MACS J1206, NASA, ESA, M. Postman (STScI) and the CLASH Team

Tracing the History of the most massive galaxies of the Universe with the Hubble Space Telescope

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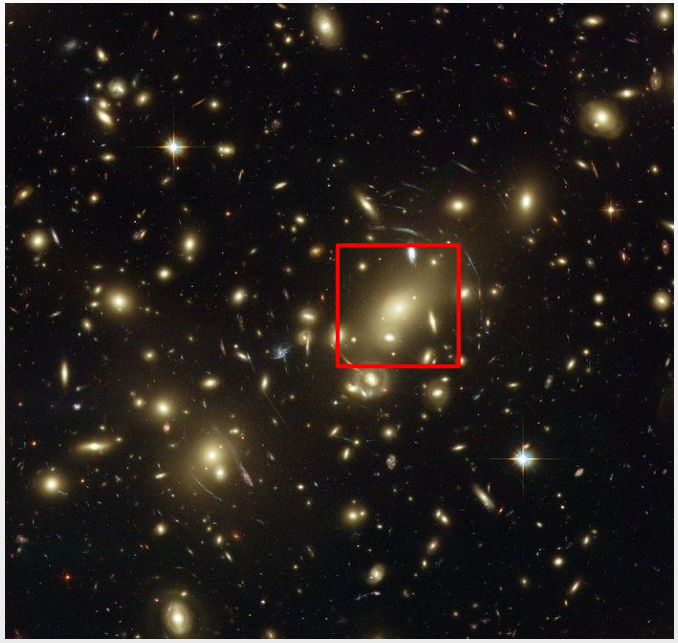
What are galaxy clusters ?

NASA, ESA, and Johan Richard (Caltech, USA)
Abell 2218

- Largest gravitationally bound structures in today's Universe
- D ≈ 1Mpc, $10^{14} - 10^{15}$ $M_\odot$
- Form by accretion of gas and mergers with smallers group of galaxies
- Latest structures to have formed

- Strong contraints for cosmological models
- Better understanding of the formation of structures

What are ~~galaxy clusters ?~~ BCGs ?



NASA, ESA, and Johan Richard (Caltech, USA)
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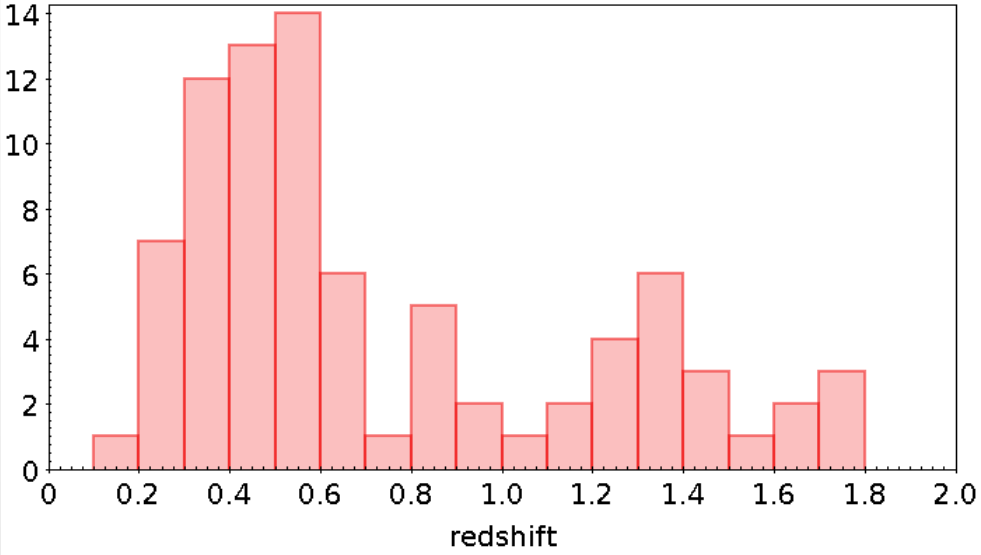
- **B**rightest **C**luster **G**alaxy
- Most massive galaxies in the Universe
- Formed by accretion of gas and mergers with smaller galaxies
- Closely linked to their host clusters

- Strong contraints for cosmological models
- Tracers of cluster formation and evolution in the cosmic web

Sample and data

- 137 clusters* initially (149 BCGs)
- 79 clusters with good data (82 BCGs)
- Redshift range : 0.18 – 1.8
- HST data



- Better resolution
- Homogeneous
- Better statistics

⇒ Trace the history of clusters and BCGs formation

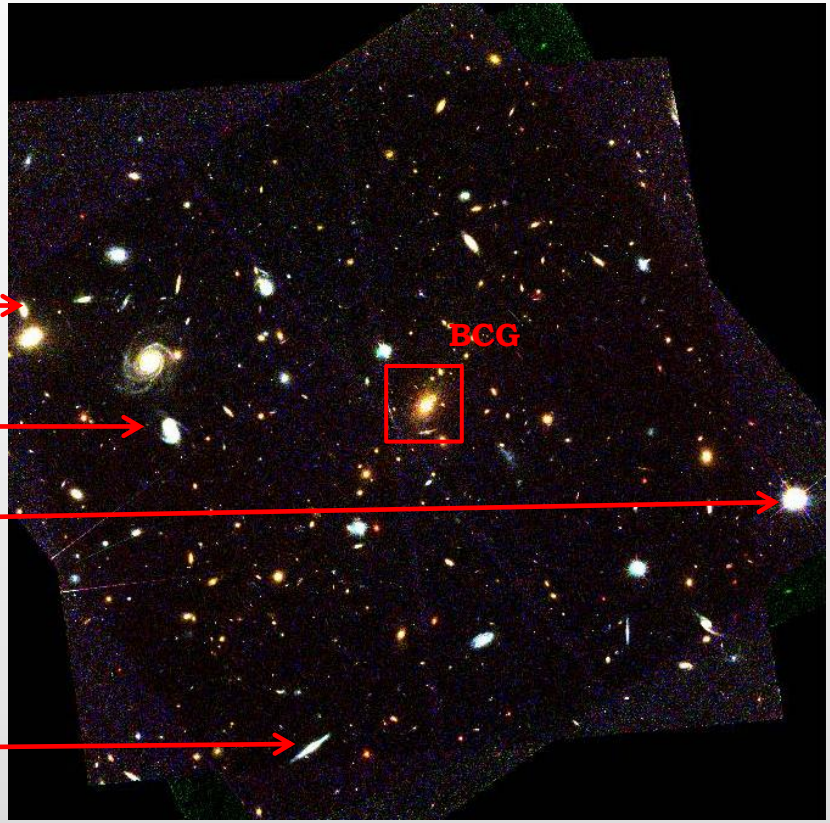
⇒ Questions: How do BCGs evolve through time ? Is there even evolution ?

*taken from:

Jee et al. 2011
Postman et al. 2012
Bai et al. 2014
Donahue et al. 2015
West et al. 2017
DeMaio et al. 2019
Durret et al. 2019
Sazonova et al. 2020

Automatic detection of BCGs

MACS J1115.8+0129, z = 0.349



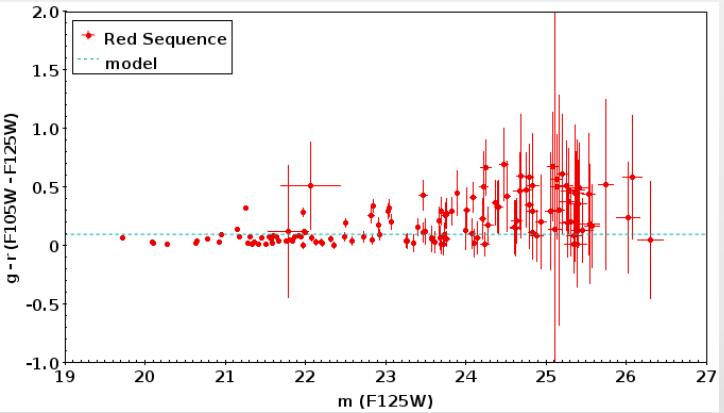
ISOLATED GALAXIES

ABSOLUTE MAGNITUDE
→ foreground sources

CLASS_STAR
→ point sources

ELONGATION
→ edge-on spirals

- Bruzual & Charlot 2003
- SFH : exponential $\propto \exp\left(-\frac{t-T_0}{\tau}\right)$
- $\tau = 0.5\ Gyr$
- $z_f = 5$
- $Z = 0.02$ (Solar metallicity)
- IMF : Chabrier



- COLORS
  → red sequence galaxies

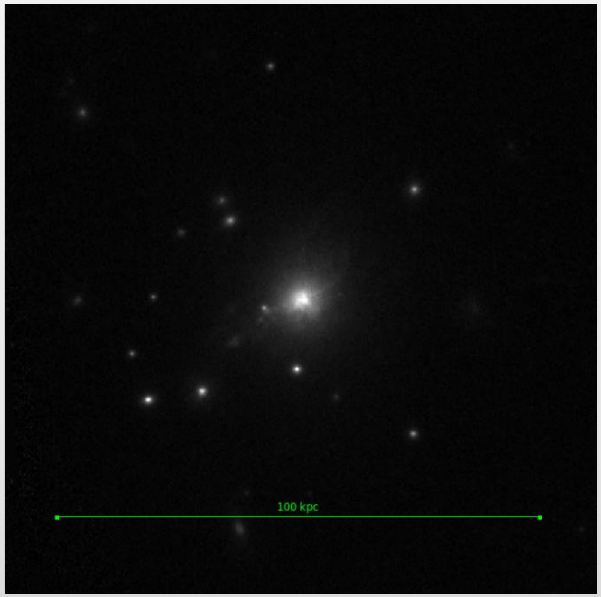
$$|(g-r)_{model} - (g-r)_{obs}| \leqslant 0.60$$

$$(g-r)_{obs} \geqslant 0$$

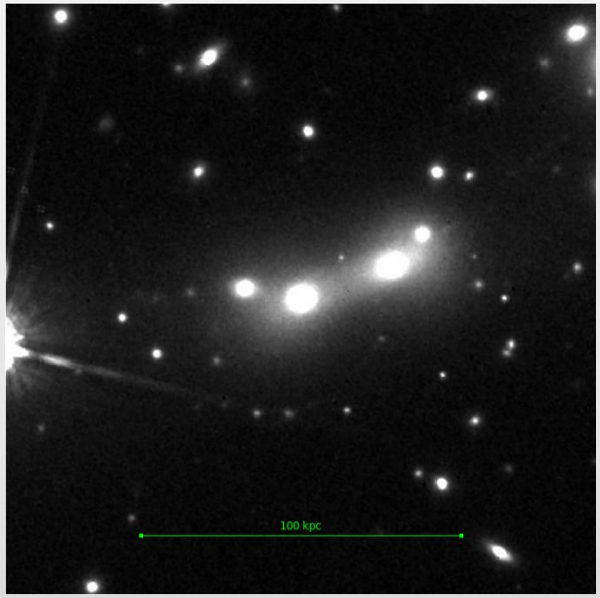
Automatic detection – red BCGs

- 97% success-rate
- Correctly detects red BCGs of any type

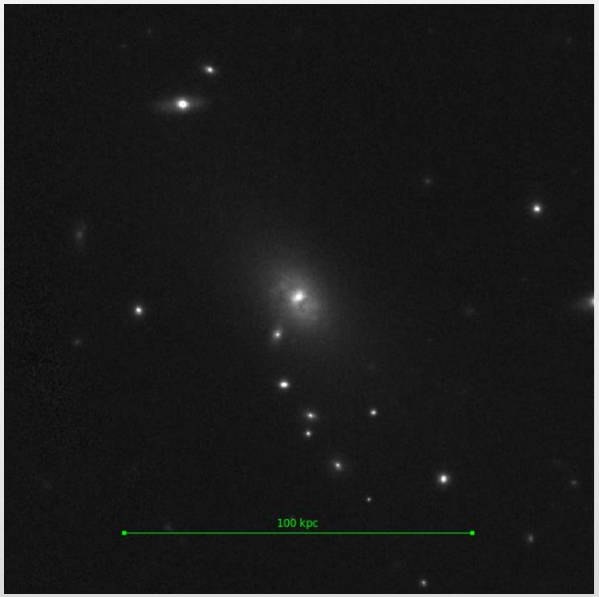
  ⇒ disturbed, active SFR, mergers, traces of dust…



MACS J0329-0211, z = 0.45



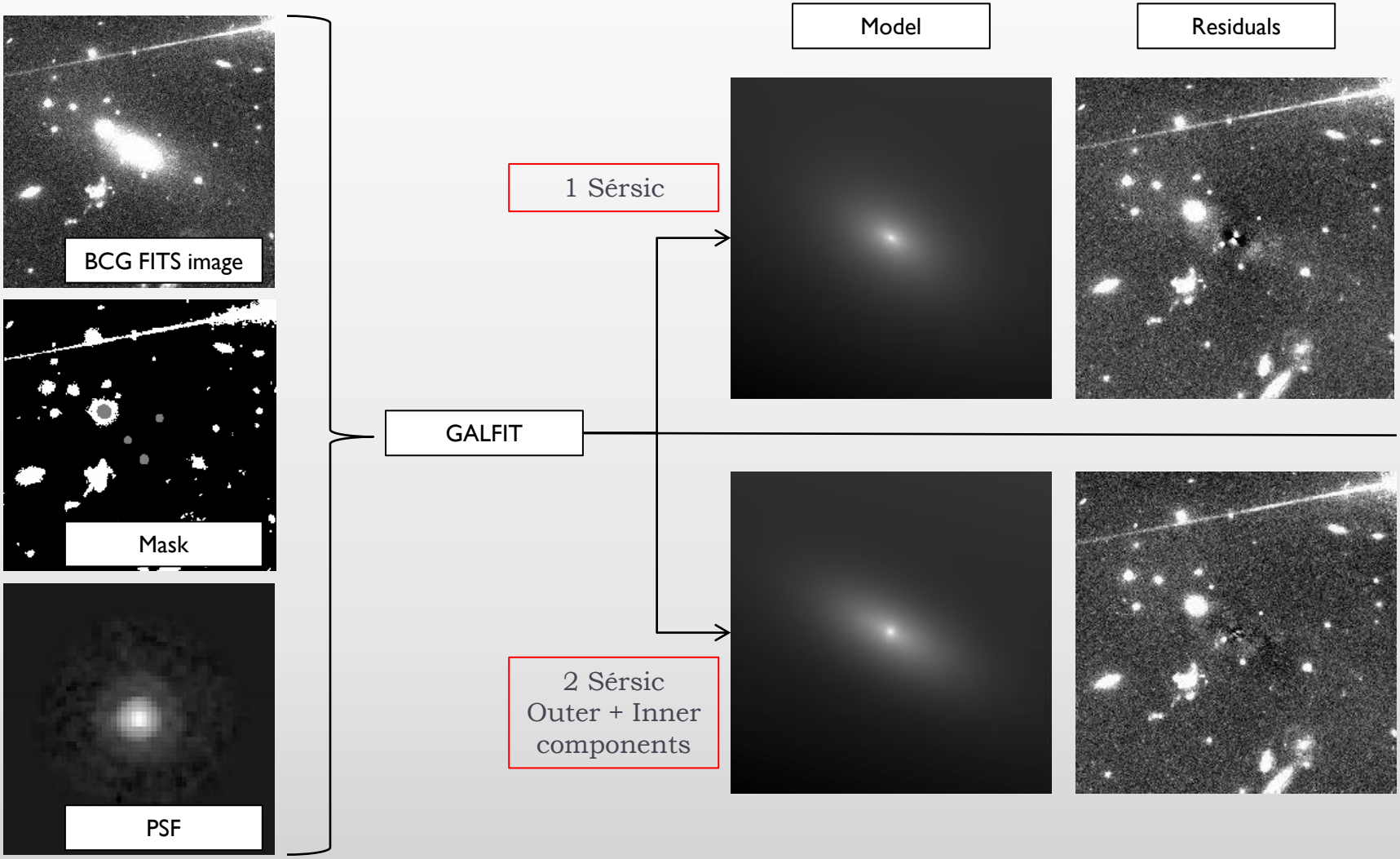
MACS J0647+7015, z = 0.59



MACS J1423+2404, z = 0.54

Luminosity profiles

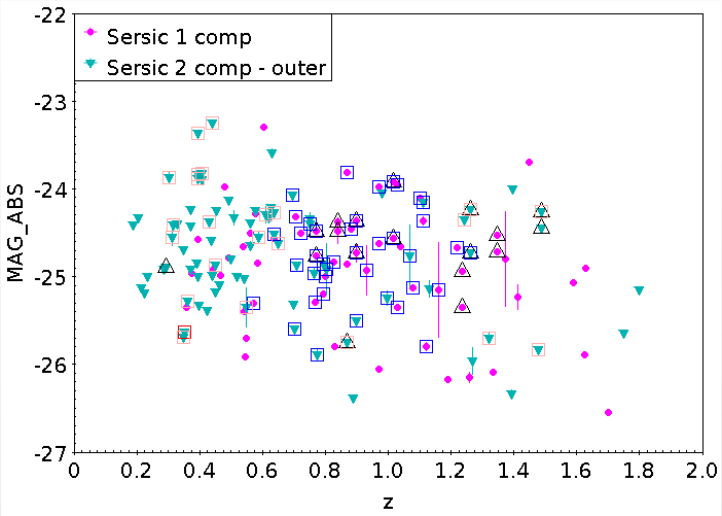
Sérsic profile: $I(R) \propto e^{-bR^{1/n}}$



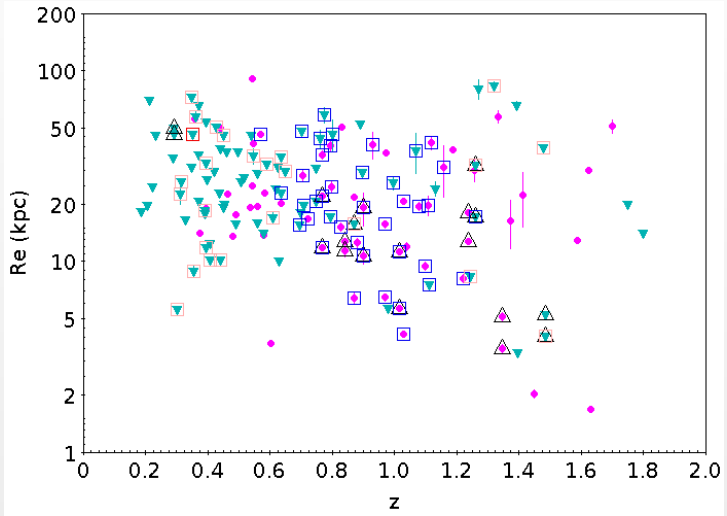
ZwCl 1332.8+5043, z = 0.62

Relations with redshift

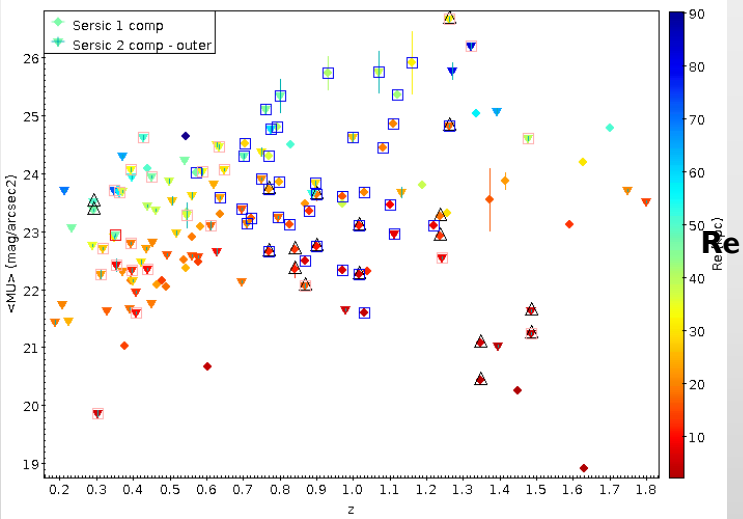
Absolute magnitude



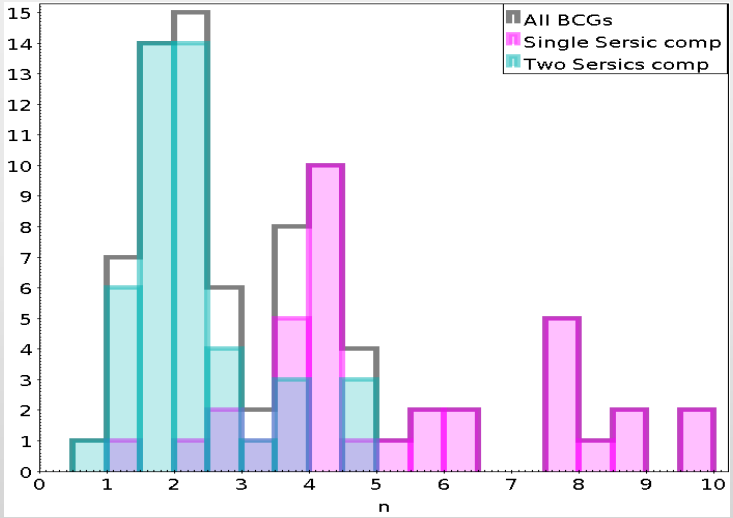
Effective radius



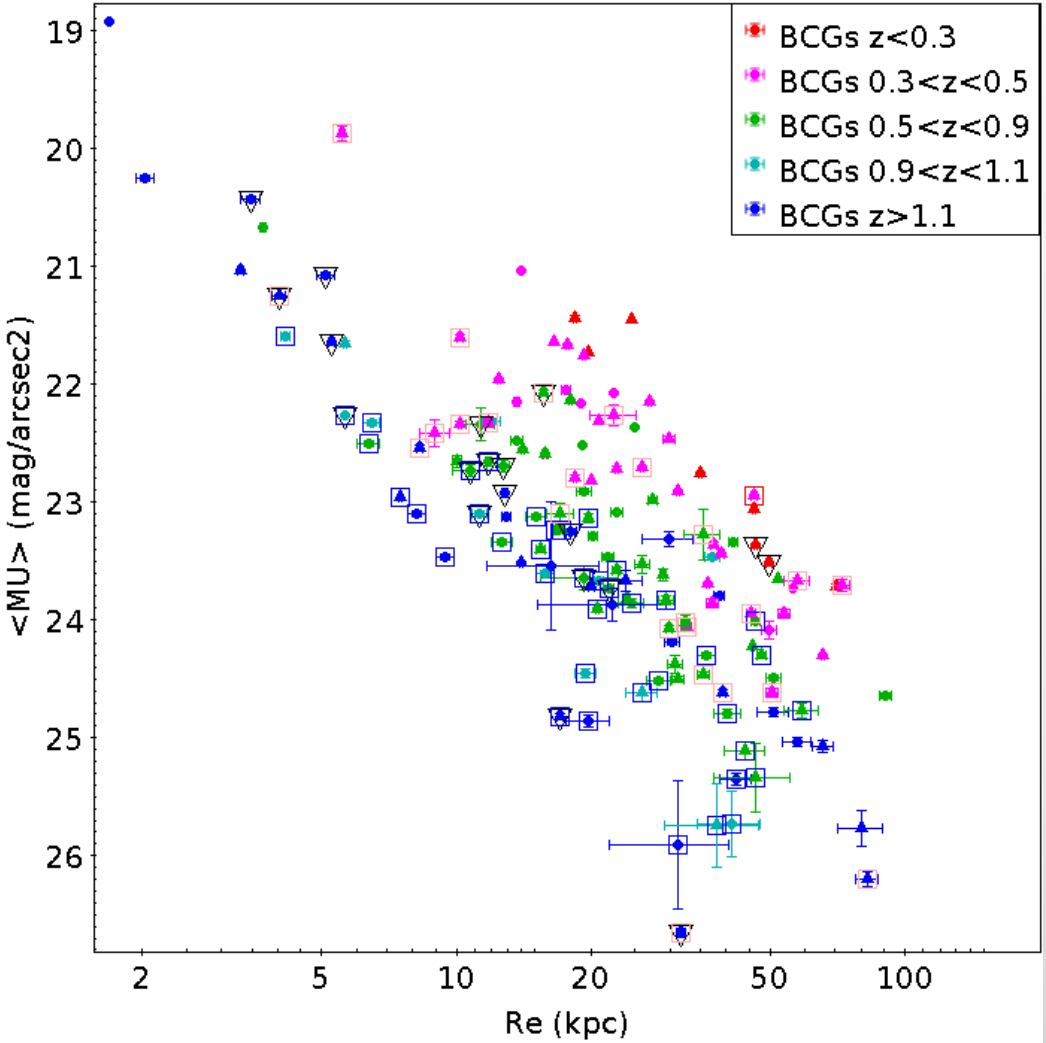
Mean effective surface brightness



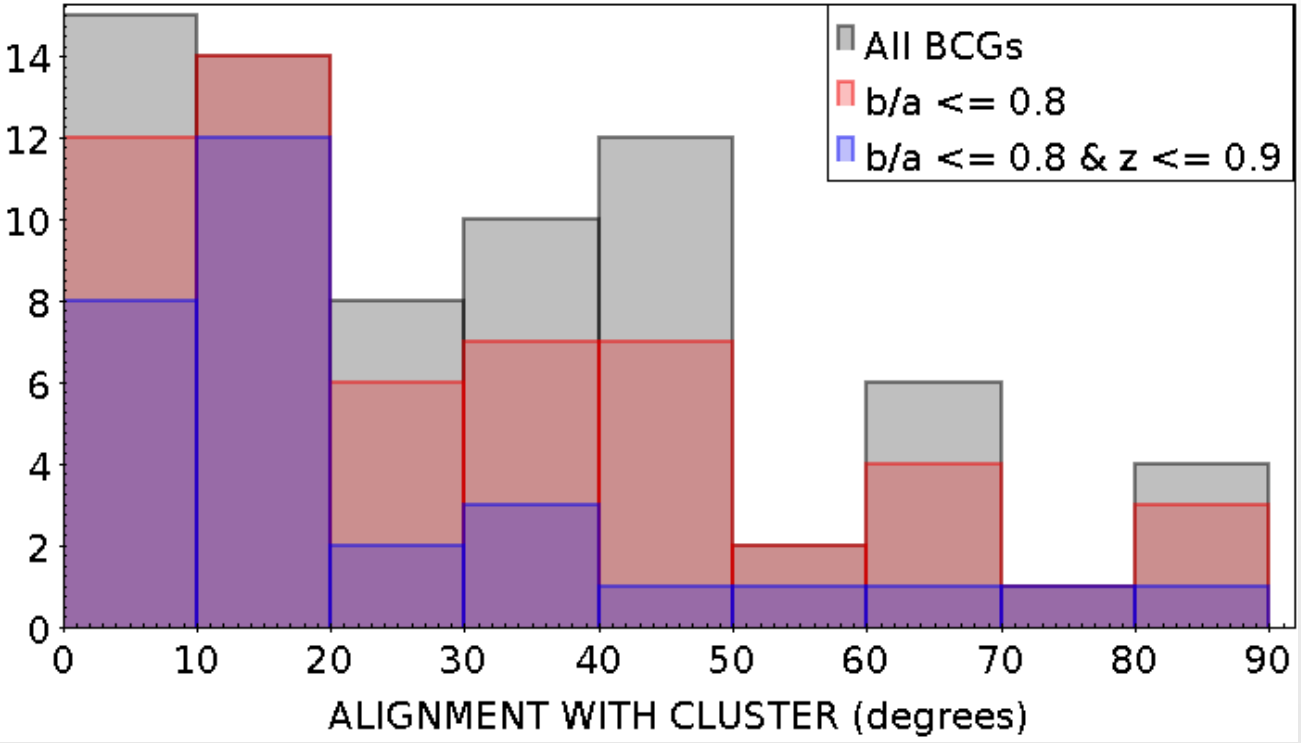
Sérsic index



Kormendy relation



BCGs alignment with their host clusters



- PA(cluster) from West et al. 2017, Durret et al. 2019
- Alignment mainly at $z \leqslant 0.9$
- 73% aligned within 30 degrees with their host cluster

⇒ Close link between the BCGs and their host clusters

Summary and perspectives

- New study which covers a large redshift range and bigger sample using HST data
- New tool to detect automatically red BCGs on optical images
- 2D modelization of the luminosity profiles of BCGs
- No clear evolution as a function of redshift
- The Kormendy relation is also a function of redshift
- Alignment of the BCGs with their host cluster at $z \leqslant 0.9$

⇒ Chu, Durret, Marquez et al. 2021
→ Accepted in Astronomy & Astrophysics
→ arXiv:2102.01557

⇒ To be applied to +1300 clusters in the CFHTLS up to z = 0.7