

# Novel optical technologies for traceable measurement of alpha contaminations

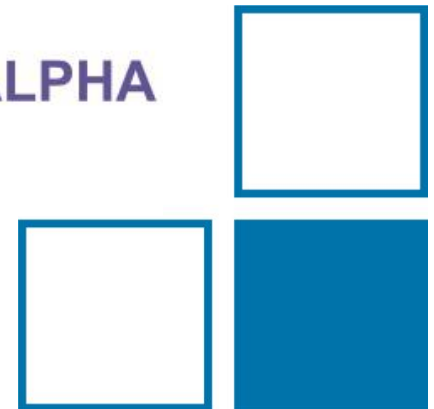
Maksym Luchkov

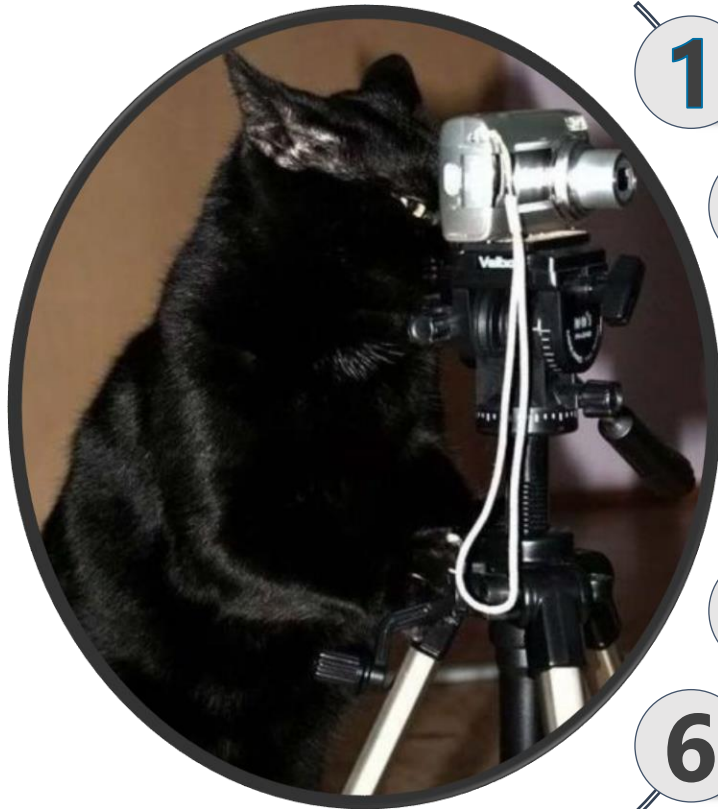
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Radiation Protection Dosimetry

National Metrology Institute of Germany (PTB)

Braunschweig, Germany





- 1 Introduction
- 2 Scanning optical systems
- 3 Data processing
- 4 Calibration
- 5 Experimental results
- 6 Conclusions and remarks

## Remote and real-time optical detection of alpha-emitting radionuclides in the environment (2020 – 2023)



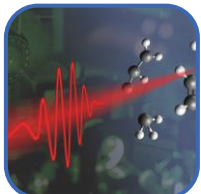
**WP1.** New instrumentation for the optical detection of alpha particle emitters in the environment



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



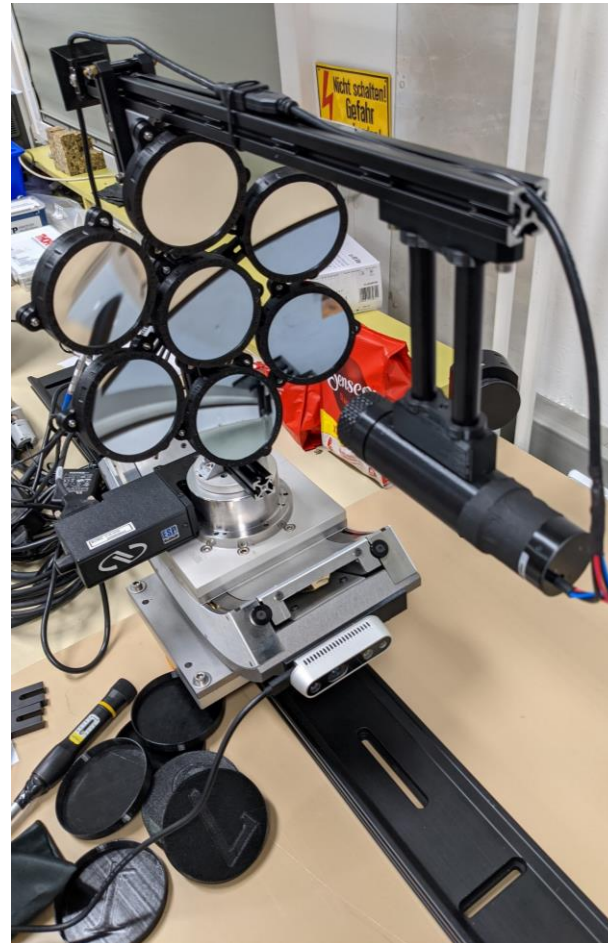
**WP3.** Mapping of alpha contaminations in the environment using UAVs



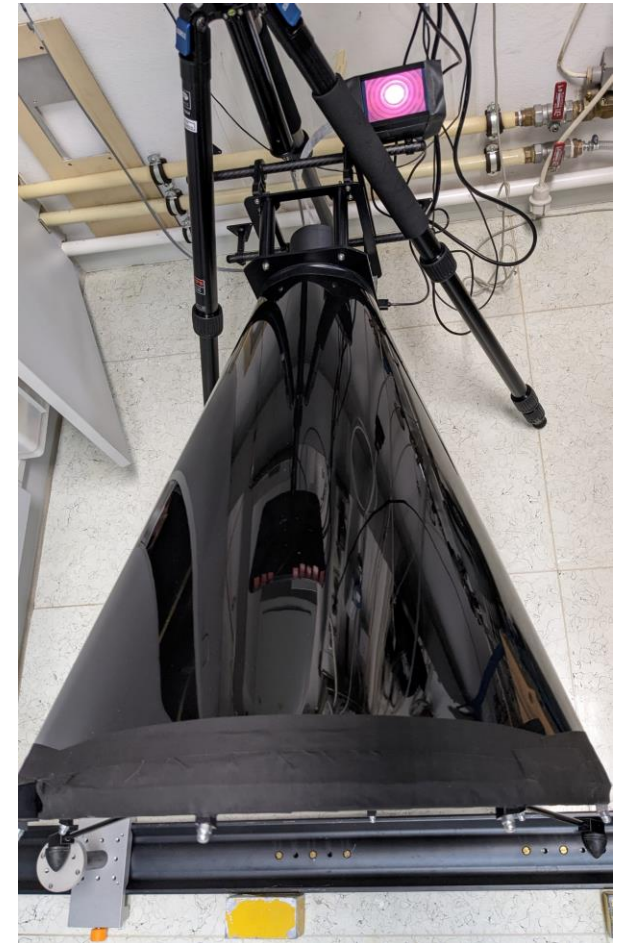
**WP4.** Feasibility study of laser-based techniques for detection of alpha emitters



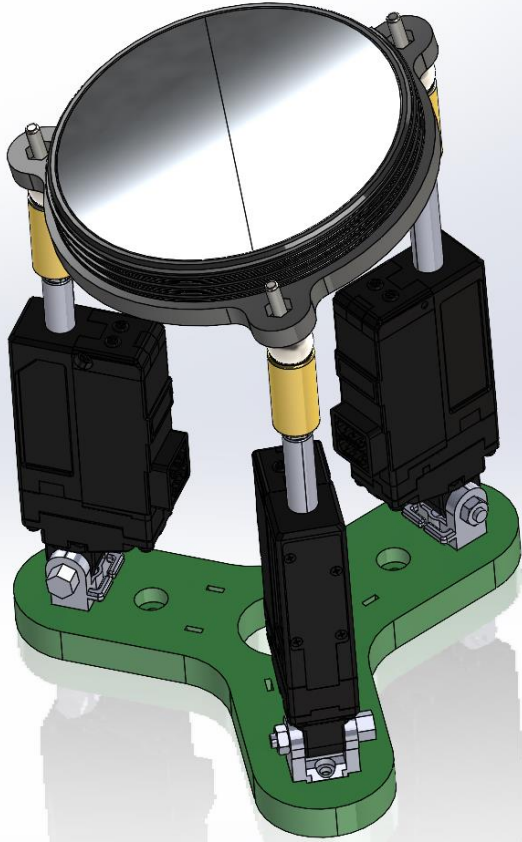
UVFS lens,  $\varnothing$  240 mm  
Scanning



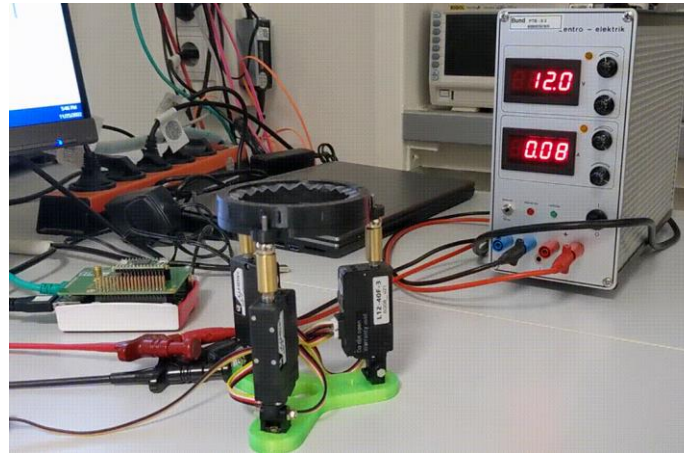
Al mirrors,  $\varnothing$  75 mm x 7  
Scanning + Drone-based



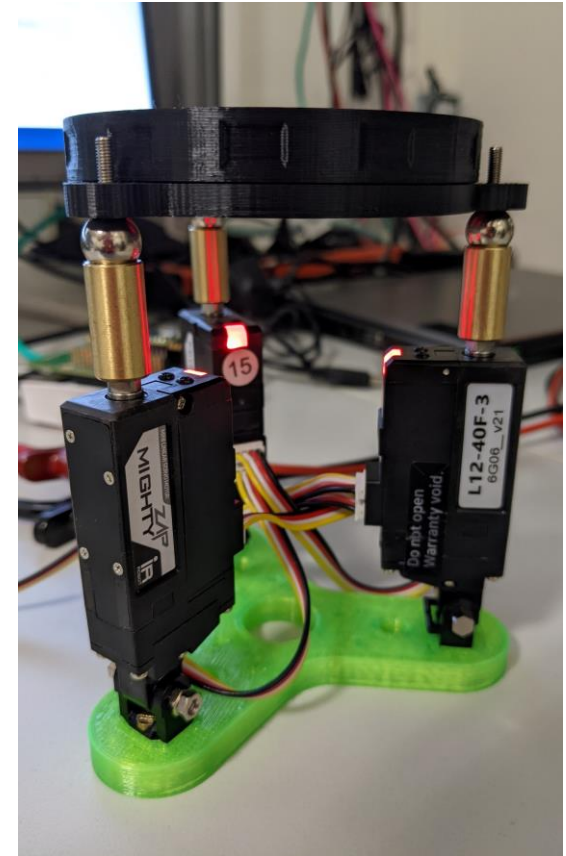
Fresnel lens,  $\varnothing$  450 mm  
Drone-based



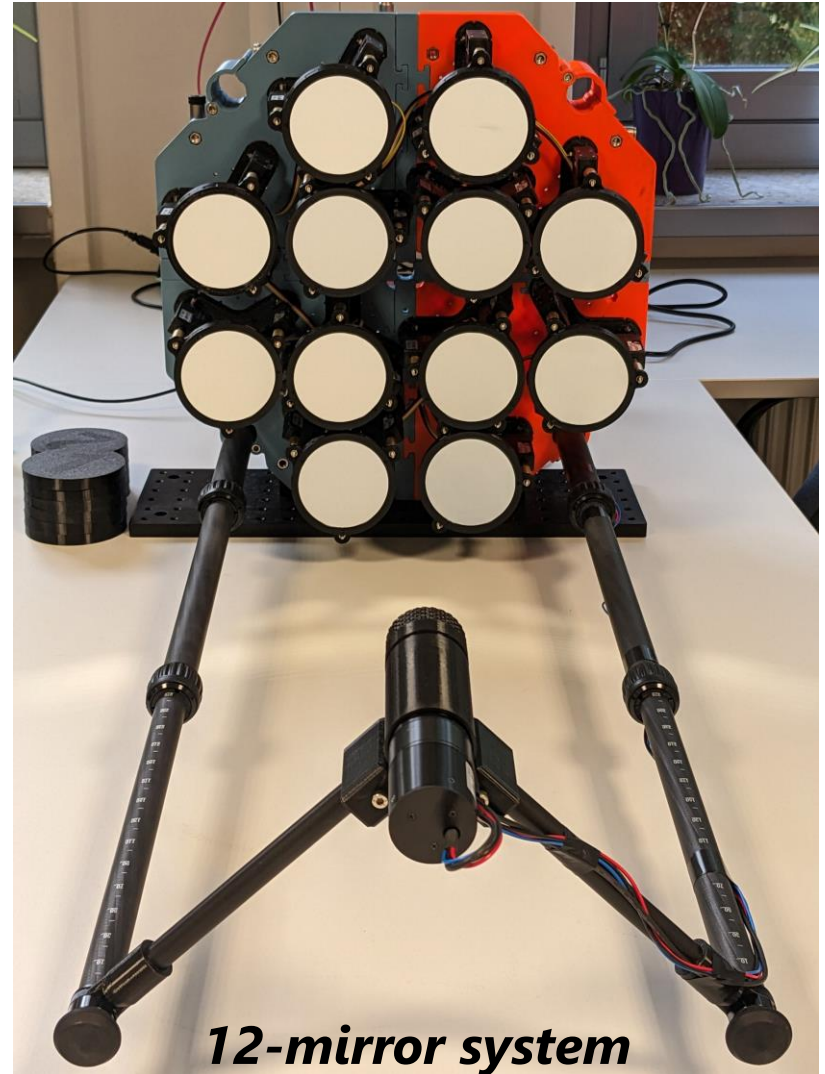
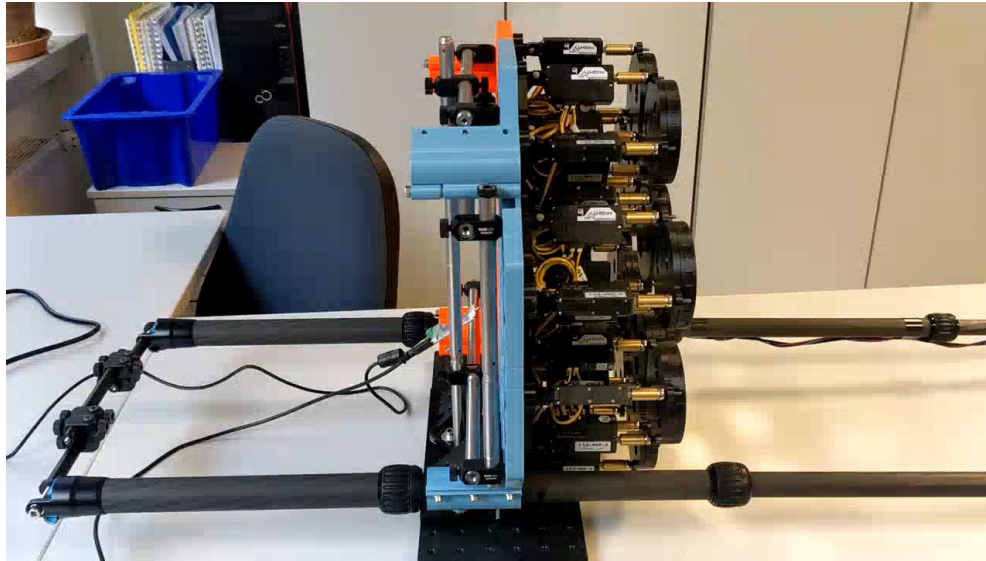
*Motion base  
3D model*



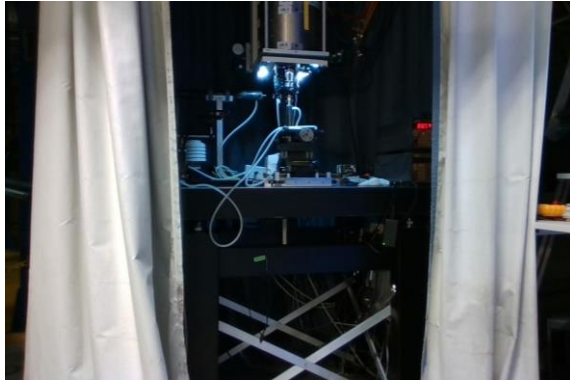
<b>Power-efficient and lightweight!</b>	
12-mirror system power usage	100 W (max.)
LiPo battery 11.1 V, 20 Ah	222 Wh
Regular scanning	≈ 2.5 h
Low-power scan.	> 5 h



*Assembled motion base  
Total weight = **300 g***

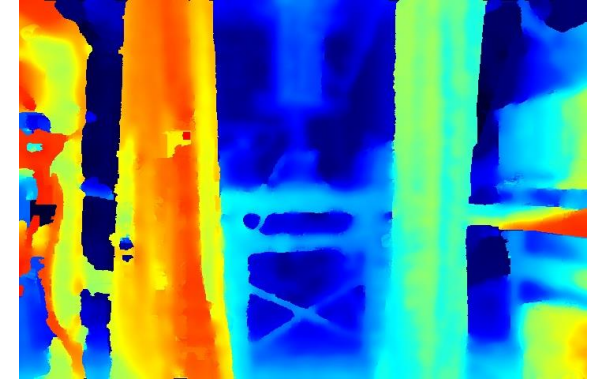
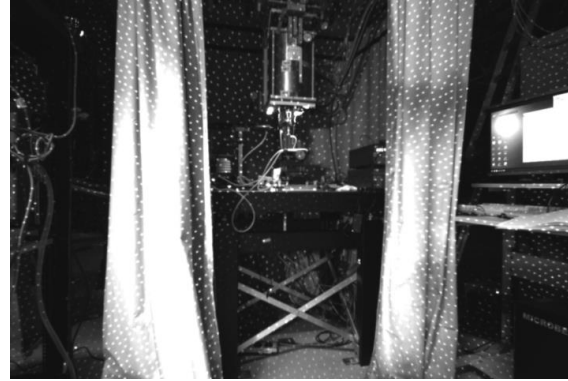


**Color image**

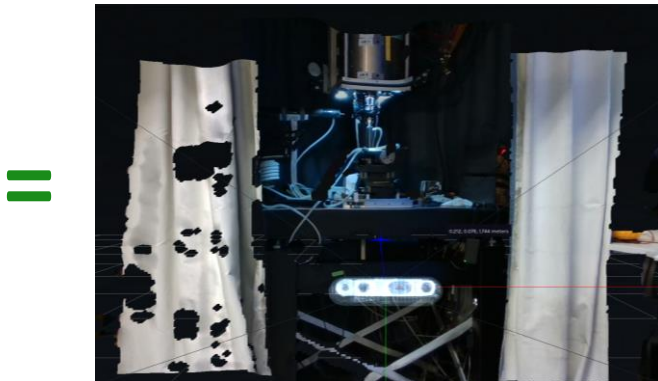


+

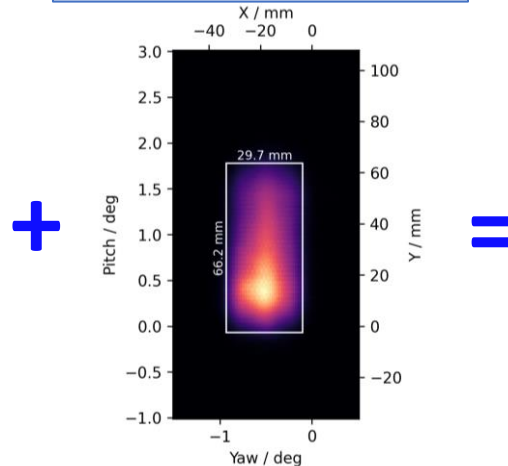
**Stereo depth image (IR)**



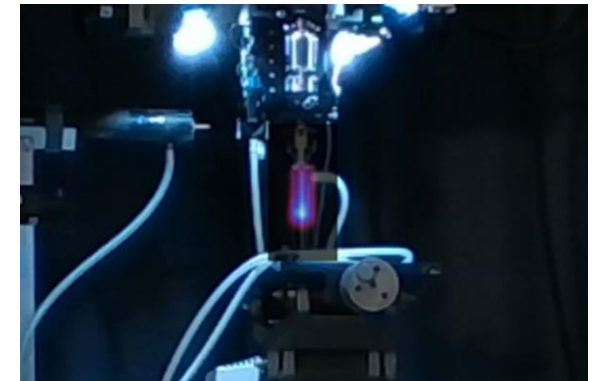
**3D model of the environment**



**2D (pitch/yaw) UV scan**



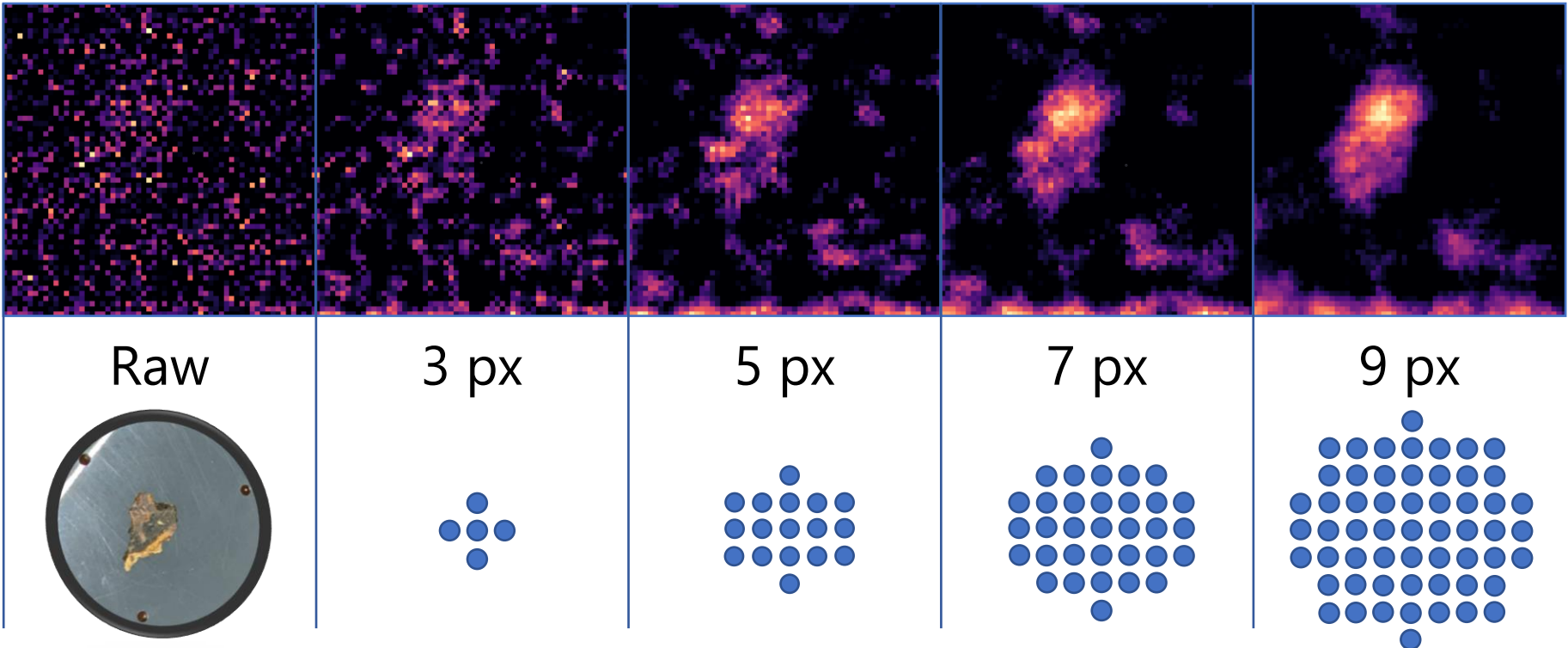
**Blending via ray tracing**



The scanning **objective** is to **distinguish the source** over the background within the **reasonable time** period

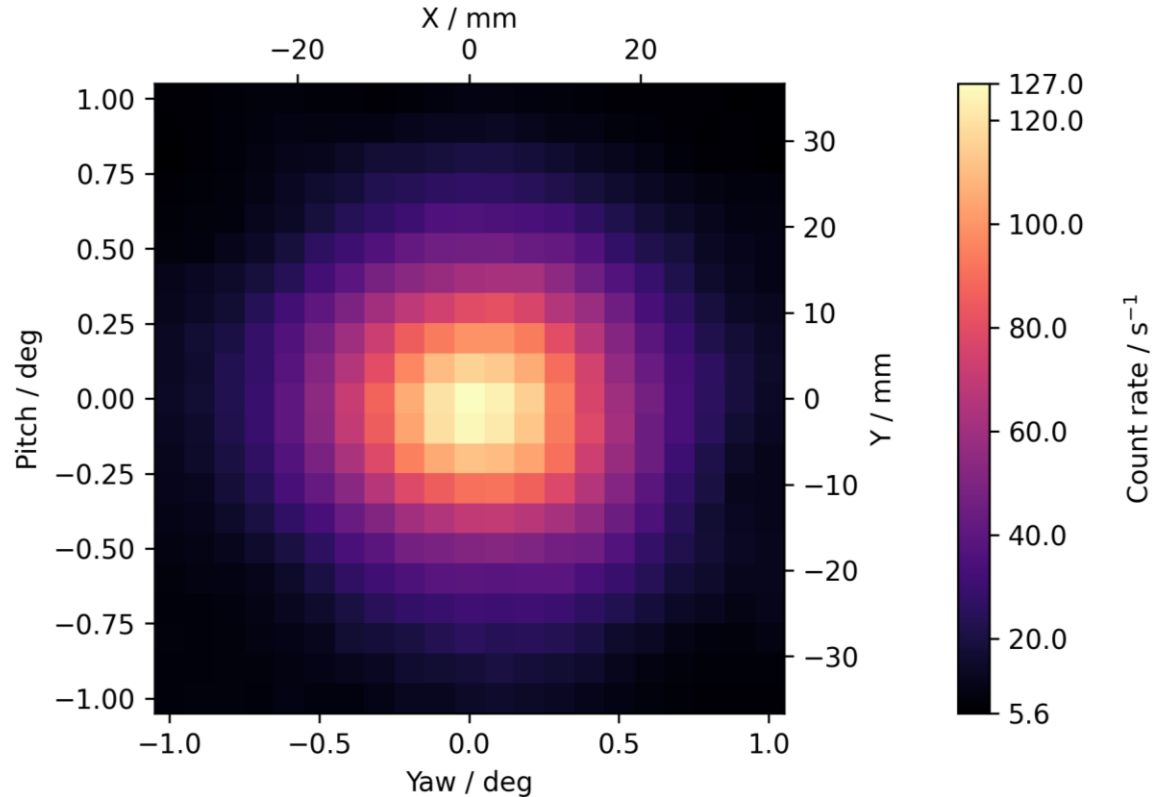
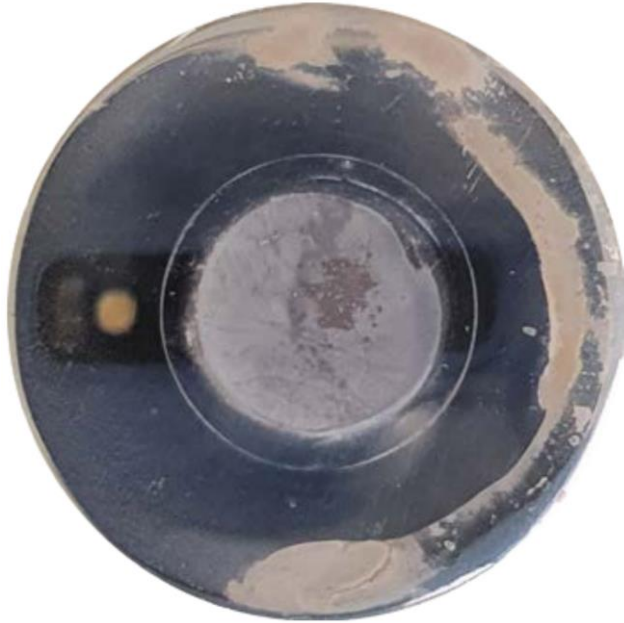


The **averaging** of a neighboring pixel group **smoothes** the image and **reveals** scan **features**





Stefan Röttger @ PTB



## $^{210}\text{Po}$

**Alpha activity standard**

Traceable to national standard

Point source!

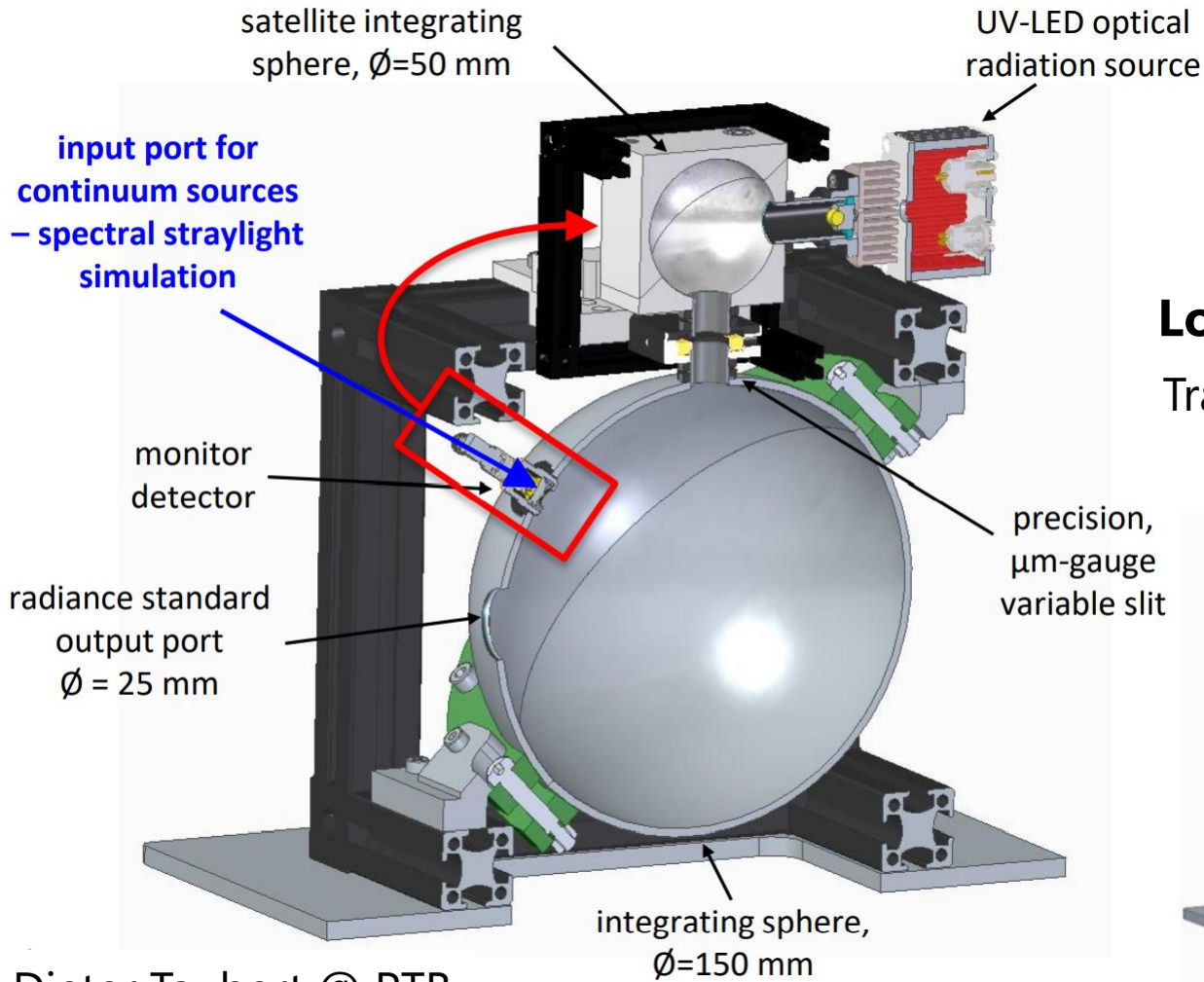
$A = 840 \text{ kBq}$

$T_{1/2} = 138 \text{ d}$

Pure  $\alpha$ -emitter!

$E_{\alpha} = 5304 \text{ keV}$

$p_{\alpha} = 99.99876$

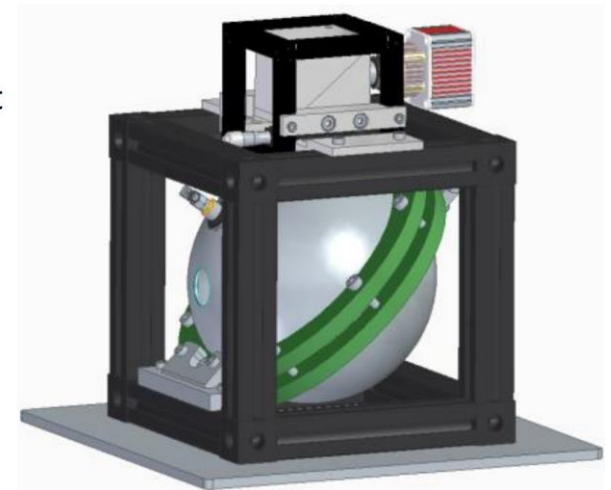


#1 – 260 nm

#2 – 340 nm

**Low photon flux standard**

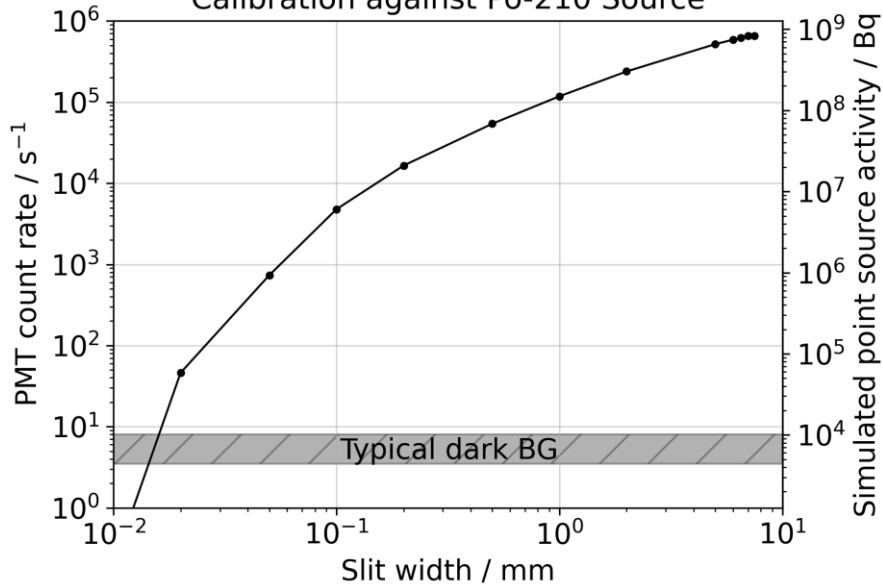
Traceable to national standard



Dieter Taubert @ PTB



340 nm Radiance Standard  
Calibration against Po-210 Source



Low photon flux

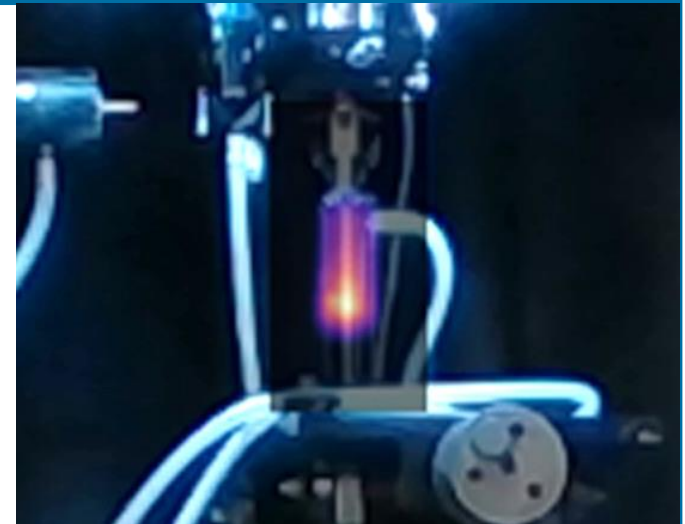
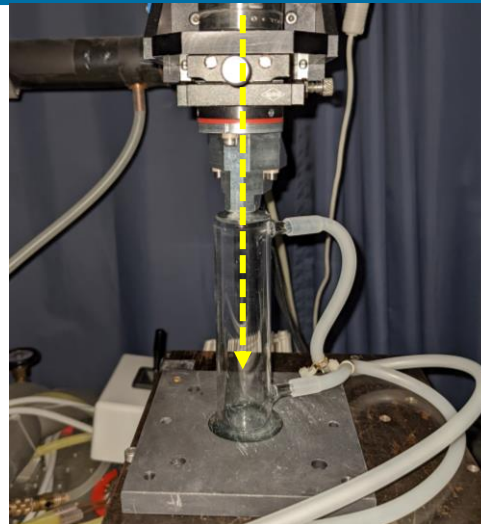
UV radiance standard

- Calibrated against the activity standard → **Transfer standard**
- **Stable** source with defined radiance
- **Adjustable** photon flux  
→ Simulates alpha activity  
from ~ **100 kBq**  
to ~ **1 GBq**

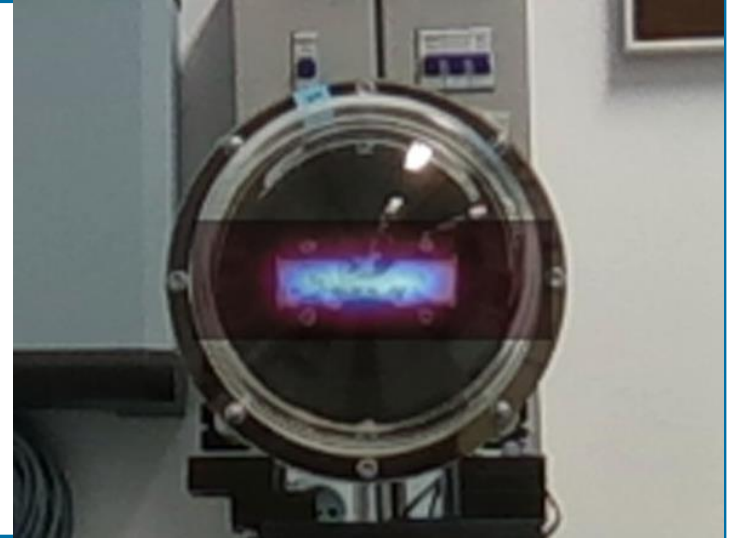
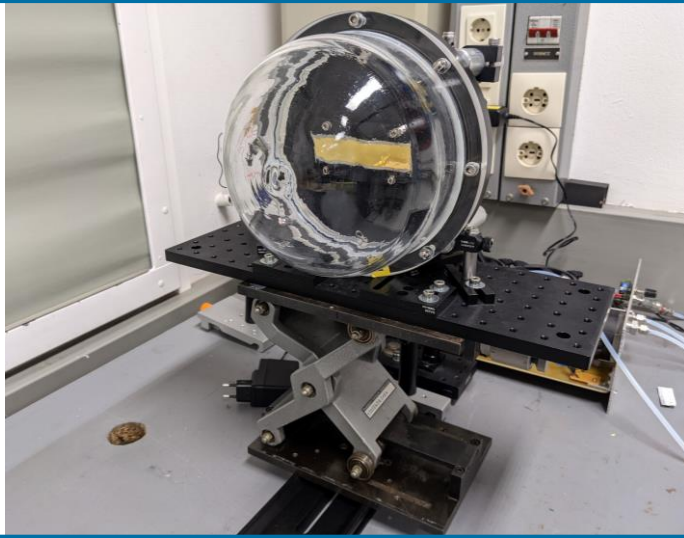
- $^{241}\text{Am}$  source
- $\varnothing$  3 mm
- Point source
- $A = 0.5 \text{ MBq}$
- 2 m distance



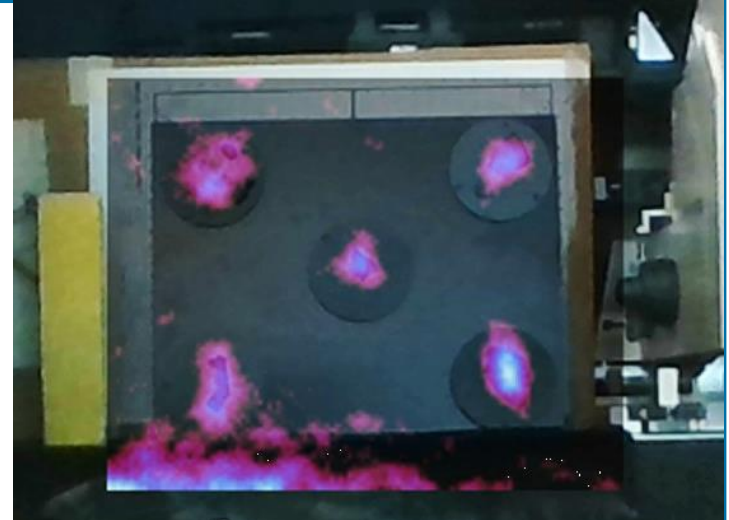
- Alpha **beam**
- $E = 6.9 \text{ MeV}$
- Stopping in air
- $100 \mu\text{m} \times 100 \mu\text{m}$
- $A = 1 \text{ MBq}$
- 2 m distance



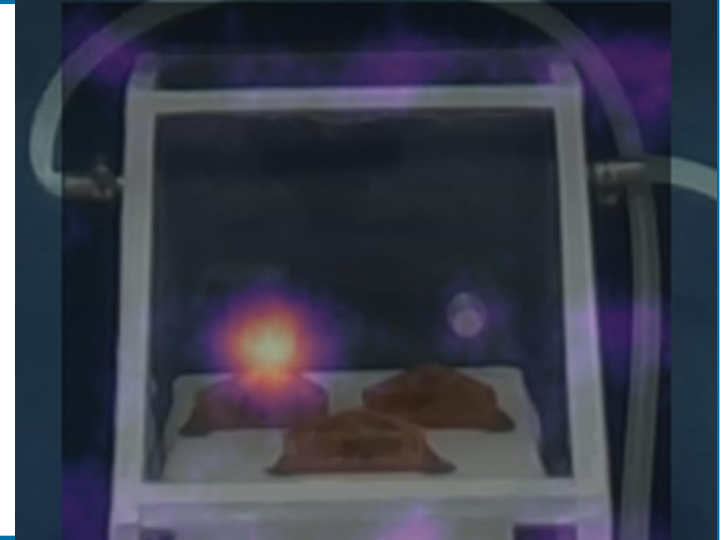
- $^{241}\text{Am}$  source
- 10 cm x 2 cm
- Au cover 2  $\mu\text{m}$
- **A = 1 MBq**
- **2 m** distance



- Env. samples  
(**Pitchblende**),  
polished
- **A  $\approx$  1 kBq**  
(each)
- **2 m** distance



- $^{241}\text{Am}$  cont.  
Leaf samples
- 45 mm
- $A_{\text{dep}} < 12 \text{ kBq}$
- 2 m distance



- $^{241}\text{Am}$  cont.  
Concrete sample
- 3 cm x 3 cm
- $A \approx 200 \text{ kBq}$
- 2 m distance





Middle

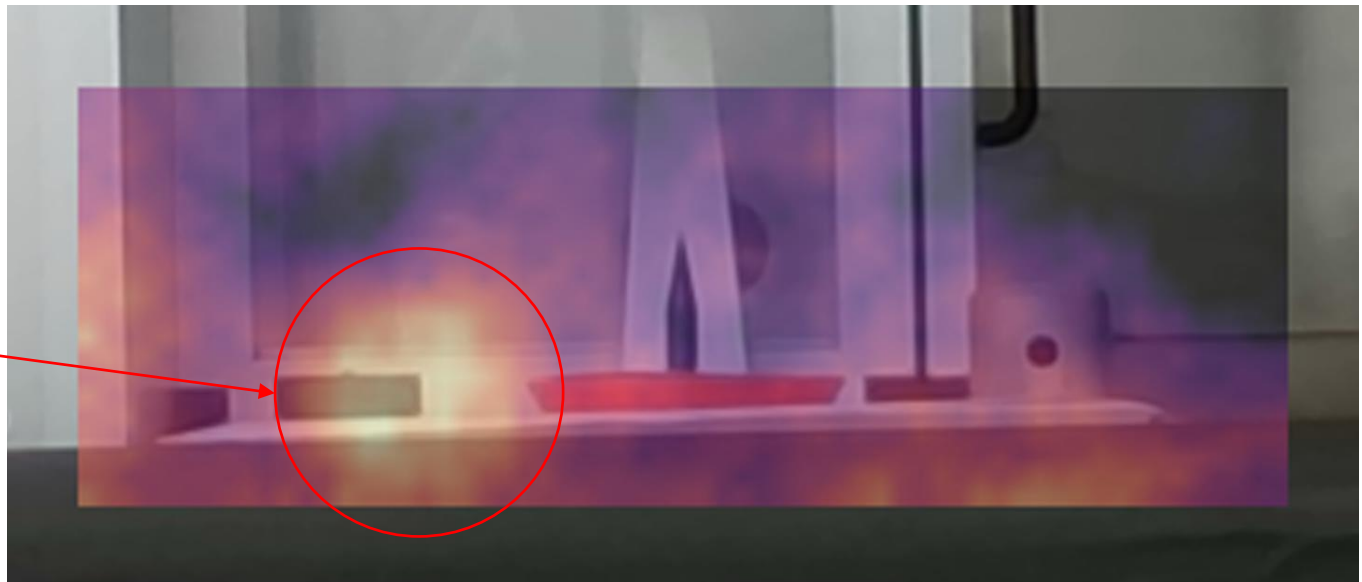
Depleted uranium bullet

Sides

DepU shielding/collimators of industrial radiography sources

**The edge of the  
left source**

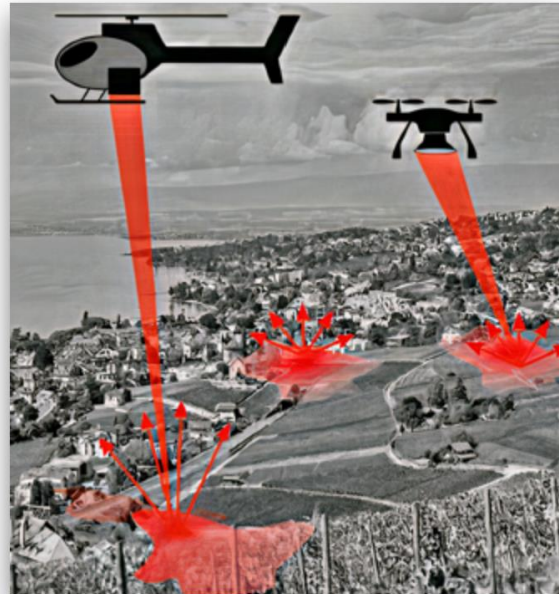
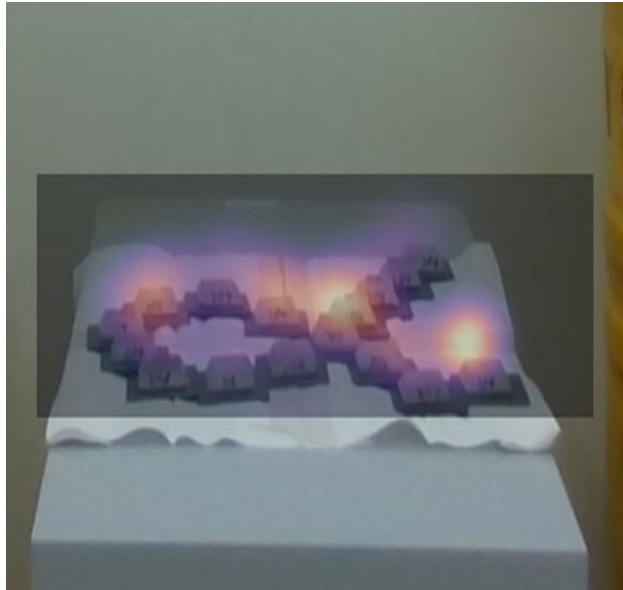
$$A_{\text{point}} = (1.7 \pm 0.4) \text{ kBq}$$



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



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



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