



cnrs

Centre de Calcul

de l'Institut National de Physique Nucléaire
et de Physique des Particules

Euclid at CC-IN2P3

FJPPL, January 30 2024, CC-IN2P3

Quentin Le Boulc'h



Outline

- The Euclid mission
- Status of Euclid
- Euclid data processing

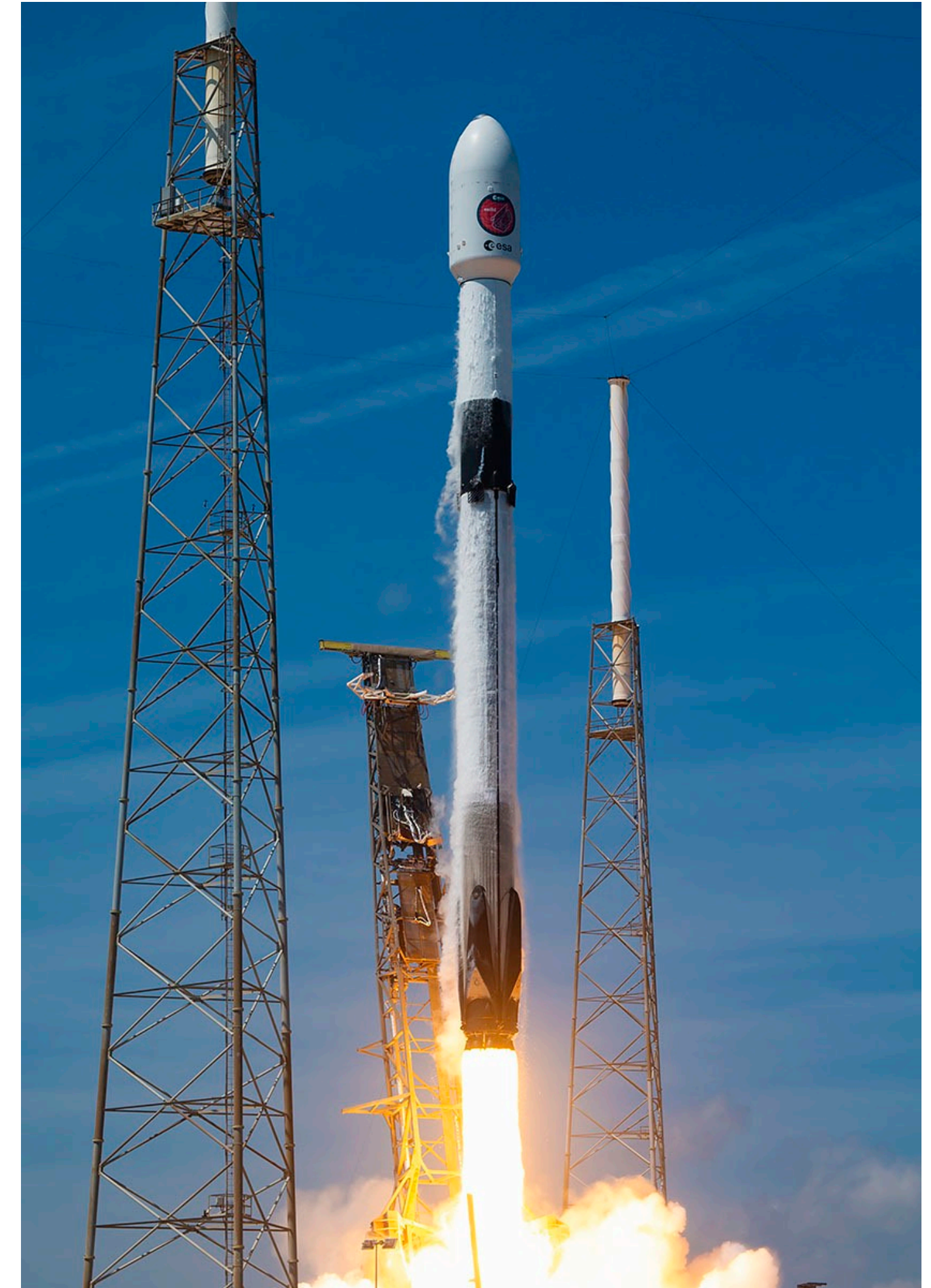
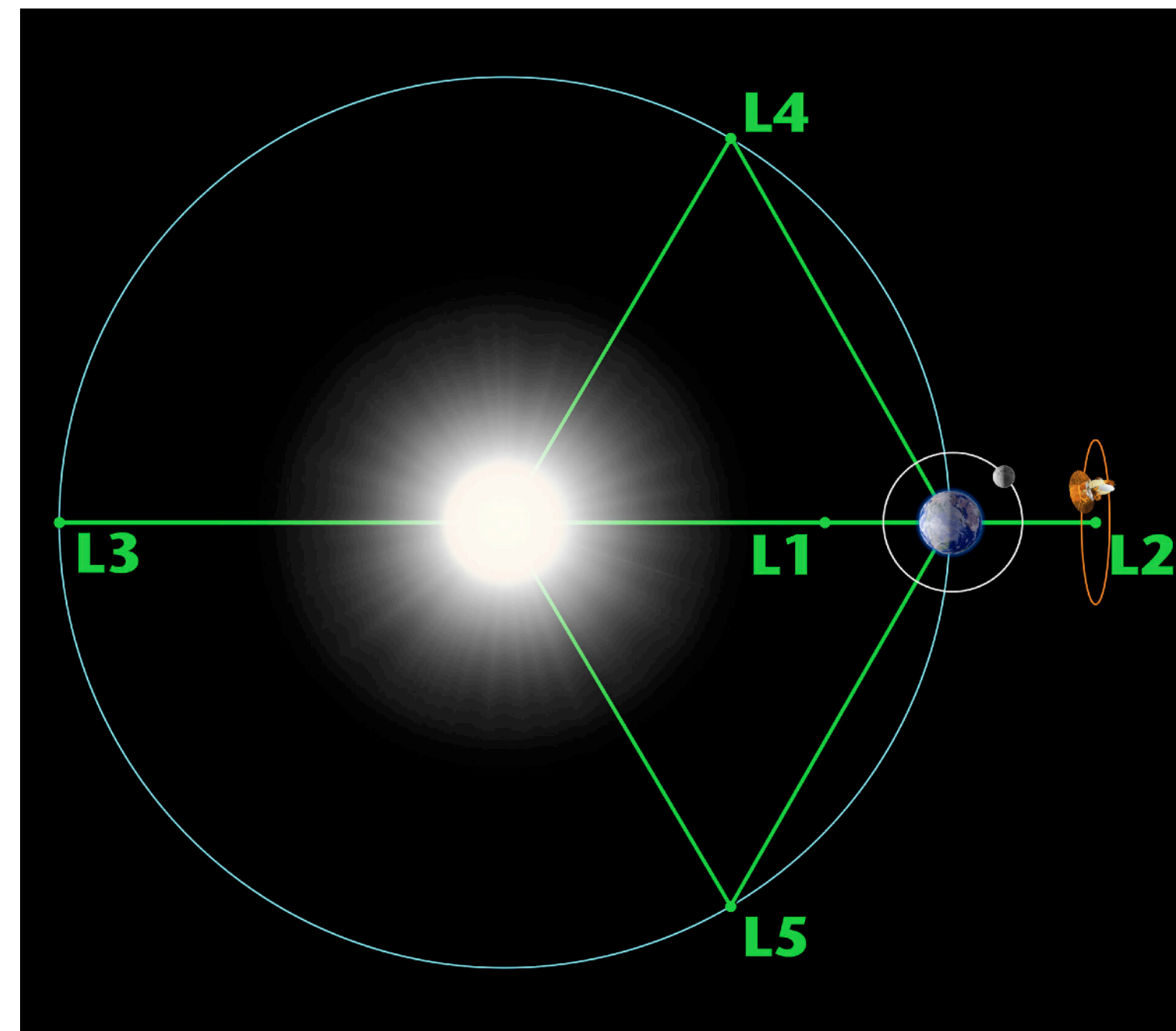


cnrs

The Euclid mission

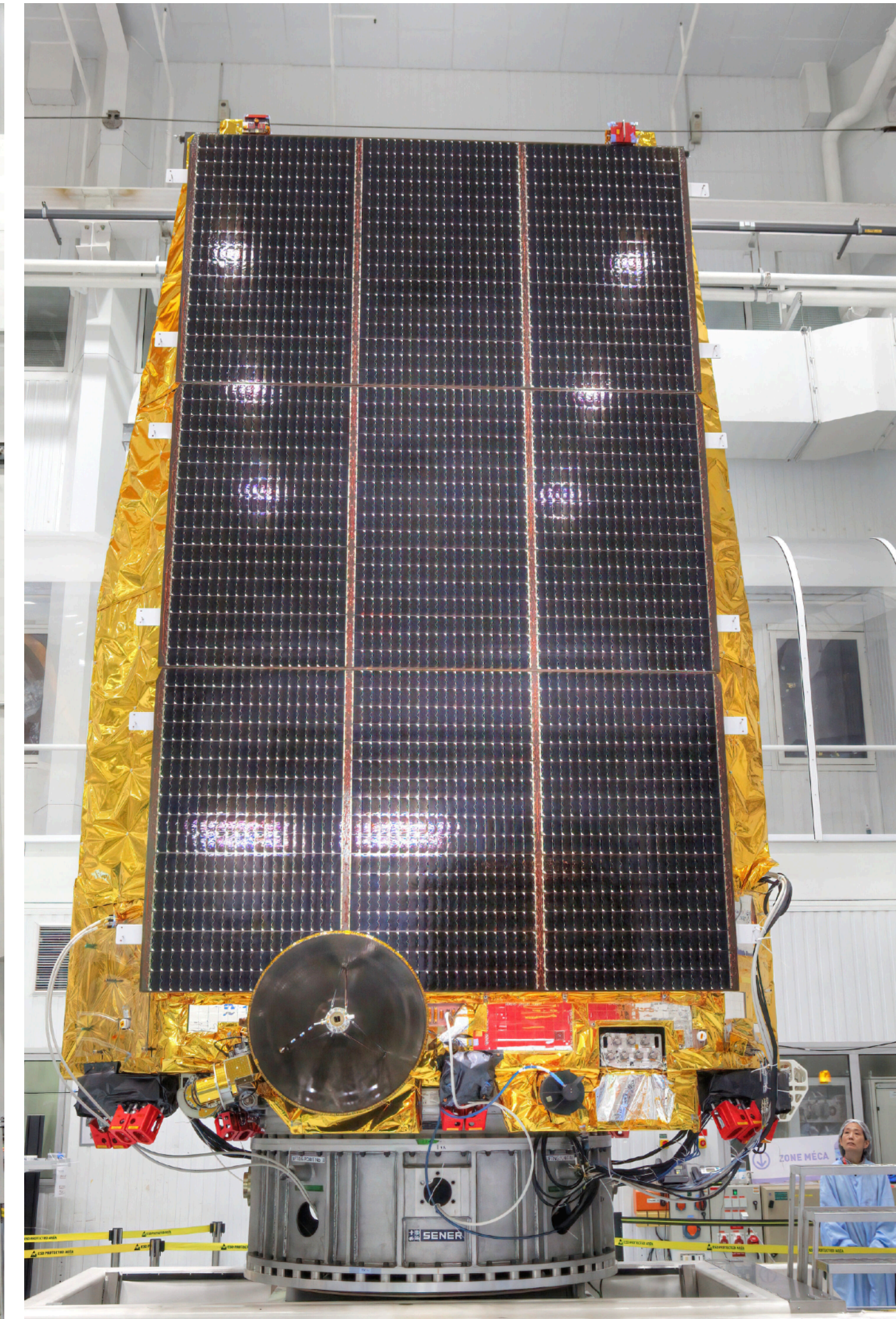
Euclid Launch

- European Space Agency mission
- Space telescope designed to understand:
 - The origin of the accelerating expansion of the Universe
 - The properties and nature of dark energy, gravity and dark matter
- Satellite launched in July 2023 by SpaceX from Cap Canaveral (Florida, USA)
- At the L2 Sun-Earth Lagrange point (1.5 million km)
- Will observe 15.000 square degrees (1/3 of full sky) during 6 years



The Euclid satellite

- 4.7 m tall and 3.7 m wide, 2.100 kg
- Very high pointing and temperature stability
- 55 Mb/s transmission, 4 hours per day (850 Gb)
- 1.2 m telescope
- Two instruments:
 - VIS: visible camera
 - NISP : infrared spectrophotometer
- 0.55 square degree field of view
 - Twice the moon
 - 1/20 x LSST
 - 200 x James Webb



<https://www.cfht.hawaii.edu/~jcc/EuclidThalesCannes2023/>

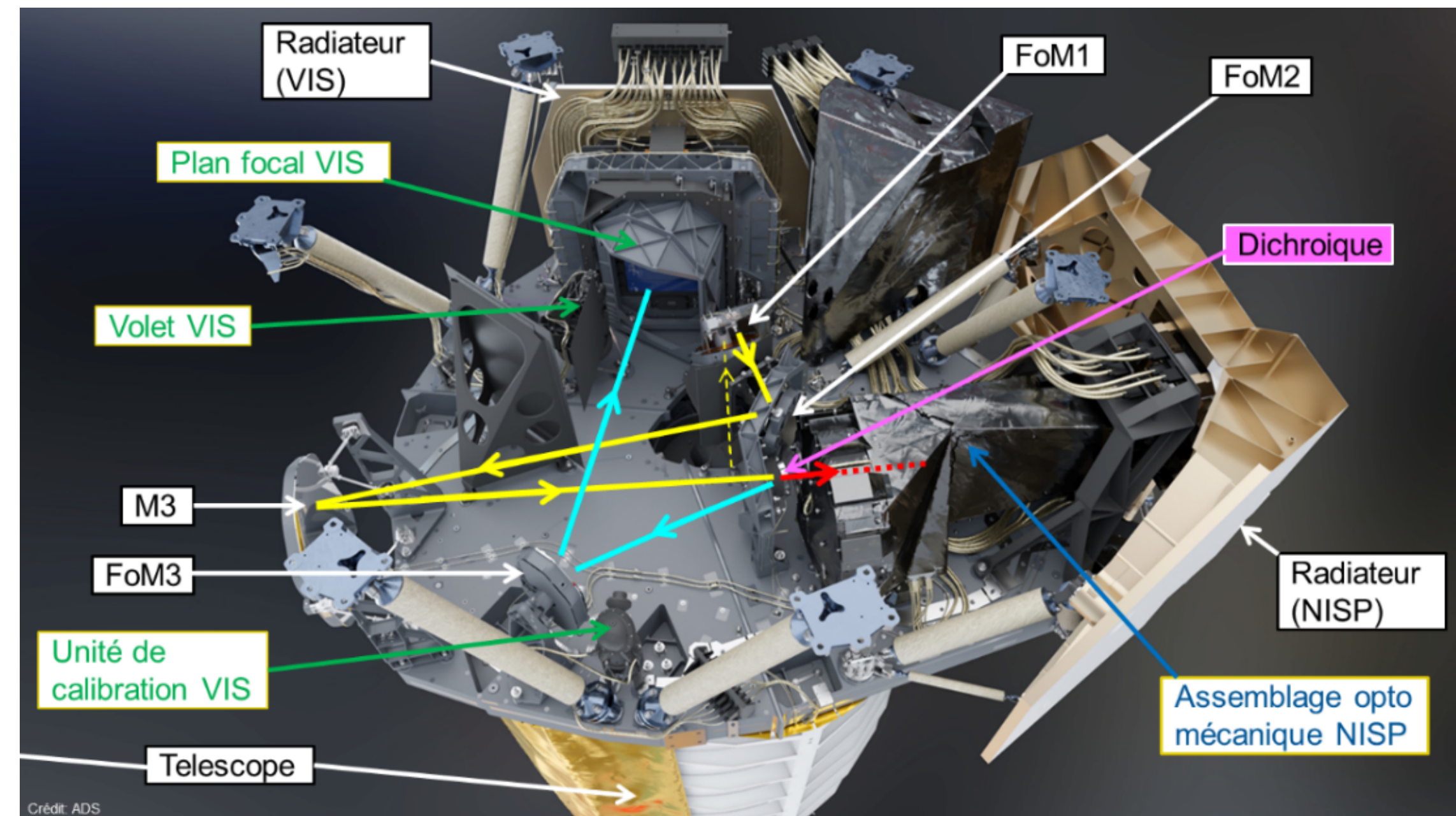
The Euclid consortium

- Science part of the mission
- Delivered VIS and NISP instruments
- In charge of the data processing and science analysis
- Contributions from 14 European countries, USA, Canada, Japan
- More than 1500 members
- France contributes to 30% (CNES, IN2P3, INSU and IRFU)



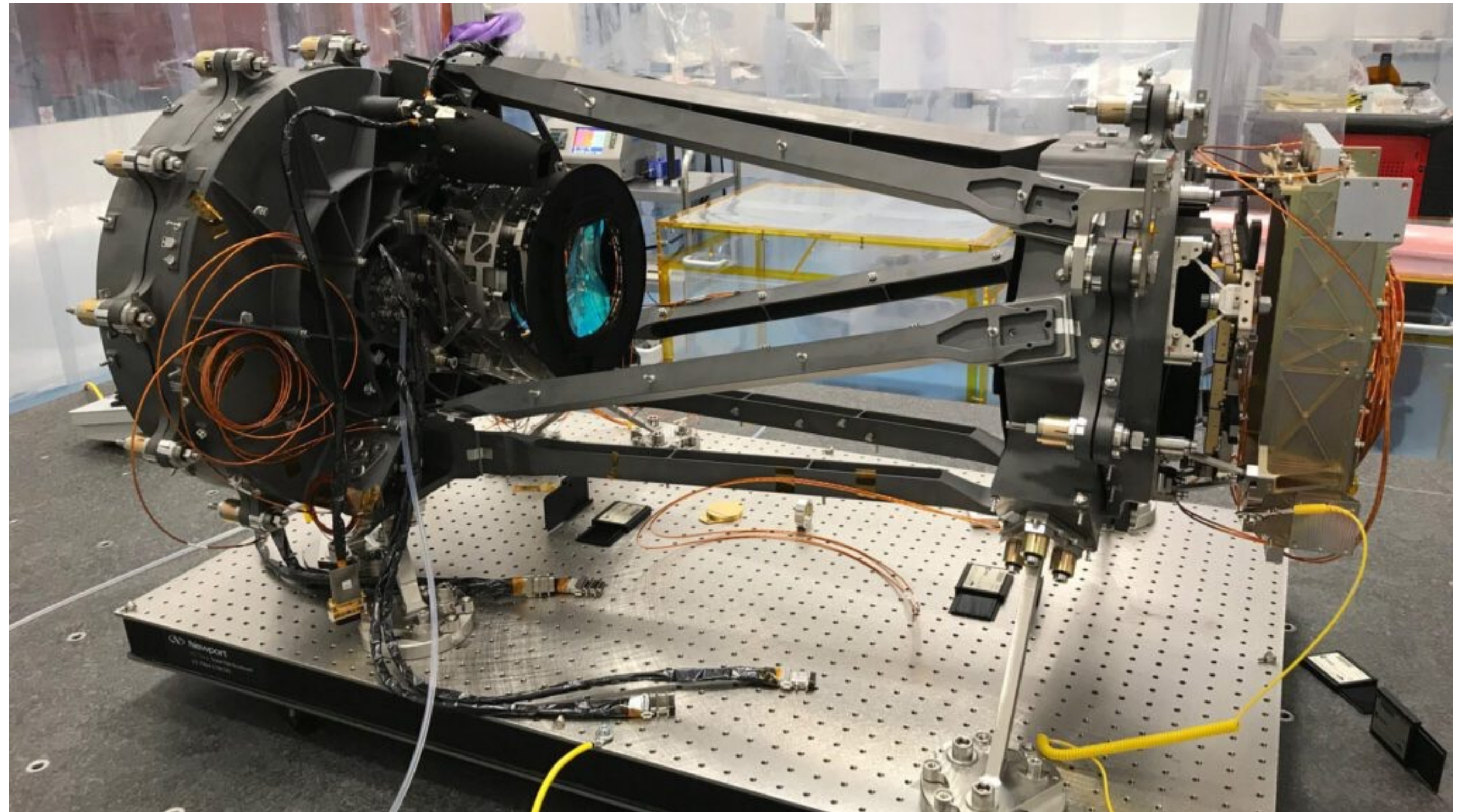
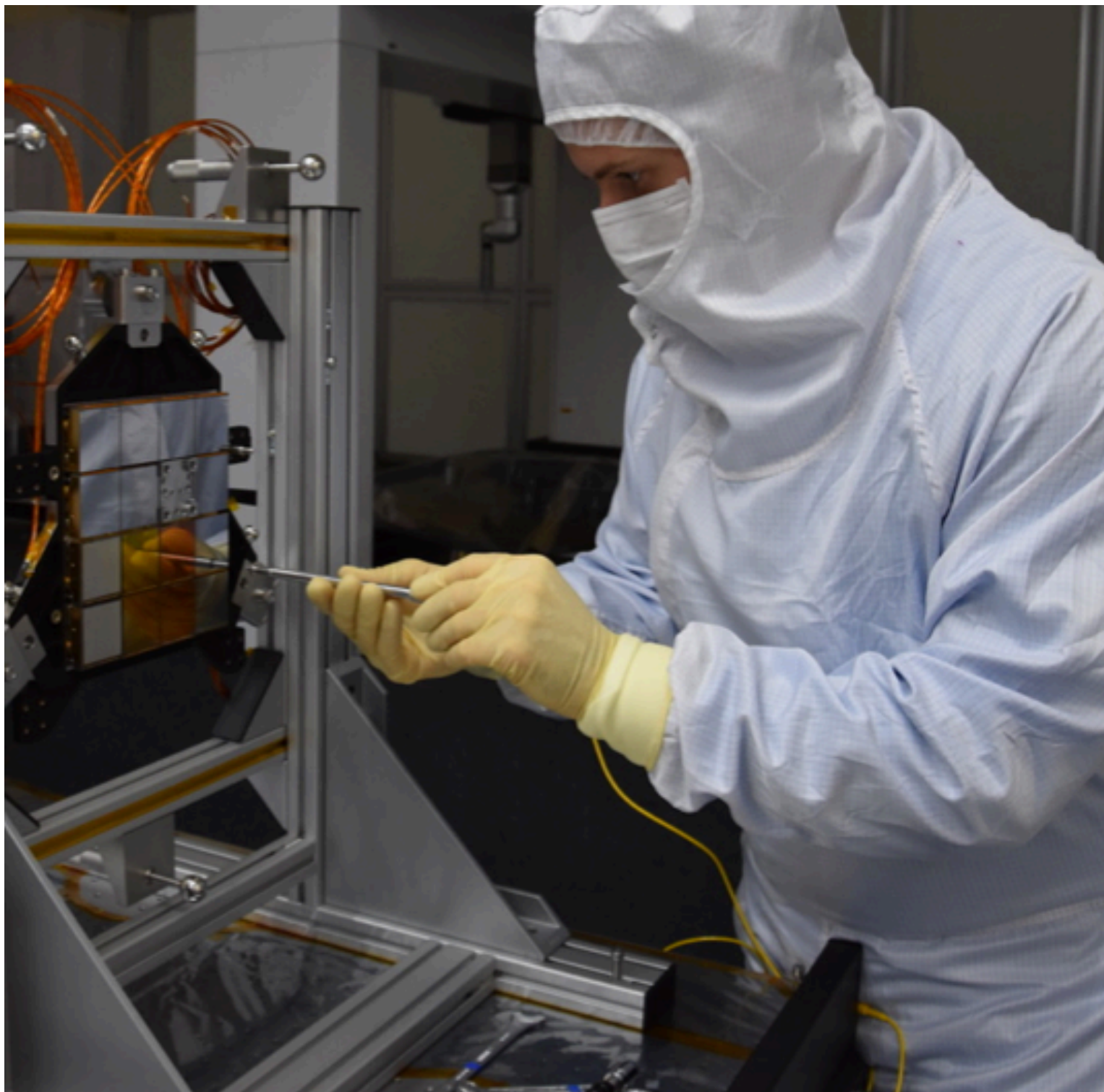
The VIS instrument

- VIS: VISible imager
 - Designed to perform precise measurement of the galaxies shape
 - Second largest focal plane sent to space
 - Focal plane: 45 cm, 36 CCD, 4k x 4k : 600 Mpixels
 - Delivered by the Mullard Space Science Laboratory (MSSL, UK)
 - Significant French contribution: focal plane, calibration unit, control electronics



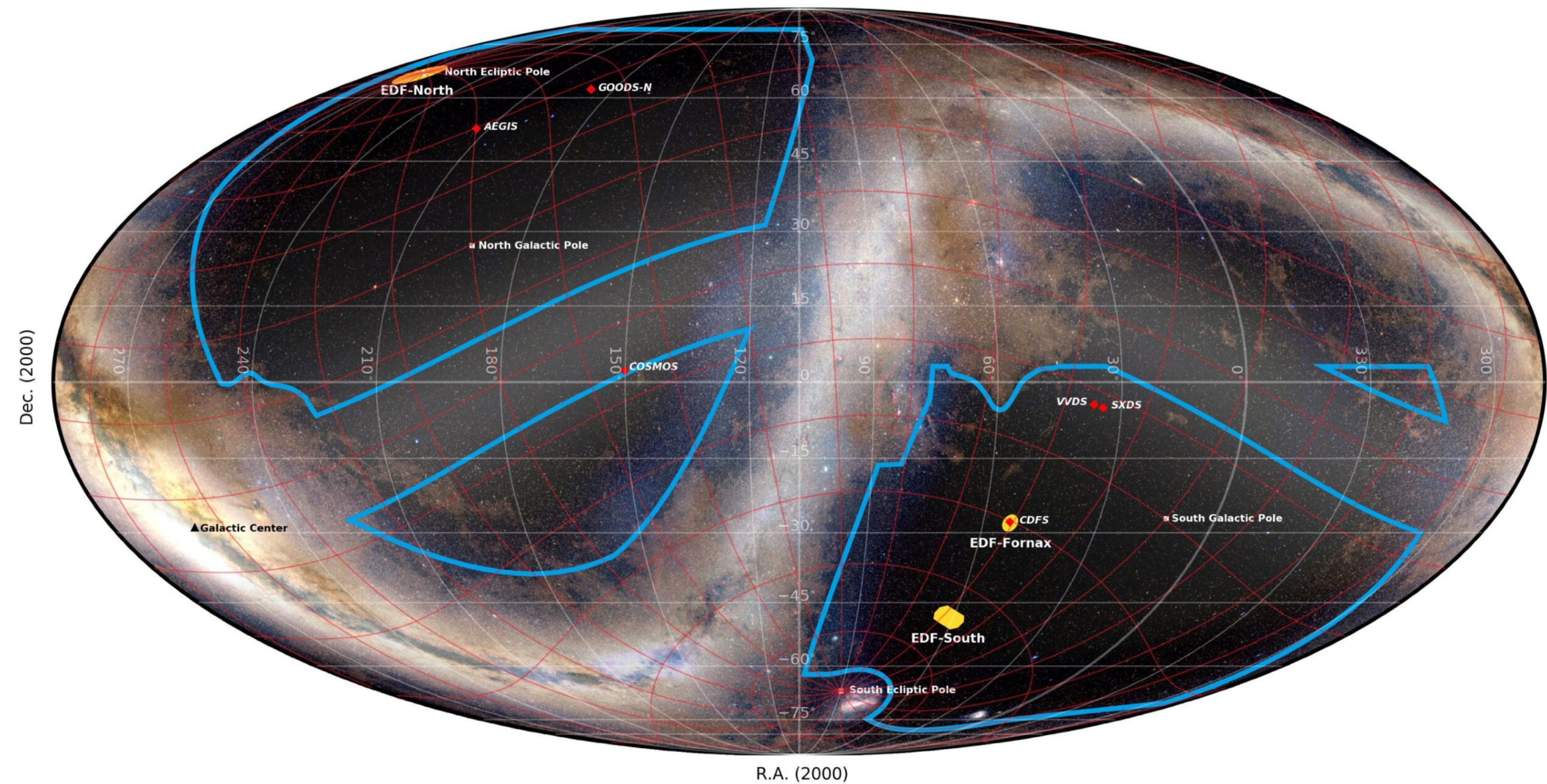
The NISP instrument

- NISP: Near infrared spectrograph and photometer
 - Measurement of the galaxy redshift (distance)
 - Infrared detector: 16 detectors, 2k x 2k : 64 Mpixels
 - Filter wheel for photometry
 - Grism wheel for spectroscopy
 - Delivered by the Laboratoire d'Astrophysique de Marseille (France)



The survey

- Wide survey:
 - 15.000 square degrees (1/3 of the sky)
 - One single observation in each pointing
- Deep survey:
 - 50 deg²
 - 40 times more observations
- Calibration fields



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 (GOODSN=0.5, AEGIS=1, COSMOS=2, VVDS=0.5, SXDX=2, CDFS=0.5 deg.²)



cnrs

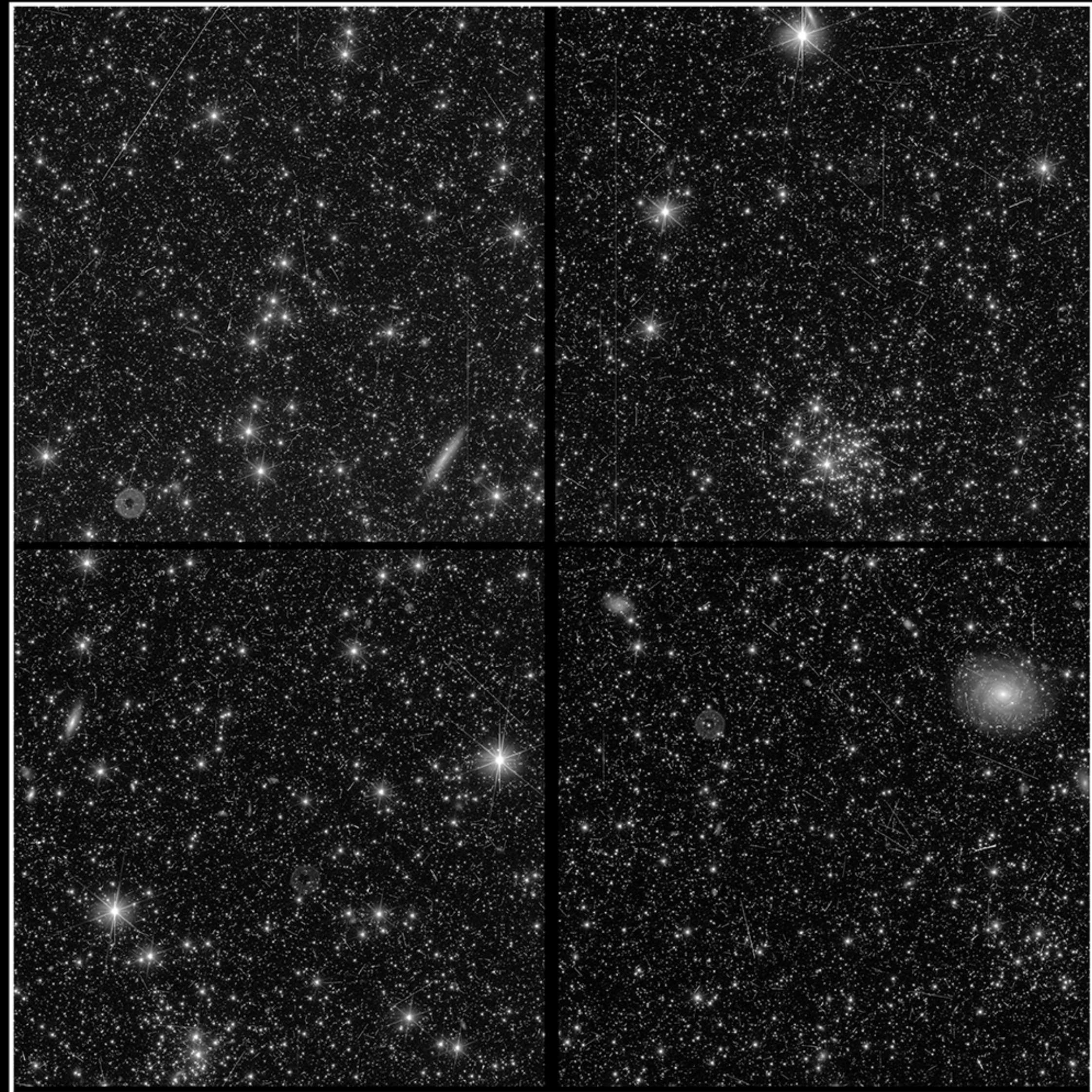
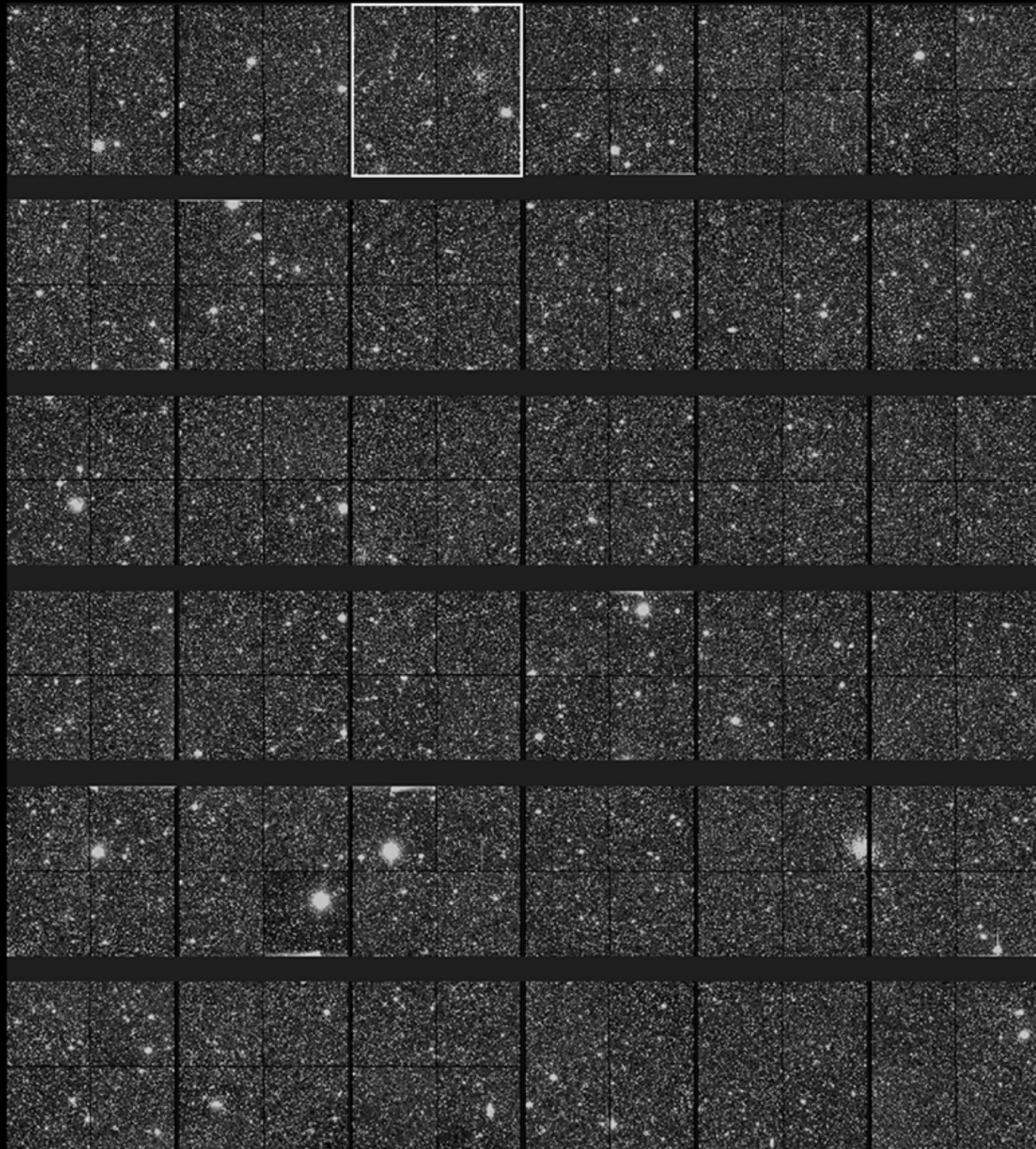
Status of Euclid

Commissioning

- Commissioning in July:
 - Position and pointing
 - Electronics, commands, temperature
 - Instruments started
 - Focus of telescope
 - First non calibrated images shown to the public (July 31)

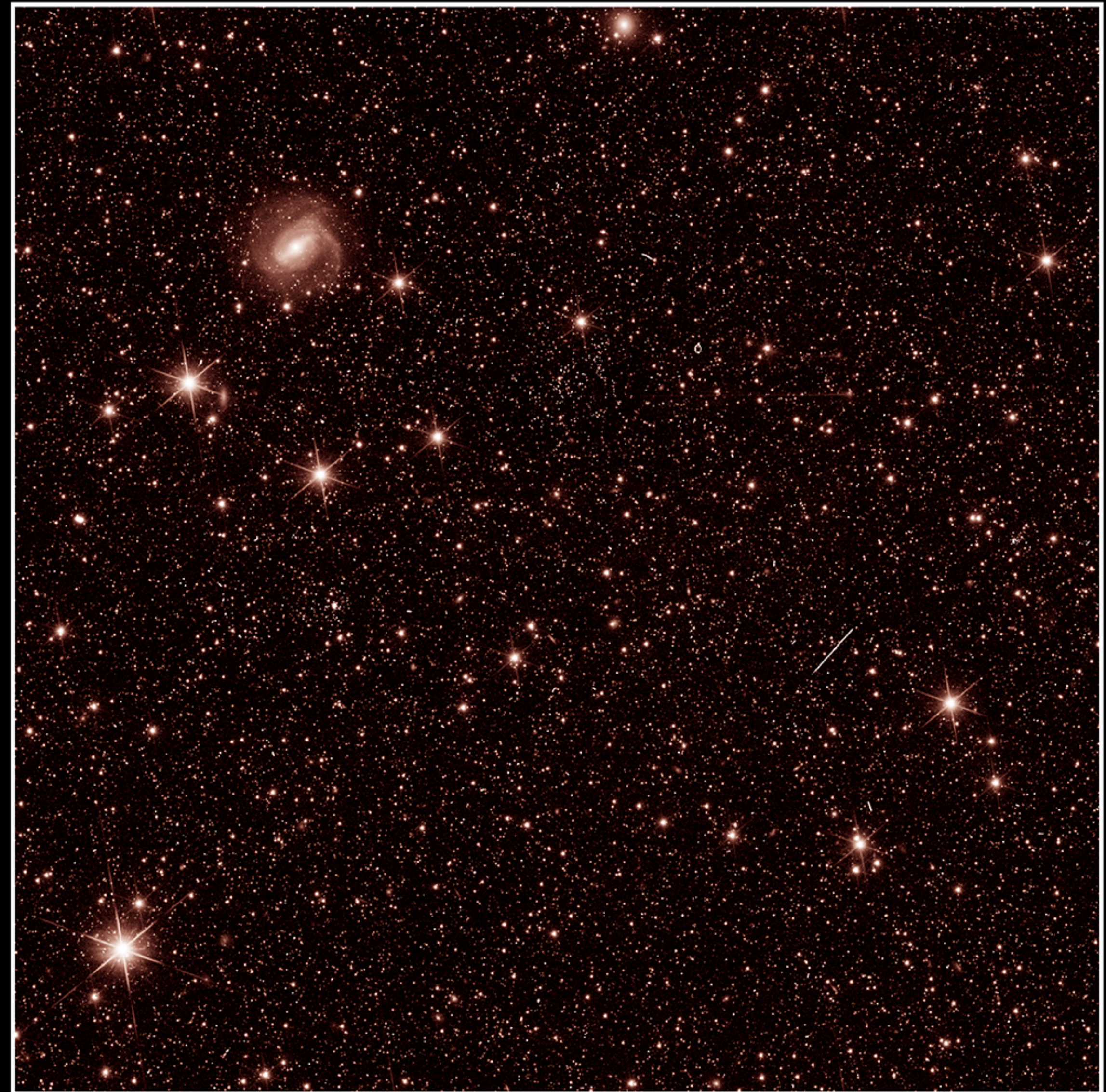
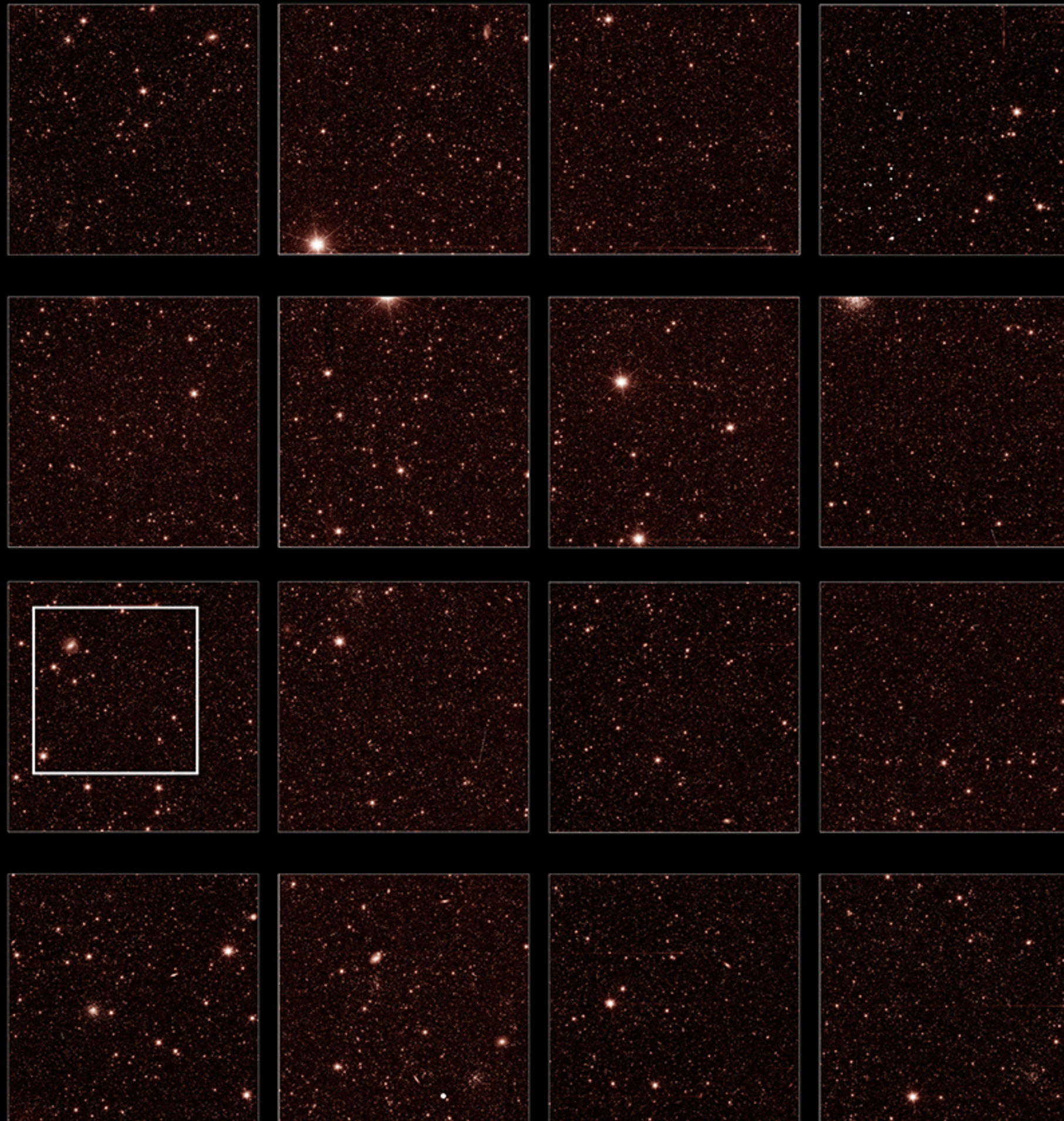
Commissioning

EARLY COMMISSIONING TEST IMAGE, VIS INSTRUMENT

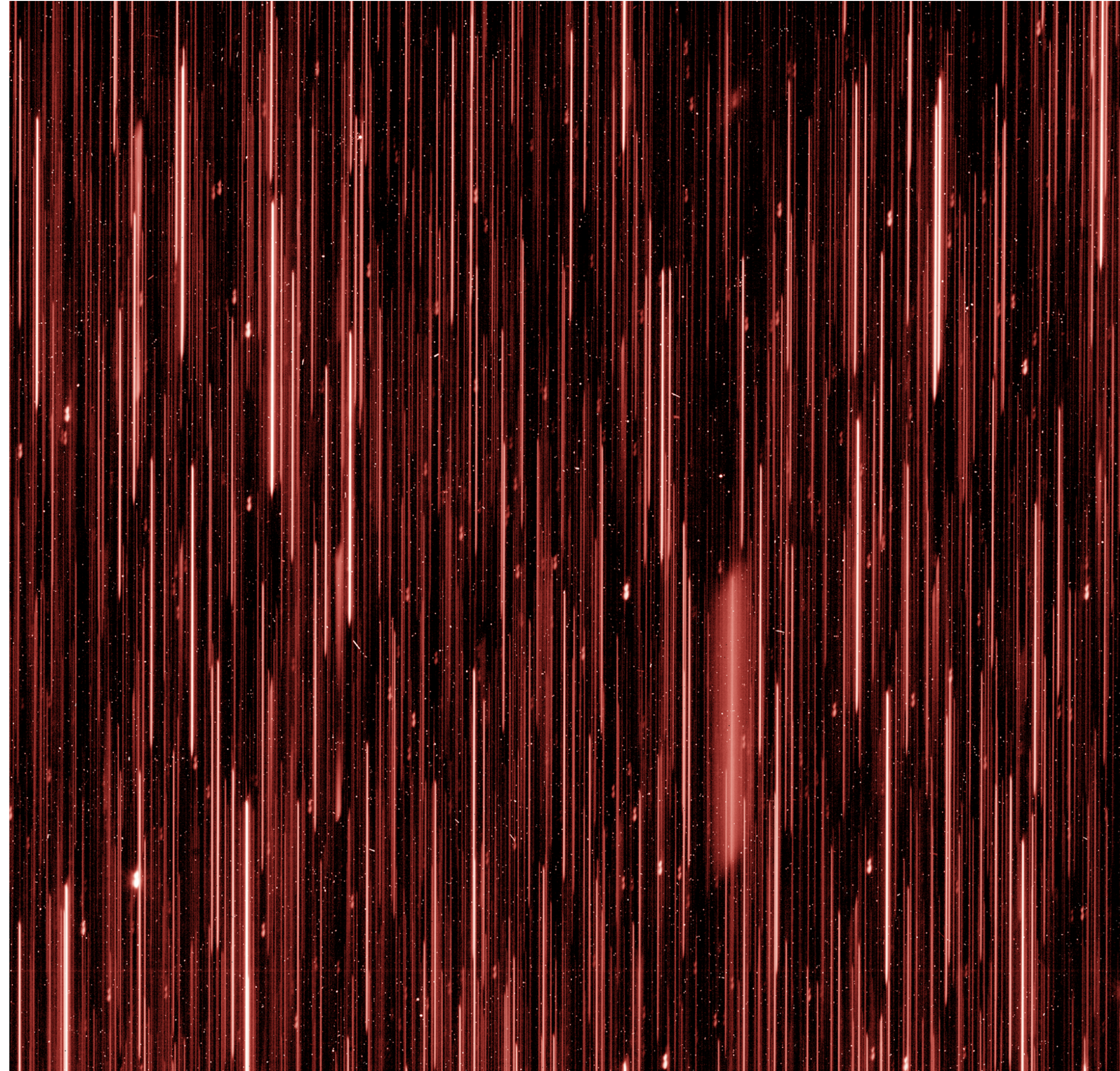


Commissioning

EARLY COMMISSIONING TEST IMAGE, NISP INSTRUMENT

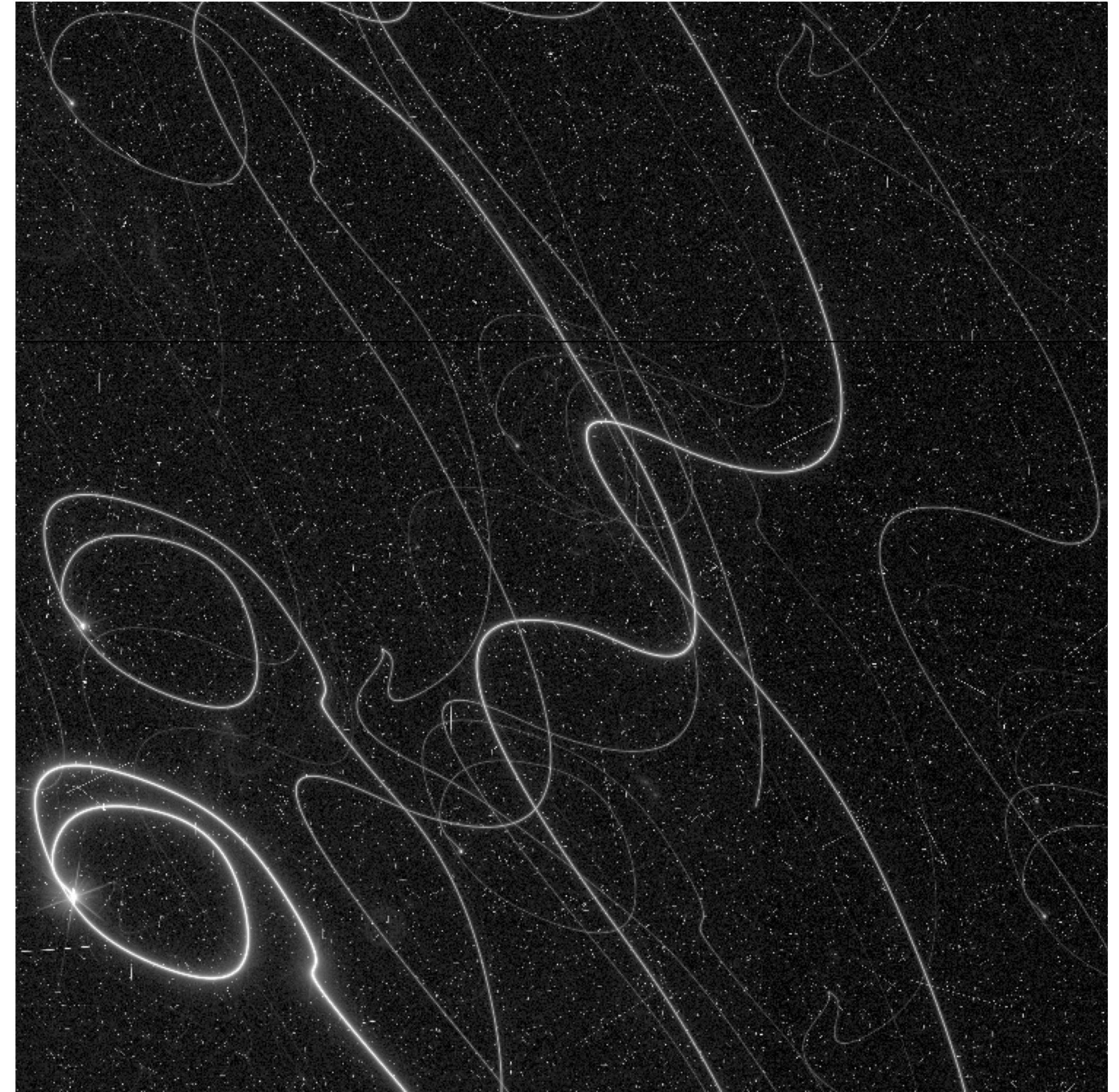


Commissioning



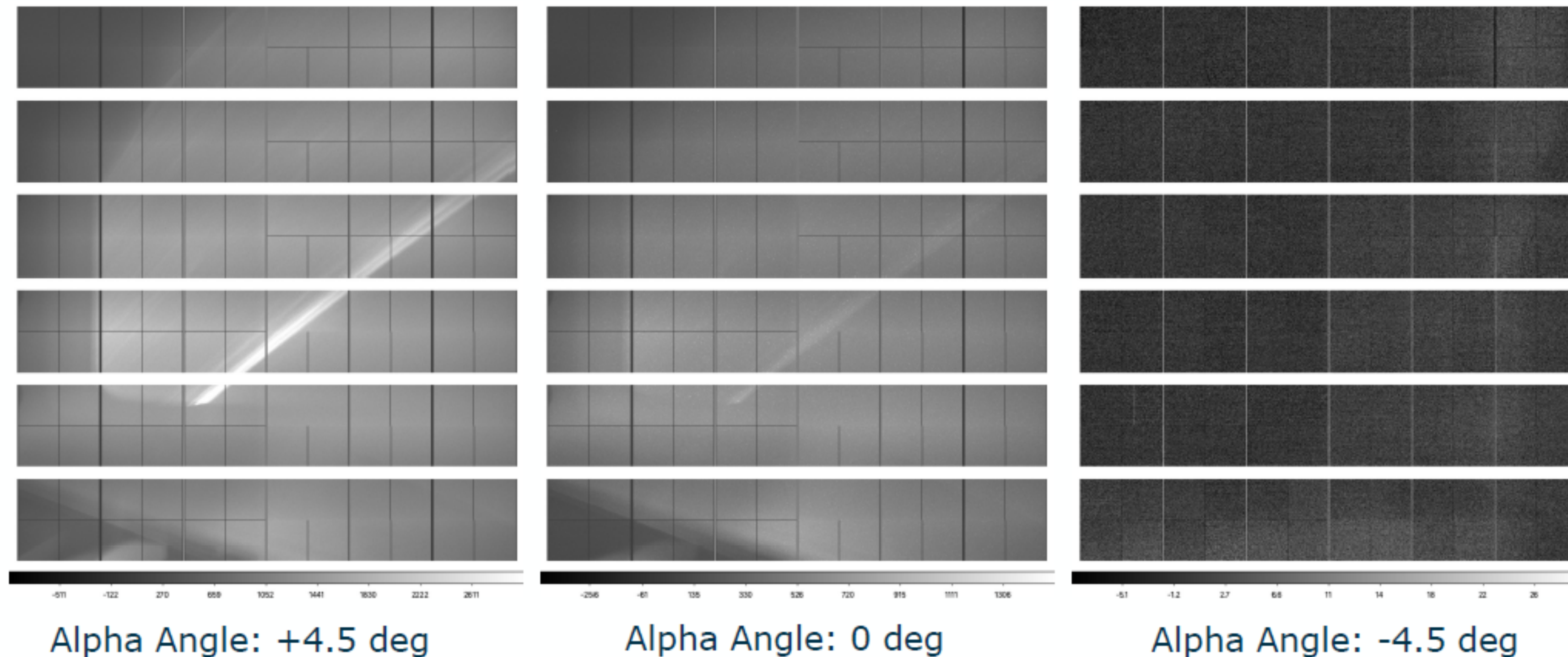
Early commissioning test image, NISP instrument (grism mode)

- Euclid Fine Guidance Sensor (FGS): guiding system used to determine exactly the telescope pointing in the sky
- Completely new development in Europe made of optical sensors that pick out and lock onto stars found by ESA's Gaia mission
- Cases when the FGS was loosing its tracking stars (too few or too many stars, many cosmic rays)
- Issue fixed by software fix that has now been uploaded onto the spacecraft
- Delay in commissioning phase



Straylights

- Euclid has its 'back' to the Sun and protected from sunlight by a dedicated sunshield.
- Small amount of sunlight is reflecting off a thruster and getting through the insulation of (VIS) instrument
- Stray light detected in observations when VIS is turned at specific angles.
- Euclid's survey re-designed to avoid these angles
- Could impact the efficiency of the survey



- X-rays emitted by the Sun during solar flares can occasionally reach the detectors, spoiling part of the images
- Solar activity is currently high since Sun activity will peak in 2024-2025
- Small fraction of lost images, could be re-observed later

Performance Verification Phase

- Performance Verification Phase in October / November
 - Observations on calibration fields
 - Processed by calibration pipelines (VIS calibration at CC-IN2P3)
 - Results analyzed by instrument experts

- Phase Diversity Calibration in December / January
 - Optical calibration with various orientation with respect to the Sun + telescope defocus
 - Thermic stabilisation of one week between each observation

- Instruments are performing very well!
- Survey will start on the 14th of February

First images

- On the 7th November were released the first Euclid full-colour images of the cosmos
- 5 targets, one day of observation in total



First images

- NGC6822 galaxy:
 - Observed for the first time in its integrity with exceptional resolution in less than one hour
 - Many star clusters discovered
 - Star formation history



First images

- Perseus Galaxy cluster:
 - 2 hours of observation
 - Hundred thousand of background galaxies never seen before





cnrs

Euclid data processing

Computing model

- Unprecedented large data volume for a space mission
 - 300 TB of raw data over 6 years
 - Dozens of PB of data products
- Processing: 20 000 CPU cores estimated at maximum
- 9 Science Data Centers (SDC)
- CC-IN2P3: 30% of storage and processing



Computing model

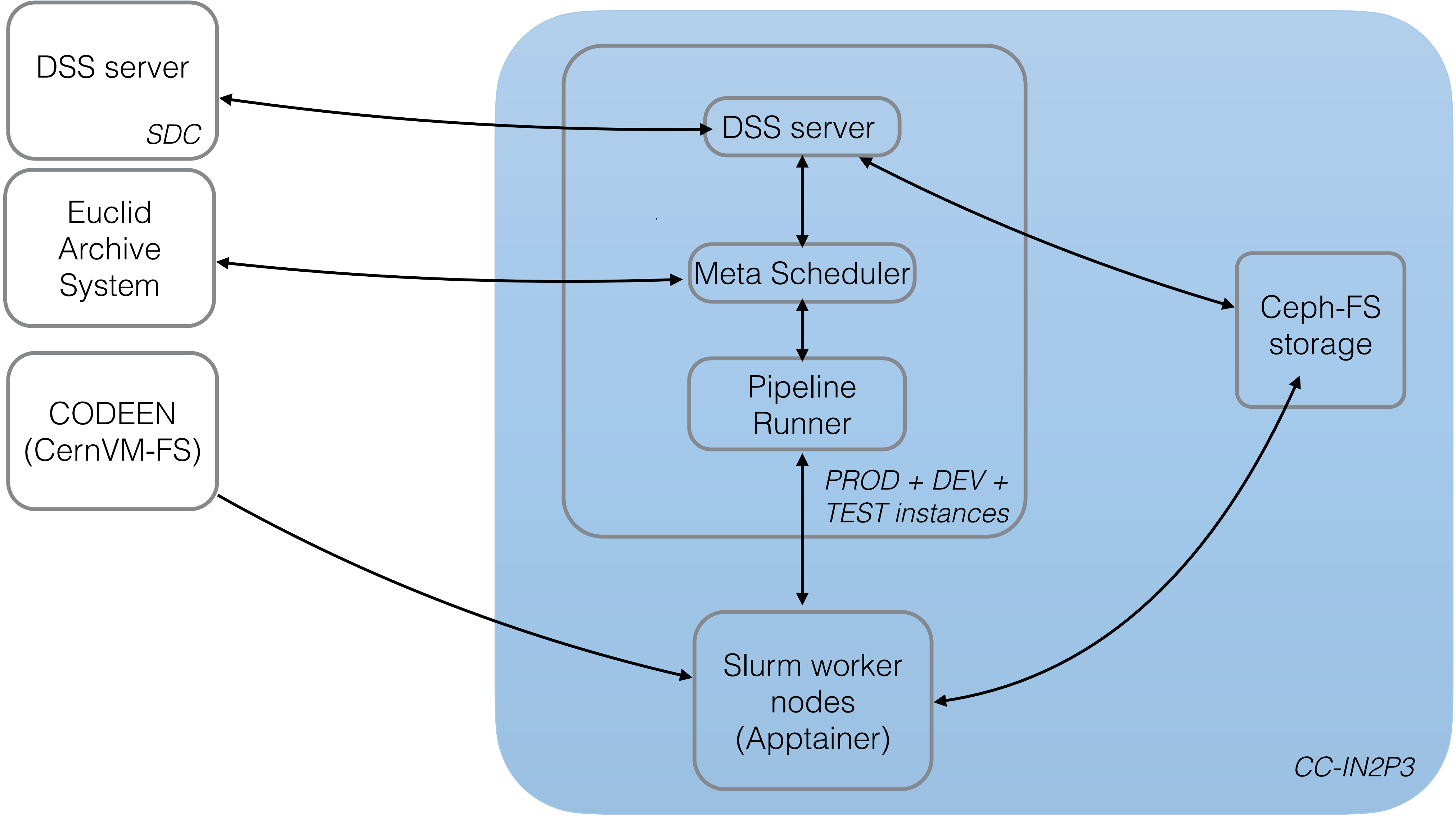
- 3 different type of processing:
 - On the fly (daily processing with latest pipeline)
 - Non regression campaign: reprocessing a set of observations with a consistent pipeline version
 - Data release: reprocessing of all observations from the beginning of the survey

- First Data Release after one year of observations
- Immediately available for the Euclid Consortium, public release one year later
- Data releases 2 and 3 after 3 years and 6 years of observations

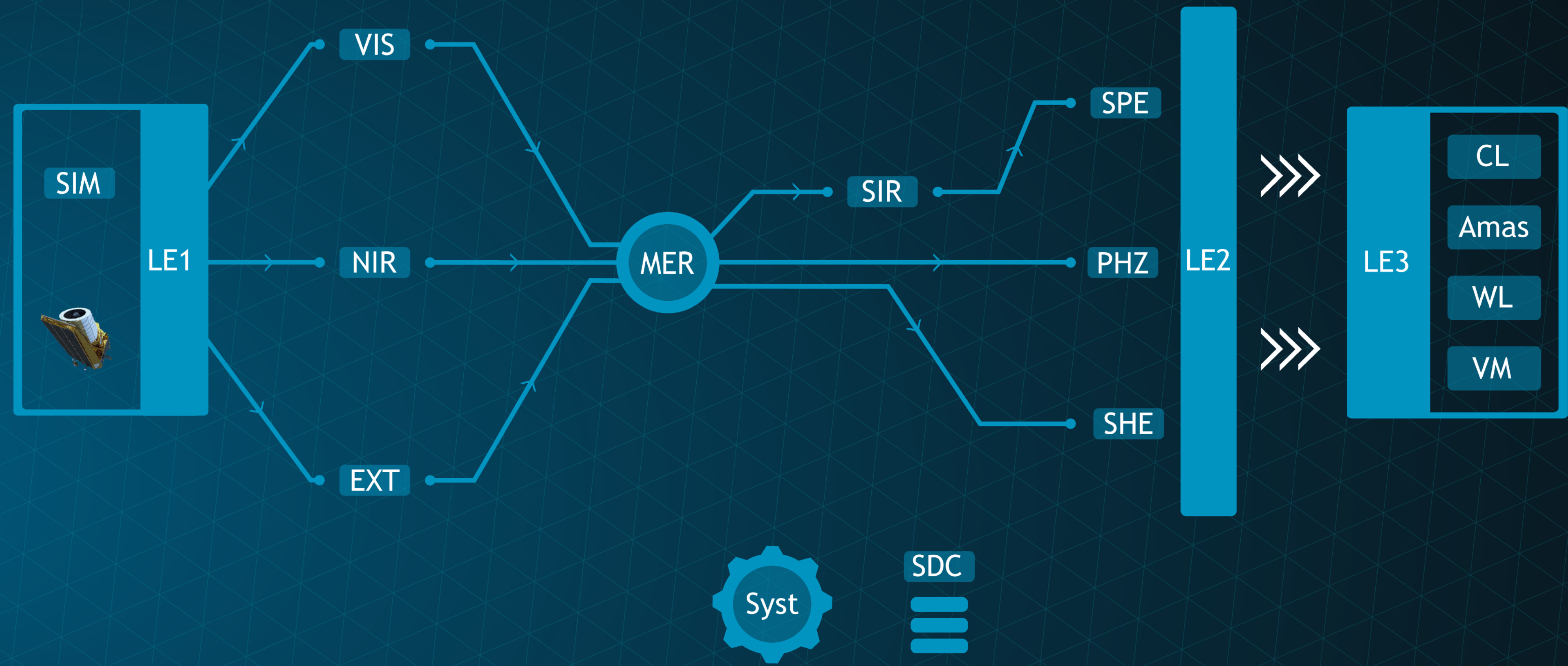
Computing model

- A « grid-like » computing model:
 - Raw data distributed to the 9 SDC
 - Each SDC runs the complete Euclid processing pipeline on its data set
 - Data products are referenced in a centralised database
 - Critical data are replicated on several SDC
 - Central services: monitoring, software CI/CD (Gitlab, CernVM-FS), orchestration, authentication,...
 - Data management and processing workflow middleware provided by the Euclid Consortium
- Most of the services have been specifically designed for Euclid:
 - Central services:
 - Euclid Archive System (central database + Science Archive)
 - Coordination and Orchestration System
 - Collaborative Development Environment (hosted in CC-IN2P3 OpenStack cloud)
 - In each Science Data Center:
 - Distributed Storage System
 - MetaScheduler (orchestration of processing in relation with central database)
 - Pipeline Runner

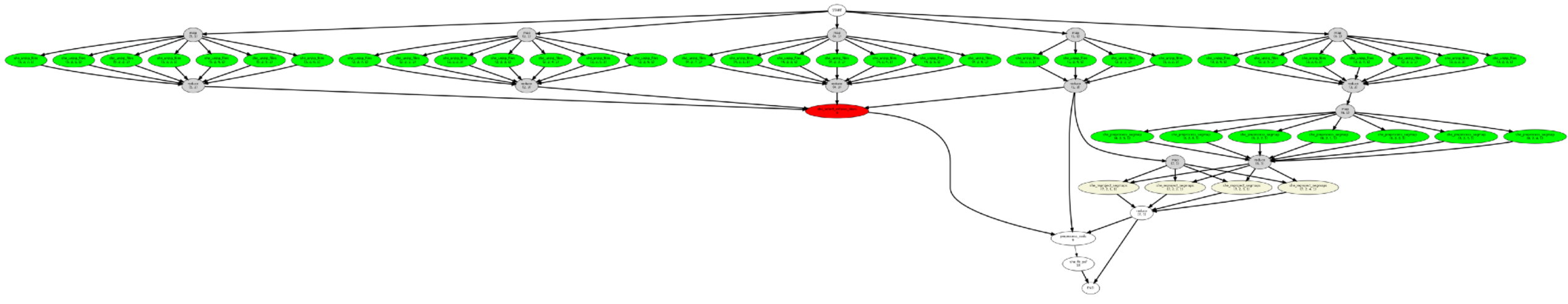
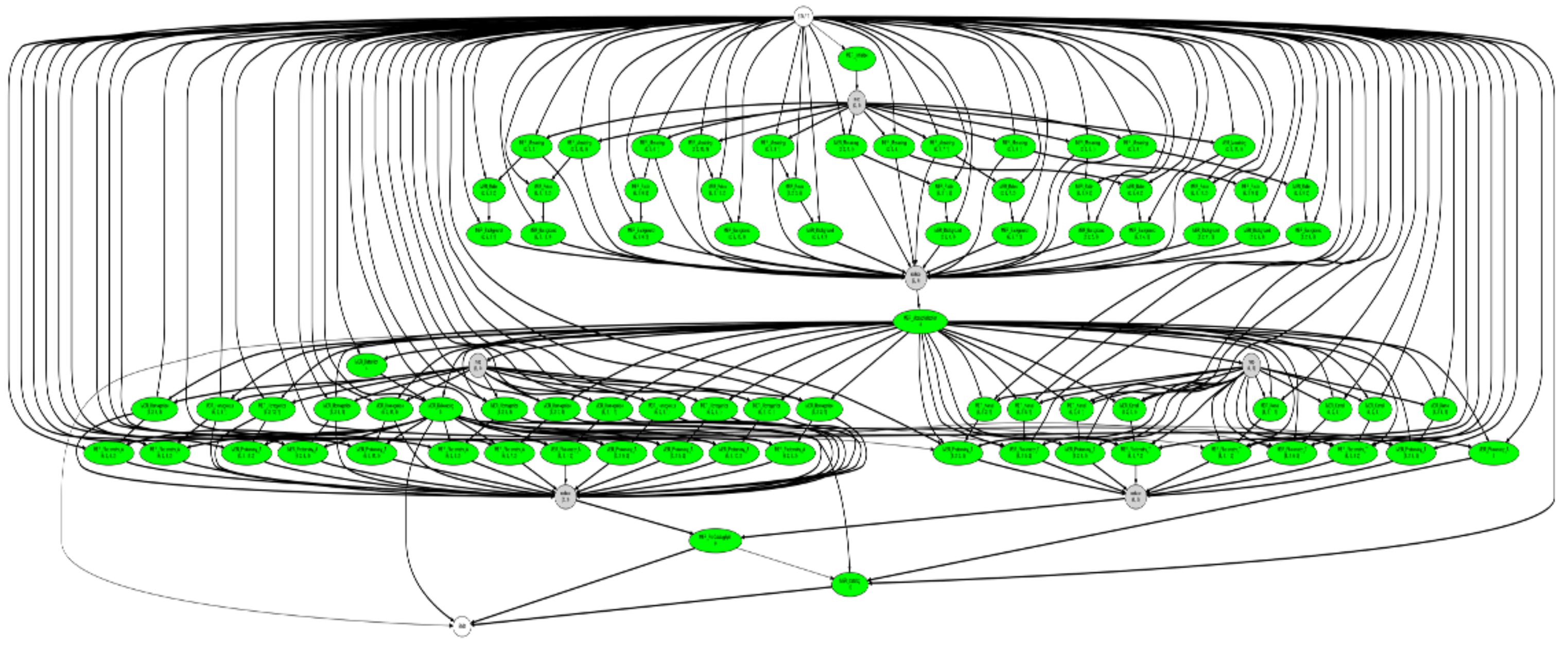
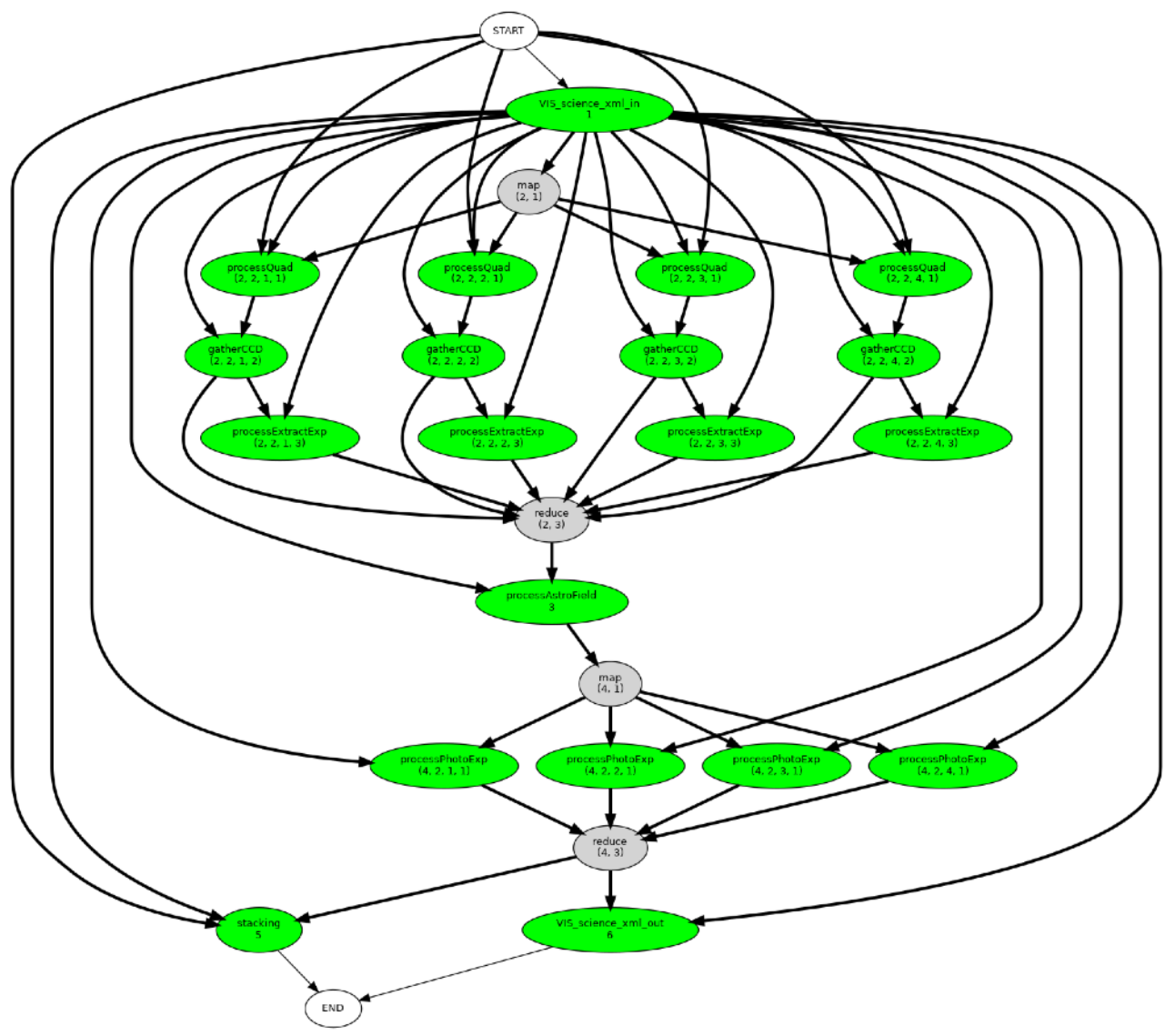
Euclid architecture at CC-IN2P3



Processing pipelines



Processing pipelines



Euclid Pipeline Runner



- Execution of Pipeline Workflow on a computing cluster
 - Python Microservice architecture using zeroMQ for fast communication
 - Python API for developer to specify their pipelines: dependancies, resources requirements
 - Using pilot jobs
 - Can run locally on a laptop or on a cluster (support SGE, PBS, Slurm, HTCondor)
 - Scalable:
 - Tested with workflow up to 800k tasks
 - Tested with up to 5k pilot jobs (20k "simulated" jobs)
 - Profiling: single task, pilot, complete pipeline, total cluster usage
 - Web dashboard: monitor progress and failures

(Credit: S. Marcin)

Euclid Pipeline Runner



Pipeline Run Server (3.2.6)

[API Docs](#)
[Pilots](#)
[Queue](#)
[Runs](#)
[System](#)
[Configuration](#)

Runs Ids

/// Tuesday, 30. January 2024 12:10PM

Search:

run (ID)	status	pipeline	submitted	terminated	duration [min]	priority	actions
<u>SIM-PV023-SDC-FR-PROD-1-YK5UPLCG-20230720-165405-0_R3</u>	ERROR	PipScript_SIM_Splitted	n/a	2024-01-27 00:45	n/a	9	Reset
<u>VIS_PF_SHORT_Autom_EUCLID_1.0.4-ON_THE_FLY-glibet-PLAN-000001-16KJDHUD-20240130-031521-1</u>	COMPLETED	PipScript_VIS_ProcessField	2024-01-30 03:24	2024-01-30 11:48	504	9	
<u>VIS_PF_LONG_Autom_EUCLID_1.0.5-ON_THE_FLY-glibet-PLAN-000001-7G9KMTCH-20240130-031514-0</u>	EXECUTING	PipScript_VIS_ProcessField	2024-01-30 03:23	n/a	n/a	9	Stop Prio++
<u>VIS_PF_LONG_Autom_EUCLID_1.0.5-ON_THE_FLY-glibet-PLAN-000001-BJOHO38I-20240130-031529-2</u>	EXECUTING	PipScript_VIS_ProcessField	2024-01-30 03:23	n/a	n/a	9	Stop Prio++
<u>VIS_PF_LONG_Autom_EUCLID_1.0.5-ON_THE_FLY-glibet-PLAN-000001-V2P5EU6S-20240130-031522-1</u>	EXECUTING	PipScript_VIS_ProcessField	2024-01-30 03:23	n/a	n/a	9	Stop Prio++
<u>VIS_PF_SHORT_Autom_EUCLID_1.0.4-ON_THE_FLY-glibet-PLAN-000001-DU1KSSLU-20240130-031513-0</u>	EXECUTING	PipScript_VIS_ProcessField	2024-01-30 03:22	n/a	n/a	9	Stop Prio++
<u>VIS_PF_SHORT_Autom_EUCLID_1.0.4-ON_THE_FLY-glibet-PLAN-000001-H0WGI24I-20240130-021520-1</u>	COMPLETED	PipScript_VIS_ProcessField	2024-01-30 02:23	2024-01-30 08:36	373	9	
<u>VIS_PF_LONG_Autom_EUCLID_1.0.5-ON_THE_FLY-glibet-PLAN-000001-B0XZOZHI-20240130-021513-0</u>	EXECUTING	PipScript_VIS_ProcessField	2024-01-30 02:22	n/a	n/a	9	Stop Prio++
<u>VIS_PF_SHORT_Autom_EUCLID_1.0.4-ON_THE_FLY-glibet-PLAN-000001-2RZC9PCP-20240130-021528-2</u>	EXECUTING	PipScript_VIS_ProcessField	2024-01-30 02:22	n/a	n/a	9	Stop Prio++
<u>VIS_PF_SHORT_Autom_EUCLID_1.0.4-ON_THE_FLY-glibet-PLAN-000001-3D9PNX5E-20240130-021513-0</u>	COMPLETED	PipScript_VIS_ProcessField	2024-01-30 02:22	2024-01-30 10:50	507	9	
<u>VIS_PF_SHORT_Autom_EUCLID_1.0.4-ON_THE_FLY-glibet-PLAN-000001-X6HDD47O-20240130-011529-2</u>	COMPLETED	PipScript_VIS_ProcessField	2024-01-30 01:23	2024-01-30 09:04	461	9	

Euclid Pipeline Runner

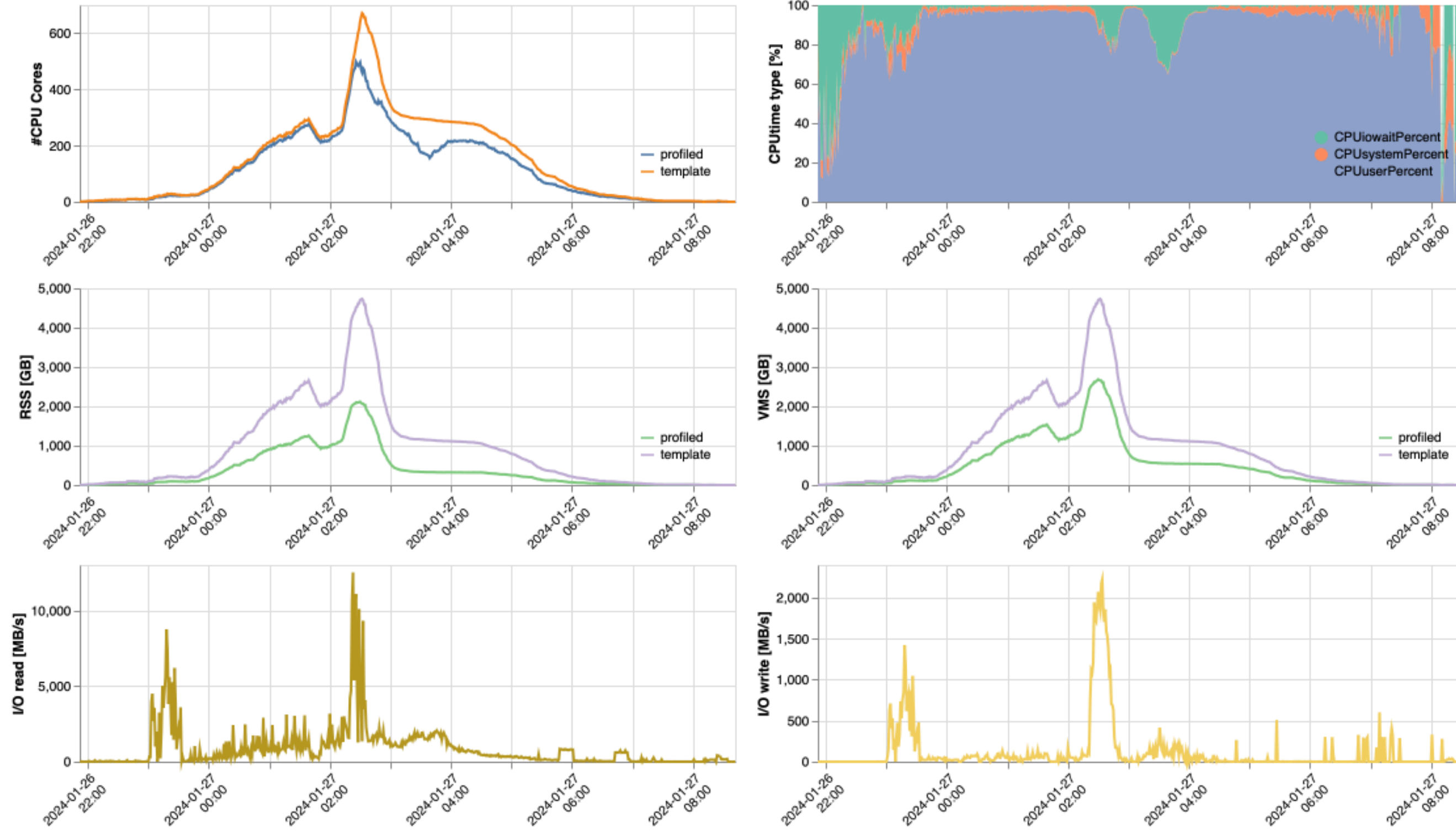


Pipeline Run Server (3.2.6)

Details for Run with ID=SIM-NISP_SPV3_R3b_ppo_20231113T153000: COMPLETED

Run Id: SIM-NISP_SPV3_R3b_ppo_20231113T153000
Processing Status: COMPLETED
Submission Date: 2024-01-26 22:26
End Date: 2024-01-27 09:43
Duration: 40589.706799
Workdir: ppos/SIM-NISP_SPV3_R3b_ppo_20231113T153000
Pipeline Source File: /cvmfs/euclid-dev.in2p3.fr/EDEN-3.1/opt/euclid/SIM_IAL_Pipelines/2.2.8/InstallArea/x86_64-conda_ry9-gcc11-o2g/auxdir/SIM_Pipelines//SIM_SplittedPipeline/PipScript_SIM_Splitted.py
Priority: 15
workDirInGB: 2463.344
Message:

Profiling of complete run



Euclid Pipeline Runner



TICK	PILOT	STATUS	DURATION	CPU	RSS [MB]	VMS [MB]	TMP [GB]
TICK	PILOT	STATUS	DURATION	CPU	RSS [MB]	VMS [MB]	TMP [GB]
apply_persistence_pkg_3.md5.niplistout.0_3_retry_0	Pilot_c4m12_240127_092259.906038_62567183_ccwslurm0005	COMPLETED	261.338147	1	100	100	0
apply_persistence_pkg_3.md5.nislistout.0_3_retry_0	Pilot_c4m12_240127_092259.906038_62567183_ccwslurm0005	COMPLETED	652.666502	1	100	100	0
apply_persistence_pkg_3.md5.nislistout.1_3_retry_0	Pilot_c4m12_240127_092259.906038_62567183_ccwslurm0005	COMPLETED	227.422502	1	100	100	0
apply_persistence_pkg_3_retry_0	Pilot_c4m12_240127_003843.663376_62552350_ccwslurm0063	COMPLETED	518.814306	1	4000	4000	0
call_pointing.reduce_2_3.md5.outputTU.0_2_3_retry_0	Pilot_c4m12_240127_090829.504052_62566814_ccwslurm0049	COMPLETED	42.056983	1	100	100	0
SimNipCombine_pkg_2_2_11_4_2_1_3_retry_0	Pilot_c8m24_240126_231131.862782_62549843_ccwslurm0129	COMPLETED	12.028533	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_10_3_retry_0	Pilot_c8m24_240126_231232.011272_62549913_ccwslurm0068	COMPLETED	30.039152	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_11_3_retry_0	Pilot_c8m24_240126_225301.106603_62549367_ccwslurm0054	COMPLETED	26.041845	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_12_3_retry_0	Pilot_c4m12_240127_004044.358318_62552456_ccwslurm0345	COMPLETED	56.063302	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_1_3_retry_0	Pilot_c8m24_240126_230601.636212_62549740_ccwslurm0312	COMPLETED	18.047982	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_2_3_retry_0	Pilot_c8m24_240126_231232.011272_62549913_ccwslurm0068	COMPLETED	12.021849	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_3_3_retry_0	Pilot_c8m24_240126_230501.566628_62549725_ccwslurm0348	COMPLETED	20.035535	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_4_3_retry_0	Pilot_c8m24_240126_231131.831349_62549847_ccwslurm0125	COMPLETED	13.042752	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_5_3_retry_0	Pilot_c4m12_240127_010120.837397_62553340_ccwslurm0350	COMPLETED	72.156955	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_6_3_retry_0	Pilot_c8m24_240126_225401.180585_62549374_ccwslurm0054	COMPLETED	13.023449	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_7_3_retry_0	Pilot_c8m24_240126_225401.180585_62549374_ccwslurm0054	COMPLETED	14.023898	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_8_3_retry_0	Pilot_c8m24_240126_225301.127392_62549365_ccwslurm0175	COMPLETED	13.023713	1	4000	4000	0
SimNipCombine_pkg_2_2_12_4_2_9_3_retry_0	Pilot_c8m24_240126_231131.831349_62549847_ccwslurm0125	COMPLETED	18.036406	1	4000	4000	0
SimNipCombine_pkg_2_2_1_4_2_1_3_retry_0	Pilot_c8m24_240126_231131.862782_62549843_ccwslurm0129	COMPLETED	13.024751	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_10_3_retry_0	Pilot_c8m24_240126_231201.895409_62549907_ccwslurm0049	COMPLETED	19.073508	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_11_3_retry_0	Pilot_c8m24_240126_231232.000646_62549914_ccwslurm0207	COMPLETED	151.170315	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_12_3_retry_0	Pilot_c4m12_240127_010221.170427_62553381_ccwslurm0172	COMPLETED	55.111161	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_1_3_retry_0	Pilot_c4m12_240127_010221.170427_62553381_ccwslurm0172	COMPLETED	54.100136	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_2_3_retry_0	Pilot_c8m24_240126_234035.177407_62550571_ccwslurm0345	COMPLETED	15.026699	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_3_3_retry_0	Pilot_c4m12_240127_013026.495665_62554216_ccwslurm0312	COMPLETED	14.02356	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_4_3_retry_0	Pilot_c4m12_240127_010251.422763_62553390_ccwslurm0340	COMPLETED	18.035957	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_5_3_retry_0	Pilot_c8m24_240126_231402.227168_62549944_ccwslurm0179	COMPLETED	131.210677	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_6_3_retry_0	Pilot_c8m24_240126_231402.216576_62549945_ccwslurm0179	COMPLETED	99.123719	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_7_3_retry_0	Pilot_c4m12_240127_004044.368740_62552455_ccwslurm0107	COMPLETED	14.022265	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_8_3_retry_0	Pilot_c8m24_240126_231131.852531_62549844_ccwslurm0125	COMPLETED	14.02439	1	4000	4000	0
SimNipCombine_pkg_2_2_2_4_2_9_3_retry_0	Pilot_c8m24_240126_232303.706157_62550212_ccwslurm0083	COMPLETED	14.019362	1	4000	4000	0
SimNipCombine_pkg_2_2_4_4_2_1_3_retry_0	Pilot_c8m24_240126_231532.455157_62549983_ccwslurm0119	COMPLETED	19.080926	1	4000	4000	0
SimNipCombine_pkg_2_2_5_4_2_10_3_retry_0	Pilot_c8m24_240126_230601.636212_62549740_ccwslurm0312	COMPLETED	14.022546	1	4000	4000	0

Conclusion

- Euclid spacecraft and instruments have shown excellent performances
- Very high quality images have already been released
- Euclid pipelines are running at CC-IN2P3 on calibration fields
- Mission survey will start on the 14th February

Thank you

