NPL National Physical Laboratory

EURAMET

PREPAREDNESS

Metrology for mobile detection of ionising radiation following a nuclear or radiological incident.

Preparedness – WP2: Transportable air-sampling systems

EMPIR Preparedness – Online Stakeholder Workshop

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WP2 - Overview

Aim: To develop transportable air-sampling systems for quick information on radioactive contamination levels in air.

Modular and portable systems, based on gamma spectrometric detectors, shall be further developed to commercially available industrial prototypes, which will allow the quick transportation to any place of interest.

This will support the collation of reliable information on radioactive releases immediately after a real emergency.

WP2 - Deliverables

	Description	Format	Partners	Deadline
D3	Procedures for in-field use of trans-portable air-sampling systems with gamma spectrometers for radiation emergency situations, including calibration, validation and operation of such systems.	Documented procedures	**NPL**, CMI, IJS	M34
D4	Report on novel air-sampling systems for radiological/nuclear event response, including two industrial pre-production models, based on spectrometric detectors developed for deployment in radiation emergency situations.	Report	**NPL**, Kromek, IJS, CMI, NUVIA *	M36

Task 2.1

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Procedures for in-field use of transportable air-sampling systems (NPL, CMI, IJS, BfS)

Activity	Description	Partners
2.1.1	Review of the state of the art of transportable air monitoring equipment	NPL, BfS, CMI
2.1.2	Review of standards	NPL
2.1.3	Procedures for in-field calibration and validation	NPL, CMI, JSI
2.1.4	Procedures and quidance document for in-field operation	NPL, CMI, JSI
2.1.5	Deliverable: guidance document	NPL, CMI, JSI

Task 2.2

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Development of transportable air-sampling systems

Activity	Description	Partners
2.2.1	Scenario modelling	NPL, Kromek
2.2.2	Upgrade of QuantAir	Kromek, NPL
2.2.3	Upgrade of MARE	JSI, NPL
2.2.4	Upgrade of CEGAM	CMI, NPL, NUVIA
2.2.5	Monte Carlo model	EHU
2.2.6	Digital data standard	JRC, NPL

Task 2.2 – Instrument #1

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QuantAir (Kromek)

- Designed for iodine monitoring in/around NPP
- Light weight, carried by hand
- CdZnTe CPG detector
- Currently designed for charcoal filter but can be adapted for standard filter
- Instrument will be calibrated with spiked filters for determination of Cs-137 in air.

kromek™

Task 2.2 – Instrument #2

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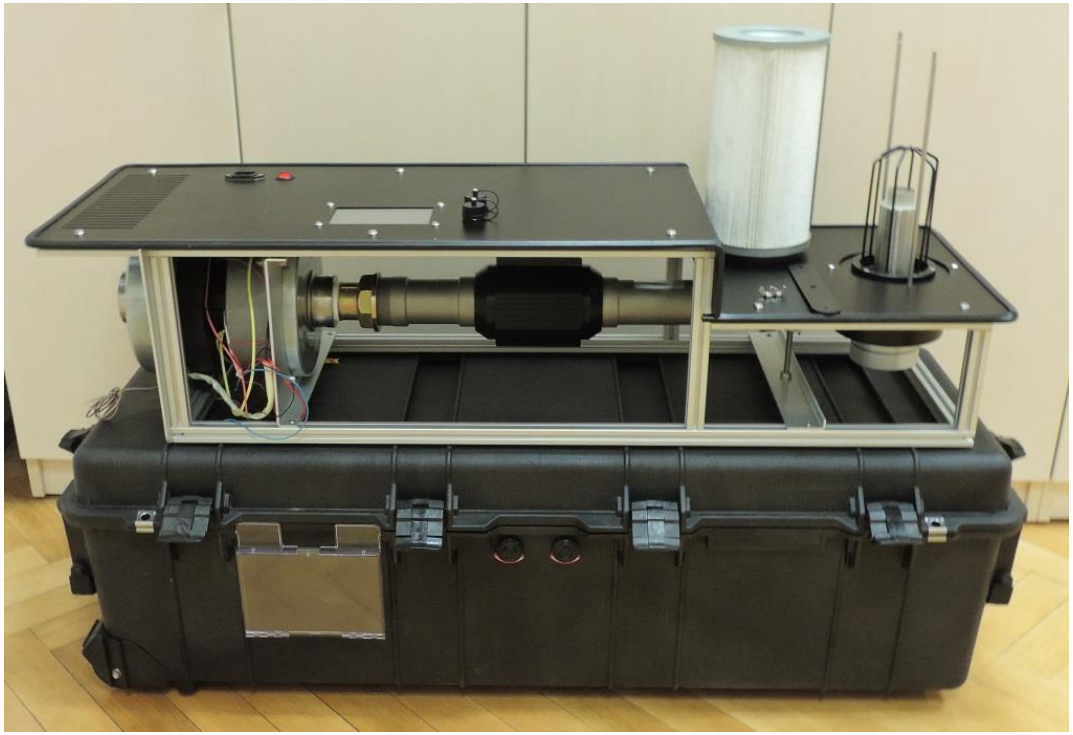
MARE (IJS, Slovenia)

- Monitoring Air-pump for Radioactive aErosols (MARE)
- Designed for environmental monitoring / nuclear preparedness
- Compact, built into flight case
- CeBr gamma spectrometer
- High volume air sampler (200 m^3/hr)
- Remote operation and 3G communication



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Task 2.2 – Instrument #2

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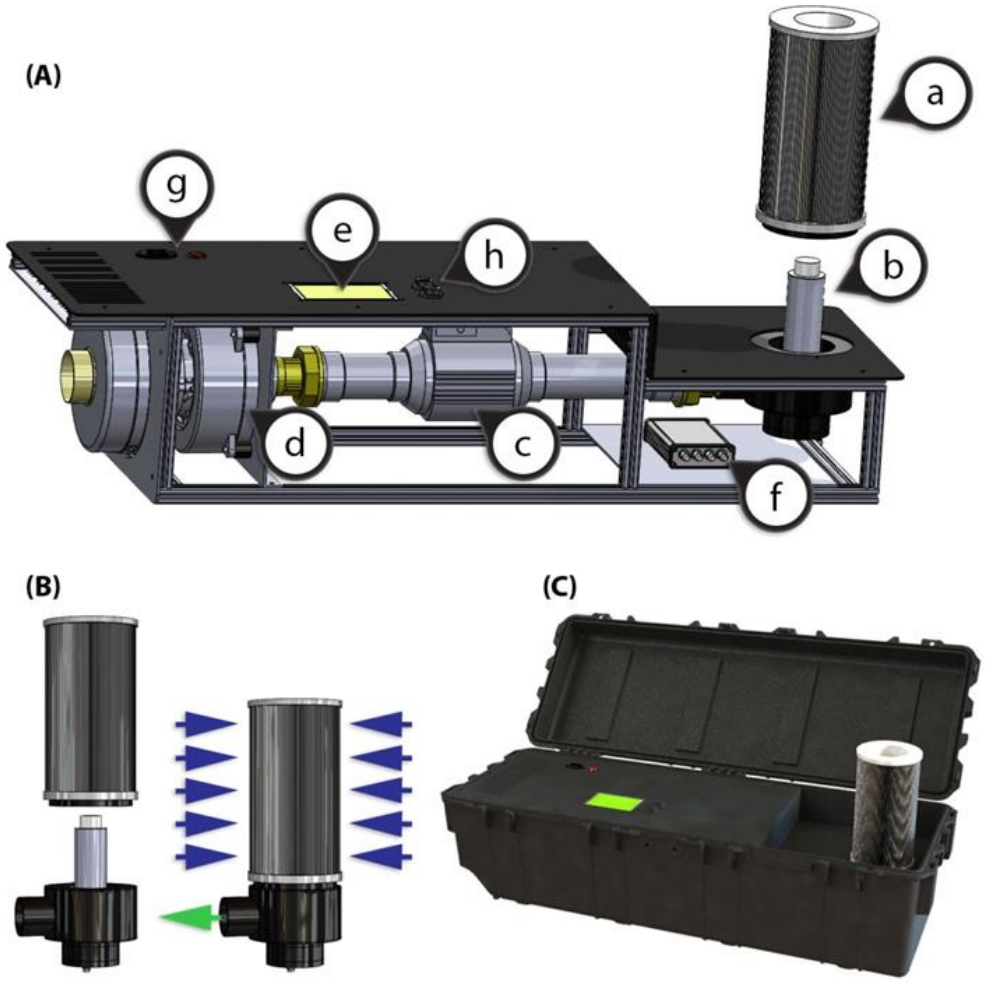
MARE (IJS, Slovenia)



- Air pump system assembly (A):
  - a) concertina aerosol filter
  - b) $CeBr_3$ detector
  - c) flow meter
  - d) air pump
  - e) microcontroller unit
  - f) preamplifier and DPU
  - g) 230 V AC power connector
  - h) 2 USB connectors
- Filter assembly and airflow (B)
- Final design of in-field monitoring device incorporated in hard duty portable Peli Case (C)

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Task 2.2 – Instrument #2

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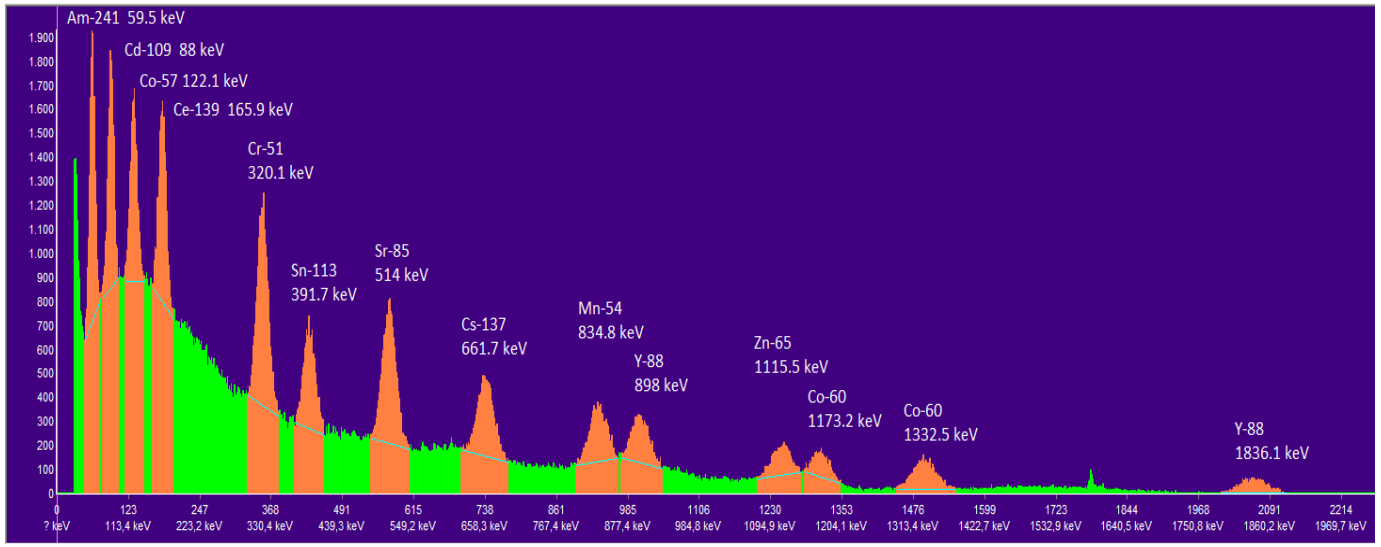
MARE (IJS, Slovenia)

Progress:

- System upgraded for fully autonomous or remote operation with communication protocol built into GAMWIN spectra acquisition and analysis software
- Isotope identification algorithm has been developed
- System being calibrated and tested with filters spiked with known activities of a range of radionuclides



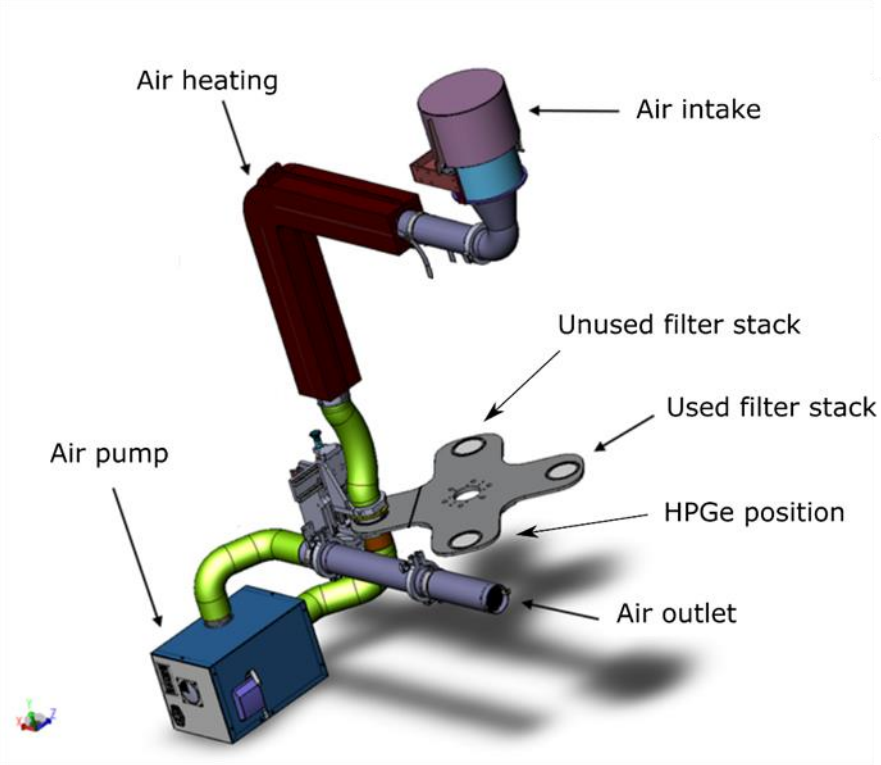
Task 2.2 – Instrument #3

CEGAM (Nuvia, CZ)

- Continuous Environmental Gas Aerosol Monitor (CEGAM)
- Designed for environmental monitoring / nuclear preparedness
- Transportable and re-deployable
- Autonomous operation
- HPGe gamma spectrometer can be installed for on-line measurement in emergency scenario. NaI(Tl) version planned
- Low background bricks used to build shielding in-situ
- Instruments may be linked via LAN/WAN/ xDSL/mobille/satellite network connection
- Air sampling rate up to 60 m^3/hr for standard glass fibre filter

Task 2.2 – Instrument #3

CEGAM (Nuvia, CZ)



- 1st position for uploaded clean filters
- 2nd position for deposition of filters
- 3rd position for measurement of deposited filters
- 4th position for unloading filters

Task 2.2 – Instrument #3

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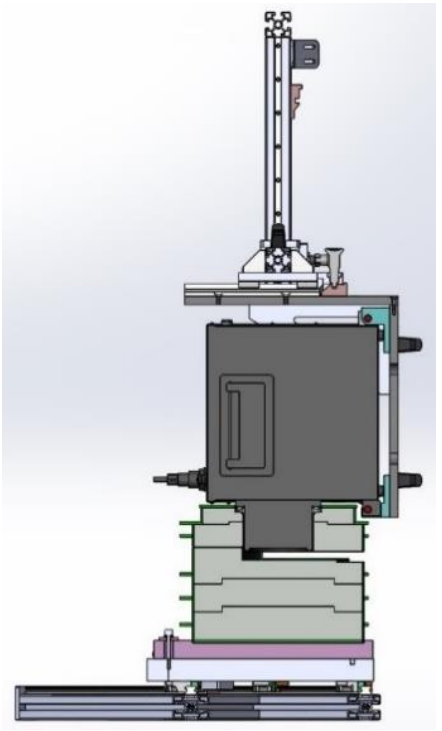
CEGAM (Nuvia, CZ)

Stacks for stored filters

Detector Ortec IDM-200V



Detector in the shielding

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Task 2.2 – Instrument #3

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CEGAM (Nuvia, CZ)

- Easily transportable to a site as ‘shipping container’
- Air conditioned and filtered ventilation
- Power supply 400 V
- LTE modem for remote access
- Meteological station
- GM tube for dose rate monitoring

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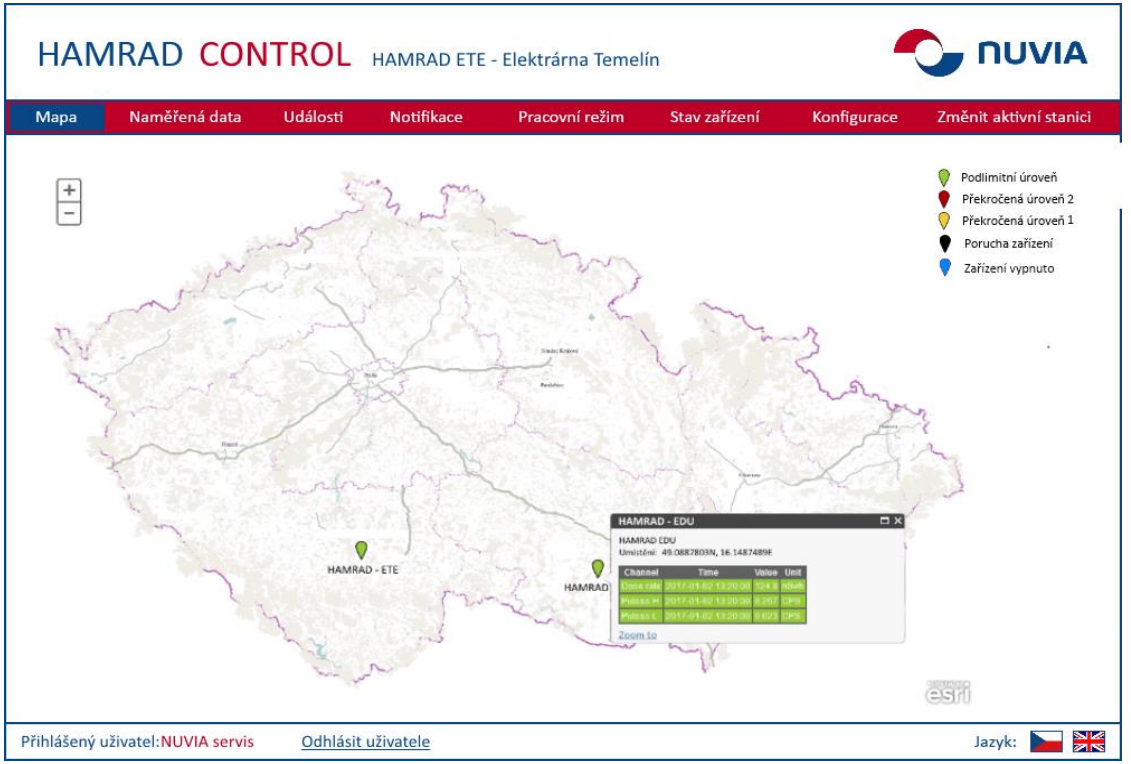
NUVIA

Task 2.2 – Instrument #3

CEGAM (Nuvia, CZ)

- System control
  - Sends commands to PLC
  - Manual/automatic regime
  - Definition of measuring sequence
    - Sampling interval
    - Sampling and measuring times
    - Air flow
    - Background measurement
- Automatic data evaluation
  - Gamma-ray spectra analysis
  - Calculation of activity concentration in air [Bq/m^3]
  - Final report writing



HAMRAD control system

Task 2.2 – Instrument #3

CEGAM (Nuvia, CZ)

Progress:

- Software developed for fully automatic operation, calibration and spectra evaluation
- Background subtraction algorithm developed and implemented
- The system was installed and tested over a year at the station monitoring surroundings of NPP Dukovany (CZ).
- Tested parameters
  - Stability of the remoted controlled operation; after some problems with the remote access occuring within the 6 first months, the system worked flawlessly
  - Measuring part stability; all parameters met conditions required by standard IEC1452
  - Sampling part stability; after some problems with uploading and unloading filters during the 3 first months, the system worked smoothly
  - Background measurement with deposited filters (only natural radionuclides occured in spectra); minimum detectable volume activities (calculated after the standard ISO 11929) for key artificial radionuclides (e.g. Co-60, Cs-137) were better than 1 mBq/m^3 (sampling time 24 hours, measuring time 12 hours)

Task 2.3

On-site comparison exercise of transportable air sampling monitors at Chernobyl

Activity	Description	Partners
2.3.1	List of transportable air monitors	NPL
2.3.2	Organise on-site comparison exercise	NPL
2.3.3	Perform on-site comparison exercise	NPL, JSI, Kromek
2.3.4	Report on on-site comparison exercise	NPL
2.3.5	Deliverable: report on development of monitors	NPL, CMI, JSI, Kromek, NUVIA

Cancelled due to COVID-19!

Aim to revive plan in future!

Task 2.4

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Rapid radiochemical separation and analysis for the determination of airborne alpha and beta emitting radionuclides

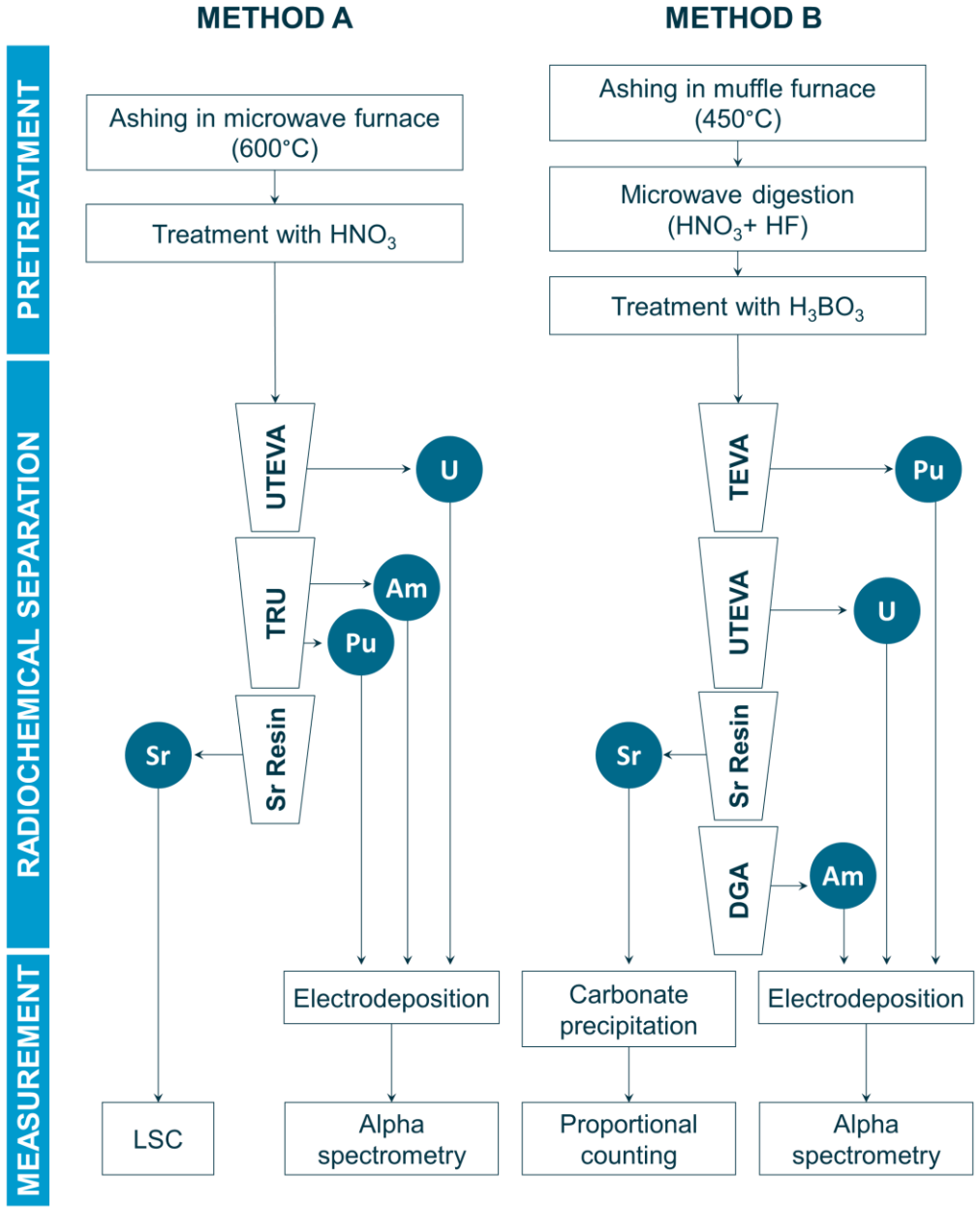
Activity	Description	Partners
2.4.1	Develop procedure for rapid radiochemical procedure	PTB, EHU
2.4.2	Test rapid radiochemical procedure	PTB, EHU
2.4.3	Measurement procedure for separated radiochemicals	PTB, EHU, NPL
2.4.4	Validation of rapid radiochemical separation and measurement procedures	PTB, EHU, NPL

Task 2.4

Rapid radiochemical separation and analysis for the determination of airborne alpha and beta emitting radionuclides captured on filters

The radionuclides under study are U, Pu, Am and Sr.

The work is ongoing and diverse radiochemical separation procedures using ion-exchange and extraction chromatography resins are being tested.



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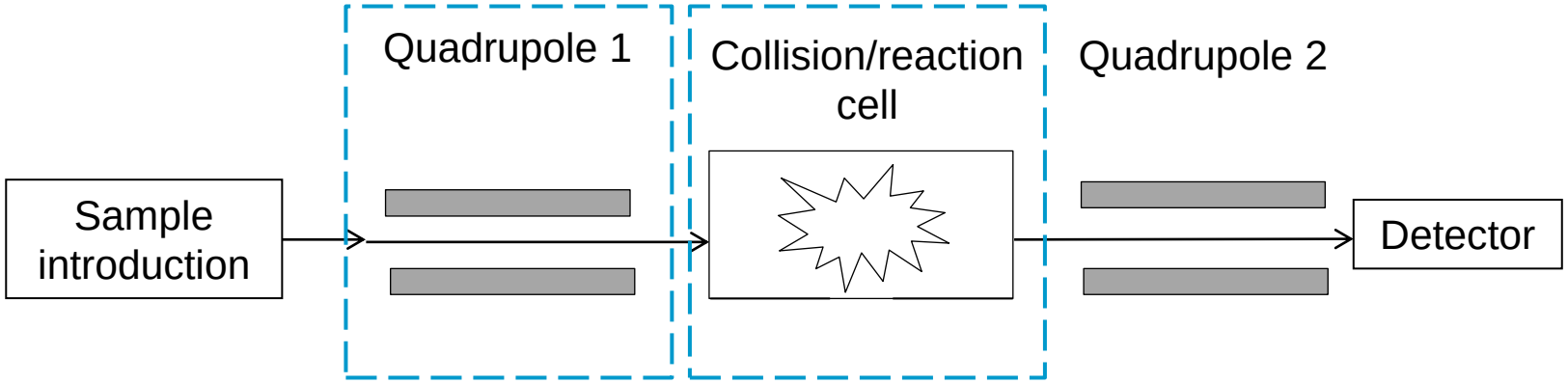
Tandem ICP-MS/MS

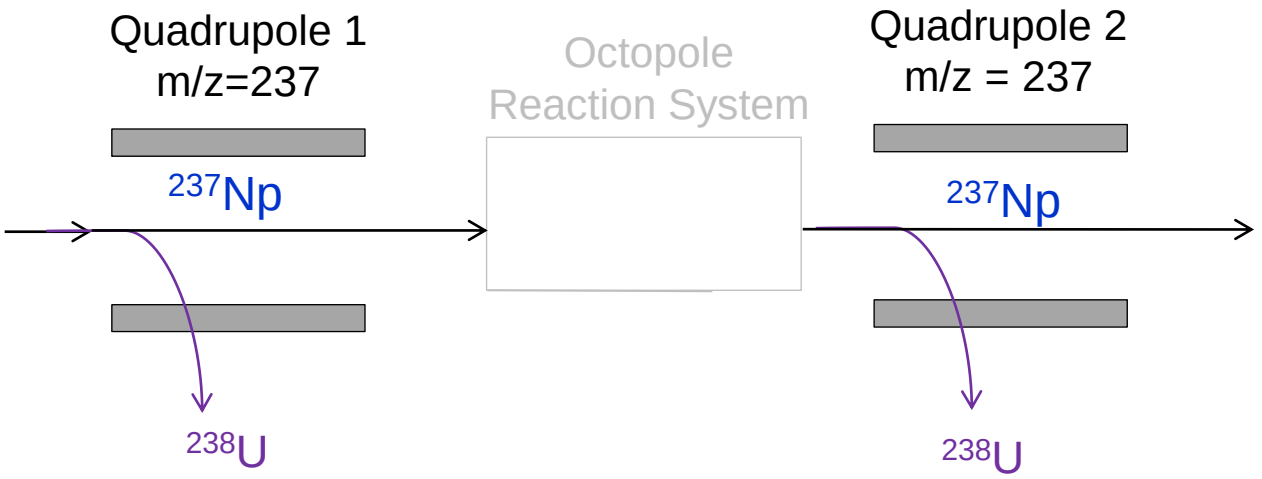


- **Additional mass filter (MS/MS mode)-**
  - Improved tailing removal capability
  - Filtering of ion beam before cell entrance improves understanding of cell chemistry
- **Collision/reaction cell**
  - Support or replacement of offline chemical separation for isobaric and polyatomic removal
- Q1 and cell can be switched on or off, cell conditions can be varied

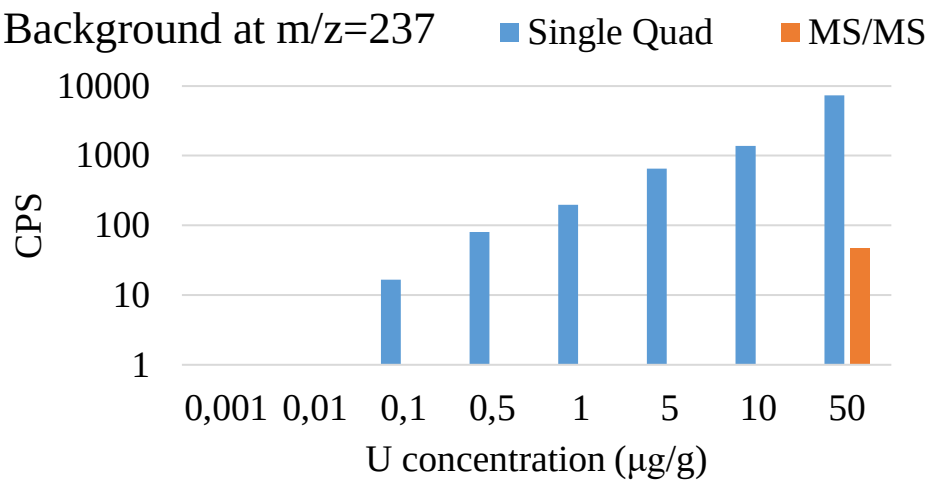
- Air filters obtained from NPL Gas and Particle Metrology Group and spiked with radionuclides of interest
- Dissolved in 10 mL concentrated HNO_3 using microwave digestion, then diluted up to 50 mL with deionised water and run by ICP-MS
- Total procedural time around 1 hour for microwave digestion, and 5 minutes per sample for ICP-MS measurement
- No chemical separation prior to measurement
- Stable element composition also assessed

Neptunium-237

- Interferences to consider:
  ^{238}U tailing

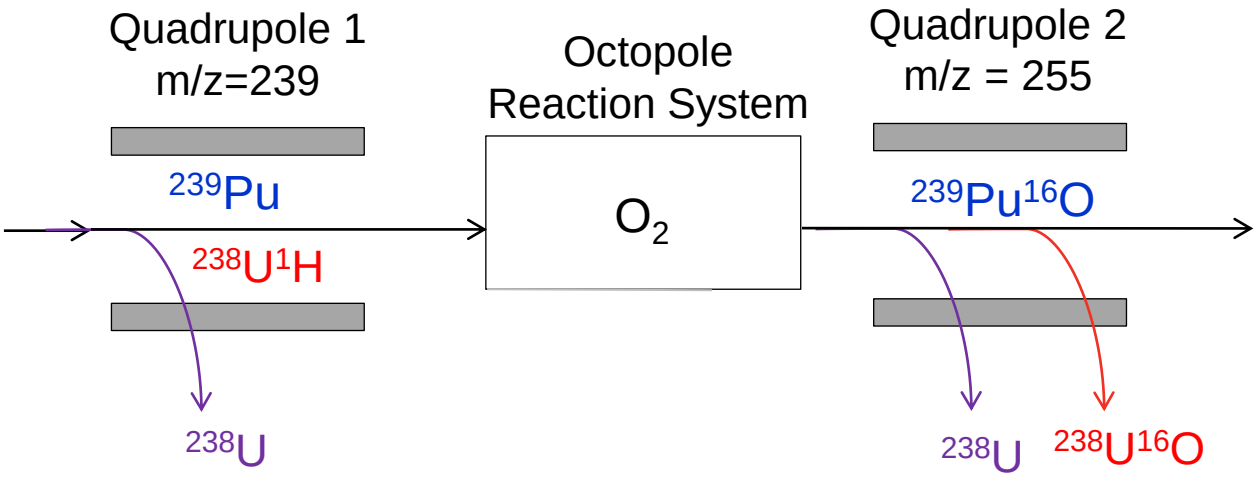


- Collision/reaction cell not needed
- Improved ^{238}U tailing removal with two mass filters (MS/MS)

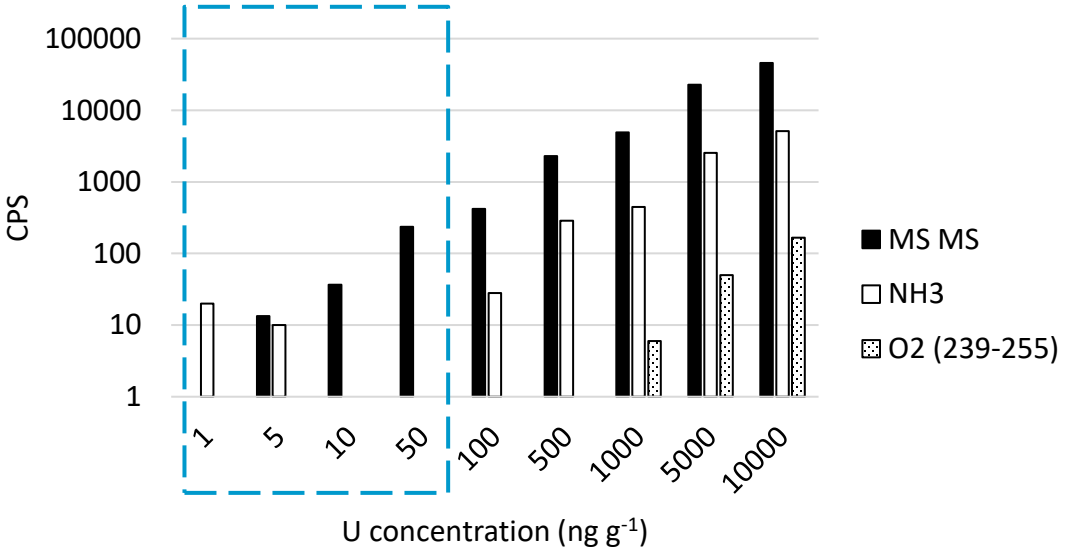


Plutonium-239

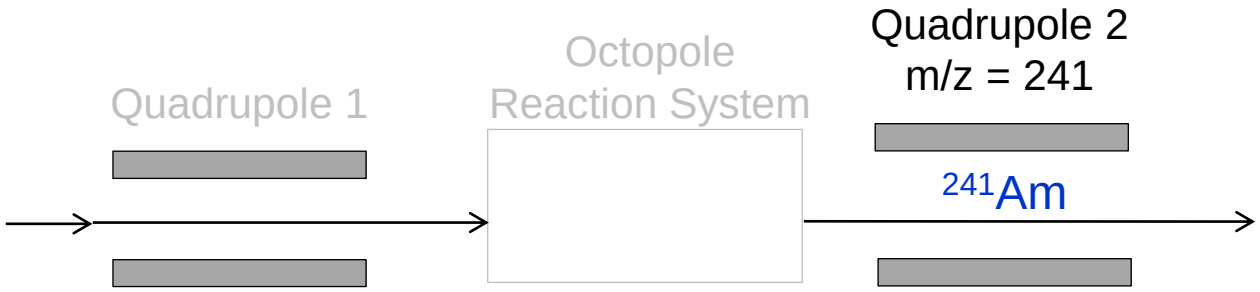
- Interferences to remove:
- Polyatomic: $^{238}U^{1}H$
- Tailing: ^{238}U



- MS/MS mode improves ^{238}U tailing removal
- O_2 gas used to shift ^{239}Pu to $^{239}Pu^{16}O$, ^{238}UH shifted to non-interfering $^{238}U^{16}O$



Th, U and Am isotopes



- Example shown for ^{241}Am
- Limited interferences to consider
- Instrument can be run in it's most 'basic' mode i.e. with only one quadrupole mass filter

All radionuclides can be measured in a single run

- Up to 8 different setups in one measurement
- A 30 second adjustment time is built in between each 'mode'
- Approximately 5 minutes per sample, ~3 mL sample used
- Future work on method development for ^{90}Sr, and additional filter types

Radionuclide	Instrument LOD (Bq g^{-1})
^{232}Th	4.1×10^{-10}
^{237}Np	1.0×10^{-5}
^{239}Pu	1.6×10^{-4}
^{240}Pu	8.4×10^{-4}
^{235}U	8.0×10^{-9}
^{238}U	1.2×10^{-9}
^{241}Am	1.3×10^{-2}

Thank you for listening!

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