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#7-148 Shield-free and lightweight alpha-beta radiation dust monitor for high-dose environments

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The Fukushima Daiichi Nuclear Power Station (FDNPS) has experienced extensive contamination due to core meltdowns and subsequent hydrogen explosions. This has resulted in elevated levels of α and β surface contamination within the reactor buildings. The ambient radiation dose rate inside these buildings is also high, ranging from several tens to 100 mSv/h. Investigations of the primary containment vessel (PCV) and decontamination efforts within the reactor buildings are ongoing, requiring strict exposure controls. Numerous zones within the reactor buildings pose significant decontamination challenges, such as rubble on the floor and piping on the ceiling. Consequently, it is crucial to monitor and control radioactive dust that may be resuspended from the surface contamination in these areas. As the extraction of fuel debris from the PCV is just starting, considerations for mechanical cutting tools and laser cutting methods for future full-scale retrieval are underway. These processes must account for the generation of dust containing actinides and fission products, which may leak out from the PCV due to unknown openings or instability in negative pressure management. Additionally, since the air ventilation system is not functioning within the reactor buildings, radioactive dust will remain airborne for a long time, posing a risk of secondary contamination and potential leakage outside the building. Therefore, in situations where the dispersal and resuspension of radioactive dust are anticipated, it is necessary to contain dust in the vicinity of the source and to monitor it effectively to minimize secondary contamination risks. The optimal approach for monitoring radioactive dust involves placing measurement equipment in close proximity to the work area, enabling *in-situ* collection and radioactivity measurement. However, because high ambient radiation necessitates significant lead shielding to minimize spurious counting due to γ-rays, the devices typically weigh several tens of kilograms, complicating transportation and deployment. To address this challenge, we are developing a dust monitoring system that can be mounted on a robot, enabling quick deployment near dust sources in various work environments. Our solution incorporates a two-dimensional radiation imaging sensor (MiniPIX, ADVACAM s.r.o.) for radiation measurement, utilizing machine learning (ML) post-processing techniques to analyze radiation signals collected from dust collection filter paper. The sensor generates energy-proportional grayscale images where each event triggers a cluster of pixels through direct interaction or energy transfer between neighboring pixels. The ML software identifies higher energy transfers from α-ray interactions and then extracts shape parameters for each event. In this context, γ-rays produce small pixel clusters due to their quasi-linear paths through the semiconductor matrix, while β-rays follow a winding path through the detector due to Coulomb interaction, resulting in snake-like pixel clusters. By employing multiple feature values for image classification, we can effectively mitigate the impact of ambient radiation without the need for lead shielding. In the irradiation tests using a ^{137}Cs source, we successfully measured and distinguished α from β radiation sources that simulated filter paper, even in conditions of γ-ray irradiation at approximately 10 mSv/h. The integration of these sensors and radiation discrimination technologies with dust collection and control devices has resulted in a prototype measuring unit that weighs approximately 3 kg. This unit was installed on a four-legged walking robot and is intended for effective measurement in contaminated environments.

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