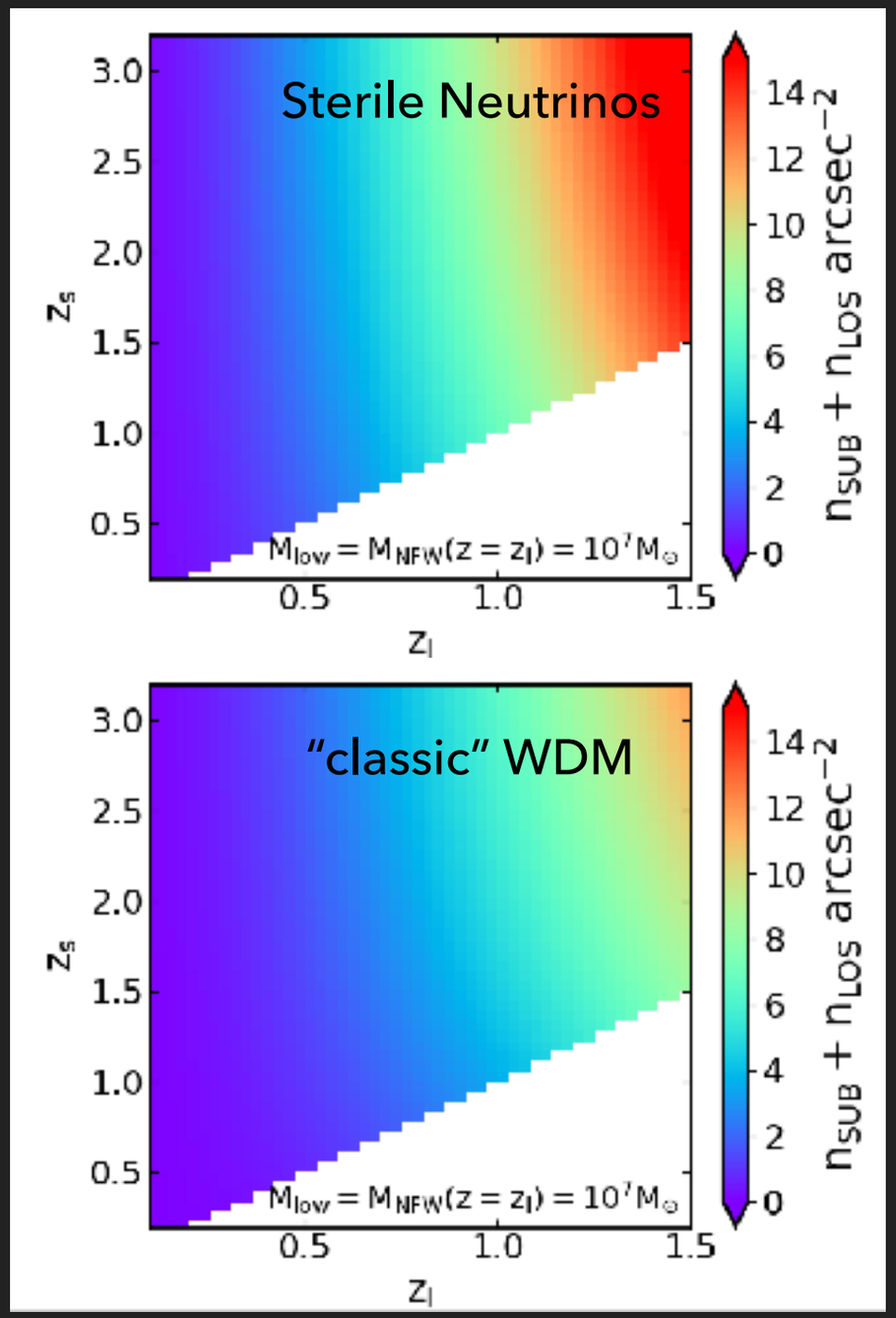

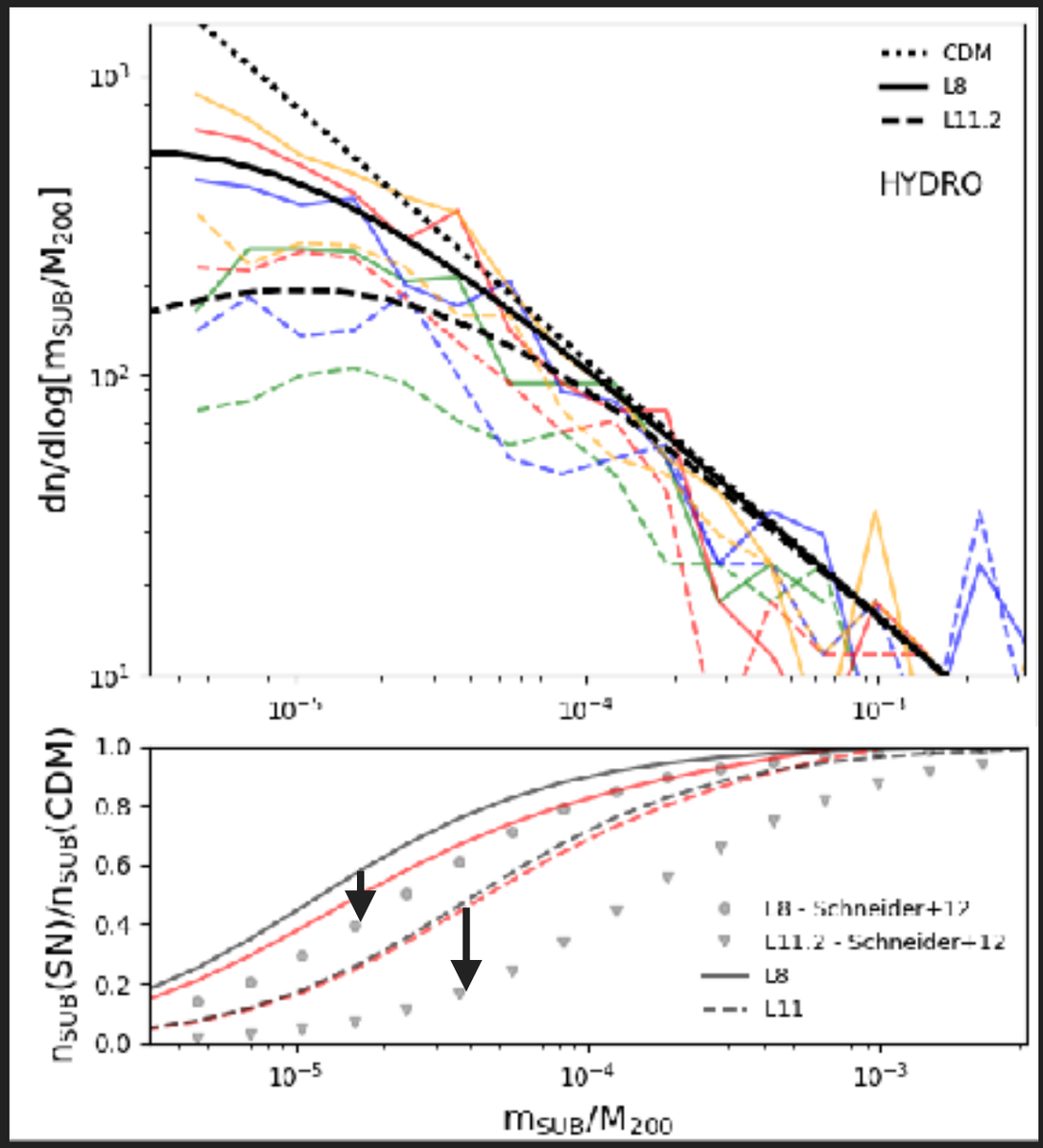

> colder than the equivalent thermal relic WDM model

$$\frac{n_{WDM}}{n_{CDM}} = (1 + \gamma M_{hm} M^{-1})^{\beta}$$

PREDICTIONS & NUMERICAL SIMULATIONS

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- the LOS population **dominates** and provides **cleaner constrains**
- with better sensitivities we'll be able to discriminate CDM/WDM
- we need to be careful with mass definitions

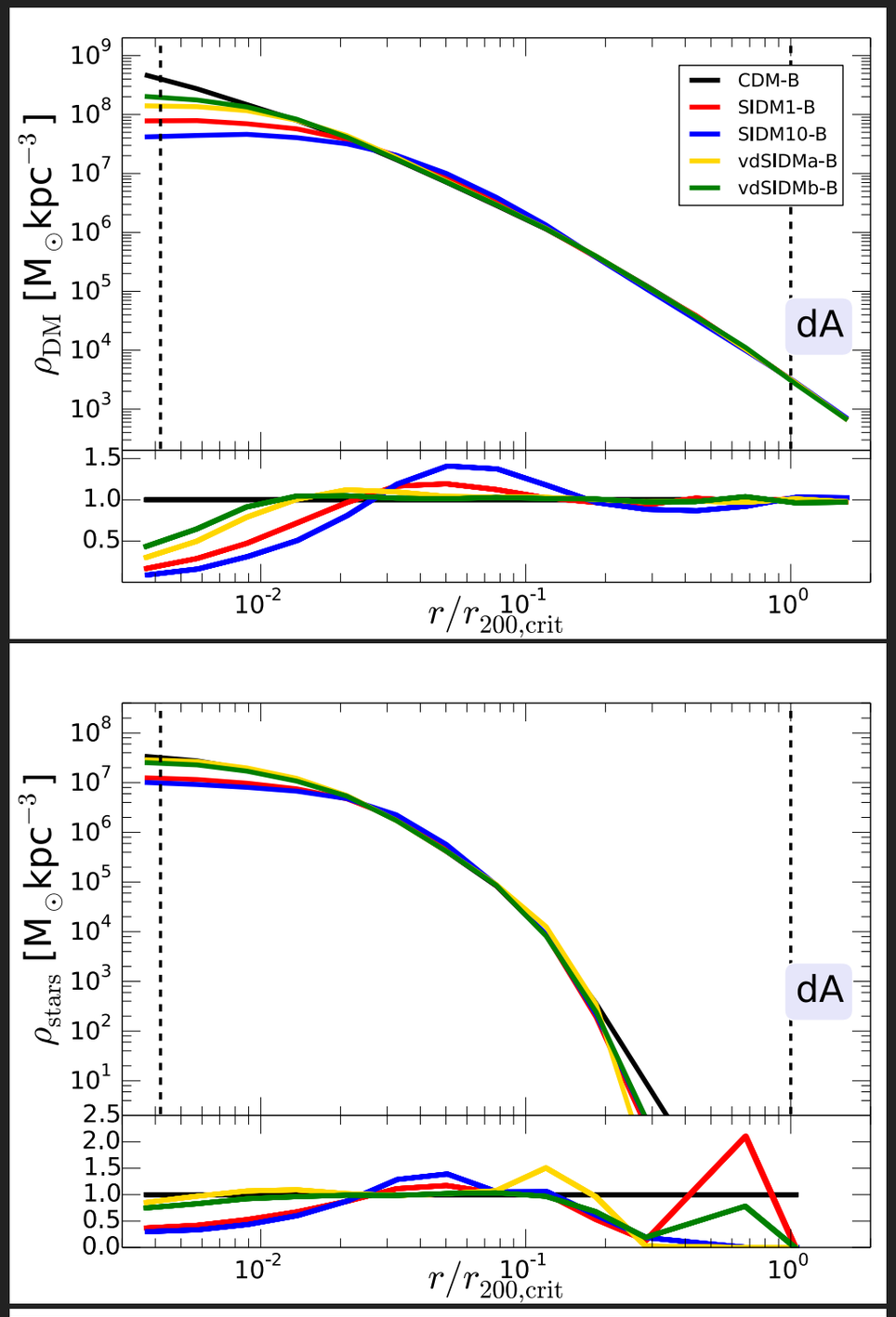
SIDM

STERILE NEUTRINOS

- the properties of the main lens remain similar
- slightly colder than the equivalent thermal relic models
- fewer subhaloes

SELF-INTERACTING DM

(Despali et al. in prep.)



- 10 ETG-analogues selected from the Illustris simulation
- resimulated with SIDM + baryons

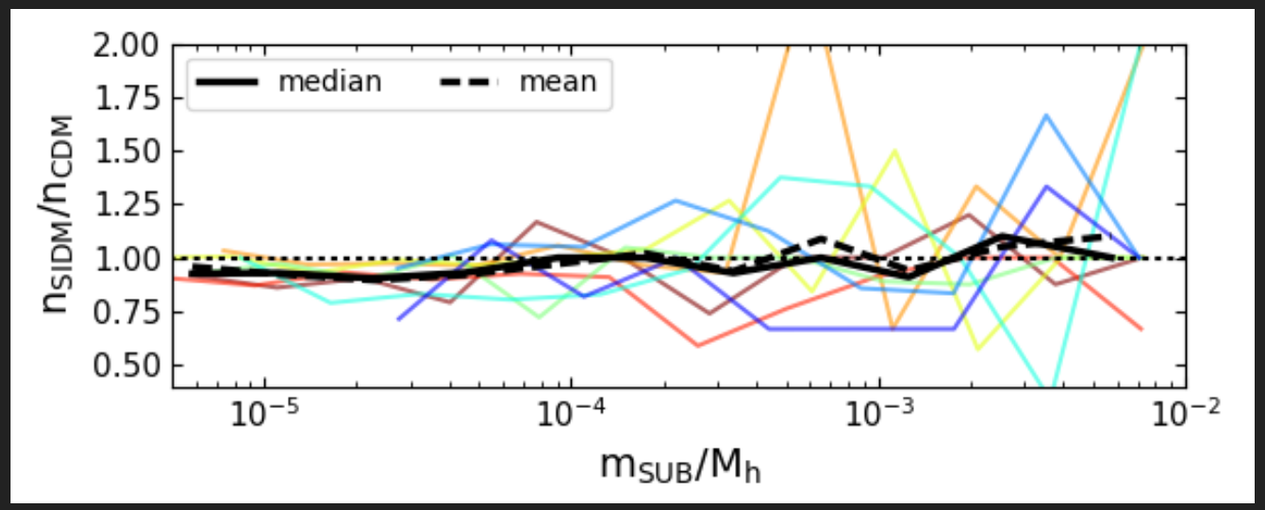
Name	$\sigma_T^{\rm max}/m_\chi$ [cm^2 g^{-1}]	v_{max} [km s^{-1}]
CDM	–	–
SIDM1	1	–
SIDM10	10	–
vdSIDMa	3.5	30
vdSIDMb	35	10

Vogelsberger et al. 2014

SELF-INTERACTING DM

(Despali et al. in prep.)

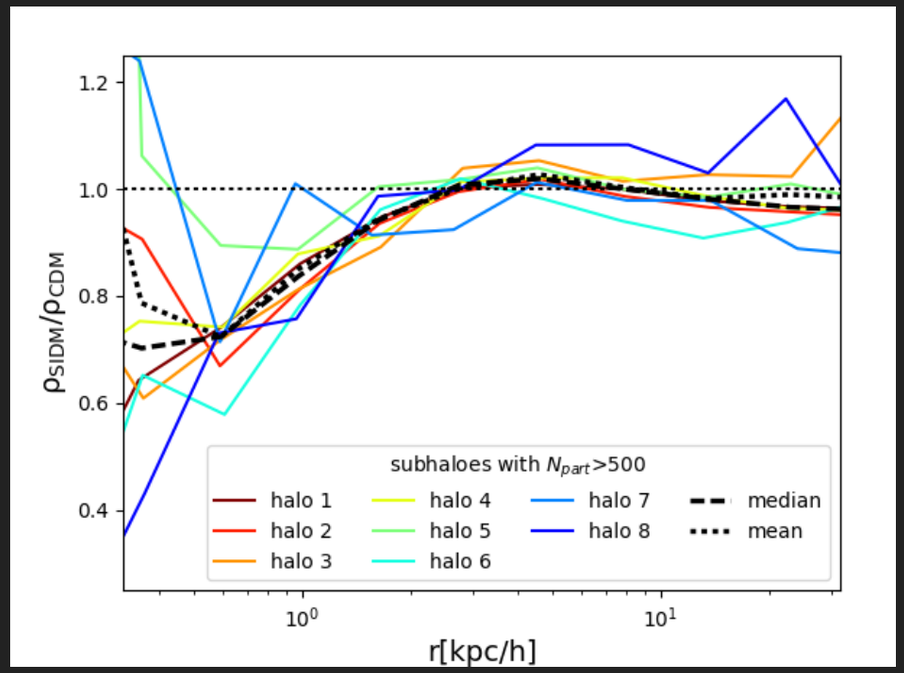
> similar subhalo population



> subhaloes have on average more cored profiles

↓

might be degenerate
with WDM abundances



SELF-INTERACTING DM

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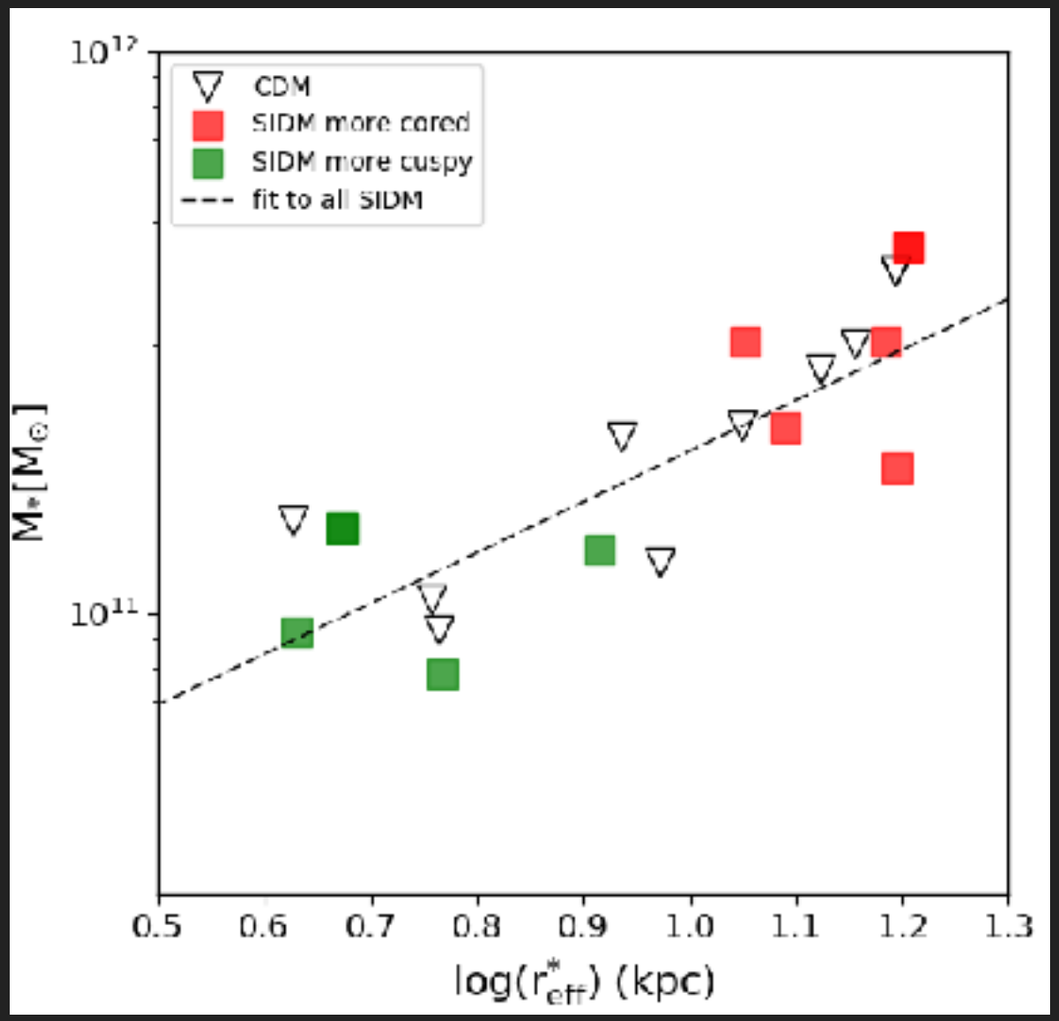
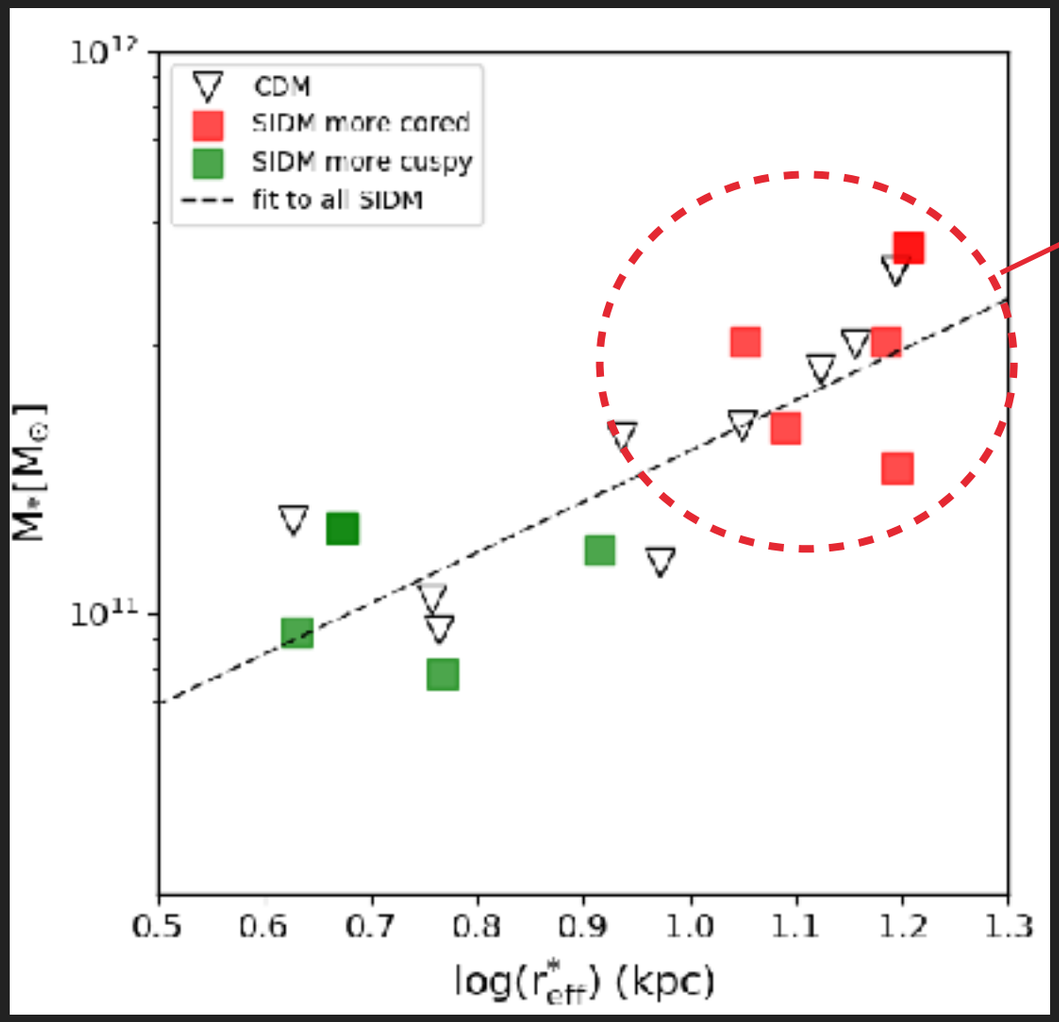
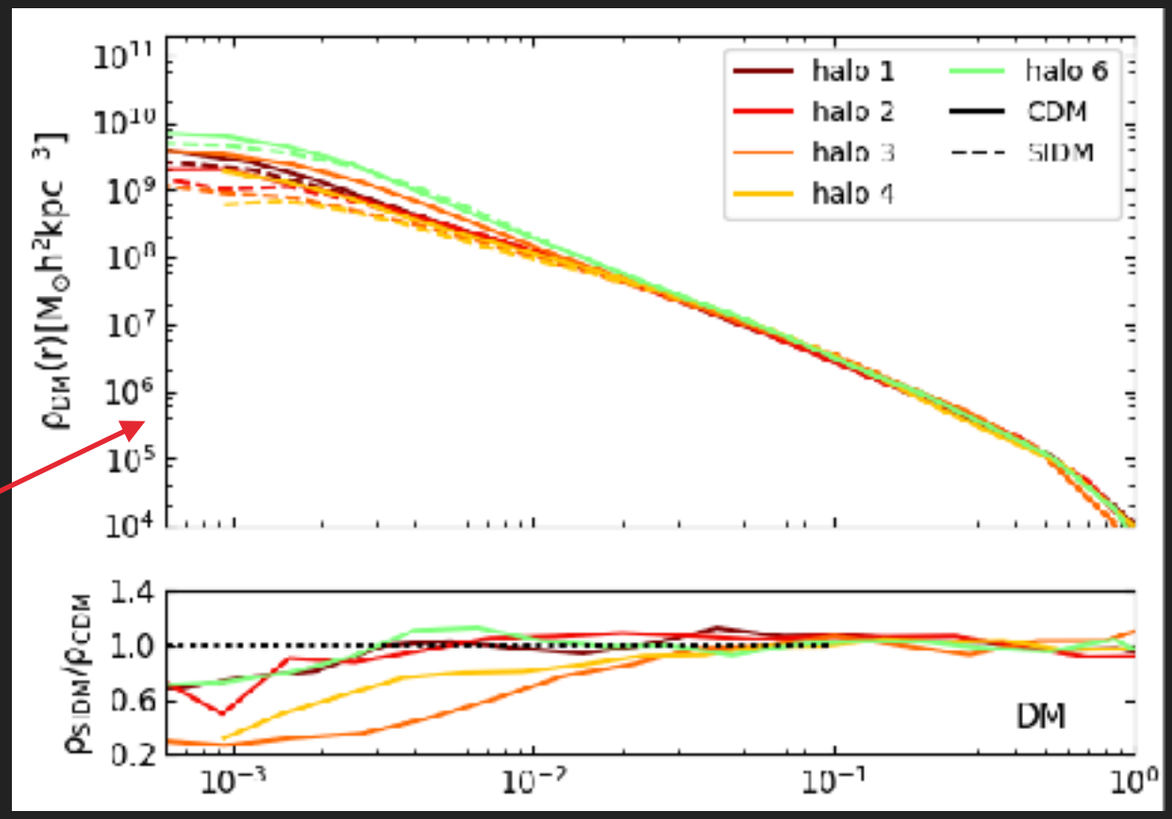


- the self-interaction influences the main halo profile

SELF-INTERACTING DM

(Despali et al. in prep.)

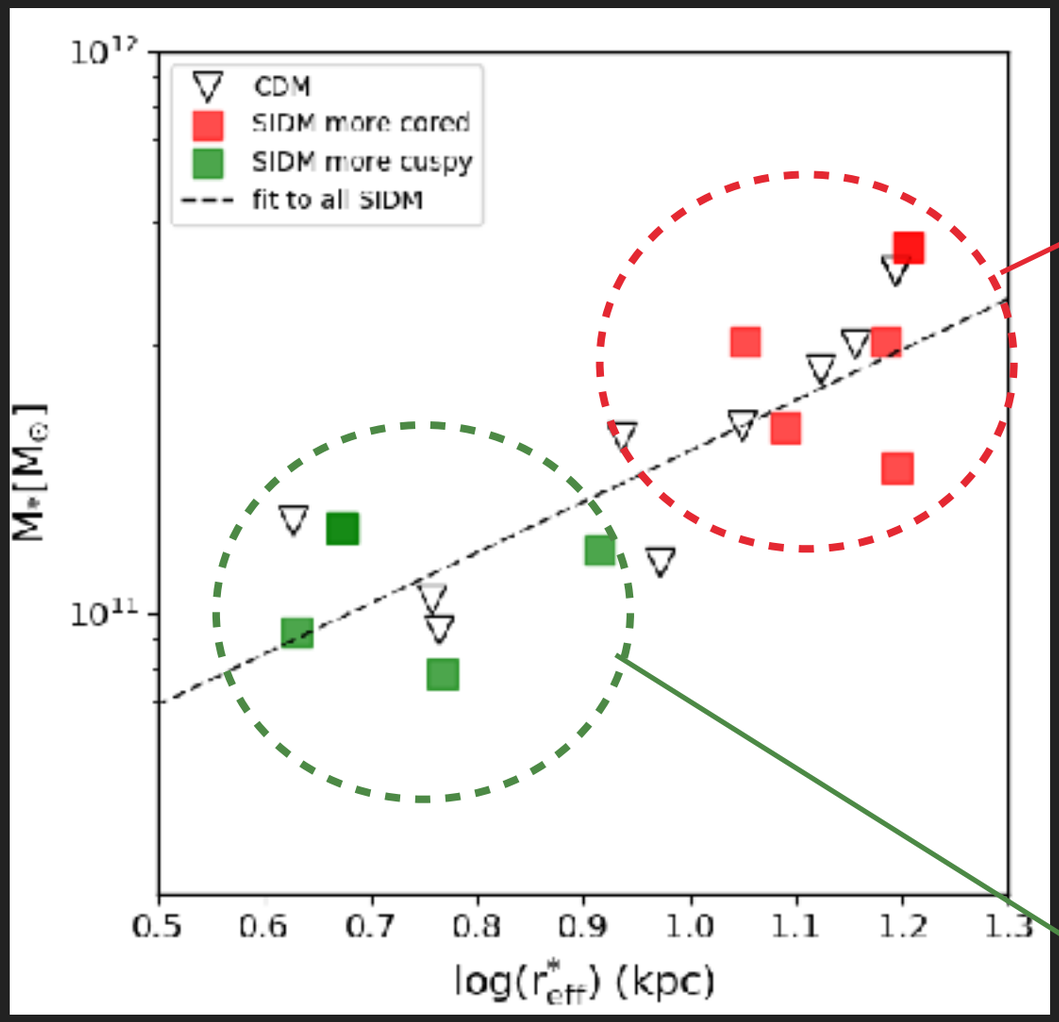


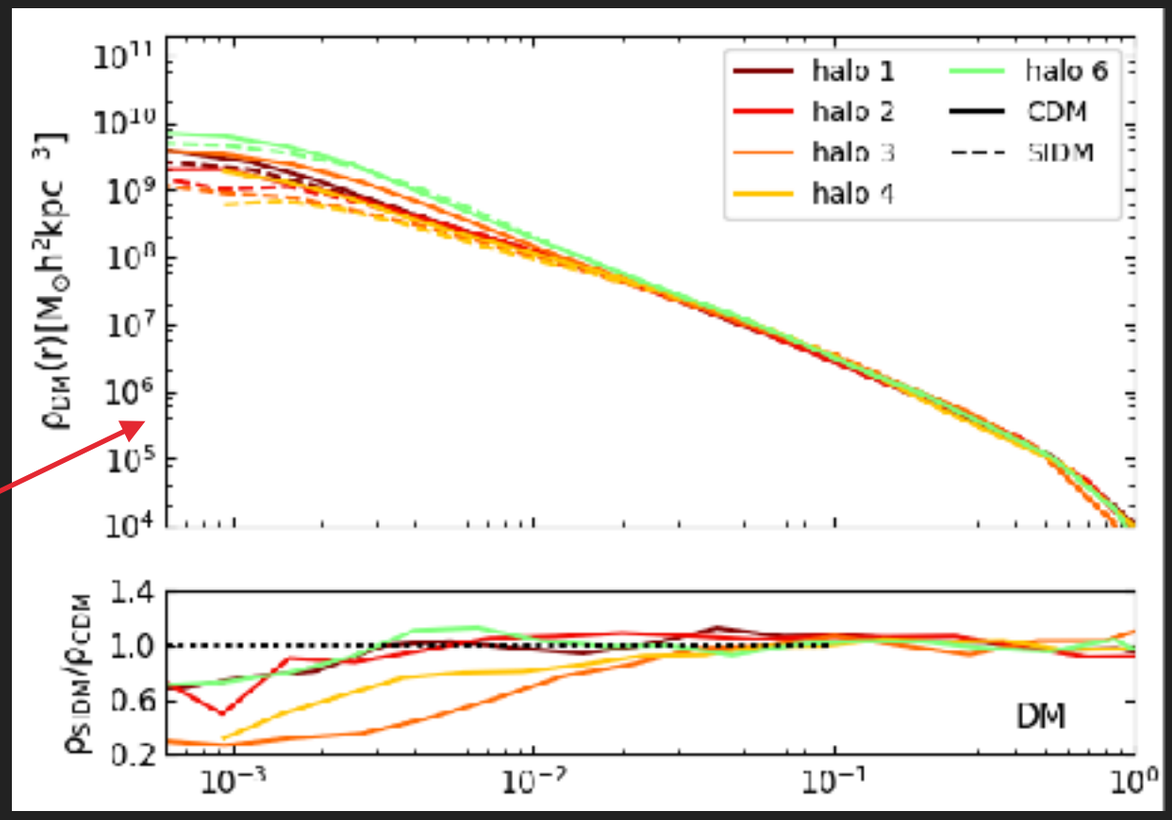


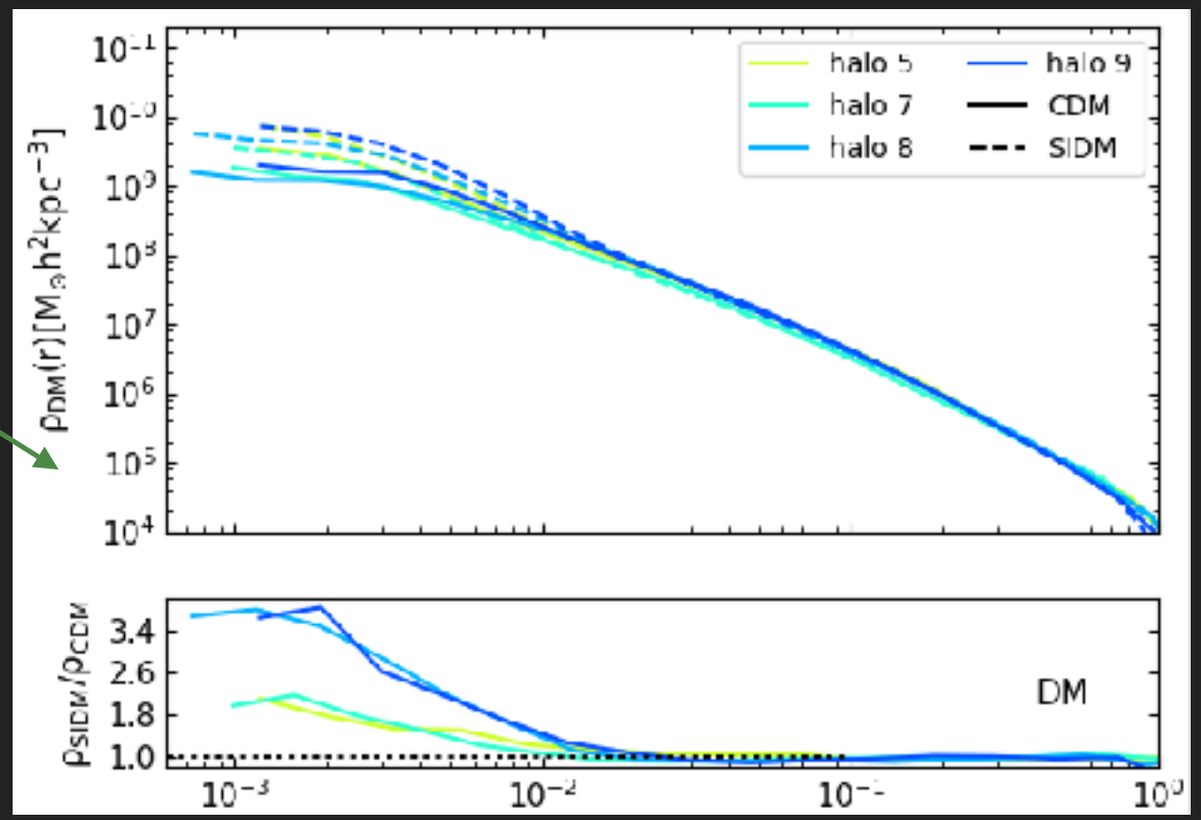
- the self-interaction influences the main halo profile
- **in the presence of baryons things are more complicated**

SELF-INTERACTING DM

(Despali et al. in prep.)





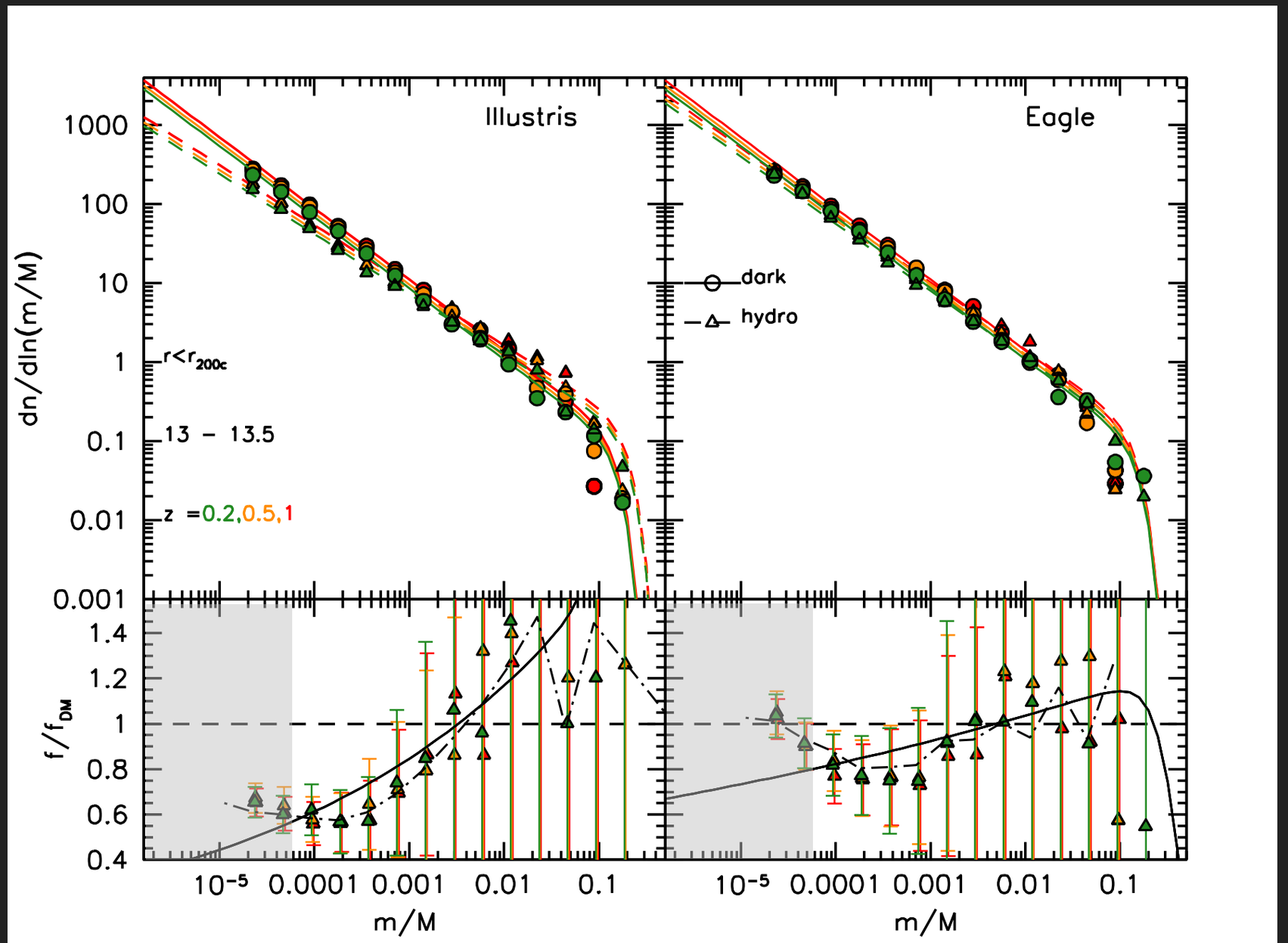


- the self-interaction influences the main halo profile
- **in the presence of baryons things are more complicated**

BARYONIC EFFECTS

(Despali & Vegetti 2017)

- Haloes from the Illustris and EAGLE main runs
- M ~ 10^{13} $M_\odot$/h
- z = 0.2, 0.5, 1



PREDICTIONS & NUMERICAL SIMULATIONS

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LINE-OF-SIGHT CONTRIBUTION

- the LOS population **dominates** and provides **cleaner constrains**
- with better sensitivities we'll be able to discriminate CDM/WDM
- we need to be careful with mass definitions

SIDM

- similar subhalo population
- but more cored sub profiles
- stronger effect on the main lens properties
- ..depending on morphological type? ..accretion history?
- possible different Einstein radii distribution

STERILE NEUTRINOS

- the properties of the main lens remain similar
- slightly colder than the equivalent thermal relic models
- fewer subhaloes

- ...we need to be careful the baryonic physics effects!