

Data-driven auto-configuration of the ATLAS reconstruction software

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Abstract. The central data reconstruction of the ATLAS experiment of LHC is a very challenging task, involving large-scale computing and a wide variety of data formats, applications and software versions. In 2009-2010, the ATLAS detector has recorded hundreds of millions of collision, single beam and cosmic events, during the commissioning period with continuously changing conditions that gradually evolved to a stable operation mode aiming at physics. In parallel, the ATLAS Collaboration processed comparable amounts of simulated data, and also produced a collection of sophisticated derived datasets. To handle all this complexity, we have developed a powerful data-driven auto-configuration mechanism and a unified configuration interface that provides a lot of flexibility: *Reco_trf*. The auto-configuration mechanism consists of inspecting the meta-data of each job's input file to automatically derive the configuration parameters relevant for the input format and the requested tasks. This also simplifies considerably the configuration of jobs from ordinary users, who can use the same script to run without modification on real or simulated data, on files belonging to different major production, using raw or derived input data of any format. Possible intermediate algorithms are automatically scheduled according to the content of the input file. *Reco_trf* is a so-called "job transformation" interface used for all centralized production tasks at CERN's Tier0 and on the Grid, and is also largely used by normal users. *Reco_trf* adds a lot of flexibility in the Production systems by allowing the execution of arbitrary python commands without building new software releases, while still bookkeeping this information in the production databases.

1. Introduction

The central data reconstruction of the ATLAS experiment of LHC is a very complex task, involving large-scale computing and a wide variety of data formats, applications and software versions. The ATLAS detector has recorded hundreds of millions of collision, single beam and cosmic events. During the commissioning quickly changing conditions had to be handled promptly. In parallel, large amounts of simulated data has been processed, and also produced a collection of sophisticated derived datasets.

The ATLAS reconstruction software has to work properly on different sites for different purposes: Prompt reconstruction at CERN computing farm (Tier0), reprocessing on a large-scale GRID (e.g. Tier1s), and user analysis (e.g. at home institutes, Tier2s). In addition it has to deal with different data formats. To handle all this complexity, a powerful data-driven auto-configuration mechanism and an unified configuration interface that provides a lot of flexibility (*Reco_trf*) have been developed.



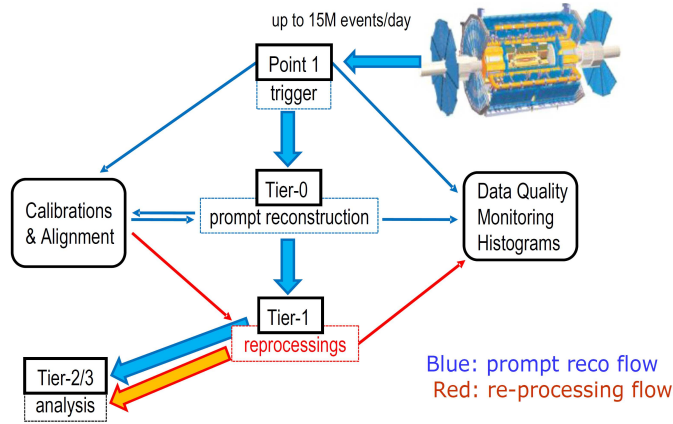


Figure 1. ATLAS data flow. Blue prompt reconstruction (Trigger, prompt reconstruction, data distribution). Red reprocessing.

2. Tasks for a fully automated job configuration

A fully automated job configuration has to fulfill at least the following tasks: It has to run in rather different environments, the Tier0 at CERN, the Tiers from the GRID, and it has to run on all institute machines for user analysis. It also has to set up different job configurations according to the different detail levels of the several ATLAS derived data sets.

2.1. ATLAS Data Flow

Events which have passed the ATLAS trigger system are reconstructed at the Tier0 at CERN during the prompt reconstruction (Fig. 1). This is first done in a so called express stream, which calculates some calibration constants. After the calibration loop, which takes maximum 36 hours, the newly calculated constants are used for the bulk reconstruction of physics streams. Parameters like the beam type, magnetic field, conditions tag, and others have to be configured for each job. These job options have to be configured before the ATLAS reconstruction software ATHENA can be launched.

New conditions or configuration parameters can be used for data reprocessing (re-reconstruction of raw data). A re-reconstruction of all data taken with an older release has to be run, for example after software updates which change the physics results. These reprocessing jobs are run on the GRID at different Tier1 centers. Additional tasks for the reconstruction software are user analysis, which are usually run at the different home institutes.

In order to configure identically *RecExCommon* (the ATLAS core code) for Tier0, Production System (Tier1s), and various user jobs, a common interface is needed. In addition, different job setups have to be specified running reconstruction jobs of Monte-Carlo simulation, cosmic muon events, single beam setup and collision data.

2.2. ATLAS Data Formats

The ATLAS Event Data Model (EDM) foresees different data formats with different detail levels and different sizes per event (Fig. 2): Detailed reconstructed objects are written in Event Summary Data (ESD) files, for detector and reconstruction studies. Smaller Analysis Object Data (AOD) files are derived from ESD, for physics analysis. TAG, dESD, and dAOD files are provided for further data reduction. TAG allows to select individual events. The dESD and dAOD formats have analysis-specific event filtering for further data reduction.

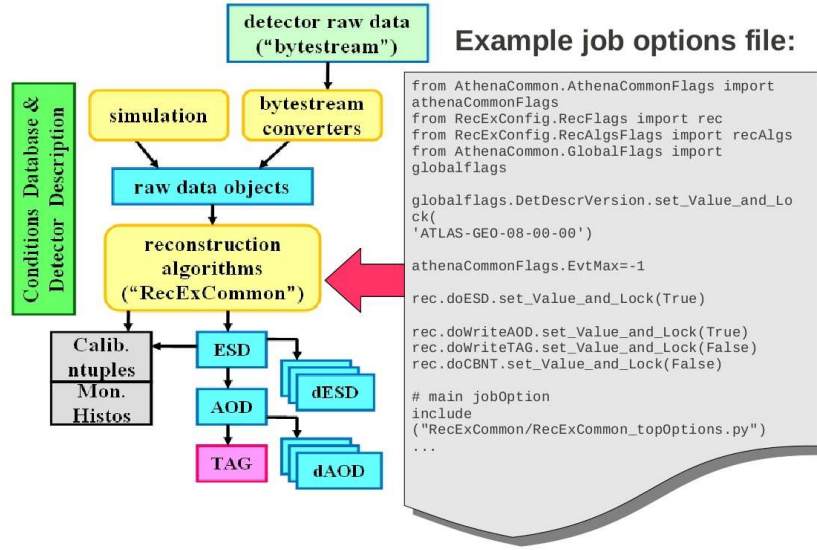


Figure 2. ATLAS data formats and example of a job option file (not using auto-configuration).

Input file specific setups are needed to handle the different data formats, in order to guarantee that only formats with lower detail level are derived from data samples with higher detail level (e.g. ESD \rightarrow AOD \rightarrow ...). Some algorithms are Monte-Carlo specific and can not be run on data samples. Automated steering of these algorithms can avoid wrongly configured job setups. This, amongst other configuration tasks, can be achieved by using an input file driven auto-configuration. In order to run complete reconstruction chains (ESD....dAOD) at once, the *Reco_trf* script can chain several processes.

3. Implementation

To fulfill the tasks described above, two tools have been implemented. An auto-configuration tool, which handles the setup of the configuration parameters by inspecting the meta-data of each input file and a job transform script *Reco_trf*, which is used as common interface to call *RecExCommon* from the different Tiers and users analysis in the same way.

3.1. Data-driven auto-configuration

The auto-configuration tool is a python based steering algorithm, which reads the meta-data of the input file and/or retrieves some information directly from the ATLAS conditions database to configure setup parameters. These parameters have to be set before a reconstruction job can be launched (Fig. 3 left).

The auto-configuration has to be added to the individual job option file. It can be run for prompt reconstruction at Tier0, large scale production jobs at the GRID and even for user analysis. To configure all possible items it can be called as:

```
autoConfiguration=everything,
```

or each item can be added separately to a list:

```
autoConfiguration=BeamType,InputFile,...
```

The auto-configuration tool does not override any user specification.

A brief overview of all items is listed below:

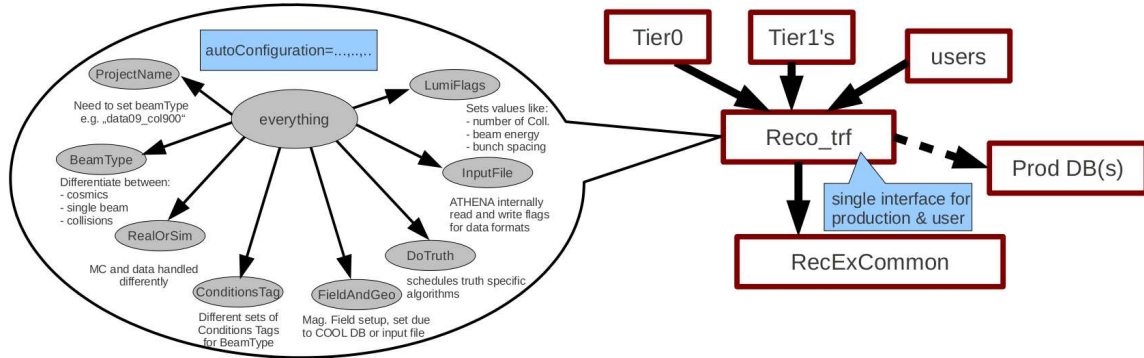


Figure 3. Left: Auto-configuration tool with specific configuration items. Right: Reco_Trf as common interface for different Tiers and users to call *RecExCommon*.

- **ProjectName:** Stored in data base. Can be used to extract the beam type and the beam energy.
- **BeamType:** Internal flag to differentiate between single beam, cosmic data, collision data, and heavy ion runs.
- **RealOrSim:** Differentiates data from Monte-Carlo samples.
- **ConditionsTag:** According to the magnetic field setups, the express and physics streams as well as for reprocessing various condition tags are available. The conditions tags are stored at the conditions data base and in the meta-data of derived data formats.
- **FieldAndGeo:** ATLAS has different geometry versions, which have to be set before launching a reconstruction job. The correct magnetic field setup has to be chosen according to the detector conditions.
- **DoTruth:** Used to steer Monte-Carlo specific algorithms.
- **InputFile:** The data format can be set according to the input file.
- **LumiFlags:** Number of collisions and bunch spacing can be configured according to meta-data.

3.2. *Reco_trf* script

Reco_trf is one single interface which can be used for "prompt" reconstruction (at Tier0), for MC production, reprocessing (e.g. Tier1), and for user jobs (Fig 3 right). Based on the input file and a list of output files, *Reco_trf* can automatically configure one or more chained athena job(s). Combining the data-driven auto-configuration and the common reconstruction interface simplifies the job configuration (like Fig. 2 right) to a few lines of code:

`Reco_trf.py`

```
inputBSFile=data09_900GeV.00142193.physics MinBias.merge.RAW.10evts.data
autoConfiguration=everything outputESDFile=myESD.pool.root
outputAODFile=myAOD.pool.root outputDESD_PIXELCOMMFile=PIXELCOMM.pool.root
```

In addition, the commands used to provide centrally produced datasets are stored in the production data base:

`Reco_trf.py AMI=f215`

So-called tags (e.g. f215), containing job option commands, can be run by the user to reproduce a specific reconstruction setup.

Table 1. Overview tools and tasks

tasks	auto-Configuration	reco jobTransform
data type	MC or data	-
data format	IS RAW, ESD, or...	chain of jobs
site	-	works T0, T1, user job
bookkeeping	auto configured values in DB	short commands (tags) stored in DB

4. Conclusion

The complexity and the different purposes of the ATLAS reconstruction software yield a solution requiring two separate tools for job submission and configuration. As described above, a combined development of a data-driven auto-configuration tool and a unified configuration interface *Reco_trf* has been chosen. Table 3.2 gives an overview of which task is covered by which tool.

Using the *Reco_trf* interface and the auto-configuration tool the amount of user/shifter interaction during data re-/reconstruction has been minimized. In combination with the stored tags in the production data base, it is very useful for bookkeeping centrally running reconstruction jobs (e.g. users can easily reproduce official reconstruction runs).

5. Acknowledgments

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