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

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

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Introduction

- Funded by Euratom research and training programme 2014-2018 under grant agreement N° 755371
- Within the NFRP 7-2016-2017 topic “Research and innovation on the overall management of radioactive waste other than geological disposal”
- Duration of 4 years; start date June 1, 2017; end date: 31 May, 2021
- Total CHANCE budget: 4,25 M€
- EC contribution: 3,98 M€
- Consortium: 12 partners from 8 European countries

Consortium

- Andra (FRA)
- CEA (FRA)
- ENEA (ITA)
- FZJ (GER)
- KEP Nuclear (FRA)
- SCK•CEN (BEL)
- University of Bristol (UK)
- University of Sheffield (UK)
- VTT (FIN)
- RATEN (ROM)
- WUT (POL)
- INCT (POL)

CHANCE objectives

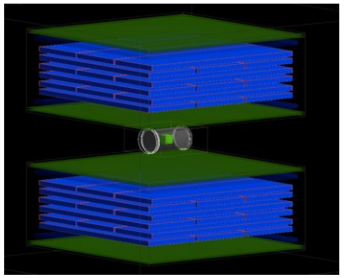
- To establish at the European level **a comprehensive understanding of current conditioned radioactive waste characterization and quality control schemes** across the variety of different national radioactive waste management programmes

  – Based on inputs from end-users such as Waste Management Organisations, regulators, waste producers and repository operators

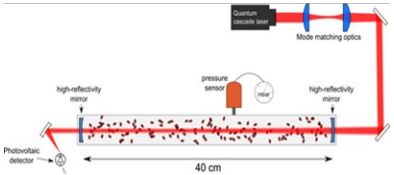
CHANCE objectives

To **further develop, test and validate non-destructive techniques that will improve the characterization of conditioned radioactive waste (CRW)** and complement current methodology while particularly targeting large and heterogeneous waste compounds

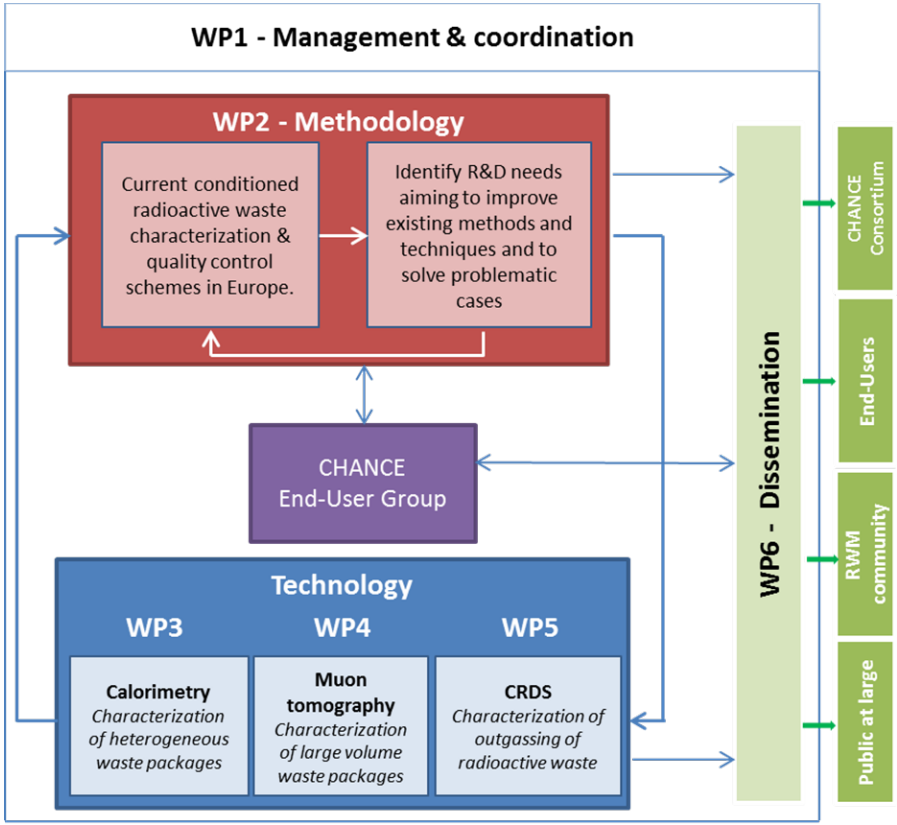
- **Calorimetry** as a non-destructive technique to reduce uncertainties on the inventory of radionuclides
- **Muon Tomography** as a non-destructive technique to control the content of large volume nuclear waste
- **Cavity Ring-Down Spectroscopy** (CRDS) to characterize outgassing of radioactive waste



Destructive technologies followed by chemical or radiological analyses are commonly used techniques for radioactive waste characterization but are not addressed in CHANCE, since these techniques are applied to the raw waste itself, this is not in the scope of this project.



CHANCE structure



WP2 METHODOLOGY

WP2 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 the end-user requirements for the characterization of radioactive waste
    - Waste Management Organizations (WMOs), regulators, disposal operators, waste producers…
  - A specific End-Users Group (EUG)

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

WP2 current status

- A questionnaire was prepared to obtain a broad overview of the characterization of conditioned radioactive waste (WAC, methods currently used, needs, special issues, etc)
  - Includes questions pertaining to Work Package 6 (socio-technical and ethical frameworks of radioactive waste characterization practices and policies)

  End-User-Group Questionnaire (available on www.chance-h2020.eu)

- Transmission of the Questionnaire to EUG members
  - 13 questionnaire answers received
  - Synthesis of questionnaire answers under finalization (available soon on www.chance-h2020.eu)

WP2 current status

Identification of Waste Acceptation Criteria (WAC)

Depend on the disposal and country considered

- Radiological: radionuclide activity, dose rate, surface contamination, content of fissile materials, heating power
- Chemical : inventory of toxic species, complexing and chelating agents, accelerators of leaching processes, organic substances, pyrophoric, flammable, corrosive, oxidizing materials
- Mechanical: compression resistance, drop resistance, matrix behavior (swelling, diffusivity and leachability)…
- Other parameters: hydrogen production, homogeneity of the waste, parameter associated to disposal container (physical dimensions and weight)

WP2 current status

Specific problematic issues for the characterization of conditioned RW

- Proper characterization of the conditioned legacy/ historical waste packages
  - Radiologic characterization: interrogators radiation have difficulties to penetrate; the measurable emissions (γ or neutron) are strongly attenuated
  - Type of different materials – often difficult to identify
- Determination of alpha and beta activities in conditioned RW due to signal attenuation by the waste packages and backfill (compacted drums, concrete)
- Little traceability of the chemical content of waste packages
- Accessibility of the waste for sampling (due to the limited access at the waste packages)
- Difficulties in monitoring and periodical control of the waste drums packed deeply in a storage facility

All results will be available soon on www.chance-h2020.eu

WP3 CALORIMETRY

WP3 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

A dedicated calorimeter (200 litres) will be designed and built by KEP Nuclear

A dedicated experimental program will be carried out with mock-up drums, and possibly real drums (CEA and SCK•CEN)

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

WP3 current status

First deliverable : Report on the Applicability of calorimetry to real waste characterization (available on www.chance-h2020.eu)

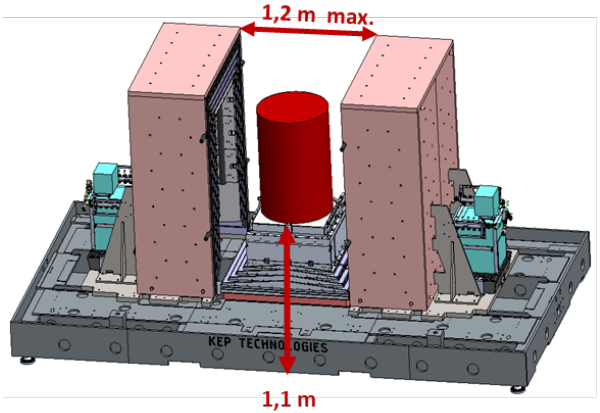
- Overview of NDA techniques (Gamma methods; Neutron methods, calorimetric methods)
- MCNP CHANCE calorimeter modelling
- Evaluation of Gamma energy and neutron deposition inside the calorimeter and impact on the measurement

Applicability of calorimetry

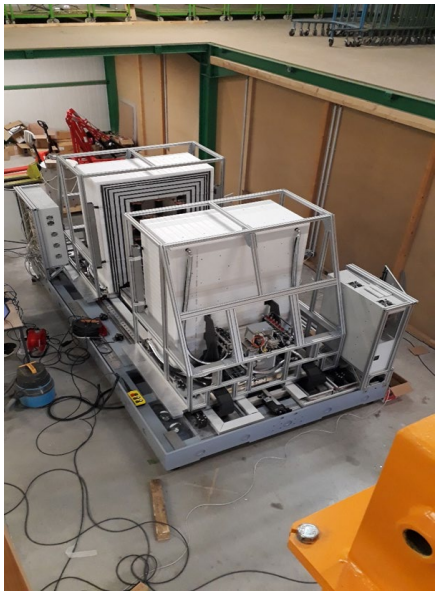
- Calorimetry is adapted to alpha and beta emitters (e.g. Pu, Am, ^{3}H) – all the heat emitted by radioactive decay can be measured (less of 1% of uncertainty)
- Calorimetry can not discriminate/ locate the heat source (s)
- Calorimetry is complementary and supplementary, mainly to gamma- and neutron spectrometry

WP3 current status

- Construction of the LVC calorimeter (200L, 10-3000mW range) with optimized lower detection limit (1.5mW)
- Commissioning and experiments to commence in summer 2019
- MCNP / GEANT4 modelling of CHANCE LVC calorimeter



LVC calorimeter (KEP)

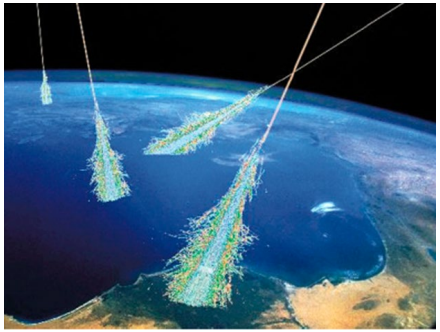


WP4 MUON TOMOGRAPHY

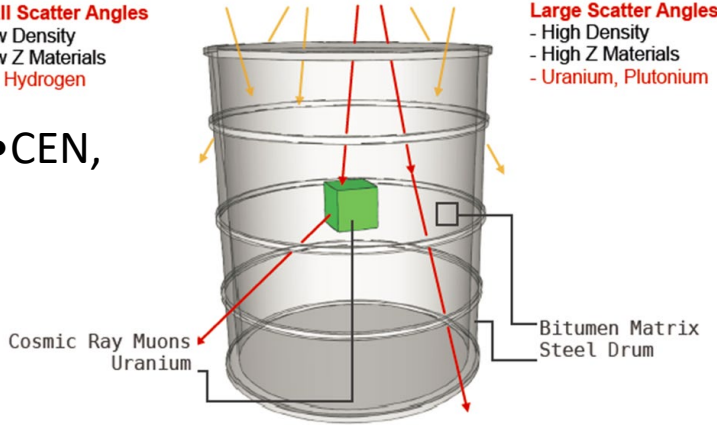
WP4 Objectives

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

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

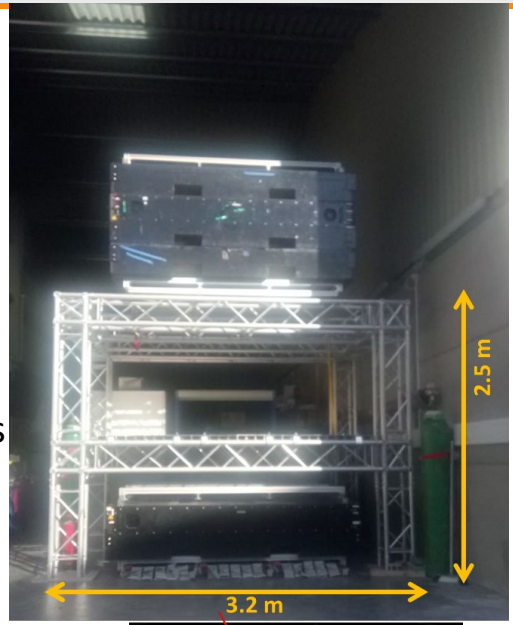


WP4 Leader: University of Bristol – Contributors: FZJ, SCK•CEN, University of Sheffield, WUT

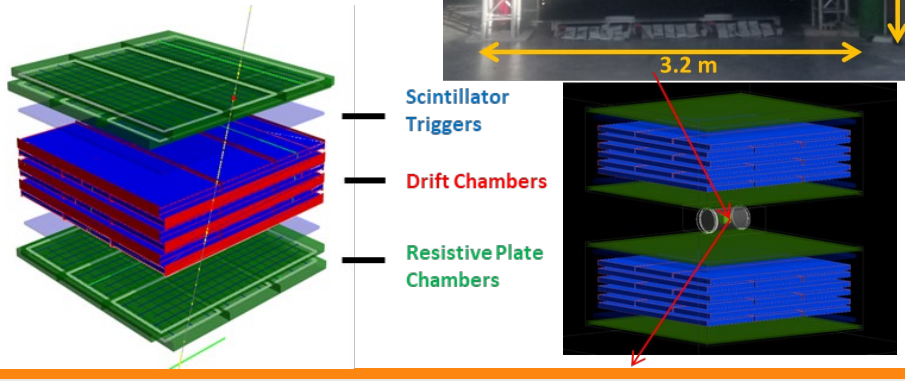


WP4 current status

- The detector system is being commissioned in a non-laboratory environment.
- Topics of interests/goals:
  - detection of U cuboids embedded in concrete with a few mm resolution.
  - distinguishing between cuboids of U, W and Pb.
  - detection of voids (e.g. gas bubbles) in the matrix.
  - Hot drum simulations and estimates for large volume and heterogeneous waste compounds

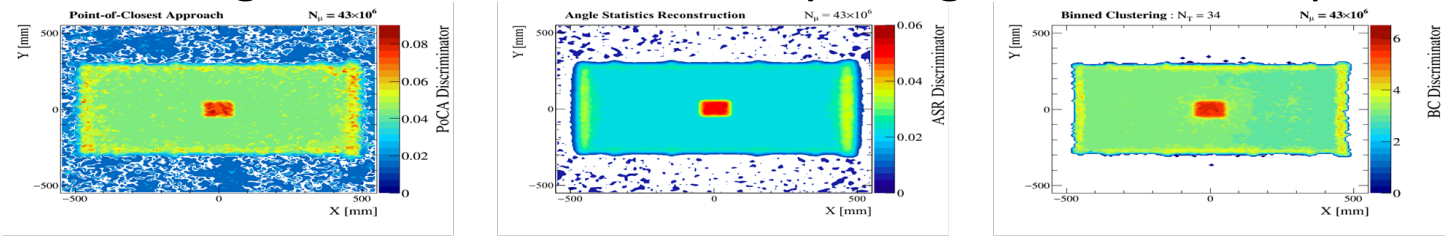


- Looking for industry partners to guide our activities
- Imaging of large-scale CASTOR drums containing high-Z material

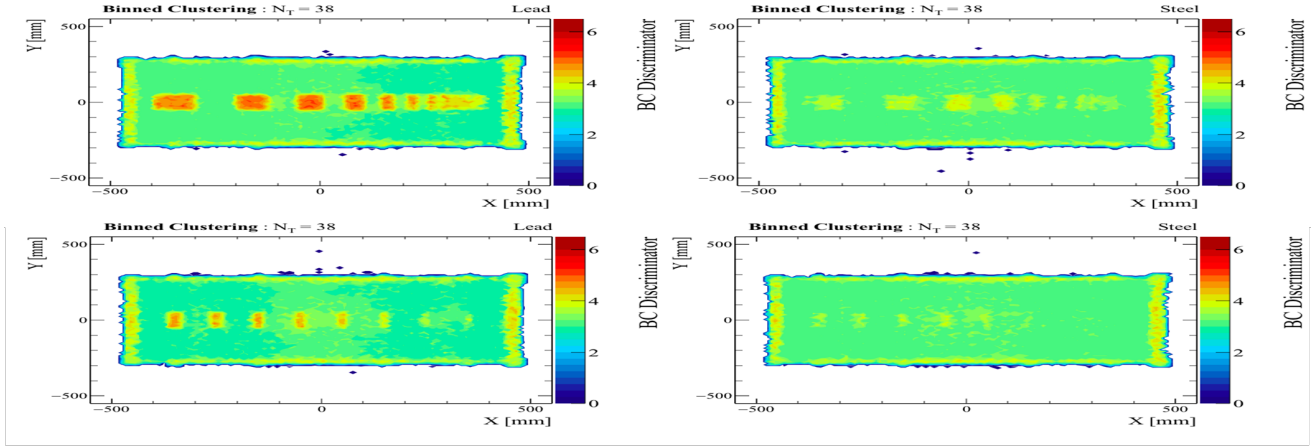


WP4 current status

MT algorithms and MCNP study of Figure-of-Merit aspects



Comparison of different algorithm outputs when imaging a 10cm long Uranium cube for 25 days of muon exposure.
The inclusion of momentum information and metric distances in the BC algorithm leads to an image with higher contrast and clarity than a simple PoCA approach.



Uranium feature (top) and size (bottom) resolution test images for lead and steel targets. The resolution has a strong correlation with the target material density as the presence of higher density materials results in more scattering vertices in the volume of interest.

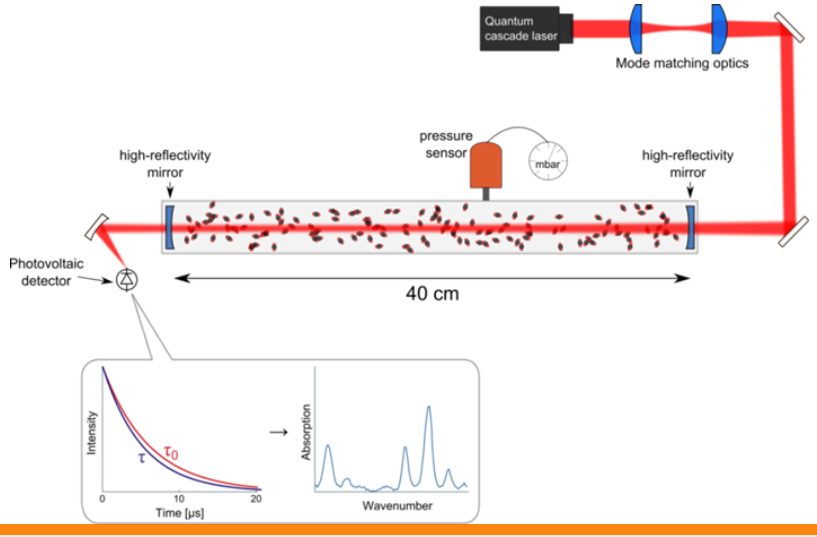
Details are published (P. Stowell et al.) at WMS Phoenix, USA, 2019, paper no. 19253, https:\\wmsym.org

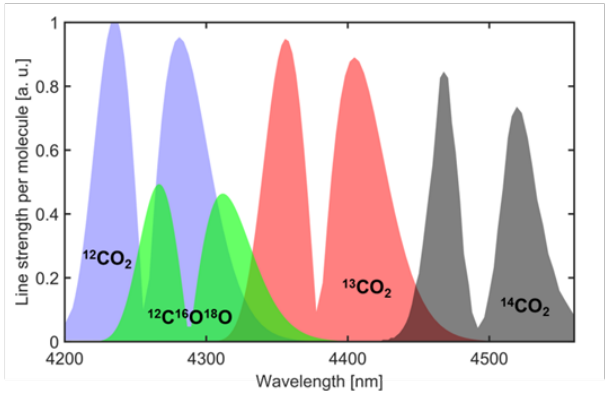
WP5 CRDS
CAVITY RING DOWN SPECTROSCOPY

WP5 objectives

- Advance the use of Cavity Ring-Down Spectroscopy (CRDS)
  - Develop new instrumentation for $H^{36}Cl$
  - Demonstrate the application of the technique to the monitoring of ^{14}C outgassing

Leader: VTT – Contributors: CEA, ENEA, FZJ

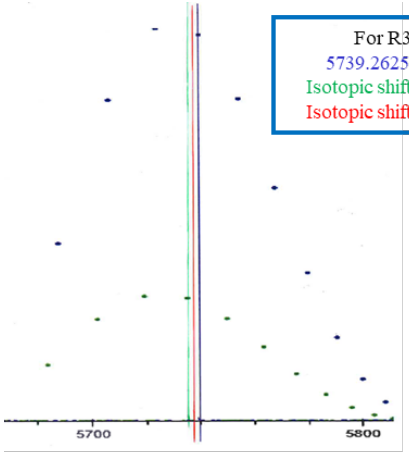




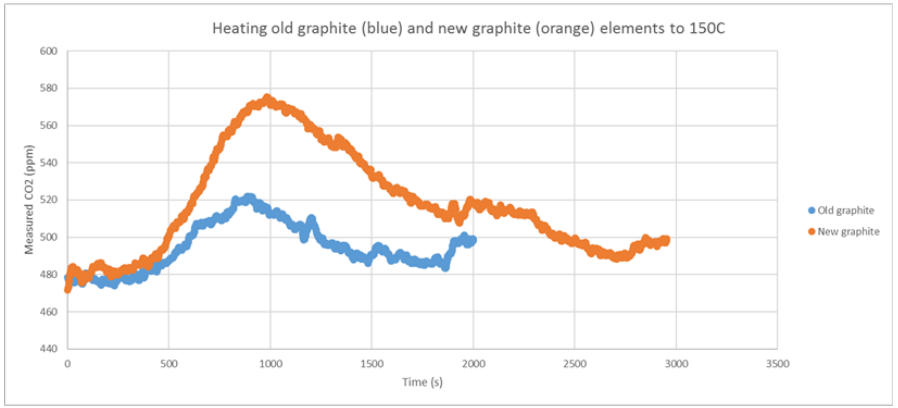
Absorption spectrum of CO_2 isotopes

WP5 current status

- Development of CRDS $H^{36}Cl$ measurement
  - Identification of a suitable $H^{36}Cl$ absorption line
  - Matrix composition – potential impact of water has been studied
- Investigation of the release behaviour of C-14
  - Study of CO_2 outgassing from non irradiated graphite



Line position of HCl isotopes



WP6 DISSEMINATION & TRAINING

Communication tools

To integrate, communicate and disseminate CHANCE results within the European community involved in radioactive waste management

- **Communication** to broader European community involved in radioactive waste disposal
- **Study on the socio-technical concerns** and uncertainties associated with the principles and characterization methodology of radioactive waste
- **Training and education** of young professionals
  - CHANCE Mobility-fund in the field of characterization of conditioned radioactive waste by means of non-destructive analytical techniques and methodologies
  - Open to Master students, PhD students and junior professionals
    - Internships, thesis preparations or scientific visits hosted by a partner of the CHANCE project
    - Participation in conferences and workshops

  Further information available on www.chance-h2020.eu
- **Synthesis** report integrating all CHANCE results

WP6 Leader: SCK•CEN – Contributors: Andra, ENEA, FZJ, INCT

Communication tools

- Public website : www.chance-h2020.eu
  - News about the project, events, Public Deliverables, Publications
- Participation to national and international events (conferences, workshops,...)
- Specific communication through IGD-TP (website, newsletter,...)
- Training course (will be organized towards the end of CHANCE project)

- CHANCE Topical Day (SCK•CEN)
  - 21 - 22 March 2019 in Mechelen, Belgium
  - Objectives were to give an overview of NDA characterization methods and share experiences and future challenges

102 persons participated at the Topical Day

141 different devices logged onto the live-stream during the day

THANK YOU FOR YOUR ATTENTION !