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A detector for radionuclide monitoring in water systems

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Content

Drinking water systems are vulnerable to contamination with radioactive material, either by accident or on purpose. Methods applied in routine monitoring of water systems (like regular sampling with subsequent laboratory analysis) cannot detect short time contaminations and can therefore not prevent a resulting radiation exposure of the population. For that purpose, based on a scintillation detector, a real-time measurement system is being developed that can detect alpha, beta, and gamma radiation with an automatic analysis and warning algorithm. The problem in detecting alpha, beta, and gamma radiation at the same time lies in their different range in matter. Gamma radiation can as well be measured outside of a water volume, short-ranged alpha and low-energy beta radiation can only be detected in direct contact to the medium. On the one hand low detection limits for alpha-emitting radionuclides can thus only be achieved by detectors with large surface areas. On the other hand for the higher energy beta and gamma emitters large detection volumes are required. Since the dimensions of the detector are limited, the detection geometry needs to be a compromise. To achieve a high sensitivity for all kinds of radionuclides, simulations with the GEANT4 based GAMOS Monte Carlo system were performed in order to optimize the detection geometry, e.g. enlarging the surface area (that is needed for alpha and beta detection) while at the same time retaining a sufficiently good light transport to the photosensor. The models used for the simulations have been validated using measurements of simple detection geometries. Based on the results of several simulations, which systematically varied different geometric parameters, a compromise was made between the different parameters. The final prototype consists of plastic scintillator cast sheets that are coupled to a photomultiplier, the housing has been adapted to the components via 3D printing. Water which is to be measured can flow between the sheets. With this setup, the surface area and therefore the sensitive volume for short range radiation can be greatly enhanced compared to scintillators solely on the outer surface of the medium, thus resulting in a higher sensitivity and lower detection limits. A software with a graphical user interface was developed to perform measurements with the detector. It allows the user to monitor the activity concentration over time as well as the spectra of the individual measurements. After an optimization of the PMT- and MCA-parameters (voltage, internal amplification, . . .), for Co-60, the first prototype with an effective volume of 300 ml achieves a lower limit of detection (LOD) of 0,07 kBq/l for a measuring time of 10 minutes while for Am-241 it is 2 kBq/l. These detection limits were accomplished using only the integral count rate without any further spectrum analysis. It is expected that these will be lowered when more sophisticated analysis of the spectra are performed. Based on these promising results of the lamellar structure a new prototype is being developed with a further increase in the surface area of one order of magnitude to lower the detection limit especially for alpha radiation.

About the Presenter

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