
Contribution ID: **178** Type: **Oral**

# The readout electronics of the SciFi Tracker for LHCb detector upgrade

*Wednesday 30 September 2015 15:15 (25 minutes)*

A new detector made of scintillating fibres read out by silicon photomultipliers (SiPM) is planned for the LHCb detector upgrade, foreseen in 2018/19. The development of a dedicated readout electronics in the harsh LHC environment bears challenges.
Each SiPM generates 10.24Gb/s of data after the digitization leading to a data rate of 9.1Tb/s for the full detector. Such a large amount of data can not be reasonably processed by a computing farm. In this paper, we describe the readout scheme and the zero suppression algorithm used to reduce the data flow below 8Tb/s.

## Summary

The upgrade of the LHCb detector is forseen during the long LHC shutdown in 2018/19. The detector has to operate at an instantaneous luminosity 5x higher than the current one. The present tracking detector can not cope with the largely increased occupancy. The main tracking system therefore will be replaced by a new detector built from 2.5m long and 250 µm thick scintillating fibers (SciFi tracker), read-out by arrays of Silicon Photo Multipliers (SiPM). The SiPMs are well suited for this application as they exhibit a fast signal response combined with a fast recovery time. However, their noise increase dramatically with the expected neutron irradiation.

In total, the SciFi tracker electronics system has to read 560k channels at 40MHz without any dead time. The SiPM outputs are then processed using a dedicated 64 channels front-end chip (PACIFIC). This ASIC uses a fast shaper with a full width at half maximum (FWHM) lower than 5ns. Afterwards, the signal is integrated over 25ns and digitized using a 3-thresholds scheme leading to a 2b resolution. Finally, the data are serialized at 160MHz on single-ended links. At this stage, each SiPM generates 10.24Gb/s of data leading to 49.1Tb/s for the full SciFi tracker.

Consequently, a strong effort has been put on reducing the data flow to a more sustainable level. A dedicated zero-suppression scheme has been developed for this purpose, based on the intrinsic characteristic of the SciFi signals. In a first stage, the clusters generated by the particle hits are built with the fired SiPM channels. Afterwards, a four-threshold algorithm allows to accurately separate the noise from the useful signal. The final stage computes the barycenter of each cluster for which the expected resolution is therefore better than the required 100µm. Finally, only the cluster barycenter is sent using optical links to the data acquisition system. The full processing is implemented in a Microsemi IGLOO2 FPGA. This FPGA has been chosen for its intrinsic radiation tolerance. The SciFi tracker generates 8Tb/s of data at this stage.

The back-end side is composed of the common read-out board for LHCb (called TELL40). Each board can cope with a maximum of 48 inputs optical links (230Gb/s) using MPO connectors and providing 100Gb/s output bandwidth. In order to optimize the link usage, two frame formats have been selected to transmit the data from the front-end boards to the TELL40 board depending on the detector occupancy. The data are finally packed in multi-event packets and sent to the PC farm for further processing.

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**Session Classification:** Systems, Planning, installation, commissioning and running experience

**Track Classification:** Systems