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Calibration systems for SiPM detector uses a novel UV-LED drivers

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We will report on several versions of the calibration and monitoring system for the SiPM-based scintillator tile hadron calorimeter for the ILC. Built and tested in the beam, the 1 m3 calorimeter prototype, uses 7600 SiPMs embedded in the small scintillator tiles and represents the biggest up-to date detector equipped with these new and perspective photodetectors. SiPMs requires a highly flexible calibration system, which can deliver stable and steerable-intensity light. We present a novel qasi-resonant LED driver solution, which can deliver light from the LED in 3.5 ns pulse. We use a novel notched-fiber optical distribution on many tiles per per single fiber basis.

Summary

Our first system was used in the 1 m3 SiPM-based scintillator tile hadron calorimeter prototype for the ILC, which was already built and tested in the testbeam in CERN and FNAL. This system is called CMB (Calibration and Monitoring Board). It consists of 12 UV LEDs (400nm) with a special fast driver optimized for rectangular pulses. The pulses are set to 10 ns width in order to match real signals from hadron showers in the calorimeter as closely as possible. By varying the control voltage, the LED intensity covers the full dynamic range from zero to saturation (about 70 minimum ionizing particles). The LED illuminates a fiber-bundle of 18 + 1. One fiber comes back to the CMB to monitor the emitted light by a PIN photo-diode with preamplifier on the board. The other 18 fibers are rooted to each scintillator tile equipped with one SiPM each.

Our second generation of calibration system uses a simplified optical distribution. Instead of using one fiber for each tile, a series of notches cut on a single optical fiber illuminates a row of tiles below the fiber. The challenge is to make the amount of emitted light from the notches almost equal among all notches. We achieved the spread of light better than 20% along the 2m long optical fibre with 72 notches.

To further improve the performance of the LED driver we abandoned the rectangular pulses. The Quasi Resonant LED driver produces short ~ 5 ns long electrical pulses for LEDs of the quasi-sinusoidal shape. The QRLED is foreseen as a source of the tunable LED light for calibration of SiPMs in the engineering hadron calorimeter module. The short electrical pulses are created in the toroidal inductor made directly on the PCB. This design resulted from the requirement on the minimal height of the electronic circuitry in the compact engineering module and from the effort to keep the EMC noise low.

The SiPM response of the both concepts of the UV LED driver and the light distribution system to the low intensity was proven to produce clear single photo electron spectra. We can conclude that the new system meets requirements for the calibration of the engineering hadron calorimeter prototype. We performed a test with shorter notched fiber (with 12 notches), which delivered the amount of light equivalent 250 MIP to each scintillator tile. We also performed a measurement of the amplitude dependence of the QRLED driver on the intensity of the magnetic field in the range of 0 − 4 T. The strength of the magnetic field is close to the field in the future ILD detector. We conclude that the relative change of the amplitude of the QRLED driver do not exceed level of -3 per mille at 1 Tesla change. If we assume that the relative time stability of the magnetic field of the ILD solenoid will be at the level of 5E-4, then the amplitude time stability of the calibration light is better than 2E-6 .

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