

Numerical Simulation of Discrepancies Between Measured and Estimated Half-Life of Strontium Sr-90

Abstract

Reliable half-life data are fundamental to many areas of nuclear science, including reactor physics calculations, environmental radioactivity studies, and the long-term management of radioactive waste. Strontium-90 (Sr-90), one of the most significant fission products produced in nuclear reactors, plays an important role in environmental monitoring and radiological safety because of its relatively long half-life and biological mobility. The currently recommended half-life for Sr-90 is 28.79 ± 0.05 years, as adopted by the international Decay Data Evaluation Project. In practice, however, experimentally determined half-life values often show small but noticeable deviations from this reference value. Such discrepancies may originate from detector efficiency variations, background radiation fluctuations, counting statistics, and other experimental conditions that influence measured decay curves.

This study investigates the potential sources of these discrepancies through a numerical simulation approach focused on Sr-90 decay measurements. A computational framework was developed to reproduce realistic experimental conditions by combining exponential decay modelling with Monte Carlo-based uncertainty propagation. Synthetic decay datasets were generated using the standard decay equation. The simulations incorporate typical measurement effects such as detector efficiency drift of approximately 1%, background radiation variability of about 3 counts min^{-1} , and Poisson counting noise. A total of 100,000 Monte Carlo iterations were performed to evaluate how these factors influence the extracted half-life.

The simulation results produced an effective half-life estimate of 28.80 ± 0.04 years, which remains consistent with the recommended value but reveals potential deviations of roughly 0.2–0.3% depending on measurement conditions. Sensitivity analysis indicates that detector efficiency instability contributes the largest portion of the bias, followed by counting statistics and background radiation fluctuations.

The findings highlight how realistic experimental conditions can influence half-life estimation and demonstrate the usefulness of numerical simulation for interpreting radionuclide decay measurements. The developed framework provides a practical computational tool for evaluating Sr-90 half-life measurements and may support improved detector calibration procedures and measurement corrections in radionuclide metrology. Ultimately, this approach contributes to more reliable application of nuclear decay data in environmental monitoring and nuclear safety assessments.

Primary author: Mr SHITU, Mohammed (Aliko Dangode University of Science and Technology Wudil Kano, Nigeria)

Co-author: Prof. BICHI, Tijjani Sale (Aliko Dangode University of Science and Technology Wudil Kano, Nigeria)

Presenters: Mr SHITU, Mohammed (Aliko Dangode University of Science and Technology Wudil Kano, Nigeria); Mr INUWA, Ibrahim Abdullahi (Aliko Dangode University of Science and Technology Wudil Kano, Nigeria)

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