O3.2-251

A Gamma-Gamma Coincidence Detection System for Radionuclide Aerosol Monitoring

A. Couture[1], A. Carman[1], H. Miley[2], H. Garland[1], L. Lidey[1], M. Larche[1], M. Moore[1], N. Elmore[1], R. Guerrero[1], S. Cheng[1], and T. Butcher[1]

[1]Pacific Northwest National Laboratory
[2]Desert Research Institute

PNNL

Presentation Date: 9 September 2025

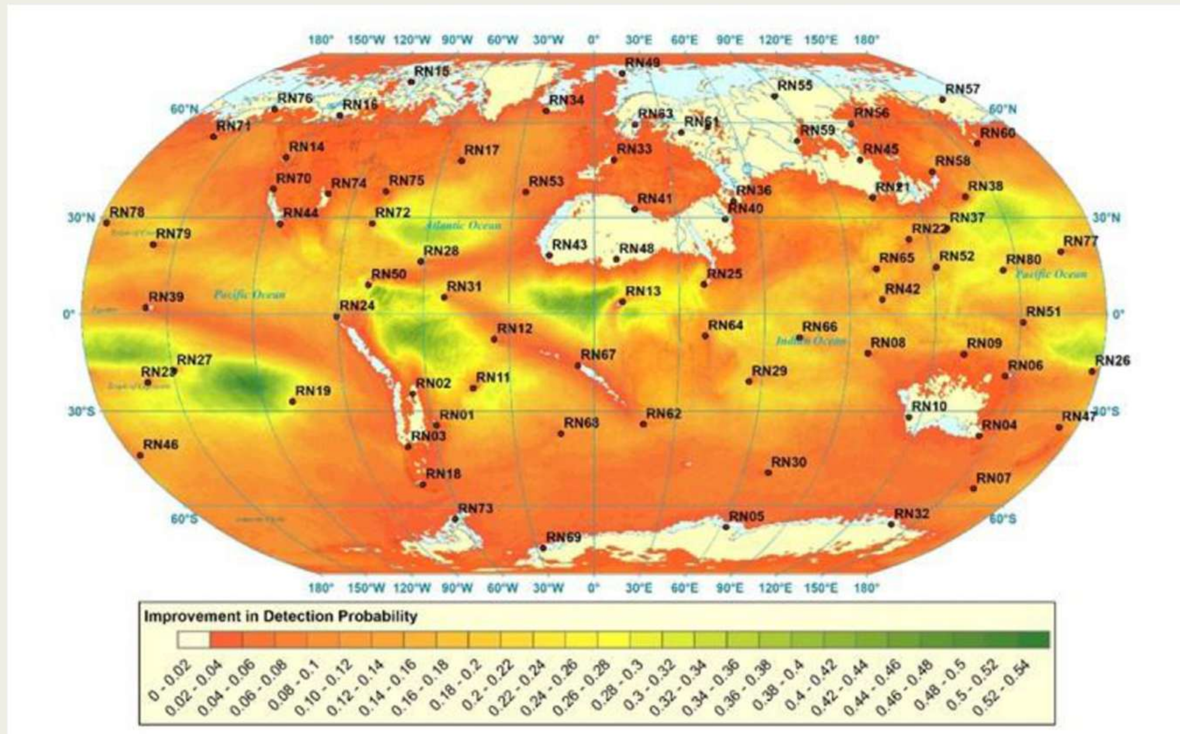
A Gamma-Gamma Coincidence Detection System for Radionuclide Aerosol Monitoring

A. Couture, A. Carmen, H. Miley, H. Garland, L. Lidey, M. Larche, M. Moore, N. Elmore, R. Guerrero, S. Cheng, and T. Butcher

Motivation

- Current IMS radionuclide aerosol monitoring stations collect, decay, and count – 24 hrs each (3 days total)
- Filter collection & HPGe measurement – either manual or automated
- Recent atmospheric transport studies indicate improved detection and location performance of the IMS network with shorter sampling intervals
- Objective: Maintain IMS requirements & shorten collection/counting intervals
- Proposed Solution: Gamma-gamma coincidence detection & ESP collection (RASA 2.0)

IMS Detection Improvement 24-hr to 12-hr Sampling



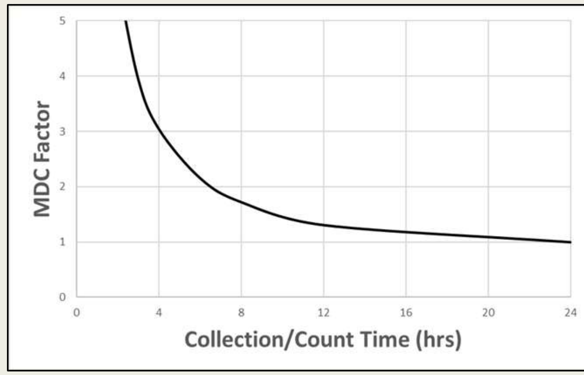
PW Eslinger, *et al. (2023)* Journal of Env. Rad., Vol 257, 107088, https://doi.org/10.1016/j.jenvrad.2022.10708

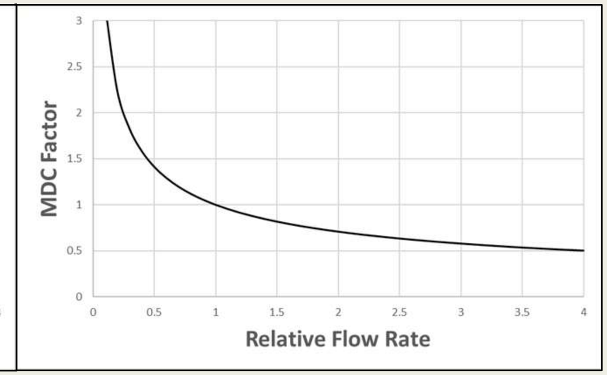
PNNL

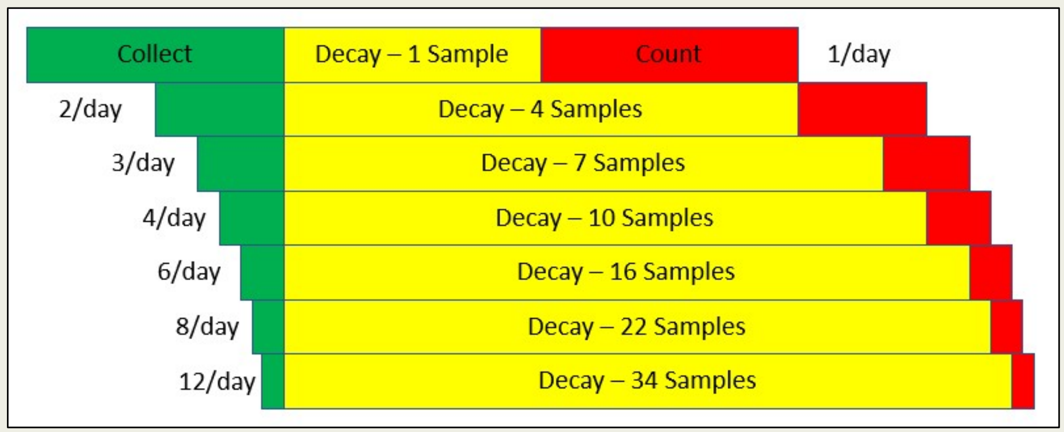
A. Couture, A. Carmen, H. Miley, H. Garland, L. Lidey, M. Larche, M. Moore, N. Elmore, R. Guerrero, S. Cheng, and T. Butcher

Timing, Flow, and Detector Efficiency

- Shorter collection times
  - → Better ATM transport
  - → Increases MDC
- Rules for Timing
  - Count = Collect (required)
  - Count + Decay + Collect =72 hrs (required?)
- Extended decay times lower ^{140}Ba MDC at high radon stations, but increase them at low radon stations
- Note sample storage complexity
- Increased detector efficiency, background reduction, & increased flow can compensate for the loss in MDC





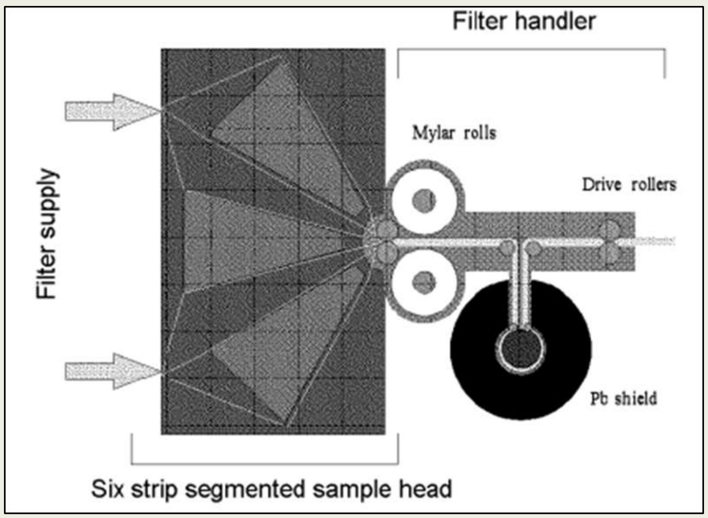


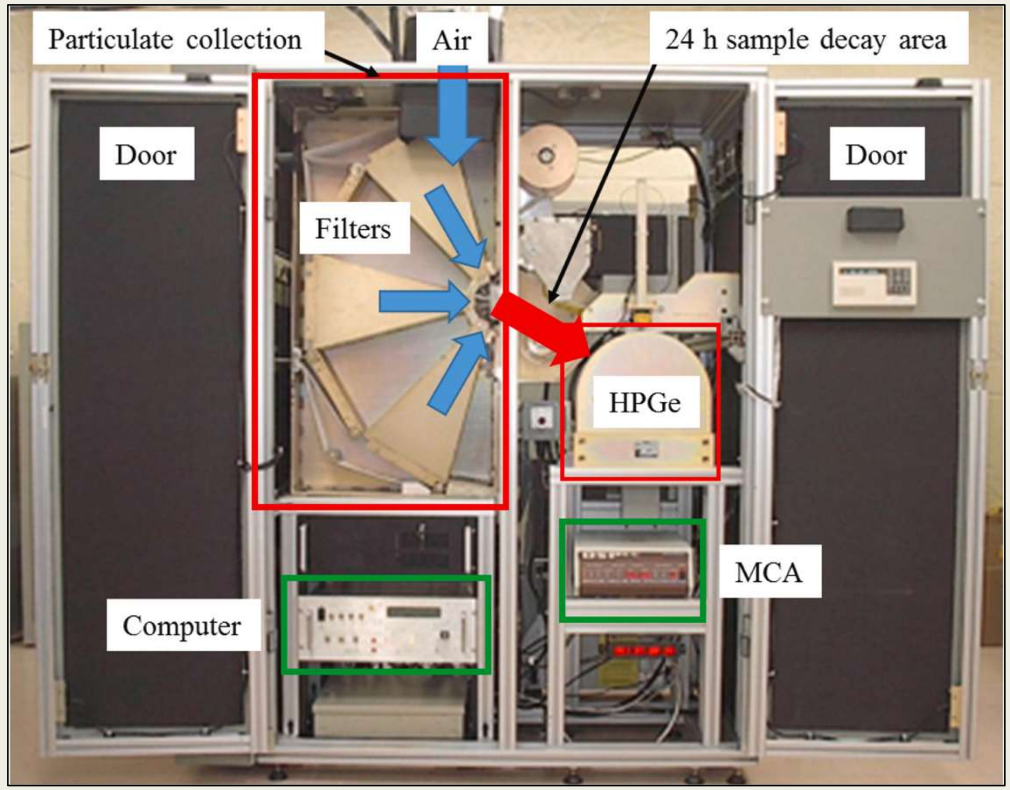
PNNL

A. Couture, A. Carmen, H. Miley, H. Garland, L. Lidey, M. Larche, M. Moore, N. Elmore, R. Guerrero, S. Cheng, and T. Butcher

RASA

- Radionuclide Aerosol Sampler/Analyzer was developed at PNNL in the 90s
- Automated particulate collection, encapsulation, and measurement





H Miley, *et al.*, (1998) J. Radioanal. Nucl. Chem., 235 (1–2) (1998), pp. 83-87, 10.1007/BF02385942

JL Burnett (2019) Nucl. Inst. Meth. A, Vol. 944 162473 https://doi.org/10.1016/j.nima.2019.162473

A Gamma-Gamma Coincidence Detection System for Radionuclide Aerosol Monitoring

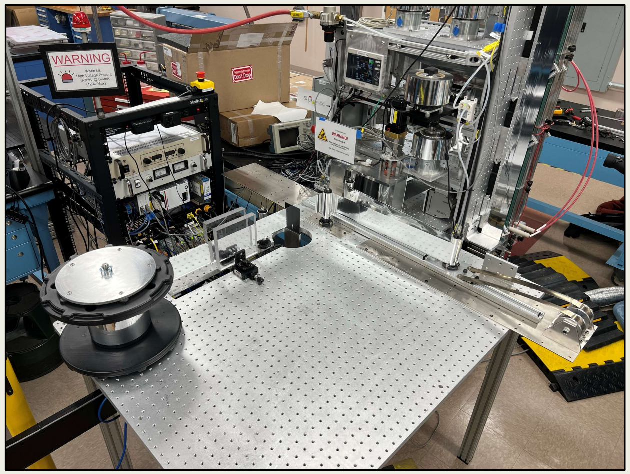
A. Couture, A. Carmen, H. Miley, H. Garland, L. Lidey, M. Larche, M. Moore, N. Elmore, R. Guerrero, S. Cheng, and T. Butcher

RASA 2.0

ESP Collector

Creare
See Swanwick O3.2-175

Sample Packaging



PNNL/Creare

Dual Gamma Detectors

PNNL

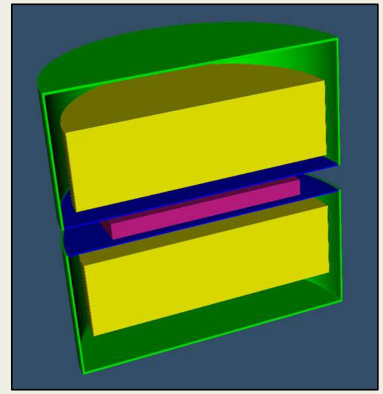
A Gamma-Gamma Coincidence Detection System for Radionuclide Aerosol Monitoring

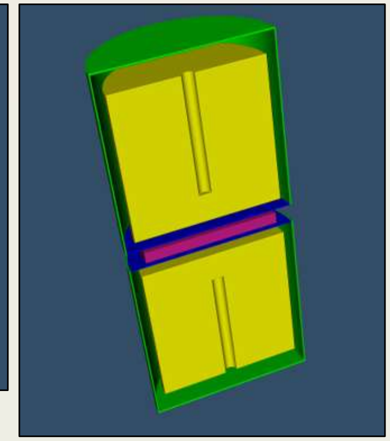
A. Couture, A. Carmen, H. Miley, H. Garland, L. Lidey, M. Larche, M. Moore, N. Elmore, R. Guerrero, S. Cheng, and T. Butcher

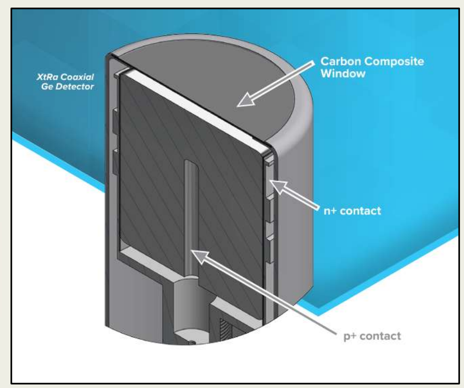
O3.2-251

Modeling for Detector Selection

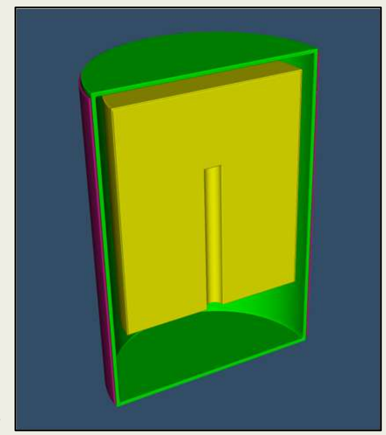
- Mylar Source: 76 x 76 x 0.63 mm (3” x 3” x ¼”)
- Detectors – (single detectors & pairs considered)
  - Stock and custom BEGe’s
  - XTRa’s – 4 large stock models
  - Original RASA (with filter) for baseline comparison
- Energy Range – 60-1600 keV
- BKGD estimated based solely on ^{212}Pb – efficiency to downscattering into ROIs (focus on ^{140}Ba)
- Calculation of detector efficiency & relative MDCs
- Cost/Sens. FOM = Rel. ^{140}Ba MDC × Price (Small = 👍)
- MCNP[1] used – no consideration of coincidence
- Mirion XTRa GX10020 selected
- Capable of 4 samples/day at ~2.5x air flow







https://www.mirion.com/products/technologies/spectroscopy-scientific-analysis/gamma-spectroscopy/detectors/hpge-detectors-accessories/xtra-extended-range-coaxial-ge-detectors

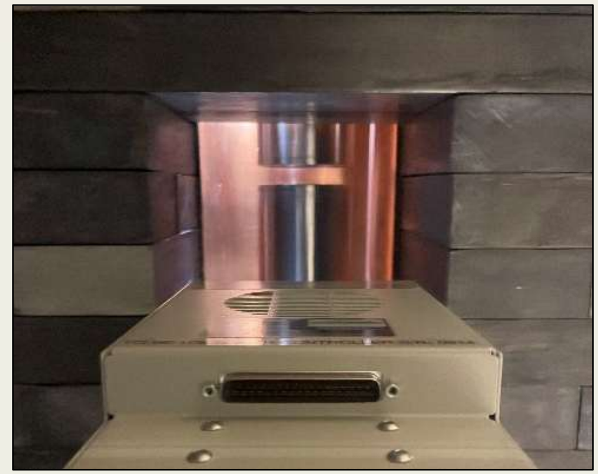


[1] C. J. Werner, *et al*. (2018)., Los Alamos National Laboratory, report LA-UR-18-20808. https://mcnp.lanl.gov/pdf_files/TechReport_2018_LANL_LA-UR-18-20808_WernerBullEtAl.pdf

A. Couture, A. Carmen, H. Miley, H. Garland, L. Lidey, M. Larche, M. Moore, N. Elmore, R. Guerrero, S. Cheng, and T. Butcher

Dual Gamma Development Testbed – ARGO2

- Advanced Radionuclide Gamma-spectrometer 2 (ARGO2)
- Pair of Mirion BE6530 in Pb cave with LYNX2 MCAs
- Control software & data processing development



M. Sharma, *et al.*, (2024) Trans. of the Am. Nucl. Soc., Vol 128, 852-853, DOI:10.13182/T128-41654

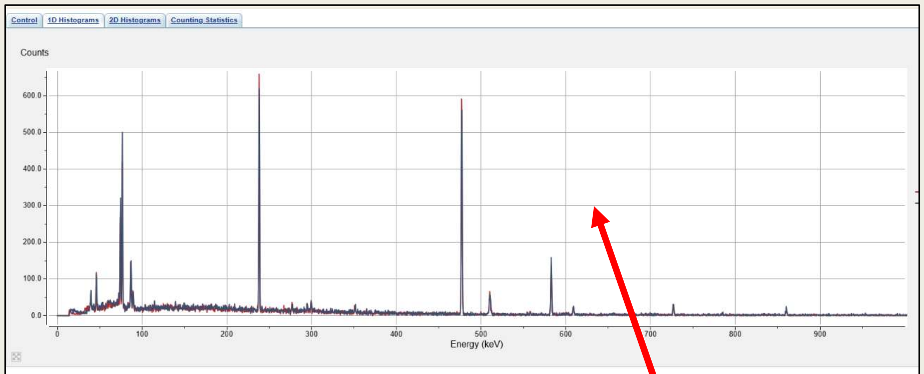
A. Couture, A. Carmen, H. Miley, H. Garland, L. Lidey, M. Larche, M. Moore, N. Elmore, R. Guerrero, S. Cheng, and T. Butcher

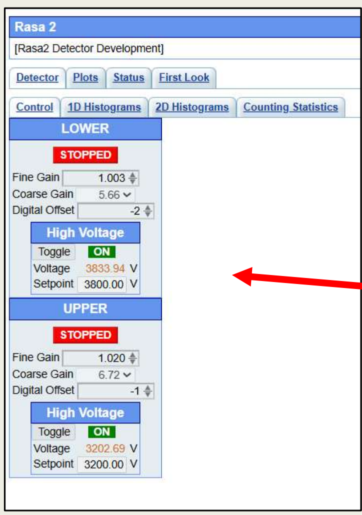
Software Development

- C++/Linux control software/WebGUI framework used in PNNL-designed beta/gamma coincidence systems (Xenon International, RL16)
- Control server developed for pairs Mirion LYNX MCAs in TLIST mode
- Live 8192 channel singles/coincidence histogram generation (20 kB/10s-100s MB)
- Updates to deal with high(er) count rate scenarios & detector resolution
  - Accidental coincidences
  - Coincidence dead times
  - Updated coincidence logic
- Binary listmode data files available, but not needed for routine operation
- ~1.5 MB/min or 2GB/day at ~1000 cps
- SoH generation – count rates, HV, cooler temperatures/power consumption, leakage currents
- “First Look” detector – H3D M400 data acquisition & spectrum viewing

A. Couture, A. Carmen, H. Miley, H. Garland, L. Lidey, M. Larche, M. Moore, N. Elmore, R. Guerrero, S. Cheng, and T. Butcher

Software Development



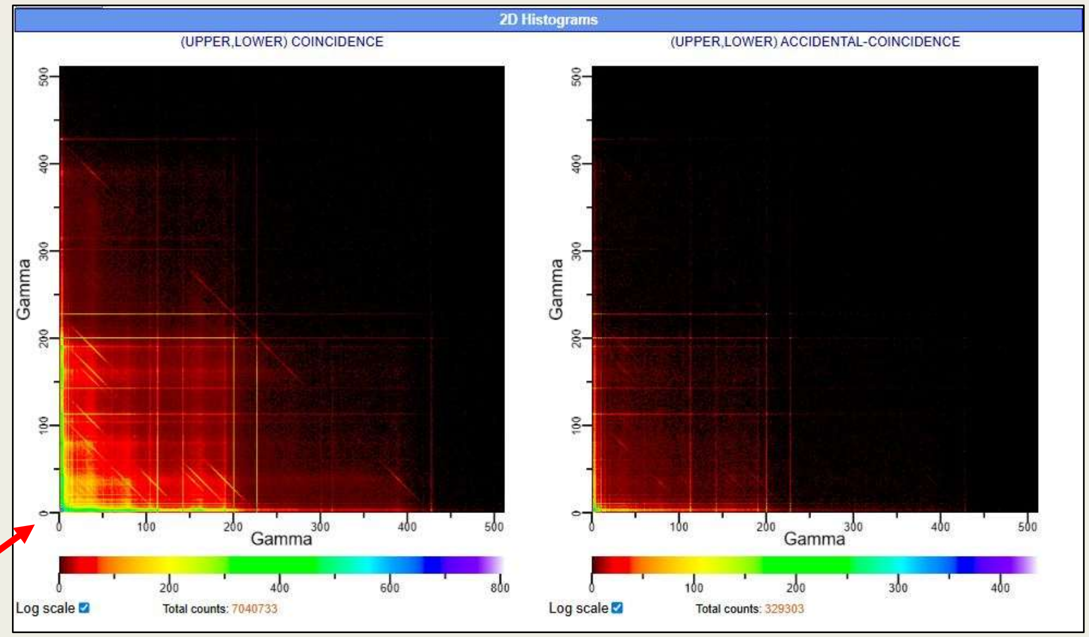


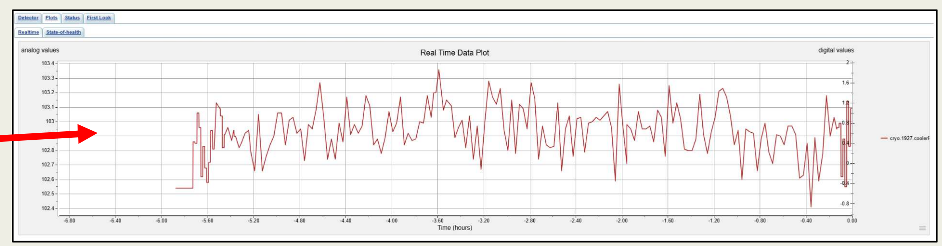
Singles Histograms

Coincidence Histograms

Acquisition Control

SoH



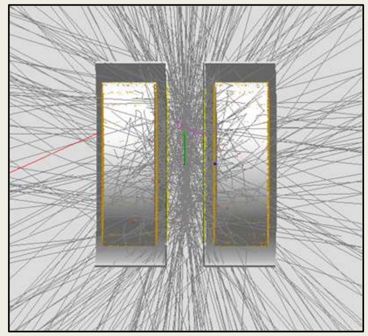


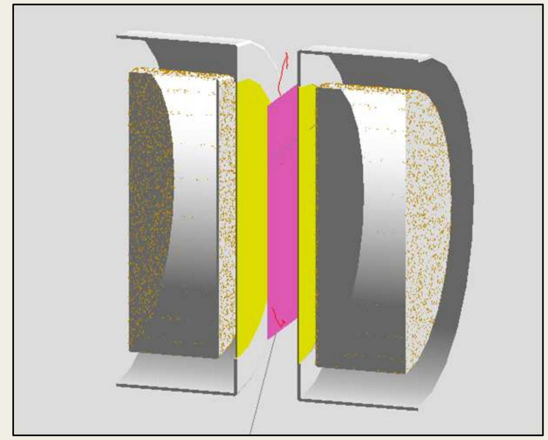
PNNL

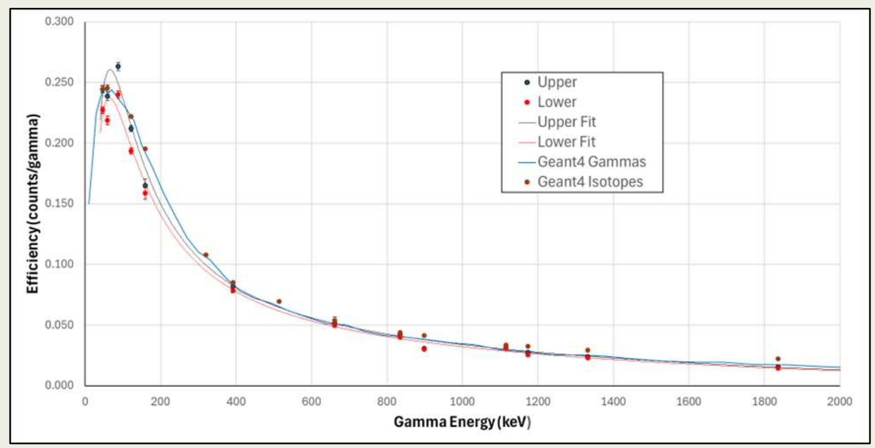
A. Couture, A. Carmen, H. Miley, H. Garland, L. Lidey, M. Larche, M. Moore, N. Elmore, R. Guerrero, S. Cheng, and T. Butcher

Geant4 Simulation – ARGO2

- Simulation of ARGO2 using the Geant4 Cascade Summing Correction application
- Model validated with comparison to mixed gamma standard
- Near term plan
  - Model RASA2.0 geometry
  - Efficiency to ^{140}Ba, ^{131}I, ^{99}Mo/^{99m}Tc
  - Estimate ambient & sample-induced BKGD for all IMS network stations with RASA2.0 → MDCs
  - Consider coincidence & Compton-summed detector pairs
  - Use ATM models to estimate network sensitivity for varying collection/count times using RASA2.0







[1]Pierson, B., Hagen, A., & Archambault, B. (2022) G4CSC, 0.1a. Retrieved from G4CSC - Geant4 Cascade Summing Corrections: https://gitlab.pnnl.gov/ares/g4csc

A. Couture, A. Carmen, H. Miley, H. Garland, L. Lidey, M. Larche, M. Moore, N. Elmore, R. Guerrero, S. Cheng, and T. Butcher

Next Steps

- Air collection campaign to assess background vs. decay time using ARGO2
- Evaluate RASA2.0 sensitivity for extended set of IMS-relevant radionuclides
- Evaluate the integration of coincidence data into the IDC spectral analysis methodology
- Further software development
  - Auto gain stabilization/matching
  - Historical SoH & spectal data viewing
  - QC-source measurements
  - External control
- Build a prototype for integration with Creare ESP
  - Detector acquisition
  - Further mechanical design

A. Couture, A. Carmen, H. Miley, H. Garland, L. Lidey, M. Larche, M. Moore, N. Elmore, R. Guerrero, S. Cheng, and T. Butcher

Thank you.
Questions?