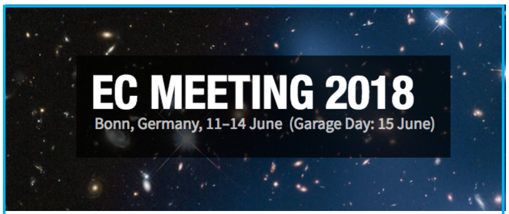
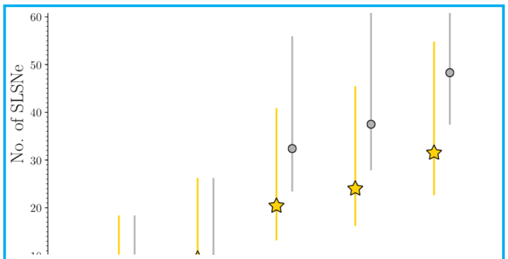
The Euclid Consortium Newsletter - Spring 2018



The Euclid Consortium meeting 2018 takes place in Bonn in June,

Project progress update from ESA

Finding strongly lensed galaxies



Superluminous supernovae in the deep survey.

IST:Forecast
Comparing codes for forecasts for cosmic shear

SPV-2
The Science Performance Verification - a glimpse of the data we will get from Euclid

ECDC
Updates from the EC Diversity Committee

OU-LE3
Updates from the Level 3 OU

OU-SIM
Updates from the simulation OU

OU-PHZ
Updates from the photo-z OU

OU-MER
Updates from the merging OU

From the editors

Welcome to yet another of the Euclid consortium newsletters. This time we get an update on the progress of the project from ESA - and the telescope is now really taking shape. We also get updates from two important preparation tasks on the science side - namely the testing of forecasting codes and the science performance verification project, updates on two important science areas, namely strong lensing and superluminous supernovae and updates from the diversity committee and several OUs

When this is being written we are less than a month away from the next Euclid Consortium Meeting and we hope to see many of you there! It is an exciting time for Euclid now that the telescope is really taking shape and it no longer feels as if the data are far away. We hope that this update on Euclid activities also provides some inspiration to our readers.

We also hope that we will continue to have the privilege of having enthusiastic help from you for the contribution of articles, a big thank you to all our contributors!

Jarle Brinchmann, Stefania Pandolfi and Margot Brouwer

The Euclid Consortium Meeting 2018 In Bonn

The EC-members at the Argelander-Institut für Astronomie are happy to welcome you to this year's annual EC meeting in Bonn. From Monday, June 11, through Thursday, June 14, followed by a Garage Day on June 15, we will have a full and diverse program, with the first two days of Plenary Sessions, followed by two days of numerous Splinter meetings.

A first meeting of the Early Career Committee on Friday morning aims at offering career and professional development activities within the EC.

All EC members are invited to join the annual meeting, to share the latest news about the mission development, and to participate in discussions -- in the sessions, during breaks, or at the social events, i.e., the reception in the Aula of the Universität Bonn on Monday or the conference dinner on the shore of the river Rhine on Wednesday.

Please visit the meeting's website

https://euclid2018.astro.uni-bonn.de/

for registration and further information. The venue of the meeting is the Stadthalle Bad Godesberg, located inside a park and with excellent access by public transport. Hotel rooms can be found either in the local neighborhood of the venue, or closer to downtown Bonn within a mere 15 minute subway drive. We are looking forward to seeing many of you in a month's time in Bonn..

Peter Schneider and Ole Marggraf
on behalf of the Local Organising Committee

News from the ECDC

The Euclid Consortium Diversity Committee (ECDC) would like to report that the Euclid Consortium Code of Conduct (CoC) is now available as a public document. The Code of Conduct affirms the strong commitment of our consortium to perform our work in a highly professional manner that is supportive and inclusive of all of our members. All EC members will be asked to officially accept the CoC as part of the EC tracking tool.

This public version does not include the conflict resolution procedure as this is specific to the organizational structure of the consortium. The complete CoC can be viewed on the internal pages under the "Top Level Documentation" link.

We remind everyone that concerns about violations of the Code of Conduct, including bullying, harassment, discrimination, and scientific misconduct, can be raised to the Euclid Consortium Diversity Committee for either informal mediation or formal complaint. The contact info for all Diversity Committee members can be found on the internal pages. The CoC also includes a specific *meeting Code of Conduct*, which was first posted on the website of the London EC meeting last year, and can also be found on the website of this year's Consortium meeting in Bonn.

Stefanie Wachter

on behalf of the ECDC

Euclid progress report from ESA

Much progress has been made in the spacecraft development since the last time we wrote on these pages. The Critical Design Review (CDR) of the spacecraft System starts in March. An independent team of ESTEC engineers will scrutinise the design of the spacecraft to confirm that the design is sound and that we can proceed with the integration of flight hardware. The System CDR follows the subsystem CDR's which have all been held already, like the CDR of the Payload Module (PLM) that was held in the first half of last year, of the Structure and Thermal Control, of the Telemetry and Telecommand (TT&C), of the Attitude and Orbit Control, and so on. Since the subsystems have been confirmed to be designed according to the Euclid specifications and engineering best practices (the ECSS norm), it is now the turn of the system to prove that everything fits together and the design meets the requirements of the System Requirements Document (SRD). The review kicked-off on March 5th and will last until the board meeting on the 3rd of May. The board will be co-chaired by the ESA's Inspector General, Toni Tolker-Nielsen, and the newly appointed ESA's Director of Science, Günther Hasinger.

The CDR is based largely on design documents, but there are also many tests which have already been performed at subsystem and system level. Virtually all the subsystem units have an Engineering Model, which is functionally and electrically representative of the flight units. These models are used at subsystem level to prove that they function correctly and at system level in a so-called Avionics Model (AVM). The AVM has been assembled at the Prime premises at Thales Alenia Space (TAS) in Torino and consists at this stage of nearly all platform units plus the VIS AVM. TAS is currently busy to run a very important verification that VIS can be switched and properly commanded on the AVM, and that it can produce internally simulated data which can be stored in the Mass Memory unit (MMU) according to the file system that Euclid uses (CFDP protocol). At a later stage we will also test that the data produced can be downloaded through the TT&C. At subsystem level many tests have also been performed, e.g. the TT&C has been tested and showed very good performance also when connected with a hardware simulated ground station which confirmed an overall very good link budget. Other tests have been performed at On Board Computer level, while the structural tests are still to be performed, as the structure of the Service Module (SVM) is being assembled at the time of writing.

Another important advancement has been achieved in the full assembly of the SiC baseplate. The baseplate is Euclid's optical bench on which all the optics and instruments are mounted. It is a large irregularly shaped structure made of Silicon Carbide (SiC) of about 2.7 x 2.4 m side. Due to limiting size of the oven needed to sinter the ceramic, the baseplate is made of four separated pieces brazed together. This construction took more than two years. The four pieces that form the STM baseplate were brazed together in February 2018 (see picture). This very impor-

Figure 1: Left panel: the Euclid SiC base plate just out of the oven, after the brazing of four separate pieces. Right panel: the Euclid Multi-purpose Trolley which is used to support the payload module during the integration process. Images courtesy Airbus Defence Systems, Toulouse.

tant milestone represents the starting point of the assembly of the PLM Structural and Thermal Model (STM). The STM is nearly identical to the flight model, and will be subjected to structural tests at PLM level. It will then be mated with the service module to undergo to spacecraft integrated structural and thermal tests.

Recognizing the close connection in development between the Operations Ground Segment (OGS) and the Science Ground Segment (SGS), it was decided to have a common milestone for the OGS and SGS before the Mission CDR. The ground segment consists of the Mission Operations Centre (MOC) in Darmstadt, the Science Operations Centre (SOC) in Madrid, and the EC-SGS with its nine Science Data Centres (SDCs) and ten Operational Units (OUs). Since the ground segment and space segment follow a different development planning, we cannot speak of a "critical" design of the ground segment at this time in the project. This milestone, the Ground Segment Design Review, comprises the endorsement of the completeness, consistency and feasibility of the elements in the ground segment, with an assessment of the maturity of the ground segment at this stage of the mission. The review itself involved more than 50 reviewers in four panels, which were active over two review phases. The reviewers had the ungrateful task of scrutinizing the ground segment design for weak elements, but despite the many review remarks and questions no show stoppers were identified. It was concluded that the Euclid Ground Segment Design status is sufficiently mature and adequate. In fact, at a more general level, the whole review process revealed the difficulty to apply a traditional milestone review to the agile development approach adopted by the SGS. This was discussed at review board level and ESA is investigating how the situation could be improved for future occasions.

After the System CDR, we will have to pass the last design review, that of the feasibility of the mission as a whole: the Mission CDR. It includes both the space and the ground segment. At M-CDR the best predictions of the "as designed" end-to-end performances will be assessed. An important input to the M-CDR is the outcome of the Science Performance Verification 2, which gives us a current best estimate of the end-to-end scientific performance of the mission, the Level 0 requirements.

René Laureijs and Giuseppe Racca

Science Performance Verification

Science Performance Verifications (SPV) are detailed studies of the performances of the Euclid Mission. All the Euclid design is driven by two top level science requirements:

- The Euclid Mission will by itself allow us to understand the nature of the apparent acceleration of the Universe. Euclid will distinguish effects produced by a cosmological constant from those produced by a dynamical dark energy. This must be done by achieving a FoM>400 from Euclid data alone.
- The Euclid Mission will by itself allow us to test gravity on cosmological scales. Euclid will probe the growth of structure and will separately constrain the two relativistic potentials, Ψ and Φ. This can be done by achieving an absolute 1σ precision of 0.02 on the growth index, γ, from Euclid data alone.

All the requirements on the instruments, the survey, and the external data are derived from these two top level requirements. The goal of the SPV is to check whether Euclid, with our knowledge of the system as it is now, meets these two top level requirements. It is the opposite of the exercise of the requirements flow-down: we simulate the mission with our knowledge of each sub-component at the time of the exercise, and we check how the mission is doing with respect to these two top-level requirements. Each SPV exercise leads to an updated major version of the Mission Performance Document. The first SPV exercise was conducted during Phase A of the project in 2012 and resulted in the first issue of this document. The SPV2 exercise started in January 2017 with the goal to inform the Mission Critical Performance Review. SPV3 will be conducted circa 2020 before the launch and should include a full End-to-End simulation (E2E) with SGS processing.

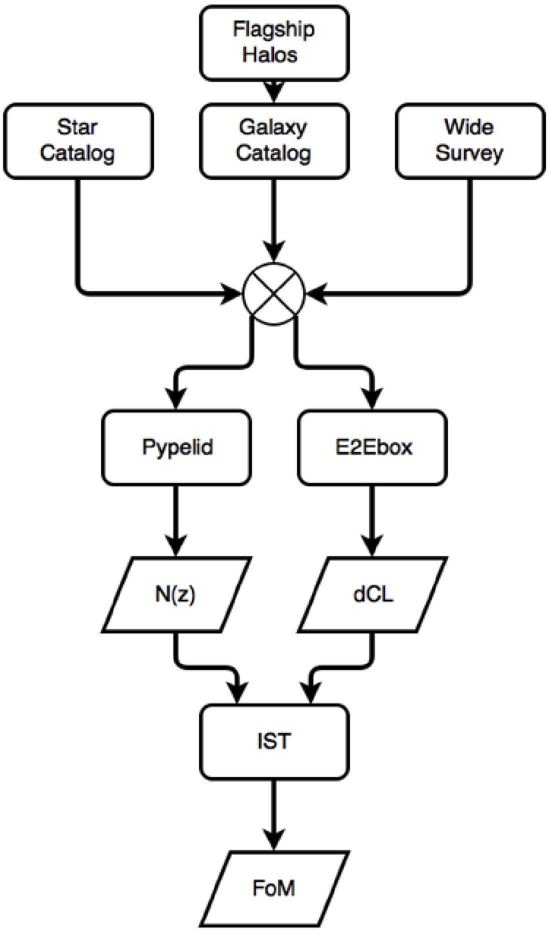


Figure 2: Schematic of the SPV2 data flow. The Euclid observations are simulated from an all sky galaxy catalog simulated from the Flagship halo simulation, a star catalog and a Euclid survey. This is passed through Pypelid and E2Ebox (see text) and the results are input to the IST Forecast Fisher matrix codes to derive a combined figure of merit.

SPV2

Ideally, a SPV exercise would consist in a full end-to-end simulation of the Euclid mission. This is not possible at this time, since the ground-segment pipelines are still being designed and coded, but remains the objective for SPV3. For SPV2, we have to rely on catalog-to-catalog simulations, bypassing the simulations at the detector level (hence their name of "**bypasses**"). However, these bypasses are as much as possible calibrated against simulations at the pixel level.

In order to conduct this exercise, a team of scientists from the many entities of the EC has been assembled:

- From the SWG-CS to provide the input galaxy catalog for the simulations
- From the EC-Survey group to provide an optimised new survey design, taking into account the conclusions from the MPDR.
- From OU-SIM to provide a star catalog as well as tools to simulate spectra.
- From OU-SPE to check the performances of the redshift measurement algorithm.
- From OU-PHZ to take into account the photometric redshift error measurements.
- From the SWG-GC to provide the bypass allowing to compute the number counts and redshift distribution of the sources used for GC measurements.
- From the SWG-WL to provide the bypass allowing to compute the number counts and redshift distribution of the sources used for WL measurements. This group will also provide the deformation to the power spectrum expected from Euclid imperfections.
- From the IST Forecast to provide the Fisher matrix analysis codes to derive the Figure of

SWG-CS: The Science Working Group (SWG) dealing with simulations of the Universe.
OU-SIM: The Organisation Unit (OU) dealing with simulated Euclid data.
OU-SPE: The OU in charge of the analysis of reduced Euclid spectra.
OU-PHZ: The OU in charge of photometric redshift estimates for Euclid.
SWG-GC: The galaxy clustering SWG.
SWG-WL: The weak lensing SWG.
IST: Inter-SWG task force.

Merit and accuracy on the growth index from the bypass outputs.

A schematic of the SPV2 flowchart is given in figure 2.

IST Forecast

The final numbers for the SPV2 exercise, e.g the FoM and precision on γ, will be delivered by IST Forecast (using a Fisher matrix formalism) from the number counts and redshift distribution of the sources measured both on the WL and GC side. A large effort of code comparison and cross-check has been undertaken by the IST to validate the Fisher matrix computations. See the IST Forecast contribution in this issue for details. On the GC side, codes from Carbone, Casas, Majerotto, Sapone, Yahiacherif-Tutusaus, Pourtsidou-Markovic and Yankelevich have now been tested, and now reach a better than percent level agreement on all the cosmological parameters in the linear case. The codes are now being improved to include non-linear effects. IST Forecast is in really good shape to be ready to compute the FoM when the new number counts and redshift distributions become available.

SWG-CS

At the other end of the chain is the production of an all-Euclid-sky catalogue of galaxies. The all-sky halo catalogue computed on the Piz Daint supercomputer (containing more than 4000+ GPU nodes) is being populated by the group with galaxies reproducing as much as possible all the observables relevant for Euclid's main cosmological probes. This "Flagship" catalogue is undergoing massive testing and improvement efforts: from its first release to SPV (version 0.3), to the publicly released version at the London consortium meeting (version 1.3.1) and continuing until version 1.6.5 that was selected as the SPV2 baseline. Kudos to the developers and testers who spent a hectic 2017 and early 2018.

ECSurvey

Following the MPDR results, a new survey has been designed by the EC survey team. As straylight has been identified as a major performance issue for Euclid infrared spectroscopy, the new survey explores sky regions closer to the ecliptic plane, but farther from the galactic plane. In February 2018, the baseline dither pattern used for Euclid observations was changed, following the recommendations of Markovic et al. (2017), from the so-called J-pattern to the S-pattern. The advantage of the latter over the former is that it does not create any holes between adjacent pointings in the spectroscopic coverage.

GC and WL E2E groups

These two groups have the delicate task of developing and calibrating the bypasses allowing to derive the number counts and redshift distribution measured by the Euclid mission from the input Flagship catalog.

Simulations of slitless spectroscopy are carried out by the **Pypelid** software, that derives the number of observed spectra and correctly measured redshifts. Pypelid's success rate is calibrated using full end-to-end simulations of spectra. Simulations of the shear measurement are created with **E2Ebox**, that derives the number of sources measured as a function of redshift, but also the perturbations to the measured power spectra induced by imperfect measurements.

What can you expect from SPV2 ?

- A honest estimation on how well the mission should perform.
- A simulated all Euclid Wide catalog that will be ingested in the Euclid archive which can be used to prepare yourself for the real data.

Stay tuned!

Hervé Aussel

IST:Forecasts – IST:Forecasts – Fisher Matrix Code Comparison

The joint use of both galaxy clustering (GC) and weak lensing (WL) makes Euclid a unique opportunity to investigate the nature of dark energy. To quantify the survey constraining power on the equation of state of the Dark Energy fluid (defined as its pressure of density) one can use the Figure of Merit (FoM), which tries to capture the performance of an experiment within a specific plane of dark energy parameters. This number is usually identified with the inverse 95% area of the likelihood ellipse in the parameter space of (w_0 , w_a), after marginalizing over all other parameters. Here (w_0 , w_a) parameterise the time dependence that the equation of state may have at late times. The larger the FoM, the smaller the area in parameter space that can be tested, i.e. the better a given experiment can constrain those Dark Energy parameters.

However, in order to make the FoM a reliable tool, it's important to make sure that both the input, i.e. the initial assumptions, and the output – the number produced by the evaluation process – are solid and reliable. The IST:Forecasts team was formed to satisfy this goal: provide a reliable pipeline for the estimation of the FoM for galaxy clustering, weak lensing and when combining both probes. The team, led by Tom Kitching, Valeria Pettorino and Ariel Sanchez, worked in close collaboration with the GC and WL SWGs on a two-step process. First, setting up the GC and WL recipes to be used for forecasting the FoM, and then implementing, comparing and validating several numerical codes, written in different programming languages, that estimate the FoM through the Fisher matrix formalism and further estimate Fisher Matrix forecasts on both the standard cosmological model and a few minimal cosmological scenarios of dark energy and modified gravity. The setup process made also sure that the constraints on all the cosmological parameters of interest and the size and orientation of the 2D projections of the full likelihood were consistent among the participating codes.

The recipe needed to specify the approach for forecasting the FoM was led by D. Markovic and E. Majerotto for GC and by M. Kilbinger for WL. The implementation and validation of the codes was led by C. Carbone and D. Sapone for GC and V. Cardone for WL. In addition, A. Blanchard, M. Kunz and F. Lacasa led an effort on the cross combination of the two probes while M. Martinelli led a joint effort to document all steps of the IST process and S.Casas made sure that the input of all models and probes was systematically used by all codes in a consistent way.

The comparison for both probes has been done following a roadmap with increasing complexity, both with respect to systematics and to account for the modelling of the non-linear regime. This was done also in order to identify the impact of different choices, hence giving as a byproduct also a set of important lessons learned, which may be useful to any other future forecast validation.

Within the GC recipe definition and implementation, the main difficulties regarded the definition and creation of reliable matter power spectra and their interpolations, in order to capture the behaviour of the Baryonic Acoustic Oscillations (BAO). Another aspect regarded the stabilisation of the derivatives of the observed galaxy power spectrum with respect to the cosmological parameters, especially to those that will be measured with the BAO, namely the Hubble parameter and the angular diameter distance.

Within the WL recipe, the shear tomography power spectrum is given by the integral along the line of sight of the product of the lensing kernel and the matter power spectrum. While the former is determined by the survey characteristics, through the source redshift distribution $n(z)$ and the probability distribution function of the measured redshift, the matter power spectrum modeling must take into account the deviations from the linear regime due to the gravitational collapse of structures on small scales. A further astrophysical contaminant of the lensing signal is the intrinsic alignment (IA) of source galaxies, which may imprint a preferred orientation of the ellipticities. This was accounted for by adding two further terms, that fit well the 2–point shear correlation function in hydro–dynamical simulations.

Once the GC and WL recipes had been set, the next step was to validate several existing and newly developed codes that estimate the FoM using the Fisher matrix formalism and to calculate a baseline result.

The first product of the GC Fisher matrix are the errors on the main observables which are divided into four cosmological parameters, which describe the shape of the power spectrum, and five redshift - dependent quantities. Two further nuisance parameters are then added to describe nonlinear effects. Seven different codes were compared as provided by nine members: C. Carbone, S. Casas, E. Majerotto, A. Pourtsidou and D. Markovic, D. Sapone, S. Yahia-Cherif and I. Tutusaus, and V. Yankelevich. The agreement reached is better than percent level over all the cosmological parameters.

The lensing FoM under different model assumptions was validated by comparing the output of five different codes provided by S. Camera, V. Cardone, S. Casas, M. Martinelli, and I. Tutusaus. It is worth noting that the five codes use different strategies to implement the same WL recipe each one adopting its own method to compute the derivatives of the shear power spectrum. Moreover, two of the five codes compute the matter power spectrum internally, while the remaining three adopt the same input. The agreement between the results is at less than five percent level for most of the cosmological parameters, except the Hubble constant which is not well constrained by WL alone.

An important novelty of the Euclid survey is the possibility to take into account the cross correlation between its primary probes. Understanding and quantifying the role of these cross correlations terms was also a task within the IST:Forecast. Two existing codes were adapted by I. Tutusaus, M. Kilbinger, M. Martinelli and M. Raveri and improved to estimate the impact of cross correlation between shear tomography and photometric galaxy clustering. The two codes are built according to different strategies and both codes were greatly improved in their robustness during this comparison. The information from photometric galaxy clustering is generally also difficult to model, including the non-linear small scales and scale dependent bias. However, when used in combination with shear tomography, this may further boost the FoM. The impact of the cross correlations on the FOM has been quantified under various different conditions, different non-linear recipes and varying the cut in angular scale; in addition, the IST:Forecast was in contact with the XCMB SWG via the link of S. Ilic to discuss and test different ways to combine Euclid forecasts with information from the CMB.

The final combination of GC, WL, and XC results has been performed with several cautional cuts in order to provide a robust total FOM, therefore quantifying how much light Euclid will be able to shine on the dark side of the universe.

The IST group worked as a team with continuous cross checking among different tasks, and the results of the validation process will be made public in a summary paper.

Vincenzo Cardone, Valeria Pettorino and Domenico Sapone on behalf of the IST:Forecast Team

What are ISTs?

IST stands for Inter-SWG Taskforces - this is a concept defined in the Science Analysis Implementation Document (the SAID, EUCL-MSS-SWG-MR-00523_01_05_SAID in Livelink). An IST differs from a work package (WP) in that a WP is a sub-set of a SWG while ISTs are viewed as super-sets of SWGs and "on an area of common mutual interest for the EC, and are required in order for the Euclid science objectives to be met" - to quote the SWG Work Package Definition Document (EUCL-MSS-WPD-8-002 in Livelink). A list of ISTs can be found on the internal web pages.

Euclid: Superluminous supernovae in the Deep Survey

Over the last decade, new dedicated transient surveys of the Universe have discovered a multitude of new phenomena. One of the most surprising examples of such new transients is the discovery of superluminous supernovae (SLSNe) which appear to be long-lived explosions (hundreds of days) with peak magnitudes far in excess of normal supernovae (5-100 times the luminosity of Type Ia and core-collapse supernovae). Recent studies suggest SLSNe could be standardized in their peak luminosities using empirical corrections similar in spirit to those used in the standardization of Type Ia supernova. In the paper of the Euclid transient group led by Inserra, we have outlined the rate of SLSNe as a function of redshift in the Euclid Deep Survey (EDS).

To calculate the number of likely Euclid SLSNe-I, we need to know: the volume sampled by the EDS as a function of epoch; the luminosity function of our transients; a model for the evolution of the star-formation rate density and that of SLSNe with respect to normal core-collapse supernovae.

The current EDS will likely comprise three separate areas with different sampling and coverage (see Figure 3, below); one near the north ecliptic pole (EDS-N), one near the south ecliptic pole (EDS-S) and a third overlapping with the Chandra Deep Fields South (EDS-Fornax), which we have ignored because of its low-visibility. We assumed a 5σ limiting magnitude of 25.5 mag for each of the individual EDS visual visits (the VIS passband is equivalent to an r + i + z passband), while we assumed Y = J = H = 24.05 mag for each Near Infrared Spectrometer and Photometer visit of the EDS.

We adopted a luminosity function with an average light-curve peak of approximatively −21.60 r-band magnitude, rising for ~25 days and declining ~1.5 mag in 30 days. To estimate the systematic uncertainty on this rate, we also used two different evolutions of the star formation density and SLSNe to core-collapse SNe ratio. We defined a "silver sample" that requires each SLSN to be detected (5σ point source) for at least three epochs (3e) of their light-curves in at least two Euclid filters (2f) per epoch (or 3e2f). Second, we defined a "gold sample" which requires a detection (5σ point source) in at least three Euclid filters, each for at least three epochs (3e3f).

In Figure 4, above, we show the results of our simulation. When determining the number of SLSNe expected from the EDS, we assume that only the northern and southern areas of the EDS (total of 30 deg2) are observed. This provides a yearly volumetric rate of 41^{+11}_{-6} yr^{-1} Gpc^{-3} for the silver sample and 27^{+9}_{-4} yr^{-1} Gpc^{-3} for the gold sample. In total, we predict Euclid will detect 140 high-quality (gold sample) SLSNe up to z ~ 3.5 over the five years of the EDS. On the other hand, the silver sample could deliver an extra 70 SLSNe, with respect to the gold, over the same five years.

The discovery of hundreds of SLSNe in the EDS will improve several areas of supernova astrophysics and the star-formation history of the

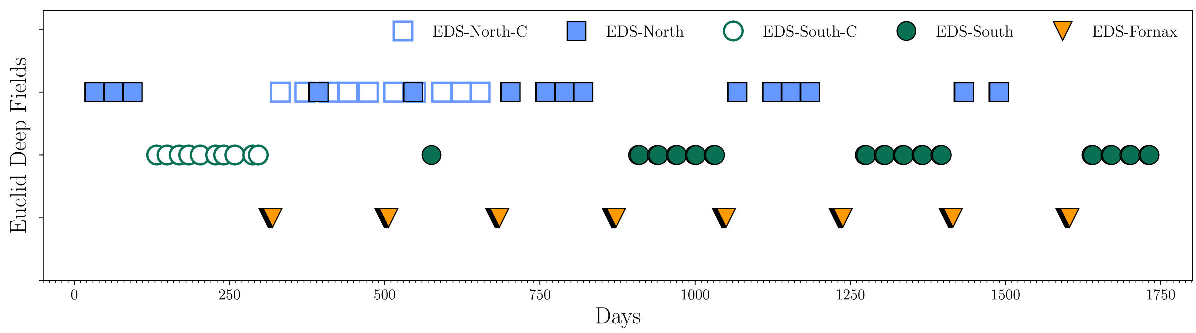


Figure 3: summary of the EDS cadence over the five-year (1825 days) survey. Open symbols refer to the calibration epochs, which are ten per field excluding the Fornax field. Calibration epochs will have the same nominal depth of whole EDS. See the paper for further details.

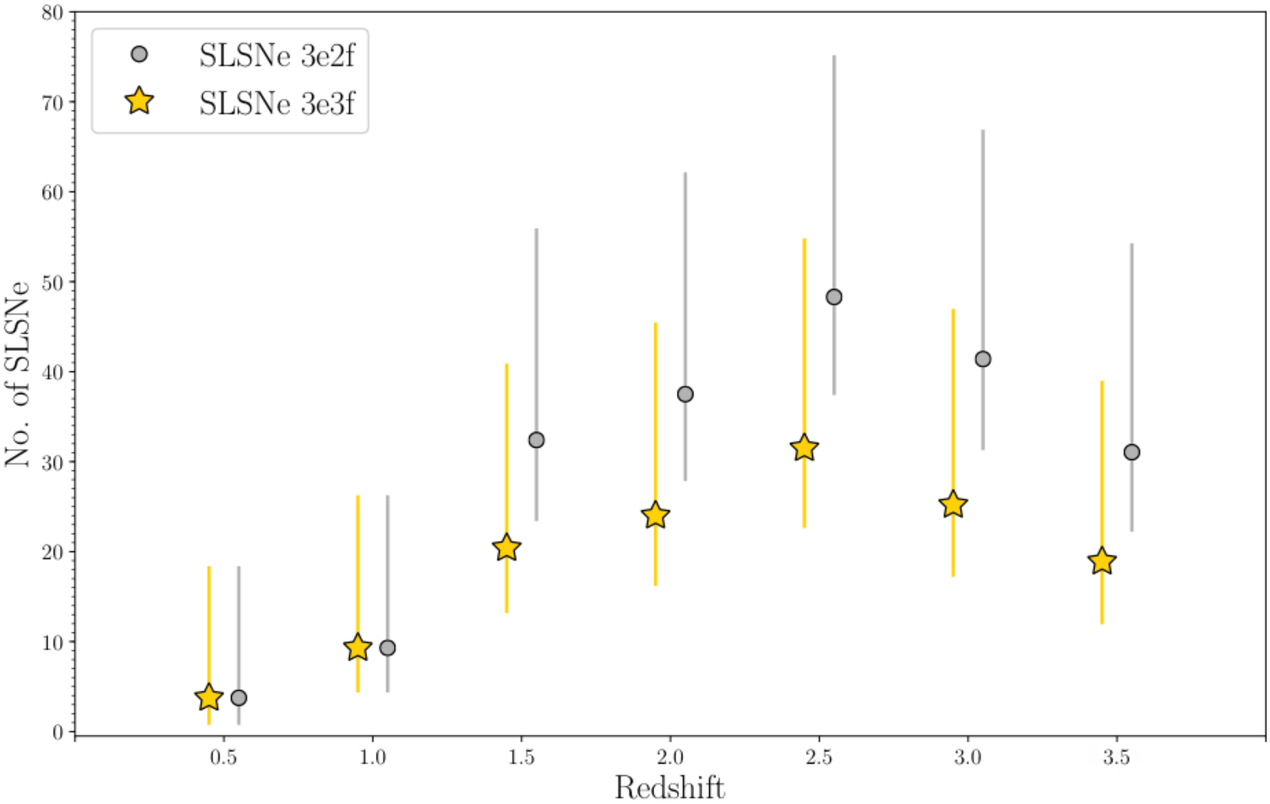


Figure 4 Number of SLSNe detected, per redshift bin ($\Delta z = 0.5$), during the five years of the EDS (combining both the northern and southern EDS observations). Gold stars denote the "gold sample" (3e3f in legend, see text), while the silver circles are the "silver sample" (3e2f, see text). The error bars are Poisson uncertainties based on the number of SLSNe in each bin. Both gold and silver points are offset of $\Delta z = 0.05$ to facilitate the reading.

Universe. Such investigations will be enhanced by follow-up observations by the next generation of large space and ground-based telescopes (E-ELT, LSST, and JWST) and provide excellent targets for these observatories.

In the Inserra et al (2018), we also investigated the possibility of constraining cosmology using these SLSNe, when combined with a low-redshift sample of 50 SLSNe (from the literature), and the expected cosmological results from the Dark Energy Survey (DES). In the case of a flat w_0w_aCDM model, our analysis suggests we could obtain an uncertainty of $\Delta w_a \sim 0.9$ which is an improvement on the DES-only result and the present constraints on this parameterization. Any additional measurements of the high-redshift expansion history of the Universe are invaluable as present baryonic acoustic oscillations observations suggest a possible tension with the standard ΛCDM model, either indicating unrecognized systematic uncertainties or dynamical dark energy.

Cosimo Inserra

OU-LE3

The goal of the Level 3 Organisational Unit (OU-LE3) is to develop the algorithms that will be used to provide ESA with the final Euclid data products, such as the weak lensing and galaxy clustering two-point correlation functions and power spectra, and the weak lensing mass-maps. As part of this development, LE3 must ensure that the algorithms achieve the maturity levels (ML) required to eventually be included in the Science Data Centre (SDC). To this end there has been much progress made by all processing functions (PFs) since the last newsletter.

As presented in the Software Design Document (SDD), for the weak-lensing high-priority PFs, Athena will form the bulk of the two-point correlation function PF, with COSEBIs also providing E and B-mode decompositions. The power spectrum PF will be composed primarily of BLACKPEARL, which will output both pseudo- and Bayesian-Cl estimates. Athena has already passed ML 2b, and the aim is for BLACKPEARL to achieve this level at the assessment in June.

In Galaxy Clustering three codes have passed ML 2a (for 3D power spectrum, two-point correlation and its covariance). The codes for three point statistics (bispectrum and correlation) are being validated. They will reach ML 2a in October.

Two methods for cluster detections have been selected for the PF DET-CL: AMICO by Bellagamba et al. and PZWAV by Gonzalez. Both methods have passed ML 1a and are being integrated in the Euclid pipeline. Work is ongoing for bringing most of the other processing functions related to the characterization of clusters of galaxies to ML 1 within the coming year.

Following the Science Ground Segment (SGS) Design Review, it was declared that LE3 had successfully passed the assessment, and there is now a short-term goal to tackle the outstanding requirements in the SGS documentation.

Over the last year, there have been a couple of changes to LE3 work package leads: Peder Norberg (Durham) has replaced Carlton Baugh (Durham) as lead of the Galaxy Clustering WP and Hervé Aussel (Saclay) has replaced Sandrine Pires (Saclay) as lead of the Internal Data work package.

In order to help achieve the broad science goals of LE3, there have been a number of joint meetings with other OUs and science working groups. The recent joint meeting was very fruitful and brought about many useful discussions, such as requirements by LE3 on the details and format of the mask, which will play a vital role in the LE3 pipelines. There has also been much communication between LE3 and OUs-SHE and PHZ, with the aim of developing the interfaces been the various PFs.

Over the coming year, LE3 is set to make significant progress in code development, with the long term aim of all PFs achieving maturity level 3b in 2020. The codes will then be included in the SDC and provide the deliverables that will be used by the scientific community to achieve the primary goal of the Euclid space mission: an unprecedented insight into the nature of the dark Universe.

Lee Whittaker on behalf of OU-LE3

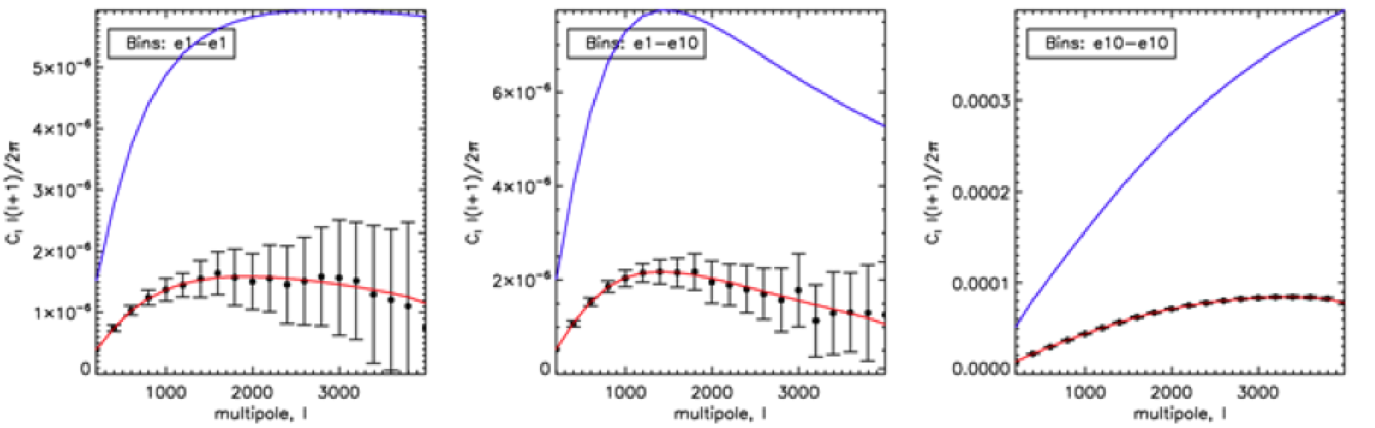


Figure 5: The mean recovered E-mode shear estimates successfully recovered from a suite of 100 Euclid-like simulations for three redshift bin combinations using the pseudo-Cl estimator. The error bars show the 1-sigma dispersions, the blue curves show the raw input Cls, and the red curves show the input Cls modelled for the effects of the mask.

OU-PHZ

Like the other components of the Science Ground Segment, OU-PHZ has recently been going through the Design Review. This has been the opportunity to start making use of the Swiss Science Data Center to transform the ideas that have been discussed in OU-PHZ into a pipeline prototype. While the pipeline is not complete and the components not finalized yet, the main components of the baseline PHZ pipeline are implemented at a level that makes it usable.

In parallel, PHZ is an important step in the Science Performance Verification #2 exercise, and has entered the Scientific Challenges that have recently been kicked off (SC#5 is the first such challenge involving PHZ). The baseline pipeline presented at the Design Review will be used for the two activities.

A very significant change has impacted the development of OU-PHZ since about 18 months: the effect of possible changes in the filter transmissions due to filter non-uniformities, different CCD quantum efficiencies, aging and even Galactic reddening. This has had a major impact on the selection of algorithms in the baseline pipeline. In addition to increasing the scatter, changes in filter transmissions would introduce a bias on the photometric redshifts. In an internal note (J. Coupon et al.), we demonstrated that it is sufficient for PHZ to know the average wavelengths of each bandpass to be able to correct for these effects. However, most algorithms cannot cope with this situations in a practicable way; for instance, template-fitting algorithms could easily deal with this problem in theory, but in practice the computational cost is prohibitive. The current PHZ baseline pipeline is now based on a machine-learning, Nearest-Neighbor approach, and on a training sample with very good knowledge of the spectral energy distributions of the objects, in order to correct the fluxes on the fly for any colour effect due to changes in filter transmissions. At the same time PHZ will recreate "true" galaxy colours, either observed or de-reddened, and determine many galaxy properties.

Stephane Paltani

OU-SIM

After an intense production period during the first half of 2017, the 9-field simulation for the Scientific Challenge 3 (SC3) was delivered. For this release, deeper simulations containing stars and galaxies up to H < 24.5 in the Euclid Visible and Near Infrared Photometric channels and H < 22.5 plus all visible Hα emitting galaxies in the near-infrared spectroscopic channel, was delivered. In addition, a new pixel simulator for the Dark Energy Survey (DES) and Kilo-Degree Survey (KiDS) was introduced and first images were simulated. This challenge has proved to be a very valuable tool for progressing in the development and integration of the Science Ground Segment (SGS) with 6 OUs involved, and was successfully reviewed during the SGS Design Review in late 2017.

The OU-SIM group has also contributed to the second Science Performance Verification exercise (SPV02) on various topics. Jointly with the SPV team, we have produced an all-sky stellar catalogue containing more than 3 billion stars. With respect to the star catalogue used in SC3, real stars have been included at the bright end to match the reference survey strategy, complemented with Besançon model stars for the faint end. Also in collaboration with the Cosmological Simulations Working Group, we have included the observed band fluxes in all Euclid and External surveys for all the Flagship mock galaxy catalogues, involving almost 8 billion sources. Finally, making use of our infrared spectroscopic image simulator known as

TIPS, has been modified to produce directly 1D and 2D spectra, bypassing the full image simulation and the processing of OU-SIR, and allowing a much faster analysis that serves to calibrate other simulations inside SPV. The adapted code named FastTIPS has been run over 25 different locations on the sky to estimate the performance under different conditions of zodiacal light and stellar density.

Early in 2018 we have been gathering the new requirements on simulations for the next Scientific Challenges, four, five and six (SC4/5/6), that will take place later this year. These simulations will include Euclid deep fields, NISP calibration fields, a more accurate and variable PSF, several new instrumental effects, updated models and a new external simulator for the Large Synoptic Survey Telescope (LSST). SC4/5/6 simulations are scheduled to be available in fall 2018.

Santiago Serrano and Anne Ealet

OU-MER

The MER Organization Unit is the section of the Euclid Science Ground Segment (SGS) responsible for the assembly of the final photometric catalogue "merging" the information from the Euclid satellite (the VIS and NIR imaging instruments) and from the euclidized external surveys (e.g. LSST, DES, KiDS, etc.). During 2017 we focused our efforts on developing the MER processing function in the framework of the Scientific Challenge 3 (SC3). This is the first SC in which OU-MER has been involved and it has been the first integrated test bench for our pipeline. All fundamental functionalities of the MER Processing Functions (PFs) have been implemented and exploited: mosaicing, background subtraction, detection, deblending, Point Spread Function (PSF) homogenization, star/galaxy separation, multi-band photometry, and catalogue assembly.

The task has been carried out working side by side with MER reference science data centres, and with its primary one, SDC-IT, playing a central role in the software development. The outcome of this challenge has been the release of a merged catalogue of nearly 300,000 sources with astrometric, photometric, and morphological information extracted from the imaging data provided by OU-VIS, OU-NIR and OU-EXT.

The core of the pipeline is dedicated to multiband photometric extraction of the sources, OU-MER's most crucial task. This required a huge effort experimenting with photometric techniques: aperture photometry on PSF-matched images, taking advantage of legacy software SExtractor (Bertin & Arnouts 1996), and template fitting photometry using a Euclid-specific version of T-PHOT (Merlin et al. 2015, Merlin et al. 2016).

All MER tasks are now under further improvement in the context of the incoming Scientific Challenges 4/5/6 for which we foresee the introduction of a detection scheme including both VIS- and NIR-detected objects, a new aperture photometry software (APHOT, Merlin et al. in preparation), a different and more flexible deblending technique based on the ASTErIsM code (Tramacere et al. 2016), an *ad hoc* method to deal with PSF variation with position and colour, improved background subtraction and star/galaxy separation tools, and inclusion of additional morphological estimators.

SC3 has been an important occasion for setting up interfaces through a fruitful exchange between MER and the other Organization Units. In fact, the most important lesson we learnt is that a constant and willing communication is fundamental in a complex system as the Euclid Science Ground Segment in order to reach the high scientific goals of the mission. This is the vision we wish to maintain as we approach the next challenges.

Stefano Pilo

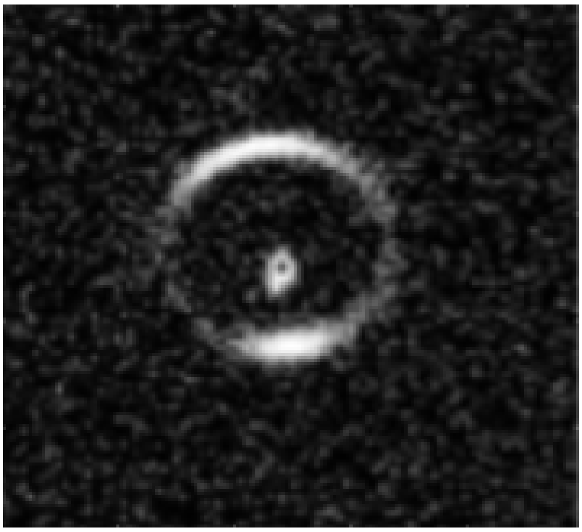
on behalf of OU-MERt

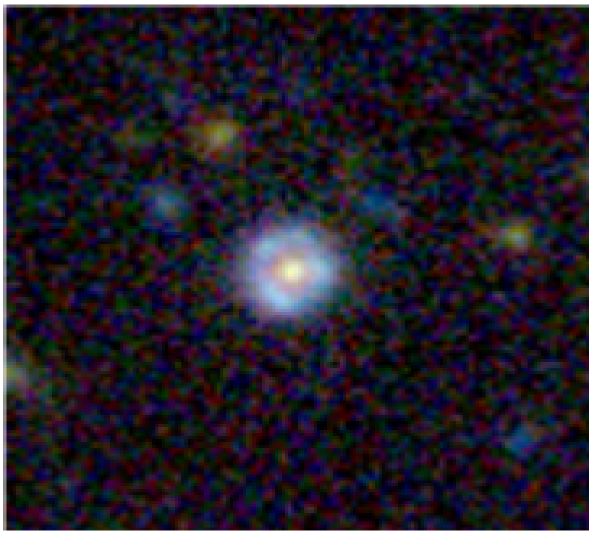
The Strong Gravitational Lens Finding Challenge

In the strong lensing regime, light from a background object is multiply imaged by a foreground mass, providing a unique probe of the distribution of intervening matter at the galaxy and cluster scales. During its mission, Euclid will observe over ten billion galaxies, creating a source catalogue of unprecedented size. The Euclid Strong Lensing SWG will search within the catalogue for brand new strong lens systems, adding hundreds of thousands to the few hundreds currently known.

before being asked to classify 100 000 test lenses in 48 hours.

Performances were evaluated by considering the ability of each algorithm to provide a complete and pure sample of lenses from the test set. Machine learning techniques proved to be the most successful, with convolutional neural networks (see e.g. Schaefer et al. 2017: https://arxiv.org/pdf/1705.07132.pdf, Lanusse et al., 2017: https://arxiv.org/pdf/1703.02642.pdf) achieving impressive overall performance. Support vector machine techniques were also found





Left: A simulated VIS band strong lens image from the mock Euclid-based dataset. Right: A real strong lens candidate within the third data release from the Kilo Degree Survey, found using one of the winning methods from the lens finding challenge (Hartley et al., 2017).

With such a large sample of strong lenses, the group will be able to extract new cosmological constraints, providing independent measurements of dark energy, of the Hubble parameter, and of galaxy evolution over cosmic history. However, finding all such rare objects will be impossible using traditional methods of visual inspection, and automated processes will be essential. The Strong Lens SWG designed an international Strong Lens Finding Challenge (Metcalf et al. 2018: https://arxiv.org/abs/1802.03609) in order to find the best algorithms for development of lens-finding pipelines. Mock datasets were designed to mimic visible (VIS) band images from the Euclid instrument and u, g, r and i band images from the ground-based KiDS survey, creating two separate challenge categories. For each category, participants were able to use 20 000 simulated lenses for training purposes,

to be useful (Hartley et al., 2017: https://arxiv.org/pdf/1705.08949.pdf), achieving a high rate of false-positive rejection. The winning methods scored significantly better than entries based on visual inspection by humans. A new challenge is now under construction, for which participants will be asked to classify a larger number of images in a shorter amount of time. Since the use of image colour was found to be important in the original challenge, simulated data representing images captured by the near-infrar red (NIR) imager will, this time, be made available in addition to mock VIS band data. We will also investigate the additional yields to be gained from the NISP spectra.

Philippa Hartley

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