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Stack data processing pipeline

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Source Term Analysis of Xenon – The STAX project

The STAX project is an experiment focused on development of a worldwide Medical Isotope Production (MIP) stack detector network to measure radioxenon released from MIP facilities and use that data to help develop and test methods to improve discrimination between industrial activities and nuclear explosions.

Background facts:

- Anthropogenic radioxenon background caused by industrial activities is frequently detected at IMS stations. In order to be able to characterise the nature of an event, the ability to discriminate between radioxenon relaesed from industrial activities from nuclear tests is of vital importance.
- The main source of radioxenon isotope in the atmosphere are medical isotope production facililities (MIPs) and nuclear power plants (NPPs), with the global emissions from the major MIPs being more than a factor of 10 higher than from all NPPs worldwide (Achim et al 2016, Gueibe et al 2017)
- While noble gas detections are most strongly affected by industrial background, other volatile radionuclides, such as Iodine isotopes, can also be released from industrial activities and are also detected by the IMS.
- The identification of an event can, under favorable conditions, be done by analysis of the isotopic composition (isotopic ratios) in a measured sample, however:
  - releases from MIPs may have isotopic ratios not distinguishable from releases from nuclear test
  - not all nuclides needed for the isotope ratio based discrimination may be above the detection limits. In fact, a large fraction of detections in the IMS are detections of ^{133}Xe only, not allowing to apply ratio based discrimination.
- As an alternative to discrimination based on ratios, if in a detected signal, the contribution of known background sources (i.e. industrial activities) can be excluded or quantified, the number of potential sources of an event can be reduced, giving higher confidence in association of a detection to a specific event.

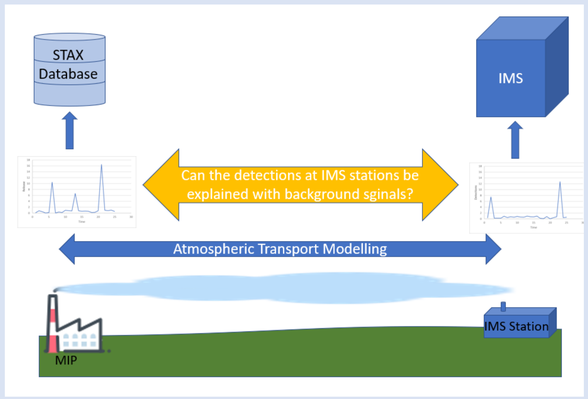


Figure 1: Basic concept of the STAX experiment: Detections of releases from the stack of facilities are associated with detections at IMS stations based on Atmospheric Transport Modelling

STAX network - technical design overview

- In order to measure the overall Xenon release of a MIP facility, STAX monitoring systems are installed in the final stack which collects all off-gases
- Sampling gas is branched of the main stack
- Sampling is performed by continuous flow through a sampling chamber which is close to or surrounds a HPGe detector system
- The time resolution of the release data is determined by the detector acquisition time, which is set to 15 minutes

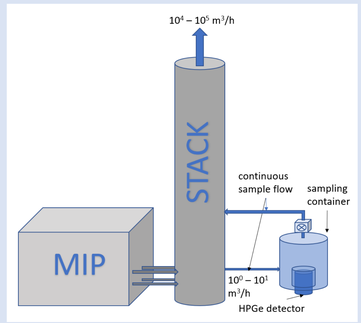


Figure 2: Layout of a STAX monitoring system

- Spectra, State-of-Health (SOH) data and analysis results are transferred to a central data server (staxdata.net) from where data can be either forwarded or downloaded to approved users:

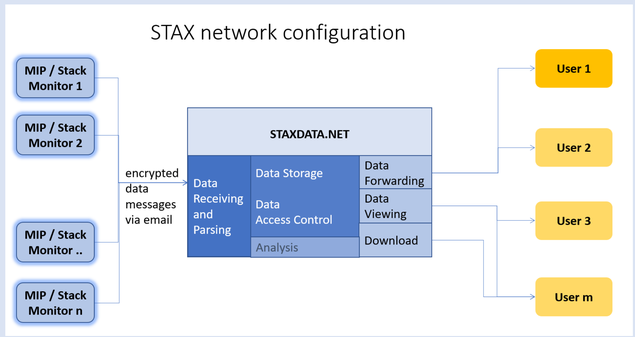
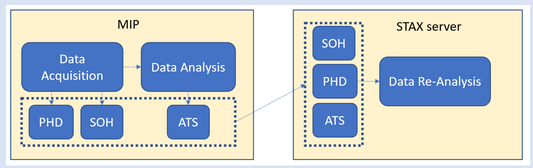


Figure 3: Overview of the STAX network layout: Data sent from MIPs are available to userse via a central data server

Data Analysis

- Facility operators may decide not to send spectra but only the amount of released isotope activities to the STAX data server, therefore, spectra analysis is performed at the medical isotope production facility, using the gamma spectra analysis software provided by the monitoring system manufacturer
- Data that are sent to staxdata.net are: analysis results (i.e. detected amounts of isotopes released from the stack), detector calibration and sample information, State-of-Health data and, optional, pulse height data (gamma spectra)
- If also spectra are sent from a facility, automated analysis is performend at the central data server for comparison with the analysis results sent from the facility



Automated Time Series (ATS) Format

- In addition to spectra (PHD) messages every 15 minutes, State-of-Health (SOH) messages every 2 hours and alerts, once per day an Automated Time Series (ATS) message is sent to staxdata.net
- The ATS has been defined in order to summarize the measurement data and results of a series of measurements within a time period. For a 24 hour period, each ATS file contains data and results from 96 15 minutes measurements. ATS files are written in JSON format (JavaScript Object Notation).

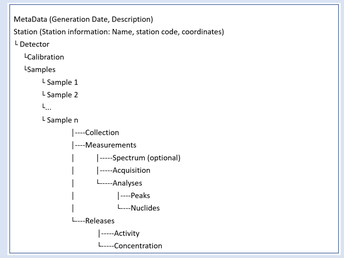


Figure 4: ATS format structure

Data Access control and data security

- e-mail messages from facilities to the central server and from the server to users are authenticated and encrypted
- Access to data from MIP facilities is only to authorized users and can be set user specific:

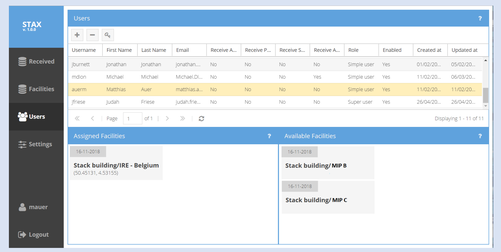


Figure 5: User access control

System monitoring and data viewing

- Tools to process and view SOH data and to view analysis results are currently under development
- Similar to IMS systems, STAX monitoring systems are sending state-of-health (SOH) data on detector and sampler status (e.g. cooler power, air flow of sampler). SOH data can be system specific and station specific alert levels for critical SOH data can be set via the STAX server interface. Operators are notified by email messages in case SOH data indicate a critical system status
- All SOH data sent by a station will be viewable on the staxdata.net
- In addition to downloading data messages from the STAX server, an isotope release viewing interface will be provided on staxdata.net. This will allow to view and download time series of isotope releases of each detected isotope. The data displayed will be activity released from the stack per a user specified time interval, e.g. release over 15 minutes, 30 minutes, 1 hour,...

References:
Achim, P., Generoso, S., Morin, M., Gross, P., Le Petit, G., Moulin, C.: Characterization of Xe-133 global atmospheric background: implications for the international monitoring system of the comprehensive nuclear-test-ban treaty; J. Geophys Res-Atmos 121, 2016

Gueibe, C., Kalinowski, M. B., Bare, J., Gheddou, A., Krysta, M., Kusmierczyk-Michulec, J.: Setting the baseline for estimated background observations at IMS systems of four radioxenon isotopes in 2014; J. Env. Rad., 178-179 (2017)

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