The LSST Data Processing and Data Analysis Centers in France

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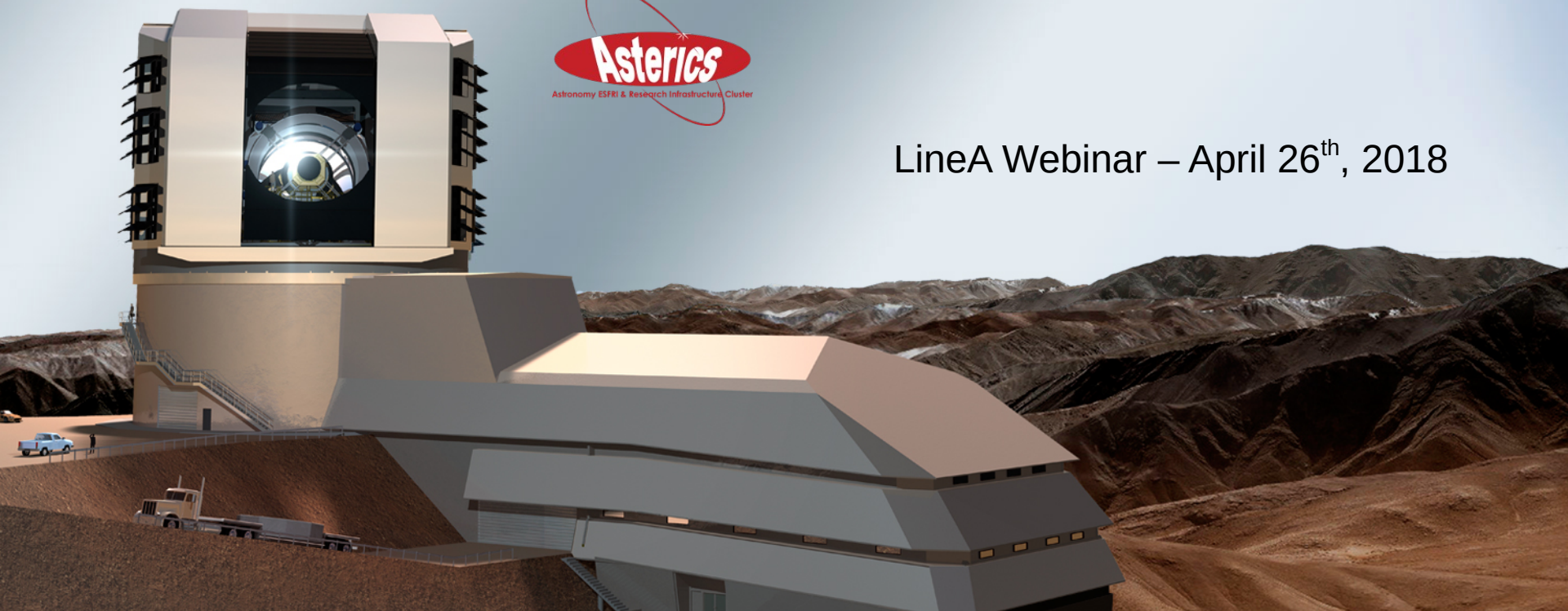
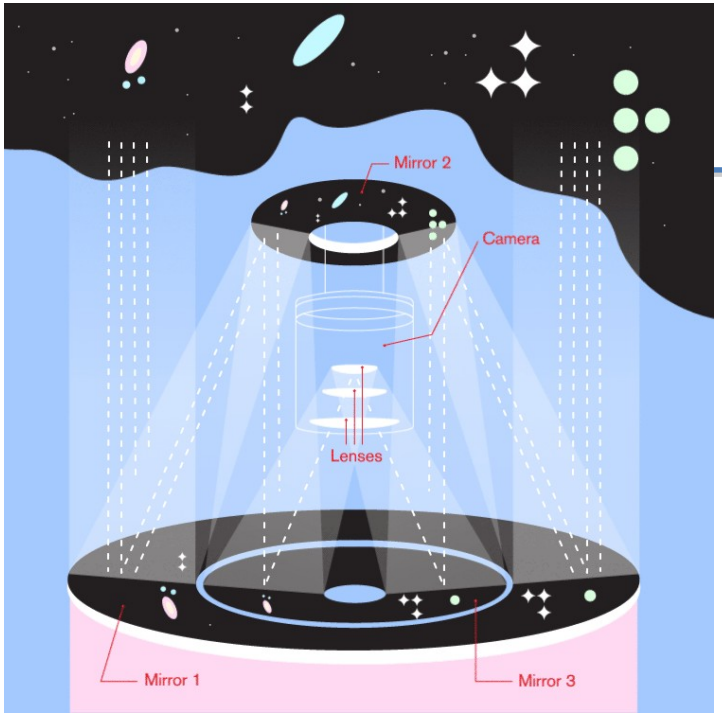
LineA Webinar – April 26th, 2018

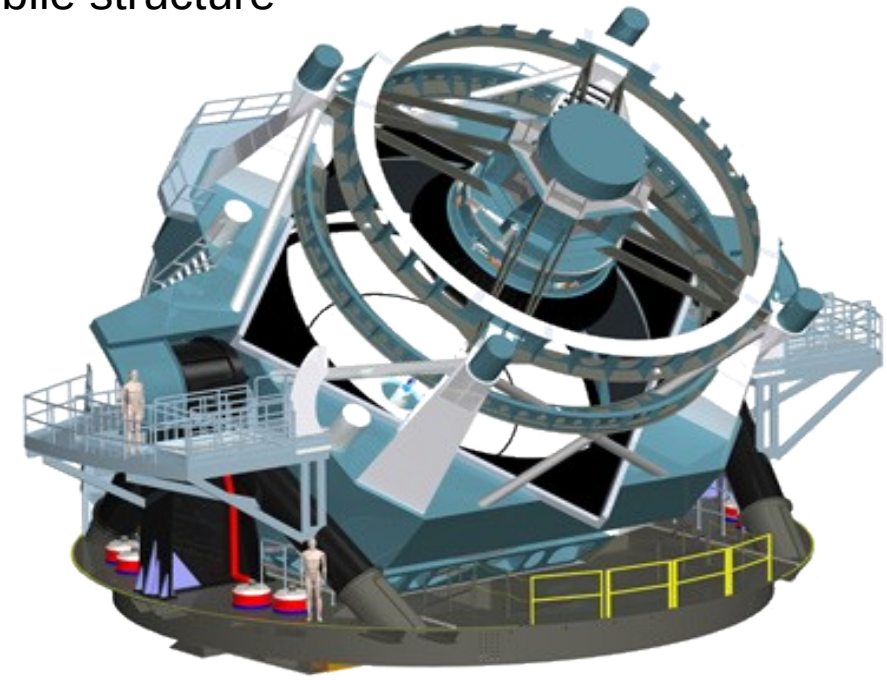


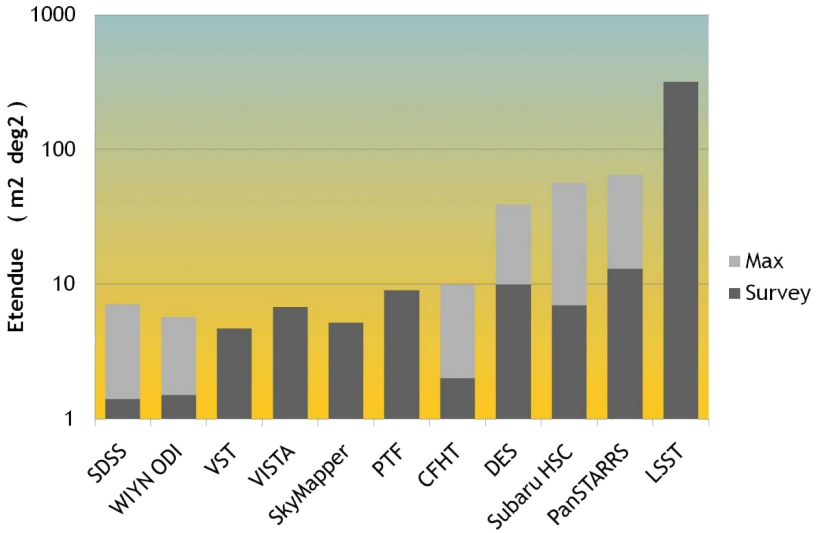
The LSST project



Artwork by Sandbox Studio, Chicago with Ana Kova

Modified Paul-Baker optical formula
D = 8.4 m (6.7 effective)
f/d = 1.23
350 t mobile structure

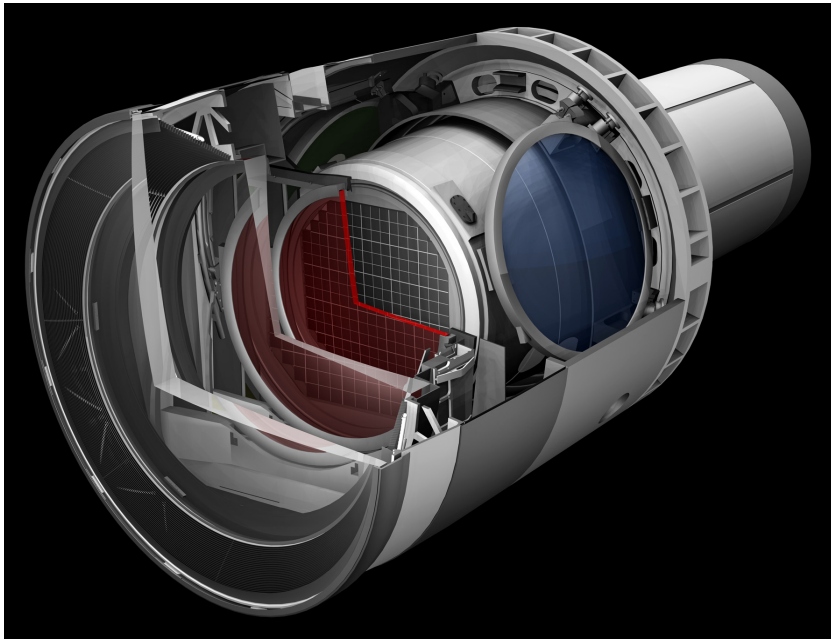




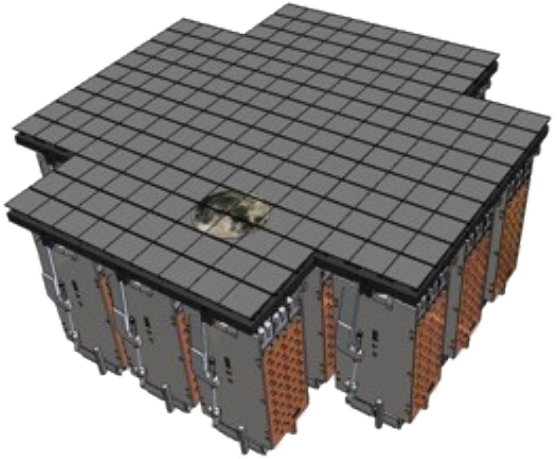
Étendue = surface X field of view
→ LSST: 319 m².deg²

The LSST Camera

Field of view: 9.6 deg^2

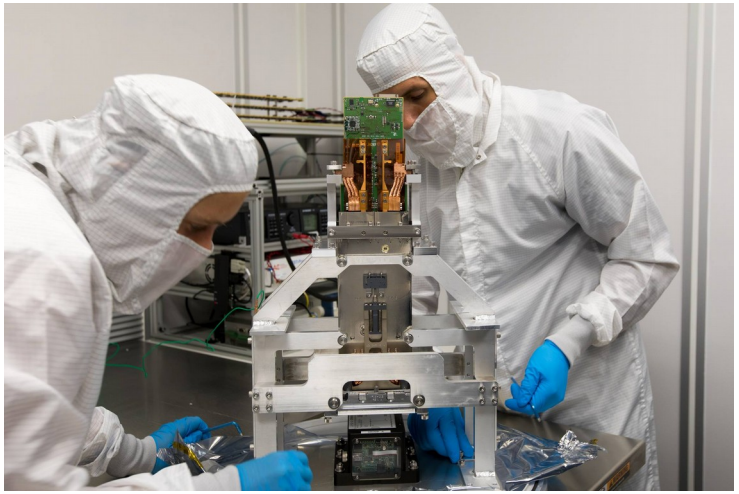


3.2 Gpixels – 0.2” / pixel
189 CCD (4k x 4k) deep depleted

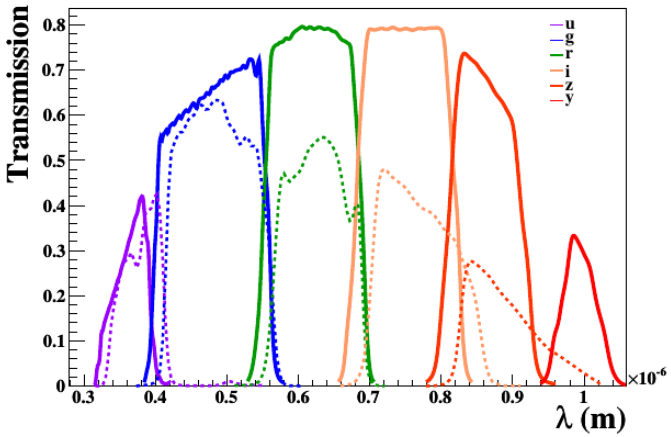


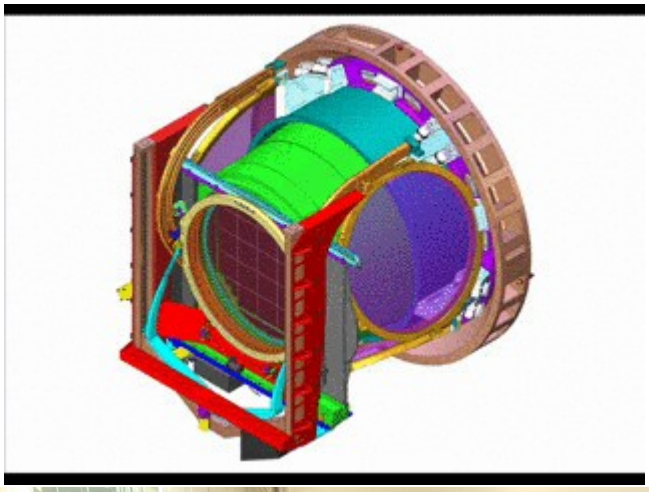
Highly segment electronics → the full focal plane is read in 2 s

2 x 15 s exposure → 40 s total time / visit
5 s to slew to a new position



LSST Filters and French Contributions





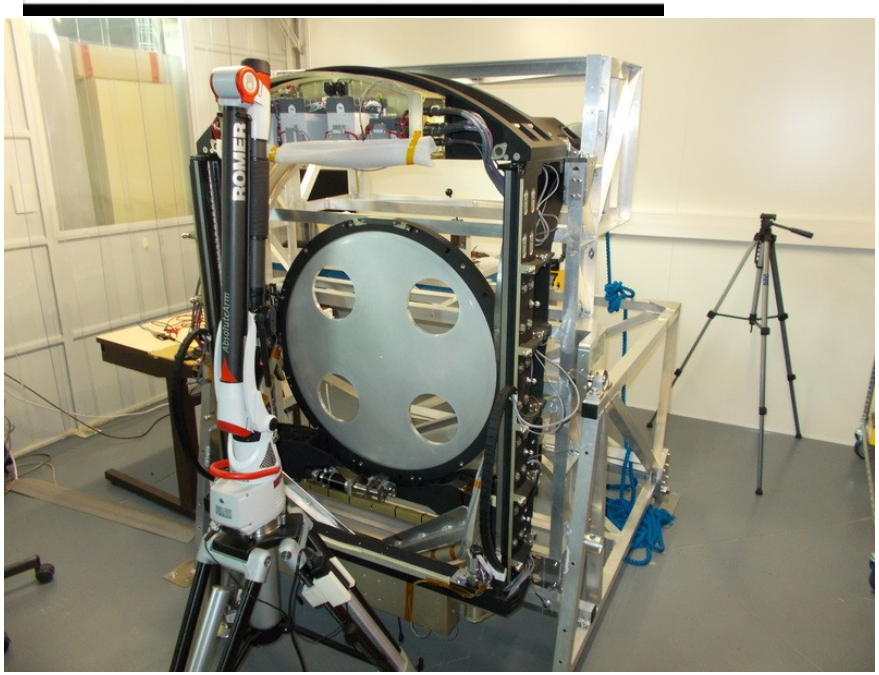
6 filters 320 – 1070 nm

- Main tool to determine photometric redshifts

The filter exchange system design and construction is a French contribution to LSST

France is also contributing to

- CCD procurement and Electronics
- Slow control
- Stand alone Optical Bench



Fast – Wide - Deep

- Survey time : 10 years
- Main survey area : 18 000 deg²
- 2.75 10^6 visits in 10 years
- <825> visits / pointing

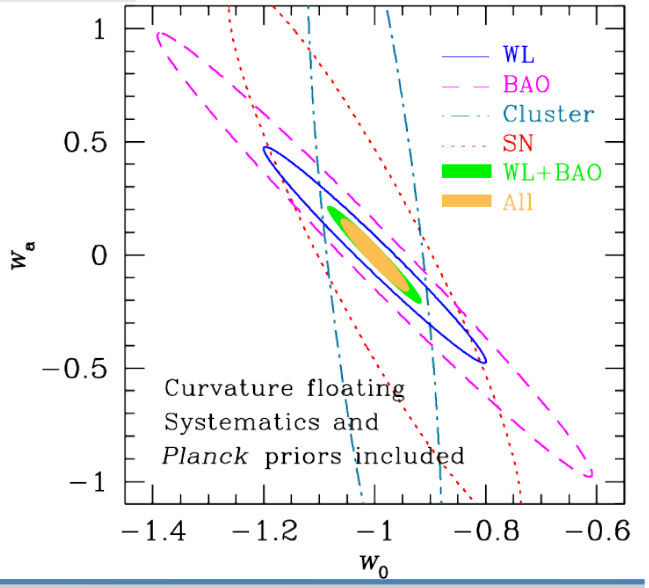
LSST will visit Deep Drilling Fields several times / night → ***Transient events detection***

	u	g	r	i	z	y
Single visit	23.9	25.0	24.7	24.0	23.3	22.1
10 years	26.1	27.4	27.5	26.8	26.1	24.9

LSST is particularly optimized for

- Fast detection of faint objects
- Transient event detection
- Precise measurement of Star positions and colors
- Precise measurement of Galaxy shapes and colors

IN2P3 is mainly involved in the Dark Energy Science Collaboration (DESC)



Summit Site at Cerro Pachón

LSST From the Astronomer's Perspective

Level 1

- A stream of ~10 million time-domain events per night, detected and transmitted to event distribution networks within 60 seconds of observation.
- A catalog of orbits for ~6 million bodies in the Solar System.

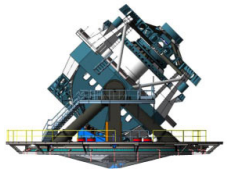
Level 2

- A catalog of ~37 billion objects (20B galaxies, 17B stars), ~7 trillion observations ("sources"), and ~30 trillion measurements ("forced sources"), produced annually, accessible through online databases.
- Deep co-added images.

Level 3

- Services and computing resources at the Data Access Centers to enable user-specified custom processing and analysis.
- Software and APIs enabling development of analysis codes.

Slide borrowed from Mario Jurić



Data Release Processing

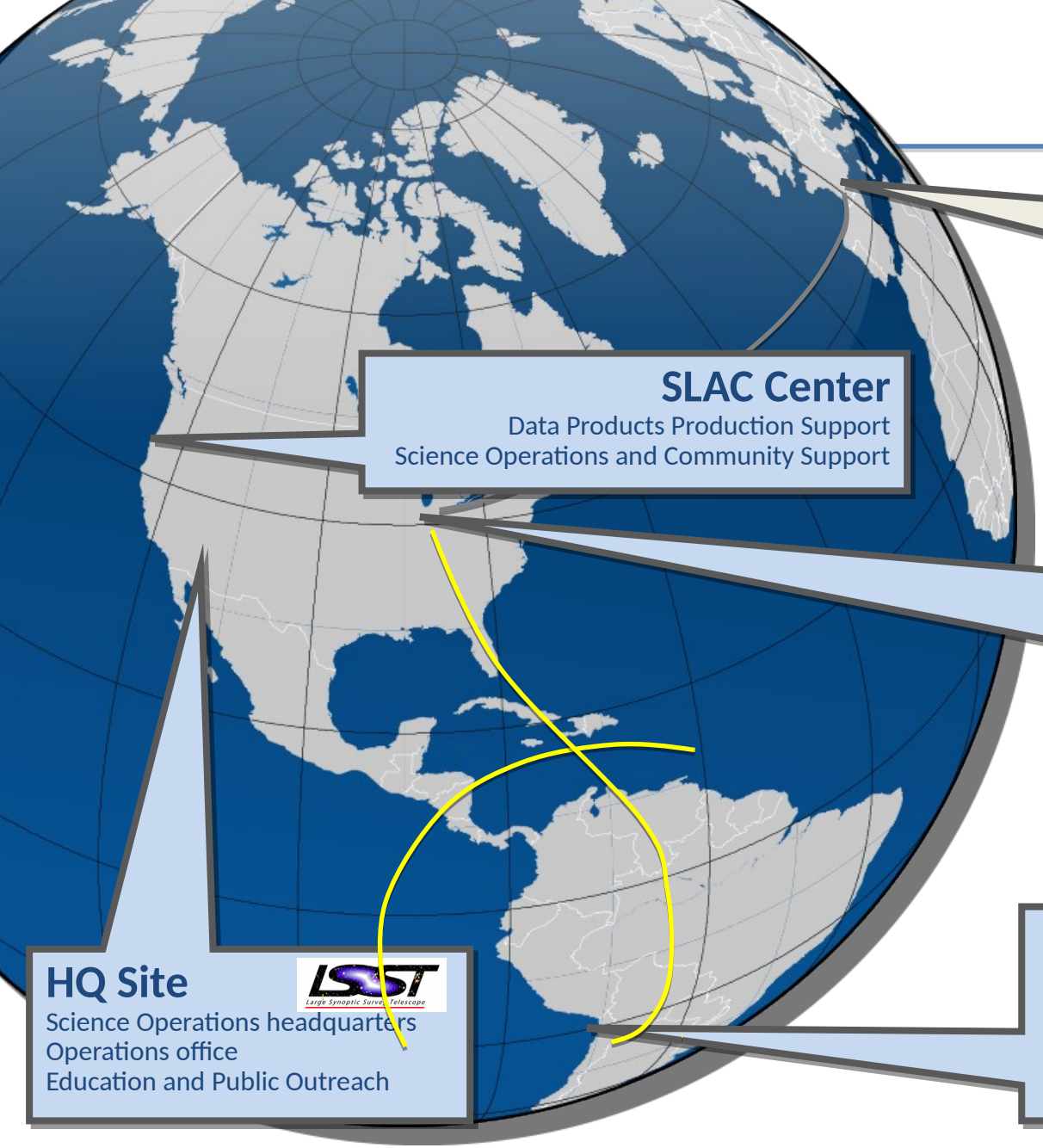
France has signed up an MOA with LSST where

- France will process 50% of the Level 2 Data Release Processing (DRP)
  - The other 50% is processed at NCSA
- France will hold a complete copy of the LSST data

NCSA is responsible to coordinate the whole DRP

In exchange of this contribution France gets 45 data rights

⇒ ***Note that Data Access and Science analysis is not covered by this agreement***



French satellite center
(CC-IN2P3, Lyon, France)

Data Release Production (50%)

French DAC

SLAC Center
Data Products Production Support
Science Operations and Community Support

Archive Site
Archive Center
Alert Production
Data Release Production (50%)
Long-term Storage (copy 2)
Data Access Center
Data Access and User Services

HQ Site
Science Operations headquarters
Operations office
Education and Public Outreach

Summit and Base Sites
Telescope and Camera Operations
Data Acquisition
Long-term storage (copy 1)
Chilean Data Access Center

The IN2P3 Computing Center
CC-IN2P3

2 computer rooms

CPU:

- 31 000 cores (330 000 HEPSpec06)

Disk storage:

- DAS : 22 PB
- Shared Filesystem GPFS: 2.2 PB

Mass Storage:

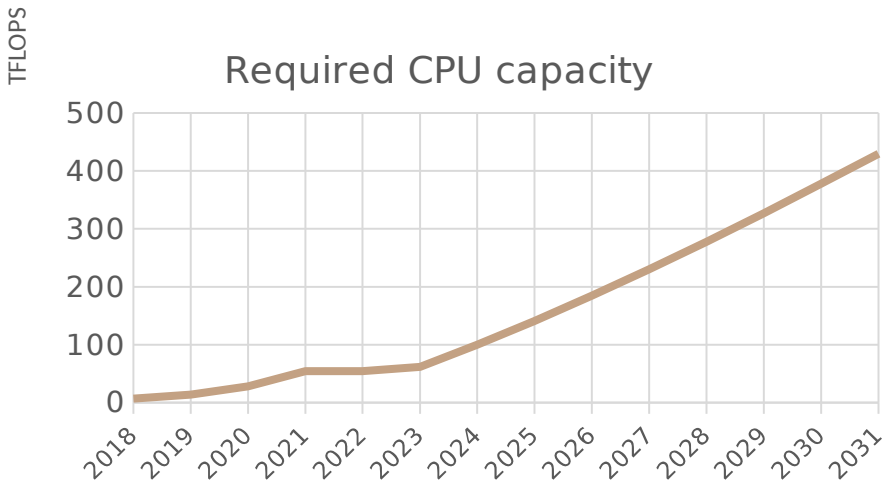
- 4 tape robots (340 PB nominal capacity)
- 50 PB in use

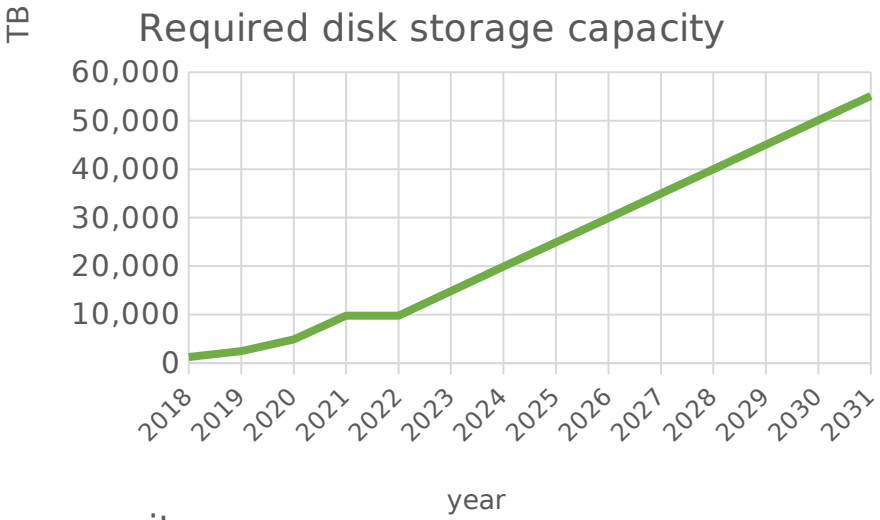
Main computing center in France for HEP, Nuclear Physics, Astroparticles and Cosmology

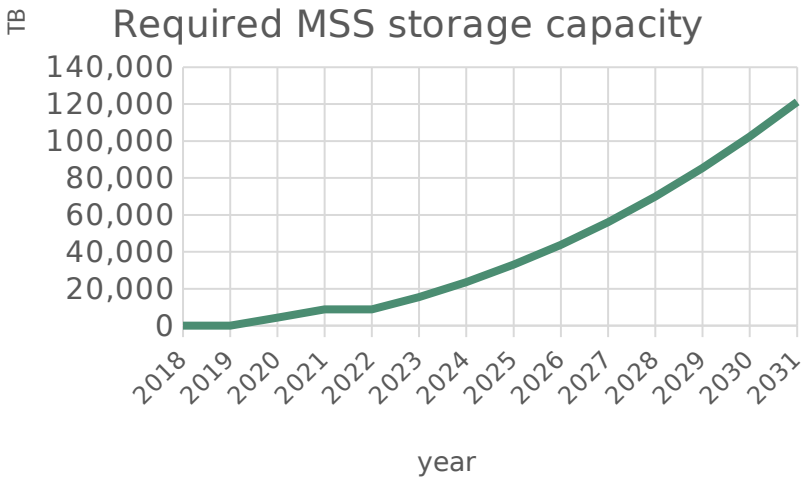
- ~65 highly skilled computing engineers
- Operating 24/24 – 365/365

- Tier-1 for the 4 LHC experiments within the Worldwide LHC Computing Grid
- Supporting ~70 experiments / projects

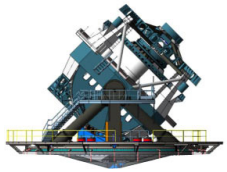
Capacity planning for LSST DRP@CCIN2P3







From Fabio Hernandez (LSST project leader at CC-IN2P3)



The LSST DM Stack

The choice of the Data Management team has been to re-use existing algorithms whenever possible but to rewrite everything from scratch

- Considerable experience from previous projects especially SDSS and also from current ones : HSC, DES, …

Develop a modular, efficient and versatile image analysis framework

- ~50 M$ funding for construction and commissioning of the LSST stack and associated middleware
- All the code is open source : https://github.com/lsst

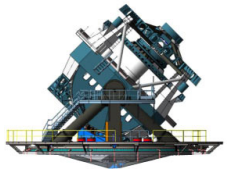
Code is in Python and C++

- Standard users are dealing with Python modules

Designed to support any CCD-based instrument : SDSS – HSC – CFHT – DES…

- DM stack is the official software package for HSC image processing

⇒ ***The LSST DM stack is a complex software system. Building up experience with it was (is) a very important goal for IN2P3***



Building up experience

Split DRP Data Challenge in 2013:

- Process SDSS Stripe 82 with DM stack
- 50% at CC-IN2P3 – 50% at NCSA and 10% in common for comparison
- Output in mySQL database
  - Had tremendous problems ingesting data but finally ok
- The whole thing was successful
  - Validated the Split DRP (NCSA / CC-IN2P3) approach

Reprocess precursor datasets

- CFHT – Galaxy clusters – SN detection and light curve
- HSC SXDS field
- The driving idea here was to
  - concentrate on relatively small fields to avoid scaling problem
  - keep a strong connection with science
- We also closely monitored the I/O in order to anticipate bottlenecks

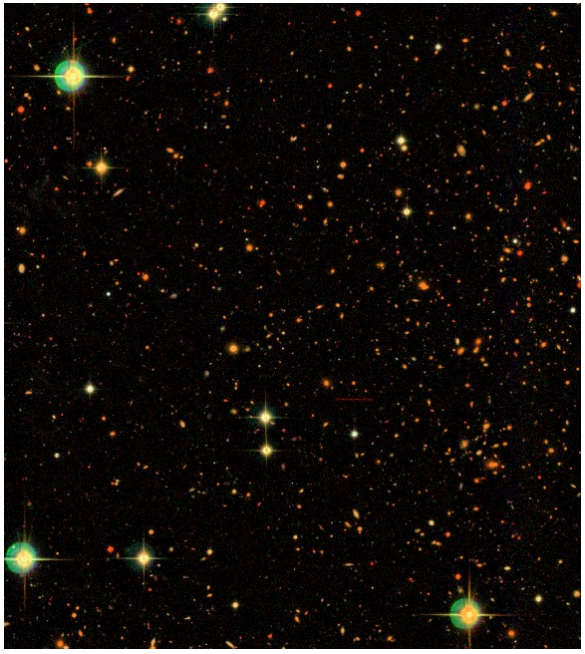
Galaxy clusters with CFHT data

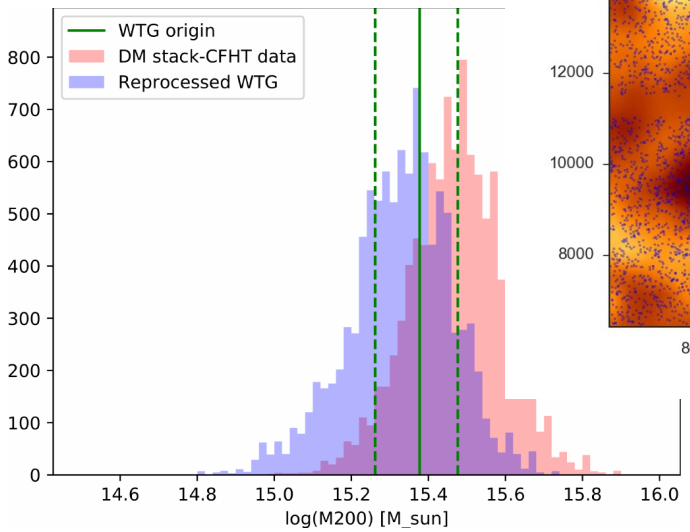
Re-measure clusters masses using shear signal from background galaxies

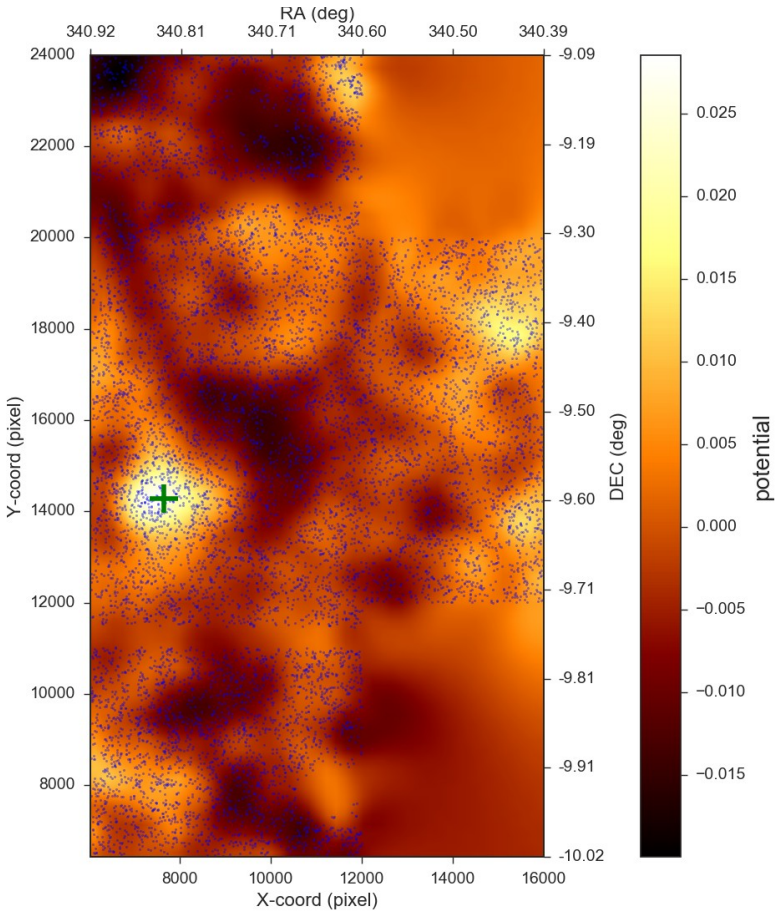
See for instance: WtG I A. vd Linden et al. MNRAS, 2014, 439, 2

Develop a full pipeline to process data from the raw images up to the cluster mass measurement

MACSJ2243.3-0935

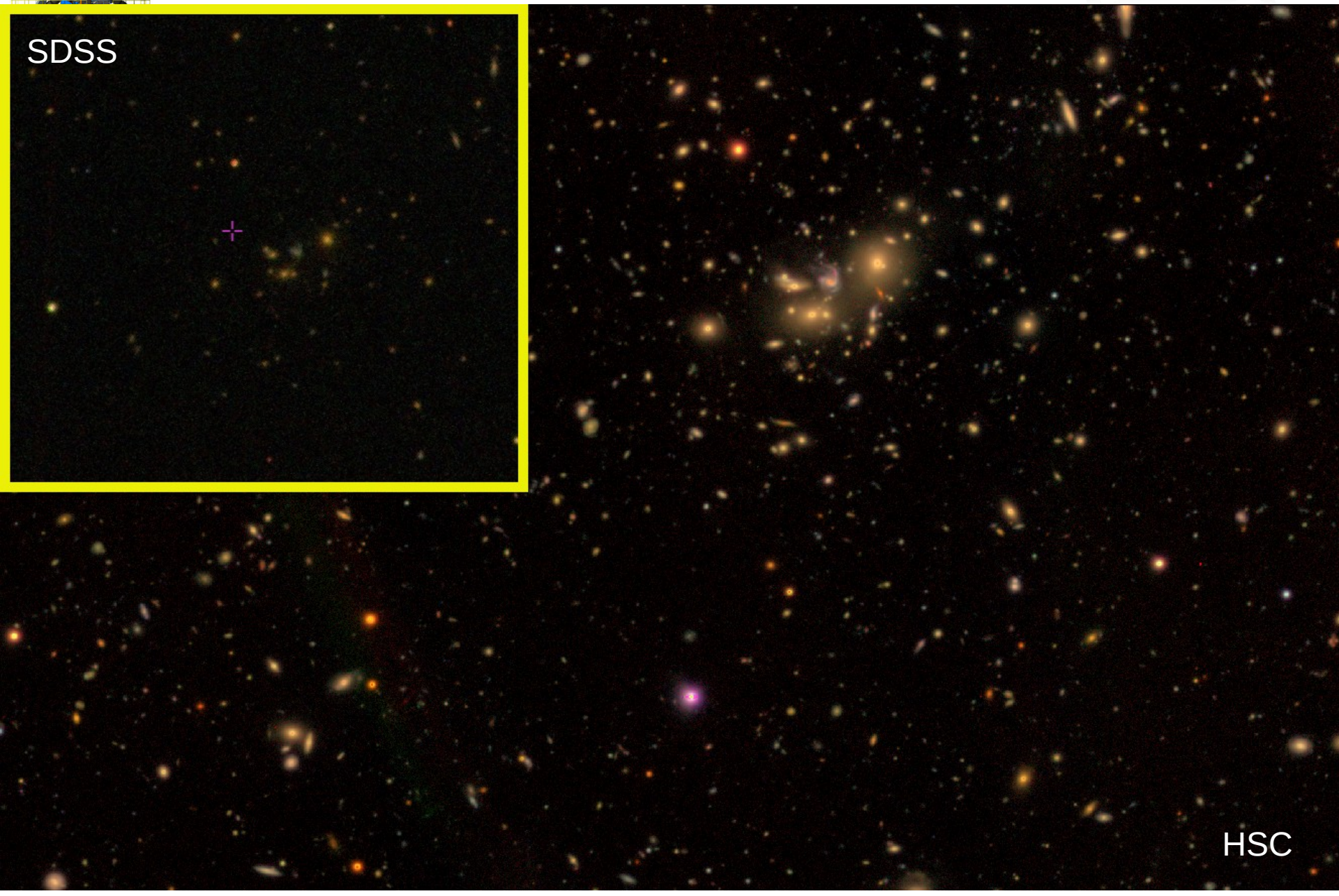


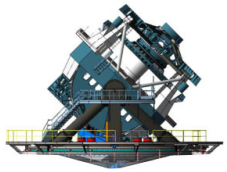




Mariana Penna-Lima Vitenti (postdoc at LAPP and moving to Brasília this summer) is developing a state of the art mass fitter

HSC image processed through the DM stack at CC-IN2P3





DESC DC2

The Dark Energy Science Collaboration has started its 2nd Data Challenge

Full simulation starting from a extragalactic catalog from a large scale cosmological simulation + Galaxies + Stars + Strong Lensing + Supernovae…

Main survey:

- Area: 300 deg²
- Survey depth: 10 years
- Using the latest optimized cadence model + dithering scheme
- Visits: (ugrizy) = (56, 80, 184, 184, 160,160) x 30 fields ~27 000 visits

Ultra Deep Drilling Field:

- 1.25 deg²
- 10 years
- 20 000 visits

Use the phosim ray-tracer to simulate realistic images including optics, atmosphere, sky background, sensor effects (tree rings, Brighter-Fatter, etc.)

- Image simulation run at NERSC

Hope to have everything done by this summer

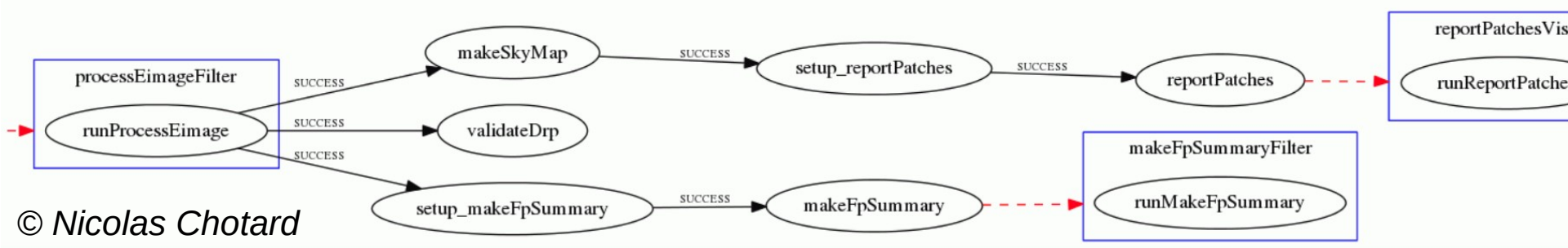
DESC DC2 @IN2P3

IN2P3 will process the DC2 datasets through DM stack to produce Data Release catalogs + difference imaging

We consider this DESC Data Challenge as an LSST Data Challenge in preparation of our future role in the DRP

- > 50 Million CPU hours (HS06)
- ~1.5 PB of output images and catalogs

Use the SRS workflow engine developed at SLAC to automatize production



© *Nicolas Chotard*

Explore:

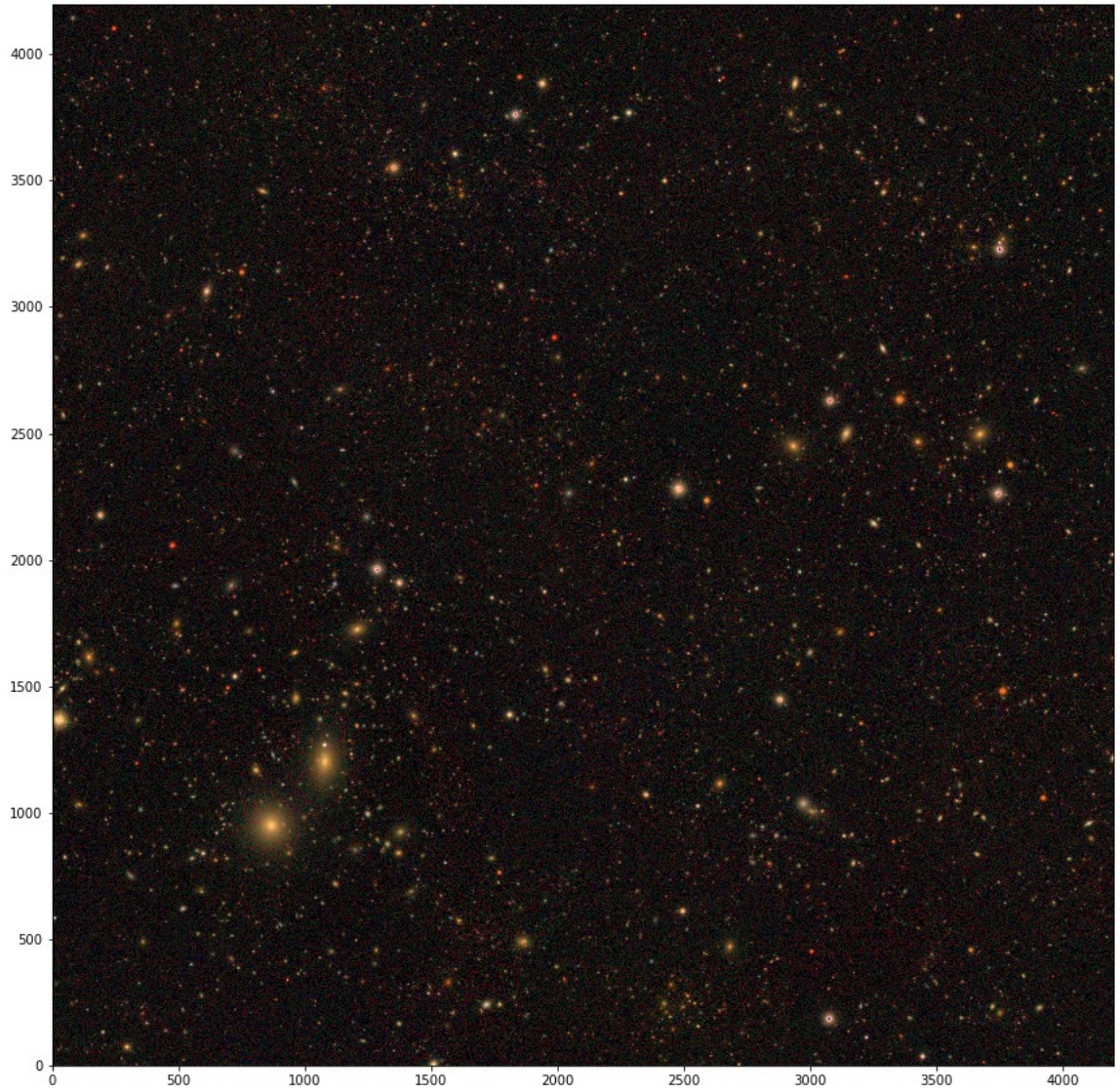
- Data transfer through transatlantic link
- I/O and memory footprint
- Optimization of the process and infrastructure

We hope to learn a lot from this big enterprise

RGB image from one sky patch (4k x 4k)

Coaddition:

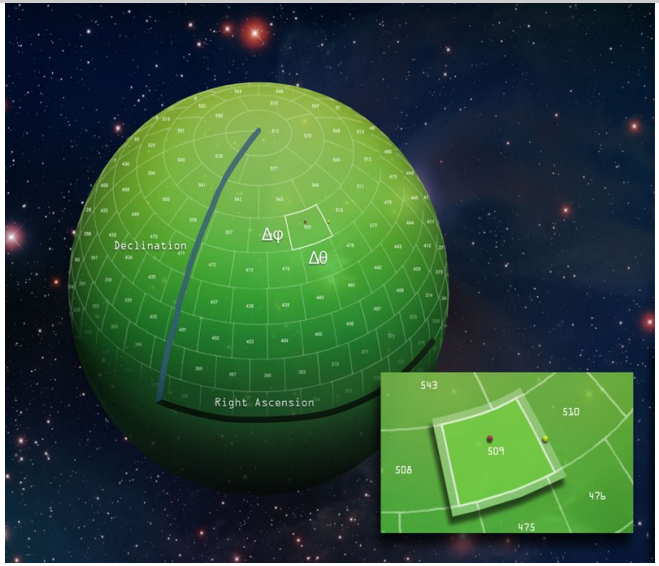
- r : 11 visits
- i : 9 visits
- g : 8 visits

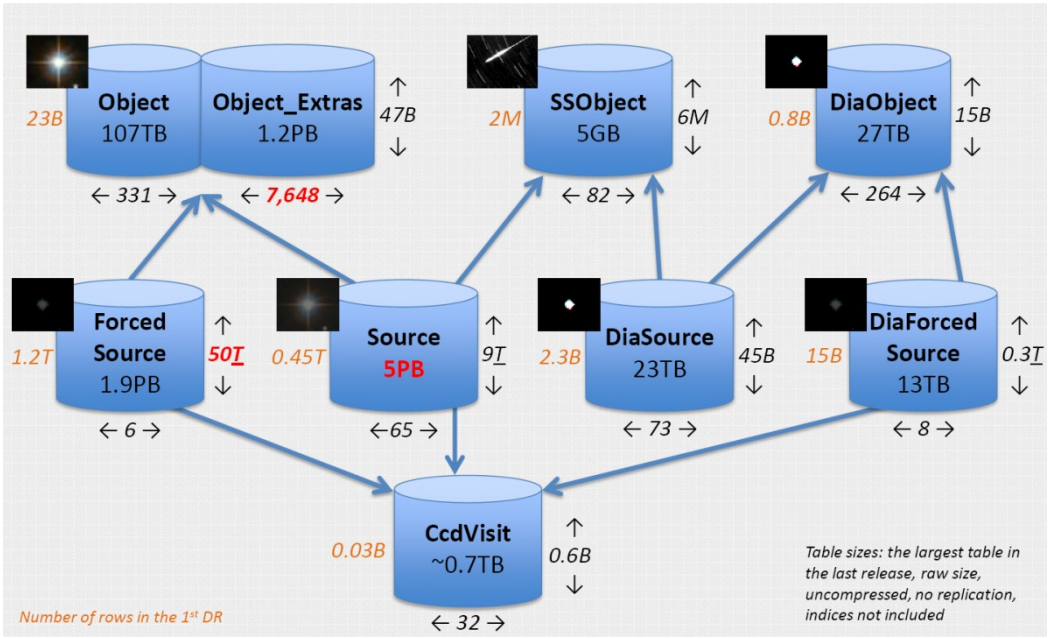


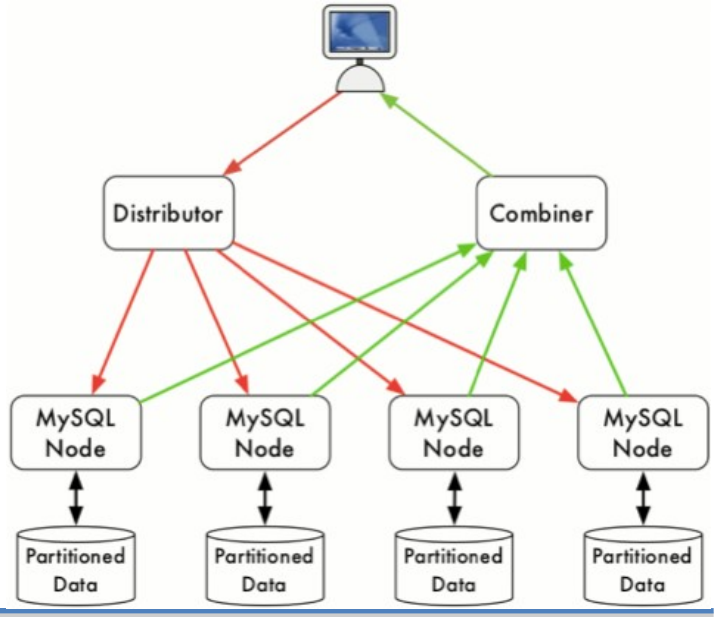
The database : a key component

The challenge is to design an SQL database system able to store trillions of objects while keeping a the access time at a reasonable value

Qserv : developed at SLAC – Design optimized for astronomical queries







Massively parallel – distributed – fault tolerant **relational database**

Total size : ~83 PB (11 Data Release)

Qserv@CC-IN2P3

CC-IN2P3 has a partnership with Dell

Setup Qserv test bench

- 50 servers (2 test benches x 25 servers)
- 400 cores
- 0.5 PB disk storage

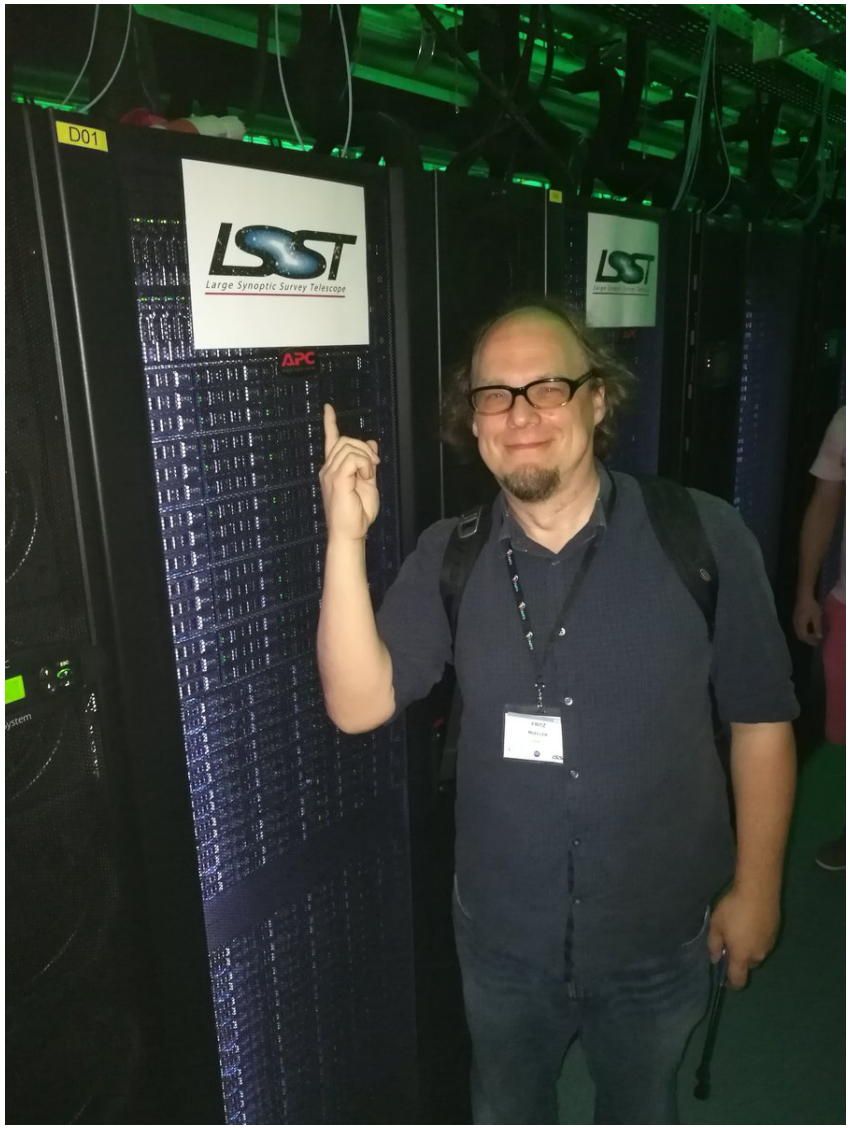
Heavily used bu Qserv developers for integration and performance tests

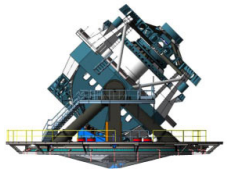
In parallel IN2P3 is developing another Qserv framework to test the Database from the ***science perspective***

- Ingest galaxy cluster data and repeat analysis
- Also plan to ingest the DESC DC2 catalogs

Alternatives to Qserv are also considered by the Data Management team

⇒ Final decision soon





Data Access Center – Science User Interface

LSST is planning to build a Data Access Center at NCSA to serve the worldwide science community
Note :
Note: Data rights does not imply Data Access ⇒ LSST will charge the access to the NCSA DAC

In France we want to give a full data access to the IN2P3 scientists

We plan to deploy a Data Access Center and a Science User Interface

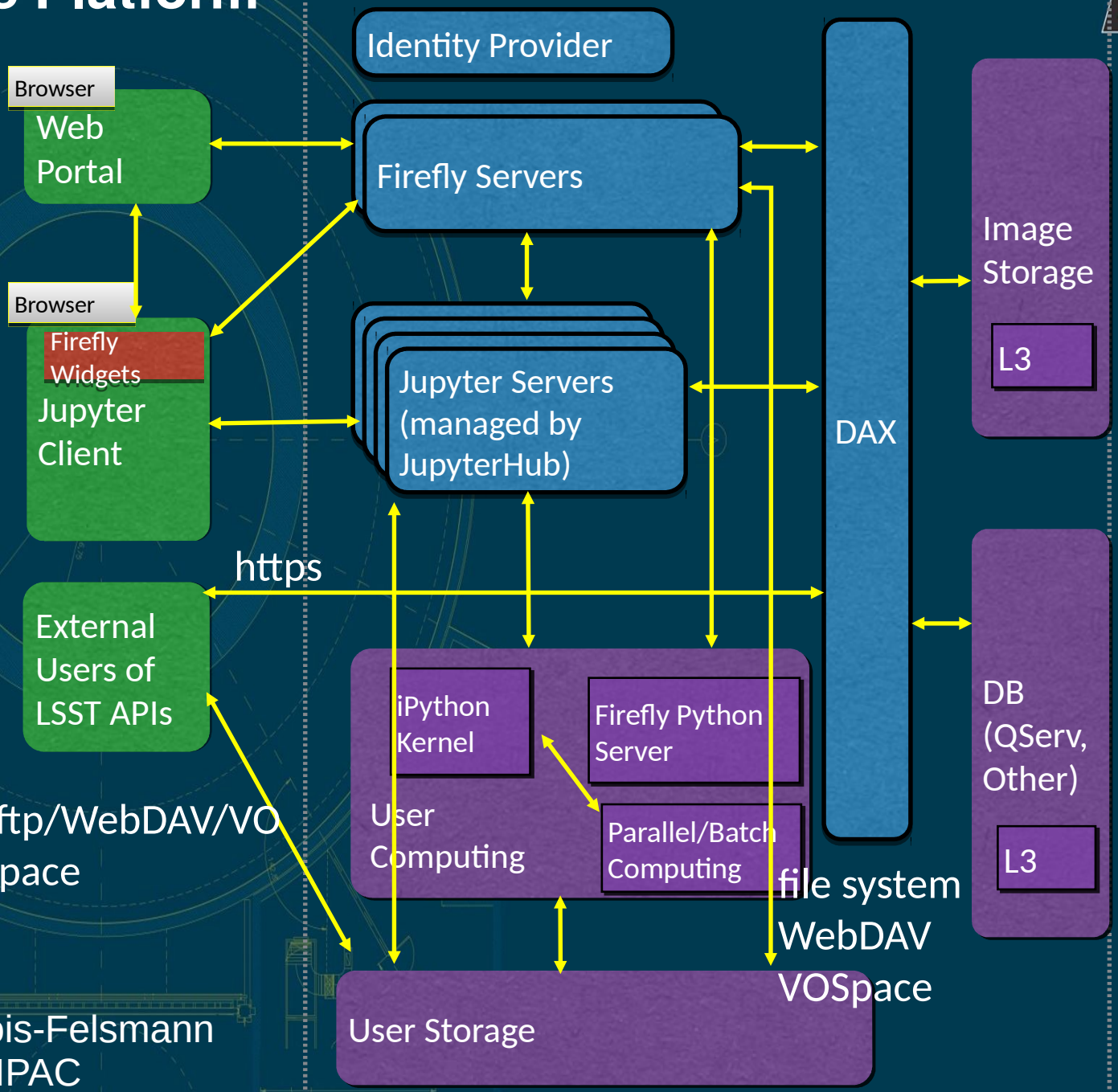
- Will re-use components being developed at IPAC as much as possible

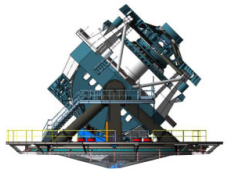
4 possible scopes for our “Science Platform” :

1. Limited to French community ⇒ Mainly DESC but also transients, stellar,...
2. Europe ⇒ within a EU project
3. Worldwide together with NCSA and maybe others ?

No decision yet – Many political and financial aspects

Science Platform





Plans

We are planning to investigate all the components of the Science User Platform by deploying prototypes at IN2P3

- Continue to use a “Science Driven Approach”
- Test using actual analyses on real precursor data or on DESC Simulated data

We also plan to check if the current model can be adapted toward a distributed approach

- Large scale data access and heavy computation within a Data Center (a.k.a CC-IN2P3 or NCSA or any other international DAC)
- Work on Jupyter notebooks, Firefly, final analysis… in remote laboratories

No reason to limit the model to LSST data only – Can be extended to multi-wavelength / multi-probes datasets

We are of fully open to future International collaborations

- Europe of course (large UK contribution in LSST)
- Brazil - Our collaboration with Mariana Penna Lima and Sandro Vitenti is a first step