Detection of Concealed Fissionable Material by Delayed Neutron Counting

Wolfgang Rosenstock

Co-authors: Theo Köble, Monika Risse, Wolfram Berky

Fraunhofer – INT, Euskirchen, D

Department Nuclear and Electromagnetic Effects

International Topical Meeting on Nuclear Research Applications and Utilization of Accelerators

Vienna, May 2009

Nuclear Security Policy and Detection Techniques

Fraunhofer

INT

Introduction – Objectives

The fear of a possible terroristic threat is increasing worldwide.

Possible attack including radioactive resp. nuclear material most severe incident

In conjunction with explosives it may be too risky to move or even touch the object → non-destructive and non-contact in situ measurements mandatory

In case of nuclear (fissionable) material emitted self-radiation is often not sufficient to detect it or can be shielded easily!

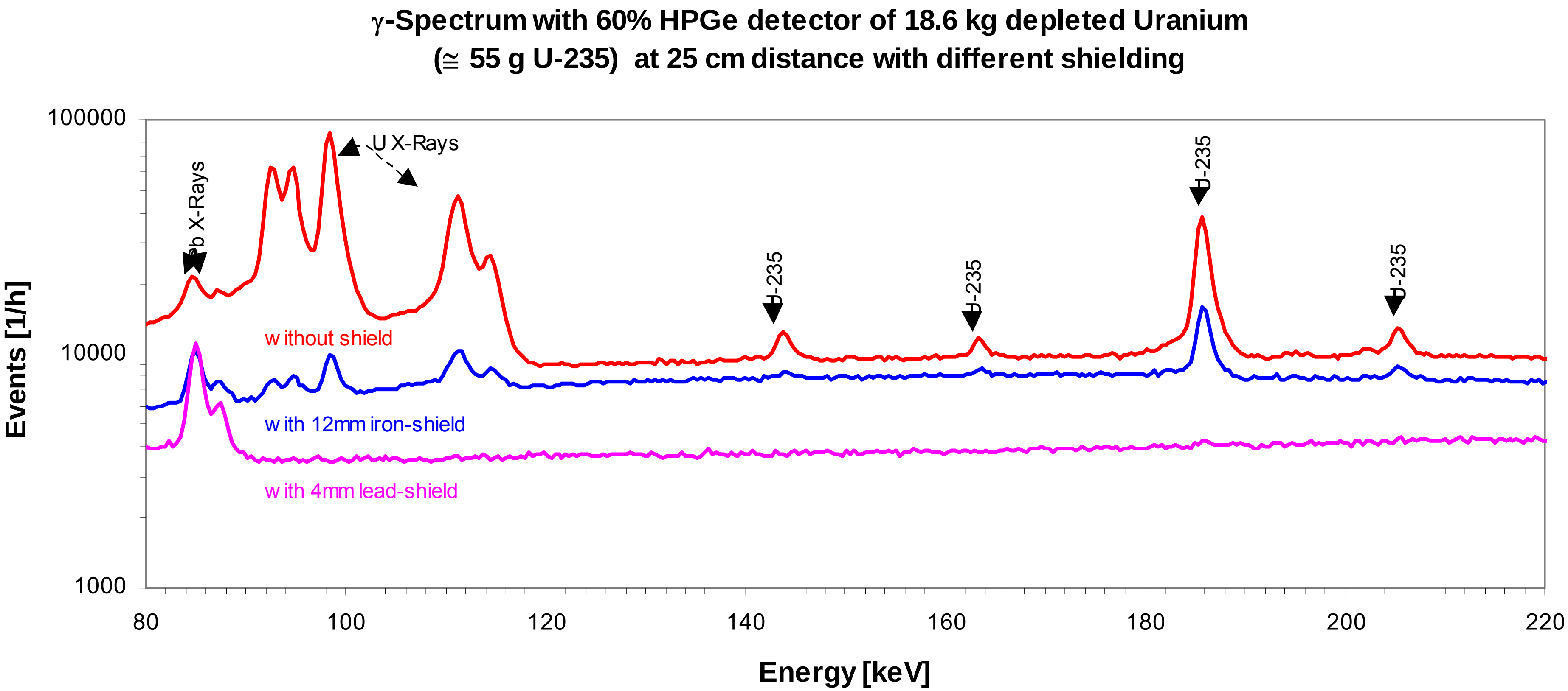
If a well-founded suspicion exists active method have to be employed → active neutron interrogation by a lightweight small neutron generator to get definite information.

Significant Gamma-Energies (E) und Intensities (I) of Nuclear Fission Material

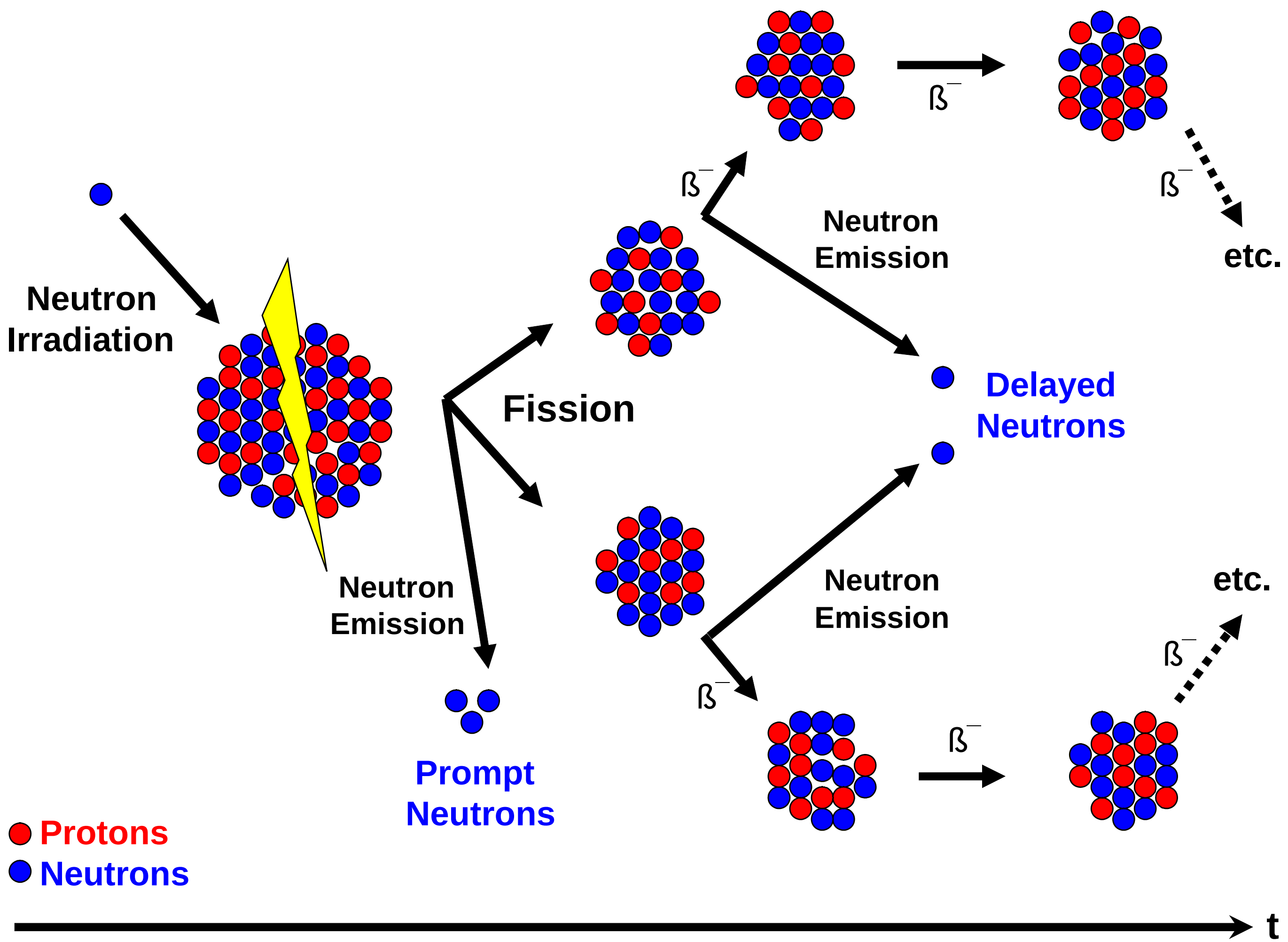
Material	E [keV]	I [γ/g. sec]
U-233	291.3 317.2	56 000 81 000
U-235	185.7	42 000
U-238	1001.0	100
Pu-239	375.0 413.7	36 000 34 000
Pu-240	160.3 212.5	33 000 2 400
Np-237	95.9	670 800
Am-241	59.4	46 670 000
Am-242^{m}	14.6	107 640 000
Am-243	749.7	4 884 000 000

Fraunhofer INT

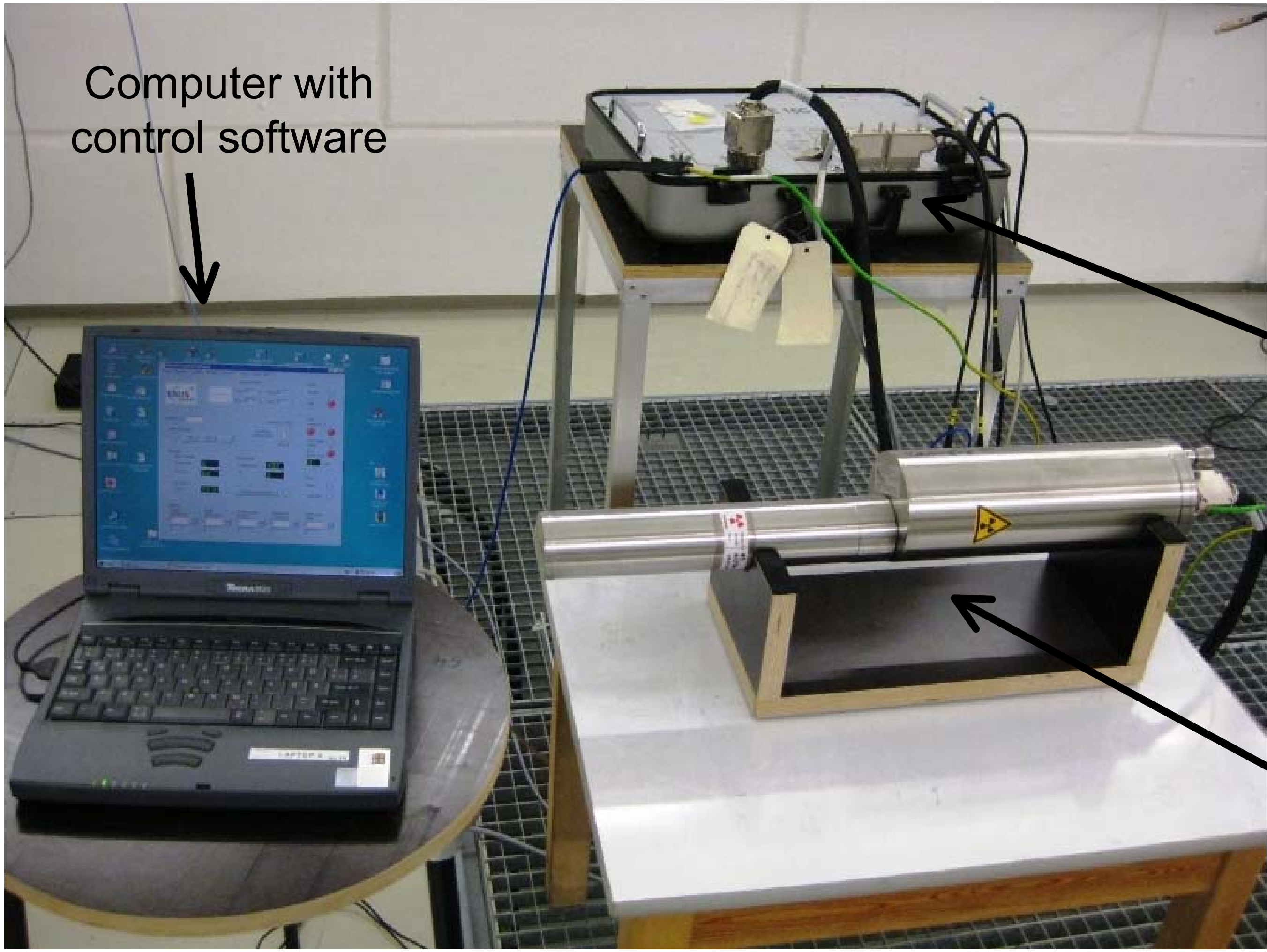
Influence of a small lead shield on U-identification



Origin of Delayed Neutrons



Neutron Generator Genie 16c



Control case

Neutron emission module

In-situ Measurements with Neutron Generator

Generator Specifications

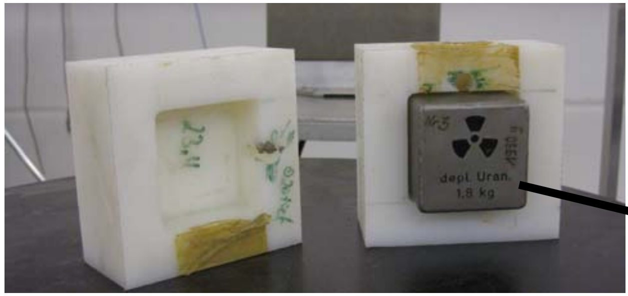
- Maximum neutron flux: $2 \cdot 10^8$ n/s (DT)
  $2 \cdot 10^6$ n/s (DD)
- Neutron energies: 14 MeV (DT),
  2.5 MeV (DD)
- control unit: small suitcase
- Weight: approx. 15 kg → portable
- Powered by mains voltage or car battery (12 V), max. power consumption < 100 W
- Maximum acceleration voltage: 110 kV
- Maximum beam current: 60 µA

Fraunhofer INT

Experimental Setup

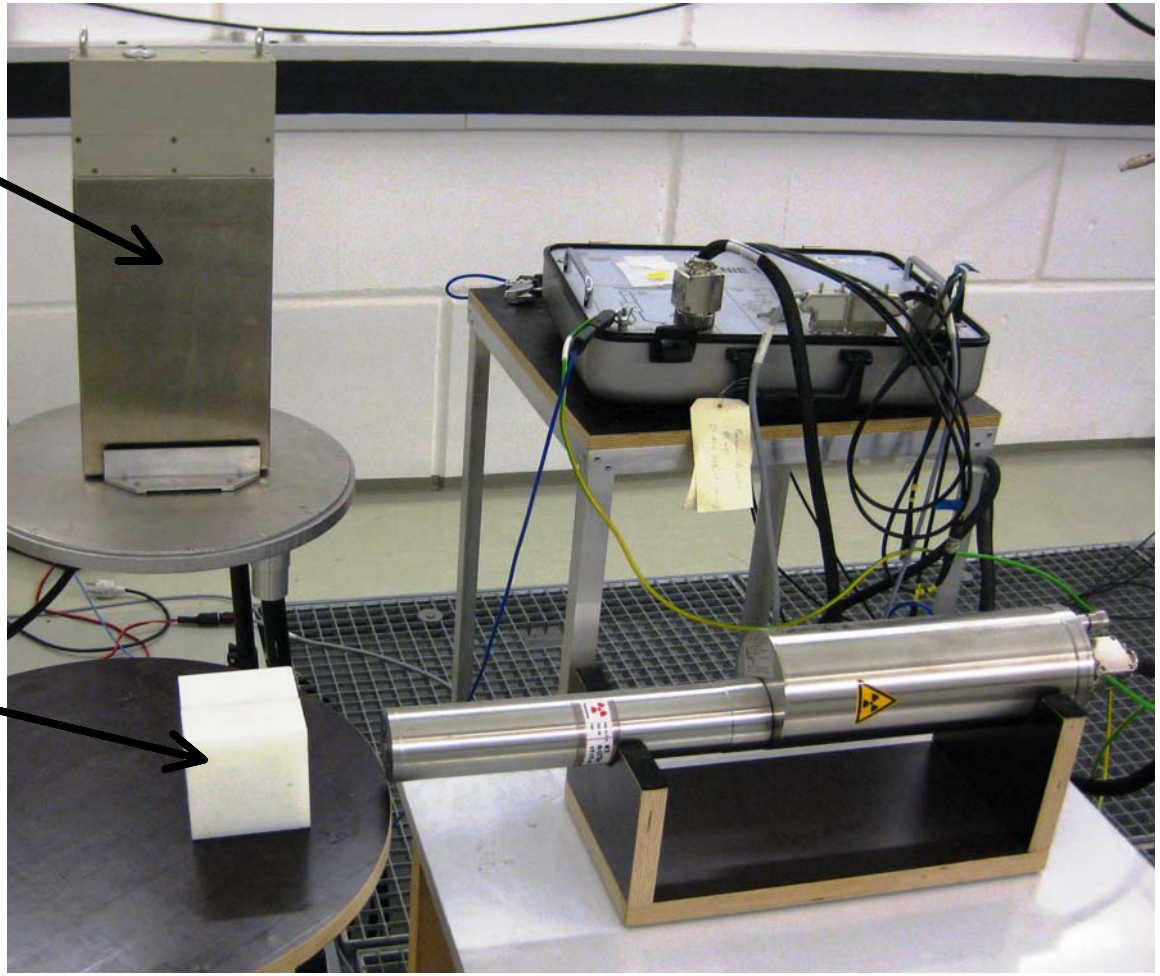
Neutron slab counter

Measured object



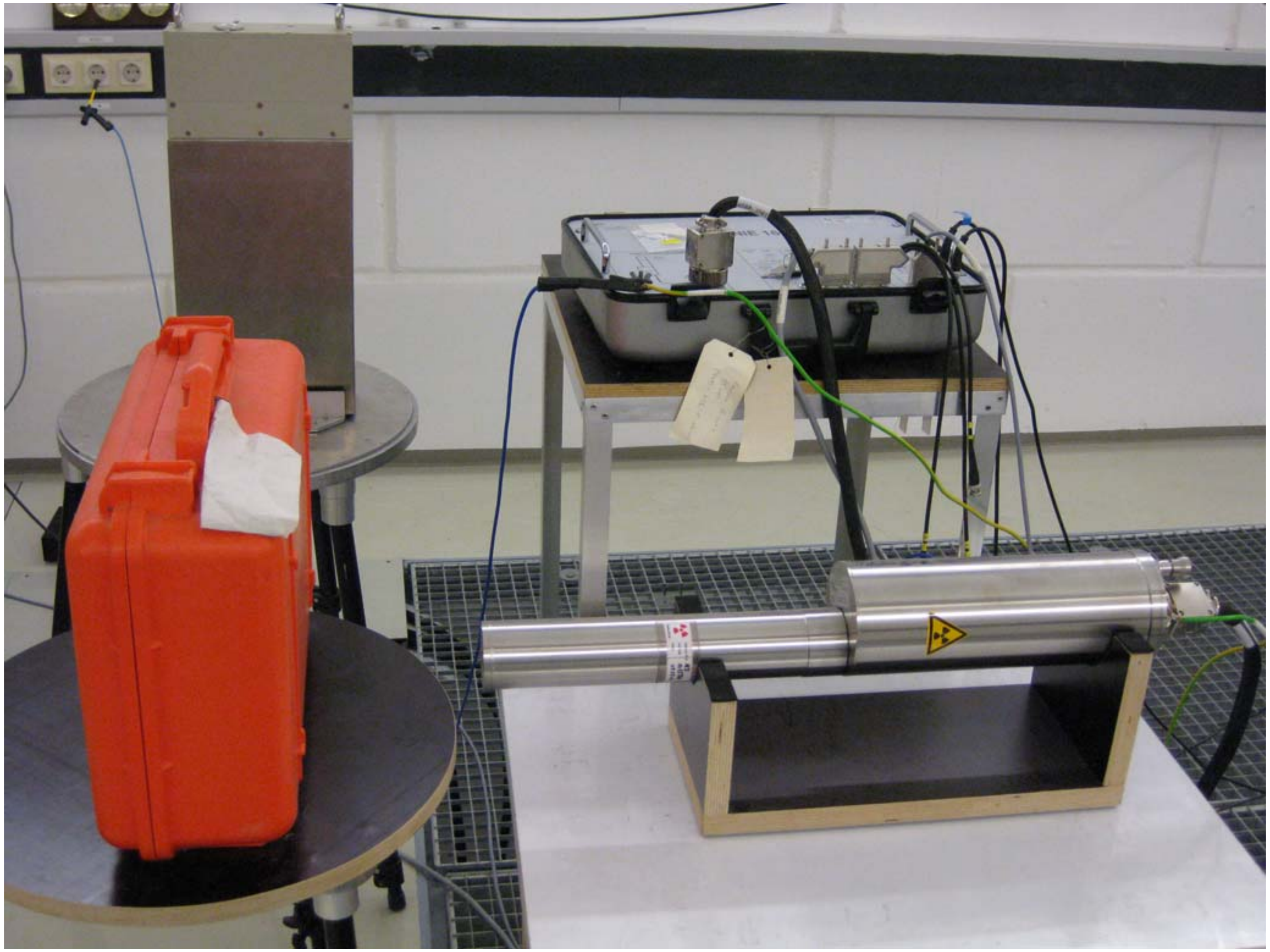
PE casing

1.8 kg depleted uranium



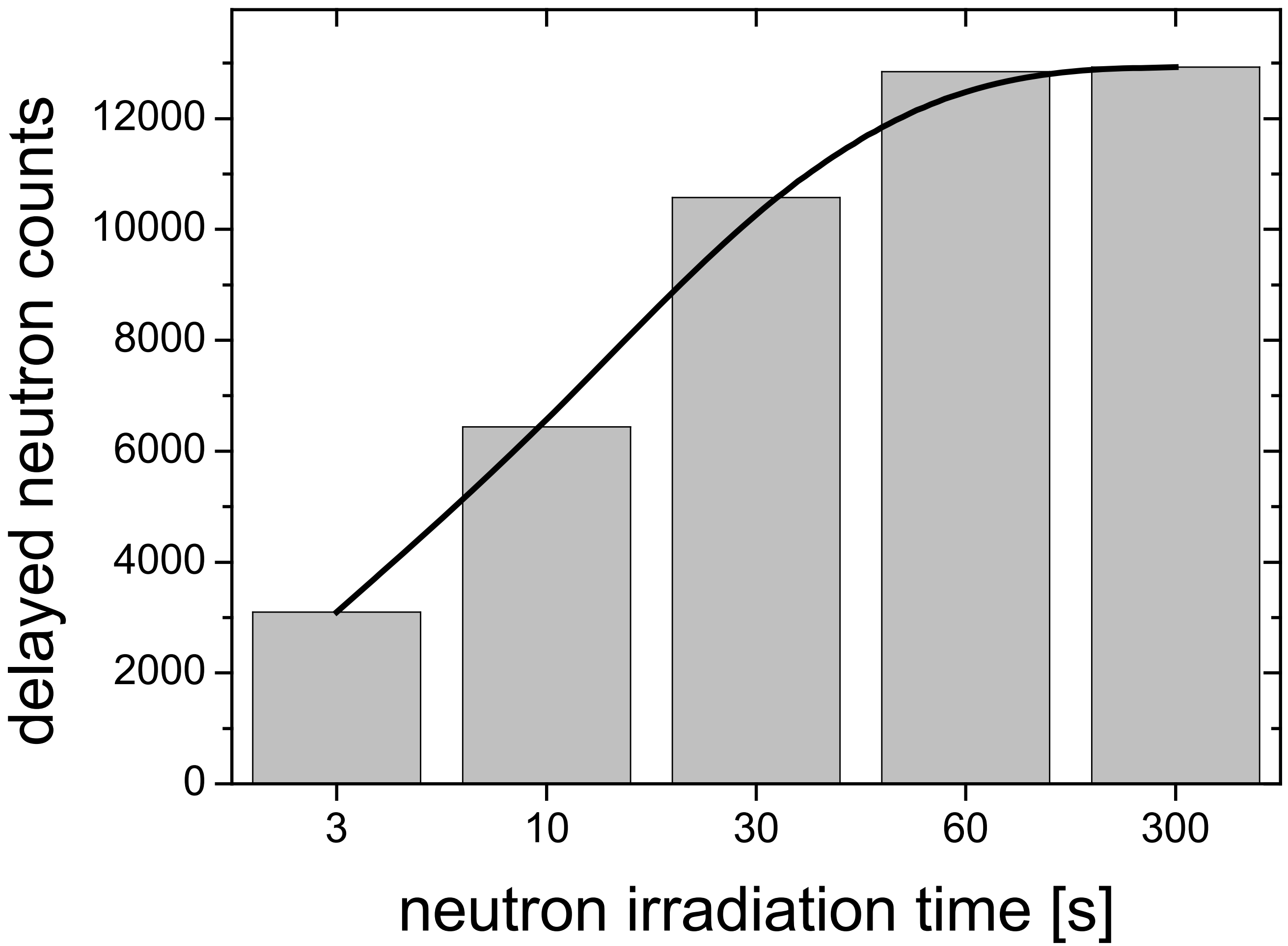
Fraunhofer INT

Setup with inspected object



Fraunhofer INT

Dependence on neutron irradiation time

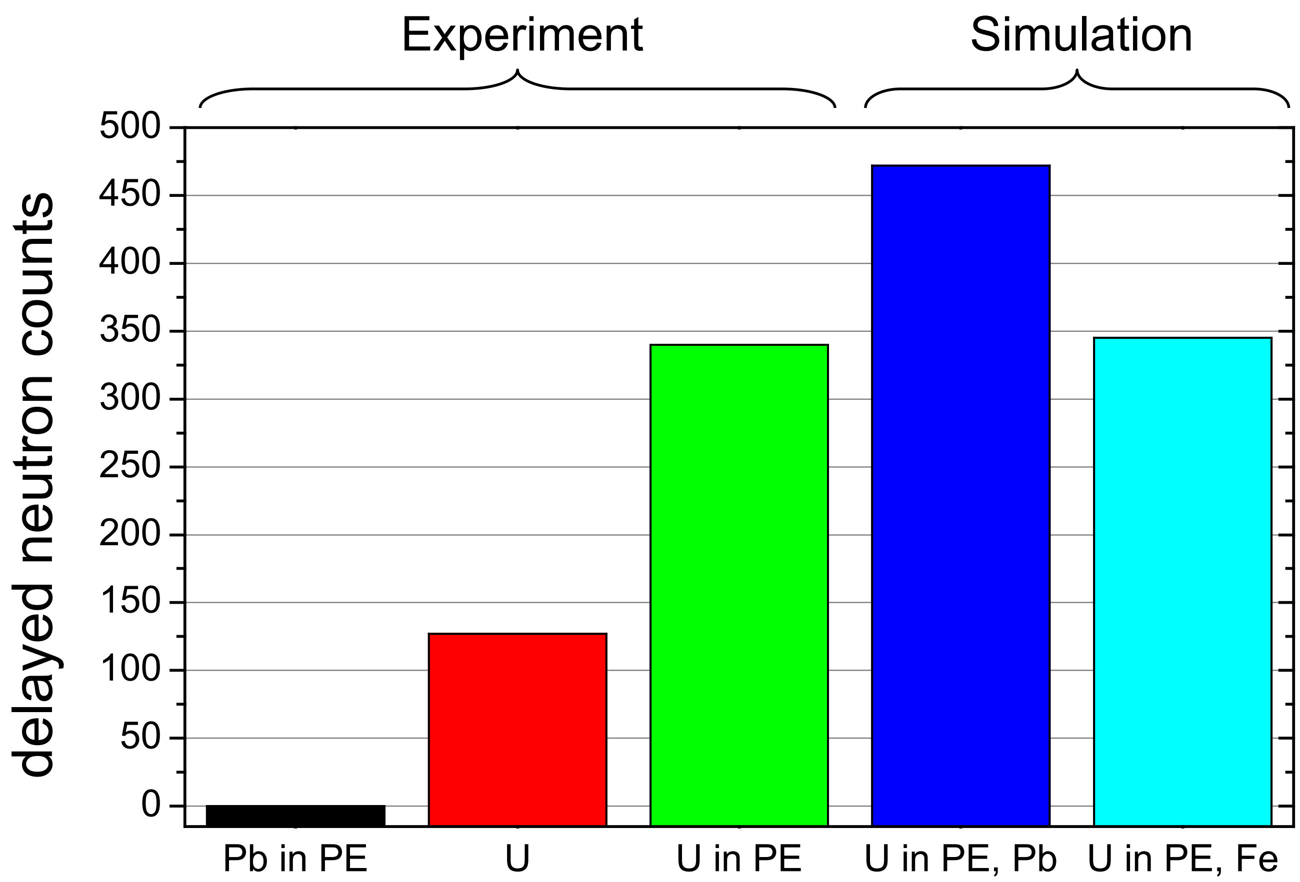


- Irradiation of depleted uranium
- 14 MeV neutrons
- Integration time 200 s

Results:

- Maximum of delayed neutron counts is reached after 60 s
- Short irradiation time (3 s) leads to satisfactory results

Dependence on object composition



Experiment:

- Neutron irradiation time 60 s
- Integration time 3 s
- 22 mm PE

Simulation:

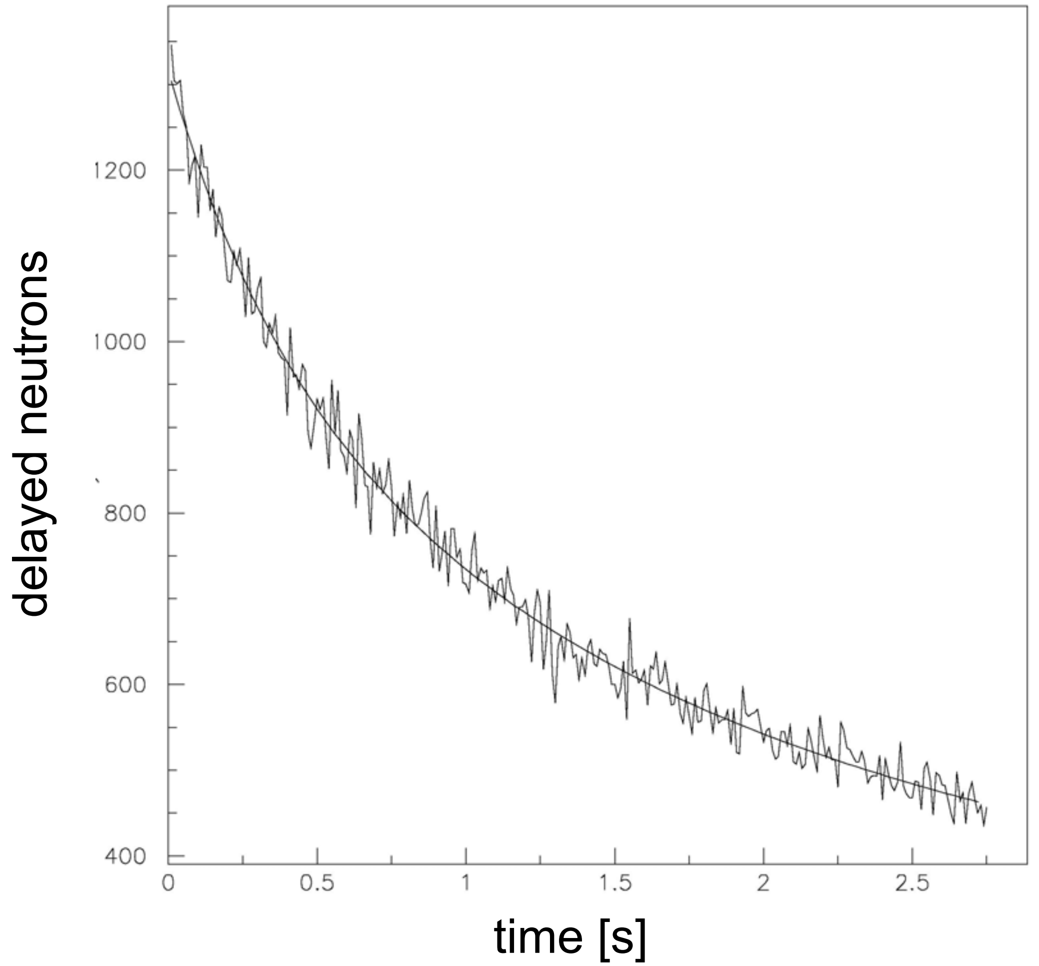
- MCNPX
- 22 mm PE, 5 cm shielding

Results:

- No delayed neutrons without uranium (e.g. Pb)
- Count rate enhanced by PE
- Shielding has minor effect

Fraunhofer INT

Decay curve



Experiment:

- Neutron irradiation time 3 s
- Integration time 3 s
- 1.8 kg DU in 22 mm PE

Fit:

- 6 fixed decay times, values from ENDF/B-VI
- Constant and 6 exponential decay functions fitted

Result:

- Fit of decay curve should yield information on the isotopic composition of fissionable material

Fraunhofer INT

Conclusion – Perspective

- Presence of fissionable material (SNM) can be proved reliably with active neutron interrogation within short time
- Information on isotopic composition (nuclide vector) and quantity within certain limits
- Small, lightweight and easy to operate neutron generators well suited for non-destructive in-situ inspection of suspicious objects

Future work:

- Evaluation of the optimal total measuring time for in field situation
- Optimization of the experimental process to gain comprehensive information on the type and quantity of suspected SNM
- Investigation on the influence of moderating and shielding material

Thank you for your interest