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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”).

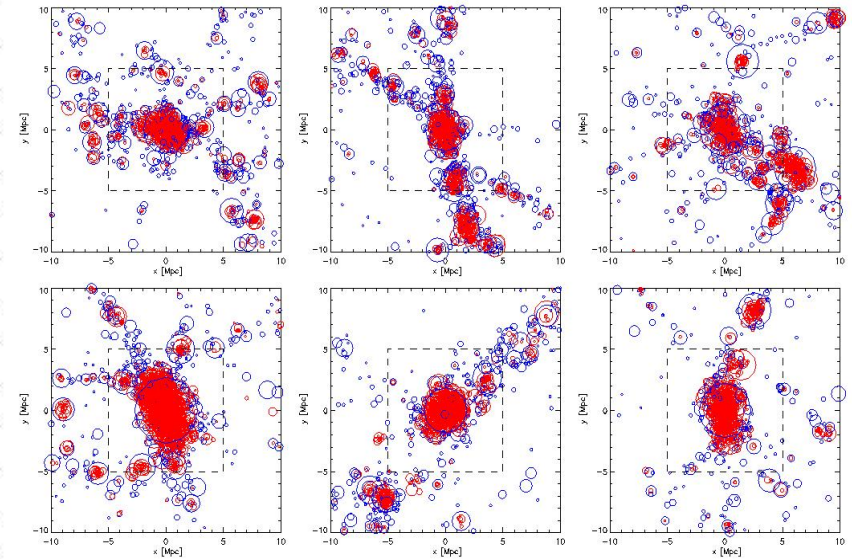
One key missing ingredient is a panoramic and homogeneous dataset of high-quality optical imaging of galaxies in a wide and largely unexplored range of cluster environments, down to the dwarf regime ($10^9 M_{\odot}$), at a redshift when the galaxy population was still rapidly evolving.

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

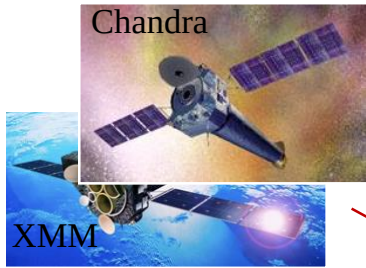
PI: A. Mercurio (INAF-Osservatorio Astronomico di Capodimonte, OANa)

300h VST survey of perform a unique wide field coverage (20x20 Mpc² 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 (~5 R_{vir}), following the infall of galaxies along filaments, within groups, or directly from the field, up to 10⁹ M_⊙, where model predictions are in tension with the data (e.g. too many dwarfs).

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



Chandra

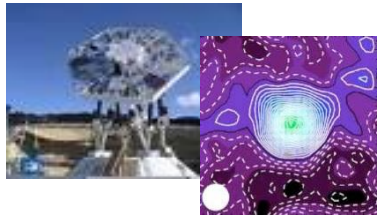
XMM

PI: M. Donahue

Baryon mass distribution
X-ray masses
ICM physics & metallicity

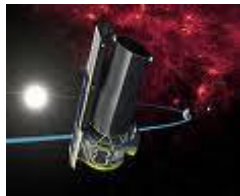
PI: S.Ettori

Bolocam, Mustang



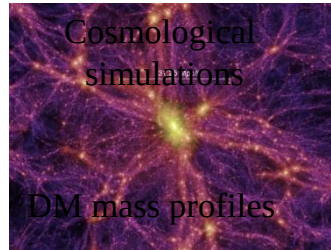
PI: K. Umetsu

Spitzer



PI: W. Zheng R.
Bowuens

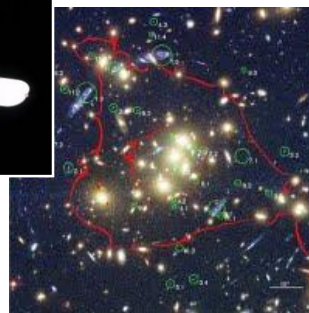
Galaxy Formation and
evolution



Cosmological
simulations

DM mass profiles

Strong Lensing
Mass profile in the core



Treasury Program
(530 orbits)
PI: M. Postman

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

High-z gals
Dynamical analysis
Stellar masses

High-z gals

WL masses profile
Stellar masses

VLT



PI: P. Rosati

LBT



PI: M. Nonino

Subaru (+ ESO-WFI)
VISTA+ VST



PI: K. Umetsu
M. Nonino
A. Mercurio

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

Strong Lensing
Mass profile

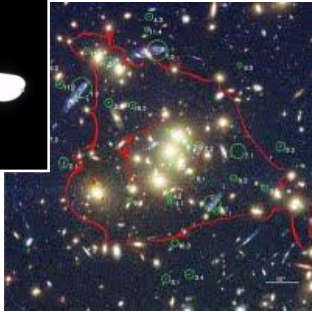
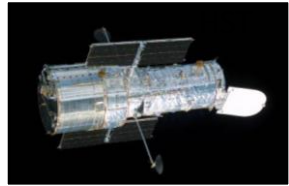
From the core

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Galaxy formation and
evolution

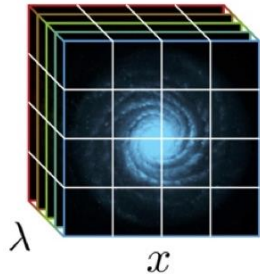
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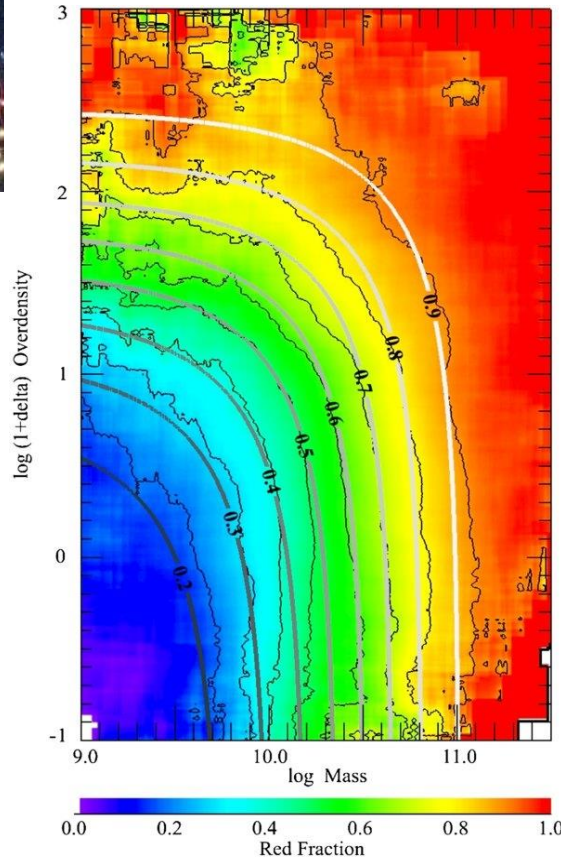
Treasury Program
(530 orbits)

PI: M. Postman

MUSE
Integral Field
Spectroscopy



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



Environment

To the outskirts

WL masses profile
Stellar masses

VST + VISTA



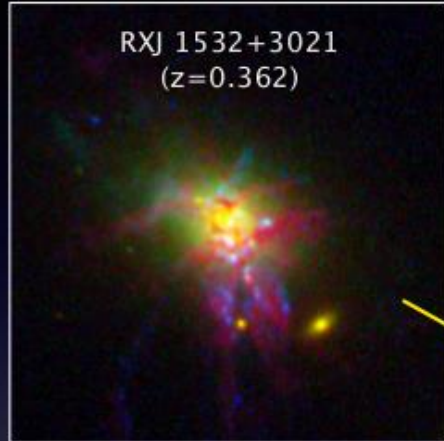
M. Nonino
A. Mercurio

Mass

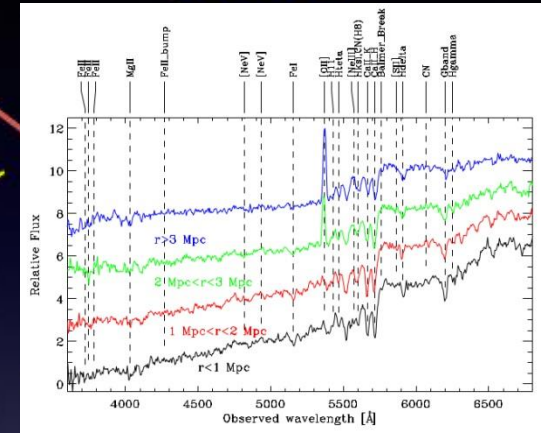
Peng et al. 2010

New avenues for galaxy evolution

BCG structure, SF, cooling



Galaxy transformation processes



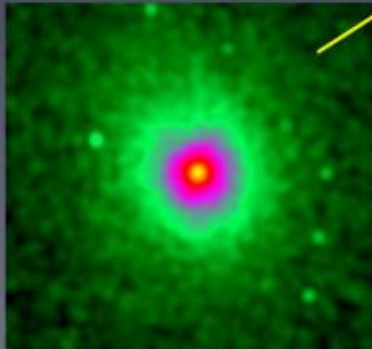
Girardi et al. (2015)

Comparison with Semi-analytic models

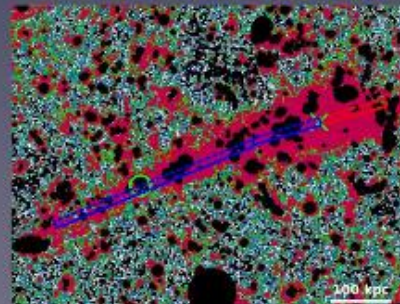
Galaxy properties over ~ 10 Mpc:

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

Intra-Cluster Medium (X-ray)

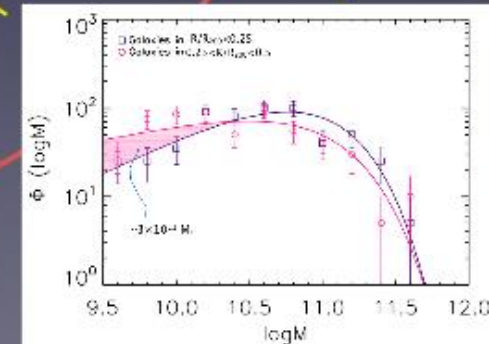


Intra-Cluster light



Presotto et al. (2014)

**Stellar
mass/luminosity fnct**



Annunziatella et al. (2014)

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

Final redshift sample (nearly final):

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

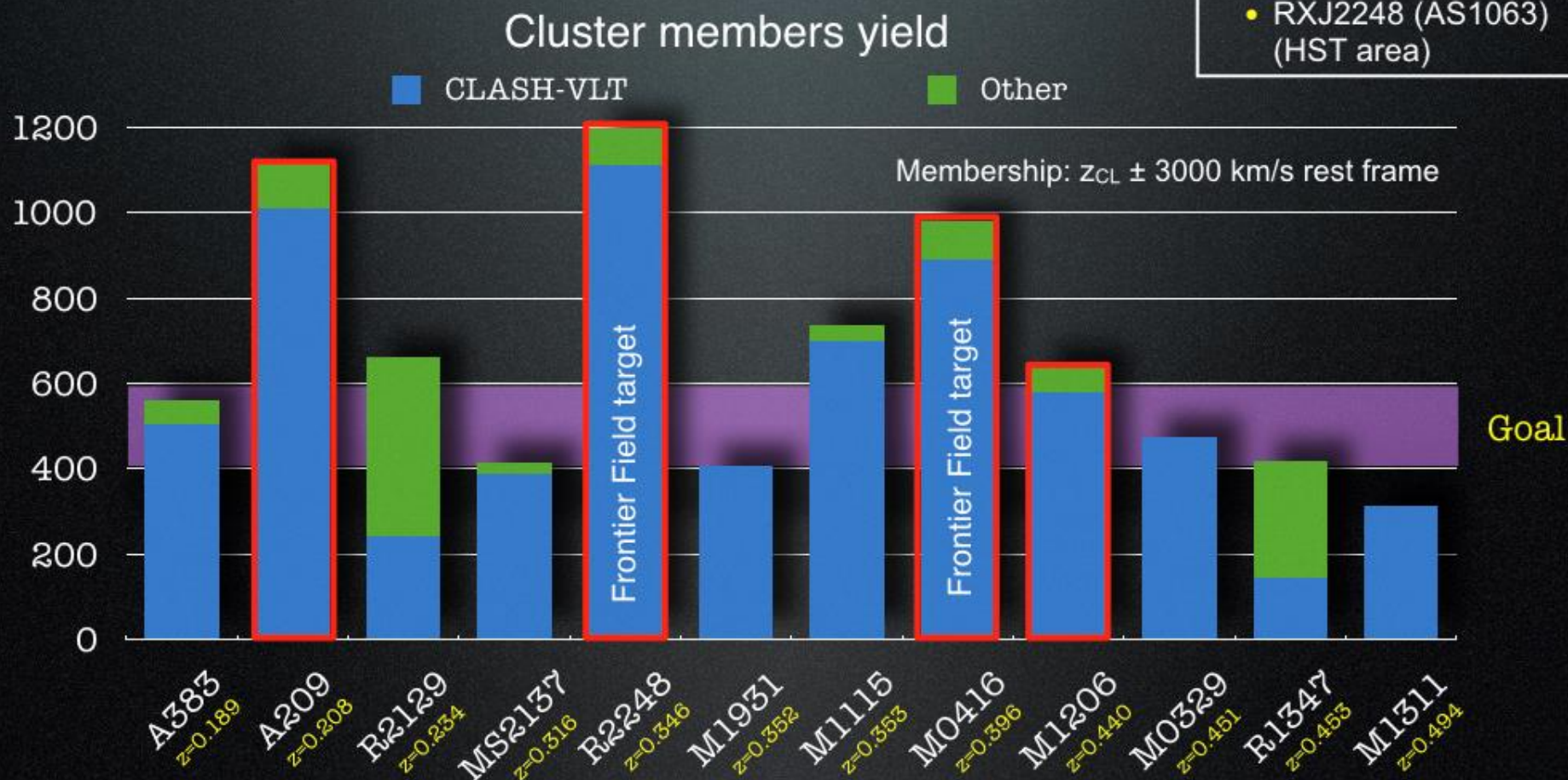
~7300 cluster members

~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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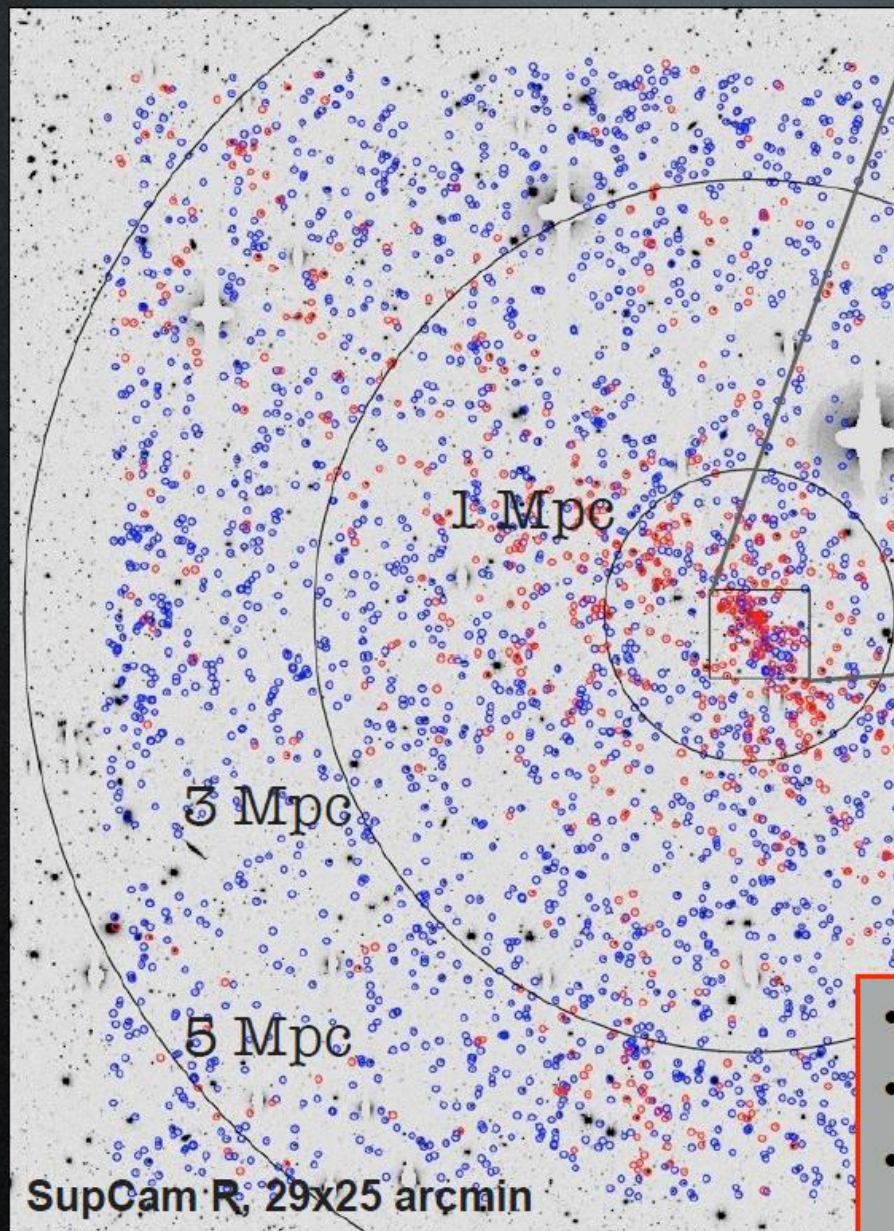
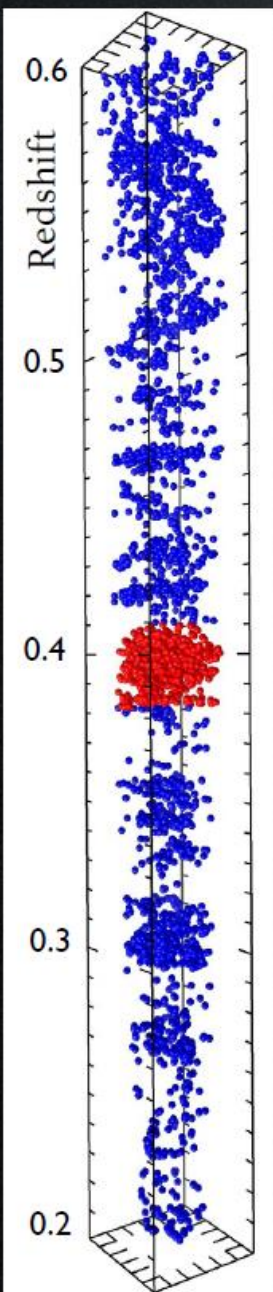
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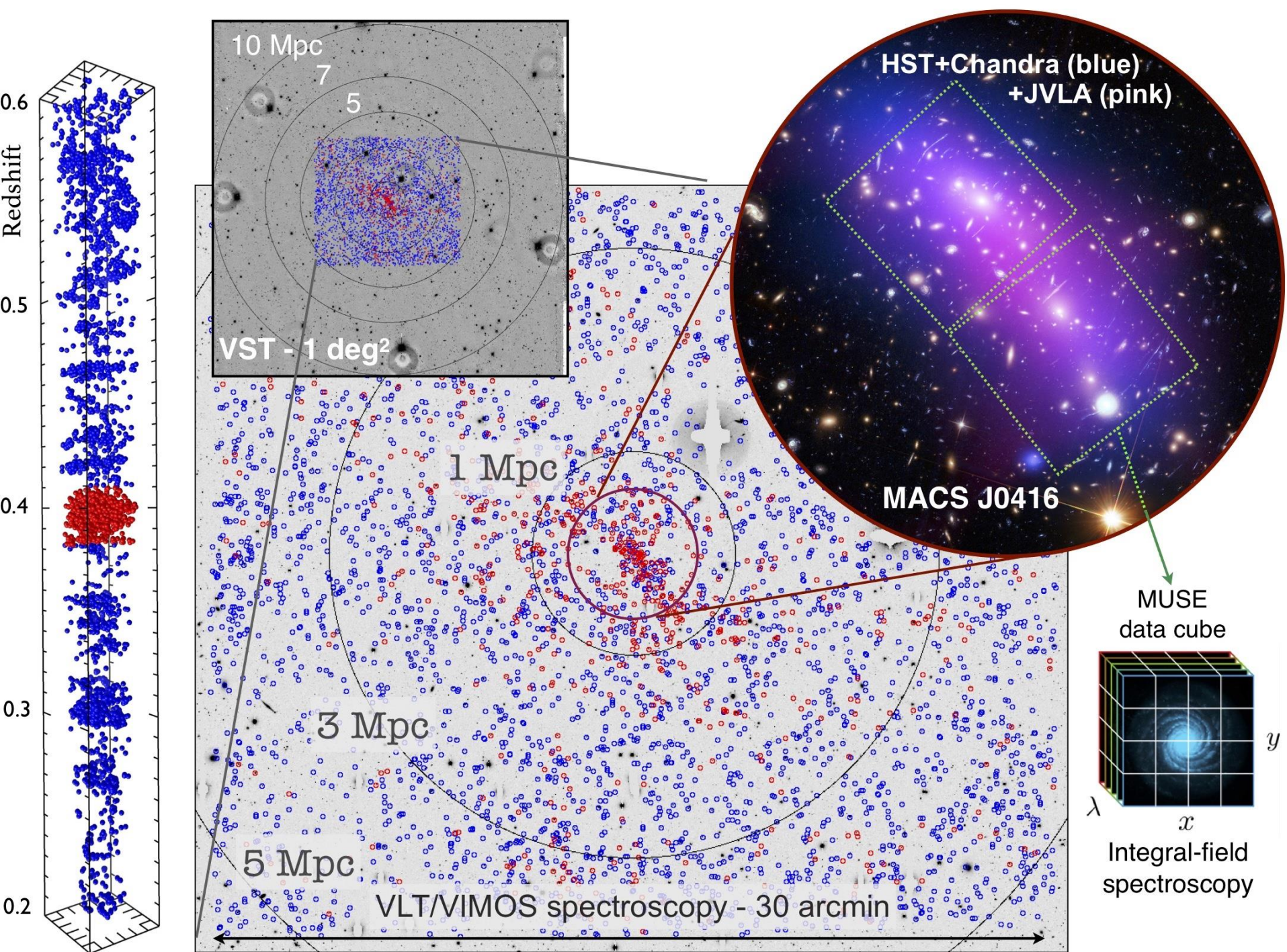


CLASH-VLT spectroscopic campaign of MACS0416

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



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

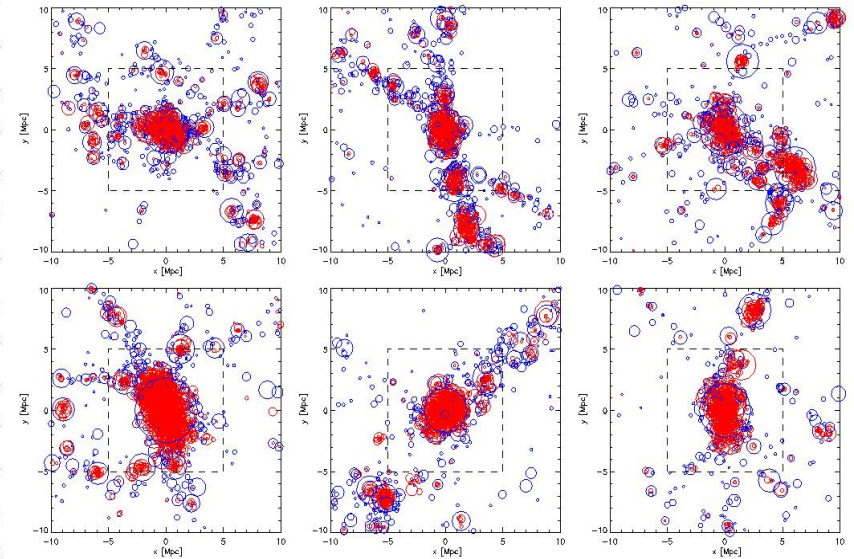


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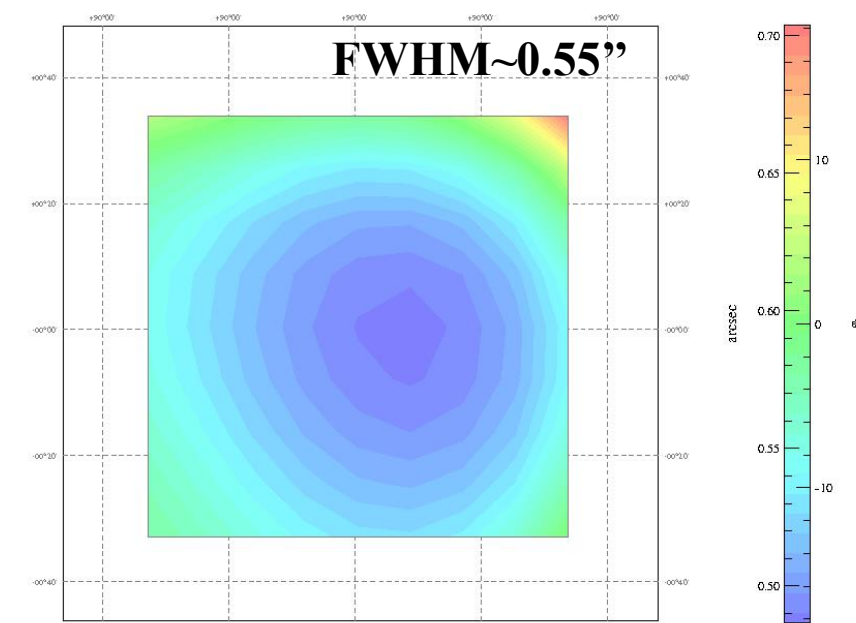
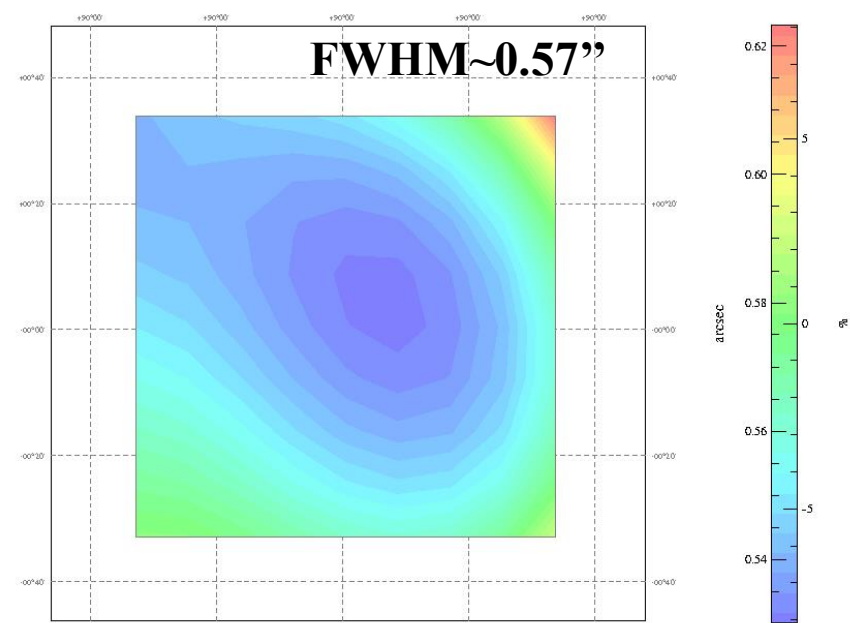
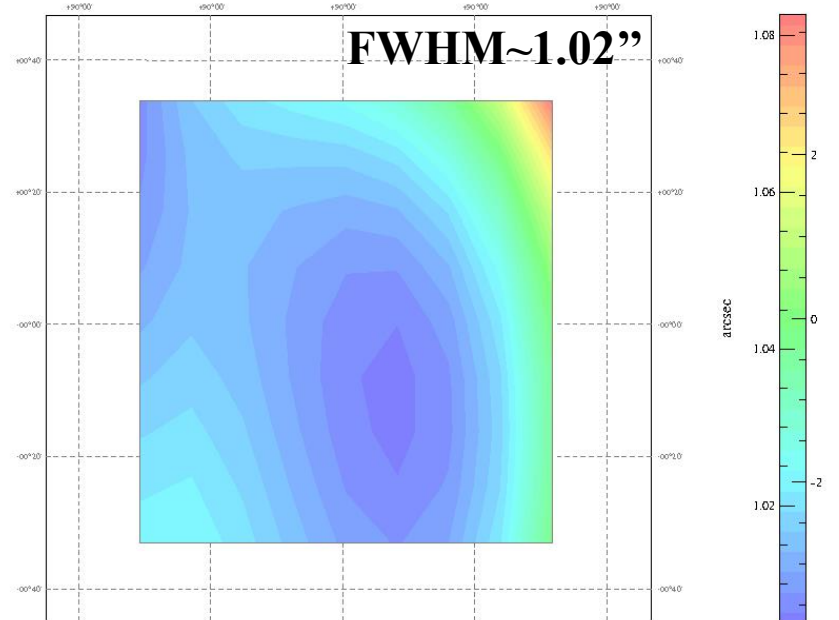
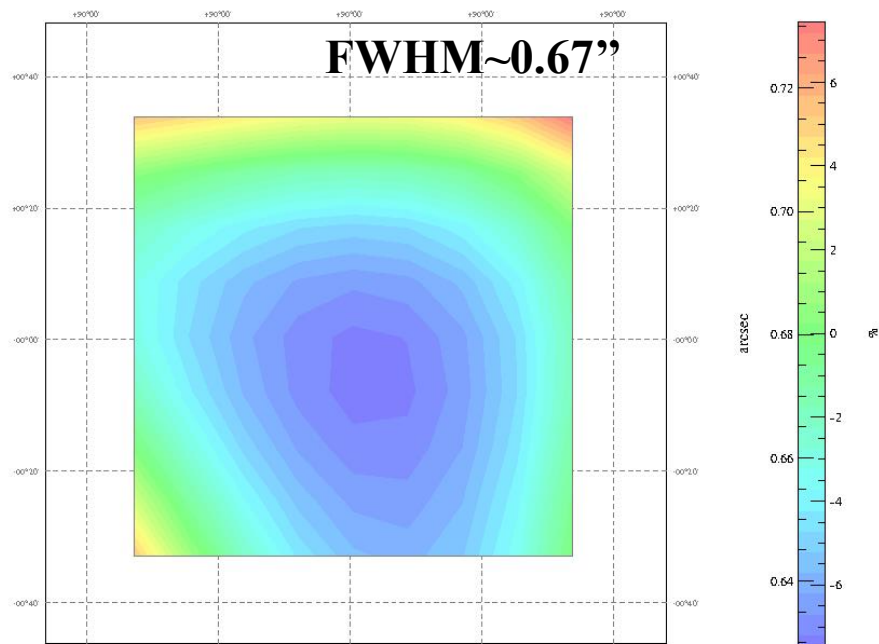
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Obs started 04/17



***u*'-band**

***g*'-band**

***r*'-band**

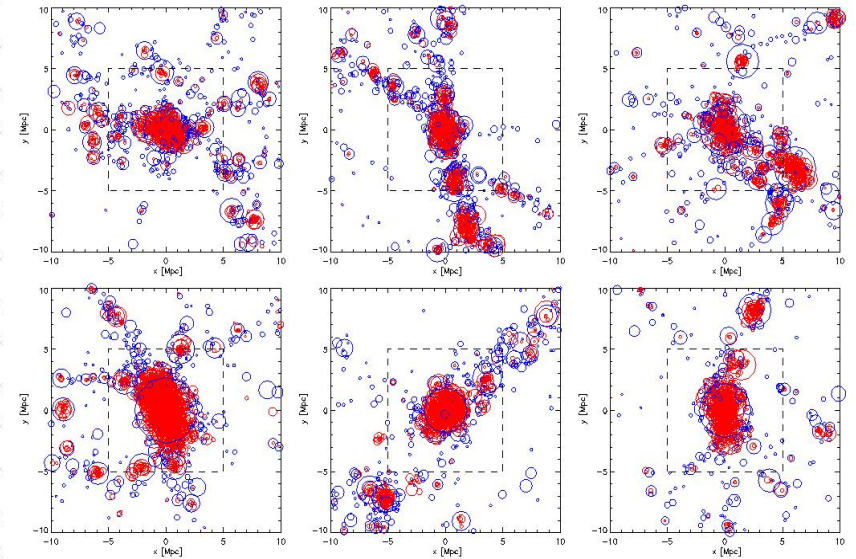
***i*'-band**

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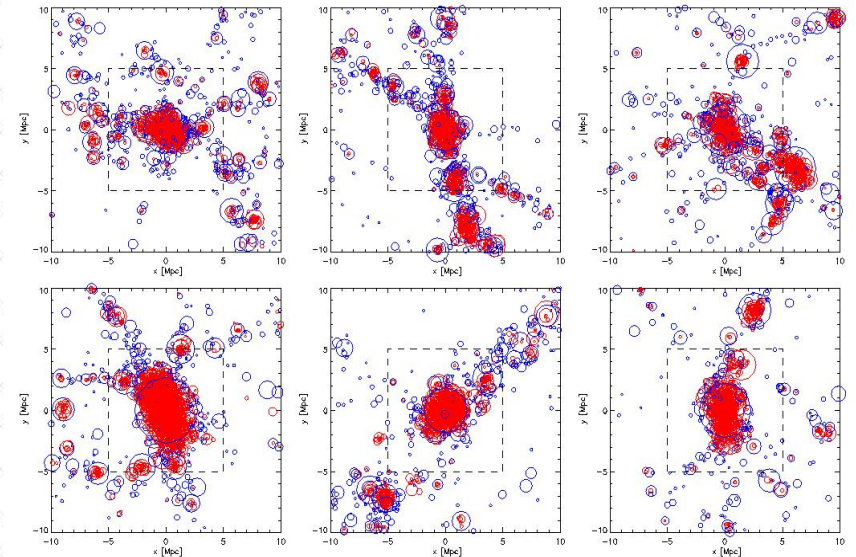
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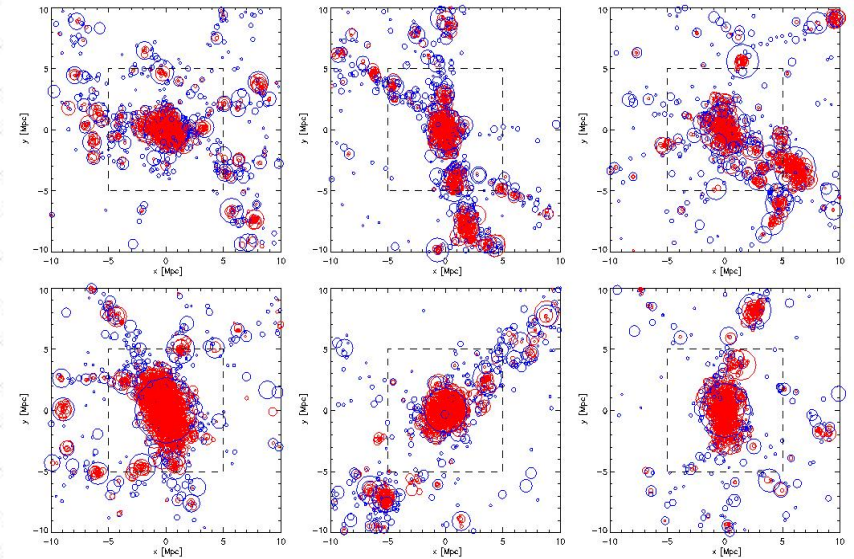
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Concerted effort which includes NIR observations of an ongoing VISTA Public Survey (560h, P.I. M. Nonino, Survey manager: A. Mercurio).

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)

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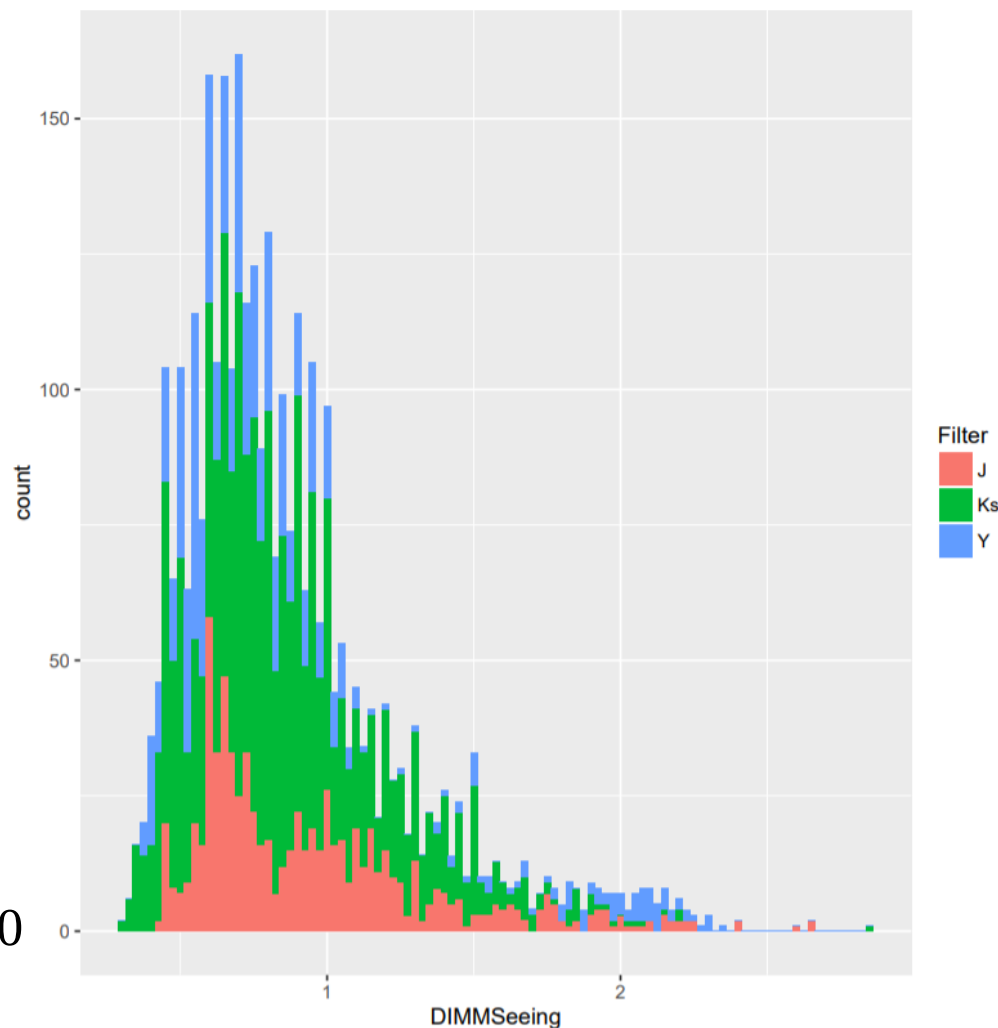
RXCJ2248 (30h)

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 $z=3-6.4$

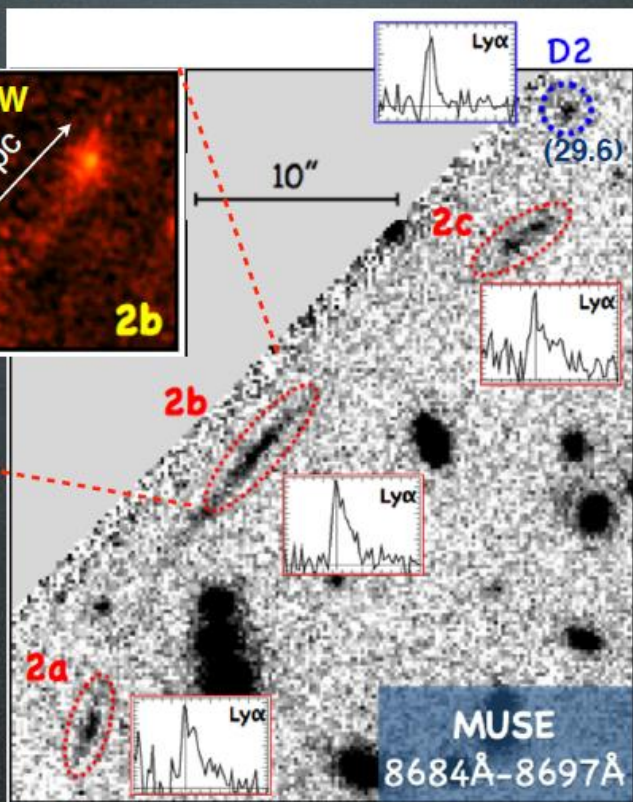
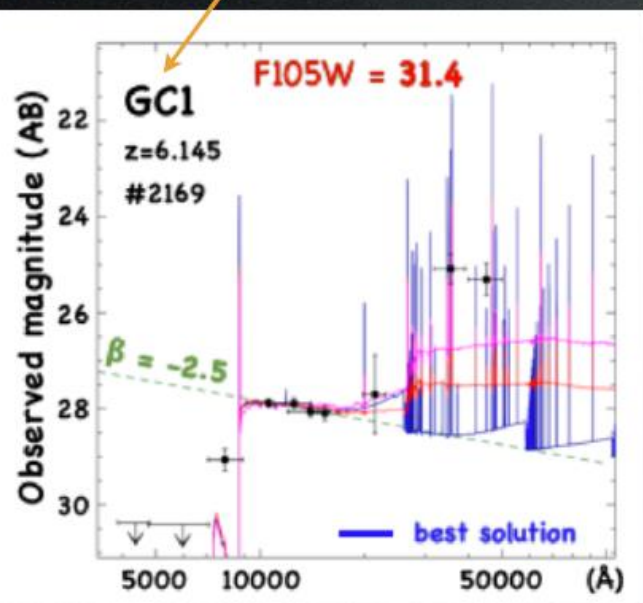
(Vanzella et al. 2017b)

($T_U = 0.85-2.1$ Gyr)

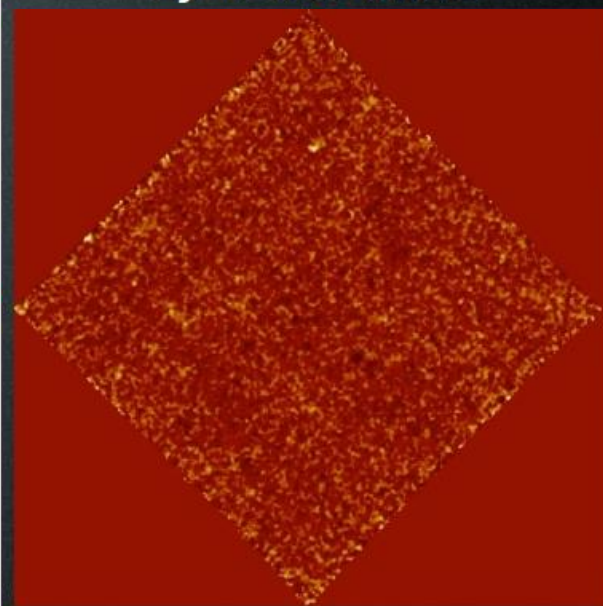
$z=6.145$



SED fit



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



$m_{\text{obs}} = 27.9$ AB, $\mu = 25 \pm 3 \Rightarrow m_{\text{UV}} = 31.4$, $M_{\text{UV}} = -15.3$
 $M_{\text{stellar}} \sim 3 \times 10^6 M_{\odot}$ ($10^6 - 10^7$), ($M_{\text{stel,D1}} \sim 10\times$)
 $R_e = 16 \pm 7$ pc (D1 ~ 140 pc)
 Age = 1 – 10 Myr, SFR = 2 – 5 $M_{\odot}/\text{yr}$, high sSFR
 Clustering ? GC1–D1 = 0.6 kpc , GC1–D2 = 27 kpc

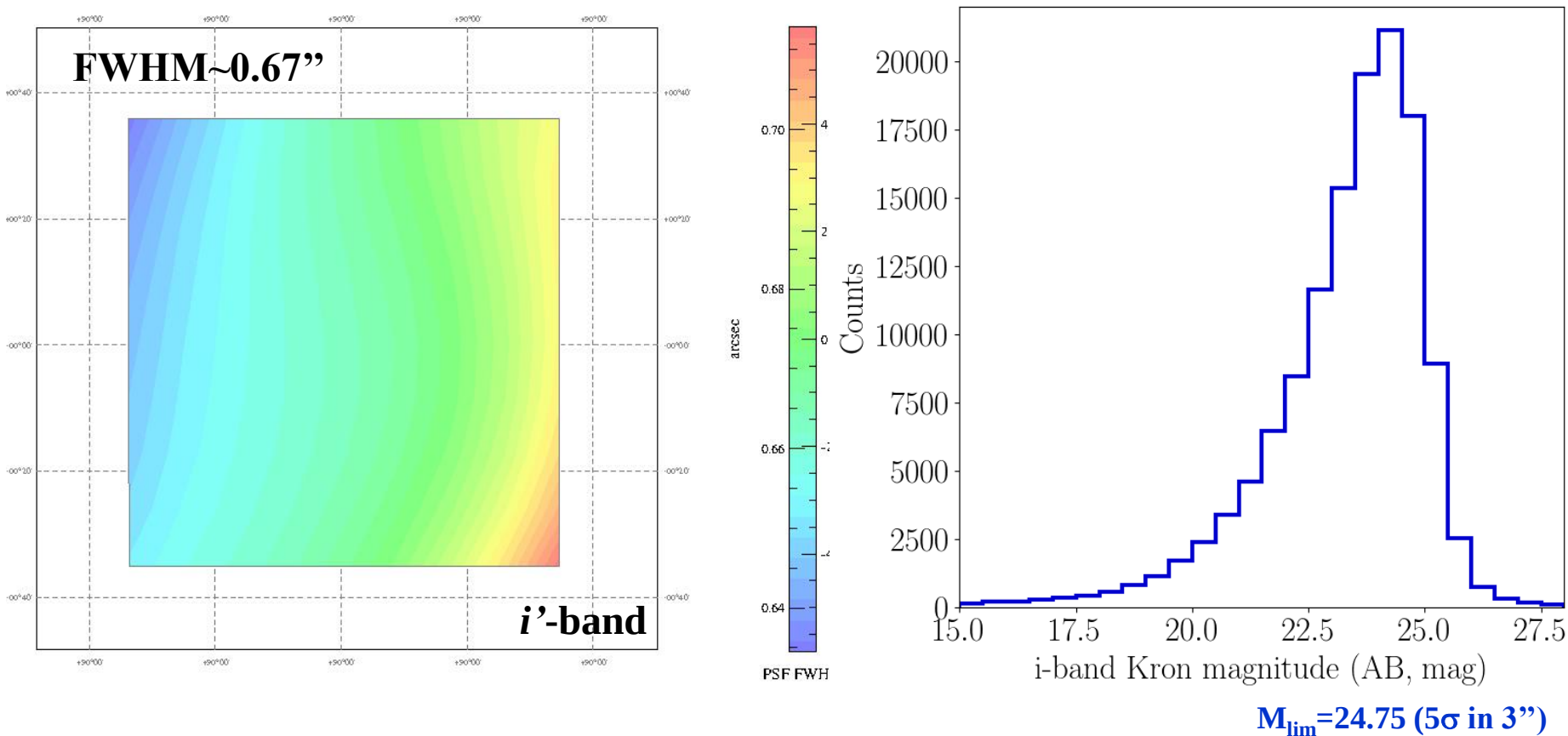
...consistent with Globular Cluster formation models or physical expectations on GC progenitors (see Renzini 2017; Boylan-Kolchin 2017)

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)
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Some numbers (E. Vanzella)....

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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!!!