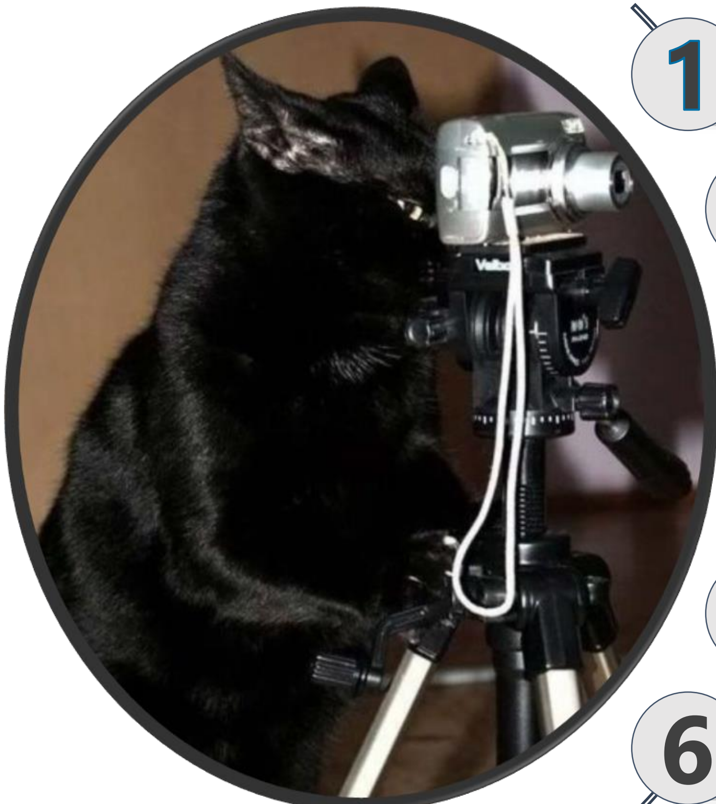
The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

Development of scanning optical systems and Radioluminescence calibration sources for Remote detection of alpha emitters

Maksym Luchkov
maksym.luchkov@ptb.de
Radiation Protection Dosimetry
National Metrology Institute of Germany (PTB)
Braunschweig, Germany

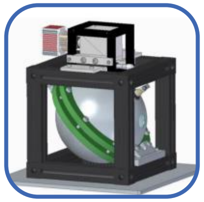
Content



EMPIR “RemoteALPHA” Project

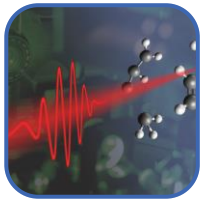
Remote and real-time optical detection of alpha-emitting radionuclides in the environment (2020 –)

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



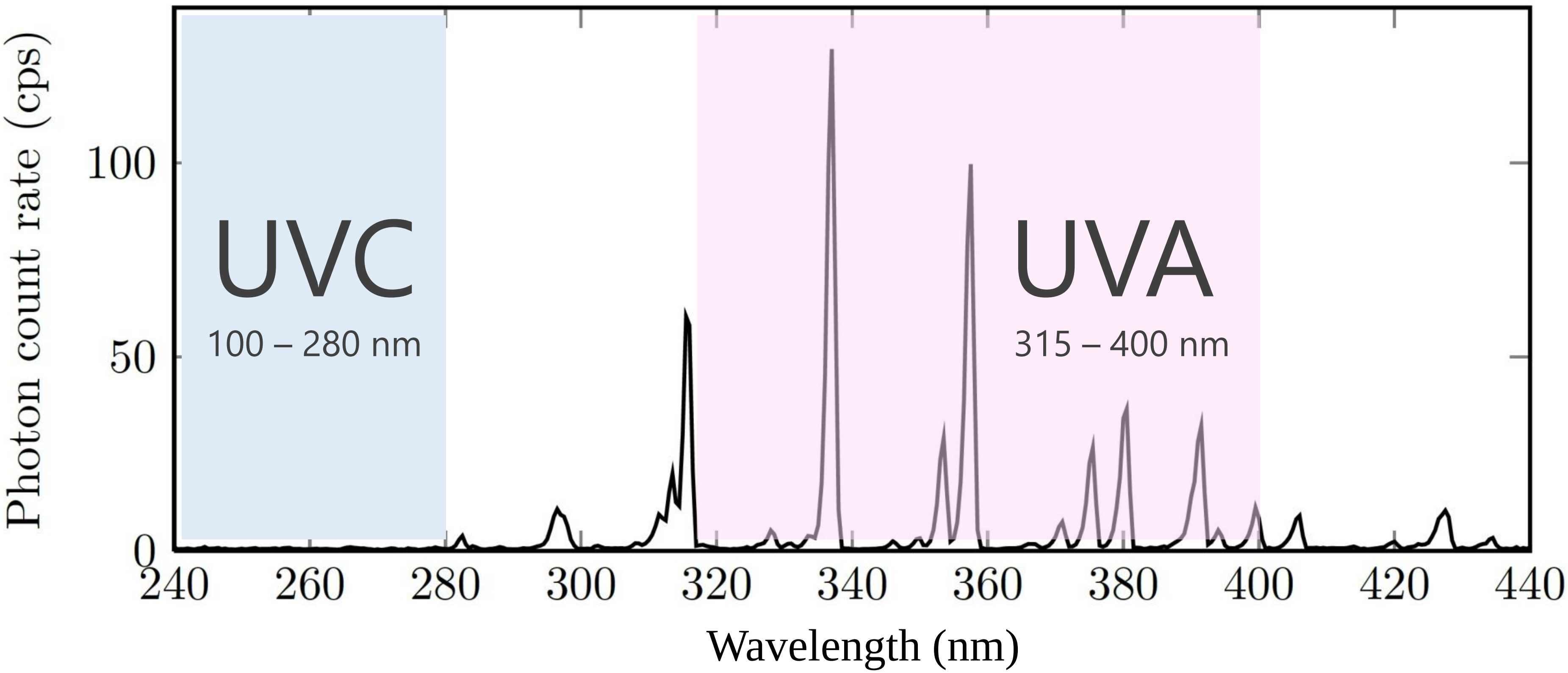
WP2. Calibration system for the novel-type radioluminescence detector systems

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 alpha particle



UV Filters

PMT

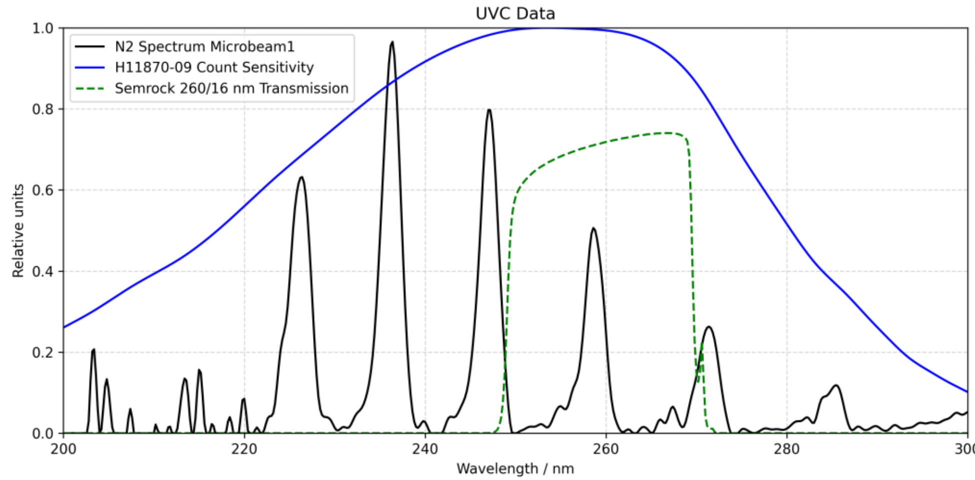
UV detection setups

UV-C: daytime measurements

- ➢ Fused silica / Aluminum optics
- ➢ CsTe photocathode PMT
- ➢ 260 nm optical filters

Advantages & drawbacks

+ Low natural BG → Daylight measurements possible
– About 1% of UVA yield in air

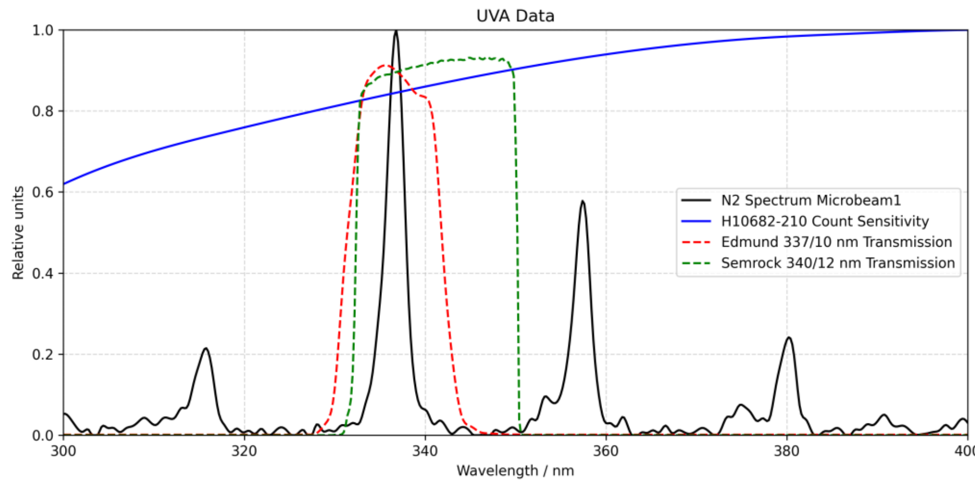


UV-A: measurements in dark conditions

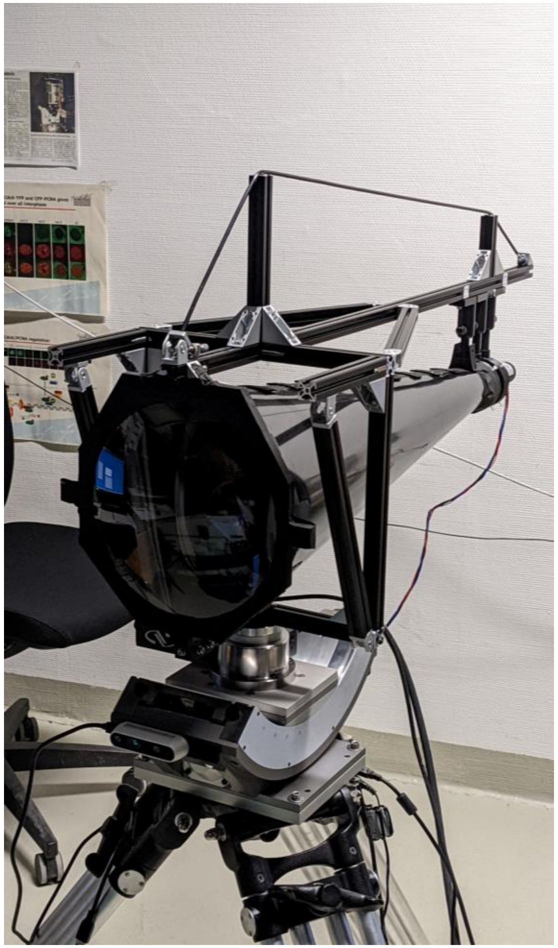
- ➢ PMMA Fresnel optics applicable
- ➢ Bialkali photocathode PMT
- ➢ 340 nm optical filters

Advantages & drawbacks

+ High yield / sensitivity
– Can't be applied under solar or conventional lighting



Instrumentation 1/3



UVFS lens, Ø 240 mm
Scanning

Al mirrors, Ø 75 mm x 7
Scanning + Drone-based

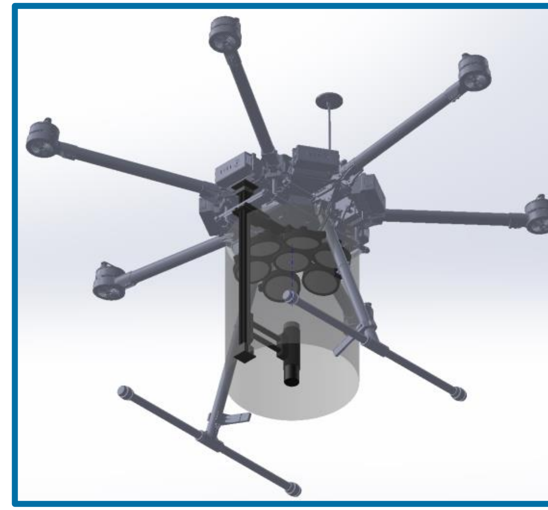
Fresnel lens, Ø 450 mm
Drone-based

Instrumentation 2/3

Fresnel lens, Ø 450 mm

<u>Main aerial system</u>

- Detector developed and characterized in PTB
- Drone integration and flight tests in UPC, Spain

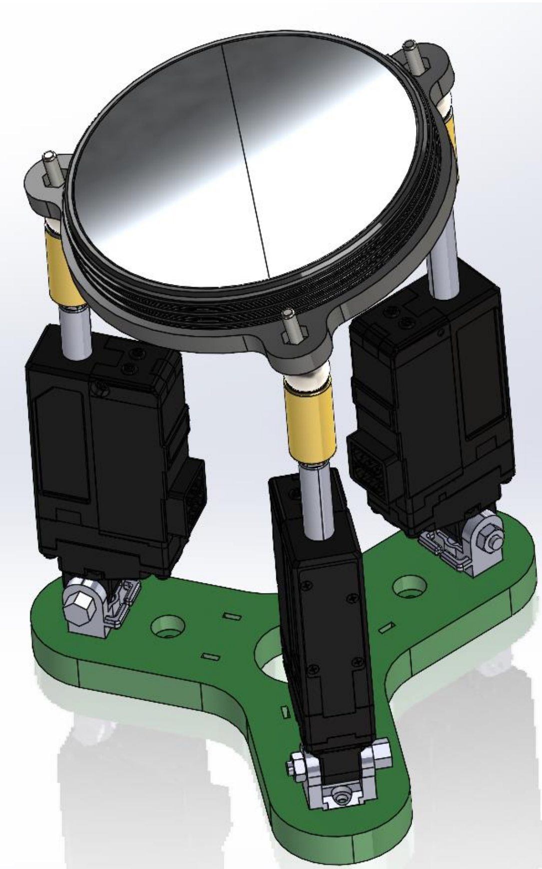


Al mirrors, Ø 75 mm x 7

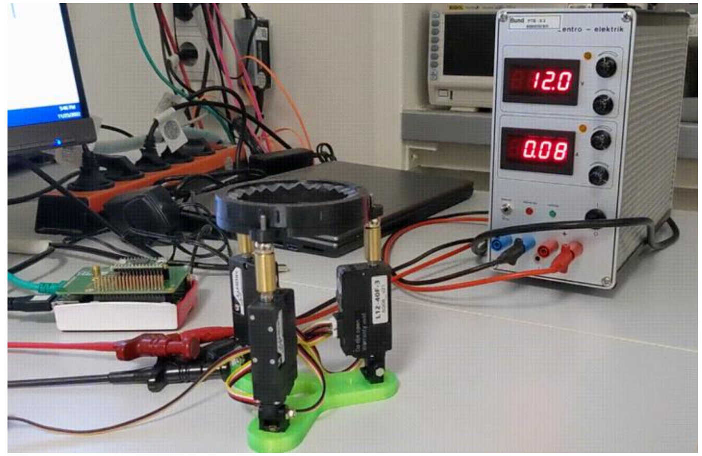
<u>Auxiliary system (compact)</u>

- Detector developed and characterized in PTB
- Drone integration and flight tests in PTB (planned)

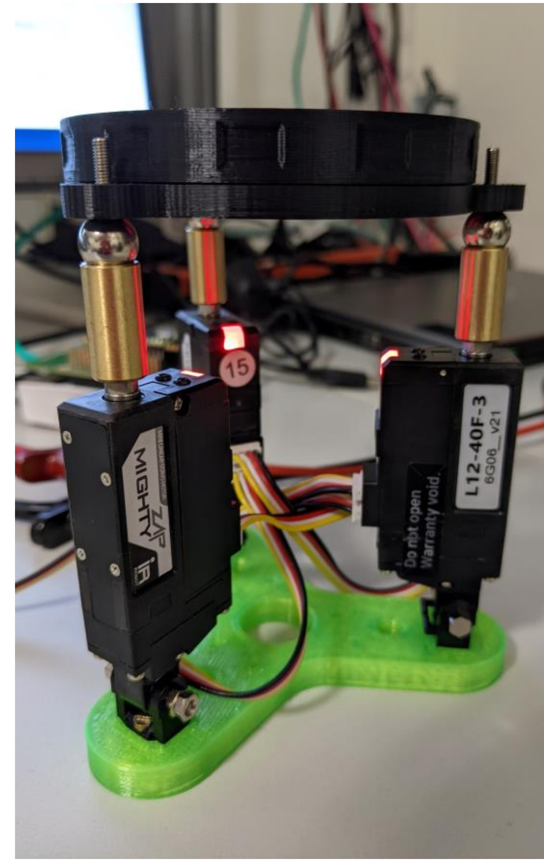
Instrumentation 3/3



3D model of a motion base to solve inverse kinematics (SolidWorks)



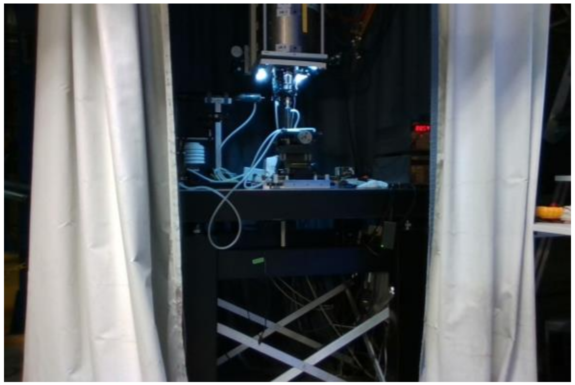
Power efficient and lightweight!	
12-mirror system power consumption	100 W (max.)
LiPo battery 11.1V 20 Ah 	222 Wh
Regular scanning (continuous motion)	≈ 2.5 h
Low-power scanning (discrete steps)	> 5 h



An assembled motion base. Total weight = 300 g

Blending UV and camera images

Color image



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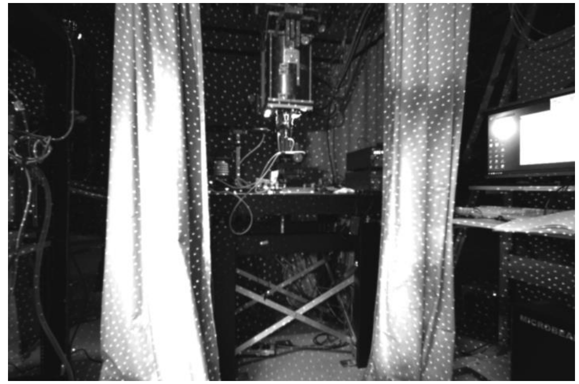
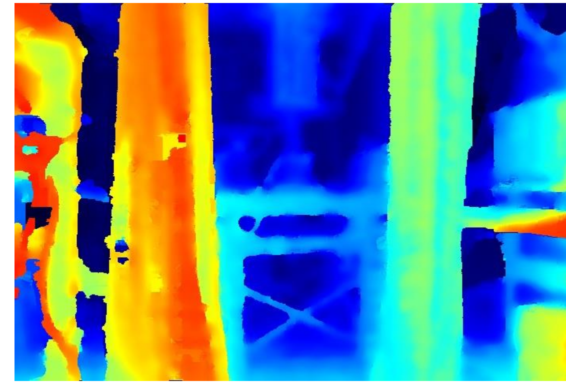
Stereo depth image (2 IR cameras + texture projector)





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

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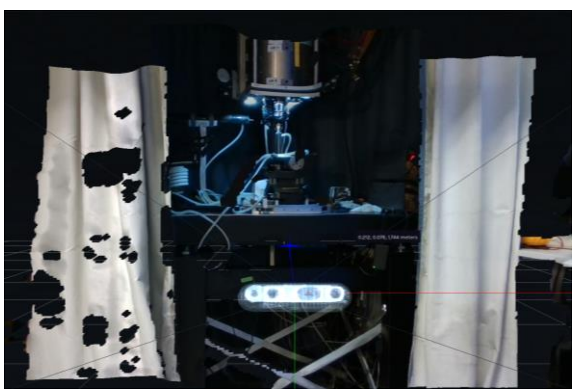

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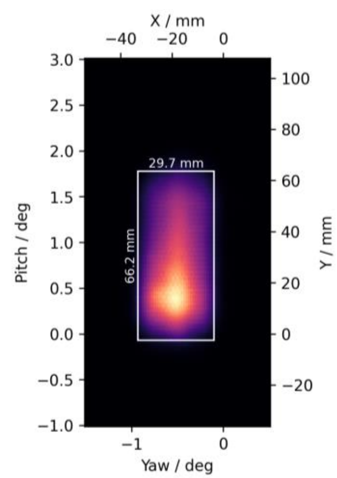
2D (pitch/yaw) UV scan



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

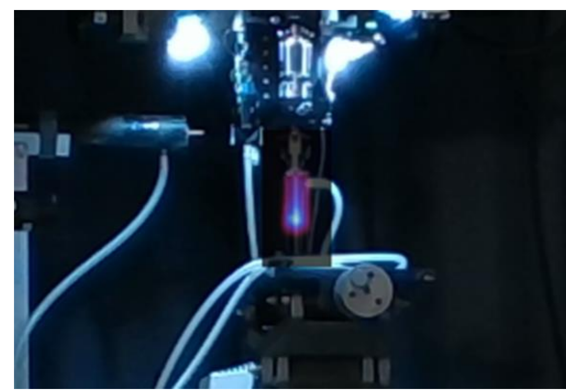
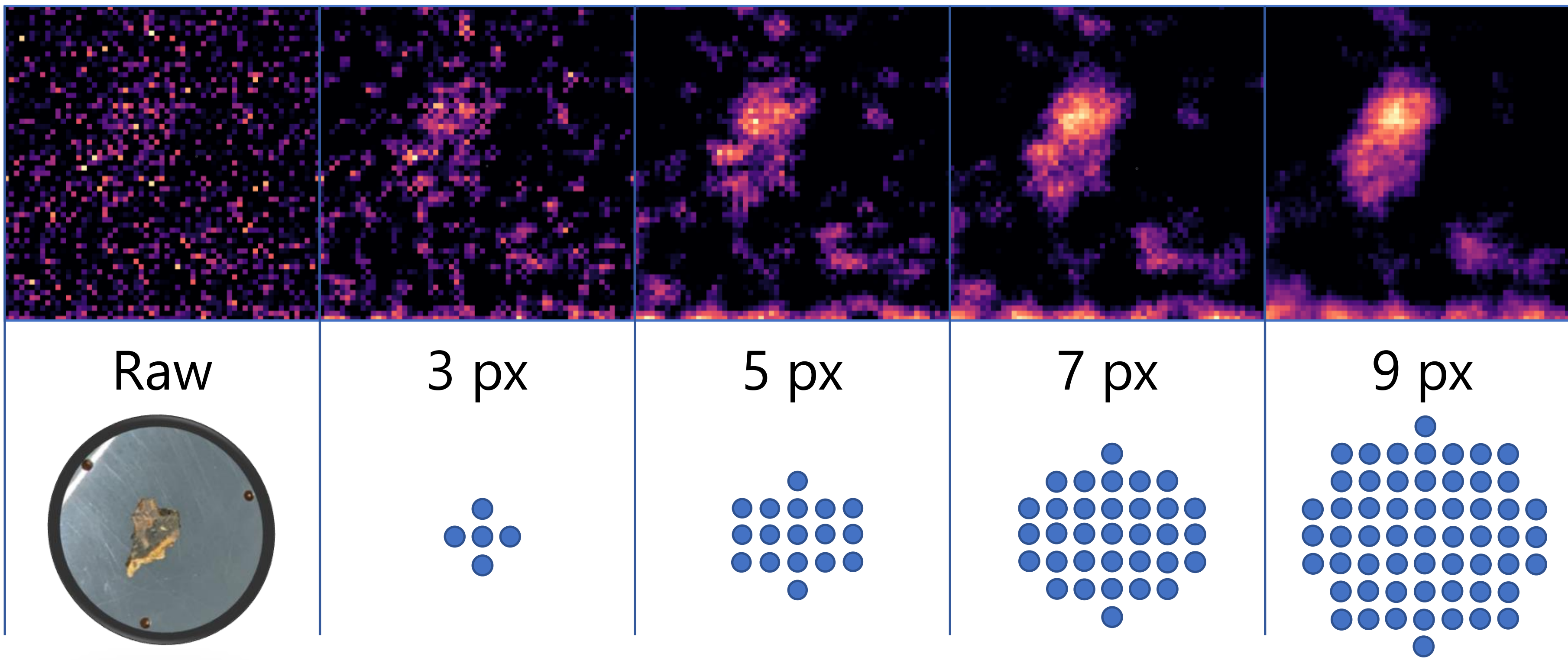


Image processing

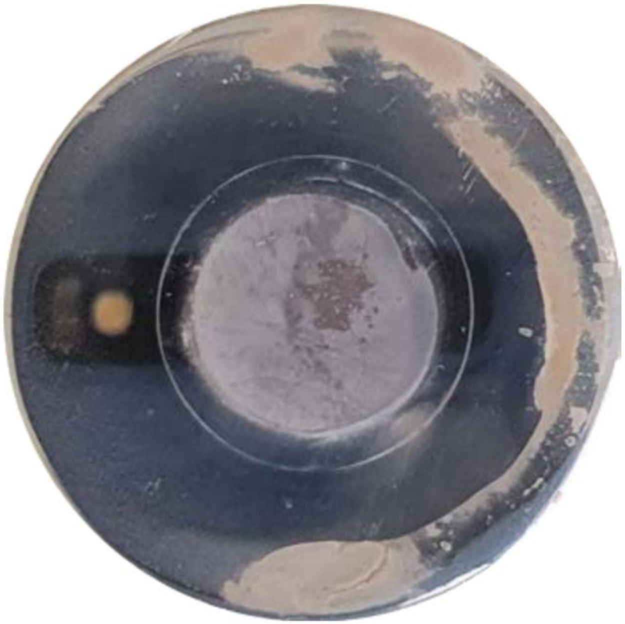
The scanning **objective** is to **distinguish the source** over the background within the **reasonable** (*better: shortest*) **time** period

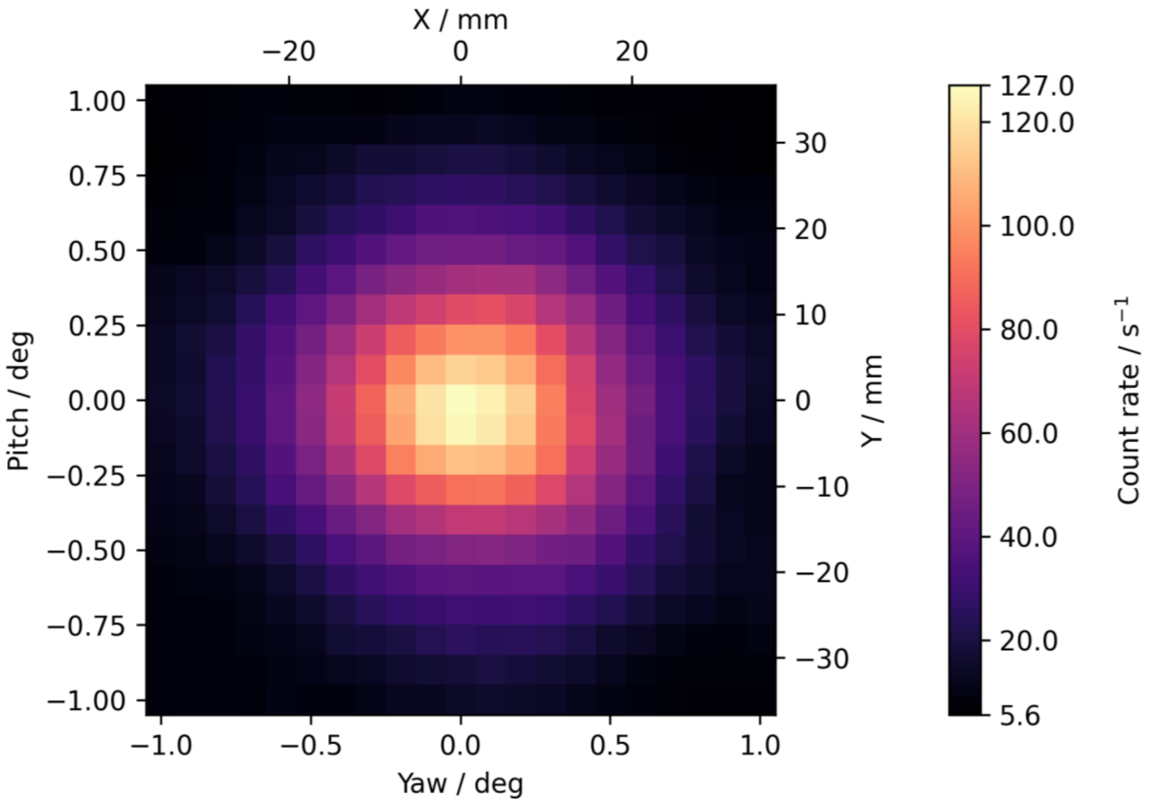
The **averaging** of a neighboring pixel group (blurring) is **necessary** to get a **uniform background** and **reveal** scan **features**



Calibration 1/3

Stefan Röttger @ PTB





^{210}Po

Alpha activity standard

Traceable to national standard

Point source!

$\boldsymbol{A}$ = 840 kBq

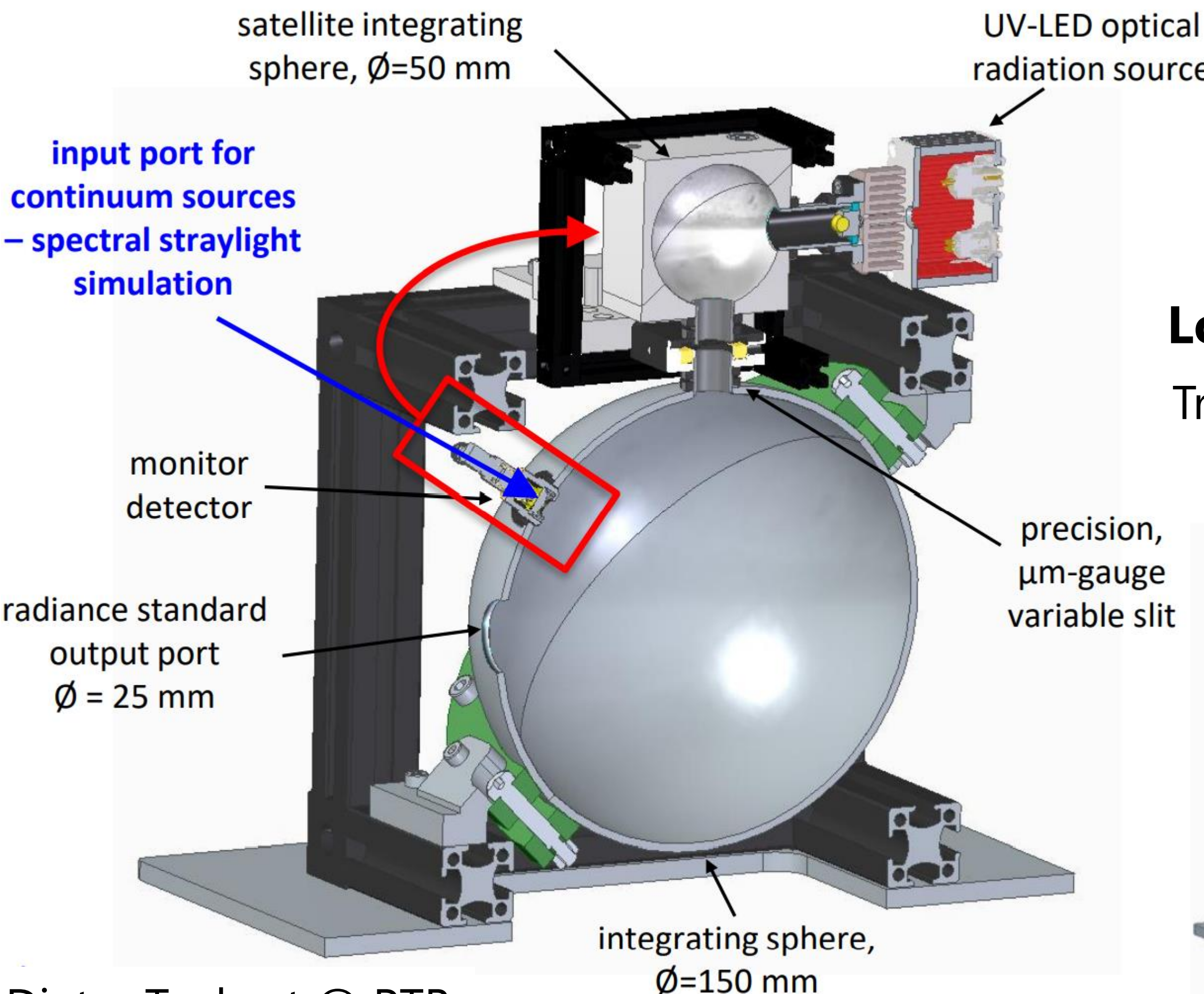
$\mathbf{T_{1/2}}$ = 138 d

Pure α-emitter!

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

$\mathbf{p_\alpha}$ = 99.99876

Calibration 2/3



#1 – 260 nm

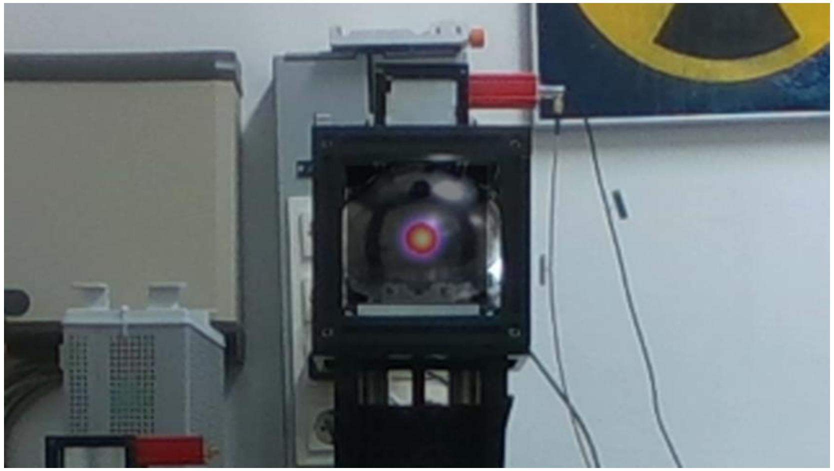
#2 – 340 nm

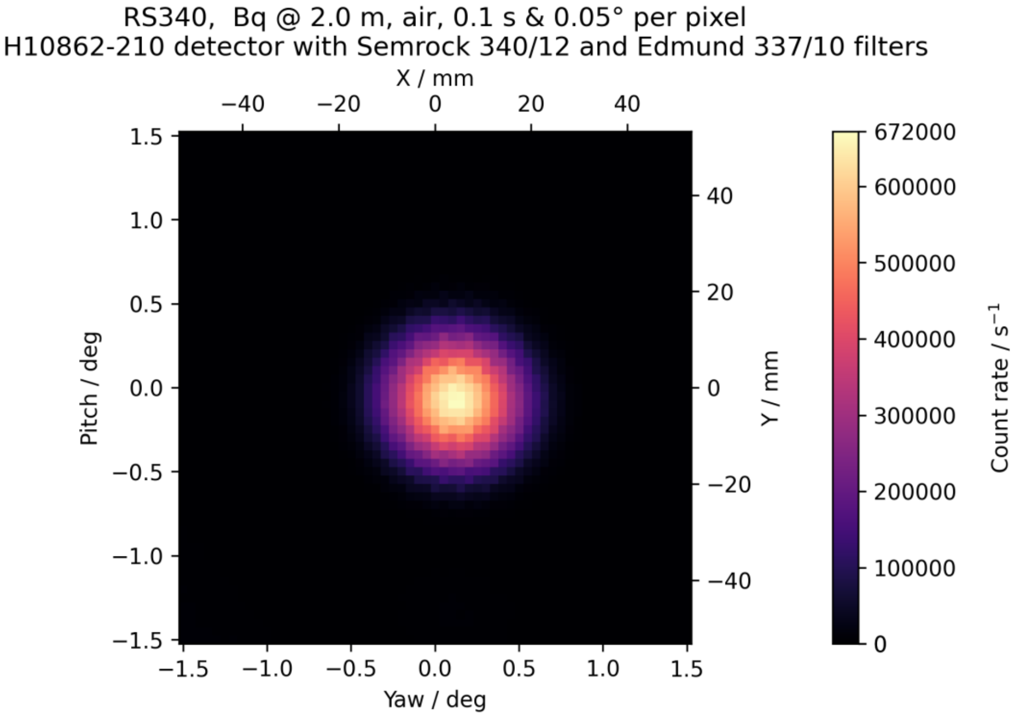
Low photon flux standard

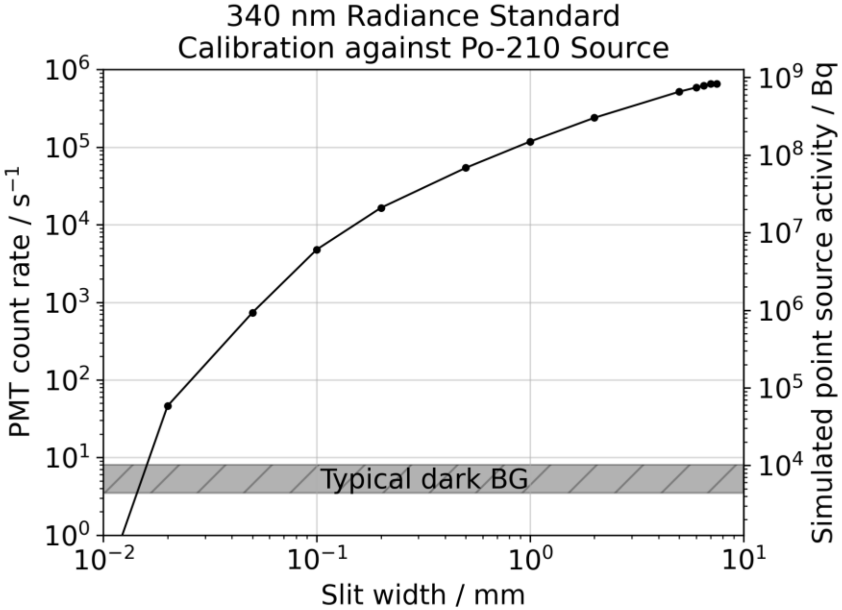
Traceable to national standard

Dieter Taubert @ PTB

Calibration 3/3







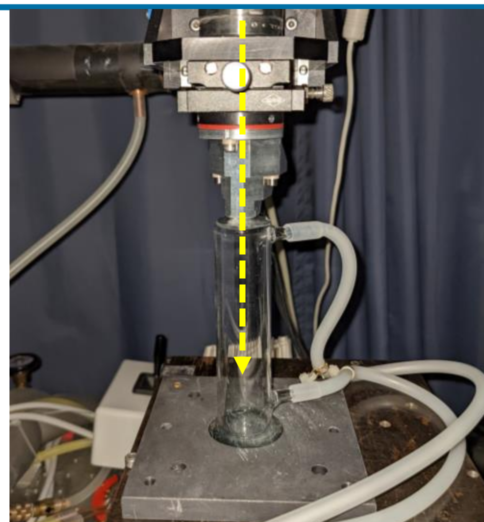
Adjustable photon flux!

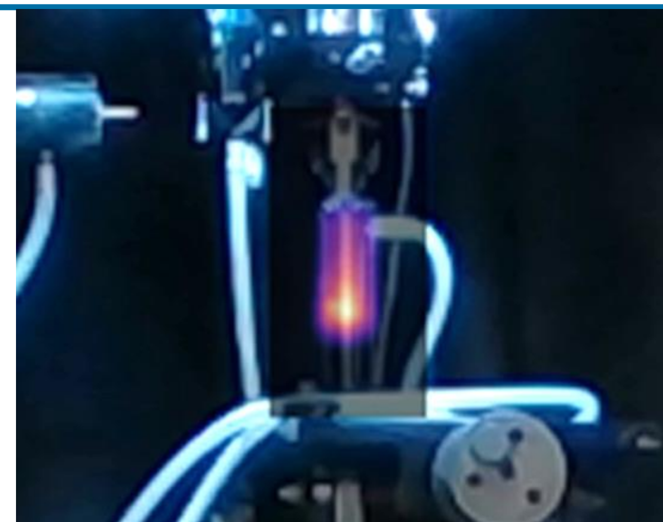
- Calibrated against the activity standard
- Simulates point source equivalent activity from **80 kBq** to **800 MBq**

Results 1/2

- ^{241}**Am** source
- Ø 3 mm
- Point source
- ***A* = 0.5 MBq**
- **2 m** distance

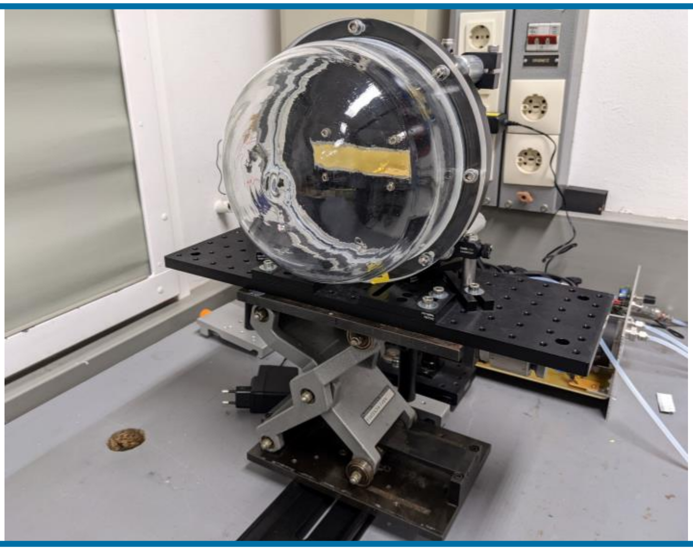
- Alpha **beam**
- ***E*** = 6.9 MeV
- Stopping in air
- 100 µm x 100 µm
- ***A* = 1 MBq**
- **2 m** distance

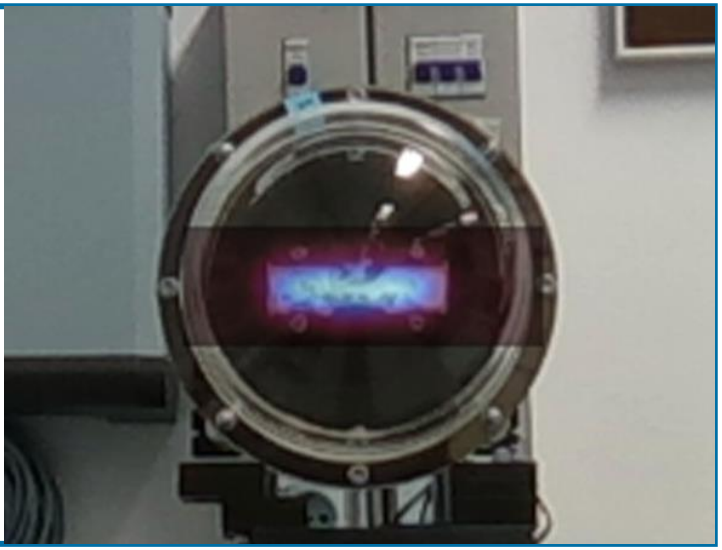




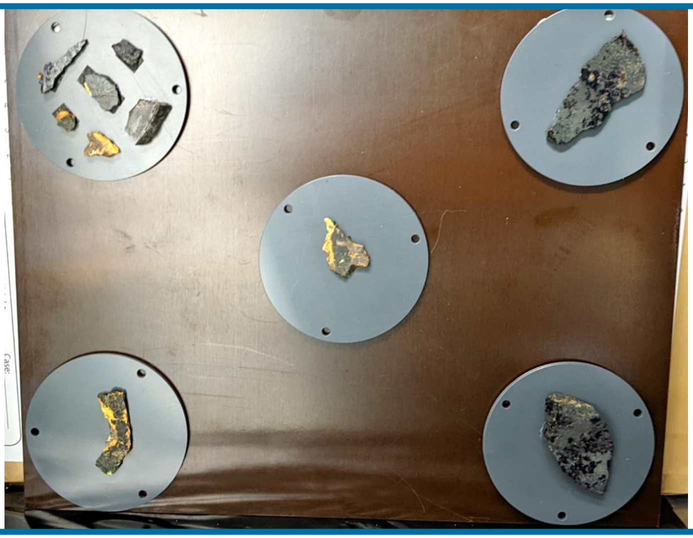
Results 2/2

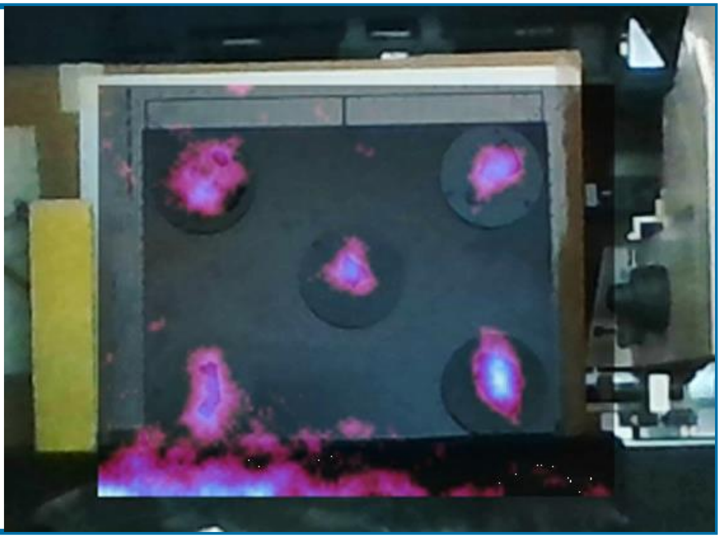
- ^{241}**Am** source
- 10 cm x 2 cm
- Au cover 2 µm
- ***A* = 1 MBq**
- **2 m** distance





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





Acknowledgements

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19ENV02 RemoteALPHA denotes the EMPIR project reference.

RemoteALPHA partners

Thanks for attention!

https://remotealpha.drmr.nipne.ro

RemoteALPHA

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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

  May, Barcelona, Spain

- Feedback / discussion

Visit the project website for more information:

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- ✓ Presentations
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