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Performance of a scintillating strip detector with MRS APD readout

The upgraded KLM detector of Belle II experiment will consist of more than 16000 scintillating detectors of 2-3 m long strips. One of possible solutions will be presented: a detector of 3000x40x10 mmˆ3 with light readout via WLS fiber and new MRS APD (CPTA) solid state photo-detector. Concept of the mechanical structure of upgraded KLM detector will be shown. Properties demonstrating the operation capabilities of such a scintillating detector: MIP registration efficiency, noise pulse rate with respect to expected background rate will be presented. Response variaton in longitudinal and transversal directions will be presented. The estimation of admissible radiation load will be given in years of operation in Belle II environment.

Summary (Additional text describing your work. Can be pasted here or give an URL to a PDF document):

After planned upgrade of the KEK collider the RPC detector of Belle experiment used for registration of muons and K0 L's (KLM detector) can not be used due to high background rate. We proposed to upgrade the BELLE II KLM detector with scintillating strip detectors covering the ring area of 6.3 m outer diameter and 2.6 m inner diameter. The detector area will be subdivided onto 4 sectors with maximal strip length approximately. 2.8 m. With 40 mm strip width one needs to have 75 strips to cover the area of one sector.

We tested the scintillating strip of made of polystyrene with POPOP+p-terphenyle dopants.
The strip dimensions were 3000x40x10 mm3. For light readout we used Y11 WLS fiber of 1.2 mm diameter with mirrored end. A MRS APD solid state detector from CPTA (Moscow) was installed at the fiber open end. The strip surface was covered with 100 u of titanium dioxide paint assuring good light collection efficiency. The WLS fiber was glued in the groove in the strip in order to increase light collection efficiency. We measured strip response along the strip and found the response variation in the 19-34 photoelectron range. The variation of strip response in the lateral direction was also measured.
We tested a batch of MRS APD's. Results of tests - distributions over photo-detector gain, noise rate, inter-pixel optical link - parameters important for APD operation. These distributions show the selection fraction for such photo-detectors. The comparison of solid state photo-detectors from various manufacturers will be also given.
The special attention was taken to study of dependence of APD noise rate on discrimination threshold. These data together with dependence of MIP registration efficiency on threshold determine the performance of the detector. The noise rate of APD detector was compared with background rate expected in the Belle II experiment environment.

The next question under consideration was the maximal dose which MRS APD could withstand.
In order to understand this we irradiated several APD's with 200 MeV/c protons at ITEP accelerator with particle flux in the range 3*109 - 4*1010 ptrotons/cm2. Then the noise rate at the threshold corresponding to 98% MIP registration efficiency was estimated and compared with expected background rate in the Belle II experiment. Measurement of dose level were performed at the current Belle detector. Then estimation of dose map at Belle II was done. We choose the allowed dose level for APD's when noise rate due to accumulated dose is equal to background rate.

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