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Long range imaging system for alpha emitters

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Short-lived, highly radioactive materials, such as plutonium, are prevalent in the nuclear industry. These substances, often alpha emitters, pose significant detection challenges as alpha particles travel only a few centimeters in air, depending on their energy. Despite their limited range, these materials are extremely hazardous; if ingested or inhaled, they can cause serious health risks, potentially leading to cancer and death. A notable example is polonium-210, one of the most radiotoxic substances globally, infamously used in the assassination of Alexander Litvinenko. Therefore, detecting such alpha emitters is crucial for both industrial and public safety, necessitating the development of technology to detect and monitor alpha-emitting radionuclides from a distance.

Current methods for alpha particle detection, such as hand-held ionization chambers, require direct interaction with alpha particles. These methods necessitate proximity, often millimeters from contaminated areas, making the approach labor-intensive and time-consuming, increasing contamination risks and dose uptake for workers, and leading to higher costs for decontaminating or replacing detectors.

We have developed a prototype alpha-imaging camera capable of detecting alpha emitters from meters away by capturing UV light emitted when alpha particles collide with nitrogen molecules in the air, a phenomenon known as radioluminescence. The system utilizes a deep-cooled CCD camera and a specially designed lens system with a low f-number to maximize signal intensity. Additionally, we have developed a novel sandwich filter system to effectively reject ambient background and a background subtraction algorithm to further enhance sensitivity, especially in environments with UV background. The design of the alpha camera and process algorithm is patented. The system is user-friendly and rapidly deployable, weighing 3 kilograms and fitting into a suitcase, with setup achievable within 10 minutes by a single operator. This capability significantly reduces radiation exposure risks and accelerates the monitoring process, potentially lowering decontamination and downtime costs. Furthermore, the camera's high-resolution CCD technology and its ability to integrate UV fluorescence with RGB imaging provide millimeter-level accuracy in contamination source identification. It adapts to various environmental conditions, from under sunlight to controlled indoor settings. Integration with existing monitoring infrastructures, such as gloveboxes and robotic platforms, enhances its utility and market appeal. Our device achieves unparalleled sensitivity for alpha detection: in environments without high UV, like inside a room lit by LED, the detection limit is 3 kBq at 1 meter in 10 minutes, while under sunlight, it is 3 MBq at 1 meter in 10 minutes. We have tested with real alpha sources under various conditions, including sunlight.

Our device improves safety and efficiency in hazardous environments by enabling workers to conduct alpha surveys from a safe distance or monitor areas remotely, thus avoiding direct exposure to high-radiation zones where human entry is restricted. This aligns with regulatory requirements and offers an ideal solution for remote operation, significantly reducing labor and equipment costs. Unlike traditional detectors that require proximity to contamination and frequent decontamination and replacement, our device operates without direct contact with alpha particles, allowing for permanent installation and minimal maintenance.

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