11th International Workshop on Ring Imaging Cherenkov Detectors (RICH2022)

Contribution ID: **2** Type: **presentation**

A SiPM-based optical readout system for the EIC dual-radiator RICH

Thursday 15 September 2022 14:40 (25 minutes)

Silicon photomultipliers (SiPM) are candidates selected as the potential photodetector technology for the dual-radiator Ring-Imaging Cherenkov (dRICH) detector at the future Electron-Ion Collider (EIC). SiPM optical readout offers a large set of advantages being cheap devices, highly efficient and insensitive to the high magnetic field (˜ 1.5 T) at the expected location of the sensors in the experiment. On the other hand, SiPM are not radiation tolerant and despite the integrated radiation level is expected to be moderate (< 10^{11} 1-MeV neq/cm2) it should be tested whether single photon-counting capabilities and the increase in Dark Count Rate (DCR) can be kept under control to maintain the optimal dRICH detector performance across the years.

Several options are available to maintain the DCR to an acceptable rate (below ˜100 kHz/mm2), namely by reducing the SiPM operating temperature, using the timing information with high-precision TDC electronics, selection cuts based on bunch crossing information, and by recovering the radiation damage with high-temperature annealing cycles.

In this presentation we present the current status of the research and the first results on studies performed on a large sample of commercial (Hamamatsu) and prototype (FBK) SiPM sensors. The devices have undergone an irradiation campaign where an increasing NIEL dose up to 1011 1-MeV neq/cm2 has been delivered to different sensor subsets. The sensors have then undergone high-temperature annealing cycles to recover the radiation damage. The results obtained with a complete readout system based on the first 32-channel prototypes of the ALCOR ASIC chip are also reported. Measurements are performed in a controlled-temperature environment where the sensors are mounted in a climatic chamber for characterisation. The setup is also equipped with a movimentation system and a pulsed LED light source to further test the response of multiple sensors and compare the performance of new sensors with the one of irradiated sensors. The time coincidence between the recorded SiPM light signal and the generated LED pulse is used to further discriminate dark-count signals from light signals.

Figure 1: Special care has been used to design a SiPM-carrier board with high-temperature resisting components and an edge connector to cope with temperatures as high as 180 C. (left) One of the custom prototype SiPM boards designed for the irradiation and high-temperature annealing campaign. The shaded area shows the region of the delivered uniform radiation field. (centre) Gafchromic film impressed by the collimated proton beam delivered by the setup shown installed at the TIFPA Trento Protontherapy Centre Irradiation Facility, demonstrating the uniform 3 mm vertical irradiation field. Special care has also been put in the design and realisation of a collimation system with micrometric movimentation to allow us to precisely deliver the proton beam in a 3 mm vertical slit with uniform radiation field. (right) Ratio of the measured current to the current measured on brand new sensor at fixed bias voltage as a function of the level of NIEL delivered radiation, before and after high-temperature annealing.

Figure 2: Measurements of the dark-count rate (DCR) performed with the full readout system coupled to the ALCOR ASIC chip. (left) Single-photon counting is demonstrated by the step-ladder behavior of the DCR as a function of the ALCOR ASIC discriminator threshold for SiPM irradiated up to 10^{11} NIEL after the annealing cycle. The figure shows a sensor that has received 10^{10} 1-MeV neq/cm^2 NIEL, although similar behavior with higher rates is observed for higher delivered NIEL. (right) A comprehensive measurement of the DCR for the large sample of new and irradiated Hamamatsu SiPM sensors shows great uniformity in the response up to

the highest delivered dose. The curves show the DCR as a function of the bias voltage at fixed ALCOR ASIC discriminator threshold (1-pe) for new sensors (blue) and irradiated sensors (red) with increasingly delivered NIEL. The width of the bands represent the dispersion of the rates measured in the large sample of sensors characterised.

Figure 3: Studies with pulsed LED light. (left) The complete prototype readout system inside the climatic chamber mounted on the XY movimentation system in front of the fixed LED light source. The readout system comprises the SiPM matrix carrier board mated with the adapter board, both visible in the picture. The adapter board is coupled with the ALCOR Front-End board which is on the back of the adapter board. The system hosts two SiPM boards, one on the left-hand side with a limited number of sensors which is used as reference for LED light stability checks and one full board for characterisation. (right) Time coincidence between the recorded SiPM light signal and the generated LED pulse.

Author: PREGHENELLA, Roberto (INFN, Bologna (IT))

Presenter: PREGHENELLA, Roberto (INFN, Bologna (IT))

Session Classification: Photon detection techniques for Cherenkov counters

Track Classification: Photon detection techniques for Cherenkov imaging counters