Long Range Alpha Camera in Radiological Crime Scene Investigations

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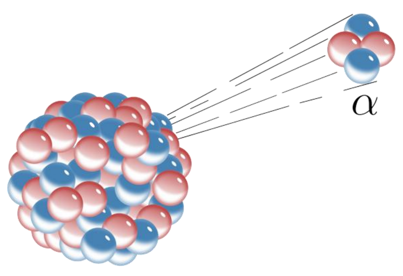
Introduction



Alpha particles, consisting of two protons and two neutrons, are identical to the nucleus of a helium-4 atom. They are typically emitted through the alpha decay of heavy nuclei, where an unstable atom releases an alpha particle to transform into a different element. The travel range of alpha particles in air is generally limited to several centimetres, which makes detection challenging

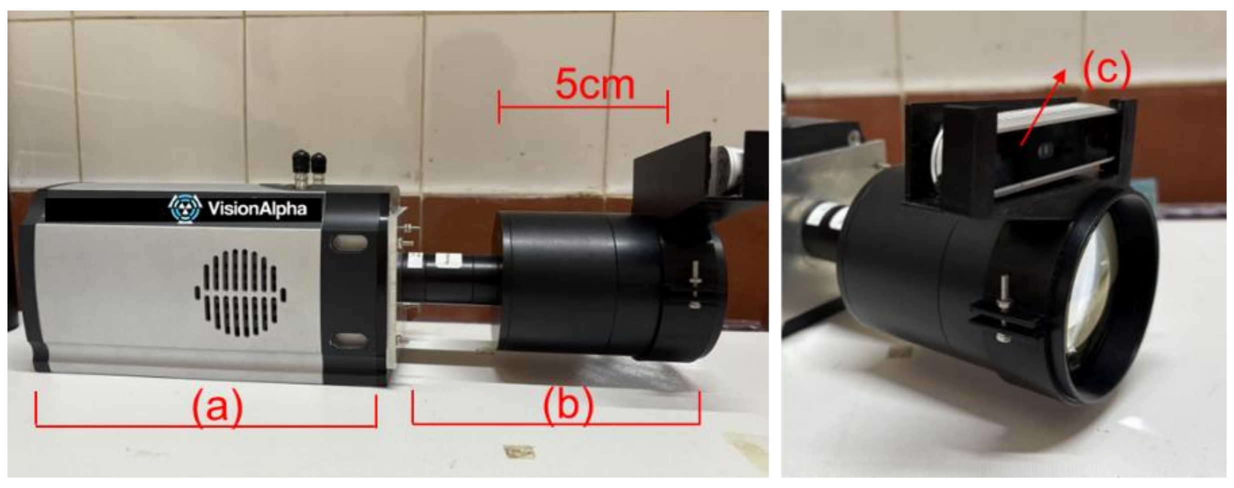
The ingestion of alpha emitters can lead to severe DNA damage and cause cancer. The poisoning of Alexander Litvinenko by 4GBq Po-210 has highlighted the forensic importance of rapid, reliable alpha detection in non-laboratory settings.

Given that many nuclear industrial applications involve actinides, predominantly alpha emitters. The detection of alpha particles is vital for:

- Preventing radiological terrorist attacks.
- Managing both intentional and accidental radiological contaminations, along with subsequent forensic analysis.
- Safeguarding public health and the environment from alpha radiation during decommissioning processes.
- Conducting remote assessments of nuclear waste conditions.

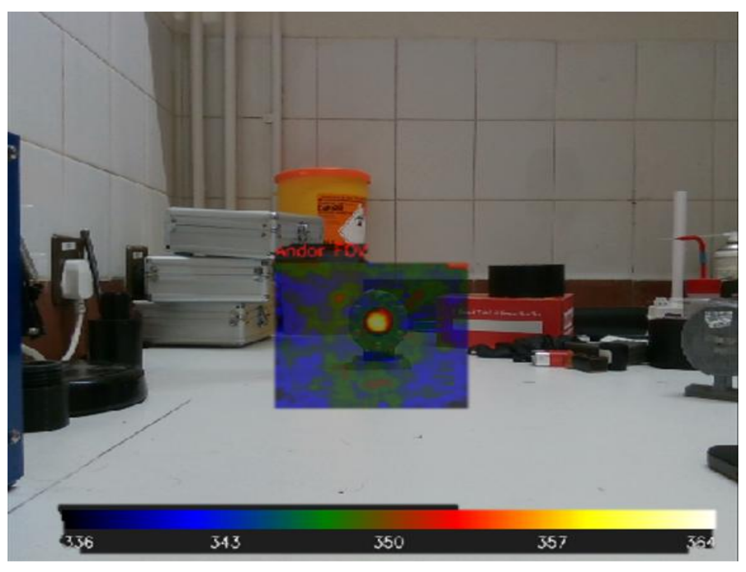
Current commercial handheld alpha radiation monitors, such as Geiger--Mueller counters and scintillator detectors, require direct proximity to the radioactive source for accurate measurement, typically within millimetres of the contamination area. This process usually requires meticulous and repeated scanning of an area to ensure no contamination is missed, making the detection process labour-intensive and time-consuming. Such procedures not only increase the risk of contamination and dose uptake for workers but also escalate the costs associated with decontaminating or replacing contaminated equipment.

VisionAlpha long range alpha camera



The VisionAlpha long range alpha camera (≈ 3.5 kg) developed at the University of Bristol has (a) ultra-sensitive, deep-cooled CCD. (b) high-aperture lens system and high blocking rate ambient light filtering system. F-number around 0.74 and angular field of view ~ 16°. (c) A co-aligned depth/RGB module provides an immediate visual context for rapid localisation of alpha-emitting areas. It has been tested in an active lab in Sellafield and is currently at TRL7

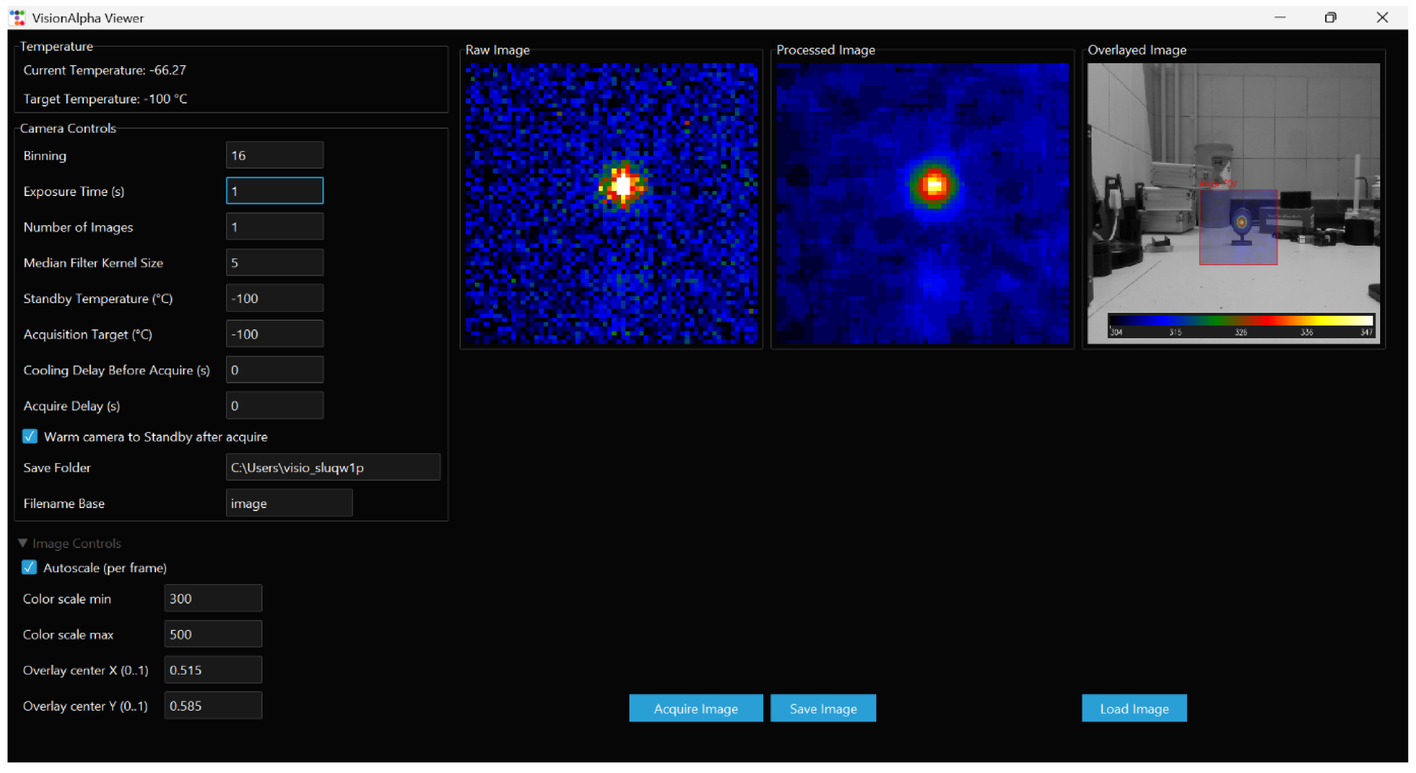
Instead of detecting the short-range alpha particles, this camera images the air radio-luminescence (RL) produced along alpha tracks, enabling stand-off localisation. The detection limit is around 500Bq/cm² at 1 meter in 1 hour.



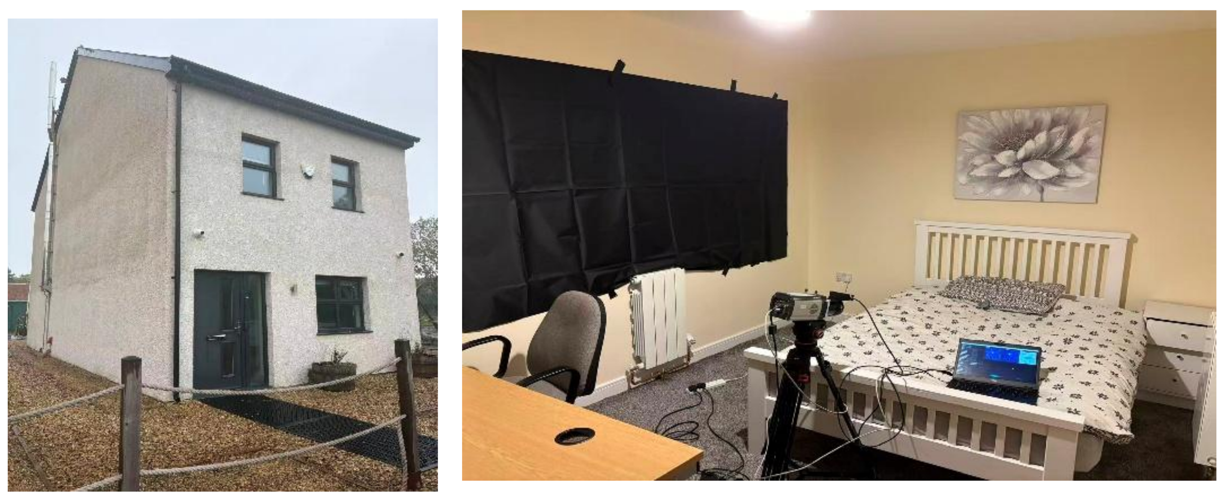
Laboratory validation has confirmed the detection of a uranium metal (surface activity: 700Bq/cm²) at 1 meter distance in one hour. The camera was also tested at an active lab in Sellafield, where it detected 2kBq/cm² alpha hot spots.

VisionAlpha long range alpha camera

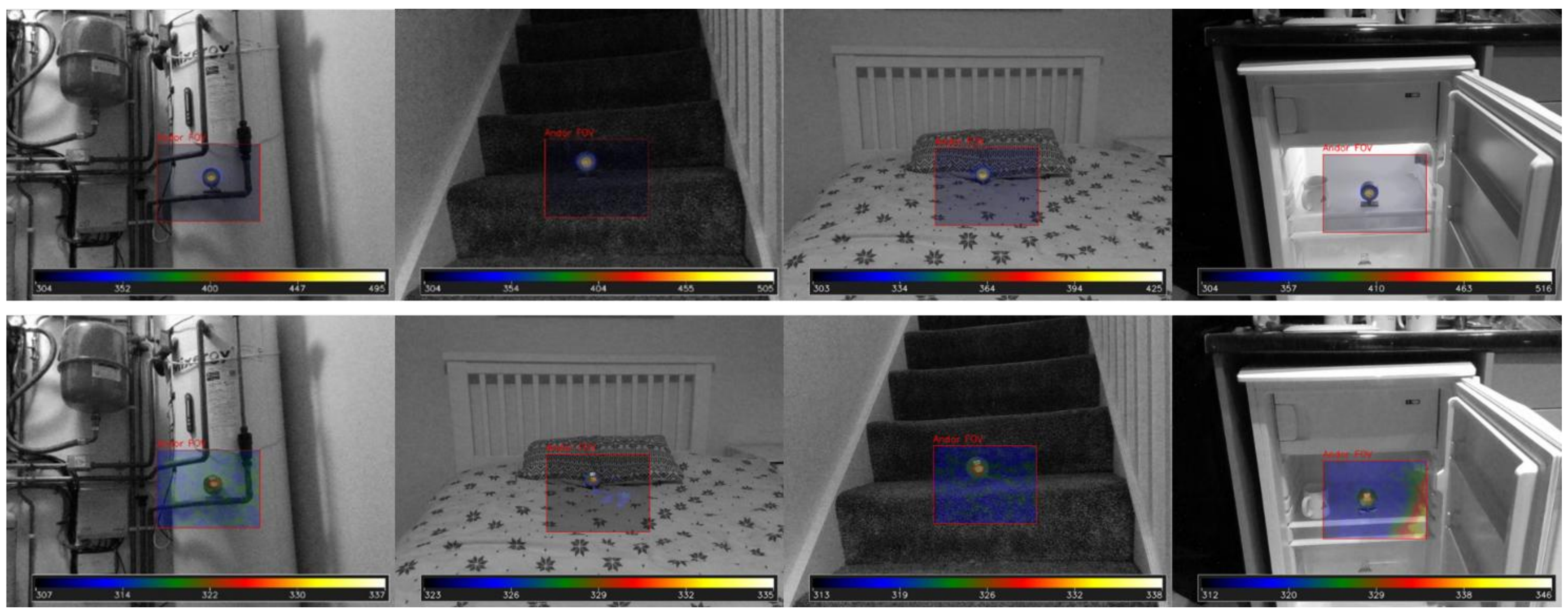
We also developed the control software; UI is shown on the right. It shows the alpha signal and the overlay image of the alpha signal with the visible reference. It allows the control of temperature, exposure time, delay time and color scale.



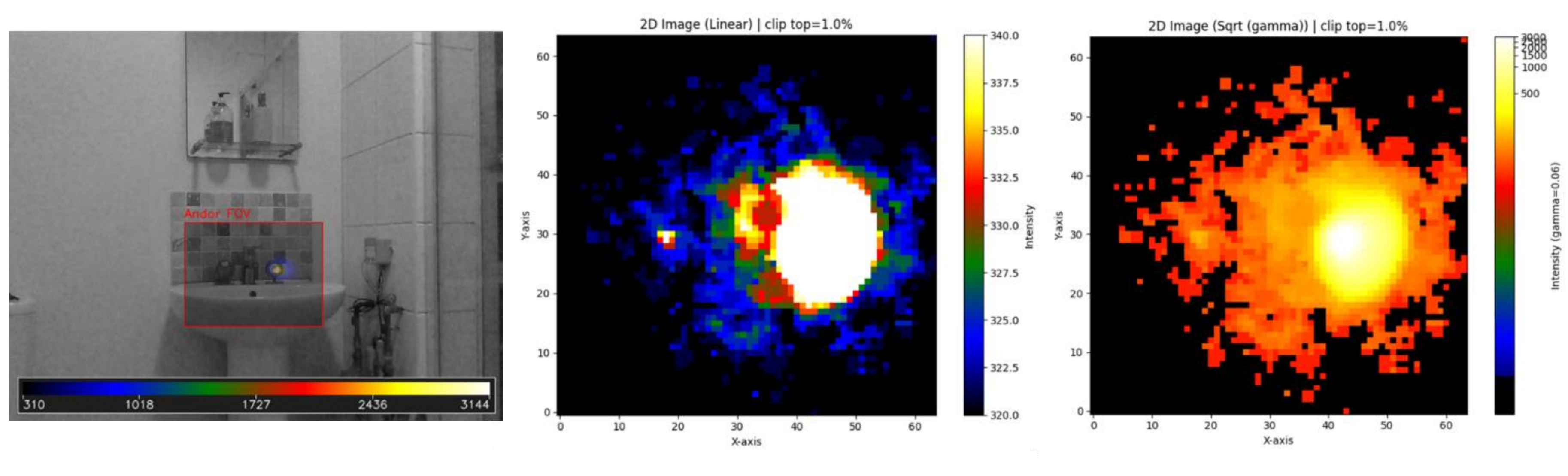
Tests



A mock house at the Berkeley Science and Technology Park was used as the test site. Two sealed Am-241 alpha sources (activities 29 kBq and 3.3 MBq) simulated criminal radioactive materials. Tests were conducted in daylight; blackout sheeting was applied to windows and door glazing to suppress ambient UV background



The sources were imaged in multiple rooms at 1.5 m distance. With 29 kBq, a 300 s exposure was enough; with 3.3 MBq, 10 s was sufficient. In all rooms the sources were clearly detected. A weak artefact appears in the lower-right corner of the 29 kBq image acquired in the fridge; this is likely the reflection of fluorescence light from ceiling.



(a) (b) (c)

To check whether the camera can detect lower contamination next to a high contamination, the 29kBq source was put 5 cm away from the 3.3 MBq alpha source in the bathroom. And the camera was set at 1.5 m away and 5 minutes exposure. under linear scaling (a), the strong source dominates and the 29 kBq signal is not visible. Lowering the display v_max (b) reveals the weaker source but saturates the 3.3 MBq signal, obscuring its spatial structure. Applying a square-root intensity mapping (c) compresses dynamic range, revealing the 29 kBq source while preserving features of the 3.3 MBq distribution.

Conclusion

The VisionAlpha camera demonstrated reliable stand-off detection and localisation of both high and low alpha sources in a mock house setting. Daytime operation was feasible using rapid window black-out to suppress ambient background. Across multiple rooms, sources were consistently imaged, and dynamic-range strategies enabled visualisation of a weak source adjacent to a strong source without saturating spatial structure. The entire series of acquisitions was completed in ~3 hours, indicating that a full-house contamination map could be produced in days, substantially faster and safer than traditional close-contact swabbing with handheld probes. This capability is directly relevant to first-responder and forensic workflows. Next steps will focus on: (i) increasing field of view to accelerate area coverage, (ii) enhancing dynamic-range handling and on-board contrast algorithms, and (iii) reducing artefacts from potential reflections.

VisionAlpha visit our website at: https://visionalpha.tech/