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Update on the cleandem project

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Submitted on 4 Mar 2024

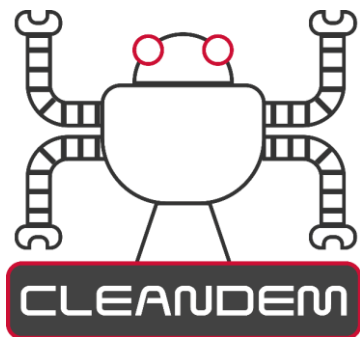
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Mr Maugan MICHEL

Job/Position: Researcher

Organization, Country: Alternative Energies and Atomic Energy Commission, France

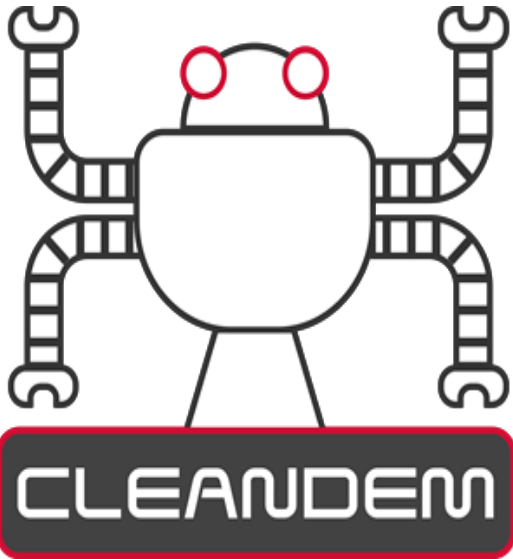


- Background in **radiation physics, radiation protection and nuclear instrumentation**, with a PhD thesis in fundamental nuclear physics in 2014, on non-linear optics phenomena applications for ionizing radiation detection.
- Worked at the **La Hague** nuclear fuel reprocessing plant with Framatome, then joined VINCI Group's nuclear division, **NUVIA**, as a **field-operating project manager**.
- Late 2019: joined the Instrumentation and Nuclear Measurement group at CEA-List, where in charge of the development of **D&D and RN threats-dedicated measurement systems**, combined or not with **SLAM and robotics**.





This project has received funding from the European Union's Horizon 2020 research and innovation programme under agreement No 945335.



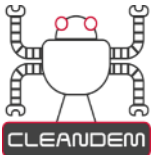
CLEANDEM

A CYBER PHYSICAL EQUIPMENT FOR
UNMANNED NUCLEAR
DECOMMISSIONING MEASUREMENTS

International Conference on Nuclear Decommissioning:
Addressing the Past and Ensuring the Future
15–19 May 2023, Vienna, Austria

Dr Maugan MICHEL, CEA
French Alternative Energies and Atomic Energy Commission
Project Director, on behalf of the CLEANDEM Consortium





Key items

Cyper physical **L** Equipment for un**m**anned
Nuclear **DE**commissioning **M**easurements

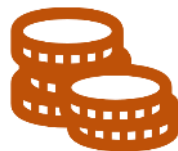


Bring **technological breakthrough** at different steps of the D&D operations:

- Initial** radiological status
- During** operations (continuous monitoring)
- Final** characterization



3 years
(Started 03/2021)



2.8 M€
(100 % EC)





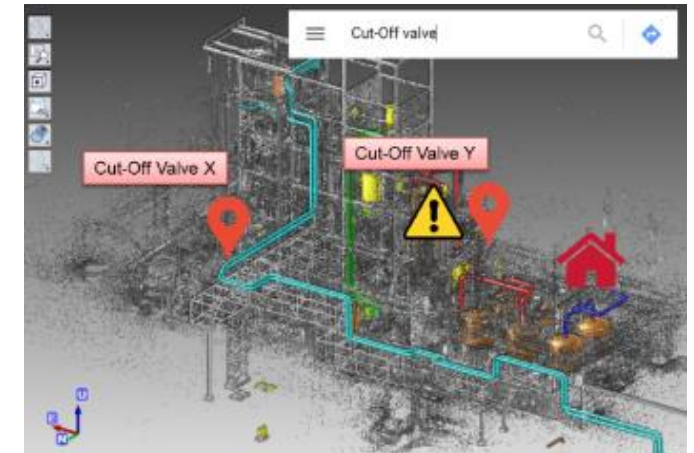
Approach and main goals

❑ Different D&D steps → different expectations:

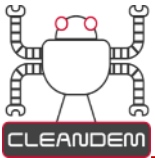
- **Initial** characterization
↔ harsh environments
- **During** D&D operations:
↔ need **real time information** on facility status
- **Final** characterization:
↔ **very low contamination level**

❑ Main goals related to CLEANDEM

- **UGV platform** for remote operations
- **Advanced dose rate** measurements
- **Hot spot** localization
- **Neutron/gamma** detection
- Air and soil **contamination** monitoring
- **Data fusion** and full **digitalization** of the plant



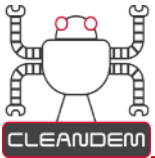
Cost, Time, Dose



The CLEANDEM Consortium

11 Partners





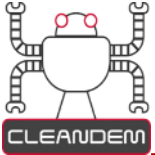
The CLEANDEM Consortium

11 Partners

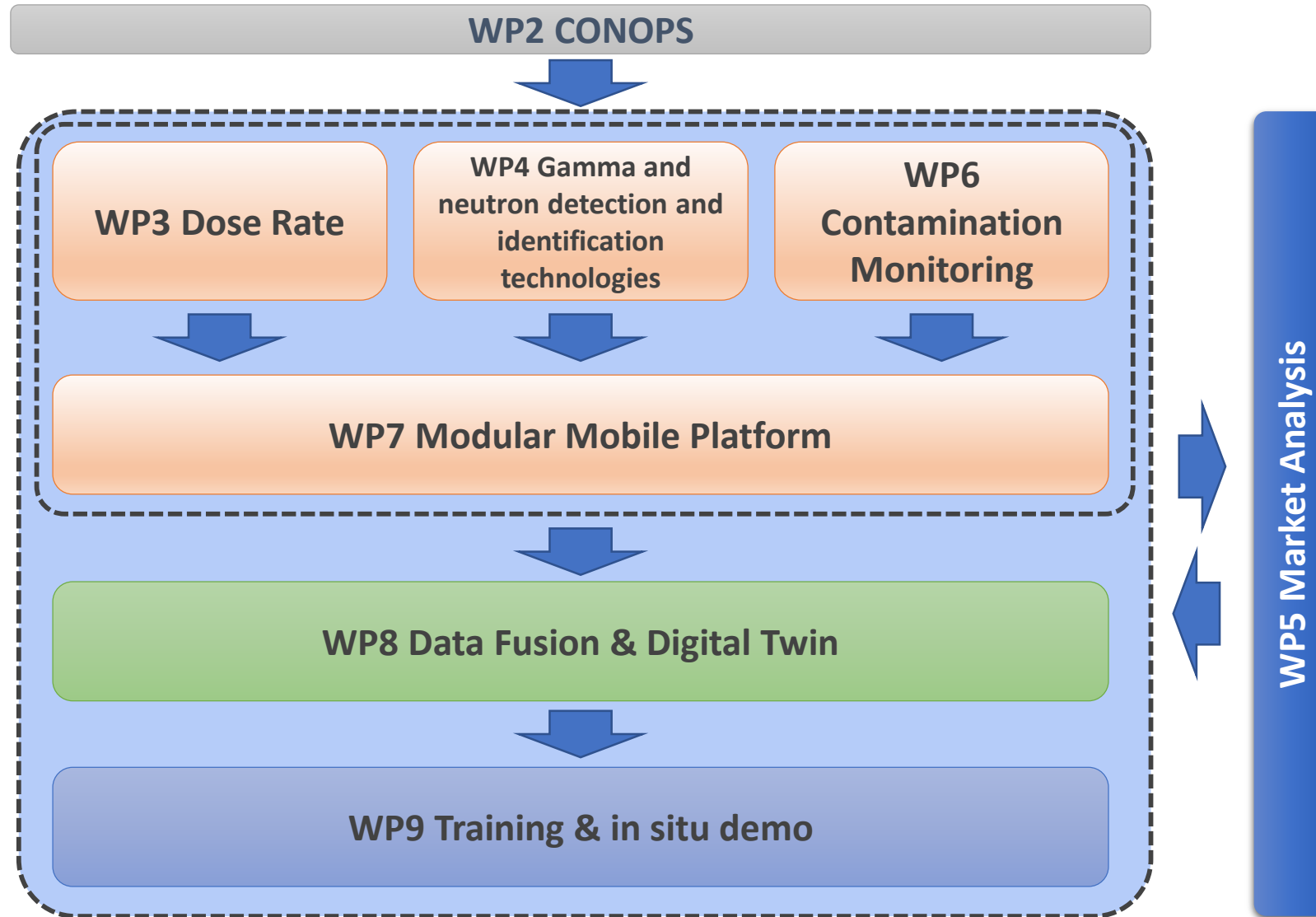


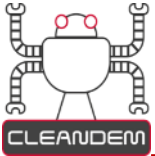
4 Countries





Work packages





✔ Definition of **Technical specifications**

For all tools, robotics elements, measuring instruments or software

- Identifying needs & requests of **End-Users**;
- Expected functions and **performances**;
- Desired **interaction** between developments;
- Thinking on post-project opportunities.

✔ Definition of **Concepts of Operations**

- Environment in which systems will be deployed;
- Constraints they will be exposed to;
- Issues to be solved.

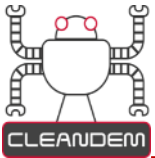
Experience & specific know-how of ORANO, SOGIN & ANSALDO to

- ambitious but realistic scenario;
- trials and final demonstration site.

Description of proposed system with generic operating conditions.

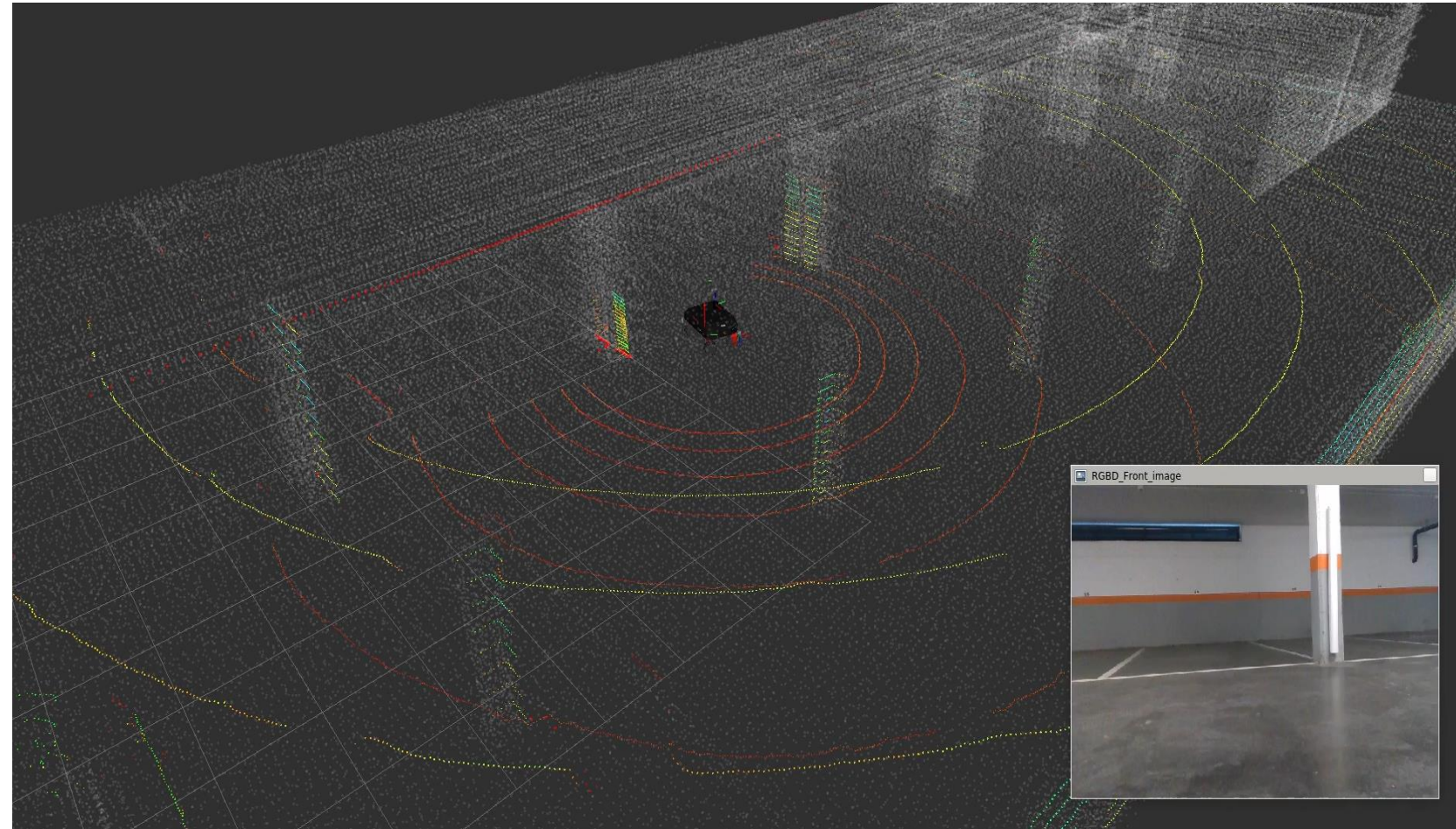
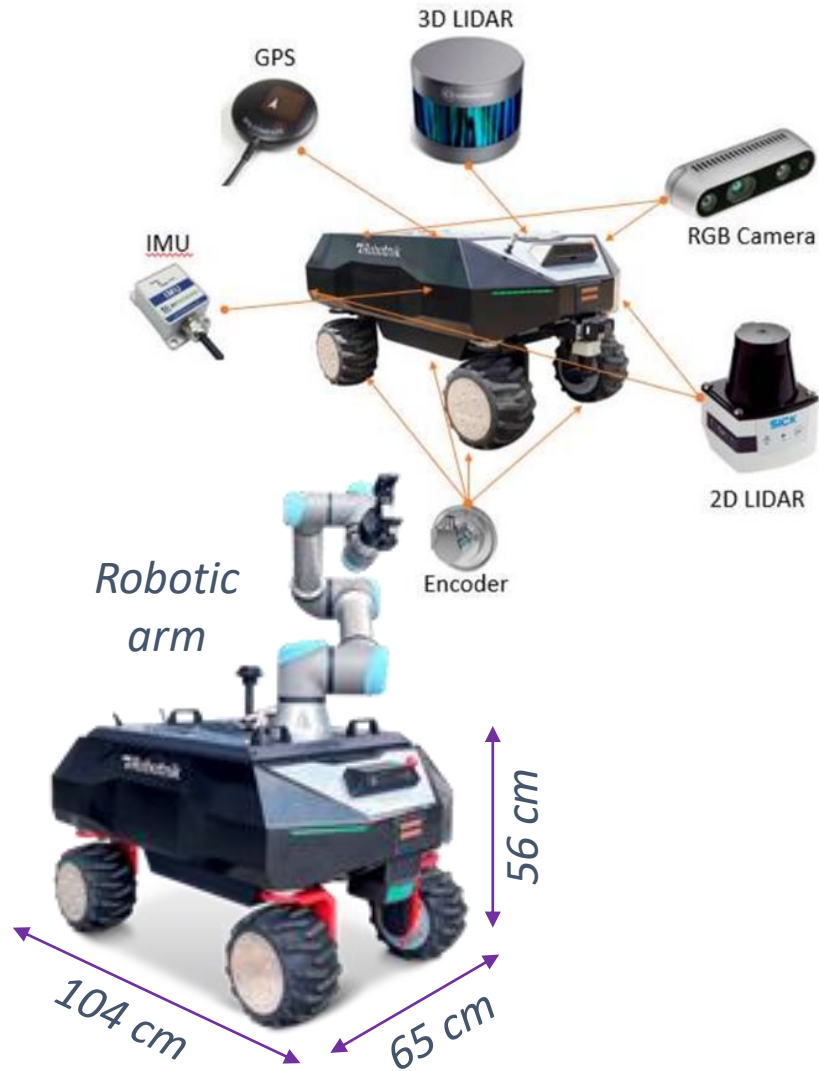
➔ Roadmap for technical developments

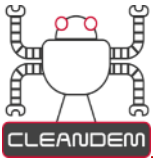
❑ **European Guideline for D&D Operation:** Delayed to M30 to benefit from Project's experience.



WP7 | Modular Mobile Platform

3D Localization & Navigation





WP3 | Dose rate

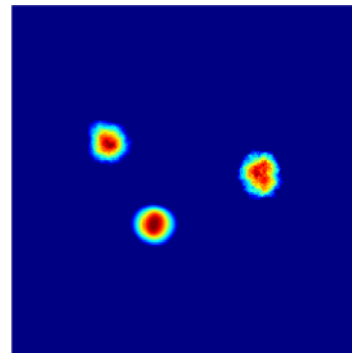
Nanopix, the smallest coded-aperture gamma imager



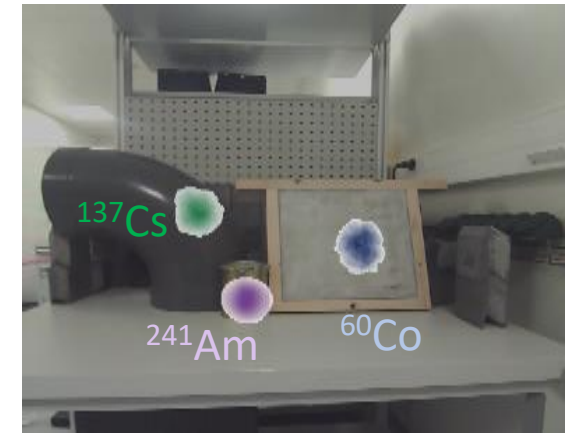
Visible image



Gamma image

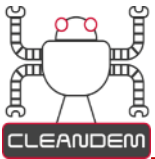


Visible + Gamma
(spectro-imaging)



TERRIFFIC
ACCELERATED CBRNE RESPONSE

aeraccess[®]
airborne engineering research



WP3 | Dose rate

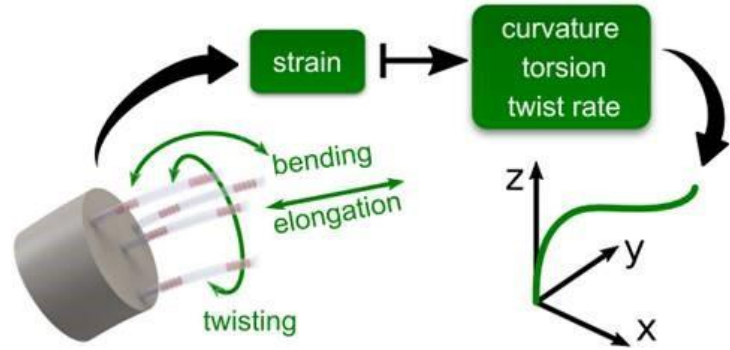
Fiber optics OSL 1D dosimetry + 3D Shape sensing

3D localization (shape sensing)



1D Dose data (INSPECT)

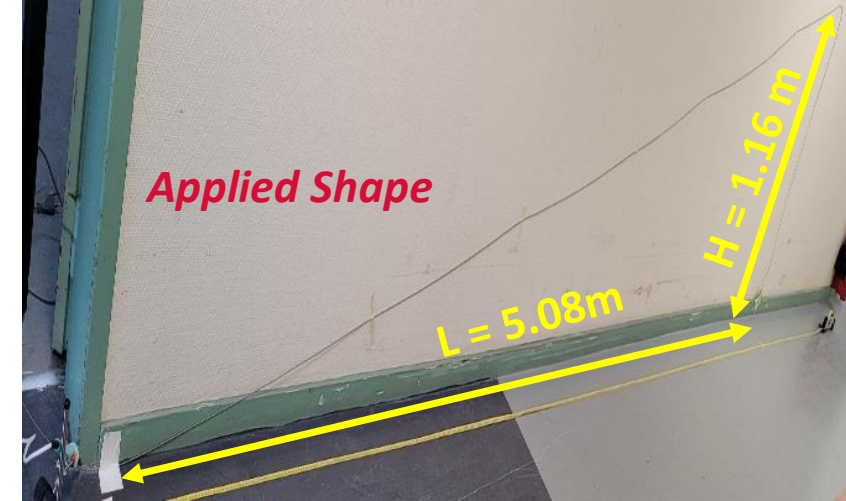
2D Shape reconstruction @6.2m



Optically
Stimulated
Luminescence

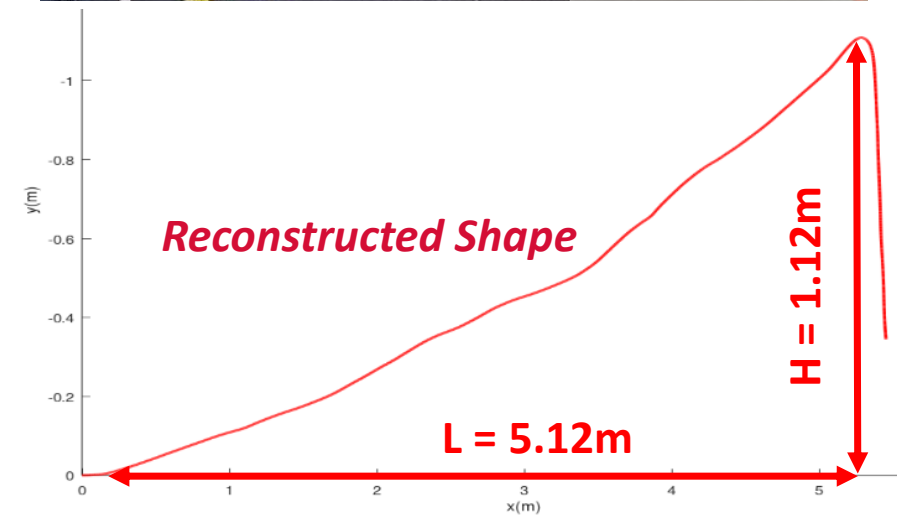
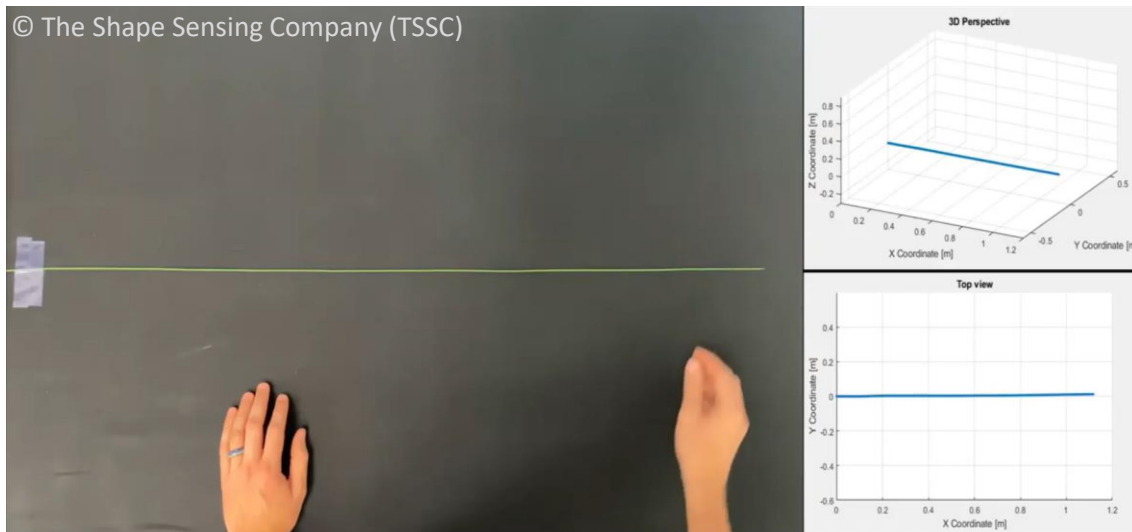


Accurate 3D dose reconstruction
within hidden/out-of-reach volumes



V. Modes *et al.*, "Shape Sensing Based on Longitudinal Strain Measurements Considering Elongation, Bending, & Twisting" in *IEEE Sensors Journal*, vol. 21, no. 5, pp. 6712-6723, 1 March, 2021, doi: 10.1109/JSEN.2020.3043999.

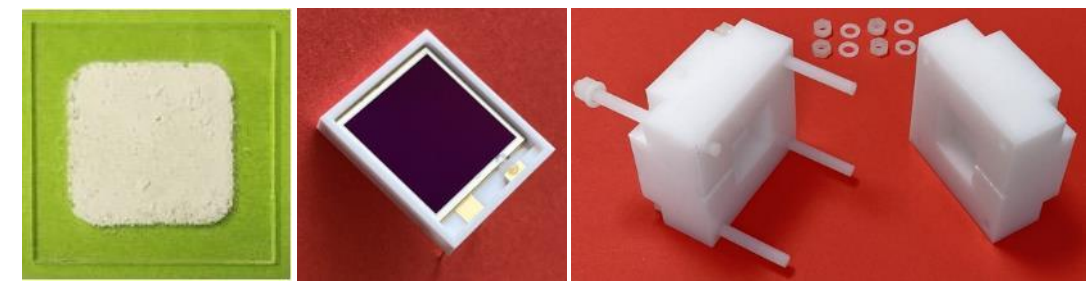
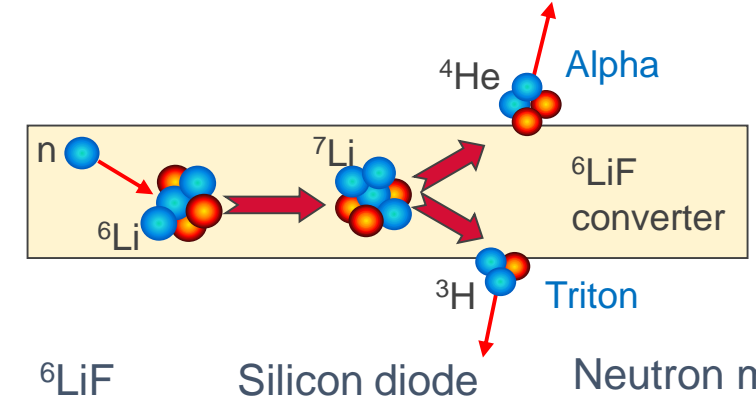
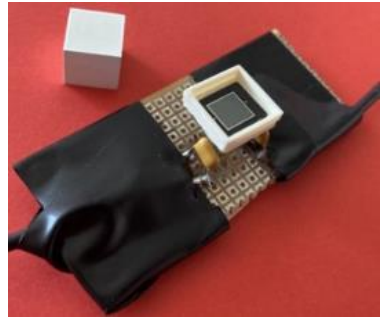
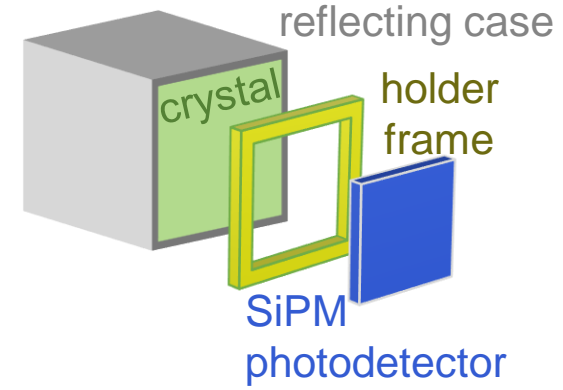
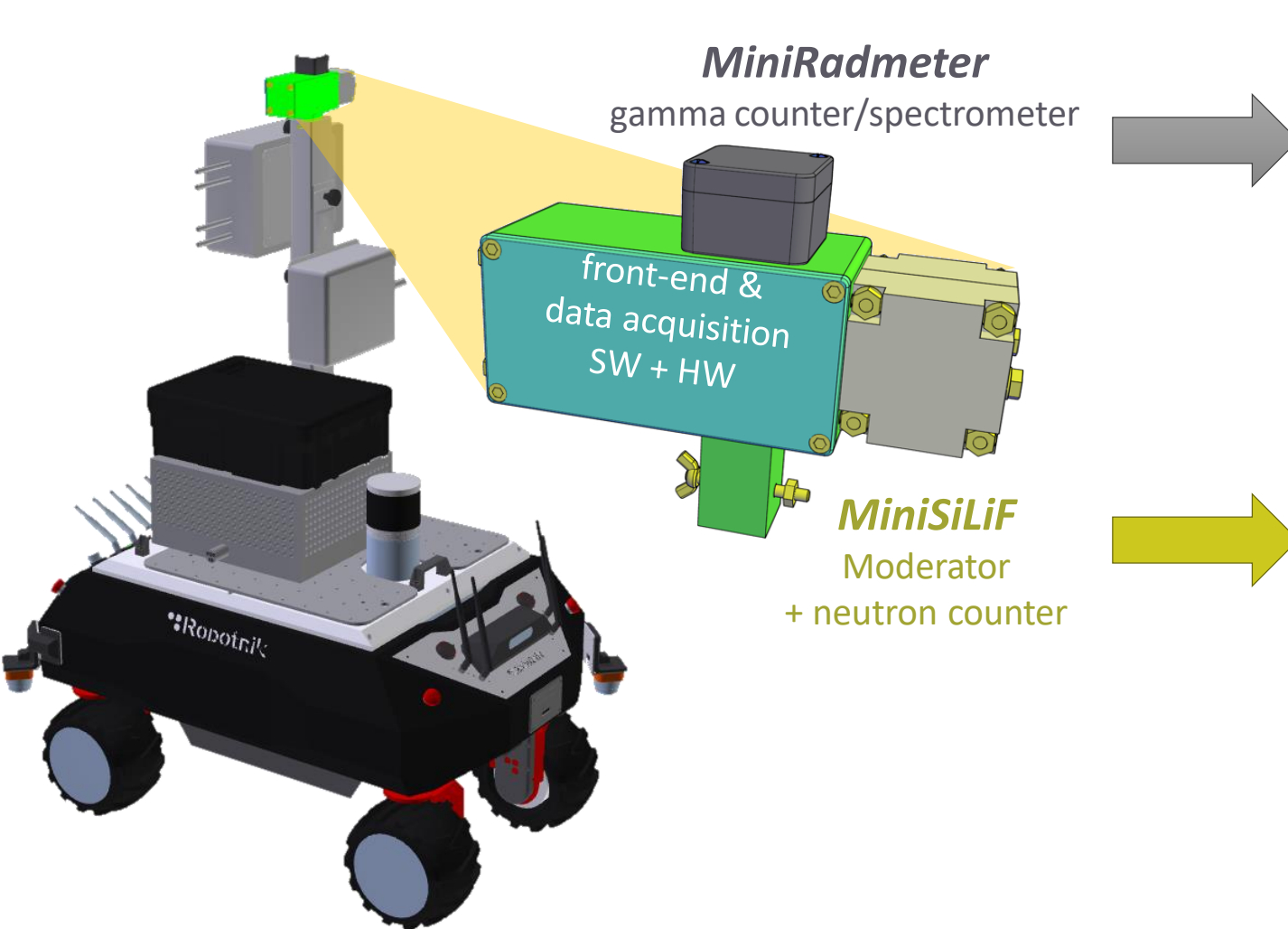
© The Shape Sensing Company (TSSC)



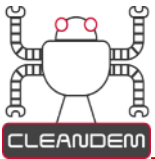


WP3 | Dose rate

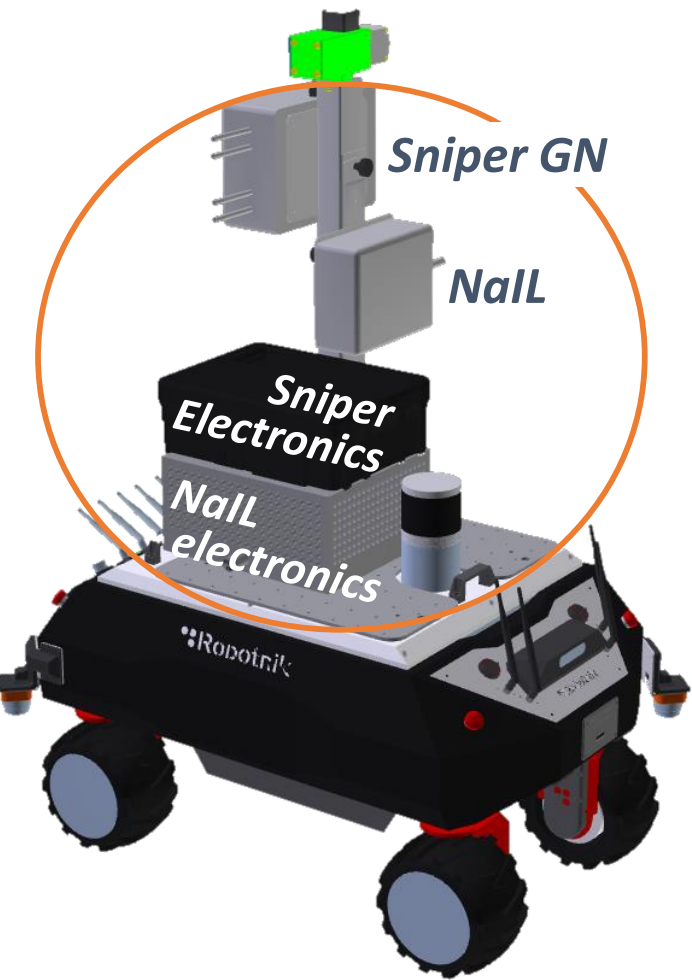
Low cost miniature γ counter/spectrometer and n counter



Rossi F *et al.* The Gamma and Neutron Sensor System for Rapid Dose Rate Mapping in the CLEANDEM Project. *Sensors*. 2023; 23(9):4210. DOI: 10.3390/s23094210

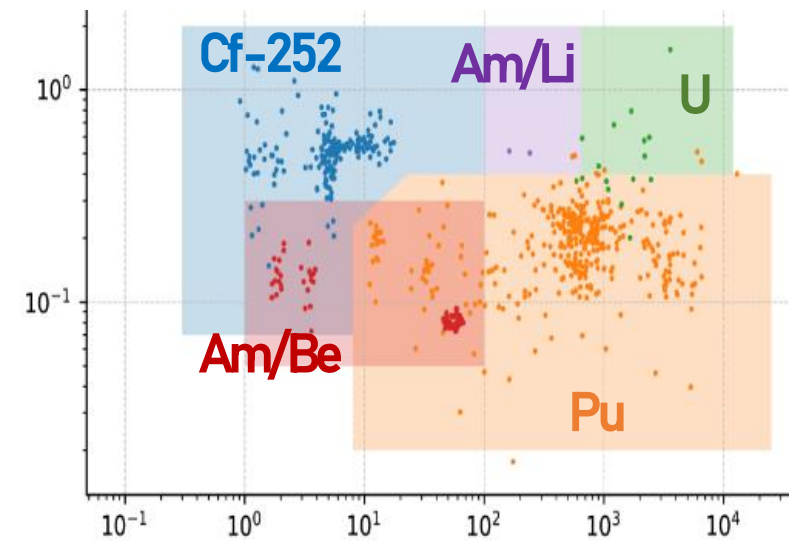
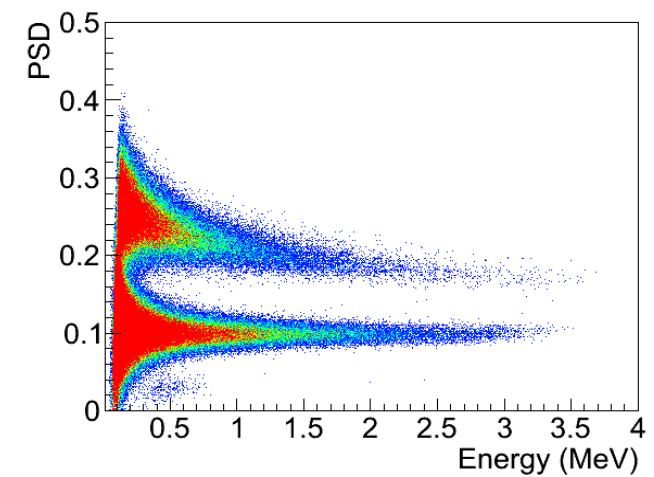


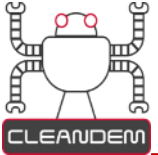
WP4 | γ/n detection and identification technologies Sniper + Gamon



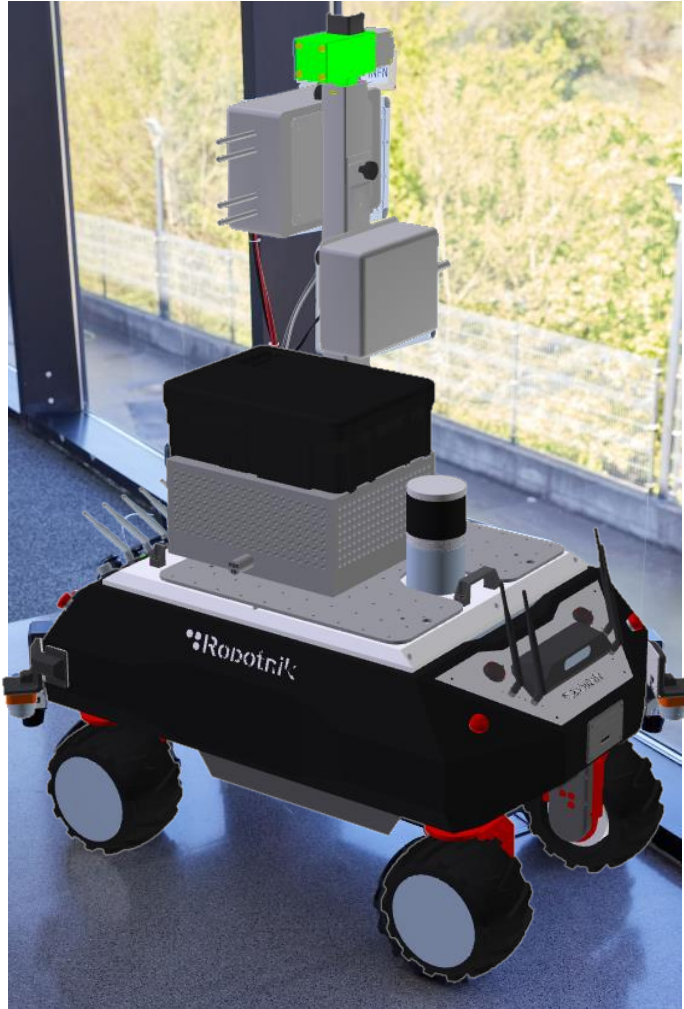
❑ **Sniper GN: Stilbene and CeBr₃**
→ detection & identification of gamma and neutron sources

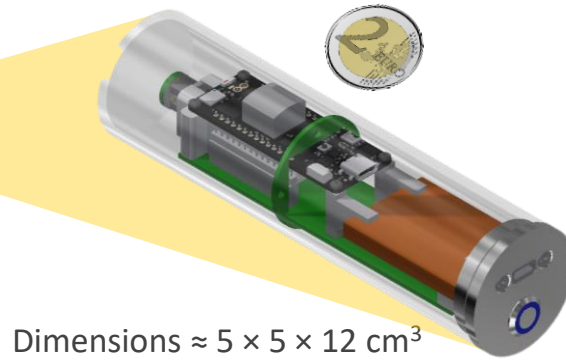
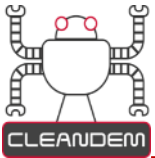
❑ **NaIL (NaI + Li)**
→ gamma spectrometry
+ neutron detection (${}^6\text{Li} + n_{\text{slow}} \rightarrow {}^7\text{Li} \rightarrow \alpha + {}^3\text{H}$)





Integration test week, April 17th–20th

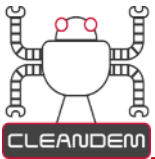




Dimensions $\approx 5 \times 5 \times 12 \text{ cm}^3$

Compact gamma semiconductor device, for:

- Deeper inspection of hot spots found out during the first step of the survey
- Checks of difficult to access zones for larger sensors
- Pipe or tube inspection Large Volume Hemispheric CZT Detector to be mounted on the UGV arm

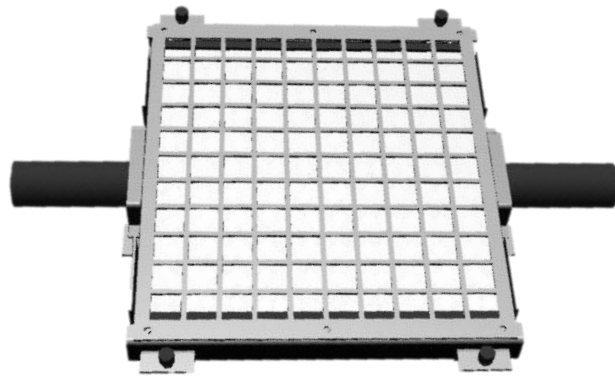


WP6 | Contamination Monitoring

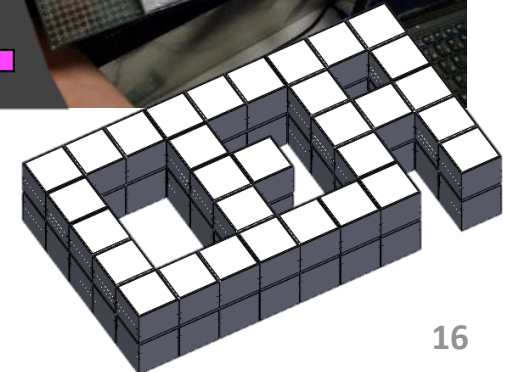
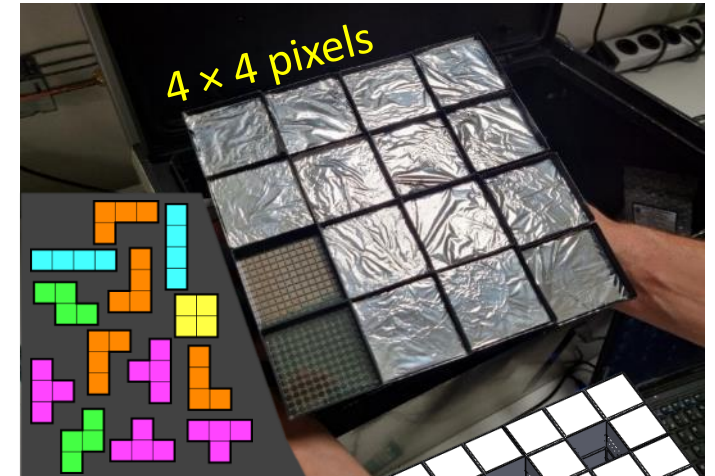
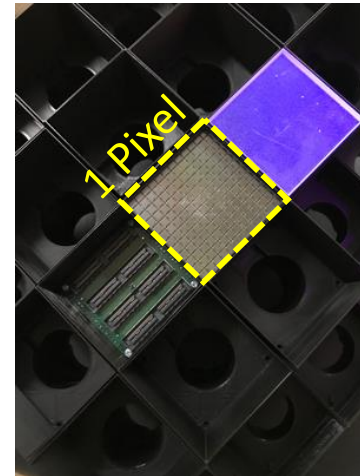
Surface contamination monitoring



Large Area α/β PSD phoswich



Pixellated β/γ plastic scintillators





WP6 | Contamination Monitoring

Air contamination monitoring

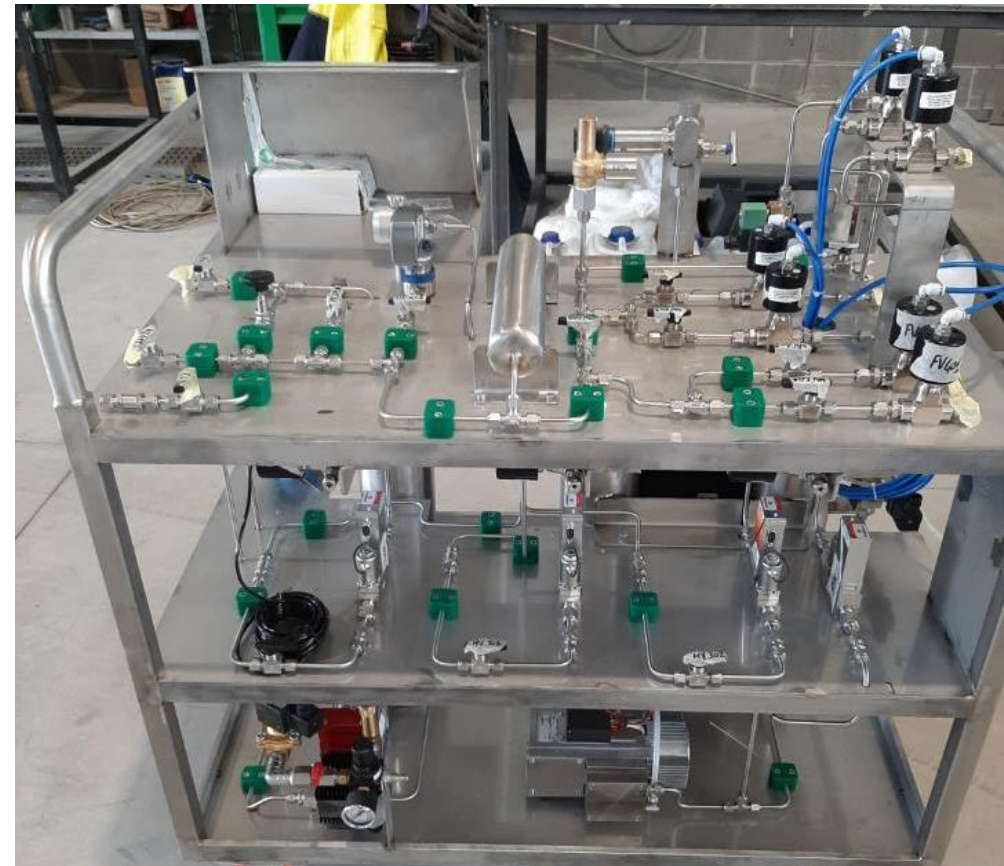


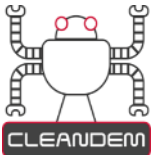
Cryogenic system for $^{14}\text{CO}_2$ monitoring

First ENEA-INMRI prototype for gas trapping



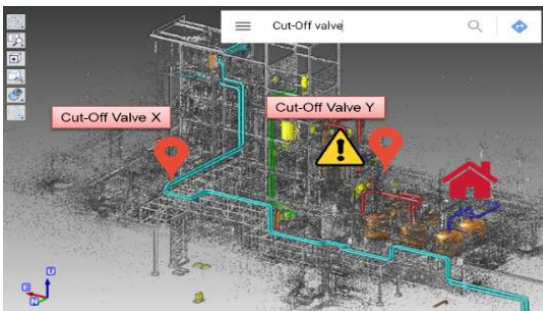
Early design of the atmospheric $^{14}\text{CO}_2$ monitoring system.





WP8 | Data Fusion & Digital Twin

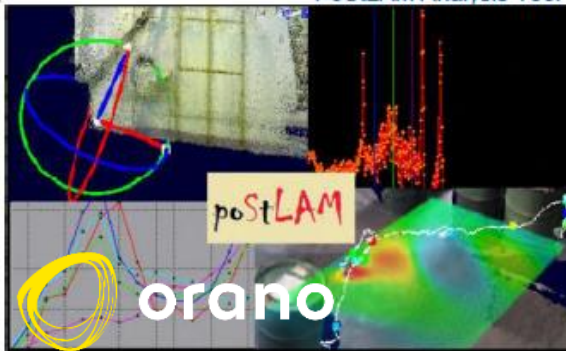
DT Qpro² Platform with PoStLAM tools



BIM based data Visualization

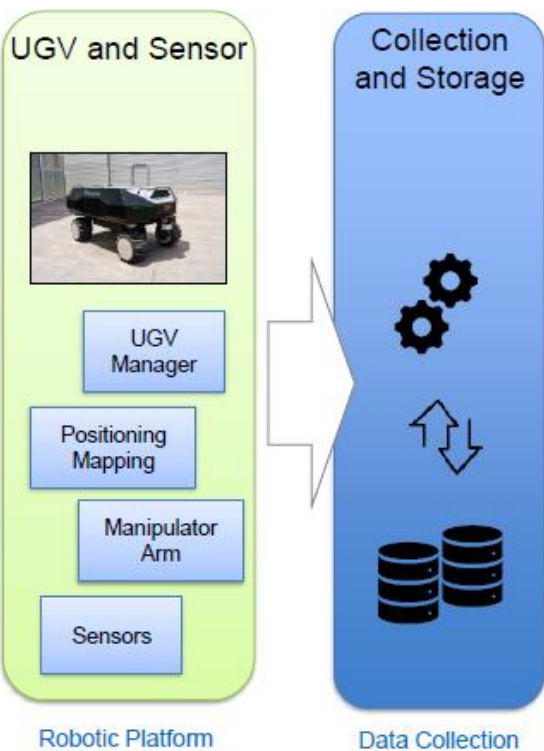


PoStLAM Analysis Tool



- ❑ Qpro² Multiplatform (RINA)
 - Based on WEB (HTML 5)
 - Safe
 - Widely configurable
 - 3D representation based on BIM (Building Information Modeling)

- ❑ PoStLAM software (ORANO)
 - designed to exploit 3D point clouds and positioned radiological data to prepare interventions



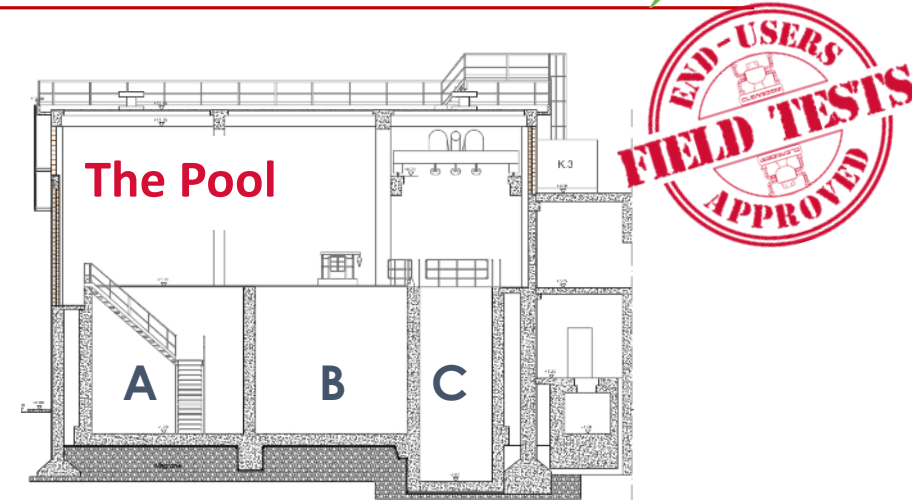
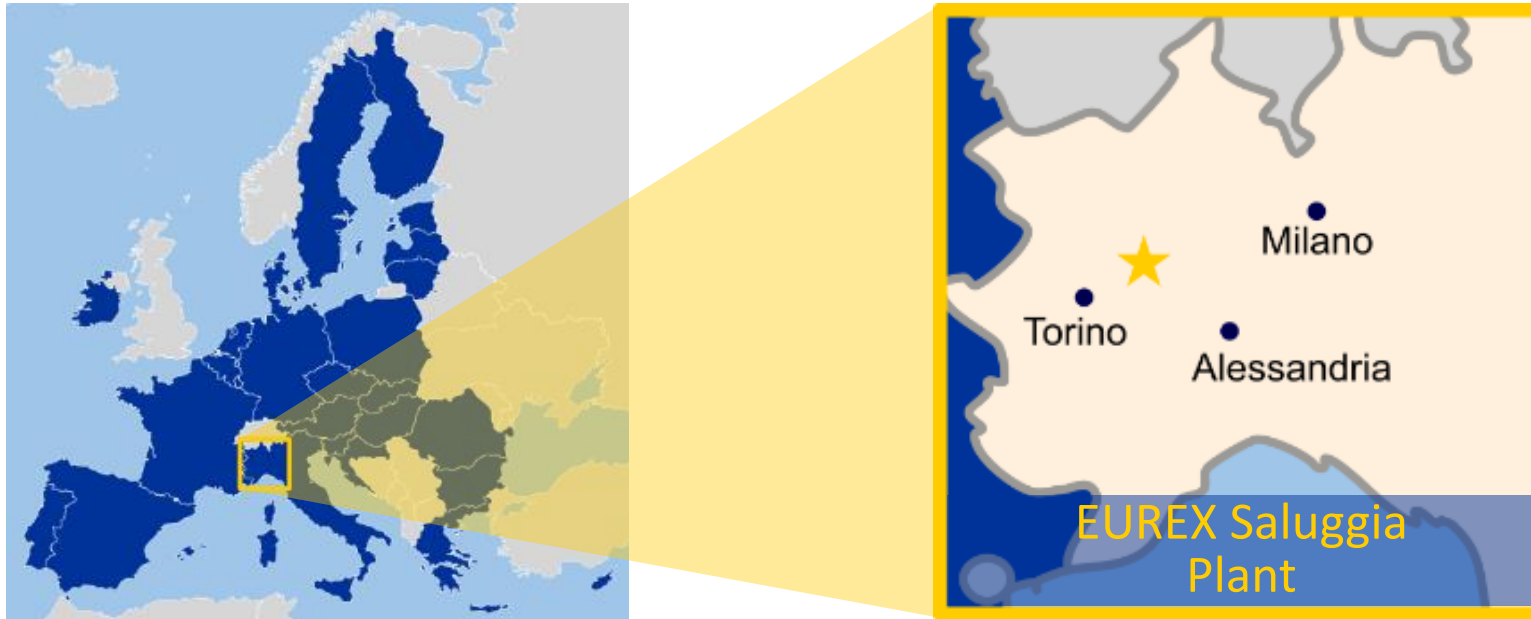


WP9 | Training & in situ demonstration

In-Situ demonstration



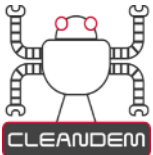
- 1) Ability to measure in hard to access areas with remote solutions
- 2) Real time information on the facility status
- 3) Ability to perform the **initial radiological characterization** of an area (in presence of **hot spots** and **very low contamination level**)



- A: Completely empty
- B: 6 vessels with sludges
- C: 3 big vessels with sludges (from remediation activities)

Expected in case of contamination:
 ^{137}Cs , ^{90}Sr , ^{238}U , $^{239,240,241}\text{Pu}$, ^{241}Am

Expected dose rate < 10 μSv .



- Feedback from End-Users
Different requirements will need training content with different focus

1st CLEANDEM Webinar

You are Invited to Join

A Robotic Toolbox for Radiological Mapping in D&D of Nuclear Facilities

Free Register

FRI DAY	SEP 16	TIME 10am
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2nd CLEANDEM Webinar

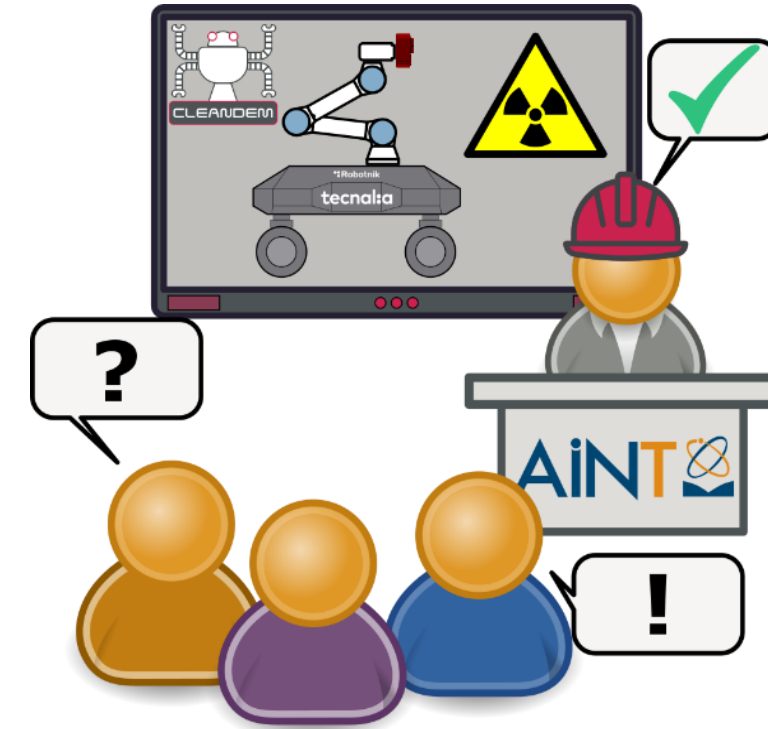
You are Invited to Join

A Robotic Toolbox for Radiological Mapping in D&D of Nuclear Facilities

Save the date!

THURS DAY	FEB 09	TIME 10am
--------------	-----------	--------------

9th February 2023, 10:00 – 11:30 am

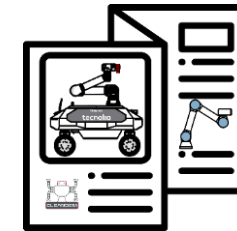




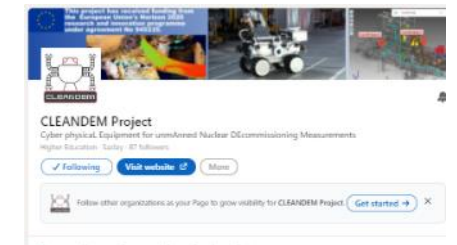
WP10 | Dissemination and Discussions

INNO4GRAPH H2020 Project	Mar 21
LD-SAFE H2020 Project	Apr 21
UK National Nuclear Laboratory	May 21
iCOND Conference, Aachen	Oct 21
World Nuclear Exhibition, Paris	Nov 21
MICADO H2020 Project 2nd GA	Jan 22
UK NNL E-U Network	Mar 22
INNO4GRAPH Project End-Users Workshop	Jun 22

CLEANDEM's EUN Webinar #1	Sep 22
MICADO H2020 Project Final demo	Jan 22
CLEANDEM's EUN Webinar #2	Apr 22
INNO4GRAPH H2020 Project	Apr 23
IAEA's DECOM 2023	May 23
ANIMMA Conference, Lucca	Jun 23
iCOND Conference, Aachen	Oct 23
World Nuclear Exhibition, Paris	Nov 23




cleandem-h2020.eu






Call for participants to the CLEANDEM End-Users Network

- To join the CLEANDEM end-users network:
Please send us an e-mail at cleandem-wp9@eurtd.com with:
- Your intentions to participate
 - Your company details
 - Your background expertise
 - Your expectations



Sign up for CLEANDEM Updates



CLEANDEM is Co-funded by the Horizon 2020 programme of the European Union
Grant Agreement N° 945335

The aim of the CLEANDEM project is to deliver an Unmanned Ground Vehicle for radiological survey to support D&D operations. The project runs from 2021 – 2024, and it is planned to engage with stakeholders via various channels and activities (Webinar, Training & In-situ demonstration).

Interested? Sign-up here to stay up to date!

Follow CLEANDEM at LinkedIn:
<https://www.linkedin.com/company/cleandem-project/>

Fill out the fields below and insert in box!

E-Mail:

Name*:	
Company*:	Position*:

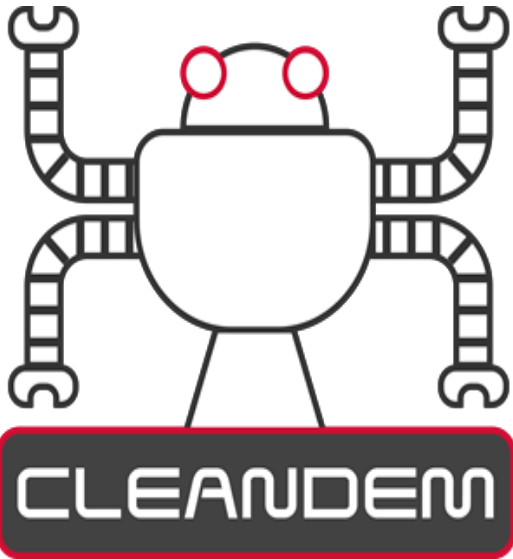
I am interested in D&D operation for following type of facility*
(NPP, Hot Cell, Nuclear Fuel Cycle, ...)

Any other detail, you want to share with us? *

I hereby declare I accept to be contacted to be part of the CLEANDEM end-users group, and understand that all data here detailed will only be used in accordance with the Privacy Policy described on the back-side of the present page.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under agreement No 945335.



Thank you for your attention

Maugan MICHEL,
on behalf of the CLEANDEM consortium

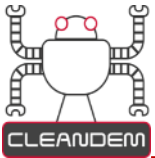


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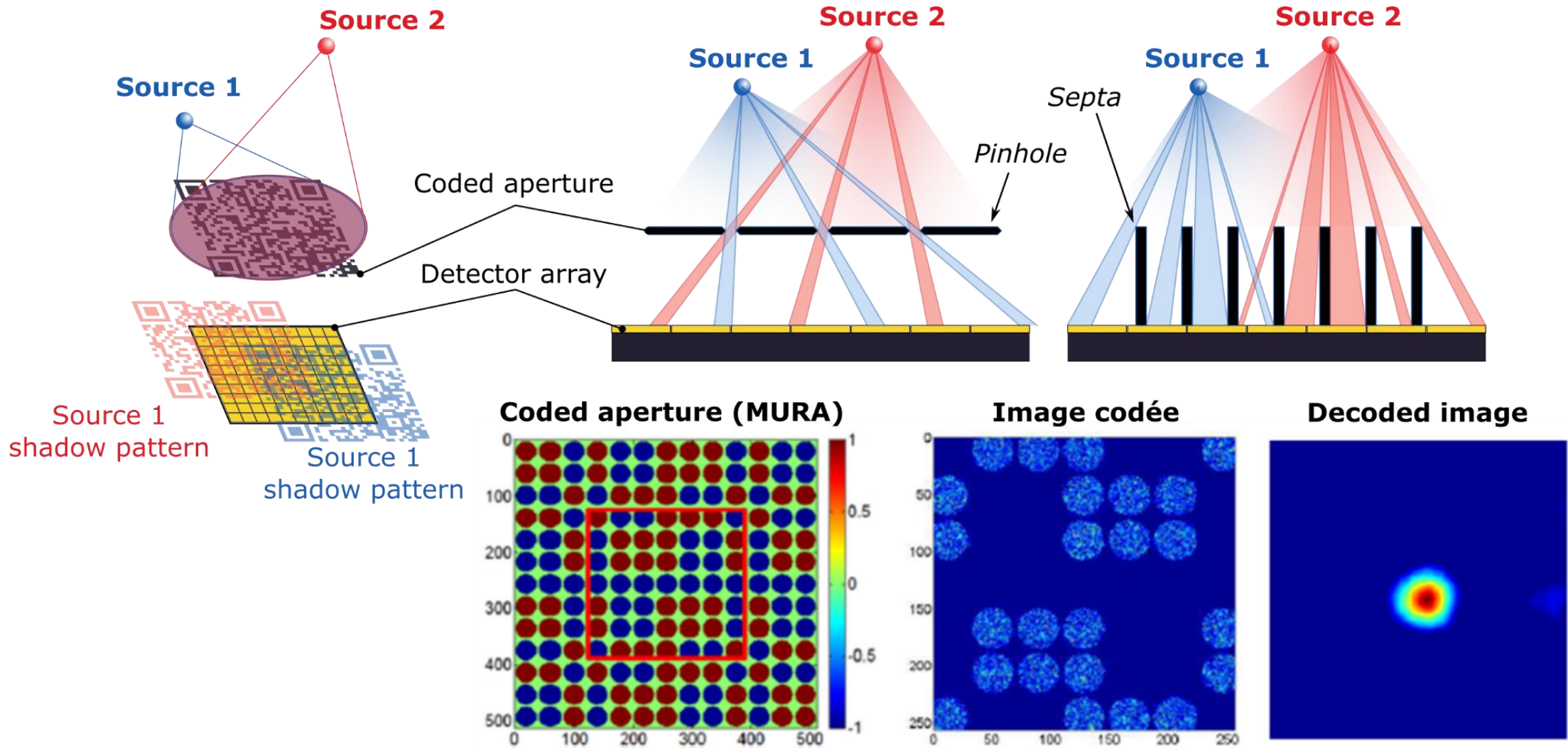


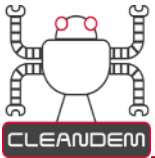
cleandem-h2020.eu





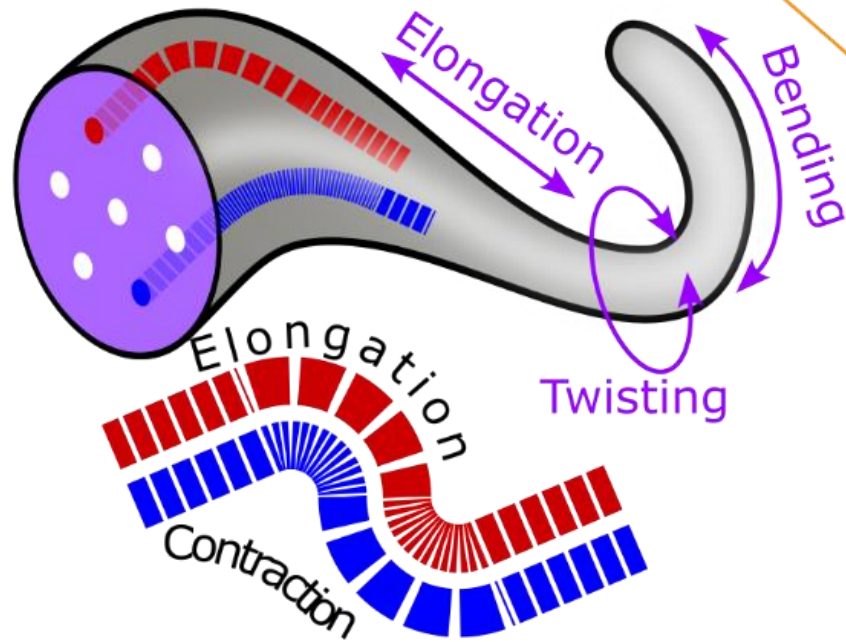
Coded aperture gamma imaging



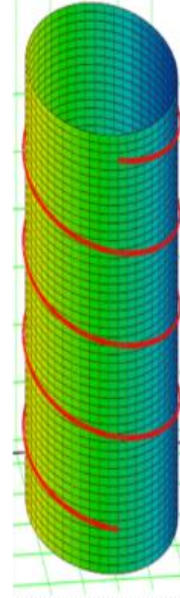


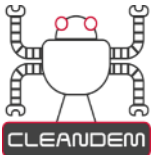
Shape sensing

Bended Multicore fibre (MCF)

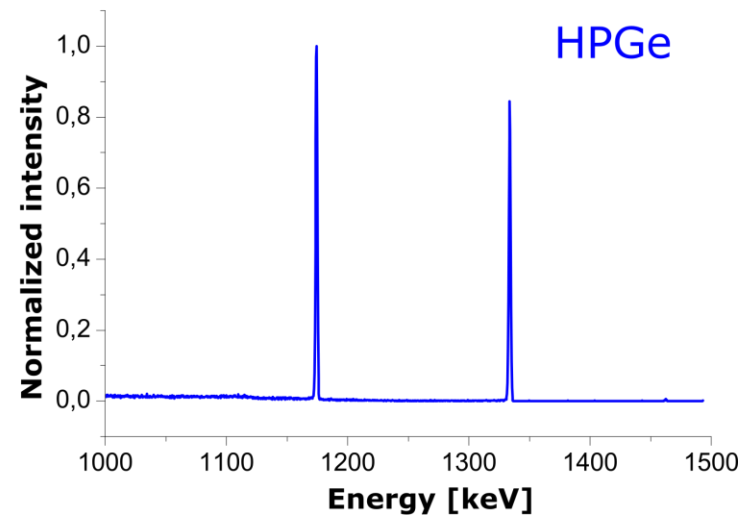
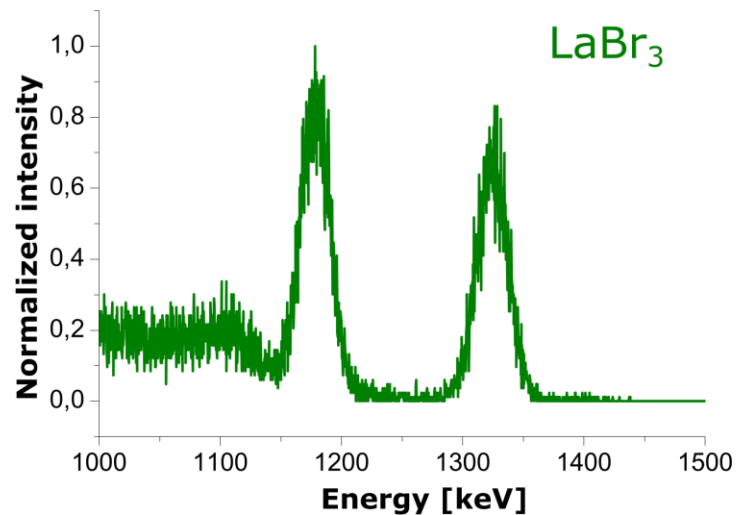
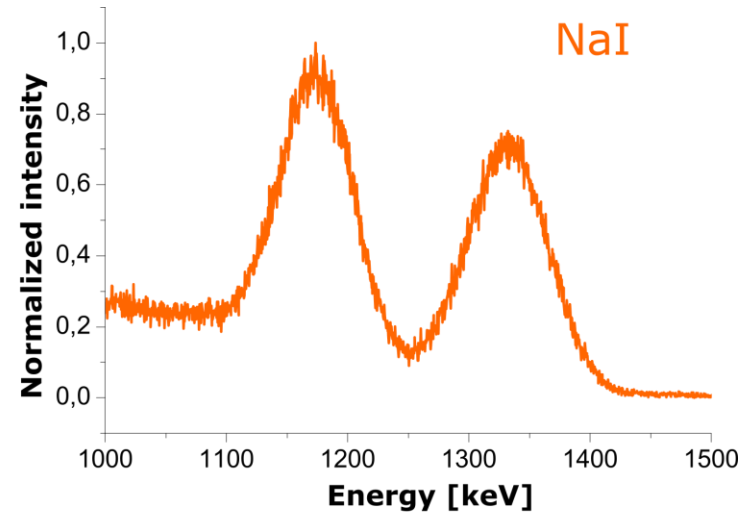
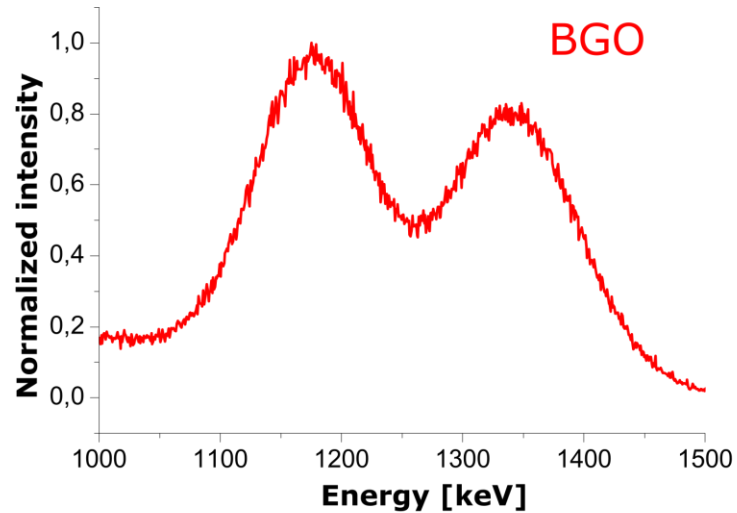


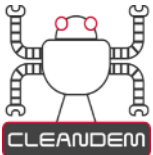
3D Reconstruction





Why is detector resolution important ?





Different interactions \rightarrow different pulse shapes

