CHIYODA TECHNOL CORPORATION

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Remote detection of alpha and gamma radioactivity by using rotary-wing unmanned aerial systems

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EMPIR EURAMET
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Institut de Tècniques Energètiques

Content

In the framework of 2 European Projects

airborne detectors installed in UAVs have been developed and tested

- Gamma-spectrometric detectors
- Localizer-detector
- Alpha remote detector

Introduction

- The research has been carried out in the framework of 2 European projects:

PREPAREDNESS
Metrology for mobile detection of ionising radiation following a nuclear or radiological incident.

(2017-2021) (http://www.preparedness-empir.eu/)

- **Spectrometric detectors** were adapted, mounted on selected UAVs and calibrated in measurement campaign. In addition **a localizer detector** was developed and tested.

RemoteALPHA (2020-2023 in progress) https://remotealpha.drmr.nipne.ro/)

- A **remote alpha airborne monitor** to be mounted in UAVs have bee developed and will be tested in experimental campaigns during the next months.

Spectrometric detectors

PTB (Germany**), UPC (Spain)**

Drone: DJI Matrice 600 Pro (payload: 6 kg)

Detector $CeBr_3$ /NaI. Total weight: 1.5 kg

CMI & Nuvia (Czech Republic**)**

Drone: SWISSDRONE SDO 50 v2

Petrol engine. Payload~45 kg

Detector HPGe. Total weight : 25 kg

I N D U S T R Y P A R T N E R S

Kromek (United Kingdom**)**

AARM with CsI or CZT detectors

Nuvia (Czechk republic**)**

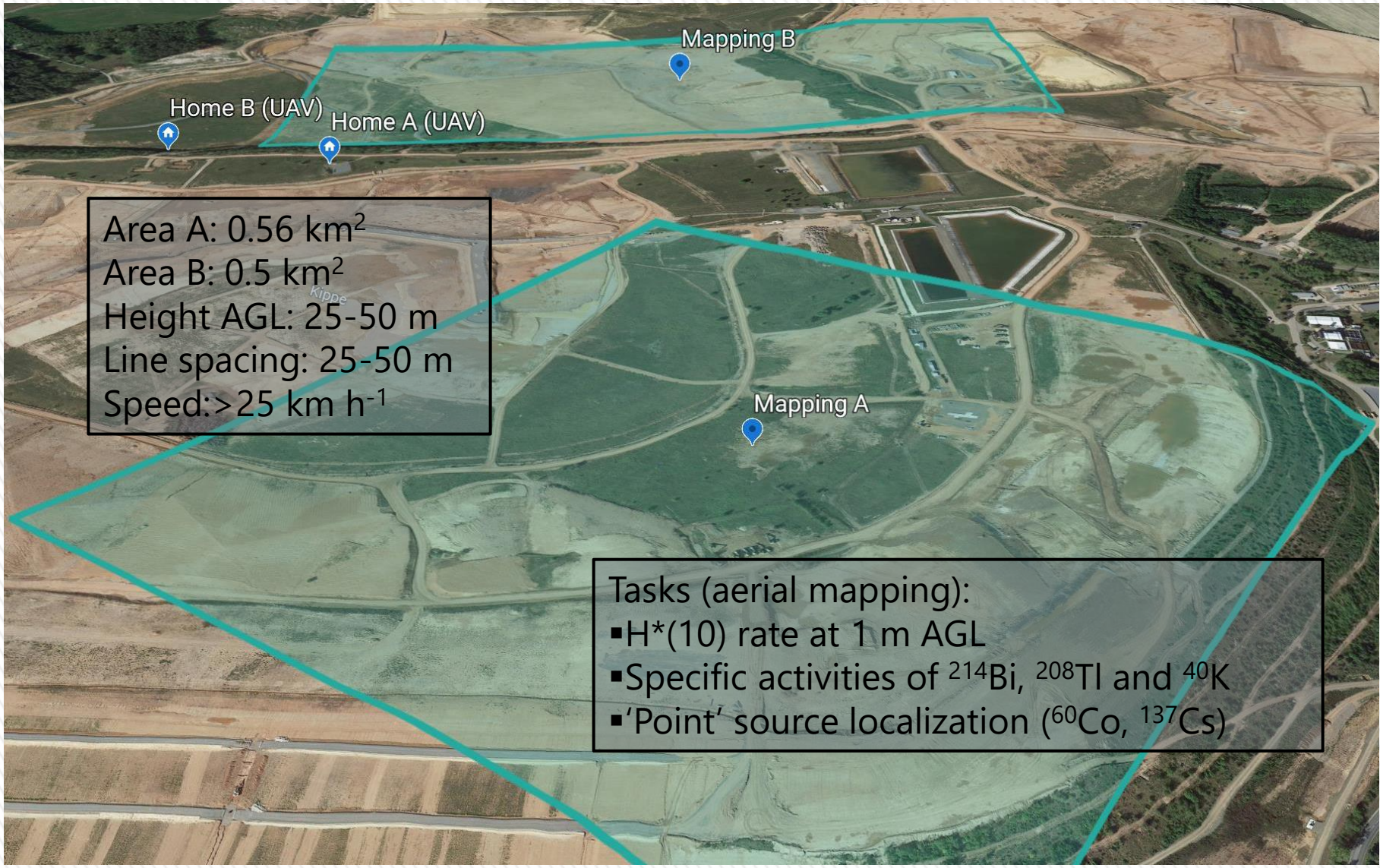
NuEM DORNES G

Variety of payload and modules

Former Uranium mine campaign

March 2020, Seelingstädt, Germany
Former uranium mines (Wismut GmbH)
Organizer: BfS (Germany)
Teams: BfS, PTB, UPC, SCK-CEN, BPOL

Former Uranium mine campaign



Robust and fast calculations

On-line parameters:

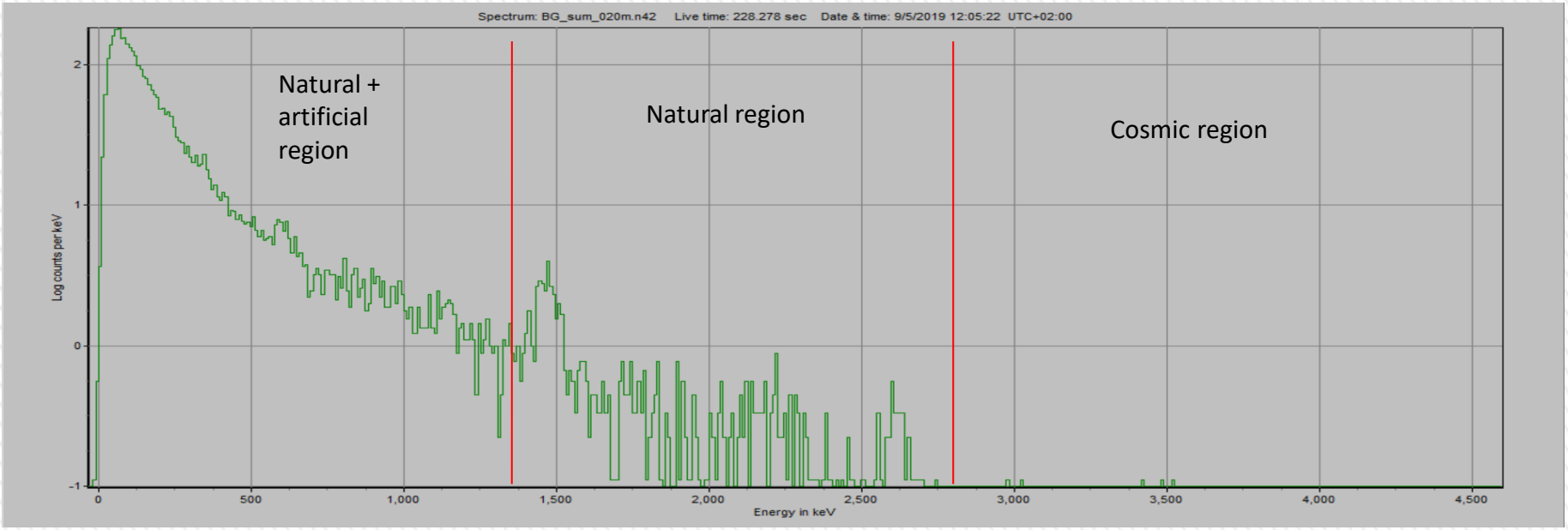
- For ***H**(10)* calculation, conversion coefficient** method is recommended because is accurate, precise and robust.

$$\dot{H}^*(10) = \sum_{i=1}^{j} w_i \, n_i \, E_i$$

- Man Made Count Rate (**MMCR**) is a robust and fast method to detect artificial radioactivity.

When no artificial radionuclides, then:

$$\text{MMCR} = \sum_{320}^{1360} n(E) - ratio \sum_{1360}^{3000} n(E) \qquad \text{ratio} = \frac{\sum_{320}^{1360} n\,(E)}{\sum_{1360}^{3000} n\,(E)}$$

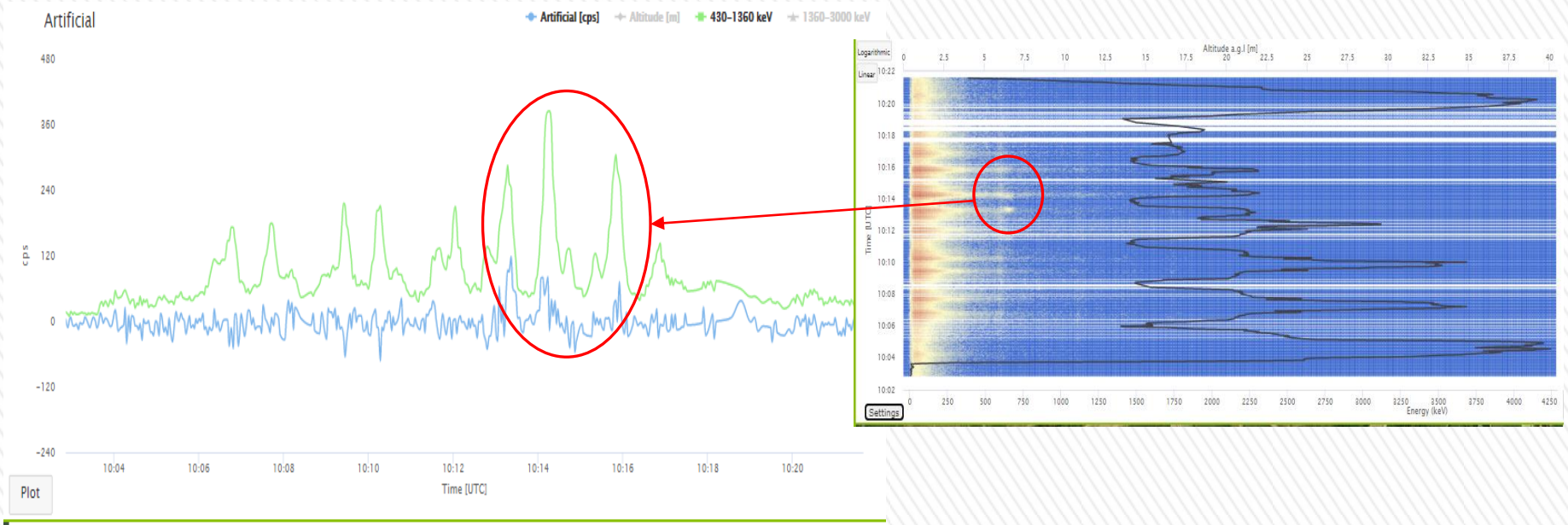


H(10)* and MMCR results

H*(10) rate in the area to find radioactive sources

H(10)* rate and **height a.g.l.**

The **MMCR method detects the artificial sources** in a simple way while with the *H*(10)* analysis its detection is not possible. **Spectra analysis by waterfall plot** is also useful



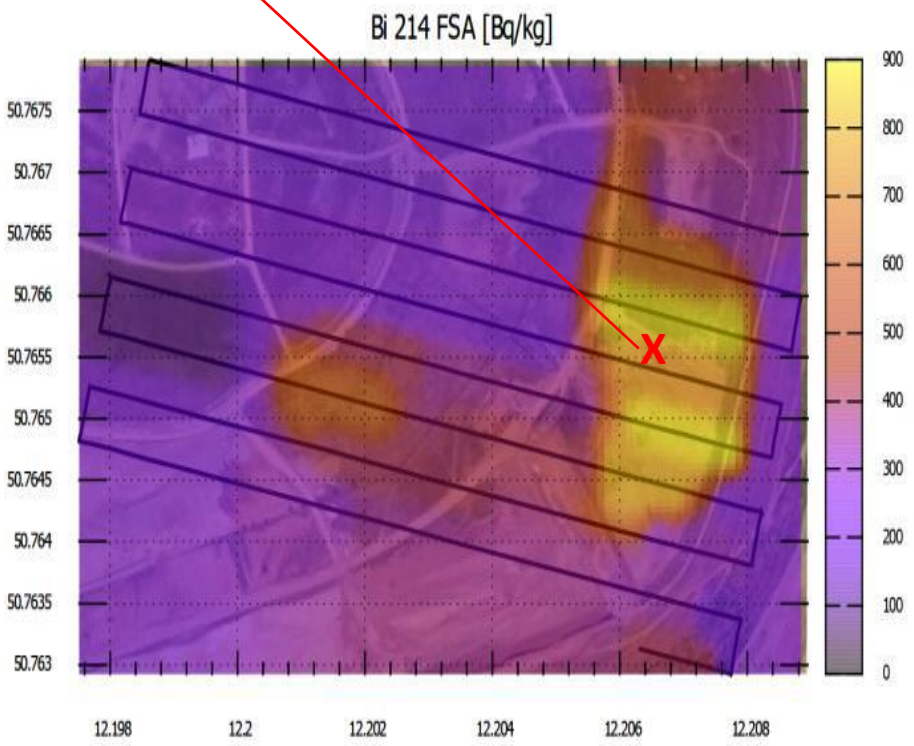
Specific activities

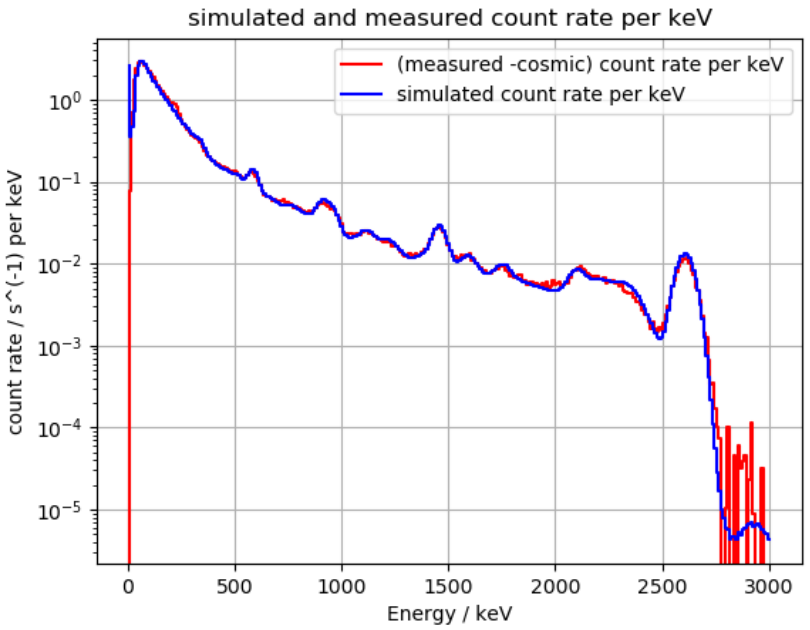
Full Spectra Analisys (FSA) → Monte Carlo (PENNOLPE/penEasy) simulations to obtain cps per Bq/kg or Bq or Bq/m^2 for each radionuclide and geometry. Then, Activities are estimated that minimize the measured and simulated spectra by a Genetic Evolution Algorithm

Cs-137 point source location (1 GBq)

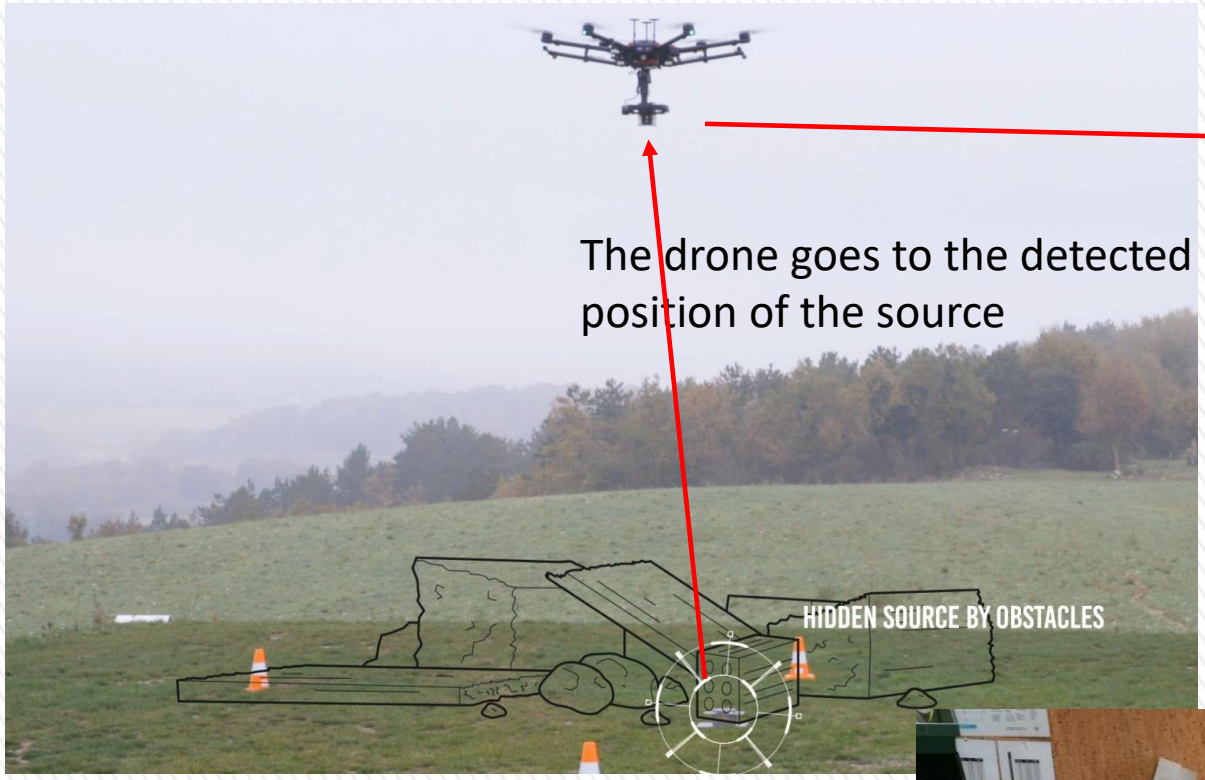
Co-60 has too low activity to be detected (45 MBq)

A (Bq/kg))
Ac-228: 165
Ra-226: 90
K-40: 600
Tl-208: 65
Cs-137: 7





Localizer-detector



8 x CsI detectors separated by shielding material to calculate the source position

Localizer mounted onto gimbal and installed on the DJI Matrice 600 Pro

Localizer-detector

Real flight at the Barcelona Drone Center to localize a 345 MBq Cs-137 source

2) Source: estimated position (black stars)

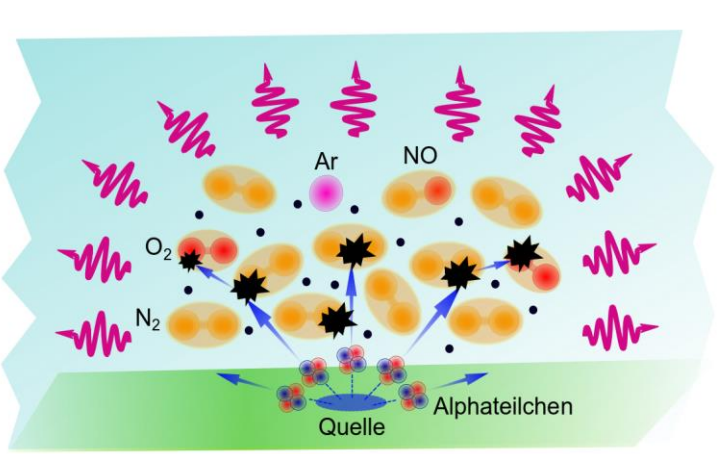
1) Drone stops when source is detected

Video preparedness: https://www.youtube.com/watch?v=IV45uvionKI&t=46s.

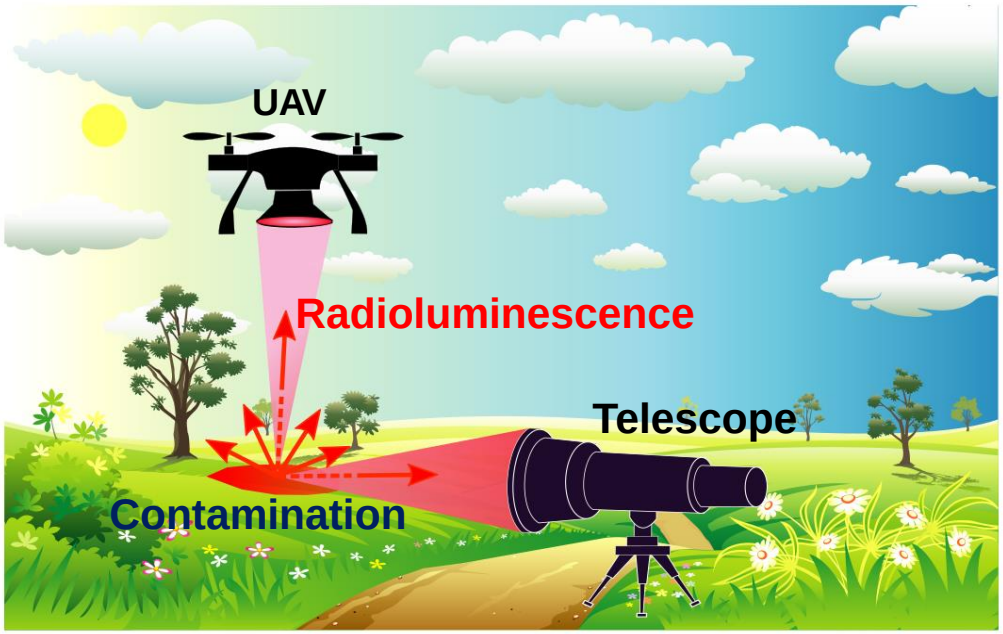
A. Vargas et al. COMPARISON OF AIRBORNE RADIATION DETECTORS CARRIED BY ROTARY-WING UNMANNED AERIAL SYSTEMS PERFORMED IN SPAIN. Radiation Measurements 145 (2021)

Remote alpha detection

Radioluminescence at a glance



*Schematic representation of **air ionization by α-particles.***



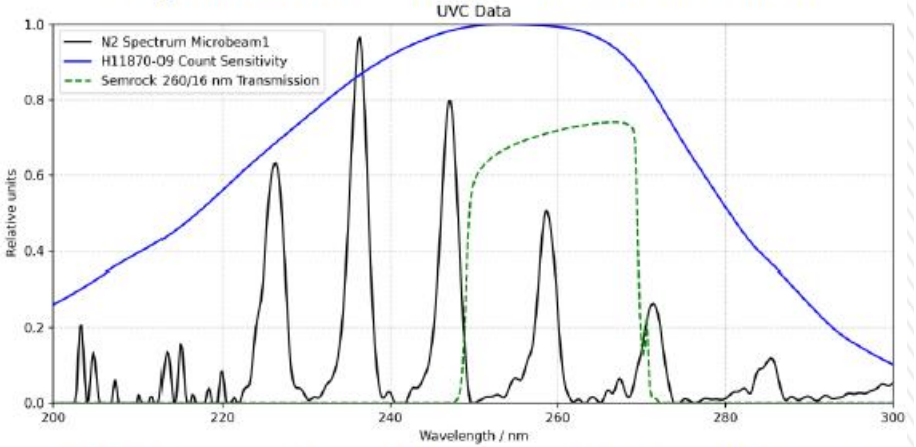
Air molecules emit fluorescent light (radioluminescence) in the **UV range** between **200 nm and 400 nm**.

Range in air:

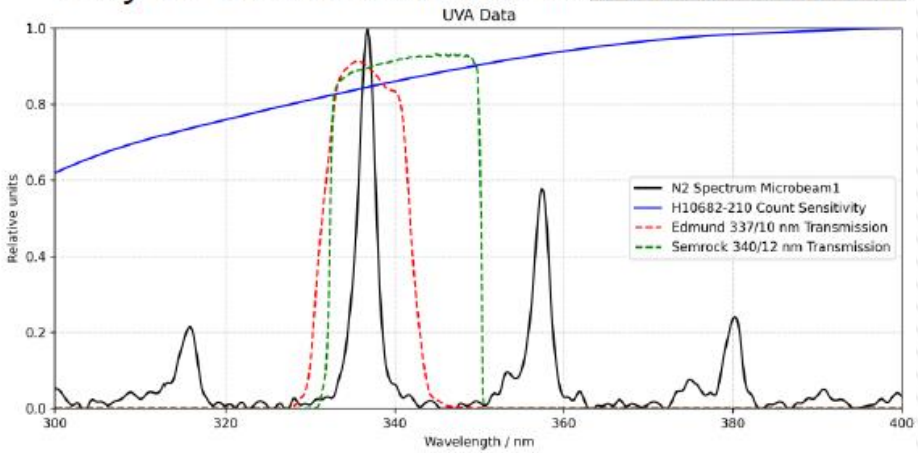
α-particles	→	0,04 m
UV light	→	500 m

Remote alpha detection

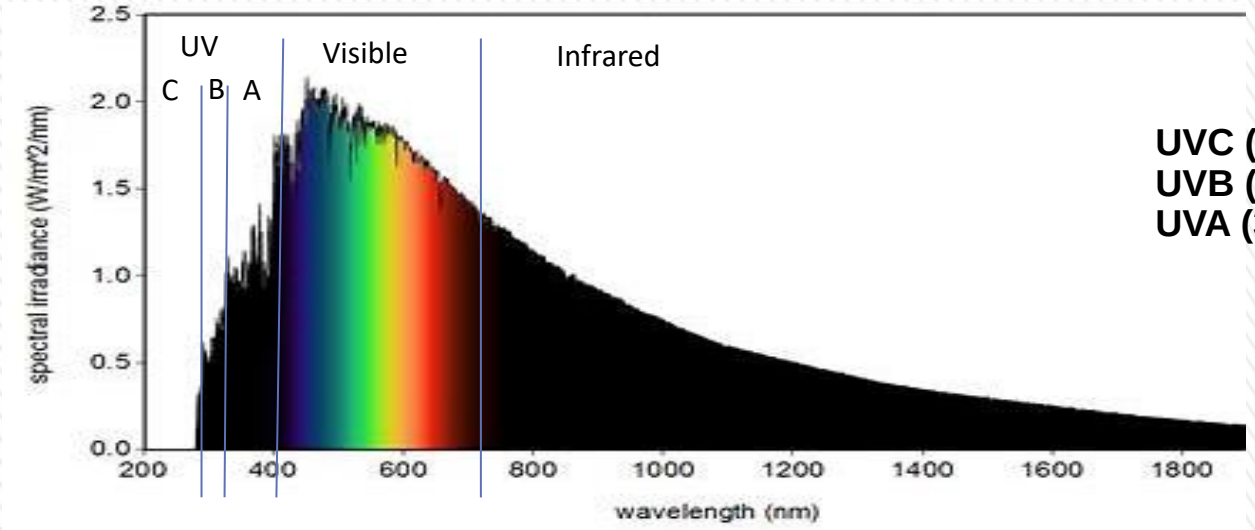
UV-C wavelength range (100 – 280 nm)
Daytime measurements are feasible



UV-A wavelength range (315 – 400 nm)
Only for measurements in dark conditions



Solar radiation spectrum (background)



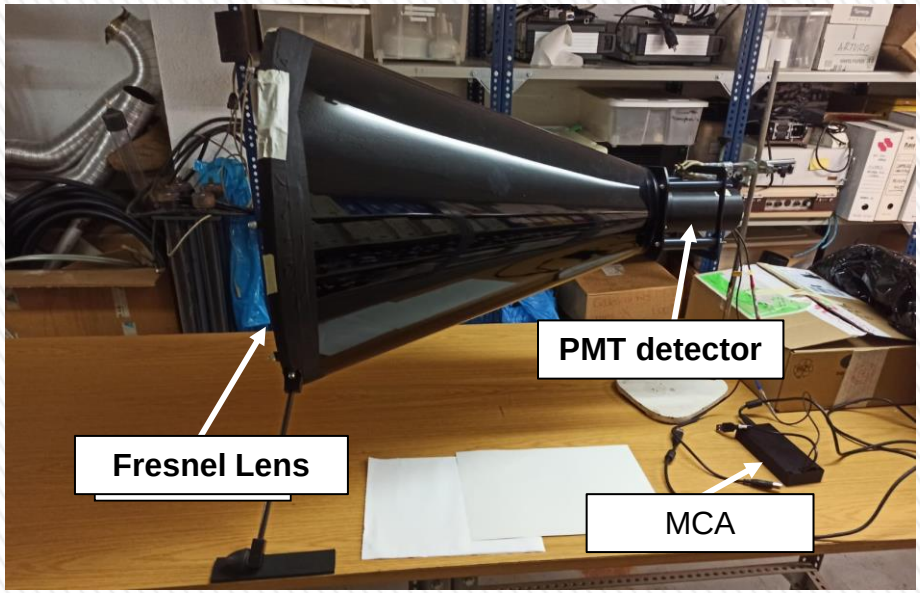
UVC (100 - 290 nm): 5 %
UVB (290 – 315 nm): 24 %
UVA (315 - 400 nm): 65 %

Remote alpha detection

Telescope

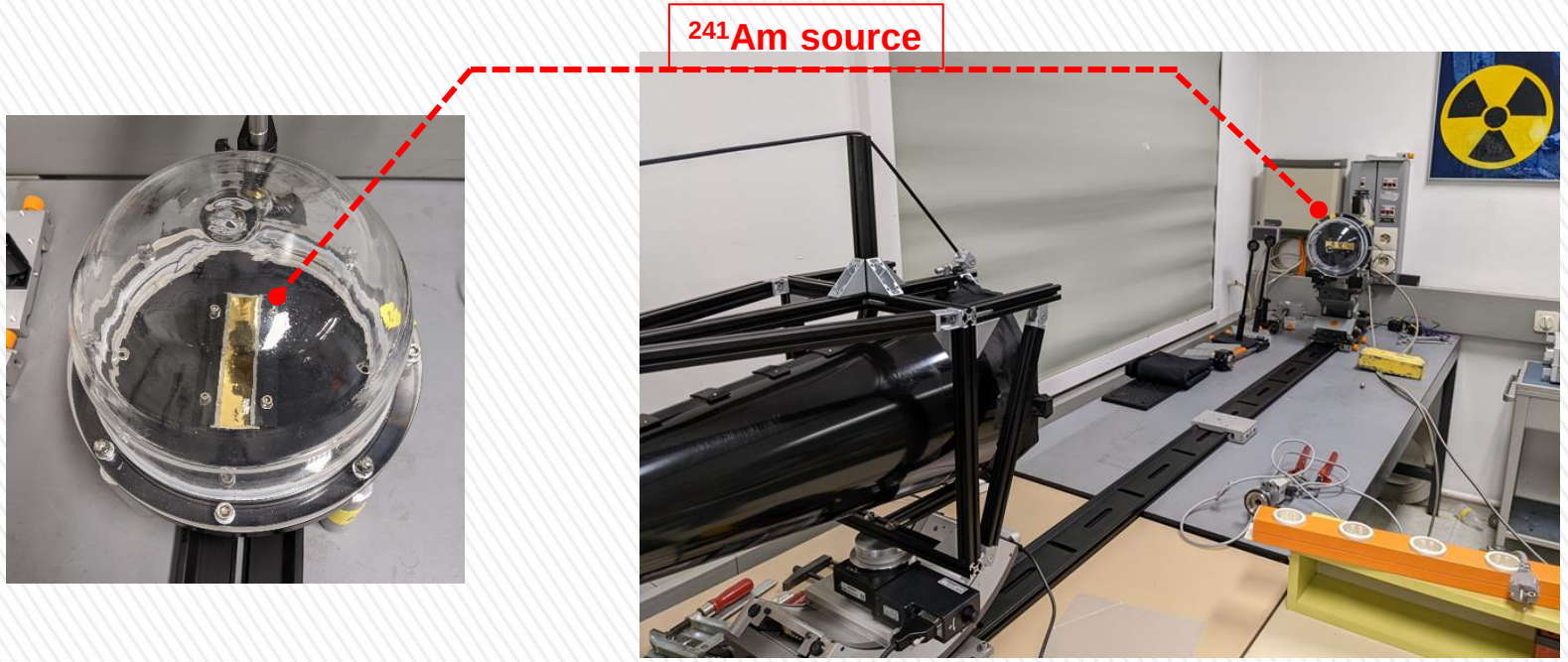
Mounted on the drone and tested in the DroneLab (UPC – Barcelona Tech)

Scaled system for the drone

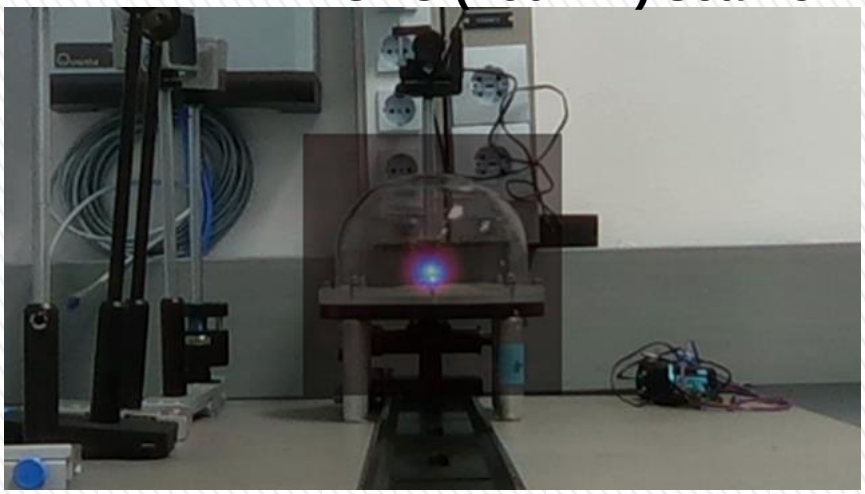


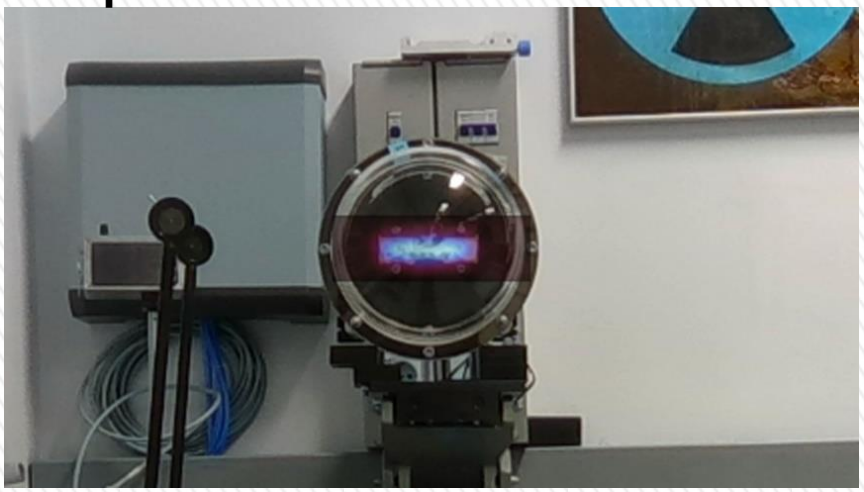
Remote alpha detection

Testing of optical detection systems with Am-241 sources (1 MBq, 10 MBq and 100 MBq)



UVC (260 nm) scan of 1 MBq Am-241



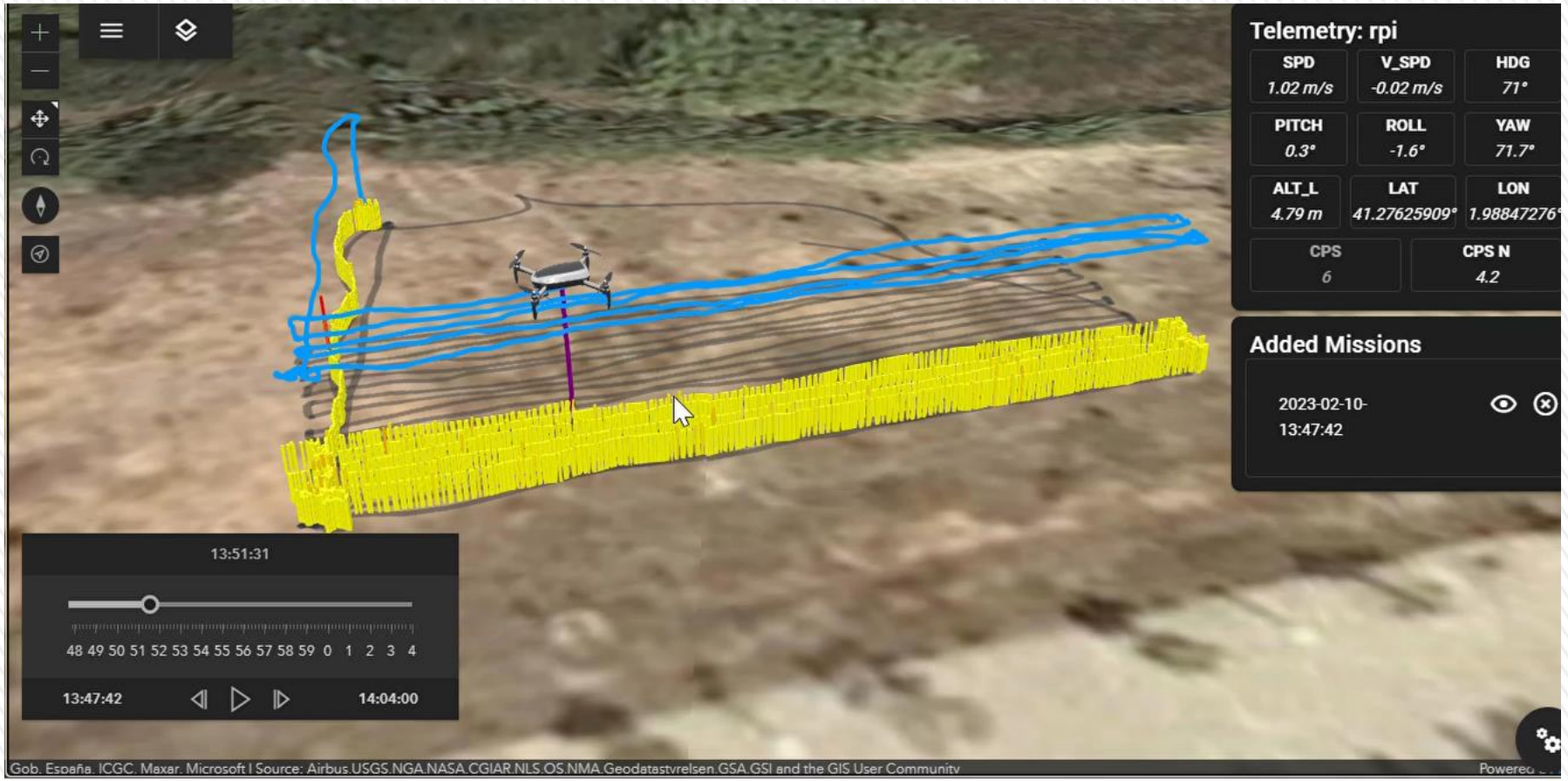


Mapping

Visualization of the detected count rate in real time during the flight with 5 UVC source emitters

Area 15 m x 30 m
Separation between lines 70 cm
Height a.g.l. 5 m
speed 1 m/s
Measurement of count rate is registered every 100 ms

On-line visualization



PREPAREDNESS
Metrology for mobile detection of ionising radiation following a nuclear or radiological incident.

RemoteALPHA

EURAMET

Acknowledgments

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16ENV04 Preapredness and19ENV02 RemoteALPHA denotes the EMPIR project reference.

Preparedness partners

RemoteAlpha partners