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Measurement of the High Energy Component of the Neutron Spectrum from a Moderated Source

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Abstract

The high energy component of the neutron spectrum from a moderated source has been measured by an improved method at the LNS synchrotron. The detector size of 7 cm diam. by 30 cm long NE-213 liquid scintillator was used and a FERDOR unfolding code was adopted for the spectrum data analysis. This result is compared with a previous measurement employing a smaller detector and a rectangular unfolding technique. The accuracy of the new method was tested by measuring the same high energy neutron spectrum which was measured and analyzed both by time-of-flight and by the FERDOR unfolding method.

1. INTRODUCTION

The neutron yield and spectra from spallation reactions have been measured as a part of a feasibility study for the German spallation source project. Measurement of the high energy component of the neutron spectrum from a moderated source has been carried out since these fast neutrons may cause shielding problems as well as unwanted background for some experiments with thermal and epithermal neutrons. In our previous work, neutron spectra measurements of this type were carried out at SIN with a commercially available 10 cm diam. by 8.9 cm long NE-213 liquid scintillator. The use of an unfolding method of analog spectra appeared to be necessary because the time-of-flight method was not applicable for spectrum measurment from a moderated source. In order to receive quick results, the pulse height spectra were analyzed with a rectangular unfolding method[1]. These measurements revealed that a large number of high energy neutrons leaked out of the moderator. Results of this type obtained for light-water-moderated target assembly and 590 MeV proton beam were presented at the last ICANS-IV meeting[1]. Since the reference concept was changed from the original energy of 600 MeV to 1.1 GeV, additional measurements were carried out at this energy at LNS, Saclay. For this measurement, a 30 cm long NE-213 detector was constructed which allowed spectrum measurements over an extended neutron energy range up to 250 MeV. In addition, The FERDOR code was employed for spectrum unfolding instead of the previous rectangular unfolding method. A comparison of the results from these two methods will be discussed in this paper. In order to check the accuracy of the new unfolding method, the same high energy neutron spectrum from a thick bare uranium target was measured and analyzed both by the time-of-flight and by the FERDOR unfolding method. The results and comparison are also presented.

2. EXPERIMENTAL DETAILS

The experimental details of the measurements are the same as those described in ref. 1. The target configuration used in the SATURNE experiment is shown in Fig. 1. In order to simulate a realistic spallation neutron target design, the primary target was composed of alternately arranged plates of lead, polyethylene, and aluminum. The polyethylene and aluminum represented the coolant and structural materials.

3. SPECTRUM UNFOLDING AND RESULTS

The rectangular unfolding method simply employs response functions of a rectangular form in a given energy bin while the FERDOR analysis employs realistic response functions. In the present work, the ORNL version of the FERDOR code[2] was used. The necessary response functions have been generated by the Monte-Carlo program of Stanton[3] as modified by Cecil et al[4]. In order to avoid problems using wide energy bins and also a wide smoothing window width, a special kick-back routine has been added to the FERDOR code. In particular, this means the first result from FERDOR is smoothed with the same window function and the differences of the first and the second results are kicked-back to the first result to correct the wide energy bin effect.

The results of spectrum measurements for moderated target configurations are shown in Fig. 2. The absolute values were determined for a 6 m distance from the source and a 5.5 mA incident beam current. The discrepancy between the FERDOR and the rectangular unfolding methods is seen at energies above about 70 MeV, while agreement below this energy is still reasonable. Above 70 MeV, the rectangular unfolding distorts the spectrum shape significantly. Integration over energy of both spectra, however, yields comparable values.

The results for the SIN spectrum measurements are shown in Fig. 3. As can be seen, the agreement between the FERDOR and the time-of-flight method is fairly good. The sharp decrease above 200 MeV in the FERDOR result is caused by a range effect in the 30 cm detector. The present results also display the typically large uncertainties associated with the FERDOR unfolding. These uncertainties can possibly be reduced by using more improved unfolding routines which have recently become available.

4. SUMMARY

The fast neutron flux from the moderated spallation source has been successfully determined using unfolding methods. The FERDOR unfolding method has shown a significant improvement over the small detector measurement and over the rectangular unfolding technique at energies above 70 MeV. It becomes clear that a large number of high energy neutrons leak out of the moderator and such a result is an important piece of information with respect to the design of spallation neutron sources.

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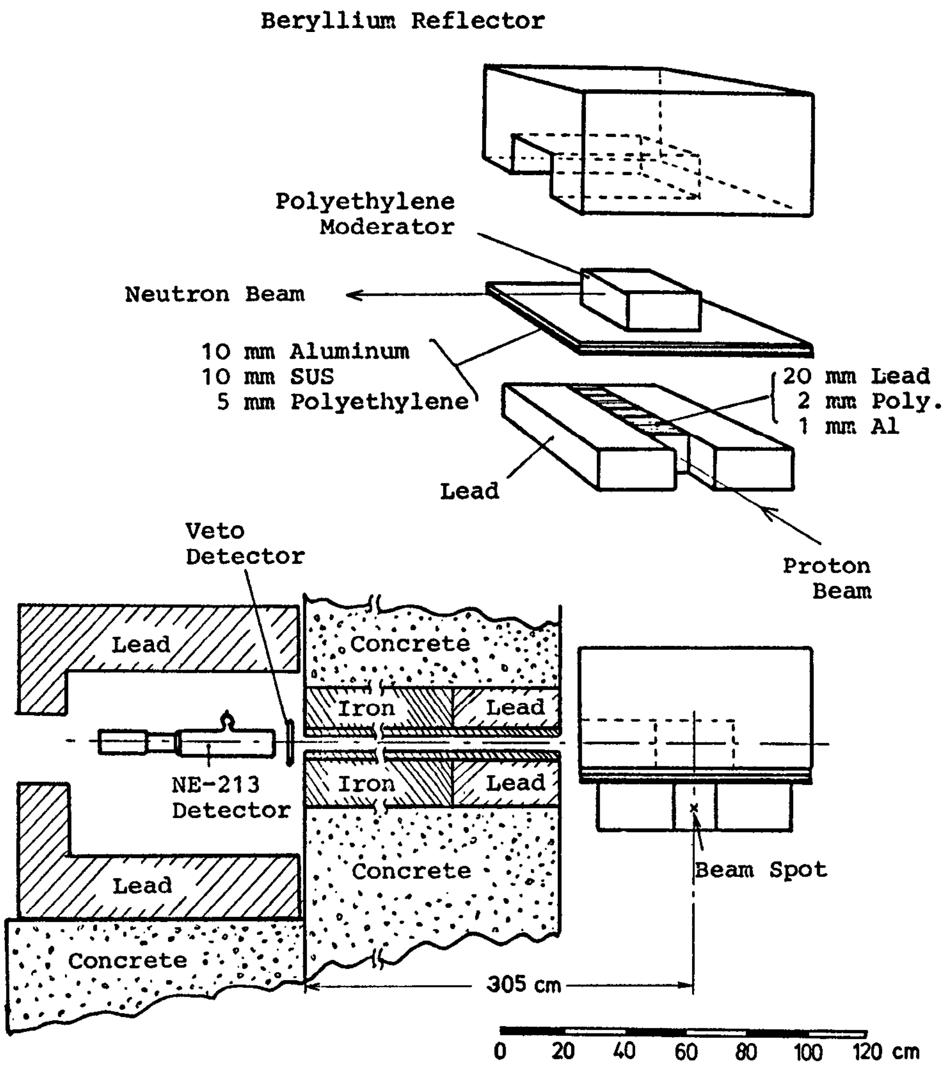

Fig. 1 Experimental arrangement for moderated neutron source.

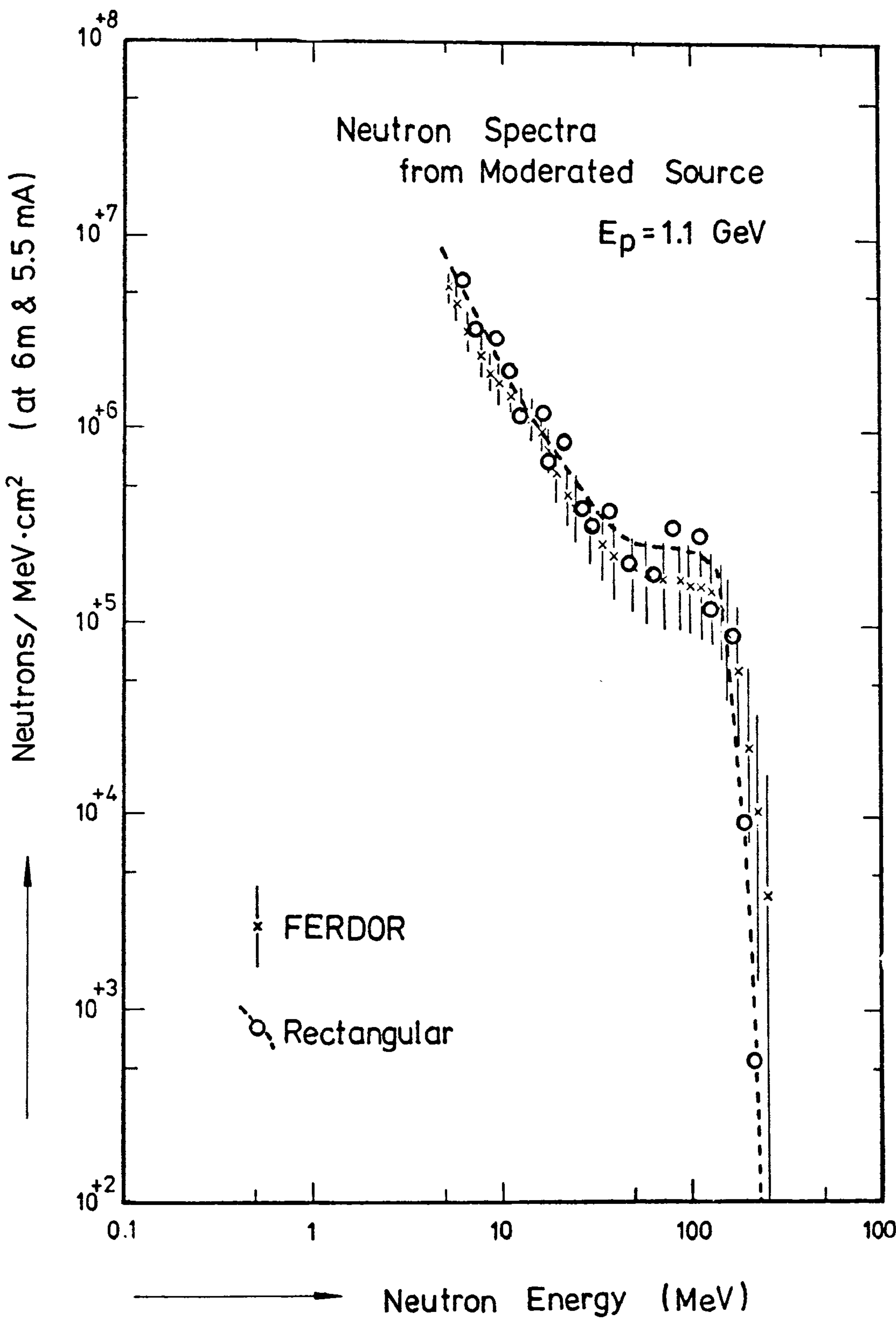

Fig. 2 Neutron spectra from moderated source. The absolute values are normalized to give the neutron flux at 6 m distance and 5.5 mA beam current.

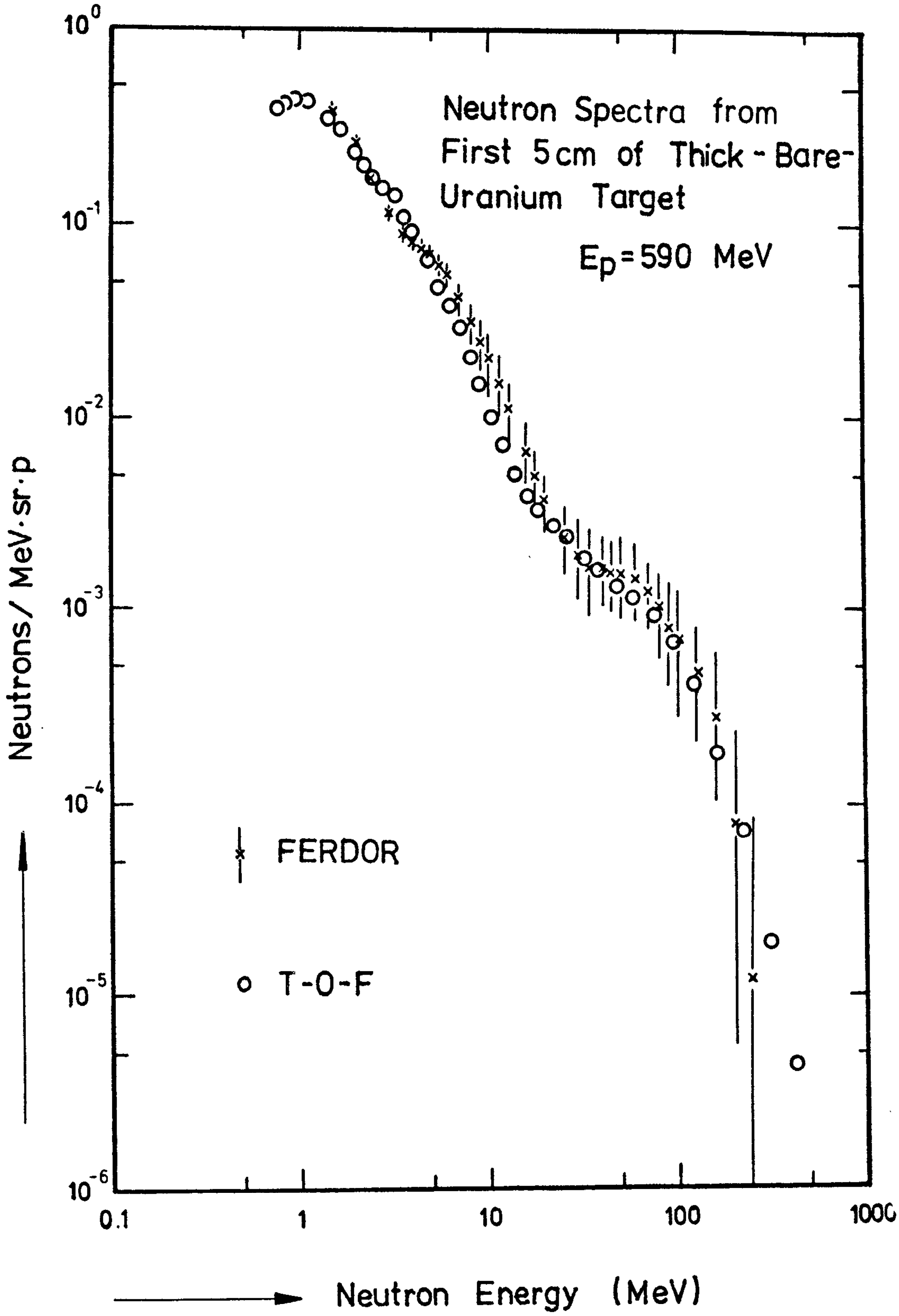

Fig. 3 Neutron spectra from thick-bare-uranium target. The absolute values are normalized to give the number of neutrons from the first block (10 x 10 x 5 cm) of the uranium target.