

Impact of blending on DC2 data: Tools and analysis

LSST-France, June 2023
Manon Ramel

Scientific context

Cosmology with galaxy clusters

Largest gravitationally bound structures in the Universe

- Size of 1 Mpc
- 50 to 1000 galaxies
- $M > 10^{13.5} M_{\odot}$, $z < 3$

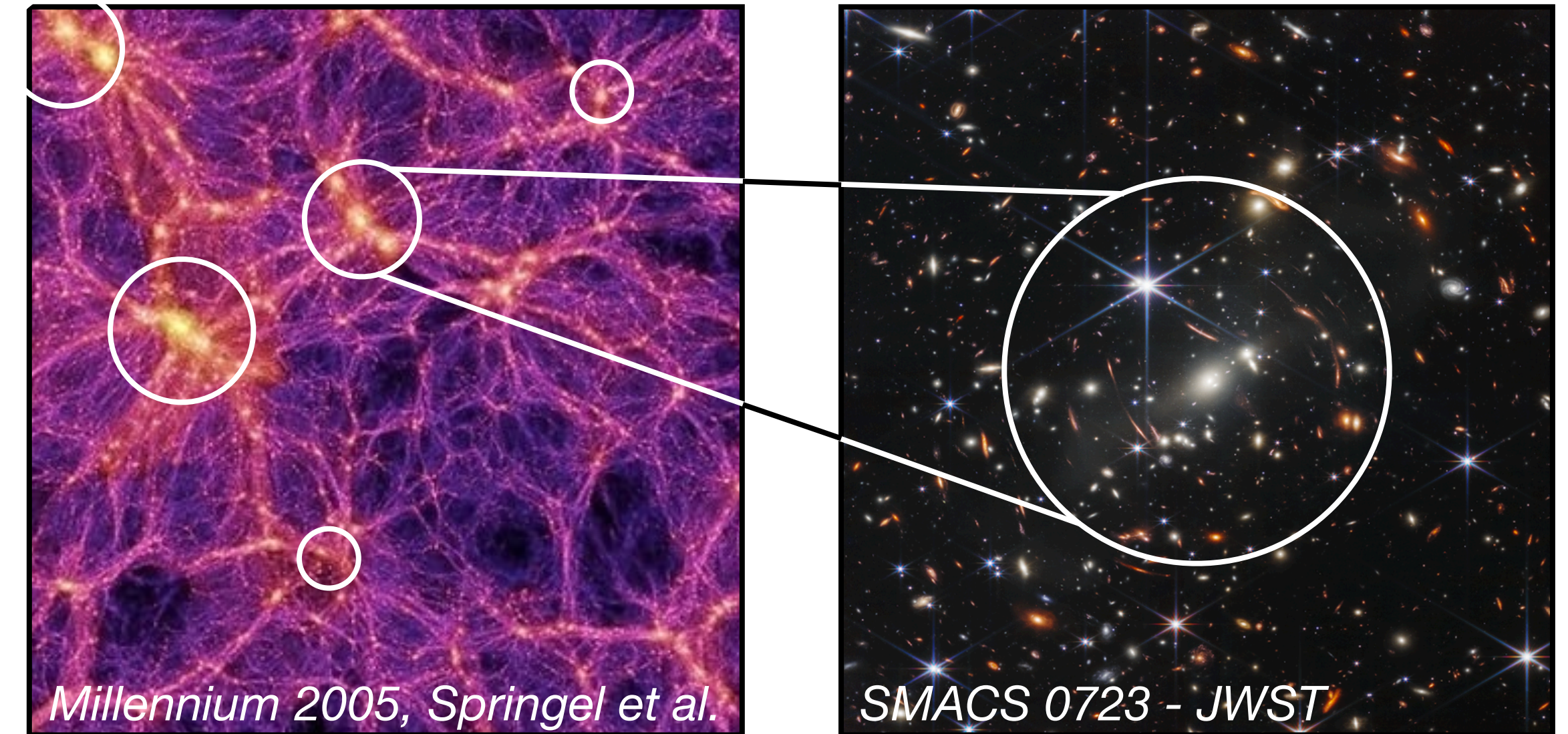
Tracers of the matter over-densities

- Abundance depends on cosmology

Studied through their counting per bins of mass and redshift

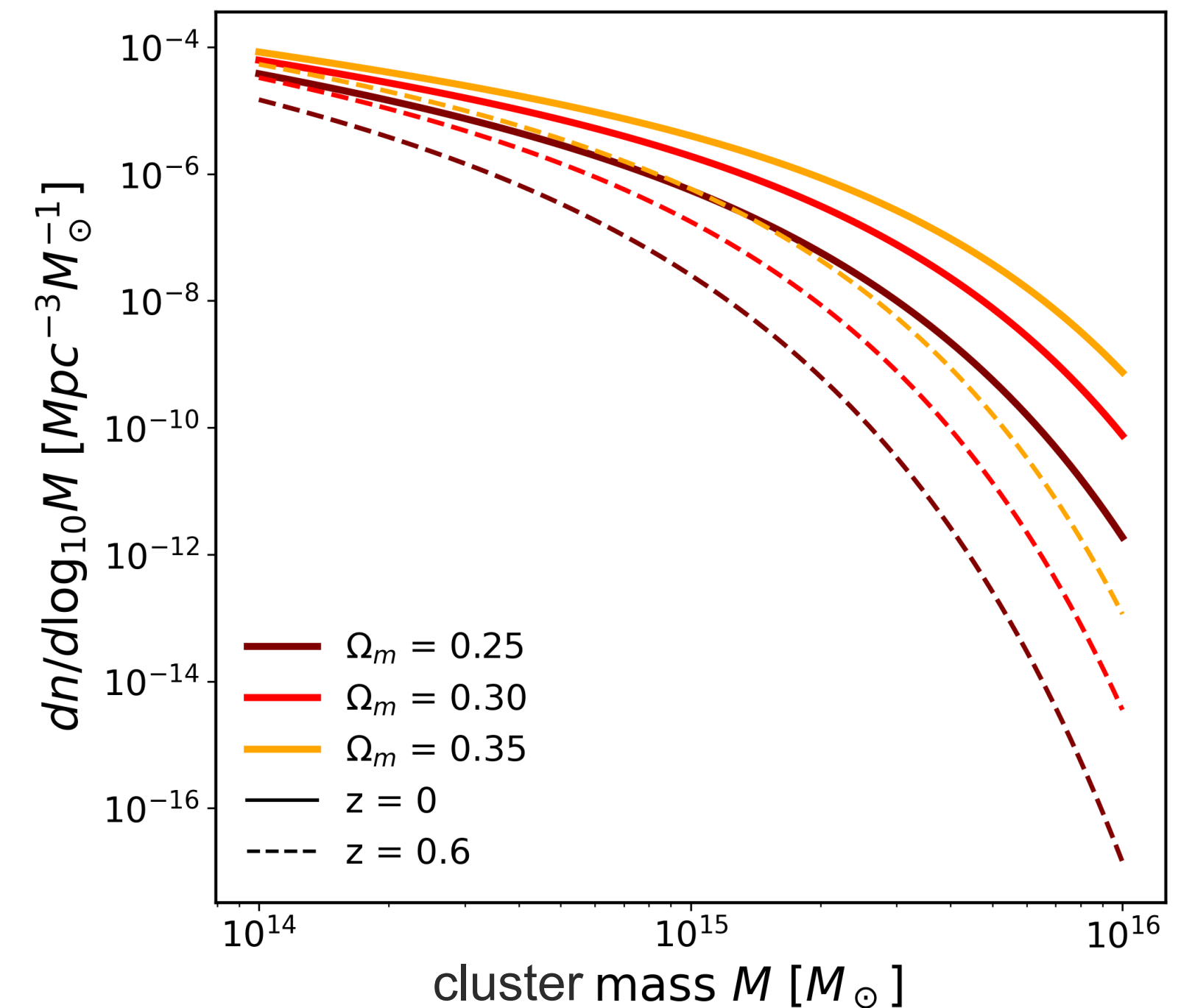
$$\frac{\partial^2 N_{th}}{\partial z \partial m} \propto \frac{dn(m, z)}{dm} \frac{d^2 V(z)}{dz d\Omega}$$

Mass is not an observable: indirect measurements through weak lensing



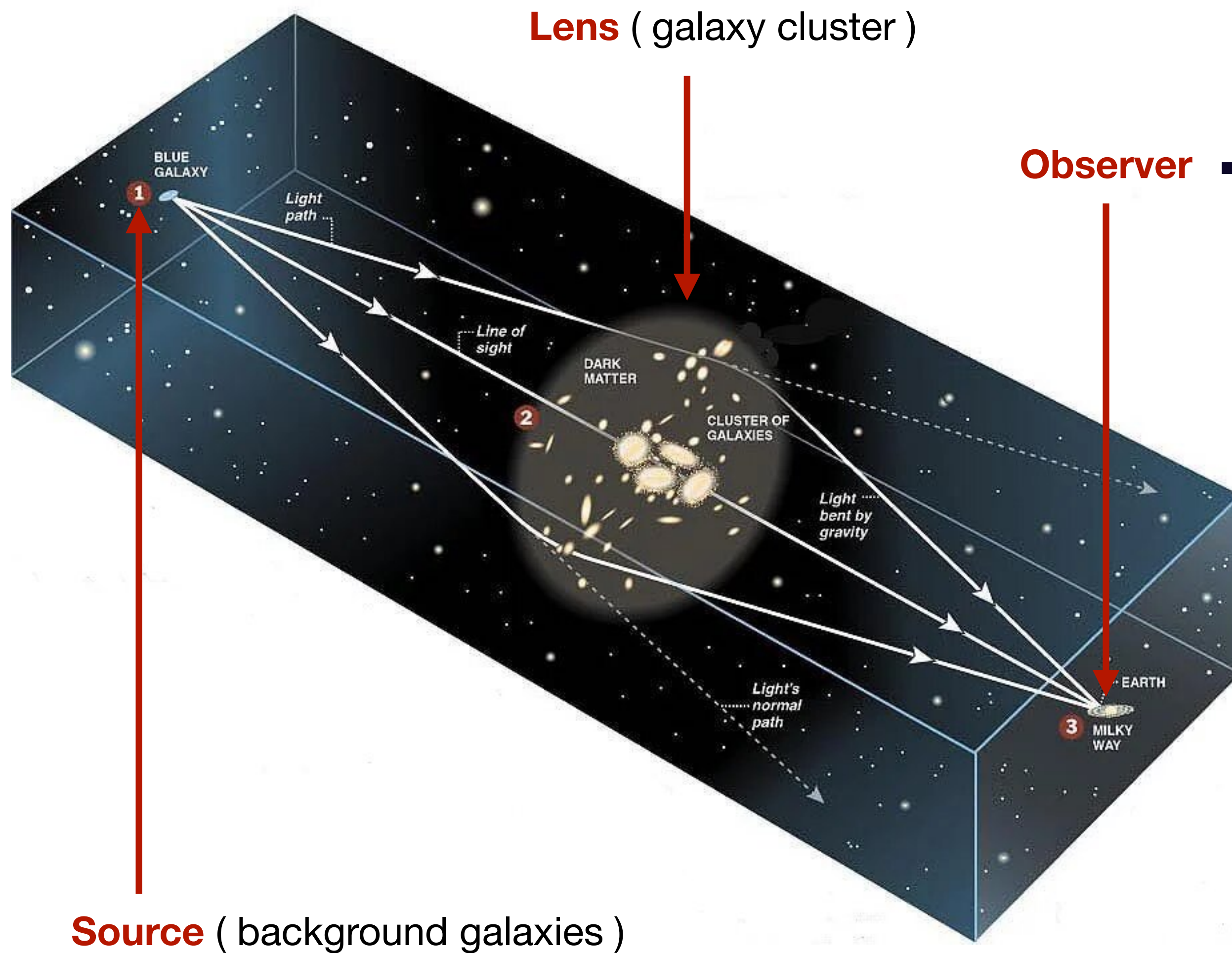
Millennium 2005, Springel et al.

SMACS 0723 - JWST



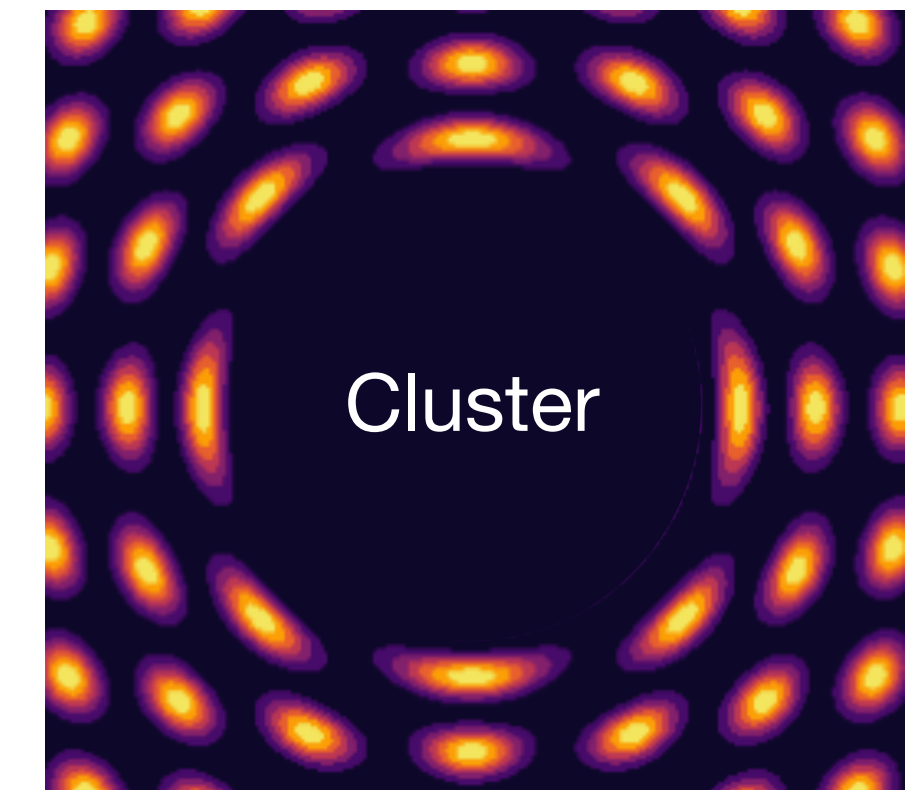
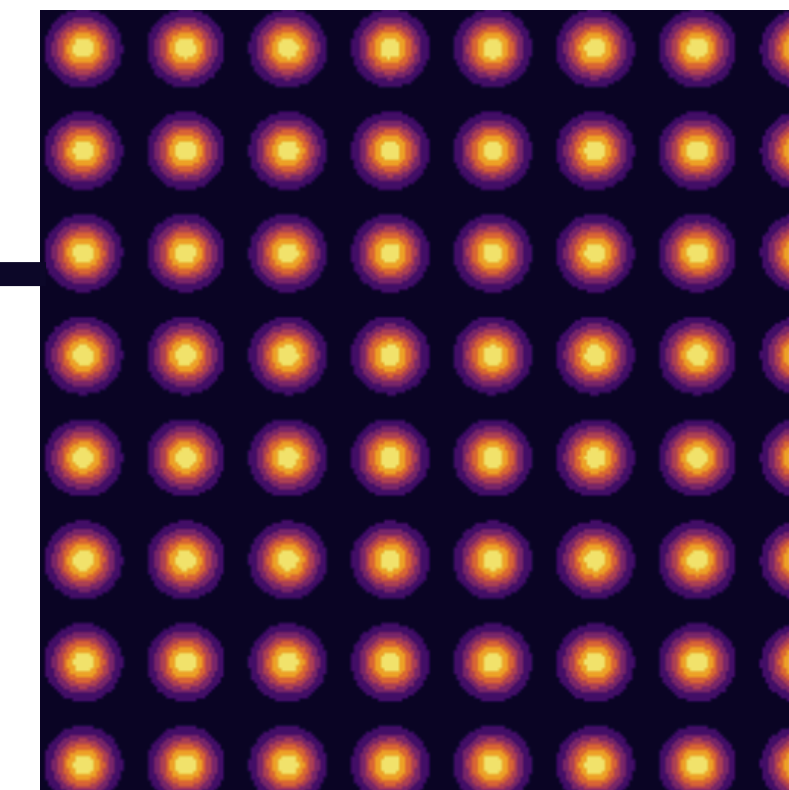
Scientific context

Weak gravitational lensing



UNLENSED

LENSED



Galaxy shapes are used to measure the *lensing shear*

Scientific context

Weak gravitational lensing

- Lensed ellipticities of background sources

$$\epsilon^{obs} \approx \epsilon^{int} + \gamma(R) \text{ shear} \quad \Rightarrow \quad \langle \epsilon^{obs} \rangle \approx \gamma(R)$$

- Excess surface density depends on the projected mass of the lens

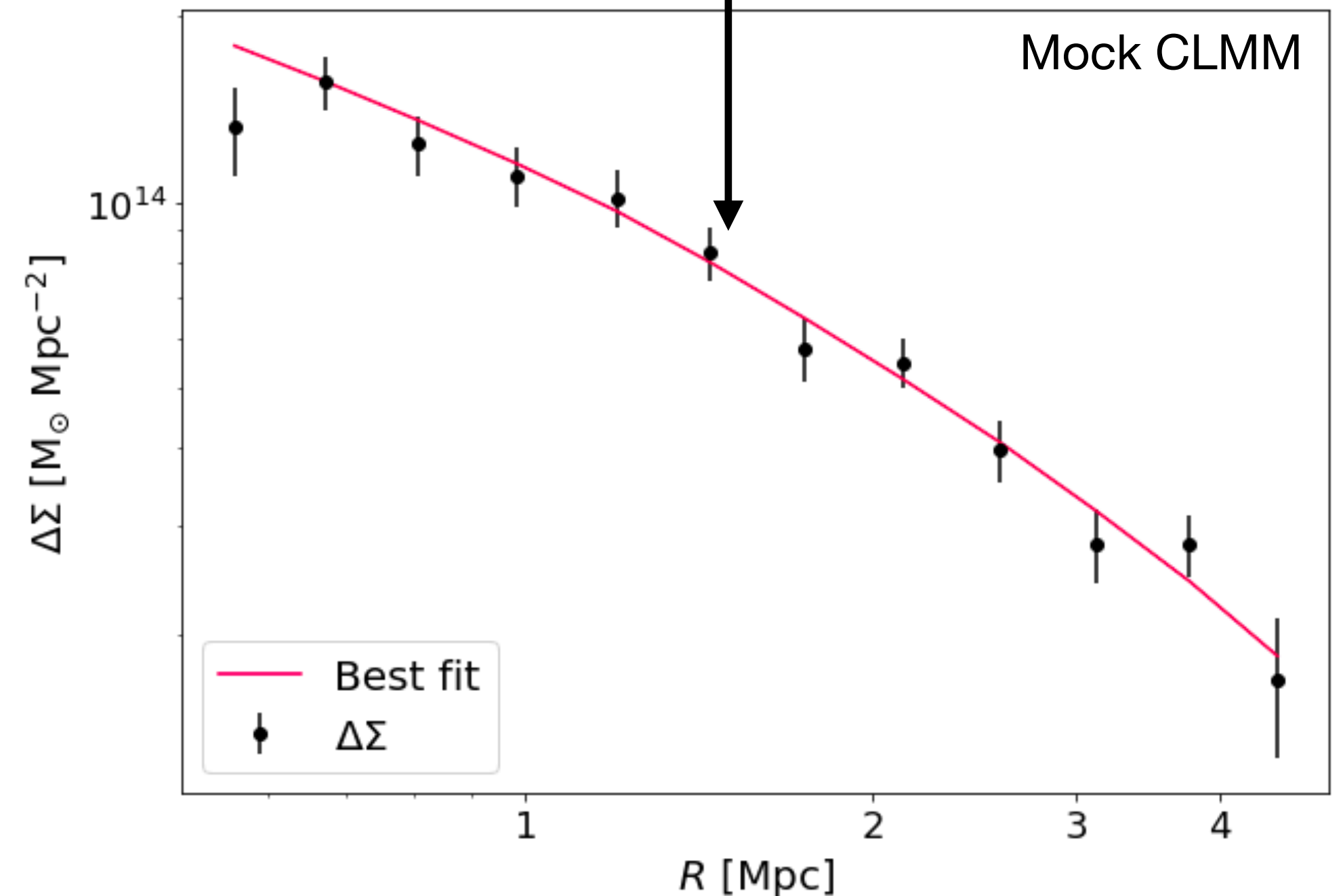
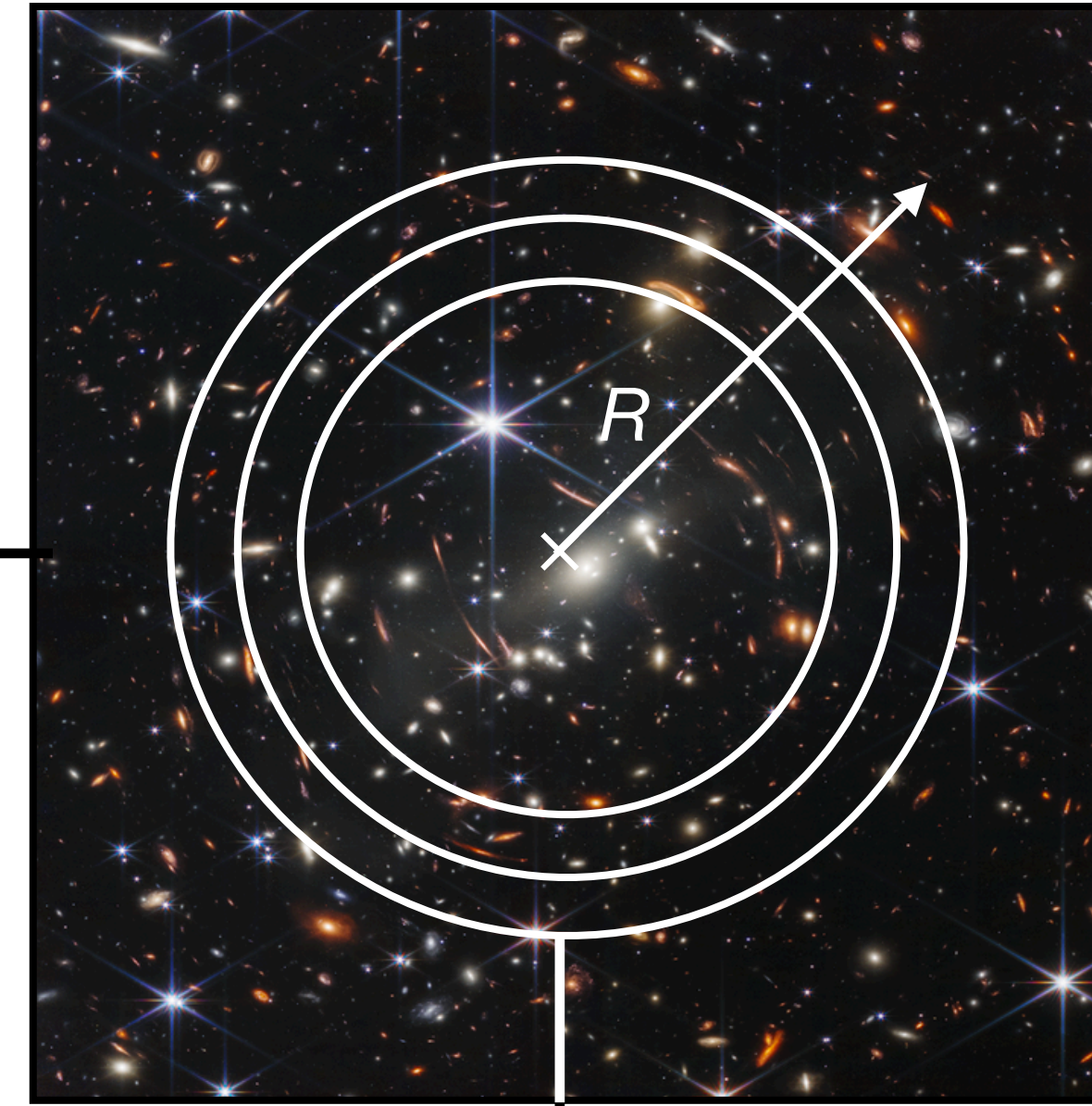
$$\Delta\Sigma(R, z_l) = \langle \underbrace{\Sigma_{crit}(z_{gal}, z_l)}_{\text{Critical surface mass density}} \underbrace{\epsilon_+^{obs}}_{\text{Tangential ellipticity}} \rangle$$

Critical surface mass density

Tangential ellipticity

Fit of $\Delta\Sigma$ = Estimate of galaxy clusters masses

Importance of galaxy shapes

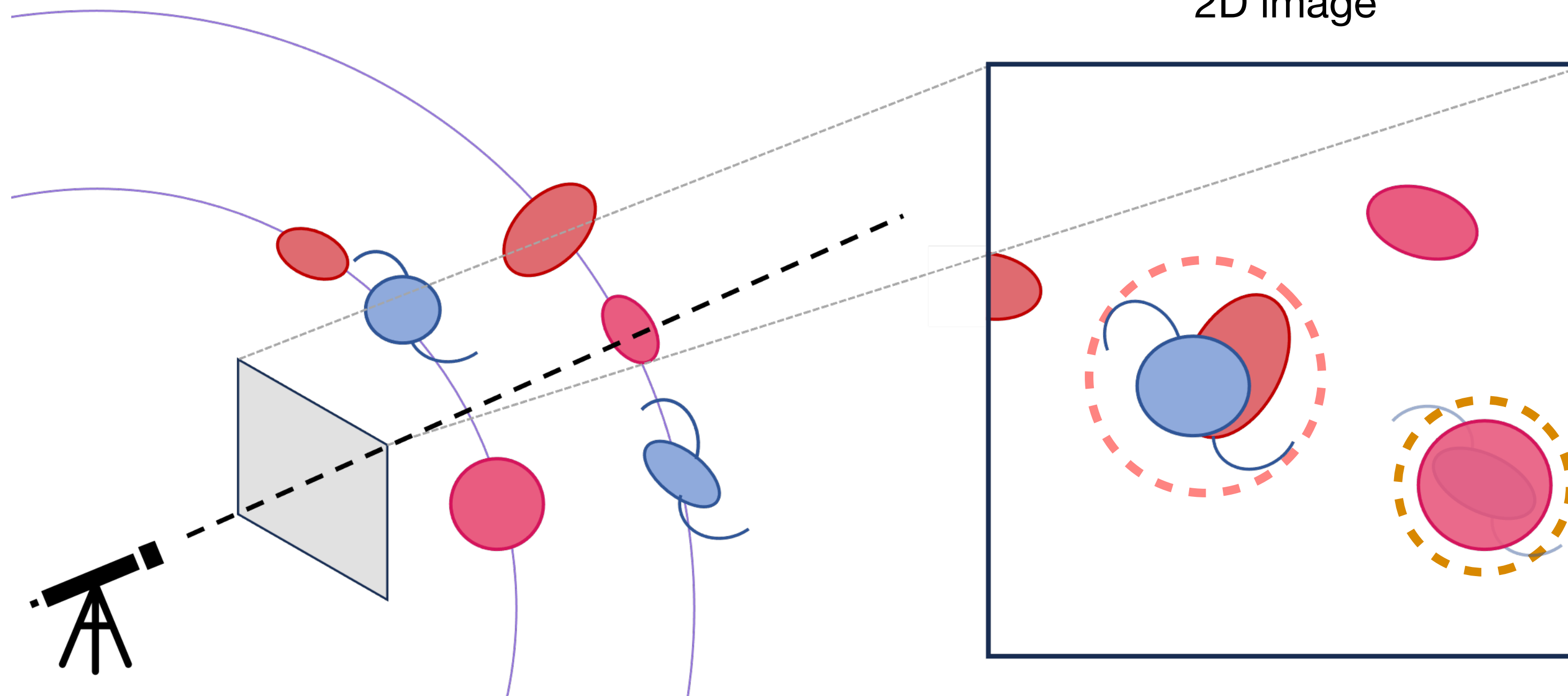


Scientific context

Blending

Superposition of galaxies on the images due to:

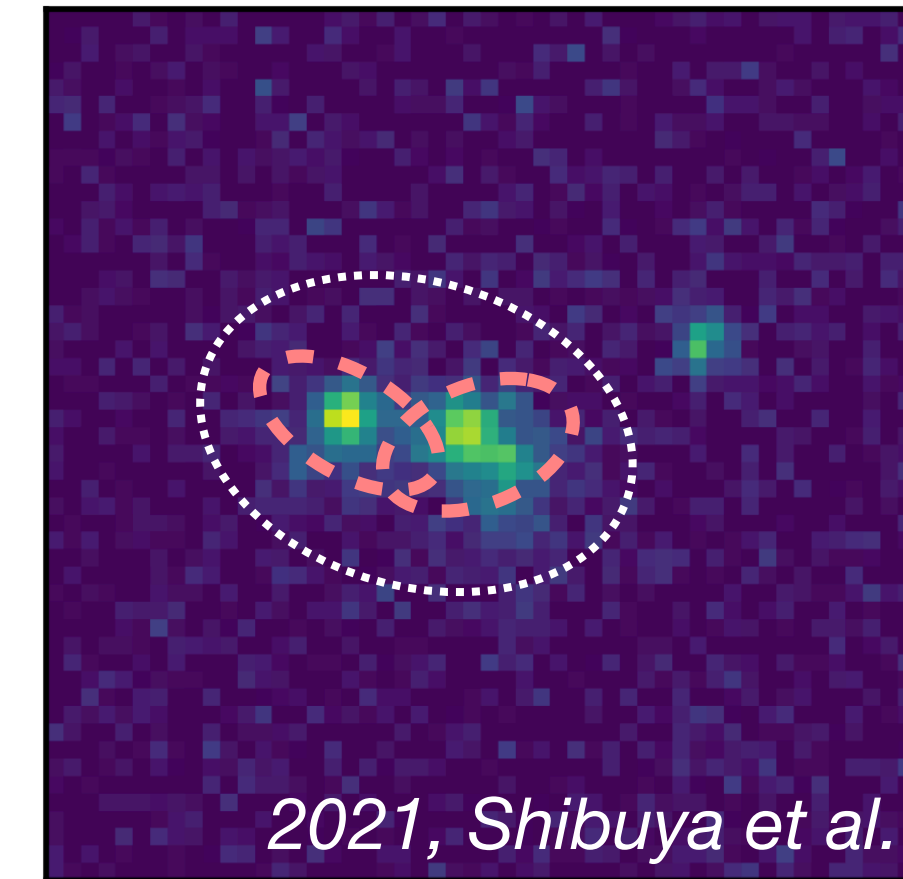
- the **depth** of observation
- the **atmosphere**



Recognized blends

~40 %

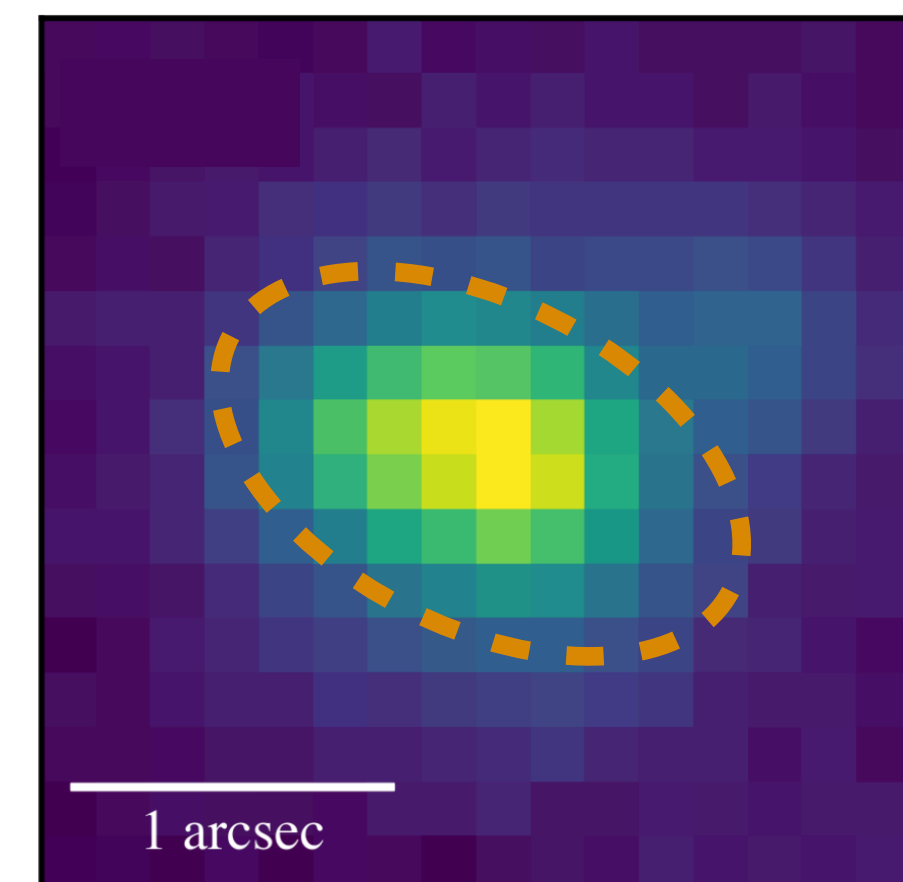
Hubble/ACS



Unrecognized blends

~14 - 20 %*

Subaru/HSC



* 2016, Dawson et al.
2022, Troxel et al.

Scientific context

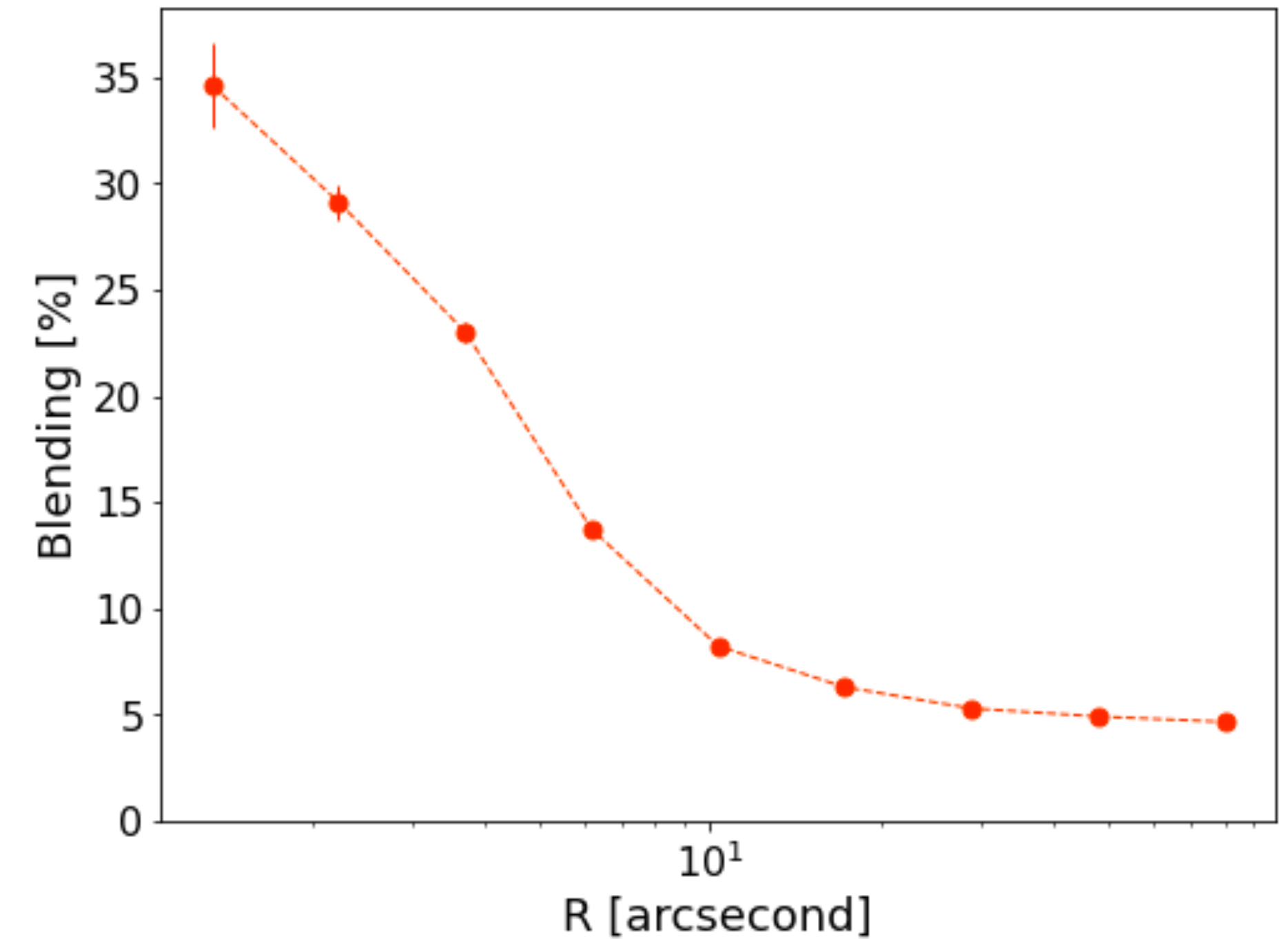
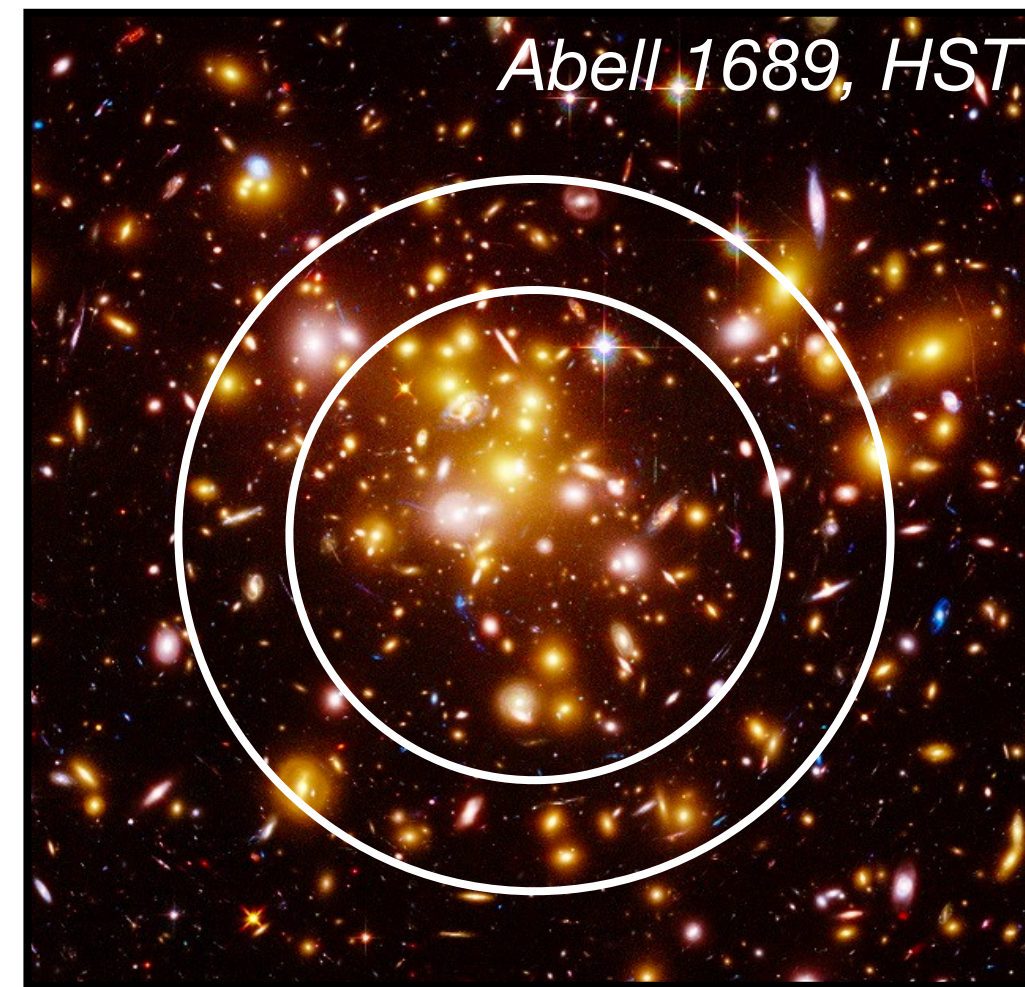
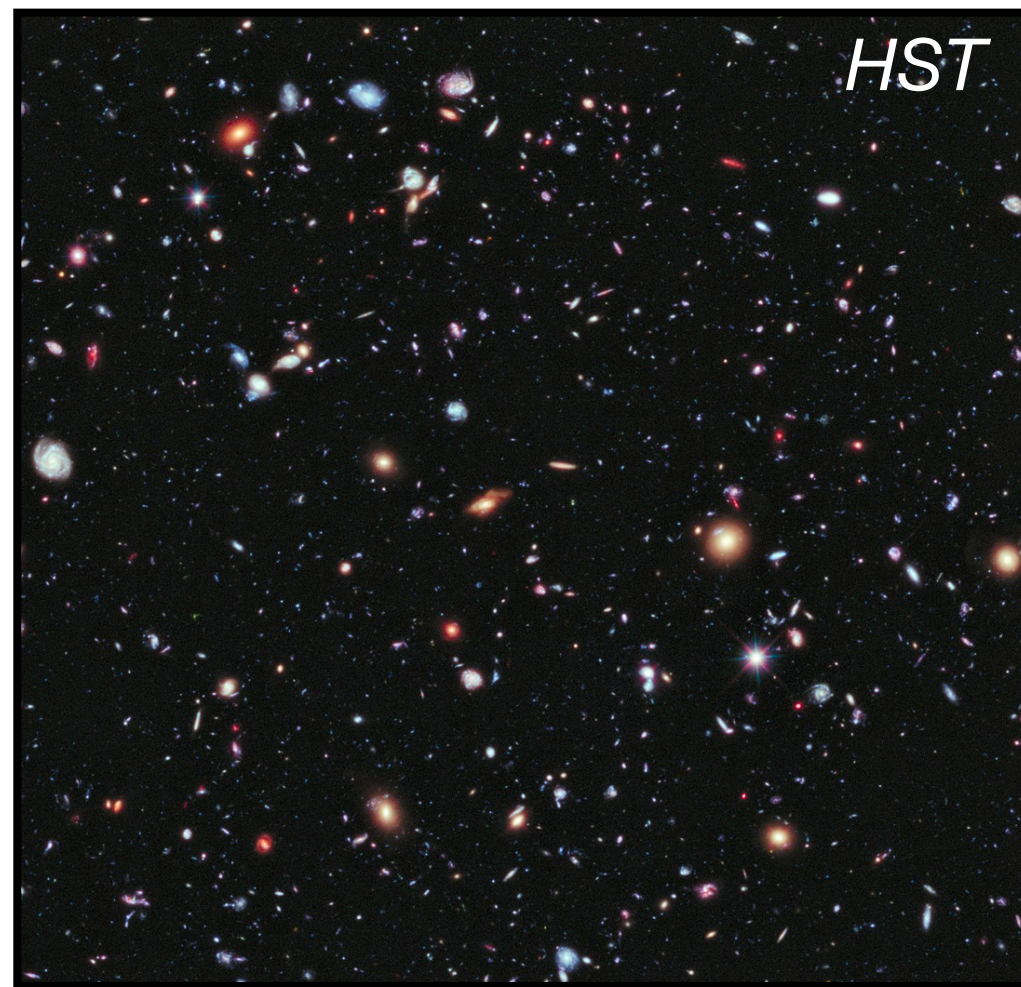
Blending around galaxy clusters

Galaxy clusters = high density regions = **blending**

High amount of blending near clusters centres

OUTSIDE

INSIDE



Blending impacts the **detection** of galaxies and the measurement of galaxy **shapes**



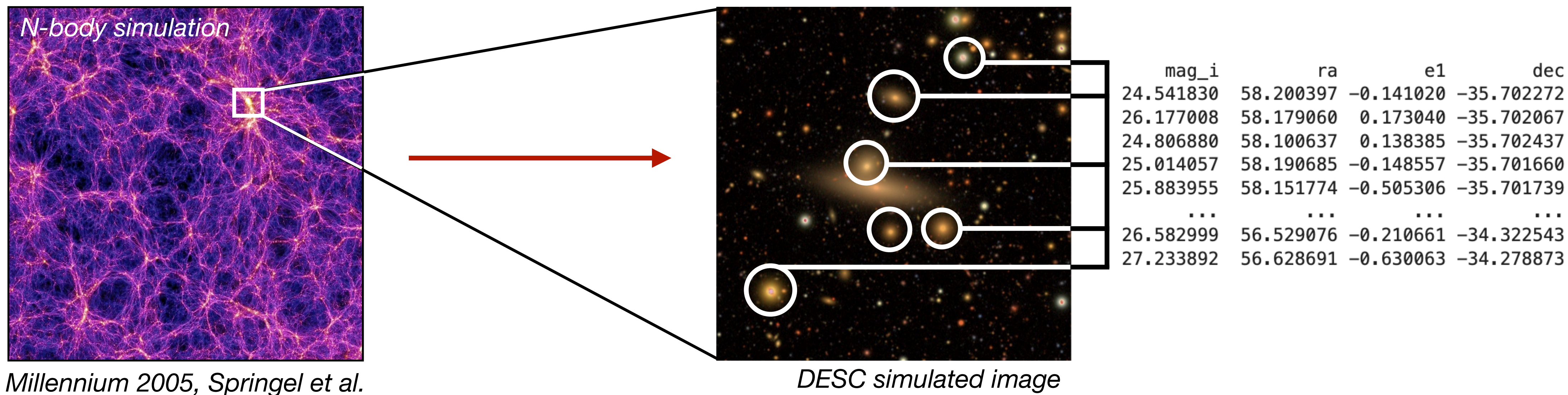
Blending will impact future Rubin/LSST weak lensing data induced by massive clusters



Tools and pre-work

Tools and pre-work

Simulated catalogs



cosmoDC2 = **truth** catalog

- 440 deg² catalog from a N-body simulation
- Reference for **galaxies** and dark matter haloes
- mag < 30, z = 3

DC2object = **object** catalog

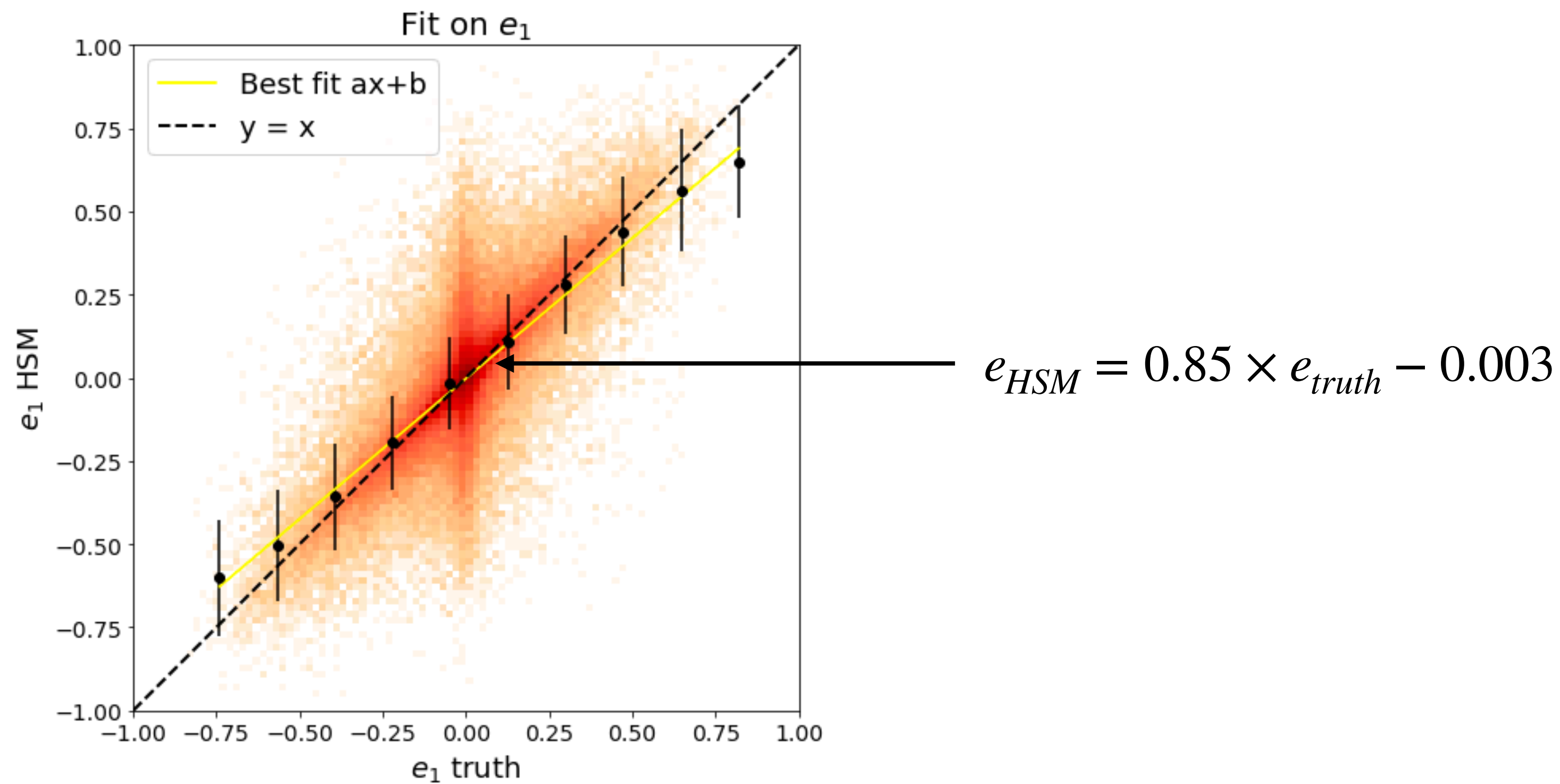
- Simulated images from cosmoDC2
- Detection of **objects**
- Measured positions, magnitudes (< 28), shapes...

Identification of blends through catalog matching

HSM calibration and DC2 photometric redshifts

$$\Delta\Sigma(R, z_l) = \langle \Sigma_{crit}(z_{gal}, z_l) \epsilon_+^{obs} \rangle$$

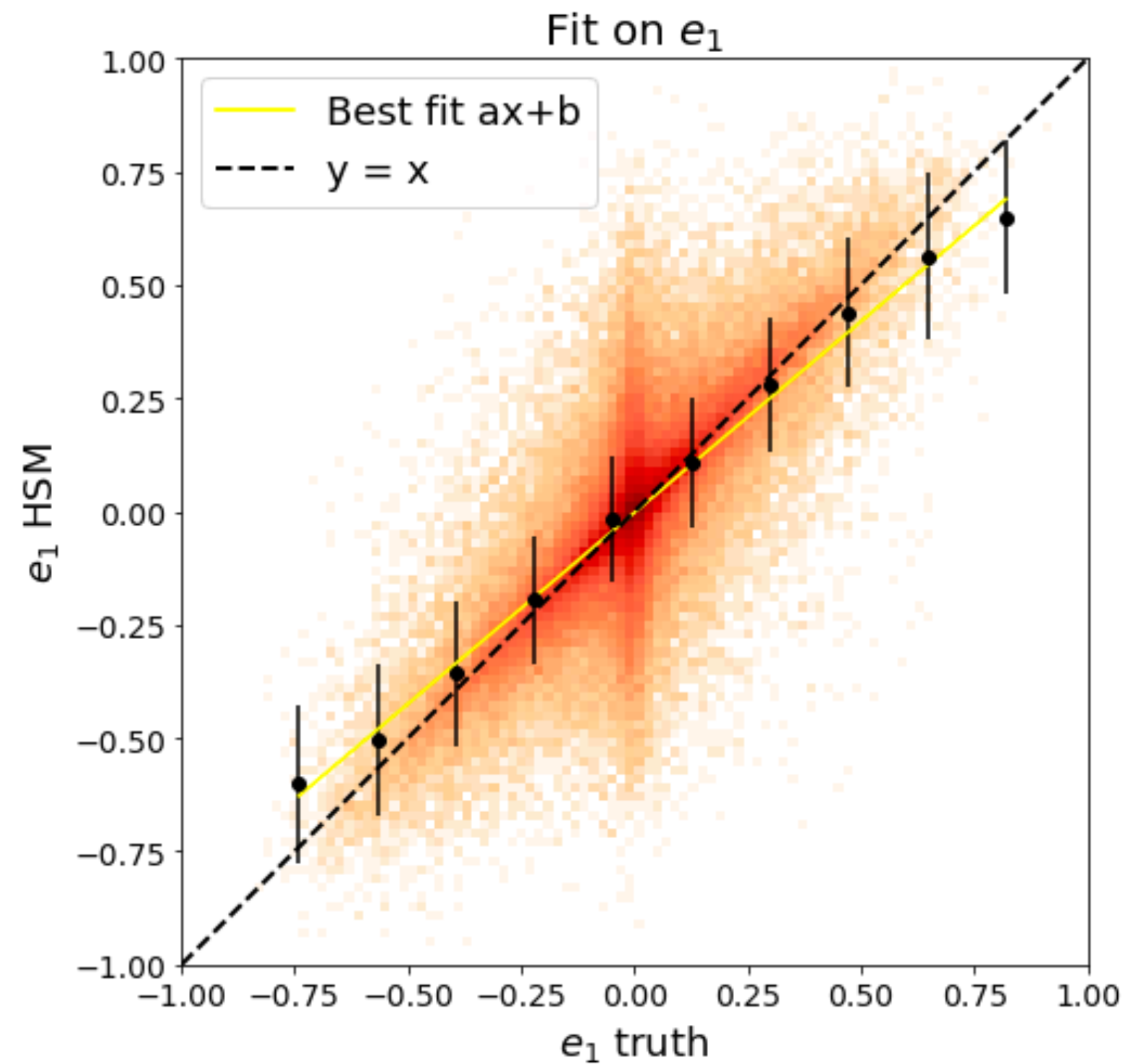
HSM ellipticities calibration



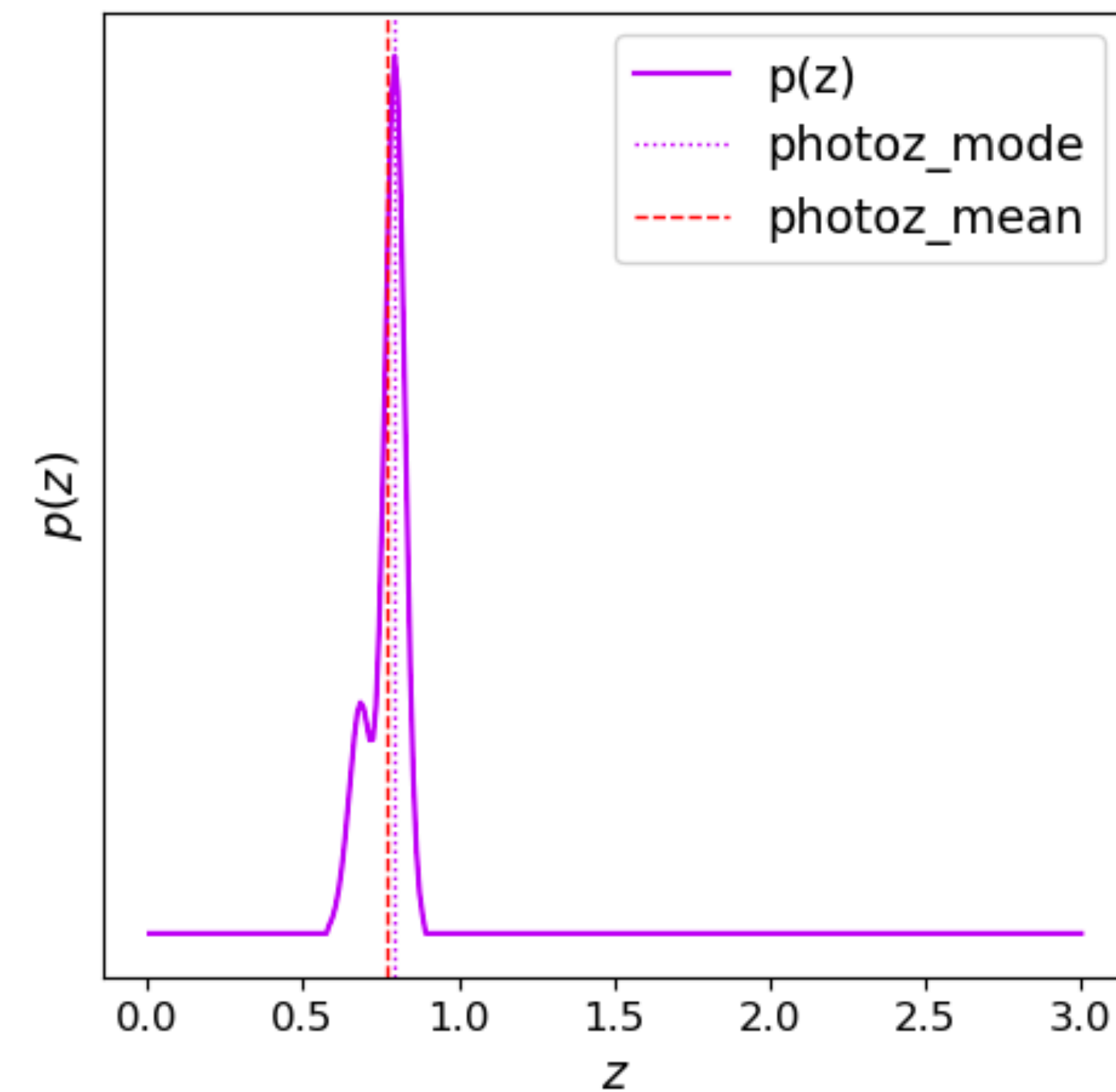
HSM calibration and DC2 photometric redshifts

$$\Delta\Sigma(R, z_l) = \langle \Sigma_{crit}(z_{gal}, z_l) \epsilon_+^{obs} \rangle$$


HSM ellipticities calibration



Photometric redshifts



Individual errors that we can calibrate → sufficient for blending?

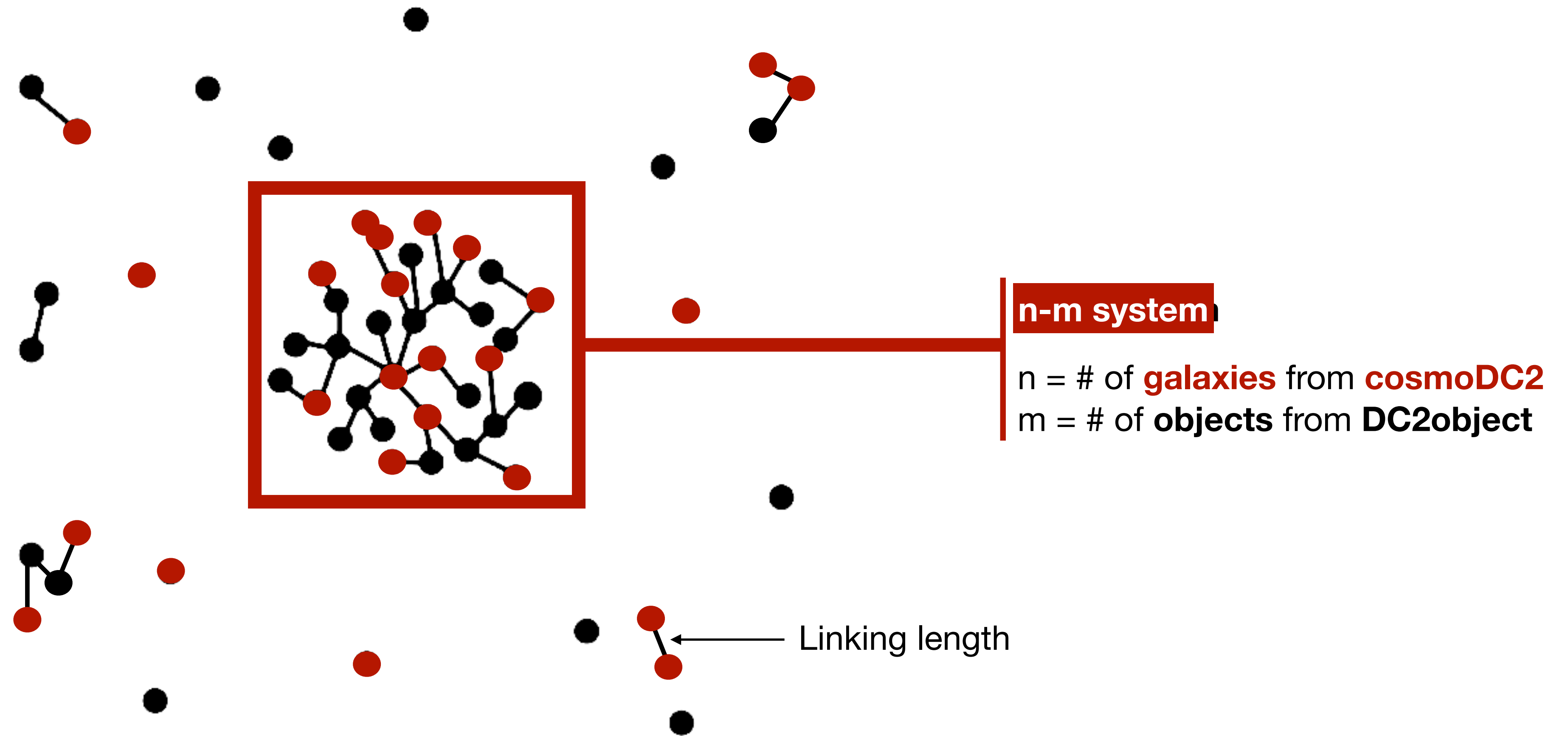


Detection of blends in DC2

Detection of blends in DC2

Friends-of-Friends

<https://github.com/yymao/FoFCatalogMatching>



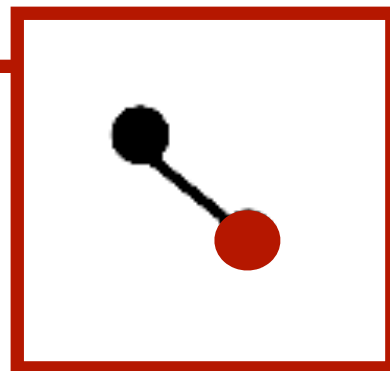
Detection of blends in DC2

Friends-of-Friends

<https://github.com/yymao/FoFCatalogMatching>

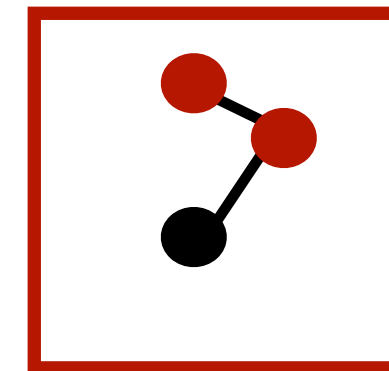
Perfect match

1-1 system



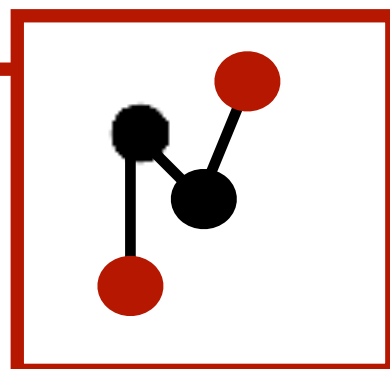
Unrecognized blend

2-1 system



Recognized blend

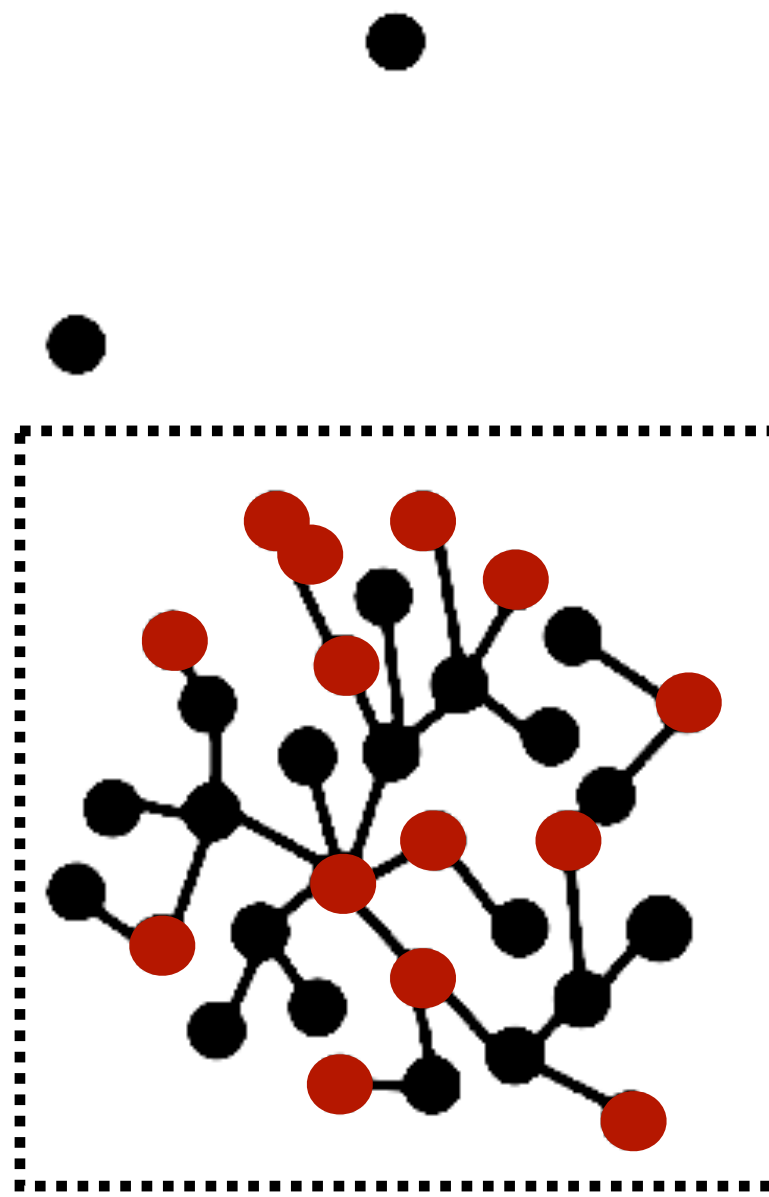
2-2 system



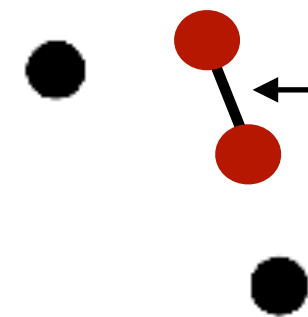
n-m system

$n = \#$ of **galaxies** from **cosmoDC2**

$m = \#$ of **objects** from **DC2object**

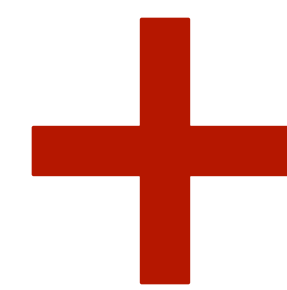
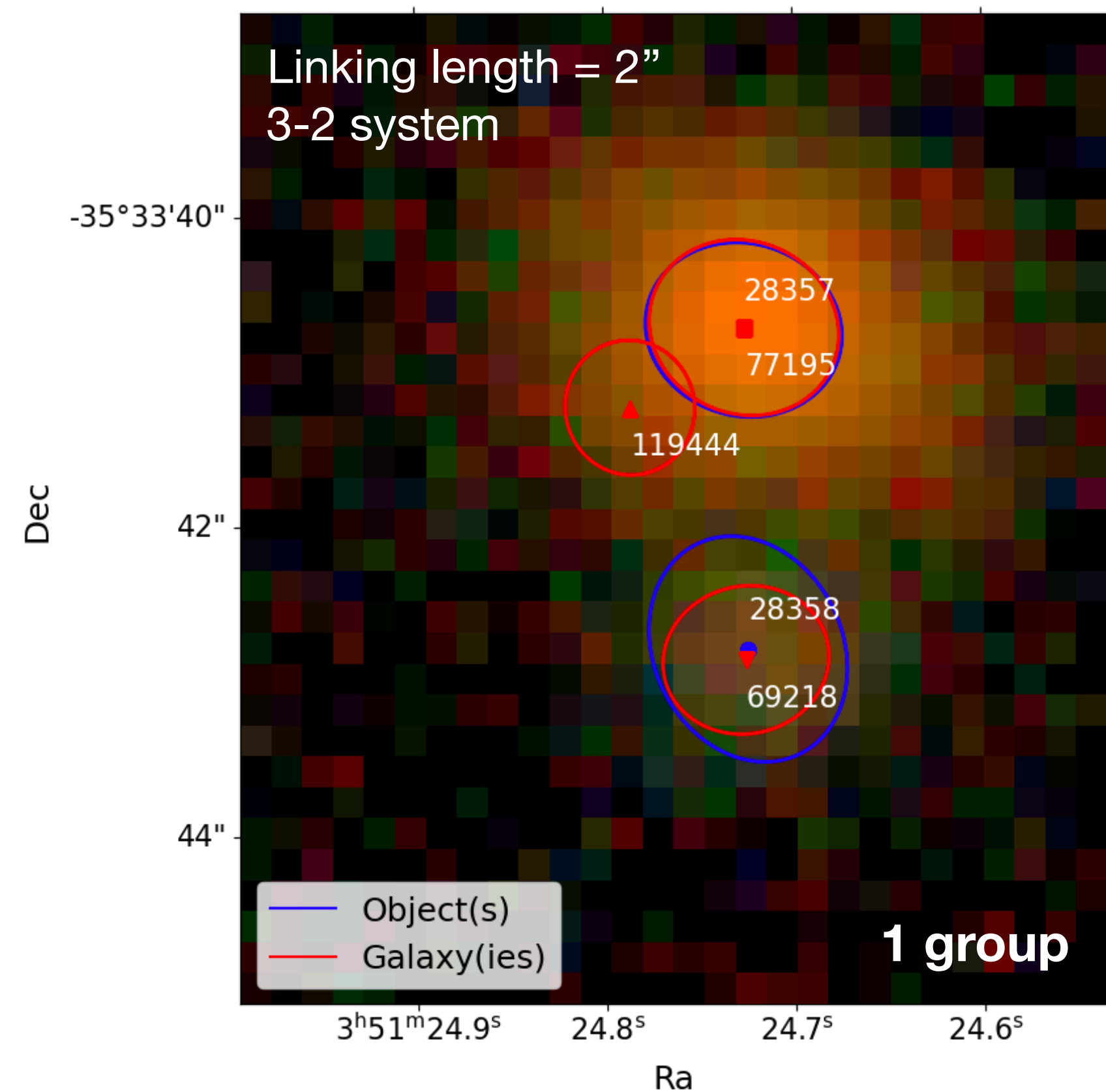


Linking length

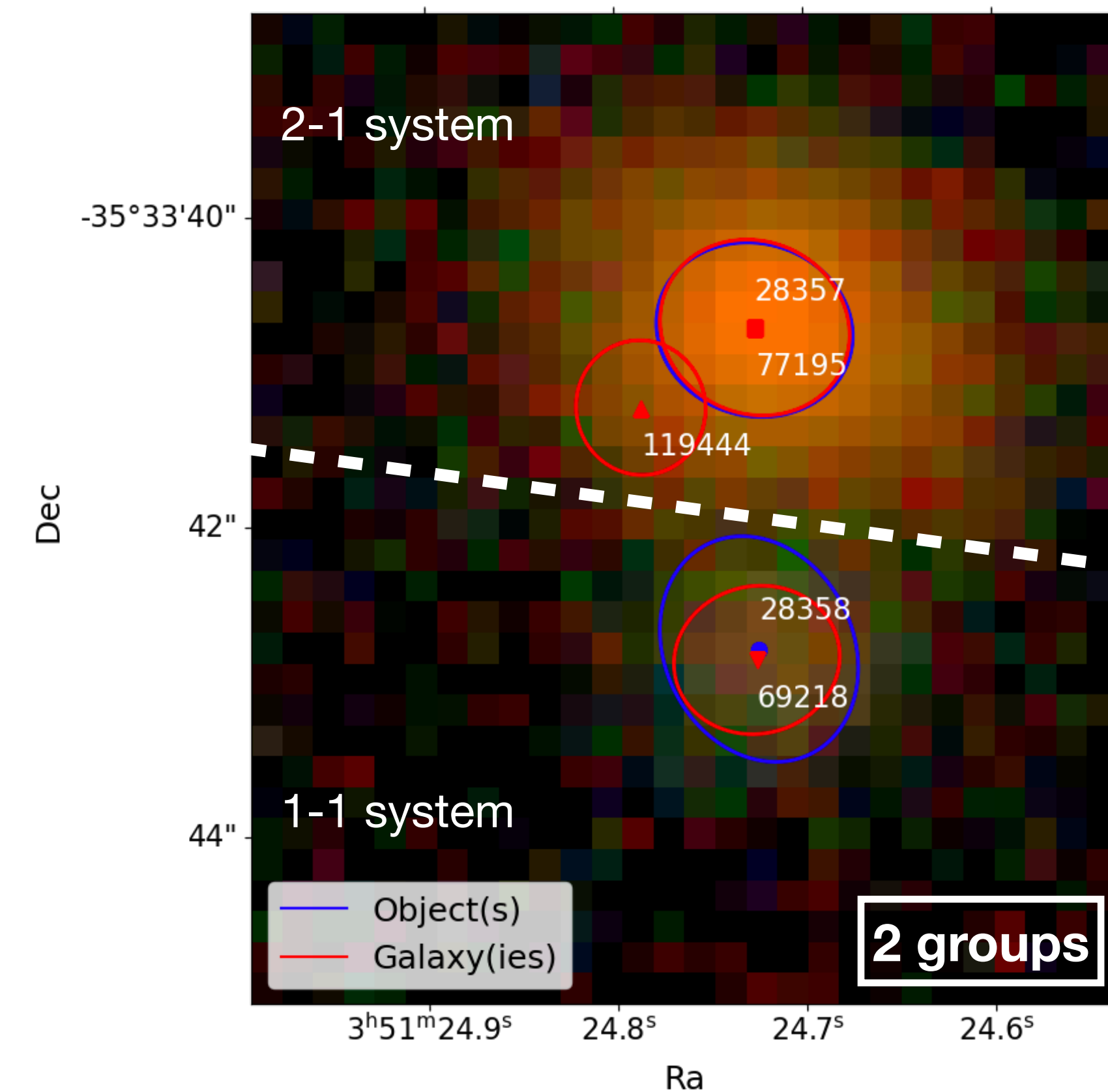


New matching algorithm: friendly

Friends-of-Friends = **distances** information



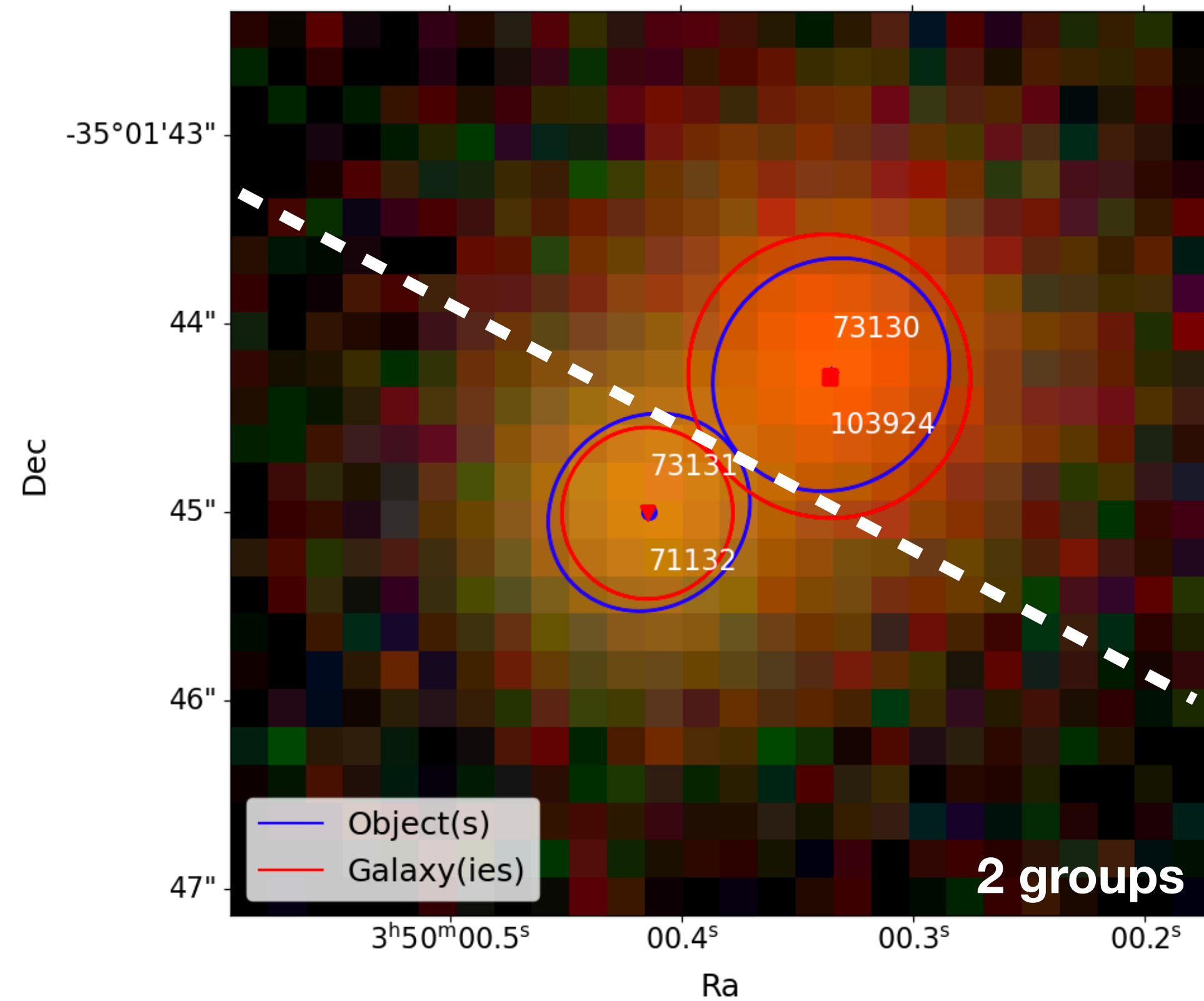
Overlap test = **shapes** information



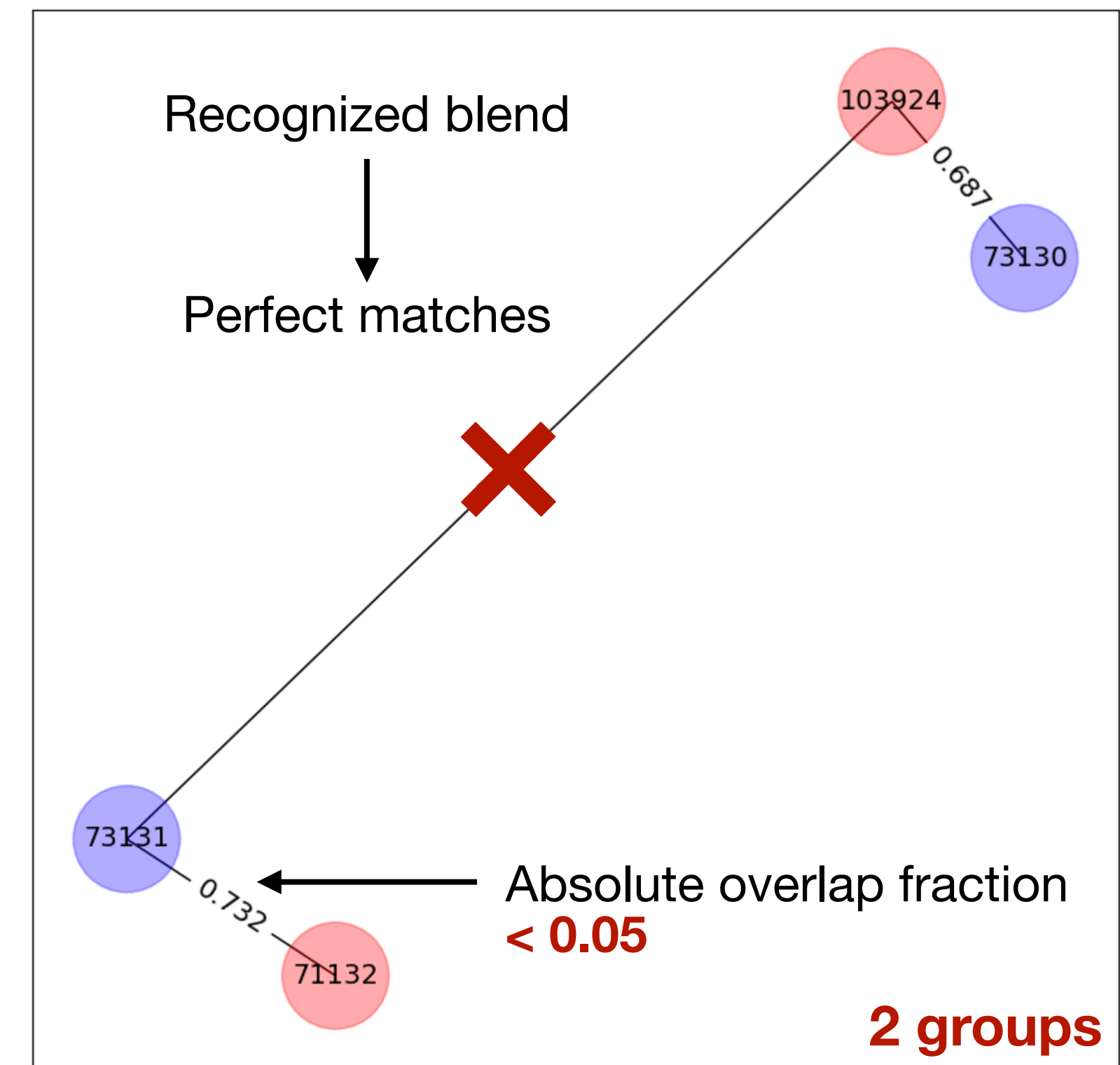
Friendly = more robust matching algorithm

New matching algorithm: friendly

Friendly group



NetworkX graph

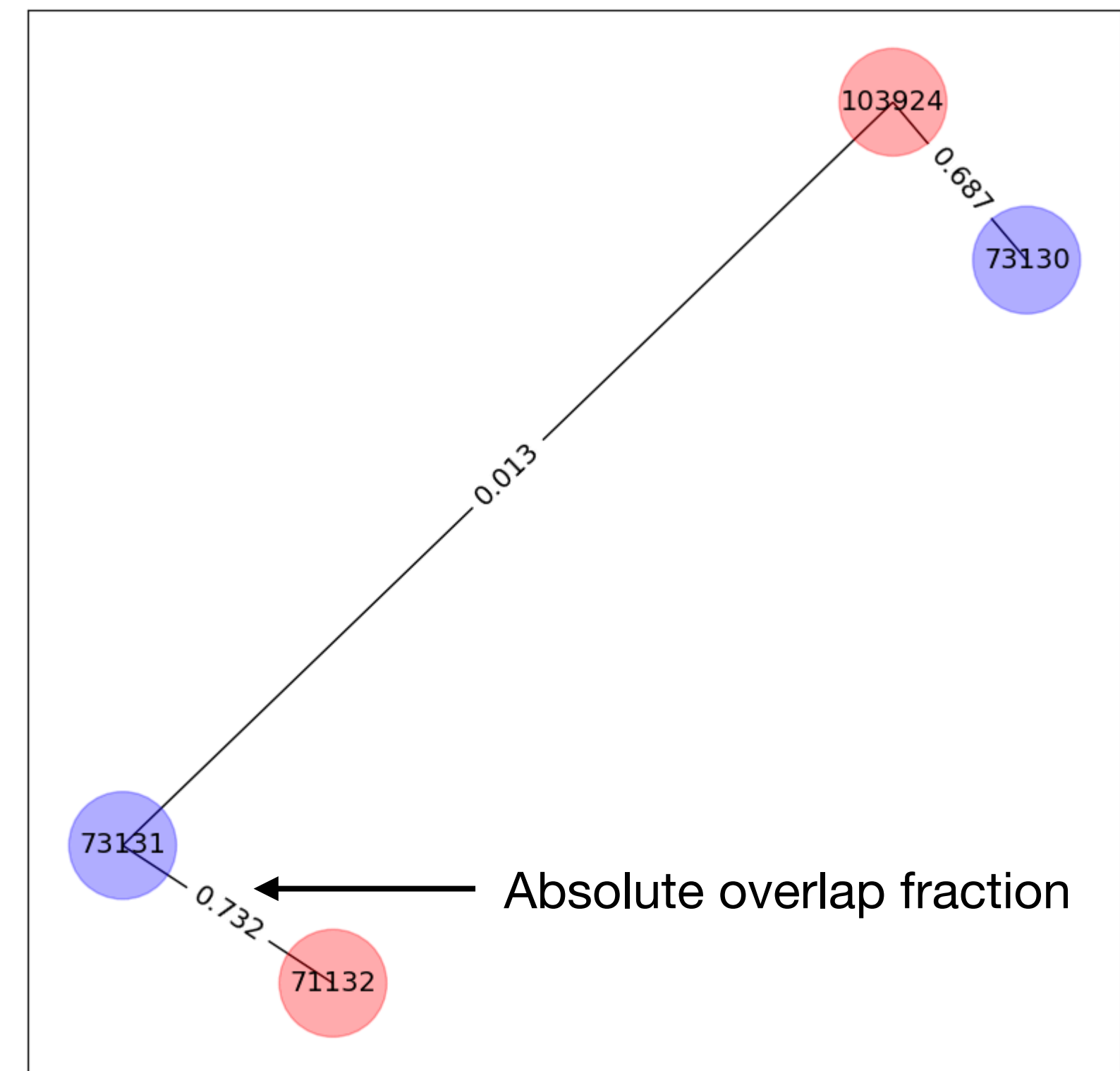


New matching algorithm: friendly

Next steps: Add metrics on the nodes/edges

- Absolute overlap fraction
- Purity
- Magnitudes/colors
- ...

NetworkX graph



Friendly = useful graph structure to better define the (un)recognized blends



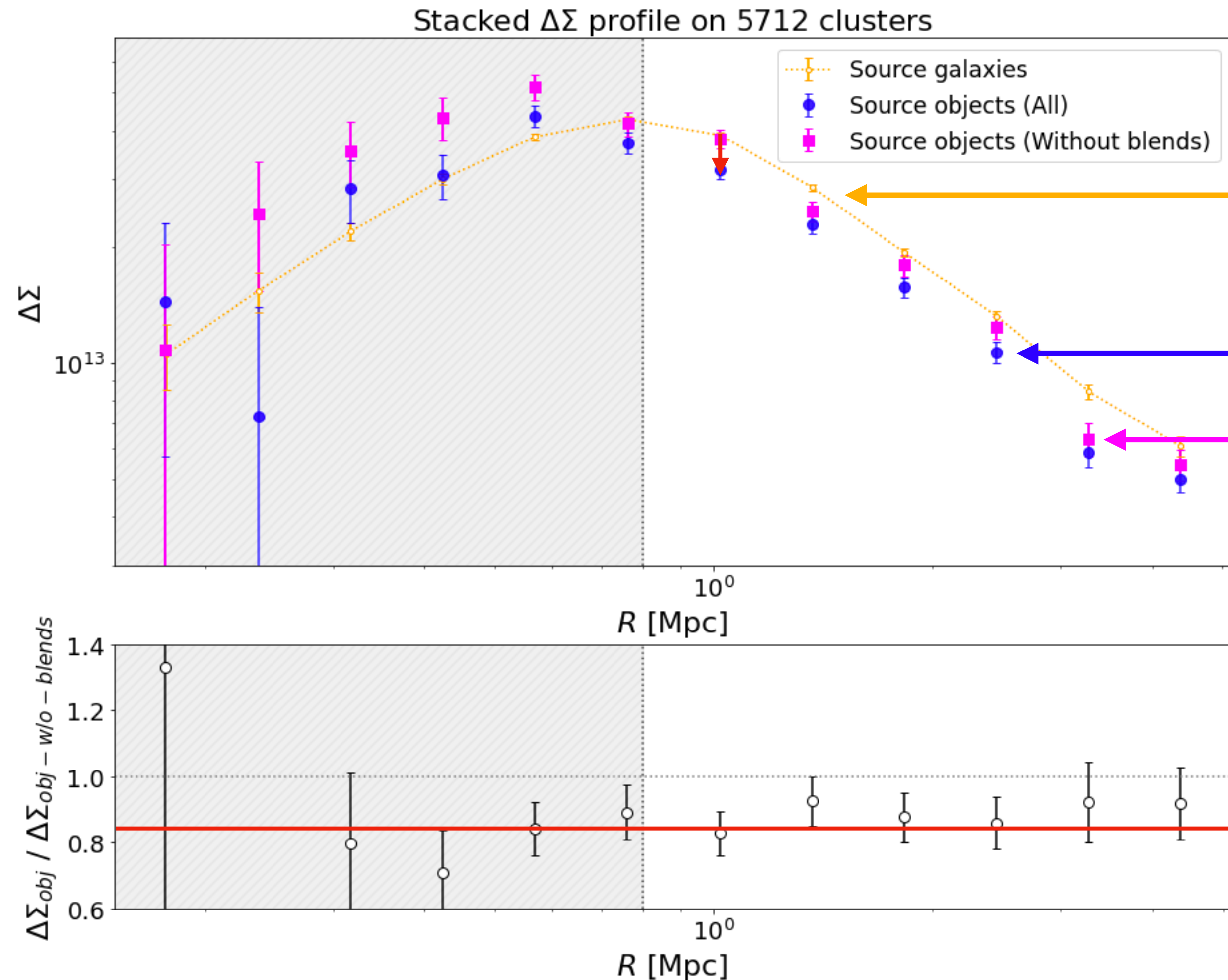
Impact of blending on $\Delta\Sigma$ profiles

Blending and weak lensing

Impact of blending on $\Delta\Sigma$ profiles

% of unrecognized blended sources: ~9 %
 % of recognized blended sources: ~30 %

Objective: study the impact of (un)recognized blends on $\Delta\Sigma$ profiles



Galaxies (from cosmoDC2)

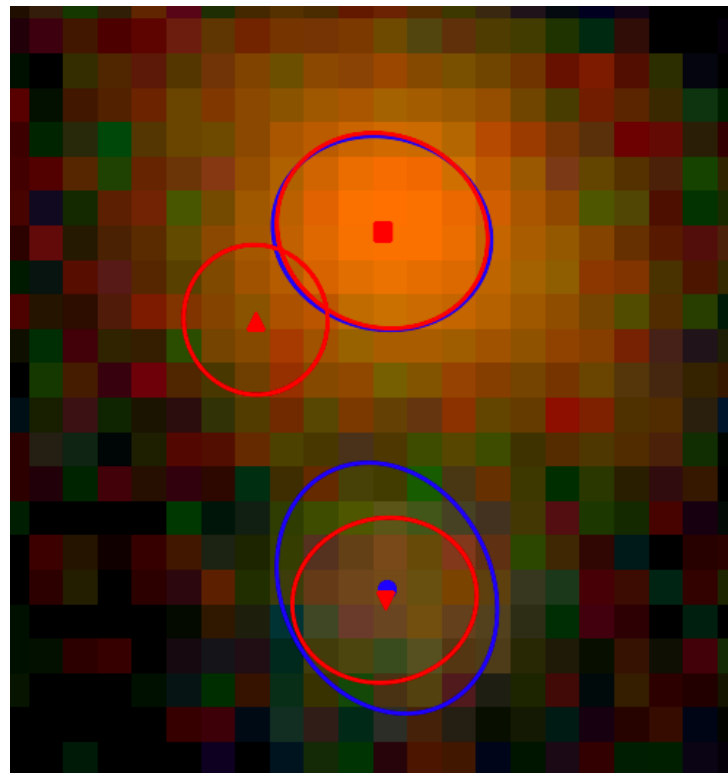
Objects (from DC2object)

Objects without recognized blends

Understand the **20% shift** between **cosmoDC2** and **DC2object** profiles

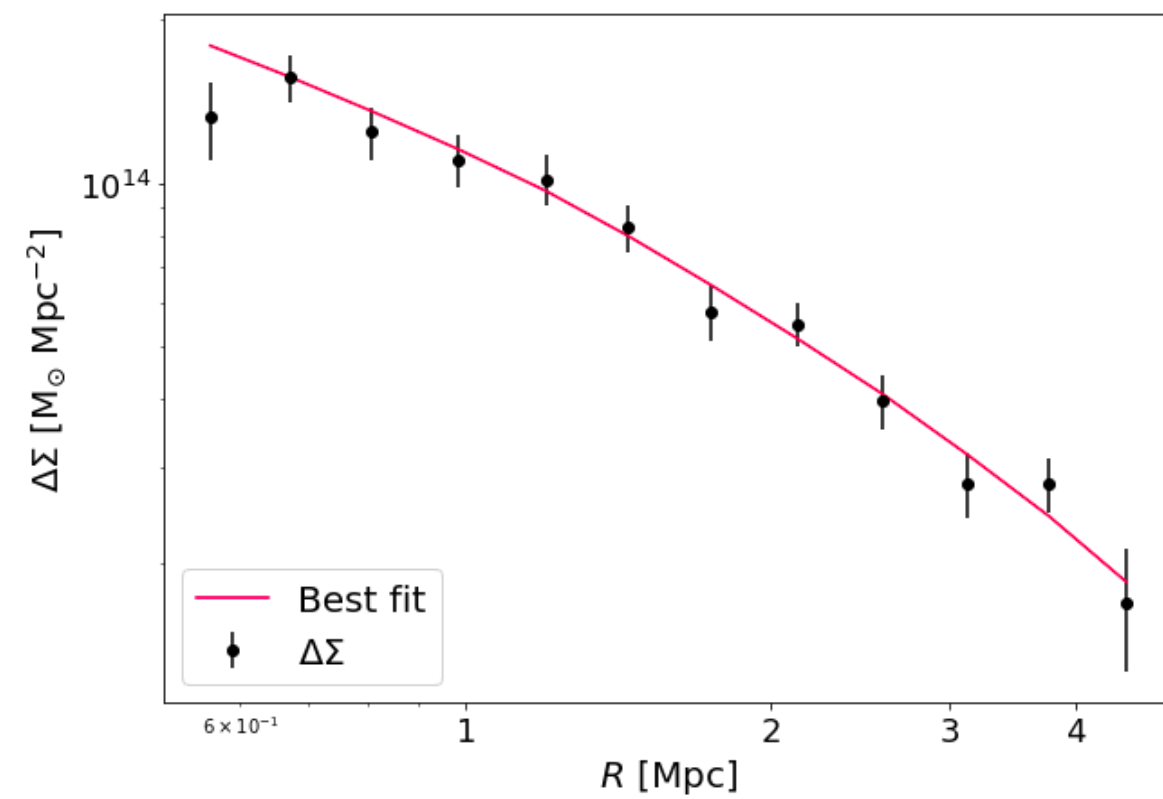
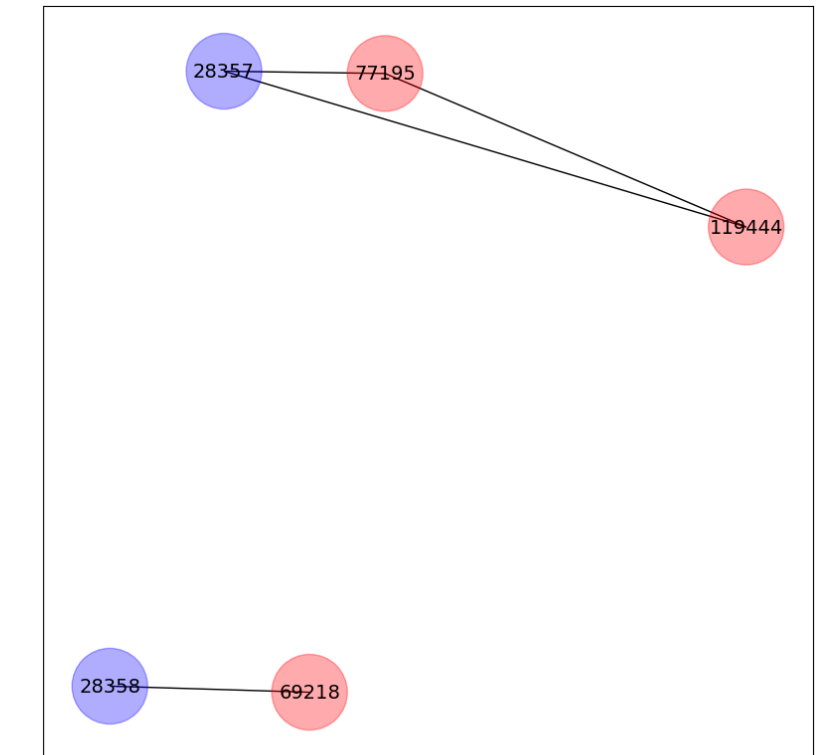
<https://github.com/LSSTDESC/CLMM>

Conclusion and perspectives



Development of **friendly**
= new blending matching algorithm

Better **definition** of (un)recognized
blends



Impact of blending on
ΔΣ profiles

Impact on galaxy clusters mass
estimates and on **cosmology**



Thank you for your attention !