Summer Student Project Report

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During my 8 week-stay at CERN I was involved in the activity of MUON group of LHCb. My personal work was concentrated mostly on the improvement of the experiment control system (ECS), particularly on design and creation of a synoptic tool for the control and monitoring high-voltage (HV) system of MUON detector, which has been implemented in working WINCC OA project. As a part of this program, I've attended WINCC course at CERN, which was very helpful for doing this job.

MUON detector is composed of five muon stations (M1-M5) of rectangular shape, placed along the beam axis as shown in figure 1 [1]. Each station consists of two mechanically independent halves, called A and C sides, that can be horizontally moved to access the beam pipe and the detector chambers for installation and maintenance. Stations M2 to M5 are placed downstream the calorimeters and are interleaved with 80 cm thick iron absorbers. Their information is used to identify and trace penetrating muons both in the online and offline analysis. Station M1 is located in front of the calorimeters and it is only used in the first level trigger. The full system is comprises 1380 chambers. Each station is equipped with 276 multi-wire proportional chambers (MWPCs) with the exception of M1R1, subject to the highest radiation, which is equipped with 12 GEM detectors.

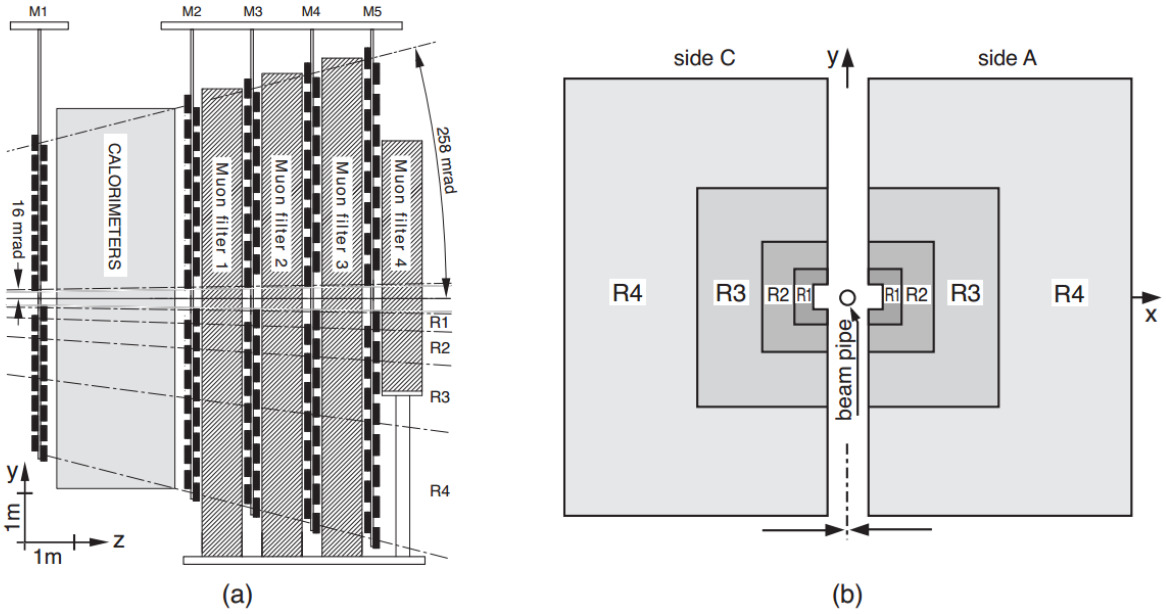

Figure 1. (a) Side view of the muon system. (b) Station layout with the four regions R1-R4.

Each single gas gap in GEM and MWPC chambers is connected to own HV-channel of one of the dedicated to it HV-system, organized in a different way depending on type of the detector in order to provide optimal gas gain and maximum efficiency in muon system. Connection scheme of muon HV-system is briefly described below.

HV-system of MUON detector is composed of three independent HV-systems:

1. INFN HV provides high voltage on 12 doubled triple-GEM chambers in central region (R1) of M1.
2. CAEN HV-system for two gaps MWPCs in R2-R4 regions on M1 and for four-gaps MWPCs in R1-R2 regions on M2-M5 stations.
3. PNPI HV-system for four-gaps MWPCs in R3-R4 regions on M2-M5 stations.

The HV-system of MUON is controlled by ECS over Ethernet and implemented within the overall framework for the control of the MUON detector, LHCb experiment and LHC.

The experiment control systems for most of the infrastructure at CERN, including LHCb, are using the SCADA package WinCC Open Architecture. The control topologies are designed in a hierarchical way with the main goal of supervising a complete installation with a single person from a central user interface. One of the key feature to handle such large systems is alarm management (generation, handling, storage, reporting). Although most of critical systems include automatic reactions to faults, alarms are fundamental for intervention and diagnostics.

The WinCC OA package has a modular architecture [2], as schematized in Figure 2. Each type of module is a running process for handling specific tasks. It is called a manager. In case of alarm handling, each value from any driver (D) is processed by the Event Manager (EV). In the case an alarm is generated, EV sends the alarm information to the Data Manager (DB) for archiving, and to all relevant managers for displaying or for processing. Figure 2 shows an example of data flow from a driver D2 through EV, to DB, CTRL and UI2.

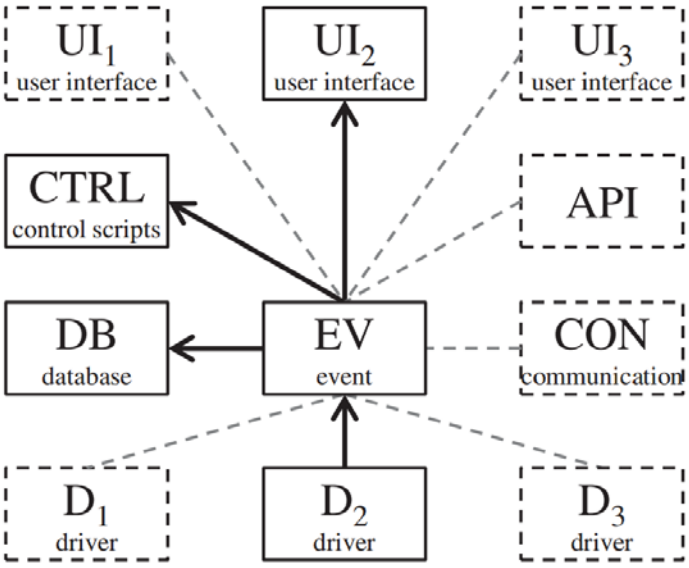

Figure 2. WinCC OA architecture. The continuous lines show an example of alarm handling data flow.

Also, WinCC OA provides tools for developing and for building the graphical user interface.

After I've got familiar with WinCC OA 3.11 and HV-system, I began to design a synoptic tool called "HV Monitor" for MUON HV-system. I did some tests and found that it is not possible to use the direct connection from graphical user interface (GUI) to hardware data-points by reason of slow execution. Actually, it is impossible to use more that forty connections to one graphical panel. So, I split project in two parts: GUI and server based on scripts.

In the server part I've placed the data collection instrument with the minimal network loading and with slow initialisation. Also, this part is contained all the preliminary data processing.

In the GUI part I created panel with adequate time redrawing. I was really surprised when I found that the changing text in text field is slower than deletion old and creation new text field with needed text. So I used last option.

Finally, after testing offline the first version of "HV Monitor" it has been implemented into MUSIDES project. This tool has been developed for the two main purposes. First and perhaps most important one is the fast monitoring of the status of HV in MUON system which is very useful for muon piquet and shifters during data taking. It contains the following functionality:

- display information about the statuses realised in colour view;
- it can be switched in mode displaying monitored voltages and currents in all in single gap or average per chamber in all chambers of each station;
- it allows to reach any chamber in the system in one click.

The position of the displayed values of high-voltage channel on the panel attached to the mechanical position of the chamber connected to this channel. Tool is user-friendly and intuitive, I hope.

You may see screenshots of the working HV Monitor below

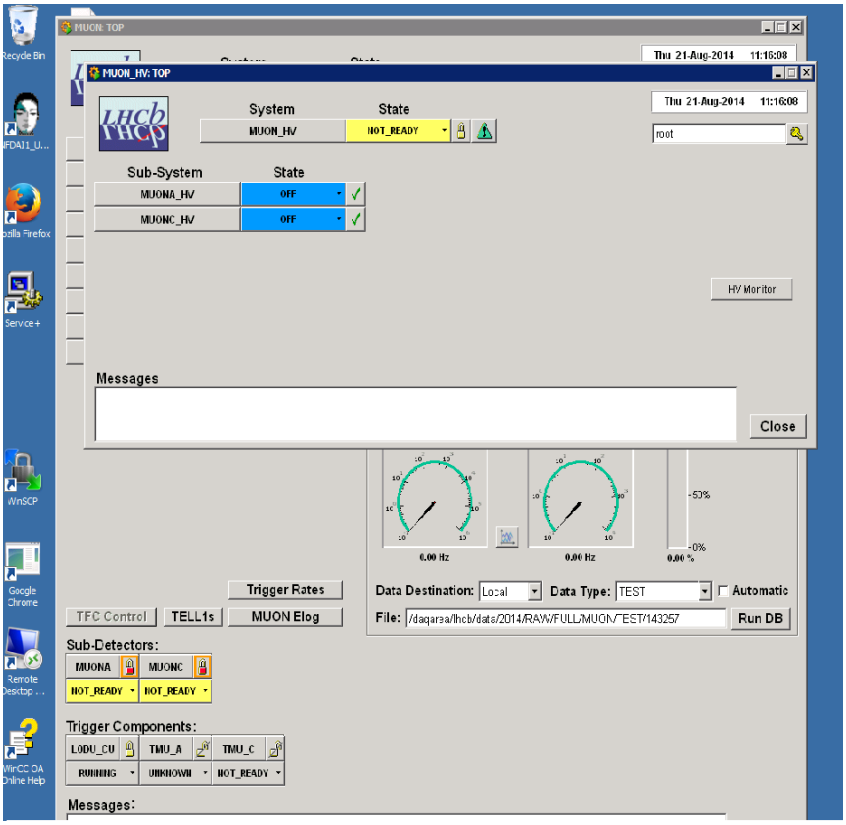

Figure 3. Button for loading the “HV Monitor”-panel from MUSIDES project.

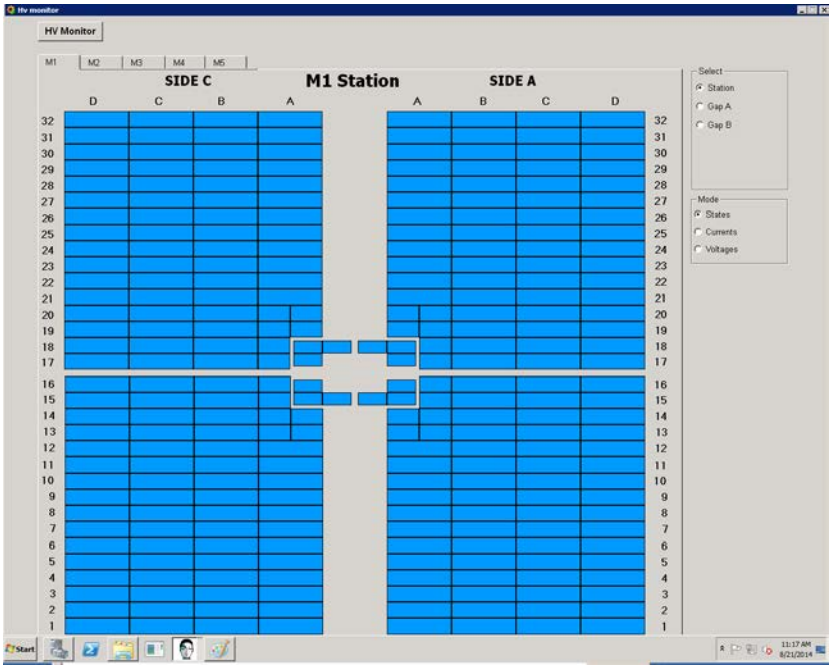

Figure 4. HV Monitor in states show mode.

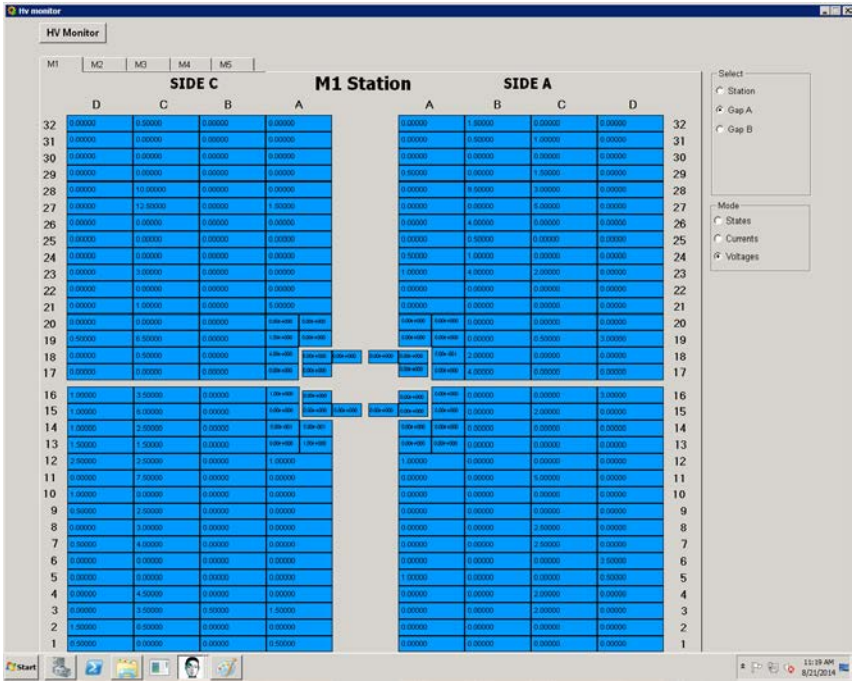

Figure 5. HV Monitor in voltage show mode.

The HV Monitor is in using already. But I am going to continue the work on this project to implement some more tools dedicated mostly for the expert analysis and for an operation with HV-system again on the expert level. It will include several tools, like histograms with currents and voltages for selected channels, tools for remapping, physical disconnecting a broken channel from the system by burning fuse, some simple analysis for spotting the dark current etc.

Acknowledgments

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References

[1] LHCb collaboration, *The LHCb detector at the LHC*, 2008 *JINST* 3 S08005.
[2] Burkimsher, Paul.(2014). Training Materials for Win-CC and The JCOP.
Part 1: Win-CC Framework. Controls Group, EN Department. CERN, Geneva.
Part2: JCOP Framework Framework. Controls Group, EN Department. CERN,Geneva.
[3] Win-CC V 3.11 *Technical Manual*.