Abstract:
The current LHCb tracking detector will be replaced with a Scintillating Fibre (SciFi) Tracker with SiPM array readout for Run 3 of LHC. The Light Injection System (LIS) is a cost effective calibration system, mandatory to set the operating voltages of the SiPMs as well as the comparator thresholds of the readout chips for more than 500 000 electronics channels. Low intensity 5 ns short light pulses are generated by red VCSELs in combination with Gbit Laser Drivers (GBLD). We present the structure of the system, tests of light output, stability, radiation hardness and its electrical performance.

Summary:
The LHCb detector will be upgraded during the Long Shutdown 2 of the LHC in order to cope with higher instantaneous luminosities and to read out the data at 40 MHz using a triggerless readout system. The current tracking detector will be replaced with a Scintillating Fibre (SciFi) Tracker. The detector will be built from 2.5 m long plastic fibres with a diameter of 250 µm, which are readout by SiPM arrays. The SiPM signals are collected and processed by 64 channel PACIFIC chips. Every channel of these chips performs analogue processing and digitization at a rate of 40 MHz. Subsequent digital electronics perform clustering and data compression before the data is sent via optical links to the back-end electronics.

A precise measurement of the internal amplification of the SiPMs requires a Light Injection System (LIS) which can cause single SiPms pixels to fire. The sum of the photocurrents from each of these pixels allows the generation of photon spectra and hence the measurement of the distance between two or more photon peaks. It is an important tool permitting the correct setting of the overvoltage and of the PACIFIC thresholds for the clustering algorithms.

The LIS generates 5 ns short light pulses with an intensity of 2-6 photoelectrons per SiPM channel. The electronics is modular, each module consisting of 2 parts: control electronics located on the Master Board (CEM) and the light generator (LG), which is implemented on a mezzanine board located close to the SiPMs. The CEM is embedded in an FPGA. It receives one data link at 80 MHz from the Master GBT used for the TFC commands and the synchronization clock from the Data GBT. The logic in the FPGA decodes the TFC commands and generates an output pulse with a constant width of 5 ns. The CEM also provides one I2C port from the Slow Control Adapter ASICs (GBT-SCA) in order to adjust the intensity of the light to balance the variations in the attenuation of the optical couplings. The LG has two channels, each consisting of one GBLD and one red VCSEL emitting red light with the wavelength of 670 nm. The GBLD provides programmable modulation and bias current for the VCSEL.

The light is guided via a plastic optical fibre (POF) to the transparent polycarbonate end-piece. It is injected through a scratch in the POF into the end-piece and is guided via the scintillating fibres and partly via the transparent end-piece to the SiPMs. In total 1152 light sources for the whole detector are needed to generate roughly equal signals for all SiPM channels.

The functionality of the LIS was tested in test beams with the detector modules and PACIFIC readout. The results show clearly separated photopeaks. The measurements also demonstrate that the intensity of the light generated by the LIS is sufficient and fits well to the dynamic range of the SiPMs. The system is ready for production, which will start in September 2017.

The LIS design concept, results from laboratory tests and testbeam measurements are presented. These studies include the characterization of VCSELs and test of their radiation hardness.