COMPACT RADIOACTIVE AEROSOL MONITORING DEVICE FOR EARLY WARNING NETWORKS

Denis GLAVIČ-CINDRO
Toni PETROVIČ
Drago BRODNIK
Matjaž VENCELJ
Jožef Stefan Institute
Ljubljana, Slovenia

Steven James BELL
Lindsey KEIGHTLEY
Selina WOODS
NPL
Teddington, UK

Dušan PONIKVAR
University of Ljubljana, FMF
Ljubljana, Slovenia
MetroERM – Metrology for Radiological Early Warning Networks in Europe

- EMRP Joint Research Project **ENV57 (MetroERM)** is funded by the European Commission and EURAMET
- **Duration:** June 2014 - May 2017
- **Coordinator:** Stefan Neumaier (PTB)
- **Partners:** NMI, DI, REG
- **Stakeholder:** national operator of early warning networks and manufacturer of dosimetry and spectrometry systems.

*EMRP = European Metrology Research Program
** ERM = Environmental Radiological Monitoring
MetroERM consortium
(16 partners from 11 countries)

Budget: \( \approx 5 \, \text{M€} \)
On the origin of radiological early warning networks in Europe

Chernobyl – accident of nuclear power plant block IV
April 26, 1986

European Commission CD 87/600 EURATOM on „Community arrangements for the early exchange of information in the event of a radiological emergency‟.
In case of a nuclear emergency, reliable and traceable radiological data are of key importance for any governmental decision!
In Europe:
- NO measurable effects on dose rate values, but
- measurable increase of $^{137}$Cs and $^{60}$Co activity concentrations in air
MetroERM project

Harmonisation of dosimetry early warning networks in Europe

DEVELOPMENT of a new detector generation

Harmonisation of airborne radioactivity monitoring networks in Europe

DEVELOPMENT of new systems

In strong collaboration with EURDEP and stakeholder –
national operators of early warning networks and
manufacturer of dosimetry and spectrometry systems
MetroERM
WORK PACKAGE STRUCTURE

Management (WP5)

Dose rate monitoring (WP1)
Airborne radioactivity monitoring (WP2)
Traceability and harmonisation (WP3)

Impact (WP4)
PRESENT STATE OF THE ART

GM counters in early warning networks

A NEW GENERATION OF “SPECTRO-DOSIMETERS”

Scintillation detectors with good energy resolution (LaBr$_3$, CeBr$_3$, SrI$_2$)

Uncooled semiconductors (CdZnTe)

In-situ measurements with IC and HPGe
AIRBORNE RADIOACTIVITY MEASUREMENTS

- Traceable calibrations
- Correction for natural background
- Comparison of methods
- Intercomparison using spiked filters

IJS (NPP Krško monitoring)

PTB, Germany
WP2: Airborne radioactivity monitoring networks

- Task 2.2: Development of novel and improved instrumentation for airborne radioactivity for field-station use
  - Portable, with a continuous on-line measurement capability and 3G networking to enable data to be relayed from remote field stations to a centralised system
  - Device consists of a high flow air pump (200 m³/h) to transport particles to an innovative concertina filter cartridge housing a novel spectrometric detector

- The device consists of 3 subsystems
  - Processing subsystem
  - Air-management subsystem
  - Detection and signal processing subsystem
SELECTION OF COMPONENTS

- **Processing subsystem**
  - graphic user interface – touch-screen based
  - internal communications between units
  - external communication to the server (SMS, GPRS, WIFI, etc.)

- **Air management subsystem**
  - concertina aerosol filter assembly
  - air flow meter with reliable and traceable airflow measuring up to 250 m$^3$/h
  - pump with stable airflow at 200 m$^3$/h
COMPONENTS FOR
DETECTION SUBSYSTEM

- DETECTOR
  - main decision parameters for detector choice were energy resolution and intrinsic radioactivity (CsI:Tl, LaBr$_3$:Ce, CeBr$_3$)
  - CeBr$_3$ scintillator selected (~4 % FWHM @662 keV)
  - classical photomultiplier tube (PMT)

- DIGITAL SIGNAL PROCESSING UNIT (DSP) – BUILT IN-HOUSE
  - fast enough to cover our detector specifications (moving window deconvolution (MWD) method)
  - wide temperature range
  - good and stable multi channel analyzer (MCA)
  - serial port communication (SPI)
**FINAL PROTOTYPE DESIGN**

- Final design of in-field monitoring device incorporated in hard duty portable Peli Case (C)

- 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)
DEVELOPMENT STAGES

- Status presented in Varese in March 2015
- Status presented in Rome in November 2015
- Status in May 2016
  (measurements at NPL, UK)
CALIBRATION AND VALIDATION

- Measurements performed at NPL in May 2016
  - Validation measurements of 2 filters spiked with mixed radionuclide solution, without active pump
  - Measurement in basement room with high activity of radon, with pump
  - Background measurements
MESUREMENTS WITH CONTAMINATED FILTERS

- 2 filters were spiked with certified mixed radionuclide solution containing Am-241, Cd-109, Co-57, Ce-139, Cr-51, Sn-113, Sr-85, Cs-137, Mn-54, Y-88, Zn-65 and Co-60
- High level filter with total activity 47.5 kBq, low level with 153 Bq
- Measurements without active pump

Spectrum of high level filter
EFFICIENCY DETERMINATION

- Photoabsorption peak efficiency curve determined on the basis of measurements with high level filter at NPL.
- 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.
- One more spiked filter will be prepared to proof the efficiency curve.
MEASUREMENTS IN THE BASEMENT ROOM

- Measurement in basement room with high activity of radon (~450 Bq/m³)
- Measurements with active pump, overnight

Spectrum of radon / thoron progenies

- Comparison of calculated activity of Pb-214 as obtained individually from two spectral lines of Pb-214 shows agreement and validates efficiency curve
- Calculated radon activities from Pb-214 and Bi-214 are not the same, radon progenies are not in equilibrium
CONCLUSIONS

- The compact radioactive aerosol particulate monitoring device developed at JSI provides continuous, sensitive, on-line airborne radioactive particulate monitoring for field station use. It enables accurate determination of activities of airborne radionuclides.

- **The main advantages of this system are:**
  - As it is incorporated in a heavy-duty portable case it is easily transportable to different measurement locations
  - Due to high flow rates also low activity airborne radionuclides can be quickly measured
  - With prompt and continuous online detection and 3G connectivity it enables human-error free data relay from remote field stations to a centralized system, as well remote control over the unit
  - During a nuclear emergency increased frequency of data transmission is possible, which enables remote analysis of plume deposition
FURTHER ACTIONS

○ Short term
  Evaluation of the effect of the background radiation of natural radionuclides on the measurements of the airborne radioactivity - the study of radon and thoron interference with the overall nuclide identification performance in CeBr$_3$- based gamma spectrometry has to be performed

○ Long term
  • Firmware update with a nuclide ID algorithm
  • To analyze the data and provide estimates on absolute radioisotope concentrations in air at sampling locations
  • Communication software upgrade to auto-synchronize spectra and all the data
http://earlywarning-emrp.eu/

About this project

The nuclear power plant accident at Fukushima Daiichi clearly confirmed the need for exchanging radiological information in real-time at an international level, even for remote accident. During a radiological emergency with transboundary implications in Europe, the European Commission will issue recommendations to EU Member States based on data from national early warning networks. This could affect millions of people and may have severe economic and sociological consequences. Therefore, metrologically sound monitoring data of ambient dose rate and airborne radionuclide activity concentrations, co-ordinated with data from international radiological networks, are a prerequisite for adequate environmental radiation monitoring in Europe.