# Additional cosmology: Clusters of Galaxies

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**Euclid Italian National meeting, 23rd -25th February 2022**

# SWG Clusters of Galaxies Workpackages

**Coordinators: L. Moscardini, J. Weller, J. Bartlett** (deputy)

**~ 180 members, ~30% Italian**

**11 Working Packages**

**7 of them with an Italian co-lead (8 in total)**

- **CG-WP1 Sample selection:** Brodwin, Gonzalez, Maturi
- **CG-WP2 Mass modelling:** Schrabback, **Sereno**
- **CG-WP3 Likelihood: Costanzi,** Sartoris
- **CG-WP4 Statistics on Cluster Samples:** Blot, **Marulli**
- **CG-WP5 Mass-Observable Relation:** Pacaud, Pratt
- **CG-WP6 Validation: Bardelli,** Pello
- **CG-WP7 Astrophysics of Clusters of Galaxies: Ettori,** Hatch, Pierre
- **CG-WP8 External Data:** Melin, Reiprich, Stanford
- **CG-WP9 Cluster Simulations: Borgani, Giocoli**
- **CG-WP10 Weak Lensing Selected Clusters:** Diego, Pires
- **CG-WP11 Proto-Clusters: Cucciati,** Dannerbauer

**Strong and positive synergy/overlapping with Ground Segment OULE3 Clusters**

# List of Key Projects approved by the ECPG

| # | Name of Project | Summary Text | Workpackage Link | Data Release |
|---|---|---|---|---|
| KP-CG-PL-1 | Validation of the Cluster Cosmology Pipeline | | CG-WP3 | PL |
| KP-CG-PL-2 | Establishing the Cluster Selection Function for Euclid | | CG-WP9 and OU-LE3 | PL |
| KP-CG-PL-3 | Precision Simulations for Cluster Cosmology | | CG-WP9 | PL |
| KP-CG-PL-4 | Euclid galaxy clusters legacy science | | CG-WP7 and CG-WP11 | PL |
| KP-CG-PL-5 | Cluster mass-observable relation | | CG-WP5 | PL |
| KP-CG-PL-6 | Meta-Catalogues for Euclid Cluster Science | | CG-WP8 | PL |

## KPs managed by OULE3 – Clusters

SWG+OULE3 joint meeting $7^{th}$-$9^{th}$ February 2022

## CGSWG-OU-LE3 Joint Meeting - Monday, February, 7th - Wednesday, 9th, 2022

Agenda:

Meeting Zoom Link: https://lmu-munich.zoom.us/j/94371295382
Meeting ID: 943 7129 5382
Passcode: 722307

Slack Channel: #swgmeeting2022 at euclidclustersswg.slack.com

**February, 7th**

Chairs: Jochen Weller

| Time | Speaker | Title |
|---|---|---|
| 15:00 - 15:40 | B. Sartoris, M. Costanzi, A. Fumagalli | WP3/KP-CL1: Likelihood |
| 15:40 - 16:20 | T. Castro, A. Fumagalli, C. Giocoli | WP9/KP-CL3: Cluster Simulations |
| 16:20 - 16:50 | Break | Coffee Break |
| 16:50 - 17:20 | A. Stanford, J.-B. Melin | WP8/KP-CL6: Velocity Dispersions Mass comparison |
| 17:20 - 18:00 | M. Bolzonella, M. Radovich, all | Discussion on complementary ground data |
| 18:00 - 19:00 | | General Discussion |

**February, 8th**

Chairs: Roser Pello, Lauro Moscardini

| Time | Speaker | Title |
|---|---|---|
| 15:00 - 15:40 | S. Pires, J. Diego | WP10: Weak Lensing Selected Clusters |
| 15:40 - 16:20 | N. Hatch, E. Koulouridis/S. Bhargava, S. Mei | WP7/KP-CL4: Astrophysics of Clusters, Intracluster Light |
| 16:20 - 16:50 | Break | Coffee Break |
| 16:50 - 17:10 | M. Sereno, T. Schrabback | WP2: Mass Modelling |
| 17:10 - 17:30 | F. Marulli, M. Romanello | WP4/KP-LE3-CL-3: Stastistics on Cluster Samples |
| 17:30 - 18:10 | A. Gonzalez, J.B. Melin, M. Maturi, E. Munari, J. Bartlett | WP1/KP-CL2: Sample Selection/Selection Function |
| 18:10 - 19:00 | | General Discussion |

**February, 9th**

Chairs: Emiliano Munari, Sophie Maurogordato

| Time | Speaker | Title |
|---|---|---|
| 15:00 - 15:40 | Cabanac/Clerc/Pello | OU-LE3/WP6 Validation |
| 15:40 - 16:20 | H. Dannerbauer | WP11/KP-CL4 Protoclusters |
| 16:20 - 16:50 | Break | Coffee Break |
| 16:50 - 17:30 | Pacaud/Ragagnin/Maughan/Biviano | WP5/KP-CL5: KP status , Covariances , ICM informed Mwl-Rich , Kinematics |
| 17:30 - 17:50 | Cabanac/Castignani | KP-LE3-CL-1: Detection of Galaxy Clusters/Cluster Catalogs |
| 17:50 - 18:30 | A. Biviano, L. Ingoglia | KP-LE3-CL-2: Properties of Detected Clusters, Introduction, Mean redshift and velocity dispersion, Mass measurements |
| 18:30 - 19:00 | | General Discussion Andreon: DR1 depths Bolzonella: Flagship1+PHZ |

**Thanks to all speakers for sharing the slides!**

## KP-CG-PL-1 PAPERS

**Validation of the Cluster cosmology pipeline**

**Leads KP1/WP3:**
**M. Costanzi & B. Sartoris**

- **Paper 1: The HSC Amico Cluster Catalog** (Coordinators: Matteo Maturi, Barbara Sartoris):

  In this paper is presented the AMICO/PzWav cluster catalog extracted from the latest publicly available HSC data. The paper will include a preliminary calibration of the selection function based on the Selection Function extrActor code (SinFoniA) developed for AMICO KiDS, and a comparison with CAMIRA, the cluster catalog produced by the HSC collaboration.

- **Paper 2: Modelling of Euclid Cluster Cosmological Likelihood- Systematics and Statistics** (Coordinators: Alessandra Fumagalli, Ziad Sakr):

  In this paper we will present the detailed modelling of the likelihood function including the treatment of systematic and statistical errors – e.g. due to projection effects or modelling of the halo mass function. Besides the cluster counts likelihood, the analysis includes the mass calibration and 2-point correlation likelihoods, as well as their correlation with the cluster number counts. The likelihood code will be tested and validated on Euclid-like mock data.

- **Paper 3: Constraints from the AMICO HSC Cluster Catalogs with the Euclid Cluster Cosmology Pipeline** (Coordinators: Matteo Costanzi, Giorgio Lesci):

  In this paper we will test the Euclid Cluster pipeline on real data, applying the methodology developed in Paper II on the catalog presented in Paper I. Given the limited area probed by HSC we will consider the possibility of including or not the 2pt. correlation function in the analysis.

# HSC CLUSTER CATALOG

1 – Definition of the galaxy catalogue

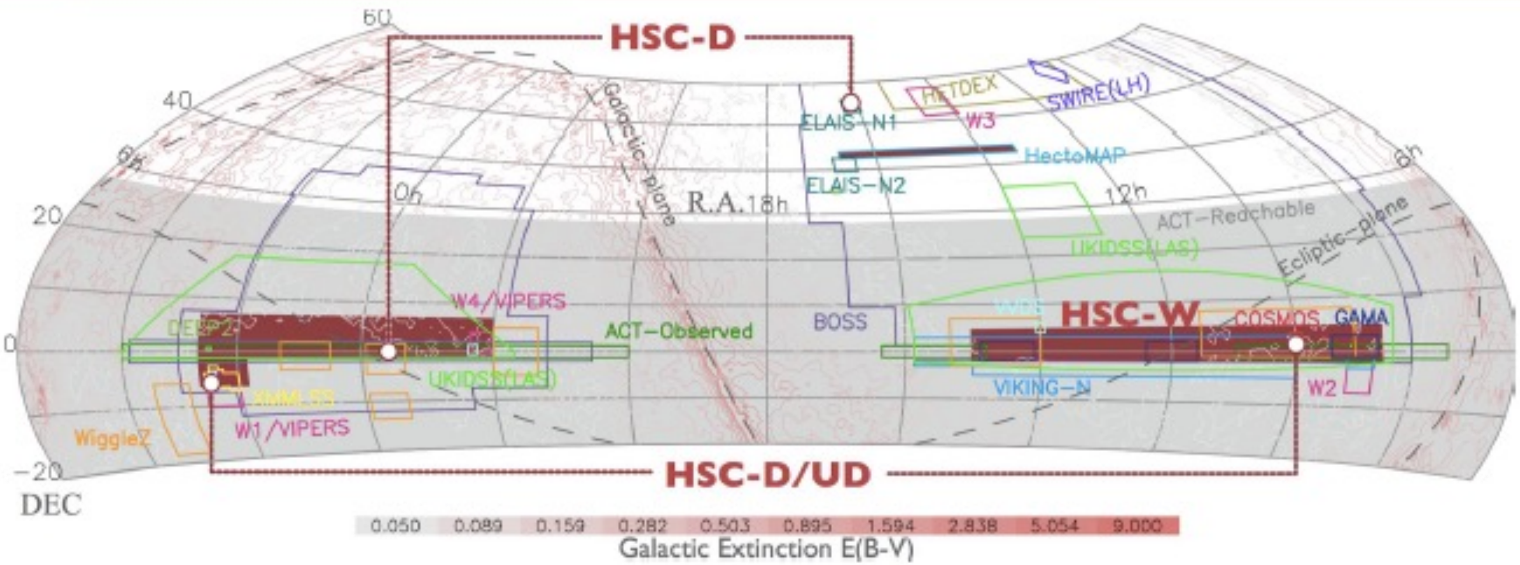
2 – Definition of the AMICO and PzWav inputs (mask, model…)

3 – Extraction of the cluster catalogues

4 – Comparison with CAMIRA (Oguri et al. ) (~ same data set)

5 – Comparison with other samples (XMMLSS, KIDS, ACT)

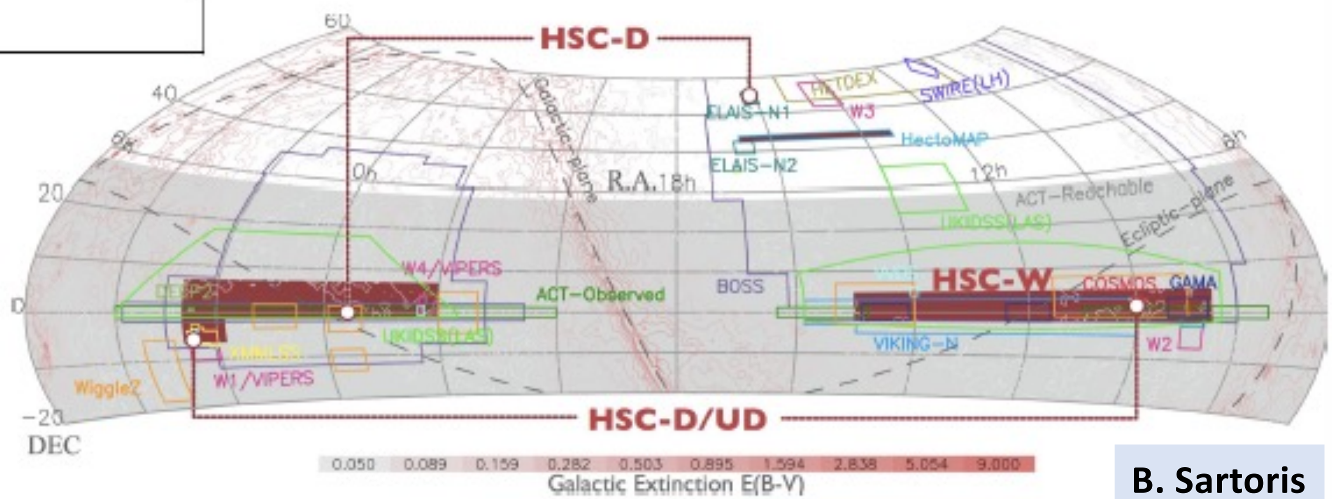
6 – Preliminary characterization of the cluster catalogue




B. Sartoris

# HSC CLUSTER CATALOG

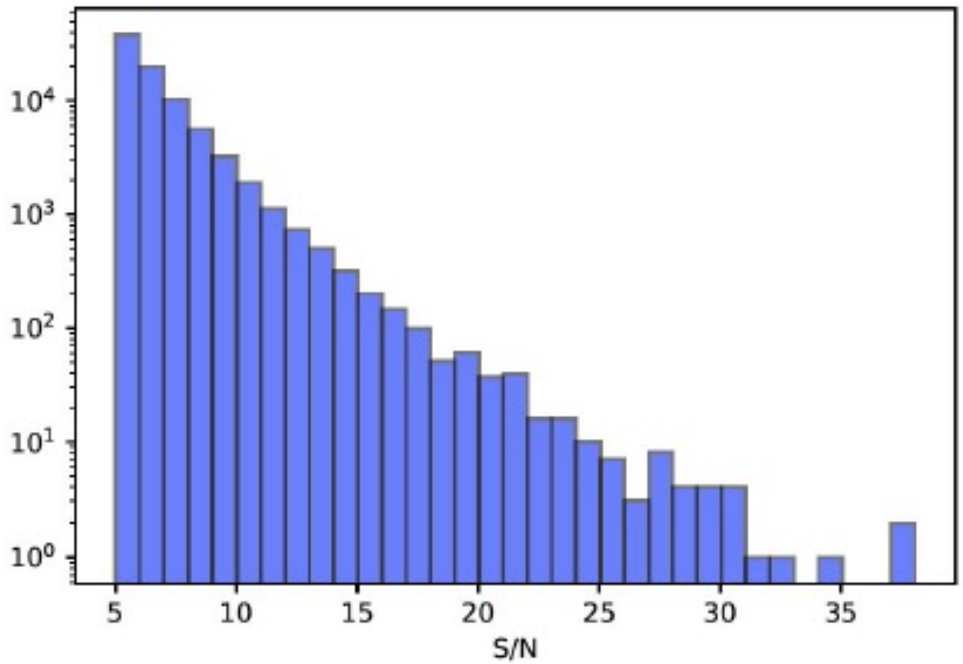
| | HSC | Euclid |
|---|---|---|
| wide survey[deg$^2$] | 232 (DR1)<br>1 114 (DR2)<br>1 400 (Goal) | 15 000 |
| deep survey[deg$^2$] | 26 | 2x40 |
| ultra deep survey[deg$^2$] | 3.5 | NO |
| filters | *grizy* | *VIS (single large band) + YJH griz(ground based, Wide)* |
| Magnitude limit (wide survey) | r~26 | VIS~24.5 |
| Magnitude limit (deep survey) | r~27(DS), r~28(UDS) | VIS~26.5 |
| FoV (single pointing) | 1.8 deg$^2$ | 0.53 deg$^2$ |

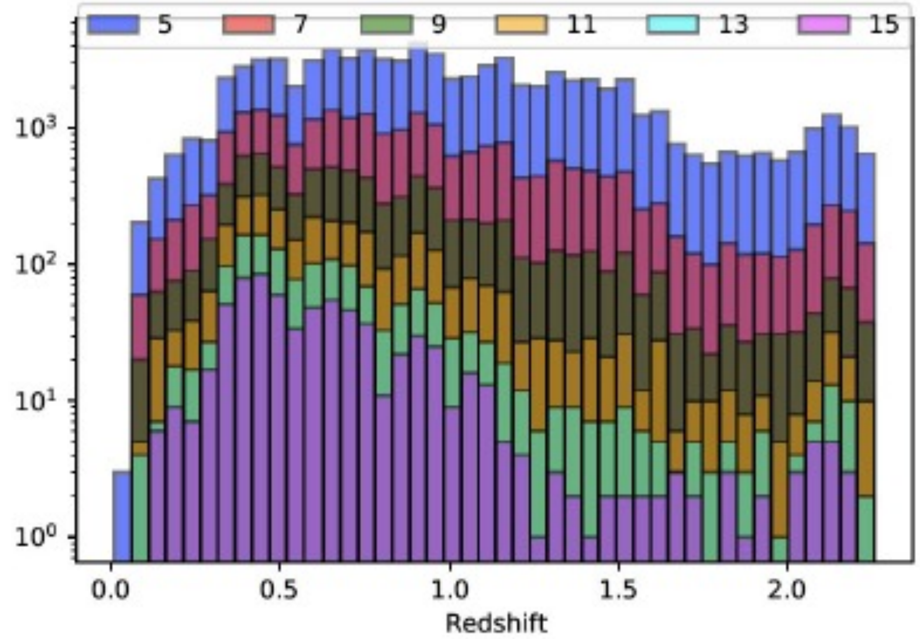



B. Sartoris

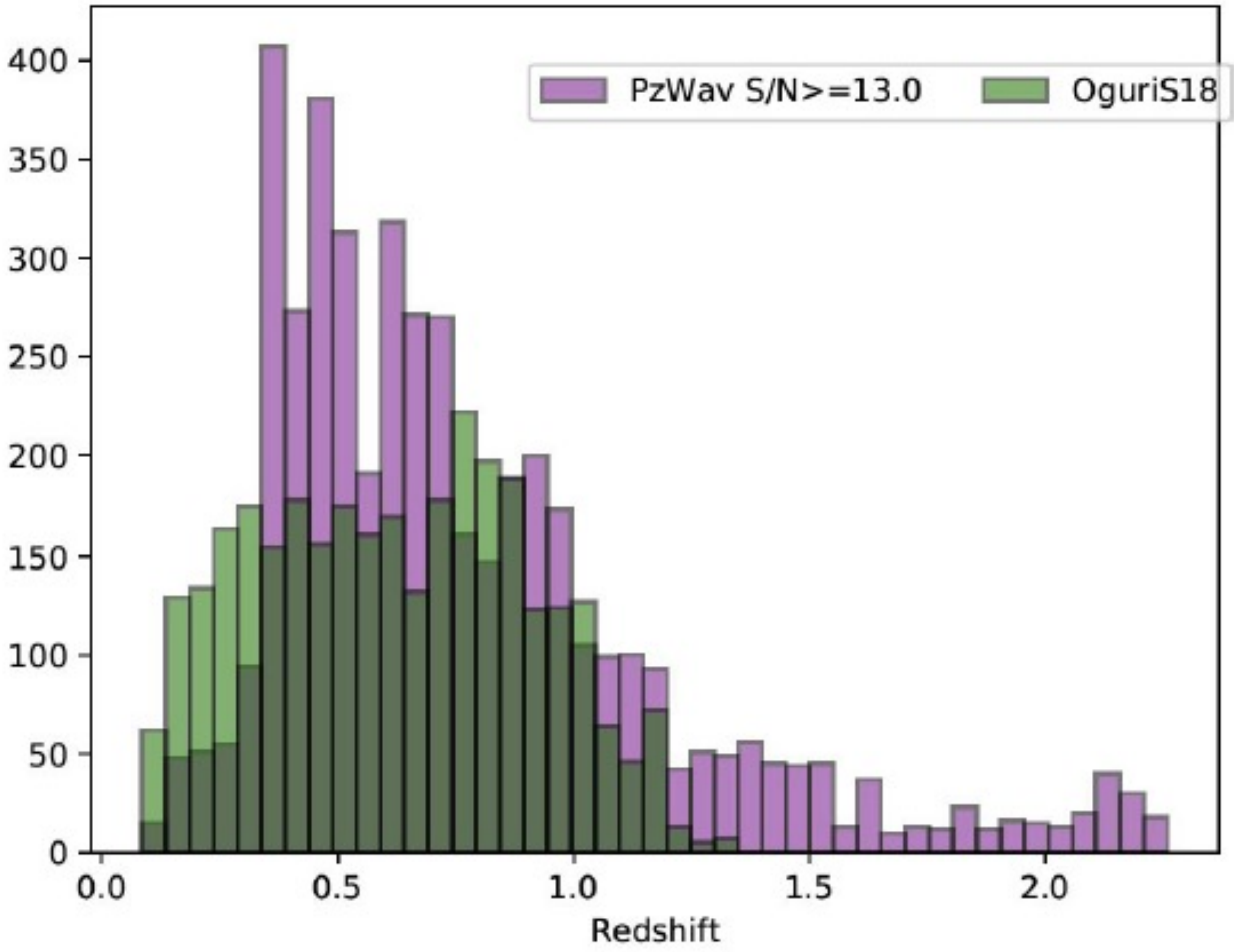
# HSC CLUSTER CATALOG

Cluster sample obtained from HSC-DR2 galaxy catalogue (y-band) with PzWav with different S/N limits



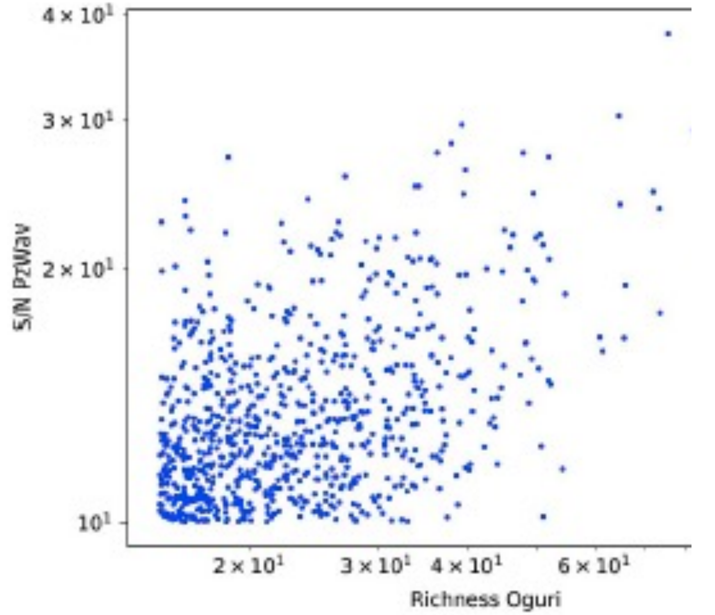




B. Sartoris





**Cluster sample obtained from HSC-DR2 galaxy catalogue (y-band) with PzWav**



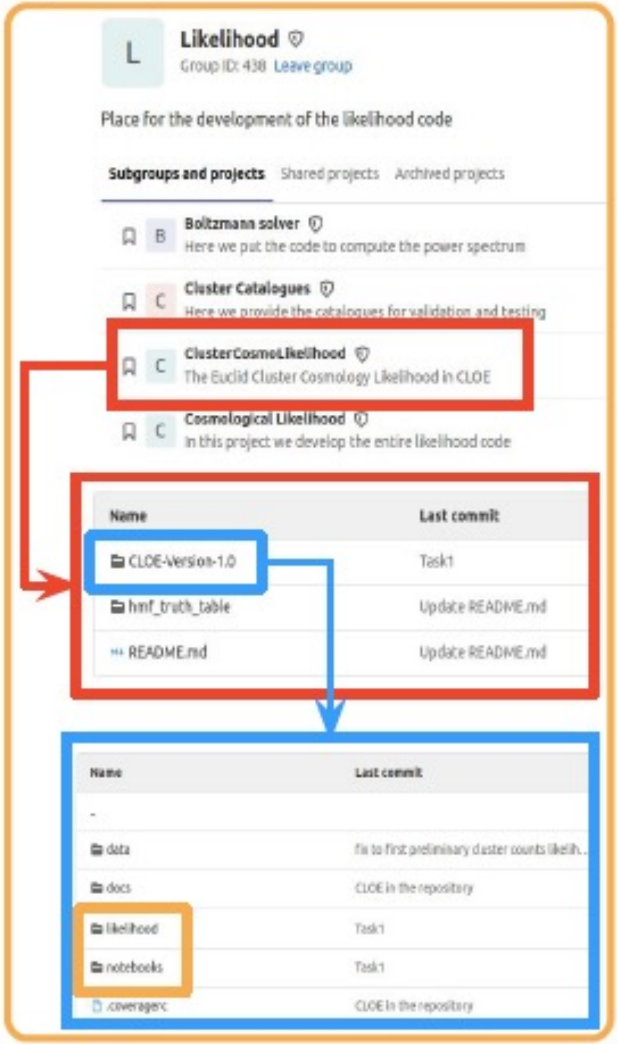


**B. Sartoris**

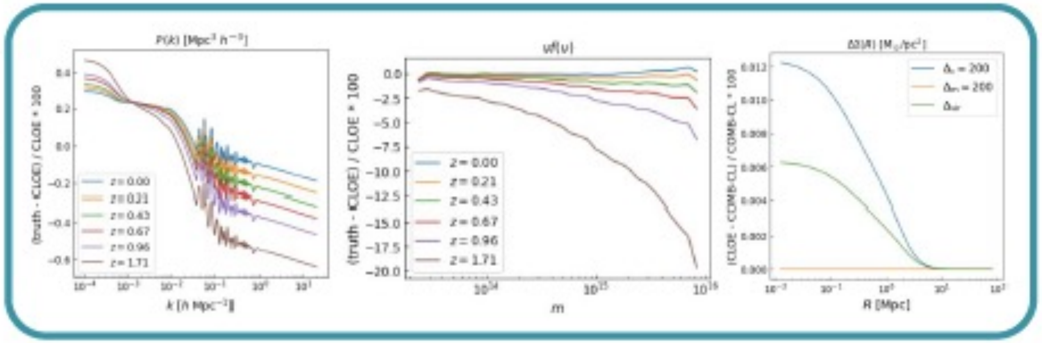
# CLUSTER COSMOLOGY PIPELINE

**M. Costanzi**

- **Cluster Cosmology Pipeline**
  - 3 Likelihoods: $\ln \mathcal{L}^{\rm tot} = \ln(\mathcal{L}^{\rm NC} \otimes \mathcal{L}^{P(k)/\xi(r)}) + \ln(\mathcal{L}^{\rm MOR})$
    - Cluster counts
    - Mass calibration (Stacked Weak Lensing)
    - Clustering of clusters (not started yet)
  - Implemented in the official Euclid pipeline CLOE
  - Code developer team: Emmanuel Artis, Giorgio Lesci, Ziad Sakr, Matteo Costanzi, Laura Salvati, Amandine Le Brun, Carlo Giocoli, Alessandra Fumagalli
  - Closely follows the IST:Likelihood standards (modularity, documentation, unit tests, etc)




[Notebook](#) **with quick start guide and validation scripts**

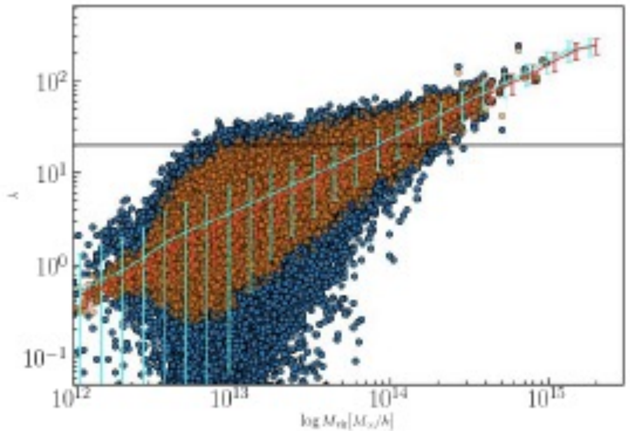


# PIPELINE VALIDATION

M. Costanzi

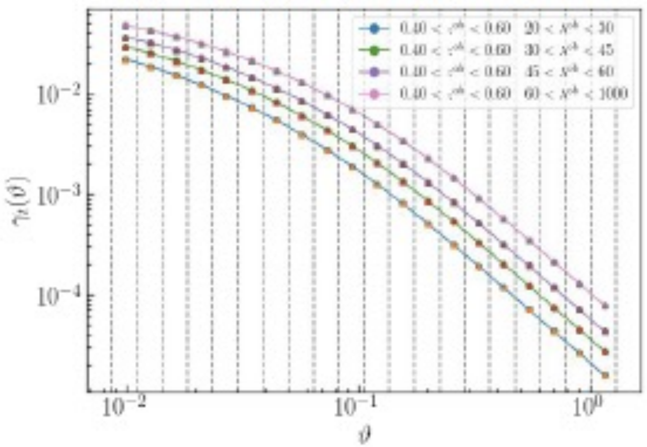
- **Mock data for code validation:**
  - From a 10.000 deg$^2$ halo light-cone catalog ($M_{vir}$>$10^{12}$ $M_\odot$/h), assigning to each halo an observed richness, redshift and lensing profiles according to the equations implemented in the code
  - Aim: validate the code implementation and test effects of modeling choice on parameter posteriors

True and observed richness mock data



- **Mock data for end-to-end validation:**
  - From AMICO run + shear measurements on Euclid-like mock galaxy catalog.
  - Aim: Validate modeling and systematics; additional robustness tests on systematics

Mean tangential shear profiles mock data



# LIKELIHOOD MODELING: CLUSTER NUMBER COUNTS

A. Fumagalli

Number counts:

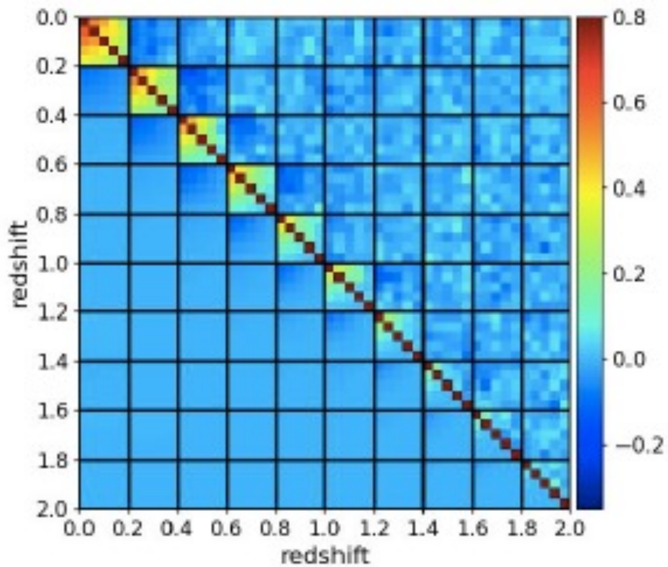
$$N_{\alpha i} = \Omega_{sky} \int_{\Delta z_\alpha} dz \frac{dV}{dz d\Omega} \int_{\Delta M_i} dM \frac{dn(M,z)}{dM}$$

Covariance model (Hu & Kravtsov 03):

$$C_{\alpha\beta ij} = \langle N \rangle_{\alpha i} \delta_{\alpha\beta} \delta_{ij} + \langle Nb \rangle_{\alpha i} \langle Nb \rangle_{\beta j} S_{\alpha\beta}$$

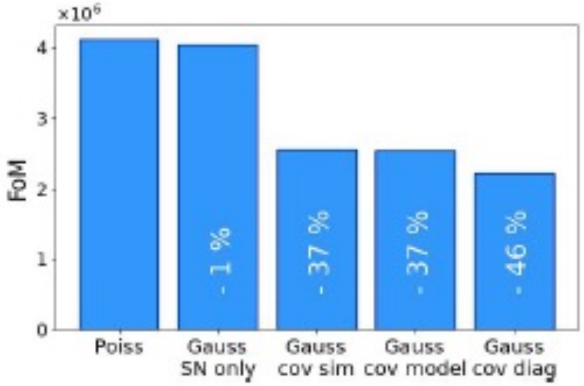
$$S_{\alpha\beta} = \int \frac{\mathrm{d}^3 k}{(2\pi)^3} \sqrt{P(k; z_\alpha) P(k; z_\beta)} W_\alpha(\mathbf{k}) W_\beta(\mathbf{k})$$

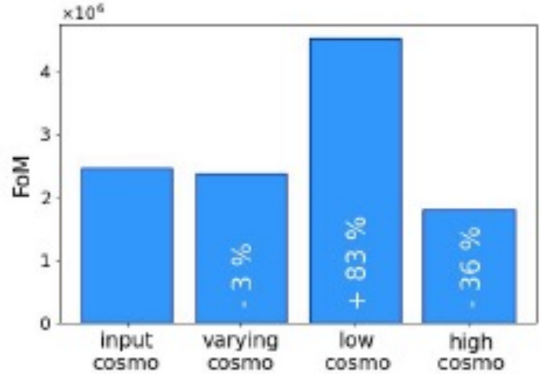
$$W_\alpha(\mathbf{k}) = \frac{4\pi}{V_\alpha} \int_{\Delta z_\alpha} \mathrm{d}z \, \frac{\mathrm{d}V}{\mathrm{d}z} \sum_{\ell=0}^{\infty} \sum_{m=-\ell}^{\ell} (\mathrm{i})^\ell \, j_\ell[k\, r(z)] \, Y_{\ell m}(\hat{\mathbf{k}}) \, K_\ell$$




**Results from Fumagalli et al. 2021:**

- Analytical covariance validated on simulations
- Sample variance non-negligible
- Redshift bins non-independent
- Cosmology-dependence non-negligible



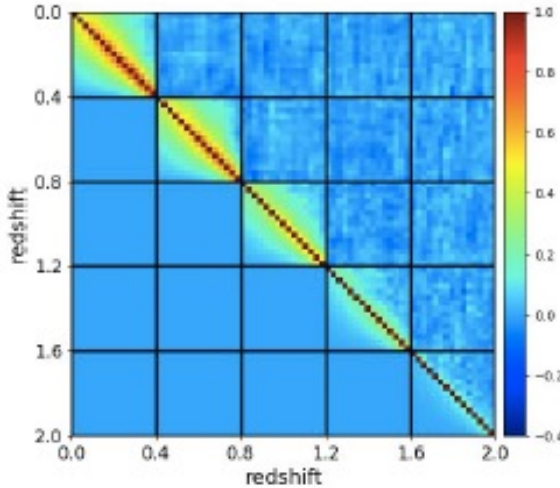



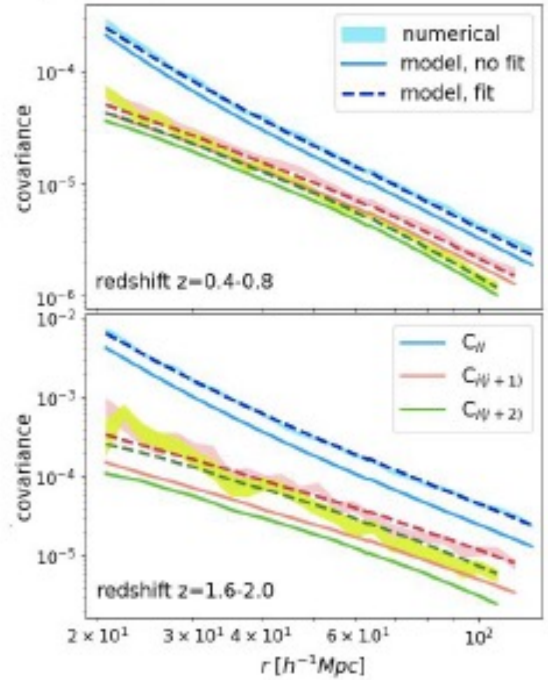
# LIKELIHOOD MODELING: CLUSTER CLUSTERING

A. Fumagalli

2-point correlation function:

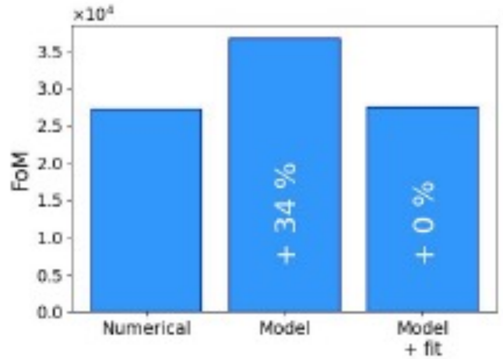
$$\xi_h(r_i, z_a) = \int \frac{dk\, k^2}{2\pi^2} (P_h)_a W_i(k)$$




Covariance model (Meiksin & White 99)

$$C_{a,ij} = \frac{2}{V_a} \int \frac{dk\, k^2}{2\,\pi^2} \left[ \left(b^2 P_m\right)_a + \left(\frac{1}{n}\right)_a \right]^2 W_i(k)\, W_j(k)$$
$$+ \frac{2}{V_a V_i} \int \frac{dk\, k^2}{2\,\pi^2} \left(b^2 P_m\right)_a \left(\frac{1}{n}\right)_a W_j(k)\, \delta^D_{ij}$$




**Results and next steps:**

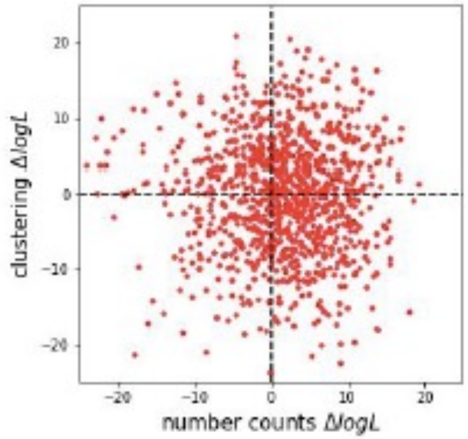
- Analytical covariance + nuisance parameters: no difference in cosmological posteriors
- Study the effect of the analytical model (cosmology dependent, parameter fit, ..) on cosmological posteriors

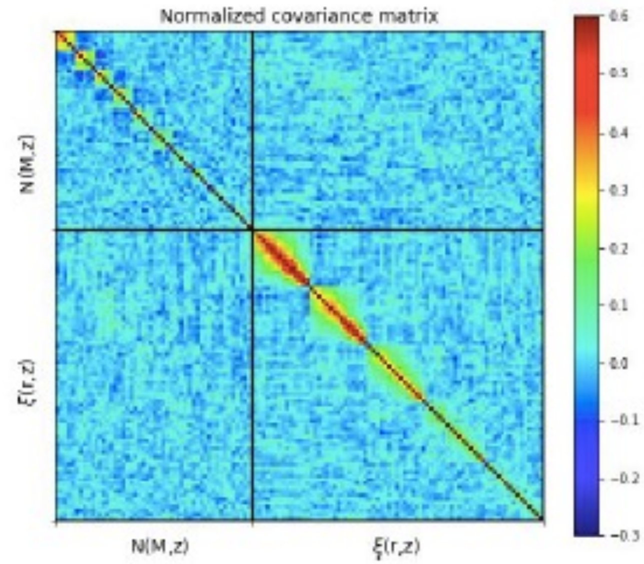
# LIKELIHOOD MODELING: JOINT ANALYSIS

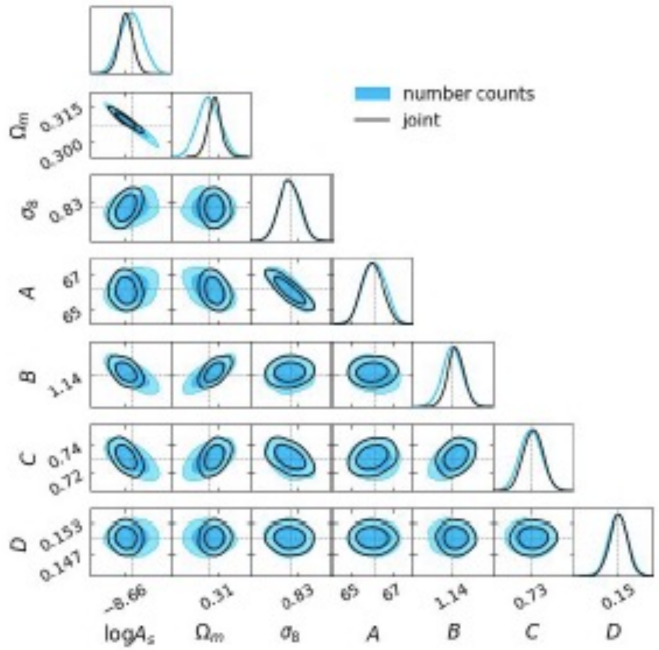
A. Fumagalli

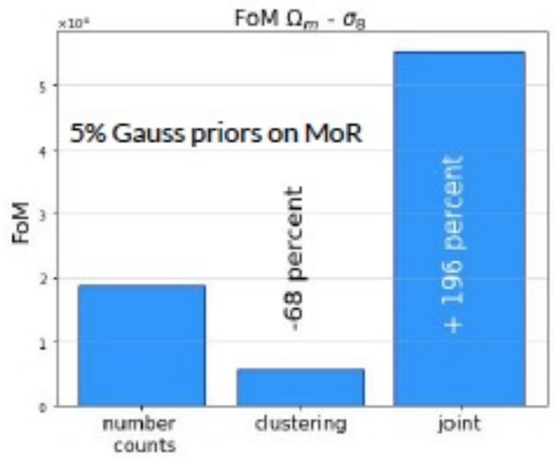
Combined analysis of number counts and clustering to improve the parameter constraints:

- Apparently, no significative correlation between the two observables (under investigation)
- Clustering contours larger than number counts, but different degeneracy direction
- Joint constraints tighter than number counts alone



# WP1 (Sample Selection)+ KP-CL-2 (Selection Function)

## KP-CL-2

**Managed jointly with OULE3**

**Coordination with KP-CL-2,** James G. Bartlett, Matteo Maturi
Establishing the Cluster Selection Function for Euclid

Goal of KP-CL-2: "Development of methods for the evaluation of the galaxy cluster selection function(s) (SF)". The KP products include:

- Methods for estimating cluster catalog completeness and purity, and distributions of noise in any quantity measured by the detection algorithms. This will be done for different potential applications of the cluster catalog. These methods will be developed in close collaboration with the relevant OU-LE3 Galaxy Cluster WP.
- Preliminary estimates of the selection functions for different applications based on pre-launch data and simulations.

# WP1 (Sample Selection)+ KP-CL-2 (Selection Function)

## KP-CL-2 Papers

**Establishing the Cluster selection for Euclid**

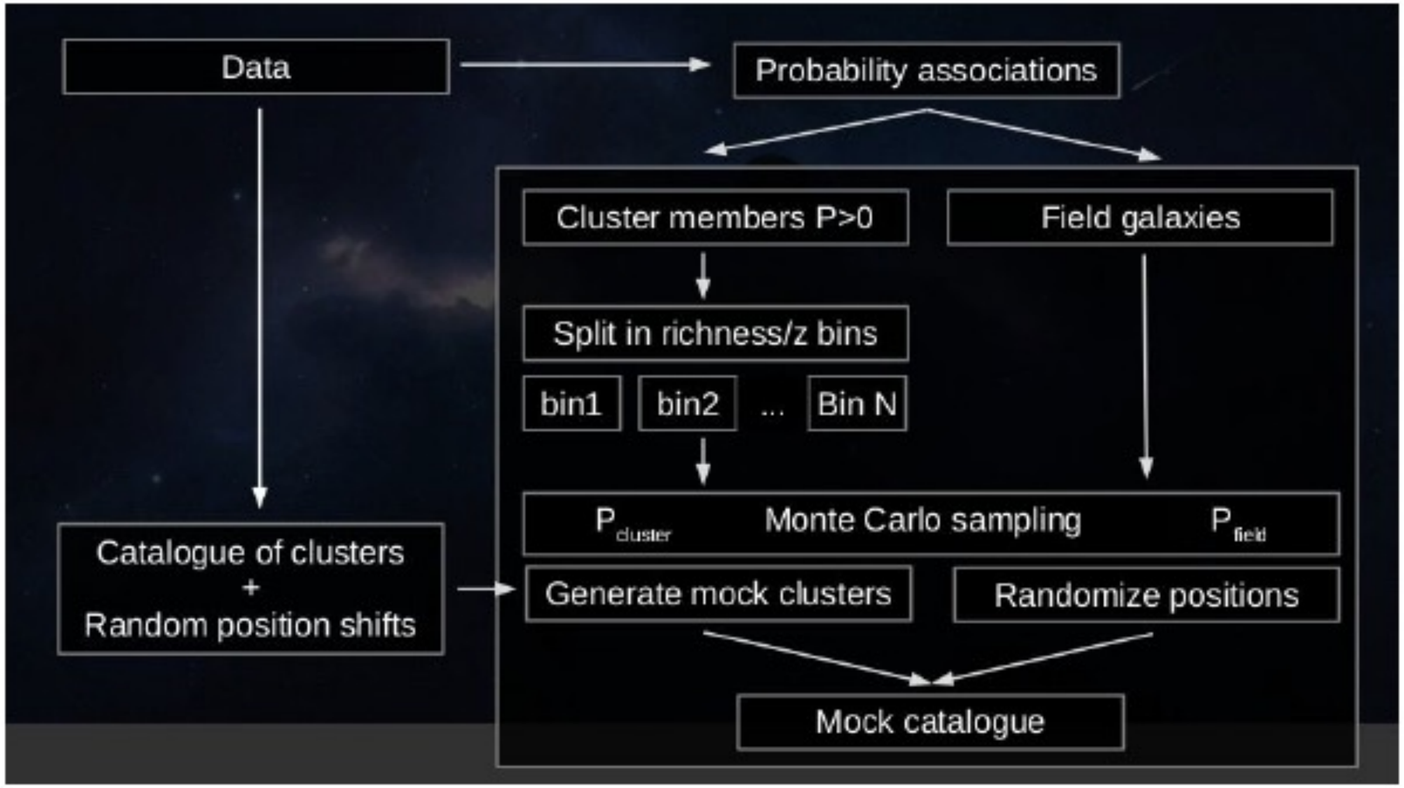
**Managed jointly with OULE3. Leads: J. Bartlett & M. Maturi**

- ❑ Euclid Preparation: Comparison of the Euclid Cluster Selection Function to Other Surveys
- ❑ Euclid Preparation: Preliminary Evaluation of the Euclid Galaxy Cluster Selection Functions
    - ❑ This work will produce a tool to be used by WP1 in their sample selection for cosmology and astrophysics (see above).
- ❑ Euclid Preparation: Testing SinFoniA against numerical simulation.
- ❑ Euclid Preparation: What are optical galaxy clusters?

SinFoniA on HSC? ok KP2 selection
test sample selection on HSC?

A call will go out through the Project Portal asking people to sign up to contribute to the papers of their interest. Once the teams are formed, we will go through the process with the teams of identifying the leads.

# SinFoniA is a data driven approach




**Mock generation**

It preserves:
- magnitudes, photo-z
- survey masks / depth / footprint
- survey depth
- correlation of field galaxies
- correlation of clusters with LSS
- reproduces the statistics of the data

P_cluster + P_field = 1

**Run detection algorithm**

**Perform matching**

**Get purity / completeness**

# CL-SWG WP-9: Simulations of Galaxy Clusters
# KP-CL-3: Precision Simulations for Cluster Cosmology

Tiago Batalha de Castro - Stefano Borgani - Carlo Giocoli

# KP-CL-3 papers

1. *Calibration of the Cluster HMF in vanilla LCDM models (R. Angulo, S. Bocquet, and T. Castro)*

- Formally study Euclid's calibration requirement for the HMF;
- Characterization of the Theoretical/Numerical systematics on the HMF.

(Castro+2022, in prep)

2. *Characterization of the covariances for cluster HMF and HB (A. Fumagalli and A. Saro)*

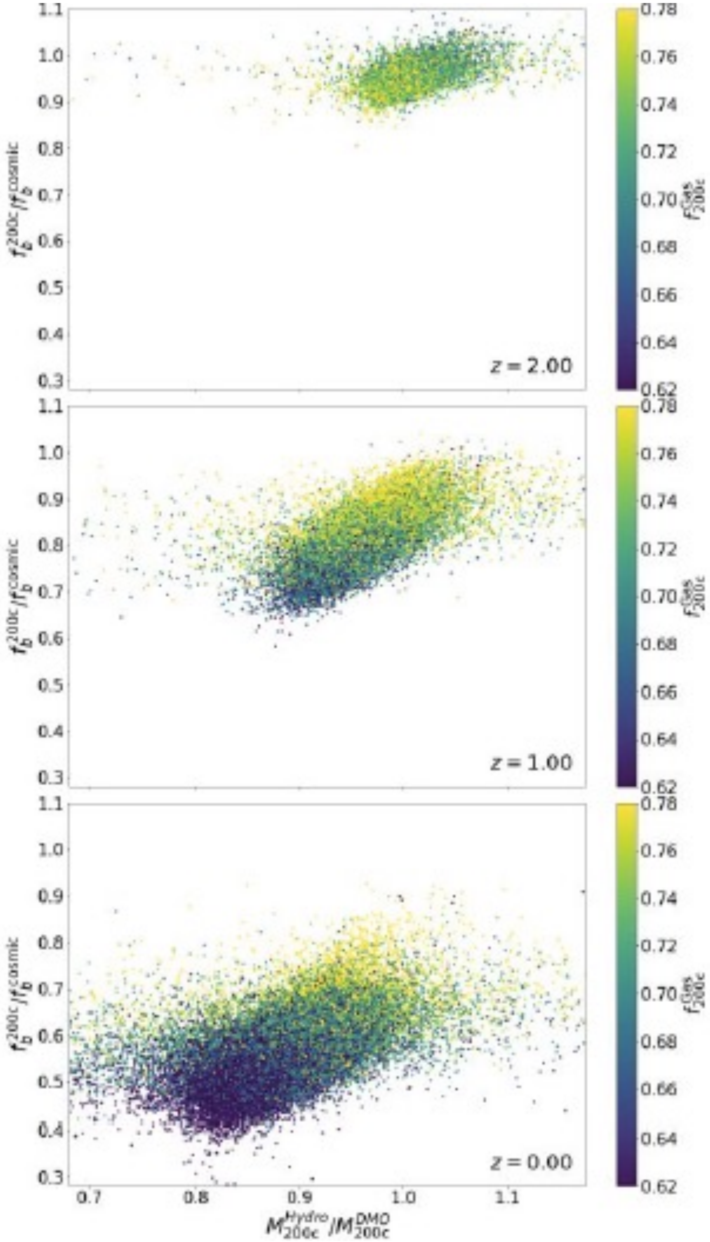
- To analyse a large ensemble of Euclid-like PLCs based on approximate methods;
- To assess the cosmology-dependence (or universality) of such covariances.

(Fumagalli+2021, arXiv:2102.08914, Fumagalli+2022)

# KP-CL-3 papers

*3. Baryonic effects on HMF and HB (S. Borgani and T. Castro)*

- Characterize the main physical mechanisms responsible for the Hydro-bias;
- Characterize the feature importance to distinguish between them;
- To define a criterion based on observable quantities to carry out a “statistical baryonic mass correction” for real clusters.

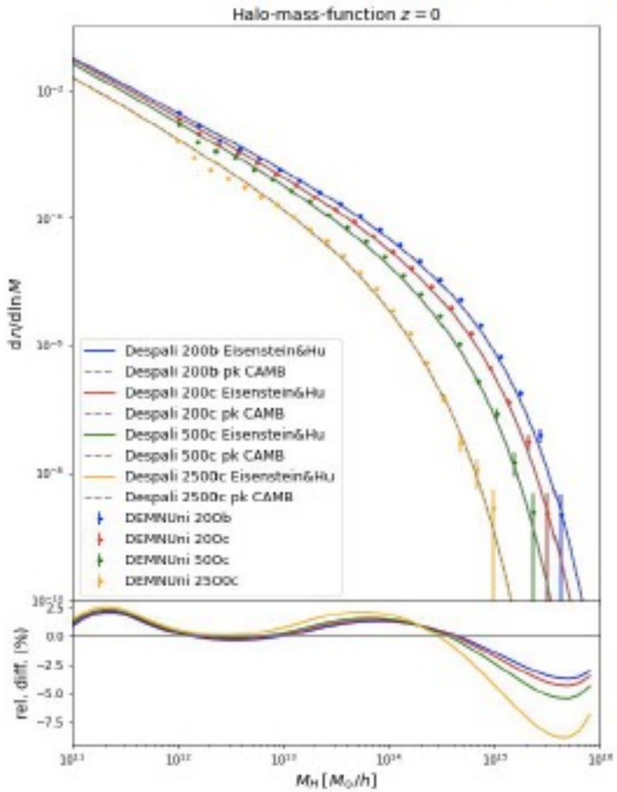


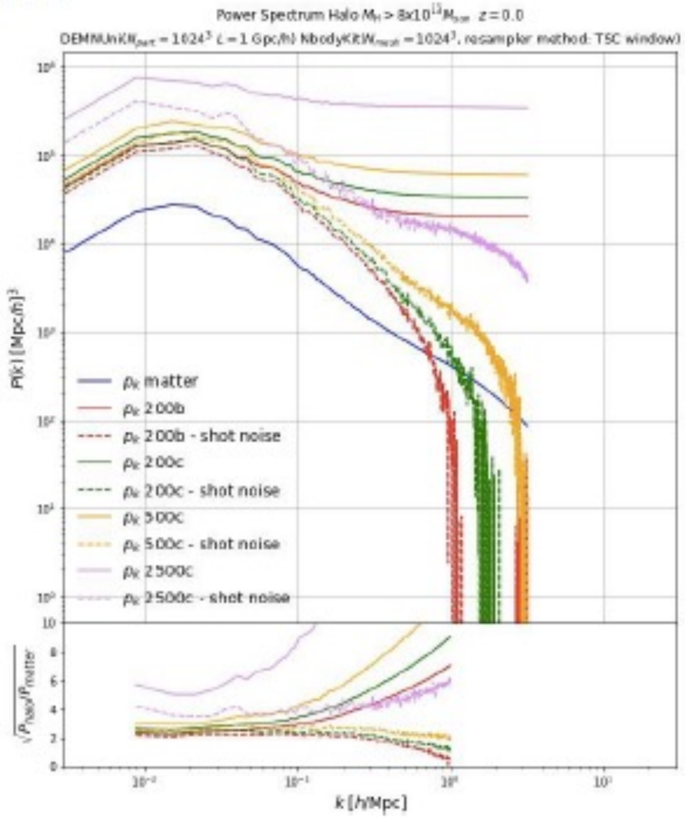
CL - SGW Meeting 2022: WP9

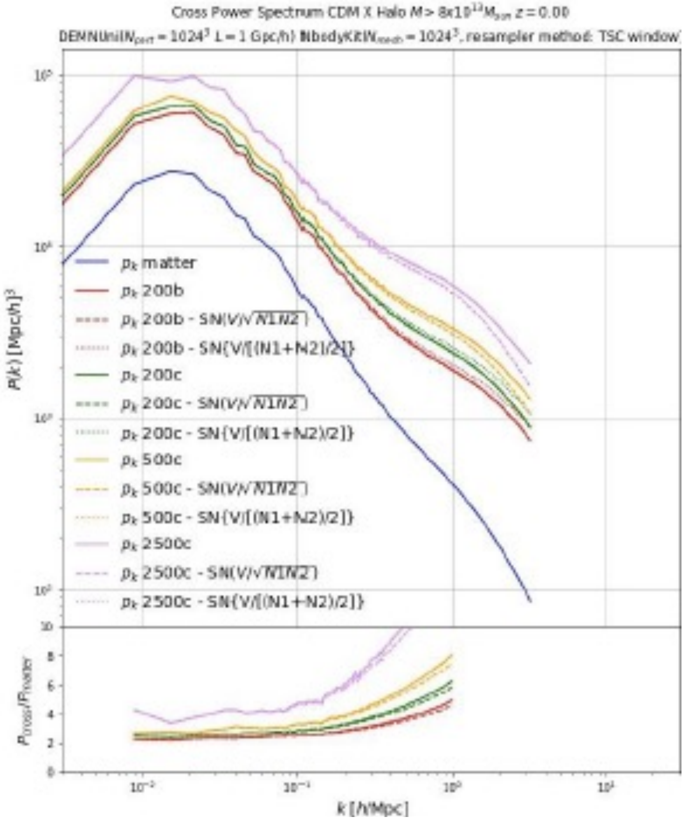
# KP-CL-3 papers

*4. HMF and HB in non-standard models: f(R) and massive neutrinos (M. Baldi and C. Carbone)*

- To collect, carry out and analyse extended sets of large N-body simulations;
- To estimate and model HMF and HB in non-standard models;
- Pipeline analysis being tested.



# KP-CL-3 papers

*5. 3D and 2D profiles: concentrations in LCDM and non-standard models (A. Le Brun and C. Arnold)*

- Since October 2021, David Motta had to step down;
- Gathered core team (~10), existing simulations;
- Decided to use a common pipeline with common halo finder (DENHF);
- Adapting DENHF to work on all simulations;
- Defined test sample for testing pipeline outputs from all simulations and test diagnostics;
- Established roadmap leading to two papers (one on Dark Matter Only simulations and one for simulations with baryons);
- Started outlining first paper and thinking about alternative ways to measure and quantify profile shapes (i.e. beyond concentration).

# KP-CL-3 papers

*6. Convergence and shear maps of simulated clusters: calibration of WL masses (C. Giocoli and S. Pires)*

- To present and deliver a database of "Euclidized" convergence and shear maps for cluster-sized halos;
- To apply methods of WL mass reconstruction from "Euclid-like" maps.

(Giocoli et al. 2021, in prep)

*7. Impact of hydrodynamical modelling on the weak lensing signal of massive halos (S. Grandis and A. Le Brun)*

- Extend the "Euclidized" maps to different simulations;
- Model the uncertainty on WL bias from hydro modelling.

# Paper I: Calibration of the Cluster HMF in vanilla LCDM models:

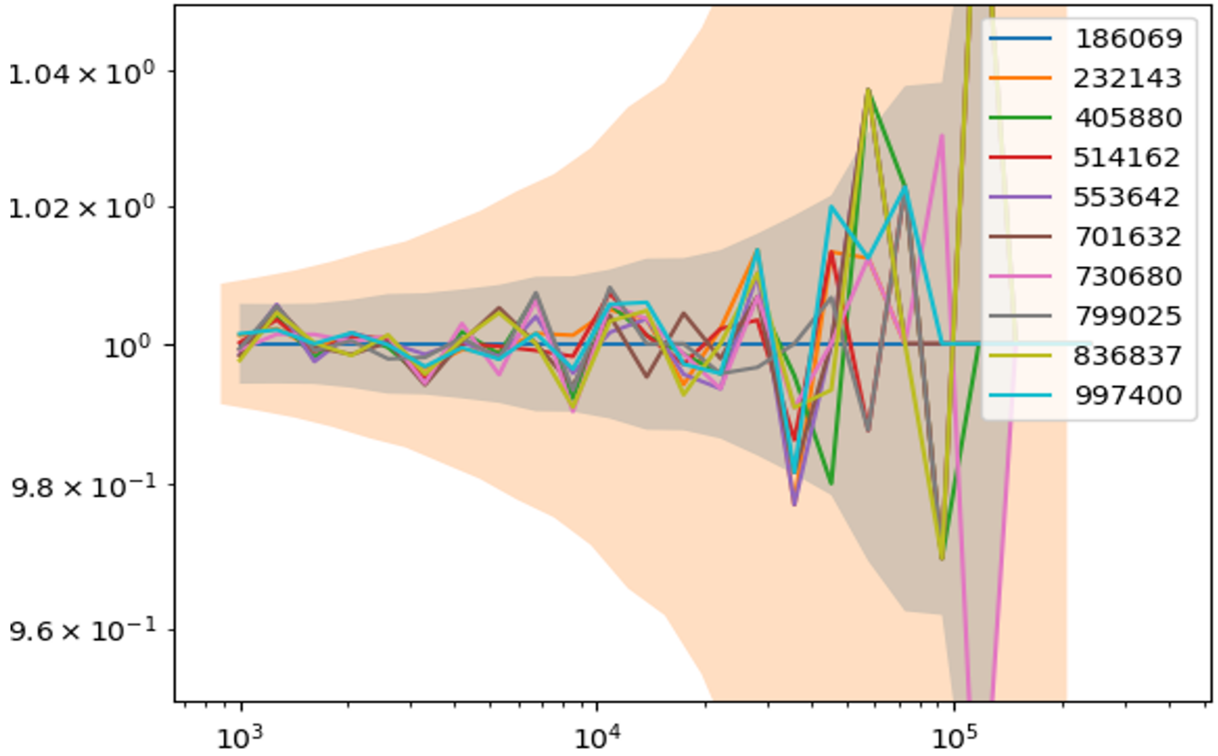
*Systematic effects can limit the precision and accuracy that the HMF can be assessed from simulations.*

- Study the impact of different N-Body codes:
  - We have carried out convergence tests for the adopted set-up of **Open-GADGET** and **GADGET-4;**
  - We have used the default set-up of the **CONCEPT** code. The default set-up of CONCEPT has been extensively tested and compared with other codes by Dakin et al. (2021);
  - Used the conservative **PKDGRAV-3** example set-up (D. Potter, 2021, priv. comm.);
  - We have used the recommended **RAMSES** set-up suggested by MUSIC and monofonIC initial conditions generator.
- Study the effect of different Halo-Finders:
  - DENHF**,** SubFind, Velociraptor, Rockstar, AHF.

T. Castro

# Calibration of the Halo Mass function (T. Castro et al.)

- **Numerical Systematics on the HMF:** butterfly effect (see, eg.: Genel, Shy et al. 2017)



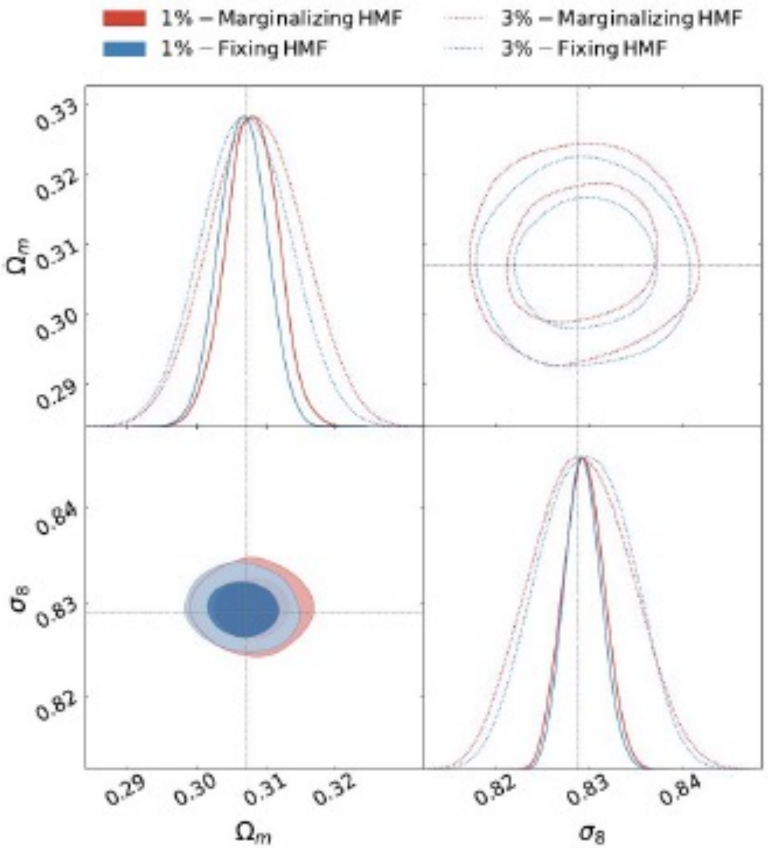

Same IC, different technical set-up (# of nodes, MPI ranks, etc). Yellow region: +/- 1-sigma Poisson errors. Blue region: +/-1-sigma obtained from synthetic catalogs drawn from one single simulation assuming that each cluster have a poisson distribution on the number of particles.

**T. Castro**

CL - SGW Meeting 2022: WP9

# Paper I: Calibration of the Cluster HMF in vanilla LCDM models:

*Impact of the HMF statistical errors on Cluster Counts:*




T. Castro

# Weak Lensing Mass Estimate from the Excess Surface Mass Density Profile

Coordinators

*Carlo Giocoli & Sandrine Pires*

Strong synergy with OULE3: COMB-CL

M. Meneghetti, E. Rasia, S. Borgani, L. Moscardini, M. Sereno and the 300 Collaboration [...]

# Goals of the paper

- Present the cluster weak lensing data-set
- Provide reference weak lensing mass estimate using a state-of-the art modelling pipeline
- Measure the mass bias considering random projections
- Redshift dependence of the mass bias
- Mass bias for preferential directions
- Stacking the signals for various projections

C. Giocoli

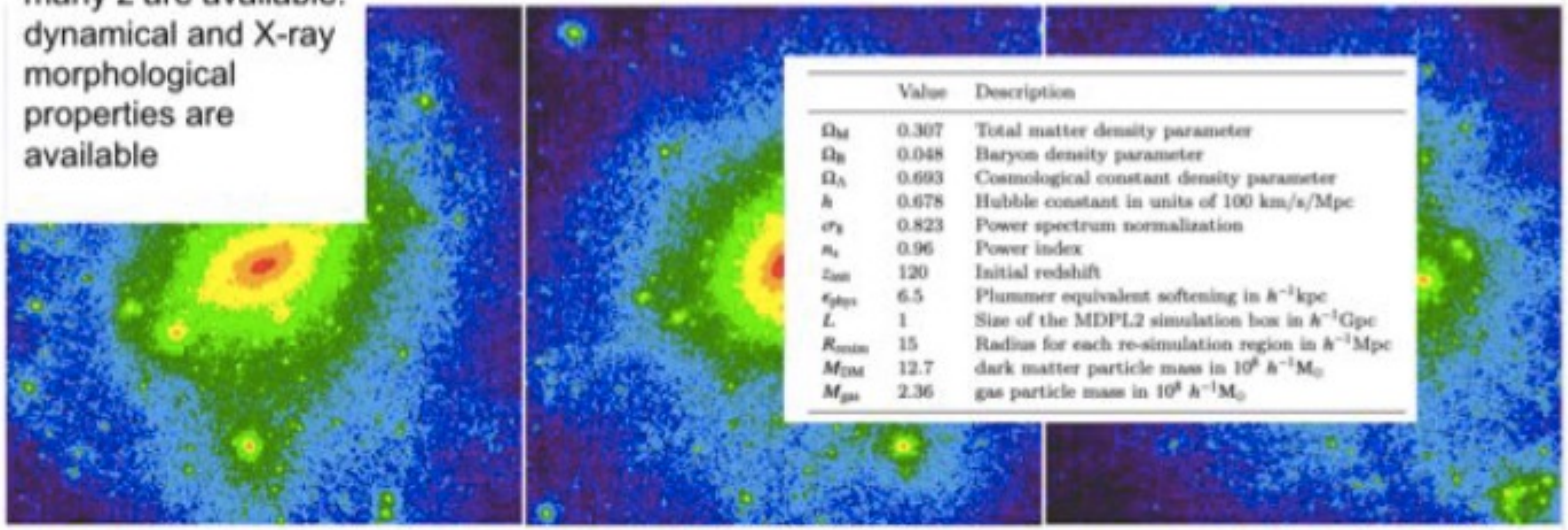
# Data-set:

ttps://arxiv.org/pdf/1809.04622.pdf

## 300th: 324 clusters at different redshifts

convergence, shear components, deflection angle and potential maps
with 2048x2048 pixels

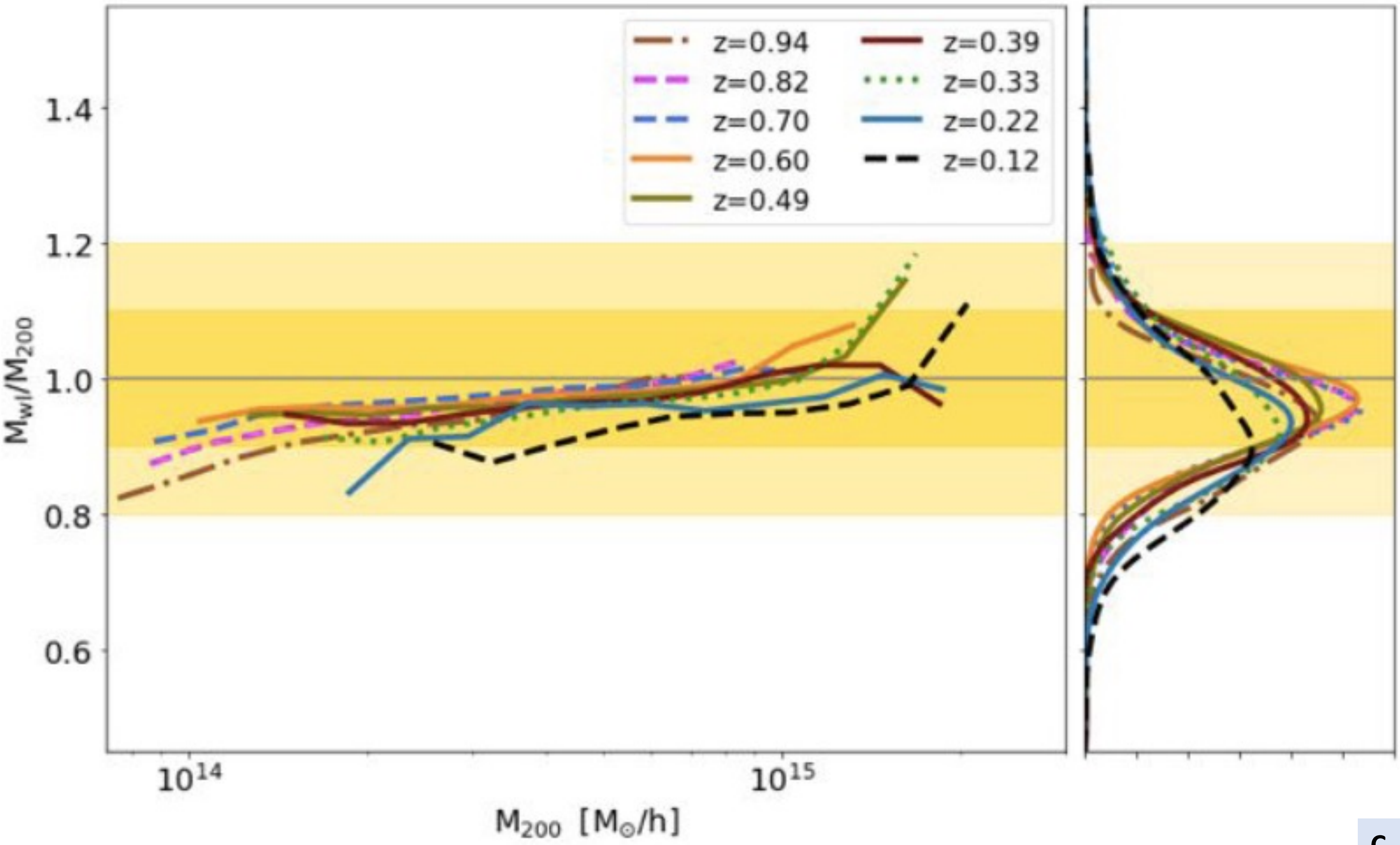
many z are available:
dynamical and X-ray
morphological
properties are
available



| | Value | Description |
|---|---|---|
| $\Omega_M$ | 0.307 | Total matter density parameter |
| $\Omega_B$ | 0.048 | Baryon density parameter |
| $\Omega_\Lambda$ | 0.693 | Cosmological constant density parameter |
| $h$ | 0.678 | Hubble constant in units of 100 km/s/Mpc |
| $\sigma_8$ | 0.823 | Power spectrum normalization |
| $n_s$ | 0.96 | Power index |
| $z_{init}$ | 120 | Initial redshift |
| $\epsilon_{phys}$ | 6.5 | Plummer equivalent softening in $h^{-1}$kpc |
| $L$ | 1 | Size of the MDPL2 simulation box in $h^{-1}$Gpc |
| $R_{resim}$ | 15 | Radius for each re-simulation region in $h^{-1}$Mpc |
| $M_{DM}$ | 12.7 | dark matter particle mass in $10^8$ $h^{-1}M_\odot$ |
| $M_{gas}$ | 2.36 | gas particle mass in $10^8$ $h^{-1}M_\odot$ |

C. Giocoli

CL - SGW Meeting 2022: WP9

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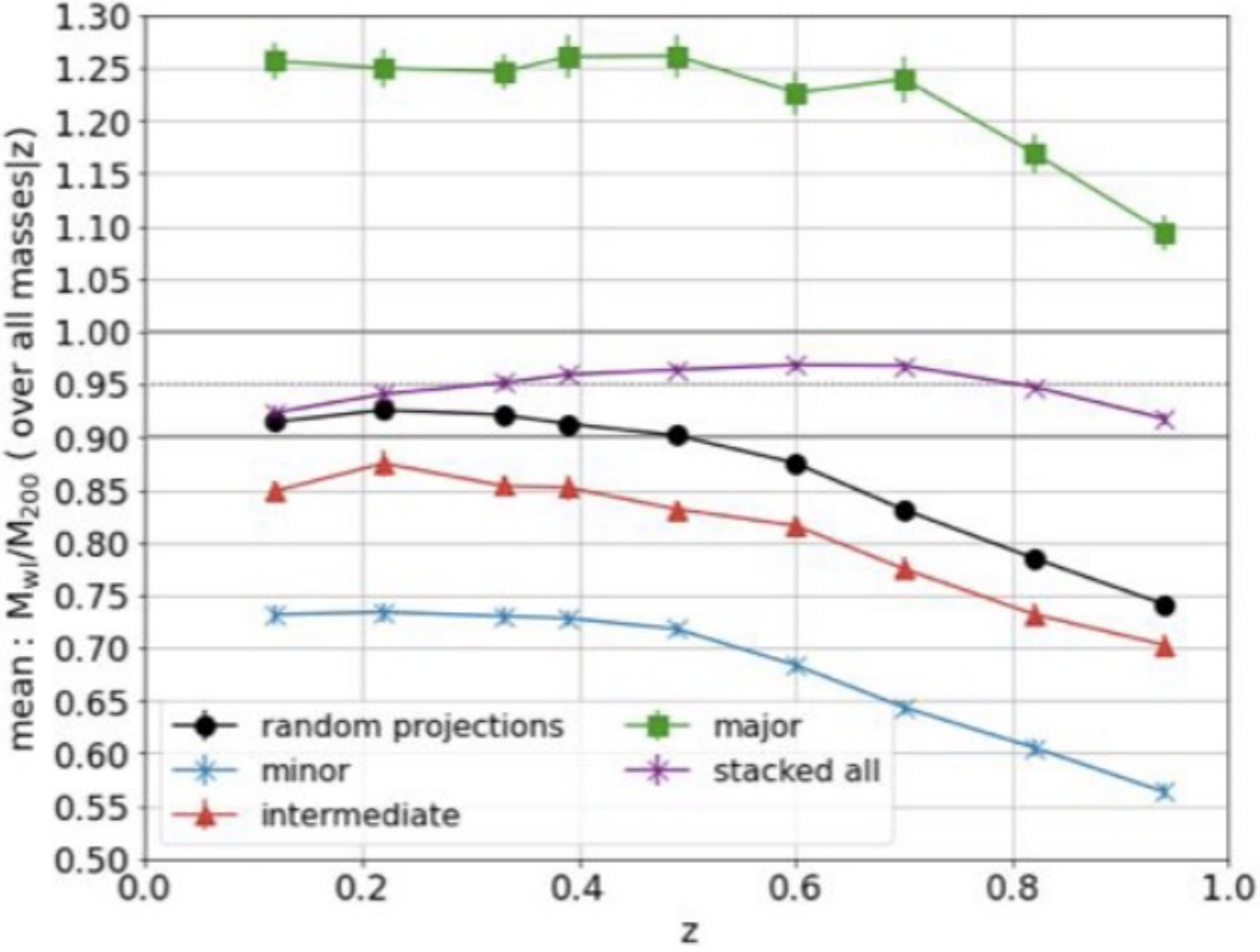

1.30
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
mean : $M_{wl}/M_{200}$ ( over all masses|z)
0.0
0.2
0.4
0.6
0.8
1.0
z
random projections
minor
intermediate
major
stacked all

C. Giocoli

# KP4: Euclid Galaxy Cluster Legacy Science

managed by WP7 (Ettori,**Hatch**,Pierre) & WP11 (**Dannerbauer,**Cucciati)

## Expected Papers

- **Paper1:** Astrophysical properties of selected/unselected clusters by different algorithms. Potential biases and systematics on cosmology and astrophysics.
- **Paper2: Definition and optimization of algorithms for the identification of clusters at z>1.5 and protoclusters in Euclid data.**
- **Paper3:** Astrophysical properties of clusters identified in pre-launch surveys, in preparation for Euclid observations in the same fields.
- **Paper4:** Improving algorithms to detect and study intracluster light from Euclid data.

**Paper1:** Astrophysical properties of selected/unselected clusters by different algorithms

**Contact Person**: **M. Pierre**

**Goal**

Astrophysical properties of selected/unselected clusters by different algorithms. Potential biases and systematics on cosmology and astrophysics.

In this paper, we will analyze cluster catalogues obtained by running different cluster finding algorithms on simulated mocks. Using the simulated catalogues, we will look for systematic differences in the haloes that are detected and not detected by the different algorithms considered (e.g. in colour or radial distribution of the cluster galaxies, kinematics of cluster galaxies, position of the brightest cluster galaxies, etc.). We will carry out the analysis both as a function of redshift and halo mass. In order to assess the robustness of the results, we will consider catalogues based on alternative and complementary mocks and, when possible, on real data. When systematic differences are found, we will quantify the implications both on cluster cosmology (e.g. through an impact on the cluster selection function) and studies of galaxy evolution in clusters.

**PRACTICALLY :**

**We propose to focus on correlations between simulated Euclid and X-ray data** (X-ray can be XMM, eRosita or Athena).

- We produce X-ray sky maps of the Flagship simulations; the X-ray "painting" of the DM halos and of the AGN will assume various models of ICM physics evolution.
- We also deliver corresponding X-ray source catalogues, assuming different selection functions. And finally, correlate the optical and X-ray catalogues in order to study the detection biases in both wavelengths.
- We shall start with the 50 deg2 sub-area for which M. Bolzonella recently computed the galaxy properties.

# KP-CG-PL-4 Euclid Galaxy Cluster Legacy Science

- ***Paper 2: Definition and optimization of algorithms for the identification of clusters at z>1.5 and proto-clusters in Euclid data***

Clusters and proto-clusters at z>1.5 are characterized by different physical scales and colour distributions than lower redshift clusters. Therefore, the identification of these structures requires the development of dedicated methods/algorithms. In this paper, we will present results of a dedicated analysis aimed at applications to future Euclid data. We will consider both existing algorithms, that will likely need to be optimized for the new data that will become available, and work on new methods. The methods developed/optimized will be tested on both existing proto-cluster samples at z>1.5, and on simulated mocks based on hydro-dynamical simulations and/or semi-analytic models developed by members of the SWG.

- ***Paper 3: Astrophysical properties of clusters identified in pre-launch surveys, in preparation for Euclid observations in the same fields***

*External data*

This paper, or series of papers, will be based on the analysis of data from follow-up surveys of the Euclid fields that have been already approved, or will be submitted to ground and space telescope facilities before launch. These include for example, the Spitzer Euclid/WFIRST Legacy Survey and the Spitzer Euclid Deep Field South survey, the CFIS survey, several proposed surveys for 4MOST (including follow-ups of NIR UKIDSS detected clusters), and MOONS follow-ups of selected clusters and proto-clusters. Again, formal details of data exchanges with these external collaborations (in particular for general EC members that are not involved in these), which are not yet covered by MoUs will be set beforehand, involving the ECL and ECB. Additional survey programmes are currently being discussed within the SWG and will be proposed by Euclid members. The analysis of these data will represent an important test-bed for preparing to the analysis of the full Euclid cluster data-set and understanding what we will be able to learn from this complete data-set.

O. Cucciati

# Definition of Papers – List of „proto-"papers

*see redmine for details:*

*https://euclid.roe.ac.uk/projects/cgswg/wiki/CG-WP11_Proto-Clusters*

**Performances of different algorithms in finding protoclusters in the Euclid surveys**

**The Voronoi tessellation Monte Carlo (VMC) mapping applied to the Euclid surveys**

**Multi-wavelength detection of clusters and proto-clusters at z>1.5**

**Proto-clusters using radio galaxies and SMGs as signposts**

**Detection of protoclusters in the Euclid surveys with AMICO**

**Detection of protocluster and high-z clusters using CARTAGO algorithm**

**Proto-clusters and high-z cluster detection with DETECTIFz**

**Detection of high-z galaxy (proto)clusters in Euclid with a python code based on DTFE**

**Characterization and detection of proto-clusters**

*in most of the cases use of simulations and real data*

O. Cucciati

# WP5/KP5 Mass-Observable relation

## KP5 papers: updated plan

- Summary paper (if topical results allow for it):
  - Paper 0: Expected mass calibration combining all observables
- Topical papers:
  - Paper 1: Covariance of ICM and optical/NIR observables (simulations) (A. Ragagnin / A. Saro)
  - Paper 2: Constraining $M_{wl}$ -$\lambda$ covariance from ICM observables (B. Maughan / Cai Wood)
  - Paper 3: Mass calibration from galaxy kinematics (A. Biviano / G. Mamon)
- Papers on hold, requiring work on data (especialy WL):
  - Paper XX: WL mass to richness scaling relation on real data
  - Paper YY: Internal photometric observables and covariances
- Individual suggestions from other WP members (e.g. ICL) ?

F. Pacaud & G.W. Pratt

# Correlation coefficients between hydrosims observables

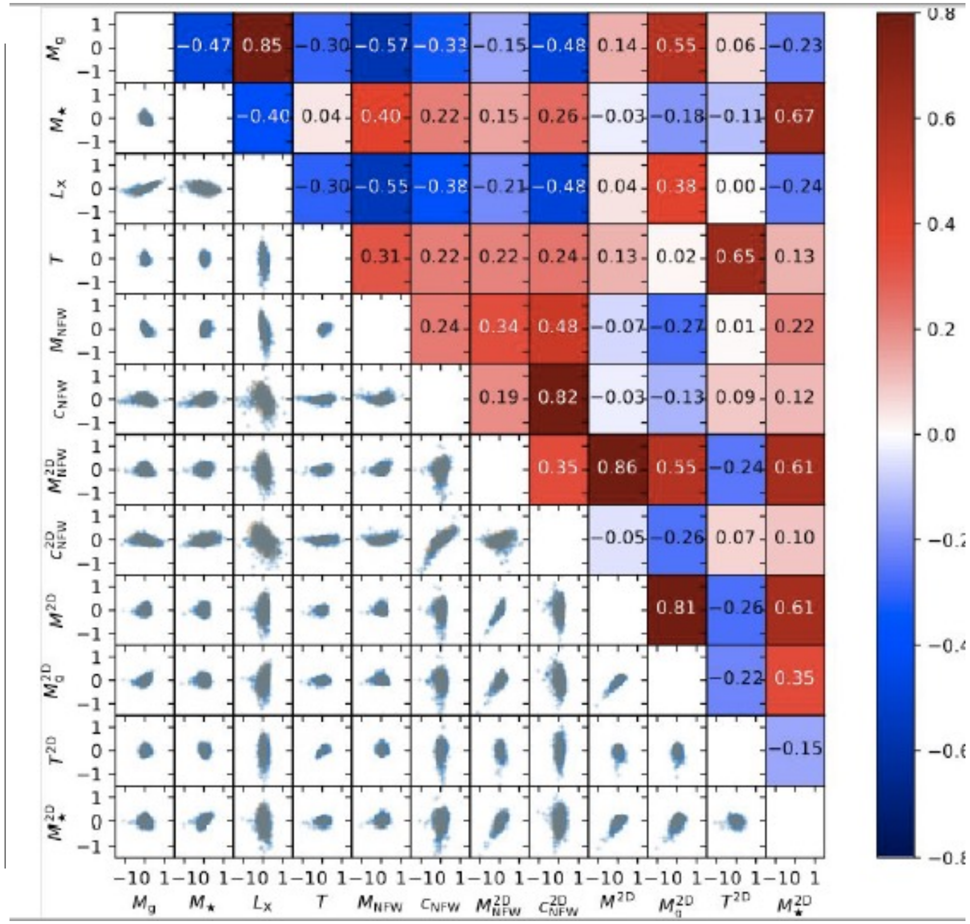
Antonio Ragagnin, Alex Saro, …

## Motivations

- Correlation coefficient from full-physics simulation MORs (e.g. gas mass)
- how does Euclid mocks MOR relates to hydrosim ones?
- How much scatter to expect from different projection effects or from different accretion history?

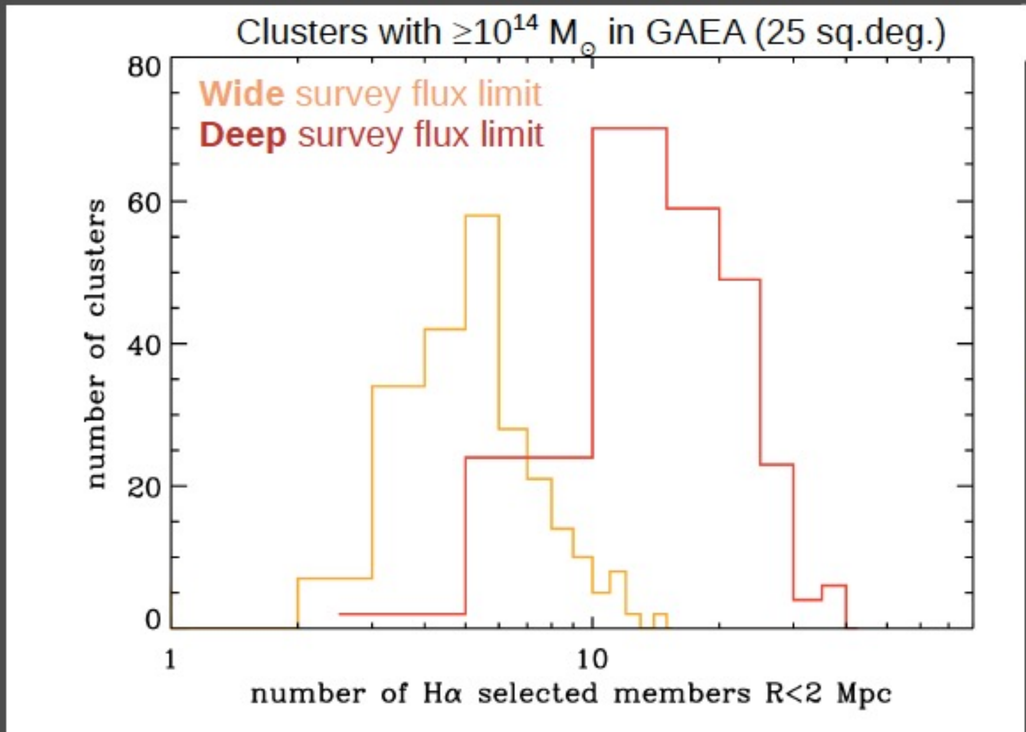
# Currently observables considered

- 3D observables (Delta=500c):
  - Mass
  - M*
  - Mgas
  - T
  - M and c from 3D NFW fit
  - Lx bolometric core-excised using APEC
- 2D observables (Delta=500c, cylinder length of 10Mpc/h)
  - Mass
  - Mg
  - M*
  - T
  - M and c from 2D NFW fit
  - … other ideas?




**A. Ragagnin**

**GAEA:** select Hα galaxies as cluster "members" in ≥$10^{14}$ $M_\odot$ halos, above the Euclid flux limit: 2 (0.5) ×$10^{-16}$ erg $s^{-1}$ $cm^{-2}$ in the Wide (Deep) survey within 2 Mpc from the "observed" cluster center, and with "observed" rest-frame velocities within 1600 km/s of the "observed" cluster <z>, taking only 1/2 identified "members" *(mimic 50% spectroscopic completeness)*



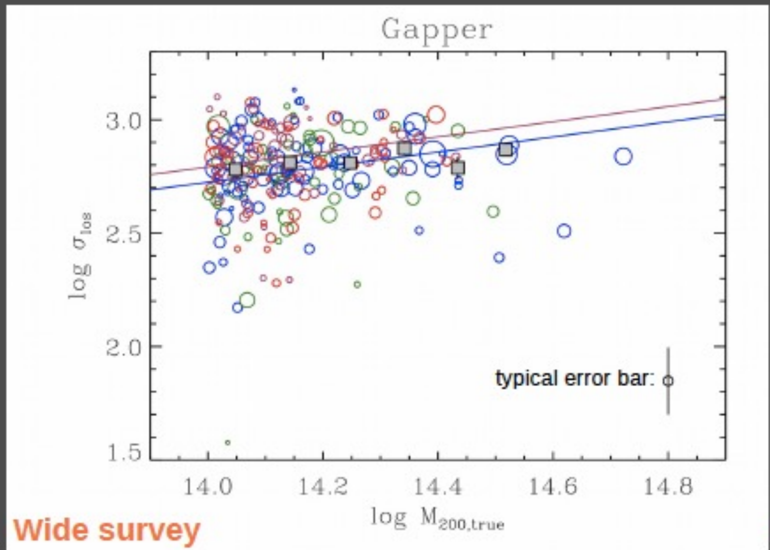

Number of clusters in GAEA mocks must be re-scaled up by the relative areas of GAEA (25 □°) and Euclid Wide (15000 □°) and Deep (40 □°)

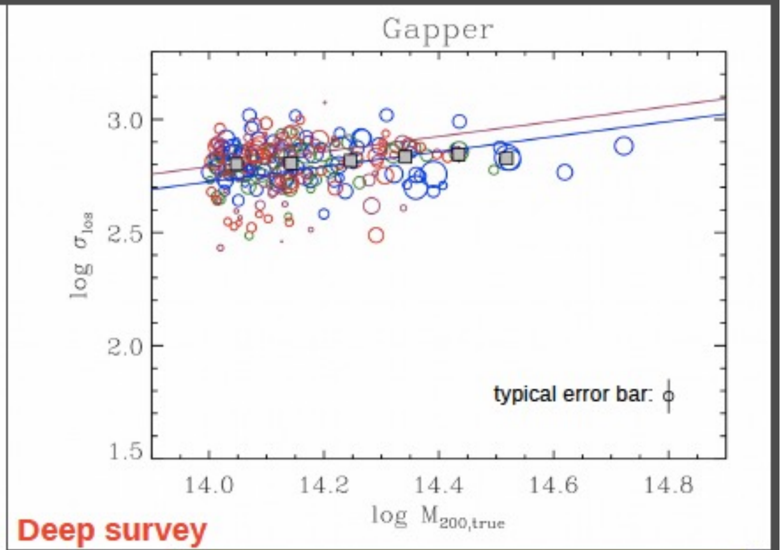
**10000** clusters with **≥ 10** "members" expected in the Euclid Wide survey,
**200** clusters with **≥ 20** "members" expected in the Euclid Deep survey



**A. Biviano**

Compute the cluster velocity dispersion $\sigma_{los}$ on the identified cluster members using the Gapper and Biweight estimators (Beers+90) and look at the $\sigma_{los}$ vs $M_{200,true}$ relation




Symbol size ∝ number of identified members

Color scaling with ↑z : *blue-green-red-maroon*

Lines: theoretical relations from Munari+13

Grey squares are averages of $\sigma_{los}$ in bins of $M_{200,true}$

Use the best-fit power-law relation to estimate the scatter in $M_{200}$ estimate at given $\sigma_{los}$:

$\delta M/M$=0.30 (0.29)
for the Wide (Deep) survey

*(the same for Gapper and Biweight)*



A. Biviano

# Summary

- GAEA Euclid mocks can be used to explore cluster kinematics
- Add uncertainties in observed galaxy redshifts, cluster RA, Dec, <z> and spectroscopic incompleteness to mimic observations
- Use LE3 Z-CL algorithm to improve cluster <z> estimate
- LE3 SIGV-CL algorithm not ready yet: use rough membership estimates
- $M_{200}$ can be estimated from $\sigma_{los}$ and MAMPOSSt with ~0.3 fractional precision, *(although estimates are biased)* in the z-range 0.9-1.8 where other mass estimators may fail *(except perhaps CMB lensing)*



A. Biviano

# WP8/KP-CL6 papers

## Meta-catalogues for Euclid cluster science

Paper 1: Velocity dispersions Meta-Catalogue

Paper 2: Consistency of masses in optical , X-ray and SZ Meta-Catalogues

**J.B. Melin, T. Reiprich, A. Stanford**

# Euclid Clusters SWG: KP6 – velocity dispersions

## Velocity Dispersions Metacatalog Paper Draft Outline

Paper 1

A. Introduction
   1) Euclid mission
   2) Purpose of metacatalog
B. Input Source Catalogs
   1) Description of catalogs of dispersions being used
   2) Table of catalogs (Name, N_clusters, Selection type [X-ray, SZ, optical], Reference)
C. Procedure of Merging Catalogs
   1) Describe how clusters with multiple entries are associated
   2) Resolution of discrepancies
D. Velocity dispersion metacatalog
   1) Description of included parameters for prime and alternate(s) sources for each cluster
      ID, RA, Dec, z, sigma, unc_sigma_orig, unc_sigma_calc, n_members, reference
   2) Distribution and Updating

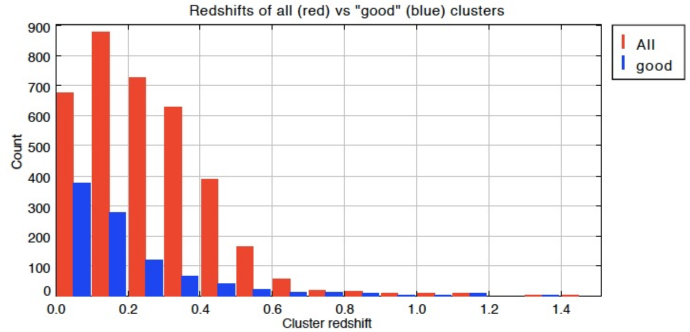
# Euclid Clusters SWG KP6 – Velocity Dispersions Metacatalog

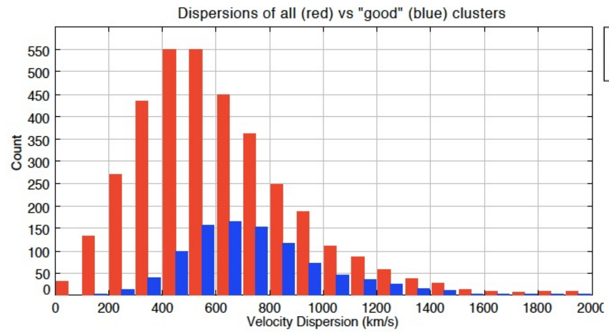
KP6 Dispersions Metacatalog - Input Sources

| Survey | Total clusters | Selection info | Reference |
|---|---|---|---|
| SPIDERS | 2740 | X-ray + optical | Kirkpatrick+2021 |
| Sereno+Ettori 2015 compilation | 564 | various | Sereno + Ettori 2015 |
| Biviano 2021 compilation | 109 | Literature survey of clusters | Biviano private message |
| ENACS | 106 | ESO nearby cluster survey | Mazure+1996 |
| MACS | 12 | X-ray | Ebeling+2007 |
| SPT | 48 | SZ | Ruel+2014 |
| CIRS,HeCS | 146 | SDSS+Rosat;400D;HeCS | Rines & Diaferio 2006,2010,2013 |
| HiFLUGCS | 62 | X-ray | Zhang+2011 |
| ACT | 16 | SZ | Sifon+2013 |
| Omega/WINGS | 76 | Multiwavelength | Biviano+2017 |
| HeCS-SZ | 36 | SZ, Planck | Rines+2016 |
| 2dFGRS | 43 | Optical | Biviano & Girardi 2003 |
| CNOC | 16 | X-ray | Carlberg+1997 |
| EDisCS | 21 | Optical; LCDCS | Jensen+2008 |
| GOGREEN+GCLASS | 14 | SpARCS+SPT | Biviano+2021 |
| Planck PSZ1 | 270 | Planck | Ferragamo+2021 |
| Planck PSZ2 | 388 | Planck | Aguado-Barahona+2022 |

Clusters SWG meeting February 2022, Adam Stanford

Metacatalog currently has 1184 “good” clusters with at least 20 members



# Possible content Paper 2

- **Matching of the meta-catalogues/catalogues**

Explain how we match the meta-catalogues and catalogues. Detail any issue.

- **Consistency of redshifts across meta-catalogues**

Check for consistency/inconsistencies of redshifts in the various meta-catalogues/catalogues before going farther in the comparison.

- **Consistency of masses across meta-catalogues**

Is there any mass inconsistency within each meta-catalogue? A priori no by construction.
We already have some elements regarding the mass comparison in the ComPRASS paper that we can point to and/or rediscuss.
We don't need to redo works already done in other papers but we can compile the information already available and focus on producing what is not available.

- **Positional error characterization between catalogues and meta-catalogues**

What is the positional error of each catalogue wrt the true cluster position? Probably also already published.
What is the positional difference between two catalogues or meta-catalogues? It would be interesting to understand.

- **A master table of clusters?**

Should we try to build a master table for all the meta-catalogues/catalogues?
The MCXC+MCSZ+ComPRASS master table already exists but we may want to have one for all the meta-catalogues/catalogues used for Euclid.

# Where do we stand?

**Meta-Catalogues and Catalogues availability**

- MCXC [Tatyana Sadibekova, Gabriel Pratt, Paula Tarrío] ✓ final version available at https://www.galaxyclusterdb.eu/ (M2C DB)
- MCSZ [Paula Tarrío, Jean-Baptiste Melin] ✓ ACT2020 now being included, current version Planck+SPT+ACT sufficient to start
- ComPRASS (X-ray+SZ) [Paula Tarrío] ✓ final version available on the M2C database
- Velocity dispersions Meta-Catalogue [Adam Stanford] → ongoing parallel effort (paper 1)
- LC^2 Meta-Catalogue [Mauro Sereno] ✓ updated versions available at http://pico.oabo.inaf.it/~sereno/CoMaLit/LC2/
- redMaPPer DES and/or SDSS catalogue (?) → publicly available for SDSS but only for the SV data for DES } manpower?
- X-ray+optical catalogue [Alexis Finoguenov] (?) → available (via Alexis) } manpower?

**It is crucial that each meta-catalogue (X-ray, SZ, velocity dispersion, etc) clearly identifies the reducible and irreducible errors in its sub-catalogues. Each meta-catalogue should also provide a homogenized mass with associated errors.**

**Content of the paper discussed at a WP8 telecon**

**Everything in place now to start working with available Meta-Catalogues**

**Note by S. Grandis:**
**DES Y1 reMAPPer catalogue available at https://des.ncsa.illinois.edu/releases/y1a1/key-catalogs/key-redmapper**

# Quick final summary

- **Pre-launch KP list**: rich and well-structured, with an expected good scientific return for the Italian community
- All planned papers are progressing as expected, a good number of them are in an advanced state, some of them close to have a final draft
- In some cases, there are problems of man/woman-power: if interested to papers, don’t be shy, contact the leads!
- Strong and robust **collaboration between all WPs and with OULE3** Galaxy Clusters, where Italy is also very active