Performance Study of an Amorphous-Silicon Flat Panel Detector for Fast Neutron Imaging of Nuclear Waste

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Introduction

For non destructive characterization of nuclear waste detailed information about massive and dense structural components are needed from radiography to improve analytical results.

Setup

Detector Design
- Commercial X-Ray detector (PerkinElmer)
- Active area: 40 x 40 cm²
- Segmentation: 1024 x 1024 pixels

Scintillator
- General purpose plastic scintillator
- EJ-260 Eljen Technology
- Thickness: 3 mm

Neutron generator
- Commercial generator Gemini16GT (Soderm)
- D-T fusion for 14 MeV neutrons
- Flux determination with monitoring foils (Al, Au)
- Distance source to foils: 30 cm
- Activity measurement with HPGe detector
- Fast neutron source strength:

$$Q_{n\text{eff}} = 15.7 \pm 2.6 \cdot 10^{10} \text{n/s}$$

Tab. 1: Analyzed reactions with corresponding activities, neutron fluxes and source strengths.

Experiment
- Neutron generator within 10-20 cm PE shield
- Distance source to detector: 42 cm
- Samples on ill table

Detection System
- a) Radiograph of PE (red) and PE (black) sample.
- b) Correlation between measured and calculated signal attenuation.

Image Analysis

Setup
- Pb brick and PE cylinder
- Distance source detector: 42 cm
- Average of 450 frames, each 24 s

Smooth
- Profiles of area with and without objects
- Set outlines to the average of the surrounded pixels

Profile Correction
- Set area without objects as background

Signal Analysis
- Fit Gaussian distribution to histogram from region of interest
- Gaussian distribution

Results

Calibration
- Radiographs of well known test samples
  - Size: 5 x 8 x 10 cm³
  - Al, Cu, Fe, Pb, W, concrete, PE
  - PE as reference
  - Combination of two samples
  - Analysis as shown before

Profile correction
- Data correction and analysis of test samples
- Gaussian fit

Summary
- First radiography with test samples successful, despite low detection efficiency and neutron intensity
- Discrimination between light and heavy objects
- Correlation between detector signal and absorption properties

Test samples
- (Al, Graphite, Fe, Pb, W, concrete, PE)

Outlook

New Scintillator
- Stack of scintillating fibres for increased neutron conversion efficiency
- Type: SCiF(3H)11500MJ from Kuraray
- Thickness: 10 mm, diameter: 1 mm

Wavelength Shifting Fibres Detector
- Prototype detector
- Plastic with ZnS as scintillator
- X-ray cross 40 W fibres
- Fibre readout with PMT
- TDC coincidences for position reconstruction
- Active area: 4 x 4 cm² (16 x 16 fibres)

This work is part of a cooperation framework with RWTH Aachen University and SIEMENS AG, funded by Federal Ministry of Education and Research (02S9022B).