

Breaking Through Blending : A Multi-Survey Approach to Dark Energy with LSST, Euclid and Roman

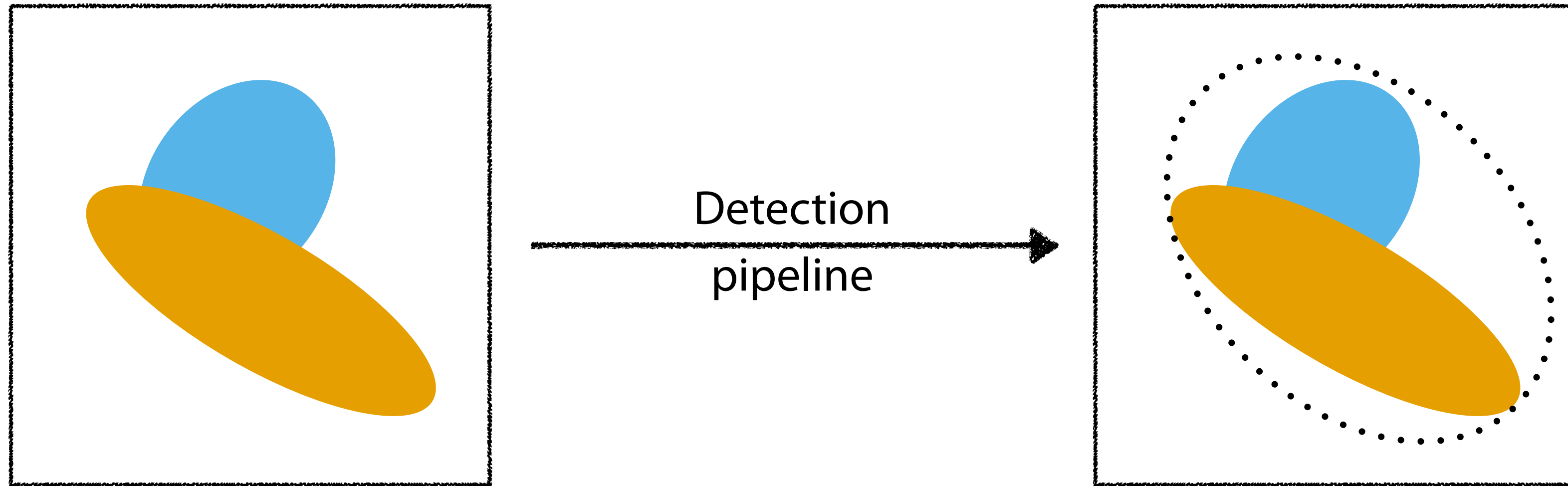
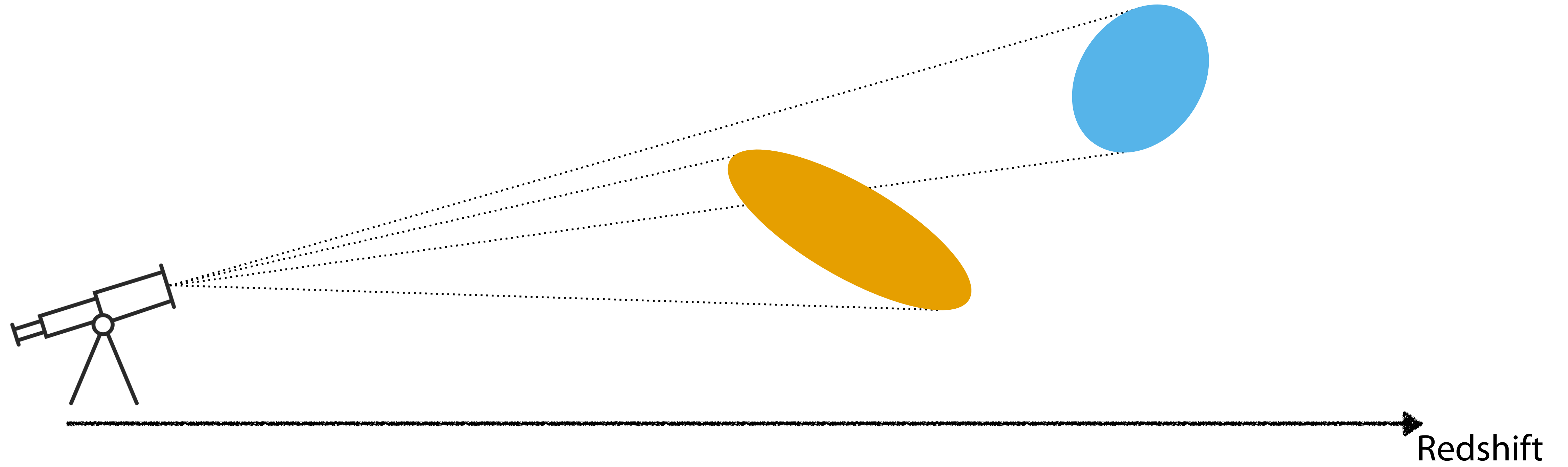
Samuel Mesquita

1st year PhD student - Supervised by Cyrille Doux

Laboratoire de Physique Subatomique et de Cosmologie (LPSC) - Grenoble, France



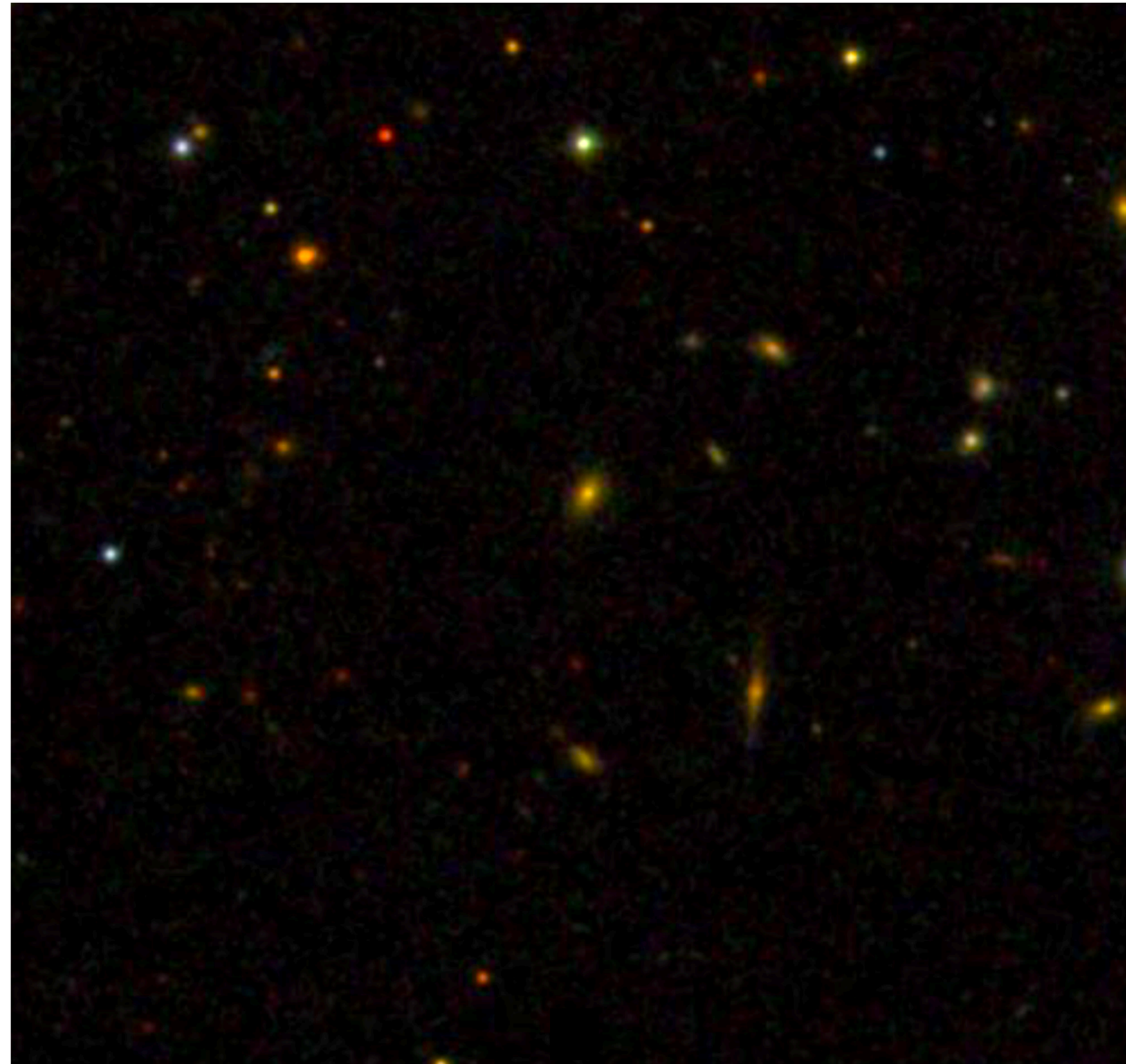
Galaxy blending



Blending dependencies

On the depths of observations

SDSS | r-mag ~ 22



Huang et al. (2018)

Samuel Mesquita | LSST France | May 20th 2026

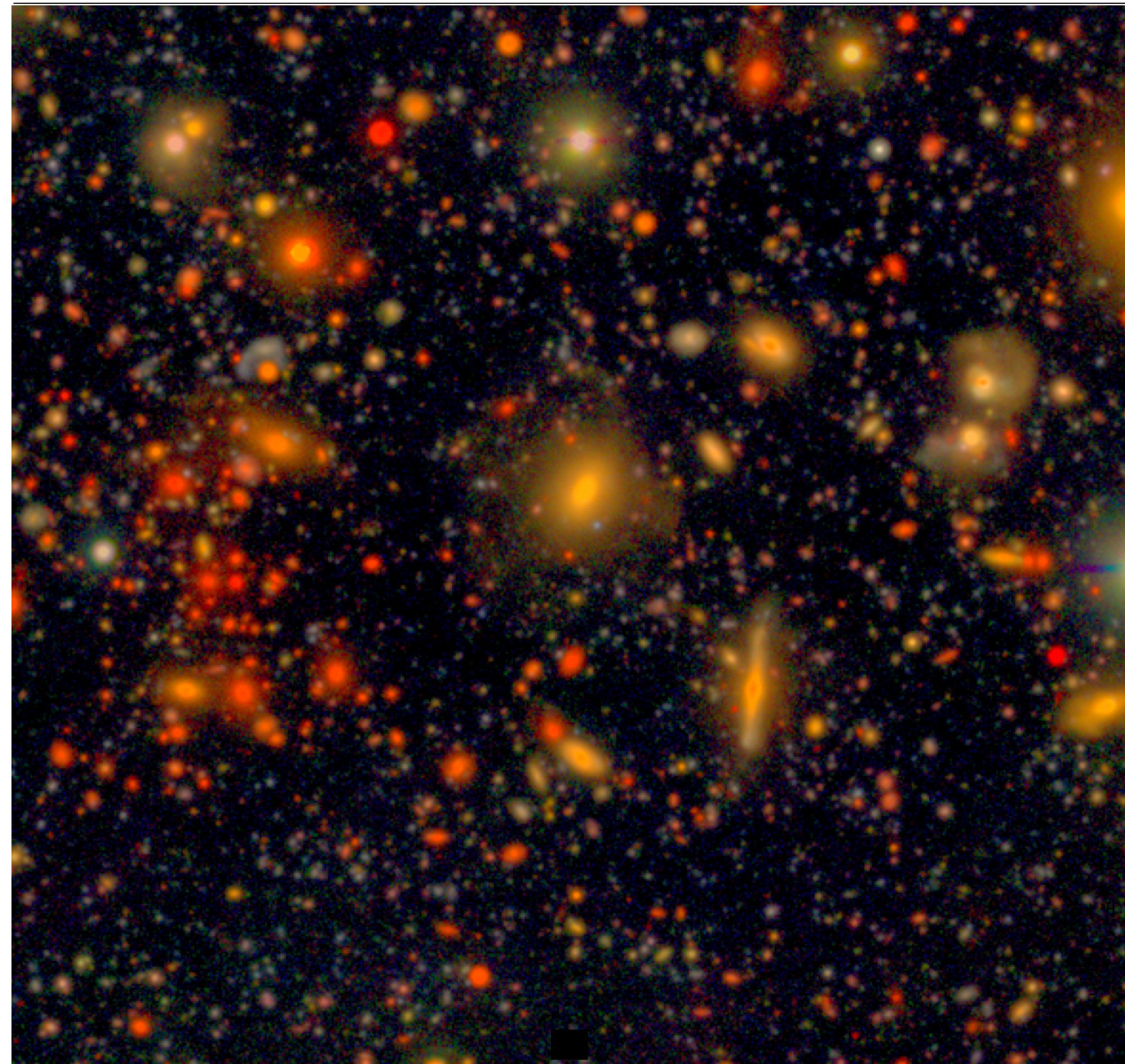
Courtesy of Manon Ramel

Blending dependencies

On the depths of observations

SDSS | r-mag ~ 22

HSC | r-mag ~ 26



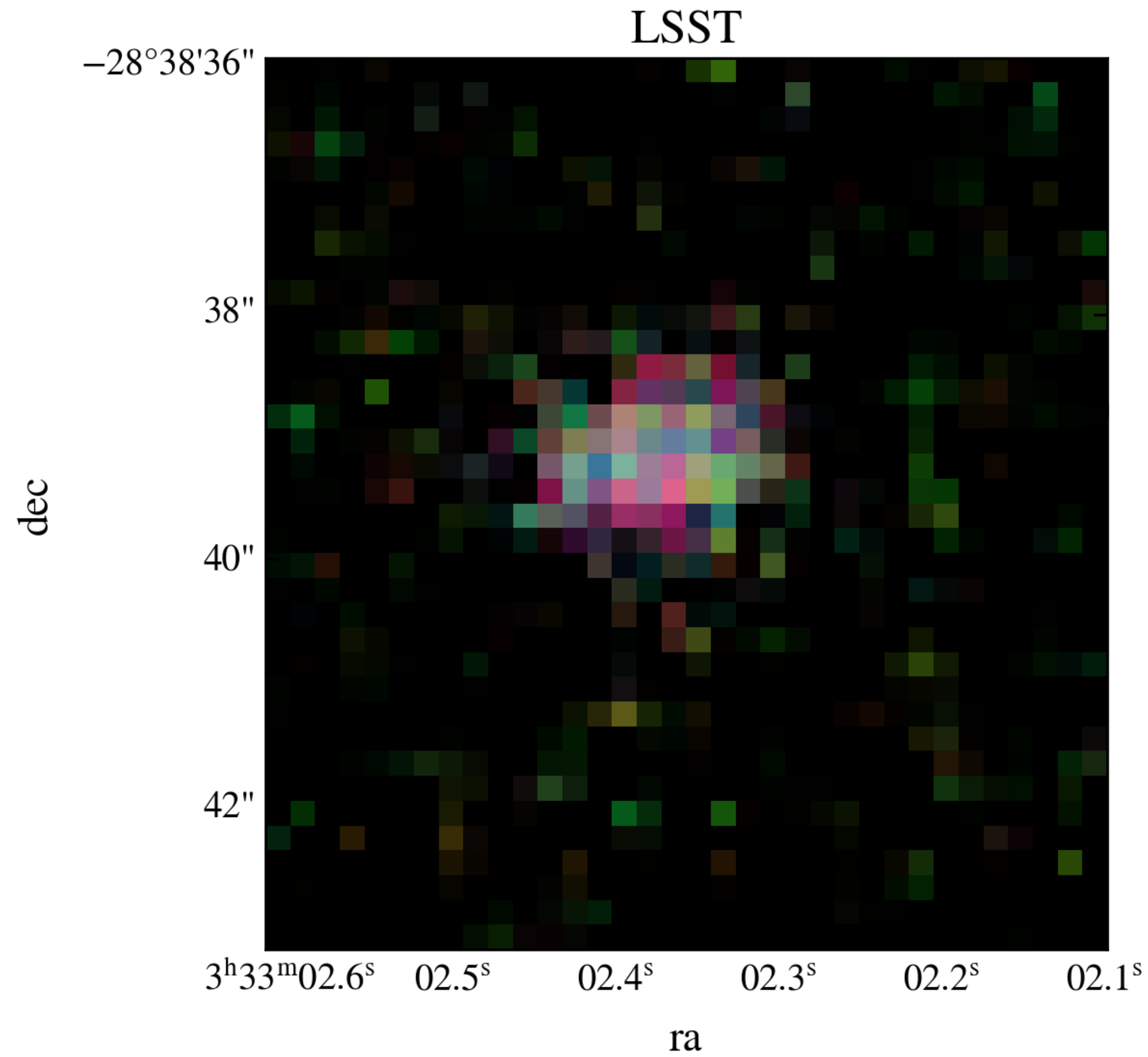
Huang et al. (2018)

Courtesy of Manon Ramel

Blending dependencies

LSST DP1 PSF $\sim 0.9''$

On the PSF

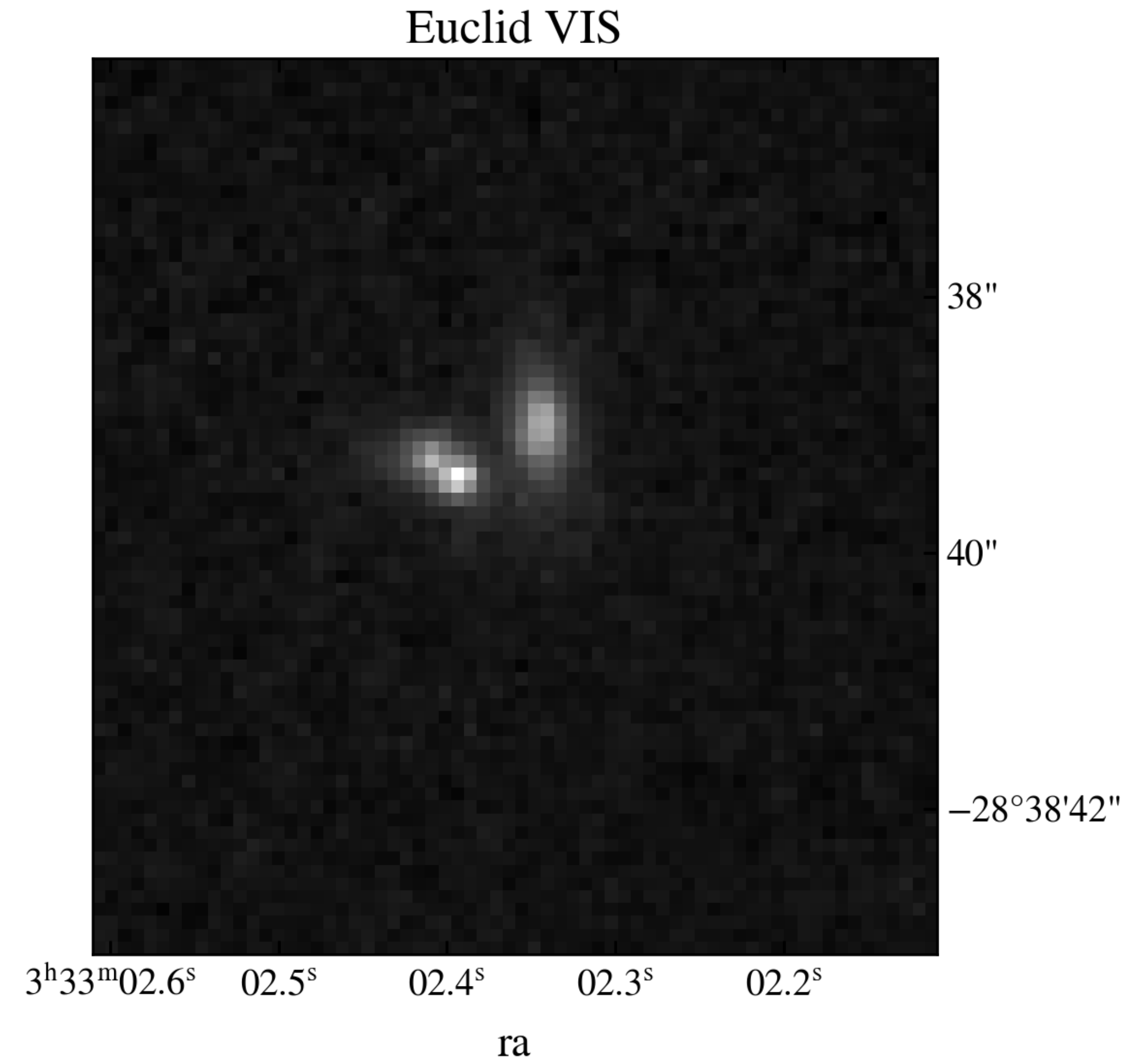
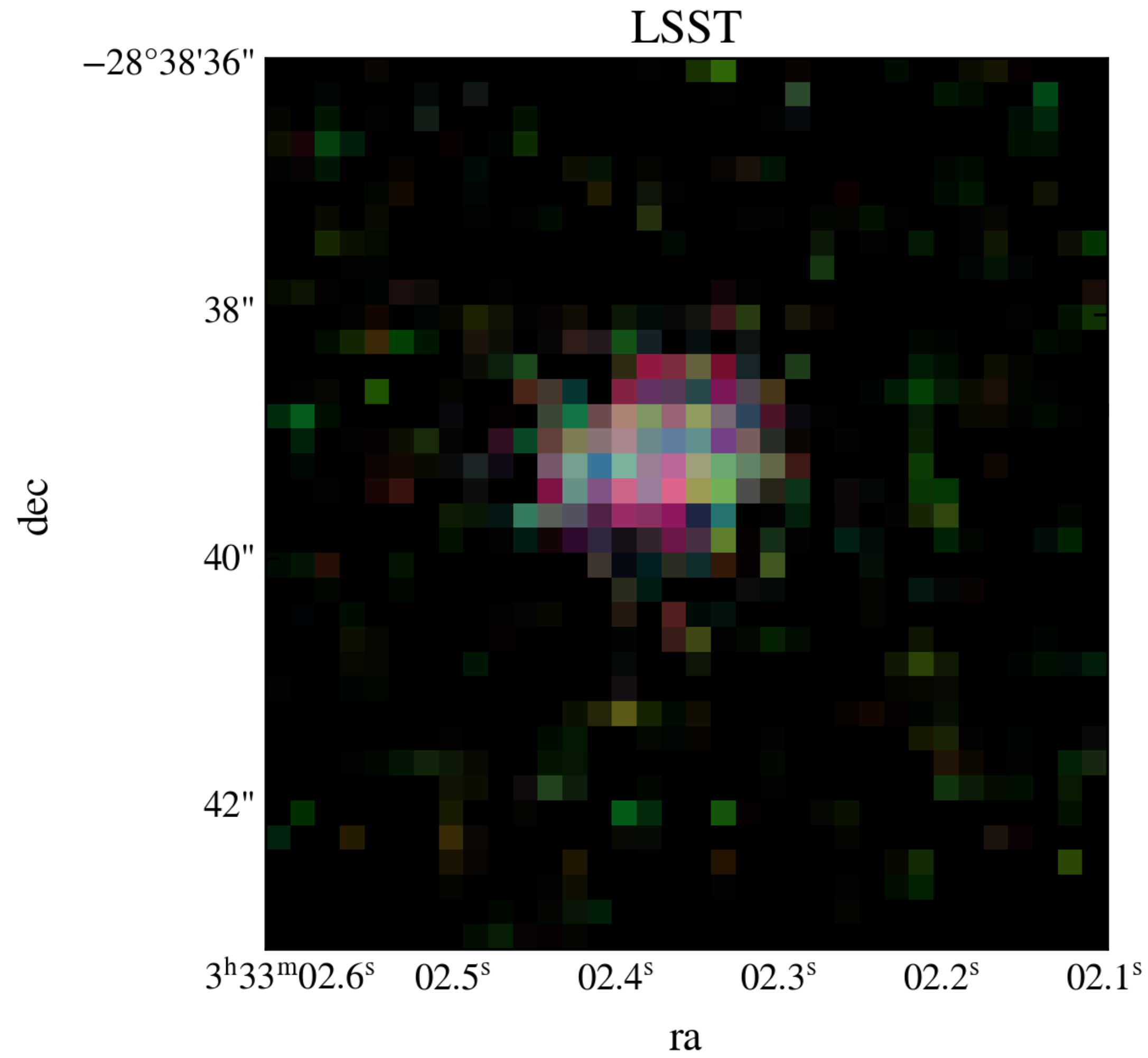


Blending dependencies

On the PSF

LSST DP1 PSF $\sim 0.9''$

Euclid VIS PSF $< 0.2''$

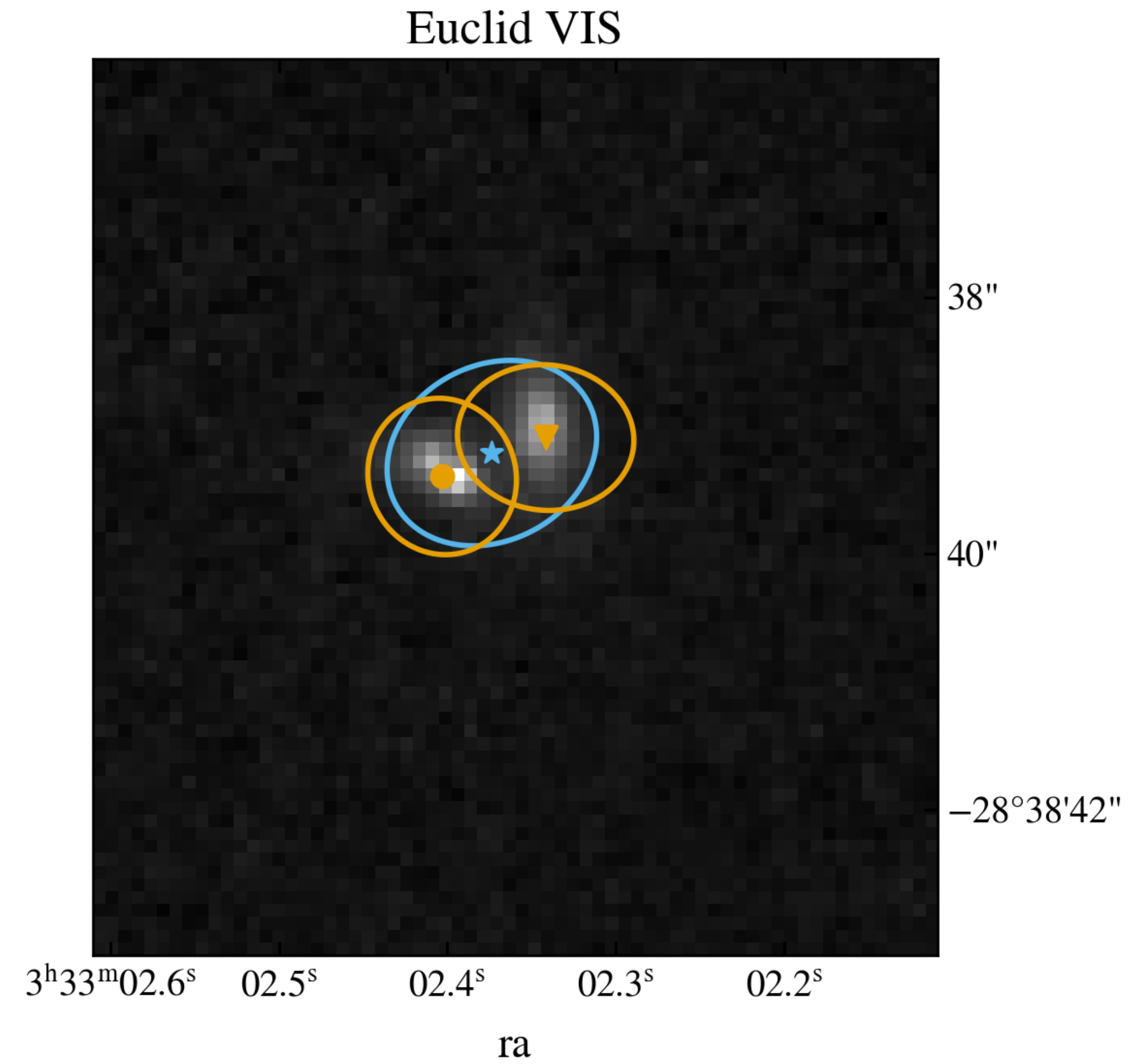
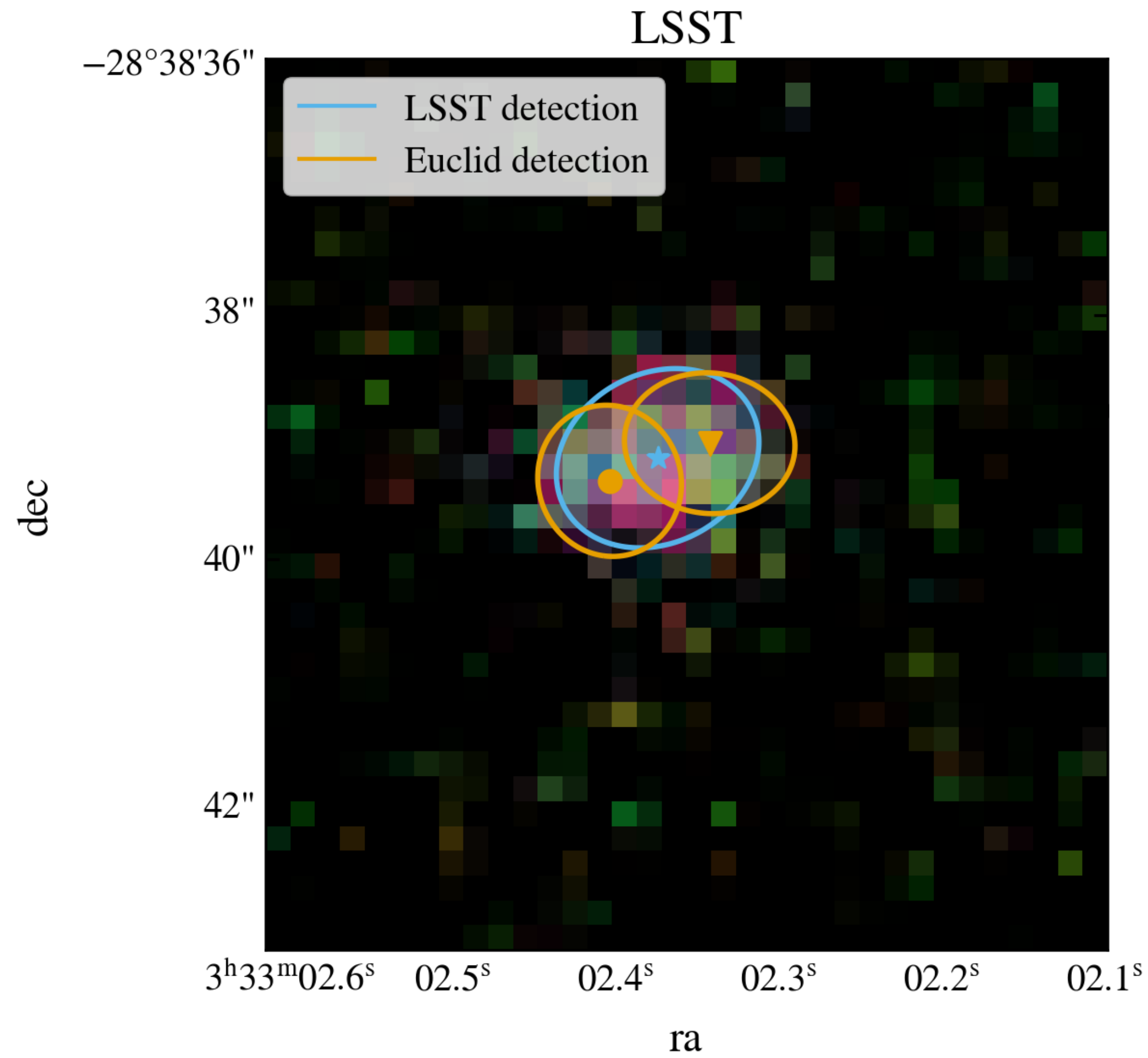


Blending dependencies

On the PSF

LSST DP1 PSF $\sim 0.9''$

Euclid VIS PSF $< 0.2''$



Types of blends

Recognized blends :

Pipeline detects multiple overlapping objects

Unrecognized blends :

Pipeline detects fewer objects than there are

Detection Truth	Recognized Blends?	
	No	Yes
Unrec-BL?	No 1	Yes 3
	Yes 2	Yes 4

Liang et al. (2025)

Impacts : shear estimations, photometry, galaxy count, photo-z, $n(z)$...

Survey field

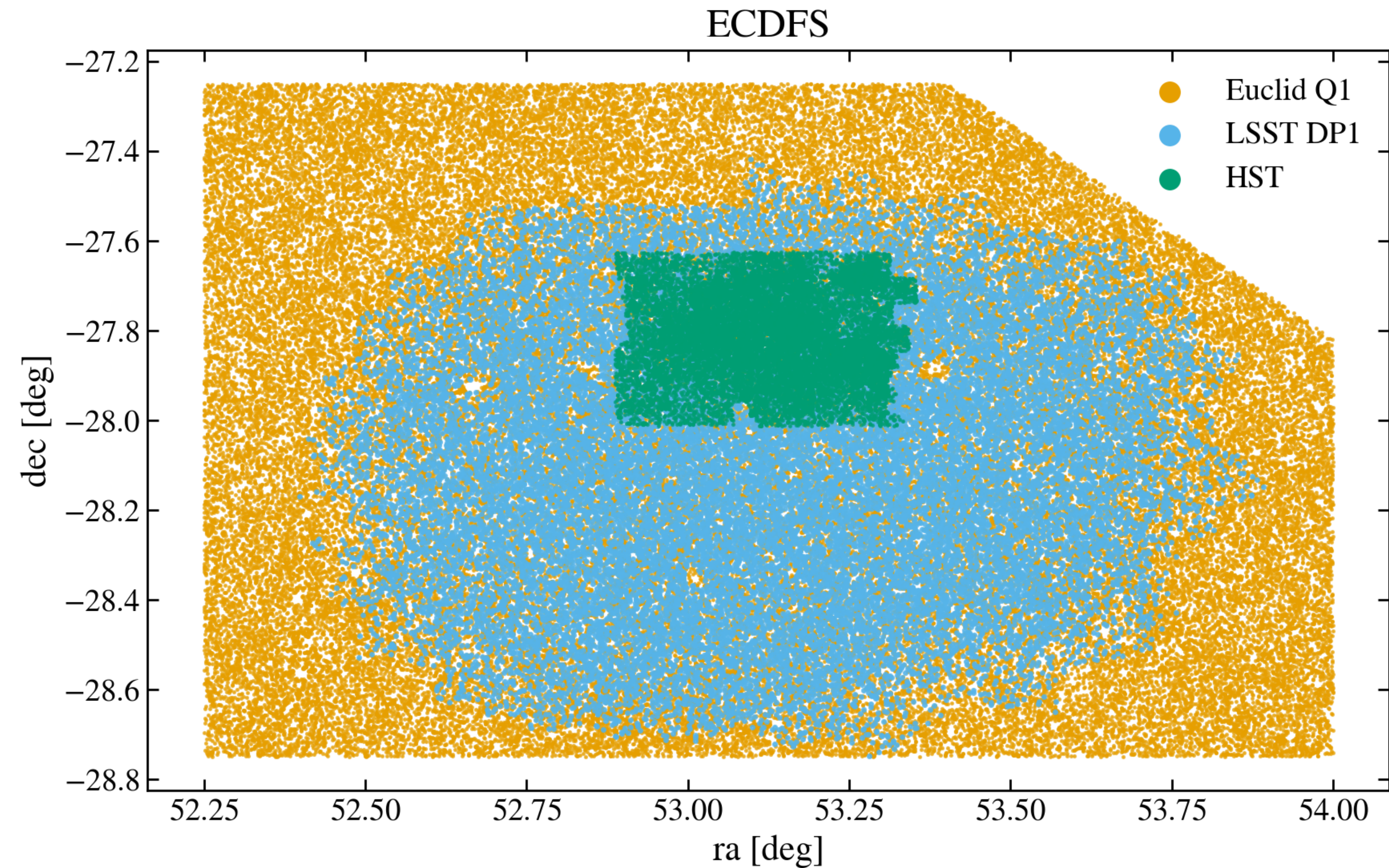
Extended Chandra Deep Field South (ECDFS)

We'll be using **HST** and **Euclid**
as our reference data

Catalog matching :

- **LSST-Euclid**
- **LSST-HST**

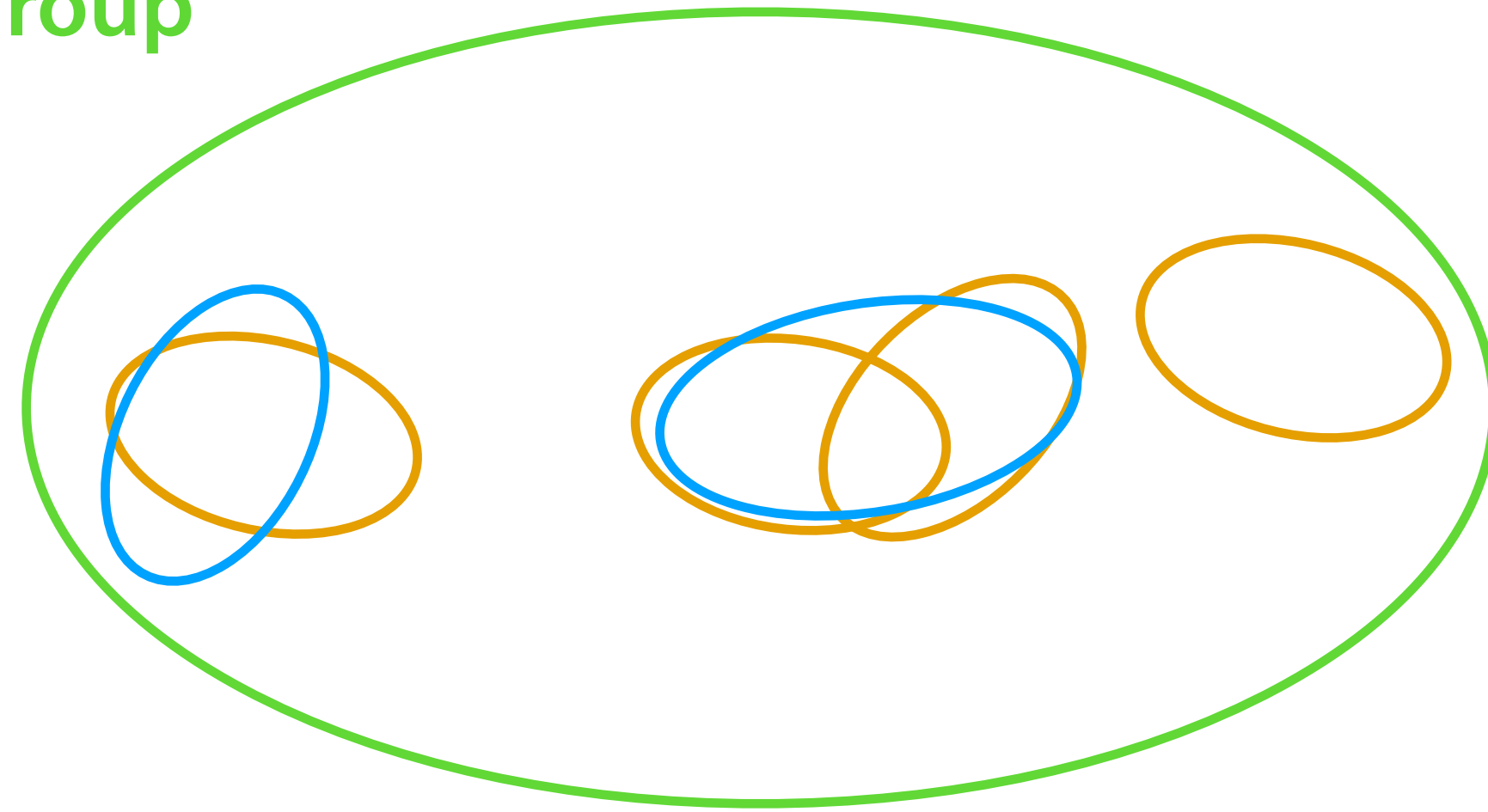
Using FoF + Ellipse Overlap Test



Matching catalogs

Ellipse Overlap Test

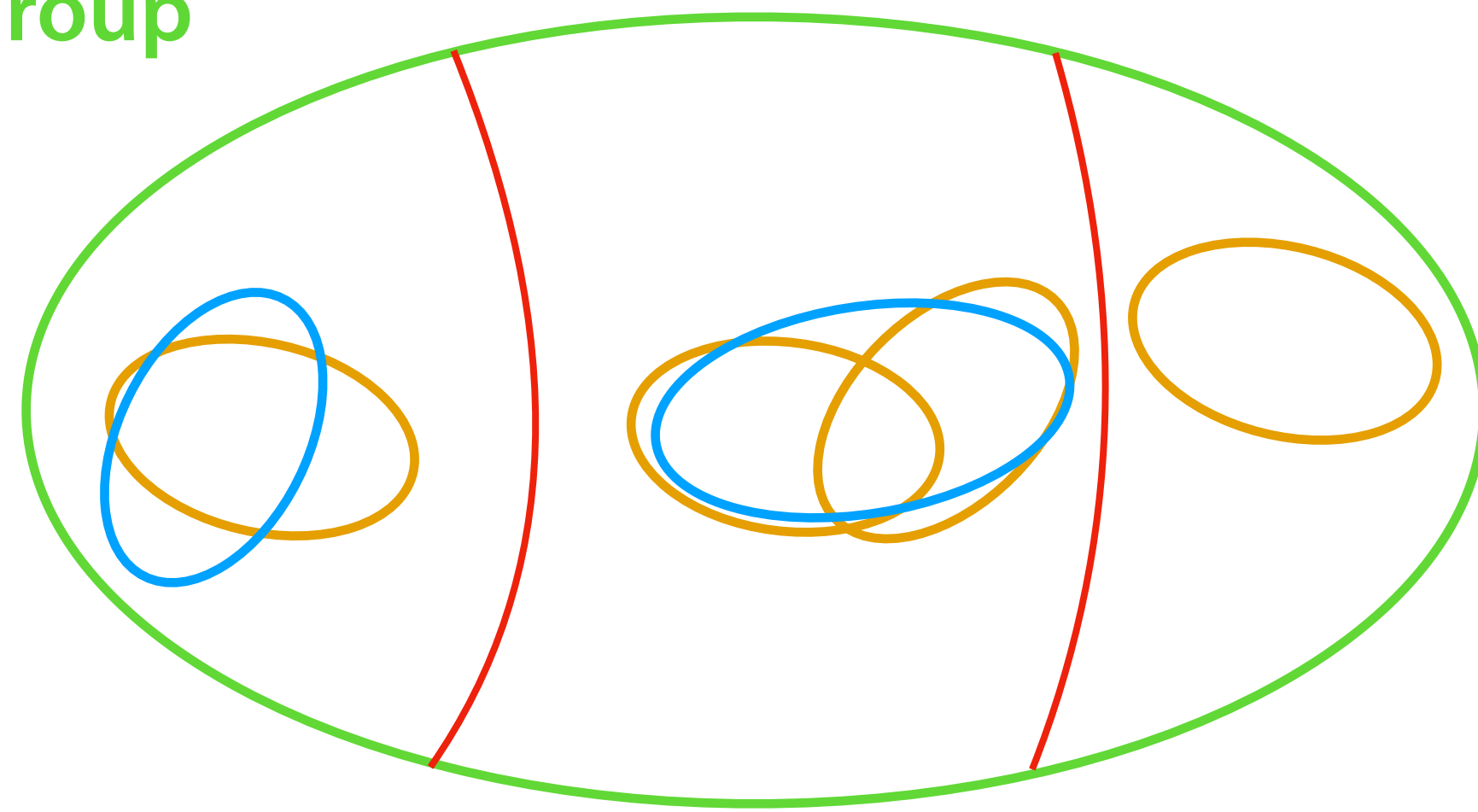
1 FoF group



Matching catalogs

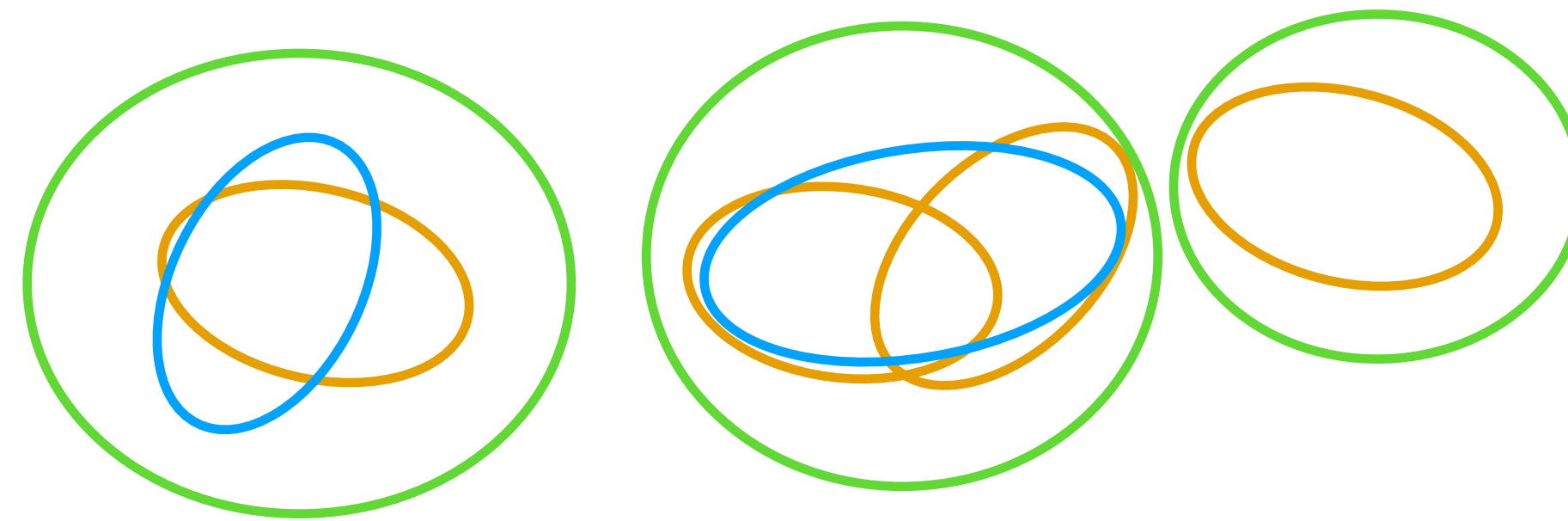
Ellipse Overlap Test

1 FoF group

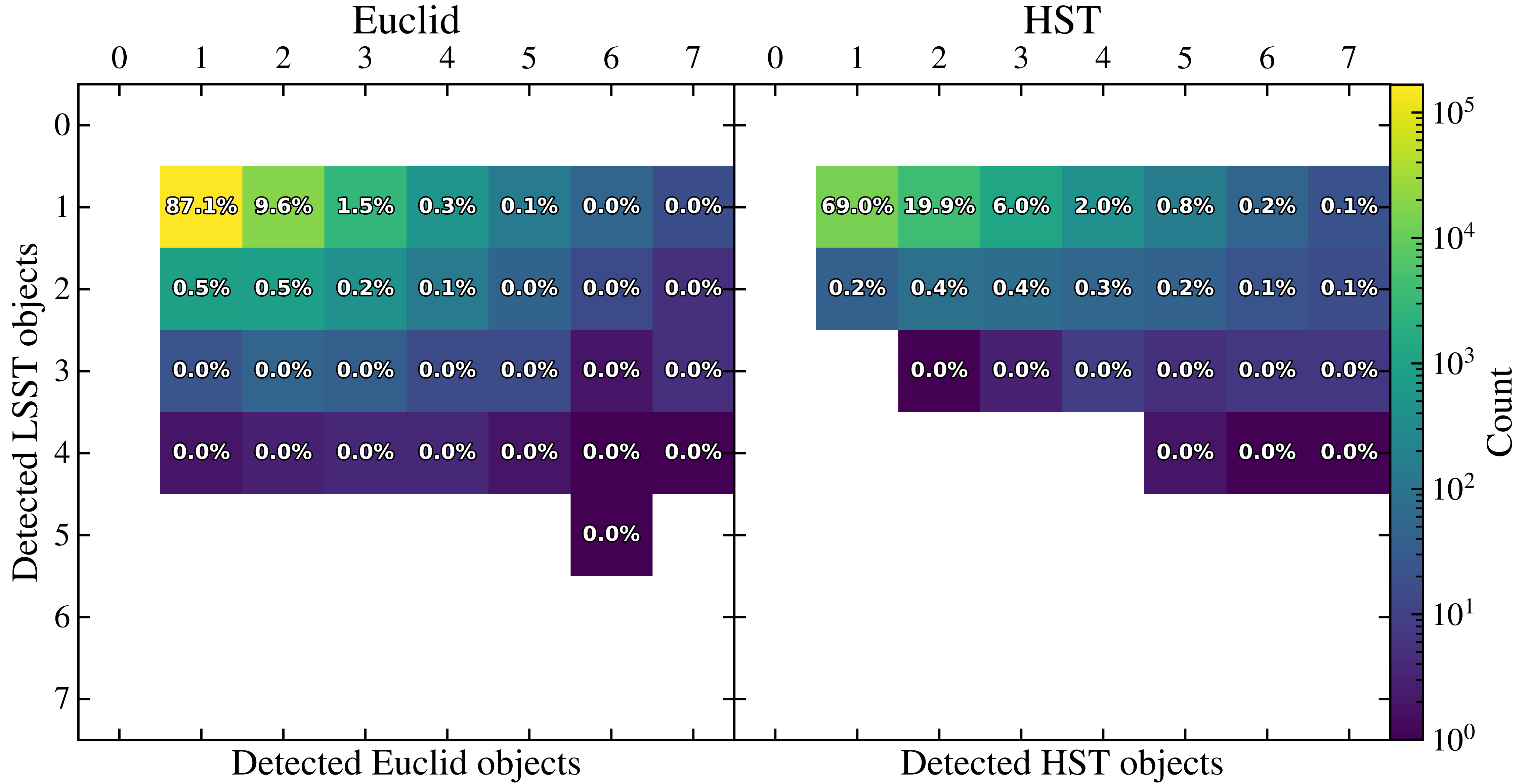


EOT

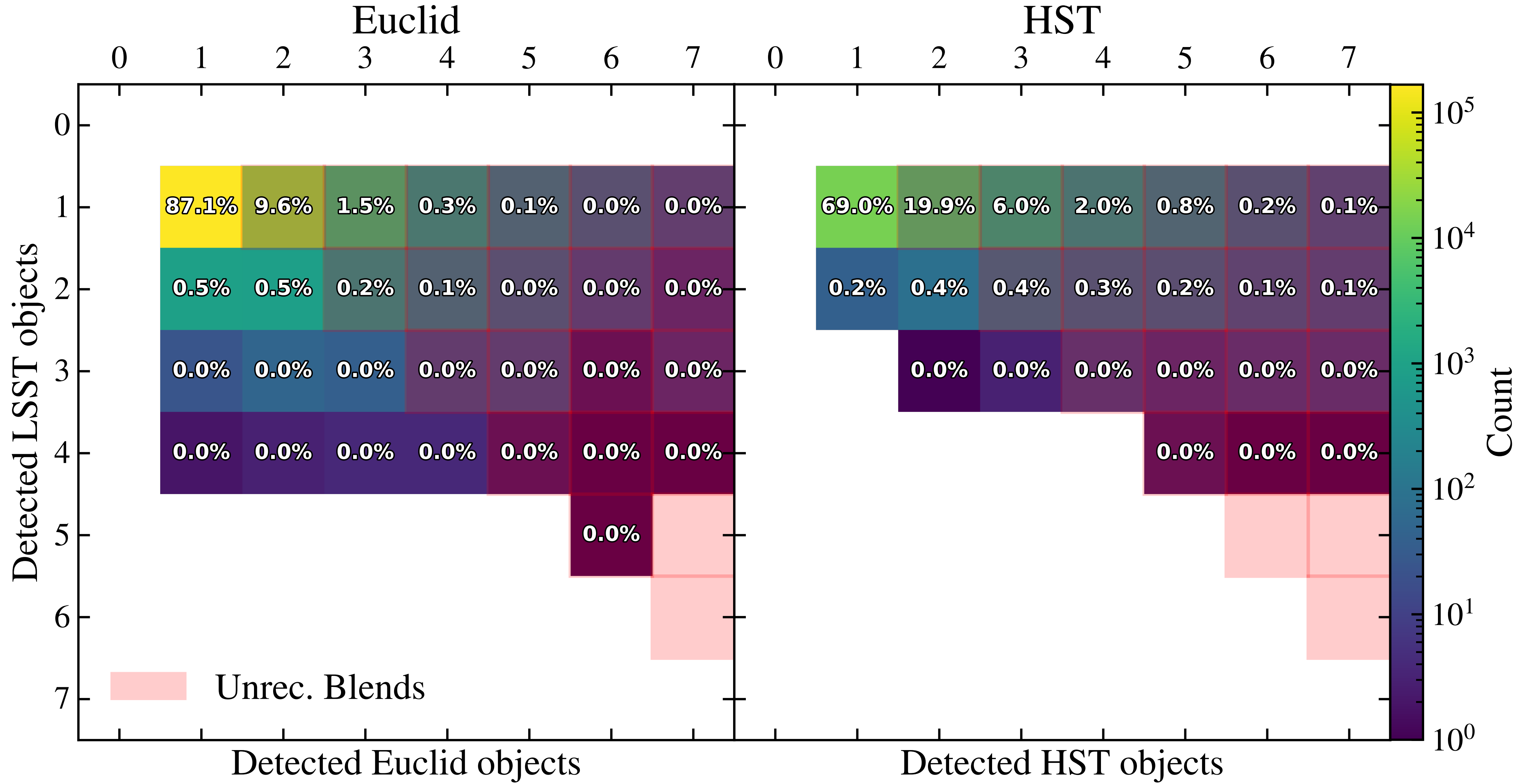
3 FoF+EOT groups



Detections per telescope



Detections per telescope



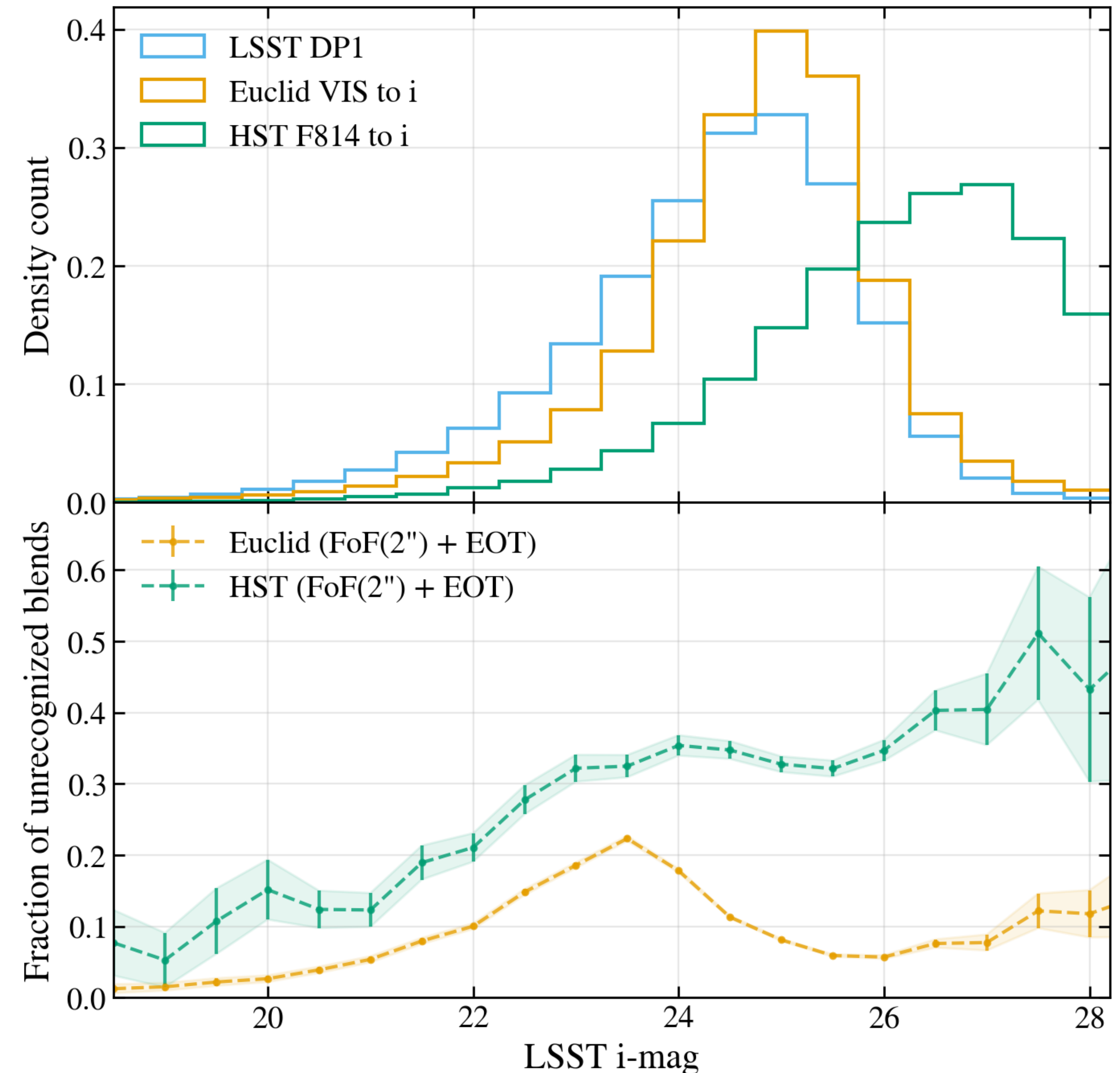
Fraction of unrecognized blends

Top graph :

- Fit on **HST F814** and **Euclid VIS** bands to compare them to **LSST i-band**
- **HST** deeper than **Euclid**, itself deeper than **LSST**

Bottom graph :

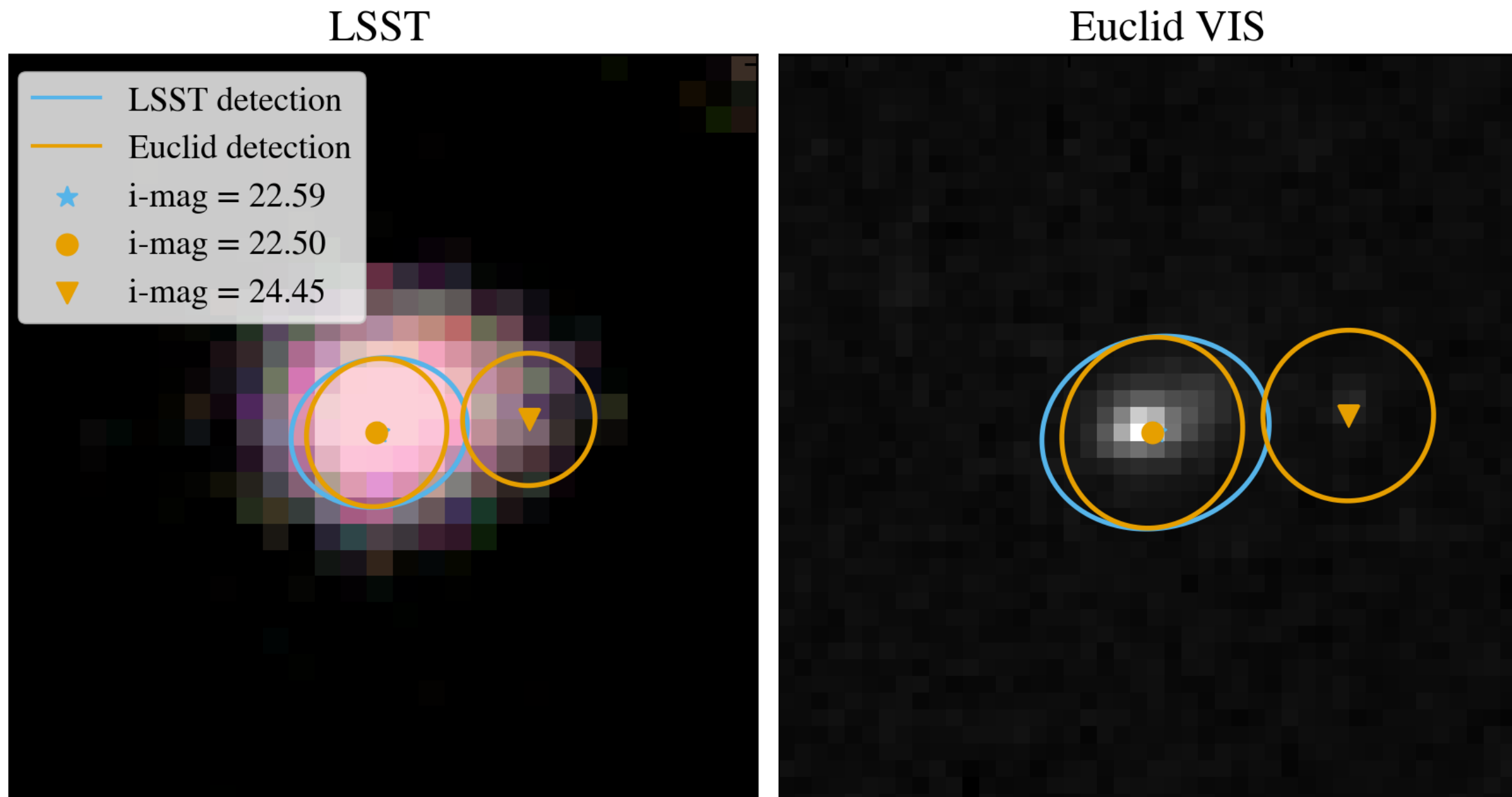
- Unrec. blends up to ~22% of the catalog for **LSST** at i-mag 23.5 when using **Euclid** as ground truth
- Drop in **Euclid** after 23.5 i-mag due to the fainter galaxies of the blends not detected
- Much higher for **HST** which is expected because deeper



Fraction of unrecognized blends

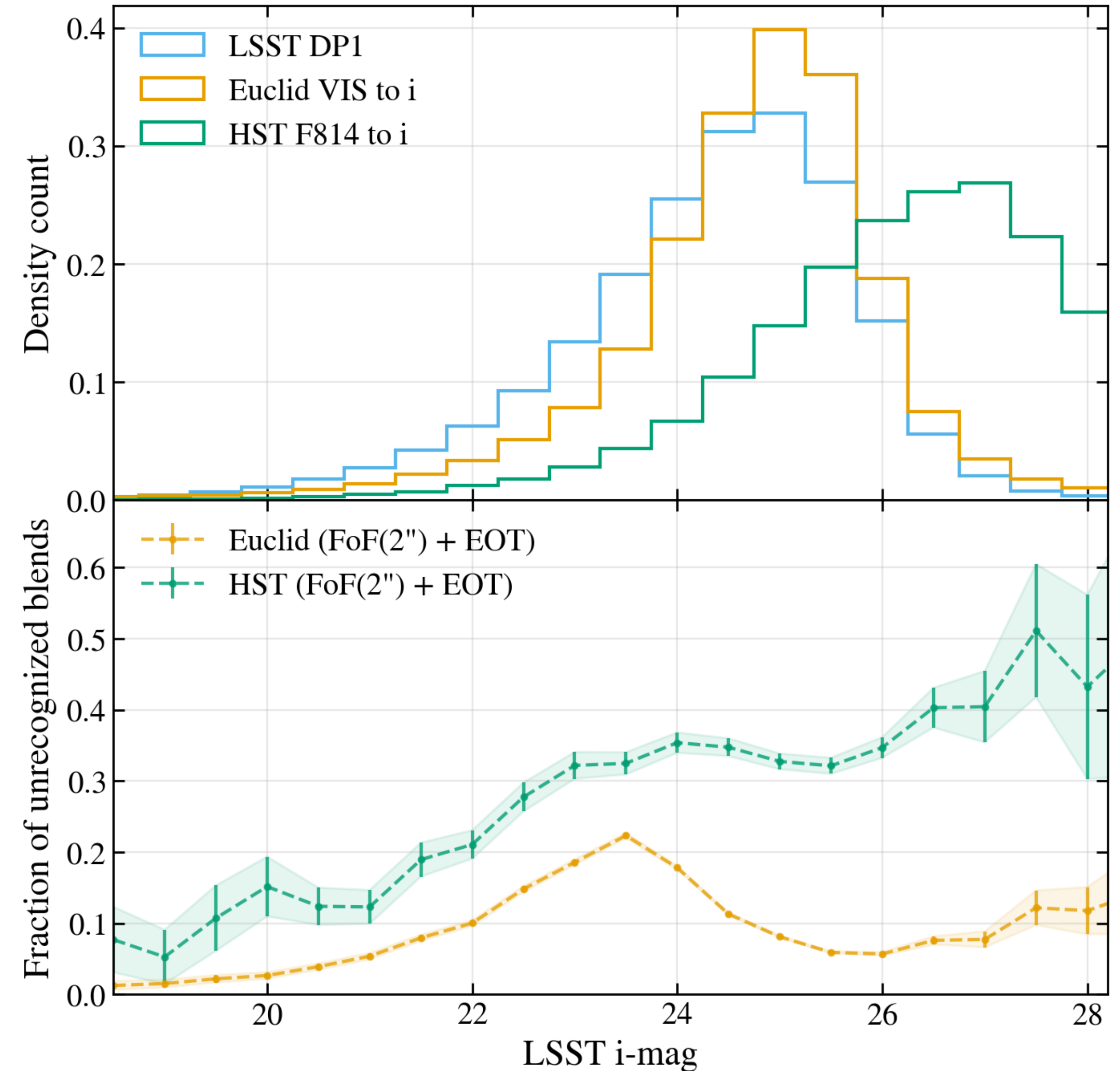
Warning for misinterpretation :

Some of those blends are not problematic at all !



New metric (Ramel et al., *in prep*) :

A detected object can plausibly be associated with several nearby galaxies, the **blending entropy (S_b)** quantifies how ambiguous this association is.

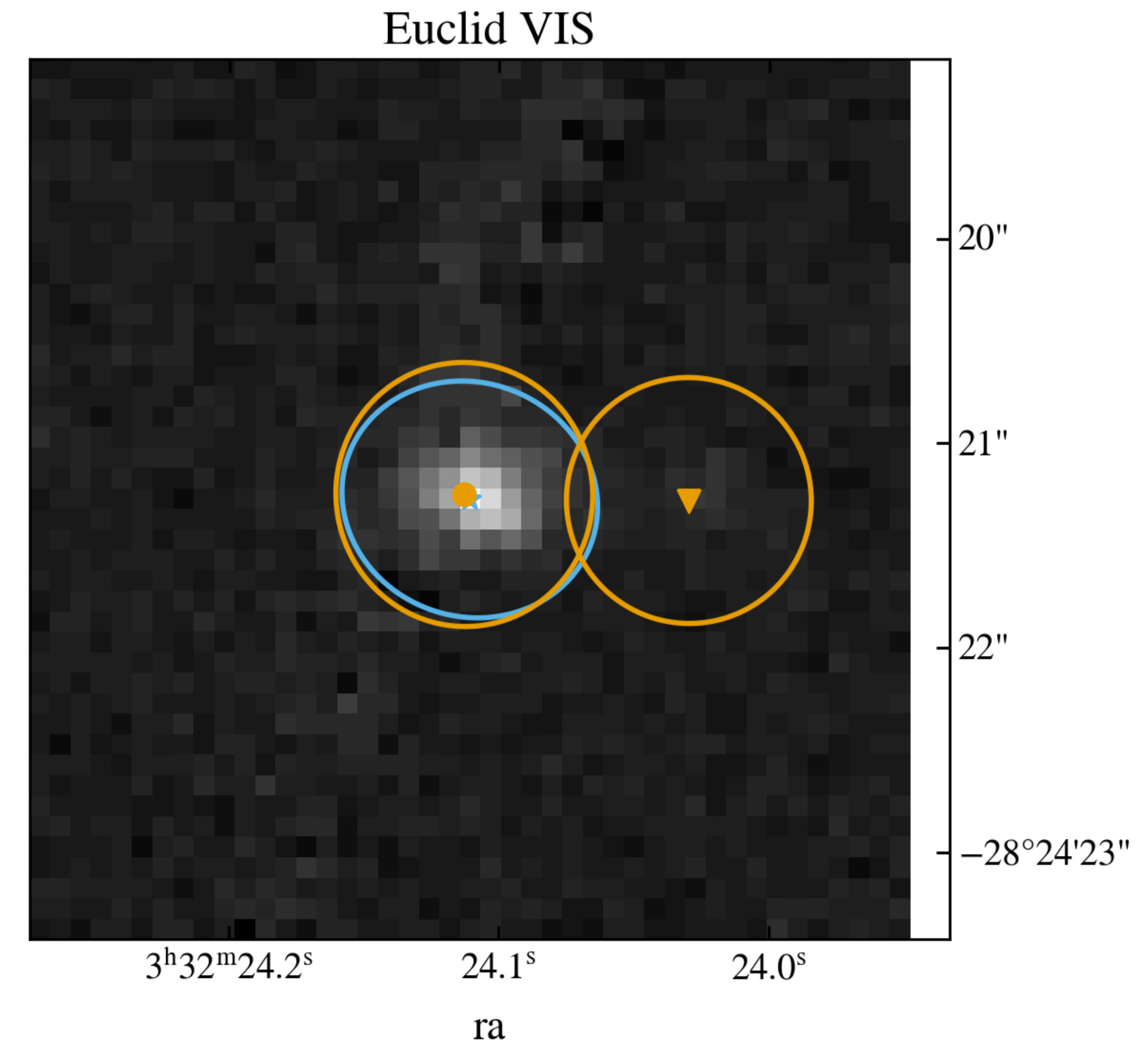
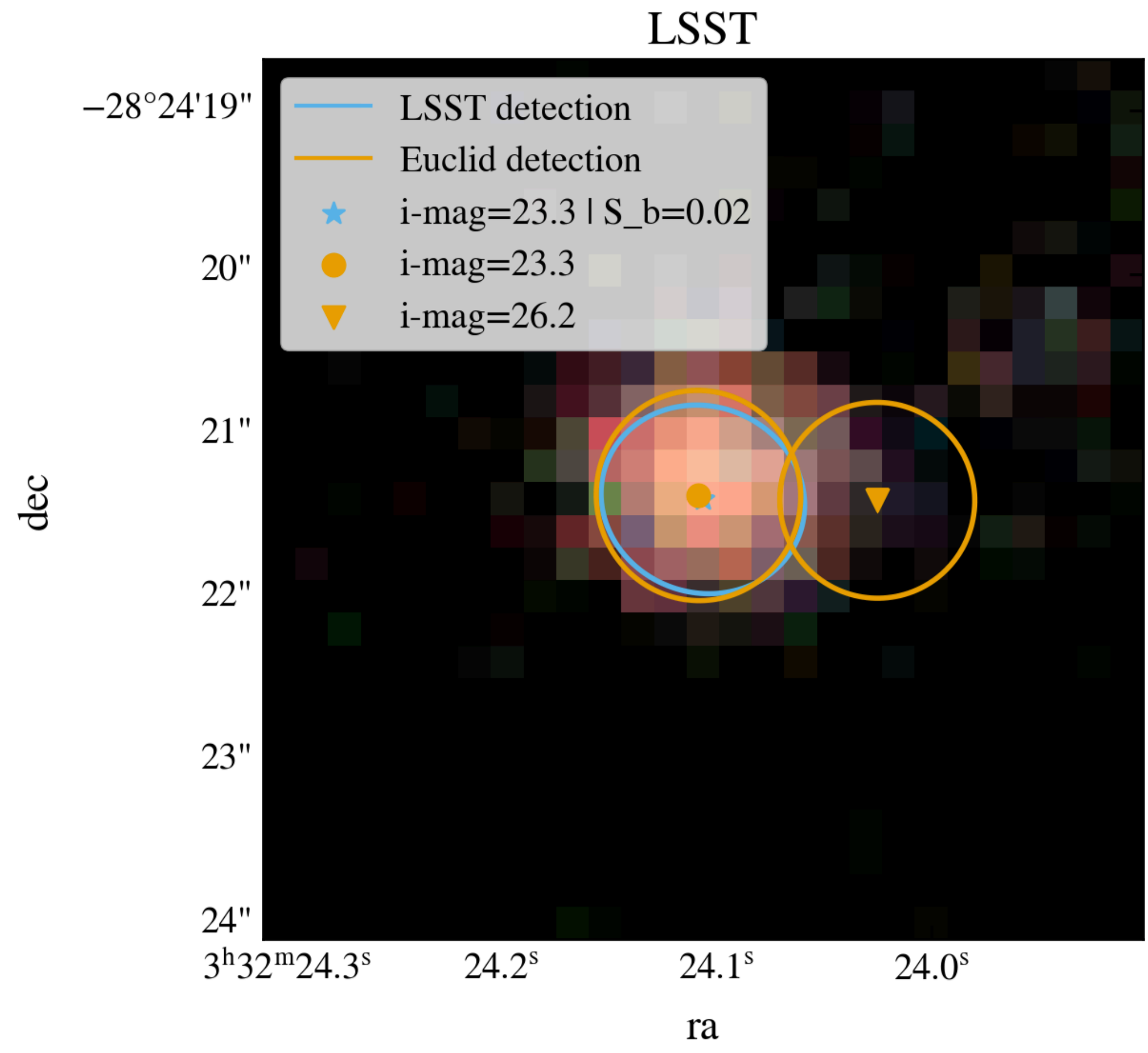


Fraction of high S_b blends

$$S_{b,o} = - \sum_g p_{og} \ln(p_{og}) \geq 0$$

$$p_{og} \propto \langle o, g \rangle \exp(-|m_o - m_g|)$$

Low S_b
blend
 $S_b = 0.02$



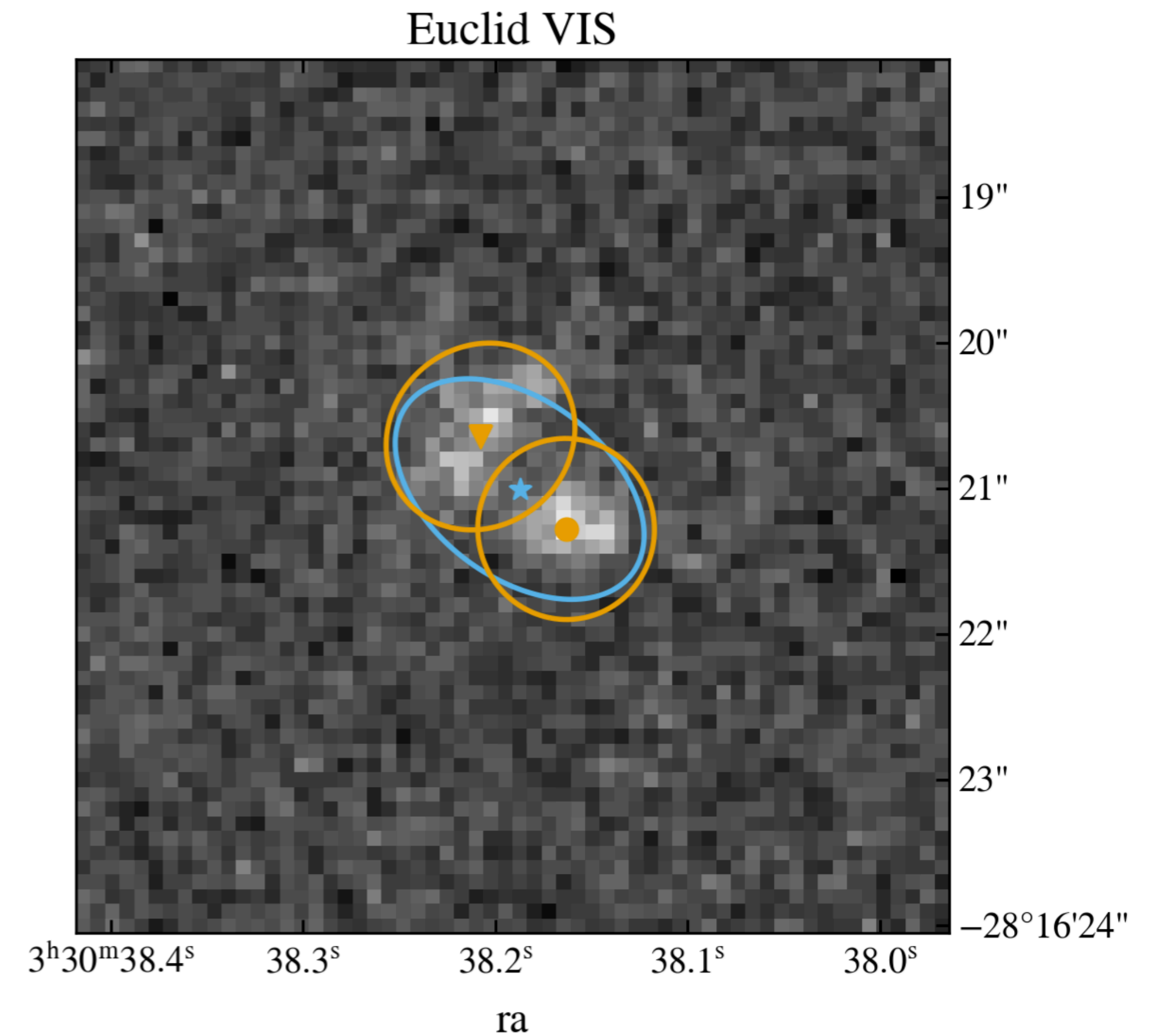
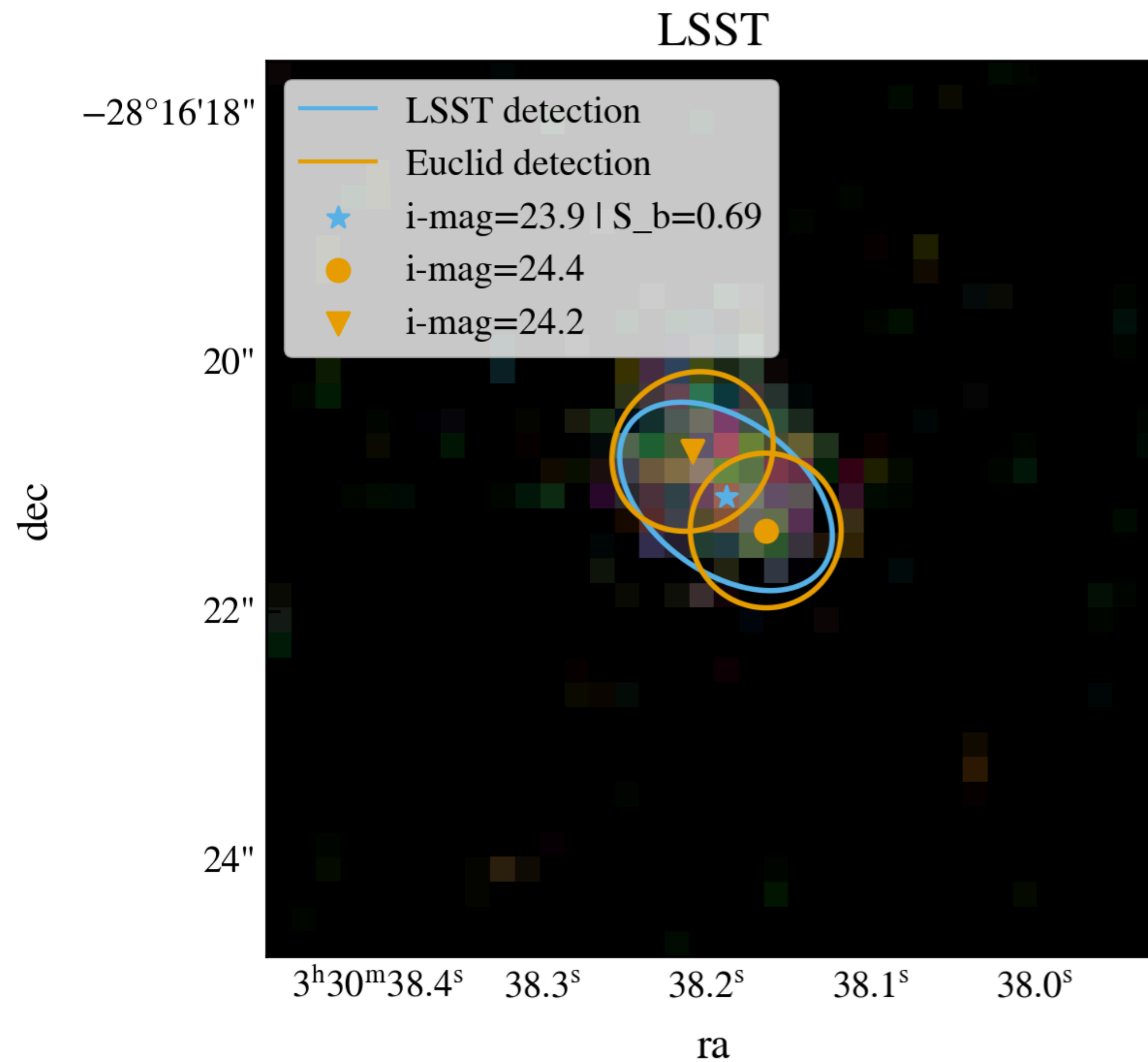
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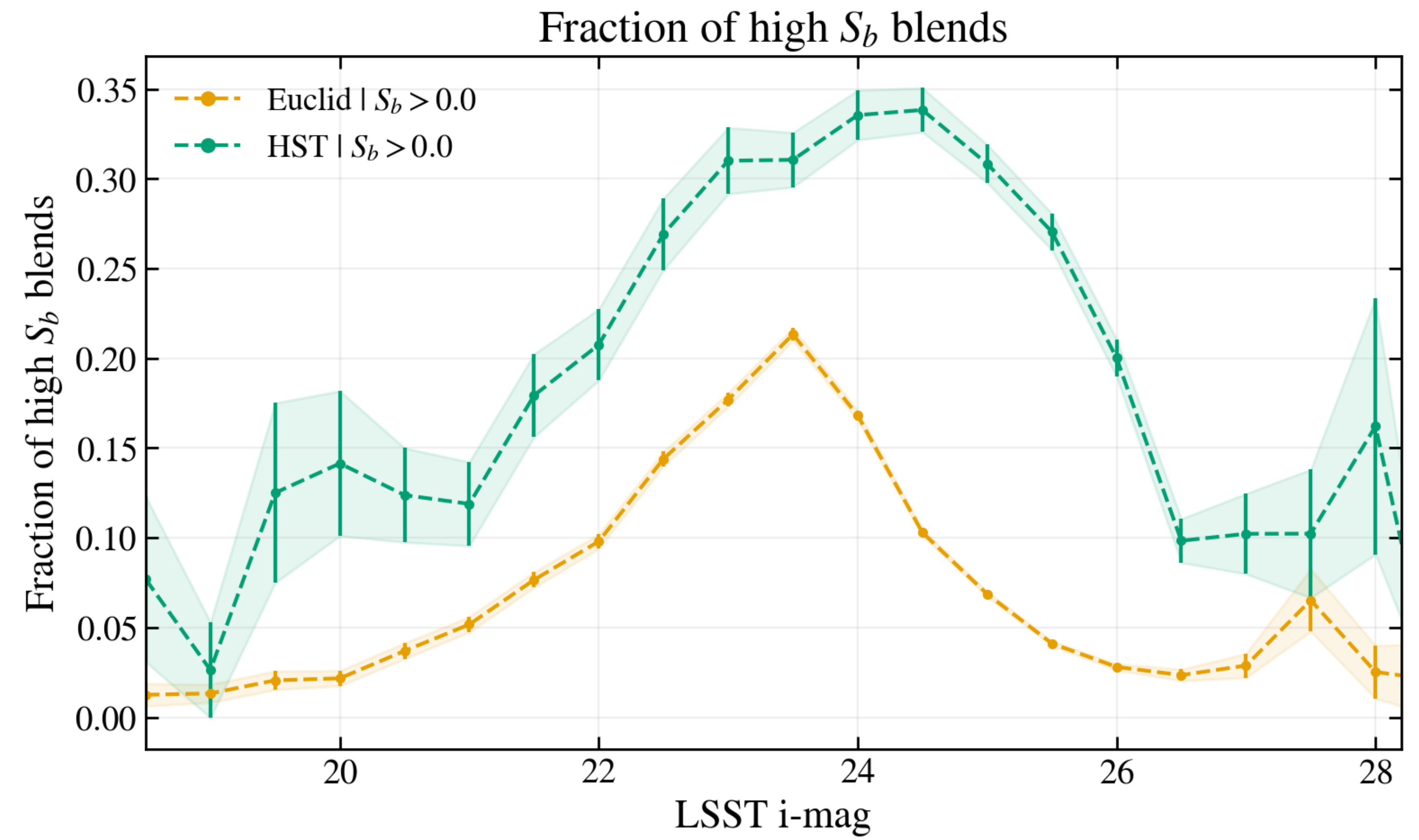
$$p_{og} \propto \langle o, g \rangle \exp(-|m_o - m_g|)$$

High S_b
blend

$S_b = 0.69$



Fraction of high S_b blends

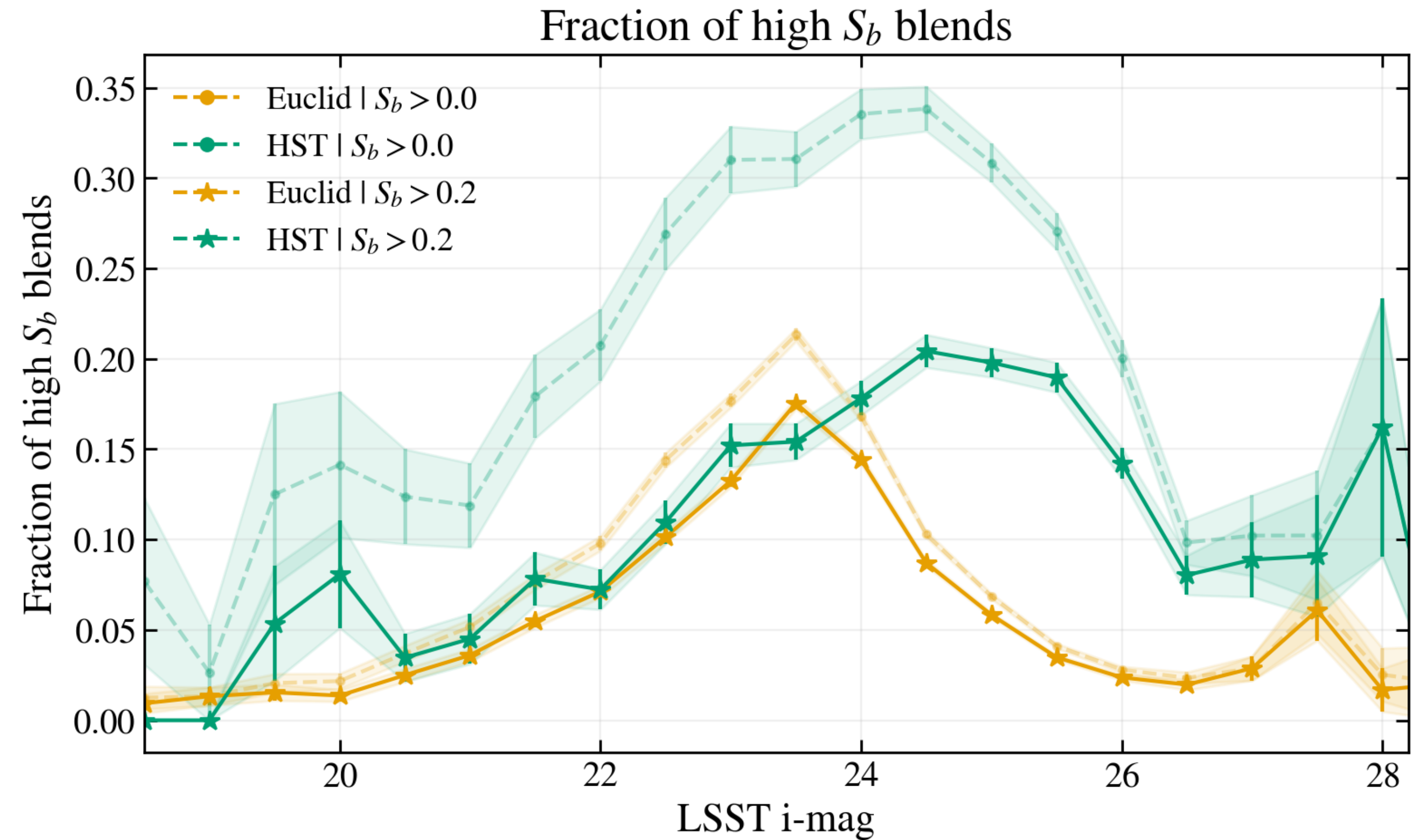


Fraction of high S_b blends

High S_b shows us the fraction of problematic blends

At $i\text{-mag} < 24$, good consistency between **HST** and **Euclid**

The problematic blends are **recognized** by both **Euclid** and **HST** for that range



Blendedness vs Blending Entropy

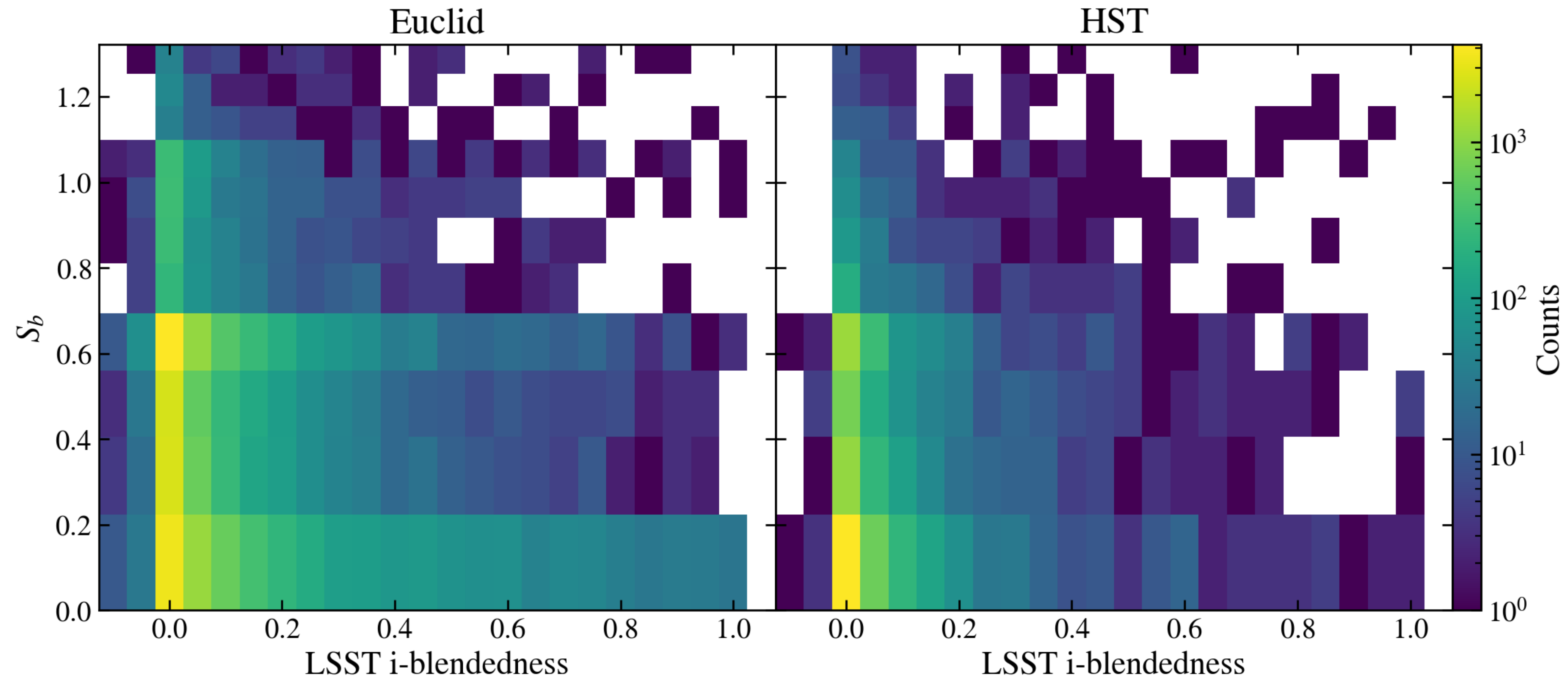
Blendedness measures the fraction of a detected object's flux that is contaminated by light from nearby sources.

- **Blendedness** : How contaminated is an object's measured light by nearby objects ?
- **Blending entropy (S_b)** : How ambiguous is the galaxy assignment for this detection ?

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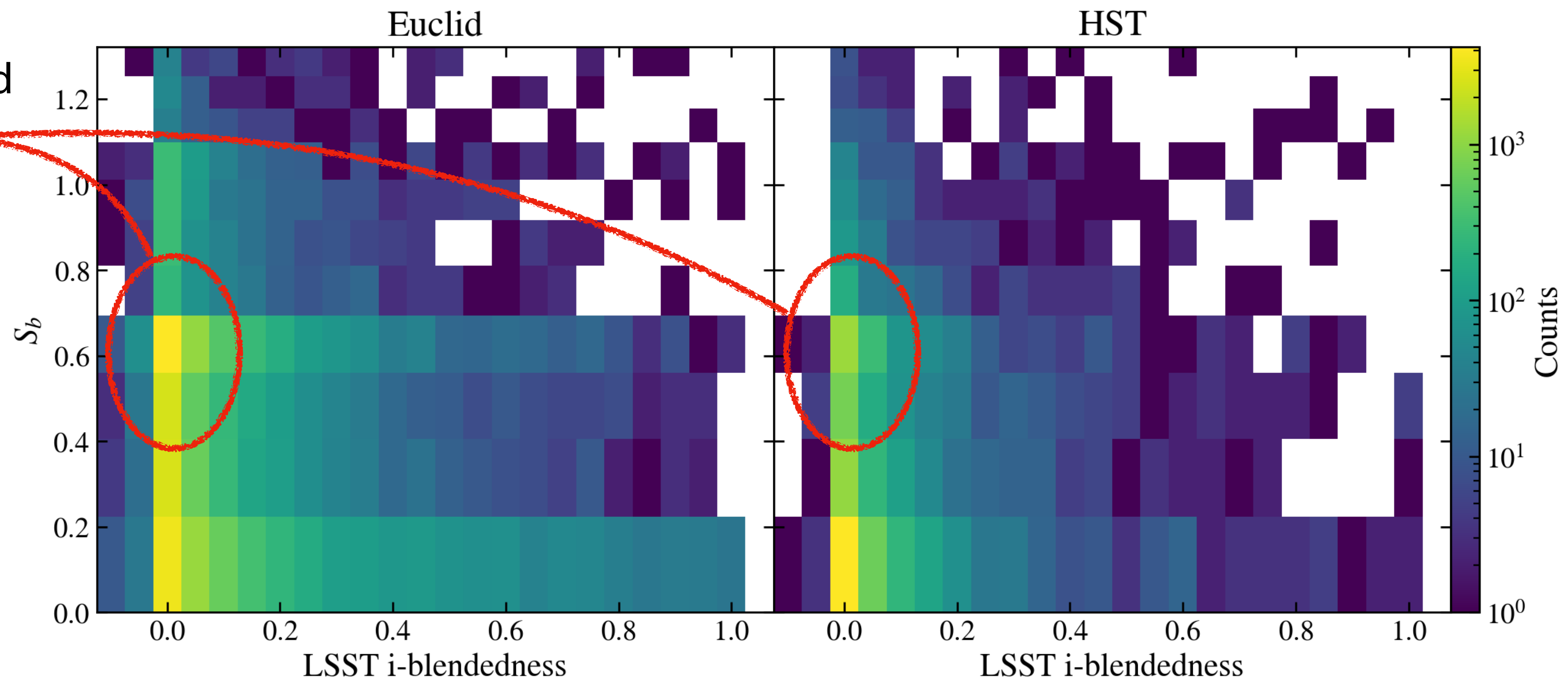


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Low blendedness/High S_b : photometry of the detected object is clean, but its *identity* is ambiguous.



Blendedness vs Blending Entropy

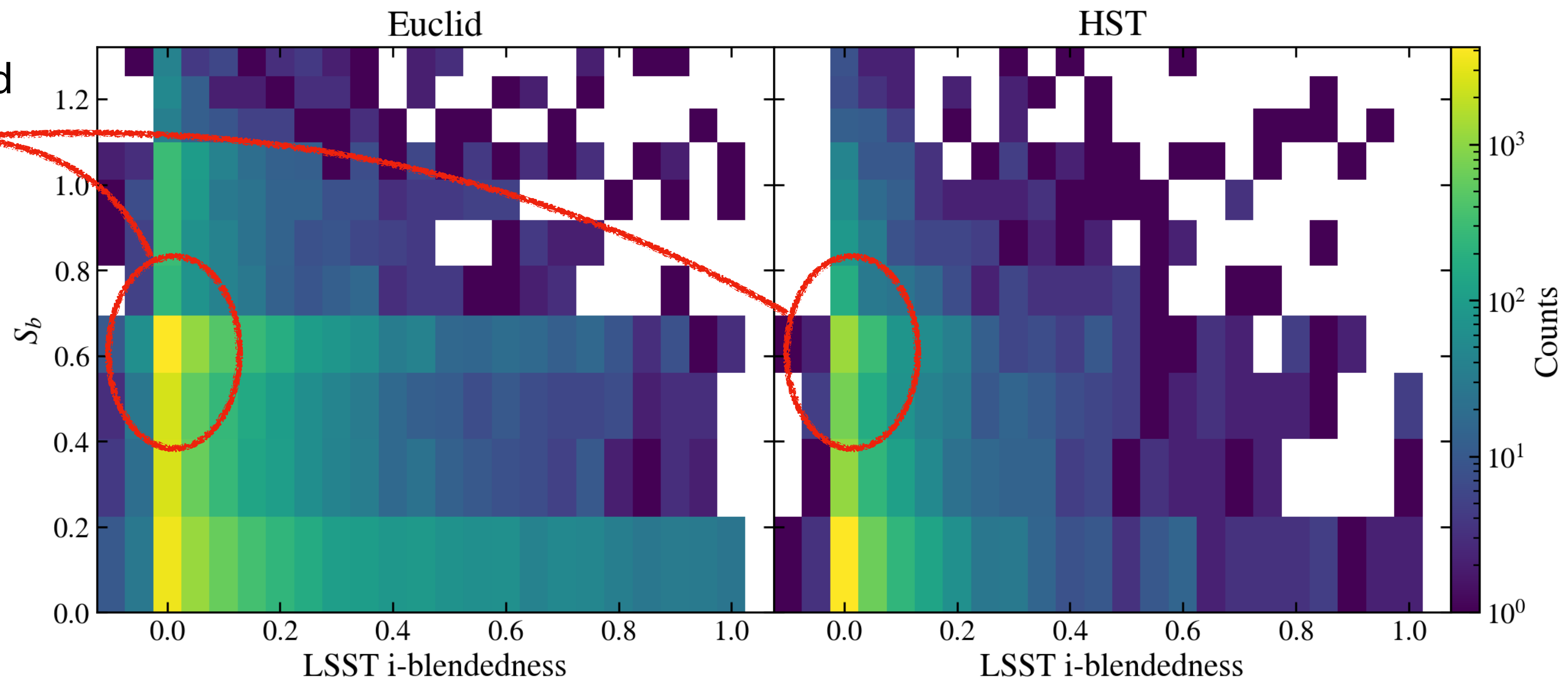
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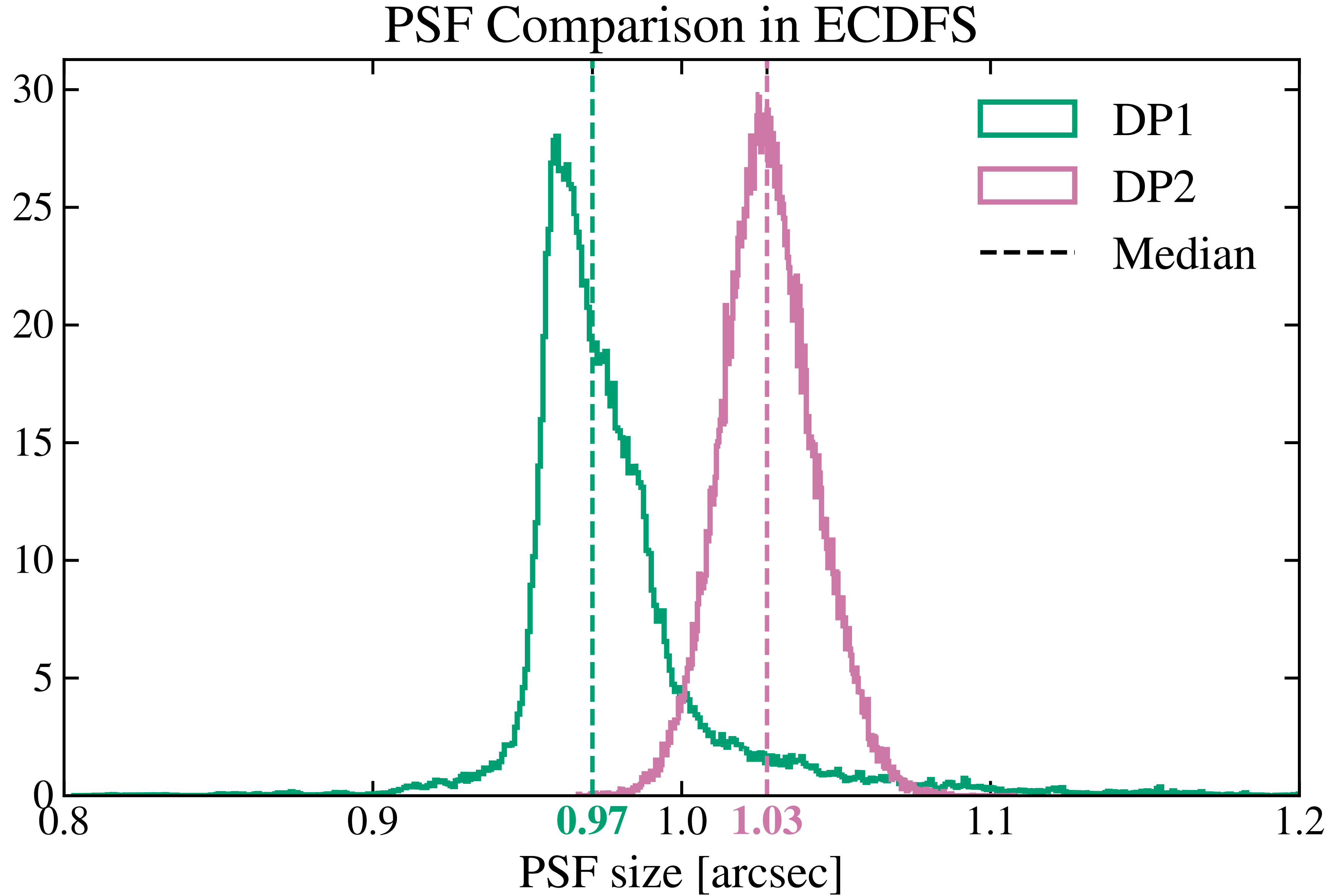
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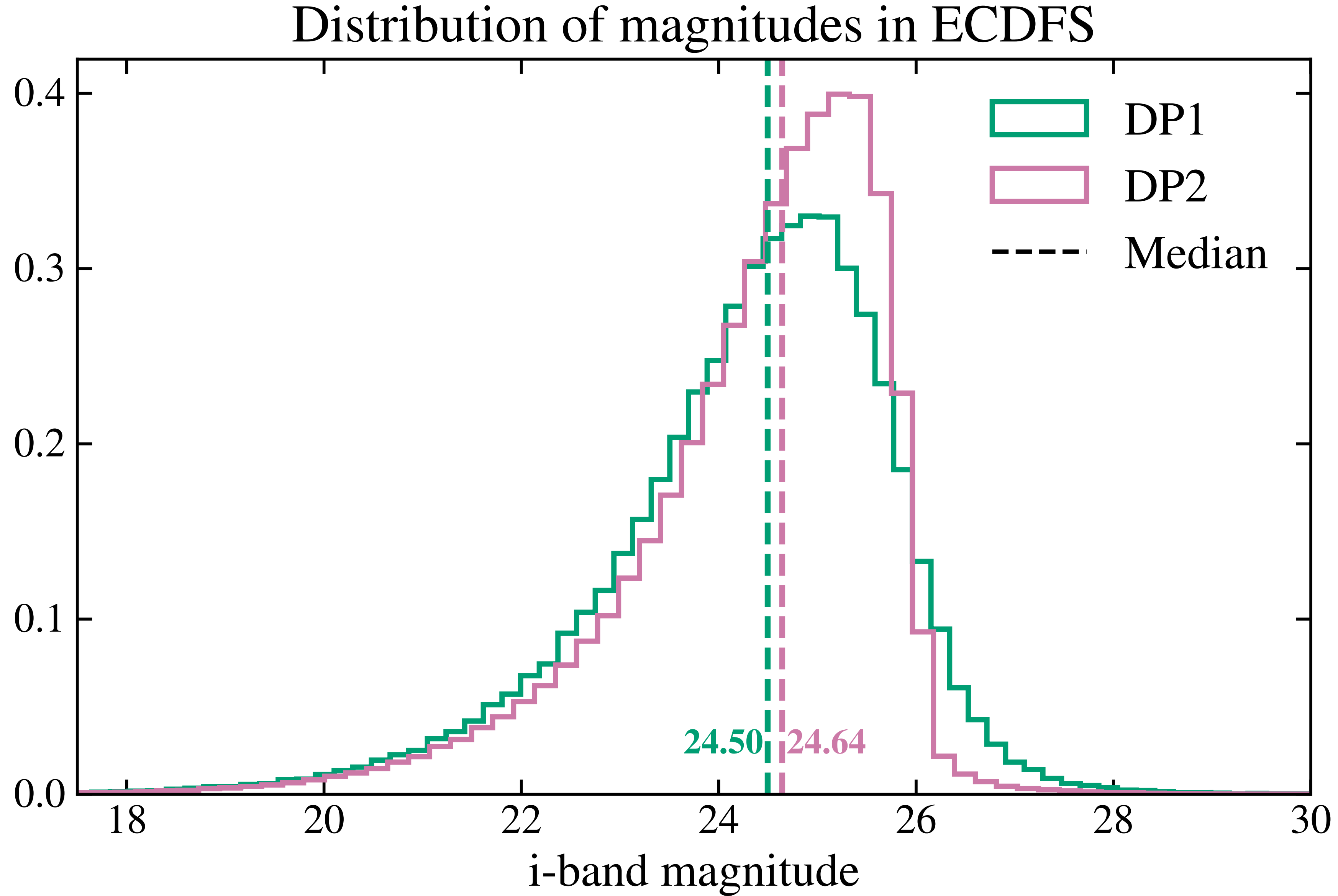
Low blendedness/High S_b : photometry of the detected object is clean, but its *identity* is ambiguous.

Blendedness alone is not sufficient to fully characterize blended objects.

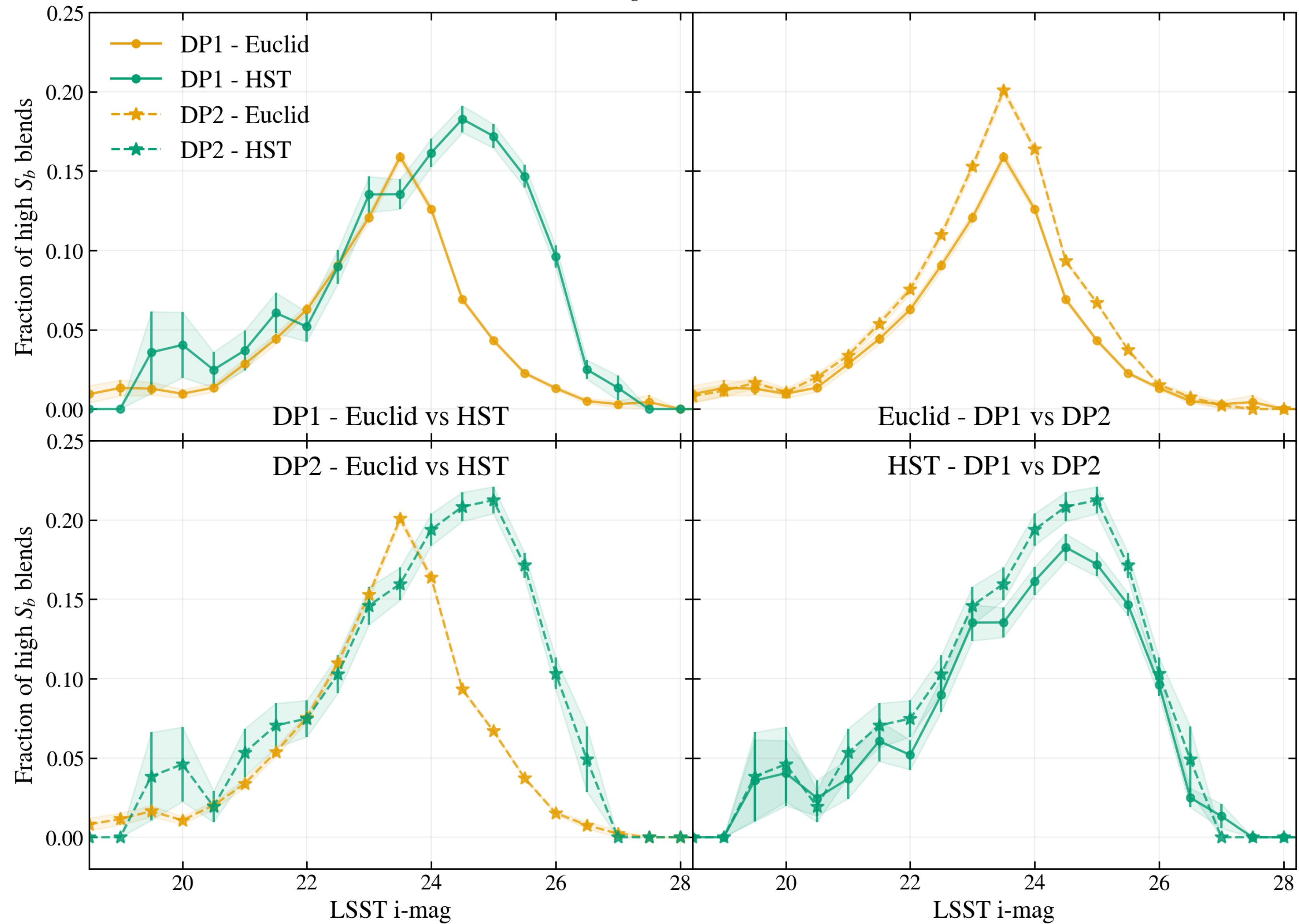
We can enhance catalogs with blending entropy.







Fraction of blends with $S_b > 0.2$ and i-blendedness < 0.1



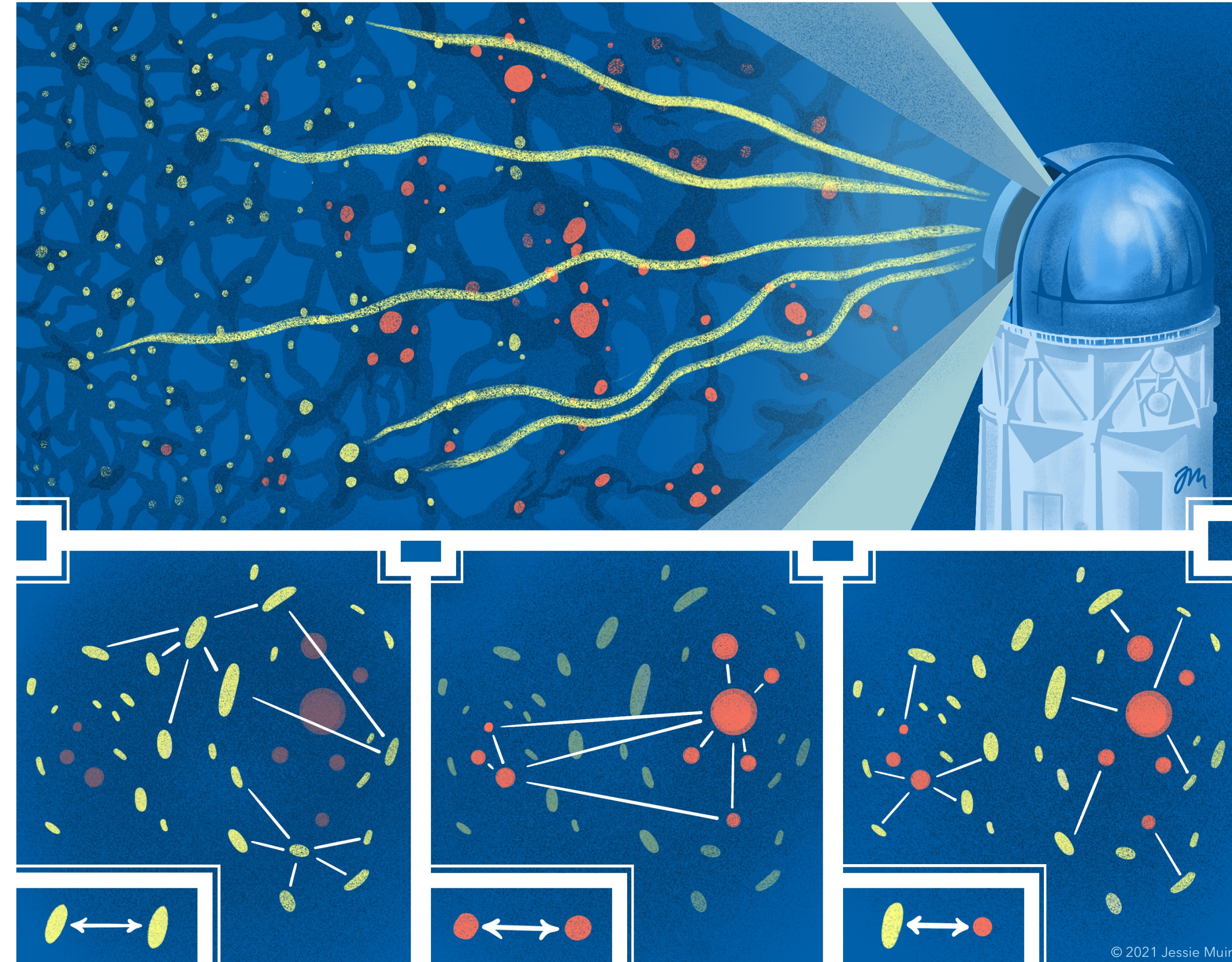
Impact of blending on 3x2pt cosmology

3x2pt :

- Shear-shear ;
- Density-density ;
- Shear-density.

How does blending contaminate every step of the 3x2pt cosmological analysis pipeline, from the $n(z)$ to the cosmological parameters ?

Use of DESC DC2 simulations and DESC tools (GCRCatalogs, treecorr, TXPipe...)



© 2021 Jessie Muir

Credit : Jessie Muir

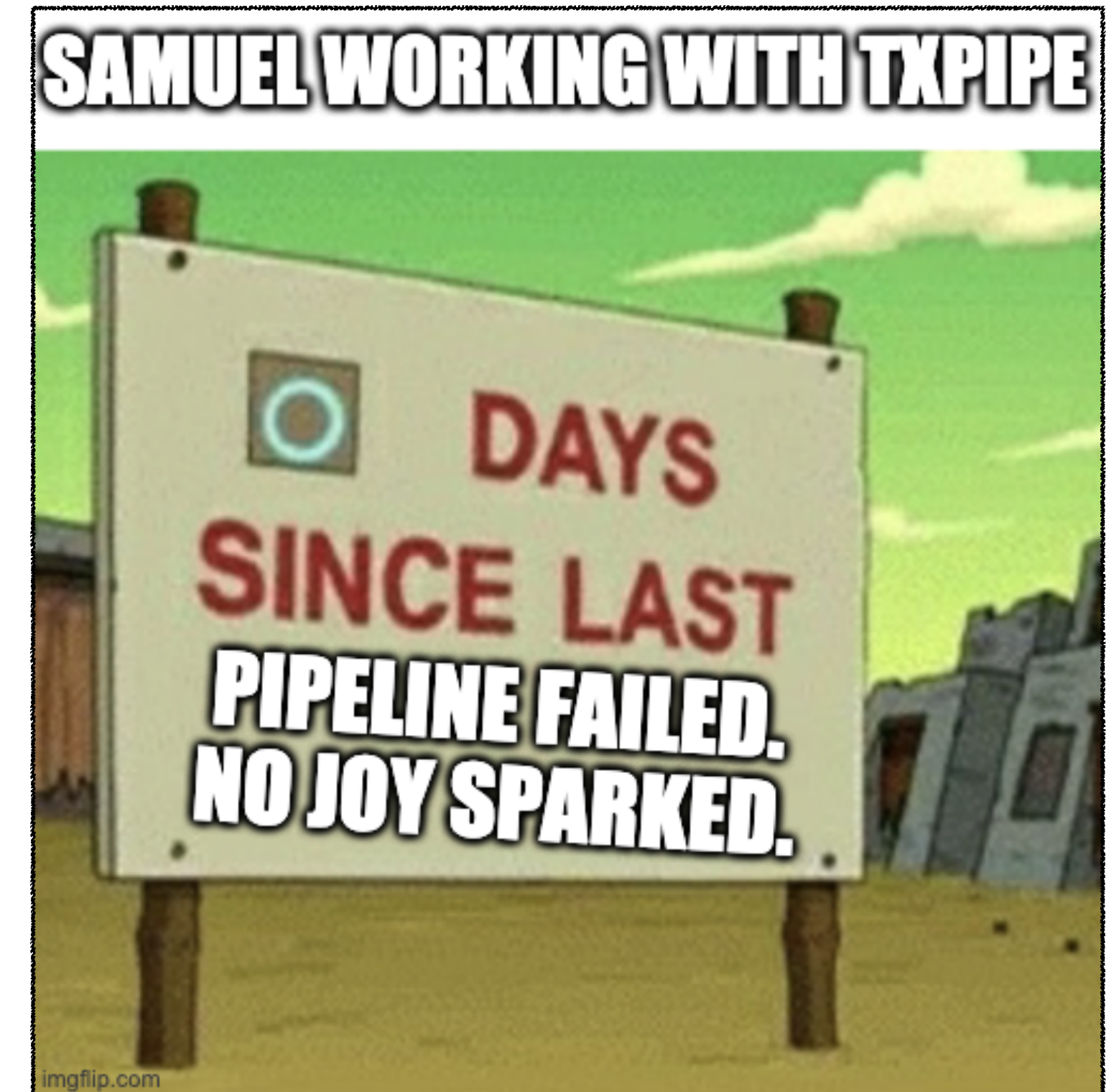
Conclusions

Characterizing blending in LSST DP1 :

- We have up to 20% of problematic blends at i-mag ~ 24 . 1/5 of the galaxies we observe at this magnitude actually hide at least another one !
- The blending entropy allows us to quantify how much a blend is problematic and allows us to enhance catalogs.

Impact of blending in multi-probe analysis :

- Blending propagation in the 3x2pt cosmological analysis using the novel blending entropy metric.
- Use of the blending entropy to justify removing potentially blended objects (which introduce errors) but losing statistical power.



Survey field

Extended Chandra Deep Field South (ECDFS)

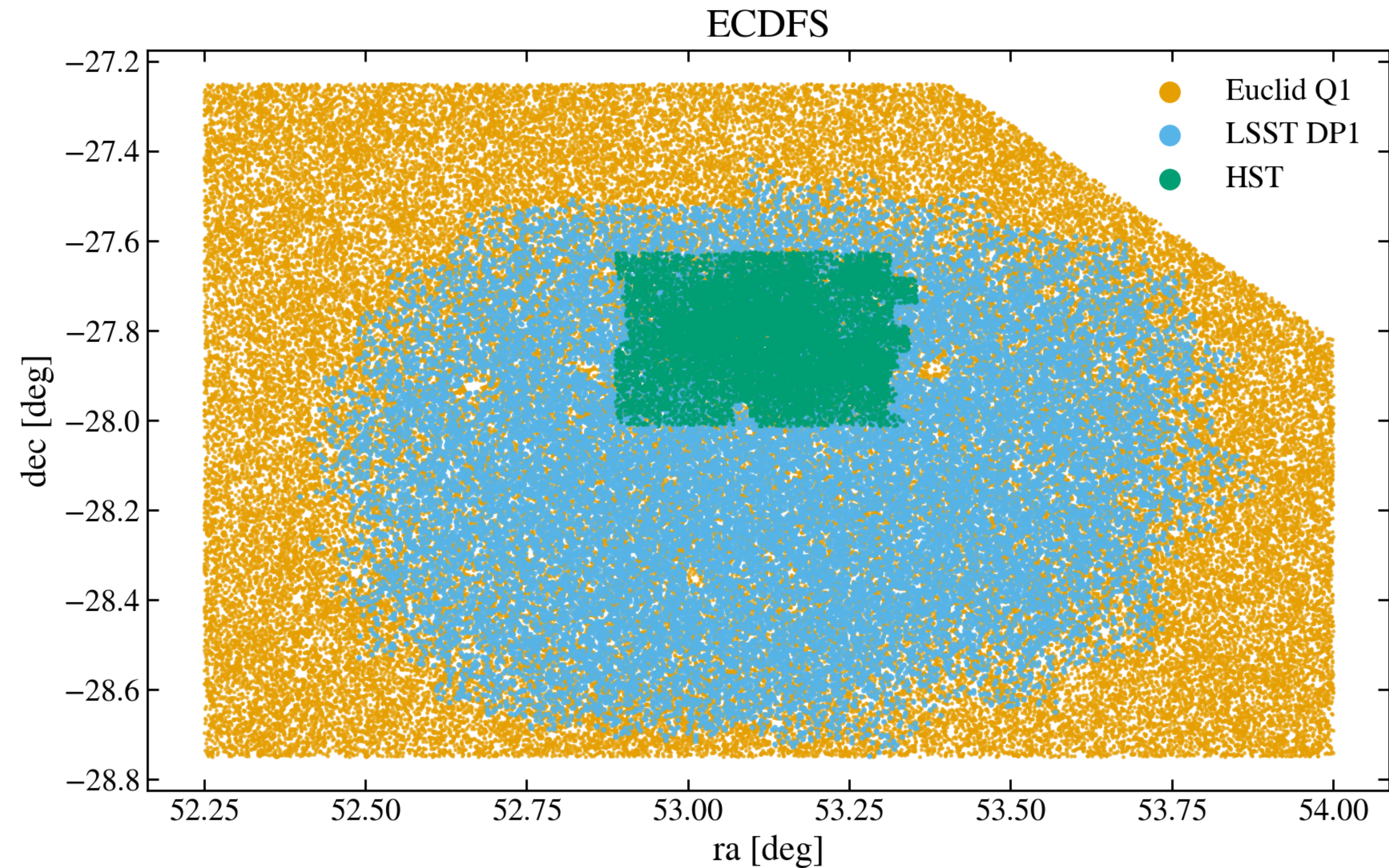
LSST DP1 : 236,559 galaxies

Euclid Q1 (in **LSST** footprint) : 555,108 galaxies

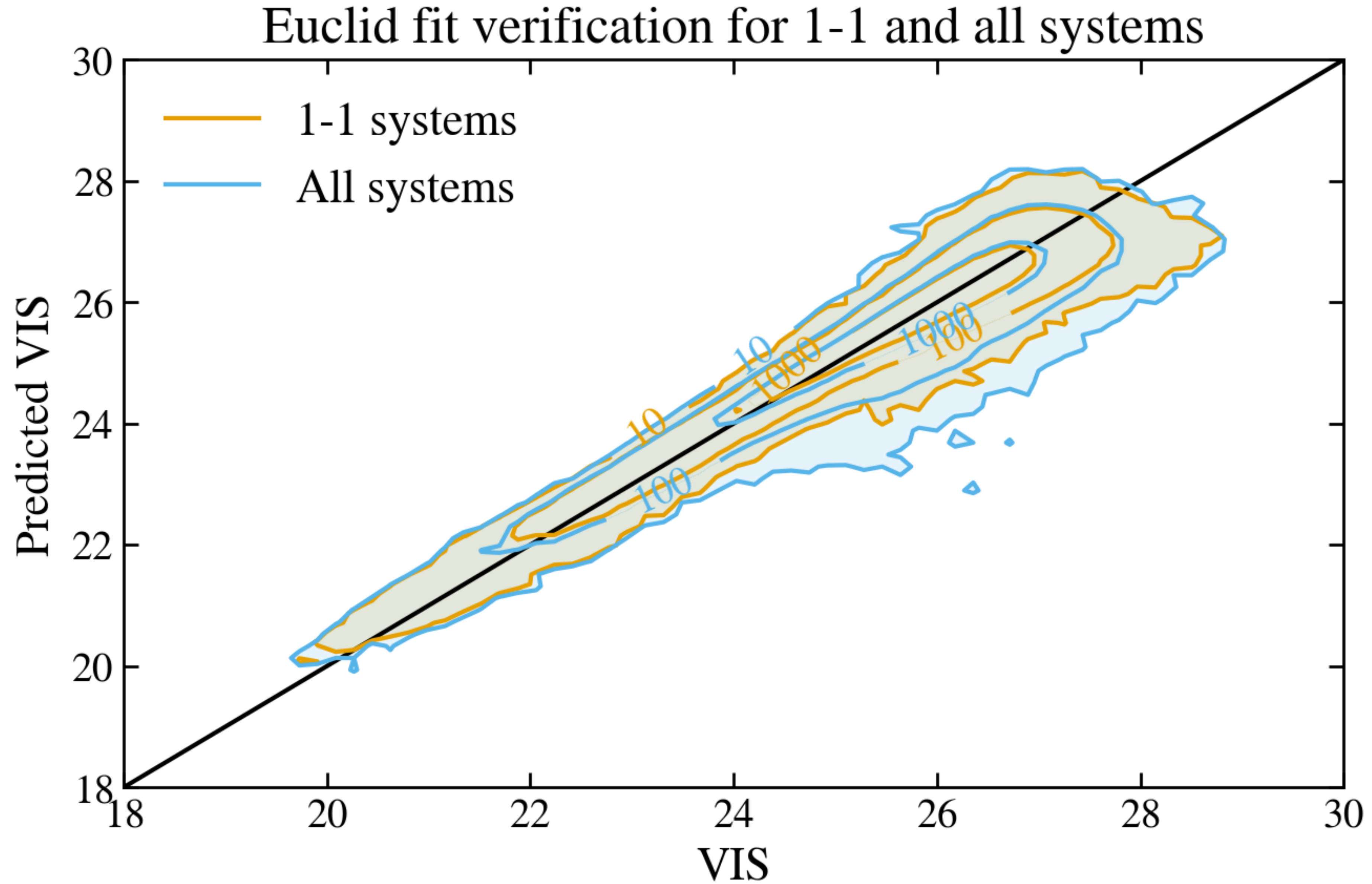
HST : 165,776 galaxies

LSST DP1 (in **HST** footprint) : 38,769 galaxies

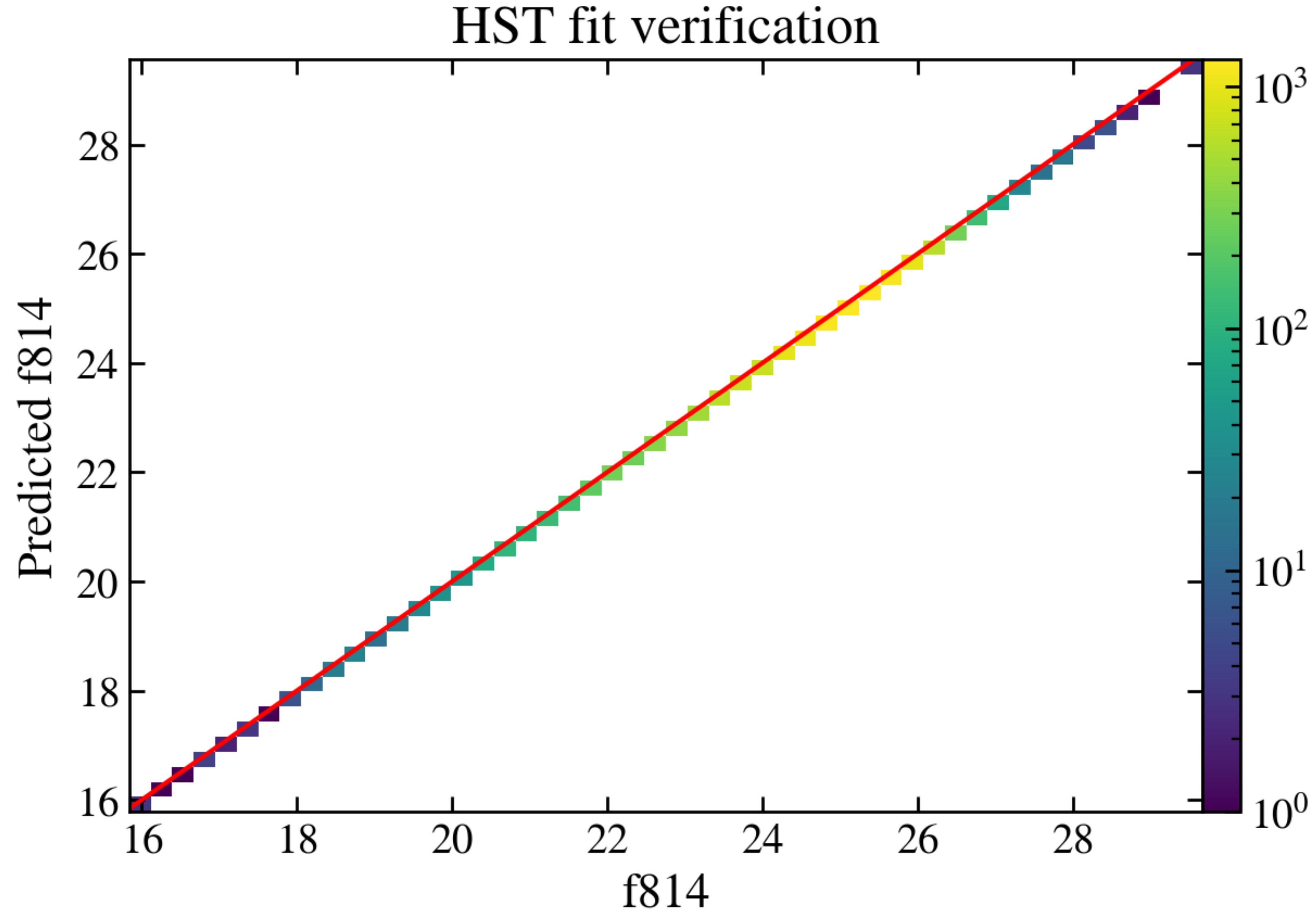
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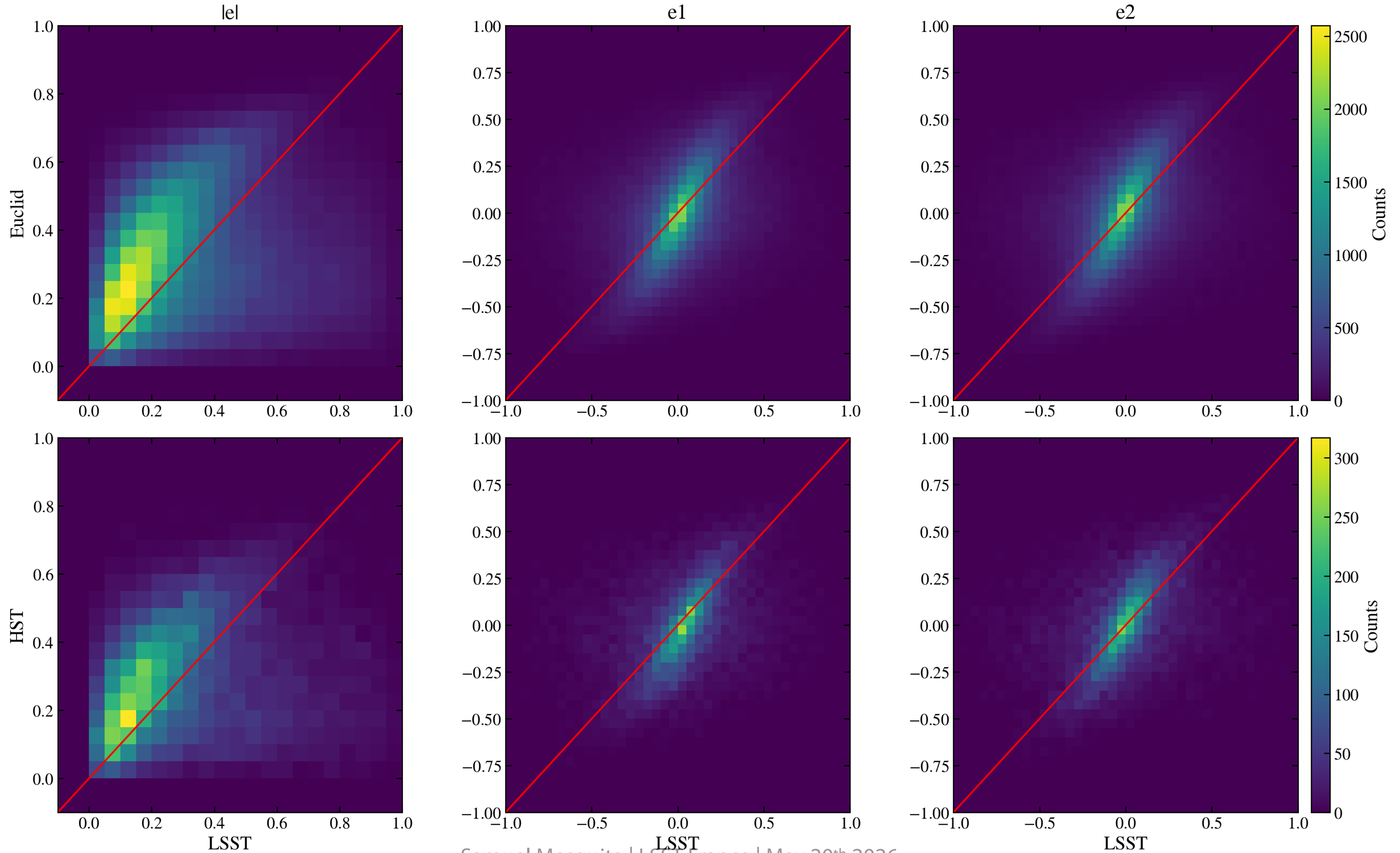
Appendix - Some tests



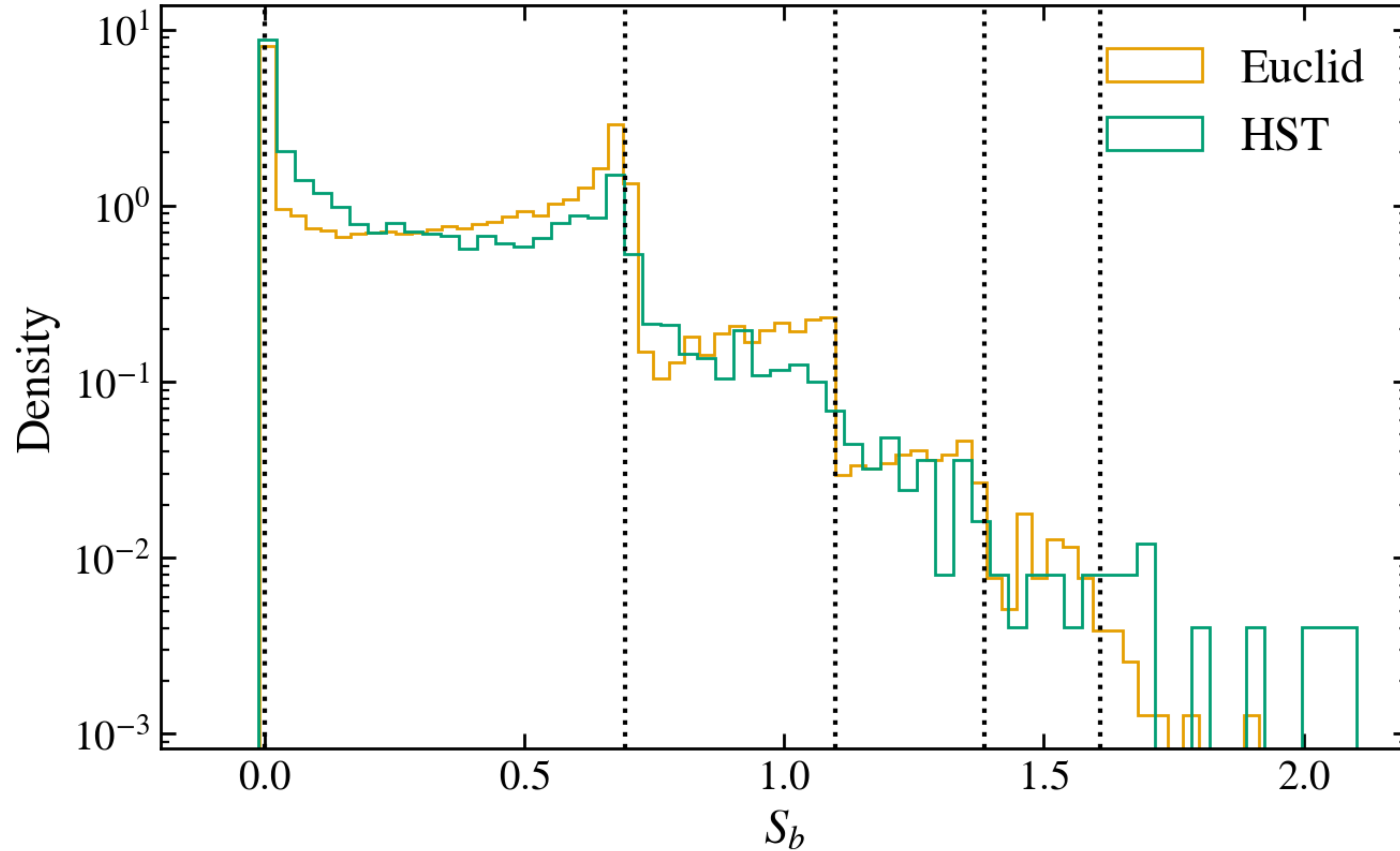
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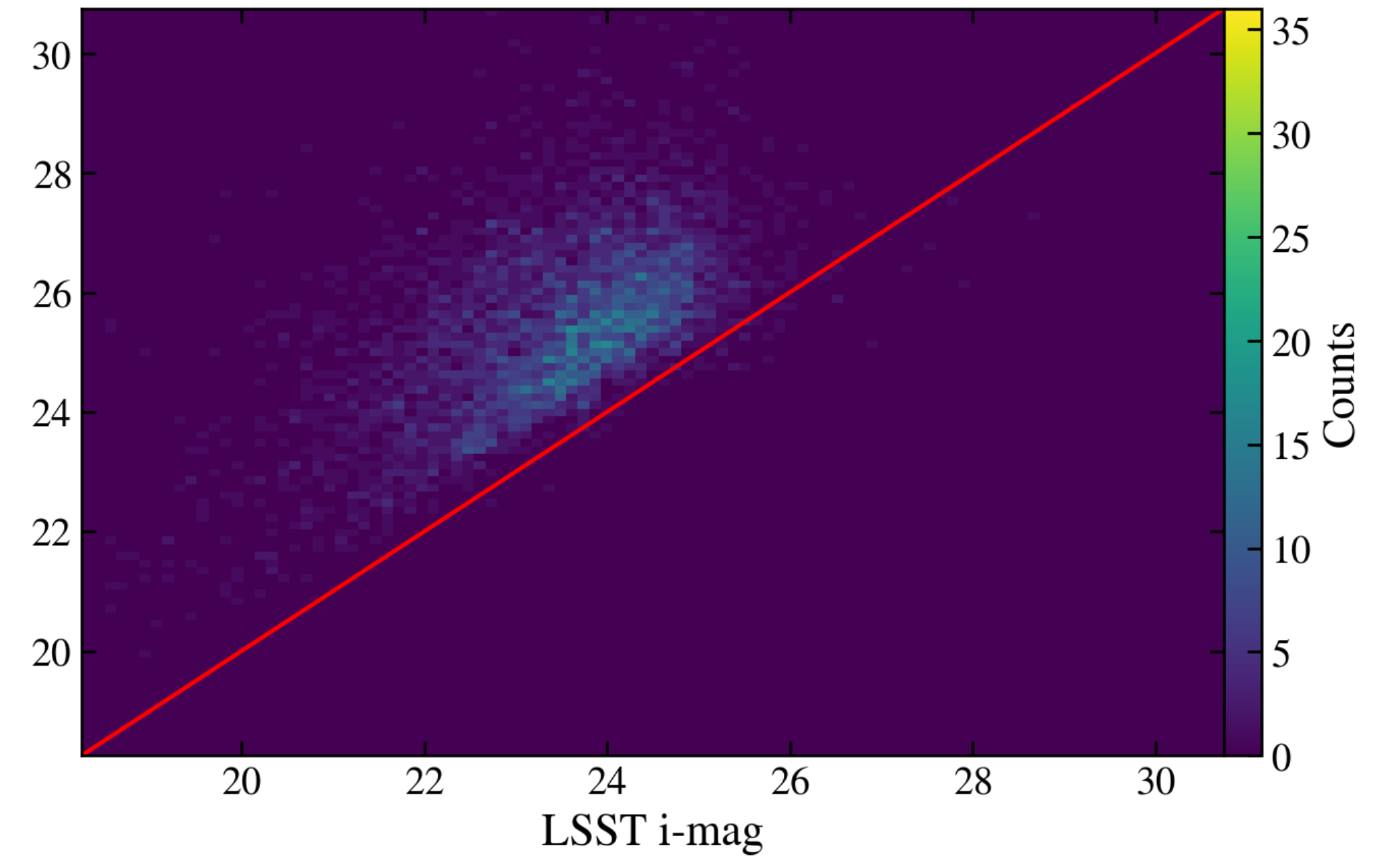
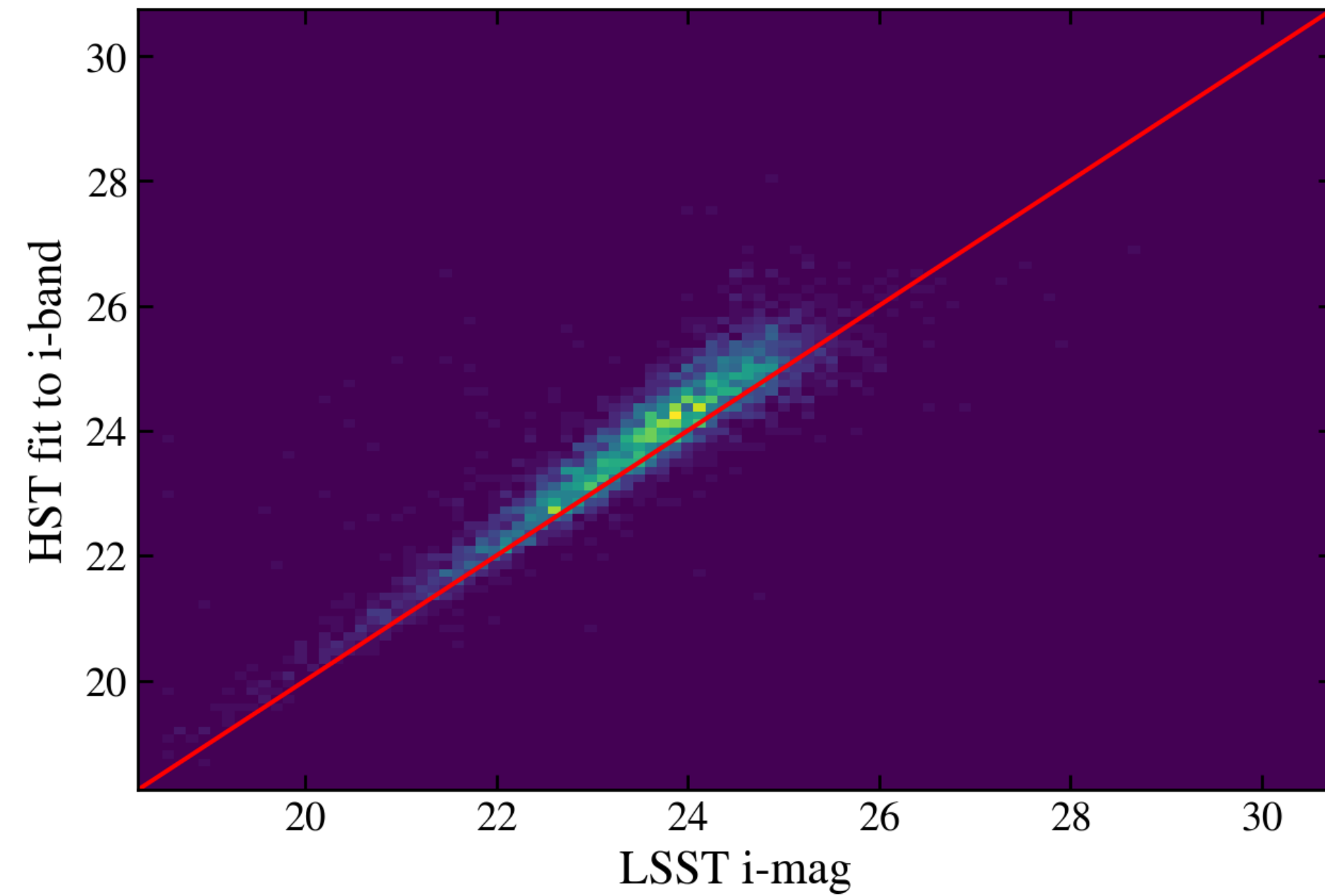
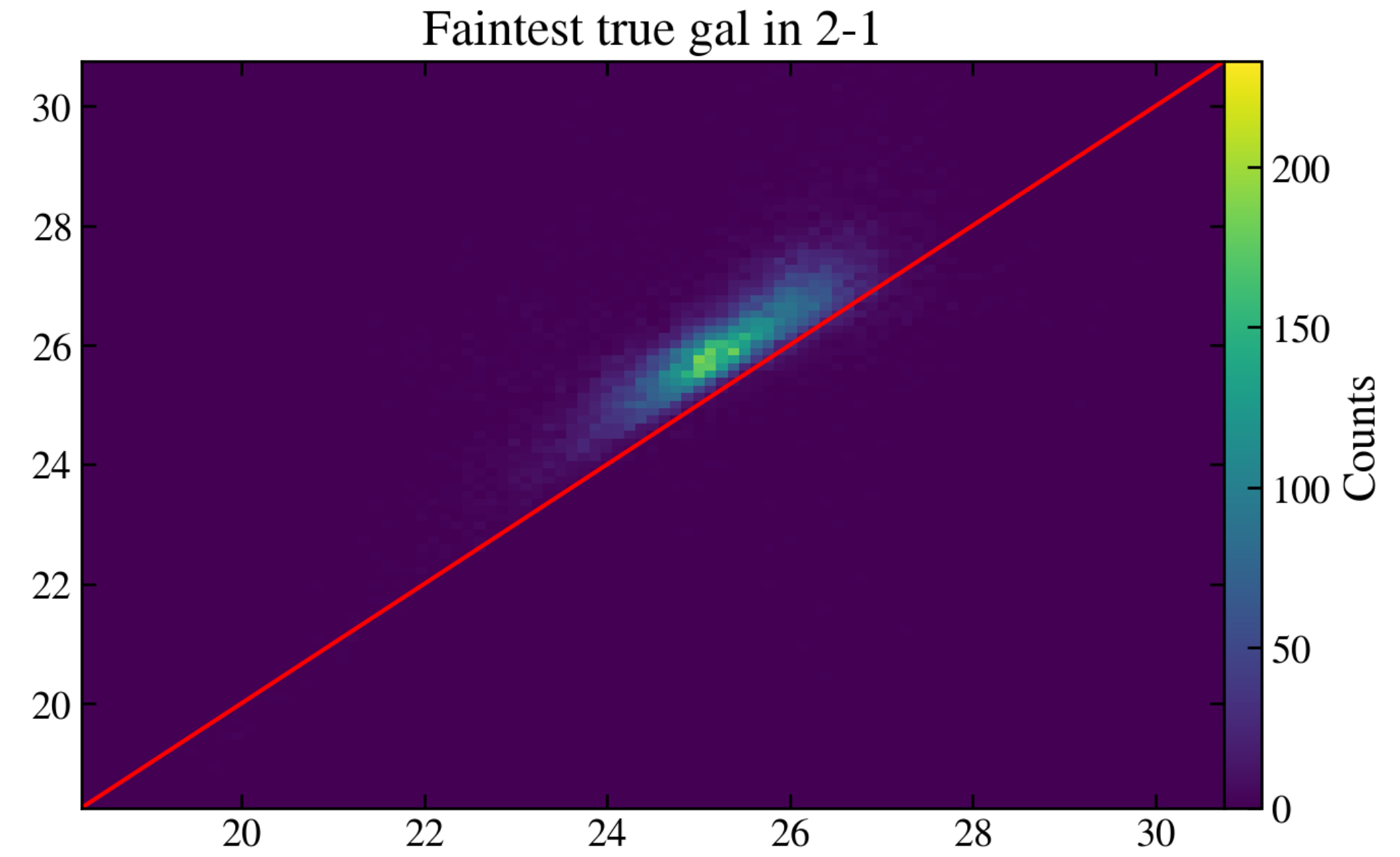
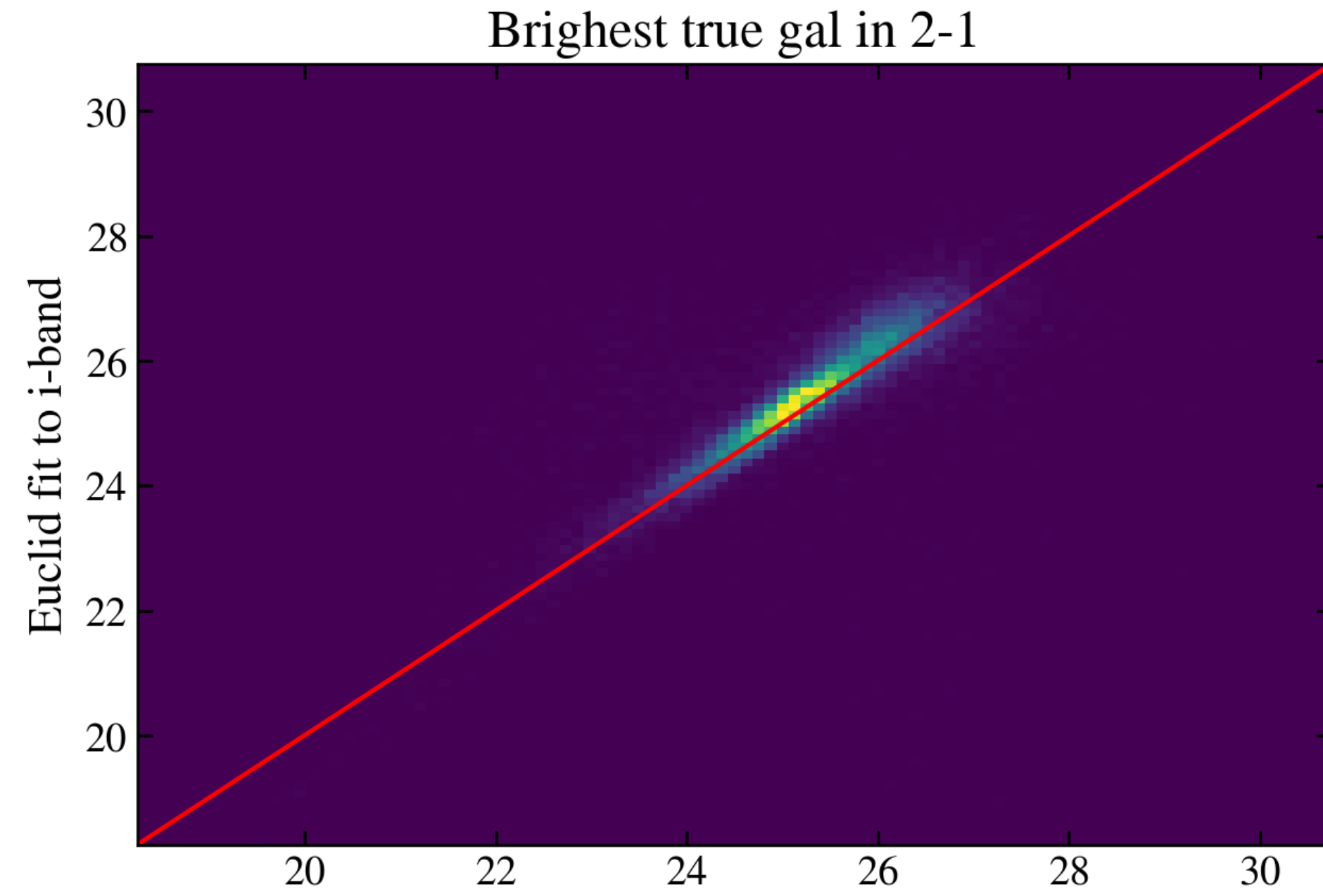
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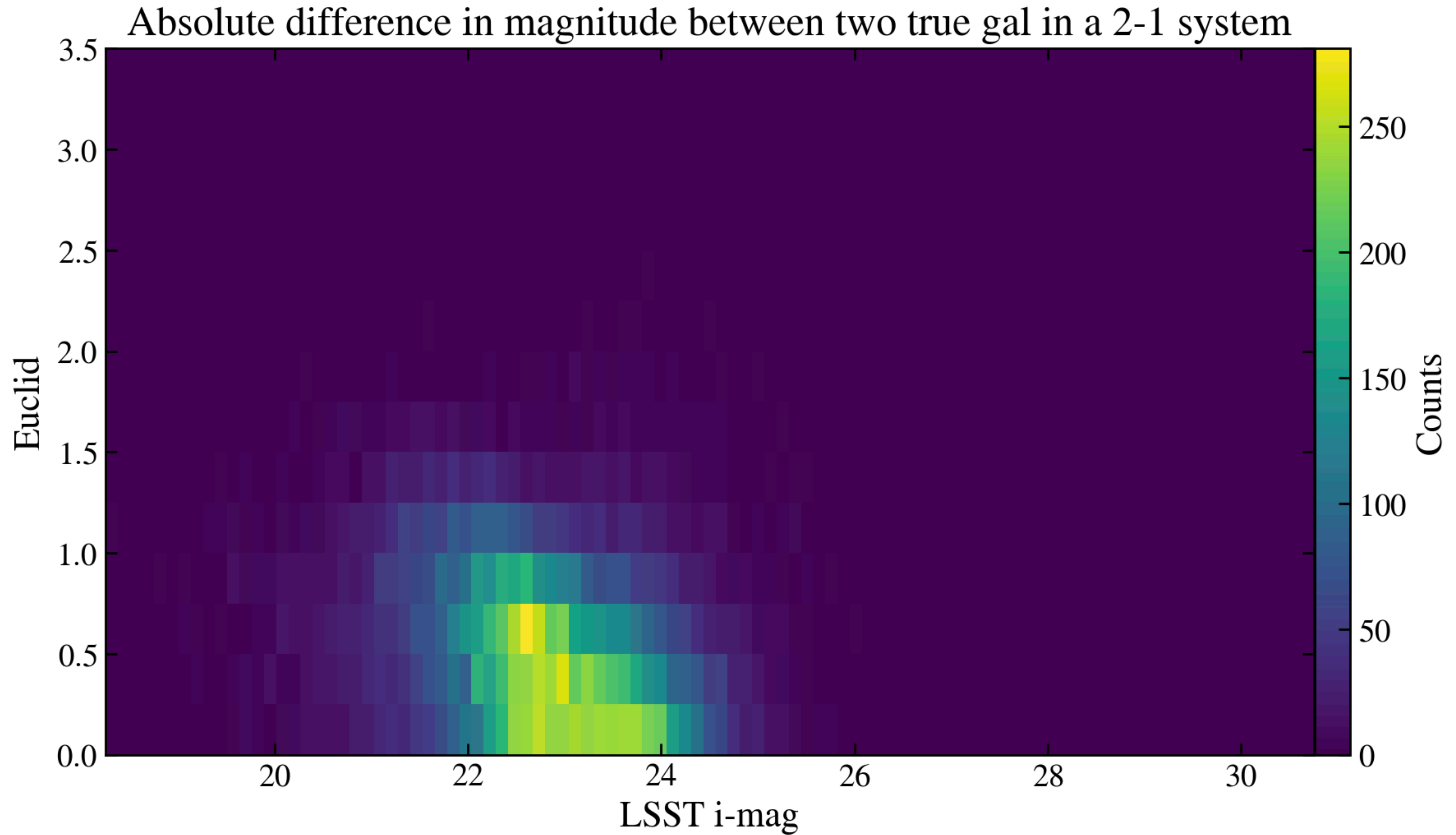
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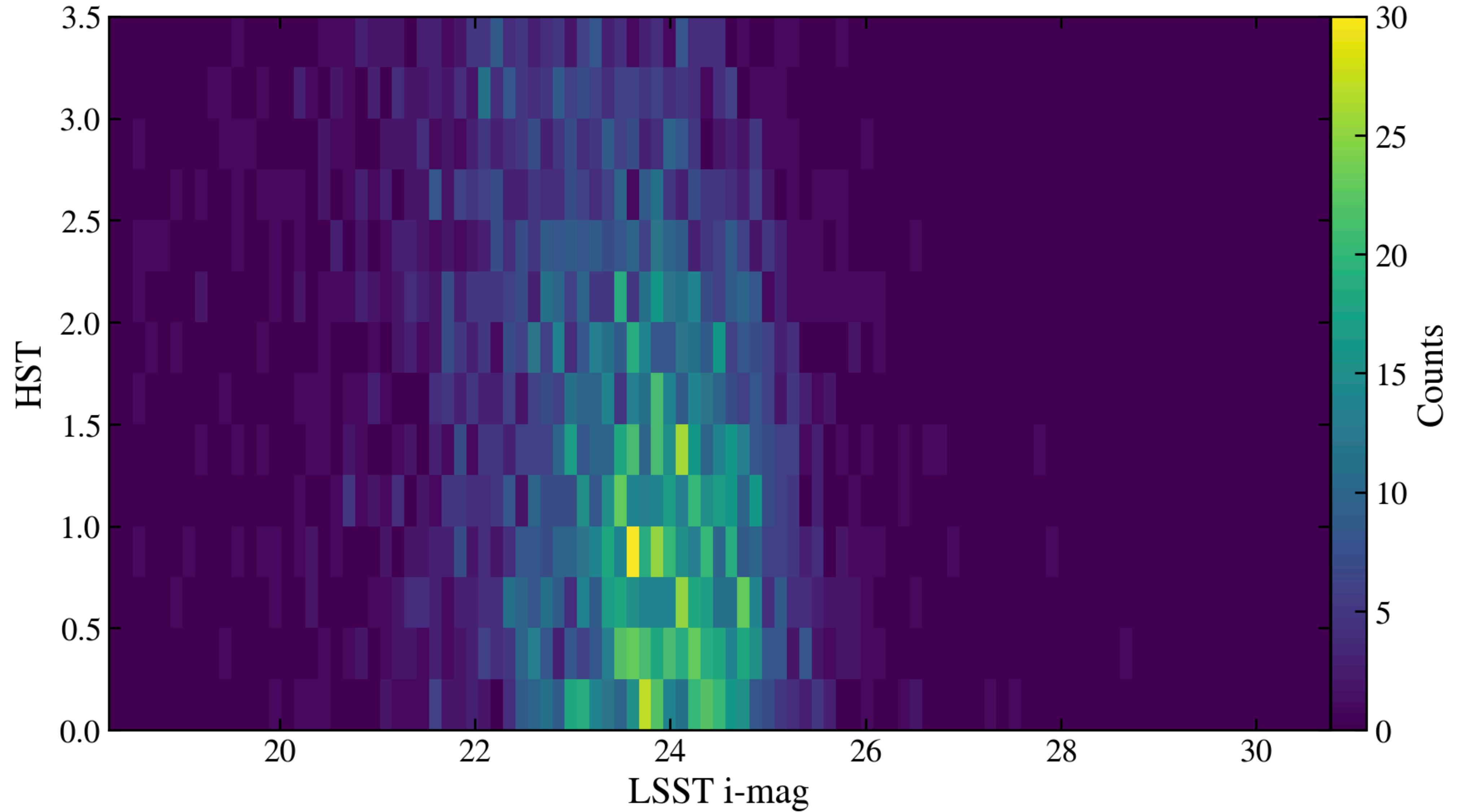
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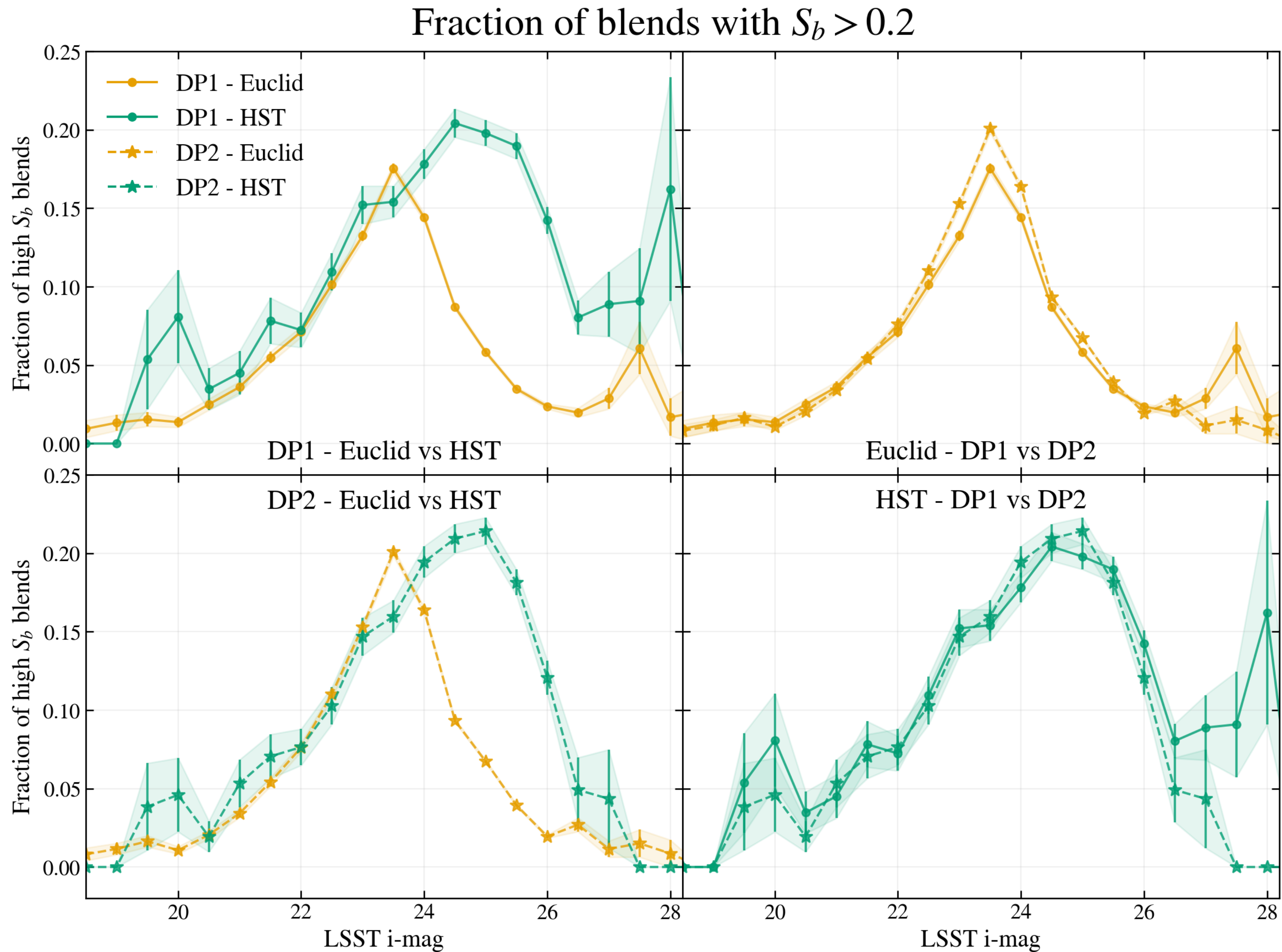
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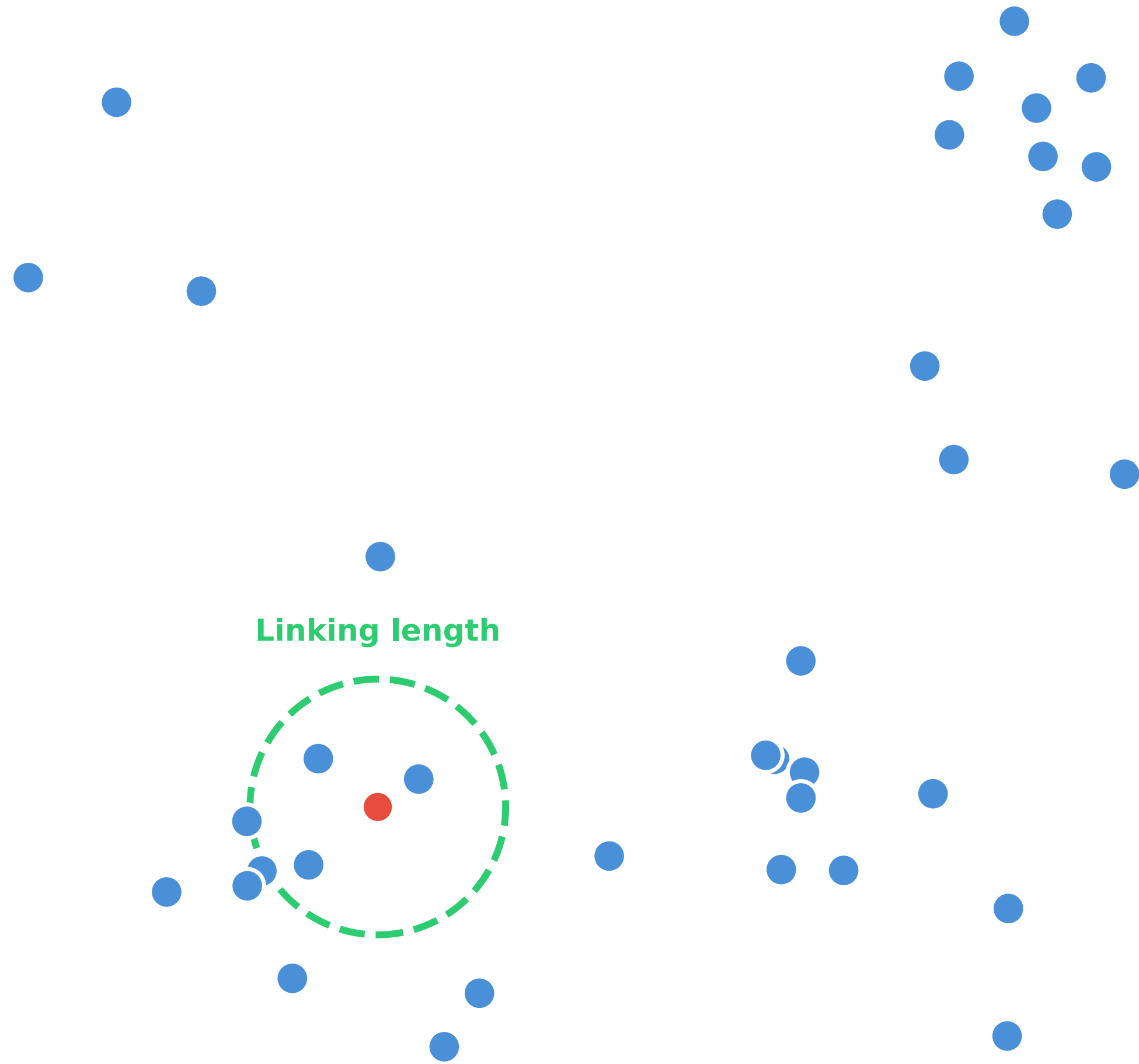


How does it compare with DP2 ?



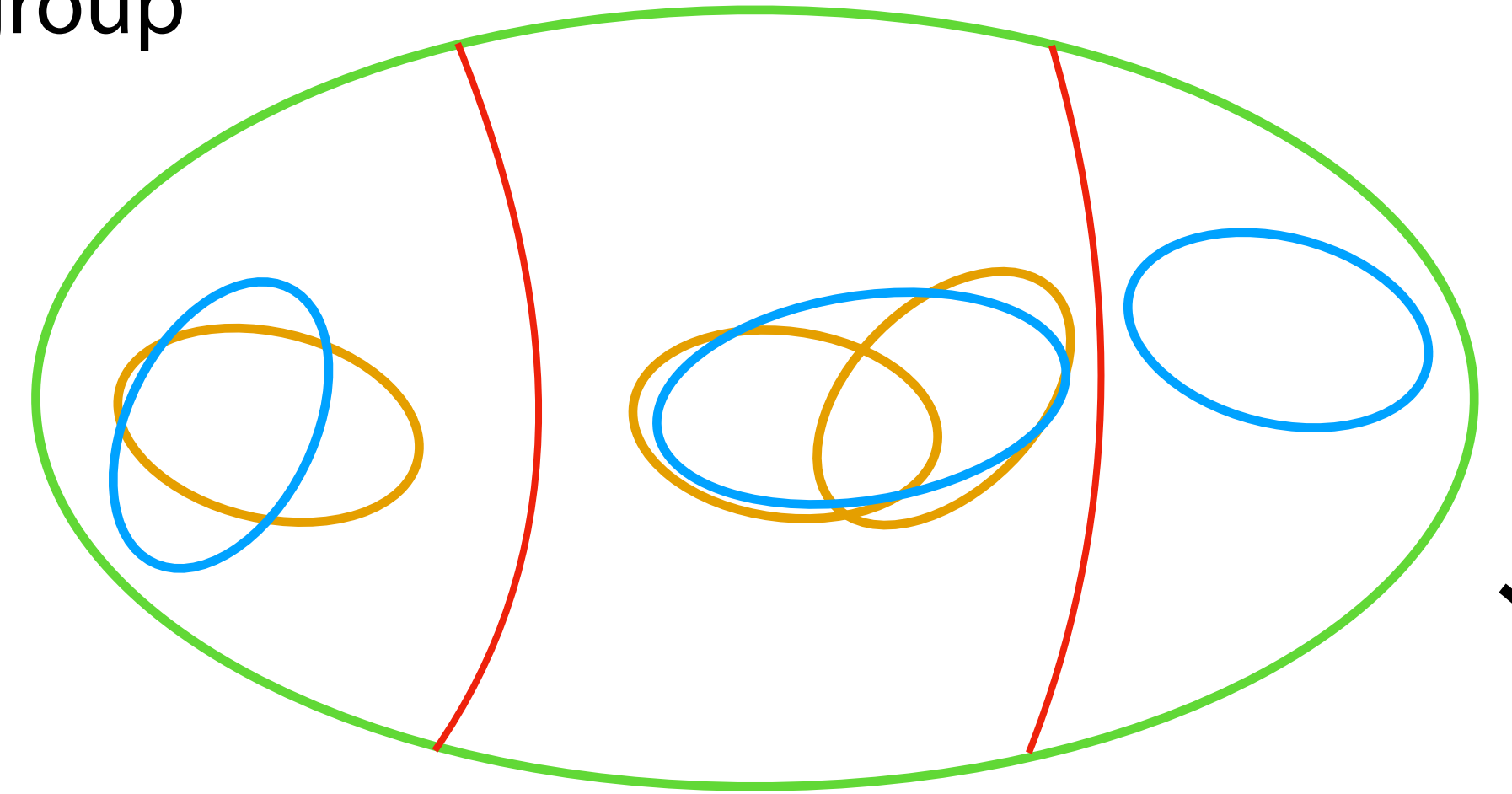
Appendix - Matching catalogs

Friends of Friends (FoF)

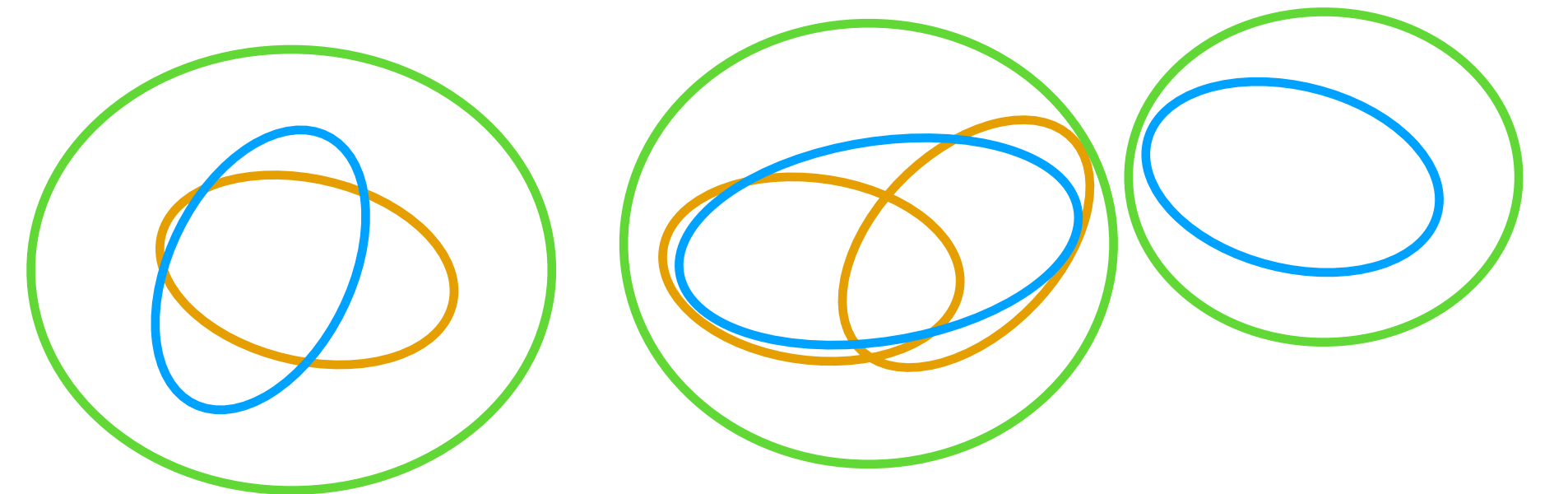


Ellipse Overlap Test (EOT)

1 FoF group

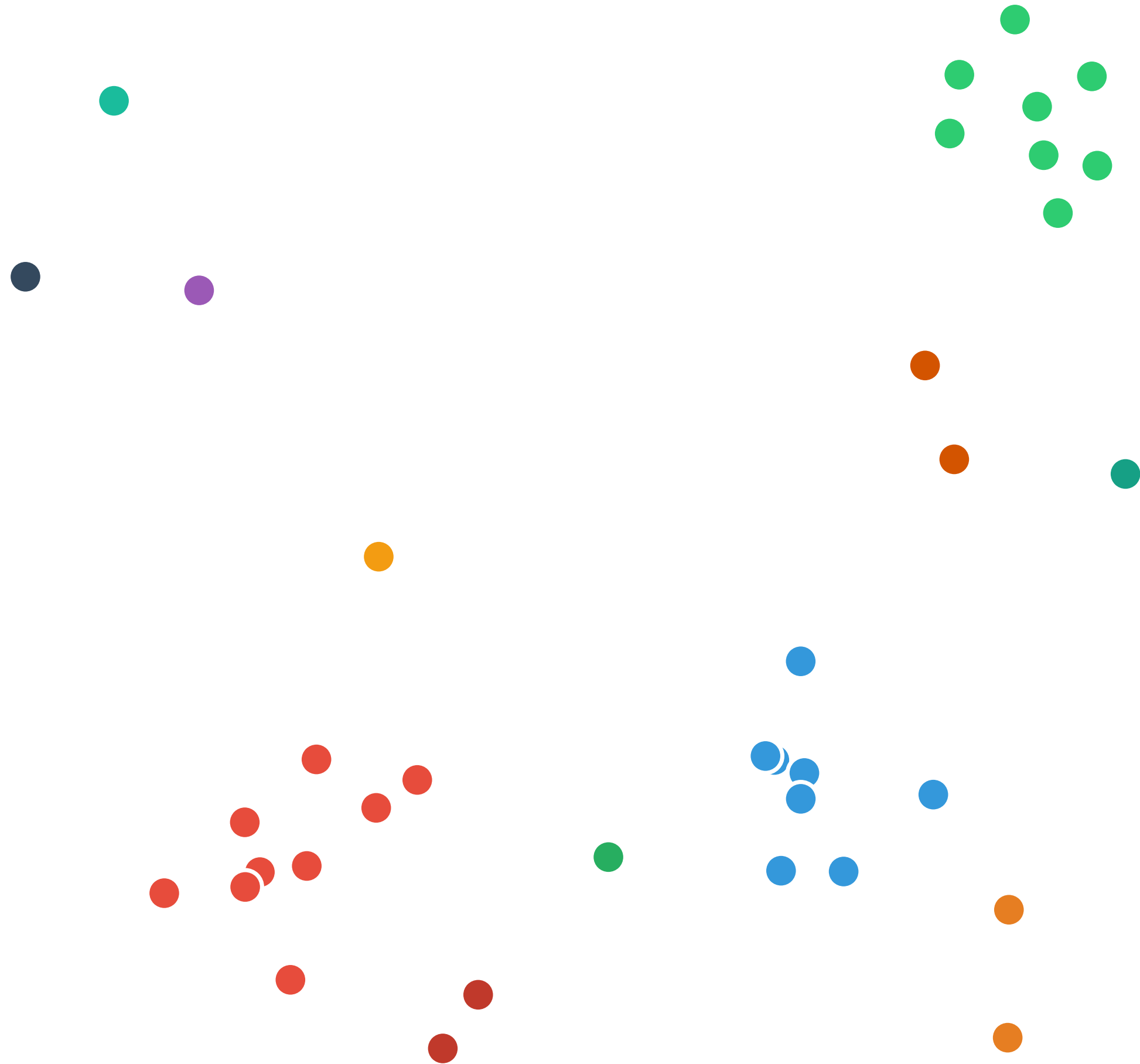


3 FoF+EOT groups



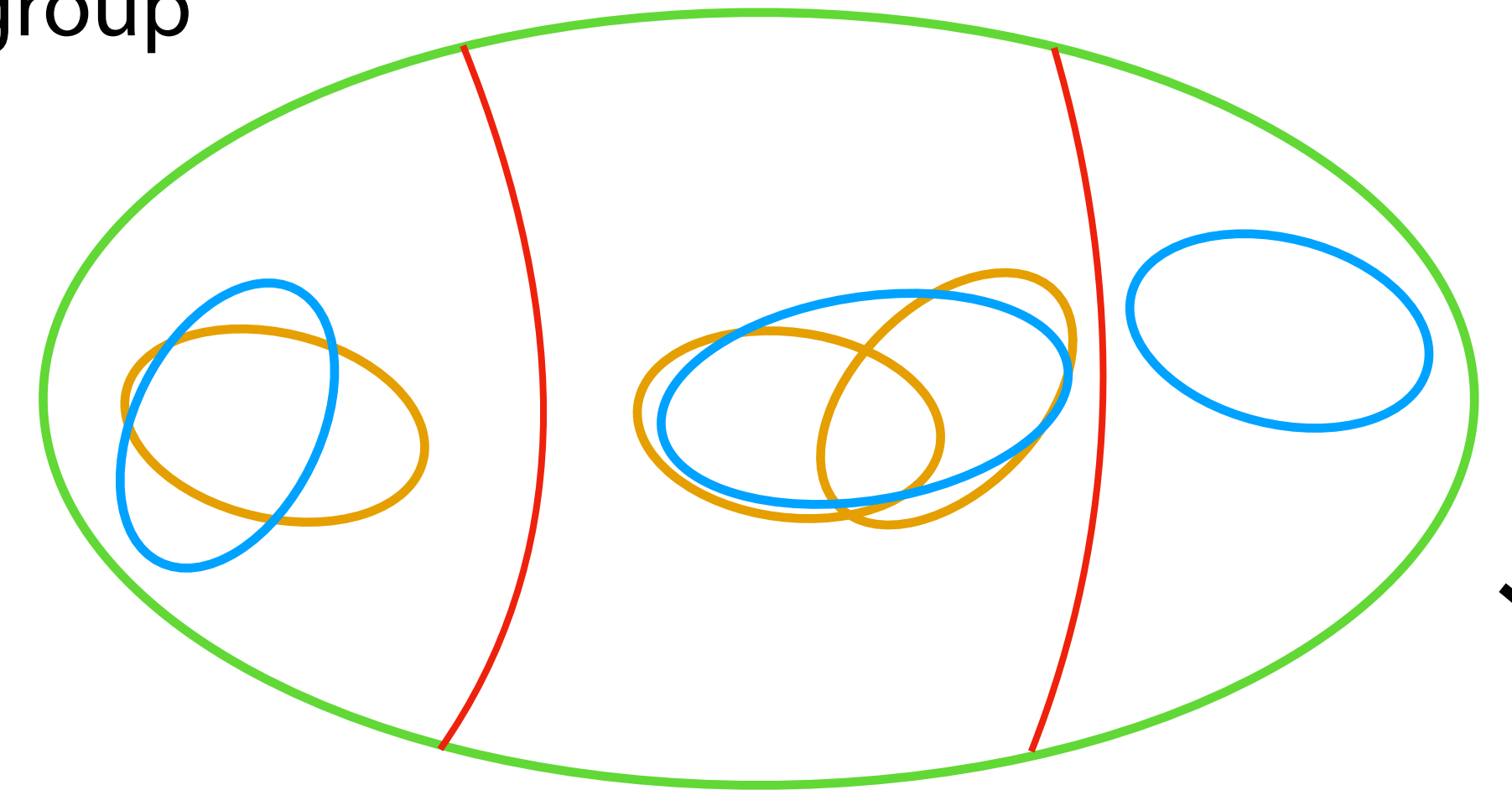
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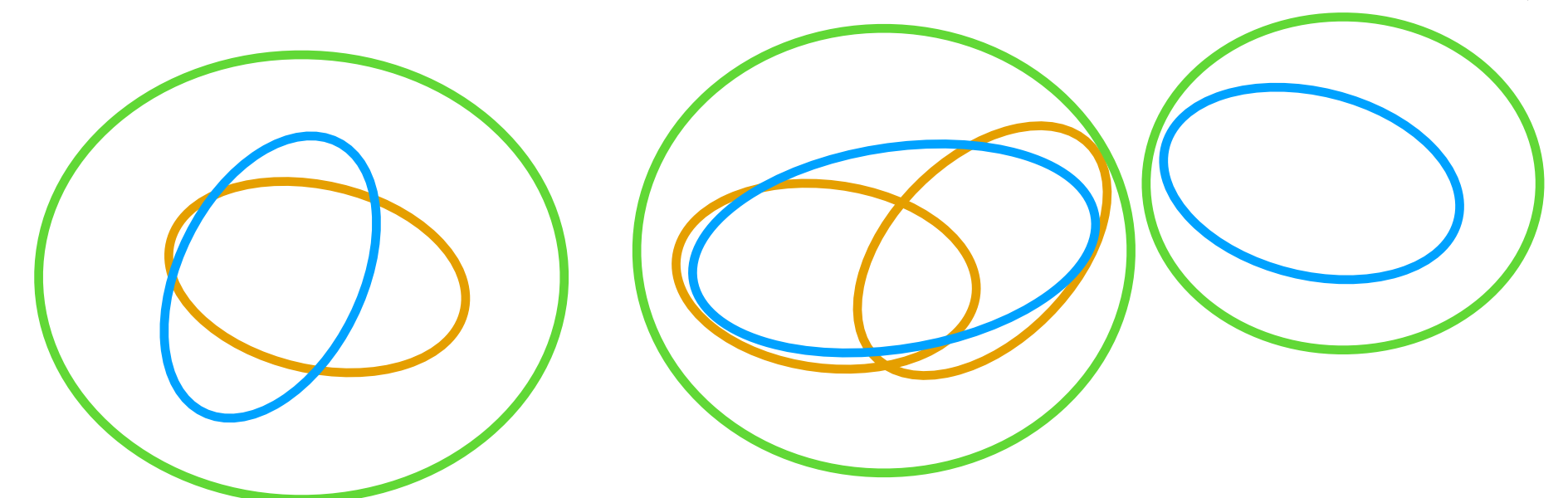


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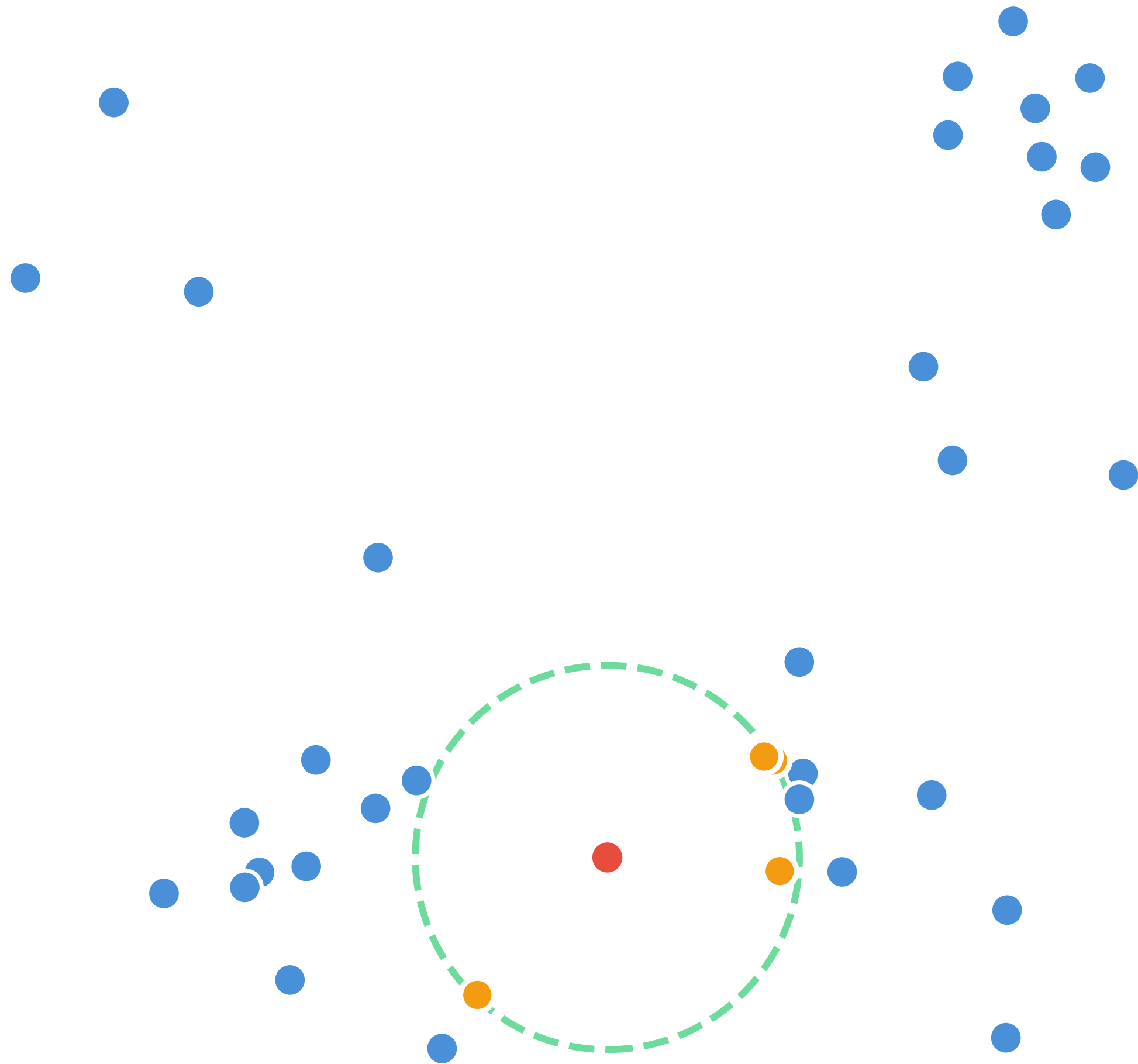
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Final groups attribution is very dependant on the linking length !

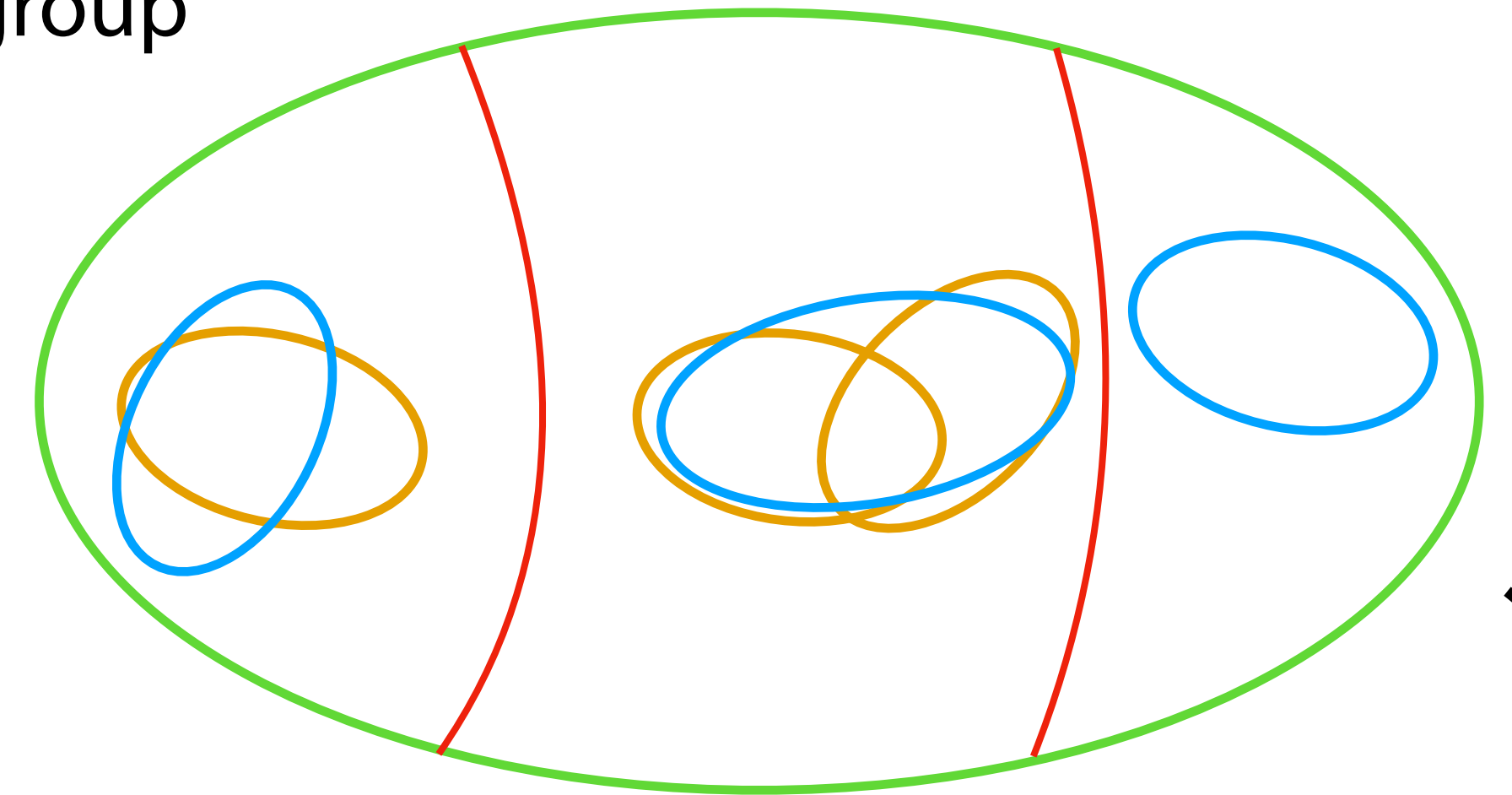
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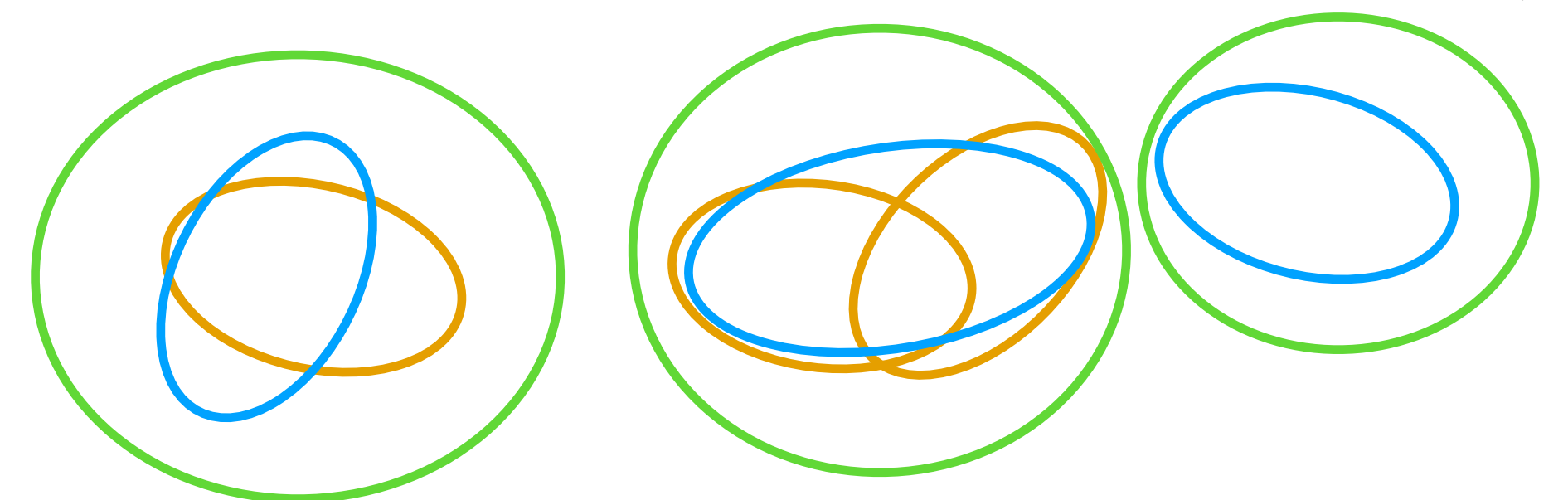


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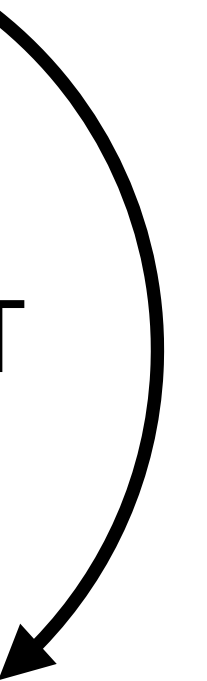
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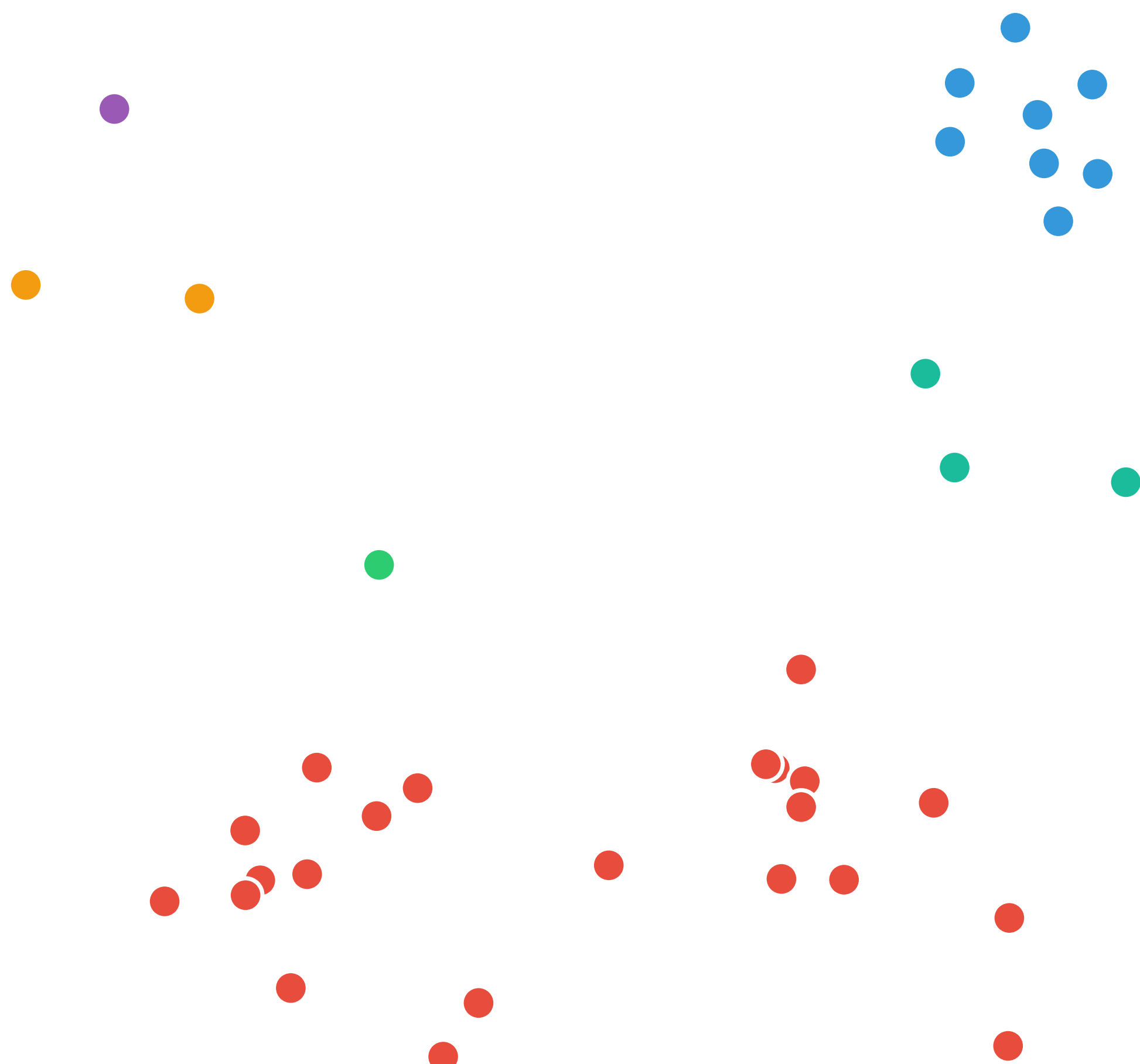
EOT



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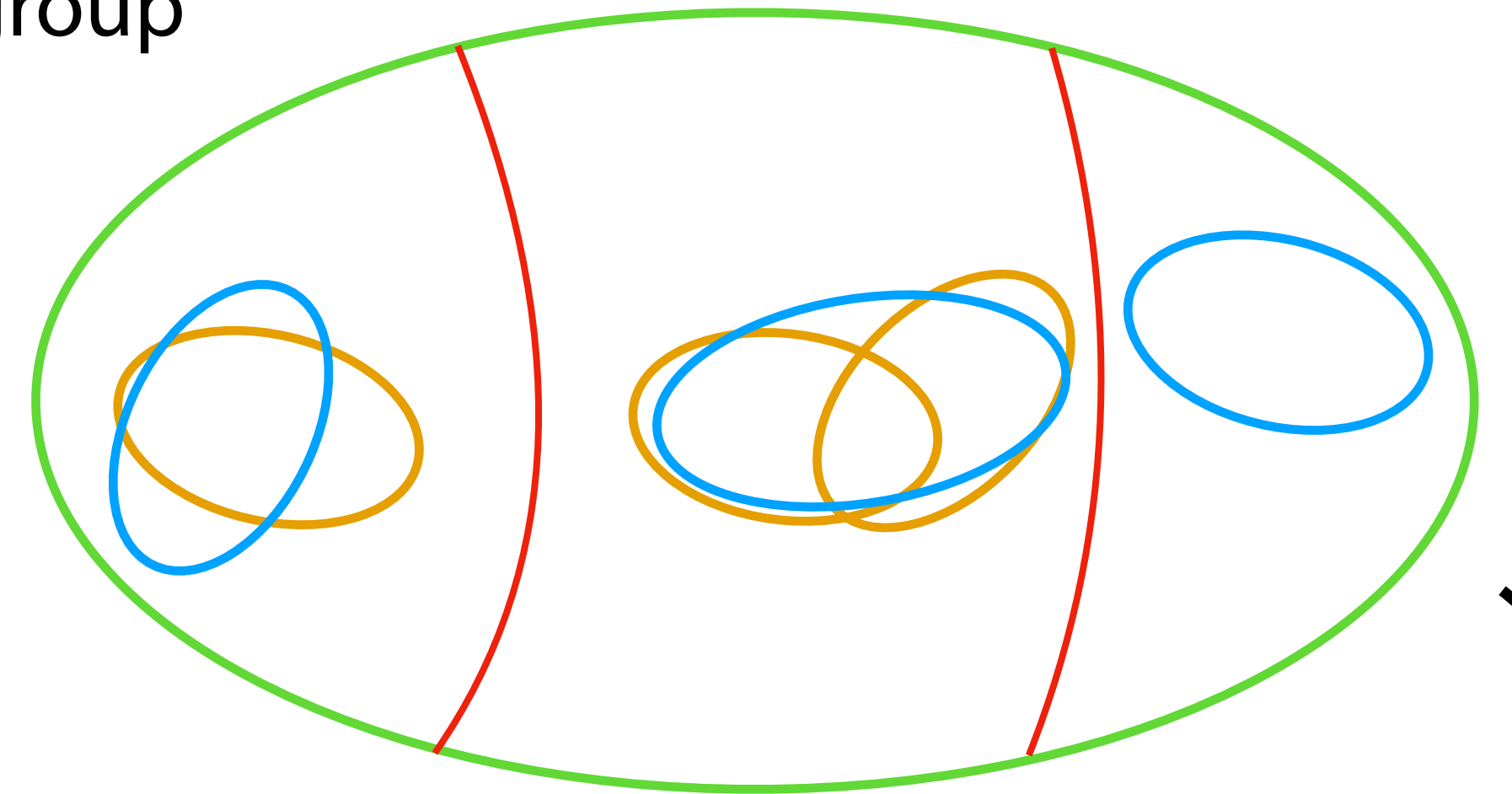
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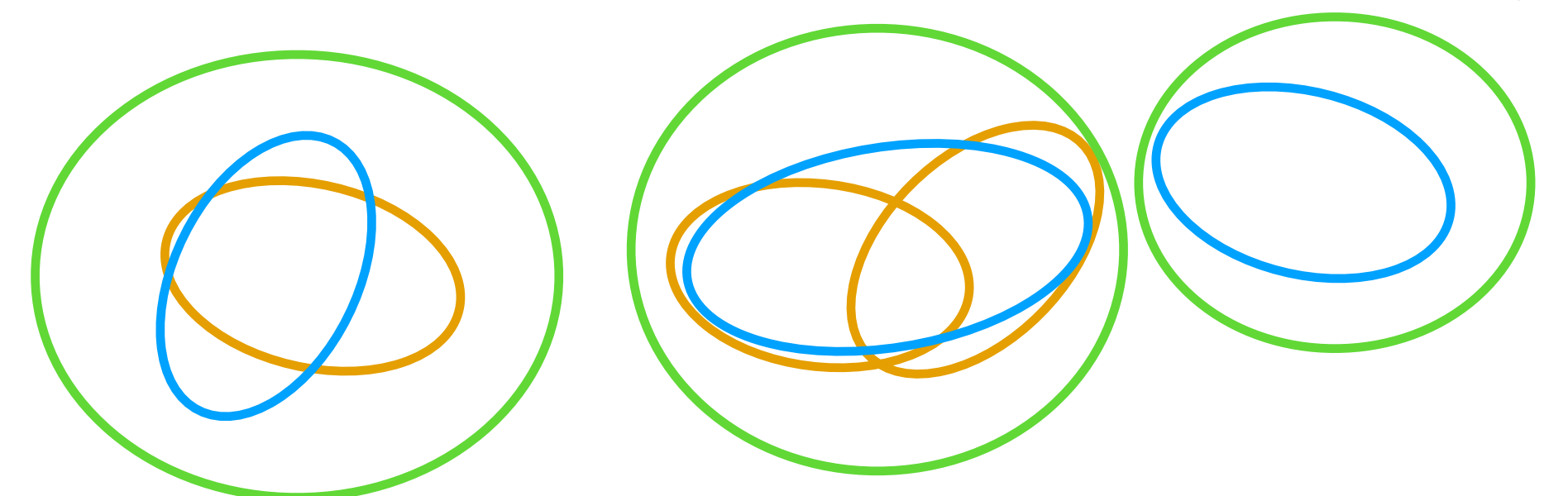
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EOT

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