The story of brightest cluster galaxies told through merger signatures in their stellar populations

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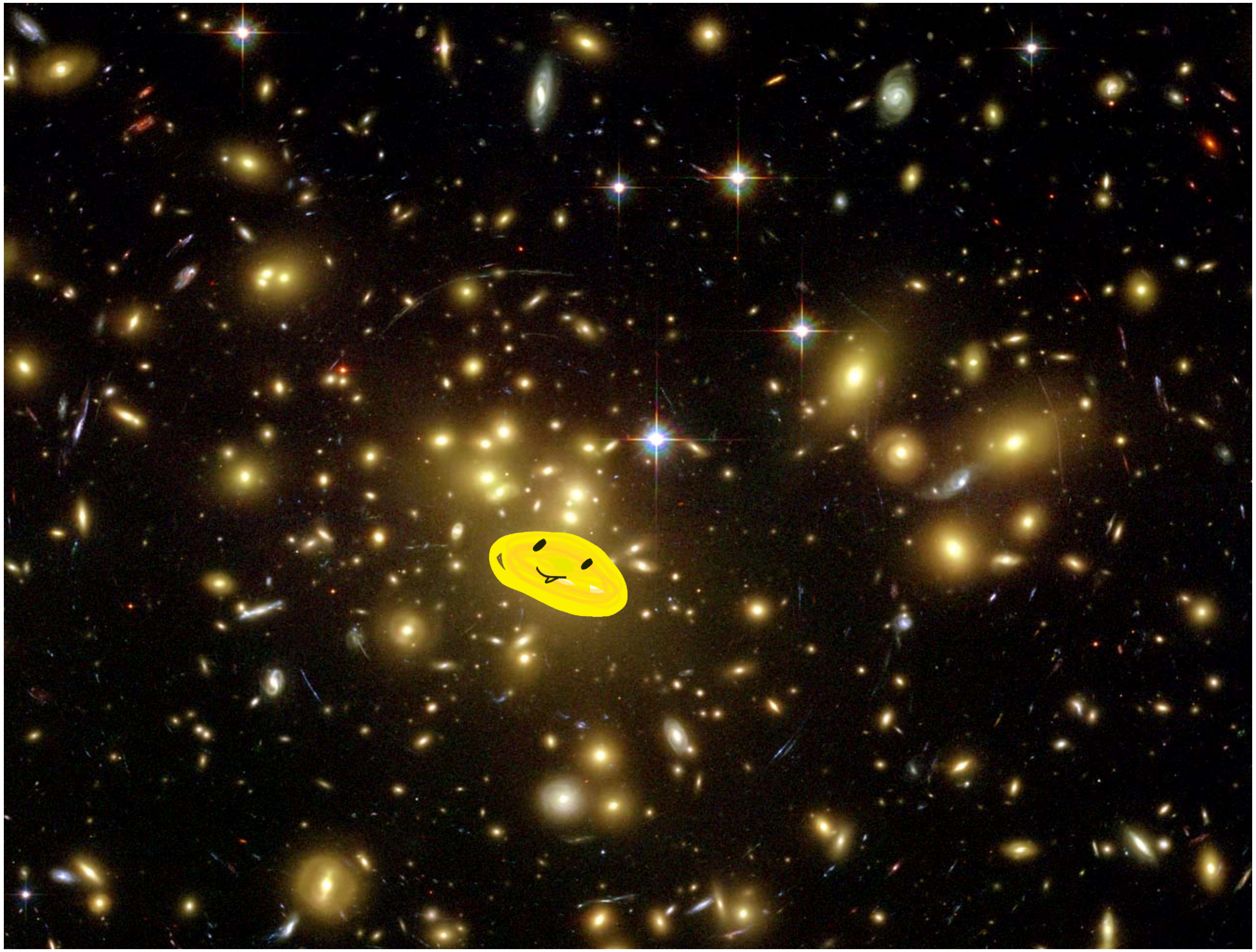
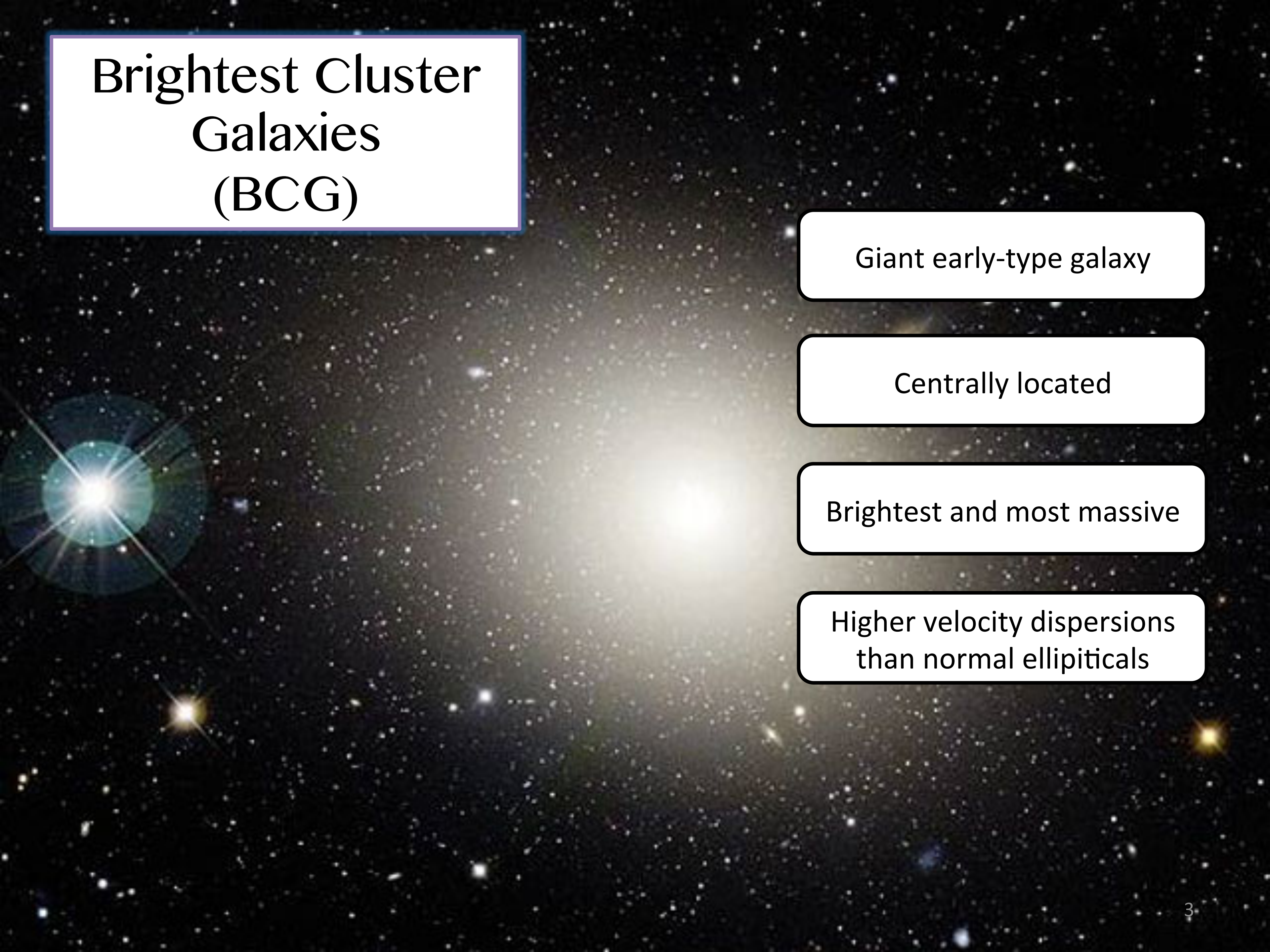
Galaxy Clusters



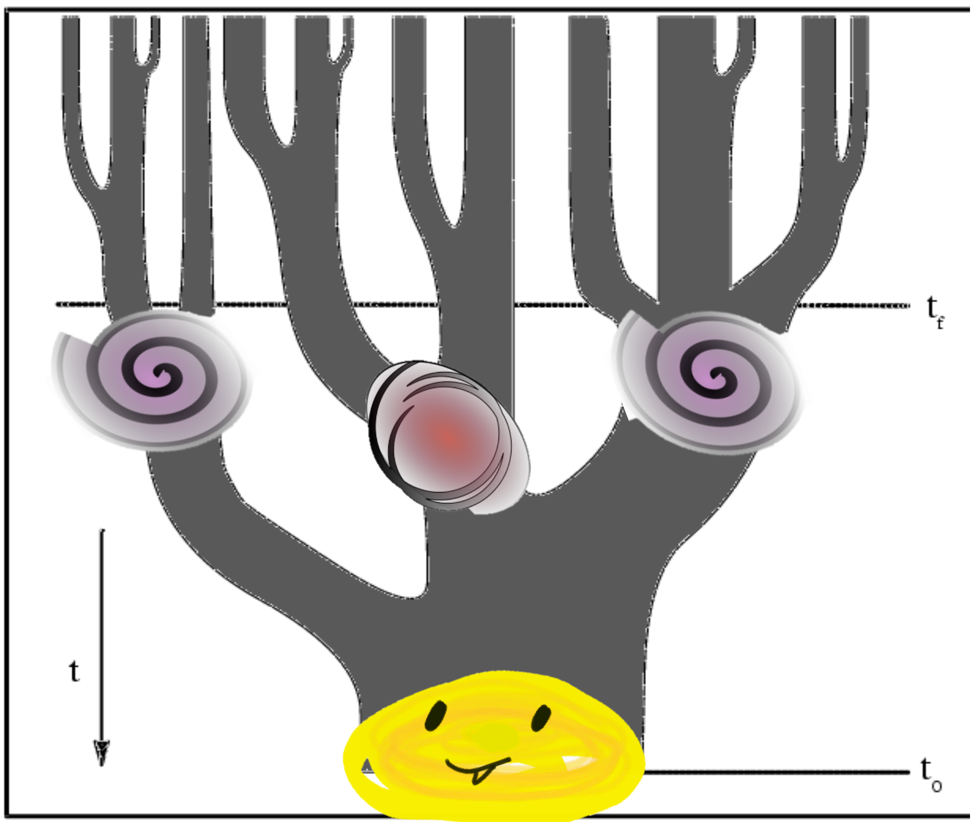
Abell 1689

Brightest Cluster Galaxies (BCG)



- Giant early-type galaxy
- Centrally located
- Brightest and most massive
- Higher velocity dispersions than normal ellipiticals

Hierarchical structure formation model



Lacey & Cole (1993)

The importance of major and minor mergers in BCGs

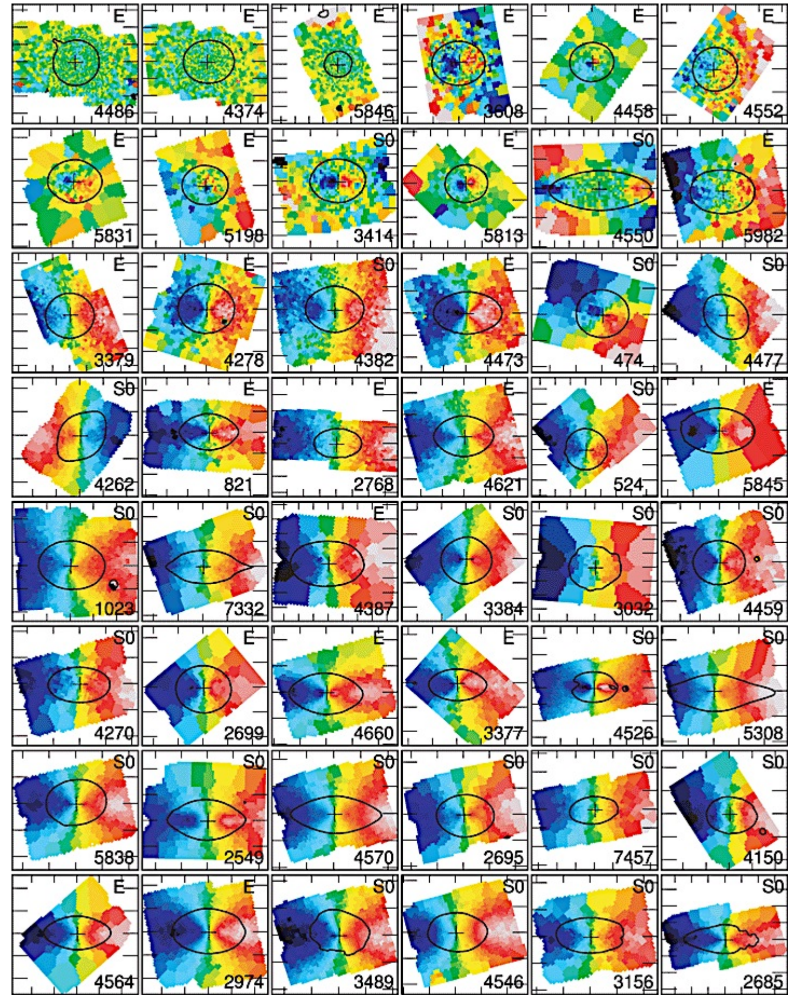
Burke & Collins et. al. (2013), Lidman et. al. (2013) and Edwards & Patton (2012):

- BGC stellar mass grows by major mergers at $0.8 < z < 1.5$
- BGC stellar mass grows by minor mergers at $z < 0.3$

Nevertheless major mergers are not impossible to occur at low redshifts (Brough et. al., 2011).

SAURON

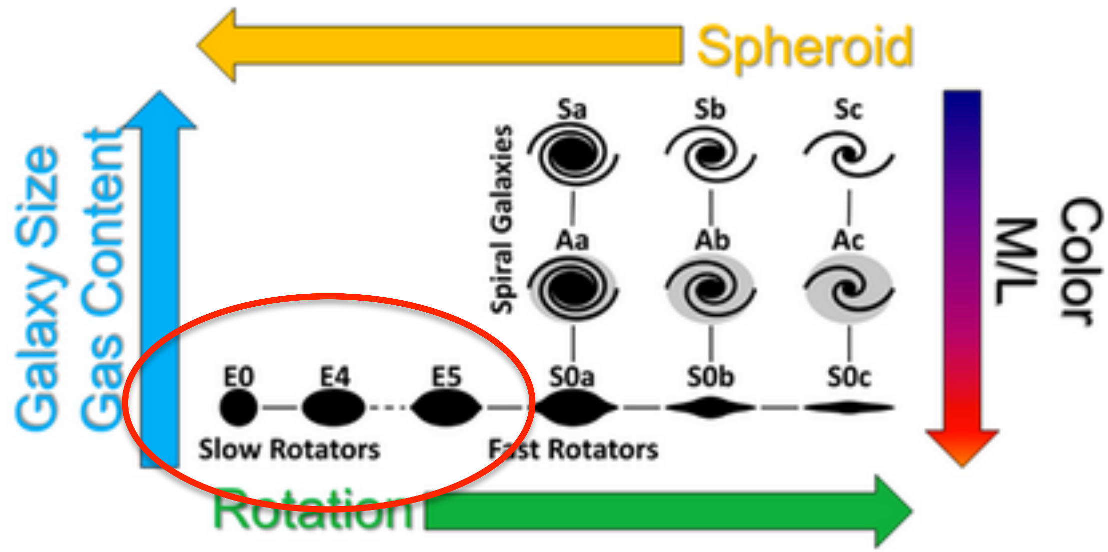
Integral Field Unit (IFU) Spectroscopy



BCG are predicted to be slow rotators…

- Angular momentum: SAURON λ_R parameter, Emsellem et al. (2007)

  ATLAS^{3D} ellipticity parameter Cappellari et al. (2011)



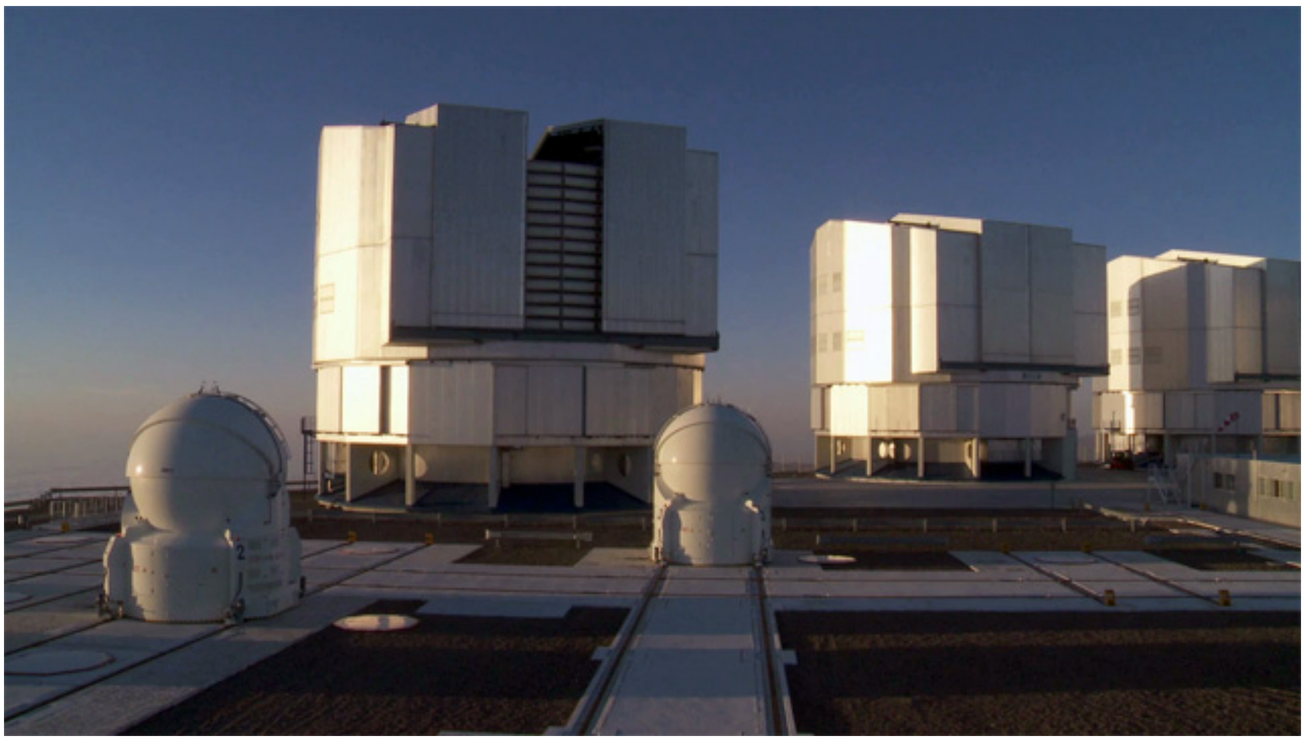
The ATLAS^{3D} comb (2011)

The SAURON sample contains only 9 galaxies with $M_* > 10^{11.3} M_{sun}$, and only 1 of them is a BCG

Data

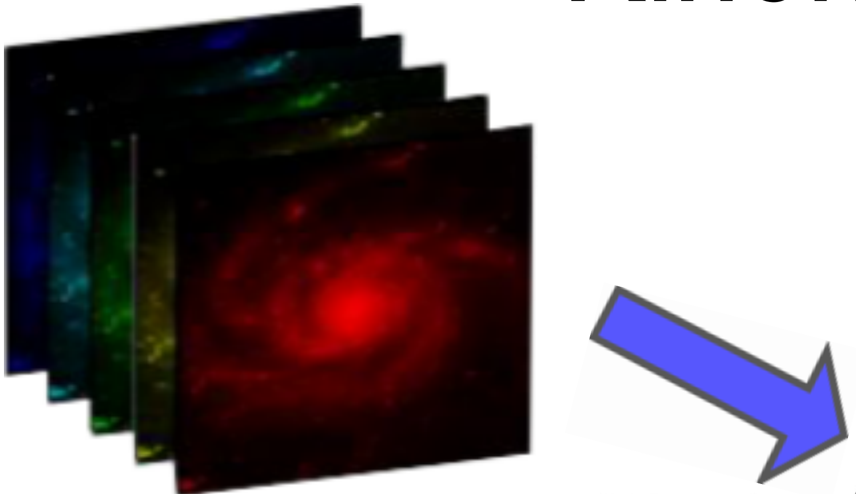
9 BCGs and 3 of them with close similar mass companions.
Observed with VIMOS on the VLT, selected from SDSS.

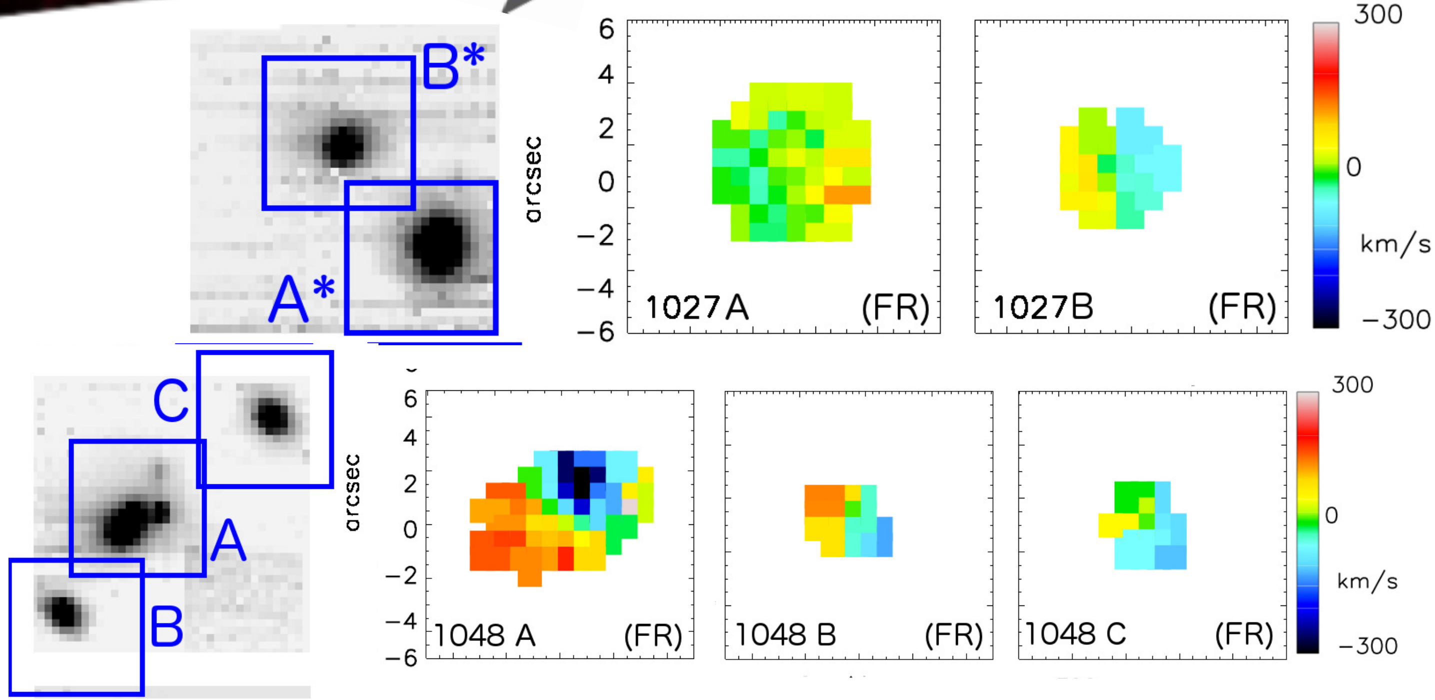
VIMOS IFU, VLT



Kinematics

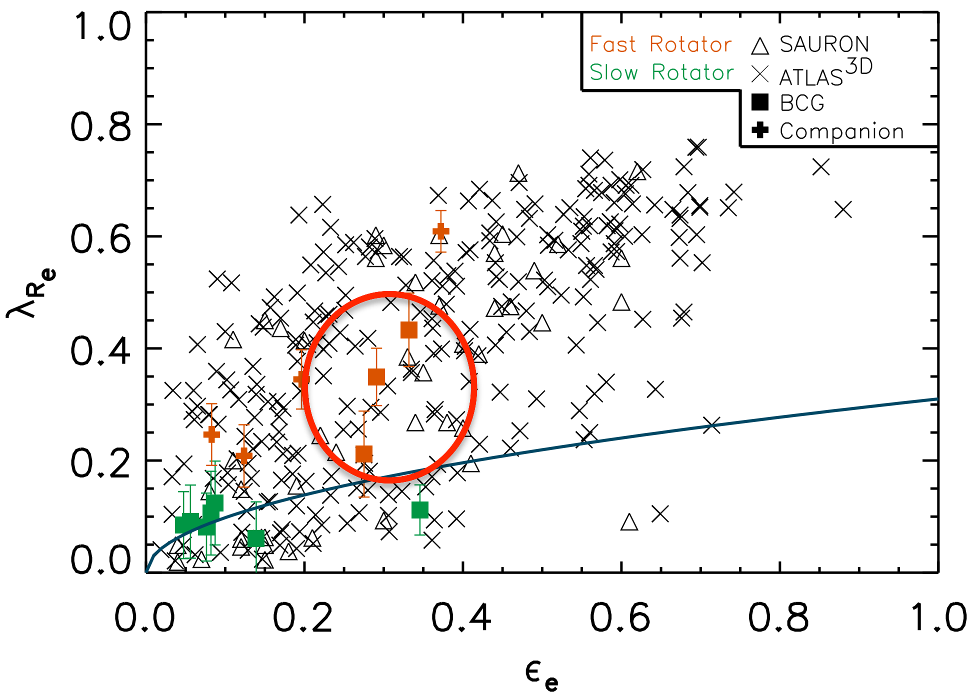
In collaboration with
Kim-Vy Tran and Jimmy
(Texas A&M University)



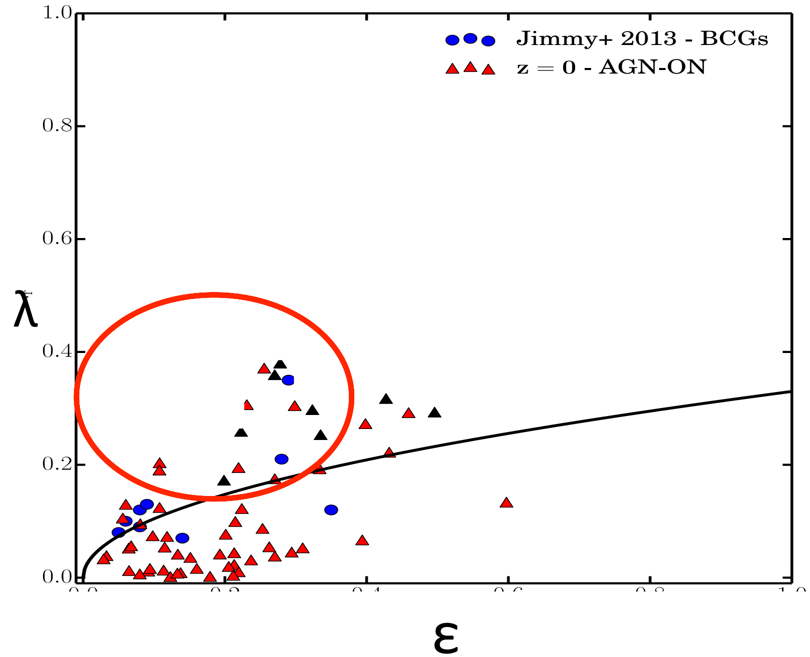


Brough et. al., 2011, Jimmy et. al. (2013)

~30% of BCGs are fast rotators

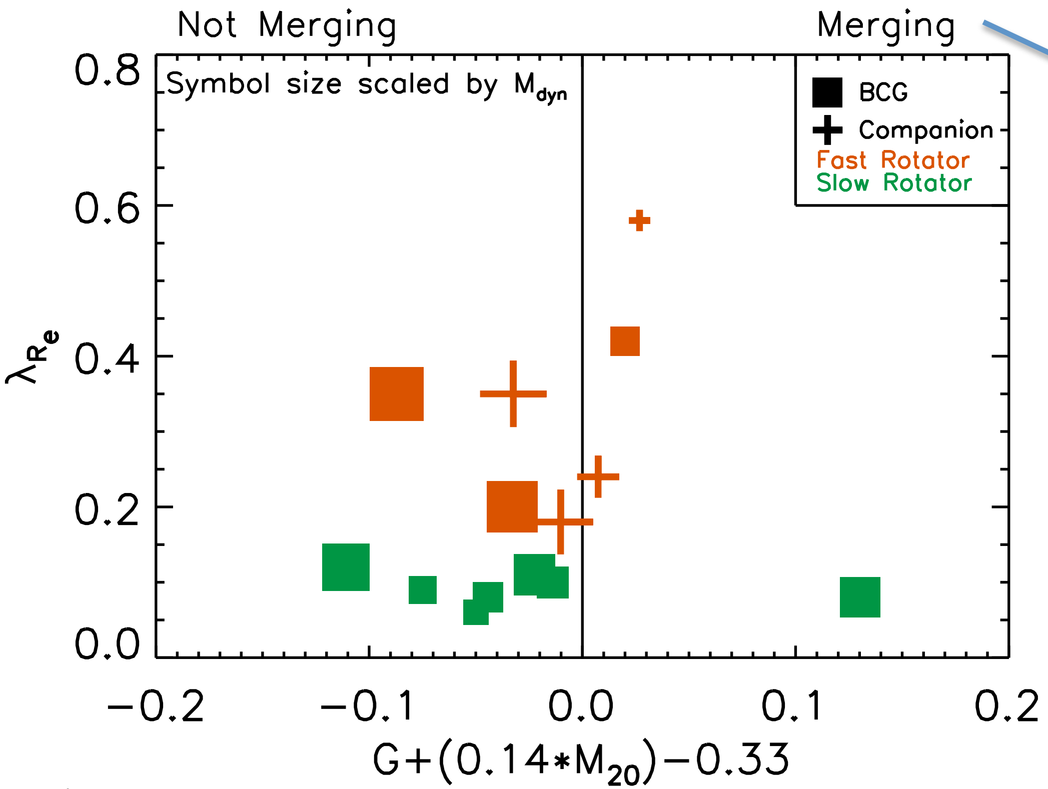


Jimmy et. al. (2013)



AMR simulations of Martizzi et. al. (2014)

Is the angular momentum a good indicator of ongoing mergers?

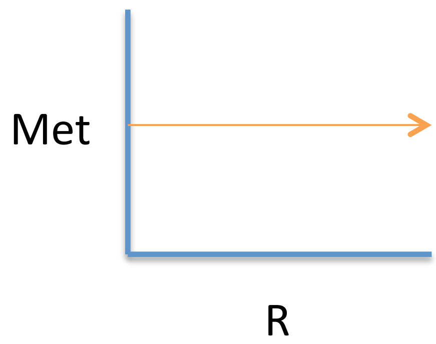


In the last 0.2Gyr (Lotz et. al., 2008)

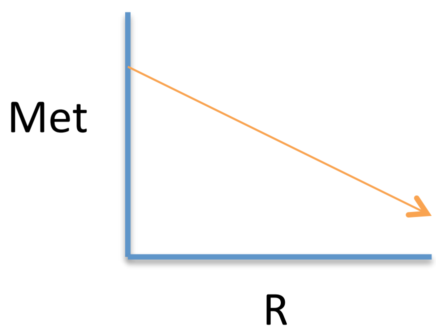
Jimmy et. al. (2013)

Irregularities in the galaxy's light distribution are morphological signatures of merging

Accretion histories from stellar population gradients



Flat gradients are the result of major dissipationless mergers.
Met gradient < -0.3



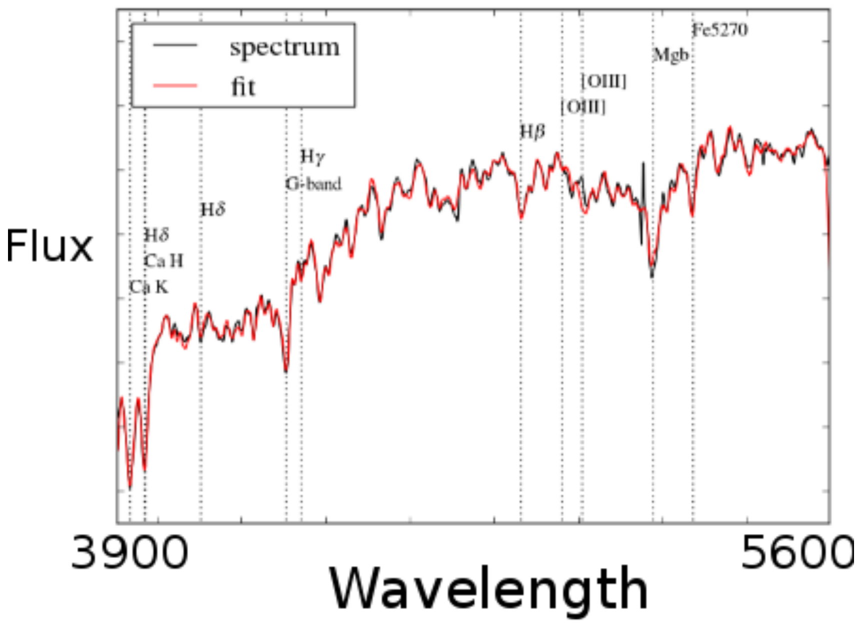
Steep gradients could be due to a core collapsed formation or major mergers Involving high fractions of gas.
Met gradient > -0.4

Kobayashi et. al. 2004, Hopkins et. al. 2009, Hirschmann in prep.

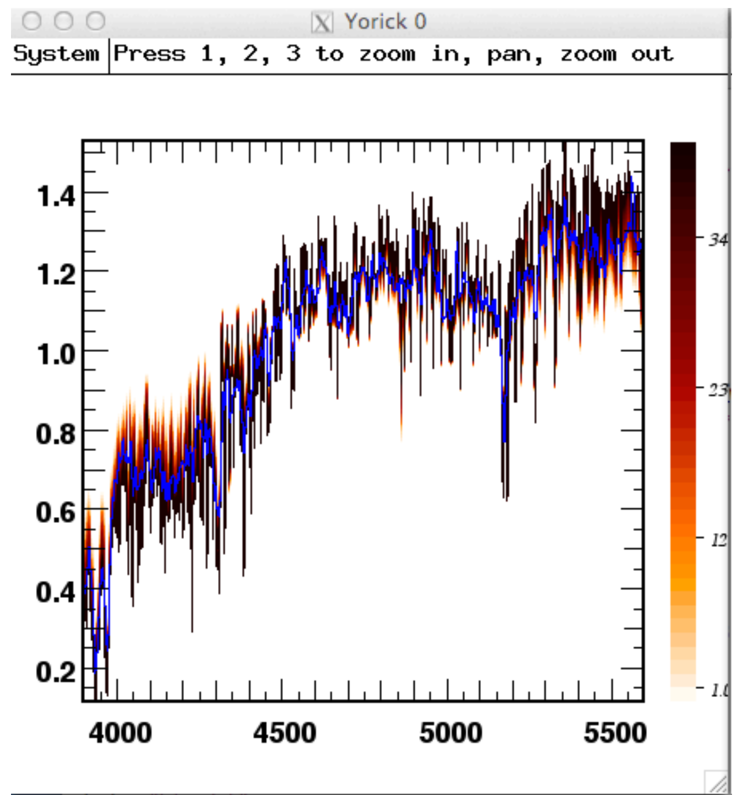
Age and metallicity estimations

Models: Vazdekis et. al. 2010
Library: MILES Sánchez-Blázquez et. al. 2006

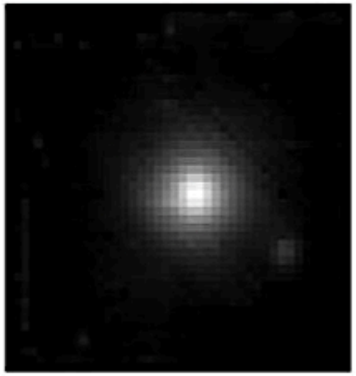
STECKMAP (Ocvirk et al. 2006a,b) uses Bayesian statistics to estimate the stellar population from the spectra. As a result we obtain stellar metallicities and ages



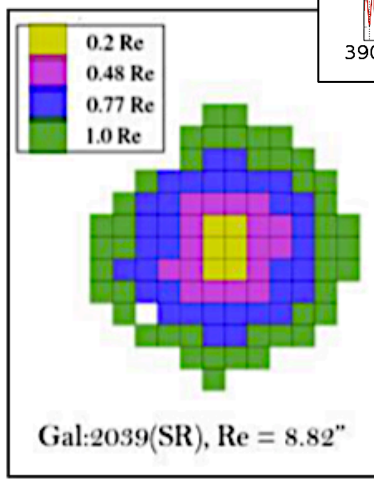
Oliva-Altamirano et. al. (submitted)



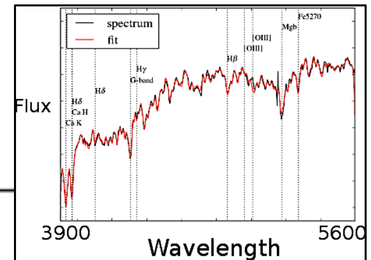
Method



VIMOS Field-of-view
27"X27"

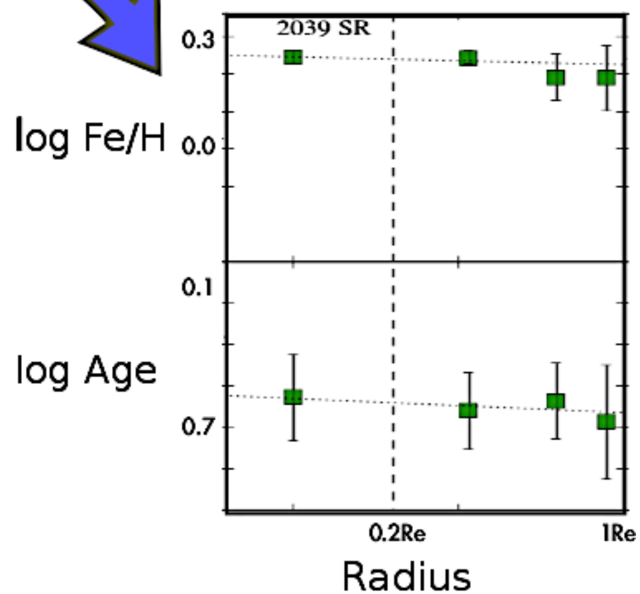


The galaxy is divided into annuli that follow flux

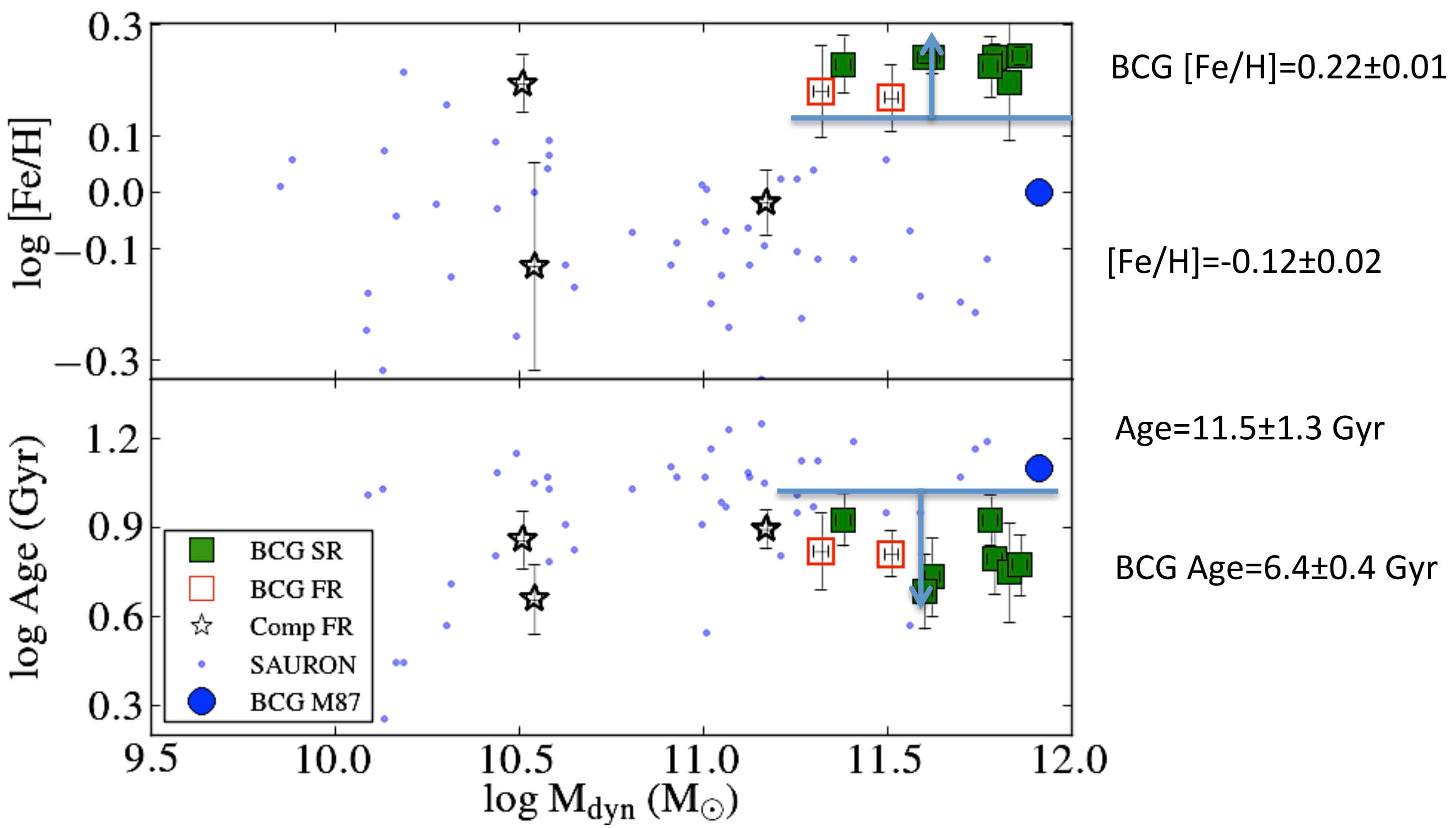


The result: one spectrum per annulus

Age and metallicity per spectrum as a function of radius

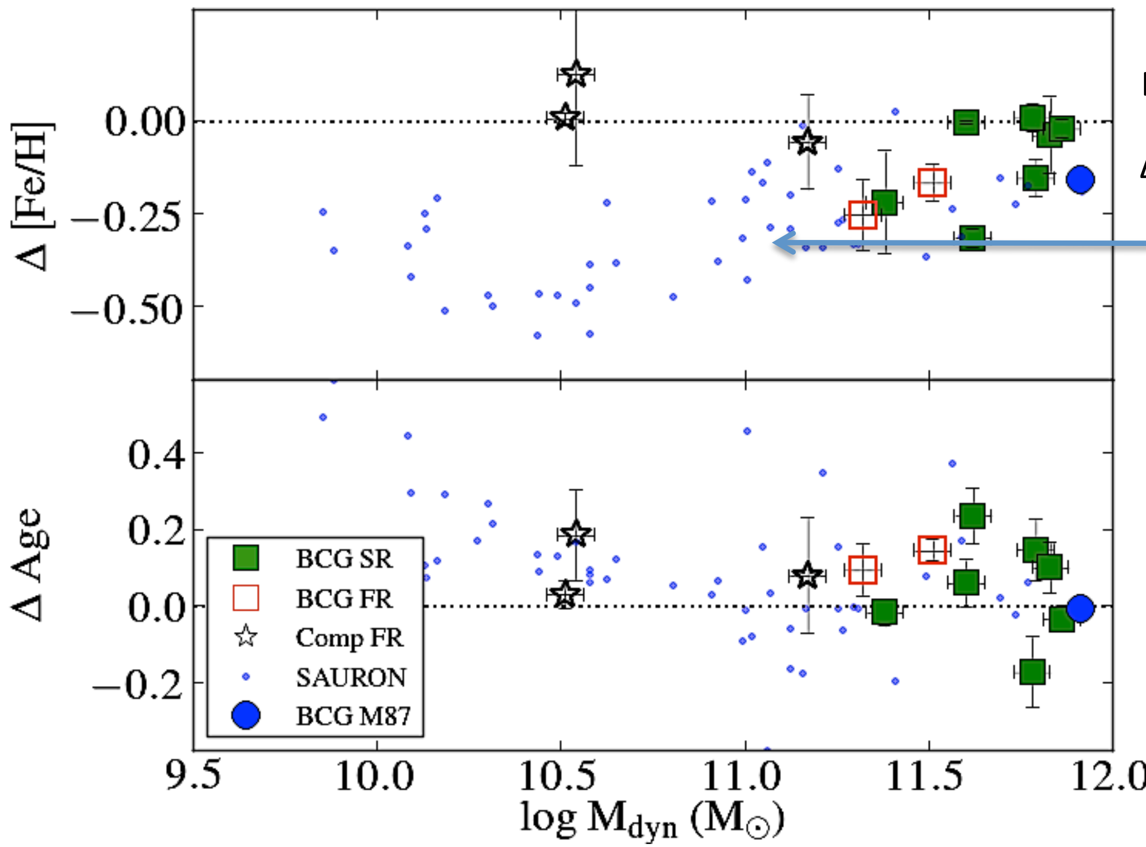


BCGs have high central metallicities and intermediate central ages.



The central stellar populations are very different compared to those of early-type galaxies.

BCGs have shallow stellar population gradients.



BCG Δ[Fe/H]=-0.13±0.04

Δ[Fe/H]=-0.22±0.04

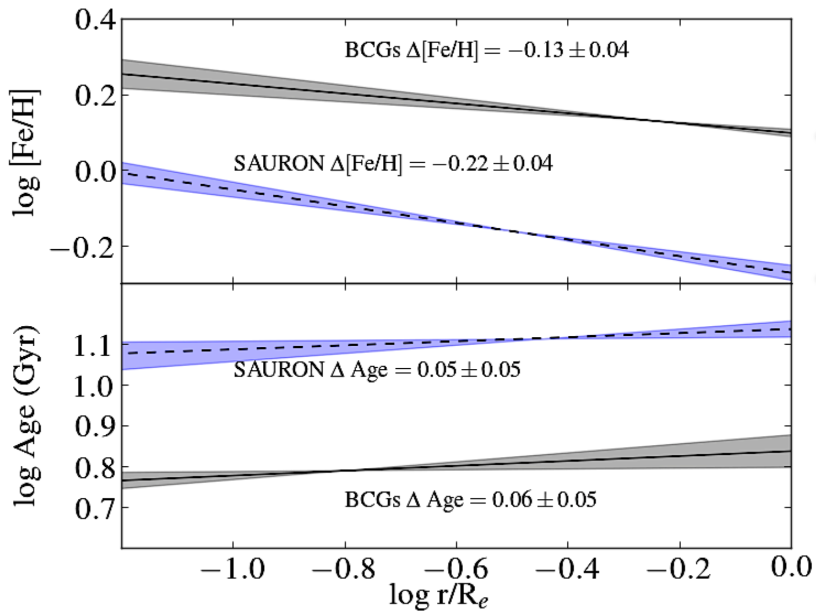
Gradient = -0.3

BCG ΔAge=0.06±0.05

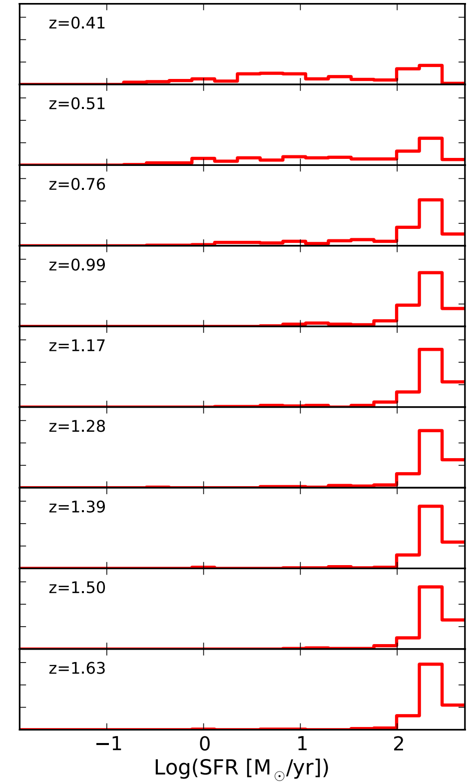
ΔAge=0.05±0.05

The stellar population gradients
are similar to those of early-type galaxies at
the same mass.

Merger Histories



Difference
In the central
Stellar Populations



Early- type galaxies:
Old–metal poor central stellar populations
Shallow stellar population gradients

Agrees with early-type galaxy simulations:
Naab et. al. 2013, Hirschmann et. al. 2013, Peeple et. al. 2014

They experience **passive** accretion histories
(No star formation since z = 2)

Brightest cluster galaxies:
Intermediate age-metal rich central stellar Populations.
Shallow stellar population gradients

Disagrees with SAM De Lucia et. al. 2007
Agrees with Tonini et. al. 2012

They experience **active** accretion histories
(Star formation up to z = 1)

Conclusions

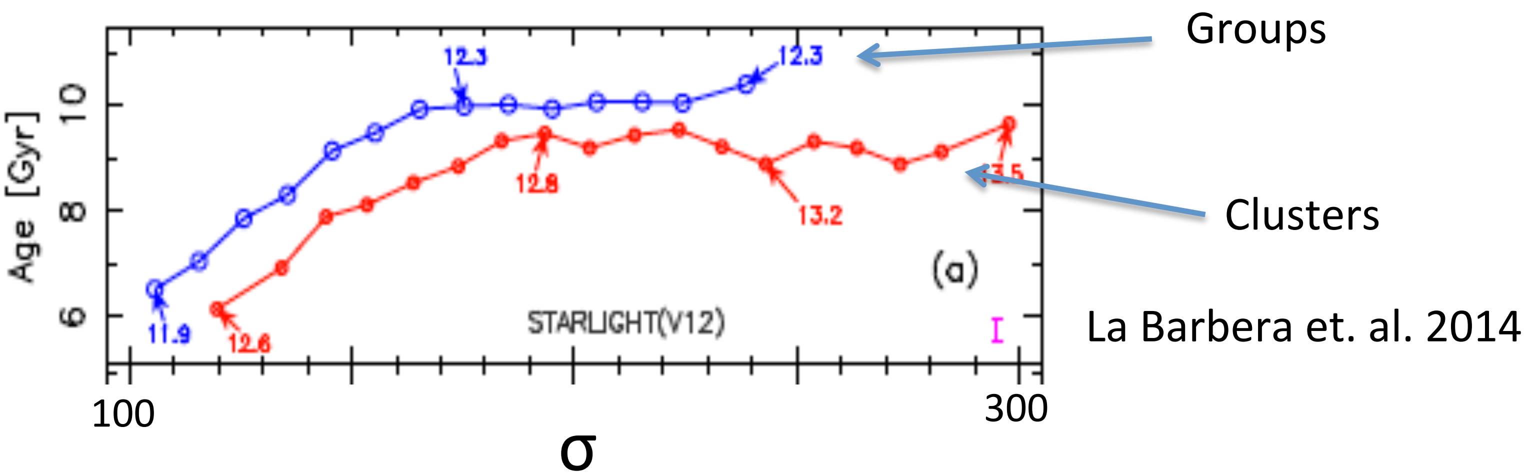
The dense environments where BCGs evolve allow them to experience many mergers in time. These ongoing accretion events will trigger star formation at $z > 1$ resulting in intermediate central ages, and will disrupt the metallicity gradients at $z < 1$.

Oliva-Altamirano et. al. (submitted)

This is what we don't know…

- Are this models suitable to study BCGs?
- When did exactly the SF quenched?
- What is going on out side 1 $R_{e?}$

Upcoming work…



1. What is the influence of environment on the angular momentum and stellar populations of central galaxies?
2. Are BGGs simply a step in the evolution of BCGs or do they have distinct accretion histories?

Upcoming work…

- SPIRAL IFU Observations (May 2012)

18 Brightest **Group** Galaxies from the GAMA.

- Kinematics
- Central stellar populations
- Stellar population gradients
- Other properties of the group: dominance, masses, emission lines.

Anglo Australian Telescope (AAT)


Thanks for your attention!