Recent improvements in on-site detection and identification of radioactive and nuclear material

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International Symposium on Nuclear Security
Vienna, March/April 2009

Nuclear Security Policy and Detection Techniques

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Introduction – Objectives

Threat

Loss or theft of radioactive respectively nuclear material – illicit trafficking

malevolent acts, in particular terrorist's threat with such material (→ dirty bomb)

Counter Measures and Protection

methods and procedures for fast search and, after detection, identification and quantification of the material in situ

Sensitive portable measuring systems giving meaningful results within short time

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In Field Measurements with Gamma Detectors

Detectors Used:

- **Micro Detective (Left and Right)**
- **InSpector 1000 (Center and Right)**

Examination of suspicious Object (abandoned trolley)

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Characterized Gamma and Neutron Detectors

γ - Detectors

InSpector 1000
with $LaBr_3$-probe

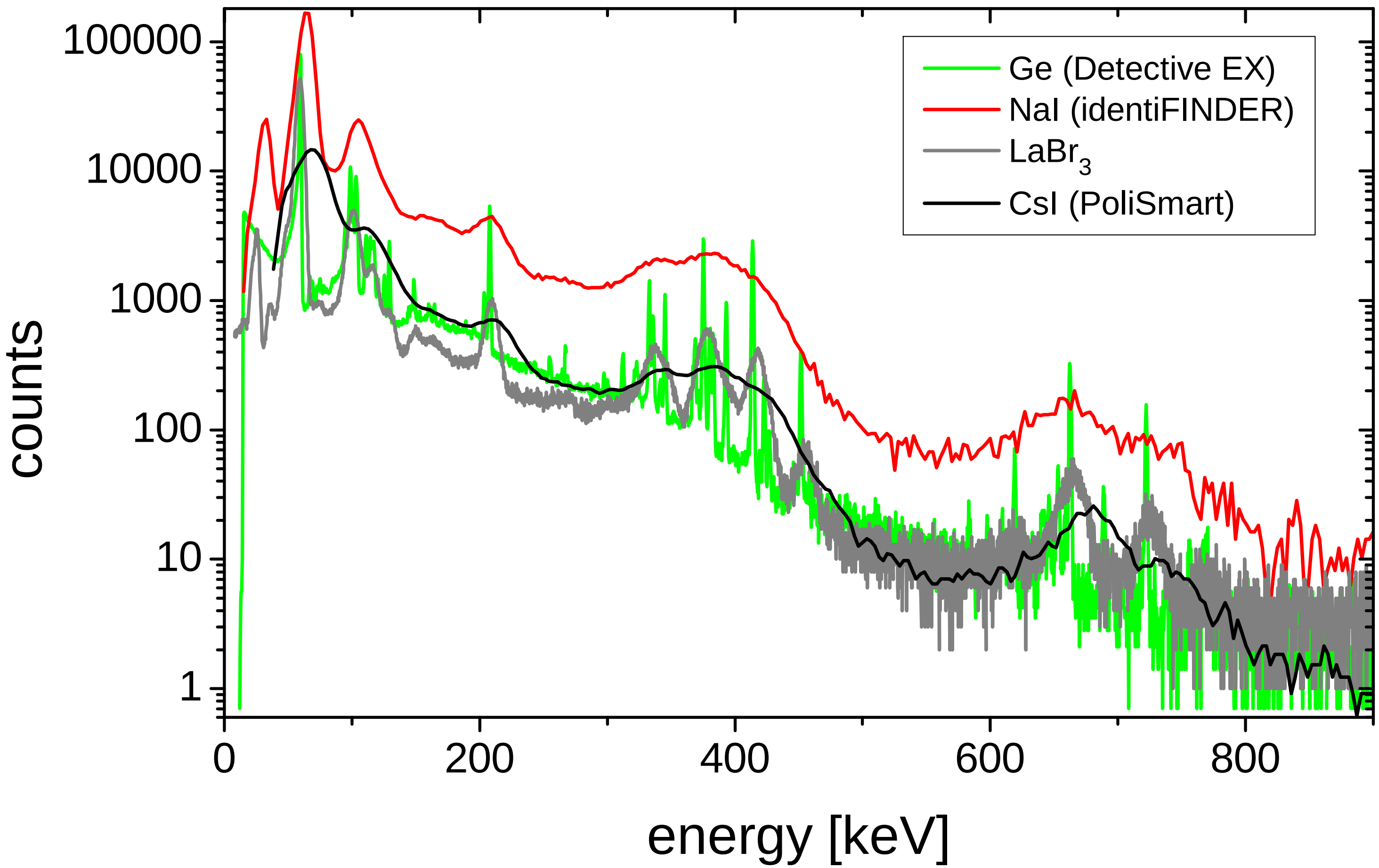
Micro Detective
(electrically
cooled HPGe)

neutron - Detectors

Fission Meter
neutron source
identification
system

N-Probe
fast neutron
spectrometer

γ-spectra obtained with different detector crystals



- source: ^{239}Pu (84 %)
- distance: 15 cm
- no shielding
- spectra normalized to the same measurement time

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InSpector 1000 with $LaBr_3$-Probe

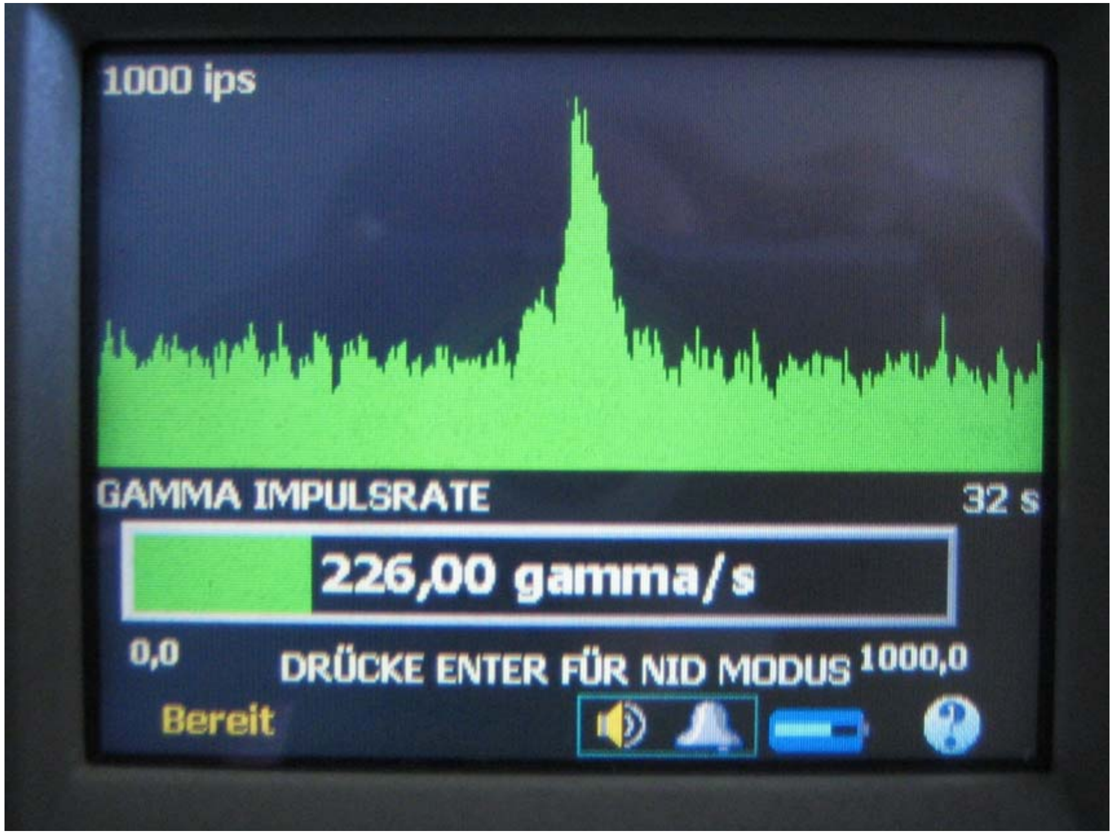
$LaBr_3$-Probe Specifications

Weight [kg]	**0.7**
Dimensions [cm]	**26 x 5 x 5**
Crystal cize (diameter [cm] x length [cm])	**3,8 x 3,8**
Energy Resolution [%]	**2.4 (at 1332.6 keV)**
Relative Efficiency [%]	**12.6** (IEEE Std 325-1996)

InSpector 1000 Specifications

Weight [kg]	**1.7**
Dimensions [cm]	**26 x 7 x 7**
Battery Life [h]	**9**

InSpector 1000 Search Mode



Screenshot of “Locator Mode”

Search for a gamma source

X-axis: time line

Y-axis: gamma intensity

Bar below: current gamma intensity

InSpector 1000 Identification Mode

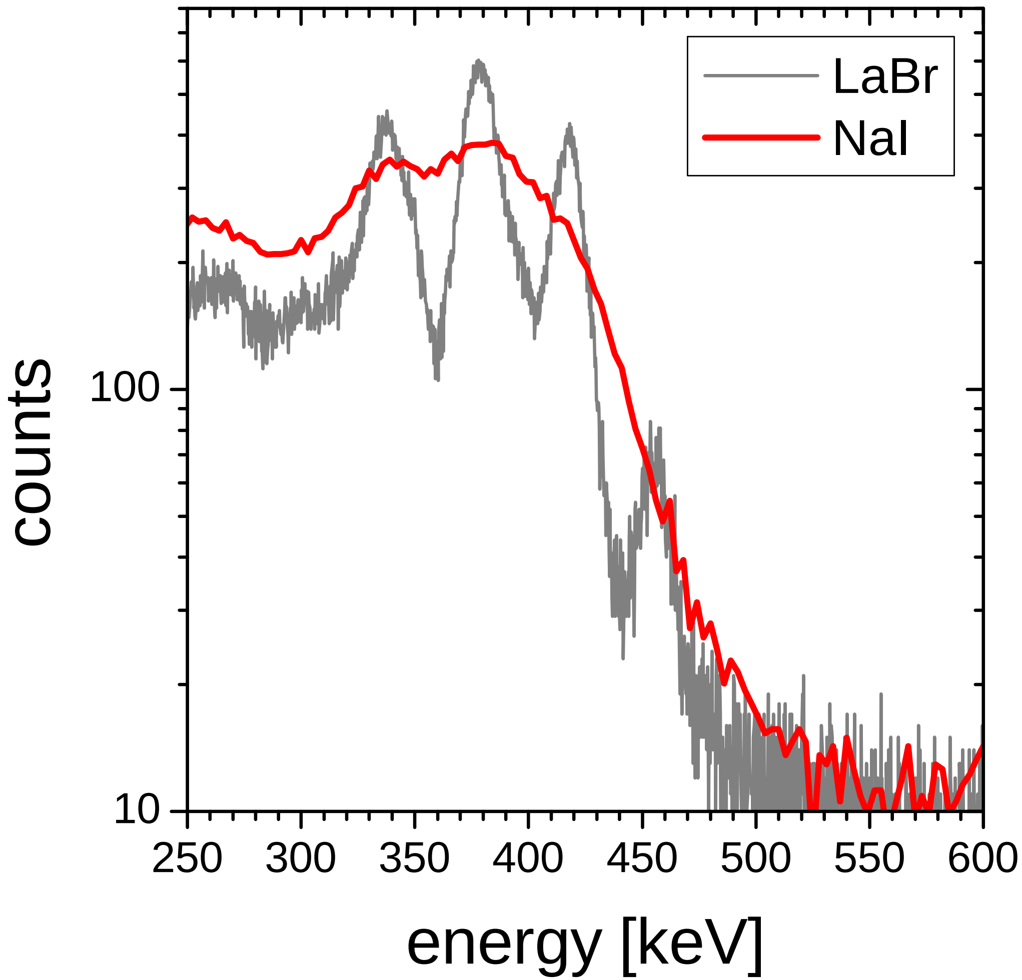
Screenshot of “Identification Mode”

Name of the nuclide (isotope)

Type of the nuclide (typical use)

Probability of identification

Energy Spectra: LaBr versus NaI Scintillator



		$LaBr_3$	NaI
resolution at [%]	122 keV	8.4	24.6
	662 keV	3.3	6.8
	1332 keV	2.4	5.8
crystal size		1.5“ x 1.5“	1.4“ x 2“
rel. efficiency		14.3 %	8 %

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Micro Detective – High Resolution Gamma Detector

Electrically cooled HPGe with battery power supply and integrated software for analysis.

Detector Specifications

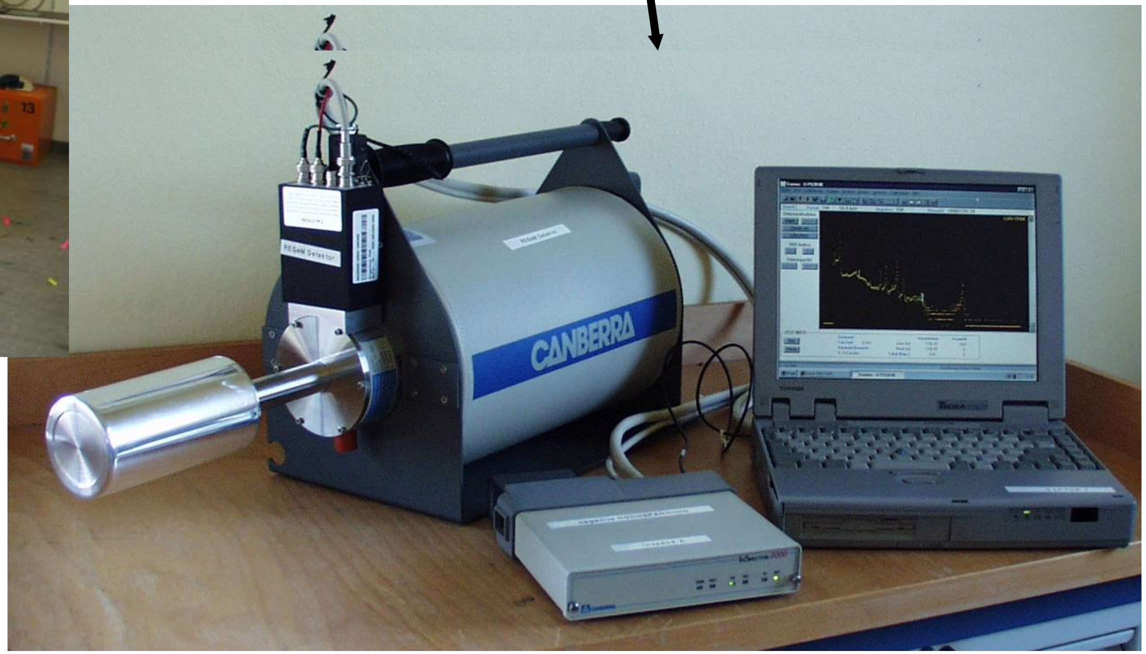
Weight [kg]	**6.9**
Dimensions [cm]	**37.4 x 14.6 x 27.9**
Battery Life [h]	**> 3 (at 25 °C)**
Cool Down Time [h]	**< 12 (at 25 °C)**
Energy Resolution [keV]	**1.99 (at 1332.6 keV)**
Energy Resolution [%]	**0.15 (at 1332.6 keV)**
Relative Efficiency [%]	**10.2 (IEEE Std 325-1996)**

produced by Ametek / ORTEC

High-Resolution Germanium Detector Systems

Survey with Electrically-Cooled Detective

LN_2-Cooled Germanium Detection System



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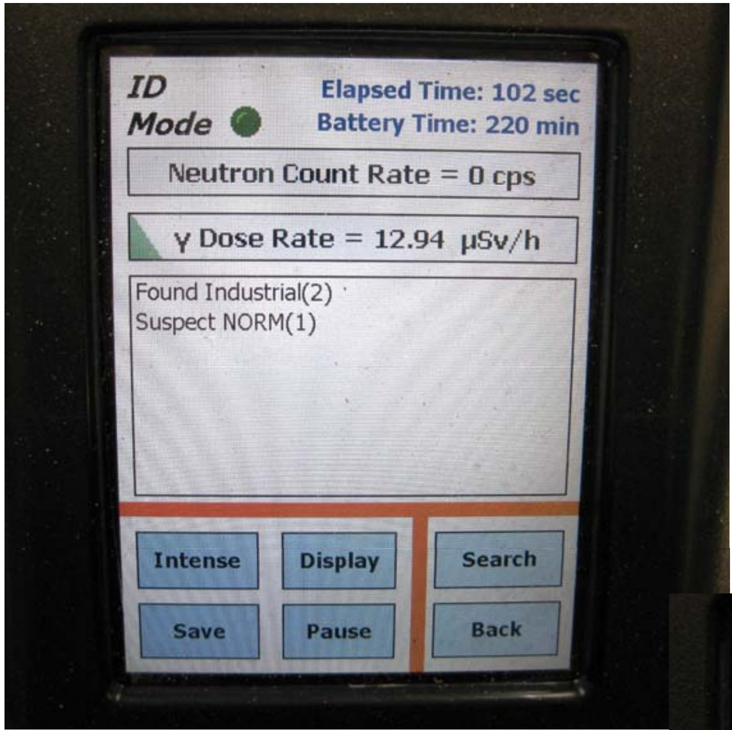
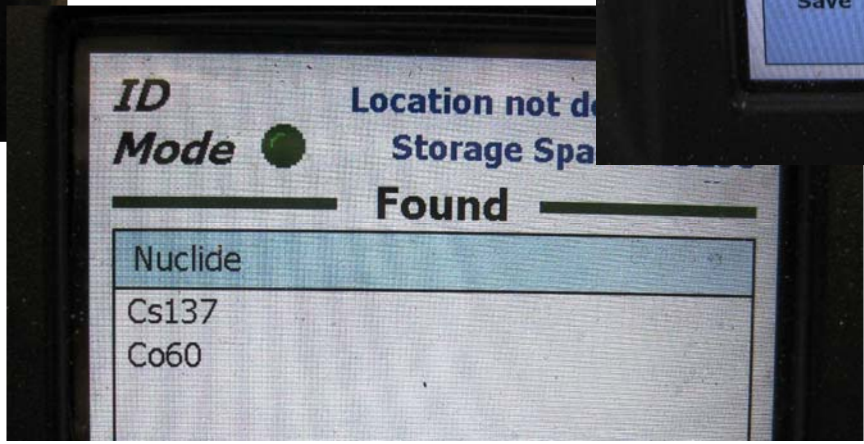
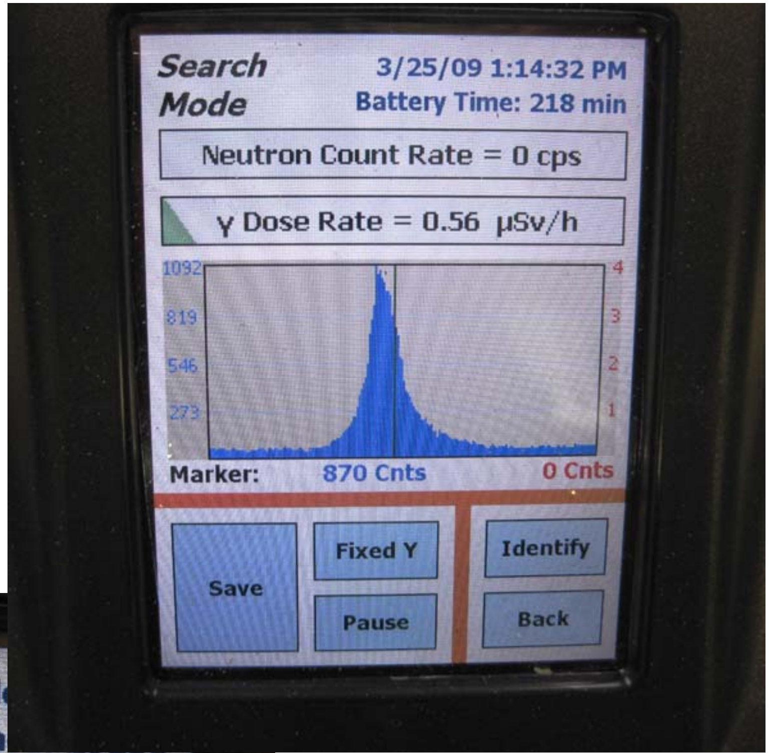
Micro Detective - Display Readings







Identification Mode

Search Mode

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The Fission Meter System

Number of tubes	15 per panel => 30 per device
Tube diameter	2.54 cm
Tube length	48.26 cm
Gas characteristics	^{3}He ($7.6 \cdot 10^{5}$ Pa)
Active area	~1800 cm^2 (15 tubes, 0° geometry)
Moderator	Polyethylene, on one side (minimum 2.54 cm)
Weight	26 kg

Fission Meter system with detector unit

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Fission Meter – covert neutron search

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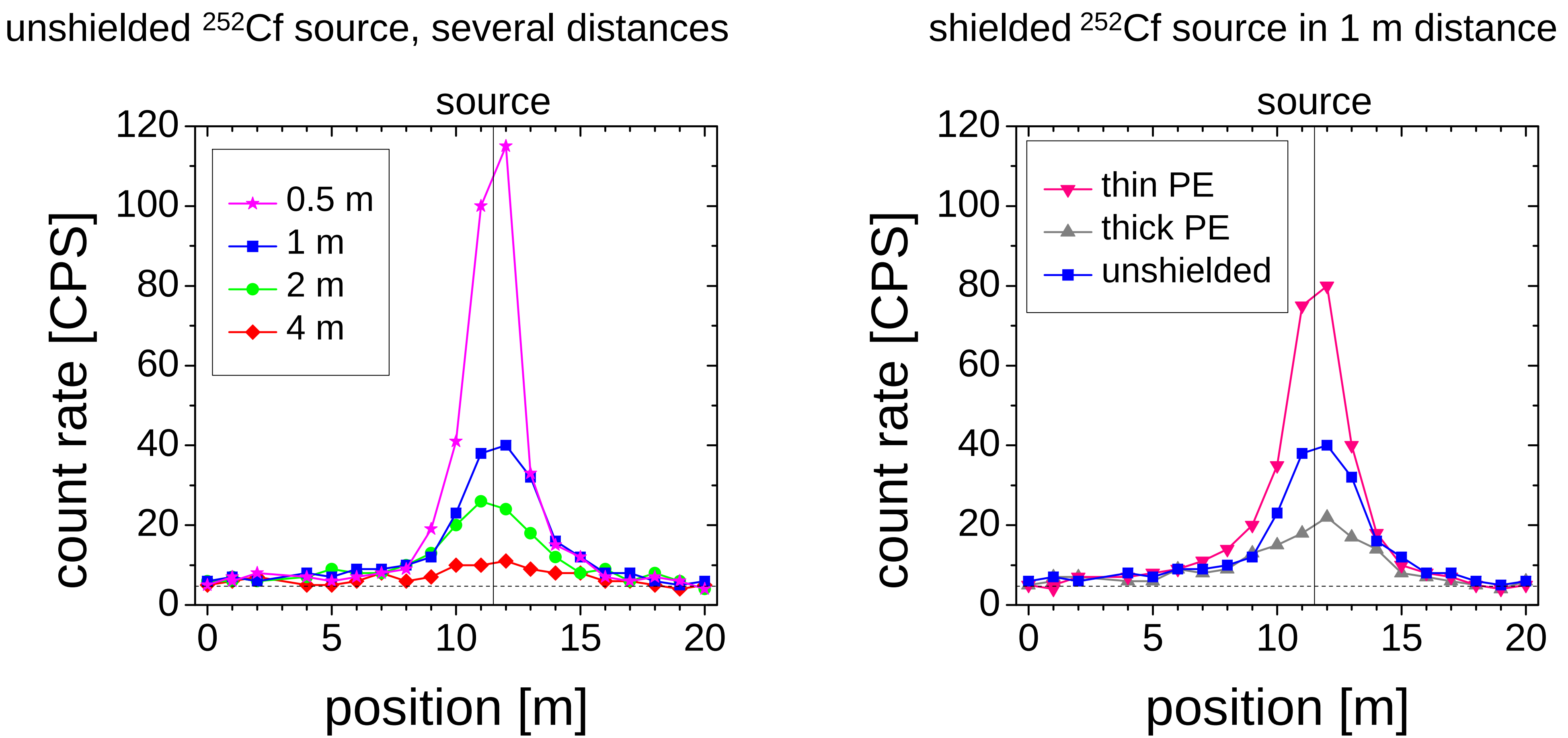
Localization of a neutron source outdoors



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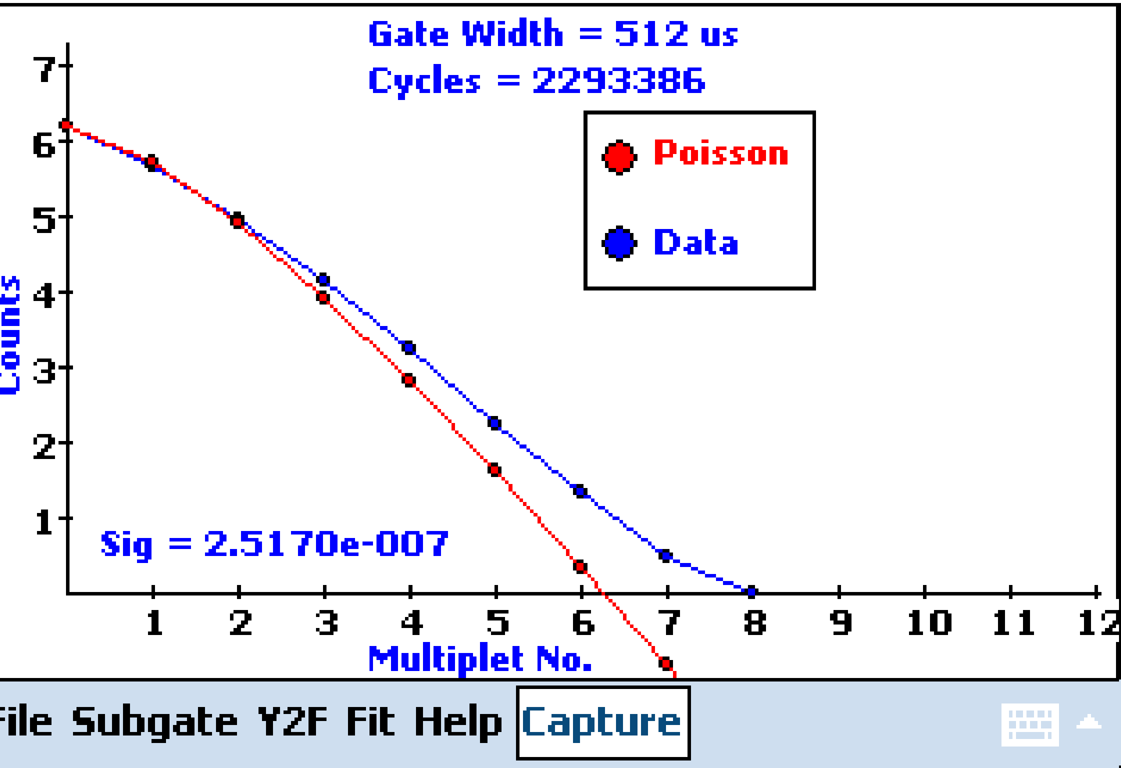
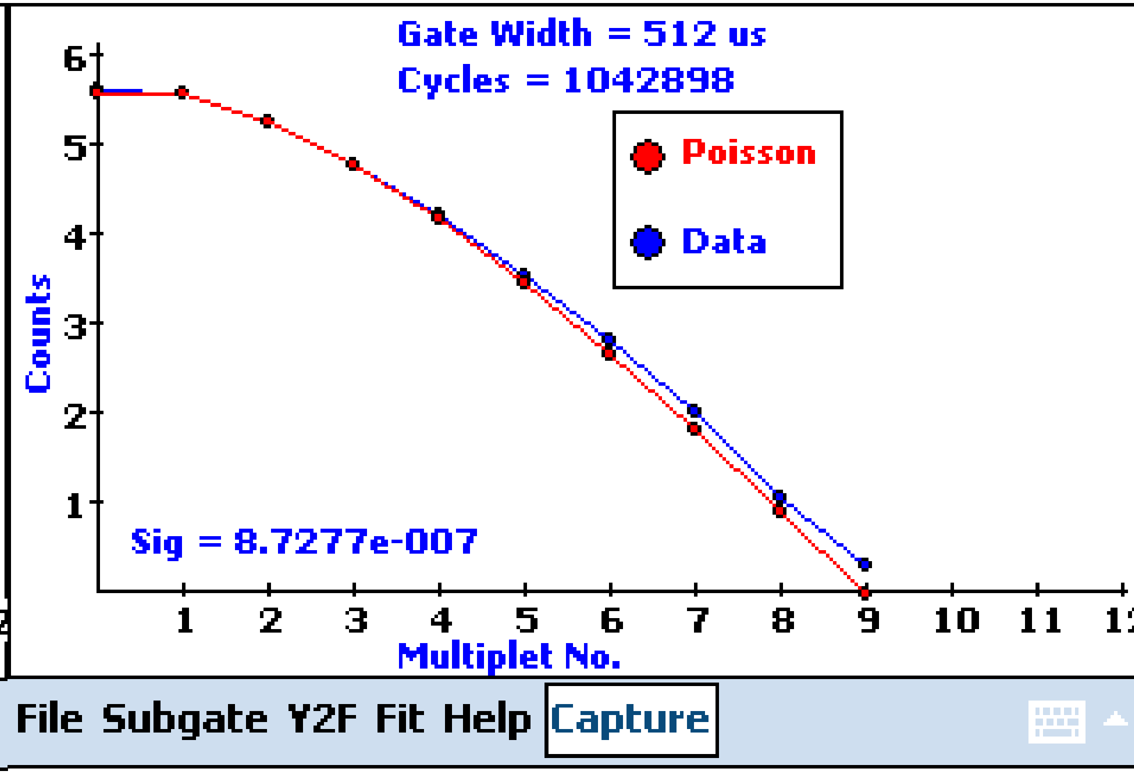
Multiplicity plots – type of neutron source



Fission source (Cf)



Industrial neutron source (Am/Li)

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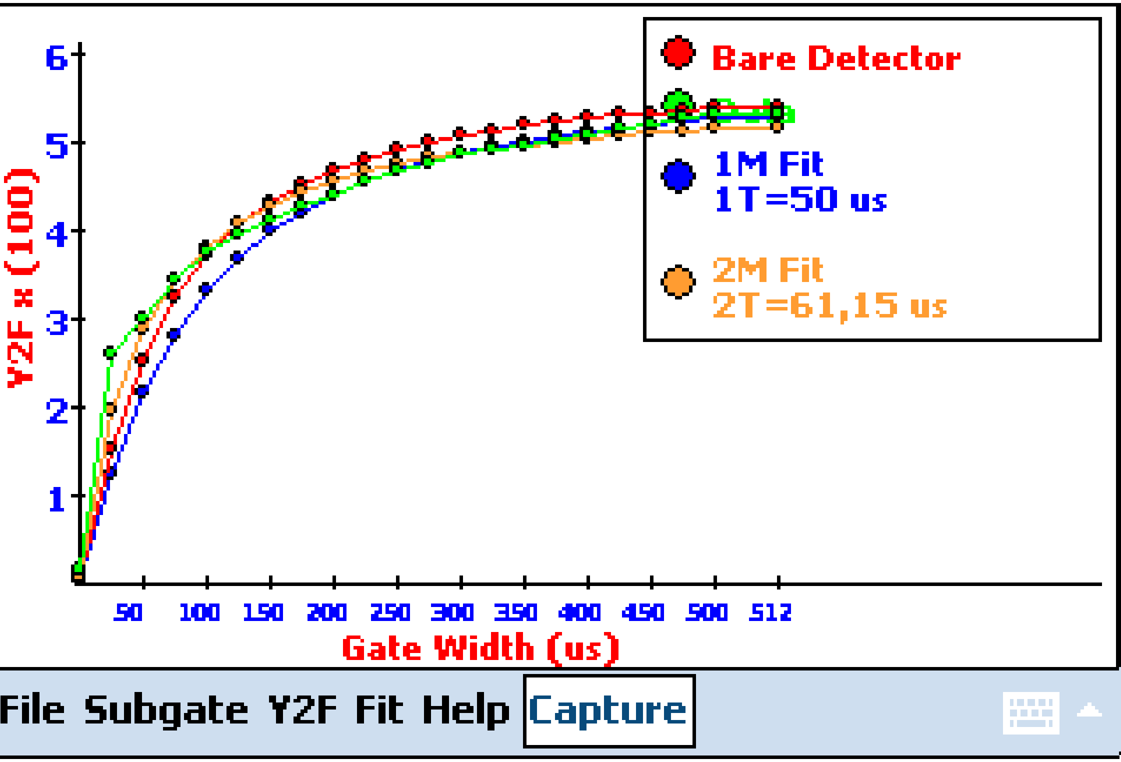
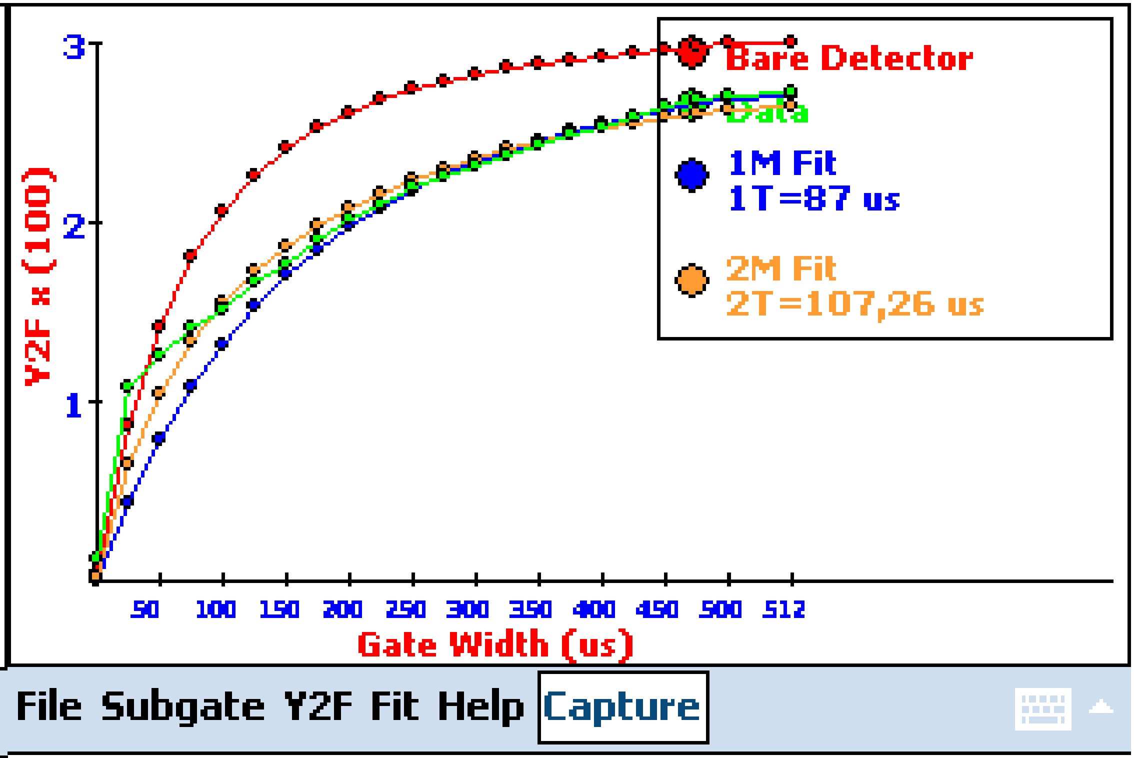
Detection of shielding: Feynman variance plots





Cf-source unshielded

Cf-source shielded with 10.4 cm PE

Benefit from Neutron Spectroscopy on site

Gives significant more information than pure neutron counting, essential for assessment of possible risk and counter measures:

Indicates type of neutron source: industrial or fission

Indicates existence of shielding material, in particular neutron moderating material

High neutron sensitivity for handheld system

Further advantages:

Non-contact measurements on the complete object without moving it

Correct neutron dose measurement using the corresponding spectral fluence to dose conversion factors

Detection of material inhomogenity

Shielded nuclear material (like HEU or Pu) is only detectable by neutrons

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N-Probe Neutron Spectrometer

N-Probe Specifications

- weight: 4,1 kg
- NE213 liquid scintillator for high energy neutrons detection
- He_3 detector for low energy neutrons detection
- measuring results: neutron spectra, flux, fluence, dose rate and accumulated dose

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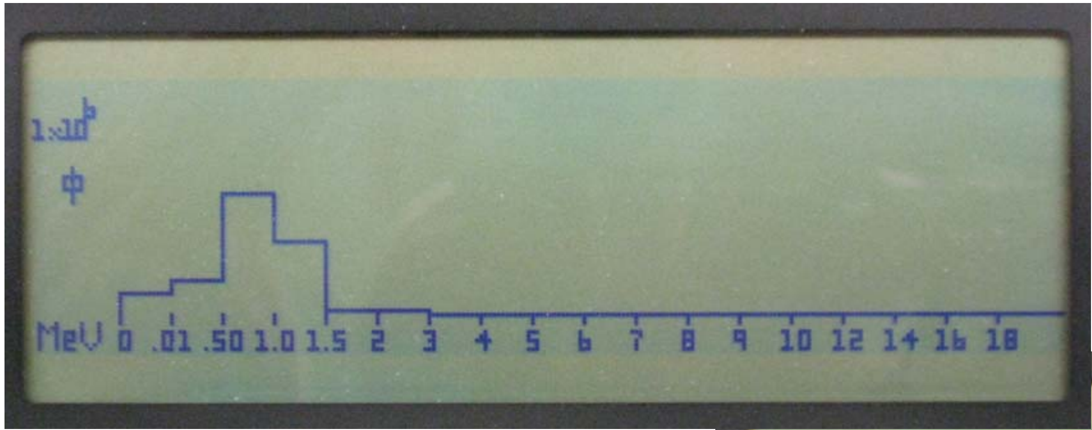
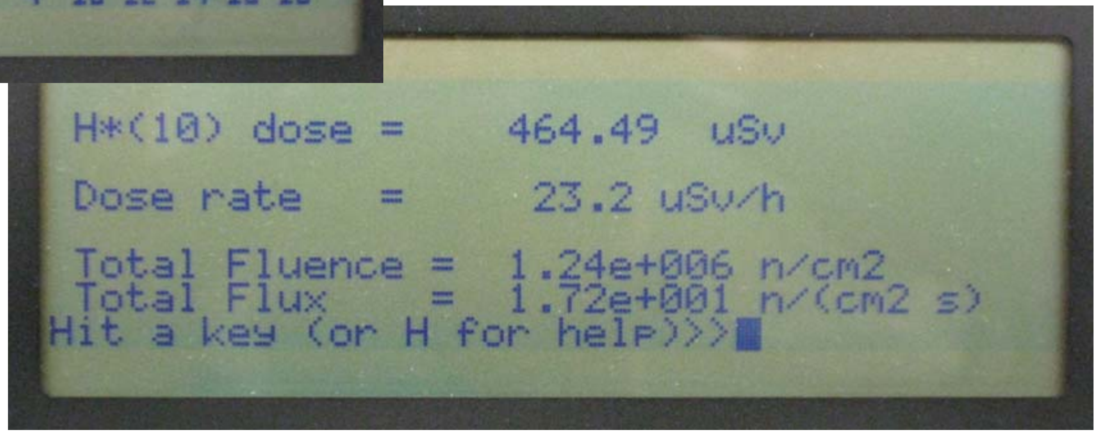
Neutron Spectrometer N-Probe: Displays



Display of the neutron spectrum (neutron fluence)

Display of the calculated results for the spectrum above



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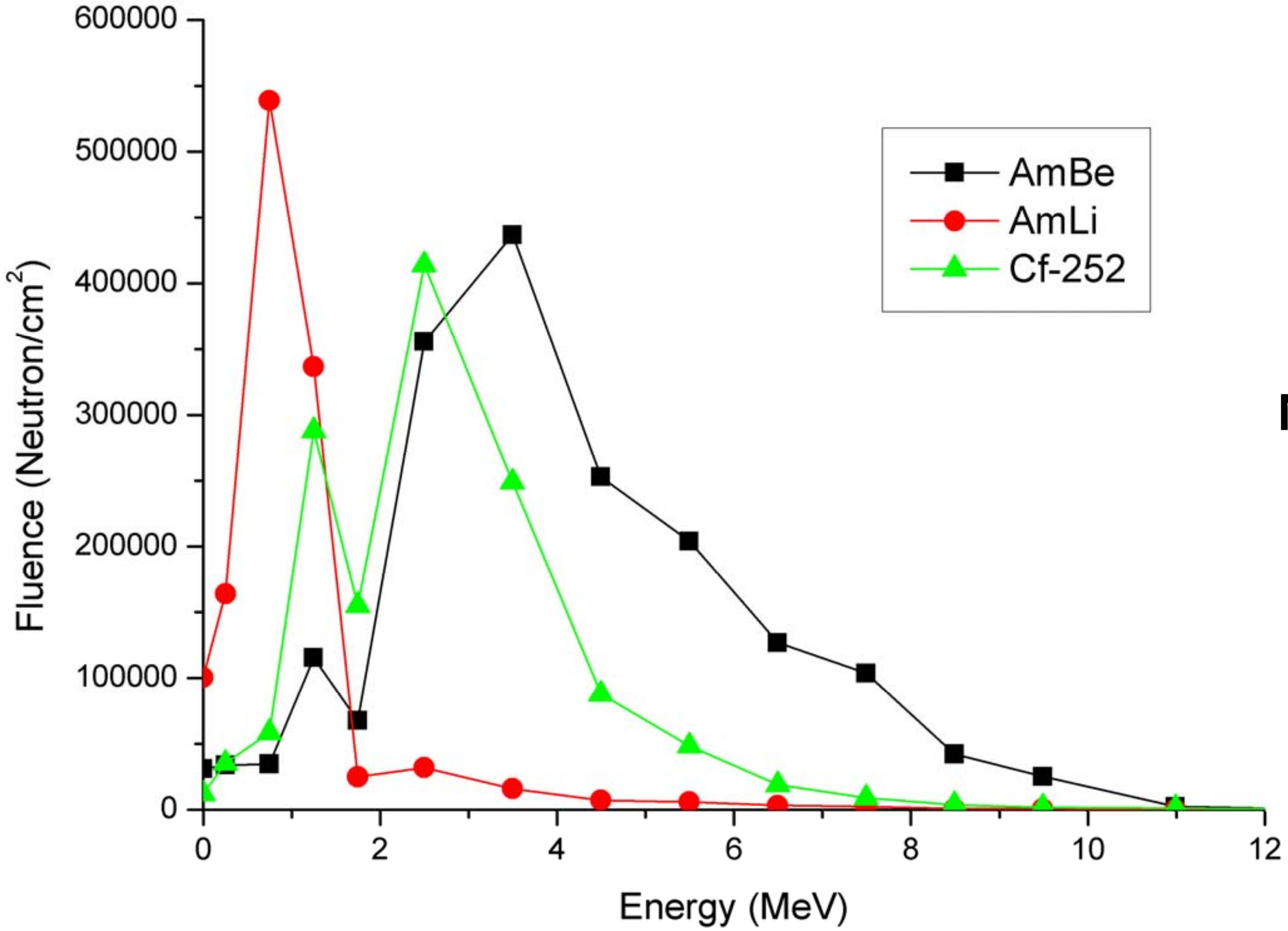
N-Probe: Neutron Spectra



Neutron spectra for different neutron sources

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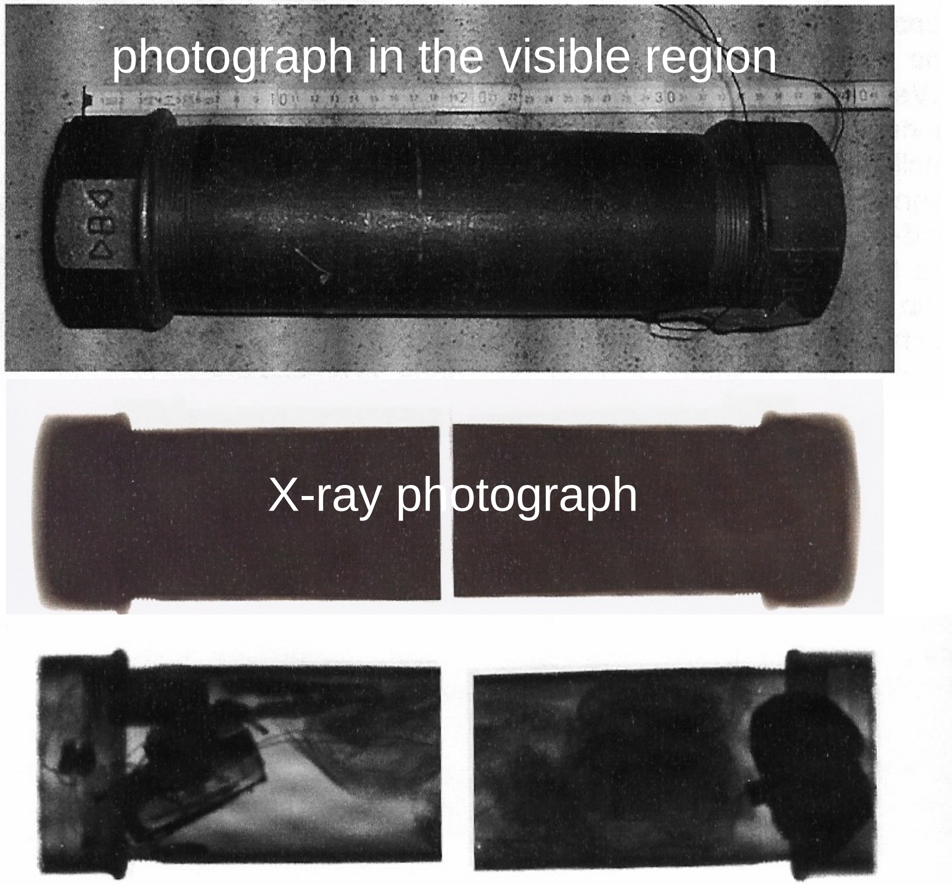
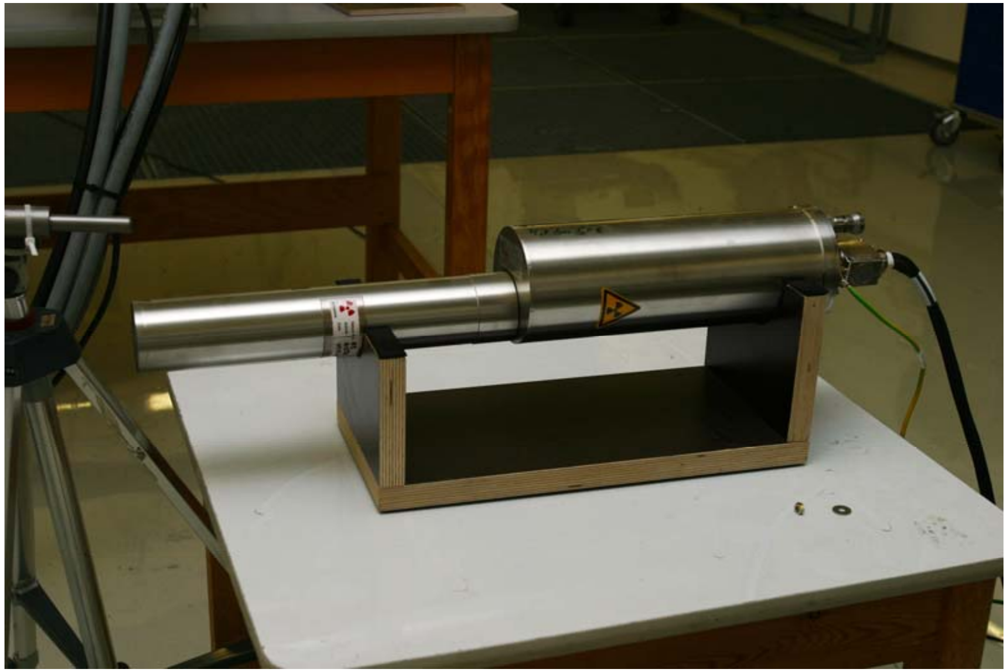
Neutron – radiography, compared to X-ray



Radiography with thermal neutrons, IED is identified unambiguously



Sealed neutron tube

D – T tube neutron intensity up to 3 · 10^8 n/sec in 4π

D – D tube neutron intensity up to 2 · 10^6 n/sec in 4π

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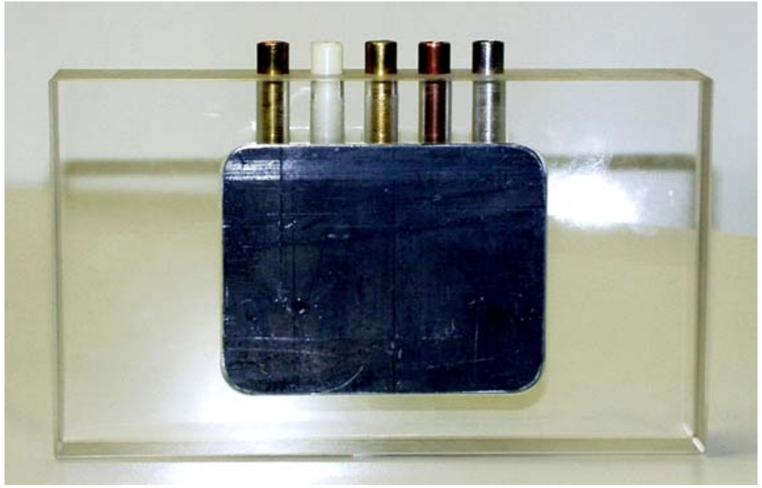
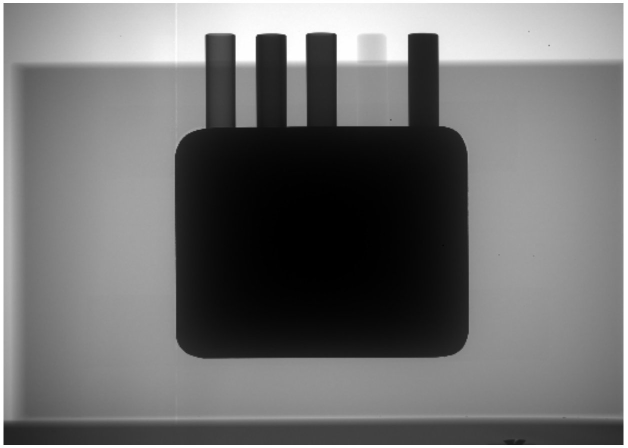
Work in progress: Mobile Neutron radiography

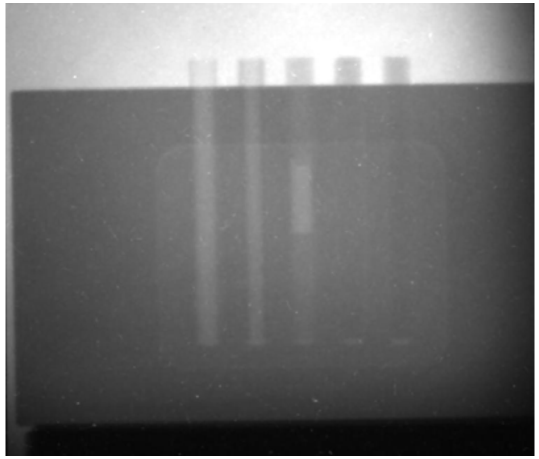
Inspected object made of polyethylene with pipes of different material



X-rays



fast neutrons



Cooperation with: Bundesanstalt für Materialprüfung (BAM), Berlin

Technische Universität München

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Conclusion – Perspective

With innovative portable devices for detection and identification of gamma and neutron radiation fast and reliable measurements are possible in the field, determining the presence of radioactive or fissionable materials in suspect objects, as well as, within certain limits, type and quantity of this material.

This gives information on the possible risk potential and recommendations can be established on further actions to be taken to minimize the possible injury.

In order to gain even more comprehensive information on the inner structure of a suspected device we will improve mobile imaging techniques, i.e. mobile neutron radiography in future.

Furthermore these portable devices may be used in the scope of on-site inspections of combating and preventing nuclear proliferation.

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