Stilbene Cell for Radioxenon Detection

MTV Kickoff Meeting
20 May 2019

C. Sivels\textsuperscript{1}, S. D. Clarke\textsuperscript{1}, A. Prinke\textsuperscript{2}, J. McIntyre\textsuperscript{2}, S. A. Pozzi\textsuperscript{1}

\textsuperscript{1}University of Michigan, \textsuperscript{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

- 67 radionuclide stations worldwide (red)
- 80 total radionuclide stations planned (grey)
- 25 radioxenon stations (R+)//

Ctbto.org
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

Isotopic Ratio Plot

Citation:
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
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

*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.
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
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.
The Consortium for Monitoring, Technology, and Verification would like to thank the NNSA and DOE for the continued support of these research activities.

This work was funded by the Consortium for Monitoring, Technology, and Verification under Department of Energy National Nuclear Security Administration award number DE-FOA-0001875