Upgrade of the QA system in the BM@N experiment at the NICA

A V Driuk¹, K I Mashitsin¹, S P Merts², S A Nemnyugin¹, V A Roudnev¹ and M M Stepanova¹

¹ Saint Petersburg State University, 7/9 Universitetskaya Emb., 199034 St. Petersburg, Russia
² Joint Institute for Nuclear Research, Joliot-Curie 6, 141980 Dubna, Moscow region, Russia
E-mail: MashKonst@yandex.ru

Abstract. The BM@N (Baryonic Matter at the Nuclotron) is an experiment at the NICA (Nuclotron-based Ion Collider fAcility). The first physics runs were carried out with the collection of experimental data in 2018. For the physics analysis of events recorded by detectors of the BM@N the BmnRoot framework is used. It provides a powerful tools for detector performance studying, event simulation, data analysis and developing new algorithms that continually improve this environment. The QA (Quality Assurance) system is used to evaluate the quality of the event reconstruction procedures and collected data. It displays the results of comparing the properties of the simulated events with the reconstructed ones. However, previous version of QA system was nonflexible because its output was just a set of PNG images. Result of QA system modernization by using JSROOT library is described in current report. After this upgrade histograms are displayed in web browser. User can zoom histograms, change scales, get value of bin by moving the cursor on it, etc. It also became possible to get sample mean and standard deviation for each histogram. Upgraded system is quite scalable, so it can easily be extended with new histograms. At the moment, the modernized system is part of the BmnRoot framework.

1. Introduction

Modern physics is interested in the study of nuclear matter under extreme temperature and density, since under these conditions matter turns into a quark-gluon plasma (QGP). The constructing in Joint Institute for Nuclear Research (JINR) accelerator complex NICA [1] will allow observing phase transitions from baryonic matter to QGP in more detail. The first experiment available at the NICA is BM@N [2]. It is aimed at studying heavy ion collisions with fixed targets. A schematic view of the experimental setup is shown in figure 1.

The BM@N inner tracking system consists of three silicon detectors and six GEM planes (see figure 1). These detectors are used to reconstruct trajectories of charged particles in magnetic field and estimate kinematic parameters of reconstructed particles [3]. In order to evaluate the effectiveness of track reconstruction and quality of parameter estimation quality assurance (QA) system was developed and implemented in BmnRoot framework [4].

This paper presents the results of upgrading the QA system using JavaScript ROOT (JSROOT) library [5]. The system is implemented as a part of the BmnRoot framework which provides powerful tools for detector performance studying, event simulation and data
The BmnRoot is built on top of the ROOT (CERN) and the FairRoot (GSI, Helmholtz Centre for Heavy Ion Research) frameworks.

Output format of the previous version of the QA system was a set of PNG images on a static HTML page. Therefore, it was decided to implement a convenient and flexible version of the QA system that meets the following criteria:

- support the functionality of the previous version,
- provide a wide range of tools for working with histograms and graphs,
- provide an opportunity for users to work with output information through a web interface,
- have a simple mechanism for adding new histograms.

These requirements could be met by the JSROOT library, which was successfully used in such CERN’s projects as Geant-val and ALICE Overwatch. This library supports almost all ROOT graphical objects which can be inserted in any webpage in interactive mode. Many useful features were implemented in JSROOT, for example, a zooming, a statbox and a context menu (see figure 2). For these reasons, it was decided to transfer our QA system to JSROOT.
3. **THttpServer class and JSROOT**

The ROOT `THttpServer` class registers objects on server providing access to them in the JSON (JavaScript Object Notation) format by network. However, a user who has not installed ROOT framework, will not be able to see the registered histograms. The JSROOT library helps solve this problem by providing interactive ROOT-like graphics in web browsers [13]. The JSROOT uses `XMLHttpRequest` class to receive JSON from remote web server. After an object has been created one can directly draw it.

Modifying the static QA system with JSROOT allowed the user to zoom histograms, switch axes to log scale, get value of bin by moving the cursor on it. In addition, options for the presentation of histograms have been added, the same histogram can be presented in almost any form, from text to 3D (see figure 3). It also became possible to get sample mean and standard deviation for each histogram directly on webpage. Some of the above features JSROOT library are shown in figure 4.

![Figure 2](image1.png)

**Figure 2.** Context menu and options available in it.

![Figure 3](image2.png)

**Figure 3.** The same histogram in various views.
JSROOT allows: (a) to get sample mean and standard deviation for each histogram, (b) to get value of bin by moving the cursor on it, (c) to switch axes to linear/log scale.

4. Algorithm description

Almost the entire scheme for transferring to online mode is implemented using BmnDrawOnline class. This is the most important class in our algorithm because its methods take histograms as an argument, perform some operations on them, and then register them on the server. Therefore, by connecting BmnDrawOnline user can add any necessary histogram to the output. The flow chart of the algorithm is shown in figure 5.

The algorithm consists of several steps: in the first step, the bmn_qa_generator.C macro takes the root-files with simulated and reconstructed data and adds BmnTrackingQa as a task for FairRoot analysis class.

In the second step, based on the received data, the BmnTrackingQa creates and fills histograms. Also it calls the BmnTrackingQaReport, that customizes the view of histograms and passes them to the BmnDrawOnline.

The BmnDrawOnline takes histograms as an argument, the height of each histogram is calculated and they are placed on a canvas of the required size, containing a set of all graphs and labels for them. The resulting canvas is placed in the ROOT-file which is created when the first constructor of the BmnDrawOnline class is called.

At the next step, user calls the second constructor (by running the special startServ.C macro) which takes the ROOT-file with histograms as an argument. It initializes the local
server and registers the canvases from the storage file to it.

Finally, the canvases are requested from localhost and drawn on a webpage using JSROOT possibilities.

![Figure 5. The scheme of the implemented algorithm.](image)

This implementation has a significant advantage, it made our QA system scalable. To extend it with new histograms, you only need to add the task to `bmn_qa_generator.C` and include `BmnDrawOnline` in the class that draws graphs. Therefore, we decided to expand the system with histograms of particle identification. The scheme of the modified algorithm and examples of the added histograms are shown in figures 6, 7.

![Figure 6. Dependence of (a) the number of true identified pions on momentum, and (b) the velocity on momentum for different types of particles.](image)
5. Conclusion
The article discussed the new opportunities appeared after the quality assurance system modification. The QA system has been developed to analyze the quality of event reconstruction in the BM@N experiment. The programming tools and libraries used in this work were described in detail and a scheme of the implemented algorithm was presented. The scalability of the system allowed us to add particles identification histograms to it. In the future our system will be filled with new histograms.

Acknowledgments
This work is supported by Russian Foundation for Basic Research grant 18-02-40104 mega. We are also grateful to the Physics Educational Center of the Research Park of the Saint Petersburg State University for support of educational projects related to the subject of the present study.

References
[1] Kekelidze V 2017 J. Instrum. 12 06012
[2] Baranov D et al. 2018 KnE Energy Phys. 3 291–6
[3] Baranov D, Batyuk P, Gertsenberger K and Merts S 2020 EPJ Web Conf. 226 03003
[4] Gertsenberger K, Merts S, Rogachevsky O and Zinchenko A 2016 Eur. Phys. J. A 52 16214
[5] Bellenot B and Linev S 2015 J. Phys. Conf. Series 664 062033
[6] Merts S, Nemnyugin S, Roudnev V and Stepanova M 2020 J. Phys. Conf. Series 1479 012043
[7] Merts S, Nemnyugin S, Roudnev V and Stepanova M 2020 EPJ Web Conf. 226 03013
[8] Brun R and Rademakers F 1997 Phys. Res. A 389 81–6
[9] Al-Turany M et al. 2012 J. Phys. Conf. Ser. 396 022001
[10] Freyermuth L et al. 2019 EPJ Web Conf. 214 05002
[11] Ehlers R and Mulligan J 2019 EPJ Web Conf. 214 01038
[12] Adamczewski-Musch J, Bellenot B and Linev S 2015 Report GSI 2015-1 508
[13] Gabdrakhmanov I and Merts S 2020 EPJ Web Conf. 226 03007