

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

A. Mercurio
and the VST-GAME team*

INAF- OSSERVATORIO ASTRONOMICO DI CAPODIMONTE

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

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

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

The main aim of the survey is to disentangle and quantify the relative impacts of [mass-quenching](#) (e.g. AGN/SN feedback) and [environmental-quenching](#) (e.g. ram-pressure and/or tidal stripping, harassment, group-cluster collisions and “starvation”).

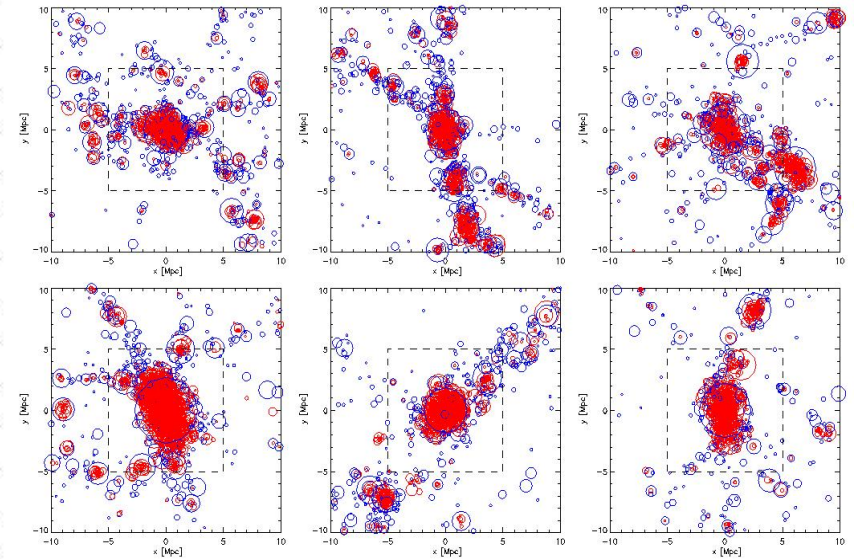
One key missing ingredient is a panoramic and homogeneous dataset of high-quality optical imaging of galaxies in a wide and largely unexplored range of cluster environments, down to the dwarf regime ($10^9 M_{\odot}$), at a redshift when the galaxy population was still rapidly evolving.

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

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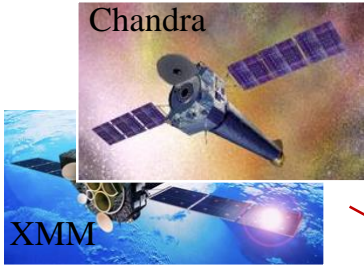
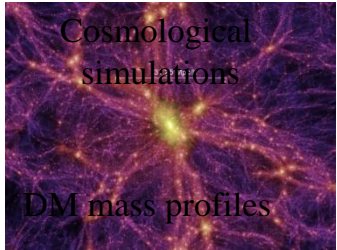
300h VST survey of perform a unique wide field coverage ($20 \times 20 \text{ Mpc}^2$ at $z=0.4$) of 12 massive galaxy clusters, at $0.2 < z < 0.6$ (z median ~ 0.4), in four bands (u' , g' , r' , i'), to explore galaxy evolution from the inner core to well beyond the virial radius ($\sim 5 R_{\text{vir}}$), following the infall of galaxies along filaments, within groups, or directly from the field, up to $10^9 M_{\odot}$, where model predictions are in tension with the data (e.g. too many dwarfs).

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Abell 1063S	22:48:45	-44:31:50	0.348	22.5



Multi-wavelength approach: from 10 kpc to ~10 Mpc

Galaxy Formation and evolution



PI: M. Donahue
Baryon mass distribution
X-ray masses
ICM physics & metallicity

PI: S. Ettori

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

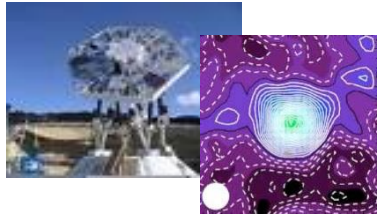


VLT

PI: P. Rosati

High-z gals
Dynamical analysis
Stellar masses

Bolocam, Mustang



PI: K. Umetsu

ICM physics
DM & Baryon masses

SZ observations

High-z gals

LBT



PI: M. Nonino

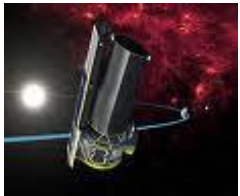
High-z galaxies

WL masses profile
Stellar masses

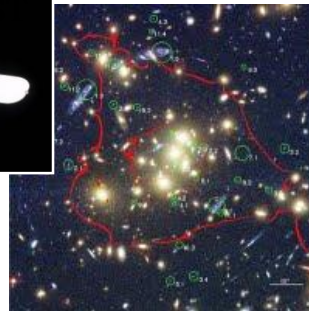
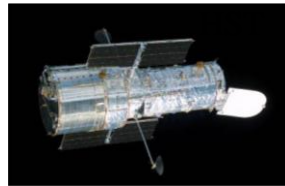
Strong Lensing
Mass profile in the core

Subaru (+ ESO-WFI)
VISTA+ VST

Spitzer



PI: W. Zheng R. Bowuens



Treasury Program
(530 orbits)
PI: M. Postman



PI: K. Umetsu
M. Nonino
A. Mercurio

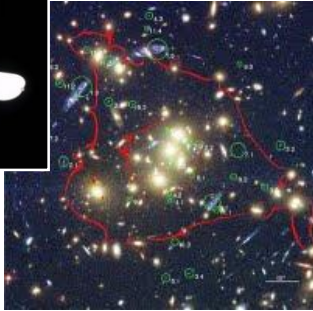
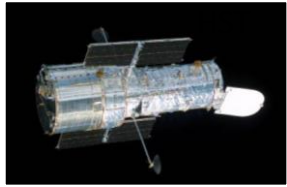
Multi-wavelength approach: from 10 kpc to ~10 Mpc

Strong Lensing
Mass profile

From the core

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

VLT



Galaxy formation and evolution

High-z gals
Dynamical analysis
Stellar masses



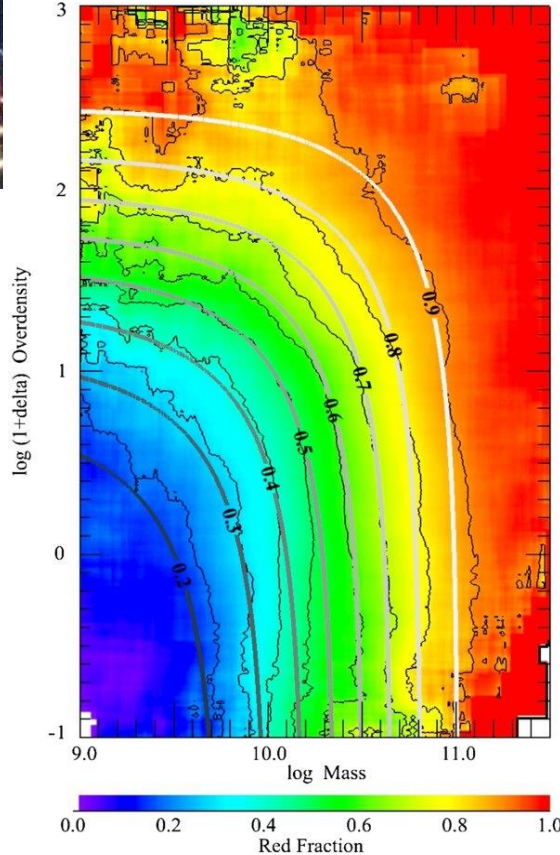
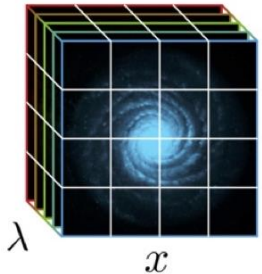
PI: P. Rosati



Treasury Program
(530 orbits)

PI: M. Postman

MUSE
Integral Field Spectroscopy



To the outskirts

Environment

WL masses profile
Stellar masses

VST + VISTA



M. Nonino
A. Mercurio

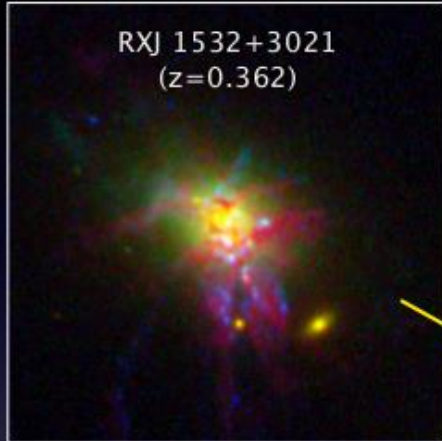
Archive and
Proprietary data
(P.I. C. Grillo)

Peng et al. 2010

Mass

New avenues for galaxy evolution

BCG structure, SF, cooling

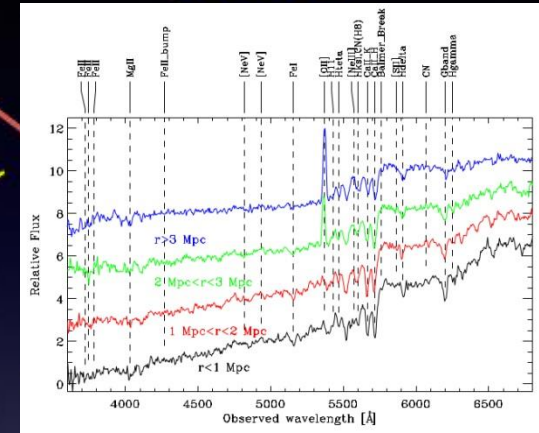


Comparison with Semi-analytic models

Galaxy properties over ~ 10 Mpc:

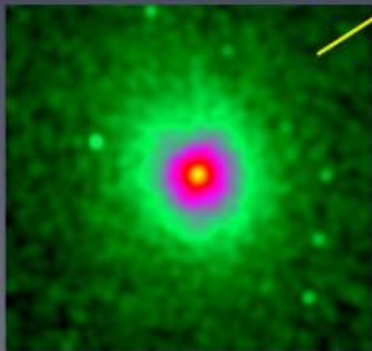
- ✓ Structural parameters
- ✓ Mstar, SFR, sSFR, ages, dust
- ✓ ICM properties

Galaxy transformation processes

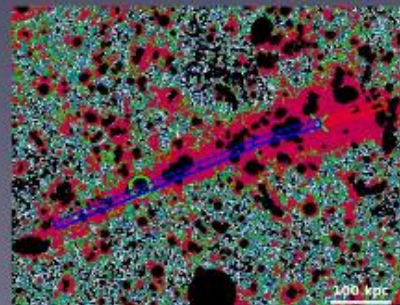


Girardi et al. (2015)

Intra-Cluster Medium (X-ray)

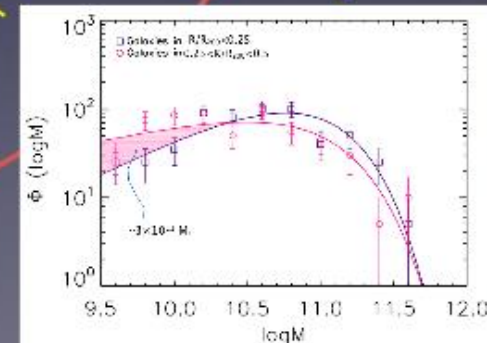


Intra-Cluster light



Presotto et al. (2014)

Stellar mass/luminosity fnct



Annunziatella et al. (2014)

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

Final redshift sample (nearly final):

~34500 redshifts (from ~50000 spectra incl. duplicates)

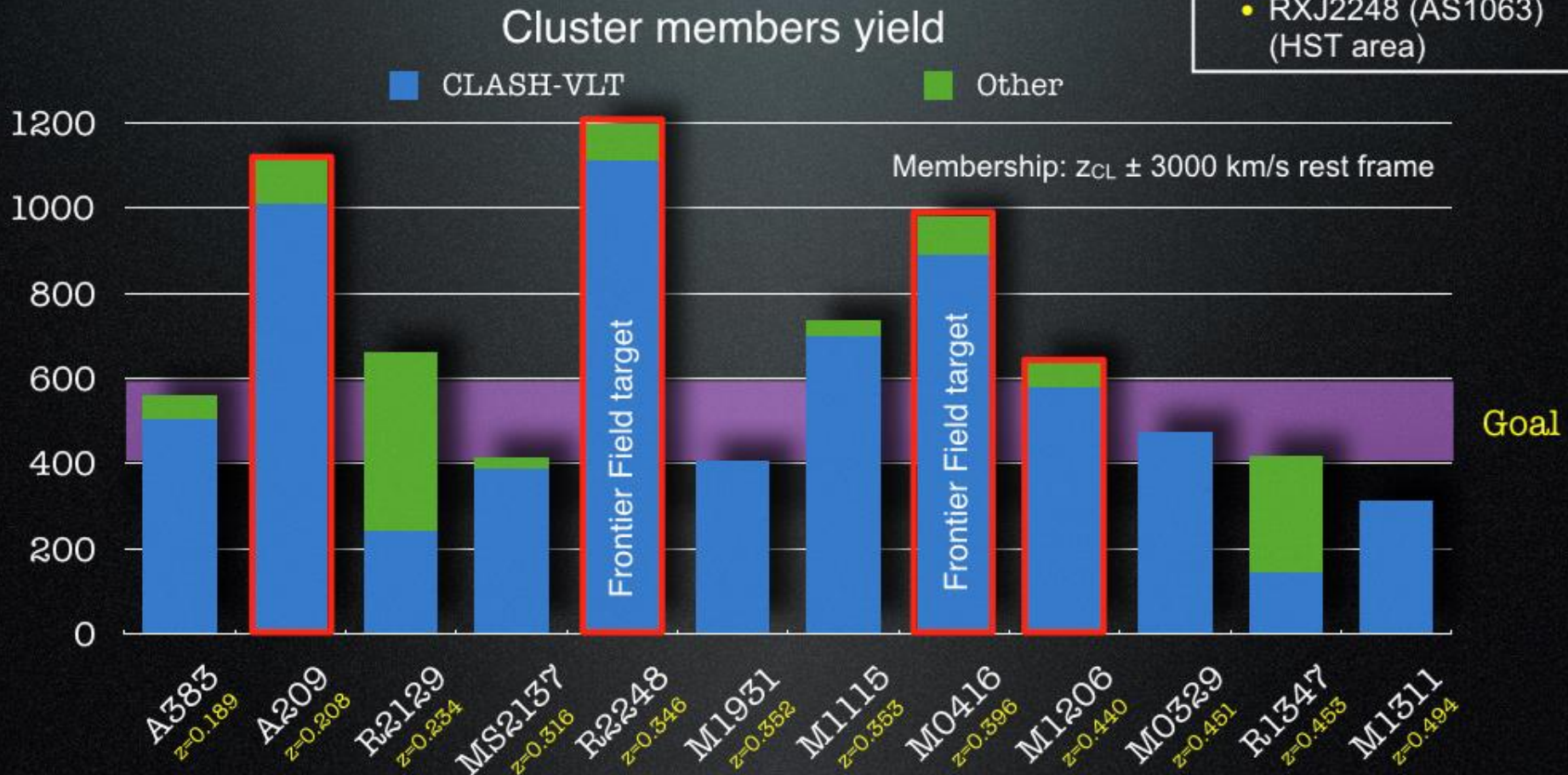
~7300 cluster members

~200 lensed galaxies to $z \sim 7$ (>300 X-ray Chandra sources)

➔ 19 published papers to date

Redshift catalogs released to date:

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



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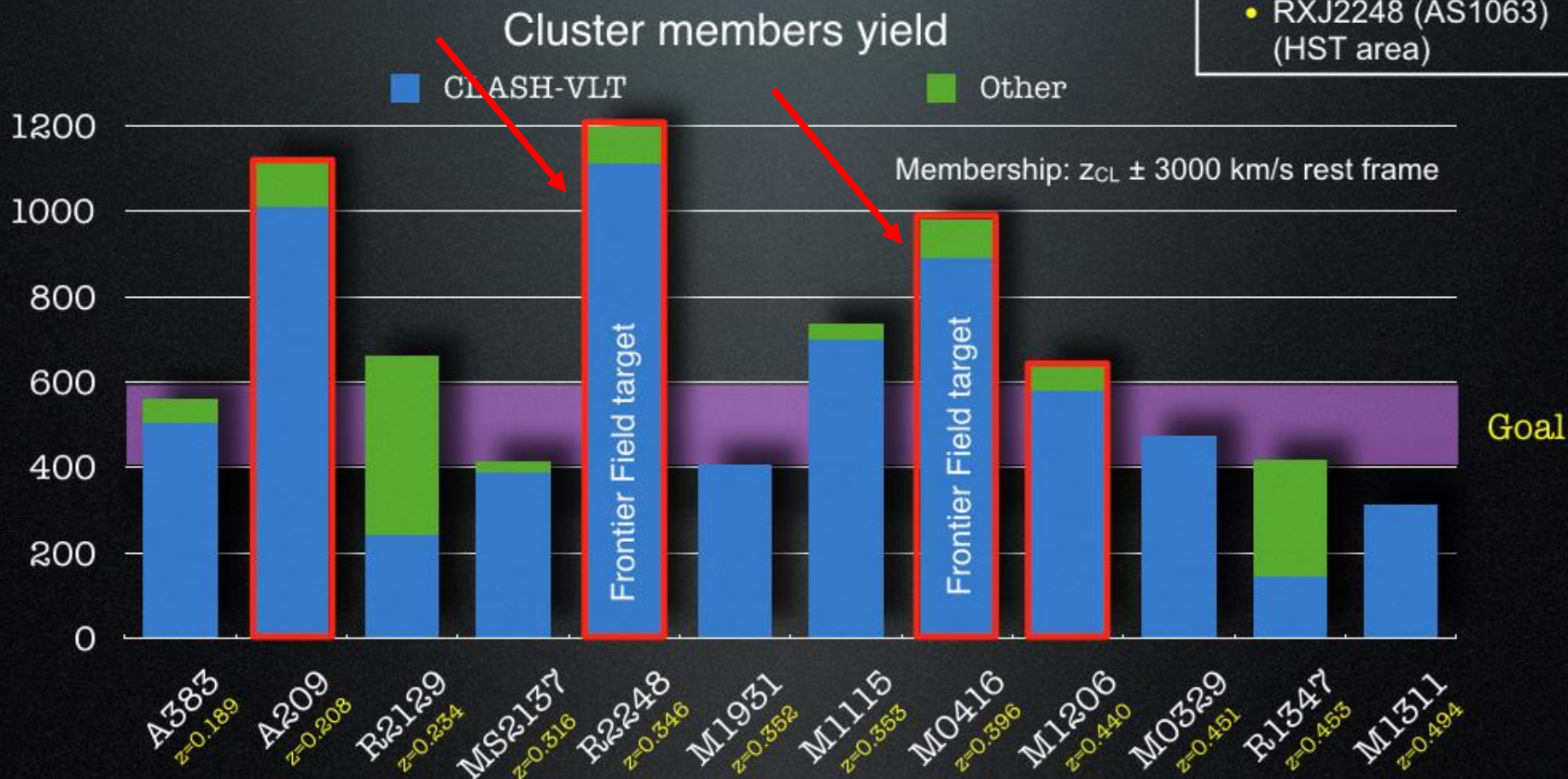
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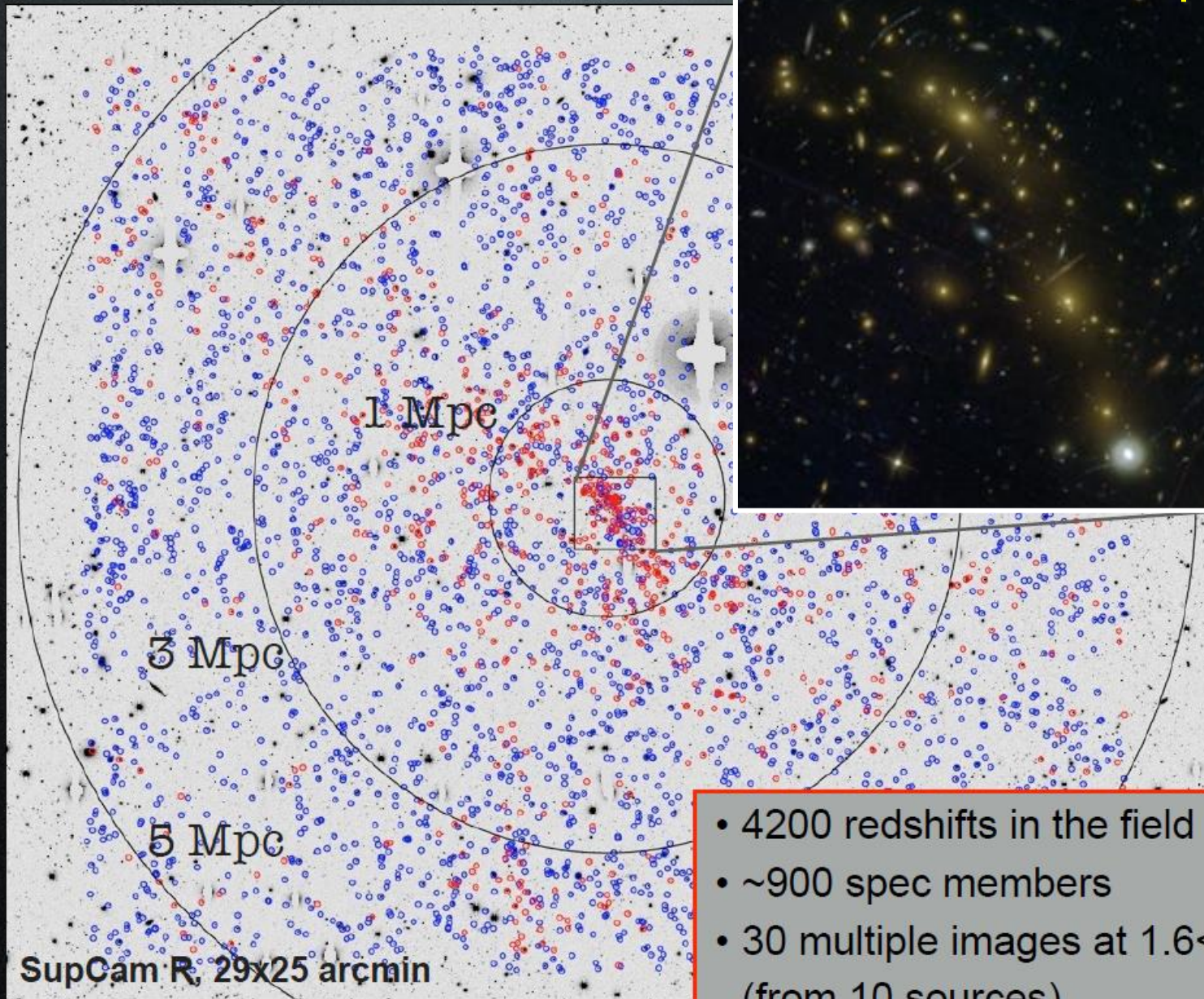
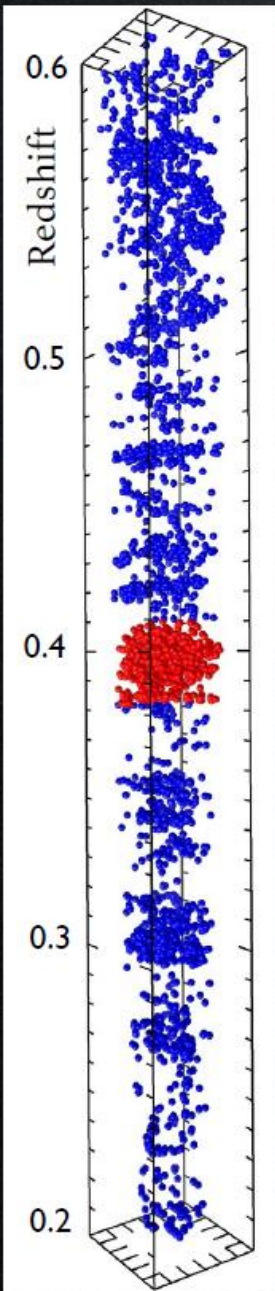
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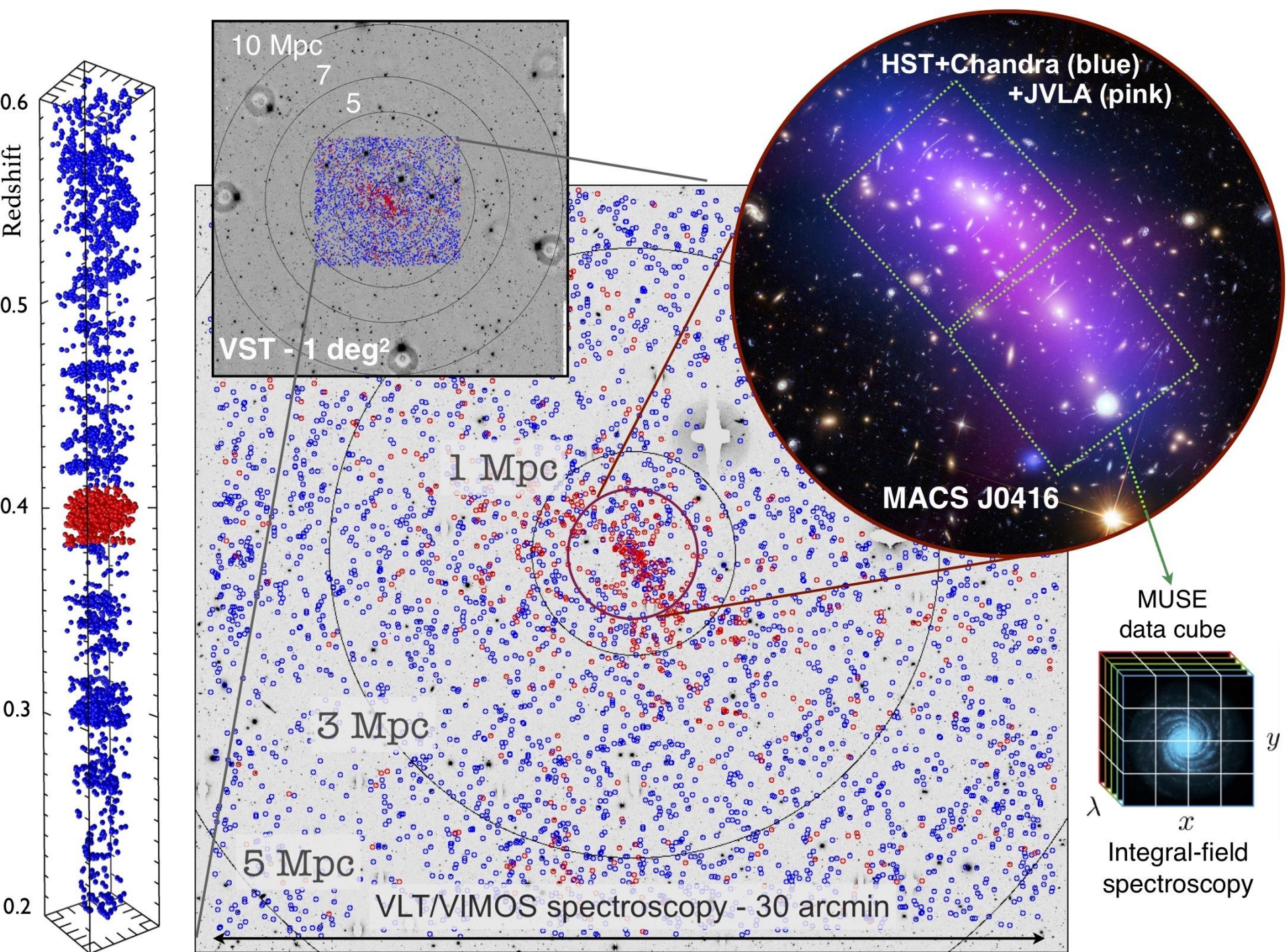
CLASH-VLT spectroscopic campaign of MACS0416

(Grillo+ 2015, Balestra+ 2016 + data release)

HST



- 4200 redshifts in the field
- ~900 spec members
- 30 multiple images at $1.6 < z < 3.2$ (from 10 sources)

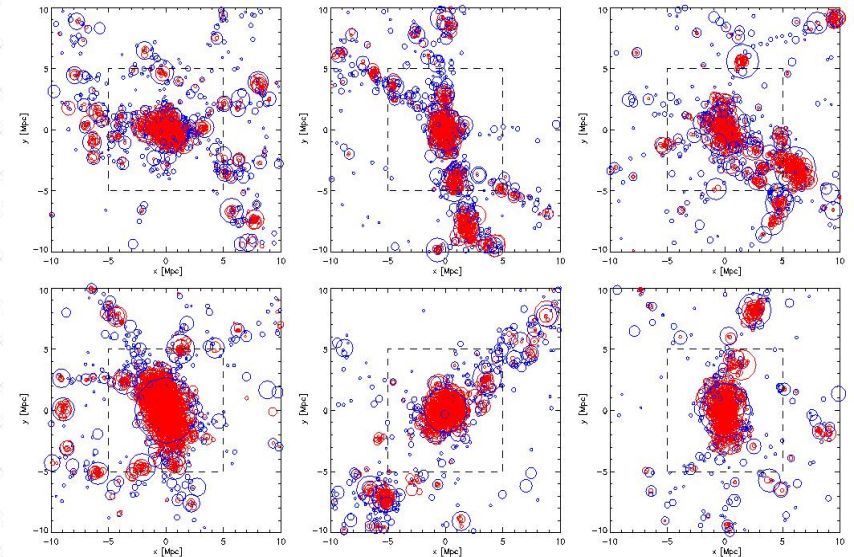


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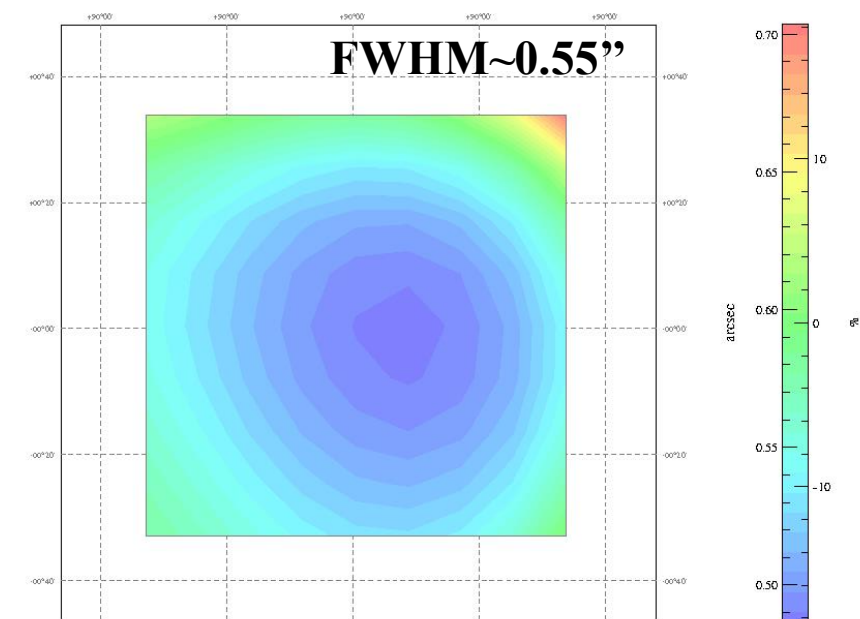
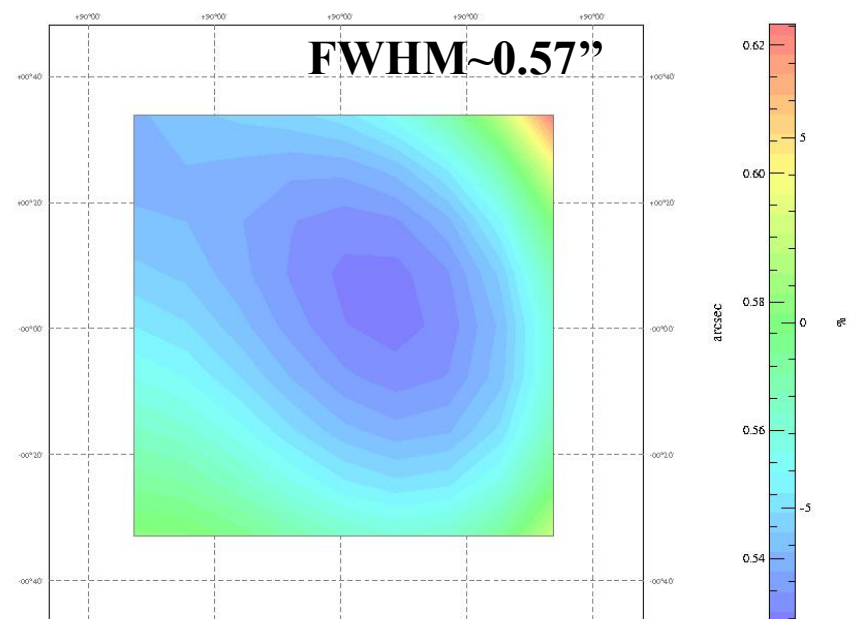
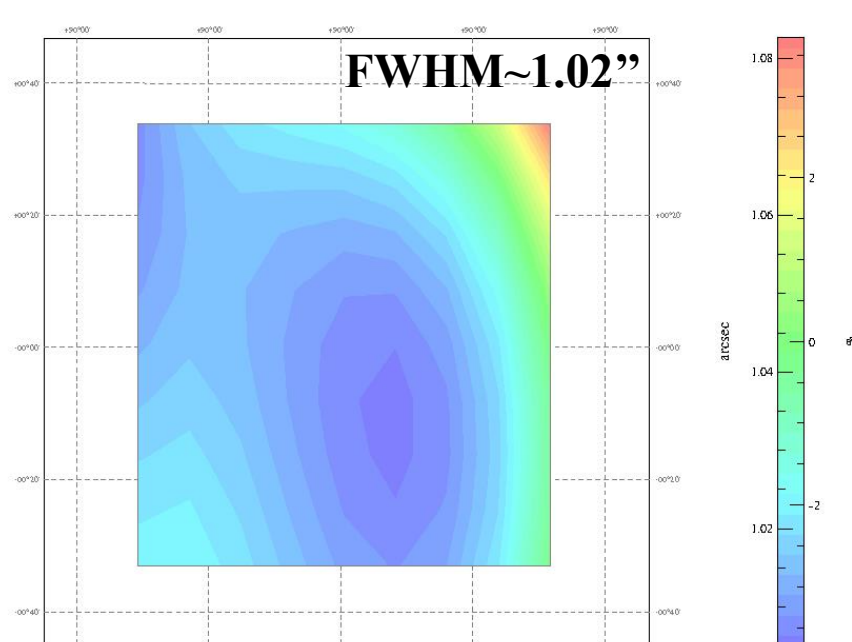
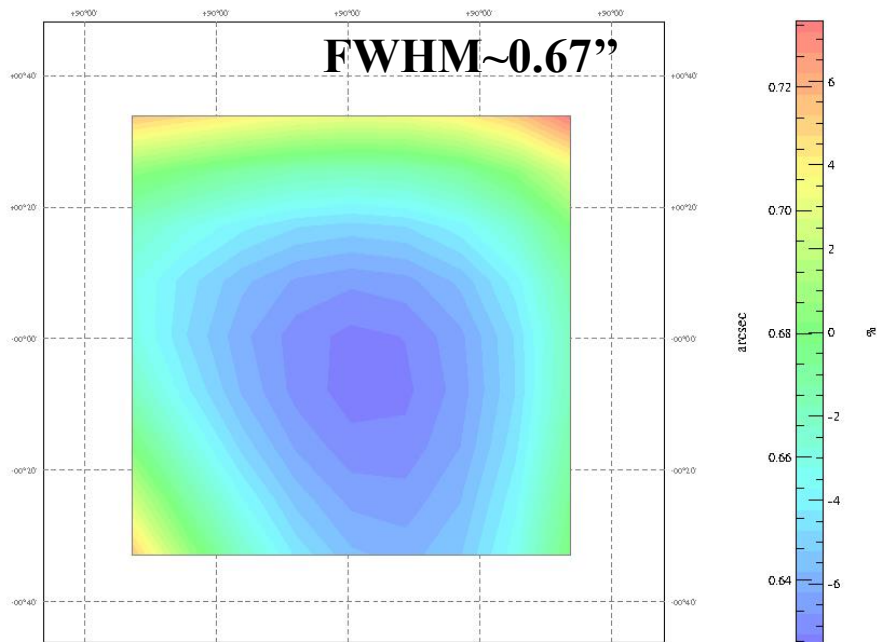
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Obs started 04/17



***u*'-band**

***g*'-band**

***r*'-band**

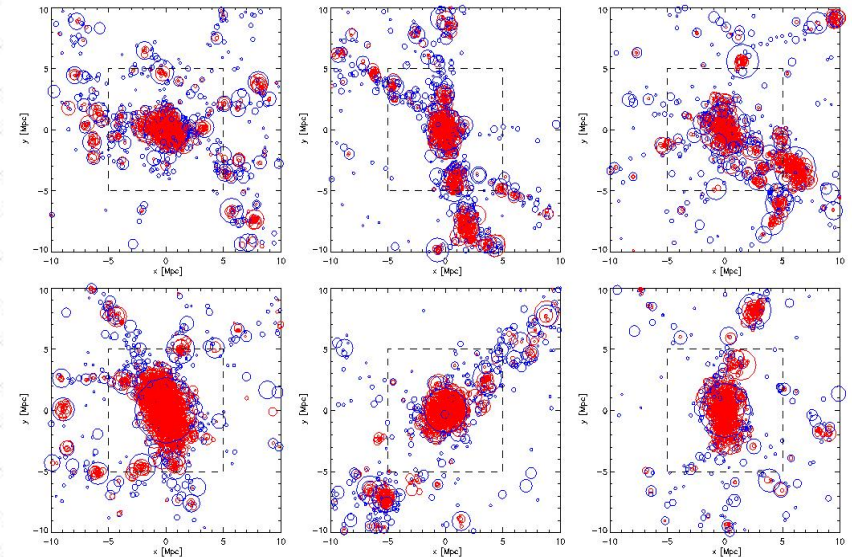
***i*'-band**

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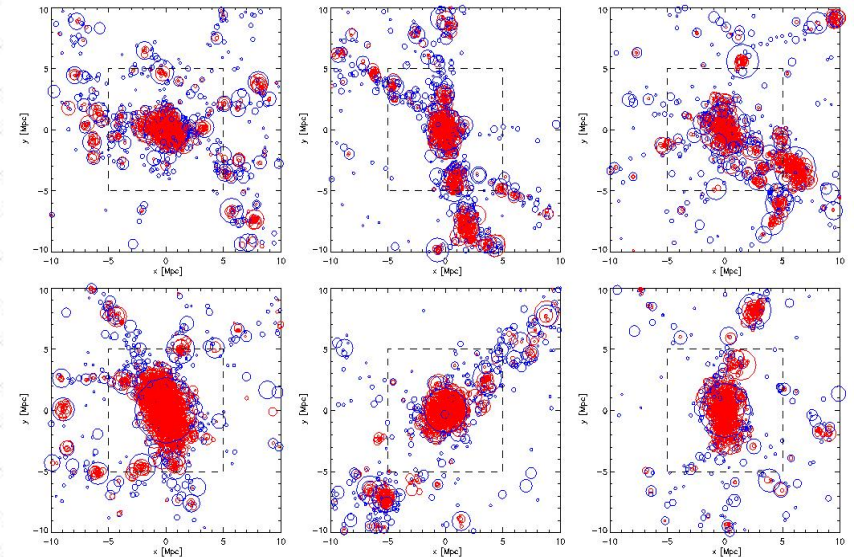
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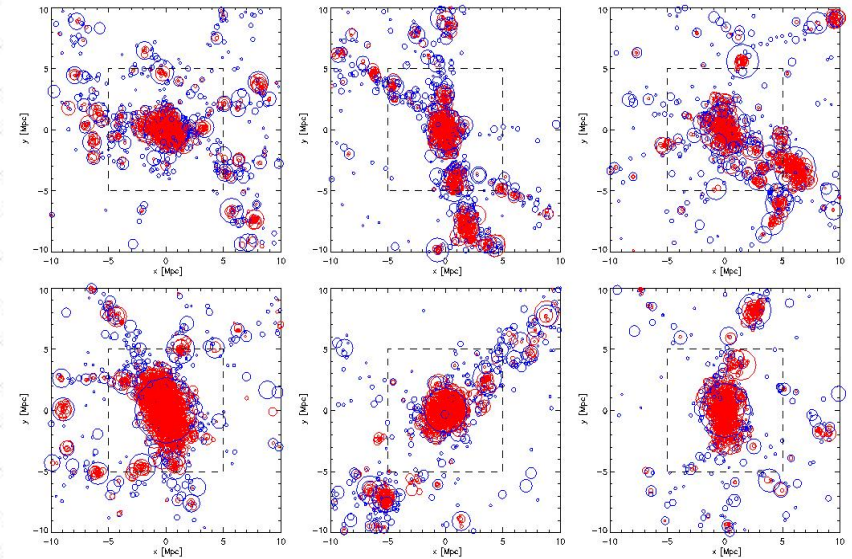
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Concerted effort which includes NIR observations of an ongoing VISTA Public Survey (560h, P.I. M. Nonino, Survey manager: A. Mercurio).

The Galaxy Clusters At Vircam (G-CAV, P.I.: M. Nonino)

G-CAV is a infrared Y, J, Ks 560 hrs long survey for a sample of 20 clusters of galaxies, to explore galaxy evolution over a large, and largely unexplored, diversity of cluster environments.

(AB, 5σ)

$23.8 < Y < 24.5$

$23.2 < J < 24.3$

$22.5 < K_s < 23.3$

Cluster z	Y	J	Ks
$z \leq 0.31$ (A)	2×12600	2×10800	2×7200
$0.31 \leq z \leq 0.5$ (B)	2×16200	2×14400	2×10800
$z \geq 0.5$ (C)	2×21600	2×19800	2×16200

Data for 5 clusters already completed:

MACSJ0416 (30h)

RXCJ2248 (30h)

PLCKG287 (26h)

RXCJ1515 (21h)

RXCJ2129 (~19h)

The Galaxy Clusters At Vircam (G-CAV, P.I.: M. Nonino)

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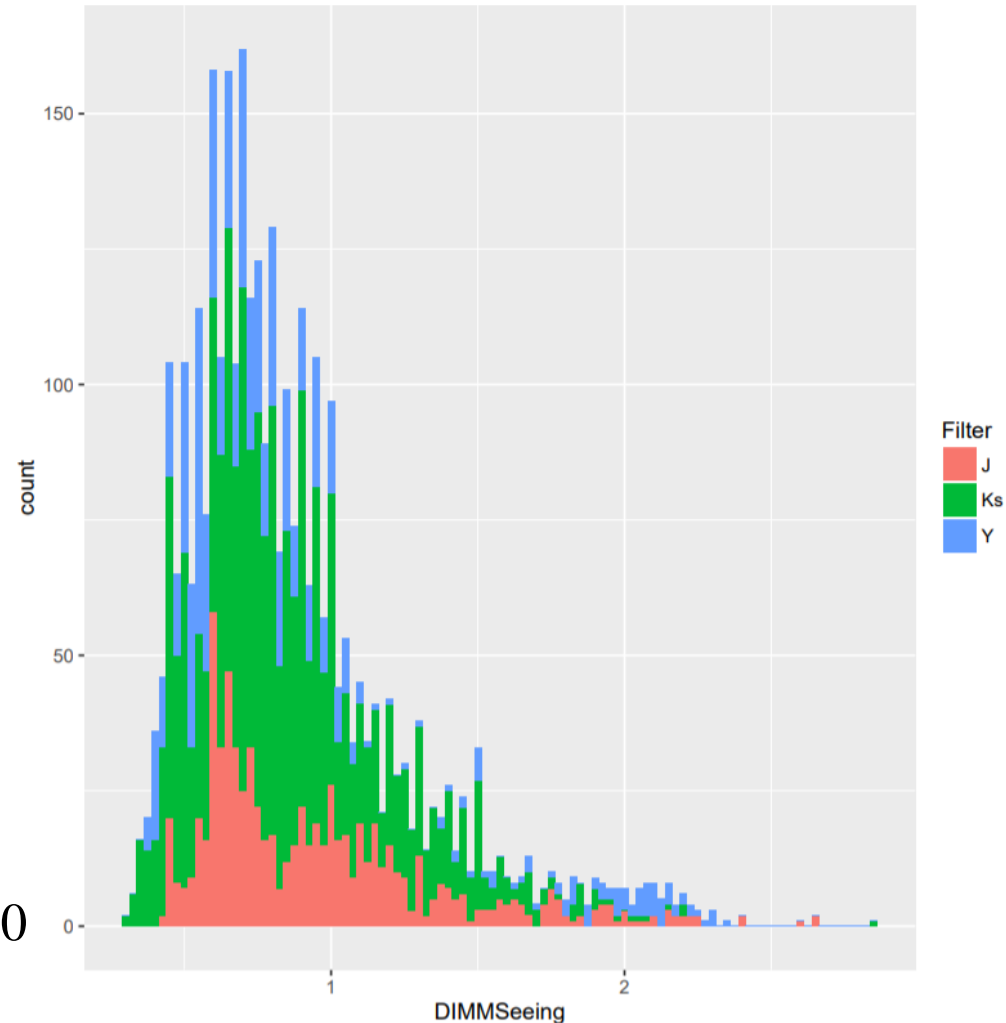
RXCJ2248 (30h)

PLCKG287 (26h)

RXCJ1515 (21h)

RXCJ2129 (~19h)

All submitted OBs observed in P98-P100



A new window on high-z “galaxies”

Magnifying “star forming clusters” at $z=3-6.4$

(Vanzella et al. 2017b)

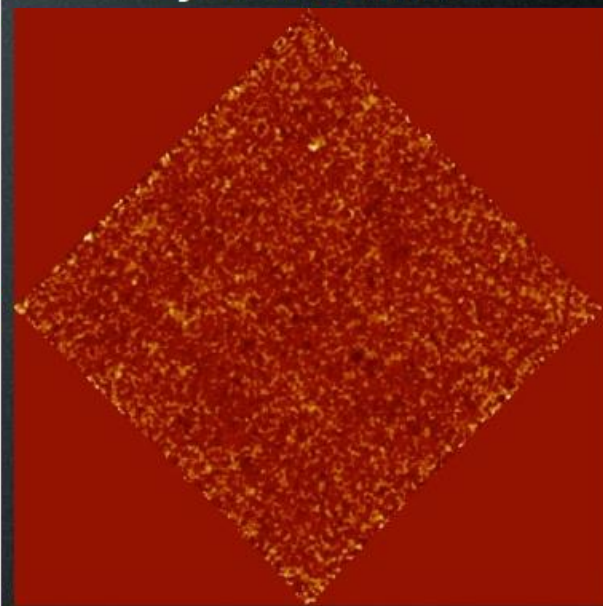
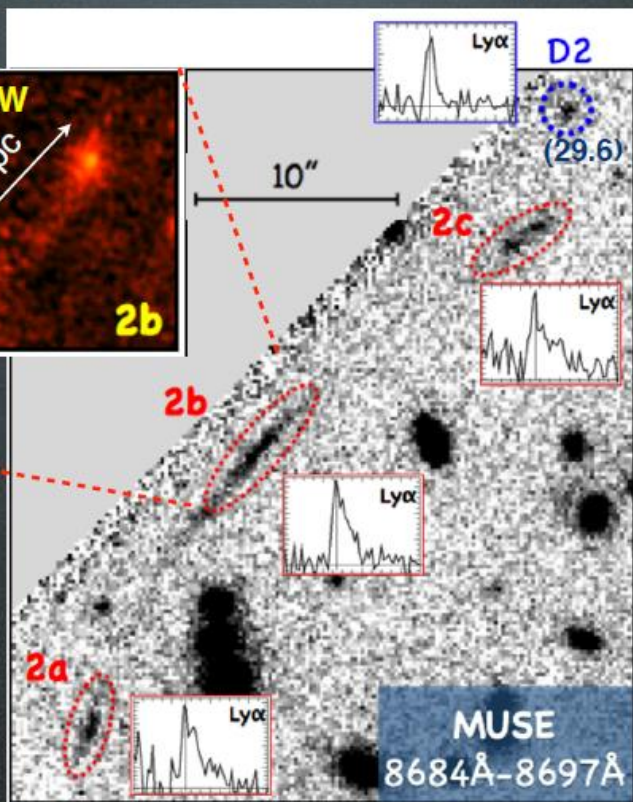
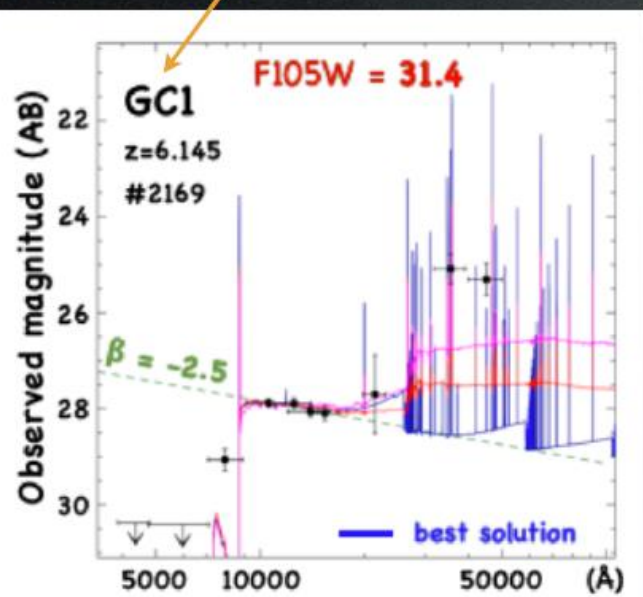
($T_U = 0.85-2.1$ Gyr)

MUSE fly-thru 8690 Å
Ly- α at $z=6.145$

$z=6.145$



SED fit



$m_{\text{obs}} = 27.9$ AB, $\mu = 25 \pm 3 \Rightarrow m_{\text{UV}} = 31.4$, $M_{\text{UV}} = -15.3$

$M_{\text{stellar}} \sim 3 \times 10^6 M_{\odot}$ ($10^6 - 10^7$), ($M_{\text{stel,D1}} \sim 10X$)

$R_e = 16 \pm 7$ pc (D1 ~ 140 pc)

Age = 1 – 10 Myr, SFR = 2 – 5 M_{\odot}/yr , high sSFR

Clustering ? GC1–D1 = 0.6 kpc , GC1–D2 = 27 kpc

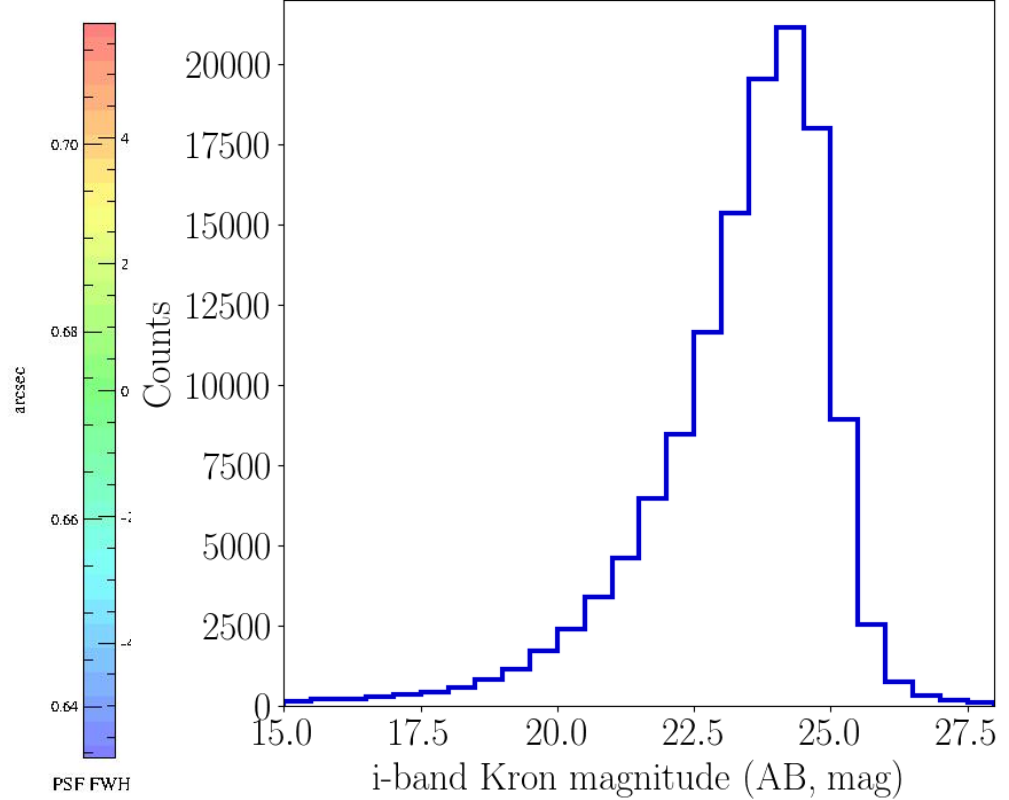
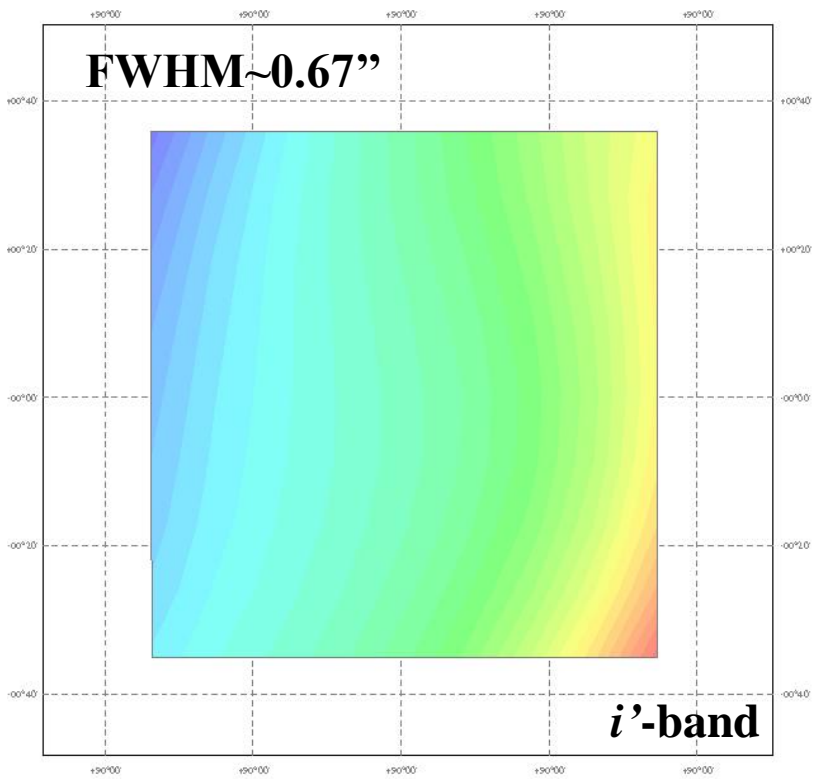
...consistent with Globular Cluster formation models or physical expectations on GC progenitors (see Renzini 2017; Boylan-Kolchin 2017)

Some numbers (E. Vanzella)....

- $z \sim 2.2$ [1.7-2.7] ~ 15000 gals per sq.deg (Reddy&Steidel 2009)
- $z \sim 3.0$ [2.5-3.5] ~ 10000 gals per sq.deg (Reddy&Steidel 2009)
- $z \sim 4.0$ [3.5-4.5] ~ 9000 gals per sq.deg (Bouwens et al. 2015, tab. A1)

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$M_{lim} = 24.75$ (5σ in $3''$)

Outlook and legacy

VST/VISTA/HST+VIMOS/MUSE

- ✓ Goldmine for galaxy evolution studies in different environments:
 - Large field of view ($20 \times 20 \text{ Mpc}^2$ at $z=0.4$) to explore a wide range of cluster environment and good data quality to reach the dwarf regime;
 - Large spectroscopic members ample critical for the analysis of galaxy properties as a function of mass + environment + dynamical status of the cluster;
 - Deep (IFU) spectroscopy to explore low-mass regimes + precise magnification maps for new exploration of (very) low mass/luminosity galaxies at $z=3-7$ beyond deepest HST fields.
 - Large Field photometry: a window on high-redshift galaxies.



The first glimpse to the science era of E-ELT and JWST.

Thanks!!!