DQM for SDHCAL detector - Status report

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Framework overview

DQM4HEP : an online monitoring system for data quality

Key points

- Event and histogram distributed system : server/client paradigm
- Set of interfaces for data analysis, adapted to DQM purpose
- Visualization interface (Qt GUI)
- Large scale remote process management
- Generic IO support for any edm (opt. LCIO)
- Full size HEP experiment to single detector prototype design
- Interface to generic online event buidler (levbdim)
- ELog interface

Set of interfaces inspired from CMS DQM system (monitor elements, collectors).

Application flow inspired from ALICE DQM system, AMORE (cycles).

Framework overview

DQM4HEP packages

One location : `https://github.com/DQM4HEP`
Webpage : `dqm4hep.github.io`

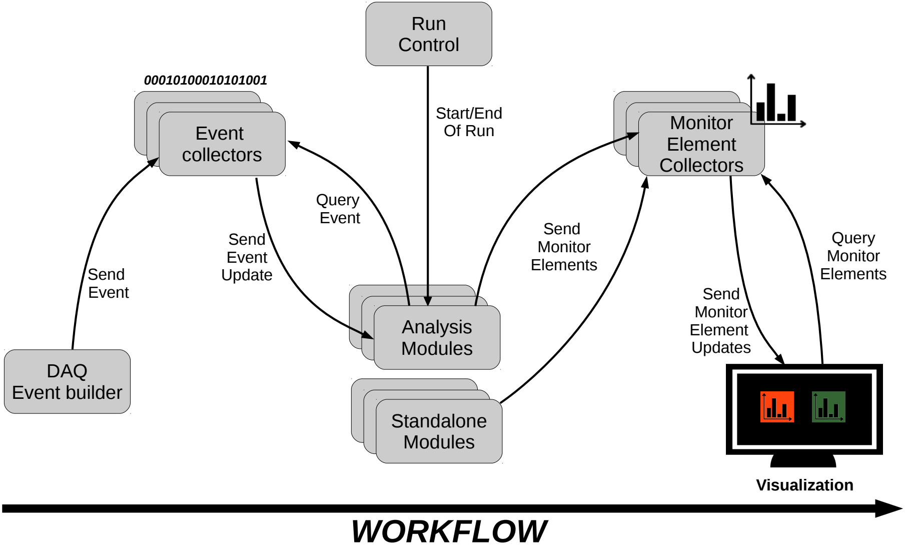
The main package : DQM4HEP

Installation package for sub-packages (CMake).
Sub-packages :

- **dim** : Distributed Information Management (Delphi). Manage client/server communications
- **dimjc** : DIM Job Control (L. Mirabito). Remote process management using dim.
- **levbdim** : DIM online event builder (L. Mirabito). Generic online multi-detector event builder
- **jsoncpp** : Json I/O for dimjc ad levbdim
- **log4cxx** : logging library (use apt-get)
- **DQMCore** : Core part of the DQM system. Client/server interfaces, analysis, IO, run control interface, plugin management ...
- **DQMViz** : Qt visualization interfaces. Job control gui client, monitoring gui client, run control server gui (standalone).
- **xdrstream** : Generic Xdr serializer
- **xdrlcio** : Lcio serialization using xdrstream (buffer -> socket)
- **DQM4ILC** : ILC specific implementation (marlin helper, lcio streamer, lcio file service, etc ...)

Framework overview

DQM4HEP workflow



Framework overview

Online builder interface

New package (optionnal) in DQM4HEP : levbdim
Use `-DBUILD_EVB=ON` cmake flag to compile levbdim support

Generic online event builder based on DIM

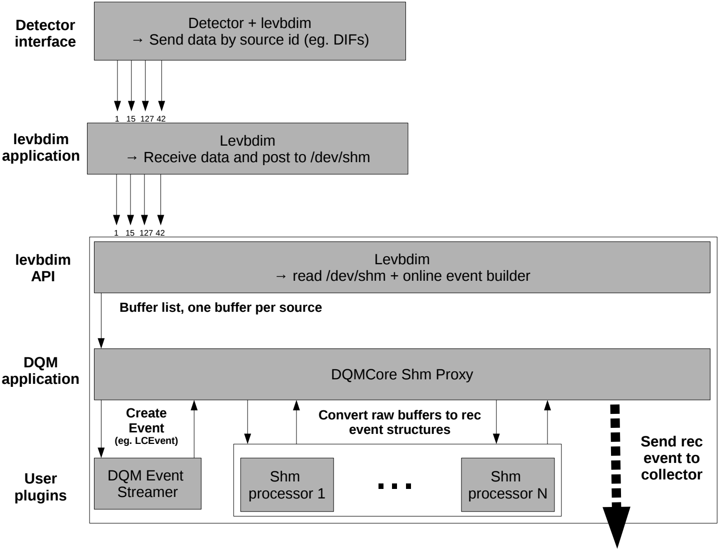
- Uses DIM sockets to collect raw data from different source and dump them in shared memory
- Groups all data packets into buffer list by reading them into shared memory
- Pass them to user callback functions

Developed by the SDHCAL team for future combined test beams with ECAL.
Can managed many subdetectors (ECAL, HCAL, Cherenkov, TPC, ...)

Interface implemented in DQMCore to feed the DQM system with raw data.
Application provided and use plugin manager to get user raw data converters to event interface

Framework overview

Online builder interface


Detector interface
Detector + levbdim
→ Send data by source id (eg. DIFs)
1 15 127 42
levbdim application
Levbdim
→ Receive data and post to /dev/shm
1 15 127 42
levbdim API
Levbdim
→ read /dev/shm + online event builder
Buffer list, one buffer per source
DQM application
DQMCore Shm Proxy
Create Event (eg. LCEvent)
Convert raw buffers to rec event structures
Send rec event to collector
User plugins
DQM Event Streamer
Shm processor 1
. . .
Shm processor N

Framework overview

Module applications - analysis module

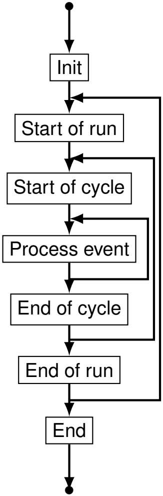
Purpose

- Receive online events from a collector server and process them
- Produce monitor elements (histograms, scalars, generic TObject)
- Follow the run control signals (SOR, EOR)

- **Init** : Initialize the application : load dlls, declare services, etc ... Wait for a SOR
- **Start of run** : start cycles loop, open archive
- **Start of cycle** : start a cycle of '*process event*'
- **Process event** : Process incoming event, fill monitor elements, etc ...
- **End of cycle** : send subscribed monitor elements, update archive (opt).
- **End of run** : Wait for SOR, close archive (opt).
- **End** : Clean and exit module.

Helpers to evaluate data quality : `DQMQualityTest` (ie. Kolmogorov or χ^2 test)
Quality test results sent together with the monitor elements to the collector

To implement online DQM analysis, user must implement the `DQMAnalysisModule` interface. A shared library must be build and loaded in the application using the plugin system (`export DQM4HEP_PLUGIN_DLL=libMyModule.so`).



Analysis module application flow

Framework overview

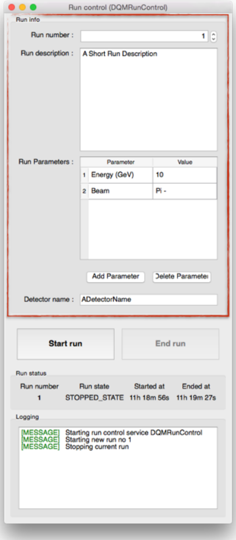
Gui visualisation

Gui interfaces for DQM client developed :

- Run control, job control, online monitoring
- Written with Qt4 framework
- Easily configurable with json and xml.

Framework overview

Run Control GUI



Run number : 1

Run description : A Short Run Description

Run Parameters :

	Parameter	Value
1	Energy (GeV)	10
2	Beam	Pi -

Detector name : ADetectorName

Run status

Run number	Run state	Started at	Ended at
1	STOPPED_STATE	11h 18m 56s	11h 19m 27s

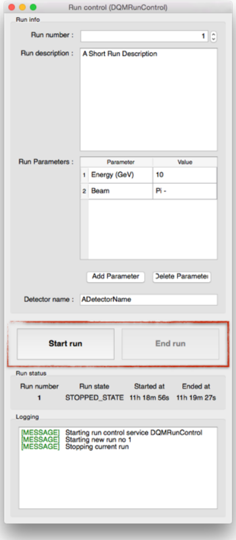
Logging

```
[MESSAGE] Starting run control service DQMRunControl
[MESSAGE] Starting new run no 1
[MESSAGE] Stopping current run
```

- Parametrisation of run with run number, detector name, run description and parameters
- Send SOR and EOR signals
- Control run status (State, Started/Stopped time)
- Every action is logged for easy information overview

Framework overview

Run Control GUI



Run control (DQMRunControl)

Run info

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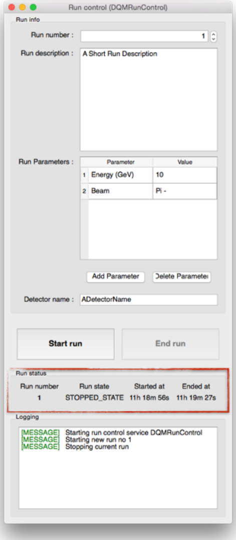
Framework overview

Run Control GUI



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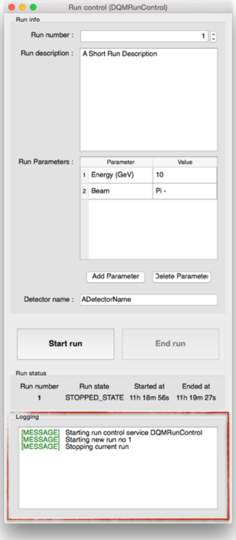
Framework overview

Run Control GUI



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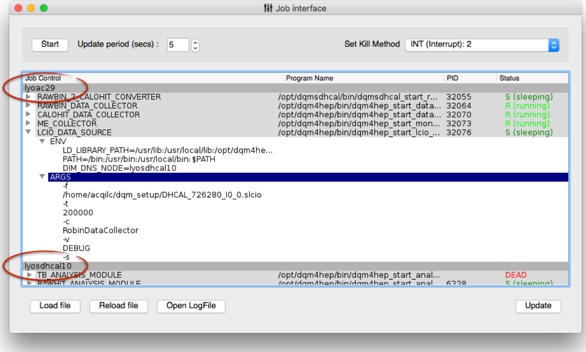
Framework overview

Job Control GUI



Update period (secs) : 5

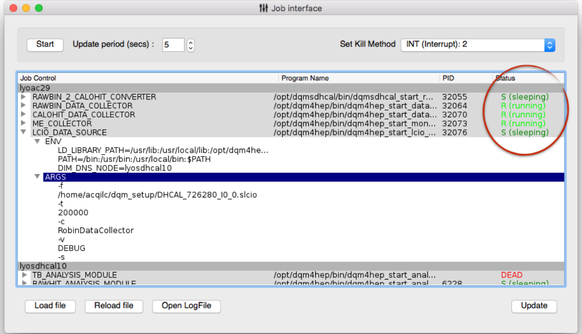
Set Kill Method INT (Interrupt): 2

Job Control	Program Name	PID	Status
lyoac29			
▶ RAWBIN_2_CALOHIT_CONVERTER	/opt/dqmsdhcal/bin/dqmsdhcal_start_r...	32055	S (sleeping)
▶ RAWBIN_DATA_COLLECTOR	/opt/dqm4hep/bin/dqm4hep_start_data...	32064	R (running)
▶ CALOHIT_DATA_COLLECTOR	/opt/dqm4hep/bin/dqm4hep_start_data...	32070	R (running)
▶ ME_COLLECTOR	/opt/dqm4hep/bin/dqm4hep_start_mon...	32073	R (running)
▼ LCIO_DATA_SOURCE	/opt/dqm4hep/bin/dqm4hep_start_lcio_...	32076	S (sleeping)
▼ ENV			
LD_LIBRARY_PATH=/usr/lib:/usr/local/lib:/opt/dqm4he...			
PATH=/bin:/usr/bin:/usr/local/bin:$PATH			
DIM_DNS_NODE=lyosdhcal10			
▼ ARGS			
-f			
/home/acqilc/dqm_setup/DHCAL_726280_I0_0.slcio			
-t			
200000			
-c			
RobinDataCollector			
-v			
DEBUG			
-s			
lyosdhcal10			
▶ TB_ANALYSIS_MODULE	/opt/dqm4hep/bin/dqm4hep_start_anal...		DEAD
▶ RAWHIT_ANALYSIS_MODULE	/opt/dqm4hep/bin/dqm4hep_start_anal...	6228	S (sleeping)

- Load and display a list of applications (Collectors, Modules, etc.) available on different hosts

Framework overview

Job Control GUI



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DIM_DNS_NODE=lyosdhcal10			
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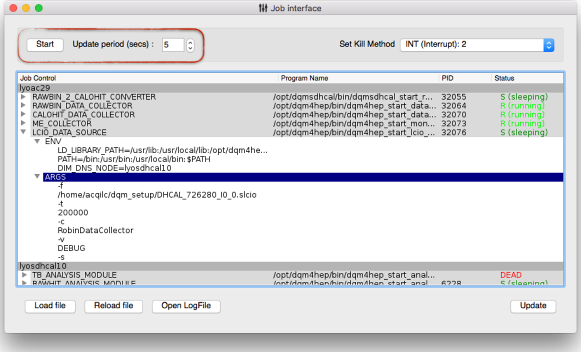

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Framework overview

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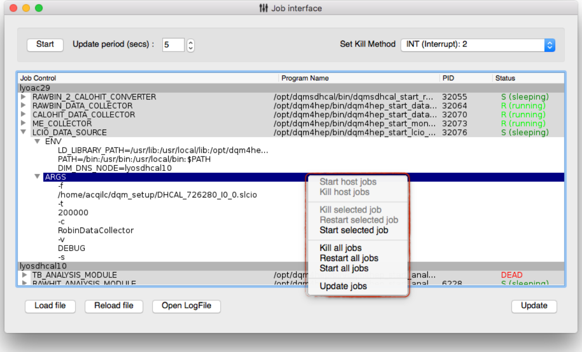

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200000			
-c			
RobinDataCollector			
-v			
DEBUG			
-s			
lyosdhcal10			
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Framework overview

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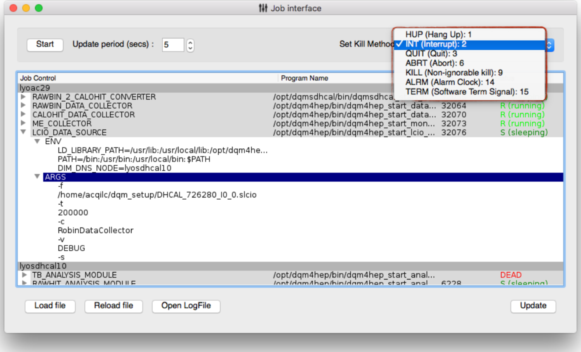

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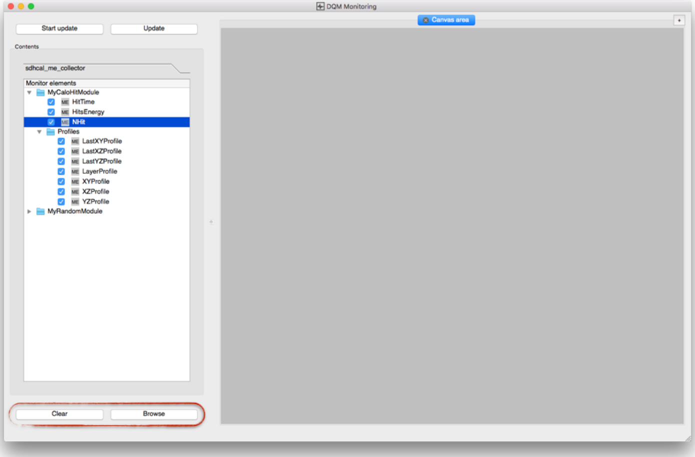
- Displays informations(Name, Host, PID, Status, etc.) about applications
- Infos can be updated in "real time"
- Manage Applications (Start/Kill/Restart) with contextual menu
- Kill method can be adjusted

Framework overview

Monitoring Gui + Browser



Framework overview

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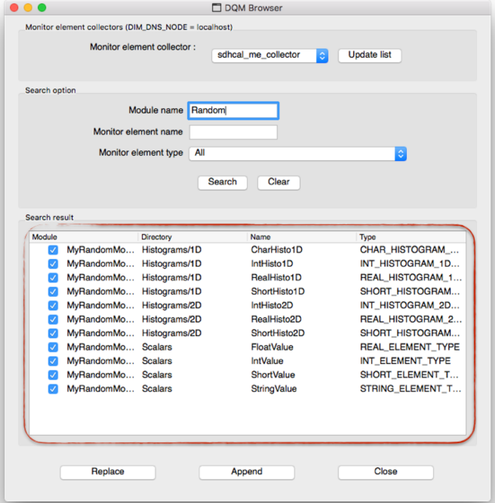


DQM Browser

Monitor element collectors (DIM_DNS_NODE = localhost)

Monitor element collector : sdhcal_me_collector

Search option

Module name: Random

Monitor element name:

Monitor element type: All

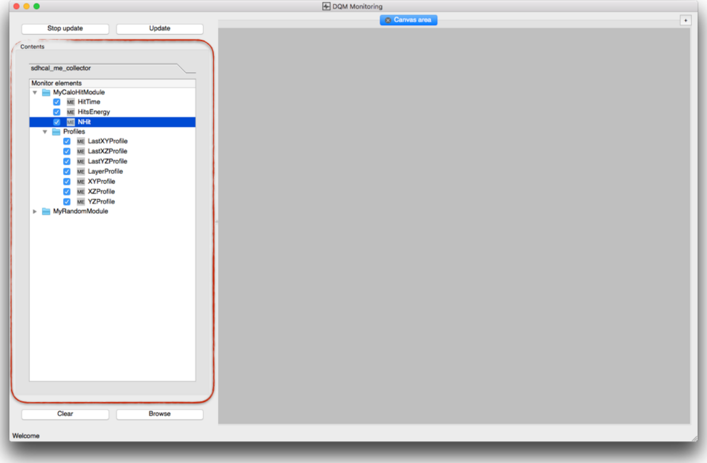
Search result

	Module	Directory	Name	Type
☑	MyRandomMo...	Histograms/1D	CharHisto1D	CHAR_HISTOGRAM_...
☑	MyRandomMo...	Histograms/1D	IntHisto1D	INT_HISTOGRAM_1D...
☑	MyRandomMo...	Histograms/1D	RealHisto1D	REAL_HISTOGRAM_1...
☑	MyRandomMo...	Histograms/1D	ShortHisto1D	SHORT_HISTOGRAM...
☑	MyRandomMo...	Histograms/2D	IntHisto2D	INT_HISTOGRAM_2D...
☑	MyRandomMo...	Histograms/2D	RealHisto2D	REAL_HISTOGRAM_2...
☑	MyRandomMo...	Histograms/2D	ShortHisto2D	SHORT_HISTOGRAM...
☑	MyRandomMo...	Scalars	FloatValue	REAL_ELEMENT_TYPE
☑	MyRandomMo...	Scalars	IntValue	INT_ELEMENT_TYPE
☑	MyRandomMo...	Scalars	ShortValue	SHORT_ELEMENT_T...
☑	MyRandomMo...	Scalars	StringValue	STRING_ELEMENT_T...

- Browser to build histograms selections to display
- Search Function to refine selection

Framework overview

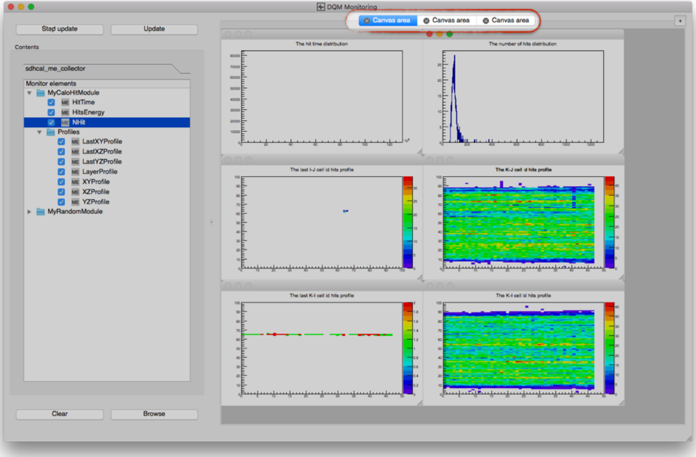
Monitoring Gui + Browser



- List of histograms added from Browser

Framework overview

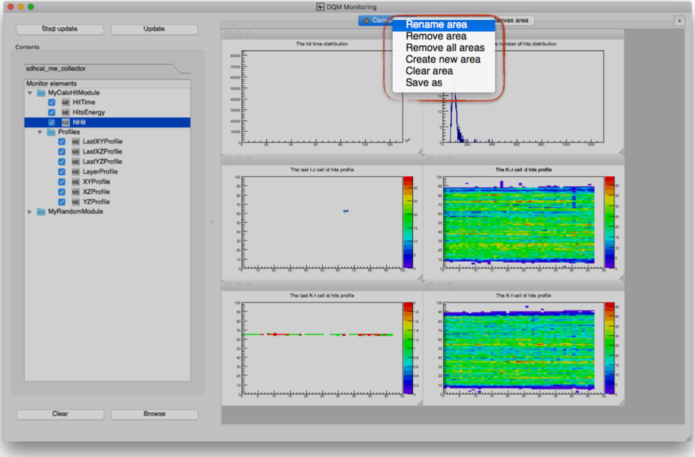
Monitoring Gui + Browser



- Multiple canvas area available

Framework overview

Monitoring Gui + Browser



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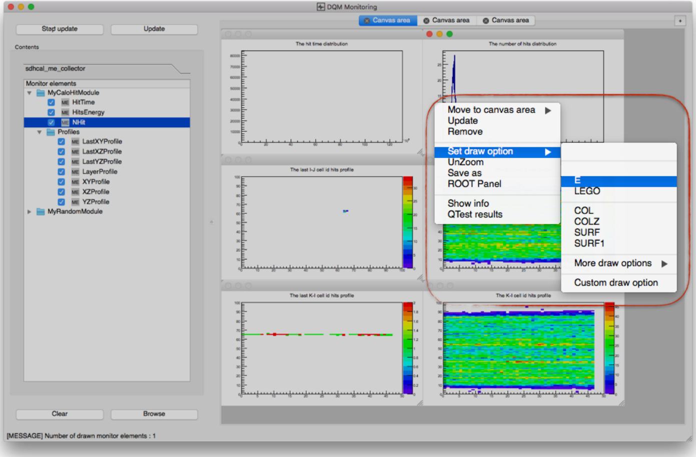
Framework overview

Monitoring Gui + Browser

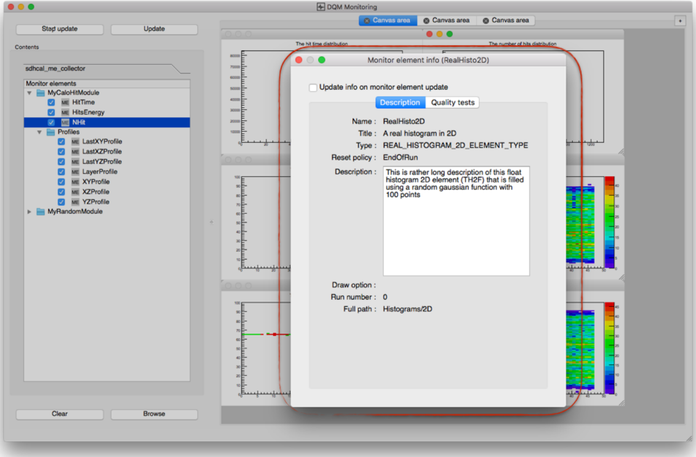


[MESSAGE] Number of drawn monitor elements : 1

- Multiple canvas area available
- Real ROOT histograms (Can be fitted, zoomed, etc.)

Framework overview

Monitoring Gui + Browser



□ Update info on monitor element update

Name : RealHisto2D

Title : A real histogram in 2D

Type : REAL_HISTOGRAM_2D_ELEMENT_TYPE

Reset policy : EndOfRun

Description : This is rather long description of this float histogram 2D element (TH2F) that is filled using a random gaussian function with 100 points

Draw option :

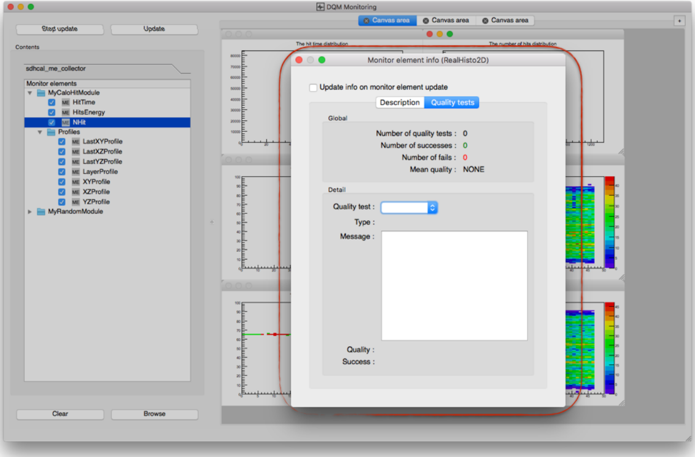
Run number : 0

Full path : Histograms/2D

- Multiple canvas area available
- Real ROOT histograms (Can be fitted, zoomed, etc.)
- Histograms descriptions and Quality

Framework overview

Monitoring Gui + Browser



□ Update info on monitor element update

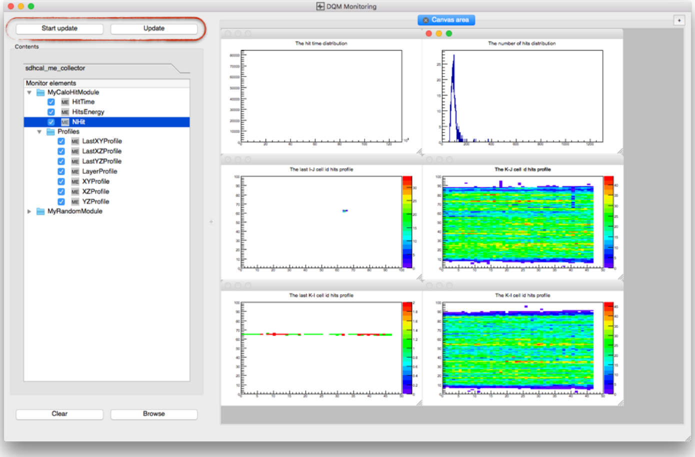
Number of quality tests : 0
Number of successes : 0
Number of fails : 0
Mean quality : NONE

Quality test :
Type :
Message :
Quality :
Success :

- Multiple canvas area available
- Real ROOT histograms (Can be fitted, zoomed, etc.)
- Histograms descriptions and Quality

Framework overview

Monitoring Gui + Browser



- Multiple canvas area available
- Real ROOT histograms (Can be fitted, zoomed, etc.)
- Auto Update

DQM for SDHCAL prototype

Implements online analysis for the SDHCAL m^3 prototype.

Development made in parallel with the DQM4HEP framework
Use last DQM4HEP version (currently v04-03-00)

Additional software used :

- **Trivent** : standalone and generic time clustering.
- **CaloSoftWare** : various SDHCAL analysis tools from A. Steen :
  - Calo Hit clustering
  - Global and local (Hough) tracking
  - Interaction finder
  - Tools for efficiency/multiplicity estimate

The DQM for SDHCAL provides :

- Analysis tools for online data treatment
- Data conversions (raw buffer -> raw calo hit -> calo hit)
- Shm processors to SDHCAL DAQ
- Set of DQM modules

DQM for SDHCAL prototype

SDHCAL analysis tools

Online data feeding

Implementation of shm plugin (levbdim) with LCEvent data structure :

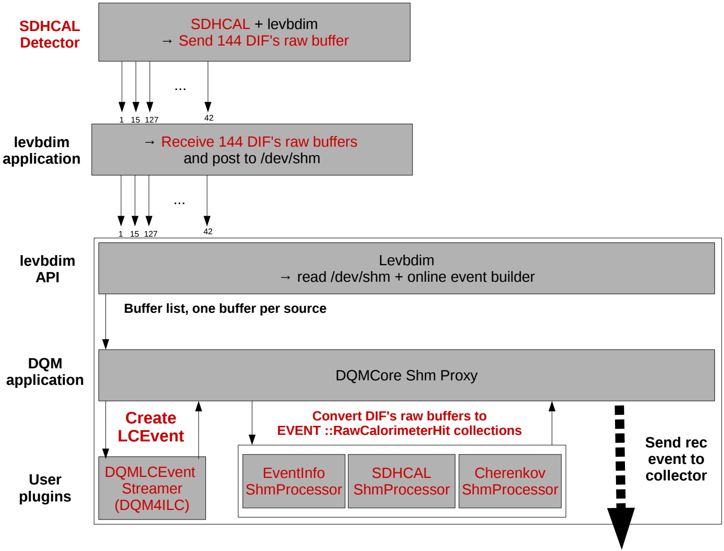
- Event info : fill LCEvent information
- SDHCAL RawCalorimeterHit collection creation : from DIFs raw buffer to hits
- Cherenkov RawCalorimeterHit collection creation : from BIF (generally DIF id=3) to cherenkov hits

Send LCEvent to event collector !

Missing : SiWECAL shm plugin. Which raw data structure ?
Need conversion to RawCalorimeterHit format (cellID + energy + time stamp)

DQM for SDHCAL prototype

Online builder - SDHCAL implementation


SDHCAL Detector
SDHCAL + levbdim
→ Send 144 DIF's raw buffer
1 15 127 ... 42
levbdim application
→ Receive 144 DIF's raw buffers and post to /dev/shm
1 15 127 ... 42
levbdim API
Levbdim
→ read /dev/shm + online event builder
Buffer list, one buffer per source
DQM application
DQMCore Shm Proxy
Create LCEvent
Convert DIF's raw buffers to EVENT ::RawCalorimeterHit collections
Send rec event to collector
User plugins
DQMLCEvent Streamer (DQM4ILC)
EventInfo ShmProcessor
SDHCAL ShmProcessor
Cherenkov ShmProcessor

DQM for SDHCAL prototype

SDHCAL analysis tools

Event classifier

Class `EventClassifier` from DQMSDHCAL package

Interface to particle ID for online analysis. User needs to implements `processEvent(LCEvent*)` and decide for one of the following tag :

`Undefined, noise event, beam muon, cosmic muon, charged/neutral em shower, charged/neutral had shower`

Various analysis in SDHCAL DQM modules uses this plugin to perform particle id dependent analysis. SDHCAL Event classifier implemented.

Missing : SiWECAL + SDHCAL event classifier. In particular, electrons will be stopped before entering the SDHCAL -> different identification

SDHCAL analysis tools

Electronics mapping

Class `DQMElectronicsMapping` from DQMCore package

Transparent conversion of (DIF id, Asic id, Channel ID) ↔ (I, J, layer) ↔ (x, y, z)
SDHCAL electronics mapping implemented (with Hardroc2).

Missing : SiWECAL electronics mapping

LCCollection converters

Class `DQMDataConverter<LCCollection, LCCollection>` from DQMCore package

Transparent conversion from one collection to another.
SDHCAL data convert implemented. Converts RawCalorimeterHit collection (DIF, Asic, Channel) to CalorimeterHit collection (x, y, z)

Missing : SiWECAL data conversion (same io types)

DQM for SDHCAL prototype

SDHCAL analysis tools

Trivent module

Class `DQMAnalysisModule` from DQMCore package and `LCTriventListener` from Trivent package

`DQMTriventModule` is a base class that runs Trivent on *trigger* event → split the input event into *time clustered* event representing each a particle event.

Global idea :

- Fill Trivent with input collections
- Run Trivent
- For each clustered event : convert each LCCollection using data converter plugins and notify user that a physics event has been reconstructed

In DQMSDHCAL, most of the analysis modules inherits this module to analyze directly particle per particle events

Modules

Modules

Module

Some modules are already available, they were developed for the SDHCAL but some of them will be easily adaptable to other detectors

- Slow Control : HV, LV, P, T
- Beam Analysis Module : Spill length, particle and clusters Rates
- Asic Analysis Module : Efficiency/Multiplicity per Plane/Asic
- Raw Analysis Module : Plane/DIF/Asic/Channel
- Hit Analysis Module study : Number Of hits per threshold
- Particle Identification : Particle counters and summary
- Event Display : Display per particle type
- Tracking (Hough Transform) : Track analysis

Modules

Modules - Slow Control

Purpose

Uses Dim to collect information about the SlowControl services registered
Completely standalone module. Easy implementation for SiWECal

Monitor Elements

Currently implemented with :

- HV Info
  - Expects a list of HV module/channel
  - Can use wildcard to get a list of services
  - Each HVInfo expects 1 integer (chID) and 4 floats : Vset, Iset, Vout, Iout
- LV Info - expects 3 floats : Vset, Vread, IRead
- Temperature Info - expects 1 float

Histograms can then be quickly configure via an xml file to display :

- Evolution of the variables in time as a TGraph
- Instantaneous values as a string

Modules

BeamAnalysisModules

Purpose

Inherits from `DQMAnalysisModule`, no time clusterisation
Can be adapted to SiWECal if providing electronics mapping and geometry conversion.

Monitor Elements

- Instant rate for the current spill for each particle (TScalar)
- Mean rate for the current run for each particle (TScalar)
- Mean number of clusters vs global rate (TProfile)
- Time between two spill (TH1, TScalar)
- Time between two ramfull (TH1, TScalar)
- Spill Length (TH1, TScalar)
- Number of ramfull per Spill (TH1, TScalar)
- Acquisition Time (TH1)

Modules

EventDisplayModule

Purpose

Inherits from `DQMTriventModule` and analyze particle per particle events.
Use CaloSoftWare to find and analyze muons (beam and cosmic ones) in detector.
Can be adapted to SiWECal by providing electronics mapping and geometry conversion.

Monitor Elements

List of Monitor Elements available for each particle type :

- Display last found particle over XY, ZX, ZY plans or in 3D
- Display all particles from the current cycle over XY, ZX, ZY plans or in 3D

Can also be parametrised through xml config file to set drawing option (color, marker etc.)

Modules

HitAnalysisModule

Purpose

Inherits from `DQMTriventModule`.
Use CaloSoftWare to find and analyze clusters in detector.
Not adaptable to SiWECal.

Monitor Elements

- Number of hits for each threshold (0,1,2) in whole detector (TH1)
- Number of hits for each threshold (0,1,2) for each layer (TH1)
- Hit Map for each threshold (0,1,2) for each layer (TH2)

Modules

HoughTransformModule

Purpose

Inherits from `DQMTriventModule` and analyze particle per particle events.
Use CaloSoftWare to find and analyze tracks in detector.
Could be adapted to SiWECal if combined analysis

Monitor Element

List of Monitor Elements already available for each particle type :

- Number of reconstructed track (TH1)
- Chi2 track distribution (TH1)
- Track length (in layers) (TH1)
- Mean cluster size per tracks (TH1)
- Track theta angle distribution (TH1)
- Track phi angle distribution (TH1)

Modules

RawAnalysisModule

Purpose

Inherits from `DQMAnalysisModule`, no time clusterisation.
Takes RawCalorimeterHits in input.
Can be adapted to SiWECal if providing electronics mapping and geometry conversion.

Monitor Element

- Occupancy of each channel (TH1)
- Occupancy of each DIF (TH1)
- Occupancy of each Chamber (TH1)
- Occupancy Map of Asic vs DIF (TH2)
- Per Layer :
  - HitMap for each threshold (TH2)
  - For each DIF in the layer :
    - Occupancy per Asic (TH1)
    - Number of hits per Asic for each threshold (TH1)

Modules

AsicAnalysisModule

Purpose

Inherits from `DQMTriventModule` and analyze particle per particle events.
Use CaloSoftWare to find and analyze muons (beam and cosmic ones) in detector.
Can be adapted to SiWECal by tunning some parameters in xml only

Monitor elements

- Layer efficiency (thr 1,2,3) (TH1)
- Layer multiplicity (TH1)
- Per layer :
  - Asic efficiency map (thr 1,2,3) (TH2)
  - Asic multiplicity map (TH2)
- Asic efficiency (thr 1,2,3) (TH1)
- Asic multiplicity (TH1)
- Asic stacked efficiency map (thr 1,2,3) (TH2)
- Asic stacked multiplicity (TH2)
- N track per asic (TH1)

Modules

TestBeam Deployment

Foreseen deployment

- Multiple event collectors (at least 2)
- Multiple monitor element collector (2 or 3)
- Analysis split among available PCUs
- How many PCUs ? 1 DAQ + 2 DQM
- How many screens ? (At least 2 or 3 would be great)

Modules

Conclusion and questions

Conclusion

- Online DQM for SDHCAL developed using DQM4HEP
- Finalizing monitoring depending on your remarks
- Need SiWECal implementation for upcoming beam test in June.

Needs from SiWECal team

- Electronics mapping. Geometry conversion of (DIF, Roc, Channel) $\leftrightarrow$ (I, J, layer) $\leftrightarrow$ (x,y,z)
- Data conversion :
  - from raw data from each DIF (ECAL format) to RawCalorimeterHit collection (DIF, Roc, Channel, time, energy)
  - from RawCalorimeterHit to CalorimeterHit using electronics mapping
- Shm processor using the raw data conversion
- Common analysis tools :
  - Combined particle ID functions

If you want to see more things implemented in the DQM system for the ECal, let us know !