CLASH-VLT survey: RXJ2248, a spectrophotometric analysis from the core to the outskirts

A. Mercurio

INAF-Osservatorio Astronomico di Capodimonte

Hubble Space Telescope
ACS/WFC F435W + F606W
ACS/WFC F814W + WFC3/IR F105W
WFC3/IR F125W + F140W + F160W

Image: Frontier Fields Science Data Products Team (A. Koekemoer, J. Mack, J. Anderson, R. Avila, E. Barker, D. Hammer, B. Hilbert, R. Lucas, S. Ogaz, M. Robberto, and the Frontier Fields Implementation Team)

P.I.: P. Rosati, + M. Annunziatella, I. Balestra, G. Bartosch Caminha, A. Biviano, M. Girardi, R. Gobat, C. Grillo, M. Lombardi, M. Nonino, B. Sartoris, L. Tortorelli, P. Tozzi, E. Vanzella and the CLASH-VLT team

CLASH

CLASH-VLT team: https://sites.google.com/site/vltclashpublic/clash-vlt-team

CLASH-VLT survey

VIMOS Large Programme (230 hr over 5 years) - PI: P.Rosati

+

Panoramic spectroscopic survey of 13 southern CLASH clusters at z=0.2-0.6

CLASH HST Treasury Program (530 orbits) - PI: M.Postman

Panchromatic (ACS+WFC3 16 filters) imaging of 25 massive clusters (z=0.2-0.9)

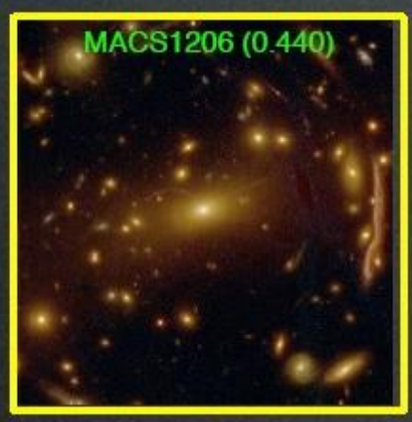
Common goals

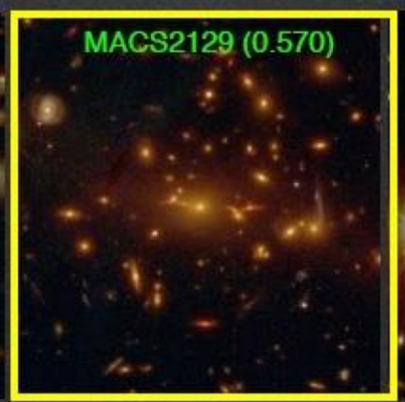
- New constraints on DM & Baryons distribution in clusters
- Discovery of primordial galaxies, exploiting magnification on the very high-z Universe

---

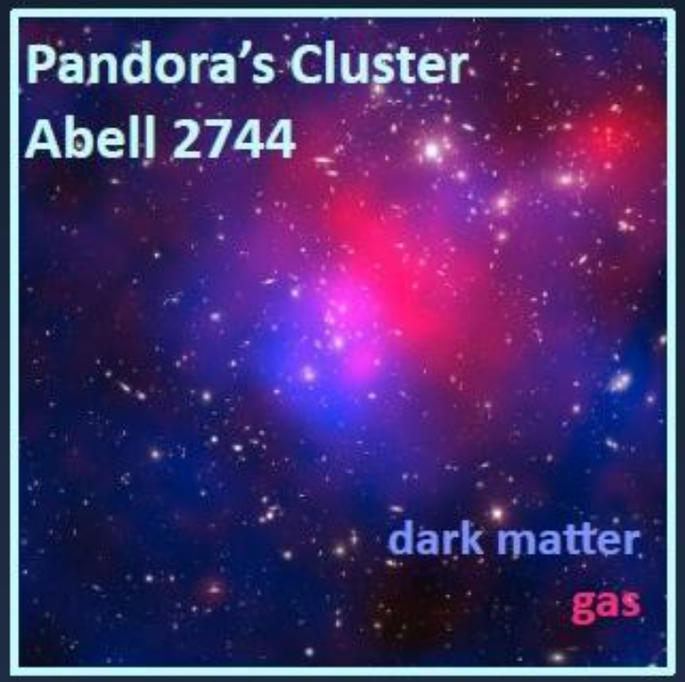
- Dynamical mass profile out to 2-3 R_{vir} and with at least ~500 members per cluster
- Background and highly magnified galaxies out to z~7
- Cluster assembly history from stellar populations, dynamics, morphologies as a function of mass and from high to low density environments

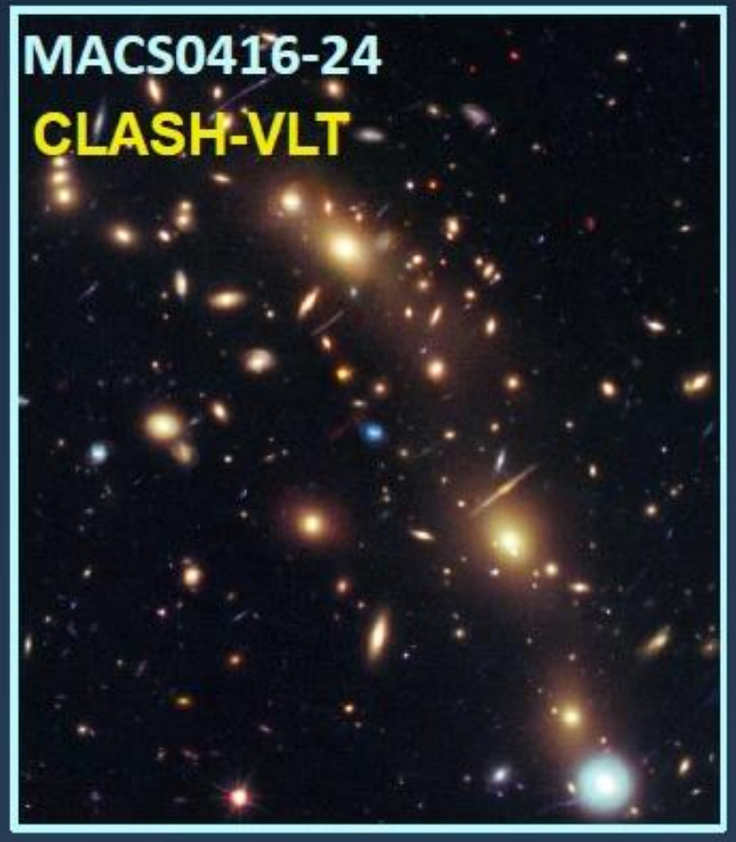
CLASH Gallery: 25 Clusters (13 CLASH-VLT)

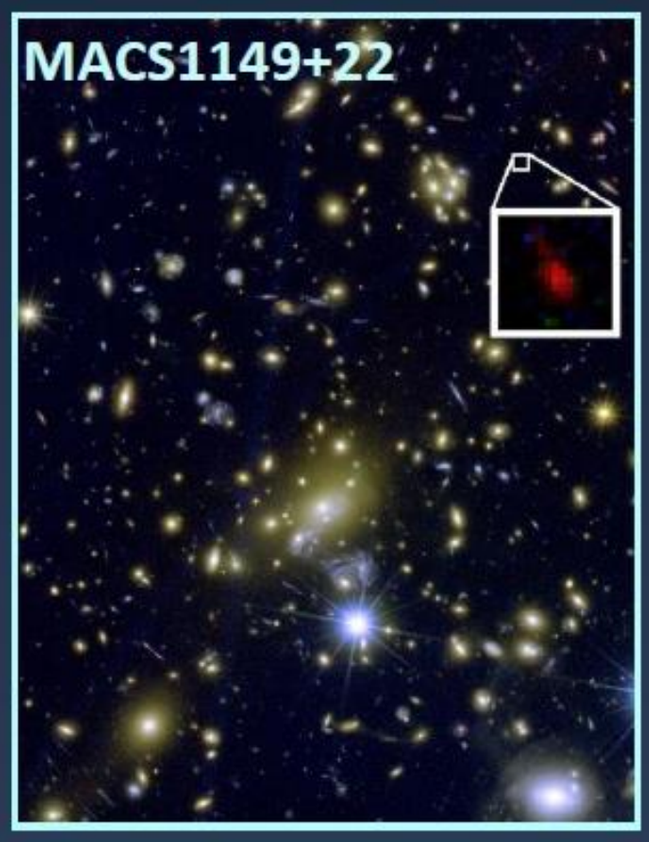


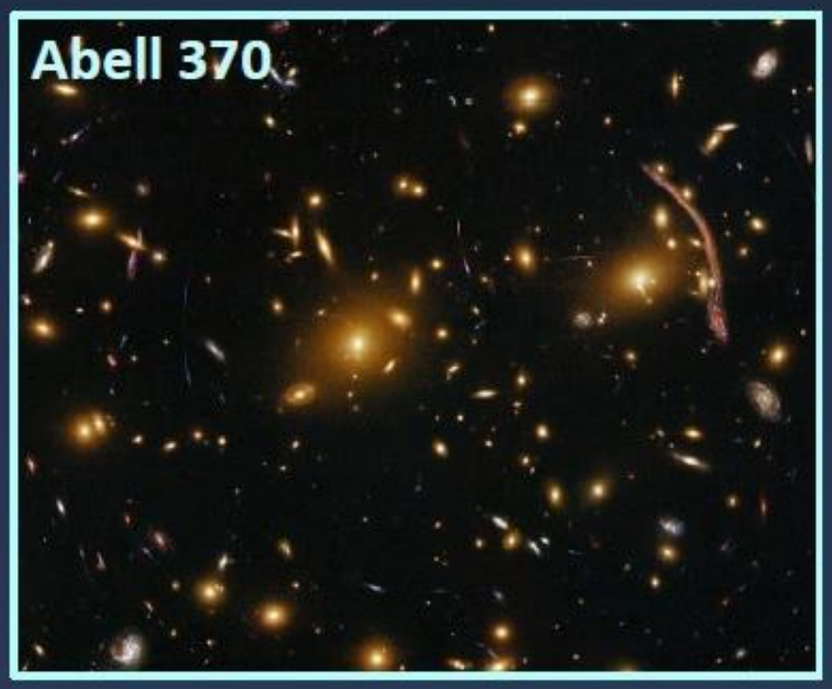


in the wake of CLASH: The Frontier Fields









➔ 70 orbits ACS + 70 orbits WFC3/IR, ~1.5mag deeper than CLASH (Fall 2013 – Fall 2016)

➔ Chandra large program (PI: C.Jones) for deep X-ray observations

CLASH multiple facilities: DM & Baryonic Mass Distribution from independent probes over the 10 kpc ~ 3 Mpc range

PI: S.Ettori

PI: M. Donahue

Baryon mass distribution
X-ray masses
ICM physics & metallicity

VLT

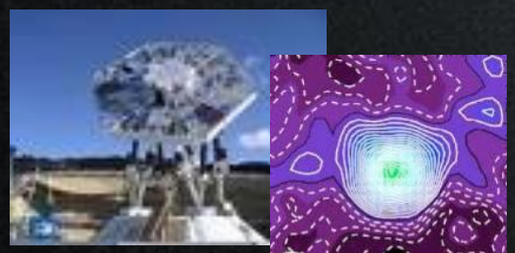
VIMOS Large Prog (230 hr)
~500 members per cluster
+ arcs redshifts

PI: P. Rosati

High-z gals
Dynamical analysis
Stellar masses

DM and Baryons in Clusters

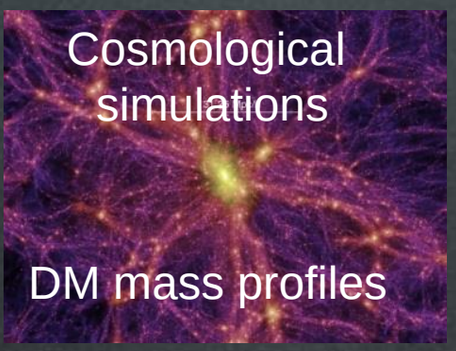
Bolocam, Mustang



PI: K. Umetsu

ICM physics
DM&Baryon masses

SZ observations



High-z gals

LBT

PI: M. Nonino

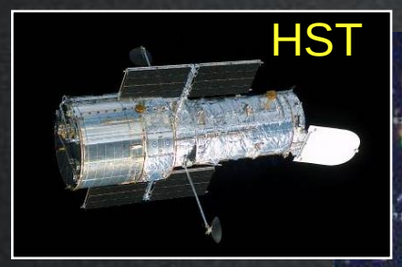
WL masses profile
Stellar masses

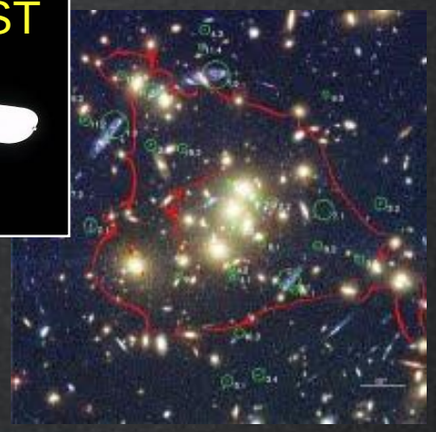
High-z galaxies

Spitzer

PI: W. Zheng
R. Bowuens

Strong Lensing
Mass profile in the core





Treasury Program
(530 orbits)
PI: M. Postman

Subaru (+ ESO-WFI)
+ VST+VISTA

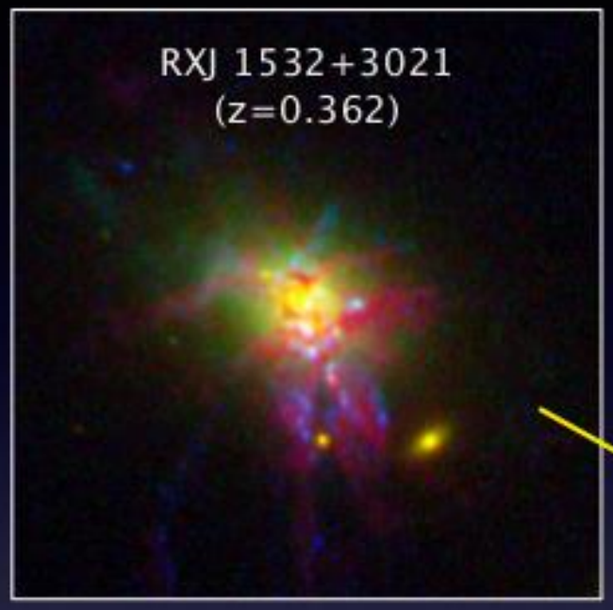
PI: K. Umetsu
M. Nonino

PI: A. Mercurio
PI: M. Nonino

Courtesy of P. Rosati

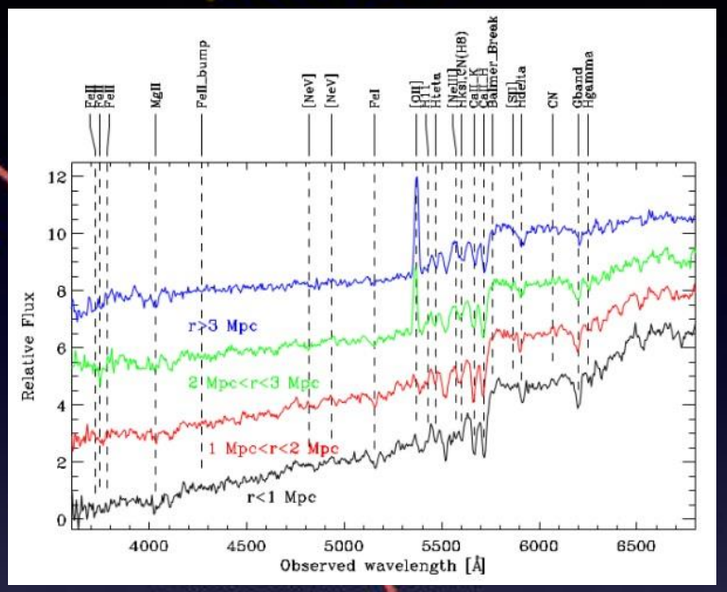
New avenues for galaxy evolution with CLASH-VLT

BCG structure, SF, cooling



Comparison with Semi-analytic models

Galaxy transformation processes

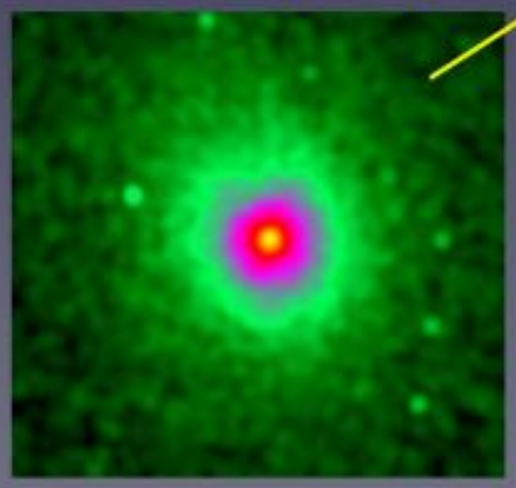


Girardi et al. (2015)

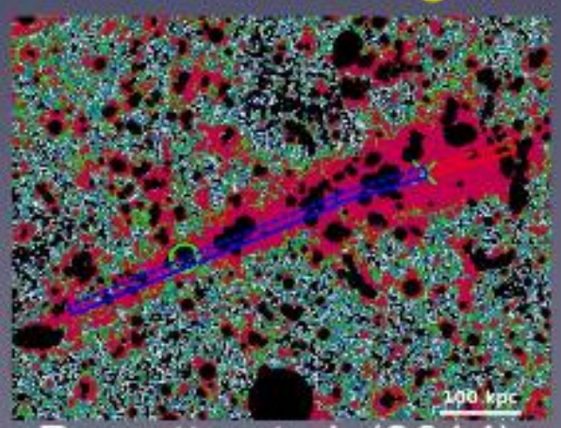
Galaxy spectro-photometric and kinematic properties over ~5 Mpc:

- ✓ structural parameters
- ✓ M_{star}, SFR, sSFR, ages, dust
- ✓ Gas metallicities of SF galaxies
- ✓ ICM properties

Intra-Cluster Medium (X-ray)

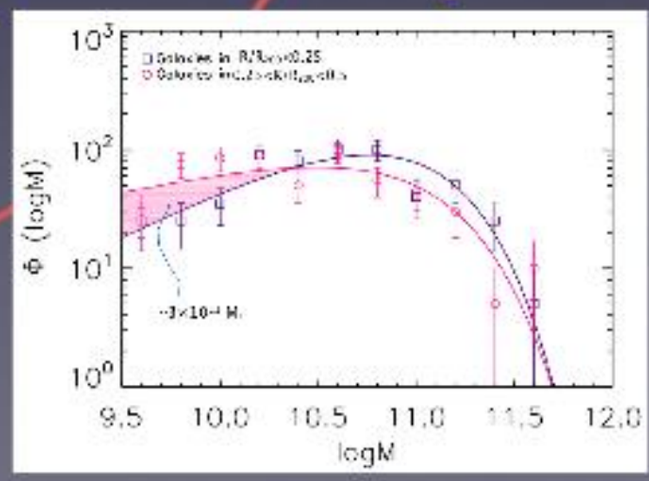


Intra-Cluster light



Presotto et al. (2014)

Stellar mass/luminosity fnct



Annunziatella et al. (2014)

CLASH-VLT LP: completed on 3/2016 (207h)

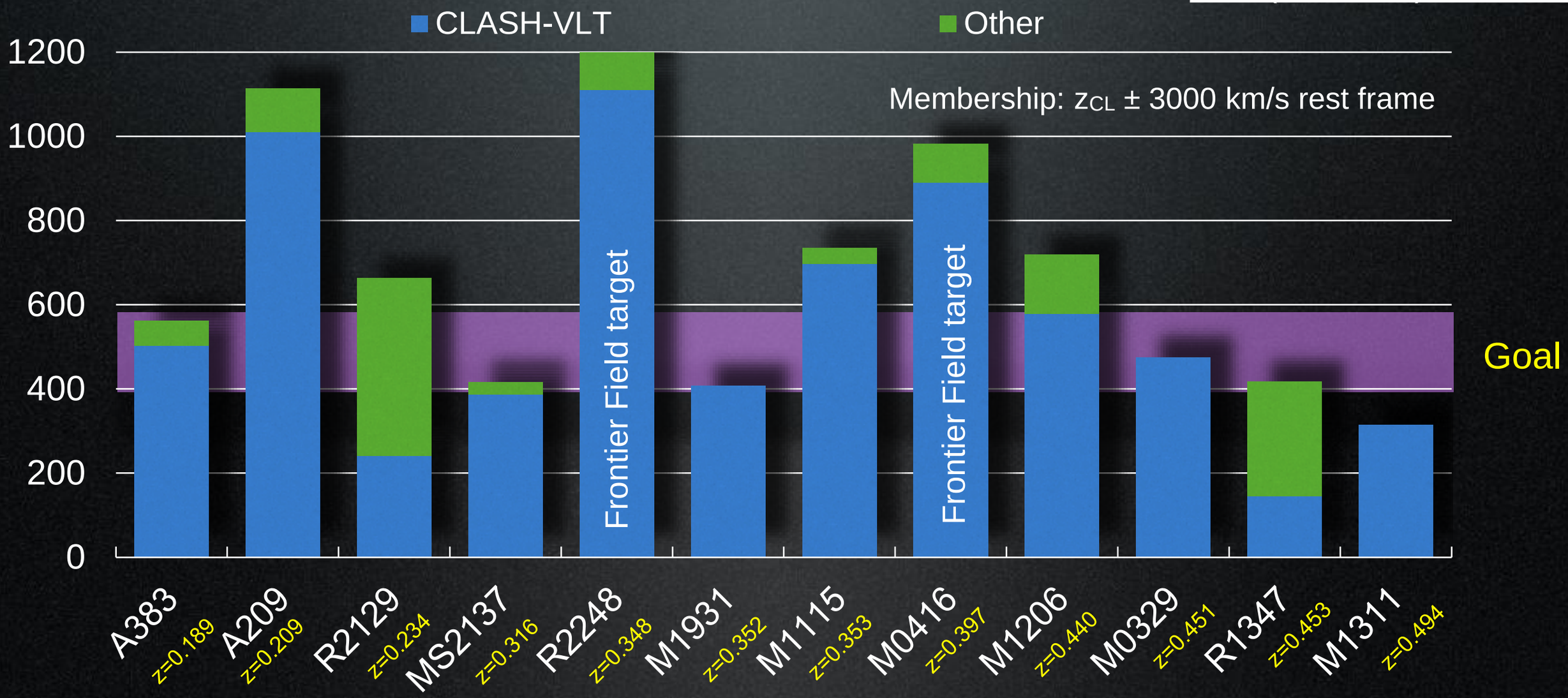
Final redshift sample now completed

~33600 redshifts (from ~53000 spectra incl. duplicates)
~7900 cluster members
~200 lensed galaxies to z~7 (>300 X-ray Chandra sources)
23 published papers to date

>~10,000 redshifts released to date

- MACS1206
- MACS0416
- MACS2129
- A209
- RXJ2248 (AS1063) (HST area)

Cluster members yield



https://sites.google.com/site/vltclashpublic

CLASH-VLT LP: completed on 3/2016 (207h)

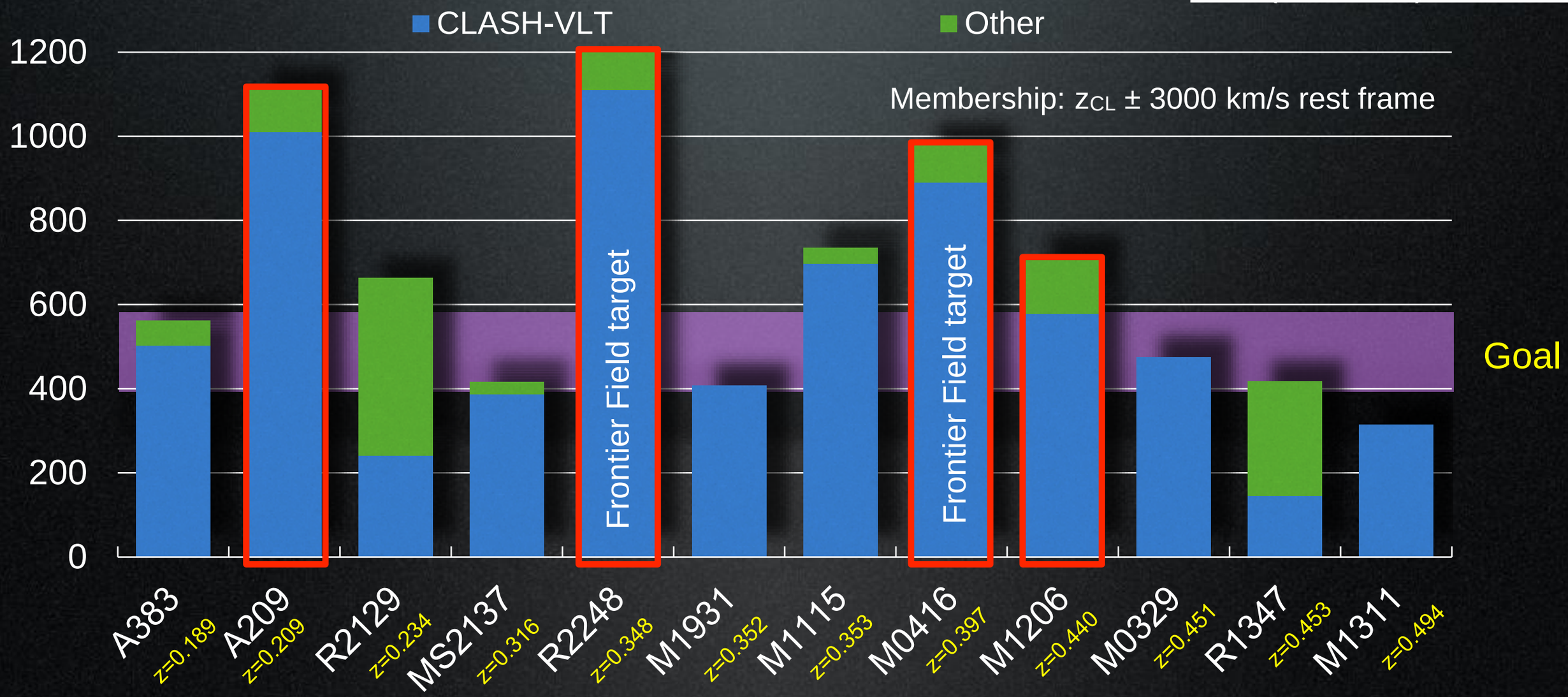
Final redshift sample now completed

~33600 redshifts (from ~53000 spectra incl. duplicates)
~7900 cluster members
~200 lensed galaxies to z~7 (>300 X-ray Chandra sources)
23 published papers to date

>~10,000 redshifts released to date

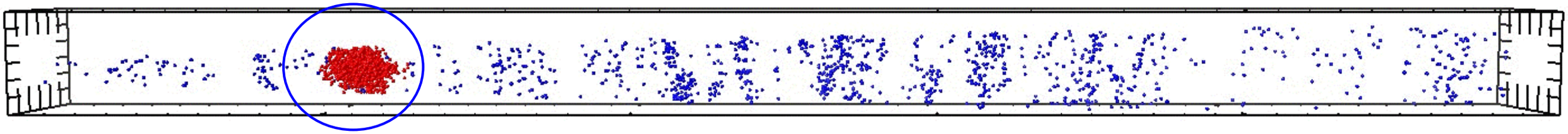
- MACS1206
- MACS0416
- MACS2129
- A209
- RXJ2248 (AS1063) (HST area)

Cluster members yield

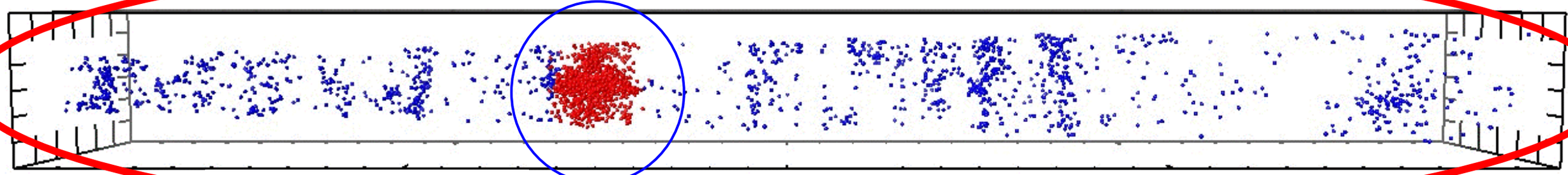


https://sites.google.com/site/vltclashpublic

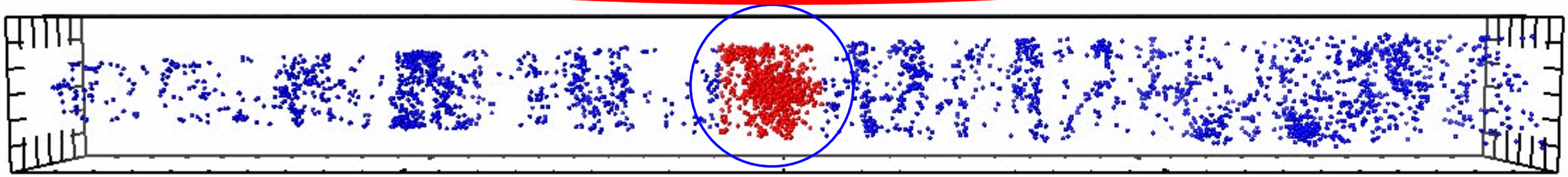
A209 ~1100 members



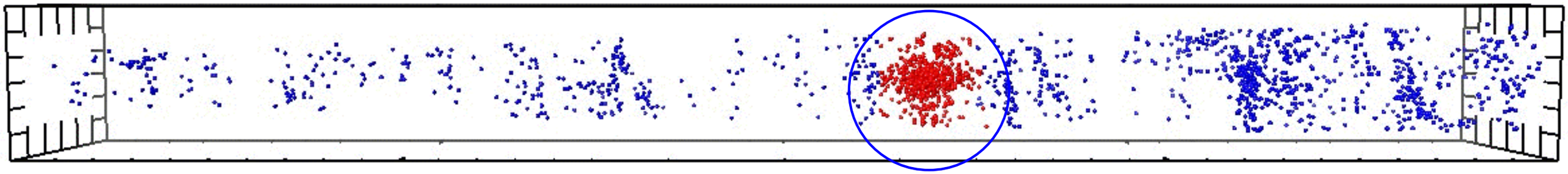
RXJ2248 ~1200 members



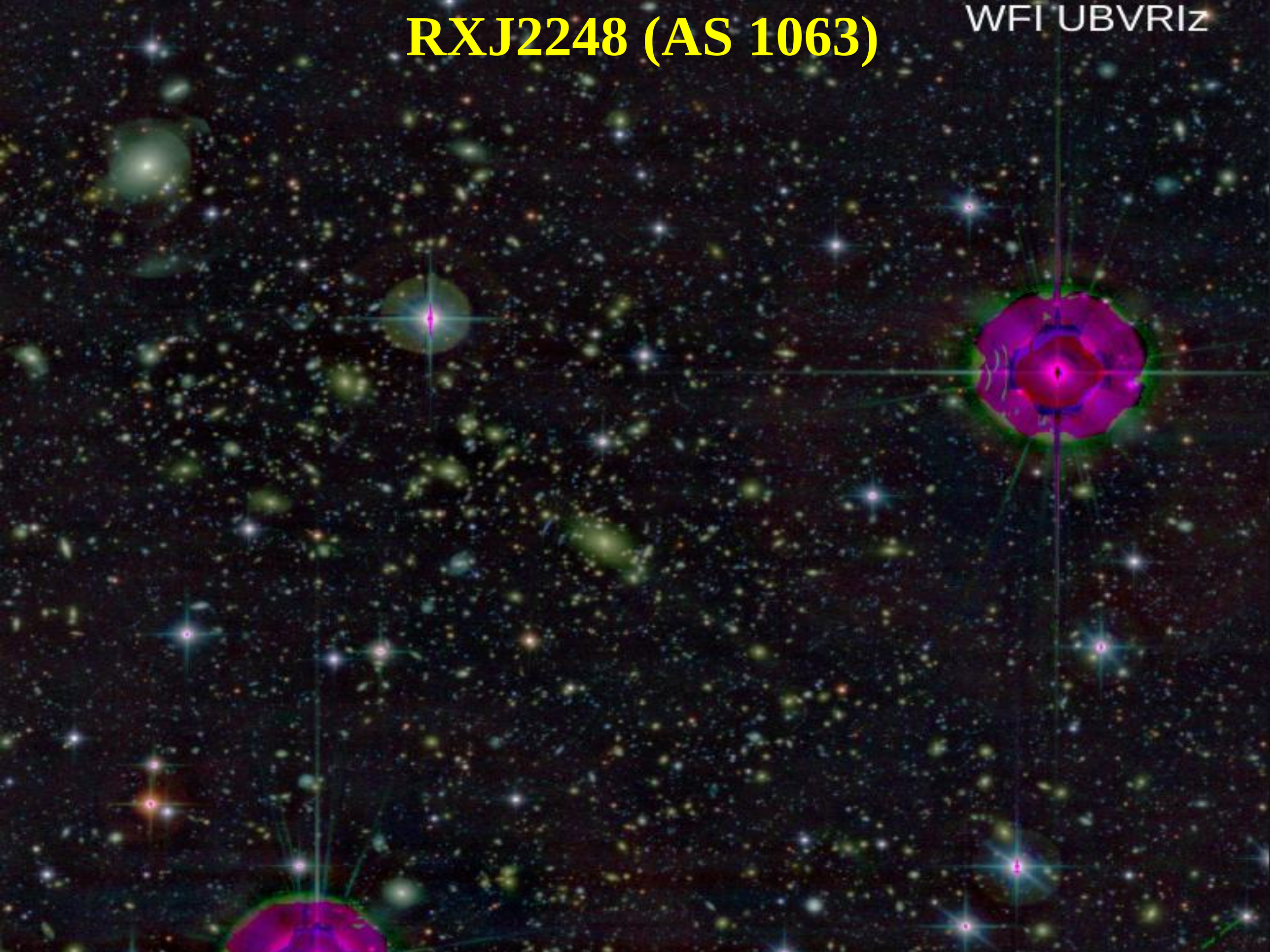
MACS0416 ~900 members



MACS1206 ~700 members



RXJ2248 (AS 1063)

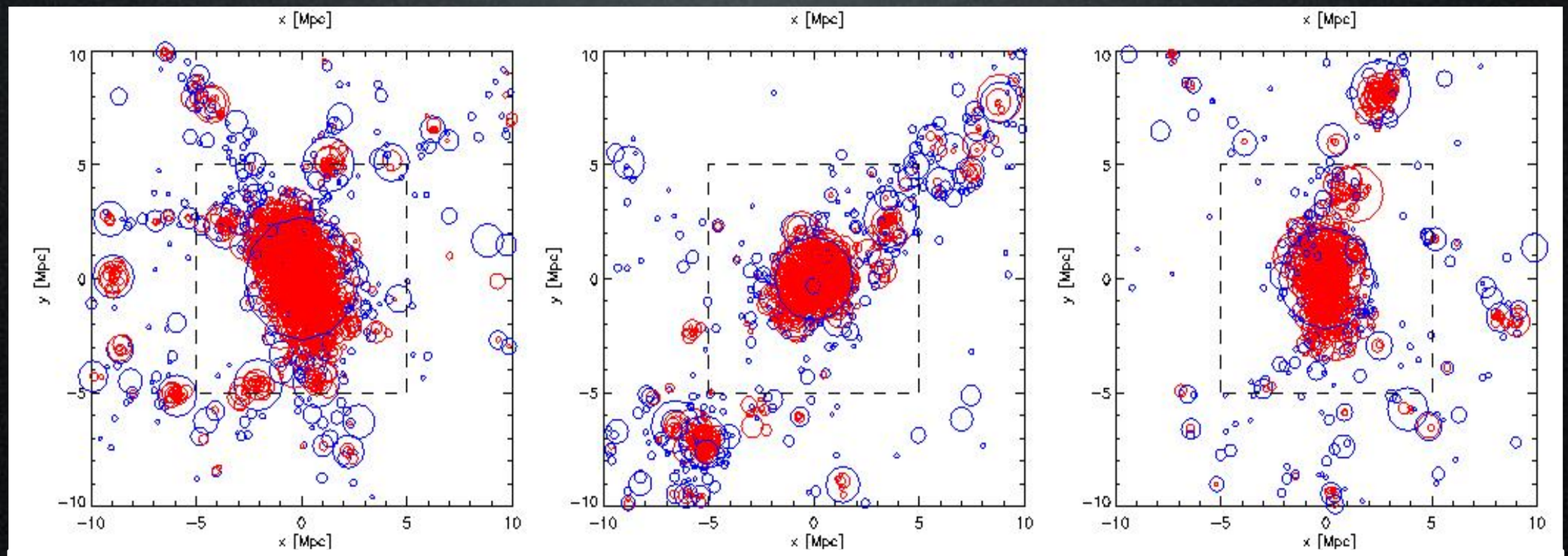


Galaxy Assembly as a function of Mass and Environment with VST (VST-GAME)

PI: A. Mercurio (INAF-Osservatorio Astronomico di Capodimonte, OANa)

Co-Is: M. Annunziatella, I. Balestra, A. Biviano, S. Borgani, M. Brescia, M. Castellano, S. Cavuoti, D. Coe, W. A. Dawson, S. De Grandi, G. De Lucia, R. De Propris, M. Donahue, L. Feretti, F. Fontanot, S. Ghizzardi, G. Giovannini, M. Girardi, R. Gobat, F. Govoni, A. Grado, C. Grillo, D. Gruen, M. Lombardi, C. Mancini, E. Medezinski, E. Merlin, M. Nonino, G. Rodighiero, P. Rosati, M. Rossetti, B. Sartoris, L. Tortorelli, P. Tozzi, K. Umetsu, E. Vanzella, T. Venturi.

300h VST survey of perform a unique wide field coverage (20x20 Mpc^2 at z=0.4) of 12 massive galaxy clusters, at 0.2<z<0.6 (z median ~0.4), in four bands (u', g', r', i'), to explore galaxy evolution in a wide and largely unexplored range of cluster environments up to 10^9 $M_\odot$.



z~0.3 – Semi-analytic moels from De Lucia & Blaizot (2007)

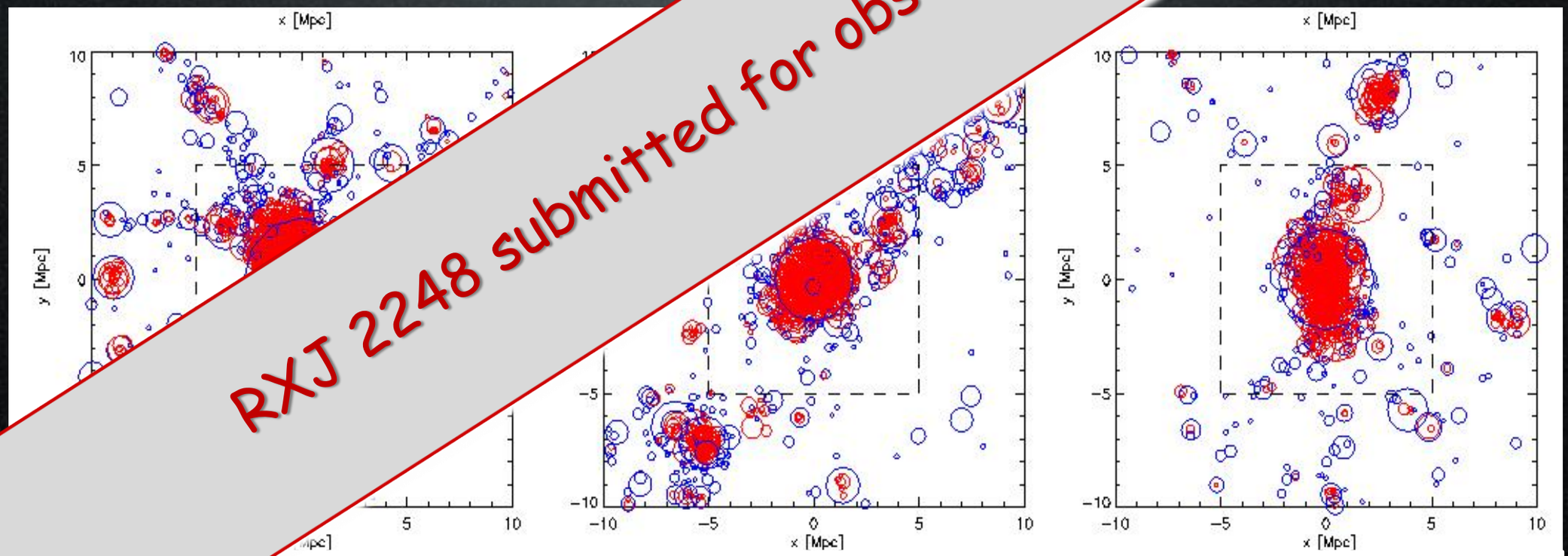
Concerted effort which includes NIR observations of an ongoing VISTA Public Survey (560h, P.I. M. Nonino, Survey manager: A. Mercurio).

Galaxy Assembly as a function of Mass and Environment with VST (VST-GAME)

PI: A. Mercurio (INAF-Osservatorio Astronomico di Capodimonte, OANa)

Co-Is: M. Annunziatella, I. Balestra, A. Biviano, S. Borgani, M. Brescia, M. Castellano, S. Cavuoti, D. Coe, W. A. D[illegible] G. De Lucia, R. De Propris, M. Donahue, L. Feretti, F. Fontanot, S. Ghizzardi, G. Giovannini, M. Girardi, R. Gobat[illegible] Grillo, D. Gruen, M. Lombardi, C. Mancini, E. Medezinski, E. Merlin, M. Nonino, G. Rodighiero, P. Rosati[illegible] Tortorelli, P. Tozzi, K. Umetsu, E. Vanzella, T. Venturi.

300h VST survey of perform a unique wide field coverage [illegible]) of 12 massive galaxy clusters, at 0.2<z<0.6 (z median ~0.4) [illegible], r', i'), to explore galaxy evolution in a wide and largely un[illegible]ster environments up to 10^9 $M_\odot$.



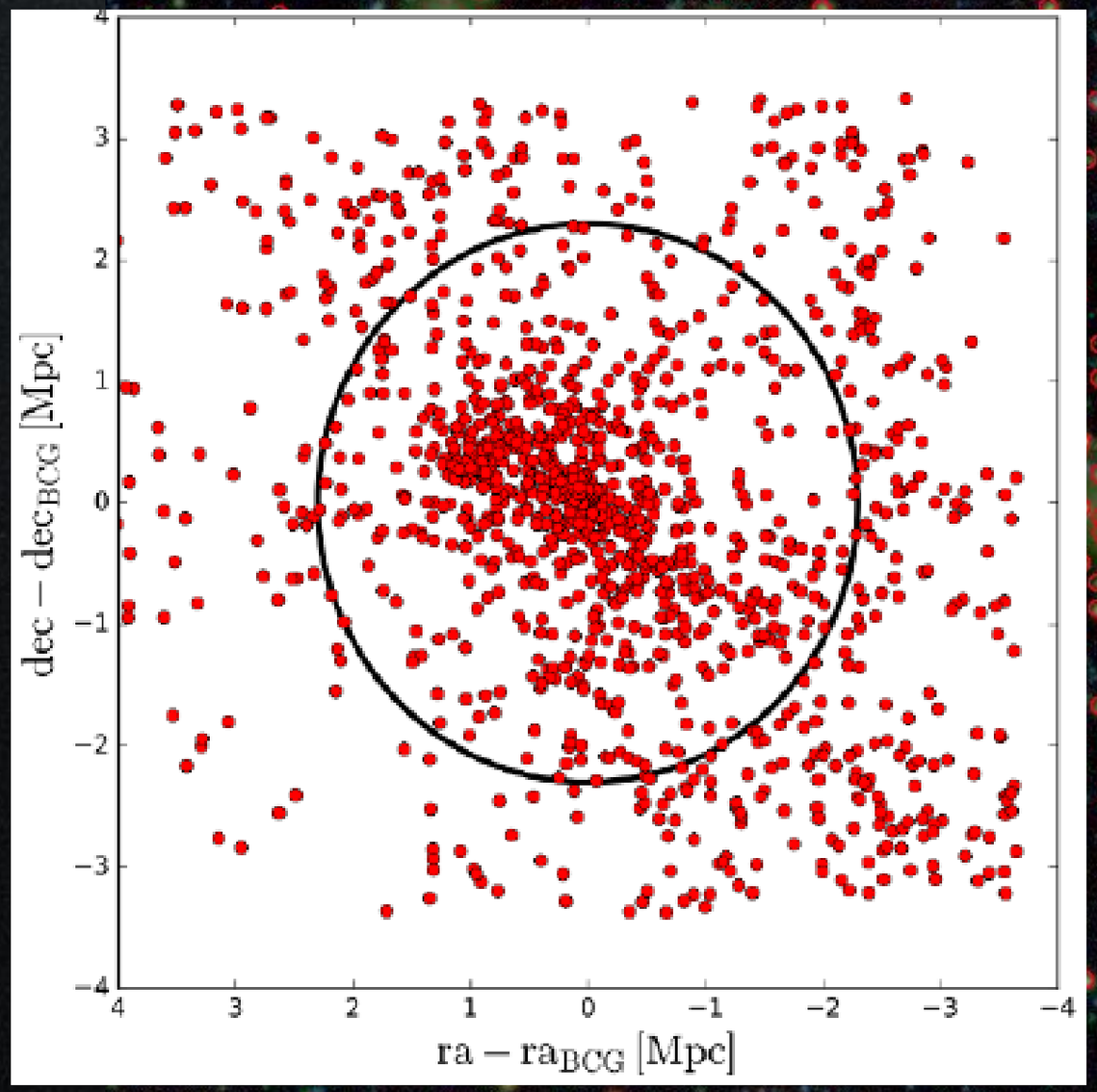
[illegible]0.3 – Semi-analytic moels from De Lucia & Blaizot (2007)

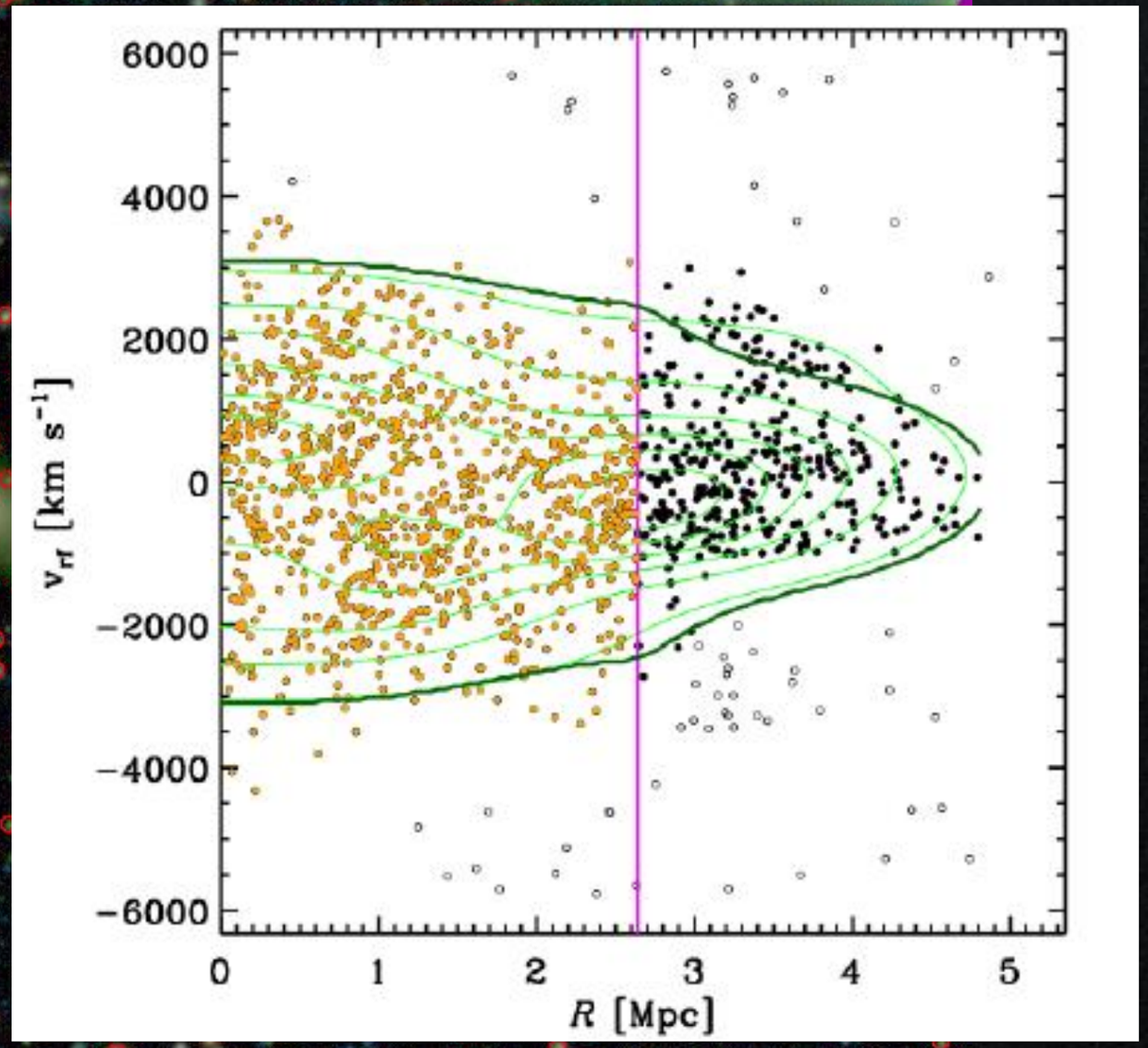
RXJ 2248 submitted for observations in P101

Conce[illegible]effort which includes NIR observations of an ongoing VISTA Public Survey (560h, P.I. M. Nonino, Survey manager: A. Mercurio).

RXJ2248 (AS 1063)
1234 members!!!

RXJ2248 (AS 1063)
1234 members!!!



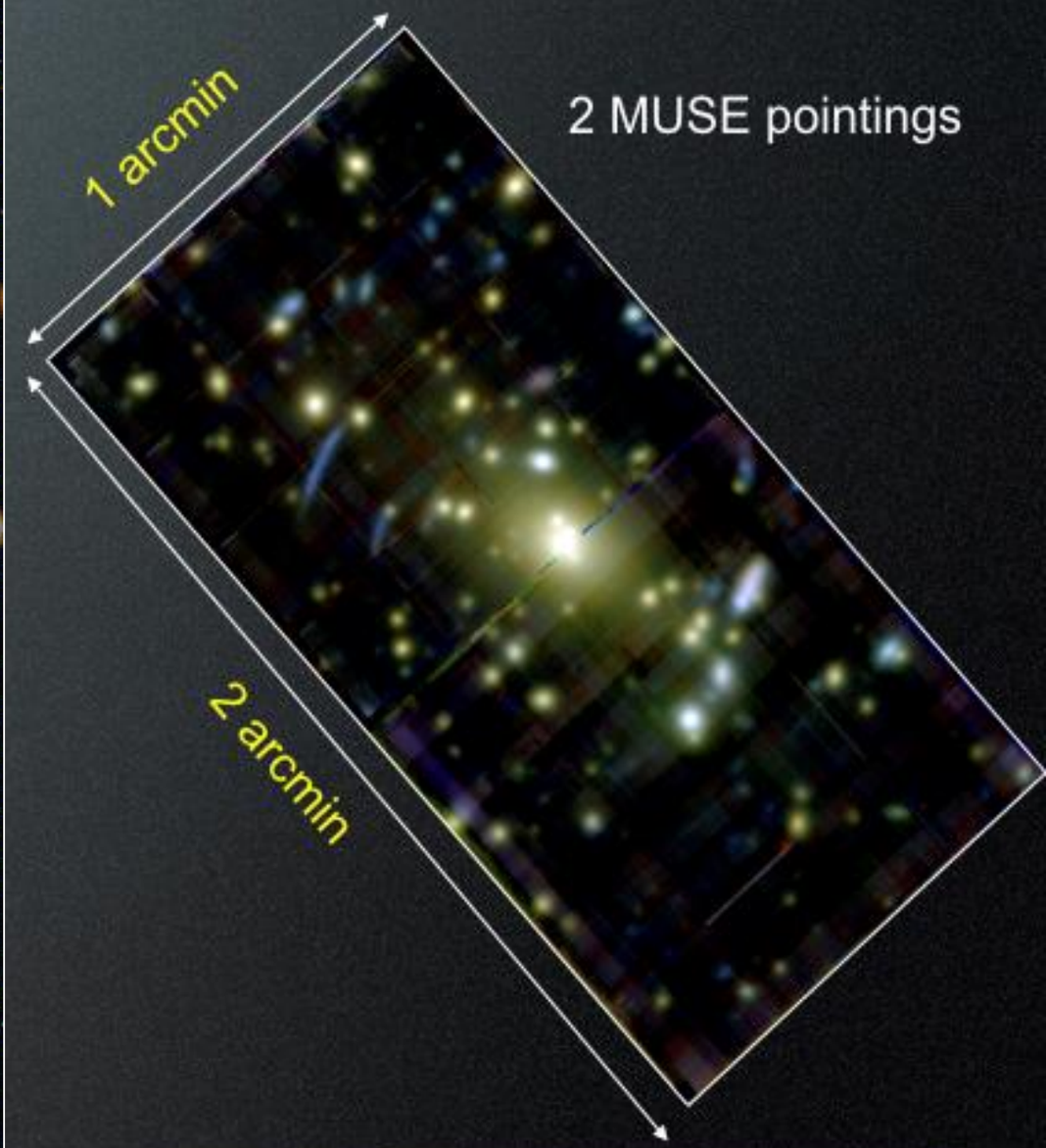


Extending CLASH-VLT with VLT/MUSE spectroscopy

Frontier Field Cluster AS1063 (aka RXJ2248)

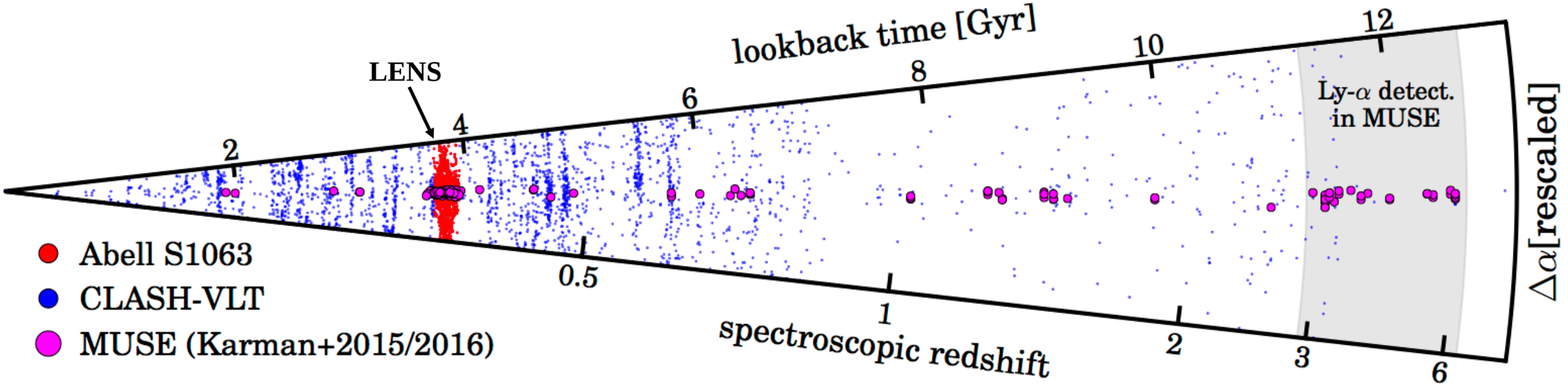
Caminha et al. 2016 (lensing model)

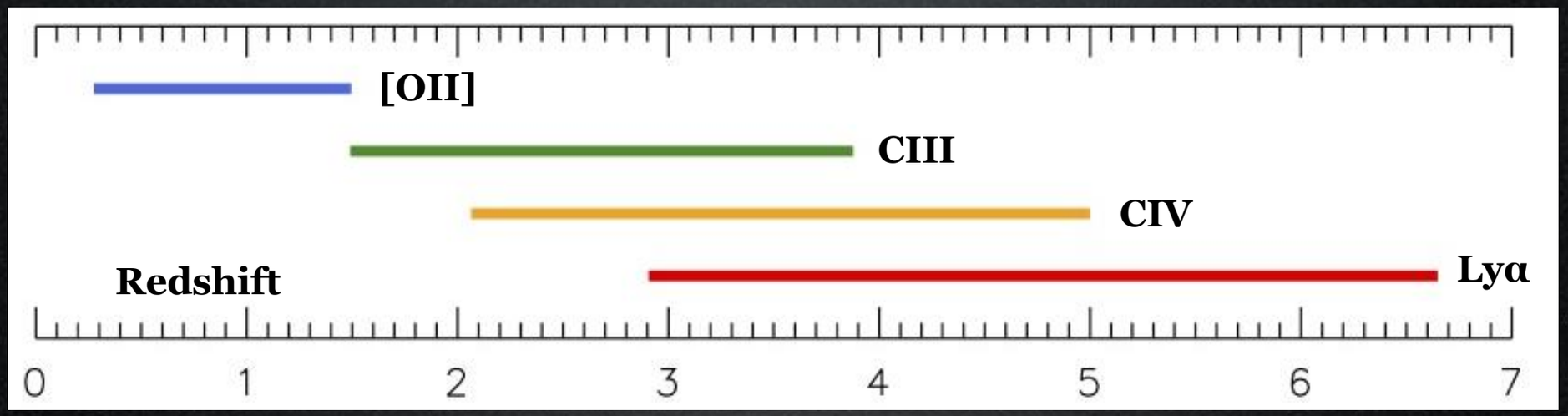
MUSE SV programme + GO (PI: K.Caputi)
(Karman et al. 2015)
(W.Karman et al. 2016, arXiv/160601471)



1 arcmin² FoV ~100 members
2.6 Å resolution (4800-9300 Å)
0.2 arcsec/pxl
Exp. = 5 hrs

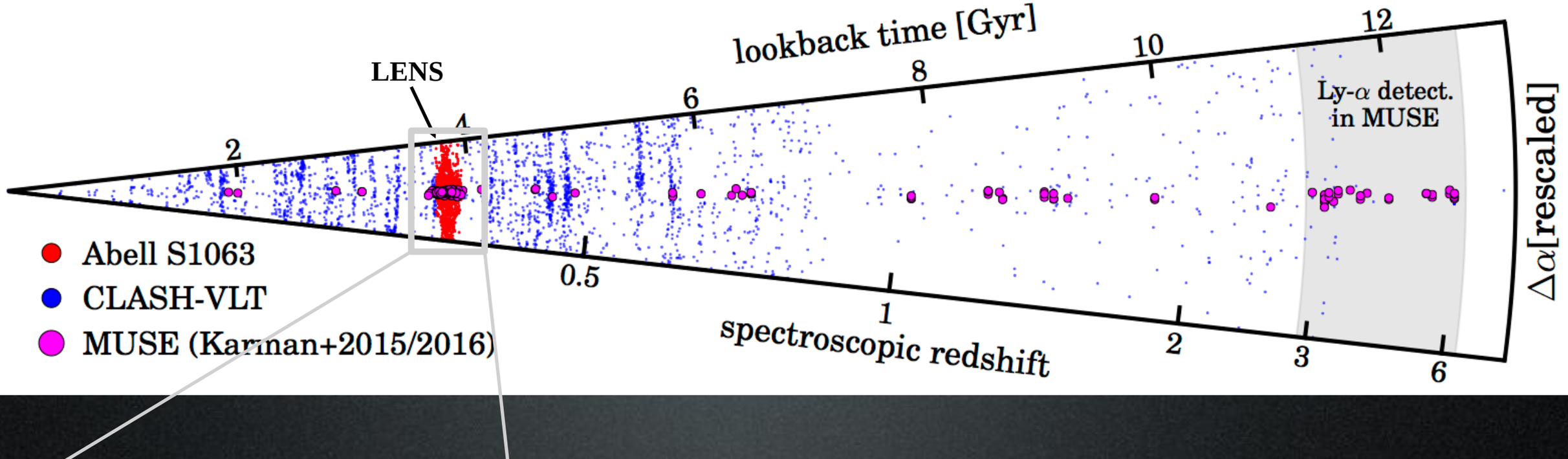
The MUSE boost in the cores

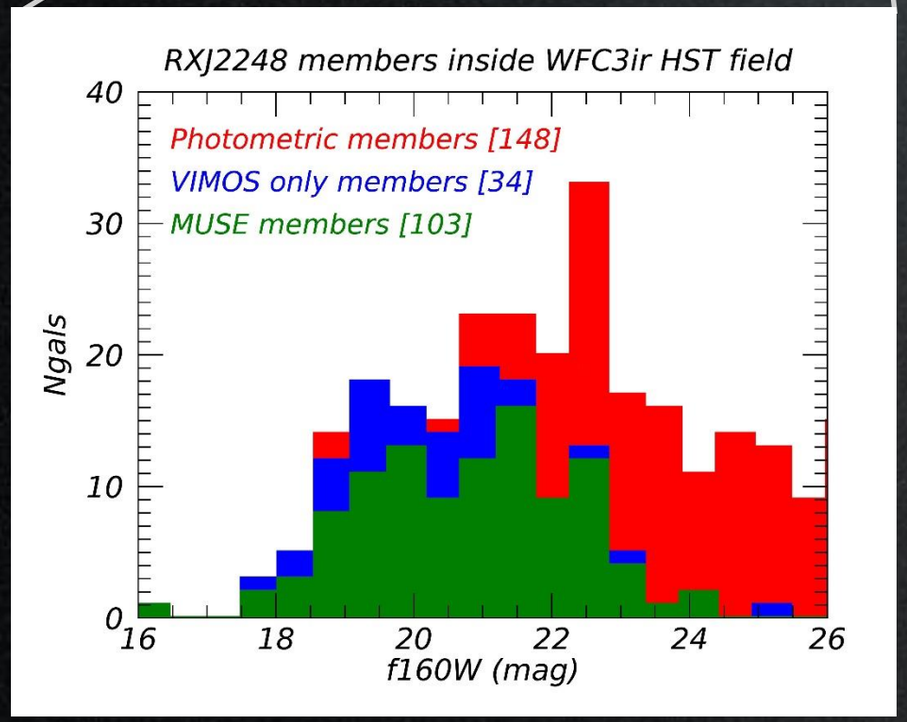




L* at z~3-6

The MUSE boost in the cores

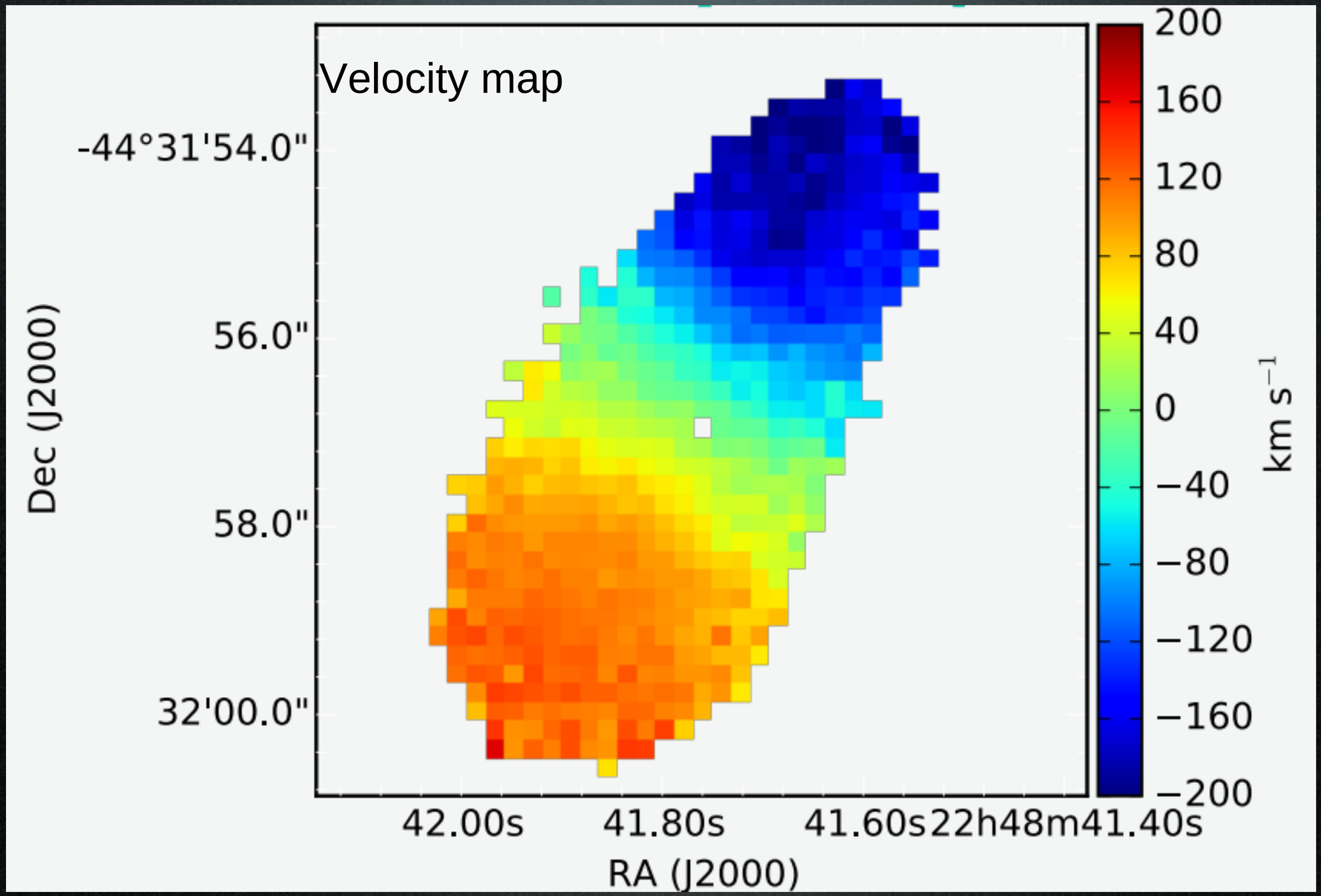




L* at z~3-6

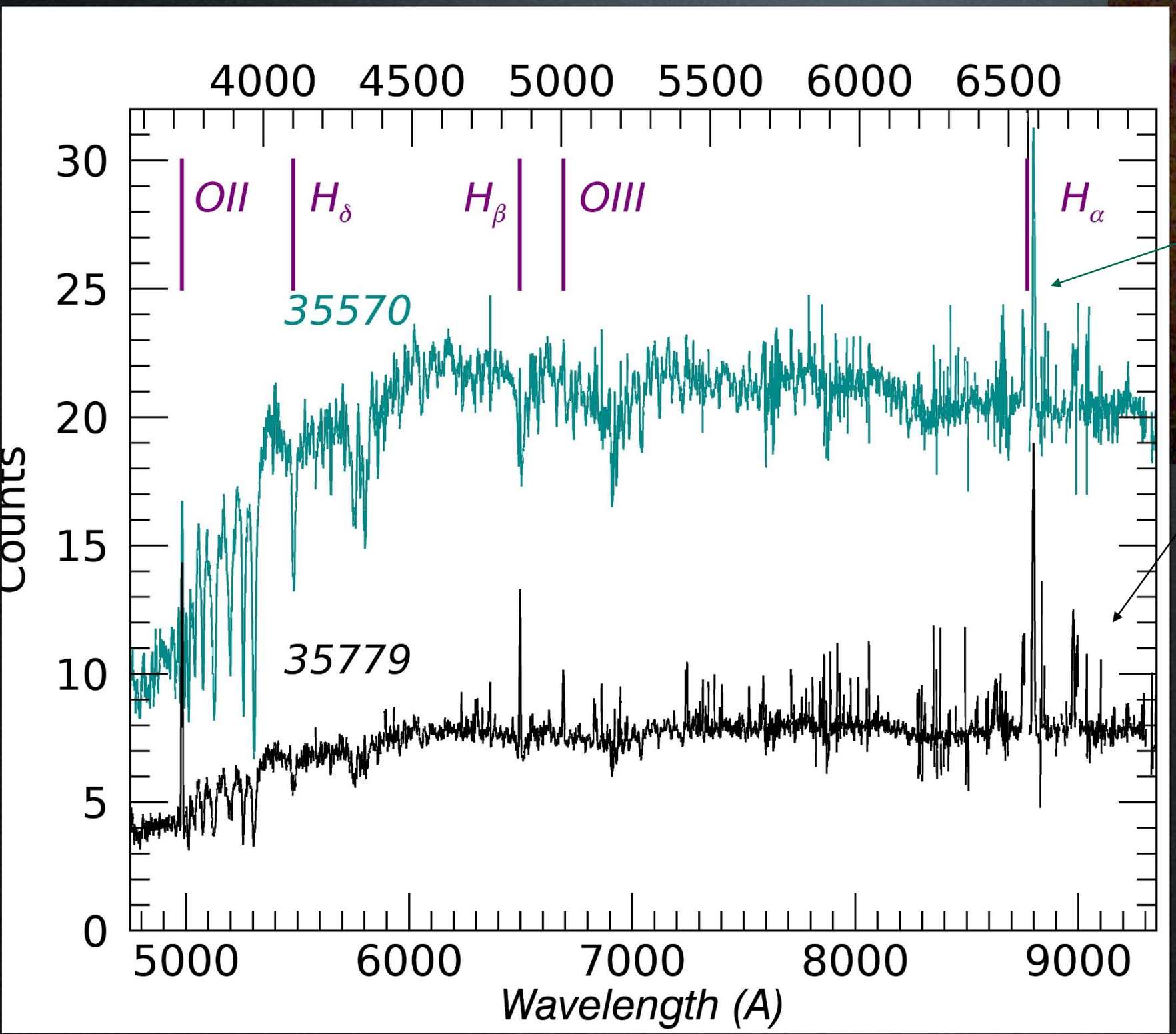
MUSE data – RXJ2248 z=0.348

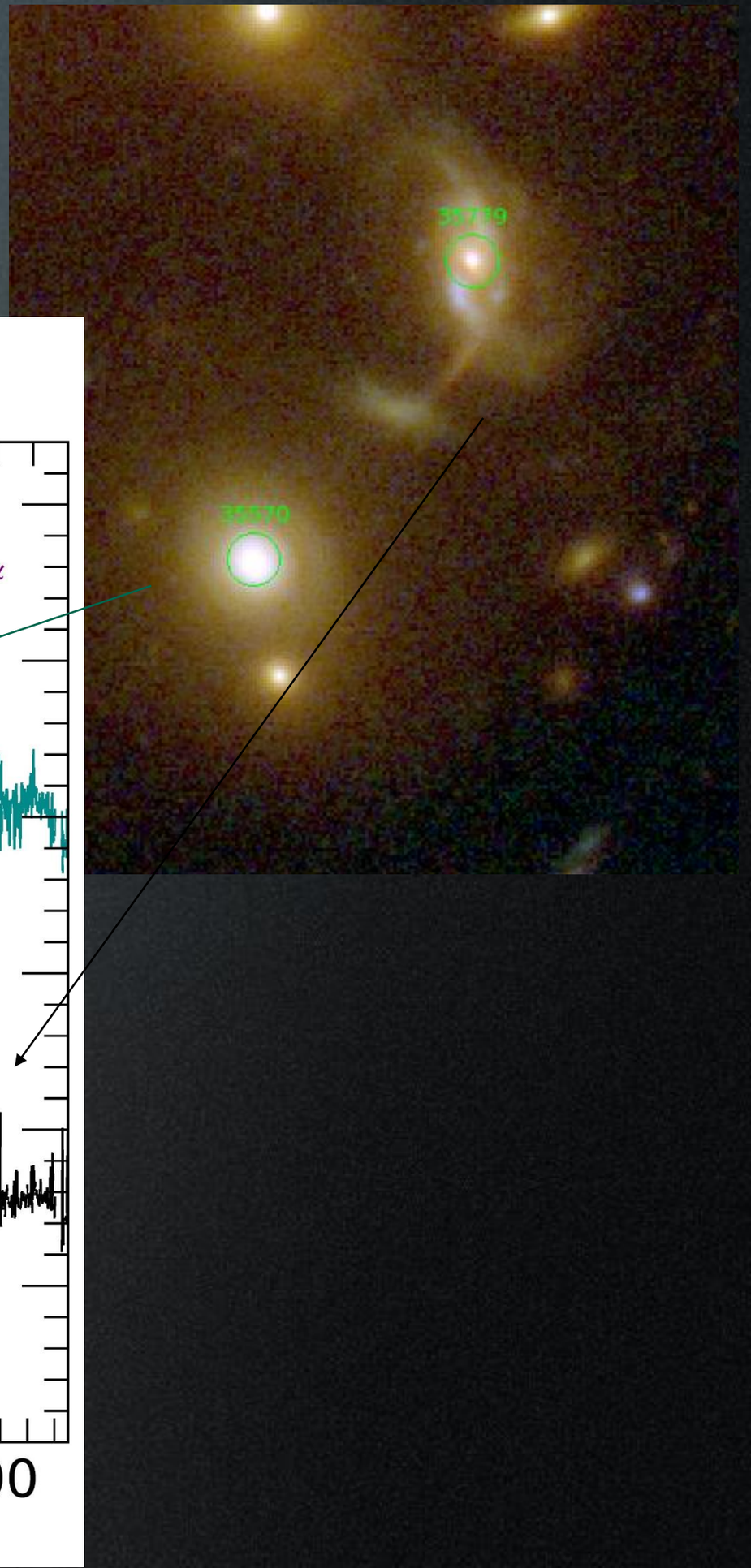
(Investigators: C. Grillo, W. Karman, P. Rosati, K. I. Caputi, I. Balestra, G. B. Caminha,, E. Vanzella, D. Coe, L. Christensen, A. M. Koekemoer, T. Kruehler, M. Lombardi, AM, M. Nonino, and A. van der Wel)



Spectral properties

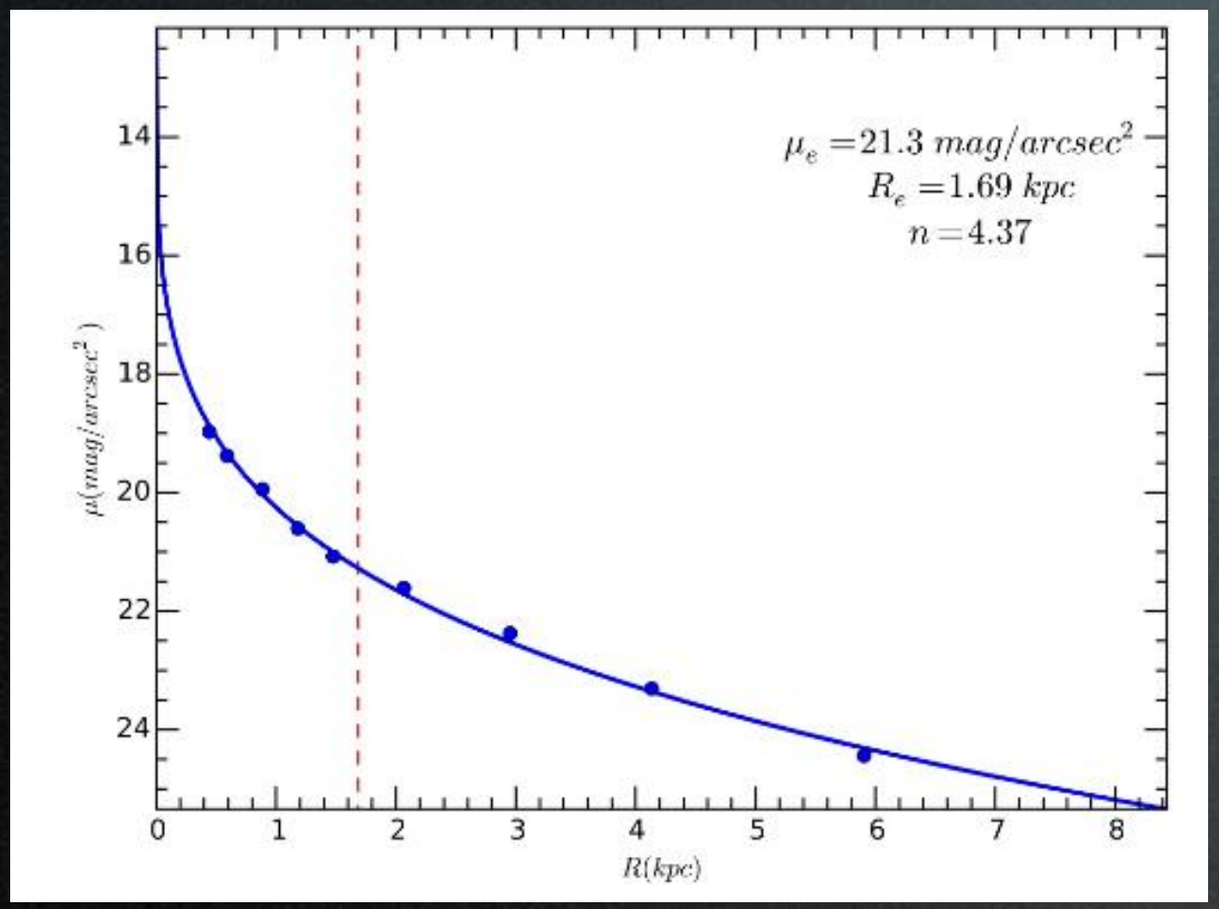
AM et al. in prep.



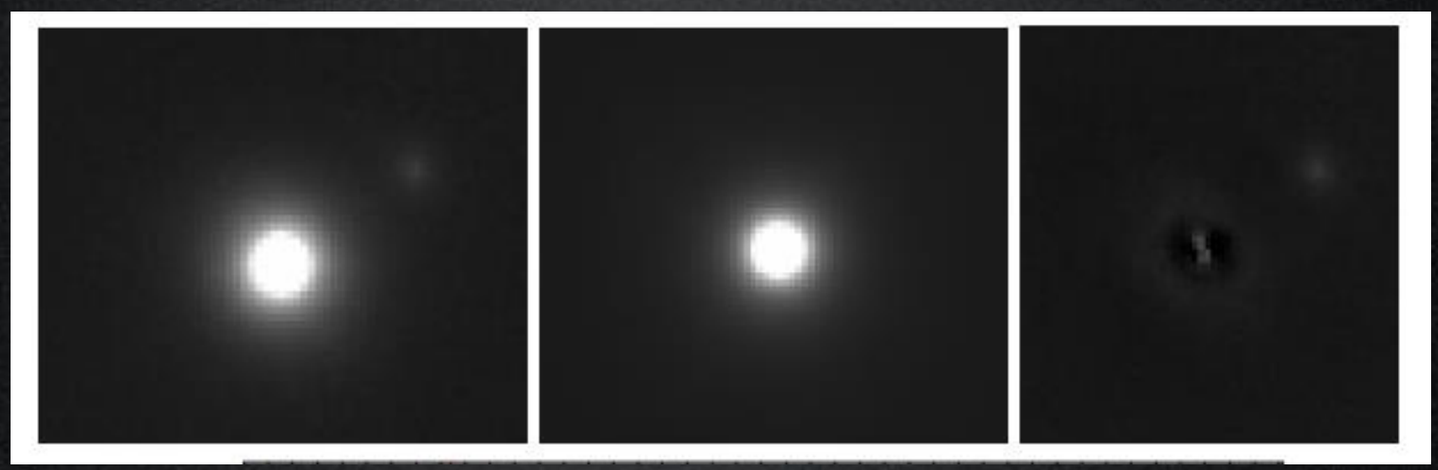


Structural parameters

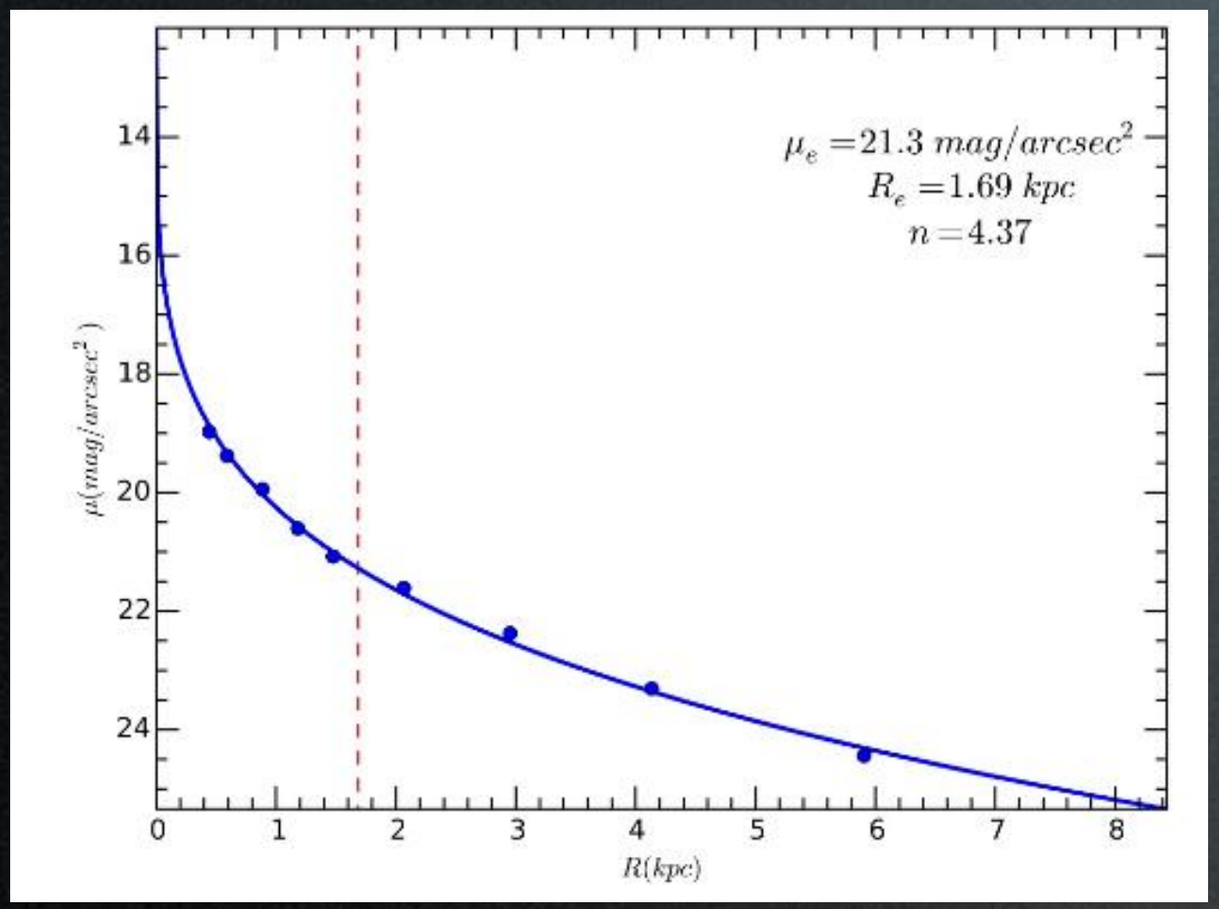
Tortorelli, AM et al. submitted

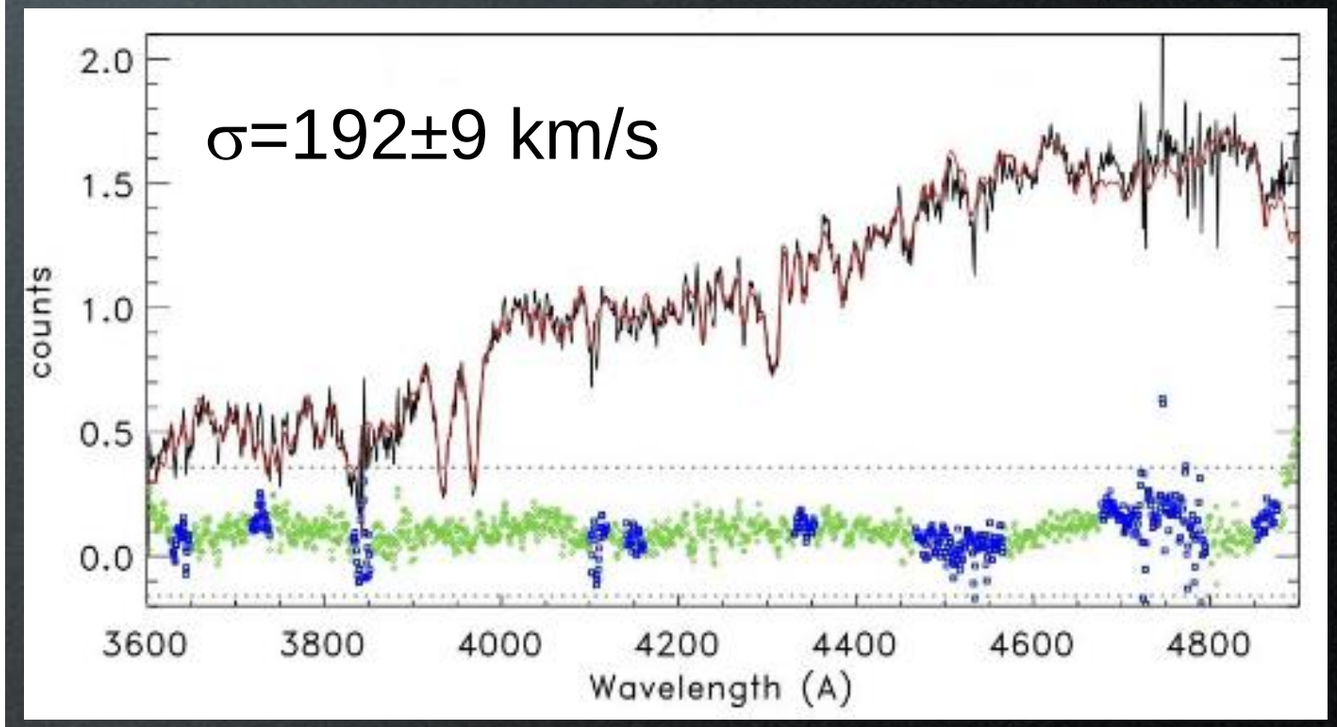


ETG: $n_{sersic} \leq 2.5$

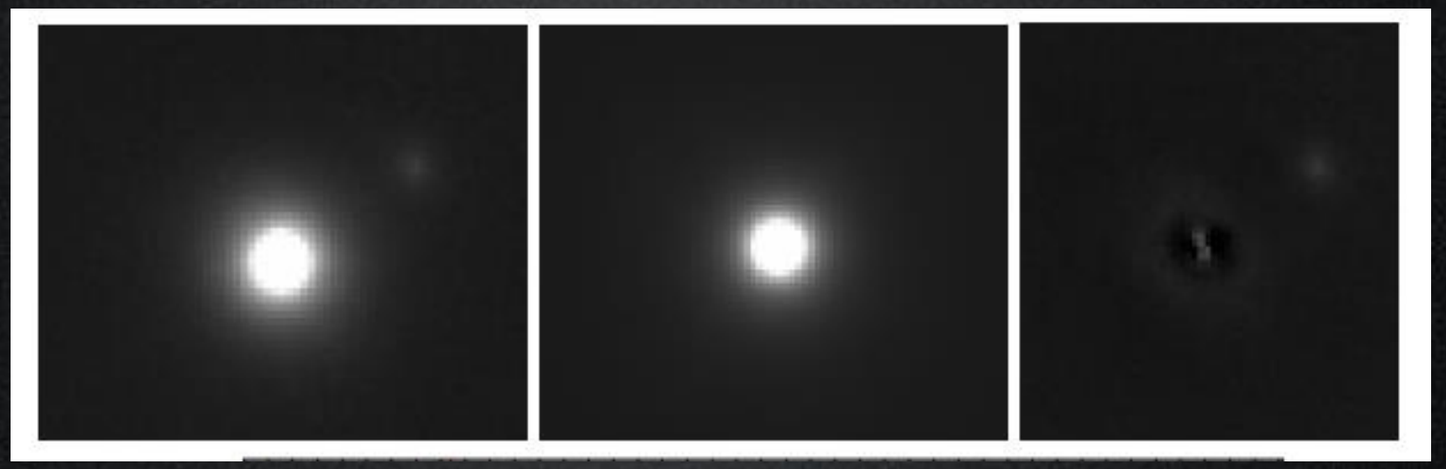


Structural parameters
and
velocity dispersion measurements



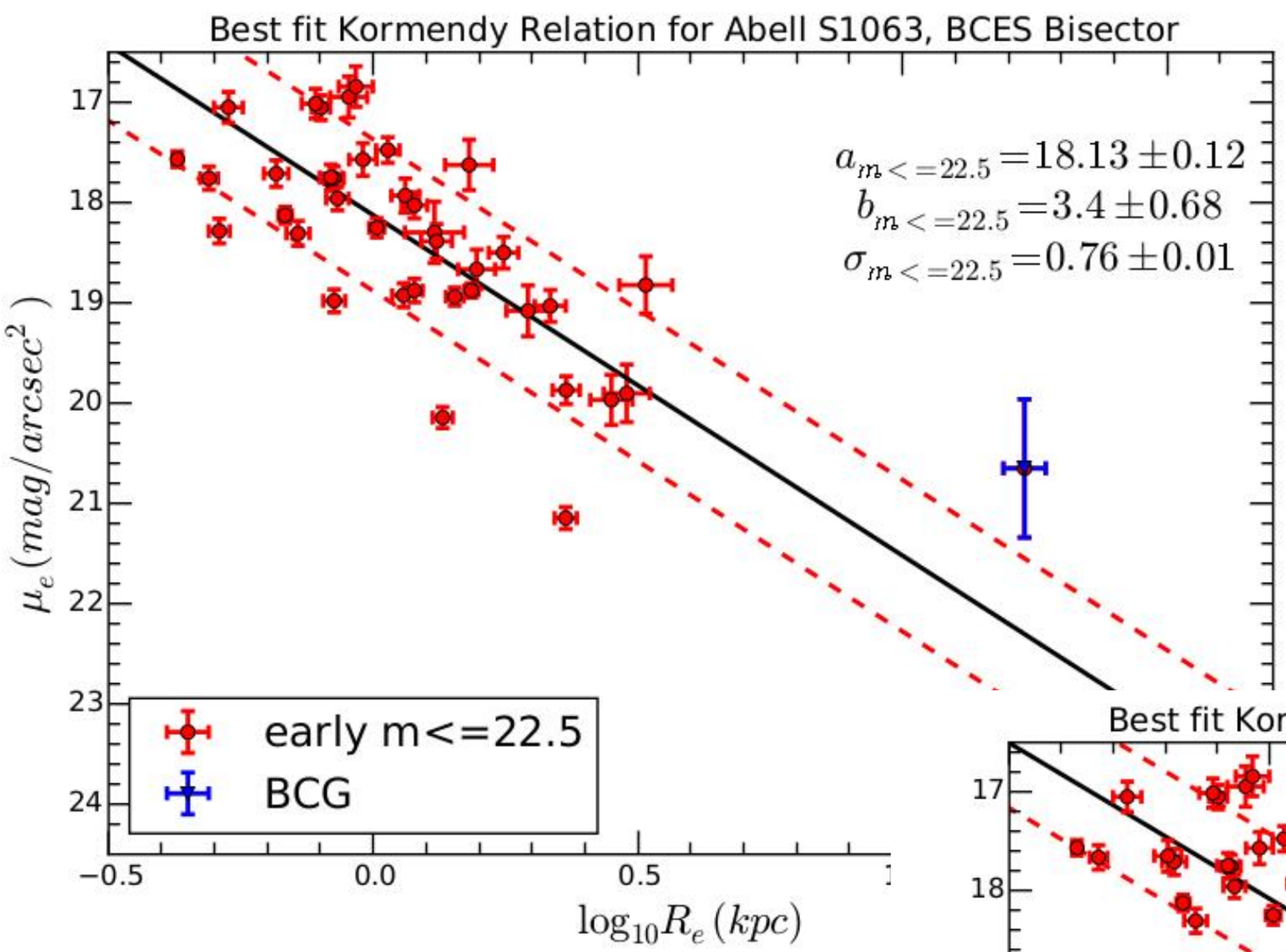


ETG: $n_{sersic} \leq 2.5$



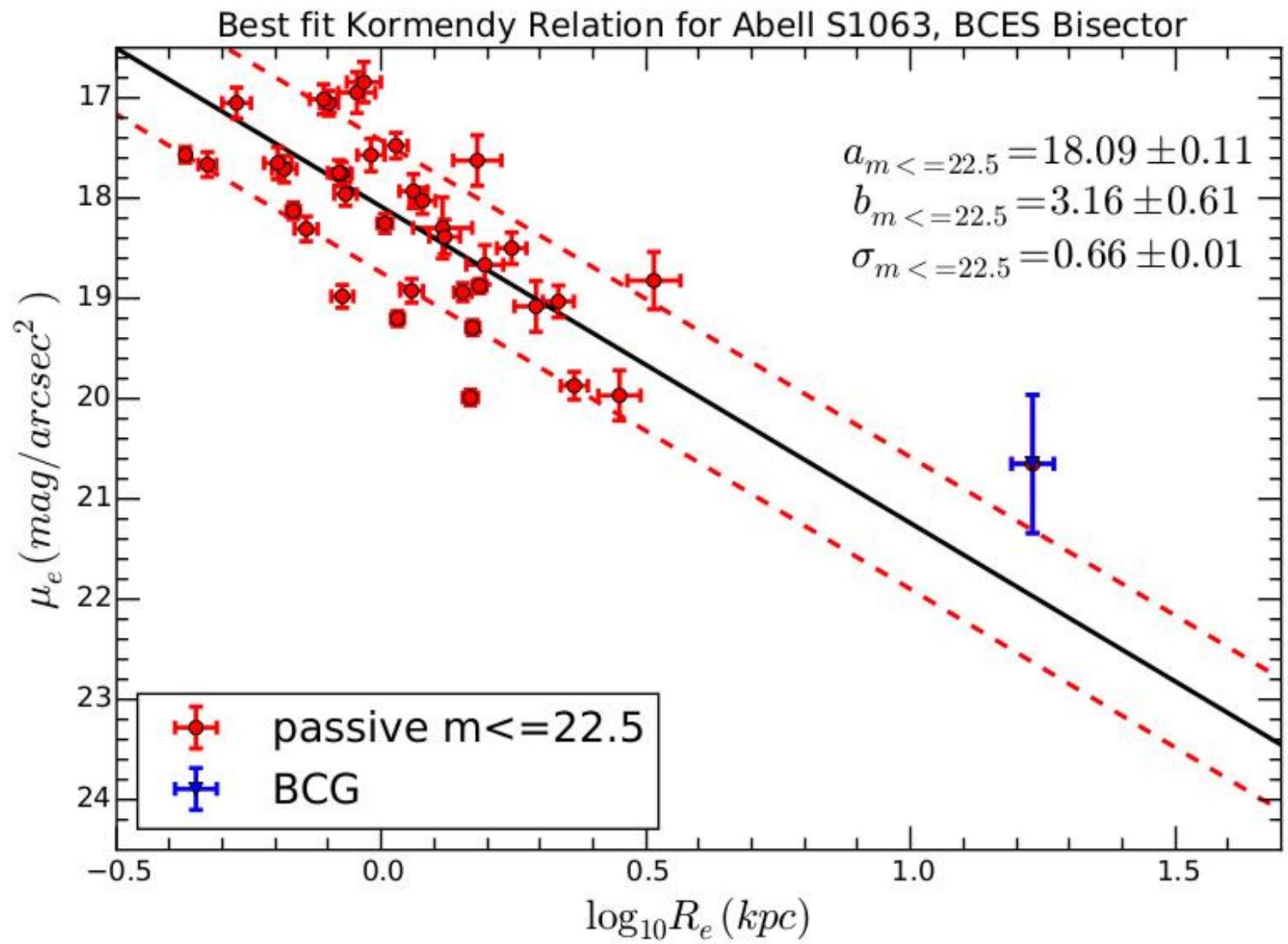
Kormendy relations

z=0.348



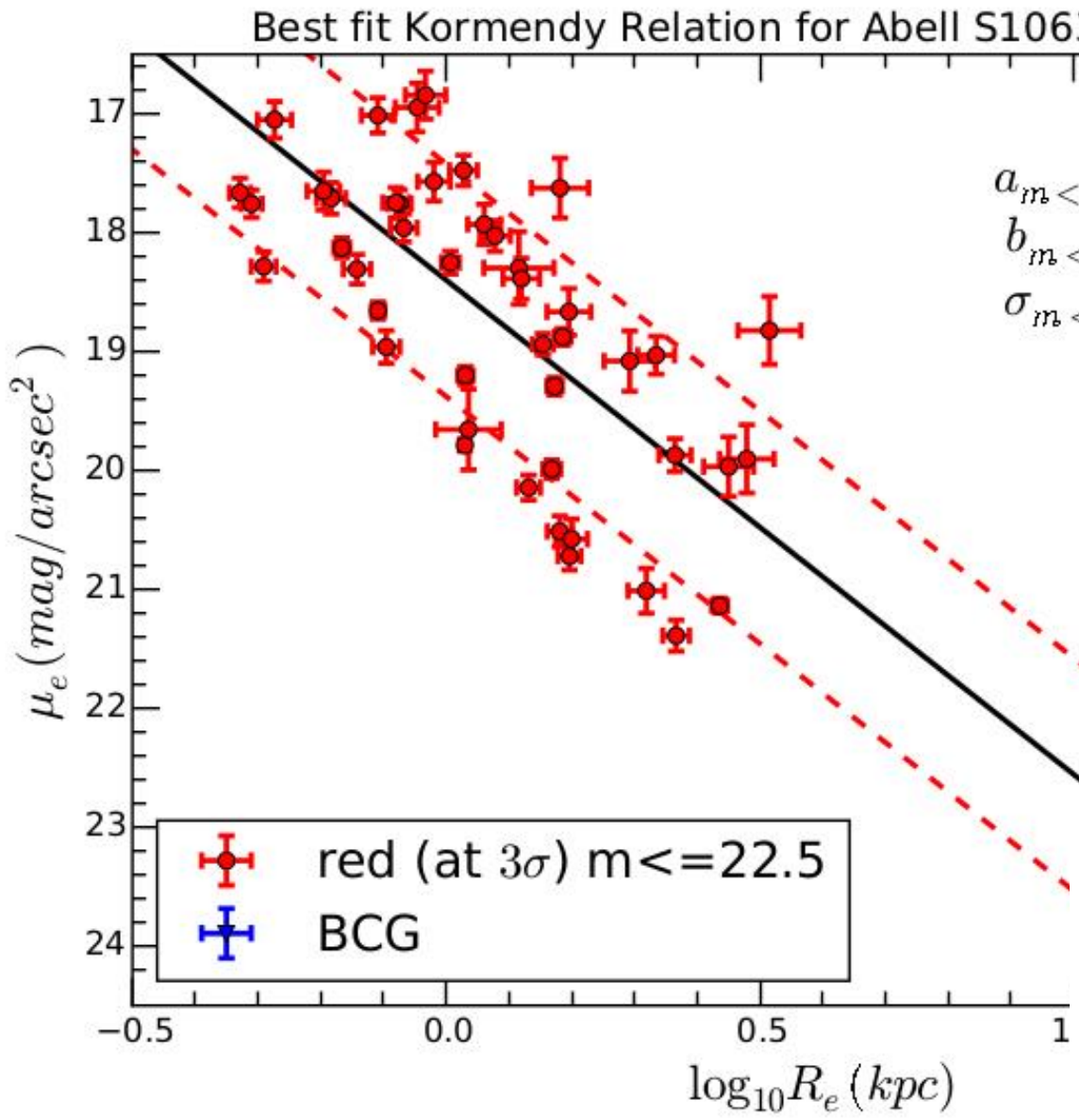
38 ETGs in RXJ2248

38 passive in RXJ2248



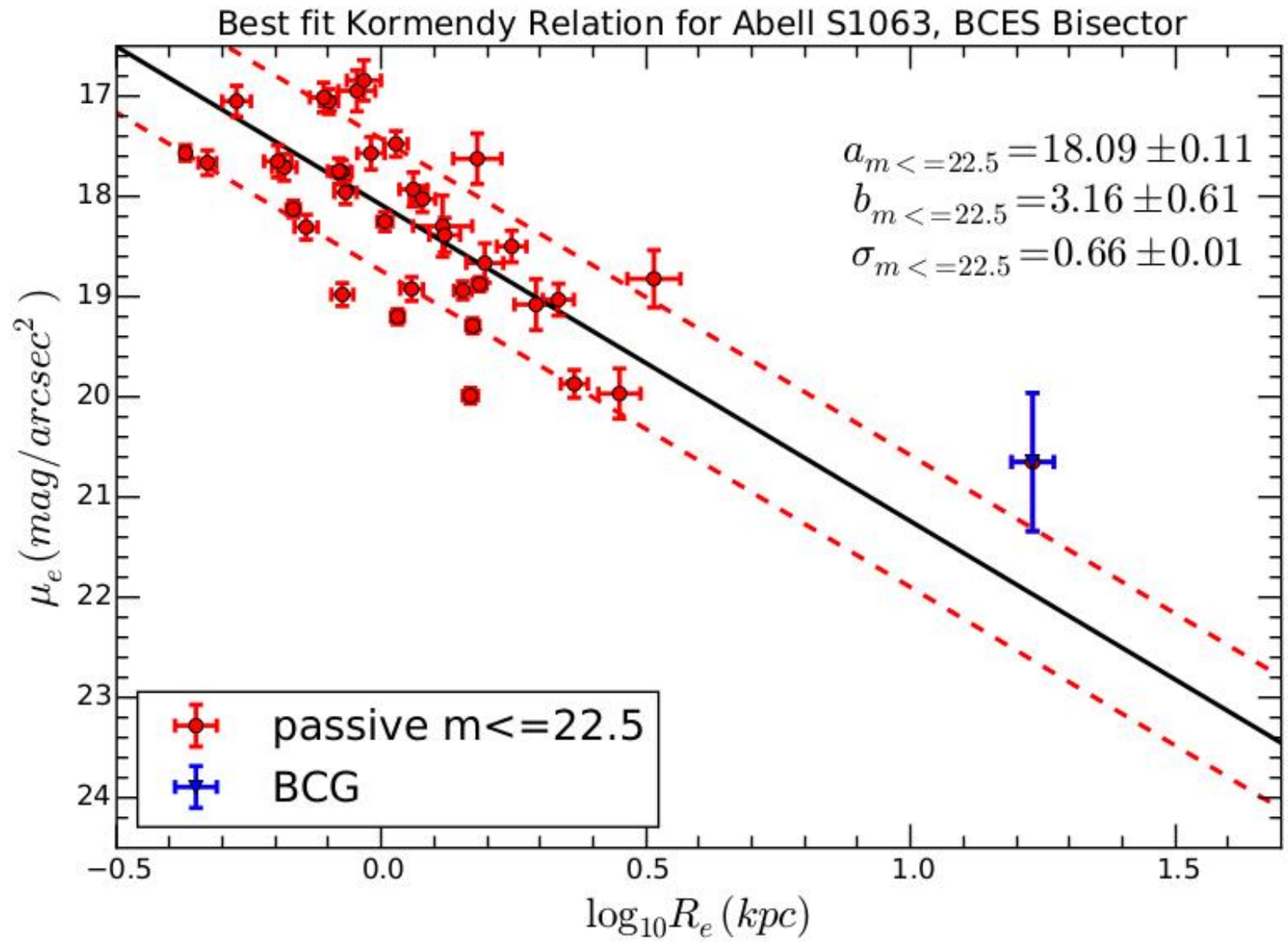
Kormendy relations

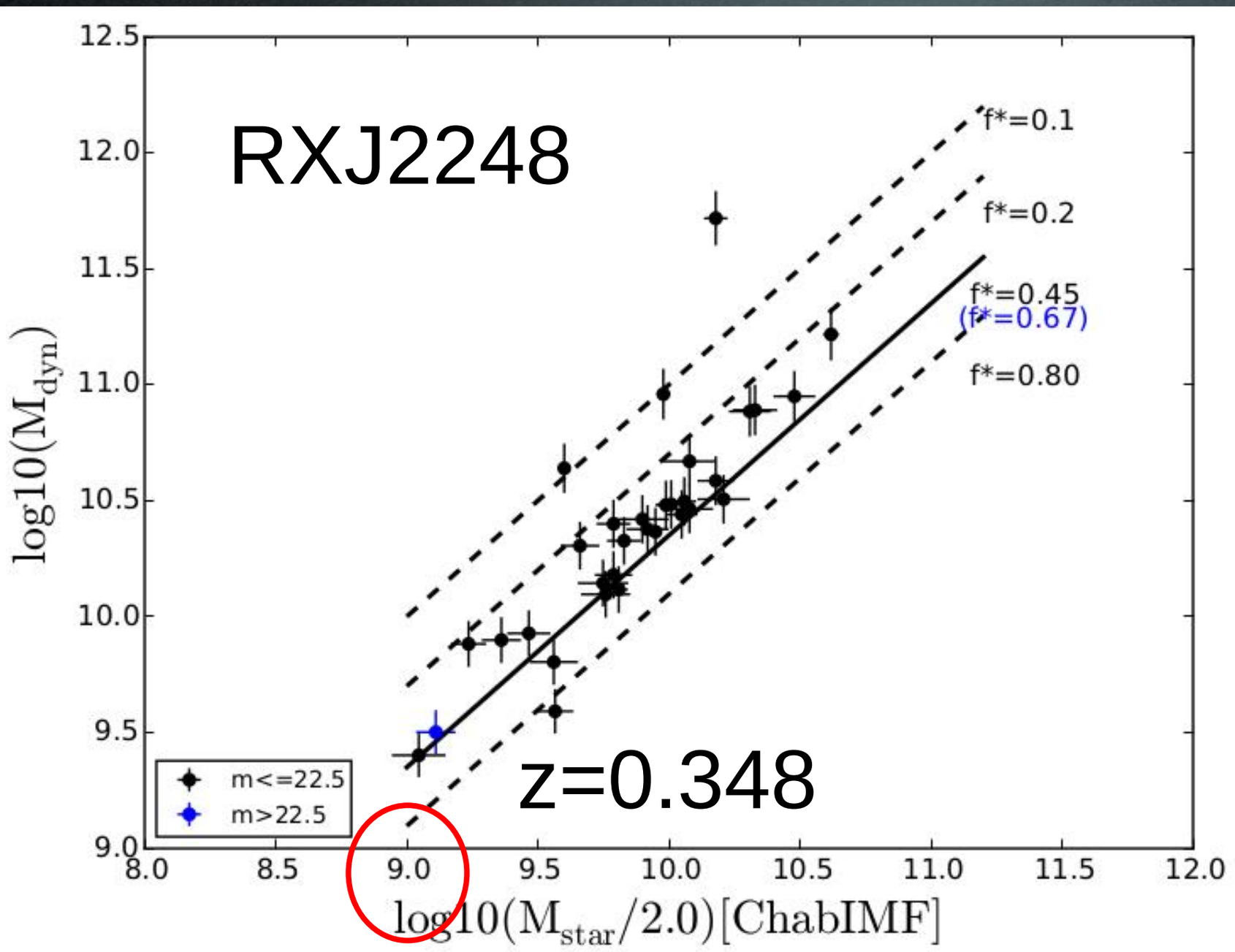
z=0.348



46 Red (3σ) in RXJ2248

38 passive in RXJ2248

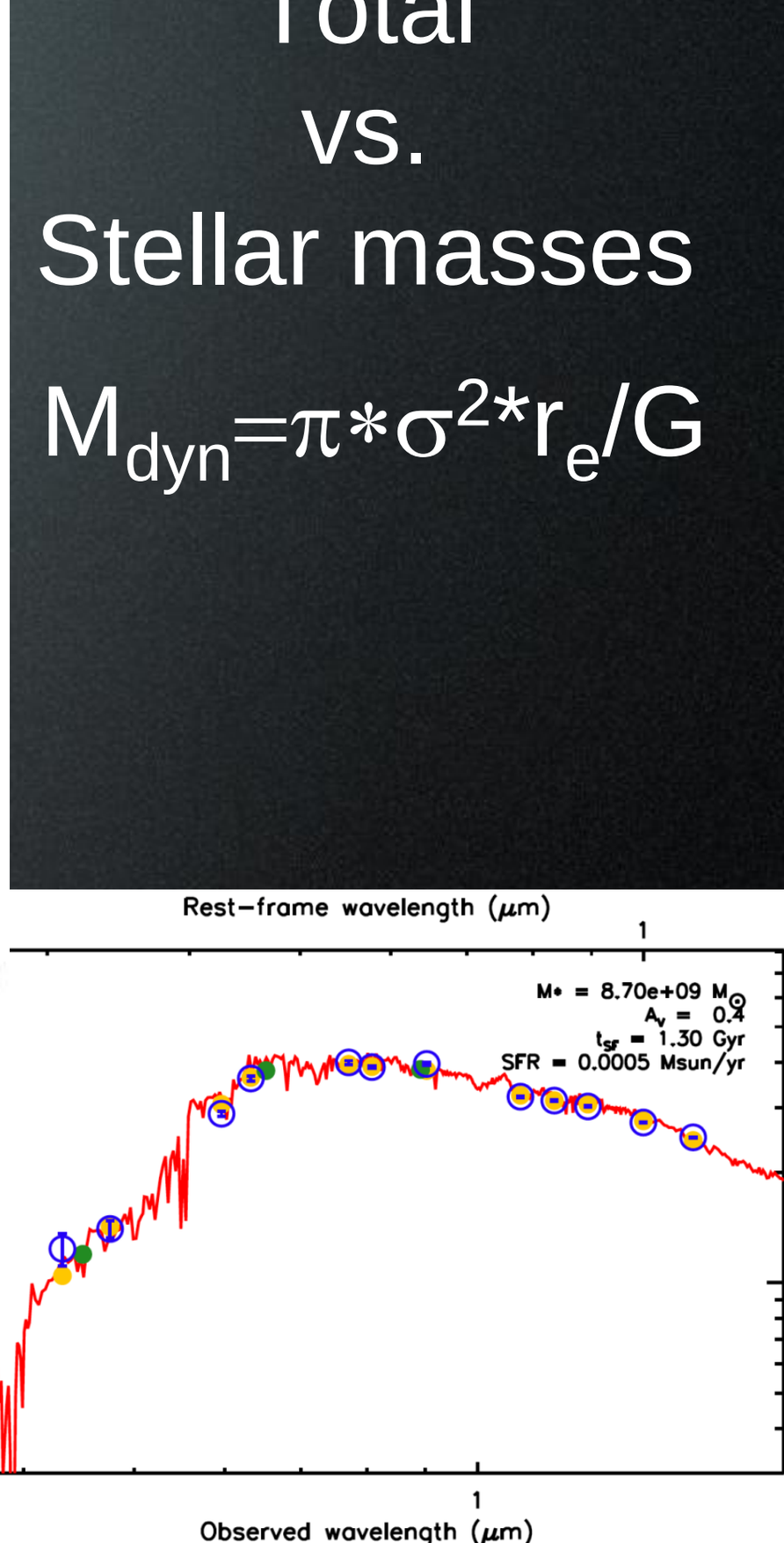




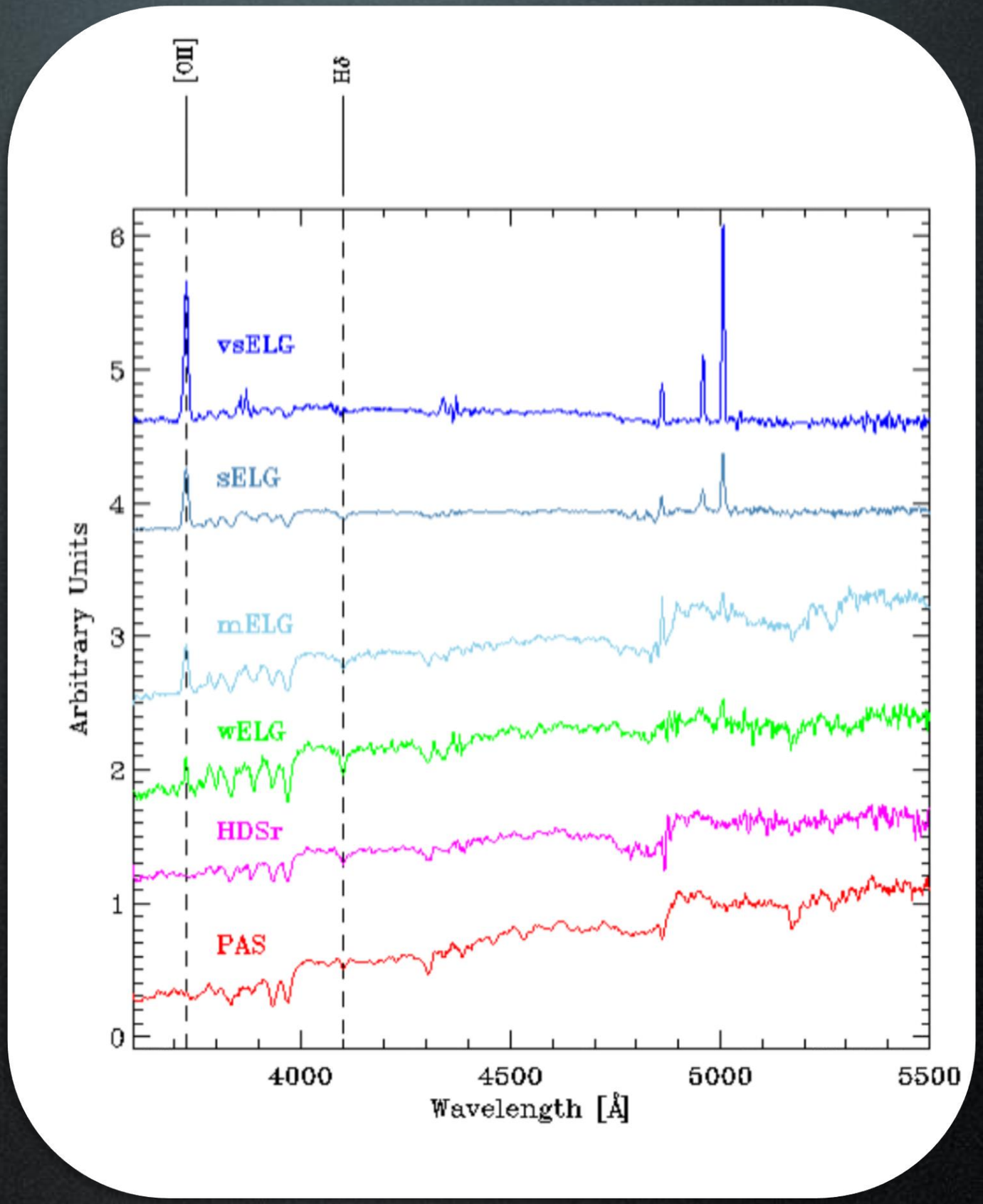
Total
vs.
Stellar masses

$M_{dyn}=\pi*\sigma^{2}*r_e/G$

Projected total masses within r_e from an isothermal model.



Spectral classification of galaxies



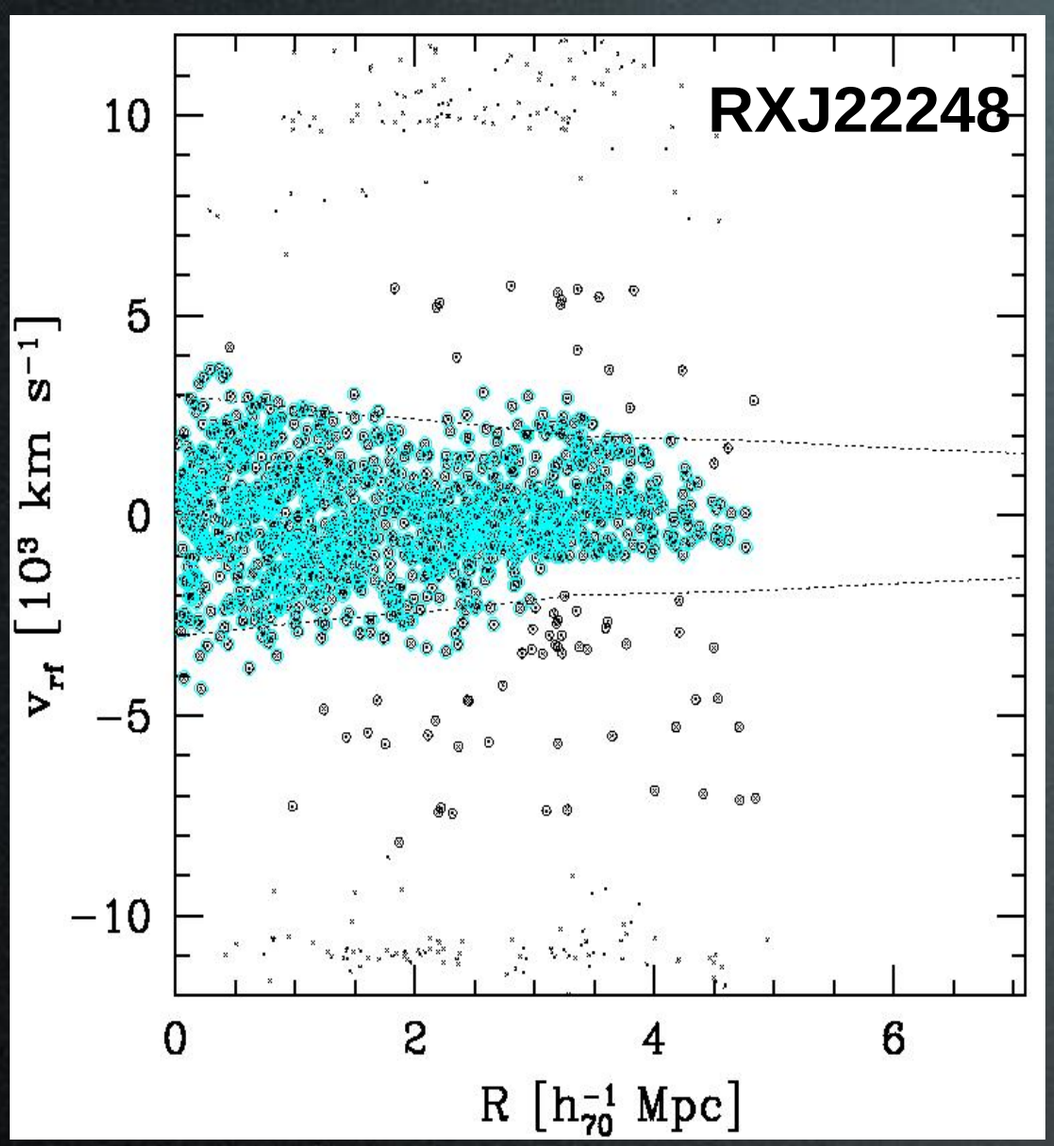
EW[OII]

Emission-line galaxies

Post-starburst

Passive

Girardi, Mercurio et al. 2015



Spectral classification

1D-DEDICA (adaptive kernel method of density reconstruct).
+ shifting gapper (MG+96).

1234 members

Dynamical analysis and mass profile: Sartoris et al. in prep.

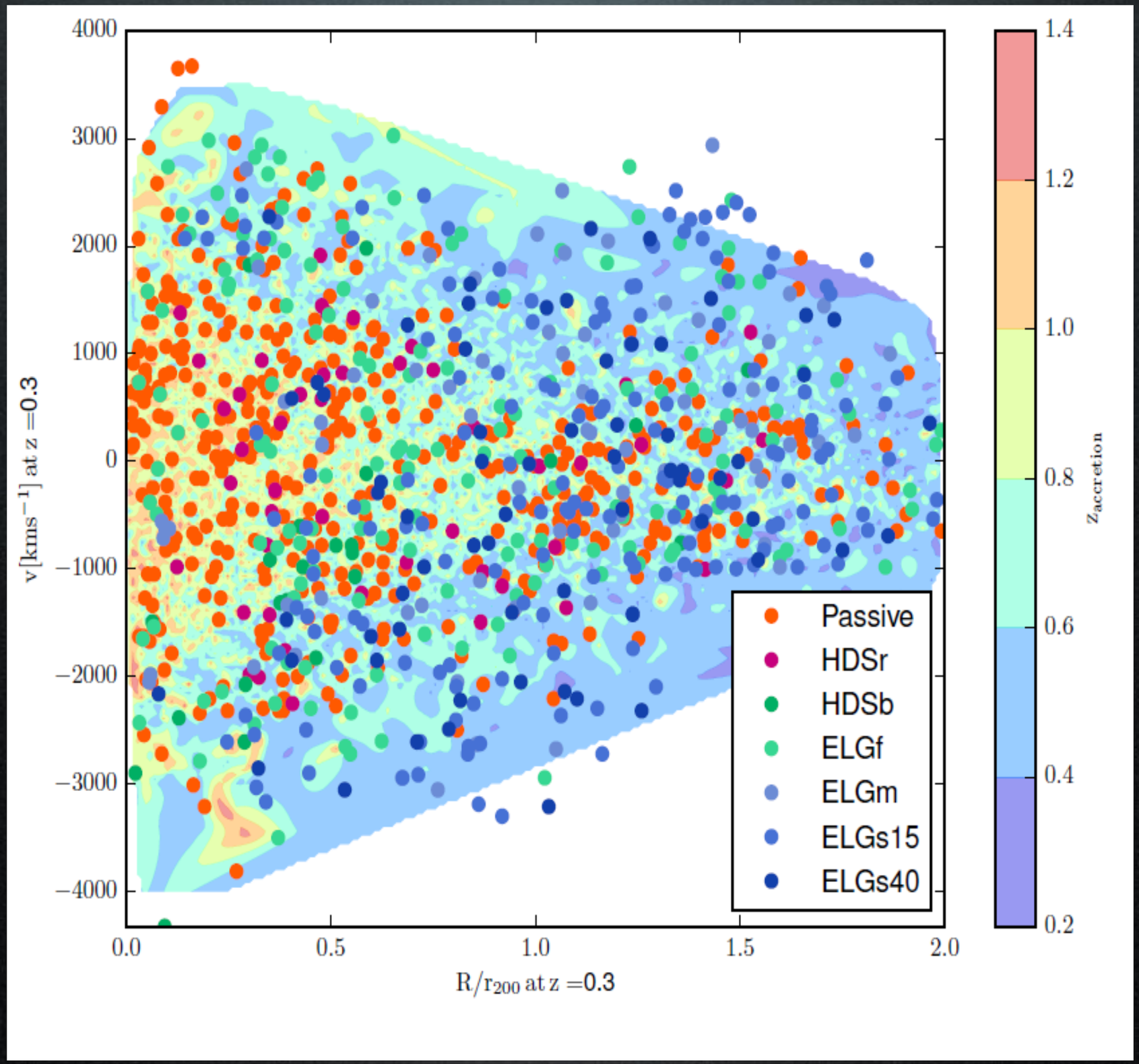
We classify:

964 Members:

44.7% Passive;
4.9%/2.4% red/blue post-starburst;
16.4% weak ELG;
7.1% medium ELG;
17.8%/6.7% strong/very strong ELG.

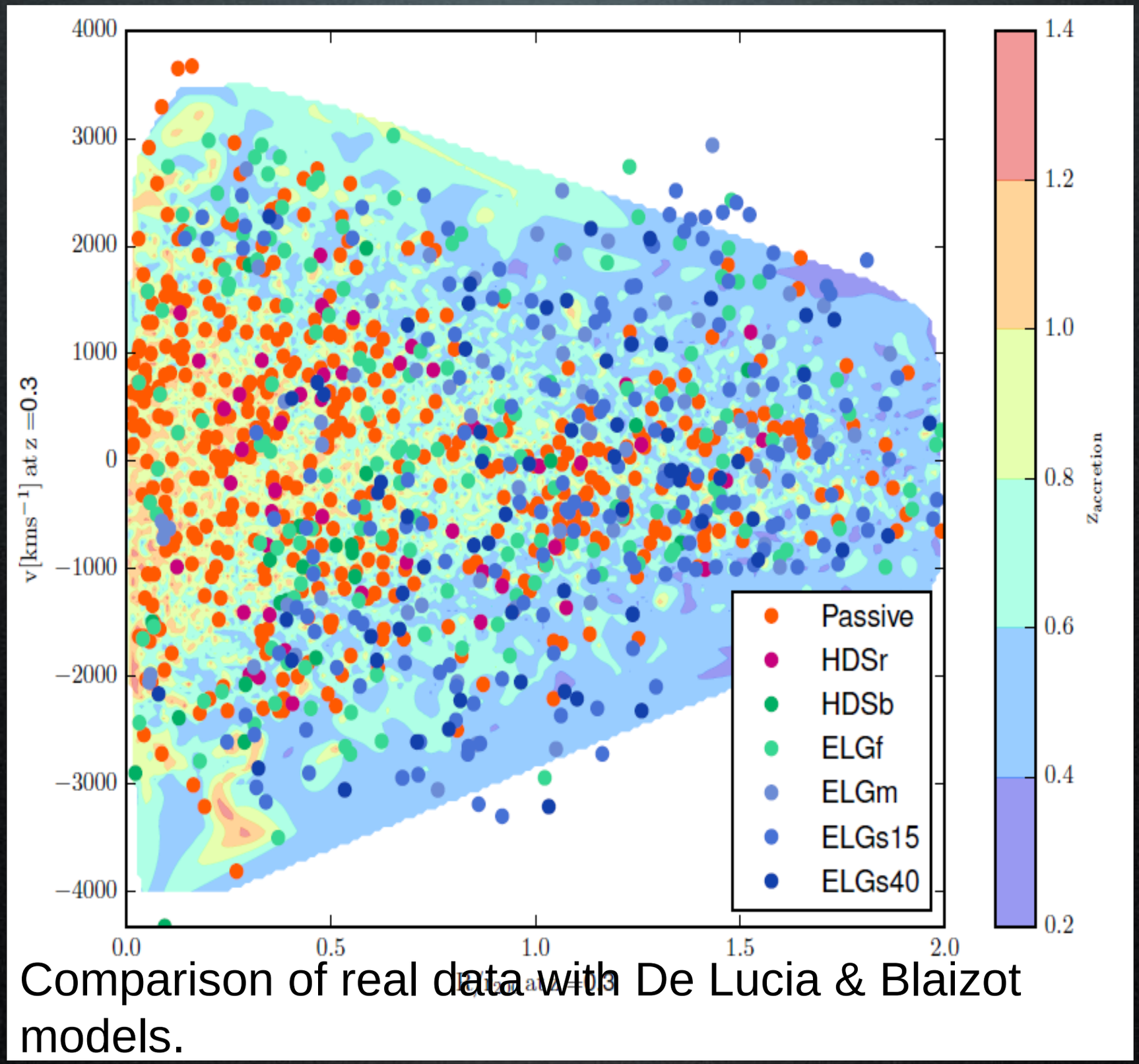
AM et al. in prep.

Position in the phase-space diagram



AM et al. in prep.

Position in the phase-space diagram



Comparison of real data with De Lucia & Blaizot models.

AM et al. in prep.

Summary

- ✓ We observed and analysed 1234 spectroscopically confirmed members in RXJ 2248 (~100 members with MUSE data).
- ✓ We used MUSE data to investigate the spatial distribution of stellar populations and we investigated scaling relations by using a morpho-spectral classification.
- ✓ By using wide field CLASH-VLT spectroscopy, we studied the distributions of galaxy populations with different spectral types in the projected phase-space diagram.
- ✓ By correlating real data with De Lucia & Blaizot models we obtained information on the accretion redshift of different spectral type galaxies.

….. In the next future, let’s see the other clusters in the CLASH-VLT sample

Thanks!