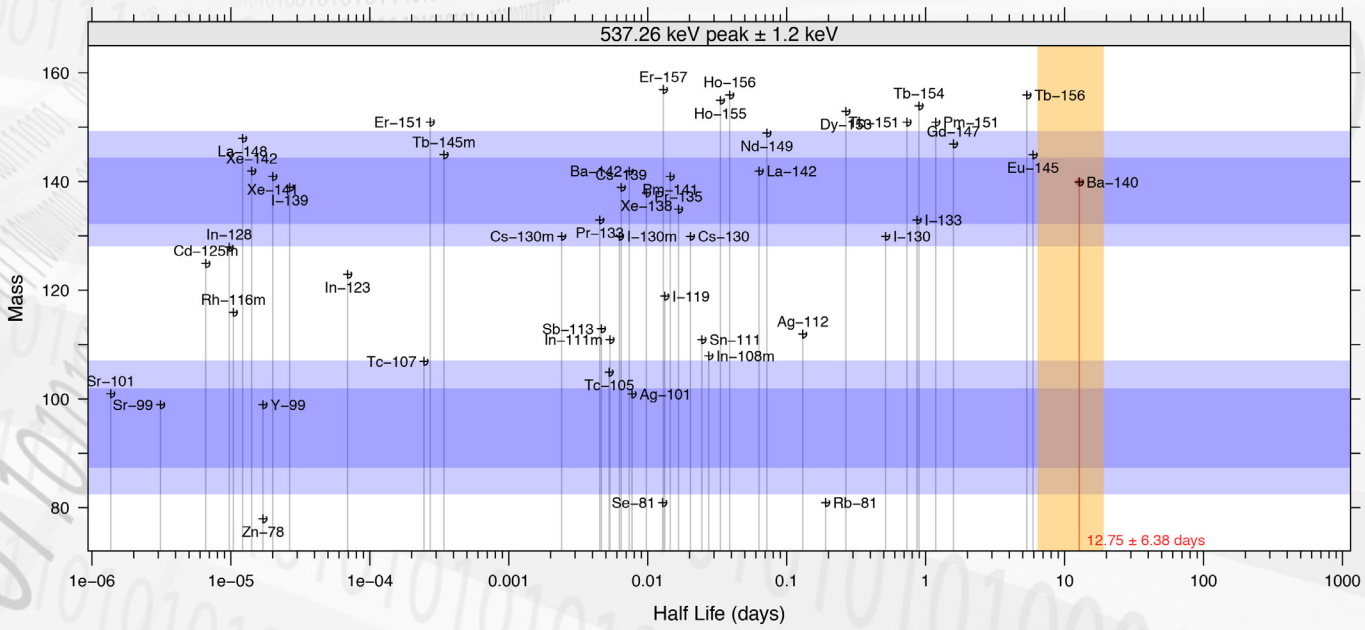


Forensic Analysis with Time-stamped Coincidence-sampled Gamma Radiation Spectroscopy

Identifying radioisotopes in complex mixtures is challenging, especially soon after their production when short-lived isotopes dominate. We developed a signature that uses isotope intensity over time to estimate half-lives for spectral peaks combined with peak location to increase confidence in identification.

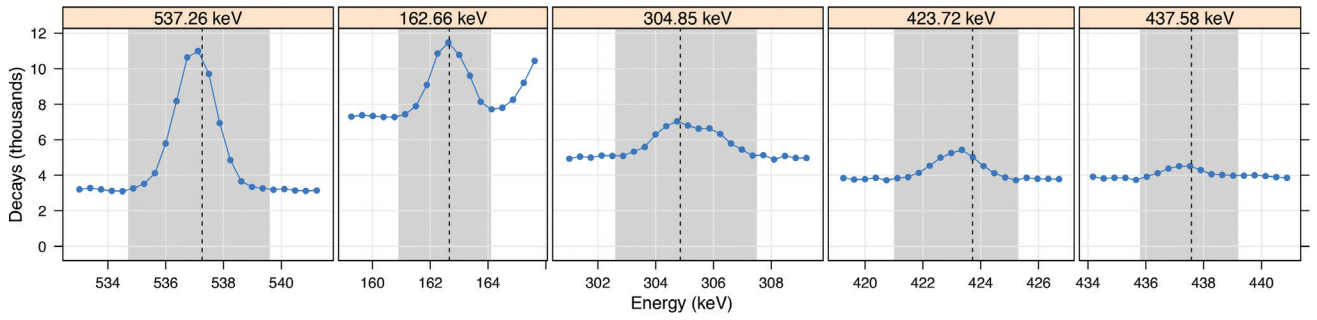
CHALLENGE

Rapid analysis of radioactive samples following neutron activation or fission is often highly desirable for understanding the origins of the material. This is difficult because the samples consist of mixtures of isotopes and often the majority of activity is caused by short-lived products with transient secular equilibria as the parent isotopes decay. The standard approach is to use radiochemical techniques to perform separations followed by spectroscopic methods applied to chemically partitioned samples. Many of the shorter-lived isotopes are gone by the time this process is complete and this approach requires radiochemical separations facilities.

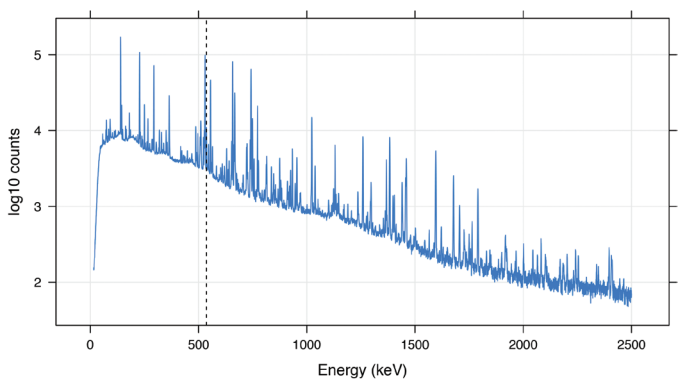
APPROACH

Two lines of evidence are extracted from listmode gamma spectroscopy data (with each photon count time and energy stamped). The data are summed to generate time-integrated spectra to be analyzed with standard spectroscopic techniques, and photo peaks of interest are evaluated as a time series of photon arrivals to estimate the spectral peak half-life. The peak half-lives are useful in distinguishing among isotopes that share peak energies. The combination of the presence of spectral features and the empirical half-lives of those features substantially reduces the number of candidate isotopes over spectroscopic methods alone.

Under certain conditions, the fingerprint isotopes associated with the origin of a material are known. We use the candidate spectral features of those isotopes and the time sequence of listmode data to estimate the half-life of each spectral peak of interest by analyzing the photon inter-arrival times. The accumulation of counts over time is used to estimate the half-life for each peak. Very often radionuclide decay exhibits multiple characteristic peaks. All of the energy regions of interest are analyzed with



Total Decays at Each Peak for ^{140}Ba, Ordered by Decreasing Branching Ratio



Time Integrated Spectrum for the ^{235}U Irradiated Target with a Vertical Cursor at the Dominant Peak for ^{140}Ba (537.26 keV)

this technique to generate individual half-lives and then combined with branching ratios to estimate a composite half-life. The branching ratios of the peaks and their apparent half-lives provide further evidence of correct identification. Using characteristic peaks combined with empirical peak half-life estimates substantially reduces the list of candidate isotopes for identification. Time sequence information also allows us to observe activity of more short-lived isotopes that change in abundance over typical integration times for spectral analysis. The method is not proposed as a replacement for standard spectroscopic identification methods, but rather as additional evidence for the presence of a particular radionuclide when standard methods yield ambiguous results.

IMPACT

Applying this technique to nuclear monitoring improves the confidence in isotope identification by generating an additional line of evidence in support of spectroscopic methods. The time to initial identification may be reduced because this method generates information from count data as opposed to using radiochemical separations followed by spectral analysis. The requirement for specialized analytical facilities is also reduced to the extent that photo peak time series analysis can substitute for radiochemical processing.

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