

Cosmology

External Scientific Advisory Committee meeting
CIEMAT (Madrid)
11-12 January 2023

Eusebio Sánchez on behalf of CIEMAT Cosmology Group

From P5 report

New paradigms

Search for new particles
Quantum imprints for new
phenomena

Quantum realm

Reveal the secrets of the Higgs
boson
Elucidate the mysteries of
neutrinos

Illuminate Hidden Universe
Determine the nature of dark matter
Understand what drives cosmic evolution

Projects

Active:

- **DES (Dark Energy Survey)**
- **PAUS (Physics of the Accelerating Universe Survey)**
- **DESI (Dark Energy Spectroscopic Instrument) and DESI-II**
- **Euclid**

In construction (commissioning):

- **LSST-DESC (Legacy Survey of Space and Time - Dark Energy)**

Possible Future Projects (among others):

- **CMB-S4**
- **Spec-S5 ...**

Current Personnel

Scientific Personnel

Seniors: **E. Sánchez** (PI, DES, PAU, DESI, Euclid, LSST), **I. Sevilla** (co-PI, DES, LSST)

Senior Computing Support: **F. J. Rodríguez** (1/2 FTE)

Postdocs: **L. Toribio** (DES, LSST)

Students: **D. Sánchez** (Phd for 2024, DES, LSST), **N. Deiosso** (PhD for 2026, DESI)

Support from other Departments (technology)

Senior Scientists: **J. de Vicente** (DES, electronics and photometric redshifts)

Foreseen Growth

Scientific Personnel

Ramon y Cajal (tenure track): **S. Ávila** (2024, DES, DESI), **S. Joudaki** (2024, DESI, LSST)

Atracción Talento CAM (tenure track): **A. Porredón** (2024, DES, DESI, Euclid)

Estabilización (senior): **J. Asorey** (2024, PAU), **J. Carretero** (2024, Euclid, computing)

Funding

Spain

Project: **Fundamental Physics and Cosmology with Extragalactic Surveys**

Funding Agency: MICINN (PGC2018-094773-B-C33)

Duration, from: **2022 to: 2025** (funded since 2006 with ~55 Keuros/year)

Funding: **237160 €**

PI: **Eusebio Sánchez** ; co-PI: **Ignacio Sevilla** (*since 2019*)

European Union

Project: **Enabling Weak Lensing Cosmology** (→ *PAU for Euclid*)

Funding Agency: EU H2020-COMPET-2017 (H2020-776247-EWC)

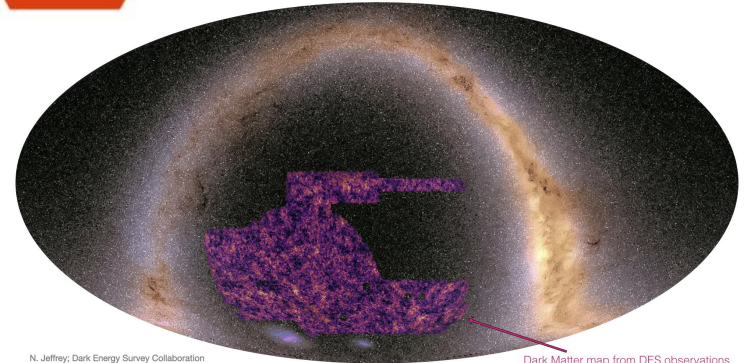
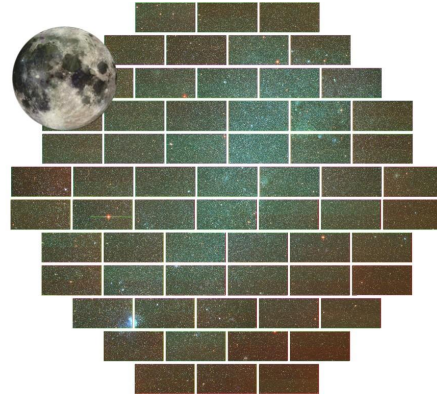
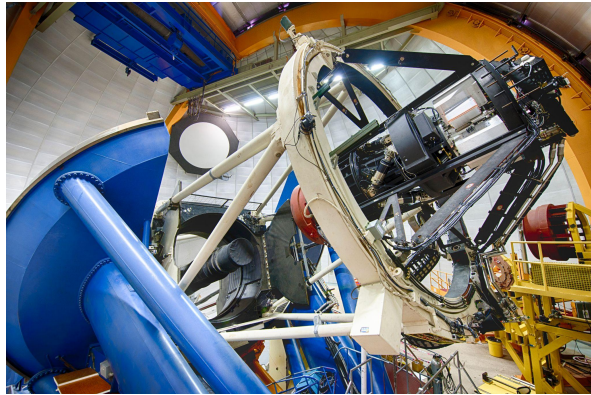
Inst.: CIEMAT, UCL, Leiden, CSIC, IFAE, Durham, INAF, CNRS, Bonn, MPI, Lisbon

Duration, from: **2018 to: 2022**

Funding: **1587153 € (TOTAL); 138569 € (CIEMAT)**

Responsible Person: **Eusebio Sánchez (CIEMAT), Thomas Kitching (UCL, coord.)**

The Dark Energy Survey (DES)

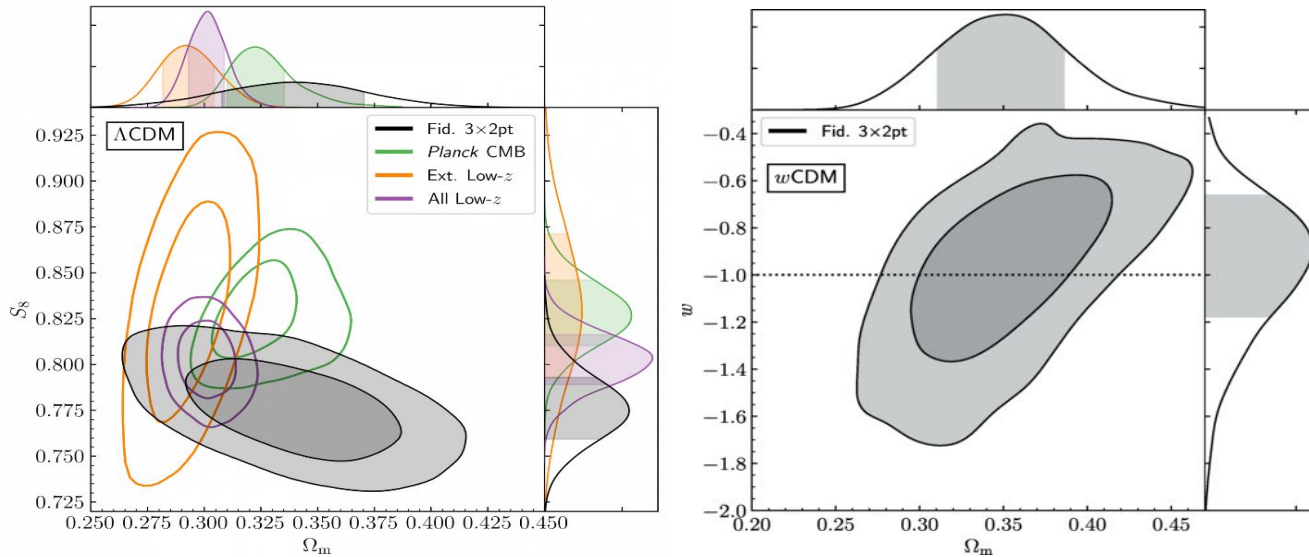


N. Jeffrey; Dark Energy Survey Collaboration

Dark Matter map from DES observations

- Largest Image survey to date from Blanco Telescope (4m, Chile).
- ~600 scientists in 28 institutions (USA, Spain, UK, Brazil, Switzerland, Germany, Australia)
- Special Camera designed, installed and operated (CIEMAT responsible for Readout)
- Construction: 2006-2012, Data: 2013 to 2019 (577 nights in 6 seasons)
- 5000 sq-deg to redshift ~ 1.3 ; ~ 500 million galaxies ; cosmology in 2024
- 4 dark energy probes: Weak Lensing, Galaxy clustering, SN-1a, Galaxy Clusters
- Many other analysis. Very rich physics program (hundreds of published papers)

Highlights 2020-2023: DES-Y3 cosmological Parameters

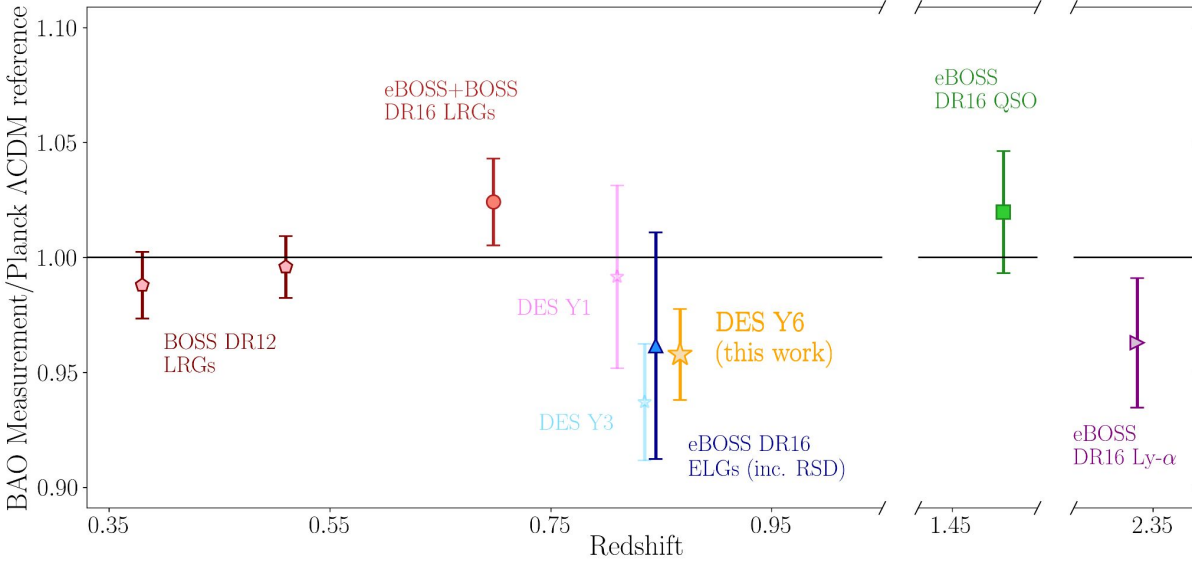
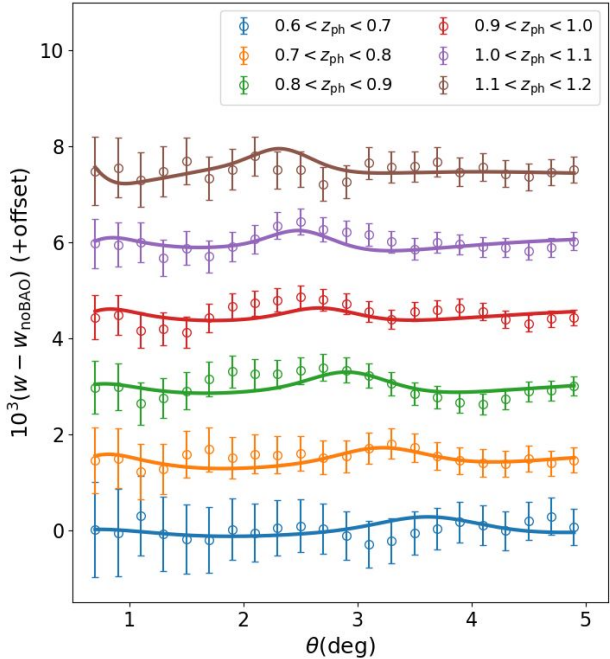


Λ CDM is a good description of DES-Y3 data, with the dark energy being the cosmological constant

DES-Y3 are the most precise measurement of the cosmological parameters ever done by any imaging survey CIEMAT led:

- The preparation and calibration of the Gold Catalog.
- The full analysis of lens galaxy clustering (PhD Martín Rodríguez 2021)
- Development of new methods to deal with observational systematic errors that became state-of-the-art
- The determination of the baryon acoustic oscillations scale

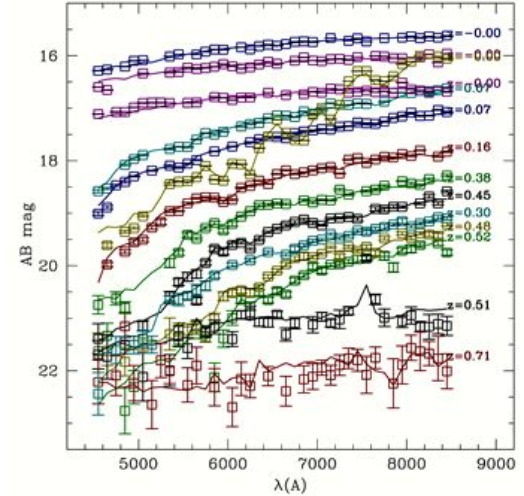
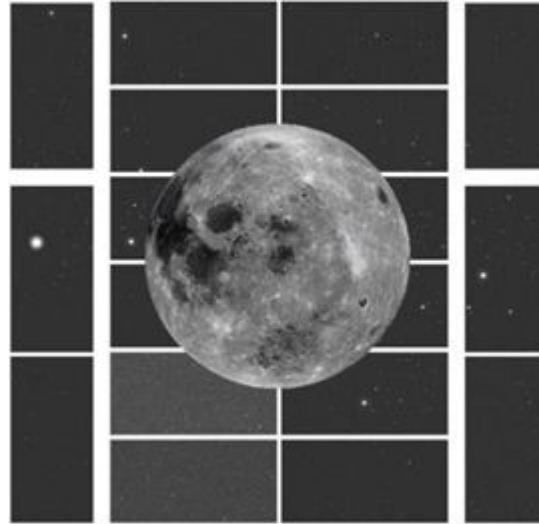
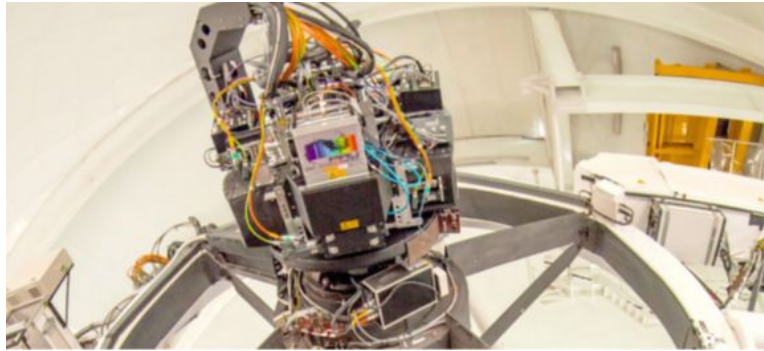
Highlights 2020-2023: DES-Y6 Final BAO Measurement



Measurement of the Sound Horizon Scale at $z \sim 0.87$ with $\sim 2\%$ precision
 CIEMAT led the whole analysis (PhD thesis of Juan Mena, 2023)



Physics of the Accelerating Universe Survey (PAUS)



PAUCam at WHT with 18 CCDs covering a 1 degree diameter field of view

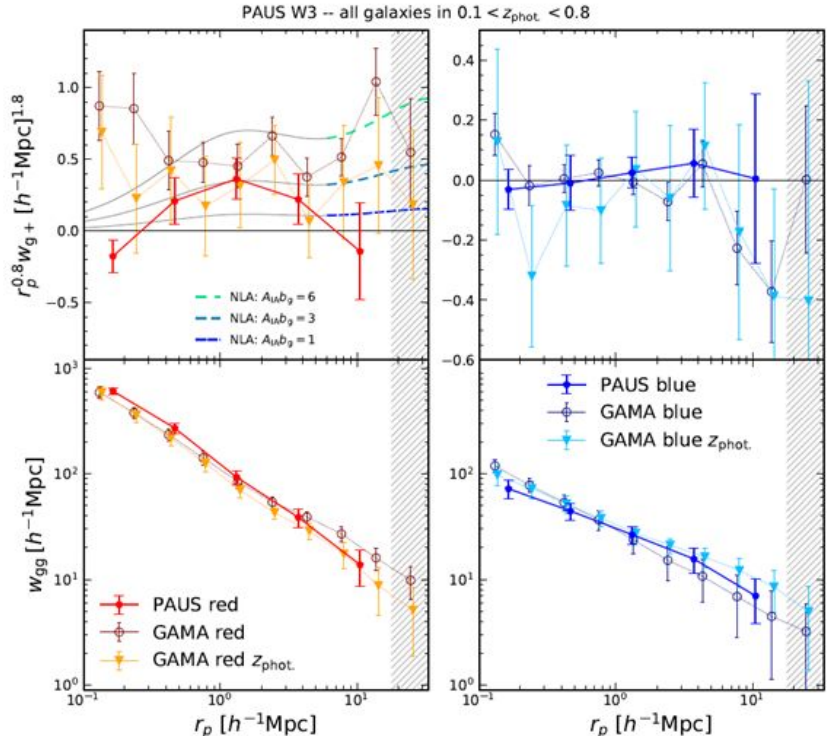
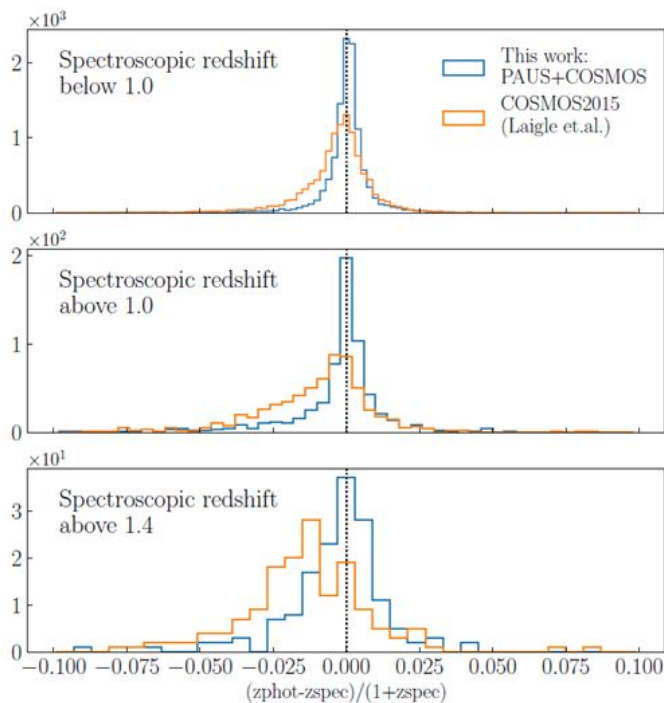
40 Narrow band filters (100 A width) and wide band (u, g, r, i, z, Y) in movable trays

Provide low resolution spectra, with a redshift resolution $\sim 0.003(1+z)$

Data from 2015 to 2019: 50 sq-deg covered with 40 narrow band filters. Up to 100 sq-deg with smaller number of filters

Collaboration: CIEMAT, Durham (UK), ETH Zurich (Switzerland), ICE, IFAE, IFT, Leiden Observatory (Netherlands), PIC, UCL (UK)

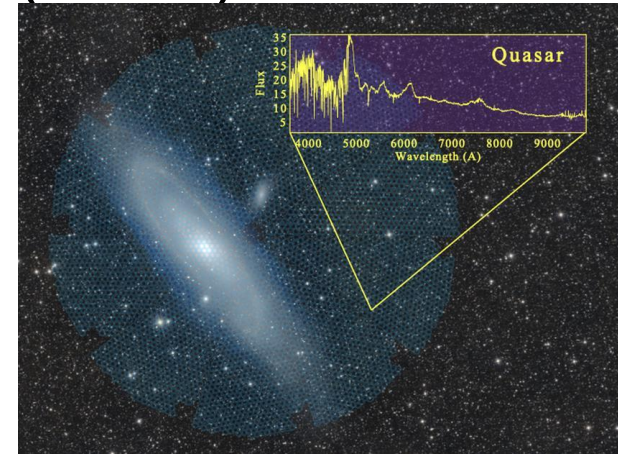
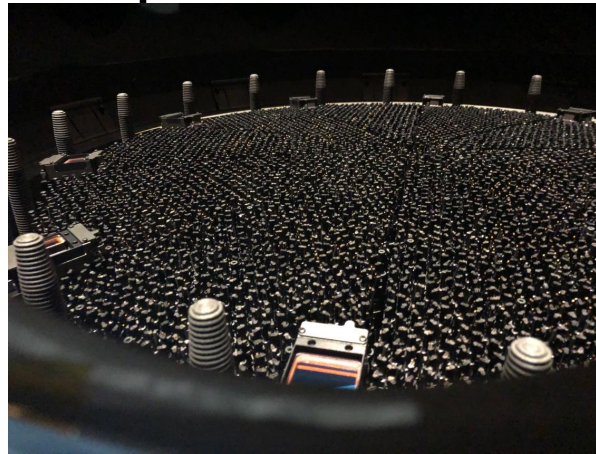
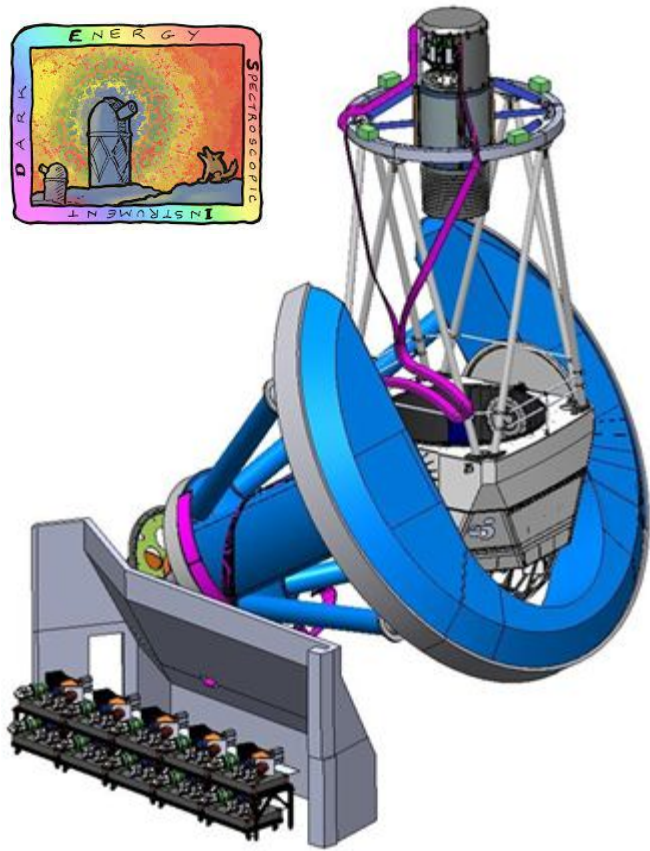
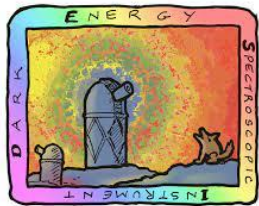
Highlights 2020-2023: PAUS



The power of narrow band filters: Improved redshift catalog in cosmos field. Already used for better calibration in other surveys like DES. Will be used in Euclid, LSST.

First measurement of clustering of galaxies and intrinsic alignment. Only a survey like PAU can do this kind of measurement

Dark Energy Spectroscopic Instrument (DESI)



The DESI collaboration has built and installed:

A new corrector for the Mayall telescope at Kitt Peak (8 sq-deg FOV)

A new top ring, barrel and hexapod

A focal plane with 5000 robots fiber positioner

10 spectrographs, following the BOSS design

Instrument control and data process systems

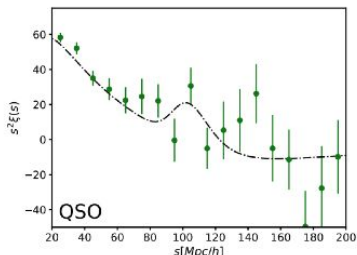
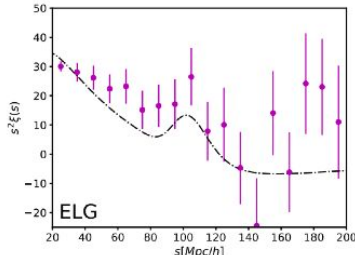
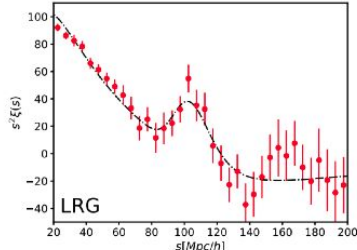
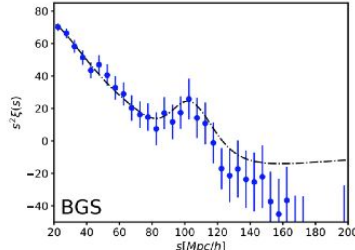
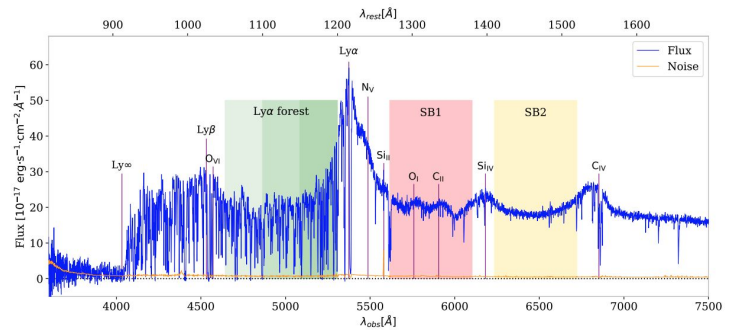
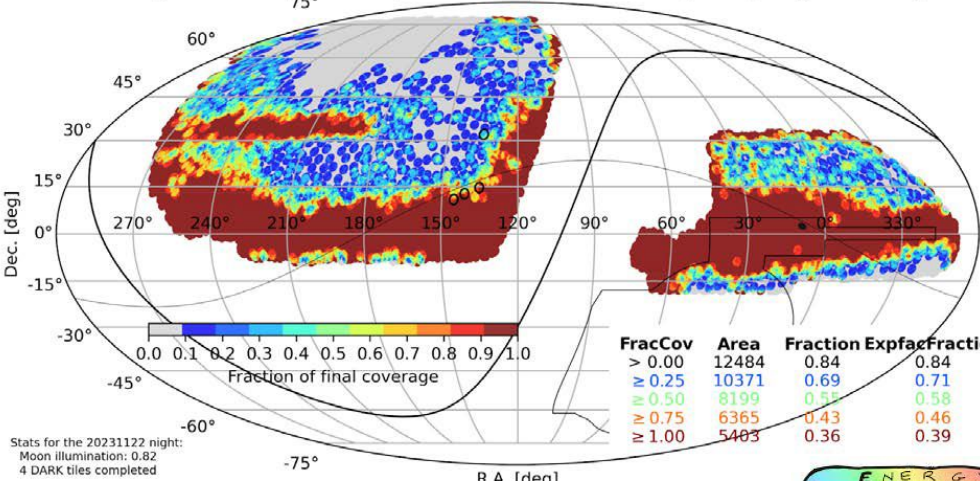
Spain: Guiding and Focus System (IFAE, CIEMAT, ICE, UAM)

Data taking started on May 17th, 2021

CIEMAT-FP Scientific Advisory Committee

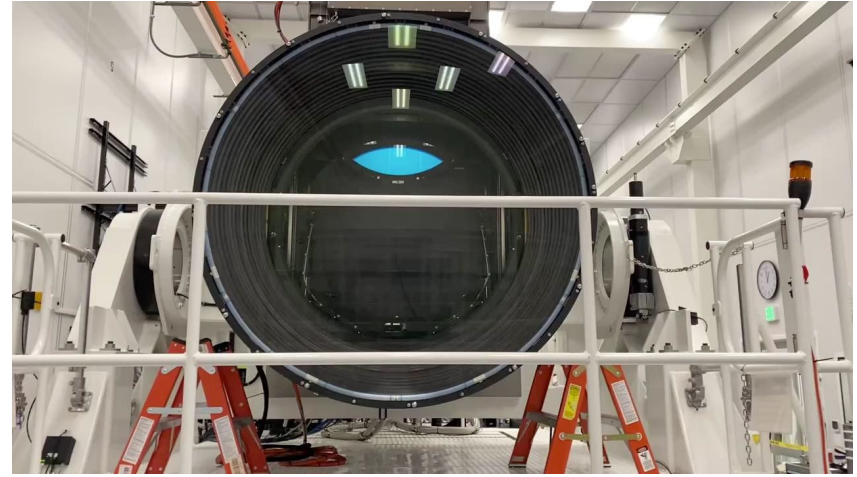
Highlights 2020-2023: DESI

Main/DARK : 5523/9929 completed tiles up to 20231122 (=56%, weighted=58%)



Early Data Release
 5 σ detection of BAO in 2 months
 More than 50% complete. Ahead of schedule
 First Cosmology results (DESI-Y1) in April

Legacy Survey of Space and Time (LSST)



New Observatory (Vera Rubin) in Chile, New telescope and new camera
Currently in commissioning. First light in 2024 and survey start in 2025
CIEMAT: Commissioning, Photo-z, management

Euclid



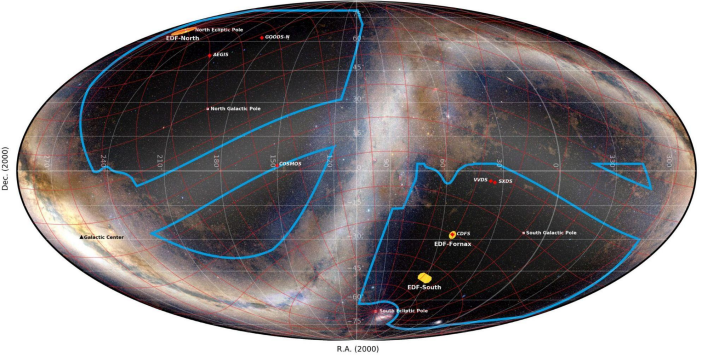
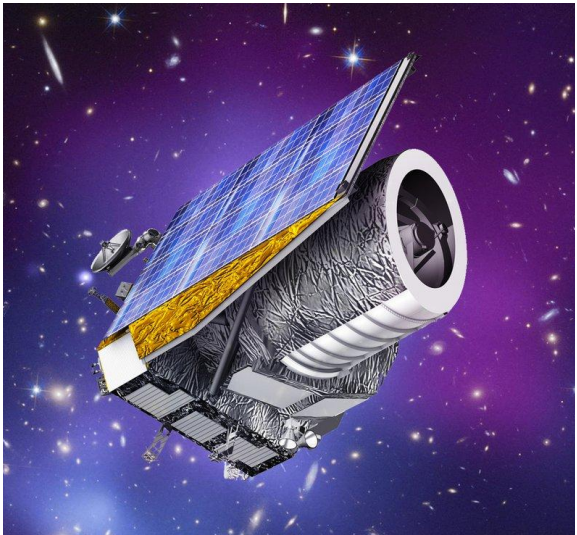
ESA space telescope with visible camera and NIR spectrometer

Survey from the Lagrangian point L2 (Earth-Sun)

Exquisite measurement of galaxy shapes (no atmosphere) for weak lensing

Launched on July 1st, 2023 with a Falcon 9 rocket of SpaceX

First Images published. Cosmology around Q4 2024



The 15,000 deg.² Euclid Wide Survey, the 53 deg.² Euclid Deep Survey, and the 6 deep auxiliary fields (6.5 deg.²) [Mollweide Celestial]

- Euclid Wide Survey region of interest: 16 Kdeg.² compliant with a 15 Kdeg.² survey
- Euclid Deep Fields: North=20 deg.², Fornax=10 deg.², South=23 deg.²
- ◆ Euclid deep auxiliary fields (GOODS=0.5, AEGIS=1, COSMOS=2, VVDS=0.5, SXDX=2, CDFS=0.5 deg.²)

Background image: Euclid Consortium / Planck Collaboration / A. Mellinger



Current Responsibilities in collaborations

DES (since 2006):

Member in the Management Committee
Chairman of the Membership Committee
Convener of the Science Release WG

PAU (since 2007):

Proponent and creator of the project and the international collaboration
Member of the Management Committee

DESI (since 2014)

Member of the IB
Member of the Meetings committee

Euclid (since 2011):

Member of the EWC consortium

LSST-DESC (since 2016):

Computing and simulations coordinator of the Collaboration
Convener of Science Release and Validation WG

Challenges and outlook

Cosmology is an outstanding probe for new physics

CIEMAT is well positioned to participate in world leading cosmology projects

Group needs to face some challenges for the near future:

Lack of personnel → New people in 2024 will help to have better visibility in DESI, Euclid, LSST-DESC

Lack of personnel → Need for more postdocs and PhD students

Need to decide for medium and long term projects after LSST-DESC → Associated technical activities and responsibilities

From P5: CMB-S4, Spec-S5

Good Scientific future for the field in the next ~25 years