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Silicon PIN diode based electron-gamma coincidence detector system for Noble gases monitoring

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Content

Detection of the CTBT-relevant xenon isotopes (Xe-131m, Xe-133m, Xe-133 and Xe-135) in the International Monitoring System network and/or in the On-Site Inspection may provide the ultimate evidence (smoking-gun) for a potential clandestine nuclear explosion in violation of the nuclear test ban treaty. These isotopes are emitting low energy gamma and X-ray photons in coincidence with beta and conversion electrons. Therefore, electron-gamma coincidence detector systems are used for their measurement. Gamma detectors used in such systems are commonly NaI crystals, with some recent developments demonstrating use of HPGe. Plastic scintillators coupled to PMTs are currently used for the electron detection. Large area silicon PIN photodiodes (SiPIN) can be used as direct full energy deposition detectors as opposed to more traditional use for collection of light produced in the coupled scintillators. SiPIN based beta-gamma detectors are the most recent developments for the radioactive Noble Gas detection applications in the context of the CTBT monitoring. The SiPIN provide superior energy resolution for electrons (<10 keV at 129 keV electron energy, a factor of four improvement compared with the plastic scintillators) which allow a clear separation of the metastable radioxenon isotopes Xe-131m and Xe-133m (129 keV CE and 199 keV CE, respectively). These isotopes are key to the discrimination of the peaceful nuclear activities such as nuclear power plant emissions or medical isotope productions from nuclear explosions. The work describes the current state of technology development, preliminary results of the long-term performance studies with integration into some of the existing Noble Gas monitoring systems. The study of the operational aspects of the SiPIN based detector systems are key in the assessment of their suitability for the deployment at sometimes remote IMS locations as well as in the field applications for the On-Site inspection verification regime. We discuss the differences in the analysis and calibration algorithms as compared to the traditional plastic scintillator based detector systems. The individual SiPIN detectors are arranged in a cube with each side being an independent detector. This segmentation and the ability of SiPIN based system to record list mode data (events) provide further ways to reduce the background and interference between isotopes. We also present preliminary thoughts and assessment of sensitivity of the SiPIN detectors in a compact field-deployable system for Kr-85 measurement, with the possible applications for the detection of undeclared nuclear fuel reprocessing activities.

About the Presenter

Mr. Khrustalev holds a MSc degree in Physics from Syracuse University, NY, USA, specializing in the experimental High Energy Physics and development of detectors for ionizing radiation. He has been involved in the Noble Gas systems development and testing since more than 10 years. After his work at Austrian Research Centers GmbH, Seibersdorf, Austria, and at CTBTO PrePcom PTS, IMS/ED section, he is now working as Senior Engineer in Lares LLC, St.Petersburg, Russia, as well as an independent engineering consultant in the area of radionuclide monitoring.

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