

## TIME-RESOLVED GAMMA SPECTROMETRY FOR DISENTANGLING NATURAL AND ANTHROPOGENIC AIRBORNE RADIONUCLIDES

*Nedime Irem Elek<sup>a,b,\*</sup>, Mohamed Abdelkader<sup>a</sup>, Matteo Albéri<sup>a,b</sup>, Engin Can Esen<sup>a</sup>, Ghulam Hasnain<sup>a,b,c</sup>, Fabio Mantovani<sup>a,b</sup>, Cassandra Giulia Cristina Raptis<sup>a,b</sup>, and Virginia Strati<sup>a,b</sup>*

<sup>a</sup>*Department of Physics and Earth Sciences, University of Ferrara, Via G. Saragat 1, 44122 Ferrara, Italy*

<sup>b</sup>*INFN Ferrara Section, Via G. Saragat 1, 44122 Ferrara, Italy*

<sup>c</sup>*University of Trento, Via Calepina 14, 38122 Trento, Italy*

*\*lkenmr@unife.it*

### Abstract

Monitoring airborne radioactivity associated with total suspended particulate matter involves both natural and anthropogenic radionuclides and poses a challenge that is not primarily driven by instrumental sensitivity. The key issue is the separation of overlapping isotopic contributions characterized by markedly different temporal behaviours. Shortly after sampling, gamma spectra are dominated by short-lived radon progeny, which mask the signals of radionuclides of environmental relevance. In this framework, the limitation is conceptual rather than instrumental.

This work presents the implementation of the EyeRAD protocol at the Italian National Institute of Nuclear Physics (INFN) Ferrara site. EyeRAD is a national INFN initiative aimed at atmospheric radioactivity monitoring based on high-resolution gamma spectrometry of particulate matter. Here, time is treated not as an operational constraint but as an analytical variable. Sequential gamma acquisitions become part of the measurement method, allowing the physical discrimination of isotopic contributions through their temporal evolution.

Atmospheric particulate matter is collected using high-volume samplers operating at 1000 L min<sup>-1</sup> on glass-fiber filters over standard 23-hour sampling cycles, corresponding to a total sampled air volume of  $\sim 1.4 \times 10^3$  m<sup>3</sup> per session. After collection, filters are folded to preserve particle retention and measured at fixed time intervals, typically 2, 5, 24, 48, and 72 hours after sampling, enabling the experimental tracking of radon progeny decay and the progressive isolation of longer-lived radionuclides.

Such a time-resolved approach requires a measurement system capable of sustaining this complexity. Gamma-ray measurements are performed using the MCA\_RAD system, consisting of two coaxial p-type HPGe detectors with 64% relative efficiency and an energy resolution of about 1.9 keV at 1.33 MeV, operated in a lead- and copper-shielded configuration that reduces background by approximately two orders of magnitude. Efficiency calibration reproduces the actual folded-filter geometry using certified reference materials of natural origin, avoiding geometry-dependent ex-post corrections.

For a sample measured 24 hours after collection with a 19-hour live time, minimum detectable activities of  $7.4 \times 10^{-5}$  Bq m<sup>-3</sup> for <sup>131</sup>I and  $6.5 \times 10^{-5}$  Bq m<sup>-3</sup> for <sup>137</sup>Cs are achieved, while <sup>7</sup>Be is routinely quantified at activity levels of  $(4.1 \pm 0.3) \times 10^{-3}$  Bq m<sup>-3</sup>. The resulting measurement is not merely an activity value, but a physically informed description of atmospheric radioactivity.