PROGRESS IN ADVANCED SPECTRAL ANALYSIS OF RADIOXENON

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ABSTRACT

Improvements to a Java based software package developed at Pacific Northwest National Laboratory (PNNL) for display and analysis of radioxenon spectra acquired by the International Monitoring System (IMS) are described here. The current version of the Radioxenon JavaViewer implements the region of interest (ROI) method for analysis of beta-gamma coincidence data. Upgrades to the Radioxenon JavaViewer will include routines to analyze high-purity germanium detector (HPGe) data, Standard Spectrum Method to analyze beta-gamma coincidence data and calibration routines to characterize beta-gamma coincidence detectors. These upgrades are currently under development; the status and initial results will be presented. Implementation of these routines into the JavaViewer and subsequent release is planned for FY 2011-2012.

OBJECTIVES

As the IMS radionuclide stations become fully populated and certified, the data collected will become more profuse. Collection and measurement of radioxenon is an important aspect for verification of treaties (Bowyer, 2002). Analysis tools that can process, display, and provide rapid calculations will be required to keep up with the data flow. The research performed by the radioxenon JavaViewer project will provide the US National Data Center (NDC) with a radioxenon viewer/analyzer for displaying and analyzing noble gas data. Additionally, the JavaViewer will provide a framework for PNNL to investigate alternative radionuclide analysis methods and, when appropriate, update the NDC analysis package with the improved methods.

Since the IMS stations use nuclear detector materials including high purity germanium (HPGe), sodium or cesium iodide and plastic scintillator the analysis software needs to be highly flexible. Currently, the JavaViewer is capable of loading and analyzing $\beta-\gamma$ data (using the sodium/cesium iodide and plastic scintillator) from the NDC. However, it is also necessary to incorporate analysis algorithms for HPGe detectors from radioxenon stations like the IMS Systéme de Prélèvements et d'Analyse en Ligne d'Air pour quantifier le Xénon (SPALAX™) (Fontaine et al., 2004) and possibly particulate stations like the Radionuclide Aerosol Sampler/Analyzer (RASA) systems in the future. This will provide the NDC with a comprehensive analysis capability and data management solution.

Two other functionalities within the current scope of the project also need to be implemented. The first functionality is the standard spectrum fitting method (Biegalski, 2007; Cooper, 2008). The first nuclear weapon test by North Korea demonstrated the need to perform spectral fitting -instead of the typical regions of interest - for samples with very low activity. To address this, standard spectral fitting is being investigated. Standard spectral analysis may be integrated into the JavaViewer, but will require significant cross checking with the current accepted analysis methods. The second functionality to be implemented into the JavaViewer is the $\beta-\gamma$ detector calibration calculations. Integrating PNNL calibration methodologies (McIntrye, 2009) into the JavaViewer will provide the calibration calculation routines to analysts and researchers in a single and consistent manner. It may potentially lead to an automated calibration routine which can be used by basic users as opposed to requiring an expert to perform the calibration.

Finally, isotopic ratio analysis and trending displays will be added to the JavaViewer beta version. Ratios between the various radioxenon isotopes can be used to better illuminate changes in the concentrations from a specific station, and help differentiate between releases from a medical isotope production facility from other sources (Carman, 2002; Bowyer, 2007). Displays of the concentrations over selected periods of time in history will provide a quick method to perform trend analysis and understand any changes to a particular station.

RESEARCH ACCOMPLISHED

The initial beta version of the JavaViewer program has been installed and is being used at the NDC. Feedback from the first 6 months of use has been received and is currently being incorporated into an update, which will be released at a later date. The feedback was primarily for changes to optimize the graphical user interface (GUI) for efficient workflow.

Currently, the new version of the JavaViewer is capable of displaying data generated from the SPALAX HPGe (see **Figure 1**) with the correct energy calibration. Work is ongoing to implement fitting routines for the data analysis. This will take the form of Gaussian peak fitting and background subtraction. Once the data fitting routine is complete and the isotopes can be resolved, concentration calculations will be implemented. The concentration calculations for the HPGe data will necessarily need to be different than for other detector material types.
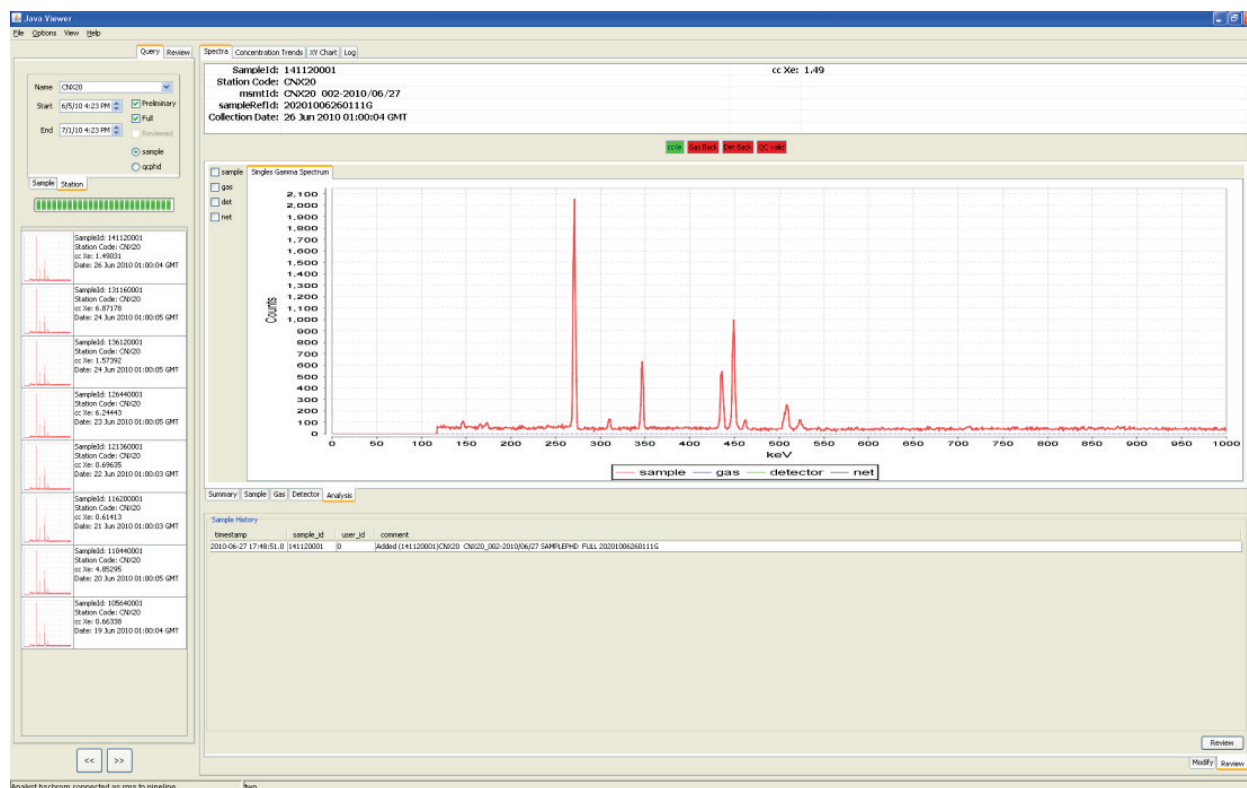
Figure 1. HPGe data from a SPALAX system as loaded and displayed in the JavaViewer software.

As part of the software development process, PNNL staff visited the International Data Center (IDC) in Vienna, Austria to receive a demonstration of the current analysis code, Simulation Assisted Interactive Nuclide Review Tool II (SAINT II). This code will be used to cross-check and validate the HPGe analysis in the JavaViewer.

Work has begun on implementing an evaluation version of the standard spectrum analysis method for use in analyzing radioxenon beta-gamma coincidence spectra. This incorporates the work of Biegalski et al. and in the first stage will add a robust user interface to a stand-alone version. The new user interface will undergo validation testing by comparing analysis results to the existing ROI analysis method. In the future, the standard spectrum fitting routines will be incorporated into the JavaViewer program itself.

Work is also underway to incorporate PNNL calibration programs into the JavaViewer. The calibration routine will determine, from appropriate data files, the ROI ratios and efficiency for a detector. The initial intent is to calibrate PNNL developed β−γ detector systems but could be broadened to include other detectors as well. This routine is only meant to be an aid for an expert analyst who will be required to ensure the energy calibration is correct.

An update to the beta version of the JavaViewer is currently undergoing testing which will help further refine the calculation accuracy and the graphical user interface.

A station history display tab has been added to the beta version of the JavaViewer to provide a display for trending analysis. Currently, the station history of radioxenon isotopic concentrations is displayed for the range of dates queried in the JavaViewer. This includes measured values as well as minimum detectable concentrations (MDC). The user interface plots activity concentration, in millibecquerel per standard cubic meter of air (mBq/SCM), versus time. The screen capture below shows the xenon concentrations for IMS station JPX38 during June 2010. The black line is the measured concentration and the red line is the MDC. As can be seen in the figure there is one day during the month which had an event above background. This plot demonstrates the importance of data trending; it shows that Xe-135 concentrations for this system likely have a positive bias.
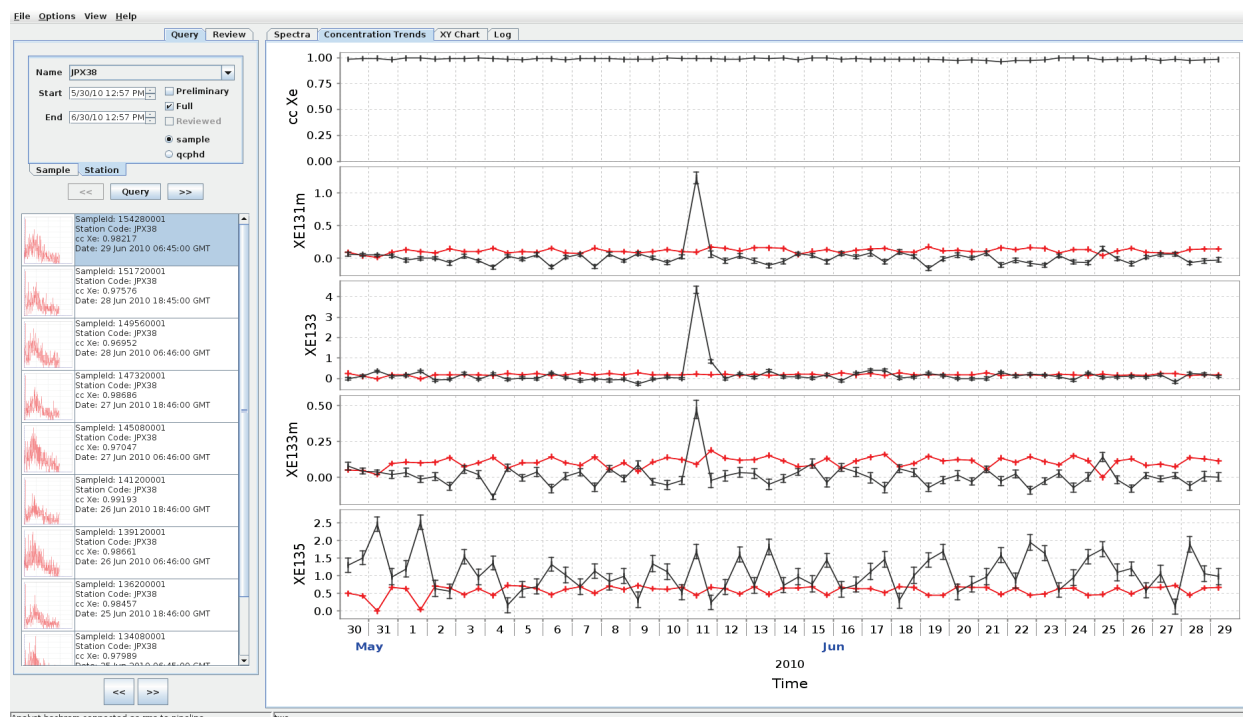
Figure 2. Screenshot of the station history function from the JavaViewer.

CONCLUSIONS AND RECOMMENDATIONS

The research presented here extends the development of the Radioxenon JavaViewer and provides a more comprehensive analysis of data produced by the IMS radioxenon network. The JavaViewer already demonstrates several features that clearly show the need for and usefulness of the application. Further work will result in a more complete data analysis system and a test bed for future improvements.

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