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SLOW CONTROL SYSTEMS AT BM@N AND MPD/NICA DETECTOR EXPERIMENTS

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Abstract

NICA (Nuclotron-based Ion Collider fAcility) is a new accelerator complex designed at the Joint Institute for Nuclear Research (Dubna, Russia) to study properties of dense baryonic matter. BM@N (Baryonic Matter at Nuclotron) is the first experiment at the complex. It is an experimental setup in the fixed-target hall of the Nuclotron to perform a research program focused on the production of strange matter in heavy-ion collisions. MPD (Multipurpose Detector) is a detector for colliding beam experiments at the complex, and it is being developed to provide: efficient registration of the particles produced by heavy ion collisions; identification of particle type, charge and energy; reconstruction of vertices of primary interactions and the position of secondary particle production. Existing Slow Control Systems for BM@N experiment, assembling, and testing zones of MPD detectors are based on Tango Controls. They provide monitoring and control of diverse hardware for efficient data taking, stable operation of detectors and quality control of assembled modules. Current status and developments as well as future design and plans for MPD Slow Control System will be reported.

INTRODUCTION

The NICA (Nuclotron-based Ion Collider facility) is accelerator facility which is now under construction at Joint Institute for Nuclear Research (JINR, Dubna) [1]. NICA accelerator complex scheme is shown in Fig. 1.

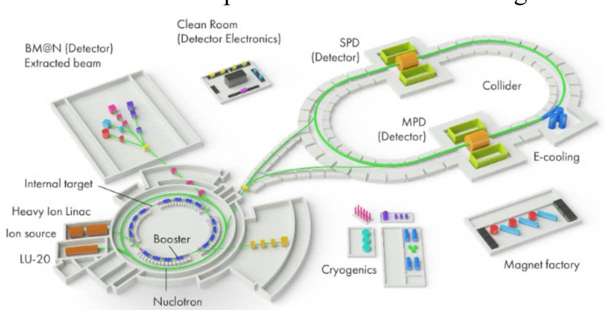

Figure 1: NICA accelerator complex scheme [2].

Two modes of operation are foreseen, collider mode and extracted beams, with two detectors: MPD (MultiPurpose Detector) and BM@N (Baryonic Matter at Nuclotron) [1].

First physical run at BM@N with basic setup was performed in spring 2018, which also included new physics program on SRC studies in collaboration with GSI, MIT, Tel Aviv University etc. BM@N experiment scheme is shown in Fig. 2.

MPD is currently under construction and its first test run is planned on 2021. MPD scheme is shown in Fig. 3.

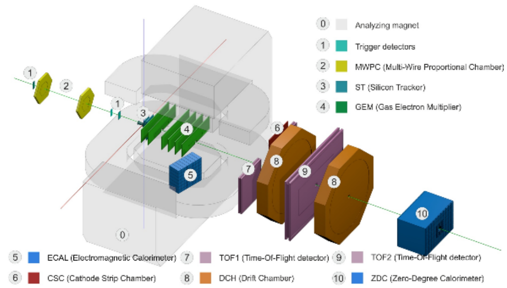

Figure 2: BM@N experiment scheme.

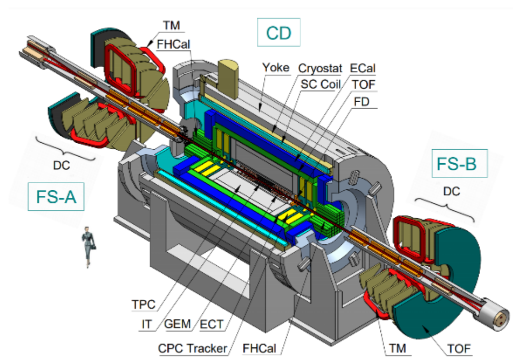

Figure 3: MPD detector scheme [2].

Though these two experiments have different principle of operation, they also have many common parts – same type of some detectors, same hardware and the most important point – same people, who develop and work with it.

So the main tasks of Slow Control Systems, which are described in this paper – monitor the statuses of the diverse hardware, archive the data from the devices in unified format to the database for further physical analysis and provide scalability of the developed system, because the number of modules and channels is different in both facilities.

Tango Controls was chosen as the base for such systems. It is free, open-source and cross-platform framework, which supports multiple programming languages and has tools that simplify the tasks mentioned above [3].

Most of the developments, described in the next section, was tested during multiple technical and physical runs on BM@N, but the same applications will be used on MPD.

CURRENT DEVELOPMENTS

It is important for the shift crew to know the states of detectors' hardware. The shift leader must start data acquisition according to the statuses of devices, proper settings and so on.

Tango device server and the client with graphical layout of detectors was developed for BM@N experiment [4]. The client window is shown in Fig. 4.

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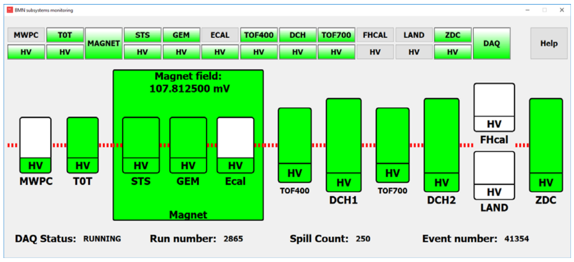

Figure 4: BM@N status client application.

This software allows not only monitor the states of equipment, but also see the value of magnetic field inside the analyzing magnet SP-41 and information from Data Acquisition (DAQ) system – DAQ status, run number, event number and spill count. Green color of the elements means that everything is working properly in subdetector, white color means that this detector is not yet implemented in the common Slow Control System, e.g. FHcal, or doesn't have any other type of devices, except High Voltage power supplies, e.g. ECal detector.

Long historical background of the subdetector groups leads to unnecessarily wide spectrum of the Slow Control hardware and software. A typical example of such situation is the high voltage power supplies in different groups. For now, the high voltage supplies produced by CAEN, Wiener/Iseg and HVSys with similar parameters are applied [5].

For example, Wiener MPOD crates and Iseg modules are used at TOF400 detector high voltage system. The communication between devices and Tango server is based on SNMP protocol, with extended precision to provide nanoampere accuracy of received current values. Acquired data displays in the program, which allows to have multiple plot forms with different settings and monitored values in one application window, example is shown in Fig. 5. It is written by our team in Python with PyTango, PyQt and pyqtgraph modules.

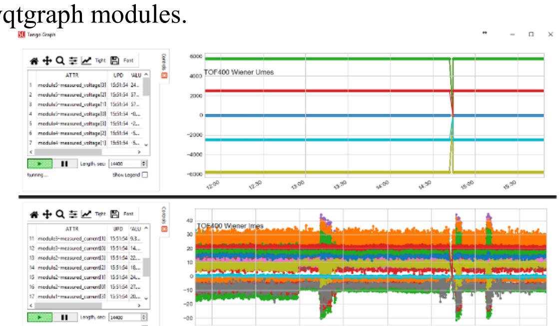

Figure 5: Voltage and current plots for TOF400 Wiener High Voltage Power Supply.

Another important part is to control infrastructure equipment, used by DAQ system and whole experiment. It is necessary for some devices to control network connection and Power over Ethernet to be able to reboot it in case of errors, firmware or settings updates. Client and server was developed to fulfil this task, which supports control and monitoring of multiple network switches in one application window.

Tango device server and client application was developed for Wiener and ELMA VME crates for DAQ modules, which provide tools for monitoring of crates' statuses and control its state. Client application window is shown in Fig. 6.

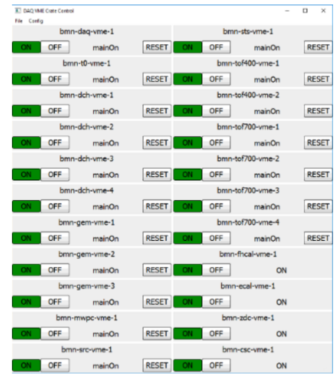

Figure 6: VME crates client control application.

There are many other subsystems and software, developed to control and monitor it, that is not covered in this paper, but also important for the experiment, such as gas systems, low voltage systems, magnet field monitoring, front-end electronics control etc.

MPD DETECTORS ASSEMBLING SITES AND TEST STANDS

The first stage of MPD detector will be put into operation in 2021. Subdetectors' groups, which take part in this stage, are preparing assembling and test stands for their modules.

TOF detectors are now in mass-production stage and test stand is ready for data acquisition on cosmic rays. The scheme of this stand is shown in Fig. 7.

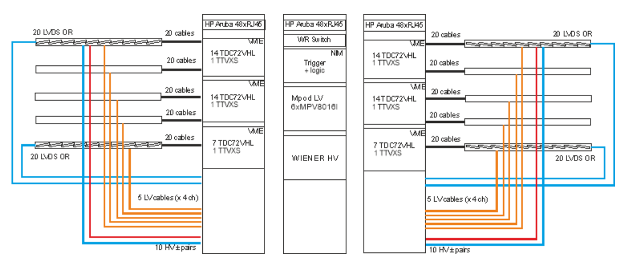

Figure 7: MPD TOF test stand scheme.

For Slow Control System on these stands it is necessary not only control proper tests of made detectors, but provide monitoring of any values that are critical for assembling process – temperature, humidity, atmospheric pressure, air dust monitoring etc. The example of such data is shown in Fig. 8.

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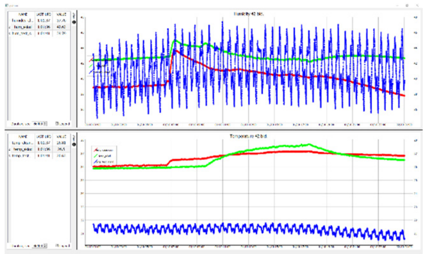

Figure 8: Humidity and temperature plots of TOF MPD assembling area.

Some developments are needed only for tests of materials, used in the assembling process. The coefficients, that can be collected and archived, will be useful for testing and further operation of made detectors.

Thin glasses are used in TOF modules and its technical specification may vary from batch to batch. Keithley 6485 picoammeter is used for testing capacitor properties made of these glasses. The processes of charge and discharge is shown in Fig. 9.

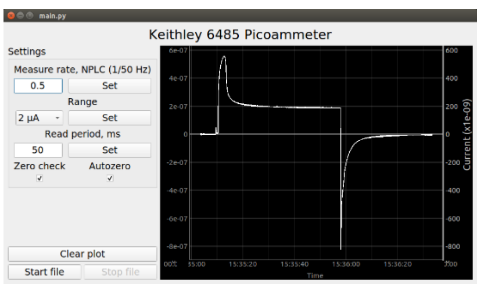

Figure 9: Keithley 6485 picoammeter control application.

PLANS

- Implement centralized configuration loading software, which will help shift crew easily change equipment settings according to the beam type or another conditions;
- Implement web tool to simplify browsing and downloading SC data for physicists;
- Implement CI/CD tools for new developments to simplify deployment process.

CONCLUSION

- Existing Slow Control System at BM@N showed good results during 5 Nuclotron runs. The data that was archived in the 55th run for one month is now actively used by physicists for data analysis;
- Mass-production test stands of MPD subdetectors are preparing or ready for tests;
- Current developments will be base for MPD Slow Control system.

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