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Poster

DQM4HEP – A generic online monitor for particle physics experiments

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DQM4HEP – A generic online monitor for particle physics experiments

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Abstract

Currently there is a lot of activity in R&D for future colliders. Multiple detector prototypes are being tested, each with different requirements for data acquisition and monitoring, which has generated different ad-hoc software solutions. We present DQM4HEP, a generic C++11 framework for online monitoring for particle physics experiments, and results obtained at several testbeams with detector prototypes using the framework as it was developed. We also present the currently ongoing work to integrate DQM4HEP and EUDAQ, which will allow these to work together as a complete and generic DAQ and monitoring system for any detector test, as part of AIDA-2020.

1 The AIDA-2020 Project and Common DAQ

AIDA-2020 is an EU project for advancing research and development infrastructures for particle physics detector development and testing, comprising 24 member countries and the CERN collaboration.

The project is split into Work Packages; Work Package 5 is "Data acquisition system for beam tests", aiming to develop hardware and software to improve the infrastructure and tools available for testing new detector components in beams, especially for testbeams involving more than one detector component.

The difficulty of this task is compounded by the various different detector types; different event data models, geometries, integration times, etc.make combining data from detector components difficult. The goal of common data acquisition is to meet this challenge by making portable software, reducing or eliminating the work of developing DAQ systems.

2 DQM4HEP – Programming Paradigms and Structures

The Data Quality Monitoring for High-Energy Physics (DQM4HEP) framework has recently been developed for use as an online monitoring and data quality tool for physics testbeams, written in the C++11 standard and using Qt4 for GUI libraries[1].

DQM4HEP is programmed with genericness as it's core paradigm, the architecture using algorithms independent of data type (int, float, ROOT object, etc.). This results in more flexible, portable and easily reusable software.

As of now, DQM4HEP does not have a standardised method to access data from the DAQ, but currently ongoing work will allow it interface with the DAQ via the EUDAQ program (see Section 6).

The generic nature of the framework lies in two core features:

- The ***Event Data Model abstraction*** allows the user to define the type and structure of an event and how serialisation should be handled.

The ***plugin system*** allows the inclusion of any user-defined classes via external libraries, such as to select the serialization process, online analysis, etc.

Each process can be linked over network via TCP/IP or HTTP

To implement this solution for a specific experiment, the user must define:

- The ***event type*** and ***serialisation method***
- The ***online analysis tasks***

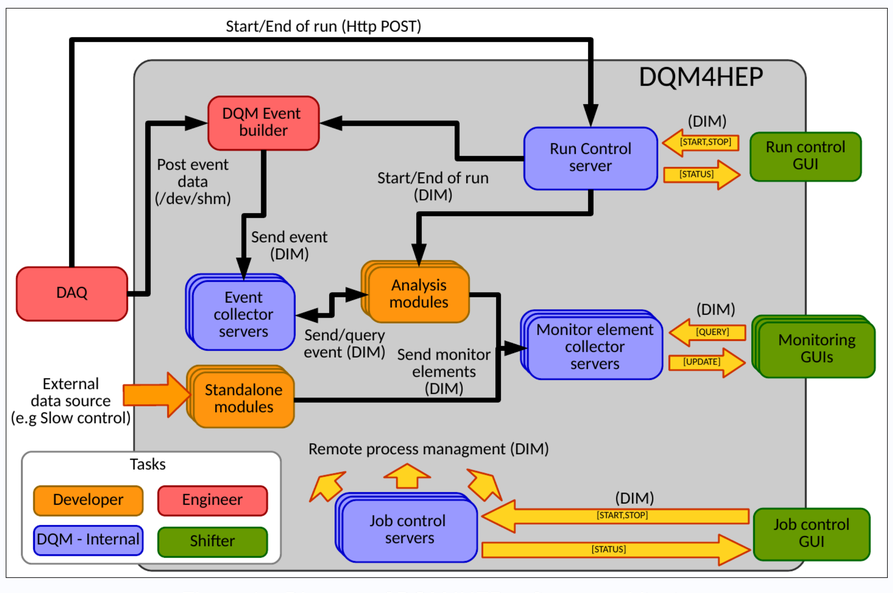

Figure 1 – Diagram of DQM4HEP software architecture

3 EUDAQ – A generic data acquisition framework

Originally designed as data acquisition software for EUDET-type beam telescopes, EUDAQ has grown to become a generic DAQ framework for other detector types. EUDAQ is designed so that the core is flexible and portable, and all hardware-specific components are separate and can be created, used or ignored at the user's discretion[2].

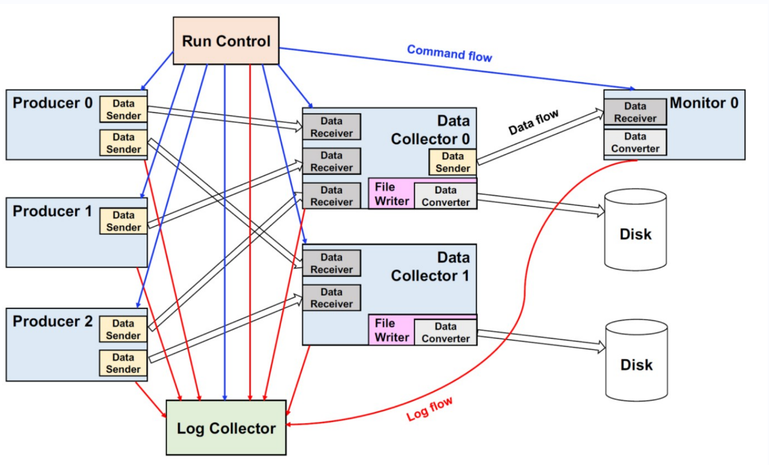

Figure 2 – Diagram of EUDAQ software architecture

The distributed process structure of EUDAQ allows individual elements to be swapped out, saving effort and development time, compared with custom-writing an *ad hoc* solution that has limited flexibility and portability.

While EUDAQ has an online monitoring component, it is not being discussed, and may be removed from future versions in favour of DQM4HEP.

4 DQM4HEP – Visualisation and GUI

Analysed data suitable are encapsulated in "monitor elements", which are the main unit of all graphs, charts, etc. The behavior, type and attributes are defined by the user during the writing of modules.

Monitoring Interface

- Manual or automatic updating
- Monitor elements are arranged in a folder- or tree-like structure
- The elements displayed are customisable via a dedicated GUI, or from a steering file
- The canvas can be custom-organised, with multiple canvases open at any time
- Monitor elements are interactive (e.g ROOT objects) so can be manipulated; zooming, scaling, fits, saving, etc.

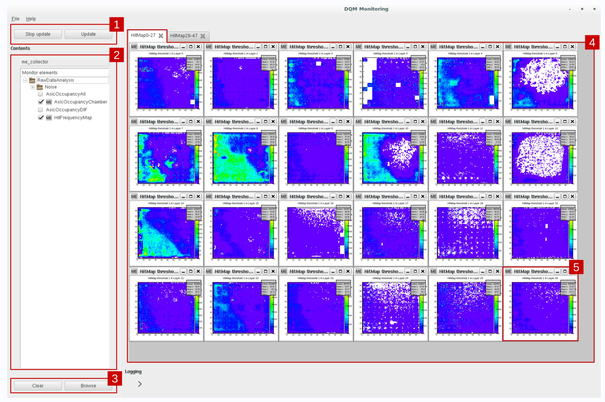

Figure 3 – A canvas of plots from an SDHCAL testbeam

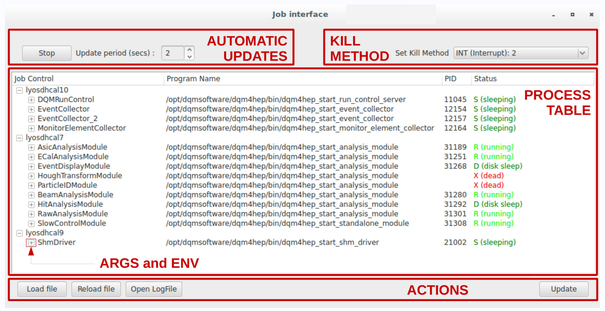

Figure 4 – Annotated picture of the job control server GUI

Job Control Server GUI

- Monitor and control the state of running processes
- Start/stop DQM4HEP processes
- View or change parameters used in analysis
- Manually control the system while running in offline mode (useful for testing analysis)
- Open logging files

5 Implementation in AIDA-2020 common testbeams

Several testbeams have been using DQM4HEP with various detector configurations and beam setups. Testbeams have taken place both at the CERN SPS and the DESY II beamlines, using the CALICE-AHCAL, EUTelescope, SDHCAL and SiWECAL detectors in various combinations.

DQM4HEP allowed shifters to quickly notice issues during the testbeam such as:

- Bad gas circulation
- Hardware faults such as dead or unresponsive channels, or noisy electronic from bad cables/connectors
- Incorrect beam configuration or placement

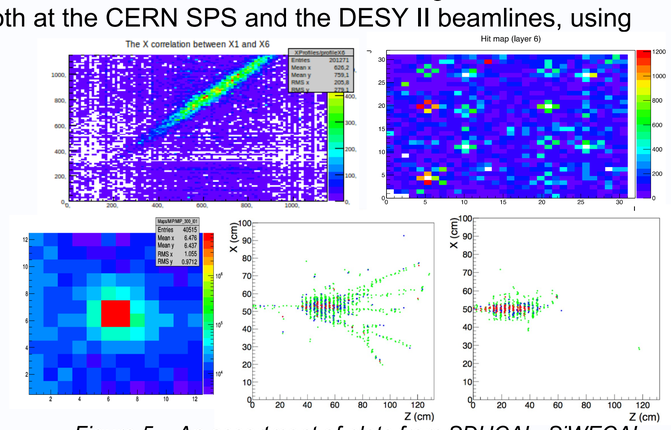

Figure 5 – An assortment of plots from SDHCAL, SiWECAL and AHCAL testbeams

6 DQM4HEP and EUDAQ – Working together

EUDAQ can be used as a generic DAQ, while DQM4HEP can be used as a generic data quality monitoring tool. Both are hardware-independent and when used in concert may form a fully-featured, generic and portable DAQ/DQM system, replacing most software used during beam tests.

Development of an online linkage is underway, which will allow EUDAQ to stream events to DQM4HEP processes online.

Once this is completed, the combined EUDAQ/DQM4HEP system will allow a fully-generic DAQ and monitoring system. The only detector-specific components will be:

- **EUDAQ Producer** and **DataConverterPlugin**
- **Event type** and **serialisation method**
- **Online anaylsis** tasks and modules

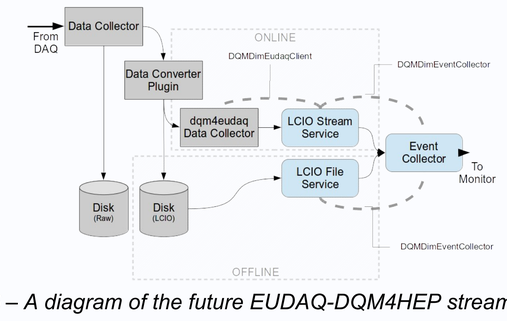

Figure 6 – A diagram of the future EUDAQ-DQM4HEP streaming

7 Conclusion

This generic and modular framework for data quality monitoring systems was created with full flexibility across the experiment's setup, including the plugin system, event data model abstraction, tools to develop dedicated and user-defined implementations (DAQ, serialisation and analysis interfaces)

The framework has been tested in dedicated implementations for two combined testbeams, producing successful and useful results during multiple campaigns both at CERN-SPS and DESY II.

The combination of EUDAQ and DQM4HEP fulfills milestone MS67 "Data quality monitoring tools ready" for Work Package 5 of the AIDA-2020 project.

References, acknowledgements and further information

[1] Eté, R. (2016, February 3). *Data Quality Monitoring for High Energy Physics (DQM4HEP)*. Retrieved August 30, 2016, from http://tinyurl.com/dqm4hep

[2] Liu, Y. (2017, June). *EUDAQ2 User Manual*. Retrieved September 8, 2017, from https://tinyurl.com/EUDAQmanual

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