

# An LHCb general-purpose acquisition board for beam and background monitoring at the LHC

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The acquisition board is used as a readout board for the LHCb beam pickups in order to continuously monitor the bunch intensities and the phase of the bunches of protons with respect to the LHC bunch clock, and as a high-speed and high-sensitivity readout system for a scintillator background monitor which records fast beam losses with time information.

In this paper we will describe its conceptual design, the many fundamental functions and its performance. We will also show results from the beam commissioning during which the board provided important information to the LHC, and during the first period with collisions.

## Summary

In this paper we will present an LHCb custom-made acquisition board which was developed for a continuous beam and background monitoring during LHC operations at CERN, its conceptual design and its performance and results during the first period of beam operations at the LHC.

The acquisition board was initially intended as a readout board for the LHCb beam pickups based on button electrodes in order to continuously monitor the intensity of each beam at the LHC bunch crossing frequency of 40 MHz and the phase of the arrival times of the proton bunches with respect to the LHC bunch clock as distributed to the experiments from the RF system. The extreme versatility of the board also allowed the LHCb experiment to build a high-speed and high-sensitivity readout system for a background monitor based on a pair of plastic scintillators, the LHCb Beam Loss Scintillators, located just in front of the LHCb Vertex Locator in order to record fast beam losses.

The board is equipped with two alternative integrator circuits, one of which is based on very fast analog current amplifiers and the other which is based on an operational transconductance amplifier, a 12-bit pipelined ADC, a 27ps resolution TDC, two 16-bit wide and 16-bit deep FIFOs, an ALTERA APEX 20K200E FPGA with more than 8000 logical elements. Configuration, control and monitoring of the board are performed via Ethernet from a PVSS based control system which is integrated in the overall Experiment Control System of LHCb. The board has demonstrated extremely good performance in many tests at the CERN-SPS during the development of the first prototype and proved to be conceptually valid during the first months of operations at the LHC. Connected to the beam pickups it provides the LHCb experiment with a real-time measurement of the total intensity of each beam and of the arrival time of each beam at the LHCb Interaction Point. It also monitors the LHC filling scheme and the beam current per bunch at a continuous rate of 40 MHz, and assures a proper global timing of LHCb.

The continuous readout of the Beam Loss Scintillators provides the LHCb experiment with high-resolution information about the beam halo and fast losses during both injection and circulating beam. It has also provided valuable information to the LHC during machine commissioning, in particular during the setup of the LHC injection kicker and collimators, the aperture scans of the LHCb long straight section, and asynchronous beam dumps. Recent results also indicate that it could contribute as a luminosity monitor independent from the LHCb experiment readout system.

Beam and background measurements are also continuously fed back to the LHC in the data exchange framework between the experiments and the LHC machine aimed at improving efficiently the experimental condition real-time.

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