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ATLAS ITk Production Database Usage

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The ATLAS detector will undergo major upgrades for operation at the High Luminosity Large Hadron Collider. To cope with the high pile-up interaction rate (with up to 200 additional interactions per bunch crossing) a new radiation-hard inner tracking detector with a fast readout is required. Building this detector will involve a large-scale manufacture of parts following a complex production flow across institutes around the globe. To maintain the tight production schedule and ensure the detector is build to specifications, continuous oversight of the collaboration activities is essential. For this purpose, a Production Database was developed. It is as a fully functional distributed data management system used by more than 140 institutions in the collaboration. It will be in use for the remaining years of construction and ten years of operation. Usage of the database is described in these proceedings.

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	components	component types	test types	institutes	users
Strips	~900k	~200	~1000	~60	>300
Pixels	~100k	~200	~1100	~60	>450

Table 1: Current PDB contents (Sept 2024): number of registered components and types, test structures, institutes and users.

1. Introduction

The ATLAS experiment [1] will be upgraded for running at the High Luminosity Large Hadron Collider (HL-LHC). This includes a new inner tracking detector (ITk), which consists of layers of pixel[3] and strip[2] detectors. It will cover an area of ~180m^2, consisting of ~9,500 pixel modules and ~18,000 strip modules. Large scale production of many different parts requires a world-wide effort such that a Production Database (PDB) is vital to track the manufacturing process. The PDB was developed and is maintained by a company for the ATLAS ITk project. It is a cloud based mongoDB application with custom frontend and an Application Programming Interface (API).

2. Database Specification

The PDB stores information for each part (component) which is used to build the ITk detector. The evolution of each component through the steps of production (stages) is logged. Data on QC and QA tests is collected and associated with stages. The database also tracks the shipment and location of all parts. This is of particular important for materials that must be returned to CERN under dual-use export license agreements.

Up to 50 users can access the PDB concurrently from anywhere in the world. Maintenance is required during ITk construction and for around 10 years of HL-LHC operation.

3. Database Content

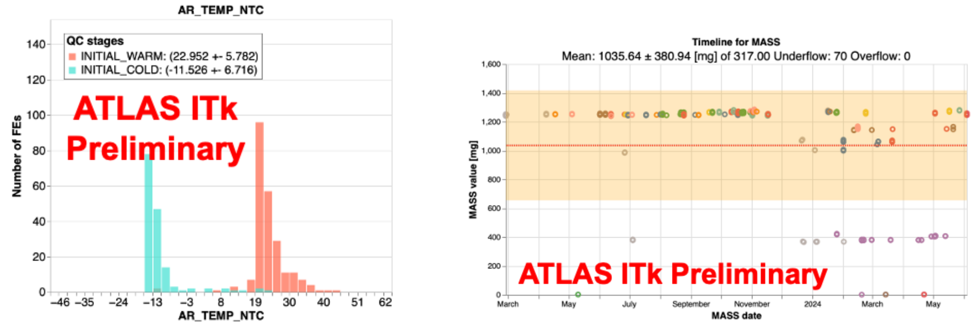
The PDB stores the production history per component including all associated QC and QA tests. By now, the generic data-structures for the majority of detector parts are implemented. As shown in table 1 around 400 component types and 2000 test types are defined. To date, it contains over one million component structures and ten million test structures.

Component information includes type, creation date and original institution, and properties which are updated over time, such as location, current stage and defects. Information on related database objects is linked such as tests and assembled components.

Test information is associated with a component stage. It includes a pass/fail flag, test date and institution, and measurement parameters and derived quantities. Information on related database objects such as the component is linked. All tests uploaded to a component are stored.

4. Database Interactions

Interactions with the PDB are handled via a centralised web-based application or API commands. Common database interactions are: component registration and test uploads; parameter



(a) Distribution of test parameters at different stages.

(b) Timeline of test parameter uploads.

Figure 1: Example data visualisations from PDB data.

updates; file attachments; and shipments. Filtered search requests extract specific information.

The PDB API is predominantly accessed by the ITk community via custom scripts combining PDB interactions. Scripts have been developed to simplify or automatate PDB interactions for users across production sites. Interface tools have been developed for GUIs, web-apps and notebooks. Many of these employ a common pythonic API wrapper which facilitates code development. All tools are made available via CERN's IT infrastructure, with scripts being distributed via git repositories and other tools hosted on CERN's online platforms.

5. PDB Uploads and Reporting

Technically data is uploaded via the API as filled schema in *json* format. If additional information is required then this is stored as attachments: small files are sent to binary storage while larger attachments are stored on EOS at CERN. This approach mitigates the price for cloud space provided by the PDB vendor.

Reporting is done outside the PDB framework by custom scripts. Reporting includes: monitoring production rates, location of parts, part production quality and overall yields. Reports are collected centrally and published for collaboration use and review. Example data visualisations using data retrieved from the PDB are illustrated in figures 1a and 1b.

Data integrity reports are made to ensure accuracy of the PDB information used for assessments of production quality. Automated reporting and alerting scripts are also deployed to help find and act upon any issues as they emerge. Furthermore, the evolution of the production rates over time can be used in simulations to predict or monitor deviations from the expected build schedule. Accurate simulations can also assist in developing mitigation strategies in case of delays in part availability.

References

[1] ATLAS Collaboration, 2008 JINST 3 S08003.

[2] ATLAS collaboration, TDR for the ATLAS Inner Tracker Strip Detector, CERN report CERN-LHCC-2017-005; ATLAS-TDR-025 (2017)

[3] ATLAS collaboration, TDR for the ATLAS Inner Tracker Pixels Detector, CERN report CERN-LHCC-2017-021; ATLAS-TDR-030 (2017)