Clusters of galaxies as probes of cosmology, dark matter, and the evolution of cosmic structures

Build a catalog of clusters up to z~1.5 to constrain

I. cosmological models – via their number density and spatial distribution

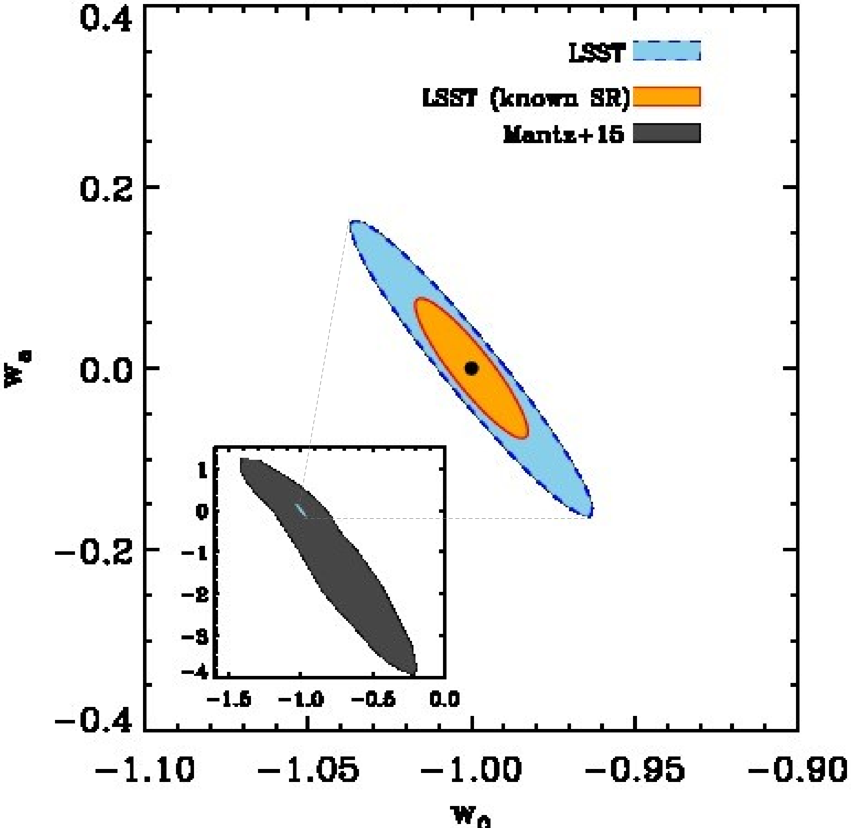
II. cluster internal structure – cmp total, stellar, diffuse plasma internal distributions

I. Cosmology:

5σ depth r=27.5
→ detection of $z \leq 1.5$, $M \geqslant 2\times10^{13}\,M_\odot$ clusters
with 80% completeness to $\sim10^{14}\,M_\odot$

$\delta z_{phot} \sim 0.02\times(1+z)$
→ minimization of projection effects
implying high sample purity
and reliable mass proxies
(richness, total stellar mass)

Median ~0.65" seeing
→ weak lensing masses ($M \geqslant 1.5 \times 10^{14}\,M_\odot$)
for calibration of mass proxies



(DE EoS; figure by B. Sartoris)

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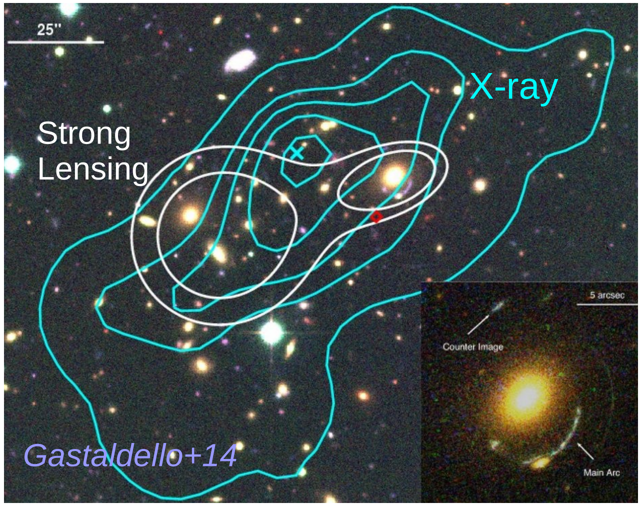
II. Cluster internal structure:

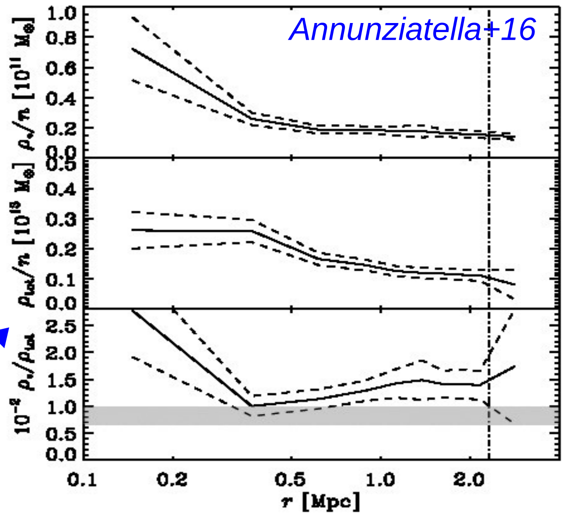
6-filter photometric coverage (324-997 nm)
→ cluster galaxy stellar masses by SED fitting
stellar mass density profile

+ total mass density profile from weak lensing
for most massive z<0.3 clusters

+ intra-cluster plasma distribution from
(available and future) X-ray and SZ data

- Self-interaction cross-section of DM particles
- Cluster assembly models by accretion-rate estimates
- Timescales and effectiveness of galaxy evolution processes in clusters (tidal stripping, dynamical friction)





Number and Total- and stellar-mass density profile ratios in z=0.21 cluster

Research group: responsibilities and scientific interests

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B. Sartoris	*Univ. TS*	CO, ST	PH, SI, TH
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Status: Staff / Postdocs / Student
Role: **core team member** / collaborator
Topics: CO=cosmology;
ST=cluster structure;
GE=galaxy evolution in clusters
Data: LE=lensing;
PH=photometric data;
SI=simulations;
TH=theory;
EX=external (X, SZ)

Totals:

Status: ***17 + 6 + 1 = 24***

Institutes: ***4 INAF + 3 Univ.***

Topics: ***12 CO + 8 ST + 4 GE***

Data: ***4 LE + 8 PH + 7 SI + 1 TH + 4 EX***

Synergy with other facilities

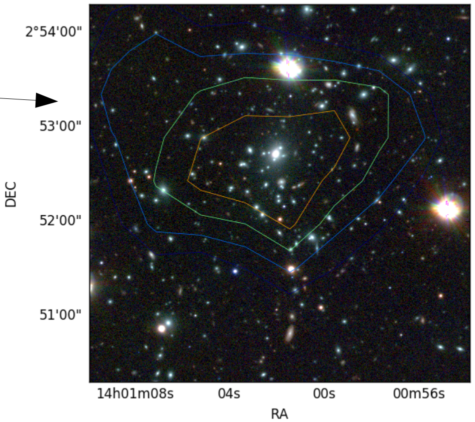
Strong involvement of the team in Euclid and the Kilo-Degree Survey (KiDS), leadership positions in Science Working Groups and Work Packages dedicated to cluster of galaxies
+ leadership in X-ray projects (X-COP, The XMM Cluster Outskirts Project, Eckert+16)
+ expertise in merging cluster data-set at different wavelengths (eROSITA and Planck)

Codes (being) developed for KiDS and Euclid → readiness for LSST data

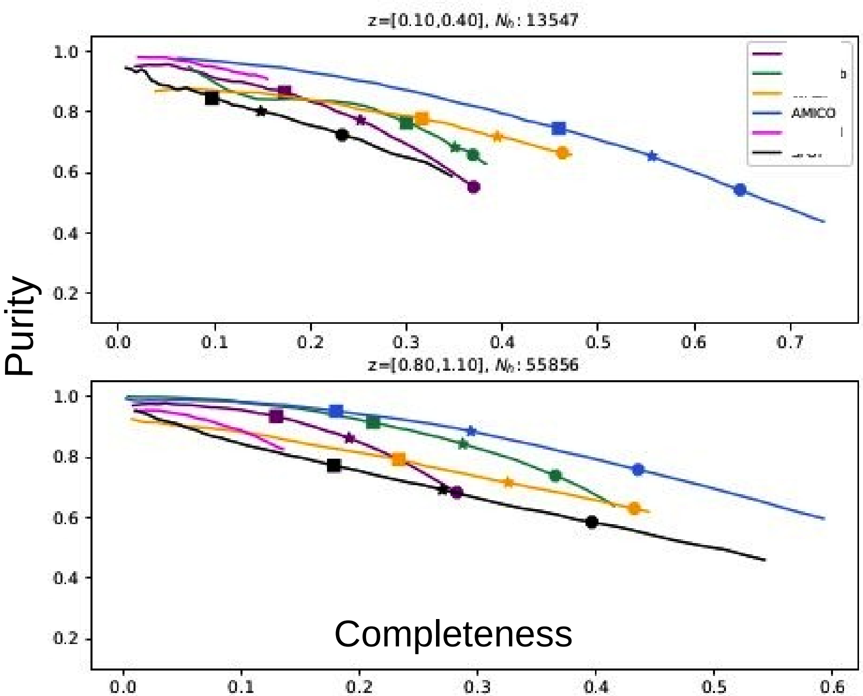
KiDS is already providing state-of-the-art weak lensing results

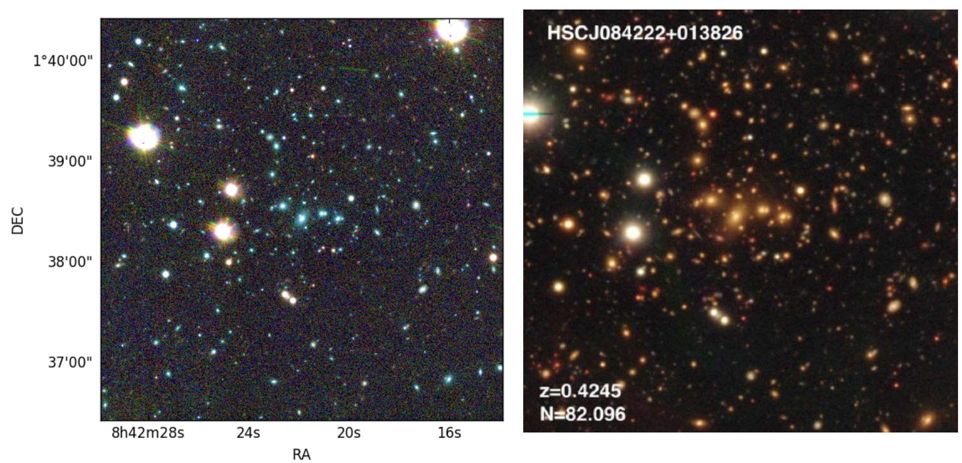
Euclid will complement LSST photometrically (920-2000 nm) and spectroscopically (0.9 ≤ z ≤ 1.8) → improve cluster catalog and mass calibration

AMICO *(Bellagamba, Maturi, Roncarelli)*: detecting clusters in KiDS and in Euclid mocks (winner of Cluster Finder Challenge)



KiDS: WL in a z~0.2 cluster





AMICO detection of z=0.425 cluster in KiDS (left) and HSC Wide (right). LSST will allow to go ~1 mag deeper than HSC.

Data analysis

Software development for the exploitation of LSST data:

Direct use of LSST data products for shape measurements and photometric data

Preparation for the exploitation of LSST data:

Cosmology:

- ≤1 yr: apply cluster detection code AMICO to existing survey data (e.g. KiDS)
- ≤1 yr: test algorithm for richness determination on mock surveys
- ≤2 yr: develop analytical definition, code, and test likelihood algorithm for cluster number counts and power spectrum
- ≤3 yr: apply AMICO to mock LSST survey to calibrate the selection function in different cosmologies
- ≤3 yr: estimate mass proxy scaling relations from photometry and lensing from hydro cosmological simulations

Cluster structure:

- ≤1 yr: test algorithms for stellar mass profile determination on real data (CLASH-VLT) and simulations
- ≤1 yr: develop and test code to estimate accretion rate from external shape of density profile on real data (CLASH-VLT)
- ≤2 yr: prepare for the LSST data the lensing techniques and tools developed for KiDS (individual cluster mass determination & stacked cluster analysis)
- ≤3 yr: test shear analysis of clusters on LSST-like data, using both simulated images (SkyLens and GalSIM) mimicking LSST depths, and public Hyper-Suprime CAM Wide data (~1 mag shallower than LSST)