Dissecting Nearby Galaxies

using SALT

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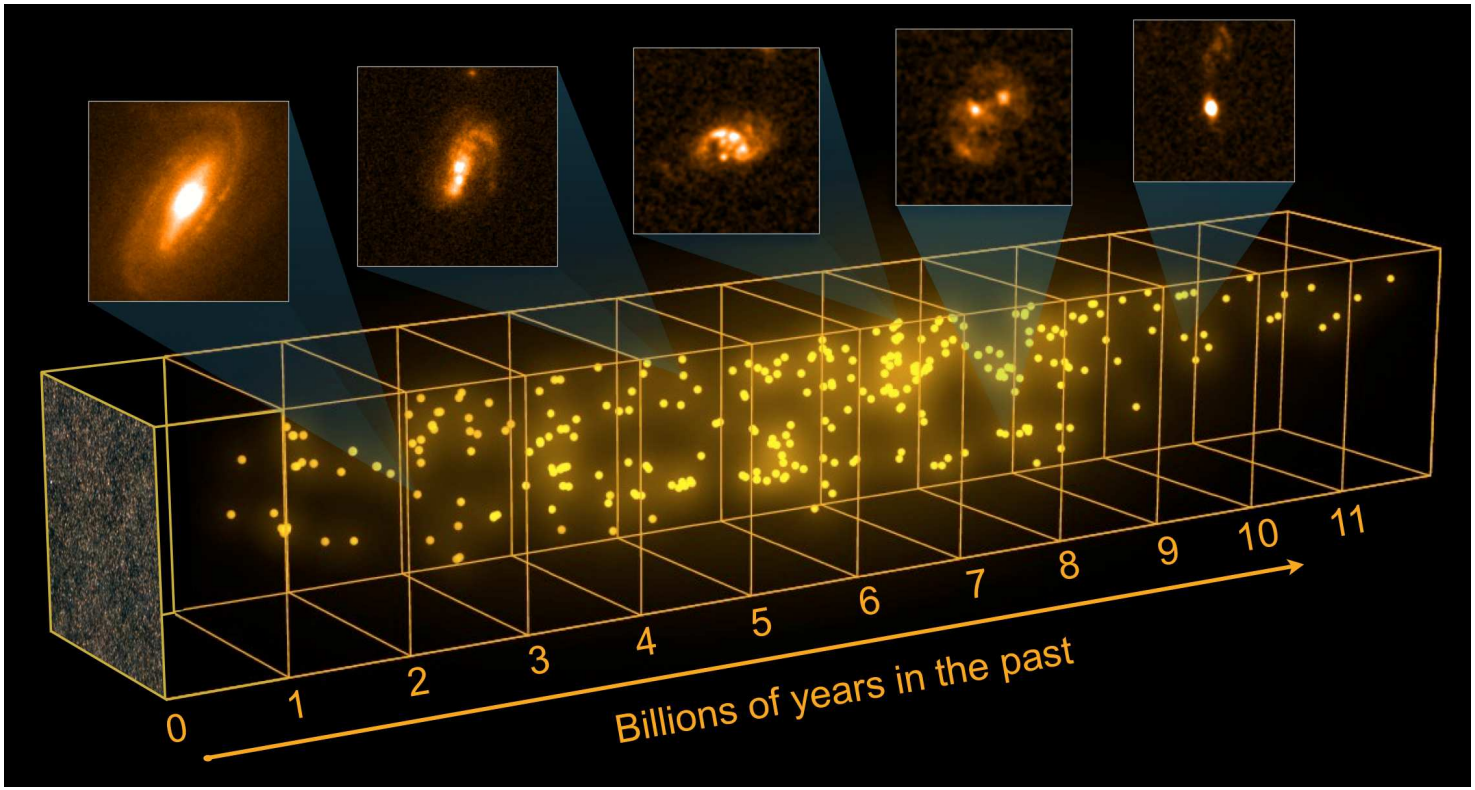
Outline

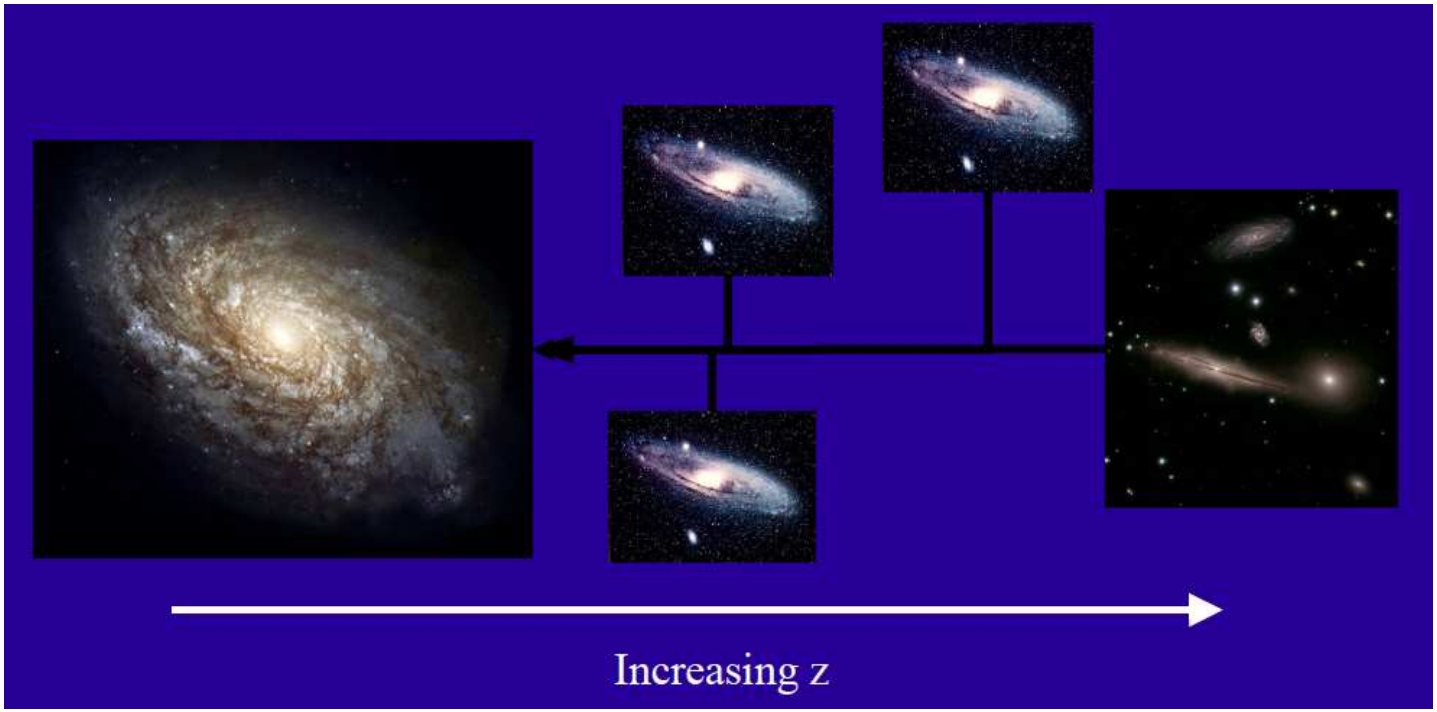
Introduction
Galactic Archeology
BCGs – Theory
Current Projects on SALT
BCGs
Summary

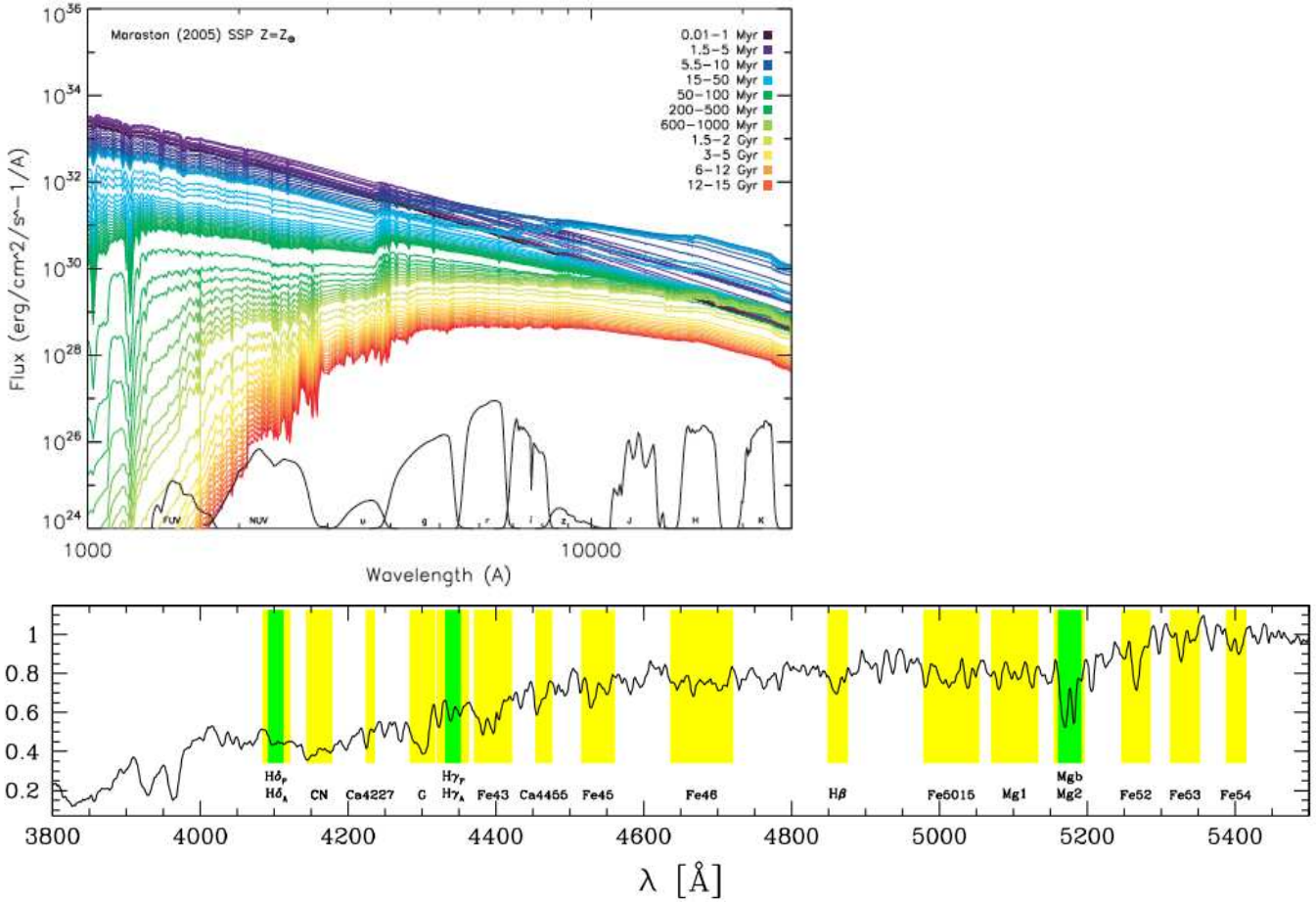
Galaxy Evolution



- Formation History Indicators: Morphology; Kinematics; Stellar Populations (ages, metallicity, chemical abundances), etc.

Formation History





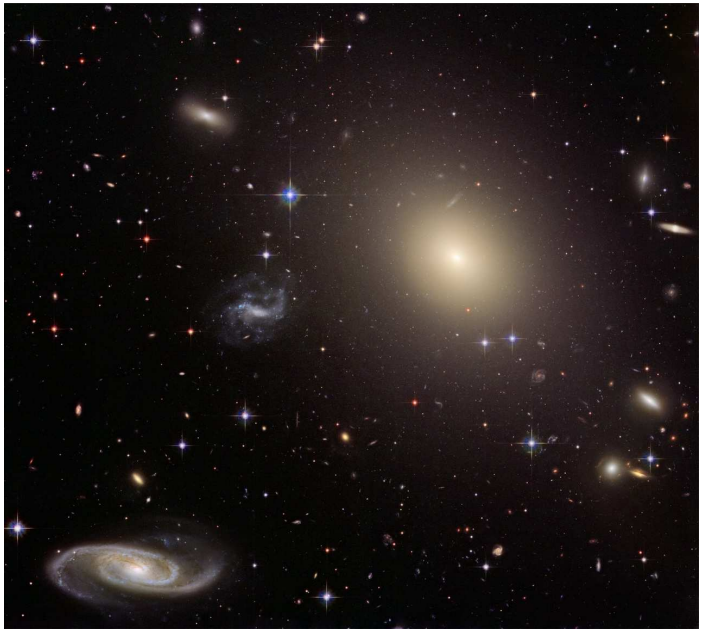
Emission-line spectrum

- Gas ionisation stage; star formation/black hole activity; gas kinematics; galactic outflows; gas accretion; gas metallicities.

Absorption-line spectrum

- stellar kinematics; dynamical stellar masses; dark matter; stellar populations; star formation histories; metal content; element abundance ratios.

Brightest Cluster Galaxies



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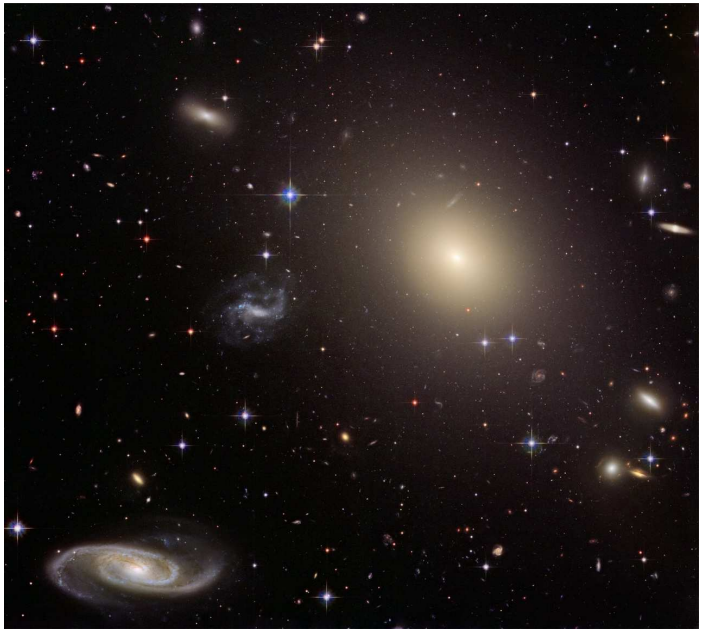

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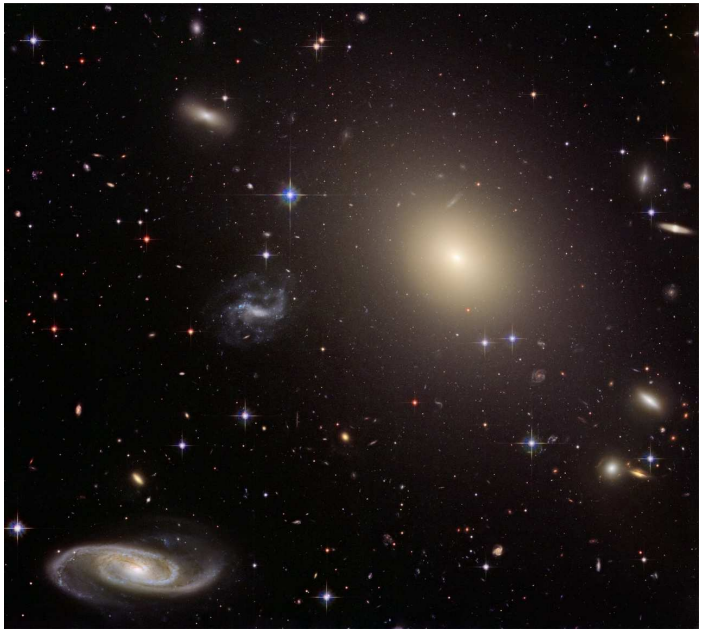

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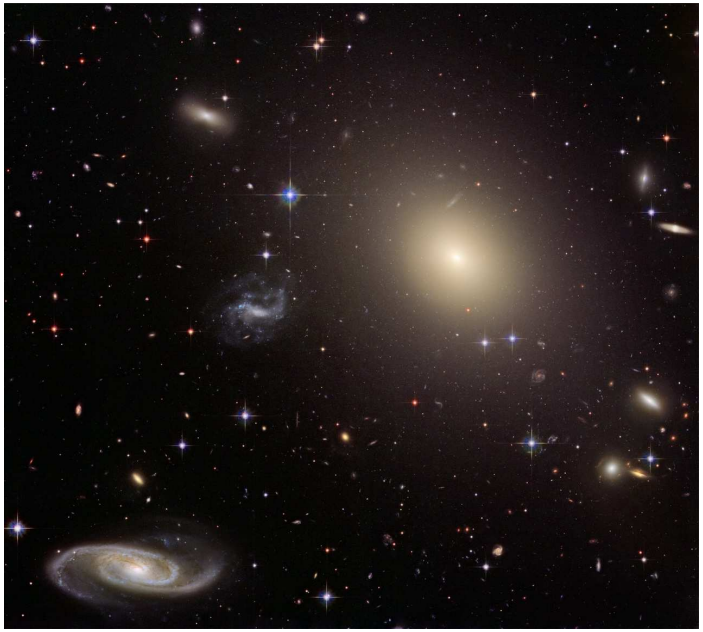

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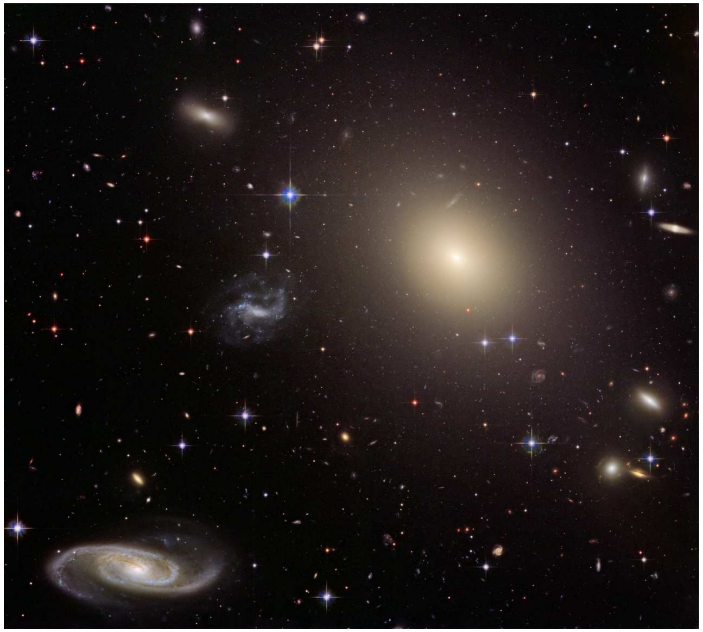

- The central supergiant galaxies in clusters
- Embedded in an extensive luminous halo
- In the cluster gravitational potential well
- Typically $10^{13} M_{\odot}$ and ~ 300 kpc
- Usually depart from the fundamental relations for elliptical galaxies

Formation Theories

- Cooling flows (Cowie & Binney 1977)
  - Intracluster cas cool and condense
  - 'Cooling flow problem' – AGN heating
- Galactic cannibalism (Ostriker & Tremaine 1975)
  - Mergers and captures of less massive galaxies
  - Observational evidense
- Tidal stripping (Gallagher & Ostriker 1972)
  - Halo formation

Figure: Abell 3827 – Multiple nuclei

Controversy

- Observations:
  - >90% BCG mass in place by $z \sim 1.5$ (Collins et al. 2009)
- N-body simulations and semi-analytical models:
  - Stars form early, but galaxies assemble late
  - 90% BCG mass in place after $z \sim 0.5$ (De Lucia & Blaizot 2007)

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Questions?

- BCGs have special properties and are found at unique locations in the Universe – do they require a special process of formation and evolution?
- What role does the environment play?

Current Projects on SALT

(a) BCG

(b) Spiral

(c) Dwarf

- **BCGs:** *Loubser (NWU), Donahue, Voit (Michigan State University)*
  1) Star formation histories
  2) Using BCGs to trace Dark Matter
  3) Emission line study of star forming BCGs
- **Spirals:** *Branken, Loubser (NWU), Sheth, Carlos-Munoz (NRAO, US)*
  Multiwavelength study of low-mass Spiral Galaxies
- **Dwarfs:** *Mentz, Loubser (NWU), Peletier (Groningen), den Brok (Texas)*
  Kinematics and Stellar populations of dwarfs in the Fornax Cluster (**See talk Jaco Mentz**)

Project 1 – Star formation histories

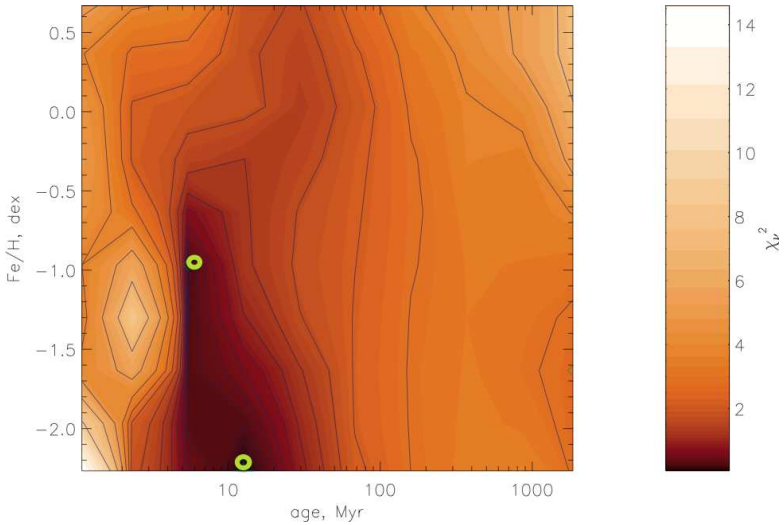
- 'Active' BCGs with Hα filaments
- Long-slit observations of 4 BCGs (10 000 seconds each)
- Measure resolved kinematics and stellar populations using ULySS
- Fit composite stellar populations to probe more complex evolutionary histories

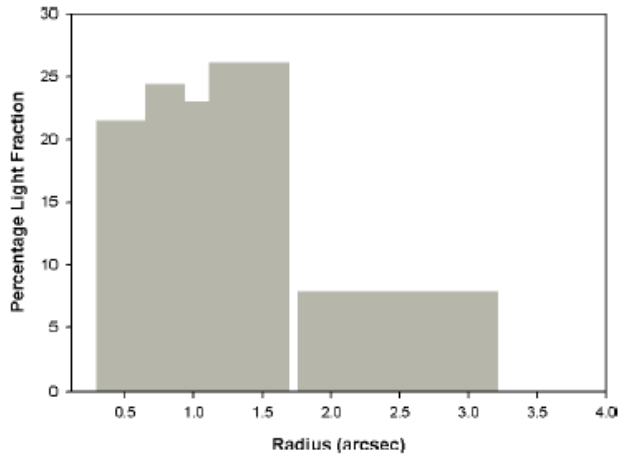
Object	Cluster	Redshift z	R_{off} (Mpc)	T_X (keV)	Classical cooling rates ($M_\odot/yr^{-1}$)	Spectrally determined ($M_\odot/yr^{-1}$)	Exposure time (seconds)
ESO541-013	Abell 0133	0.057	0.017	3.5	110	0.0	9704
MCG-02-02-086	Abell 0085	0.056	0.046	6.5	108	2.2	6353
PGC023233	Abell 0644	0.071	–	6.5	136	1.5	6800
2MASXJ17122774-2322108	Ophiuchus	0.028	0.019	8.6	41	0.0	14030

Loubser, MNRAS, submitted

Project 1 – Results

- 3 of the 4 BCGs have very young (10 – 100 Myr) components of stellar populations contributing 5 – 20% of light
- Only 1 of 3 are in 'Cooling flow clusters'
- →Another mechanism for recent star formation?





(d) 2MASXJ17122774-2322108

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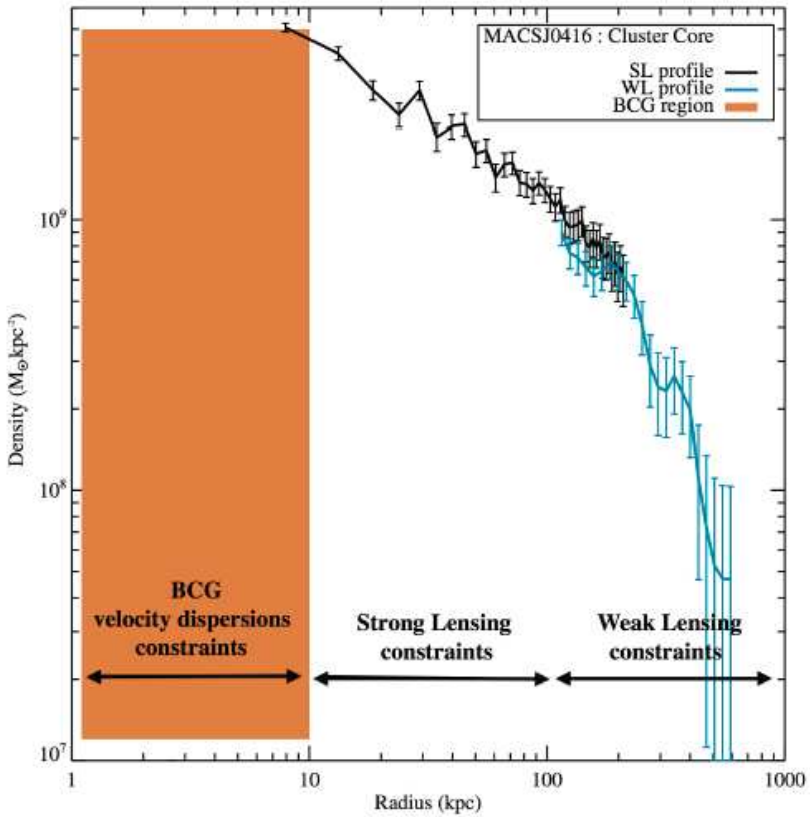
Project 2 – Using BCGs to trace Dark Matter

- Long-slit to measure velocity dispersion of BCGs in the Hubble CLASH survey
- Currently 2 BCGs with 17 000 – 22 000 seconds exposure each ($z \sim 0.3$)
- Existing HST lensing measurements (and mass models) will allow us to constrain the distribution of dark and baryonic material in cluster

Project 2 – Using BCGs to trace Dark Matter

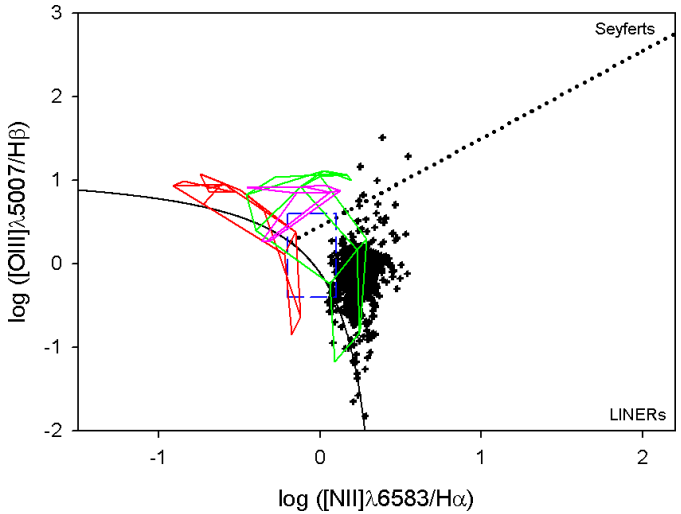
Combining two techniques that probe scales from the inner 10 kpc (BCG kinematics) to the 100 kpc scales typical of strong lensing.



Project 3 – Emission line study of star forming BCGs

- Measuring emission lines of the gas fuelling the star formation
- Derive electron density and gas temperature →accurate abundances
- Currently 2 (very nearby) objects observed with $\sim$ 10 000 seconds each
- Dominant excitation mechanisms to be identified

Project 3 – Emission line study of star forming BCGs



The black solid curve is the theoretical maximum starburst model. The black-dashed curve represent the Seyfert-LINER dividing line. The blue boxe show the predictions of photoionization models by pAGB stars. The purple lines represent the shock grids. Grids of photoionization by an AGN are indicated by green and red curves.

Summary

- Optical spectroscopy is a very useful tool to probe galaxy evolution
- especially if combined with X-ray, UV, Radio, ... observations to fully probe the physical processes in the cluster centre.
- Outlook
  - SALT observations underway to probe the dark matter distribution in the centres of clusters
  - SALT observations underway to probe the origin of the gas fuelling star formation in some of the most massive galaxies in clusters.