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Crescenzo Tortora



Napoli

Napolitano
La Barbera
D'Ago
Spiniello
Spavone
Getman
Cavuoti
Brescia
Longo
Capaccioli
.....

Groningen

Koopmans
Verdoes Kleijn
Petrillo
Vernardos
Chatterjee
.....

Other institutions

Kuijken
Radovich
.....





Wider Than Before

Deeper Than Before

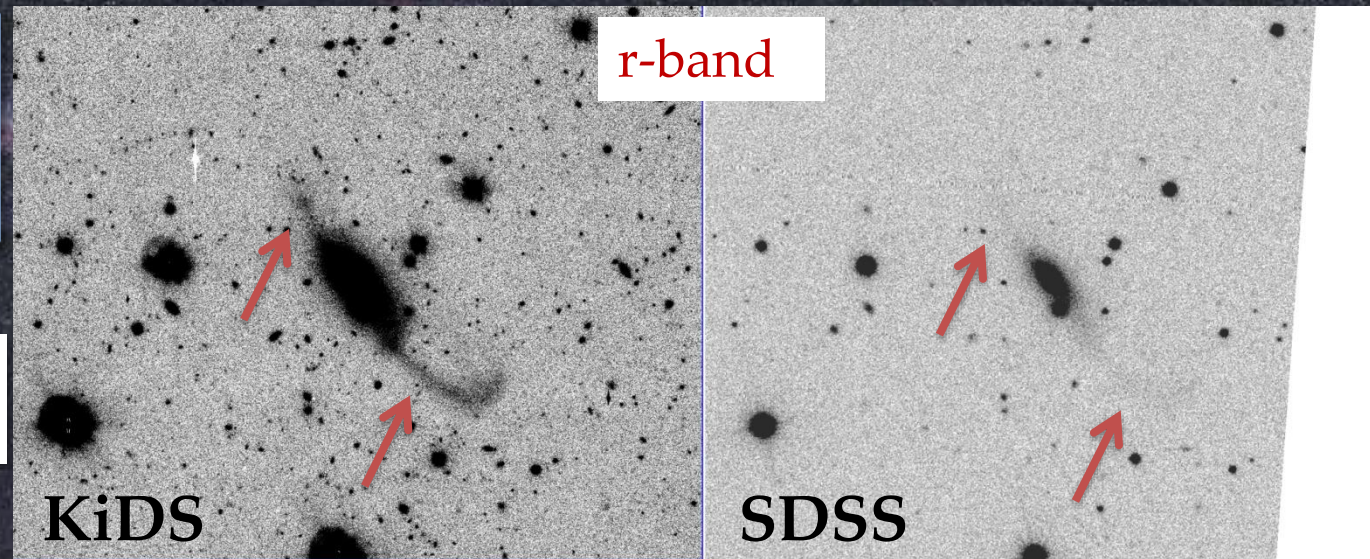
Better Than Before

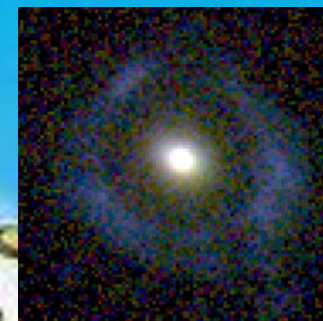
KiDS@VST aims to image 1500 square degrees in 4 optical bands (complemented in the NIR with VIKING@VISTA).

Deeper and with better quality and higher spatial resolution than previous surveys.

Pixel scale $0.2''/\text{pxl}$
Seeing $0.7''$ (r-band)
Depth $r = 25$ (r-band)

Why KiDS?





DR1/2/3 (440

Sources: ~ 60

Galaxies: ~ 22 millions with photo-z
> 3 millions with high-quality photo-z
~ 1 millions with structural parameters



Ultra compact galaxies

Gravitational arcs/rings

Lensed quasars

Spiniello's talk



KABS science

Napolitano's talk

GAMA vs KiDS

D'Ago's talk

Better Than Before



**Towards a census of supercompact massive galaxies
in the Kilo Degree Survey**

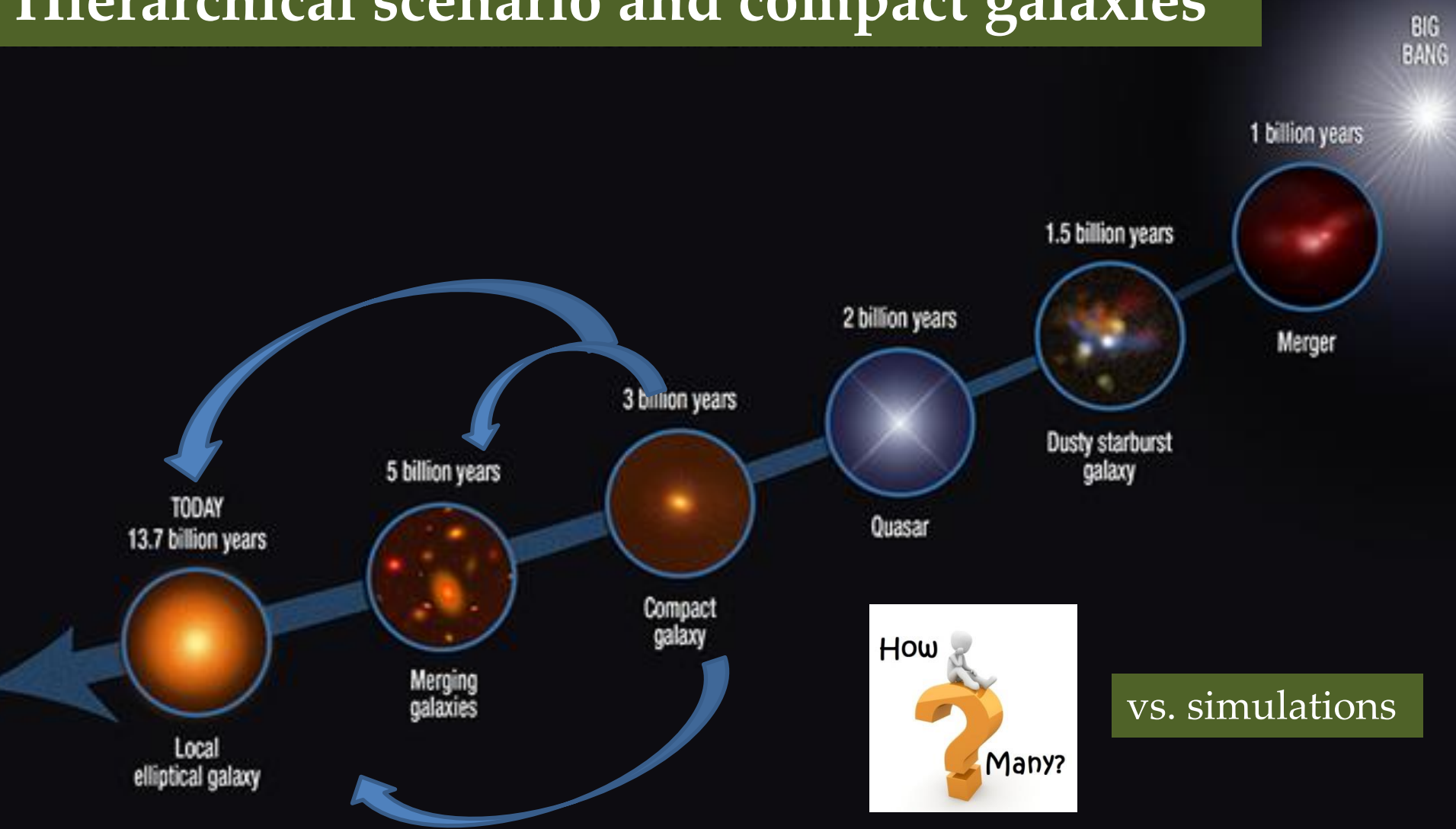
C. Tortora,^{1*} F. La Barbera,¹ N. R. Napolitano,¹ N. Roy,^{1,2} M. Radovich,³
S. Cavuoti,¹ M. Brescia,¹ G. Longo,² F. Getman,¹ M. Capaccioli,² A. Grado,¹
K. H. Kuijken,⁴ J. T. A. de Jong,⁴ J. P. McFarland⁵ and E. Puđu¹

**The first sample of spectroscopically confirmed ultra-compact
massive galaxies in the Kilo Degree Survey**

C. Tortora^{1*}, N.R. Napolitano², M. Spavone², F. La Barbera², G. D'Ago², C. Spiniello²,
K. H. Kuijken³, N. Roy^{2,4}, M. A. Raj², S. Cavuoti^{2,4}, M. Brescia², G. Longo⁴,
V. Pota², C. E. Petrillo¹, M. Radovich⁵, F. Getman², L.V.E. Koopmans¹, I. Trujillo^{6,7},
G. Verdoes Kleijn¹, M. Capaccioli⁴, A. Grado², G. Covone⁴, D. Scognamiglio²,
C. Blake⁸, K. Glazebrook⁸, S. Joudaki^{8,9,10}, C. Lidman¹¹, C. Wolf¹²

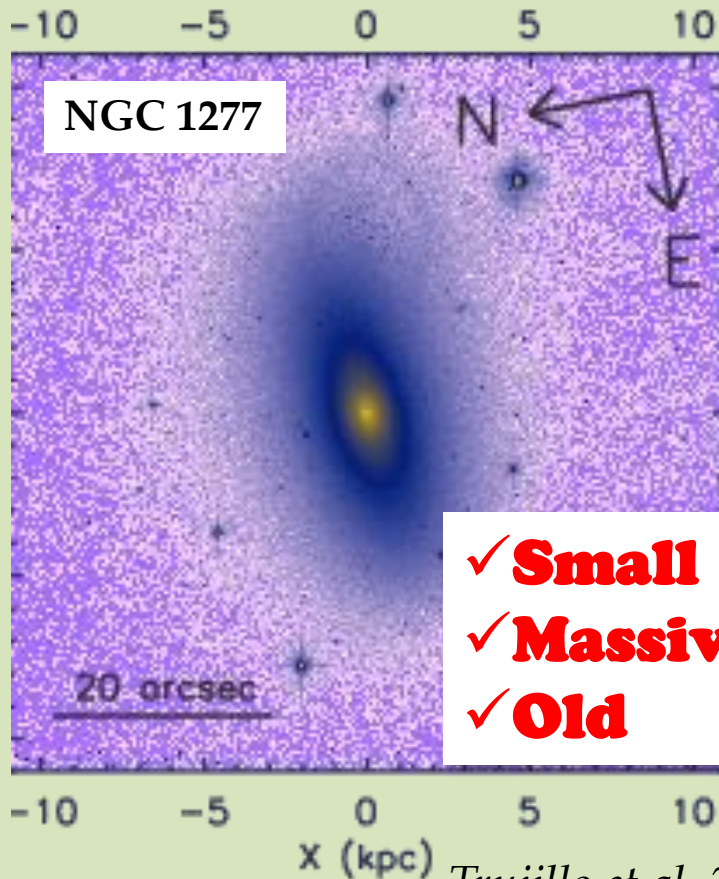
Better Than Before
The census of ultra-compact massive galaxies

Hierarchical scenario and compact galaxies



Ultra-compact massive galaxies (UCMGs)

“LOCAL RED NUGGET”



- ✓ **Small**
- ✓ **Massive**
- ✓ **Old**

Trujillo et al. 2014

UCMGs definition

$$R_e < 1.5 \text{ kpc}$$

$$M_\star > 8 \times 10^{10} M_\odot$$

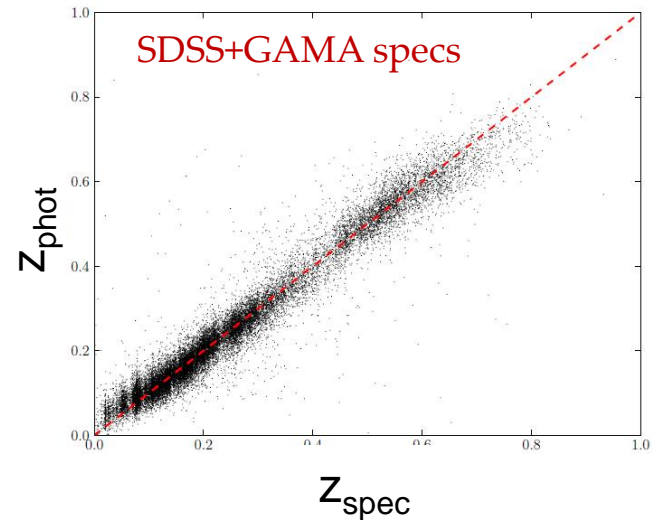
Data analysis

Photo-z

(machine learning, specs to train the network)

scatter ~ 0.03

Cavuoti et al. 2015, 2017



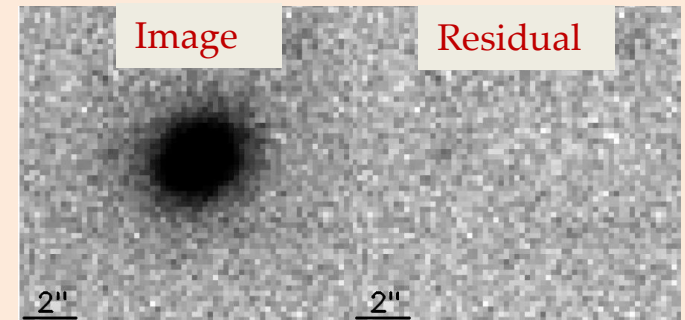
Stellar masses

(SED-fitting, using Lephare program)

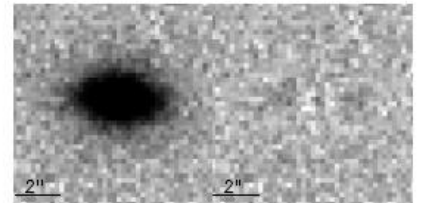
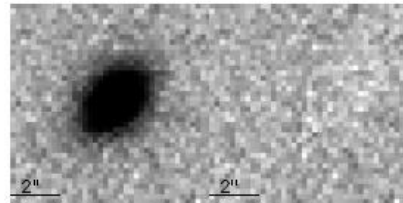
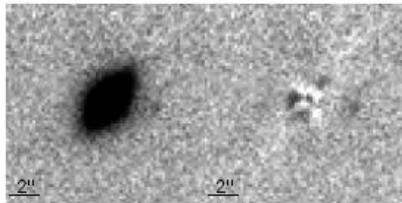
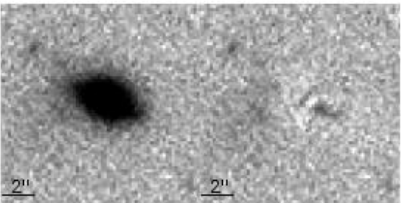
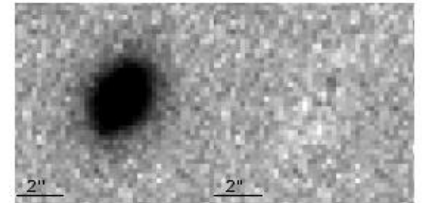
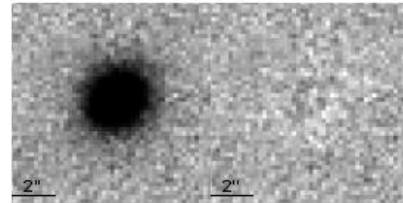
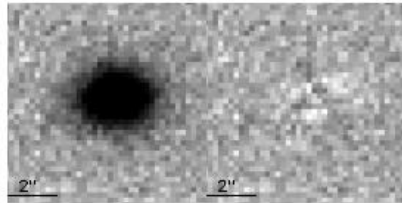
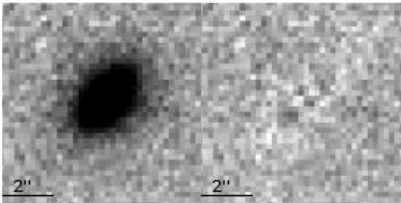
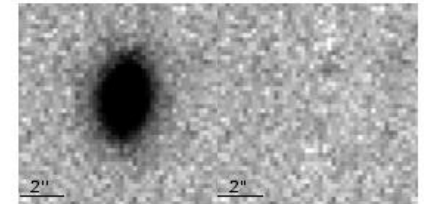
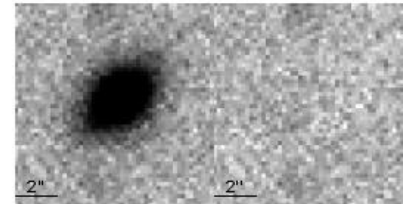
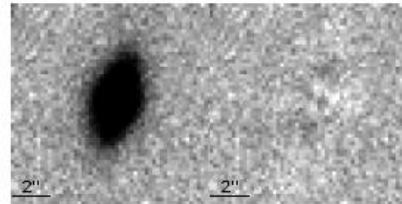
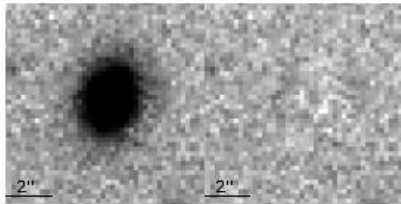
Structural parameters

(2DPHOT, Sérsic fit, modelling the PSF)

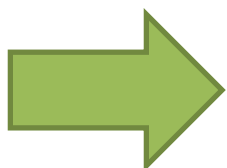
La Barbera et al. 2008; Roy et al., MNRAS submitted



Some UCMG candidates



Complete at $z < 0.5$



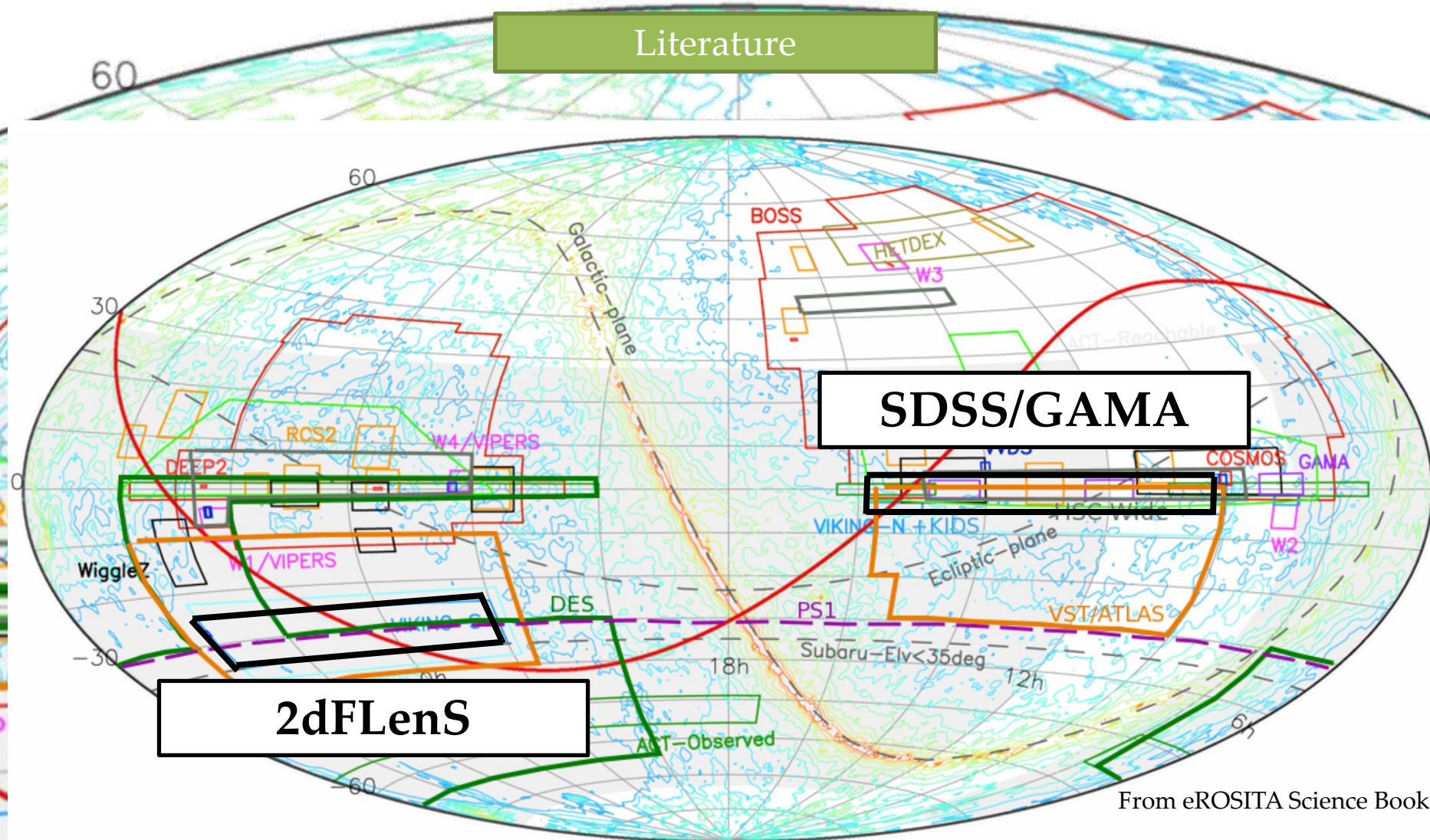
Spectroscopic redshifts

Literature

New observations

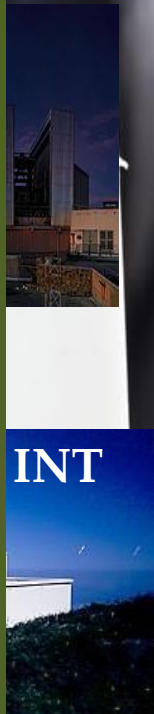
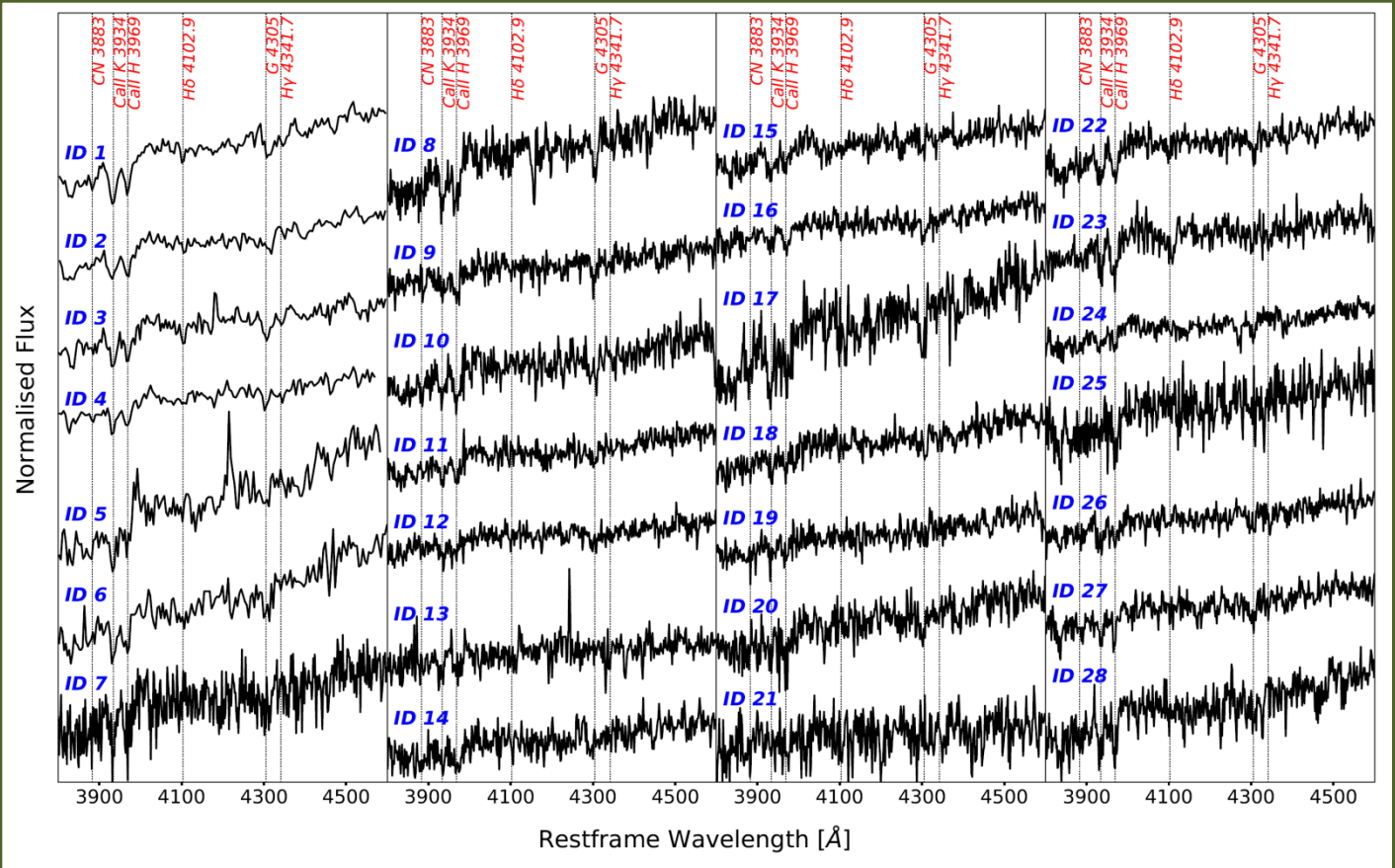
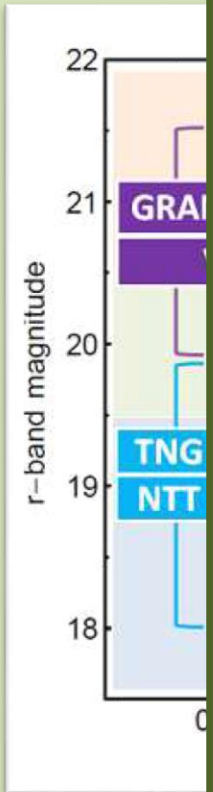


Literature



From eROSITA Science Book

New observations




28 observed and reduced (TNG-1st, NTT)
 ~45 observed and to be reduced (TNG-2nd, INT)
 ~20 to be observed (TNG-3rd)



Spectroscopic redshifts

Literature

New observations

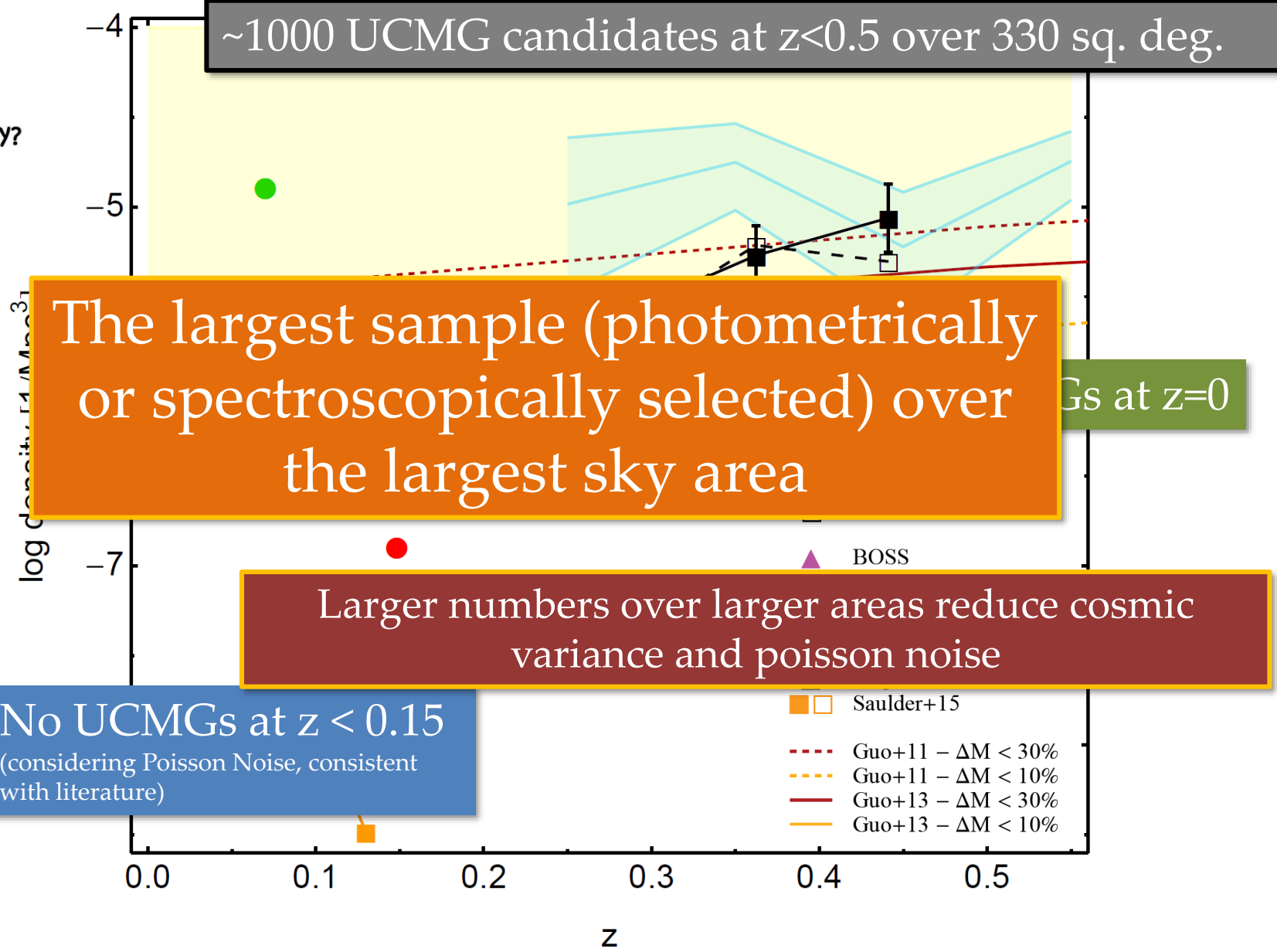
- 
- ✓ Contamination (false positive)
 - ✓ Incompleteness (false negative)



False Positive



False Negative





Finding strong gravitational lenses in the Kilo Degree Survey with Convolutional Neural Networks

C. E. Petrillo,^{1*} C. Tortora,¹ S. Chatterjee,¹ G. Vernardos,¹ L. V. E. Koopmans,¹
G. Verdoes Kleijn,¹ N. R. Napolitano,² G. Covone,³ P. Schneider,⁴ A. Grado²
and J. McFarland¹

Better Than Before

The census of gravitational lenses

galaxy

SLACS Survey strong lens object
SDSSJ1430

Einstein ring

distant galaxy

nearby massive galaxy

Einstein ring

The most precise galaxy mass estimate

Dark matter and mass density slope

Dark substructures

NASA/ESA



 SDSS J1420+6019	 SDSS J2321-0939	 SDSS J1106+5228	 SDSS J1029+0420	 SDSS J1143-0144	 SDSS J0955+0101	 SDSS J0841+3824	 SDSS J0044+0113	 SDSS J1432+6317	 SDSS J1451-0239
 SDSS J0959+0410	 SDSS J1032+5322	 SDSS J1443+0304	 SDSS J1218+0830	 SDSS J2238-0754	 SDSS J1538+5817	 SDSS J1134+6027	 SDSS J2303+1422	 SDSS J1103+5322	 SDSS J1531-0105
 SDSS J0912+0029	 SDSS J1204+0358	 SDSS J1153+4612	 SDSS J2341+0000	 SDSS J1403+0006	 SDSS J0936+0913	 SDSS J1023+4230	 SDSS J0037-0942	 SDSS J1402+6321	 SDSS J0728+3835
 SDSS J1627-0053	 SDSS J1205+4910	 SDSS J1142+1001	 SDSS J0946+1006	 SDSS J1251-0208	 SDSS J0029-0055	 SDSS J1636+4707	 SDSS J2300+0022	 SDSS J1250+0523	 SDSS J0959+4416
 SDSS J0956+5100	 SDSS J0822+2652	 SDSS J1621+3931	 SDSS J1630+4520	 SDSS J1112+0826	 SDSS J0252+0039	 SDSS J1020+1122	 SDSS J1430+4105	 SDSS J1436-0000	 SDSS J0109+1500
 SDSS J1416+5136	 SDSS J1100+5329	 SDSS J0737+3216	 SDSS J0216-0813	 SDSS J0935-0003	 SDSS J0330-0020	 SDSS J1525+3327	 SDSS J0903+4116	 SDSS J0008-0004	 SDSS J0157-0056

SLACS

SLACS: The Sloan Lens ACS Survey www.SLACS.org

A. Bolton (U. Hawai'i IfA), L. Koopmans (Kapteyn), T. Treu (UCSB), R. Gavazzi (IAP Paris), L. Moustakas (JPL/Caltech), S. Burles (MIT)

Image credit: A. Bolton, for the SLACS team and NASA/ESA

Now: ~ 600 lenses known



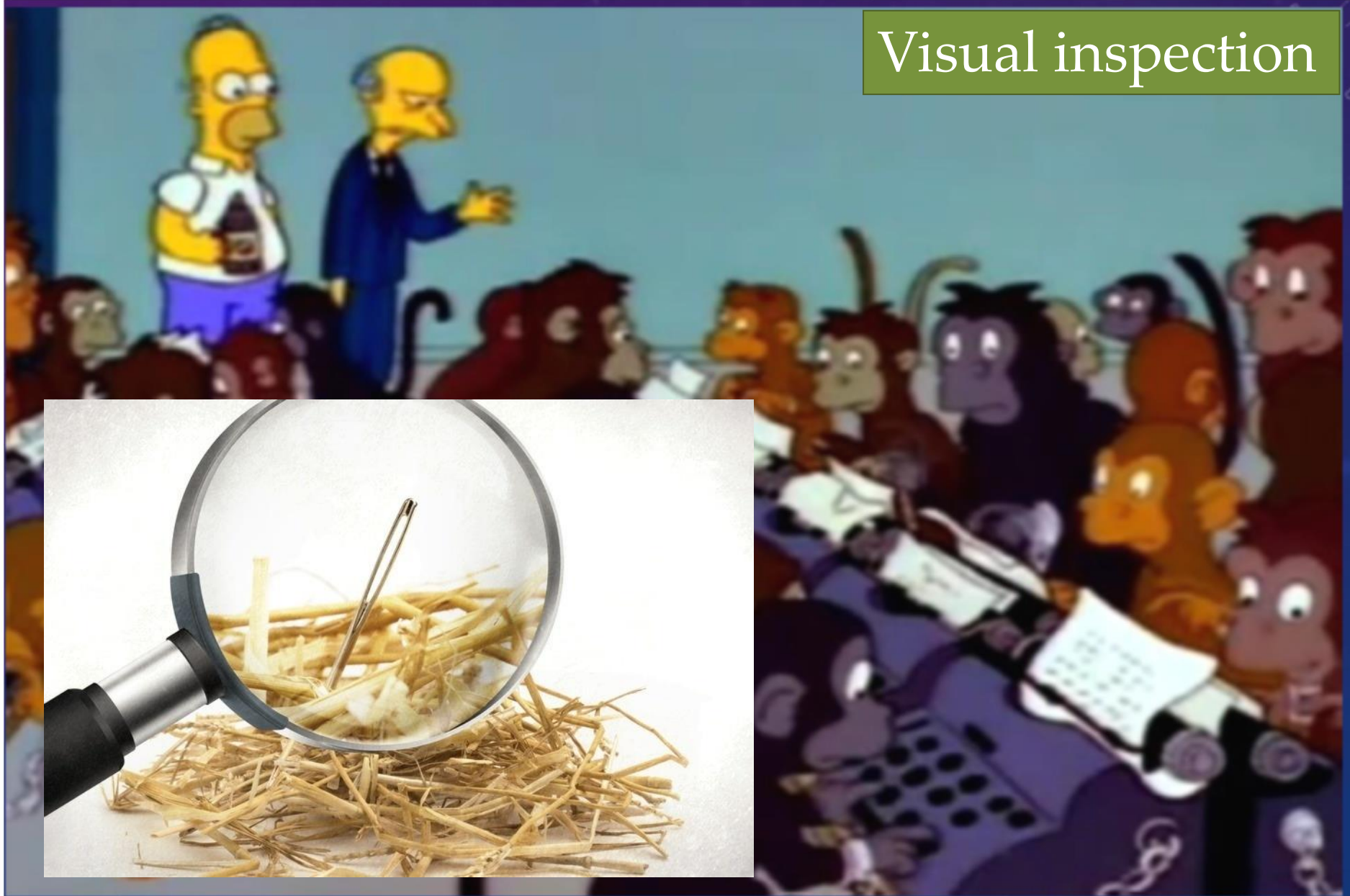
KiDS: ~ 2400 lenses (*Petrillo+17*)



EUCLID (after two months)



Visual inspection





Automated search



cat



dog



Training sample: an issue

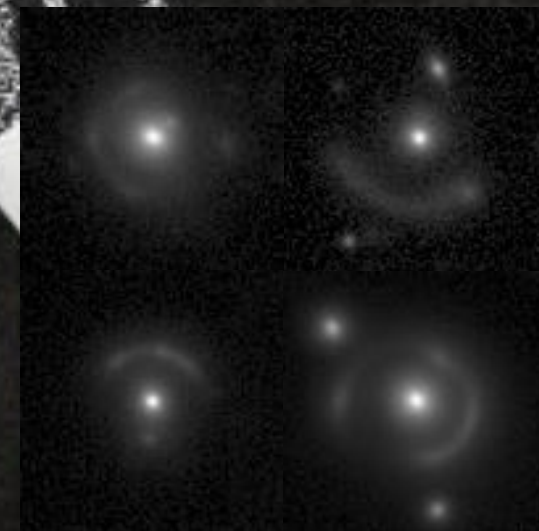
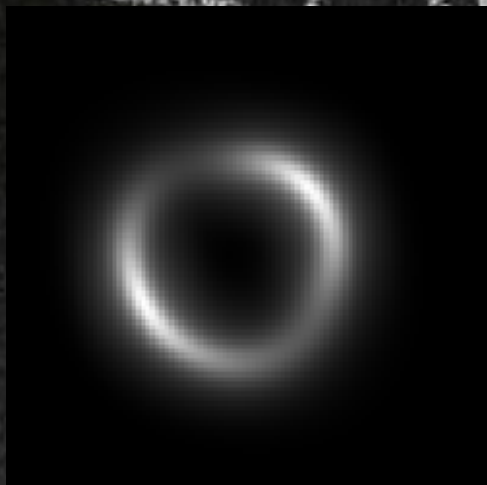
CNNs need large “training set”!



A few hundred of observed gravitational lenses

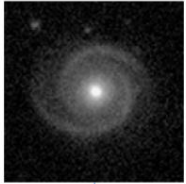


Mock gravitational lenses

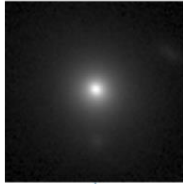


The strategy

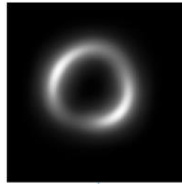
False positives and
contaminants



LRGs

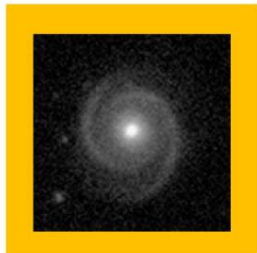


Mock lensed sources

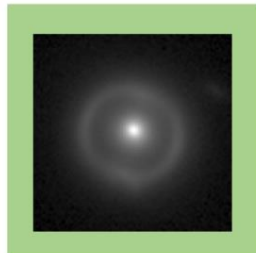


OR

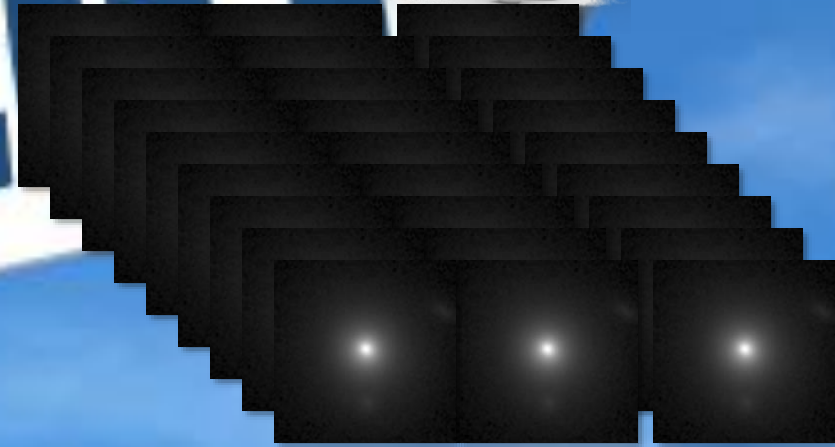
+



Non-lens Examples




Lens Examples



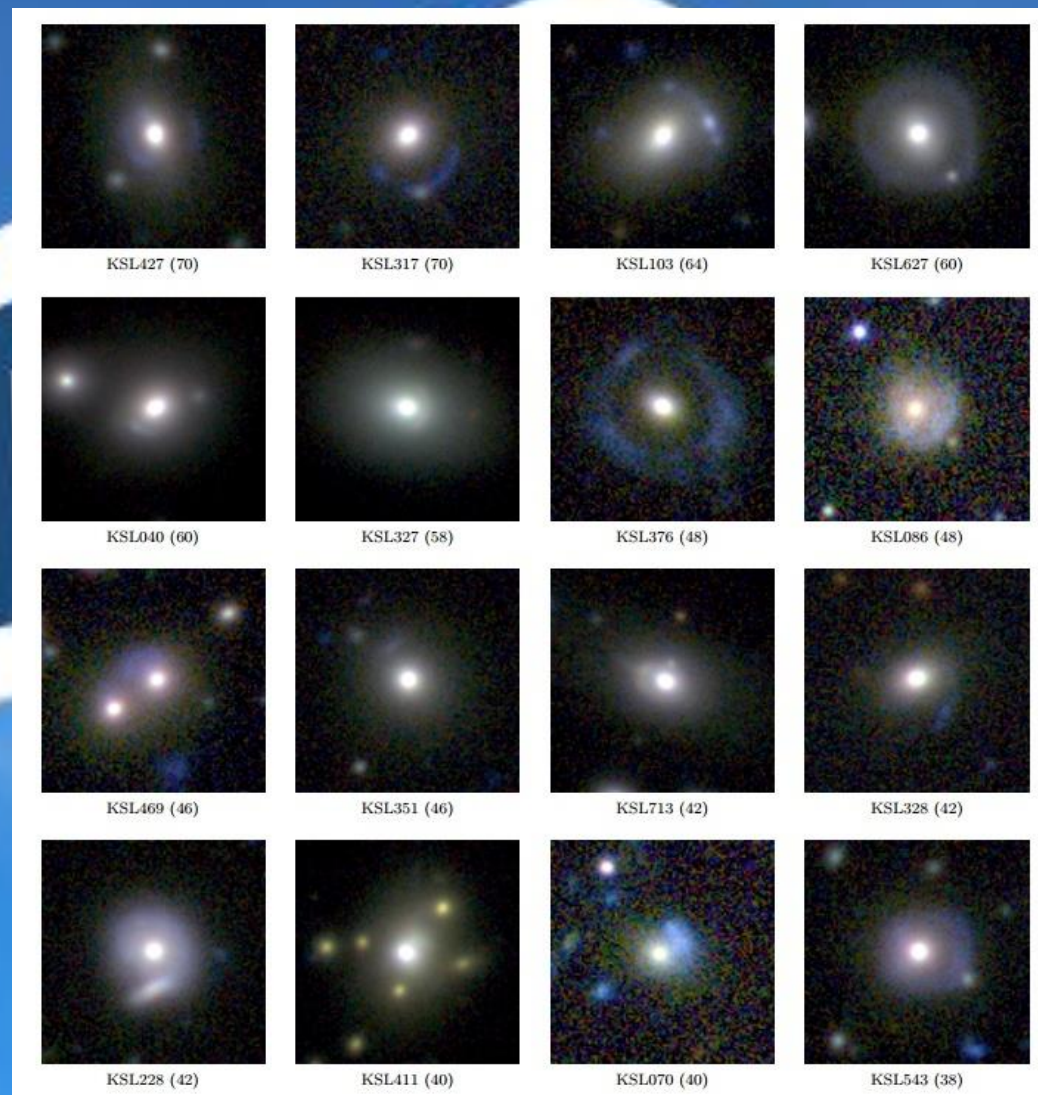
The lens sample

From $\sim 22,000$ color selected LRGs in KiDS DR3 (255 sq. deg.), in few minutes the CNN selects **746 lens candidates**.



We choose the best **56 lenses** with a joint visual inspection.

Prediction from LensPop (Collett 2015): ~ 50 LRG lenses in KiDS DR3 with $ER > 1.4''$.



Known lenses



J085446-012137



J114330-014427



J1403+0006

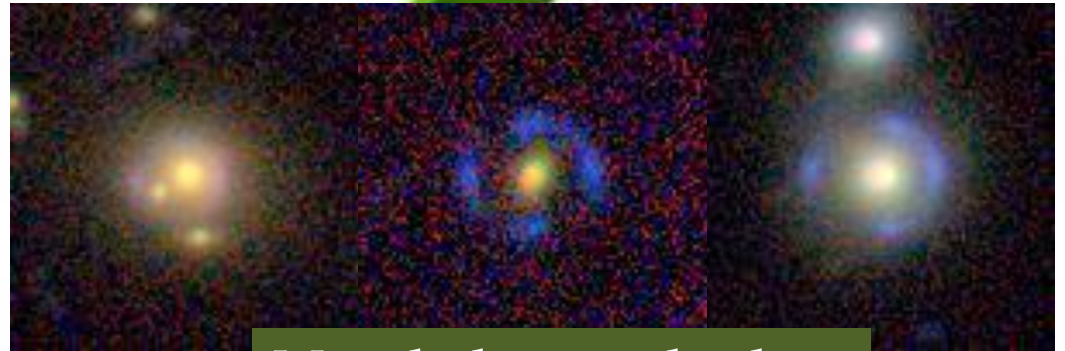


FALSE

On-going improvements



Just morphology



Morphology and colour

- ✓ Network architecture
- ✓ Sample selection
- ✓ Survey area (soon 900 sq. deg.; KiDS-DR4)
- ✓

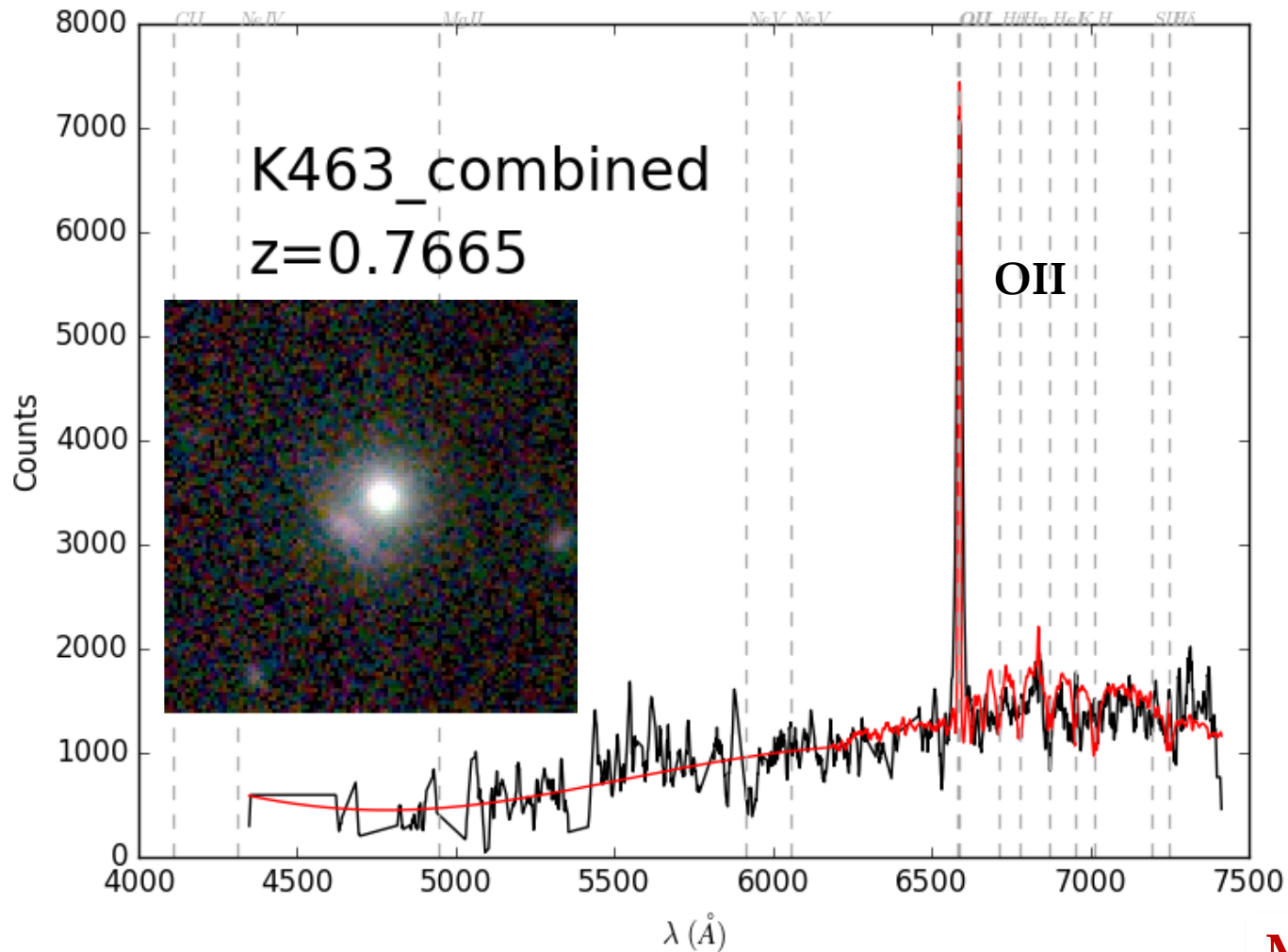


Some new candidates



We are putting the basis of the
 future lens searches

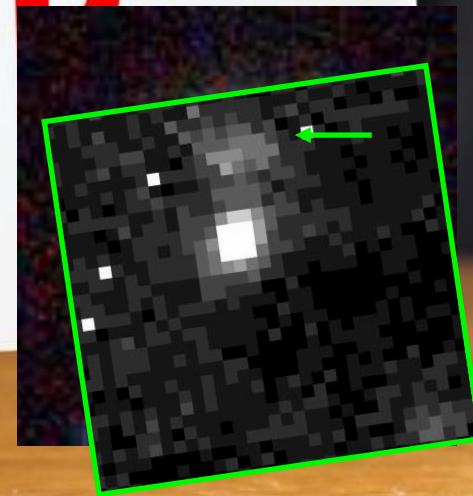
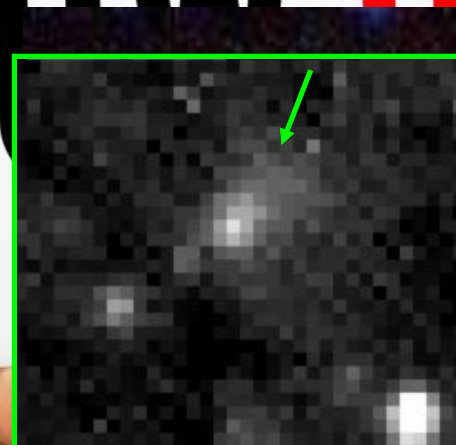
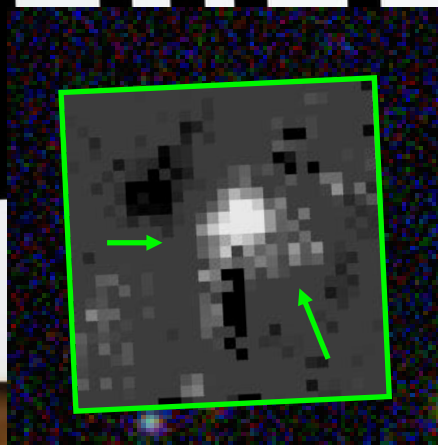
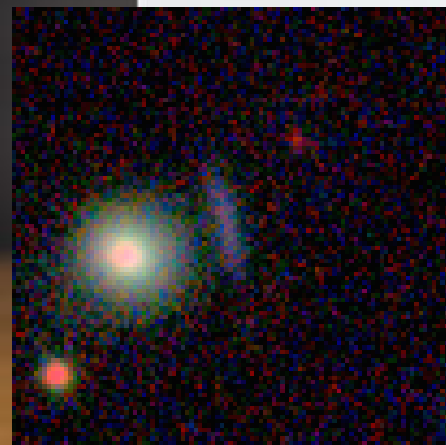
Spectroscopic follow-up (SALT)

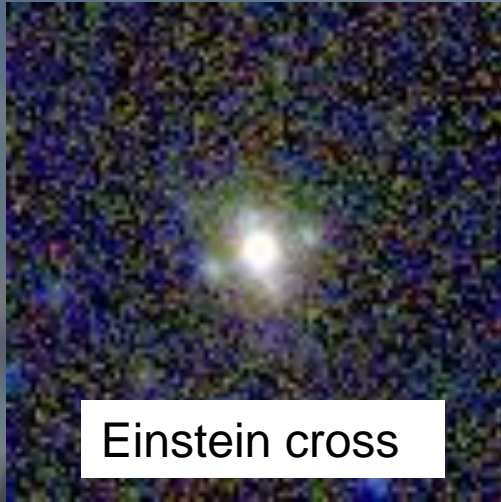


Spectroscopic follow-up (VLT)



FOLLOW UP





Einstein cross

Not searched but found by our CNN.

Lensed quasars are rarer (only ~100 known)!



Spiniello's talk

