Neutrons from spontaneous or induced fission indicate the presence of Special Nuclear Material (SNM). That is why ANSI and IAEA standards require hand-held Radio-Nuclide Identification Devices (RID) to be equipped with neutron detectors. Due to space limitations the detection performance must be achieved at minimum detector size. For obtaining efficiency in a small volume instrument, a high gas pressure for He-3 tubes is essential. However, pressurized devices above 2.8 atmospheres are conflicting with international transport regulations. As an alternative, scintillators containing $^6\text{Li}$ or other constituents with large neutron capture cross section combine small size with superior efficiency while preventing the safety risks due to high gas pressure. $^6\text{LiI(Eu)}$ scintillators with photomultiplier readout can even be deployed as combined neutron and gamma detectors. The light yield of neutron capture signals corresponds to 3-4 MeV gamma equivalent energy, providing for discrimination against gammas from radioactive decays. The energy resolution of ~7.5% measured for 662 keV gamma radiation [1,2] is poor compared to the ~3% achieved with $\text{LaBr}_3(\text{Ce})$ detectors [3].

The present paper focuses on neutron counting with $^6\text{LiI(Eu)}$ using digital electronics. The combining of this scintillator with a large-area photodiode (PD) results in a compact, efficient design [4]. Digitized signals of a $^6\text{LiI(Eu)}$-PD combination were processed with standard algorithms. An energy resolution of 6.5% measured for the neutron capture peak in spite of the PD noise contribution and a basic detector configuration was sufficient for discrimination against gamma counts in the scintillator. Signals due to direct x-ray or gamma interactions with the PD bulk material turned out to be a serious source for interference. Such events are unavoidable in mixed gamma-neutron fields and generate pulse amplitudes interfering with the spectrum of neutron capture signals. Since scintillation signals can be identified by the increased rise time caused by the light decay in $^6\text{LiI(Eu)}$, pulse shape analysis provides a means for suppressing these bulk events. Measurements demonstrate excellent separation of neutron captures from x-ray and gamma background by applying algorithms to signals at sampling rates of 10 MS/s. Such systems can be realized with state of the art miniaturized electronics.

References