11th International Workshop on Ring Imaging Cherenkov Detectors. 12-16 September 2022

Slow control of the Belle II Aerogel Ring Imaging detector

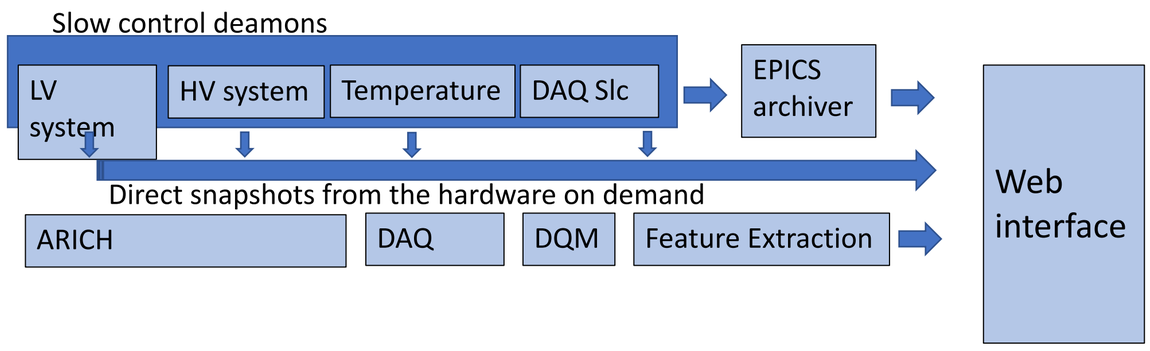
Rok Pestotnik

on behalf of the Belle II ARICH group

Institut "Jožef Stefan" Ljubljana, Slovenija

Since 2018 an aerogel proximity focusing Ring Imaging Detector (ARICH) efficiently separates hadrons in the forward endcap of the Belle II spectrometer. Cherenkov photons emitted in the double layer aerogel radiator are expanded in the 16 cm space and detected on the photon detector comprising 420 Hybrid avalanche photodiodes and backside readout electronics working in a threshold mode. Each of the sensors requires six different high voltages and a supply of four low voltages for the electronics. Due to power dissipation, the system also incorporates a cooling system implemented by circulating cold water through the Al pipes thermally coupled to the readout electronics. The reliable control of the supply voltages and monitoring of the environmental observables and the status of the sensors ensure the stable operation of the ARICH detector and early response to sudden current changes, single events upsets, the overheating, and other faults. In the contribution we will present the slow control system of the ARICH and the data quality monitor used for performance tracking.

The slow control system of the Belle II ARICH \cite{tdr} consists of two four subsystems: The high Voltage system is responsible for the control and monitoring of the high voltages, Low Voltage Control System is used to control and monitor the voltage supply of the readout electronics, Environmental monitor, used to monitor the temperature of the detector and the Front End Board Control system responsible for firmware upload, settings of the readout chip parameters, temperature control, and control of the single event upset mitigation controller.

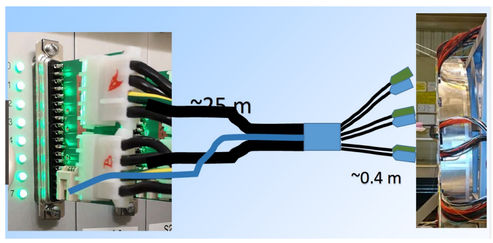


The daemons communicate with other processes using the common Belle II NSM2 protocol and accept requests for switching the supply channels on or off and adjusting the setting of the hardware. The configuration setting is loaded from a common Belle II database, allowing flexible and controlled change of values. The slow system is also responsible for constant monitoring of voltage and current readings as well as other detector parameters - e.g., temperatures and number of single-event upsets. The values are regularly stored in the EPICS Archiver database and allow for monitoring each single-bias channel. Note that only the values that change significantly from the previous reading are stored, thus reducing the storage of huge amounts of data.

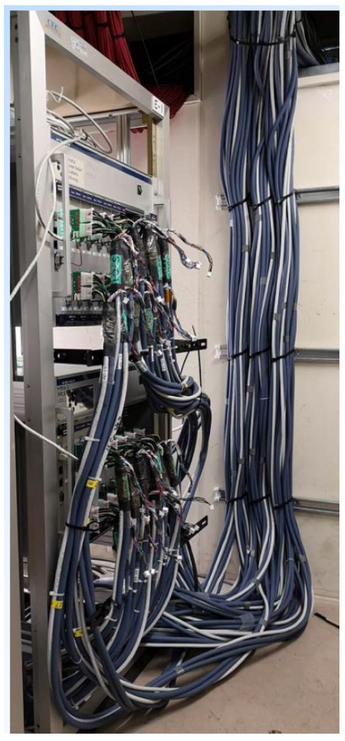
The High Voltage system consists of 8 CAEN SY4527 crates, 45 CAEN A7042P 48 Channel 500 V Common Floating Return Boards used to supply four bias voltages and one guard voltage for each of the 420 HAPDs and 28 CAEN A1590 - AG590 16ch 9kV boards used to supply 420 high voltages. The system is controlled by HV daemons which communicate with the hardware using the CAEN HV wrapper library. To minimize possibilities for discharges, the operation of all 6 HV channels supplying a particular HAPD should be synchronous. and should follow well-defined transitions between different system states.

The low voltage system consists of two Wiener MPOD systems and 12 low voltage modules WIener MPV8008LI(0-8V/5A; 8 channels; 40W /ch; floating; <2mVp-p ripple). The power supply modules deliver +3.8V, +2V, and -2V to the 420 front end boards and +1.5V and +3.8V to the 72 merger boards, responsible for the data concentration and communication with common Belle II acquisition cards.

There are 24 25 m long cables: 2x4 cores (AWG14) and 8 core sensing wire (cat7). The voltage drop on the wire is about 1V.

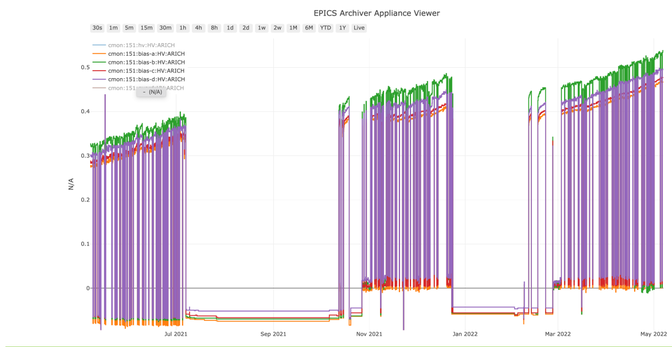


Additional daemons are constantly monitoring the important parameters from the reconstruction, for example, Cherenkov angle, number of hits per track, number of hot and number of dead channels, timing distribution of hits, and allow to monitor the time variation of those parameters using several web interfaces.

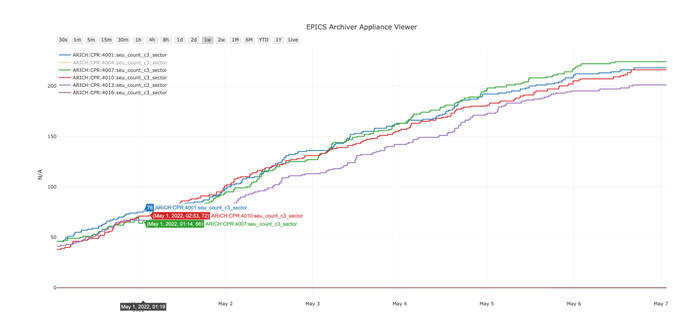


The data acquisition control implements a slow control that controls the parameter settings of the readout boards and monitors the basic functionality of the boards - measured values of supply voltages, temperatures, and SEU counts. Additional temperature sensors are read out by a common Belle II environmental monitoring system.

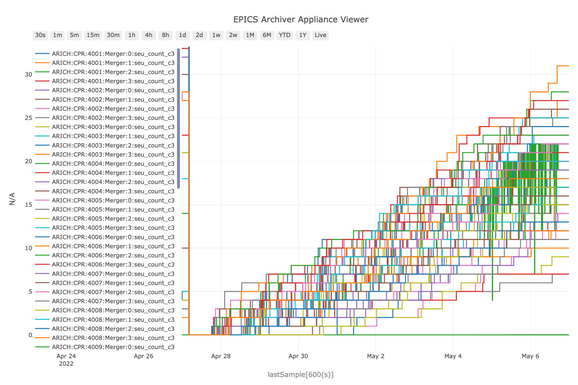
Monitoring of the bias currents: Due to the irradiation of the sensors, the bias currents increase. The time evolution allows to estimate and project the operation usability of the sensors.



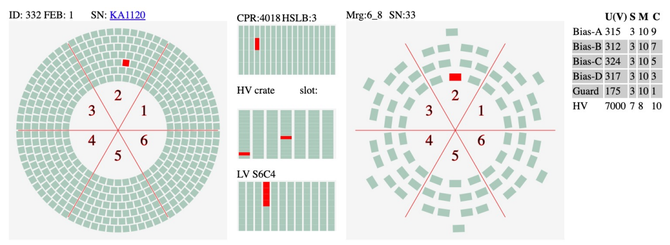
Cumulative number of single event upsets detected in the merger using custom SEU mitigation controller.



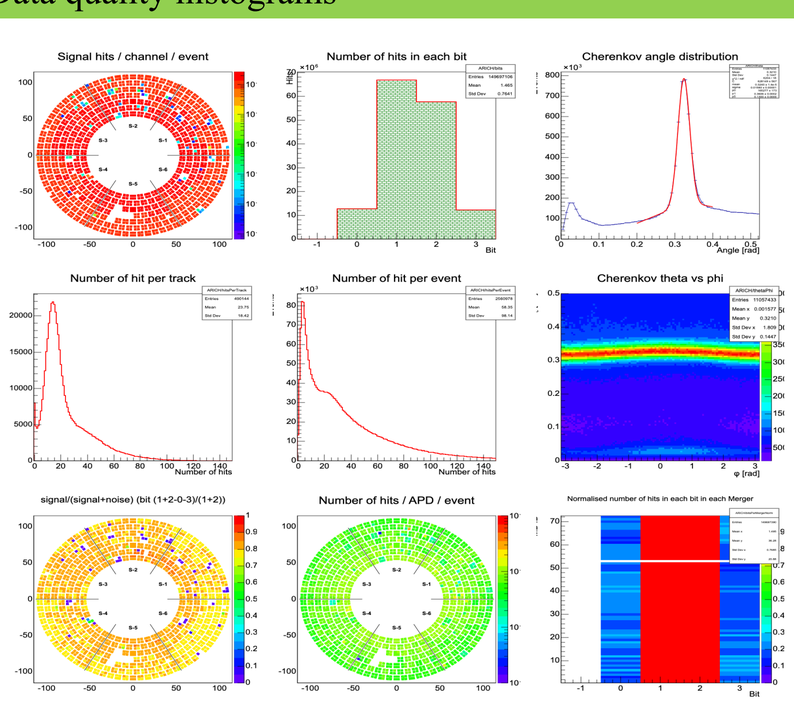
Cumulative number of single event upsets detected in the several front end boards.



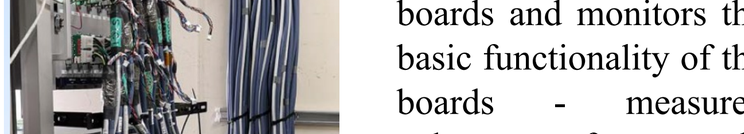
Debug and mapping window.



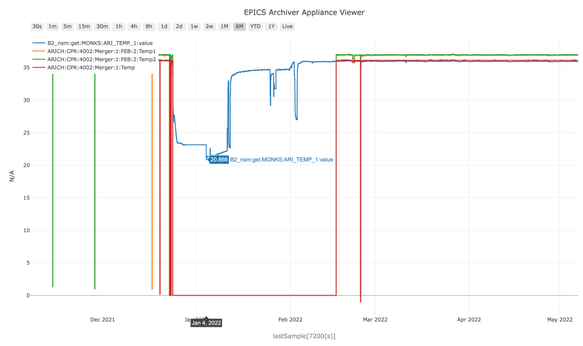
Data quality histograms



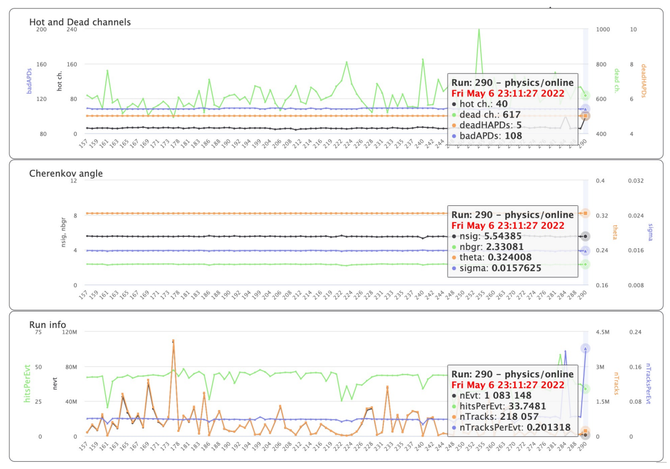
Calibration runs - threshold scan.



Time variation of reconstruction parameters.



Time variation of reconstruction parameters.



The slow control of the Belle II ARICH is working smoothly without any major problems and allows to operate the detector for successful particle identification.