Andra Call for Projects
with the support of the
Investments for the Future Programme

ComptonCAM

Development of an ultra-sensitive portable gamma camera to locate and characterise post-dismantling radioactive waste

Project supported by Andra under the "Investments for the Future Programme" ("Investissement d'Avenir") - Selected under the Andra Call for Projects: "Optimisation of post-dismantling radioactive waste management", organised in cooperation with the French National Research Agency (ANR).

Duration: 48 months

Project launch: 02/2017

Total project cost:
€3.6 million

Sum covered under the Investments for the Future Programme: €1.8 million

Type of financial support: Subsidy with ROI guarantees for the State

Locations:
Orsay, Cersot, Paris

Coordinating body: Centre de Sciences Nucléaires et de Sciences de la Matière (CNRS/Paris-Sud University)

Partners:
- Centre de Sciences Nucléaires et de Sciences de la Matière (CNRS/Paris-Sud University)
- Institut de Physique Nucléaire d'Orsay (CNRS/Paris-Sud University)
- SYSTEL Electronique SAS
- THEORIS SAS

Certification: Nuclear Valley

Contact: Vincent TATISCHEFF
vincent.tatischeff@csnsm.in2p3.fr

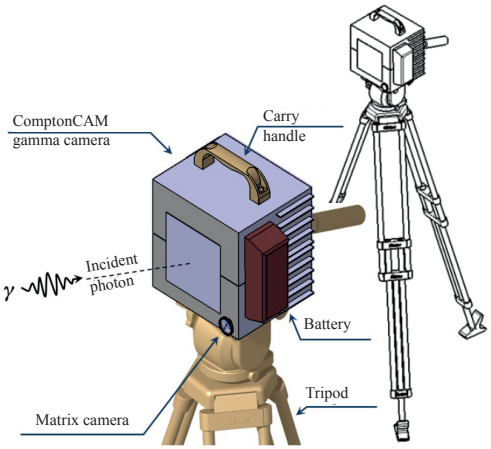
BACKGROUND

The dismantling of nuclear facilities first requires radioactive elements (radionuclides) to be located and identified in potentially high volume areas. Gamma-emitting radionuclides are detected via a camera that can insert a gamma-ray image into an image within the visible spectrum of the observed field of view. Several portable gamma cameras already exist in the nuclear industry and are used particularly for maintenance operations in regulated areas: nuclear plant outages (refuelling or maintenance outages) or laboratory inspections. However, the gamma cameras currently on the market do not have adequate sensitivity to quickly locate very low-level radioactive contamination (it currently takes several hours), which represents the majority of the total volume of radioactive waste generated during dismantling operations.

OBJECTIVES

ComptonCAM is an Experimental Development project that aims to produce a pre-industrial prototype of an ultra-sensitive portable gamma camera based on innovative detection technologies developed for gamma-ray astronomy instruments in space. These technologies are currently being researched in CNRS laboratories to prepare for a future space mission. The gamma camera will use an optimal Compton camera principle to achieve the following properties:

- excellent **sensitivity** to characterise very low-level radioactive waste in minutes, and distinguish it from sources of natural radioactivity;
- a very wide **field of view,** close to 2 pi steradian (which is around the solid angle of the human gaze), to view a substantial part of the area to be characterised in a single image;
- optimised **angular resolution** to best locate radioactive contamination;
- very good **high-energy response,** over a mega-electronvolt, for rapid detection of cobalt-60 radioactivity, which is a radionuclide present in the majority of radioactive waste.



ComptonCAM gamma camera on tripod

PROJECT SEQUENCE

The ComptonCAM project brings together two CNRS Research Organisations, the CSNSM and IPNO laboratories, and two SMEs, SYSTEL Electronique and THEORIS.

Experimental proof of concept for operation of the gamma camera was provided before project launch in the CNRS laboratories specialised in gamma-ray astronomy. The four-year project goal is to produce a camera prototype very close to the intended industrial configuration in terms of performance, weight, portability and cost, which will be qualified in a representative environment during the final year.

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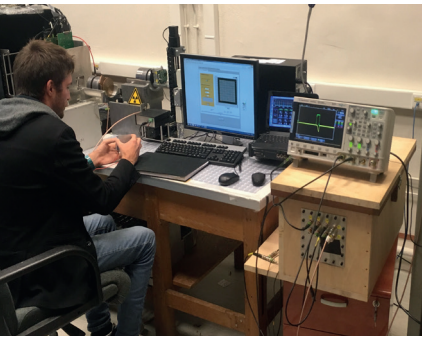
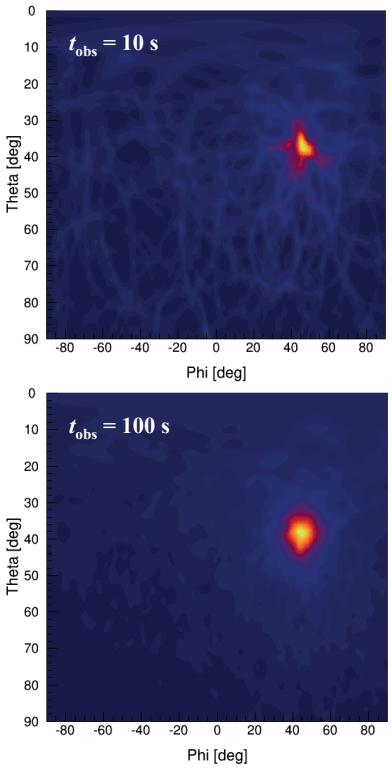
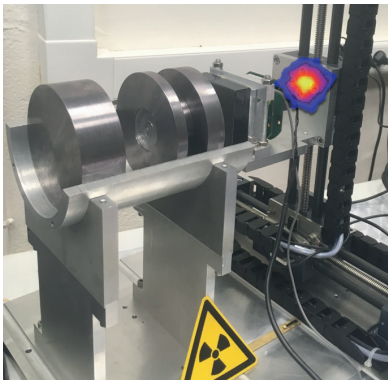
ComptonCAM: Development of an ultra-sensitive portable gamma camera for the localisation and characterisation of post-dismantling radioactive waste



Development of the ComptonCAM gamma camera



Simulated images of a radioactive source observed with ComptonCAM for 10 and 100 seconds



Detector test bench with a simulated image of a radioactive source observed using the ComptonCAM

EXPECTED RESULTS

Innovation

While the majority of gamma cameras currently used in the nuclear industry work by blocking some of the incident gamma rays, the ComptonCAM project aims to develop an optimal performance Compton-type gamma camera by using several innovative detectors to analyse all the incident radiation. The development and final design of the camera involve highly detailed digital simulation work performed using computer tools initially designed for preparing future gamma-ray astronomy space instruments. The ComptonCAM also intends to innovate in the following areas:

- development of ultra-low-noise and highly compact electronic systems for picking up gamma detector signals;
- use of an artificial neural network (algorithms) to optimise the response to gamma photon detectors;
- production of an optimal data acquisition and processing system to generate a real-time image of the gamma-emitters in the broad field of view observed.

Economic impact

The targeted performance of the ComptonCAM is perfectly suited to various target markets, including nuclear reactor operation, the dismantling of basic nuclear installations and the characterisation of radioactive waste packages.

The long-term goal is to produce a competitive industrial offering (sale of gamma camera and associated service) for both the domestic (France and Europe) and international market, which currently represents 437 reactors in operation across 30 countries. Many other basic nuclear installations (research laboratories, waste processing facilities, etc.) are also potential clients (France has over one hundred basic nuclear installations). The final industry-ready product should be available from 2022, about one year after project completion, for deployment on the European and international market from 2025.

Impact on radioactive waste management

The ComptonCAM camera will generally be used in a nuclear facility room during decontamination, the first dismantling phase, or for inspecting radioactive waste packages when they are moved, for example from surface storage to the disposal facility. Its high sensitivity will enable better control of the contamination level of facilities, thereby increasing the safety of staff and minimising waste volumes ("just as needed" decontamination). Due to its extreme sensitivity, the ComptonCAM camera will require much shorter acquisition times (minutes, rather than several hours currently) than those required for other cameras on the market.

Social impact

Spin-off benefits in terms of employment will be primarily for SYSTEL Electronique, which will have the long-term responsibility for manufacturing and marketing the gamma camera. It is estimated that in terms of direct jobs, the SME will need to recruit one mechanical assembly worker and one radiation protection technician to provide the service associated with the sale of this equipment. It is estimated that THEORIS will need to recruit an extra engineer to supplement the team for software development, maintenance, update integration and support activities.

APPLICATION AND COMMERCIALISATION

The technologies developed for the ComptonCAM project come from space research and development and are of obvious interest for the future of gamma-ray astronomy. They could also benefit medical imaging, and particularly proton and hadron therapy.

Moreover, the extreme sensitivity of the ComptonCAM to very low gamma-ray fluxes could make it a key element in the safety systems associated with detecting the illegal smuggling of radioactive materials.