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Investigation on the suitability of a CdTe detector for inventory measurements in concrete of bioshields

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Introduction

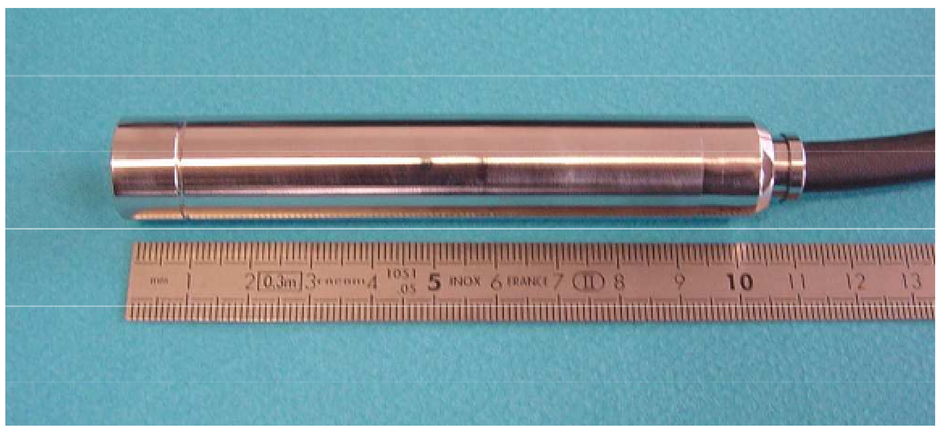
CdTe detector investigated for applicability to mapping of activation and inventories in bioshield concrete.

CdTe detectors: small and light, high Z materials Cd and Te → response to photons with energies in the range of several hundred keV could be sufficient to measure and identify gamma-emitting activation and contamination in reactor structures.

CdTe detectors have a high energy resolution on the order of 2-3% and can be operated at room temperature.

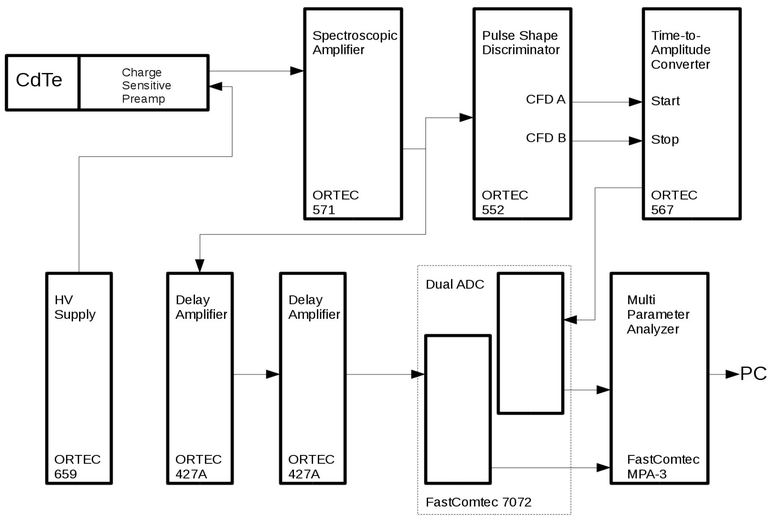
Such a detector suitable to be carried by a robot and used for automatic mapping of dose rates, activated inventories and contamination?

Here: CdTe detector with dimensions of 5x5x2 mm^3 investigated using standard gamma sources of isotopes typically found in concrete structures (^{133}Ba, ^{152}Eu).

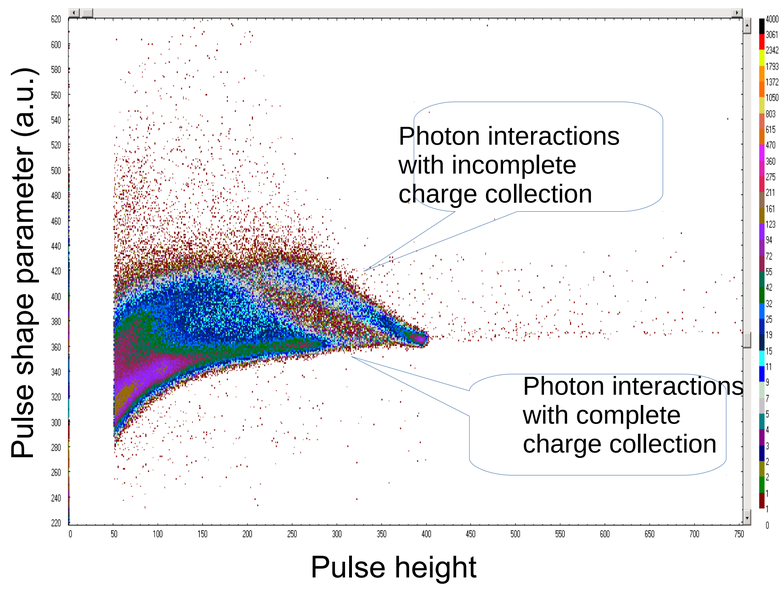


SO16 type CdTe detector from EURORAD. The metal tube contains the CdTe detector and the charge-sensiitive preamplifier.

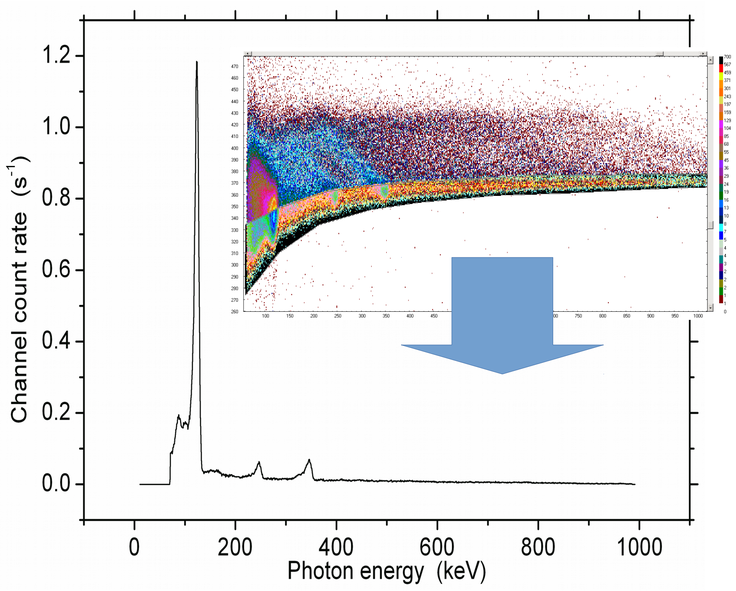
Signal processing



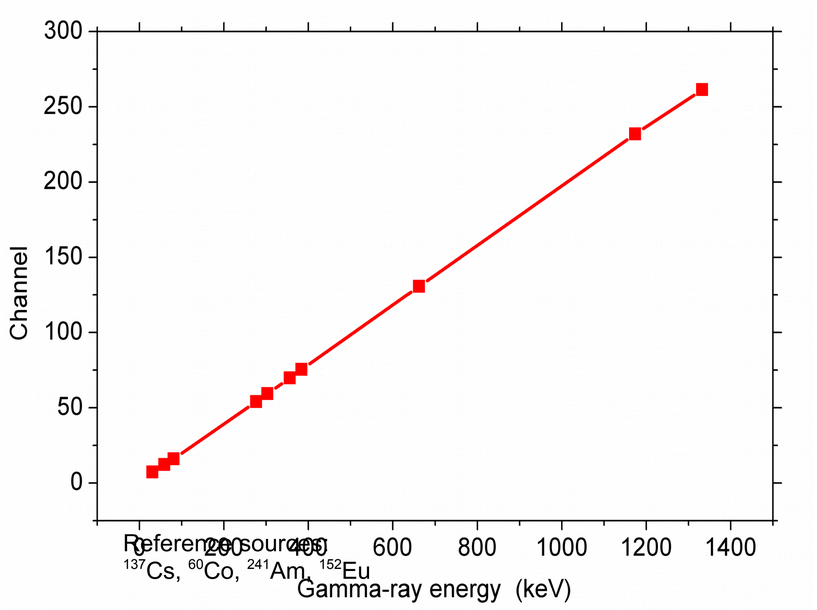
The electronic circuit for signal analysis evaluates the pulse height and the pulse shape. Both signals are fed into a multi-parameter analysis system.



Representation of pulse shape parameter and pulse height for recorded photon interactions in the detector in a 2d histogram. Example: ^{152}Eu

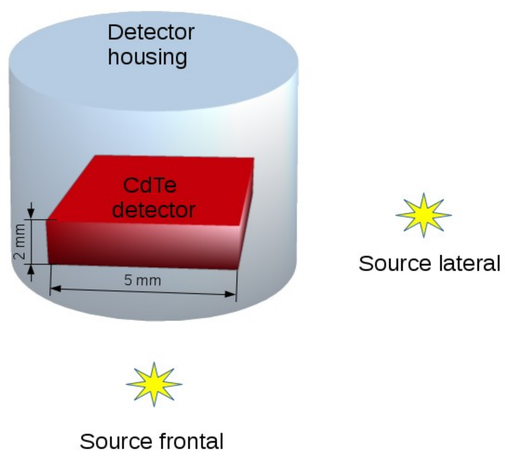


Events with full charge collection selected in a region of interest and projected onto energy axis → gamma spectrum.

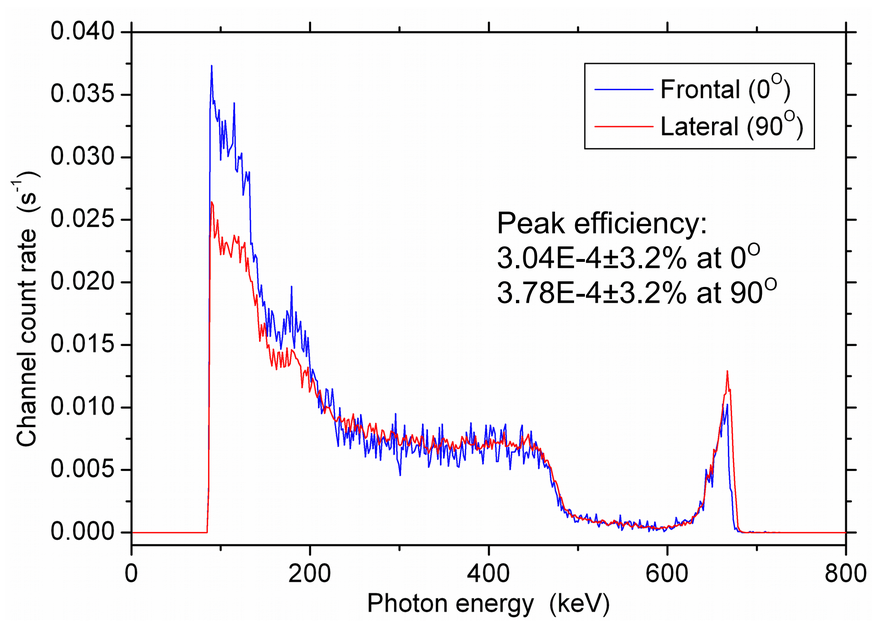


Linearity of the energy response of the CdTe detector considered here. The energy resolution ranges from 12% at 81 keV to 2.7% at 391 keV.

Response to photons



Response of detector depends on angle of irradiation, investigated with a ^{137}Cs (662 keV, 1.3E7 Bq) at 0^{O} and at 90^{O} with respect to detector axis, distance 50 cm



Photon spectrum measured under two irradiation angles with ^{137}Cs source. Note that the count rate differs significantly at lower Compton energies.

Isotope identification

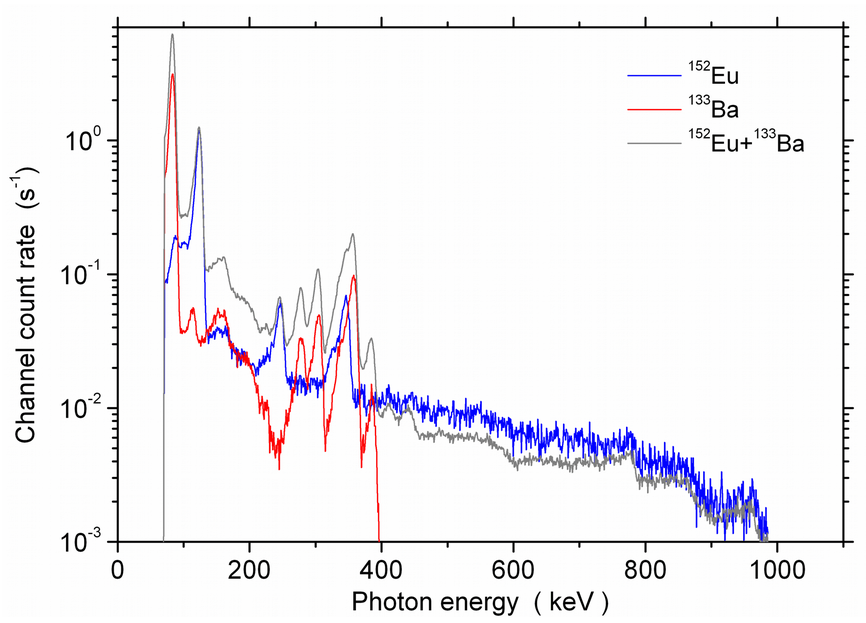
Typical dominating neutron-induced and γ-emitting activities in concrete bioshields a few years after shut-down are ^{152}Eu and ^{133}Ba.

Here simulated with calibration sources to determine whether the detector is able to resolve these isotopes and also whether it is possible to perform quantitative measurements

Calibration sources:

^{152}Eu	1.51E4 Bq	3.6 µSv/h contact dose rate
^{133}Ba	1.27E4 Bq	0.8 µSv/h contact dose rate

Tests on concrete activated with an intensive neutron generator in laboratory are underway with the main goal to check the detectors response in presence of background activity.



Relevant gamma lines emitted by ^{152}Eu and ^{133}Ba and their properties.

Isotope	Energy (keV)	Intensity (%)
^{152}Eu	121.8	28.6
	244.8	7.6
	344.3	26.5
	778.9	12.9
	964.1	14.6
^{133}Ba	81.0	34.1
	276.4	7.2
	302.8	18.3
	356.0	62.0
	383.8	8.9