Contribution ID: **83** Type: **Poster**

Comprehensive study of silicon photomultiplier based readout of the large plasticscintillator based neutron detector NeuLAND

Tuesday 6 September 2022 18:14 (2 minutes)

The NeuLAND (New Large-Area Neutron Detector) plastic scintillator based time of flight detector for 0.2-1.6 GeV neutrons is currently under construction at the Facility for Antiproton and Ion Research (FAIR), Darmstadt, Germany. In its final configuration, NeuLAND will consist of 3,000 2.7 m long plastic scintillator bars that are read out on each end by fast timing photomultipliers. Here, data from a comprehensive study of an alternative light readout scheme using silicon photomultipliers (SiPM) are reported. For this purpose, a typical NeuLAND bar was instrumented on each end with a prototype of the same geometry as a 1"photomultiplier tube, including four 6×6mmˆ2 SiPMs, amplifiers, high voltage supply, and micro-controller. Tests were carried out using the 35 MeV electron beam from the ELBE superconducting linac with its ps-level time jitter in two different modes of operation, namely parasitic mode with one electron per bunch and single-user mode with 1-60 electrons per bunch, using Acqiris fast digitizers. In addition, offline tests using cosmic rays and theNeuLAND data acquisition scheme were carried out. Typical time resolutions of σ≤100 ps were found for ≥99% efficiency, improving on previous work at ELBE and exceeding the NeuLAND timing goal of σ<150 ps. Over a range of 10-300 MeV deposited energy in the NeuLAND bar, the gain was found to deviate by ≤10% (≤20%) from linearity for 35µm (50µm) SiPM pitch, respectively, satisfactory for calorimetric use of the full NeuLAND detector. The dark rate of the prototype studied was found to be 70-200 sˆ−1, sufficiently low so as not to overload the data acquisition system if the standard trigger condition is applied.

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Session Classification: Poster session