Low Level $^{140}$Ba Measurements on High Volume Air Filters using Gamma Coincidence Systems
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**Objective**

- Experimentally measure $^{140}$Ba using gamma coincidence and singles at low levels for detection limit comparisons.
- Use exposed RASA filters with 24 hour and 1 week decay times to simulate measurements at a station versus counting at a laboratory.

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Method

140Ba was purified from a thermal irradiation of uranium.

Purification followed a series of ionic exchange and precipitation steps.

Stock solutions of 140Ba were quantified at high level using standard gamma spectroscopy.

Dilutions were made to spike filters at roughly 0.07 and 0.15 Bq of 140Ba rapidly to minimize the ingrowth of 140La.

Spiked filters included 24 hour of aerosol collection followed by either 24 hour or 7 days of decay prior to measurement.
Quantification and Characterization

- Stock $^{140}$Ba quantified by high level gamma spectroscopy at 174 Bq
- Gamma-Gamma coincidence at high level indicate which gamma pairs result in good data.
  - X-ray data less reliable
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Measurements

Low Background HPGe detectors in underground Laboratory
- P-type detector, 112% relative efficiency, copper housing with carbon fiber window

Advanced Radionuclide Gamma Spectrometer (ARGO)
- Coincidence BEGe detectors
- $^{140}$Ba coincidence energy lines 162.7 and 304.8 keV.
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Singles at 0.07 Bq $^{140}$Ba and 0.15 Bq $^{140}$Ba

- First experiment measurement (0.07 Bq)
- Start Acquisition 11-MAR-2020 14:00
- Count time 80k s

- Second experiment measurement (0.15 Bq)
- Start Acquisition 19-MAR-2020 12:54
- Count time 86k s

No Zero Time Information
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**Putting an End to Nuclear Explosions**

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**Title:** Coincidence at 0.15 Bq $^{140}$Ba/La

- Using gamma coincidence measurements, both $^{140}$Ba and $^{140}$La are observable due to the reduction in background.

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**Summary:**

- Coincidence at 0.15 Bq $^{140}$Ba/La

- Using gamma coincidence measurements, both $^{140}$Ba and $^{140}$La are observable due to the reduction in background.

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**Figure:**

- Calibrated & summed detector energy projections

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**Additional Information:**

- Pacific Northwest National Laboratory, U.S.
- AWE, UK
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24-hour Results Summary (IMS Station)

- RASA filters spiked with $^{140}$Ba
- 24-hour collection
- 24-hour decay delay
- 24-hour count (Blue squares)
- Week-long count (Red squares)

**Key Observation**

$^{140}$Ba is only observable using coincidence methods during a 24-hour count at ~0.07 Bq.

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One Week Results Summary (IMS Lab)

- RASA Filter spiked with $^{140}\text{Ba}$
- 24-hour collection
- 1 week decay delay
- 24-hour count (Blue Squares)
- 1 week count (Red Squares)

Key Observation

$^{140}\text{Ba}$ is observable using both coincidence and singles methods at ~0.07 Bq.

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Gains from Gamma- Gamma Coincidence

Coincidence measurements at IMS stations would detect $^{140}$Ba/La at levels that would otherwise be missed.

Lower detection limits afforded by coincidence methods likely extends to many radionuclides that decay with coincidence signatures.

Isotopes with a lower energy than $^7$Be would gain in detection.

Gamma singles measurements for IMS Laboratory scenarios are equivalent gamma- gamma coincidence measurements when the gamma energies are higher than $^7$Be.

Due to long radon decay times typical for IMS laboratory measurements- gains in coincidence background reduction are not as critical in station measurements.