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# Modern Detector Concepts for Fast-Neutron Radiography

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The presented topic is part project PERTINaX (periodic testing by imaging with neutrons in addition to X-rays) which has started in November 2016. The project is funded by the German Federal Ministry of Economic Affairs and Energy (BMWi) under the funding code 1501534 and continues work and research done in the project NISRA (neutron imaging system for radioactive waste analysis) [1].
Aim of the PERTINaX project is the development of a mobile fast-neutron radiography system which can be combined with neutron activation analysis for non-destructive testing of high density and shielded components. A neutron generator from Adelphi Technology, Inc., which emits fasts neutrons (2.45 MeV neutrons) with a neutron yield of 1E9 neutrons/sec will be used in combination with a detector system that is currently under development.

**Detector system - scintillator materials**

The main task of PERTINaX is the development of a detector system that offers sufficient spatial resolution. Different scintillator materials in combination with Silicon Photomultipliers (SiPMs) for read out will be used. In an environment where γ-radiation is present, γ-fogging of taken neutron radiographs is a known problem due to the fact that most scintillator materials are also sensitive to γ-radiation. Organic scintillators like trans-stilbene, plastic scintillators like EJ-276 or liquid scintillators, e.g. EJ-301 from Eljen Technology [2], allow pulse-shape-discrimination (PSD) which can be used to distinguish between γ- and neutron radiation and therefore to reduce γ-fogging. Stilbene-compound scintillators (investigated by Seung Kyu Lee et al. [3]) or liquid scintillators filled in matrices of thin glass capillaries represent another alternatives.

**Scintillator readout via SiPM**

Applying PSD requires detectors which can provide timing information. Furthermore the detector should have a spatial resolution in the range of $mm^2$. Therefore, SiPM arrays which are combining these properties can be used for the scintillator read out. Such arrays are currently used in positron emission tomographs for instance. Appropriate analogue and digital electronics for signal read out, especially for digitizing the signals and applying PSD to a large number of cells resp. pixels is under development.

**Neutron radiography and neutron activation analysis**

Neutron radiography can be used to specify the geometry/homogenity of specimen such as closed barrels for radioactive waste that often contain radiation shields or hydrogen containing materials. The presence of shielding components leads to large uncertainties for neutron activation analysis. These components can be identified (structural information) with neutron radiography. Their influence on parameters such as neutron-self- shielding factors or neutron flux could then be used to improve the results of the neutron activation analysis.

*[1] J. Kettler et al., NISRA Abschlussbericht, 2015.*

*[2] http://eljentechnology.com/products/liquid-scintillators/ej-301-ej-309 (Apr 2018)*

*[3] Seung Kyu Lee et al., Scintillation Properties of Composite Stilbene Crystal for Neutron Detection, in: Progress in NUCLEAR SCIENCE and TECHNOLOGY, Vol. 1, p.292-295, 2011.*

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