EURAMET

EMPIR 16ENV04:

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

(„Preparedness“)

Stefan Neumaier, PTB (16ENV04 coordinator)

Outline

- Need of “Preparedness”
- Objectives and Work packages
- Preparedness Consortium
- First results

Need of „Preparedness“:

about 180 nuclear power plants are operational in Europe!

In case of a nuclear emergency,

reliable and traceable radiological data

are of key importance for any governmental decision!

First responders at Chernobyl had been strongly exposed to ionising radiation and radioactivity in air

Outline

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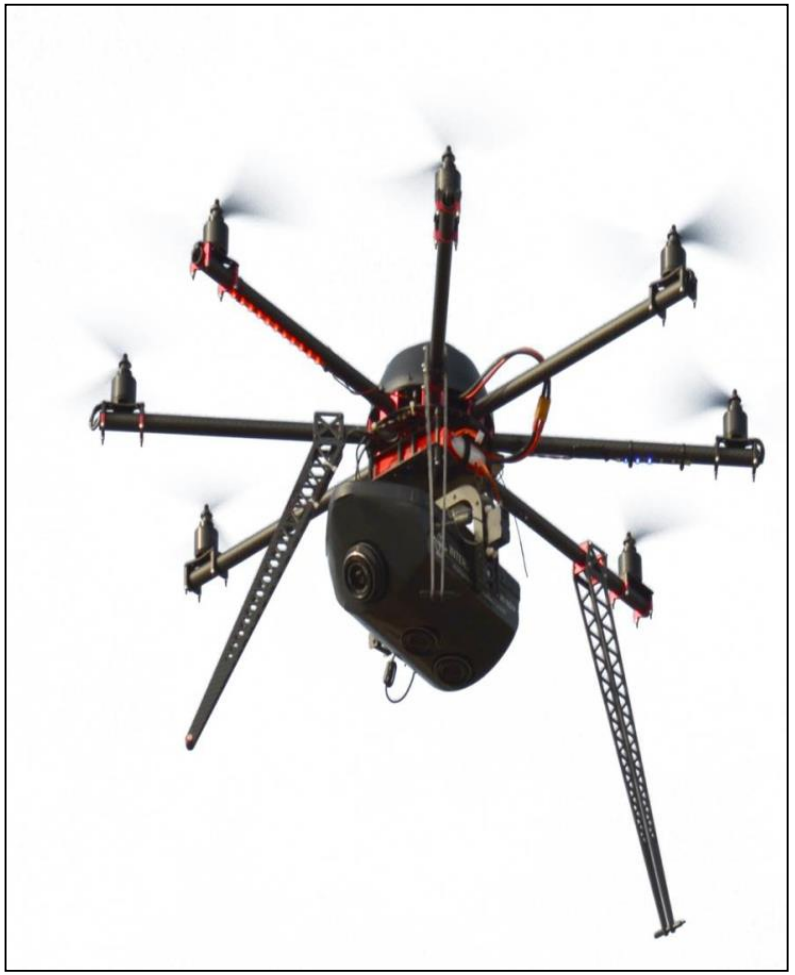
- First results

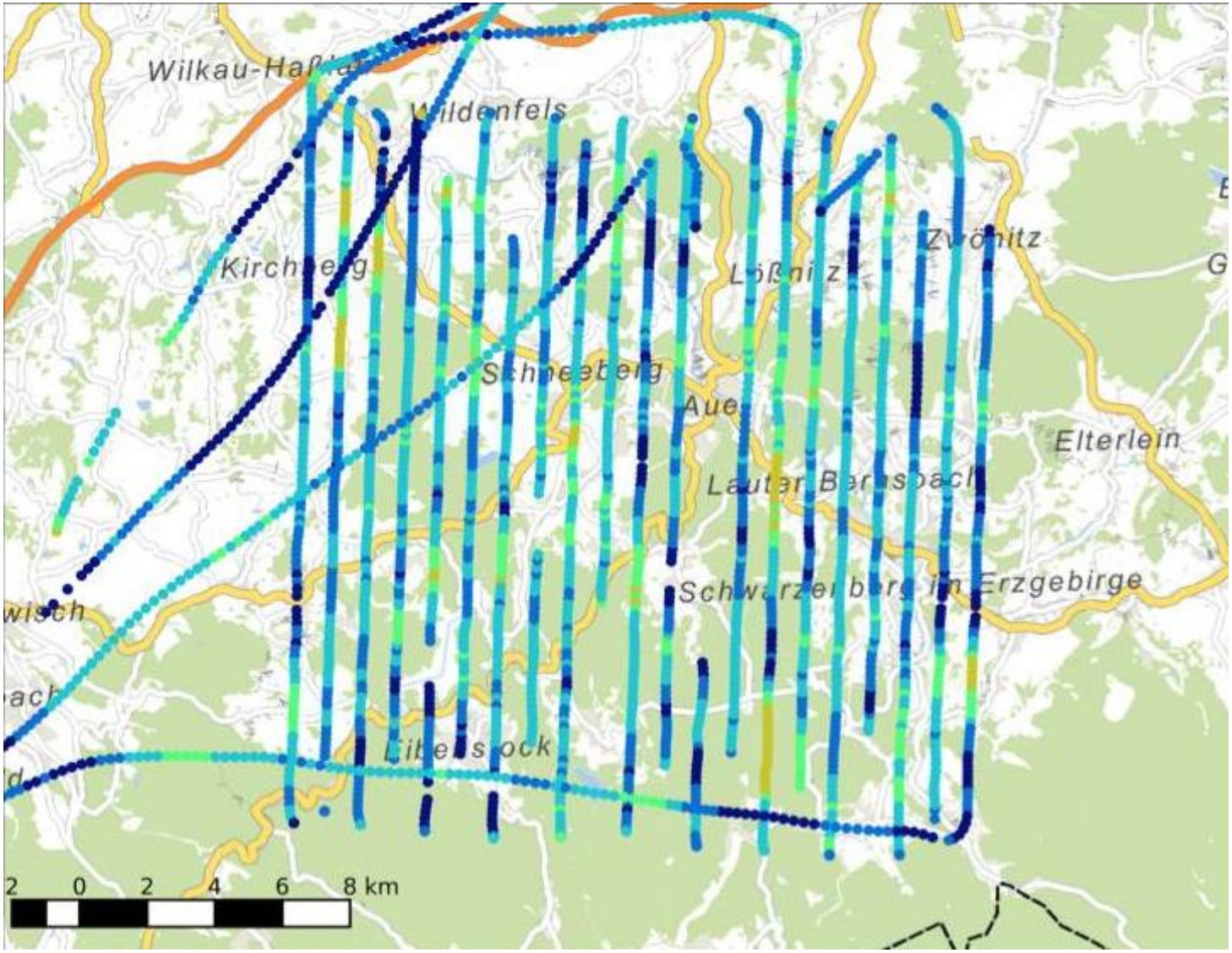
Preparedness Objectives and WP structure

- WP1: **Remote measurements** of dose rates and radioactivity concentrations, by detection systems installed on drones and unmanned helicopters (UAVs)
- WP2: **Transportable air samplers**;
  Development and validation of methods
- WP3: **Metrological relevance of dose rates provided by Measuring Instruments used in Non-governmental Networks (MINNs)**; („crowd sourced monitoring“);
- WP4: **Passive dosimetry**;
  Long-term survey of contaminated areas
- WP5: **Uptake and impact**;
  Improvement of the metrological infrastructure in EU
- WP6: Management and coordination (S. Neumaier)

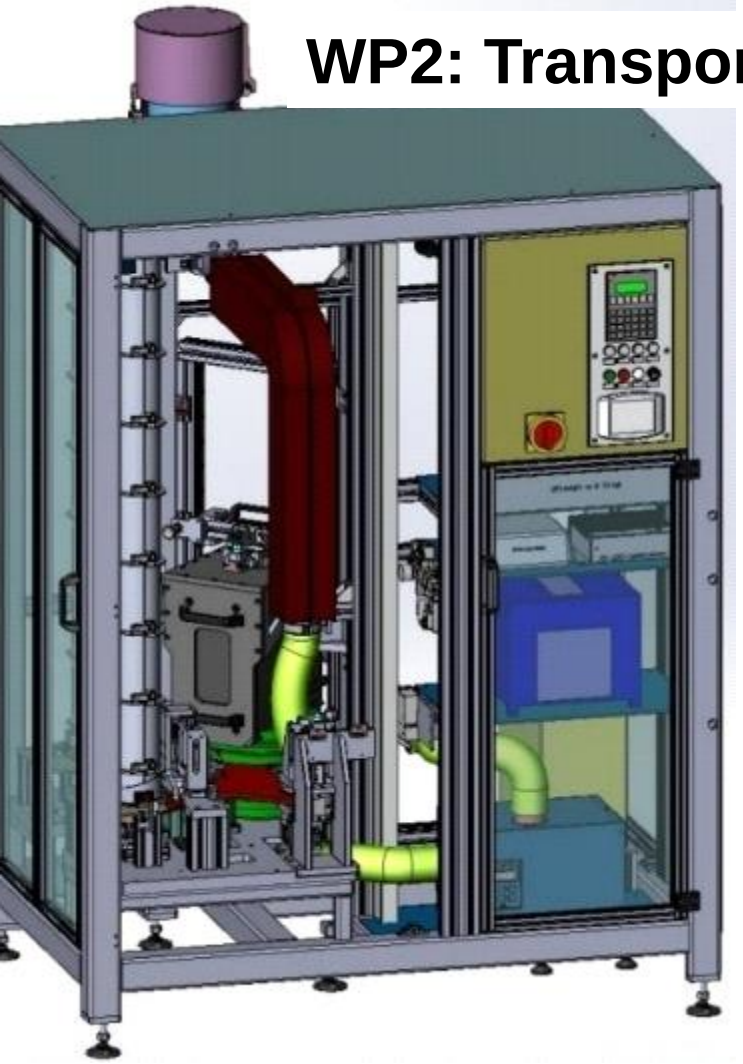
WP1: Spectrometric monitoring systems operated on Unmanned Aerial Vehicles (UAVs),
to protect health and life of first responders



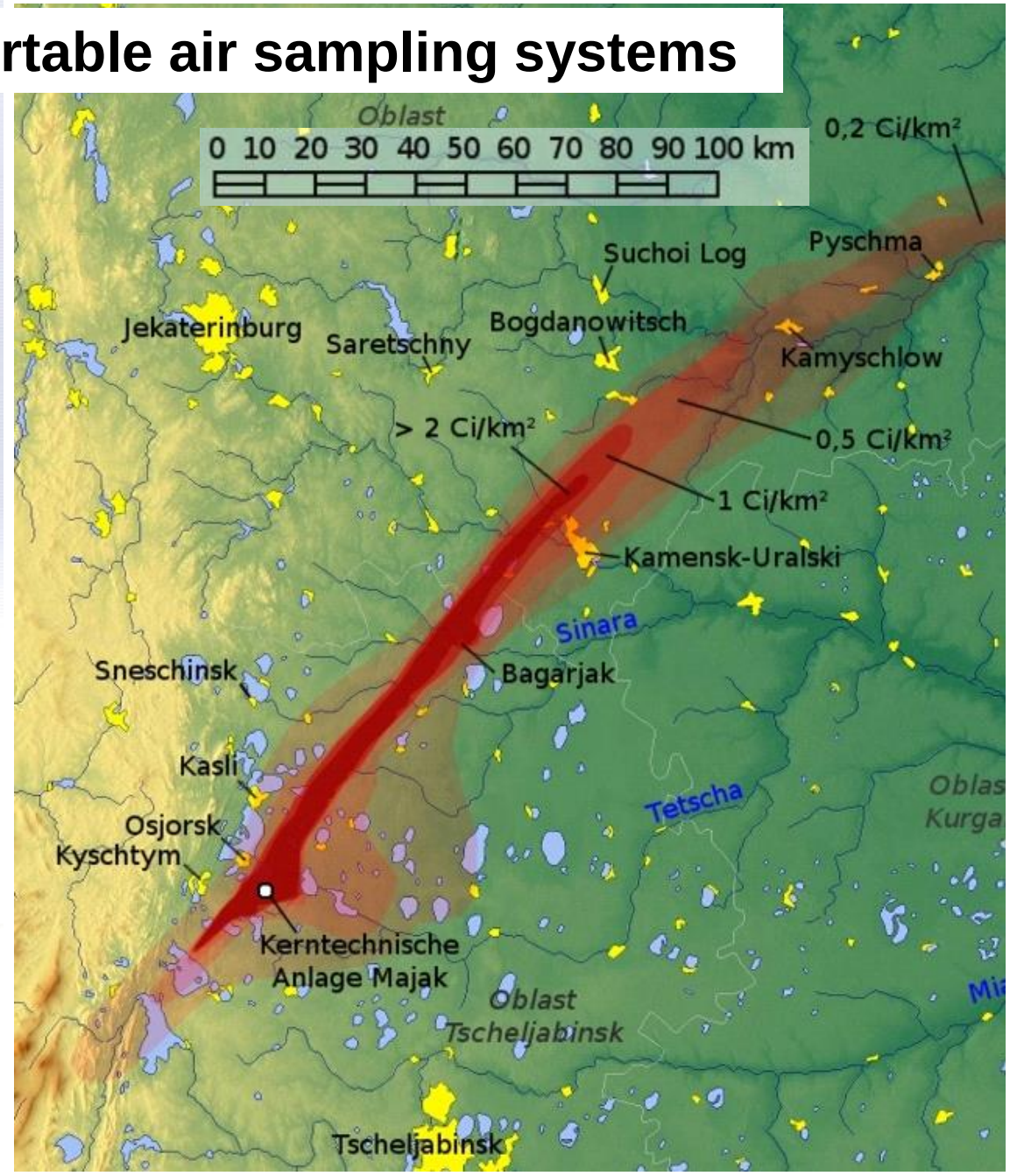
Remote mapping of contaminated areas



WP2: Transportable air sampling systems

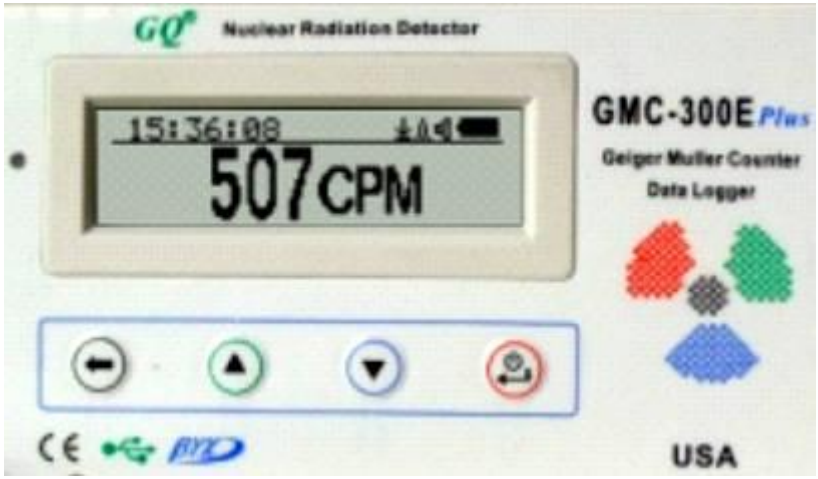


Transportable fully automated air sampling system with online capability (HPGe detector, CMI)



Long-term monitoring of contaminated areas may also require passive dosimetry (WP4)

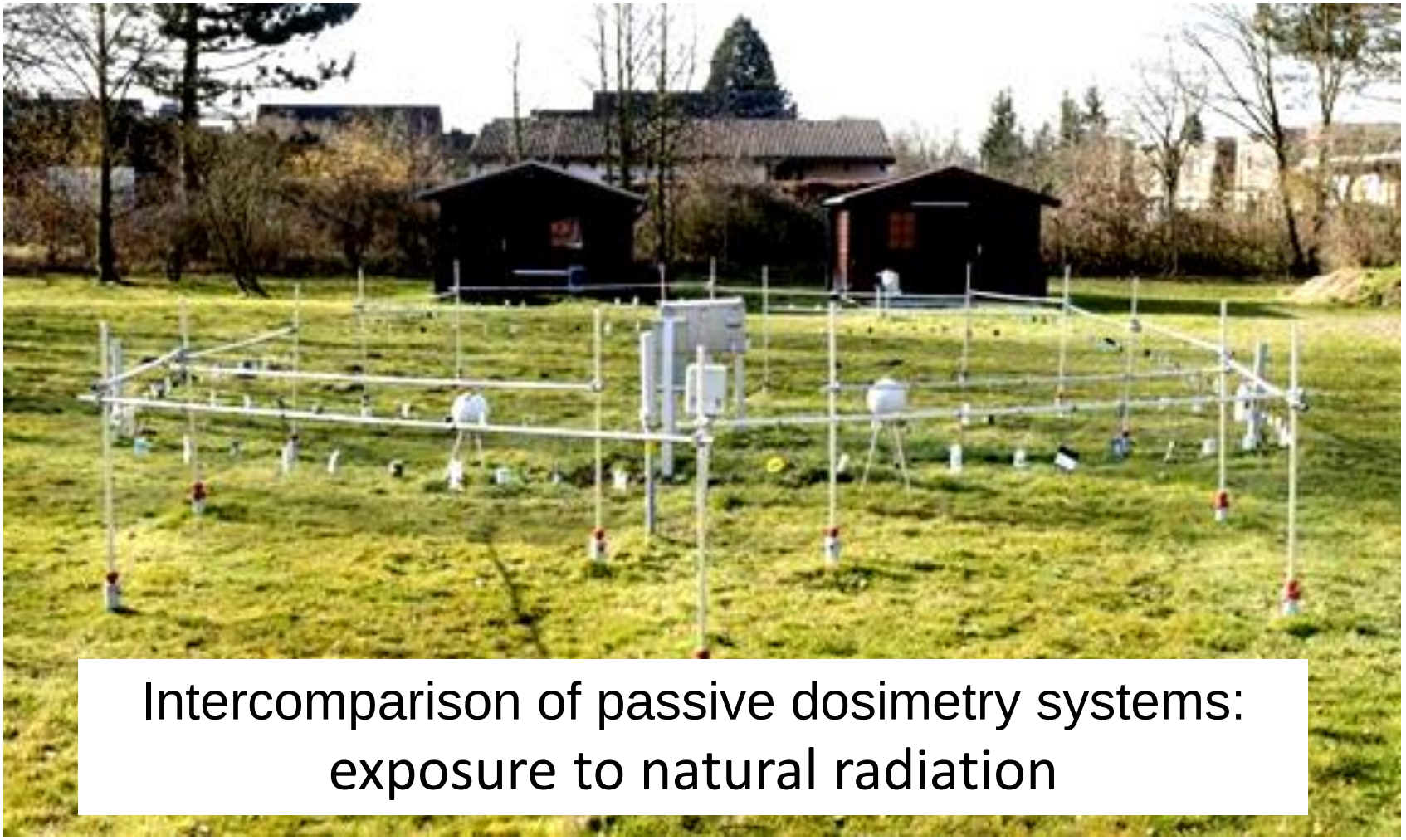
WP3: Non governmental dose rate monitoring



MINNs are typically based on non-compensated GM counters

Investigation of the metrological reliability and relevance of non governmental dose rate data!

WP4: Long-term monitoring of nuclear contaminations



Intercomparison of passive dosimetry systems: exposure to natural radiation

Outline

- Need of “Preparedness”
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- First results

Preparedness consortium

17 partner institutions from 11 European countries

6 Internal (**NMI**/DI): **PTB, NPL, CMI**, JSI, IRB, VINCA

10 External: AUTH, BfS, CLOR, EHU, ENEA, Kromek, MTI, UPC, NUVIA and EC-JRC (Ispra; Geel)

1 Unfunded: SCK·CEN

+ about 10 external collaborators

EMPIR 16ENV04 „Preparedness“ Kick-off meeting

Outline

- Need of “Preparedness”
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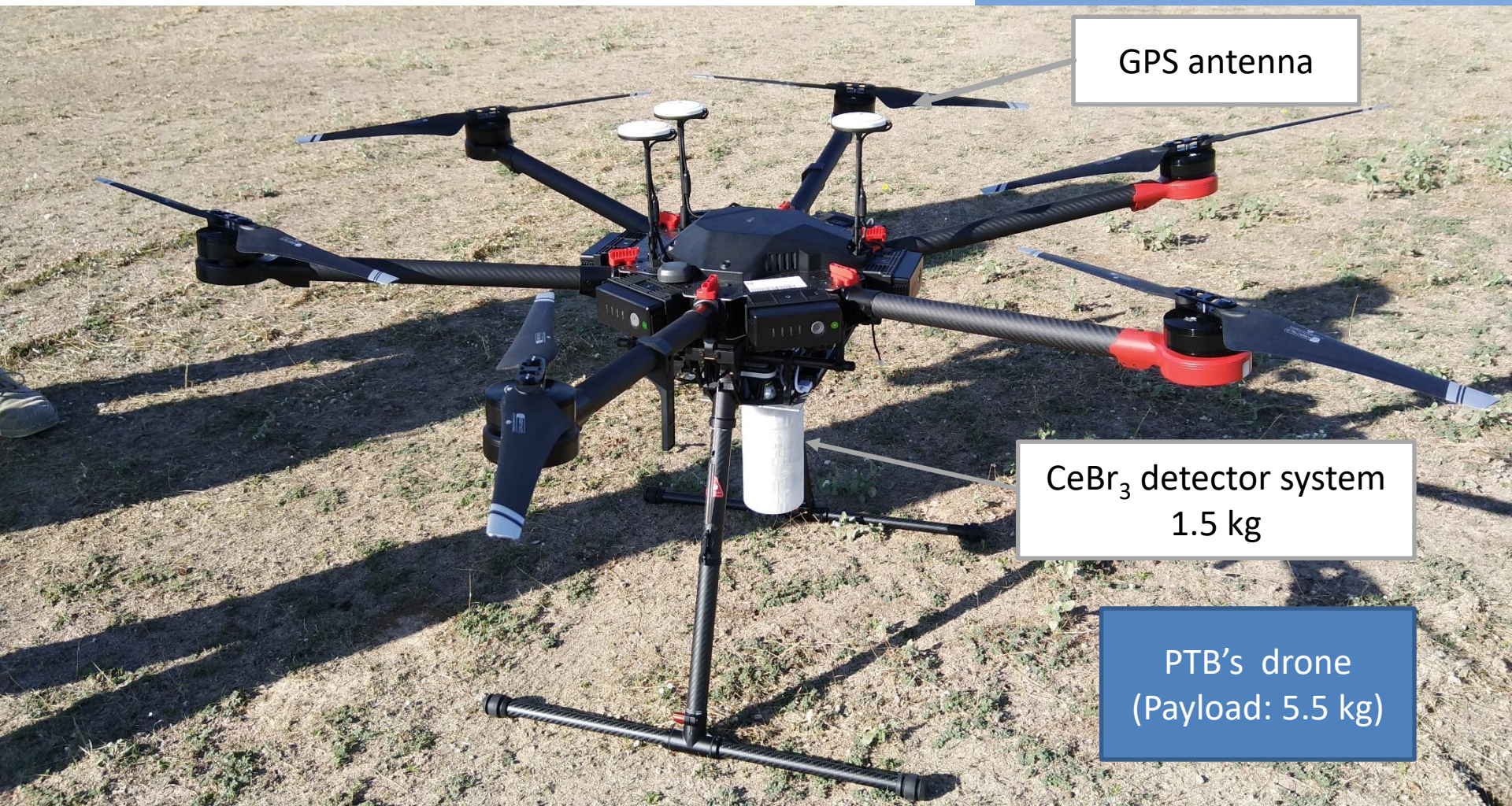
First results

WP 1:

UAV based spectrometric measurements



1.5″ $CeBr_3$: Inherent Background

UDO II PTB Underground Facility, background level ≈ 1.4 nSv/h

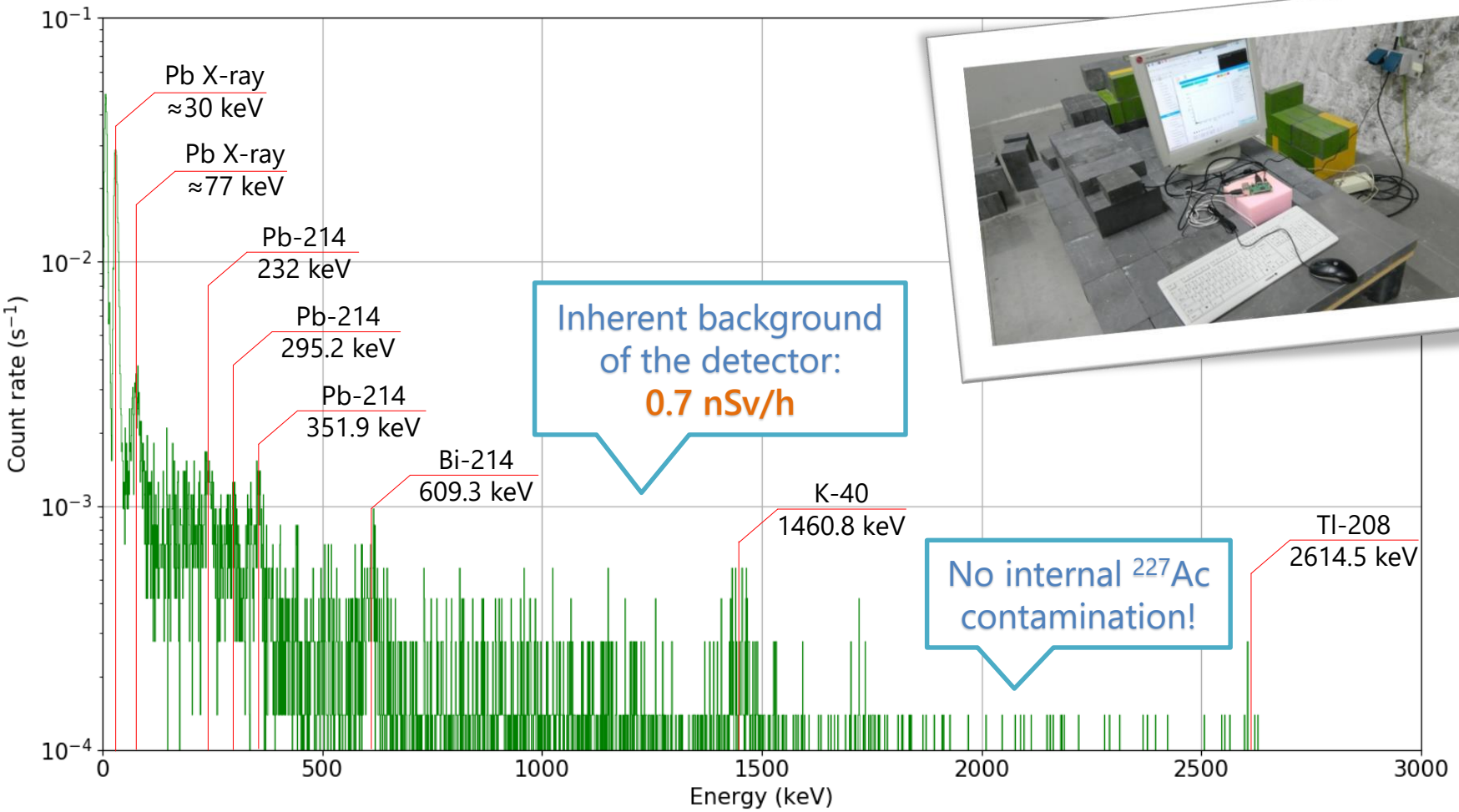


Figure: UDO II 1.5″ $CeBr_3$ inherent background measurement inside a lead castle

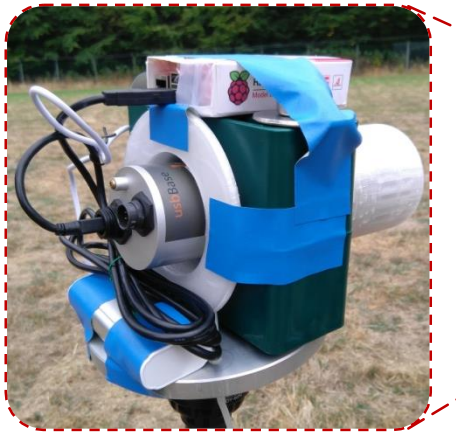
1.5” $CeBr_3$: Free Field Measurements

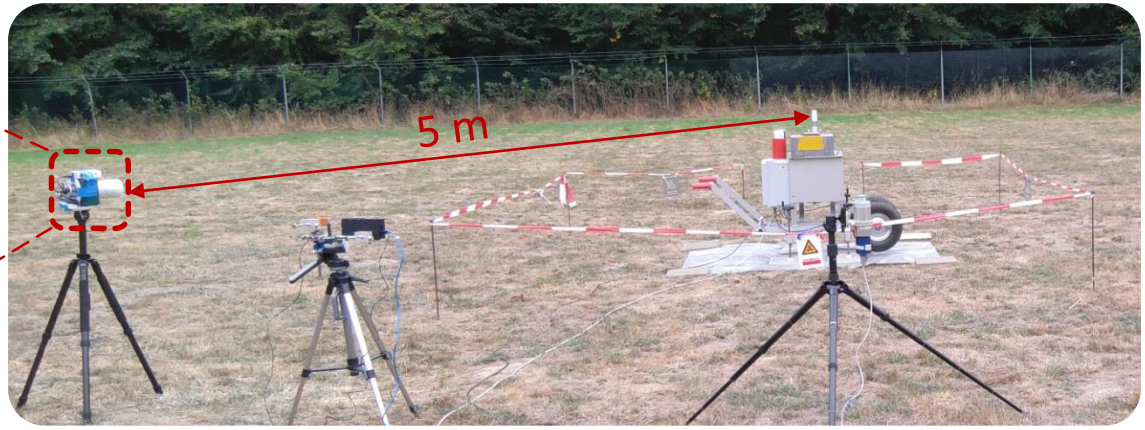
Spectrometric system setup:

- Detector is positioned at reference point

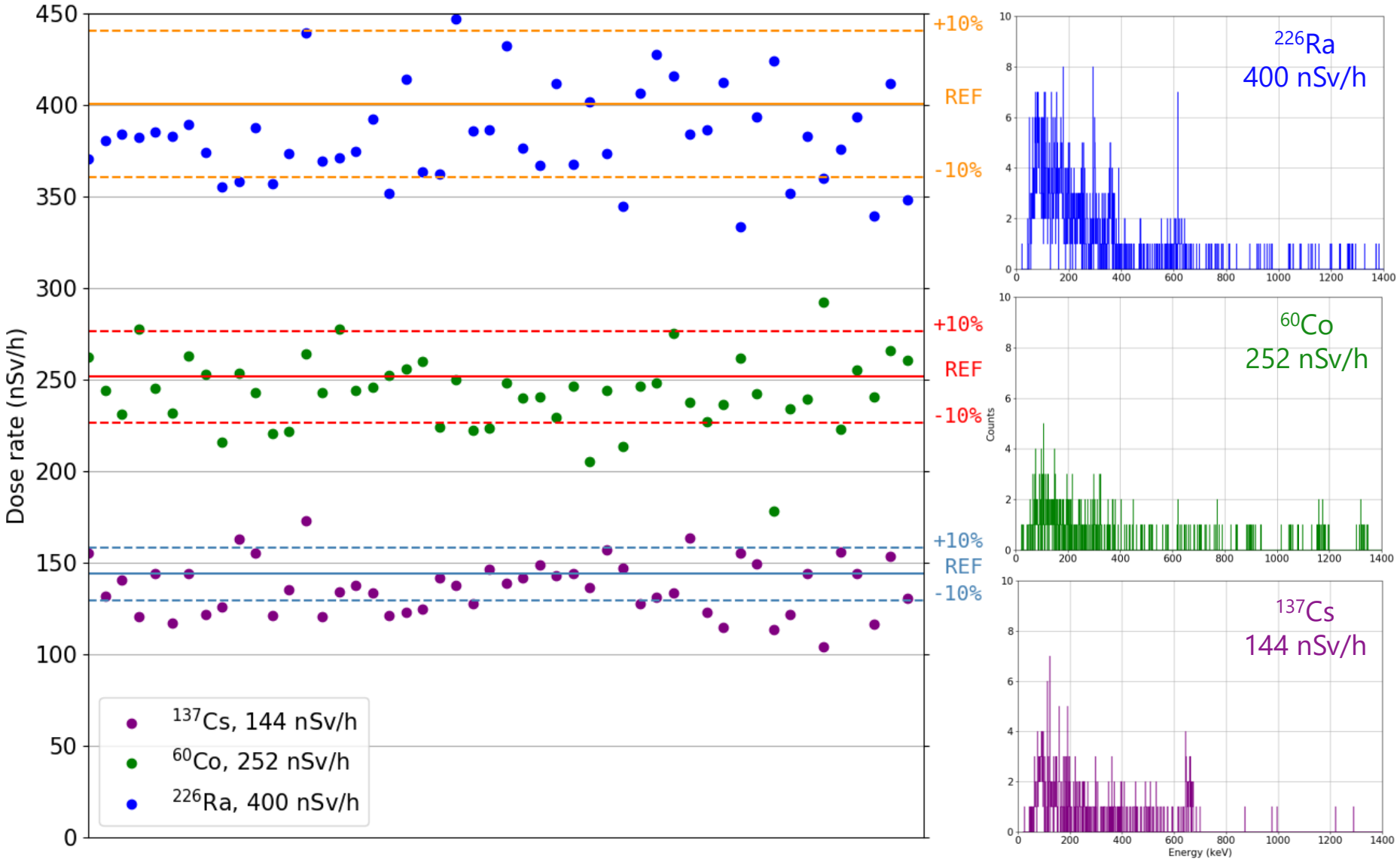
  1 m above the ground, 5 m away from the source

- Detector is placed in drone-dedicated encasing
- Standalone acquisition with Raspberry Pi and power bank
- **2 seconds per measurement**





1.5” $CeBr_3$: Free Field Measurements



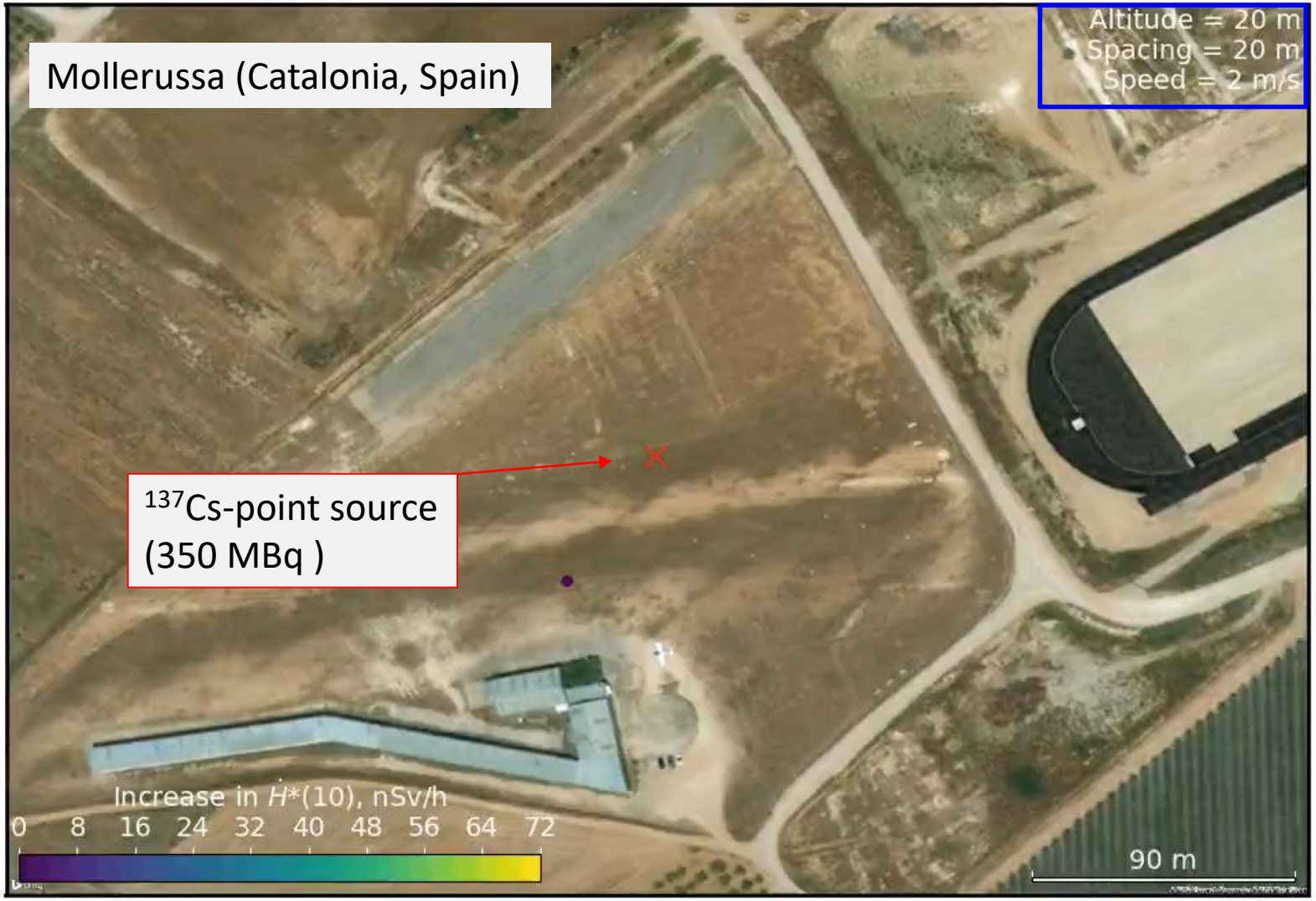
Measurement campaigns with spectro-dosemeters on UAVs

First exercise:
Aerial site Mollerussa, Lérida (Spain)
Aerial site Mollerussa, Lérida (Spain)
Performed in September 2019

Next exercises:
Seelingstädt (Germany) and Vyskov (Czech Republic)

Planned for March / April 2020

Test flight at an aerial test site



WP2 – Overview*

Aim: To develop transportable air-sampling systems for quick information on radioactive contamination levels in air.

Modular and portable systems, based on gamma spectrometric detectors, shall be further developed to commercially available industrial prototypes, which will allow the quick transportation to any place of interest.

This will support the collation of reliable information on radioactive releases immediately after a real emergency.

More details by Jiri Suran (next presentation)!

*Steven Bell‘s presentation at the M27 meeting (Bilbao, Spain)

Task 2.2 – Instrument #1*

NPL National Physical Laboratory

QuantAir (Kromek)

- Designed for iodine monitoring in/around NPP
- Light weight, carried by hand
- CdZnTe CPG detector
- Currently designed for charcoal filter but can be adapted for standard filter

*Steven Bell‘s presentation at the M27 meeting

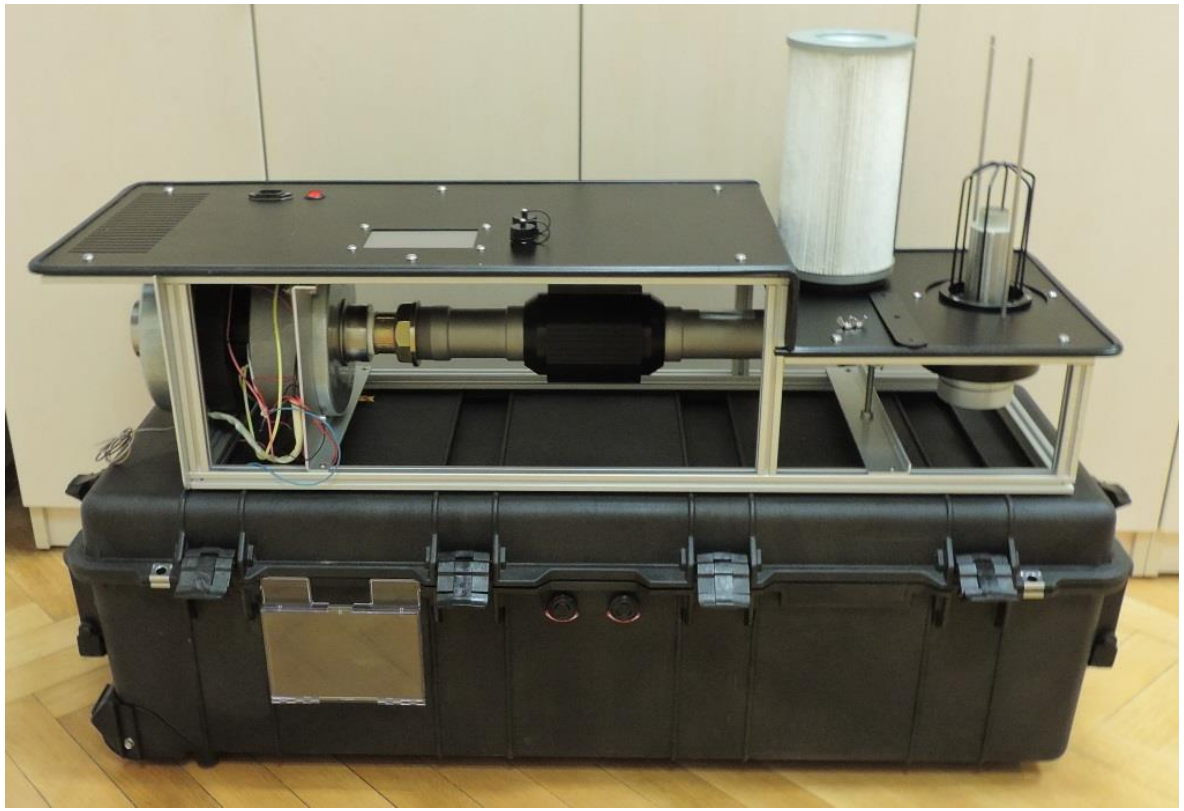
kromek™

Task 2.2 – Instrument #2*

NPL National Physical Laboratory

Compact Radioactive Aerosol Monitor (IJS, Slovenia)

- Designed for environmental monitoring / nuclear preparedness
- Compact, built into flight case
- CeBr3 gamma spectrometer
- High volume air sampler (200 m^3/hr)
- Remote operation and 3G communication



*Steven Bell‘s presentation at „M27“

”Jožef Stefan” Institute

Task 2.2 – Instrument #3*

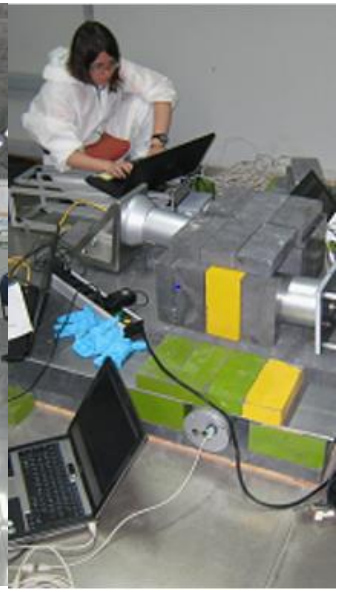
Transportable Air-Sampling System (Nuvia, CZ)

- Designed for environmental monitoring / nuclear preparedness
- Transportable and re-d yable
- Autonomous op
- HPGe ga n be installed for on-li ergency scenario.
- d bricks used to build shielding
- Instruments may be linked via LAN/WAN/ xDSL/mobille/satellite network connection
- Air sampling rate up to 60 m^3/hr for standard glass fibre filter

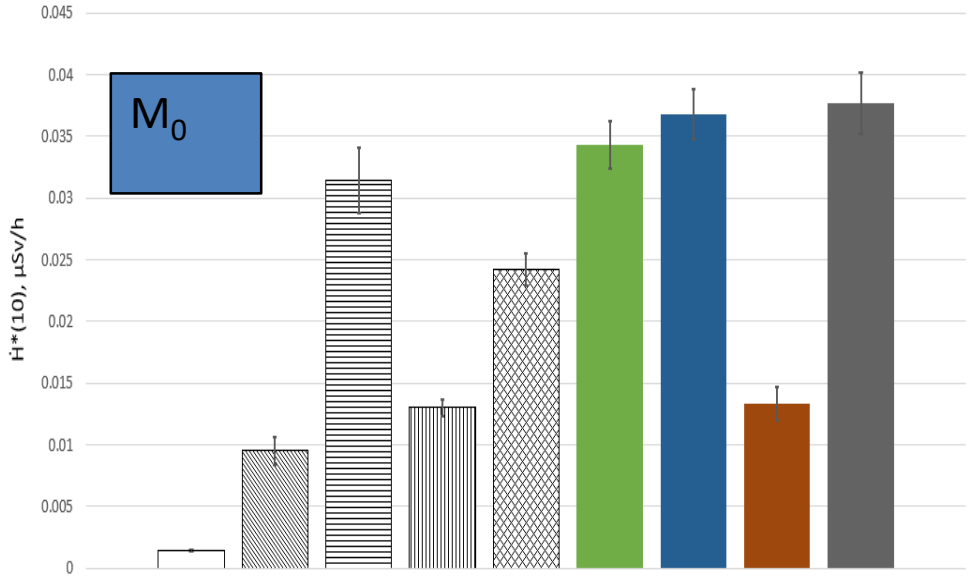
Next presentation by Jiri Suran!

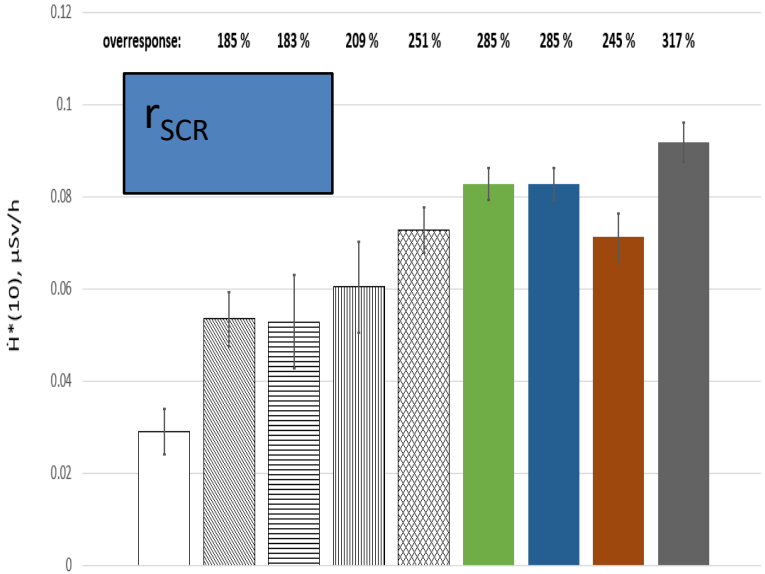
*Steven Bell‘s presentation „M27“

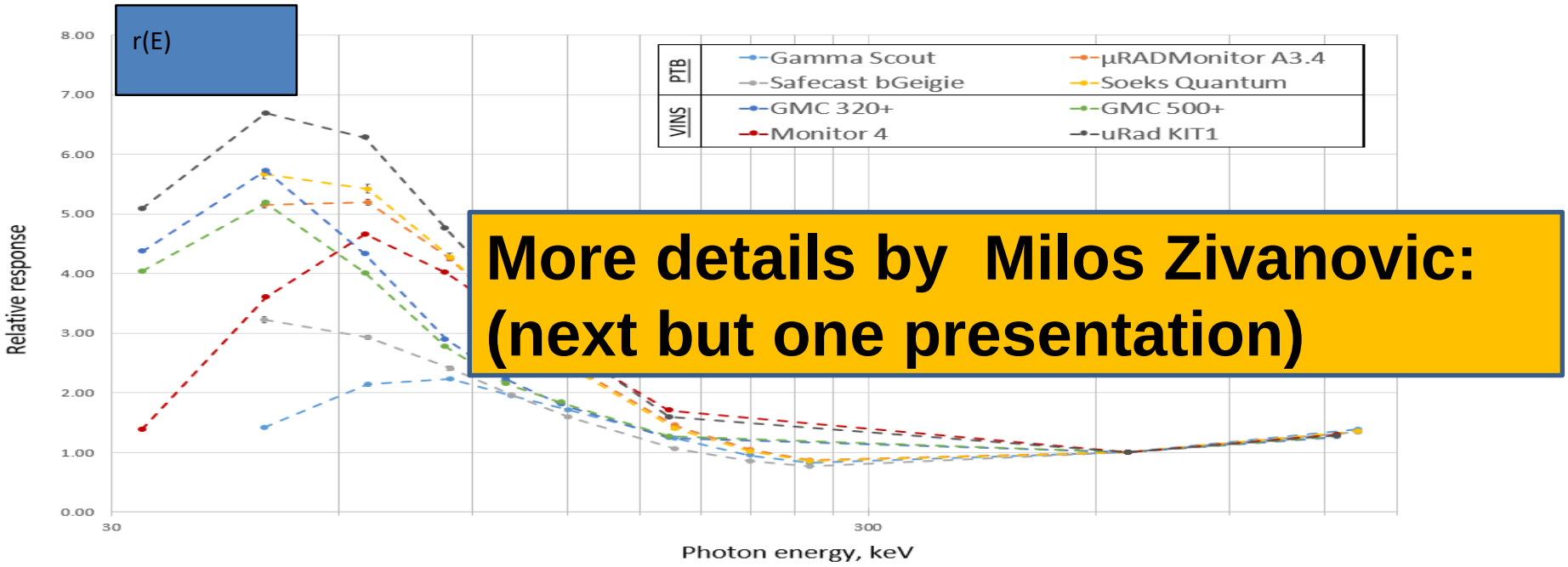
WP3: Intercomparison of MINNs at PTB reference sites



Results WP3: (Viacheslav Morosh, PTB)



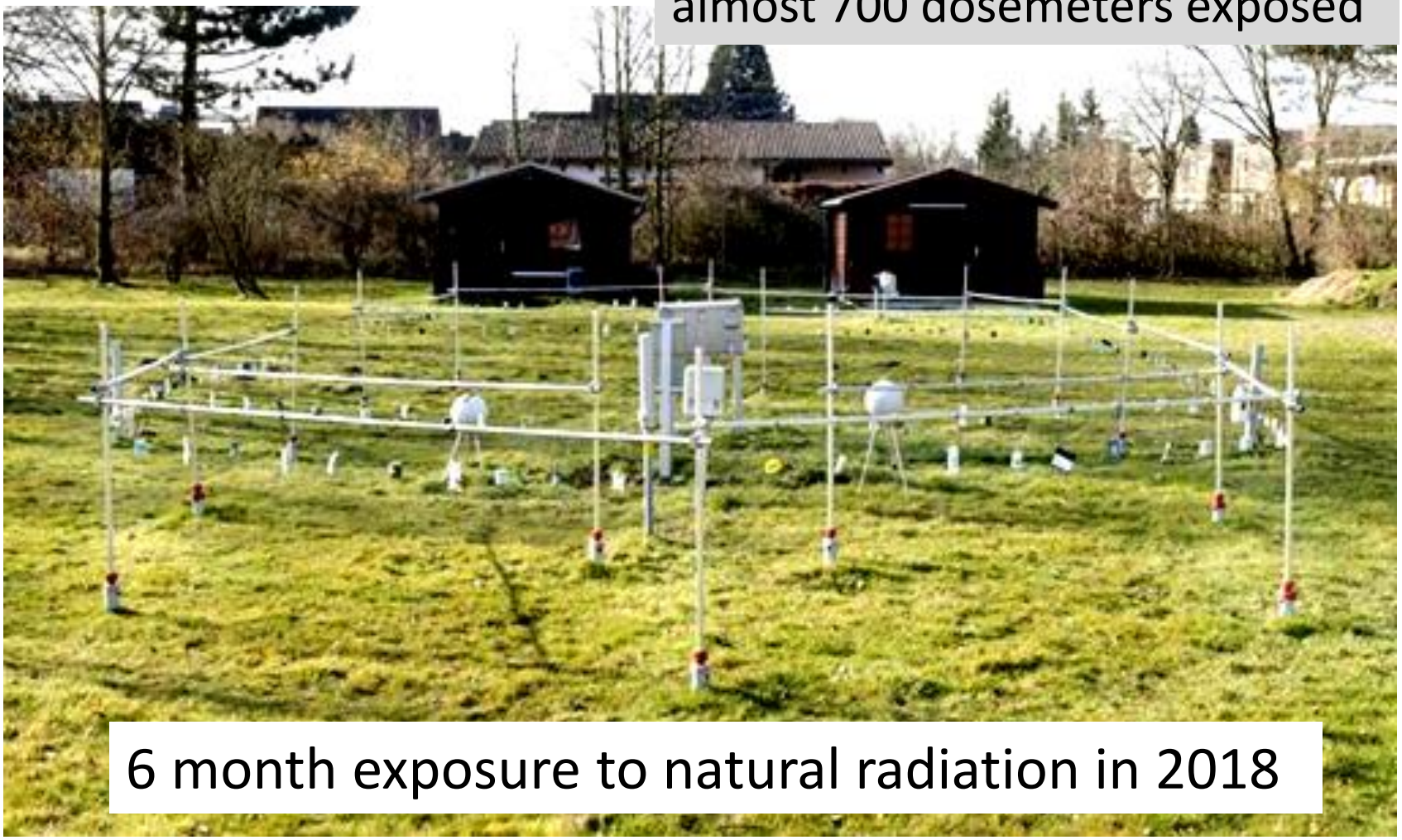




More details by Milos Zivanovic: (next but one presentation)

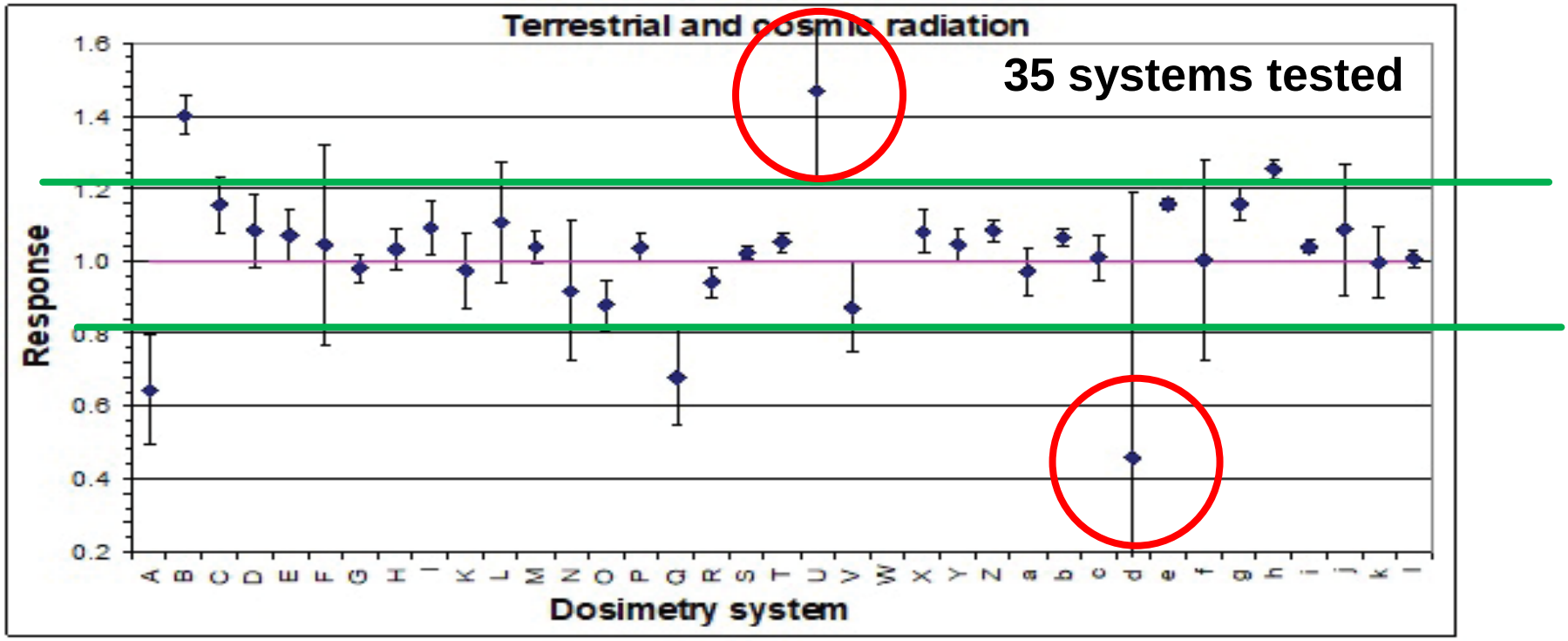
WP4: Intercomparison of passive dosimetry systems
(relevant for long term monitoring of nuclear contaminations)

almost 700 dosemeters exposed



6 month exposure to natural radiation in 2018

First results WP4: Intercomparison exercise at PTB



- **Good agreement of most reported results with the reference values (± 20%).**
- **Identification of problems at some dosimetry services**

Summary

- Preparedness reached **"M29"**; i.e. **7 months to go!**
- **3 intercomparison exercises: passive dosimetry, non-governmental dose rate meters (64, mainly GM based), Flight with spectro-dosemeters on drones in Spain …**

- **Only 3 peer-reviewed publications so far (12 are promised)**
  Some non-peer reviewed and some non open-access
- **Already 56 presentations at conferences !**
- **Ten official collaborators**

Publications:

- Royo P, Pastor E, Macias M, Cuadrado R, Barrado C, Vargas, A. **An unmanned aircraft system to detect a radiological point source** using RIMA software architecture. Remote Sensing 2018;10:1712. doi: 10.3390/rs10111712
- Dombrowski, H.: Preparedness **intercomparison of passive H*(10) area photon dosemeters in 2017/2018 (IC2017prep).** Journal of Instrumentation (2019), doi:10.1088/1748-0221/14/10/P10008
- Neumaier, S. et al.: **Metrology for the mobile detection of ionising radiation following a nuclear or radiological incident – "Preparedness",** Arh Hig Rada Toksikol 2019; 70:62-68

M27 meeting – Sept. 2019 in Bilbao (Spain)

Thank you for your attention!

Calculation of *H**(10) from pulse-height spectra

$H^*(10) = \Phi(E) * C(E)$

$n(E) = \Phi(E) * M$ M = triangular → M^{-1} exists

$\Phi(E) = n(E) * M^{-1}$

$H^*(10) = (n(E) * M^{-1}) * C(E) = n(E) * (\underbrace{M^{-1} * C(E)}_{w(E)}) =$

$= n(E) * w(E) = \sum_i n(E_i) * w(E_i)$

Gamma dose rate at the flight position of maximum proximity

- $H^*(10) = \Gamma * A / r^2$; $\Gamma\ (^{137}Cs) = 9{,}25*10^{-2}$ **mSv * m² / h * GBq**

  $= 9{,}25*10^{4}$ nSv/h * (m² / GBq)

A (GBq)

r (m)

A = 350 MBq = **0,35 GBq**

r² = (20 m)² + (about 5 m)²  * **= (20,6 m)² = 424 m²**

- $H^*(10) =$ 9,25*10⁴ **nSv/h * 0,35 / 424 = 76,3 nSv/h**

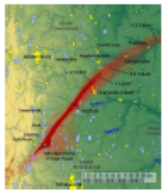
* Pythagoras

JRP-v18 - Metrology for mobile detection of ionising radiation following a nuclear or radiological incident

EURAMET

Need

Preparedness for a nuclear or radiological emergency to protect people and the environment (EC - Directive 2013/59/EURATOM and IAEA Safety Standards)
Mobile unmanned aerial detection systems for the „Health protection of emergency workers"
Reliable radiological data on dose rates and contamination levels at the earliest possible stage



Radioactive plume, Majak, 1957

Objectives

- Development and validation of unmanned aerial detection systems installed on drones and helicopters for the remote measurement of dose rates and radioactivity concentrations (WP1)
- Development and validation of transportable air-sampling systems (WP2)
- Metrological relevance of 'crowd sourced monitoring' data on dose rates (WP3)
- Procedures to measure dose rates of contaminated areas by passive dosimetry (WP4)
- Facilitate the take up of the technology and measurement infrastructure developed in the JRP (WP5)

This requires large-scale approaches beyond the capabilities of single NMIs / DIs.

Low-cost counter and false alarm of a non-governmental network

Progress beyond the state of the art

Metrologically sound procedures for the mobile and remote detection of radioactivity and ionising radiation

Impact

Knowledge transfer and uptake by: workshops, training courses, website, publications and ISO / IEC standards

Unmanned aerial radiation detection

Environmental:
- Early indication of affected areas
- Quick and appropriate countermeasures

Social:
- Improved protection of the population
- Increase of credibility and acceptance of reported radiological data by media and by the general public
- Sound radiological data for appropriate governmental decisions

Economic:
- Reduction of follow up costs by minimisation of exclusion or evacuation zones
- Fast and more reliable determination of contaminated agricultural products and other goods

Scientific and technological excellence:
- Novel instrumentation and procedures for unmanned aerial vehicle (UAV) based mapping of contaminated areas
- Pre-series industrial prototypes of transportable air-sampling systems
- Low-cost dosemeters for stationary and mobile use

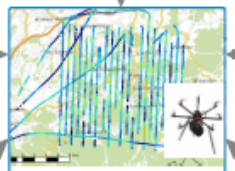
Metrological:
- Traceable radiological data for a quick and adequate response
- Higher accuracy (of dose rate values and ground contamination levels) by at least a factor of 2
- Novel metrological infrastructure e.g. radiological test sites for UAVs with artificial radiation
- Information on the quality of radiological data provided by non-governmental networks and the feasibility to use such data
- Harmonisation of passive dosimetry in Europe for long-term monitoring

Transportable automated air-sampler with HPGe gamma spectrometer

WP5

Unmanned aerial radiological measurements
- Novel unmanned airborne monitoring systems
- Hard- and software for data acquisition, transmission and analysis
- Procedures for testing, calibration and validation

WP1



Survey of contaminated areas and radioactive plumes

Transportable air-sampling systems
- Procedures for in-field use
- Development of transportable air-samplers
- On-site comparison exercise
- Rapid radiochemical separation and analysis

WP2

Non-governmental dosimetry networks
- Evaluation of instruments
- Feasibility study on the reliability of dose rate data
- Development of novel common dose rate instruments for governmental and non-governmental use

WP3

Passive dosimetry
- Technical and methodological investigations
- Electret ion chambers
- Harmonisation of passive dosimetry

WP4

Management and coordination