

IMPROVED PREDICTIONS OF NEUTRON DETECTION EFFICIENCY FOR HYDROCARBON
SCINTILLATORS FROM 1 MeV TO ABOUT 300 MeV

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In order to measure absolute neutron cross sections at the IUCF, it is necessary to measure or calculate reliably the detection efficiency of the neutron counters. The latter approach provides increased flexibility to change counter types or sizes. Although much work has been done to develop computer codes to calculate neutron counter efficiencies for low-energy neutrons, less work has been done for medium-energy neutrons. Since our work at the IUCF requires that the neutron counters be operated with relatively high pulse-height thresholds to prevent overlap of low-energy neutrons from one beam burst with high-energy neutrons from the next beam burst, it is important to develop computer calculations which are reliable at high thresholds. In order to obtain such calculations, we have made several modifications to the Monte-Carlo neutron detector efficiency code of Stanton¹⁾ to provide improved agreement with several different detector efficiency measurements. The modifications include a new adjustment of the cross sections and kinematics for the carbon inelastic reaction channels, addition of a C(n,2n) reaction channel, adoption of new light-response functions,²⁾ the use of relativistic kinematics, and the correct determination of light deposited by charged-particle recoils which escape the counter. Of these various changes, the most significant improvements over earlier codes result from the new adjustment of the cross sections and kinematics for the C(n,np) reaction channel.

The calculations of neutron counter efficiencies with the improved Monte-Carlo code provide good agreement, especially at high detector thresholds, with

available measurements. The consistently good agreement of our calculations with high-threshold data is not seen in earlier computer calculations of neutron detector efficiencies. In Fig. 1a we compare our Monte-Carlo calculations with the measurements of Riddle *et al.*³⁾ for a 7.6 cm thick by 17.78 cm diameter NE-102 counter at four thresholds between 1 and 22 MeV equivalent-electron energies. The calculations reproduce the measurements well at all thresholds. The recent measurements of Betti *et al.*⁴⁾ for a 15.3 cm diameter by 27.0 cm thick NE-110 (CH_{1.1}) scintillator are shown compared against calculated efficiencies in Fig. 1b for four thresholds from 2.80 MeV to 15.75 MeV equivalent-electron energy. Again the agreement is good. Additional comparisons of calculated efficiencies with measured efficiencies for both plastic and liquid scintillators are presented in a paper submitted to Nuclear Instruments and Methods.

Since the calculations agree with the available data to better than 10%, and usually much better, and since any one efficiency measurement probably includes some systematic error, we estimate that these calculations are accurate to a few percent (except near threshold) for the range of experimental parameters tested here, namely, for neutron energies from 1 MeV to about 300 MeV and for detector thresholds from below 0.1 MeV to above 22 MeV equivalent-electron energy. The calculations may be reliable over an even wider range of neutron energies and detector thresholds, but remain untested because of a lack of experimental measurements.

- 1) N.R. Stanton, COO-1545-92 (February 1971).
- 2) R. Madey *et al.*, Nucl. Instr. and Meth. 151, 445 (1978).
- 3) R.A.J. Riddle *et al.*, Nucl. Instr. and Meth. 121, 445 (1974).
- 4) G. Betti *et al.*, Nucl. Instr. and Meth. 135, 319 (1976).

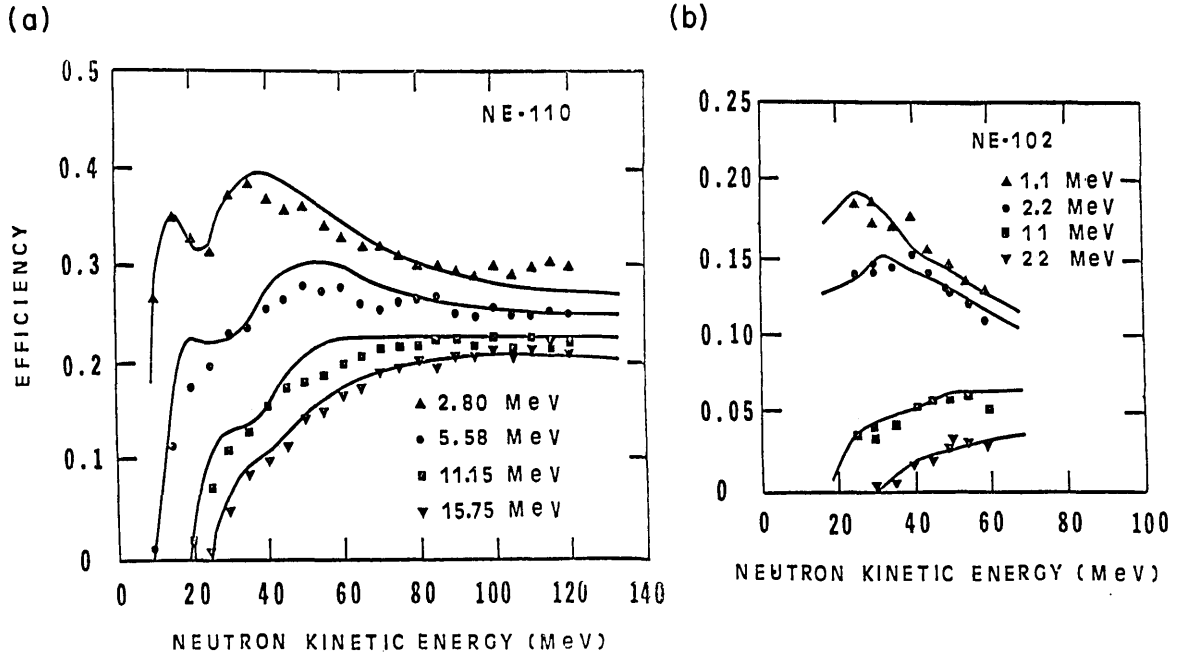


Figure 1. Comparison of efficiency measurements with calculations of the Monte-Carlo computer code for plastic scintillators with thresholds set from 1.1 to 22.2 MeV equivalent-electron energies: (a) Riddle *et al.*,³⁾ and (b) Betti *et al.*,⁴⁾