Galaxy Clusters in the Early Universe.
Pucon, Chile.
November 9-12, 2009

A New Morphological and Photometric Study of the Galaxy Population in XMMU J2235.3-2557

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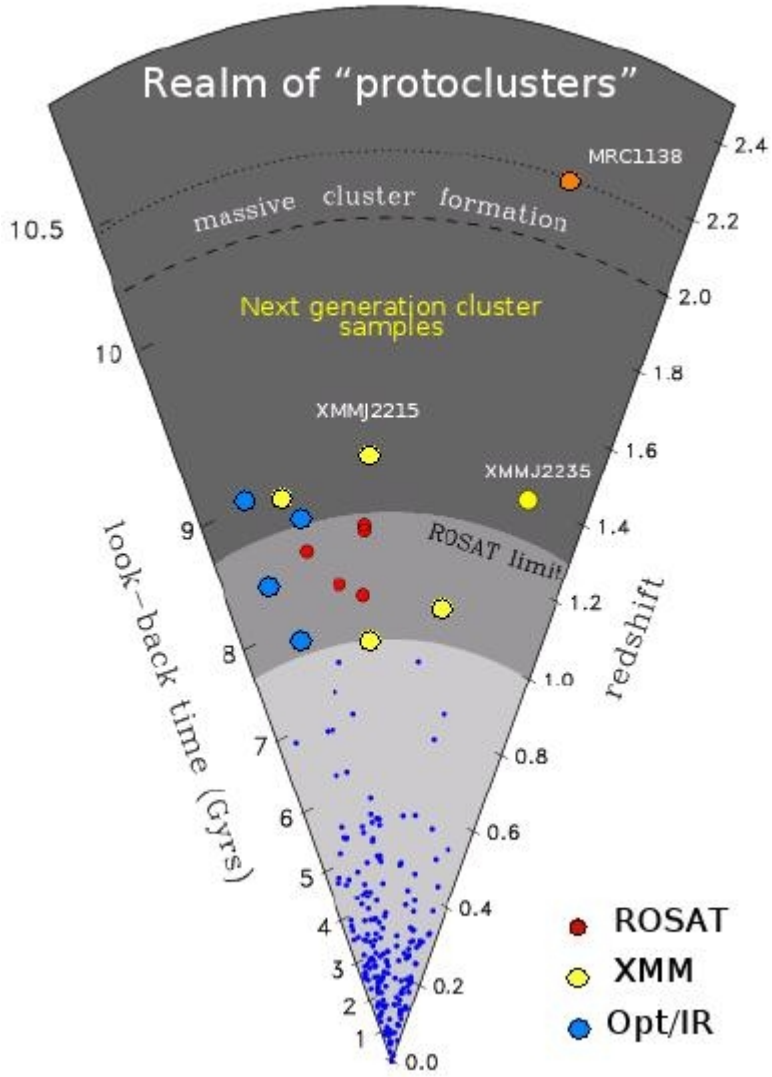
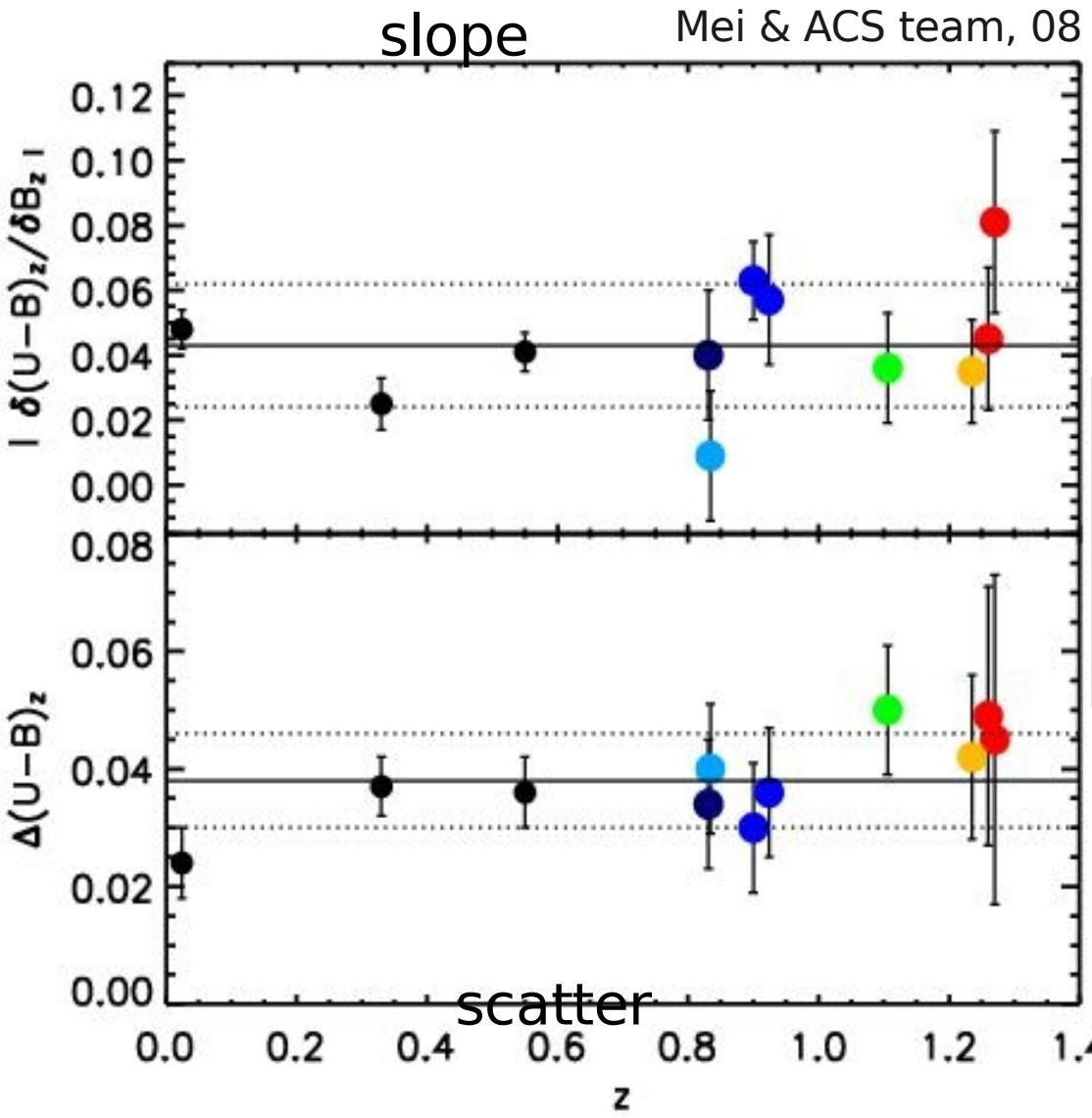
GALAXY CLUSTERS AT HIGH REDSHIFT

1.4<z<2.5: a critical epoch for the formation of baryonic structure

- ≲50% of the stellar mass is assembled
- The global SF rate and the BH mass accretion rate peak there
- The morphology-density relation and the red sequence emerge
- The morphological Hubble sequence emerges
- The first massive (≳10^{14} $M_{\odot}$) virialized structures form (?)



THE RED SEQUENCE AT HIGH REDSHIFT

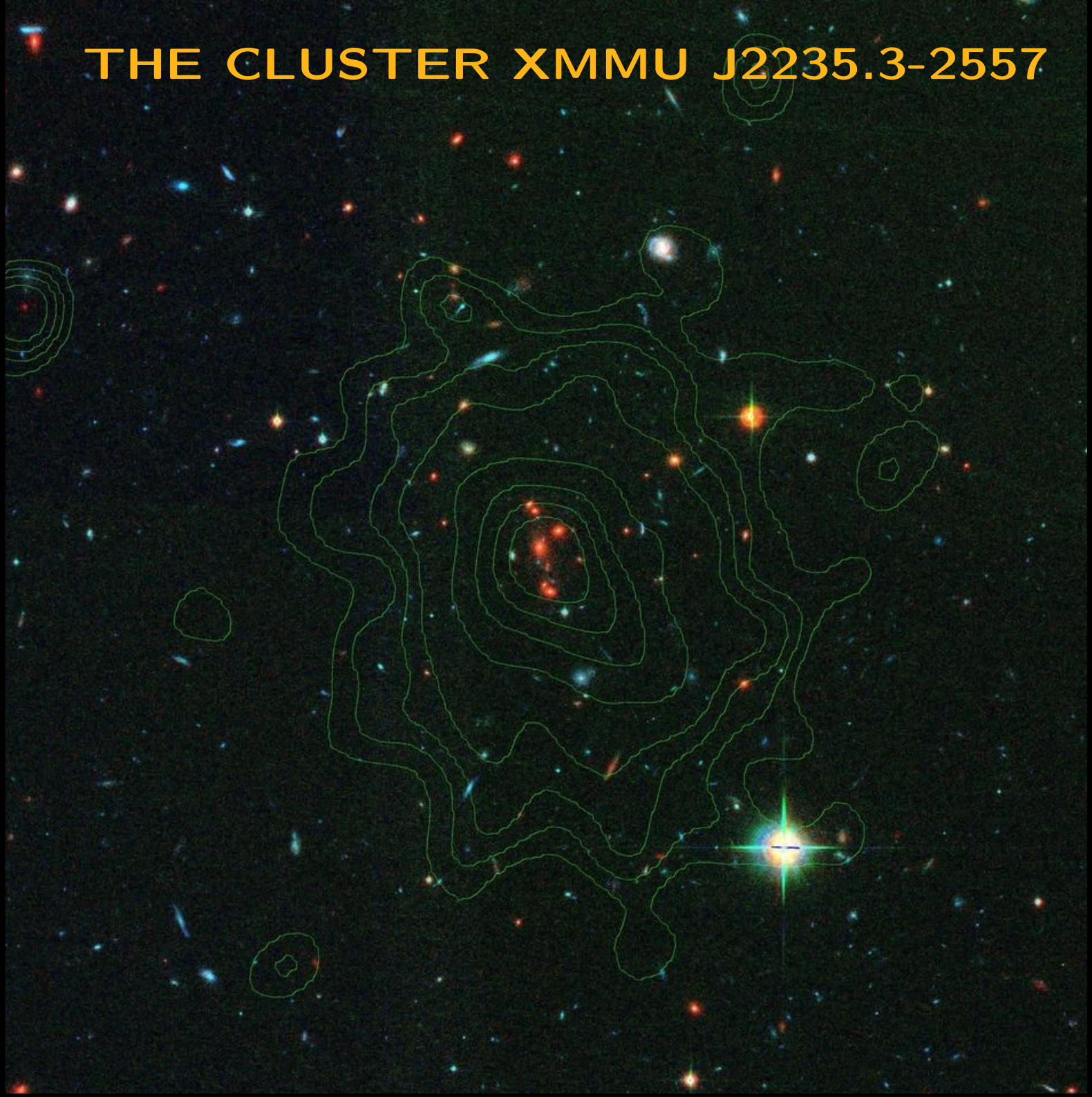


No evolution of the CMR slope and scatter out to z=1.4

➔ The Cluster RS frozen over ~9 Gyr, well within 0.1 mag!

Based on studies by Bower et al. 92, Ellis et al. 97, Standford et al. 97, vanDokkum et al. 01, Blakeslee et al. 06, Homeier et al. 06, Blakeslee et al. 03, Mei et al. 06a, Mei et al. 06b, Santos et al. 08

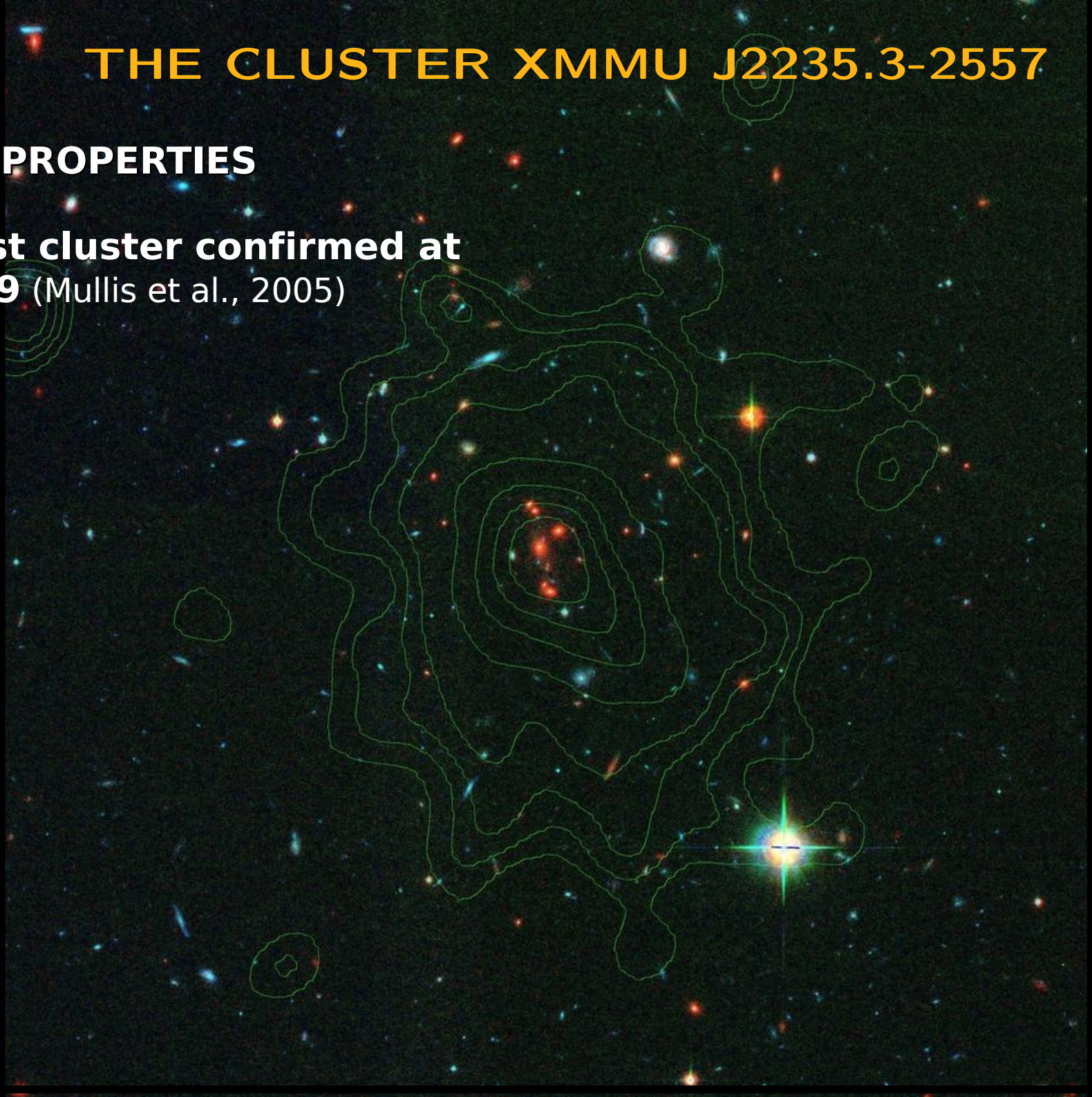
THE CLUSTER XMMU J2235.3-2557



THE CLUSTER XMMU J2235.3-2557

MAIN PROPERTIES

1. First cluster confirmed at z=1.39 (Mullis et al., 2005)



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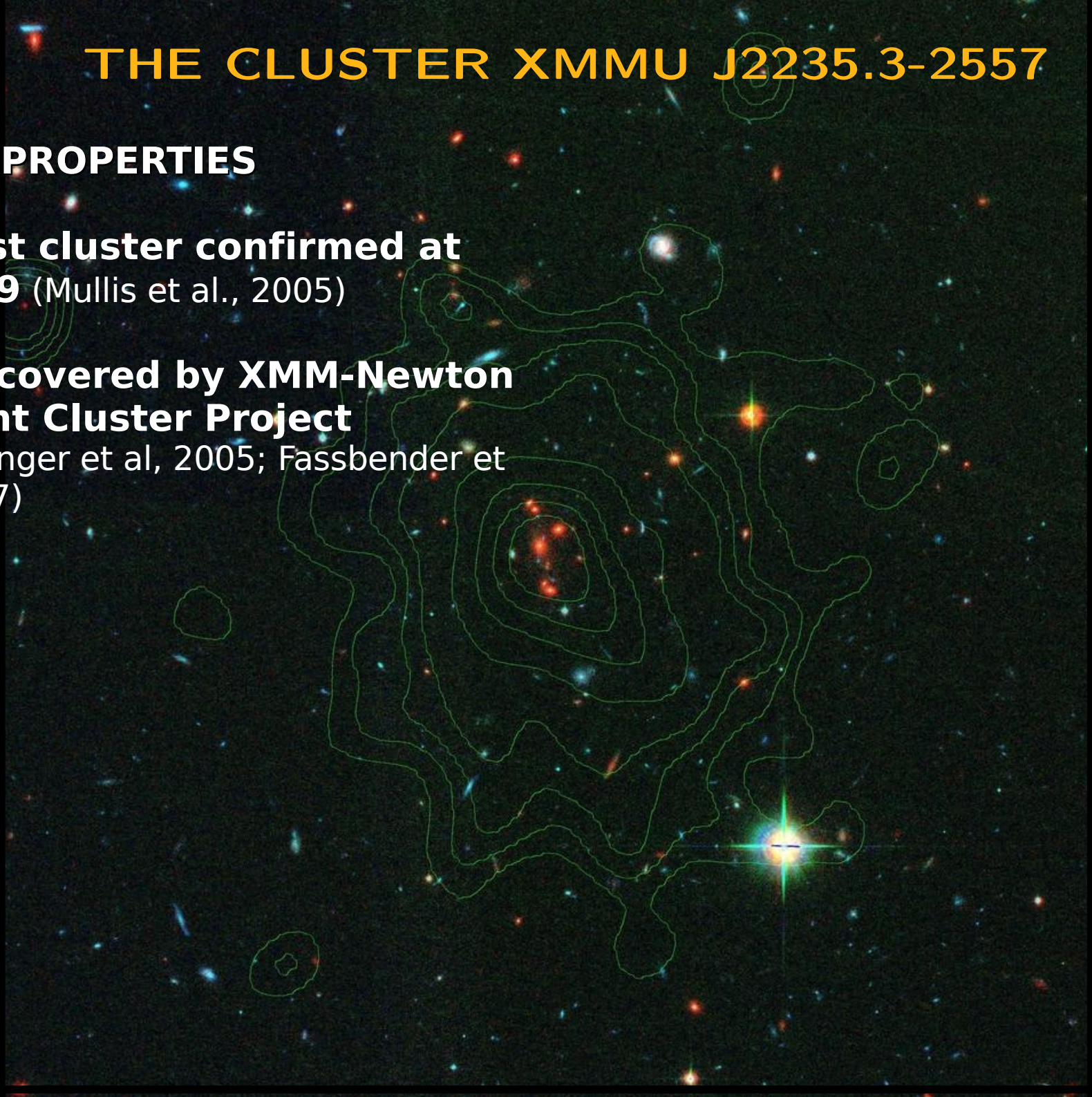

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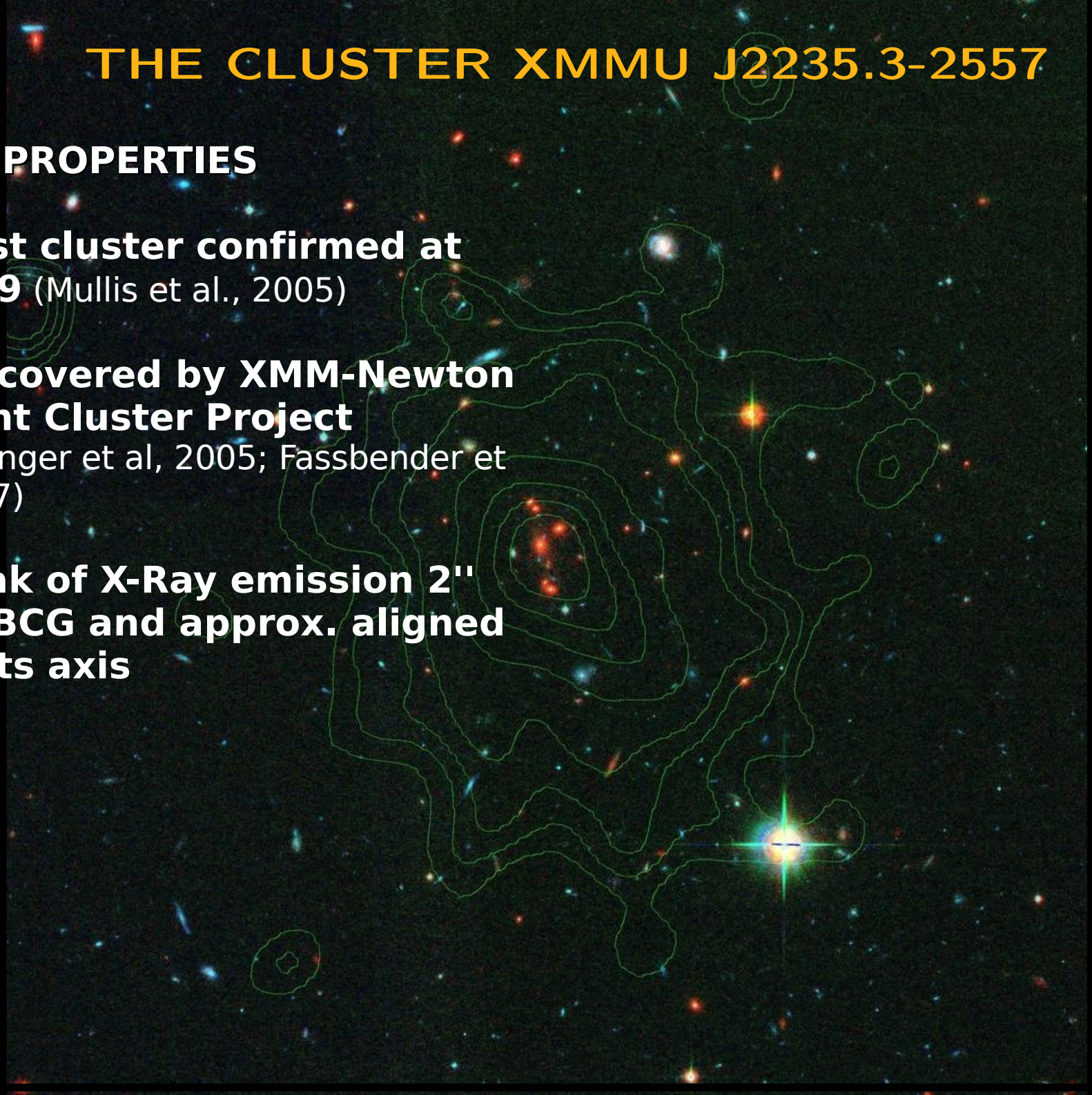

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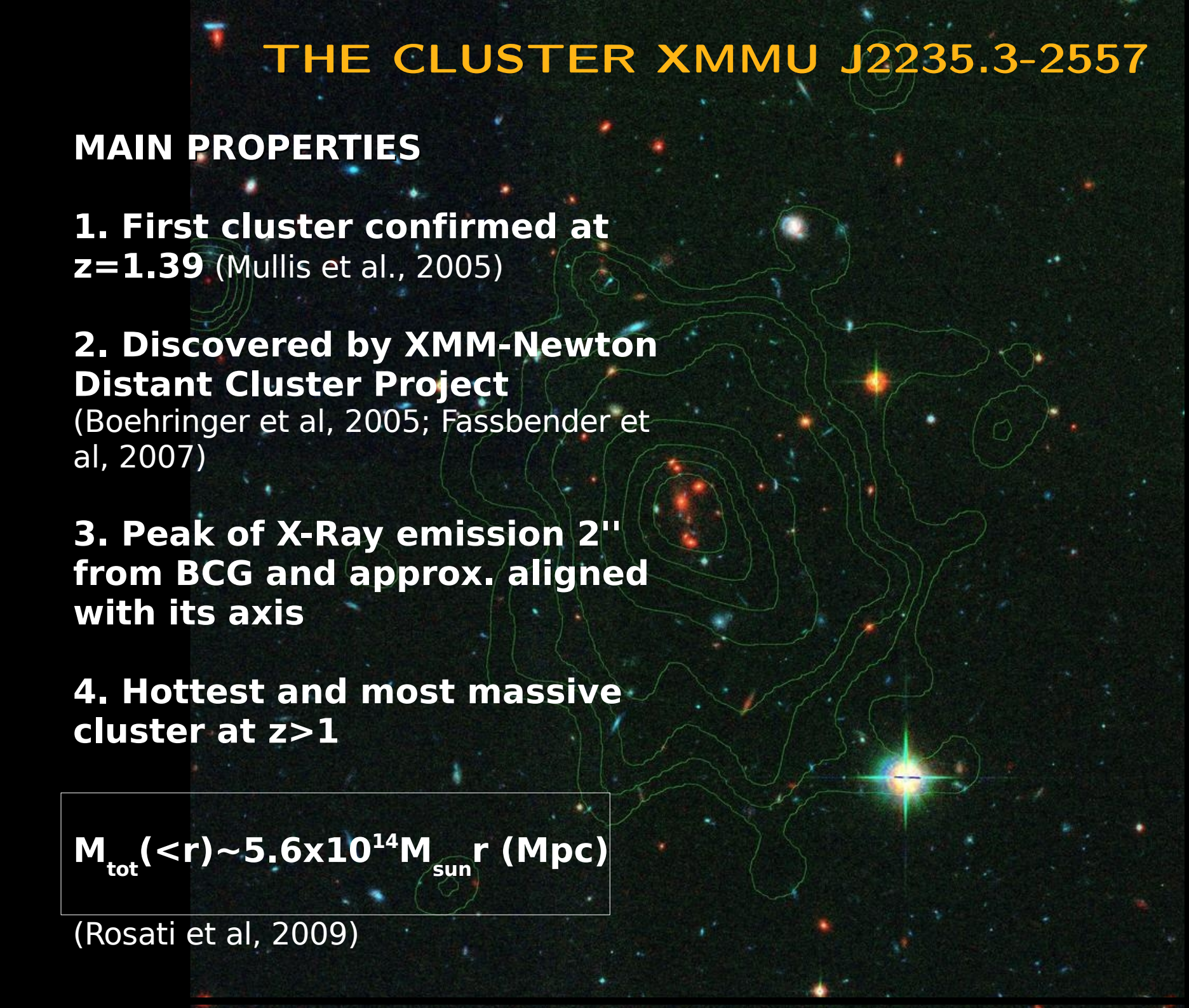

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4. Hottest and most massive cluster at z>1

$$M_{tot}(<r) \sim 5.6 \times 10^{14} M_{sun}\ r\ (Mpc)$$

(Rosati et al, 2009)

DATA SET (PHOTOMETRY+SPECTROCOPY)

IMAGING DATA:

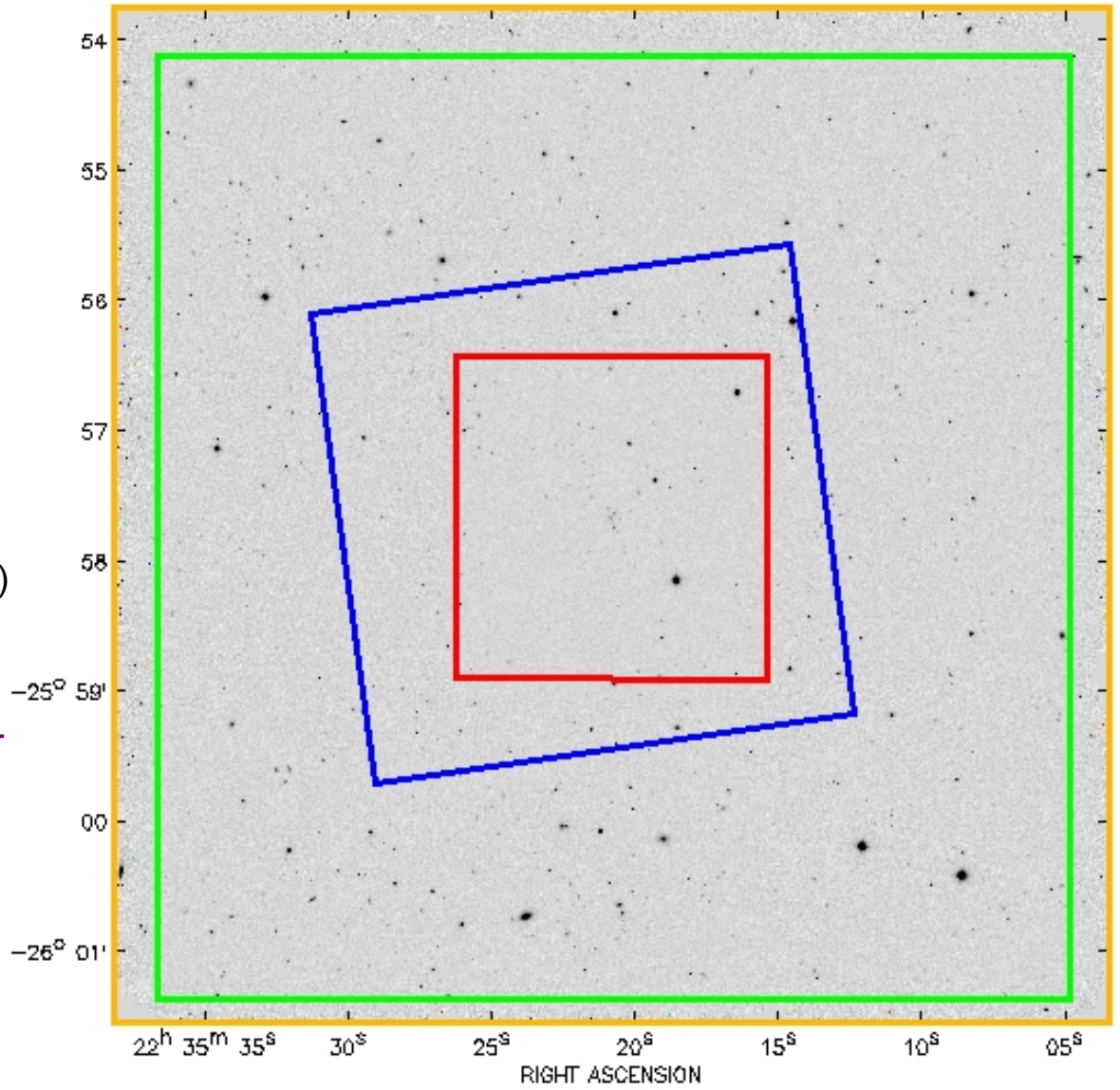
- VLT/FORS2 (r_{gunn},z)
- VLT/ISAAC (J,K_s; also SOFI)
- HST/ACS (i_{775},z_{850})
- NICMOS (H)
- Spitzer/IRAC (3.6-4.5)
- VLT/VIMOS (U)
- VLT/HAWKI (J,Ks) (Lidman et al, 2008)

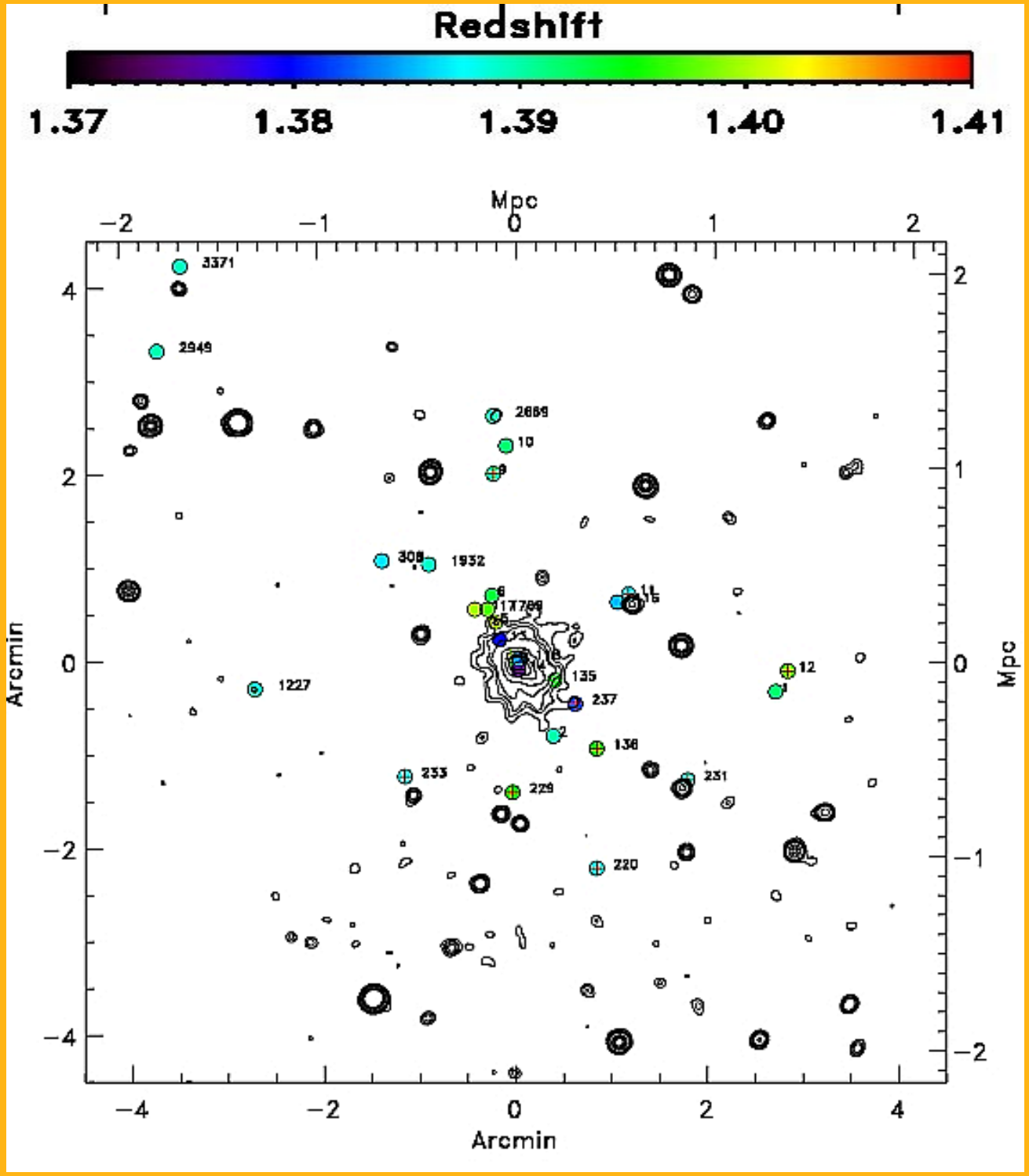
SPECTROSCOPIC CAMPAIGN:

- VLT/FORS2

X-RAY DATA:

- CHANDRA 200ks
- XMM 100ks

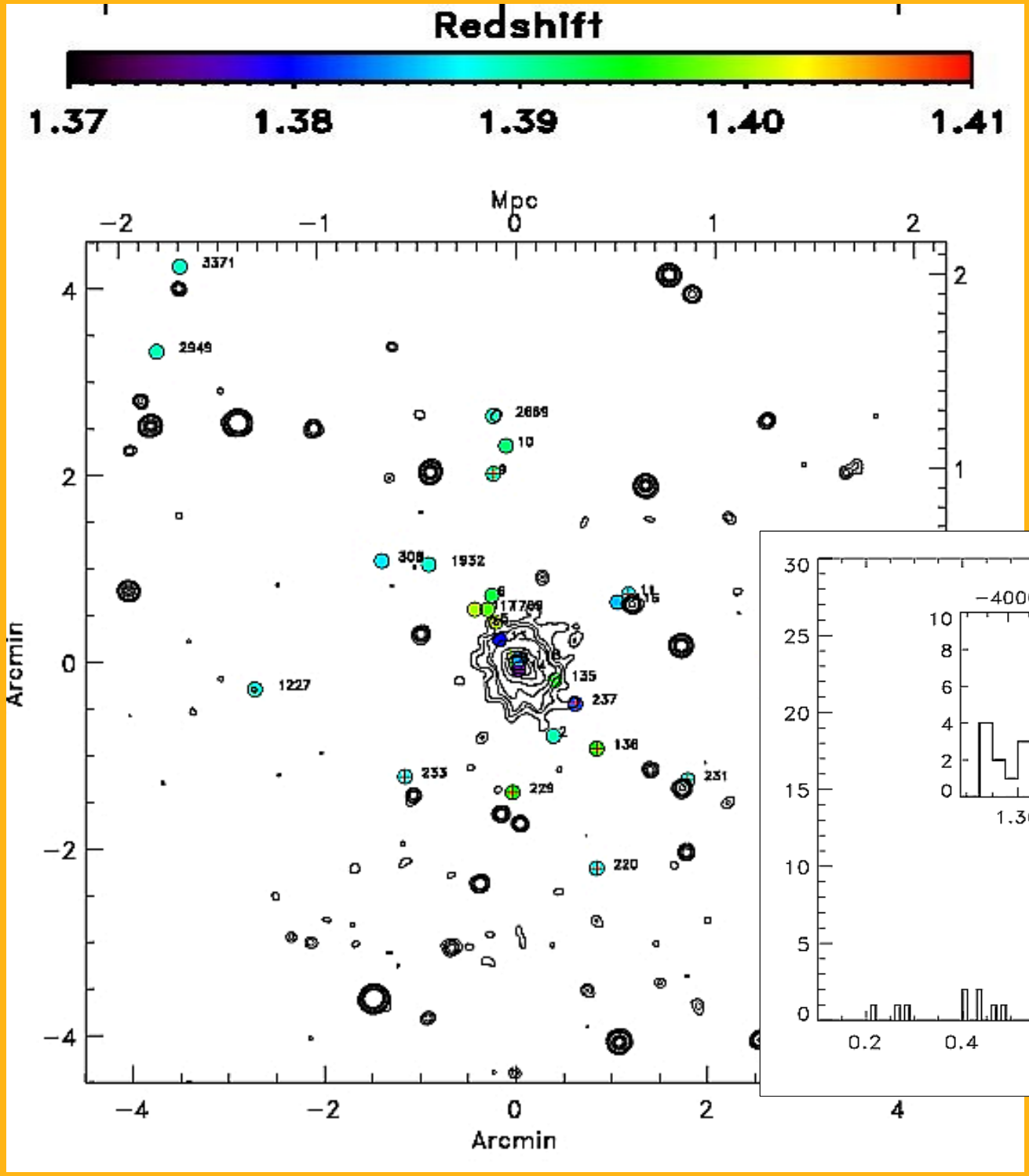




33 spectroscopic members:

17 passive

16 star forming



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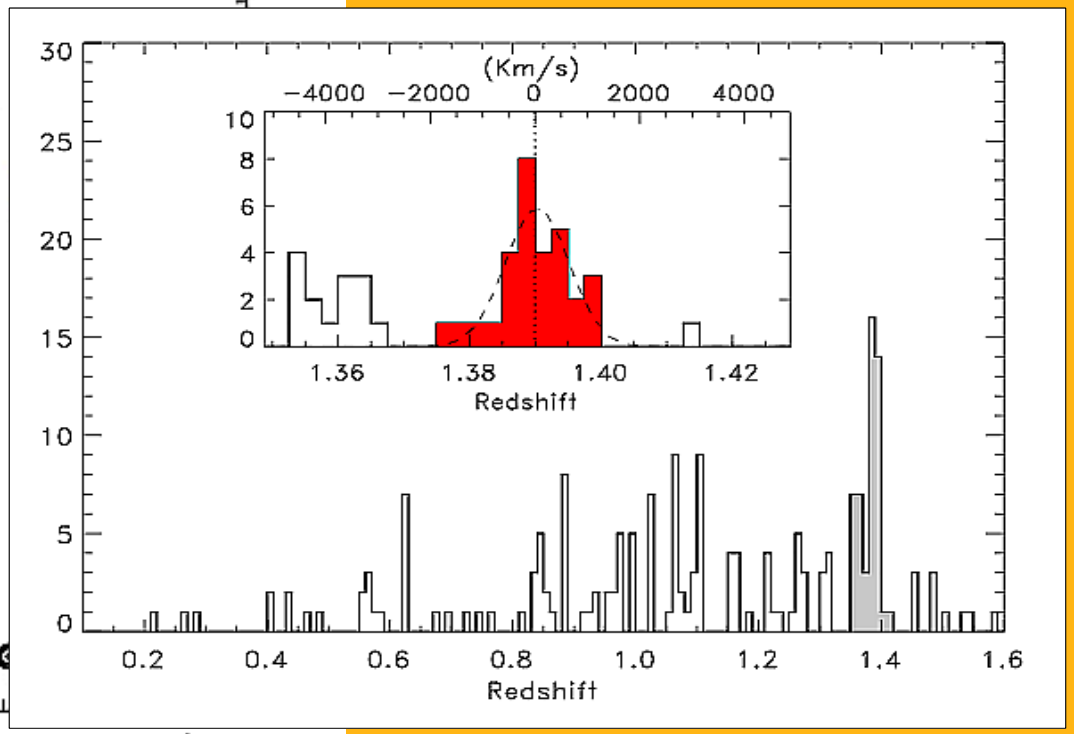
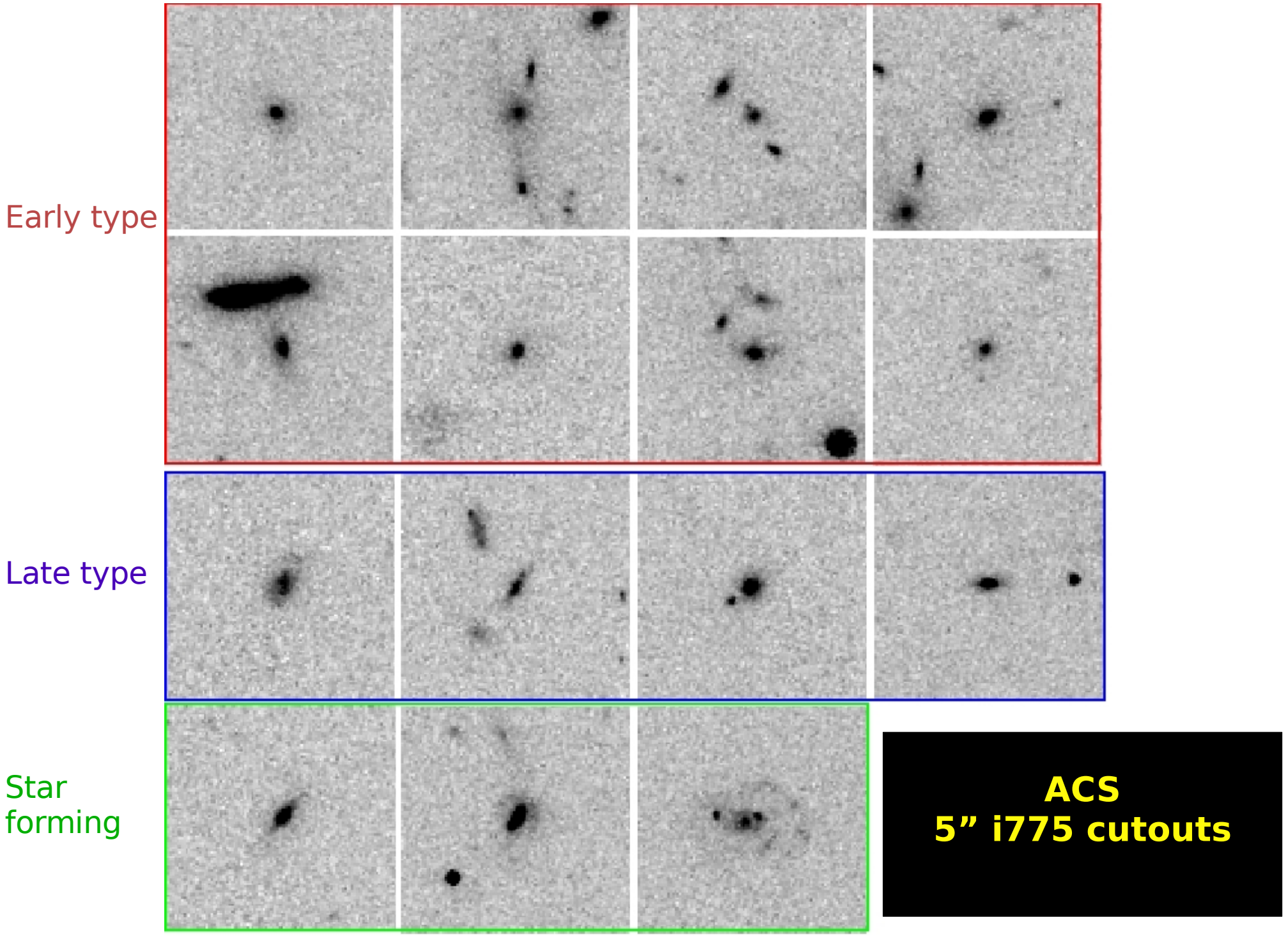
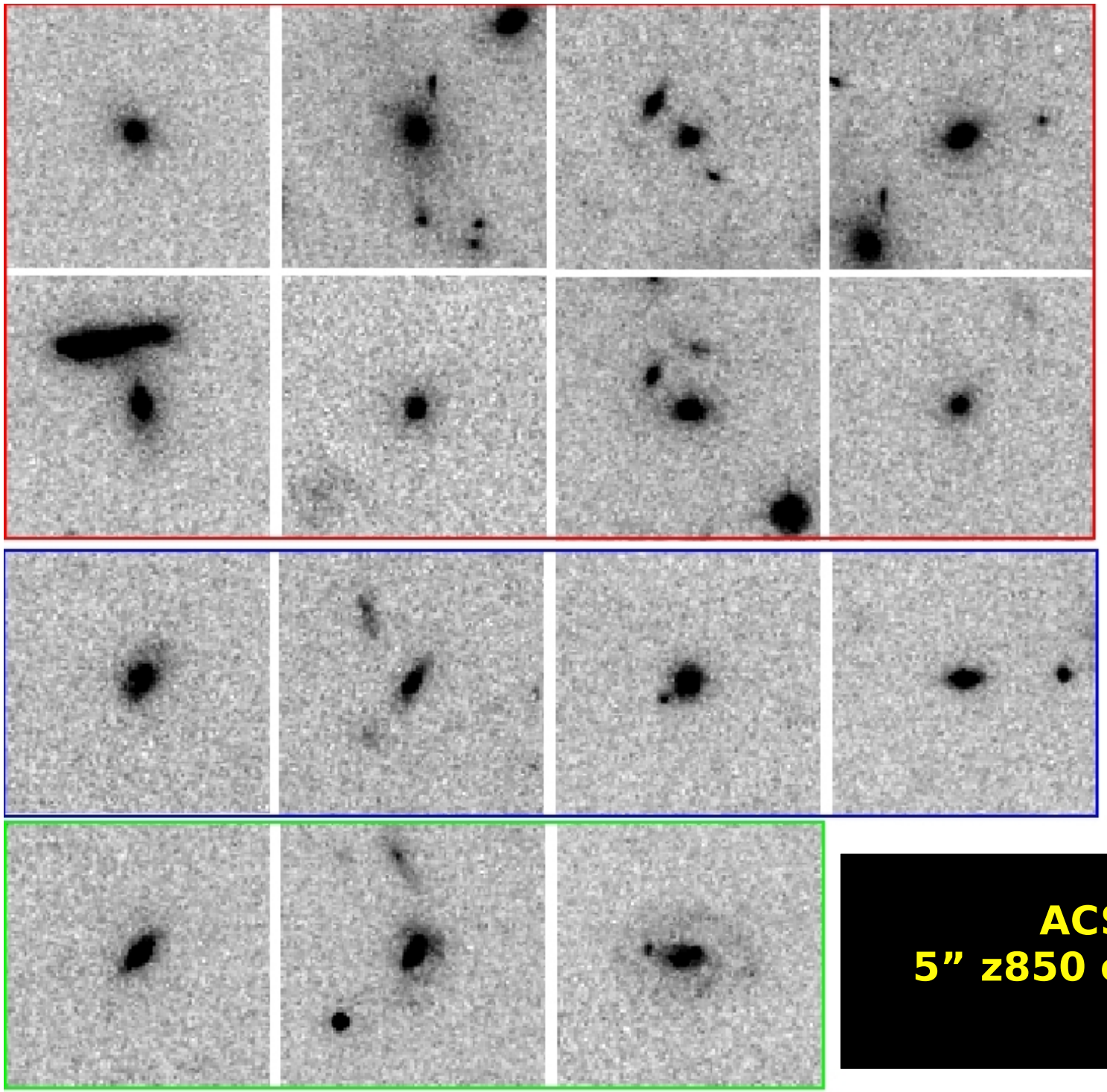
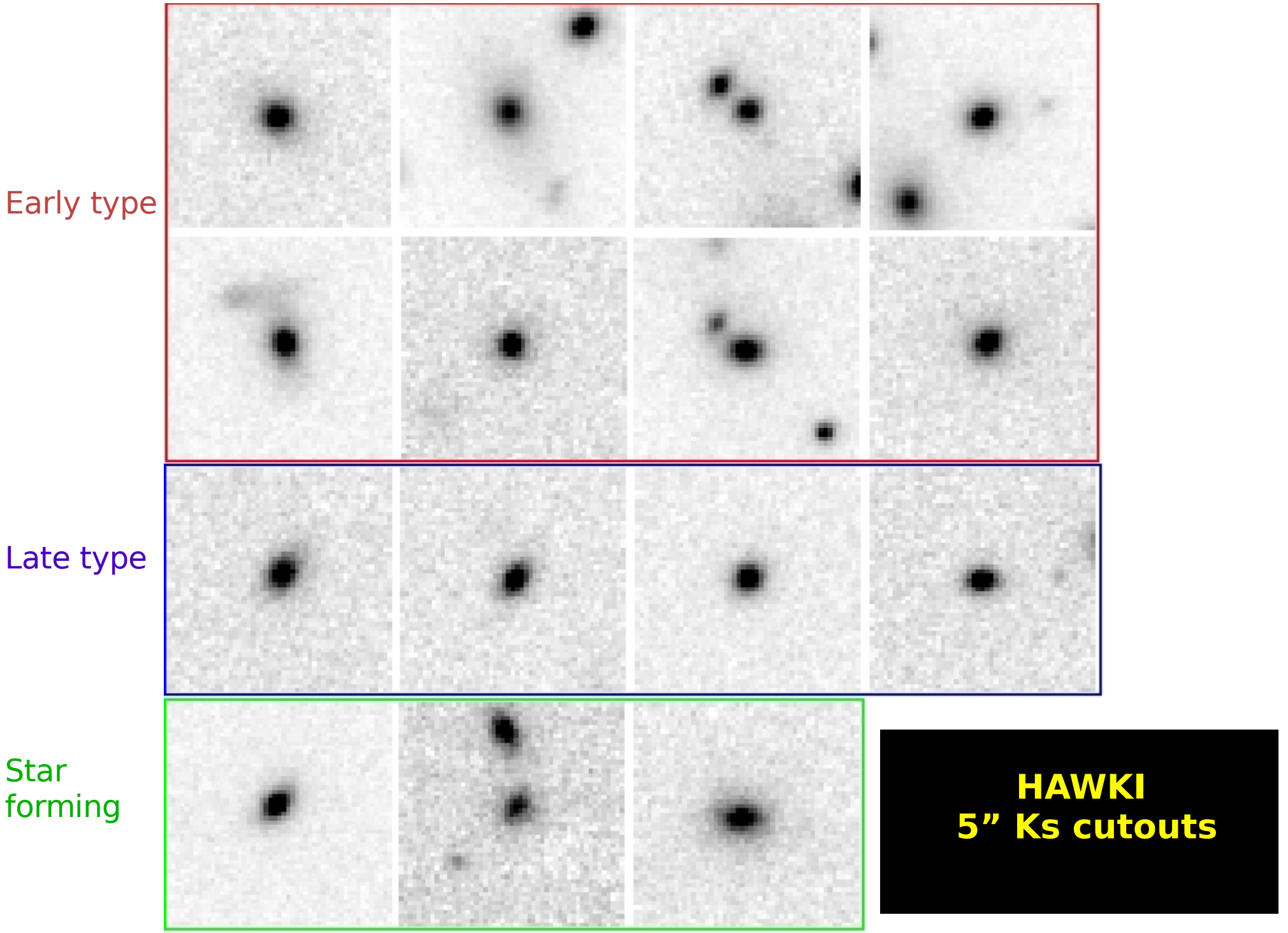


Rosati et al, 2009


Early type
Late type
Star forming
ACS
5” i775 cutouts

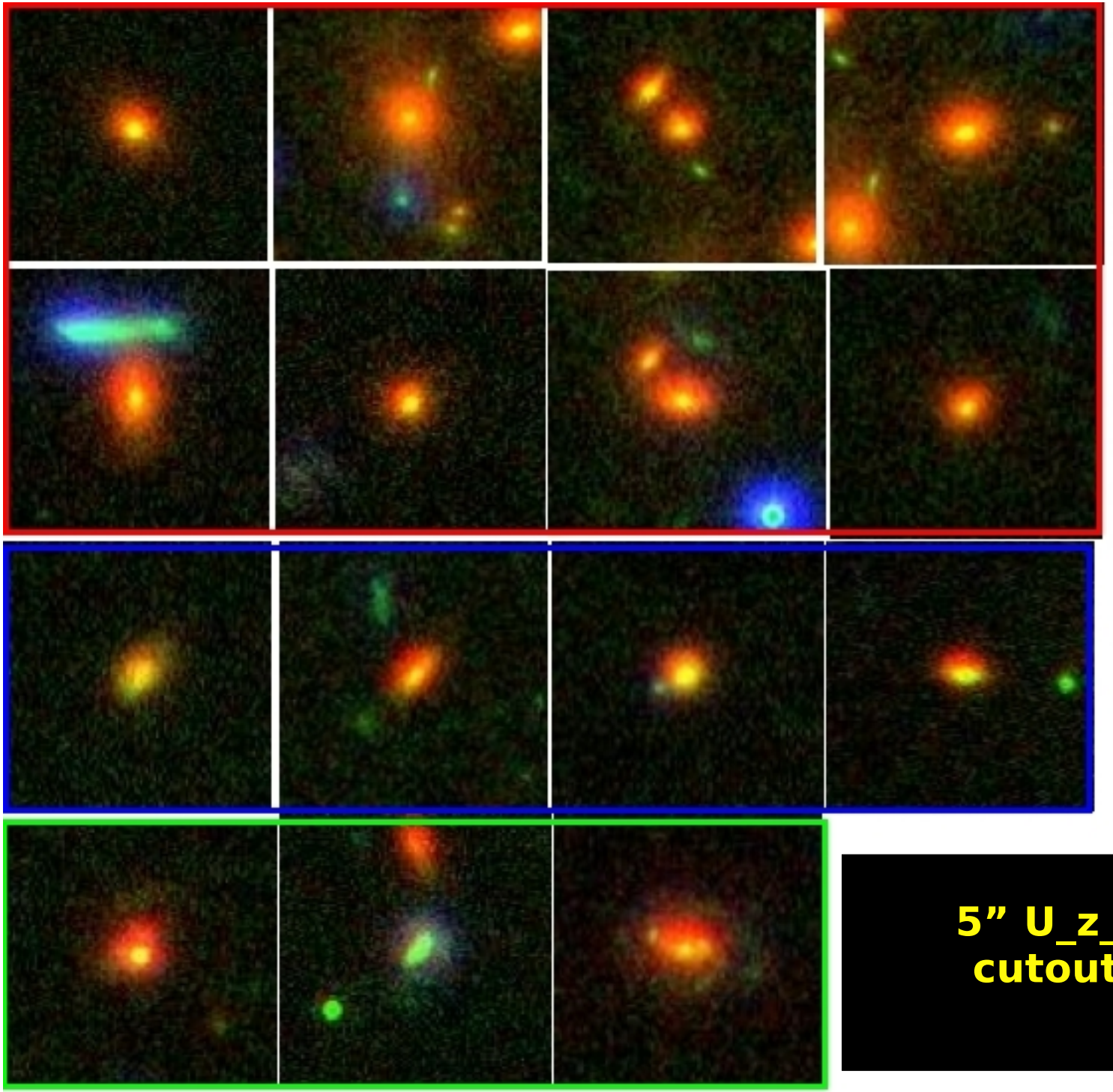

Early type
Late type
Star forming
ACS
5” z850 cutouts


Early type
Late type
Star forming
HAWKI
5” Ks cutouts

Early type

Late type

Star forming



5” U_z_Ks cutouts

STRUCTURAL PARAMETERS:

GALFIT (Peng et al, 2002)

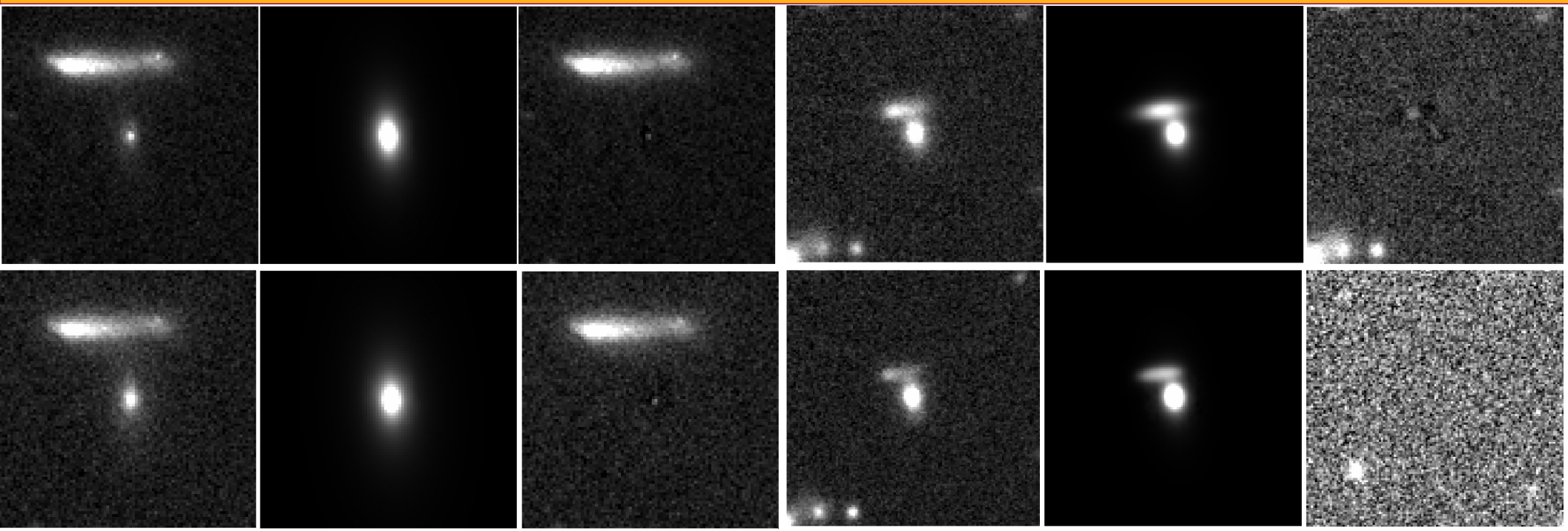


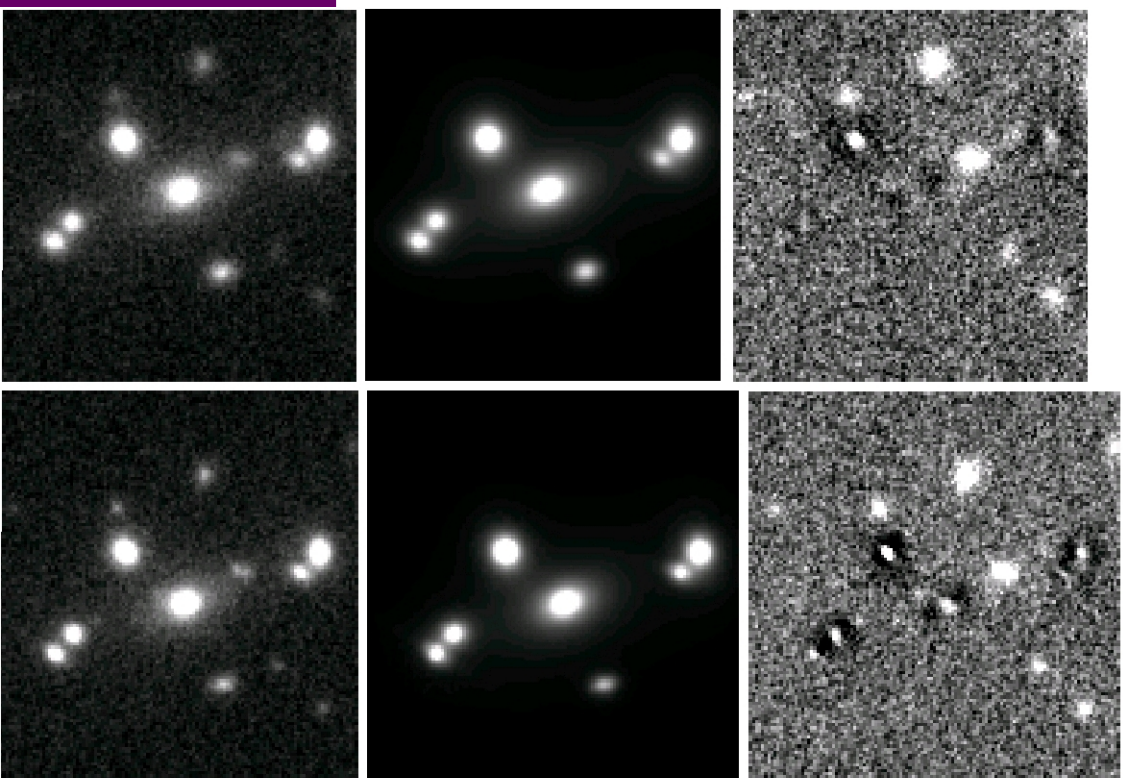
IMAGE MODEL RESIDUAL IMAGE MODEL RESIDUAL

ACS **HAWKI**

BCG Properties:

$M_s = 9 \times 10^{11} M_{sun}$ (SED fitting, R.Gobat)

$z_{AB} = 21.6$ mag (SExtractor)



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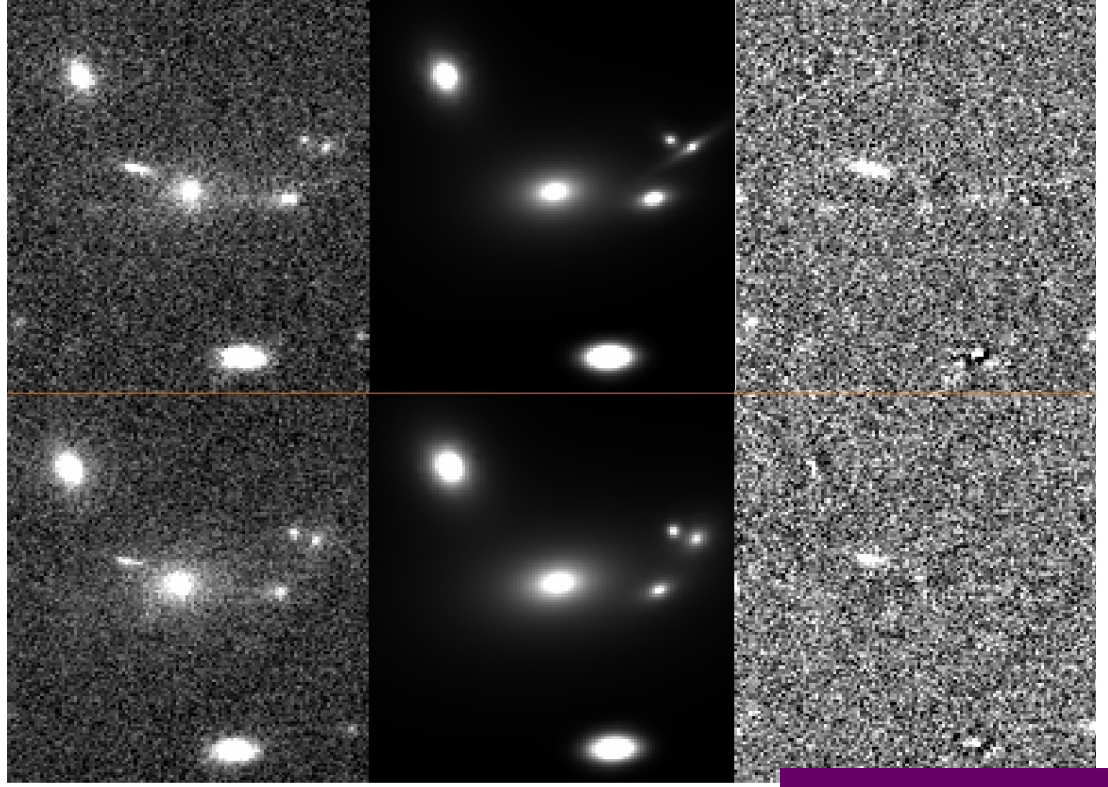


ACS

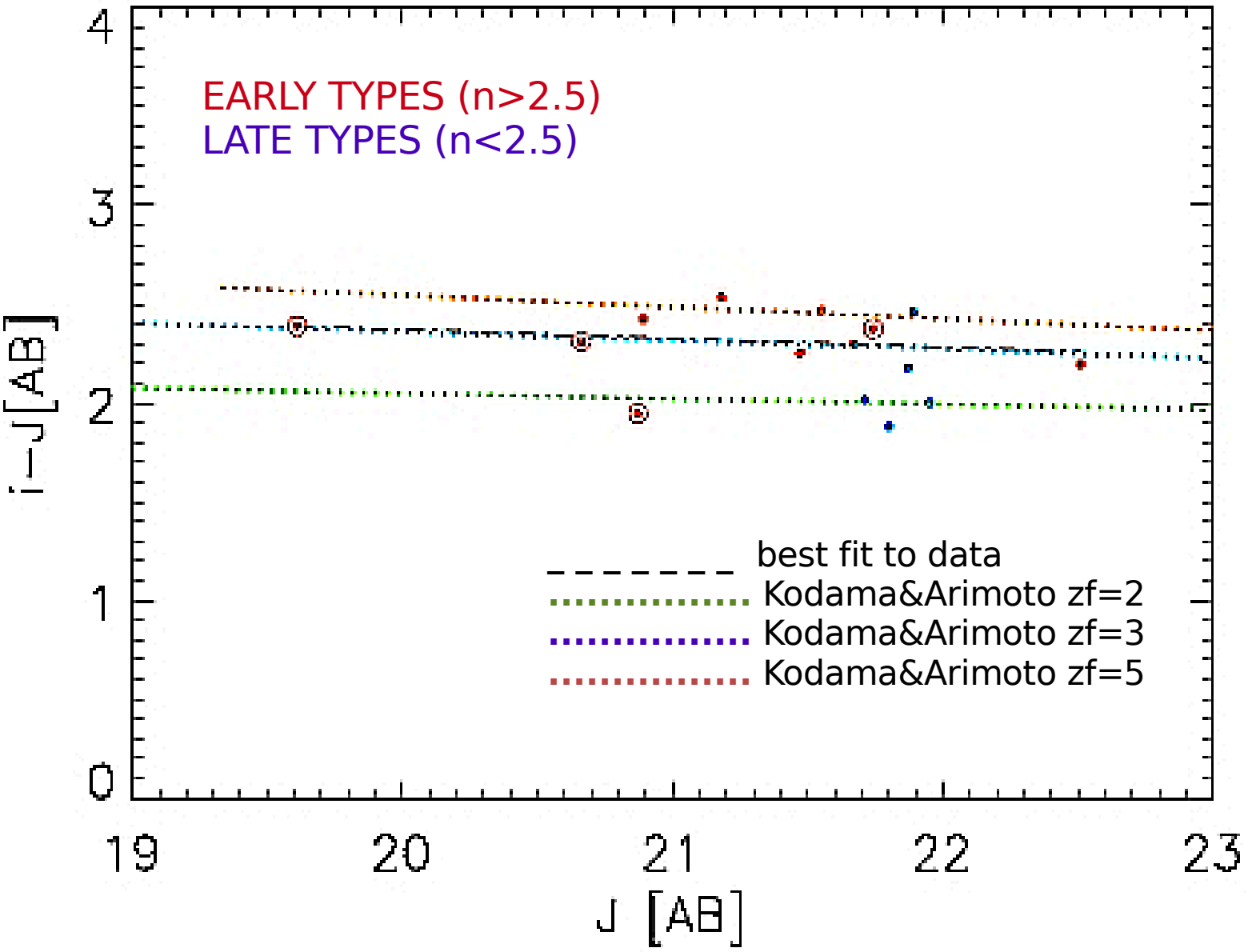
BCG Properties (GALFIT)

$z_{AB} = 21.31 \pm 0.12$ mag

$n = 3.02 \pm 0.25$

$R_e = 17.8 \pm 2.7$ Kpc

COLOR-MAGNITUD RELATION FOR MODEL MAGNITUDES (aperture radius= 0.5")



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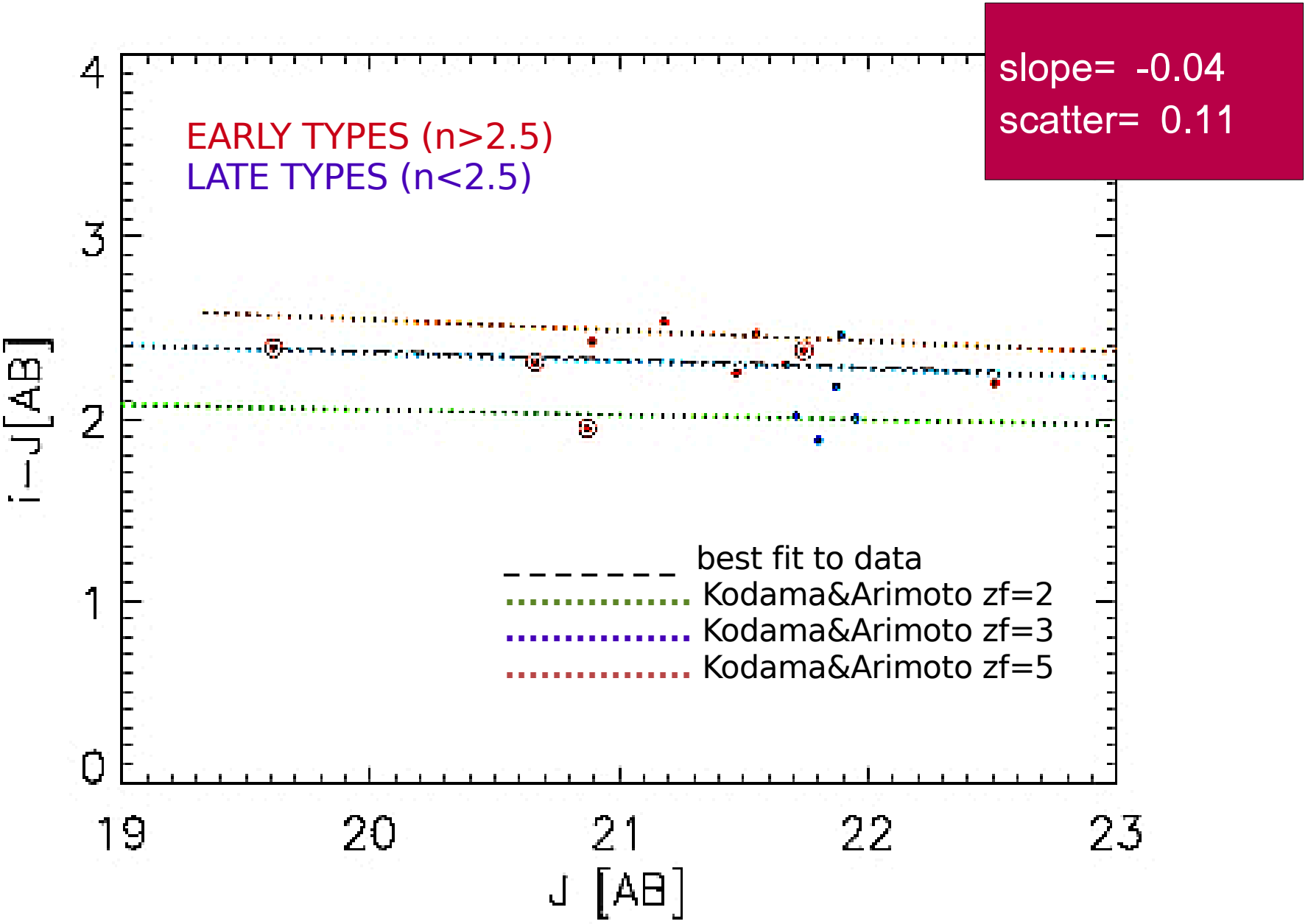
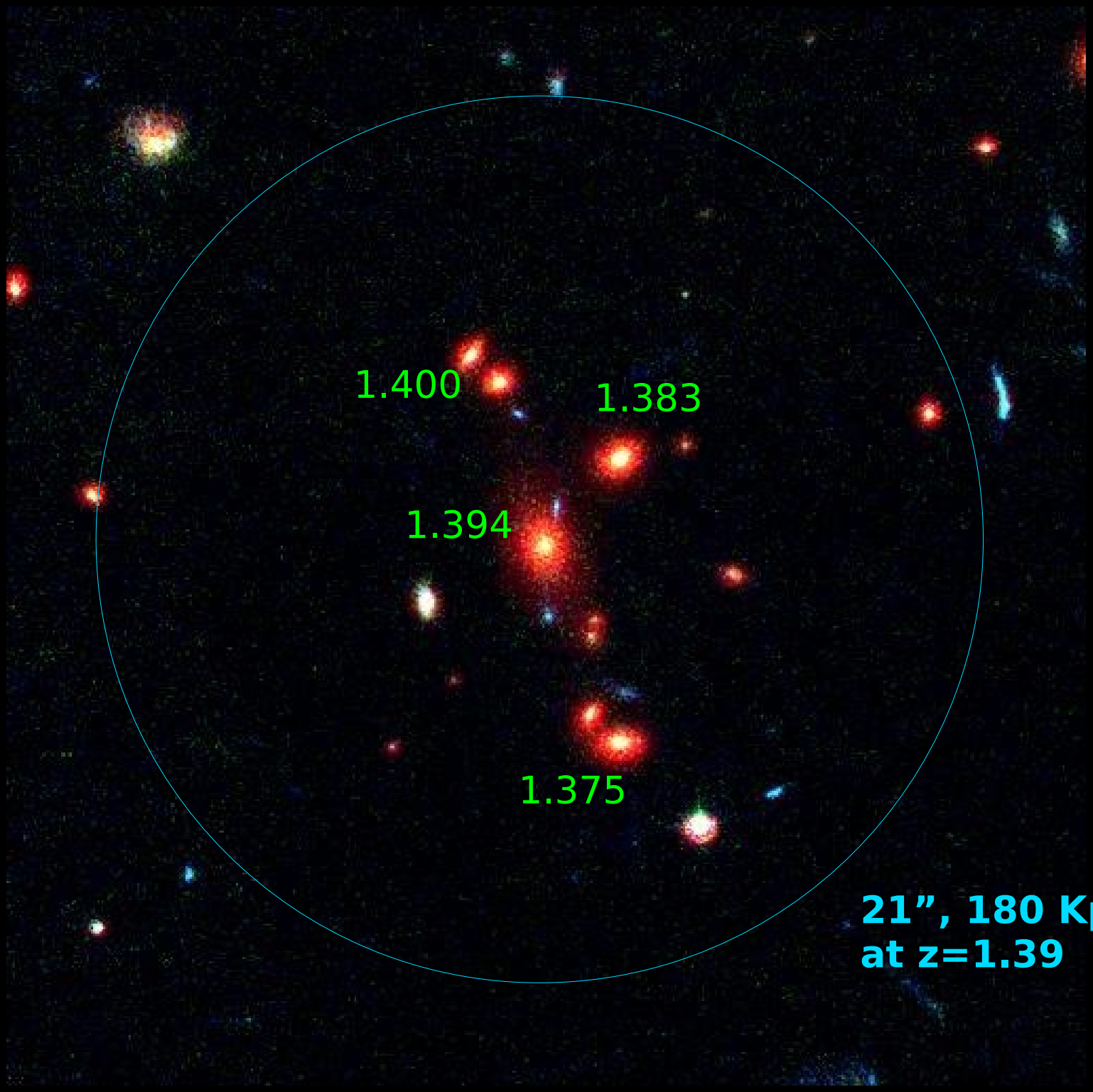
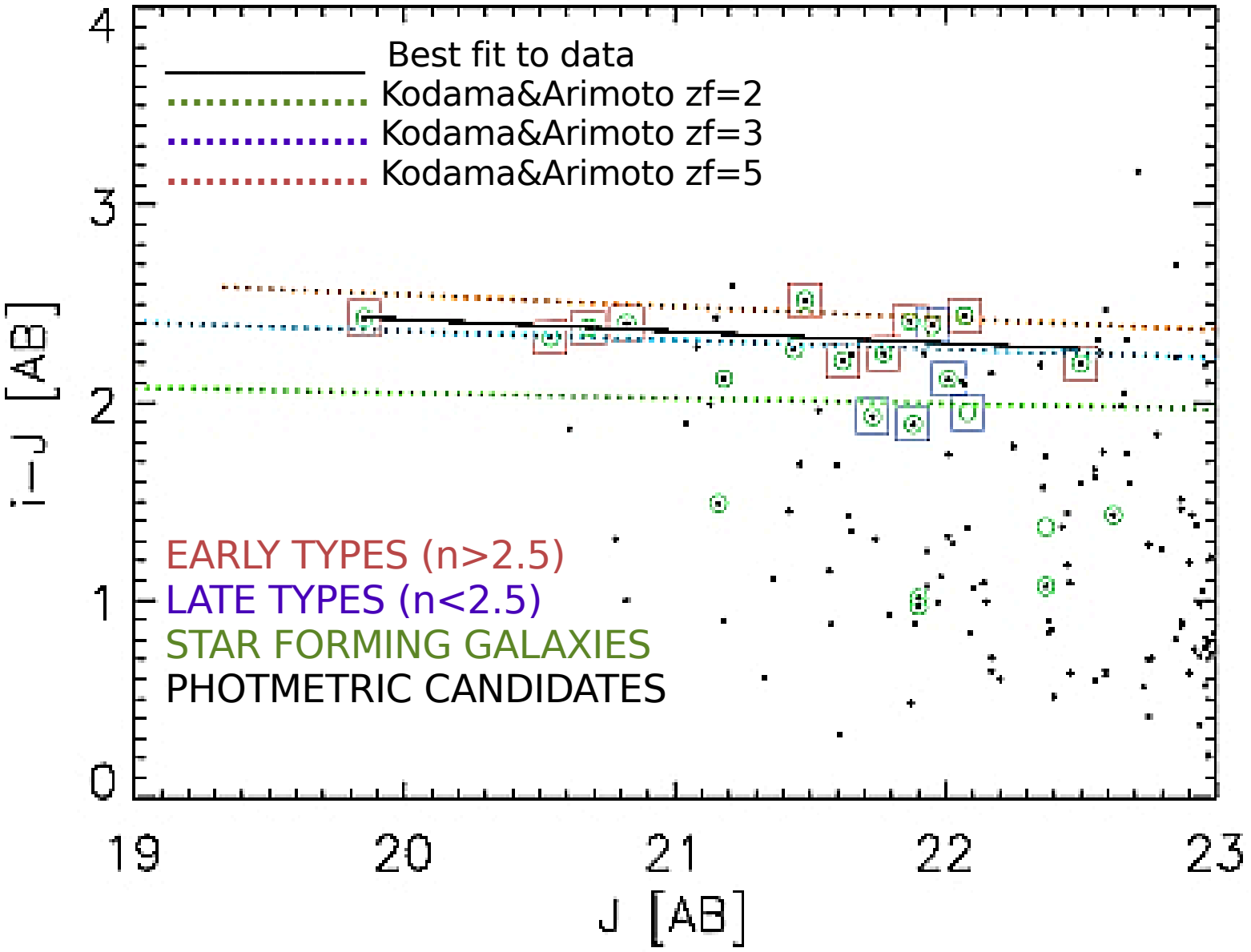



1.400
1.383
1.394
1.375
21”, 180 Kpc
at z=1.39

COLOR-MAGNITUD RELATION WITH PSF CORRECTED PHOTOMETRY (aperture radius)= 0.5”

Photometry by V. Strazzullo



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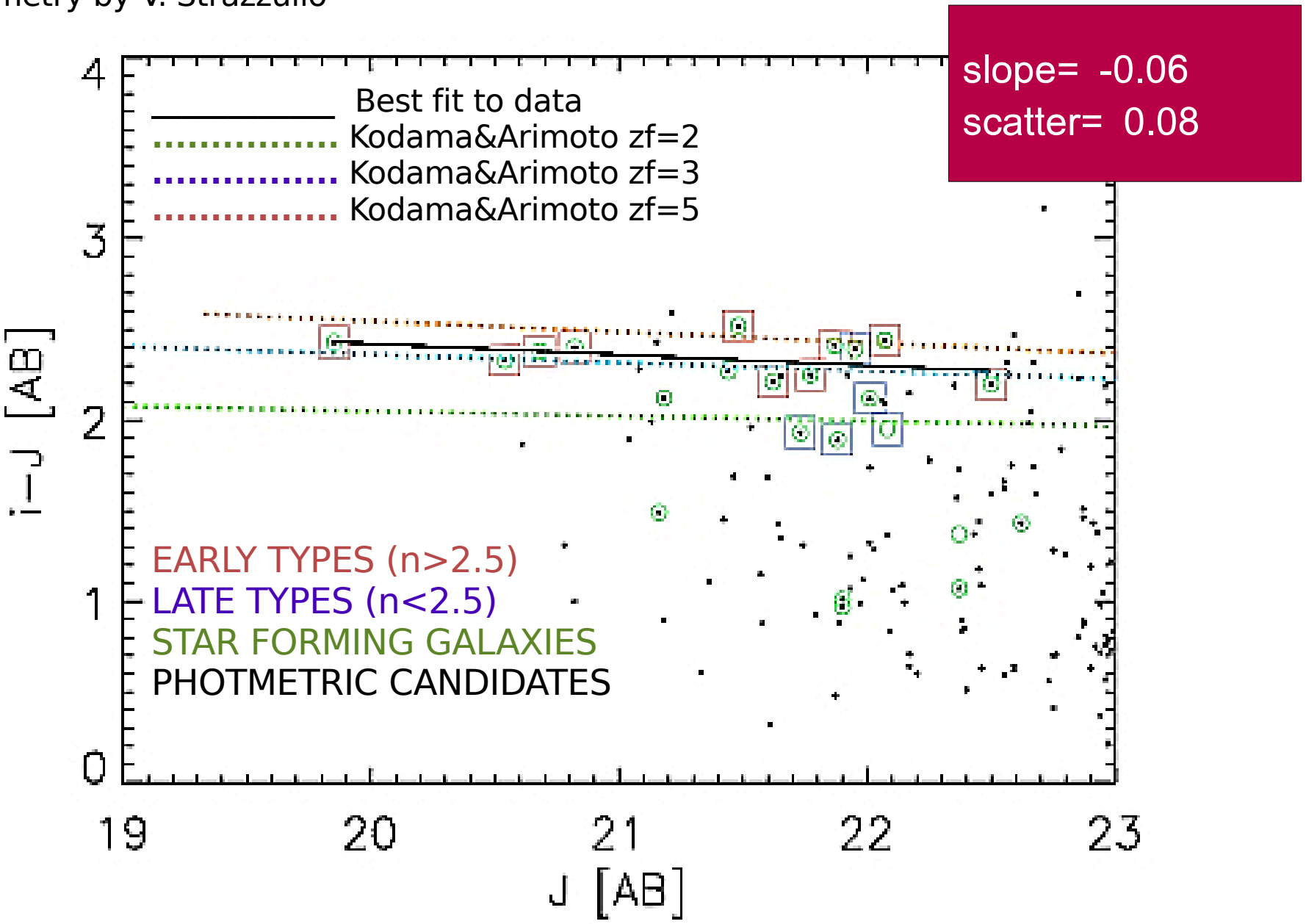

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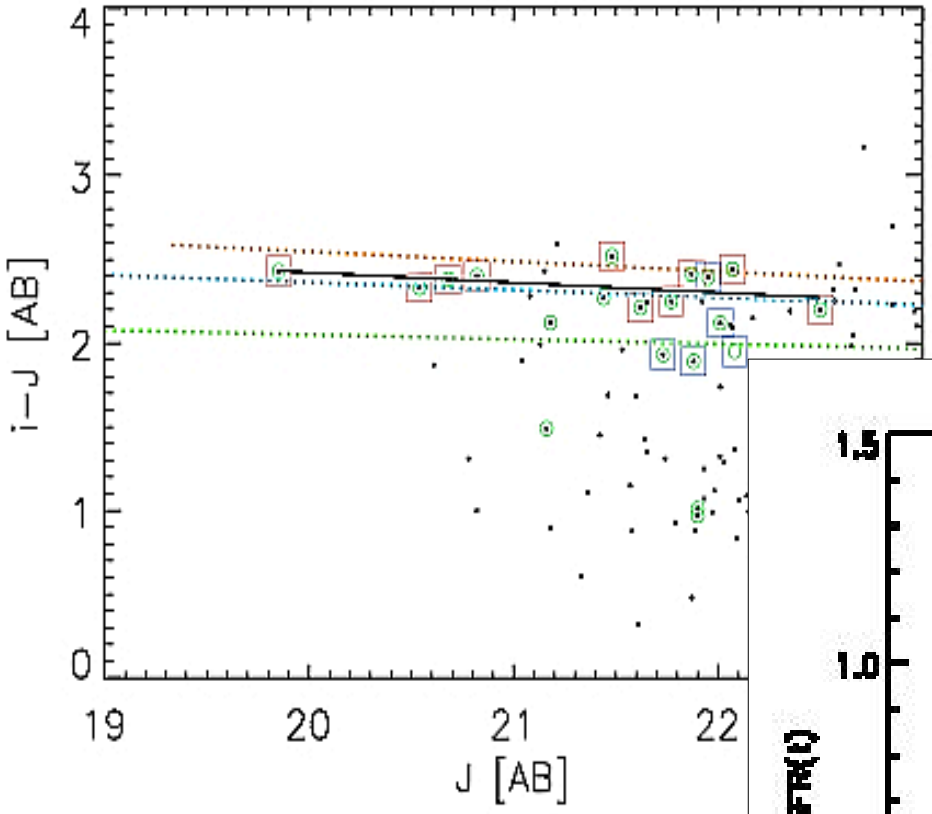
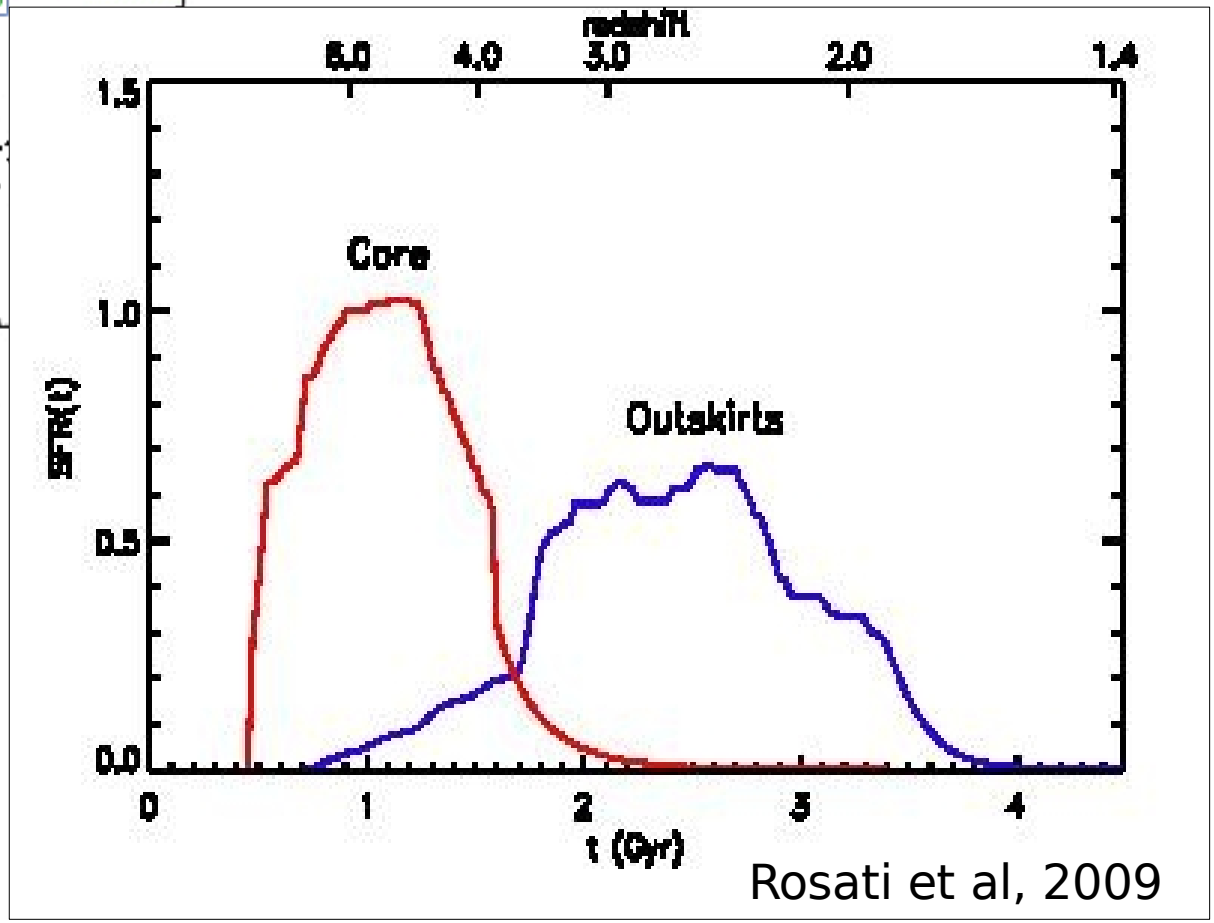
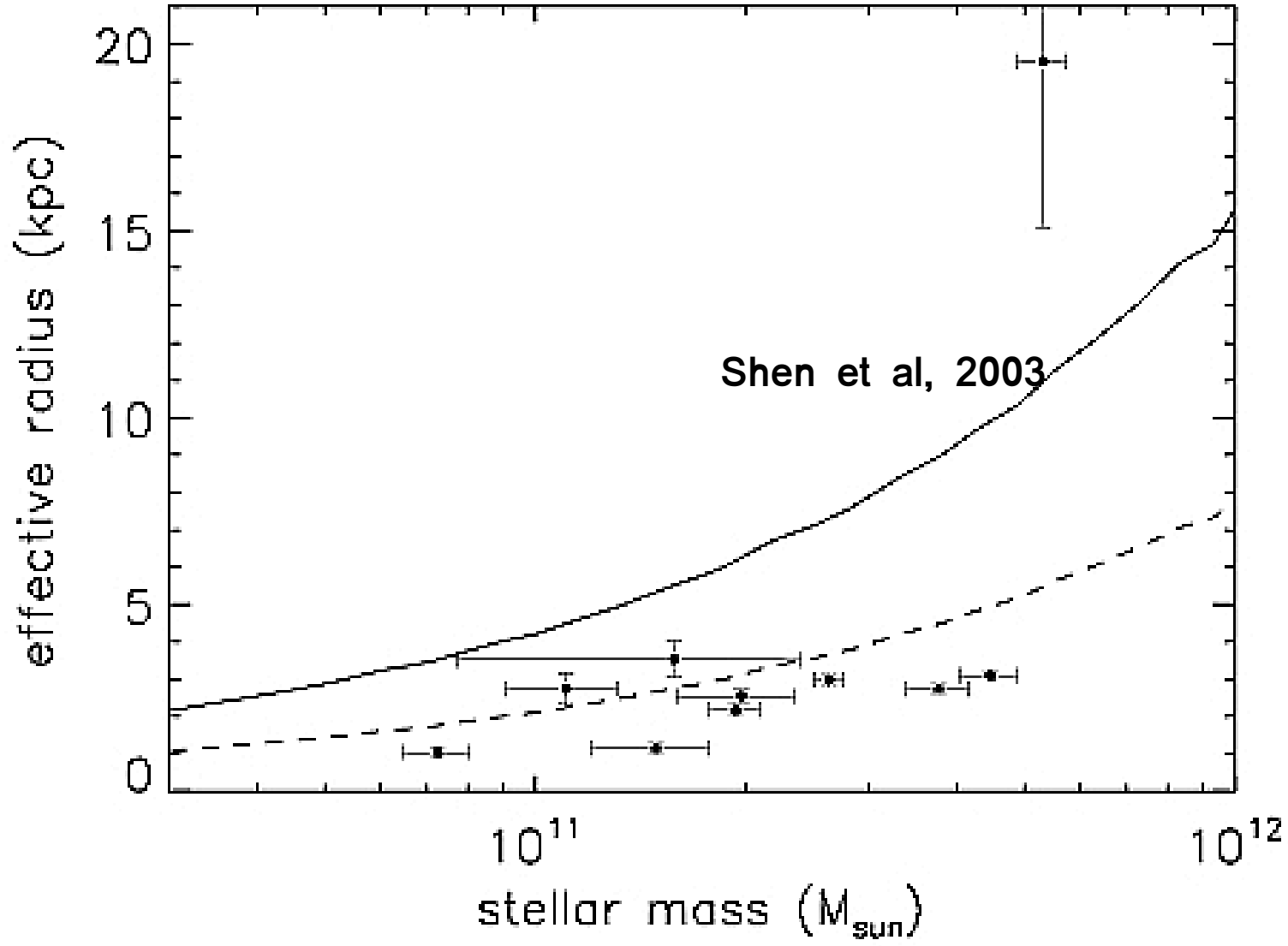




Rosati et al, 2009

SIZE-STELLAR MASS RELATION (K BAND)



SUMMARY & CONCLUSIONS

- At 1/3 the current age of the universe, 2235 shows already a tight Red Sequence.

- Red Sequence shows differences in star formation history for the galaxy population of the cluster (core vs. outskirts)

- Evolution in structural parameters from morphology can be seen in the rest-frame with HAWKI good quality data