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Towards an Economic Large-Area Fast-Timing Detector for Charged Particles with Silicon Photomultipliers

The research prize-money has been awarded for the observation of the "Competitive Double-Gamma Nuclear Decay", 85 years after its postulation due to theoretical arguments from quantum physics. This discovery has recently been published in Nature [C.Walz et al., Nature 526, 406 (2015)]. It was made possible by exploiting the fast-timing properties of novel inorganic scintillation detectors for gamma radiation and potentially opens up a new route to nuclear research. This provides the scientific basis for a research project in the new Sonderforschungsbereich SFB 1245 at the Institut für Kernphysik. The prize-money enables us to initiate detector-technology research for an economic large-area fast-timing detector for charged particle beams based on plastic scintillators read-out by novel Silicon Photomultipliers (SiPMs).

For detailed studies of nuclear reactions, their products must be identified individually. Particle identification is performed by determining the atomic number (Z) and the mass-to-charge ratio (A/Q) for each nuclide. Usually Z is determined from an energy loss measurement in an ionization chamber, while A/Q can be derived from the Time-of-Flight (ToF) of the particles between two plastic scintillators from which particle-induced light-flashes are read-out by Photomultiplier Tubes (PMTs) providing good time resolution. Although the use of scintillators coupled to PMTs is a well-known technique for particle detection, it is desirable to develop a higher segmented, less bulky, lower cost option for ToF measurements in emerging high-intensity charged-particle beams.

Our research project aims at using segmented SiPMs that are much smaller and more economic than PMTs. The use of SiPMs to read-out plastic scintillators is a comparatively new technique which may offer an attractive replacement for PMTs in many applications in nuclear and particle physics. For determining the optimum setup for timing measurements, we are currently performing measurements on strips of different types of scintillator materials attached to SiPMs of different sizes and with different numbers of microcells for segmentation. The crucial point is to determine the time resolution achievable with these devices. All measurements are performed in the laboratories of the Institut für Kernphysik. We thank the Freunde der TU Darmstadt for supporting our investigations on the optimal setup to be used for timing applications with SiPMs.