Contribution ID : **52** Type : **Oral Presentation**

Laboratory analysis of low-level radioxenon samples in support of the International Monitoring System

Thursday, 29 September 2016 14:20 (0:20)

Content

The radionuclide component of the International Monitoring System (IMS) is based on a worldwide network of 80 radionuclide monitoring stations. In support of the Comprehensive Nuclear Test Ban Treaty (CTBT) verification regime, these stations are designed to perform continuous monitoring of atmospheric radioactivity (for both aerosols and noble gases). The IMS is supplemented by group of 16 certified laboratories, in charge of network quality control and in-depth re-analysis of anomalous samples. Measurements of relevant radioxenon mixtures (133-Xe, 133m-Xe, 131m-Xe, 135-Xe) in laboratory are hampered by i) radioactive decay during sample transportation, ii) low initial activity of the samples (1-100 mBq range), iii) low (gamma/X) emission energy of xenon isotopes and iv) gaseous state of the samples. The French laboratory (RL08) at CEA has set up a complete system designed to perform these specific analyses. As samples are not measurable as received, the first step consists in transferring the content of the stainless steel 0.5 l archive bottle into an optimized 13 cm3 double-sided measurement cell fitted with carbon epoxy windows. Cryogenic separation is used to remove the carrier gas (He or N2) from Xenon so as to maintain the cell internal pressure in an acceptable range. The Gamma3 spectrometry facility [1] is used to perform activity measurements. This system is fitted with state-of-the-art passive and active shielding. The background level achieved with this configuration is found to be among the lowest for a ground-level facility (integral count rate: 2x2.1 cpm, range [20-1000 keV]). Fully digital electronics and listmode data acquisition are implemented so as the three high efficiency Canberra BEGe5030P gamma spectrometers composing the Gamma3 system can operate either in single, additive or (anti)coincidence mode. For radioxenon analysis, the measurement cell is inserted in between two face-to-face gamma spectrometers making a virtual very high efficiency single spectrometer (full-energy peak efficiency > 50% over [20-150 keV] energy range). Finally, Gas-Phase Chromatography (GPC) on stable Xe is used to assess the gas transfer yield and the air equivalent volume as sampled by the on-field station. Taking benefit of the combined high detection efficiency and the very low background of the system, sub-mBq detection limits are achievable within three days measurement time. Except for the very short-lived Xe-135, this extreme sensitivity is not only able to encompass radioactive decay during transportation from remote locations to the laboratory (<10 d) but also in some cases too enhance significantly the station detection capabilities.

[1] An introduction to γ3 a new versatile ultralow background gamma spectrometer. Background description and analysis. A. Cagniant et al, Appl. Radiat. Isot. 87 (2014) 48–52

About the Presenter

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Session Classification : Special Session: Monitoring Networks

Track Classification : Special Topic: Monitoring Networks