WG6 IPNDV Experimental Technology Data Sheet

December 3, 2019 , Japan Atomic Energy Agency, Japan

Name of Experimental Campaign:

Belgium exercise to investigate performance of measurement methods

Technology Name: Compton Gamma Imager

Physical Principle/Methodology of Technology:

Compton type gamma imager with CZT detectors

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

Presence/absence of NED/SNM (Pu), shape change of SNM (Pu)

What Is the Applicability to IPNDV:

- Presence/absence of NED/SNM (Pu) in container
- Chain of custody of NED/SNM (Pu)

Type of Data Collected by the Technology:

Gamma-ray spectrum, gamma-ray Compton scattering image

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):

Can start measurement quickly, shielding is basically not required (required with higher dose rate), distance and measurement time is to be determined by dose rate and sample size (FOV)

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

- Sample: MOX bundle (Table 1)
- Shielding: Bare bundle, Pb: 10 mmt, (Cd: 2 mmt, Polyethylene: 50 mmt)
- Measurement distance: 110 cm from center of MOX bundle (Figure 1)
- Measurement time: 5~10 minutes
- Equipment: H3D Polaris-H Quad (Figure 2)
  - Detector: >19 cm3 CdZnTe
  - Energy resolution: $\leq$ 1.1% FWHM@662 keV
  - Radiation FOV: 4π (360°)
  - Angular resolution: ~30° FWHM (real time measurement), ~20° FWHM (post-process)
  - Imaging energy range: 250 keV–3 MeV
  - Sensitivity: localize Cs137 point source with ~3μR/h in <90seconds
  - Others: 24 x 9 x 18 cm, 3.5 kg, >6hr battery life @23°C

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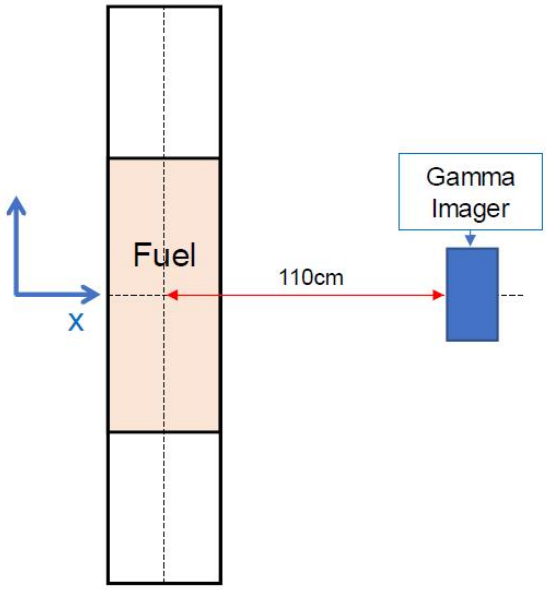


Figure 1. Experimental setup

Figure 2. Equipment photo

Specific Objects Measured (which of the experimental objects were measured; if not described elsewhere, describe experimental objects here):

Process Required to Analyze the Data (include any software used):

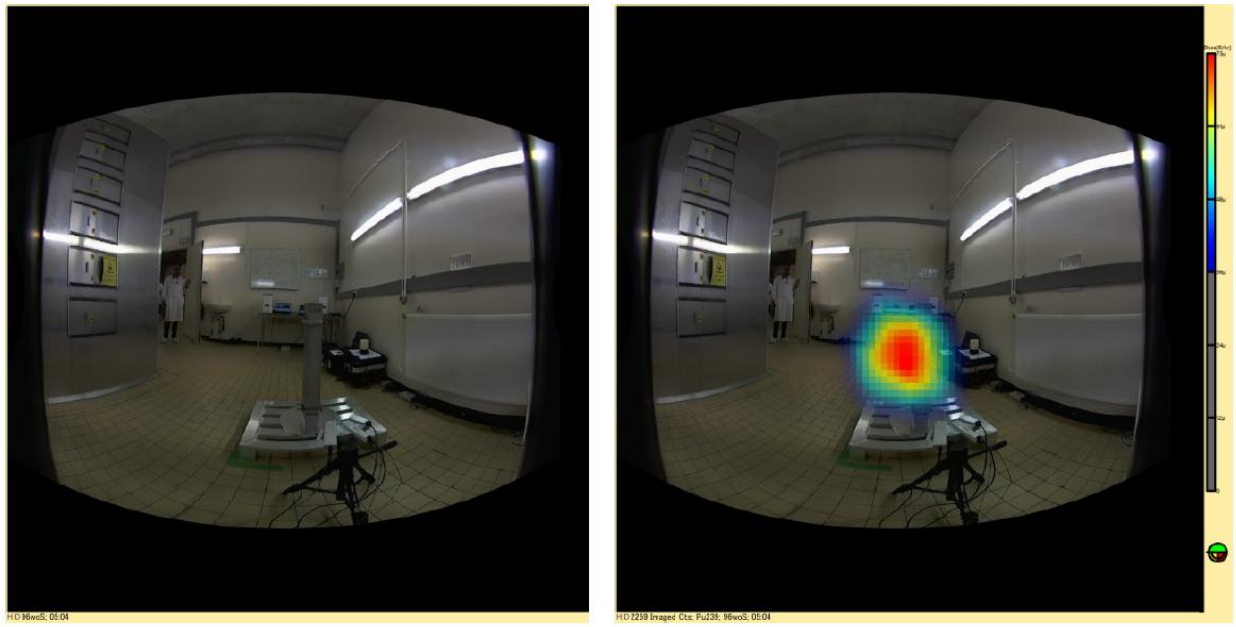
Not required (or post-imaging processing for more detailed analysis with H3D Visualizer)

Preliminary Results (qualitative, not quantitative; e.g., did the method perform as expected, if not how was it different):

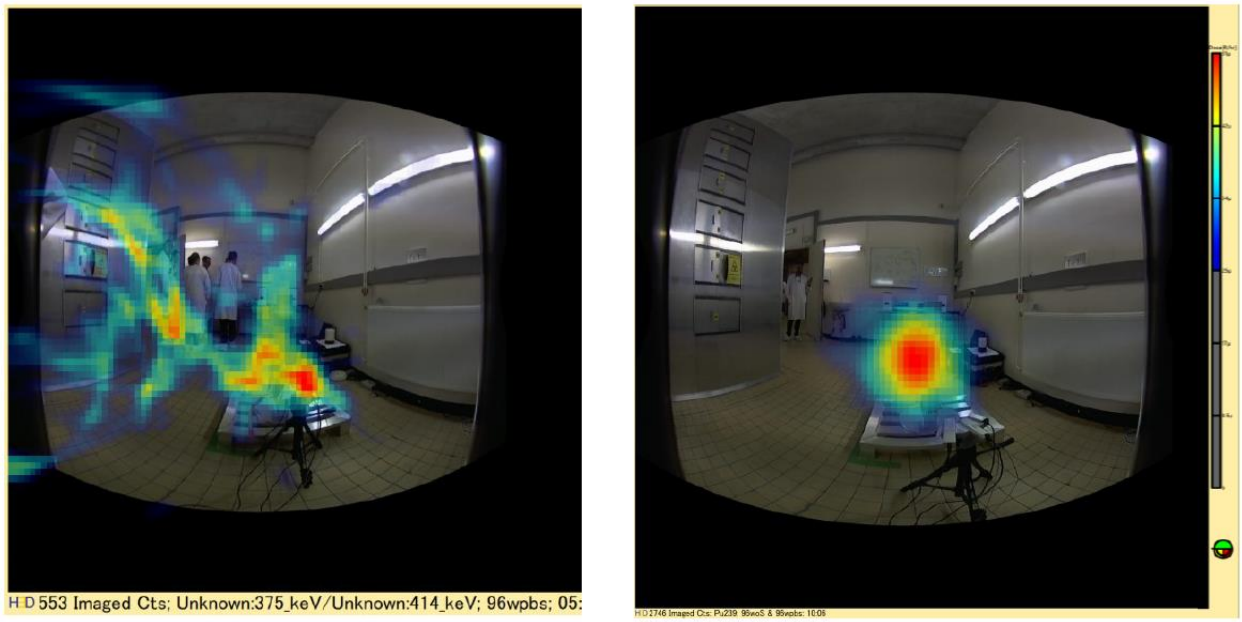
- Pu239 source imaging is possible with 5–10 minute measurement for >200 g bare and Pb-shielded WG Pu.
- Detailed shape of Pu239 source cannot be recognized, but shape change for 50 cm range is detectable with 1 m distance measurement.
- Shielding is required for imaging of high radiation source.
- Gamma source imaging for <200 keV (i.e., U235) is impossible with Compton type gamma imager.

Applicable for Pu absence/presence measurement for container. Shape change detection of Pu239 source for CoC is also possible.

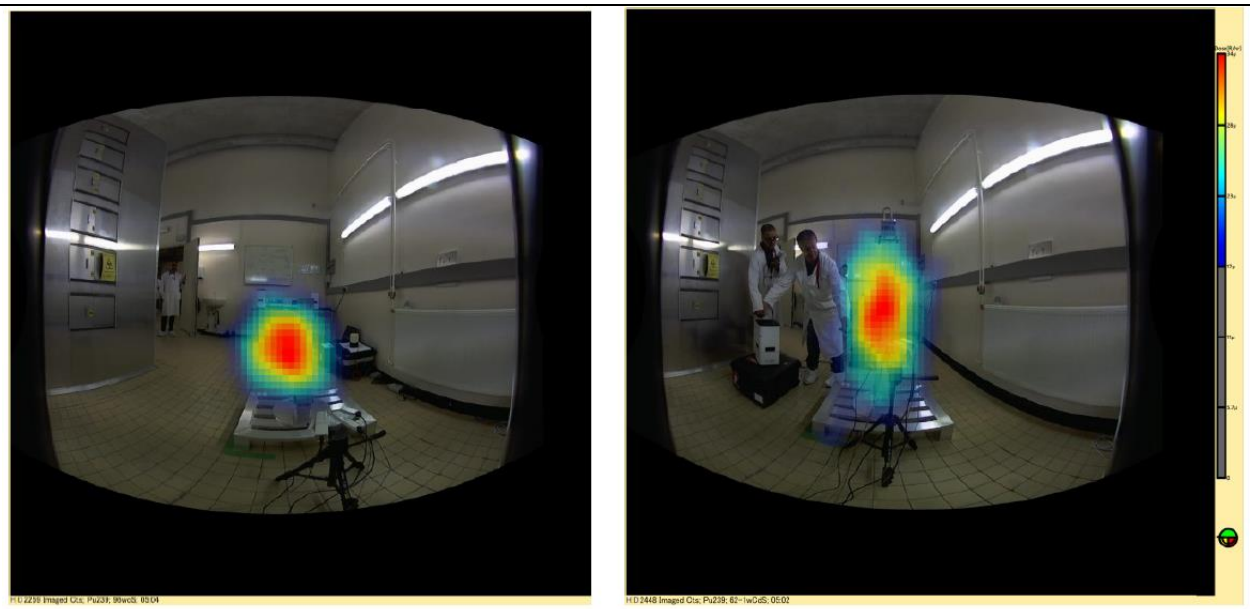
Final Results (if available; if not, estimate of when final results will be available):



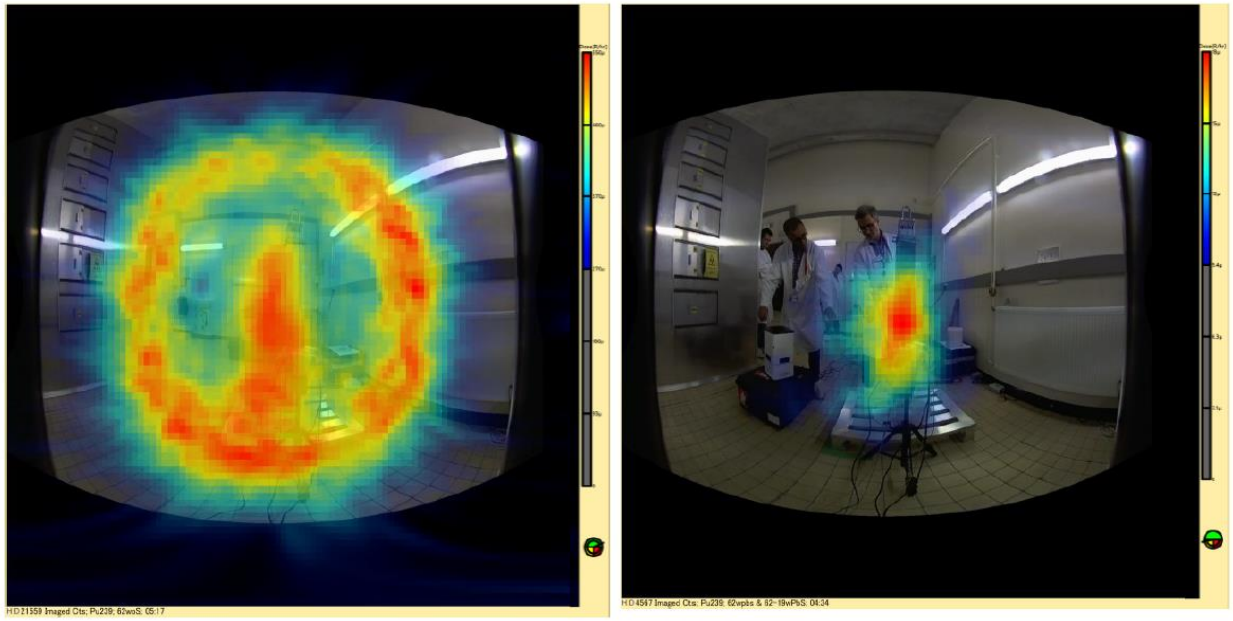
96 w/o Pu239, bare bundle, 5 min



96 w/o Pu239, Pb shielded, left: 5 min and right: 10 min



Bare bundle, 5 minutes, left: 96 w/o Pu239 (50 cm), right: 62 w/o Pu239 (100 cm, 1 pin)



62 w/o Pu239, 5 minutes, left: bare bundle, right: Pb shielded

Figure 3. Gamma-ray images

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?):

- ~10min measurement with Compton type gamma imager could be enough to analyze location and/or shape of SNM (Pu) with <1 cm Pb shielding. It means that it could be used also for presence/absence measurement for SNM (Pu) in container.
- Compton type gamma imager is not applicable for detection of HEU.