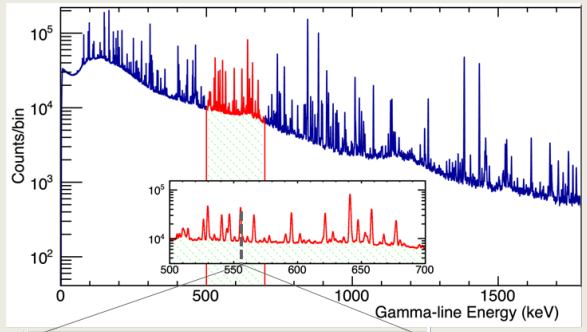
Machine Learning, Deep Learning, and High-Performance Computing: Transforming CTBTO's Operations in Global Monitoring and Verification

PANEL

Dr. Brian Archambault
Pacific Northwest National Laboratory, Richland, WA, USA

Computer Spectroscopist (P3.6-220)

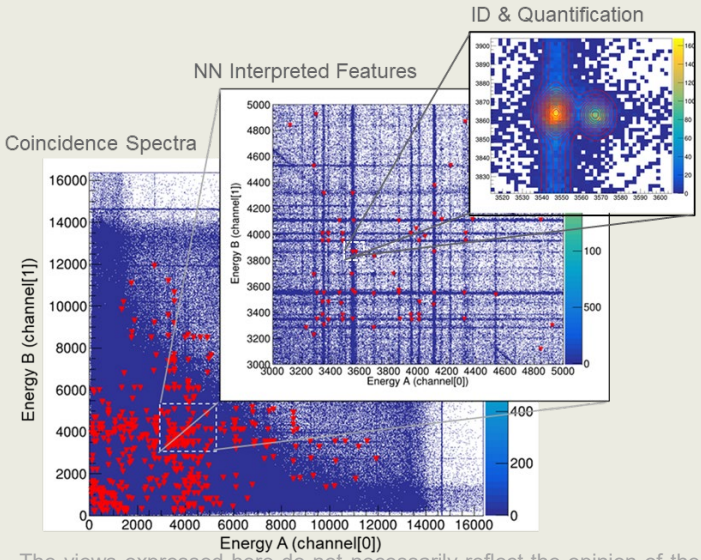


We are developing a comprehensive database of over 100,000 analyzed gamma-ray spectra from an archive containing decades of radiometric analyses of a diverse range of radionuclide samples by trained gamma spectroscopists.

Embedding domain expert interpretation and analysis of gamma-ray spectra into trained semi-supervised AI/ML models and algorithms for enhancing the speed, precision and robustness of gamma spectroscopic analysis.

Results	Energy (keV)	Difference	Phot/Decay	Nuclide	Parent Halflife
Th-227	563.70	-0.03	3.240e-05	Rn-219	18.50 days
Ra-223	563.70	-0.03	3.240e-05	Rn-219	11.40 days
Nd-149	563.80	+0.07	9.324e-05	Nd-149	1.73 hrs
Gd-149	563.48	-0.25	1.022e-04	Gd-149	9.40 days
Tc-95m	563.48	-0.25	9.487e-05	Tc-95m	61.00 days
Eu-152	563.99	+0.26	4.890e-03	Eu-152	13.537 yrs
Tl-200	564.08	+0.35	3.488e-04	Tl-200	1.09 days
Xe-122	564.12	+0.39	1.800e-01	I-122	20.10 hrs
Sb-122	564.12	+0.39	7.067e-01	Sb-122	2.70 days
Ce-134	563.25	-0.48	3.619e-03	La-134	3.00 days
Lu-169	563.24	-0.49	4.001e-03	Lu-169	1.42 days
Pu-236	563.20	-0.53	1.000e-06	Pu-236	2.9 yrs
Br-76	563.18	-0.55	3.550e-02	Br-76	16.20 hrs
As-76	563.18	-0.55	1.201e-02	As-76	1.10 days
Bi(n,g)	563.14	-0.59	1.509e-02	Bi(n,g)	NA
Ag-105	564.39	+0.66	7.038e-05	Ag-105	41.00 days
Pu-239	563.05	-0.68	2.147e-09	Am-241	2.41e+004 yrs

Physics-Informed AI/ML for Coincidence Spectroscopy (1,2)



Leveraging physics-informed AI/ML for automated analysis of list-mode data-streams from advanced multi-particle (ɣ-α-β-ɣ) coincident spectroscopic radiation detection systems.

Multiple modalities of counting (β-veto, β-ɣ, ɣ-ɣ, etc…) enable enhanced radionuclide identification confidence and break spectral interference degeneracies, reducing the burden on trained spectroscopists for timely interpretation and review.

1. Archambault, B.C., Pierson, B.D. et al. Precise quantification of radioisotopes by coincident ɣ-ɣ HPGe spectrometry." Presented at "International Conference on Methods and Applications of Radioanalytical Chemistry (MARC)", MARC XII, March 23-28, 2025.
2. Pierson, B.D., Archambault, B.C., Greenwood, L.R. et al. Alpha/beta-gated gamma–gamma spectroscopy of mixed fission products for trace analysis. J. Radioanal. Nucl. Chem. 331, 5453–5467 (2022)

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