SLOW CONTROL SYSTEM AT BM@N EXPERIMENT

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Big modern physics experiments represent a collaboration of workgroups and require wide variety of different electronic equipment. Besides trigger electronics or Data acquisition system (DAQ), there is a hardware that is not time-critical, and can be run at a low priority. Slow Control system are used for setup and monitoring such hardware.
Slow Control systems in a typical experiment are often used to setup and/or monitor components such as high voltage modules, temperature sensors, pressure gauges, leak detectors, RF generators, PID controllers etc. often from a large number of hardware vendors.
Slow Control system also has to archive retrieved data for further analysis and handling by physicists and to warn personnel about critical situations and contingency.

Keywords: NICA, BMN, Slow Control, detector

1. Slow control system at BM@N experiment

Baryonic Matter at Nuclotron (BM@N) detector is the first stage experiment of NICA complex. It is the fixed target experiment to run with beams from protons to gold ions with the kinetic energy from 1 to 6 GeV per nucleon.

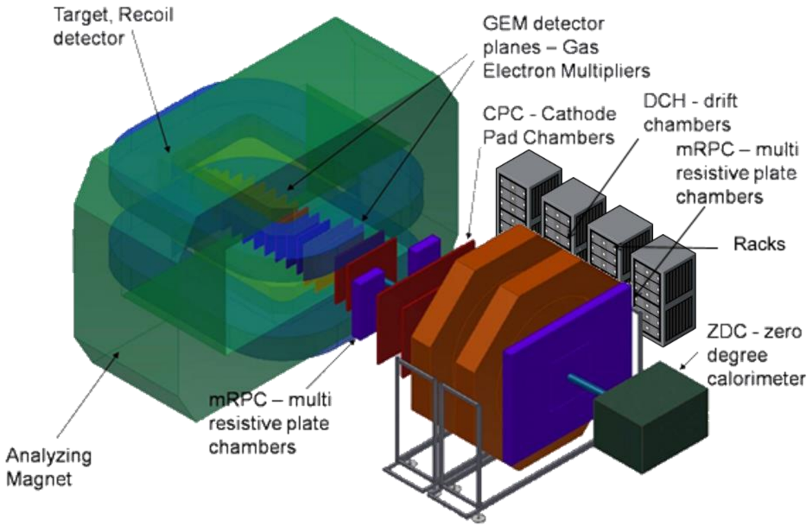

Figure 1. The BM@N subdetectors layout

BM@N consists of several subdetectors and subsystems, which were designed and developed by different groups. Usually they choose equipment for their needs according to experience, historical background and special requirements.

Systems that control and monitor diverse equipment in large physical experiments are called Slow Control systems. These tasks are not time-critical and can be run at a low priority. Slow Control system is used to control and monitor components such as high voltage and low voltage modules, temperature sensors, pressure gauges etc. Main tasks of typical Slow Control system are centralized management and archiving data from devices.

There are many solutions that can be used to develop Slow Control system. For BM@N experiment, Tango Controls was chosen as the main backbone, because of many advantages, such as open-source and cross-platform architecture, code generation and it is already being used at Nuclotron.

2. Parts of BM@N Slow Control system

2.1. Status monitoring at BM@N experiment

Monitoring of states and statuses of all devices, that are used in the experiment, is very important for shift staff. Shift leader can start and stop data acquisition according to the conditions of BM@N subsystems.

Application that shows states of equipment was developed to fulfil this task. There is BM@N schematic setup on the form with three-stage indication for each detector. Green color means that everything is OK, yellow – warning, something is wrong with devices – e.g. some parameters are in warning zone, red – alarm, critical error that requires quick actions and decisions (white – devices are not yet implemented in centralized Slow Control system). Devices are grouped by detector and their type – all high voltage devices in one group and everything else – in another.

In the situation presented on Figure 2 magnetic field is lower than required, and some channels of the TOF700 high voltage system are off or turning on or have wrong values. Everything else is working properly.

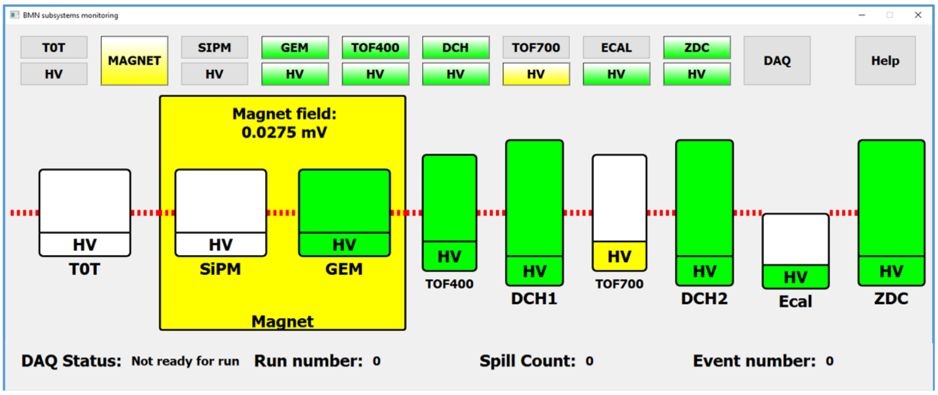

Figure 2. BM@N status monitoring application window

2.2. Trigger unit monitoring

Due to subdetector group policy and hardware complexity, Slow Control system does not have direct access to the devices. All required data is transferred in JSON format (which is standard for data exchange in BMN SCS) through TCP-socket server, and handled by our JSON Parsing Tango server, which converts received data to Tango attributes.

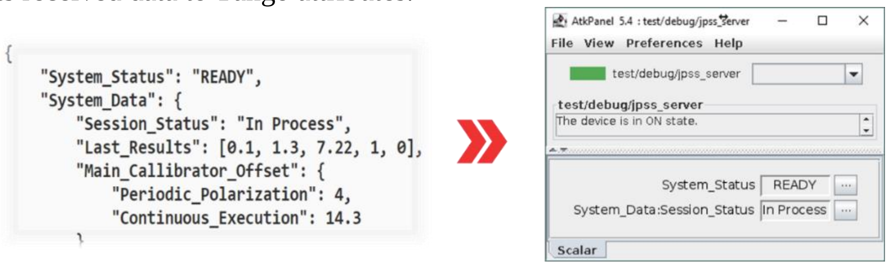

Figure 3. JSON Parsing Tango server example

2.3. Magnet field monitoring

The value of magnetic field is very important for data acquisition and further data analysis. Existing hall sensor is connected to ADC made by ICP DAS, and Tango device server archives data into Slow Control database.

2.4. GEM, DCH and Si tracker high voltage and low voltage systems

These detectors are using similar devices for their high voltage and low voltage systems. Software, which controls and monitor parameters of systems, was developed by them in LabVIEW. Tango Controls has binding for LabVIEW, so these equipment was easily incorporated into existing centralized Slow Control system.

2.5. TOF400 equipment control and monitoring

The gas system of the setup is designed to produce a required gas mixture and supply this mixture for gas-filled detectors. The first loop is intended to mix inert gases that are used in the proportional chambers. In the second loop, the mixture is prepared on the basis of freons, which is required for operation of the multigap resistive plate chambers (MRPCs). [1]

The working mixture is prepared with a high accuracy regarding the ratio of its components using modules made by MKS Instruments, particularly MKS PAC 100 control unit. Tango Device server, which communicates with devices by Modbus protocol, and control application was developed and the whole system was tested during 54th run of Nuclotron. Plot of recorded data from control unit is presented on Figure 4.

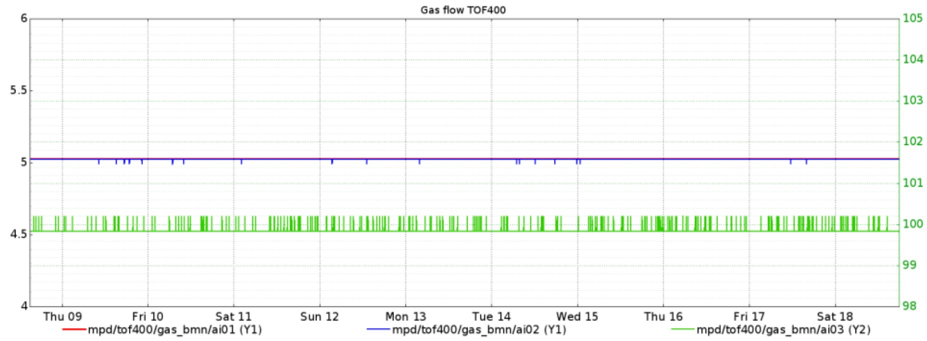

Figure 4. Gas flow values recorded from TOF400 gas system during 54th run of Nuclotron

In addition to previous task, it is very important to know when gas bottle will run out. In this case we use scales with RS-232 interface, model CAS PB-60, which are read by Tango device server. The server also can calculate how much time left for the cylinder, according to the current flow from gas system.

Another task for TOF400 detector is to monitor and control frontend electronics. Communication with them is based on RS-485 and MOXA Serial-to-Ethernet converters. User with the help of developed control application can monitor input and output voltages, temperature of gas and board, and change its thresholds.

2.6. TOF400, TOF700, ZDC and ECal high voltage systems

High voltage systems for these detectors were made by HVSys. Devices are operated by application that was developed by manufacturer and it has TPC-server, which can transfer data in JSON format. These values are handled by our JSON Parsing Tango server, which converts received data to Tango attributes.

2.7. Infrastructure control and monitoring

All detectors share the same infrastructure equipment, such as switches, crates, uninterruptible power supplies (UPS) etc.

These devices already have existing software, webpages, buttons to control and monitor their states, but it is not convenient if there are dozens of them.

Control and monitor application was developed for switches made by HP. It presents information about devices, that are connected to every port of the switch, name of device and power consumption, and allows user to turn on and off power over Ethernet and network on multiple ports simultaneously.

"Wiener crate control" application shows basic information about crates made by Wiener, such as state and status message. User can turn on and off crates (one by one or all at once) and reset them.

"BMN UPS monitoring" application shows values of parameters of UPSes, that are used at BMN setup. Shift staff can see input and output parameters of every device, its load and battery status.

All these applications are scalable and can be easily configured. Examples are presented on Figure 5.

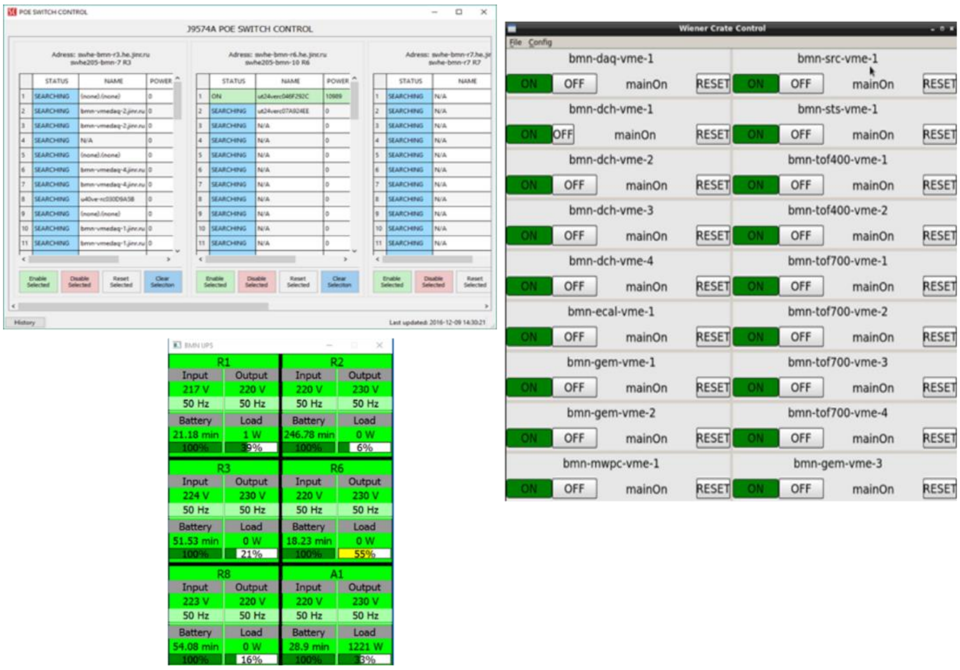

Figure 5. Examples of developed monitoring and control applications for infrastructure devices

6. Conclusion

- Existing Slow Control system worked during 3 Nuclotron runs;
- Archived values from devices are used for data analysis;
- Detectors groups are using developed control and monitor applications.

Future plans include increasing number of connected devices to Slow Control system, implementation of configuration database for equipment and improving user notification system.

References

[1] V.A. Babkin, S.N. Bazylev, M.G. Buryakov, S.V. Volgin, V.M. Golovatyuk, A.V. Dmitriev, P.O. Dulov, D.S. Egorov, S.P. Lobastov, V.A. Petrov, M.M. Rumyantsev, V.M. Slepnev, I.V. Slepnev, A.V. Terletskiy, I.A. Philippov, A.V. Shutov, A.V. Schipunov, and V.I. Yurevich *The MPD Test Beam Setup for Testing Detectors with the Nuclotron Beams.* Instrum Exp Tech (2017) **60**: 307.