Galaxy Clusters @ WEAVE

A. Mercurio
on behalf of the Clusters Science Team*

Co-Leads : J. A. L. Aguerri, A. Aragón-Salamanca, R. Peletier, S. Trager

*http://www.ing.iac.es/weave/science_team.html

WEAVE Italian Workshop

1. **Nearby Cluster Survey** (J. A. L. Aguerri, R. Peletier);
2. **Infall Cluster Survey** (A. Aragón-Salamanca);
3. **Evolution of stellar populations in galaxies in clusters & cosmology with clusters** (S. Trager).

For each layer:

- ✓ **Scientific question to be addressed;**
- ✓ **Sample selection;**
- ✓ **Observing strategy.**

Nearby Cluster Survey

The origin of low-mass cluster galaxies is a matter of hot debate:

- **Are dwarf galaxy primordial or end-products of galaxy transformations?**
- **What processes drive the dwarf galaxy transformation in clusters?**
- **How do these processes depend on galaxy properties and/or local environment?**

Nearby Cluster Survey

Clusters Layer 1 will observe with:

Telescope, diameter	WHT, 4.2m
Field of view	2° ⌀
Number of fibers	960 (plate A)/940 (plate B)
Fiber size	1.3″
Number of small IFUs, size	20 x 11″x12″ (1.3″ spaxels)
LIFU size	1.3′x1.5′ (2.6″ spaxels)
Low-resolution mode resolution	5750 (3000–7500)
Low-resolution mode wavelength coverage (Å)	3660–9590
High-resolution mode resolution	21000 (13000–25000)
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Nearby Cluster Survey

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- **stellar populations, metallicities, and the star formation history;**

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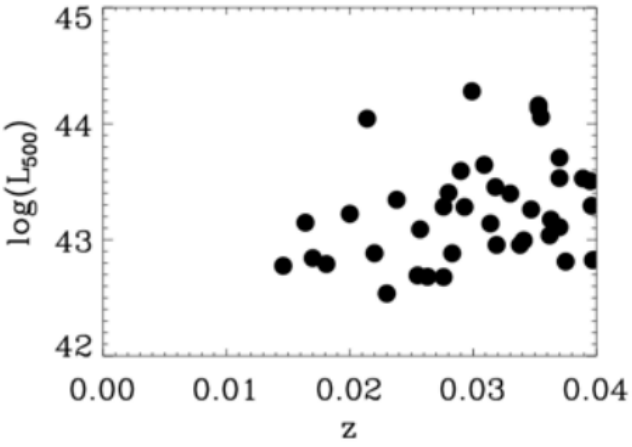
- **galaxy orbits;**
- **scaling relations;**
- **matter distribution;**
- **the internal angular momentum;**
- **stellar populations, metallicities, and the star formation history;**
- **ionized gas.**

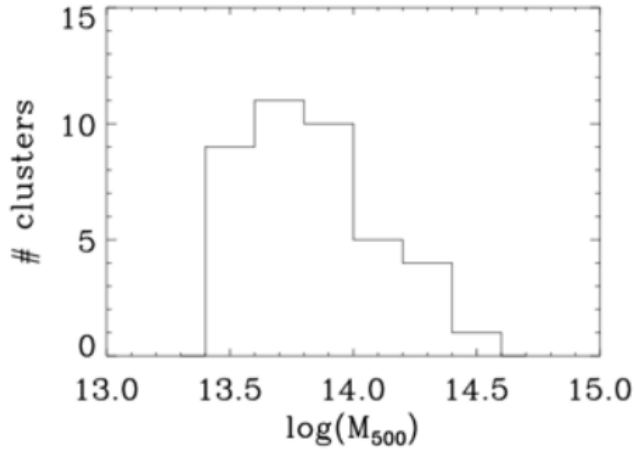
Nearby Cluster Survey

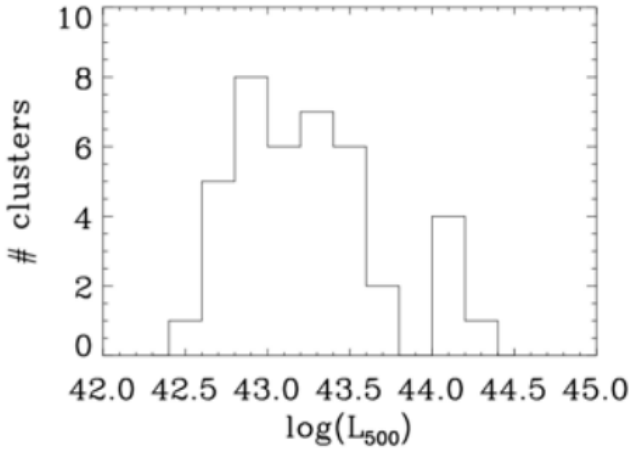
Cluster sample selection (mainly X-ray selection):

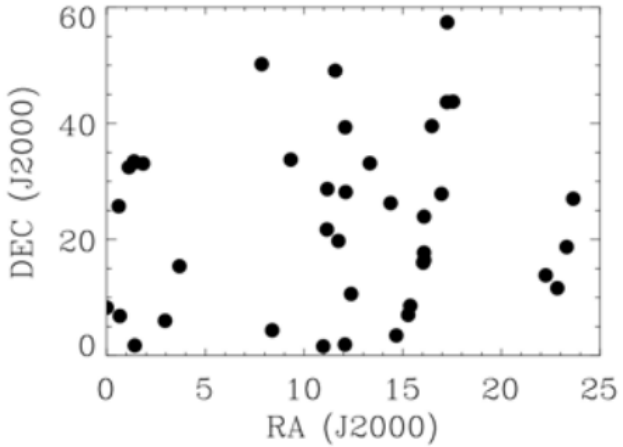
- Parent sample of 69 clusters in the north hemisphere based on Piffaretti et al. (2011) catalogue. This is a meta-catalogue based on X-ray data.
- 49 clusters selected with: z<0.04 in the north hemisphere [No Virgo, No Coma], including 40 clusters having SDSS data from: Ebeling et al. 1998 (90% complete Lx >4.4 10^{-12}) and Ebeling et al. 2000 (75% complete Lx > 2.8 10^{-12}).

Nearby Cluster Survey







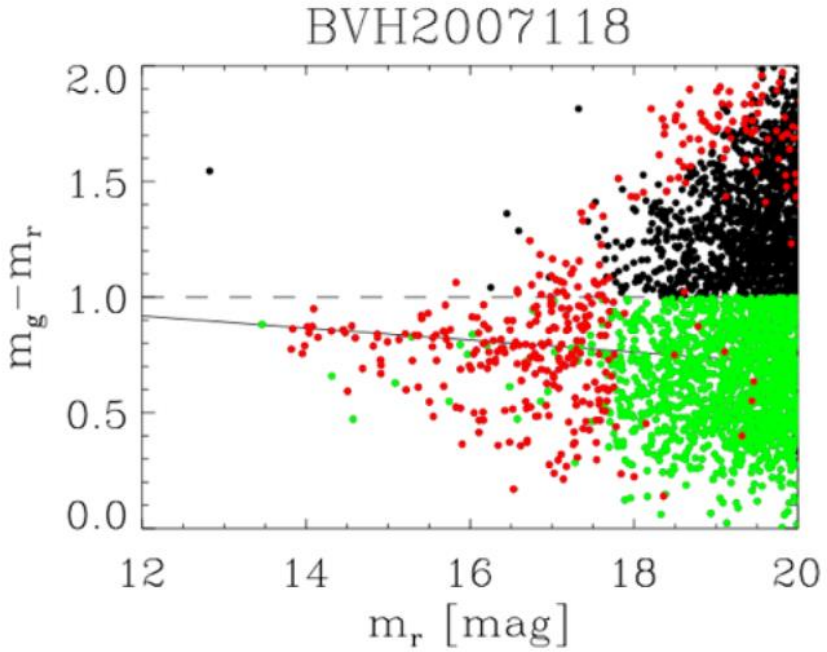


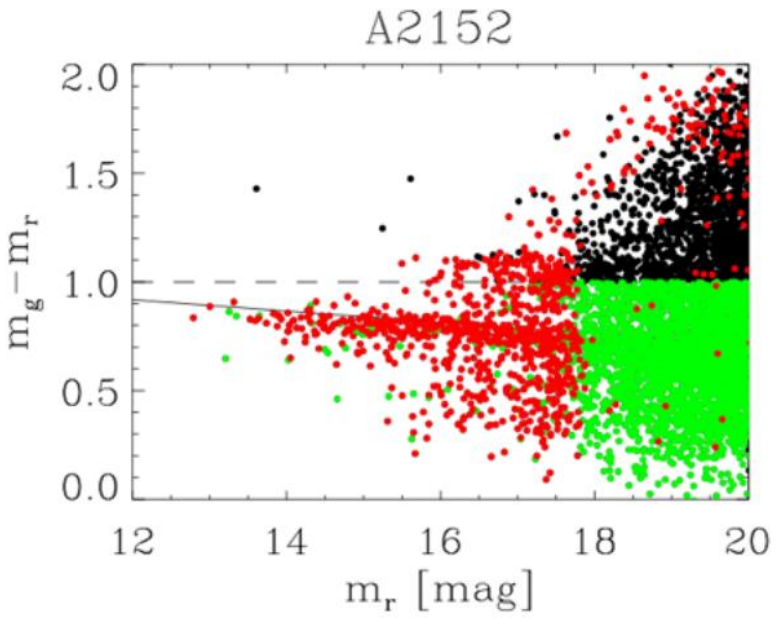
Nearby Cluster Survey

Target selection for each cluster:

galaxies with apparent magnitude m_r<20.0 mag;

color cut: g-r < 1.0.



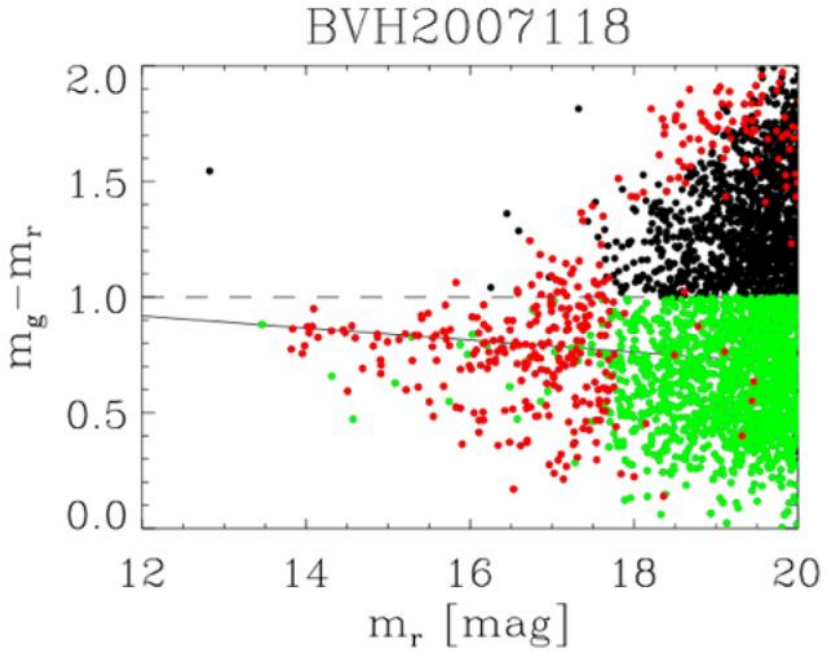


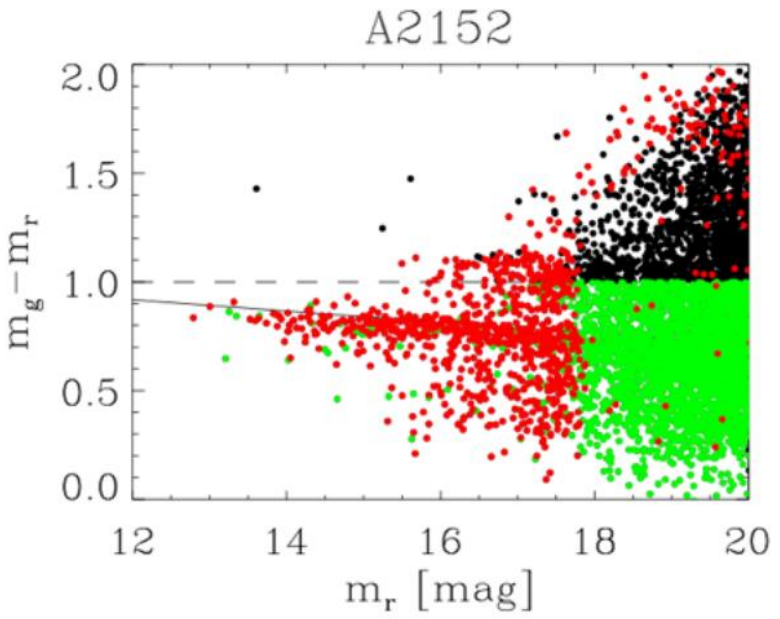
Nearby Cluster Survey

Target selection for each cluster:

~ 2000 dwarfs per cluster (randomly selected - mean);

~ 2 pointings per cluster (mean).

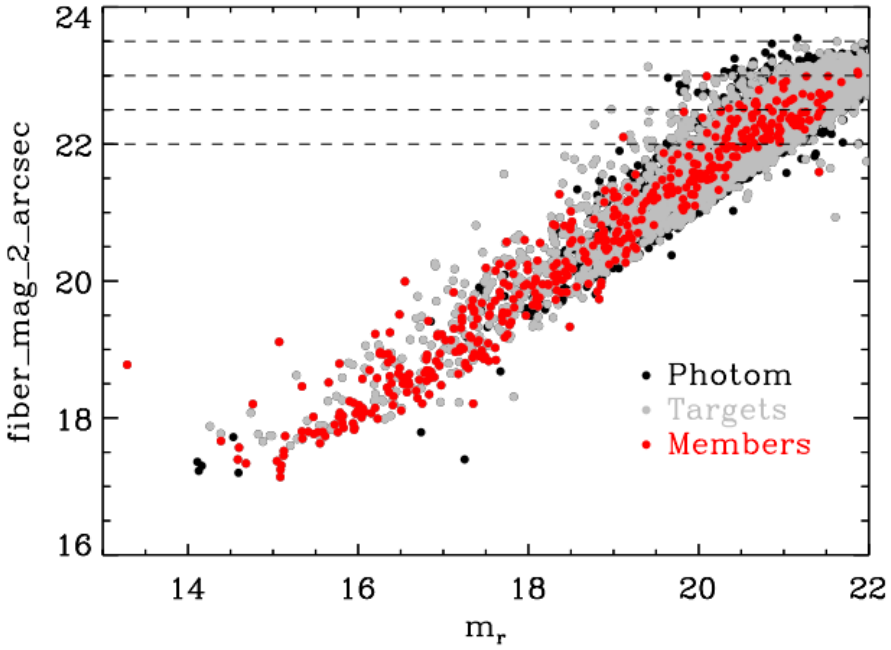


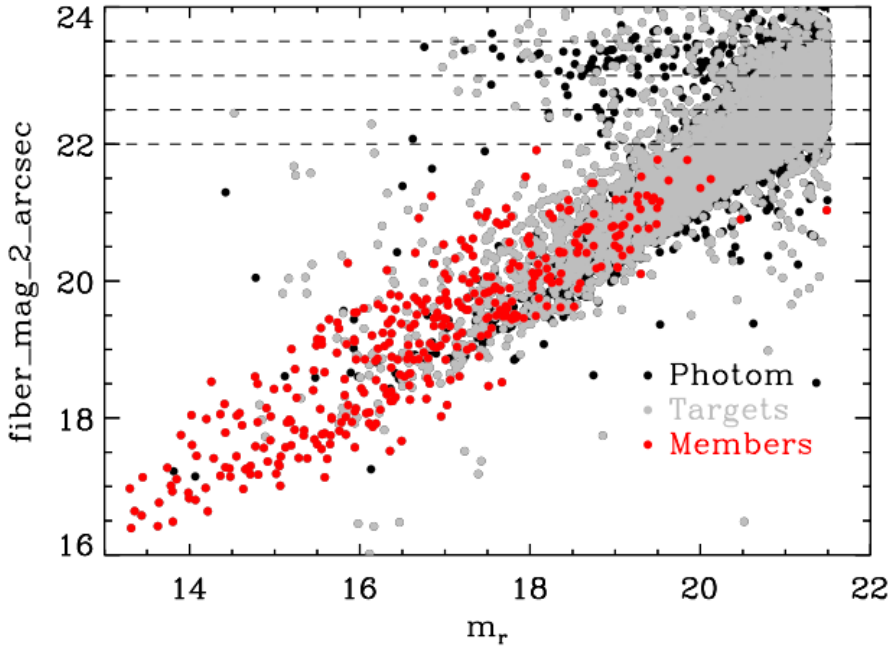


Nearby Cluster Survey

Target selection for each cluster:

Considering the fiber dimension:





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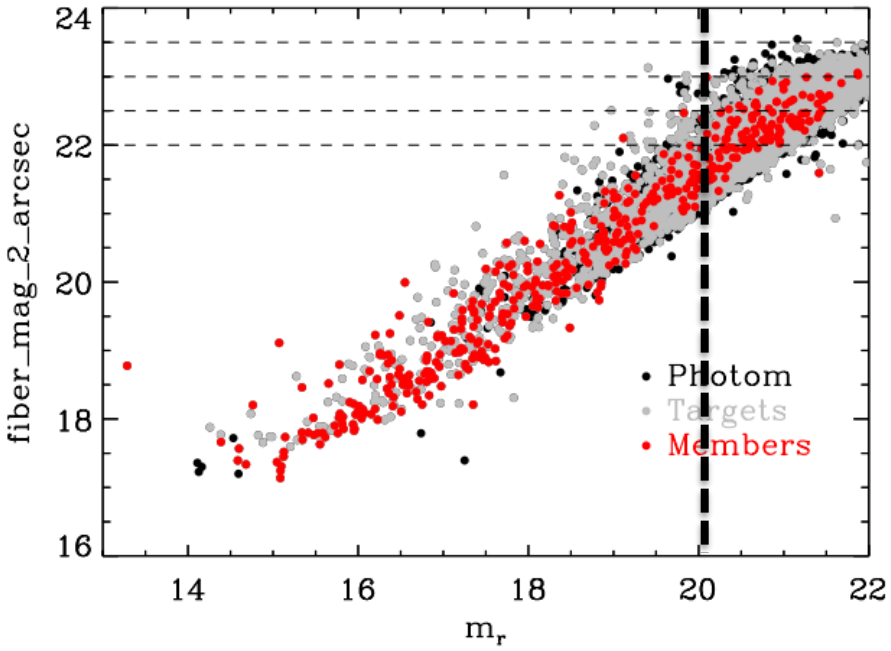
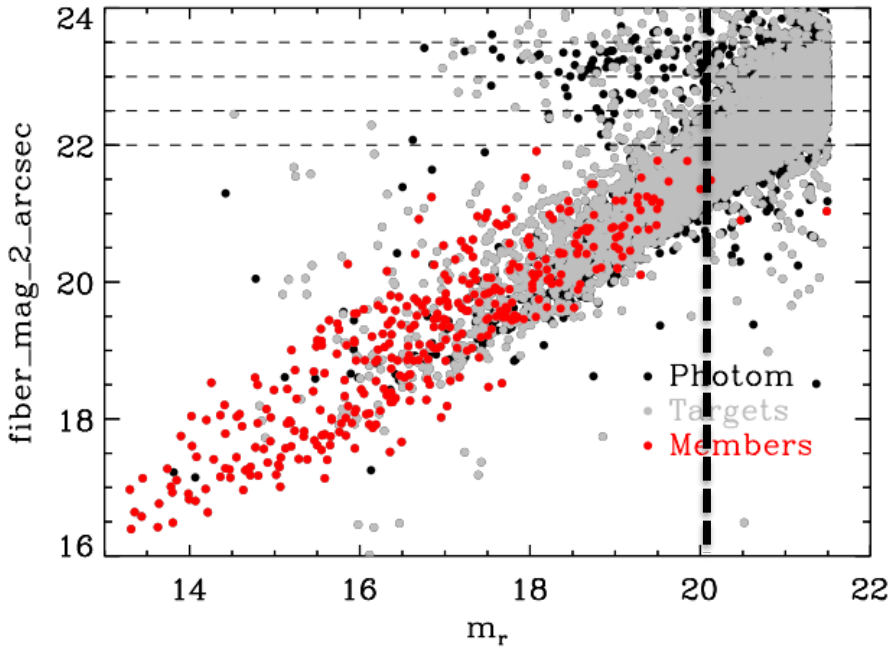


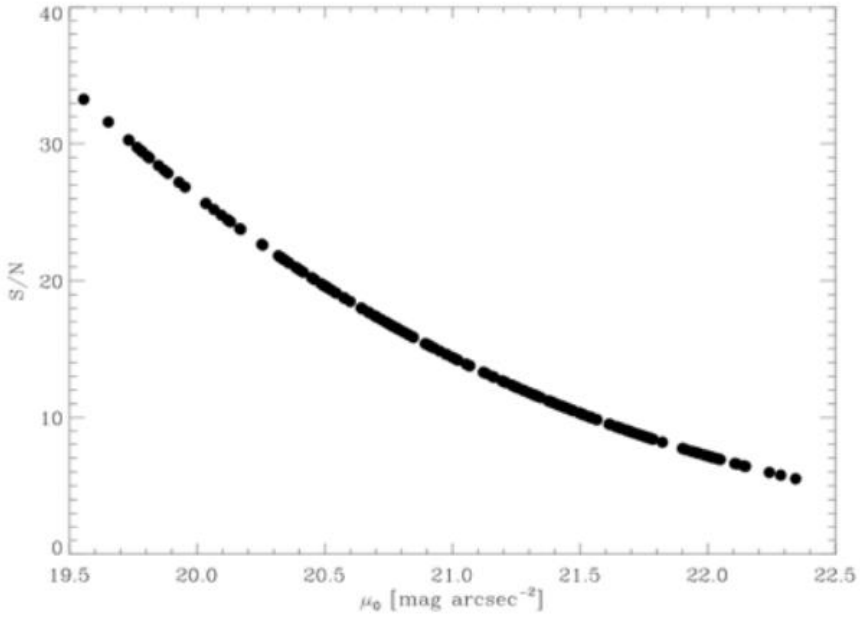


Nearby Cluster Survey

Target selection for each cluster:

1h exposure corresponds to an expected S/N of:

- **WEAVE ETC estimates**
- **S/N > 4 @ mu=23.0**
- **S/N > 8 @ mu=22.0**
- **S/N > 16 @ mu=21.0**
- **S/N > 28 @ mu=20.0**



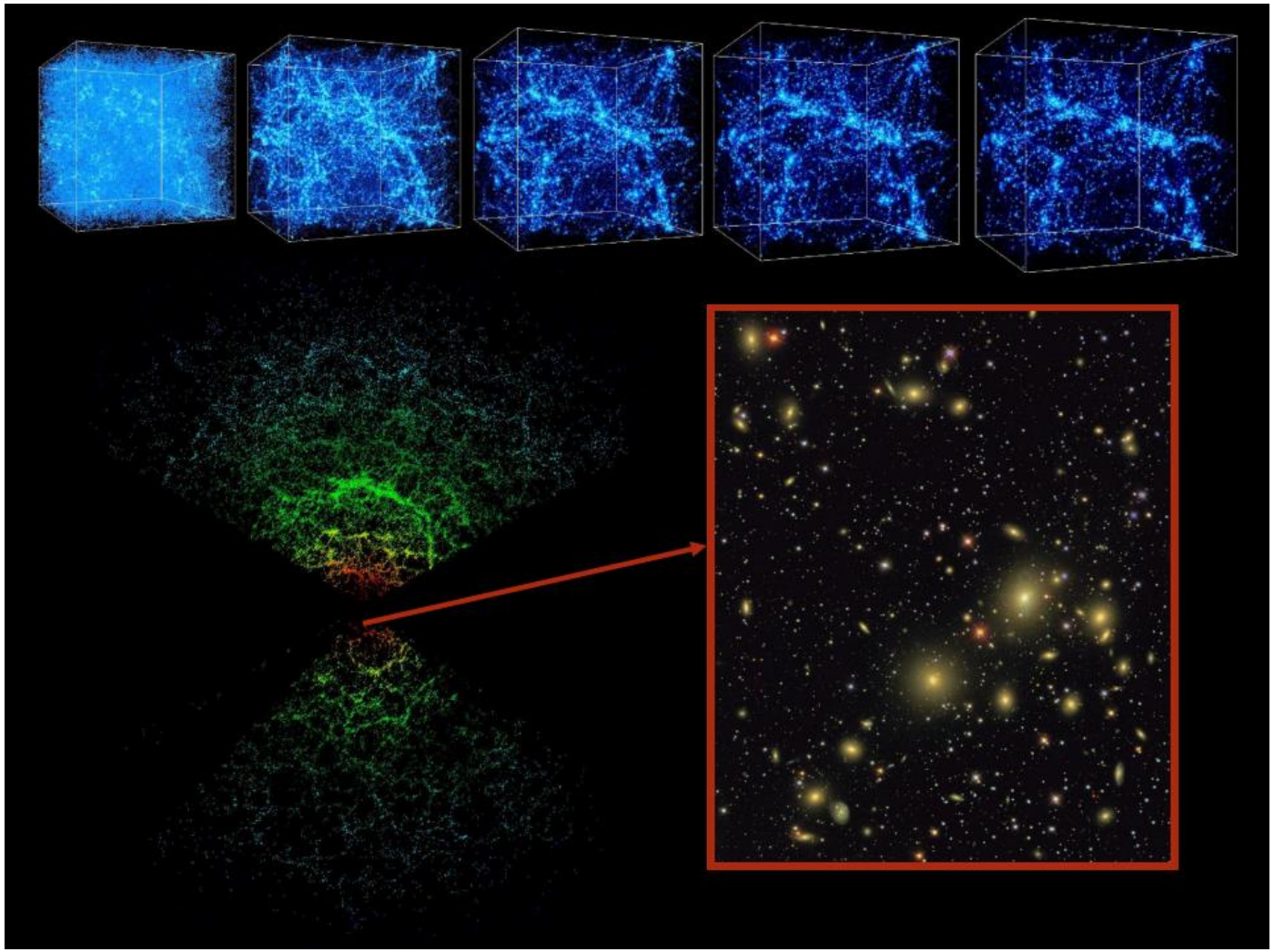
Nearby Cluster Survey

For clusters with (0.01 < z < 0.025) we plan to observe with mIFU mode for the most nearby clusters to:

~ 2 pointings per cluster (about 20 gals/pointing);

~ 1000 dwarfs in total.

Infall Cluster Survey



Infall Cluster Survey

Clusters Layer 2 will observe with:

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Field of view	2° ⌀
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Fiber size	1.3″
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Infall Cluster Survey

We aim to map and understand filamentary nature of LSS:

- **What is the nature of the filaments?**
- **Are they formed by distinct groups infalling into the clusters, or are they formed by individual galaxies falling into the clusters along the filaments? Or both.**
- **What is the fraction of galaxies in each case?**

Infall Cluster Survey

…And to understand mechanisms driving galaxy transformations:

- **What is the main parameter that governs the environmental effects on galaxies? (Radial distance to the cluster centre? Local density? Belonging to a group or a cluster? Belonging to a filament?)**
- **What are the main physical mechanisms driving galaxy transformation in each environment?**

Infall Cluster Survey

To this aim we plan to:

- **obtain deep spectroscopy of galaxies in the infall regime of a sample of 16 clusters selected from WINGS out to ~ 5 r_{vir} with Mr=-17.0 at mr=20 mag;**
- **MOS mode in low resolution;**
- **10 pointings per cluster in order to cover the infall cluster region (3x3 grid; to pointings in the centre);**

Infall Cluster Survey

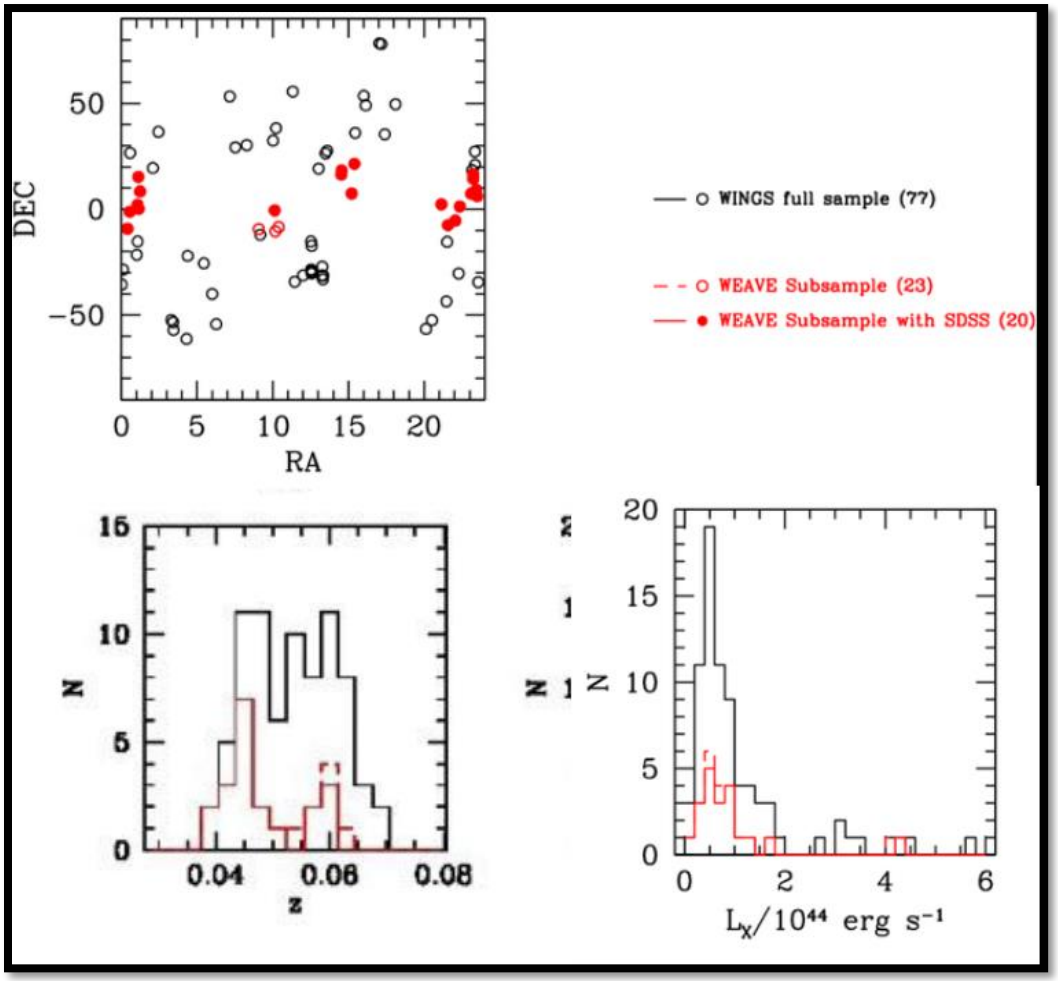
To this aim we plan to:

- **160 pointings in total in order to observe the 16 clusters proposed;**
- **Obtain ~2500 spectra per cluster structure, with ~1000-1500 in infall region;**
- **Obtain SF history on different timescales, e.g. AGN activity, chemical composition.**

Infall Cluster Survey

~1h of exposure time to observe gals with mr≤20.0mag (i.e. stellar masses ~10^9 $M_{\odot}$).

S/N>5-8 at the faintest limits.



Cosmological Cluster Survey

The main scientific goals are:

- ✓ **Study the evolution of the stellar population for a large sample of massive/luminous galaxies in the central regions of galaxy clusters in the last few Gyr;**

- ✓ **Obtain the mass calibration and global scaling relations for a complete sample of SZ selected clusters.**

Cosmological Cluster Survey

Clusters Layer 3 will observe with:

Telescope, diameter	WHT, 4.2m
Field of view	2° ⌀
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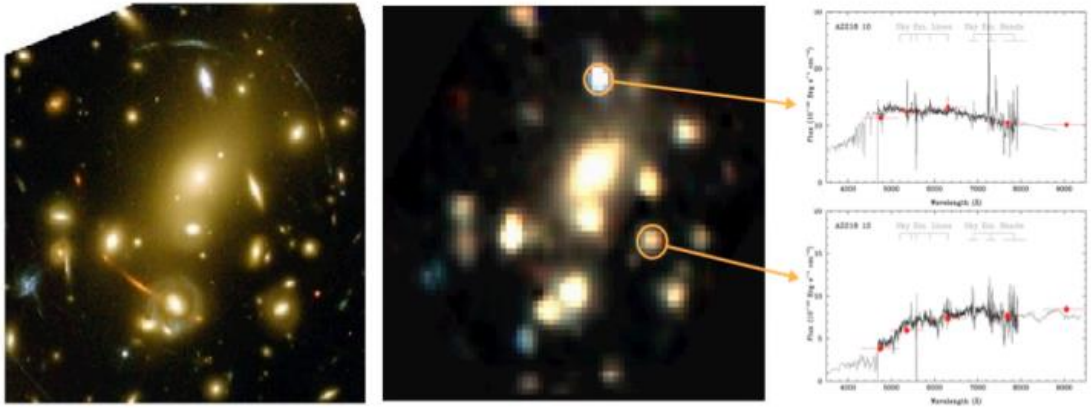
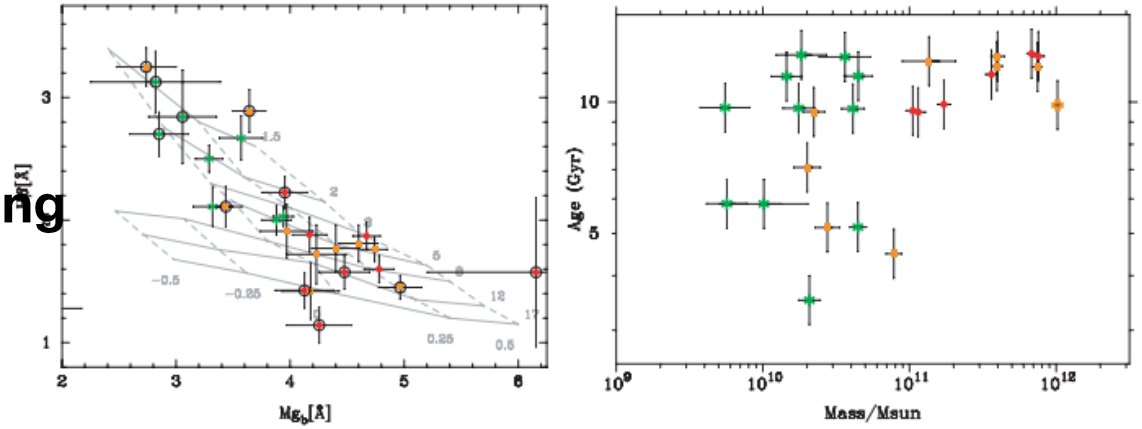
Cosmological Cluster Survey

<u>Stellar pop. Evolution:</u>

Wide-field IFUs could be used to probe <u>all</u> galaxies in a cluster core.

Sánchez+07, studying A2218, obtained challenging results with [6h@3.5m] telescope.





Cosmological Cluster Survey

Encouraged by this result, one of the earliest-planned WEAVE science cases was a study of clusters at $0.25 \leq z \leq 0.5$ with the LIFU.

The basic idea was to study cluster galaxies as a function of redshift, cluster mass, and galaxy velocity dispersion, with roughly 20 clusters per $\Delta z = 0.05$ bin.

Cosmological Cluster Survey

Cosmology with clusters:

- **Improve significantly the calibration uncertainty of the mass scaling laws;**
- **Understanding possible biases.**

By:

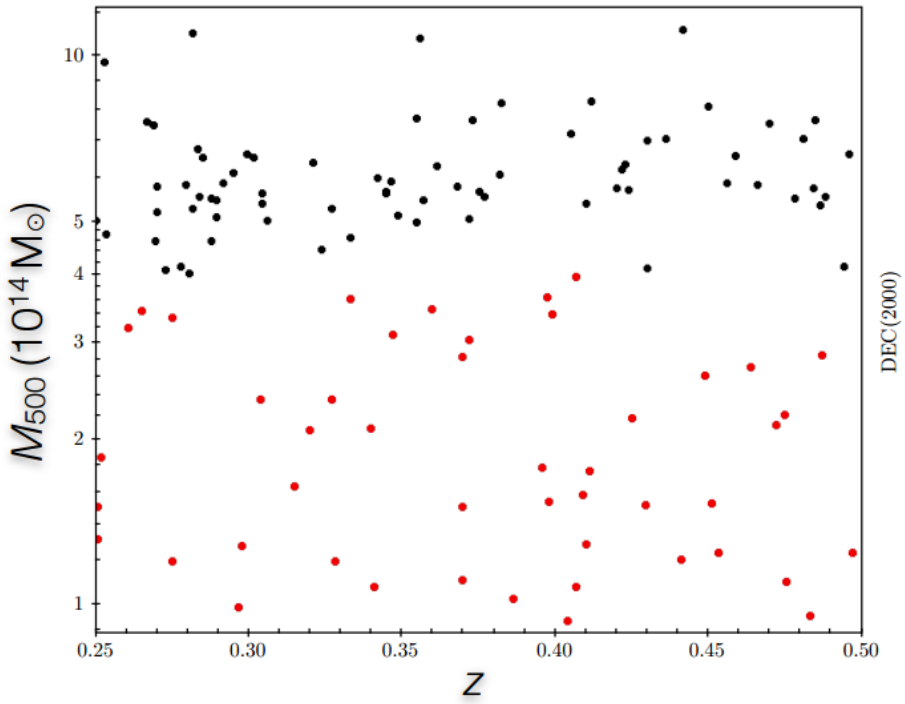
- **Estimating dynamical masses;**
- **measuring radial velocities of galaxy cluster members to estimate velocity dispersions for clusters of the PSZ1 & PSZ2**

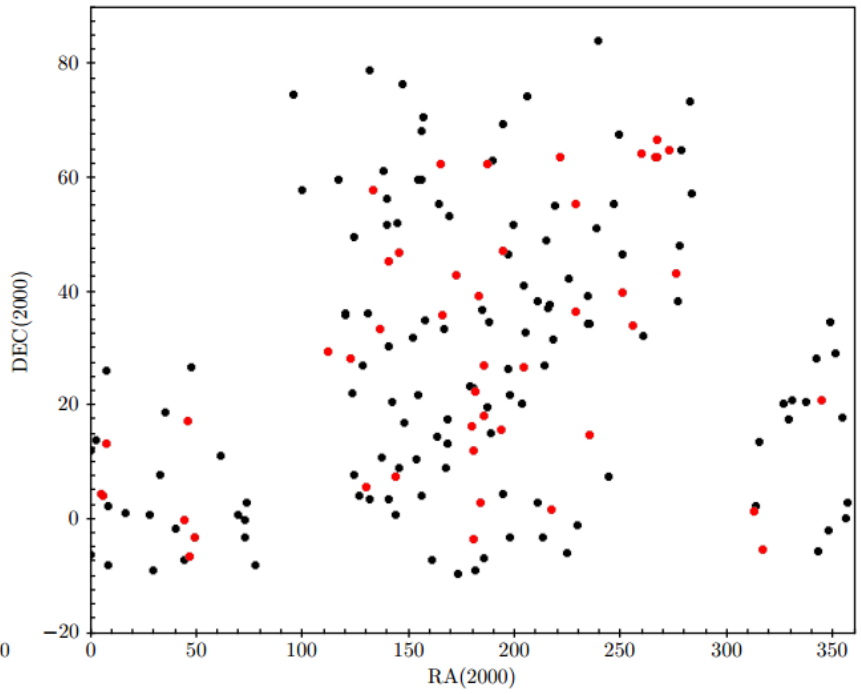
Cosmological Cluster Survey

Cluster sample selection (mainly X-ray selection):

- High-mass clusters ($M>4\times10^{14}\ M_{\odot}$) selected from PSZ
- Low-mass clusters ($\approx9\times10^{13}>M>4\times10^{14}\ M_{\odot}$) selected from Piffaretti+11
- All clusters selected to have $\delta\geq-10^{o}$ and $|b|\geq20^{o}$.
- Randomly selected ~80 clusters in total.

Cosmological Cluster Survey





Preliminary cluster samples from the 'high-mass' (PSZ, black points) and the 'low-mass' (Piffaretti et al. 2011, red points). left: cluster mass as a function of redshift; right: distribution on the sky.

Cosmological Cluster Survey

~ 4 hours of exposure per LIFU pointing including dithering: galaxy with $\langle \mu_I \rangle$=22.3 mag/arcsec^2 yields S/N≈35, sufficient for stellar population analysis from full-spectrum fitting.

A three-point dither pattern to have 100% coverage, but only 2x increase in exposure time over single pointing.

Cosmological Cluster Survey

Full coverage out to the virial radius of each cluster is out of scope!

Single (dithered) pointings of LIFU may be sufficient for many clusters, as core radius is ~5–10% of virial radius (cf. Łokas+Mamon03) – (massive) clusters are typically very concentrated.

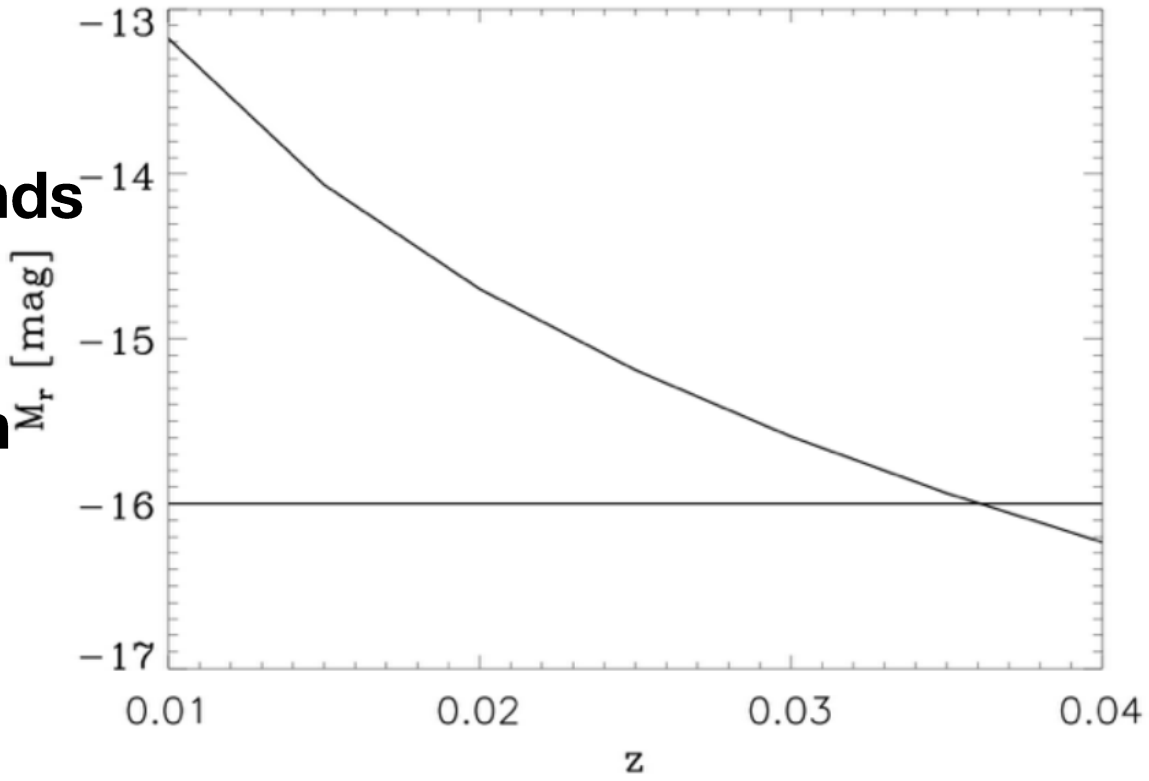
LIFU effective radius of ≈0.74′ should be sufficient to cover majority of galaxies in each cluster, even in massive z=0.25 clusters

Thanks!

Nearby Cluster Survey

Target selection for each cluster:

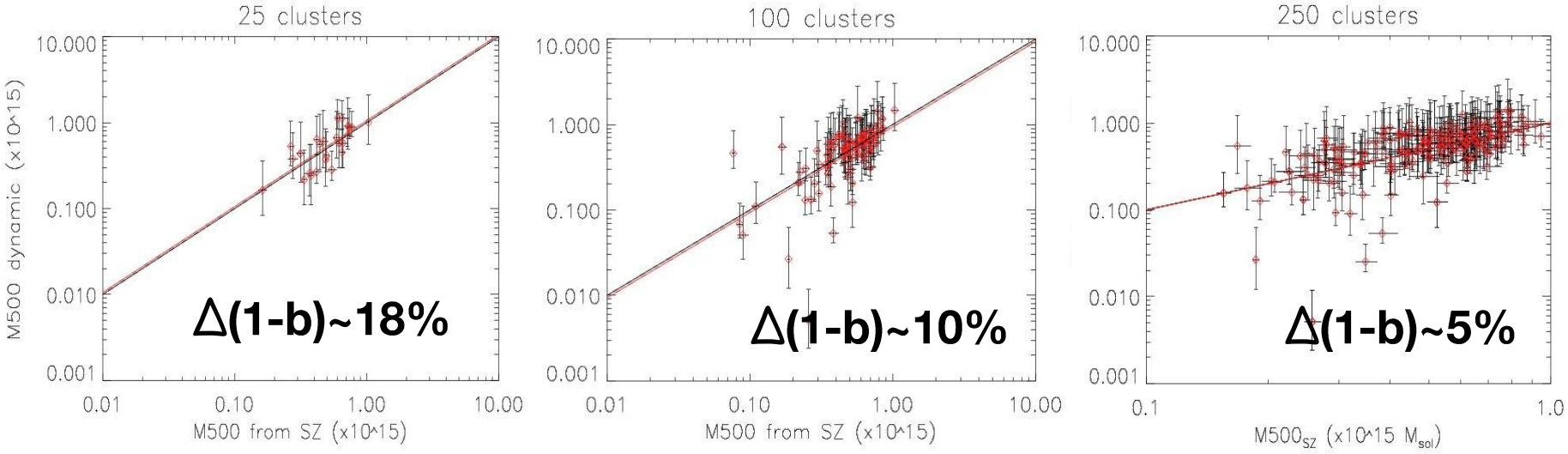
The cut in apparent magnitude corresponds to an absolute magnitude cut, which depends on redshift.



Cosmological Cluster Survey

Cosmology with clusters:

We need ~ 80 clusters:



Cosmological Cluster Survey

MOS exposures

Targets	Clusters at z<0.3	Clusters at 0.3<z<0.5
WEAVE set-up	800 fibers	LIFU (FOV 75x90 arcs)
FOV	>10x10 arcmins	<2.5x2.5 arcmin (*)
λ range	4000-7000 A	4800-7500 A
Resolution	5000	2500
r-mag limit	<20	<20
S/N limit	>5	>5
Δv limit	<50 km/s	<50 km/s
Target density	<2 per sq. arcmin	>5 per sq. arcmin