



Characterization of Conditioned Nuclear Waste  
for its Safe Disposal in Europe

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

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# CHANCE

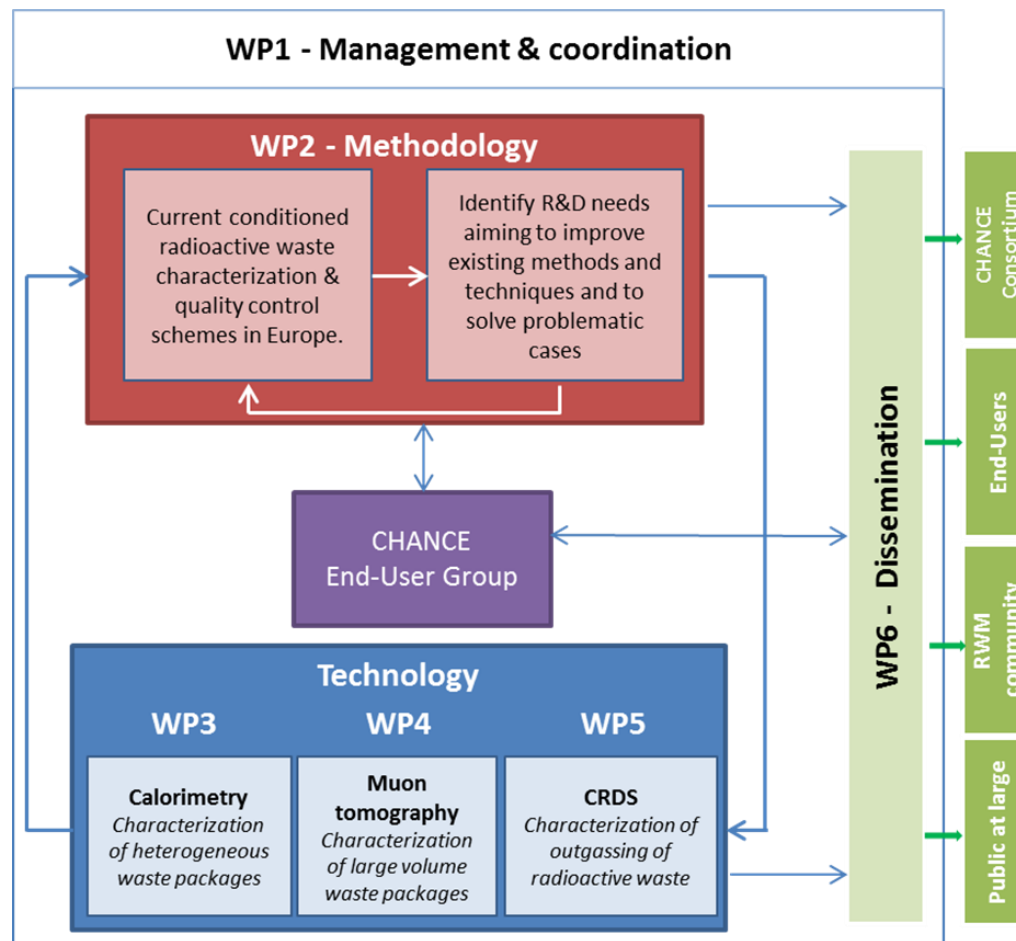
Characterization of Conditioned Nuclear Waste  
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- Euratom research and training programme 2014-2018
- NFRP 7-2016-2017 topic "Research and innovation on the overall management of radioactive waste other than geological disposal"
- 4 years project: 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



- 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

## CHANCE structure



## WP2 – Methodology: 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
    - Waste Management Organizations (WMOs), regulators, disposal operators, waste producers...
  - A specific End-Users Group (EUG)

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

- A questionnaire was prepared to obtain a broad overview of the characterization of conditioned radioactive waste (WAC, methods currently used, needs, special issues, socio-technical and ethical frameworks, etc)
  - **End-User-Group Questionnaire**  
(D2.1 available at [www.chance-h2020.eu](http://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](http://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)

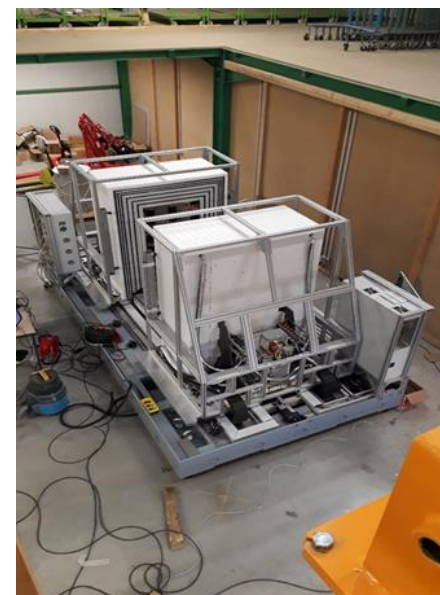
## Inventory of radionuclides by measuring Beta or alpha radiation heat sources

- identify how calorimetry can complement existing, widely-used techniques (gamma spectrometry and neutron passive measurement)
- uncertainties assessment related to calorimetry and its coupling to other non-destructive techniques



Development of a novel calorimeter with an optimized detection limit able to host a 200L drum

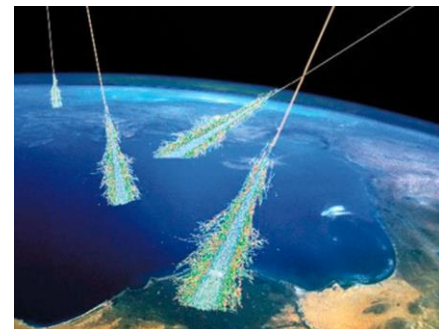
Dedicated experimental program with mock-up drums and possibly real drums



# Muon tomography

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

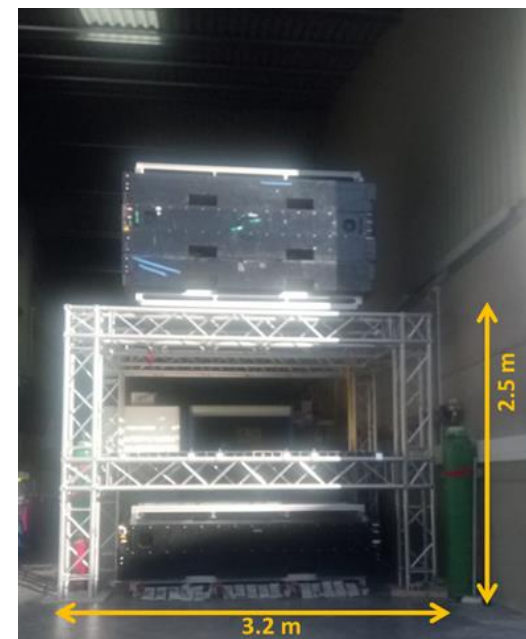
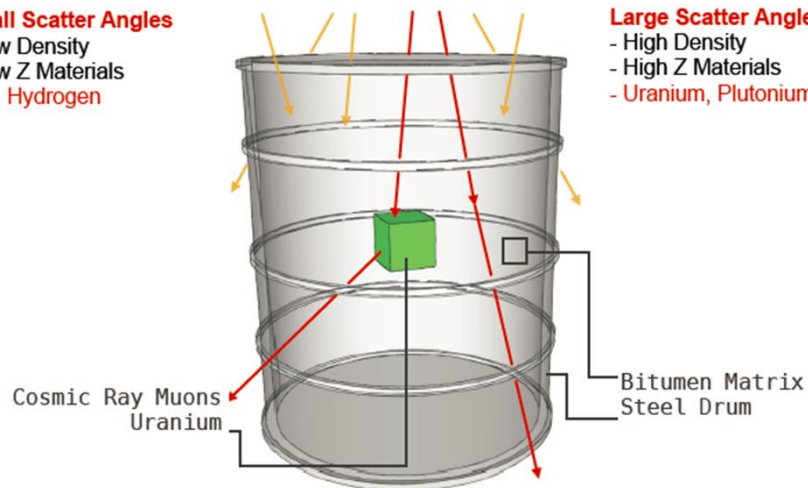


## Small Scatter Angles

- Low Density
- Low Z Materials
- Air, Hydrogen

## Large Scatter Angles

- High Density
- High Z Materials
- Uranium, Plutonium



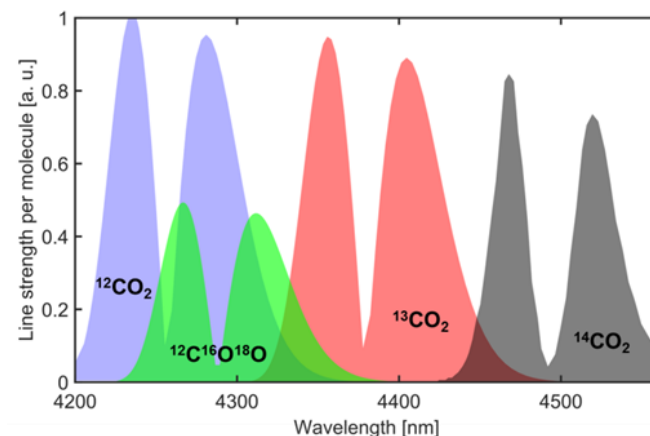
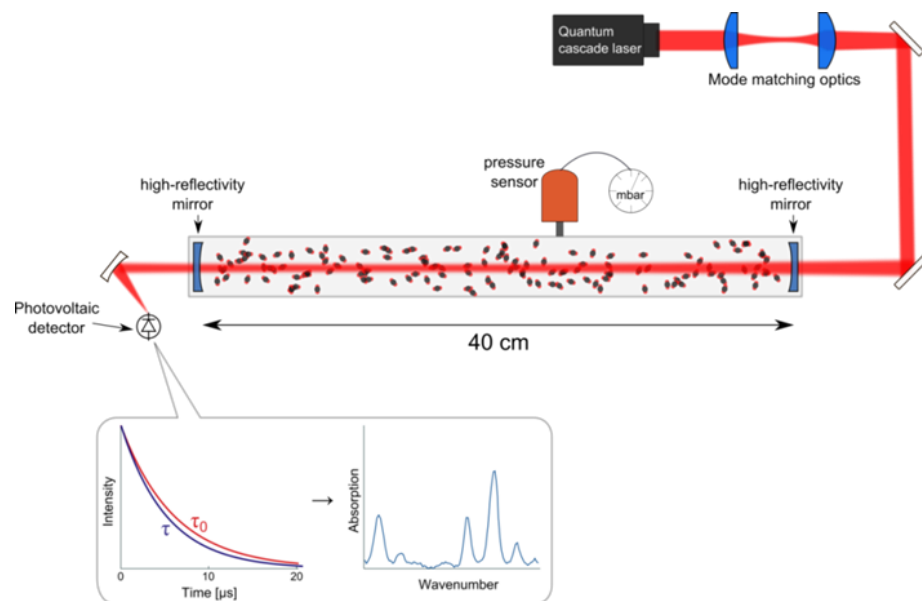
Leader: University of Bristol – Contributors: SCK•CEN, University of Sheffield, WUT



# Cavity Ring-Down Spectroscopy

On-line measurements of waste outgassing based on optical spectroscopy

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



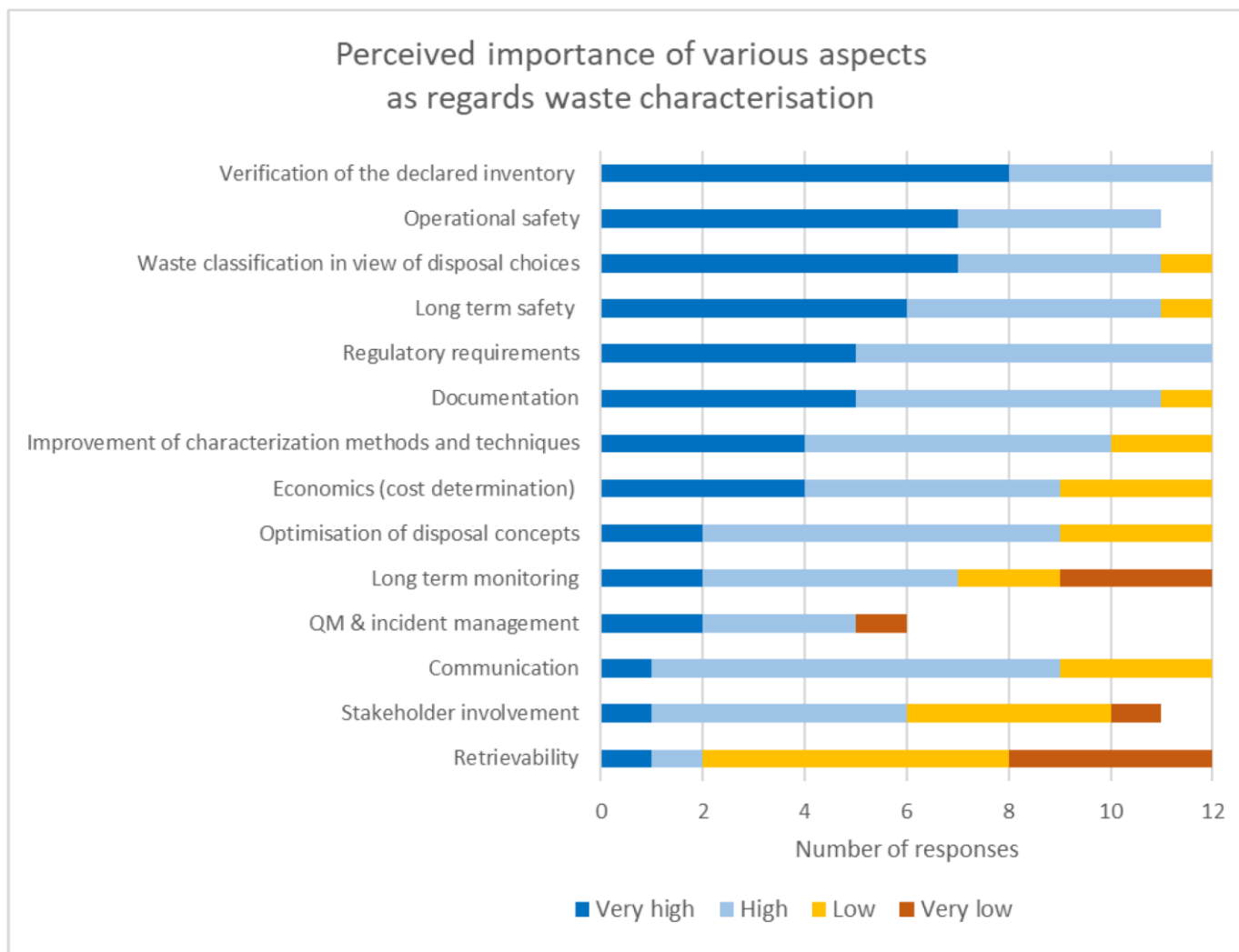
*Absorption spectrum of  $\text{CO}_2$  isotopes*

# Survey synthesis

# Waste acceptance criteria

- Large variability of waste *radiological, chemical* and *mechanical* parameters in different countries
  - different conditioning matrices are used, such as bitumen, cement, glass or polymers
  - diverse treatment technologies, ...
- Waste acceptance criteria ***harmonisation is challenging***
  - for ***safety relevant parameters***, harmonisation is considered neither possible nor desirable
  - harmonisation may be appropriate and achievable for the underlying rationale for waste acceptance criteria
- a variety of characterization methods are needed

## Importance of waste characterisation



## Main methods currently used

- nuclide vector and scaling factor methods
- direct information about the origin of waste streams under consideration
- dose rate conversion with approved nuclear vectors
- spectroscopic techniques (alpha, beta and gamma spectrometry)
- neutron measurements in some specific cases
- calorimetry and X-ray inspection in some cases

# 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.

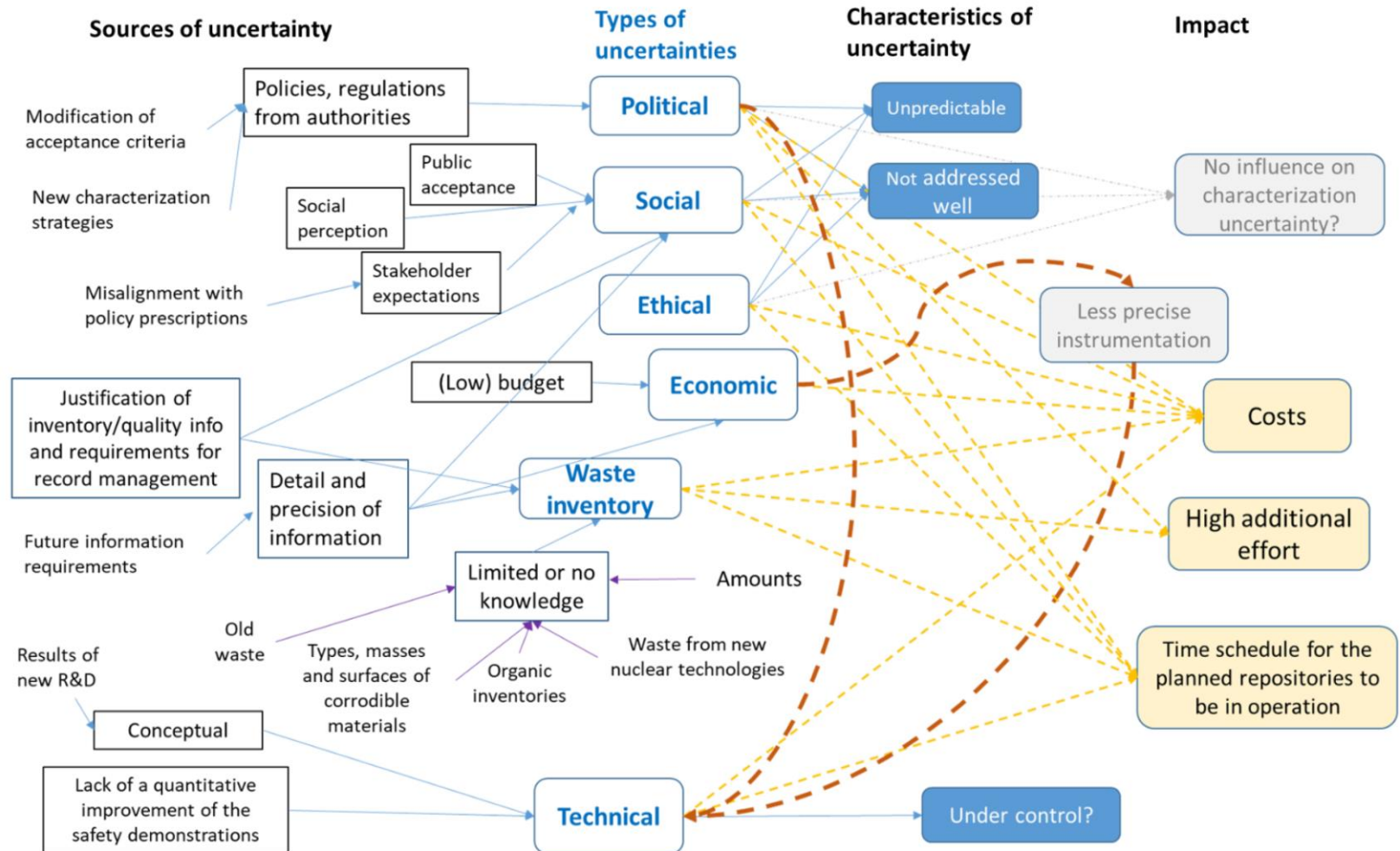
- Developing of ***non-destructive methods*** capable to detect the radiological (including  $\alpha$  and  $\beta$  emitters) and fissile mass, as well as the chemical content
- The new developed methods should be able to be applied:
  - for **homogeneous and heterogeneous waste**
  - on waste packages of **different sizes**, including SNF casks.

## On-going R&D programs

- High energy X-ray imaging
- Gamma-ray spectroscopy
- Passive neutron measurement
- Active neutron interrogation
- 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**



## Impact of measurement uncertainties



- Combination of different methods
  - Reduce uncertainties
  - Increase flexibility
- use same methods for different types of characterisation tasks
- many methods at early stage of development
  - validation of methods developed in CHANCE and elsewhere with real waste
  - Feedback from end-users to adapt methods to specific needs
  - important to also consider commercialisation aspects to ensure uptake of developed method by end-users



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# Thank you for your attention !