# STATO ATTIVITÀ

# EUCLID INFN-FE

Mario Ballardini (Unife)
11 settembre 2026

# THE INFN–EUCLID FERRARA UNIT

| Nome | Qualifica | Percentuale |
|---|---|---|
| Mario Ballardini (RL) | RTD Unife | 0.4 |
| Lorenzo Bazzanini | Assegnista Unife | 1.0 |
| Giorgia Di Rosa | PhD Unife | 1.0 |
| Michele Fogliardi | PhD Unife | 1.0 |
| Luca Pagano | PA Unife | 0.3 |
| Antonio Raffaelli | PhD Unife | 0.5 |
| Piero Rosati | PO Unife | 0.2 |
| **Totale** | | **4.4** |

**+2 FTE with respect to 2025/2026**

All members affiliated with INFN CSN2.

# RESEARCH ACTIVITIES

The Ferrara unit is currently active in four *Euclid* Science Working Groups:

- **Theory – COTH**
  Initial conditions · cosmological likelihoods · emulators · DR1 analysis

- **CMB Cross-Correlation – CMBX**
  CMB lensing × Euclid · likelihood development · DR1 pipelines

- **Strong Lensing – SL**
  Deep learning · lens searches · lens modelling · DR1 catalogues

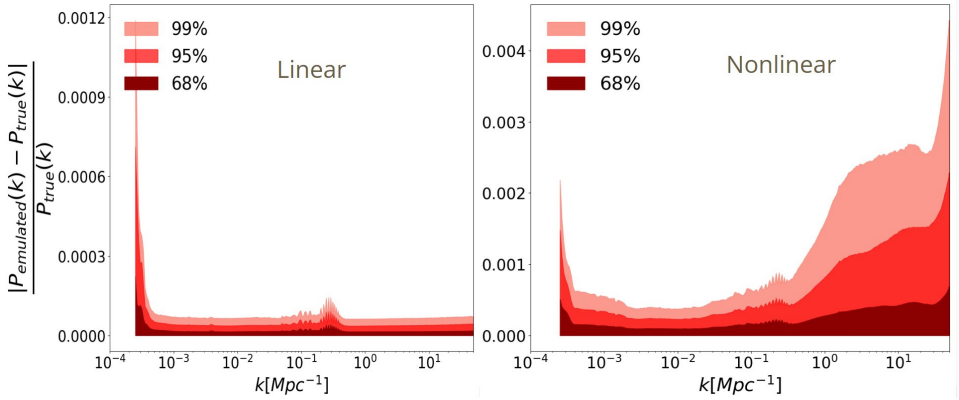
- **Clusters of Galaxies – CG**
  Cluster strong lensing · spectroscopy · ground-based follow-up

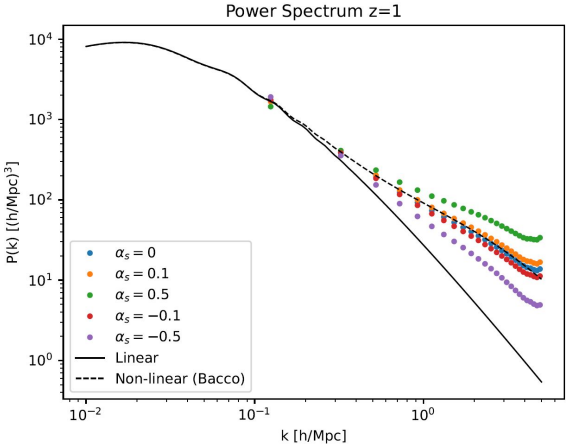
# THEORY

Preparing non-standard cosmology analyses for DR1.

**Main activities in 2025–2026:**

- Development of CosmoPower emulators for linear and non-linear matter power spectra (and CMB)




Emulators based on CosmoPower (CAMB + HMcode-2020).
Emulators based on new N-body simulations (Gadget + bacco).

# THEORY

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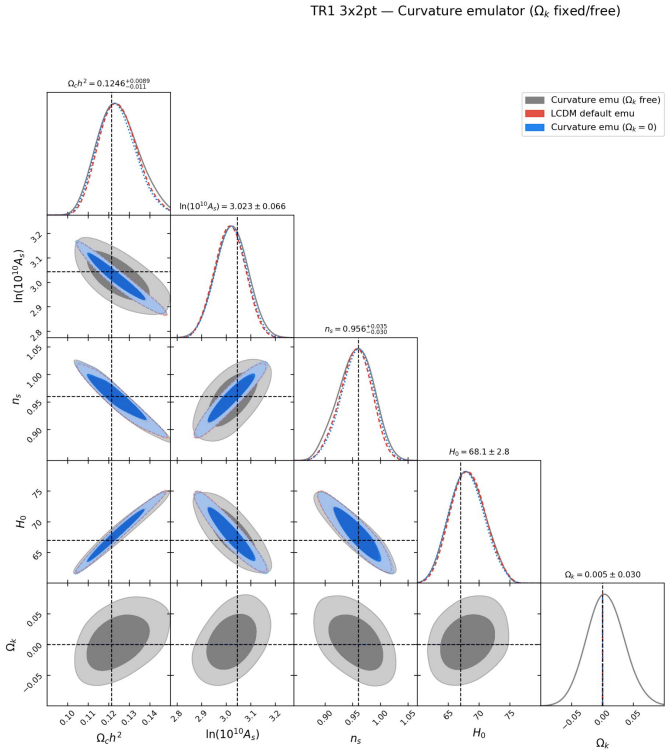
- Development of **CosmoPower emulators** for linear and non-line
- Integration of the emulators into the official likelihood framework
- Extension of the likelihood infrastructure to non-standard ICs
- Scale-cut tests on TR1-like and DR1-like simulated data
- Implementation and validation of the spectroscopic likelihood



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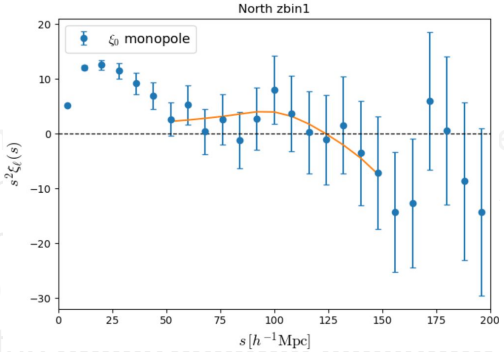


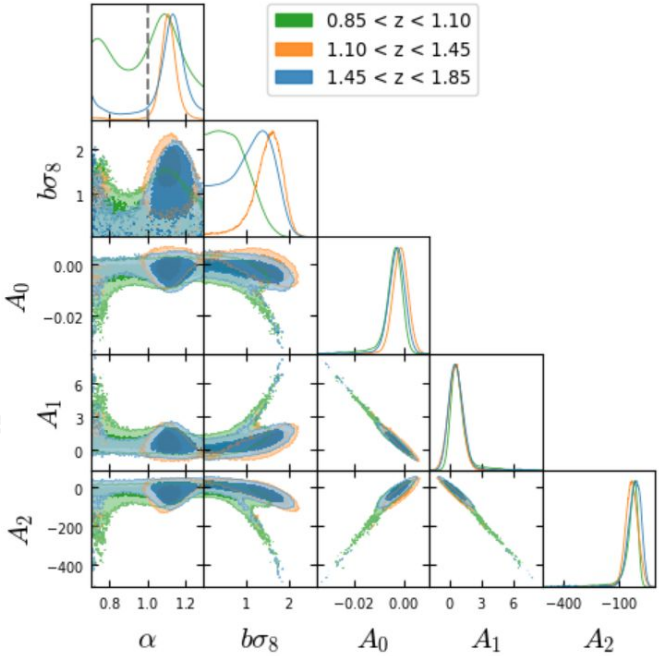


- Development of a two-point correlation-function analysis for primordial features

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**Ferrara coordination and responsibility:**

- MB co-leading (w Kazuya Koyama and Noemi Frusciante) the TWG
- MB co-leading (w Nicola Bartolo) TWG-WP3 on initial condition
- MB coordinator of DR1-KP-TH-1-3

# CMB CROSS-CORRELATION

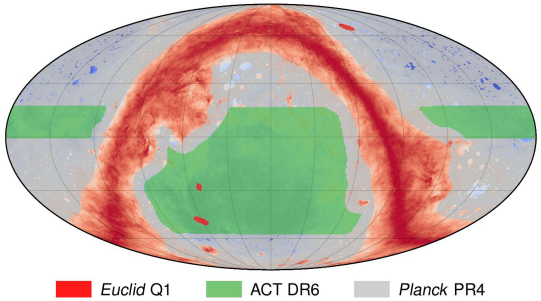
Use CMB lensing cross-correlations both as a cosmological probe and as an important cross-check of *Euclid*-specific observational systematics.

**Main activities:**

- Development, integration, and validation of CMBX theory and likelihood modules within cloe
- Analysis of *Euclid* Q1 photometric galaxy clustering
- Cross-correlation with CMB lensing maps from *Planck* PR4/NPIPE and ACT DR6
- Validation against Galactic extinction, stellar contamination, survey-depth variations and CMB foreground residuals
- Preparation and validation of the DR1-KP-CMBX-2/3 pipeline

# Euclid Quick Data Release (Q1): clustering of photometrically selected galaxies and their cross-correlation with Cosmic Microwave Background lensing

G. Fabbian[⋆1], L. Legrand, M. Lembo, L. Pagano[⋆⋆2], G. Piccirilli, R. Kou, W. D'Assignies, S. Gouyou Beauchamps, W. Hartley, N. Tessore, I. Tutusaus, CMBX SWG, GC SWG, and others



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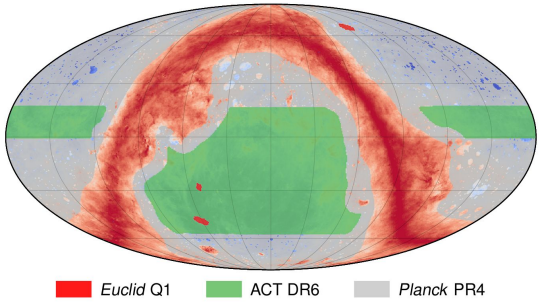
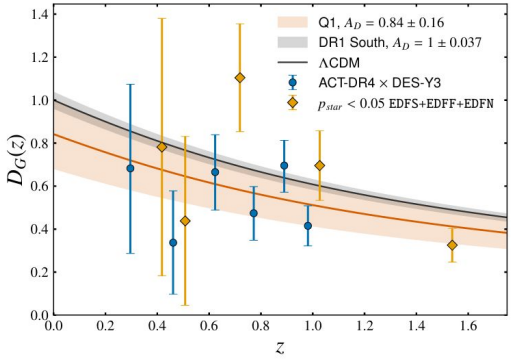
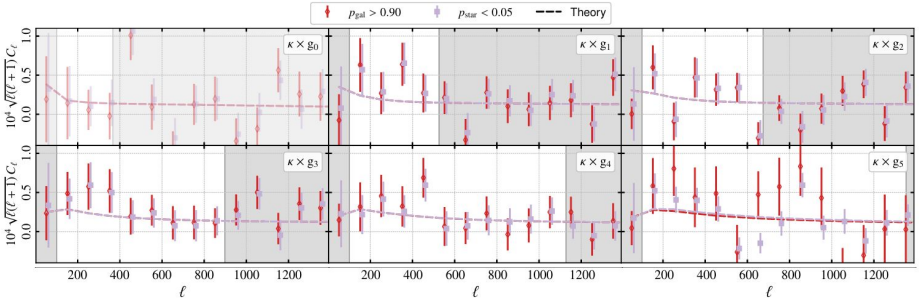
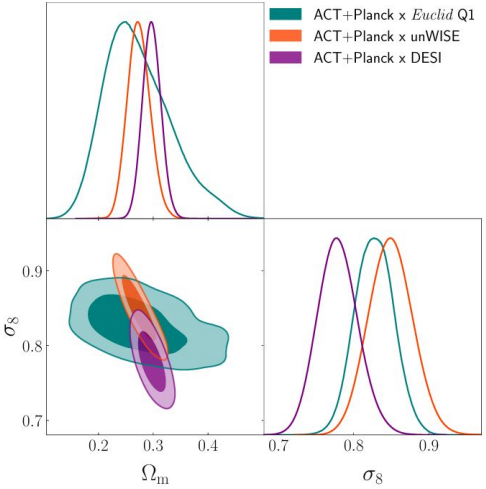


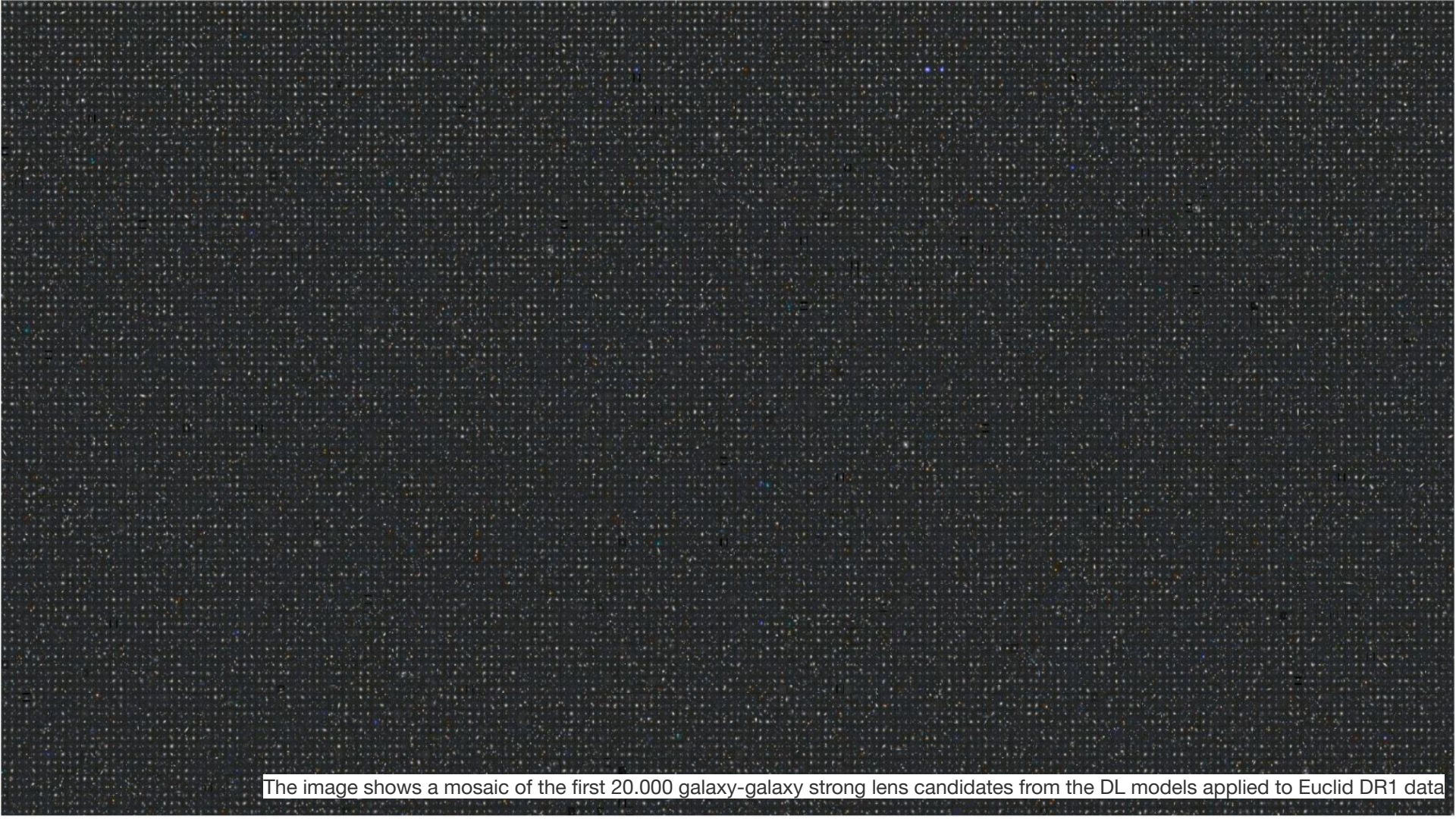
# STRONG LENSING

Automated discovery and modelling of *Euclid* strong lenses.

**Main activities:**

- Deep-learning search for galaxy–galaxy strong lenses. His model is implemented in the *Euclid* Strong Lens Discovery Engine and will contribute to the DR1 lens catalogue
- Application of deep-learning techniques to the automated detection of giant gravitational arcs in galaxy clusters, extending the Q1 analysis to incoming *Euclid* survey data
- Strong-lensing modelling of *Euclid* galaxy groups and clusters, including reconstruction of the total mass distribution and dark-matter component

The activity now moves from algorithm development and Q1 validation to large-scale application on DR1 data.



The image shows a mosaic of the first 20.000 galaxy-galaxy strong lens candidates from the DL models applied to Euclid DR1 data

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# CLUSTERS

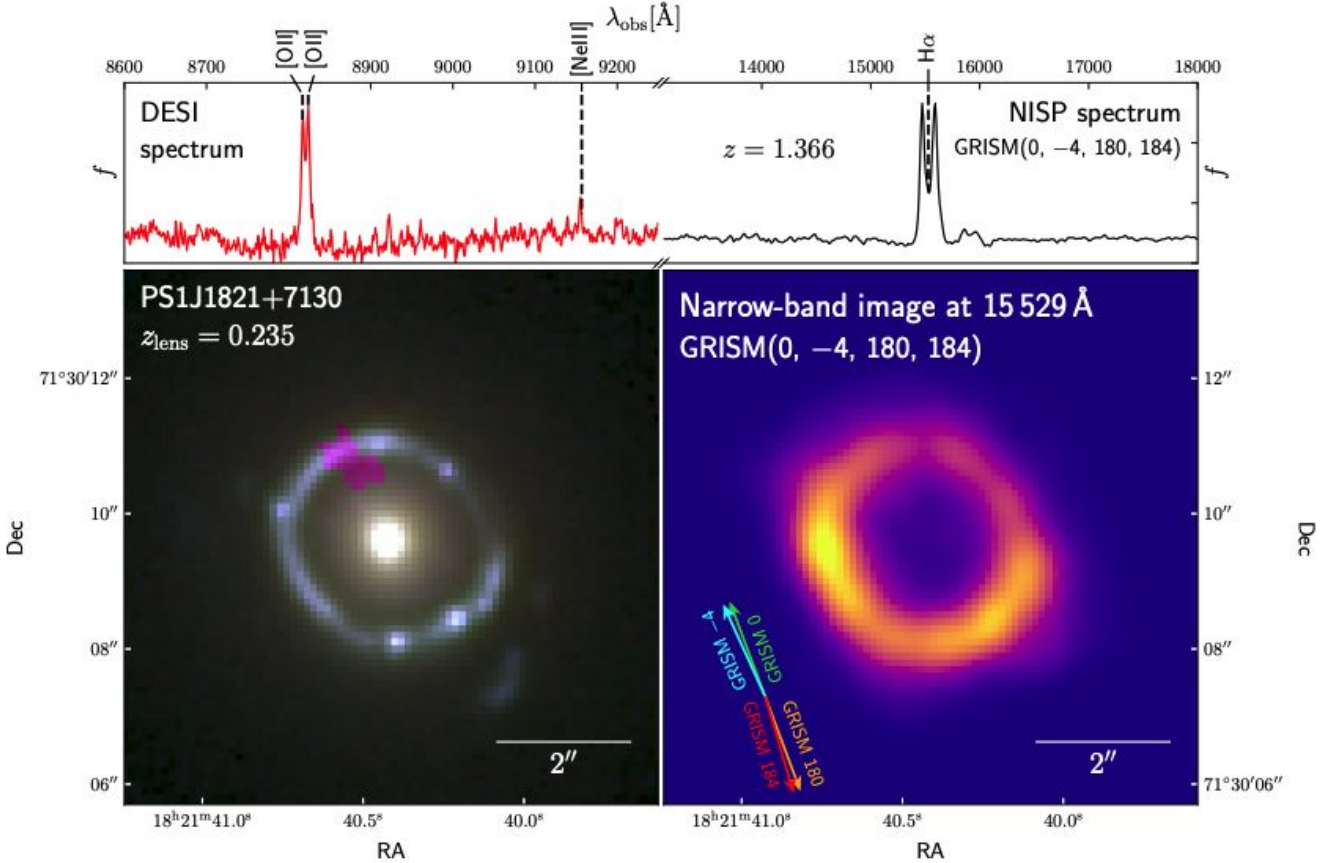
Spectroscopic follow-up studies.

## Main activities:

- Spectroscopic follow-up of group- and cluster-scale lenses identified in Q1 and DR1
- Ongoing observing programmes with VLT/MUSE and FORS2
- Complementary observations with Asiago/Ekar
- Exploitation of *Euclid*/NISP slitless spectroscopy to measure redshifts of gravitational arcs and multiple images
- Contribution to the construction and characterization of *Euclid* strong-lensing cluster samples

## Scientific outcome:

Reliable source redshifts provide a key ingredient for accurate cluster mass models and their astrophysical and cosmological applications.




*Euclid* data of the galaxy-scale strong lensing system PS1J1821+7130 at z=0.235. Bottom-left: RGB image of the lensing system obtained by combining *Euclid* photometric bands (R: H, G: Y, B: I). Bottom-right: Narrow-band image centred at 15529 Å showing the Hα emission associated with the arc. The image is produced by combining the dispersed spectroscopic images from grisms with position angles of 0, -4, 180, and 184 deg, indicated by the green, cyan, orange, and red vectors, respectively. Top-right: Stacked Euclid NISP spectrum, showing the detected Hα emission from the Einstein ring, smoothed with a Gaussian kernel of standard deviation 10 Å. Top-right: DESI spectrum highlighting the [OII] doublet and [NeIII] emission lines at wavelengths consistent with the redshift measured from the *Euclid* data (Bergamini et al., 2026).

# REQUESTS

- Euclid Consortium meeting (Paris)
  M. Ballardini, L. Pagano, A. Raffaelli, P. Rosati
- Theory Working Group meeting
  M. Ballardini, A. Raffaelli
- CMBX meeting
  L. Pagano
- Euclid Italia meeting
  M. Ballardini, L. Pagano, P. Rosati
- Strong Lensing Working Group meeting
  L. Bazzanini, G. Di Rosa, M. Fogliardi, P. Rosati

| Parziali (k€) | | Totale (k€) | |
|---|---|---|---|
| Richieste | SJ | Richieste | SJ |
| 6.00 | 0.00 | | |
| 2.50 | 0.00 | | |
| 1.50 | 0.00 | 14.5 | 3 |
| 0.00 | 3.00 | | |
| 4.50 | 0.00 | | |
| 2.00 | 0.00 | 2 | 0 |
| | | 16.5 | 3 |