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|-----------------------------------------|-------------------------------------------------------------------------------------------------|
| <b><i>Publication Year</i></b>          | 2018                                                                                            |
| <b><i>Acceptance in OA</i></b>          | 2020-10-13T09:40:00Z                                                                            |
| <b><i>Title</i></b>                     | Rare Treasures in the KiDS Survey                                                               |
| <b><i>Authors</i></b>                   | TORTORA, CRESCENZO                                                                              |
| <b><i>Publisher's version (DOI)</i></b> | 10.5281/zenodo.1303321                                                                          |
| <b><i>Handle</i></b>                    | <a href="http://hdl.handle.net/20.500.12386/27753">http://hdl.handle.net/20.500.12386/27753</a> |



# Crescenzo Tortora



university of  
groningen

## Napoli

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

## Groningen

Koopmans  
Verdoes Kleijn  
Petrillo  
Vernardos  
Chatterjee  
.....

## Other institutions

Kuijken  
Radovich  
.....

Better Than Before  
Rare treasures in the KiDS survey



**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).

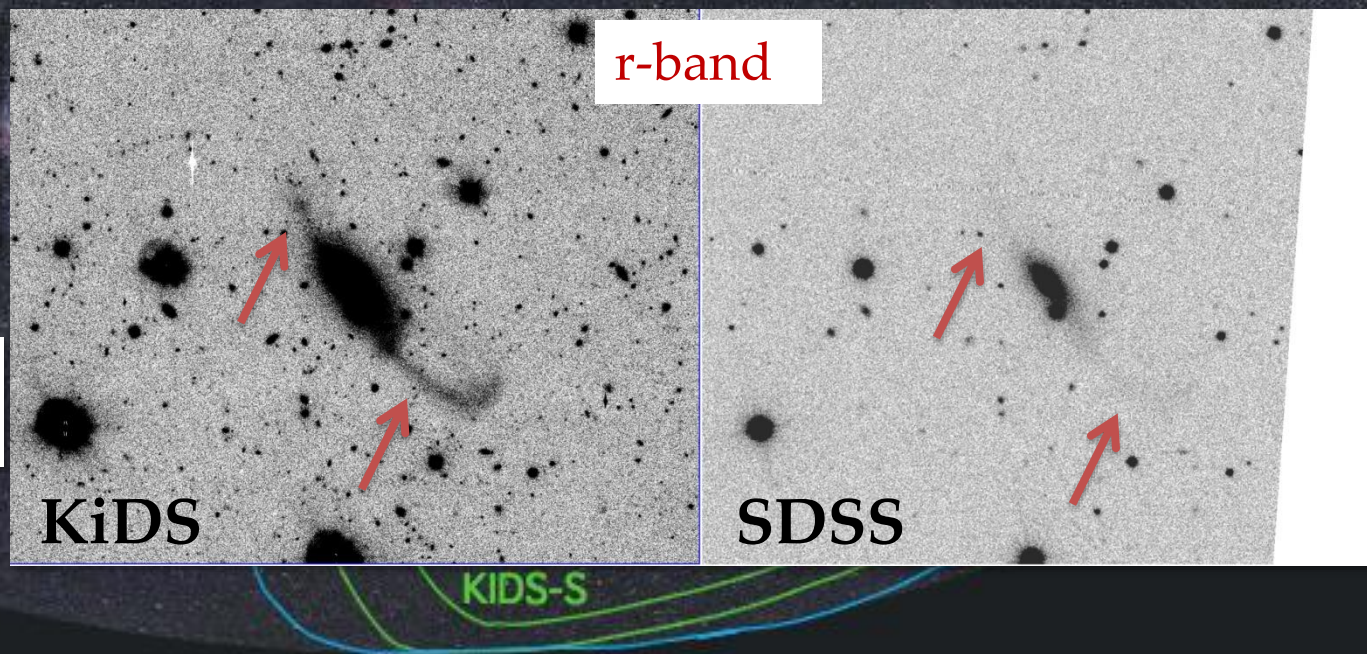
Deeper and with better quality and higher spatial resolution than previous surveys.

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**

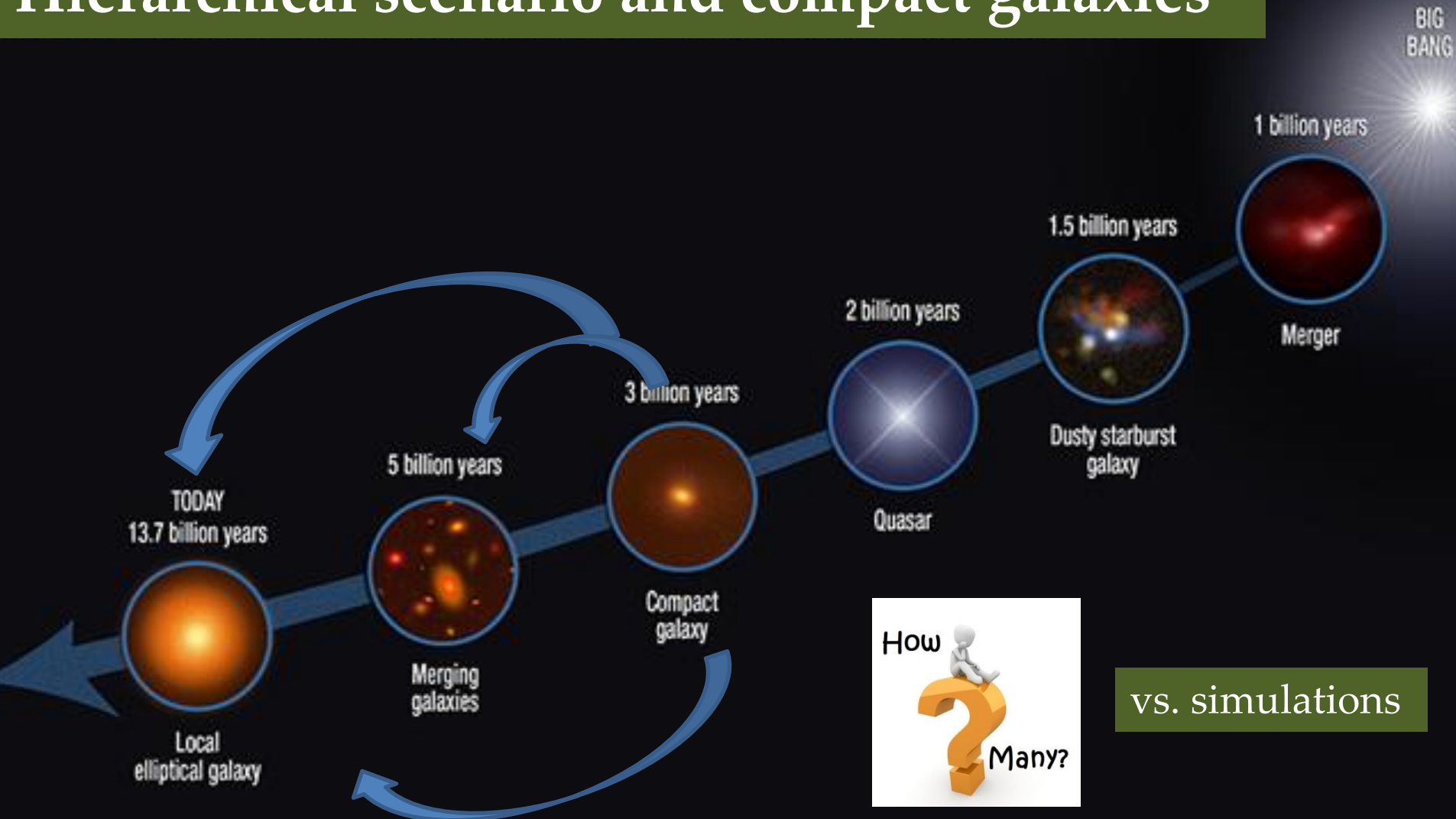
C. Tortora,<sup>1\*</sup> F. La Barbera,<sup>1</sup> N. R. Napolitano,<sup>1</sup> N. Roy,<sup>1,2</sup> M. Radovich,<sup>3</sup>  
S. Cavuoti,<sup>1</sup> M. Brescia,<sup>1</sup> G. Longo,<sup>2</sup> F. Getman,<sup>1</sup> M. Capaccioli,<sup>2</sup> A. Grado,<sup>1</sup>  
K. H. Kuijken,<sup>4</sup> J. T. A. de Jong,<sup>4</sup> J. P. McFarland<sup>5</sup> and E. Puddu<sup>1</sup>

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

C. Tortora<sup>1\*</sup>, N.R. Napolitano<sup>2</sup>, M. Spavone<sup>2</sup>, F. La Barbera<sup>2</sup>, G. D'Ago<sup>2</sup>, C. Spiniello<sup>2</sup>,  
K. H. Kuijken<sup>3</sup>, N. Roy<sup>2,4</sup>, M. A. Raj<sup>2</sup>, S. Cavuoti<sup>2,4</sup>, M. Brescia<sup>2</sup>, G. Longo<sup>4</sup>,  
V. Pota<sup>2</sup>, C. E. Petrillo<sup>1</sup>, M. Radovich<sup>5</sup>, F. Getman<sup>1</sup>, L.V.E. Koopmans<sup>1</sup>, I. Trujillo<sup>6,7</sup>,  
G. Verdoes Kleijn<sup>1</sup>, M. Capaccioli<sup>4</sup>, A. Grado<sup>2</sup>, G. Covone<sup>4</sup>, D. Scognamiglio<sup>2</sup>,  
C. Blake<sup>8</sup>, K. Glazebrook<sup>8</sup>, S. Joudaki<sup>8,9,10</sup>, C. Lidman<sup>11</sup>, C. Wolf<sup>12</sup>

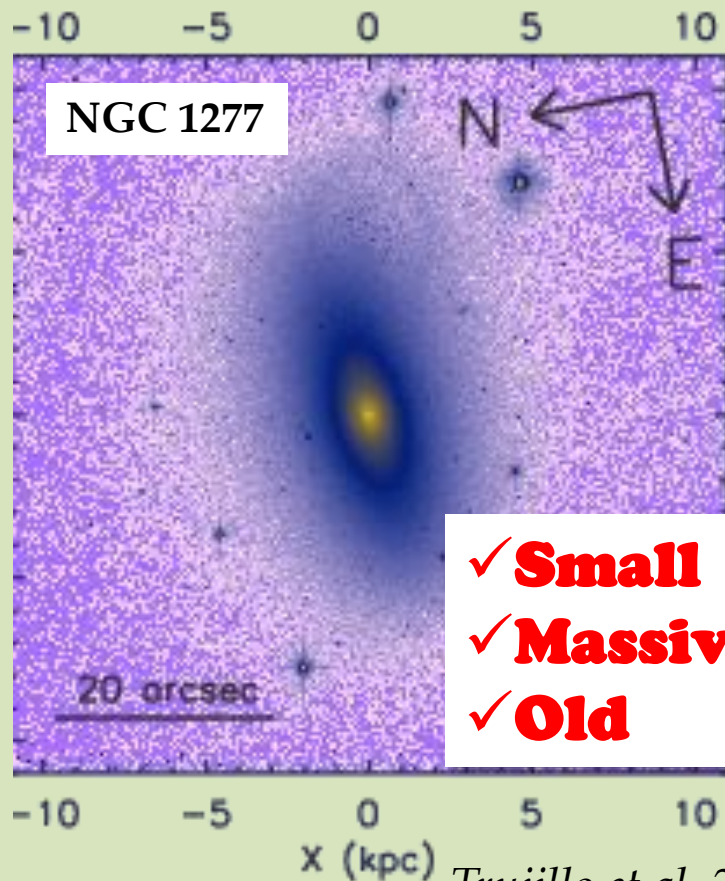
**Better Than Before**  
**The census of ultra-compact massive galaxies**

# Hierarchical scenario and compact galaxies



# Ultra-compact massive galaxies (UCMGs)

## “LOCAL RED NUGGET”



*Trujillo et al. 2014*

## UCMGs definition

$R_e < 1.5 \text{ kpc}$

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

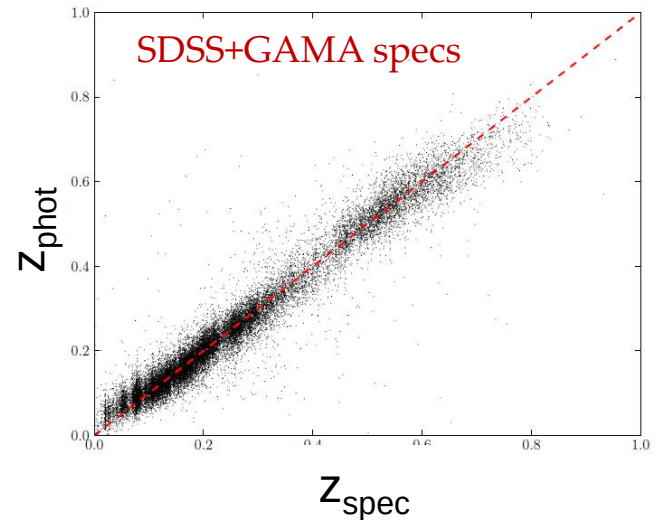
# Data analysis

## Photo-z

(machine learning, specs to train the network)

scatter  $\sim 0.03$

*Cavuoti et al. 2015, 2017*



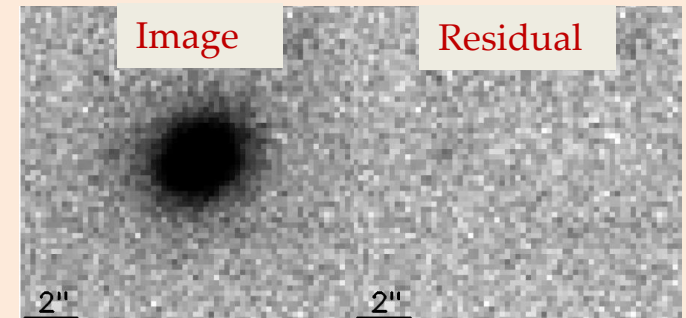
## Stellar masses

(SED-fitting, using Lephare program)

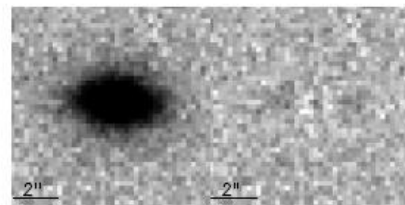
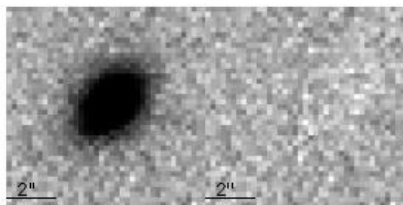
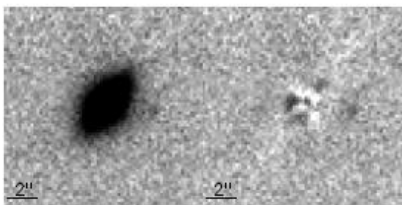
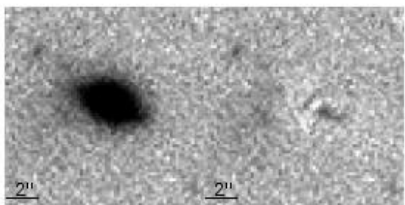
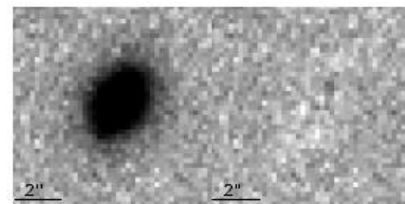
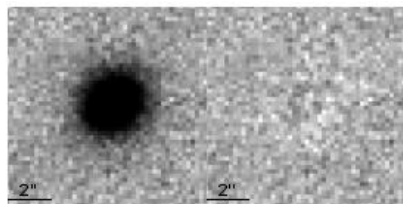
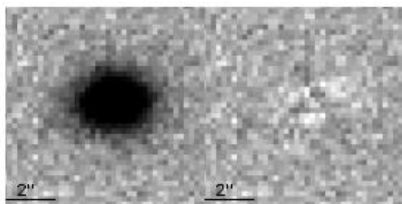
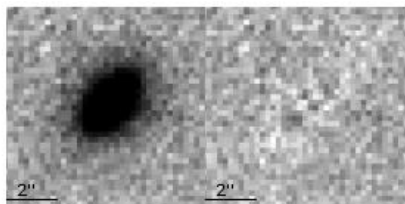
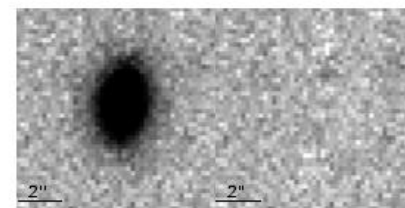
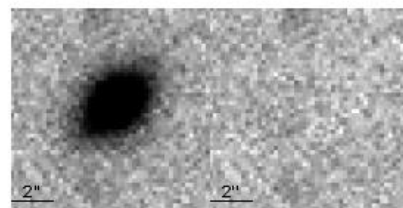
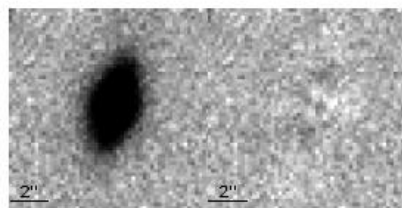
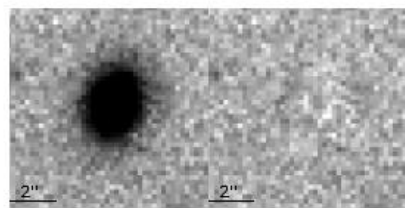
## Structural parameters

(2DPHOT, Sérsic fit, modelling the PSF)

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



# Some UCMG candidates



Complete at  $z < 0.5$

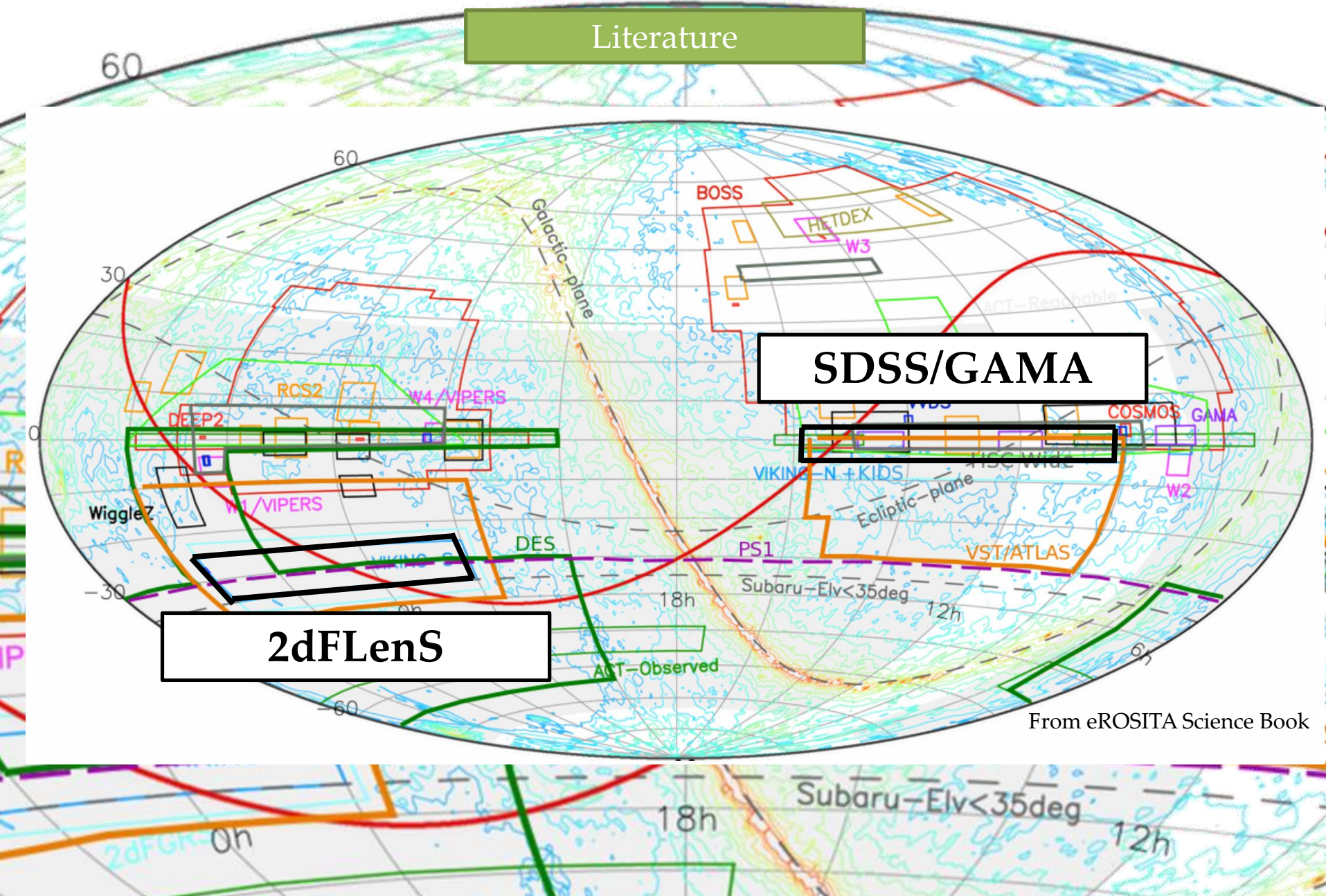


Spectroscopic redshifts

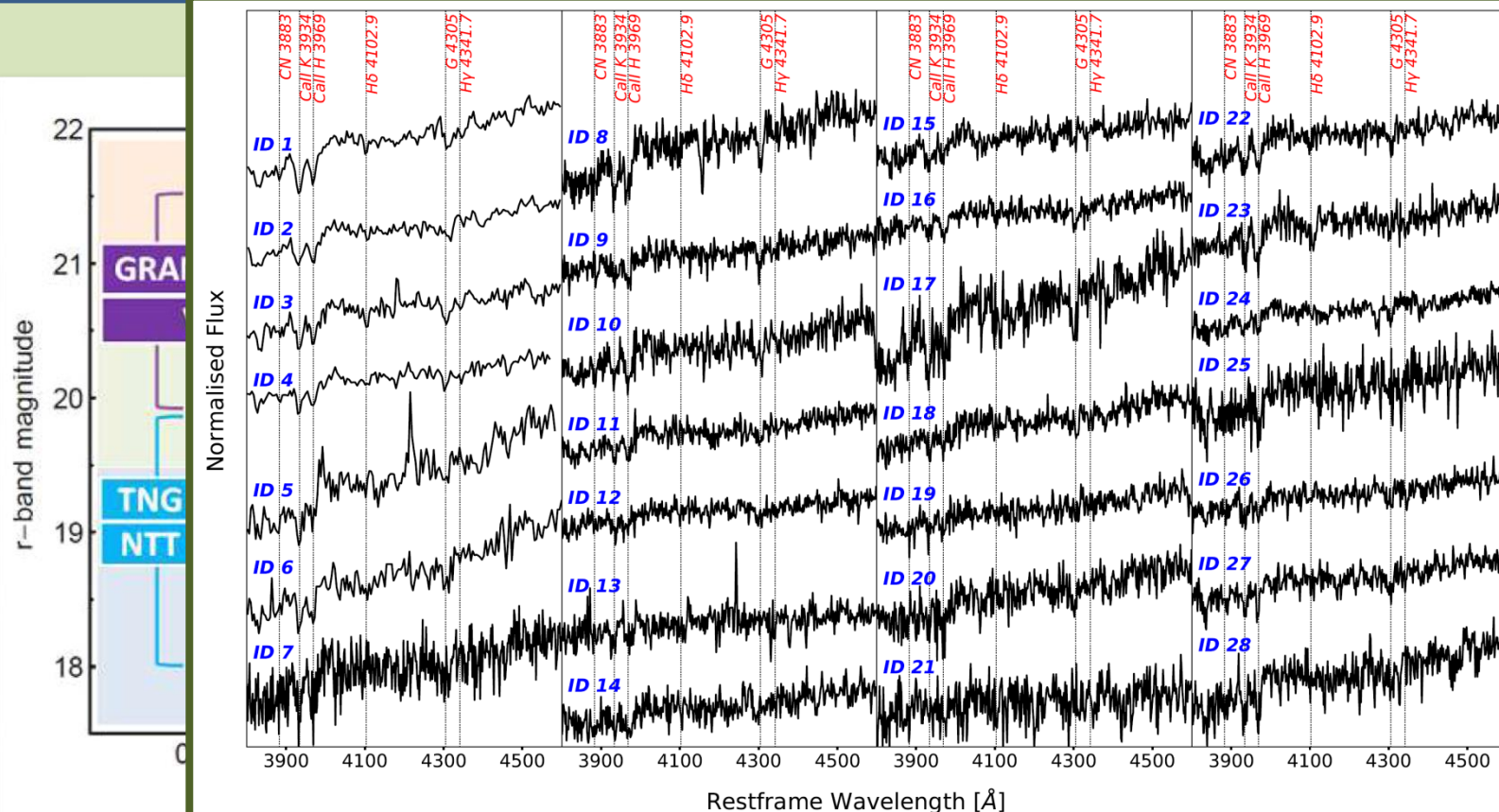
Literature

New observations

## Literature



## New observations



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





## Spectroscopic redshifts

Literature

New observations

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



False Positive

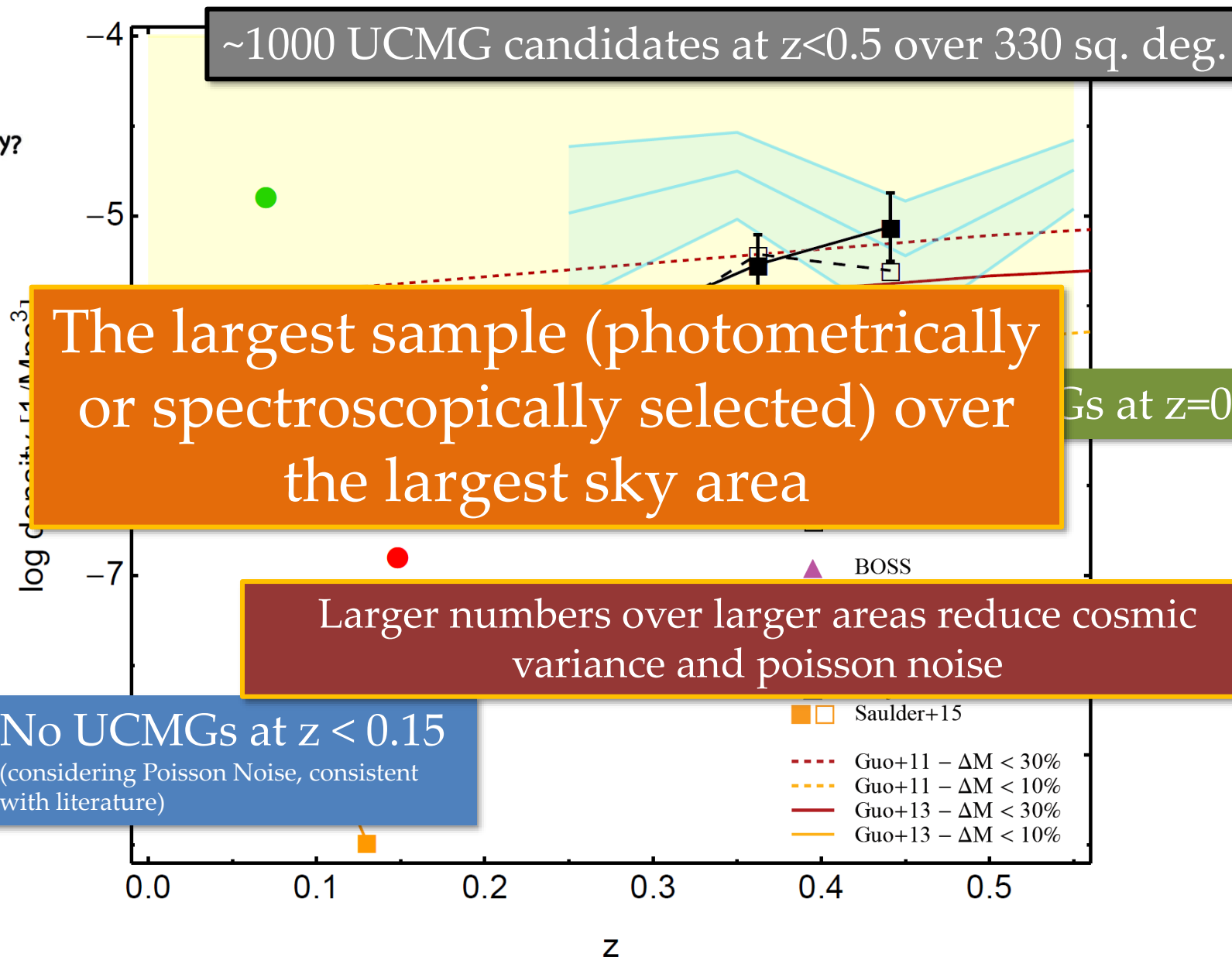


False Negative

How



Many?





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

C. E. Petrillo,<sup>1★</sup> C. Tortora,<sup>1</sup> S. Chatterjee,<sup>1</sup> G. Vernardos,<sup>1</sup> L. V. E. Koopmans,<sup>1</sup>  
G. Verdoes Kleijn,<sup>1</sup> N. R. Napolitano,<sup>2</sup> G. Covone,<sup>3</sup> P. Schneider,<sup>4</sup> A. Grado<sup>2</sup>  
and J. McFarland<sup>1</sup>

**Better Than Before**  
**The census of gravitational lenses**

galaxy

SLACS Survey strong lens object  
SDSSJ1430

Einstein ring

distant galaxy

nearby massive galaxy

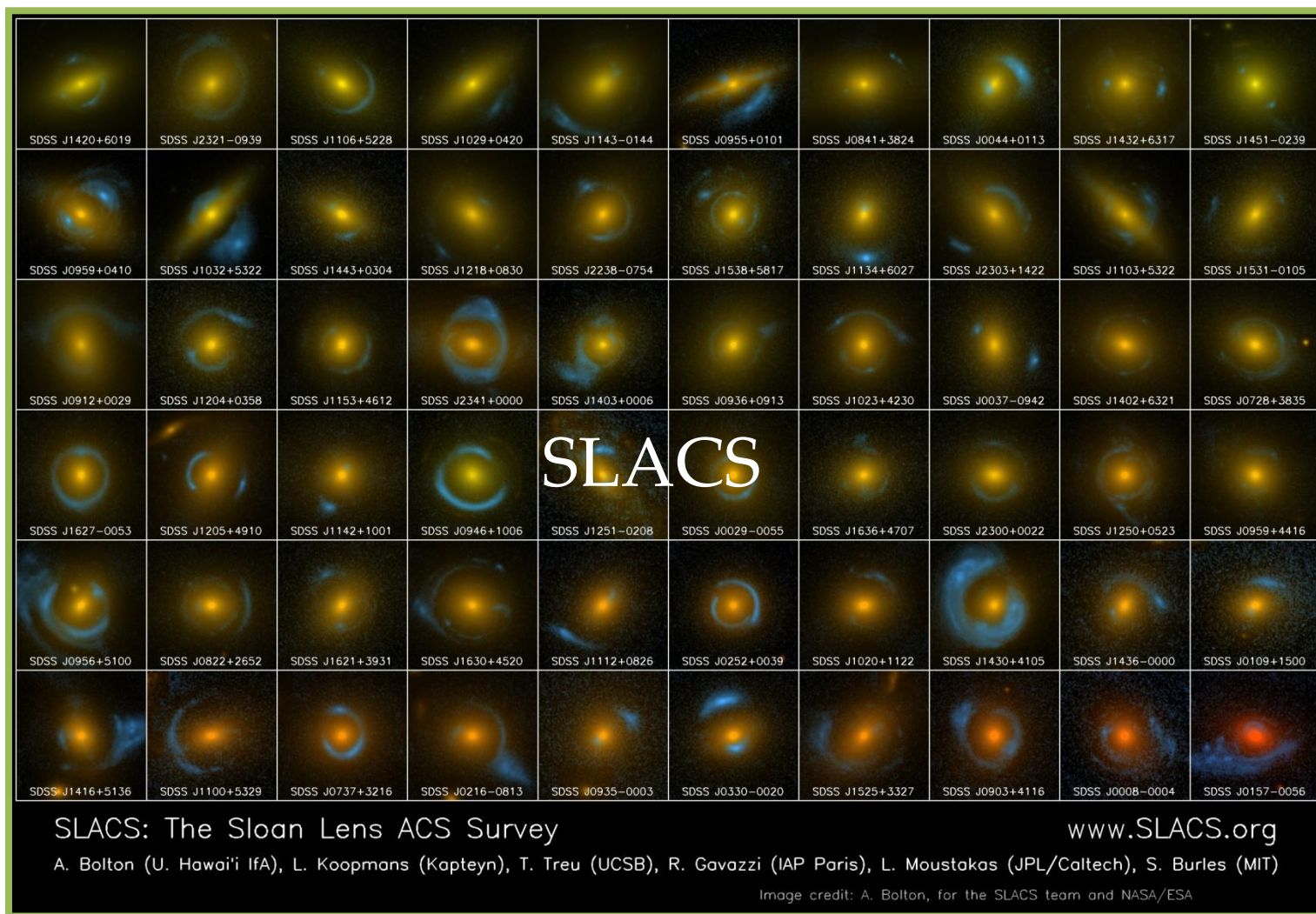
Einstein ring

The most precise galaxy mass estimate

Dark matter and mass density slope

Dark substructures

NASA/ESA



Now: ~ 600 lenses known



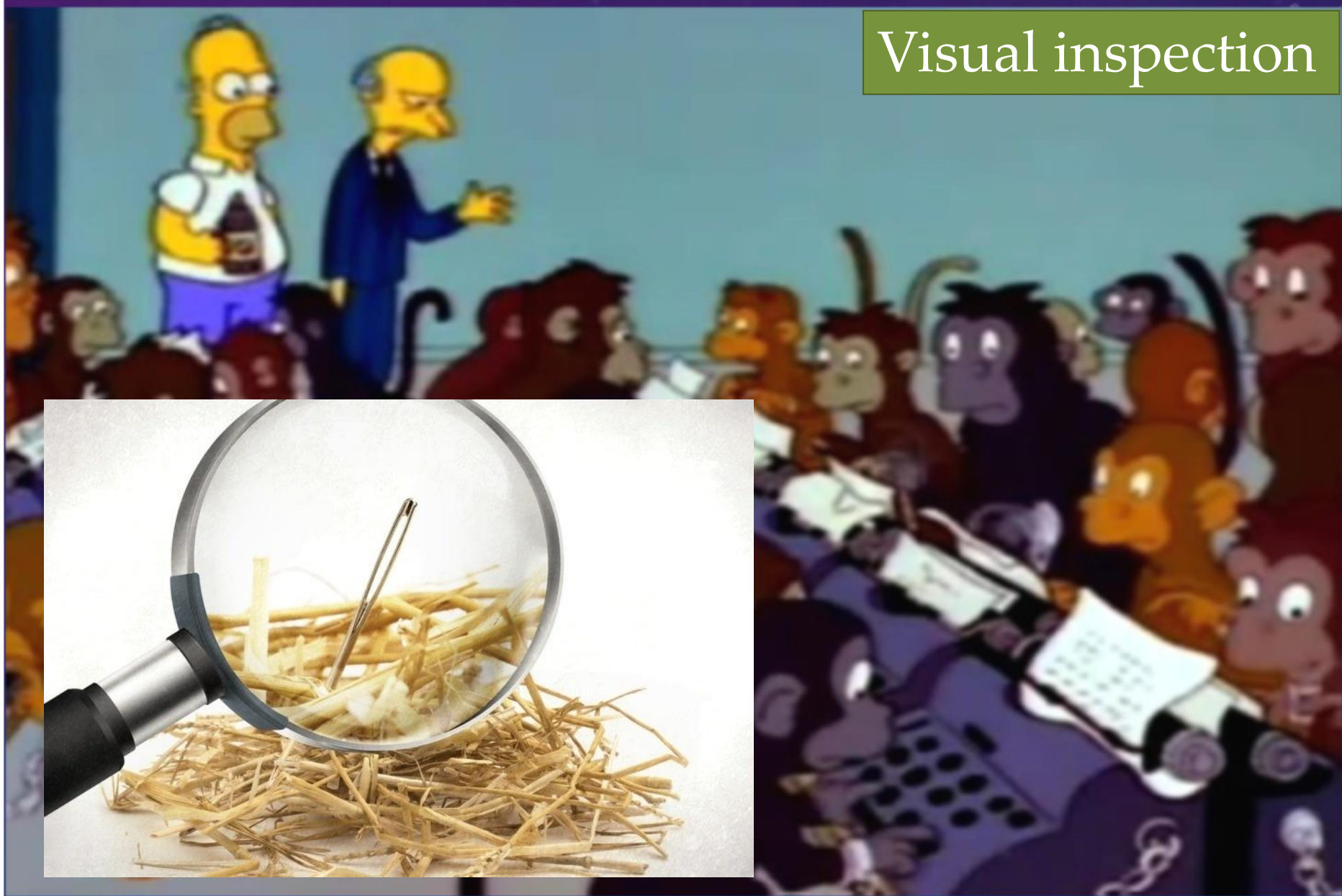
KiDS@VST

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



EUCLID (after two months)

# Visual inspection



# Automated search



cat



dog



# Training sample: an issue

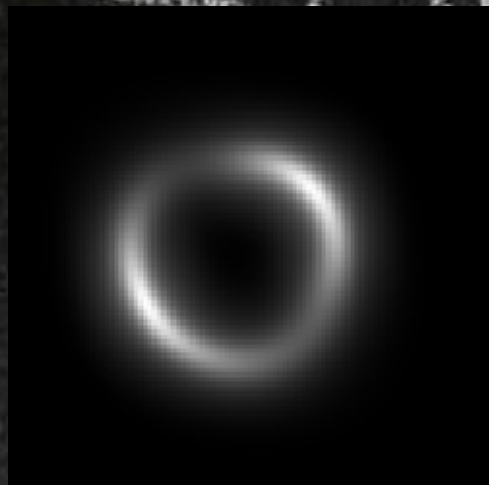
CNNs need large “training set”!



A few hundred of observed gravitational lenses

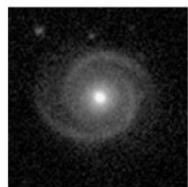


Mock gravitational lenses



# The strategy

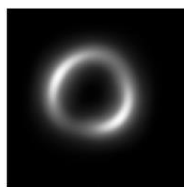
False positives and  
contaminants



LRGs



Mock lensed sources

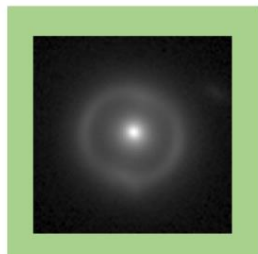


OR

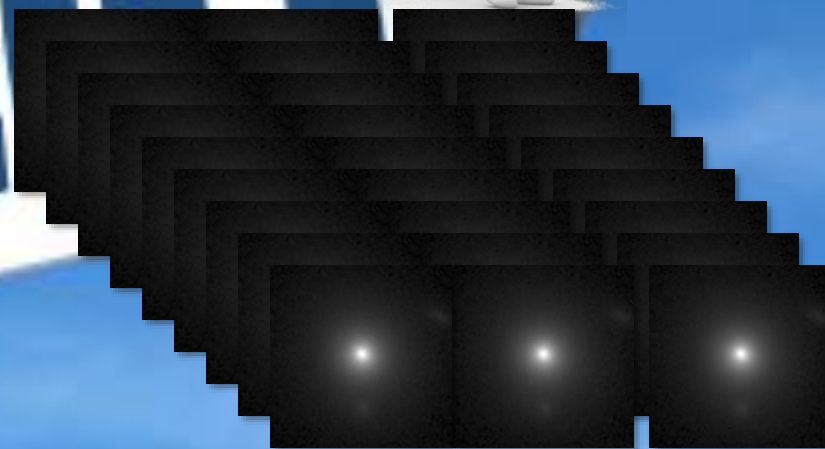
+



Non-lens Examples



Lens Examples



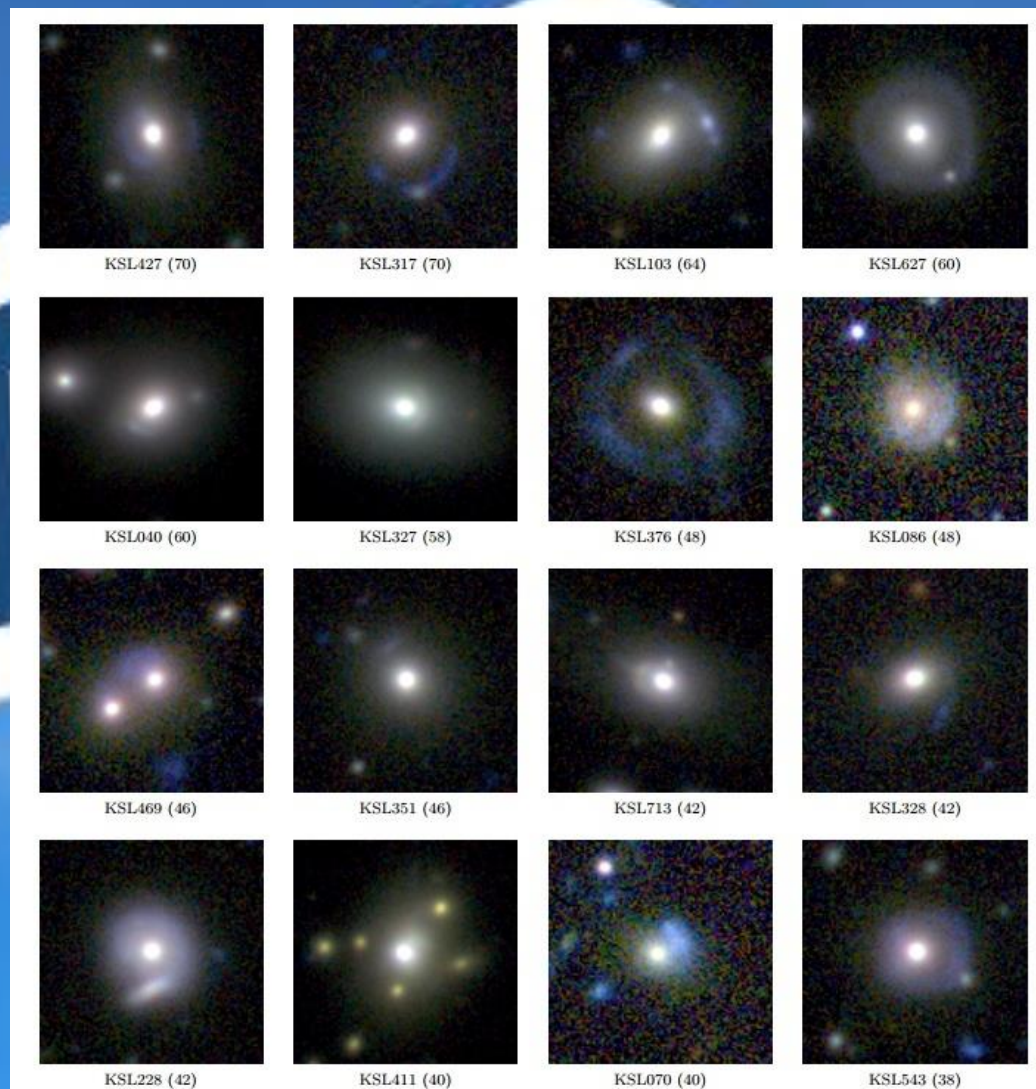
# The lens sample

From ~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

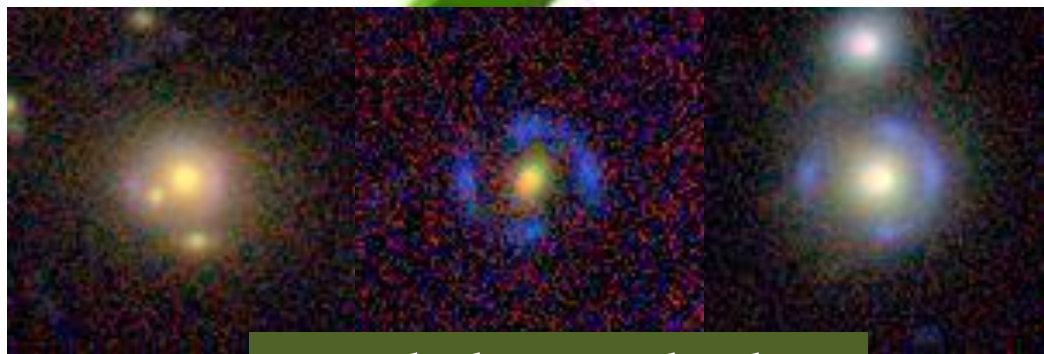


**FALSE**

# On-going improvements



Just morphology



Morphology and colour

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

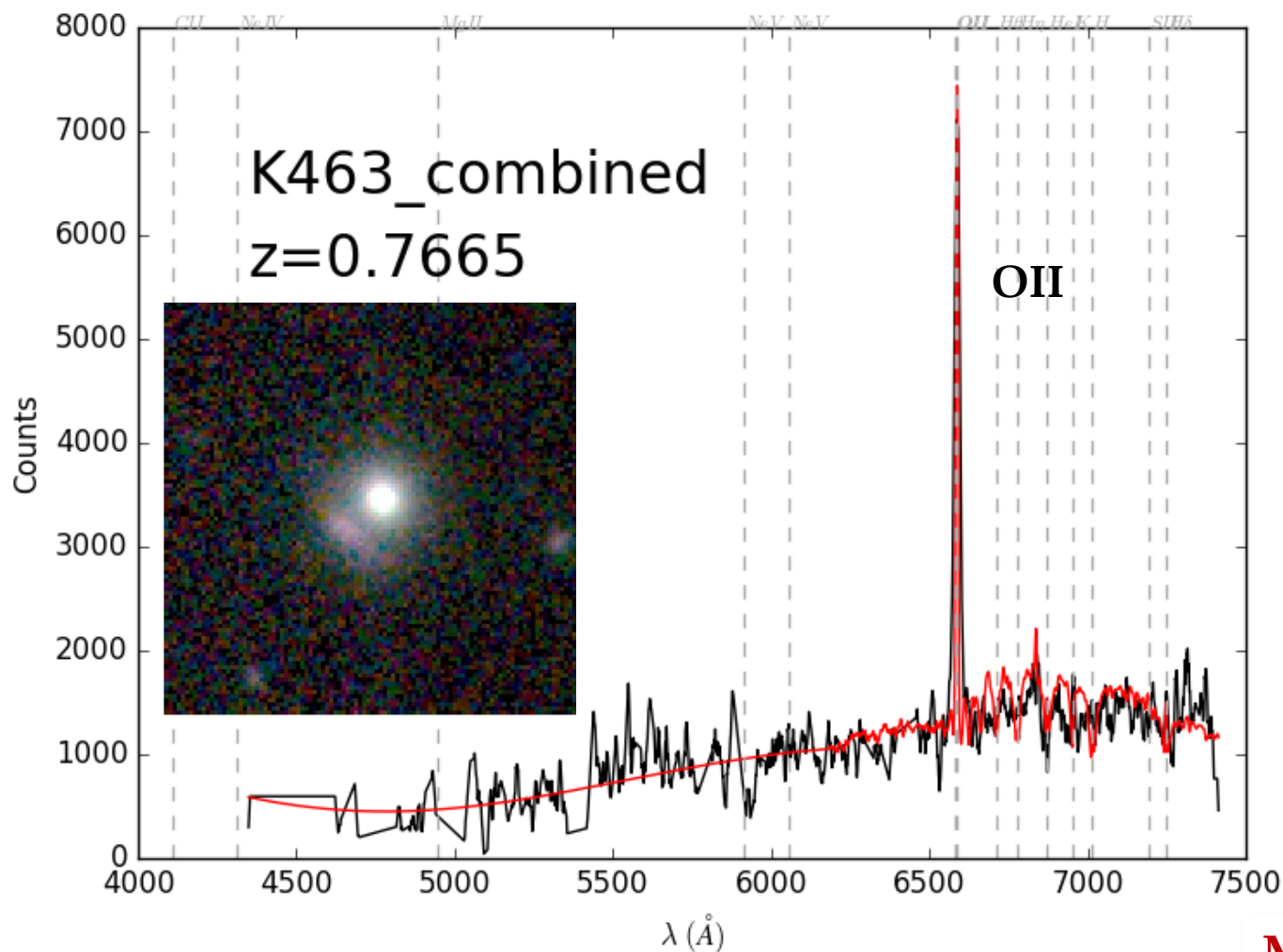
# Some new candidates



We are putting the basis of the  
future lens searches



# Spectroscopic follow-up (SALT)

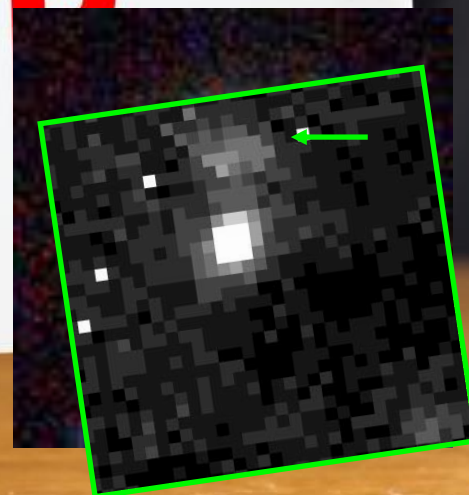
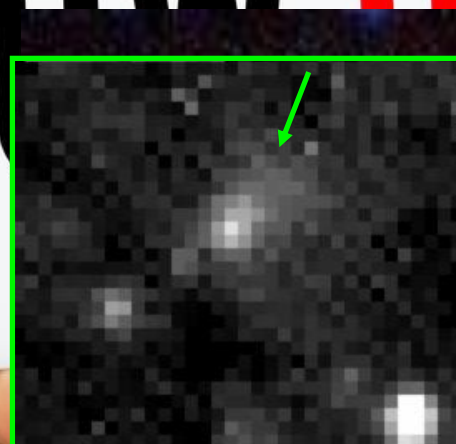
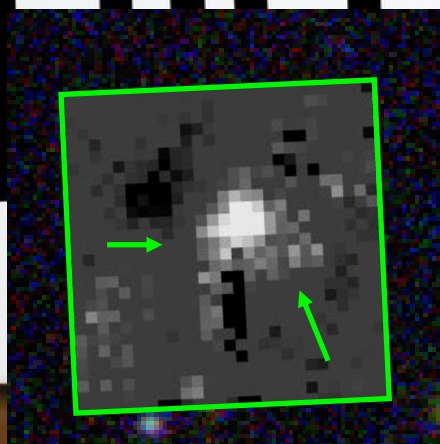
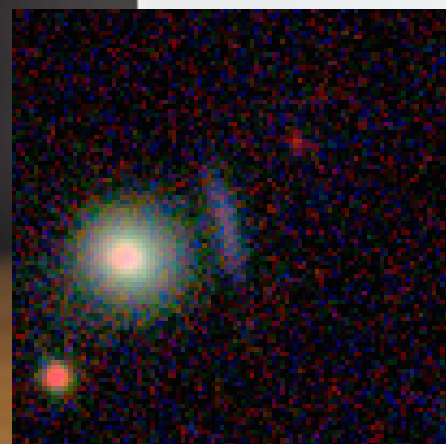


Marchetti's talk

# Spectroscopic follow-up (VLT)



FOLLOW UP



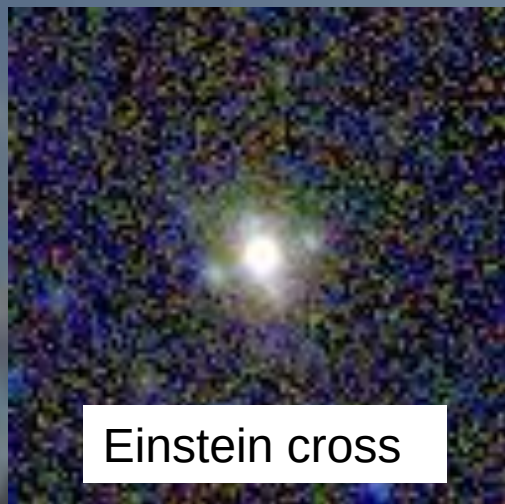
*Napolitano et al. in prep.; Spiniello et al. in prep.*

Not searched but found by our CNN.

Lensed quasars are rarer (only ~100 known)!



**Spiniello's talk**



Einstein cross

