O3.6-799

Analysis of 12 months of radioxenon monitoring array data in the UK

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AWE NUCLEAR SECURITY TECHNOLOGIES

9th September 2025

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Motivation

Of the 300+ nuclear reactors in the world, we know very little about the radionuclide source release parameters. This work aims to characterise the radionuclide fingerprint of one reactor type – the advanced gas-cooled reactor (AGR), through partnership with Hartlepool Nuclear Power Station in the UK.

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Characterising the Radionuclide Fingerprint of an Advanced Gas-Cooled Nuclear Power Reactor

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Figure 1. XENAH project team (left) and Hartlepool Nuclear Power Station (right)

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SAUNA Q_B Array in the UK

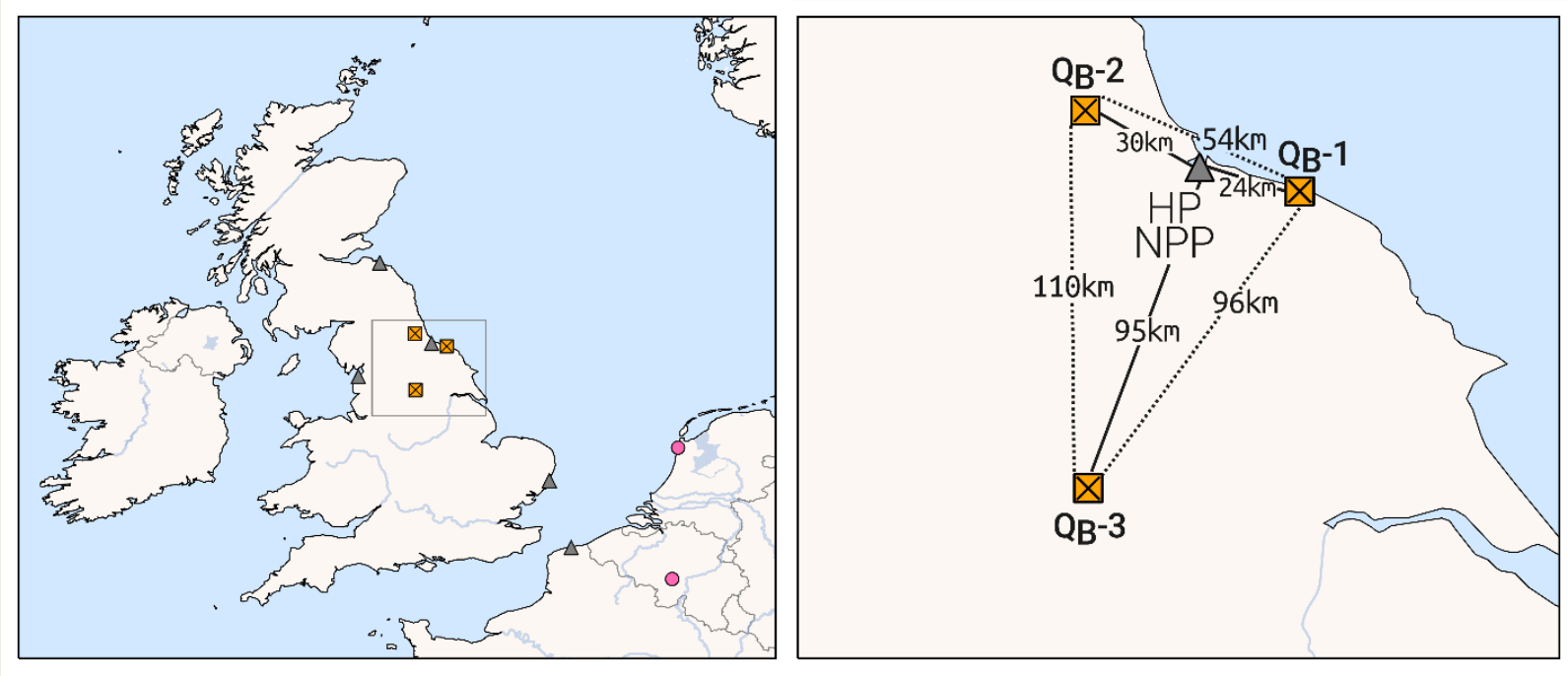

Figure 2. XENAH Q_B array (orange) with Isotope Production Facilities in pink and nearby nuclear power reactors (grey)

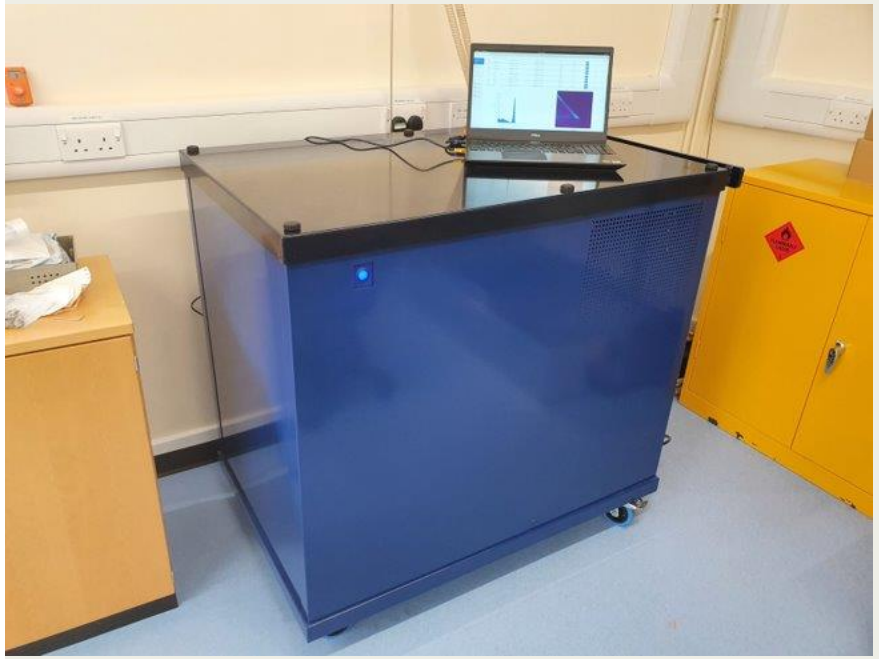

Figure 3. SAUNA Q_B installed in the UK

The SAUNA Q_B array operated between March 2022 and February 2023. Custom software was deployed to remotely monitor the system and retrieve data. For the XENAH work, analysis is completed by FOI using OpenSpex (Beta-gamma matrix method).

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^{133}Xe Array Detections

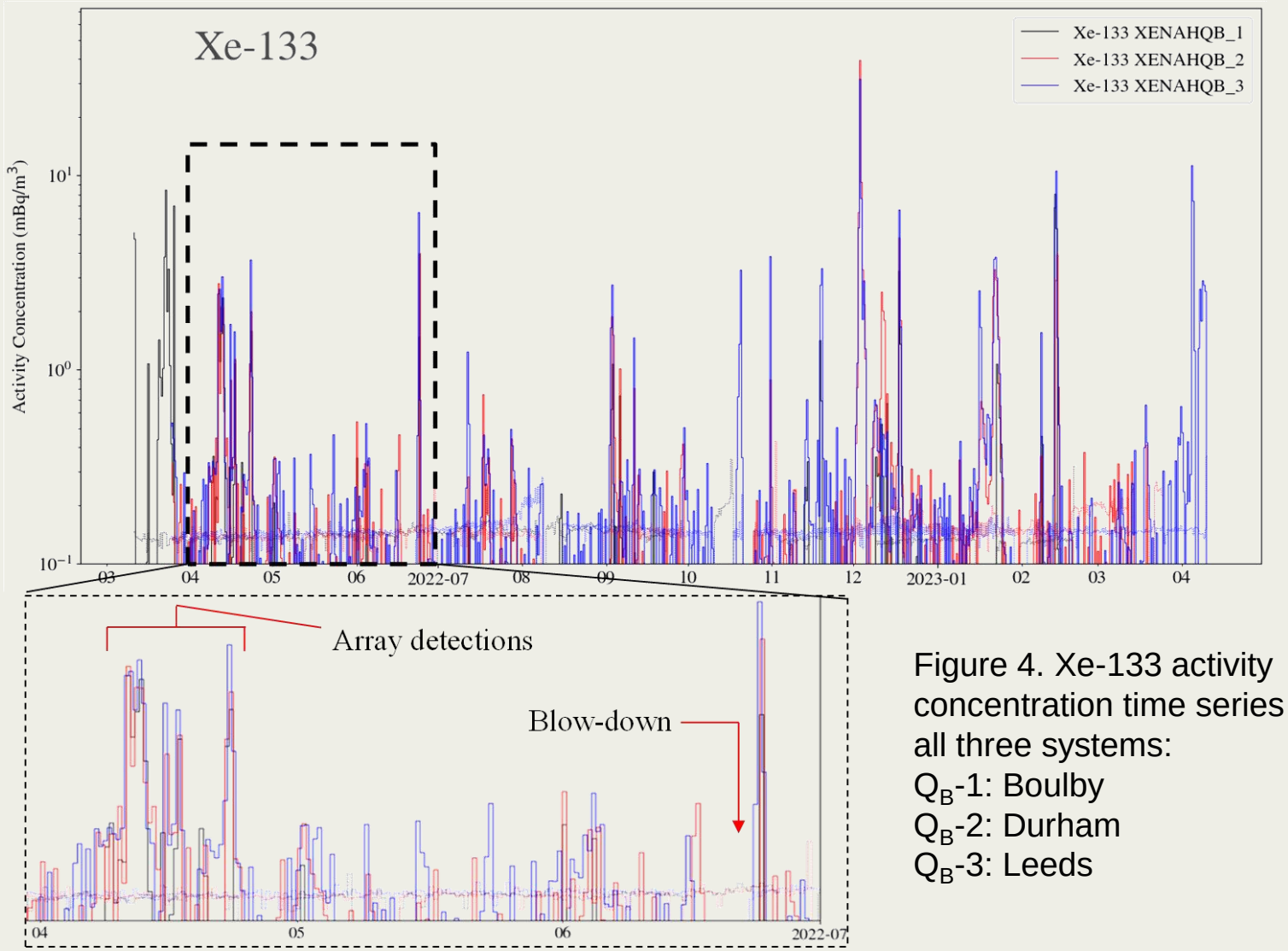

Figure 4. Xe-133 activity concentration time series for all three systems:
Q_B-1: Boulby
Q_B-2: Durham
Q_B-3: Leeds

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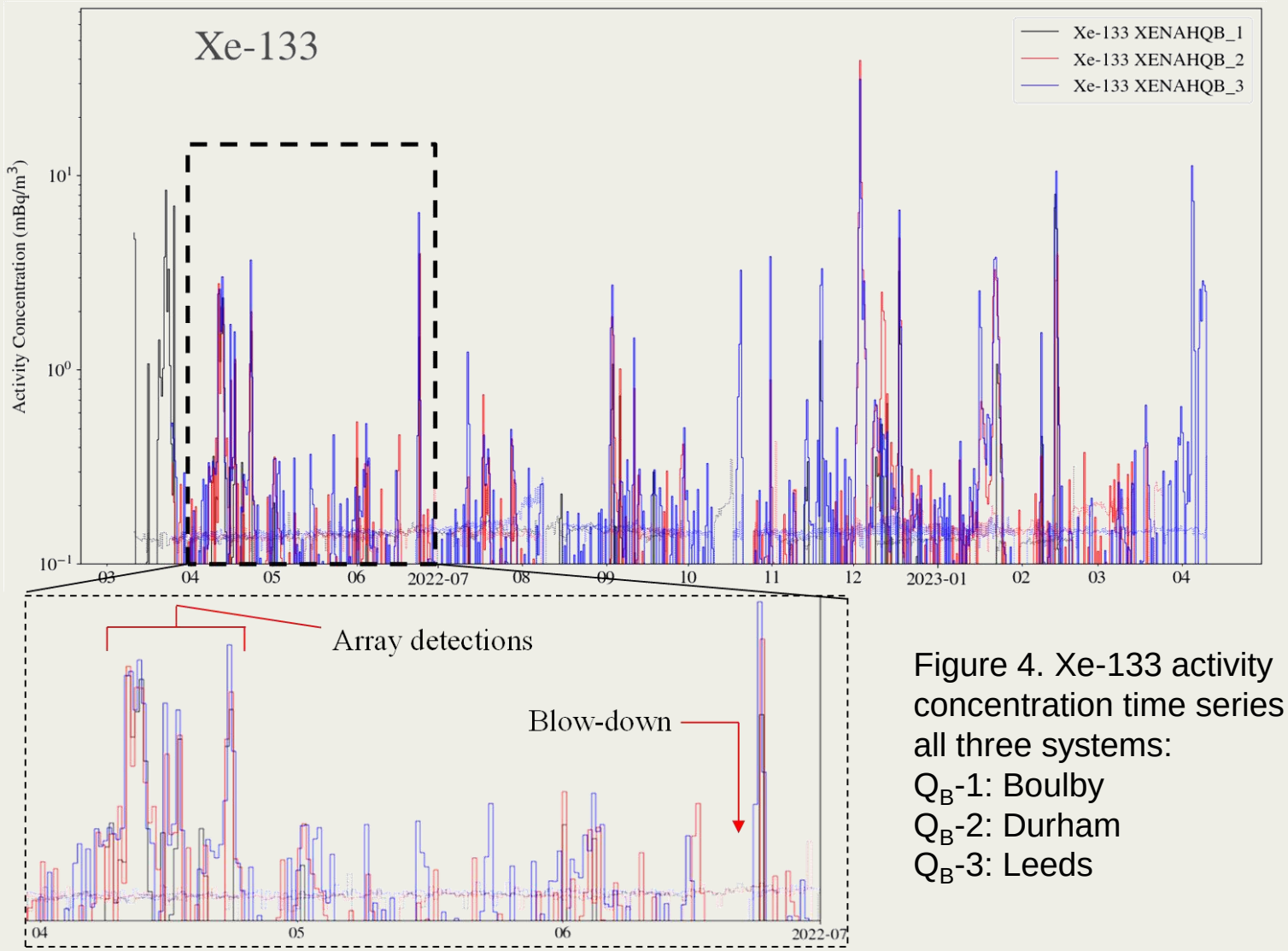

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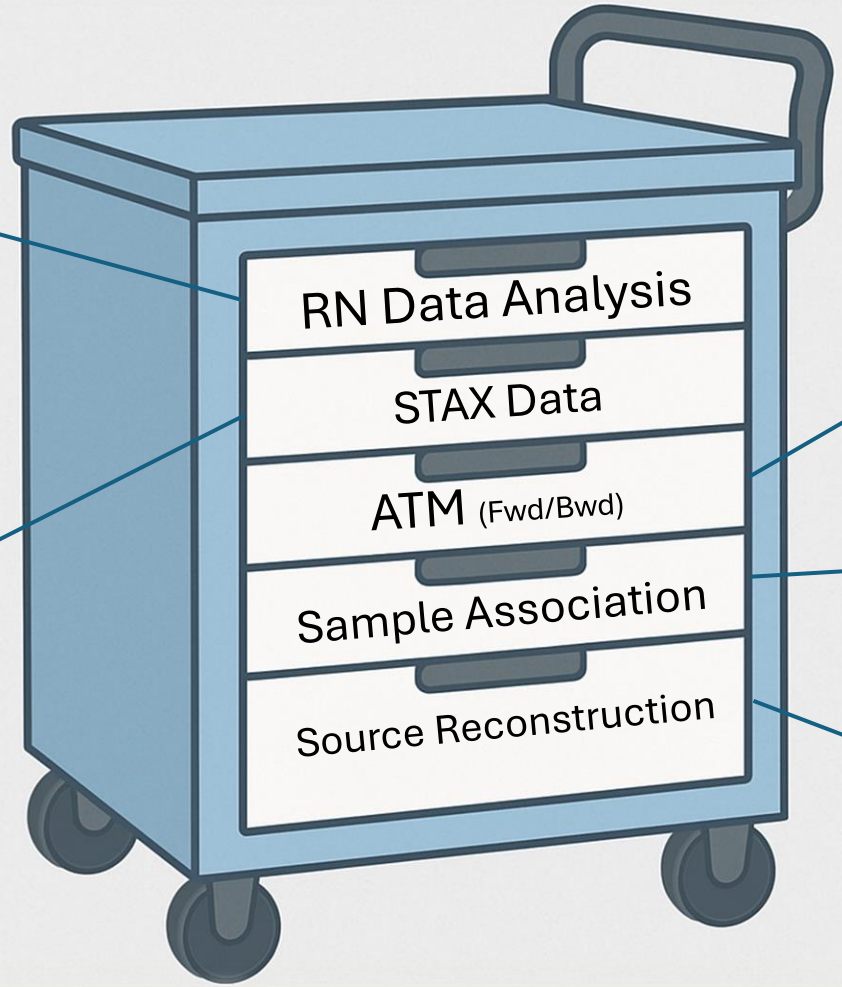
The RN Detection Analysis Toolkit

Identify anomalies, compare ratios

What can we remove as a known background source?



e.g. Possible Source Region (PSR)

Identify correlated detections

Unknown source parameter estimation E.g. Bayesian Inference

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Assessing the ^{133}Xe contribution from IRE to the XENAH Q_B Array

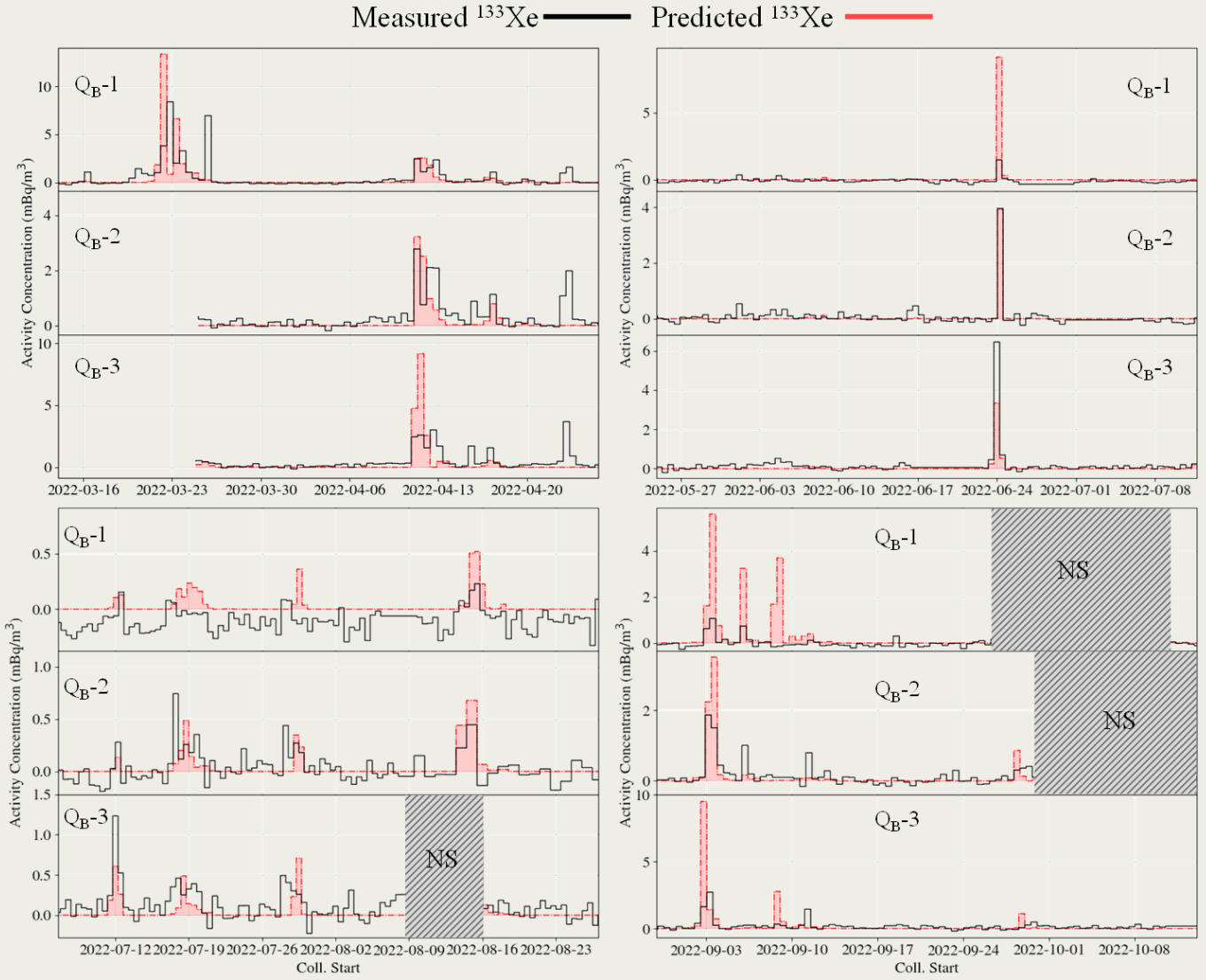

Figure 5. Measured versus simulated Xe-133 activity concentration at Q_B-1 (Boulby)

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March 2022 Blowdown

June 2022 Blowdown

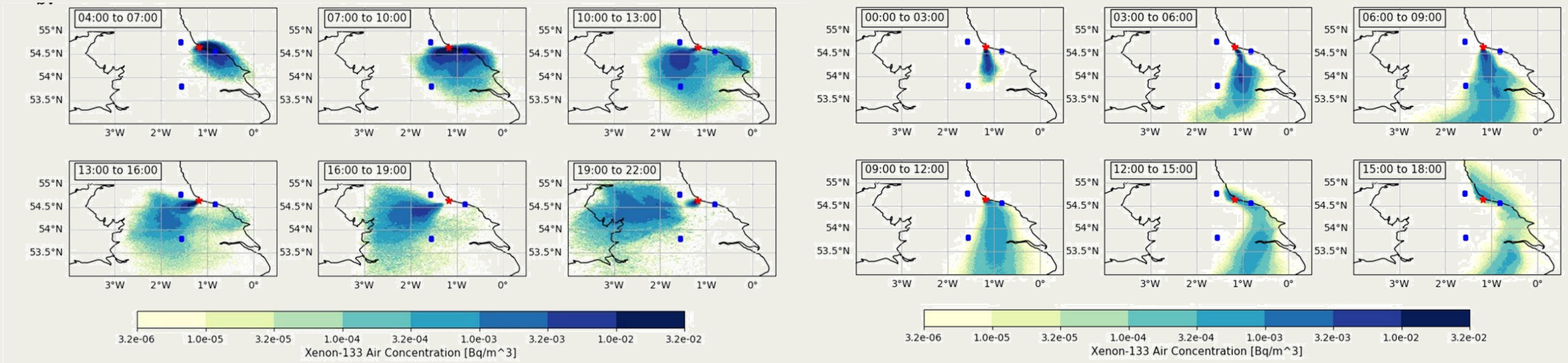

Figure 6. ATM Simulation (NAME) plots showing the plume following the March 2022 and June 2022 reactor blowdowns.

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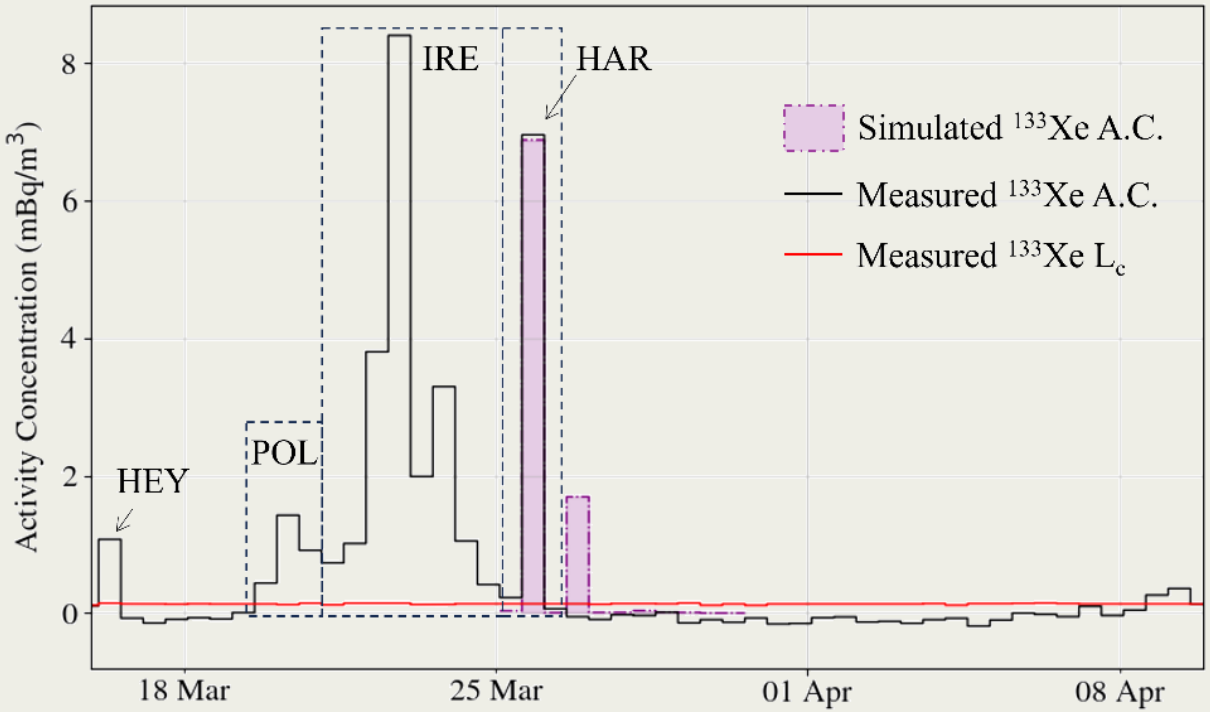
Attributing detections to likely sources



HEY: Heysham
POL: Polatom
IRE: IRE Fleurus
HAR: Hartlepool

Figure 7. Activity concentration time series for ^{133}Xe at the beginning of the SAUNA Q_B measurement campaign. The Q_B-1 system was activated around mid-March and the other systems came online in late-March. Possible sources have been assigned to the most prominent detections. Purple shows the simulated activity concentration of ^{133}Xe using GAM-calculated stack emission data from Hartlepool.

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Bayesian Source Reconstruction of anomalous detections

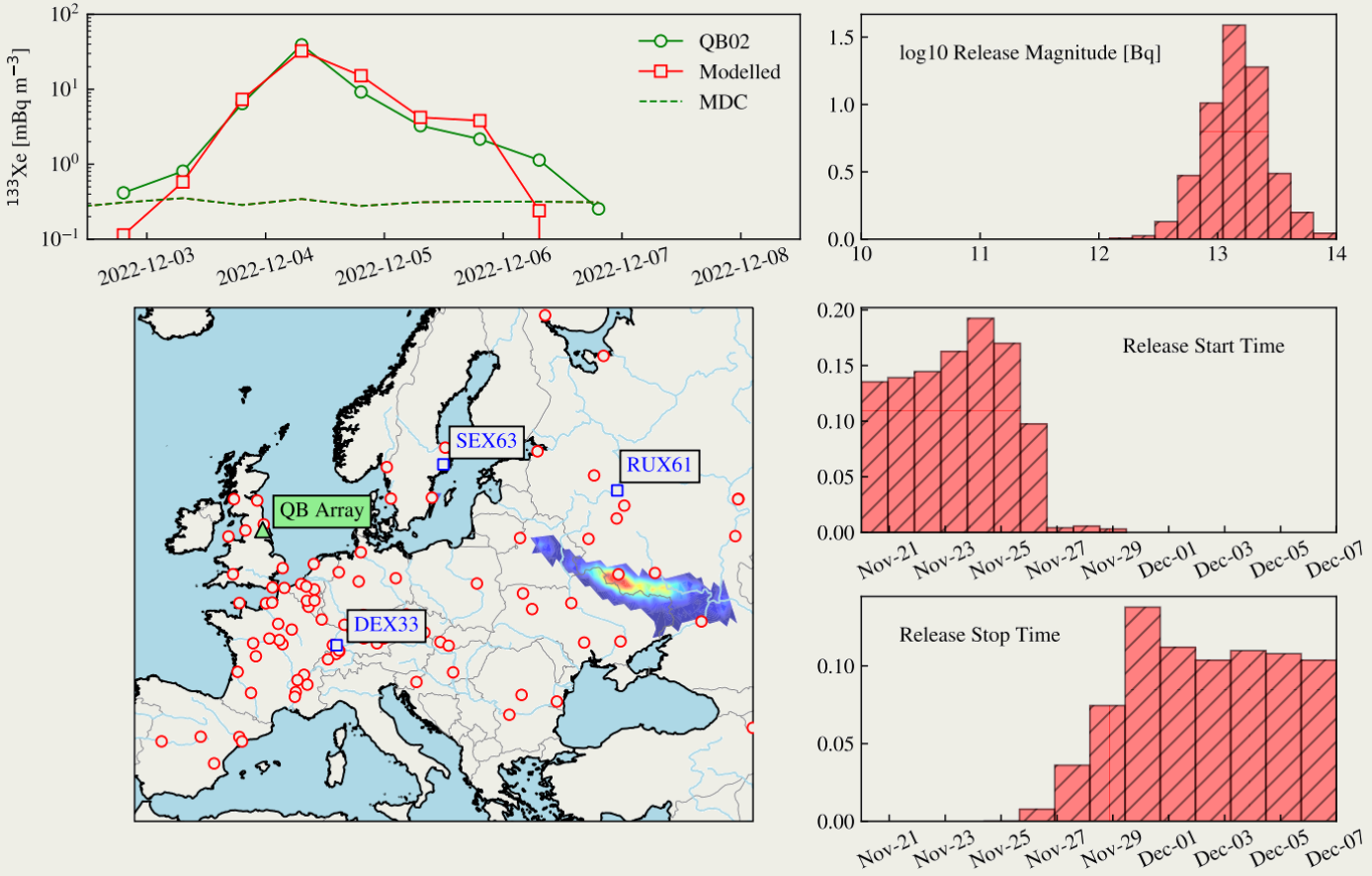

Figure 8. FREAR Bayesian source reconstruction using detections (and non-detections) on Q_B-2 during December 2022

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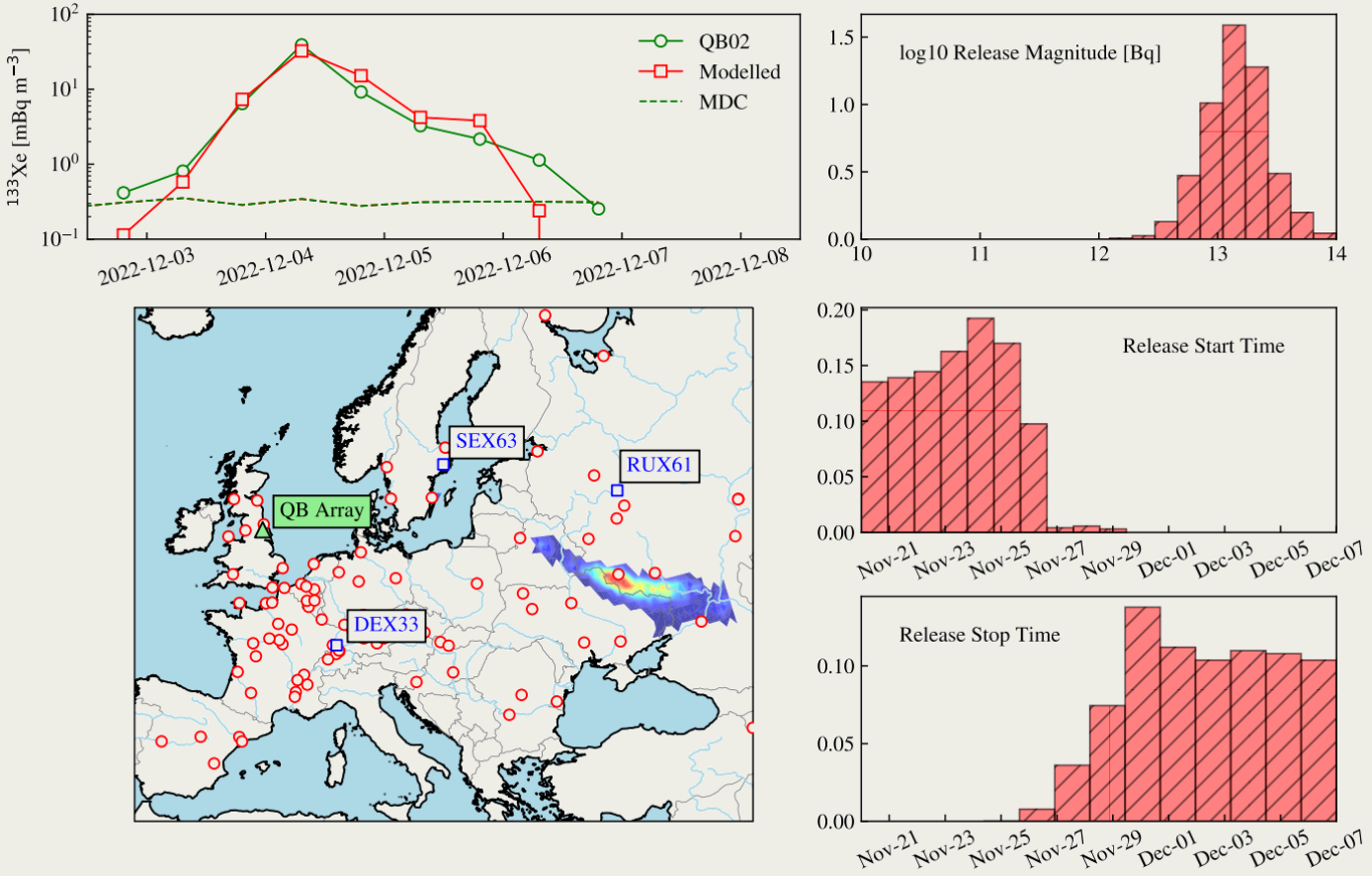

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Using an array of sensors versus a single sensor/station

Utilising multiple detects (and/or non-detects) can help constrain a source location and release parameters. Using the same set of detections from December 2022, the probability density functions show how the uncertainty in source parameters is reduced when using “array information” – compared to a single sensor.

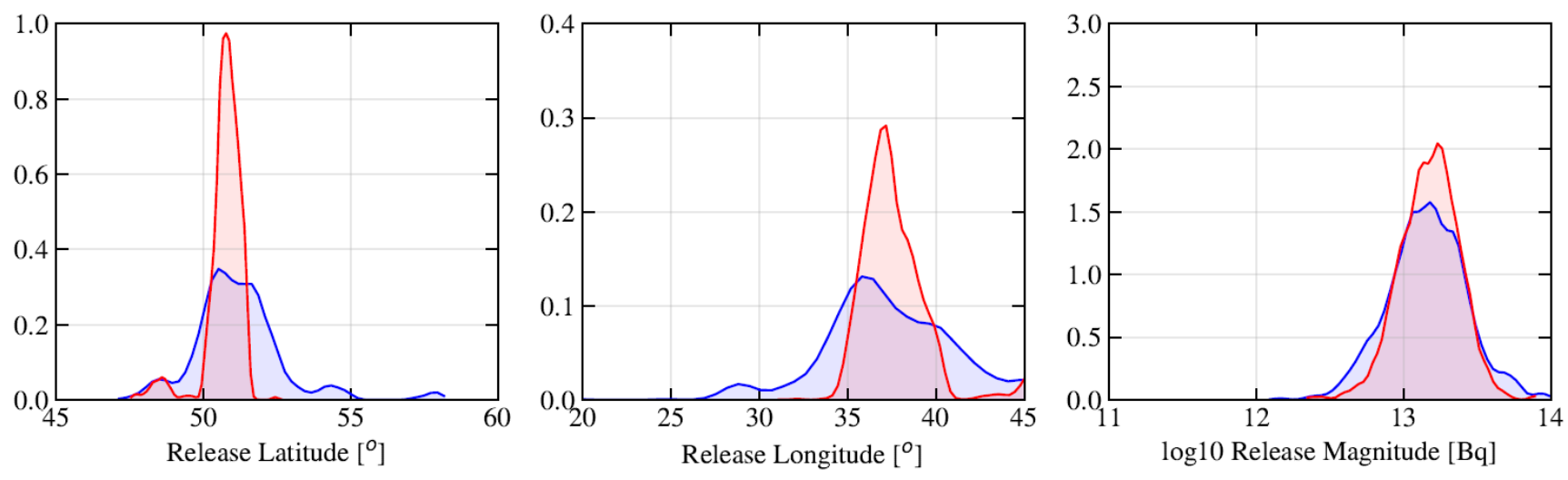

Figure 9. Comparison between probability density functions of source parameters from a FREAR analysis, using a single system (blue) versus the two systems in the array (red) for detections in early December 2022.

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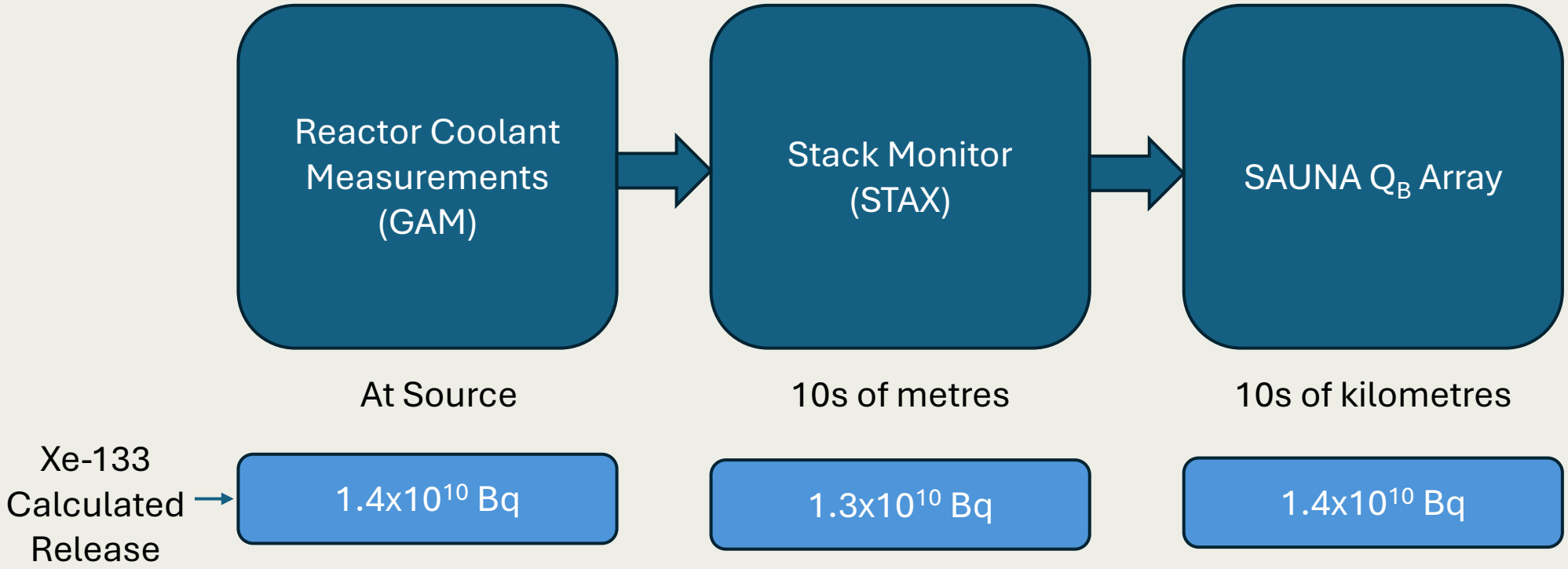
Radioxenon Quantified throughout the lifecycle



Petts, A., *et* al., (2024) Measurements of radioxenon activities during periods of gaseous release from an advanced gas-cooled reactor
https://doi.org/10.1103/PhysRevApplied.22.044060

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Summary

Our work involved the analysis and interpretation of around **350** detections of ^{133}Xe on the SAUNA Q_B array. Just one detection was definitively linked to Hartlepool Nuclear Power Station. Over **280** other detections have been positively attributed to at least one facility. **195** detections were linked to IRE (Fleurus, Belgium), which is expected to dominate the background. STAX data from IRE was extremely useful for identifying which detections were from IRE emissions.

Such a measurement campaign, focussed on emissions from Hartlepool Nuclear Power Station, would not have been successful without the IRE STAX data, due to the number of detections that were attributed to IRE and the magnitude of the background.

For ^{133}Xe detections identified on the SAUNA Q_B array and ATM simulations, it was possible to confirm the total release magnitude (1.4×10^{10} Bq), which agreed well with calculated releases from source.

The Hartlepool reactors had few operational difficulties during this measurement campaign, and as such, there were no unplanned releases of radioxenon. This confirms the binary nature of AGR emissions - almost entirely limited to reactor depressurisation.

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Questions?

Look out for our latest paper – current being revised for publication in Journal of Environmental Radioactivity – "*Analysis of Measurements from an Array of Radioxenon Samplers near to Hartlepool Nuclear Power Station*"

Would you be interested in getting involved in work like this? We are working on a new project to characterise the radionuclide fingerprint of a pressurised water-cooled reactor (PWR) in the UK. See poster **P5.1-371**.

Contact us – matthew.goodwin@awe.co.uk