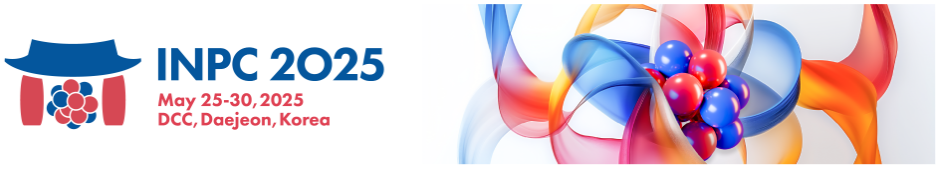

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# Machine Learning for the Automated Analysis of Data from Large-Scale Gamma-Ray Spectrometers

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Recent decades have witnessed exponential growth in both the quality and volume of experimental nuclear data, driven by advancements in detector technologies and accelerator capabilities. Gamma-ray spectroscopy, in particular, has benefited from these technological improvements, enabling the collection of increasingly complex datasets from large-scale spectrometers such as GRIFFIN and TIGRESS at TRIUMF, located in Vancouver, Canada. However, the traditional, labor-intensive methods of visually inspecting one- and two-dimensional histograms, time-gating on gamma-gamma coincidences, fitting spectra, and building upon existing level diagrams have struggled to keep pace with the mounting data.

To specifically address the challenges associated with constructing excited-state decay schemes, this research reformulates the construction of level schemes as an inverse optimization problem, taking the gamma-ray singles spectrum and symmetric gamma-gamma coincidence matrices as primary inputs into the algorithm. Using modern software packages for numerical optimization, a machine learning framework is employed to recover directed level-scheme graphs. Furthermore, we investigate hybrid quantum machine learning algorithms and alternative paradigms in high-performance computing to improve scalability and optimization convergence when dealing with higher-dimensional coincidence matrices. Preliminary benchmarking of these frameworks will be presented.

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