EU-H2020- SHARE-Decommissioning
On-line Workshop, December 1-3, 2020

Group C
Session 4: CHARACTERISATION

Session will start at 13:50, CET

Laura ALDAVE-DE-LAS-HERAS, JRC

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 847626.

Group C / Session 4: CHARACTERISATION

Agenda

Dec. 1st	**International initiatives**		
	13:50	4.A	Presentation of EU-H2020 Project INSIDER by Danièle ROUDIL, CEA *(10min)*
	14:00	4.B	Presentation of EU-H2020 Project MICADO "Measurement and Instrumentation for Cleaning And Decommissioning Operations" by Massimo Moricchi, CAEN *(10min)*
	14:10	4.C	Presentation of EU-H2020 Project CLEANDEM by CEA or CAEN *(10min)*
	14:20	4.D	Presentation of EU- EMPIR Metrodecom "Metrology for Decommissioning", by Ben Russell, NPL, *(10min)*
	14:30	4.E	Presentation of EU-H2020- CHANCE by Denise RICARD, ANDRA, *(10min)*
	14:40	4.F	Presentation of first achievements from SHARE in this area + introduction to post it session, by Laura ALDAVE-DE-LAS-HERAS, JRC
	15:00- 16:50: Post it session by sub-thematic area		
	Link MURAL 36	36	Inventory assessment (Radiological and non-radiological)
	Link MURAL 35	35	Methodology for historical site assessment

Group C / Session 4: CHARACTERISATION

Agenda

Dec. 2nd	**9:00- 12:00: Post it session by sub-thematic area**		
	Link MURAL 37	37	Characterization of activated components and areas: Metal
	Link MURAL 83	83	Characterization and survey of containerized radioactive waste
	Link MURAL 39	39	Characterization of activated components and areas: Graphite
	12:00- 13-00: Lunch Break		
	13:00- 16:50: Post it session by sub-thematic area		
	Link MURAL 53	53	In situ Radioactive Waste characterization and segregation
	Link MURAL 40	40	Technologies for hard to access areas (high walls, embedded components, harsh environment...)
	Link MURAL 42	42	Standards for statistical sampling
	Link MURAL 44	44	Sample analysis technologies
	Link MURAL 43	43	Geostatistical software applications
Dec 3d	**9 :00- 12:00: Post it session by sub-thematic area**		
	Link MURAL 38	38	Characterization of activated components and areas: Concrete
	Link MURAL 45	45	Alpha and beta non-destructive measurements
	Link MURAL 41	41	Development of modelling and simulation software for characterization of irradiated components
	12:00- 13-00: Lunch Break		
Dec. 3d	**13:00 CET- 16:00: Plenary session (see general program)**		

CETAMA
Métrologie et Analyses Chimiques

INSIDER

SHARE
A roadmap for research in Decommissioning

NUCLEAR SITE INTEGRATED CHARACTERIZATION FOR RADIOACTIVE WASTE MINIMIZATION: THE INSIDER PROJECT

D. Roudil[1], P. Peerani [2], S. Boden [3], B. Russell [4], M. Herranz [5], M. Crozet [1], L. Aldave de la Heras [2],

[1] CEA Nuclear Energy division, [2] European Commission Joint Research Centre, [3] SCK-CEN, [4] NPL [5] UPV/EHU

Share WP3 Workshop December 1-3, 2020

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 755554.

About the INSIDER project

http://insider-h2020.eu/

Highlights of the development within the WP

Perspectives: Methodological guides and recommendations

About the INSIDER project

http://insider-h2020.eu/

Development status report- Use case studies

Perspectives: Methodological guides and recommendations

Main objectives

- Improved Nuclear SIte characterisation for waste minimisation in D&D operations under constrained EnviRonment
- **A EU-funded Horizon 2020 project:**
  - ❑ "Research and innovation on the **overall management of radioactive waste other than geological disposal**"
  - ❑ "Management of **non-standard waste** including D&D waste"

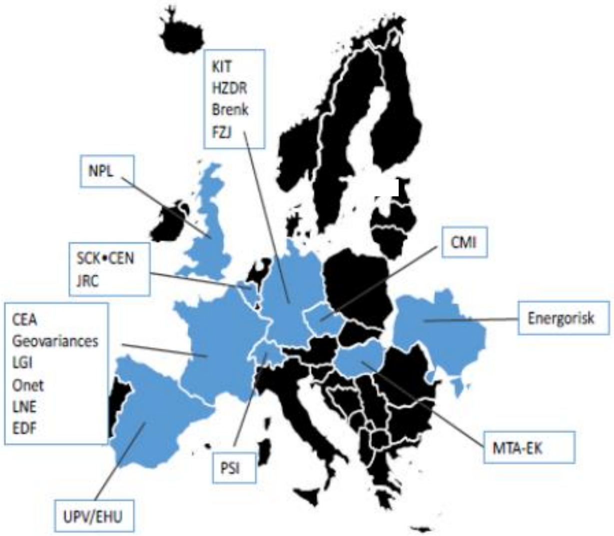
- **Main Objective**

  To develop and validate a new and improved integrated characterization methodology and strategy during nuclear decommissioning and dismantling operations (D&D) in a waste-led approach.

- **Results are being validated through 3 case studies:**
  1. Liquid waste storage tanks : Fuel cycle facility
  2. Nuclear reactor Biological shield : NPP
  3. Contaminated soil: Post incidental

A European Consortium

- Launched in June 2017: 4-year project
  - Probably delayed to end of 2021 du to lockdown
- 17 partners from 10 European countries



EUG
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KAERI
ORANO
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ENGIE

Project organisation

WP1 PROJECT MANAGEMENT

Overall project management coordination, including financial and contractual aspects

WP3 SAMPLING & STRATEGY

Drafting of a guideline for sampling of initial nuclear site characterisation in constraint environments in view of decommissioning, based on a statistical approach

WP7 DISSEMINATION & EXPLOITATION

Setting up an end-user group, developing and updating the State of Knowledge on the project's key topics, establishment of guidelines, pre-standards, recommendations, dissemination and communication of the project's outcomes,build-up of competences in the field

WP2 USER REQUIREMENTS & VALIDATION

Identification of the end-users' needs, state-of-the art and gap analysis to identify R&D topics, benchmarking on decommissioning activities

WP4 REFERENCE MATERIALS & RADIOCHEMISTRY

Production of a set of reference materials, assessment of radiochemical measurement techniques and recommendations

WP6 PERFORMANCE ASSESSMENT - UNCERTAINTY EVALUATION

Testing the ability of different methods to carry out measurements

WP5 IN SITU MEASUREMENT

Definition & implementation of practical considerations about in situ radiological characterisation

Global methodology

Establish common methodologies to deploy reference guidelines

identification, development, implementation

In situ and in lab measurements: suitability, proficiency, performances

Uncertainty sources and different impact factors

About the INSIDER project

http://insider-h2020.eu/

Highlights of the development within the WP

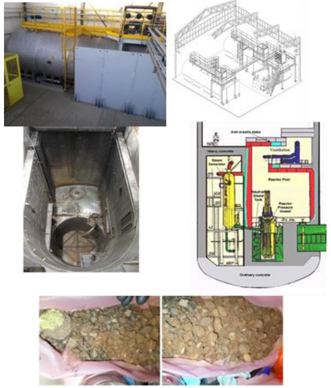
Perspectives: Methodological guides and recommendations

WP2 objectives and methodology

WPL : *Paolo Peerani*

Objectives

- **Present practices and actual needs**
  - operational needs and regulatory)constraints
  - Objectives for cartography and characterisation
  - State of the art and technological gaps
  - Economic impact assessment
- **Define and organise an experimental benchmark**
  - As a common validation of the INSIDER concept under real conditions
- **Elaborate good practices and guidelines**



1. Decommissioning of a back/end fuel cycle and/or research facility - Ispra (JRC)
2. Decommissioning of a nuclear reactor - Mol (SCK/CEN)
3. Post accidental land remediation - (CEA)

Methodology

- Survey involving partners and EUG
- Identification of on going relevant D&D project
- Derive lesson/compare to present practices

WP3 objectives & global methodology

sck cen Belgian Nuclear Research Centre *WPL : Sven Boden*

Objectives

- Statistical approach development and implementation
- Application to 3 different reference use cases
- Statistical approach guide

Selection of state of the art techniques concerning sampling design optimization

Use of prior information and multiple iterations

Testing this approach in different UCs

Use REX from overall uncertainty calculations

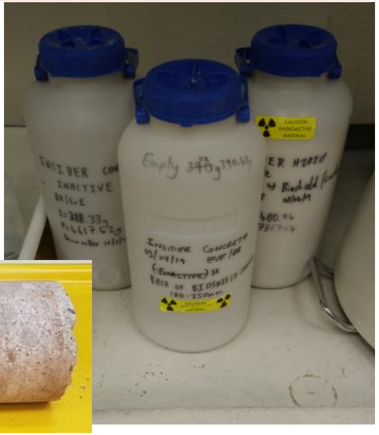
INSIDER

WP4 objectives and methodology

NPL National Physical Laboratory *WPL : Ben Russel*

- **Comprehensive review of radiochemical measurement techniques,**
  - Based on a survey
- **Validation of a radiochemical microsystem for Fe-55 extraction**
- **Provide 2 certified reference materials, characterised for radionuclide content to an accuracy better than 10 % at 95 % confidence level**
  - Matrix representative: real concrete spiked (^{133}Ba, ^{152}Eu, ^{154}Eu, ^{60}Co) and liquid
  - Certification by 3 NMI within the project

Characteristic	Aqueous CRM
Matrix	Spiked aqueous sample
Radionuclides	^{63}Ni (1-10 Bq/g) ^{90}Sr (1-100 Bq/g) ^{238}Pu (0.1-10 Bq/g) $^{239,240}Pu$ (0.1-10 Bq/g) ^{241}Am (1-10 Bq/g) ^{60}Co (0.1-10 Bq/g) ^{137}Cs (1-200 Bq/g) ^{55}Fe (0.1-5 Bq/g) ^{238}U (0.1-10 Bq/g)
Additional information	• Stable element composition



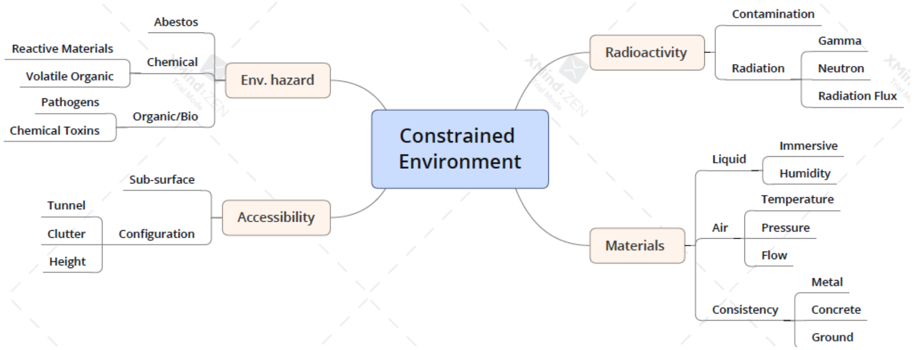
$$x_{MRC} = y_{car} + \delta_{hom} + \delta_{lts}$$
$$u^2_{CRM} = u^2_{car} + u^2_{hom} + u^2_{lts}$$

WP5 objectives and status

WPL : Margarita Herranz

Universidad del País Vasco / Euskal Herriko Unibertsitatea

- **Review the different available techniques for in-situ measurements in constrained environments**
- **Classification of the constrained environments and suitability of existing methodologies**
- **Organization of the participation in the in-situ measurement campaigns**
  - BR3 nuclear reactor
  - ISPRA tanks
- **Adaptation / Validation in situ**



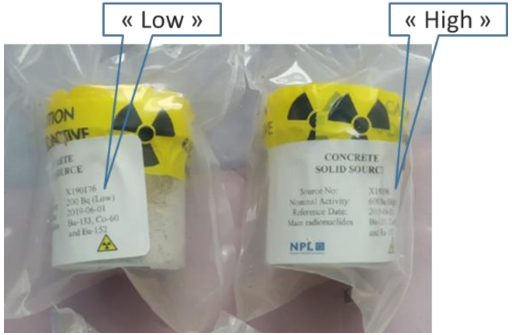
Rooms	Type of installation	Step	Contamination	Gamma Dose rate	Neutron Dose rate	Radiation flux
Process Hot cells	Reactors Plants	Initial Intermediate Final	very high high	very high high	very high high	no
Process ducts	Reactors Plants	Initial	very high high	very high high	very high high	no
Ventilation ducts	All	Intermediate	low	no	no	no
Chimney	All	Final	low	no	no	no
Reactor coolant system	Reactors	Initial	very high high	Very high high	very high high	no
secondary cooling system	Reactors	Intermediate	low	no	no	no
Tanks	All	Initial Intermediate	very high high	very high high	very high high	no

WP6 objectives and status

WPL : Marielle Crozet

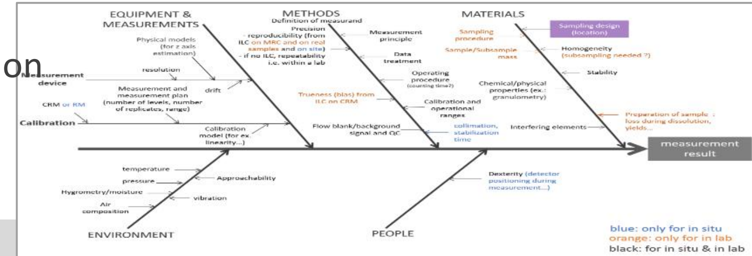
Objectives

- **Test the ability of different techniques/methods (proficiency test) to carry out measurements**
- **Estimate the measurement (in lab or in situ) uncertainty on synthetic and real samples**
- **Try to establish a complete uncertainty budget including every step of the INSIDER methodology (geostat & measurement)**



Methodology

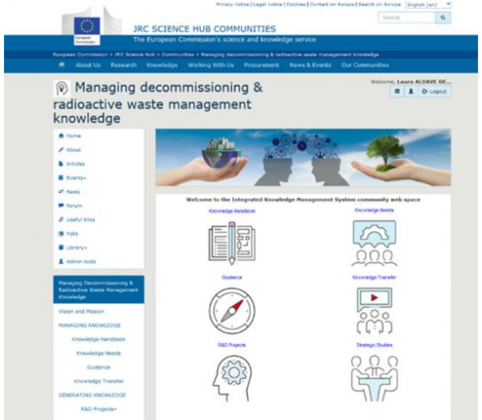
- **InterLaboratory comparisons on Certified Reference Materials (CRM)**
  - Proficiency test and method performance
- **Benchmarking results analysis for in situ measurement and on real samples**
  - proficiency test and measurement performance in realistic condition
- **Uncertainty budget**
  - *Different sources and relative importance*

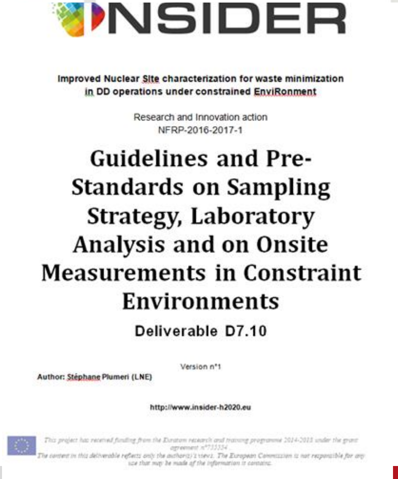


WP7 objectives and methodology

WPL : Laura Aldave de la Heras

- EUG assessment and interface management
- Public communications
- Dissemination
  - State of knowledge (JRC Hub)
  - Standardisation commission
    - Mapping of existing standards linked to INSIDER's topics is achieved. ISO, NF, AIEA documents…
  - Trainings (Elinder initiative)
  - Project workshops




INSIDER

Improved Nuclear Site characterization for waste minimization in DD operations under constrained EnviRonment

Research and Innovation action
NFRP-2016-2017-1

Guidelines and Pre-Standards on Sampling Strategy, Laboratory Analysis and on Onsite Measurements in Constraint Environments

Deliverable D7.10

Version n°1

Author: Stéphane Plumeri (LNE)

http://www.insider-h2020.eu

About the INSIDER project

http://insider-h2020.eu/

Highlights of the development and benchmarking


INSIDER

Improved Nuclear Site characterization for waste minimization in DD operations under constrained EnviRonment

Research and innovation action

NFRP-2016-2017-1

Guidelines and Pre-Standards on Sampling Strategy, Laboratory Analysis and on Onsite Measurements in Constraint Environments

Deliverable D7.10

Perspectives: Methodological guides and recommendations

Final main guides and recommandations

WP	Title
WP2	Design of the benchmarking exercise Result summary of the benchmarking exercise
WP3	Software of statistical approach - Statistical approach guideline
WP4	Reference material certification report
WP5	Recommended in situ measurement techniques for constrained environments Guideline on the requirements for method implementation Guideline for method validation
WP6	ILC and benchmarking results – Estimated uncertainties Establishment of uncertainty budget
WP7	State of knowledge for sampling strategy, in lab and on site measurements Existing standards mapping Guidelines, pre-standard and recommendations Training

Conclusions

Innovative metrological study based on a multidisciplinary network and D&D key activities

- New D&D matrix reference materials development
- Intercomparisons on real samples and Inter-team comparison
- Analytical innovation needs identification, development and implementation
- Advanced integrated approach for site radiological characterisation and automation of characterization process…
- Decommisionning operating experience

Methodological guides updated according to benchmarking feedback

- Established link with standardisation commissions (ISO) for future international standards
- Contribution to European learning (ELINDER)
- Potential Interface with other EU initiative (SHARE, METRODECOM projects)

Discussions

Potential further opening of the project in the future Horizon Europe Euratom work program

- Extension/application of the methodology and approaches : historic wastes, graphite reactors, NORM…
- Nuclear reference material(CRM)
- Support to D&D Standards (sampling, measurements and validated methods,…)
- Management of other waste (legacy waste, NORM, future waste…)
- Decommissioning standardized practices, remediation issues
- further links or interface with digital tools: Imaging, virtual and augmented reality

THANK YOU for your attention

Any questions?

Project coordinator: Danièle Roudil, CEA
Contact us: contact@insider-h2020.eu

Visit our website: **www.insider-h2020.eu**

Follow us on LinkedIn and Twitter!
@InsiderH2020

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 755554.

CLEANDEM PROJECT

Frédérick CARREL

On behalf of the CLEANDEM consortium

frederick.carrel@cea.fr

Context and main purposes

❑ Main items of the EURATOM call

- EURATOM **NFRP 2019 call** (Nuclear Fission and Radiation Protection Research)
- "Fostering innovation in **decommissioning** of nuclear facilities"
- Dead-line of the call: September 2019
- **Innovation Action**

❑ Some key words of the EURATOM call

- "Need for improved and **efficient decommissioning strategies and technologies**"
- "Exploiting **remotely operated technologies** coupled with current technologies for measurements"
- Focus on Technology Readiness Levels **5 to 7**
- Budget target: **2.8 Meuros**

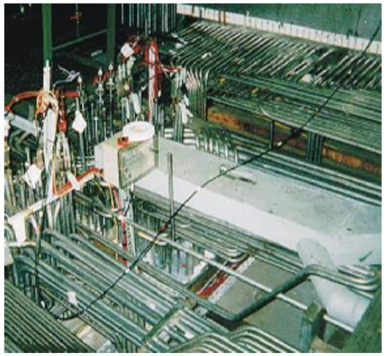
CLEANDEM project: key items

❑ The CLEANDEM consortium

- Led by **CEA LIST** / Administrative coordination by **ARTTIC**
- **11** partners / **4** countries (France, Italy, Germany, Spain)
- SMEs, large companies, research institutes
- **36 month** duration (previsional start in March 2021)
- EURATOM grant: **2.8 Meuros**

❑ Main purpose of the CLEANDEM project

- Bring **technological breakthrough** at different steps of the decommissioning operations
  - ✓ **Initial** radiological status
  - ✓ **Continuous** monitoring during D&D operations
  - ✓ **Final** characterization



CLEANDEM project: approach and main goals

- Different decommissioning steps, several expectations
  - Initial characterization: ability to measure in **harsch environments** with remote solutions
  - During D&D operations: **real time information** on the facility status
  - Final characterization: ability to measure **very low contamination level**
- Some main goals related to CLEANDEM
  - Advanced **dose rate** measurements
  - **Hot spot** localization
  - **Neutron/gamma** detection
  - Air and soil **contamination** monitoring
  - **Remote** operations
  - **Data fusion** and full **digitalization** of the plant

CLEANDEM project: advanced toolbox of technologies

❑ Advanced technological solutions

- Miniaturized **gamma camera** (Nanopix technology)
- **Advanced materials** for gamma and neutron discrimination
- **Low-cost** solutions for dose rate measurements
- New measurement systems for air and soil monitoring

❑ Different deployment modes according to the decommissioning step

- Measurement solutions embedded on a **UGV platform**
- **Stationary technologies** for continuous monitoring (OSL)
- **Handheld** solutions for end-users

➡ Tools will be deployed in the frame of a representative **training programme**

The MICADO project and future perspectives

E. Fanchini

EU-H2020- SHARE-Decommissioning On-line Workshop,
December 1-3, 2020

The MICADO project

Measurement and Instrumentation for Cleaning And Decommissioning Operations

Kickoff Meeting,
Viareggio – 11th June 2019

9 partners over 5 countries (IT, FR, BE, DE, CZ); a good mix of universities, research centers, one large company ad SMEs.

This project has received funding from the European Union's **Horizon 2020** research and innovation programme under grant agreement No 847641

The Idea

Development of the Radiological Characterisation & Monitoring System (RCMS) DigiWaste Platform that could become a referenced standard facilitating and harmonizing the methodology used for the in-field Waste Management and D&D operations

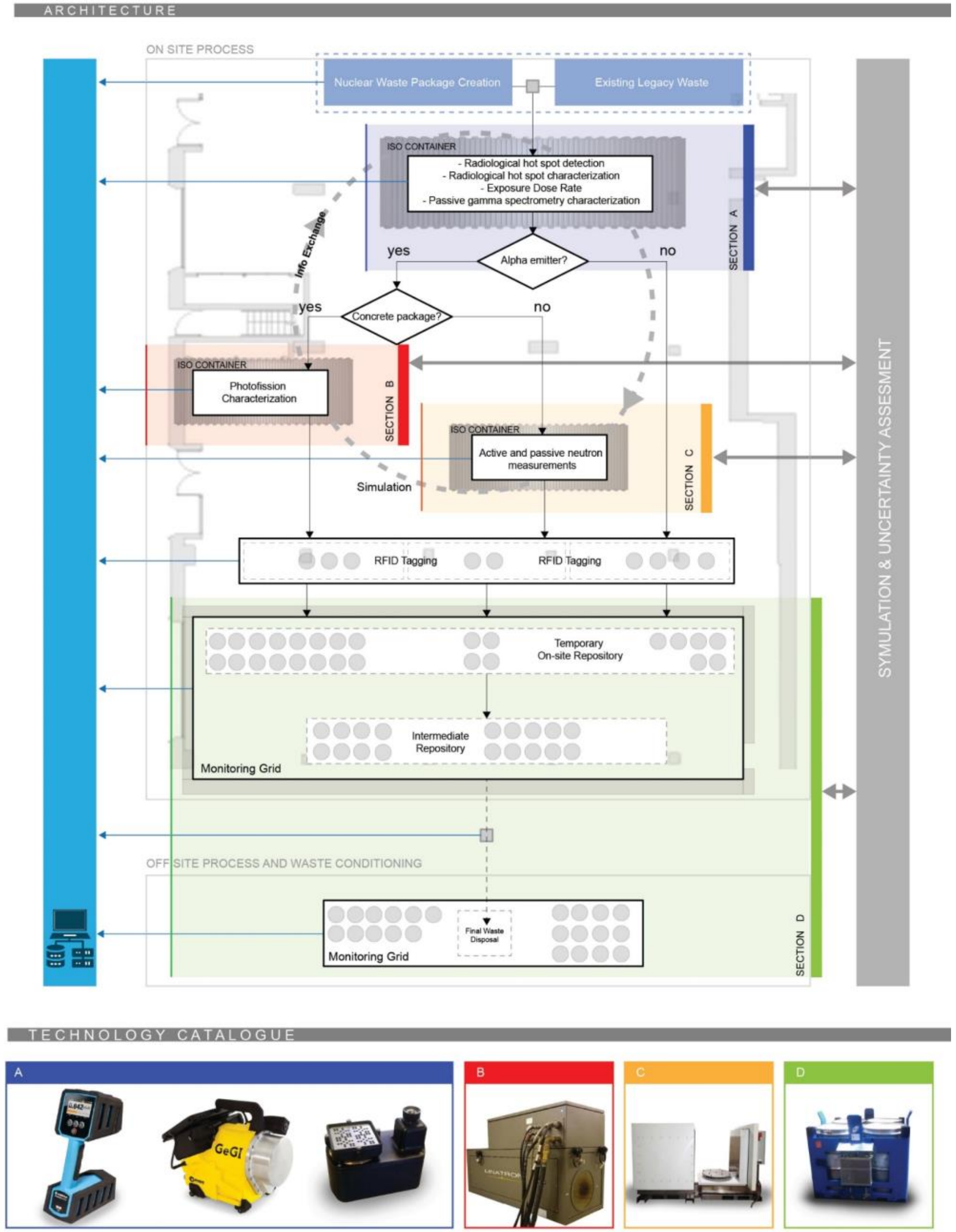
The platform performs non-destructive analysis capable to define the characterization procedure for the supplied waste package providing a complete integrated waste management solution for the full traceability of the waste:

- ***Flexibility***: it assures the complete characterization of different types of waste addressing geometry, package, volume/density;
- ***Transportability***: different technologies embedded in ISO containers. This solution allows an easy relocation of the systems without moving waste;
- ***Digitization***: execution in real time the digitization of the waste package under measurement with a direct real-time data storage on a customizable database and integrating all information of the producer;
- ***Quantification***: execution final quantification of fissile, fertile mass and the content of the actinides to fully characterize the nuclear waste using an artificial intelligent SW solution that could support the "expert analysis";
- ***Traceability***: Platform Software a Database with a complete tracking of the waste movements using the RFID technology as well as the waste disposal monitoring technology for long term verification of the good status of the containment.

Procedure and techniques

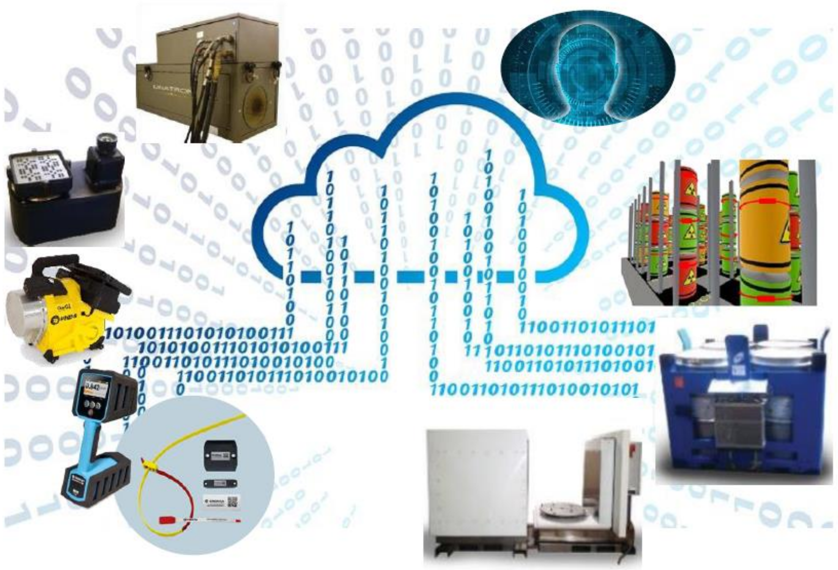
The main techniques are:

- ***Hot spot search and gamma spectroscopy*** for the identification of the energy spectra and the quantification of the gamma emitters (^{60}Co, ^{137}Cs…) for the detection of fissile materials (U, Pu) and define isotopic compositions and activities. The identification of hot spots of a higher activity will help on the material handling or repackaging;
- ***Neutron active and passive measurements*** based on ^{3}He detectors to evaluate the Pu activity, combined to gamma measurements. Neutron coincidence techniques are also used to measure the spontaneous fission (Pu and Cm) or measure the U and Pu fissile mass and their activities using neutron induced fissions;
- ***Photofission measurements*** to evaluate the U and Pu activities for higher or high-density waste packages
- ***Long term monitoring system*** based on scintillating optical fibers and SiLi6Fi technology to have a low cost and distributed grid of sensors surrounding the waste packages in the storage repository.



Software elements

- ***Uncertainty assessment pipeline:*** Uncertainty evaluation of all detection techniques to verify the uncertainty reduction due to the combination of multiple measurements. A Monte Carlo error propagation will be used to evaluate the proper probability distributions for all relevant parameters and finally, perform a global sensitivity analysis allowing further optimizing the approach
- ***RCMS DigiWaste Platform:*** infrastructure to collect, elaborate and store data. Detection technologies, uncertainty assessment pipeline, RFID tags information, waste management database and cloud software are the elements



The RCMS software is:

- Integrating and securely transferring external inputs, analyzing and combining them
- Associating a digital ID of the waste
- Providing a unique digital traceability of the output of the waste
- Controlling the localization of the drums during the full process
- Controlling the monitoring grid and the status of all technologies
- Test the full structure to guarantee the operationalities

Nuclear waste overview

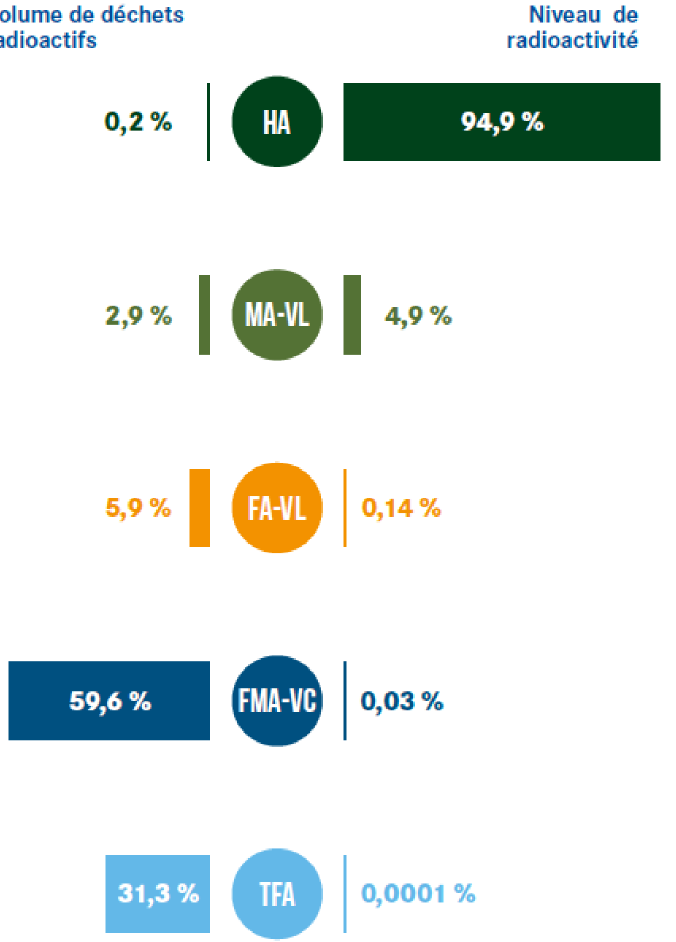
HA = High level waste
MA = Intermediate level waste
FA = Low level waste
FMA =Intermediate or Low level waste
TFA = Very low level waste
VT = Long half life
VC = Shoryt half life

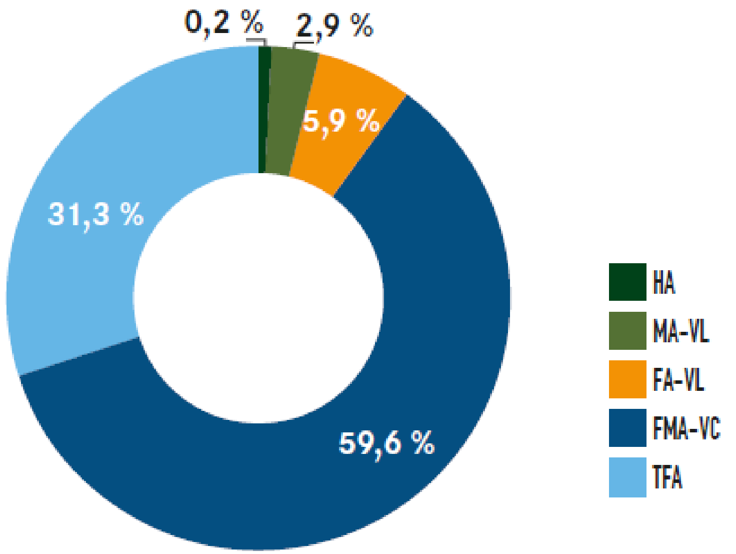
The french example:

- 94 % of the radiaoctivity come from High Radiactive waste

BUT

- The 6% of the radioactivity corresponds to the 99% of the waste volume!!!





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Waste overview

	Matrix						Storage/Disposal
	Glass	Concrete	Bitumen	Epoxy resin	Mortar	No filling matrix	Storage/Disposal
Legacy Waste	X	X	X	X	X	X	Surface or underground geologic storage
VLLW							Temporary storage
LLW-LHL							Surface or underground geologic storage
LLW-SHL							Surface storage
ILW-SHL							Surface storage
ILW-LHL							Underground geologic storage
HLA	X	X					Underground geologic storage
VSHL						X	Temporary storage

MICADO WILL NOT COVER the characterization of **metallic waste** stored in **containers**, Volumes > 2 m^3
This is requiring a different geometrical setup of the measuring system!!!

VVL= Veru Low Level Waste
LLW = Low Level Waste
ILW = Intermediate Level Waste
HLA = High Level Waste

LHL = Long Half Life
SHL = Short half Life
VSHL = Very Short Half Life

Large volume Metallic Waste

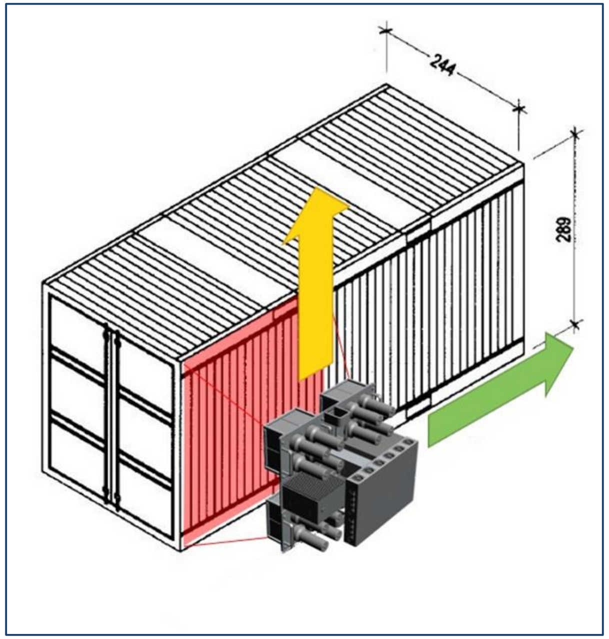
Container filled with metallic waste, mainly from the dismantlying of research centers and nuclear industry

- Content: Tubes, pipes, slabs, cables etc..
- Waste in the LLW/MLW categories
- Matrexes: no matrixes or concrete filling
- Large volumes: 2, 4, 10 m^3

The challenge

The main problems related to these waste packages:

- Not uniform density
- Inner radioactive surfaces of the pipes
- High Z (metal)
- Concrete filling
- Large dimensions to be covered



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 847641.
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Thanks for your attention

In-situ metrology for decommissioning nuclear facilities:

The main outcomes of MetroDECOM2 project

Ben Russell, NPL

Prepared by Peter Ivanov, NPL, MetroDECOM2 Coordinator

SHARE online workshop 2020

MetroDECOM II Project

- Coordinator: NPL
- Consortium:
  - ✓ 8 NMIs/DIs,
  - ✓ 8 External Partners
  - ✓ 14 Collaborators/Stakeholders
- 6 Work packages
- Runtime: 09/2017 - 02/2021

http://empir.npl.co.uk/metrodecom/

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

European Metrology project 16ENV09 MetroDecom II: September 2017 – September 2020

Nuclear industry

Instrumentation

NMIs

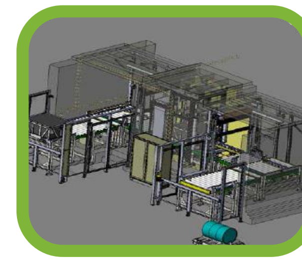
Objectives

WP1

- **Rapid methods** for measuring the radioactivity content of materials on a nuclear site

WP2

- Novel **automatic measurement system** to check whether waste packages can be free released or must be treated as radioactive waste



WP3

- **Radioactive waste characterisation** system, suitable for use as a waste repository acceptance system for very low, low and intermediate level radioactive waste

WP4

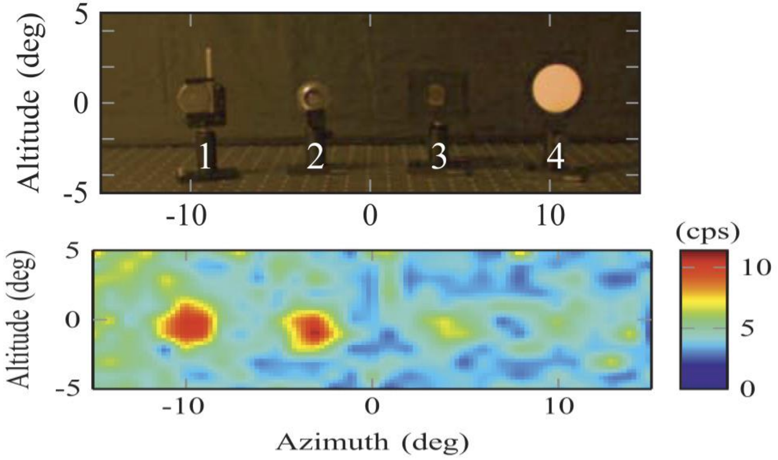
- On site measurement systems and methods for **monitoring of radioactive waste repositories**, including airborne radioactivity, temperature & strain

Mapping inside nuclear facilities

NPL National Physical Laboratory

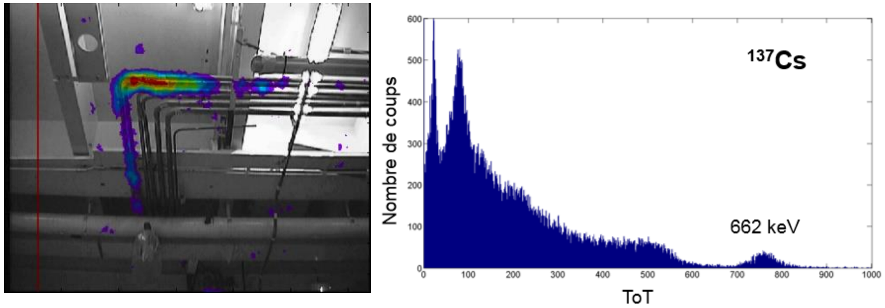
Mapping alpha emmiters (TTY)

✓ Developing UV based stand-off detection methods for detecting & monitoring

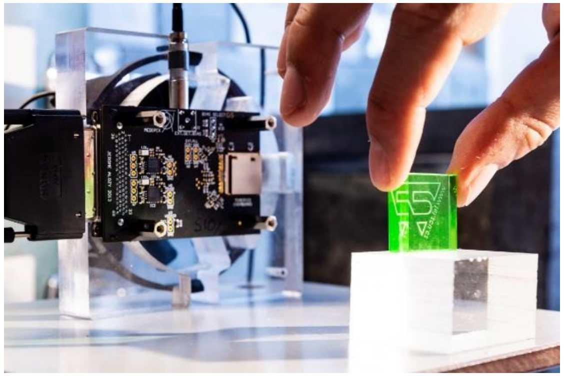


Localization of radioactive hot spots (CEA)

✓ Validation of the spectrometric performances of the GAMPIX γ-camera based on new reference sources produced by LNHB



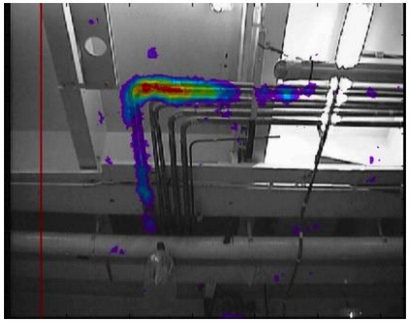
✓ Evaluation of the spectrometric performances of advanced pixelated chips (Timepix 3)



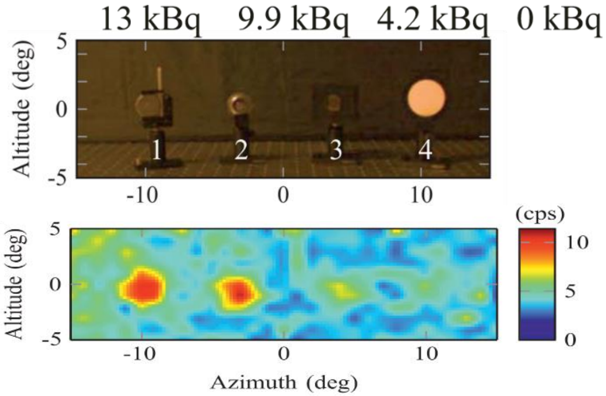
Timepix3 chip (1 mm thick CdTe sensor) under noise calibration with Uranium Glass

Mapping inside nuclear facilities

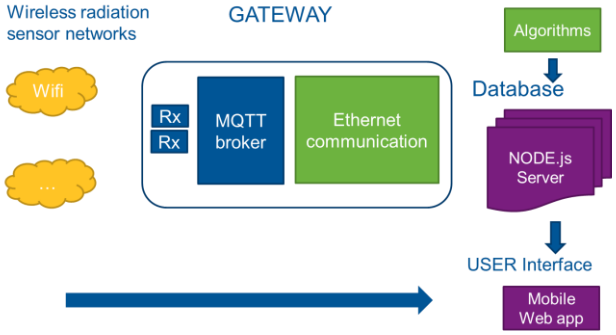
- Mapping of gamma emitters (CEA)- validation of GAMPIX gamma camera for radionuclides including ^{241}Am, ^{133}Ba, ^{137}Cs and ^{60}Co using point and surface sources



- Alpha mapping system with automated control (Tampere University) that can overcome high UV background using a narrow solar blind wavelength region (Kerst and Toivonen 2019)



- Real-time dose-rate mapping (MAGICS) using cheap compact detectors wirelessly linked validated through demonstration with waste management firm



Mapping inside nuclear facilities and radiochemical analysis

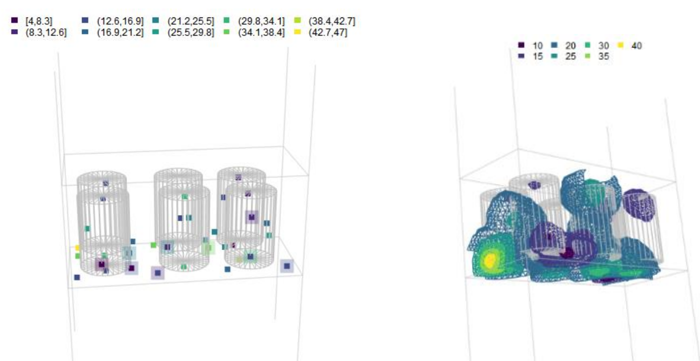
NPL National Physical Laboratory

Wireless network for real-time dose mapping (MAGICS)

✓ Developing a system for real-time dose-rate mapping based on compact radiation detectors, linked wirelessly to a central computer

✓ Setup at SCK-CEN

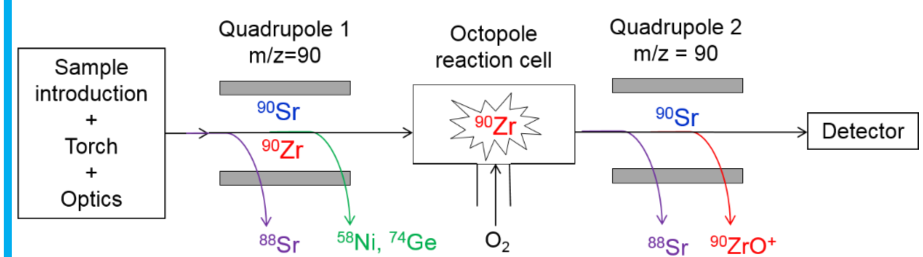
- 6 drums in Frisomat facility
- 264 records from random positions measured



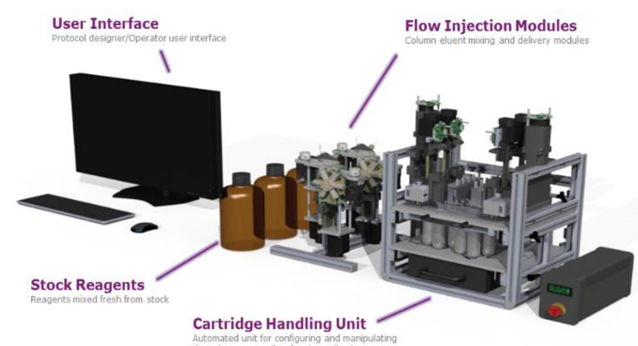
Dose map of a set of six drums

Rapid radiochemical analysis (NPL, PTB, NNL)

✓ Developing rapid radiochemical methods for the determination of selected radionuclides of interest in nuclear decommissioning (^{41}Ca, ^{90}Sr, ^{93}Zr, U and Pu isotopes)



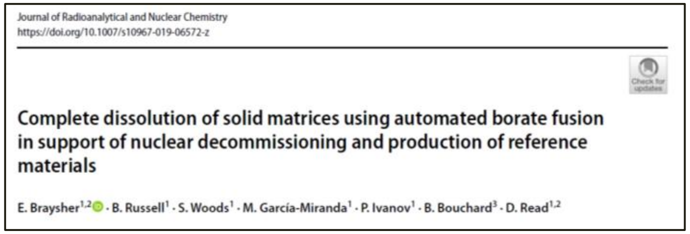
^{90}Sr analysis by ICP-QQQ-MS



Automated radiochemical separator NiV™ developed at NNL

Destructive radiochemical analysis

- Dissolution of up to 5g concrete samples using automated borate fusion (Braysher *et al*. 2019)

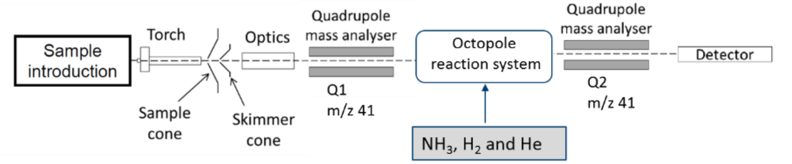

Journal of Radioanalytical and Nuclear Chemistry
https://doi.org/10.1007/s10967-019-06572-z

Complete dissolution of solid matrices using automated borate fusion in support of nuclear decommissioning and production of reference materials

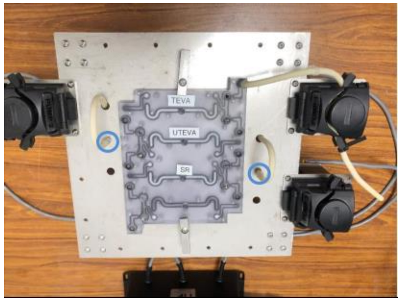
E. Braysher[1,2] · B. Russell[1] · S. Woods[1] · M. García-Miranda[1] · P. Ivanov[1] · B. Bouchard[3] · D. Read[1,2]

- Radiochemical separation schemes developed for ^{93}Zr (Thompkins *et al*. 2020), ^{41}Ca, ^{90}Sr, U and Pu

- Tandem ICP-MS procedures developed for these radionuclides (Warwick *et al*. 2019)



- Automated separation developed by NPL based on procedures from PTB using microfluidic device



Facility for pre-selection of waste and free release measurement

NPL National Physical Laboratory

The facility installed on CIEMAT's decommissioning site

- ✓ Easily transportable modular system
- ✓ Low-background concrete shielding
- ✓ 4 plastic scintillators for pre-selection .
- ✓ 4 HPGe detectors for free release
- ✓ 3 ^{6}LiF/ZnS(Ag) neutron detectors
- ✓ NaI(Tl) detector for scanning of wastes
- ✓ Complex measurement and evaluation SW

On site calibration and validation of the facility

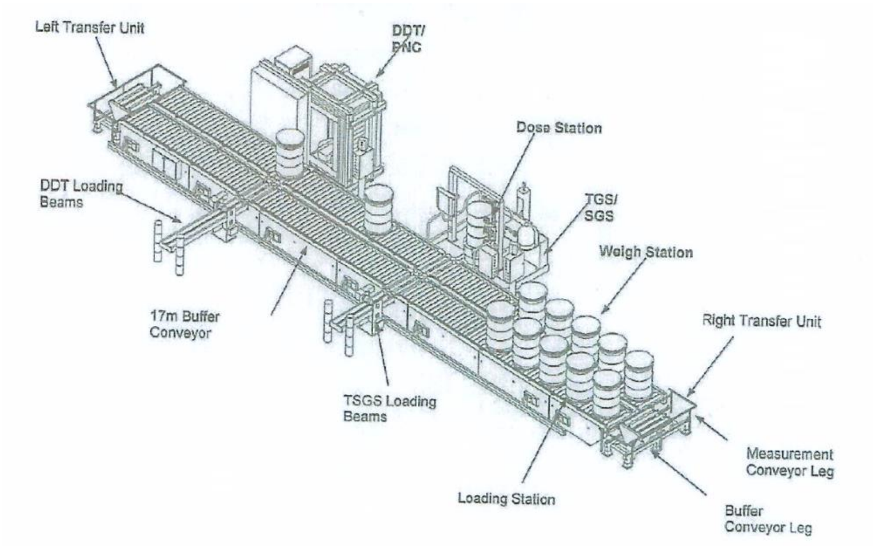
- ✓ Calibration for IP1 and IP2 containers 0.5 m^3, drum 0.2 m^3 and big-bag 0.4 m^3, using validated MCNP and PENELOPE Monte Carlo models
- ✓ Validation by certified reference materials, point-like standard radionuclide sources and real decommissioning wastes
- ✓ Maximum deviation between measured and calculated measuring efficiencies and mass activities 10% for free release and 20% for pre-selection measurement
- ✓ Reference calibration materials gravel, steel and clay balls traceable to primary standards, for homogeneously contaminated wastes measurement.
- ✓ Standard radionuclide sources traceable to primary standards, for hot-spots identification.

Waste Characterisation System (WCS) at JRC Ispra

NPL National Physical Laboratory

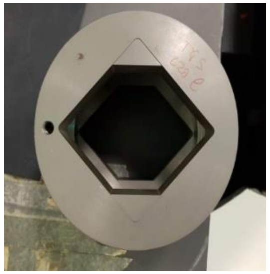
There are five measurement stations:

- ✓ Bar-code reading/identification
- ✓ Weighing station
- ✓ Dose measurement (in contact, and 1 metre distance)
- ✓ **Passive/active neutron measurement station**
- ✓ **Tomographic / Segmented gamma measurement station (TSGS)**



TGS/SGS station @WCS

- ✓ Eu-152 transmission source (2.5MBq)
- ✓ Electronic chain (DSPEC, HPGe, Pulser)
- ✓ 6K4 rotary motor and horizontal
- ✓ 6k4 vertical arm movement
- ✓ The SGS and TGS method has been described in term of procedure for calibration of the system with 220l drum (i.e. simulated matrix drum of various density), MDA, TGS_FIT analysis software, error determination and reporting file.
- ✓ Measurement campaign on 35 real LLW and ILW 220l waste drums performed with the gamma station at JRC Ispra.

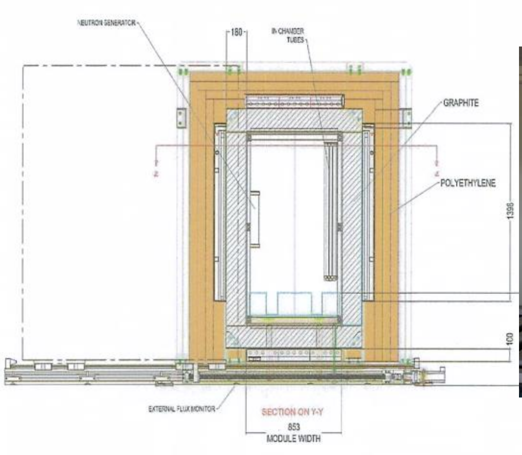


TGS/SGS station and W collimators

Waste Characterisation System (WCS) at JRC Ispra

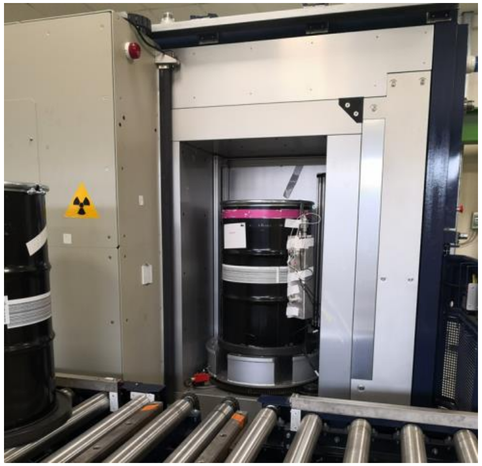
Passive/active neutron station

- ✓ For passive and active interrogation:
  - Fission neutron counters
- ✓ For active interrogation:
  - n-cavity, thermal flux monitors (on-barrel monitors)
  - External source monitor (monitor emission from n-generator)



Results passive/active neutron measurement station

- ✓ Measurement campaign on 12 real LLW and ILW 220l waste drums performed with the passive neutron station of the Waste Characterisation System (WCS) of the Nuclear Decommissioning Unit in JRC Ispra
- ✓ The passive & active neutron station has been characterised and waste analysis procedure described in two JRC reports



Repository monitoring- portable and rapidly deployable gas and water monitoring systems

Testing of the innovative radioactivity monitoring system WILMA (LL) combining a low-level, LS-based radioactivity detector and an automated fluid handling system

WILMA water monitor (automated LSC)

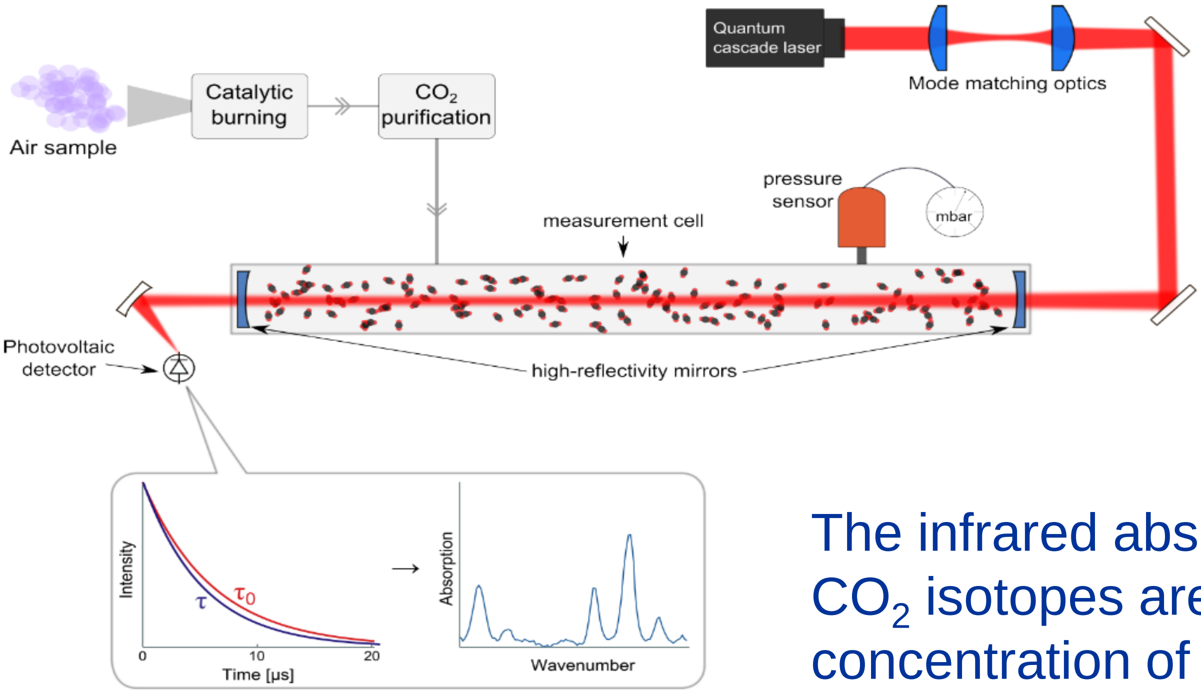
WILMA-Bubbler – On-line air/water monitoring system

http://lablogic.com/radiation-safety/instruments/wilma

- Based on WILMA (LabLogic).
- Gas is trapped in fluid through bubbler and automatically mixed with scintillant before being passed to LSC for for ^{3}H and ^{14}C analysis in air samples to create a portable air monitoring station
- Furnace for conversion of methane, HT and organics
- Tested on-site at CCFE

Airborne radioactivity measurement, laser spectroscopy (VTT)

- Pre-production of automatic instrument for in-situ detection of gaseous emissions
- The instrument measures the concentration of radiocarbon gaseous emissions through the detection of radiocarbon dioxide



The infrared absorption lines of the different CO_2 isotopes are identified to measure the concentration of each isotope (i.e. $^{14}CO_2$)

Summary

Motivation

- Improve safety of radioactive waste management
- Reduce cost of nuclear decommissioning
- Minimise the environmental impact

Objectives

- Mapping inside nuclear facilities
- Waste sentencing and free release
- Monitoring of repository sites

Impact to date

- 7 publications
- 8 international quality standards
- 25 conference presentations
- 5 trainings on radiological characterisation
- 3 end-user uptakes & exploitation

EMRP
European Metrology Research Programme
Programme of EURAMET

The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

Department for Business, Energy & Industrial Strategy

FUNDED BY BEIS

Nuclear industry

Instrumentation

NMIs

The National Physical Laboratory is operated by NPL Management Ltd, a wholly-owned company of the Department for Business, Energy and Industrial Strategy (BEIS).

EURAMET
European Association of National Metrology Institutes

NPL
National Physical Laboratory

CHANCE

Characterization of Conditioned Nuclear Waste for its Safe Disposal in Europe

CHANCE Project - Characterization of conditioned nuclear waste for its safe disposal in Europe

Denise Ricard (ANDRA)

with G. Genoud, C. Bruggeman, C. Bucur, C. Carasco, O. Gueton, A. Kopp, D. Kikola, W. Kubinski, C. Mathonat, B. Rogiers, J. Stowell, A. Rizzo, D. Tefelski, L. Thompson, E. Valcke, J. Velthuis, G. Zakrzewska-Koltuniewicz, B. Ferrucci, B. Perot, A. Rizzo.

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 755371

CHANCE
Characterization of Conditioned Nuclear Waste for its Safe Disposal in Europe

- Euratom research and training programme 2014-2018
- NFRP 7-2016-2017 topic “Research and innovation on the overall management of radioactive waste other than geological disposal”

- 4 years project: 1.6.2017 - 31.5.2021 (probable extension to 30.11.2021)

- Total budget: 4.25 M€ (3.98 M€ EC contribution)

- Consortium: 11 partners from 7 European countries

ANDRA French national radioactive waste management agency · University of BRISTOL · cea · ENEA · RATEN REGIA AUTONOMĂ TEHNOLOGII pentru ENERGIA NUCLEARĂ · VTT · ichtj · KEP Nuclear · SCK•CEN STUDIECENTRUM VOOR KERNENERGIE CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE · POLITECHNIKA WARSZAWSKA WARSAW UNIVERSITY OF TECHNOLOGY · The University Of Sheffield.

CHANCE

Characterization of Conditioned Nuclear Waste for its Safe Disposal in Europe

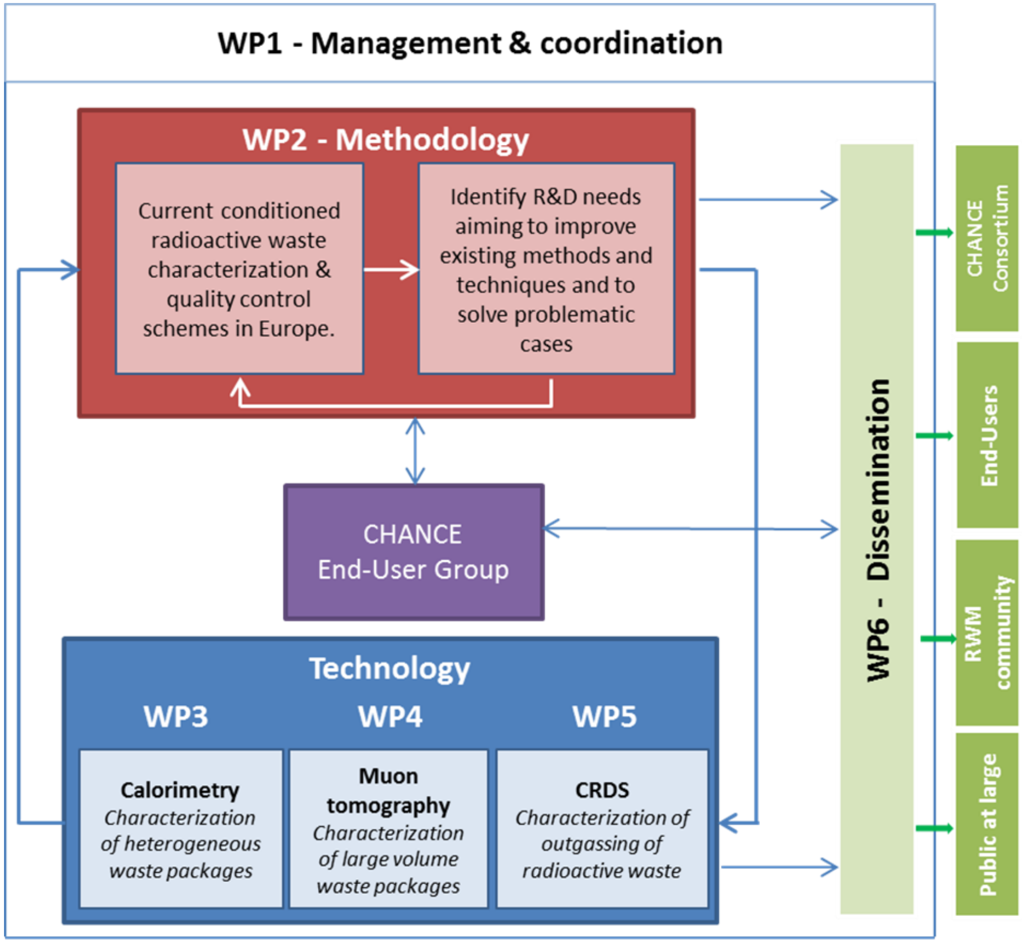
CHANCE objectives

- To establish at the European level **a comprehensive understanding of current conditioned radioactive waste characterization and quality control schemes** across the variety of different national radioactive waste management programmes

- To further develop, test and validate **novel non-destructive techniques** that will improve the characterization of conditioned radioactive waste
  - **Calorimetry** as a non-destructive technique to reduce uncertainties on the inventory of radionuclides
  - **Muon Tomography** as a non-destructive technique to control the content of large volume nuclear waste
  - **Cavity Ring-Down Spectroscopy** (CRDS) to characterize outgassing of radioactive waste

Characterization of Conditioned Nuclear Waste for its Safe Disposal in Europe

CHANCE structure



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Characterization of Conditioned Nuclear Waste for its Safe Disposal in Europe

WP2 – Methodology

Leader: Andra – Contributors: CEA, ENEA, SCK•CEN, RATEN, INCT

Objectives

To identify **current methodologies** and shortcomings of current characterization and metrology of CRW in Europe

- **Key parameters** that need characterization and uncertainties assessment
- **Technologies commonly used** for conditioned waste characterization
- **Specific problematic issues** for the characterization of CRW
- **Knowledge and technology gaps** for radioactive waste package characterization methodologies
  - Driven by end-user requirements for the characterization of radioactive waste

Status

- A questionnaire was prepared to obtain a broad overview of the characterization of conditioned radioactive waste
  - **End-User-Group Questionnaire** (D2.1 available at www.chance-h2020.eu)
- Questionnaire completed by EUG members (13 questionnaire answers received)
  - **Synthesis of questionnaire answers** (D2.2 available at www.chance-h2020.eu)
- Identification of **R&D needs** on characterization of conditioned radioactive waste
  - Under progress (final version expected for the first quarter 2021)

WP3 -Calorimetry

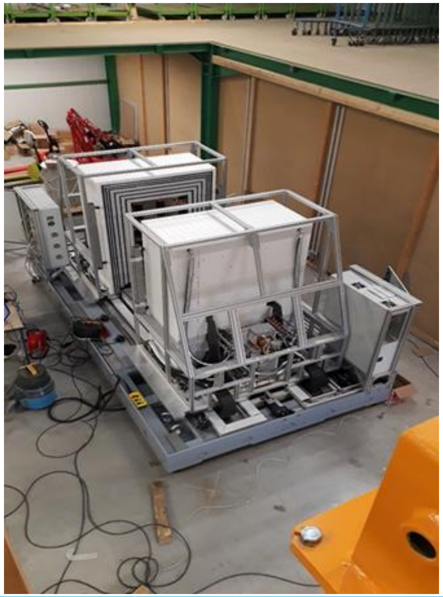
Leader: KEP Nuclear – Contributors: CEA, SCK•CEN, WUT

Objectives

- To test and evaluate the performance of calorimetry for inventory of radionuclides (measure Beta or alpha radiation heat source)
- To identify how calorimetry can complement existing, widely-used techniques (gamma spectrometry and neutron passive measurement)
- To carry out an exhaustive study of uncertainties assessment related to calorimetry and its coupling to other non-destructive techniques

Status

- Construction of a novel calorimeter with an optimized detection limit (1.5mW) to host a 200L drum (10-3000mW range)
- Measurements of mock-up drum (Pu pellet (100 microW) in concrete matrix
- Monte Carlo modelling of calorimeter combined with gamma spectrometry



Characterization of Conditioned Nuclear Waste for its Safe Disposal in Europe

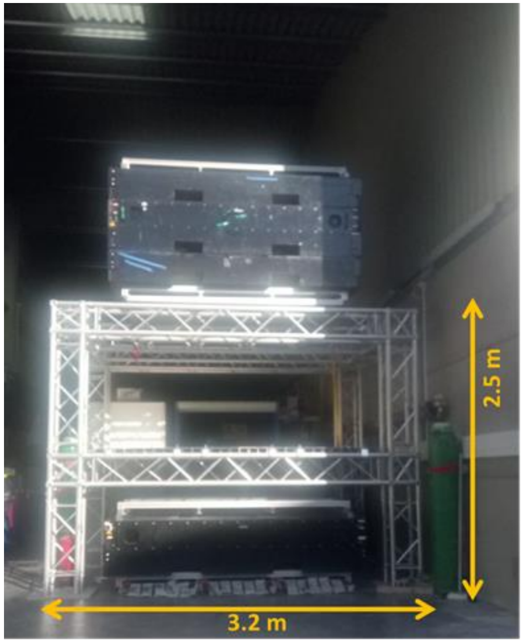
WP4-Muon tomography

Leader: University of Bristol – Contributors: SCK•CEN, University of Sheffield, WUT

Objectives

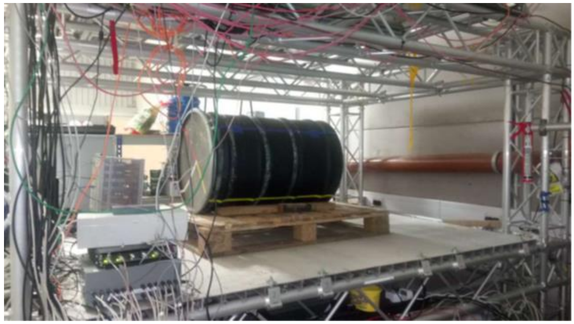
To develop mobile muon tomography instrumentation to address imaging of large volume and heterogeneous nuclear waste packages

- build a suitable mobile muon detection system
- demonstrate real waste drum muon tomography
- evaluate performances of the technique



Status

- The detector system was commissioned in a non-laboratory environment
- Track fitting and image processing for imaging a mock-up drum in progress
- Modellings associated to identification of materials and image reconstruction have been done



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WP 5 - Cavity Ring-Down Spectroscopy

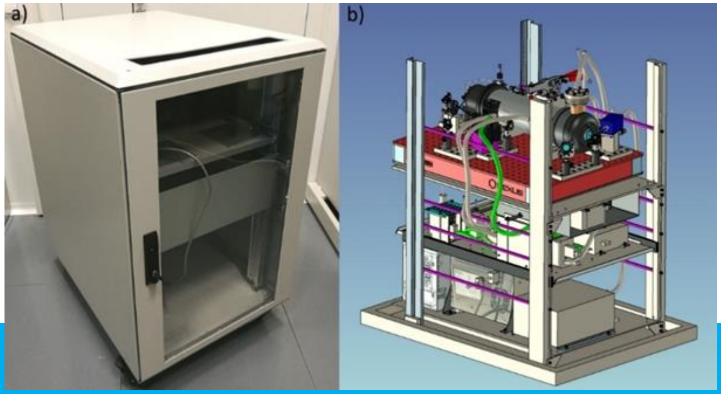
Leader: VTT – Contributors: CEA, ENEA

Objectives

- Develop new CRDS instrumentation for $H^{36}Cl$
- Study ^{14}C waste outgassing using CRDS (e.g. from irradiated graphite)

Status

- Identification of a $H^{36}Cl$ absorption line
- Some challenges associated to the experimental measurements of $H^{36}Cl$
- Development of a transportable C-14 instrument for analysis of irradiated samples in a radiation laboratory
- Analysis of outgasing from solid graphite pieces has been started



Characterization of Conditioned Nuclear Waste for its Safe Disposal in Europe

Survey synthesis

CHANCE
Characterization of Conditioned Nuclear Waste for its Safe Disposal in Europe

Challenges regarding characterisation

- proper characterization of the ***conditioned legacy/ historical waste packages***
- determination of a viable **source term** in already conditioned waste
- detection of **difficult to measure isotopes** and sealed radioactive sources
- **little traceability** of the chemical content of waste packages
- **accessibility** of the waste for sampling, difficulties in monitoring waste drums packed deeply in a storage facility
- characterization and reconditioning of the **waste already stored** in a repository
- the **lack of standardized processes** for the characterization and repackaging (or reconditioning) of spoilt drums/containers.

Main R&D needs

- Developing of ***non-destructive methods*** capable to detect the radiological (including α and β emitters) and fissile mass, as well as the chemical content

- The new developed methods should be able to be applied:
  - for **homogeneous and heterogeneous waste**
  - on waste packages of **different sizes**, including SNF casks.

Characterization of Conditioned Nuclear Waste for its Safe Disposal in Europe

On-going R&D programs

- High energy X-ray imaging (detectors, higher energy, dual energy imaging)
- Gamma-ray spectroscopy (detectors, electronics, data processing)
- Passive neutron measurement (detectors, correction of matrix and localization effects)
- Active neutron interrogation (detectors, correction of matrix and localization effects)
- Active Photon Interrogation (i.e. photofission)
- Prompt Gamma Neutron Activation Analysis
- Fast Neutron Analysis with the Associated Particle Technique
- Beryllium characterization by photon activation analysis
- **Calorimetry, muon tomography, CRDS in CHANCE**

Next steps

- Finalisation of state of art about on going R&D techniques for the characterization of conditioned radioactive wastes
    - Feedback from end-users
- Training courses
- Combination of different characterization methods to reduce uncertainties
- Validation of methods developed in CHANCE if possible with real waste

CHANCE

Characterization of Conditioned Nuclear Waste
for its Safe Disposal in Europe

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 755371

Thank you for your attention !