Deploying a Radioxenon Sensor Array in the UK

Matthew Goodwin[1], Brian Milbrath[2], Anders Ringbom[3], Andrew Petts[4], Daniel Chester[1], Jim Hayes[2], Lance Lidey[2], Michael Mayer[2], Paul Eslinger[2], Mattias Aldener[3], Tomas Fritioff[3], Johan Kastlander[3], Chris Toth[5], Paula Chadwick[6], Patrick Stowell[6], Barbara Brooks[7], Ryan Neely[7], Susan Leadbetter[8]

1. AWE Aldermaston, Reading, UK; 2. PNNL, Richland WA, US; 3. FOI, Sweden; 4. EDF Energy, UK; 5. STFC, UK; 6. Durham University, UK; 7. NCAS, Leeds University, UK; 8. Met Office, UK

Introduction

As part of the Xenon Environmental Monitoring at Hartlepool (XENAH) collaboration, a team of scientists from the UK, US and Sweden have deployed three radioxenon sampling and measurement systems to the North of England, near to the Hartlepool Power Station. The power station comprises two 1600 MW(th) advanced gas-cooled nuclear reactors (AGRs). The array of SAUNA Q_B ("cube") radioxenon measurement systems have been in operation since March 2022 and have detected significant activities of ^{133}Xe, ^{131m}Xe and ^{133m}Xe – key isotopes of xenon that can be indicative of a nuclear explosion. This collaboration seeks to better understand the impact of civil nuclear reactors on the global radioxenon background.

Figure 1 shows the results of forward atmospheric transport modelling (ATM) simulations from Hartlepool power station and the sister station (Heysham, approx. 130 km away). The maps illustrate the detection probability at locations in the North of England.

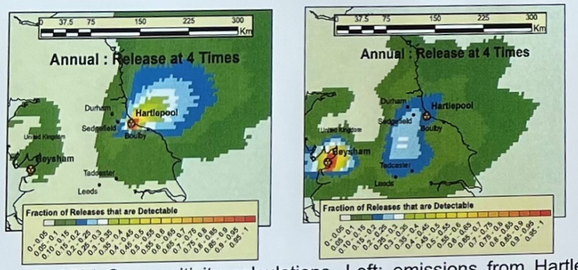


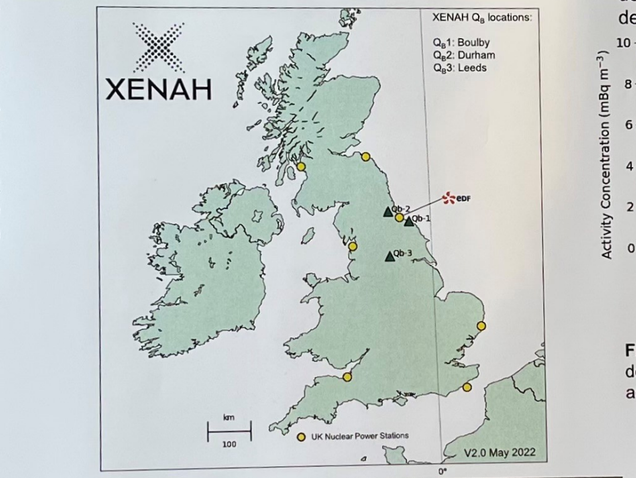
Figure 1. ATM Q_B sensitivity calculations. Left: emissions from Hartlepool reactor. Right: Emissions from Heysham reactor. Both reactors are operated by EDF Energy UK. Simulations performed using HYSPLIT with GFS met data.

System Overview

The SAUNA Q_B system samples in 12-hour intervals, collecting ~1.3 cm^3 of xenon gas each period. The xenon is measured using a beta-gamma coincidence detector system with a NaI(Tl) (γ/X-ray detection) and plastic scintillator (β/e^- detection).

Each Q_B unit is designed to have a smaller footprint, be more transportable and cost less than similar IMS-type systems, for a small drop in sensitivity (^{133}Xe minimum detectable concentration (MDC): 0.4 mBq/m^3 (Q_B) vs. 0.2 mBq/m^3 (SAUNA-III)).

The system requires 200 L of N_2 per day to process the sample, which is supplied by gas bottle(s). The data is stored in an on-board database, which is mirrored by the analysts' organisation.



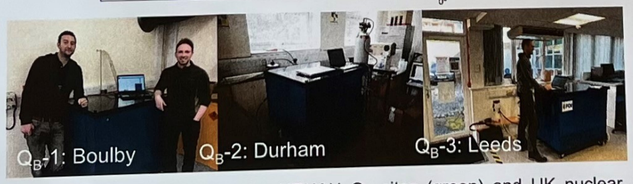


Figure 2. Above: Map showing XENAH Q_B sites (green) and UK nuclear power station sites (yellow). EDF Hartlepool is labelled with the EDF logo. Bottom: Installation photographs showing the three Q_B systems in situ.

Acknowledgements

AWE, PNNL & FOI wish to thank EDF, STFC Boulby, Durham University, University of Leeds (NCAS) and Met Office for their support in this project.

Special thanks to Ashley Davies for his part in setting up the XENAH collaboration.

Initial Results

The MDCs are around 0.5 mBq/m^3 for ^{133}Xe and 0. ^{131m}Xe and ^{133m}Xe. A background measurement h performed on two systems, so detection limits are preli Since the systems have been running, there have be detections of ^{133}Xe, ^{133m}Xe & ^{131m}Xe, and data to indic detections may be from Hartlepool Power Station.

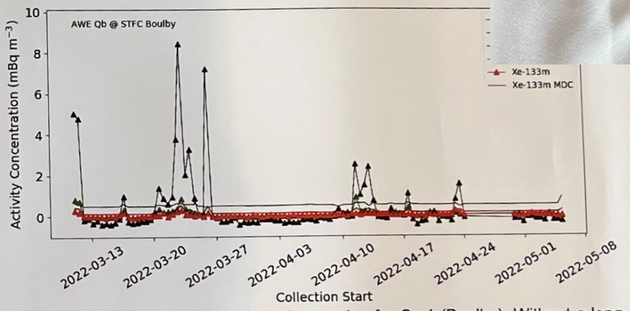


Figure 3. Activity concentration time series for Q_B-1 (Boulby). Without a long detector background measurement, the Xe-135 activity cannot be calculated accurately and hence is not shown here.

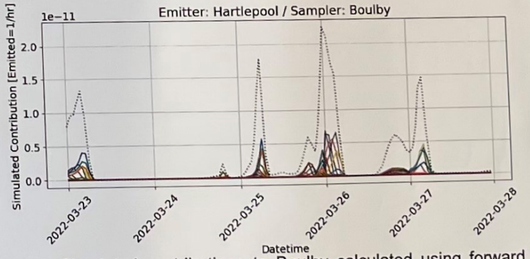


Figure 4. Simulated contributions to Boulby calculated using forward ATM simulations from Hartlepool. Simulations were completed using the Met Office NAME code and UK meteorological data (~1.5 km spatial resolution). An emission was simulated every hour between 23-MAR – 27-MAR. The dashed line shows the cumulative contribution.

The detections and simulations shown here will be combined with STAX data to determine whether they are correlated [1][2]. Early indications suggest the ^{133}Xe detection on 26th March may be from Hartlepool Power Station. **Next steps will include array analysis, STAX data inclusion, isotopic ratio analysis and further ATM simulations.**

For more information, see presentation by Andrew Petts (EDF)

[1] Goodwin, M.A. Davies, A.V., Britton, R., *J. Env. Rad.*, (2021)
[2] Ringbom *et al., Pure Appl. Geophys.* 178 (2021), 2677–2693

matthew.goodwin@awe.co.uk