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#09-64 Deconvolution methods used for the development of a neutron spectrometer.

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This presentation stems from a thesis project in progress, leading to a unique multi detectors Bonner sphere. Neutron spectrometers like Bonner spheres have been studied and developed for more than 60 years for astrophysics and radiological protection applications. In particular, in radiological protection, it is a crucial challenge to determine the initial energy of the incident neutrons with a sufficient accuracy, to evaluate their damage to human body.

During the simulation part of the development, GEANT4 simulations were performed to study the response of Bonner spheres instrumented with 30 to 50 active detectors. The aim of these studies is the optimization of the number and size of the active detectors and the diameter of the sphere. One of the most significant issues was the unfolding of the different simulated “measures” obtained by the active detectors to get the original energy spectra with neutron energies between 0 and 20 MeV and to evaluate the errors related to these spectra. This unfolding is a key point for the optimization of the multi detector Bonner sphere.

In particular, three deconvolution methods have been developed and tested : the least-squares, the maximum entropy coupled to maximum likelihood and the maximum likelihood methods, which require a certain number of parametrical adjustments to become optimal. In general, every method needs a converging algorithm to be accurate.

- For instance, in the maximum likelihood methods, where the likelihood function is based on Poisson distribution, it is due to the nonlinearity of the involved equations, which cannot be analytically solved. However, these methods work for underdetermined –in case of an insufficient number of detectors in comparison to the number of groups of energies - as well as overdetermined problems, and can be coupled to the maximum entropy method ;

- In the least-squares methods, it is due to the important sensitivity to perturbations related to the matrix inversion and to non-positive solutions. To resolve this, the iterative Levenberg-Marquardt’s method can be used. It implies nonlinear equations as well but leads in particular to only positive solutions, by inserting exponential functions in the solution and a Levenberg-Marquardt’s parameter λ which has to be modified after each iteration. But this method does not work for underdetermined problems.

The results obtained with these methods have been compared to the unfolding package distributed by the Nuclear Energy Agency, UMG 3.3 - Unfolding with MAXED and GRAVEL. This package consists of two unfolding programs based on maximum entropy (MAXED) and least-square methods (GRAVEL), one spectrum analysis program (IQU) and one graphical display program (UMGplot).

The different methods will be introduced, then some examples of unfolding spectra will be presented and the performances of the different methods discussed. Finally, firsts results of optimizations of the dimensions of the sphere and the dimensions and number of active detectors will be exposed. First developments and tests of neutron detectors dedicated to the multi detector Bonner sphere will also be presented.

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