Letter to the Editor

Data Analysis in Time-of-Flight Measurements of Spontaneous Fission Spectra

Since ^{252}Cf is likely to become a standard neutron source,[1-4] increasing interest is paid to its neutron energy spectrum. Unfortunately, there is no agreement among these authors about the kind of best-fit distribution, Maxwellian or Watt, and the spread of values for the average energy is beyond the associated errors. Detailed review is given in Refs. 4 through 9.

Most of the recent accurate measurements of the ^{252}Cf neutron fission spectra have been performed by means of the time-of-flight (TOF) method, and the present evaluations[4,9] rely to a large extent on such work, e.g., the measurements of Green et al.[10] and Knitter et al.[11] Green et al.[10] claim the highest accuracy for a Maxwellian temperature parameter, 1.406 ± 0.015 MeV, and find this representation to be adequate to ±5% from 0.7 to 8 MeV. These authors report a clear deviation from this distribution, particularly below 0.7 MeV and above 8 MeV, and develop a model to overcome this discrepancy.

In almost all measurements using the TOF technique, the neutron detector pulses are used to start and properly delayed pulses originating from fission fragments or prompt fission gamma rays are used to stop a time-to-amplitude converter (TAC). The corrections applied in data analysis are dealt with in detail in Refs. 5 and 10. Nevertheless, one correction has not yet been accounted for, and this becomes important if nonperiodic (randomly distributed) events are investigated by TOF.

Let us assume that a signal from a neutron event has started a "normal" TAC (which accepts only the first stop after a start). If the correlated stop is expected to occur at a time t after the start, it can only be accepted if the TAC has not been stopped during the time interval $(0,t)$ by an uncorrelated stop pulse. If trigger dead-time effects are neglected, $\epsilon_N = 1 - A\cdot\Delta t\cdot N$ seems to be a good approximation for the stop efficiency ϵ_N associated with time channel N, where A is the average stop rate and Δt is the analyzer channel width. The exact description of TAC data analysis is somewhat complex and beyond the aim of this Letter.[12]

It is surprising to observe that this simple consideration has not been accounted for in the literature on TOF measurements of the ^{252}Cf neutron spectrum. Although in many cases this correction is small and can be neglected, it becomes important when long flight paths and, therefore, relatively high count rates are used.

For example, Green et al.[10] used a ^{252}Cf source with an emission of $6.13\cdot10^5$ fission/s. The efficiency of their gas scintillator was ~70%, the flight path was 3.7 m, and the delay was ~400 ns. Assuming that there are no additional stops caused by the $9.6\cdot10^6$ alpha particle/s emitted in 2π or any other events, this results in correction factors from 1.01 at E_n = 0.5 MeV to 1.16 at E_n = 10 MeV, which should have been applied to the measured data raising the Maxwellian temperature to ~1.43 MeV and to some extent weakening the discrepancy at high energies. In Ref. 13, the correction is slightly larger; with the sandwich-type fission detector of Ref. 11, it can probably be neglected, because the stop rate was by far not as high as can be concluded from the paper.[14] Thus, it seems necessary to revise the existing ^{252}Cf spectrum evaluation, taking into account the above-described correction.

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