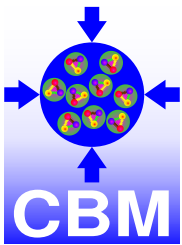
A data Quality-Assurance framework for online and offline applications for the CBM experiment

CHEP2024, Kraków, Poland



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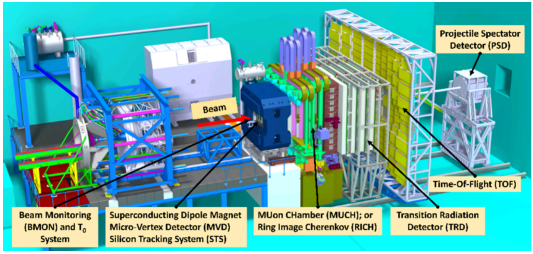
October 22, 2024

The Compressed Baryonic Matter experiment

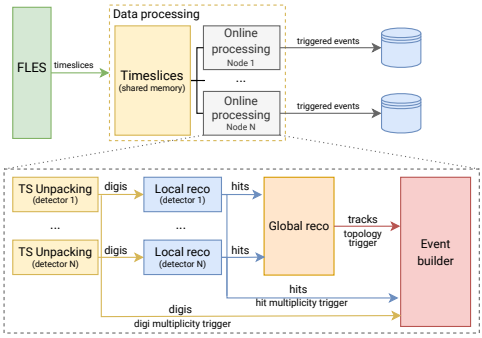


CBM@FAIR (Darmstadt, Germany):

- exploration of QCD phase diagram at large μ_B
- fixed-target setup, under construction (available from 2028, test mini-CBM setup takes data)
- high interaction rates – 10 MHz
- free-streaming readout, software event triggering

Online data processing:

- triggering and storing interesting events
- full event reconstruction
- reduction of data rates from 1TB/s to 10GB/s



Data quality assurance in CBM

QA-task(module) – fixed set of reference histograms:

- detector subsystem calibration and occupancy
- reconstruction algorithms performance

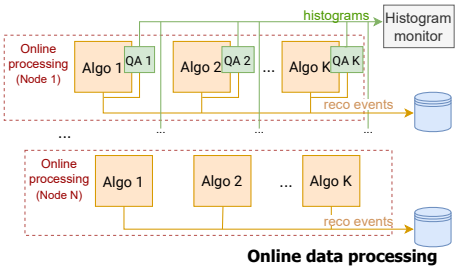
⇒ **data-driven automatic and systematic bug/malfunction monitoring**

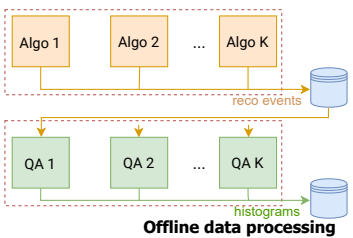
Online scenario:

- processing data from each reco algorithm for **selected** nodes
- **performance-critical** ⇒ limited number of histograms
- monitoring (no analysis step)

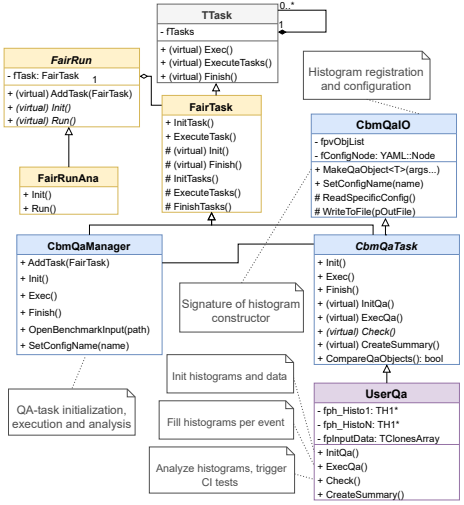
Offline scenario:

- post-processing of stored reco events
- available for simulated data as well
- analysis step: data-driven problem detection and validation (CI)



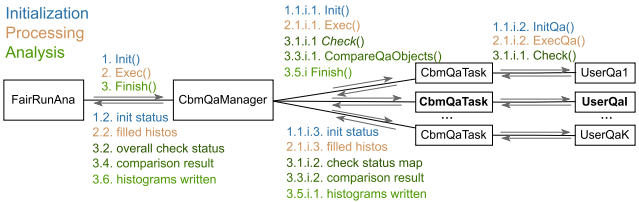


Offline scenario for data QA



Framework:

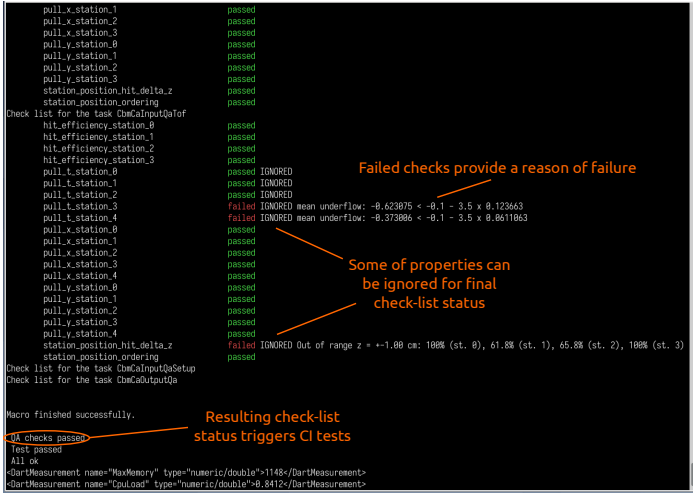
- a set of histograms, filling approach, validation criteria of histogram properties from user
- tasks are processed sequentially on a single thread
- all details are unified and automatised



Analysis step:

- check of histogram properties, requested by user
- compare of current histograms with the benchmark ones (different code version, geometry, ...)

Offline scenario for data QA



QA check-list:

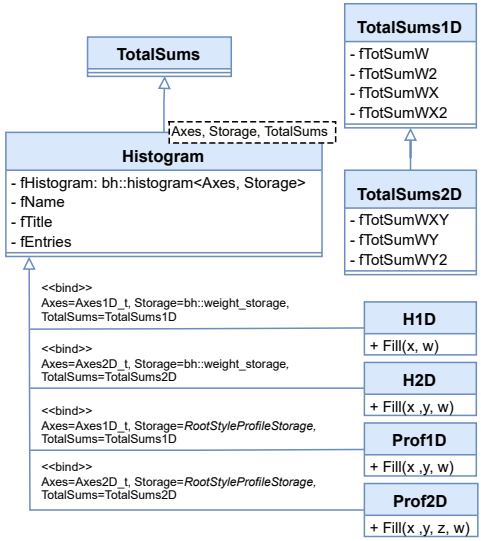
- data-driven checks: properties of collected histograms
- multiple checks for each QA-task
- failed checks are collected by the QA-manager and trigger CI-tests

Online scenario for data QA

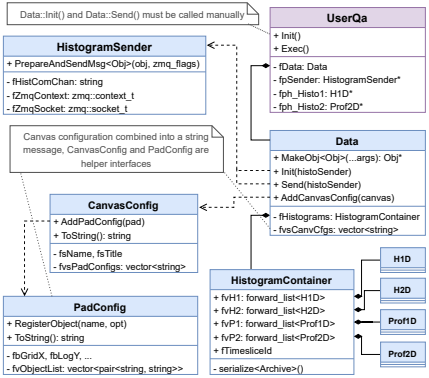
Avoiding ROOT dependencies on the data processing nodes for performance

⇒ **custom histograms**:

- based on `Boost::histogram`
- ROOT-like basic interface (ctors, fill, reset)
- fully reproduce statistical properties (errors, moments)



Online scenario for data QA

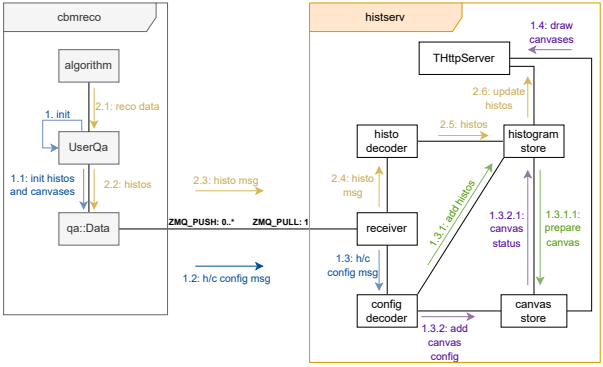


QA modules:

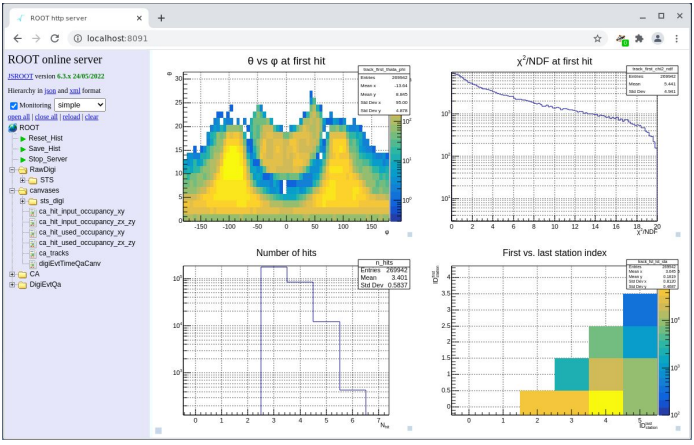
- keep histograms on stack in lists
- hide details from user
- send histograms to the histogram monitor via ZMQ_PUSH socket after each processed TS

Histogram monitor (histserv):

- standalone process, has ROOT
- receives histograms from multiple reco nodes via ZMQ_PULL socket (**a single socket both for configuration and content**)
- no information on source QA-modules
- updates histograms to the web-interface



Online scenario for data QA



Histogram web-interface:

- ROOT `THttpServer`
- shows/stores integrated histograms and(or) histograms vs. timeslice ID

Summary

- Flexible and user-friendly data QA framework is implemented and used in the CBM experiment:
  - offline QA is a part of official CI tests as a machinery for problem catching
  - online QA performed successfully in mini-CBM runs in spring of 2024

- Several features under development:
  - version control: histogram comparison in different setups for different code version
  - configurable histogram property checks in the online scenario (YAML and UI)
  - combining of the online and offline QA-frameworks (a single UserQA class for both scenarios)

Thank you for your attention!