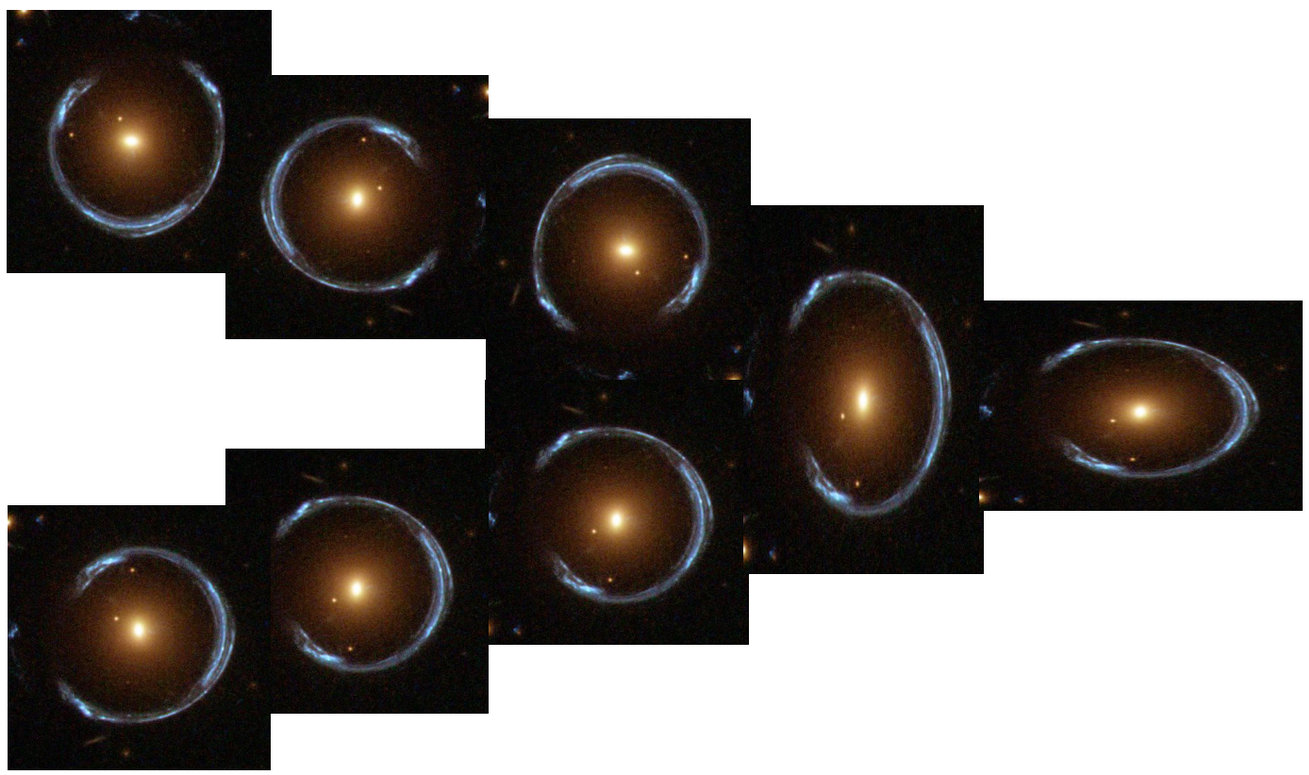
Galaxy-scale Strong Lensing in DES, UNIONS, Euclid



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European Research Council
Established by the European Commission

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Ecole Polytechnique Fédérale de Lausanne (EPFL)

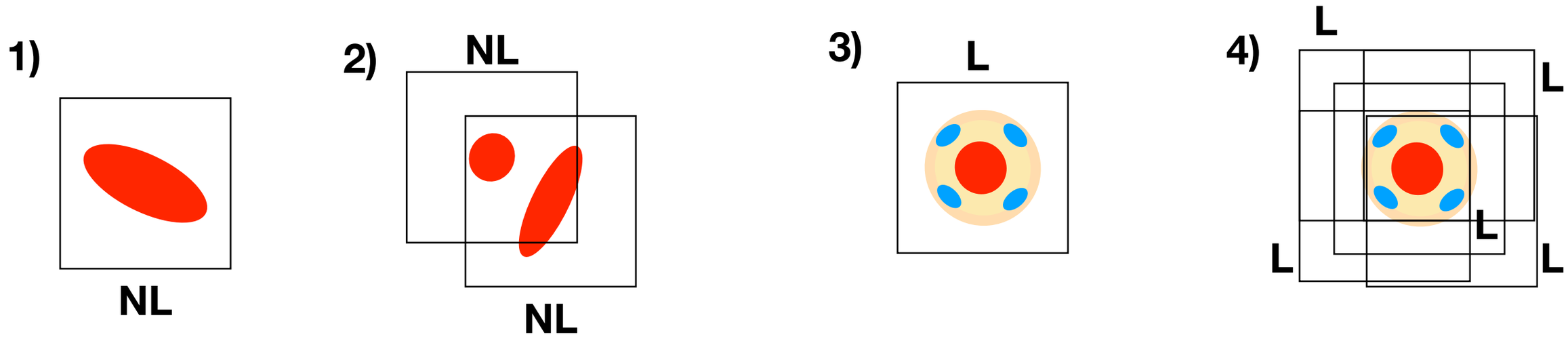
Paris/IAP - Oct 2021

Motivations, challenges and questions

- Use **real data as a test bench** for strong-lens finding in Euclid
- Explore **diversity** of different lenses
- What preselection?
- **Color or resolution?** Is one better than the other ?

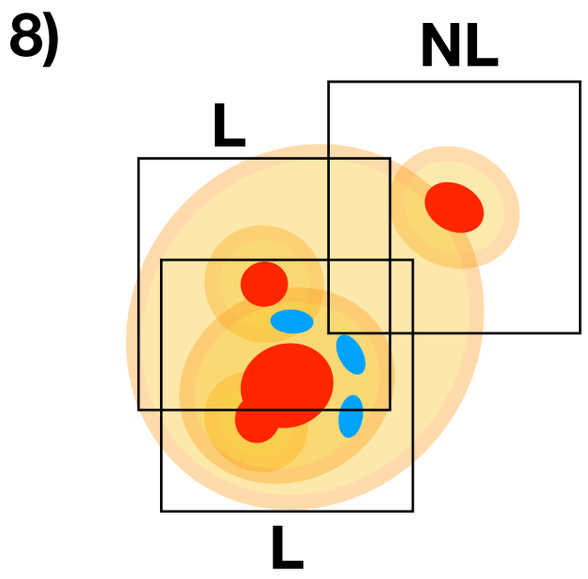
- Build catalogues of **contaminants** on real data
- Find lenses in large numbers to **enable follow-up** already
- Test lens **modeling tools** on real lenses
- Test lens/source **deblending** methods
- Eventually **use real Euclid images** as a training set or to do « self-supervised learning »

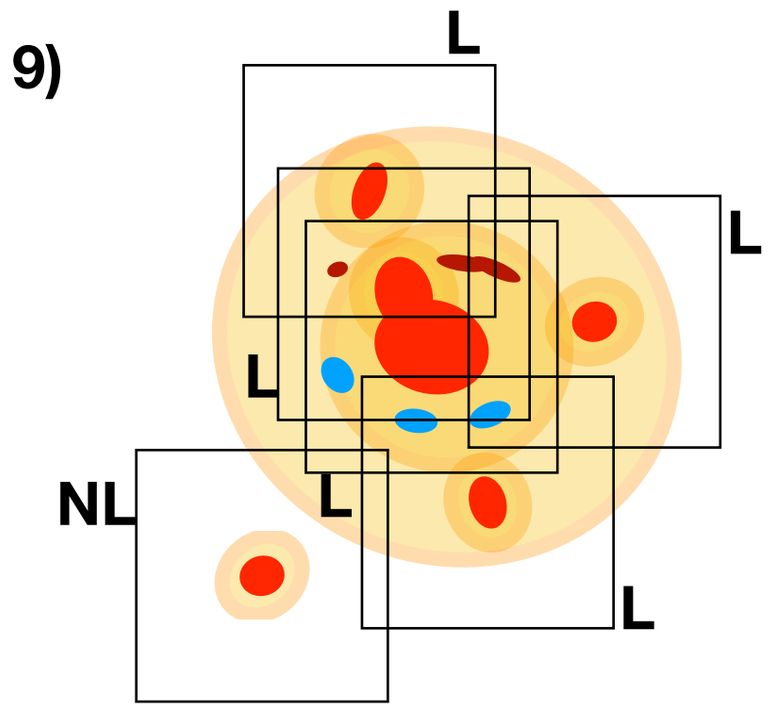
Challenge 1: Variety in lens properties

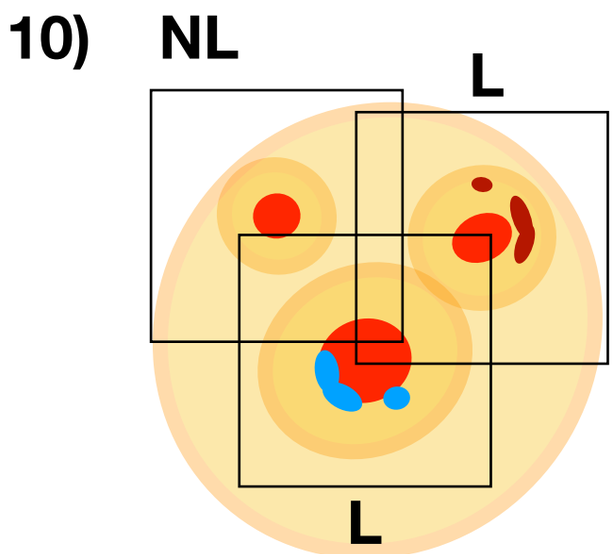


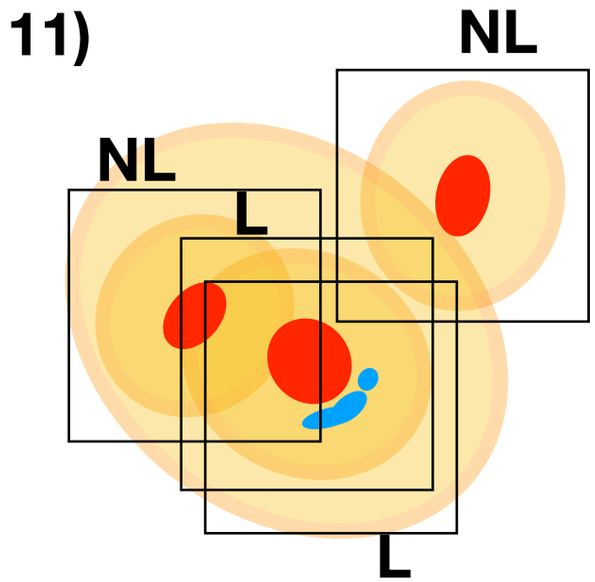
Courtesy: B. Clément

Challenge 1: Variety in lens properties









Galaxy Light

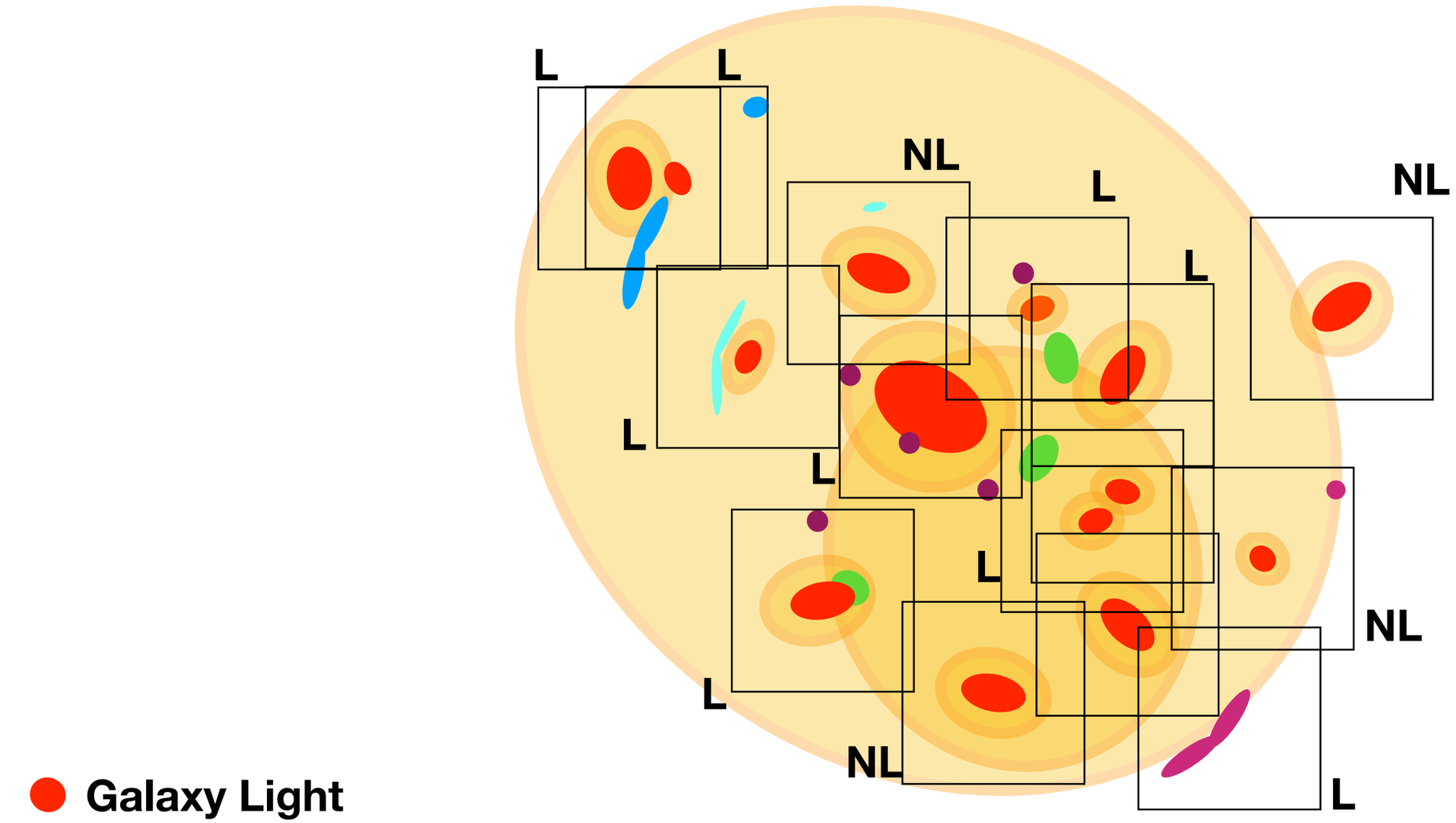
Mass

Arc

10”x10” cutout

Courtesy: B. Clément

Challenge 1: Variety in lens properties



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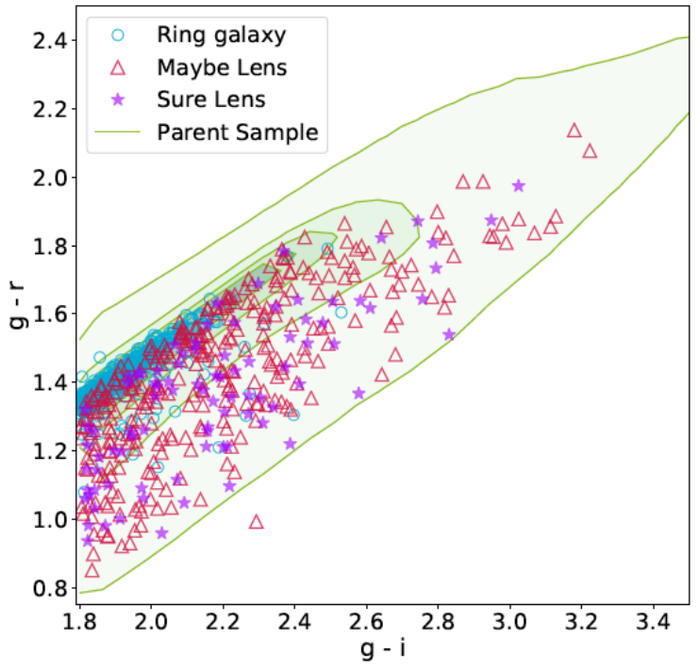
Challenge 2: Preselection for training and lens search

DES



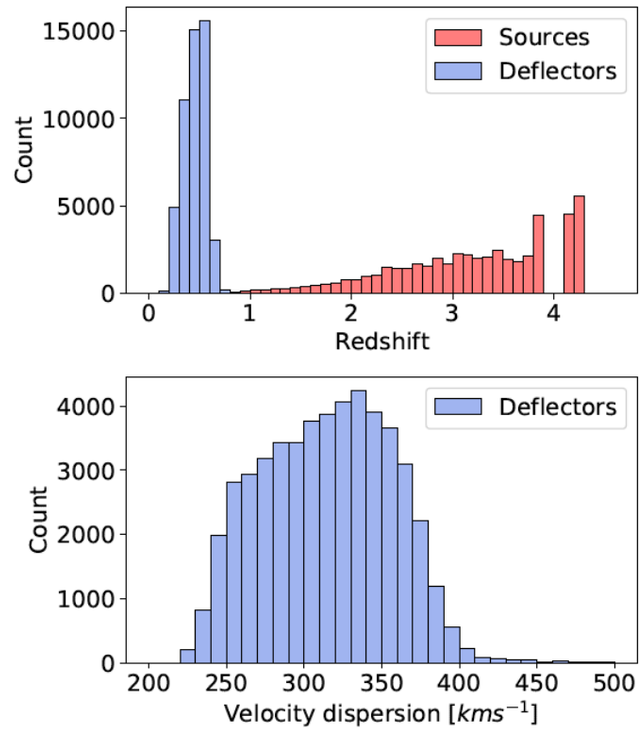
$$
\begin{aligned}
&1.8 < g - i < 5,\\
&0.6 < g - r < 3,\\
&18 < r < 22.5,\\
&g > 20,\\
&i > 18.2,
\end{aligned}
$$

Parent sample: 18 745 029 LRGs
5186 sq degree of DES DR1
13” x 13” stamps (50 pix)
g, r, i bands used
No redshift and no velocity dispersion

Proxy to allocate a velocity dispersion to each galaxy

Rojas, Savary, Clément, et al. (2021, arXiv2109.00014)

CFIS



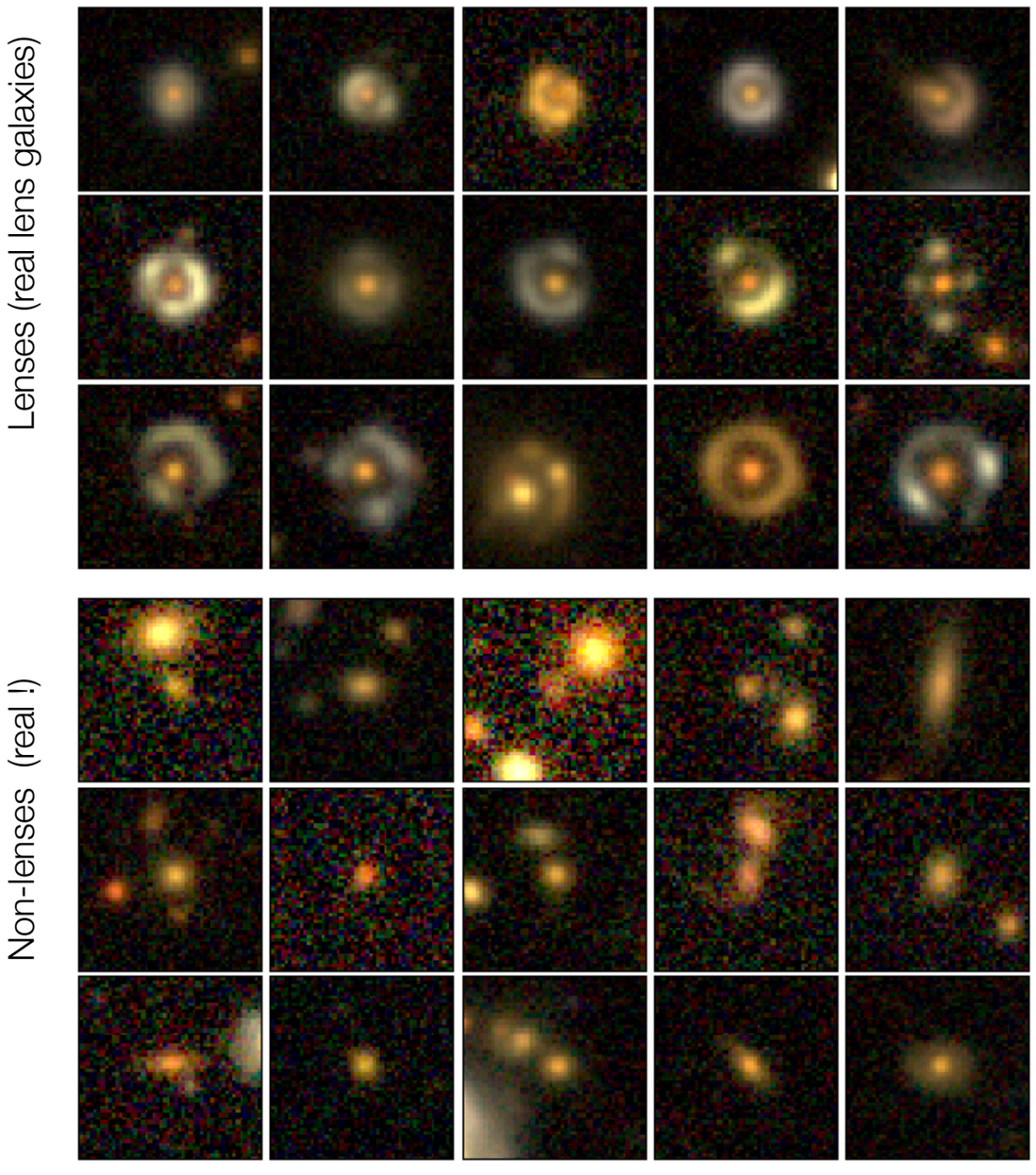
Parent sample: 2 344 002 LRGs
2500 sq degree of CFIS imaging
8” x 8” stamps (44 pix)
Only r-band but color from PANSTARRS
Redshift and vel. disp. for the training set

Color selection as in Cañameras et al. 2020, A&A 644, A45

Savary, Rojas, Clément, et al. (2021, arXiv0000.00000)

Challenge 2: Preselection for training and lens search

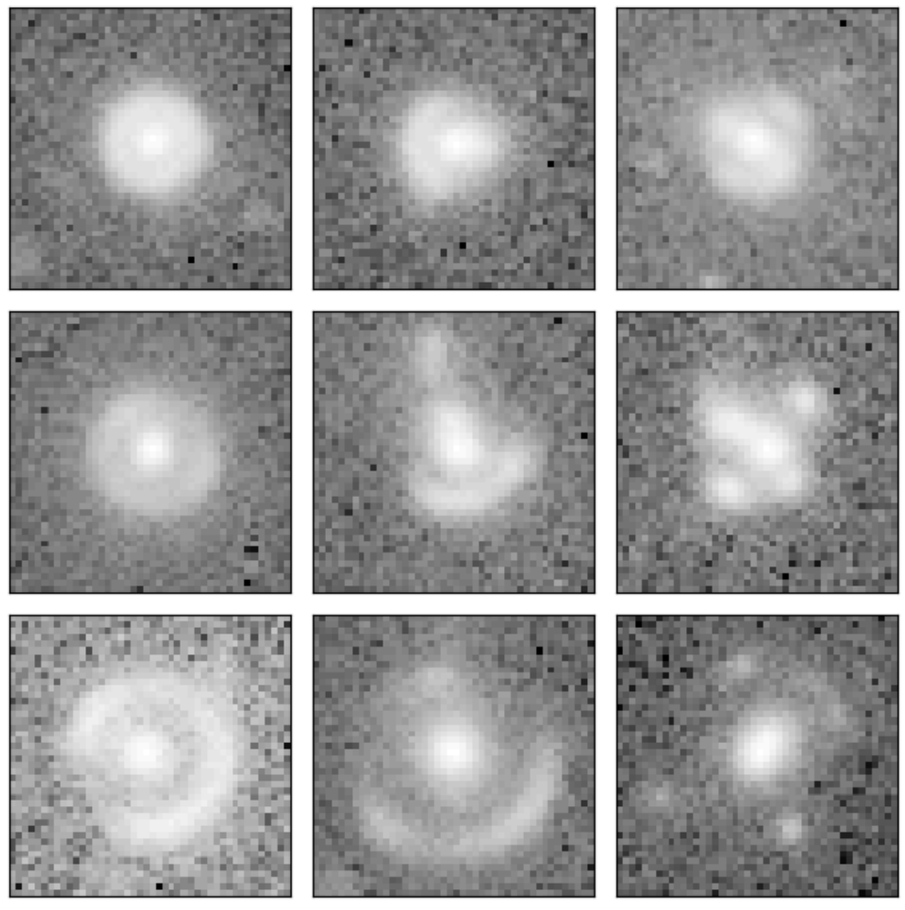
DES simulation



100 000 simulated lenses with 1.2” < R_E < 1.8”

Rojas, Savary, Clément, et al. (2021, arXiv2109.00014)

CFIS simulation



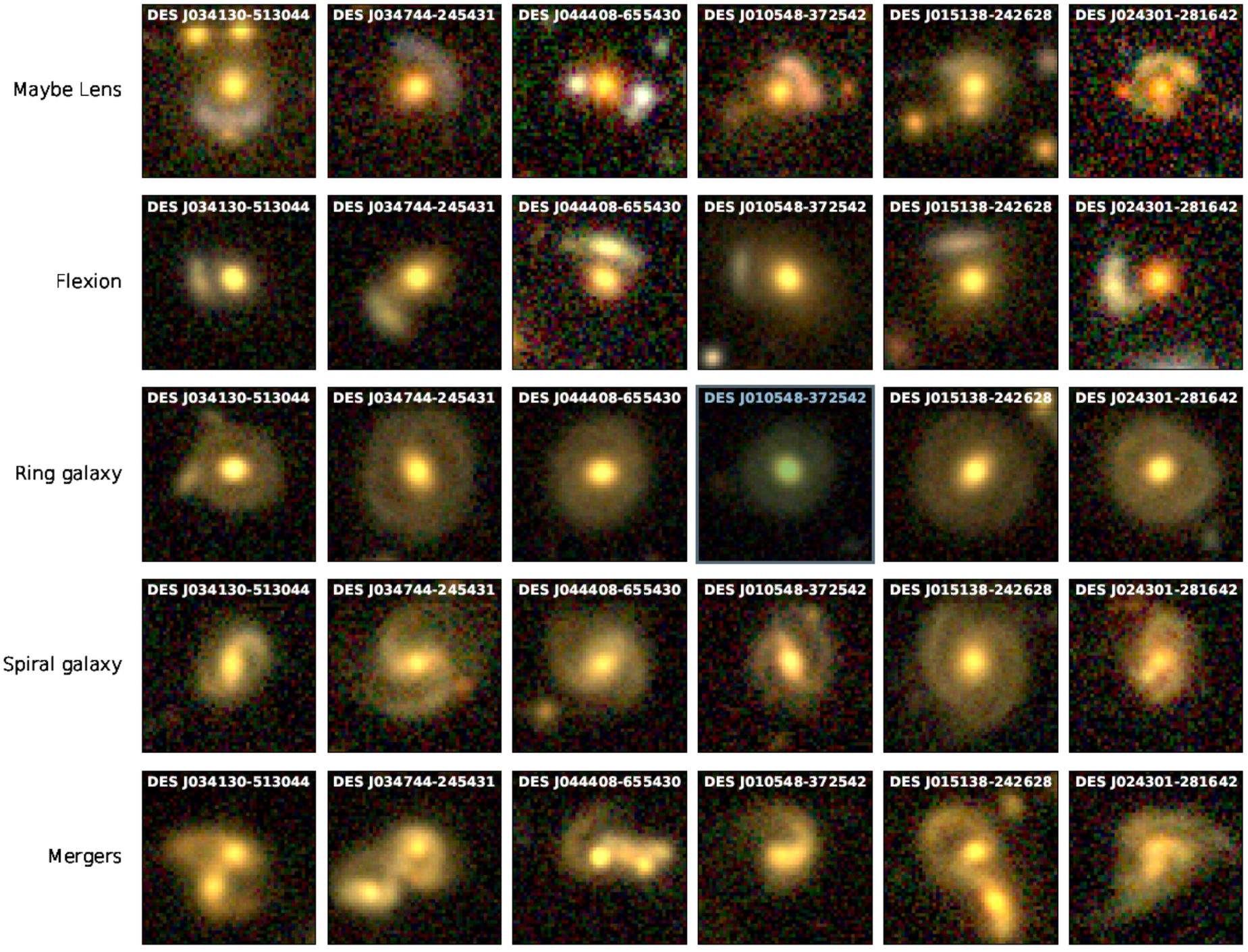
10 600 simulated lenses with 0.8” < R_E < 3.0”

We do NOT attempt to follow realistic distributions in R_E but sample uniformly (both in DES and CFIS)

Lenses sources come from HST but with HSC colors

Savary, Rojas, Clément, et al. (2021, arXiv0000.00000)

Challenge 3: Visual inspection (takes a few days)

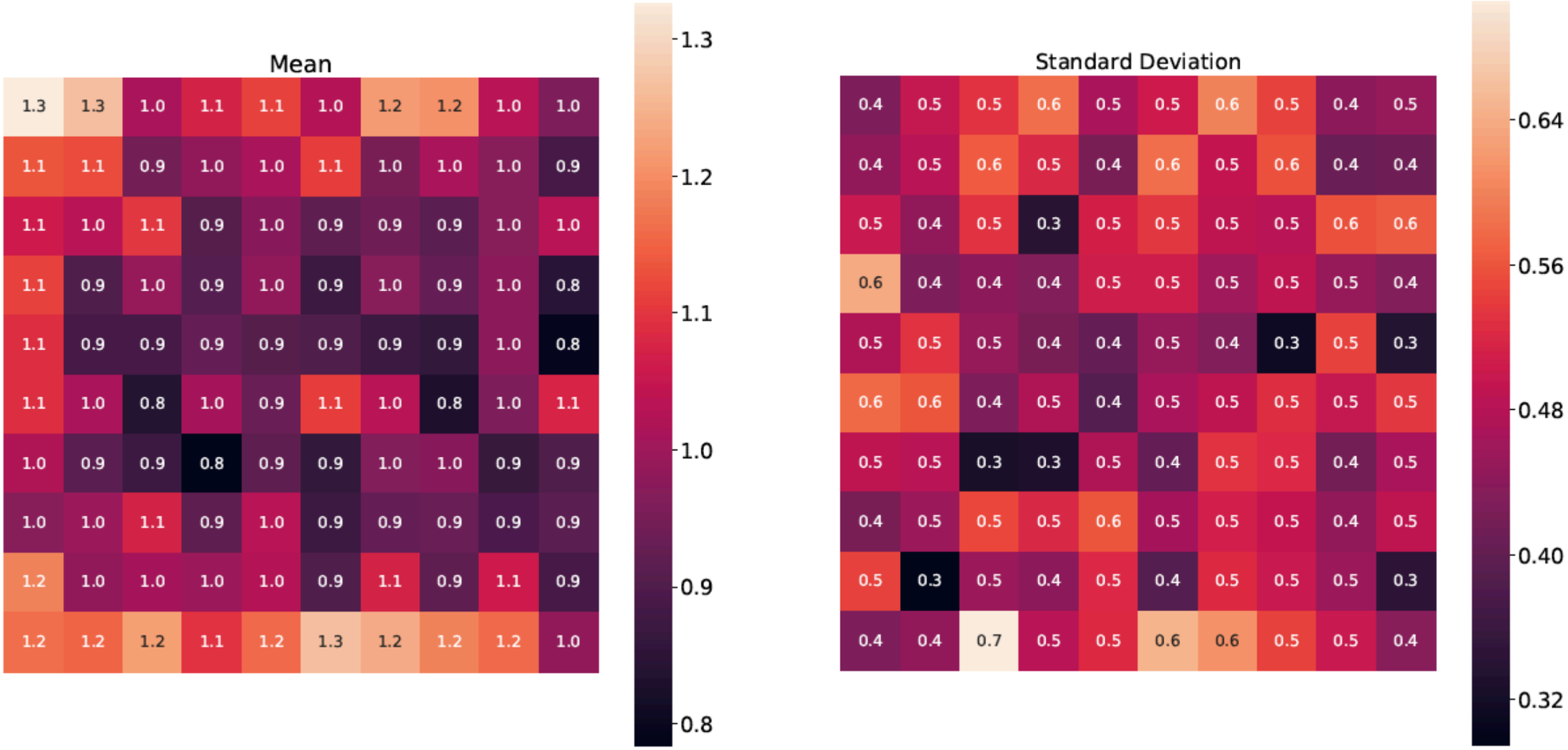


Rojas, Savary, Clément, et al. (2021, arXiv2109.00014)

Challenge 3: Visual inspection (takes a full week)

76 000 objects with CNN score > 0.9 in DES
9 460 objects with CNN score > 0.5 in CFIS
7 « inspectors » among the authors

6 different users inspect mosaics of 100 x 100 objects (Step 1): Lenses & ring galaxies
Detailed classification (Step 2): sure lens, maybe lens, flexion, ring, spiral, merger



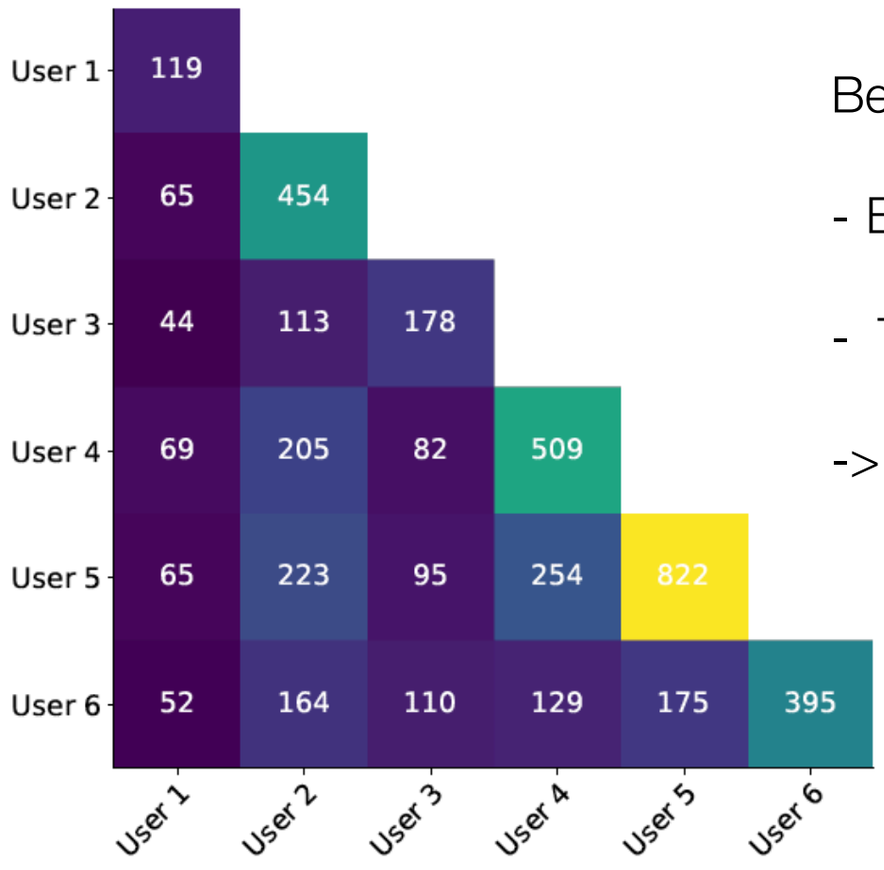
Rojas, Savary, Clément, et al. (2021, arXiv2109.00014)

Challenge 3: Visual inspection (takes a few days)

Comparison of « inspectors » in the CFIS data

Classification	User 1	User 2	User 3	User 4	User 5	User 6
NL	4492	4151	4389	3941	3398	4012
FL	17	23	61	178	408	221
ML	96	423	144	474	775	357
SL	23	31	34	35	47	38

Non-lens
Flexion
Maybe lens
Sure lens



Before the mosaic classification and detailed classification:

- Establish a joint classification scheme

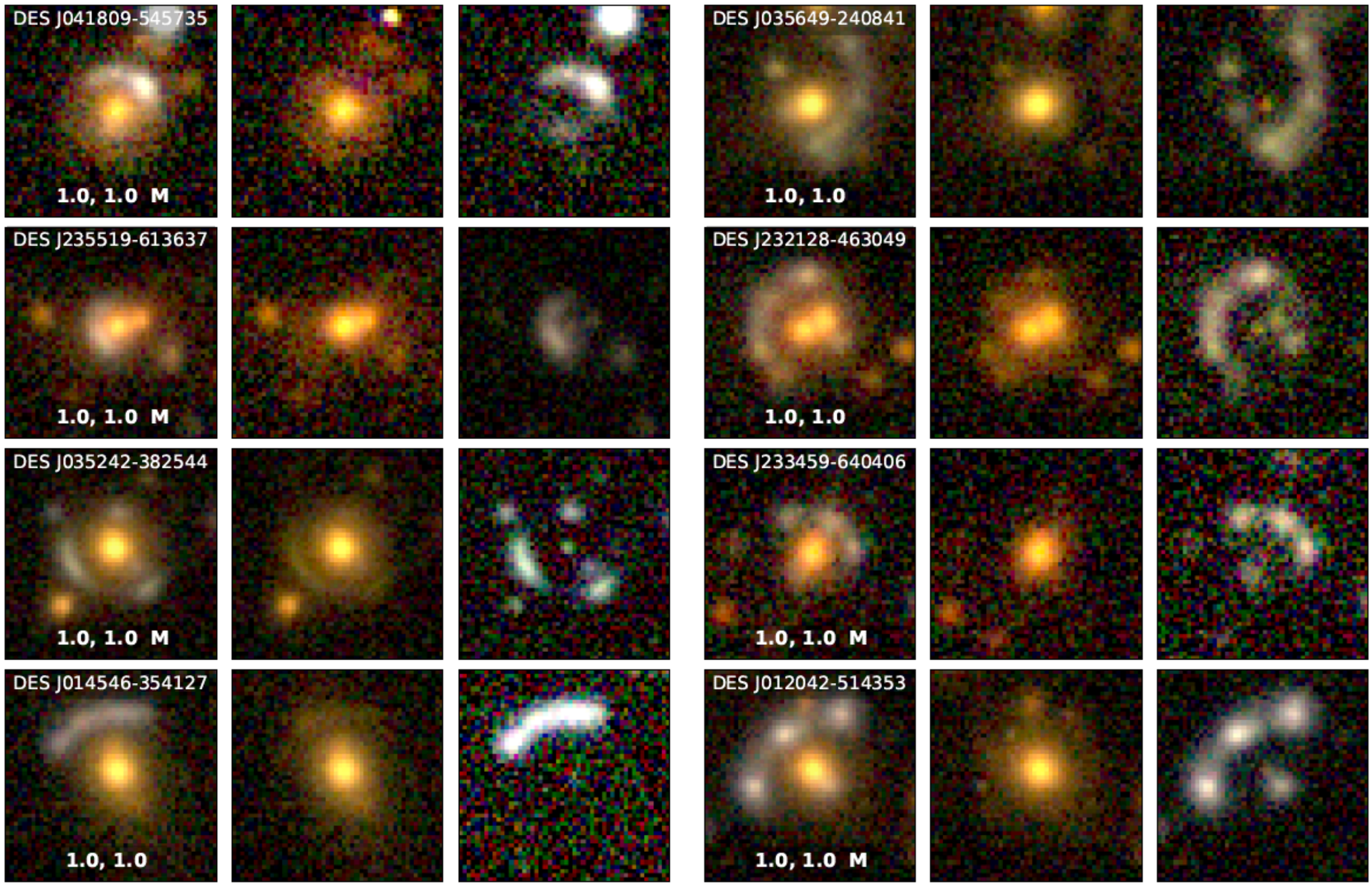
- Train on a few dozens of objects

-> still **little overlap** between the classification of the 6 inspectors

Savary, Rojas, Clément, et al. (2021, arXiv0000.0000)

Challenge 4: deblending the lens and source light

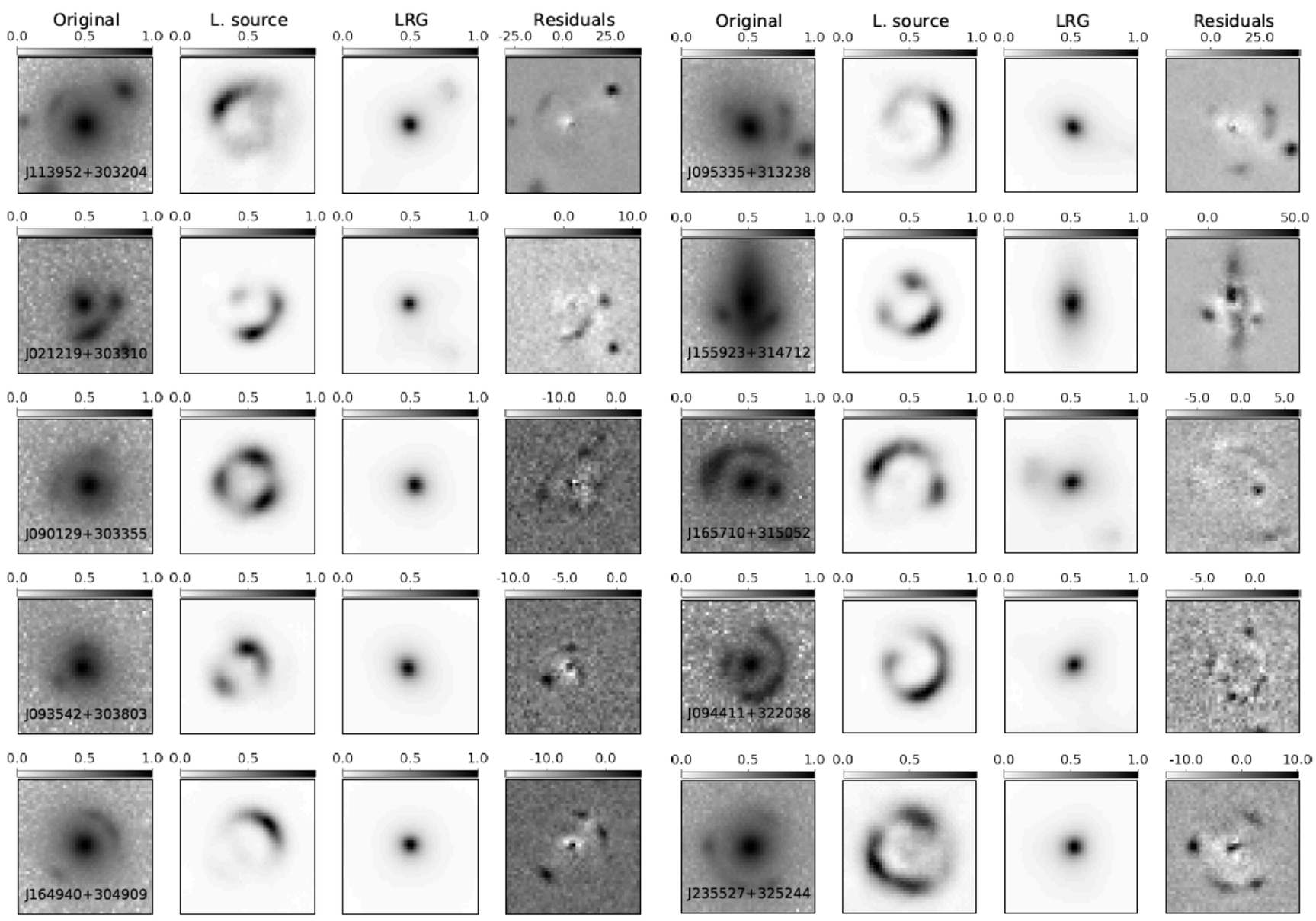
If **color information available** (DES) then use Multiband morpho-Spectral Component Analysis Deblending Tool (MuSCADeT; Joseph, Courbin, Starck, 2016 A&A 589, A81)



Rojas, Savary, Clément, et al. (2021, arXiv2109.00014)

Challenge 4: deblending the lens and source light

If **no color information available** (CFIS) then use auto-encoders (here shown for some of the CFIS « Sure Lenses »)
Use mapping between inputs and labels
Training on 10000 simulated lenses and 5000 real LRGs with no lensing



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Quick word about Euclid lens finding

- Reduction pipeline produces **tiles** of 32’ x 32’
- 15000 deg^2 ~ 50000 tiles
- To Euclid depth in the wide survey 1000 objects have VIS < 22
- Collett (2015) expects 170000 lenses in the full survey
- This is 3 lenses per tile
- Euclid does 20 tiles per day
- 60 lenses expected per day, among 20000 objects to test
- 0.5% false positive rate (what we **measure** in CFIS and DES) means 100 objects to check per day -> feasible?

Summary - expectations for Euclid

- 405 Sure or maybe lenses in DES DR1, starting from 18 million objects
- 133 Sure or maybe lenses in CFIS starting from 2.3 million objects
- Overall numbers compatibles with other searches
- Quality of training set prevails over « quality of network »
- Color information less important than high resolution

- For Euclid, use single-band: VIS is the best but complemented by NIR
- No color selection, to enable lensing by anything and make pipeline simpler
- Far too many false positives so far (0.5%)
- Towards a fully data-driven training set? After 1 year of mission?
- Citizen science to clean from false positives?
- Modeling step with standard models: 2h per lens