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Development of a simulation toolkit for lifetime studies based on Doppler-shift methods

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The Doppler-Shift Attenuation Method (DSAM) and the Recoil-Distance Method (RDM) are powerful tools to measure nuclear level lifetimes in the (sub) pico-second range which are used to determine model-independent transition strengths.
With respect to the common analysis of DSAM experiments, one can distinguish between analytical approaches and tools using Monte-Carlo methods. The latter subdivides into tools that only describe the slowing-down process (based on an initial velocity distribution and tabulated stopping powers) and the nuclear decay scheme on the one hand, and Geant4-based simulations which also incorporate the interaction of radiation with matter and allow to take into account different detector geometries on the other hand. Many dedicated Geant4 based simulations already exist. However, the vast majority is tailored to specific experimental conditions, e.g. with respect to the covered detector geometries and the nuclear reaction mechanism used to populate the states of interest. This hampers the applicability and transfer to modifications of the experimental conditions.
While Monte-Carlo methods are commonly used in DSAM experiments, the majority of RDM experiments are analysed using analytical methods based on the fitting of the fast and slow components in the RDM γ-ray spectrum. The only clear exception are RDM experiments with fast radioactive beams for which Monte-Carlo methods in the analysis are well accepted.
In this talk we will present a Monte-Carlo simulation based on Geant 4.10 which enables generating DSAM as well as RDM γ-ray spectra. The code allows to simulate typical reaction mechanisms, e.g. fusion evaporation and multi-nucleon transfer reactions. In addition, various HPGe detector geometries are implemented, ranging from single crystals to highly-segmented crystals such as SeGA or AGATA. Special emphasis was put on a modular concept, which allows to implement further reaction mechanisms as well as detector geometries rather easily. We will apply the simulation tool to experimental data to demonstrate the flexibility of the code. We will show our approach to describe the nuclear de-excitation based on a mixture of Geant4-based modules and self-developed classes.

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