EURAMET

Radon metrology: Sensor networks for big buildings and future cities

➡ EPM 23IND07 RadonNET
➡ EURATOM NuClim

METROLOGY PARTNERSHIP | EURAMET

The project (23IND07 RadonNET) has received funding from the European Partnership on Metrology, co-financed from the European Union's Horizon Europe Research and Innovation Programme and by the Participating States.
NuClim – Nuclear observations to improve Climate research and GHG emission estimates – EURATOM GAP 101166515

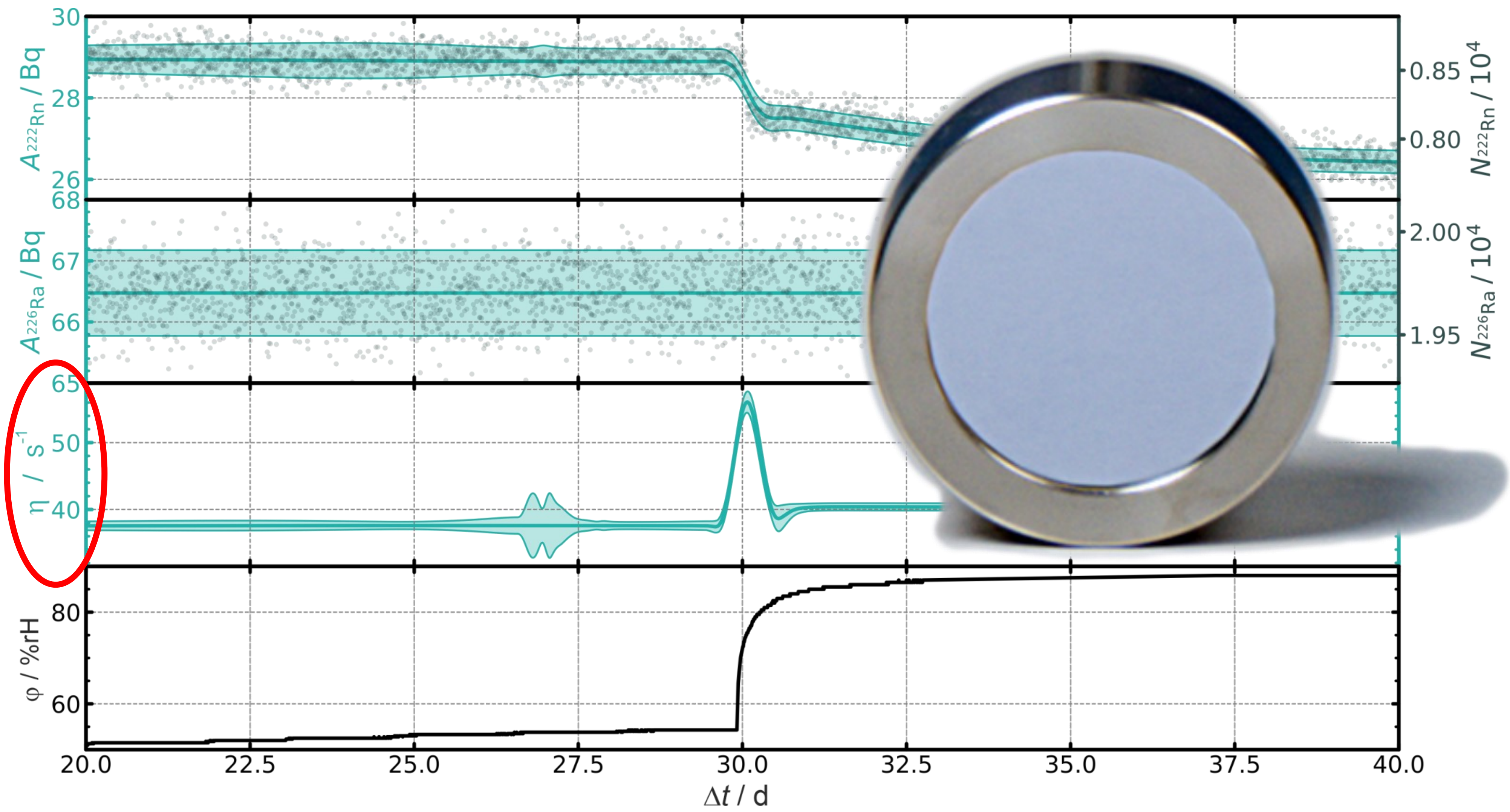
Stefan Röttger

BMUV, 2024-10-15

EURAMET

- History of European Radon Projects
- RadonNET
- NuClim
- Calibration and Standards

^{222}Rn activity from 2018-1121



History and simple network connections

EU **Metrology** **Network** **Project**

European Commission

HORIZON 2020

EMPIR

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

Horizon Europe Framework Programme for Research and Innovation (2021-2027)

METROLOGY PARTNERSHIP | EURAMET

Support BSS

RADIATION PROTECTION

GAP-Workshop

MetroRADON

traceRadon

RADON.NET

Horizon Europe

THE NEXT EU RESEARCH & INNOVATION PROGRAMME (2021 – 2027)

Euratom Research in Action & Opportunities for Europe

EU Strategic Autonomy & the Future Energy Systems

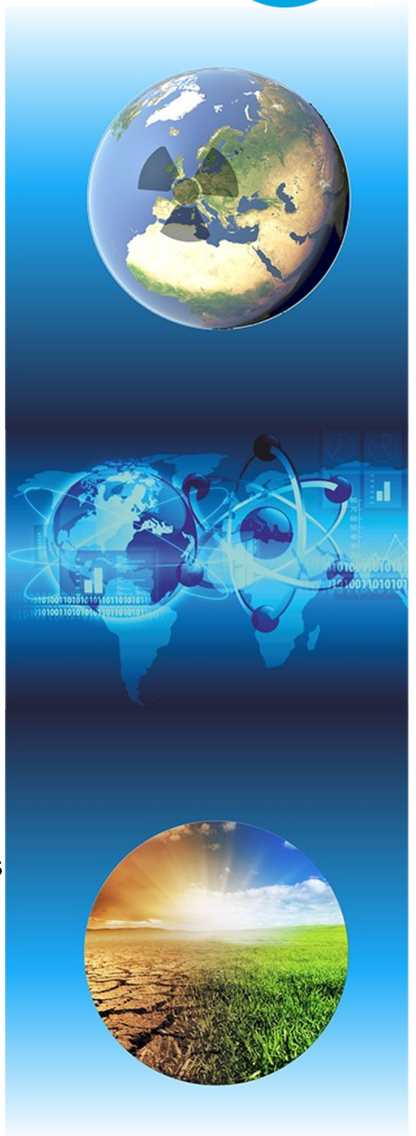
NuClim

Nuclear observations to improve Climate modelling and GHG emission estimates

PRT: REG25

Metrology support for Regulation

Validated service platform for emergency management for radiological events



History and simple network connections

EU | Metrology | Network | Project

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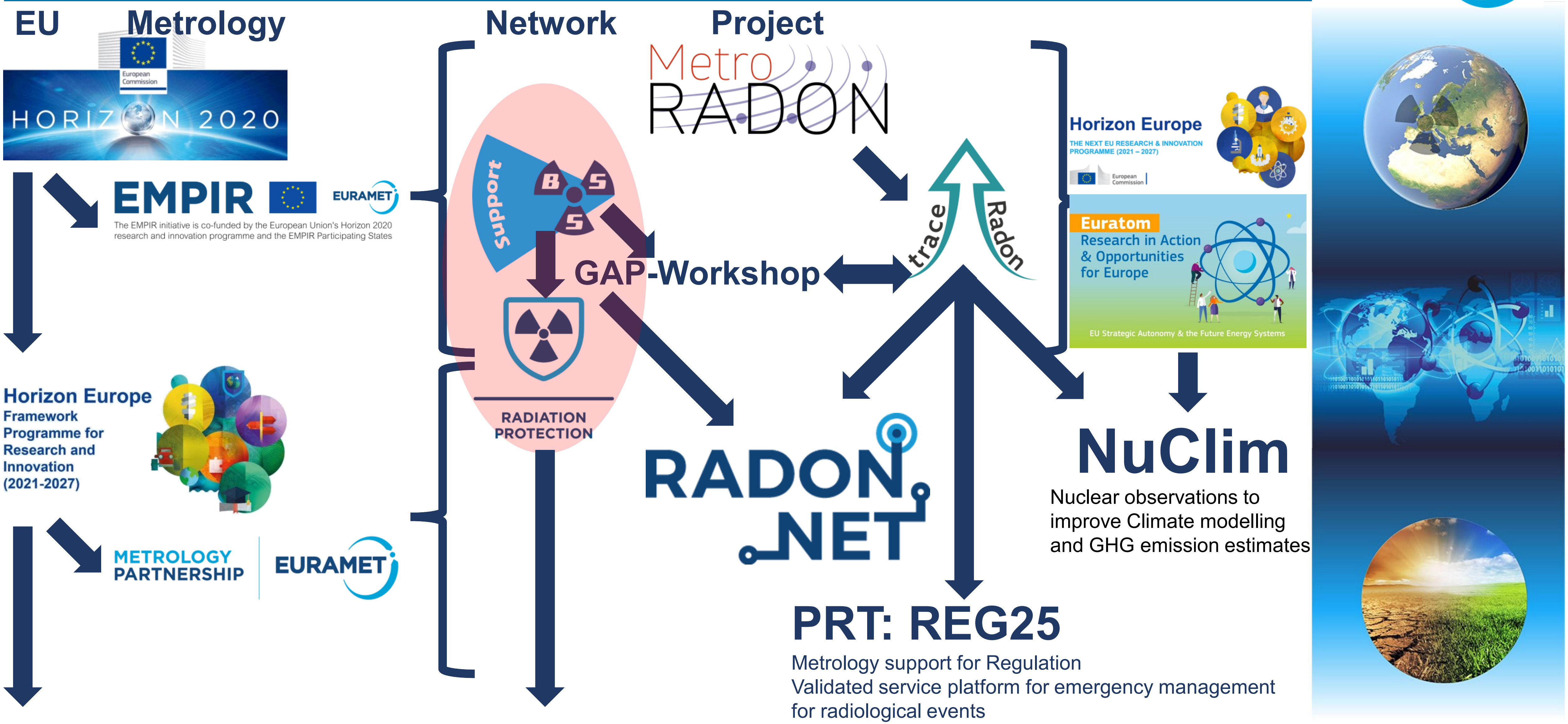

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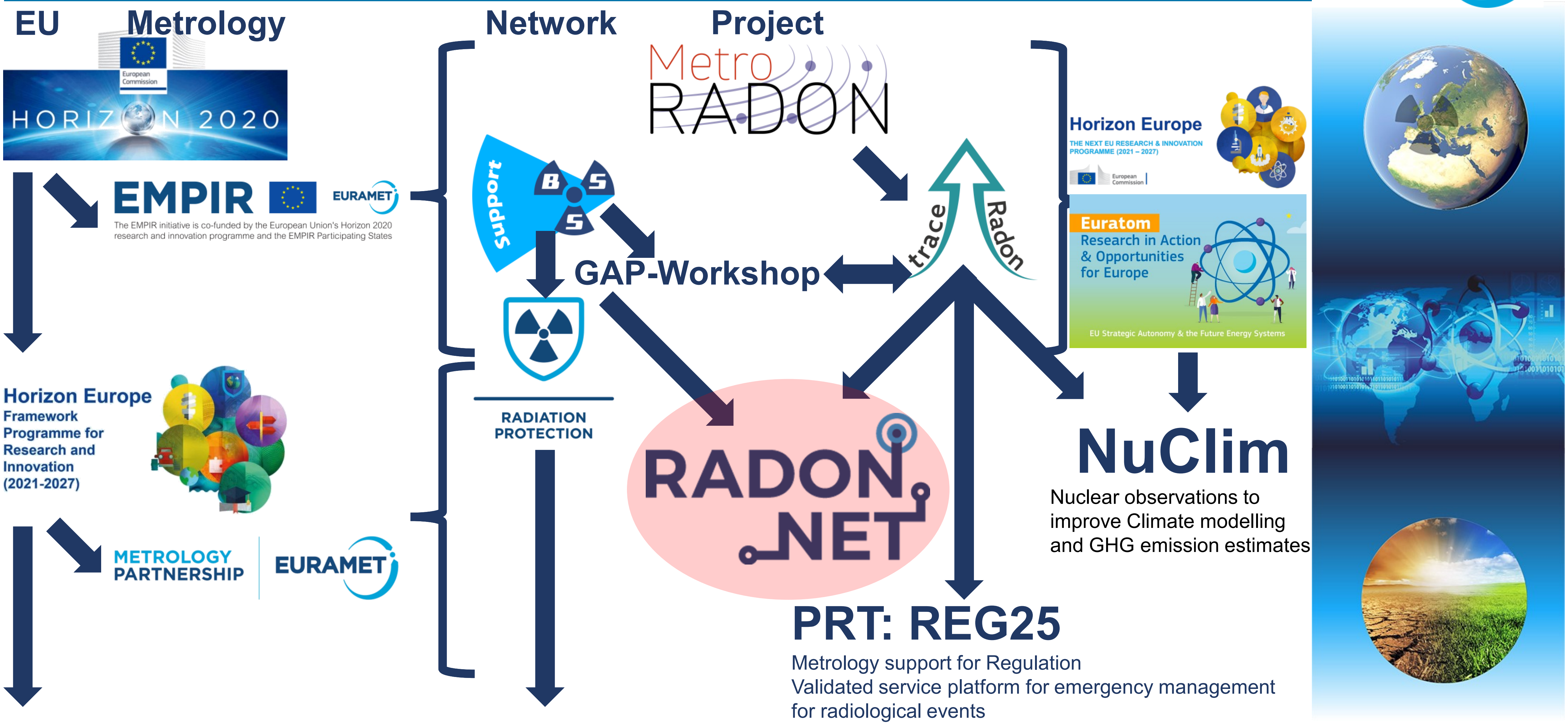

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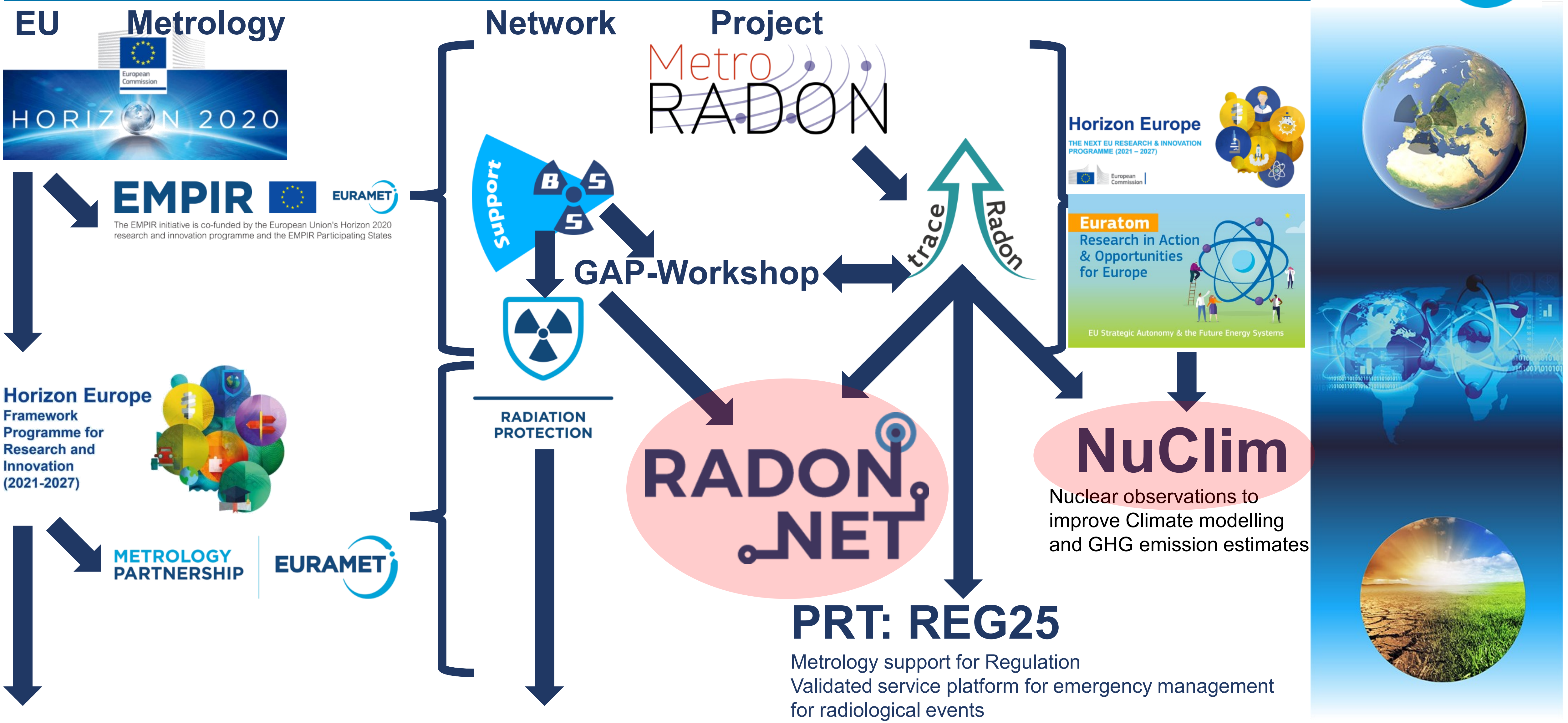

Radon metrology: Sensor networks for big buildings and future cities

The goal of the project is to eliminate preventable lung cancer from radon (^{222}Rn) by improving indoor air quality in Europe through the development of advanced sensor networks and calibration techniques: ultimately leading to more energy-efficient and healthier buildings for the future → **Reduce radon risk, as easily as using a thermostat**

Needs and objectives

- Radon concentration limits are defined at 300 Bq·m^{-3} by Directive 2013/59/Euratom
- Efficient ventilation is necessary to mitigate radon risks and maintain indoor air quality; balancing energy efficiency and radiation protection is key
- Smart sensor networks need to monitor variations in radon levels; improving sensor metrology for cost-effective and efficient calibration is a priority

Utilizing fast-response connected devices with precise calibration standards via a network is the best solution to support cost-effective radon mitigation

Calibrated radon network for cost-effective mitigation and a healthy future for European citizens

Scientific research and excellence through four work packages

WP1: New concepts and methods for radon concentration measurements

- *Current state of the art*: Costly detectors unsuitable for direct radon mitigation
- *Progress beyond the state of the art*: Develop novel sensor concepts and methodologies to detect and measure radon activity concentration indoor; based on three detection concepts:

Silicon-semiconductors

Pulse ion chamber

Inorganic porous scintillators

WP2: Traceable, *in situ* operando calibration procedures

- *Current state of the art*: Costly calibration in laboratory, no time response consideration, dynamic range and linearity is missing (RadonNORM and TraceRadon output)

- *Progress beyond the state of the art*:

RADON NET

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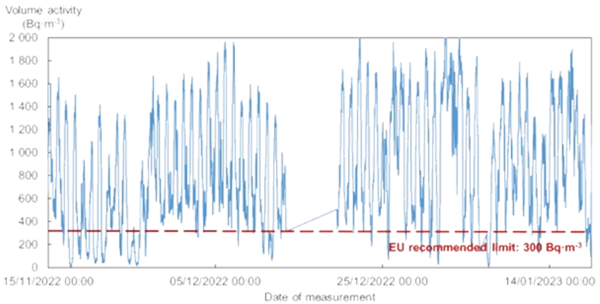
EPM 23IND07 RadonNET

WP3: Network of radon sensors

- *Current state of the art*: No radon sensor network and corresponding calibration for energy-efficient, cost-effective radon mitigation

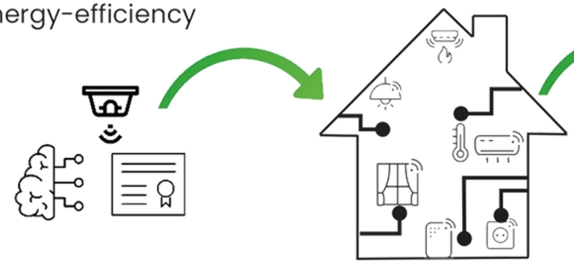


Exemple of collected data : Mitigation is not linked to radon measurement

- *Progress beyond the state of the art*:
  - Develop a quality-assured sensor network for large buildings and future cities using sensors from WP1 and calibration from WP2
  - Develop a data collection testbed, associated analysis, and analytical methods to extract the background, perform anomaly detection, and determine data analysis locations within sensor networks

WP4: Extended network for risk mitigation with energy saving

- *Current state of the art*: Ventilation for radon mitigation; not compatible with energy-efficiency



- *Progress beyond the state of the art*:
  - Develop an extension of the radon sensor network from WP3, integrating various sensor networks in connected buildings to optimise energy use, air quality management, and radiation protection
  - Extend the testbed from WP3 to incorporate data from other sensors, including novel air quality sensors
  - Investigate synergies between air quality and radon measurements, indoor and outdoor radiation measurements, and other sensor networks

Stakeholder support

Radioprotection Institutes | National Metrology Institutes | Private Companies | Ministries and Norms | Universities

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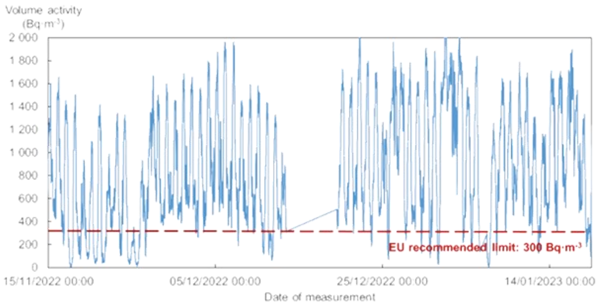

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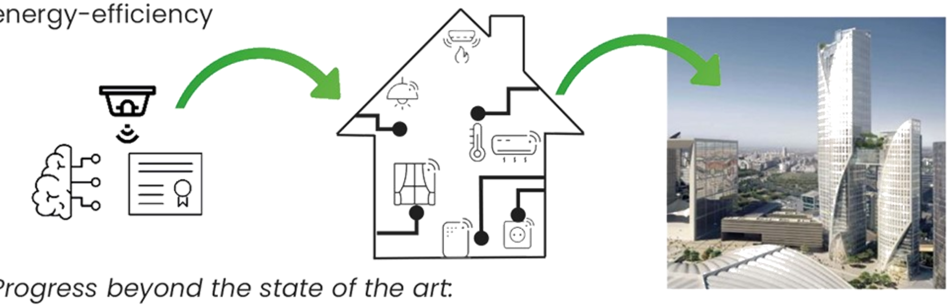

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BUDAPEST FŐVÁROS KORMÁNYHIVATALA

NPL National Physical Laboratory

LIVAIR

radonova The global leader in radon measurement

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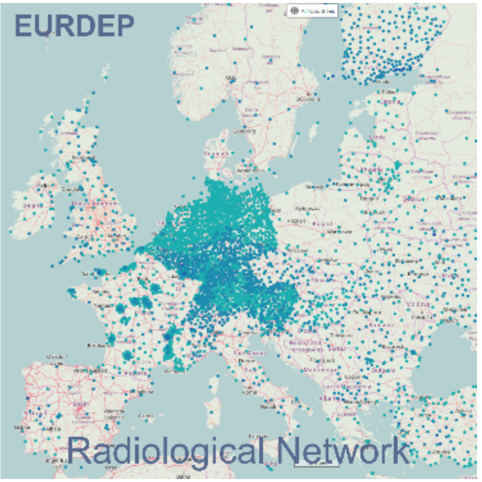


Climate change is one of the greatest challenges of our time.

The temperature rise of the atmosphere of our planet, due to the greenhouse effect, is caused by the increase of GHG emissions.

- **ICOS**: Monitoring of GHG emissions, the dispersion of GHGs and the resulting GHG concentrations in air, is of utmost importance for appropriate climate change mitigation measures.
- **EURDEP**: Collection and exchange of radiological monitoring data between participating countries of the radiation in the environment.

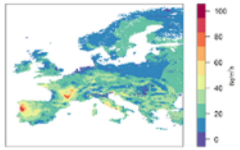
Both networks could profit from radon measurements at the outdoor level. But **traceability to the SI system** is not established yet.

What was done

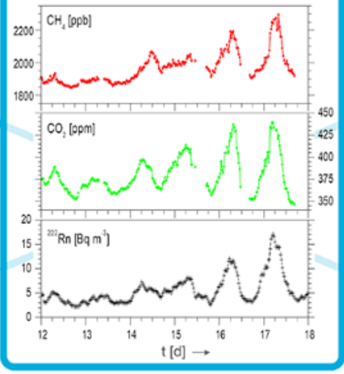
Traceability to the SI system

Radon and radon flux in maps for radiation protection issues **WP4**

- Identification of RPA
- Quantifying the radon wash-out peak
- Data accessibility and public engagement



$$j_{CH_4} = j_{Rn} \cdot \frac{\Delta c_{CH_4}}{\Delta c_{Rn}}$$

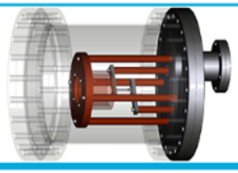


Validation of radon flux models and inventories using radon flux and terrestrial data **WP3**

- Radon flux maps in GHG and climate change studies
- Inclusion of data from radiological early warning systems
- Validation of radon flux maps using radon flux measurements and outdoor radon activity concentrations

Traceable measurements of outdoor radon activity concentrations **WP1**

- Traceable low-level radon sources
- Development of a transfer standard
- Calibration and long-term stability



Radon flux measurements **WP2**

- Development of a reference radon flux monitor
- Test under field conditions
- Measurement campaigns
- RTM application

Management and coordination **WP6**

Seven leading European NMI/DI in the field of climate observation and ionising radiation. ICOS, JRC and other stakeholders directly involved as JRP-partners. Sufficient further external partners with high-level expertise to cover the broad spectrum of two scientific communities. High interest by stakeholder community, expressed by 65 letters of support and a large group of 34 potential collaborators.

Follow up: EURATOM NuClim

- **Nu**clear observations to improve **Clim**ate research and GHG emission estimates (2.6 M€, 4 a)
  - **Goal:**

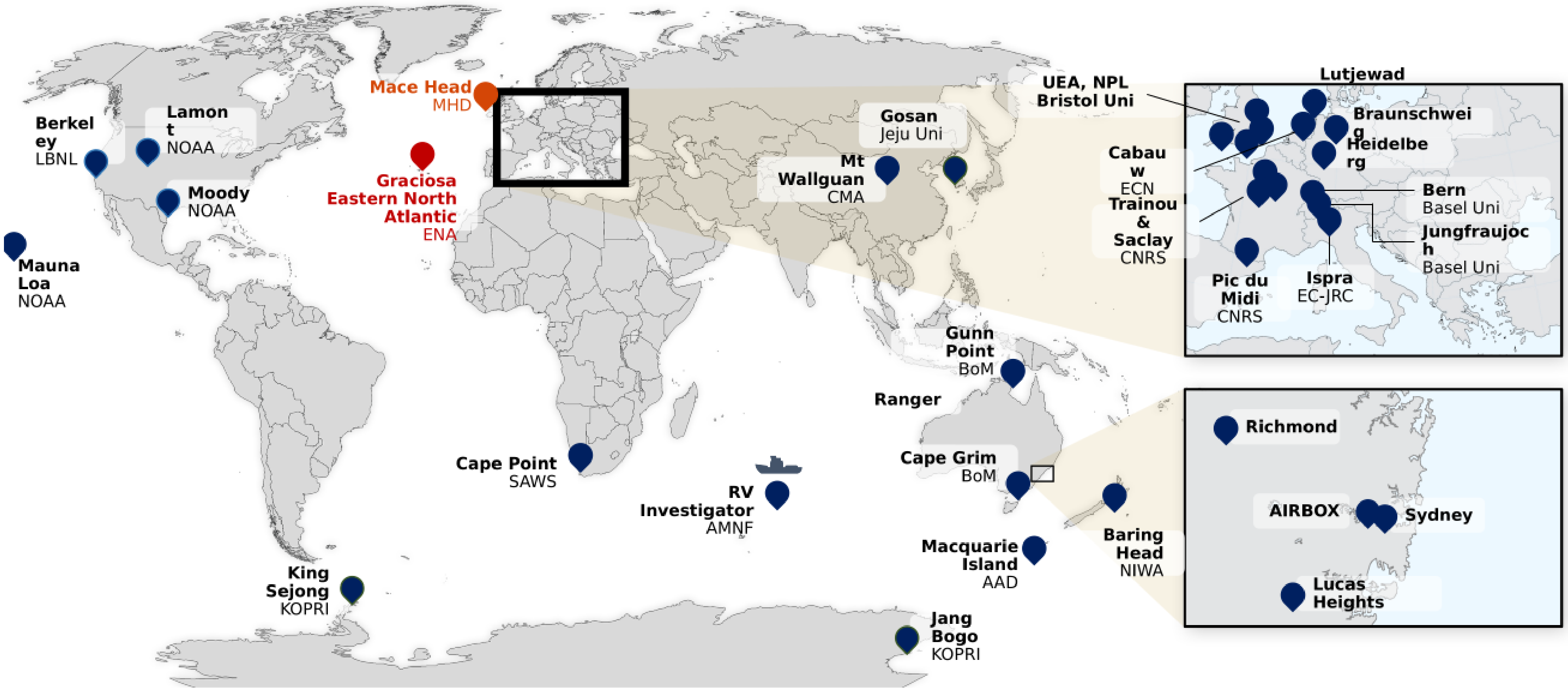
    Provide an accurate and time-varying **baseline reference** level for European GHG concentrations based on nuclear observations
  - **Strategy:**

    Use atmospheric radon concentrations at **oceanic remote** sites to identify baseline conditions, representative of hemispheric background values

INESCTEC · FINNISH METEOROLOGICAL INSTITUTE · PTB · IFIN-HH · OLLSCOIL NA GAILLIMHE UNIVERSITY OF GALWAY · UNIVERSITY OF LODZ · NPL National Physical Laboratory · University of BRISTOL · UAc UNIVERSIDADE DOS AÇORES

NuClim sites

- WMO/GAW/ICOS stations with **existing capability** for deriving the most accurate atmospheric “baseline” measurements
- Proposed in NuCLIM project: Mace Head station **upgrade the capability** for deriving the most accurate atmospheric “baseline” measurements
- Proposed in NuCLIM project: Graciosa Eastern North Atlantic station **establish the capability** for deriving the most accurate atmospheric “baseline” measurements



NuClim: Observations & Applications

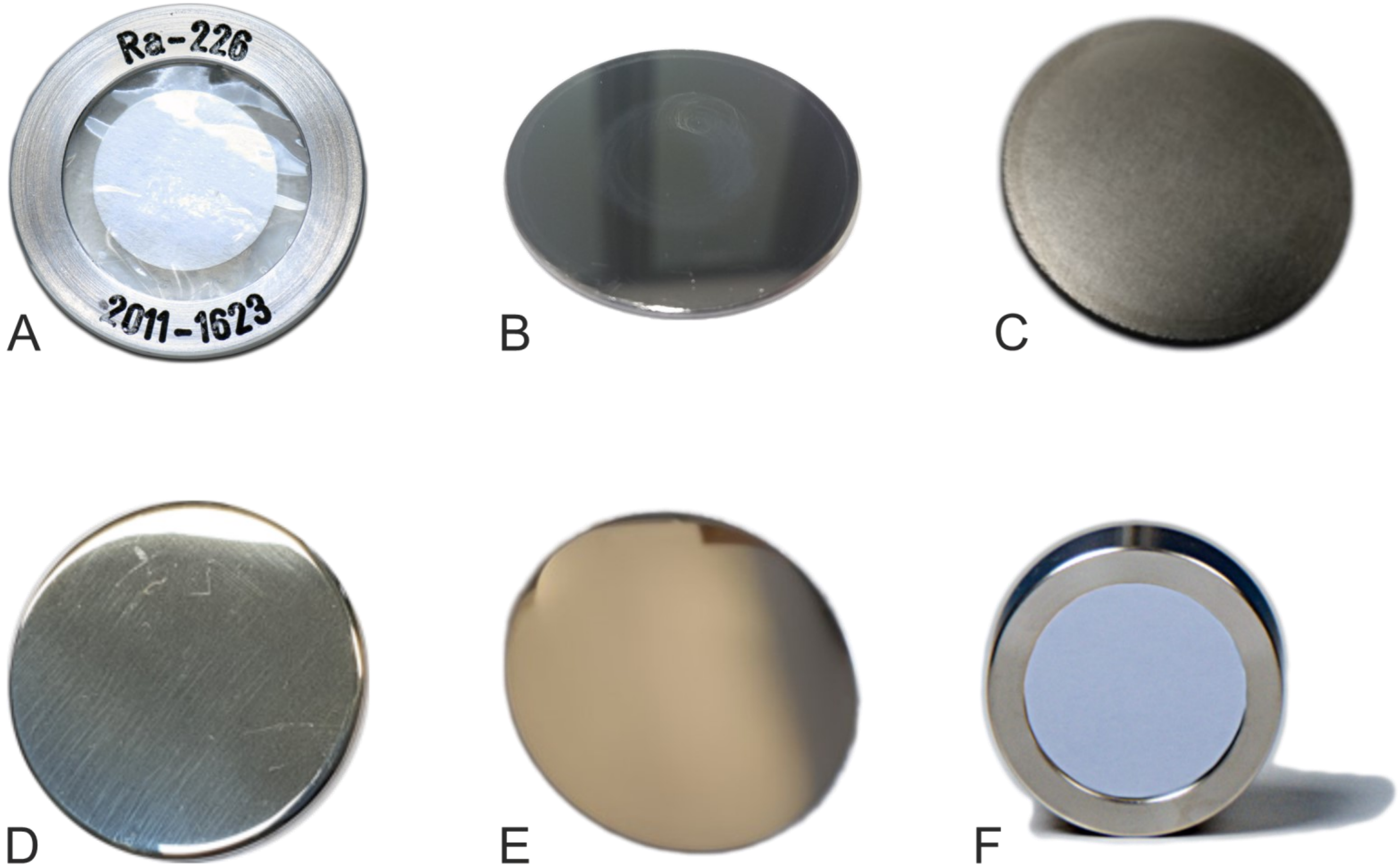
➢ Observations:

- Atmospheric radon activity concentrations
- GHG concentrations (CO_2, CH_4)
- Ambient gamma dose rate

➢ Applications:

- Estimation of GHGs background levels
- Characterisation of pollution events, clouds, and aerosols
- Assessment of the Influence of plankton organisms on marine GHGs emissions

^{222}Rn emanating sources

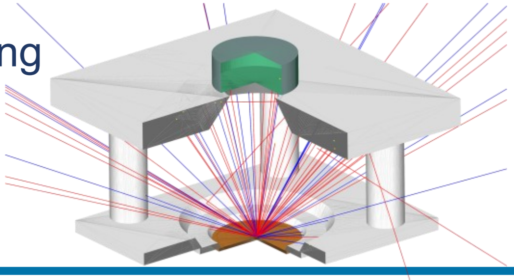


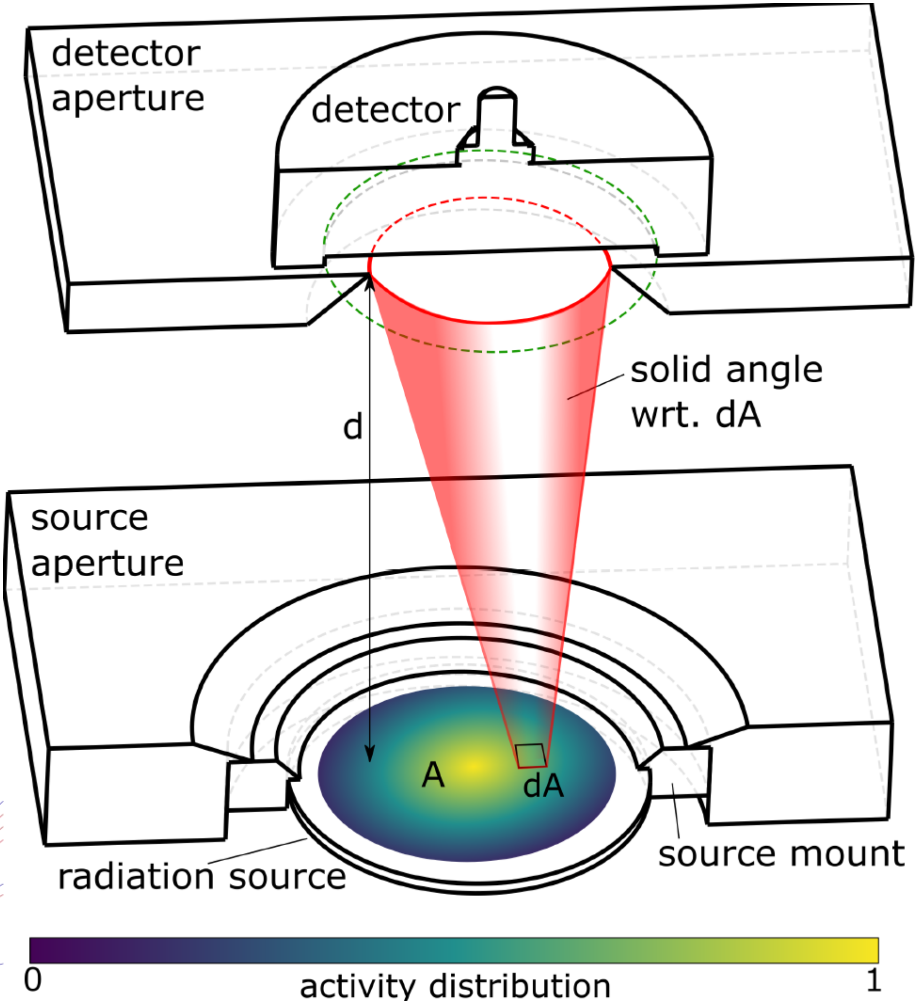
Activity of ^{226}Ra sources

- one of the most precise standardisation methods for α emitting nuclides
  - ➡ $\sigma_A < 0.5$ %
- primary method
  - ➡ does not need other radioactive standards
  - ➡ representation of [Bq] traceable to [s] and [m]
- detector efficiency is determined very precise by geometrical parameters
  - ➡ apertures

$$\epsilon = \frac{1}{4\pi}\frac{\int \Omega_{dA} w_{dA} dA}{\int w_{dA} dA}$$

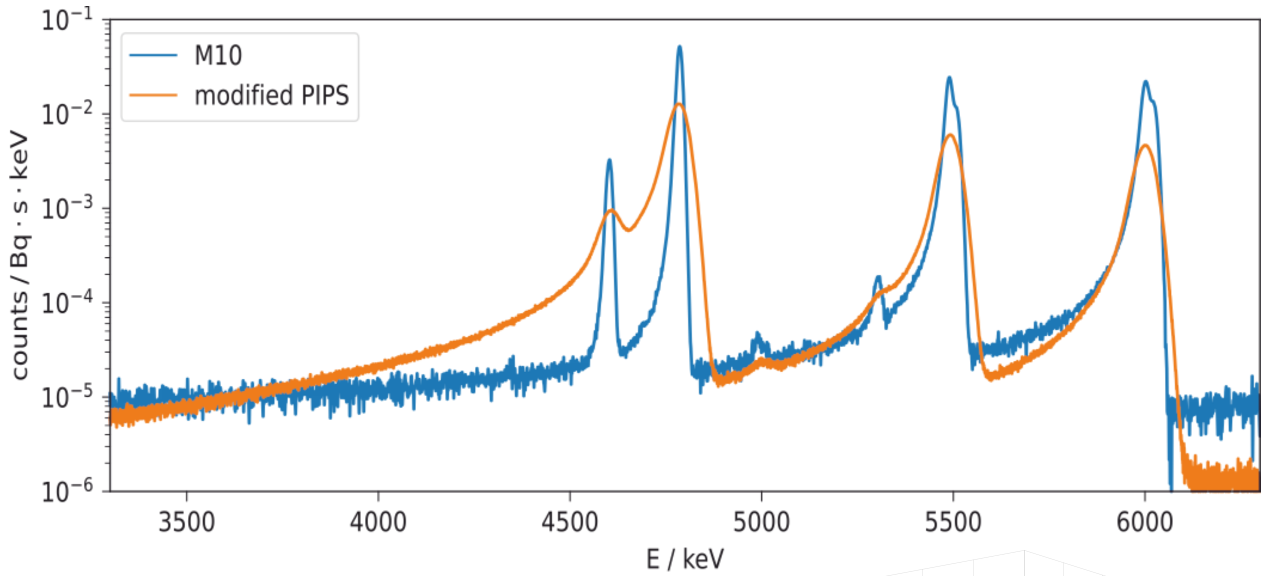
- influence through activity distribution on source
  - ➡ autoradiography
  - ➡ Monte-Carlo sampling



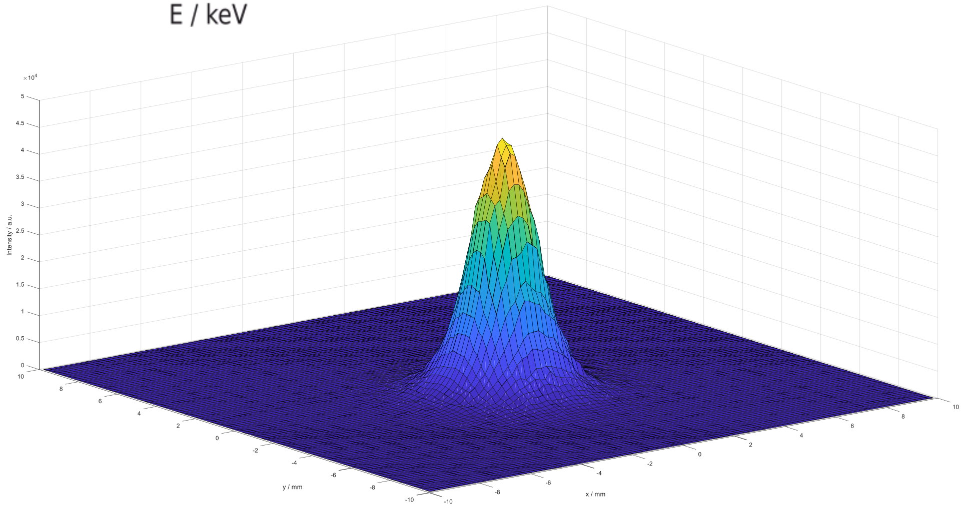


^{226}Ra activity 2018-1121

α-spectrometry:



auto radiography:

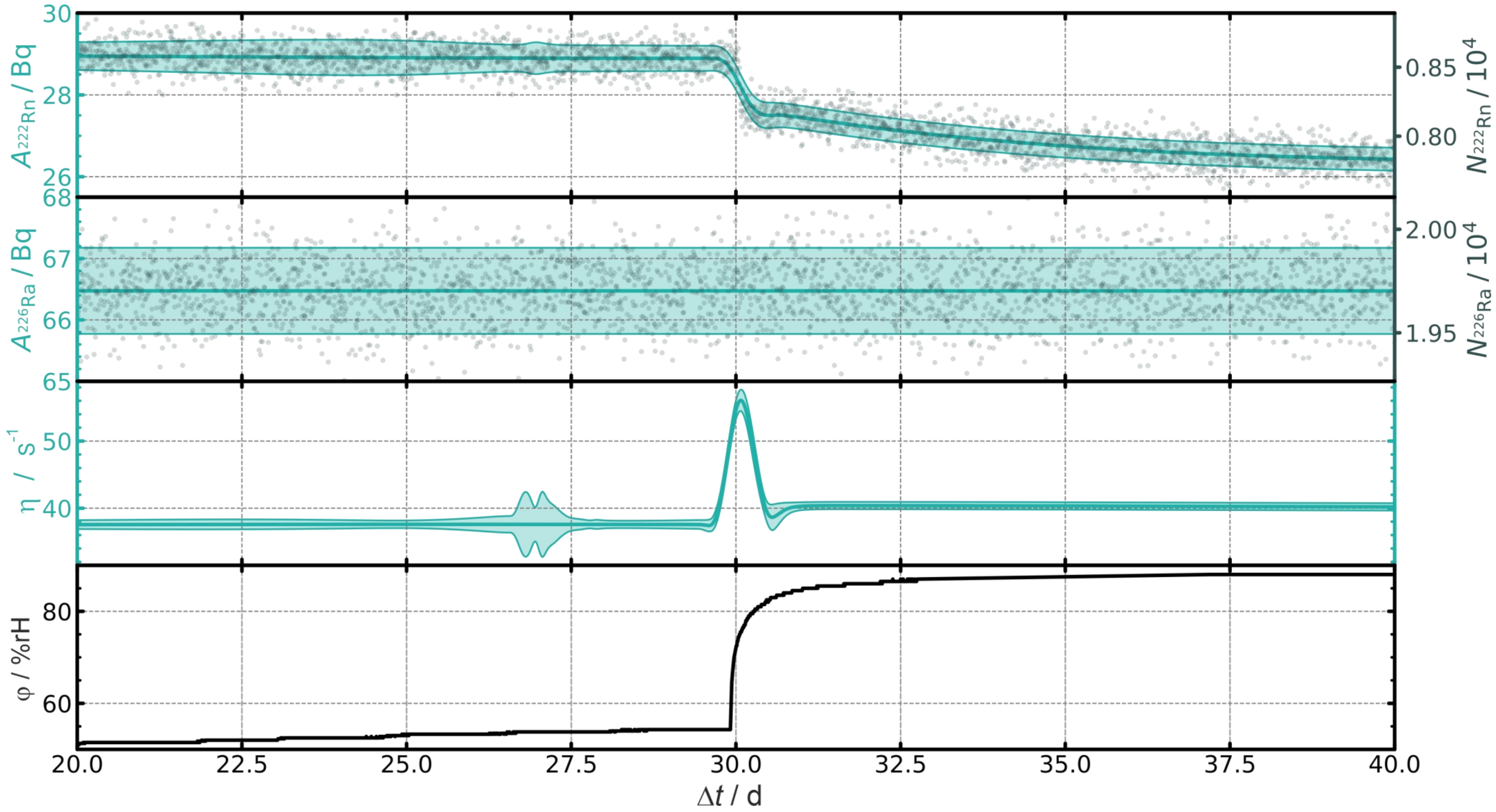


➡ activity of 2018-1121:

***A(^{226}Ra)* = 1104.1(63) Bq**

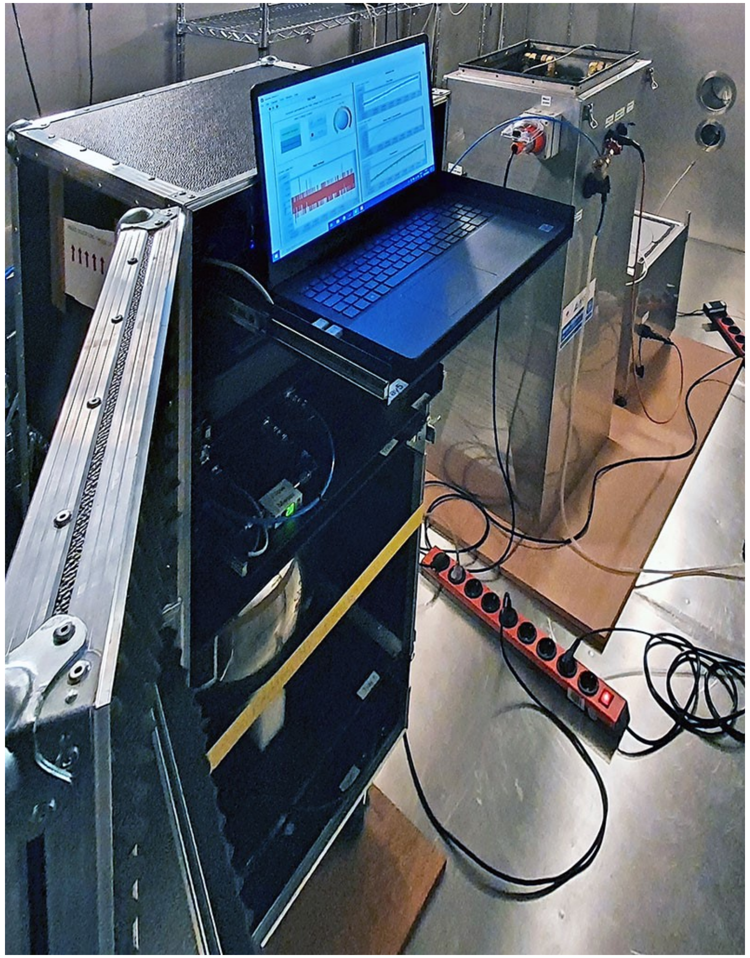
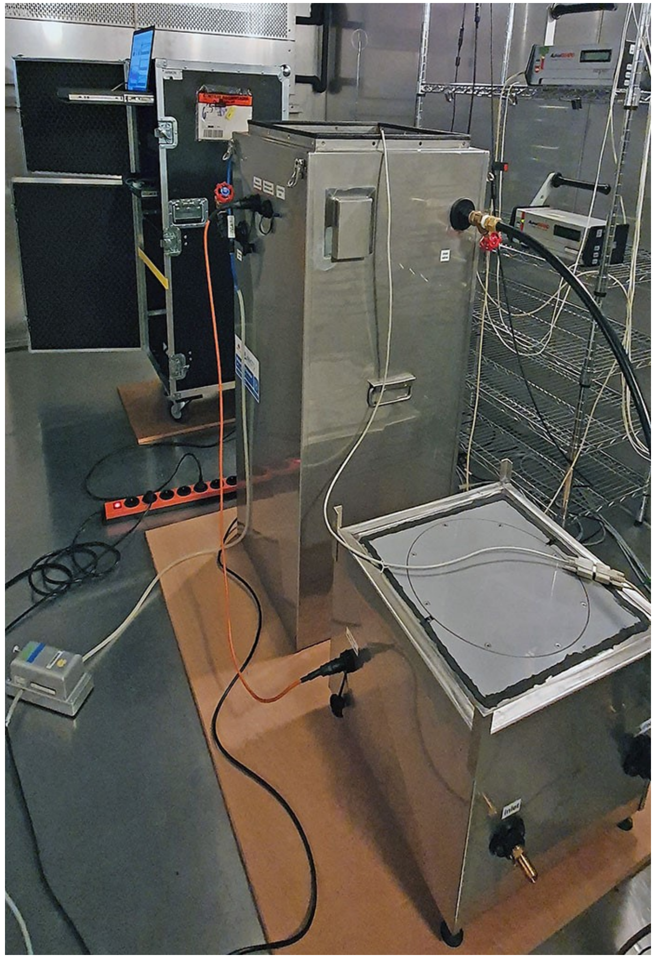
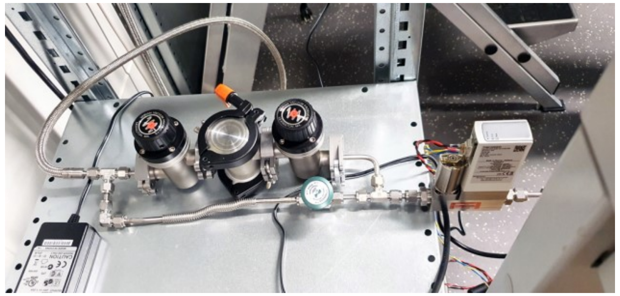
(confirmed with γ-spec.)

^{222}Rn activity from 2018-1121

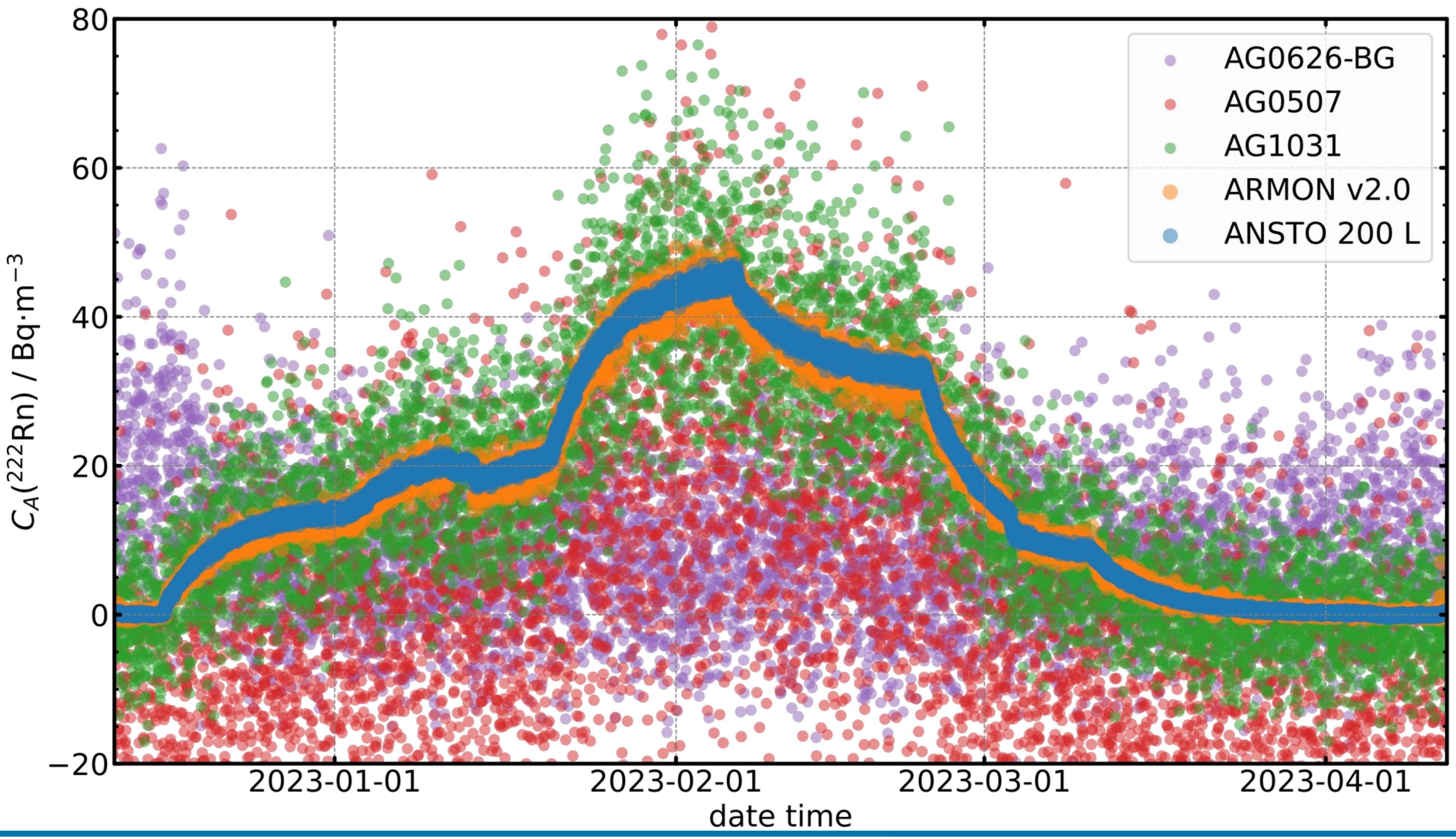


Detector Calibration

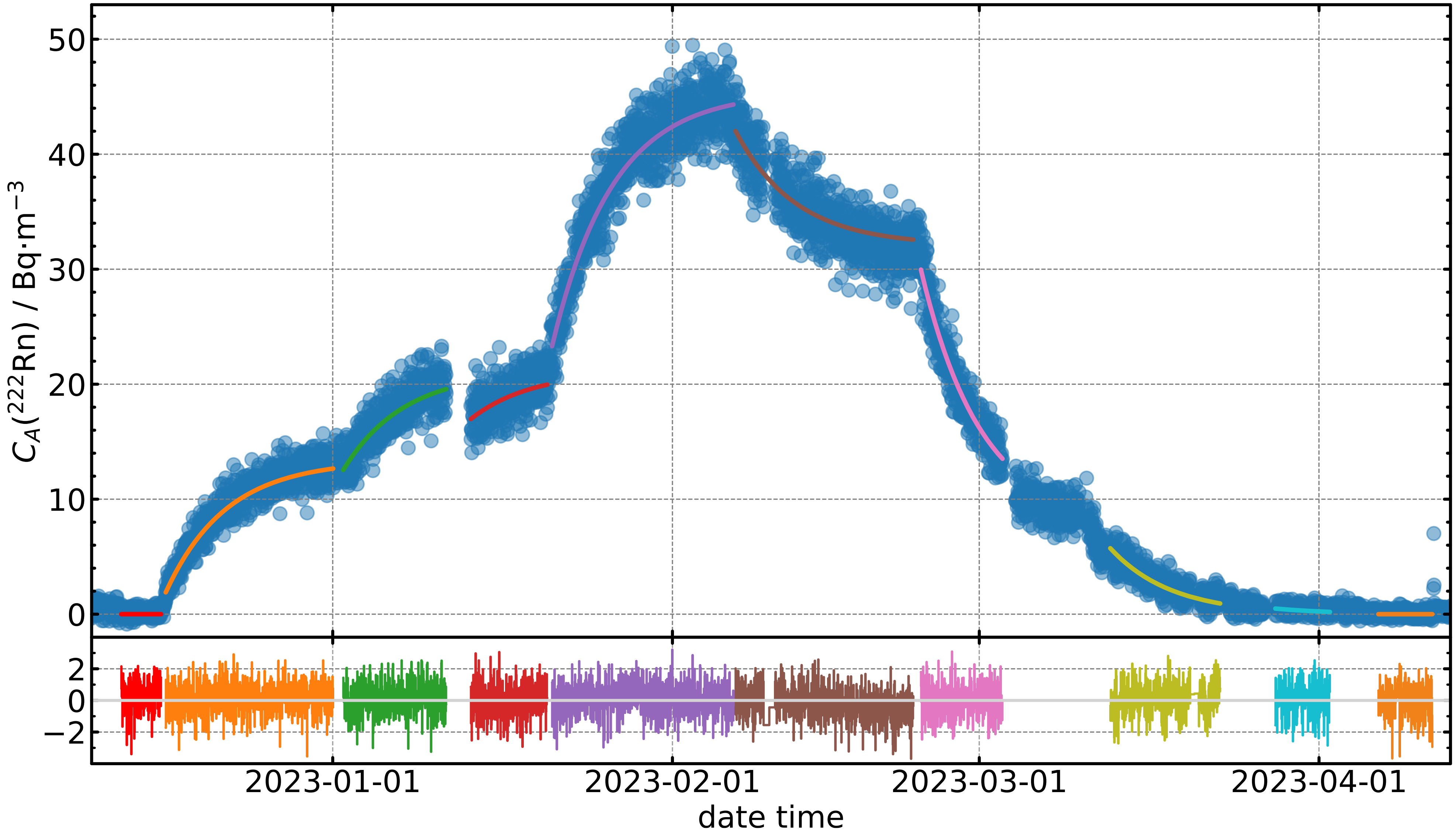
ARMON v2.0 and ANSTO 200 L in 20 m³ climate chamber

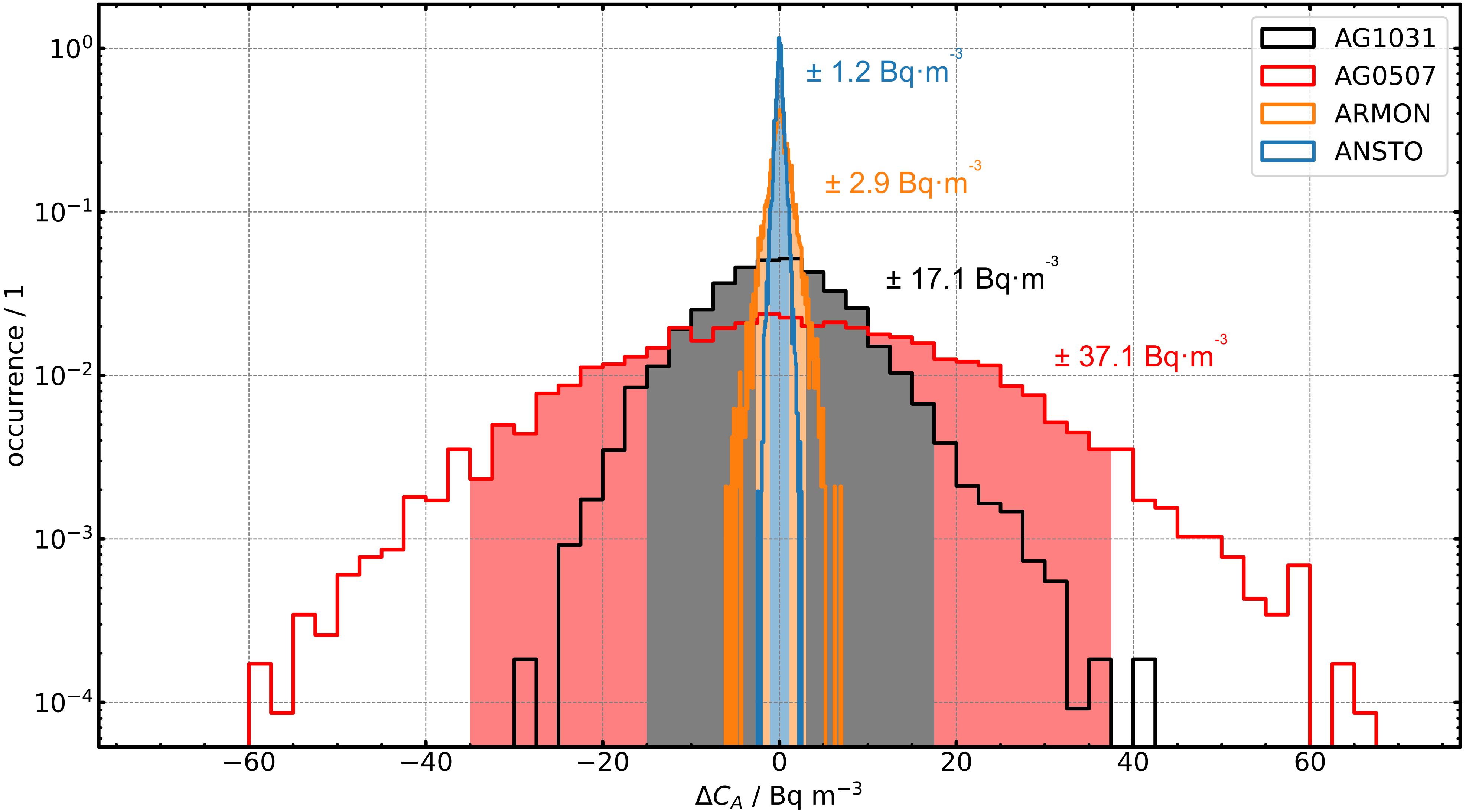
Data collection



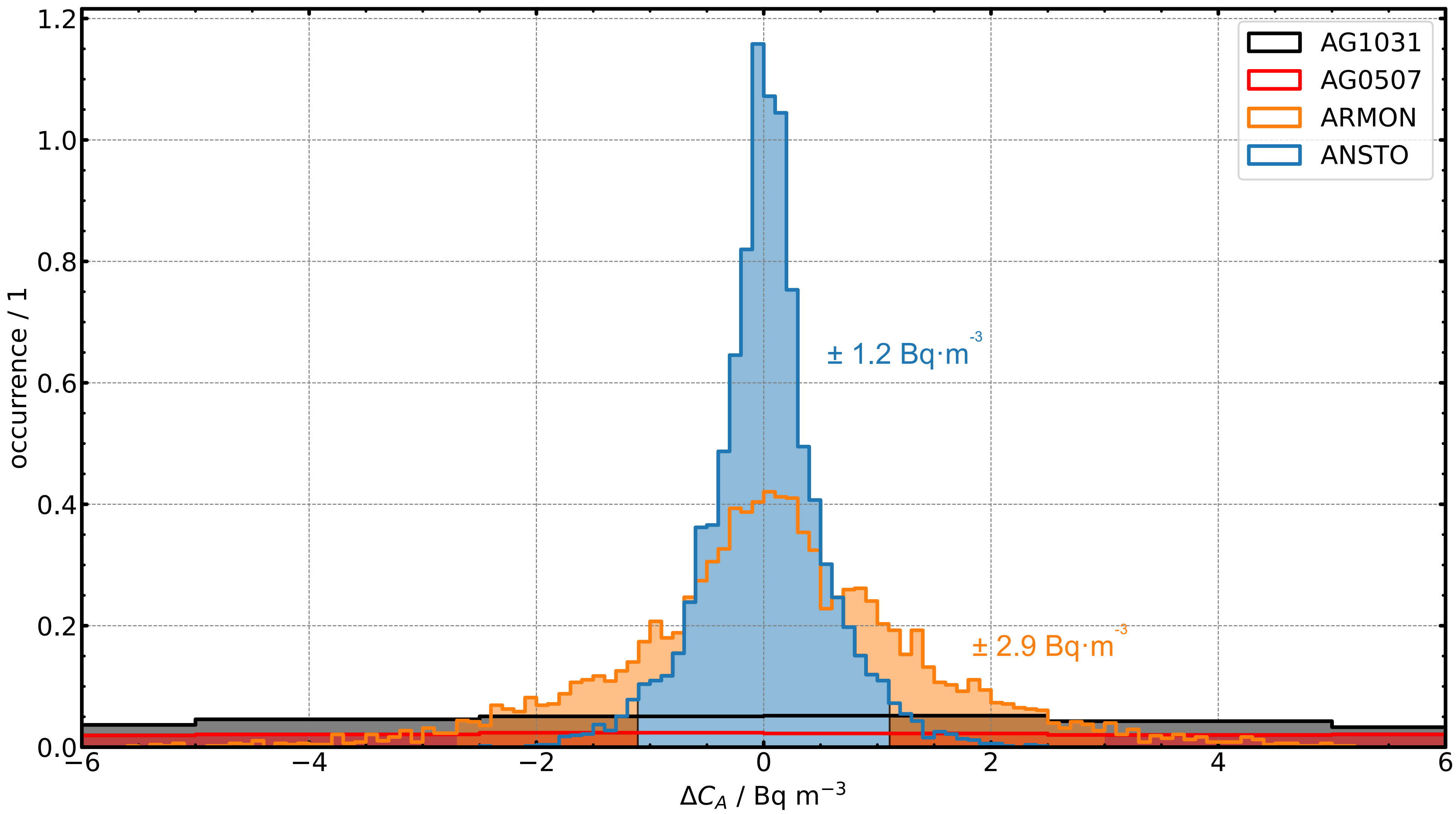
Comparison with model



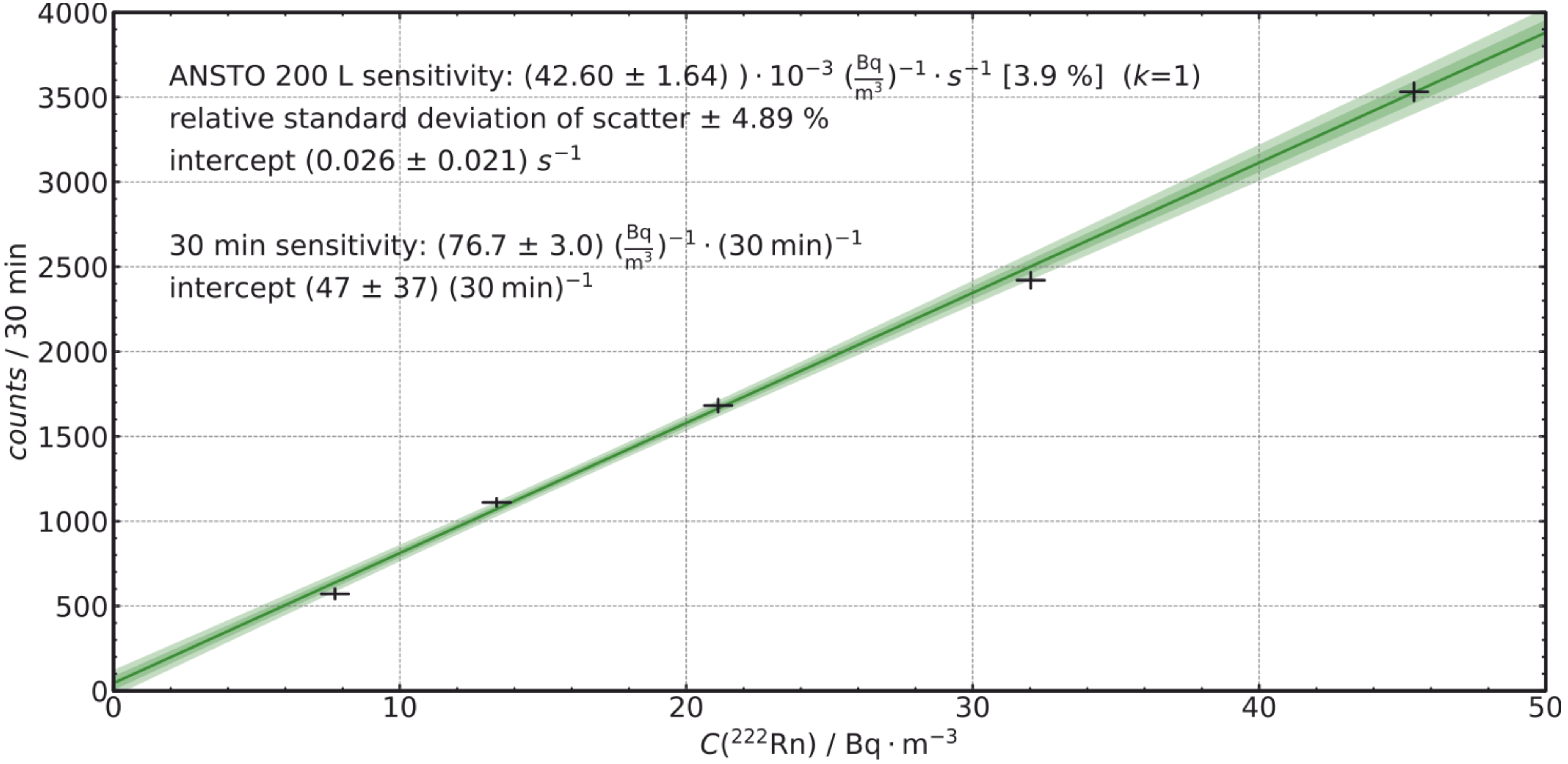
Data deviation (1)



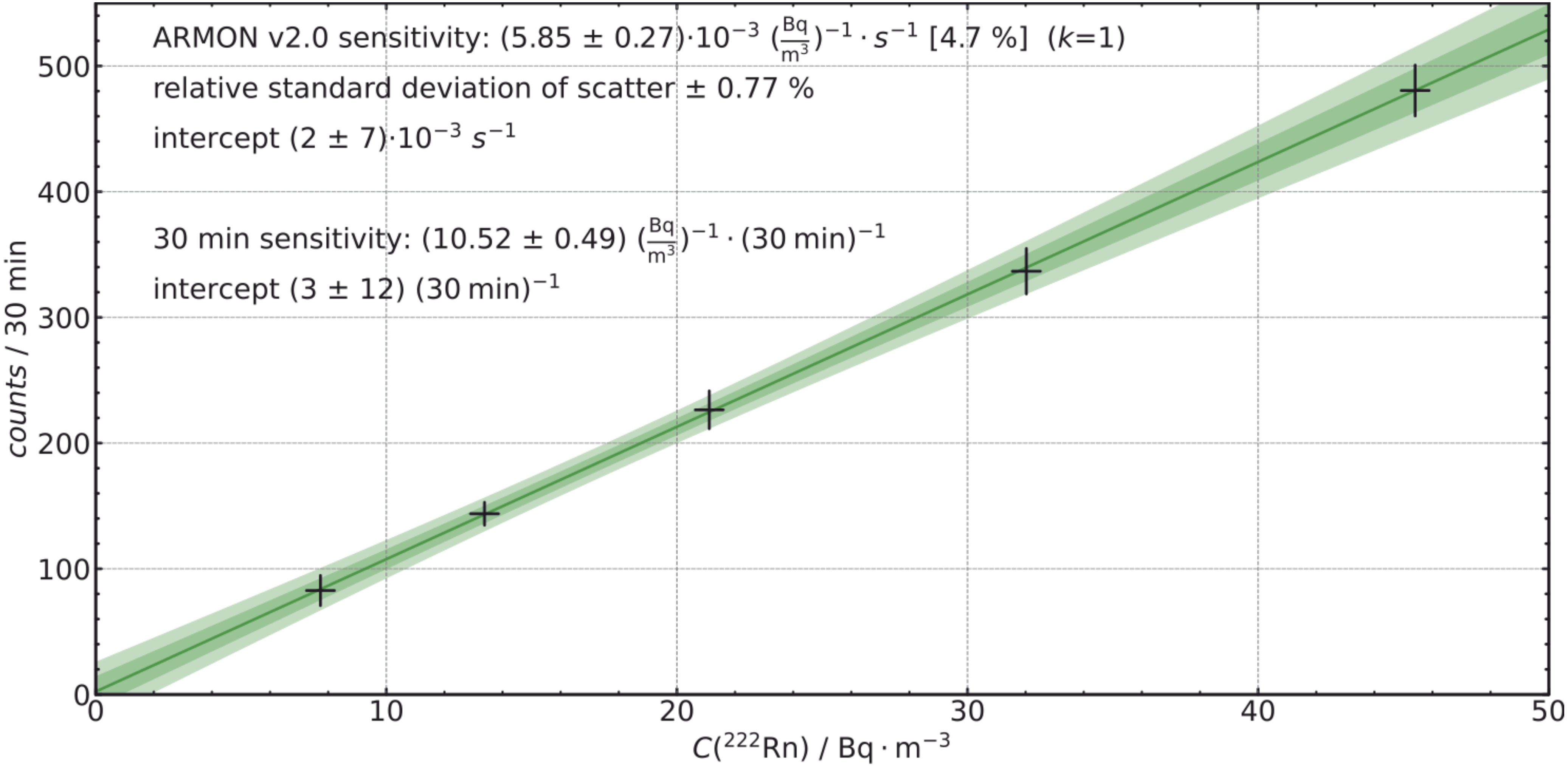
Data deviation (2)



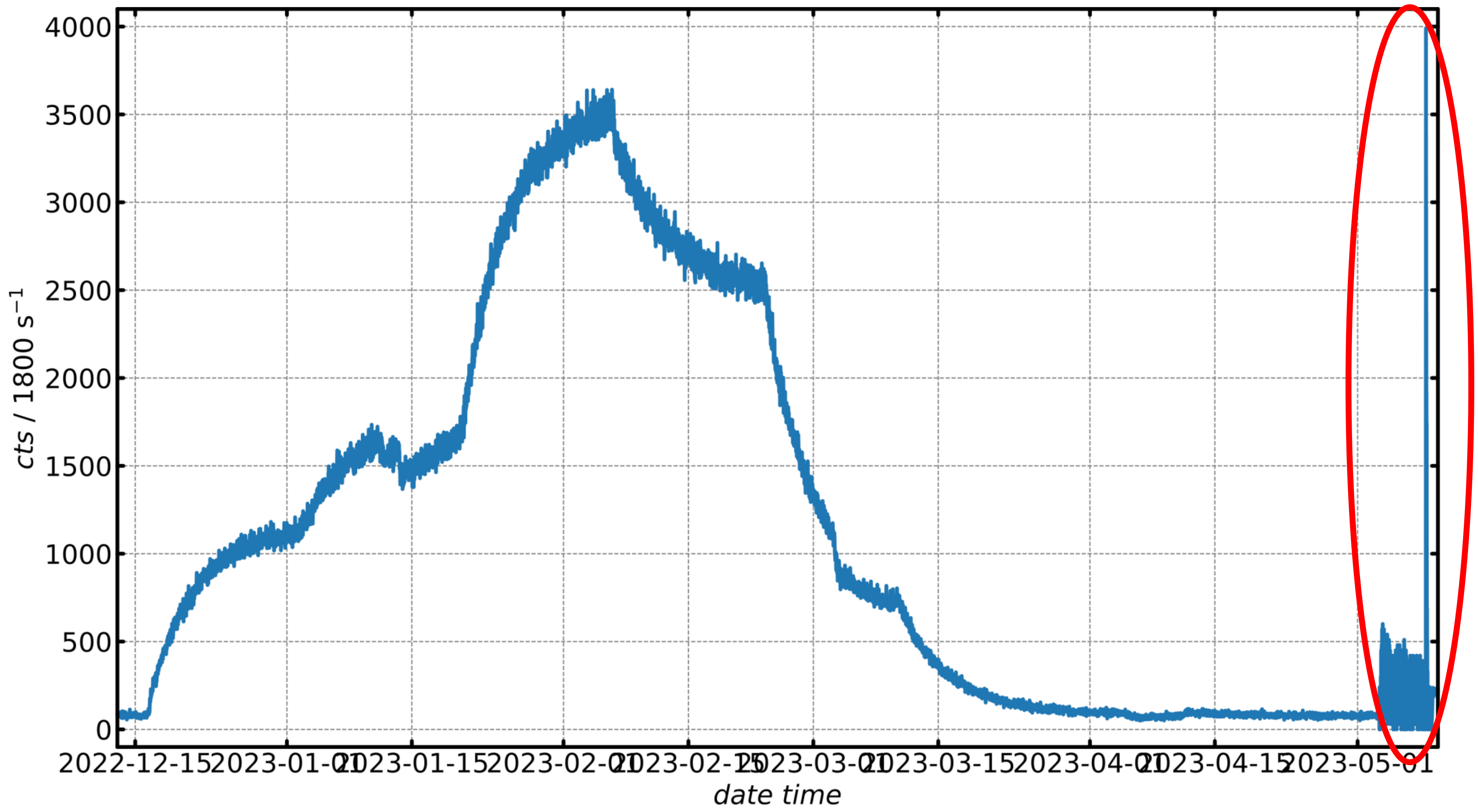
ANSTO 200 L calibration



ARMON v2 calibration



Puls calibration for in field



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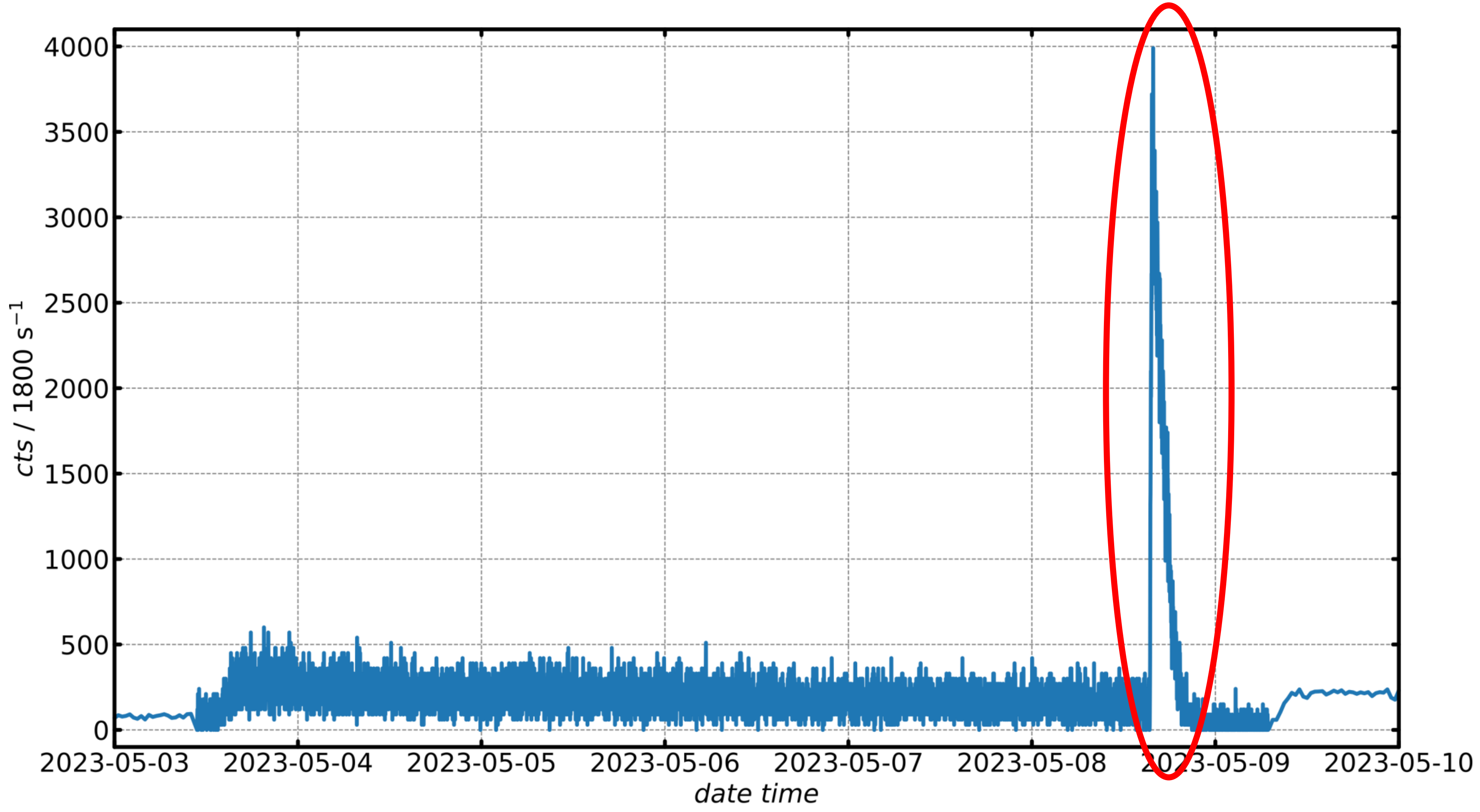

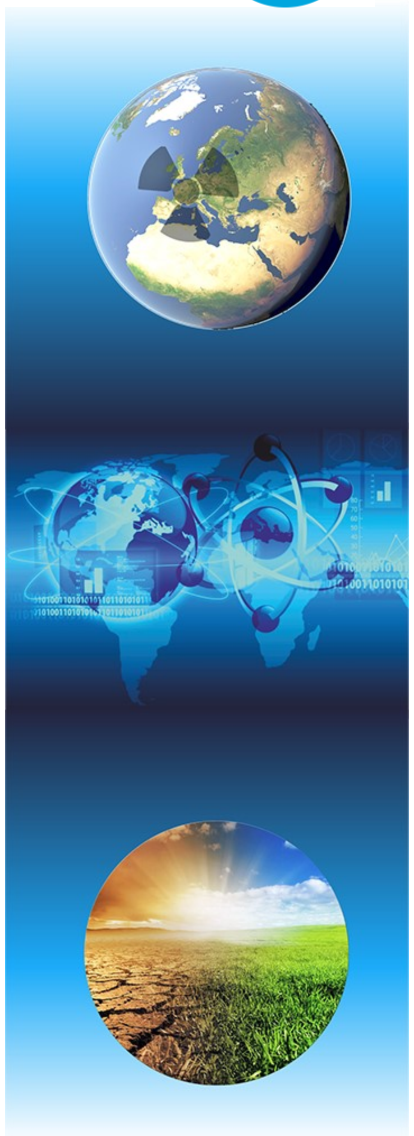

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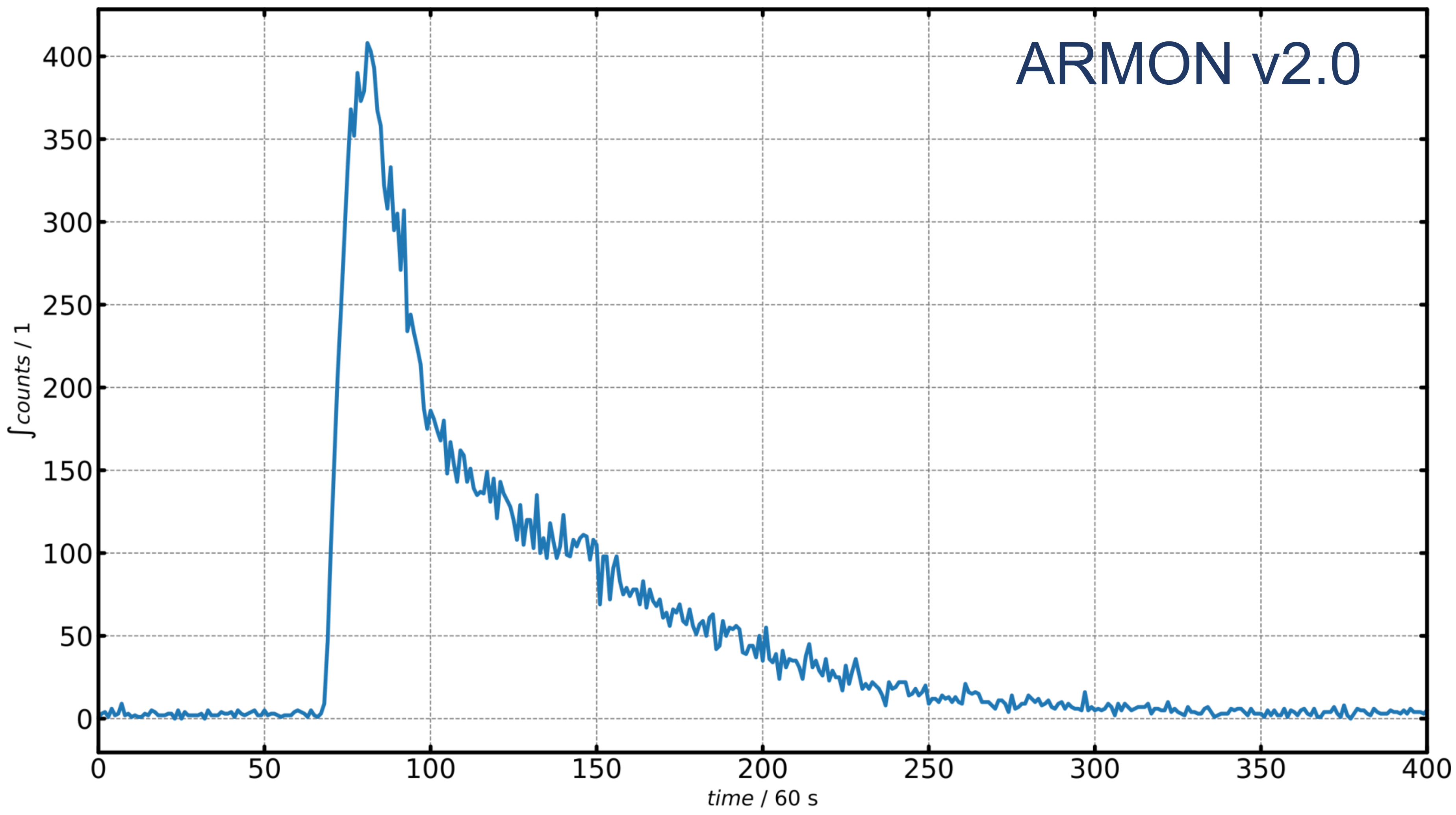

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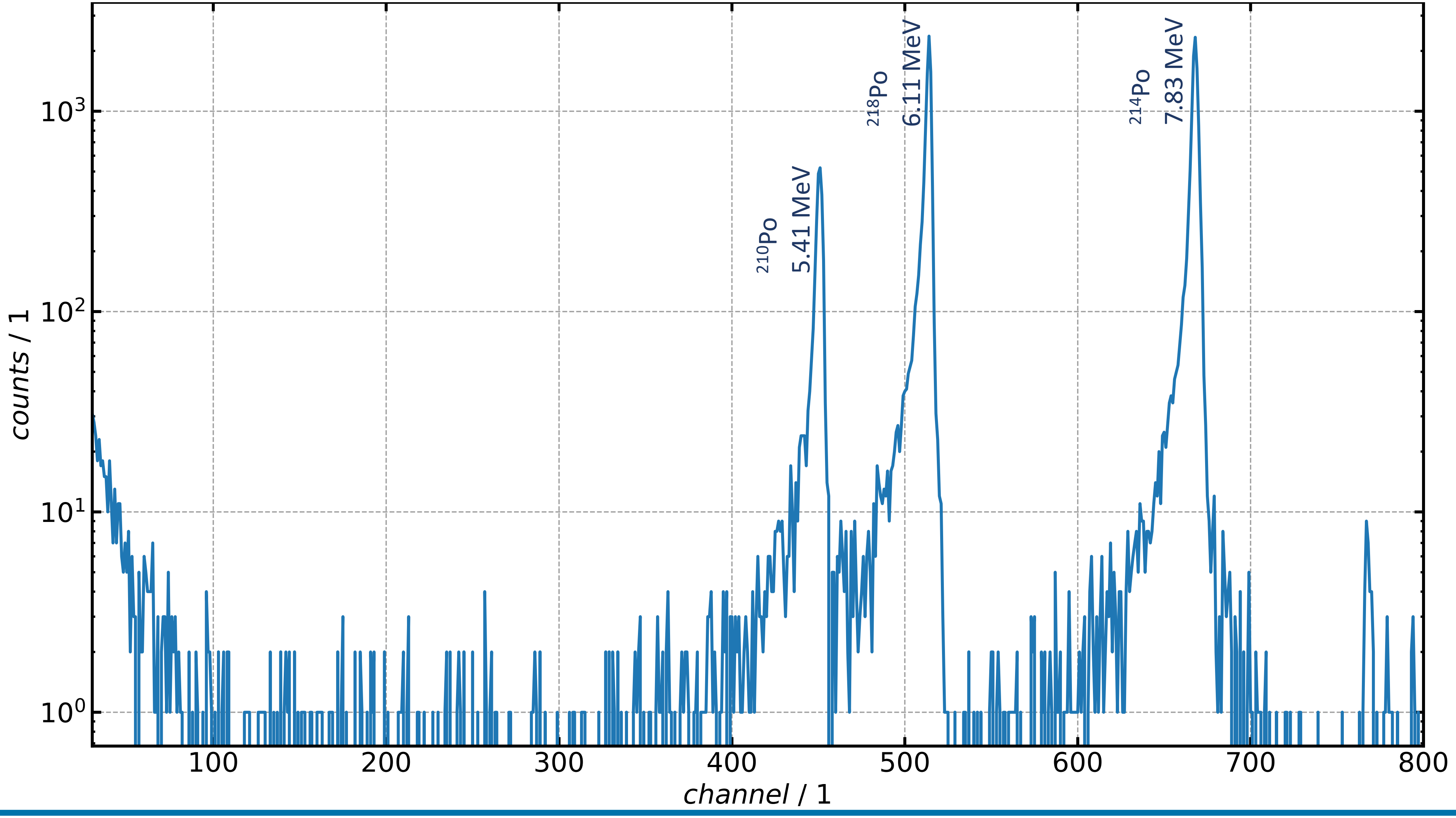

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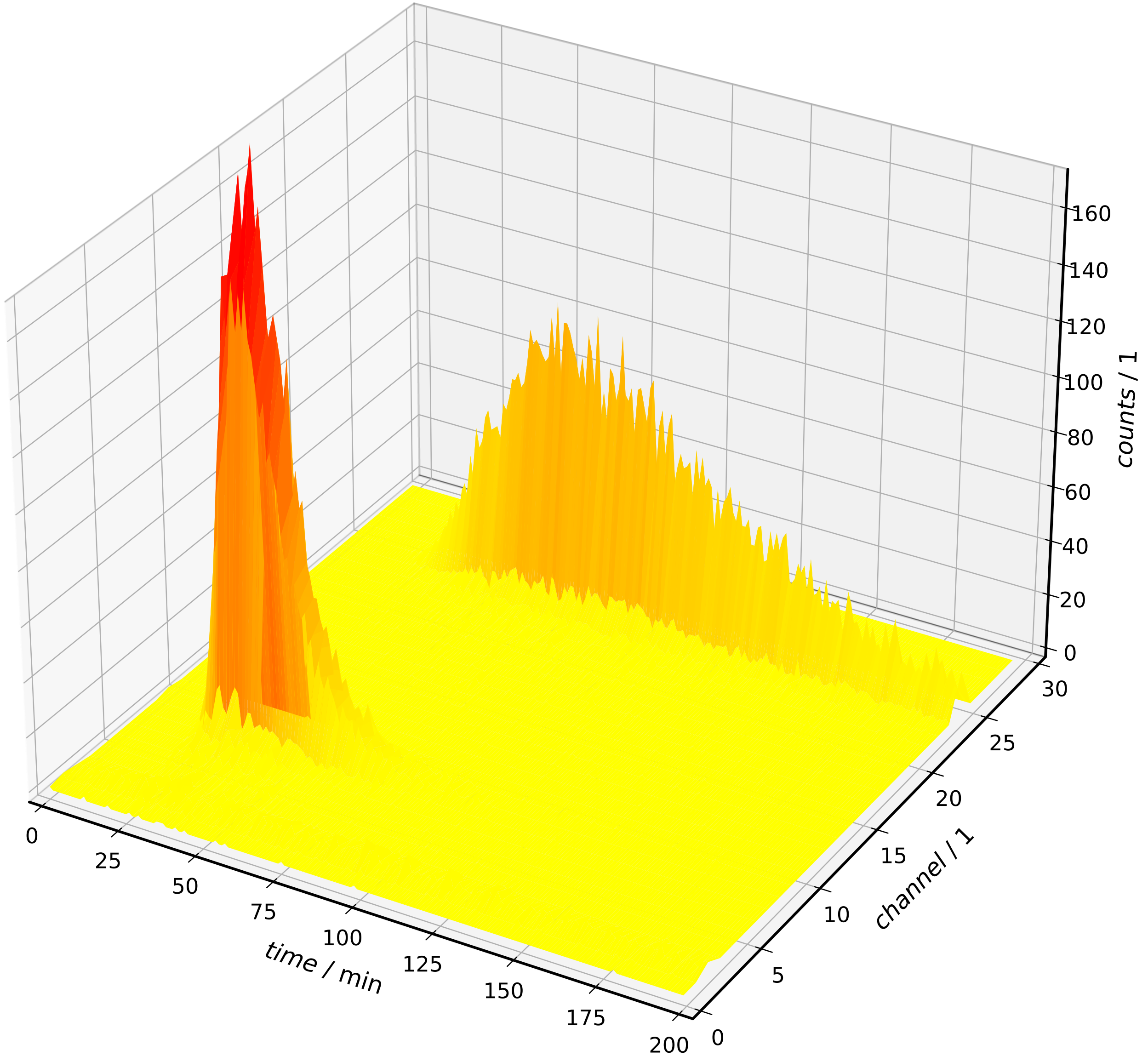

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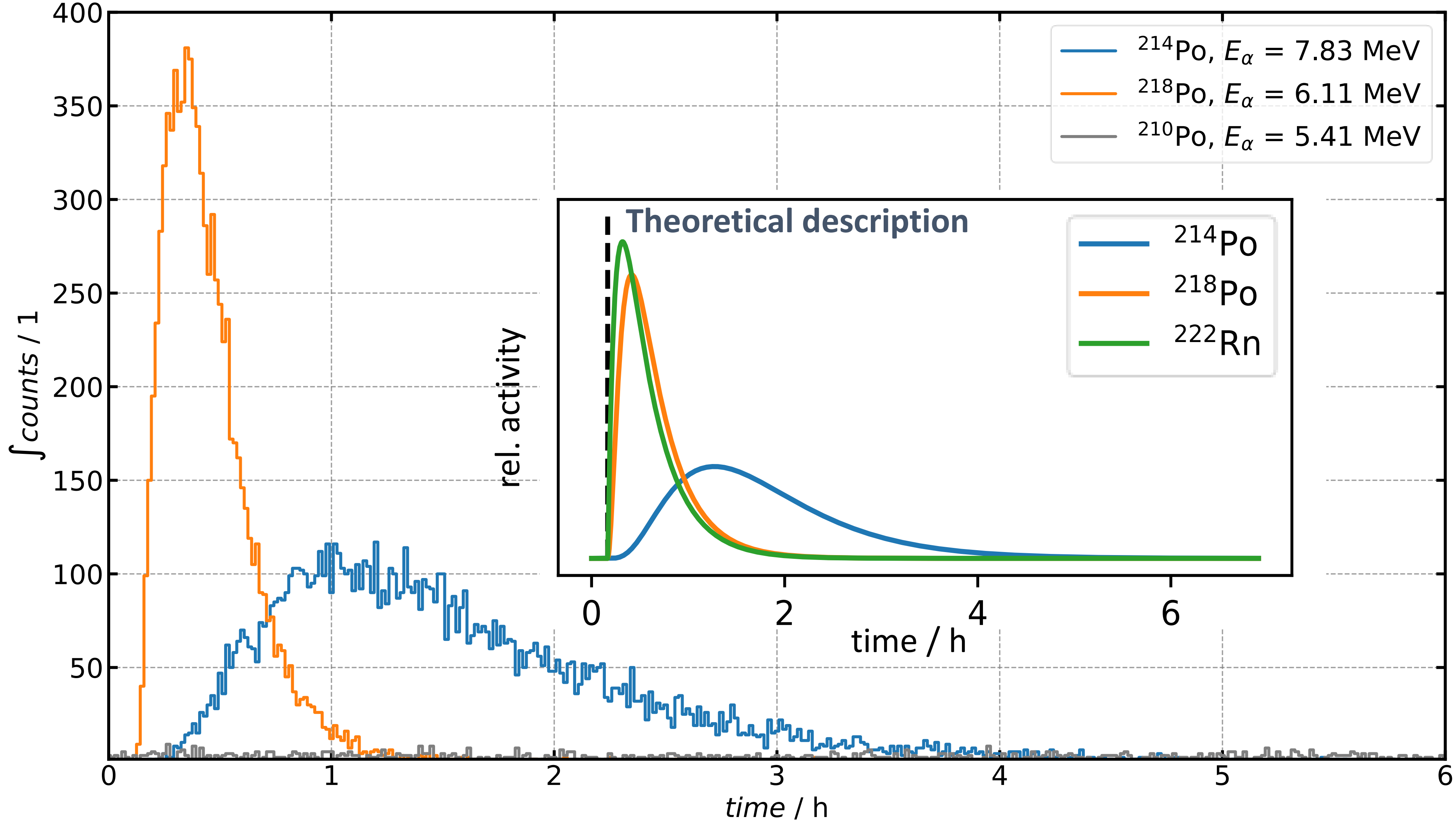

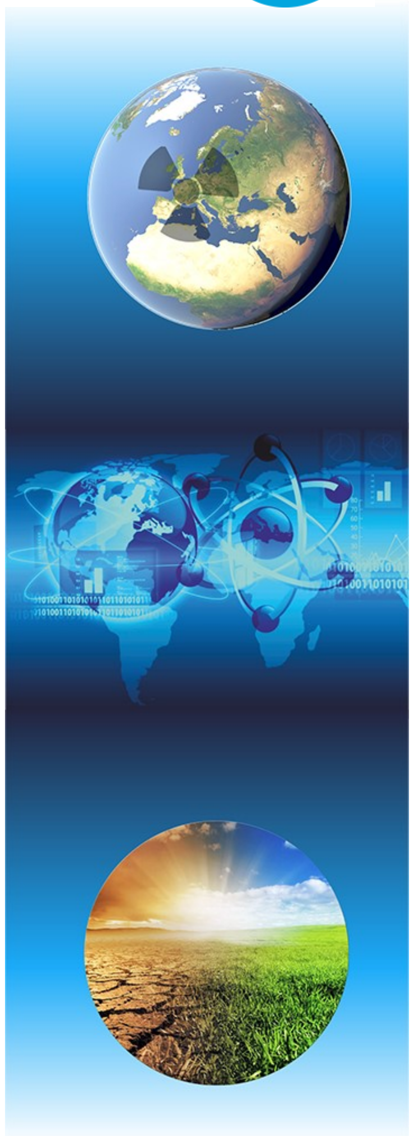

Thanks…

… to the RadonNET partners:

… to the NuClim partners:

… to the Stakeholder Committee, Stakeholders, EURAMET, EURATOM

… and for your attention!

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Accurate

Objective

Passionate

Physikalisch-Technische Bundesanstalt (PTB)
The National Metrology Institute of Germany

Stefan Röttger
Telefon: +49 531 592-6130
E-Mail: Stefan.Roettger@PTB.de
Bundesallee 100
38116 Braunschweig
Germany

Thanks for your attention!

Questions?

Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
Bundesallee 100
38116 Braunschweig
Germany

Stefan Röttger
Telefon: +49 531 592-6130
E-Mail: Stefan.Roettger@PTB.de
www.ptb.de