

ESARDA activities

Monte Carlo benchmark exercises of the NDA Working Group

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Foreword: The last issue of the ESARDA Bulletin was a special issue entirely dedicated to a single paper. This decision could have surprised the ordinary Bulletin reader, also because of the choice of a quite specialised topic, not of broad interest, such as benchmark of simulation tools for NDA equipment. The ESARDA Editorial Committee feels the need to give a wider view about this topic in order to explain to the non specialist in Monte Carlo, why this subject is important for the Safeguard community and where this project is placed within the ESARDA activity. For this reason the chairman and the secretary of the NDA working group were requested to write this very short description on the working group activities in the field of physical modelling and numerical simulation.

Numerical simulation in NDA

Monte Carlo simulations applied to non destructive assay systems are commonly used as a design tool for NDA equipment, to optimise their performance and to predict their response in different kind of configurations, but also as a computational calibration technique [1,2].

The capability of computational tools has increased dramatically with the development of computer performances. In the case of NDA instruments for nuclear safeguards, it is possible to simulate the operation of the devices with mathematical models and reproduce the experimental data with a satisfying accuracy and with reasonable computing times. Computational modelling can provide fruitful improvements in the measurement procedures and must be considered as one of the available tools in experimental physics.

When considering the field of nuclear measurements applied to safeguard of nuclear materials, one of the most immediate among the several possible applications of computational modelling is the calibration of neutron counters. Calibration of NDA devices requires always a large experimental effort

in terms of time and manpower and the availability of suitable calibration standards. The goal that we try to fulfil through computational modelling is a reduction both in the experimental work and in reference material requirements.

Benchmarking and validation of models

Notwithstanding Monte Carlo simulation has widely proven in the recent years the capability to model and accurately reproduce the response of NDA equipment, any project needs to pass through an intensive check procedure in order to assess:

- the general validity and limitations of the physical models used by the codes
- the quality of the physical data and parameters (such as nuclear cross sections)
- the applicability of the code to the specific problem

We generally refer to the first two steps as benchmarking and it is devoted to prove in a general way the quality of a methodology, whereas we call validation the third step and is application dependent.

The ESARDA NDA Working Group has always devoted a large interest to the application of Monte Carlo techniques to the numerical simulation of NDA instruments in general and neutron counters in particular. In this frame the working group has organised several benchmark exercises especially devoted to assess the potentiality and to demonstrate the capability of the technique.

Moreover under specific request of the IAEA, the NDA-WG is currently redacting a “Good Practice Guide in the use of Numerical Simulation in NDA”. The objective is to set up a system of behaviour rules to be followed by anybody who is using computational modelling applied to NDA techniques. The correct implementation of these rules will constitute a sort of quality certification that will allow helping in the acceptance of modelling results in measurement techniques and evaluation procedures.

Monte Carlo benchmarks of the ESARDA NDA-WG

Three benchmark exercises have been carried out in the last years in order to assess the capabilities of Monte Carlo to reproduce the experimental data:

- one was on a simple geometry [3]: a point californium source placed at a fixed distance from a slab detector with interposed layers of moderator (polyethylene) and absorber (cadmium). The purpose was to analyse the influence of the main basic physical parameters (influence of fission spectrum, thermal treatment, cross section dataset,...
- another one dealt with the comparison of models for the prediction of the real coincidence rates from a reference PWR fuel assembly measured with an active neutron collar [4]
- the most recent one intended to model a passive multiplicity counter and the results of this exercise have been described in the final report that

has been object of the special issue of the ESARDA Bulletin [5].

A follow-up of this latter benchmark is now ongoing. The idea is to repeat the exercise with an experimental pulse train acquired in LIST mode, instead of a simulated one. The goal is to compare the available software for LIST mode data analysis in view of possible future developments of neutron counting towards the abolition of shift register analysers and direct acquisition and processing of pulse trains by a PC.

References

- [1] P. Peerani, M. Looman: "Computational modelling of NDA instruments for nuclear safeguards", Proceedings of the 24th ESARDA Annual Meeting, Luxembourg, (2002), pages 131-137.
- [2] http://esarda2.jrc.it/references/Technical_sheets/TS-Monte-Carlo-Simulation-060412-fin.pdf
- [3] ESARDA Bulletin, # 33, (February 2006), pages 26-39.
- [4] ESARDA Bulletin, # 31, (April 2002), pages 18-22.
- [5] ESARDA Bulletin, # 34, (September 2006), pages 2-32.