MetroERM Stakeholder Workshop: Airborne Radioactivity Monitoring Networks

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JRC-Ispra
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Airborne radioactivity monitoring networks

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Focus:

- Monitoring of radioactivity-in-air (Bq/m^3) by nuclear facility operators, national early warning networks and first responders

Work package aims to:

- Investigate new gamma spectrometer technologies for monitoring applications
- Develop new on-line, spectroscopic monitoring instruments
- Develop new or improved spectrum analysis techniques
- Determine best practice for calibration and operation of instruments
- Optimise radiochemical methods for filter measurements
- Disseminate findings through stakeholder engagement, peer-reviewed publications, conference presentations and E-learning modules

Transportable air-sampling system

Transportable Air-Sampling System (Nuvia, CZ)

- 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

Transportable air-sampling system

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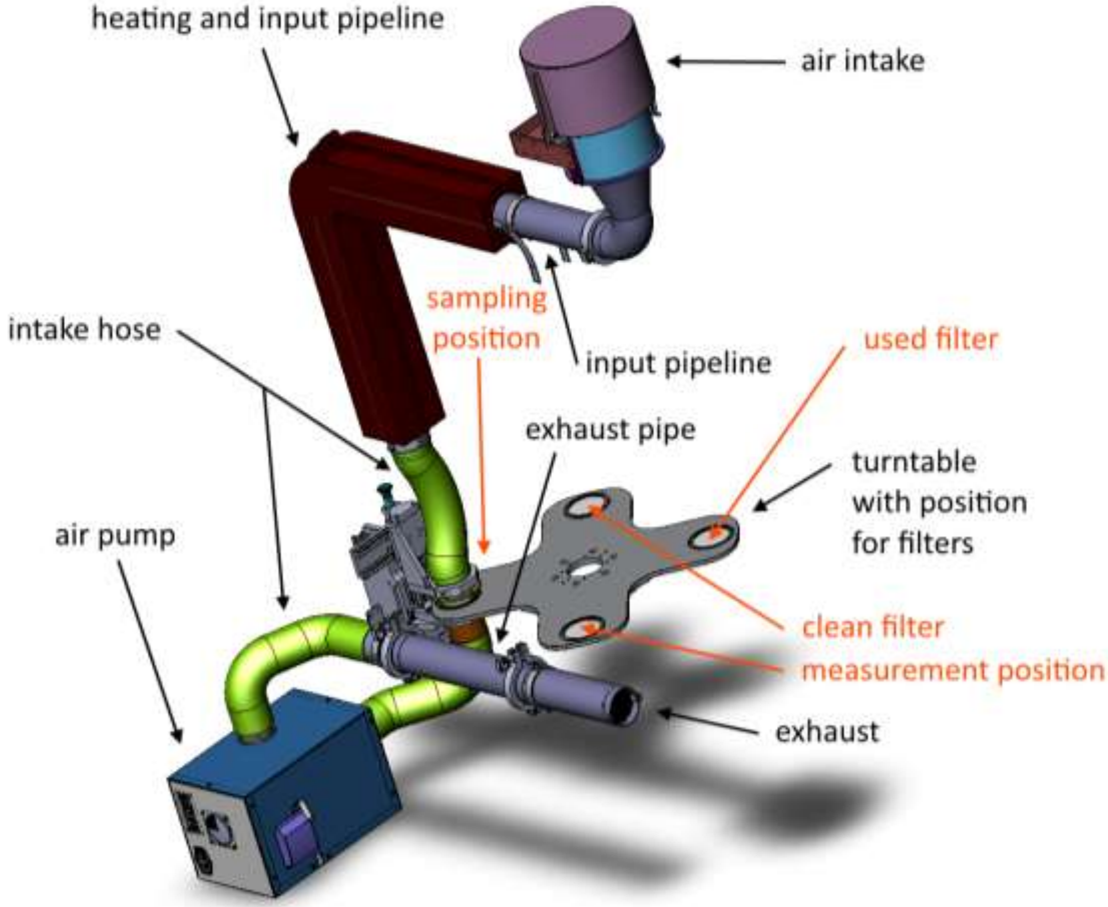

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NUVIA

Continuous airborne radioactivity monitor

Continuous airborne radioactivity monitor (CIEMAT, Spain)

- Designed for continuous & autonomous monitoring at ESMERALDA field station
- Electro-mechanically cooled HPGe gamma spectrometer
- Belt-fed filter
- 25 m^3/hr air sampling rate
- Belt and pump controlled by Raspberry Pi
- Calibrated with spiked filter

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Continuous airborne radioactivity monitor

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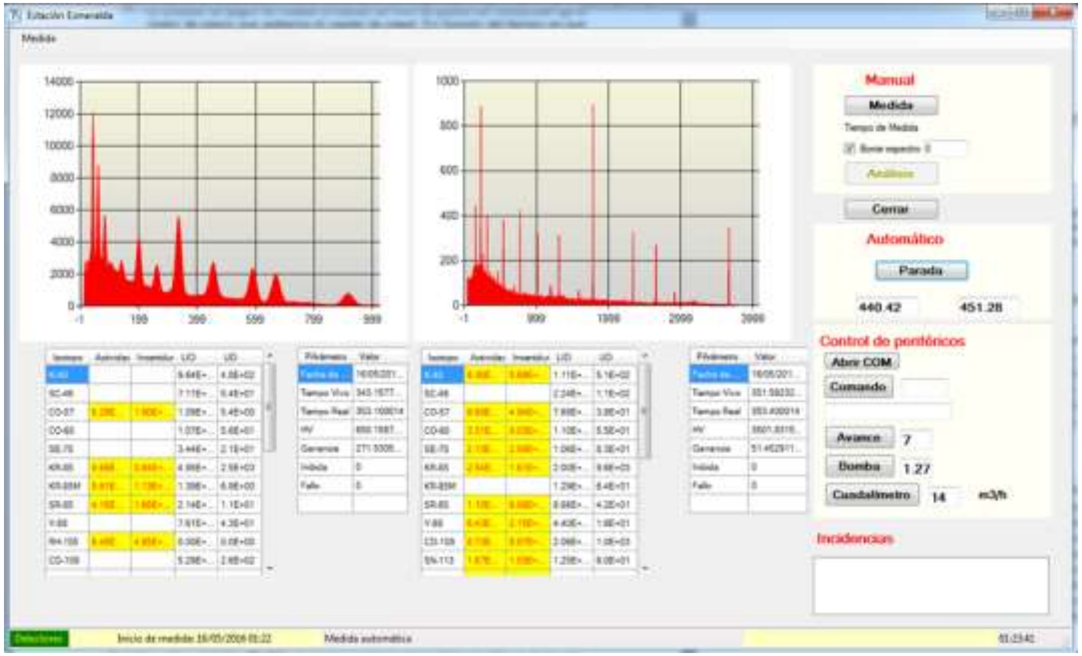
Operation:

- Routine mode*:* 1h measuring intervals. Filter paper is displaced forward after 6h intervals
- Emergency mode:10 min monitoring intervals (but adjustable)
- Software for control, data acquisition, fitting and analysis and record keeping developed at CIEMAT (Visual basic with Active X controls and Genie 2k, libraries, SQL database for data records)



Ciemat
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Continuous airborne radioactivity monitor

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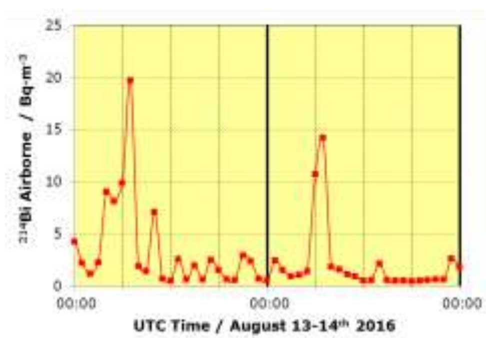
Validation:

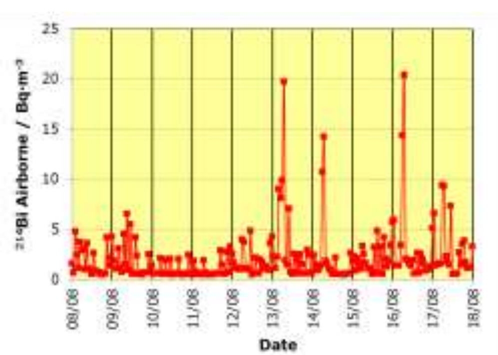
- The system has been running under test conditions for 6 months (May to Oct 2016)
- Unattended operation up to four weeks, with real-time access to results by remote connection

Naturally occurring radionuclides (^{214}Bi)

System sensitivity enables activity concentrations of 1 Bqm^{-3} to be detected

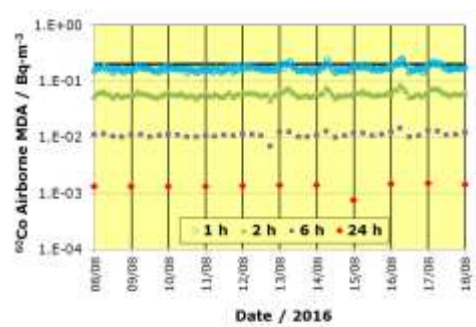


Observed time pattern: close match to 'daily radon progeny cycle' due to radon exhalation

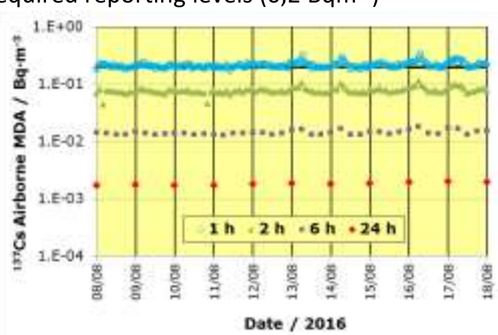


Man-made radionuclides (^{60}Co; ^{137}Cs)

MDA variation with integration time



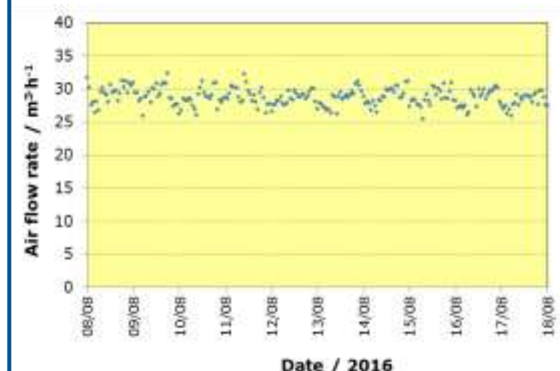
MDAs for 1h integration time-similar to required reporting levels (0,2 Bqm^{-3})



A slight influence of the radon progeny deposited onto the filter is observed when compared with ^{214}Bi time pattern

Air flow rate variation

Maintained constant within 10 % deviation during routine operation



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Compact radioactive aerosol monitor

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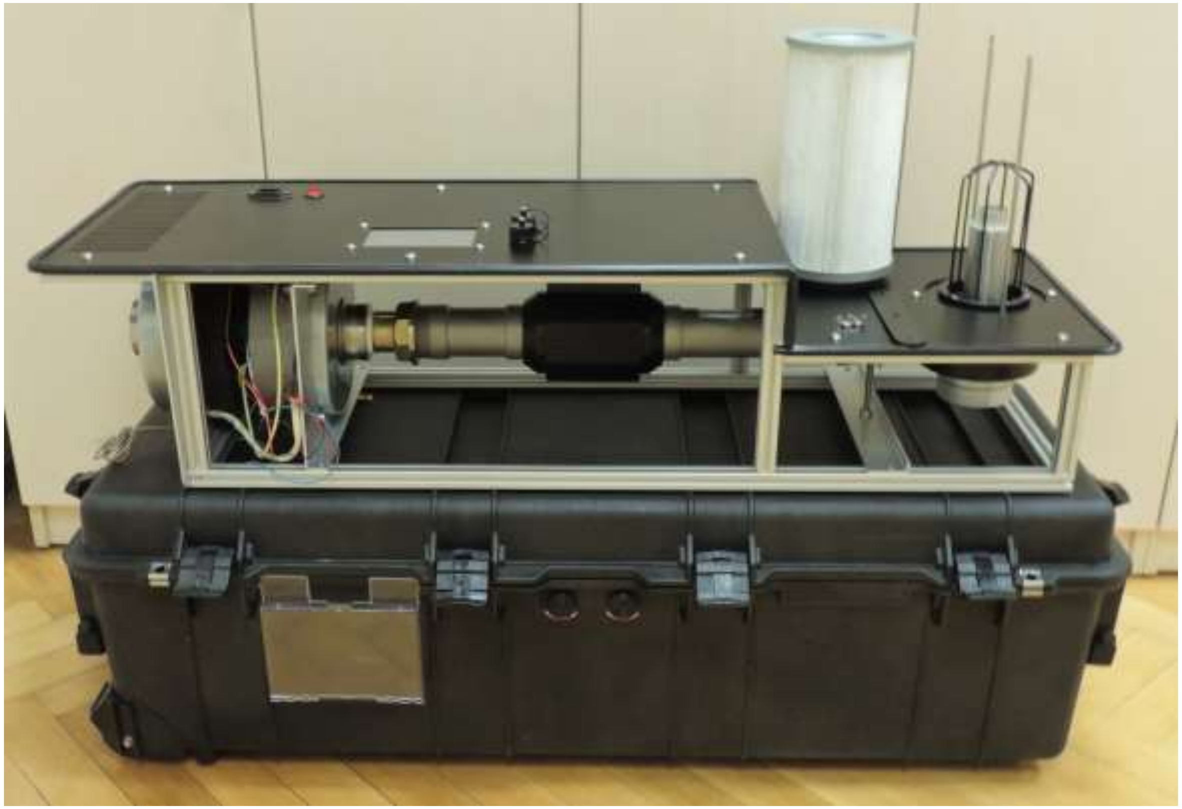
Compact Radioactive Aerosol Monitor (IJS, Slovenia)

- 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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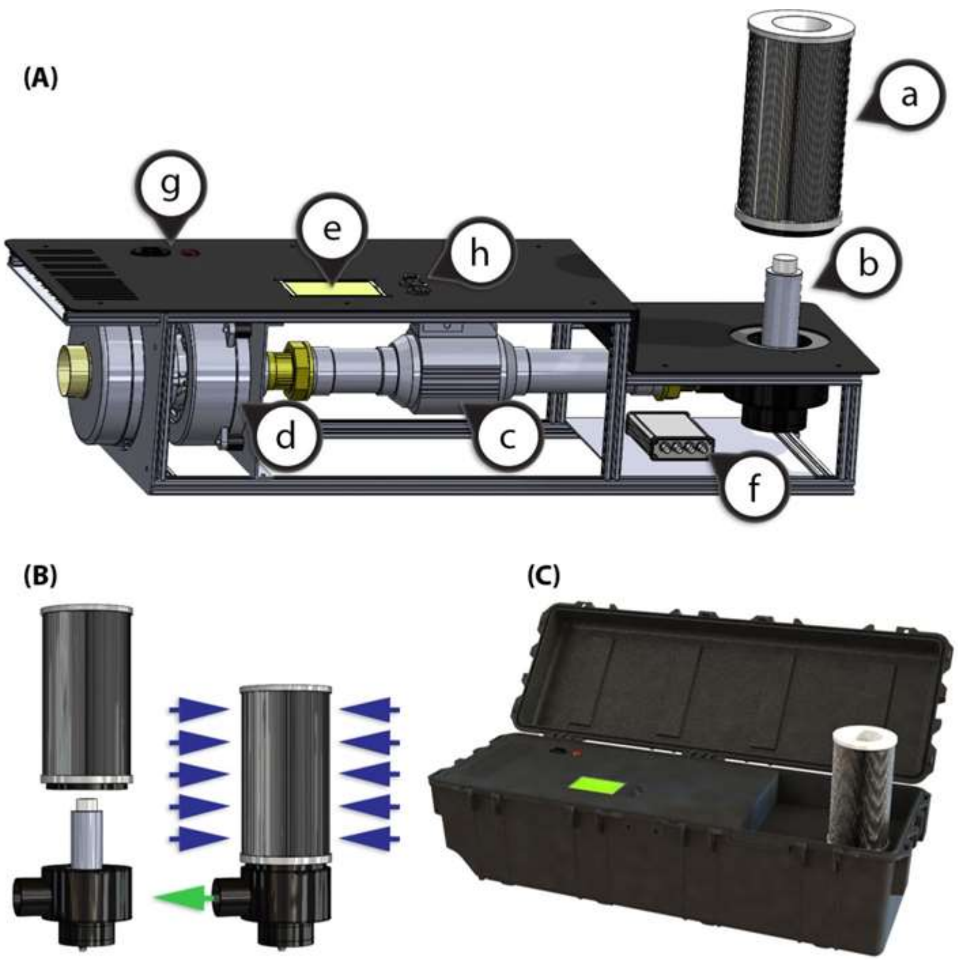
Compact radioactive aerosol monitor



- Air pump system assembly (A):
  - Concertina aerosol filter
  - CeBr3 detector
  - Flow meter
  - Air pump
  - Microcontroller unit
  - Preamplifier and DPU
  - 230 V AC power connector
  - USB connection (x2)
- Filter assembly and airflow (B)
- Hard duty portable Peli Case (C)

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Compact radioactive aerosol monitor

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Calibration and validation:

- Measurements performed at NPL in May 2016 and ENEA in Jan 2017
- Validation measurements of 2 filters spiked with mixed radionuclide solution, without active pump
- Background measurements in lab and elevated radon environment with pump
- Measurements in ENEA walk-in radon chamber for three cases:
  - High radon concentration of about 3000 Bq/m3 without production of artificial aerosol
  - High radon concentration of about 3000 Bq/m3 with production of artificial aerosol
  - Low radon concentration of about 1000 Bq/m3
  - Compared with alpha measurements made by Tracer-lab and AlpaGUARD

ENEA

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Compact radioactive aerosol monitor

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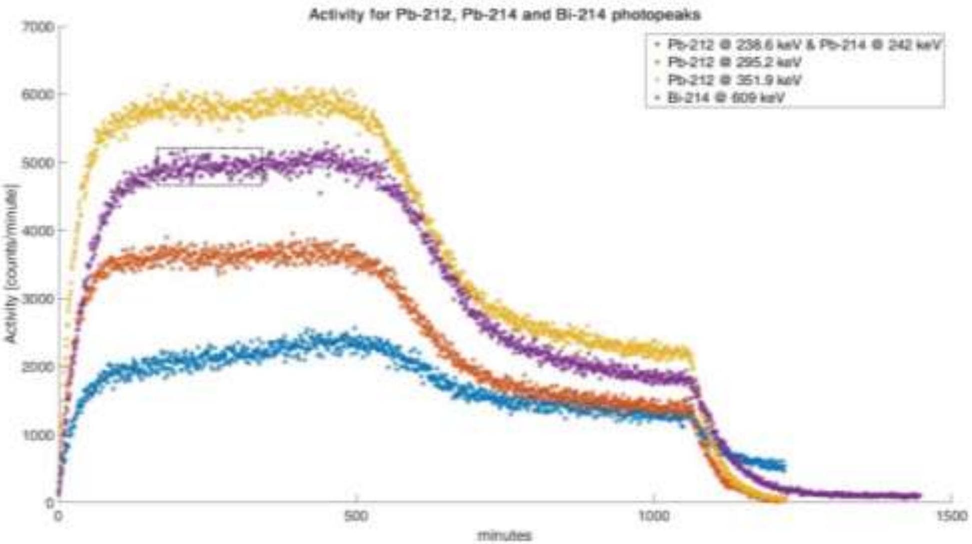
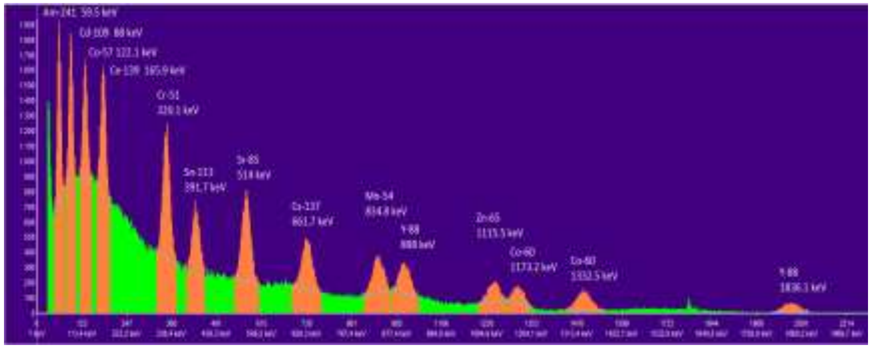
Results:

- Total photo-peak efficiency peaks at slightly less than 1 %, consistent with the size of the detector crystal and the average distance from the filter paper
- Not possible to directly compare the activity of radon-in-air, measured by in-air alpha spectrometry, to the gamma activity of its progeny trapped on the filter as equilibrium in air not reached
- But is possible to compare 609 keV gamma emission following Bi-214 decay to 7.83 MeV alpha emission of Po-214 decay





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Detector comparison

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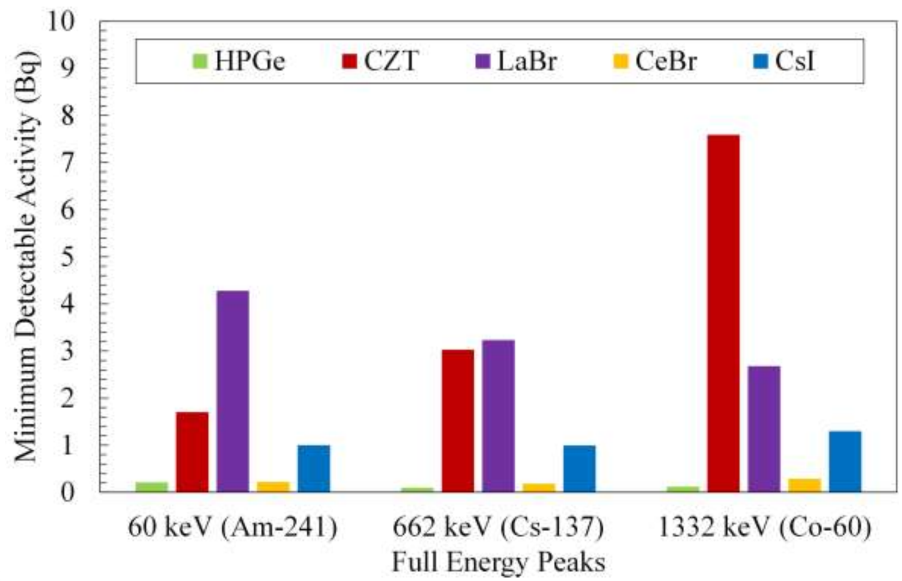
Purpose:

- To support project partners and instrument manufacturers make informed decisions regarding choice of detector



Applications of Novel Scintillators for Research and Industry 2016 (ANSRI 2016) IOP Publishing
Journal of Physics: Conference Series **763** (2016) 012010 doi:10.1088/1742-6596/763/1/012010

A comparison of emerging gamma detector technologies for airborne radiation monitoring

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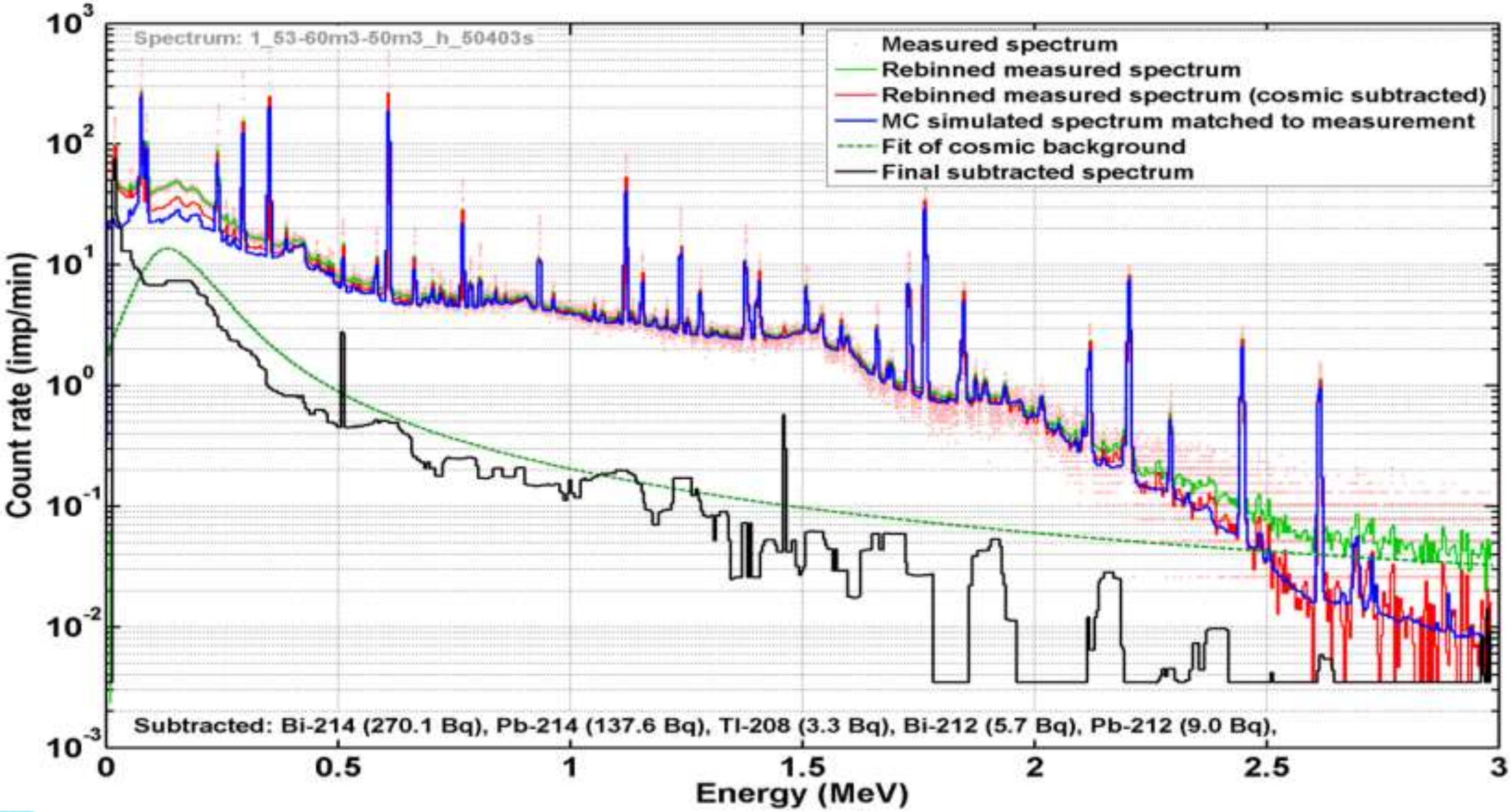
Abstract. This paper presents a comparison of new and emerging gamma detector technologies that have the potential to improve in-situ dose and radioactivity-in-air measurements for national monitoring networks. Five detectors were chosen for investigation: $LaBr_3$(Ce), $CeBr_3$, SiPM-CsI(Tl), Cd(Zn)Te and electromechanically-cooled HPGe. These detectors represent the full range of the price-performance matrix. Comparisons have been made of energy resolution, detection efficiency and minimum detectable activity by exposing each detector to a mixed radionuclide source drop-deposited across a filter. Other factors, such as internal radioactivity, linearity, size and cost have also been considered.

Conclusions:

- HPGe best performing
- CZT / CsI most compact
- $LaBr_3$ has internal radioactivity but this offers gain stabilisation
- $CeBr_3$ provides compromise between price and performance

“Software shielding”

- Subtraction of natural radionuclide contribution to gamma-ray spectra measured by HPGe detector



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NPL Aerosol Facility

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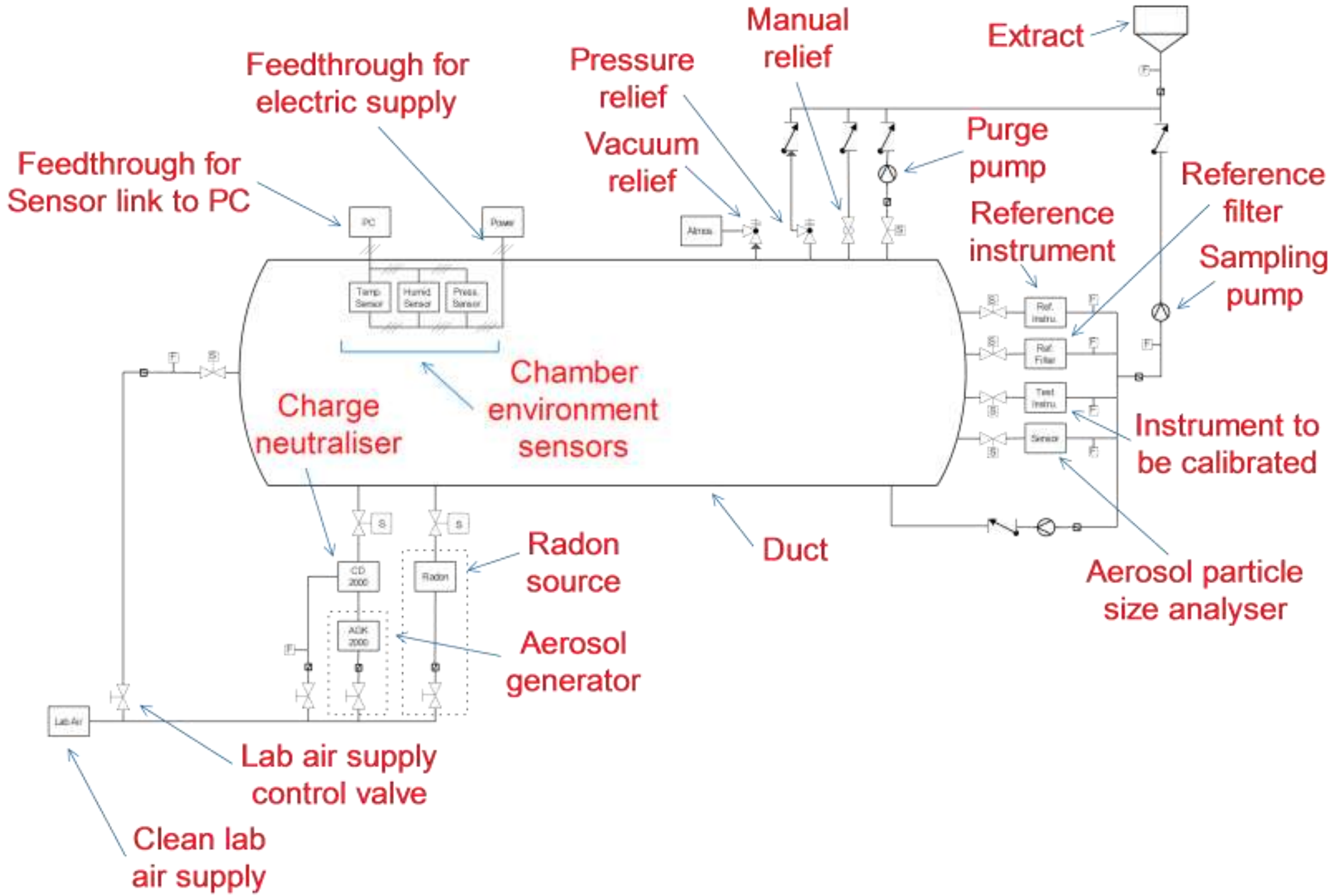
Overview:

- Facility to generate radioactive aerosol for the calibration of radioactivity-in-air monitors and spiked filters
- Development of novel radio-labelled microspheres
- Collaborations with University of Essex and NPL Instrumentation Group
- Prototype built and tested. Second phase currently being built. Further investment required for full system.

NPL Aerosol Facility



Rapid radiochemistry techniques

Purpose:

- Develop faster and radiochemical methods of analysis
- Radionuclides: Alpha & beta emitting radionuclides; U, Pu, Am, Sr-90
- Samples: aerosols collected by high volume air samplers (monitoring networks)
- Faster than common methods (ideally to complete the analysis in 24 h)
- Simultaneous radiochemical separations
- Testing and validation using adequate samples and reference materials

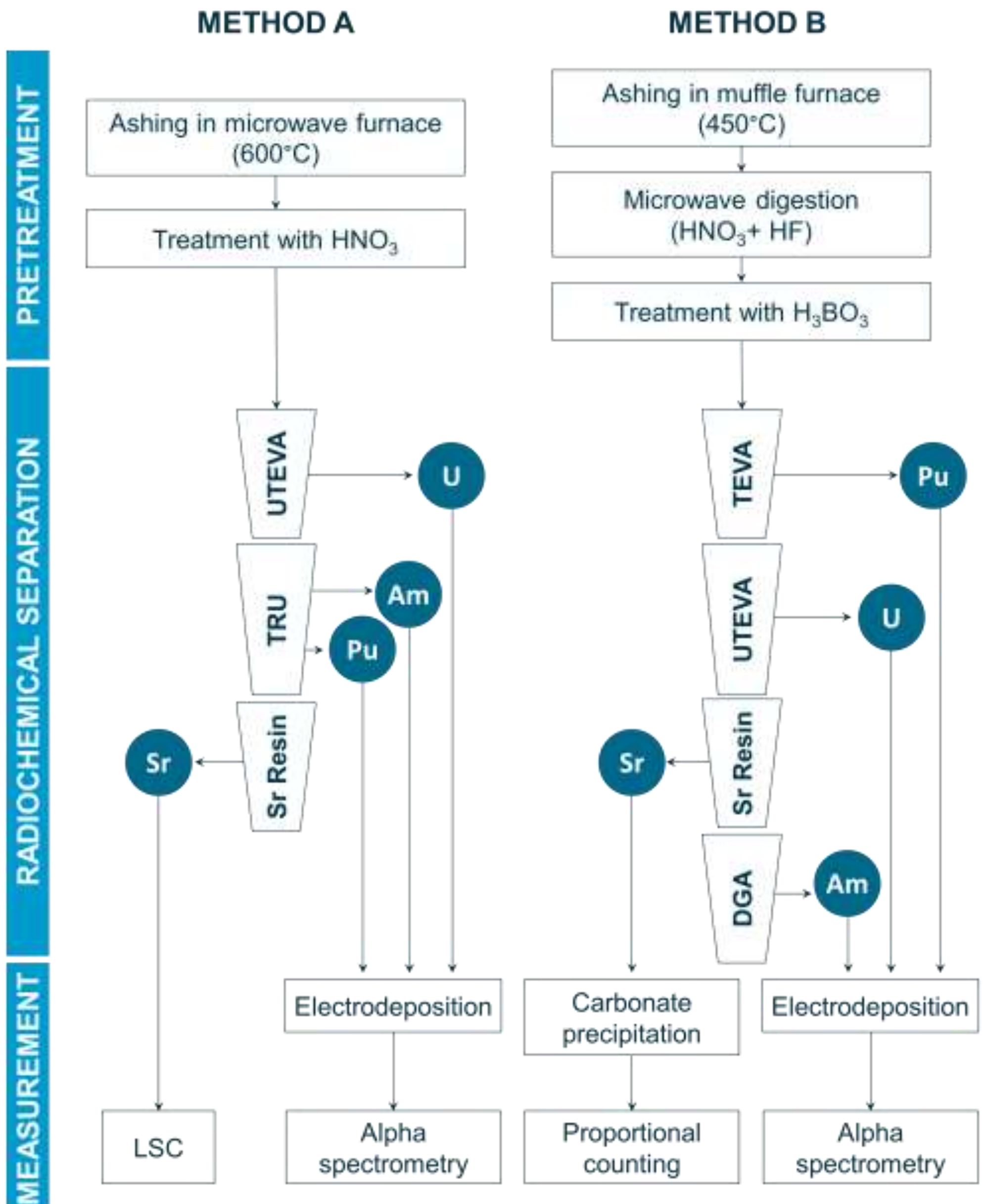
Rapid radiochemistry techniques

National Physical Laboratory

Results:

Recoveries by tests with a reference material (RM):

	Method A	Method B
Am	55 % - 78 %	94 % - 109 %
Pu	51 % - 81 %	87 % - 98 %
U	63 % - 92 %	78 % - 93 %
Sr	78 % - 93 %	92 % - 94 %



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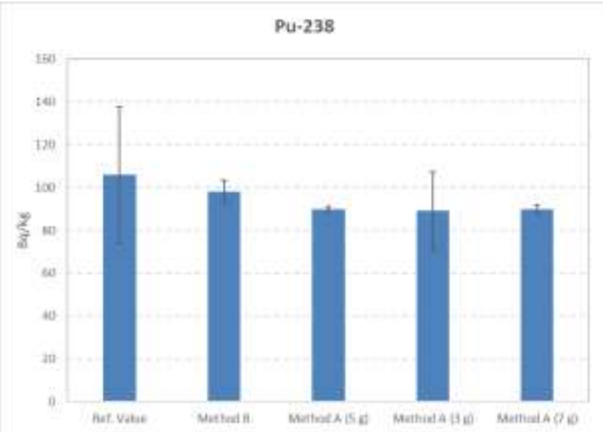
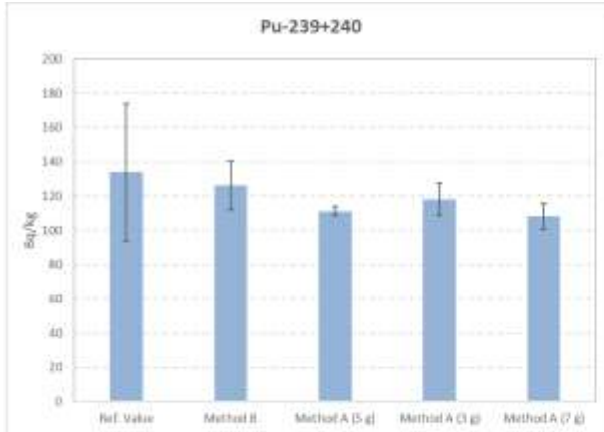
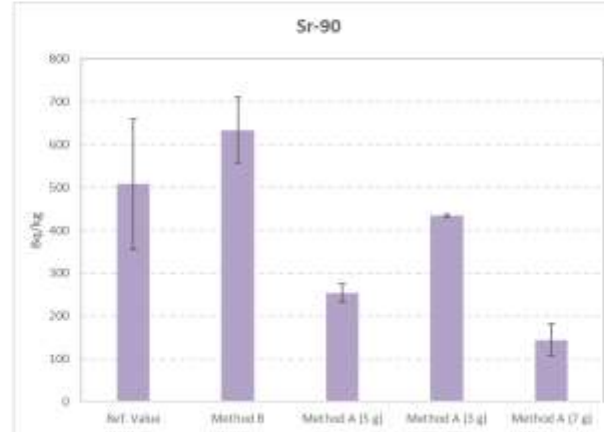
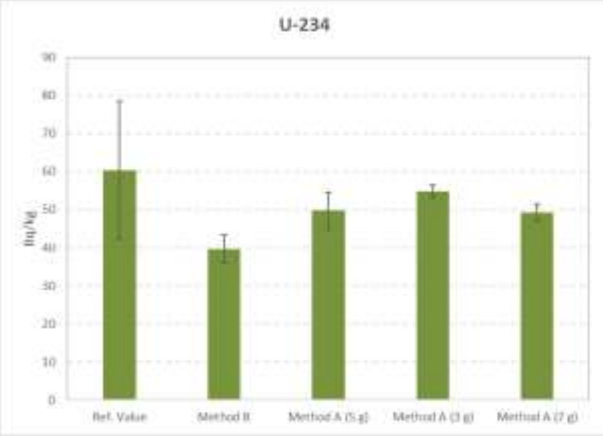
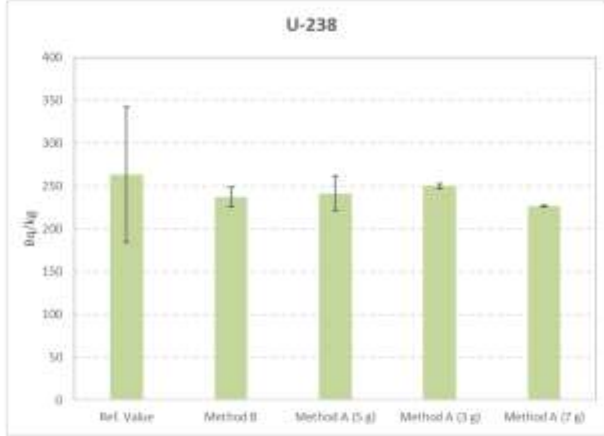
Rapid radiochemistry techniques

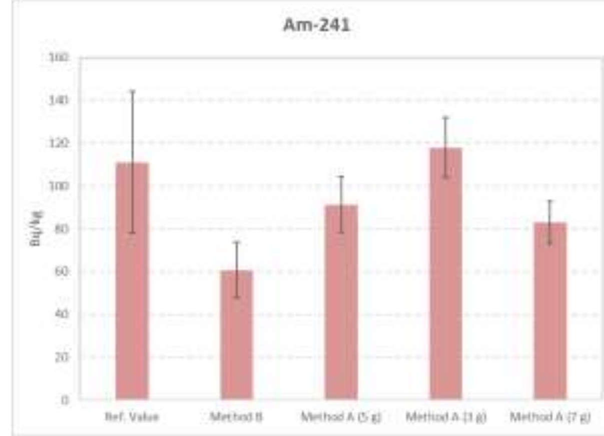












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