cherenkov telescope array

DIRAC
THE INTERWARE

The workflow management system for the Cherenkov Telescope Array Observatory (CTAO)

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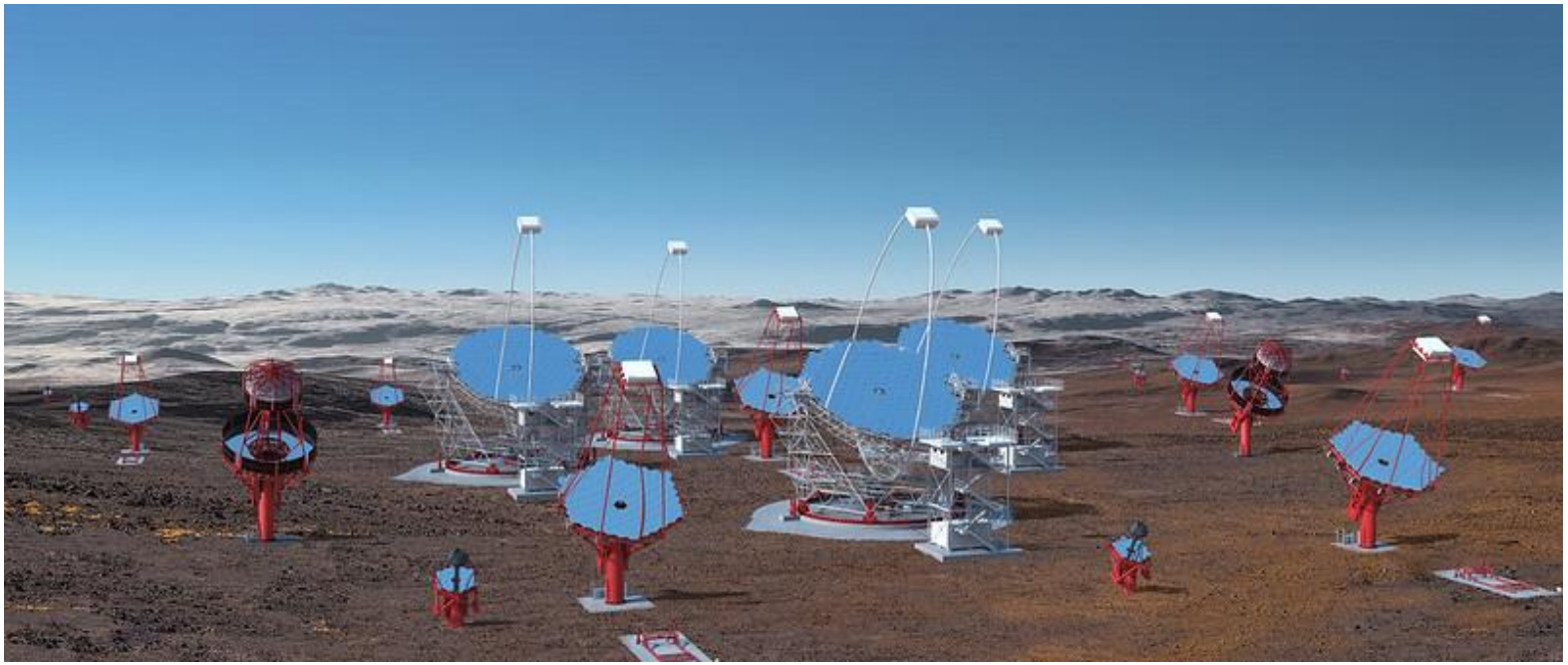
The CTA Observatory

- The next generation ground-based observatory for **gamma-ray astronomy at very high energies**
- Construction has started, operations start in the next years for about 30 years



The CTAO Telescopes

Two arrays of **Cherenkov telescopes,** located in two sites:

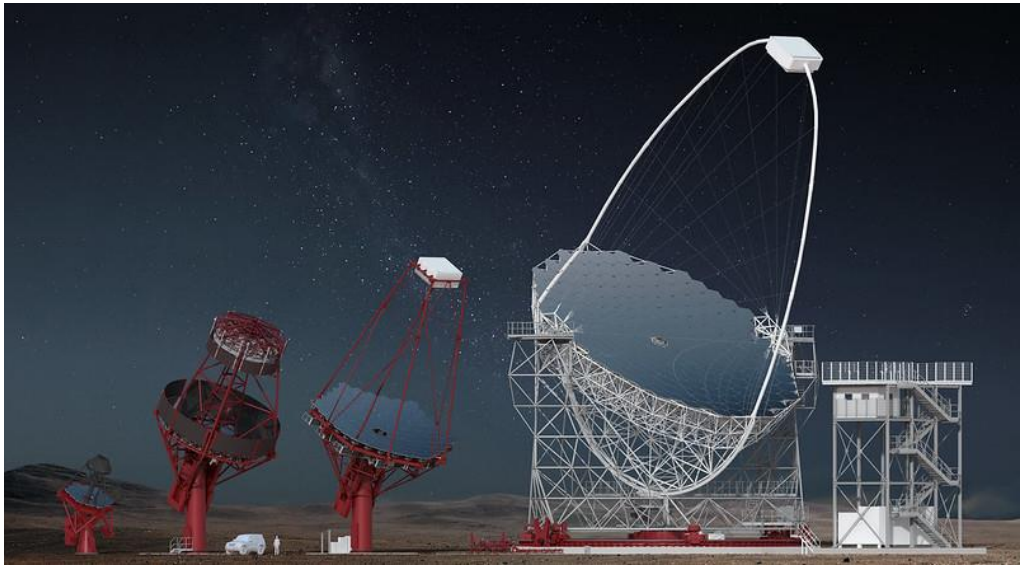
- North : La Palma, Spain
- South : ESO site in the Atacama desert, Chile

Three different telescope sizes.

Primary mirrors :

- ~4m (SST)
- 12m (MST)
- 23m (LST)

In total : more than 60 telescopes



Computing Model for off-site processing

CTAO will have a **distributed computing model** using **4 existing academic Data Centers**

- Optimize resources, allow expertise mutualization and minimize costs
- Computing and storage shared among the 4 DC

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- Computing and storage shared among the 4 DC

CTAO is negotiating with the following Data Centers:

- PIC, Barcelona in Spain
- DESY Zeuthen in Germany
- CSCS, Lugano in Switzerland
- INAF/INFN, Frascati in Italy

DIRAC

A complete grid solution to access **distributed heterogeneous resources** for computing and storage.

It's an open-source software started by LHCb and used today by many experiments.

DIRAC for CTAO

CTAO has been using DIRAC since 2011 for **Workload and Data Management,** for distributed MC data production :

- Operating its own instance with services distributed in 3 sites (CC-IN2P3, PIC, DESY-ZEUTHEN)
- Developing a software extension called **CTADIRAC:**

DIRAC for CTAO

CTADIRAC has an interface to easily configure **CTAO jobs** and a service to collect **provenance metadata.**

CTAO is also contributing to DIRAC core development (e.g. Production System for workflow management).

DIRAC systems for workflow management

Workflow Management is based on the DIRAC **Transformation and Production systems.**

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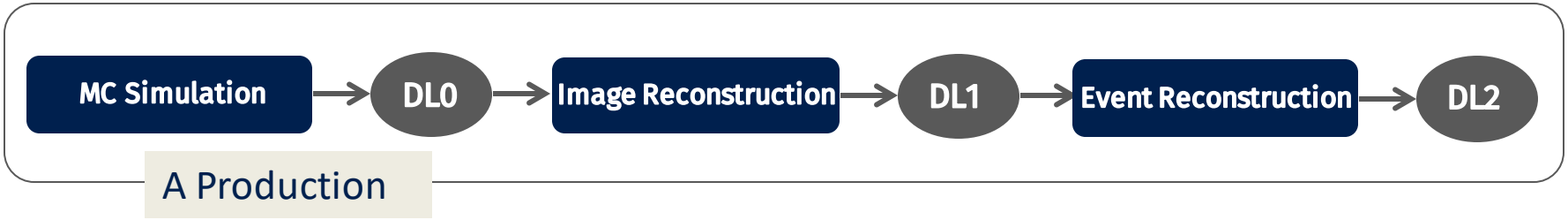
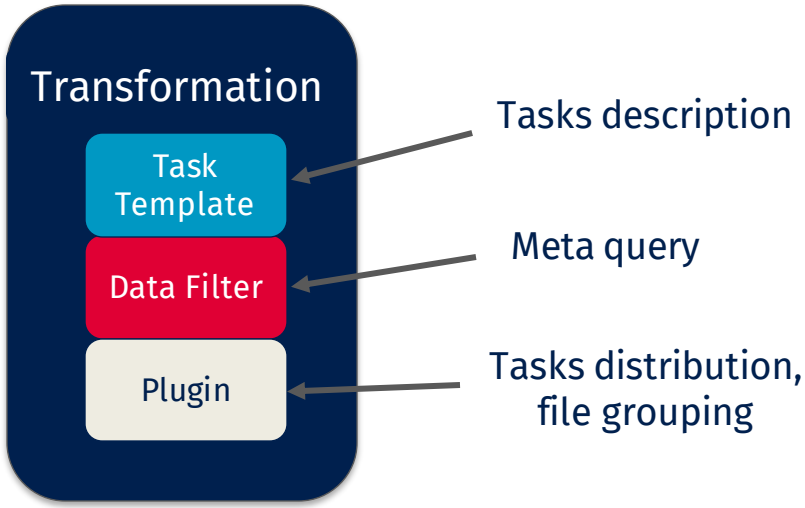


Workflow Management is based on the DIRAC **Transformation and Production systems.**

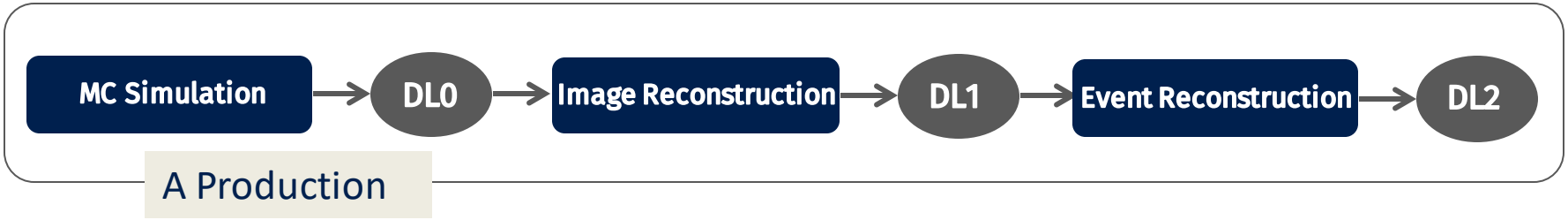
- A **Transformation** is a set of similar tasks applied on data.
- A **Production** is made of several Transformations and their associations.

The Transformation System

A Transformation is identified by : a **description of the tasks**, a **query on metadata** to select input/output data, and **rules** to distribute tasks and group input files.



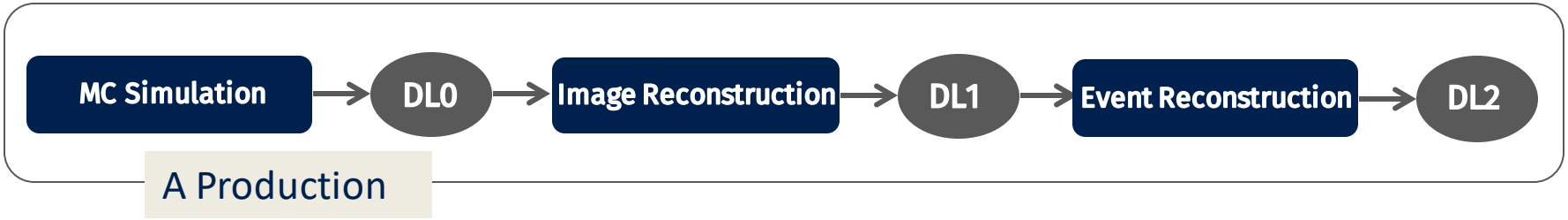
The Production System



It is a high-level system built on top of the Transformation System.

It is used to automatically instantiate the different Transformations that compose a Production.

The Production System



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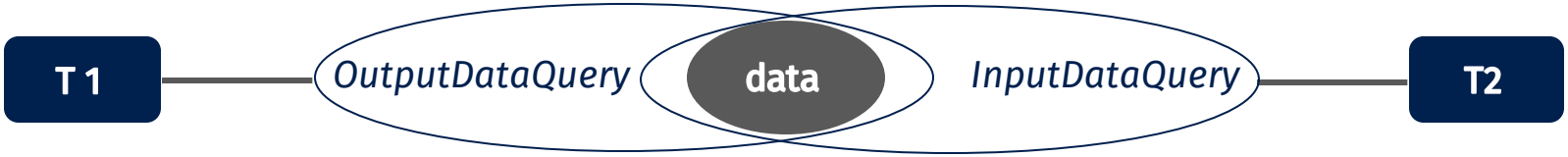
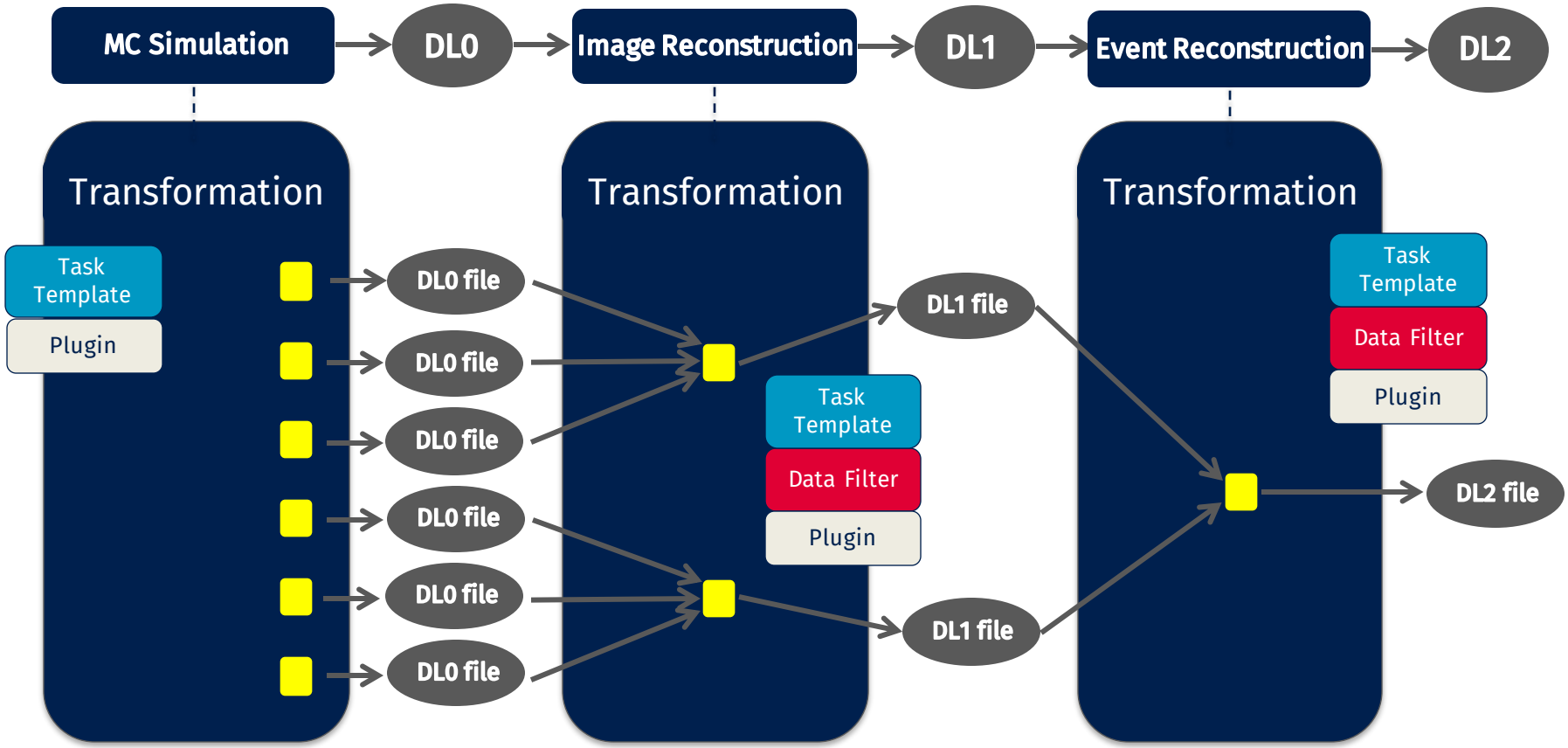


Two transformations are connected if the output data of T1 intersects the input data of T2. The workflows are **data-driven**.

The Production System

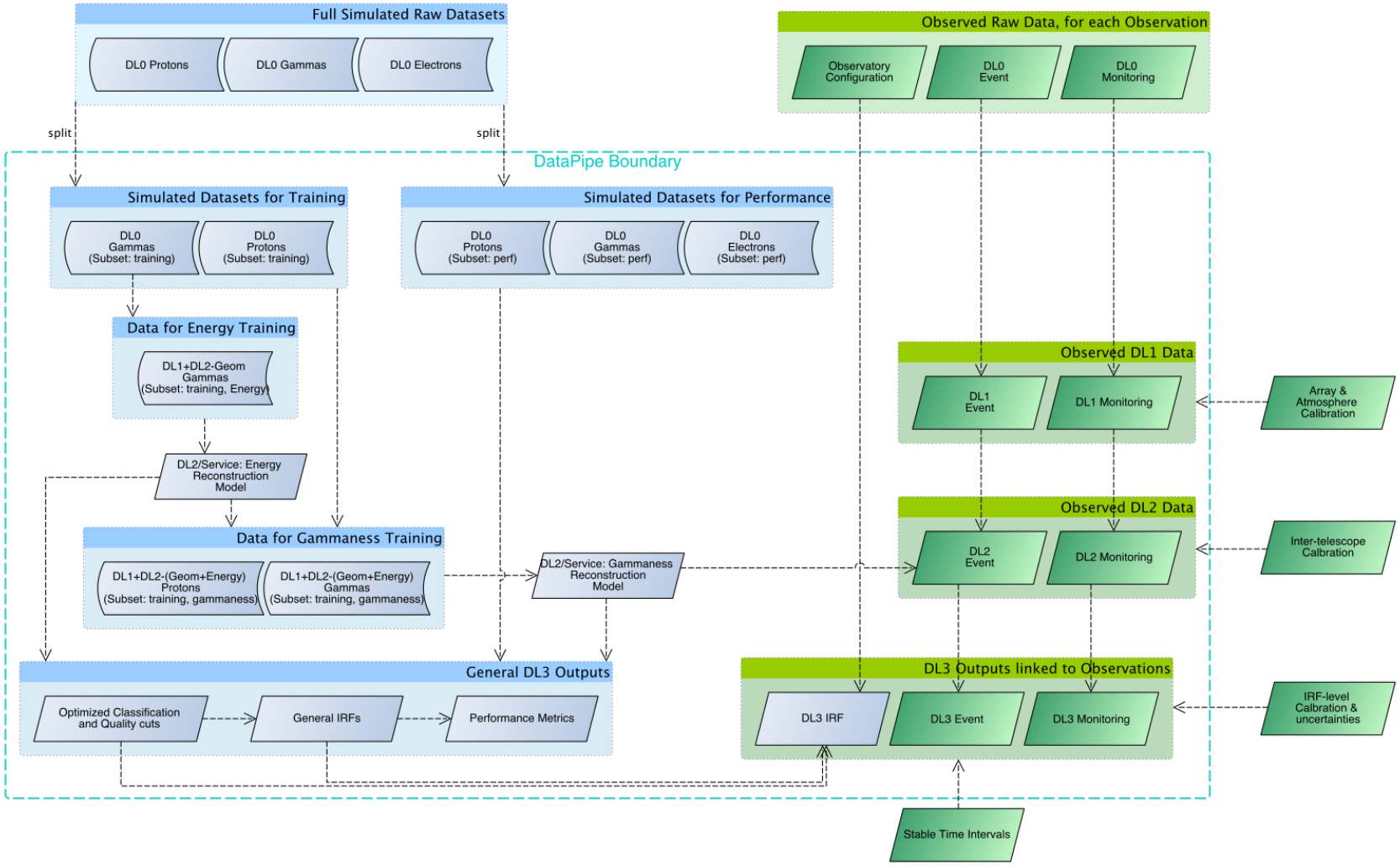


The Production System

In CTADIRAC, we have developed a **high-level interface** for the configuration and submission of productions.

With this interface we are able to submit **complex workflows** more easily.

The Production System



The Production System Interface

Simple workflow description in a YAML file :

```yaml
ProdSteps:
  - ID: 1
    input_meta_query:
    job_config:
      type: MCSimulation
      version: 2022-08-03
      site: Paranal
      particle: electron
      pointing_dir: North
      zenith_angle: 20
      n_shower: 100
      moon: dark, half
  - ID: 2
    input_meta_query:
      parentID: 1
      moon: dark
    job_config:
      type: CtapipeProcessing
      version: v0.17.0
      group_size: 5

Common:
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  base_path: /vo.cta.in2p3.fr/user/a/afaure/prod6/
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Transformation input/output defined by meta-data specification

Automatically builds the queries on meta data from the workflow description

Specify parent/child transformation connections, possibly adding extra meta-data specifications

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- We developed the interface in the CTADIRAC software extension but we plan to port it in vanilla DIRAC
- Each users community can specify its own meta-data

CWL

Standard for describing workflows

Composed of several steps (**command lines** / expressions)

A CWL runner (e.g. **cwltool**) **parses** the steps described in **YAML** and **runs** the workflow

CWL & DIRAC

Standard for describing workflows

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A CWL runner (e.g. **cwltool**) **parses** the steps described in **YAML** and **runs** the workflow

Different workflow types : **Jobs** / **Transformations** / **Productions**

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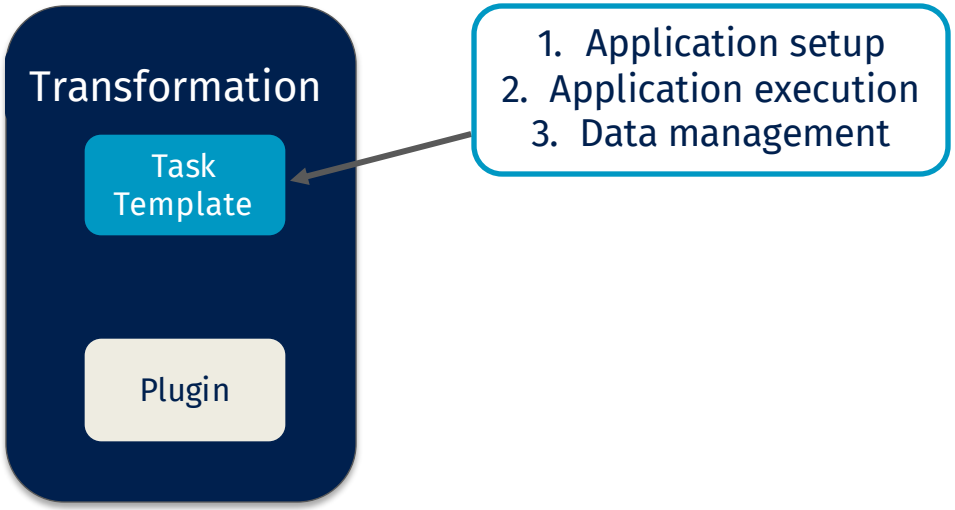
Run on **distributed data centers**

Example of MC simulations

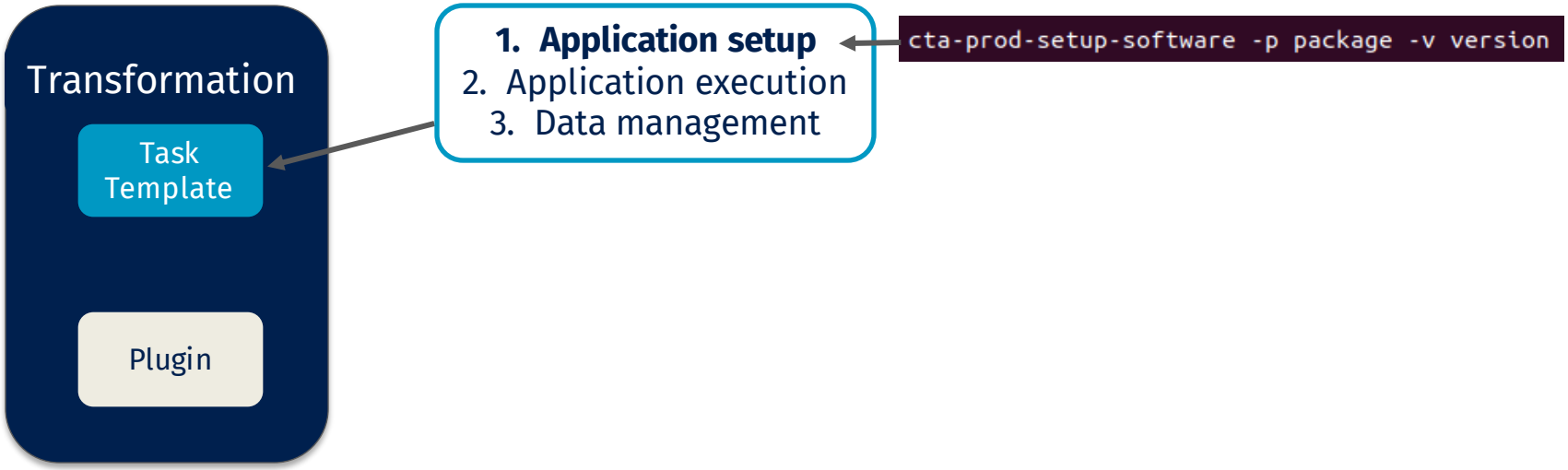
In CTADIRAC a Monte Carlo simulation is a Transformation **without input data.** The **tasks** (or jobs) operated on data in this example are composed of **3 steps**.



Example of MC simulations

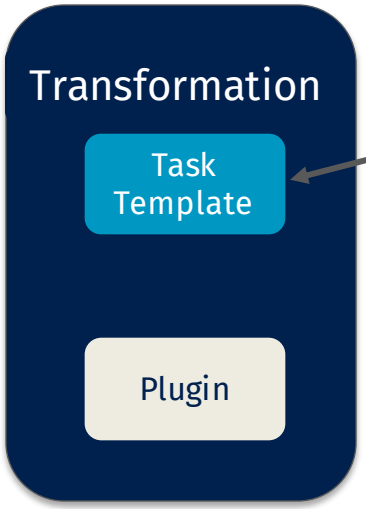
In CTADIRAC a Monte Carlo simulation is a Transformation **without input data.** The **tasks** (or jobs) operated on data in this example are composed of **3 steps**.

Each step is the execution of a **command line.**



Example of MC simulations

We are now able to create each step of the task from a **CWL description** in a **commandLineTool**.



1. **Application setup**
2. Application execution
3. Data management

```yaml
name_package: corsika_simtelarray
version_number: "2022-08-03"
```

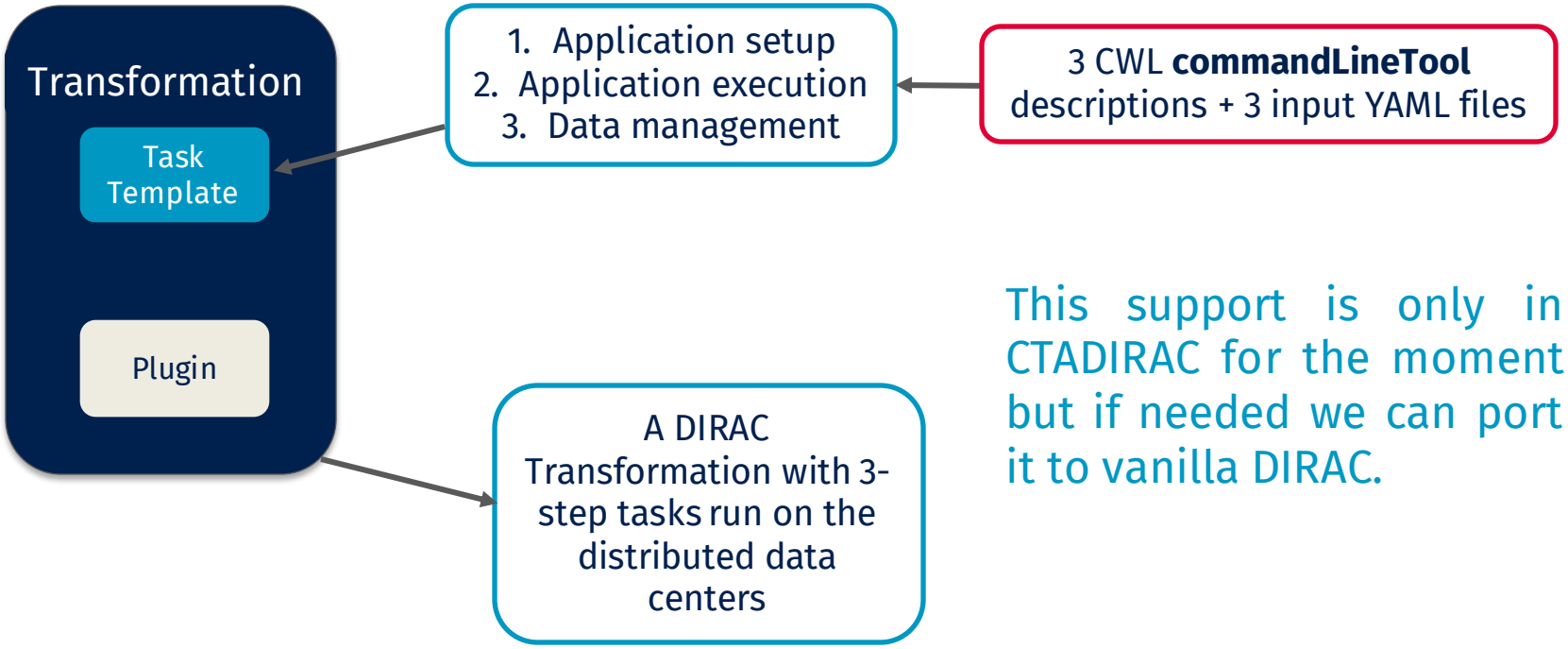
Input YAML file

```yaml
cwlVersion: v1.2

class: CommandLineTool
label: setup cta prod software
baseCommand: cta-prod-setup-software

inputs:
    name_package:
        type: string
        inputBinding:
            prefix: -p
            position: 1
    version_number:
        type: string
        inputBinding:
            prefix: -v
            position: 2
outputs:
    dirac:
        type:
            type: array
            items: File
        outputBinding:
            glob: "dirac*"
```

CWL description

Example of MC simulations

We can then run a Transformation made of similar **jobs** that execute **several command lines** based on **the CWL descriptions of these command lines.**

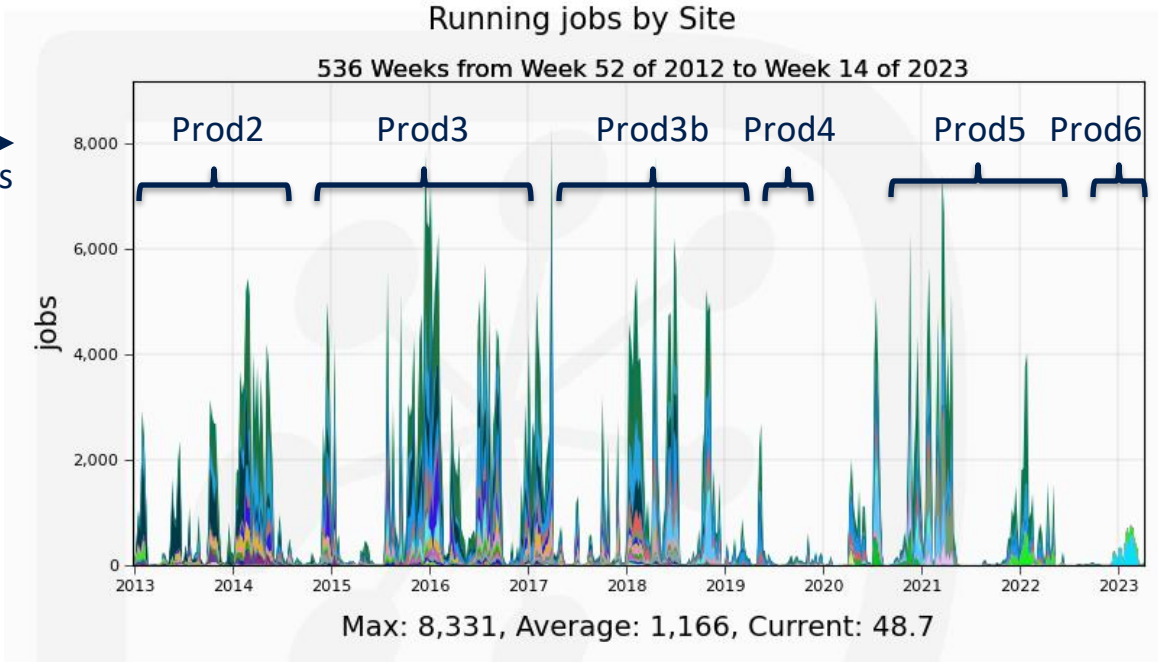


This support is only in CTADIRAC for the moment but if needed we can port it to vanilla DIRAC.

Large scale productions

Massive simulation campaigns are run since 2011 to produce the reference response functions of the telescopes.

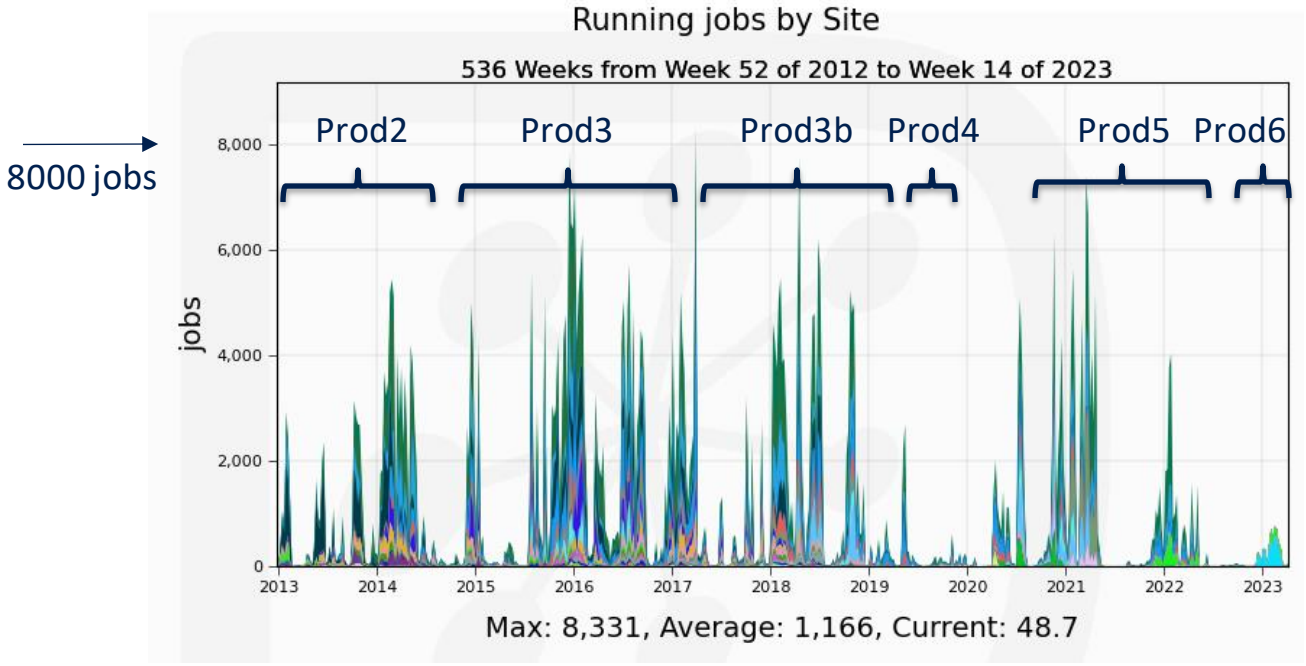
8000 jobs



Large scale productions

Over the last ten years, CTAO computed on average for 100 million HS06 hours in 2 million jobs per year.

It produced on average 50PB of data on disk per year.



Conclusion

- We have been successfully operating a DIRAC instance for CTAO simulations using the DIRAC **Transformation and Production systems** for the workflow management.
- In CTADIRAC, we have developed a user **interface** to the DIRAC **Production** System to easily configure and submit complex workflows.
- In CTADIRAC, we have introduced support for workflows described in **CWL** in the DIRAC **Transformation** System**.**
- CTAO will use CTADIRAC for the workflow management of simulations and data processing of observation data.

Plans

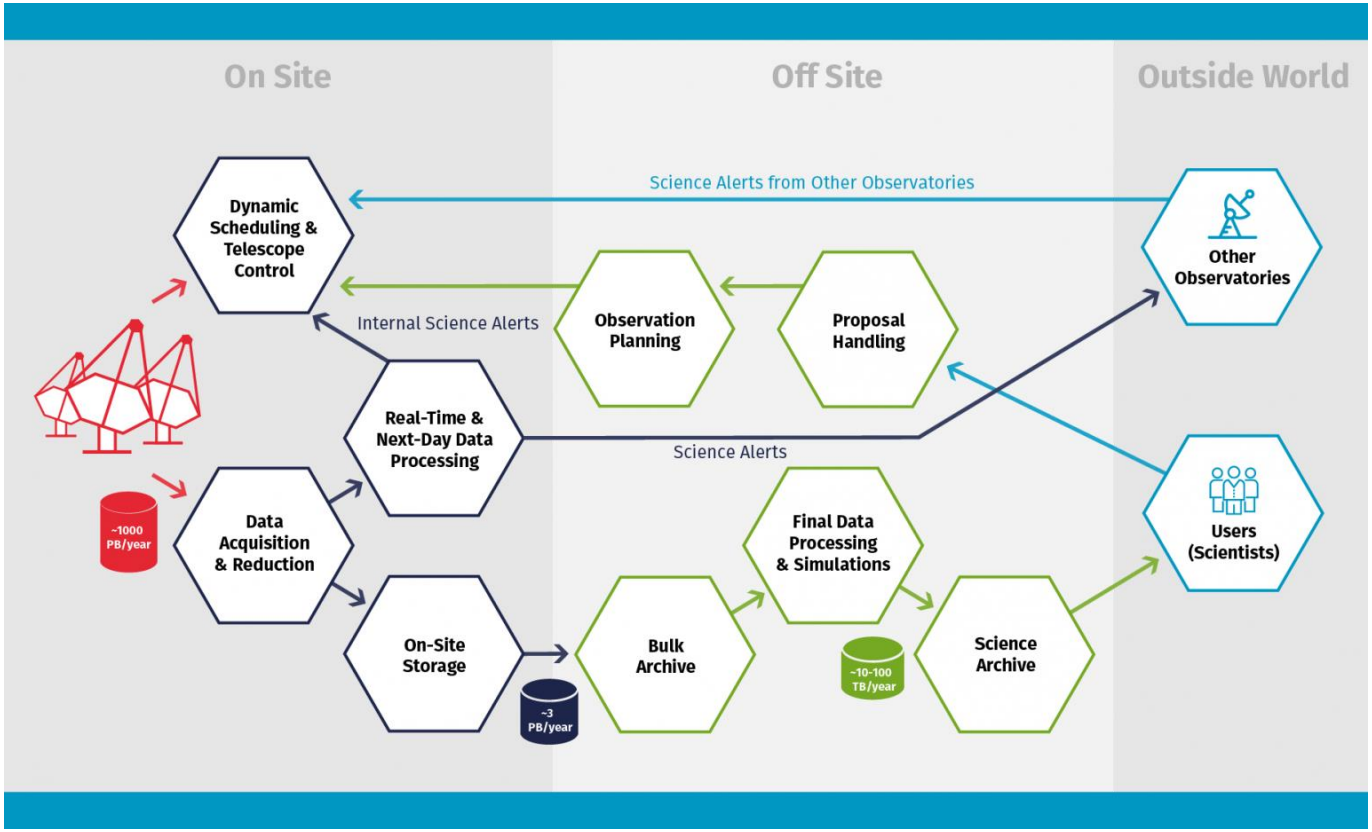
- We are going to investigate how we could use input and output meta queries with CWL in order to launch a **Production** made of several Transformations.

- We plan to port the Production System Interface and the CWL support to **vanilla DIRAC**.

Thank you for your attention

Back-up

Data flow and operations



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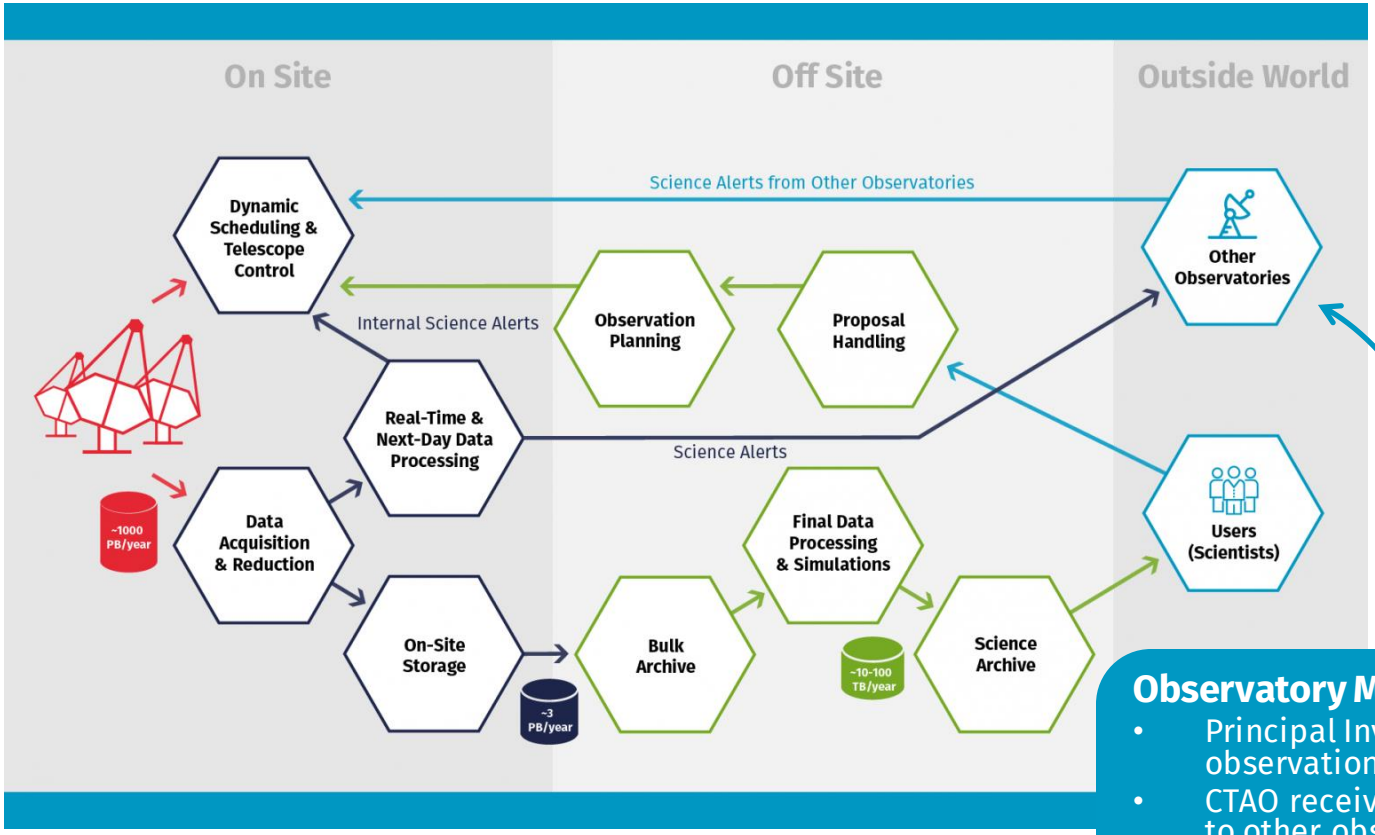
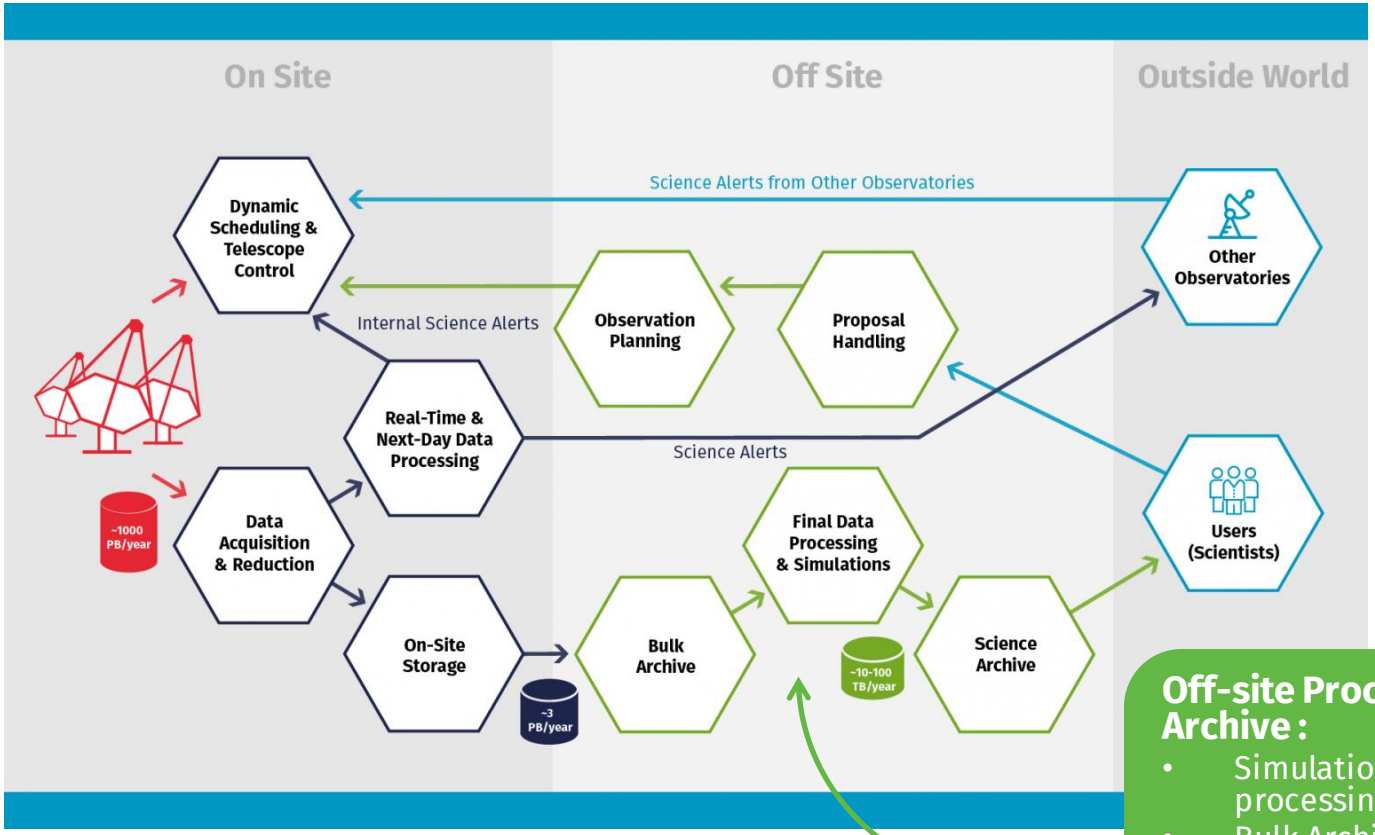


Observatory Mode :

- Principal Investigators submit observation proposal
- CTAO receives and sends alerts to other observatories when a source is detected
- Data becomes public after a proprietary period

Data flow and operations



Off-site Processing and Archive :

- Simulations and final processing (DL0 -> DL3)
- Bulk Archive (DL0-DL3)
- Science data preparation (DL3 -> DL6)
- Science Archive (DL3-DL6)

Data volume reduction

Data transfers over intercontinental fibers are planned with 2Gbps. The **Data Volume Reduction ratio** will have to grow in line with the telescope deployment planning and data volume growth.

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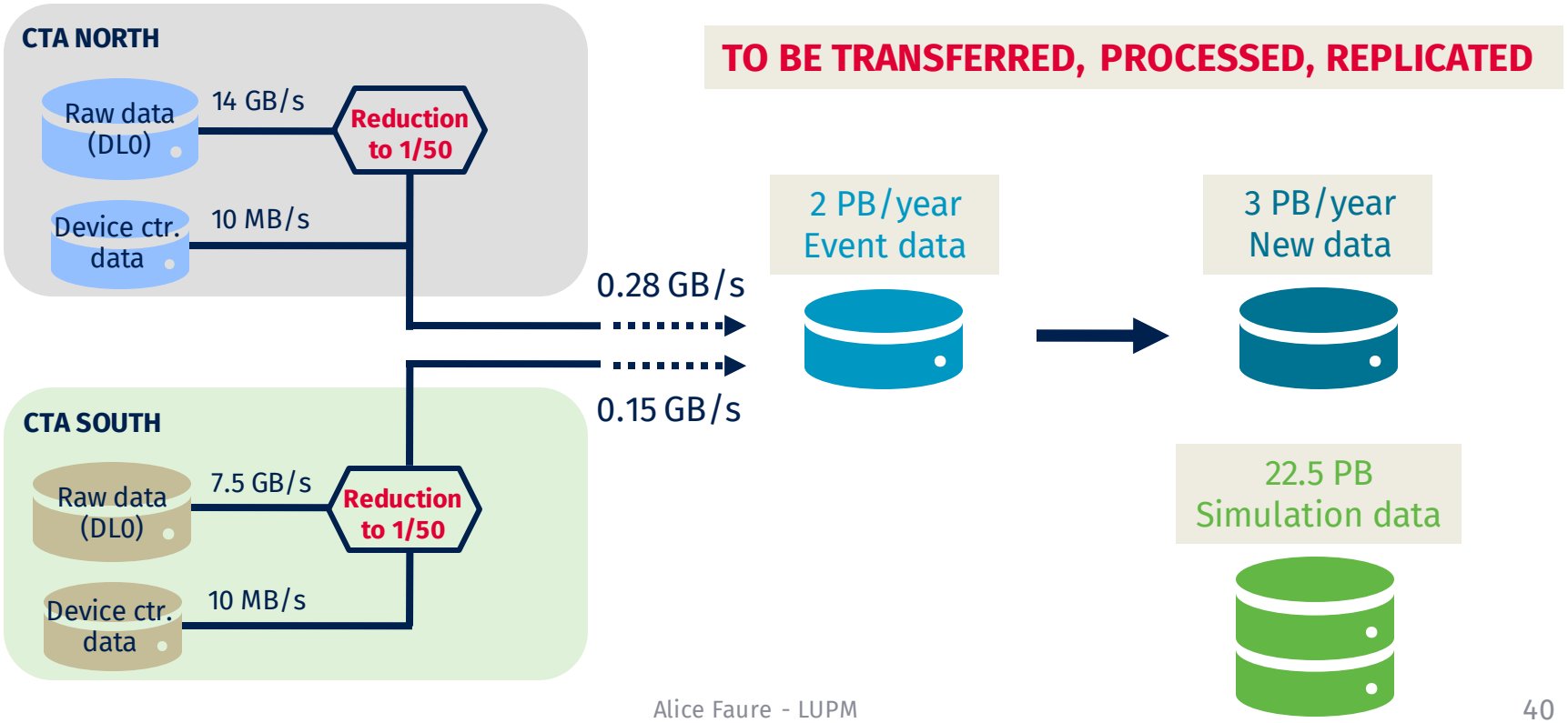
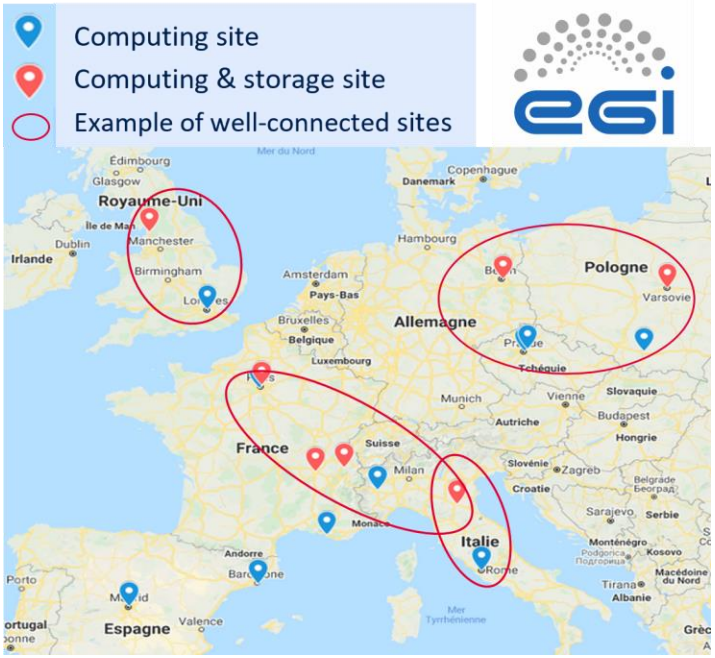


Current CTA Computing Model

CTA uses EGI grid resources through the **CTA Virtual Organization** since 2008:

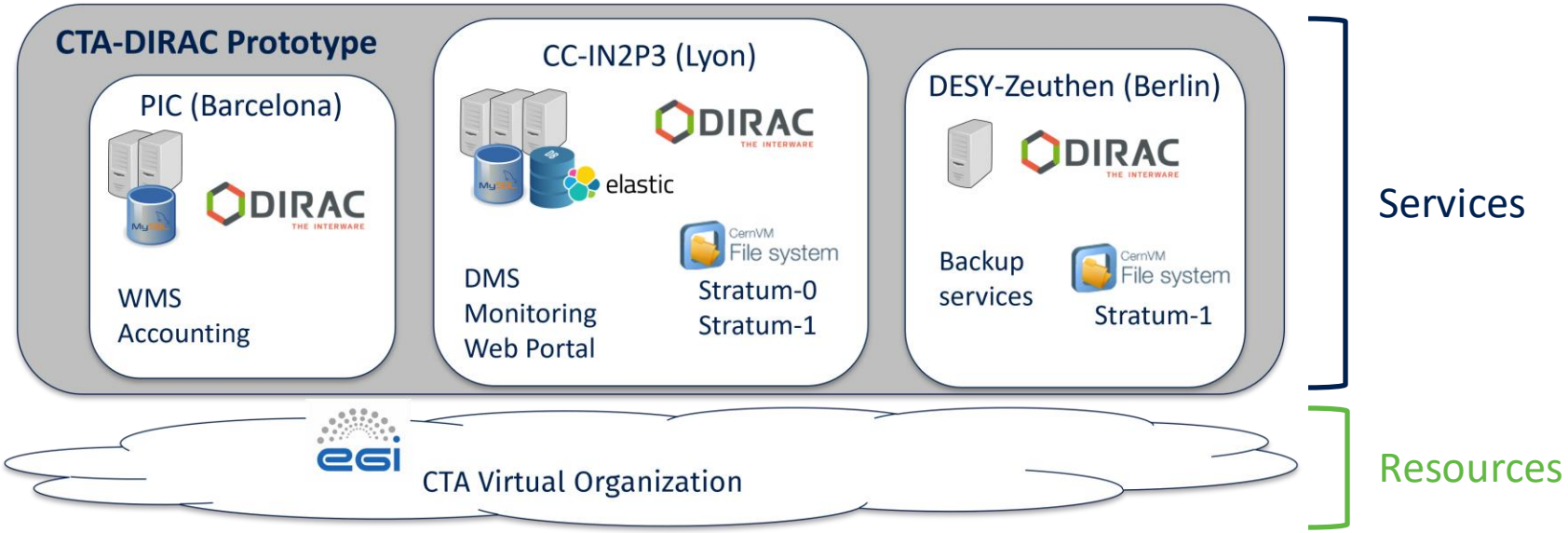
- On a best-effort basis
- 15 sites providing ~10k cores
- 7 sites also providing global storage capacity : ~7PB (disk + tape)



We run two main kinds of jobs :

- Monte-Carlo simulations
- Data processing

DIRAC for CTAO



CWL support in CTADIRAC

- We are able to run workflows described in CWL with CTADIRAC using DIRAC Transformations.
- This is limited to **atomized workflows** described in CWL where each step is the execution of a command line.
- This will enable pipelines users using CWL to run their workflows both locally and on the distributed data centers with DIRAC.
- We have to investigate how to use input and output meta queries with CWL in order to launch a **Production** made of several Transformations.