Tests of Silicon Photomultipliers for NeuLAND *

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NeuLAND, the successor of the LAND time-of-flight neutron spectrometer is planned to be constructed of $5 \times 5 \times 250\,\mathrm{cm}^3$ scintillator bars of RP-408 [1] or equivalent. Light readout will be performed by $1''$ photomultiplier tubes (PMTs). A demonstration prototype of the detector concept was recently tested at GSI [2]. During the operation of the complete detector with 6,000 channels a significant number of photomultiplier tubes may have to be replaced each year. Recent developments in the field of semiconductor based photon readout systems [2, e.g.] raise the possibility of using Silicon Photomultipliers (SiPMs) for this task.

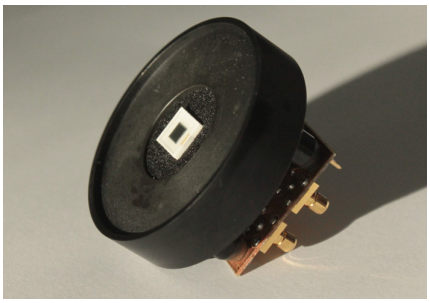

Figure 1: Setup to fix a $3 \times 3\,\mathrm{mm}^2$ SiPM on the $1''$ diameter side of a NeuLAND bar, mechanical support structure and preamplification board.

A cylindrical scintillator of EJ-200 (equivalent to RP-408) with a length of 15 mm and a diameter of 10 mm is instrumented subsequently with $3 \times 3\,\mathrm{mm}^2$ silicon photomultipliers of various manufacturers (fig. 1). For the supply of the high voltage and the preamplification of the signal, a dedicated electronic board was developed at HZDR. A collimated $^{90}\mathrm{Sr}/^{90}\mathrm{Y}$ β-source was used for measurements in self-triggering mode with one SiPM time-determining. It was found that a mean time resolution of $\sigma_t = 210\,\mathrm{ps}$ can be achieved assuming symmetric contributions of both KETEK PM3360 SiPM (figs. 2 and 3).

Coincidence timing resolution measurements on the scale of $\sigma = 100\,\mathrm{ps}$ are challenging, because they require a reference detector with similar time resolution. In contrast, the ELBE facility at HZDR provides electrons of 30 MeV in bunches of 5 ps length and a reference clock signal of better than 20 ps resolution. This allows testing of fast detectors with minimum ionizing particles.

First tests with a NeuLAND type scintillation bar instrumented with Hamamatsu R2059 PMT and $3 \times 3\,\mathrm{mm}^2$ SiPM

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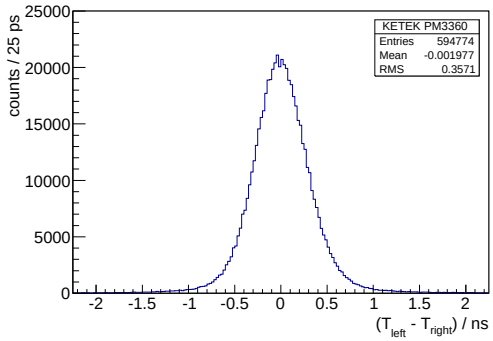

Figure 2: Averaged time from right and left side of setup with a small EJ-200 scintillator, a KETEK PM3360 SiPM and a collimated $^{90}\mathrm{Sr}/^{90}\mathrm{Y}$ β-source.

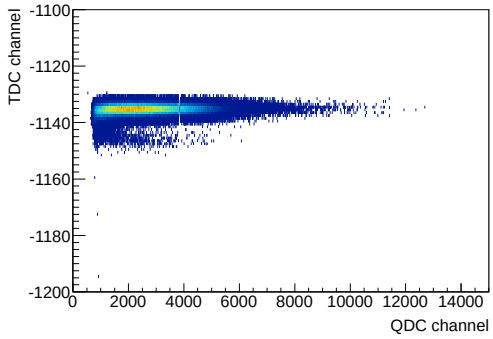

Figure 3: Charge versus time spectra for one KETEK PM3360 SiPM measured with $^{90}\mathrm{Sr}/^{90}\mathrm{Y}$ β-source.

in a hybrid setup and also with one SiPM on each side have been performed at ELBE. Light collection and dark count rate were identified as main issues for achieving the timing as well as efficiency requirements on large scale. Work is ongoing with SiPMs of $3 - 6$ mm side length from various manufacturers.

References

[1] NeuLAND@R3B: A Fully-Active Detector for Time-of-Flight and Calorimetry of Fast Neutrons, NeuLAND Technical Design Report, http://www.fair-center.de/fileadmin/fair/experiments/NUSTAR/Pdf/TDRs/NeuLAND-TDR-Web.pdf

[2] K. Boretzky *et al.*: NeuLAND@R3B. A Progress Report. GSI Annual Report 2012.

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