VELO DCS alarm visualization: a greater use of the HV alarms and analysis on the LV alarm panel

Alice Cipriano Blanco Dominguez
CERN Summer Student Programme 2023

Abstract
The Vertex Locator (VELO) is a silicon detector that detects tracks of ionising particles coming from the beam collision region at the LHCb and thereby measures the location of interaction vertices, displaced decay vertices and the distances between them. Due to its small distance to the LHC beam and complex mechanics, the monitoring of the current and voltage of the VELO systems is vital to assure the proper data acquisition of the detector. The aim of this project was to explore better ways in which the current alarm definitions can be used.

Keywords
CERN Summer Student report; LHCb; VELO; High Voltage; alarms.

1 Introduction

1.1 The LHCb experiment

LHCb is one of the four main experiments that operate on the Large Hadron Collider, a two-ring-superconducting-hadron accelerator and collider installed in a 27 km tunnel between 45m and 170m below the surface, located at CERN (Conseil Européen pour la Recherche Nucléaire). The LHCb detector is designed to focus on the search for new physics through studies of CP-violation and decays of heavy-flavour hadrons. It has recently undergone an upgrade before the third LHC run, that featured an expected increase, by a factor 5, of the instantaneous luminosity to $\mathcal{L}$ =2 × 10^{33} cm^2 s^{-1} and collection of events at the LHC crossing rate of 40 MHz [1].

1.2 The VELO detector

The inner part of the LHCb features the VELO, a particle tracker composed of pixelated hybrid silicon detectors, which are arranged into modules and cooled by a silicon microchannel cooler. It has 52 modules divided into side A and side C, with sensors and chips that approach the interaction point to within 5.1 mm [2].

The VELO encompasses an electronic system that has the function of transporting the data from the VeloPix ASICs to the off-detector processing units. The electronic components of the system are located in three places: on the detector module, immediately outside the VELO vacuum vessel and off detector, with dedicated cabling running between them. The information we are interested in is the monitoring of the temperature and voltages of each module of the VELO.

2 VELO Monitoring System

Across each VELO half there are 730 temperature sensors split between monitoring and safety readout systems. Within each cooling loop, which contains two modules and one shared isolation valve, 50 temperatures are monitored (54 for the seventh module pair) [1]. In addition, for each module, there are 2 digital and 2 analogue low voltage lines plus its OPB, which is powered with 1 LV line. There are 26 modules in each half, which gives 130 independent LV readings. Furthermore, there are 4 high voltage lines per module, totalling 104 independent HV voltages.

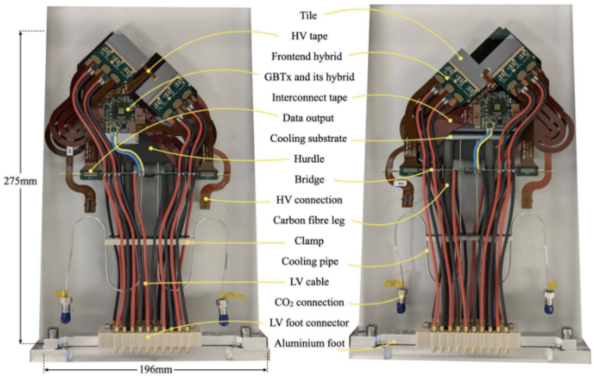

Figure 1: Photo of the (left) upstream and (right) downstream faces of a fully-assembled VELO module. [1].

2.1 The Summary Panel

The software currently used to build control and data acquisition systems of the experiment is SIMATIC WinCC Open Architecture. It is a tool that stores the information from the VELO as data points, and facilitates their access and control with panels, that are built using C++. The VELO summary panel takes the monitoring information mentioned above and displays it in a concise way.

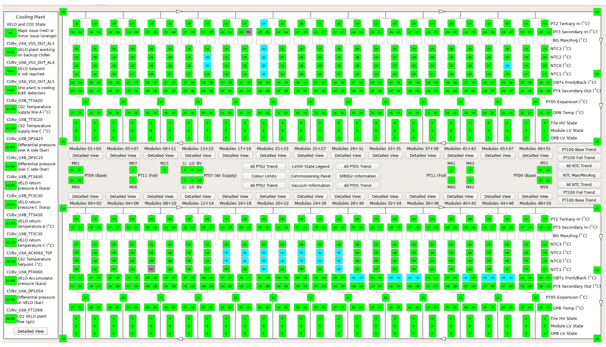

Figure 2: VELO monitoring Summary Panel.

This panel also features some sub-panels for a detailed view of the module information. That is where the voltage is displayed. Before this work, the fields in charge of the HV section displayed two pieces of information: the actual value and a color, which indicated the state of the channel, as shown in Fig. 3. The parameter to define the color was created by the panel developer, and divided in hot warning, hot, good and cold, as can be seen in Fig. 4.

2.2 HV Alarms in the Summary Panel

The update done in the detailed view of this panel has the aim to make the color scheme clearer for anyone that is to access the panel and consistent with the limits in the HV Alarm Panel currently in use. It also makes the alarm definitions more accessible for anyone checking the monitored information of the VELO. Because the data points used to define the colors are directly the alarm ranges, as shown in Fig. 4, as soon as an alarm is raised, it will be immediately visible in the Summary panel. We now have green for good, yellow for warning, orange for error and red for fatal.

The second part of the update consisted in displaying the current information, rather than only the voltage. The current is not only very relevant to the monitoring of a semiconductor, but it is also included

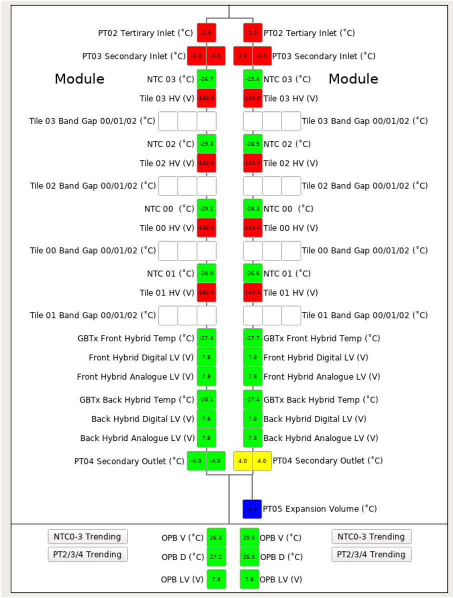

Figure 3: Summary Panel Detailed View before update.

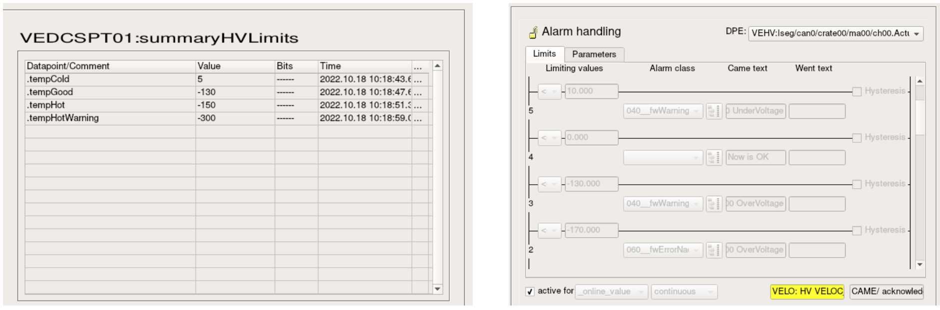

Figure 4: Left: Previous color definition parameters. Right: Current color definition parameters.

in the HV Alarm Panel, which concludes the full incorporation of the alarms in the high voltage part of this panel.

In order to test if this function was in fact working, the limits were momentarily changed in the Alarm Panel, as shown in Fig. 5. The final result can be observed in Fig. 6.

3 LV Alarm Panel

Similar to the High Voltage system, there is also an alarm panel for the Low Voltage part of the VELO. However, this one still has to go through testing and review on its limits, so it is not currently activated. This analysis is a report on its current state and hopefully will be a step forward in the direction of bringing it to use.

3.1 Communication with PARA

In WinCC OA, the module PARA is where the panel developer or user is able to see where the panel is getting and sending information to in the computer [3]. In order to check if that function is being correctly executed, a value in the alarm panel was changed to see if the information propagated properly from there to the PARA module. As shown in Fig. 7, that test was successful and the values are being

Figure 5: Color test through the HV Alarm Panel. A current's high warning and high error values were changed to create an error state. Voltage low warning was changed to create a warning state.

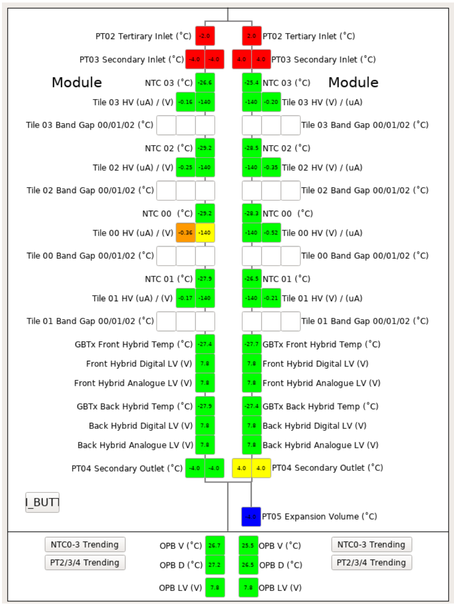

Figure 6: Summary Panel Detailed View after update. Tile 00 HV displays the voltage in warning state and the current in error state.

updated as expected. However, the recipe cache in which it is happening is wrong. It is currently going to "RecipeCache/LV_READY" when it should be in "RecipeCache/PHYSICS/Switch_ON".

3.2 Alarm Limits

The alarms limits are not fully established in this panel. The limits in the "TRANSITION" and "ONLINE" states are completely undefined. A recurring problem in the current limits is the presence of negative lower limits. In Fig. 8 is an example of the current history in one of the channels in the READY state, that shows that in the last few months there was no negative current registered, even though the limits are -1.00 A, -2.00 A and -3.00 A. The same happens in the voltage, where there is a fatal limit of -99.00 V while there are no registered negative voltages.

The absence of negative values is expected, since the VELO power supply cannot deliver negative voltages. That being said, the appearing of a negative current or voltage might indicate that something is wrong with the software. In that case, given the fact that any negative value would be problematic, the presence of a single fatal limit of zero would be enough to detect any negative value and indicate that kind of situation.

The rest of the limits in the "READY" and "OFF" states are reasonable, with some inconsistencies

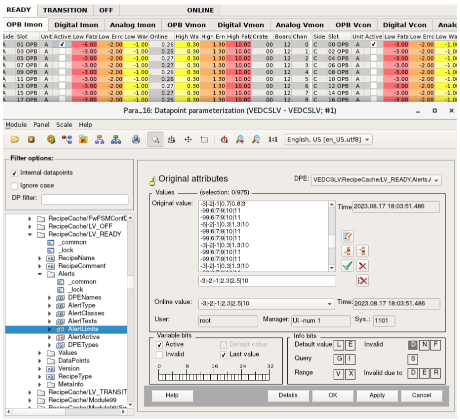

Figure 7: LV Alarm Panel PARA module check.

in how big is the jump between each state. Keeping in mind that in the HV alarm panel there are equal gaps between each upper limit, that might be something to consider in these cases.

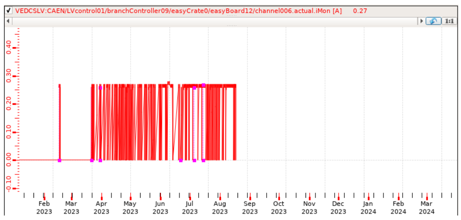

Figure 8: LV OPB Crate 0 Board 12 Channel 6 current history.

4 Conclusion

The Summary Panel has undergone an update in order to display the current and the alarm state of the high voltage section of the VELO, directly communicating with the High Voltage Alarm Panel. The Low Voltage Alarm Panel still has to go through the VELO experts, but it has proven itself to be functional, with a few adjusts. Once it is activated, a next step would be to do the same incorporation in the low voltage part of the Summary Panel.

Acknowledgements

I wish to extend my gratitude to my supervisor Mr. Stefano de Capua for all the guidance and patience throughout this project and everyone at the LHCb for offering such a welcoming and rich environment to learn. I would also like to thank the CERN Summer Student Progamme for the amazing opportunity to broaden my horizons academically and personally.

Bibliography

[1] LHCb collaboration. The LHCb upgrade I. 2023. `arXiv:2305.10515[hep-ex]`.

[2] T. Poikela and R. Ballabriga et al. The VeloPix ASIC. 2017 `https://iopscience.iop.org/article/10.1088/1748-0221/12/01/C01070/pdf`.

[3] SIMATIC WinCC Open Architecture Version 3.18 Documentation `https://www.winccoa.com/documentation/WinCCOA/3.18/en_US/index.html`.