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Remote and real-time optical detection of alpha-emitting radionuclides in the environment

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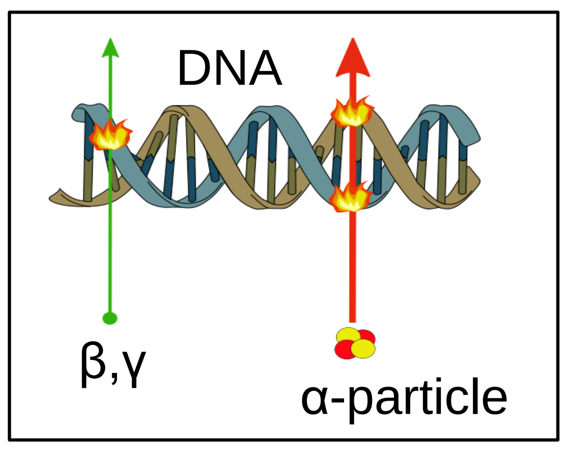
Motivation

While remote gamma detection is performed on a routine basis, this is not yet possible for alpha emitting radionuclides without or only weak gamma lines, such as many of the actinides. If these alpha-emitting radionuclides are released into the environment, either on purpose or accidental, a fast and secure screening method is needed for this kind of radiological emergency.

Current state of the art

Due to the short range of alpha particles, conventional detectors must be placed close (a few cm) to the contamination.

http://www.argonelectronics.com/blog/the-value-of-applied-learning-for-radiation-safety-training

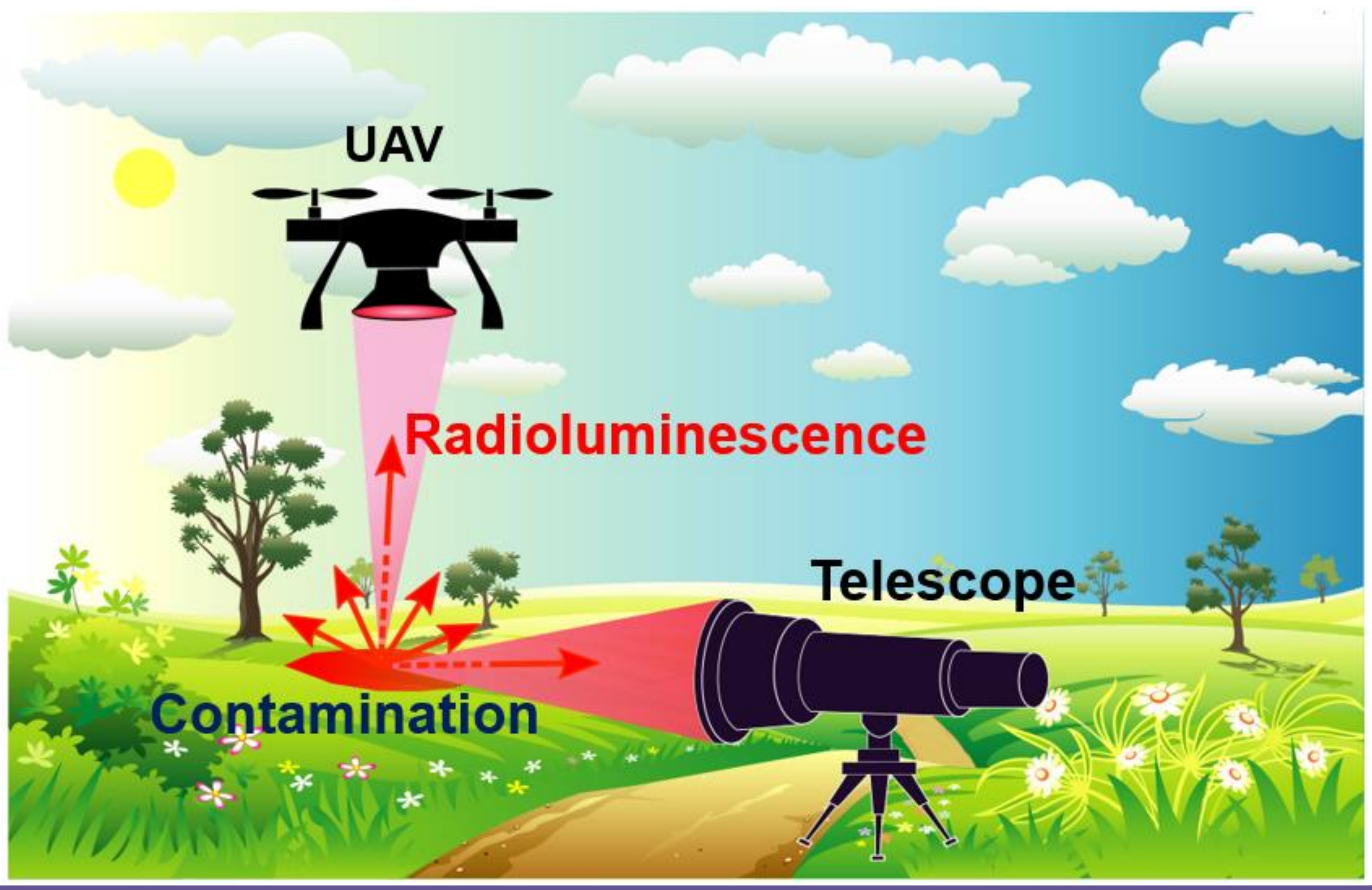


Cellular damage from alpha particles: irreparable DNA double-strand breaks.

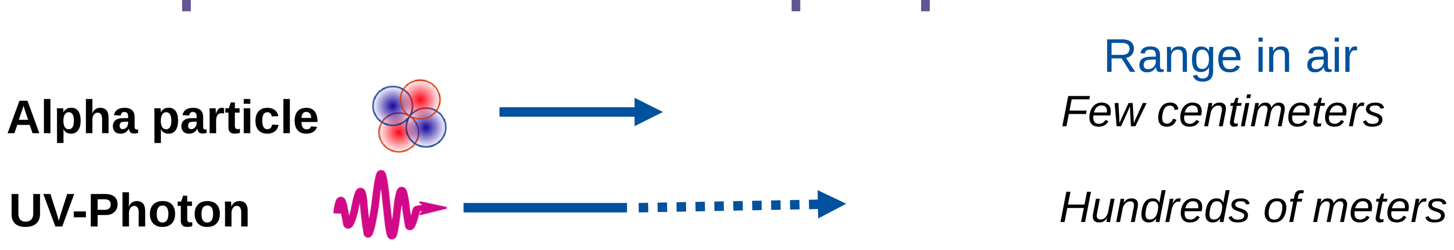
This causes considerable risk to emergency teams not only due to ionizing radiation but also to potentially hazardous materials, fire and debris.

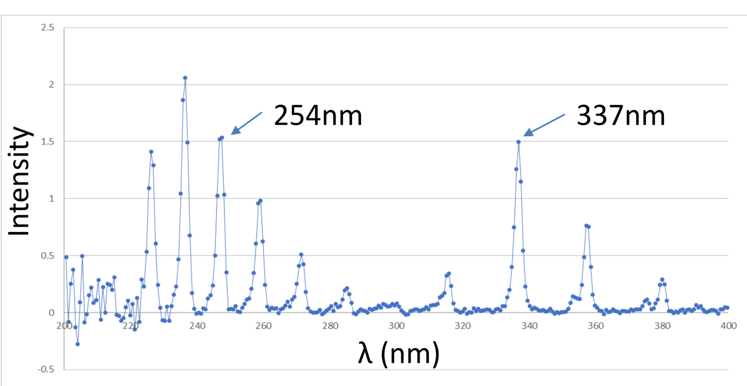
Aim of the project

RemoteALPHA[1]→ Sensing of a radiological threat at safe distances



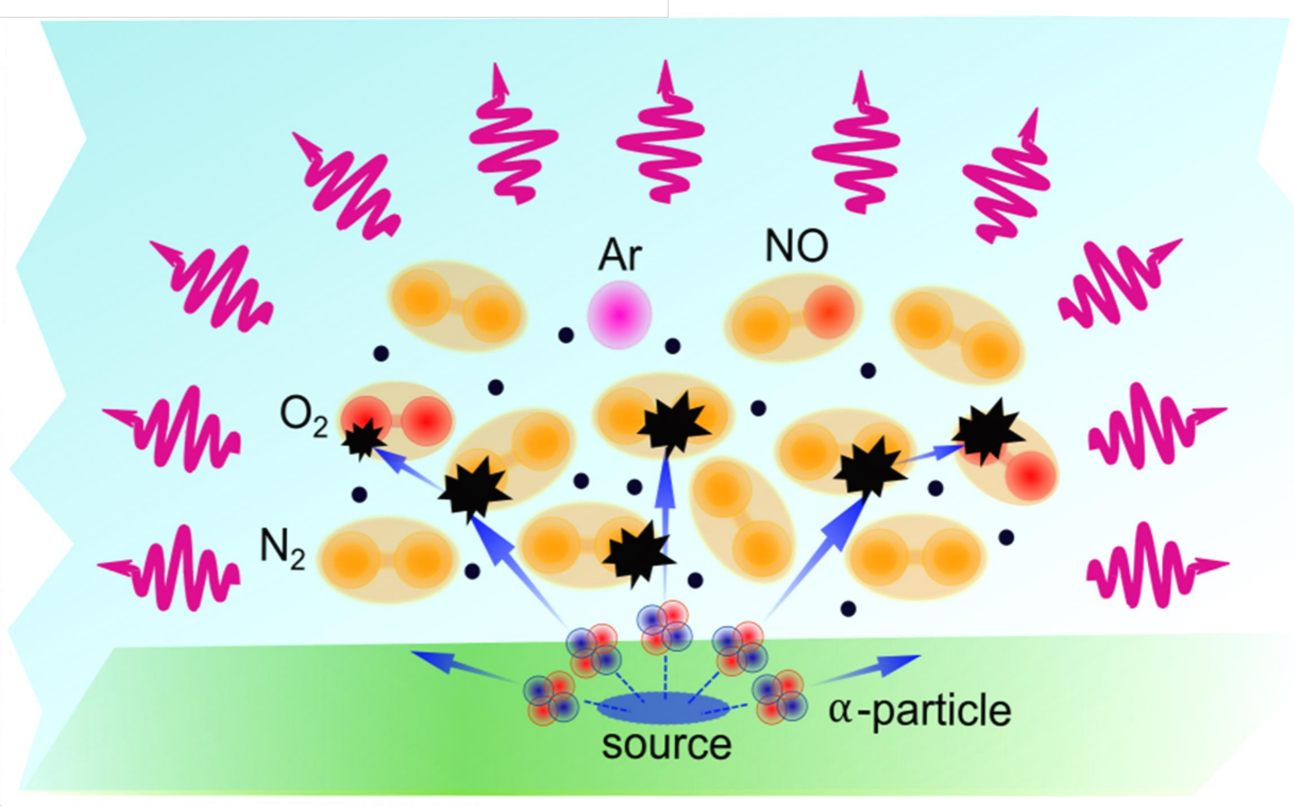
Optical detection of alpha particles





The alpha particle interacts with nitrogen, which leads to emission of UV-photons.[2]

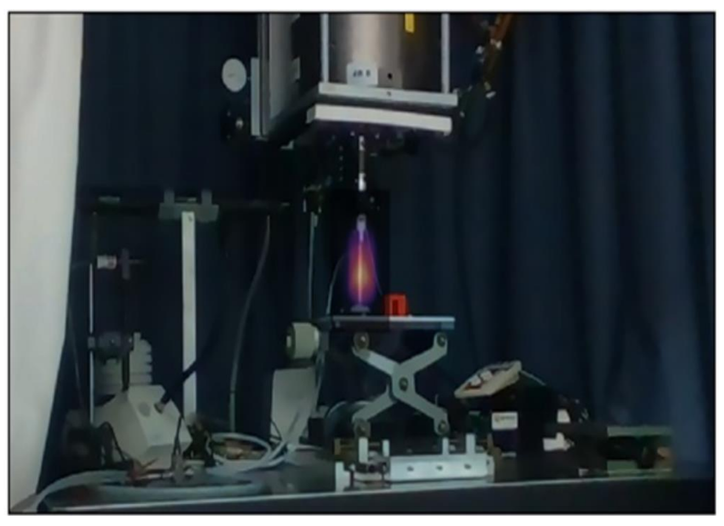
Measurement of 337 nm (UVA) and 254 nm (UVC) emission lines.



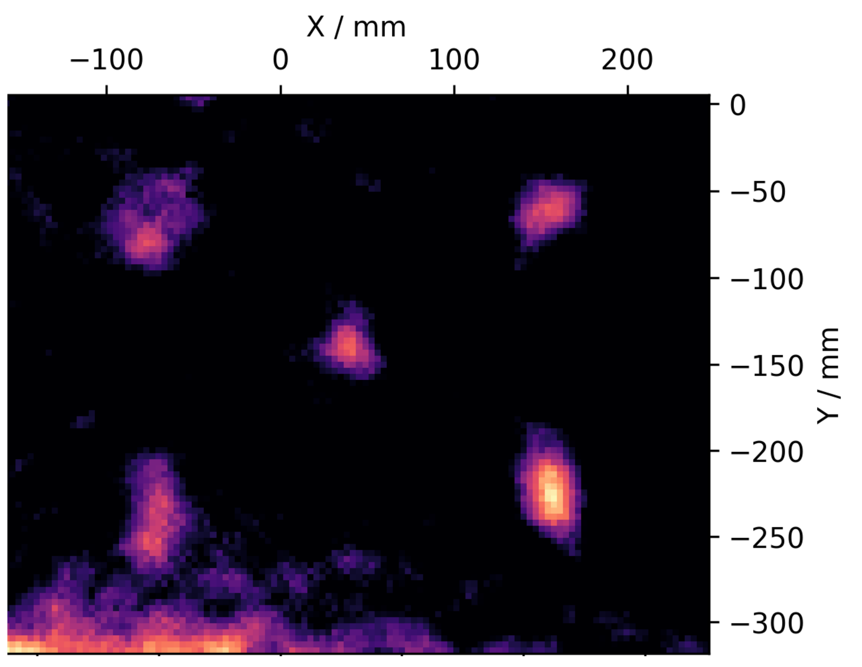
Optical detection system

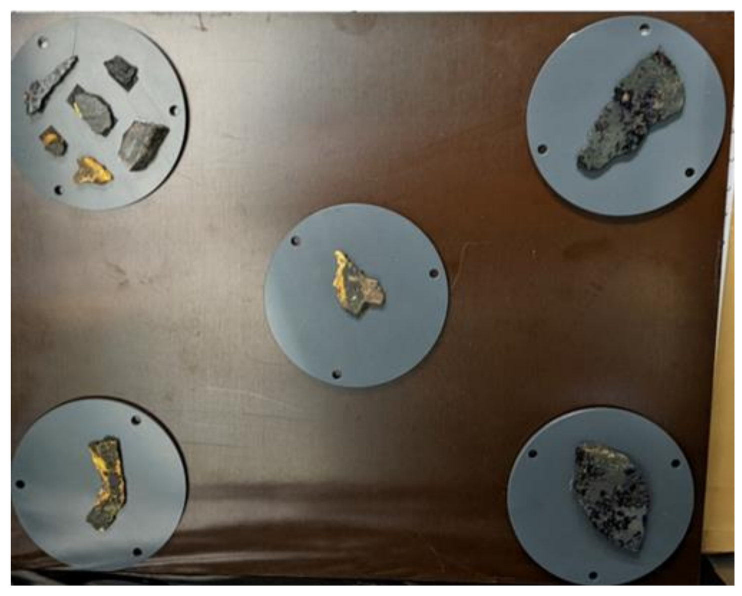
Radioluminescence imaging

The experiments were performed with a fused silica lens to collect the photons. The lens and the PMTs were mounted on a goniometer in a way that it can scan the sample area. The distance between sample and lens is 2 m.

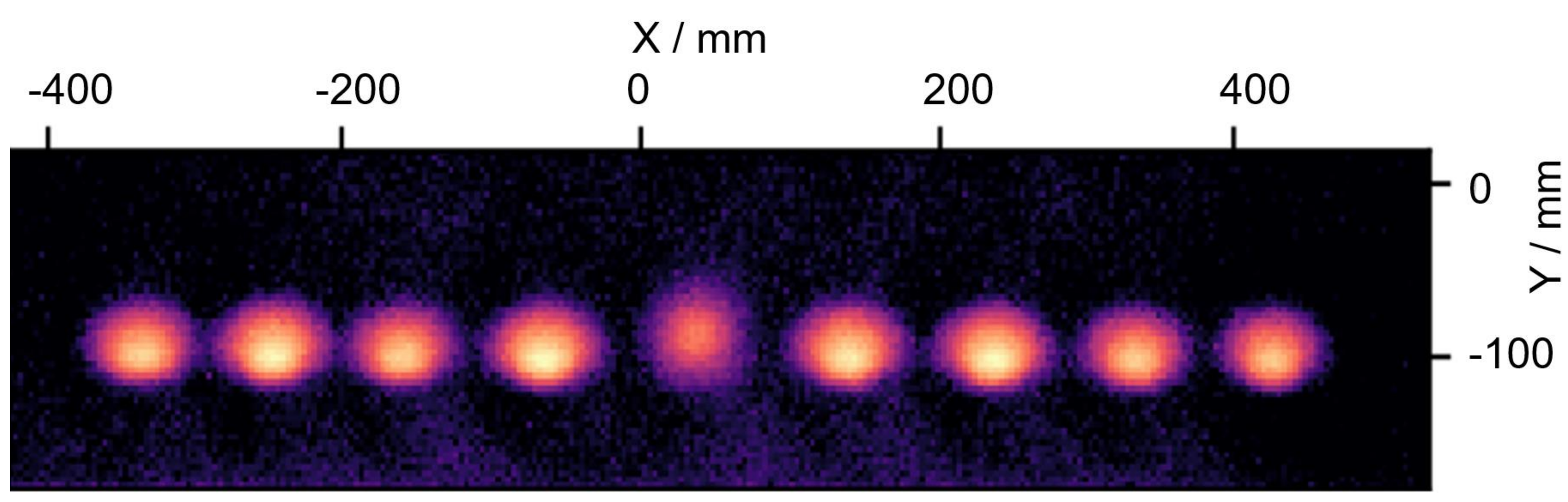


UVC radioluminescence image of accelerated alpha particles (Microbeam at PIAF)[3]. Here, a compact cyclotron and microbeam system was used to provide a narrowly focused alpha beam with a tunable particle rate from 5 x 10^4 s^{-1} to about 4.5 x 10^7 s^{-1} with an entrance energy of 8.3 MeV





UVA radioluminescence image of the pitchblende mineral samples[4]. The measurement was performed in air and lasts 64 hours. The surface count rate per sample is about 1000 cps and 1500 cps.



UVA radioluminescence image of concrete samples spiked with ^{241}Am. The one in the middle with 165 kBq and the others with around 520kBq. The total photon count rate per second is between 229 and 333. The 165 kBq sample has a photon count rate of 140 s^{-1}.

References

[1] www. euramet.org/research-innovation/search-research-projects/details/project/remote-and-real-time-optical-detection-of-alpha-emitting-radionuclides-in-the-environment/
[2] Sand, J. et al.: Stand-Off Radioluminescence Mapping of Alpha Emitters under Bright Lighting, IEEE Transactions on Nuclear Science, 2016, 63, pp. 1777–1783
[3] Luchkov, M. et al.: Novel optical technologies for emergency preparedness and response: Mapping contaminations with alpha-emitting radionuclides, Nuclear Inst. and Methods in Physics Research, 2023,A 1047
[4] Klose, A. et al.: On the way to remote sensing of alpha radiation: radioluminescence of pitchblende samples, Journal of Radioanalytical and Nuclear Chemistry, 2022, 331, pp. 5401–5410

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