Running productions with DIRAC

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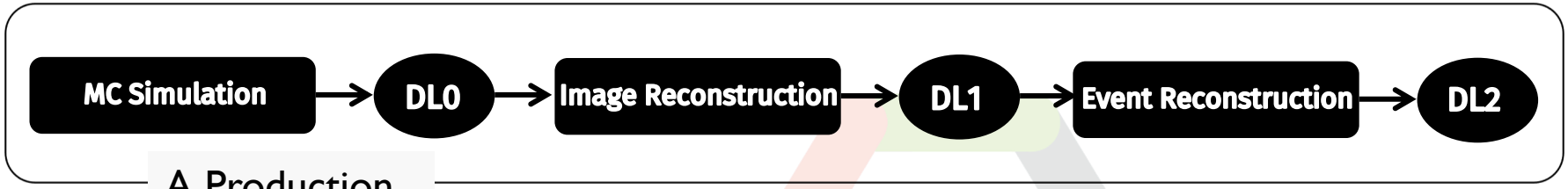
Running productions with DIRAC

- The DIRAC communities that need to manage massive productions with complex workflows use the Transformation System (see doc here) combined with a higher level system built on top of the it, called Production System
- Historically each of these communities has developed its own Production System
- Since v7r0 DIRAC provides its own Production System which is used by CTAO for now (see doc here)
- We present here how CTAO and LHCb run their productions with DIRAC and LHCbDIRAC Production Systems

DIRAC Production System

Simple workflow example

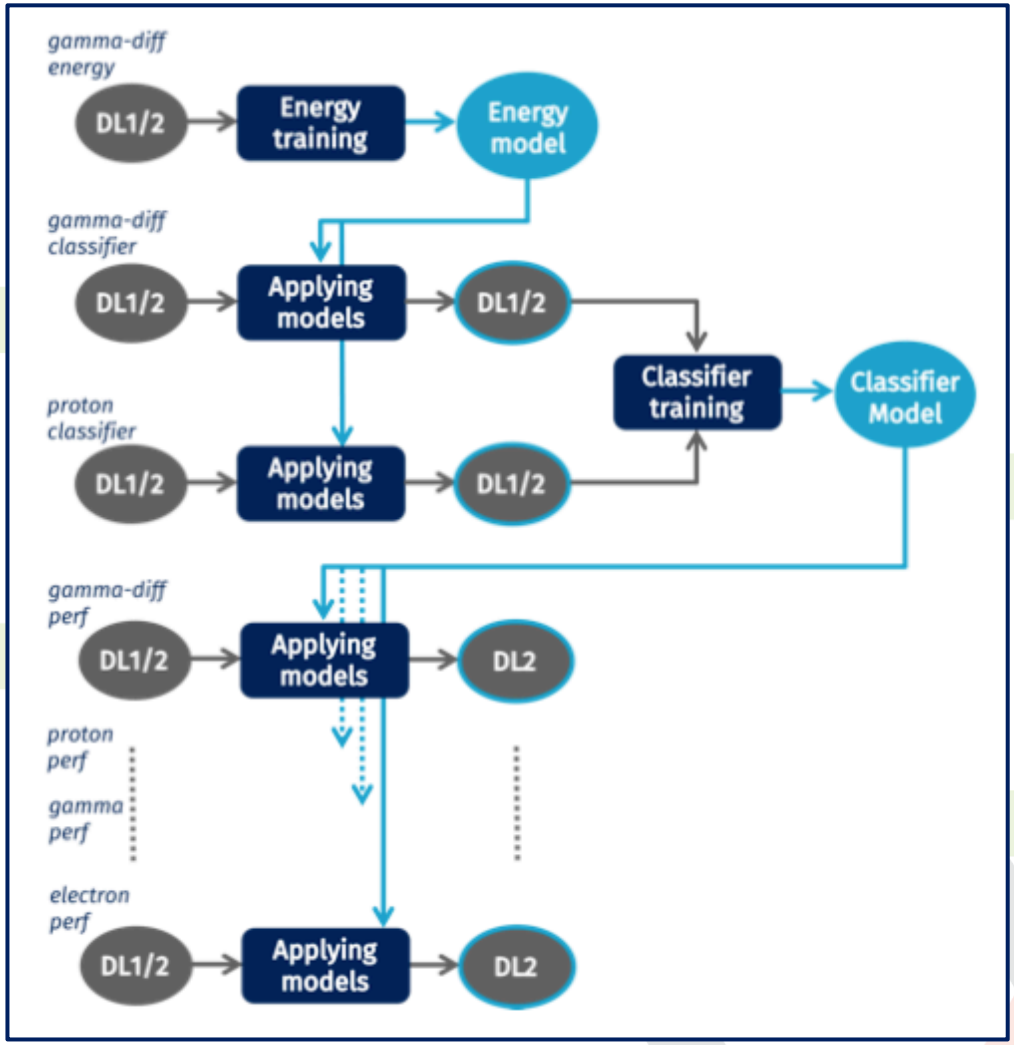


The Production System is a high-level system built on top of the Transformation System.

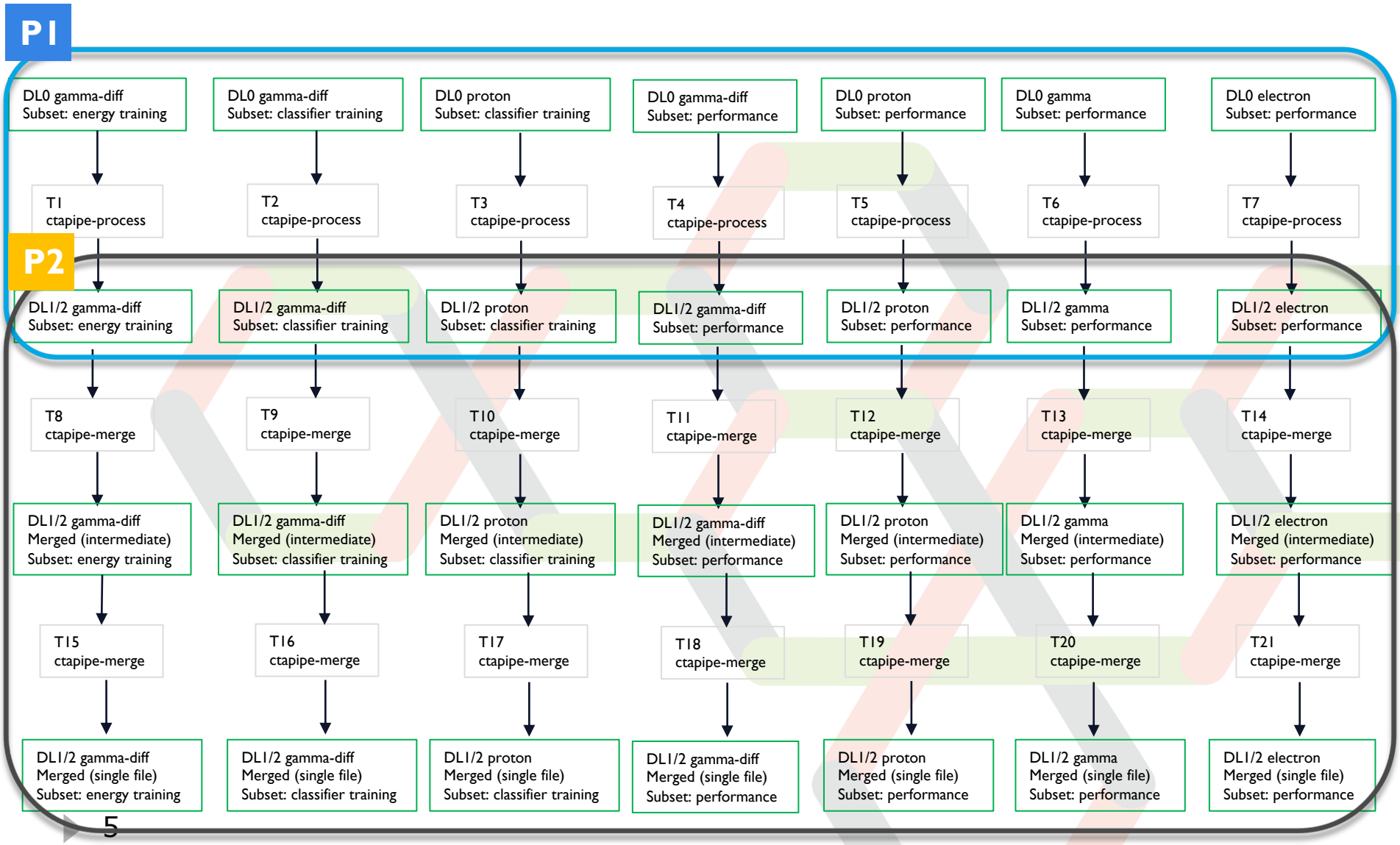
It automatically instantiates the different transformations that compose a Production.

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

CTAO processing workflow example



CTAO processing workflow example (detailed view 1/2)



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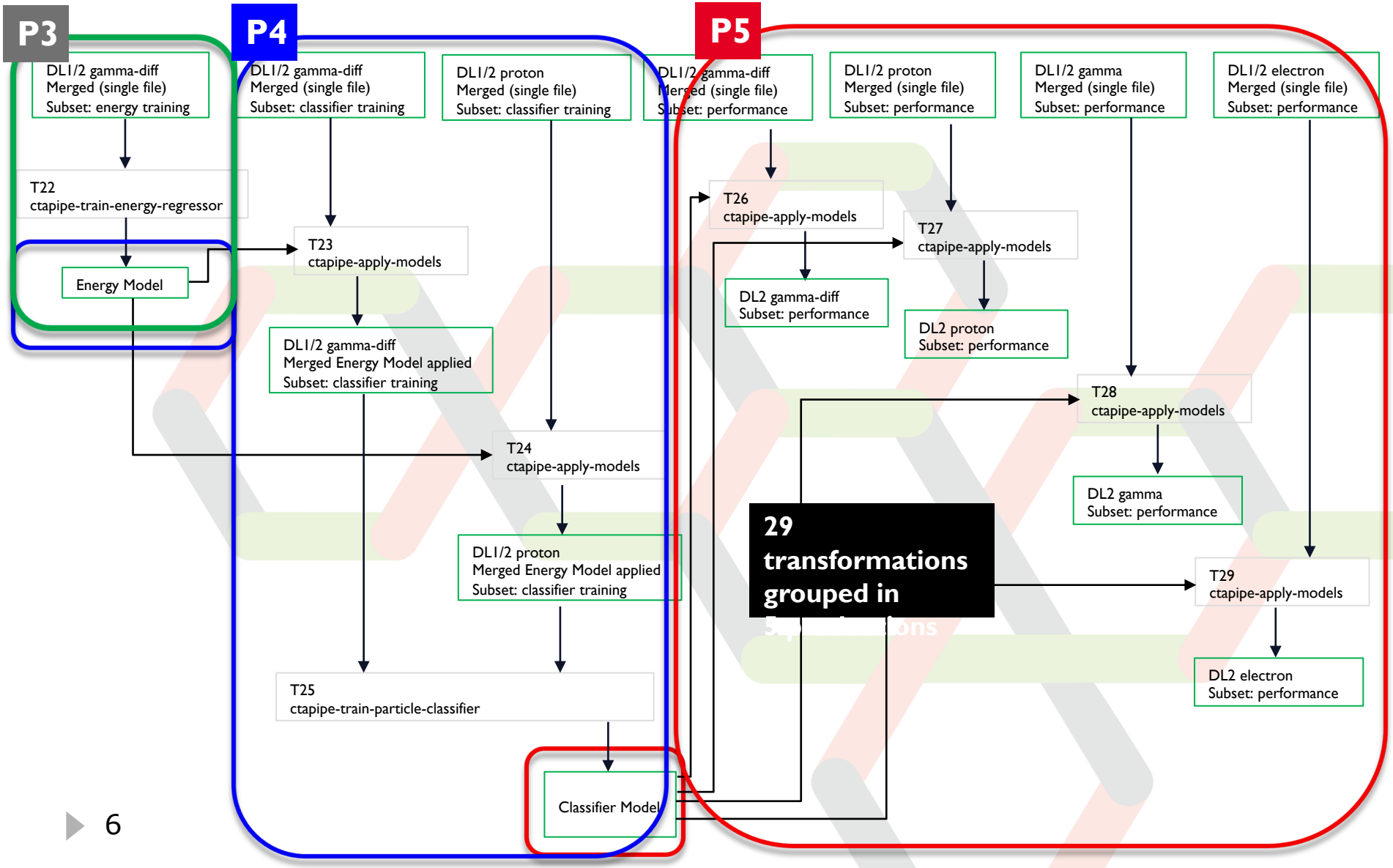


User interface for the Production System

- The Production System user interface comprises a Python API a limited CLI

  -> Not very practical to configure and submit complex workflows

- For our convenience in CTADIRAC we have developed a YAML-based user interface (A. Faure)
- Currently it's specific to CTAO but it can be generalized and port it to vanilla DIRAC

User interface for the Production System

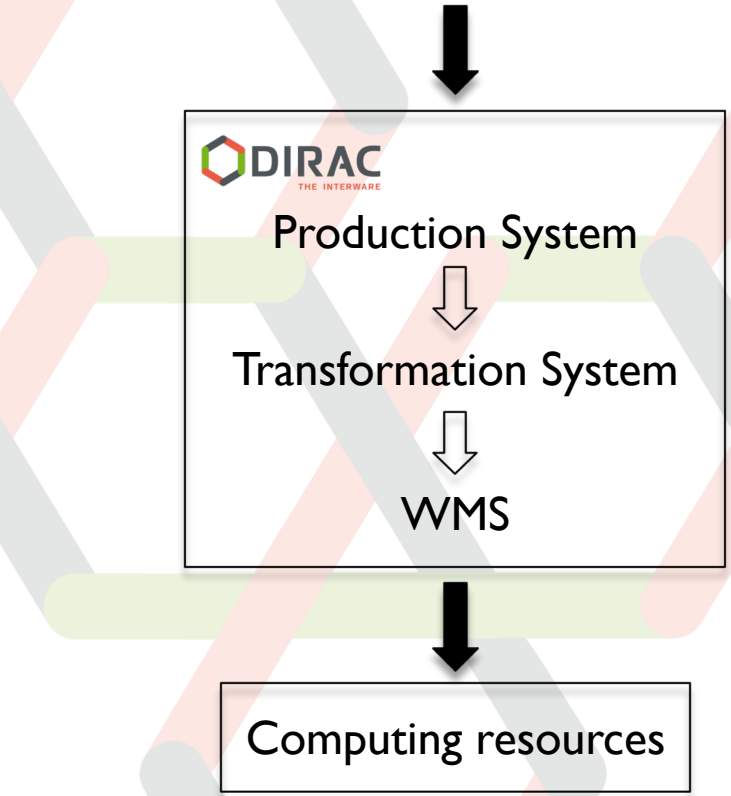
Production description in YAML

```yaml
ProdSteps:
  - ID: 1
    input_meta_query:
      parentID:
      dataset: Prod5b_LaPalma_AdvancedBaseline_NSB1x_electron_North_20deg_R1
    job_config:
      type: CtapipeProcessing
      version: v0.19.2
      array_layout: Alpha
      group_size: 2
      output_extension: DL2.h5
      data_level: 2
      options: --config v3/dl0_to_dl2.yml --config v3/prod5b/subarray_north_alpha.yml
  - ID: 2
    input_meta_query:
      parentID: 1
      dataset:
    job_config:
      type: Merging
      version: v0.19.2
      group_size: 5
      output_extension: merged.DL2.h5
  - ID: 3
    input_meta_query:
      parentID: 2
      dataset:
    job_config:
      type: Merging
      version: v0.19.2
      group_size: 2
      output_extension: alpha_train_en_merged.DL2.h5
      options: --no-dl1-images --no-true-images
      catalogs: DIRACFileCatalog

Common:
  MCCampaign: Prod5bTest
  configuration_id: 15
  base_path: /vo.cta.in2p3.fr/tests/prodsys/MC
```

CLI User Interface

*cta-prod-submit <prodName> <**workflow.yml**>*



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Step 1

Step 2

Step 3

A production is described by several steps, i.e. transformations

User interface for the Production System

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A production is described by several steps, i.e. transformations

Each step is described by :

- Input data query

User interface for the Production System

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An input data query can be specified :

- By a dataset

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A production is described by several steps, i.e. transformations

Each step is described by :

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An input data query can be specified :

- By a dataset
- By a parent step (i.e. a query on the metadata of the outputs of the parent)

User interface for the Production System

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```

Another production example

```yaml
ProdSteps:
  - ID: 1
    input_meta_query:
      parentID:
      MCCampaign: PROD5
      array_layout: AlphaNectarcam
      site: Paranal
      particle: gamma-diffuse
      split: train_en
      thetaP: 20.0
      phiP: 0.0
      analysis_prog: ctapipe-merge
      analysis_prog_version: v0.19.3
      data_level: 2
      outputType: Data
      configuration_id: 8
      merged: 2
      moon: dark
    job_config:
      type: CtapipeTrainEnergy
      version: v0.19.3
      options: -c v3/train_energy_regressor.yml
```

A production is described by several steps, i.e. transformations

Each step is described by :

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An input data query can be specified :

- By a dataset
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- By a set of meta-data key-values

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- By a set of meta-data key-values

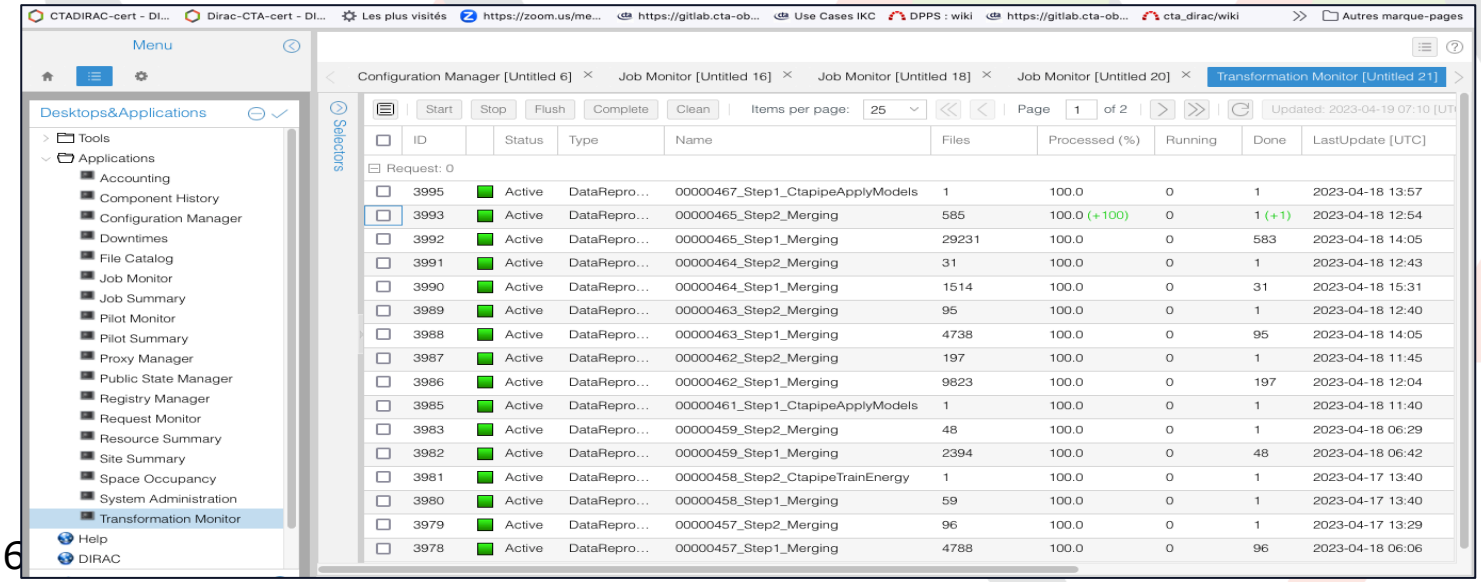
For each step, the metadata of the outputs are automatically built from input data and job configuration

Monitoring productions

Production System CLI : start, stop, complete, monitor productions, etc.

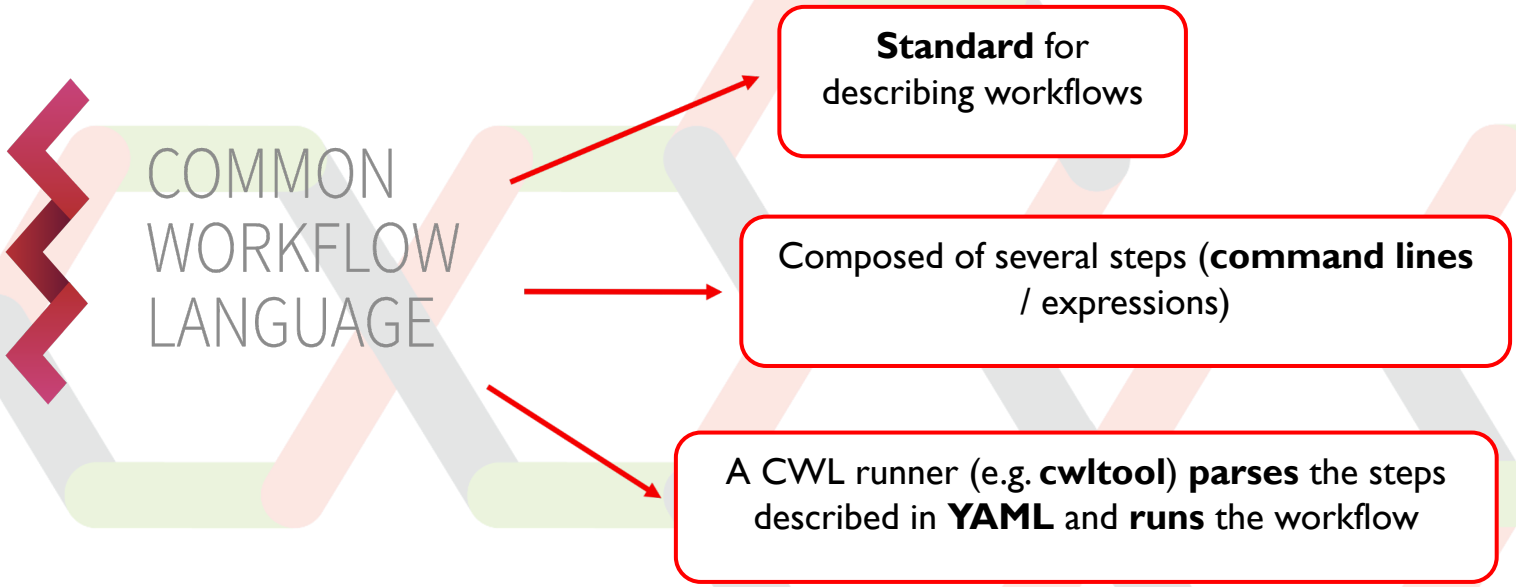
```
$ dirac-prod-get-trans 649

    TransformationName       Status F_Proc. F_Proc.(%) TransformationID
 1 00000649_Step10_Merging Active      38 100.0                  4468
 2 00000649_Step11_Merging Active    9977 100.0                  4469
 3 00000649_Step12_Merging Active     139 100.0                  4470
 4 00000649_Step13_Merging Active       5 100.0                  4471
```

WebApp Transformation Monitor



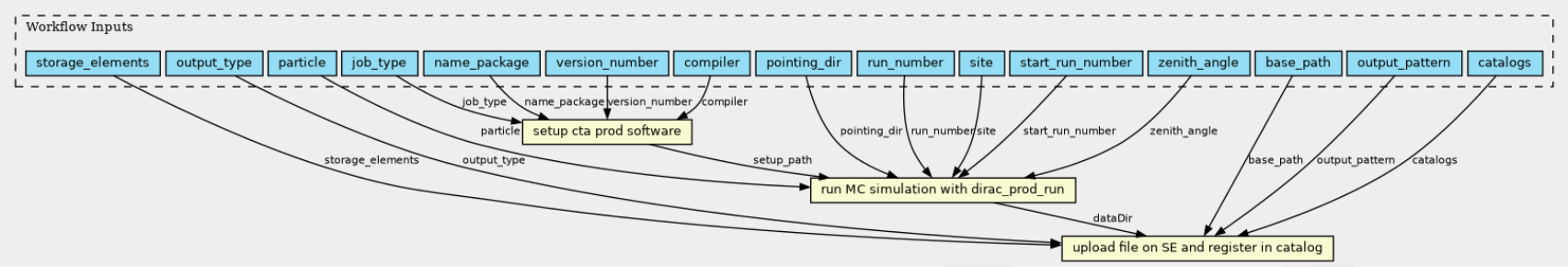
Support of CWL for describing transformations

- Initial support of transformations described in CWL (see Alice's talk at CHEP 2023)



Support of CWL for describing transformations

- Motivations
  - Use a common workflow language both for local execution (e.g. by software developers for testing purpose) and execution through DIRAC
- Advantages of using CWL
  - Standard language
  - Syntax validation
  - Workflow graph automatically generated



Support of CWL for describing transformations

- In principle CWL could be used to describe workflows at different levels :
  - Job workflows : the different steps (executables) executed within a job
  - Production workflows : the different transformations composing a production

In CTADIRAC we have developed a tool :

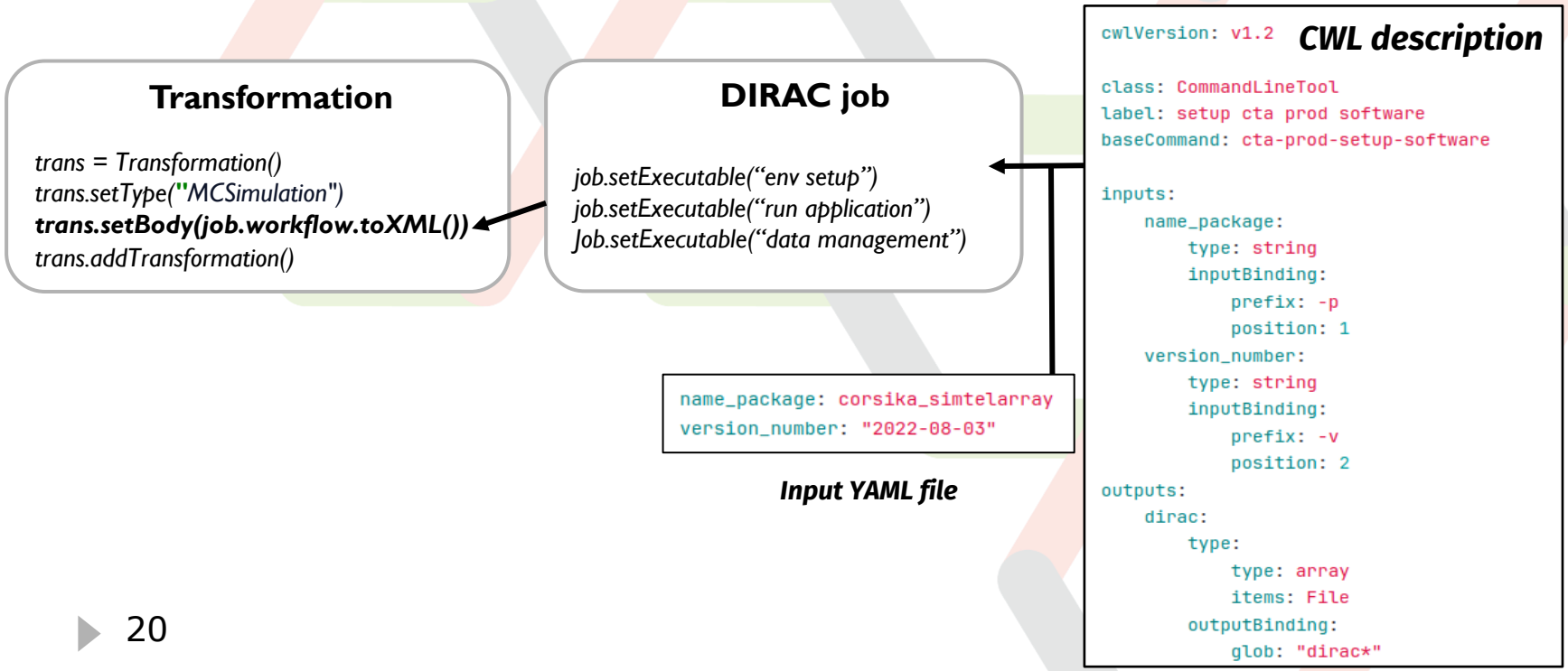
cta-prod-submit-from-cwl

to parse CWL descriptions at job level and to submit transformations

Support of CWL for describing transformations

cta-prod-submit-from-cwl

1. Parses a workflow description in CWL using cwltool functions to extract the command lines and builds a DIRAC job (using DIRAC Job API)
2. From the job description, it builds and submits a transformation



Perspectives on CWL support

- We want to generalize our tool to build any kind of transformation
- We would like to explore the possibility to use CWL to describe DIRAC productions
- Explore how to take benefit from CWL scatter/gather functionality

DIRAC
THE INTERWARE

Backup

Support of CWL for describing transformations

- ***cta-prod-submit-from-cwl*** supports
  - Workflows described using the CWL CommandLine class
  - Workflow described using the CWL Workflow class

Support for CWL CommandLine

cta-prod-submit-from-cwl

- Uses *cwltool* functions to generate the command lines from CWL description
- Builds DIRAC Jobs from the generated command lines

```
job.setExecutable( "command-line-1")
job.setExecutable( " command-line-2")
....
```

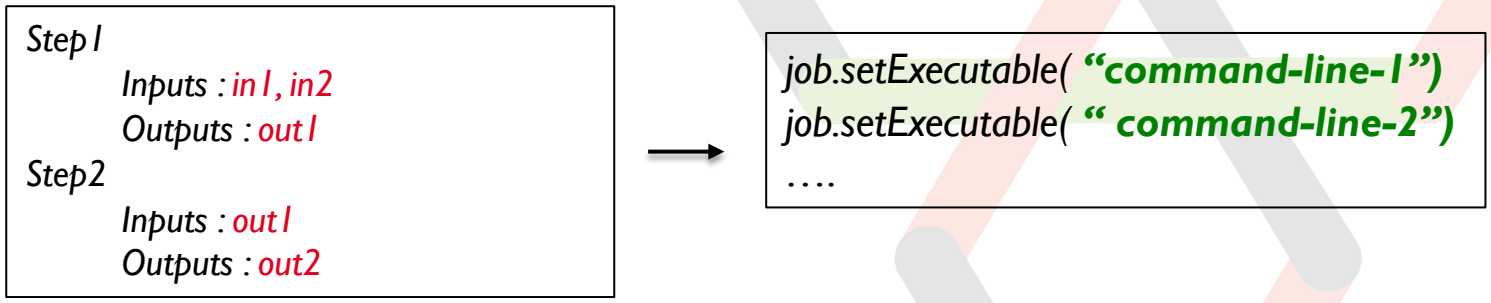
- Current limitations
  - It doesn't support Javascript expression
  - All inputs needed for the execution must be present in the command line, *e.g.* we don't support *initialWorkDirRequirement*

Support of CWL Workflows

- A CWL workflow is made of different steps
  - The execution order depends on their I/O relations
  - If 2 steps are indipendent *cwltool* executes them in parallel

cta-prod-submit-from-cwl

- Determines the execution order using the same logic as *cwltool* and builds DIRAC jobs but with all steps in sequence



Support of CWL Workflows

- Current limitations
  - The tool is not generalized yet to build any kind of transformation starting from CWL description
    - The Body of the transformation is built from CWL description, while the other attributes are not, i.e. Type, Group Size, InputDataQuery, etc.
- CWL functionalities not supported by our tool
  - I/O of array type
  - Sub workflows
  - Conditional workflows
  - Scattering workflows

CWL for DIRAC productions?

- We could imagine a CWL description where
  - A CWL Workflow corresponds to a DIRAC production
  - CWL sub-workflows correspond to DIRAC transformations
- In order to link the different transformations the Production System uses their Input and Output Queries
  - We could determine which sub-workflows are linked together based on their I/IO
  - For each sub-workflow we build a transformation where the OutputQuery is built from the job parameters and the InputQuery is built from the OutputQuery

-> However this looks quite specific to each users community