The development of a dual-use low-cost CsI(Tl)-SiPM detector for radiation monitoring by authorities and members of the public

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EMPIR Preparedness

- Metrology for mobile detection of ionising radiation following a nuclear or radiological incident
- 3-year pan-European research project funded by EURAMET
- Collaboration of NMIs, monitoring agencies and industry
- Four technical work packages;
  - Drone mounted detector systems
  - Transportable air monitoring equipment (see poster)
  - **Citizen radiation monitoring**
  - Passive dosimetry for environmental monitoring
- Stefan Neumaier to present more details later…

PREPAREDNESS

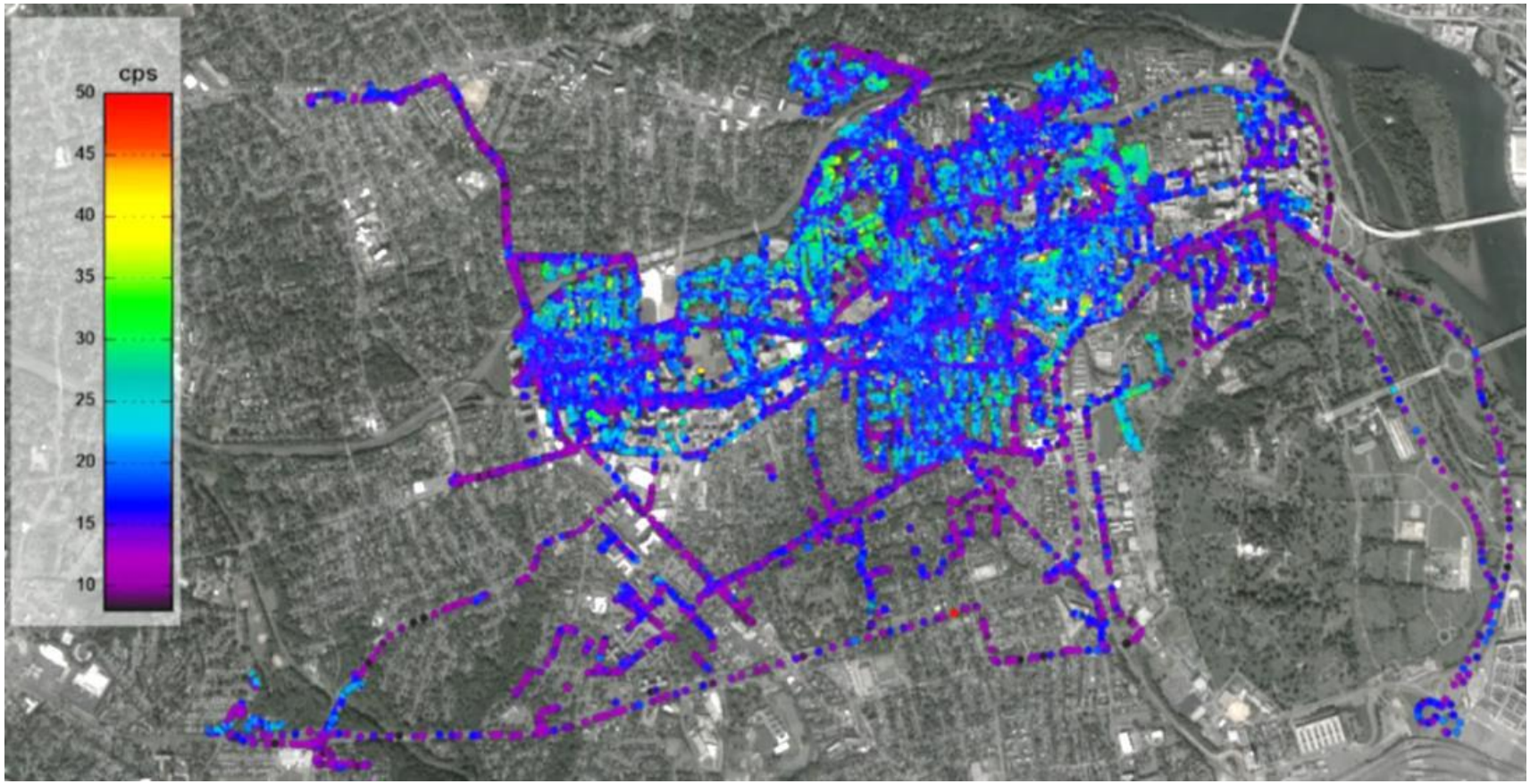
Metrology for mobile detection of ionising radiation following a nuclear or radiological incident.

Kromek D3S

- Dual gamma and neutron detector for homeland security
- Designed to be worn by government employees (police, fire, postal etc) for real-time radiation mapping of urban environment

Specifications:	
Gamma detector :	CsI(Tl)-SiPM, 2” x 1” x 1/2”
Energy resolution:	7% (at 662 keV)
Energy range:	30 to 3,000 keV
Sensitivity:	500 cps/µSv/h
Dose rate limit:	15 µSv/h (at 662 keV)
Connectivity:	Micro USB, Bluetooth®
Neutron detector:	LiF:ZnS-SiPM, 32 mm × 100 mm
Count rate limit:	5,000 cps
Size:	132 × 80 × 23.5 mm^3
Weight:	237 g
Battery life:	12 h

Kromek D3S



Radiological “heat” map of urban area produced by centralised database collecting data from multiple D3S units (DARPA trial, Washington DC)

Kromek D3M

- Modified version of D3S
- Photodiode used for high dose-rate measurement
- Other improvements:
  - IP65 rating
  - Improved battery life (24 hours)
  - Indoor tracking for GPS denied areas
  - Local display and alert (OLED Screen)
  - Vibrational and Sounder alarm
  - Internal storage (8GB MicroSD card)
  - Improved Linearity and stability for reduced false alarm rates
  - Low Energy Bluetooth (BLE)
- Preliminary dosimetric measurements made at NPL
- D3M will be produced for purchase and use by members of the public

Preliminary measurements – Experimental set-up

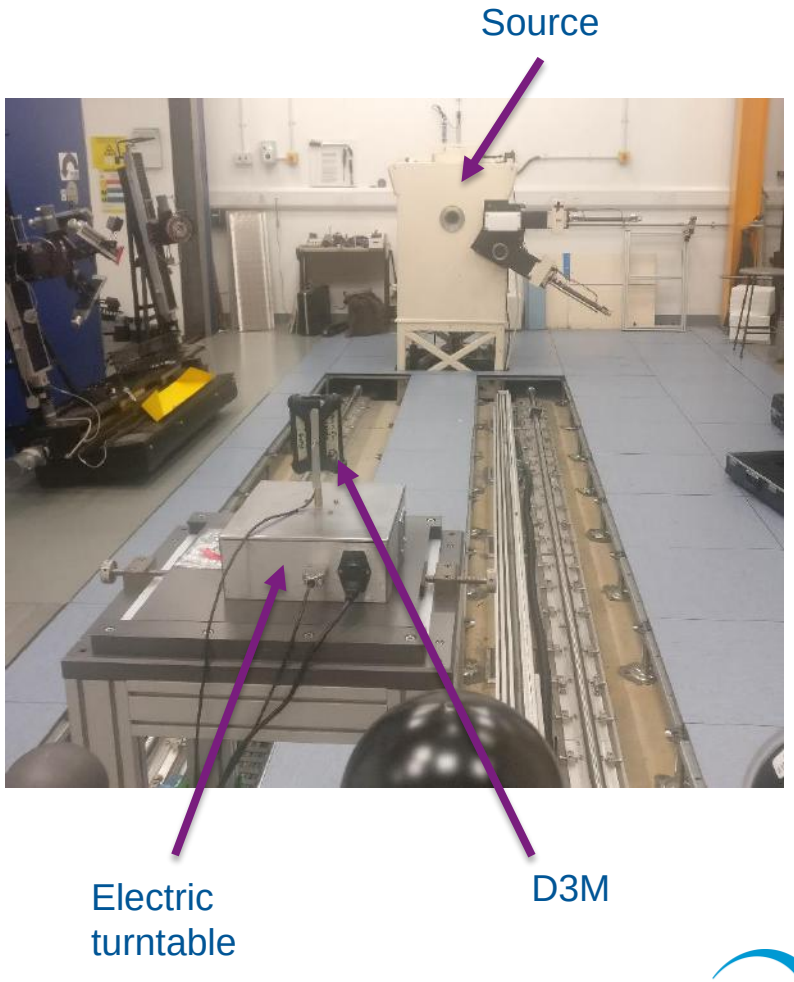
Range and accuracy:

- Each device was exposed to nine sources in turn – one Am-241, four each of Cs-137 and Co-60 at a range of distances
- For Cs-137, dose rates of <0.5 μSv/hr to >1 Sv/hr were possible

Rotational dependence:

- One device was exposed to a high-rate and a low-rate dose field for each source, and rotated 360° in 16 increments
- Both yaw and pitch was tested
- An electric turntable was used to facilitate the measurements

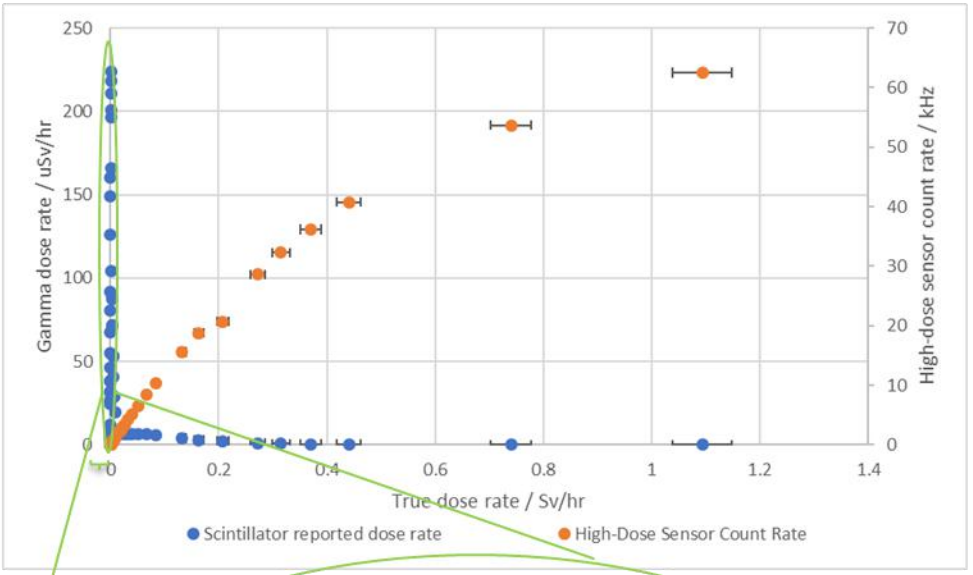
For all tests, the gamma spectrum, scintillator dose, and high-dose sensor reading, were recorded.

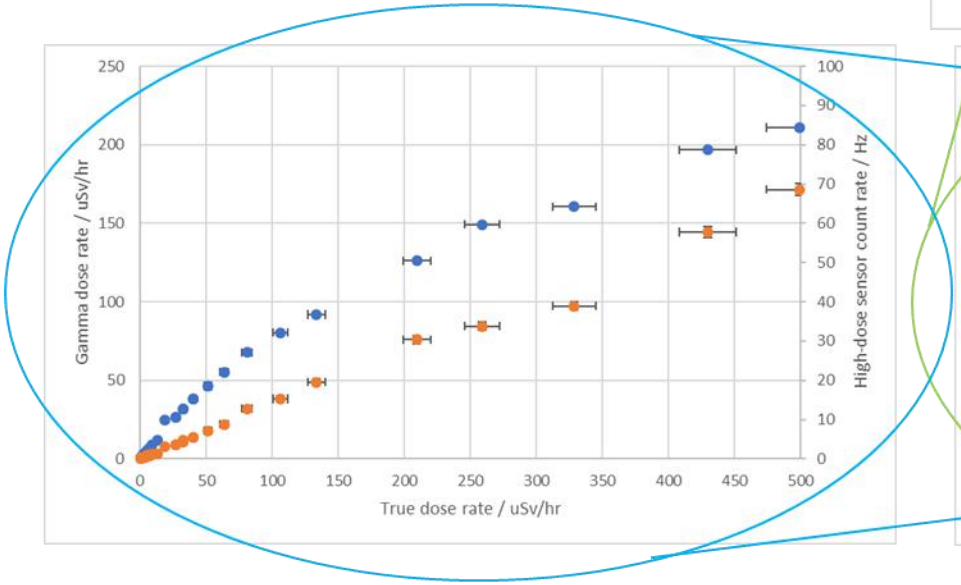


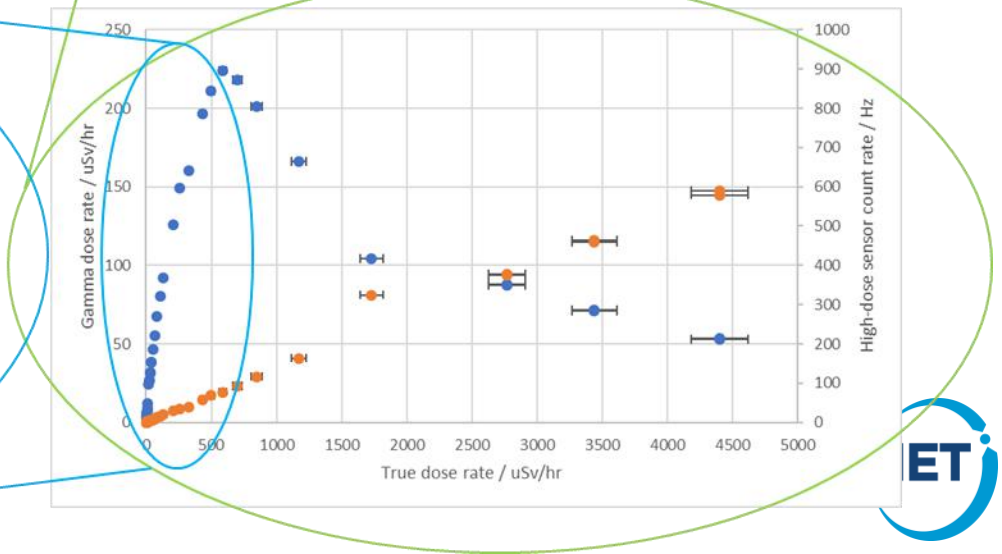
Preliminary measurements – Dose range and accuracy

Plotted are the responses for Cs-137 (blue: scintillator dose reading, orange: high-dose sensor count rate)

The scintillator dose rate was accurate at low dose rates for both Cs-137 and Co-60, staying within 10% up to 50 µSv/hr





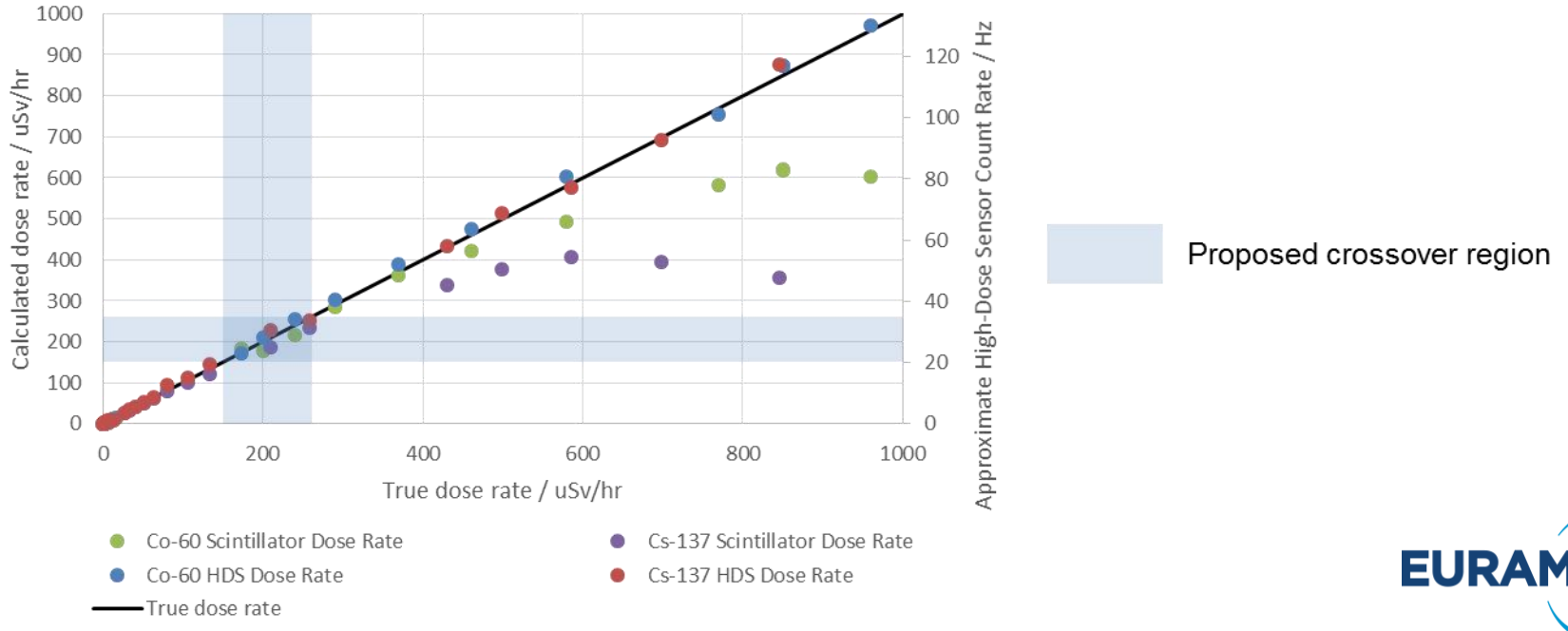


Preliminary measurements – Deadtime

The theoretical dead time model used for the scintillator dose rate calculation was found to be inaccurate beyond 50 Sv/hr

Modification of the deadtime extended the accurate (± 10%) dose rate range up to 200 Sv/hr for Cs-137 and Co-60

200 Sv/hr proposed as crossover point from scintillator to high dose-rate sensor.

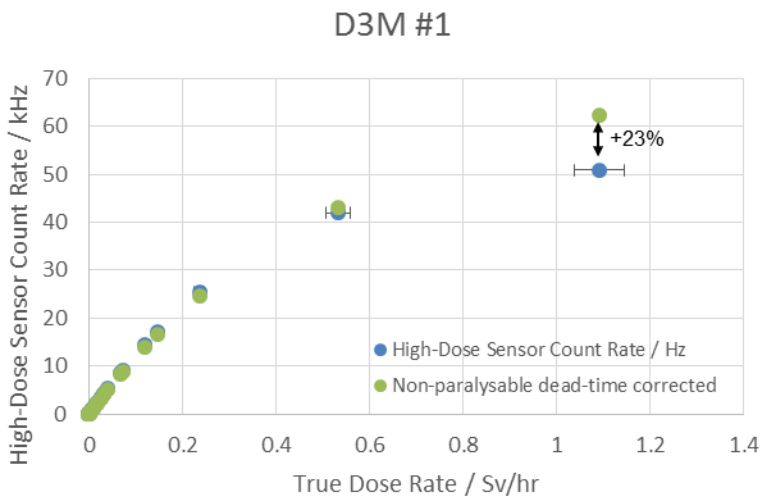


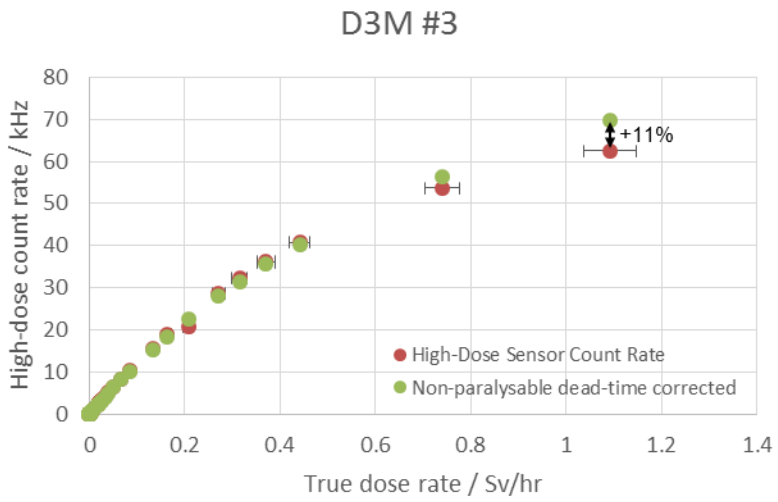
Preliminary measurements – High dose-rate sensor

High dose-rate sensor responsive beyond 1 Sv/hr

By applying a non-paralysable deadtime model, a deadtime of 8 µs was determined

Deadtime model accurate to approx. ±20% at ~1.1 Sv/hr





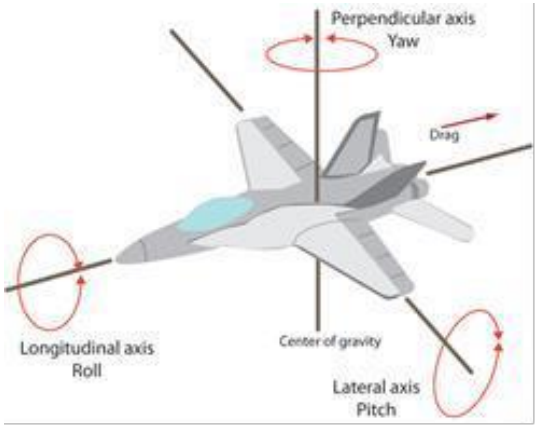
Preliminary measurements – Angular response

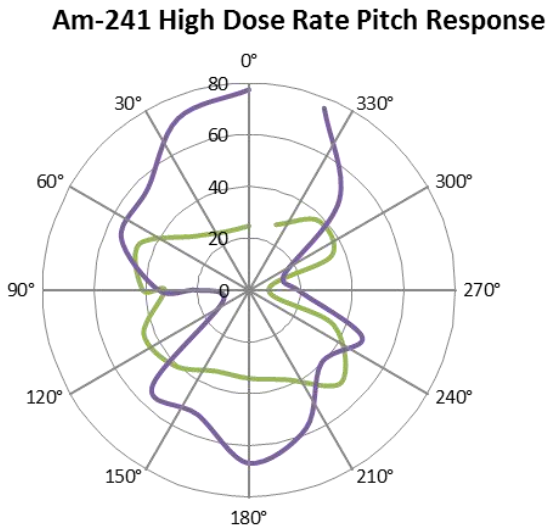
Device exposed to low and high dose rates from three radionuclides:

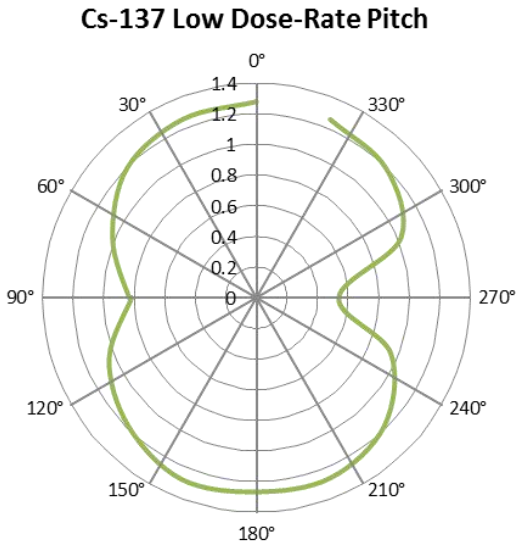
- Am-241: 16 µSv/hr and 620 µSv/hr
- Cs-137: 1.2 µSv/hr and 2.3 mSv/hr
- Co-60: 1.8 µSv/hr and 1.0 mSv/hr

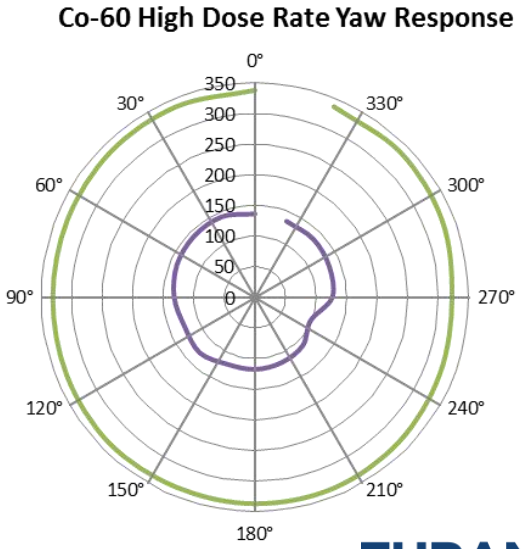
The scintillator dose rate in the first and third plots were calculated from spectra which were saturated in the high dose-rate field

Low dose-rate response of high dose-rate sensor not plotted as count rate too low









Spectrum Dose Rate (from scintillator) / µSv/hr
High-Dose Sensor Count Rate / Hz

Next steps

- A website will be trialled for the sharing of radiation measurements by members of the public. This will be developed with support from EURDEP, the European Radiological Data Exchange Platform [1].
- NPL and PTB will continue to metrologically validate the new instrument. This will include measuring the spectral response in the range 60 to 1,250 keV using X-ray and gamma-ray irradiation facilities, investigating the unit-to-unit variability.
- An extended site trial will be performed with comparisons made to passive or existing dose monitoring infrastructure.

[1] EURDEP, https://eurdep.jrc.ec.europa.eu/Entry/Default.aspx.

Thank you for listening!

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