DQM4HEP – A generic online monitor for particle physics experiments

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12 September 2017

The AIDA-2020 Advanced European Infrastructures for Detectors at Accelerators project has received funding from the European Union’s Horizon 2020 Research and Innovation programme under Grant Agreement no. 654168.

This work is part of AIDA-2020 Work Package 5: Data acquisition system for beam tests.


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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 experiments, written in the C++11 standard and using Qt for GUI libraries. DQM4HEP is programmed with generics as its 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 for EUDAQ, 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

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. 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 reusability 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

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 SIN HCAL 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

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.

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 analysis tasks and modules

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 campaign tests both at CERN-SPS and DESY II. The combination of EUDAQ and DQM4HEP fulfills milestone M6/7 “Data quality monitoring tools ready” for Work Package 5 of the AIDA-2020 project.

References, acknowledgements and further information


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The authors would like to thank the CERN-SPS and DESY II beamline staff, and the Forschung mit Lepton Collidern (FLC) group at DESY.