STRONG LENSING:
Illuminating galaxies clusters and the structures behind them

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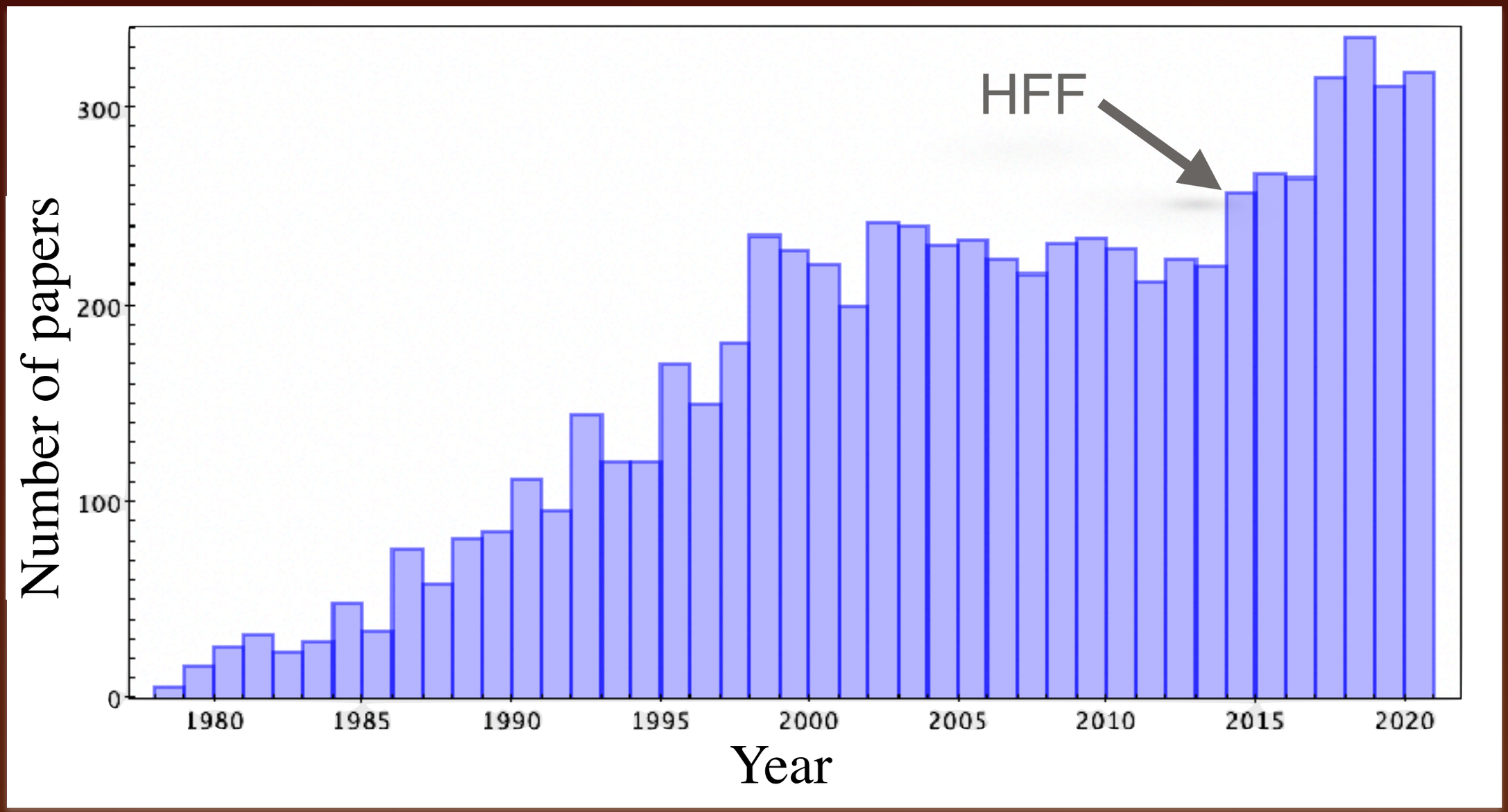
Durham University

Main collaborators:
Mathilde Jauzac, David Lagattuta, Keren Sharon, Johan Richard, Mike Gladders, Jane Rigby

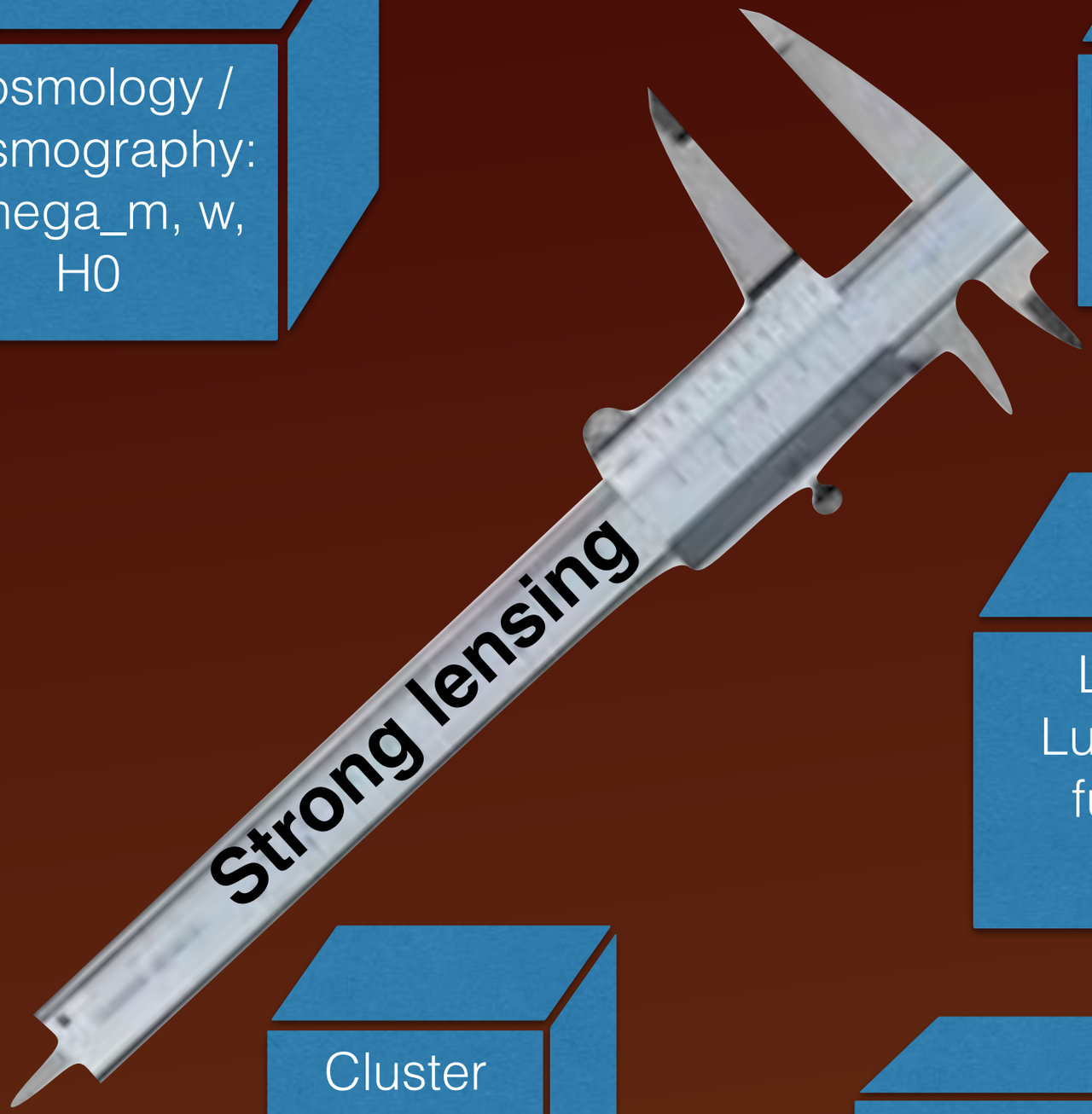
Observatoire de la cote d'Azur

Sept 20th 2022

Strong lensing is rising !



Strong lensing is a tool



Cosmology / Cosmography: Omega_m, w, H0

Resolved properties of Lensed galaxies

Nature of dark matter

Lensed Luminosity function

IMF study

Cluster physics

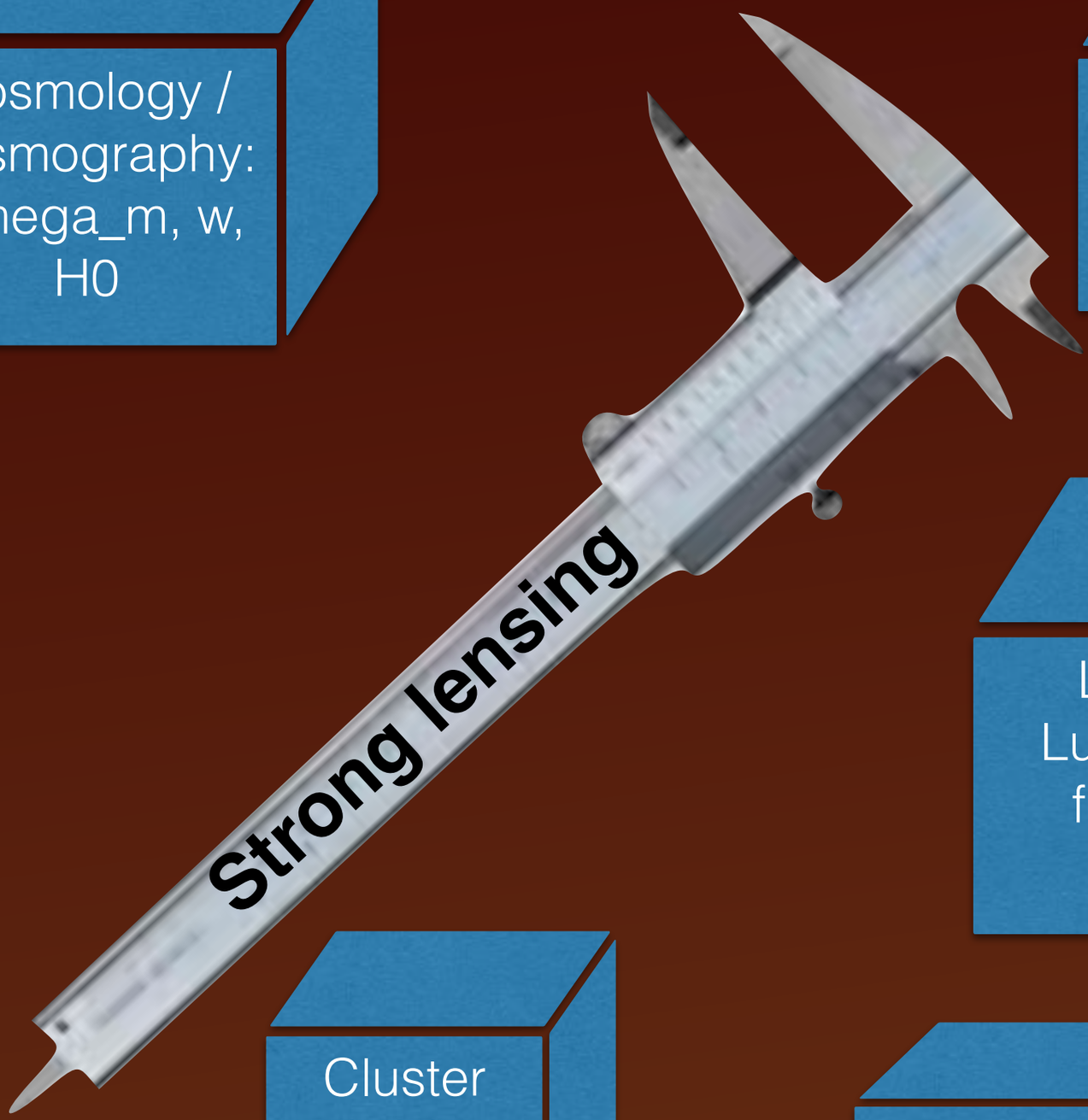
Gravitational waves

Strong lensing is a tool

Cosmology / Cosmography: Omega_m, w, H0

Resolved properties of Lensed galaxies

Nature of dark matter



Lensed Luminosity function

IMF study

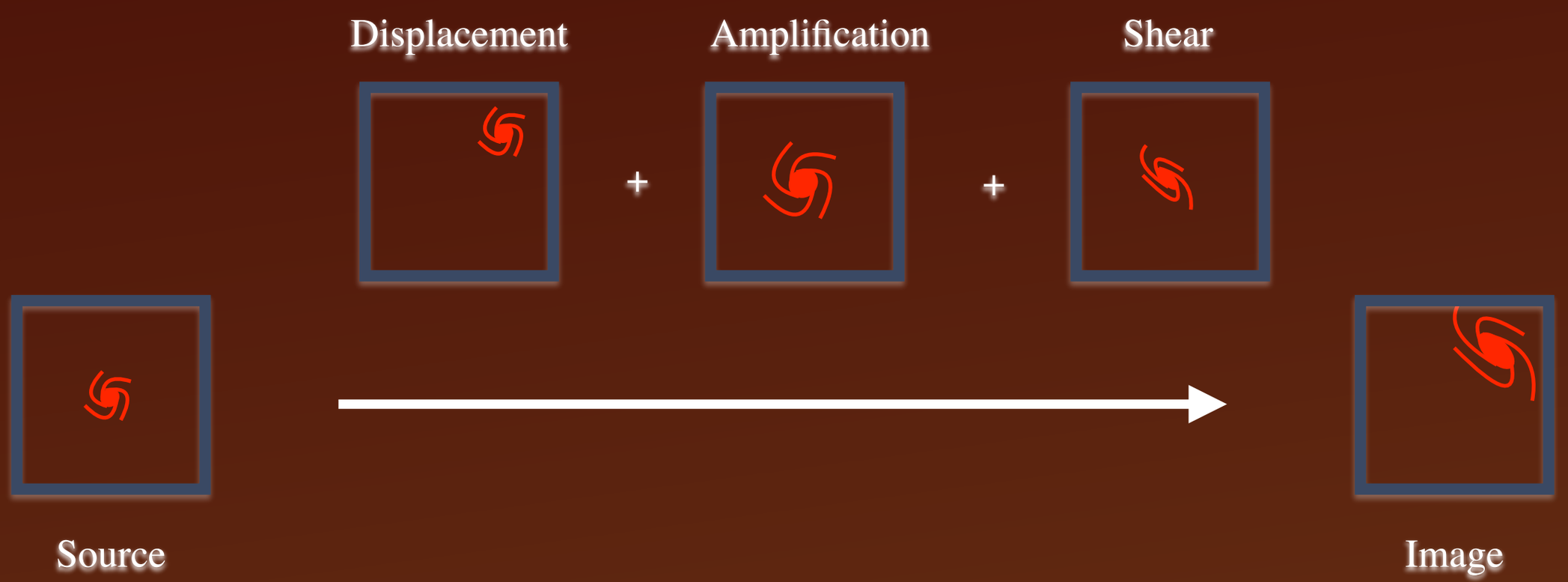
Cluster physics

Gravitational waves

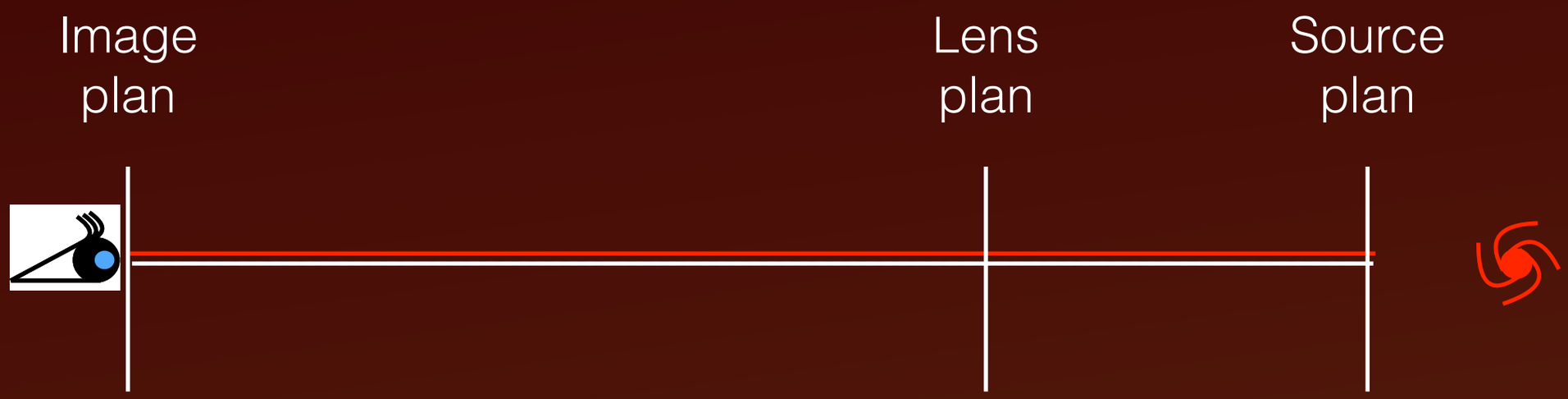
Crash course on lensing

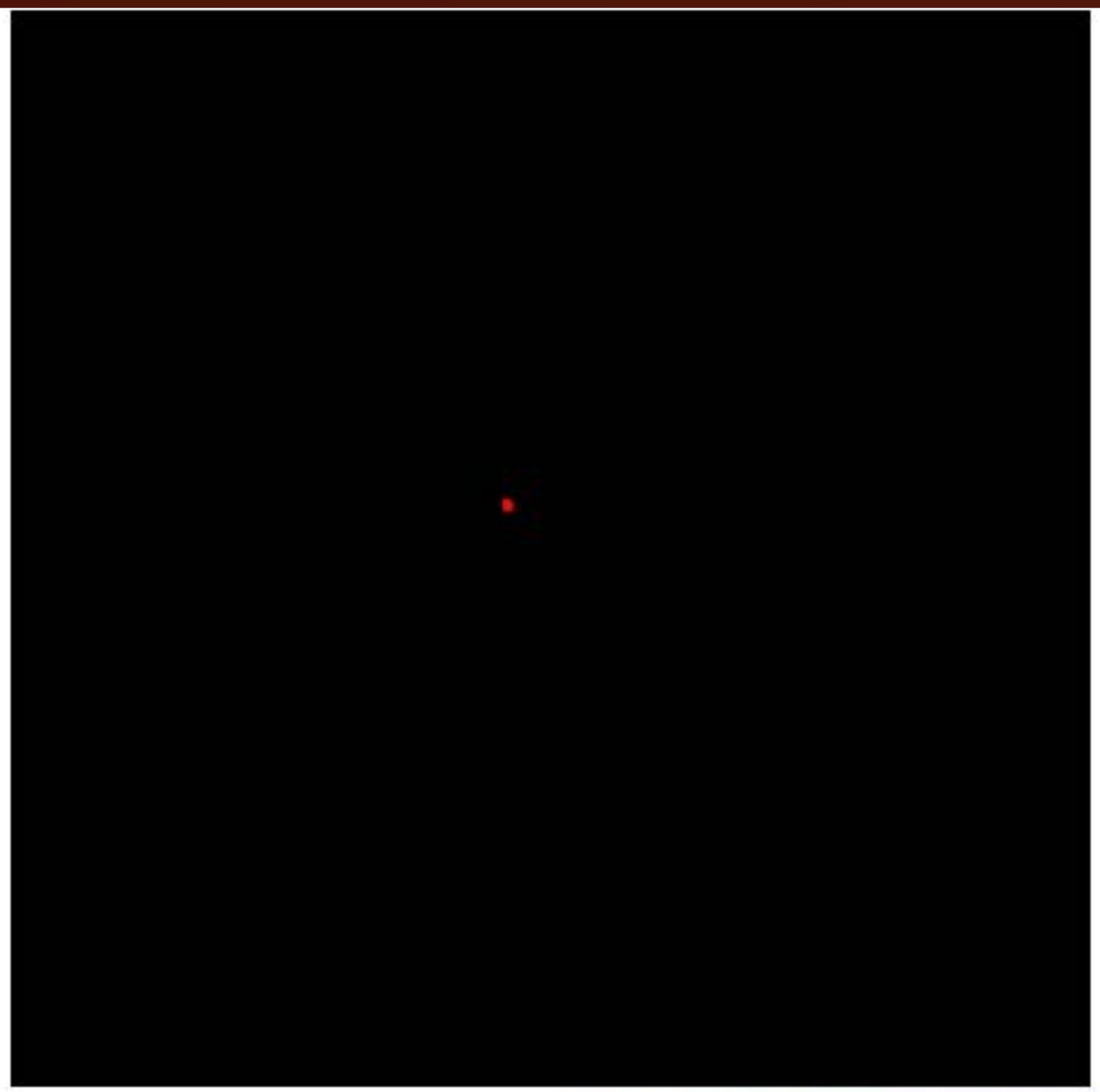
When a light source is aligned with a mass and the observed, the path of light is apparently disturbed and the image of the source is transformed

3 majors transformations :



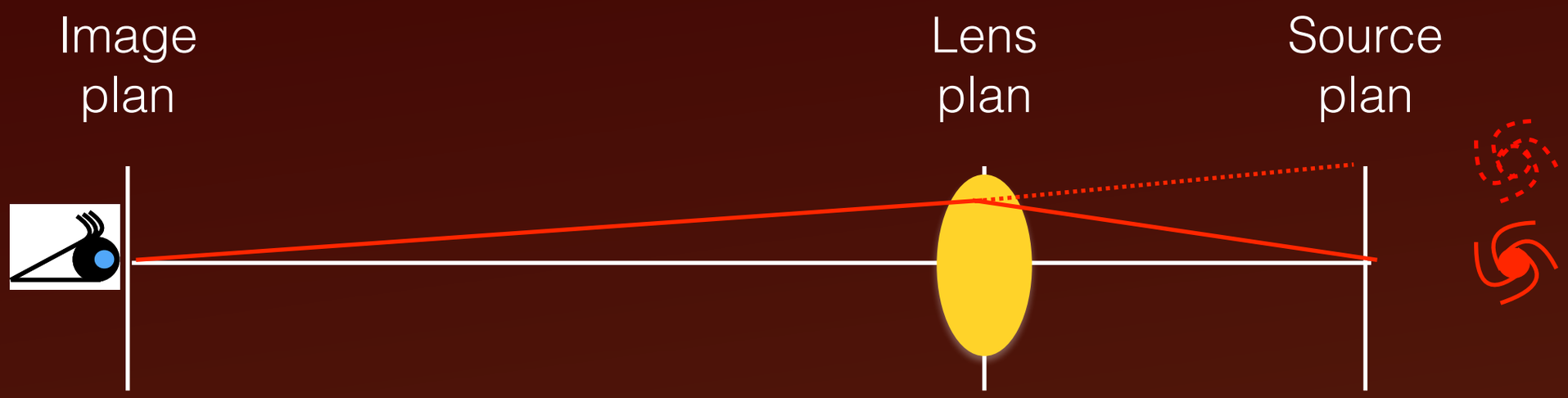
Crash course on lensing

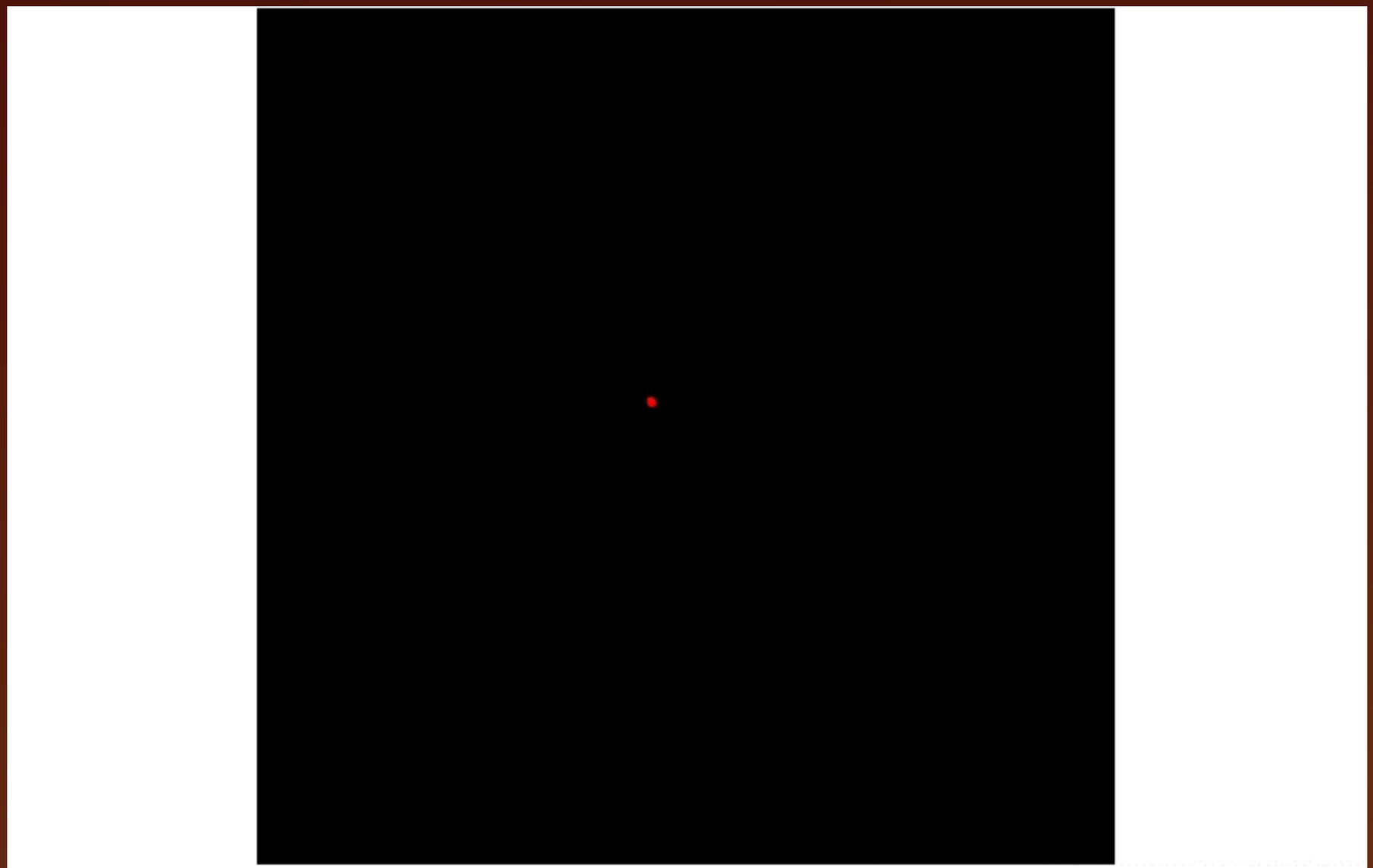




Crash course on lensing

Mass increase





Crash course on lensing

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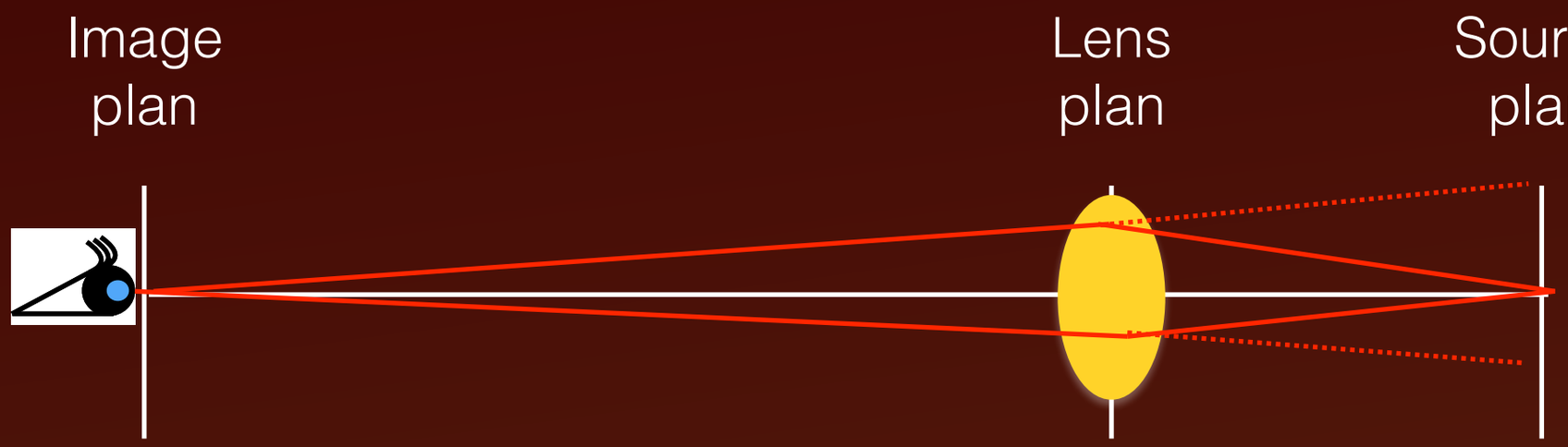
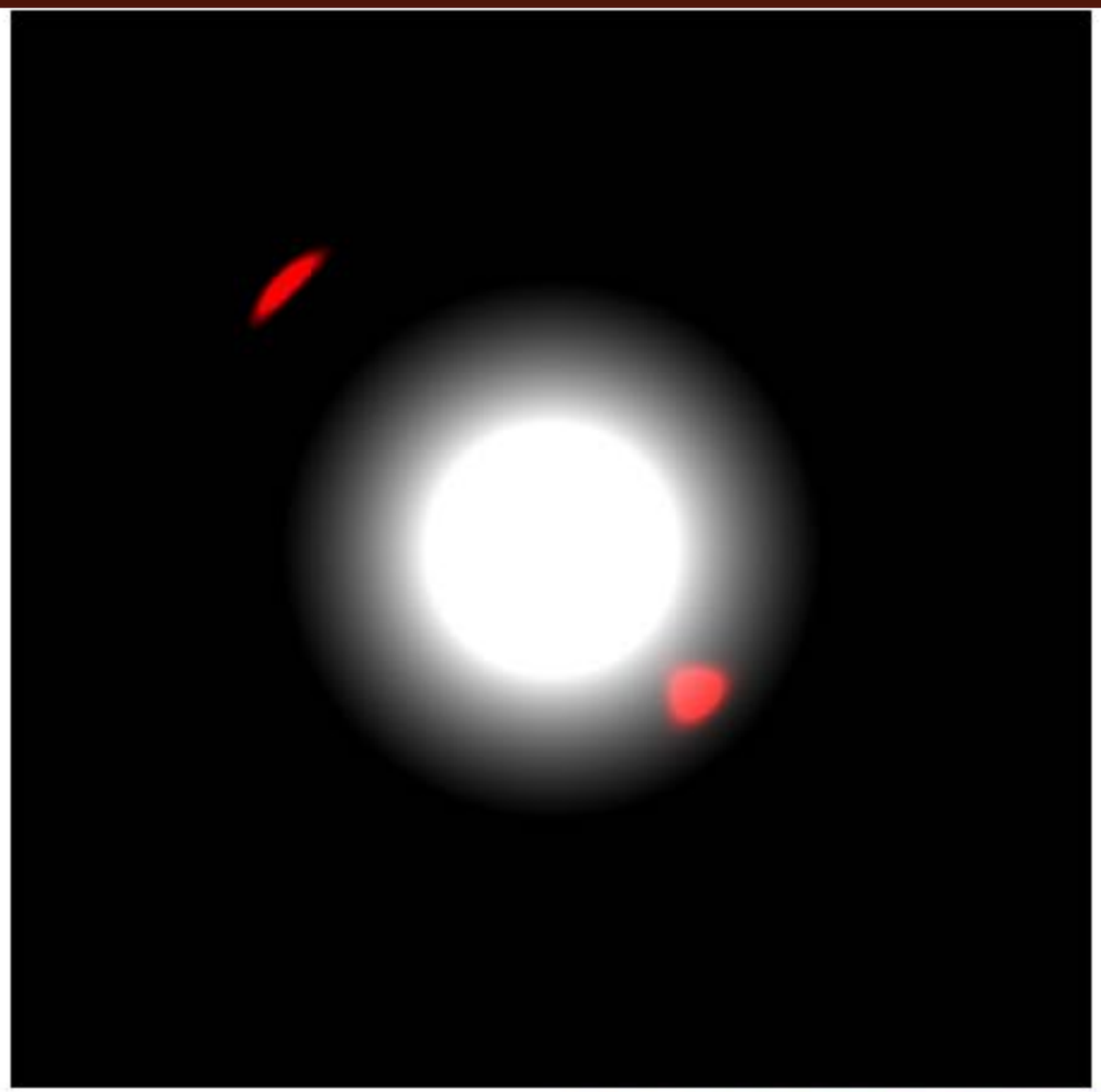
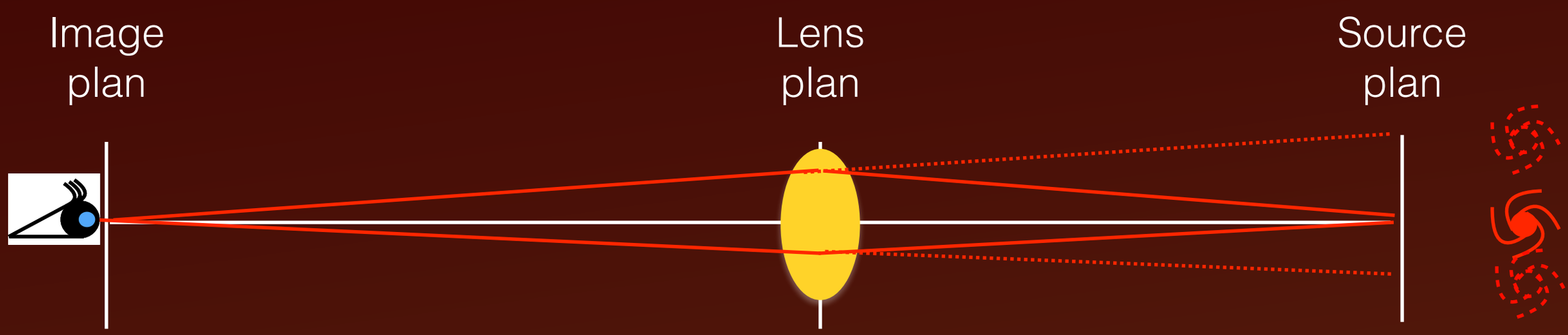


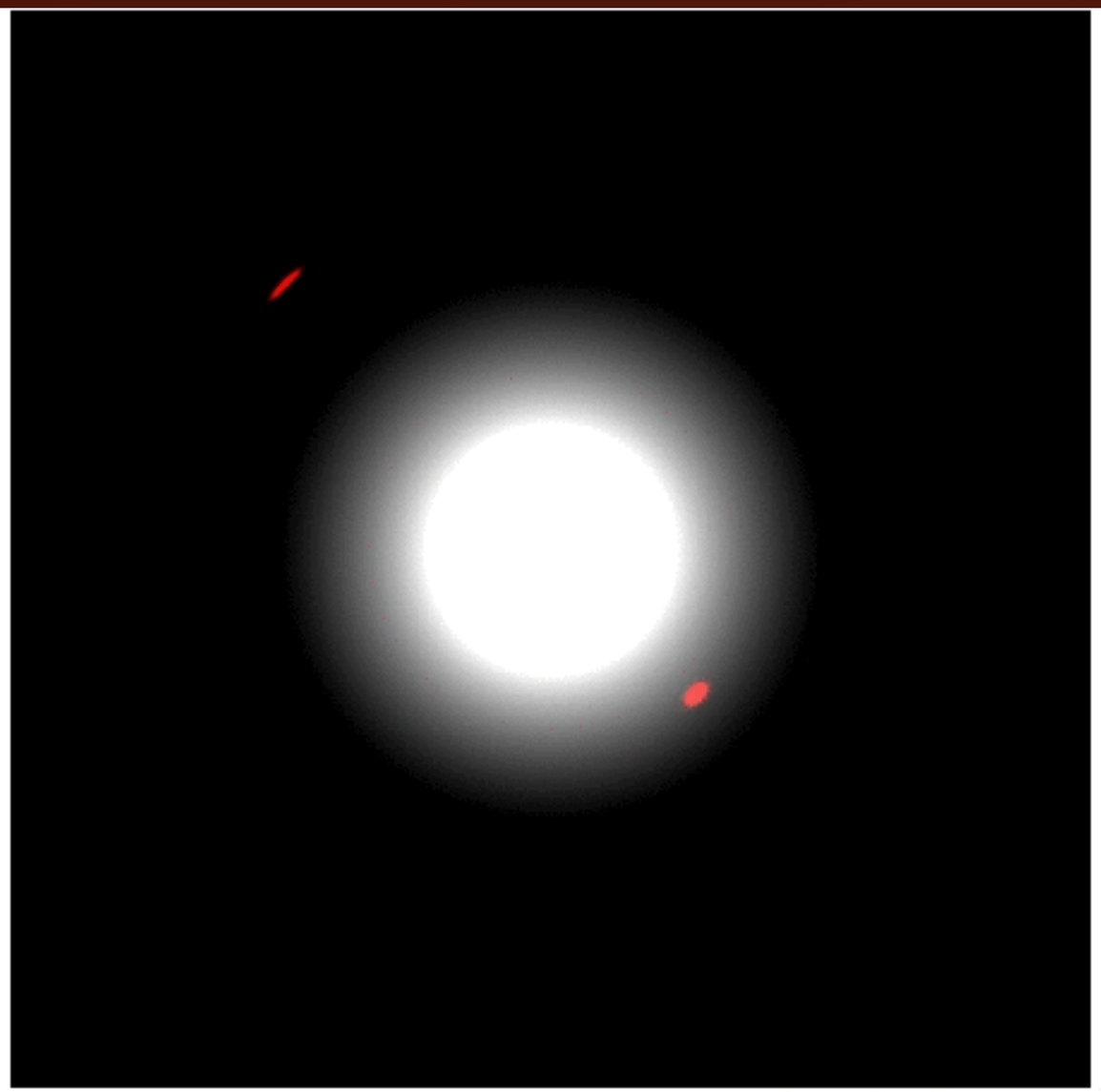
Multiples images appearance



Crash course on lensing

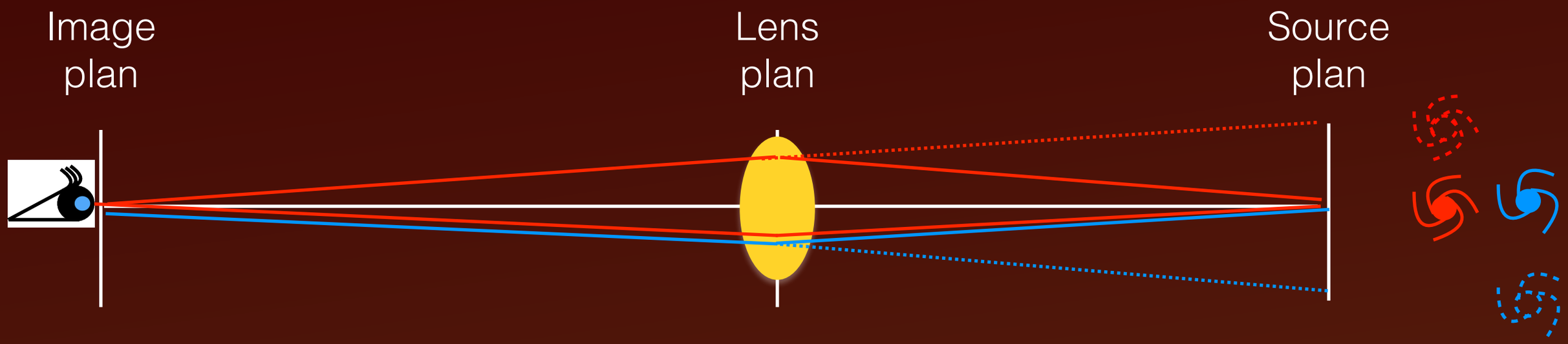
Redshift increase

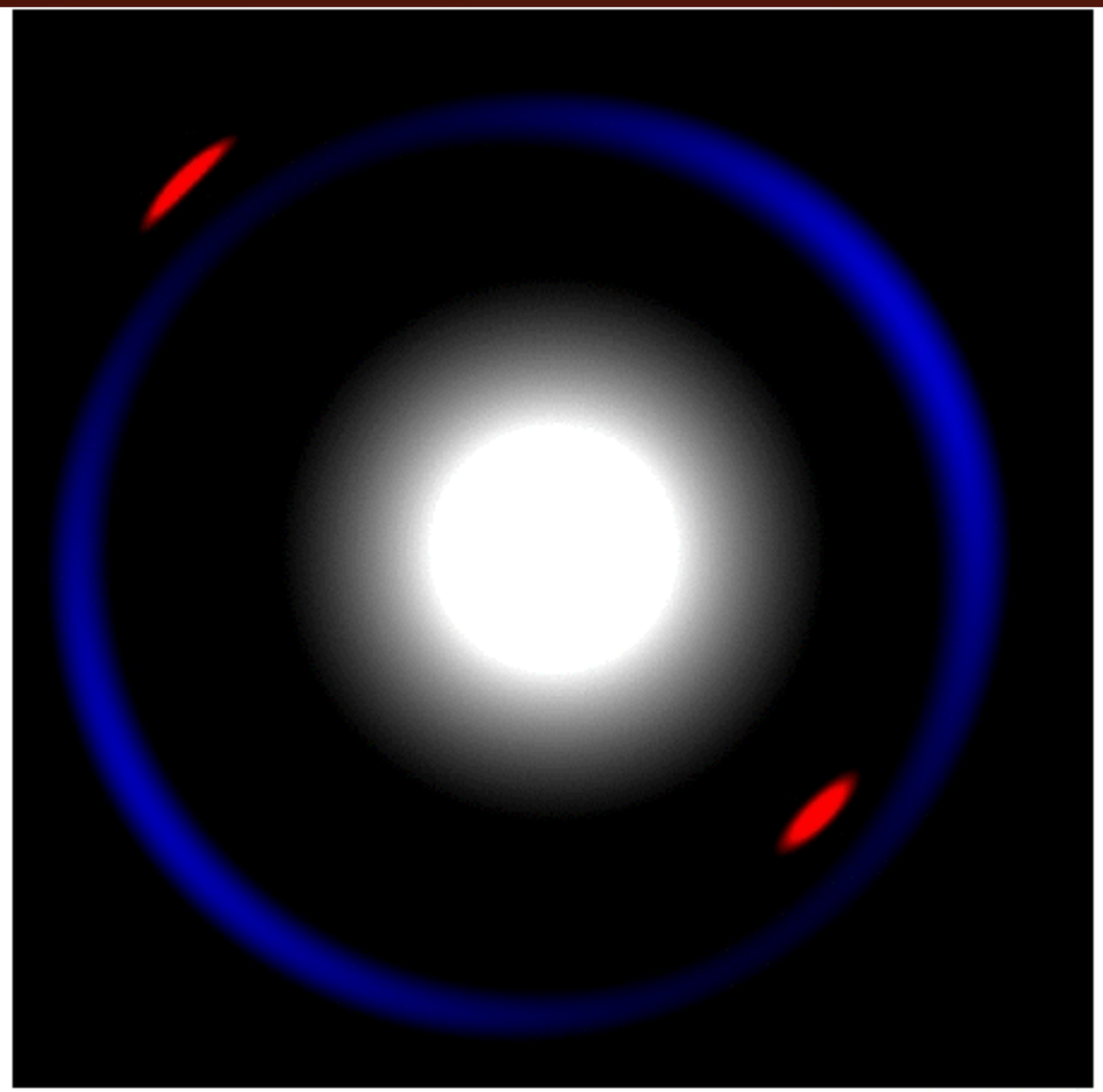




Crash course on lensing

Different mass distribution

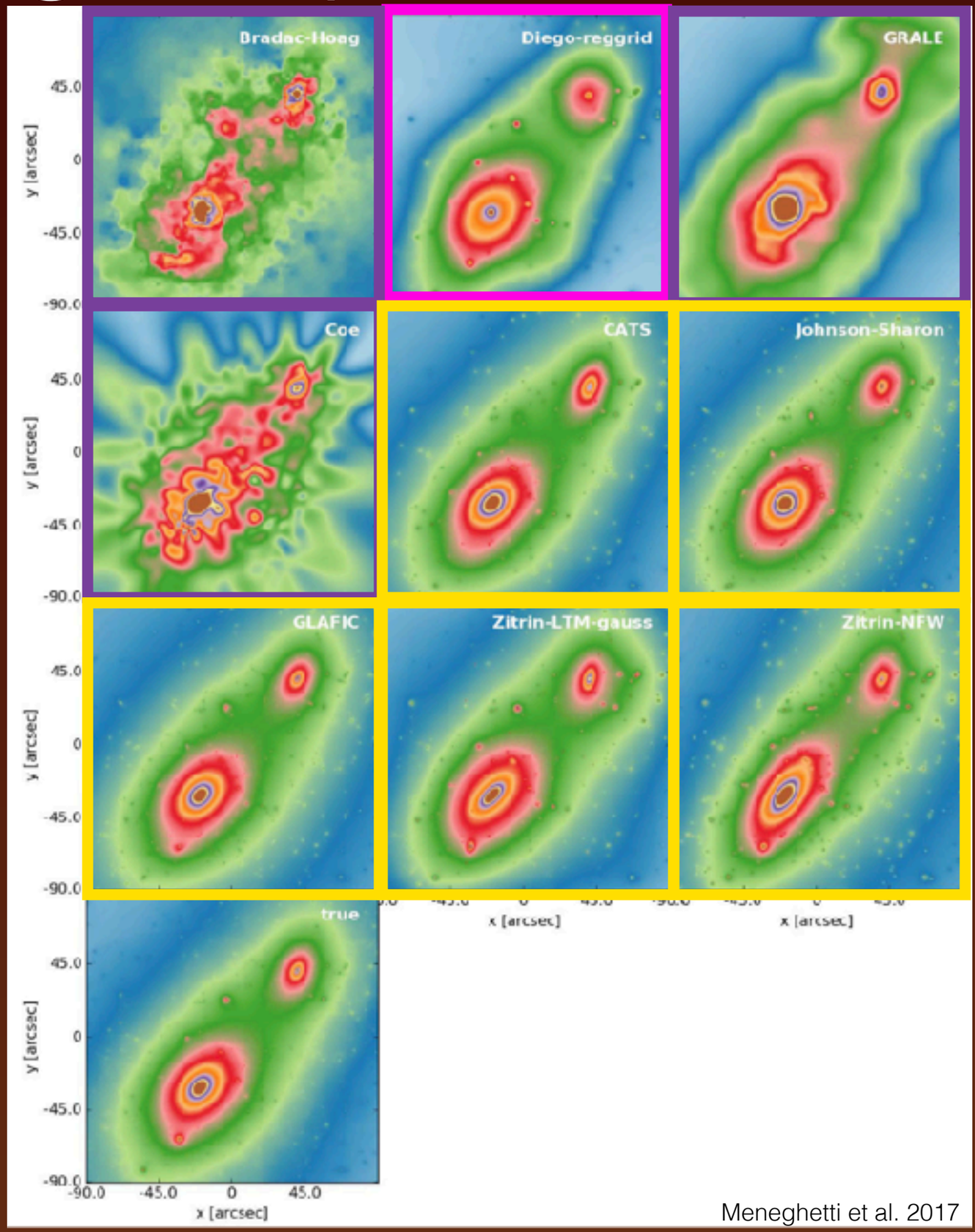




Second galaxy

Inverting the problem

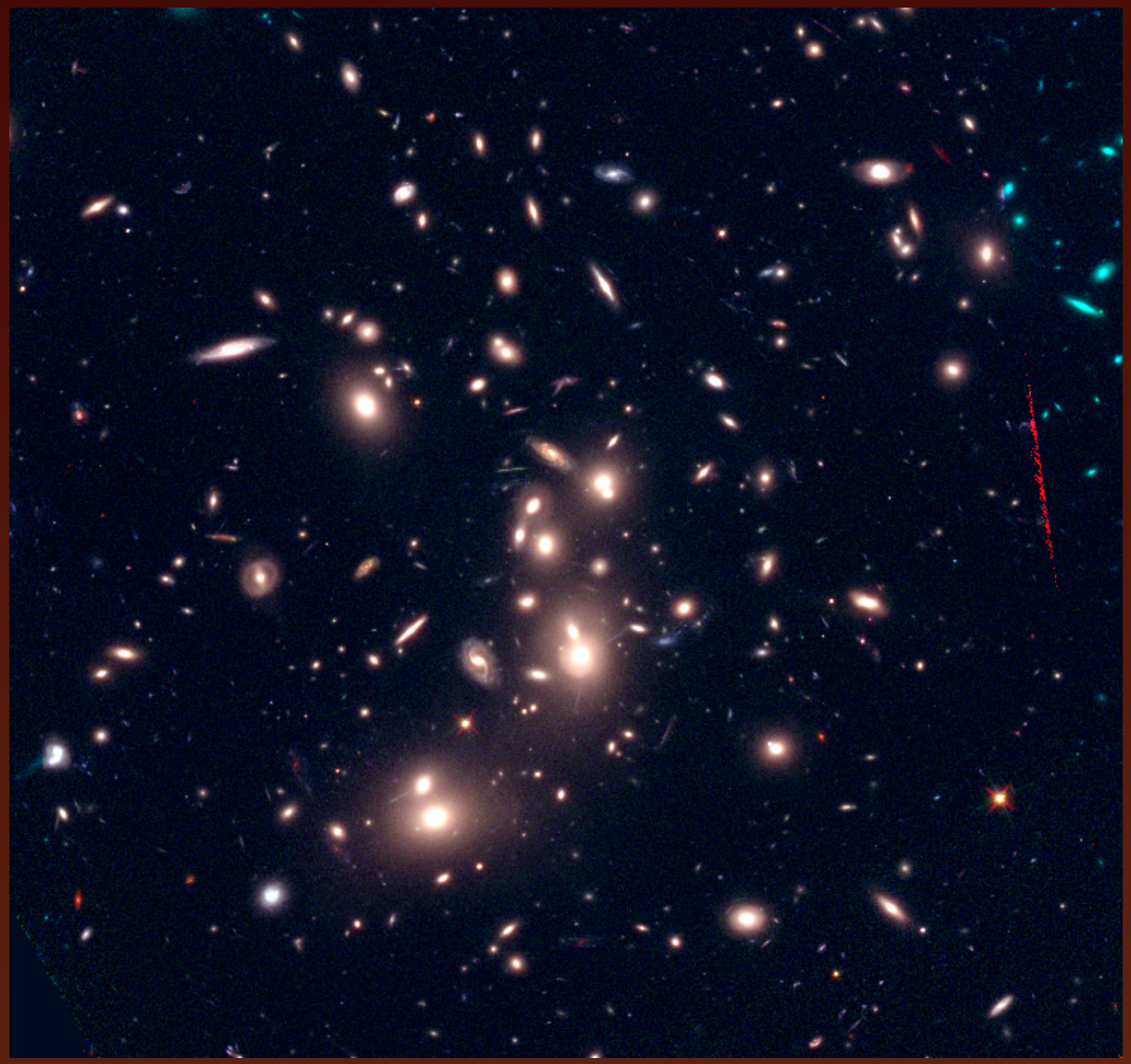
- Parametric
- Free-form
- Hybrid



Meneghetti et al. 2017

Building a lens model

…with Lenstool



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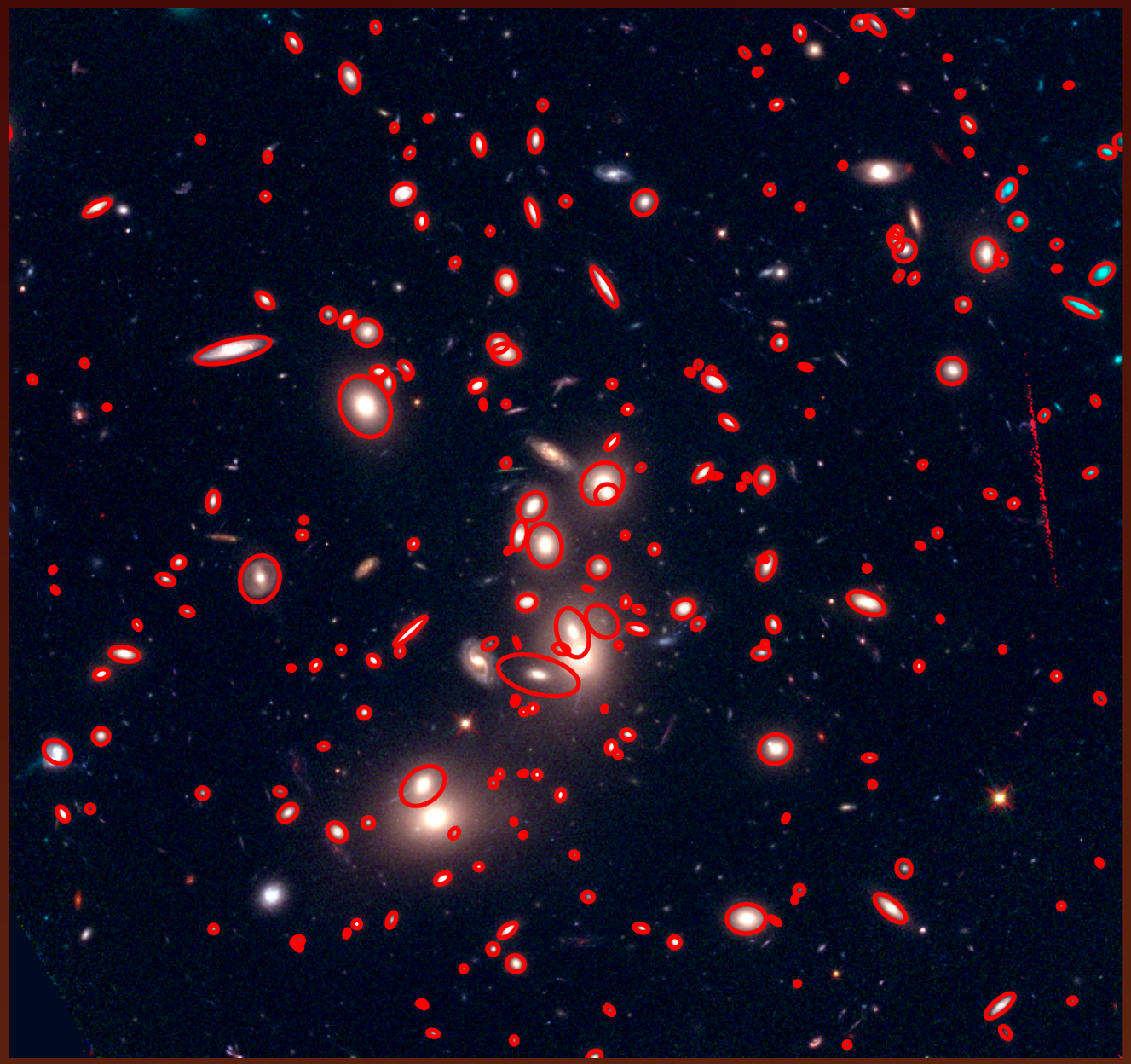


Select the cluster members

Building a lens model

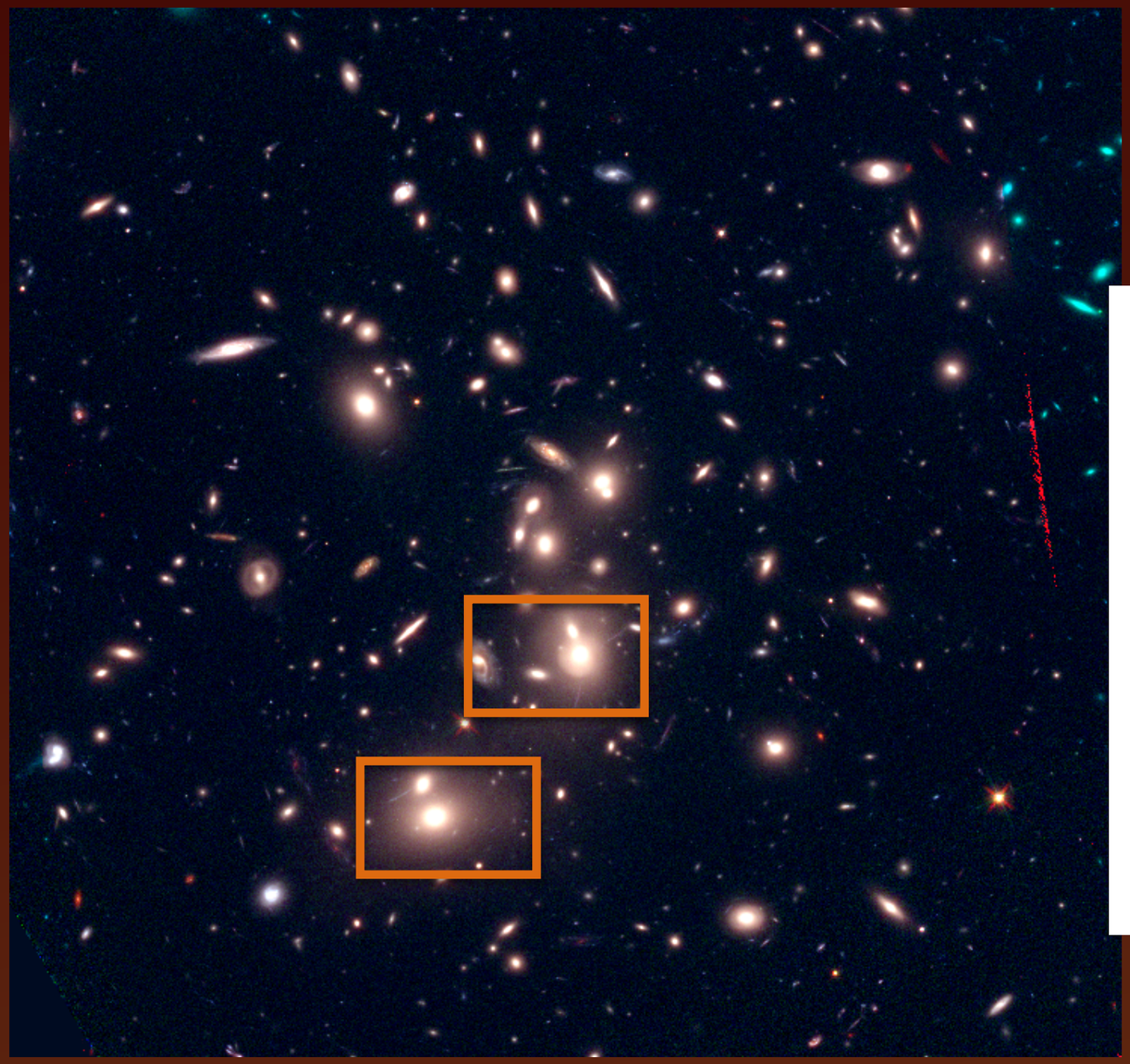
…with Lenstool

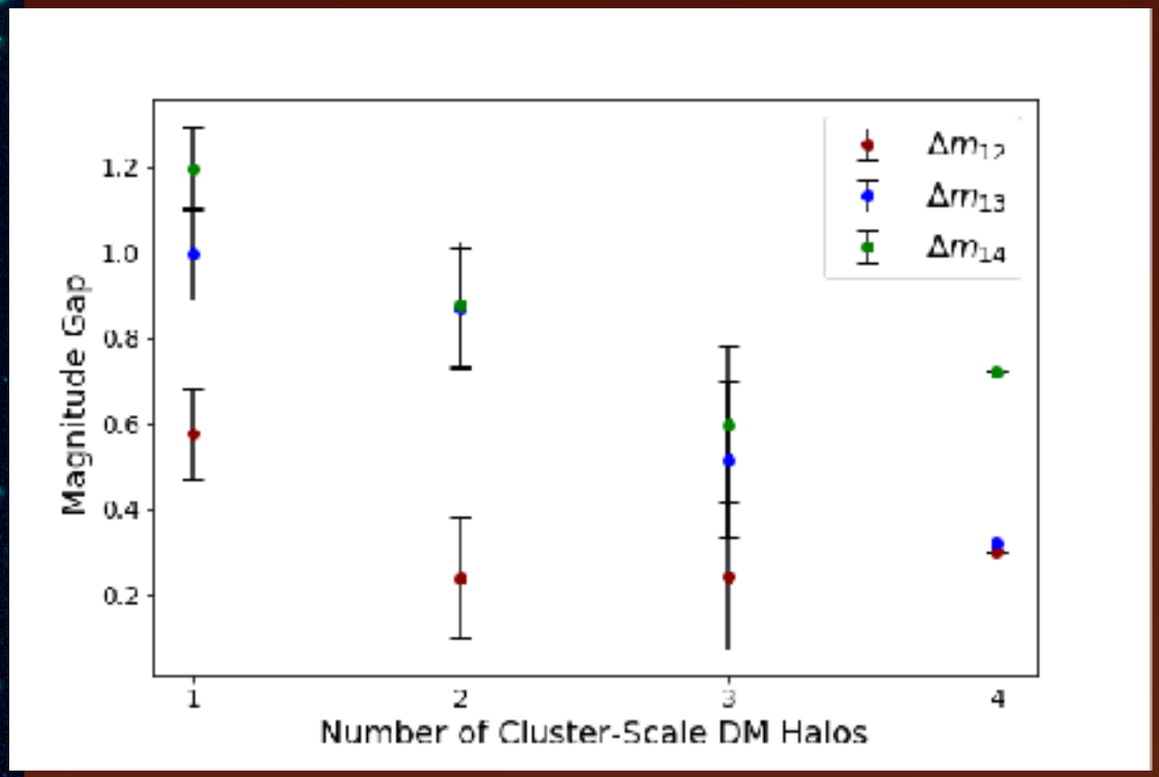
Select the cluster members

Find the lensing constraints

Building a lens model

…with Lenstool





work with Lucy Reynolds Lv4 student at Durham

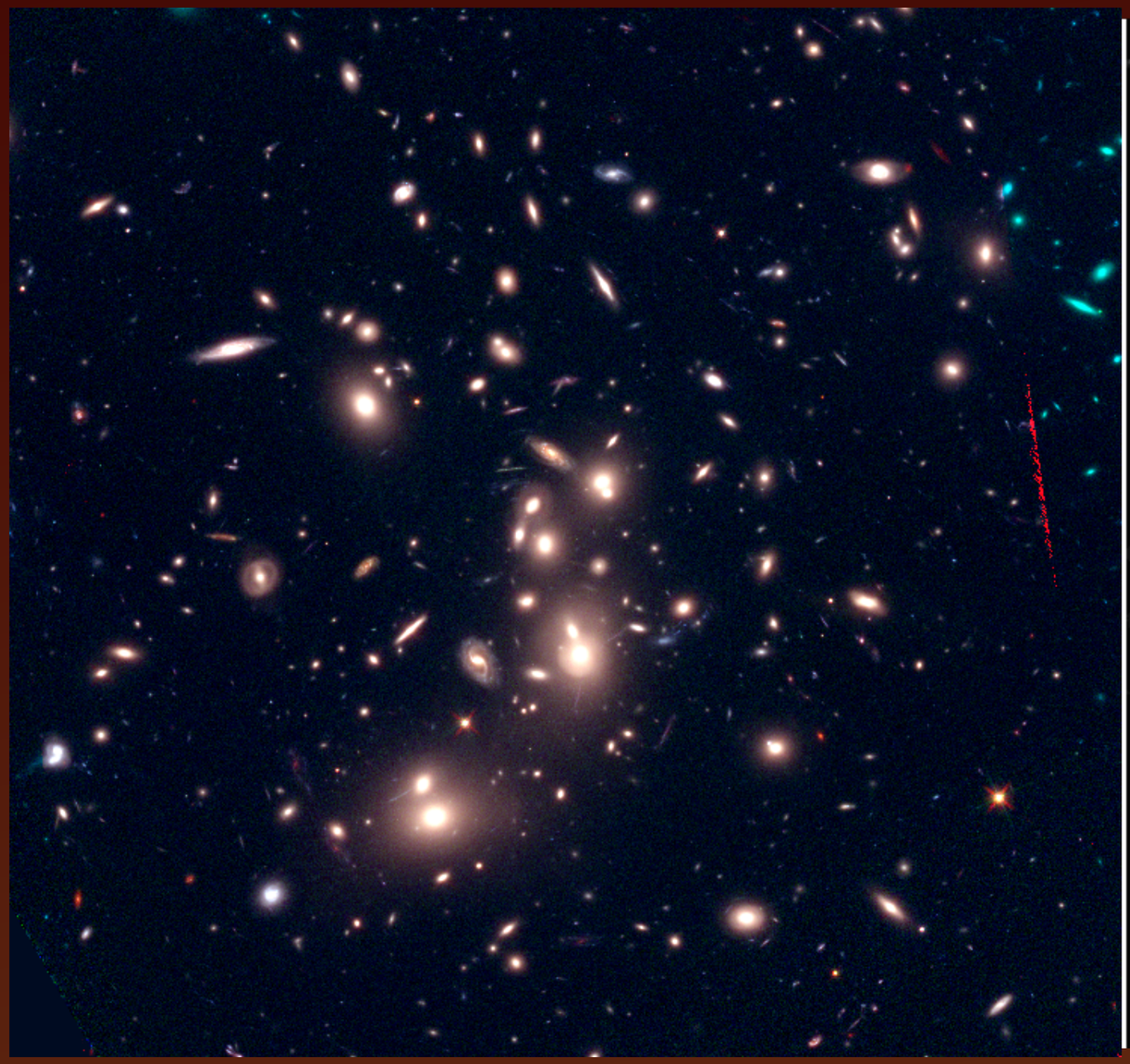
Select the cluster members

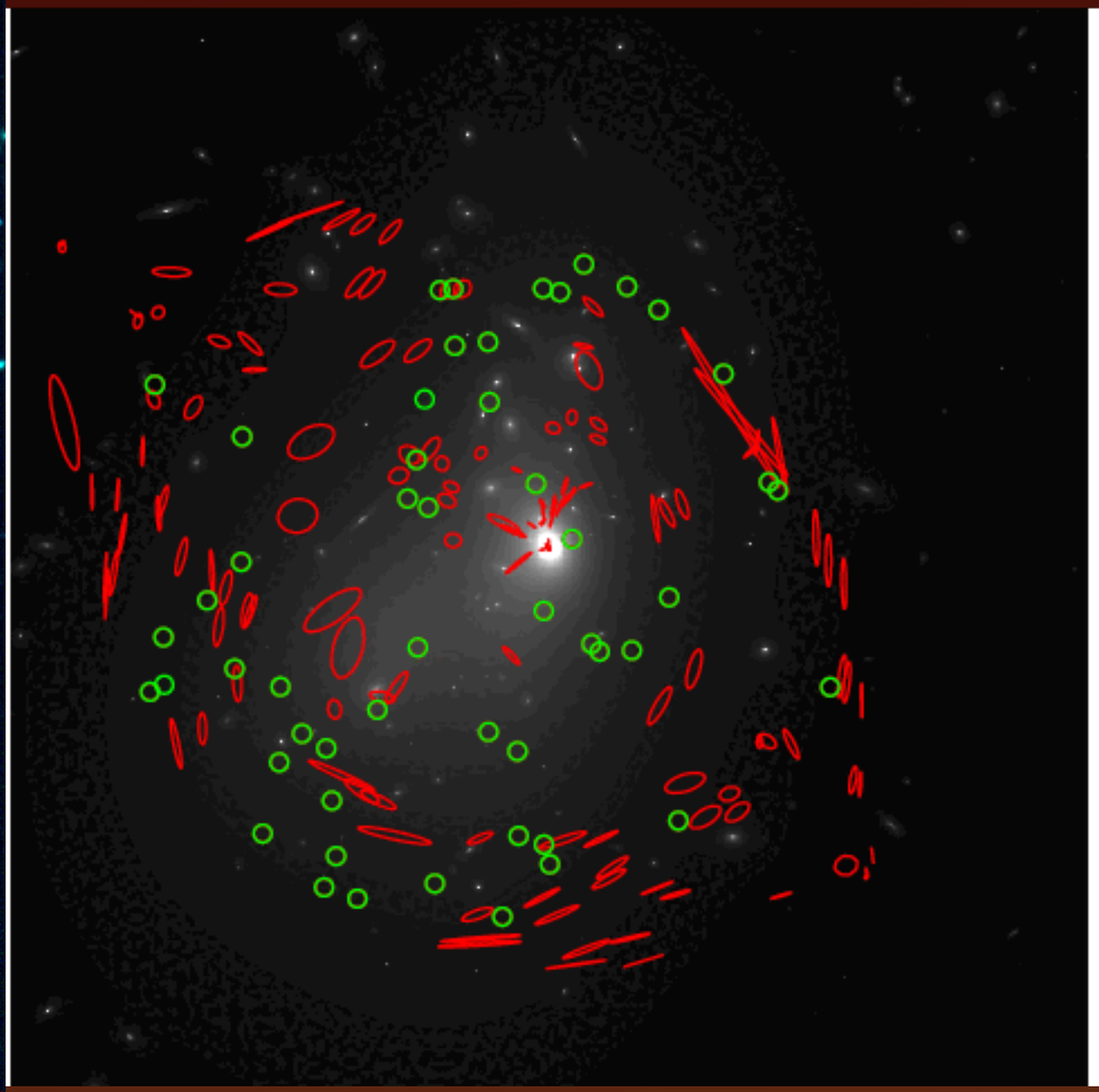
Find the lensing constraints

Add Dark matter halos

Building a lens model

…with Lenstool





And know what do you do with that ?

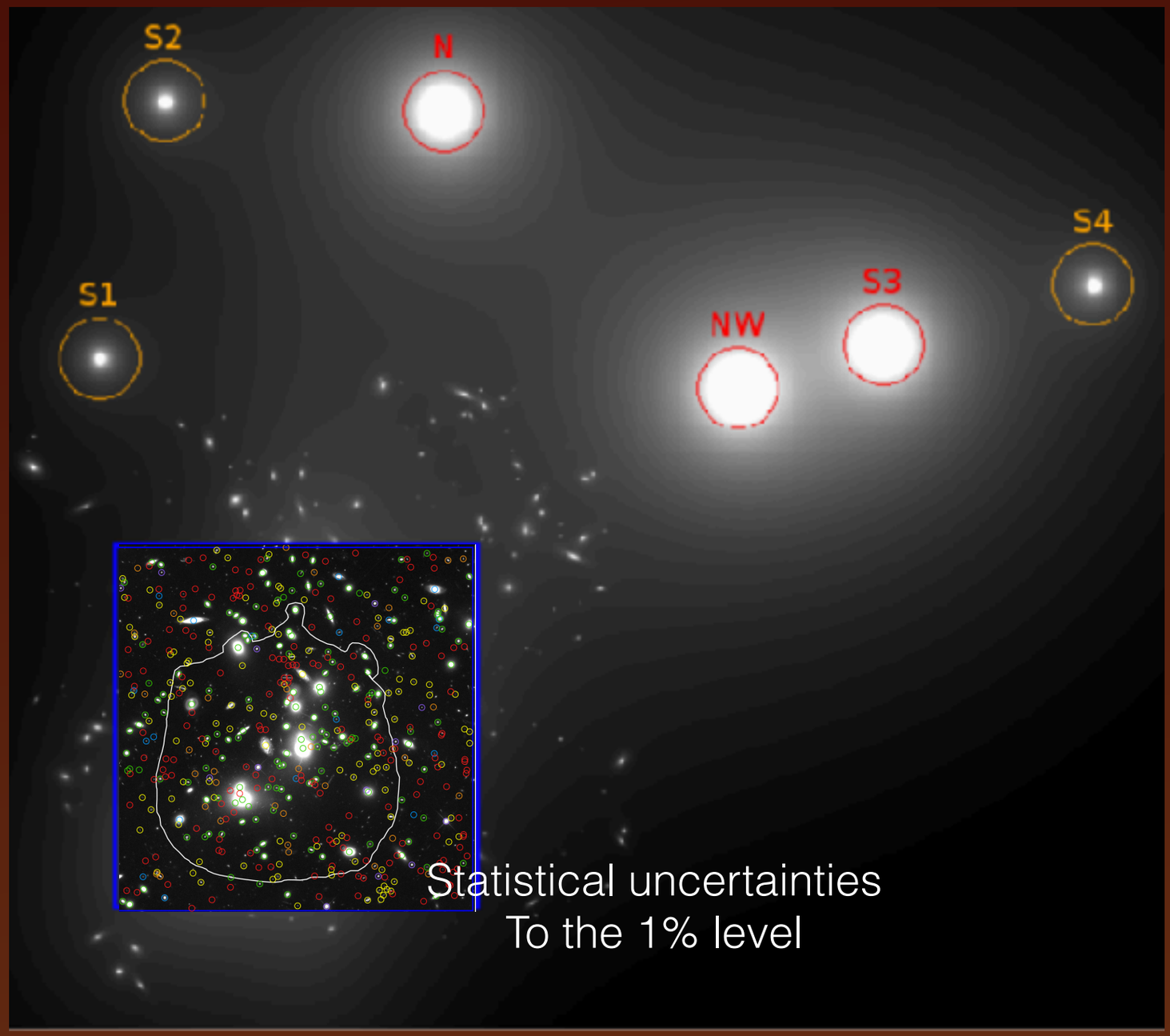
Cluster physics
and substructures

Lensed universe

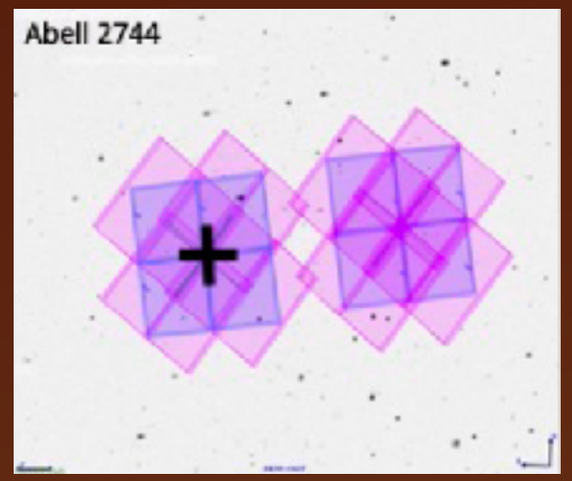
The dark matter distribution

Mahler et al. 2018

Sensitive to the outskirts masses



Statistical uncertainties
To the 1% level



Buffalo program

SMACS J0723.3-7327

SMACS J0723.3-7327

6 lensing models

3 pre-JWST

2 models as part of the public release of RELICS:
1 Lenstool
1 GLAFIC

1 LTM models in Golubchik+2022

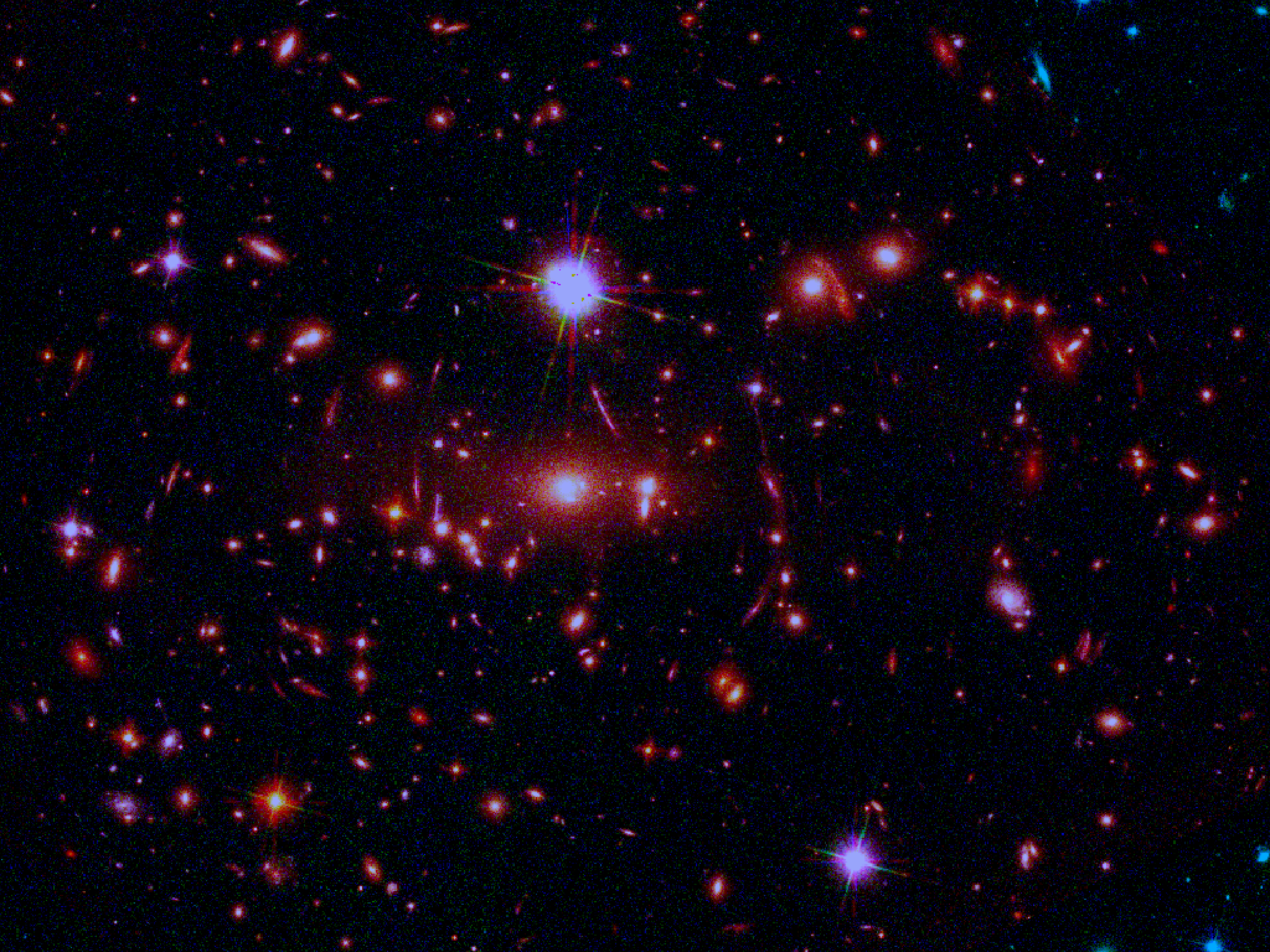
3 post-JWST

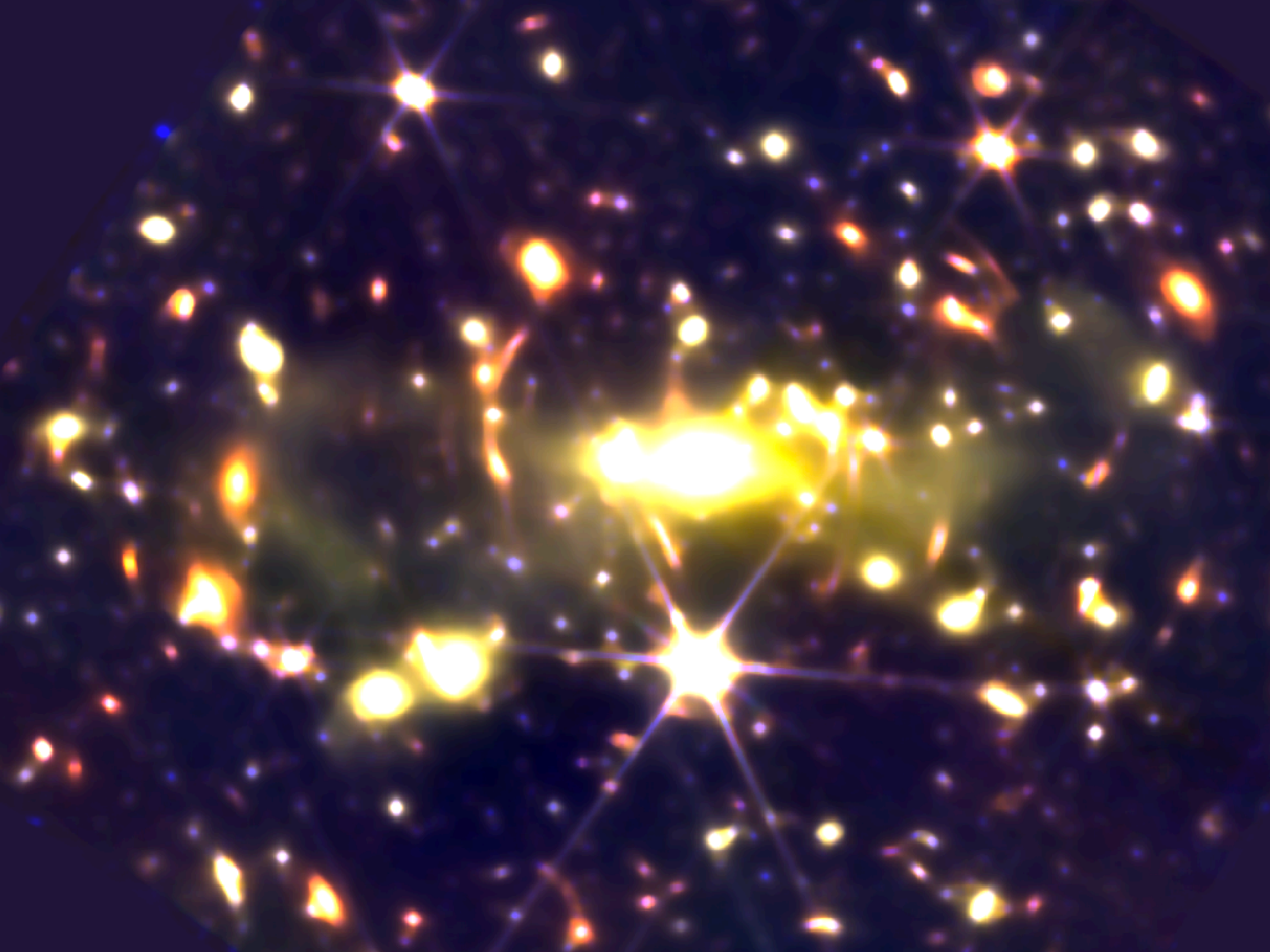
3 models:

Mahler et al 2022 - Lenstool

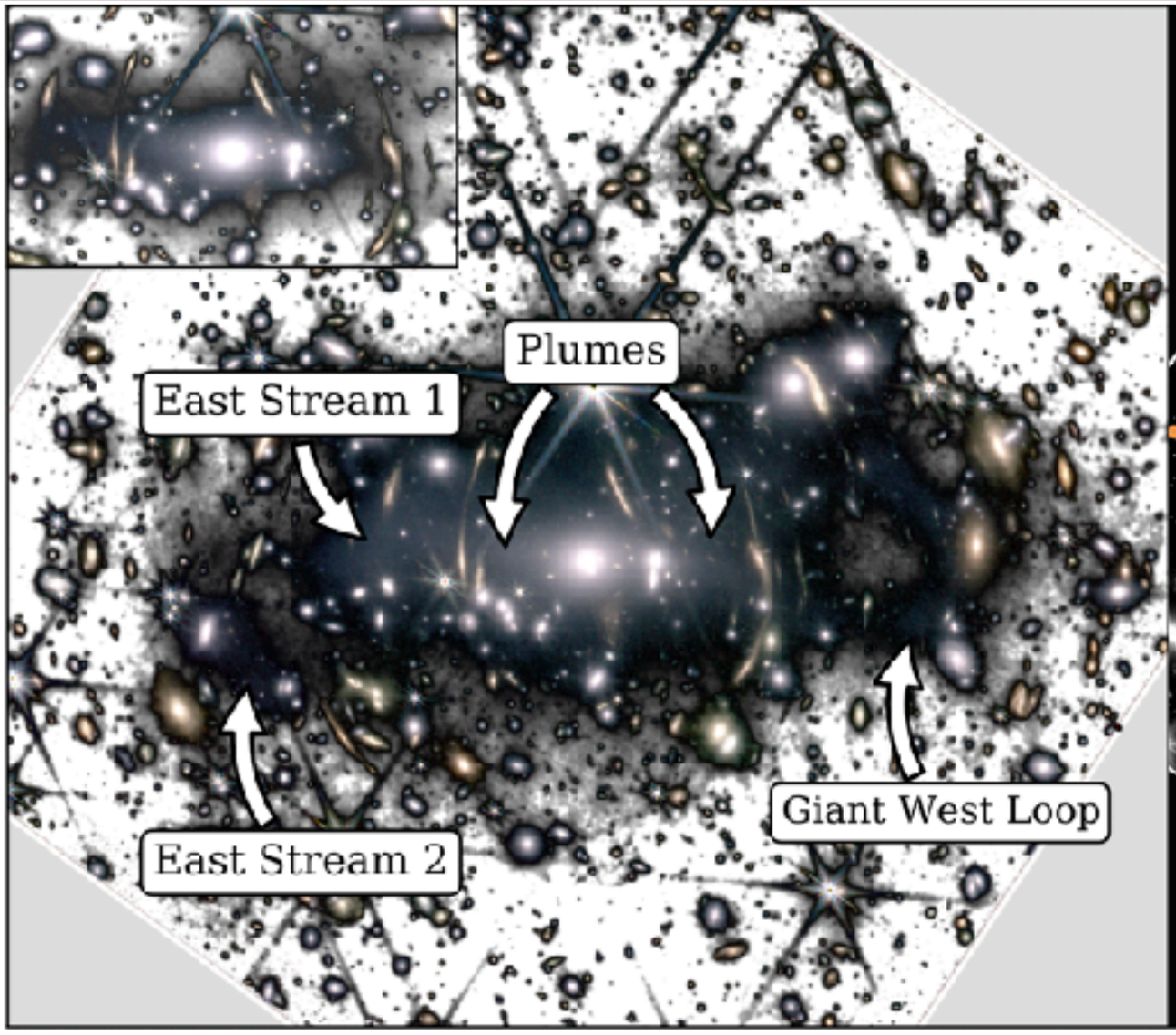
Pascale et al. 2022 - Parametric

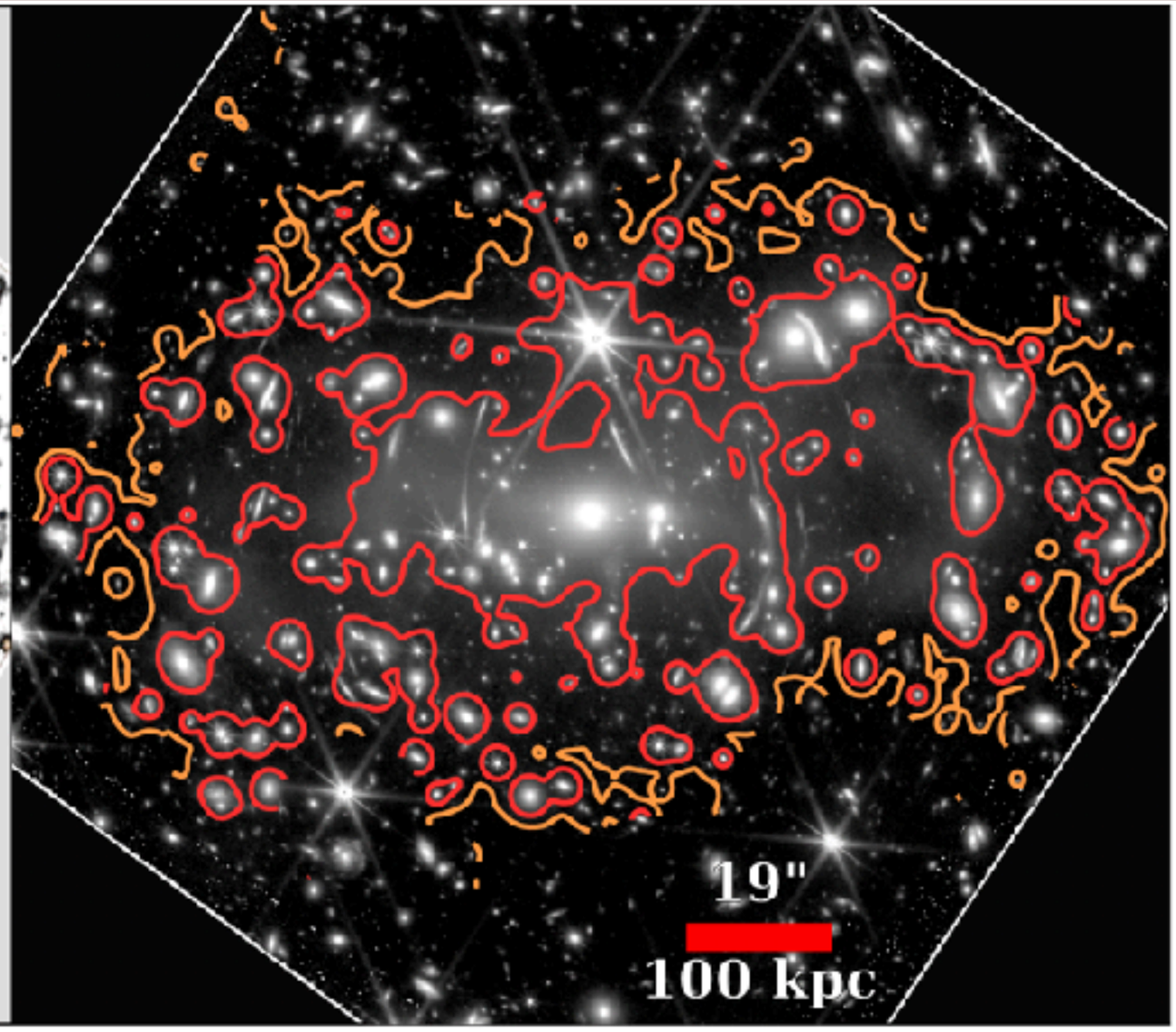
Caminha et al 2022 - Lenstool





The complexe structure of the Intra-Cluster Light

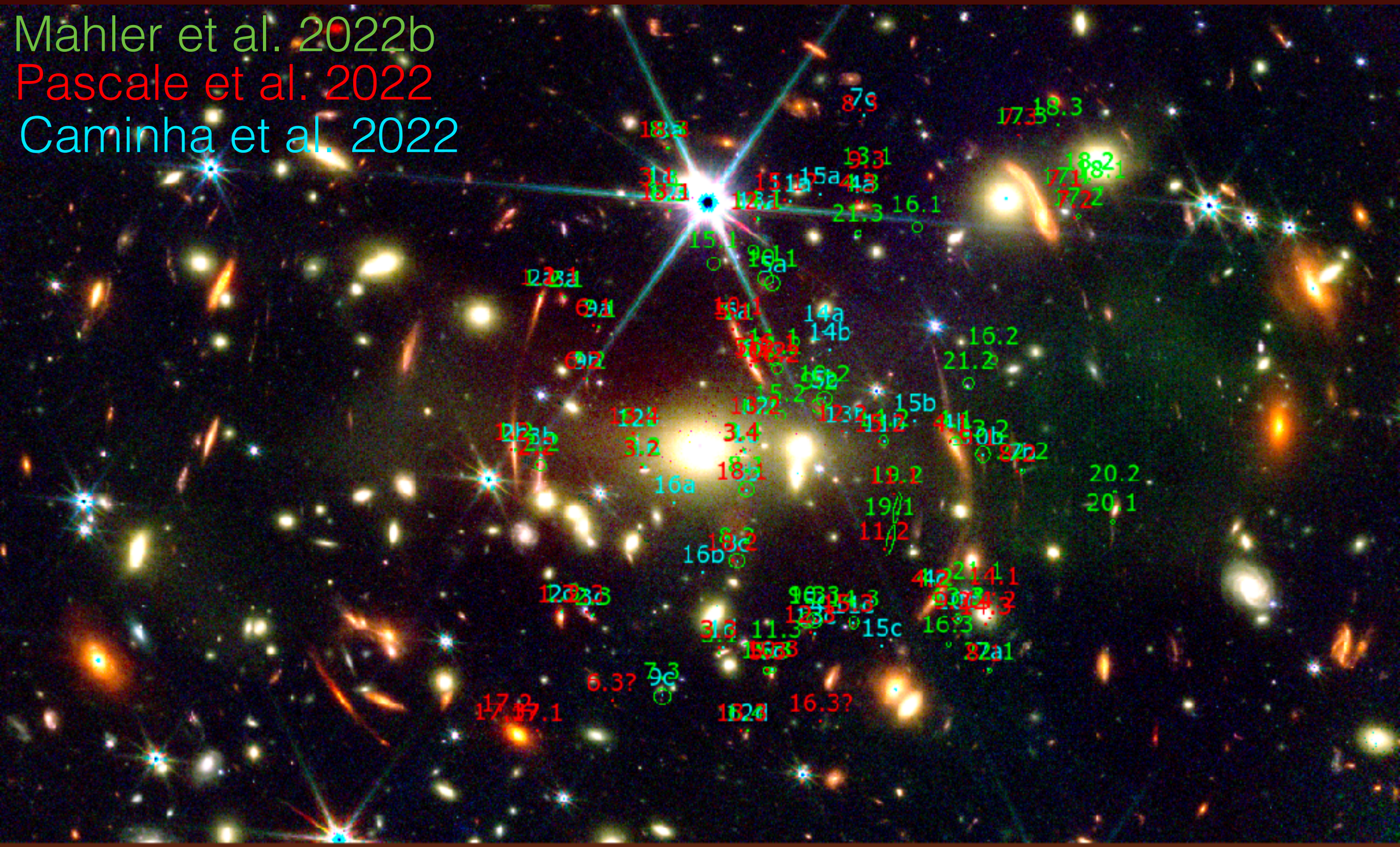




Montes & Trujillo 2022

We harmonised the labelling

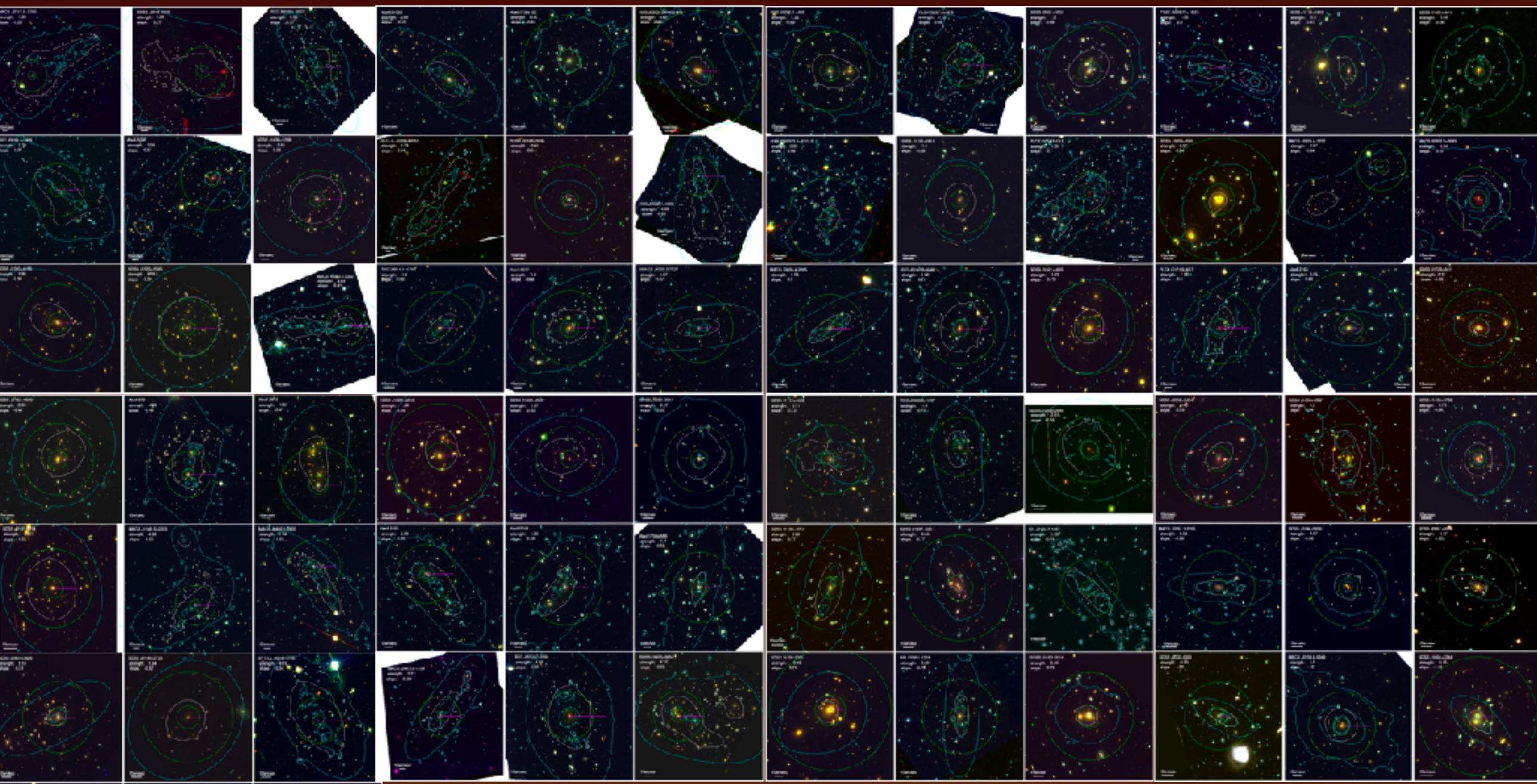
Mahler et al. 2022b
Pascale et al. 2022
Caminha et al. 2022



We harmonised the labelling

And what about more than one cluster?

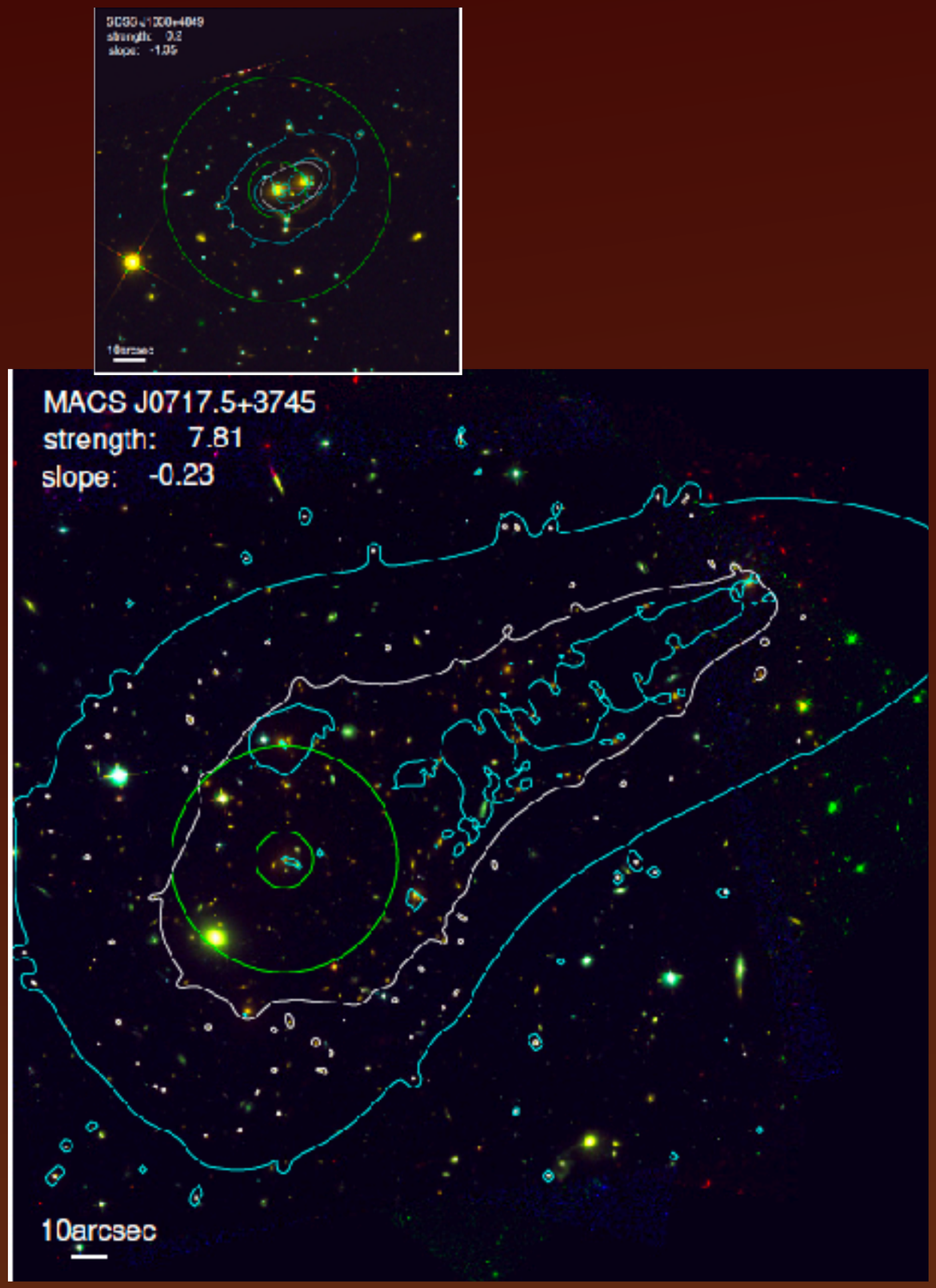
And what about more than one cluster?



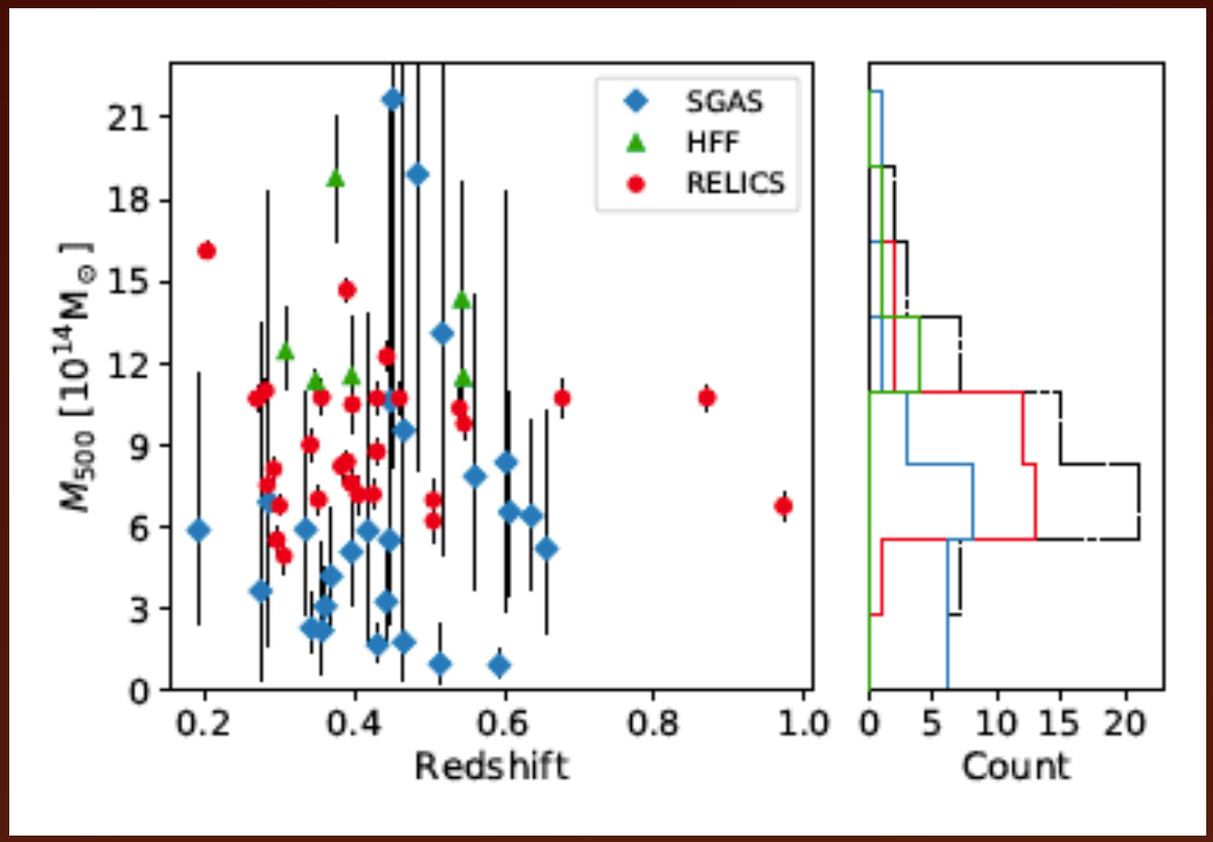
Fox et al. 2022

74 cluster fields 94 lens models

What does magnification correlates with?



Fox, Mahler et al. 2022



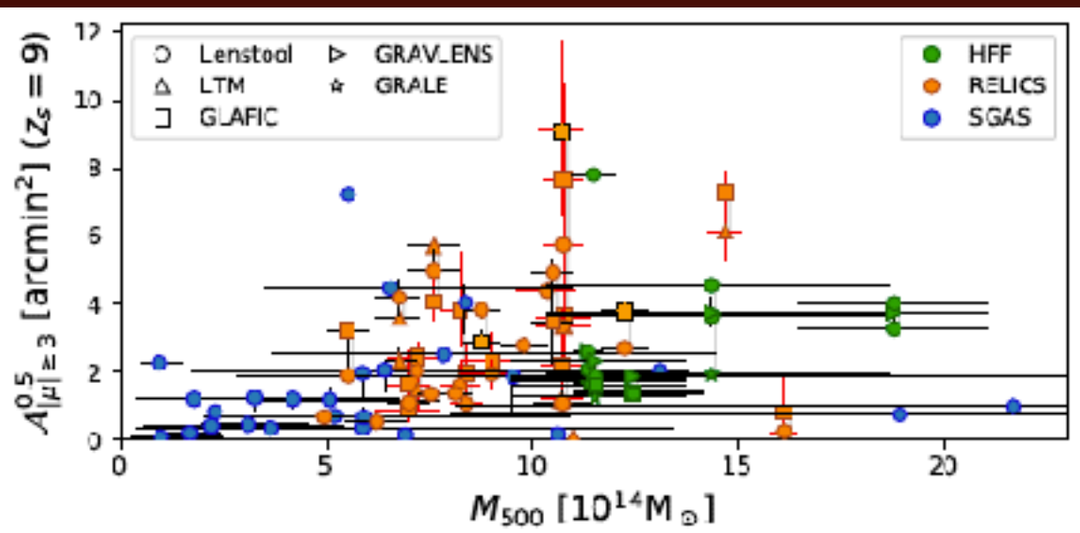
Fox, Mahler et al. 2022

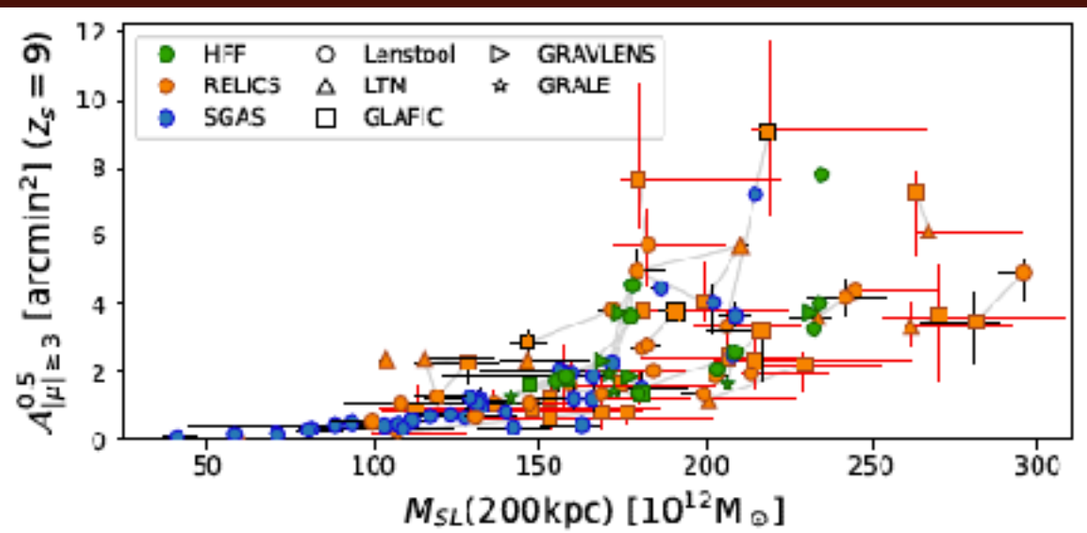
We are looking at:

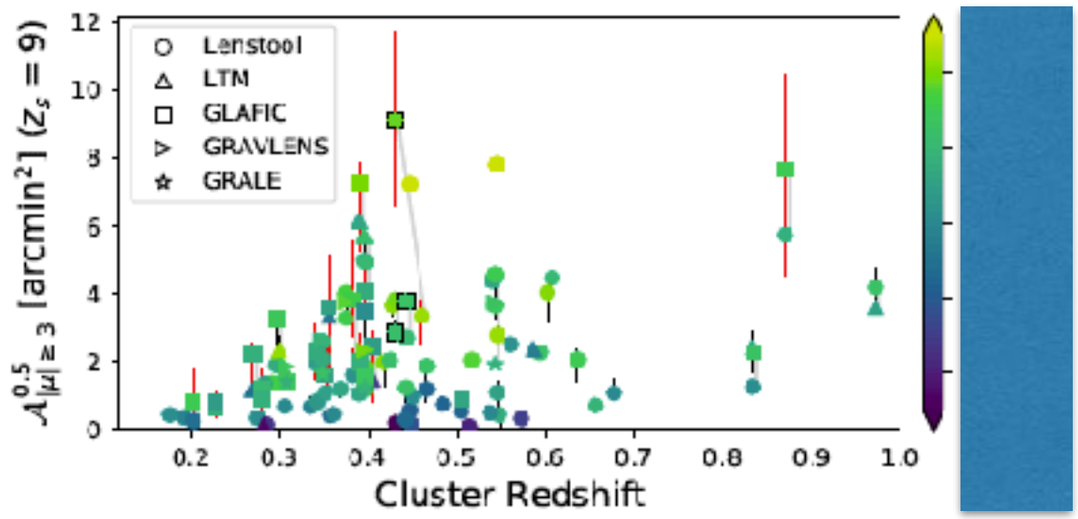
- Flatness of the profile
- The area magnified >3

What does magnification correlates with?

Fox, Mahler et al. 2022







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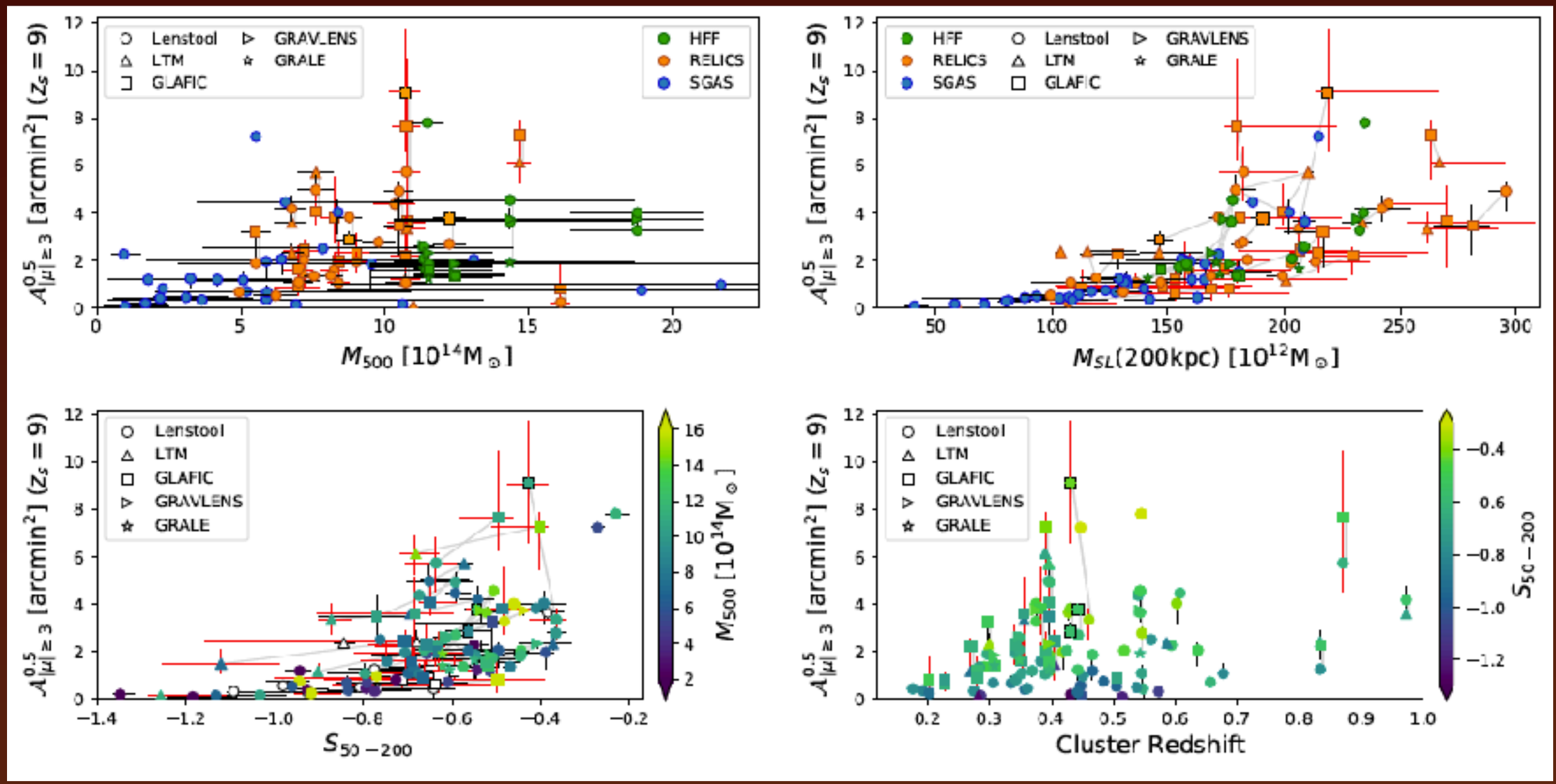
Fox, Mahler et al. 2022



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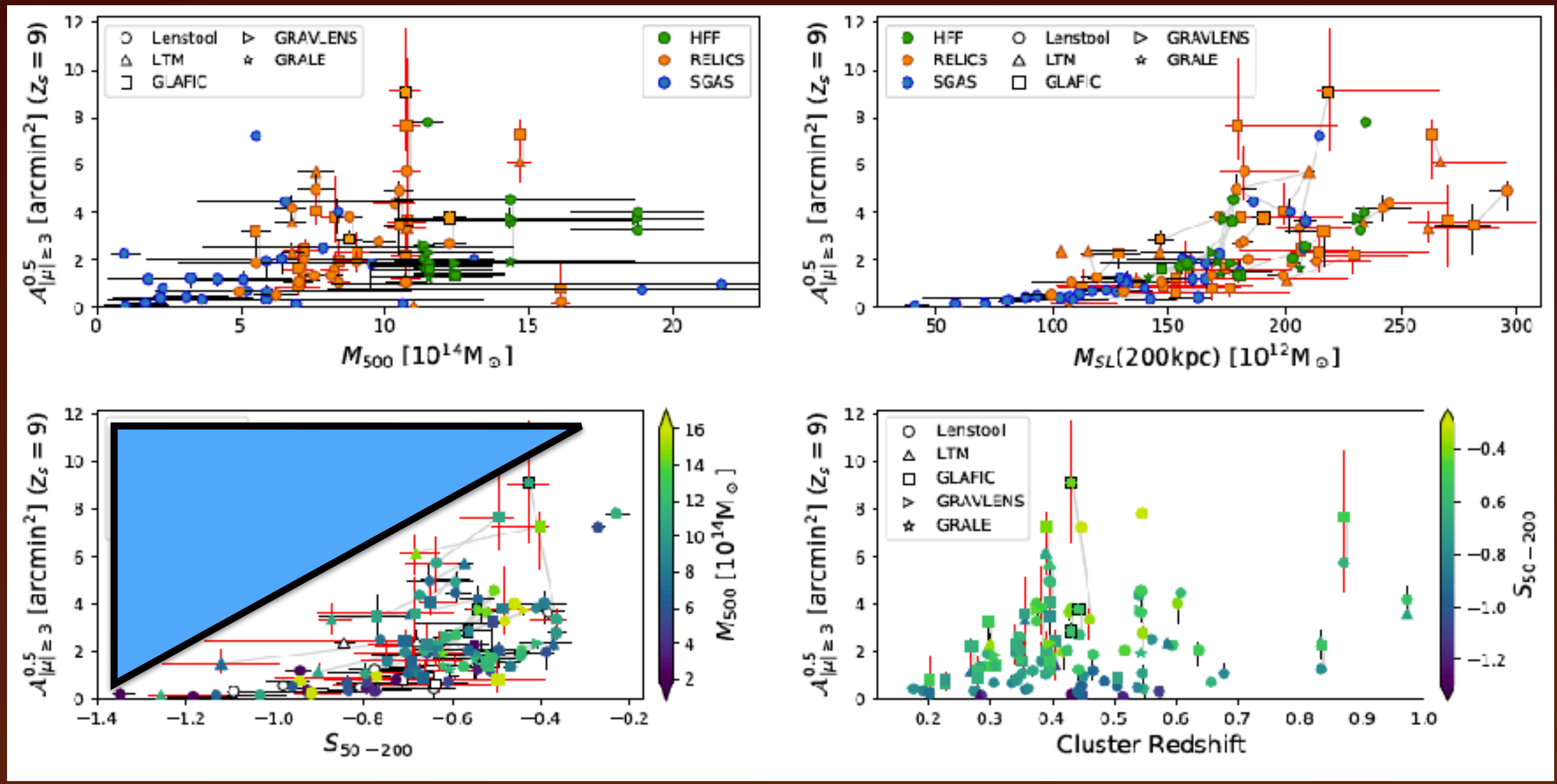
Fox, Mahler et al. 2022

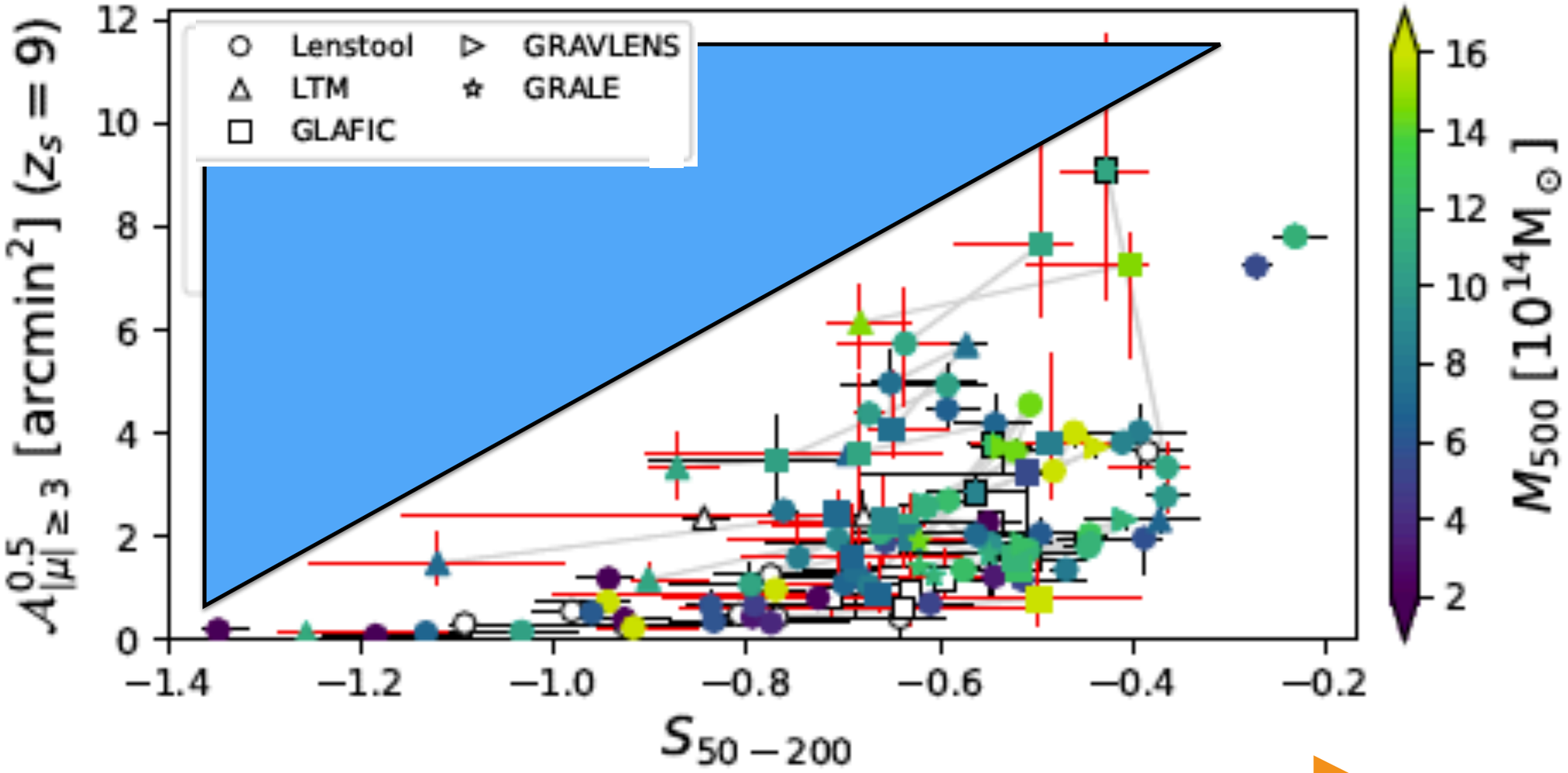


Can this challenge CDM?

But “good” lenses are not compact

Fox, Mahler et al. 2022

Good Lens



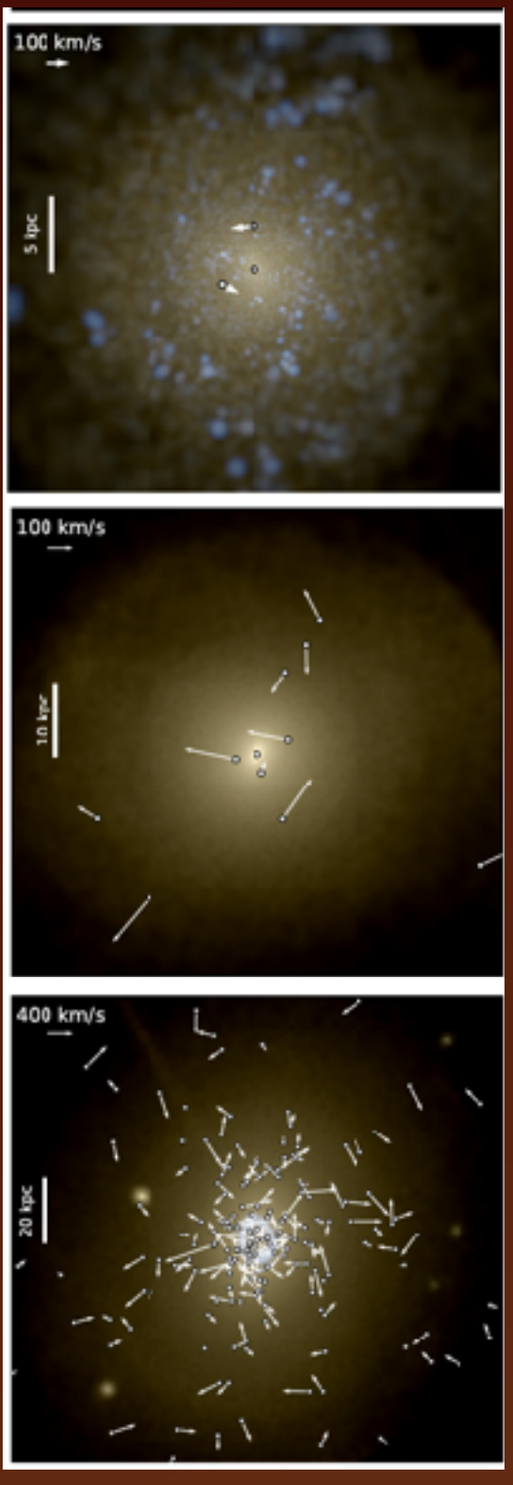
Bad Lens

Peaky

Flat

*Good here mean the size of the μ>3 magnified area at z=9 is large

Cluster members and supermassive black holes

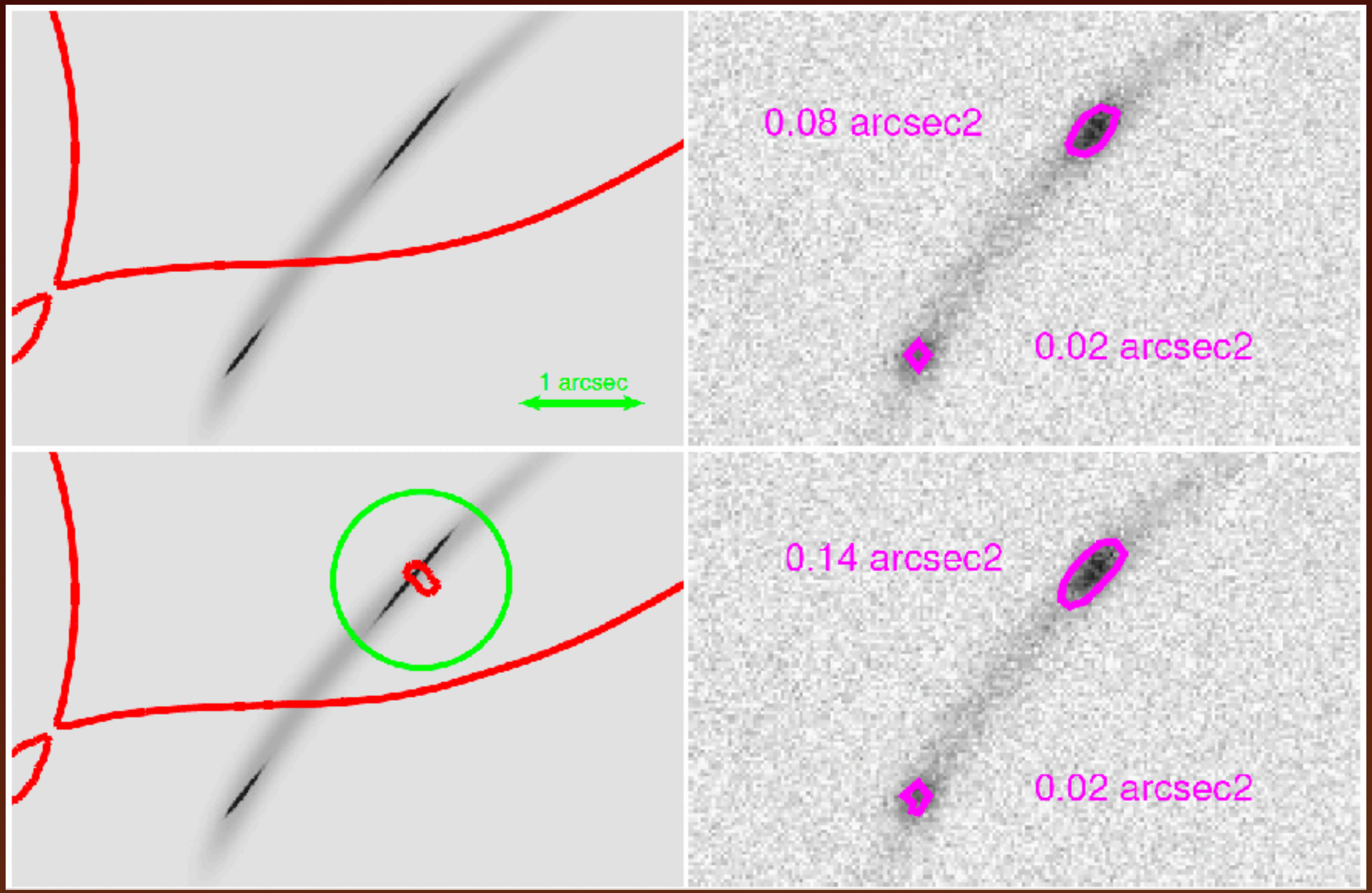


Ricarte et al. 2021

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 ?



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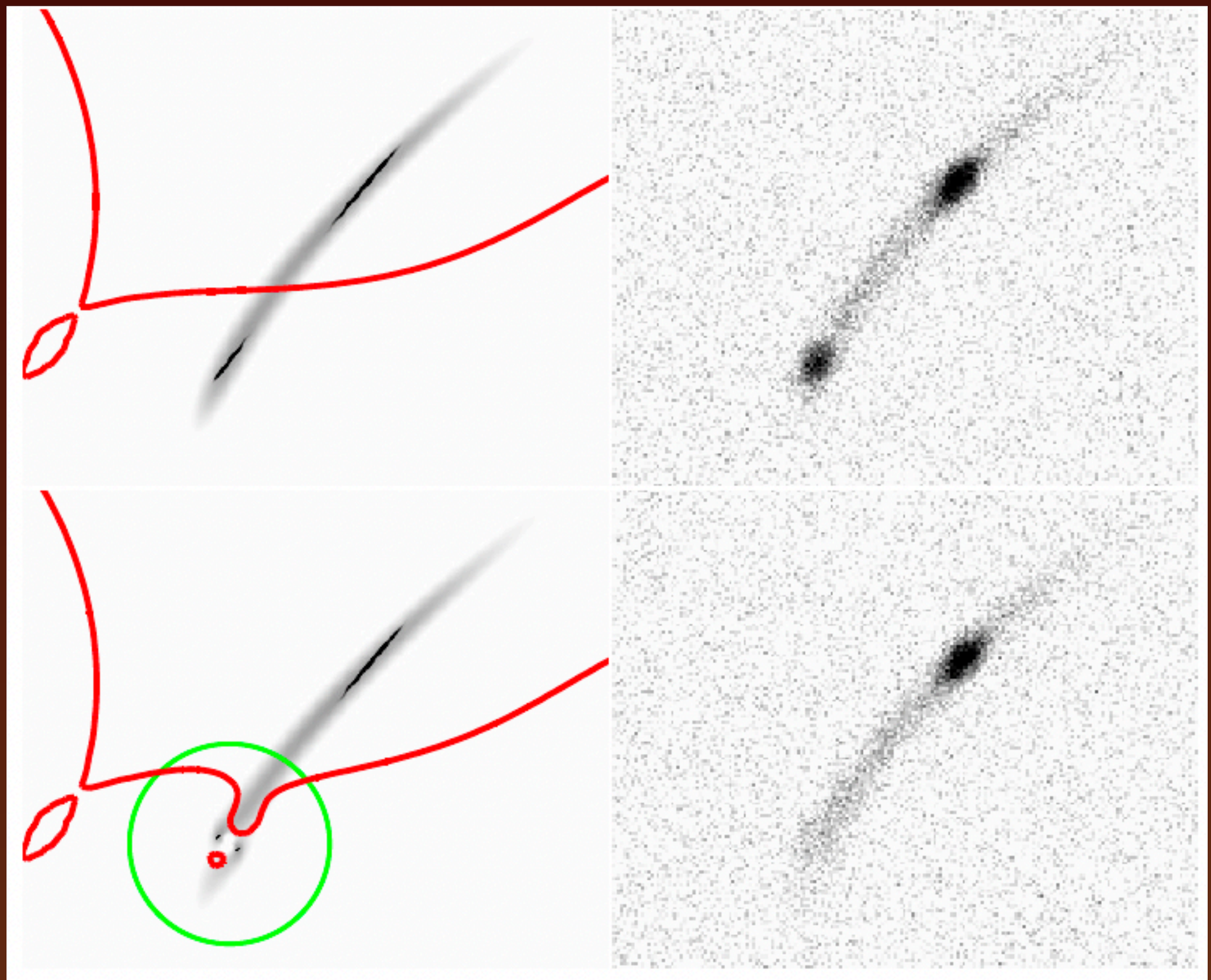

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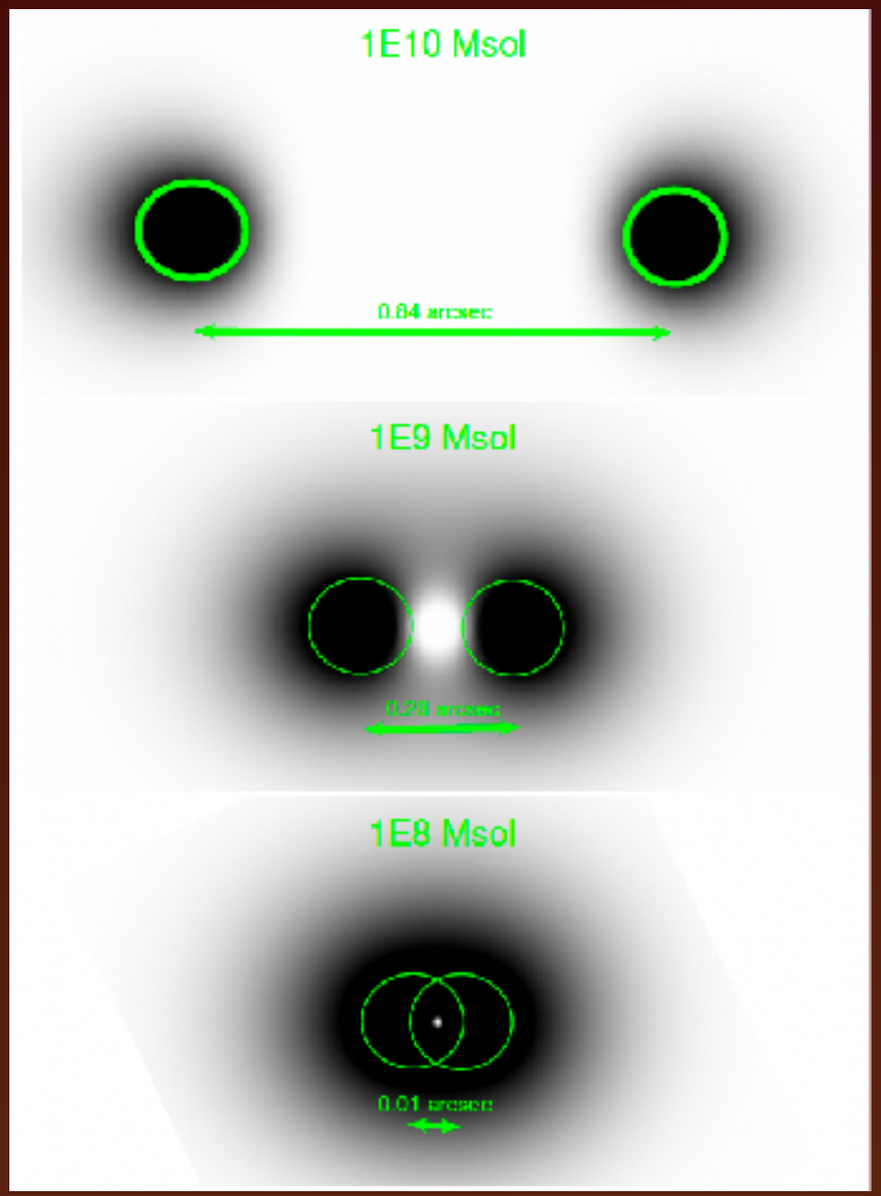

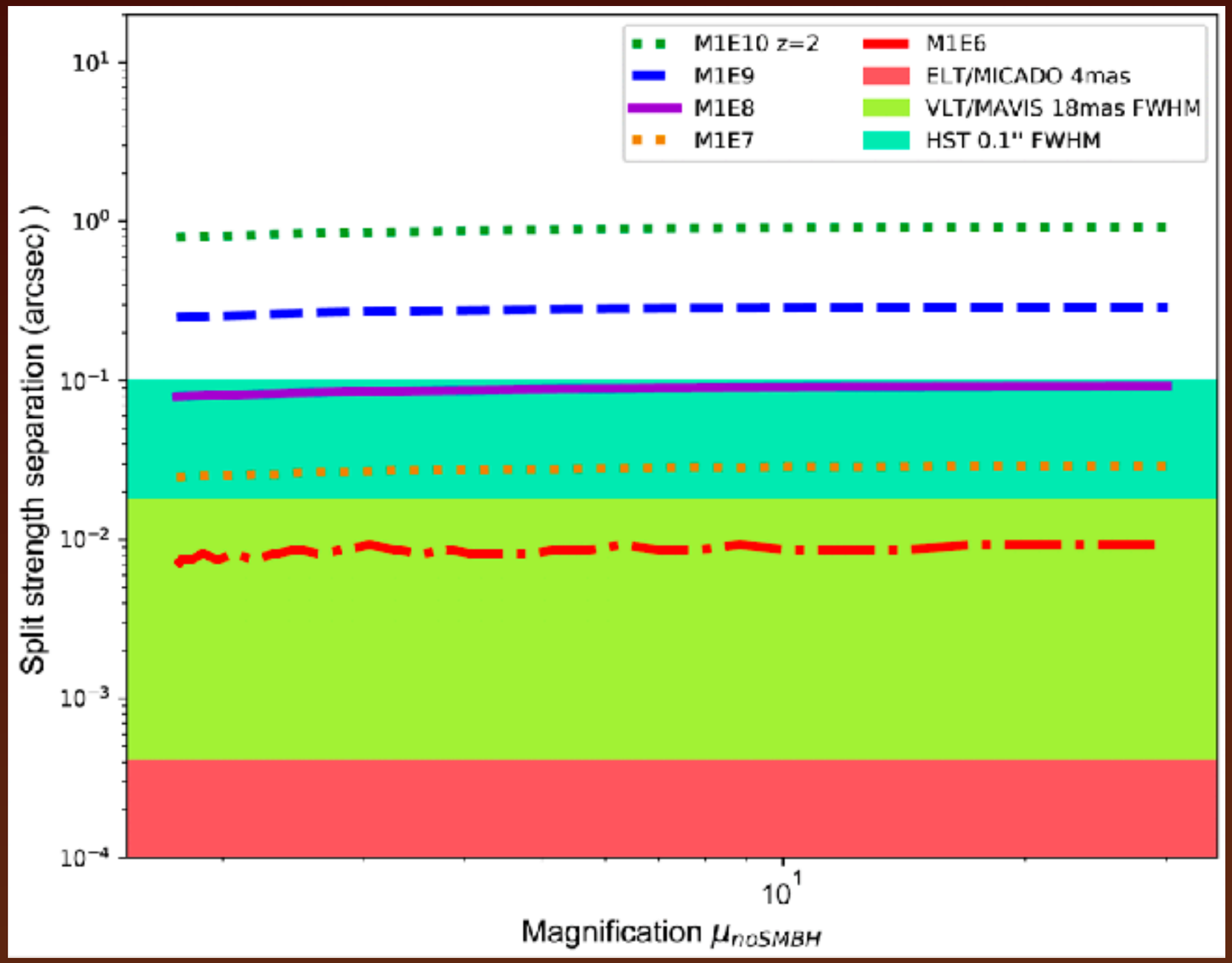

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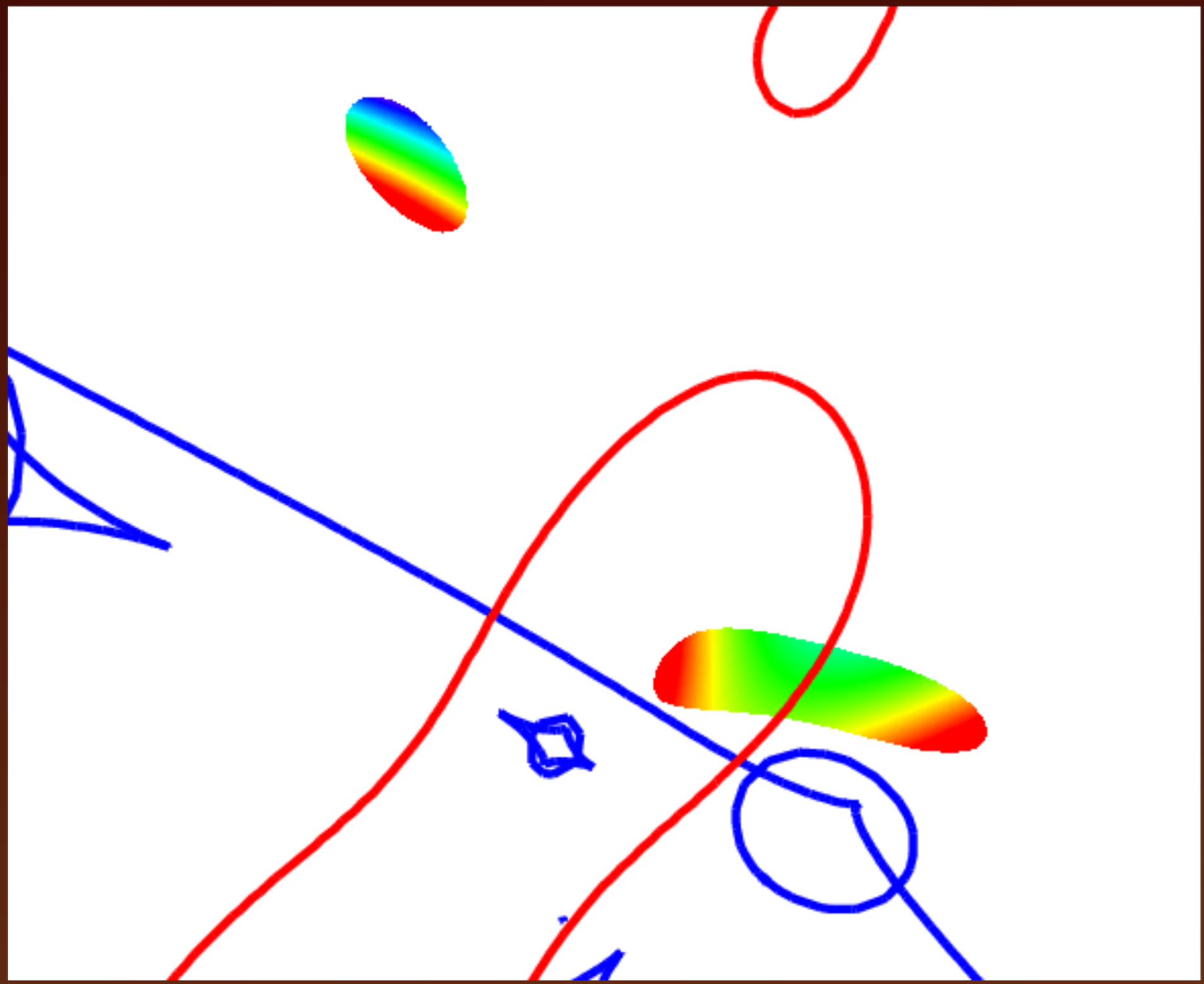
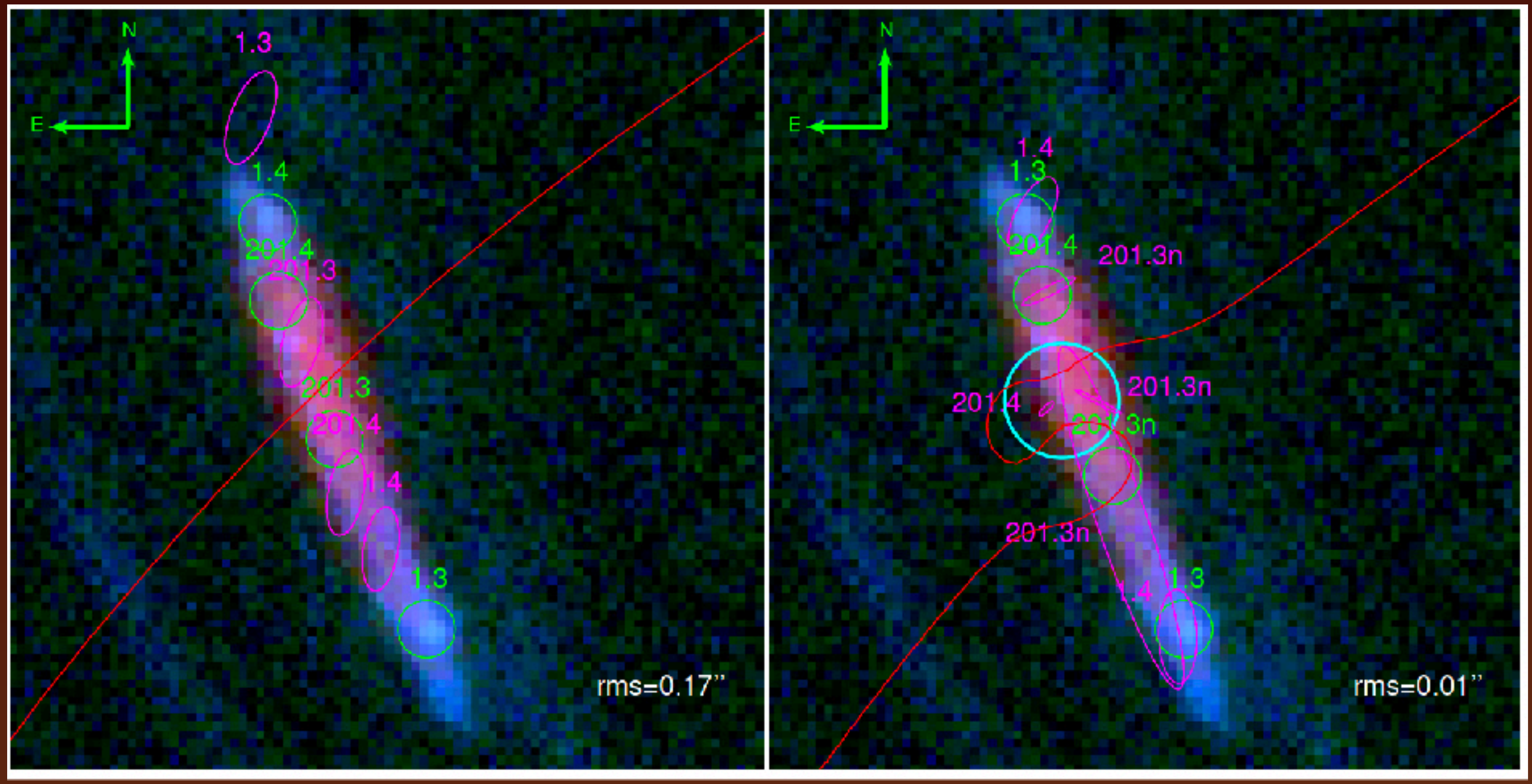
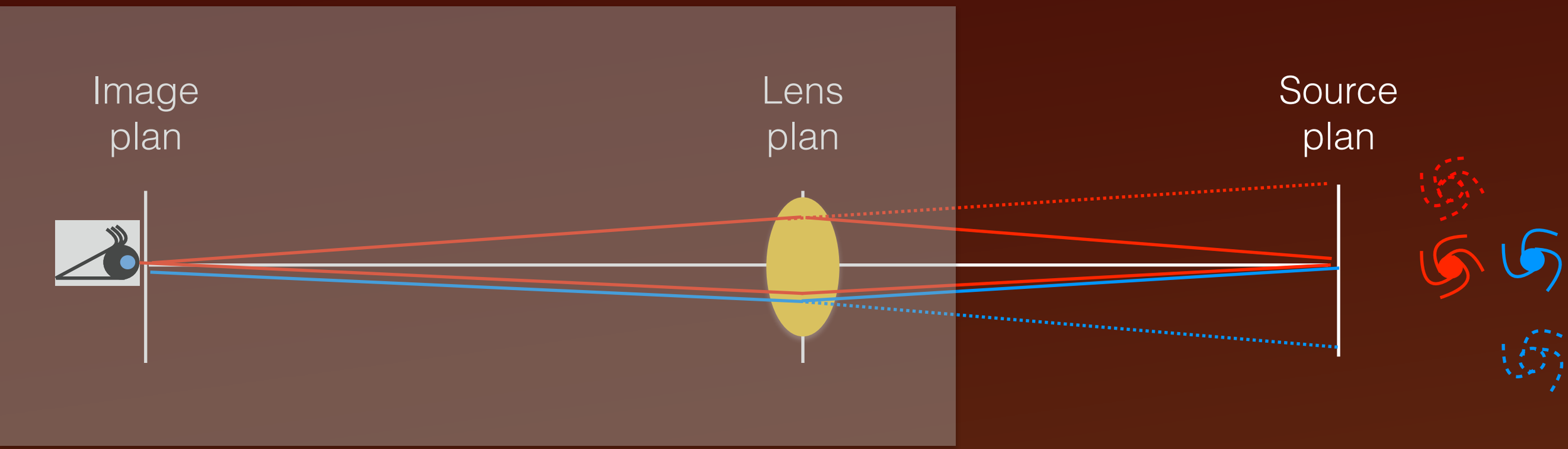


Simulation and wanderers



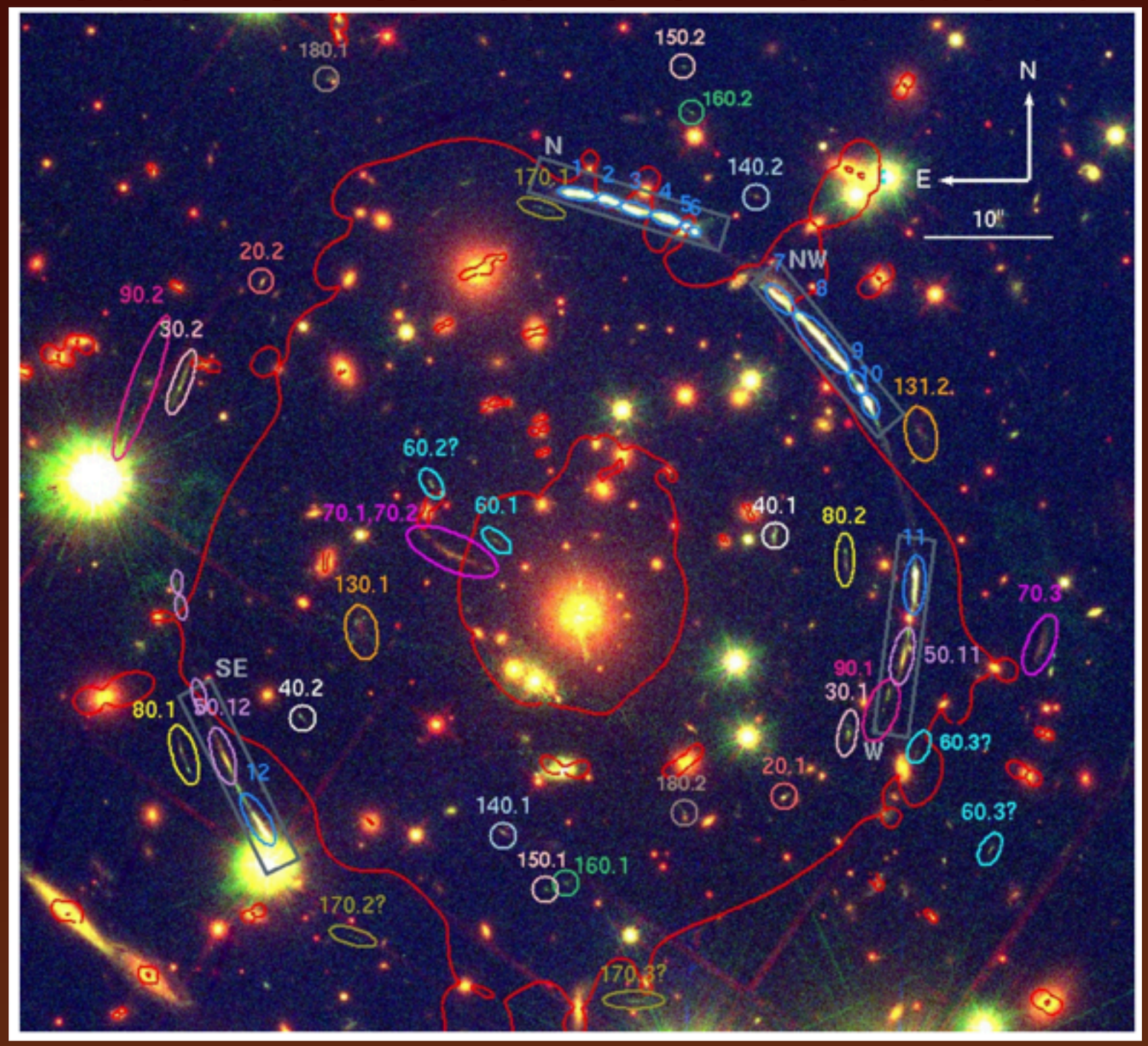
Behind the lens



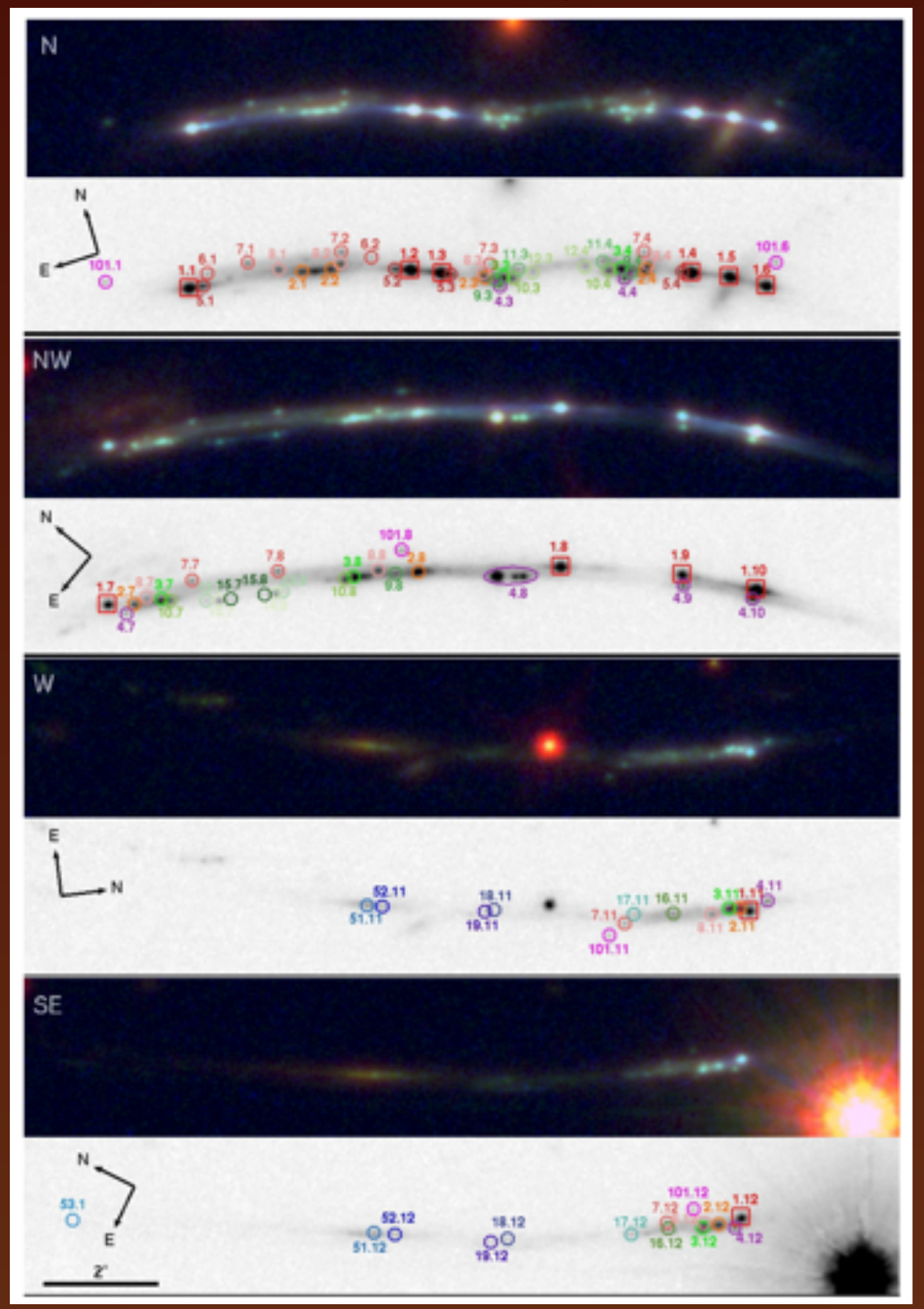
Behind the lens

.....Magnifying the universe

Cluster PSZ1 G311.65–18.48 - The sunburst arc

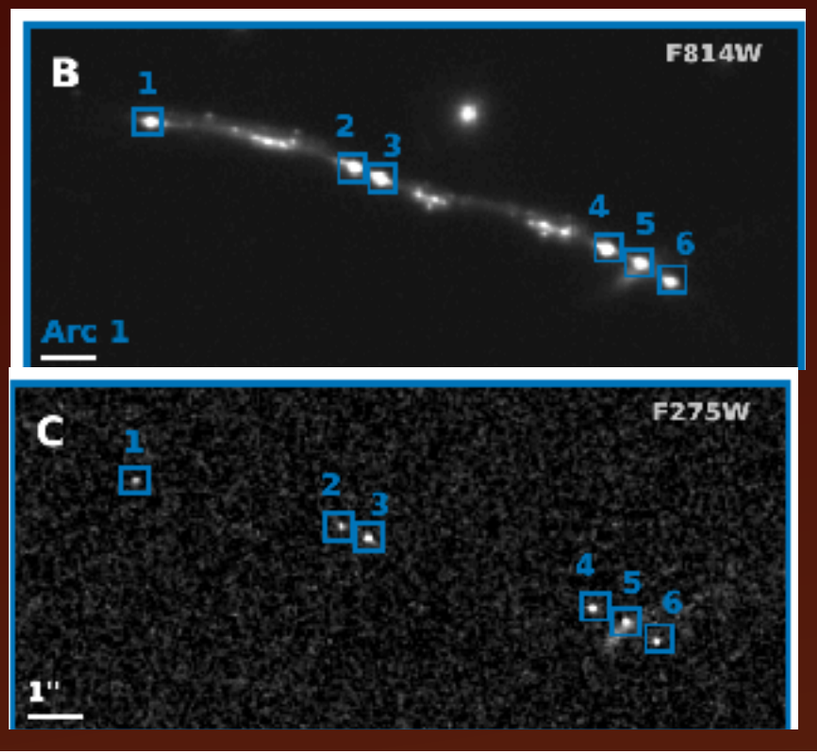


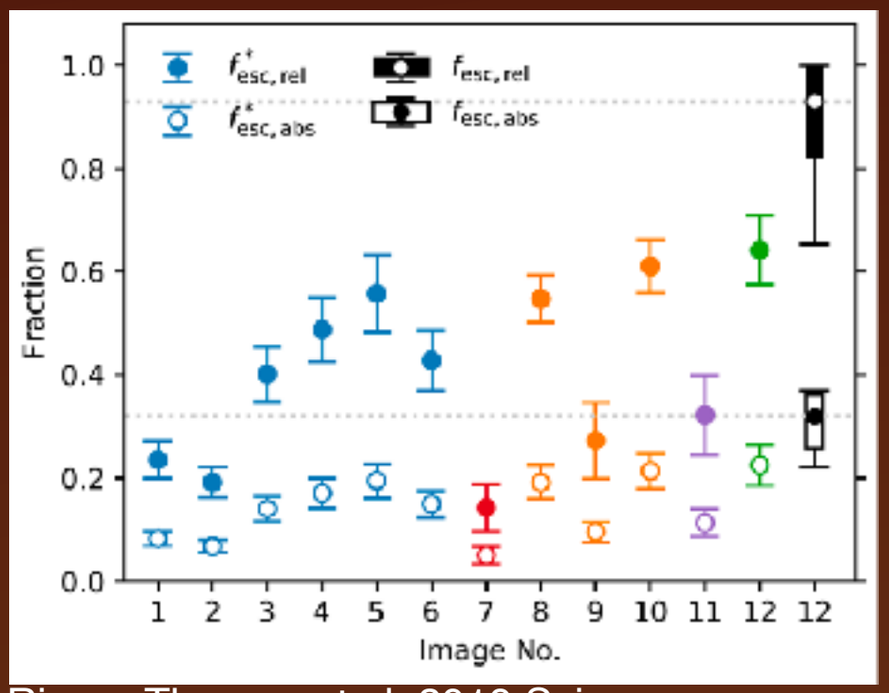
Sharon, Mahler et al. 2019



Behind the lens

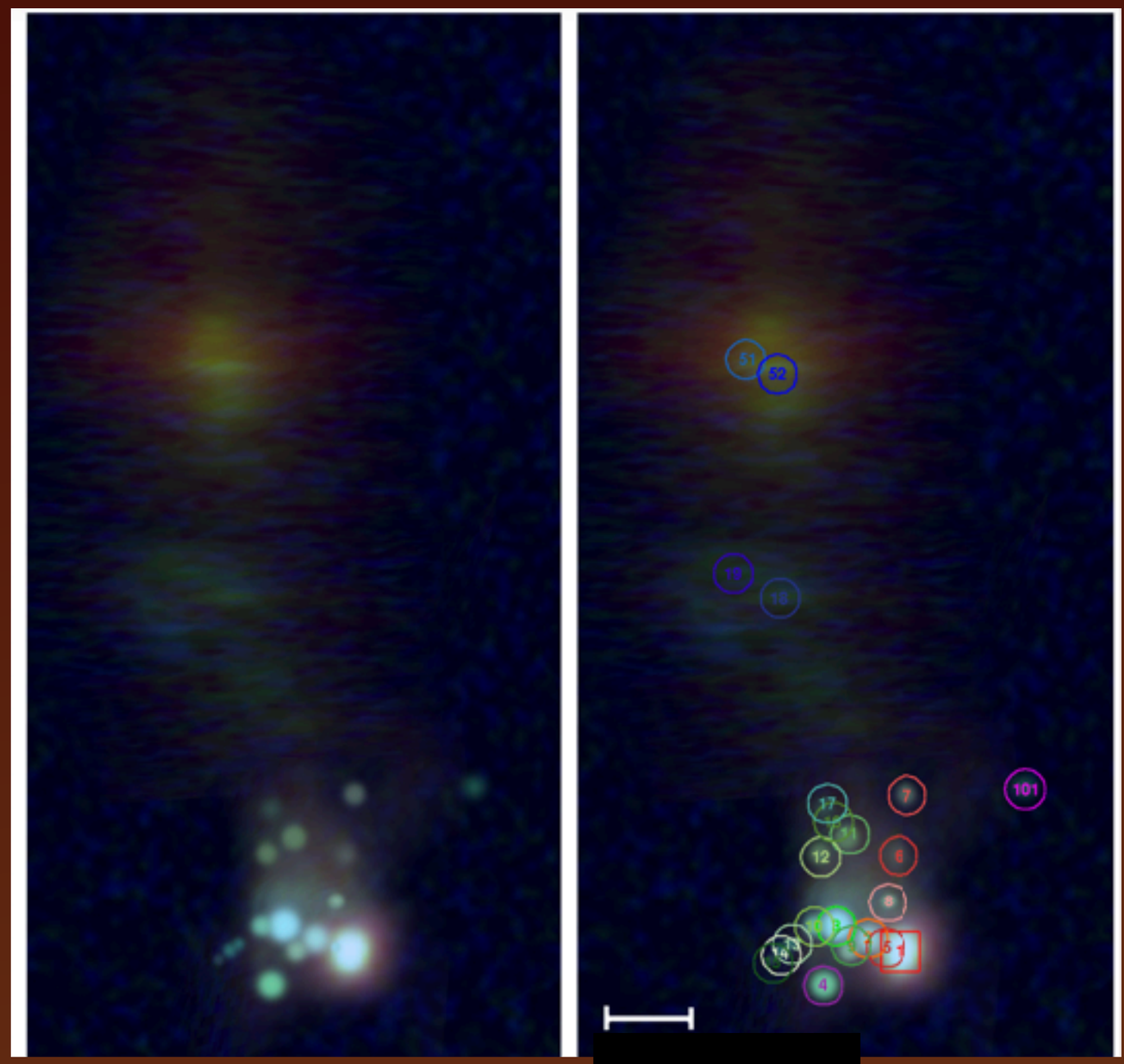
.....Magnifying the universe



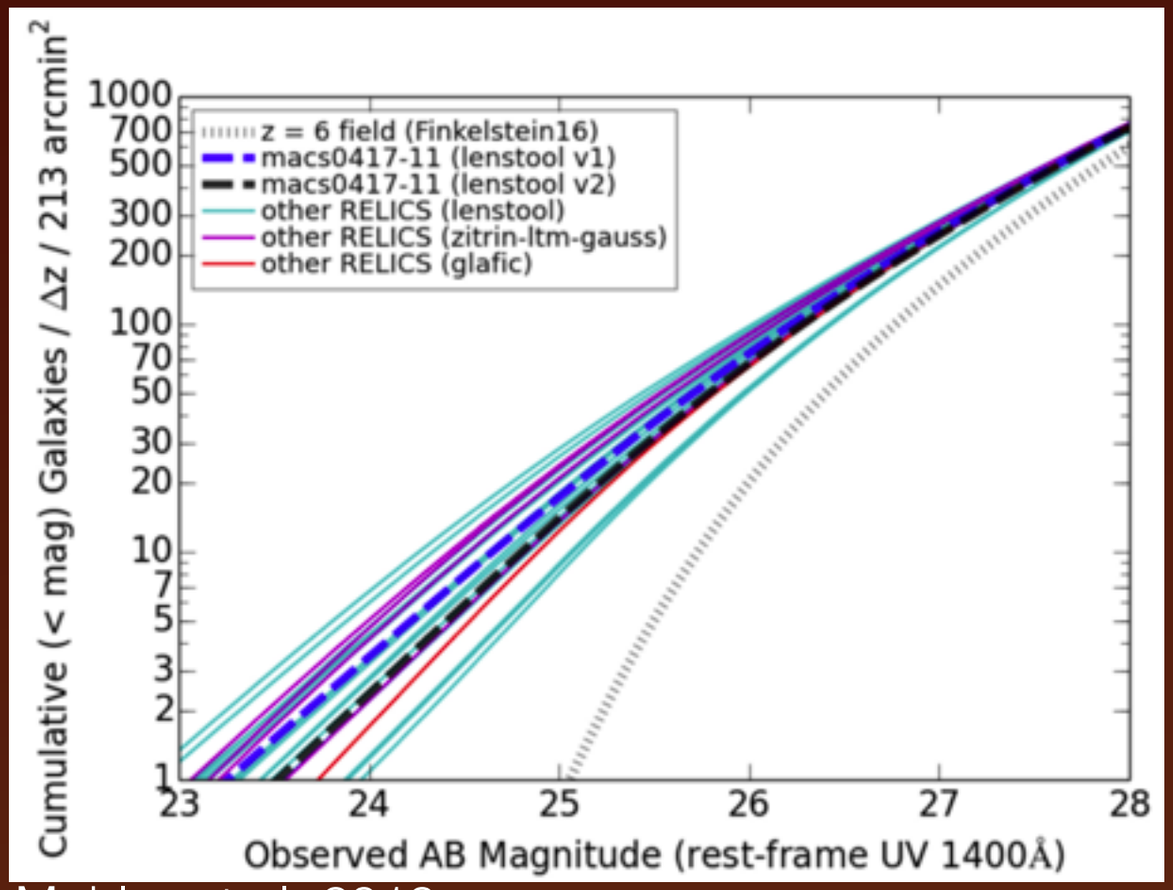


Rivera-Thorsen et al. 2019 Science

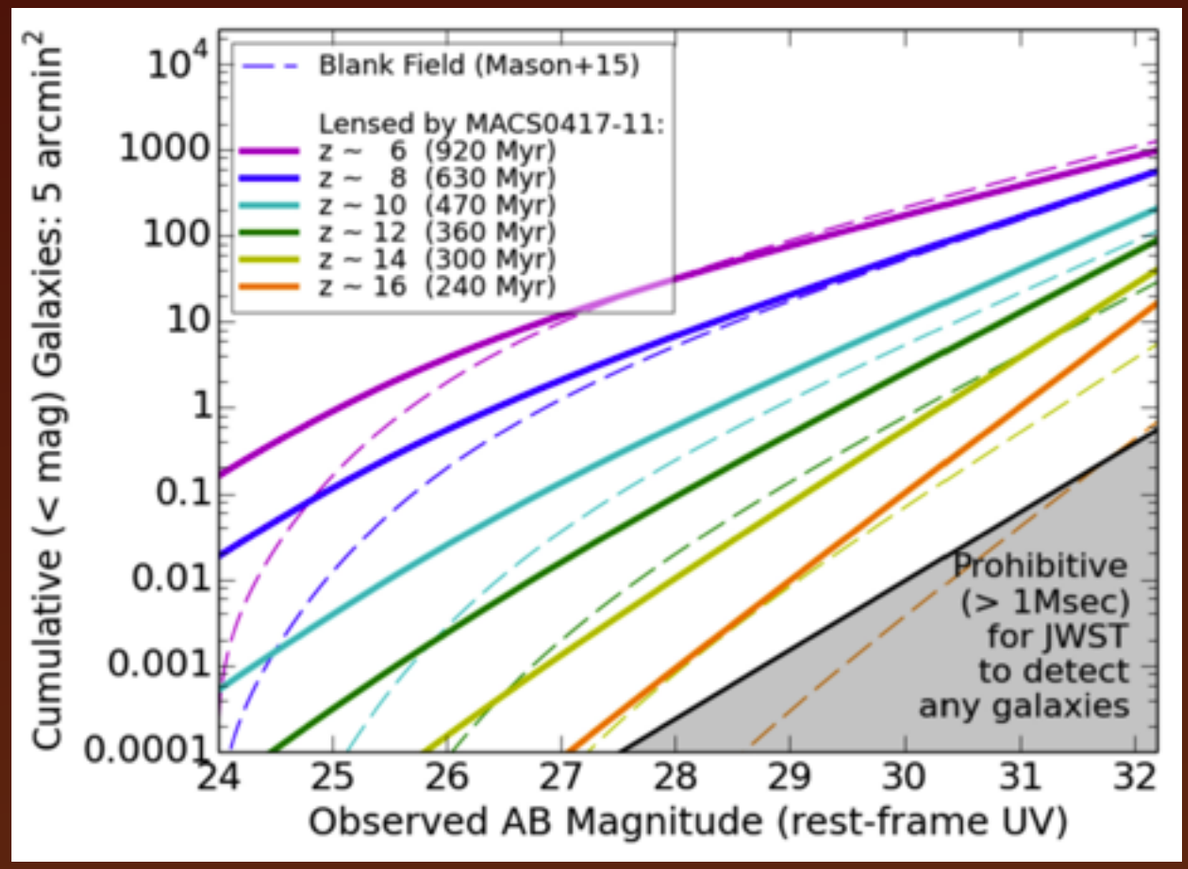
Sharon, Mahler et al. 2019



At high-redshifts lensing win

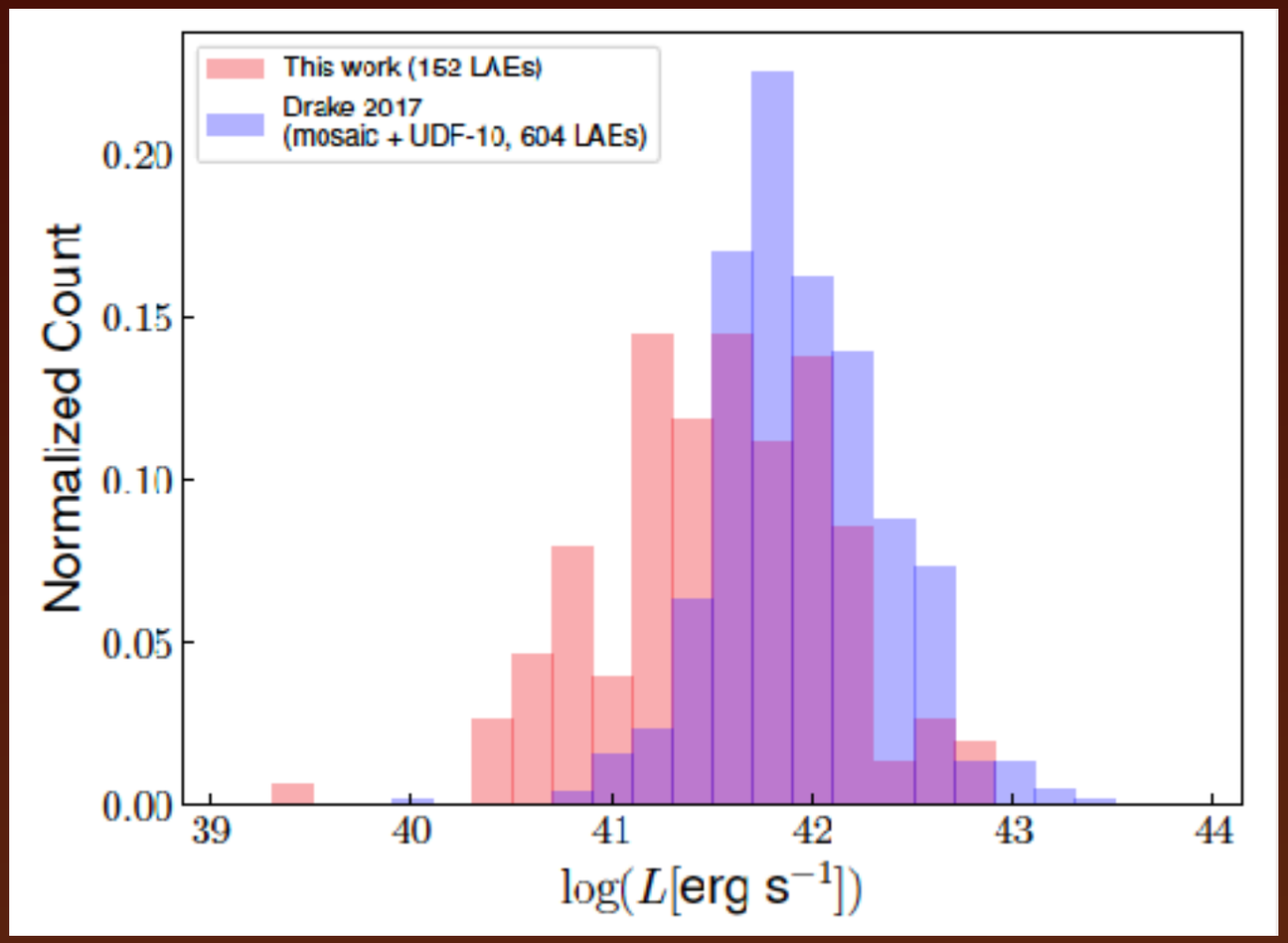


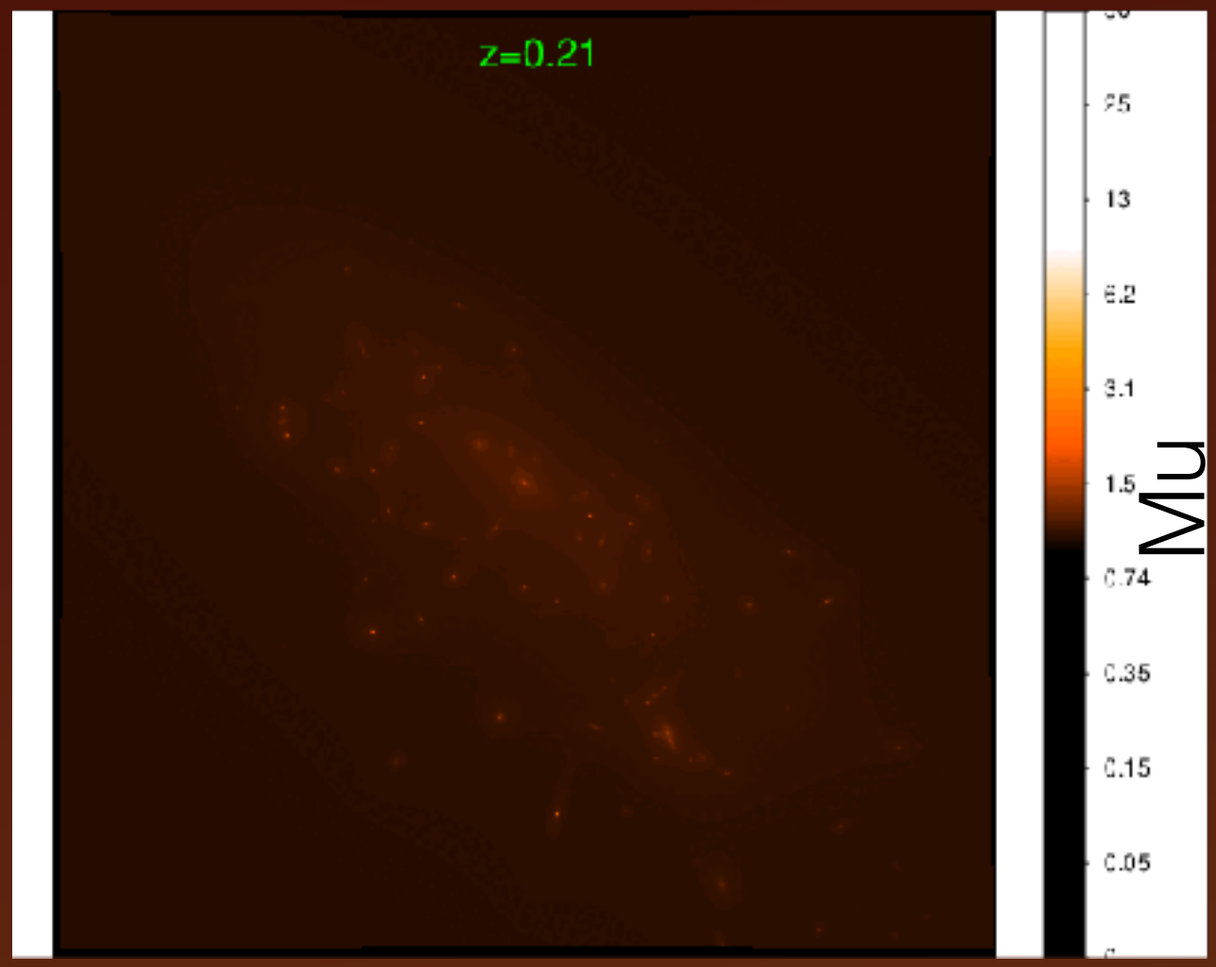
Mahler et al. 2019



Drawn from Mason et al 2015, shown in Mahler et al. 2019

Luminosity function



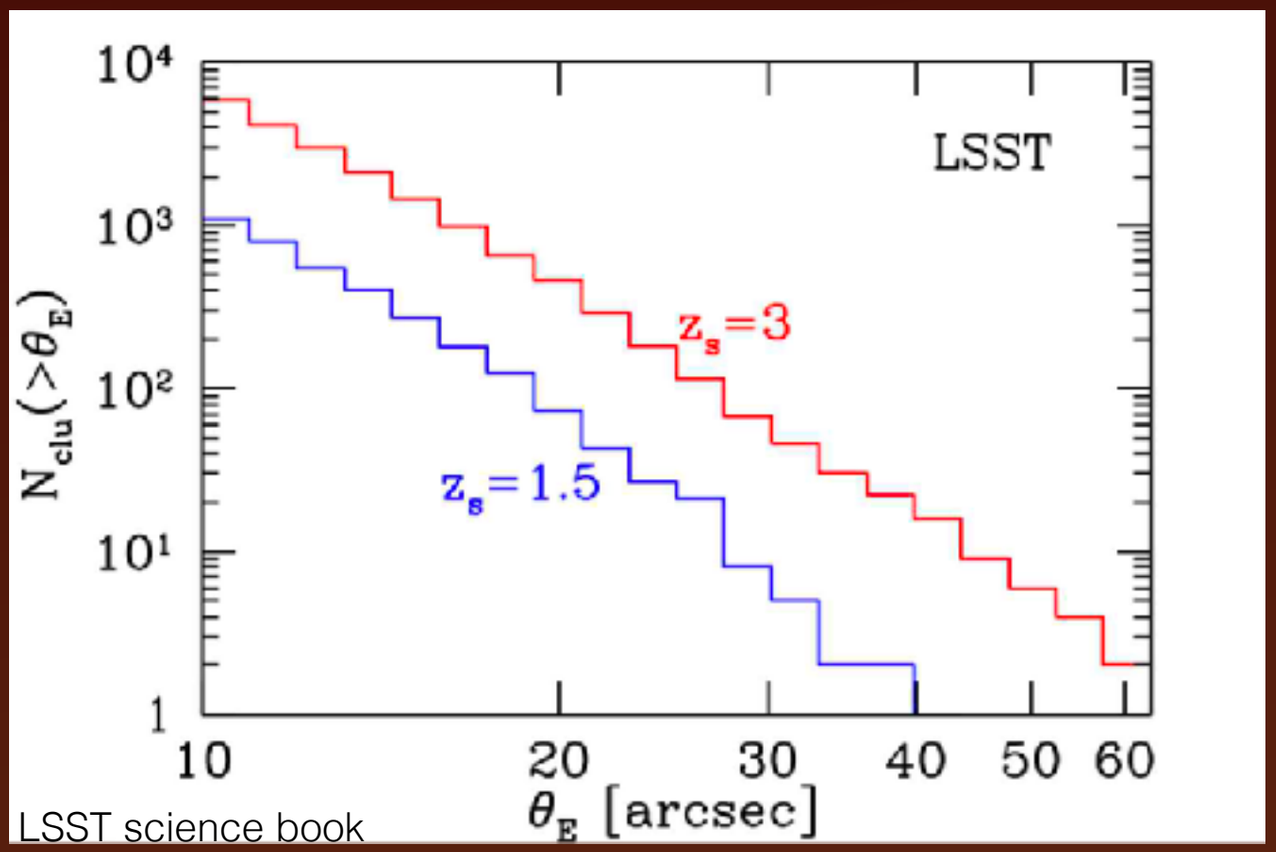


De la Vieuville et al. 2019

Future generations of telescopes

LSST

20,000 deg2

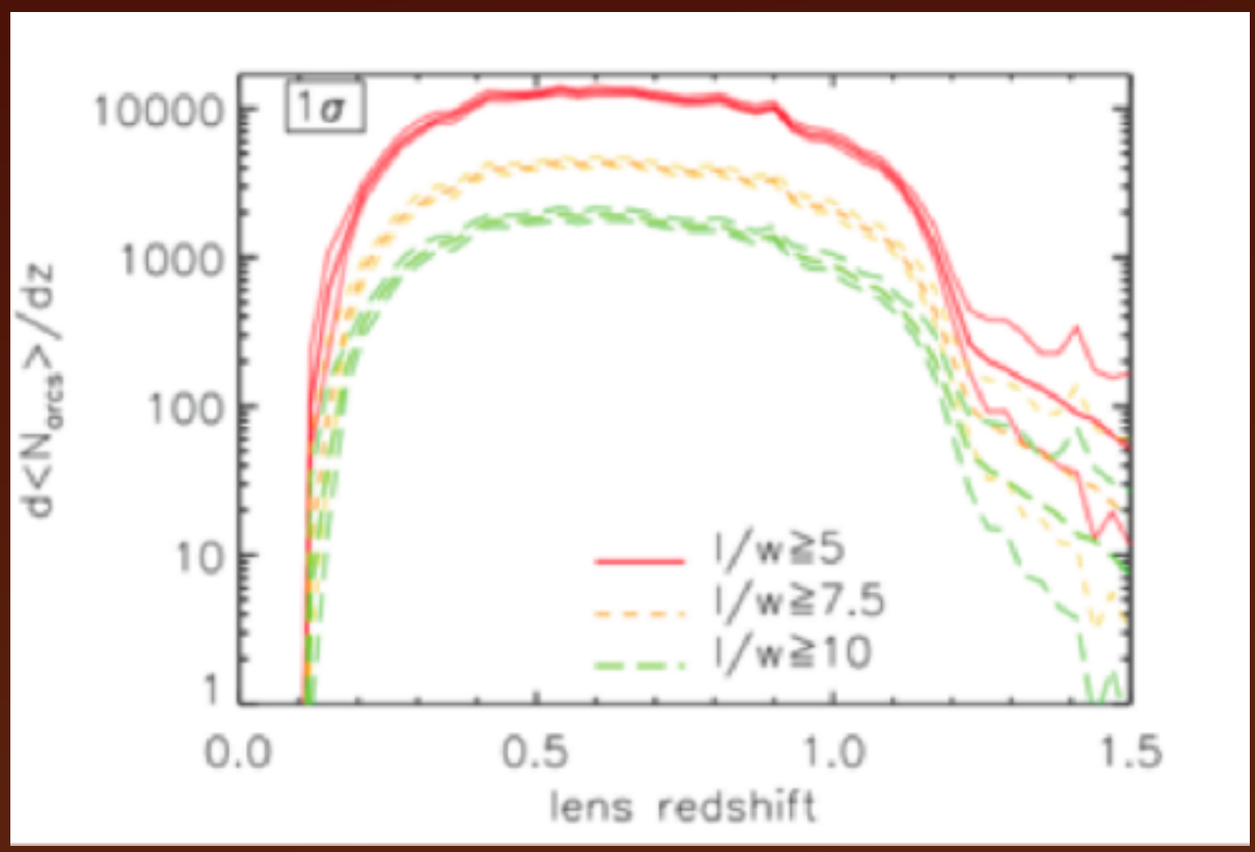


LSST science book

Galaxy-galaxy lensing (Collett 2015)
• 140,000 lenses in the wide survey

Euclid

15,000 deg2



Giant arcs in clusters (Boldrin et al 2015)

1300 arcs wit L/w >10

8000 arcs with L/w > 5

Galaxy-galaxy lensing (Collett 2015)
• 140,000 lenses in the wide survey

Take away message:

Take away message:

Lensing is awesome!!!

Thank you

Take away messages:

- Inner core slope correlates with magnification power
- Futur (non)detection of wandering SMBHs in clusters
- Increased resolution, do the science of tomorrow, today
- Observed the faint end of the population, unreachable otherwise

Thank you