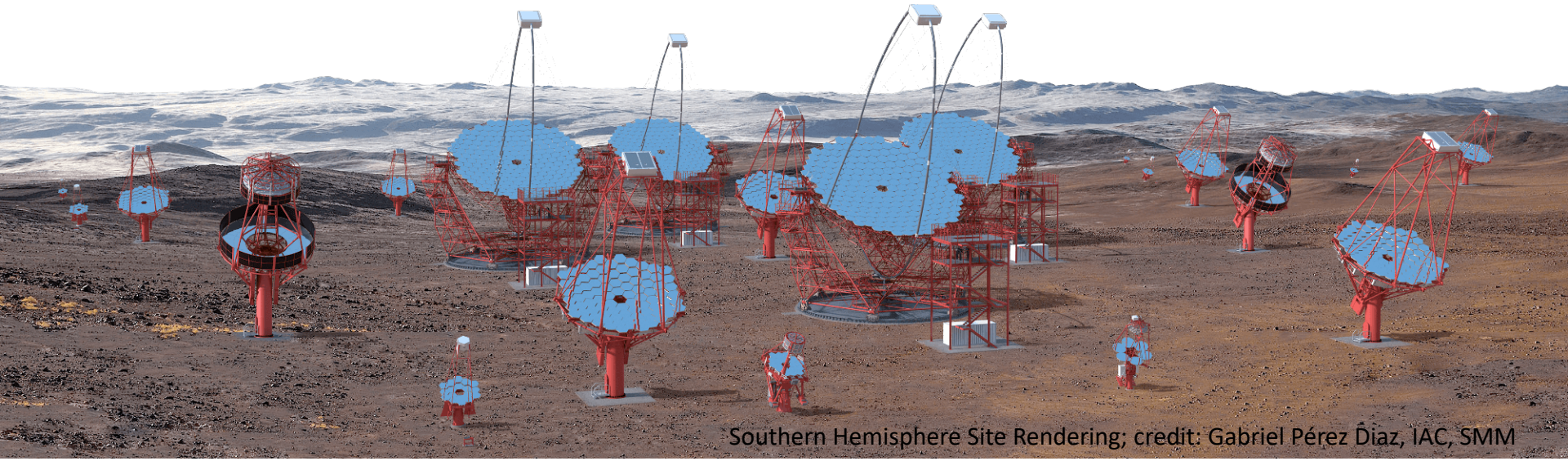
Pipeline execution and tracing with CTADIRAC



Southern Hemisphere Site Rendering; credit: Gabriel Pérez Diaz, IAC, SMM

Michèle Sanguillon[(1)], Luisa Arrabito[(1)], Johan Bregeon [(2)], Karl Kosack [(3)], Patrick Maeght[(1)]

[(1)] LUPM, Montpellier, France [(2)] LPSC, Grenoble, France [(3)] CEA, Paris, France

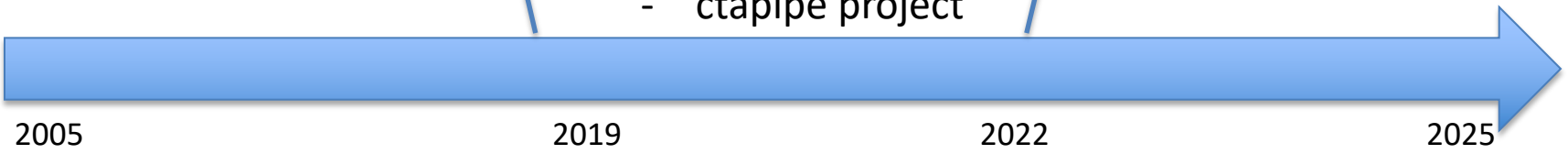
CONTEXT

- Next Generation Gamma-Ray Astronomy (succeeding H.E.S.S., MAGIC and VERITAS)
- Two arrays of 99 (South) and 19 (North) Cherenkov telescopes (4, 12 et 24 m in diametre)
- Observatory open to the Astronomy community
- Timeline:

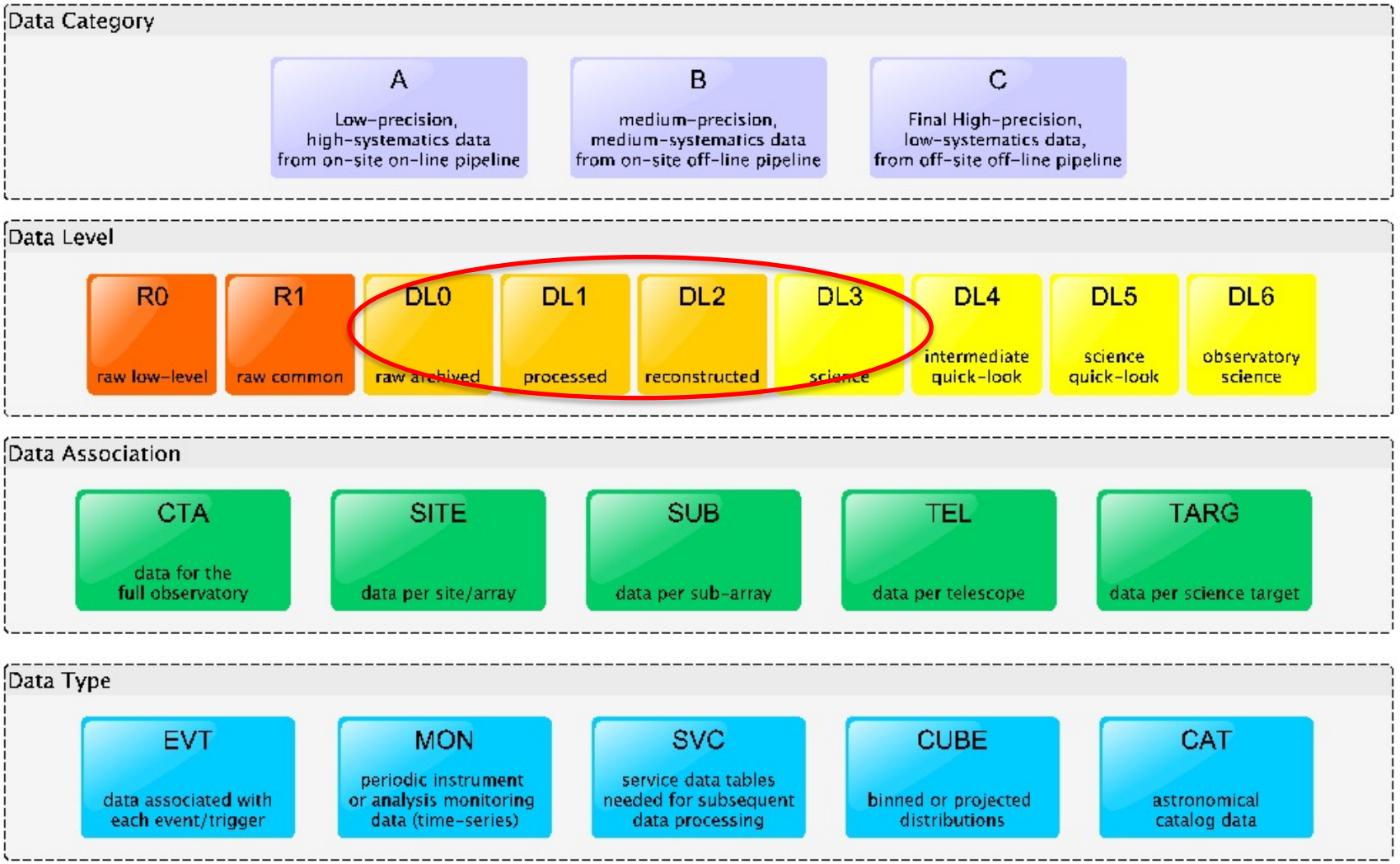
Pre-Construction phase:
- Simulations

Pre & Production phase:
- Data model definition
- Software development
  - Prototype OPUS
  - ctapipe project

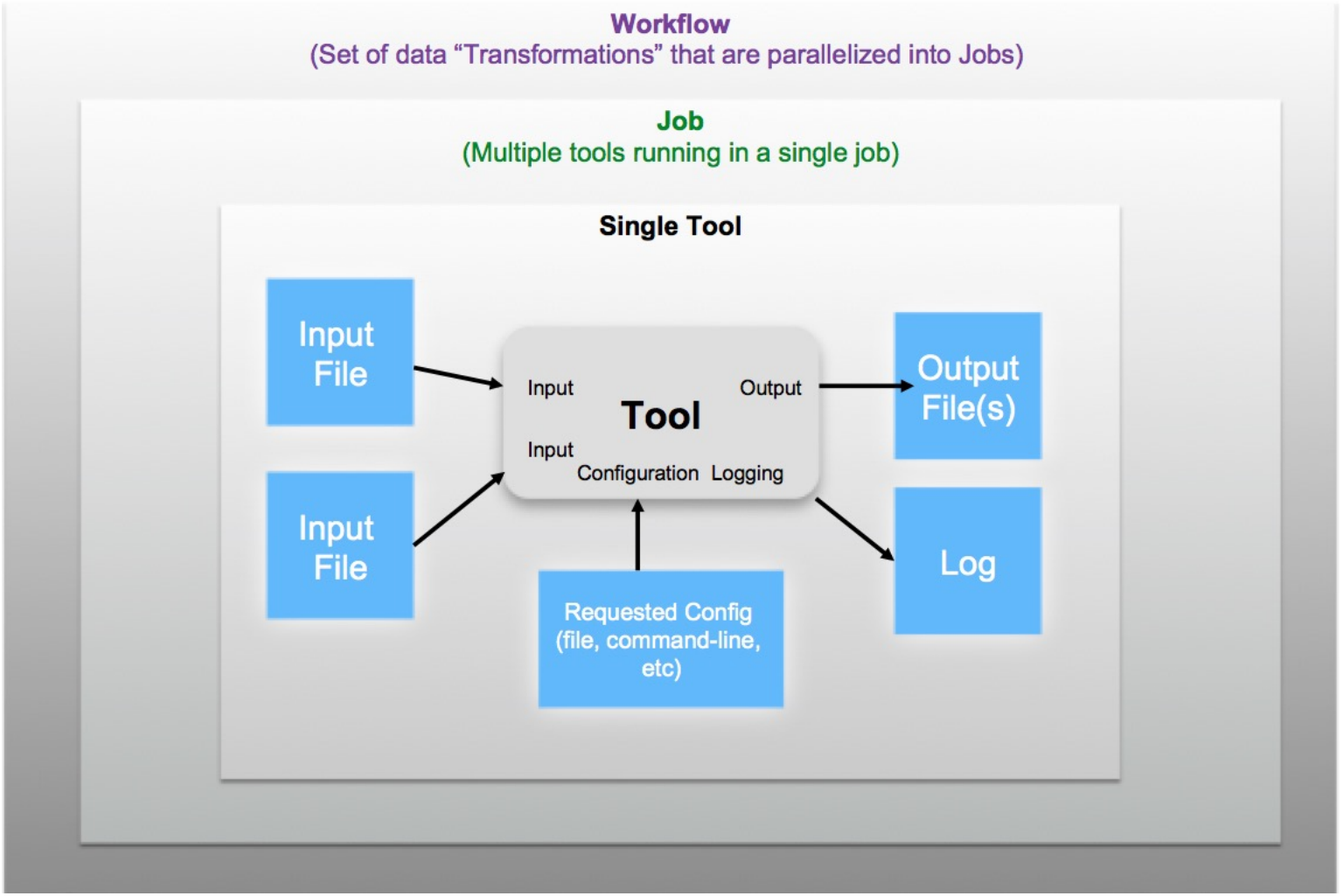
Operation phase:
- Acquisitions
- High level data available



Data Model


Data Category
A
Low-precision, high-systematics data from on-site on-line pipeline
B
medium-precision, medium-systematics data from on-site off-line pipeline
C
Final High-precision, low-systematics data, from off-site off-line pipeline
Data Level
R0
raw low-level
R1
raw common
DL0
raw archived
DL1
processed
DL2
reconstructed
DL3
science
DL4
intermediate quick-look
DL5
science quick-look
DL6
observatory science
Data Association
CTA
data for the full observatory
SITE
data per site/array
SUB
data per sub-array
TEL
data per telescope
TARG
data per science target
Data Type
EVT
data associated with each event/trigger
MON
periodic instrument or analysis monitoring data (time-series)
SVC
service data tables needed for subsequent data processing
CUBE
binned or projected distributions
CAT
astronomical catalog data

Reconstruction pipeline



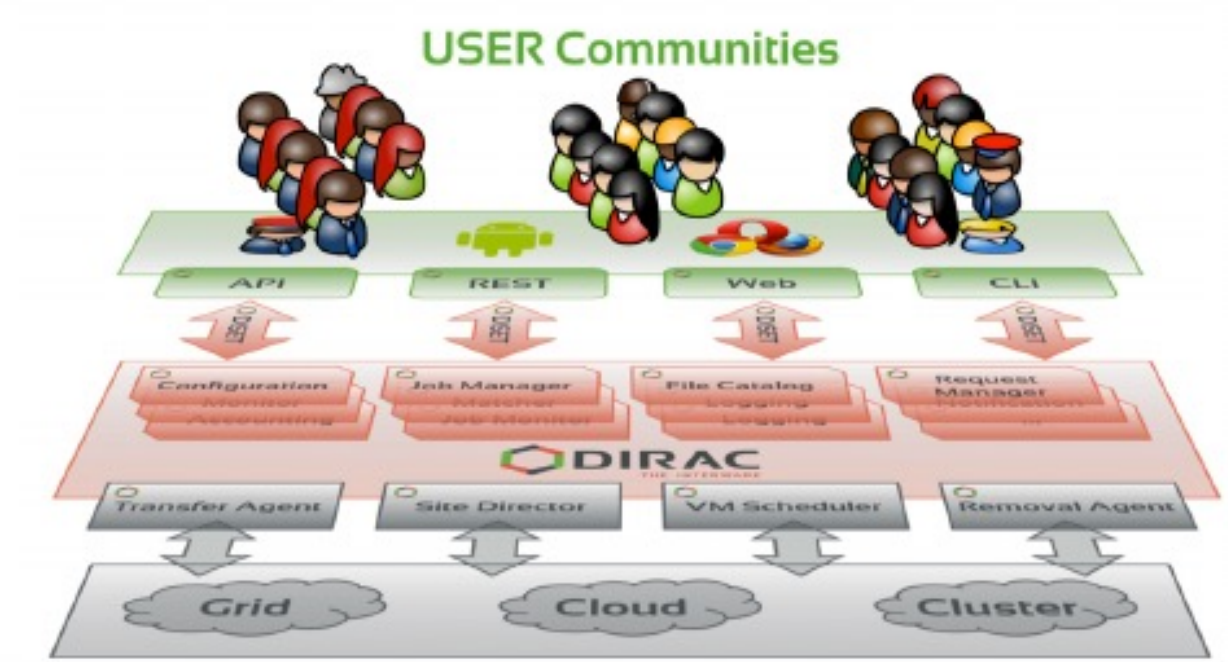
ctapipe

- Ctapipe (Karl Kosack et al.) :
  - « Framework for prototyping the low-level data processing algorithms for the Cherenkov Telescope Array »
  - Documentation: https://cta-observatory.github.io/ctapipe/
  - Framework containing different tools (Python)
  - Provenance Tracking is integrated in the ctapipe framework => Provenance module (ctapipe.core.provenance)
  - Capture of Provenance in each tool of ctapipe
  - Storage of Provenance in a file
  - Source: **https://github.com/cta-observatory/ctapipe**

ctapipe


```
[{'activity_name': 'ctapipe-display-muons',
  'activity_uuid': '93fc2206-59de-4852-868d-ec045ec2
5d1d',
  'config': {'MuonDisplayerTool': {'events': 'proton
_20deg_180deg_run22___cta-prod3-demo-2147m-LaPalma-b
aseline.simtel.gz'}},
  'duration_min': 0.01649999999998819,
  'input': [{'role': 'dl0.sub.evt',
    'url': '/Users/bourgeat/Documents/CTA/Provenance
/ctasoft/ctapipe/tests/proton_20deg_180deg_run22___c
ta-prod3-demo-2147m-LaPalma-baseline.simtel.gz'}],
  'output': [{'role': 'dl1.tel.evt.muon',
    'url': '/Users/bourgeat/Documents/CTA/Provenance
/ctasoft/ctapipe/tests/muons.hdf5'}],
  'start': {'time_utc': '2019-05-07T06:28:44.605'},
  'status': 'completed',
  'stop': {'time_utc': '2019-05-07T06:28:45.595'},
  'system': {'arguments': ['/Users/bourgeat/anaconda
3/lib/python3.6/site-packages/ipykernel_launcher.py'
,
    '-f',
    '/Users/bourgeat/Library/Jupyter/runtime/kernel-
d793d0e4-abd3-4989-a71c-19b68194ea9e.json'],
   'ctapipe_resources_version': '0.2.15',
   'ctapipe_svc_path': None,
   'ctapipe_version': '0.6.1',
```

DIRAC et CTA-DIRAC



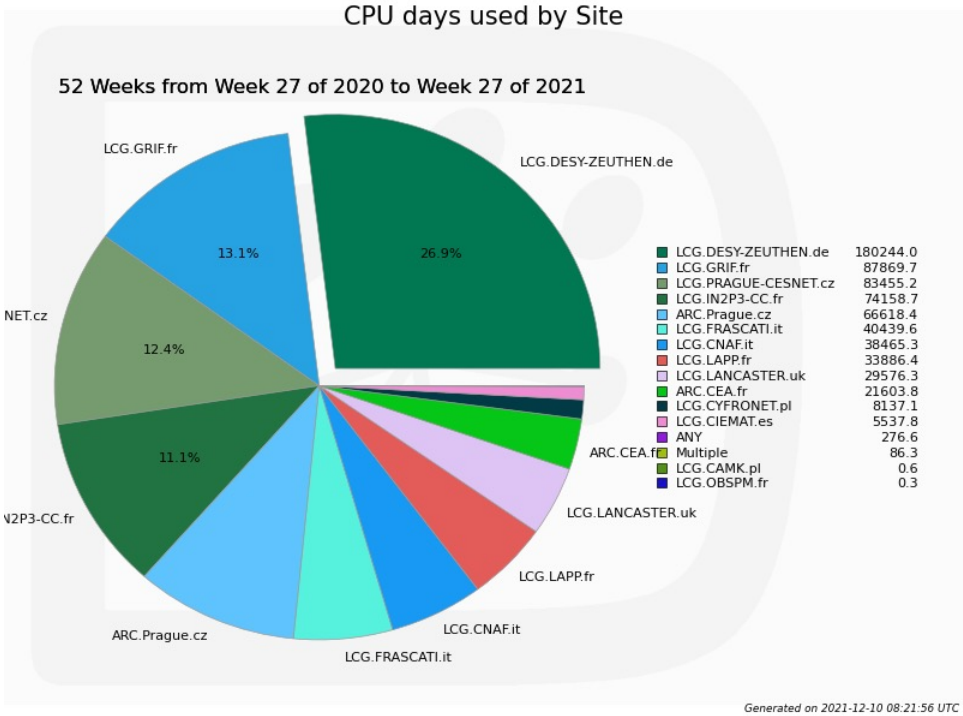
CTADIRAC: Prototype based on DIRAC - L. Arrabito - LUPM used to manage distributed computing on heterogeneous resources (grid, cloud, clusters) for the CTA experiment

CTA-DIRAC

Grid resources used for Prod5(b) (mid 2020 to mid 2021)

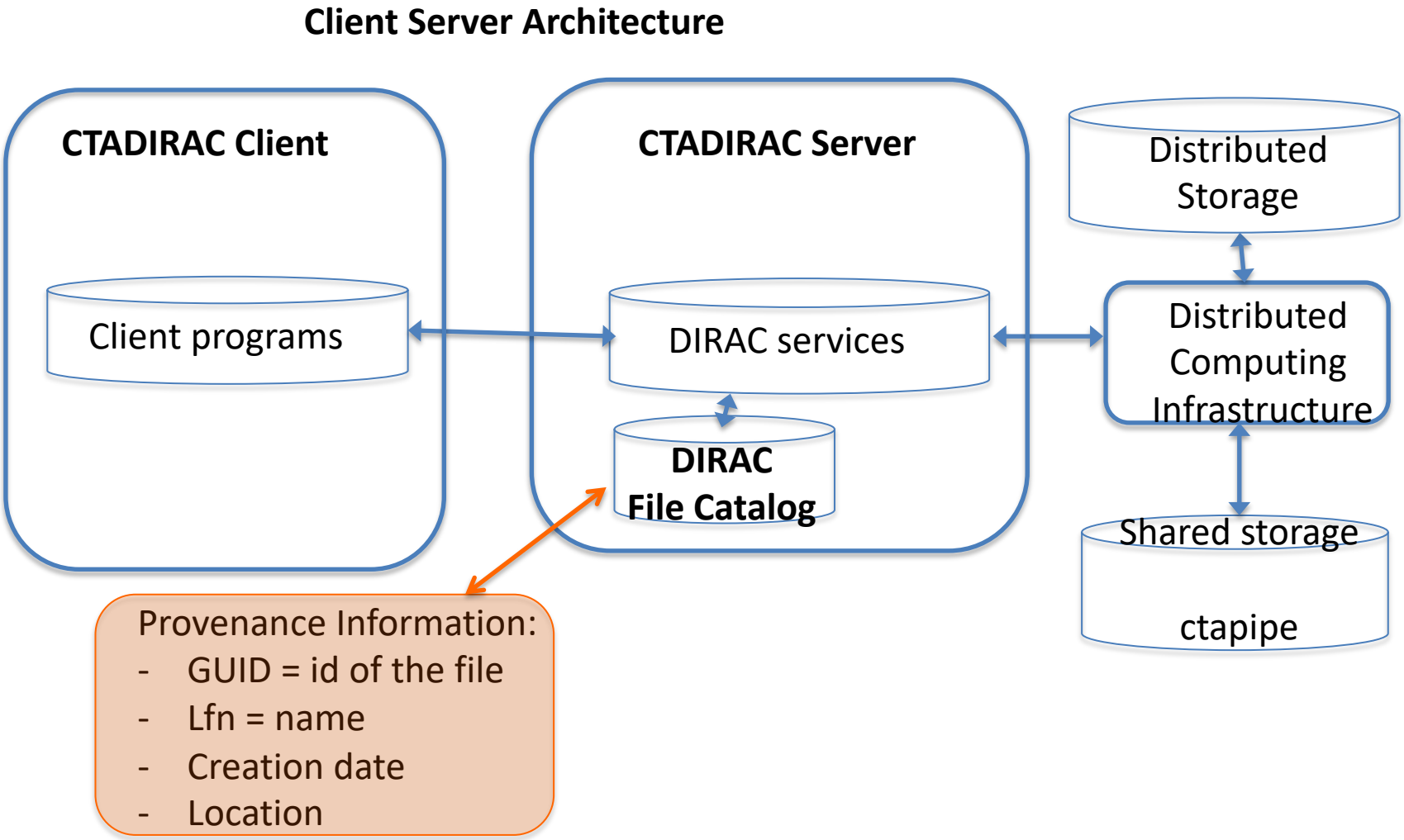
Total CPU: 164 million CPU hours HS06

Total disk: ~1.7 PB



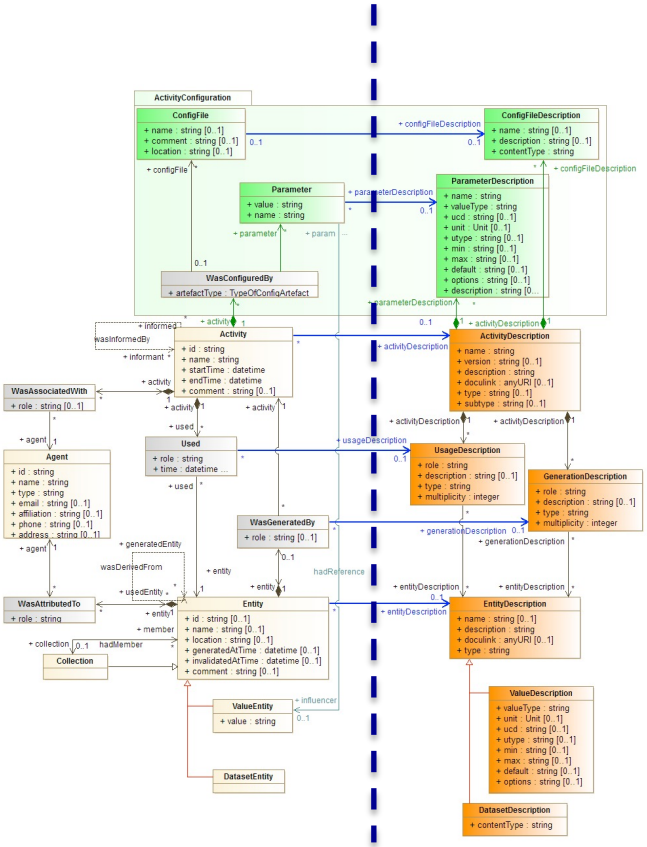
Site	Used (TB)
DESY-ZEUTHEN	158
IN2P3-CC	112
GRIF (LPNHE+CEA+LLR)	486 (154+4+328)
IN2P3-LAPP	70
INFN-T1	676
UKI-NORTHGRID-LANCS-HEP	163
Total	1665

CTA-DIRAC


Client Server Architecture
CTADIRAC Client
Client programs
CTADIRAC Server
DIRAC services
DIRAC
File Catalog
Distributed
Storage
Distributed
Computing
Infrastructure
Shared storage
ctapipe
Provenance Information:
- GUID = id of the file
- Lfn = name
- Creation date
- Location

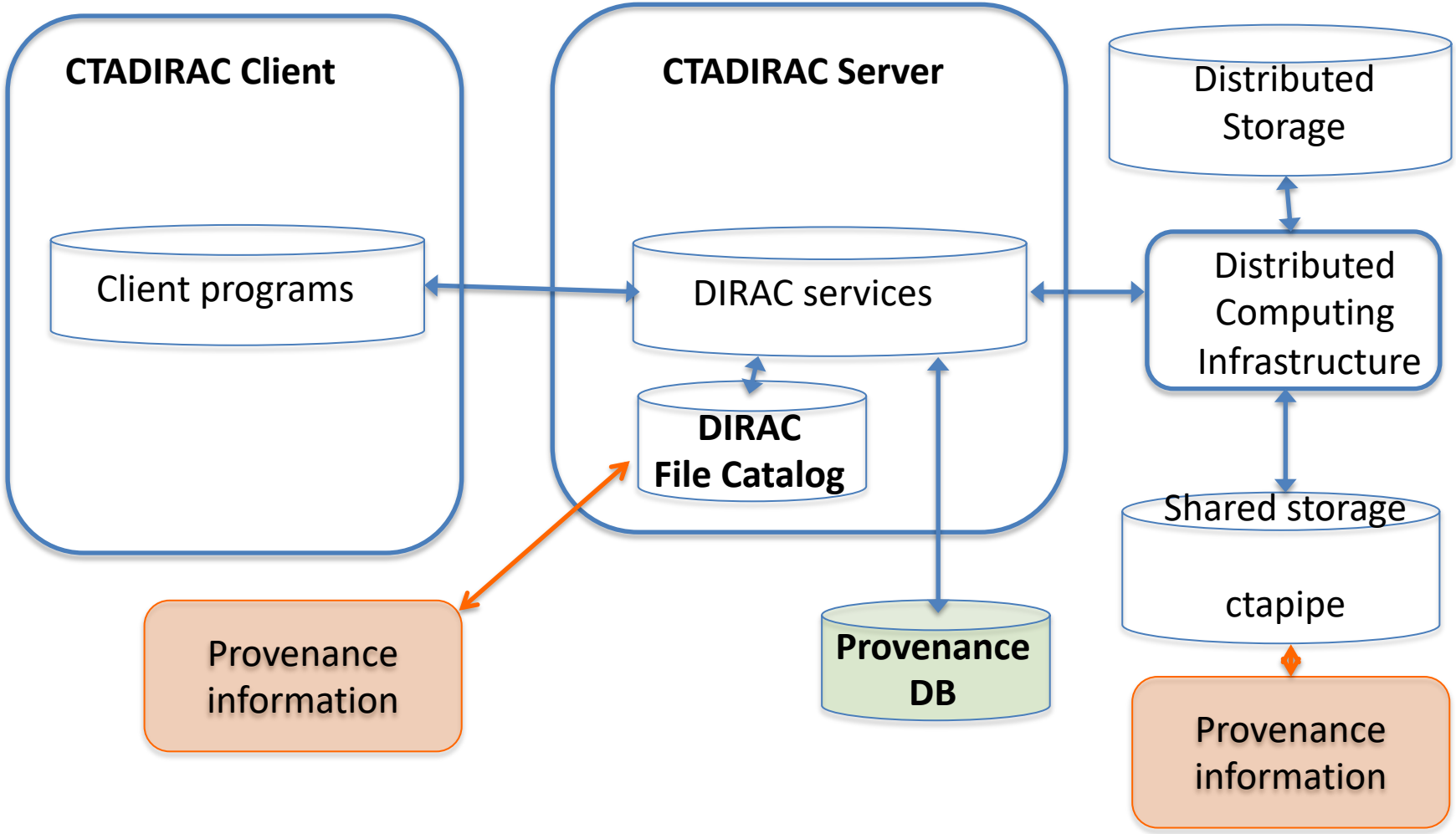
IVOA Provenance DM

Information relative to each execution of tool



Descriptions relative to each type of tool

Goal


CTADIRAC Client
Client programs
CTADIRAC Server
DIRAC services
DIRAC
File Catalog
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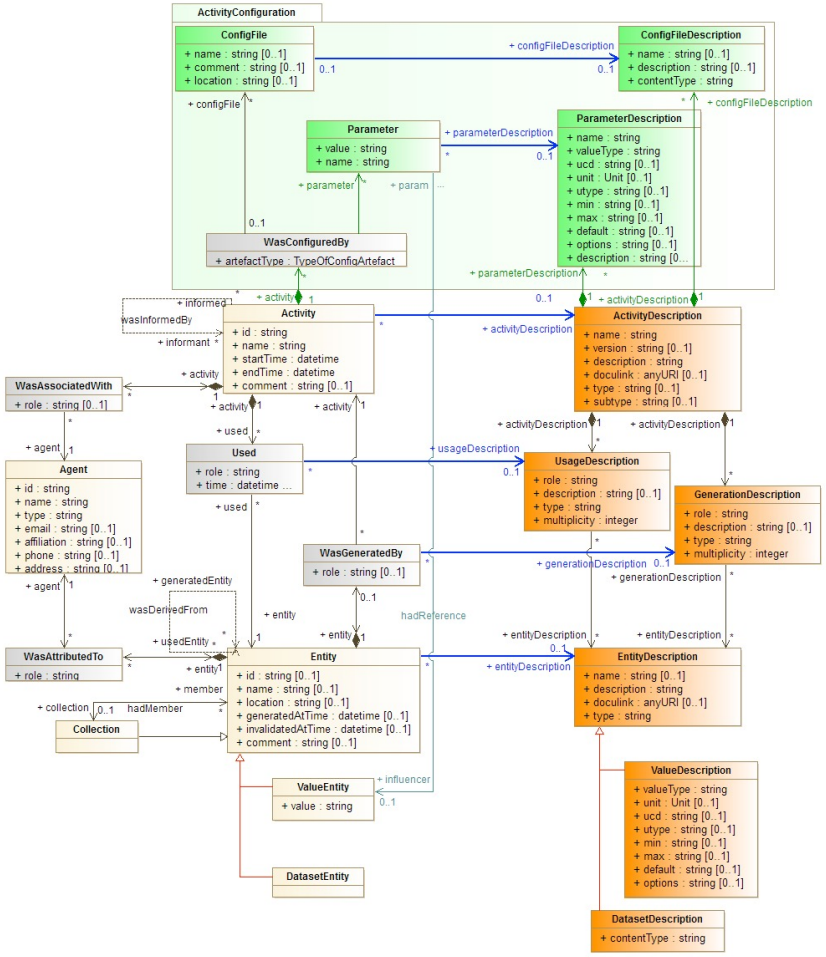
Computing
Infrastructure
Shared storage
ctapipe
Provenance
information
Provenance
DB
Provenance
information

IMPLEMENTATION

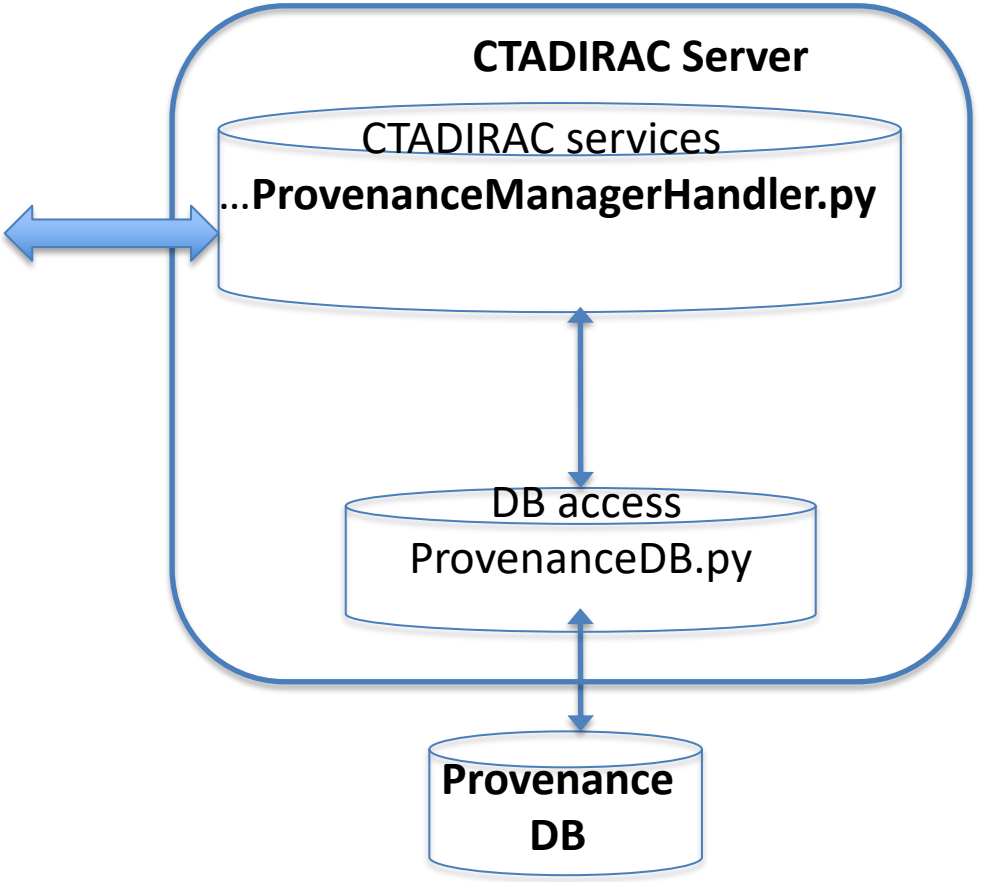
Provenance DB



- Postgresql DB
- Sqlalchemy module
- Each table has an auto incremented internal key (not in the model)
- Model restrictions:
  - ActivityDescription : unicity of (name, version)
  - UsageDescription & GenerationDescription: unicity of (ActivityDescription, EntiityDescription, role) => multiplicity = 1
  - Link Parameter to ValueEntity not yet implemented

CTADIRAC Server

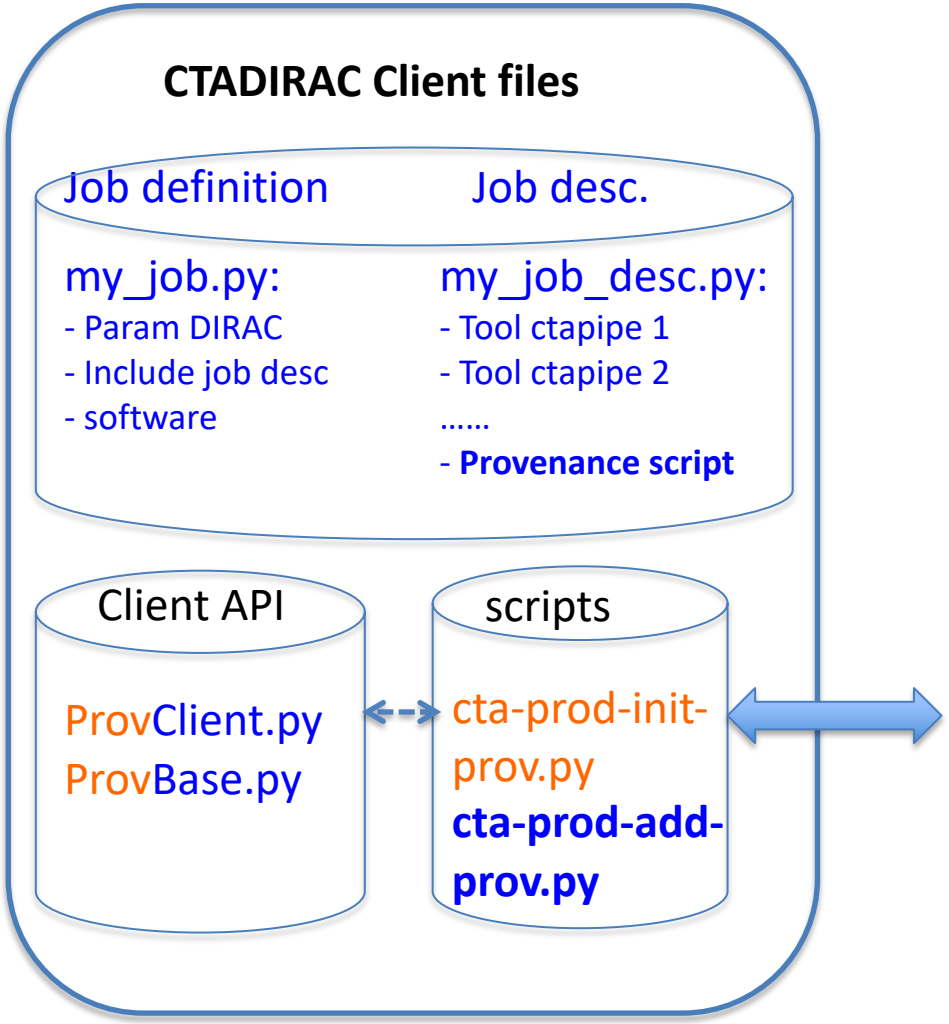
- Server:
  - Provenance Manager
  - Provenance DB access



CTADIRAC Client

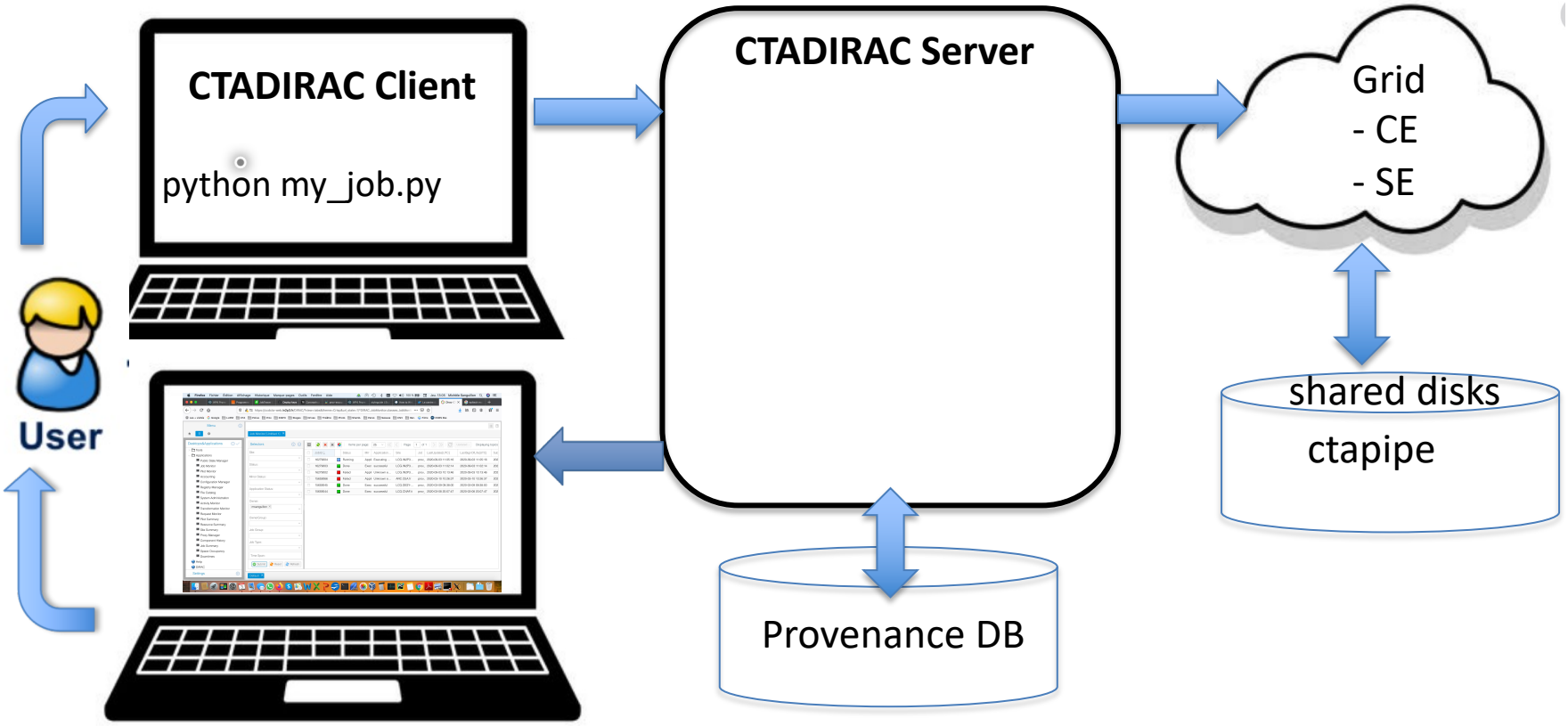
- API
  - ProvBase (Objects)
  - ProvClient (Functionalities)
- Scripts
  - Script to add the descriptions and the agent (CTAO)
  - Script to add the provenance execution information
- Job definition
  - DIRAC job definition
  - Job description (steps)

Used to add description information
Used to add execution information



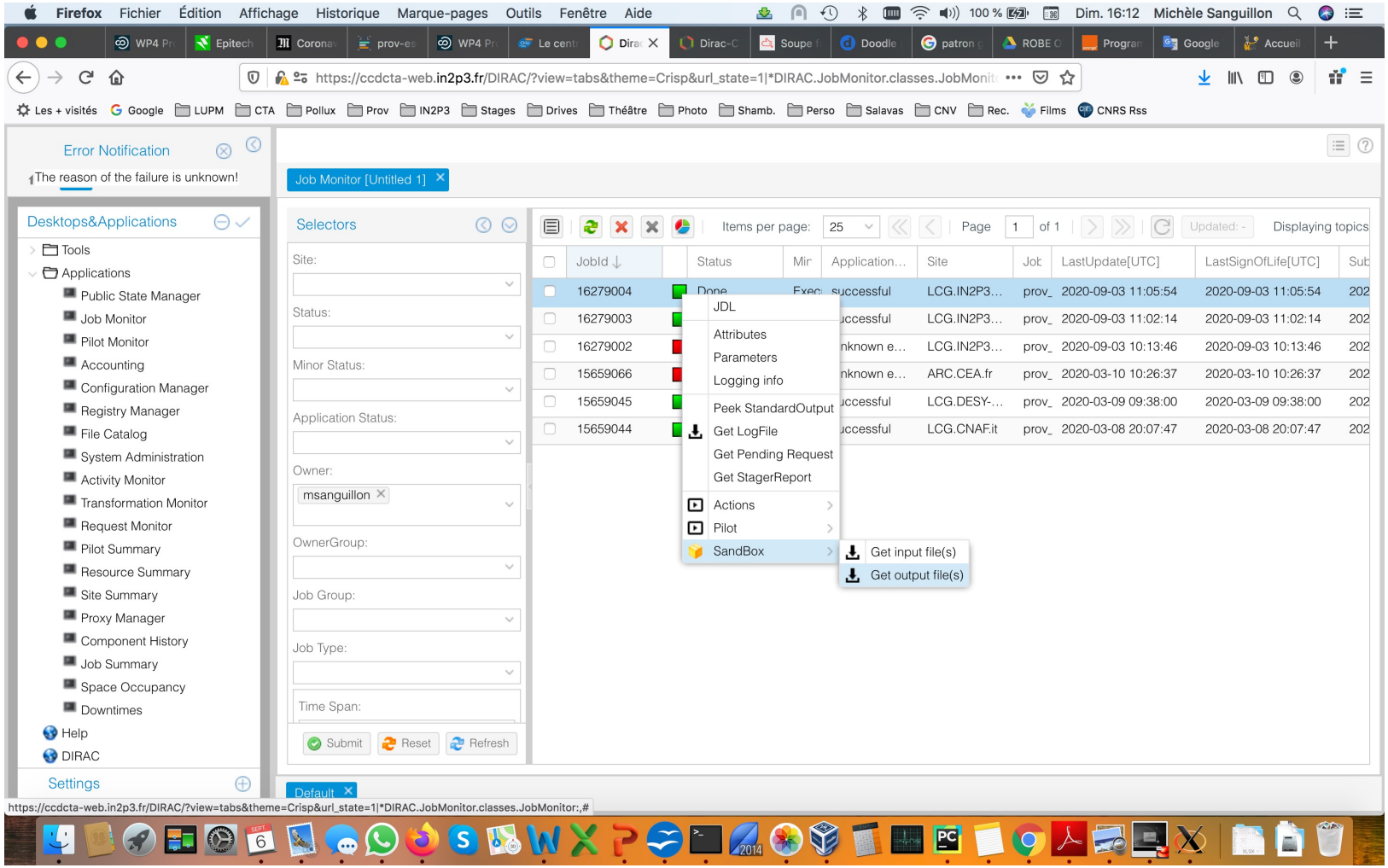
USAGE

Job execution usage

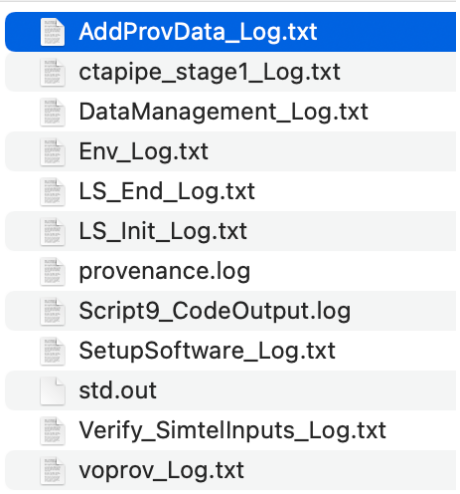


Job monitoring

https://ccdcta-cert.in2p3.fr/



Sandbox content




```
{"comment": "", "name": "ctapipe-display-muons", "activityDescription_key": 1, "startTime":
"2020-09-03T11:05:32.873", "endTime": "2020-09-03T11:05:38.361", "id":
"a4342513-329d-4d3d-806b-20d08b6164ad"}
{"agent_key": 1, "activity_key": 3, "role": null}
{"agent_key": 1, "entity_key": 1, "role": null}
{"activity_key": 3, "role": "dl0.sub.evt", "usageDescription_key": 1, "entity_key": 1, "time":
null}
{"agent_key": 1, "entity_key": 2, "role": null}
{"activity_key": 3, "role": "dl1.tel.evt.muon", "generationDescription_key": 1, "entity_key":
2}
{"generatedAtTime": null, "comment": null, "name": "status", "classType": "value",
"entityDescription_key": 3, "location": null, "invalidatedAtTime": null, "id":
"a4342513-329d-4d3d-806b-20d08b6164ad_status"}
{"activity_key": 3, "role": "status", "generationDescription_key": 2, "entity_key": 4}
Done
```

DB content

```
ctaprovtest=> select * from "activities";
 internal_key |                  id                  |         name          |        startTime        |         endTime         | comment | activityDescription_key
--------------+--------------------------------------+-----------------------+-------------------------+-------------------------+---------+-------------------------
            1 | 5dc245d2-aa16-4026-9da9-8c763b148a2c | ctapipe-display-muons | 2020-09-03T10:13:17.790 | 2020-09-03T10:13:24.010 |         |                       1
            2 | 4ed870fb-a3a0-48e9-8444-45dd63460996 | ctapipe-display-muons | 2020-09-03T11:01:49.802 | 2020-09-03T11:01:55.353 |         |                       1
            3 | a4342513-329d-4d3d-806b-20d08b6164ad | ctapipe-display-muons | 2020-09-03T11:05:32.873 | 2020-09-03T11:05:38.361 |         |                       1
            4 | 993734a7-52b7-496a-a9ed-87ddbf79f697 | ctapipe-display-muons | 2020-09-03T13:05:47.367 | 2020-09-03T13:05:53.020 |         |                       1
(4 rows)

ctaprovtest=> select * from "activityDescriptions";
 internal_key |         name          | version |     description      |      type      | subtype | doculink
--------------+-----------------------+---------+----------------------+----------------+---------+----------
            1 | ctapipe-display-muons | 0.6.2   | Muon reconstruction | Reconstruction |         |
(1 row)

ctaprovtest=> select * from "entities";
 internal_key |                   id                        |                                                         name
|    location     |   generatedAtTime    | invalidatedAtTime | comment | classType | entityDescription_key
--------------+---------------------------------------------+------------------------------------------------------------------------------------------------------------------
+-----------------+----------------------+-------------------+---------+-----------+-----------------------
            1 | 1C1A6113-481A-C0E9-ADF3-26A9E3F19AC6        | /vo.cta.in2p3.fr/user/s/sanguillon/proton_20deg_180deg_run22___cta-prod3-demo-2147m-LaPalma-baseline.simtel.gz
| {CC-IN2P3-USER} | 2019-05-02 12:00:52 |                   |         | dataset   |                     1
            2 | 9CD2D6F0-E512-7ED3-0825-271B083201C1        | /vo.cta.in2p3.fr/user/s/sanguillon/LaPalma/PROTON/provtest/0000/Data/-01xxx/muons_22.hdf5
| {DESY-ZN-Disk}  | 2020-09-03 11:02:03 |                   |         | dataset   |                     2
            3 | 4ed870fb-a3a0-48e9-8444-45dd63460996_status | status
|                 |                      |                   |         | value     |                     3
            4 | a4342513-329d-4d3d-806b-20d08b6164ad_status | status
|                 |                      |                   |         | value     |                     3
            5 | 993734a7-52b7-496a-a9ed-87ddbf79f697_status | status
|                 |                      |                   |         | value     |                     3
(5 rows)

ctaprovtest=> select * from "used";
 internal_key |    role     | time | activity_key | entity_key | usageDescription_key
--------------+-------------+------+--------------+------------+----------------------
            1 | dl0.sub.evt |      |            2 |          1 |                    1
            2 | dl0.sub.evt |      |            3 |          1 |                    1
            3 | dl0.sub.evt |      |            4 |          1 |                    1
(3 rows)
```

I thank you for your attention