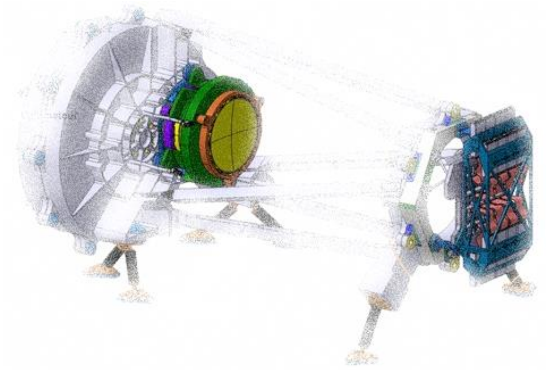
Euclid @ OAS Bologna:

experimental activities, ground segment and scientific exploitation preparation.
Status and perspective



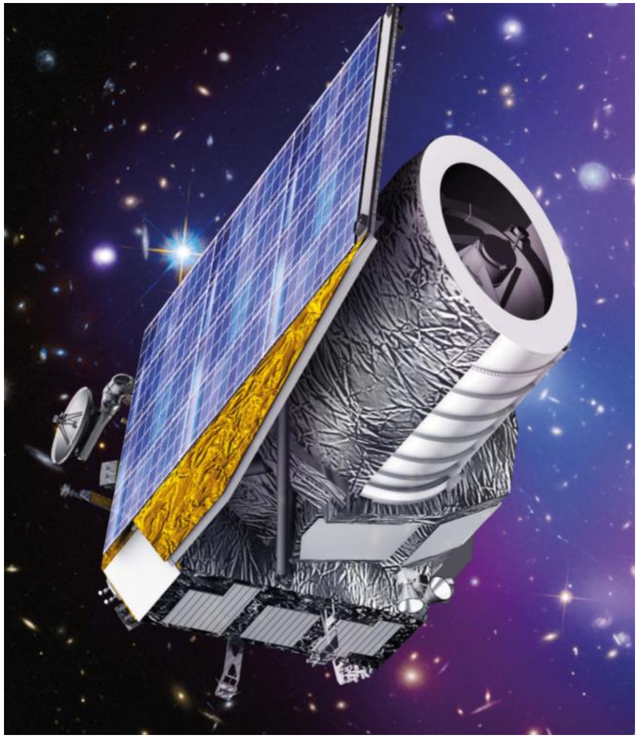
Natalia Auricchio & Elena Zucca
On behalf of the Euclid Consortium

SUMMARY

- The Euclid mission
- VIS&NISP
- NISP: General Architecture and current status
- People

EUCLID

- ❑ ESA mission dedicated to the study of dark energy and dark matter
- ✓ Selected in Oct. 2011 ⇨ Fully funded
- ✓ Partners: ESA, TAS, Airbus DS, Euclid Consortium (EC)
- ✓ Overall mass: ~**2020 kg**, Power: **1920 W** (E0L), Data rate**: 850 Gbit/day**
- ✓ **6.25 years** mission

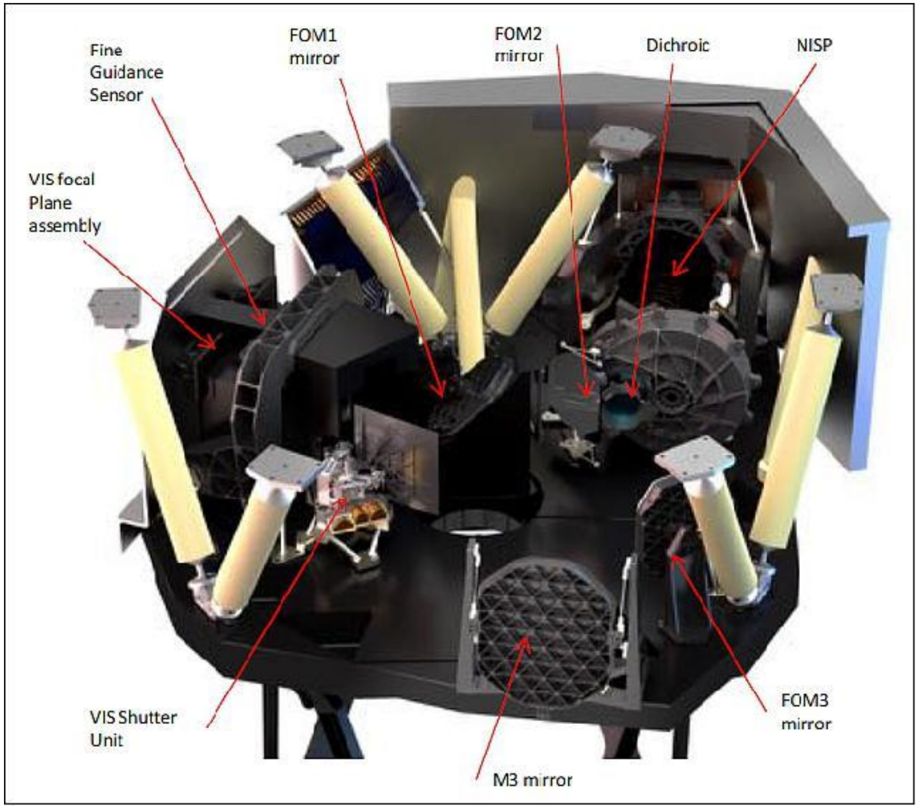


- ❑ Technology:
- ✓ Telescope 1.2m aperture (T=125K)
- ✓ 2 cryogenic instruments ⇨ VIS&NISP (T=**100-150K,** passive)

- ❑ L2 orbit
- ✓ Launch Vehicle –Soyuz-Fregat
- ✓ Launch date: **2022**, from Kourou space port

❖ **Euclid Consortium, A space mission to map the Dark Universe: https://www.euclid-ec.org/**

Euclid overview: VIS & NISP

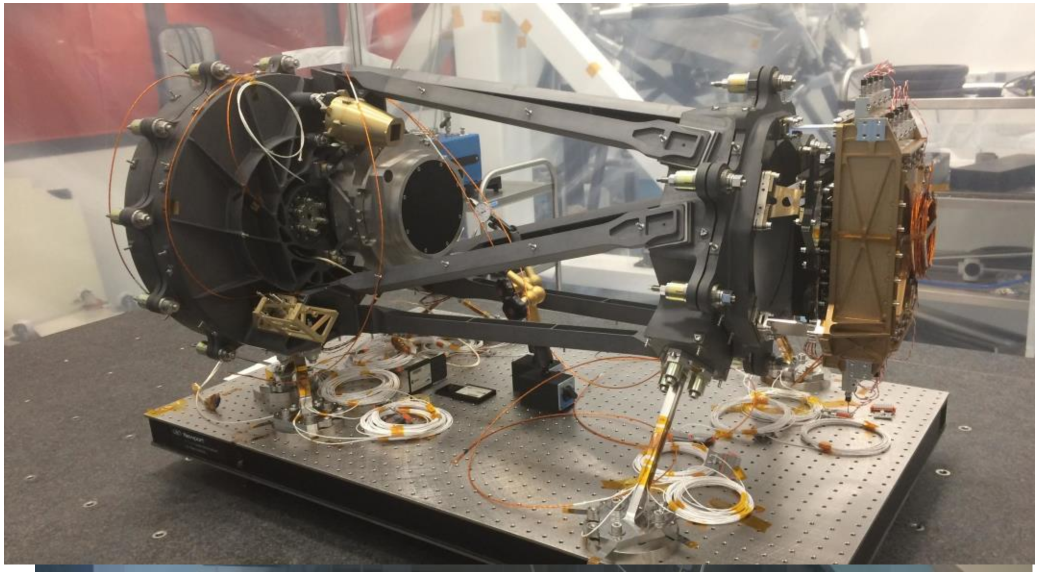


Payload

- ❑ 36 CCDs, 4kx4k pixels, 12 µm
- ❑ Pixel size: 0.1 arcsec
- ❑ Spectral band: 550-900 nm
- ❑ Data volume: **423** Gbit/day
- ❑ Temperature: 150-155 K (passive)

- ❑ 16 2kx2k H2RG NIR detectors
- ❑ Pixel size : 0.3 arcsec
- ❑ Spectral band: 920-2000 nm
- ❑ Data volume: **290** Gbit/day
- ❑ Temperature: 100-140 K (passive)

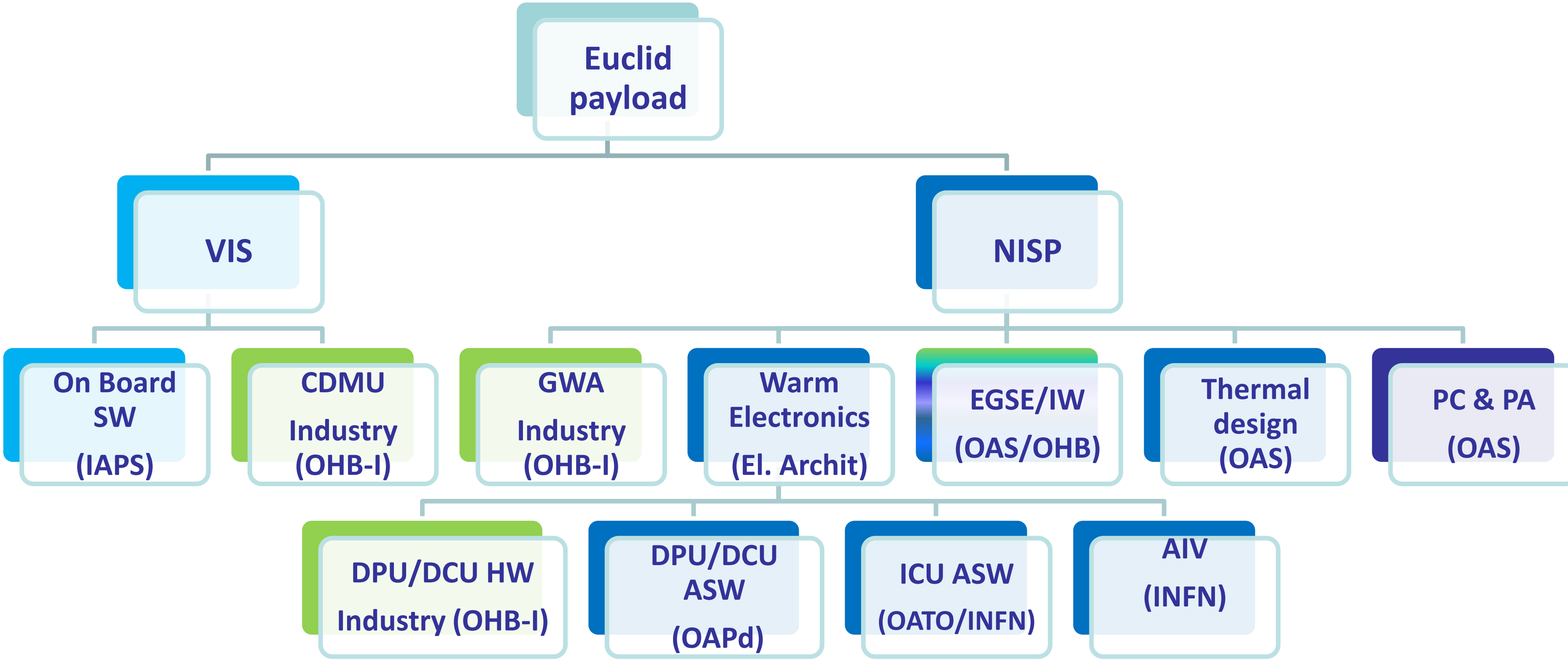
- **Budgets: Box Size: 1.0x0.5x05 m, Mass: 160 kg, Power: 200 W**



- **3 main assemblies:**
  - **NI-OMA: Opto Mechanical Assembly**
  - **NI-DS: Detection System**
  - **NI-WE: Warm Electronics**

NISP FM global overview

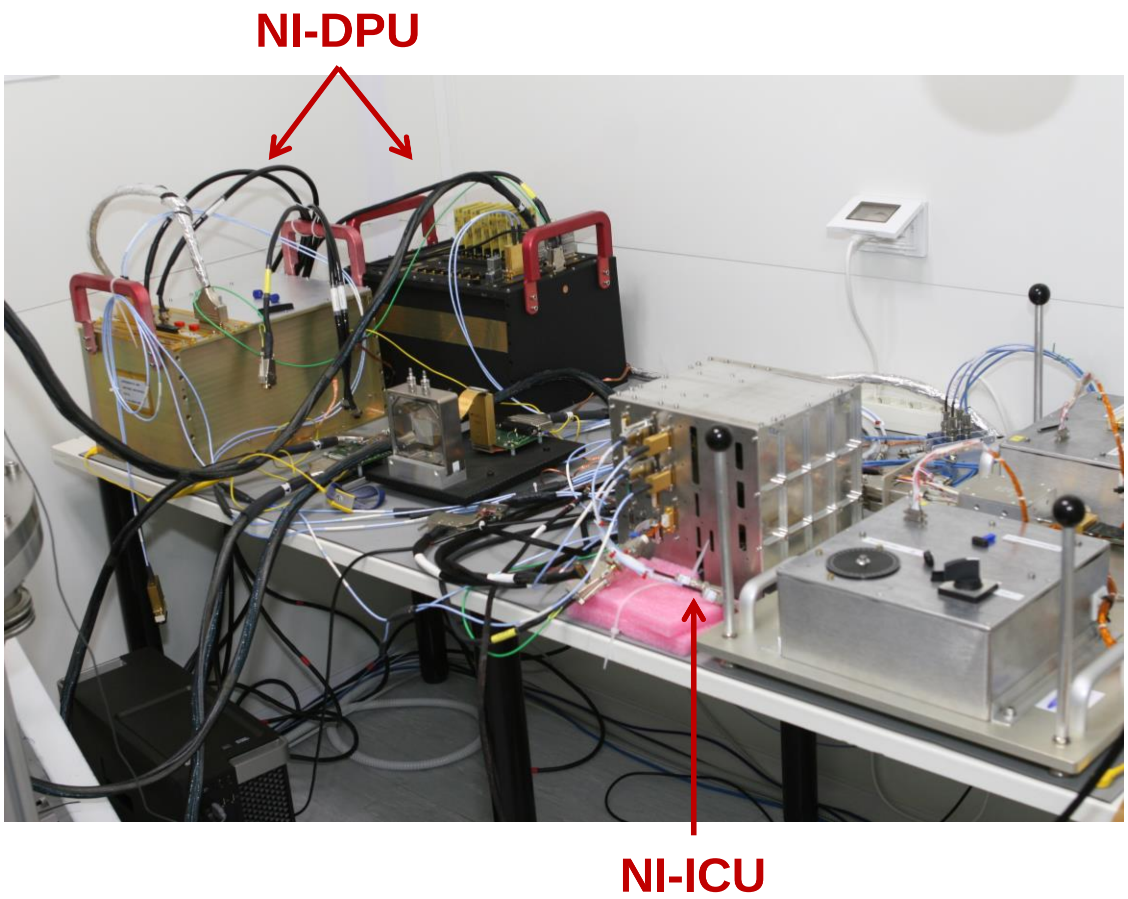
Italian contribution (I)



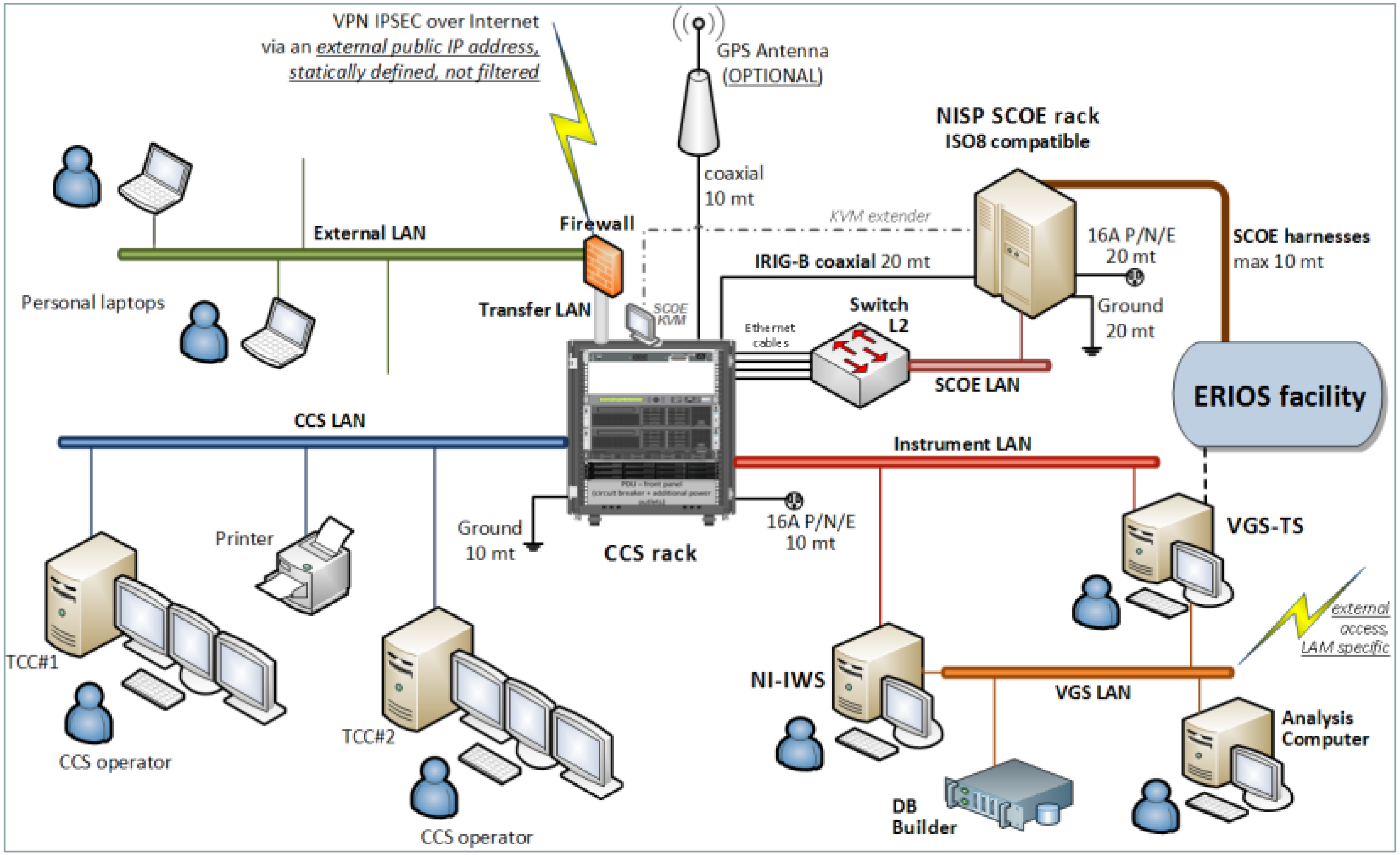
OATS is responsible for the Science Ground Segment

NI-WE (Warm Electronics)

- NI-**DPU/DCU**: two **Data Processing Units**, 8 **Detector Control Units** for each DPU.
- NI-**ICU: Instrument Control Unit**
- NI-**DPU Application SW**
- NI - **ICU Application SW**



The **NISP EGSE** (including CCS, SCOE and IWS) was moved to LAM (Marseille) to perform the NISP EM TV test at mid –January 2019.



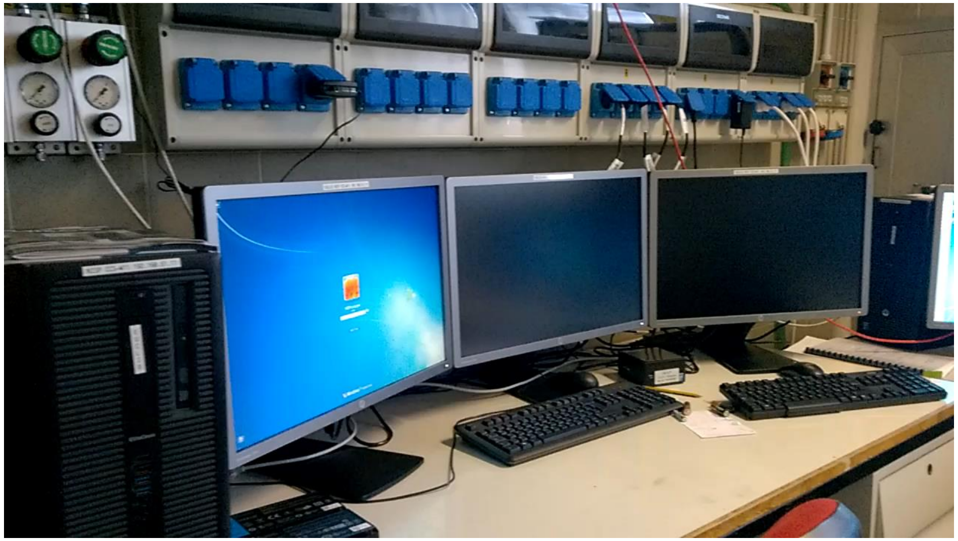
The **NISP EGSE** is a set of Test Equipments that will support all the AIV/AIT campaigns.

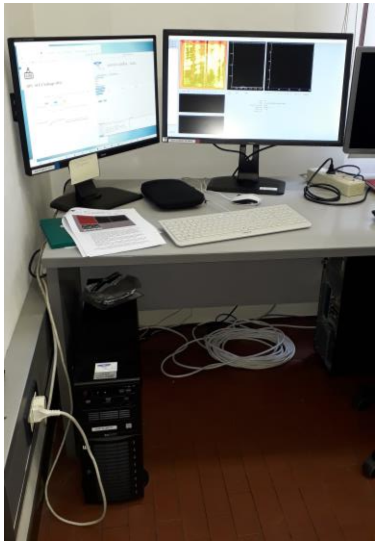
The EGSE is composed by three main HW parts, and involves two main SW tasks:

NI-CCS (NISP Central Checkout System), provided by ESA: the combination of SW (mission database, other configuration data, and test sequences) and HW (4 servers and 4 client stations) that implement the main control system used in all test campaigns at the NISP instrument level.

NI-SCOE (NISP Special Check-Out Equipment), provided by ESA**:** a rack, including two computers and many specialized devices, controlled through the CCS, acting as a spacecraft interface simulator for the payload under test.

NI-IWS (NISP Instrument WorkStation), provided by INAF/OAS-BO**:** a standalone workstation, interfaced with the CCS, providing quick-look capabilities, FITS data storage, and off-line analysis tools.





NISP: Current Status

- ❑ **Euclid STM: delivered in 2017**
- ❑ **NISP Avionic Model**: DPU&ICU EM and NIOMA&NI-DS electrical simulators ⇨ delivered to TAS-I (Turin) in June 2018 to perform the Integrated PLM Functional Test activities.
- ❑ EGSE/IWS & DPU EQM delivered to LAM last week to perform the NISP EM TV test in ERIOS.
- ❑ **E(Q)M** test: all functional elements, including NI-DS, tested at Operating Temperature on bench. Full functional test. 1 month operations.
- ❑ **Flight Model**:
  - ➢ NIOMA: ready at LAM
  - ➢ DPU/DCU FM already manufactured. Integration phase in progress. FM 1 and 2 will be delivered in March/ April 2019
  - ➢ ICU FM to be delivered in June 2019
  - ➢ DS FM to be delivered in March 2019
  - ➢ NISP FM test: July-August 2019. Delivery in September 2019

Italian contribution (II)

NISP Local PM: **Luca Valenziano** INAF OAS Bo

INAF OAS Bologna: **Enrico Franceschi, Massimo Trifoglio, Fulvio Gianotti, John B. Stephen, Stefano Silvestri, Andrea Bulgarelli, Francesca Sortino, Natalia Auricchio, Gianluca Morgante, Adriano De Rosa, Filomena Schiavone, Gian Paolo Guizzo, Luciano Nicastro, Paola Battaglia, Elisabetta Maiorano**

INAF OA Torino: Donata Bonino, Vito Capobianco, Leonardo Corcione, Sebastiano Ligori

INAF OA Padova: Andrea Balestra, Favio Bortoletto, Carlotta Bonoli, Maurizio D'Alessandro, Ruben Farinelli, Eduardo Medinaceli

INFN Bologna: Donato Di Ferdinando, Federico Fornari, Francesco Giacomini, Nicoletta Mauri, Laura Patrizii , Gabriele Sirri, Claudia Valieri , Carlo Veri

INFN Padova: Enrico Borsato, Stefano Dusini, Fulvio Laudisio, Chiara Sirignano, Luca Stanco, Sandro Ventura
INFN Genova: Stefano Davini, Sergio Di Domizio

OHB-I: DPU/DCU team: Raoul Grimoldi, Giovanna Ober, Fabio Camozzi, Sergio Legramandi, Elio Mangraviti GWA team: Paolo Radaelli, Andrea Moroni, Matteo Grespi, Sergio Legramandi, Elio Mangraviti. **TEMIS srl**: Luca Marrocchi, Marco Bossi. **S.A.B. Aerospace srl**: Valentina Latini

Euclid at OAS Bologna

NISP Instrument:

Enrico Franceschi, Massimo Trifoglio, Fulvio Gianotti, John B. Stephen, Stefano Silvestri, Andrea Bulgarelli, Donato di Ferdinando (INFN) ⇨ **EGSE/IWS, AIV, support to Project Management;**

Francesca Sortino ⇨ **Project control, configuration, Contract management, Support to PO;**

Natalia Auricchio ⇨ **PA & AVM/EM test support;**

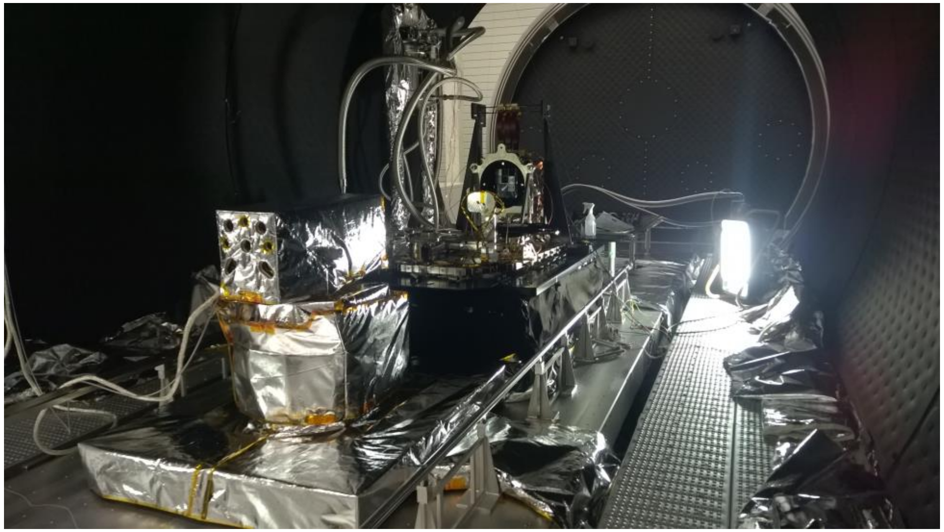
Gianluca Morgante, Adriano De Rosa ⇨ **NISP design and thermal modeling**

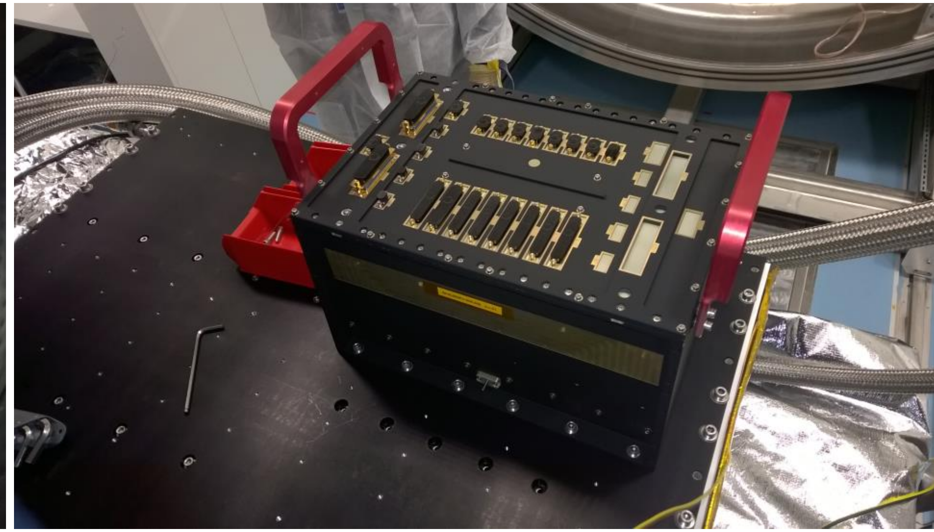
Filomena Schiavone ⇨ **Clean Room support**

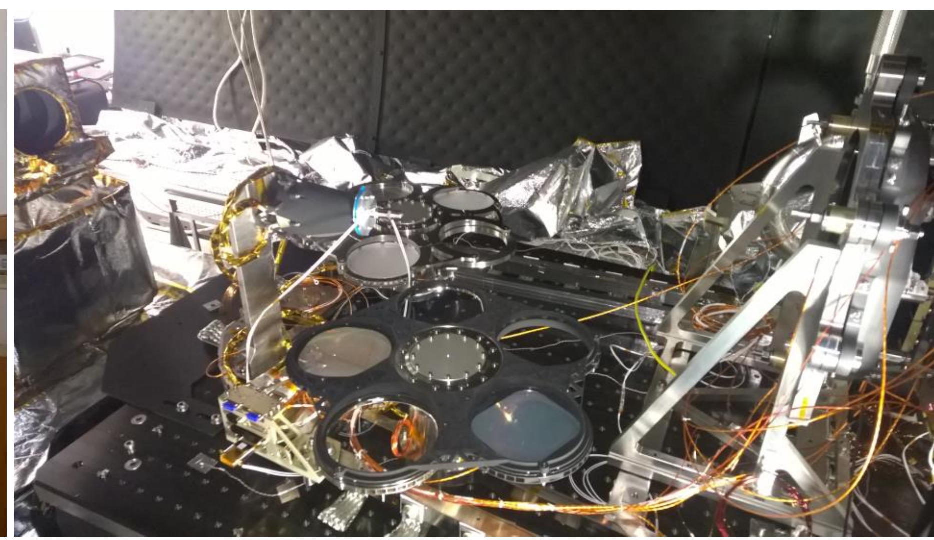
Gian Paolo Guizzo ⇨ **Electrical Architect**

Luca Valenziano, Paola Battaglia, Elisabetta Maiorano ⇨ **Operations**

NISP

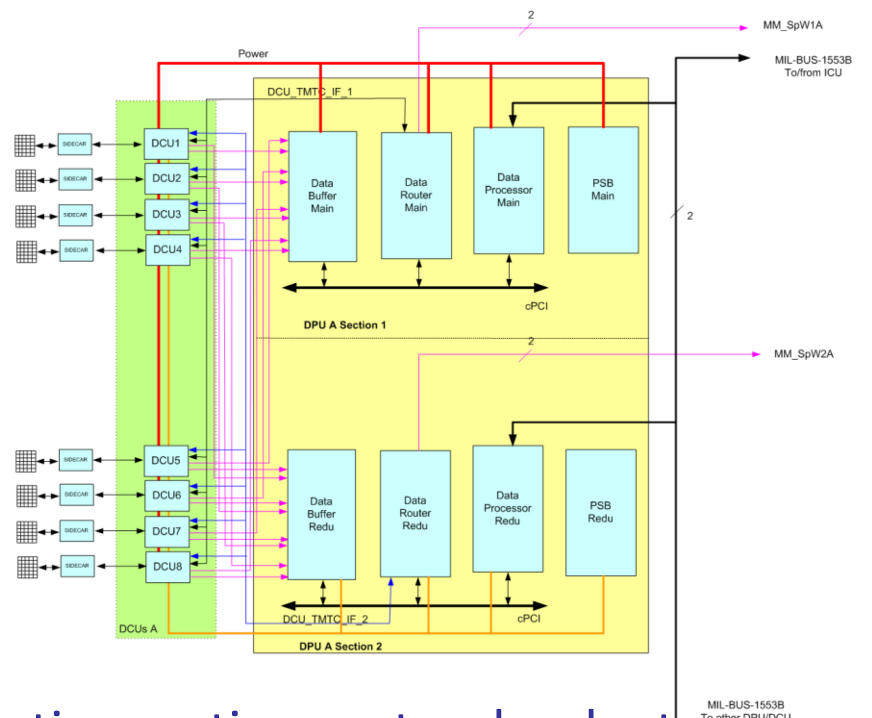






DPU/DCU ARCHITECTURE

- ➢ DPU/DCU functionalities: **detector control, data acquisition and processing, science data delivery to S/C**
- ➢ DPU/DCU units: 2 identical, each composed by 2 DPU sections and 8 DCUs



- ➢ Each DPU section hosts:
  - 1 Data Processor board (DPB)
  - 1 Data Router board (DRB)
  - 1 Data Buffer board (DBB)
  - 1 Power Supply board (PSB)

- ➢ Cold redundancy

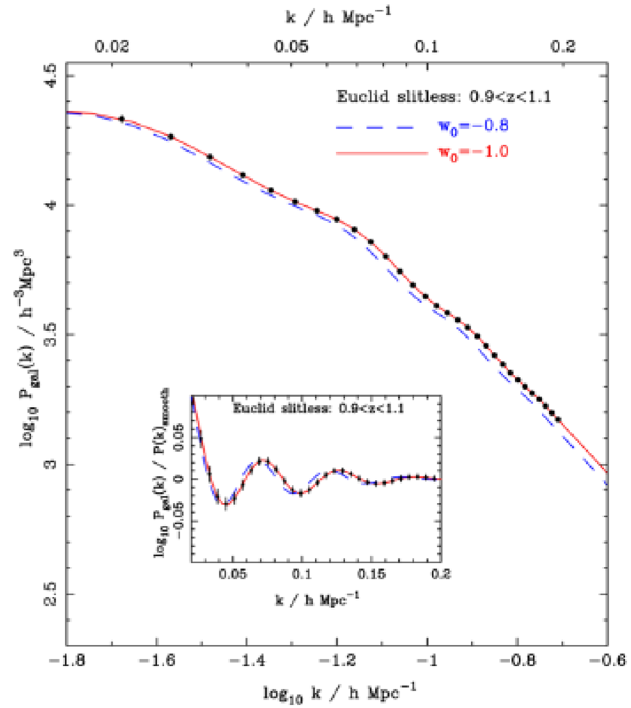
- ➢ 8 DCUs powered by the PSB of the active section, not redundant

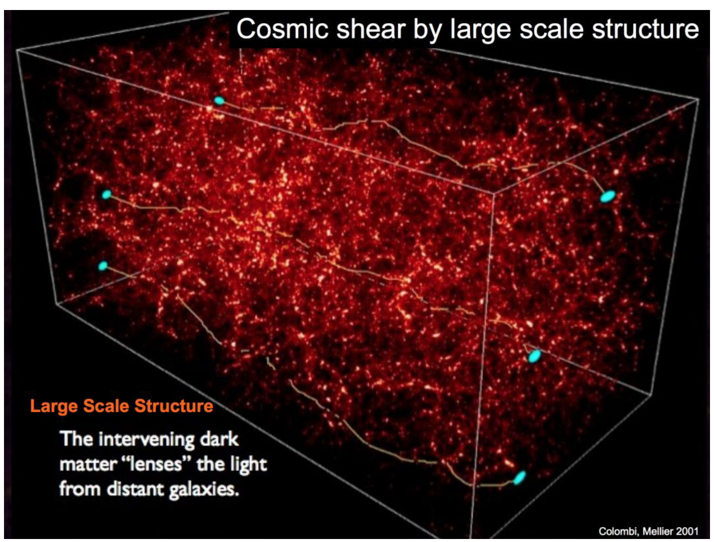
- ➢ Total daily produced data: ~4 TBytes

Scientific objectives

- Euclid will investigate two of the most puzzling quantities in modern cosmology, Dark Energy and Dark Matter, combining two methods:

✓ **Weak Gravitational Lensing** to map the 3-D Dark Matter distribution in the Universe. This requires extremely high precision measurements of galaxy shapes, realised with the VIS, and the inference of galaxy distances by means of photometric redshifts with the NISP.





✓ **Baryon Acoustic Oscillations** as a function of time, by measuring galaxy clustering properties. This task will be carried out by the spectroscopic channel of the NISP instrument.

Euclid Scientific Objectives

Issue	Euclid's Targets
What is Dark Energy: *w*	Measure the DE equation of state parameters w_p and w_a to a precision of 2% and 10%, respectively, using both expansion history and structure growth.
Beyond Einstein's Gravity: γ	Distinguish General Relativity from modified-gravity theories, by measuring the growth rate exponent γ with a precision of 2%.
The nature of dark matter: m_ν	Test the Cold Dark Matter paradigm for structure formation, and measure the sum of the neutrino masses to a precision better than 0.04eV when combined with Planck.
The seeds of cosmic structure: f_{NL}	Improve by a factor of 20 the determination of the initial condition parameters compared to Planck alone. n (spectral index), σ_8 (power spectrum amplitude), f_{NL} (non-gaussianity)

+ LEGACY SCIENCE

Science Working Groups (SWGs)

Galaxy clustering

Clusters

CMB cross-correlations

Strong lensing

Cosmological Theory

Primeval galaxies

Galaxy/AGN evolution

Cosmological simulations

Weak lensing

Nearby galaxies

Milky Way

Planets

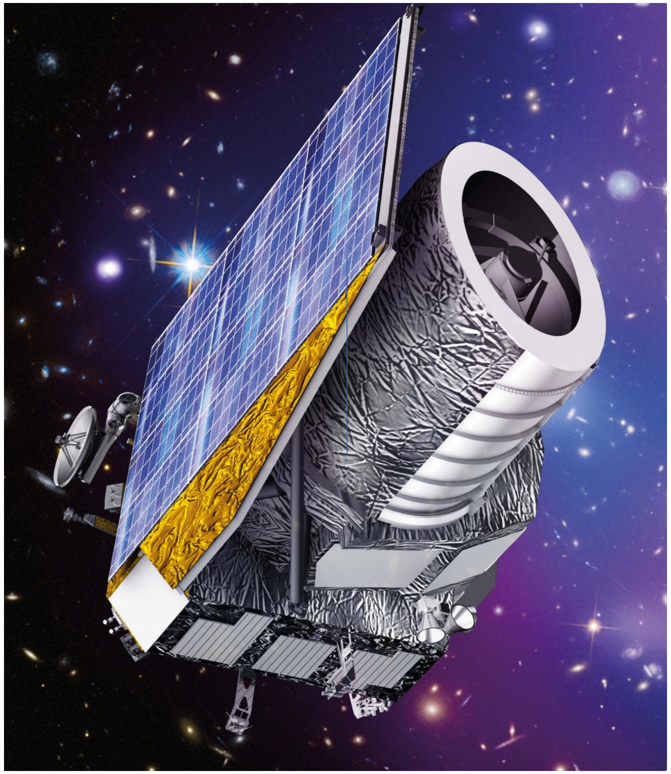
Supernovae and Transients

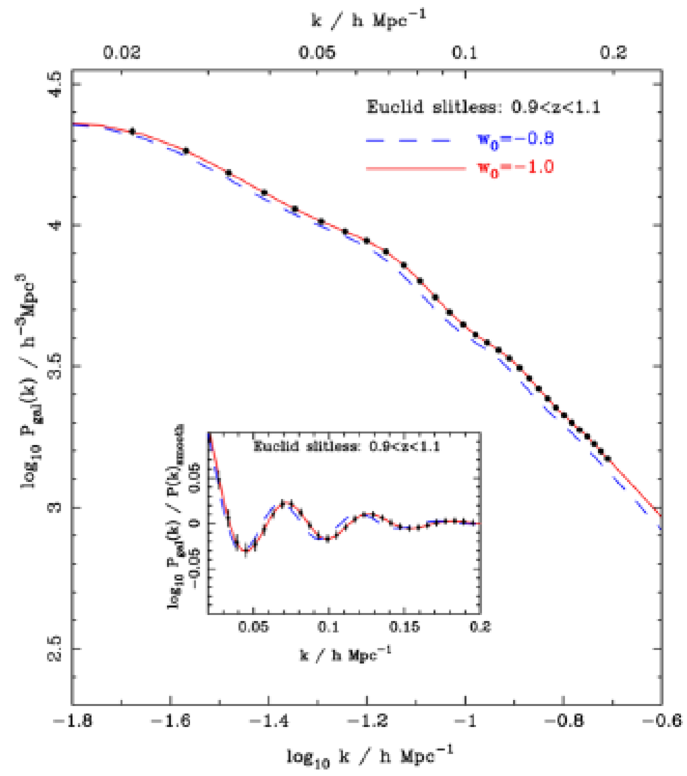
Solar System Objects

SWG Coordination

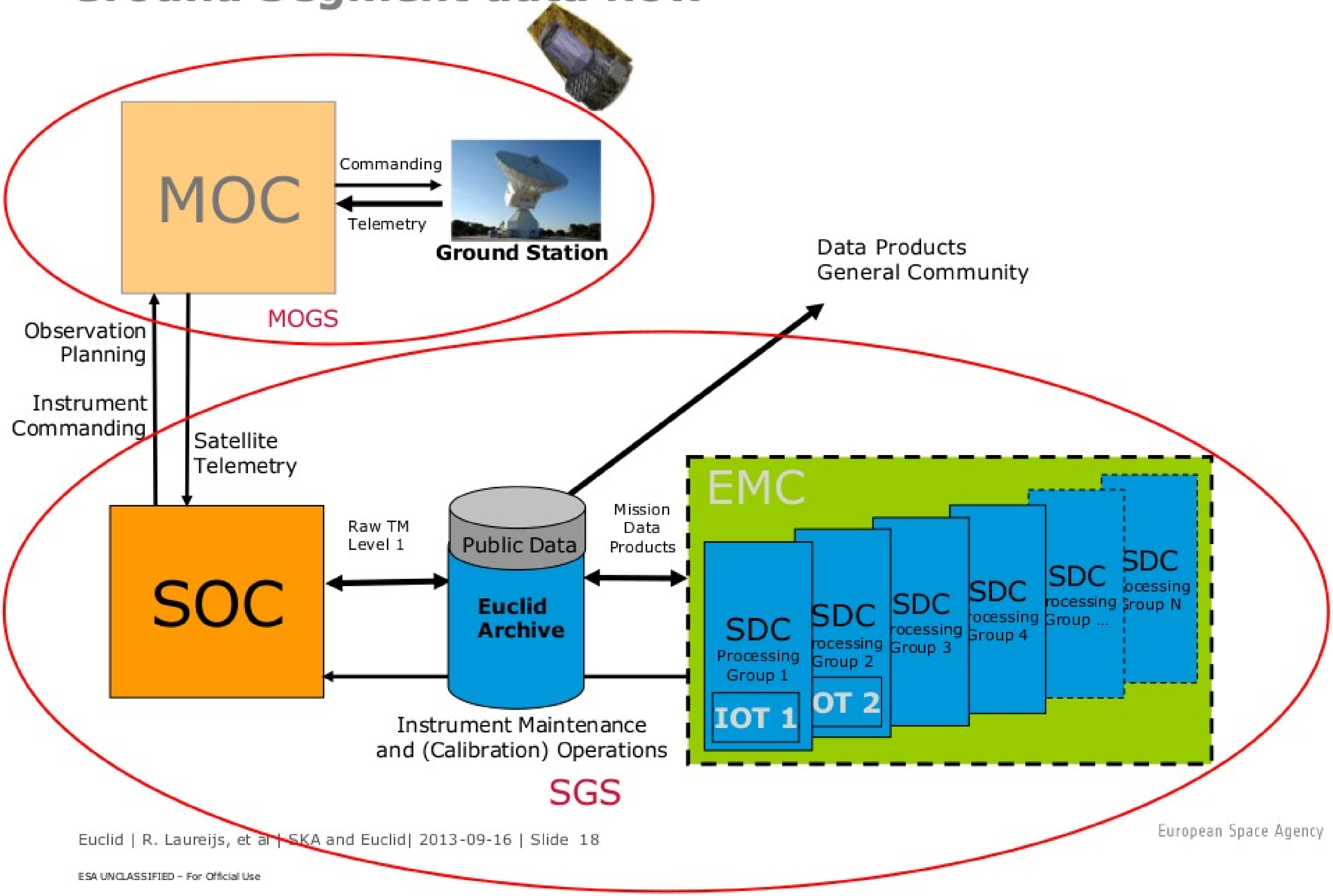
Red = primary science
Blue = legacy science

From satellite to science

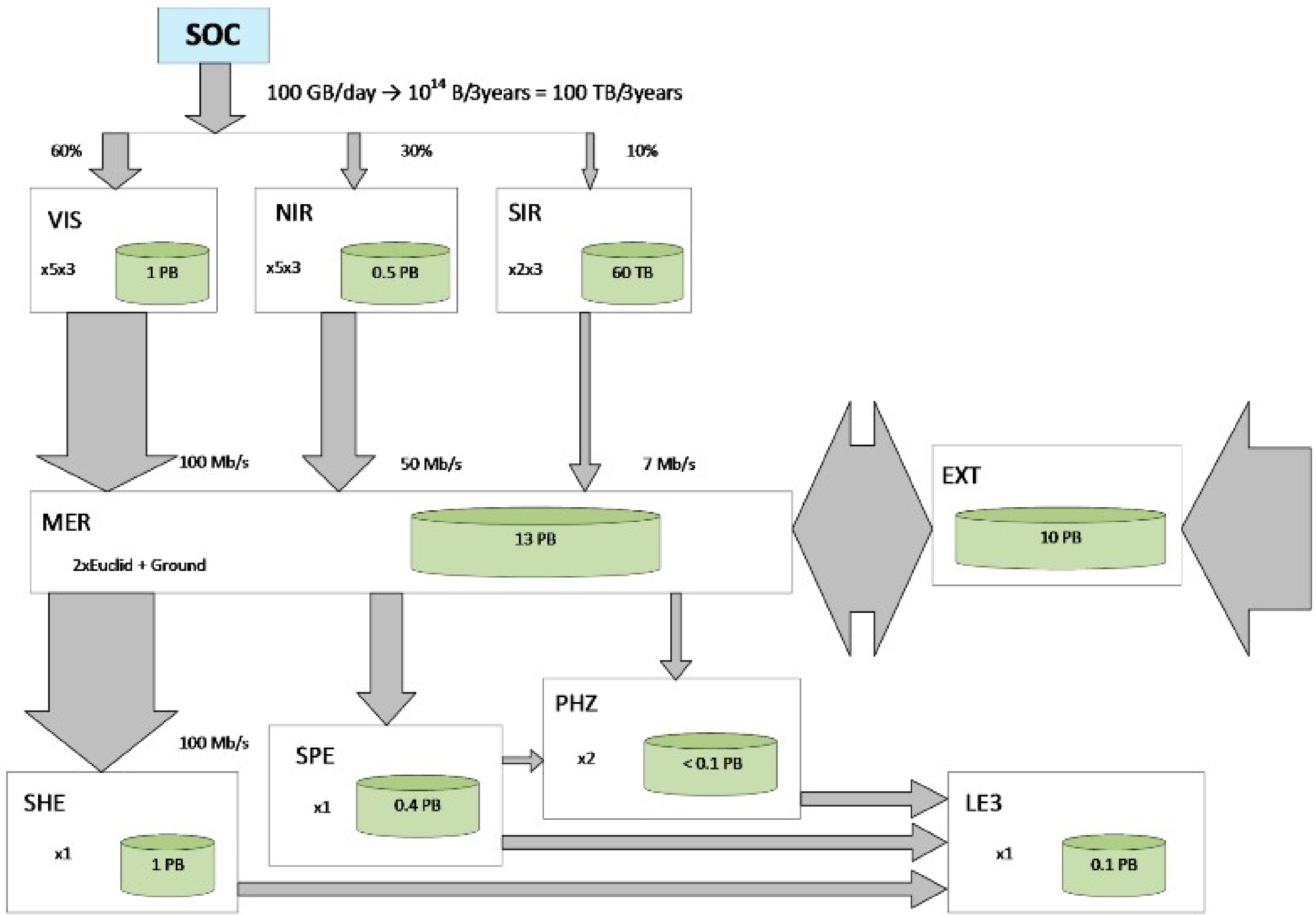




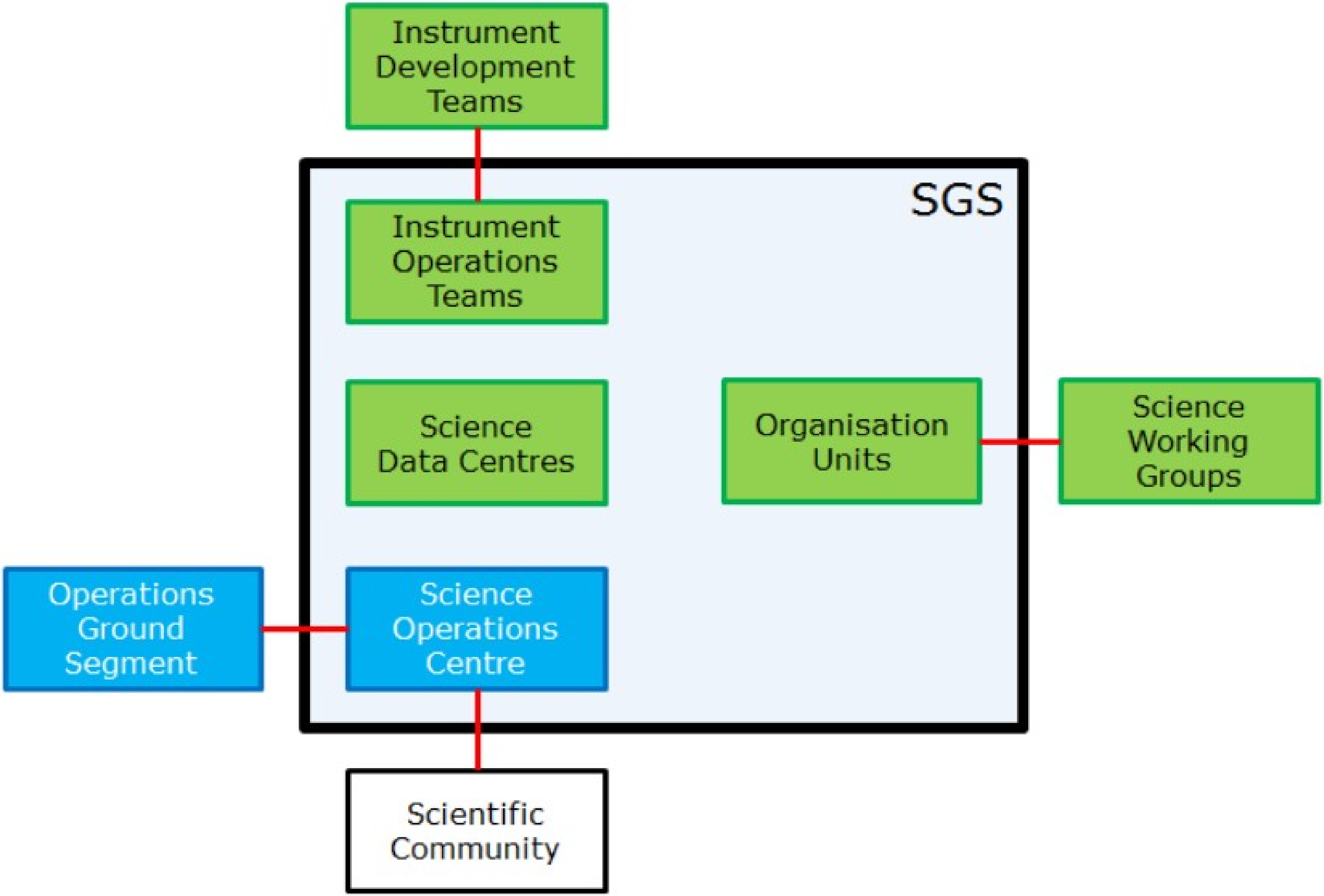
Ground Segment data flow

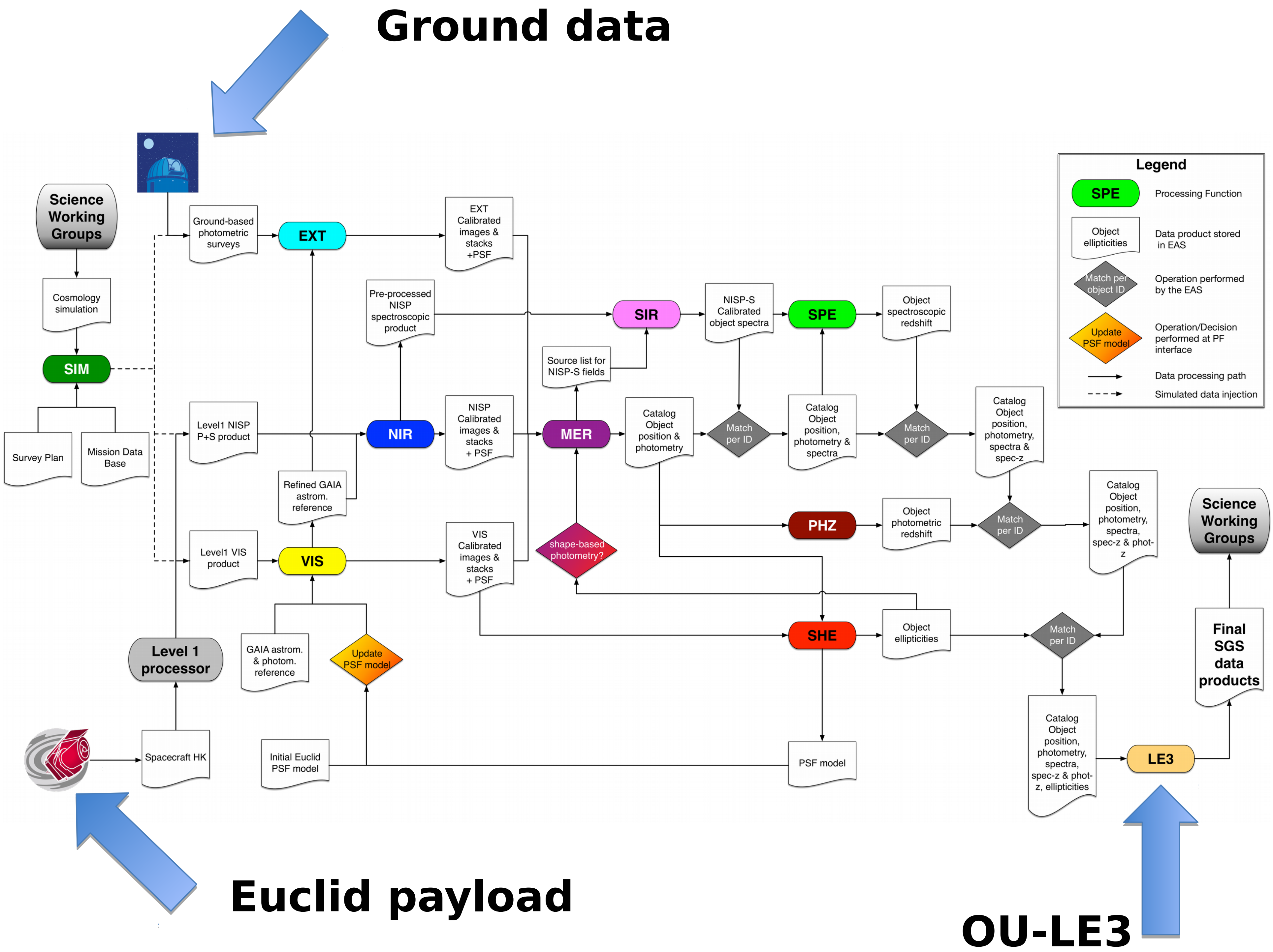


Euclid Data Flow



Science Ground Segment




Ground data
Euclid payload
OU-LE3
Legend
SPE
Processing Function
Object ellipticities
Data product stored in EAS
Match per object ID
Operation performed by the EAS
Update PSF model
Operation/Decision performed at PF interface
Data processing path
Simulated data injection
Science Working Groups
Cosmology simulation
SIM
Survey Plan
Mission Data Base
Ground-based photometric surveys
EXT
EXT Calibrated images & stacks +PSF
Pre-processed NISP spectroscopic product
SIR
NISP-S Calibrated object spectra
SPE
Object spectroscopic redshift
Source list for NISP-S fields
Level1 NISP P+S product
NIR
NISP Calibrated images & stacks + PSF
MER
Catalog Object position & photometry
Match per ID
Catalog Object position, photometry & spectra
Match per ID
Catalog Object position, photometry, spectra & spec-z
Refined GAIA astrom. reference
PHZ
Object photometric redshift
Match per ID
Catalog Object position, photometry, spectra, spec-z & phot-z
Science Working Groups
Level1 VIS product
VIS
VIS Calibrated images & stacks + PSF
shape-based photometry?
GAIA astrom. & photom. reference
Update PSF model
SHE
Object ellipticities
Match per ID
Level 1 processor
Final SGS data products
Spacecraft HK
Initial Euclid PSF model
PSF model
Catalog Object position, photometry, spectra, spec-z & phot-z, ellipticities
LE3

Organization Units (OUs)

The OUs are responsible for defining the set of tasks which the SGS must perform.

Organisation Unit for Visible Imaging (OU-VIS)

Organisation Unit for NIR Imaging (OU-NIR)

Organisation Unit for NIR Spectra (OU-SIR)

Organisation Unit for External Data (OU-EXT)

Organisation Unit for Simulation (OU-SIM)

Organisation Unit for Merging (OU-MER)

Organisation Unit for Spectral Measurement (OU-SPE)

Organisation Unit for Shear (OU-SHE)

Organisation Unit for Photo z (OU-PHZ)

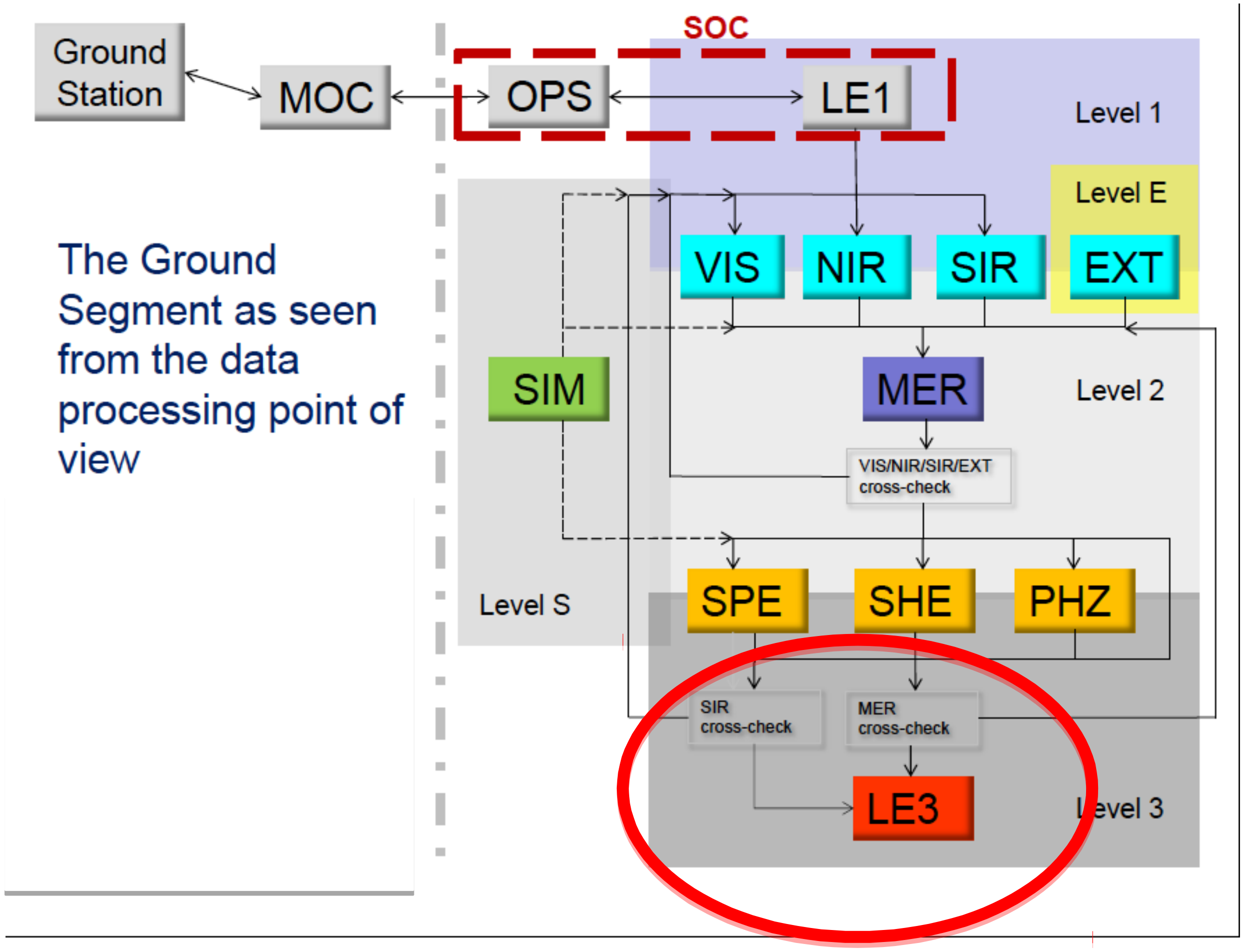
Organisation Unit for Level 3 products (OU-LE3)

Euclid OUs @OAS Bologna

OU-SPE Spectral feature measurements (5300)
Maiorano, Palazzi, Pozzetti, Vergani

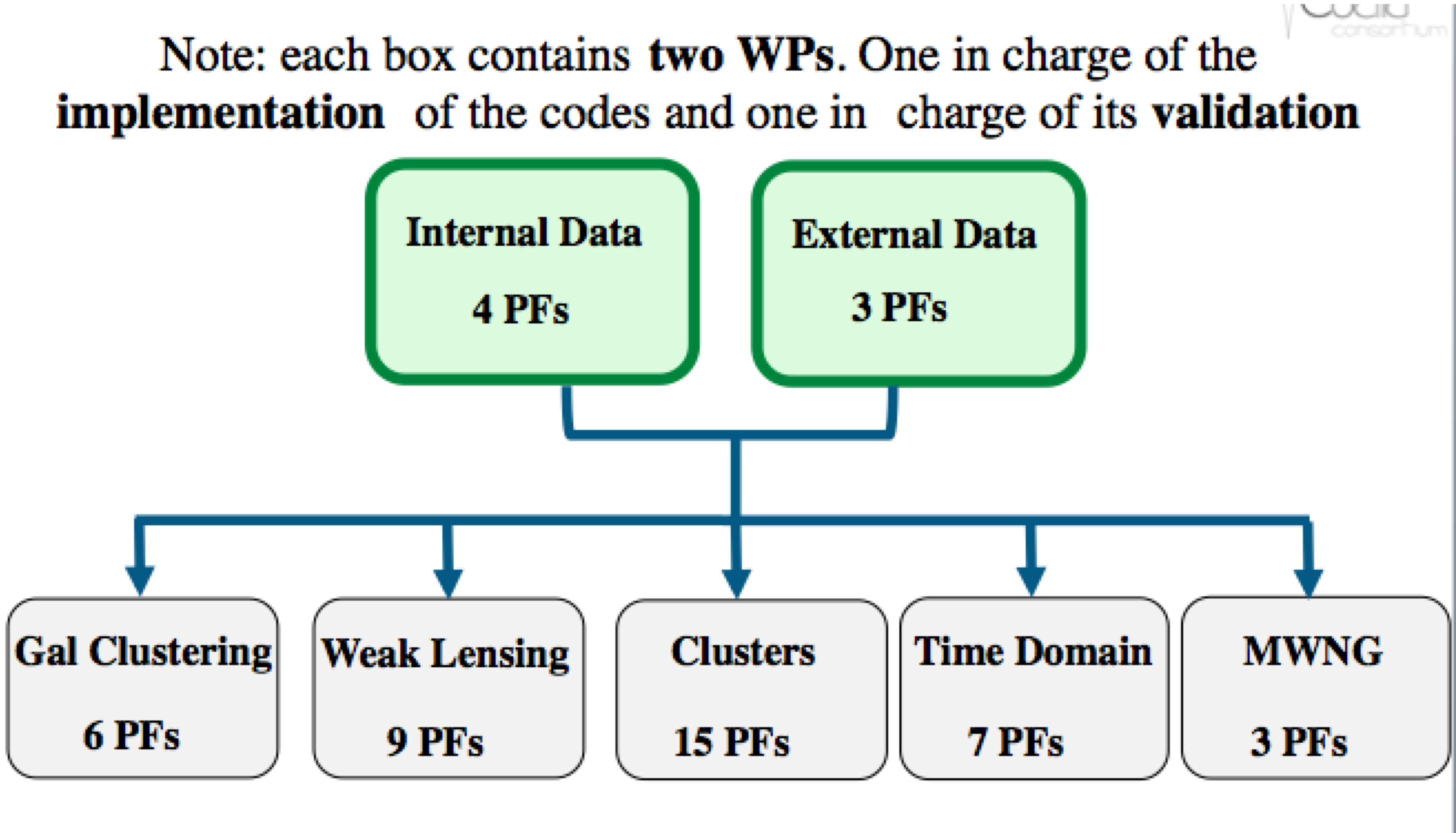
OU-PHZ Physical parameters and model templates
Bolzonella, Pozzetti

OU-LE3 Internal data, External data, Clusters of Galaxies
Bardelli, Bolzonella, Cappi, Cucciati, Sereno, Zucca



GOAL: Provide the **science ready data products** to the science working groups [SWGs].

OU-LE3 structure



Requirements from SWGs for 47 processing functions

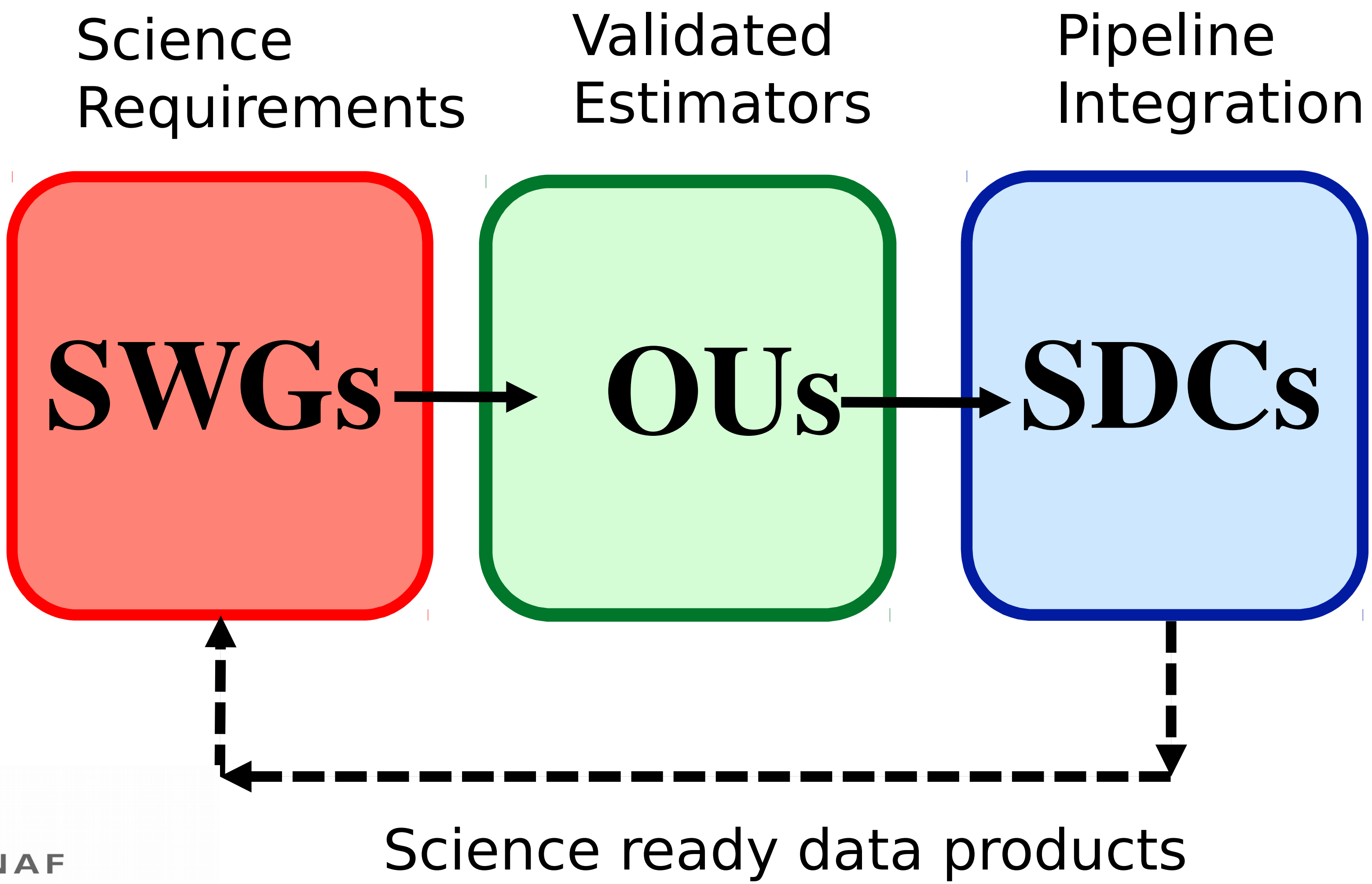
As an example...

OU-LE3 Internal data is in charge of 4 PFs

VMPZ-ID	survey photometric mask
VMSP-ID	survey spectroscopic mask
SEL-ID	selection function
LMF-ID	luminosity and mass functions

the data products to be delivered are not “simple” outputs, but complex analysis tools

The virtuous circle



Euclid OUs/SWGs @OAS Bologna

OAS people	OUs	SWGs	other
Sandro Bardelli	LE3	CG / GA	
Micol Bolzonella	LE3 / PHZ	CG / GA / CS	E2E / SPV
Alberto Cappi	LE3	CG	
Paolo Ciliegi	LE3 / SIR / SPE		
Olga Cucciati	LE3	CG / GA	
Stefano Ettori		CG	
Fabio Finelli		CMBXC / COTH	
Alessandro Gruppuso		CMBXC	
Elisabetta Maiorano	SPE		ESSWG
Massimo Meneghetti		SL	
Marco Mignoli	SPE		
Eliana Palazzi	SPE		
Daniela Paoletti		CMBXC / COTH	
Lucia Pozzetti	SPE / PHZ	GA / GC / CS	E2E / SPV / blue grism
Mauro Sereno	LE3	CG	
Daniela Vergani	SPE		
Gianni Zamorani		GA / PU	
Elena Zucca	LE3	CG / GA	

Strength points

Our expertise in this scientific field (in particular galaxy evolution, clusters of galaxies, strong lensing, CMB) and our previous experience in following all the stages of galaxy surveys play a fundamental role.

A number of OAS people not only is working in Euclid but is covering a leading position.

Euclid OUs/SWGs @OAS Bologna

OAS people	OUs	SWGs	other
Sandro Bardelli	**LE3**	**CG** / GA	
Micol Bolzonella	**LE3** / **PHZ**	**CG** / GA / CS	E2E / SPV
Alberto Cappi	LE3	CG	
Paolo Ciliegi	LE3 / SIR / SPE		
Olga Cucciati	**LE3**	CG / GA	
Stefano Ettori		CG	
Fabio Finelli		CMBXC / COTH	
Alessandro Gruppuso		CMBXC	
Elisabetta Maiorano	SPE		ESSWG
Massimo Meneghetti		**SL**	
Marco Mignoli	SPE		
Eliana Palazzi	SPE		
Daniela Paoletti		CMBXC / COTH	
Lucia Pozzetti	SPE / PHZ	**GA** / **GC** / **CS**	E2E / SPV / **blue grism**
Mauro Sereno	LE3	CG	
Daniela Vergani	SPE		
Gianni Zamorani	SPE	GA / PU	
Elena Zucca	**LE3**	**CG** / **GA**	

Euclid OUs/SWGs @DIFA Bologna

- Marco Baldi
- Fabio Bellagamba
- Andrea Cimatti
- Paola Focardi
- Carlo Giocoli
- Mahmoud Hashim
- Federico Marulli
- Ben Metcalf
- Michele Moresco
- Lauro Moscardini
- Mauro Roncarelli
- Emanuel Rossetti
- Margherita Talia

Euclid OUs/SWGs @DIFA Bologna

- Marco Baldi
- Fabio Bellagamba
- Andrea Cimatti
- Paola Focardi
- Carlo Giocoli
- Mahmoud Hashim
- Federico Marulli
- Ben Metcalf
- Michele Moresco
- Lauro Moscardini
- Mauro Roncarelli
- Emanuel Rossetti
- Margherita Talia

Critical issues

Need of software engineers for specific support
[not necessarily exclusive for Euclid]

Heavy commitment (both in money and in FTE)
with no immediate return (in terms of publications)
[critical in particular, but not only, for young people]

People with specific expertise moving to Institutes outside
the Euclid Consortium and/or leaving the field:
their training and their expertise are lost
[it is not simply a problem of man power]