Analysis of Radioxenon Detections in the UK

Matthew Goodwin[1], Ashley Davies[1], Rich Britton[2]

[1] *UK NDC, AWE Aldermaston, UK, RG7 4PR*
[2] *PTS, CTBTO, Vienna*

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Matthew.Goodwin@awe.co.uk

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GBL15 SAUNA II Lab IMS System

- Swedish Automatic Unit for Noble Gas Acquisition (SAUNA)

Fig. 1. UK CTBT Noble Gas Radionuclide Laboratory (GBL15) SAUNA System

Two modes of operation:

LAB Mode: For the re-analysis of samples from IMS stations
(The CTBT certified process)

IMS Mode: For sampling, processing and measuring samples collected from the local air.
(Operated on an ad-hoc basis)

Laboratory was certified in December 2017 – **one** of **four** CTBT Noble Gas Laboratories in the world.

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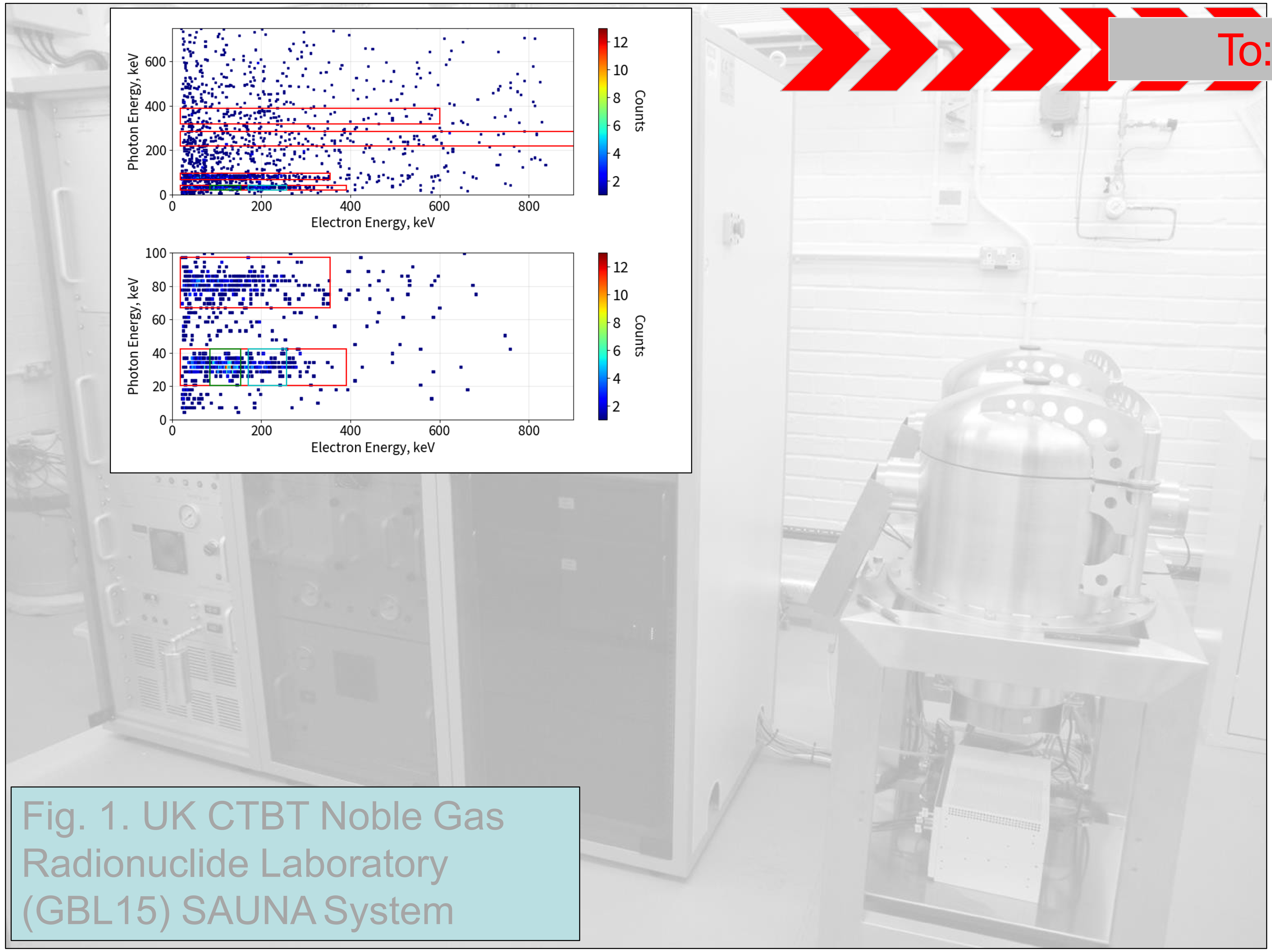

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To: UK NDC RN PIPELINE

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UK NDC Plume Analysis

- Data transferred to the UK NDC and processed by the RN Pipeline. The pipeline identifies ‘plumes’ of ^{133}Xe based on detections above the MDC

~ 100 mBq/m^3 ^{133}Xe !!!

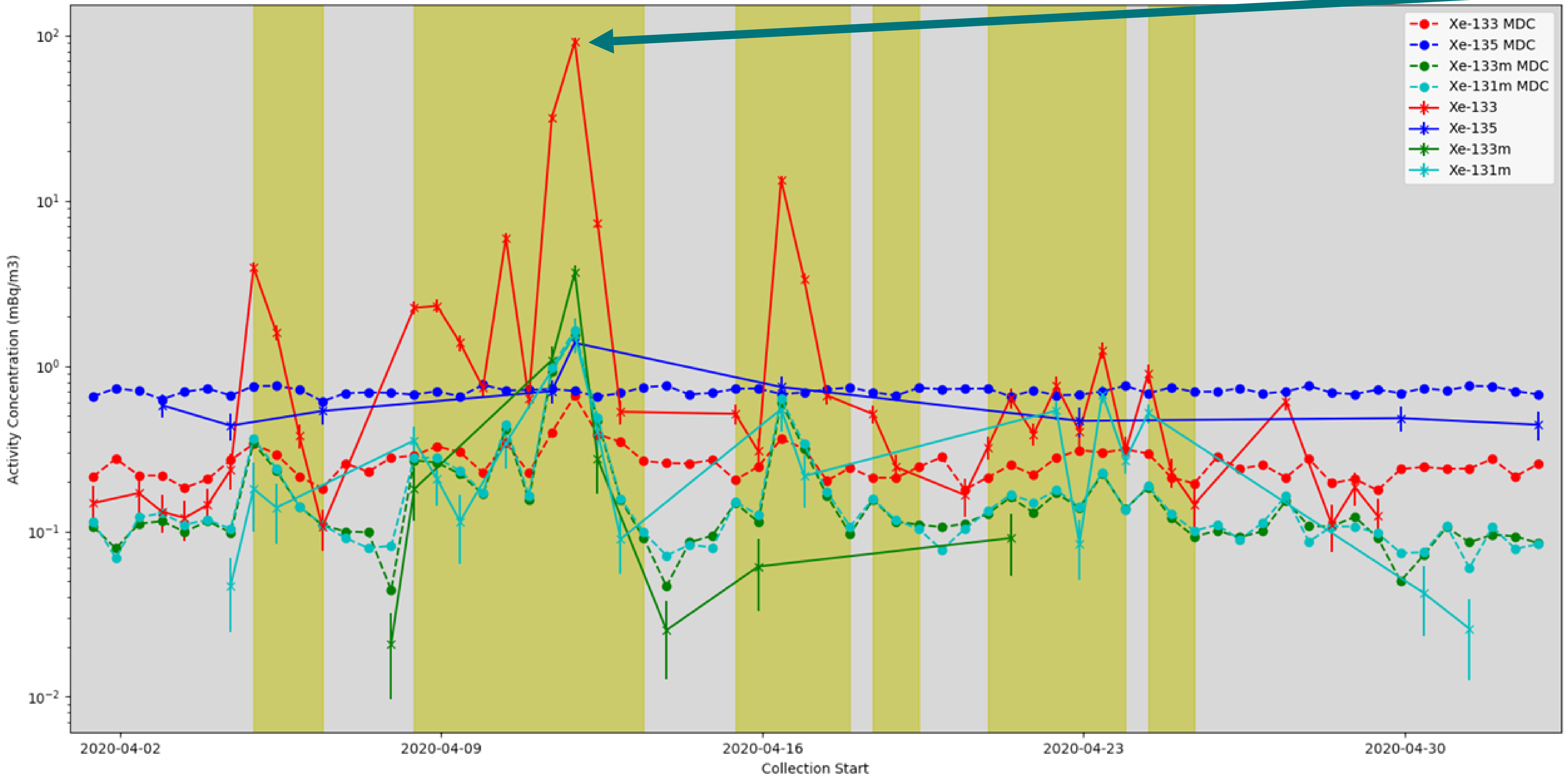


Fig. 2. Radioxenon detections during April 2020 at GBL15. Yellow shading shows detected ‘plumes’

Periods of SAUNA operation

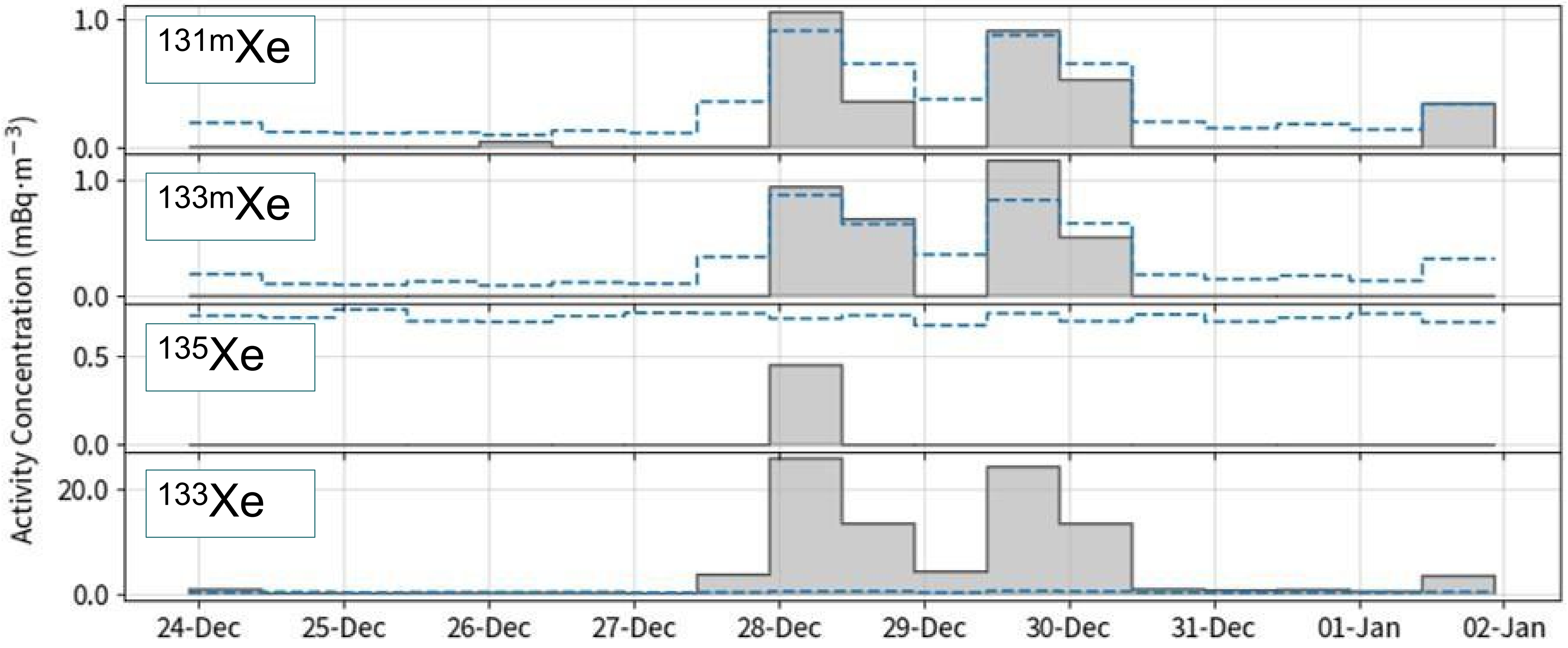


Fig. 3. Time-series activity concentration results (grey histogram) and minimum detectable concentrations (MDC) (dashed blue line) for four radionuclides measured at GBL15 during period 1

Period	Period start	Period end
1	24-Dec-2019	02-Jan-2020
2	20-Mar-2020	25-Mar-2020
3	01-Apr-2020	15-Apr-2020
4	16-Apr-2020	30-Apr-2020

Regional Considerations

- There are dozens of reactor facilities in the region, including NPPs and MIPFs

- First effort is to look at Trajectory Models from HYSPLIT – a low-fidelity but fast process. This indicates the source region possibly includes IRE

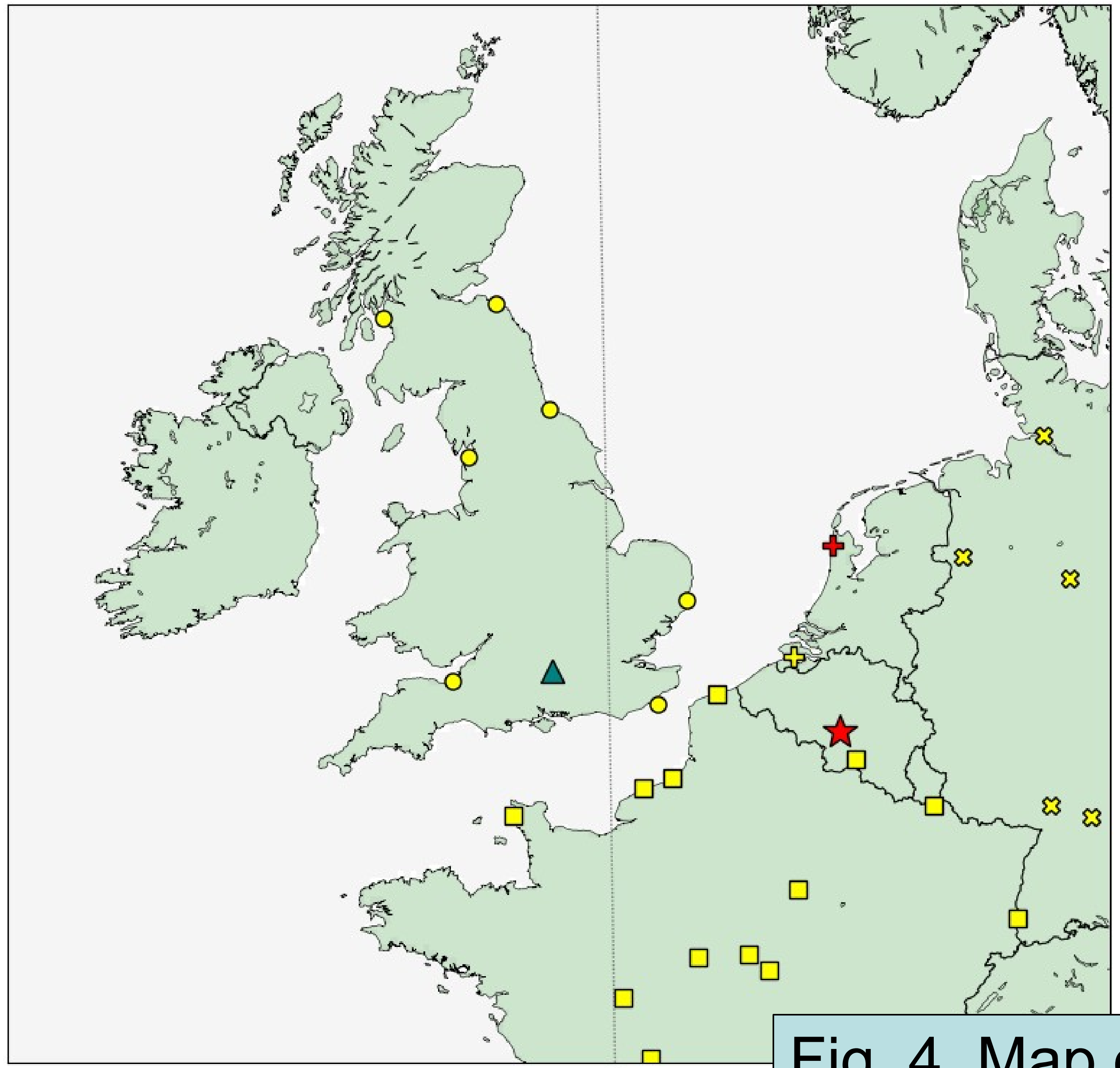


Fig. 4. Map of the UK and parts of mainland Europe, showing GBL15 (triangle) and IRE, Belgium (red star), UK NPPs (circle), French NPPs (square), Dutch NPP (yellow plus) Dutch MIPF (red plus) and German NPPs (cross).

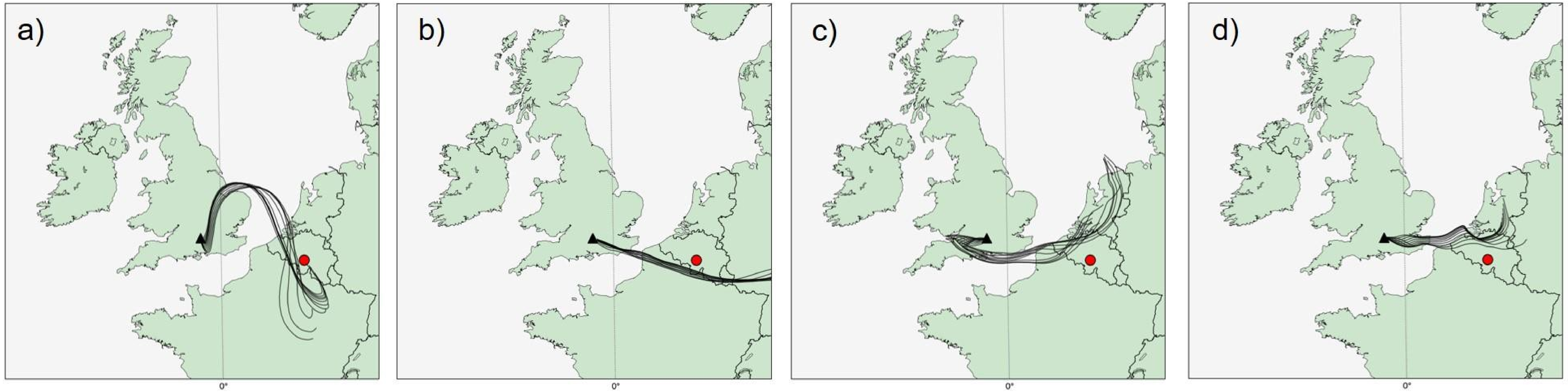
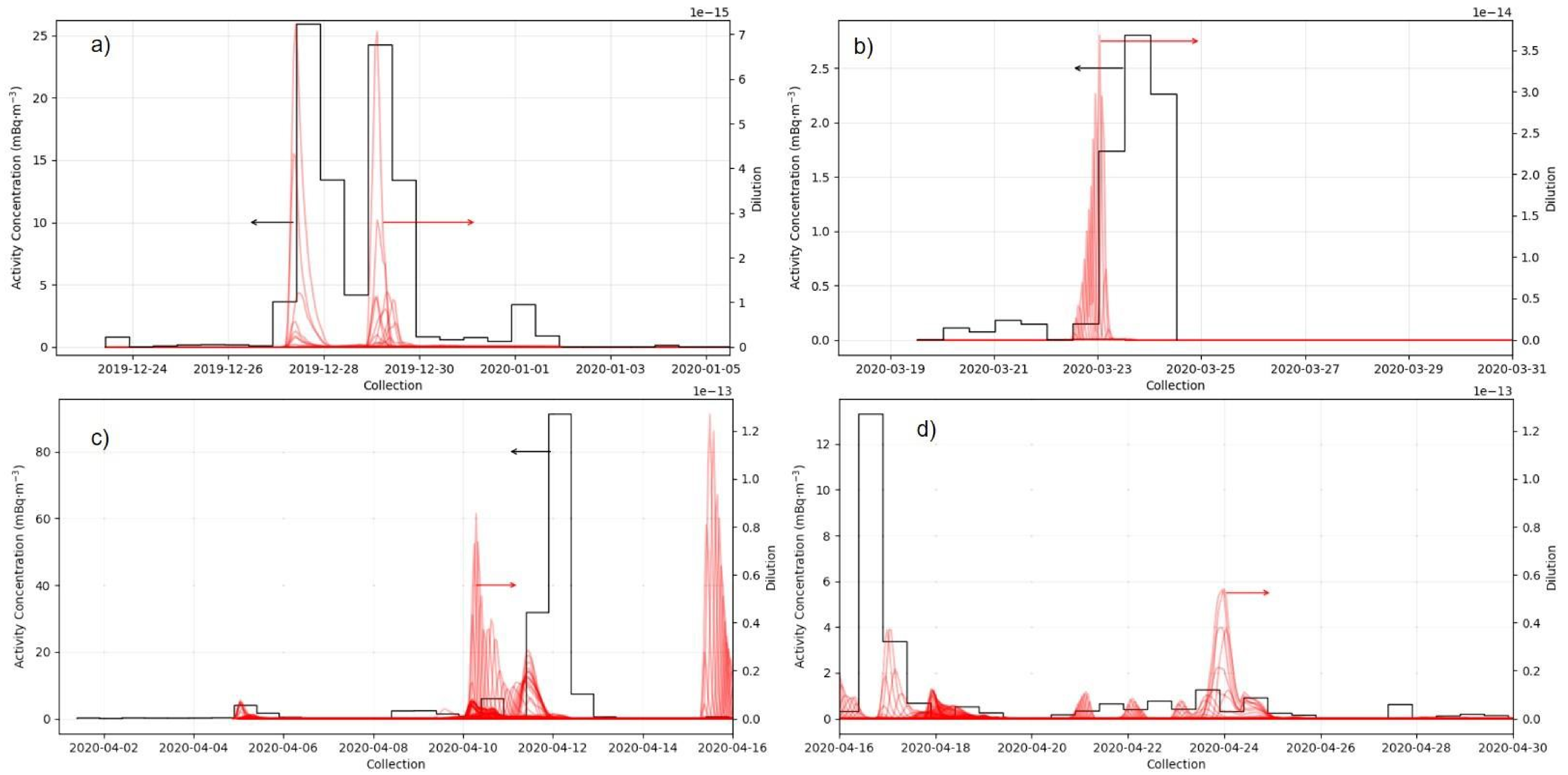


Fig. 5. HYSPLIT Trajectory plots for events 1-4 (a-d). Each black line represents a trajectory plot for a 1-hour period of the collection. Red circle is IRE MIPF in Belgium

Atmospheric Transport & Dispersion Modelling (ATDM)

- Forward ATDM simulations from IRE, assessing the contribution to GBL15
- Period 1 shows a good match in time between detections and simulated contributions



Based on no ground-truth emissions data

Fig. 6. Measured (**black**) ^{133}Xe activity concentrations and simulated IRE dilution factors (red) at GBL15 during the four periods (plots a-d). Each simulated contribution is based on a one-hour emission with an emission rate of 1 Bq/hr.

STAX Overview

- Can we use the STAX data to gain confidence that the source is IRE?
  1. Download data from STAX source
  2. Create CNF files
  3. Analyse using Genie U-SDK
  4. Archive spectra and results

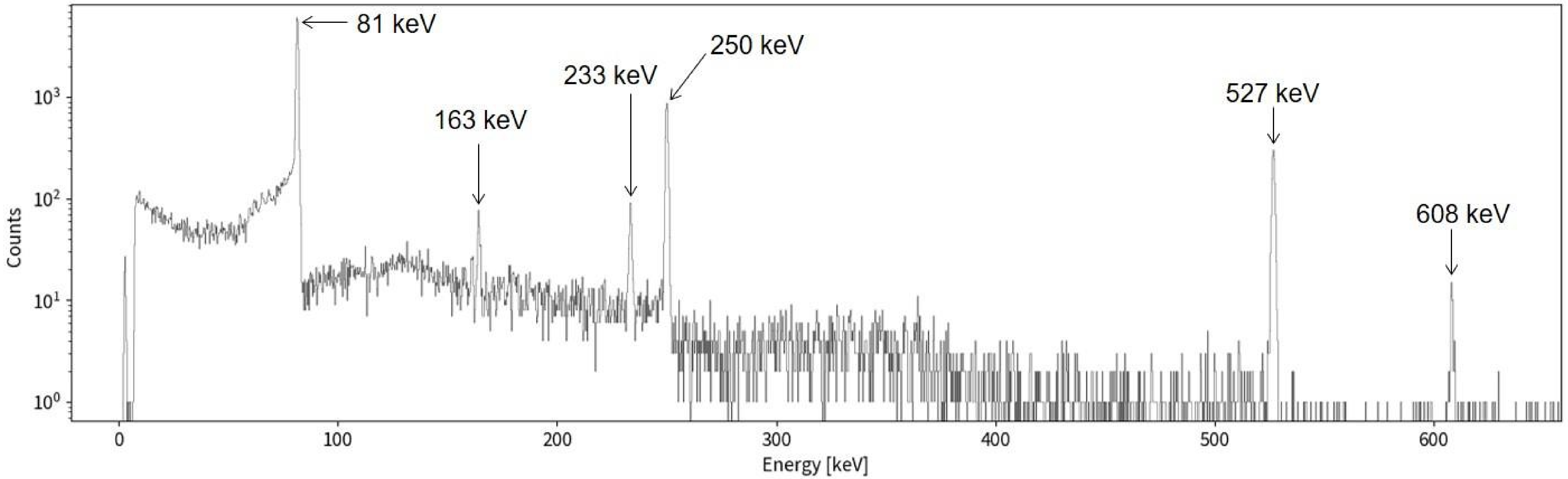


Fig. 7. High-resolution γ-ray spectrum of a STAX measurement from IRE, identified peaks correspond with radioxenon isotopes; 81 keV (^{133}Xe), 163 keV (^{131m}Xe), 233 keV (^{133m}Xe), 250 keV (^{135}Xe), 527 keV (^{135m}Xe), 608 keV (^{135}Xe). Acquisition time=900 s

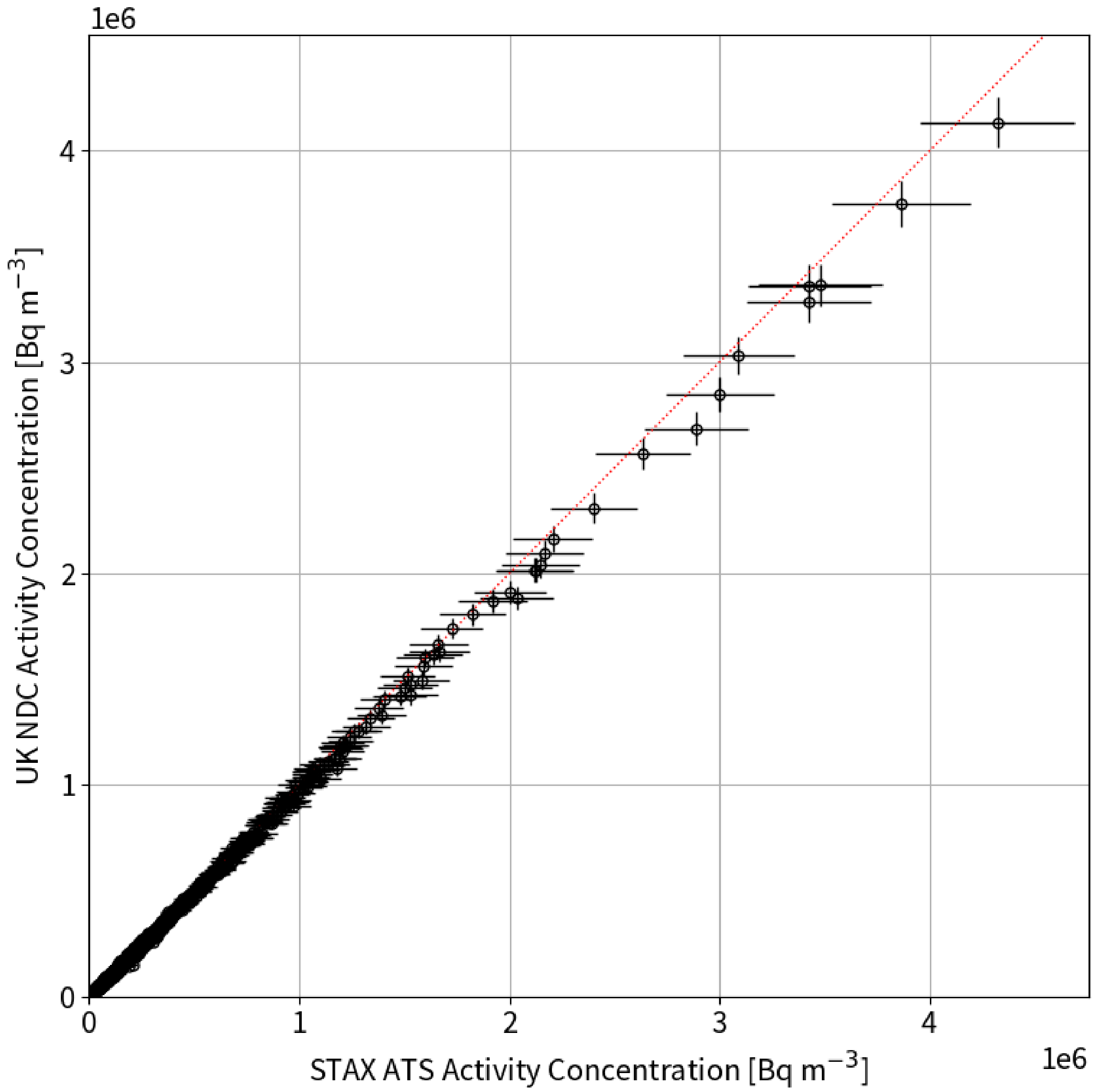


Fig. 8. Comparison of STAX-produced activity and UK NDC-produced activity

STAX Data Analysis (IRE)

- UK NDC STAX Database used to assess IRE emissions

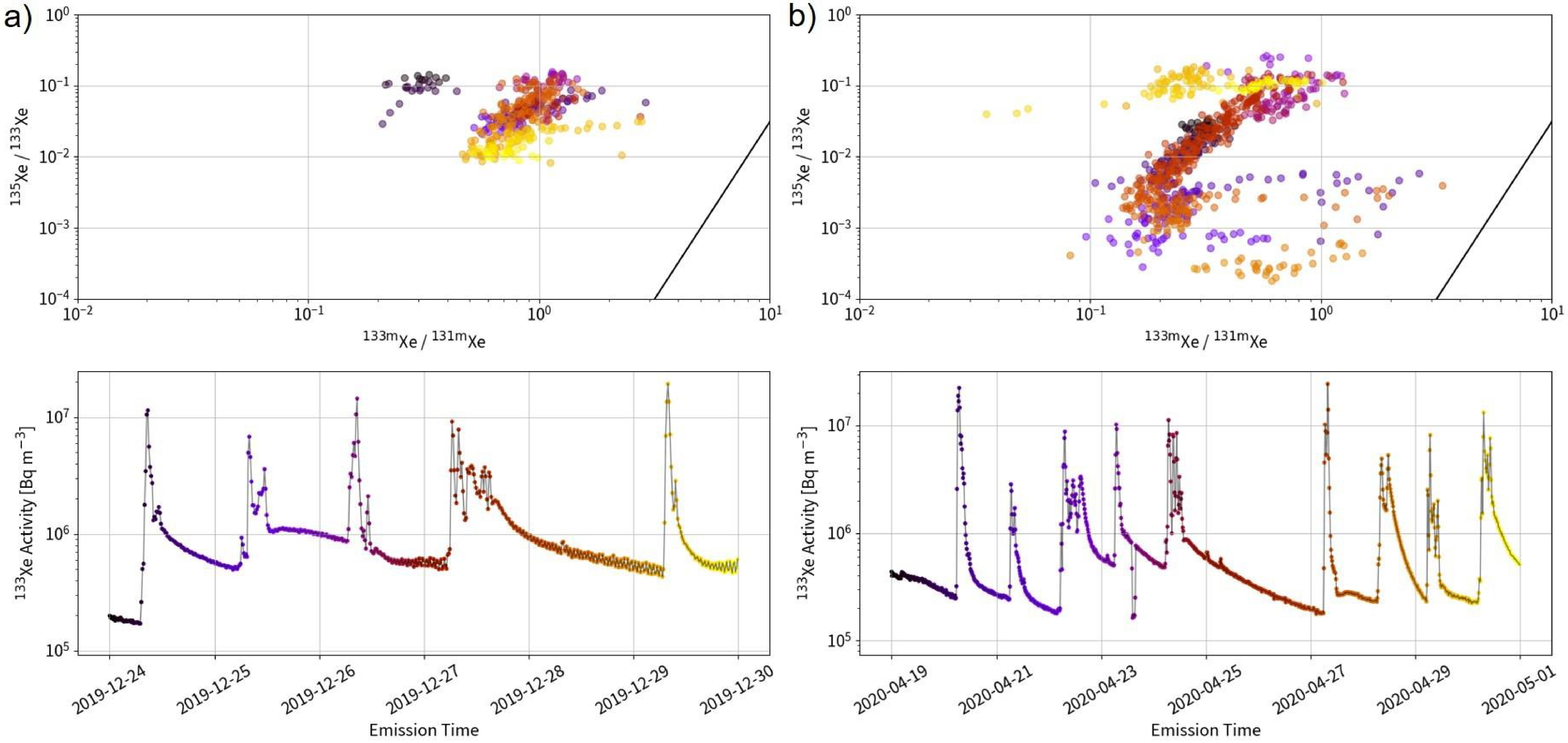


Fig. 9. STAX profile and ratio analysis, showing the evolution in the 4-isotope ratio over time for (left panel) dates in December 2019, and (right panel) dates in April 2020. The black line on the 4-isotope plot represents the discrimination line (see Kalinowski *et al.*).

STAX & ATDM Simulations vs. Measured

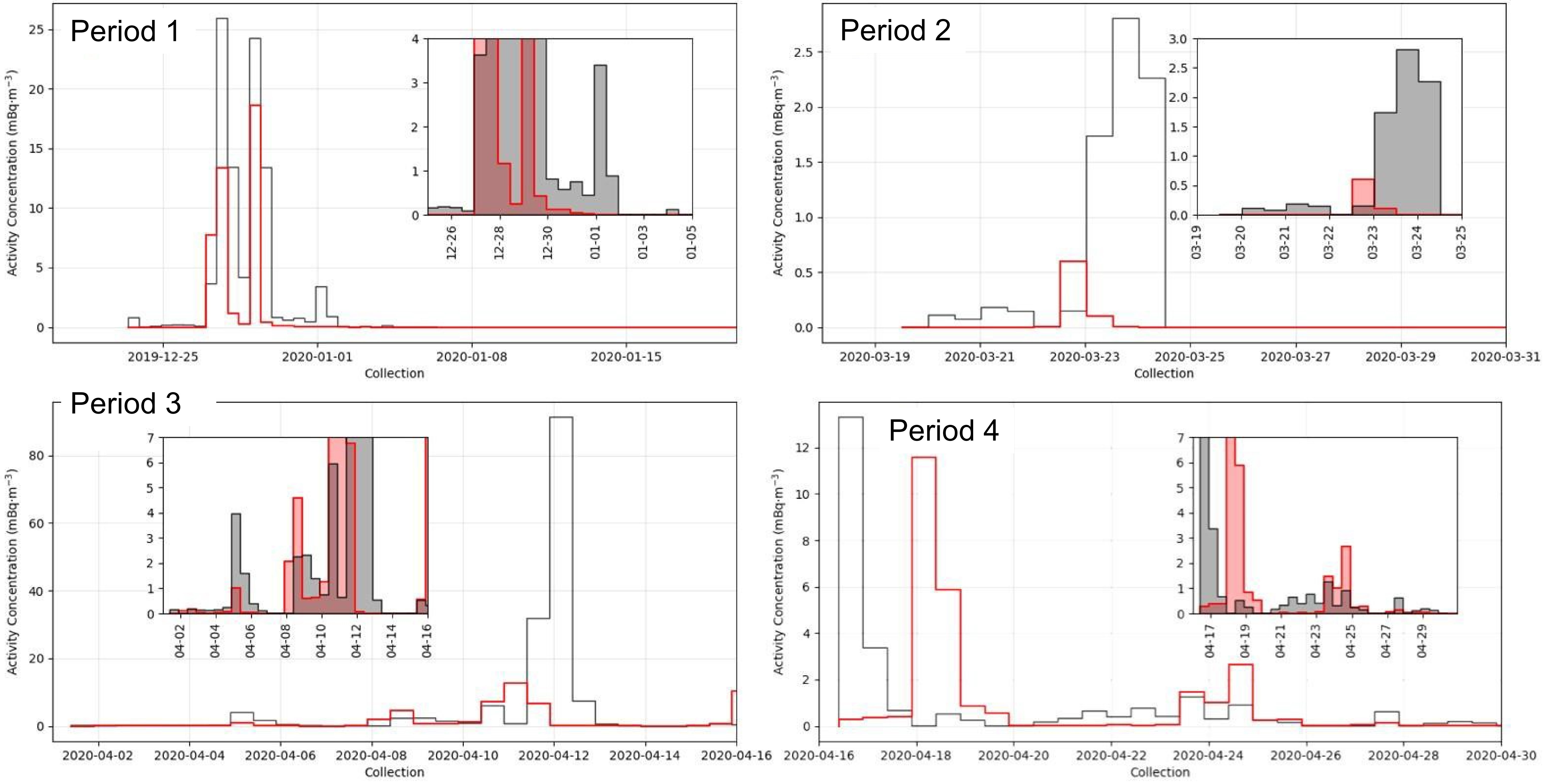
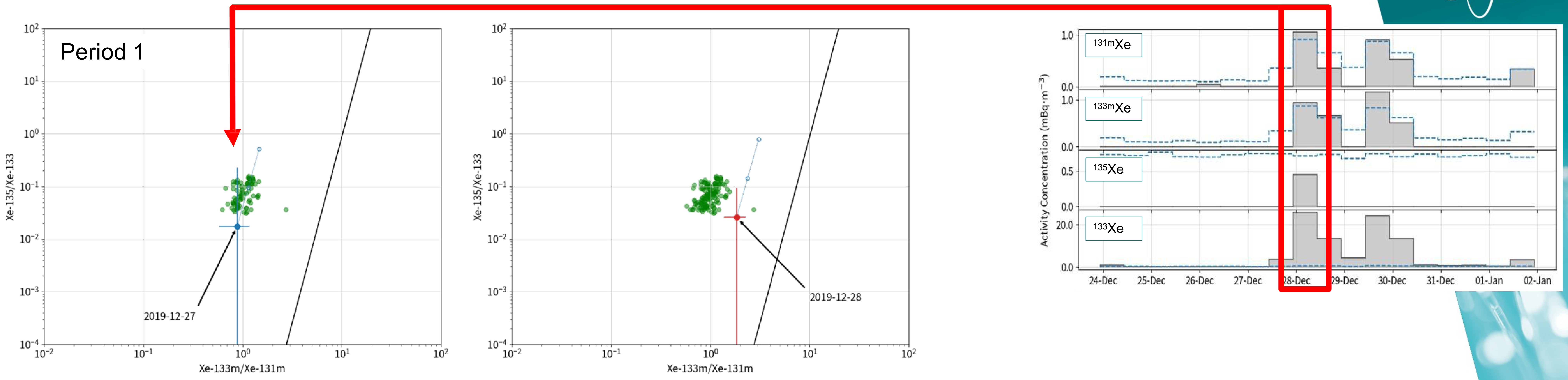


Fig. 10. Comparison of measured (**black**) and simulated (red) ^{133}Xe activity concentration at GBL15 for periods 1-4. Inset shows a zoomed and shaded view of the same data

Ratio comparison



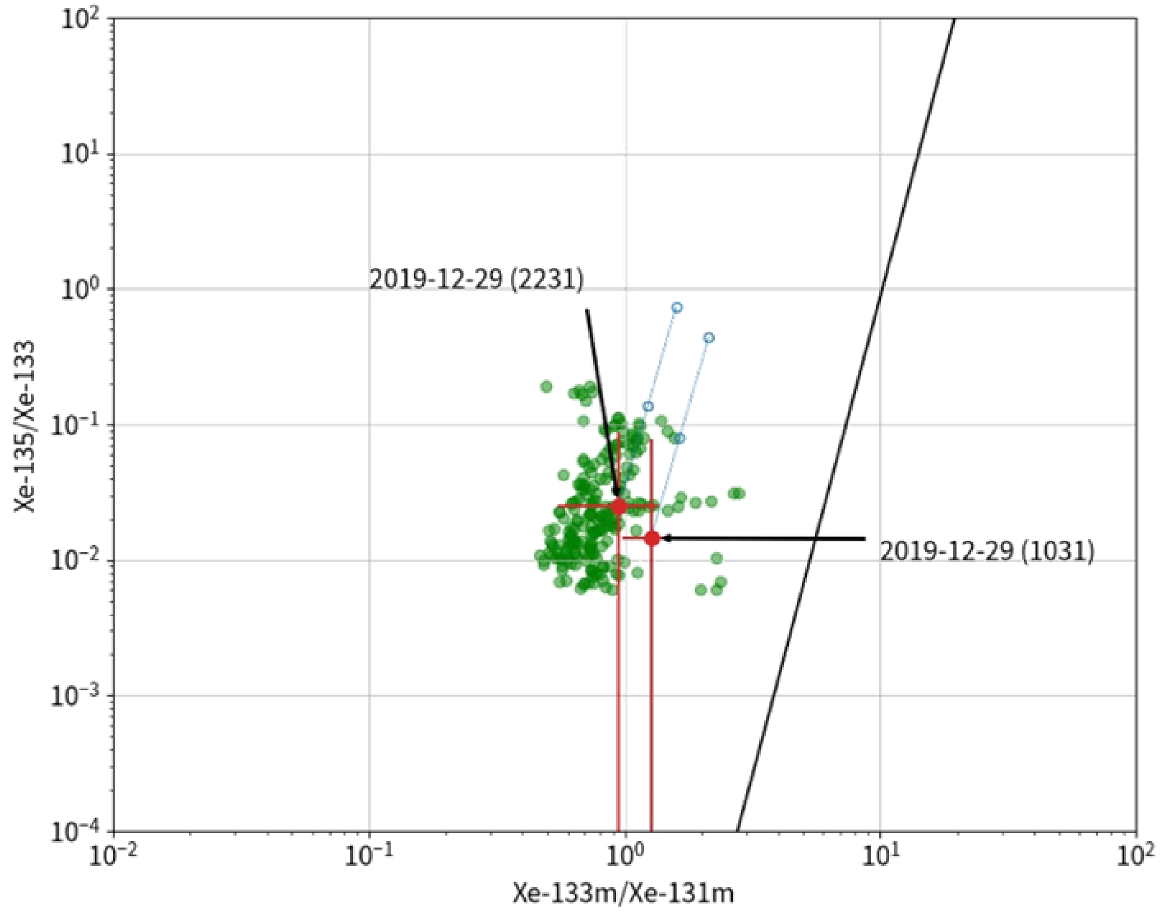


Fig. 11. Comparison of STAX ratios (green) with measured 4-isotope ratios (blue) and 3-isotope ratios (red). The blue lines represent the decay-corrected measurement for 24 & 48 hours.

NB. 3-isotope ratios are calculated using 1 L_c measurement and the uncertainty lines are expanded to show this

Conclusions

- STAX data continuously cross-checked with independent analysis
- STAX data has been used to support assessment of radioxenon detections in the UK
- Measured isotopic activity ratios are mostly consistent with STAX emissions
- Possible false positive ^{135}Xe detections (highlighted in blue box). Possible FPs will be investigated using new analysis methods such as 'OpenSpex' (FOI software)
- Figures taken from Goodwin *et al.* https://doi.org/10.1016/j.jenvrad.2021.106629

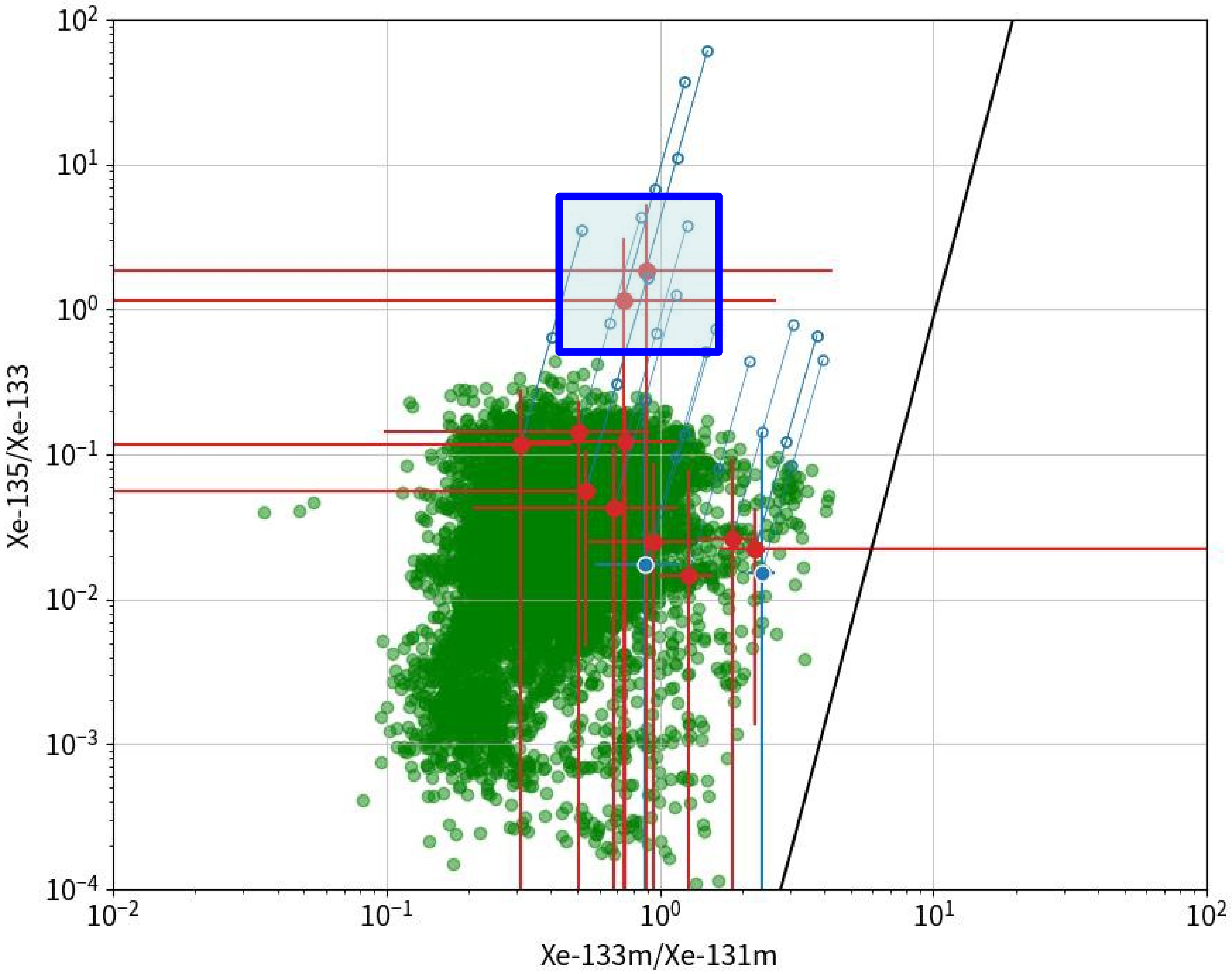


Fig. 12. Comparison of measured 4-isotope activity ratios from IRE emissions (green) and measured ratios red: 3 isotopes and an L_c and blue: 4 isotopes.

Acknowledgements

- We wish to thank PNNL for managing STAX and IRE for the provision of stack-monitoring data.

… Questions?