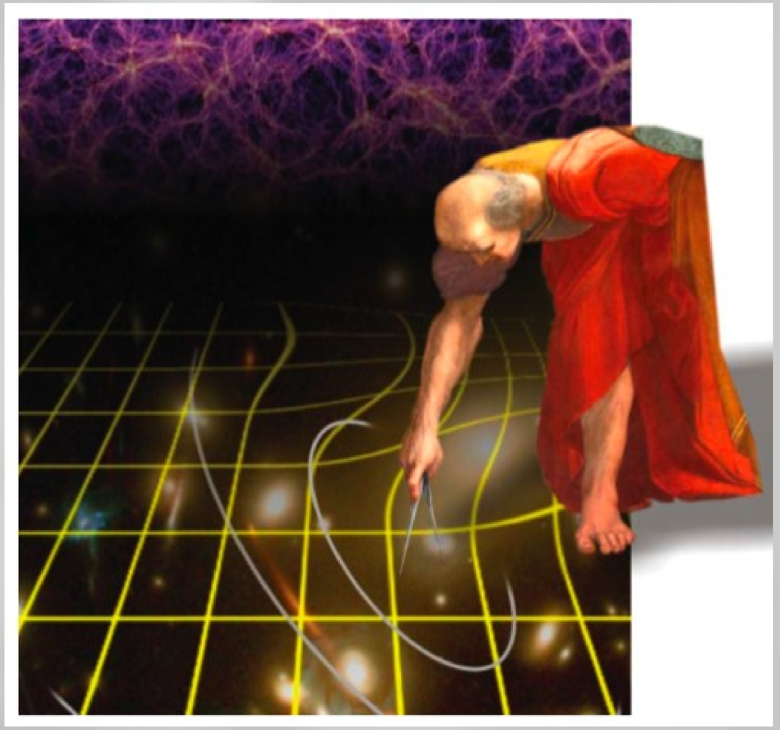
High-z clusters astrophysics with Euclid

A. Biviano, INAF/Oss. Astr. Trieste

On behalf of the
Euclid Consortium
and the
Euclid Clusters of Galaxies Science Working Group



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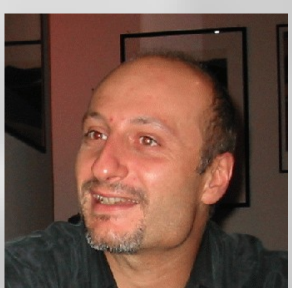
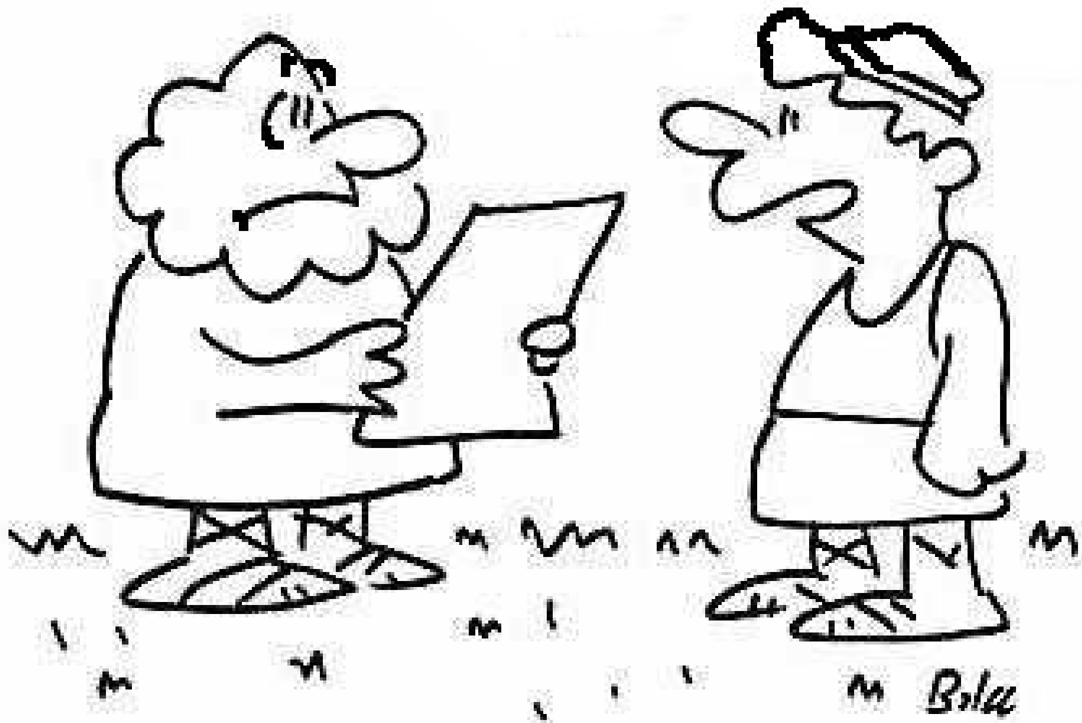


with special thanks to:
Sandro Bardelli
Jim Bartlett
Stefano Borgani
Sophie Maurogordato
Lauro Moscardini
Jochen Weller

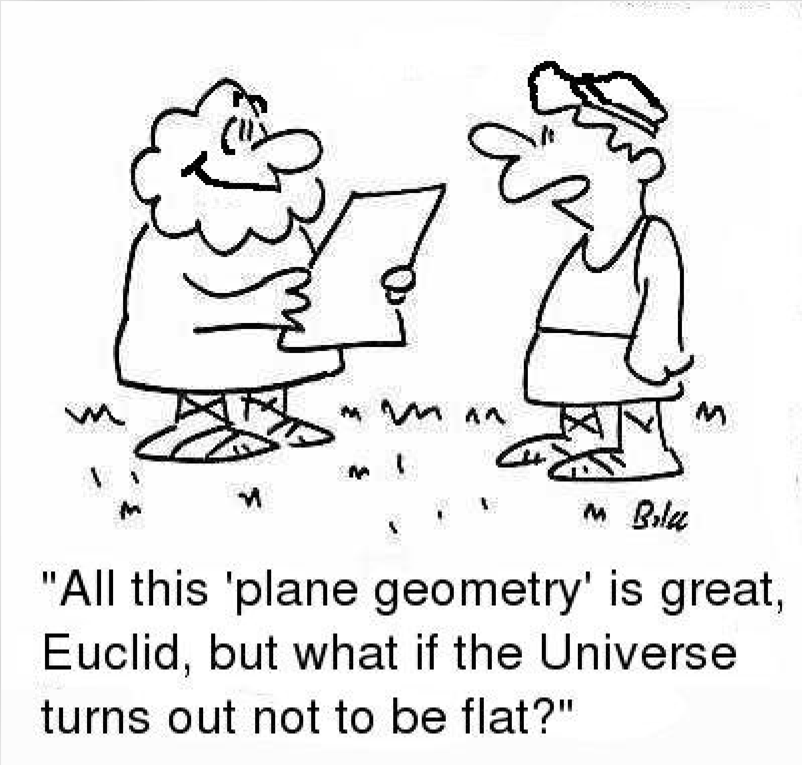


Why Euclid?



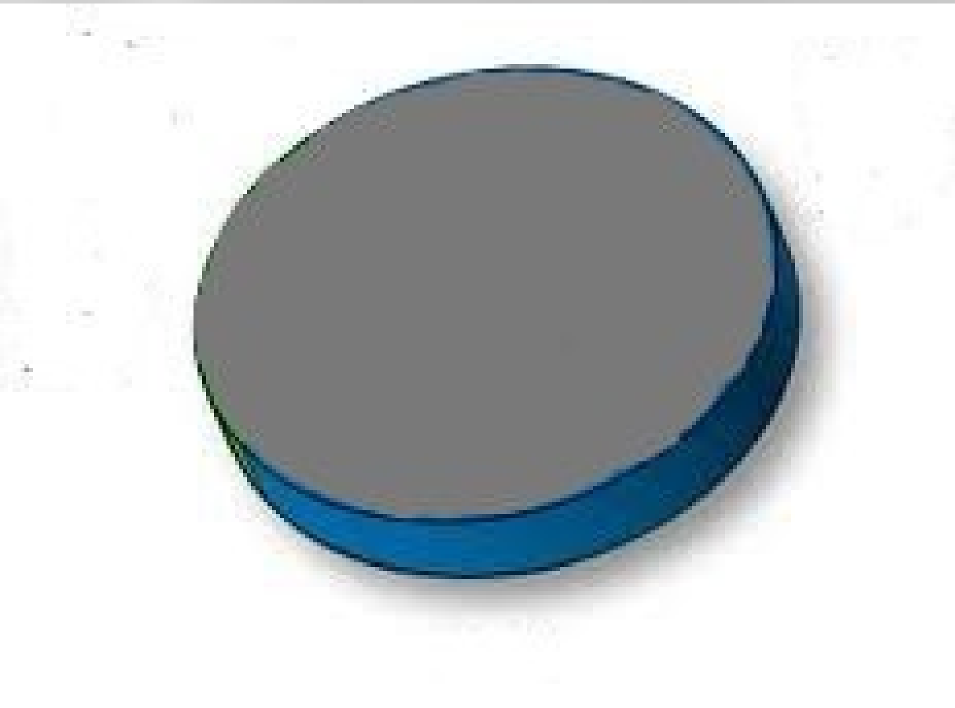
"All this 'plane geometry' is great, Euclid, but what if the Universe turns out not to be flat?"

Why Euclid?



The Universe IS flat!

(de Bernardis et al. 2000)



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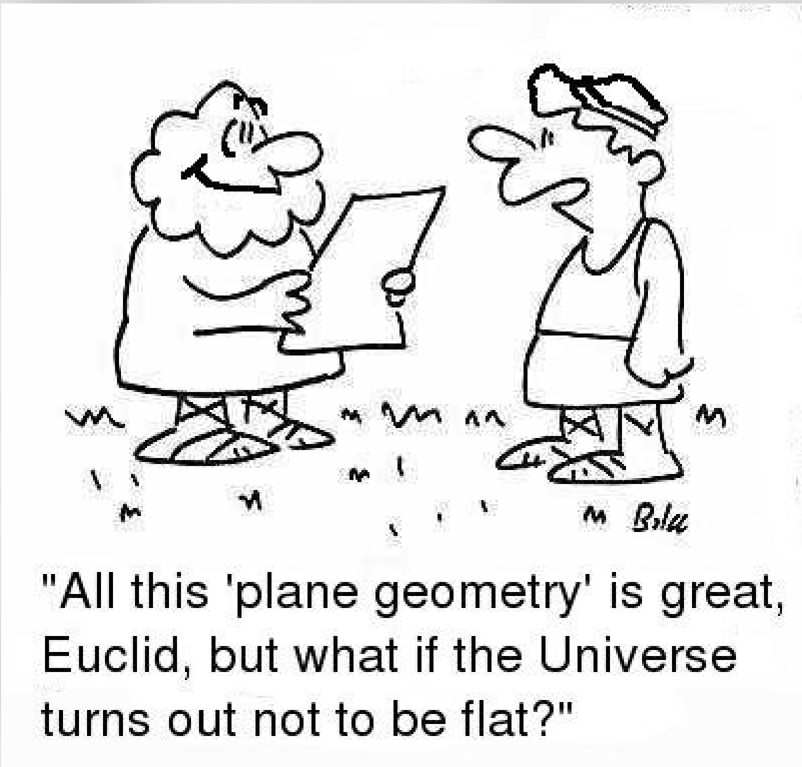

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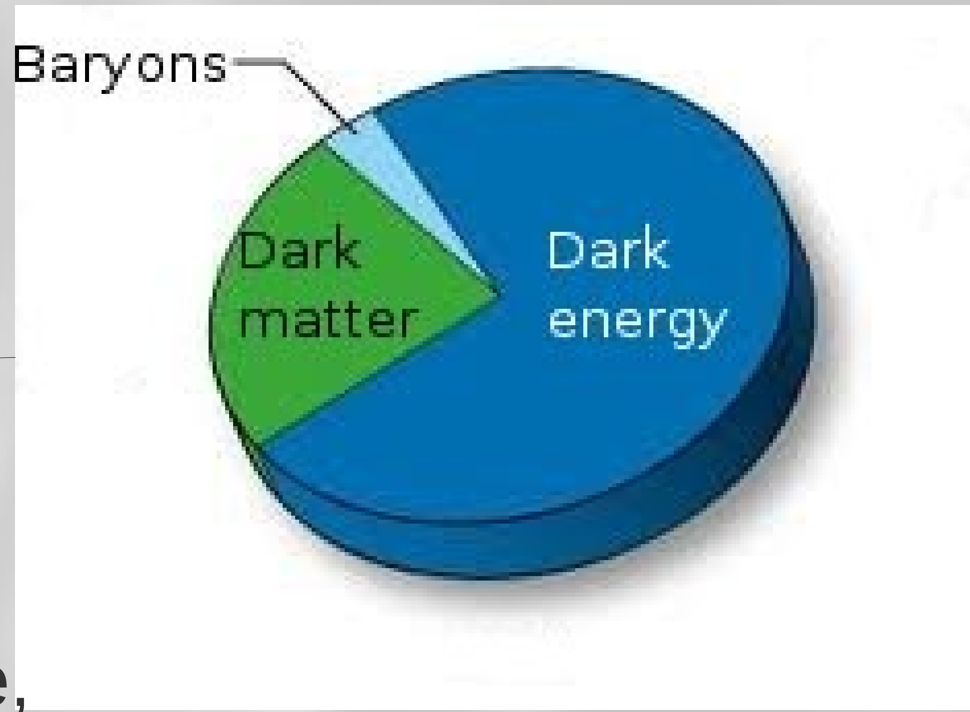
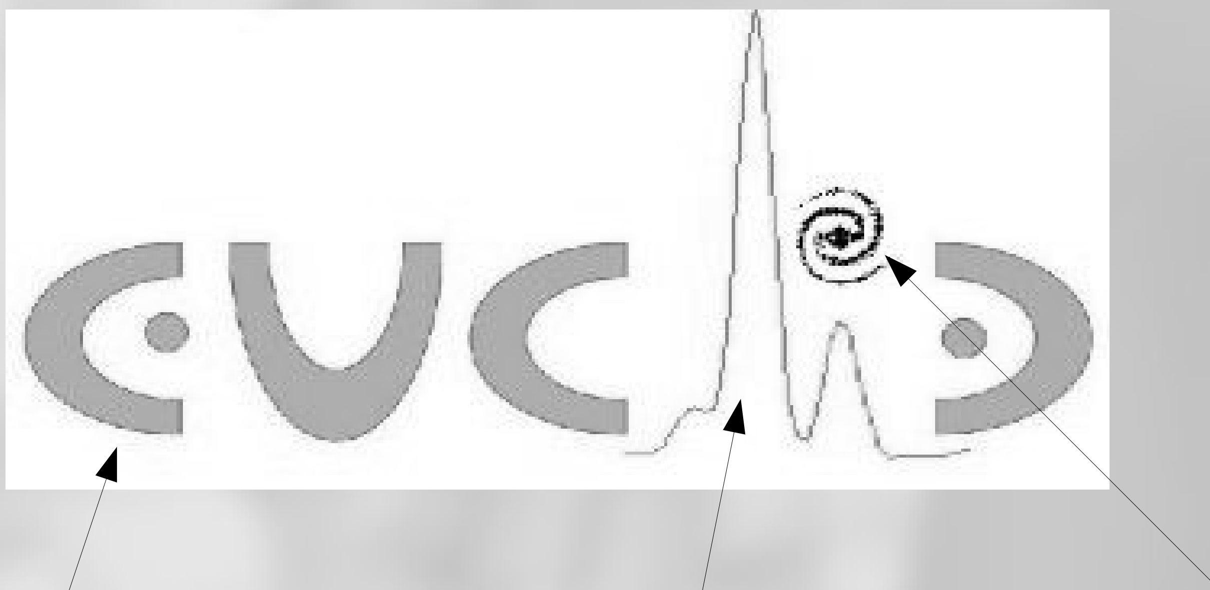


Euclid will study the ingredients of the Universe pie, **dark energy**, but also **dark matter** and **baryons** as well as the cook of the pie, **gravity**

How? Euclid's strenghts:



Lensing   Hα spectroscopy   Imaging

deep, in the visible and near-IR,
from space, over 15000 deg^2

Euclid & clusters of galaxies

How many clusters will Euclid see, and how massive, and how far?

Three ways of selecting galaxy clusters:

- Gravitational lensing peaks
- Overdensities in z-space
- Overdensities in projected space

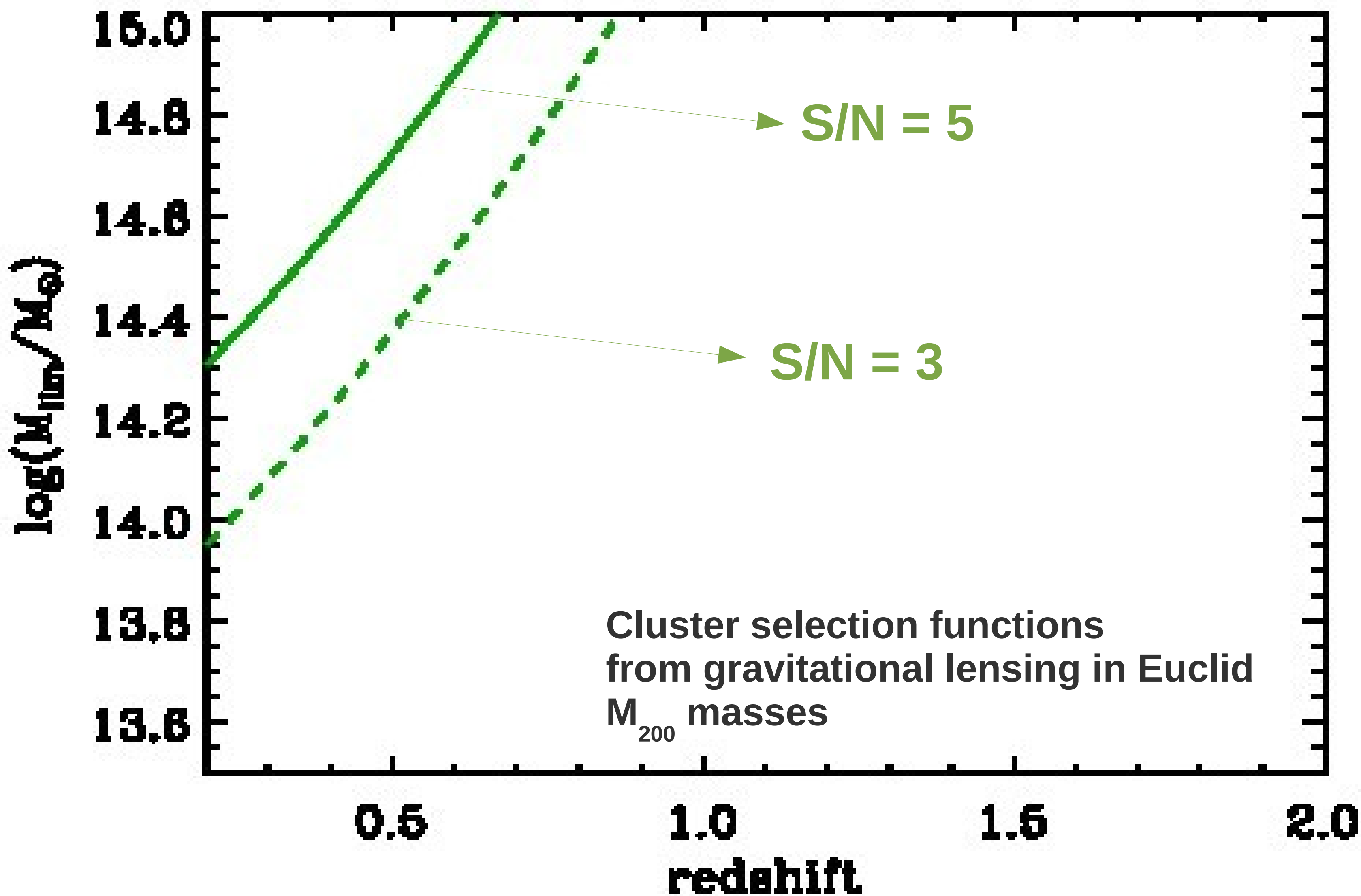
Euclid & clusters of galaxies

How many clusters will Euclid see,
and how massive, and how far?

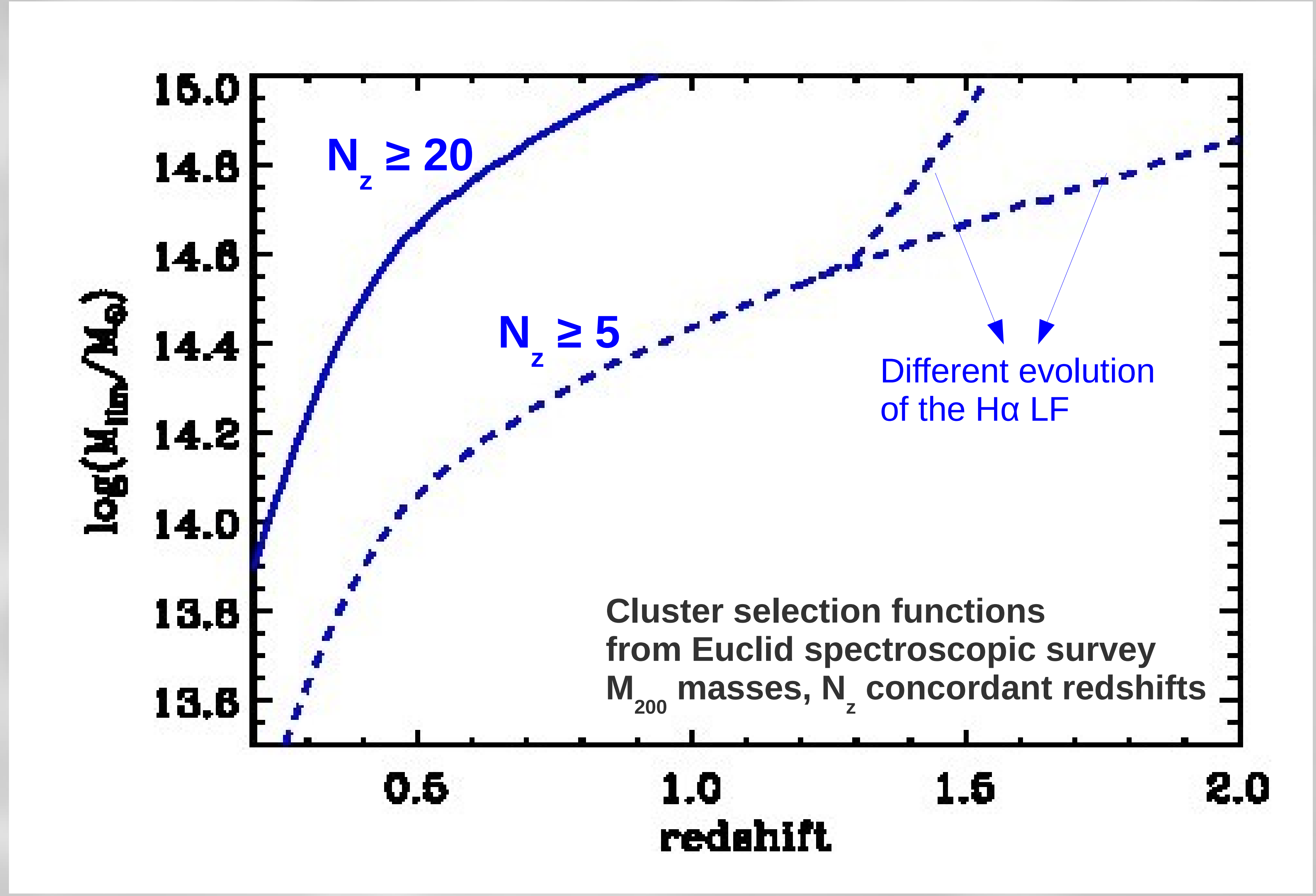
Selection functions evaluated analytically
(so far...):

- Weak lensing: *see Bergé et al. (2010)*
- Photometric & spectroscopic surveys:
  Based on observed LFs

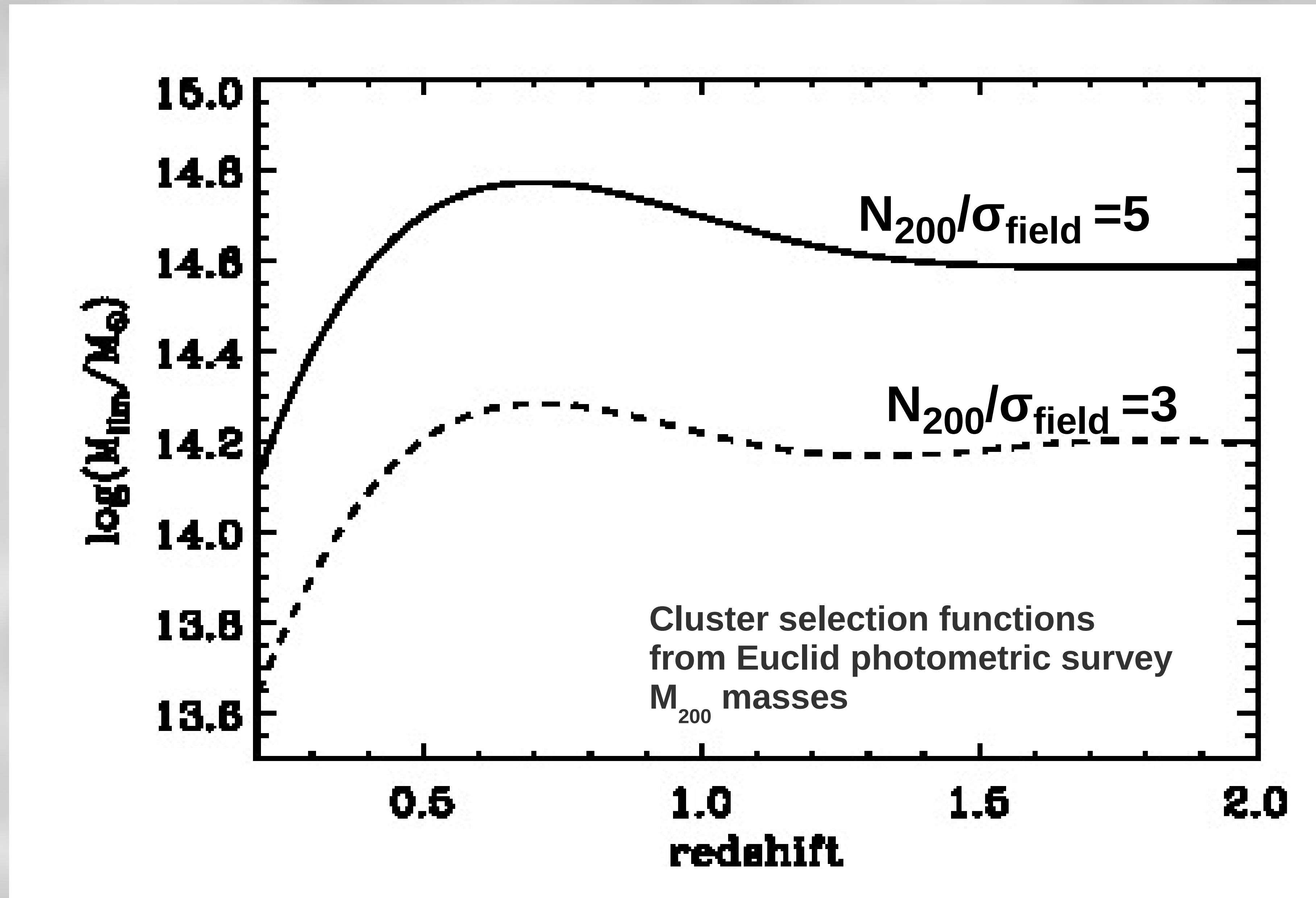
Gravitational lensing peaks



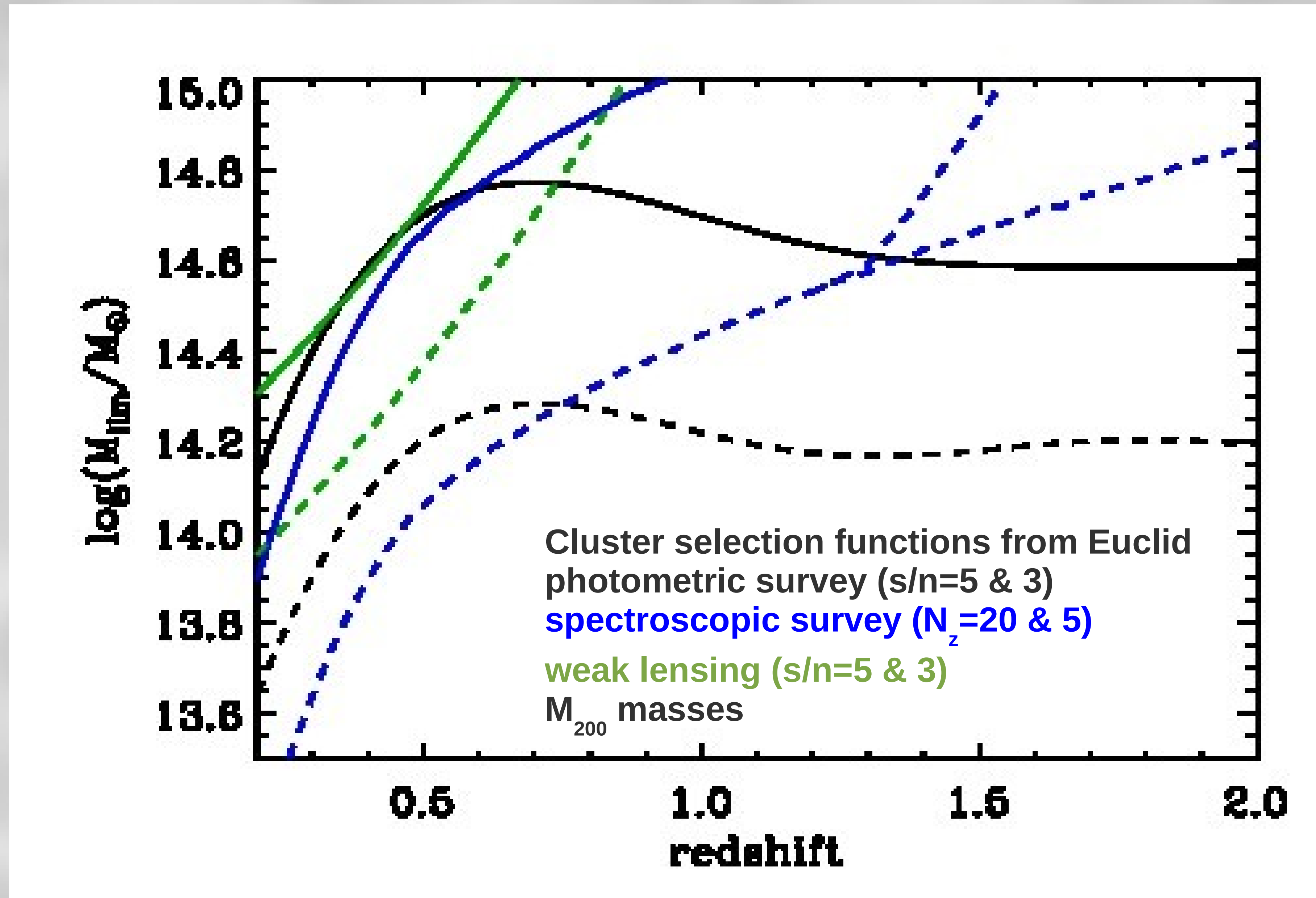
Overdensities in z-space



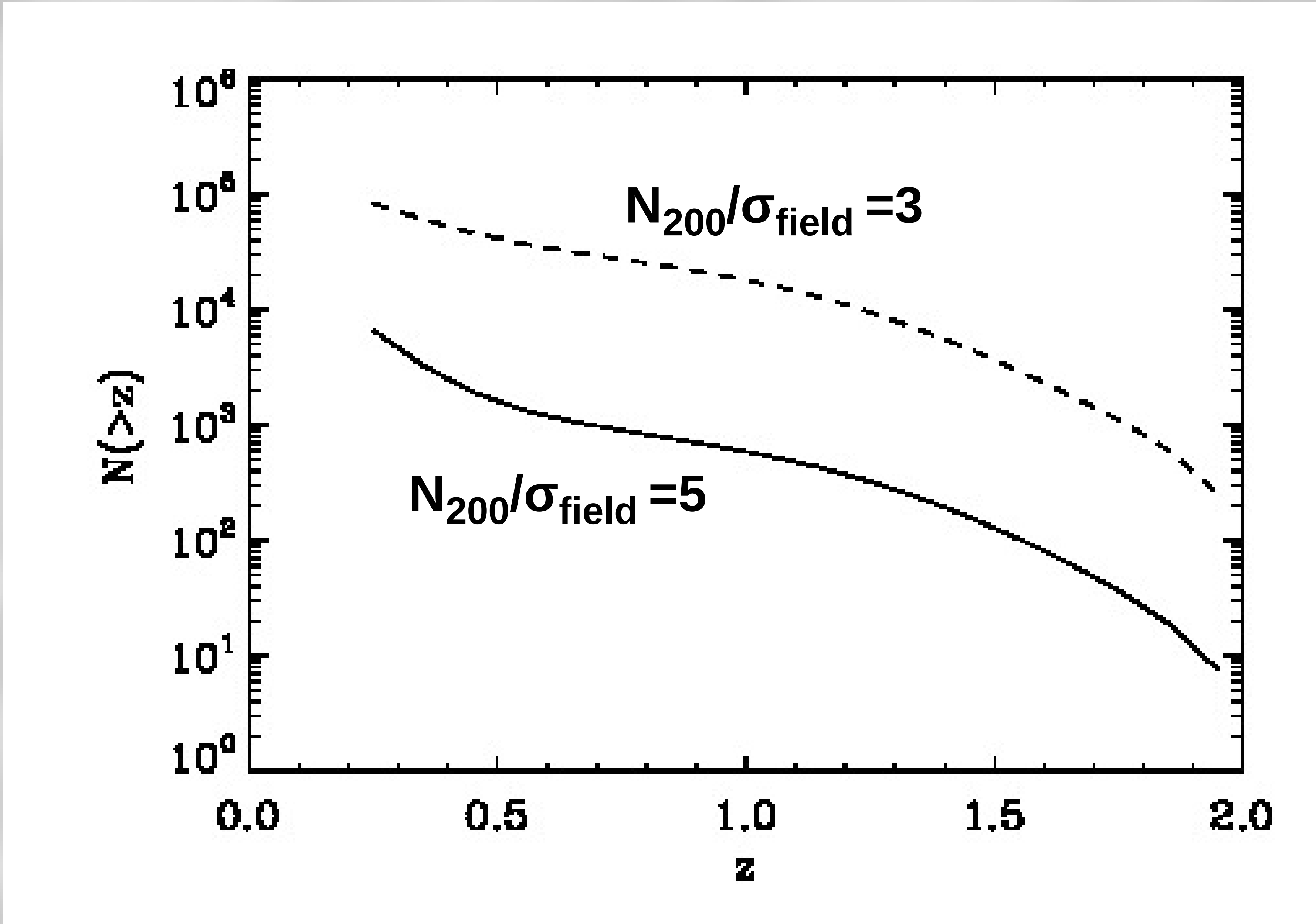
Overdensities in projection



Selection functions for clusters



Number of detected clusters



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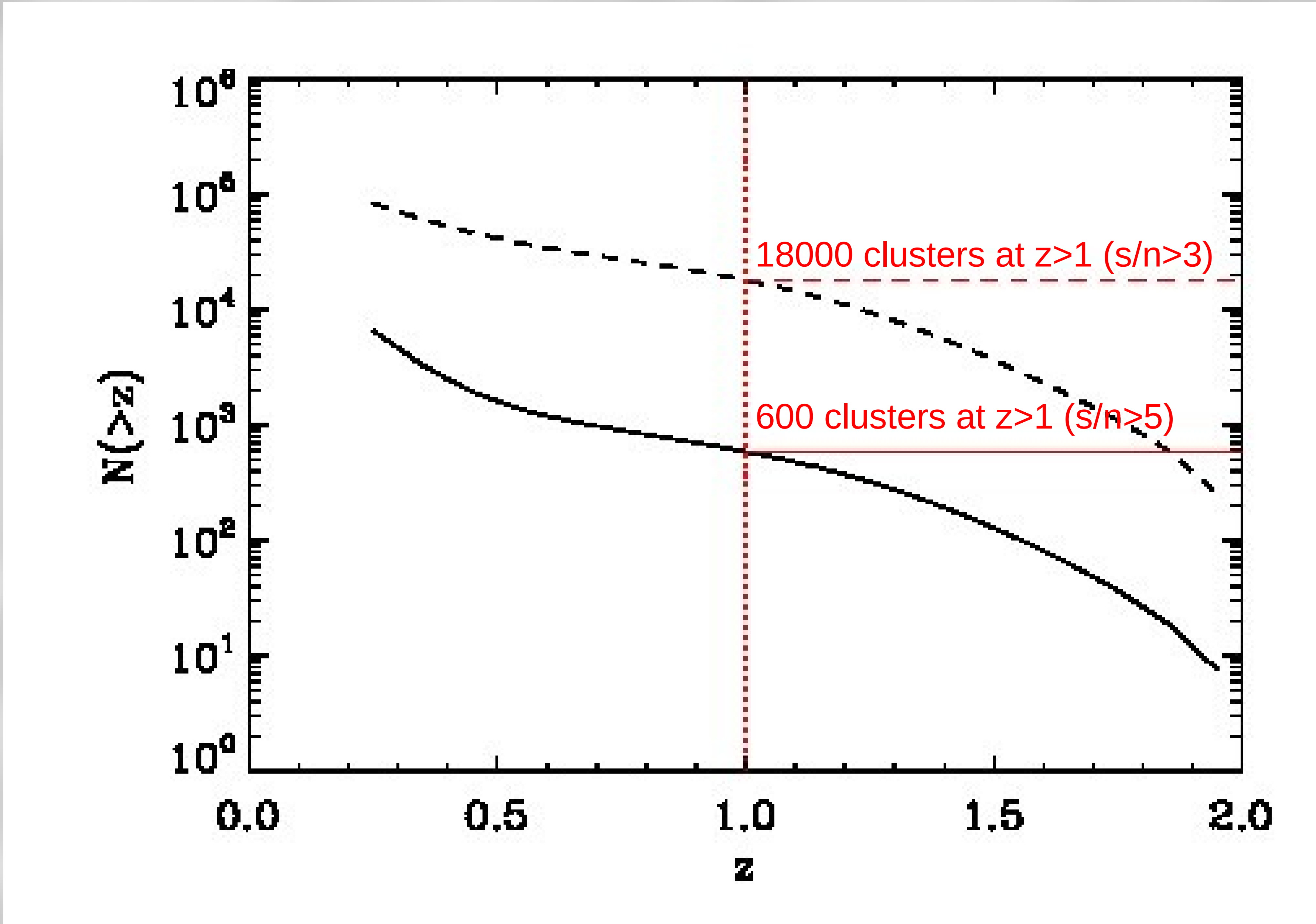


What can we do with all these high-z clusters?

- Cosmology; use cluster mass function to constrain:

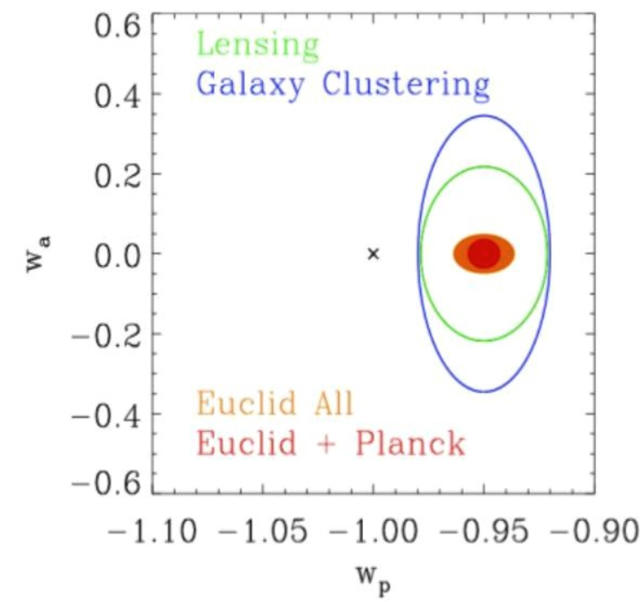
➔ Dark Energy equation of state
➔ Modified gravity (cosmological growth factor)

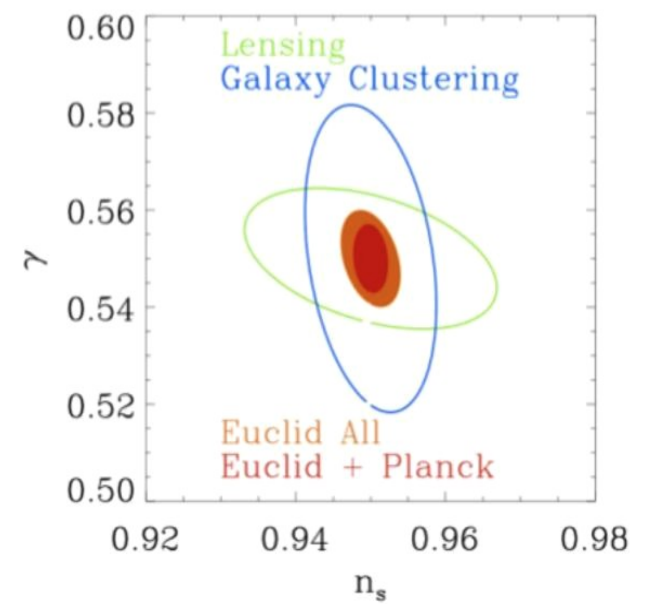
- Astrophysics; constraints on:

➔ Dark Matter profile of massive halos
➔ Evolution of baryons in dense environments

Cosmology: DE equation of state & modified gravity

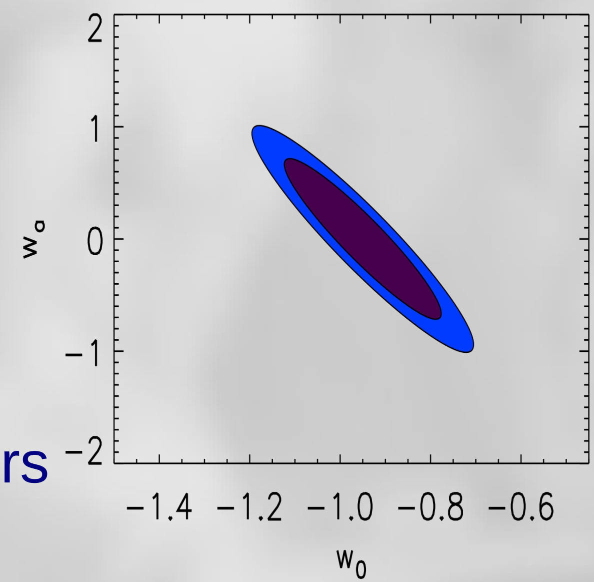
Main Euclid cosmological probes (WL shear & BAO)

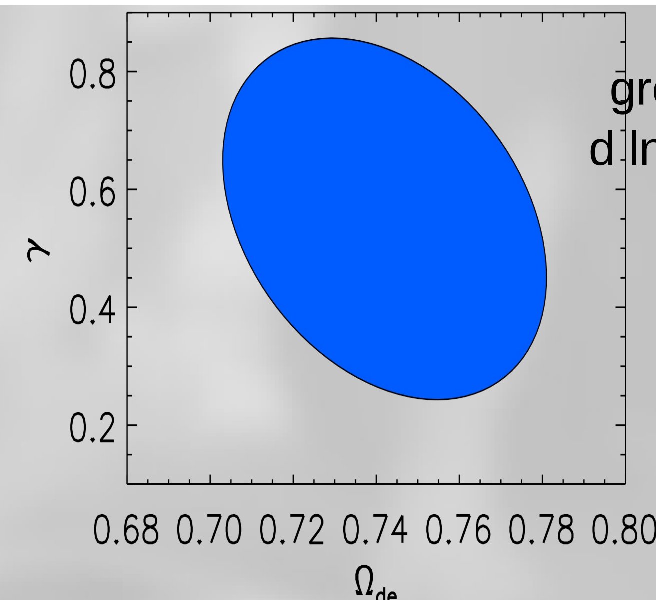




$P/\rho = w(a)$

$w(a) = w_0 + w_a(1-a)$





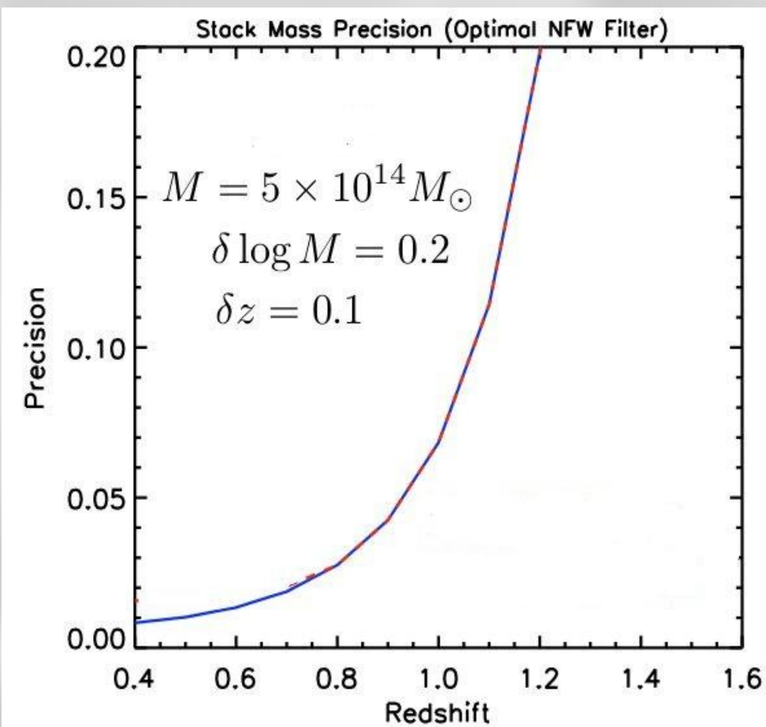
growth factor:
$d \ln \delta / d \ln a = \Omega_m^{\gamma}$

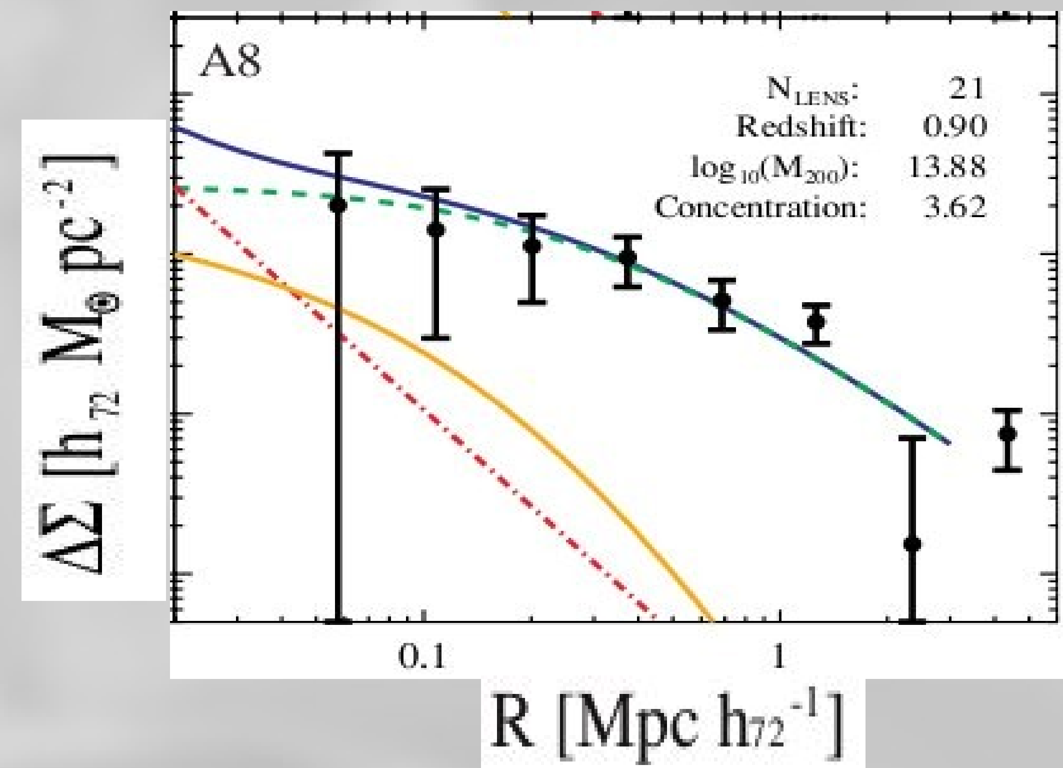
Clusters with Planck priors

Astrophysics: structure of DM halos

Detect WL signal from stack of clusters detected in the photometric Euclid survey, determine their surface mass density and therefore M(r) for several z and mass bins

Expected accuracy is ~100 times the current one *(Leauthaud et al. 2010)* up to z=1, and ~5 times at z>1, where there are no real WL constraints on M(r)



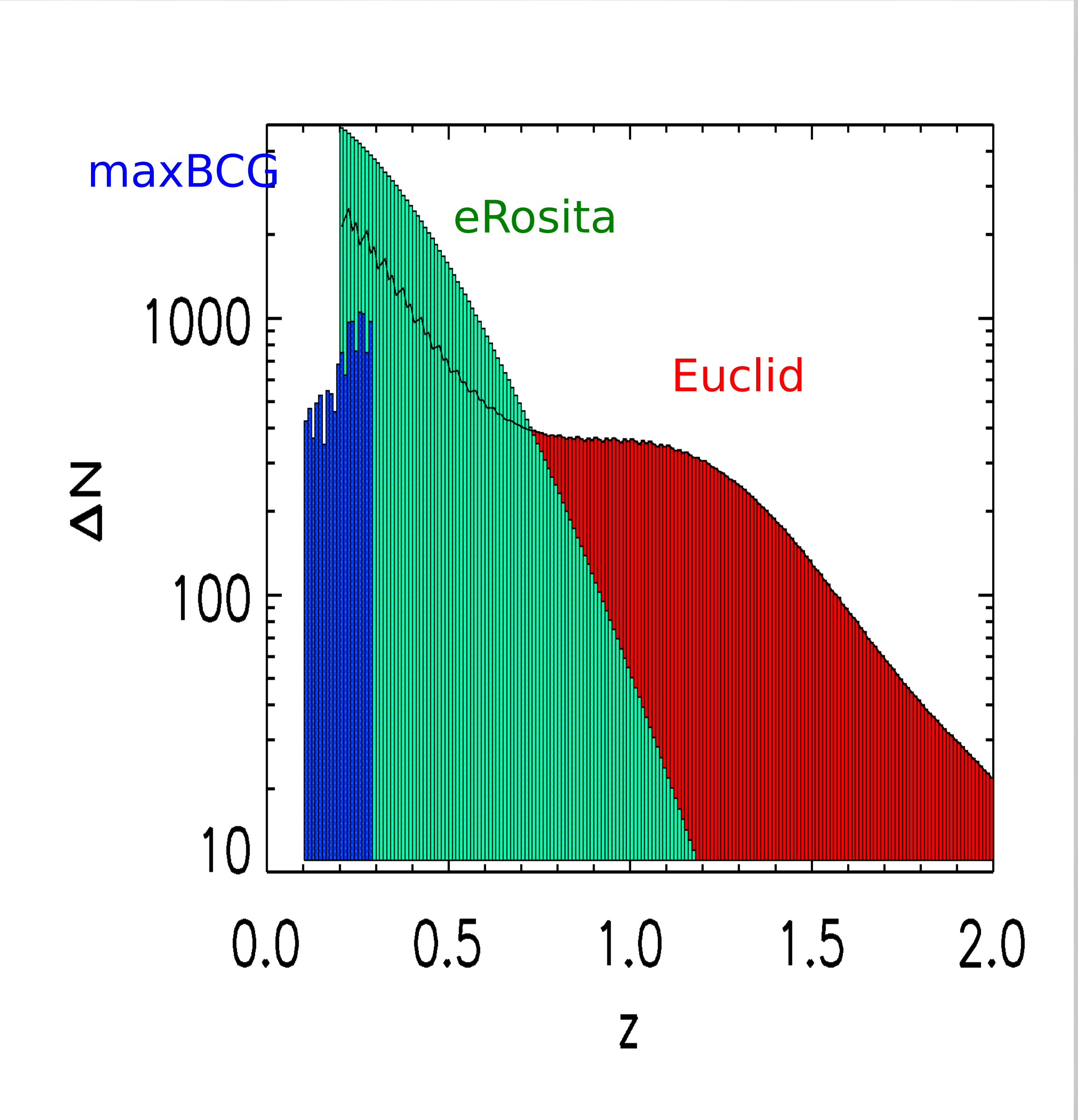


Astrophysics: L_x vs. L_{opt} and vs. M

~All distant **eROSITA** clusters will be detected in the Euclid photometric survey, and with ≥5 concordant galaxy redshifts from the spectroscopic survey

L_x (eROSITA) vs.
L_{opt} (Euclid photom. survey)
and vs. M (stacked WL signal)
+ <z> (Euclid spectro. survey)

→ powerful constraints on the evolution of the baryonic content of clusters (up to z~1.1)

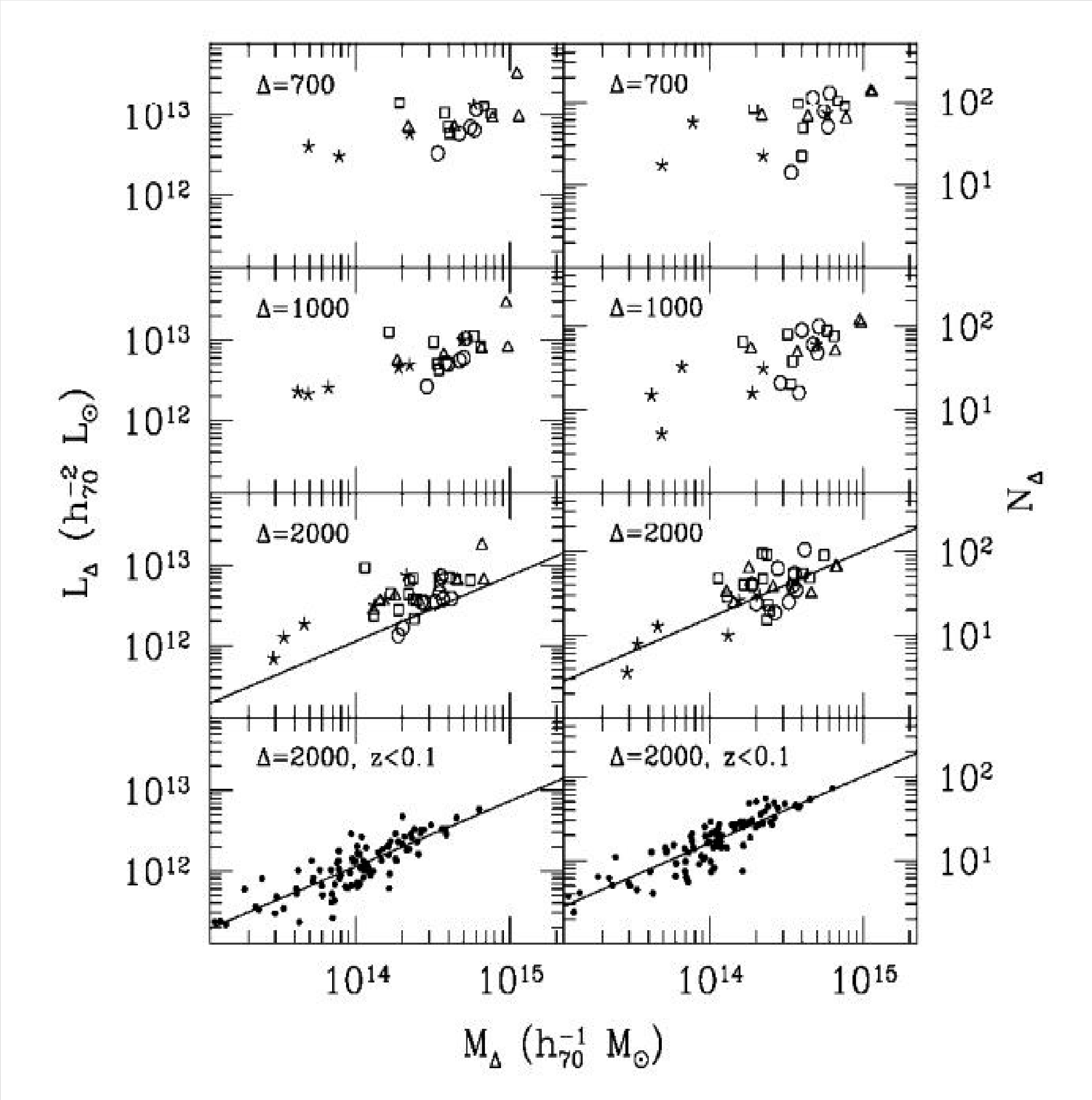


Astrophysics: N and L_{opt} vs. M

Richness and/or L_{opt} vs. Mass as a function of z:

→ **halo occupation distribution** models (how do galaxies form and evolve in overdense regions)

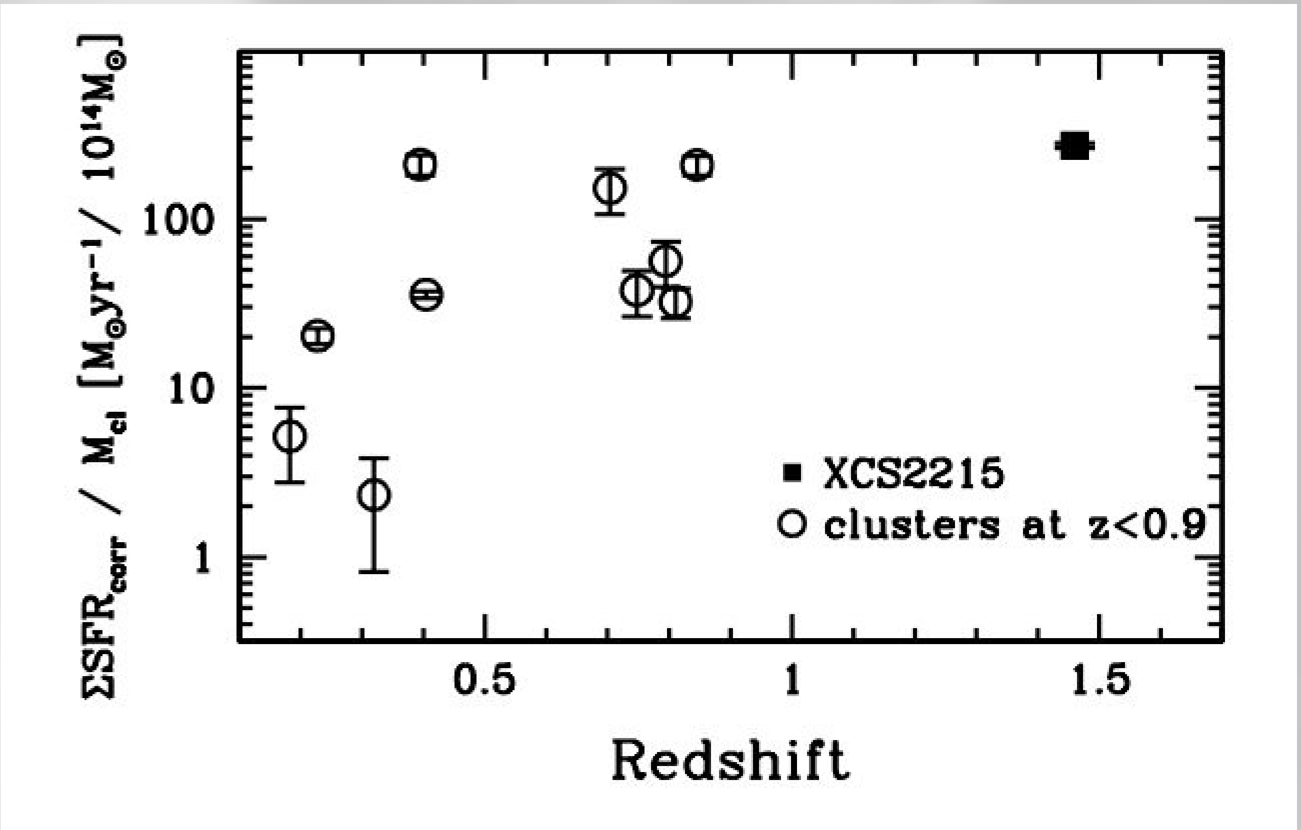
Euclid will improve by ≥1 order of magnitude the statistical sample compared to the current observational situation *(Lin et al. 2006)* and extend to z>1 this analysis



Astrophysics: ∑SFR/M

Euclid spectroscopic survey: SFR from Hα
for ~1000 emission-line galaxies in z≥1 clusters

→ determine the evolution of the **SFR per unit mass** in clusters to an unprecedented precision *(cmp. with Hayashi et al. 2011)*



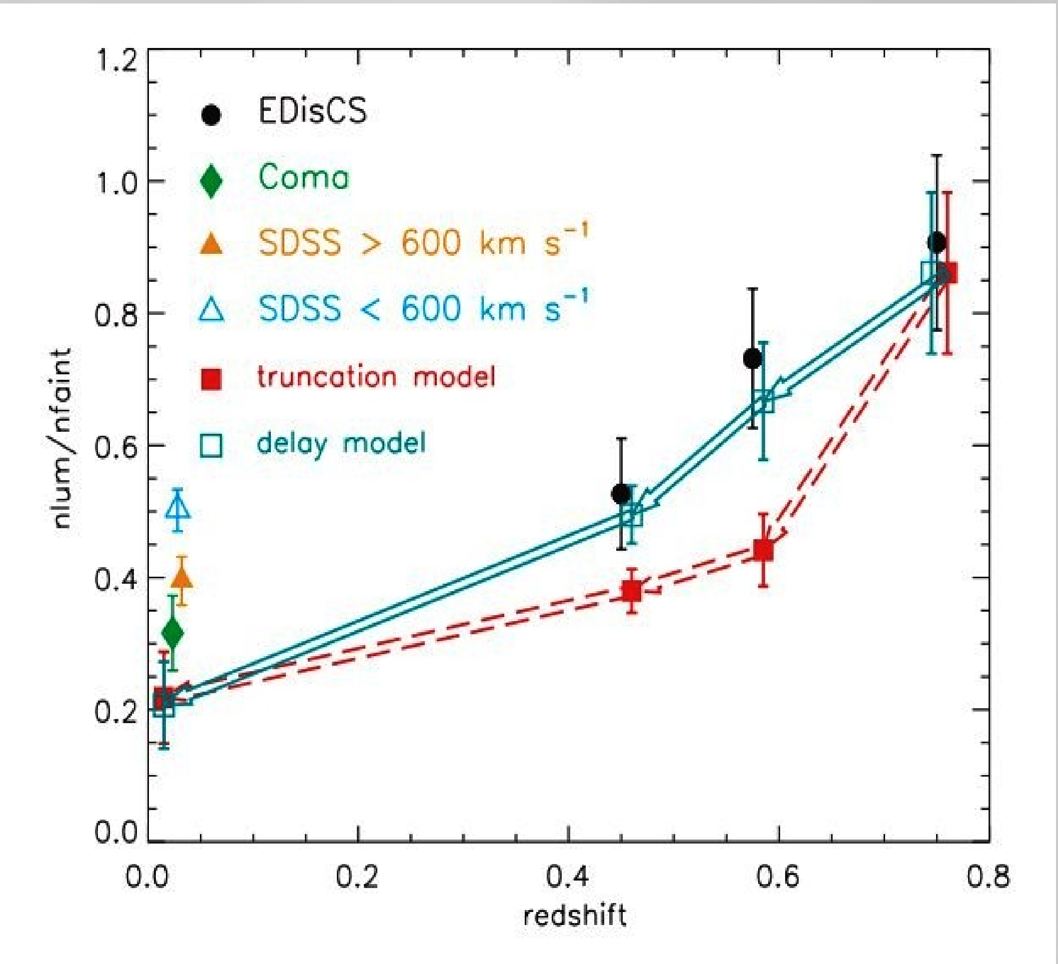
Astrophysics: the Red Sequence

RS evolution constrains formation epoch of cluster galaxies as a function of their luminosities (masses).

Euclid will determine the evolution of the cluster RS down to ~H_{AB}^{*}+2 out to z~2 using:

~30000 galaxies (resp. 4000)
in ~700 clusters (resp. 100)
at z≥1 (resp. z≥1.5)
with sufficient z_{phot} accuracy

(cmp. with ~20 clusters in De Lucia et al. 2007, none at z>1)



Euclid: optimised for shape measurements

Euclid Consortium

M51

SDSS @ z=0.1 Euclid @ z=0.1 Euclid @ z=0.7

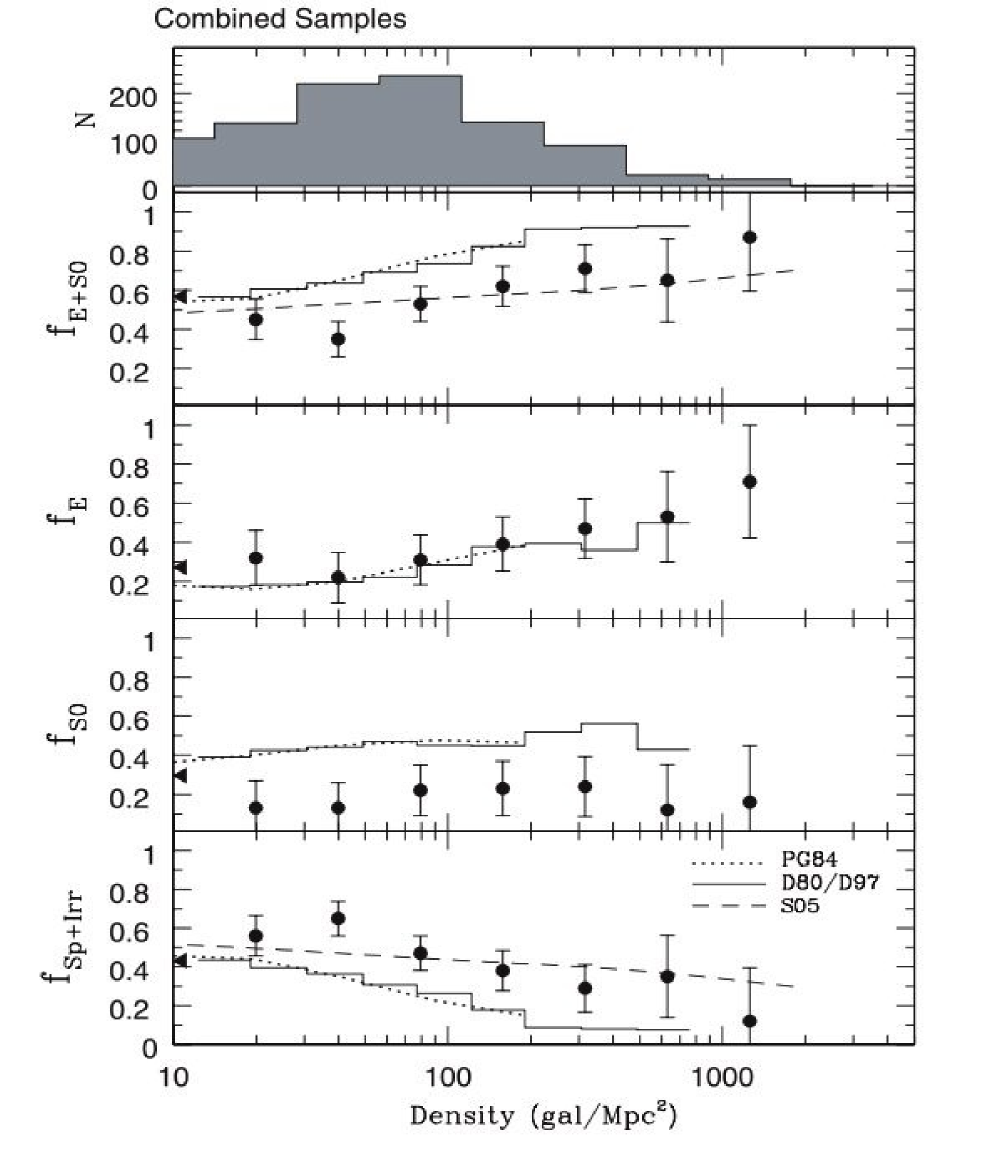
- Euclid images of z~1 galaxies: same resolution as SDSS images at z~0.05 and at least 3 magnitudes deeper.

Astrophysics: the Morphology-Density relation

Important to constrain *both* the *color* (from the study of RS) *and* the *morphological* (from the study of **MDR**) evolution of galaxies to understand which physical processes are at work.

Euclid will determine the evolution of the cluster MDR in the VIS channel down to ~M_{AB}^{*} +2 at z≤1.4, (M_{AB}^{*} at z>1.4) using ~5000 galaxies in ~700 clusters at z≥1, of which ~1800 with z's.

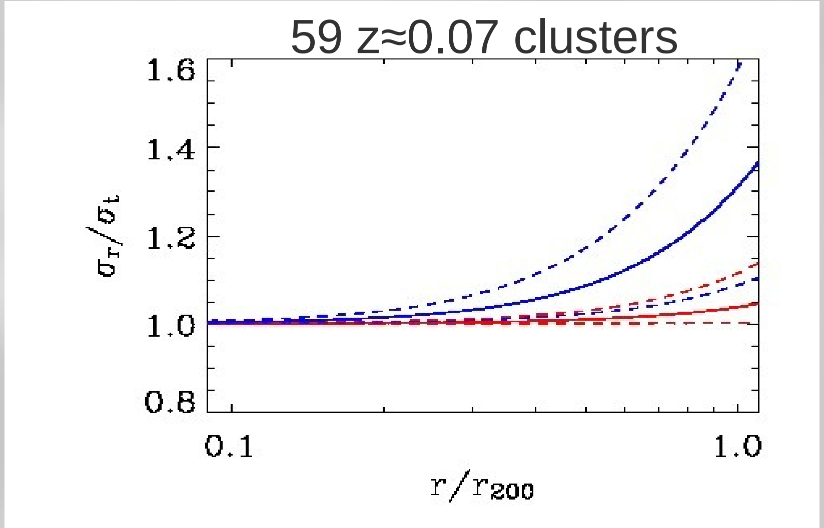
(cmp. with ~2000 galaxies with z_{phot} only and no z's in ~15 clusters, Postman et al., Smith et al. 2005)

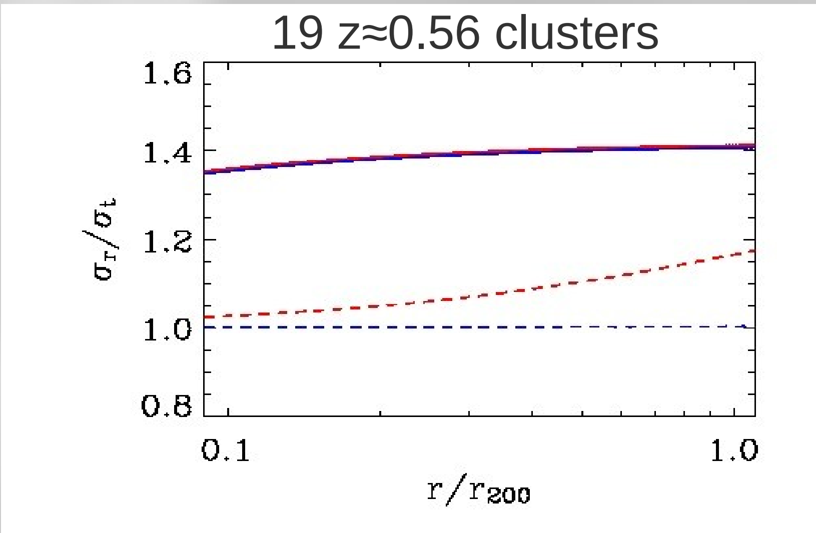


Astrophysics: the orbits of galaxies in clusters

Clusters grow via the accretion of field galaxies. How does this accretion rate change with time? How long does it take for the cluster environment to shut off star formation in infalling field galaxies? The **orbits** of galaxies in clusters hold clues about these items.

By combining M(r) from stacked WL analysis with galaxy z's from spectroscopic survey Euclid will be able to determine the orbital anisotropy of cluster emission-line galaxies for the first time out to z≥1 with an improvement x5 wrt the current observational situation at z~0.6 *(Biviano & Poggianti 2009)*





Conclusions:

Clusters in **Euclid** will help the main cosmological probes (WL shear maps and BAO) in constraining the nature of DE and Gravity.

Clusters in **Euclid** will hugely improve our understanding of how the gas and galaxies evolve in clusters thanks to the combination of lensing, redshifts, photometry & the complementarity with other missions.

Conclusions:

We are 62 (out of 600 in the Euclid Consortium) scientists at work for the galaxy clusters in Euclid.

If you want to contribute contact:

Science:

Jim Bartlett, Lauro Moscardini, Jochen Weller,
managers of the
Galaxy Clusters Science Working Group

Algorithms implementation and validation:

Tommaso Giannantonio, Sophie Maurogordato, Roser Pelló, myself,
managers of the
Galaxy Clusters Work Packages


Mission launch 2020,
end of mission 2027
...another 15 years in
this position... no
wonder that I suffer
from back pain!