CS IN2P3
Computing and Data Processing

Rubin-LSST - Euclid - CTA Real Time Analysis

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with many contributions from colleagues

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Thanks and Credits

Rubin - LSST:

- Fabio Hernandez (CC-IN2P3)
- Emille Ishida (LPC)
- Julien Peloton (IJCLAB)

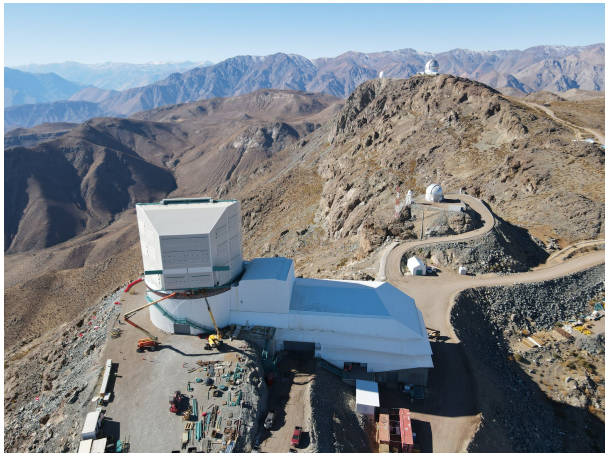
Euclid:

- Quentin Le Boulch (CC-IN2P3)
- Yannick Copin (IP2I)
- Stéphanie Escoffier (CPPM)
- Ken Ganga (APC)
- Smaïn Kermiche (CPPM)

CTA - Real Time Analysis:

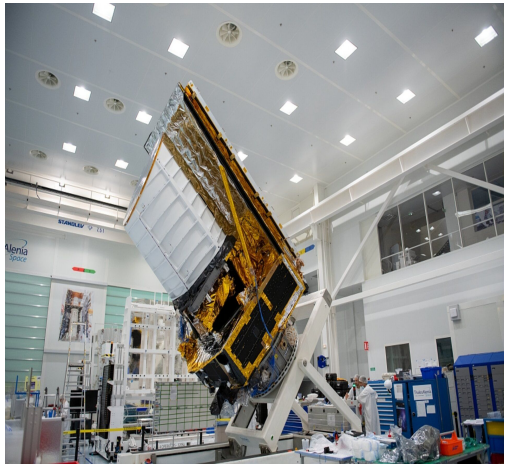
- Sami Caroff (LAPP)

2 large extragalactic surveys for cosmology



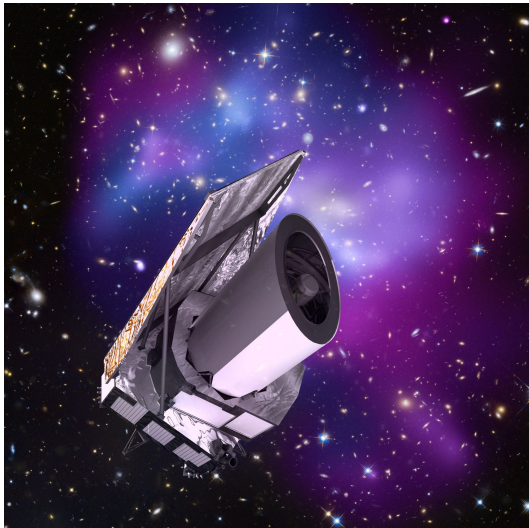
Rubin-LSST on the ground

- 8.4 m primary mirror
- 3.2 Gpixel camera
- 10 deg² field
- 6 optical bands (near UV → near IR)
- 18 000 deg² x 10 years
- Survey start mid-2024



Euclid in space (L2)

- 1.2 m primary mirror
- Visible imager (lensing)
- IR imager (photometry)
- Slitless NISP spectrograph
- 0.5 deg² field
- 15 000 deg² x 6 years
- Launch date ???
- Needs external ground data for photometric redshifts



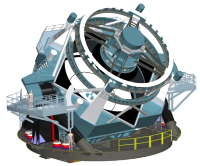
Rubin and Euclid Datasets

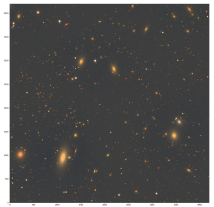
VERA C. RUBIN OBSERVATORY

Single exposure time	30 s
Total amount of data including intermediary products	2 EB (2000 PB)
Number of objects in the final catalog	37 10^9 • 20 10^9 detected galaxies, • 17 10^9 stars 3 10^9 measured galaxies
Raw data / 24 hours	~20 TB
Raw data + calibration after 10 year	60 PB
Number of images collected	5.5 millions
Final catalog database size	15 PB

Single exposure time	90 s in photo mode / 550 s in spectro mode
Total amount of data including intermediary and external products	150 PB
Number of measured galaxies	2 10^9
Number of galaxies with spectroscopic measurements	30 - 50 10^6
Raw data / 24 hours	140 GB

Rubin computing model





Transient sky

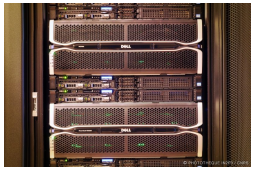
Prompt processing at US Data Facility:

- process each image
- compare to reference image
- identify differences
- stream of alerts (10 millions / night)

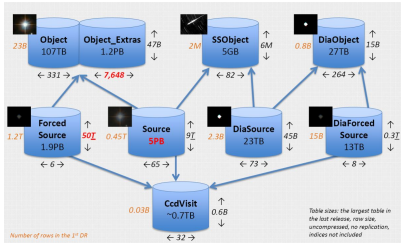
Brokers:

- get the stream
- classify
- enrich
- distribute to the science communities

Static sky
Accumulate images

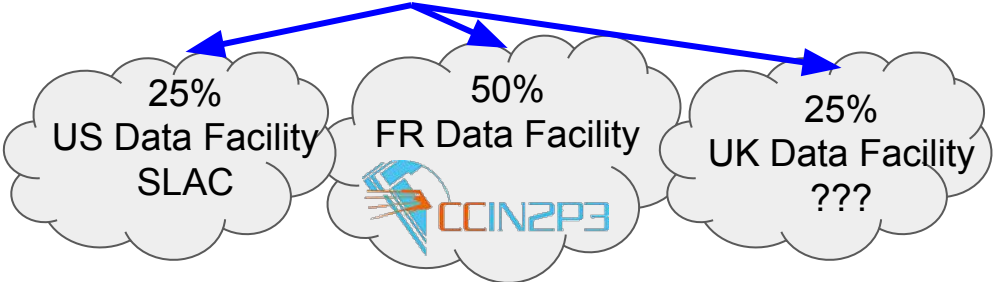


Catalogs stored in **Qserv** database

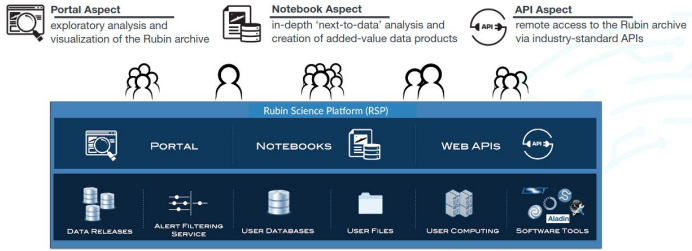


Data Release Processing (DRP)

- 6 months, 1 year, 2 year, …
- Whole dataset (re)processed



Rubin Science Platform (RSP)



Rubin computing model

- CC-IN2P3 in charge of annually reprocess 50% of the raw images collected to date
- Already performing realistic exercises for delivering Data Previews
- Involved in the architecture and workflow definition and testing

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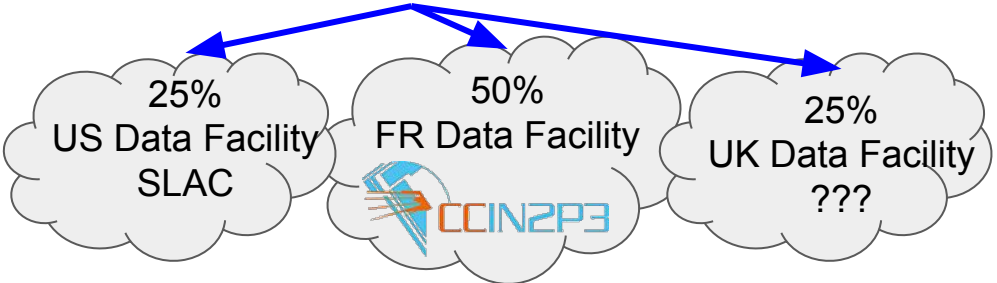


Rubin computing model

Fink broker developed and deployed at IN2P3

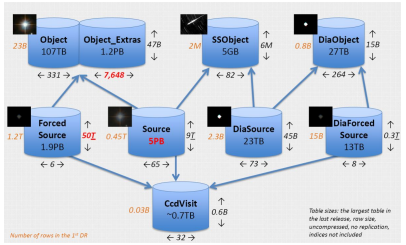
Brokers:

- get the stream
- classify
- enrich
- distribute to the science communities

Rubin computing model

- Contribution to Qserv development (LPC)
- Deployment at CC-IN2P3
- Scientific validation (LAPP)
  - Catalogs available for scientist to run their analyses

Catalogs stored in **Qserv** database



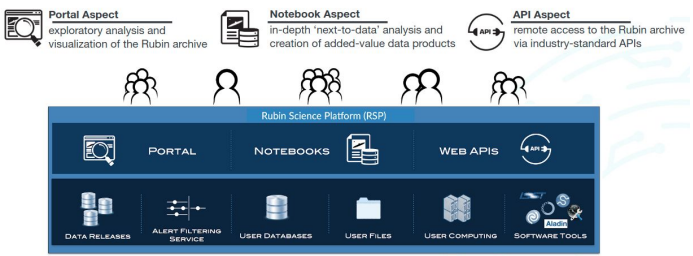
Rubin computing model

- Kubernetes Expertise at LAPP, LPC, CC-IN2P3
- Test platform at LAPP
- Platform being adapted and deployed at CC-IN2P3

Platform based on Jupyter Notebooks and using a python A.P.I. to give access to the data

- Becoming a standard
- CC-IN2P3 will have to provide this kind of service to several communities

Rubin Science Platform (RSP)



Technologies…

Cloud

- Rubin computing is currently running on the **I**nterim **D**ata **F**acility deployed on Google Cloud
- The actual **US D**ata **F**acility will be hosted at SLAC, probably heavily / fully relying on Google Cloud

Kubernetes

- Virtualization based on container management
- Fully integrated with Google Cloud
- Qserv database
- **R**ubin **S**cience **P**latform

Infrastructure as Code

- Infrastructure described and managed through description files
- Automated deployment
- git-like versioning

But… also implementing:

- PanDA (ATLAS) for the job orchestration
- RUCIO and FTS for data replication

All these technologies will have to be deployed and to inter- operate on the 3 Rubin Data Facilities

- Google Cloud (USDF)
- OpenStack (UKDF)
- On-premise / bare-metal (CC-IN2P3)

Need to develop expertise in :

- DevOps
- Performance analysis and code tuning

⇒ **This is crucial !**

Science…

Rubin is not doing any science

Rubin is in charge of:

- Building the instrument
- Building the software and computing environment
- Operate the telescope
- Process data and produce catalogs

Science is done in 8 independent collaborations

- Cosmology → DESC

DESC will primarily rely on Rubin catalogs but may require extra / alternative processing

- SNIa
- Weak Lensing

May need to run partial re-processing at pixel level

DESC computing hosted at NERSC (HPC Center)

Crucial to keep a DESC computing environment at CC-IN2P3 to guarantee the scientific return

- Need to have the data at CC-IN2P3
- Need to have enough extra computing resources to run partial local reprocessing

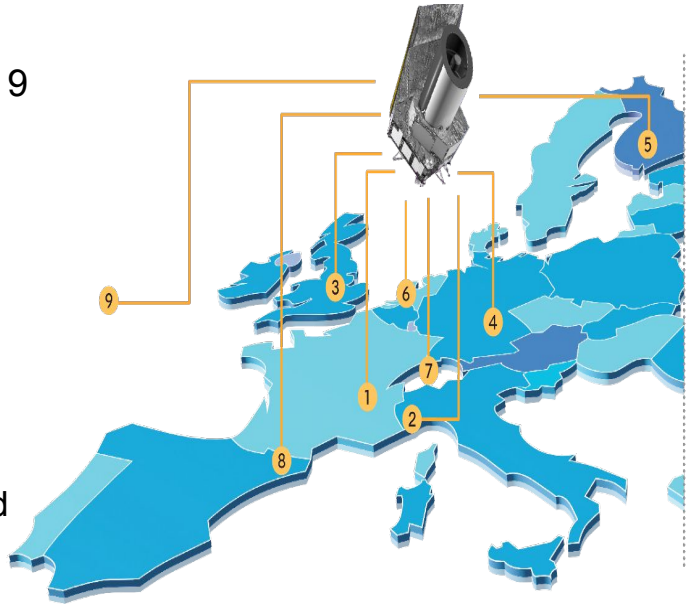
Risk of divergence between Rubin and DESC computing due to lack of coordination

Euclid ground segment

Euclid computing is distributed over 9 Science Data Centers (SDC)

The French SDC is hosted at CC-IN2P3

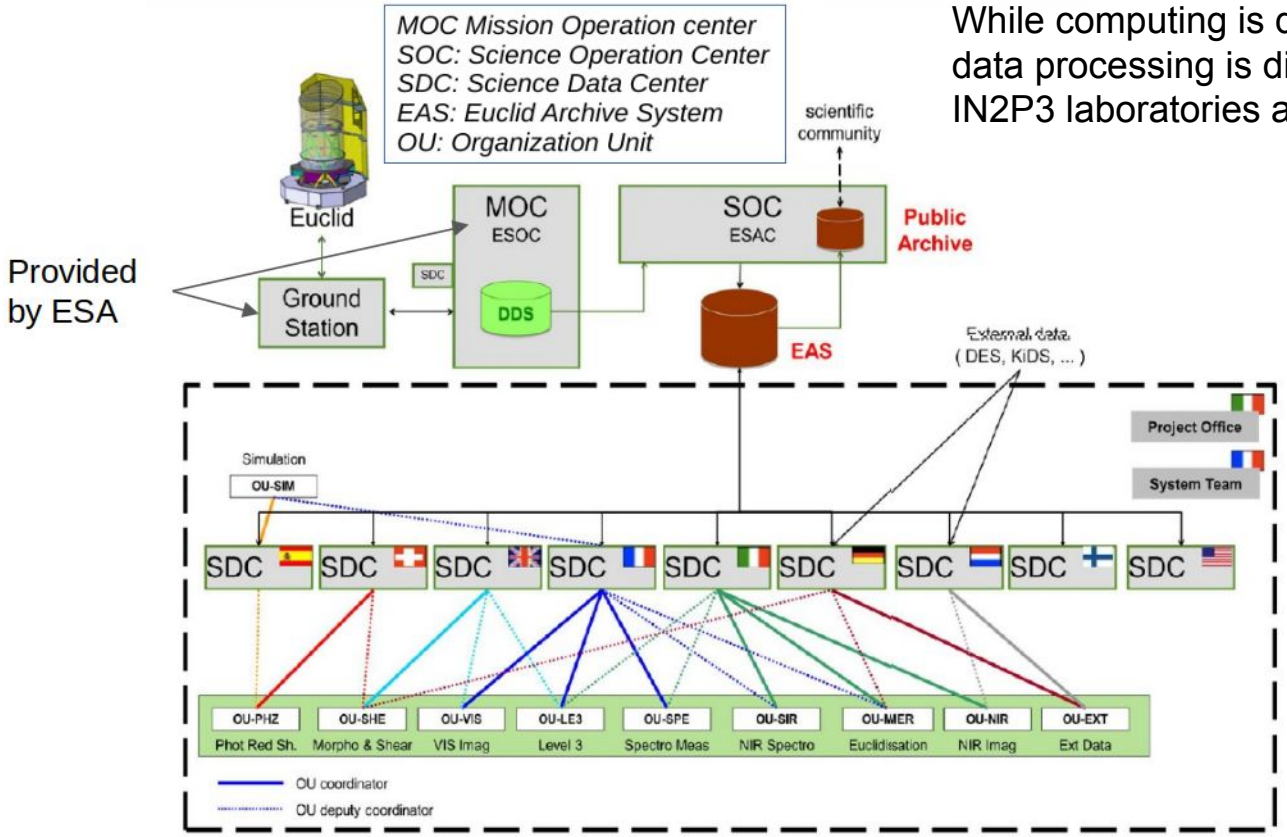
- The computing infrastructure at CC-IN2P3 is funded by IN2P3, and CNES is funding 3 fixed-term engineer contracts.
- New agreement being discussed for the rest of the mission



France contributes ~30% to Euclid construction with contributions from CNES, IN2P3, INSU and IRFU.

CC-IN2P3 will provide roughly 30% of the storage and processing capacity.

Pipeline organisation



Provided by ESA

While computing is distributed over the data centers, data processing is divided into units in which the IN2P3 laboratories are involved.

Pipeline organisation

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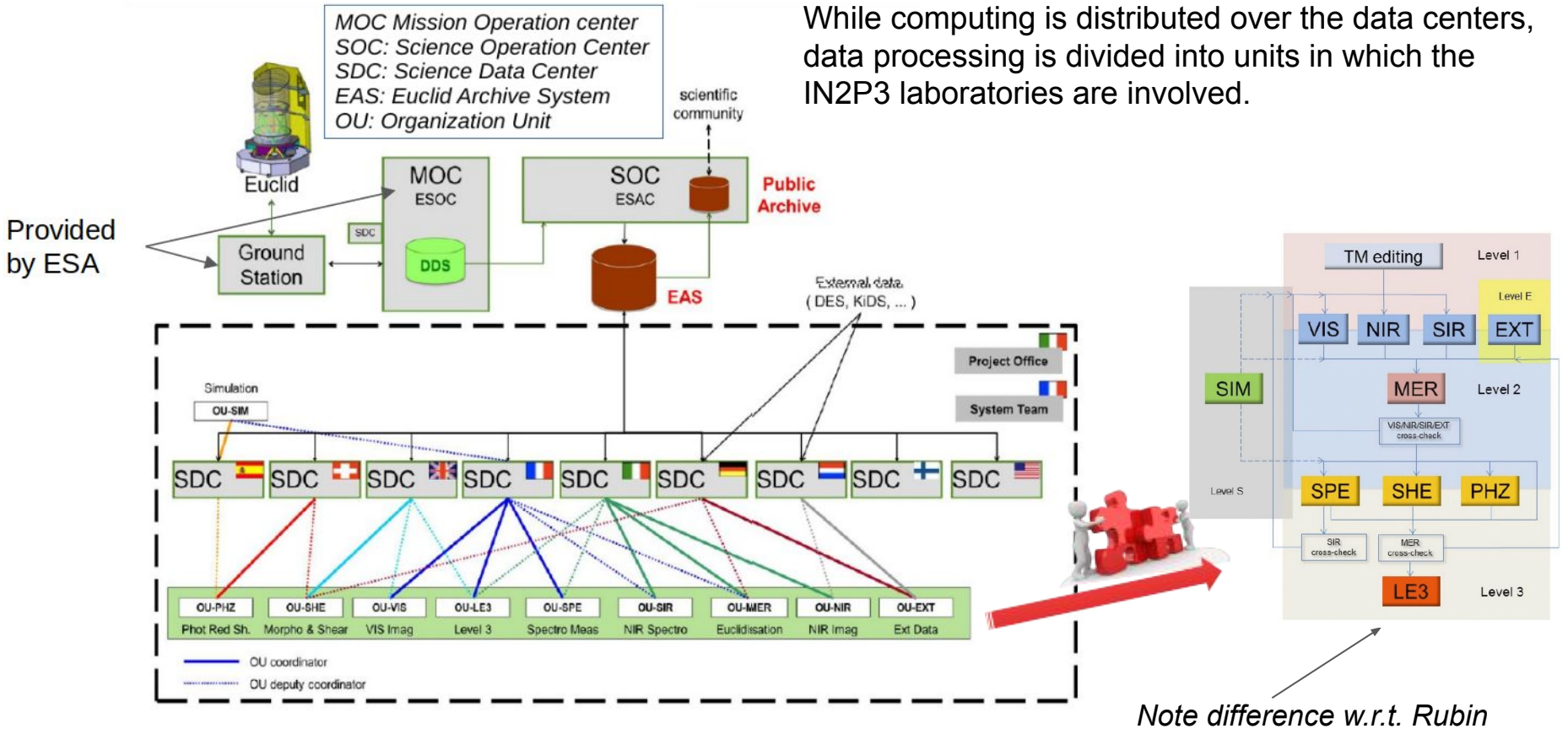
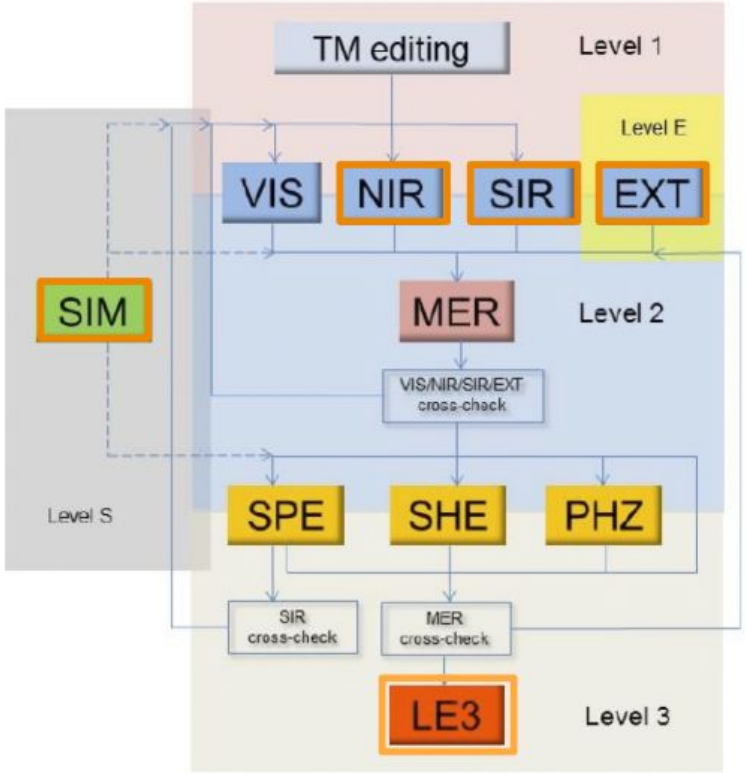


Note difference w.r.t. Rubin

Pipeline organisation



While computing is distributed over the data centers, data processing is divided into units in which the IN2P3 laboratories are involved.

IN2P3 contributions (in orange)

Development of Common Tools

Development of the Common Tools is managed and performed as a main contribution of the French **S**cience **D**ata **C**enter in collaboration with other Euclid components

- Git to share code and track code changes
- CODEEN (COmmon DEvelopment ENvironment) for testing the builds and run tests on the target platforms
- RedMine wiki to report about bugs and features

CODEEN is managed by APC and is hosted at CC-IN2P3 (mirror at SDC-UK)

Science…

Computing and storage needs for the scientific exploitation are not included in the Euclid Ground Segment:

- Identification in each Science Working Groups (SWG) is underway within Euclid Consortium

But, the situation today is that resources used by the Euclid French community are based on regional clusters / ”mesocenters” using HPC architecture, without financial support at the institutional level:

- an HPC infrastructure is essential for all correlation type data analysis (2-point correlation, higher order,..)
    - analysis being applied on catalogs of millions of objects, multiplied by thousands of mock.

Science / Data Challenges

Both Rubin and Euclid rely on Science and Data Challenges to test the pipelines and identify bottlenecks

Rubin / DESC:

- Full image processing of DESC DC2
  - Generate catalogs
  - Users access to data
- Data Previews:
  - 0: DC2 reprocessing
  - 1: Commissioning camera on sky
  - 2: Full camera on sky

Euclid:

- IN2P3 major contributor to all Euclid scientific challenges
- SC1 in 2015 - 0.5 deg²…
- … up to SC8 with 150 deg²
- Performance verification rehearsal (commissioning)

These challenges require significant human-power and resources but are essential to learn how the system works and to ensure the computing infrastructure is able to cope

It is crucial to have CC-IN2P3 engineers directly participating to the challenges

- They need to receive full recognition for this and to become members of the collaborations

CTA Real Time Analysis / Science Alert Generation

Full responsibility of CTA@LAPP

Promptly analyse telescope data to generate science alerts

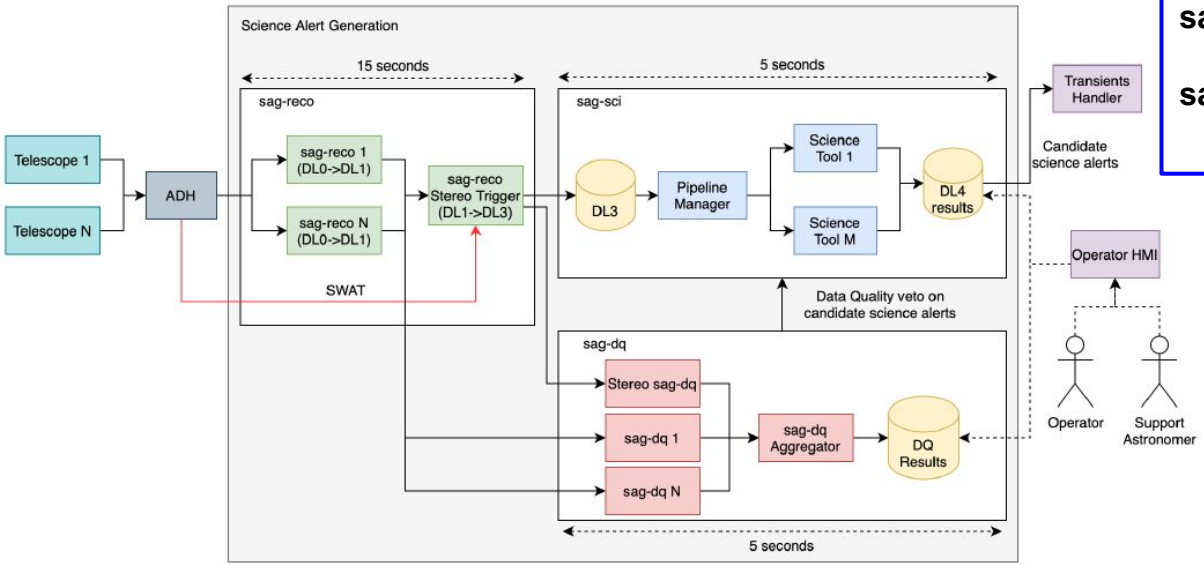
- Alert generation toward the science community
- Will also allow real-time repointing of the CTA telescopes

Developed within the LST collaboration - Will be delivered to CTAO upon completion (2026)

sag-reco:
- low level reconstruction pipeline < 15 s

sag-dq:
- Data quality assessment < 5s

sag-sci:
- Science analysis and alert generation < 5s



Highly optimized HPC approach exploiting the most advanced features of modern CPUs

- vectorization
- caching
- …

⇒ **Crucial expertise to be further developed at IN2P3**