The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Ultraviolet imaging of alpha sources via radioluminescence

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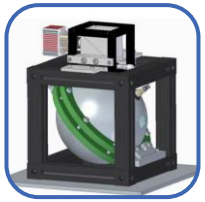
Content

EMPIR “RemoteALPHA” Project

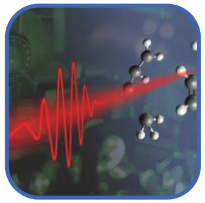
Remote and real-time optical detection of alpha-emitting radionuclides in the environment (2020 –)

WP1. New instrumentation for the optical detection of alpha particle emitters in the environment



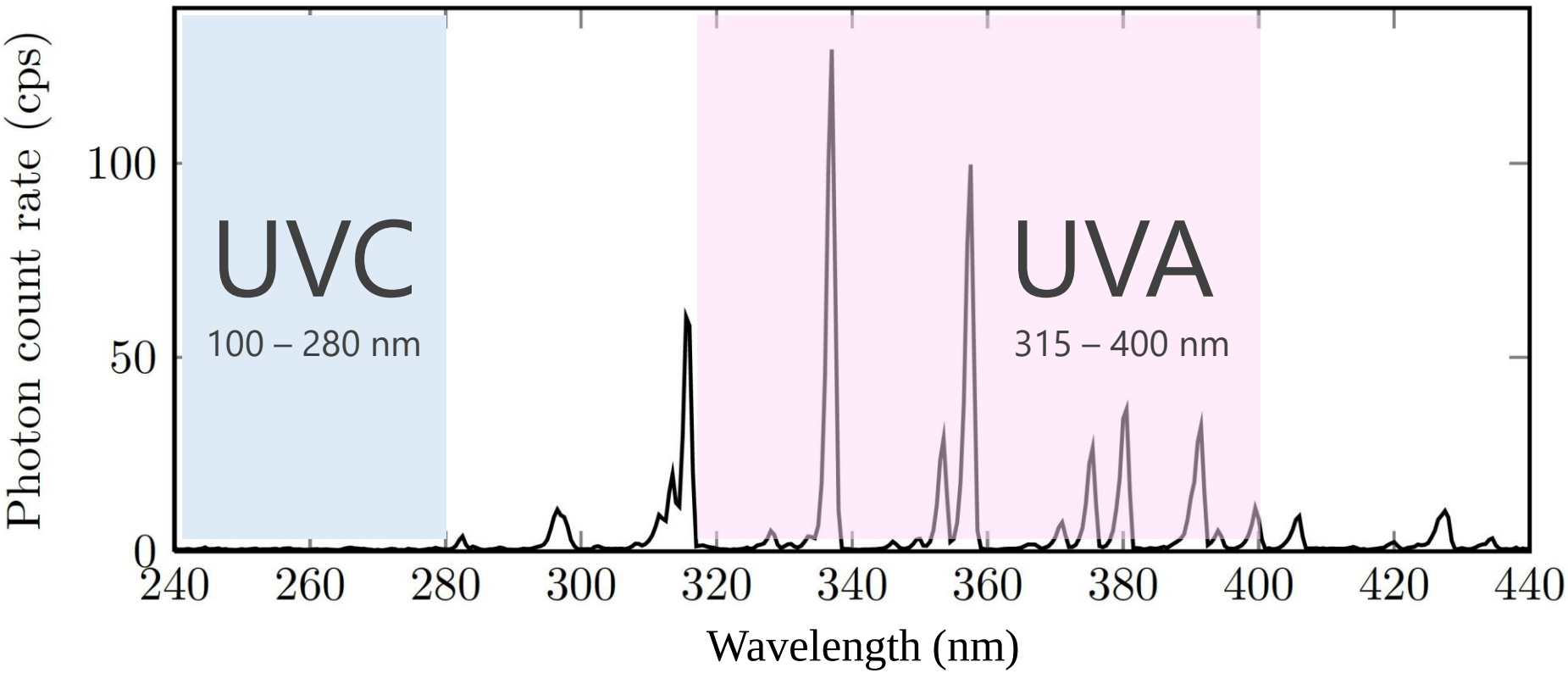
WP2. Calibration system for the novel-type radioluminescence detector systems

WP3. Mapping of alpha contaminations in the environment using UAVs



WP4. Feasibility study of laser-based techniques for detection of alpha emitters

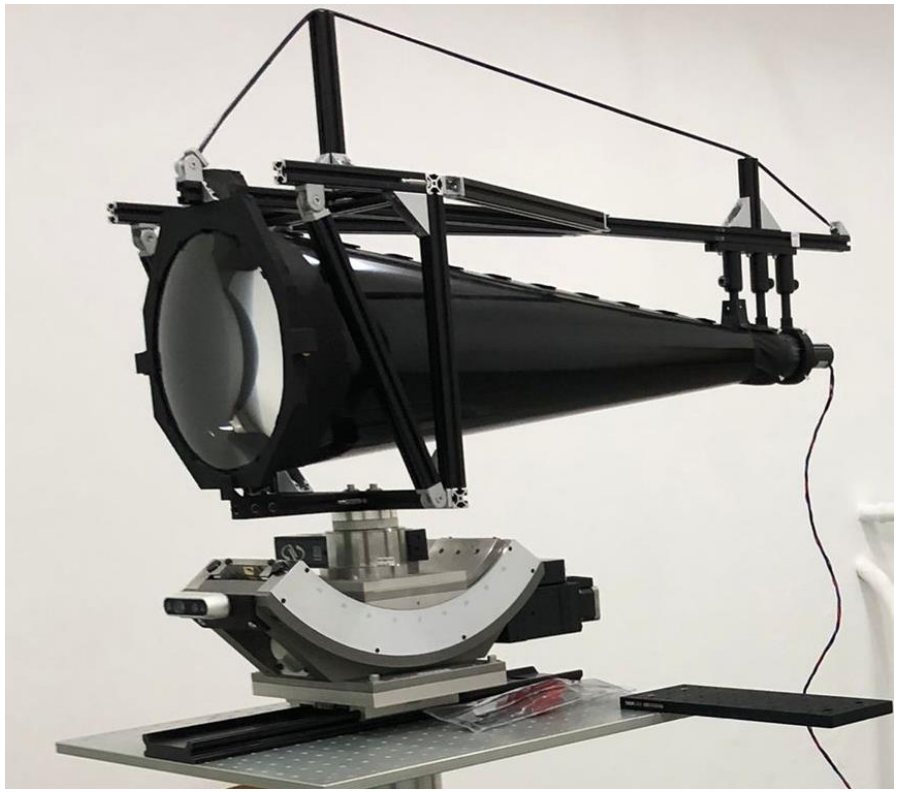
UV signature of an alpha particle



UV Filters

PMT

Instrumentation 1/2



UVFS lens, ø 240 mm

Scanning

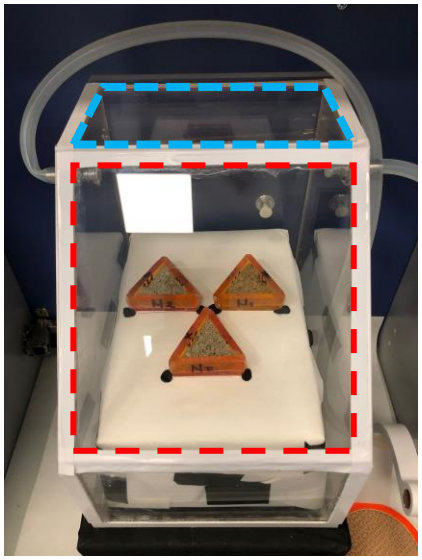
Al mirrors, ø 75 mm x 7 pcs

Scanning + Drone-based

Instrumentation 2/2

Enclosure box for radioactive sources:

- ✓ Handling open sources
- ✓ Configuring luminescent environment with the gas flow system
- ✓ Fused silica window, 90% transmission

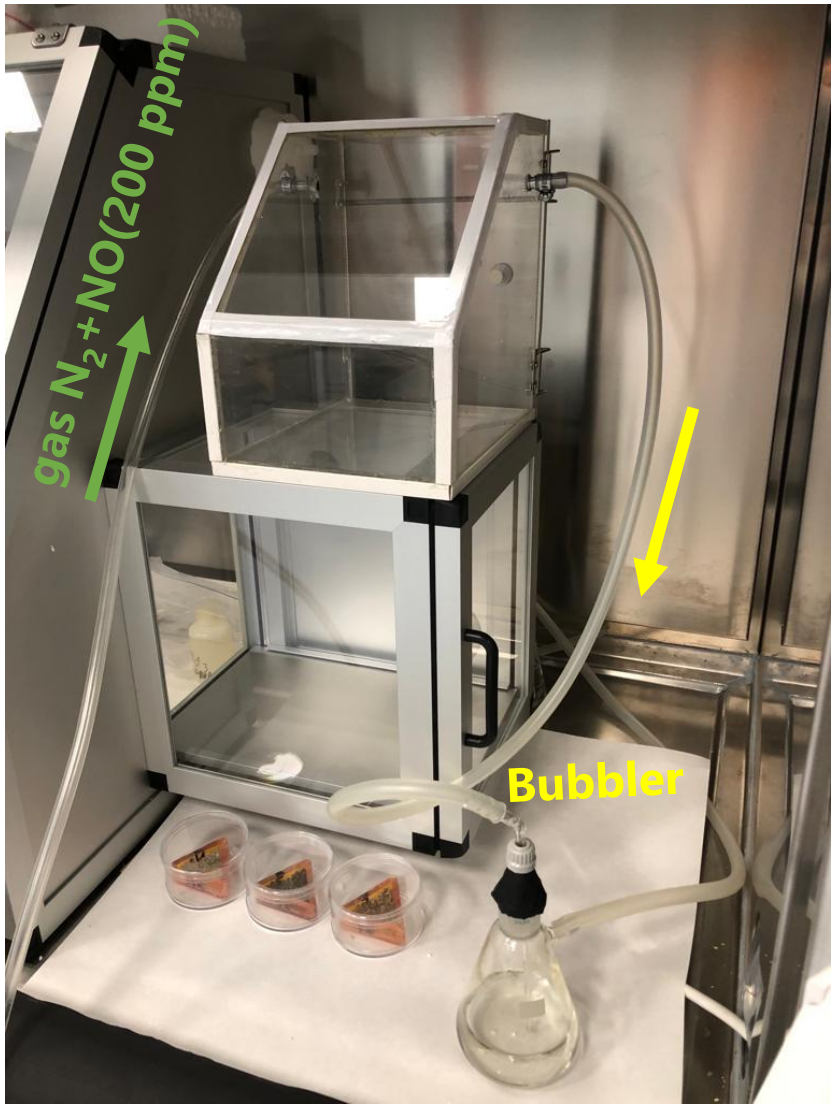


Plexiglass sides

L25 x W21 x H27 cm

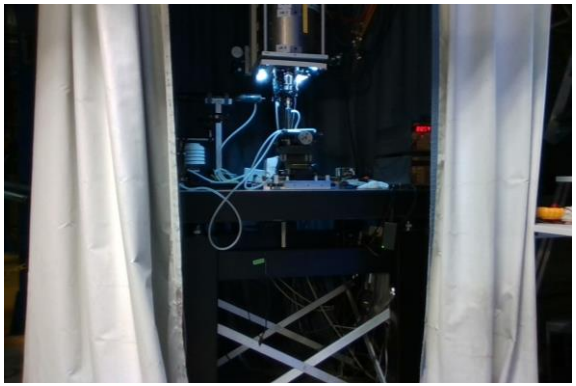
UVFS window @ 45°

L20 x W20 cm



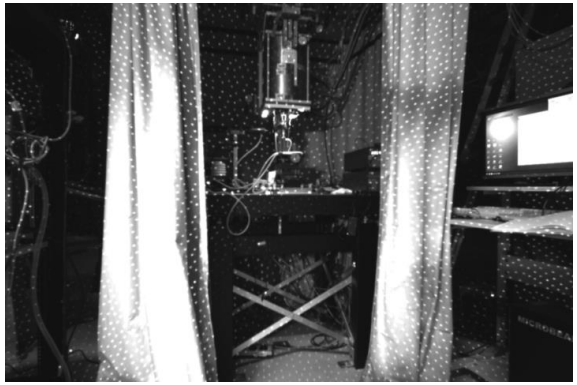
Blending UV and camera images

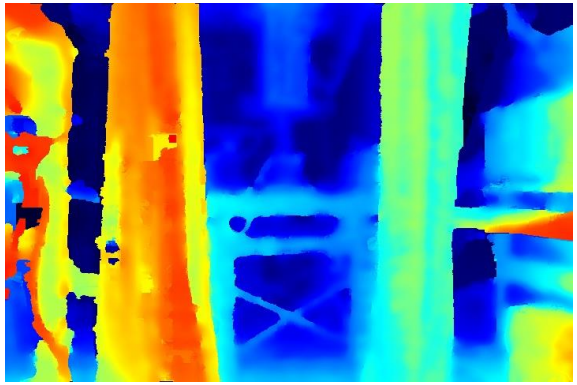
Color image



+

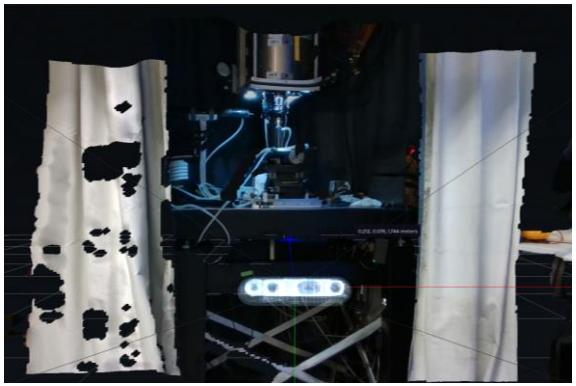
Stereo depth image (2 IR cameras + texture projector)





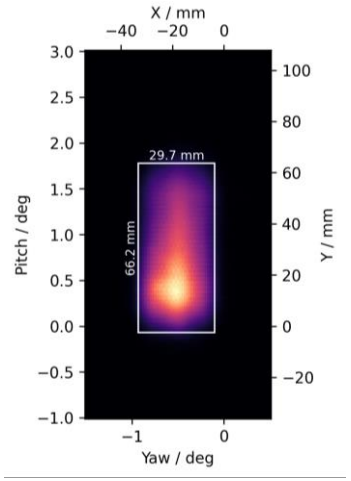
=

3D model of the environment, a.k.a. „pointcloud“



+

2D (pitch/yaw) UV scan



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The known offset of the camera and UV imagers allows ray tracing

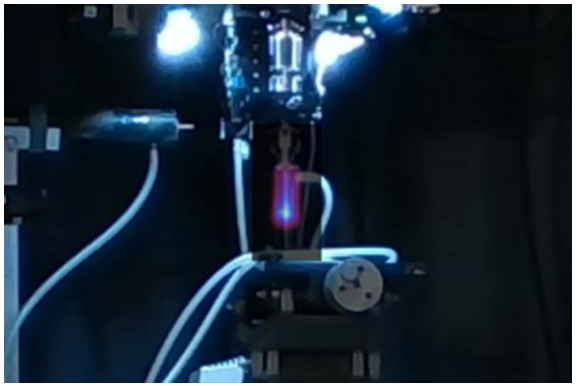
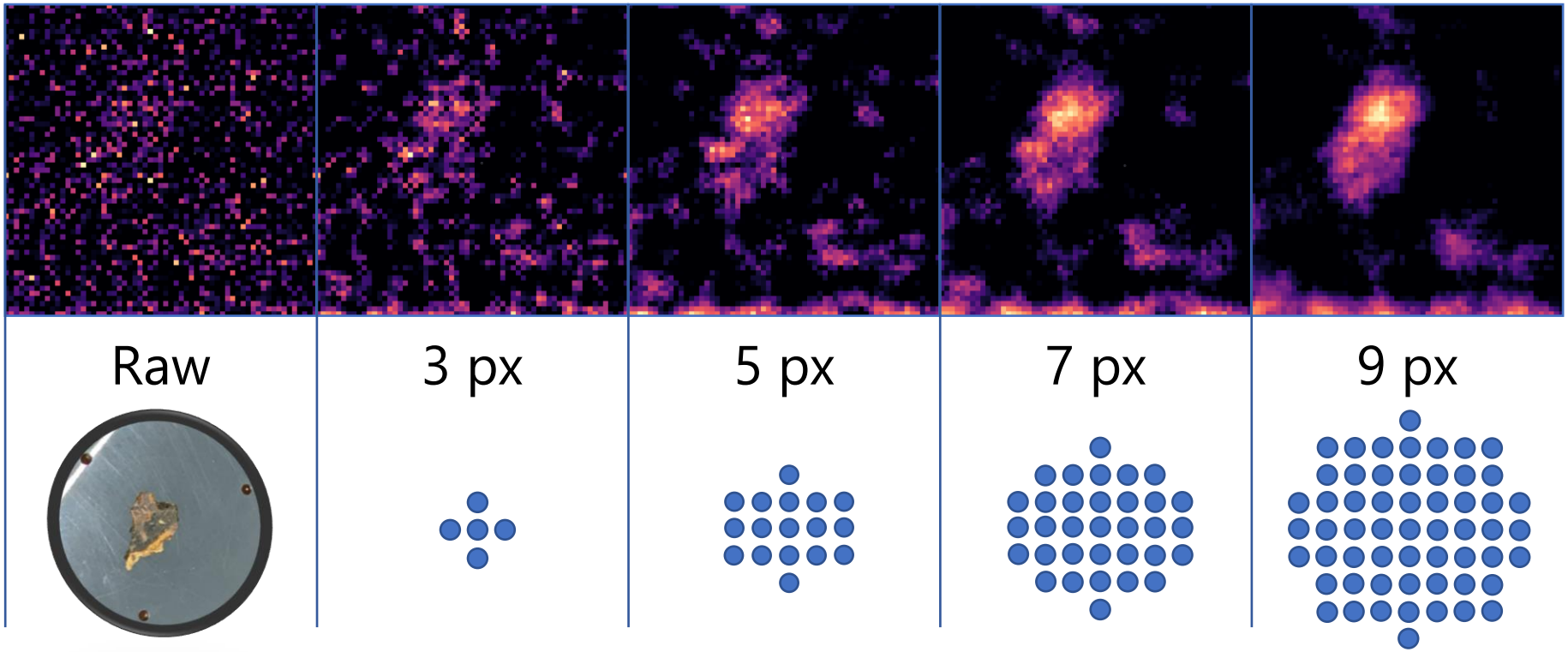


Image processing

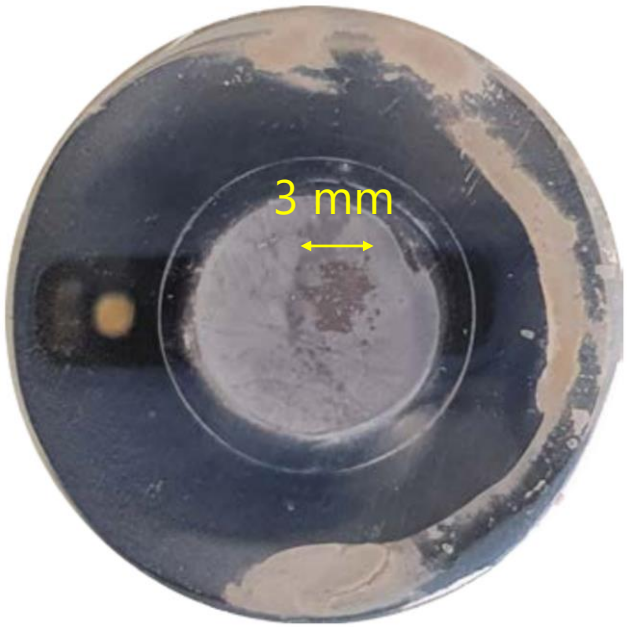
The scanning **objective** is to **distinguish the source** over the background within the **reasonable** (*better: shortest*) **time** period

The **averaging** of a neighboring pixel group (blurring) is **necessary** to get a **uniform background** and **reveal** scan **features**



Calibration 1/4

Stefan Röttger @ PTB



Calibration coefficients (NTP)

Optics / Filtering / Gas	Sensitivity, $\frac{s^{-1}}{MBq\ MeV}$
Lens / UVA / Air	166 ± 12
Lens / UVC / Air	2.03 ± 0.17
Lens / UVC / N_2NO (sat.)	12000 ± 800

$$R_{Po210} = \frac{S[\text{UVC / } N_2NO \text{ (sat.)}]}{S[\text{UVA / Air}]} = 72 \pm 7$$

^{210}Po

Alpha activity standard

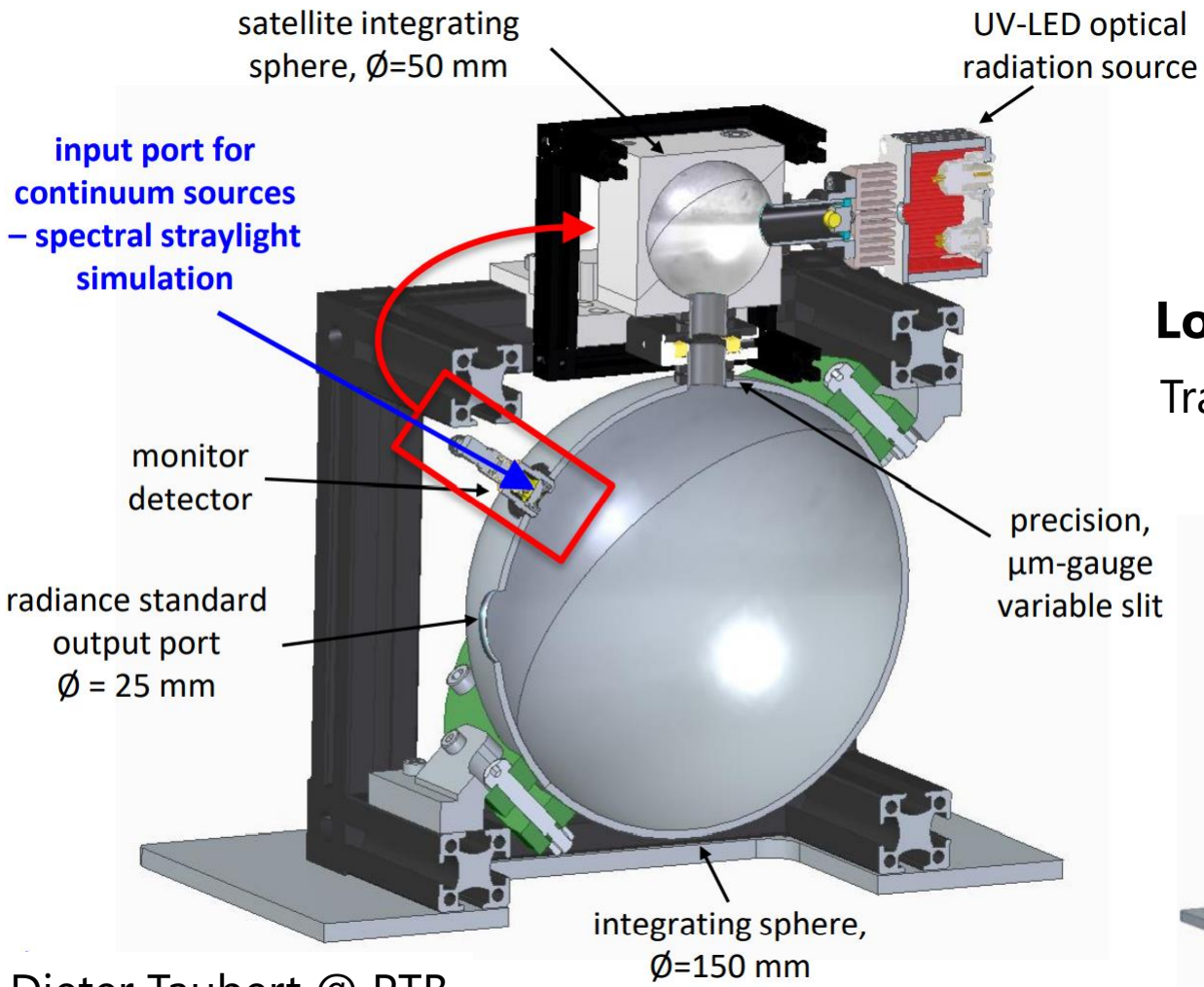
Traceable to national standard

Pure α-emitter!

E_α = 5304 keV

p_α = 99.9988%

Calibration 2/4



#1 – 260 nm

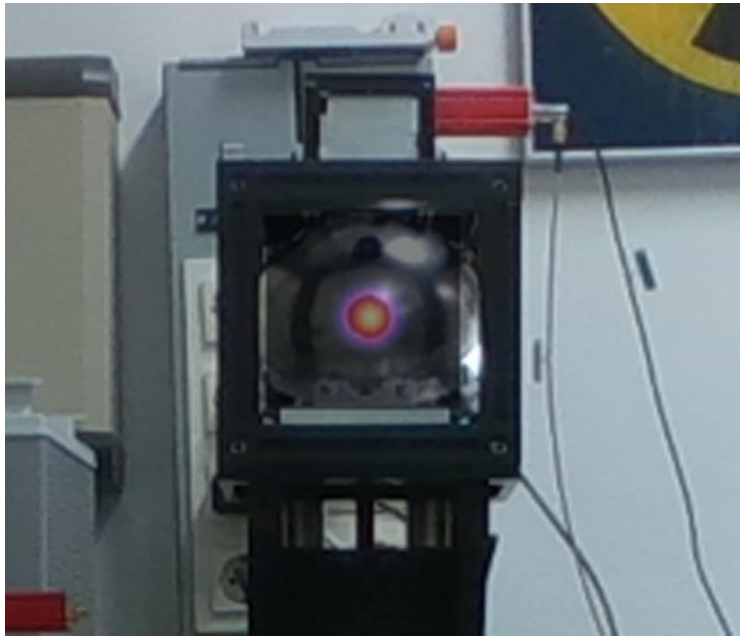
#2 – 340 nm

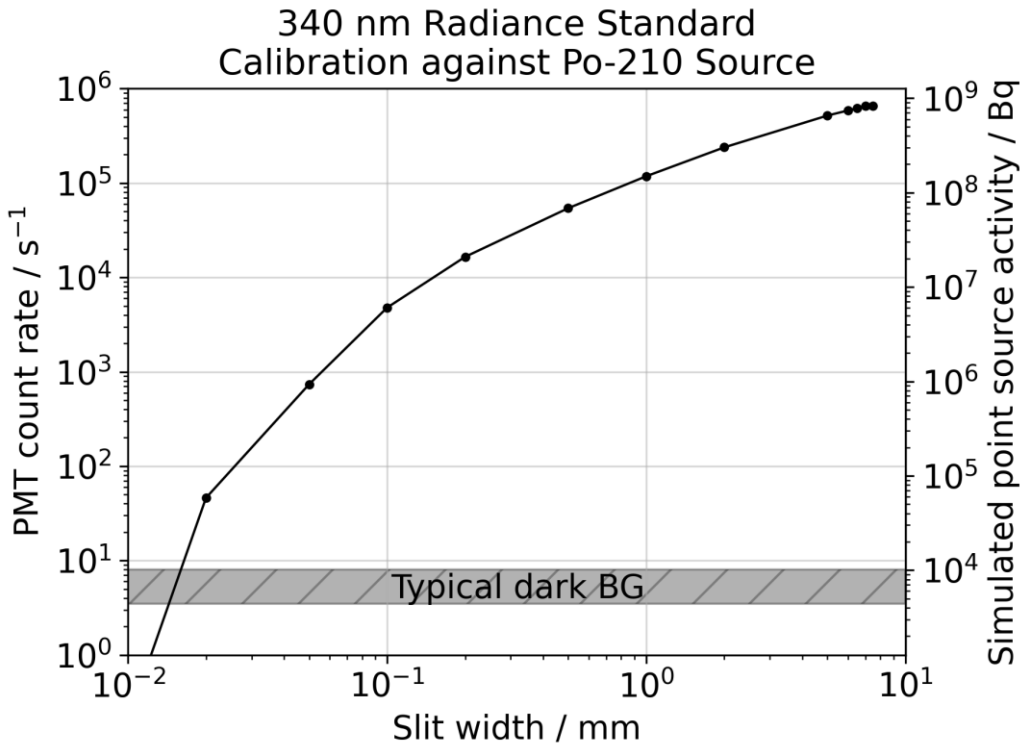
Low photon flux standard

Traceable to national standard

Dieter Taubert @ PTB

Calibration 3/4





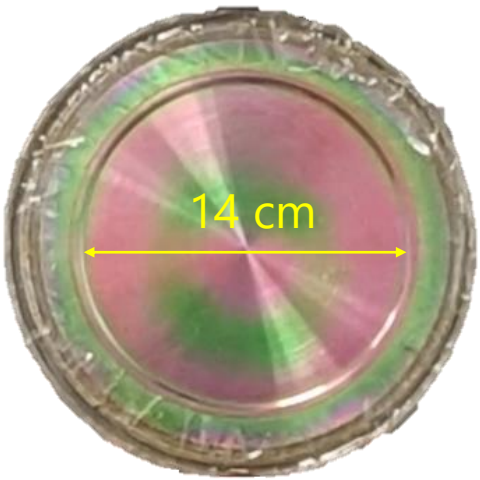
Transfer Standard

Adjustable photon flux!

- Calibrated against the activity standard of Po-210
- Simulates activity from **80 kBq** to **800 MBq**

Calibration 4/4

IFIN-HH



Calibration coefficients

Optics / Filtering / Gas	Sensitivity, $\frac{\mathrm{cm}^2\ \mathrm{s}^{-1}}{\mathrm{kBq\ MeV}}$
Lens / UVA / Air	5.2 ± 1.0
Lens / UVC / N_2NO (sat.)	332 ± 27

$$R_{\mathrm{Pu239}} = \frac{S[\mathrm{UVC\ /\ N_2NO\ (sat.)}]}{S[\mathrm{UVA\ /\ Air}]} = 64 \pm 13$$

$$R_{\mathrm{Po210}} = 72 \pm 7$$

^{239}Pu

Alpha reference source

Traceable to national standard

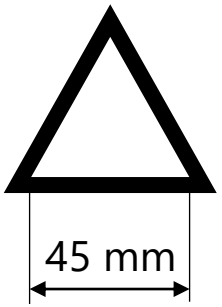
$$A_s = (31.1 \pm 1.4)\,\frac{\mathrm{Bq}}{\mathrm{cm}^2} \qquad \bar{E}_\alpha = 5149\ \mathrm{keV}$$

Environmental samples

Deposited activity of Am-241

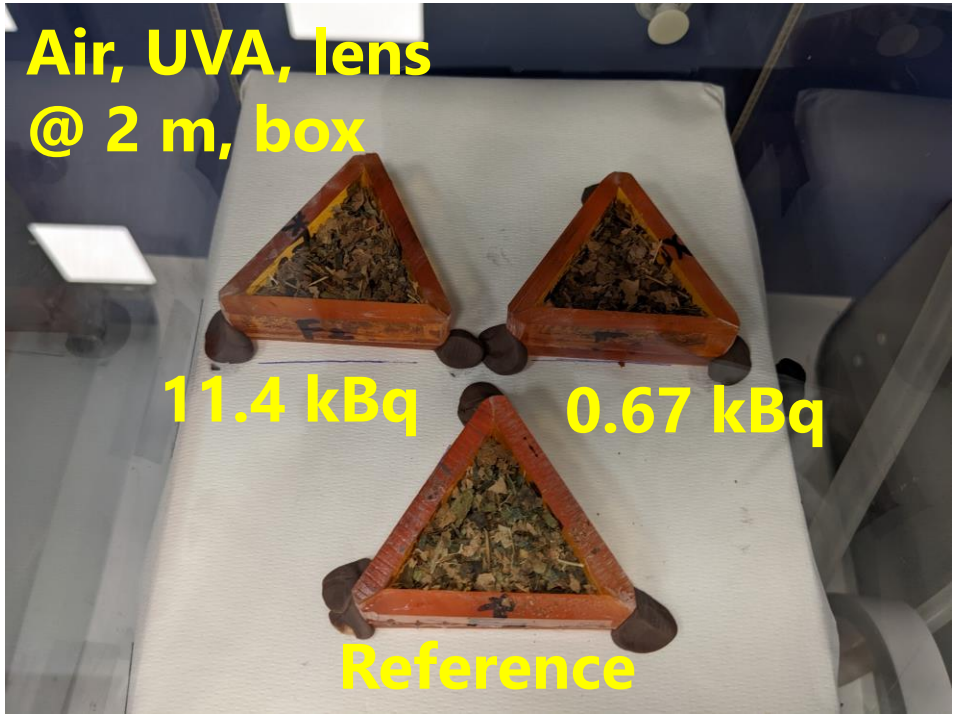
Sample	Sand 1	Sand 2	Sand 3	Soil 1	Soil 2	Soil 3	Leaves 1	Leaves 2	Leaves 3
Activity (kBq)	–	1.3	9.5	–	1.3	11.4	–	0.67	11.4

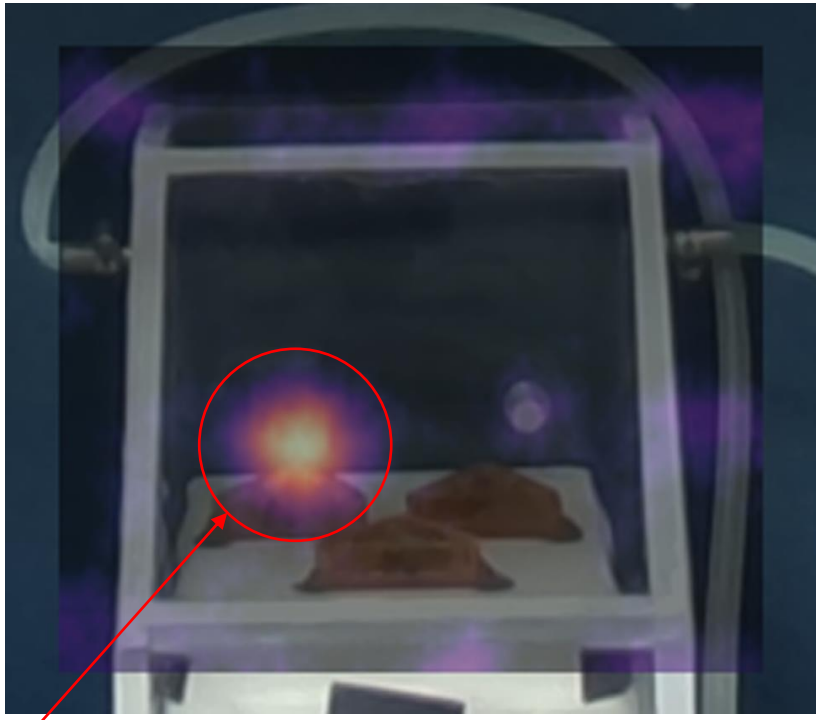






Leaf samples: Air

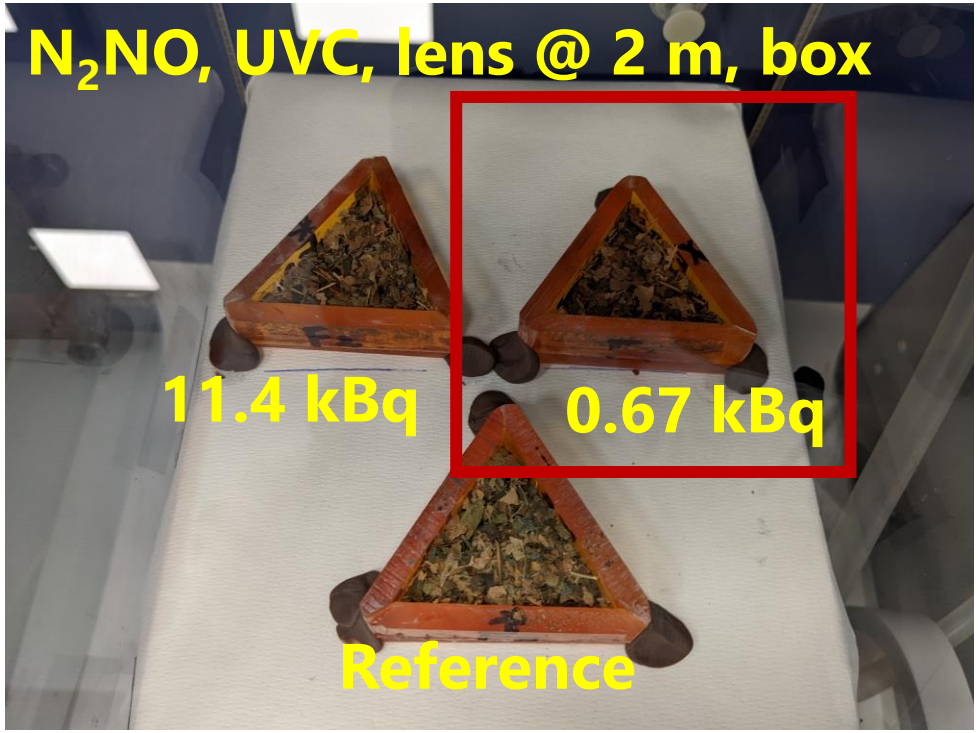


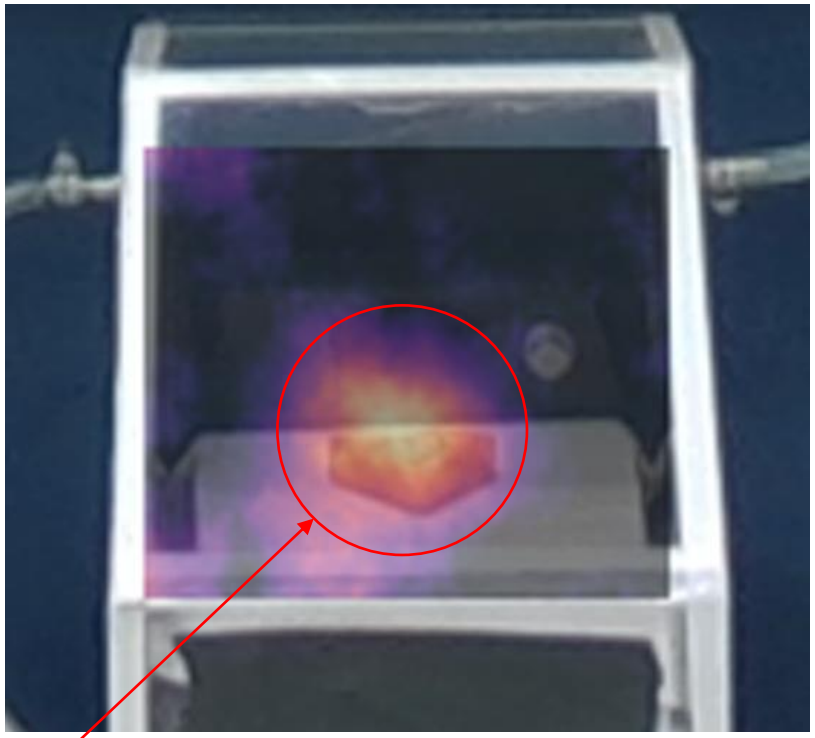


$$\boldsymbol{A}_{\mathbf{point}} = (1.42 \pm 0.16)\ \mathrm{kBq}$$

$$\text{Emissivity} = (12.5 \pm 1.4)\ \%$$

Low-A leaf sample: N_2NO



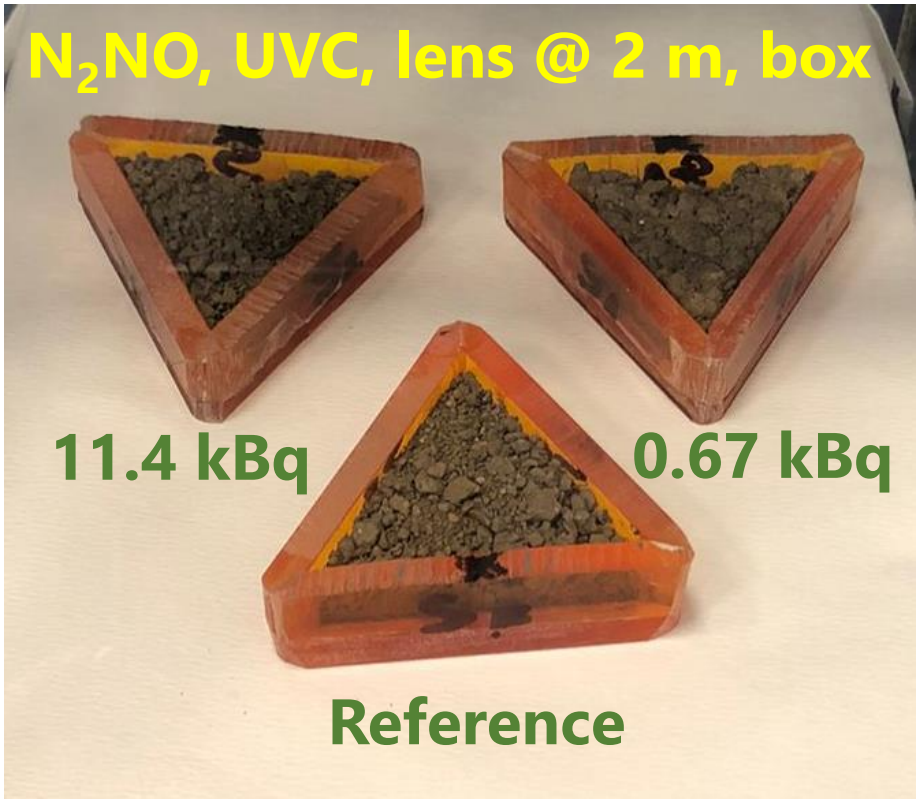


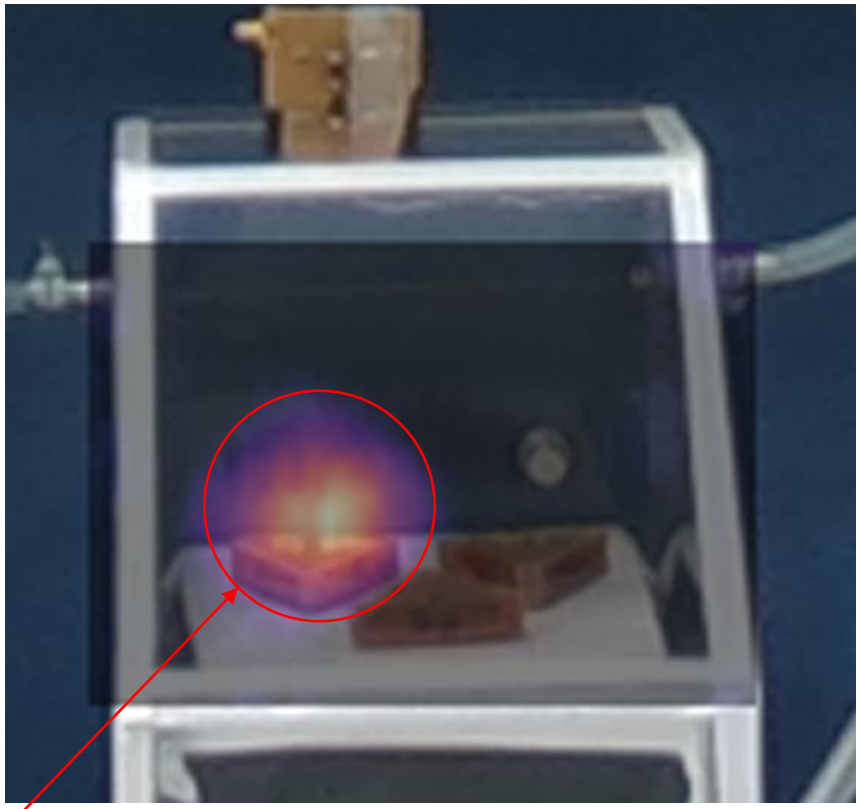
NOT DETECTED in AIR

$$A_{\mathrm{point}} = (24 \pm 3)\ \mathrm{Bq}$$

$$\mathrm{Emissivity} = (3.6 \pm 0.4)\ \%$$

Soil samples: N_2NO



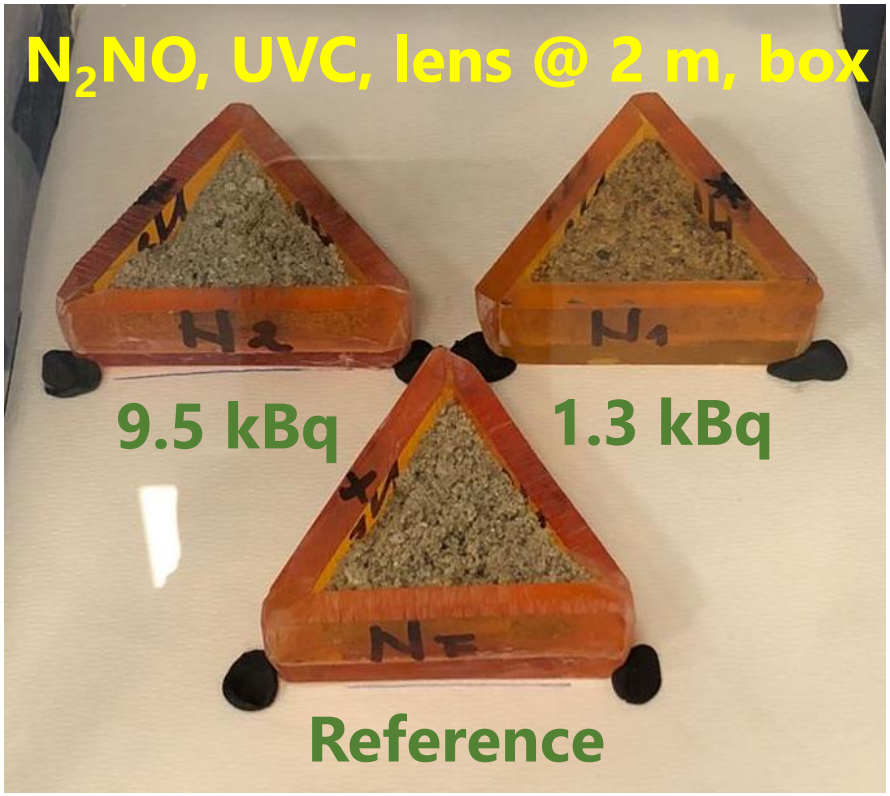


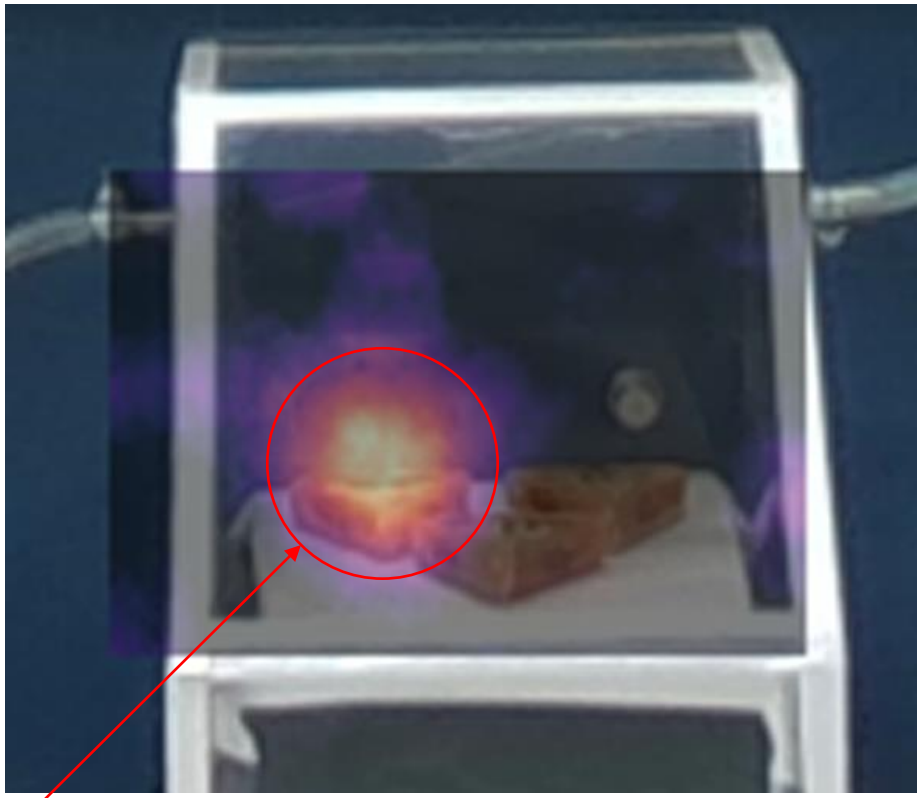
NOT DETECTED in AIR

$$A_{\mathrm{point}} = (107 \pm 18)\ \mathrm{Bq}$$

$$\mathrm{Emissivity} = (0.94 \pm 0.16)\ \%$$

Sand samples: N_2NO



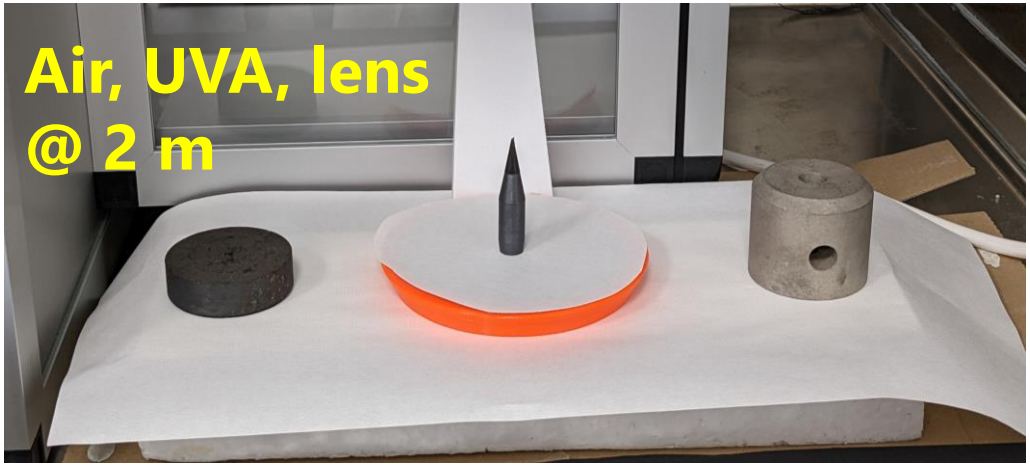


NOT DETECTED in AIR

$$A_{\mathrm{point}} = (106 \pm 19)\ \mathrm{Bq}$$

$$\text{Emissivity} = (1.12 \pm 0.20)\ \%$$

Depleted Uranium samples 1/2



<u>Middle</u>

Depleted uranium bullet

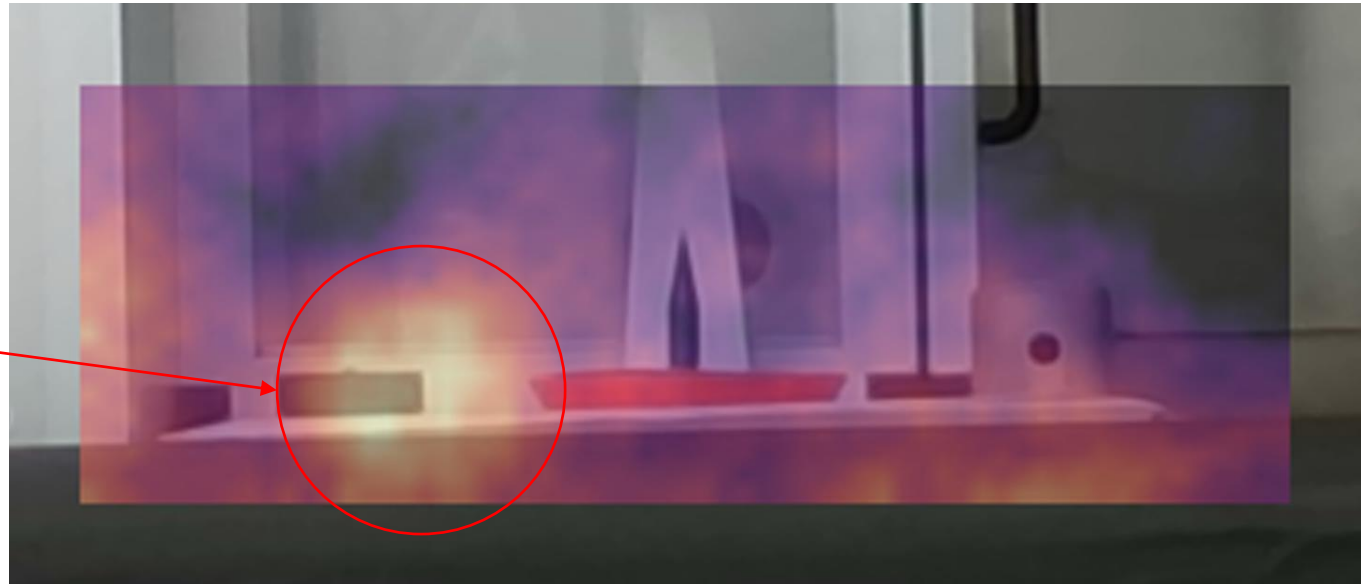
<u>Sides</u>

DepU shielding/collimators of industrial radiography sources

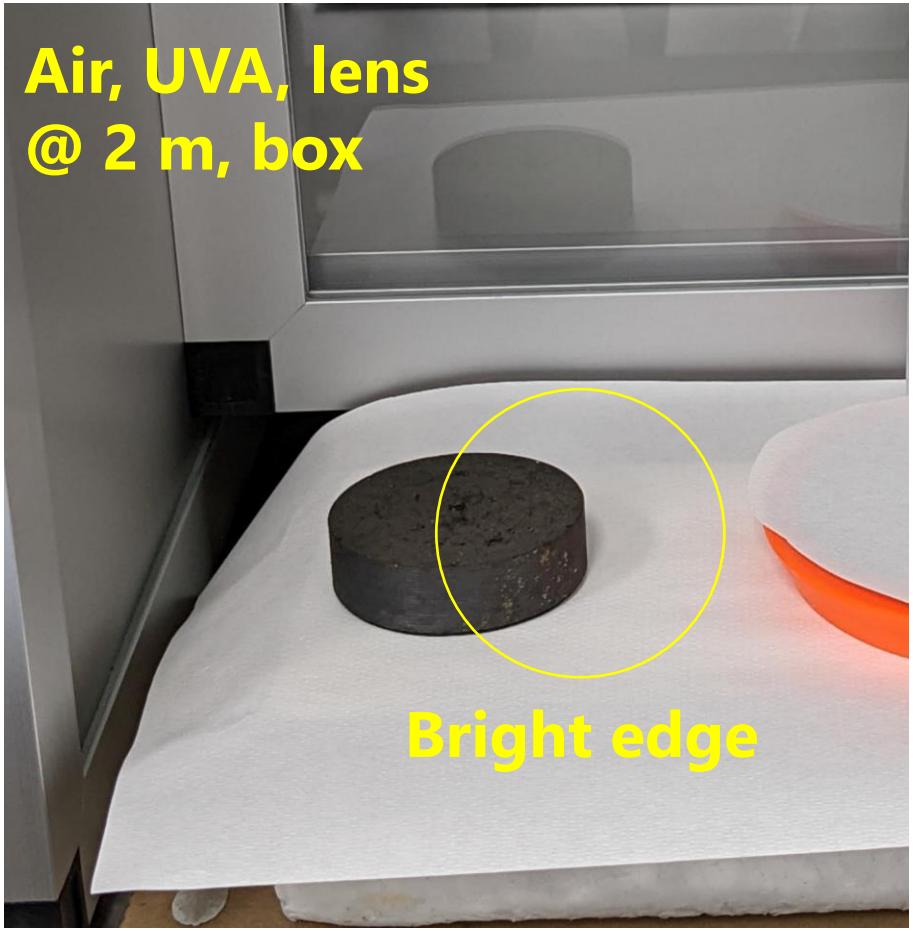
The edge of the left source

A_{point}

$= (1.7 \pm 0.4)\ \text{kBq}$

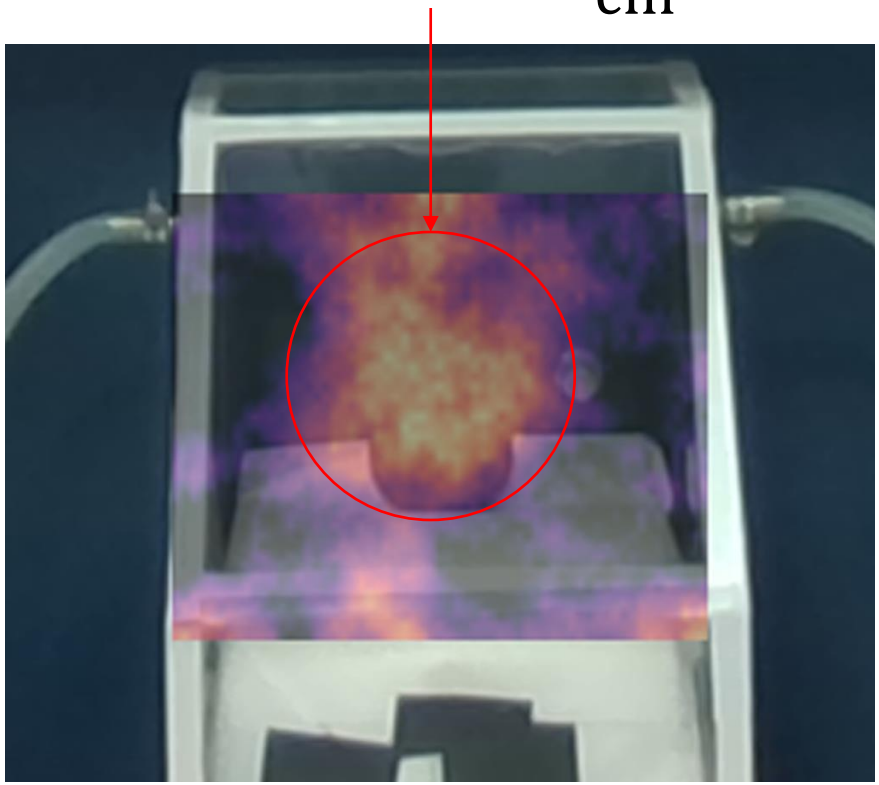


Depleted Uranium samples 2/2



Now estimated as a distributed source

$$A_s = (20 \pm 5)\,\frac{\mathrm{Bq}}{\mathrm{cm}^2}$$

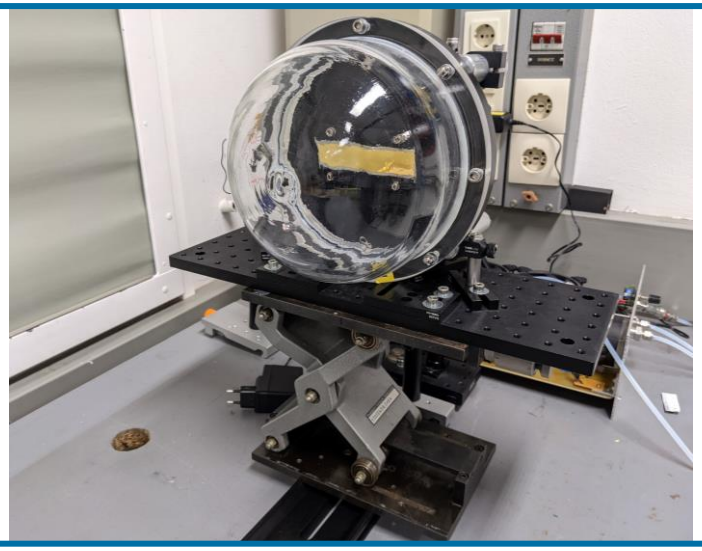


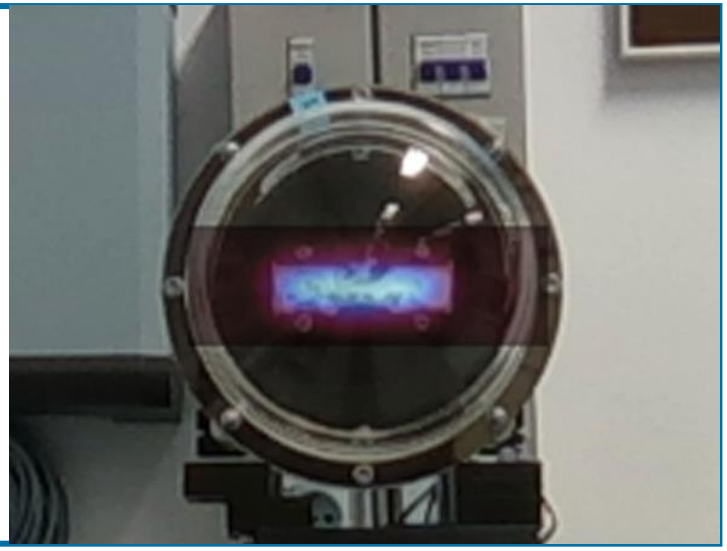
Left DepU piece is investigated

Other sources

IFIN-HH

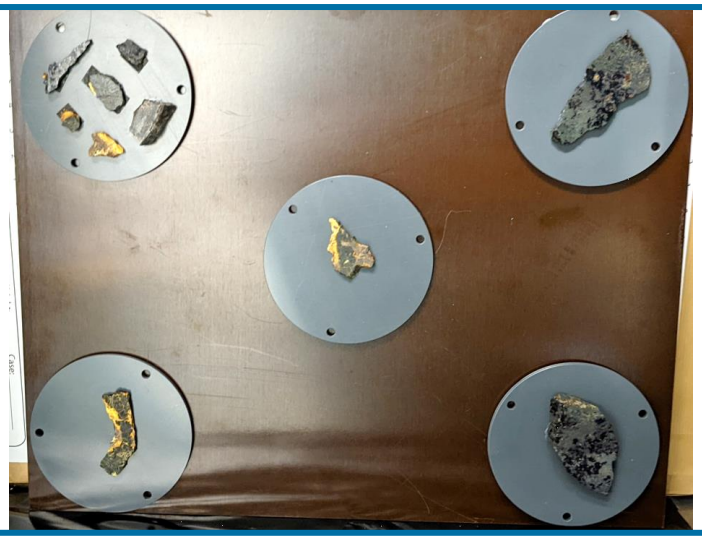
- **^{241}Am** source
- 10 cm x 2 cm
- Au cover 2 µm
- $\boldsymbol{A = 1}$ **MBq**

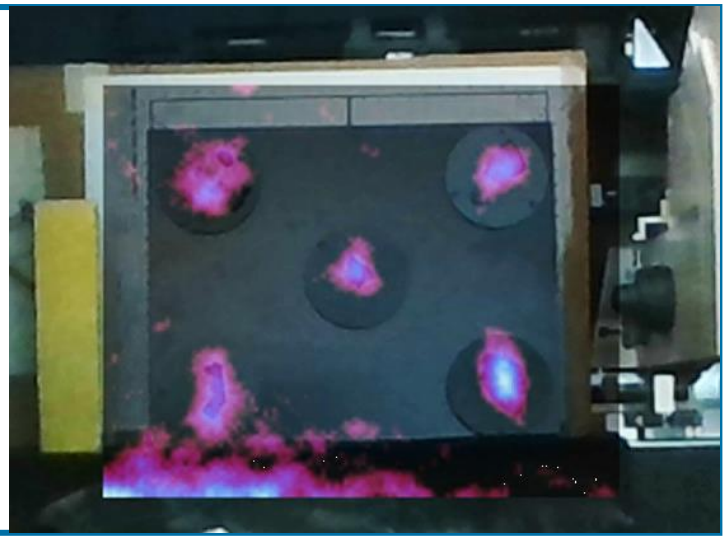




LUH-IRS

- Env. samples (*Pitchblende*)
- Polished
- $\boldsymbol{A_s \approx 60\,\frac{\mathrm{Bq}}{\mathrm{cm}^2}}$





Acknowledgements

RemoteALPHA

EMPIR EURAMET

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19ENV02 RemoteALPHA denotes the EMPIR project reference.

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Thanks for attention!

https://remotealpha.drmr.nipne.ro

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

Interested in the project?

Join the stakeholder community:

- Workshop / exhibition June, Barcelona, Spain
- Feedback / discussion

Visit the project website for more information:

- ✓ Publications
- ✓ Presentations
- ✓ Posters
- ✓ ...and more!

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