Exploring the identity of dark matter with strong lensing Einstein rings

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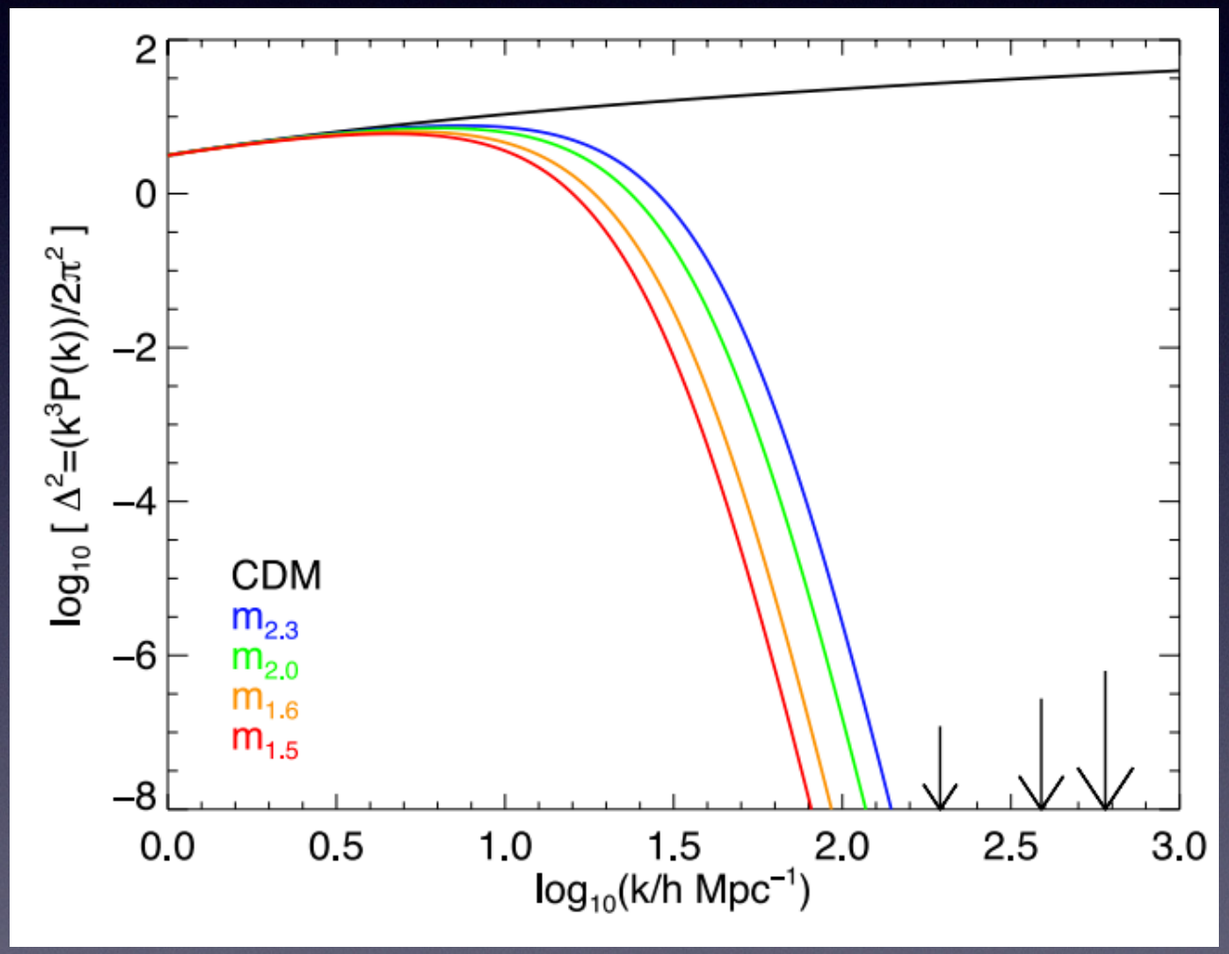
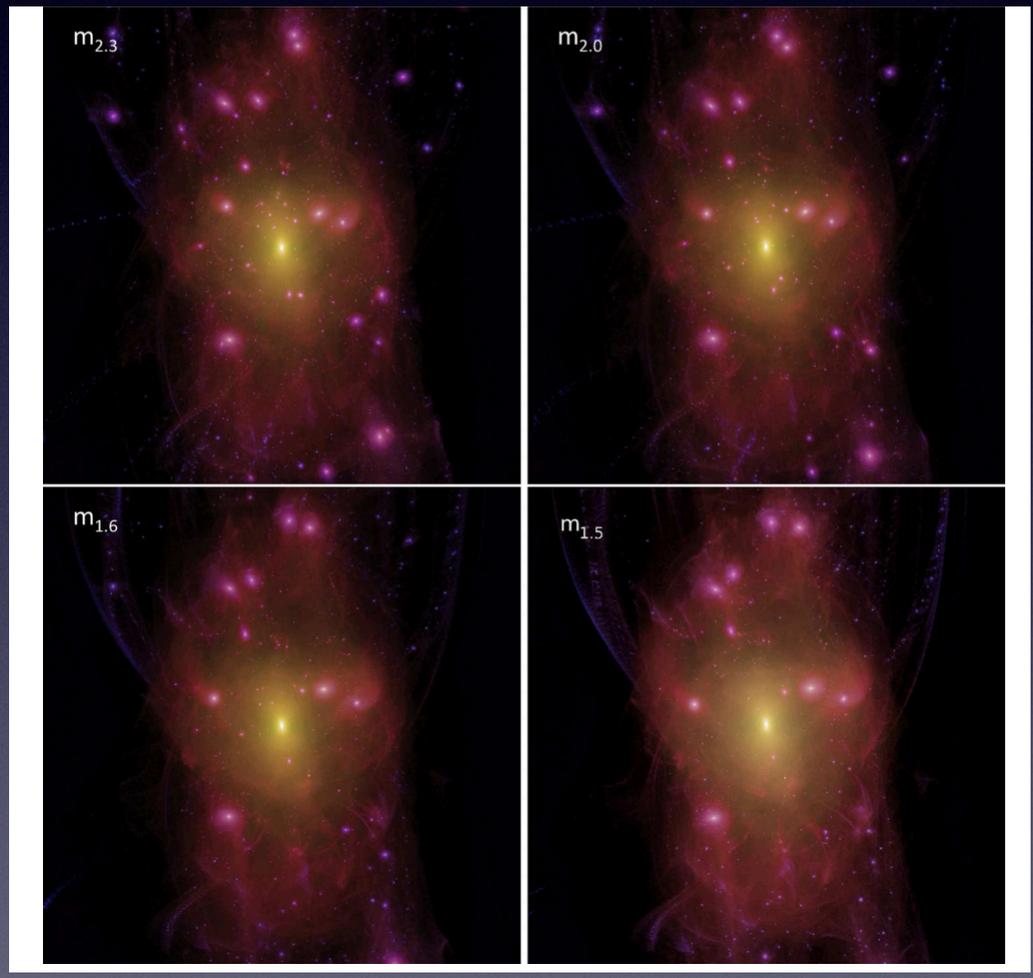
CDM vs WDM

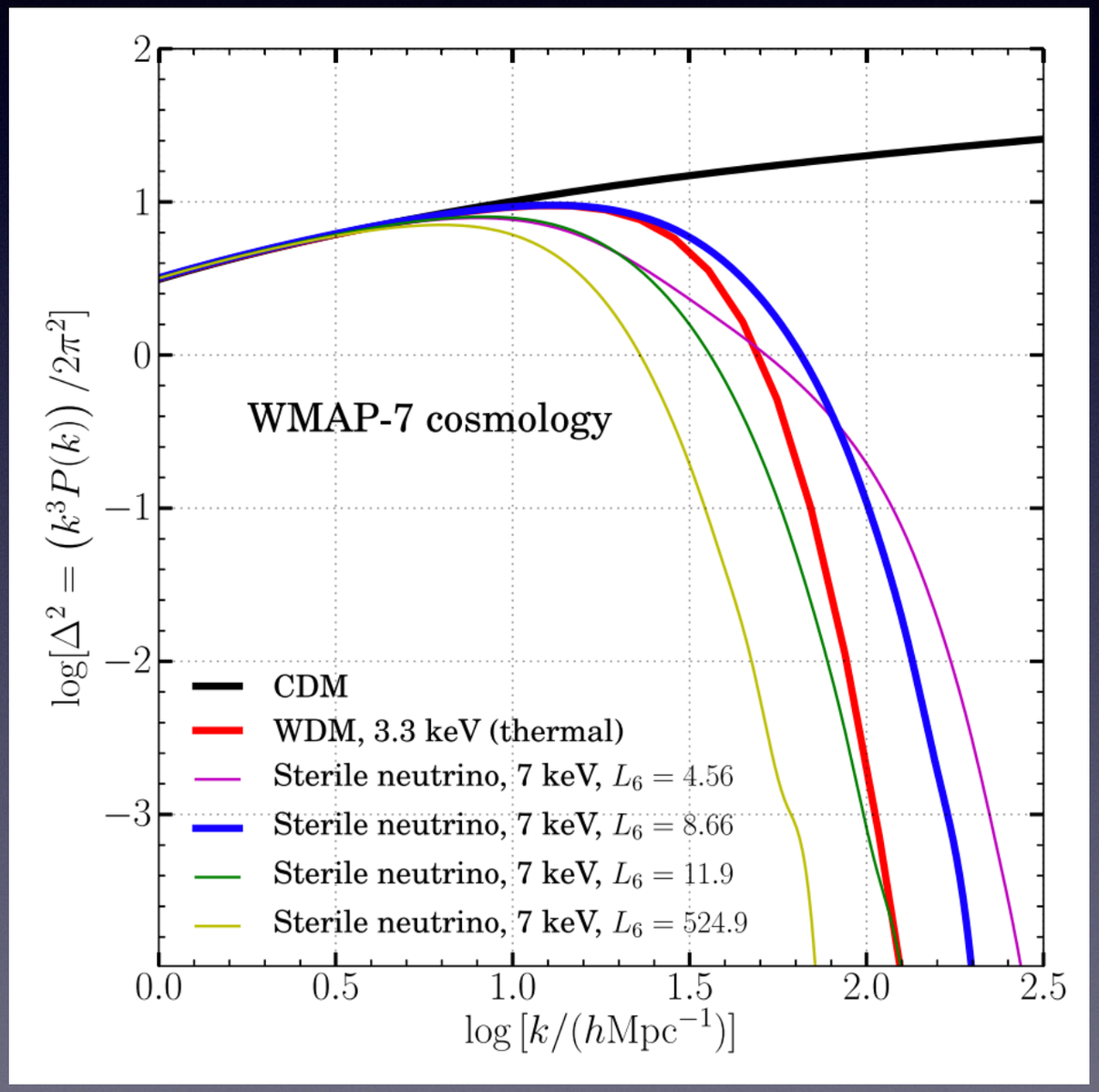




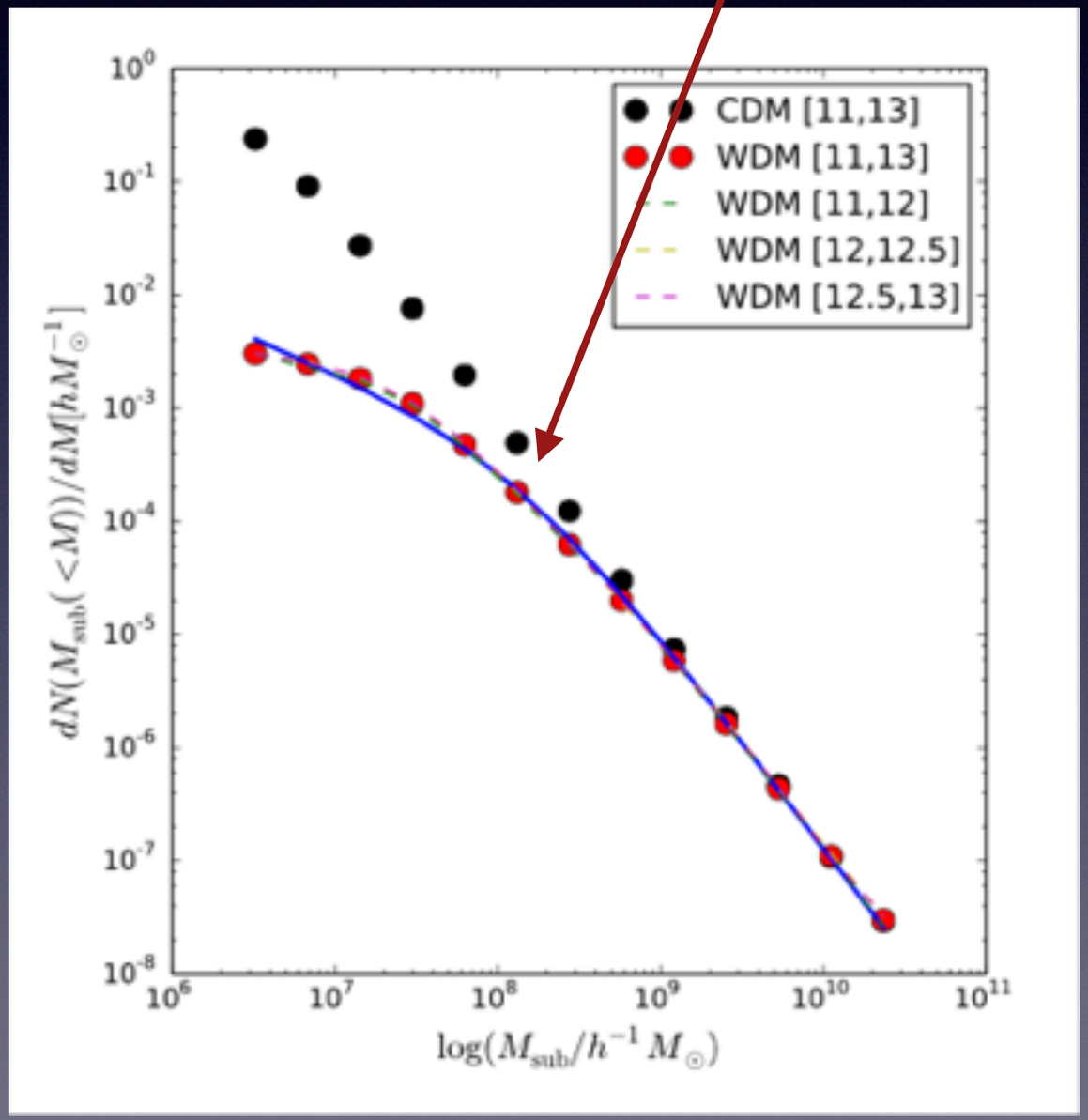
Lovell et al. 2014

Sterile neutrino

$$n_{\rm WDM}/n_{\rm CDM} = (1 + m_{\rm c}/m)^{-\beta}$$

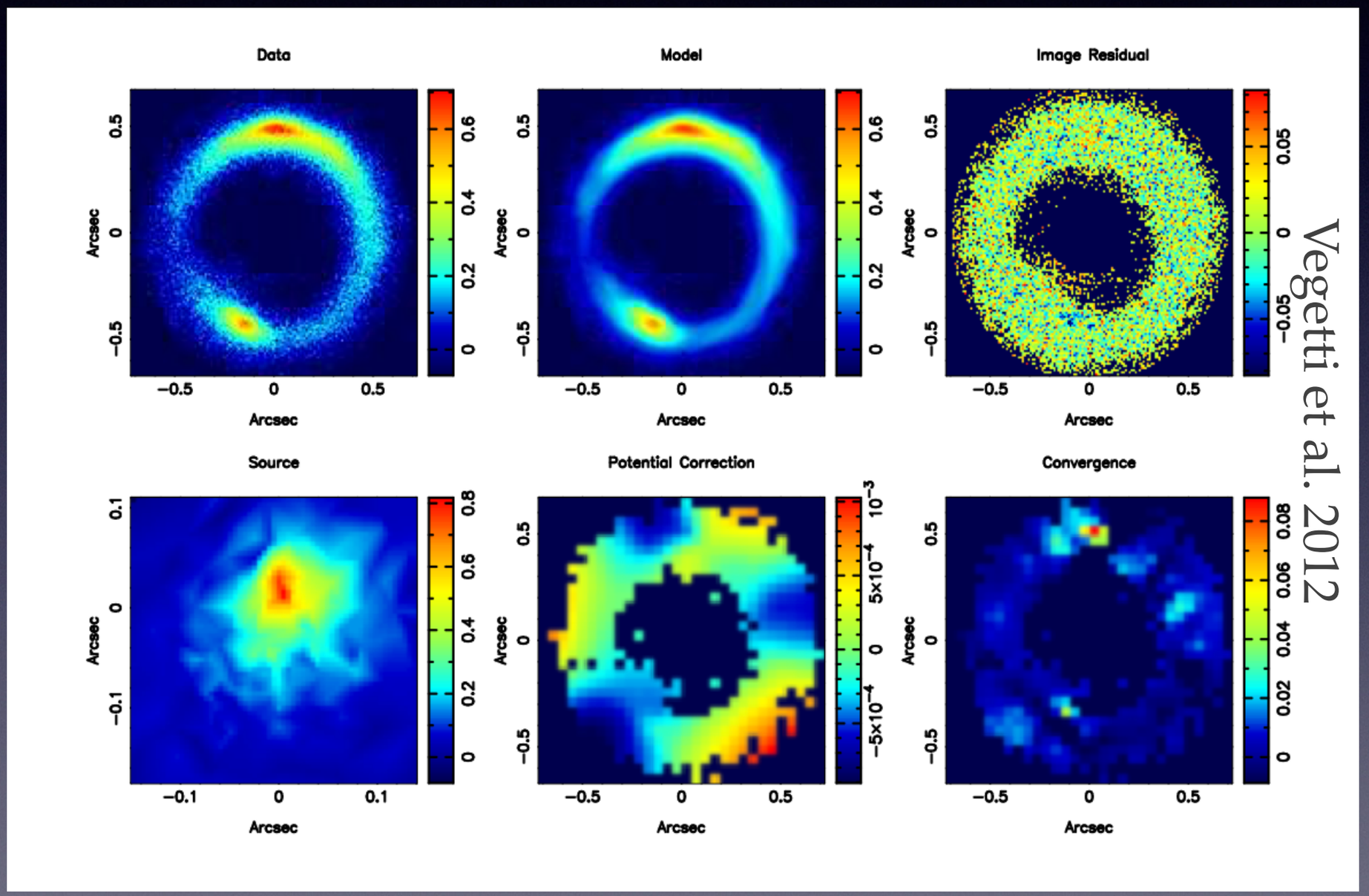


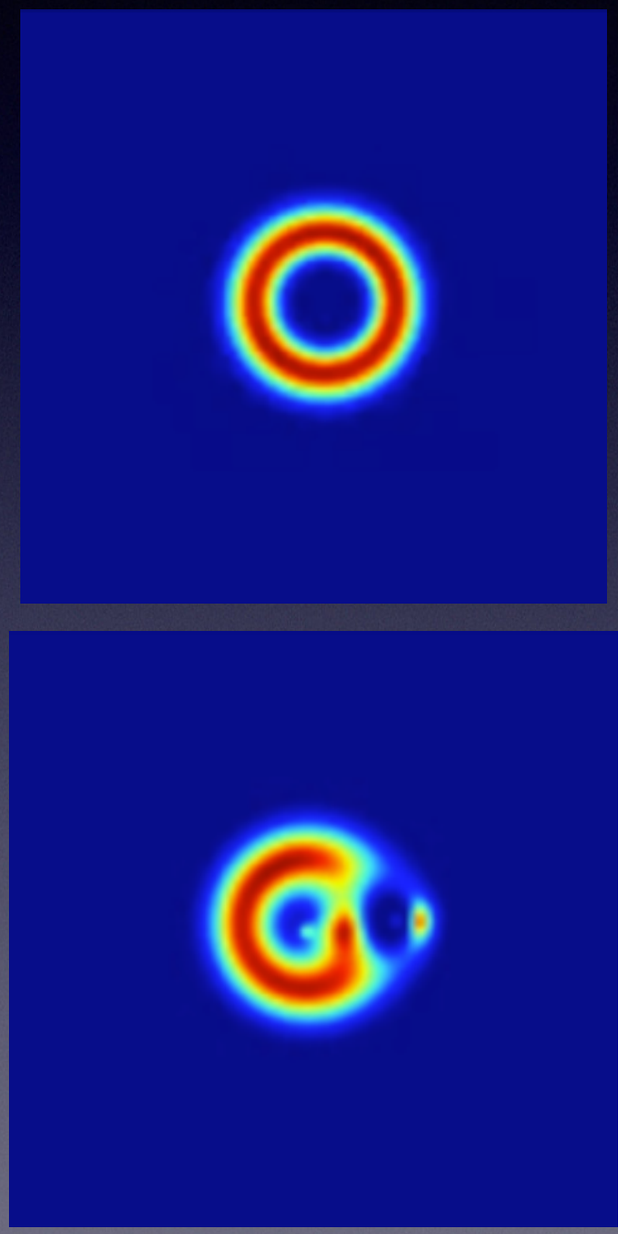
Bose et al. 2016



Li et al. 2016

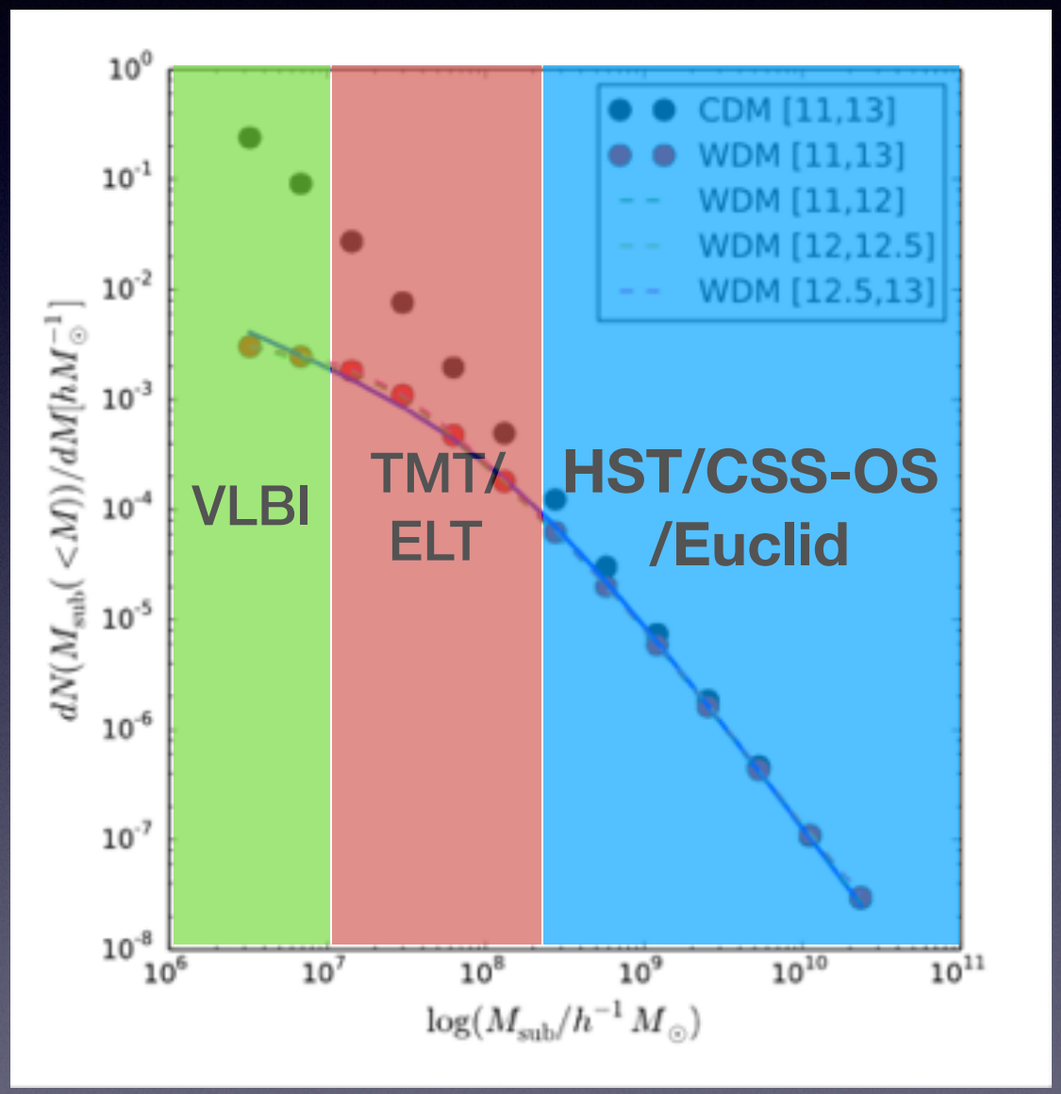
DM on small scales: Substructure detection

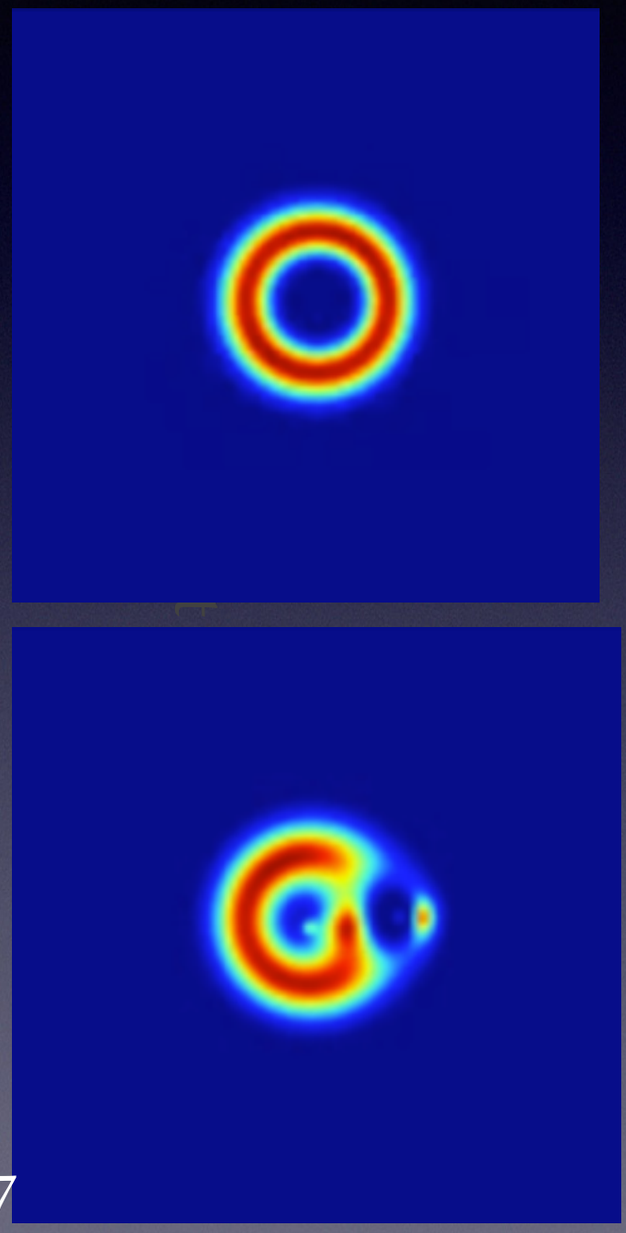




Vegetti et al. 2012

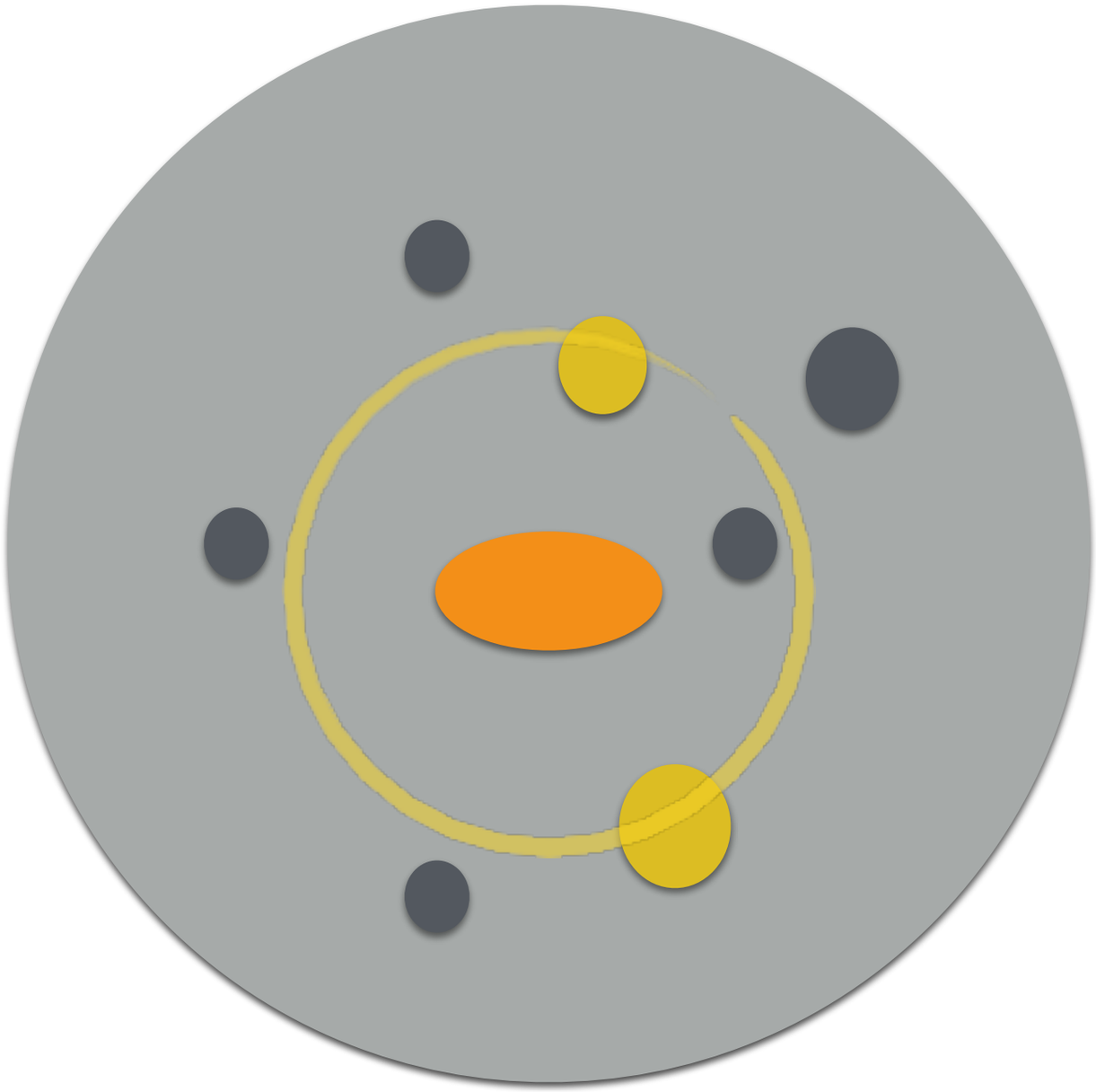
DM on small scales: Substructure detection



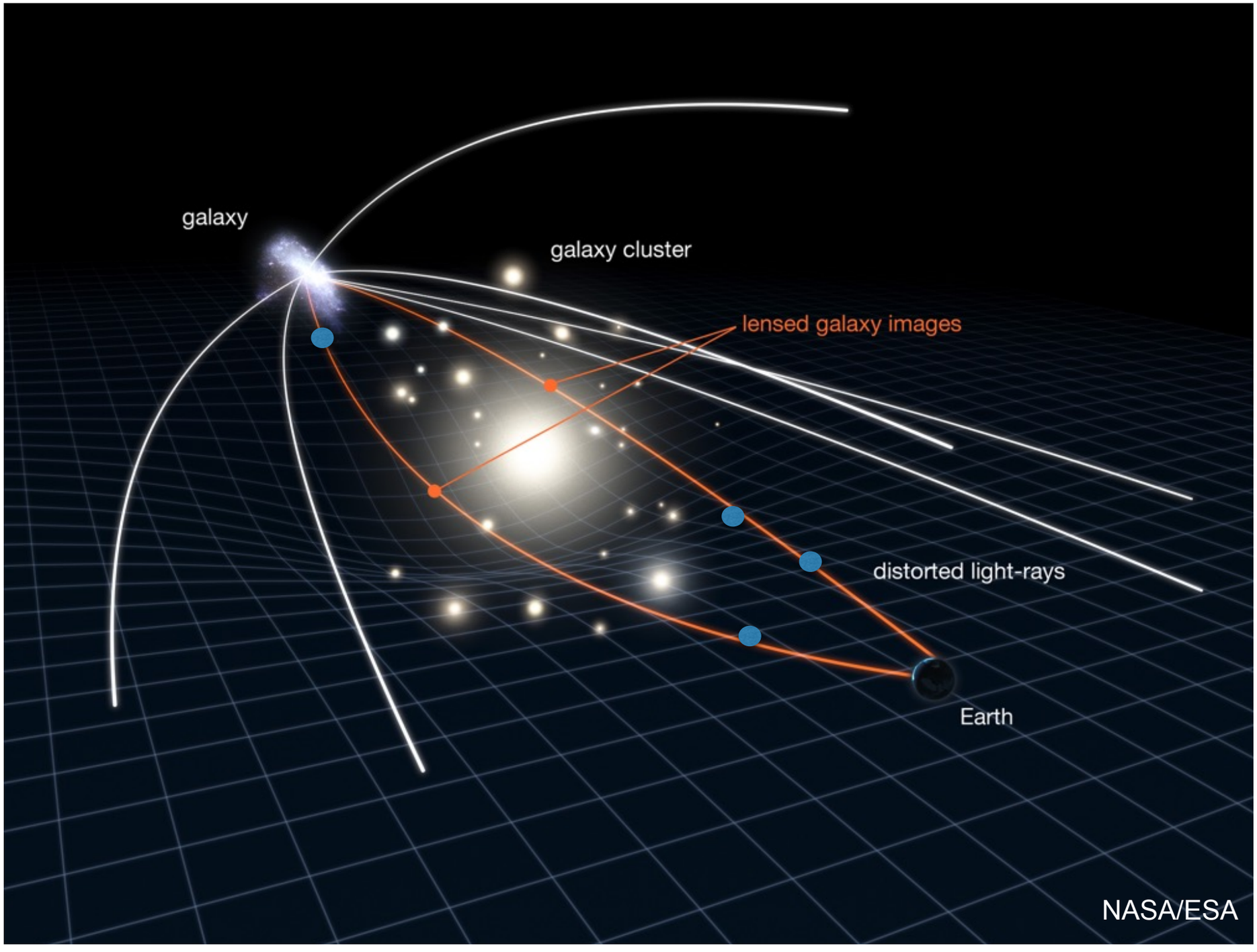


RL, CSF, SC et al. 2016 arxiv 1512.06507

How many lenses do we need?

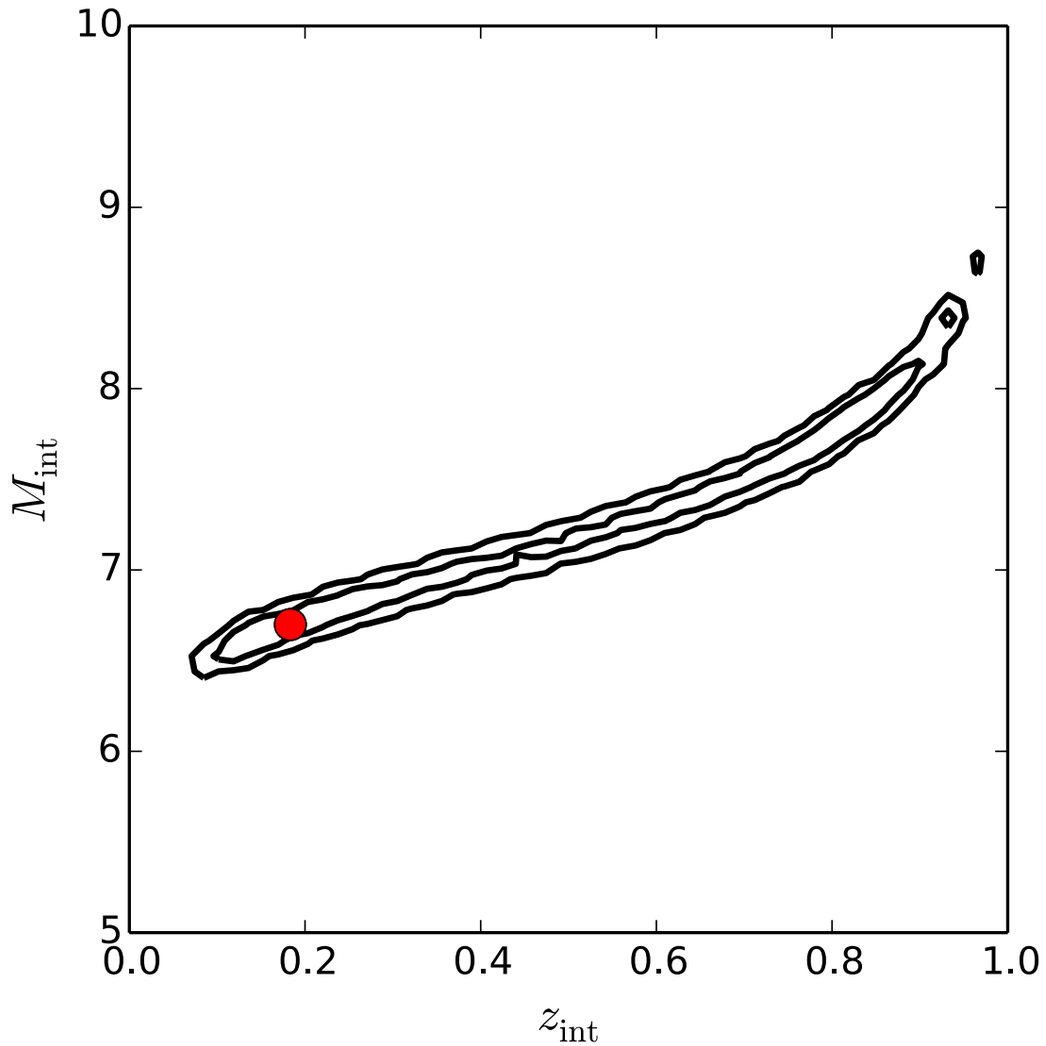


LOS perturber

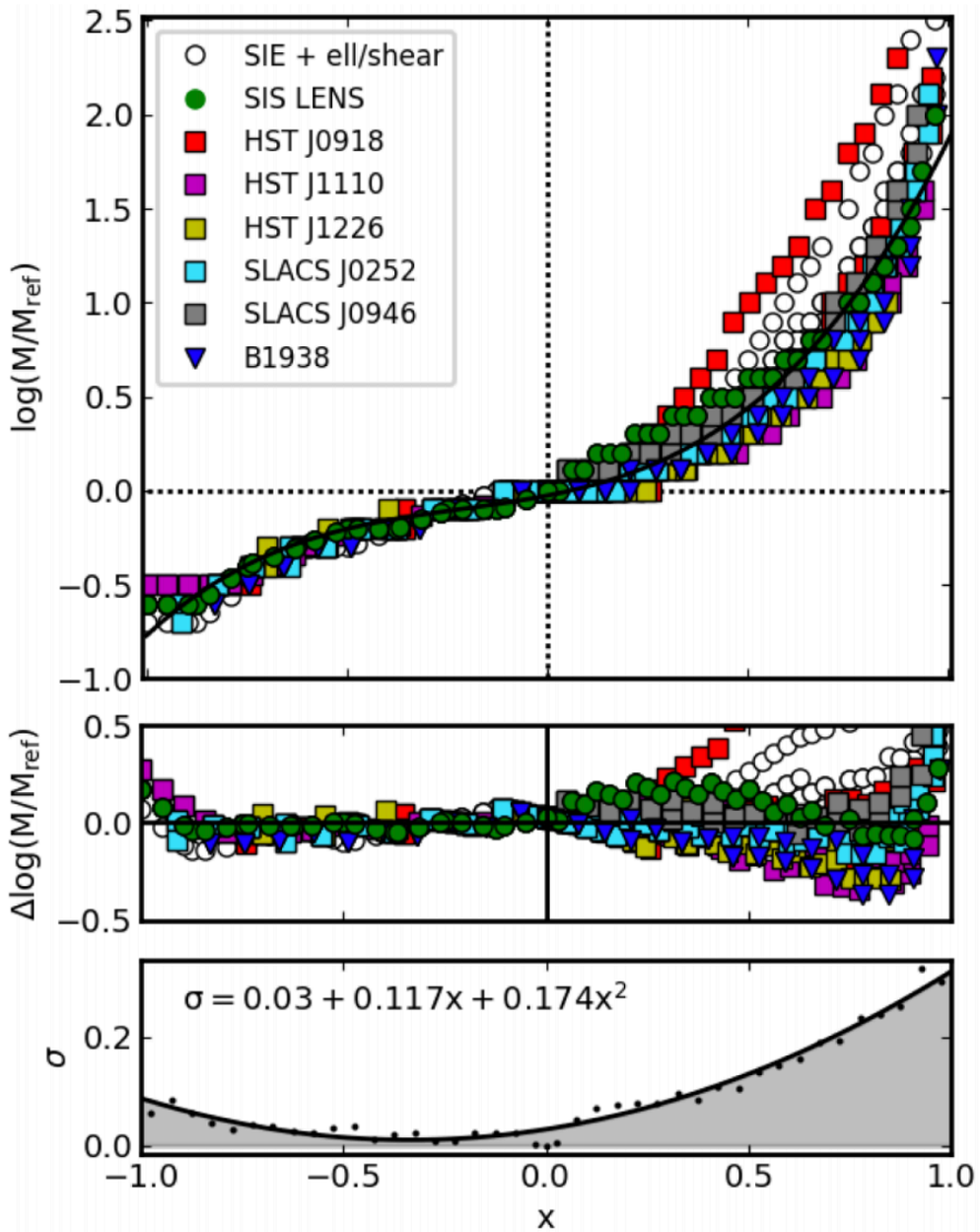


Line-of-sight perturbers

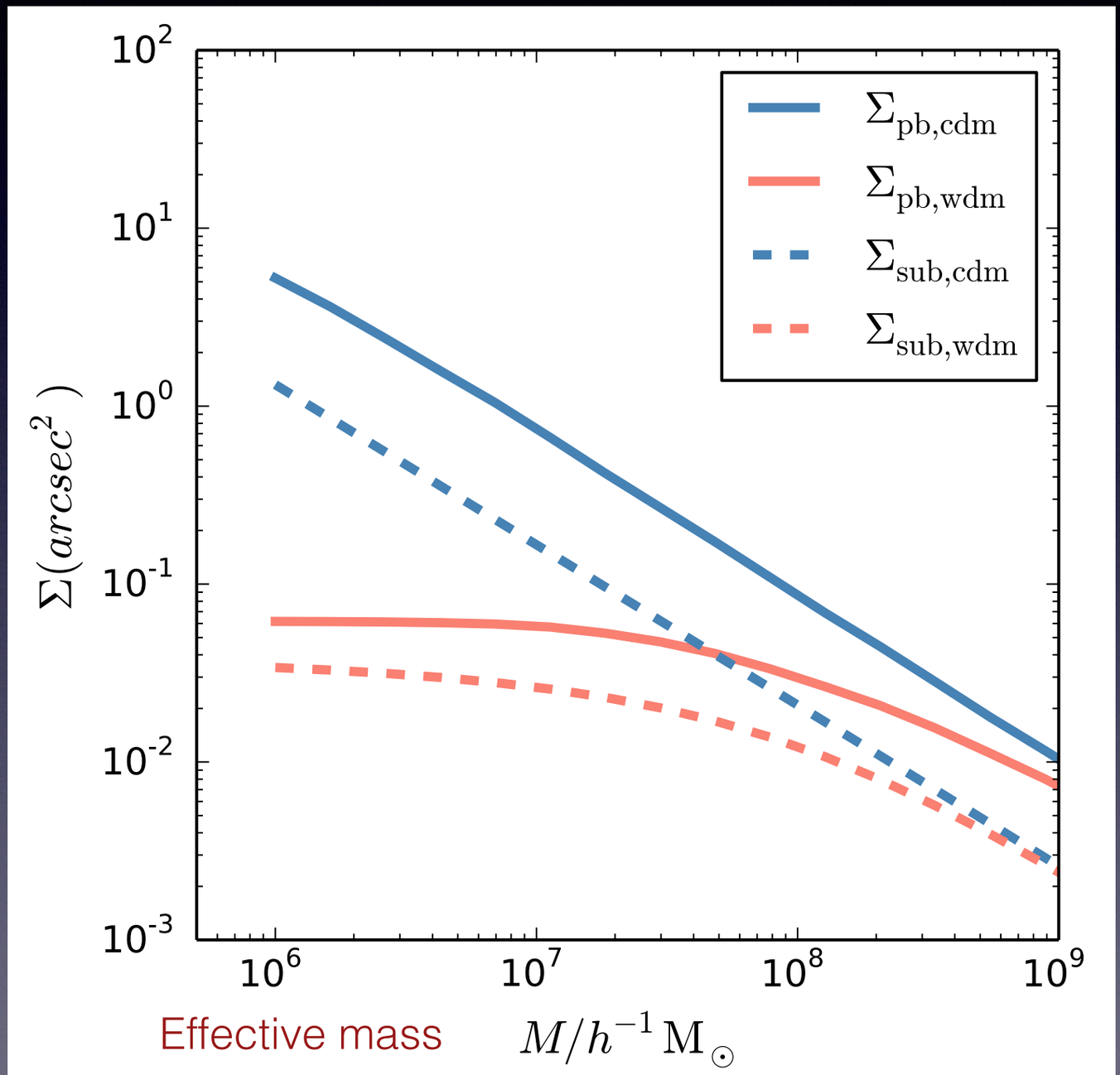
RL, CSF, SC et al. 2017, arxiv:1612.06227



Despali et al. 2018

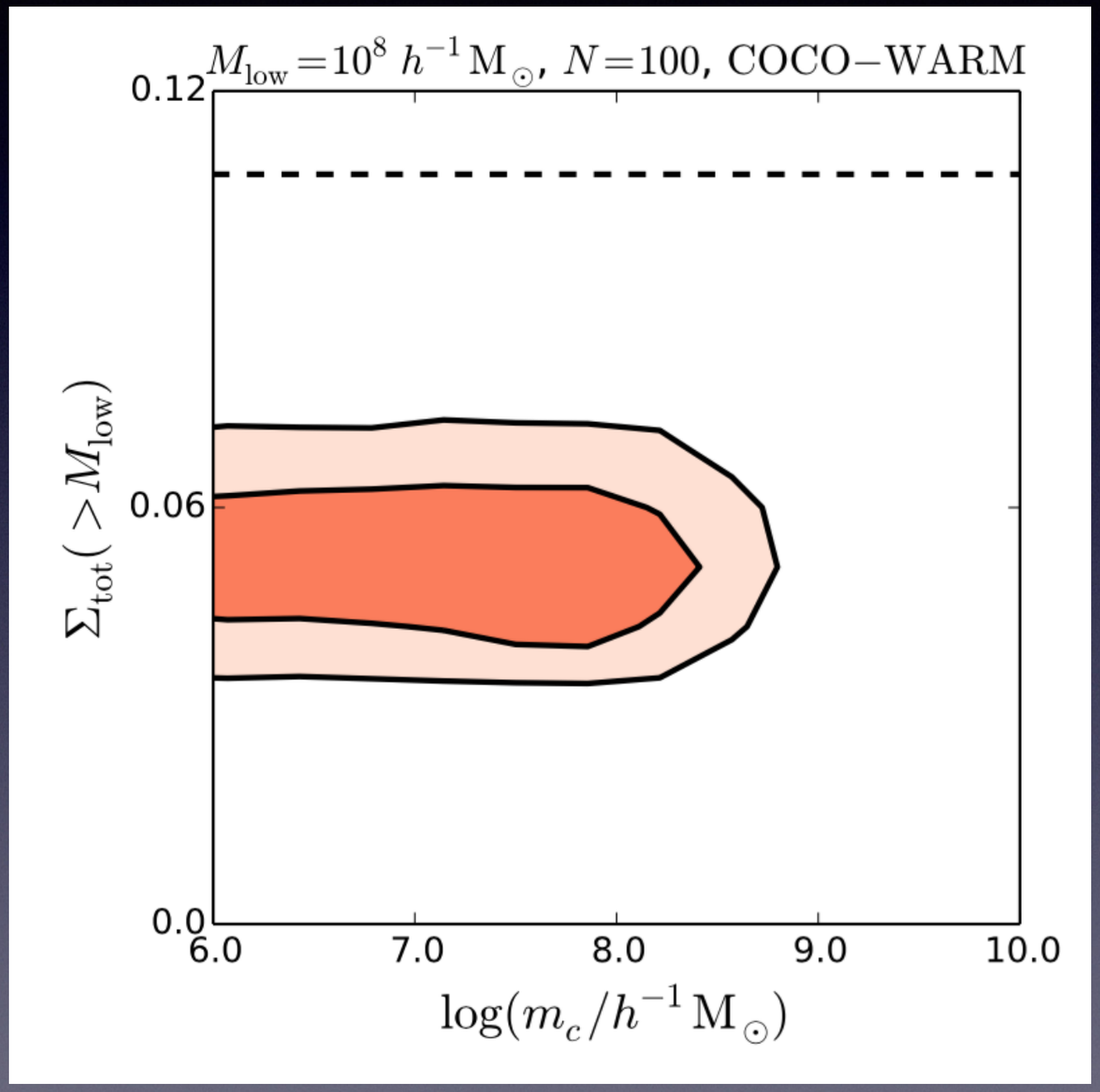


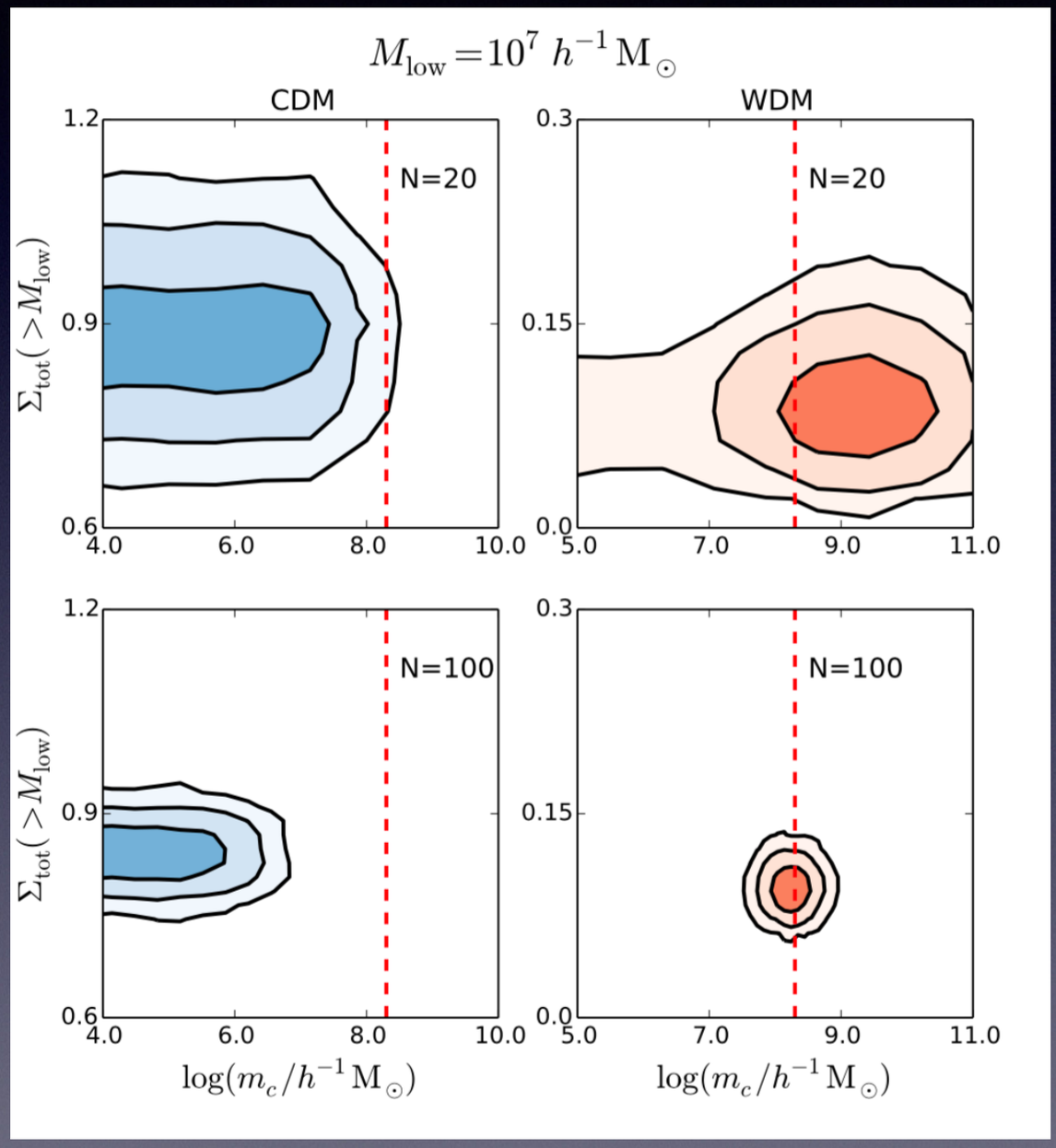
Perturber mass function



RL, CSF, SC et al. 2017, arxiv:1612.06227

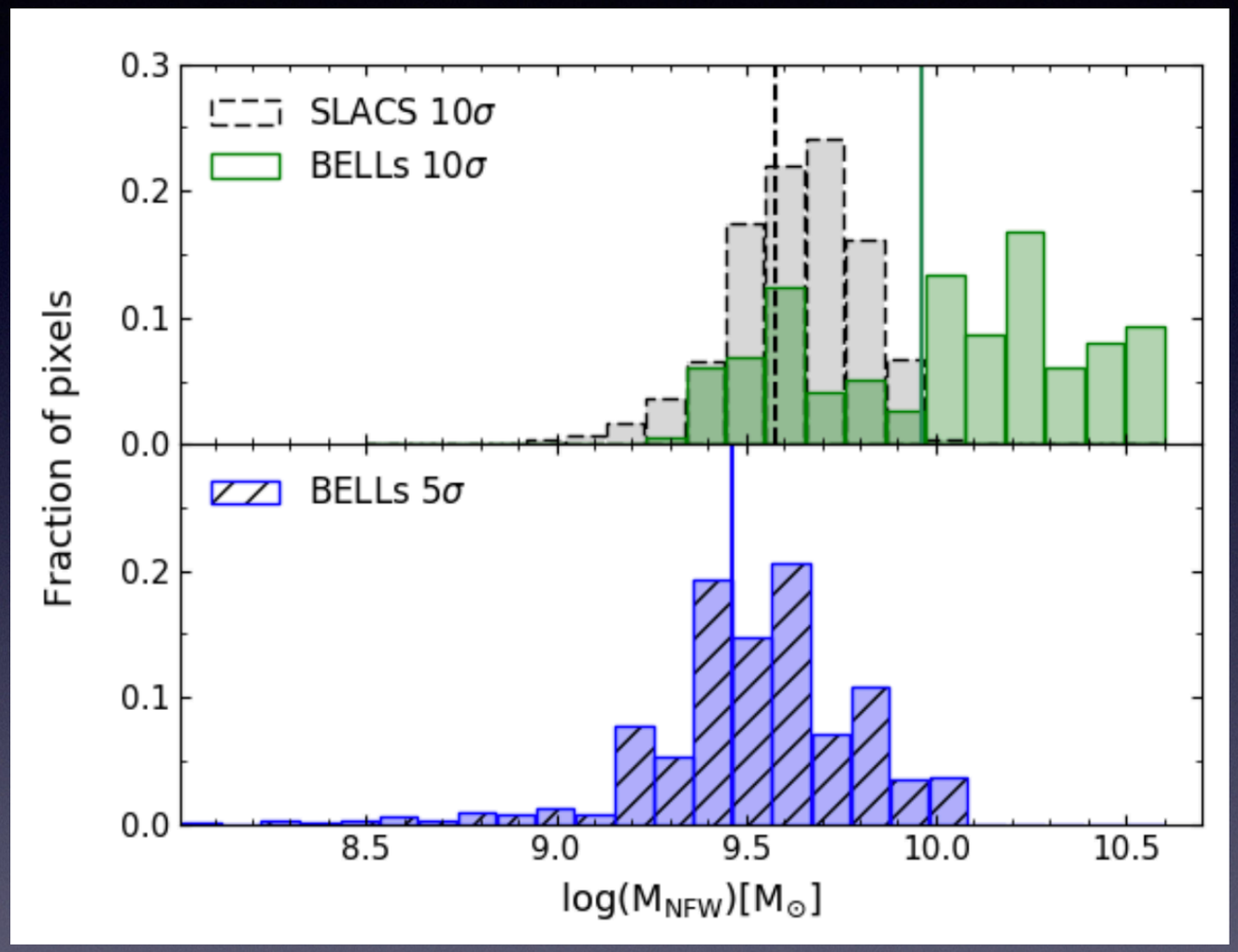
Forecast



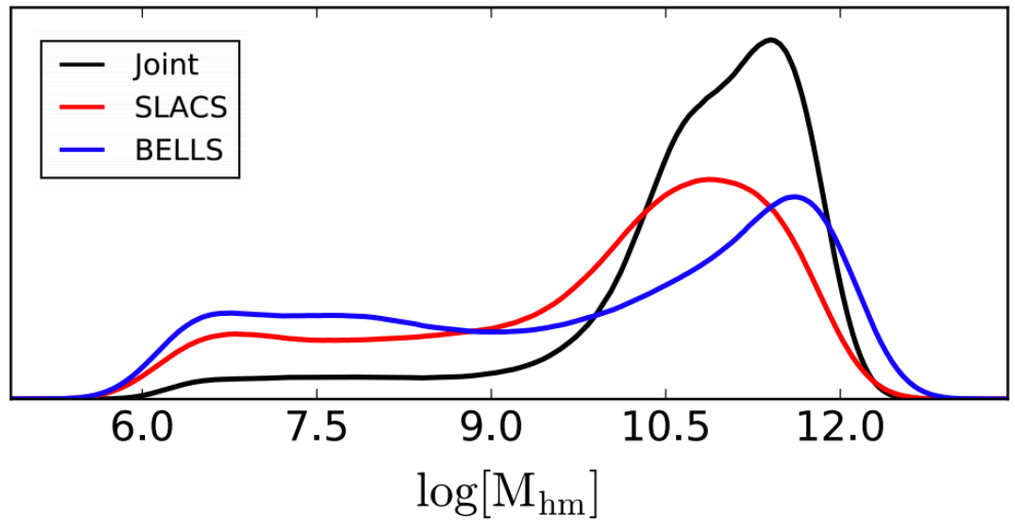


Li RL, CSF, SC et al. 2017, arxiv:1612.06227

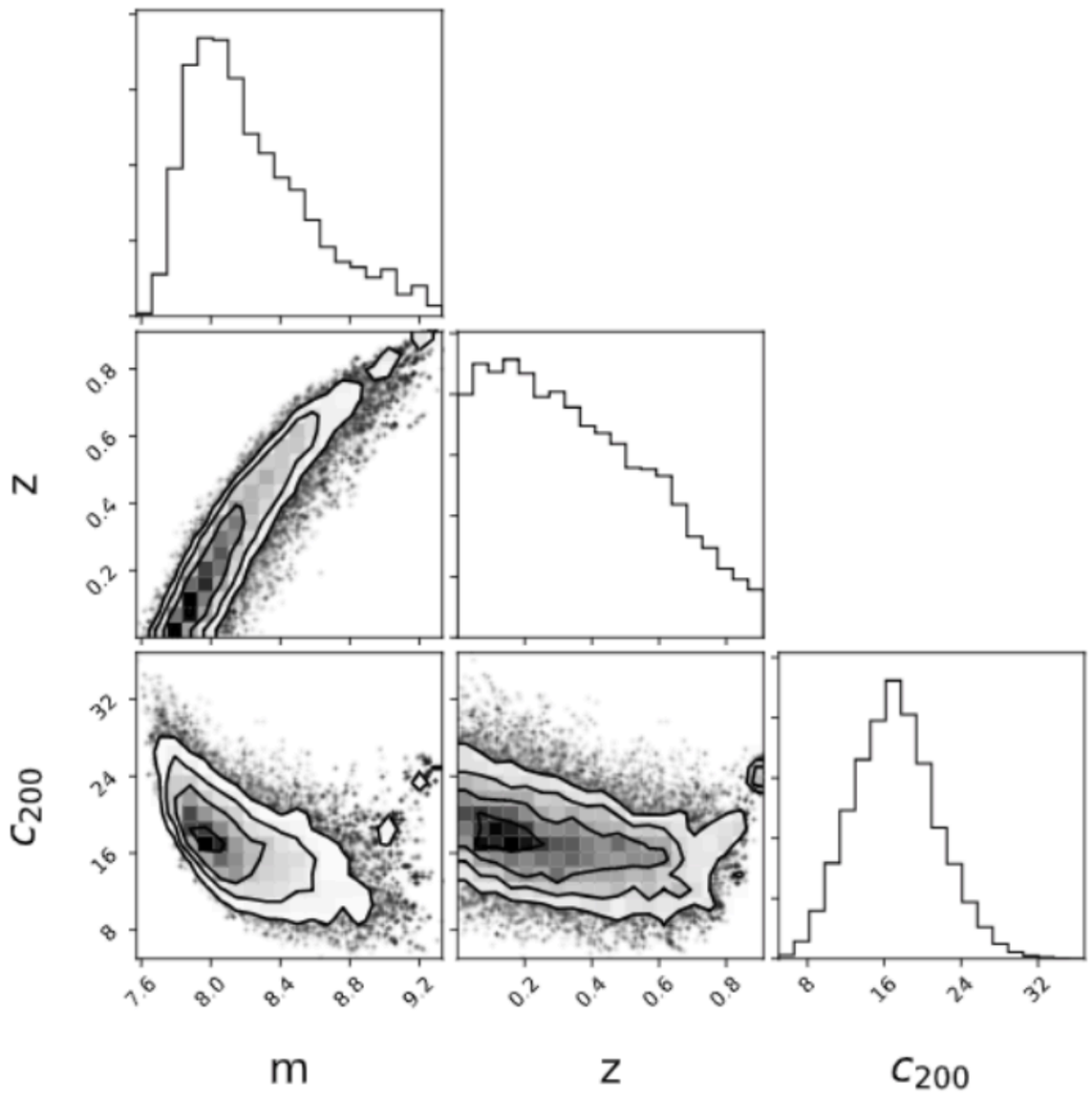
Constraint from observation

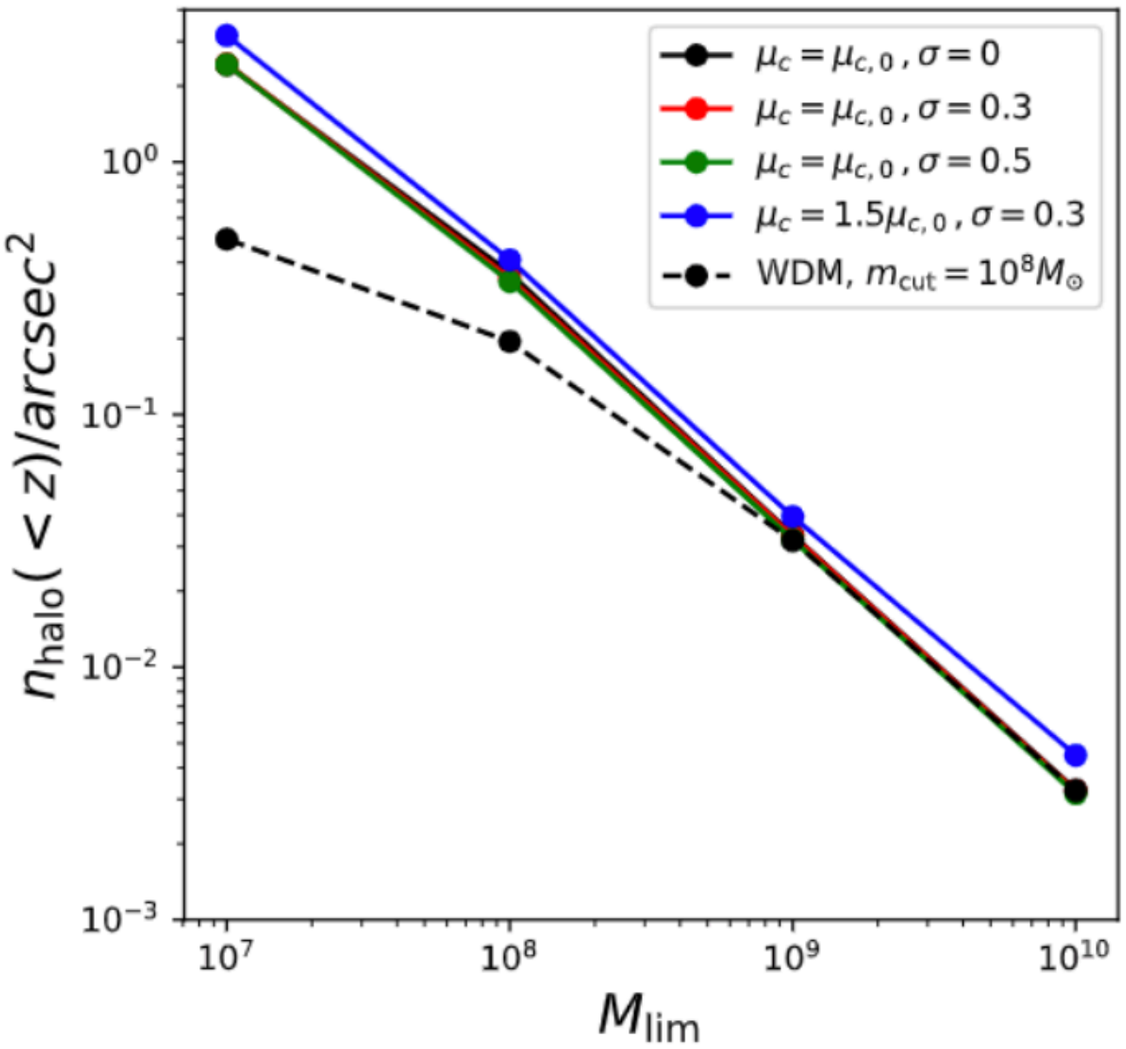


Ritondale et al. 2019



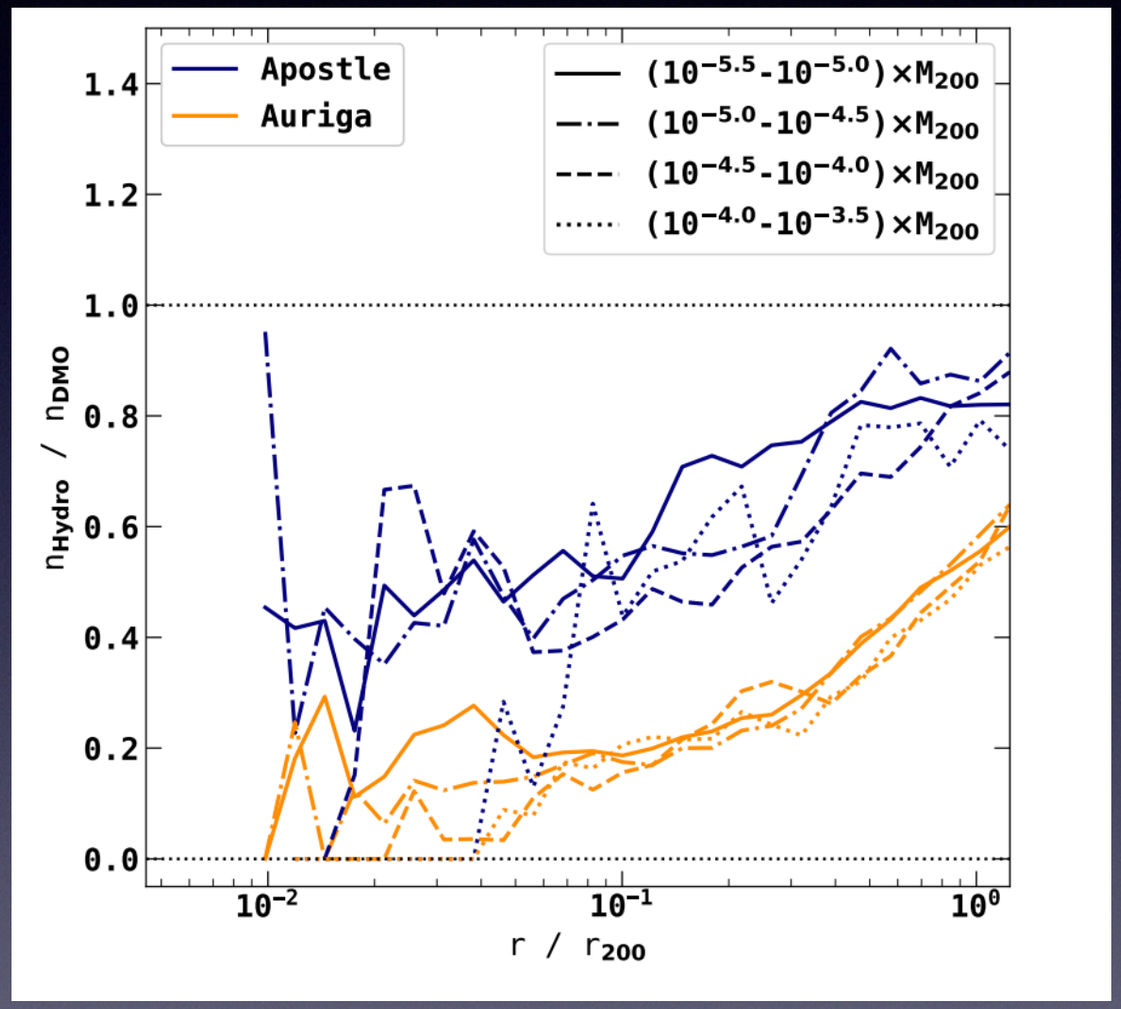
Halo structure



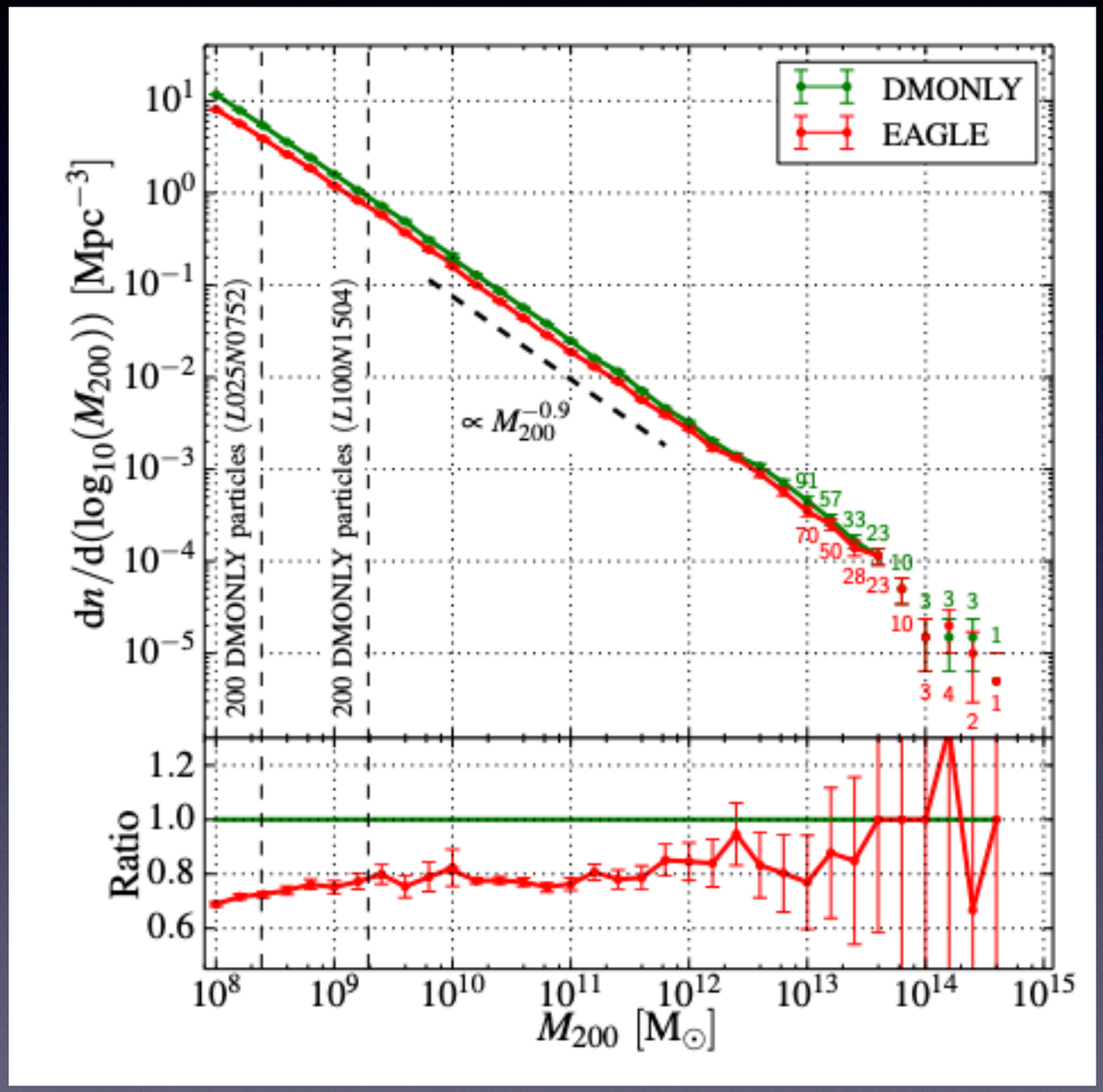


Li et al. in prep

Baryonic effects



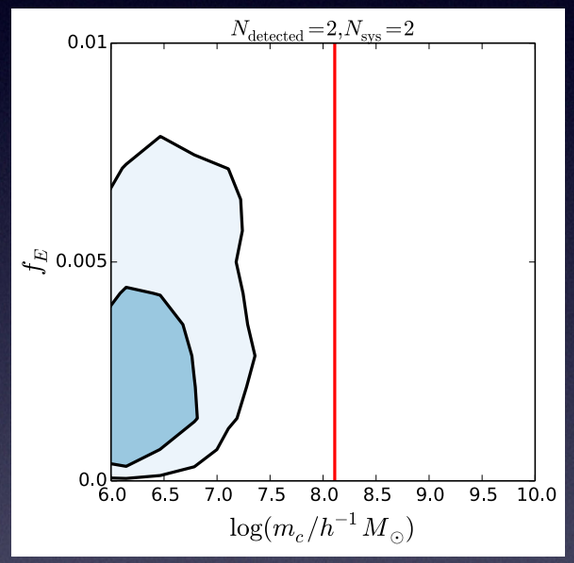
Richings et al. 2018



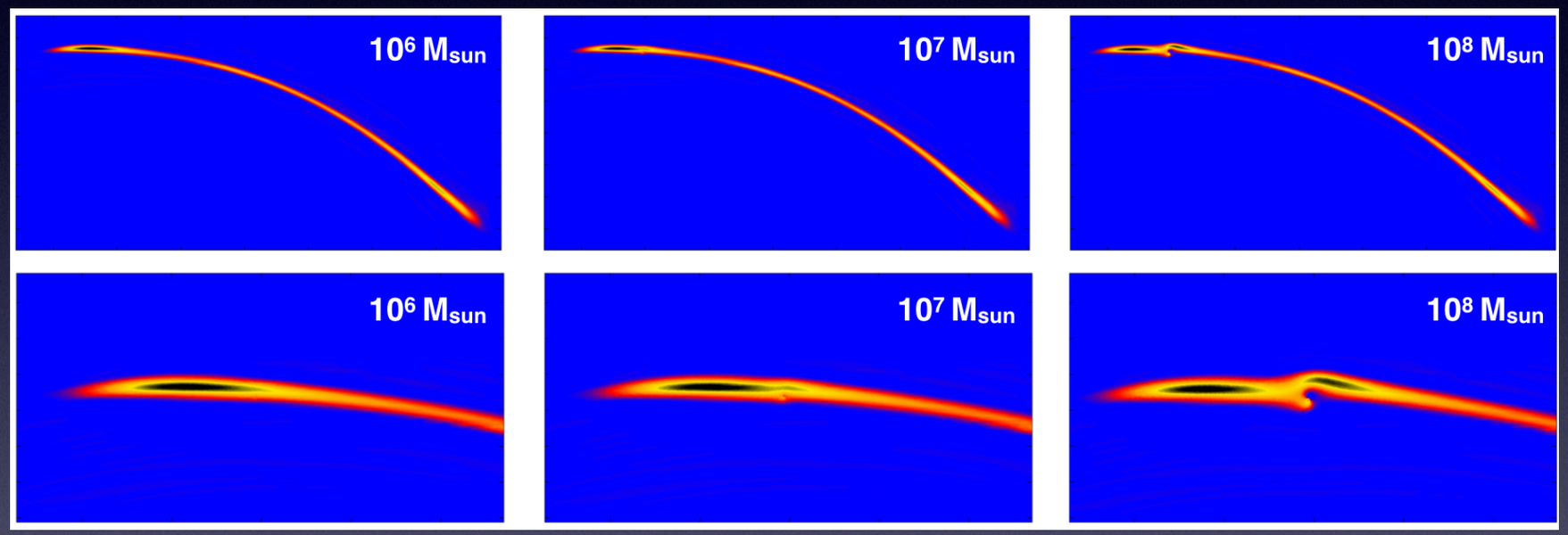
Schaller et al. 2014

VLBI like observation

McKean et al. 2015



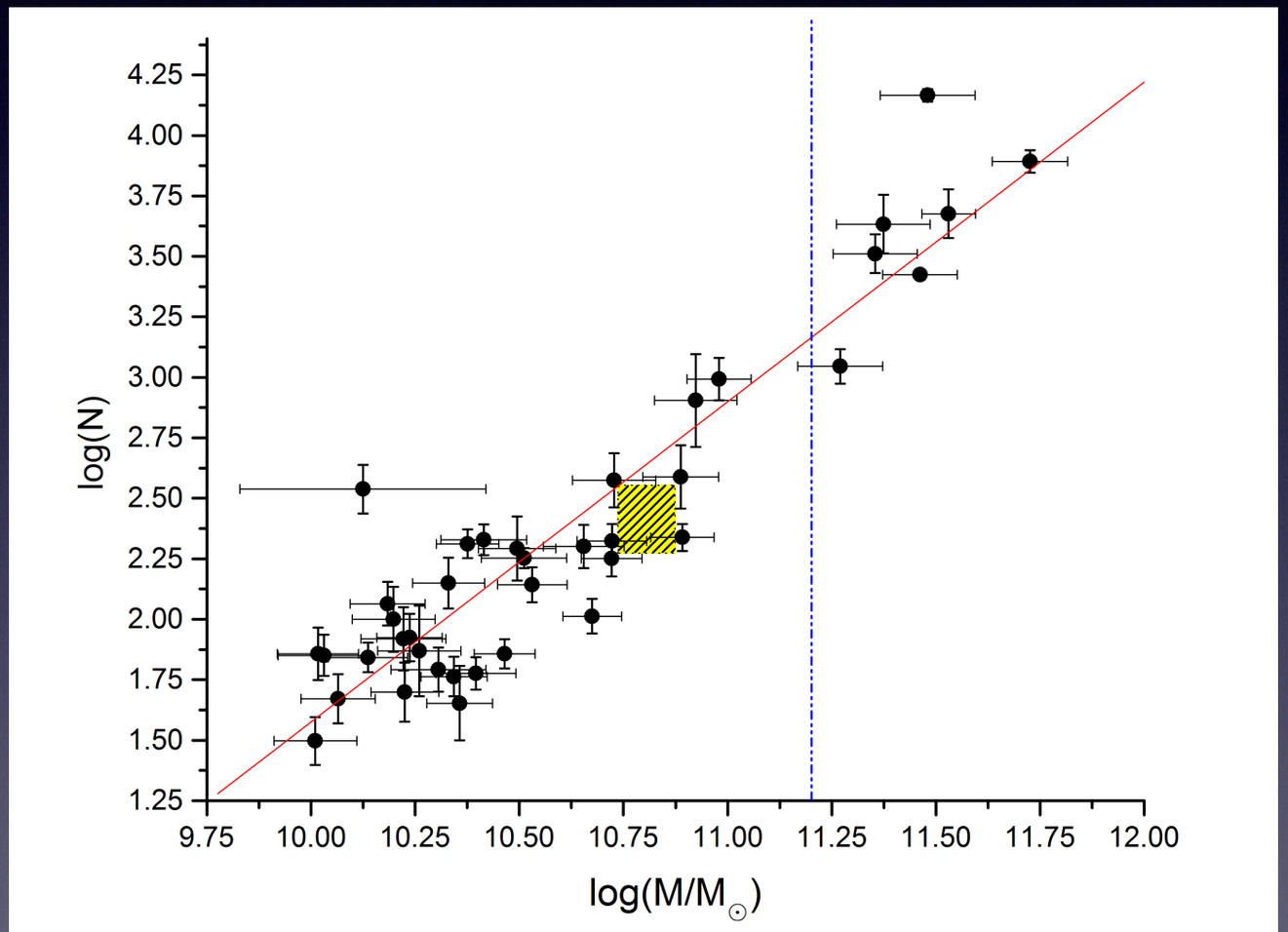
Mlow=10^6 Msun,
2 detection

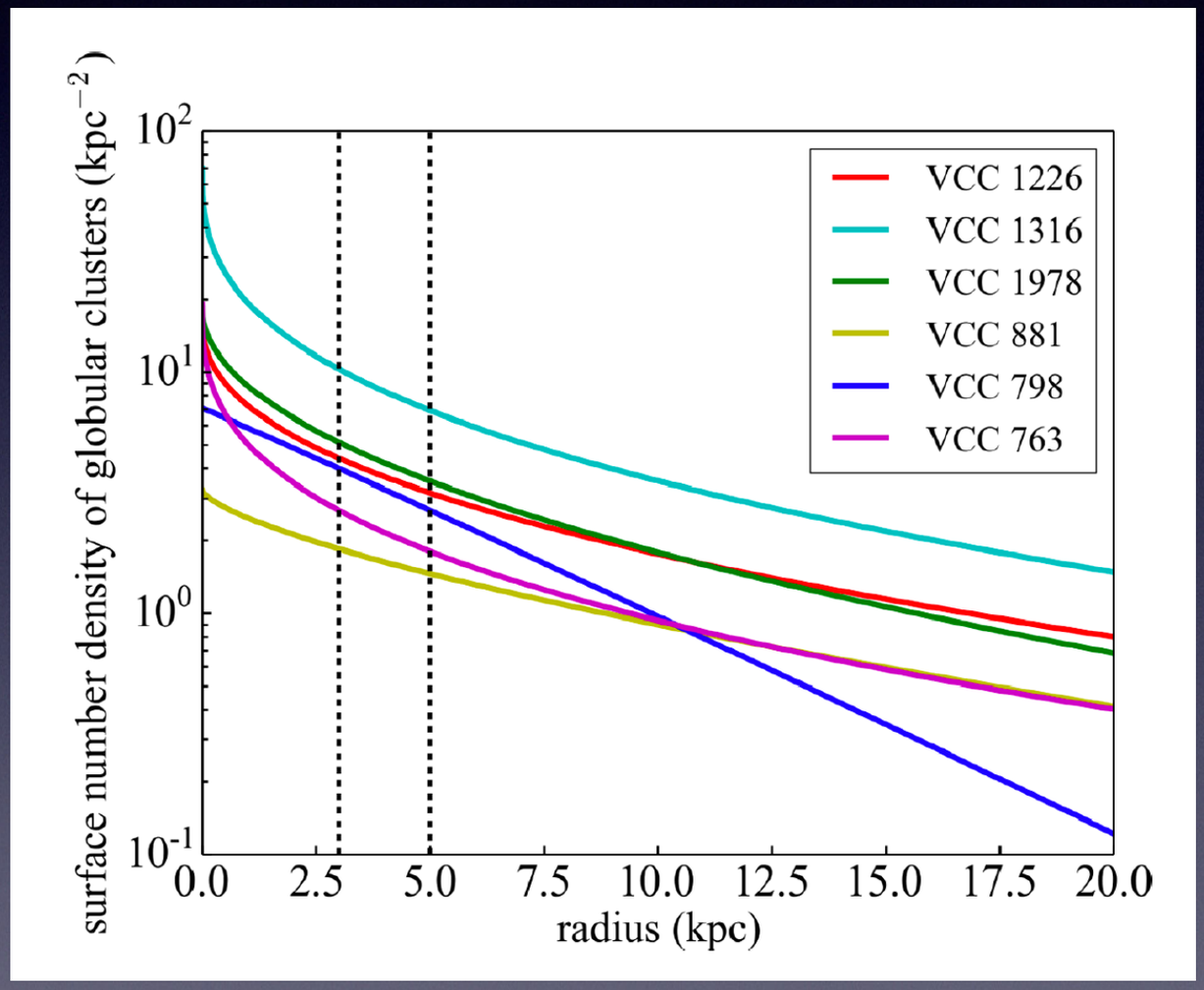


For a VLBI resolution image,
the detection of 10^6 Msun halo is possible,
the 10^7 Msun halo is visible

Globular clusters

QH, RL et al. 2018

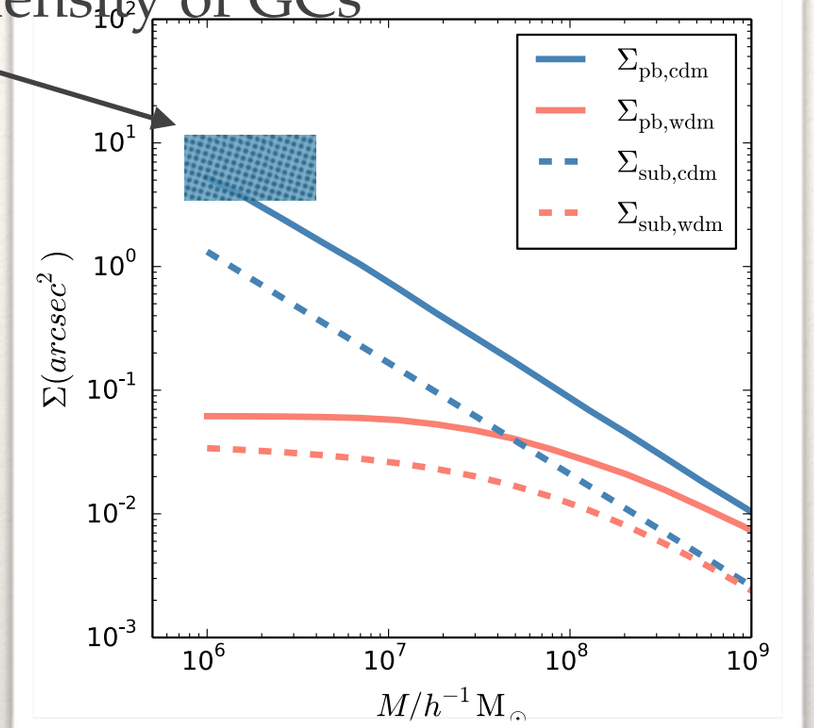


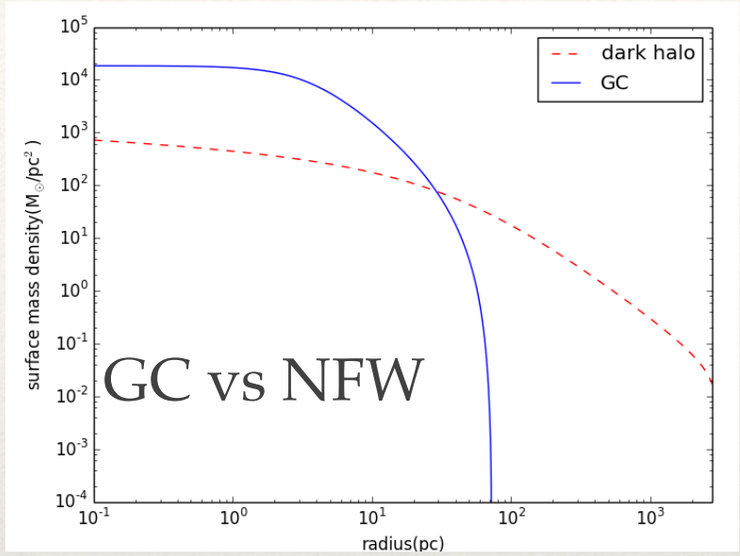


- There are ~1000 of globular clusters in massive early galaxies.

Effects of Globular Clusters

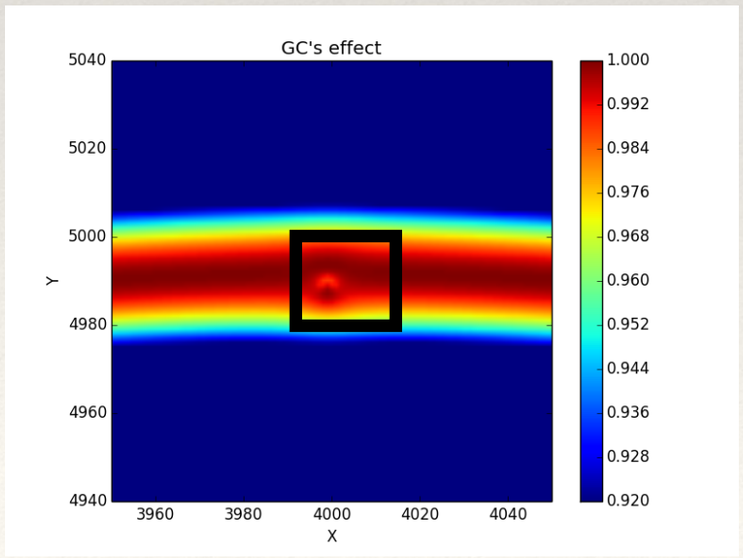
Number density of GCs



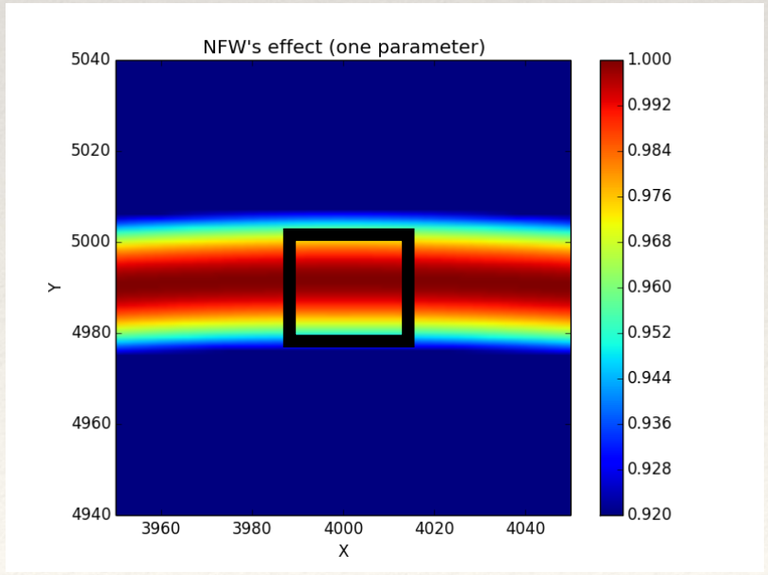


QH, RL. et al. 2018

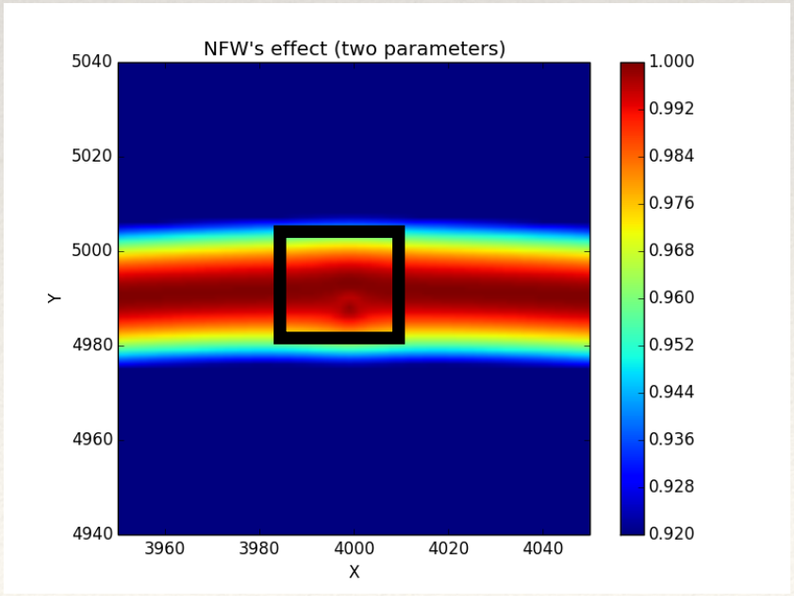
GC



NFW



NFW fit GC

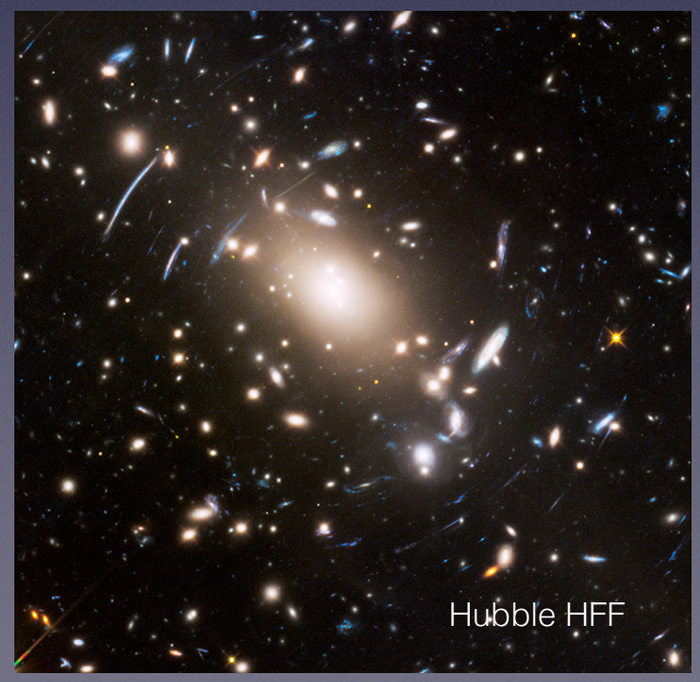


Expectation for CSS-OS

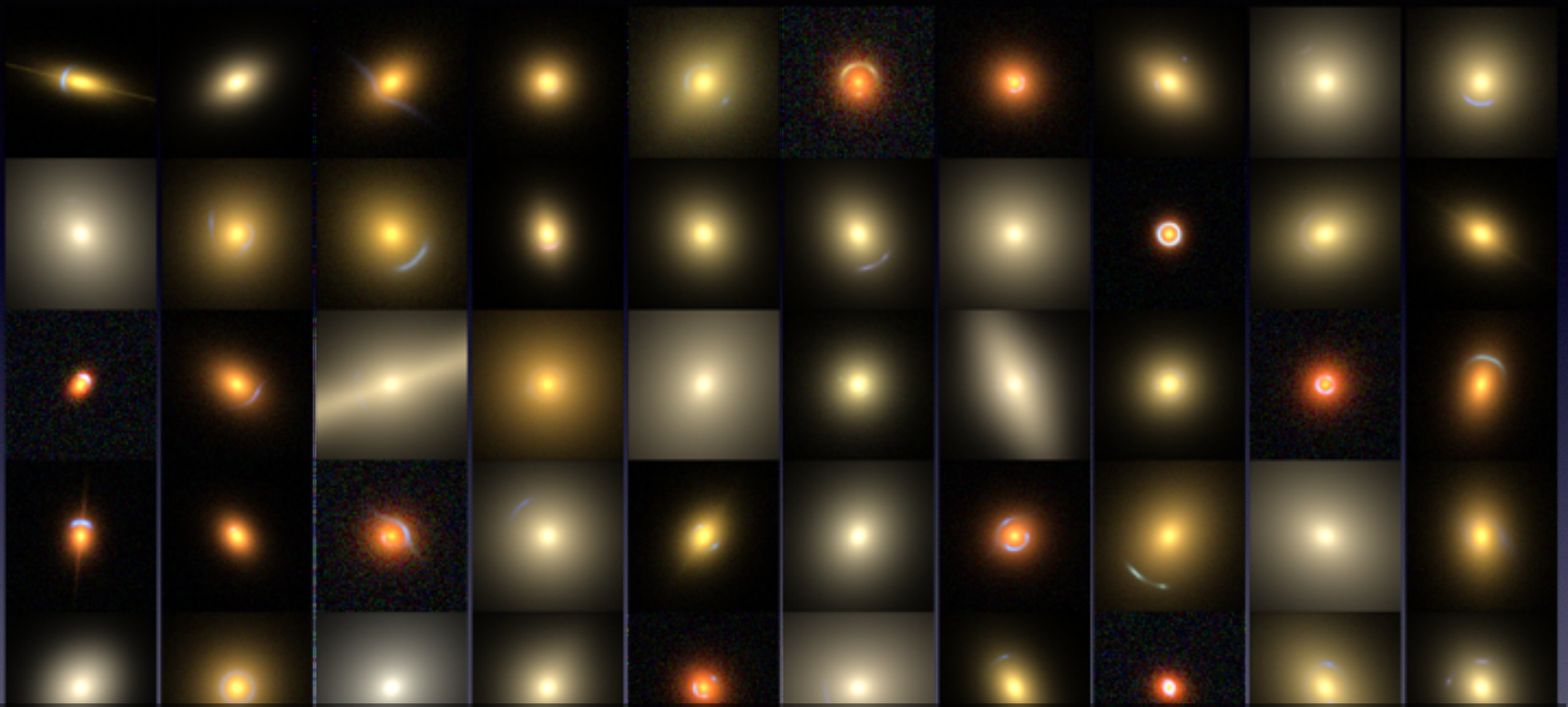
- ~100000 galaxy scale strong lens systems (currently ~400), Including ~1000 double lens system
- Hundreds of massive clusters with many multiple images
- Accurate photo-z for both lens and source.

Chinese Space Station telescope
Launch in 2023/2024

Provide by Yiping Shu



Hubble HFF



500k simulated galaxy-galaxy strong lenses based on CosmoDC2. Each image includes the flux in gri-bands, and the morphological model of the galaxies (both lens and source) is bulge + disk in the form of Sersic profile.

By Nan Li, Dezi Liu, Ran Li

Summary

- Subhaloes detected from Einstein ring systems provide a promising way to distinguish WDM and CDM model.

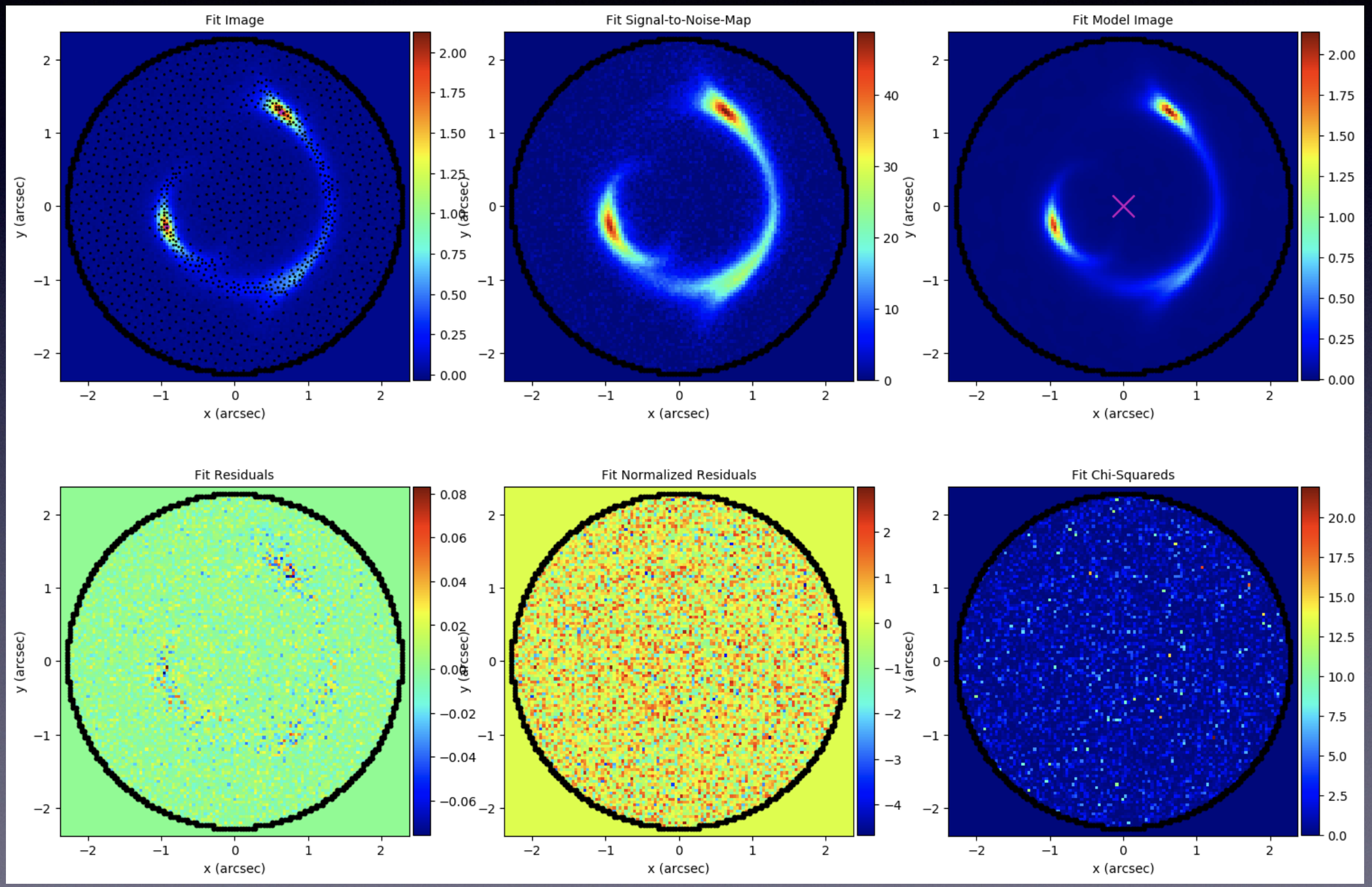
- 20 lenses with M_low=10e7 Msun, can put strong constraints on the mass function cut-off in WDM.

- Decreasing M_low is much more important than increase N_lens.

- LOS effect and structure of perturbers are important.

- For VLBI-like observation with mas resolution, GCs can be detected on strong lensing Einstein ring.

Calibrate the false detection rate



By Xiaoyue Cao