EURADOS

Drone Mounted Systems
Alpha Detection

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EEAE ΕΛΛΗΝΙΚΗ ΕΠΙΤΡΟΠΗ ΑΤΟΜΙΚΗΣ ΕΝΕΡΓΕΙΑΣ
GREEK ATOMIC ENERGY COMMISSION

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Intro

Why choose remote alpha detection?

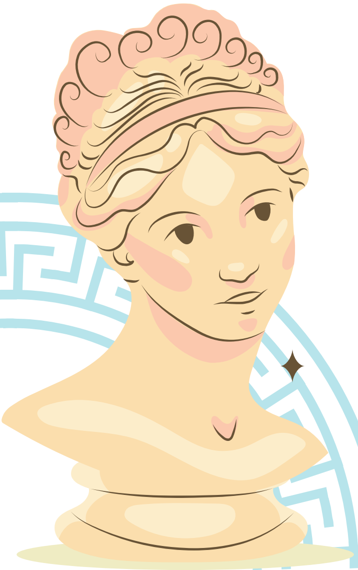
- Quickly localize and quantify large-scale contaminated areas
- Reduce exposure to radiation
- Overcome traditional contamination detection techniques

Use

- Scan / Map alpha contamination in the environment
- Nuclear facility decommissioning
- Radiological crime scene management

RemoteALPHA (EMPIR project – EURAMET)

- New detectors and detection methods
- Novel metrological infrastructure
- Fresh studies to take over, develop and use in emergency response plans

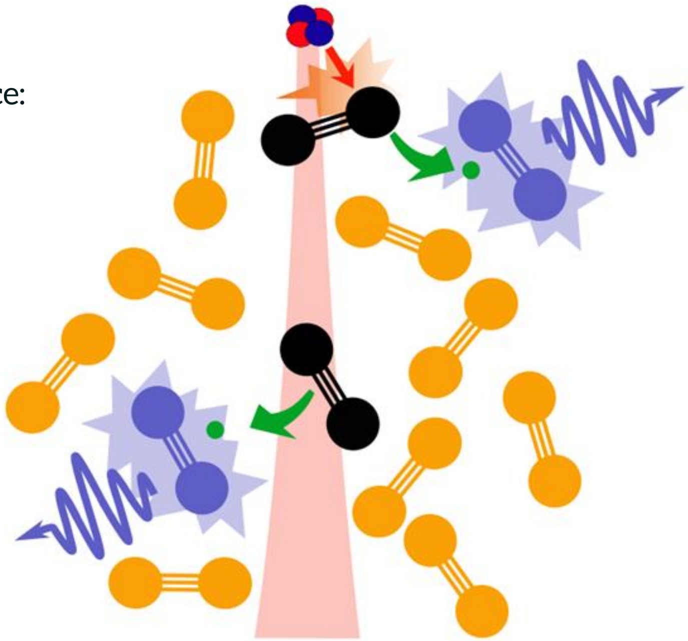


Alpha-induced radioluminescence

Air composition:

	N_2	O_2	Ar	NO + H_2O
%	(78)	(21)	(1)	(trace)

Air radioluminescence:
→ optical emissions from N_2 and NO



Alpha particle loses energy in air

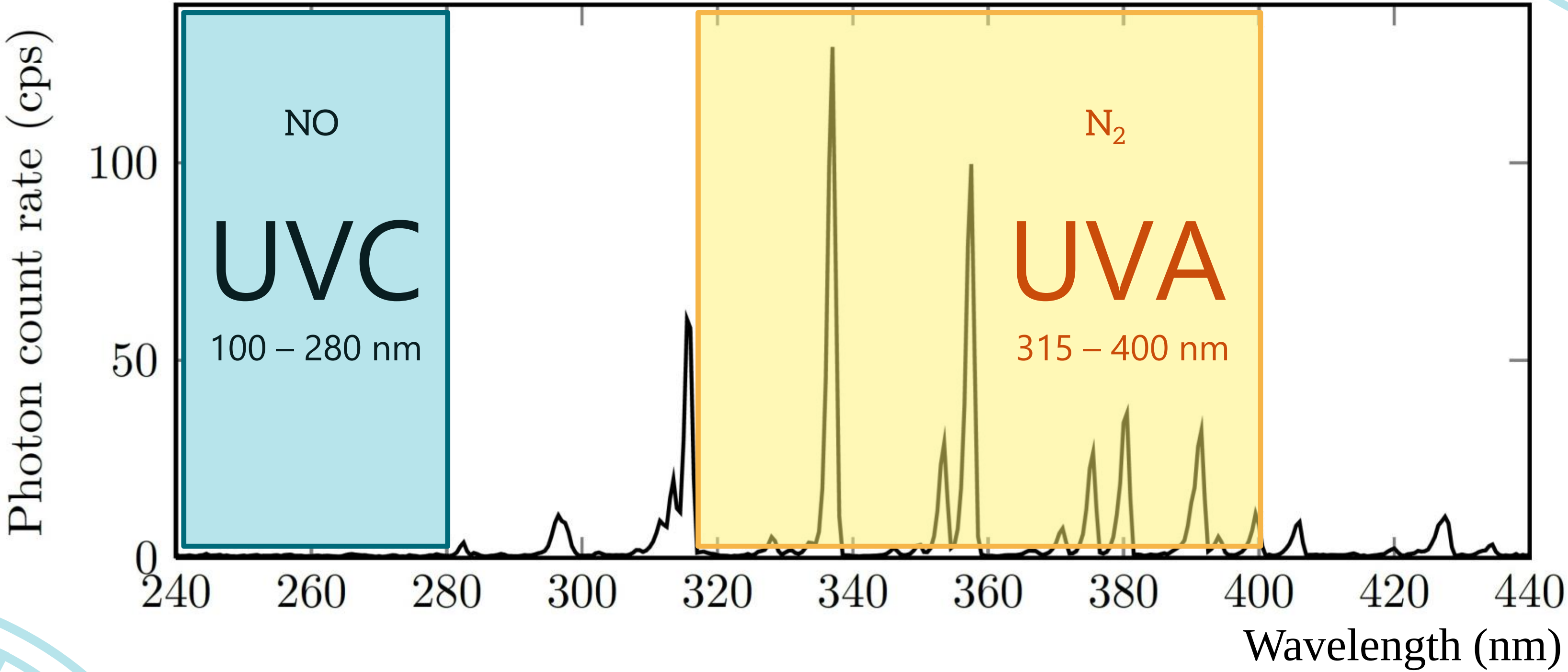
Released secondary electrons

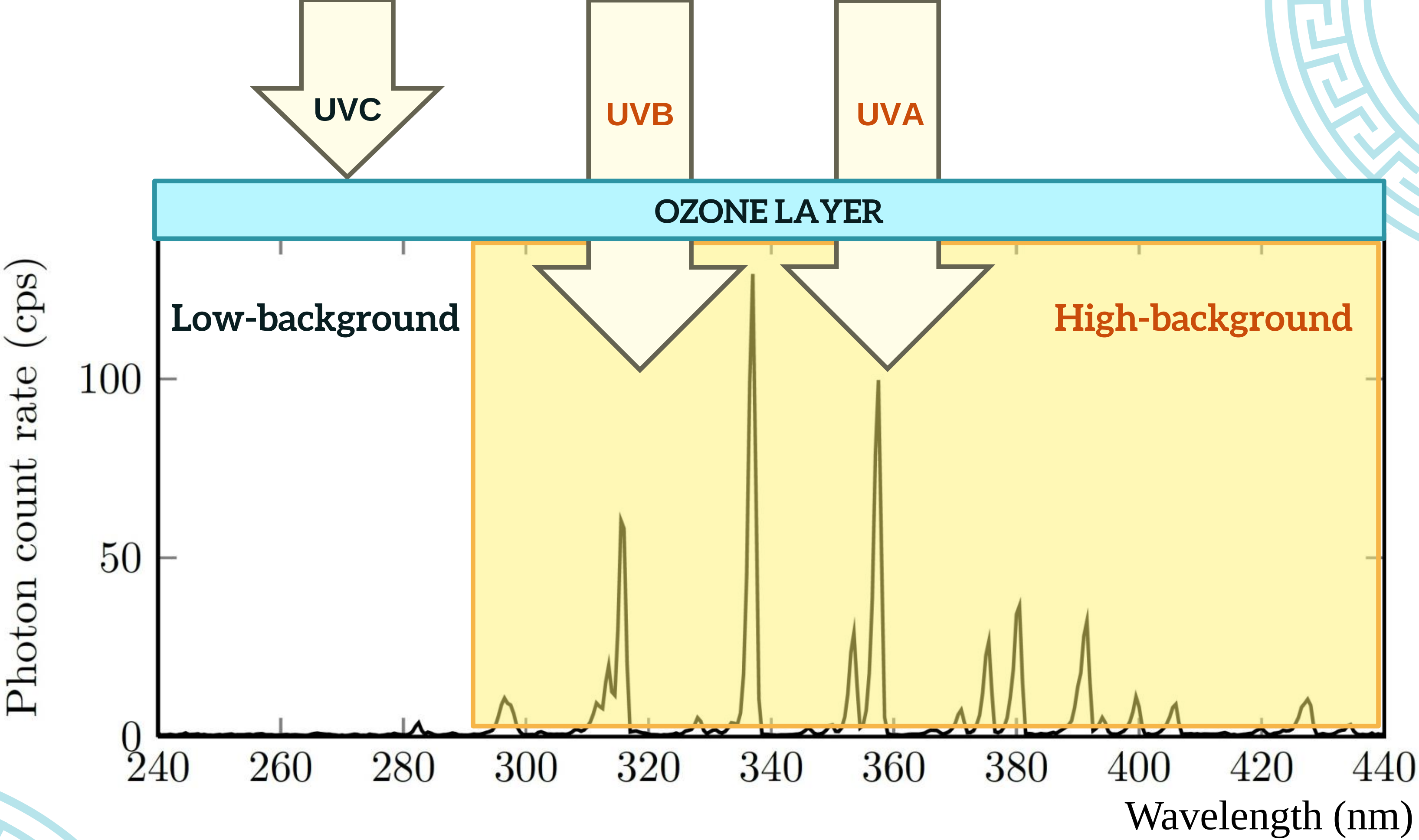
Electron impact
➔ ionization and excitation of N_2 and NO molecules to higher energy states

Energy transfer from excited N_2 to ground NO
➔ excitation of the NO molecule

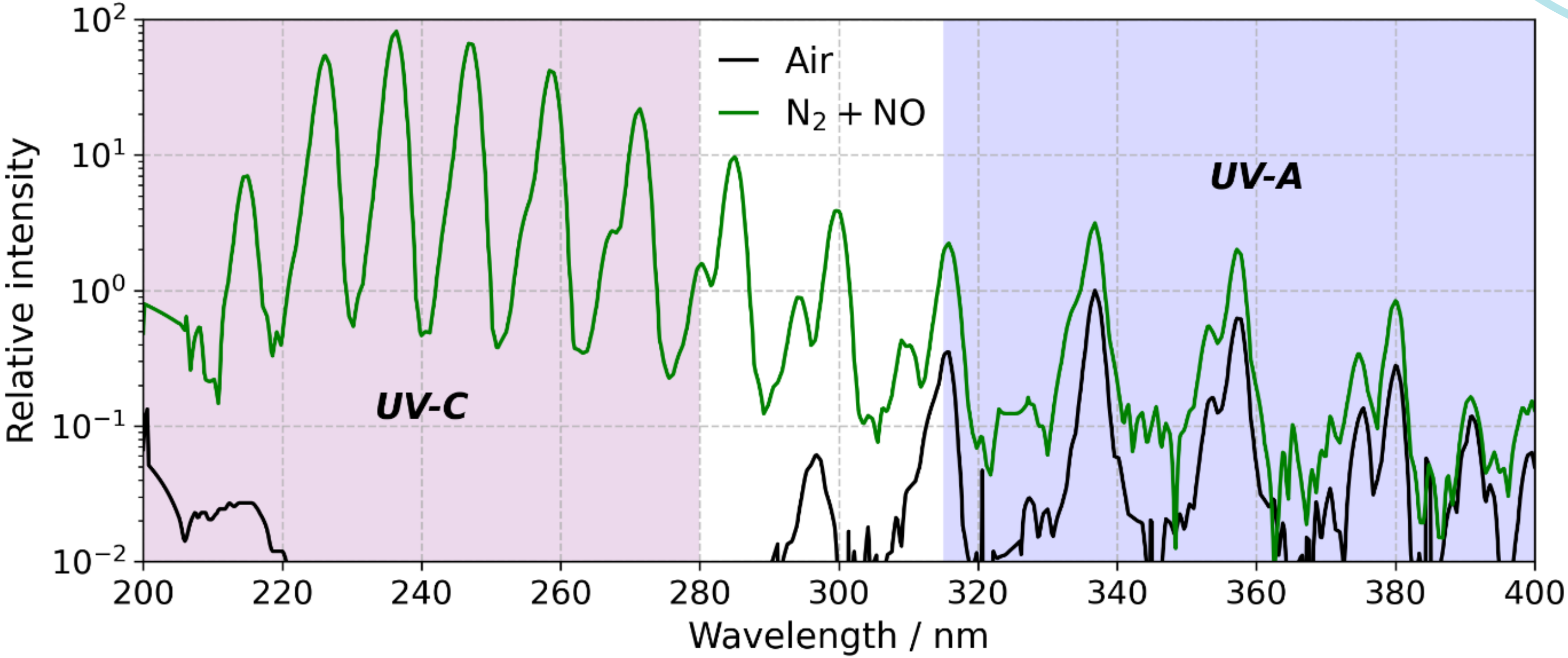
An excited molecule transitions to a lower energy state by emitting a **transition photon**.

Radioluminescence spectrum




UVC
UVB
UVA
OZONE LAYER
Low-background
High-background
Photon count rate (cps)
100
50
0
240
260
280
300
320
340
360
380
400
420
440
Wavelength (nm)

Enhanced radioluminescence



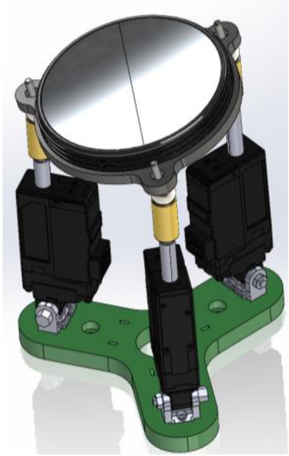
@ PTB Ion Accelerator Facility – PIAF, measured with a CAS140D spectroradiometer

Radioluminescence detection

= optical detection

Johan Sand @ Alfa Rift
& TAU

iXon Ultra 897 EMCCD - Andor - Oxford Instruments (oxinst.com)



Tools:

cameras, photomultiplier tubes, optical filters, optical lens (diameter-important), optical mirrors

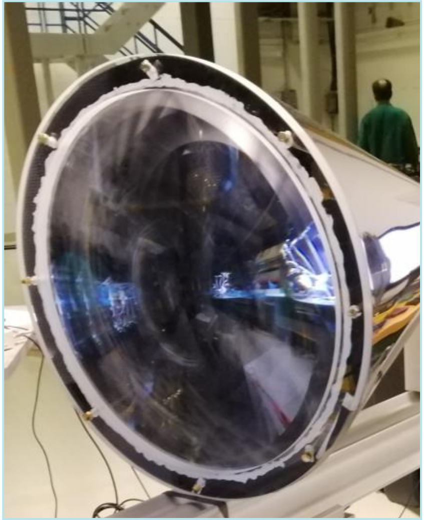
Lens-based systems

Johan
Sand @
Alfa Rift
& TAU

ø 100 mm

UVFS lens
89 - 91% UVC - UVA

ø 240 mm

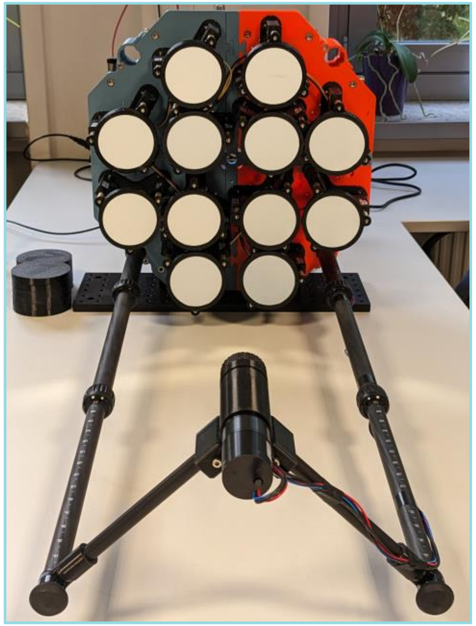


PMMA lens
20 - 90 % UVC - UVA

ø 450 mm

Mirror-based systems

Ø 75 mm 7-mirror system



12-mirror system

UV filters + PMTs

UV-C: daytime measurements

- CsTe photocathode PMT
- 260 nm optical filters

Advantages & drawbacks

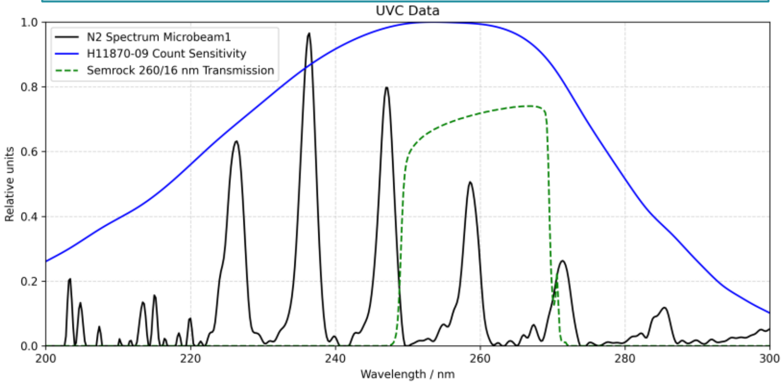
\+ Low natural BG → Daylight measurements possible
– About 1% of UVA yield in air

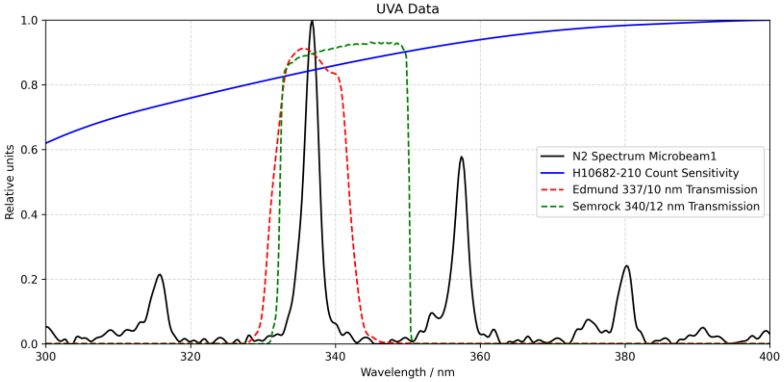
UV-A: measurements in dark conditions

- Bialkali photocathode PMT
- 340 nm optical filters

Advantages & drawbacks

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

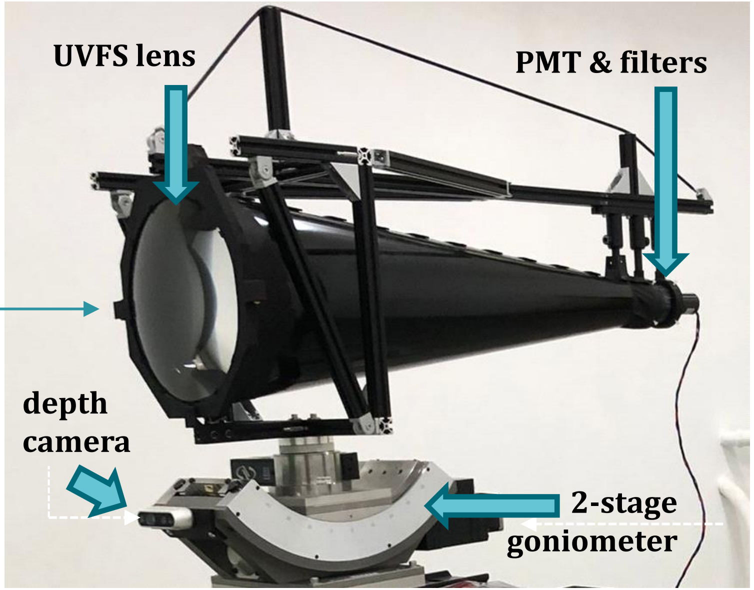




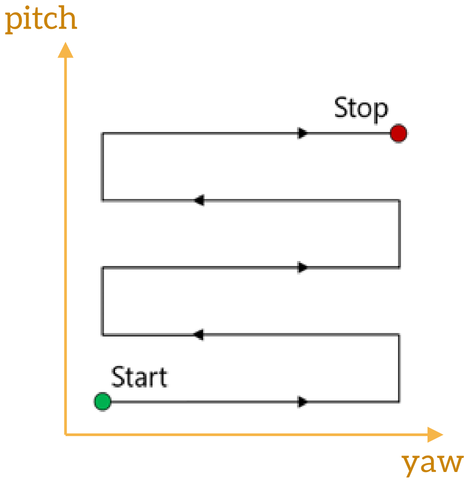
Scanning

^{239}Pu
reference source
Ø 140 mm

2m

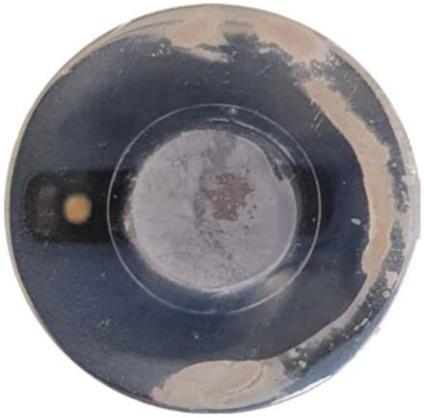


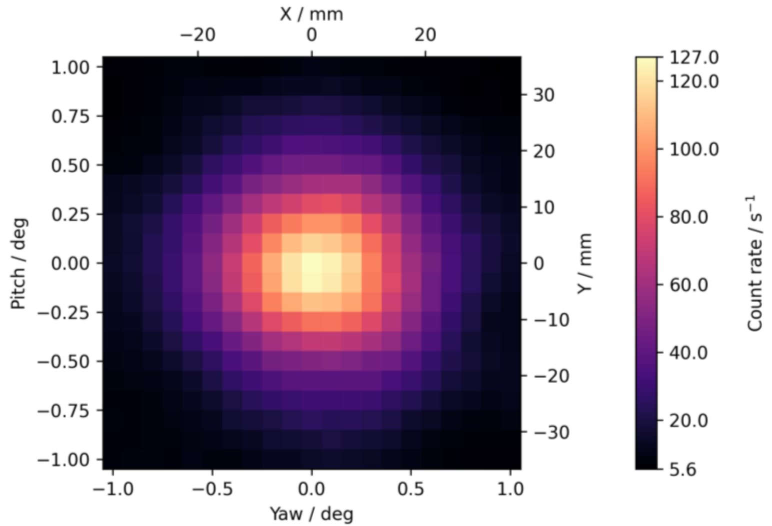
UVFS lens Ø 240 mm



Activity Standard

Stefan Röttger @ PTB





^{210}Po

Alpha activity standard

Traceable to national standard

Point source!

$\boldsymbol{A}$ = 840 kBq

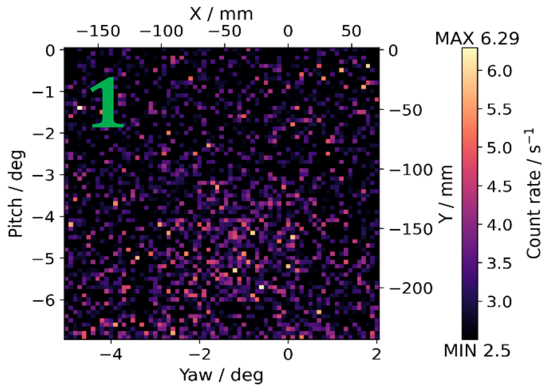
$\mathbf{T_{1/2}}$ = 138 d

Pure α-emitter!

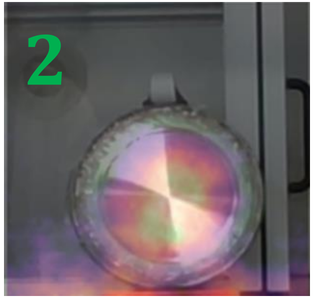
$\boldsymbol{E_\alpha}$ = 5304 keV

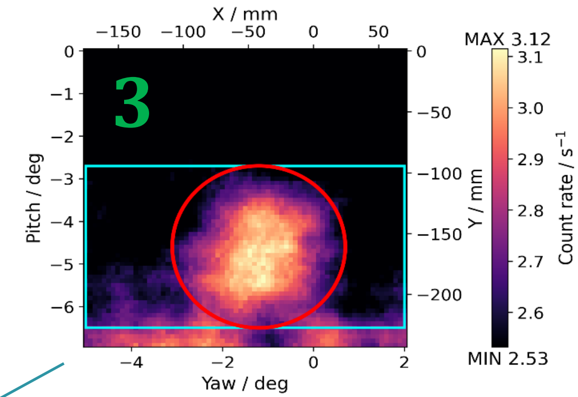
$\mathbf{p_\alpha}$ = 99.99876

Scanning



localization



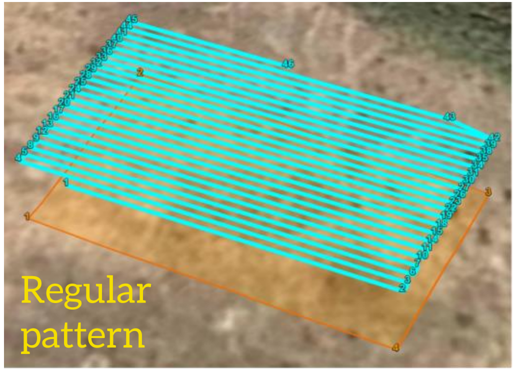


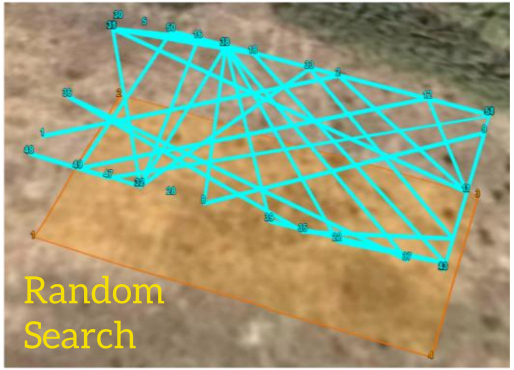
quantification

$$A_s = k\frac{\Sigma_{net}}{s}$$

A_s (kBq)	System	Time	Medium
5.76 ± 0.51	Mirrors	14 h	air
5.76 ± 0.65	Lens	13 h	air
2.58 ± 0.17	Lens	12 min	N2+NO
4.924 ± 0.216	calculated	-	-

Mapping





Technical constraints:

- Large diameter
- Small focal length
- Lightweight (<6 kg)
- High sensitivity

- GPS accuracy
- Drone speed
- Wind counteraction
- Altitude control
- No active stabilization

Mapping – drone measurements

PMMA Fresnel lens, Ø 450 mm, FOV ~ 10 cm

Main aerial system

First aerial system for alpha detection

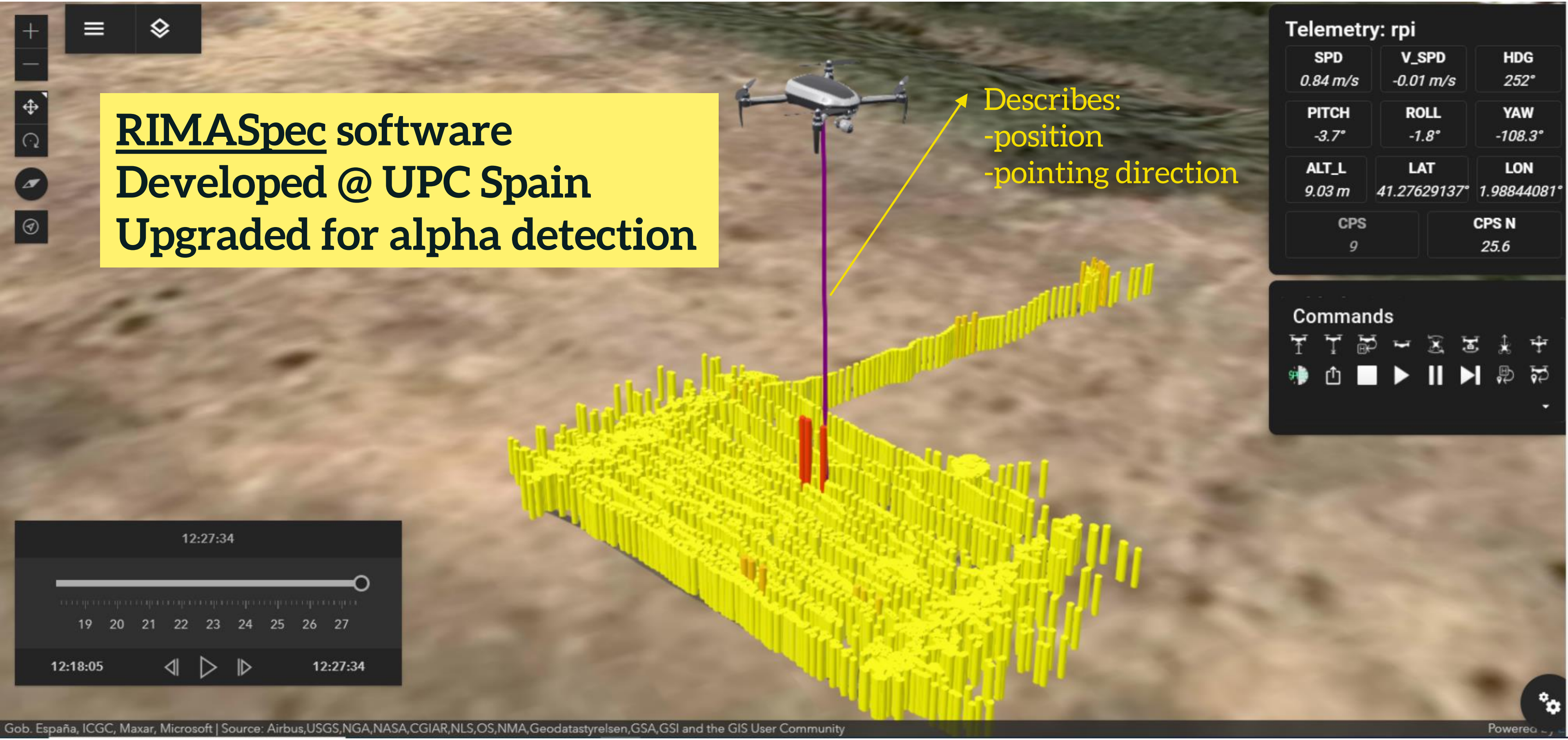
developed and characterized at PTB (Germany)
drone integration and flight tests in UPC (Spain)

DJI Matrice 600 Pro – improved control accuracy, ease of payload integration

Modified landing gear – integrated into the lens frame

Laser-altimeter – distance to the ground ($\pm$ 0.1 m accuracy)

Onboard computer - fuses real-time telemetry and detector count rate data → real-time mapping


RIMASpec software
Developed @ UPC Spain
Upgraded for alpha detection
Describes:
-position
-pointing direction
Telemetry: rpi
SPD 0.84 m/s
V_SPD -0.01 m/s
HDG 252°
PITCH -3.7°
ROLL -1.8°
YAW -108.3°
ALT_L 9.03 m
LAT 41.27629137°
LON 1.98844081°
CPS 9
CPS N 25.6
Commands
12:27:34
19 20 21 22 23 24 25 26 27
12:18:05
12:27:34
Gob. España, ICGC, Maxar, Microsoft | Source: Airbus,USGS,NGA,NASA,CGIAR,NLS,OS,NMA,Geodatastyrelsen,GSA,GSI and the GIS User Community

Mapping – UV sources

5 LEDs (275 nm)

100 MBq ^{241}Am (100 x 20 mm)

Flight planning for alpha detection

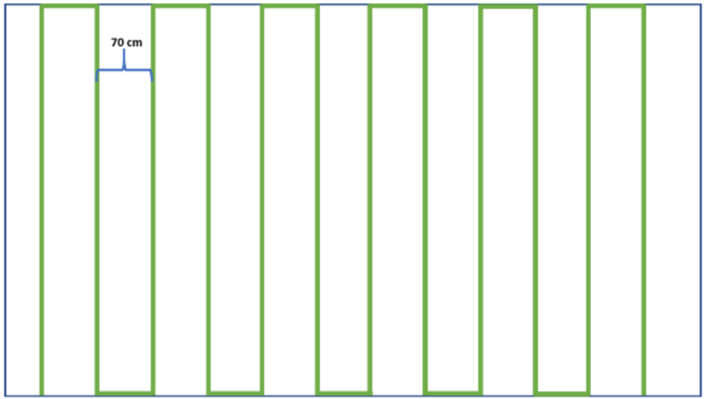
Flight planning for **point alpha source** detection:

Optimal value of the **FOV - 10.7 cm** at 5 meters
- mapping performed at **5m height**
- plan tracks should be very close together (10 cm), limited at **70 cm**
- drone speed very slow at **1 m s^{-1}**
- integration time short **0.1 s**

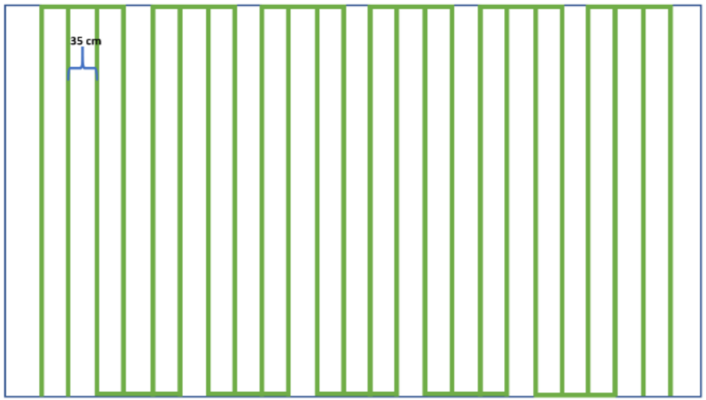
Scan pattern: back and forth

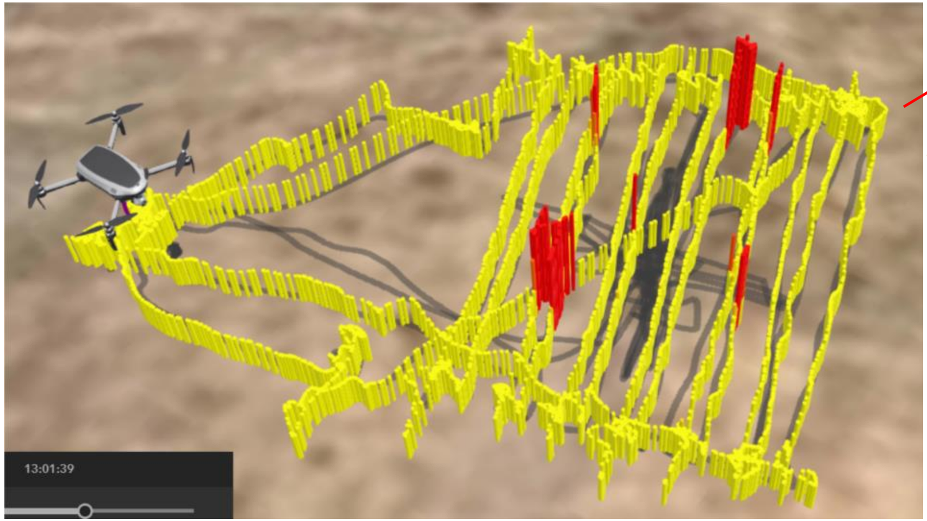
If the sources are not detected in the first iteration of the flight plan, a second iteration with an offset is performed.

One iteration



Two iteration with offset





Flight tests performed at the UPC DroneLab

Preliminary flights (only LEDs)
5 flights – probability of detection 60 %

1 flight – detection of 4/5 LEDs and Am-241 (center)

Localization of alpha contamination only in UVC

Recommendations – use in EP

- Usage of UVC spectral range
- Maximize FOV of the system (for point sources)
- Use short integration time – to increase the probability of detection
- Short distance between flight lines
- Slow speed

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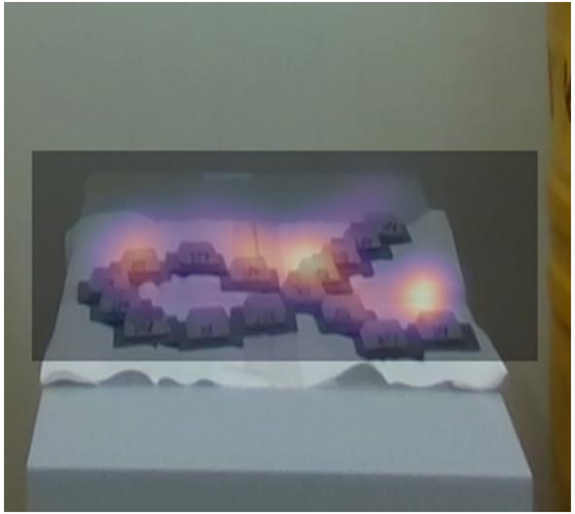
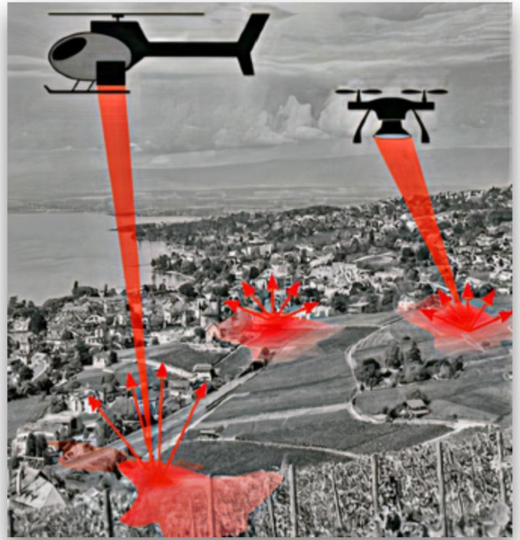
RemoteALPHA

EMPIR EURAMET

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

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





Visit the project website

for more information:

- ✓ Publications
- ✓ Presentations
- ✓ Posters

https://remotealpha.drmr.nipne.ro

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RemoteALPHA partners

PTB Messen • Forschen • Wissen

Budapest Főváros Kormányhivatala

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Alfa Rift Oy

Leibniz Universität Hannover

Tampere University

UPC Universitat Politècnica de Catalunya BarcelonaTech

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Thanks!

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