Fast timing with Geiger-mode Avalanche Photodiodes

A. Stoykov, R. Scheuermann, K. Sedlak

Laboratory for Muon Spin Spectroscopy,
Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland

In this work we report a time resolution $\sigma\sqrt{E} = 18$ ps·MeV$^{0.5}$ for a plastic scintillator readout by a Geiger-mode Avalanche Photodiode. The result competes the best ones reported with photomultiplier tubes.

High time resolution detection of ionizing radiation has been a subject of numerous theoretical and experimental studies reviewed in [1]. The best time resolution by using plastic scintillators readout by photomultiplier tubes (PMTs) with the signals being processed by constant fraction discriminators has been established as $\sigma\sqrt{E} = 19$ ps $\cdot$ MeV$^{0.5}$, where E is the energy deposited in the scintillator [1, 2].

In this work we focus on achieving the best timing using Geiger-mode Avalanche Photodiodes (G-APDs) [3]. The tests are done with a Hamamatsu S10362-33-050 MPPC coupled to a BC-422 plastic scintillator. The method is similar to that described in [1], i.e measuring time resolution versus signal amplitude (energy) by selecting narrow amplitude windows from the signal spectrum. Figure 1 shows the experimental data on the energy dependence of the time resolution. As in the case with PMTs, the time resolution is inversely proportional to the square root of the detected energy, scaling to 18 ps at 1 MeV. This result is as good as ever measured with PMTs and promises a breakthrough in fast timing detection of ionizing particles especially in high magnetic fields.

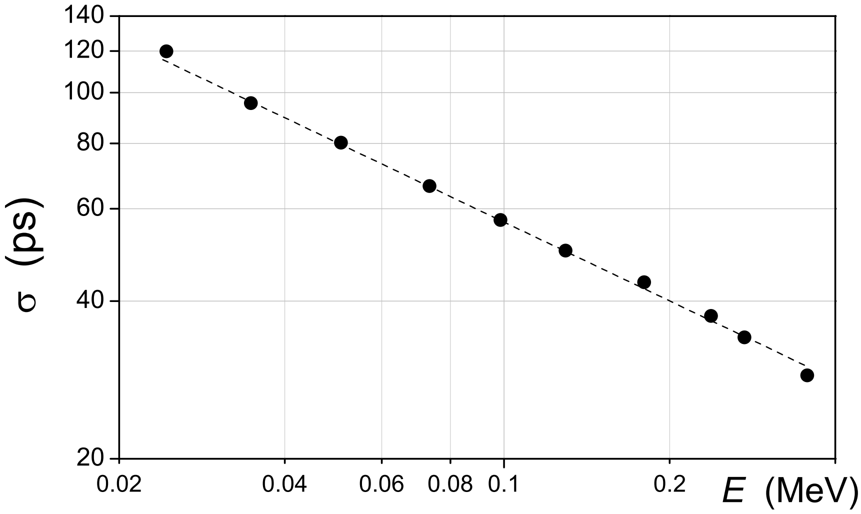

Figure 1: Time resolution measured with a 3 x 3 x 2 mm^3 BC422 plastic scintillator readout by a 3 x 3 mm^2 active area G-APD (Hamamatsu MPPC S10362-33-050) vs. energy E deposited in the scintillator. The dashed line is a fit to $\sigma = \sigma_{1\mathrm{MeV}}/\sqrt{E}$, with $\sigma_{1\mathrm{MeV}} = 18$ ps $\cdot$ MeV$^{0.5}$.

References

[1] M. Moszynski, B. Bengtson, Nucl. Instr. and Meth. 158 (1979) 1.

[2] M. Moszynski, Nucl. Instr. and Meth. A 337 (1993) 154.

[3] D. Renker, Nucl. Instr. and Meth. A 567 (2006) 48.