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ESTIMATION OF UNCERTAINTIES FOR SUBCRITICAL BENCHMARK MEASUREMENTS

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ABSTRACT

Subcritical measurements are used for many applications including nonproliferation, treaty verification, in-situ monitoring for criticality, and reactor subcriticality monitoring. Most analysis methods involve correlated neutron detection, based upon the property that fission events can create multiple neutrons that are born at nearly the same time (on a scale of 10^{-13} or 10^{-14} seconds). Many different time-correlated methods have been used since the 1950s and are still widely utilized today. This particular work describes an uncertainty analysis of measured data using the Hage-Cifarelli formalism of the Feynman Variance-to-Mean method. The Feynman Variance-to-Mean method was introduced by Feynman et al. in 1956 and is based upon the differences between the detector count data and the data that would be expected from measurements taken from a Poissonian source. The Hage-Cifarelli formalism relates moments of the Feynman histograms to several parameters of a system: leakage multiplication (M_L), spontaneous fission rate (F_S), (α,n) neutron emission rate (S_α), detector efficiency (ε), and the moments of the number of neutrons emitted per fission (ν). The first part of the uncertainty analysis described in this work will show how to determine uncertainties of the first (R_1) and second (R_2) reduced factorial moments of the Feynman histograms. The second part of the analysis will describe how to determine the uncertainties in the other parameters given uncertainties in the reduced factorial moments (in particular, this work will focus on determining the uncertainties in M_L and F_S. Application to other parameters of interest (total multiplication, k_{eff}, neutron lifetime) will be discussed in the full paper. This work will utilize measured data from a recent benchmark evaluation with a 4.5 kg sphere of α-phase plutonium to validate the uncertainty analysis.