19ENV02 RemoteALPHA

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

F. Krasniqi, PTB

The project 19ENV02 RemoteALPHA has received funding from the EMPIR programme co-financed by the Participating States and from the European Union's Horizon 2020 research and innovation programme.

19ENV02 RemoteALPHA denotes the EMPIR project reference.

Motivation: Emergency Response Plans

Safety standards for the protection against the dangers arising from the ionising radiation:
The European Directive 2013/59/EURATOM

Article 97

Emergency Management System

-Member states should ensure that account is taken of the fact that emergencies may occur in their territory…
-The emergency management system shall provide for the establishment of emergency response plans…

Article 98

Emergency Preparedness

-Member States shall ensure that emergency response plans are established in advance for the various types of emergencies…
-Member States shall ensure that emergency response plans are tested and revised at regular intervals…

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International Cooperation

Member States shall cooperate with other Member States and with third countries in addressing possible emergencies on its territory which may affect other Member States or third countries…

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Possible radiological emergency:
Accidental or deliberate dispersion of alpha emitting radionuclides in the environment

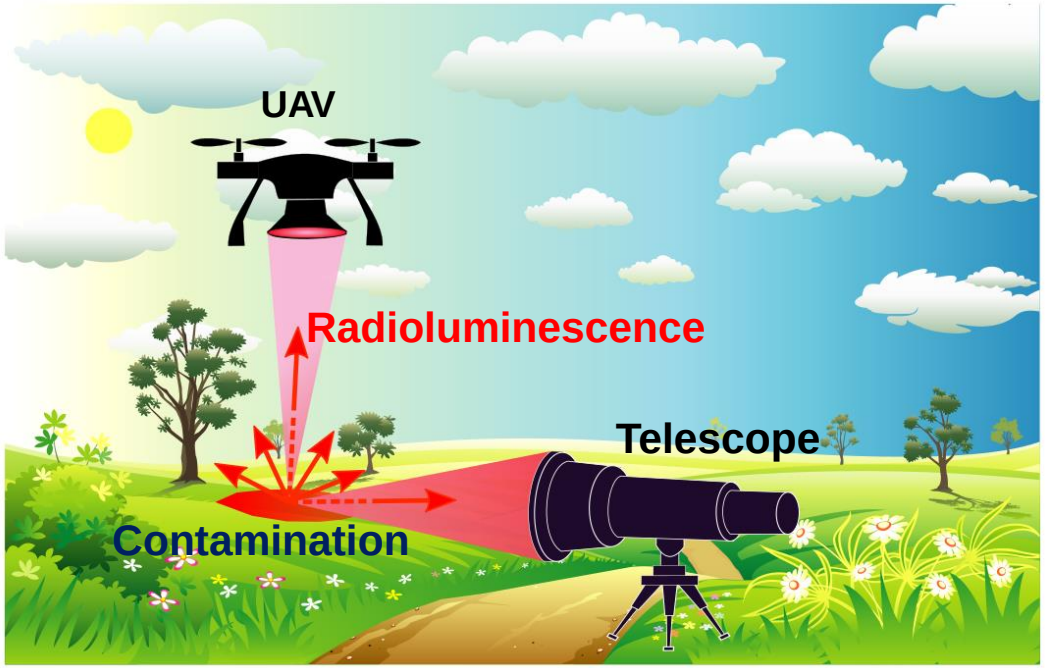
Alpha Particles. Close Proximity Detection

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

Traditional detection methods (proportional counter, scintillator counter, PIPS detectors) are:

- **time consuming and tedious,**
- involve **scanning very close to the surface** of the contaminated area,
- require the use **personal protective equipment**,
- **Expose the personel to other hazards and risks (other types of radiation, fire, etc.)**.

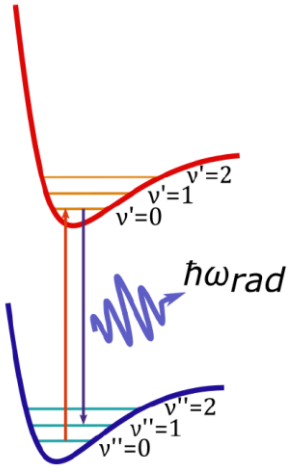
Motivation: Remote detection of alpha particles



Concept of remote detection of alpha particles.

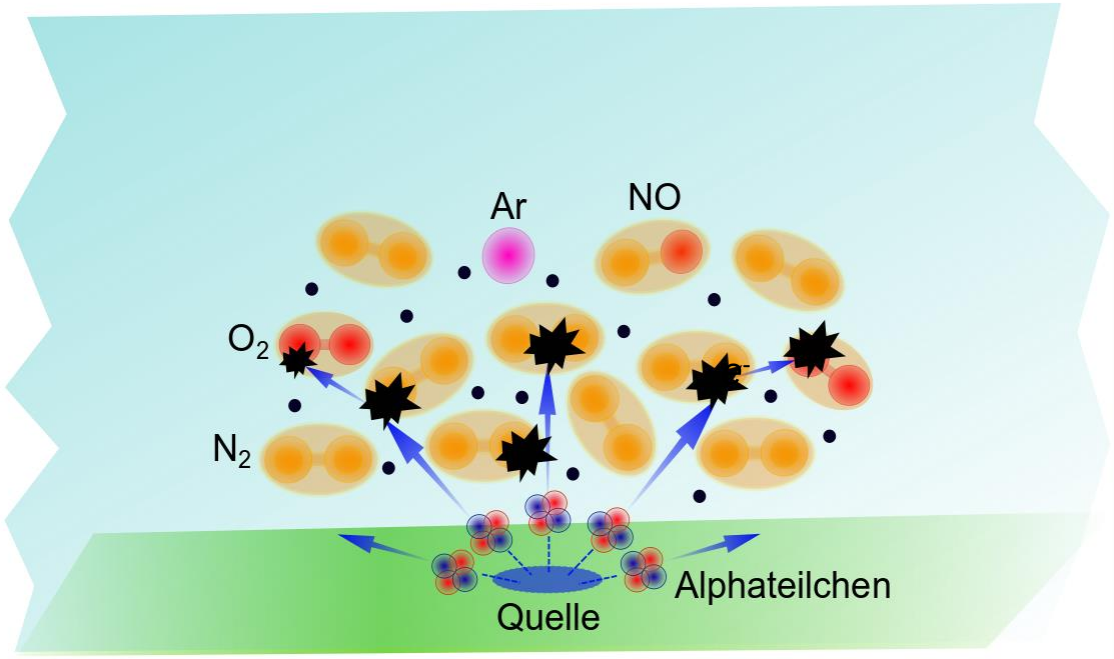
Advantages:

- Operators are kept out of the radiation field,
- Efficient scanning of large areas.



Use of optical transitions in gas molecules: **radioluminescence**

Radioluminescence at a glance



Schematic representation of air ionization by α-particles.

High-energy alpha particles ionize air (predominantly molecular nitrogen).

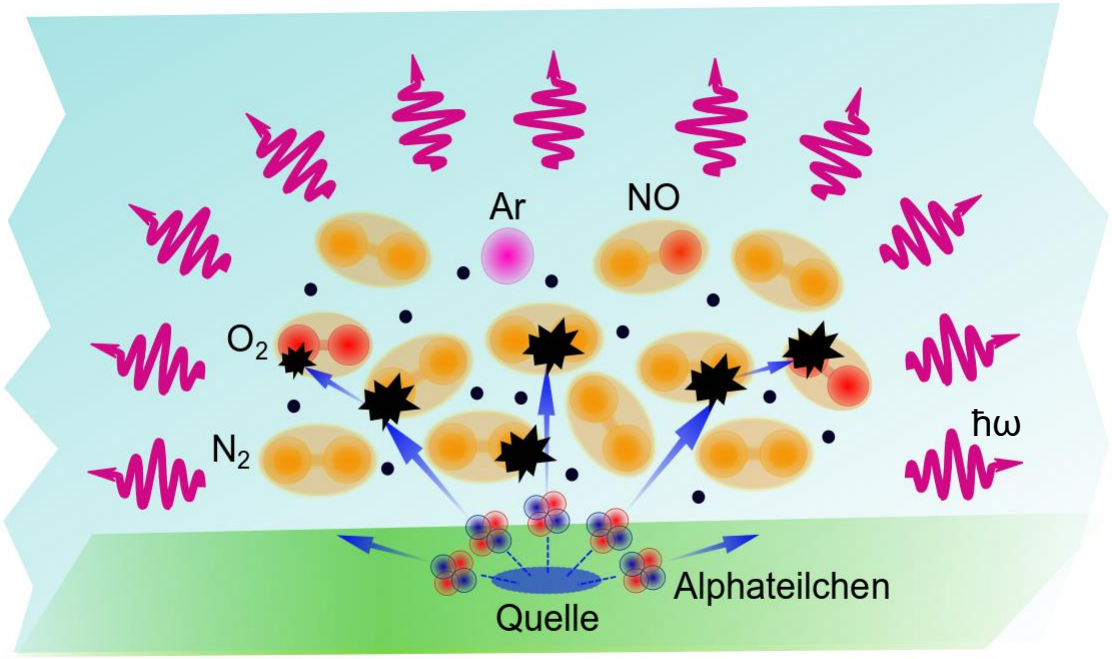
Secondary electrons excite the air molecules, e.g.,

$$e^- + \mathrm{N_2}\left(\mathrm{X}^1\Sigma_g^+\right) \rightarrow \mathrm{N_2^*}\left(\mathrm{C}^3\Pi_u\right) + e^-$$

$$e^- + \mathrm{N_2^+}\left(\mathrm{X}^2\Sigma_g^+\right) \rightarrow \mathrm{N_2^*}\left(\mathrm{C}^3\Pi_u\right)$$

$\mathrm{X}^1\Sigma_g^+, \mathrm{C}^3\Pi_u \rightarrow$ Molecular levels

Radioluminescence at a glance



Schematic representation of air ionization by α-particles and radioluminescence.

Air molecules emit fluorescent light (radioluminescence) in the UV range between 200 nm and 400 nm.

Range in air:

α-particles	→	0,04 m
UV light	→	500 m

EMPIR Project: RemoteALPHA

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Partners

PTB – Messen ▪ Forschen ▪ Wissen

Budapest Főváros Kormányhivatala

IFIN-HH

Tampere University

Leibniz Universität Hannover

Universitat Politècnica de Catalunya BARCELONATECH

Szent István University

Alfa Rift Oy

Collaboration:

Australian Government – ANSTO

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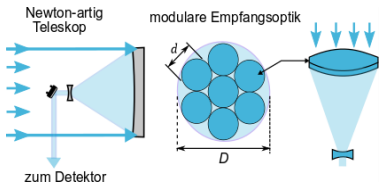
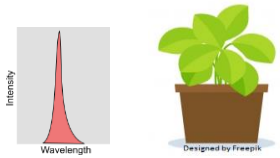
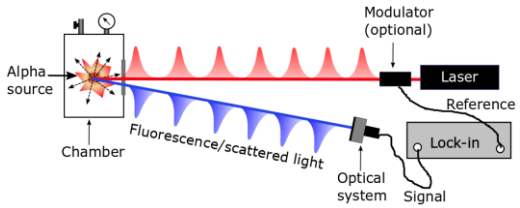
Technical Workpackages







RemoteALPHA: 01.09.2020 - 31.08.2023

WP1	New instruments for the optical detection of alpha emitters in the environment
WP2	Calibration system for the novel radioluminescence detector systems
WP3	Mapping alpha contamination in the environment using UAVs
WP4	Feasibility study on laser-based techniques for alpha emitter detection

Acknowledgments

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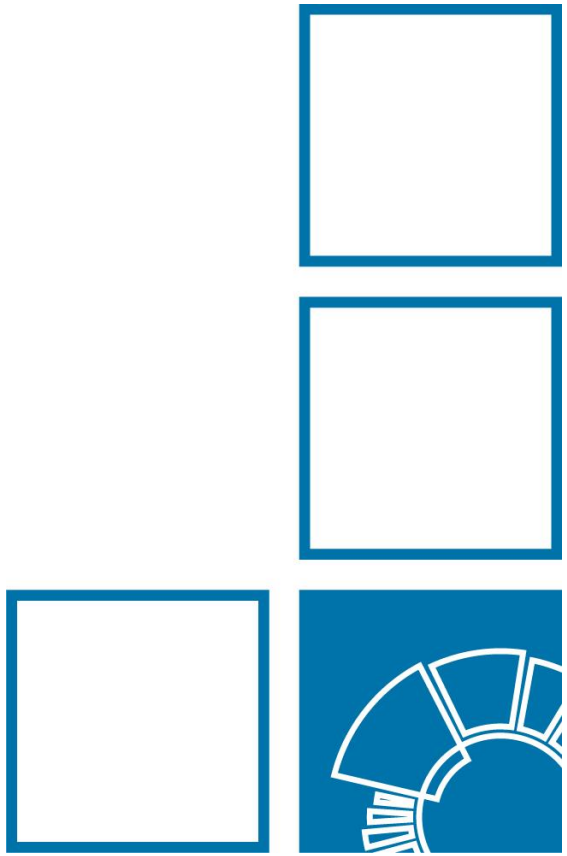
Thank you!



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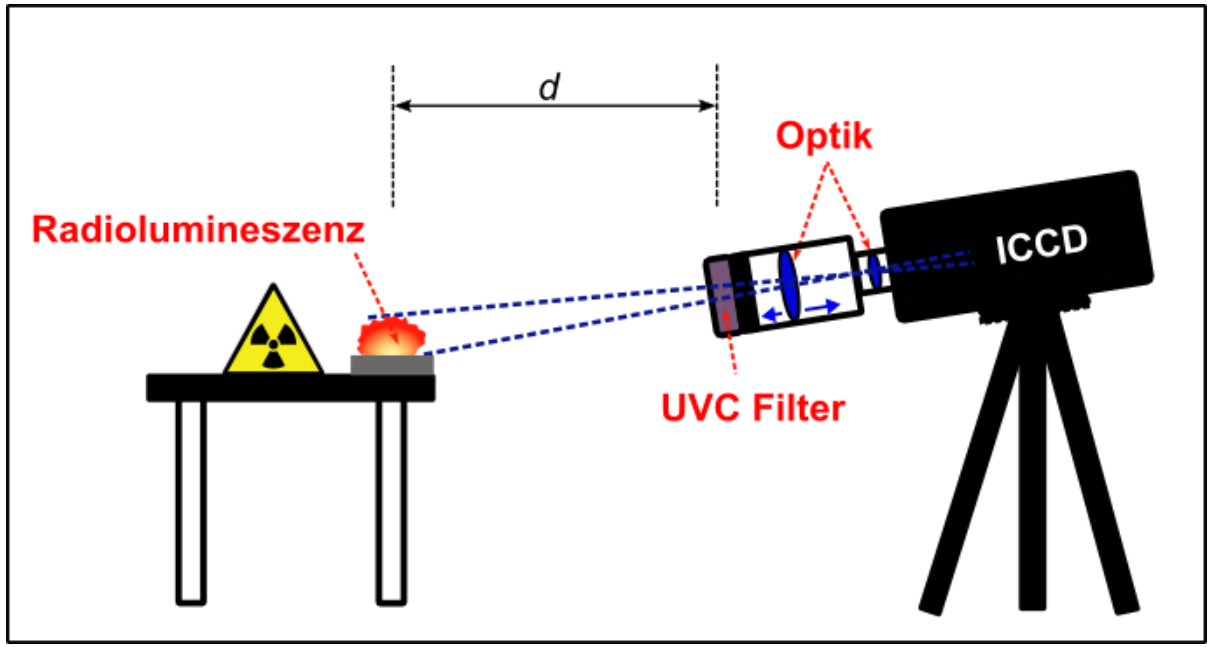
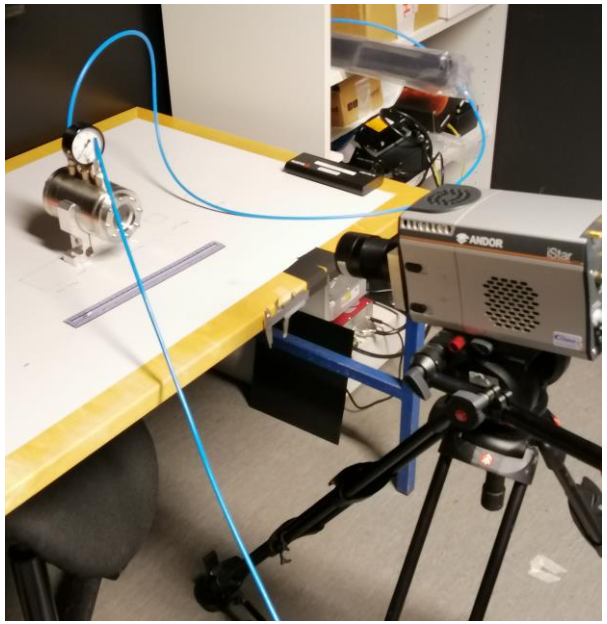
Imaging of alpha emitters in the UVC (solar-blind) spectral range

Experiments at the University of Tampere (Finland), Research Group of Prof. Juha Toivonen

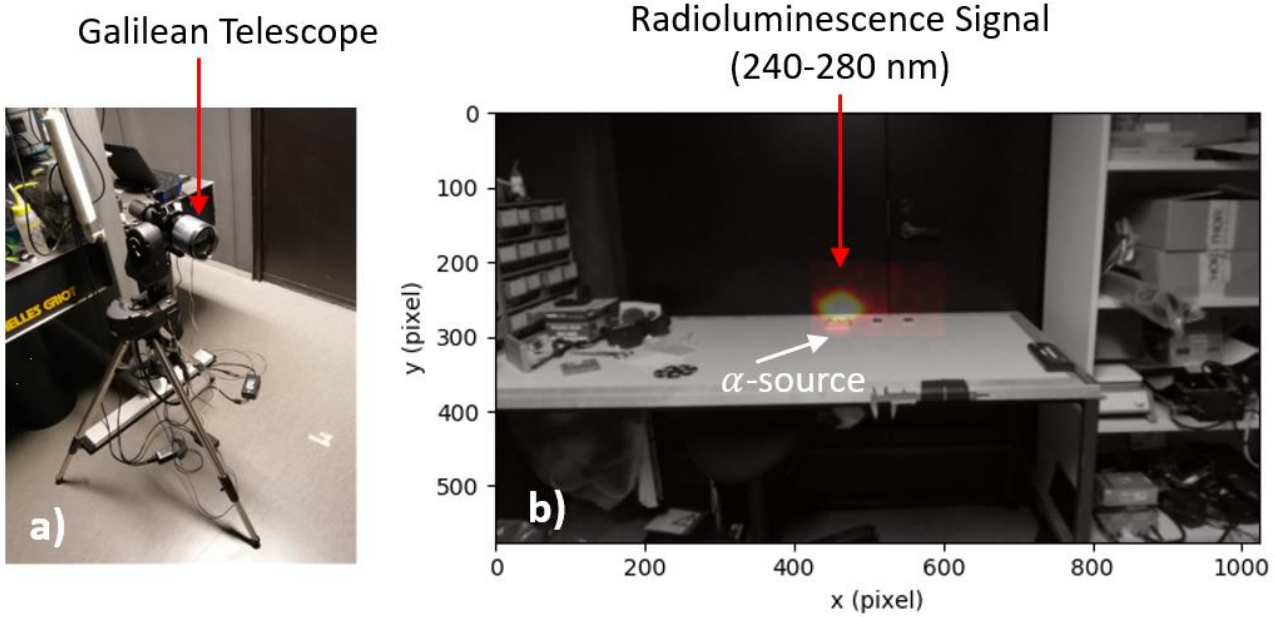
F. S. Krasniqi, T. Kerst, M. Leino, J.-T. Eisheh, H. Toivonen, A. Röttger, J. Toivonen,
Nuclear Inst. and Methods in Physics Research, A **987** (2021) 164821



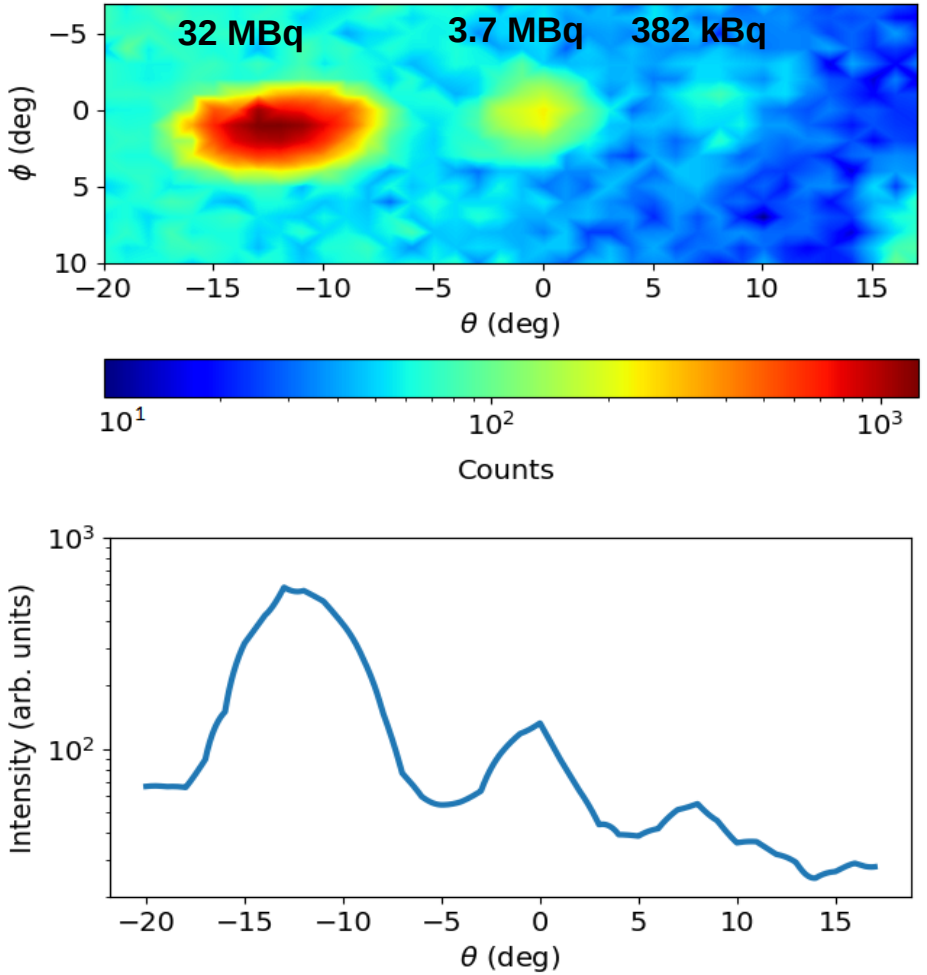


Schematic representation of the UV-C test setup.

UV-C radioluminescence: Detection with telescope and PMT



(a) A photo of the optical system for alpha particle detection. (b) Radioluminescence image of the Am-241 sample (32 MBq) in the UV-C spectral region.

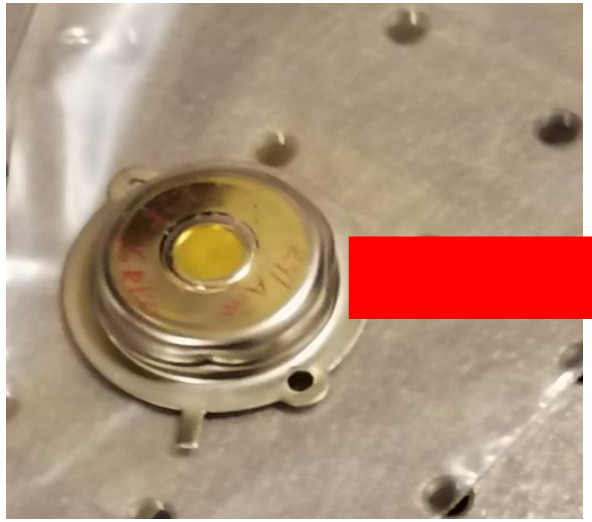


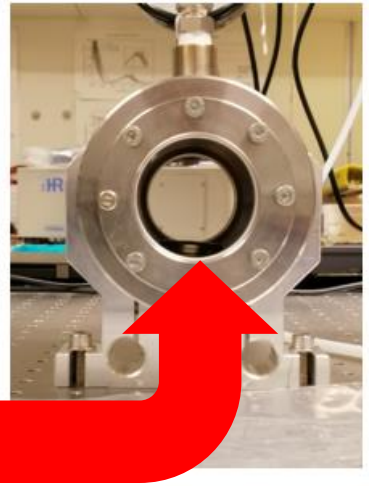
Typical radioluminescence intensity distribution.

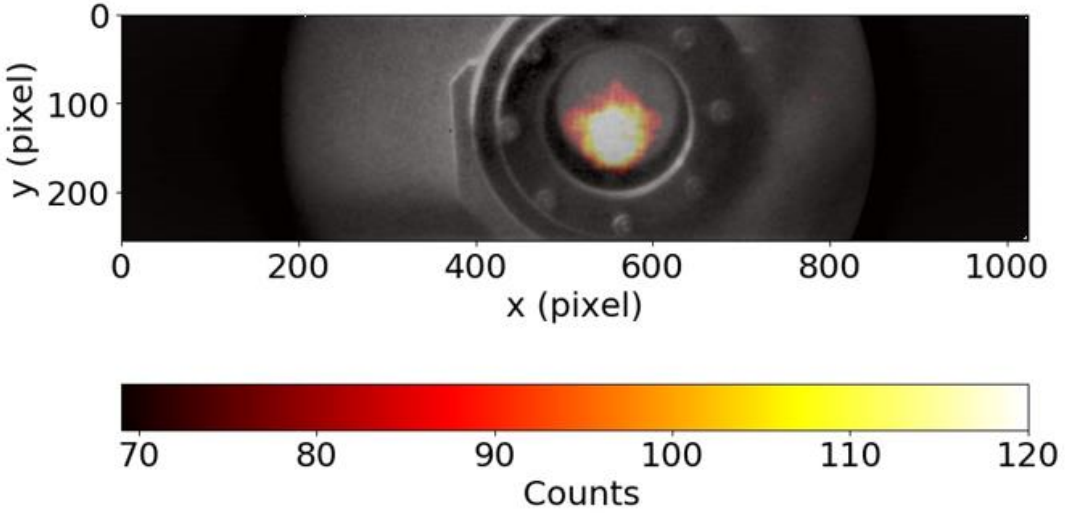
UV-C radioluminescence: Amplification with NO

By adding only 3 ppm NO to the air/N_2 amosphere,
up to 500-fold increase of the radioluminescence signal.

9.9 kBq Am-241
smoke detector ionizer







UVC radioluminescence image of a 9.9 kBq source (right) and a photo of the sample in the experimental chamber (left).