Contribution ID : **36** Type : **Poster**

Development of a dual-HPGe low background gamma-gamma coincidence/anticoincidence spectrometer

Wednesday, 28 September 2016 14:46 (0:02)

Content

The Comprehensive Nuclear-Test-Ban-Treaty (CTBT) verification regime includes a network of radionuclide laboratories. The certified laboratory must meet certain sensitivity requirements for CTBT relevant radionuclides. The Radiation Protection Bureau (RPB) of Health Canada has been running such a certified laboratory (CAL05) since 2005. RPB has recently designed and developed a multi-detector gamma-beta spectroscopy system to improve the sensitivity of measurements and process efficiency for treaty compliance. The spectrometer consists of two HPGe detectors, a PIPS beta gas cell detector (will be installed), plastic cosmic veto detectors and an XIA LLC Digital Gamma Finder (DGF)/Pixie-4 software and card package for list-mode data acquisition. Such design enables a more selective measurement of radioactive xenon (135Xe, 133mXe, 133Xe, 131mXe) released from underground nuclear tests to atmosphere, and a significantly improved resolution and background reduction with beta-gamma coincidence mode. The use of a list-mode data acquisition technique enables each sample be counted once and processed multiple times to get coincidence and anticoincidence spectra for further improved detection limits, which allows an accurate and timely quantification of radionuclides that decay via both singular and cascade gamma emission, greatly enhancing the laboratory effectiveness. The shield of the spectrometer includes four inches very low background lead (Doe Run Lead, <30Bq/Kg), two inches 2% boron in polyethylene neutron layer, one inch ultra-low background inner lead shield (<3Bq/Kg) and a cosmic veto active shielding layer. The spectrometer integral background rate from 40 to 2700 keV is about 0.3 counts per second. Its background characteristics and cosmic veto efficiency are discussed.

A series of measurements were conducted with the spectrometer to determine the intensity and attenuation factors of cosmic-muon. Data were obtained at several sites in two different laboratories, one at surface level and one in an underground location. The results indicate that the overburden in the building at surface level absorbs a large part of cosmic ray protons while attenuating the cosmic-muon intensity by 20-50%. The underground facility has the largest overburden of 39 m water equivalent, where the cosmic-muon intensity is reduced by a factor of 6. The study provides a cosmic-muon intensity measurement and overburden assessment, which are important parameters for analysing the background of an HPGe counting system, or for comparing the background of similar systems.

About the Presenter

Dr. Zhang's research focused on developing and improving gamma, beta and alpha-spectrometry for improved monitoring of environmental radioactivity and investigating radiation exposure to humans from natural and anthropogenic radiation sources.

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Session Classification : Radiometrics

Track Classification : Radiometrics