SUMMER STUDENT REPORT

VELO DCS summary panel: the VELO readiness to take data at a glance

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August /2023

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1 Introduction

The Large Hadron Collider (LHC) is a two-ring-superconducting-hadron accelerator and collider installed in a 27 km tunnel between 45m and 170m below the surface, localized at CERN (*Conseil Européen pour la Recherche Nucléaire*) in the border of Switzerland and France. The LHC is nowadays the world's largest and most powerful particle accelerator [1]. The two beams circulating the tunnel collide in four distinct places, that are the four main experiments of LHC: ATLAS, CMS, ALICE and LHCb.

The LHCb (Large Hadron Collider beauty) Experiment is dedicated to study the asymmetry between matter and antimatter, searching for CPV effects on decays involving quarks b and c, as well as studying rare decays and spectroscopy. Contrary to ATLAS and CMS, LHCb is a single arm spectrometer, as can be seen in Fig. 1 that uses a series of sub-detectors to track mainly forward particles [2].

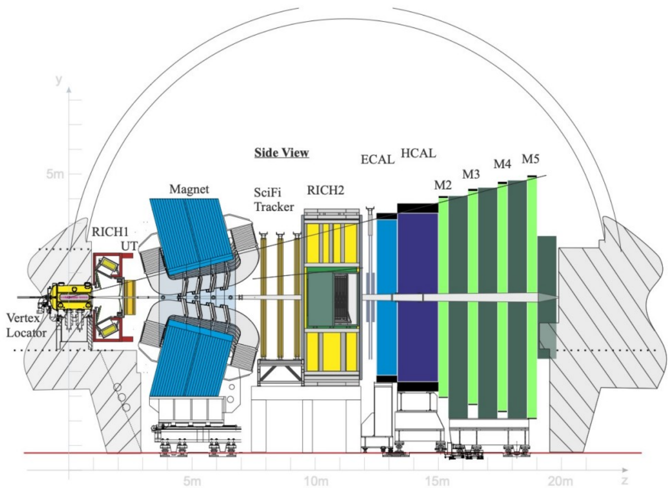

Figure 1: LHCb detector [3]

The Vertex Locator (VELO) is one of the LHCb's sub-detectors and measures the distance between the collision point and the point where B hadrons decays into other particles by detecting tracks of ionising particles coming from the beam collision region. Beside measuring the charged particles trajectories and thus the position of interaction vertices, it also provides discriminatory information for event selection [3]. Such a delicate and fundamental detector has to be under constant monitoring to ensure that everything is working properly and the data is being taken. To ease this task, a summary panel has been developed in this project, using SIMATIC WinCC Open Architecture, to ease the monitoring of status of the electronics, from the low voltage to the data acquisition board showing all the status of the electronics.

2 VELO

2.1 VELO module

The VELO consists of pixelated hybrid silicon detectors, arranged into modules and cooled by CO2 circulating in silicon microchannels. The 52 modules are set out into two movable halves, the side C and side A. The VELO module, as can be seen in Fig. 2, brings together the silicon detectors, their cooling, powering, readout and mechanical support into a single repeating unit.

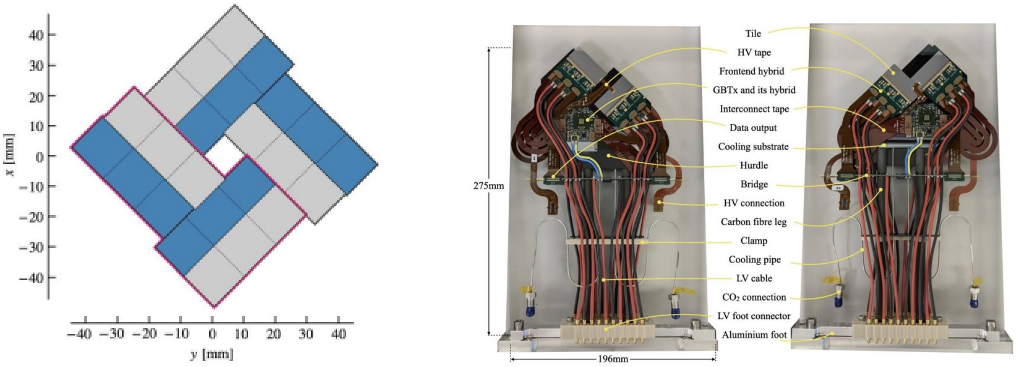

Figure 2: Left: sketch of the nominal layout of the ASICs around the z axis in the closed VELO configuration. The upstream module is represented in grey and the downstream in blue. The module on side C is highlighted in purple. Right: fully-assembled VELO module with the upstream (left) and downstream (right) faces [3].

2.2 VELO Electronics and Readout chain

The electronic components of the VELO are placed into three locations: on the detector module, immediately outside the VELO vacuum vessel and off-detector. With dedicated cabling running between them, as can be seen in Fig. 3.

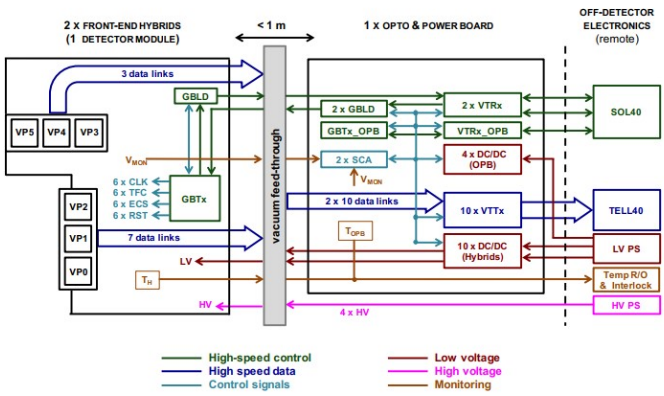

Figure 3: Sketch of the electronics and readout chain [3].

The electronics system is mainly responsible for transporting data from the VeloPix ASICs to the off-detector processing units, as well as allowing the communication and configuring between the various ASICs and the powering up. The opto- and power board (OPB) is the interface between the detector modules and the off-detector electronics, and receives the serial data that comes from the hybrids through high speed serial links transmitted out of the secondary vacuum.

3 The VELO Dashboard

The summary panel, named VELO Dashboard, was developed using SIMATIC WinCC Open Architecture to built the graphical interface. The panel brings together the status of all the electronic components in a single screen, from the low voltage components to the data acquisition. The final layout can be seen in Fig. 4.

Figure 4: VELO Dashboard panel.

The first column from the left to right represents the Low Voltage components, that are responsible for powering the electronics. Then there is the RxReady and the DC/DC components of the OPB. The DC/DC converters transform the five input voltages to the ten supplies needed by the detector module and four voltages required by the OPB itself. The next component of the panel, the High Voltage, is applied to bias the sensors. After this, there is the GBTx (gigabit transceiver) and the VeloPix, the GBTx chip distributes timing signals and fast control instructions to the VeloPix ASICs via the FE hybrid and on each module face there are two FE hybrids and one GBTx hybrid. The TELL40 Links represent the data acquisition cards and are used for processing the twenty high-speed GWT data serial links of a single module. Then, there is the TELL40 FSM (Finite State Machine) and the Data Rate indicating the data flux through the TELL40 Links.

Each LED represents a component of the system and has a function to change its colour according to the status of this subsystem. The colour pattern varies for the different elements, but the default configuration is:

- **green:** indicates that everything is working right and the detector is on the PHYSICS mode;
- **blue:** indicates that everything is working right but the detector is not on the PHYSICS mode;
- **orange:** indicates that this element needs attention;
- **red:** indicates an error;
- **grey:** indicates that this element is disabled.

In addition to the colour function, the LEDs have another features, such as the ToolTip text option, that shows what element of the system this LED represents, and also the click buttom option that opens a more specific panel associated to this element for a closer look at the system. This features can be seen in Fig. 5.

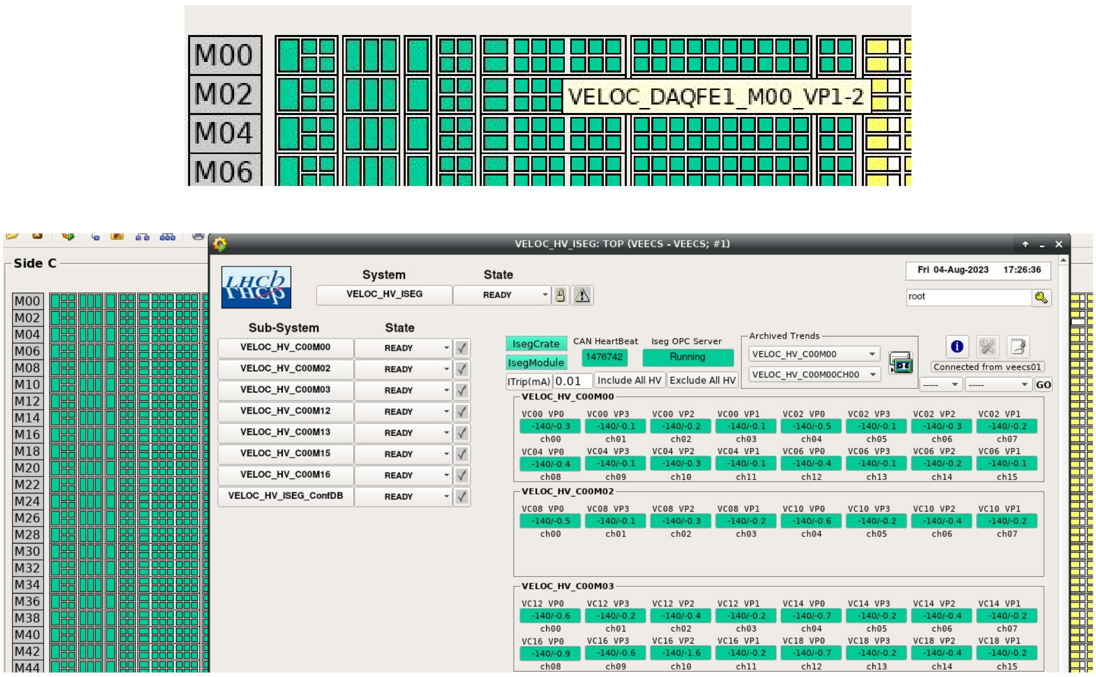

Figure 5: VELO Dashboard panel features: ToolTip text (Top) and Click button option opening the High Voltage panel (Bottom).

However, besides this useful features, the main role of the VELO Dashboard is to provide an easy error identification. On Fig. 6 it is possible to see that the LEDs for the TELL 40 links of the Module 11 on Side A are indicating an error, yet a look at this whole module line shows that this is error goes back until the Low Voltage and this may indicate that a malfunction in the low voltage is causing all the subsequent errors. In this way, just by looking at the panel it is possible to have a faster identification of the elements with errors and even trace back the origin of the error in order to fix it.

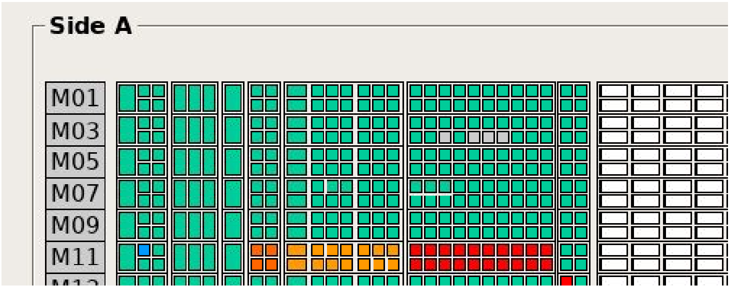

Figure 6: VELO Dashboard panel with LEDs indicating an error.

4 Conclusion

The Velo Dashboard panel developed during this Summer Programme is now available to be used by the LHCb VELO system, which should hopefully simplify the monitoring process in the LHCb Control Room and also speed up the error identification. The panel was built using SIMATIC WinCC Open Architecture to construct the graphical interface.

References

[1] Lyndon Evans and Philip Bryant. “LHC Machine”. In: *Journal of Instrumentation* 3.08 (Aug. 2008), S08001. DOI: 10.1088/1748-0221/3/08/S08001. URL: https://dx.doi.org/10.1088/1748-0221/3/08/S08001.

[2] The LHCb Collaboration and A Augusto Alves Jr et al. “The LHCb Detector at the LHC”. In: *Journal of Instrumentation* 3.08 (Aug. 2008), S08005. DOI: 10.1088/1748-0221/3/08/S08005. URL: https://dx.doi.org/10.1088/1748-0221/3/08/S08005.

[3] LHCb collaboration. *The LHCb upgrade I*. 2023. arXiv: 2305.10515 [hep-ex].