Contribution ID: **169**

Type: **Poster**

The upgrade of the LHCb calorimeter

Wednesday 25 September 2013 18:09 (1 minute)

The LHCb collaboration foresees a major upgrade of the detector for the high luminosity run that should take place after 2018. Apart from the increase of the instantaneous luminosity at the interaction point of the experiment, one of the major ingredients of this upgrade is a full readout at 40MHz of the sub-detectors and the acquisition of the data by a large farm of PC. The trigger will be done by this farm and should increase the overall trigger efficiency with respect to the current detector, especially in hadronic B meson decays. A general overview of the modifications foreseen to the calorimeter system and the integration of the electromagnetic and hadronic calorimeters in this new scheme will be described.

Summary

The LHCb detector is located on the ring of the LHC accelerator at CERN. The fields of research of the collaboration are CP violation, charm physics and rare decays of the B meson. More than 3fb^{-1} have been recorded since the LHC start-up, mainly in 2011 and 2012. The data quality permitted to make important measurements. The B_s meson decay in a pair of muons and other new decays of the B_s have observed, the B_c mass has been measured with the best precision ever, etc\ldots\\
The performances of the detector are very satisfactory although the beam conditions have been far more aggressive than what was foreseen during the design period. The pile-up was roughly 1.7 in 2012, in spite of the expected nominal conditions foreseen to be 0.4 during the installation of the detector. The confidence of the collaboration in the detector justified those conditions, the gain in statistics being larger than the relative degradation of the data quality due to the higher number of collisions per crossing.\\
Since a few years, the upgrade of the LHCb detector is being prepared in order to improve the measurements in major areas of flavor physics and to reach ultimately the theoretical uncertainties in several fields. The upgrade will take place during the long shut-down of 2018 (LS2) and should permit to increase the instantaneous luminosity up to $2 \times 10^{33}\text{cm}^{-1}.\text{s}^{-1}$. All the sub-detectors are affected by this upgrade. The pile-up leads to some drastic modifications of the tracking and particle identification systems. But, the most important modification concerns the first hardware trigger (L0) which will be removed. A pure software trigger, more efficient and more flexible, will remain. The suppression of the L0 implies that each sub-detector sends its data at 40MHz to the computer farm on which the trigger program is running. Estimations of the impact of the software trigger (not considering the increase of luminosity) show that the event yield should be more than doubled in B meson hadronic decays (the improvement could be larger for high multiplicity final states with up to 6 charged particles), after the suppression of the present hardware trigger. \\
The first level trigger will disappear, but part of its electronics can be re-used and adapted in order to reduce the bandwidth at the input of the PC farm. The purpose here is not to limit the bandwidth systematically at a fixed rate like the L0 does, but to reduce the bandwidth between 1 and 40 MHz, depending on the needs and altogether to enrich the sample. The reasons for such a Low Level Trigger (LLT) are a possible stagging of the size of the PC farm at LHC start-up or an occasional problem on the farm.\\
The calorimeter system of LHCb will evolve by reducing its complexity, the present scintillating pad detector and the preshower will be removed, their disappearance being compensated by the future software trigger and the improved tracking system. The module performances can be affected by radiations. Hence, some of the cells in the inner region (the closest to the beam pipe) may be replaced during LS2. The calorimeter of LHCb, like the other sub-detectors should adapt its electronics (common to the electromagnetic and hadronic calorimeters) to the new running conditions of the upgrade. The consequences of the upgrade for the elec-

tronics are: the readout of the data is done at 40MHz ; the gain of the PMT will be reduced by a factor 5 in order to keep them alive during the high luminosity run, this reduction is compensated by an increase of the gain of the electronics (without increase of the noise with respect to the present system) ; the calorimeter implementation of the first level trigger will be adapted to the new low level trigger. This implies the design of a new front-end electronics. A fraction of the existing system will be kept: the crates, the backplanes, some of the power supplies. The front-end and control boards will be removed and the architecture will be revised. The architecture will consists in acquiring 32 PMT per front-end board. The analog electronics should be made either from on an ASIC component or a system based on "commercial-off-the-shelf" (COTS) components. The shaping and integration of the signal in the two concurrent techniques are very different but give comparable performances. After the sampling of the output of the analog part of the front-end electronics, FPGA will be used to perform several operations : baseline subtraction, calibration of the signal for the low level trigger, event building, \ldots The output bandwidth of each front-end board will reach 20 Gbits/s. 5 Optical links driven by GBT components, designed at CERN, are used: 4 for the data acquisition path and 1 to send the low level trigger information to the counting room. A front-end crate will contain up to 16 boards, the middle slot of each crate being filled by a control board. This card receives from the counting room the clock, the slow control signals and the fast (synchronous) commands of the experiment and propagates them to the backplane and finally to the front-end boards. The control board will receive or emit the signals (slow control, commands, clock) through a bi-directional link based on the GBT system.\\
One of the particularity of the calorimeter electronics is its location: on the gentry which is just above the calorimeter itself. Radiation levels in this region are high and extra safety precautions are essential to protect the electronics against the cumulated dose and the single event effects. Commercial components should be tested in beam in order to guarantee their usage in such conditions; the ASIC is designed with specific conception techniques; flash-based FPGA will be used in the digital part of the electronics, etc\ldots \\
Prototypes for the analog part (both ASIC and COTS) and the digital part exist. They have been tested with a spare ECAL module in November 2012 at CERN in an electron beam. The performances obtained from the data are close to the expected ones and a few modifications are foreseen in order to obtain a fully satisfactory design. \\
Peripheral systems permit to follow continuously the performances or to control the functioning of the calorimeter. These include the electronics providing high-voltage to the photo-multipliers, the pulsing system for the LED or the radioactive source based calibration of the hadronic calorimeter. A fraction of it can be kept as is or simply adapted in order to be able to receive (like the new control board described above) its slow control or clock signals and commands from the LHCb time and fast control system, through the GBT driven optical links.\\

Primary authors: MACHEFERT, Frederic (Laboratoire de L'Accélérateur Linéaire (LAL), Orsay); MAURICIO FERRE, Juan (University of Barcelona (ES))

Presenter: MAURICIO FERRE, Juan (University of Barcelona (ES))

Session Classification: Poster