BM@N experiment online data processing and QA system.

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1. Overview

The BM@N experiment (Baryonic Matter at Nuclotron) is a fixed target experiment and the first stage of the NICA project (Nuclotron based Ion Collider fAcility). The experimental facility is designed to explore properties of dense quark matter.

In order to analyze the experimental data the BmnRoot framework is being developed on the basis of FairRoot and CERN ROOT packages. The data processing chain includes raw data decoding, online monitoring and event reconstruction procedures.

One of the crucial parts of data processing is the signal filtering in the strip detector subsystems such as Gas Electron Multipliers (GEM), silicon strip detectors and Cathode Strip Chambers (CSC).

Then decoded data is transferred to the monitoring via the ZeroMQ sockets. The QA frontend uses the CERN jsROOT library. The user is able to monitor any detector subsystem, select specific station, plane, time or strip profile histograms in 1/2/3D view. The QA functions currently are presented by reference run auto-selecting and consequent overlaying histograms.

3. BM@N experiment

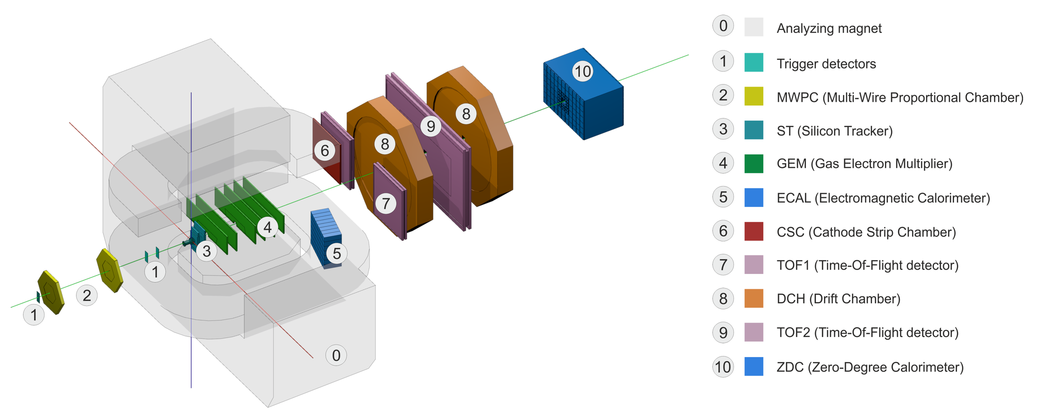

Figure 1: BM@N detector 2018 run configuration

The BM@N experiment is designed to study heavy ion collisions with energy range **2 – 3.8 *AGeV***. It is built as the first stage of the NICA project.

One of the indications of deconfinement phase transition is the enhanced yield of strange particles. Thus one of the main requirements for the BM@N tracker system is the ability to reconstruct decays of hyperons and hypernuclei.

Figure 2: BM@N live photo

2. NICA complex

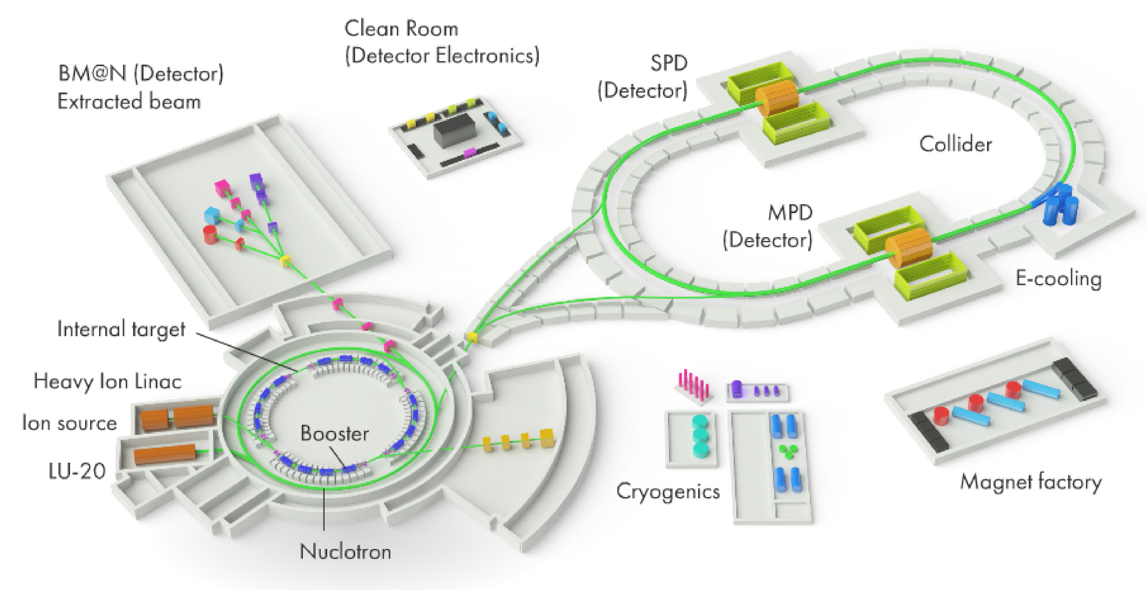

Figure 3: NICA complex

The new acceleration complex - NICA [1,2] being built in the JINR is aimed to study heavy ion (up to Au-Au) collisions at maximum baryon density in order to explore equation of state and properties of phase transition between baryonic matter and quark-gluon "plasma".

The experimental conditions being reached on the facility are close to the ones in the neutron stars and existed in the Quark epoch of the Universe.

4. Data processing flow

The raw data on every event is collected and aggregated by the Data Acquisition (DAQ) system, it is written in data files and also mirrored via the TCP stream. The monitoring system is capable of using both input channels.

The system is functionally organized as follows (see Fig. 4). The raw data decoder and the web monitoring were implemented as separate processes for the purpose of flexibility. The single raw data decoder can produce data for several monitoring processes which can run either on a same machine or on a different ones.

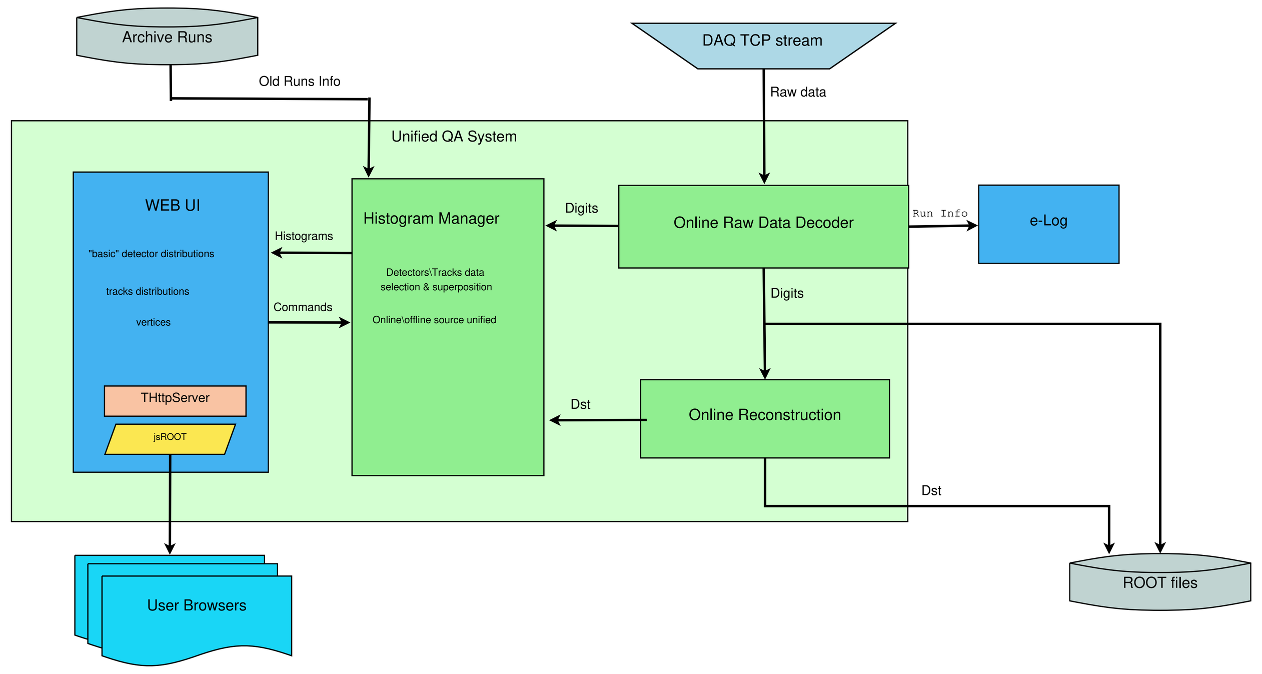

Figure 4: Data processing workflow for the next run in 2022

The raw data decoder includes two functional elements implementing two subsequent data operations: the raw data converter – parsing raw binary data into ROOT format so-called DAQ-digits (ADC, TDC, TQDC, HRB, . . .) containing information in terms of electronic signals, and the data decoder – decoding "DAQ-digits" into the detector digits.

The decoding workflow includes filtration, executing noise reduction, applying the channel-strip mapping and making preparation for a subsequent physical analysis. The processed data of each event is then sent to the monitoring process via the ZeroMQ [3,4] pub socket. Lighttpd [5] web server is used on a frontend where jsROOT[6,7] library finally draws object in the browser. The more detailed description of the system is done in [8,9].

5. Signal filtering

Data from detectors like GEM, Silicon, CSC are being gathered by ADC (analog to digital converter) boards. Each detector plane includes 2 or 4 detecting layers with strips connected to the readout ADC boards.

Due to electronics faults some channels may produce constant high signal noise even without real charged particles passing through. Also voltage on each board as a whole slowly oscillates shifting signal values.

The latter occurs because high multiplicities (common for heavy ions) imply simultaneous activation of many channels what moves ADC boards far outside stable voltage mode.

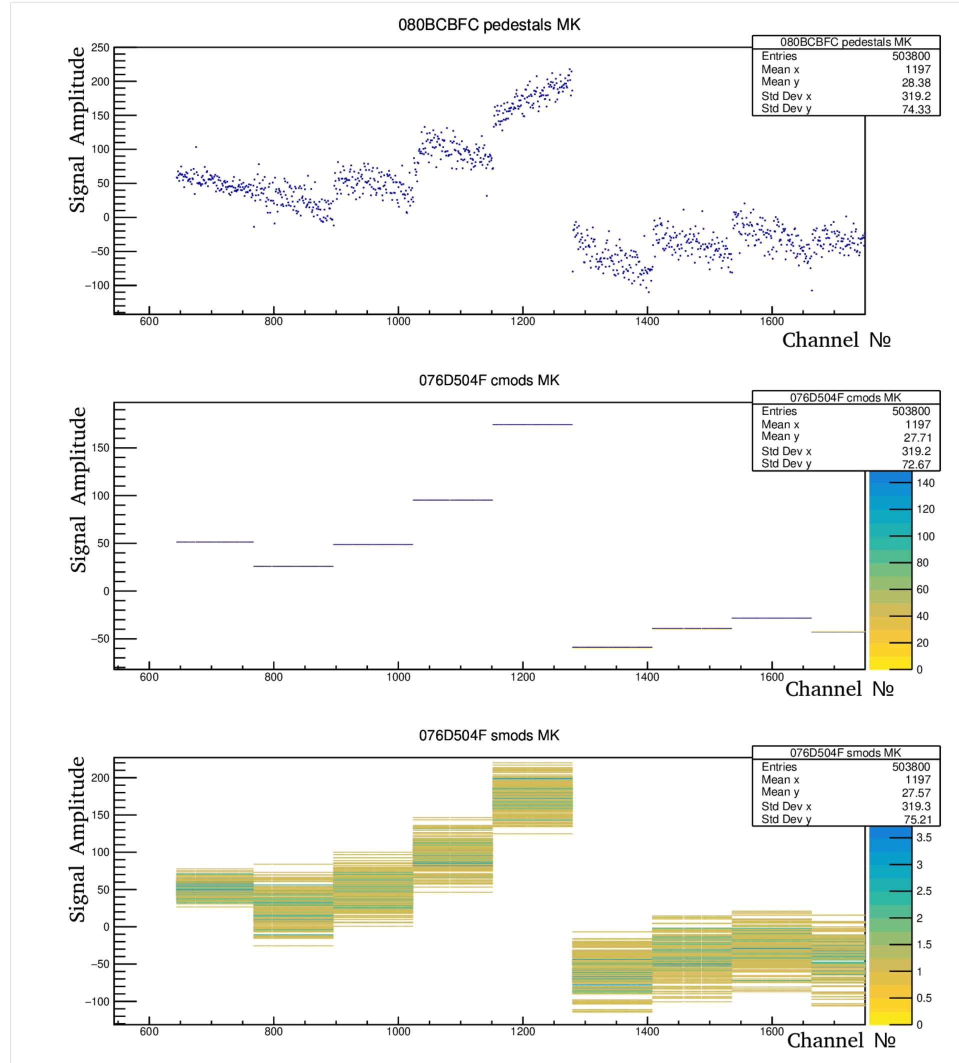

Figure 5: ADC signals respectively: raw ones, common modes, event signal modes

Thus the multi-iteration procedure is being used. The pedestals (signals without real particles) are being gathered. CMS (common mode signals) are calculated - the average pedestal signal on the each ADC chip over large number of event. As well as signal modes (average signal on the chip in the single current event).

So in order to clear up the signal one should subtract the pedestal on the respective strip then subtract (CMS with subtracted signal mode) of course excluding noisy channels. The average mode calculation logic repeats until all excessive values are gone. The crucial point is what the same algo is applied for the pedestal calculations too.

After all subtractions are done one applies threshold cut one gets clear particle signal. Sample signal distributions illustrating the workflow are shown in Fig. 6.

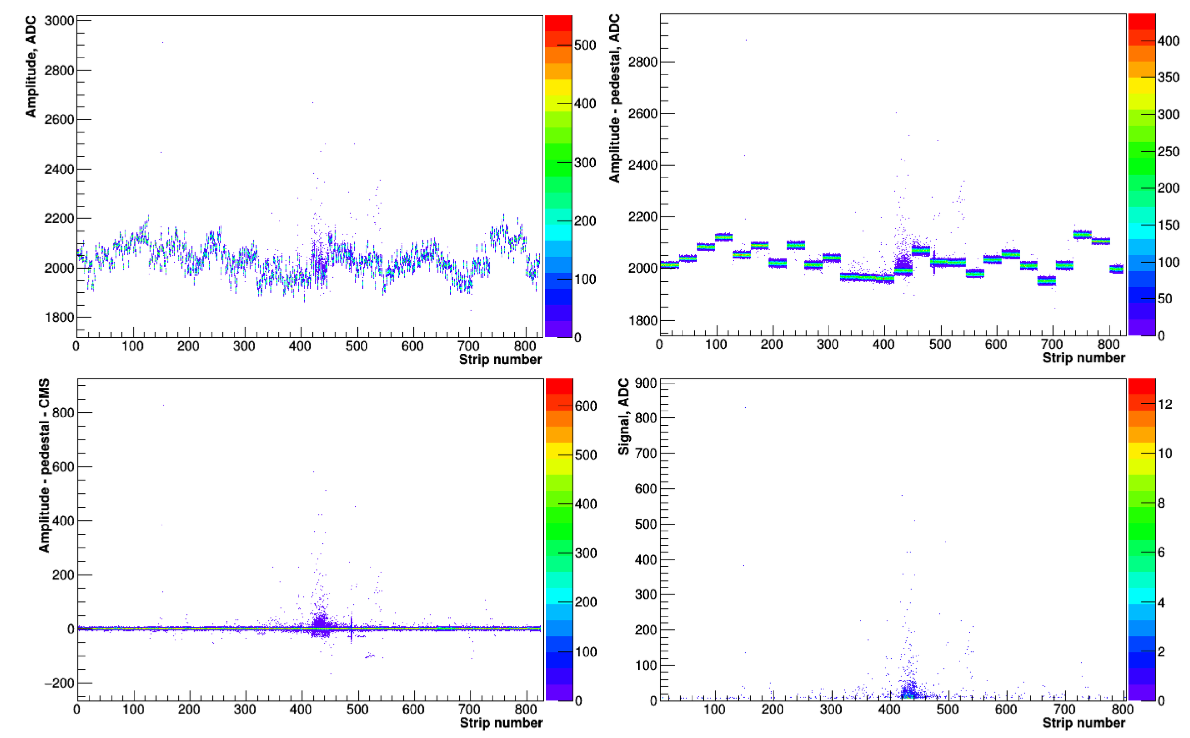

Figure 6: Filter stages

6. Frontend view

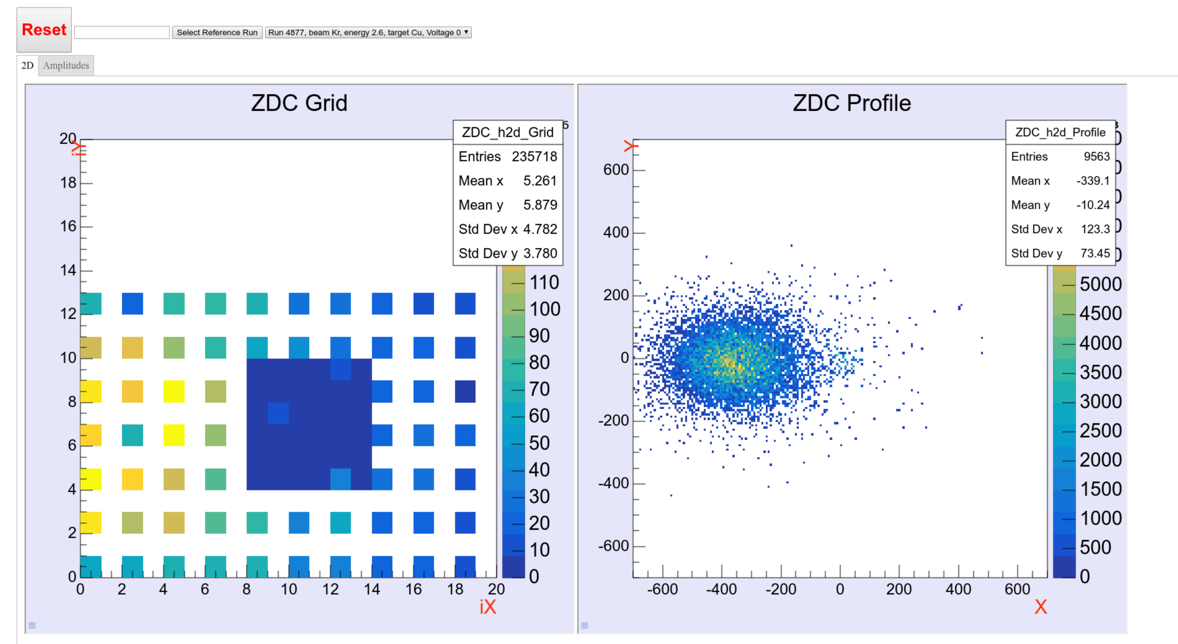

Figure 7: Zero degree calorimeter plots

The system is capable to provide a detailed information about every detector subsystem.

Also the system allows users to select reference run from past runs and impose it on the current run in order to detect possible deviations in the histogram form as can be seen in Fig. 8 for the Drift Chambers time distribution.

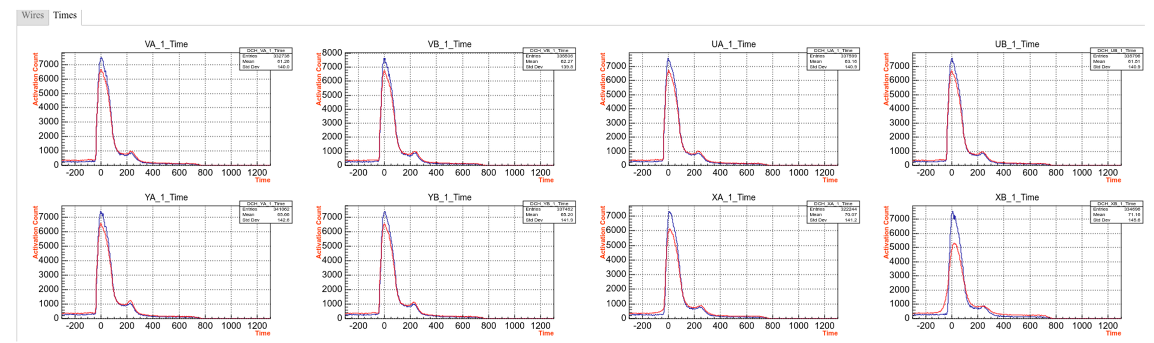

Figure 8: Drift Chamber time histograms

7. References

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