DEMON Detector Efficiency in the NIMROD Set-up

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Inclusion of the DEMON detectors in the NIMROD set-up allows direct measurement of the neutron energy distributions and direct comparison with the proton distributions extracted from the charged particle array. In the coalescence framework ([1] and other reports of the group), the n/p ratio is then determined directly from the data, as a function of the nucleon energy. The direct measurement of neutron energies also greatly improves our calorimetric determinations of excitation energies using the total multiplicities determined from the neutron ball.

In our recent experiments, five DEMON detectors were located approximately 2 meters from the target in a plane including the beam axis, at 46 degrees with respect to the horizontal plane. A gap between two sectors of the neutron ball was created in order to open a window between the target and the DEMON detectors.

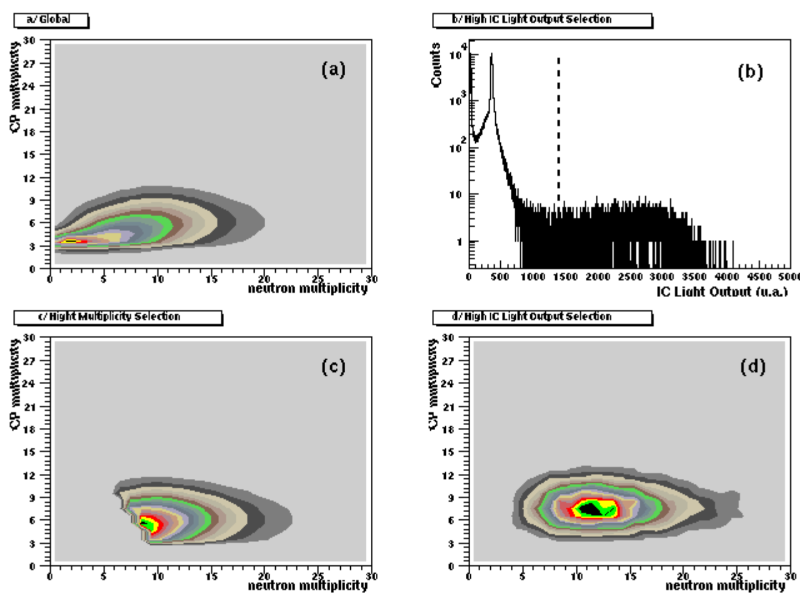

Figure 1: (a) Charged particle and neutron multiplicity correlation with a minimum bias trigger. (b) IC light output distribution. (c) High multiplicity trigger. (d) Result of the IC high signal selection on the multiplicity correlation spectrum.

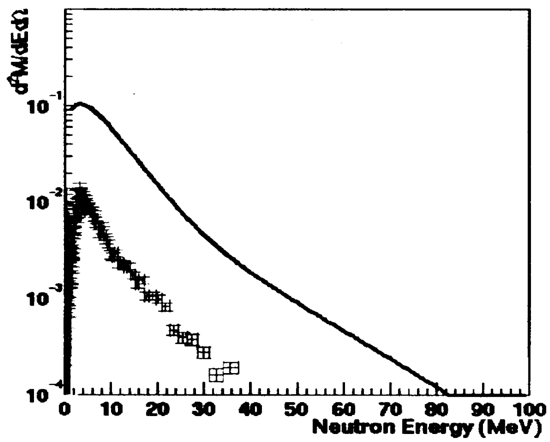

Figure 2: Experimental neutron energy distribution compared to the results from reference 2 (full line).

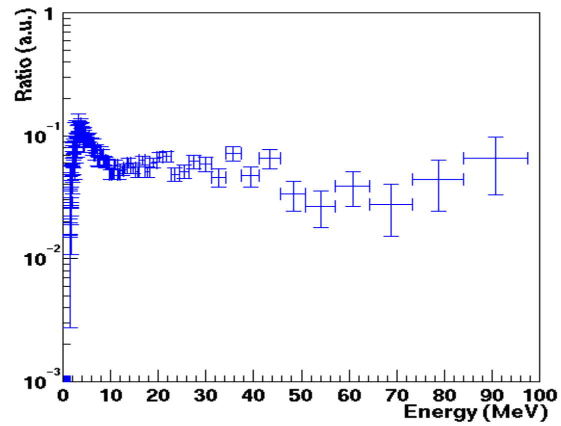

Figure 3: Total detection efficiency as a function of the neutron energy at 45 degrees with respect to the beam axis.

The DEMON counters are still shadowed by the charged particle array which is relatively thick. As a result the neutron yield at each detection angle is attenuated rather strongly. Nevertheless, the measured spectra for a standard test reaction are quite similar in shape to those previously observed. In fact, in order to estimate the attenuation coming from the charged particle array, we reproduced the experiment ^{40}Ar(26 AMeV)+^{92}Mo observing the neutron multiplicity associated with the evaporation residues (ER) detected at forward angles and already studied in reference [2].

In the NIMROD experimental set-up, the ionization chamber (IC) placed in front of each ring (13) allows us to detect the ER at angles up to 4 degrees. Using rings 2 to 5, we cover the detection angles between 4 and 15 degrees. Figure 1b shows the energy distribution in one sector of the IC and the result of the high energy selection (to the right of the dashed line) on the two dimensional spectrum associating the charged particle and neutron multiplicities (Figure 1d).

In order to increase the statistics of the detected neutron yield associated with the ER, we decided to trigger on the high multiplicity events shown in figure 1c and assume the same average neutron multiplicity as in figure 1d.

This selection allows us to take into account the ER recoiling at lower angles with respect to the beam axis (below the experimental coverage). With this selection, the total observed neutron distribution is compared to the results from reference 2.

Figure 2 shows an example for the DEMON detector at 45 degrees with respect to the beam axis. Figure 3 shows the ratio between the experimental result using the NIMROD set-up and the standard result in reference 2. The behavior of this ratio is directly related on one hand, to the intrinsic efficiency of the DEMON detectors and on the other hand, to the large attenuation due to the matter between the target and the detectors. With a threshold of 500 keVee, the total detection efficiency including all effects is ~5-10%.

To try to understand in greater detail the large attenuation of the neutrons in the charged particle array, GEANT simulations are being carried out.

References

[1] K. Hagel *et al.*, Phys. Rev. C **62** (2000).
[2] K. Yoshida *et al.*, Phys. Rev. C **46** (1999).