Performance of a novel gamma-ray imager for nuclear security applications

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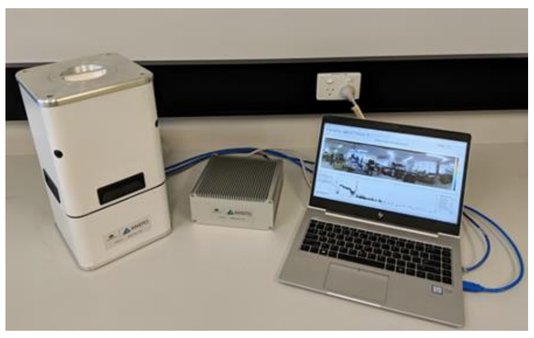
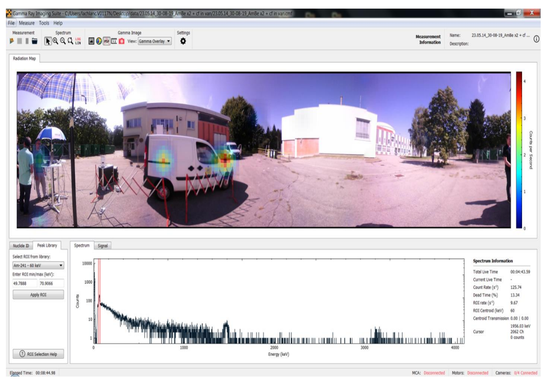
Gamma-ray and neutron imaging technologies have many potential applications in nuclear security, safeguards, waste management and decommissioning. In particular, gamma-ray imaging enables one to remotely locate, identify, and quantify gamma emitting radionuclides, including; Naturally Occurring Radioactive Materials (NORM), industrial, medical or special nuclear materials (masked or shielded). These technologies can provide crucial information e.g. for a secondary inspection of a passing cargo at border crossing, the development of an efficient decommissioning plan, a survey of an area at a nuclear facility amongst other applications. This paper describes the performance of a gamma-ray imaging system that satisfies some, if not most, of the requirements for use in nuclear security applications, as well as nuclear safeguards and decommissioning applications. In essence, the system is based on the theory of compressed sensing and employs rotary masks that perform compressive measurements which considerably reduces the number of measurements (and time) required to acquire a gamma image. Most importantly, the system can image in a wide energy range and over a wide field of view. Emphasis is given to nuclear security applications to combat the illicit trafficking of nuclear materials and other radioactive sources out of regulatory control. Preliminary results acceptance testing within EUSECTRA and ITRAP facilities at the JRC-Ispra are shown below.

- A versatile gamma-ray and neutron imager based on compressed sensing
- Combining differing positive attributes of currently commercialized systems with:
  - Large field of view (360° × 90°)
  - Wide energy range (40 keV to 3 MeV)
  - Angular resolution better than 18°
  - Peaks and non-peak imaging region
  - Fast and cost effective
  - CLLBC ($Cs_2LiLa(Br,Cl)_6$) scintillator - detects both gamma and neutrons

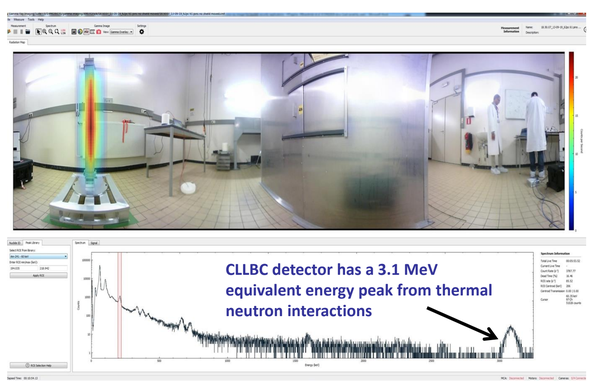


- Gamma imaging system developed by ANSTO
- ANSTO-JRC collaborative for further R&D (2019-2020)

Test Cases

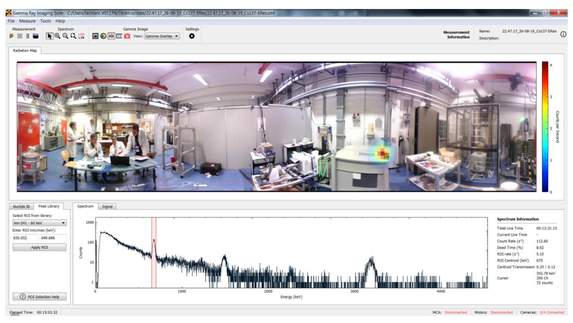


AmBe sources at JRC Ispra located and identified in a few minutes



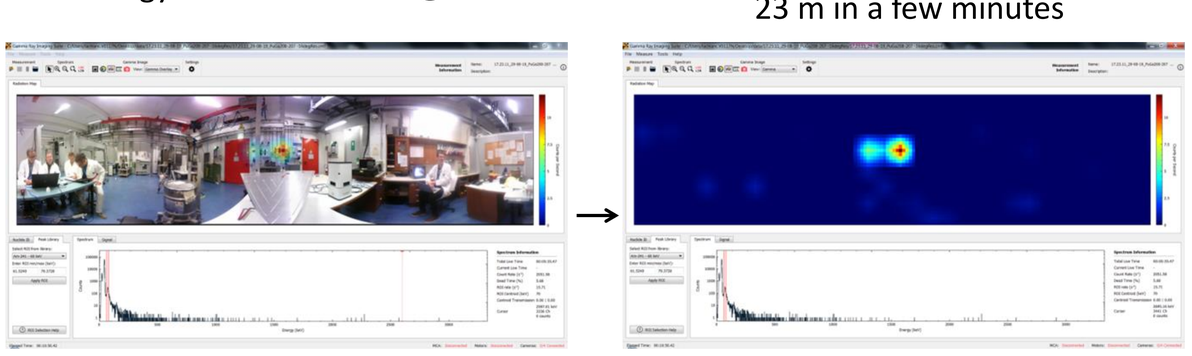
Imaging of 61 fuel pins bundle (62% ^{239}Pu, unshielded) IPNDV campaign, SCK-CEN, Belgium

Imaging Performance



^{137}Cs energy resolution: 3.5% @ 662 keV

^{241}Am peak localized at distance of 23 m in a few minutes

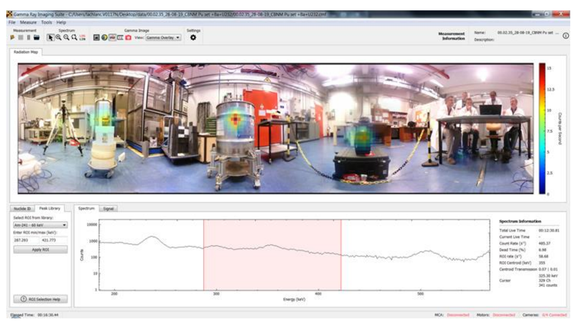


Angular resolution of 16° measured on a test rig with non-infinitesimal sources size (2 PuGa discs) measured at the JRC-Ispra

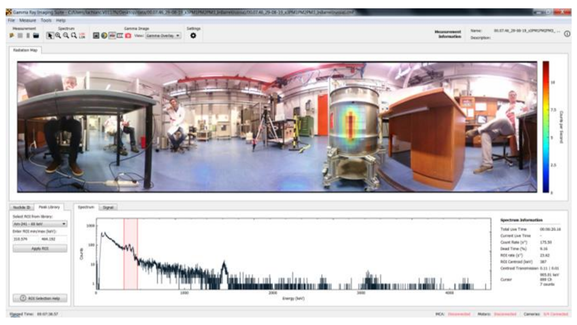
CBNM Pu set + ^{133}Ba + ^{232}U

^{133}Ba peak

^{232}U peak



Broad ROI



Pu metal samples in the Russian (AT400) nuclear weapon container used in Trilateral exercises at JRC-Ispra in 2001

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Joint Research Centre

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