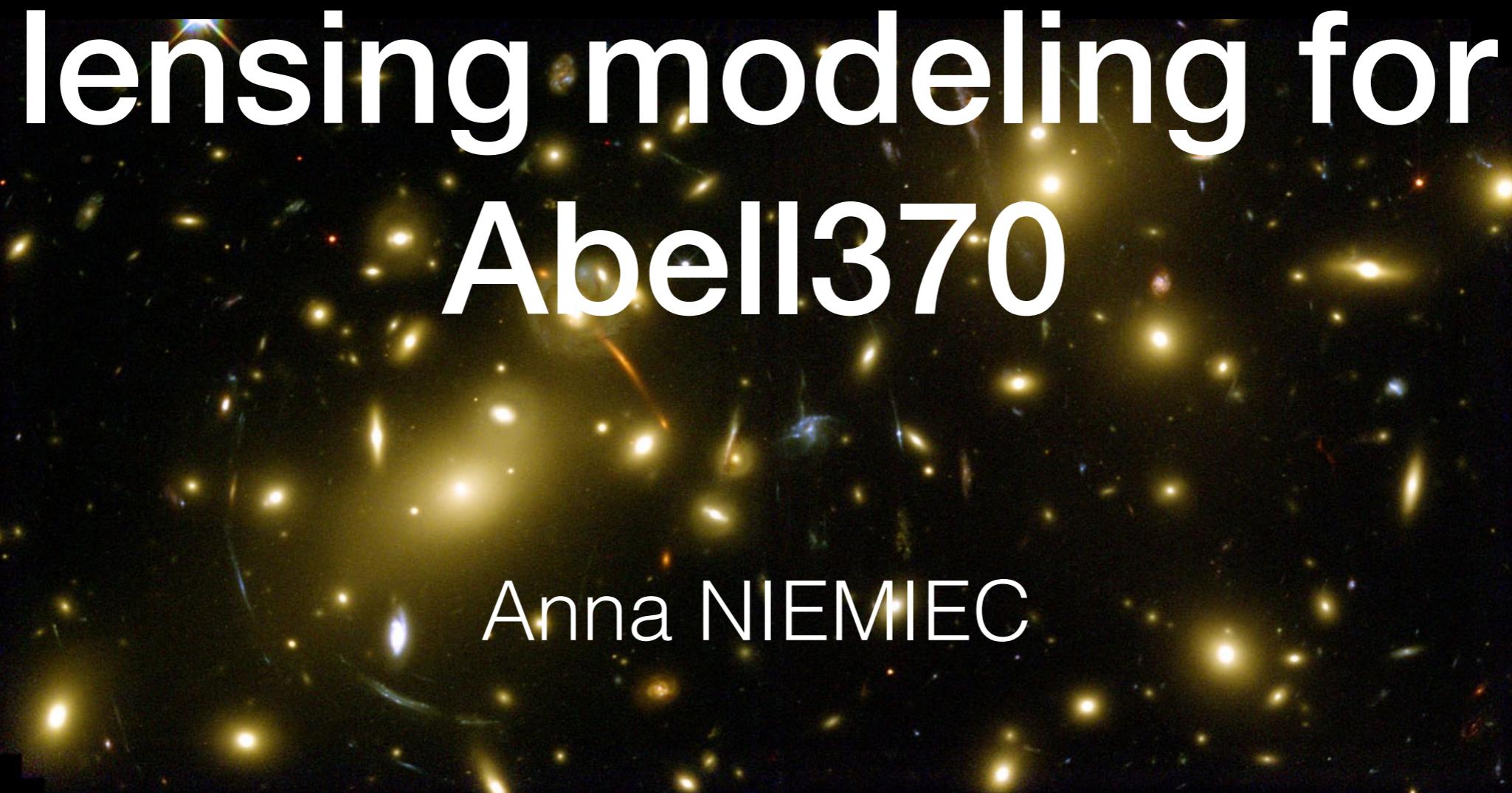




# Strong + weak lensing modeling for Abell370



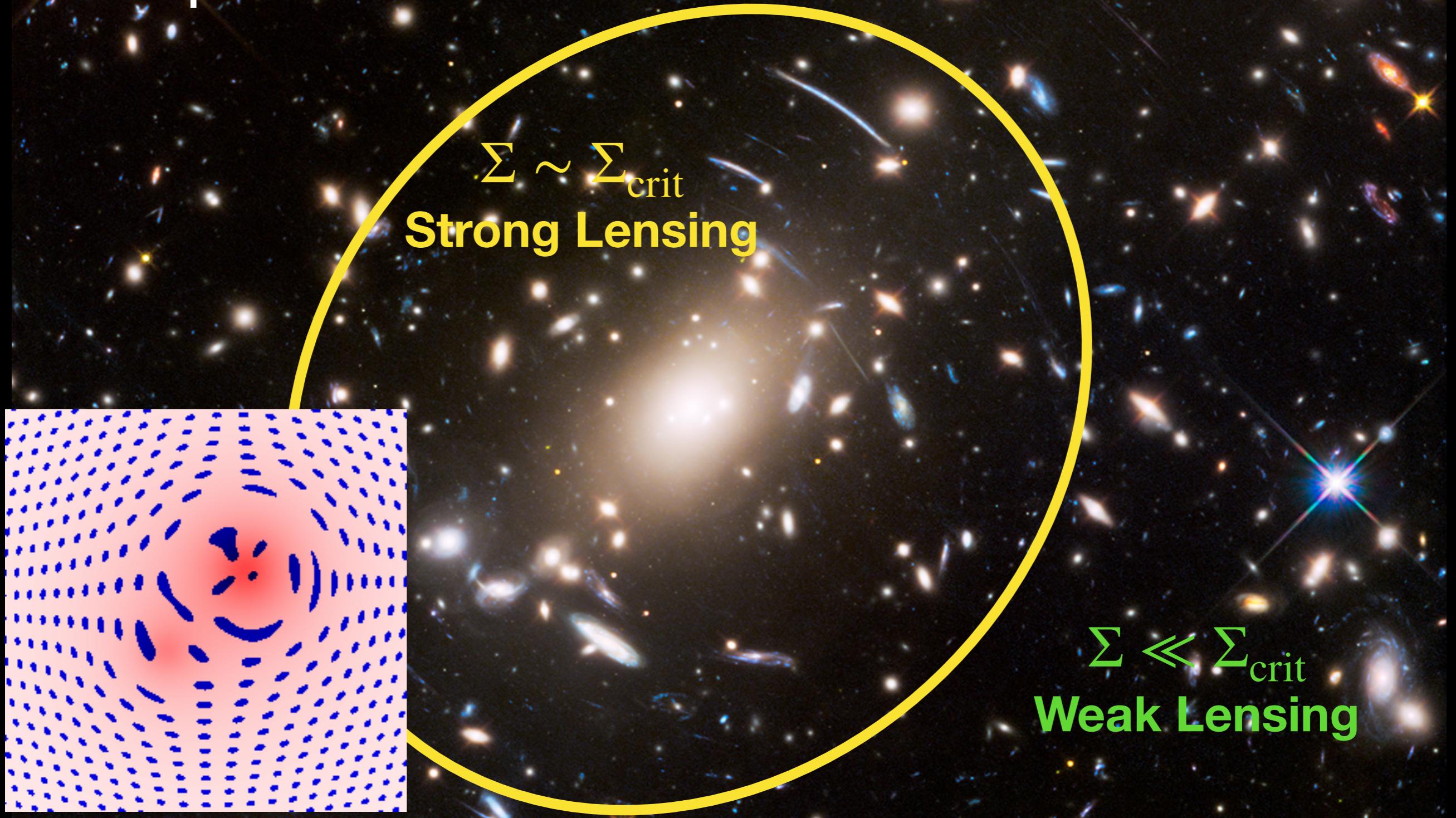
Anna NIEMIEC

## Galaxy Clusters lens modeling:

- cluster physics
- dark matter properties
- highly magnified galaxies
- high-z universe
- cosmology
- ...

**Need to model mass distribution with high precision and accuracy !**

# Gravitational lensing to probe matter distribution



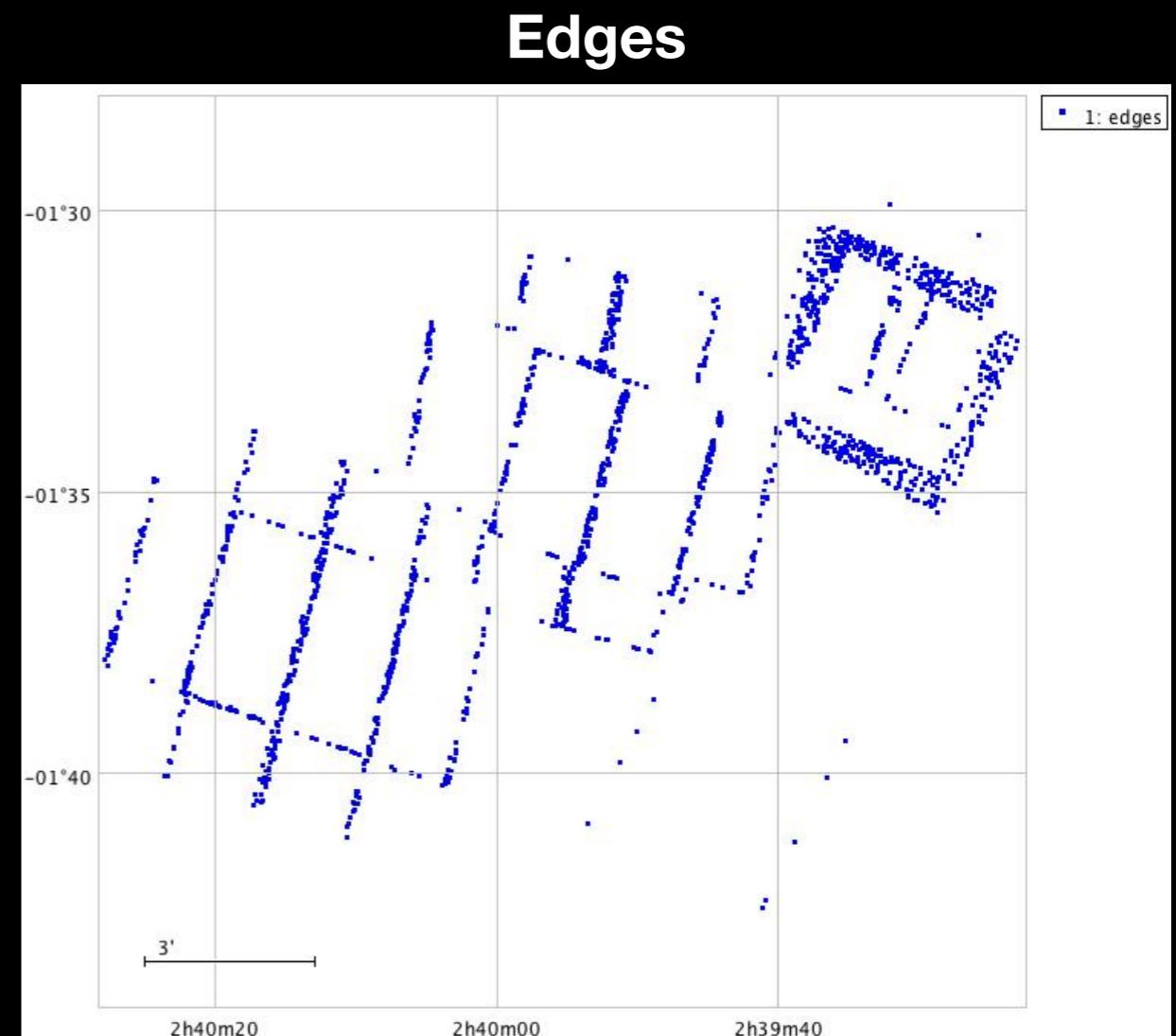
→ Model cluster projected mass distribution with SL and/or WL constraints

# Weak lensing catalogue for A370 : Shape measurement

- Run **pyRRG** on F814W :
  - Source detection on full mosaic + measure on single exposures
  - PSF correction in pyRRG for each position in the drizzled image :
    - Create a grid of positions covering the entire drizzled image
    - For each position, measure the PSF for each image covering this position
    - Take the average of the moments for each

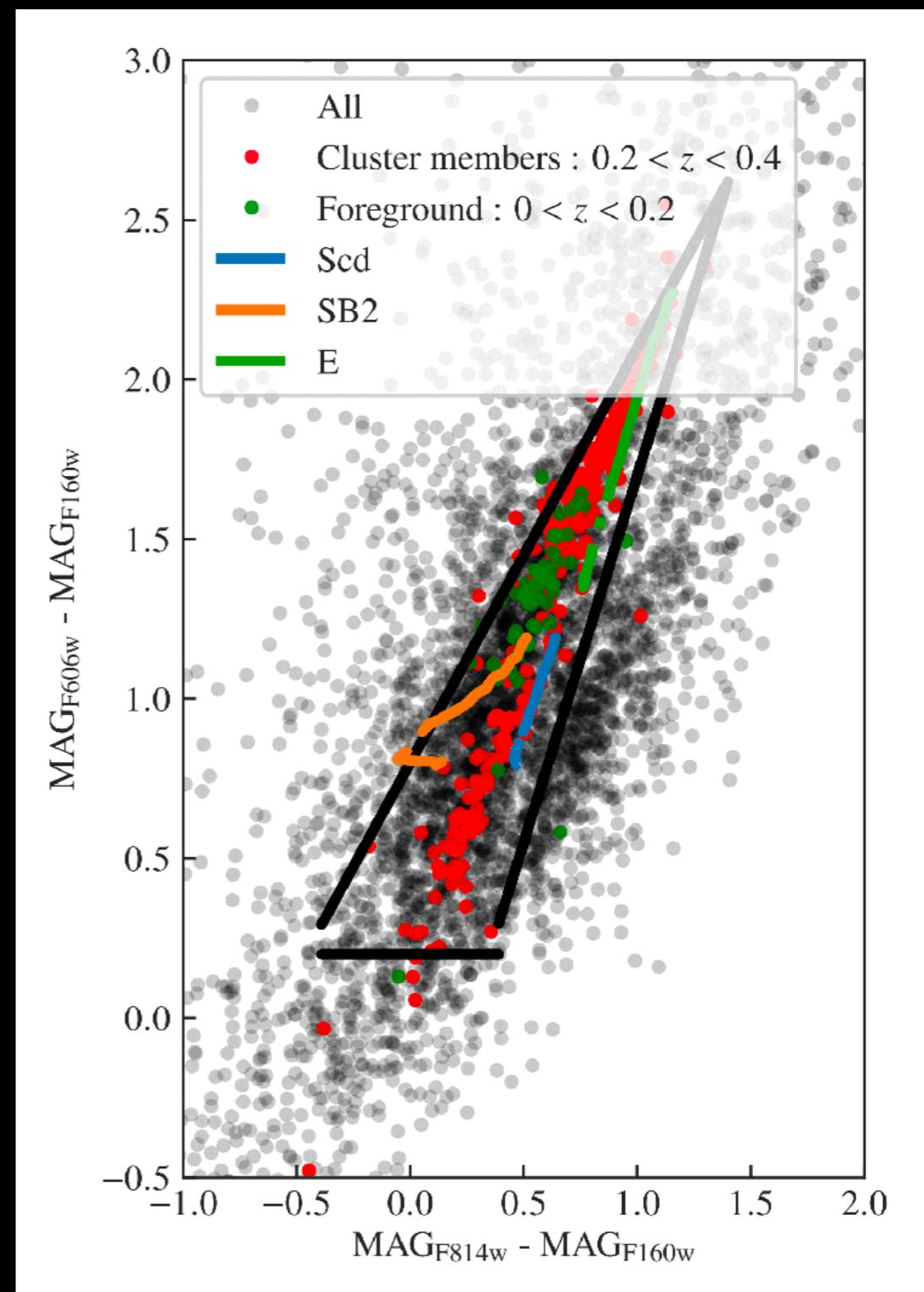
# Catalogue cleaning

- **Clean edges** with nExp :  
edges = ( $nExp < 4$ ) or ( $18 < nExp < 23$ )  
or ( $24 < nExp < 90$ )
- **Size** cut :  
 $gal\_size * 0.03 > 0.11$
- **Magnitude** cut :  
< 28.5 for HFF, < 27 for BUFFALO ;  
> 23 for all
- **Ellipticity** cuts :  
 $0 < e < 1$  ;  $e1/e2\_err > 0$
- Remove SL region



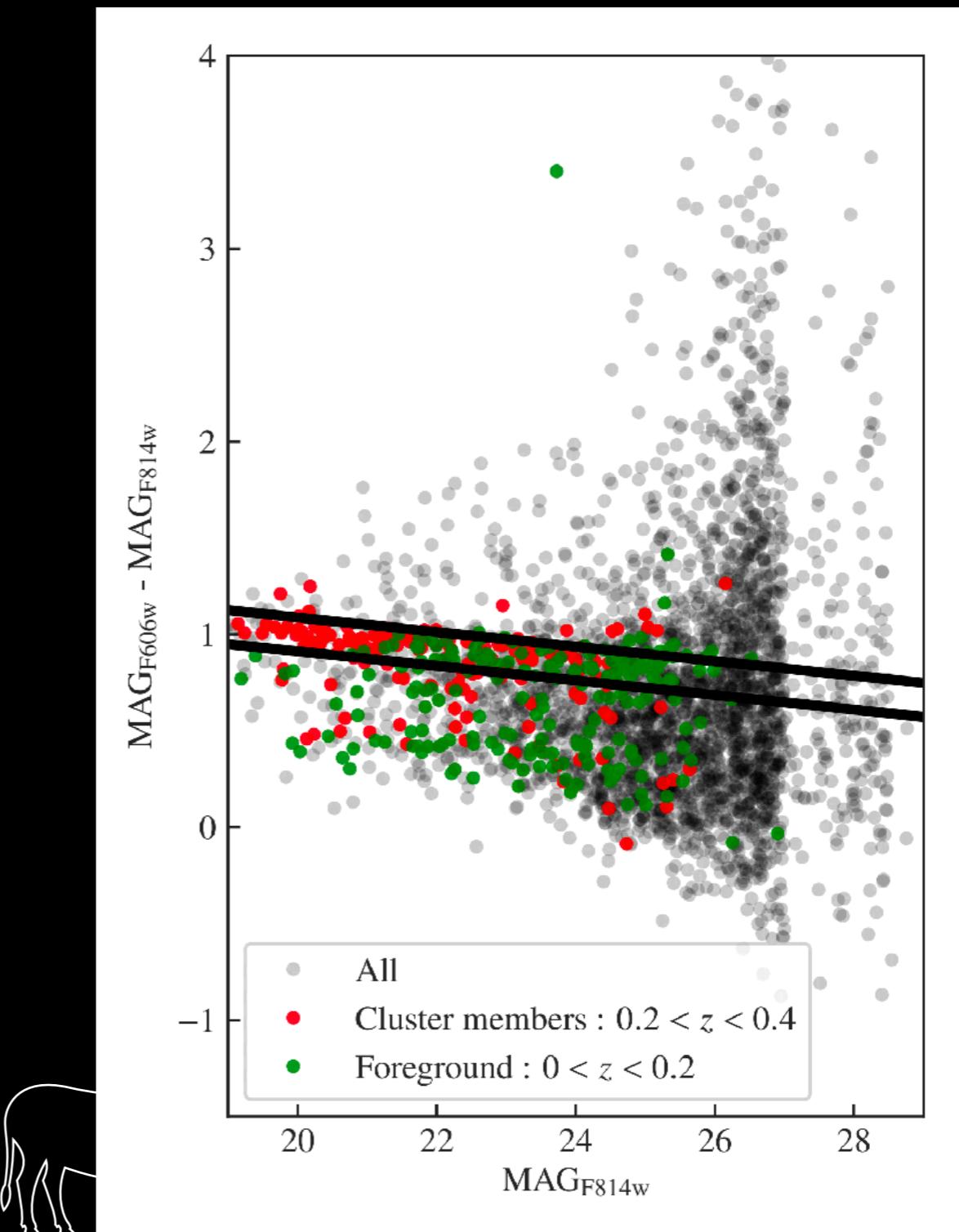
# Background galaxy selection

- sExtractor dual mode on F814w, F606w and F160w + match with redshift catalogue
- Galaxies with 3 bands : color-color cut
  - + alternative cc cuts
  - > no significant difference



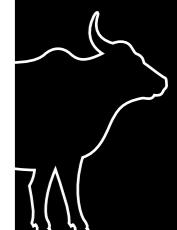
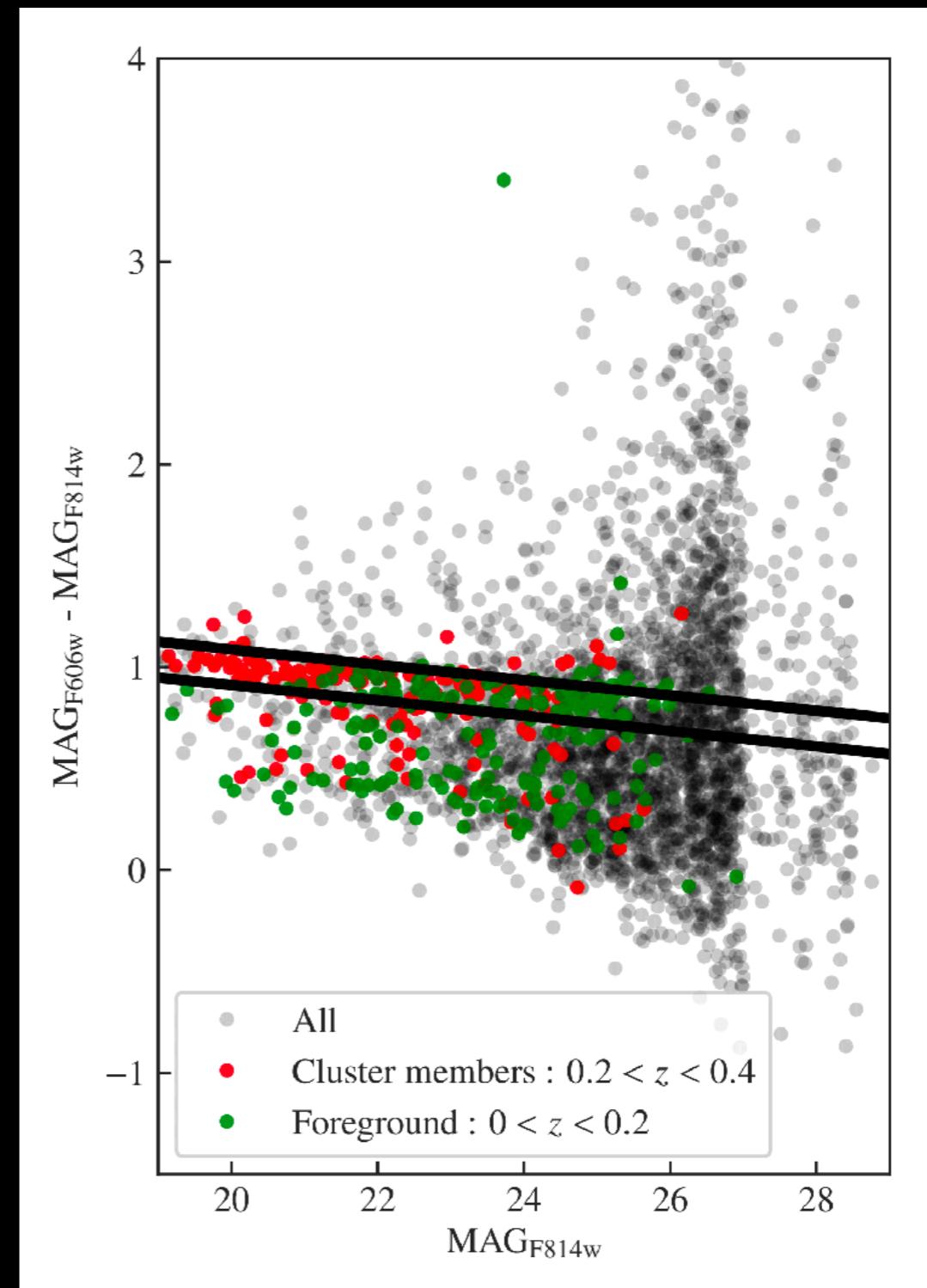
# Background galaxy selection

- sExtractor dual mode on F814w, F606w and F160w + match with redshift catalogue
- Galaxies with 3 bands : color-color cut
- Galaxies with 2 bands : color-magnitude cut



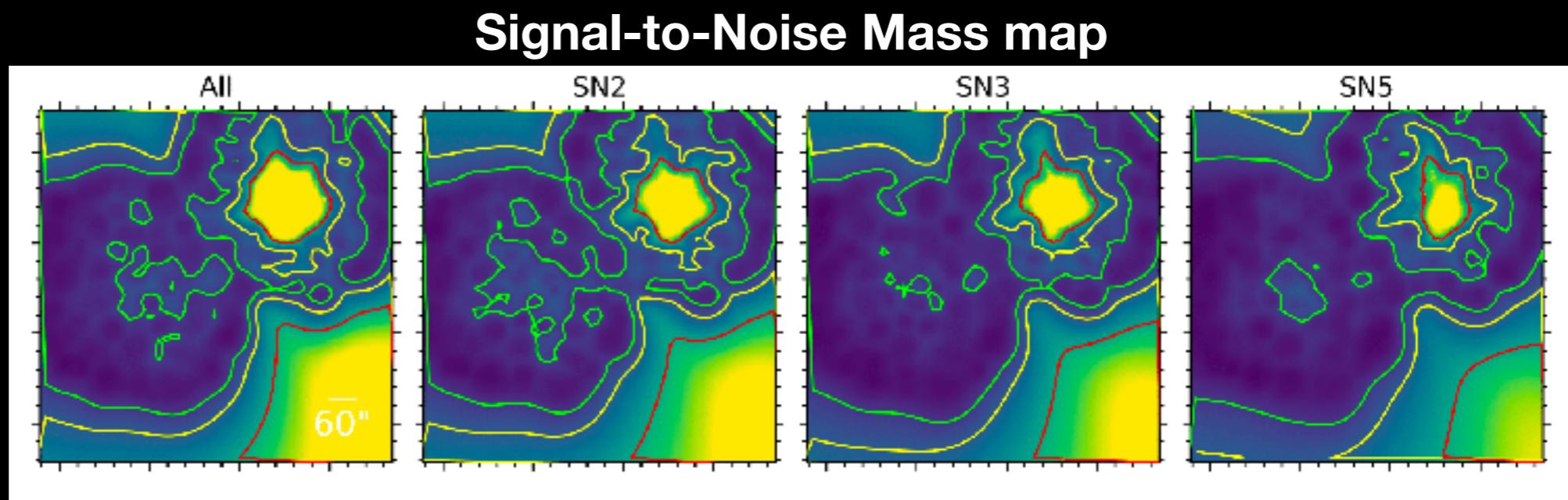
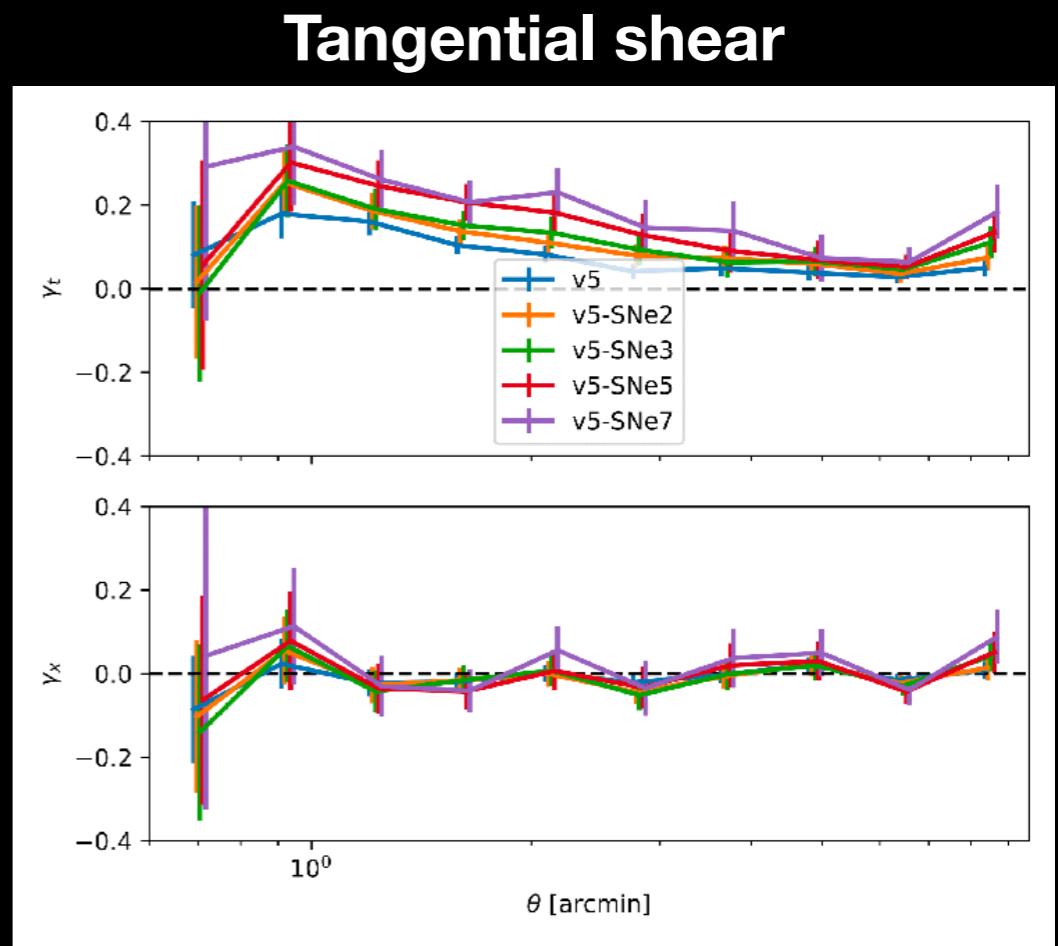
# Background galaxy selection

- sExtractor dual mode on F814w, F606w and F160w + match with redshift catalogue
- Galaxies with 3 bands : color-color cut
- Galaxies with 2 bands : color-magnitude cut
- Galaxies with 1 band : magnitude cut  $F814W < 26.5$



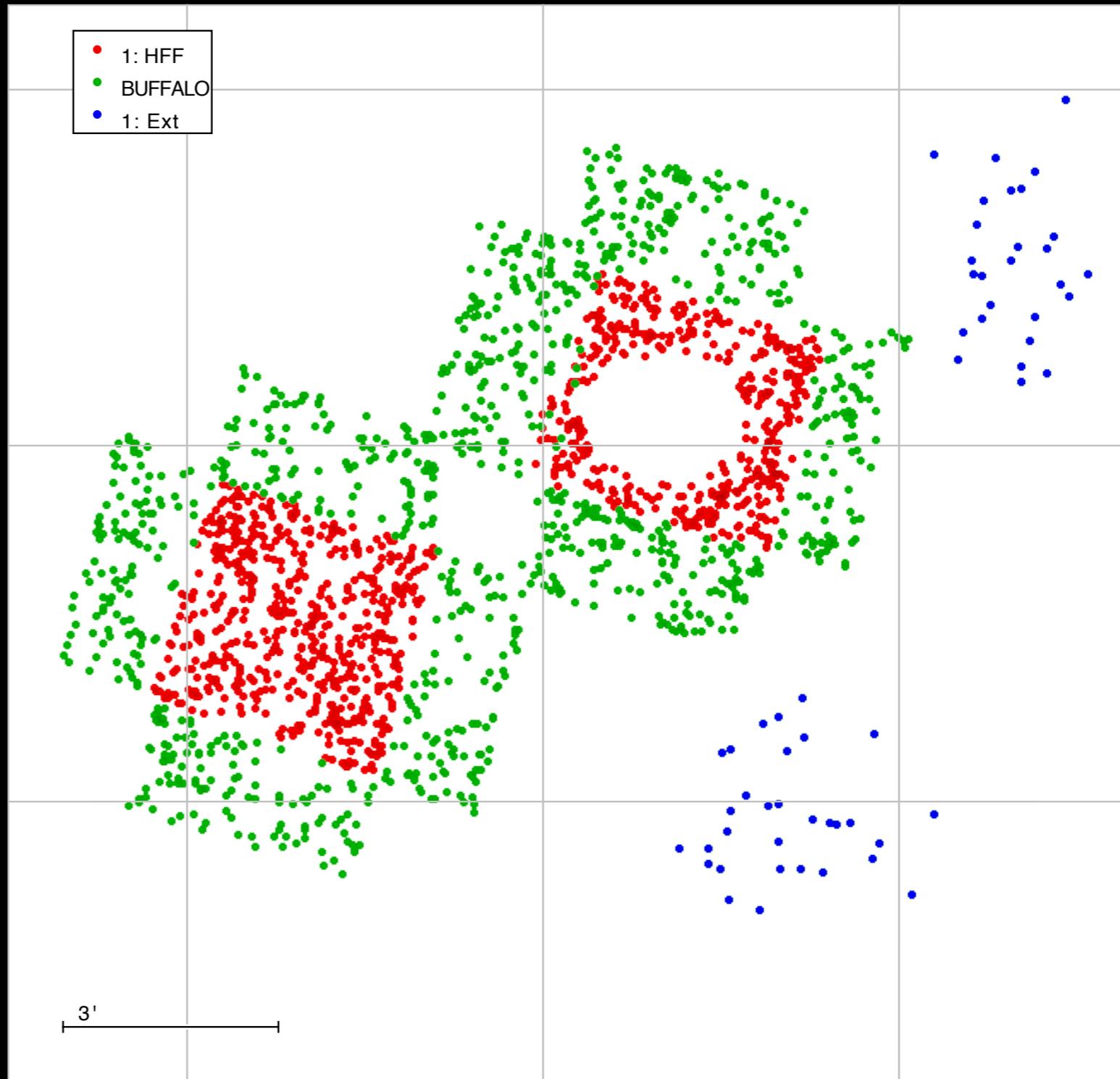
# Signal-to-Noise cut

- Some galaxies with high error on  $e_1, e_2 \rightarrow$  SN cut
- Try SN > 2,3,5,7
- Cut at SN > 2



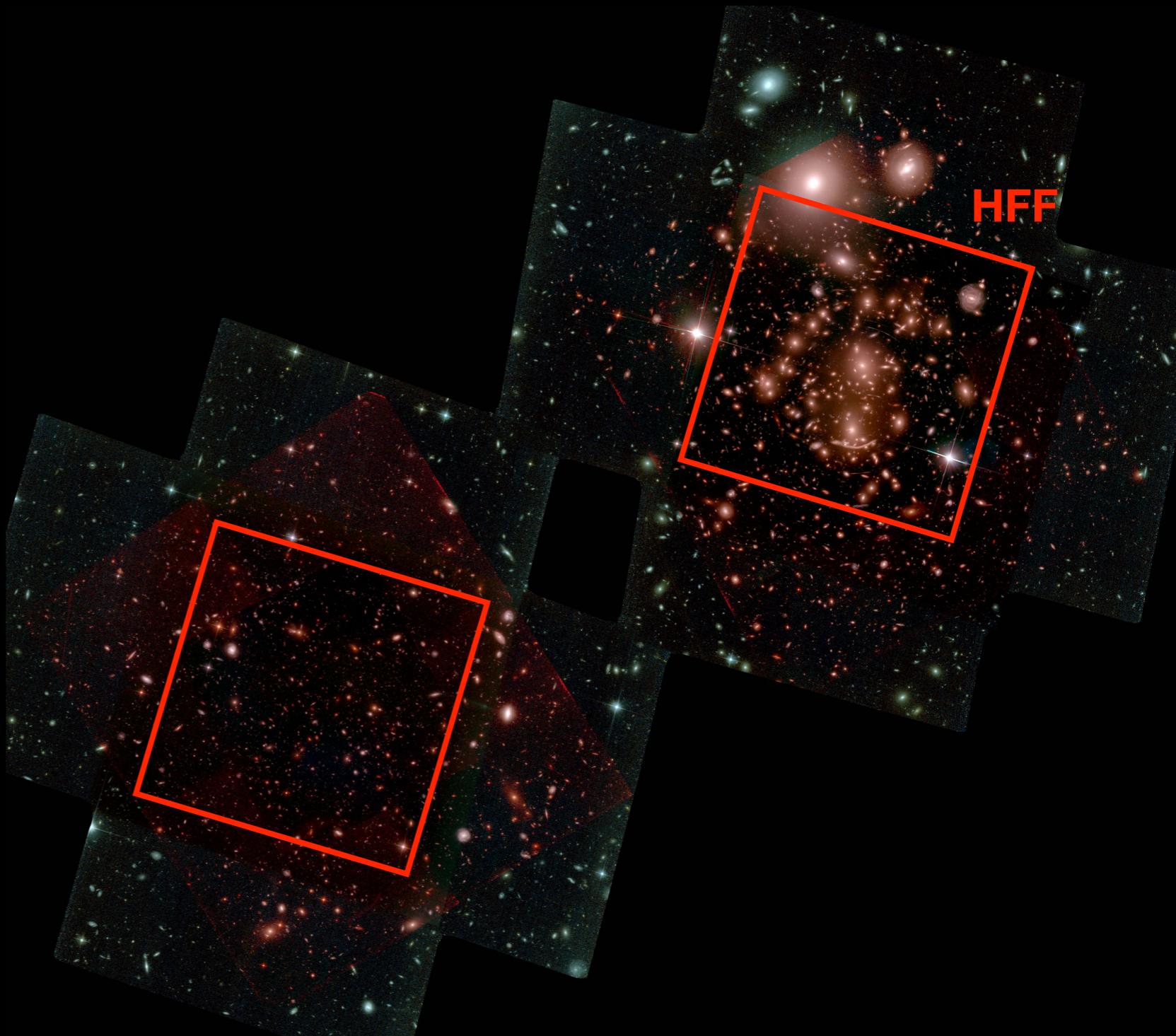
# Final catalogue

- Final catalogue :  
1964 galaxies
- $n_{\text{HFF}} = 42 \text{ sources/arcmin}^2$   
 $n_{\text{BUFF}} = 20 \text{ sources/arcmin}^2$   
 $n_{\text{Ext}} = 2.5 \text{ sources/arcmin}^2$



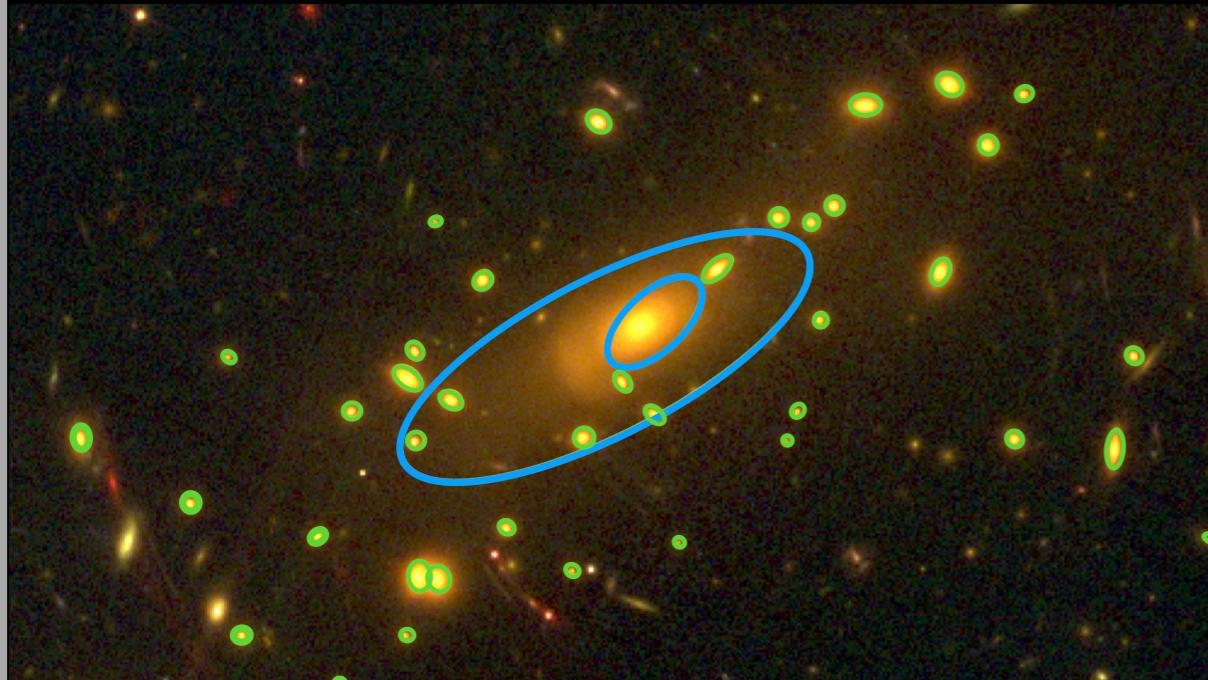
# h-Lenstool model for Abell370

- ▶ Latest SL model for A370 (*Lagattuta+2019*):  
4 large-scale potentials + **external shear**
- ▶ Could including substructures replace the external shear ?



# Cluster mass modeling

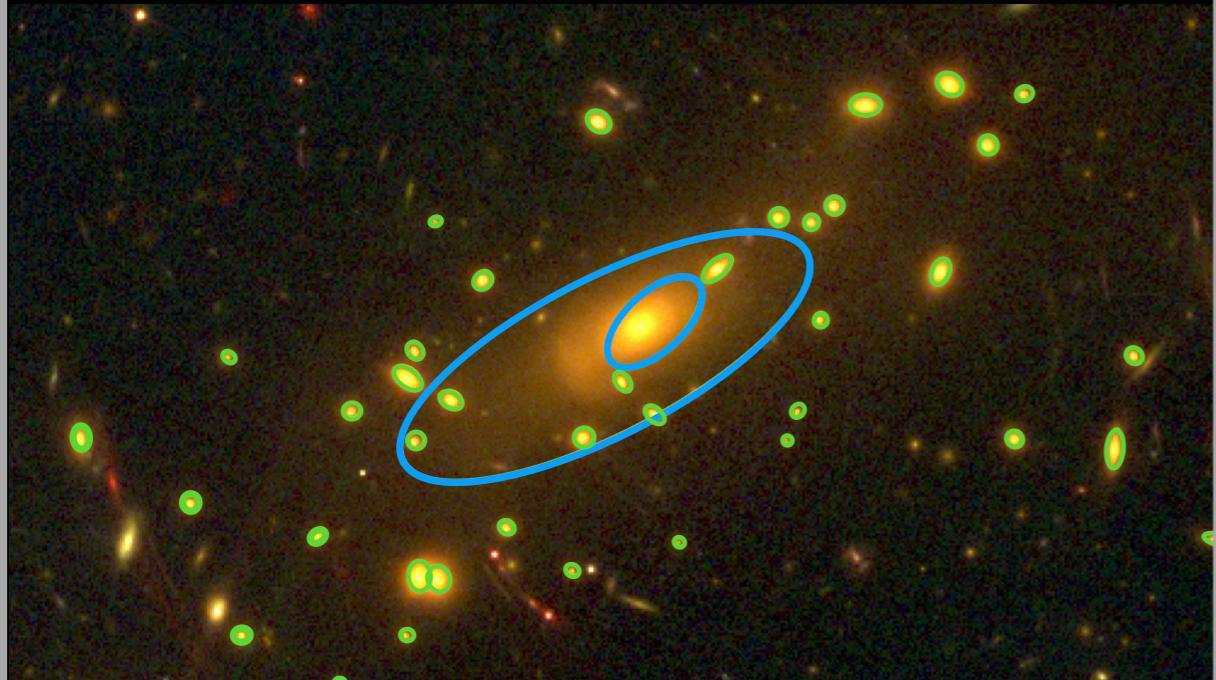
## Parametric mass modeling



- Physically motivated mass components
- Sparse distribution of SL constraints
- Ex: Glafic (*Oguri+2010*), LTM (*Zitrin+2012*), GLEE (*Suyu+2010*), **Lenstool** (*Jullo+2007*)...

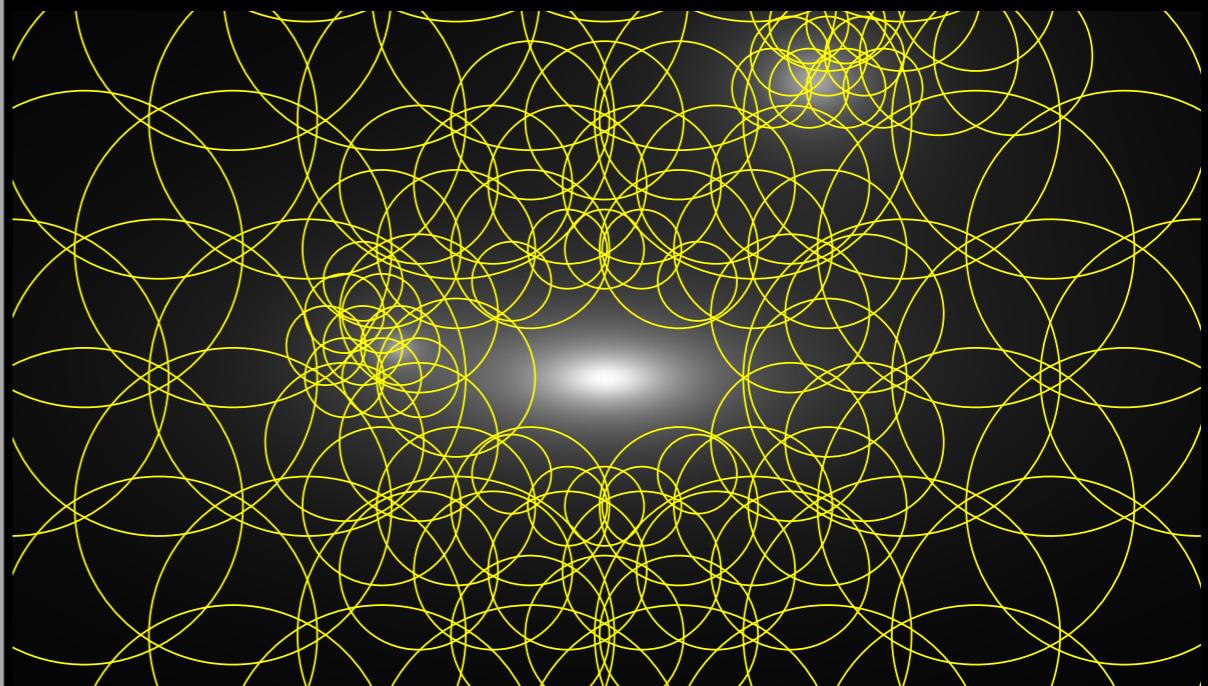
# Cluster mass modeling

## Parametric mass modeling



- Physically motivated mass components
- Sparse distribution of SL constraints
- Ex: Glafic (*Oguri+2010*), LTM (*Zitrin+2012*), GLEE (*Suyu+2010*), **Lenstool** (*Jullo+2007*)...

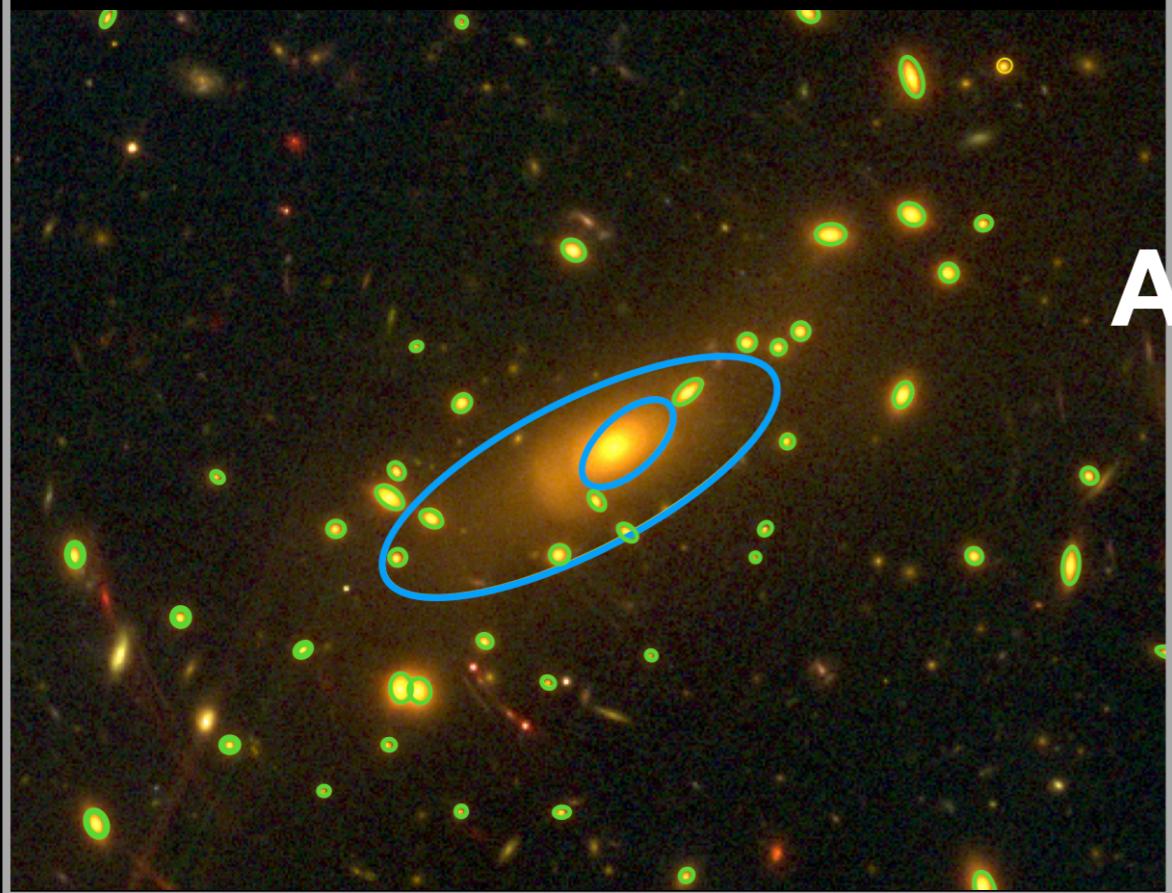
## Free-form mass modeling



- Grid of mass “pixels”
- More flexible for substructure detection
- Ex: SWUnited (*Bradac+2005*), WSLAP+ (*Diego+2005*), GRALE (*Liesenborgs+2006*), LensPerfect (*Cole+2008*), SaWLens (*Merten+2011*), **Lenstool** (*Jauzac+2012, Jullo+2014*)...

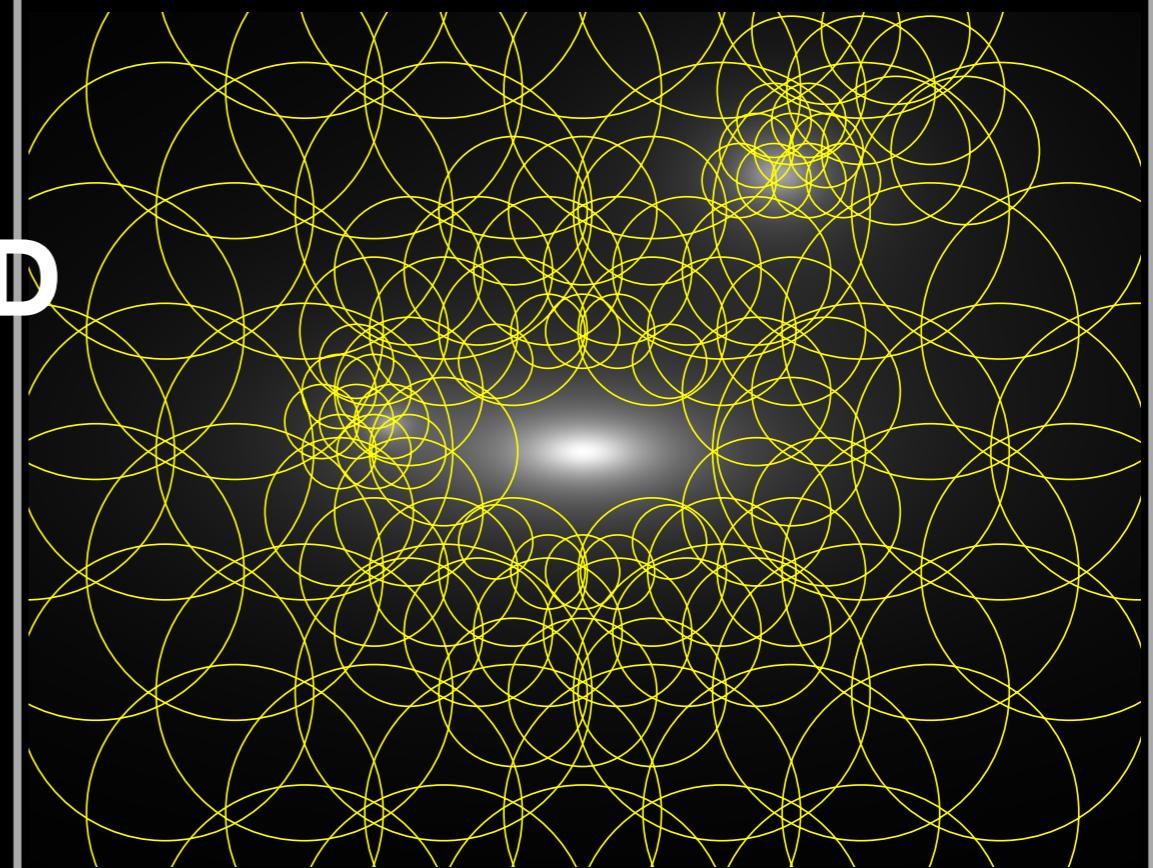
# *hybrid*-Lenstool mass modeling

- Cluster core:  
parametric model



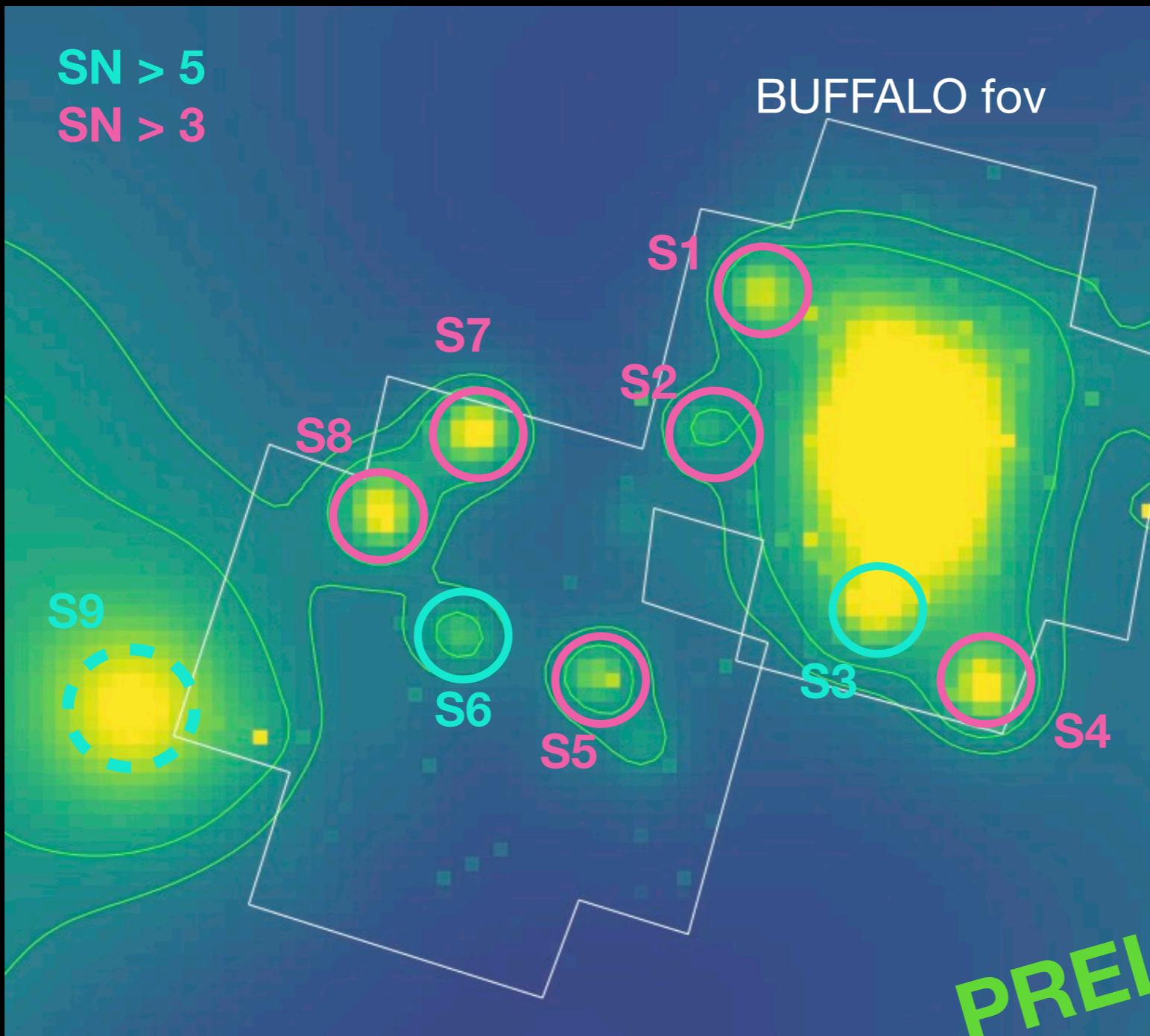
AND

- Outskirts:  
non-parametric



—> Hybrid-Lenstool : combine parametric + grid and optimize both simultaneously with SL and WL constraints

# Sequential model : Best fit SL parametric + WL grid

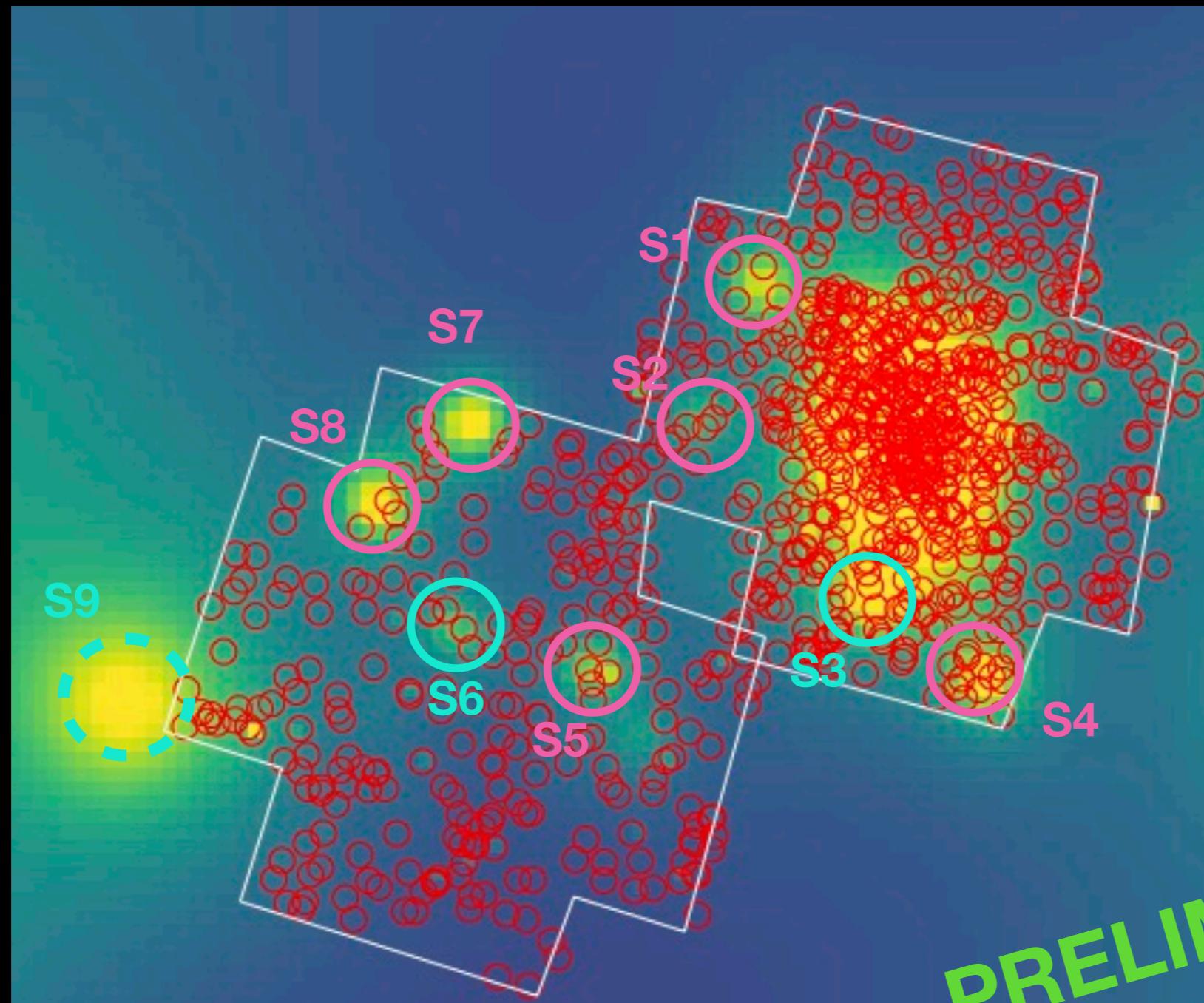


Mass within 150kpc:

S1 ~ $5 \times 10^{13}$ Msun
S2 ~ $4 \times 10^{13}$ Msun
S3 ~ $6.5 \times 10^{13}$ Msun
S4 ~ $5.5 \times 10^{13}$ Msun
S5 ~ $4 \times 10^{13}$ Msun
S6 ~ $4 \times 10^{13}$ Msun
S7 ~ $5 \times 10^{13}$ Msun
S8 ~ $5.5 \times 10^{13}$ Msun
S9 ~ $7 \times 10^{13}$ Msun

PRELIMINARY

# Are the substructures « real » ?

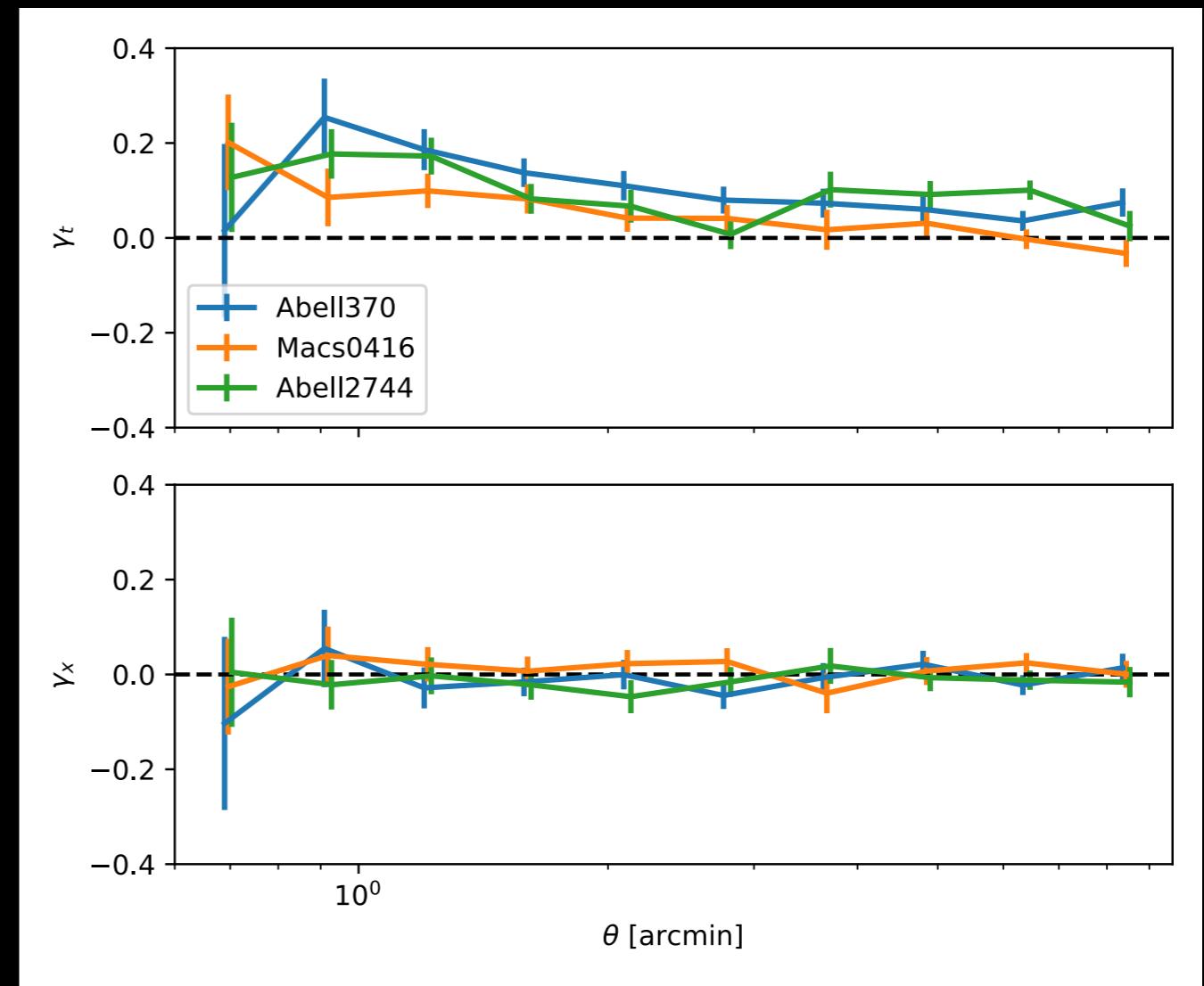


PRELIMINARY

1. Cluster member distribution
2. X-ray comparison  
→ future

# Other clusters : work in progress

- Need redshift catalogue for background selection :
  - Macs0416 : MUSE + VIMOS
  - Abell2744 : MUSE + Owers+2011
  - Macs0717 : catalogue from Mathilde
  - AS1063 : ?



# Summary

- Cluster lensing to probe cluster physics, DM properties, high redshift universe, cosmology → need to model with precision and accuracy
- Combining parametric model in SL region and non-parametric grid model in WL region with Lenstool
- Model for A370 (+ other BUFFALO clusters) soon to come