Laboratory Statistics: Handbook of Formulas and Terms

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Exploring Stochastic Sampling in Nuclear Data Uncertainties Assessment for Reactor Physics Applications and Validation Studies

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Abstract: The quantification of uncertainties of various calculation results, caused by the uncertainties associated with the input nuclear data, is a common task in nuclear reactor physics applications. Modern computation resources and improved knowledge on nuclear data allow nowadays to significantly advance the capabilities for practical investigations. Stochastic sampling is the method which has received recently a high momentum for its use and exploration in the domain of reactor design and safety analysis. An application of a stochastic sampling based tool towards nuclear reactor dosimetry studies is considered in the given paper with certain exemplary test evaluations. The stochastic sampling not only allows the input nuclear data uncertainties propagation through the calculations, but also an associated correlation analysis performance with no additional computation costs and for any parameters of interest can be done. Thus, an example of assessment of the Pearson correlation coefficients for several models, used in practical validation studies, is shown here. As a next step, the analysis of the obtained information is proposed for discussion, with focus on the systems similarities assessment. The benefits of the employed method and tools with respect to practical reactor dosimetry studies are consequently outlined.

Keywords: neutronics; nuclear data; stochastic sampling; Pearson correlation coefficient; nuclear reactor dosimetry; uncertainty analysis; Monte Carlo simulation; light water reactor; validation

1. Introduction

It is a very well established and principally important practice in the nuclear safety field to validate calculation methodologies and tools against experimentally-based reference data. In fact the validation process constitutes a key component of an overall qualification process of a methodology, accompanied by the calculation uncertainty quantification procedure and the methodology benchmarking as well (see e.g., [1,2]). For instance, in the domain of criticality safety assessment, a very comprehensive validation resource is already established thanks to large international efforts invested in the past decades to collect, evaluate and combine all publicly available critical experiments in a single database [3]. The work was done under the auspice of the Organization for Economic Co-operation and Development (OECD) and involved in total twenty different countries [3]. Similar databases exist for other classes of experimental data, like reactor measurements, spent nuclear fuel isotopic compositions (from post-irradiation examination campaigns) and dosimetry measurements. However, despite the good state of the publicly available experimental databases, it is often desired to increase in size the validation database to advance the comprehensive validation of some particular methodologies and to increase the calculated to experiment (C/E) sample size in order to avoid unnecessary conservative penalties in safety assessments. Therefore, it is a very important task to identify an existence and the

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