CVT Workshop

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Further Advances in Modern Radioxenon Detector Design

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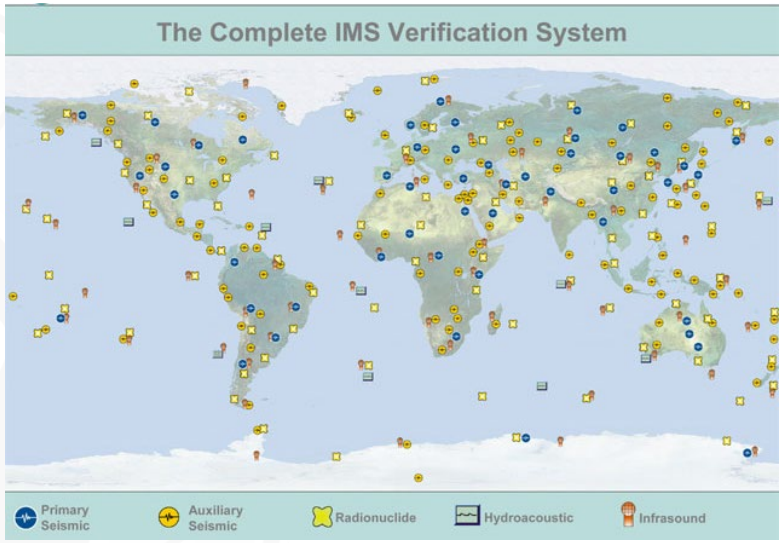
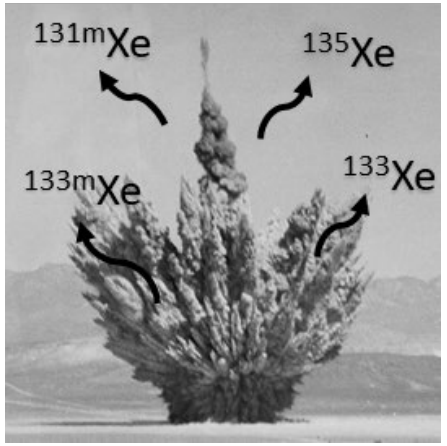
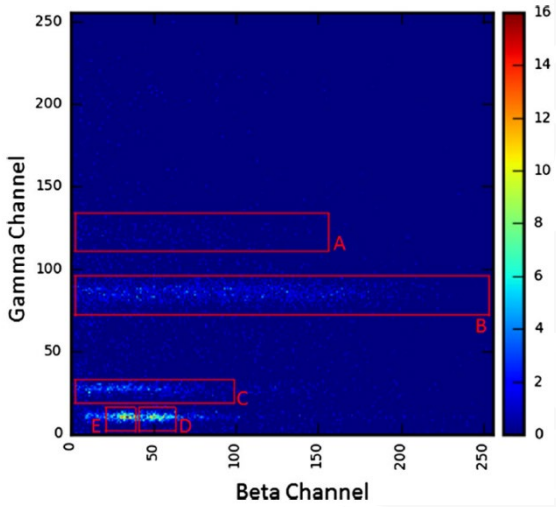
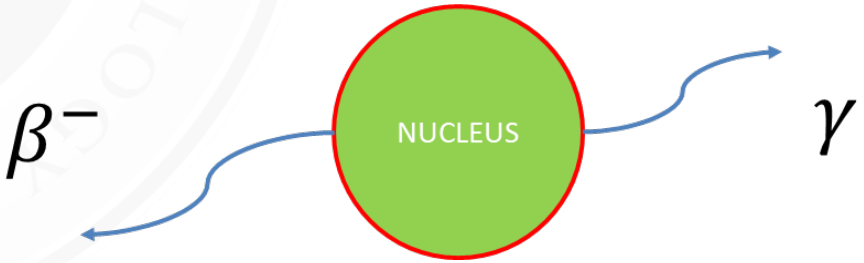
Introduction and Motivation

- Clandestine nuclear threats
  - Atmospheric radioxenon detection
  - 4 isotopes (^{131m}Xe, ^{133}Xe, ^{133m}Xe, ^{135}Xe)
- International Monitoring System (IMS)
  - Beta-Gamma Coincidence



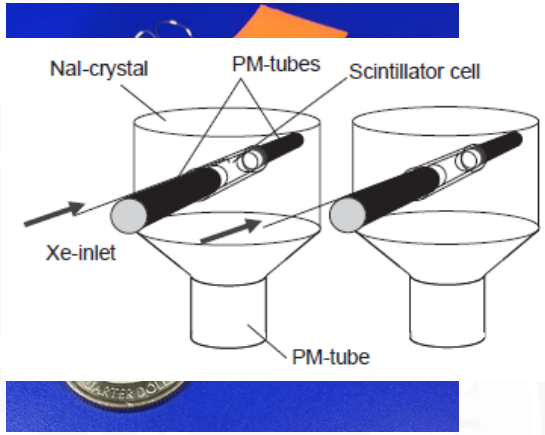


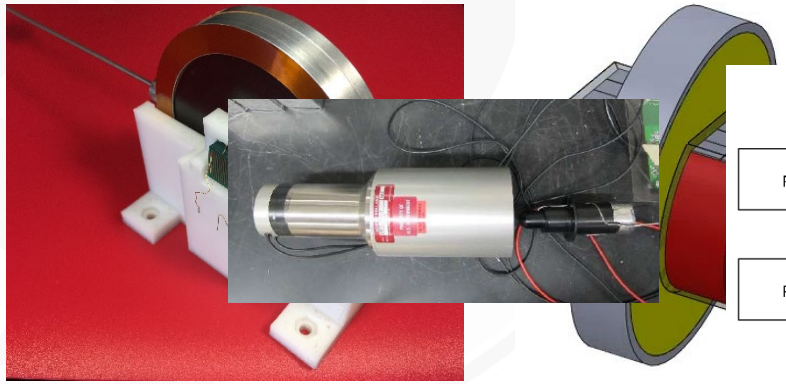


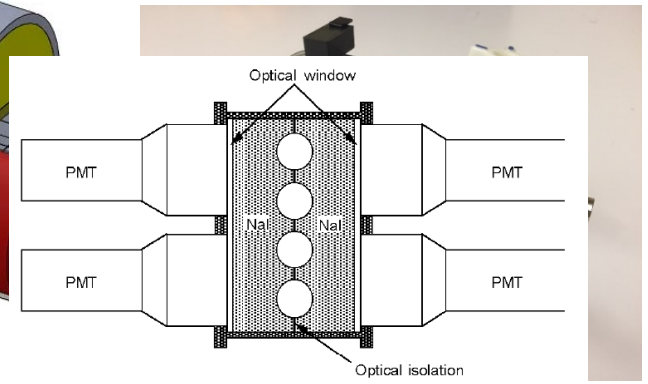


Mission Relevance

- Enhance US verification and monitoring capabilities
  - Nuclear detonations
- Improve the state-of-the-art
  - New technologies
    - Modern detectors/electronics
  - Reduces cost and complexity
  - High performance
- CVT Impact

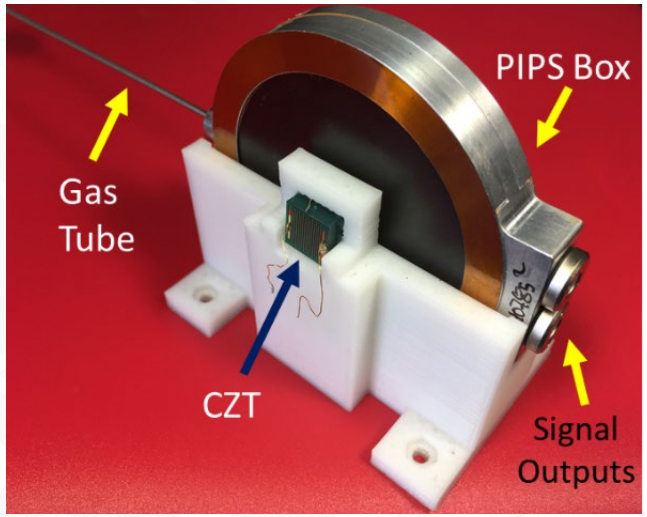


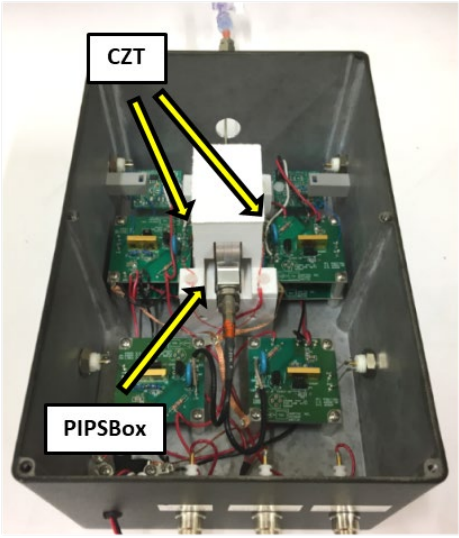


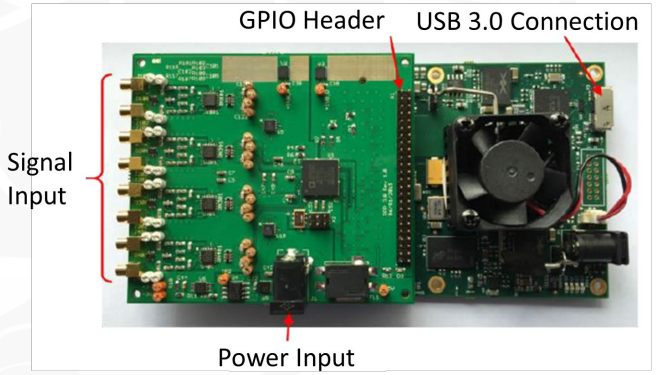


PIPS-CZT & DPP8

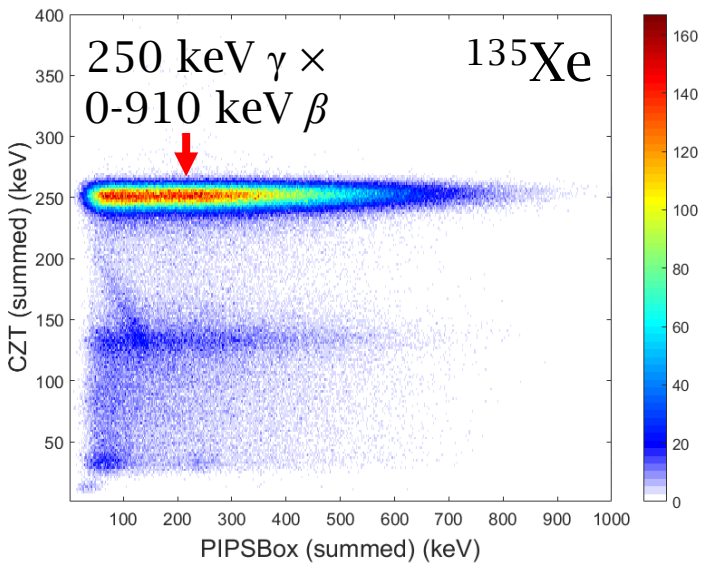
- Four independent detecting bodies
  - Electron detection: **PIPSBox**
    - Two Passivated Implanted Planar Silicon (PIPS) wafers
  - Photon detection: 2 x **Coplanar CZT**
- Eight-Channel Digital Pulse Processor (DPP8)
  - Multiple independent channels
  - Field-Programmable Gate Array
  - Real-time coincidence identification

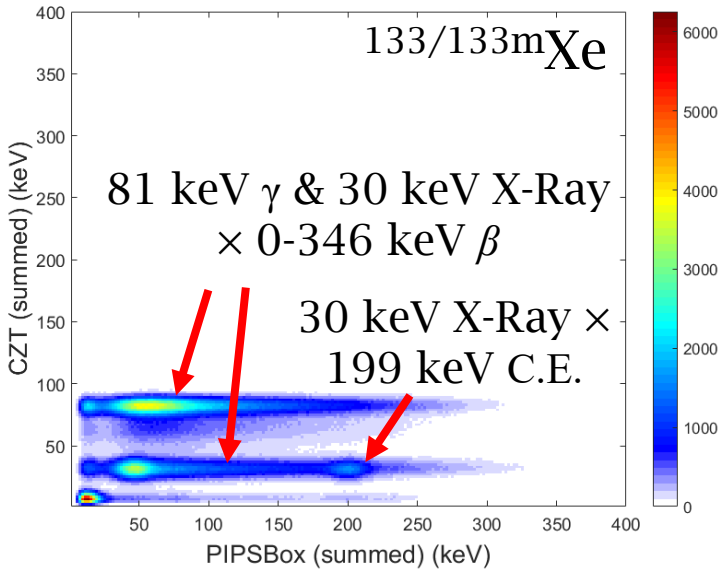


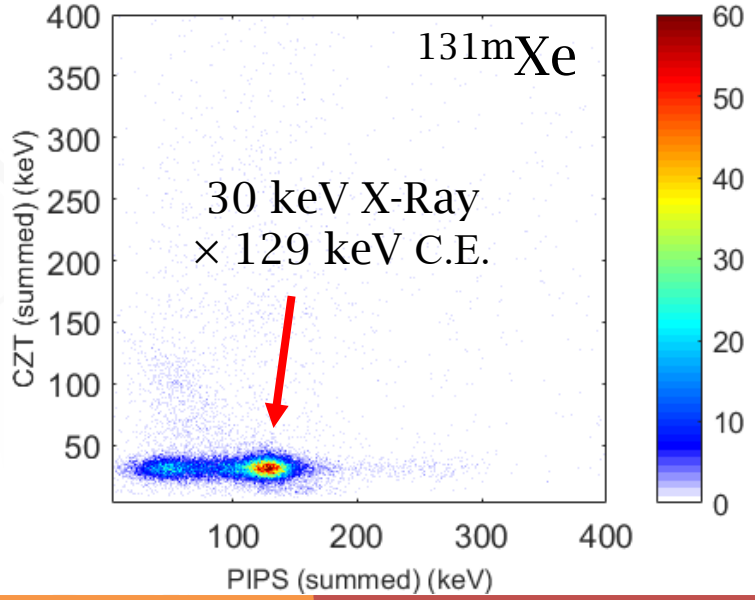


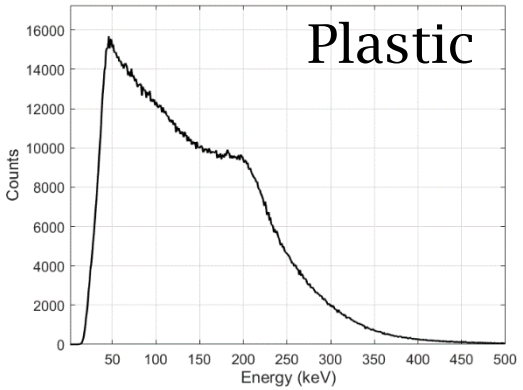


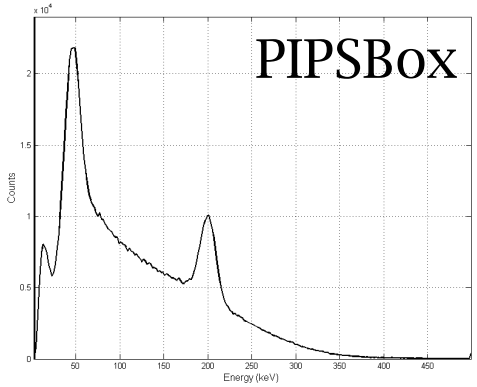
PIPS-CZT & DPP8











133/133mXe Electron Spectrum

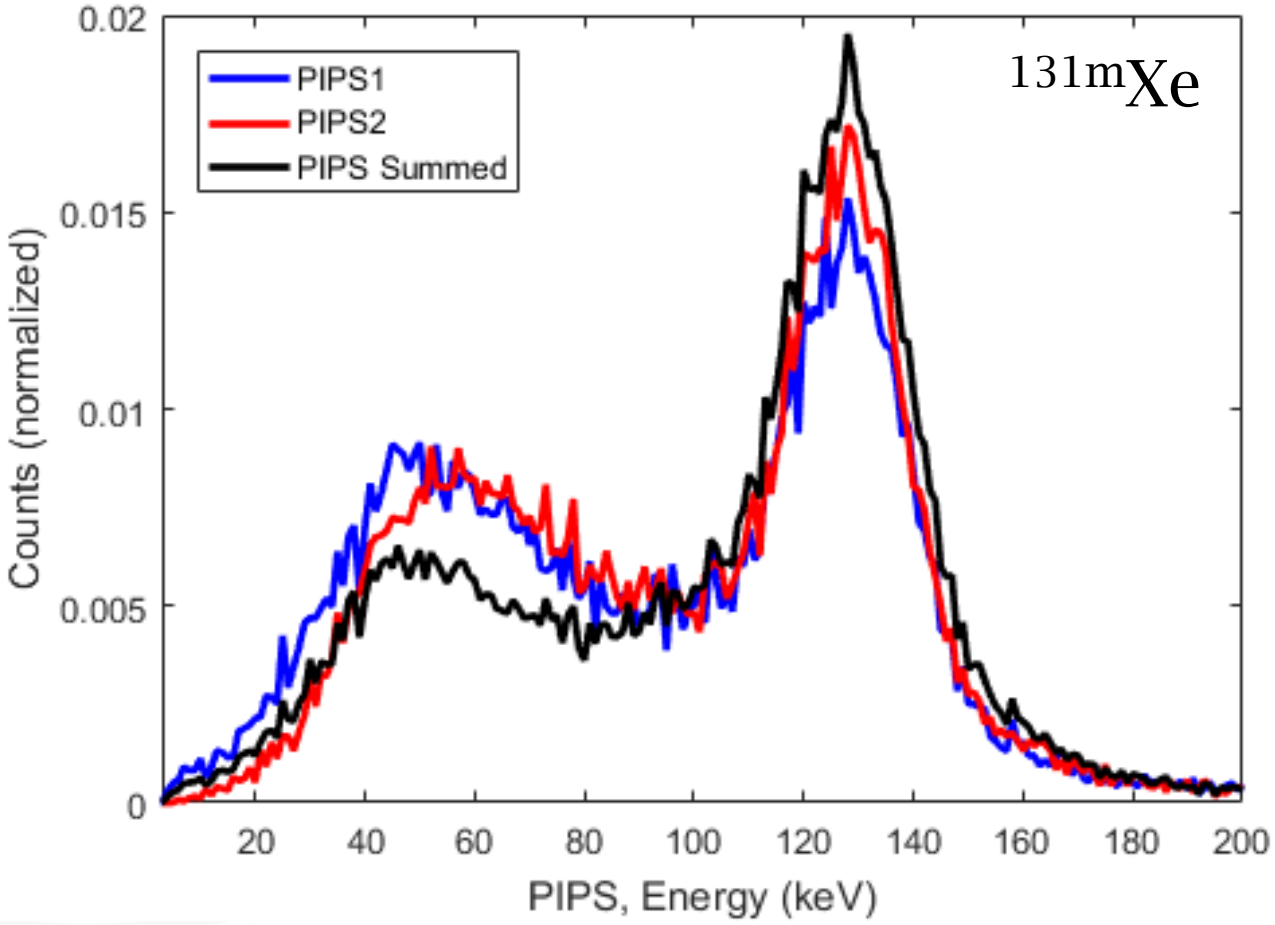
Radiation	% FWHM	% FWHM (plastic)
129 keV C.E.	12.5%-14.3%	23.7%
199 keV C.E.	8.8%-9.1%	23.3%
30 keV X-Ray	30%-35%	
81 keV Gamma	12.2%	
250 keV Gamma	5.1%	

Memory Effect:
0.257% ± 0.034%

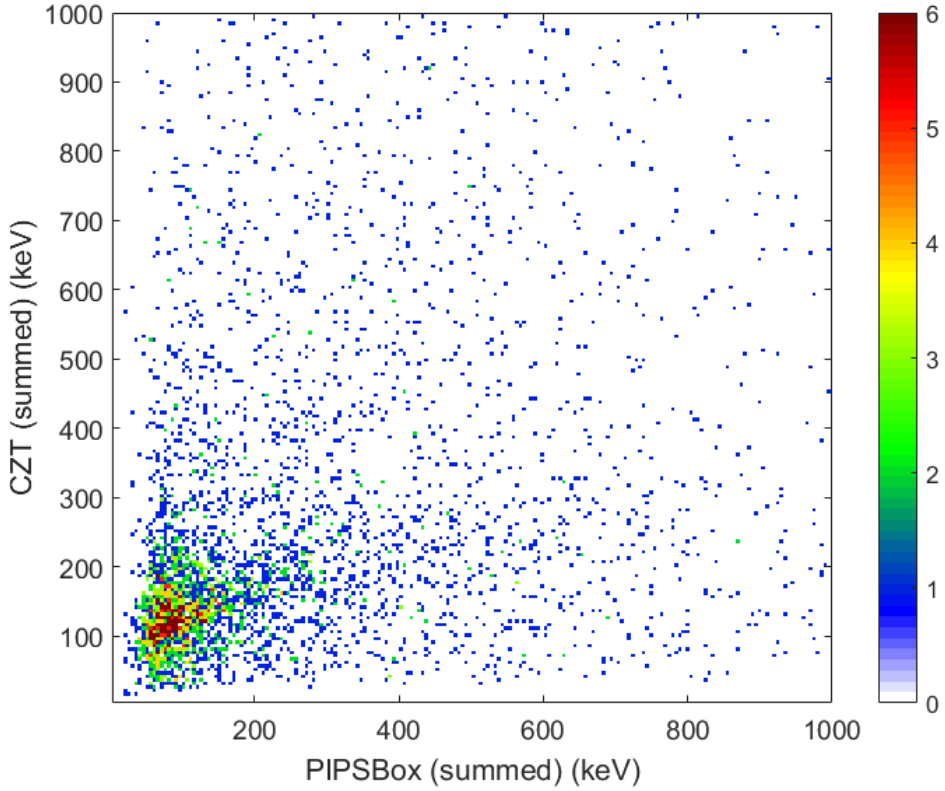
PIPS-CZT & DPP8

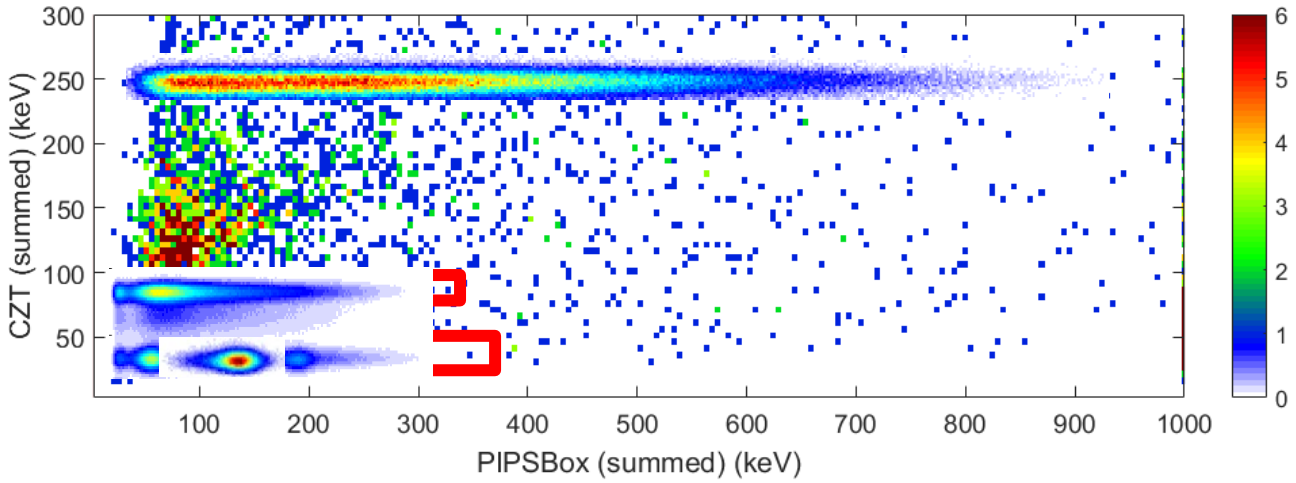
Detector	Tail/Total	Peak/Total
PIPS1	74.1%	25.9%
PIPS2	71.3%	28.7%
PIPS Summed	37.8%	62.2%

- Further backscatter reduction
  - Preamplifier
  - Statistical Methods (Sandia)



PIPS-CZT & DPP8



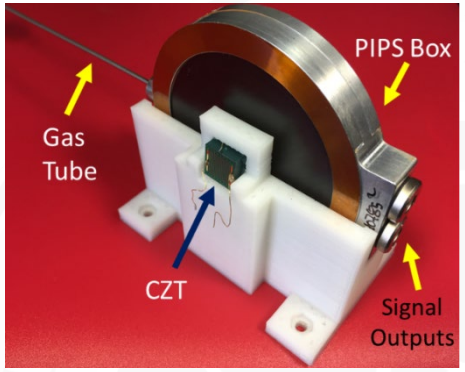


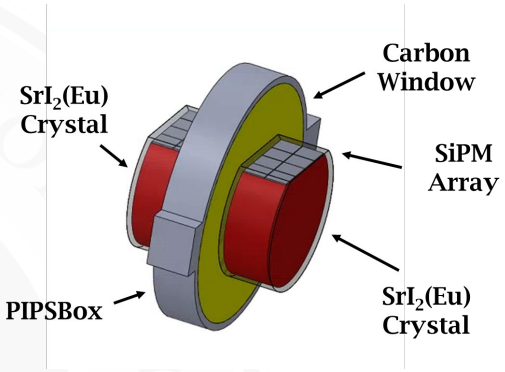
99.35% background rejection rate (single events/noise)

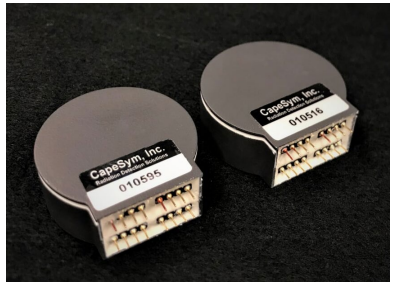
Isotope	MDC (simulated $\varepsilon_{\beta\gamma}$)	MDC (experimental $\varepsilon_{\beta\gamma}$)
^{131m}Xe	0.443 ± 0.100	1.678 ± 0.457
^{133m}Xe	0.270 ± 0.137	1.080 ± 0.566
^{133}Xe	0.914 ± 0.079	3.126 ± 0.528
^{135}Xe	6.166 ± 0.441	7.570 ± 1.249

Moving Forward -> Transitions

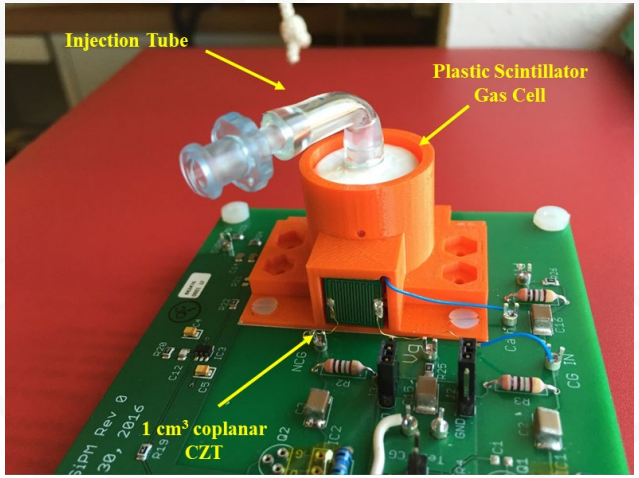
- PIPSBox + $SrI_2(Eu)$ + SiPM
  - High resolution
  - Rapid response time
  - Higher efficiency
  - Testing (PNNL)

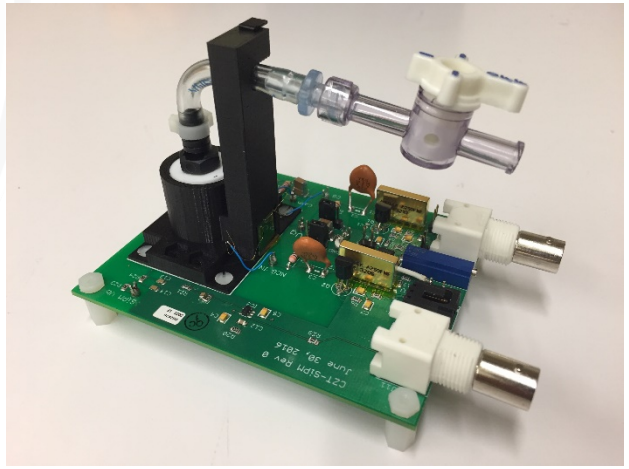






- CZT + Stilbene + SiPM
  - Better electron resolution
  - Low/no memory effect





Conclusion

- Deter/detect undeclared nuclear activities (CTBTO/IMS)
  - New technologies/methods for atmospheric radioxenon detection
- PIPS-CZT Prototype
  - Low (~0.25%) memory effect, high (99.4%) background rejection
  - High resolution (~9% for 199 keV electrons, 12.2% for 81 keV photons)
  - Backscatter, MDC, background counts, and noise
- DPP8
  - Real-time coincidence identification
- Future Efforts
  - Better backscatter reduction via hardware and algorithms
  - SrI_2(Eu) + SiPMs + PIPSBox, Stilbene + SiPMs + CZT
  - PNNL work

Acknowledgements

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