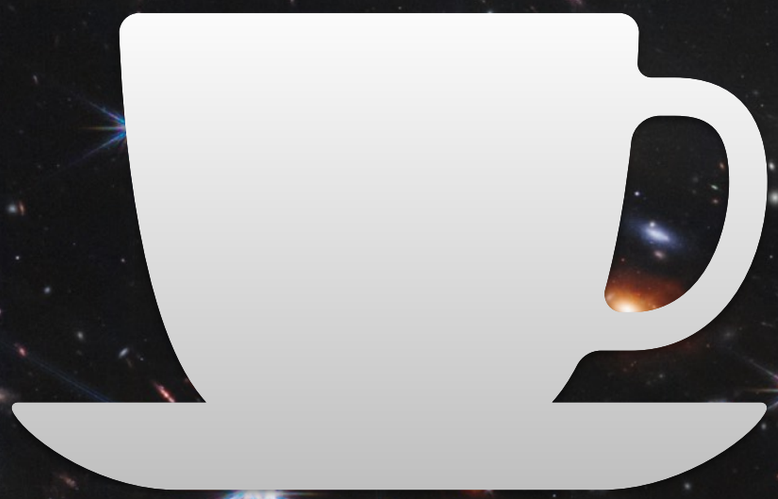
The Challenges Brought by the JWST Observations of the Distant Universe.

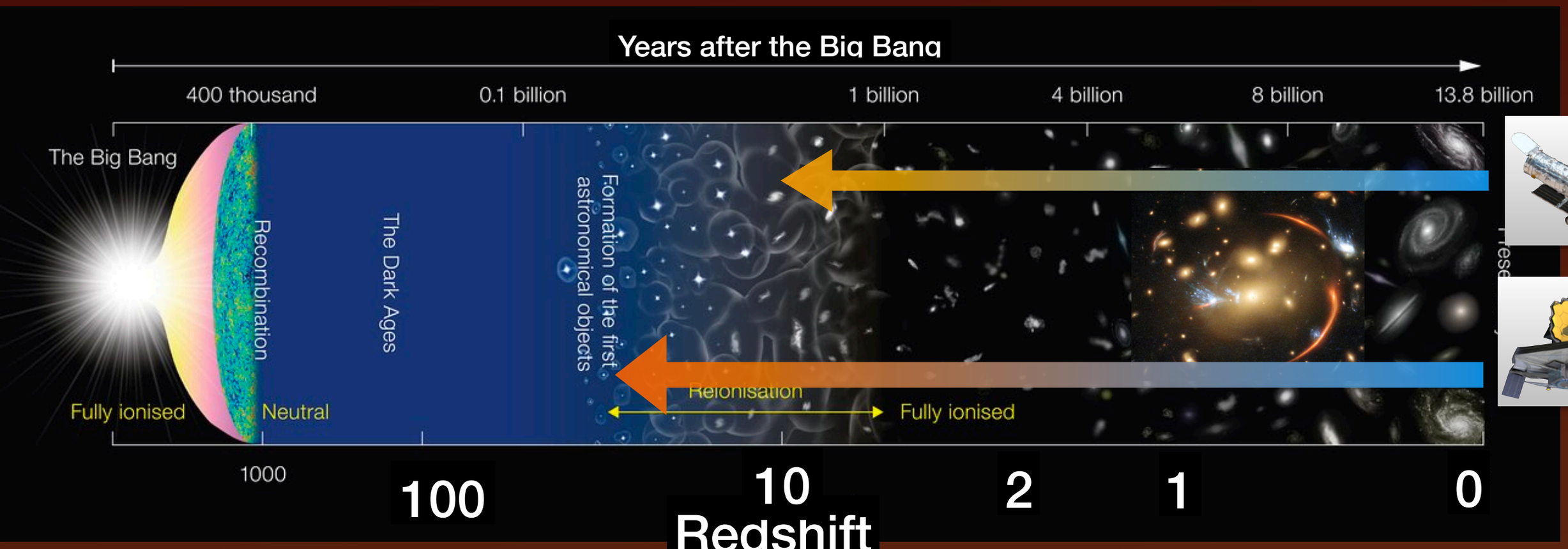
Guillaume Mahler (he/him) "Gyom"
Durham University

Main collaborators:
Mathilde Jauzac, David Lagattuta, Catherine Cerny, Nency Patel, Anna Niemiec, Keren Sharon, Johan Richard, Mike Gladders, Jane Rigby, Richard Massey

News From the Dark 8 - Université Libre de Bruxelles 13 September 2023



Cosmological evolution of our universe

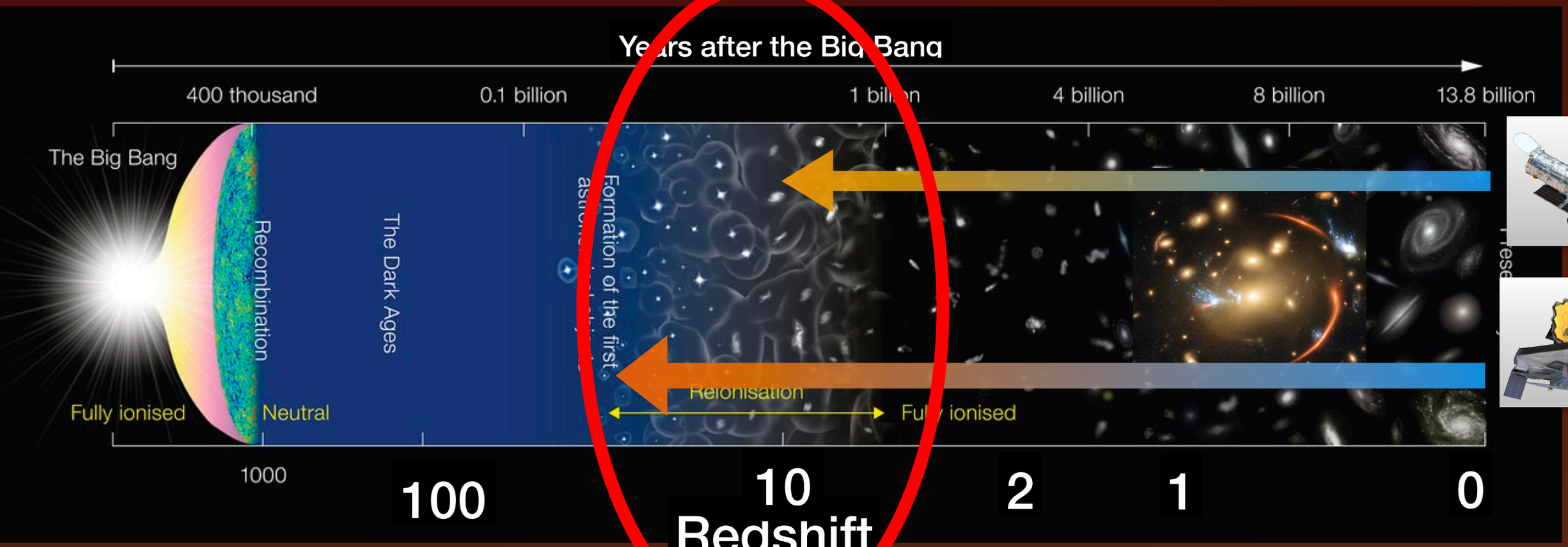


JWST can see the first galaxies

Cosmological evolution of our universe

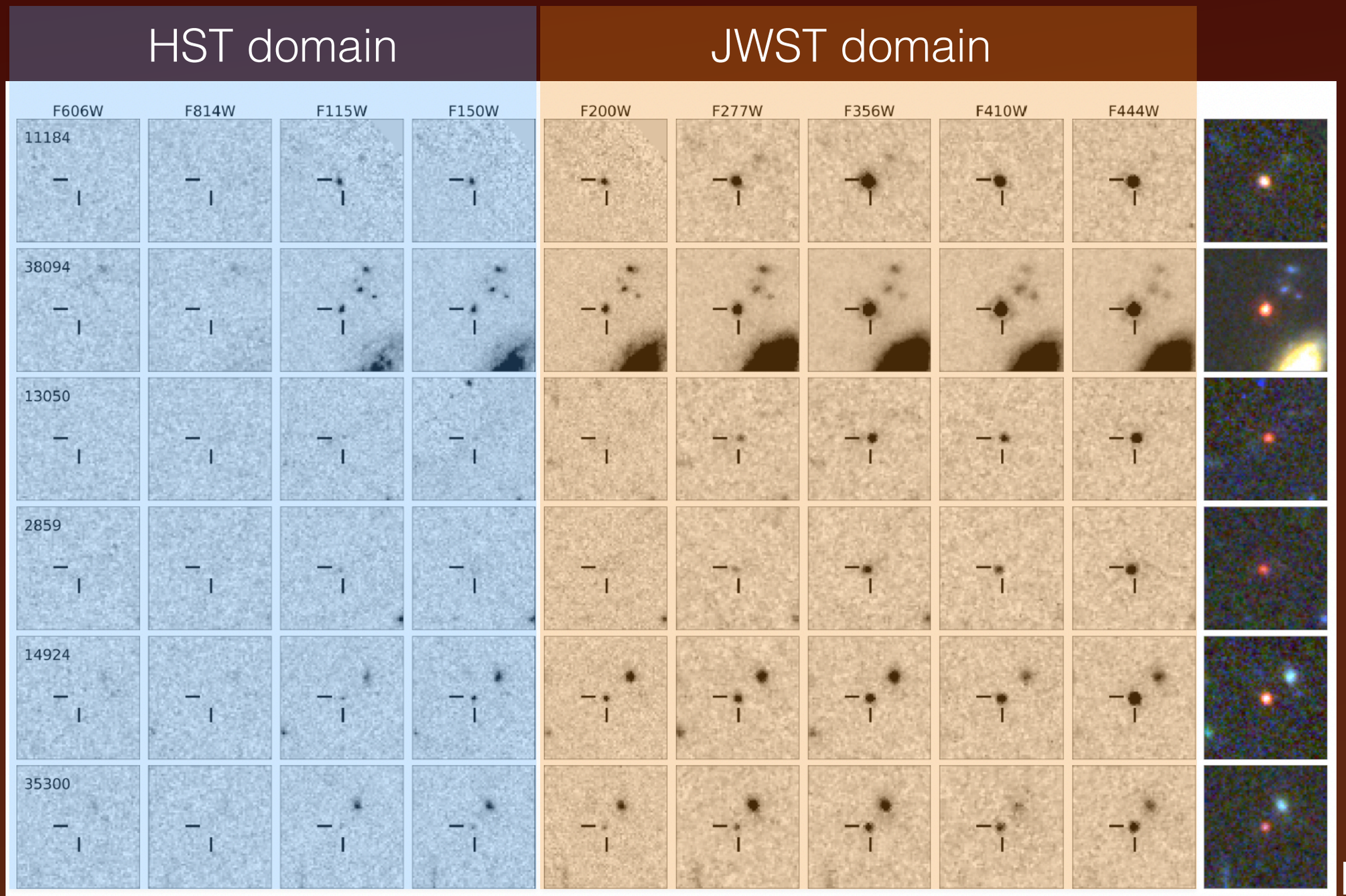
JWST can see the first galaxies

Cosmological evolution of our universe



JWST can see the first galaxies

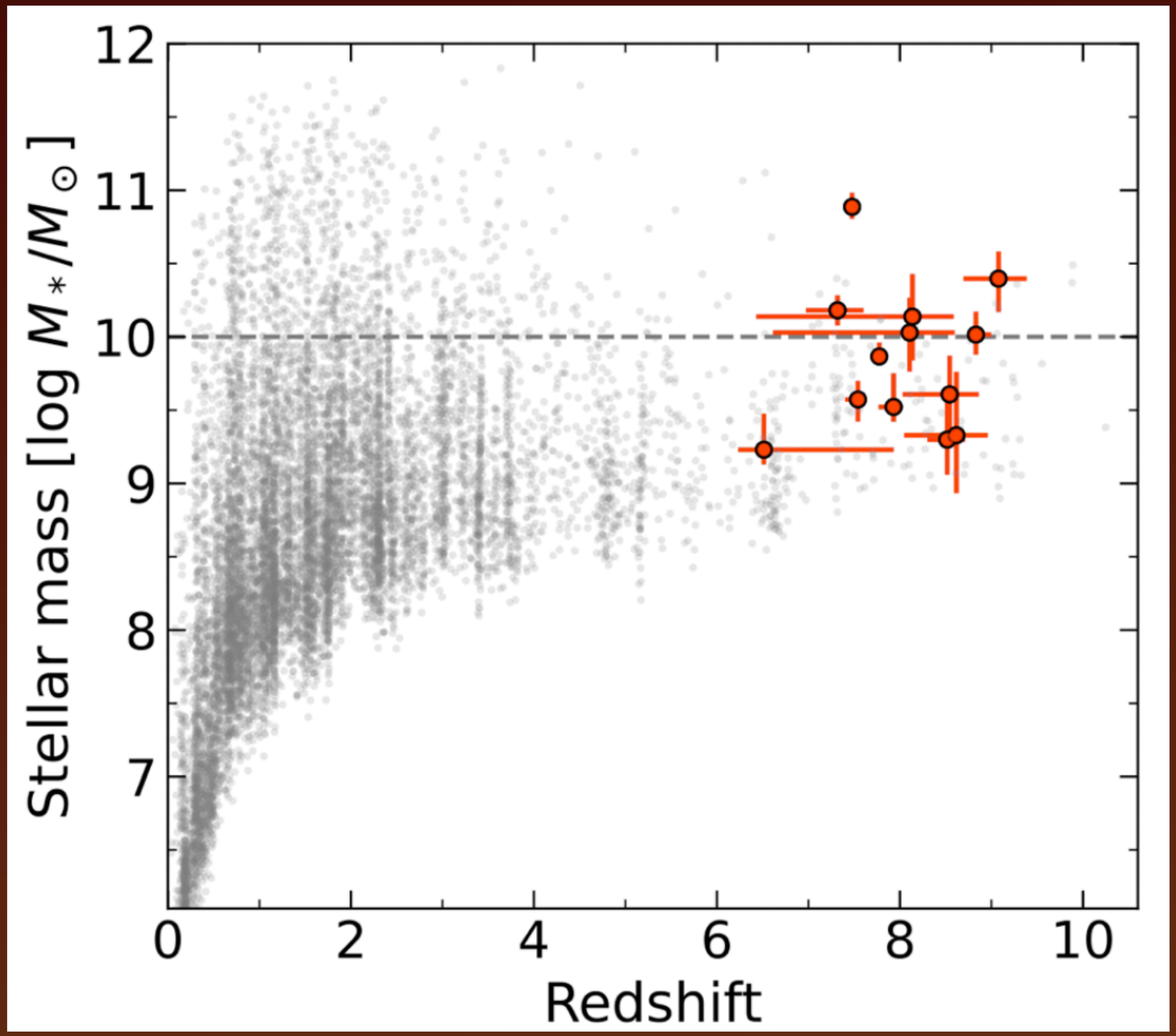
Very high-z massive galaxies, too massive?



Labbé+23

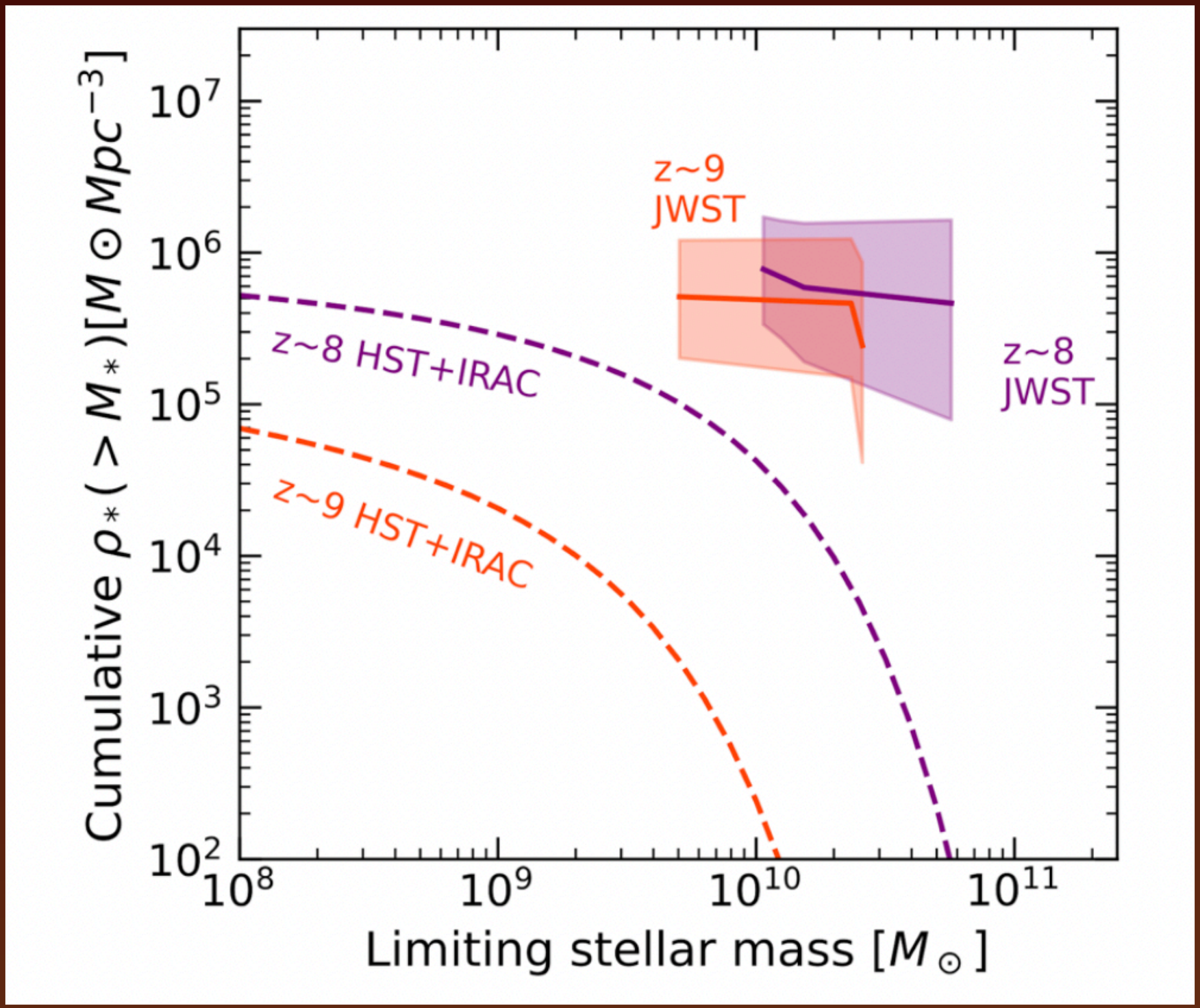
JWST first year programs (CEERS, ERO, FRESCO, etc..), reported 10^9 Msun Atek+22; Finkelstein+22); Harikane+22); Naidu+22); Yan+22, Biagetti+23, Labbé+23, Xia+23 and others.

Very high-z massive galaxies, too massive?



Labbé+23

Very high-z massive galaxies, too massive?



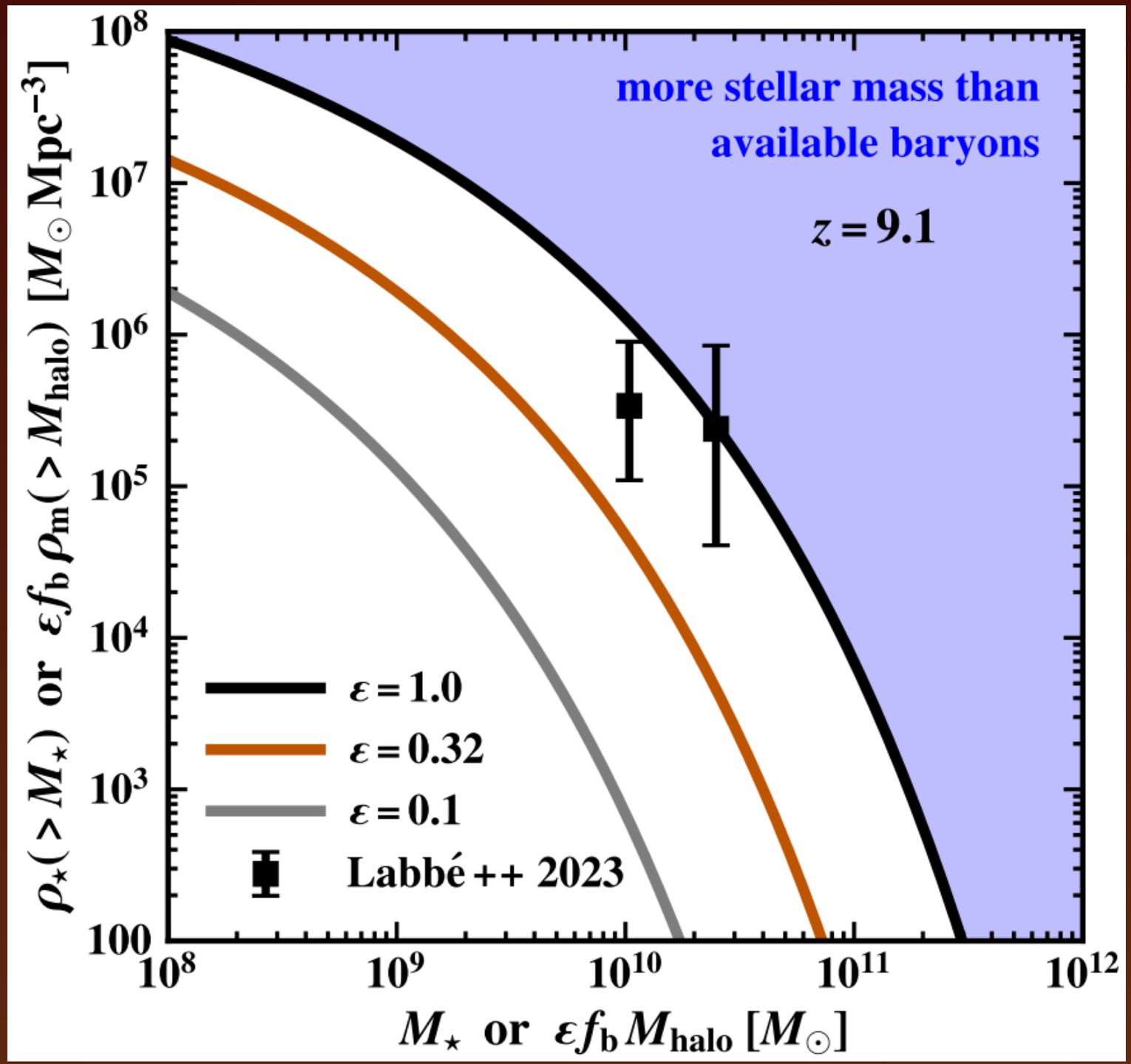
Labbé+23

Very high-z massive galaxies, too massive?

$$M_\star = \varepsilon f_\mathrm{b} M_\mathrm{halo}$$

f_b = 0.156
Planck+2020

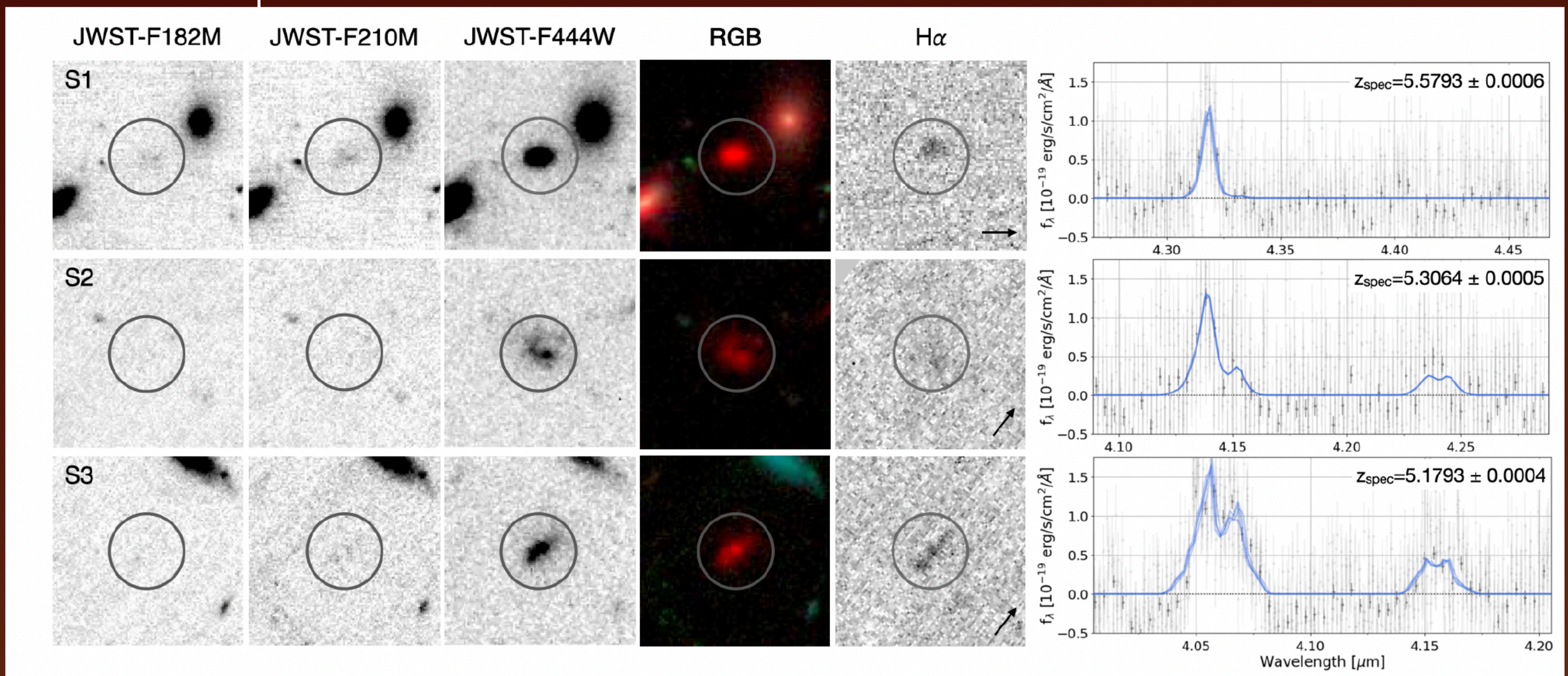
ε Efficiency to convert baryon to stars



Boylan-Kolchin+23

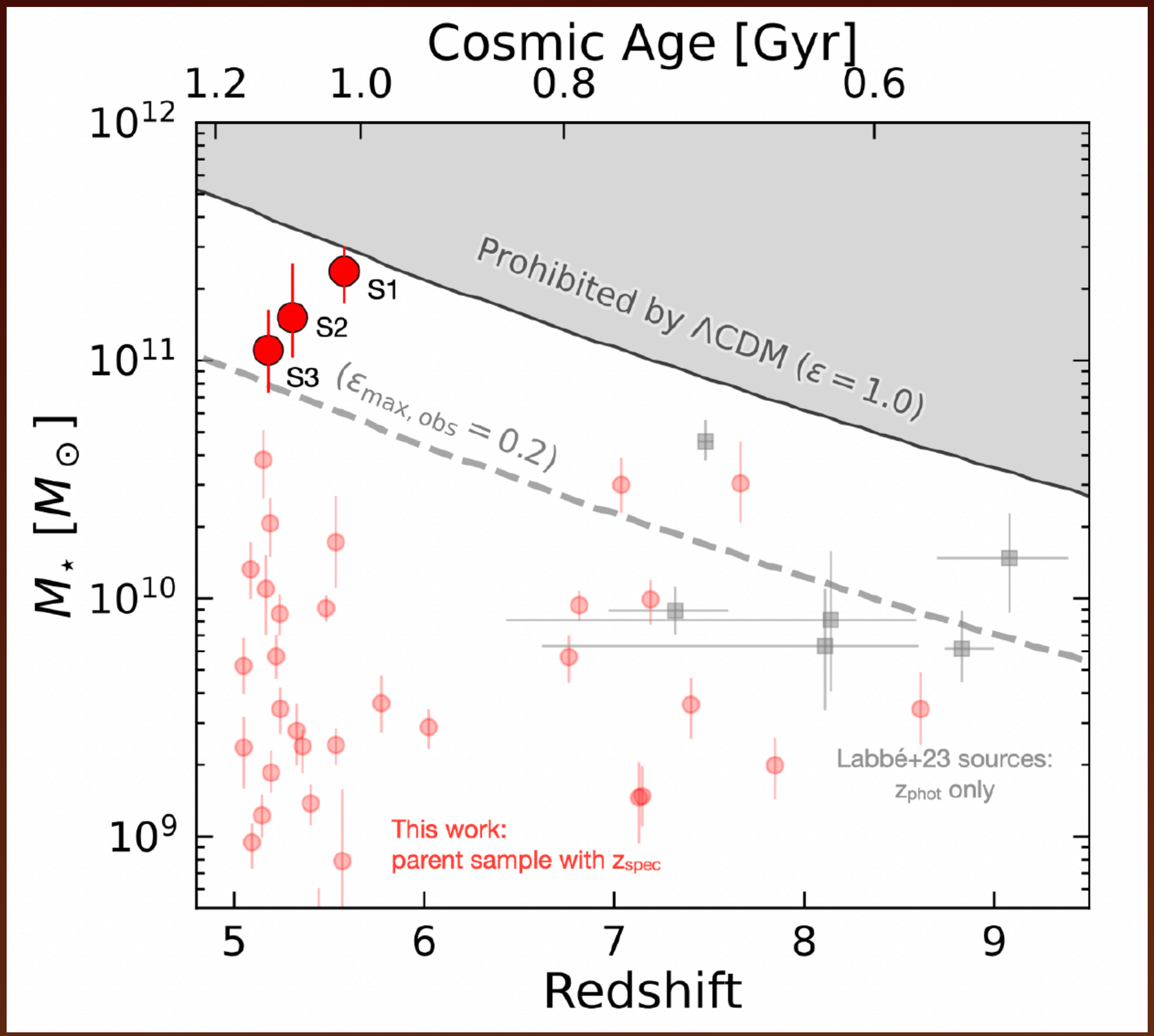
Very high-z massive galaxies, too massive?

Even with spec-z



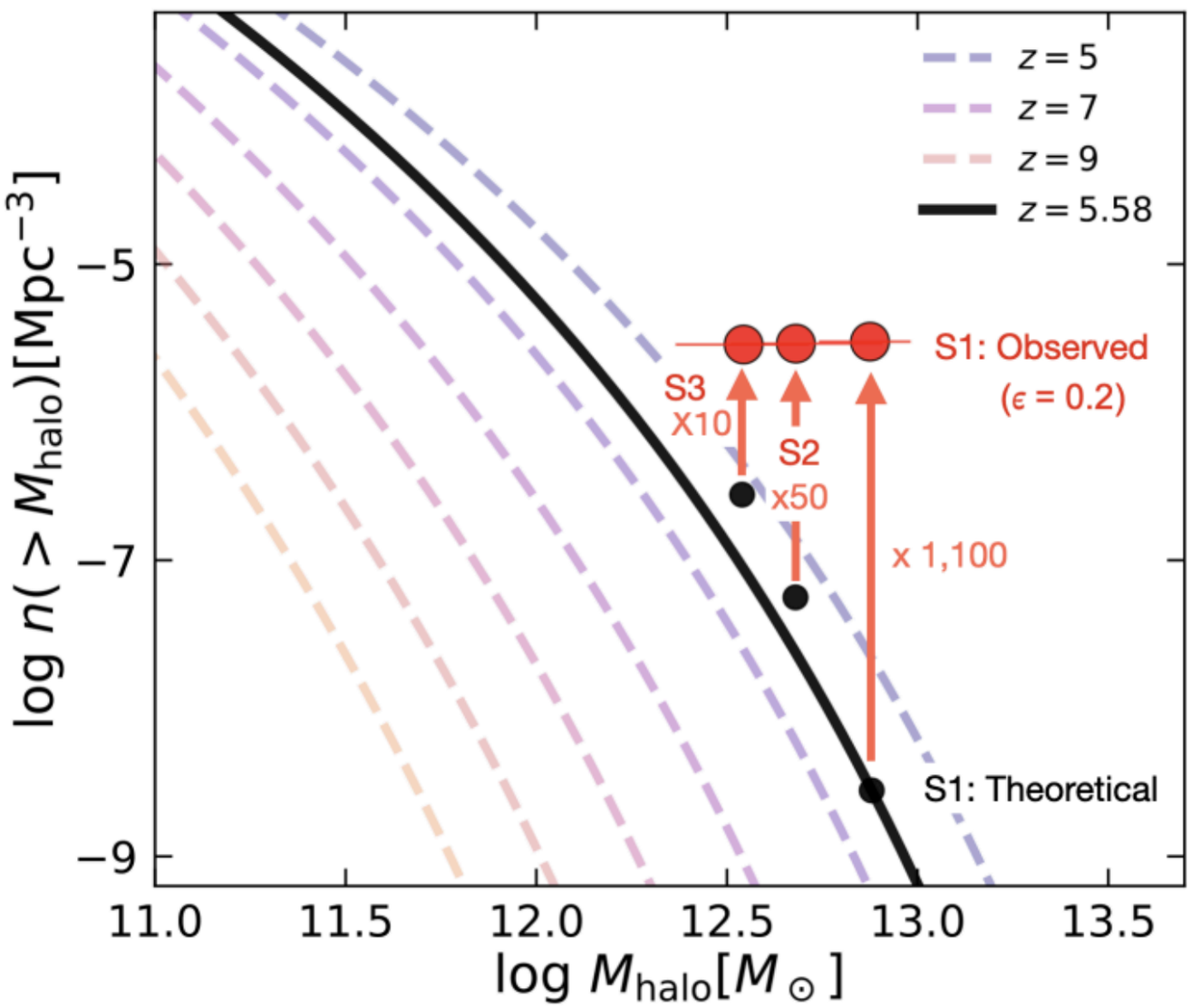
Xiao,Oesch+23

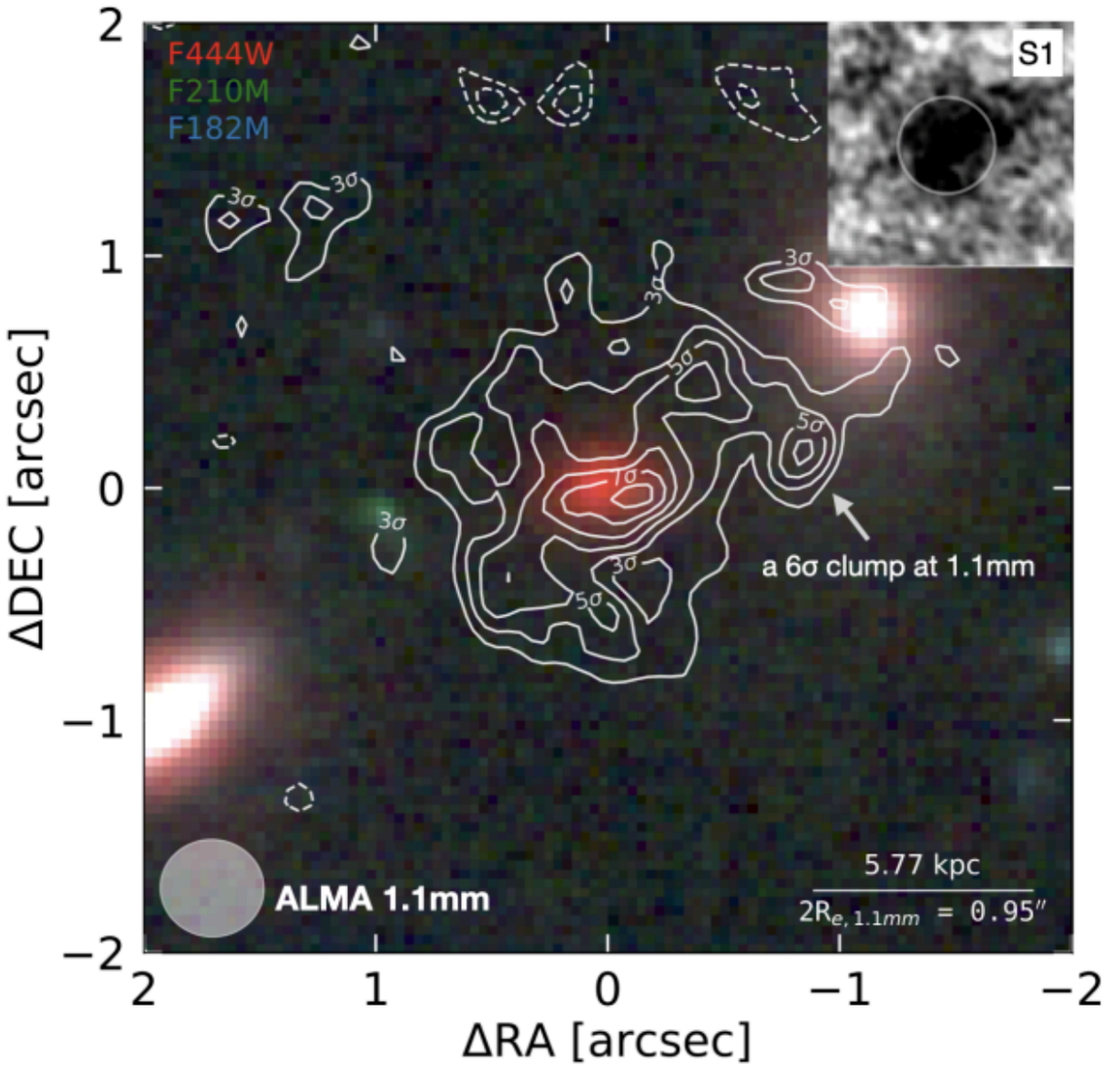
Very high-z massive galaxies, too massive?



Xiao,Oesch+23

Very high-z massive galaxies, too massive?





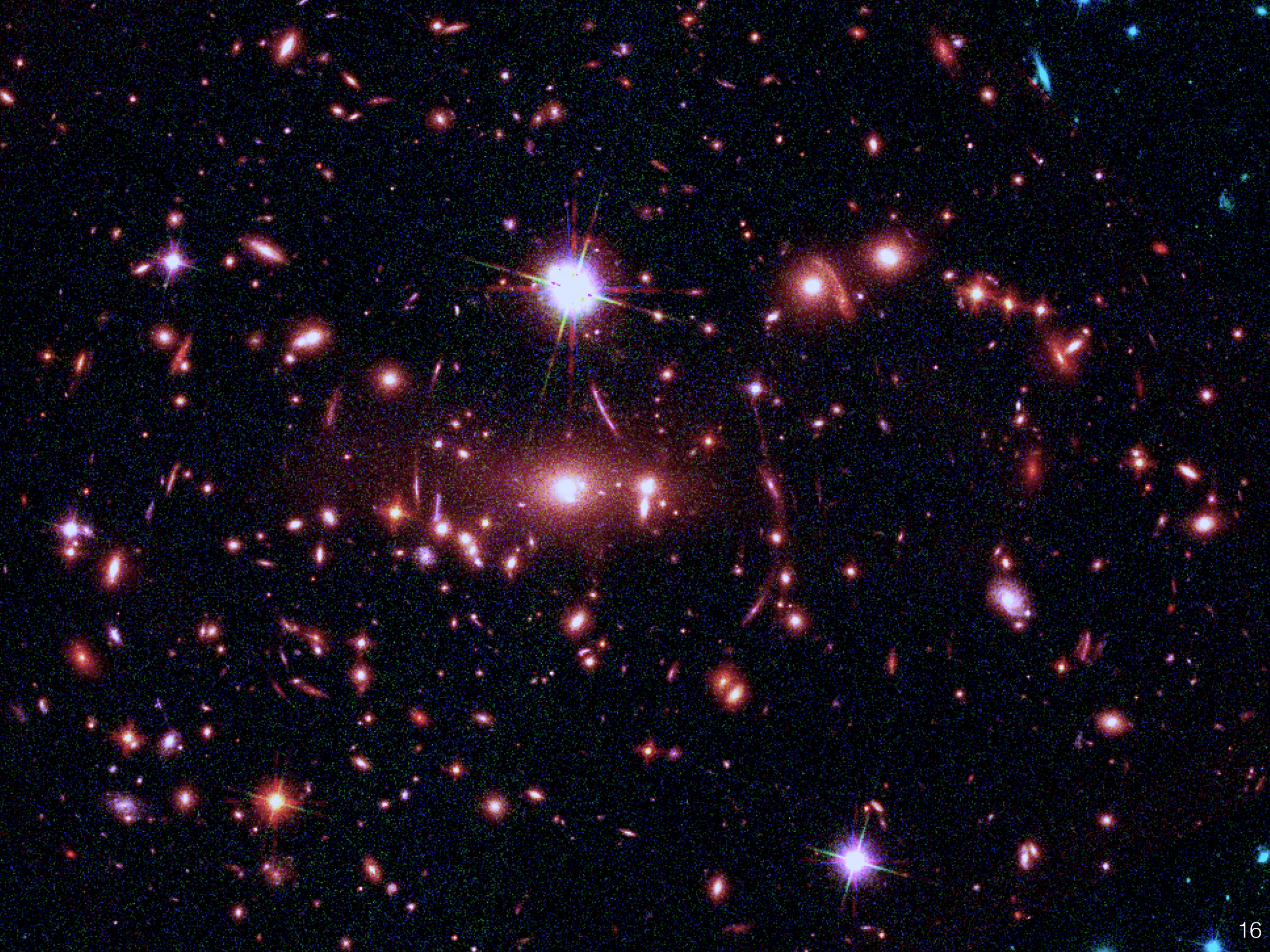
Xiao,Oesch+23

What strong lensing is ?

www.spacetelescope.org

SMACS J0723.3-7327

The journey to a mass model…



Building a lens model

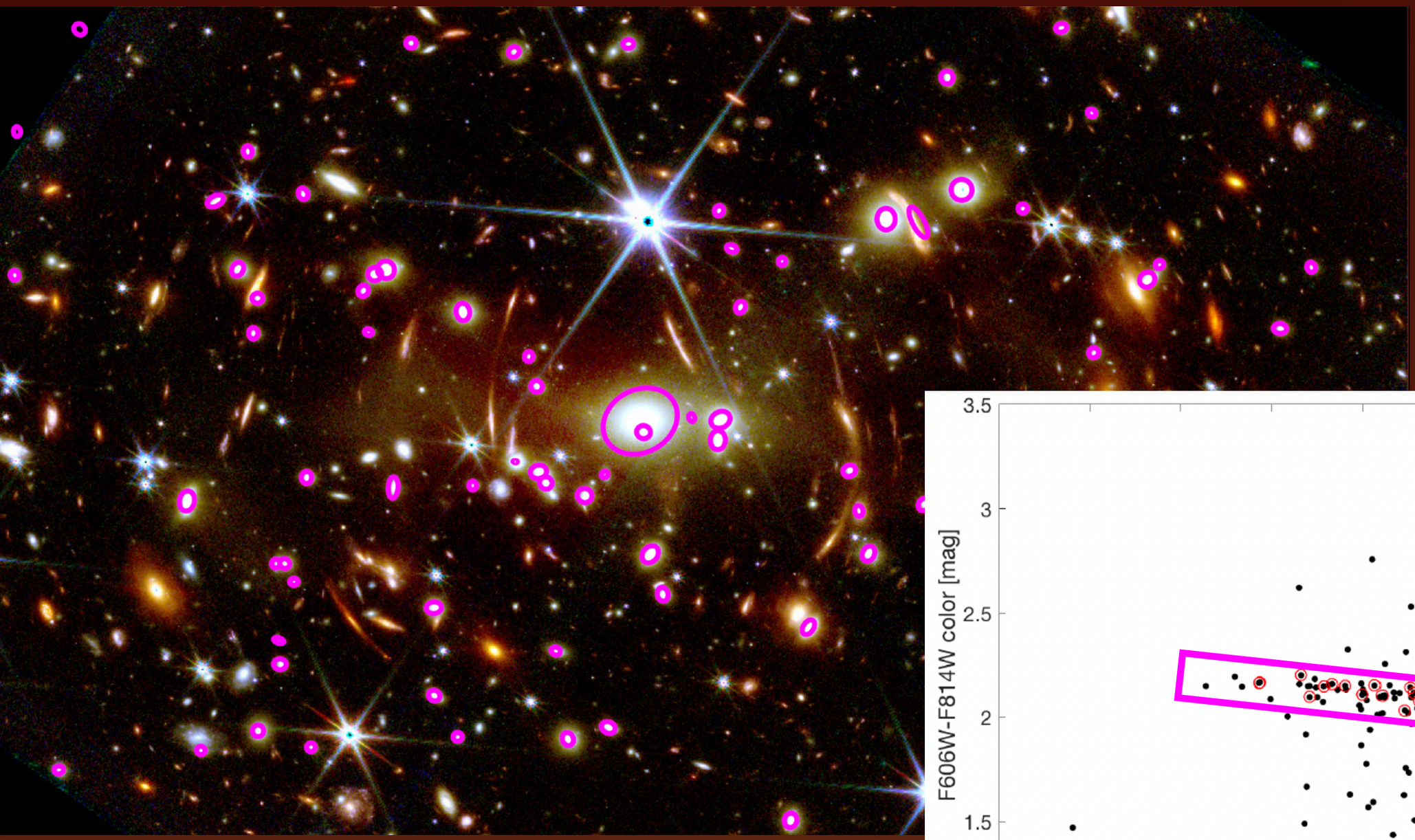
…with Lenstool

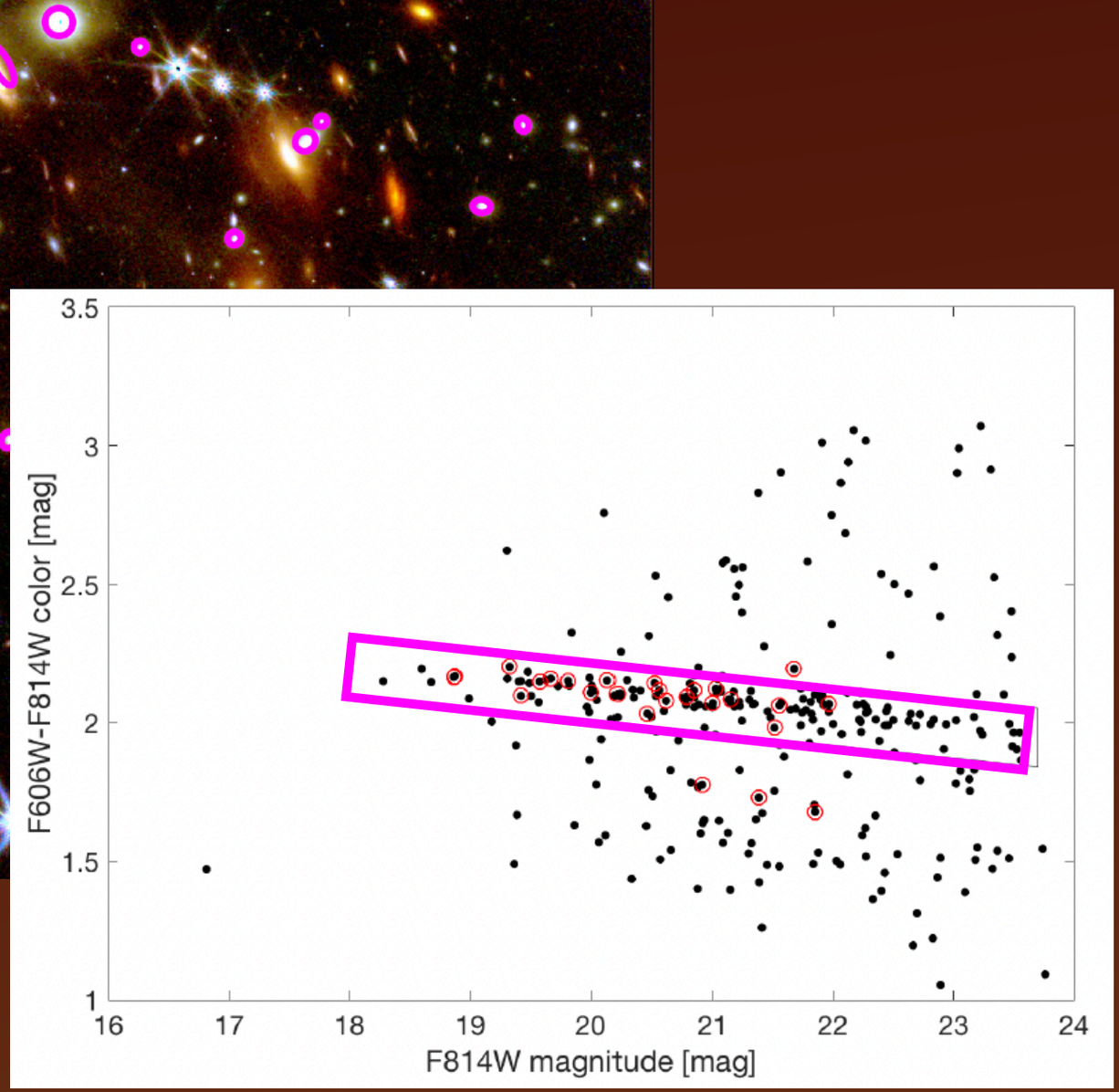
Find the lensing constraints

SMACS0723

Building a lens model

…with Lenstool

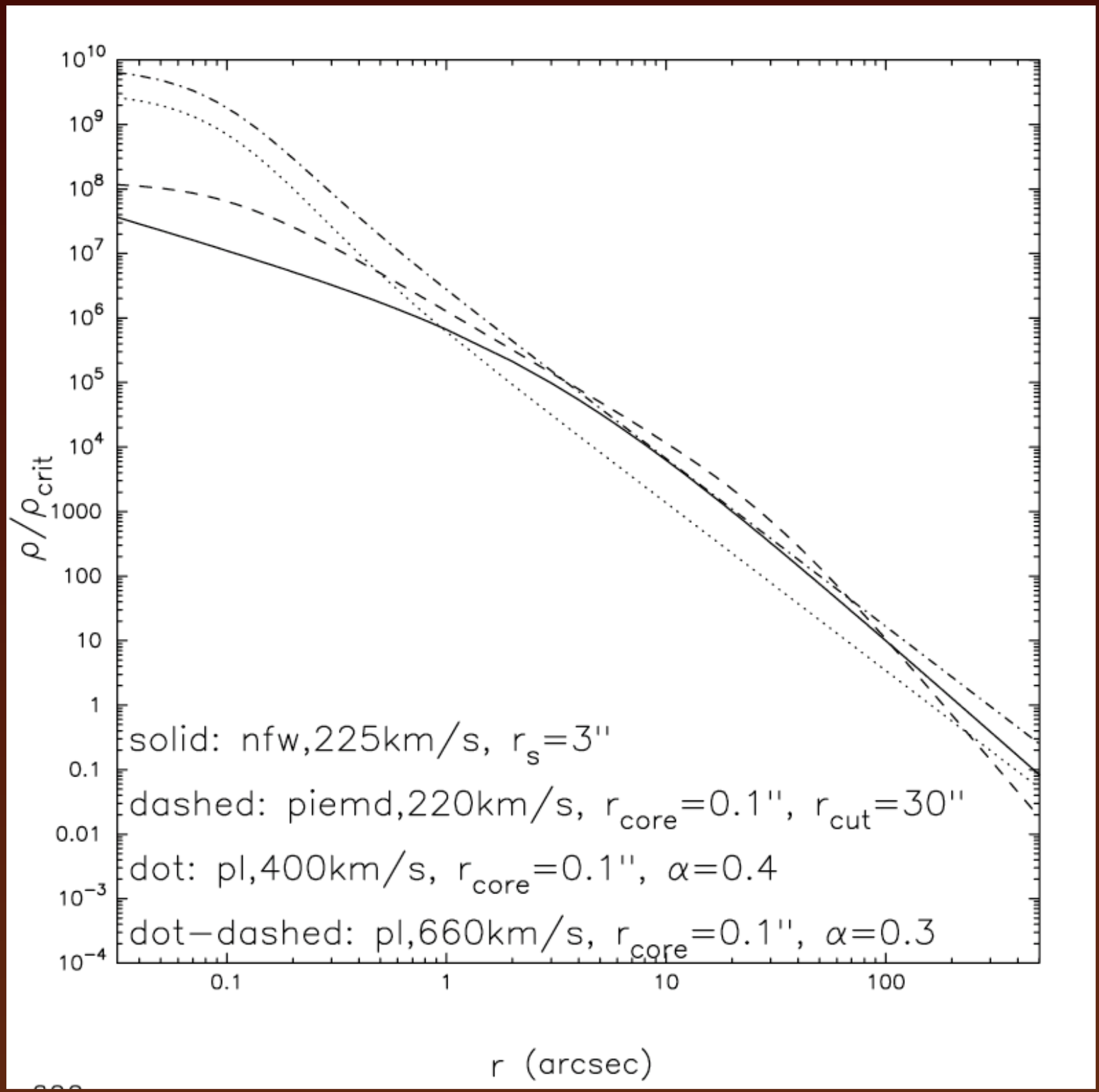




Locating the “red sequence”

Building a lens model

…with Lenstool

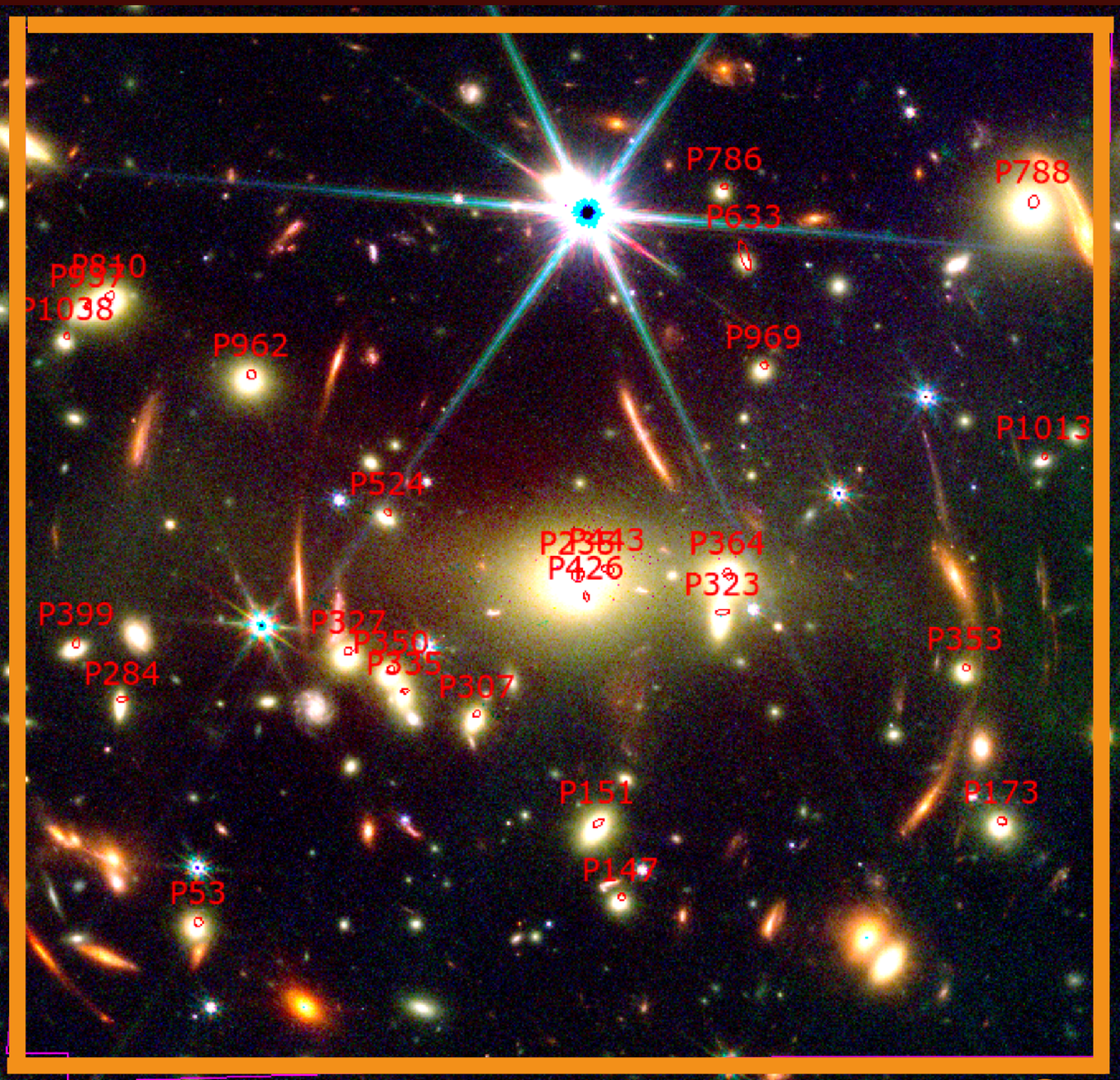


Limousin+05

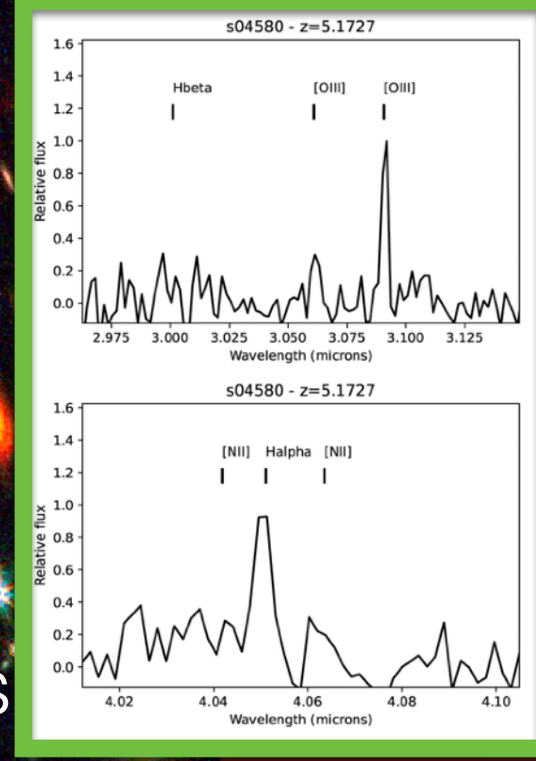
Building a lens model

…with Lenstool

NIRSpec

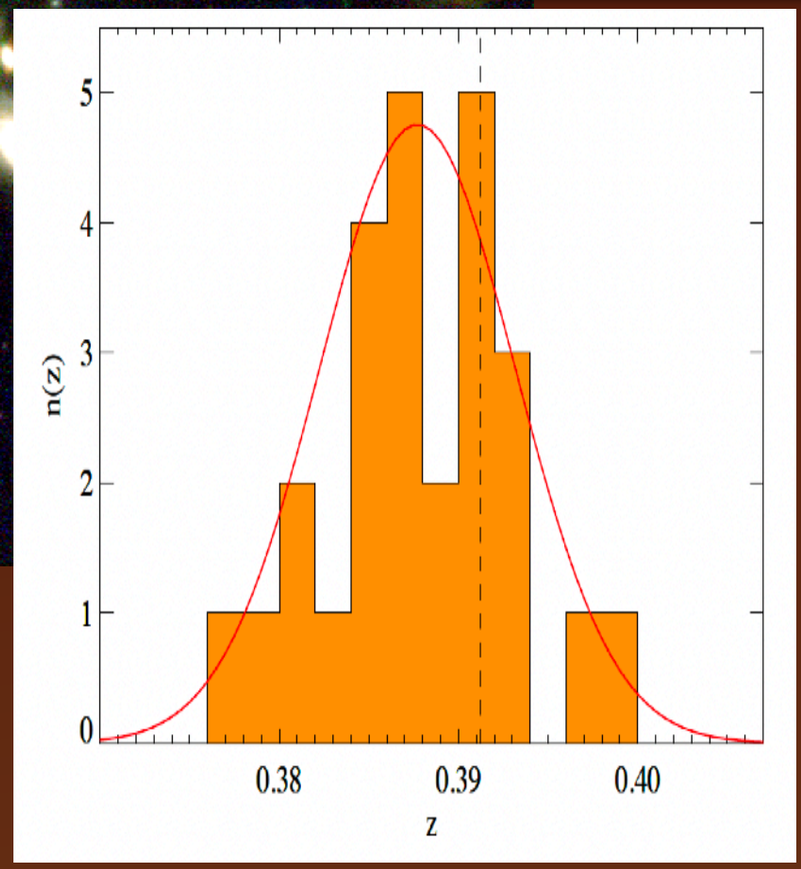


MUSE



Lensed galaxies

Cluster



Help with spectroscopy

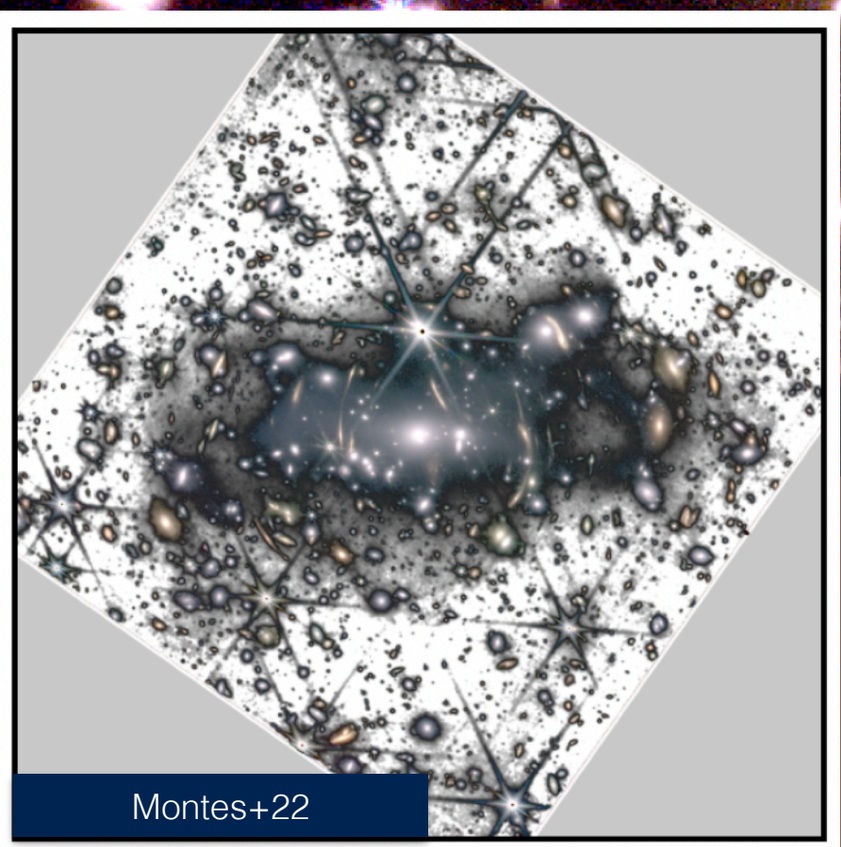
Building a lens model

…with Lenstool

Placing Dark matter…

Building a lens model

…with Lenstool



Montes+22

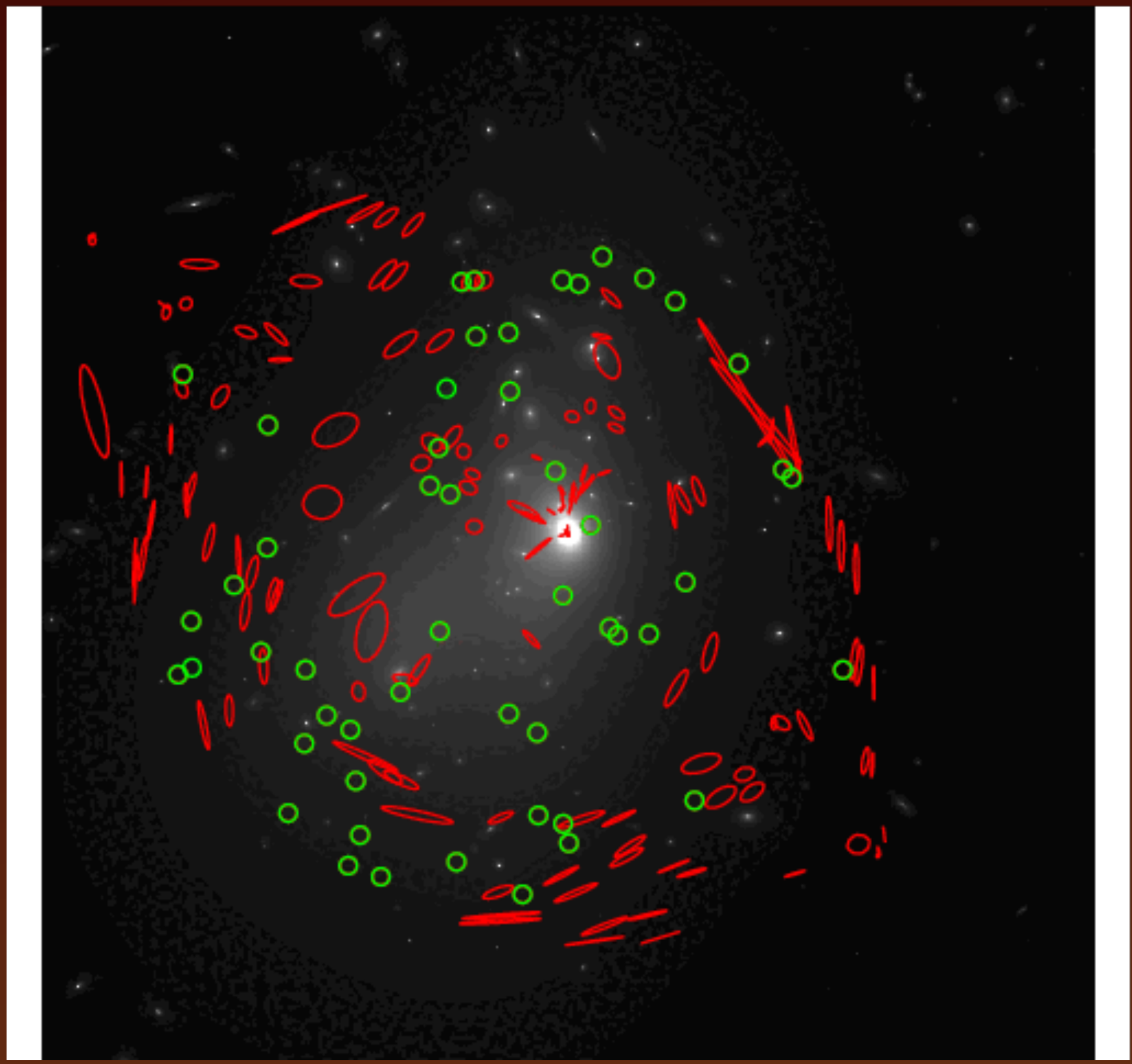
Placing Dark matter…

The unexpected importance of the ICL!!!

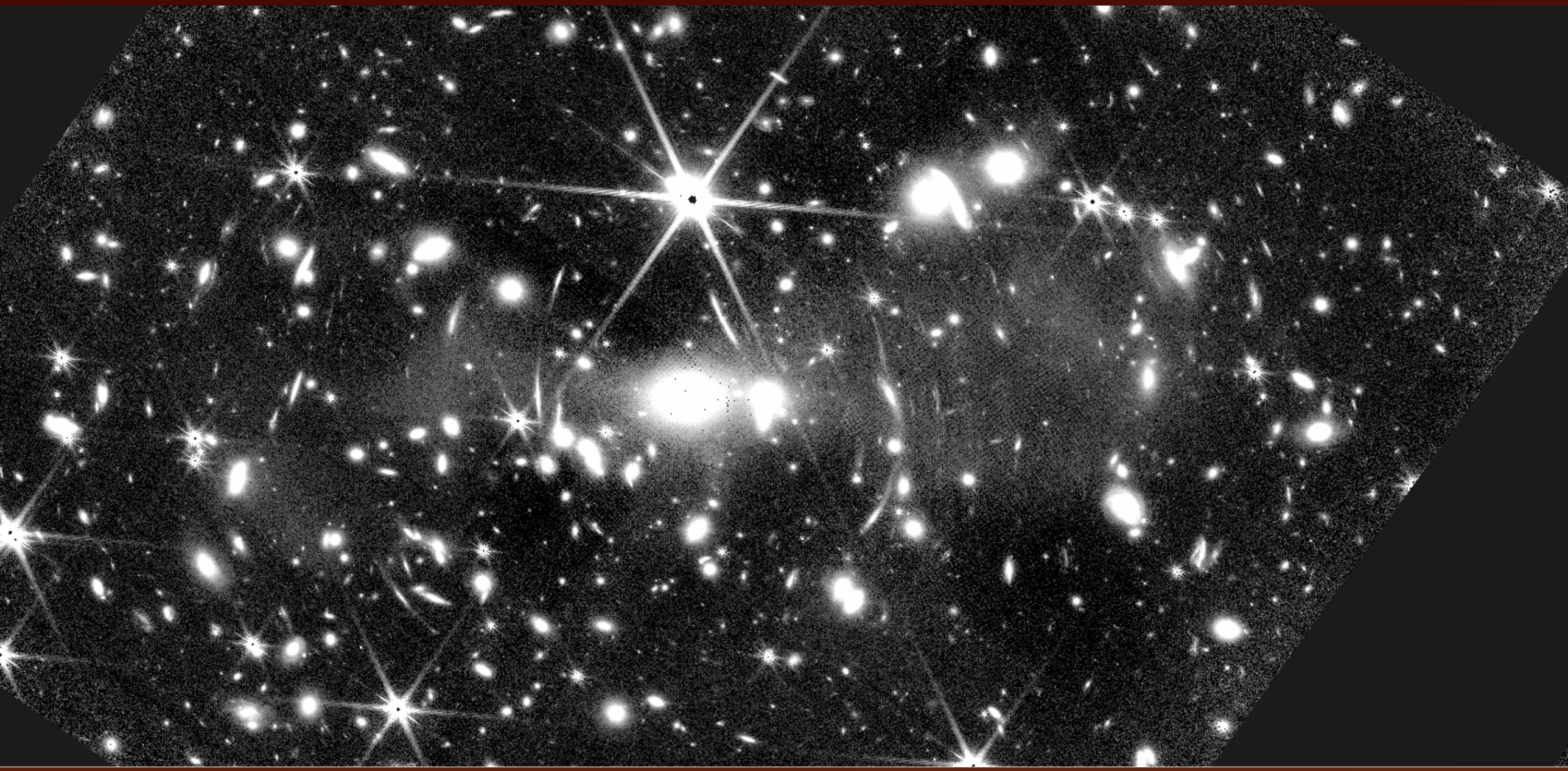
The run of the MCMC chains

Constraints

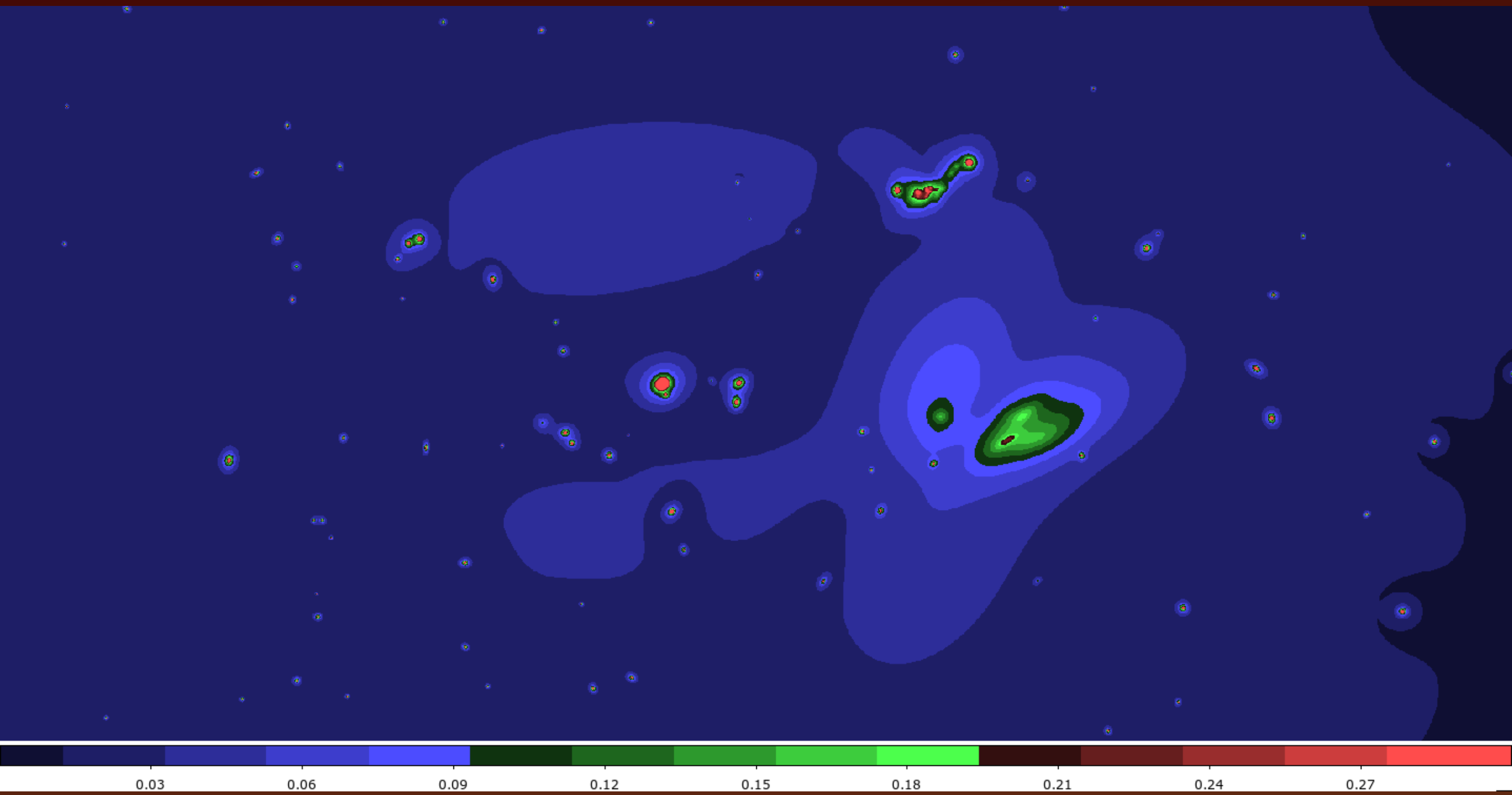
Predictions



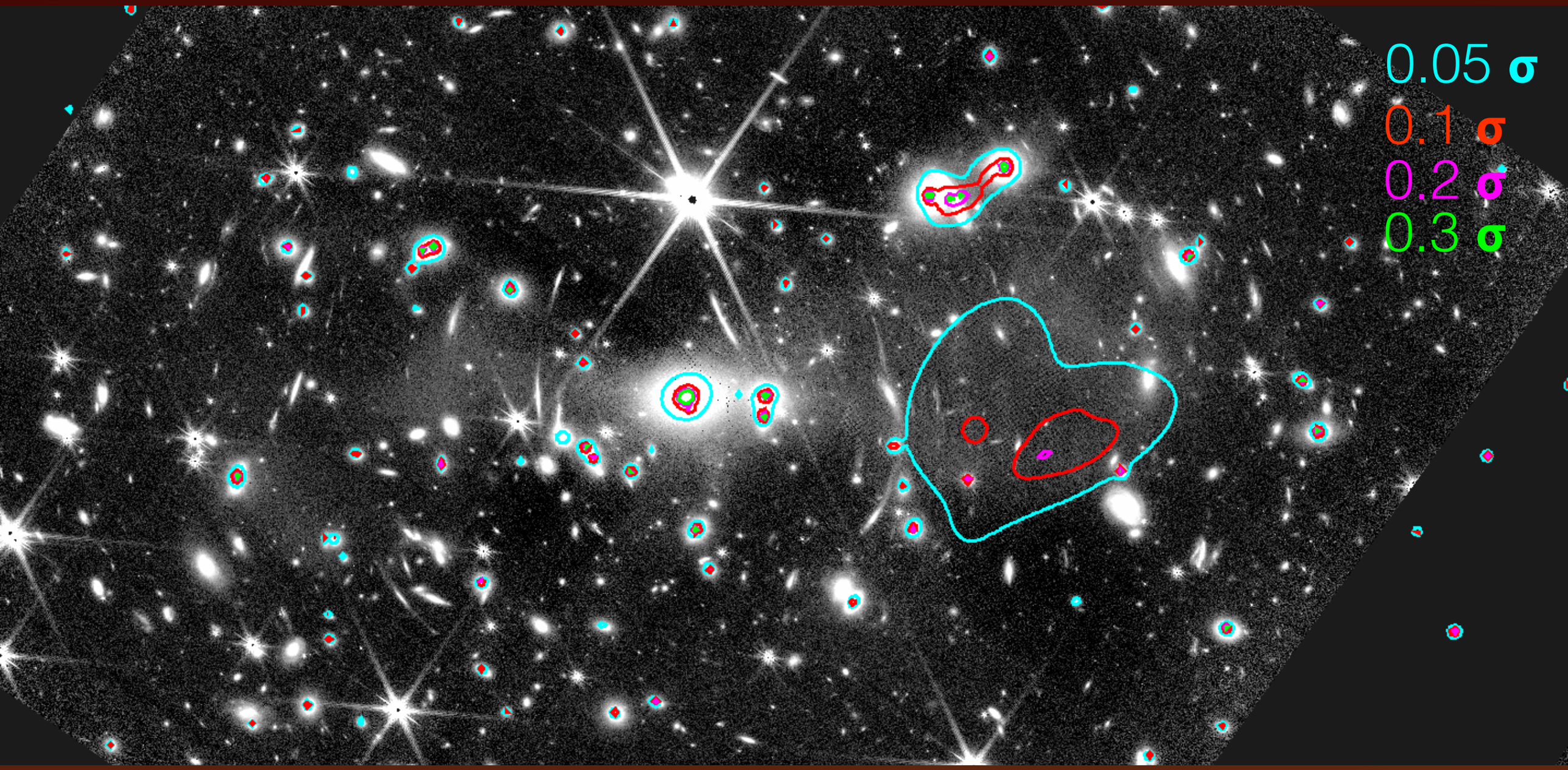
The complexe structure of the Intra-Cluster Light



The complexe structure of the Intra-Cluster Light



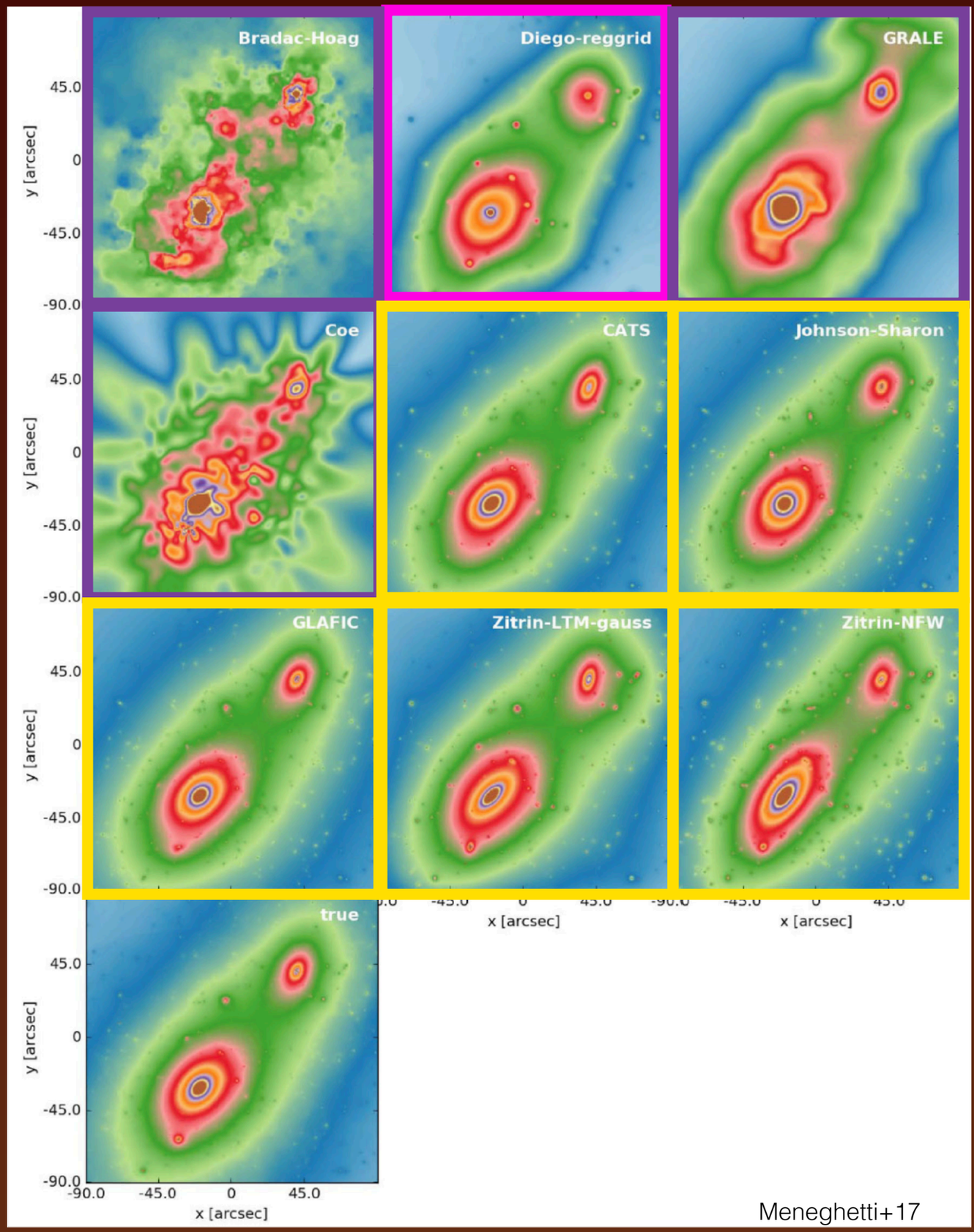
The standard deviation of the mass map



NO ICL clump model rms ~0.85” BIC 454
ICL clump model rms ~0.32” BIC 256

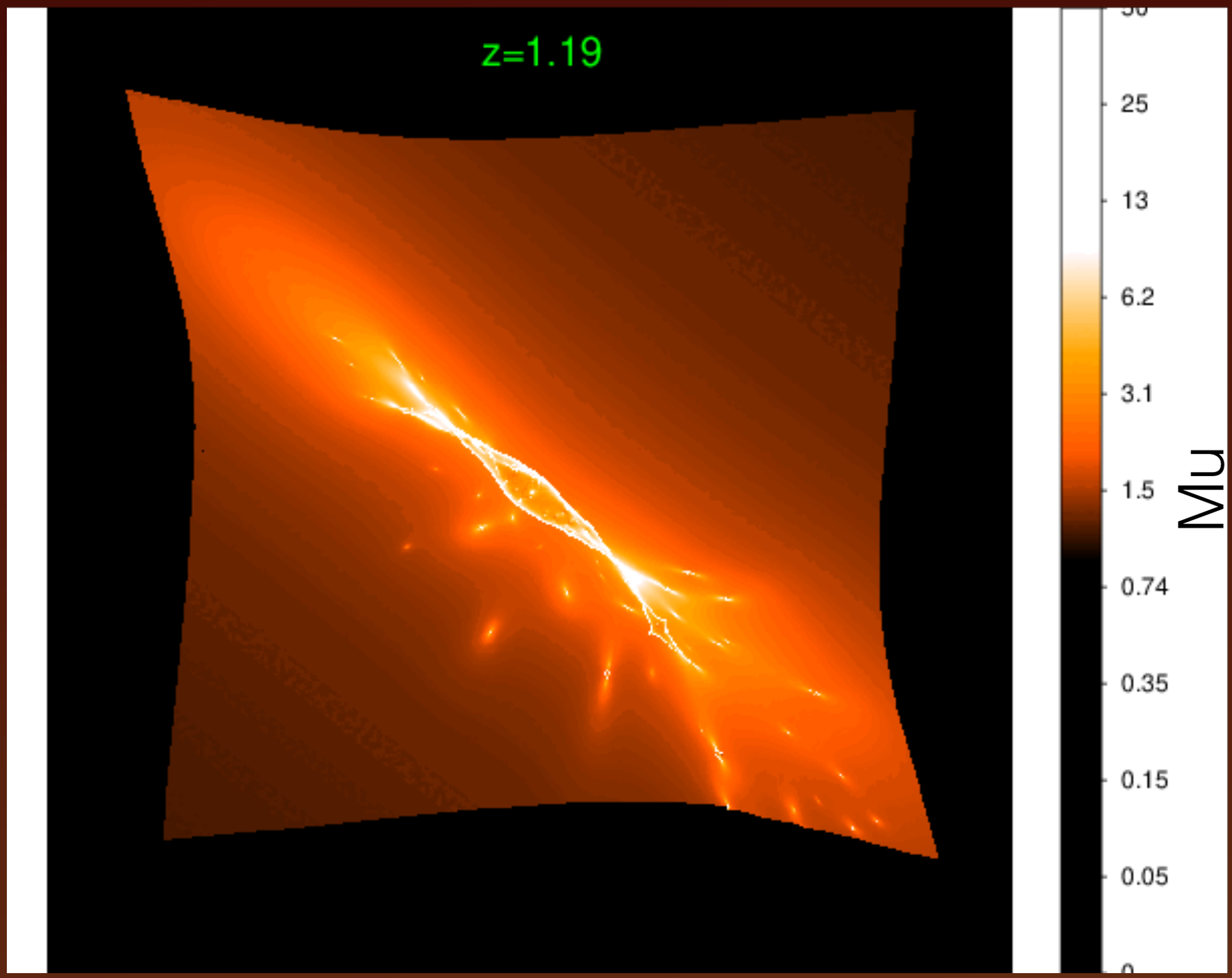
Reverse lensing - modelling

- Parametric
- Free-form
- Hybrid



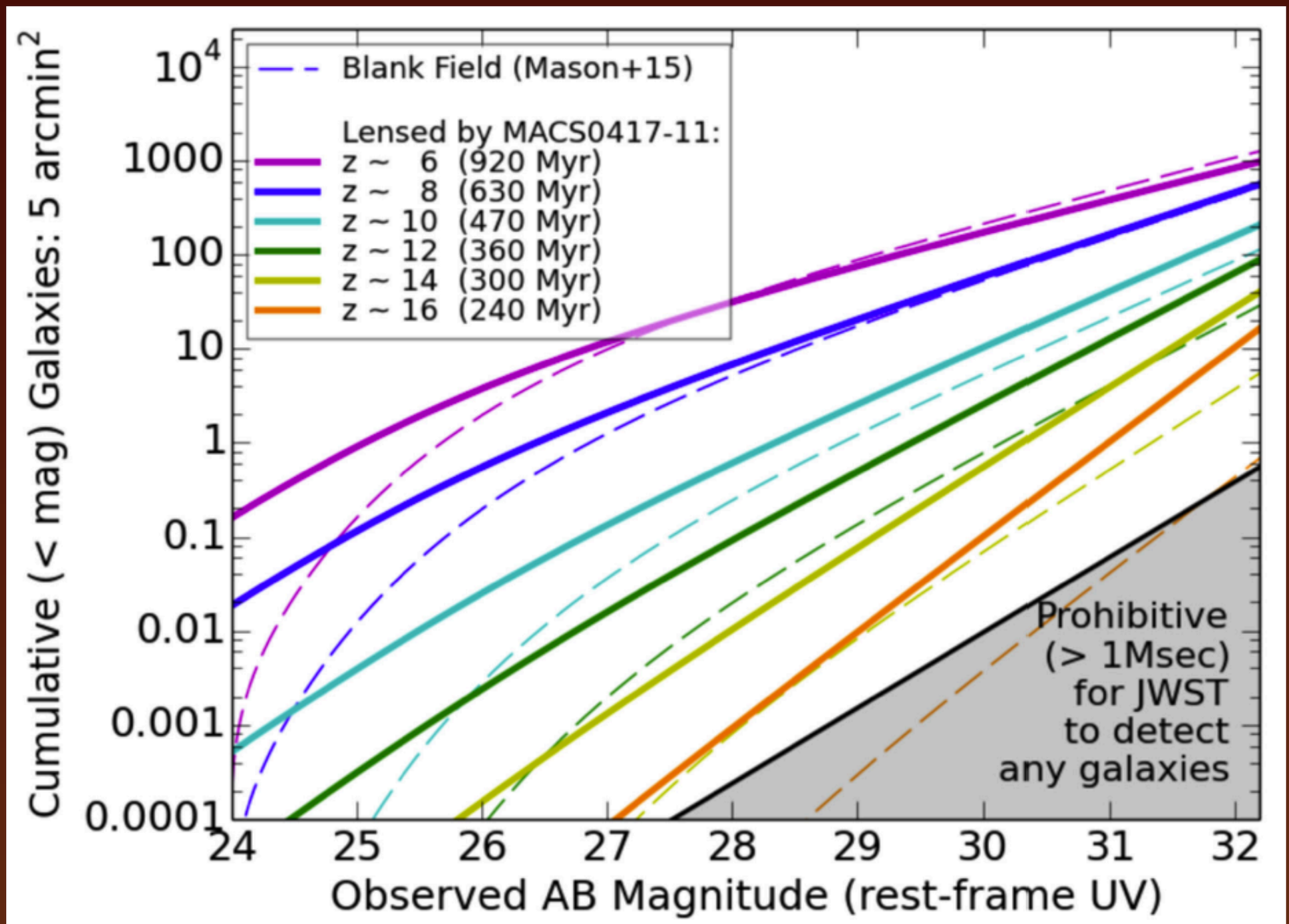
Meneghetti+17

Luminosity function



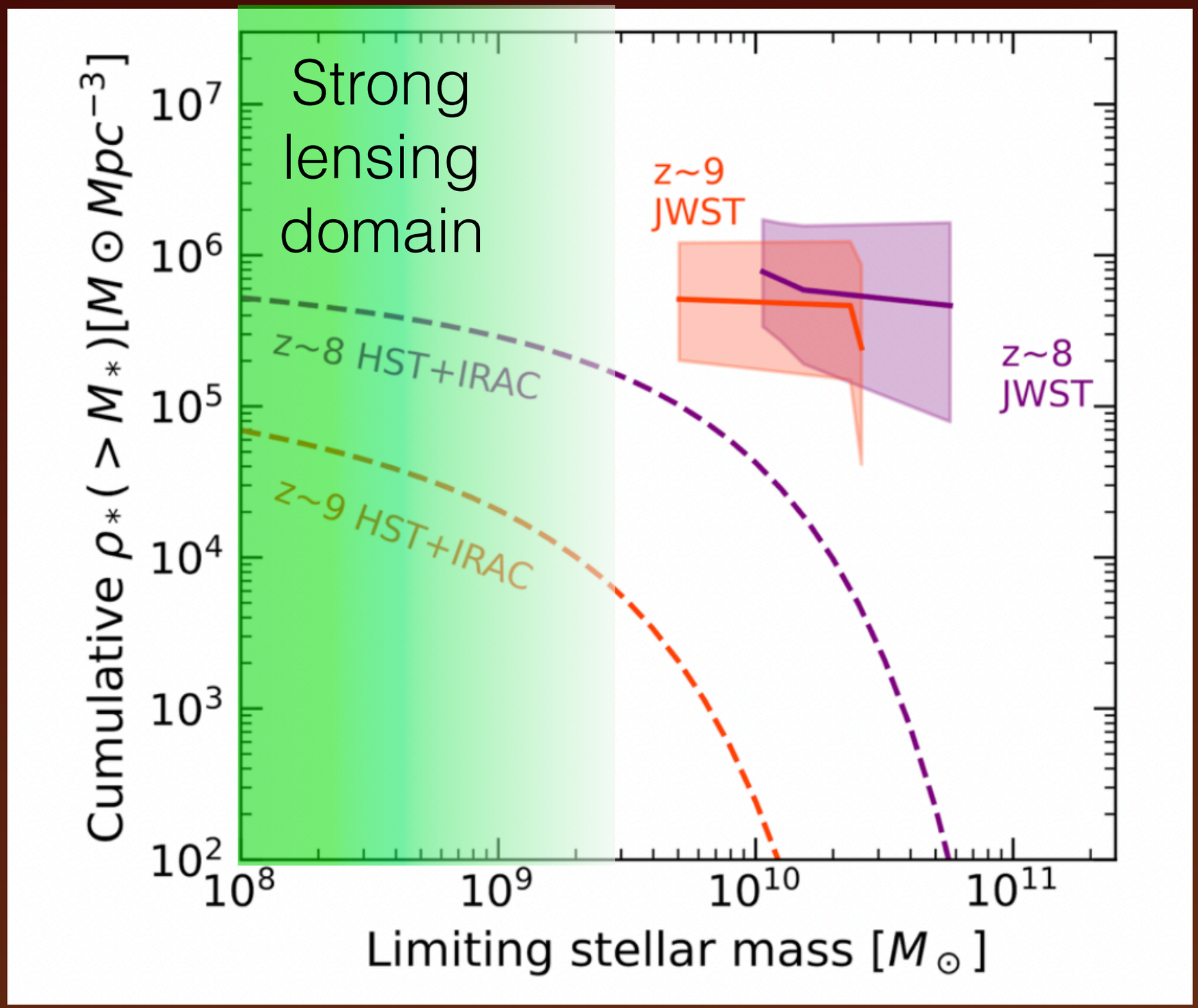
Luminosity function

Mahler+19



Mu

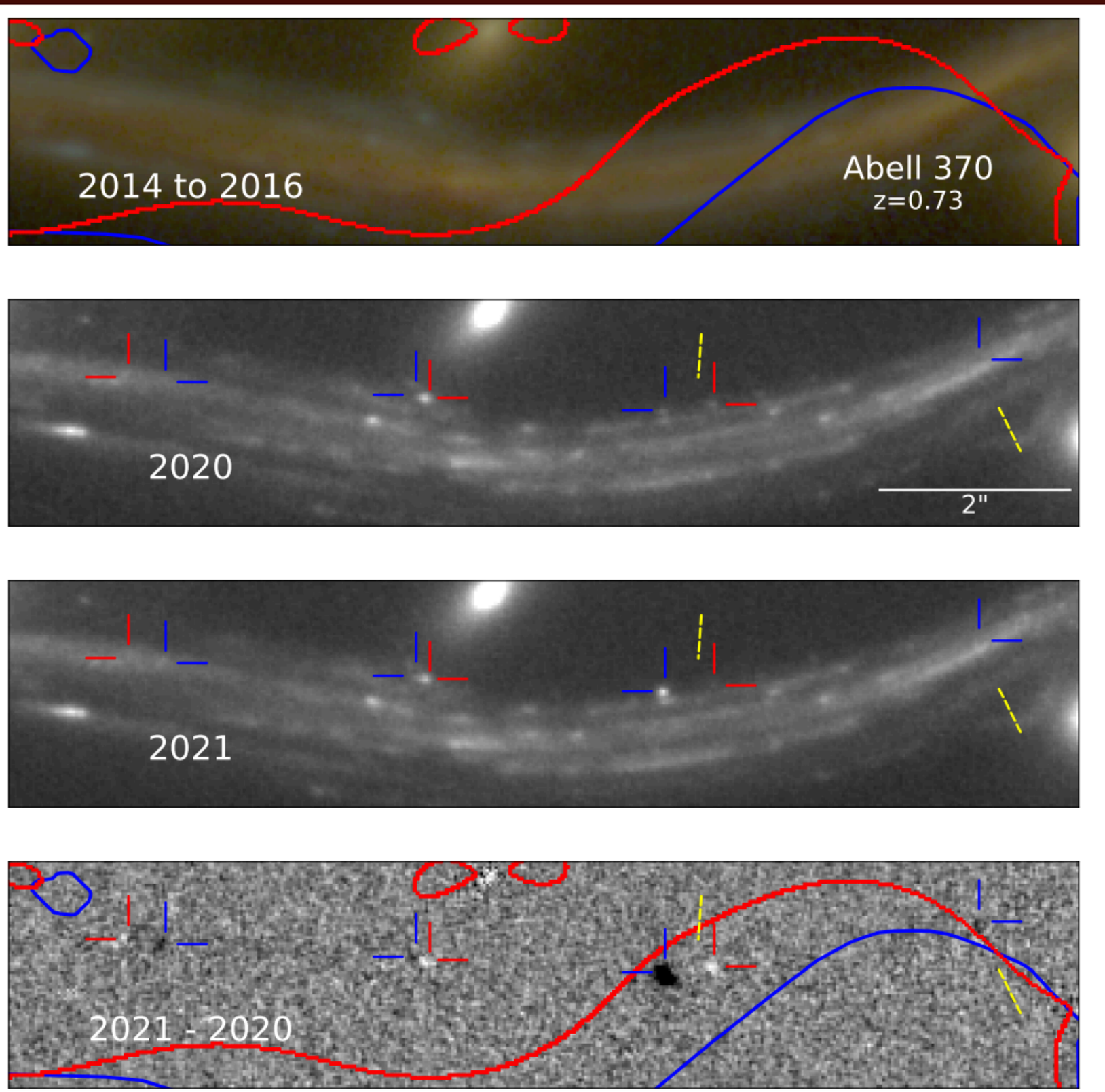
Luminosity function



Mu

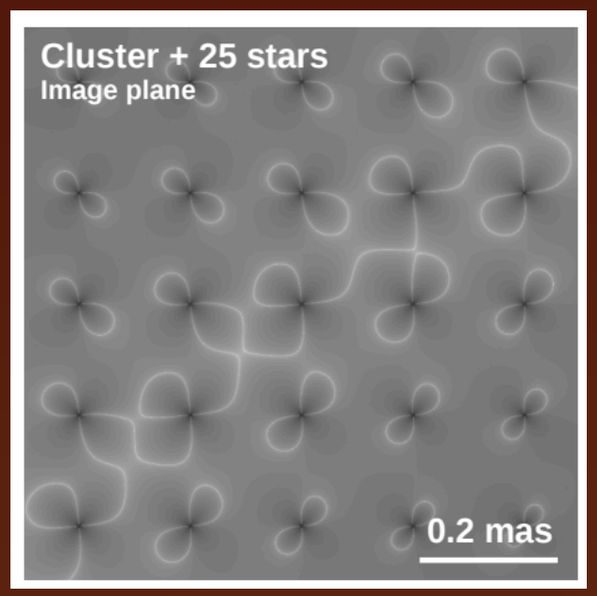
Labbé+23

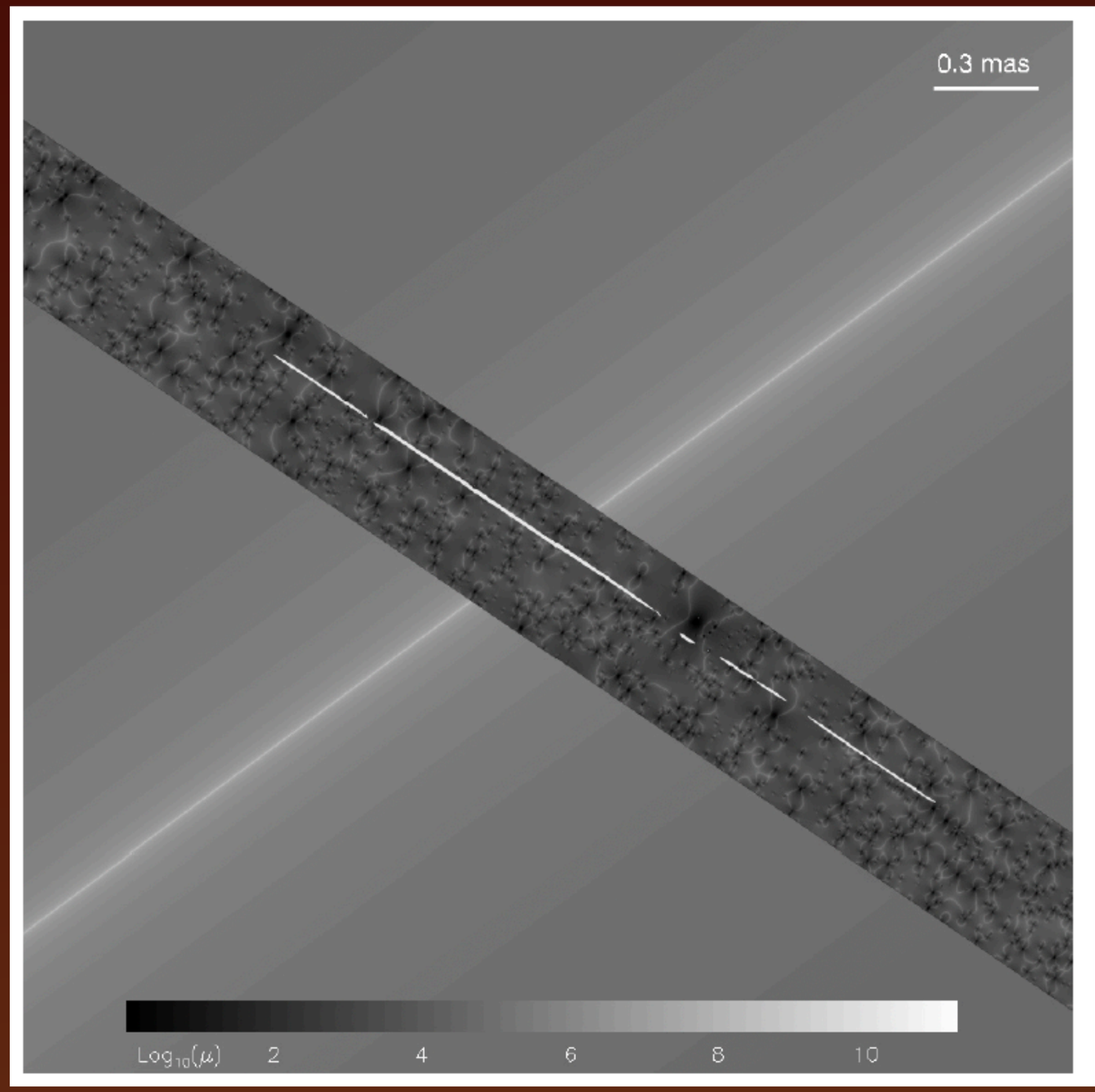
Causstic crossing events



Kelly+22

Caustic crossing

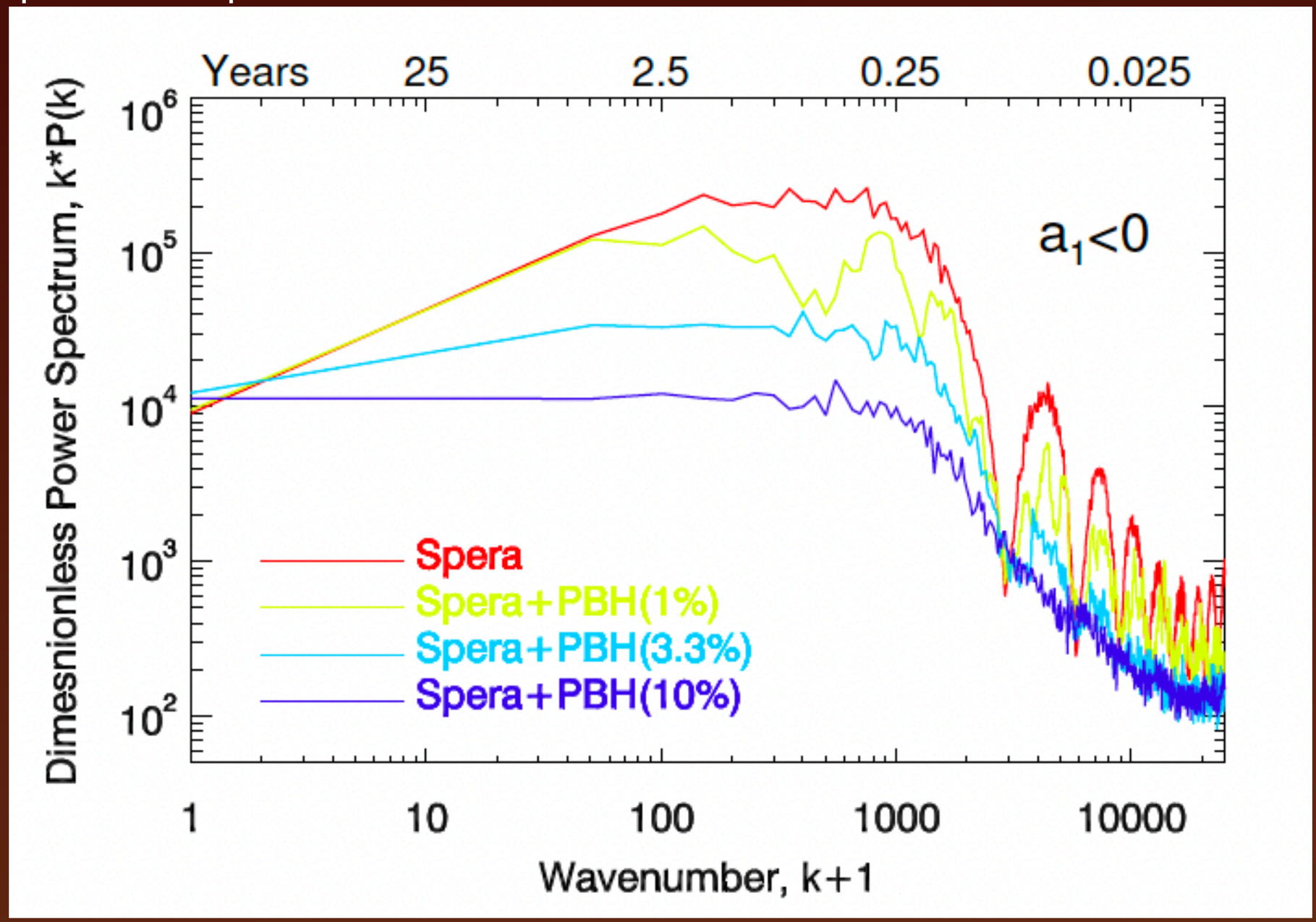




Diego+18

Caustic crossing

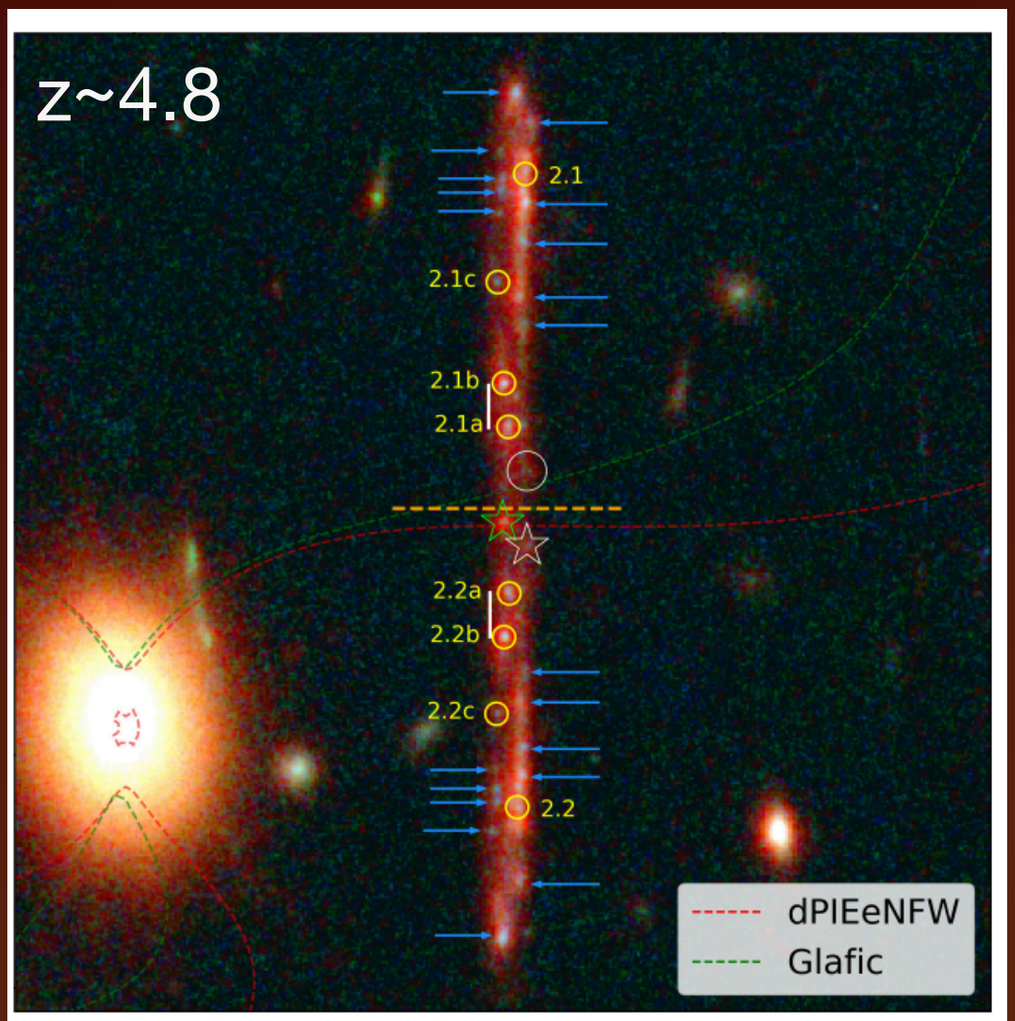
Light curve power spectra



Diego+18

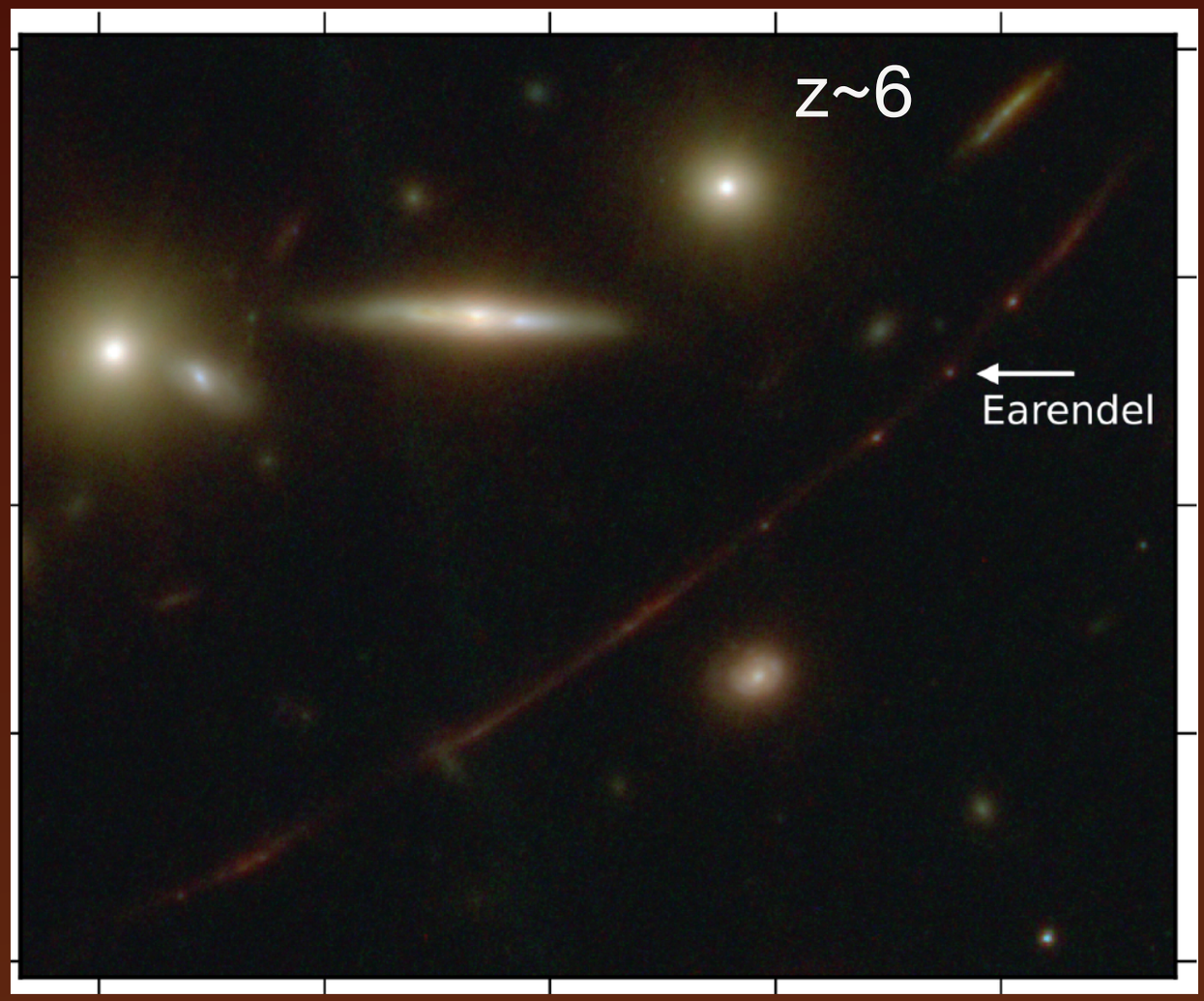
Lensed stars at high-z

MACS J0647.7+7015



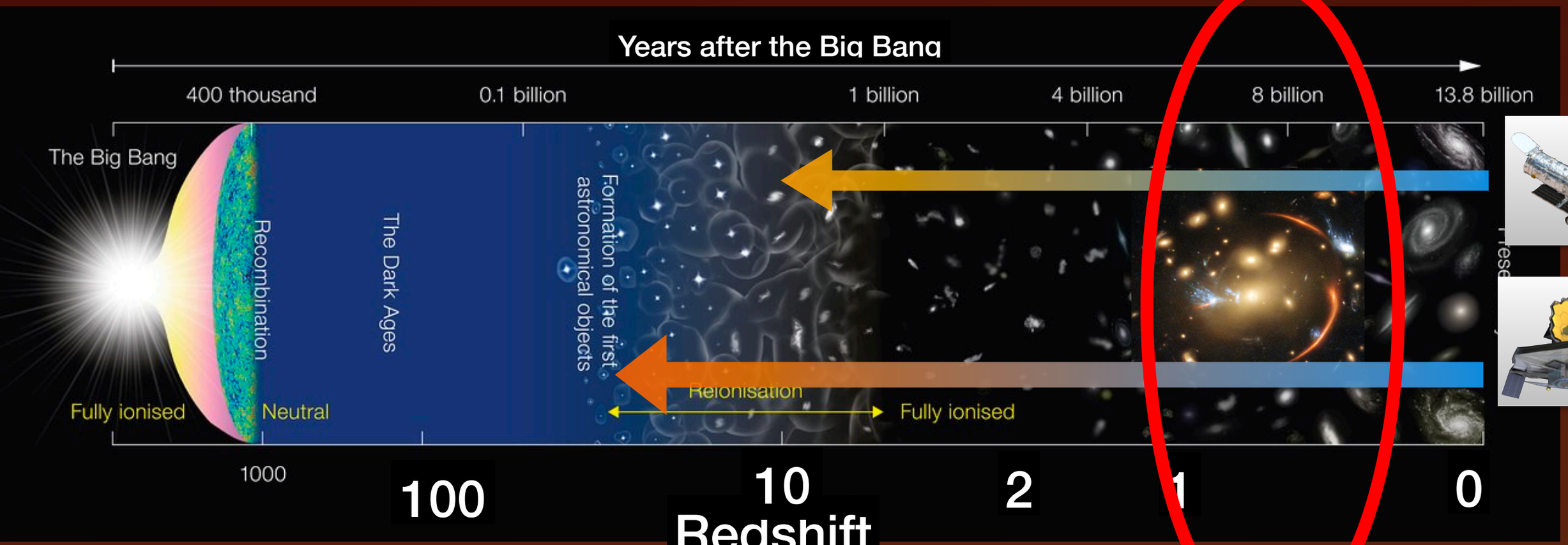
Meena+23

WHL0137

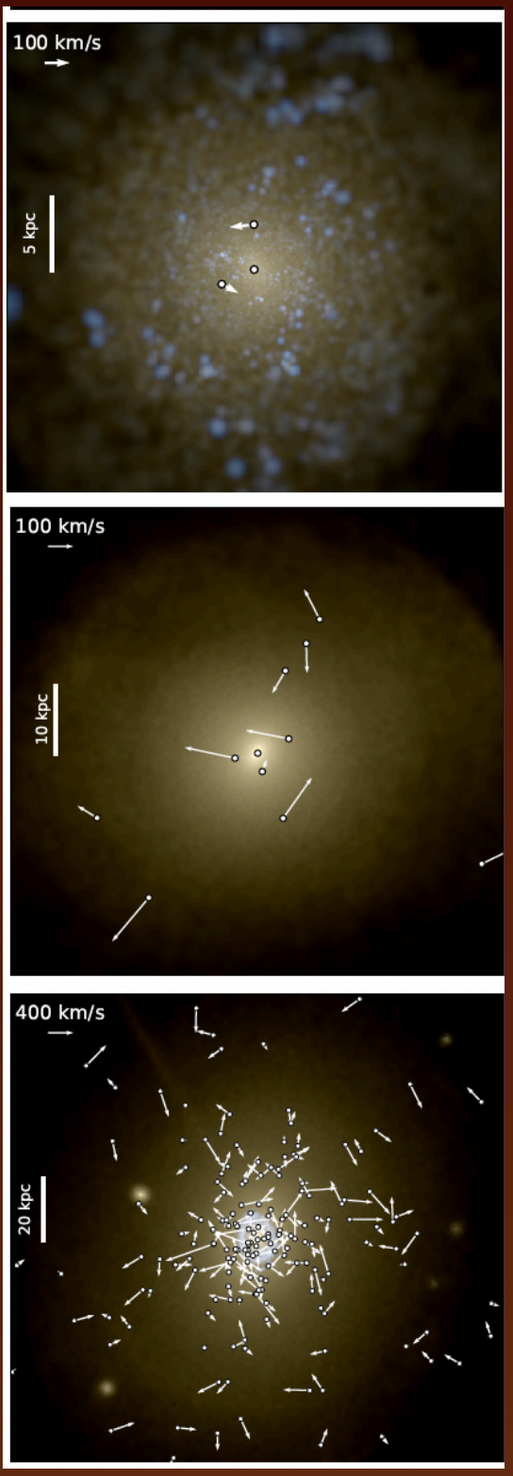


Welch+22

Cosmological evolution of our universe



Cluster members and supermassive black holes

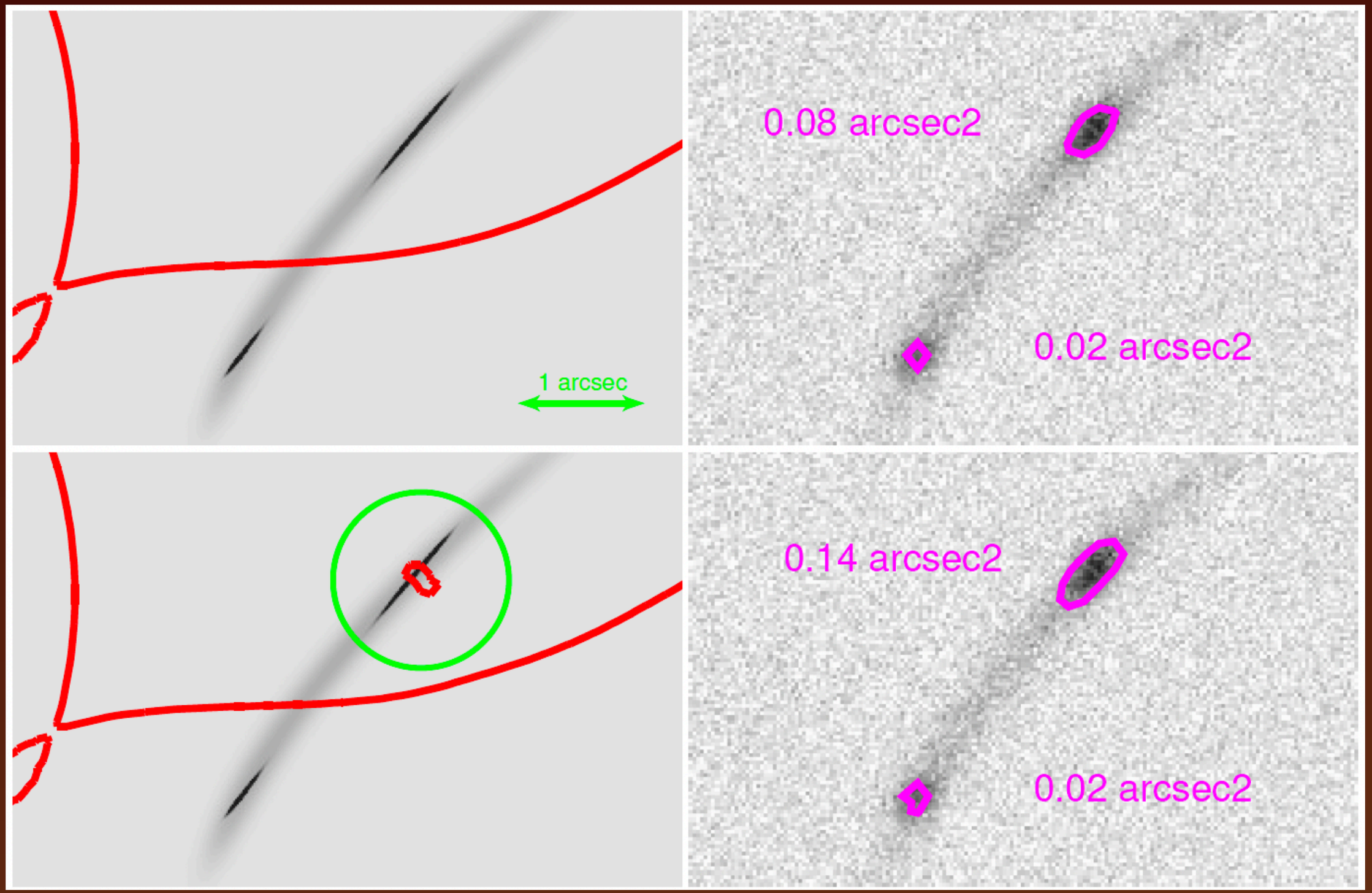


Ricarte et al. 2021

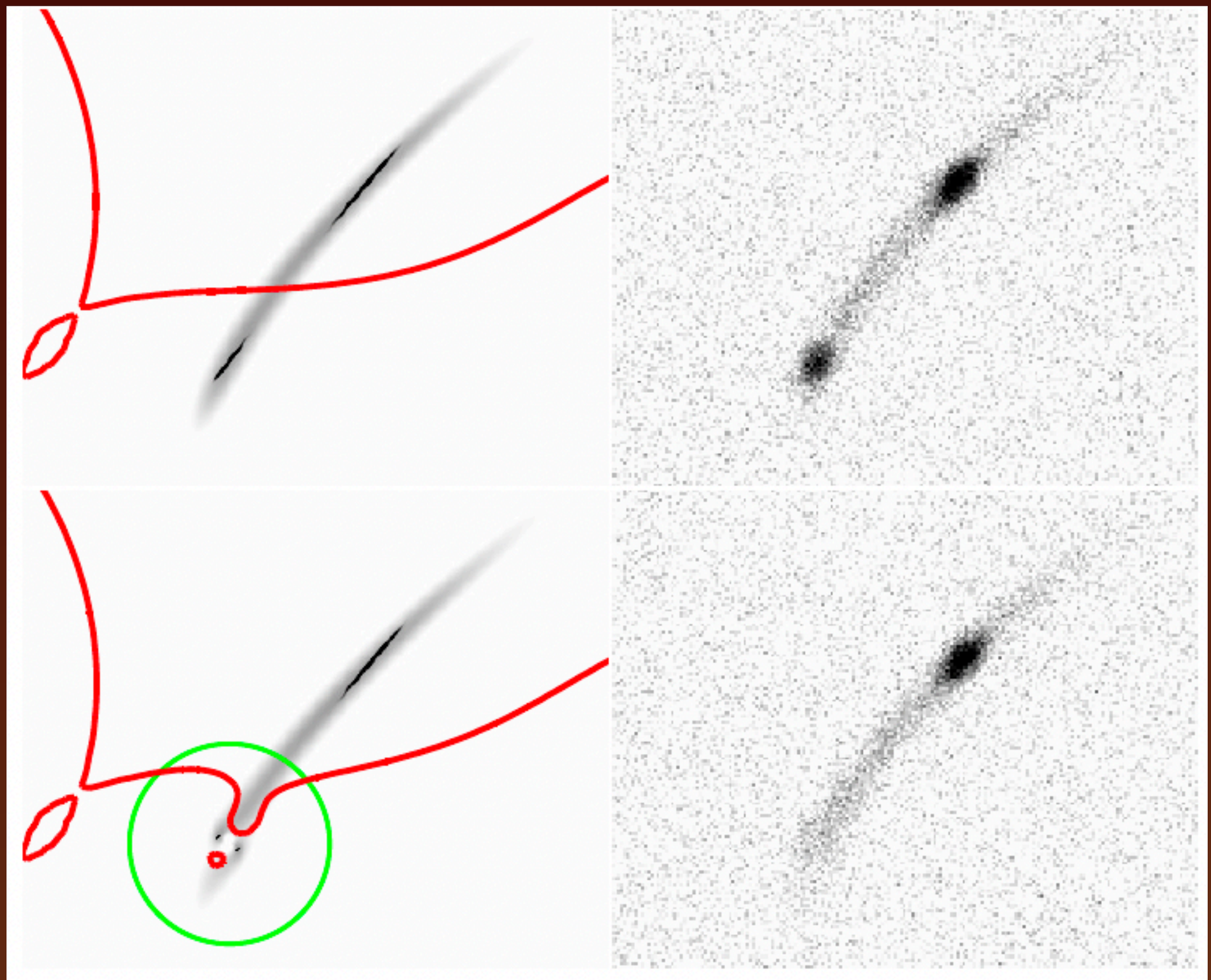
Found 1000s of wandering SMBH in >10^14 Msol halos

Can we see them? Maybe with lensing….

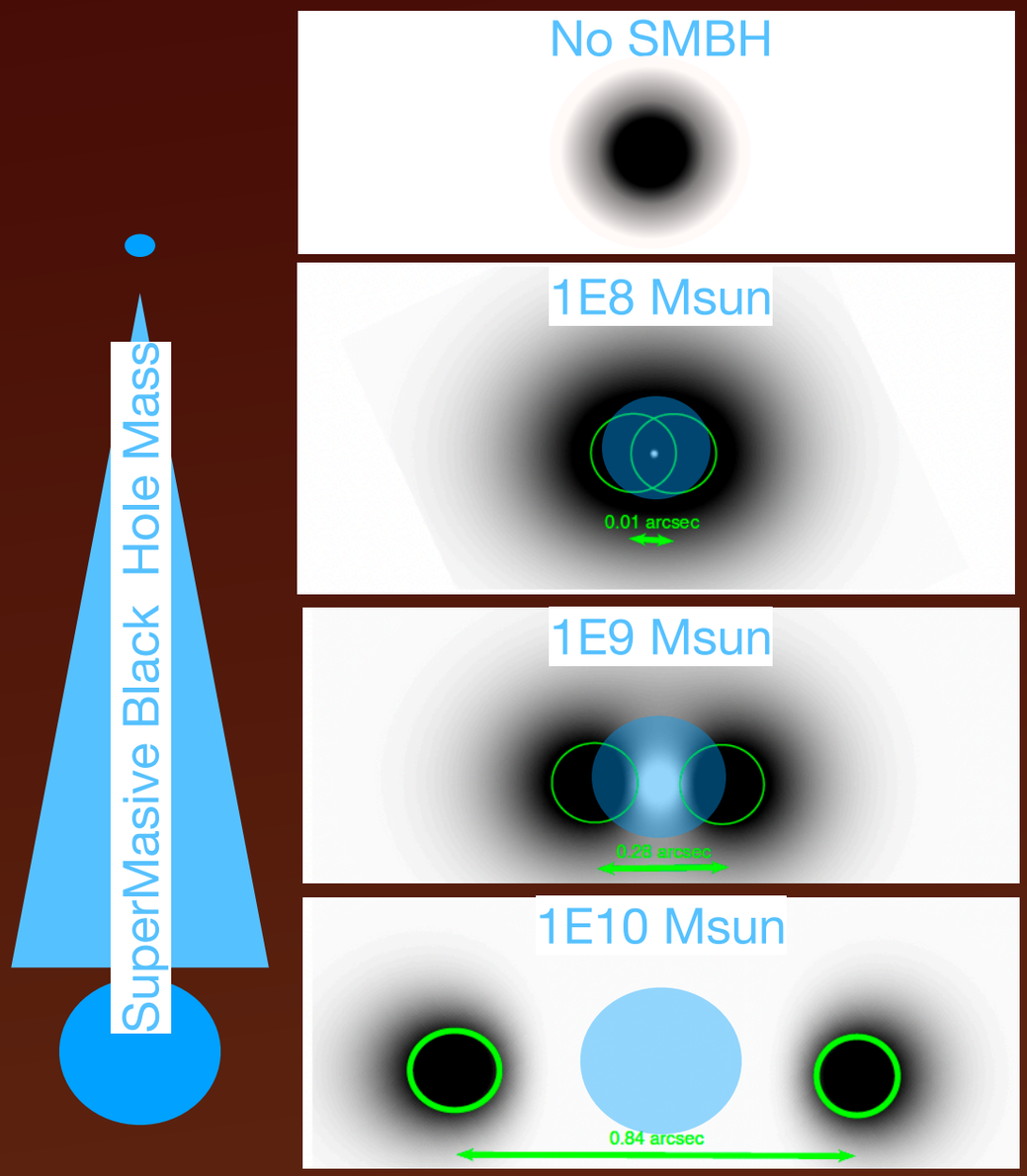
What if a wandering SMBH aligned with a lensed galaxy ?

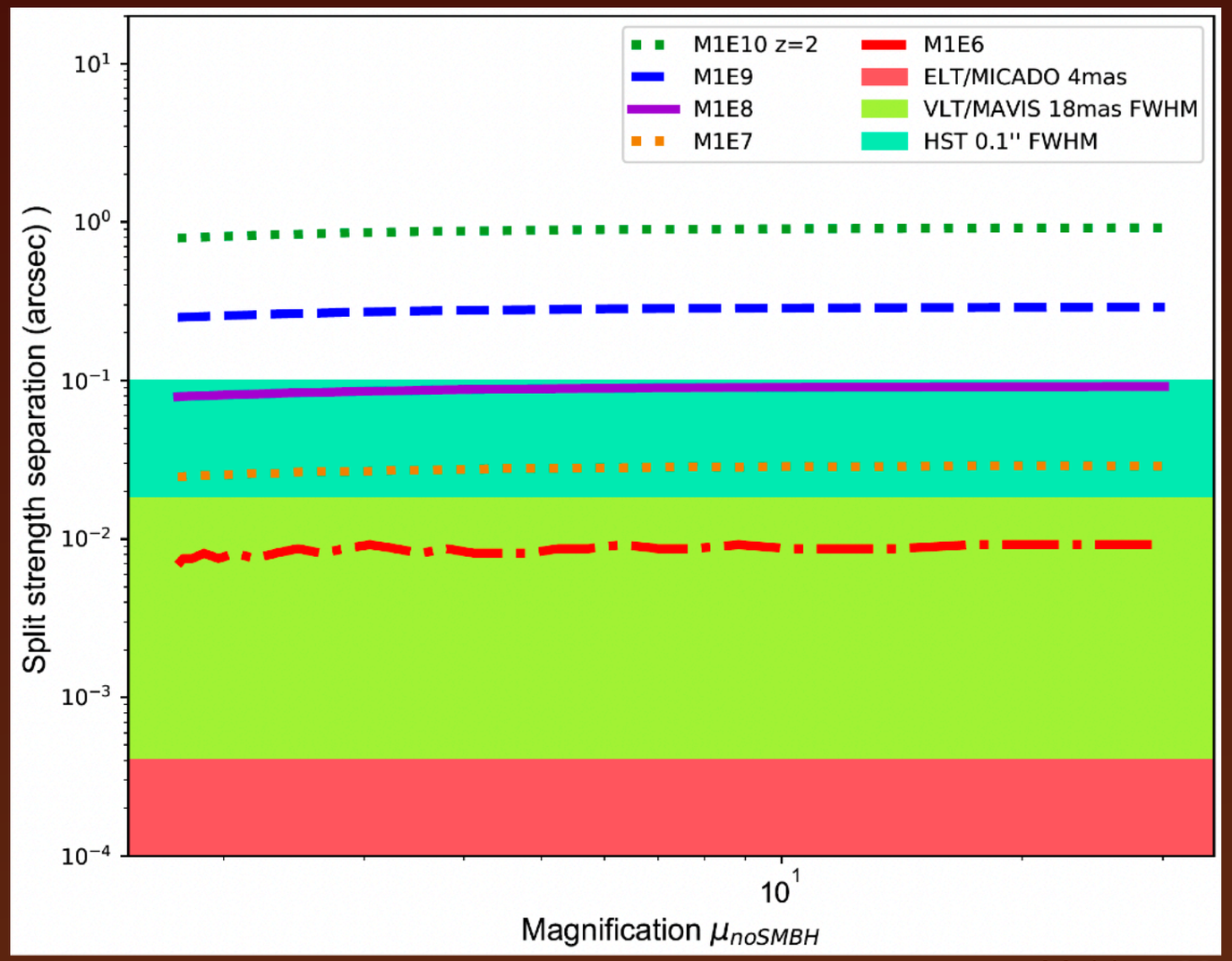


What if a wandering SMBH aligned with a lensed galaxy ?



Using the power of lensing

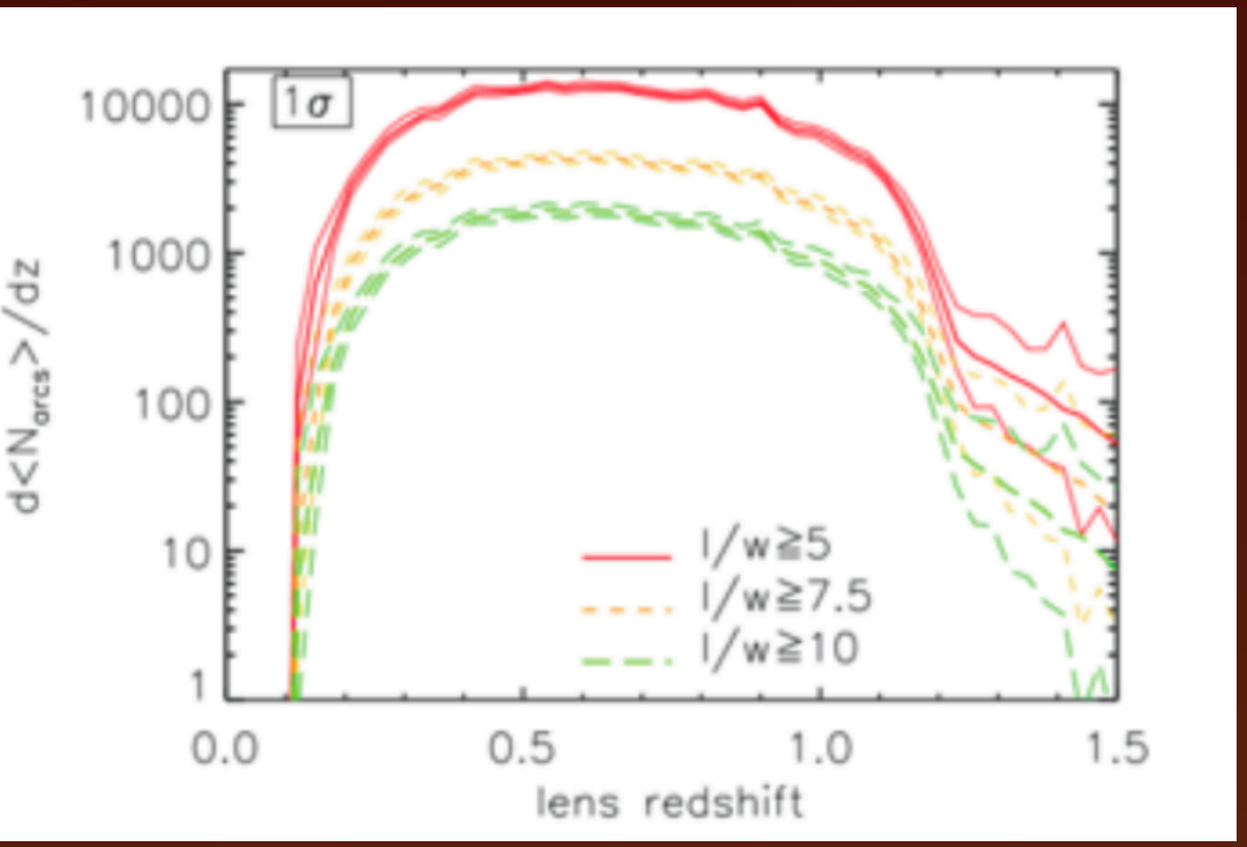




Mahler+23a

One 1E8 Msun every 5000 clusters

Euclid predictions



Giant arcs in clusters (Boldrin+15)

2 000 000 clusters total and

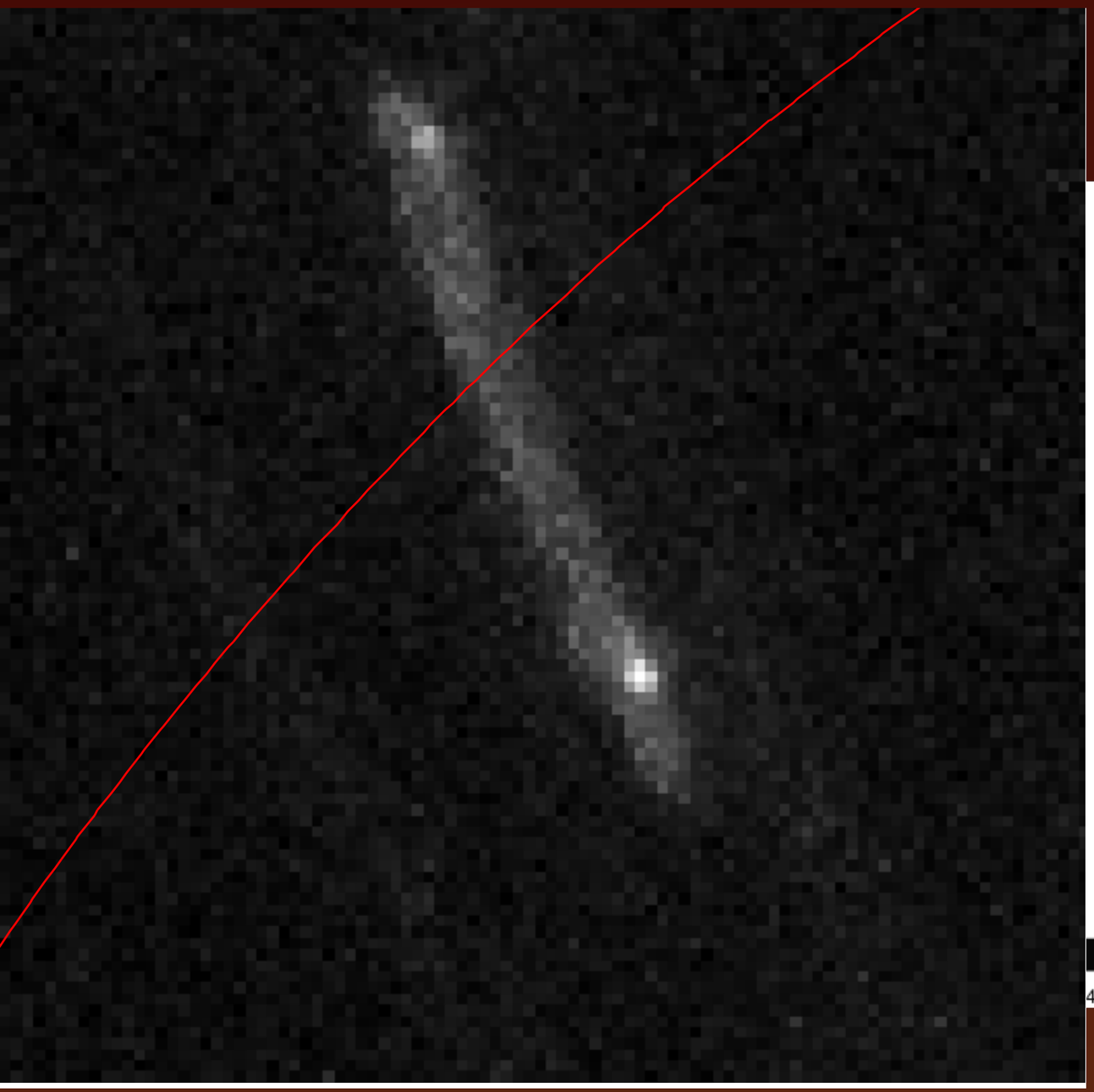
10 000 lenses l/w>5

4 giant arcs' clusters every day for 6 years!!!

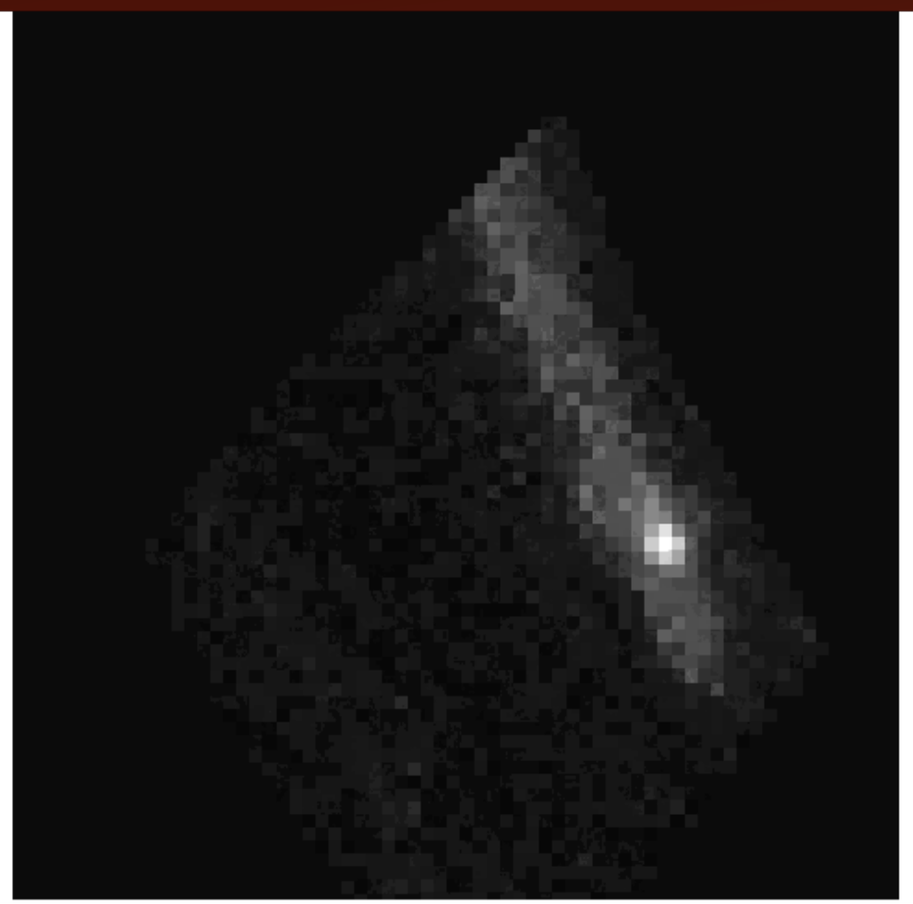
SGAS0033 - witnessing AGN driven wind at 100pc in a galaxy at z=2.39

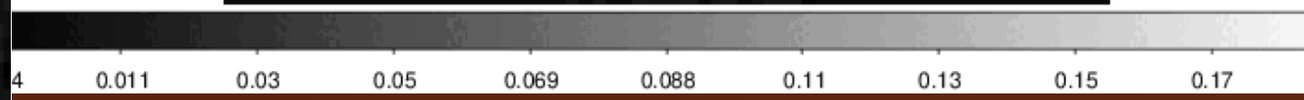
Fisher, Mahler+2019

Using the power of lensing



z=0.48 -> z=2.39

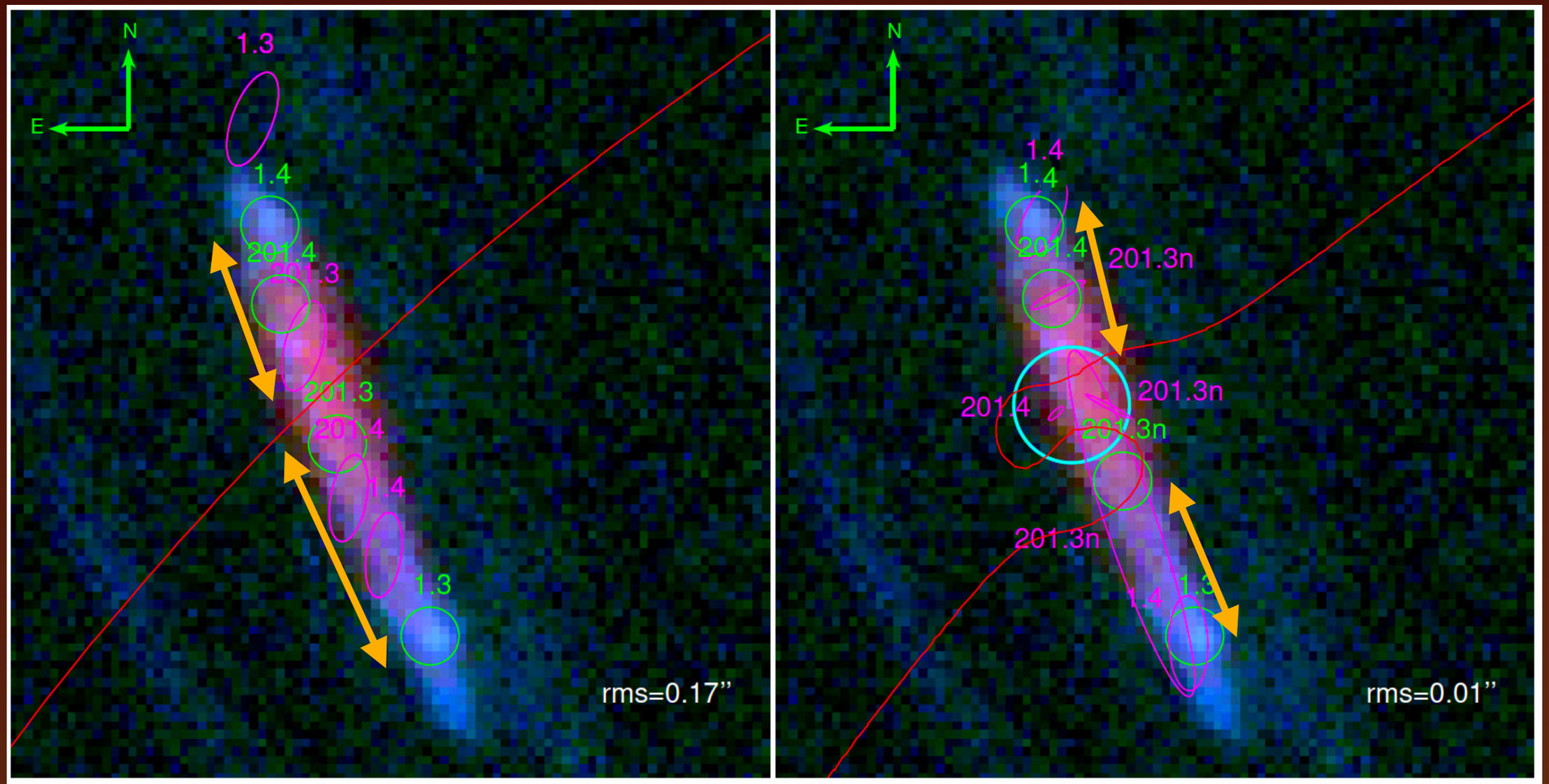




Using the power of lensing

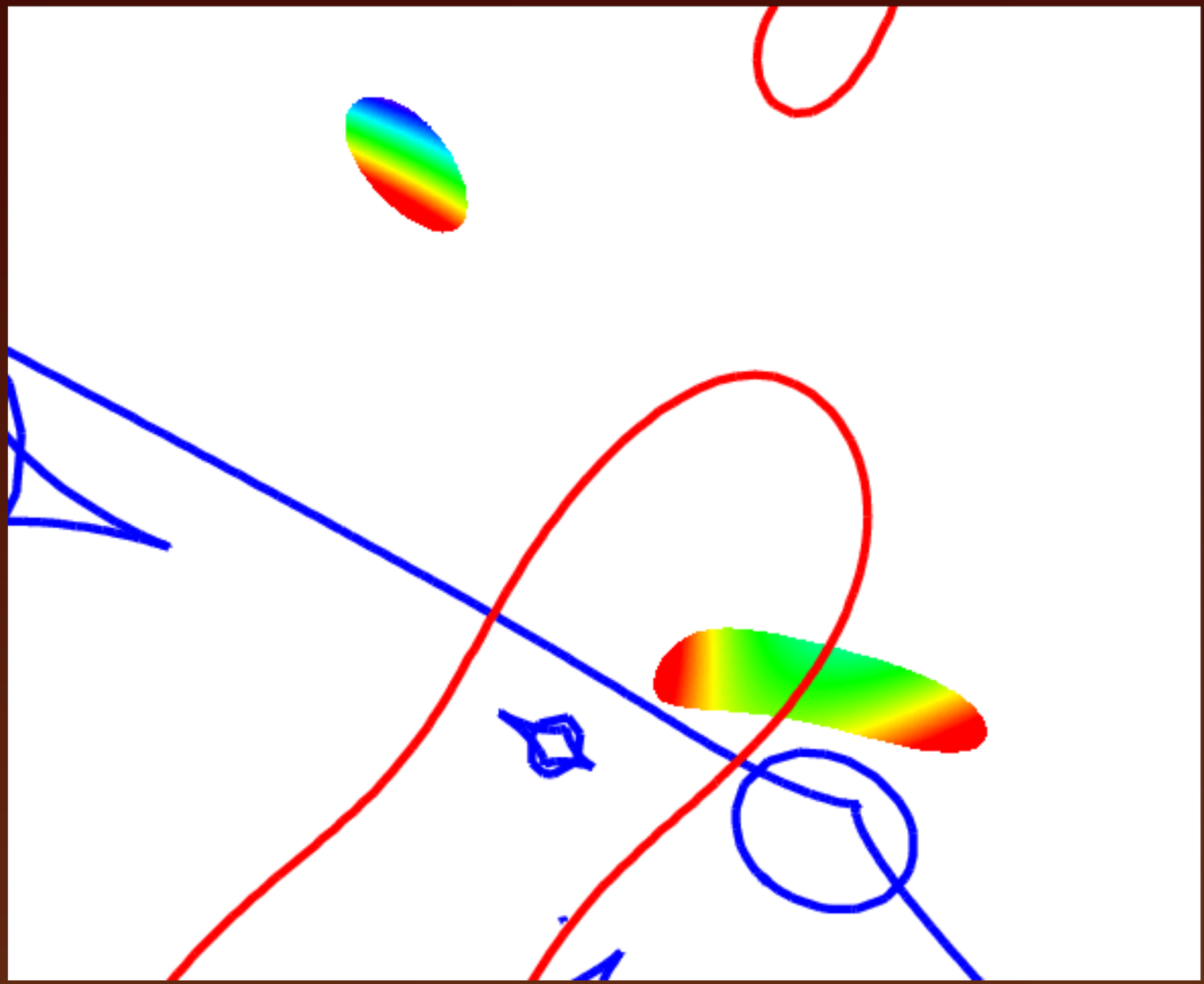
A wanderer candidate?

Mahler+23a

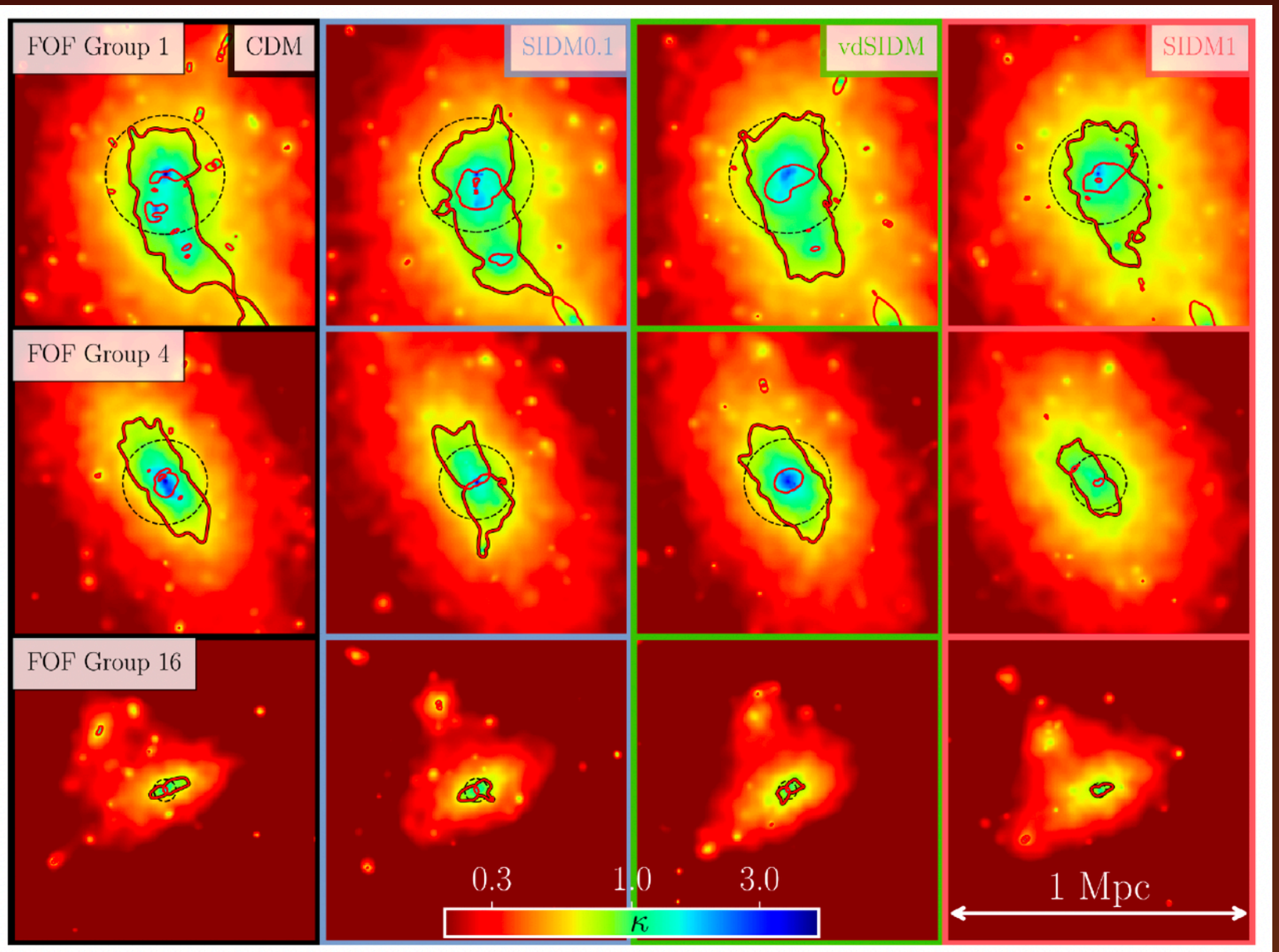


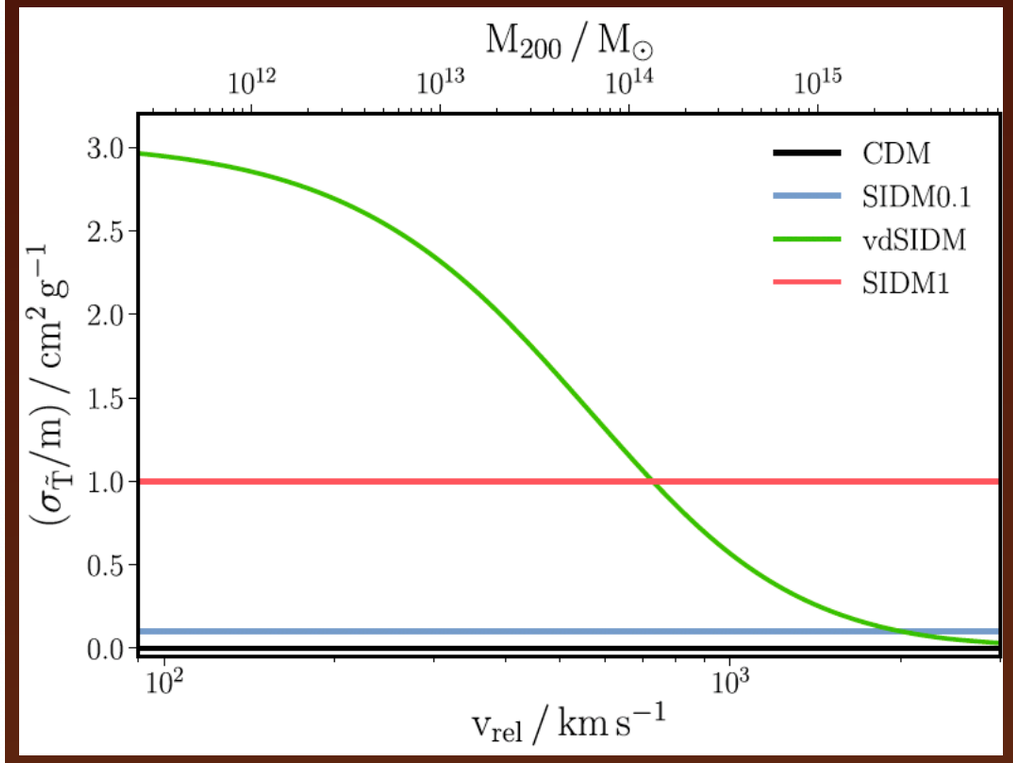
M_SMBH = 4.7 ×E8 Msun

What if a wandering SMBH aligned with a lensed galaxy ?



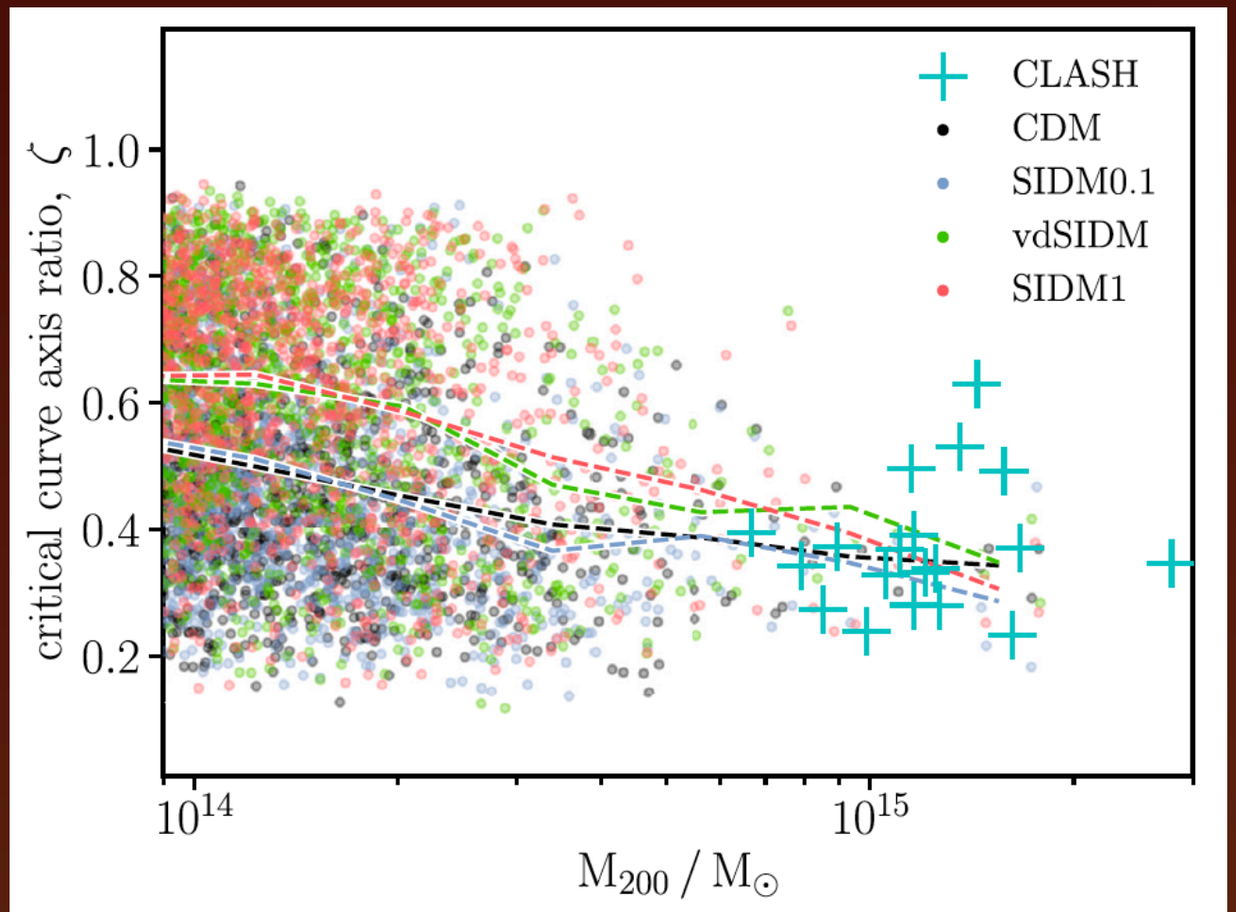
Self interaction dark matter cross section



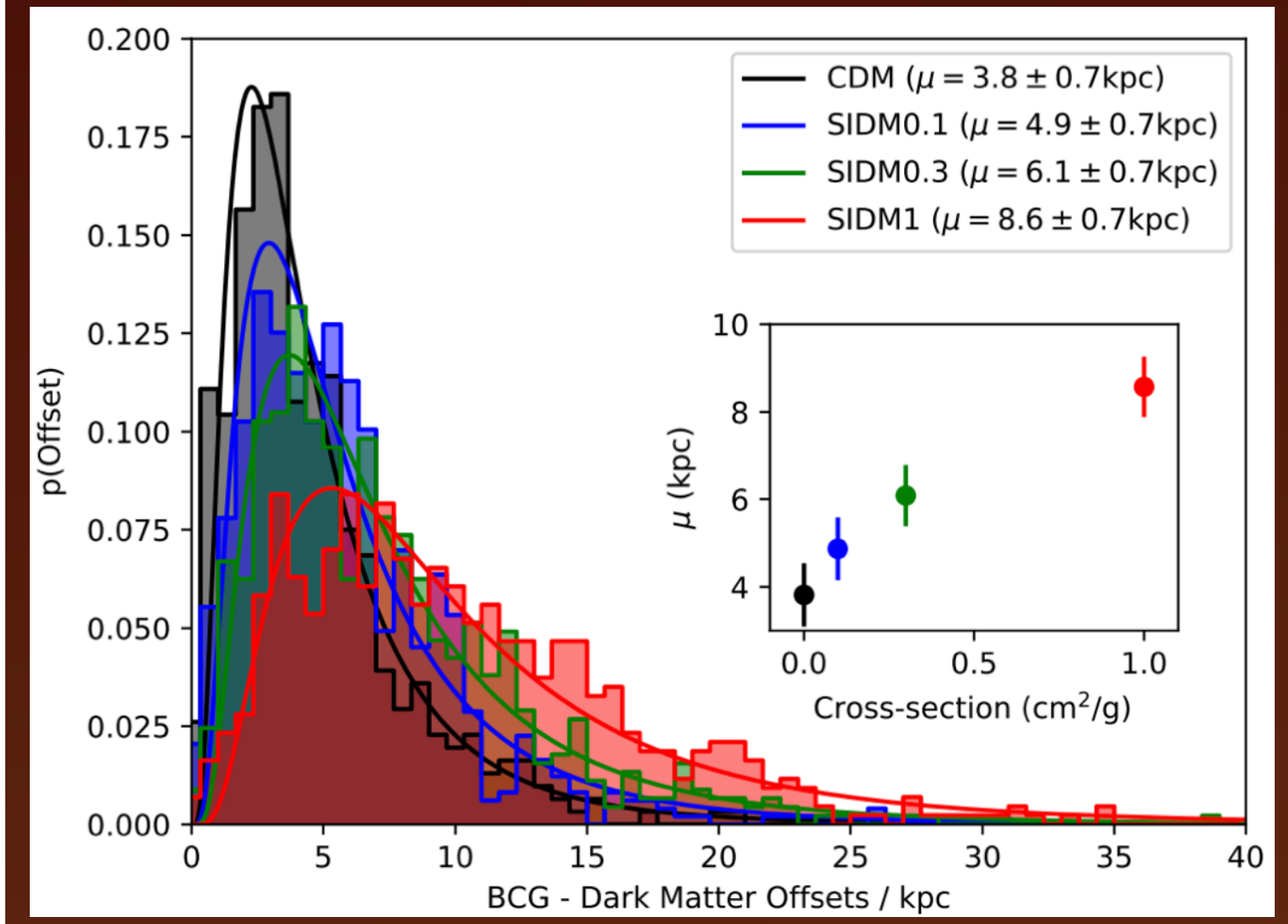


Robertson+19

SIDM cross section



Robertson+19



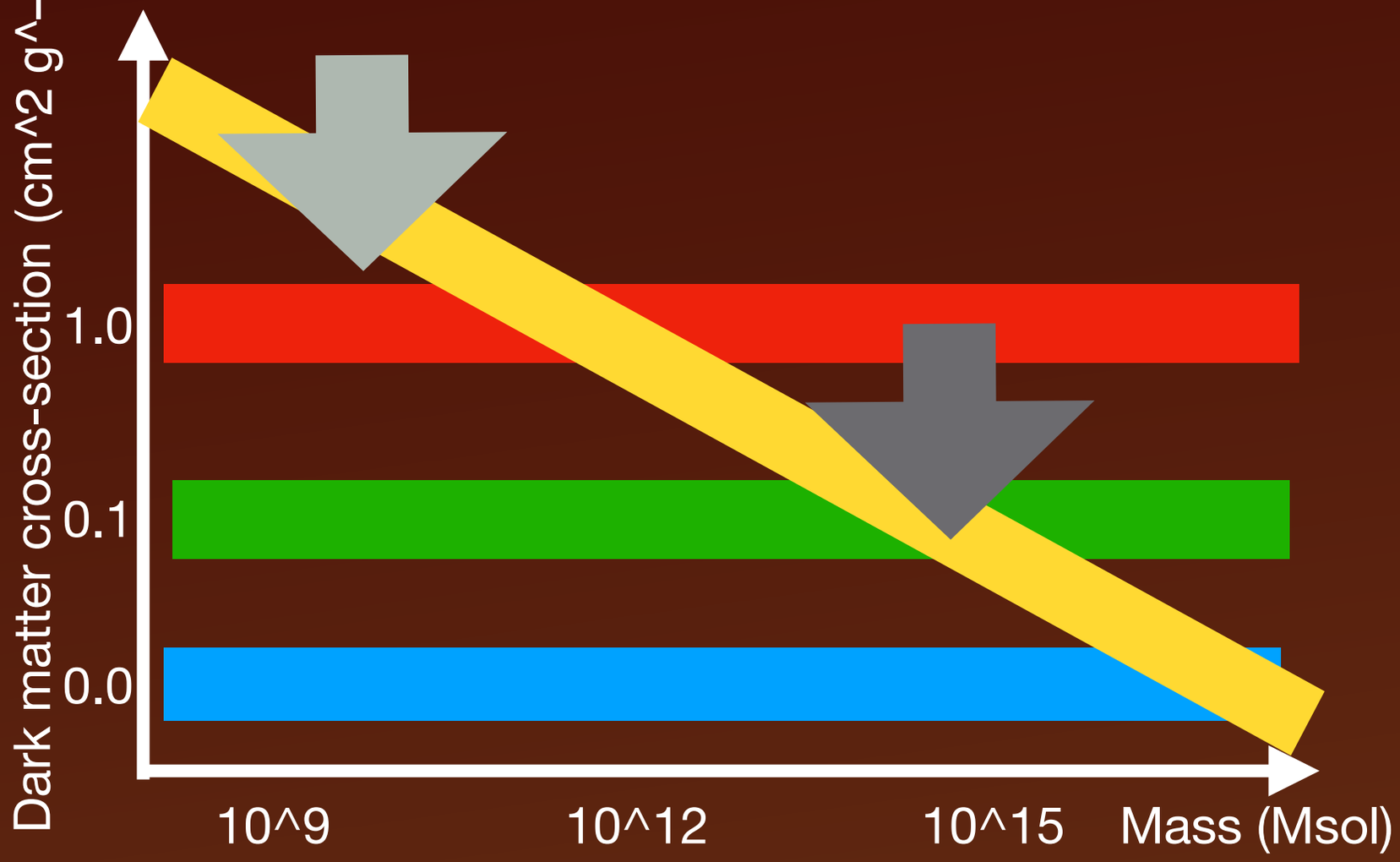
Harvey+19

SIDM cross section

Low mass upper lim Ren+18

High mass upper lim Andrade+22

σ Self-interacting DM cross section per unit mass (Robertson+19)



Conclusions

- The high-z universe is rich in phenomenon to observe properties of mark matter, taking astrophysics into account
- JWST's sensitivity and resolution offers new probe to the dark matter:
    - High-z galaxy and Dark Matter halo
    - Faint end of the high-z UV Luminosity function
    - Caustic crossing events
    - ICL+disrupted galaxies - Dark Mater tidal structure?
    - Wandering SMBH and dark clumps
- Future missions such as Euclid open a new Era for statistical analysis