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Applicability of Digital SiPMs in RICH Detectors

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Silicon photomultiplier (SiPM) seems to be a promising photon sensor to be used in future large-scale Ring Imaging Cherenkov (RICH) detectors of the modern experiments due to their potentially low costs, compactness and immunity to magnetic field. The only drawbacks are relatively high dark counts and radiation hardness issues.

Digital SiPMs integrating most of the front-end electronics on chip may offer even more to conventional SiPMs: more compactness, superior timing resolution at the level of tens of ps, SPAD-size position resolution and individual control on SPADs.

In June 2012 an aerogel RICH detector prototype based on dSiPMs from Philips named Digital Photon Counter (DPC) was tested with a mixed hadron beam at CERN. The prototype consisted of a 20x20 cm DPC array with 2304 pixels of 4x4 mm size each. Dead time of the DPC was 720 ns. In order to reduce the dark count rate and raise the photon detection efficiency the detector was cooled to -40℃ in addition to disabling individual SPADs. Cherenkov rings with 12 photoelectrons in average for relativistic particles were observed, single photon timing resolution was estimated at 50 ps, inter-pixel crosstalks were 4%. Signs of radiation damage was observed during this test. Later we studied radiation damage for Philips DPC cooled down to -20℃ with a proton beam at FZJ reaching a proton fluence of 4*10^11 p/cm^2. Dark count rate of damaged DPC as function of proton fluence and temperature is studied. Annealing effect during 7 hours at +45℃ was also studied. Absolute PDE measured for a few DPC pixels and corrected for dead time is about 20% for 470 nm wavelength.

Measured characteristics of the current DPC design prevents from using it in RICH application mainly due to large dead time and susceptibility to radiation.

Desired dSiPM parameters for RICH applications are proposed for discussion.

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