# Supporting alpha-emitting radionuclides metrology with Geant4 simulations of alpha induced luminescence in air

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## INTRO

The remote detection of alpha sources is made possible by their ultraviolet (UV) signature. Ionizations occurring while alpha particles interact with air excite its constituent molecules, which then relax via radiative channels, producing radioluminescence photons in the UV spectral region. The long range of these photons allows optical detection systems to map alpha sources at a distance.

This work presents how simulating the generation of radioluminescence effects at the surface of alpha sources can support the development and application of novel optical detection systems, by calculating photon distributions of complex alpha particle sources in ambient conditions as well as contributing to the interpretation of the measured data.

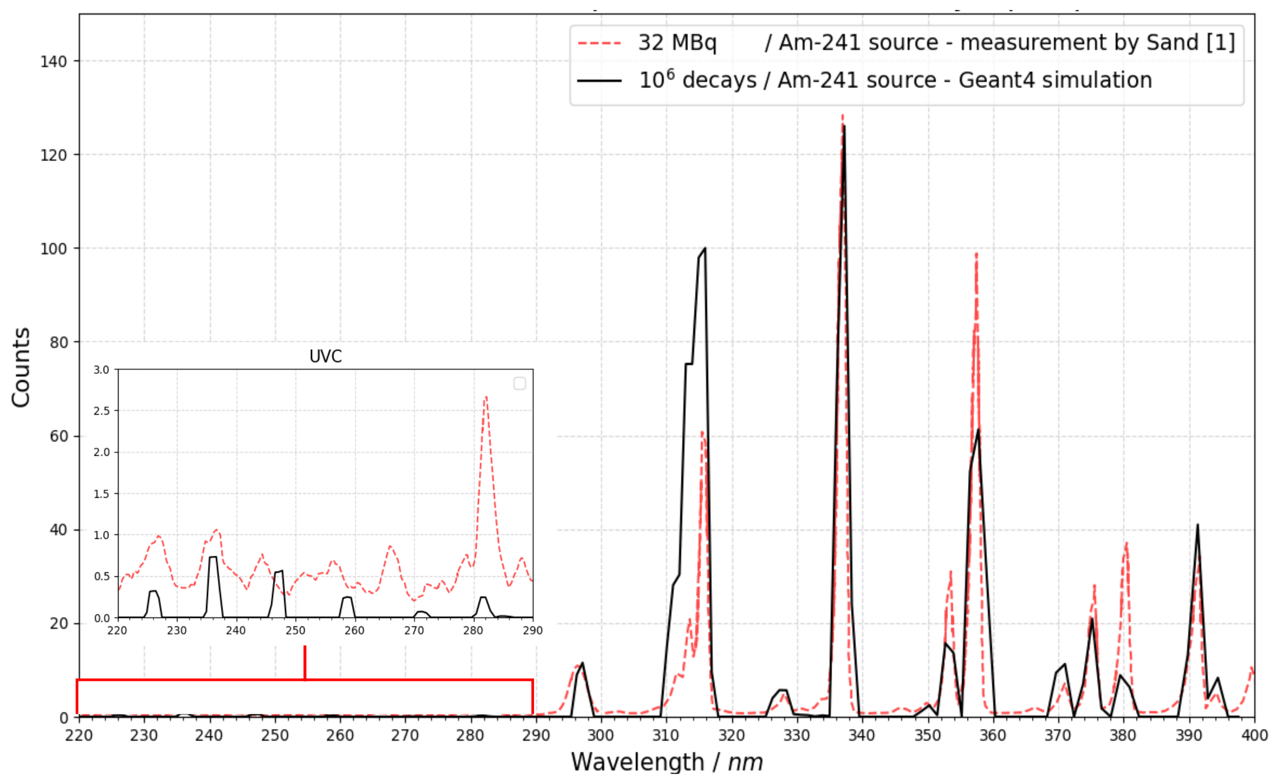


*Fig. 2: Simulated air radioluminescence emission spectrum scaled to the experimental spectrum from Sand [1]*

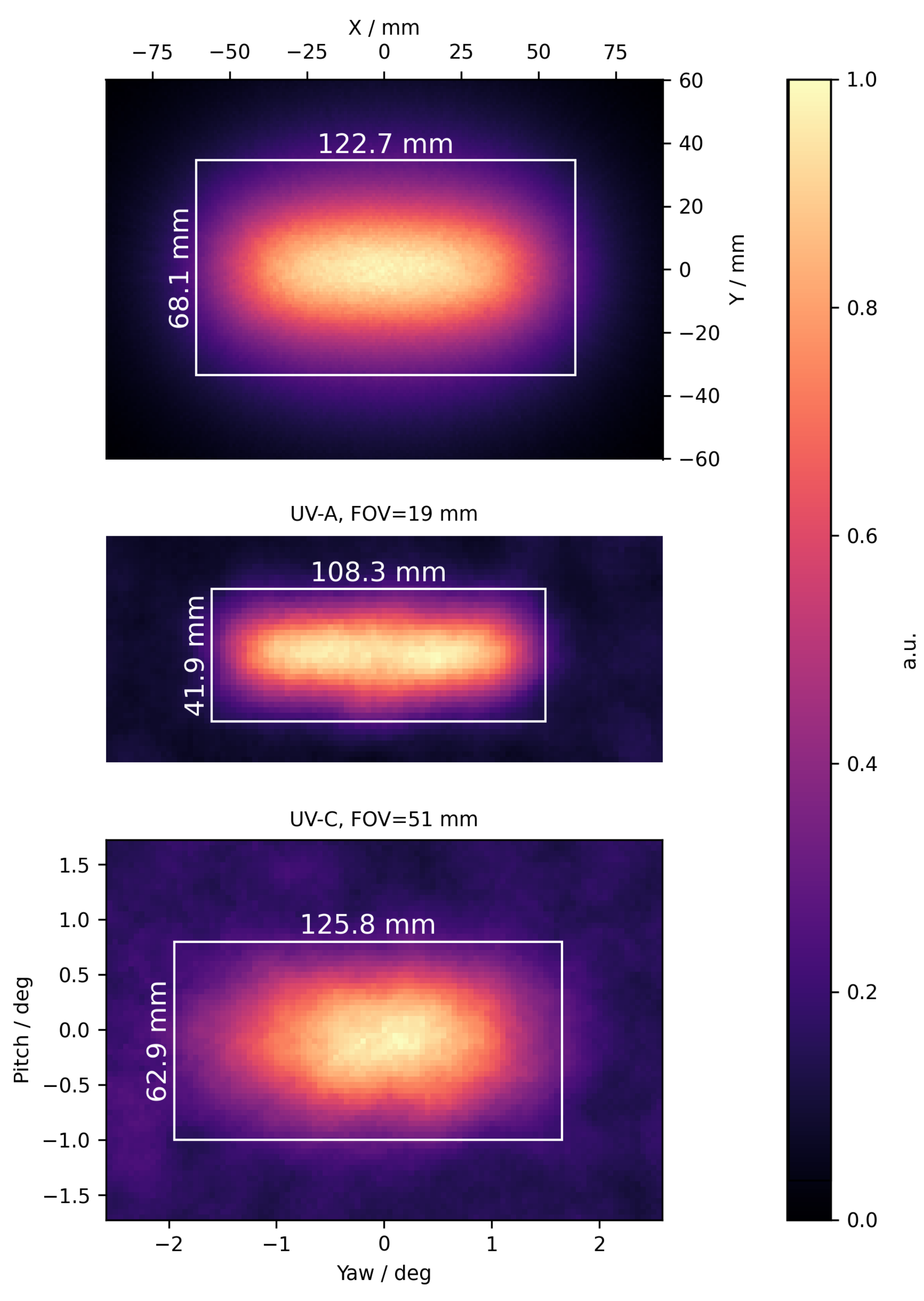


*Fig. 1: Simulated (top), UV-A, and UV-C radioluminescence images*

## SIMULATION vs. EXPERIMENT

The simulated UV image (Fig.1) of an $^{241}$Am source placed in air at NTP conditions was computed using the Geant4 toolkit [2], by registering the spatial distribution of the radioluminescence photons passing through a virtual scoring surface. The generation of optical photons was simulated using semi-empirical data, leading to an emission spectrum coherent with experimental results (Fig.2). Scanning measurements in UV-A (340 nm) and UV-C (260 nm) were performed at a distance of 2 meters from the source using the fused silica lens detection system developed within the EMPIR RemoteALPHA project.

The comparison illustrates consistency between the shape of the source (Fig.3), while the luminescence size grows proportionally with the field of view characteristic to detector configurations (UV-A and UV-C).

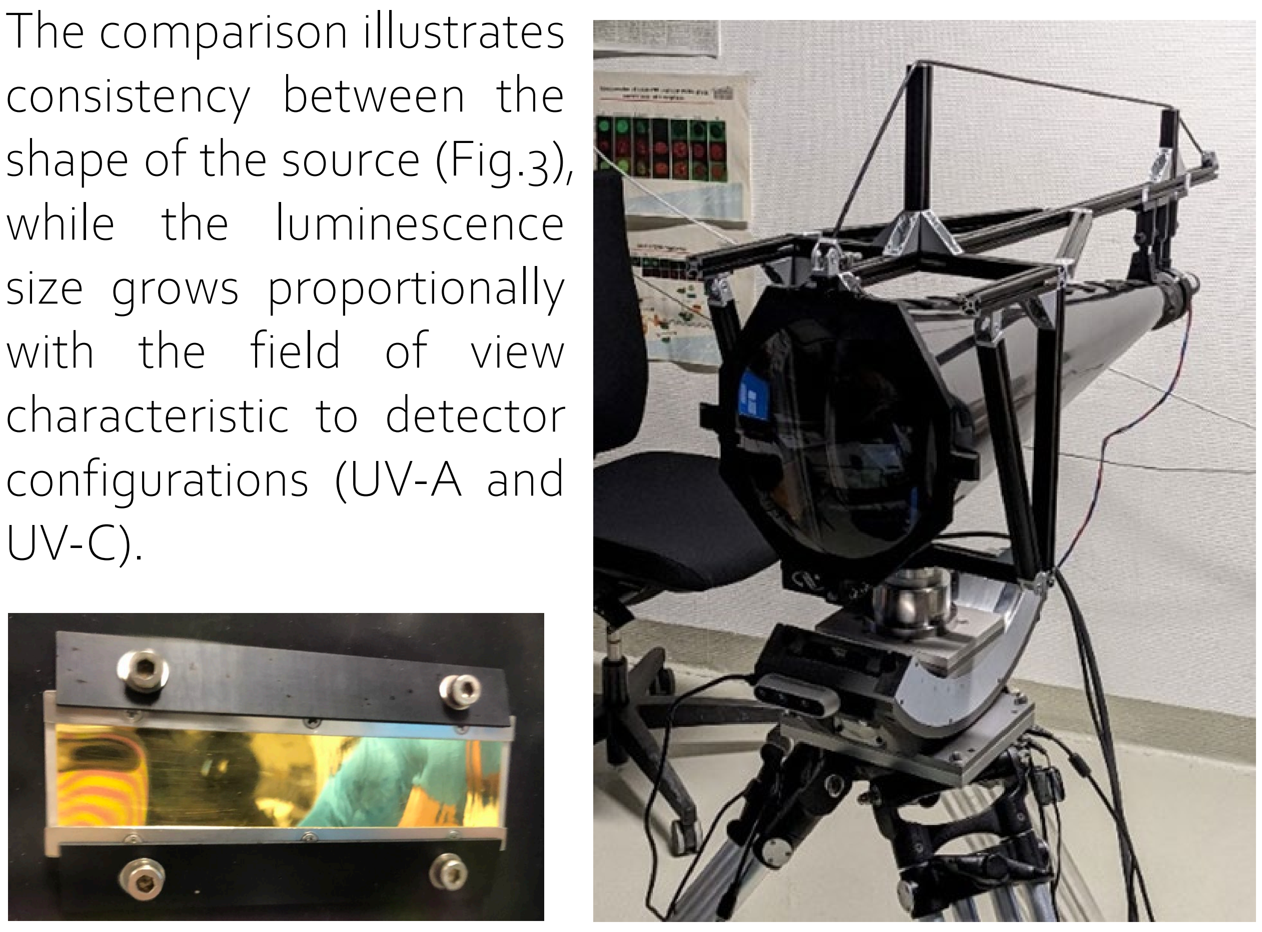

*Fig. 3: $^{241}$Am source and fused silica lens scanning system (right)*

## NUCLEAR SECURITY & RADIATION METROLOGY

The remote detection method is expected to bring new expertise to radiological emergency monitoring and nuclear security applications, by providing improved tools used in site evaluation for dispersion of alpha contaminants. Moreover, its adaption for on-site safeguards inspections at nuclear facilities could lead to an efficient assessment of the diversion of nuclear materials from declared uses.

The developed simulation approach can be applied to analyze the impact of the contaminated surface geometry (shape and roughness) on its emittance which in turn influences the detection limits of the detector and the extent of the radioluminescence glow size. Simulated UV images can thus be useful in determining the proper parameters used for processing experimental scans.

[1] Alpha Radiation Detection via Radioluminescence of Air. / Sand, Johan. Tampere University of Technology, 2016. 61 p.
[2] https://geant4.web.cern.ch/ toolkit.

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https://remotealpha.drmr.nipne.ro/