Stilbene Cell for Radioxenon Detection

MTV Kickoff Meeting

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C. Sivels[1], S. D. Clarke[1], A. Prinke[2], J. McIntyre[2], S. A. Pozzi[1]

[1]University of Michigan, [2]Pacific Northwest National Laboratory

Motivation: Verification of The Comprehensive Nuclear-Test Ban Treaty

- Bans all nuclear testing
- Has been signed by over 150 countries but is not yet ratified
- Established a verification regime consisting of 4 continuously monitoring technologies:
  - Seismic
  - Infrasound
  - Hydro acoustic
  - **Radionuclide**
    - Noble gases can reach the surface even in underground explosions

International Monitoring System: Radionuclide Stations

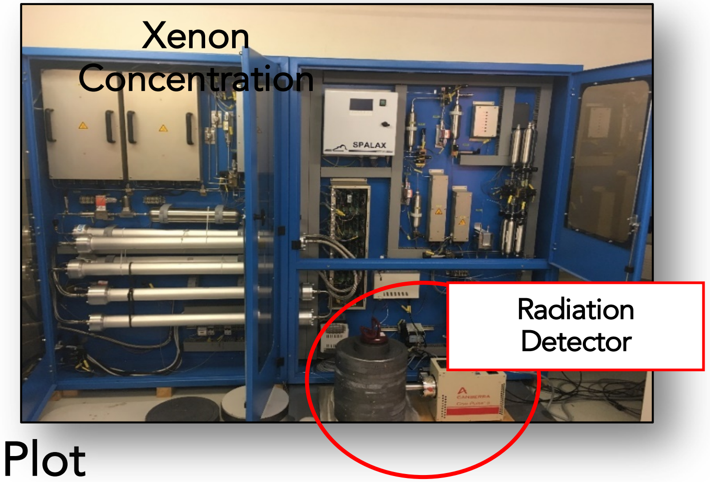
Ctbto.org

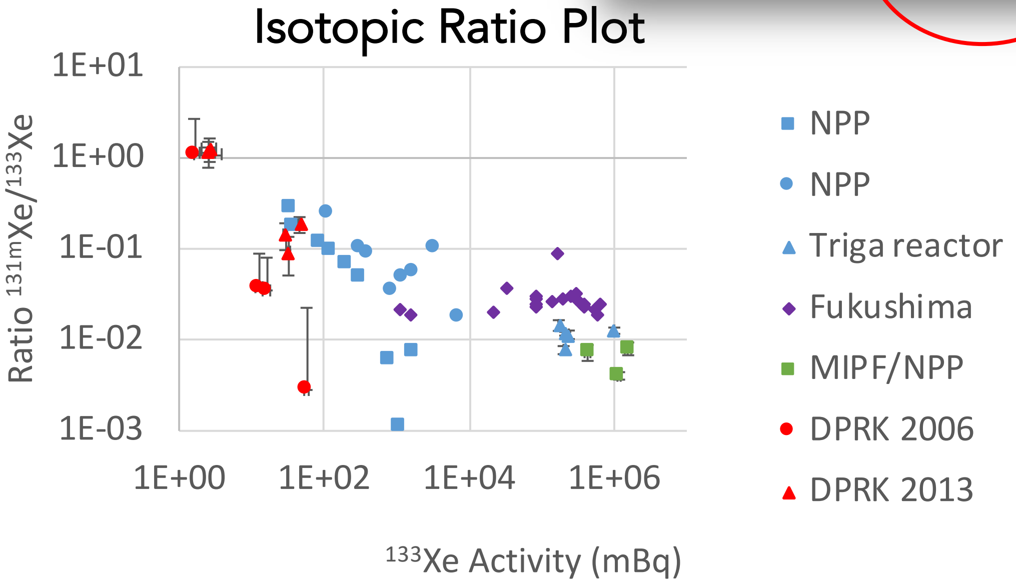
67 radionuclide stations worldwide (red)
80 total radionuclide stations planed (grey)
25 radioxenon stations (R+)

Mission Relevance
Radioxenon for Nuclear Explosion Monitoring

- Radioxenon has the highest cumulative fission yield of the noble gases produced
- Various modes of decay
- Detection systems consist of two main components
  - Gas processing
  - Nuclear detector
- Radioxenon has been measured from a variety of sources such as Chernobyl, Fukushima, and DPRK nuclear tests

CTBTO SPALAX Station (Vienna, Austria)

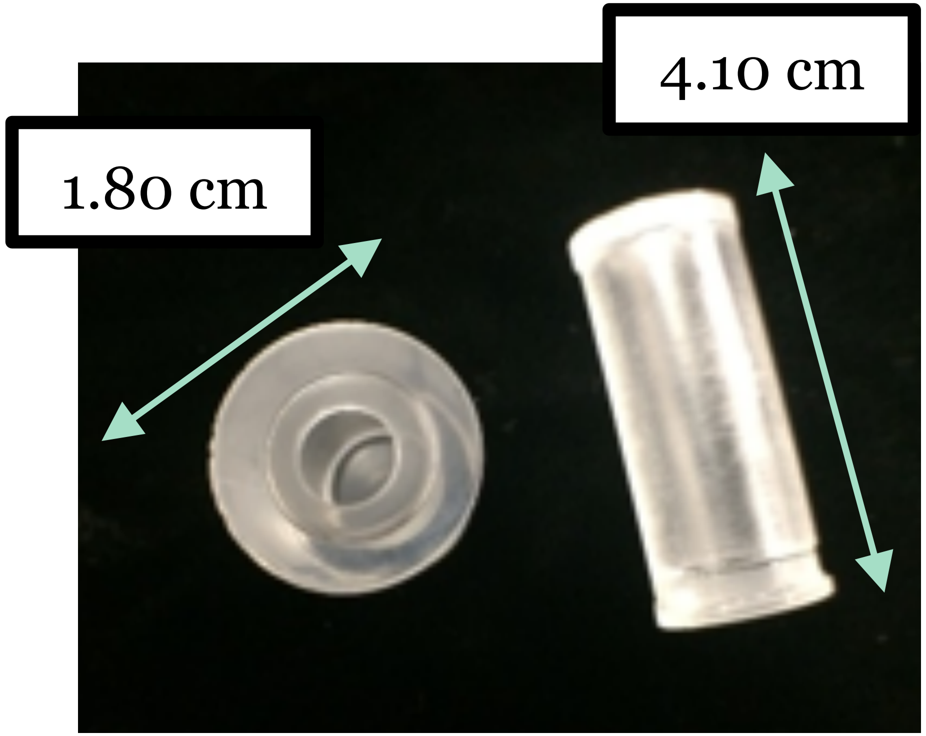




C. B. Sivels, A. M. Prinke, J. I. McIntyre, S. D. Clarkei, S. A. Pozzi, "Anticoincidence analysis for radioxenon detection," Journal of Radioanalytical and Nuclear Chemistry, vol. 318, 1, pp. 561-567, 2018.

Technical Work Plan

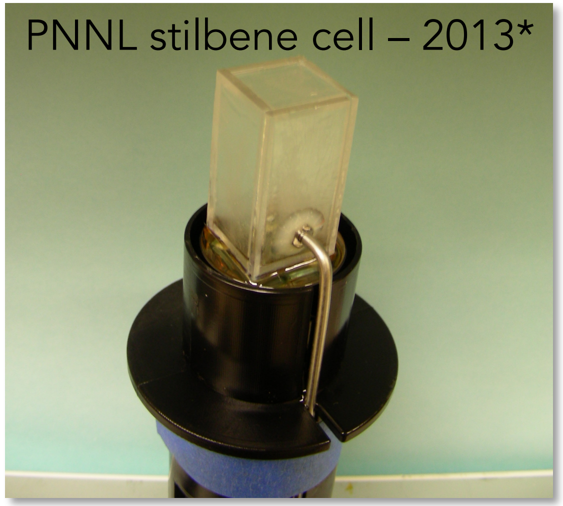
- Working with our laboratory collaborators at PNNL and LLNL, we propose to develop new detection systems for radioxenon monitoring
- We will explore the use of multiple coincidence detection, for example triplets such as (beta, gamma, gamma) detections, exploiting the low energy x-rays emitted by radioxenons
- We will also explore the use of stilbene or silicon detectors as beta detectors to replace the plastic scintillator

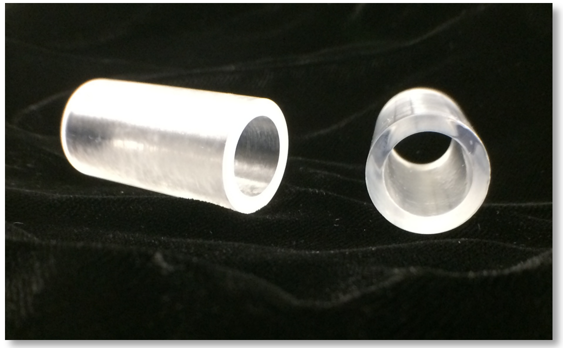


Prototype stilbene cell developed in collaboration with Inrad Optics

Advantages of Stilbene

- Improved energy resolution
  - Decreases ROI bounds leading to increased sensitivity
- Pulse Shape Discrimination
  - Discrimination of radon alphas and xenon betas
- Decreased memory effect
  - Improves detector sensitivity and extends measurement time
- Alternative scintillator
  - Maintains geometry and efficiency


PNNL stilbene cell – 2013*


Early stilbene cell prototypes developed with Inrad Optics

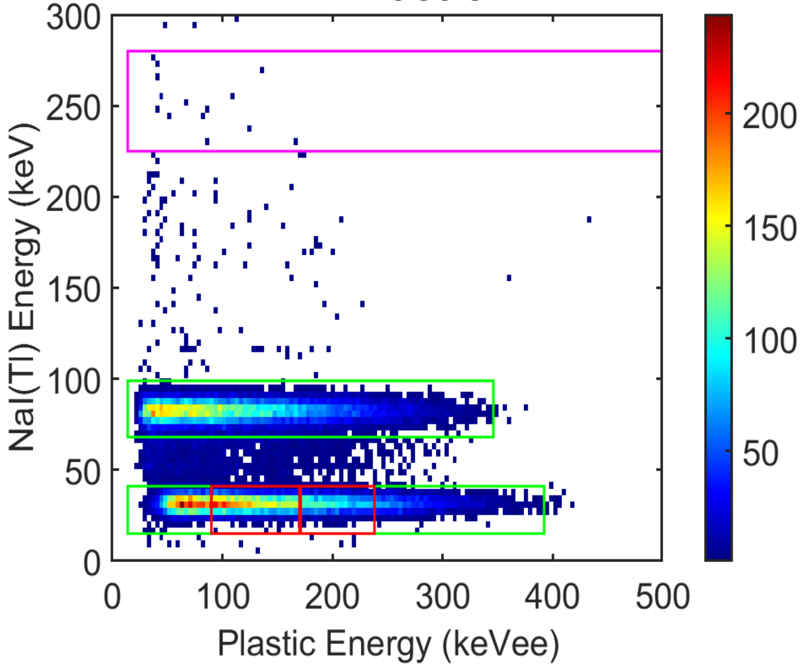
*W.K. Warburton, "Stilbene Research to Support a Portable β/γ Scintillation Detector with Improved Radioxenon MDC's" RMR 2014

Preliminary Result

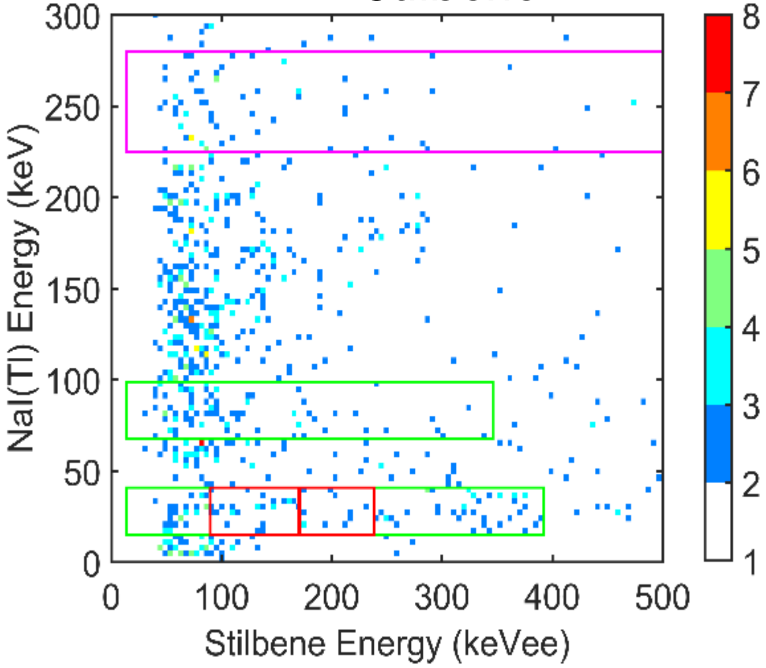
Memory Effect Analysis – Xe-133

- Residual activity remaining: 4.5% plastic and 0.043% stilbene
- Memory effect is 100-times smaller.

Plastic



Stilbene



Expected Impact

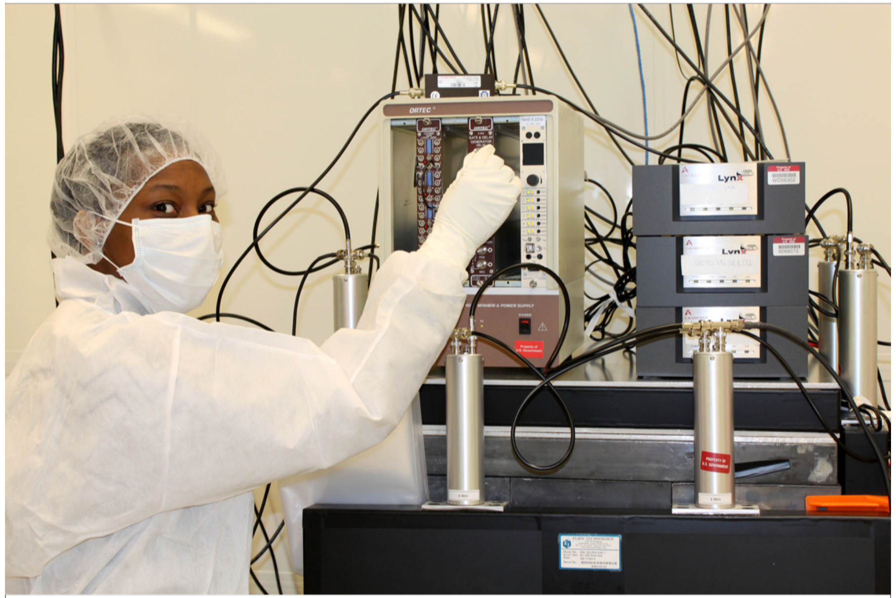
- Reduced memory effect eliminates the need for gas background measurements, which are a time consuming component in current systems

- A reduction of the background interference will allow for more frequent cycles of data collection

- IMS stations would have extended time to measure atmospheric samples = **increased sensitivity**

MTV Impact

- This project will build on existing collaborations with Pacific Northwest National Laboratory
- Collaborations with PNNL will create unique opportunities for students to perform field measurements
- Engagement with potential user community (CTBTO) through international workshops



2016, 2017, PNNL, Ciara Sivels
Mentor: Justin McIntyre

Pacific Northwest
NATIONAL LABORATORY

Conclusion

- We will explore sensitivity improvements of radioxenon detection systems through new materials and new analysis techniques

- The almost negligible memory effect of the stilbene cell can improve the overall sensitivity of the verification regime

- A balance between light collection and ruggedness is needed for in-field use of the stilbene cell to obtain maximum performance

Acknowledgements

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