WG6 IPNDV Experimental Technology Data Sheet

Hungary

Name of Experimental Campaign: Belgium exercise to investigate performance of measurement methods

Technology Name: Neutron Detection

Physical Principle/Methodology of Technology: Neutron Detection by Scintillation Detector

What Does the Method Determine/Measure (e.g., presence of nuclear material, isotopics, mass): presence of spontaneous fissionable nuclides

What is the Applicability to IPNDV: Plutonium always contains fissionable isotopes. Those can be demonstrated by neutron detection

Type of Data Collected by the Technology: neutron pulses

Constraints (e.g., time to install the equipment, measurement times including distance from object, dose rate required, required Cd shielding to limit the count rate): time to install: 30 min, measurement time: 30 min. No shielding is required, shields provided by the organizers did not prevent the detectors from detection.

Physical Description/Diagram/Photos of the Experimental Setup/Layout:

The measuring campaign of the IPNDV found its place at the SCK●CEN campus in Mol, Belgium. The scene was in the vicinity of a large shielded RaBe source which gave a neutron background of 7 cps/channel. The aim of the campaign was to demonstrate the presence of fissile material being shielded or unshielded in a nonzero background environment.

The measurements were carried out with 2 sets of ^{6}LiF doped scintillating detector system of Symetrica. Each system contained 8 detector blades inserted into a moderator block. The pulses of each detector were registered on a separate channel of the PTR-32 (list mode pulse train reader). 2 configurations of detectors were applied:

B: the 2 blocks was placed one behind. The neutrons arrive perpendicular to the plane of the detectors.

C: the detectors surround the fuel assembly, each blade is put in a separate moderator block, the neutrons arrive perpendicular to the plane of the detectors.

Configuration B

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The big square represents the shielded RaBe source, the hexagon the source and the 2 blocks stand for the detector blades.

During the background measurements the sensitivity factor of each detector blade was determined. These factors were used for correction in evaluation.
As the neutrons pass through the detector system they are moderated and captured. As a result, the thermal and epithermal neutrons are mostly captured in the first few blades, the higher energy neutrons are captured in the deeper layers.

We could demonstrate the presence of the fissile material even in the case of the weakest source (fuel assembly) with the strongest shielding available. The detailed evaluation gave further insight to the structure of the source.

As the data proves the presence of the Cd shield changes neither the flux nor the energy spectrum of the neutron radiation.

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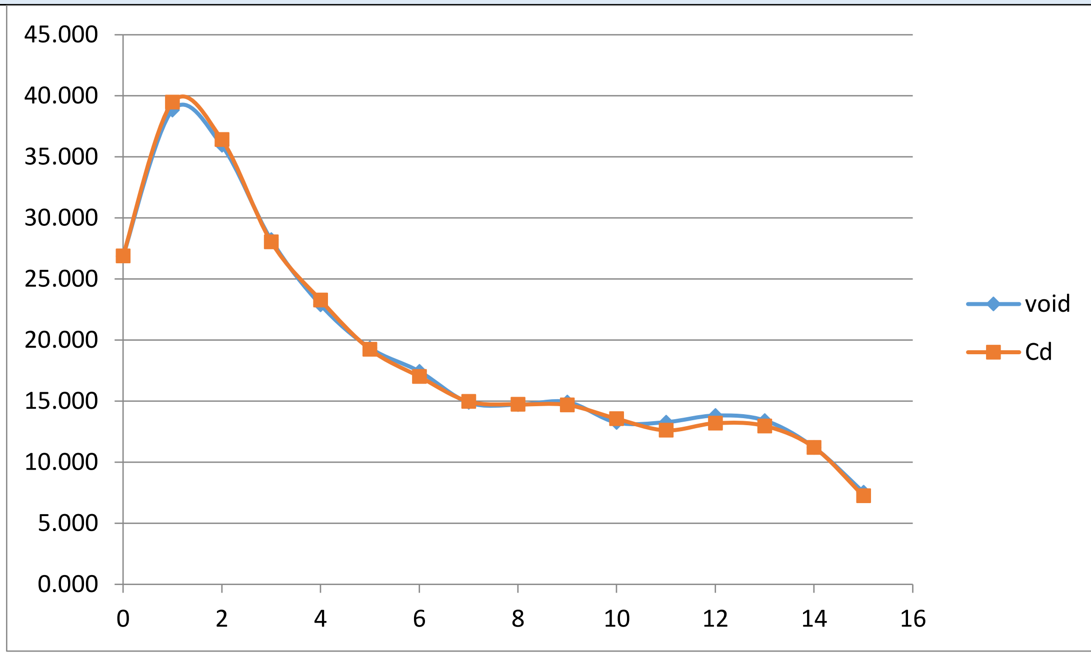
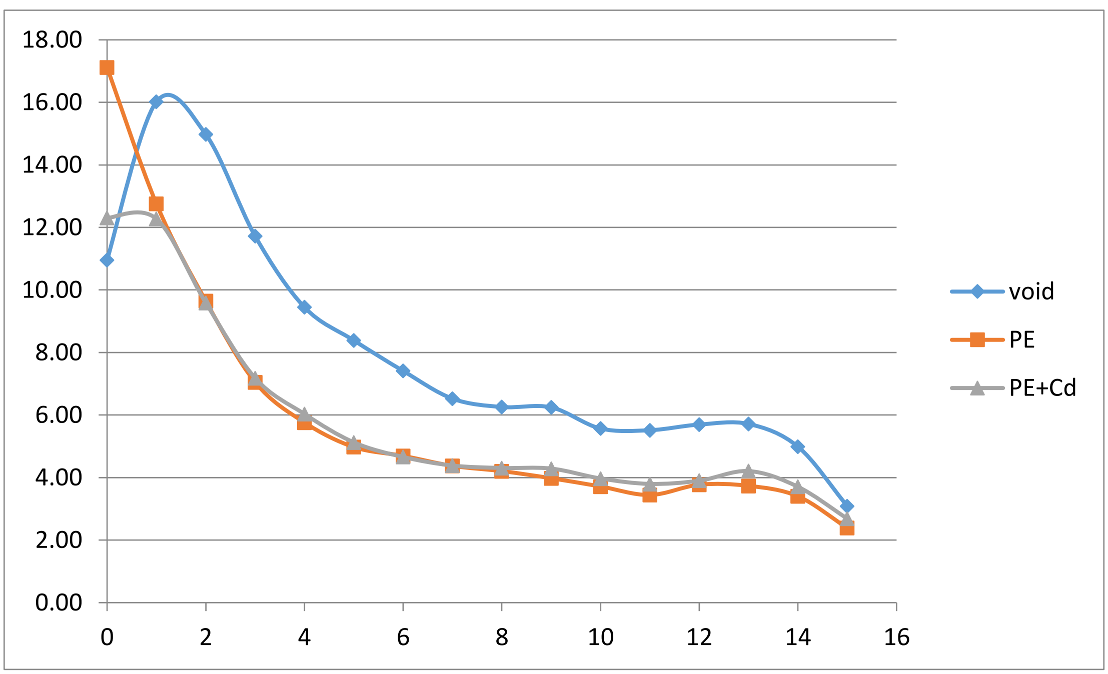


The polyethylene (PE) shield moderates the neutrons which cause a count rate loss in cannels 1-15 and a gain in channel 0. Subsequent Cd shield cause a sharp drop in channel 0 and has no influence for channels 2-15.



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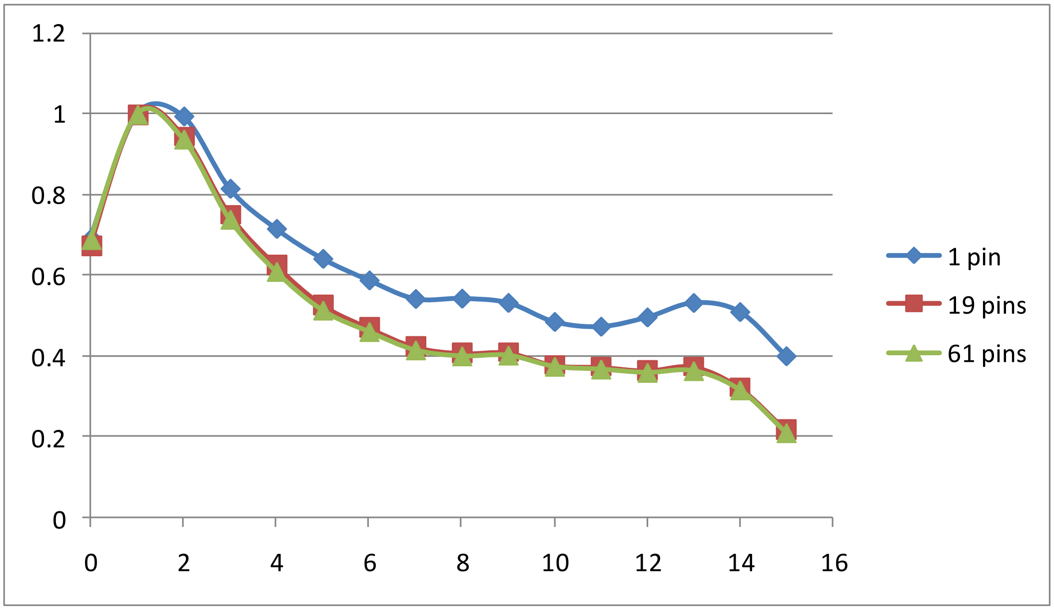
The fuel assembly contained 1, 19 and 61 fuel pins. We checked whether the count rate were linearly proportional to the number of pins. The answer is negative, the assembly containing 1 pin seems to be stronger then 1/19 or 1/61 part of the assembly containing 19 and 61 pins, resp. The blade sequence spectrum of 19 and 61 pin assembly seems to be more moderated than that of 1 pin.



The count rate in channel 1 was taken as 1.

Configuration C
Coincidence Counting

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Detector blades each in separate moderator block surround the fuel assembly measured.

The efficiency of the whole detector system in configuration C is 1.4-2.5 times higher than that of conf. B. The change of the efficiency ratio is not yet clear.

According to the measurements done the rate of double coincidences is two low or even negative. In order to check the feasibility of coincidence measurements new configurations must be tested.

Conclusions

The presence of the fissile material could be easily detected in any case even if it was small and behind the provided shielding. In this sense the test was successful.

In the configuration B the measuring system provided some kind of spectral information. This should be calibrated by means of Monte Carlo simulation. After calibration the material between the source and the detector may be characterised in some degree.

The configuration C gives a higher efficiency than the configuration B. However, the hope for the coincidence counting was not realised.

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Specific Objects Measured (which of the experimental objects were measured; if not described elsewhere, describe experimental objects here): MOX fuel assemblies were measured
Process Required to Analyze the Data (include any software used): Software belonging to PTR-32 were used
Preliminary Results (qualitative, not quantitative; e.g., did the method perform as expected, if not how was it different): Presence of spontaneously fissioning material was demonstrating in every experimental setup with and without any available shielding.
Final Results (if available; if not, estimate of when final results will be available):): Presence of spontaneously fissioning material was demonstrating in every experimental setup with and without any available shielding.
Lesson Learned (e.g., what went well what went wrong or not as expected, do the results confirm what we said in the technology tables): Neutron detection is a very effective method for detecting the presence of Pu. The available shields did not block the signal.
Simulations (if the participant envisages to carry out simulations, which ones; indicate willingness to share the simulations results with IPNDV): Simulations has not been carried out until now.
Willingness to Share the Experimental Data within IPNDV: ☒ Yes ☐ Yes, anonymously ☐ No