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A Determination of the Neutron Energy and Spatial Distributions of the Neutron Beam from the TSR-II in the Large Beam Shield

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OAK RIDGE NATIONAL LABORATORY

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A DETERMINATION OF THE NEUTRON ENERGY AND SPATIAL DISTRIBUTIONS OF THE NEUTRON BEAM FROM THE TSR-II IN THE LARGE BEAM SHIELD

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ABSTRACT

The TSR-II reactor of the ORNL Tower Shielding Facility has recently been relocated within a new, fixed shield. A principal feature of the new shield is a beam port of considerably larger area than that of its predecessor. The usable neutron flux has thereby been increased by a factor of ∿ 200.

The bare beam neutron spectrum behind the new shield has been experimentally determined over the energy range from 0.8 to 16 MeV. A high level of fission product gamma ray background prevented measurement of bare beam spectra below 0.8 MeV, however neutron spectra in the energy range from 8 keV to 1.4 MeV were obtained for two simple, calculable shielding configurations. Also measured in the present work were weighted integral flux distributions and fast neutron dose rates. Results are presented in detailed tabular form and, where feasible, in the form of graphs.

INTRODUCTION

In order to conduct precision shielding experiments which will be useful in verifying the increasingly more accurate calculational methods now being utilized in fast reactor shield designs, it is necessary to determine with high precision the neutron energy and spatial distribution for the neutron beam which is the source for the shielding experiments. It is also desirable for this source of neutrons to be very intense so that the neutron and gamma-ray transmission through very thick shields can be determined. Neutron attenuations on the order of 10^{14} are required in the reactor shield for the Clinch River Breeder Reactor (CRBR), therefore it is desirable to be able to measure neutron attenuations of approximately this magnitude.

By placing the reactor in a new reactor shield which has a 3-ft diam beam port and also allows the shielding samples to be positioned close to the reactor core, the intensity of the source was increased by a factor of 200 over that for the old beam shield configuration which had a 10-in. diam beam port passing through a shield which was about four feet thick.

The new large beam shield for the TSR-II consists of a layer of stainless steel and water, which acts as a thermal shield, surrounded by a thick layer of concrete. This shield is not designed to be picked up by a hoist, as was the previous configuration. A horizontal cross-section of the new shield is shown in Fig. 1. Also shown is a sketch of the earlier shield configuration which helps to indicate the large increase in solid angle between the reactor core and the outer end of the beam port achieved in going from the old to the new configuration.

INSTRUMENTATION

High energy (0.8 - 19 MeV) neutron spectra were measured with a system employing a nominal 2-in. x 2-in. cylinder of NE-213, an organic scintillator. The system is essentially that described by Burrus and Verbinski[1]. The FERDOR code, described in the same paper, is used to unfold the pulse height data. FERDOR predicts the upper and lower bounds within which the true spectrum is expected to lie, given a 68% confidence level.

Two spherical proportional counters 4.64 cm in diameter and filled primarily with hydrogen gas were used to measure the neutron spectra in the energy range from 8 keV to 1.4 MeV. One of these counters is filled to a pressure of 10 atm with pure hydrogen. Its useful energy range extends from about 300 keV to 1.4 MeV. The second is filled with a mixture of 85% hydrogen, 10% methane, and 5% nitrogen to a pressure of 3 atm. It is useful in a one-parameter mode for spectra in the range 100 - 400 keV. By employing a two-parameter pulse rise-time gamma-ray discrimination technique, the range of the second counter is extended down to a neutron energy of about 8 keV. The SPEC4 code of Kemshall, et al.[2] is used to unfold the proton recoil pulse height data.

The Bonner ball detectors measure an integral of the neutron energy flux weighted by the energy dependent response function of a given ball. The Bonner ball detector consists of a 2-in.-diam spherical proportional counter filled with approximately 1/2 atm of $^{10}BF_3$. The counters are used bare, with a cadmium cover, or they are enclosed in either a 3-in.- or a 6-in.-diam polyethylene shell. Bonner ball experimental results are predicted analytically by folding a calculated neutron spectrum with the Bonner ball response functions calculated by Maerker et al.[3].

Fast neutron dose rate measurements reported here were obtained using a 1/16-in.-thick, 1/2-in.-diam Hornyak button as the dosimeter. A Hornyak button consists of a disk of lucite containing very small particles of zinc sulfide dispersed uniformly in the disk. A description of the properties of such buttons has been published by Muckenthaler[4].

NEUTRON SPECTRA MEASUREMENTS

The configuration for the measurement of the neutron spectrum for energies higher than 0.800 MeV is shown in Fig. 2. The NE-213 neutron spectrometer was located on the beam axis, at a distance of 40 ft from the core center, within a concrete block shield. A 5 ft x 5 ft x 4.5-in.-thick ^{238}U (depleted) slab was placed in the beam 20 ft from the core center in order to reduce the gamma-ray flux incident upon the detector to a tolerable level.

Before any data were taken, the solid angle seen by the detector was determined by traversing a ^{60}Co gamma source across the face of the ^{238}U slab. The result is shown in Fig. 3. The term "umbra" is defined as the region over which the count rate is high and uniform; the "penumbra" is the transition region where the count rate varies from full intensity to background.

In order to minimize the possibility of errors in these important measurements, three independent determinations of the TSR-II bare beam neutron spectrum were made. Data from the three NE-213 runs are presented in Tables 1, 2, and 3. Agreement is seen to be excellent. The integrals of the flux from 0.8 to 16 MeV agree nearly exactly for the data of Tables 1-3. Plots of the three runs have been combined as Fig. 4 in order to emphasize the excellent agreement in spectral structure.

The proton recoil counters could not be used in the unattenuated bare beam because of the high level of fission product gamma rays. Spectra over the energy range from about 8 keV to 1.4 MeV were obtained, however, for 2 simple shield configurations. The first consisted of a nominal 12-in.-thick slab of iron placed directly against the beam shutter. The spectrometer was located on the beam axis, 12 in. behind the iron slab. Concrete walls 24 in. thick bounded the slab on both sides, and a 12-in.-thick lithiated paraffin slab covered its top. Fig. 5 shows this configuration.

The spectrum transmitted by the iron slab is listed in Table 4 and plotted as Fig. 6. In order to cover the desired energy range satisfactorily, 4 independent runs were made at different gain settings and with different counters. These pulse height distributions are unfolded sequentially, beginning at the high energy end. The individual runs can be distinguished in the figure, particularly in the overlap near 40 keV, where the two runs disagree in one energy interval. The observed disagreement, which occurs in the energy region where the two-parameter gamma-ray discrimination technique is used, results from the processing required to unfold the data. Before the SPEC4 code can be used, it is necessary to process the two parameter data to separate the gamma-ray component from the neutron component. For this process, a curve derived from a run with ^{60}Co is used. Small differences in shape between the ^{60}Co curve and the experimental gamma-ray curve acquire excessive importance where the neutron count rate is low. In general, where a disagreement exists, more confidence should be placed in the lower energy region of each segment.

The second configuration used during the proton recoil measurements is shown in Fig. 7. It consisted of a nominal thickness of 12 in. of iron located a distance of 9 ft 9 3/16 in. from the core center. This configuration was run in order to simplify the source description for the analysis of this data. With the iron slab removed from the reactor, there is no multiple scattering of neutrons between the 12-in. iron slab and the reactor or the shield that must be accounted for in the calculation. The detectors were placed on the beam axis 12 in. behind the iron slab.

The spectrum observed behind the configuration of Fig. 7 is tabulated in Table 5 and plotted in Fig. 8.

BONNER BALL DATA

Bonner ball traverses were completed along the beam axis (Table 6), along a vertical line through the beam axis 20 ft from the TSR-II core center line (Table 7), along a horizontal line through the beam axis 20 ft from the core centerline (Table 8), and in a horizontal plane through the beam axis radially from the core center at angles of 30 and 45 deg south from the beam axis (Table 9).

FAST NEUTRON DOSE RATES

The Hornyak button dosimeter was used to determine fast neutron dose rate along the beam axis (Table 10), along a vertical line through the beam axis at a distance of 3 ft 2 3/4 in. from the core center line (Table 11), and along a horizontal line through the beam axis at a distance of 3 ft 2 3/4 in. from the core center line (Table 12). The data of Tables 11 and 12 have been combined to produce the fast neutron dose profiles shown in Fig. 9. The asymmetry that is evident is real, and results from the fact that the lower half of the core is contained in a hemispherical section of the pressure vessel, whereas the upper half of the core is contained in a cylindrical section of the pressure vessel. The upper region of the core is surrounded by air-filled aluminum tanks which were designed to minimize the variation in the leakage between the upper and lower regions of the core; however, some asymmetry remains.

The Hornyak button was also used to map the fast neutron dose distribution in a horizontal plane through the beam axis, at various distances from the core center and various angles from the beam axis. The results are plotted to scale in Fig. 10.

Five fast neutron dose rate measurements were made at the NE-213 spectrometer position on the beam axis 40 ft from the core center in the concrete shelter. They are listed in Table 13.

During the course of these experiments, fast neutron dose rates were periodically measured at two distances from the core center, at 3 ft 2 11/16 in. and at 2 ft 11 1/8 in. The results were very consistent. The mean of 9 measurements at 3 ft 2 11/16 in. was 4.93×10^{1} $erg \cdot g^{-1} \cdot hr^{-1} \cdot W^{-1}$. The standard deviation of a single measurement from the mean value was approximately 3.6%. The mean of 9 measurements at 2 ft 11 1/8 in. was 6.25×10^{1} $erg \cdot g^{-1} \cdot hr^{-1} \cdot W^{-1}$, with a standard deviation of 1.2%. When least-squares fitted as a function of time, both sets of data displayed a slight systematic drift toward higher count rate, of the order of 0.5% per day.

SUMMARY

Measurements of the neutron energy and spatial distribution are presented in this report which allow an accurate specification of the neutron source for future shielding experiments utilizing the large beam shield. Analysis of these results using a combination of reactor leakage calculations and the measured spatial distribution determinations will provide a multi-dimensional source description for the input to the DOT radiation transport code. The NE-213 neutron spectrum measurements will be corrected for the attentuation of the uranium slabs in the beam and compared with the calculated leakage spectra from the reactor core. The energy spectra between 8 keV and 1.4 meV will be compared by calculating the transmission through the 12-in.-thick iron slab and comparing these results with the measured results. A simplified source configuration will be chosen, either as a point source or a plain disc source, which will allow the

prediction of the measured energy and spatial distribution as presented in this report. Corrections will be made for the asymmetry of the source so that the total number of neutrons emitted from the source is predicted correctly. The new source description is being generated by R. E. Maerker of the Shielding Analysis and Reactor Physics Group. The results of this analysis will be published by Maerker, et al..

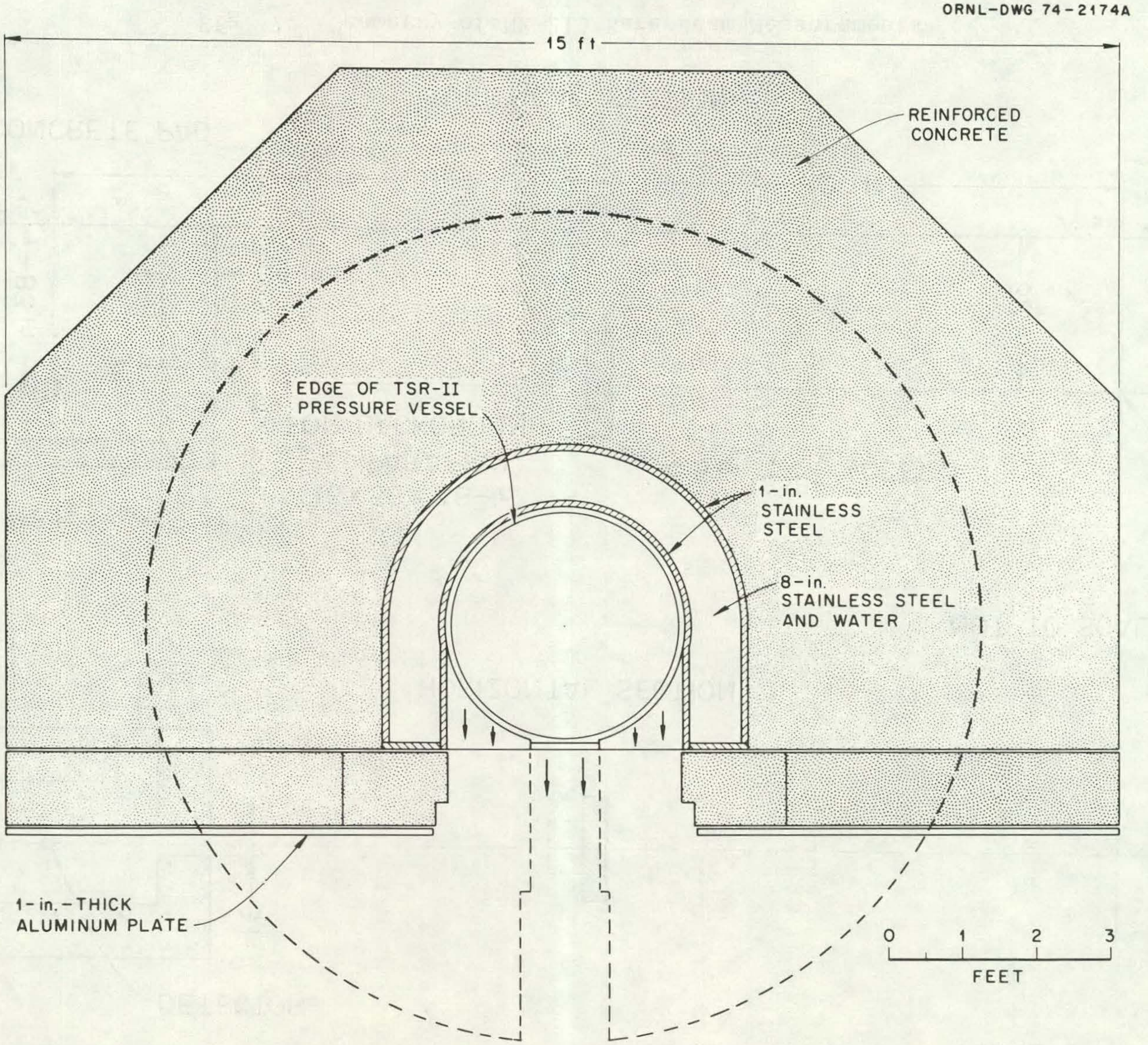

Fig. 1. Schematic of TSR-II Large Beam Shield Through Horizontal Midplane

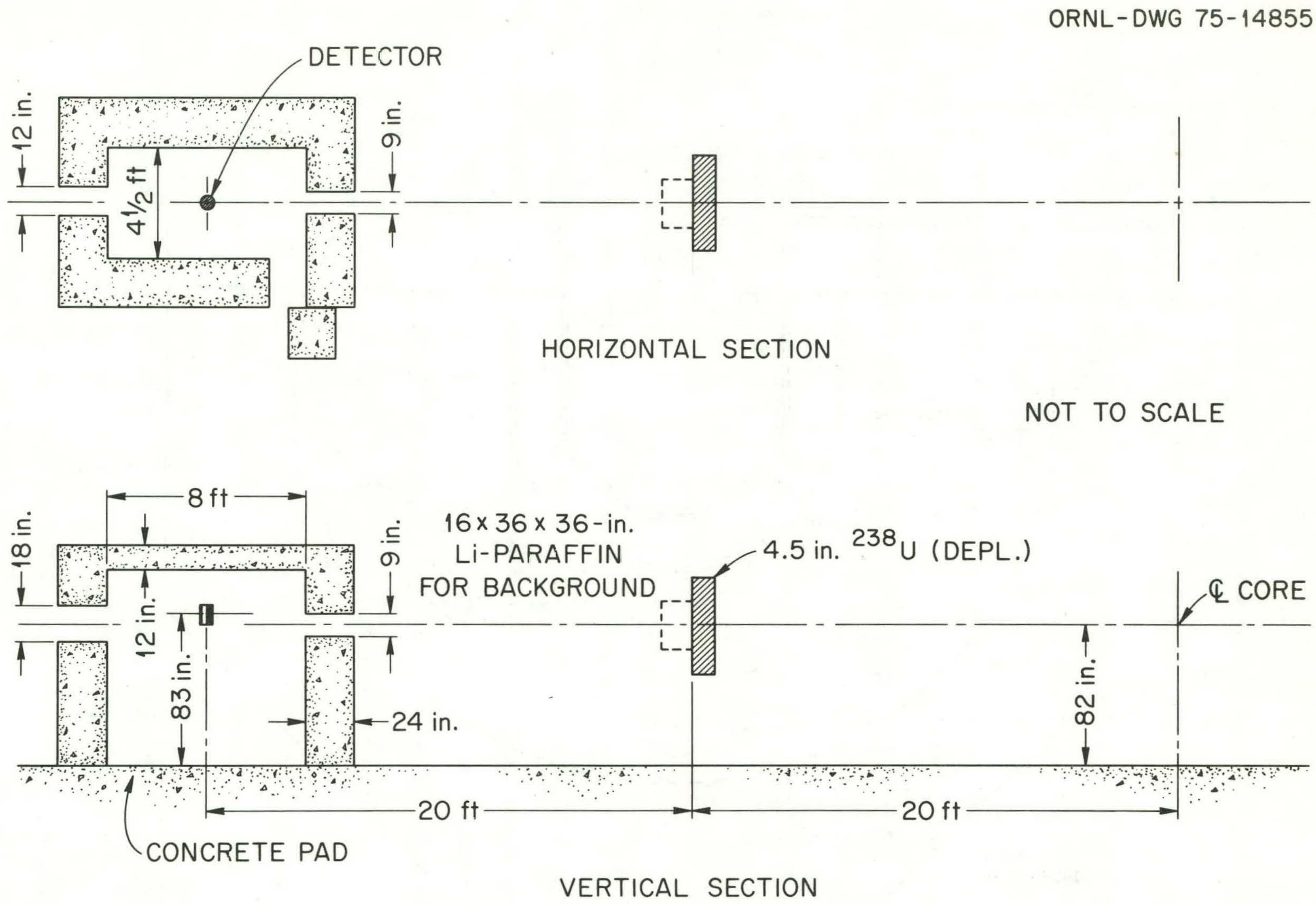

Fig. 2. Geometry of NE-213 Bare Beam Measurements

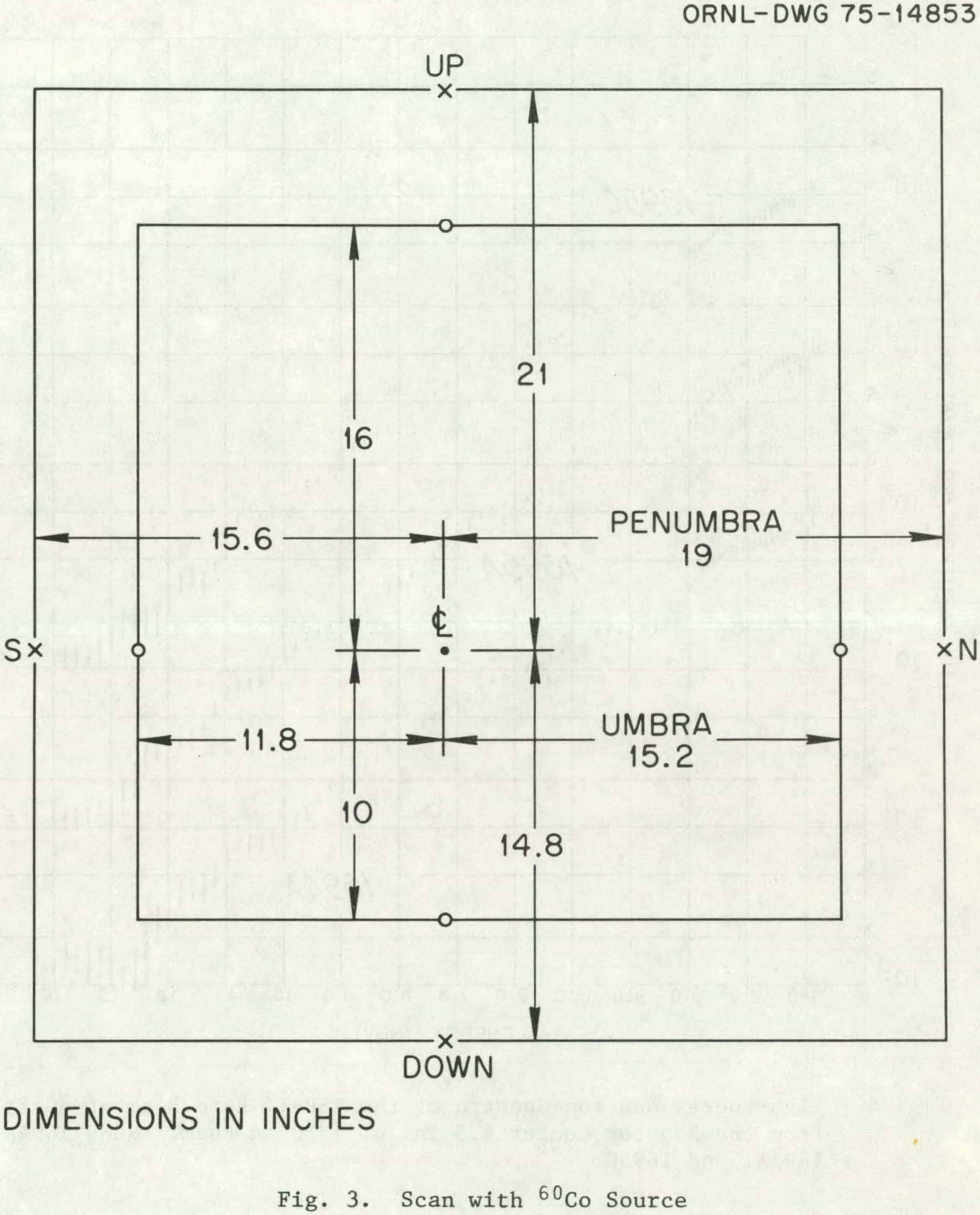

Fig. 3. Scan with ^{60}Co Source

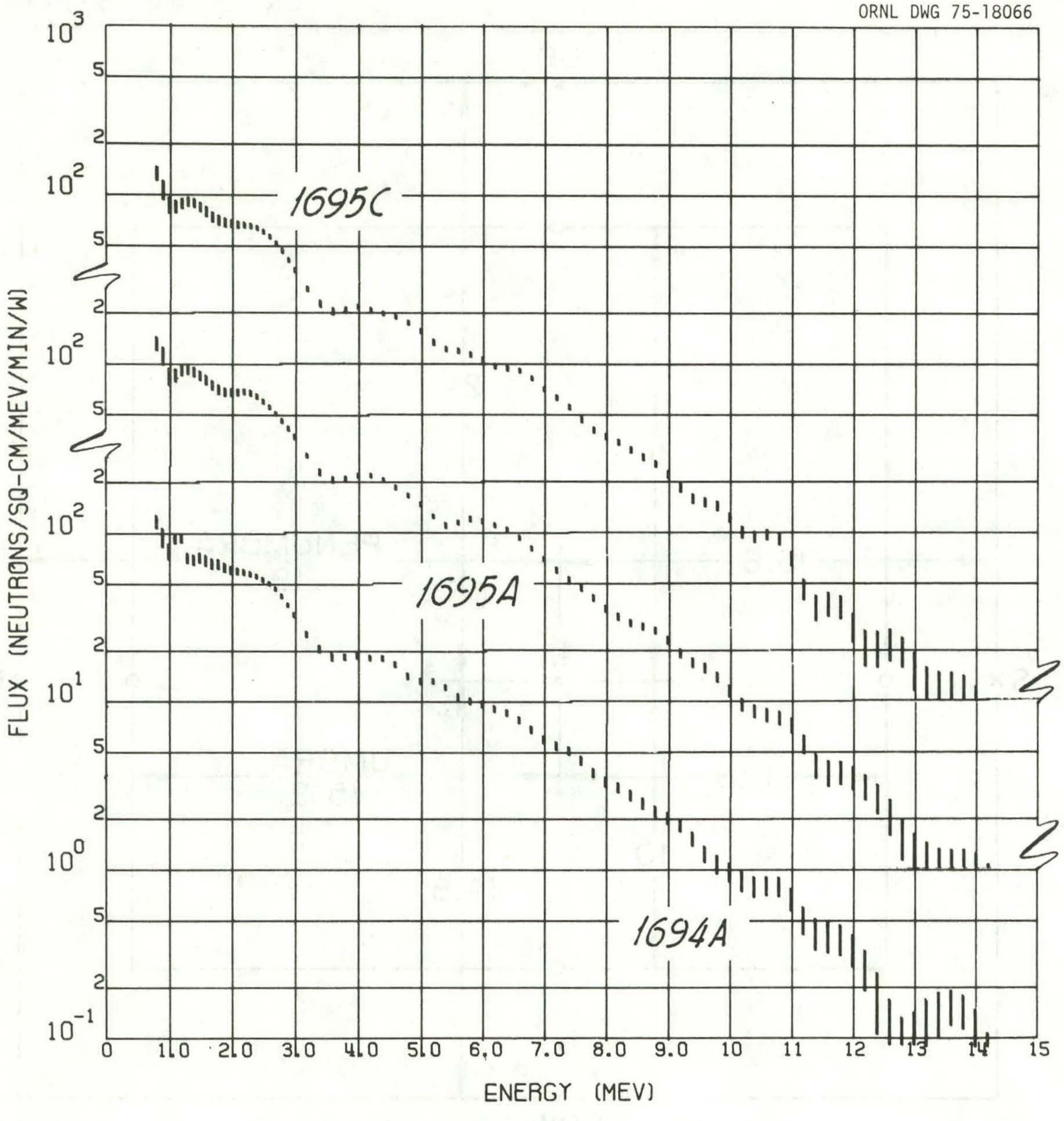

Fig. 4. High-Energy Neutron Spectra of the TSR-II Bare Beam at 40 ft. from the Reactor Center 4.5 in. of ^{238}U in Beam. Runs 1694A, 1695A, and 1695C

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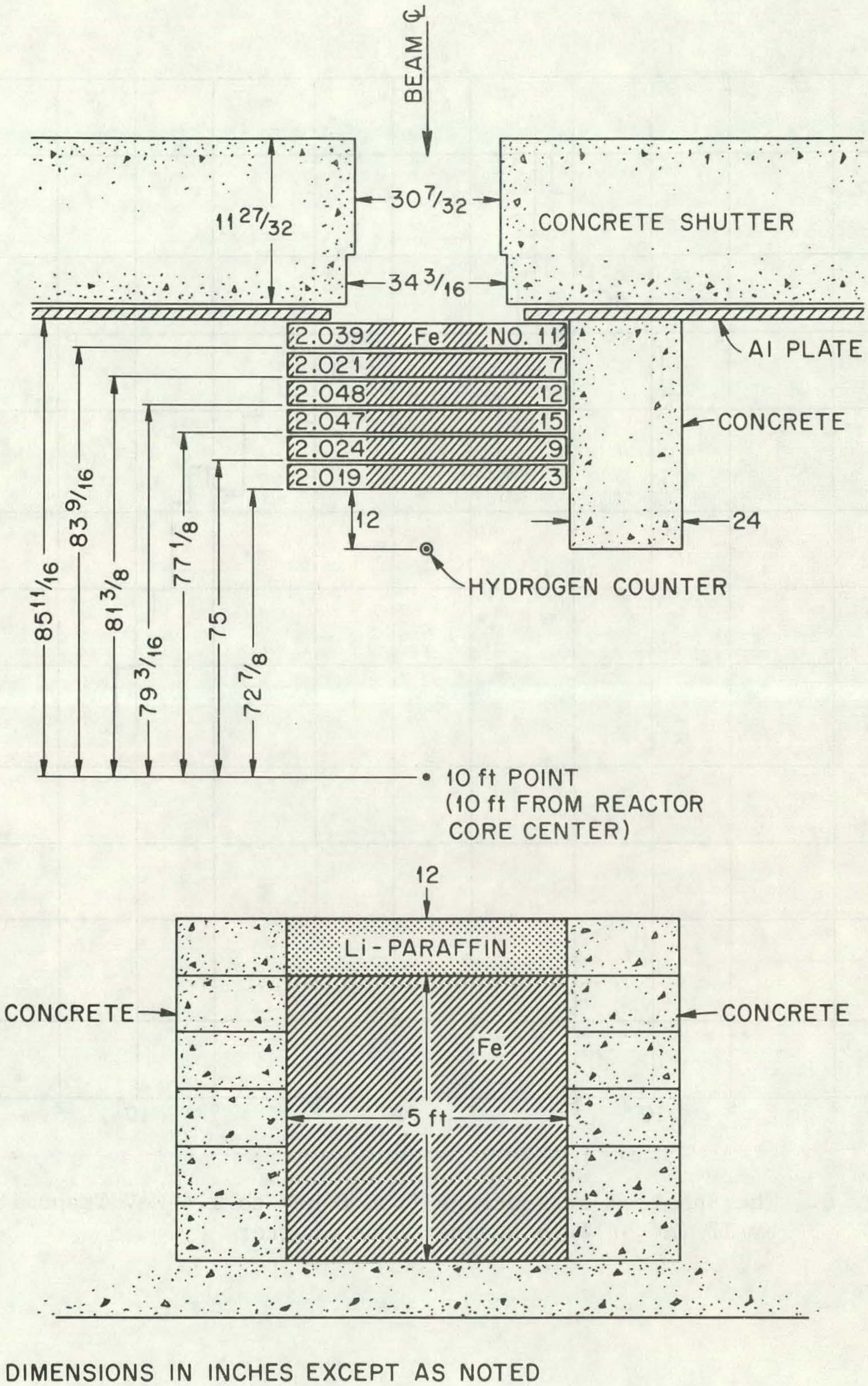

Fig. 5. Experimental Arrangement for Proton Recoil Counter Run: 12 in. Iron Against Beam Shutter

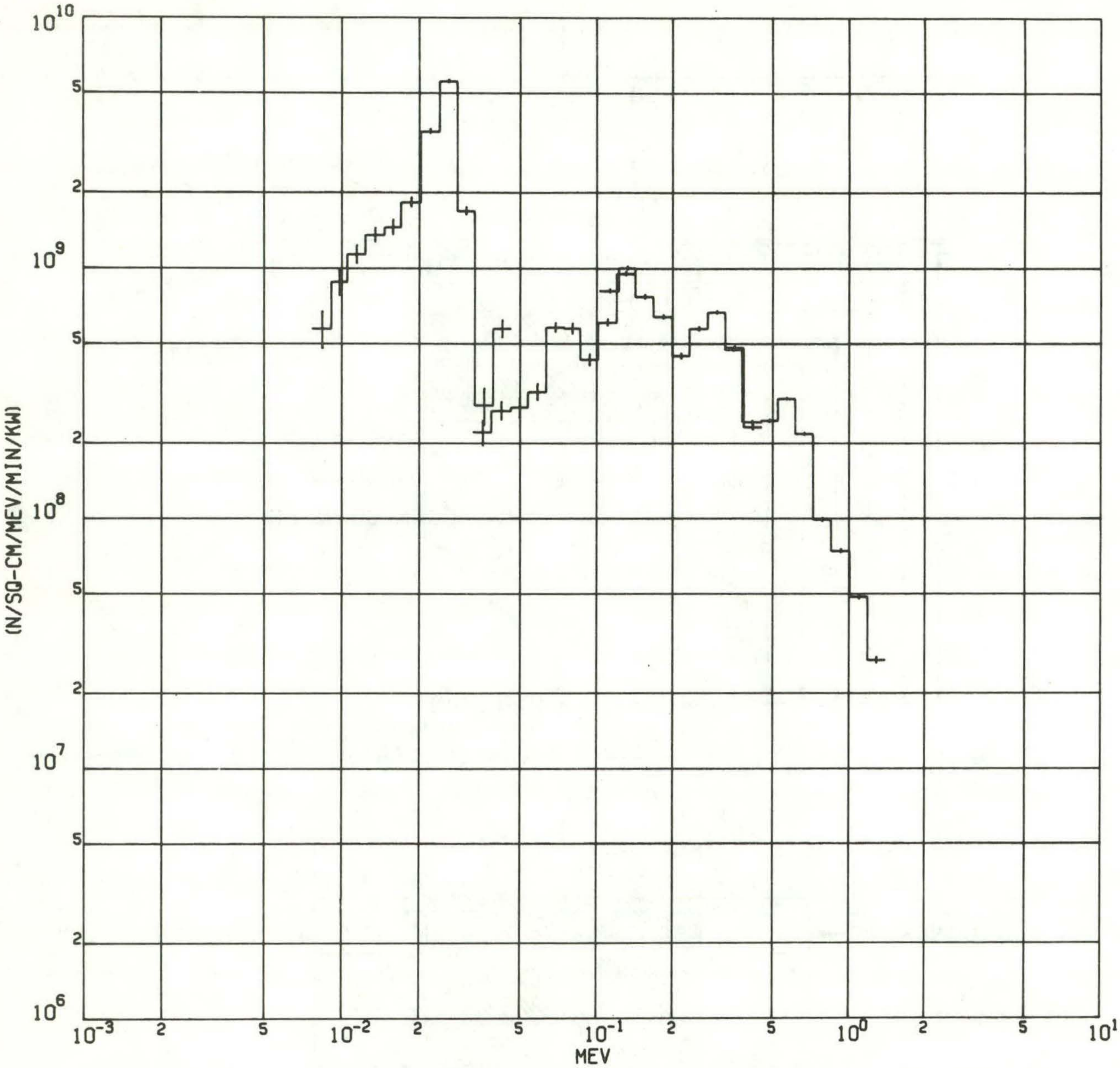

Fig. 6. The Spectrum of Neutrons from 8 keV to 1.4 MeV Transmitted by 12 in. of Iron Against Beam Shutter

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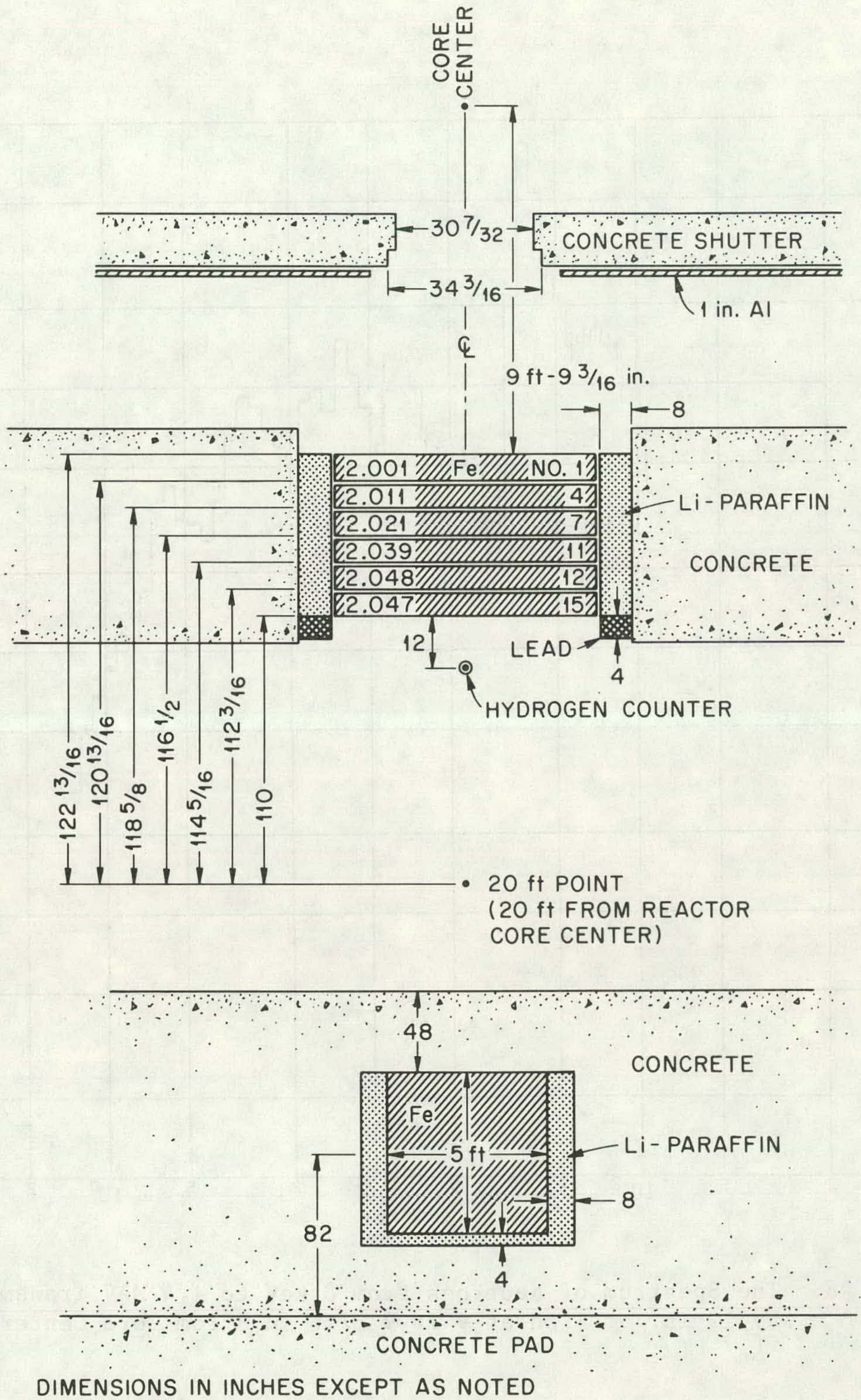

Fig. 7. Experimental Arrangement for Proton Recoil Counter Run: 12 in. of Iron at 9 ft 9 3/16 in. from Core Center

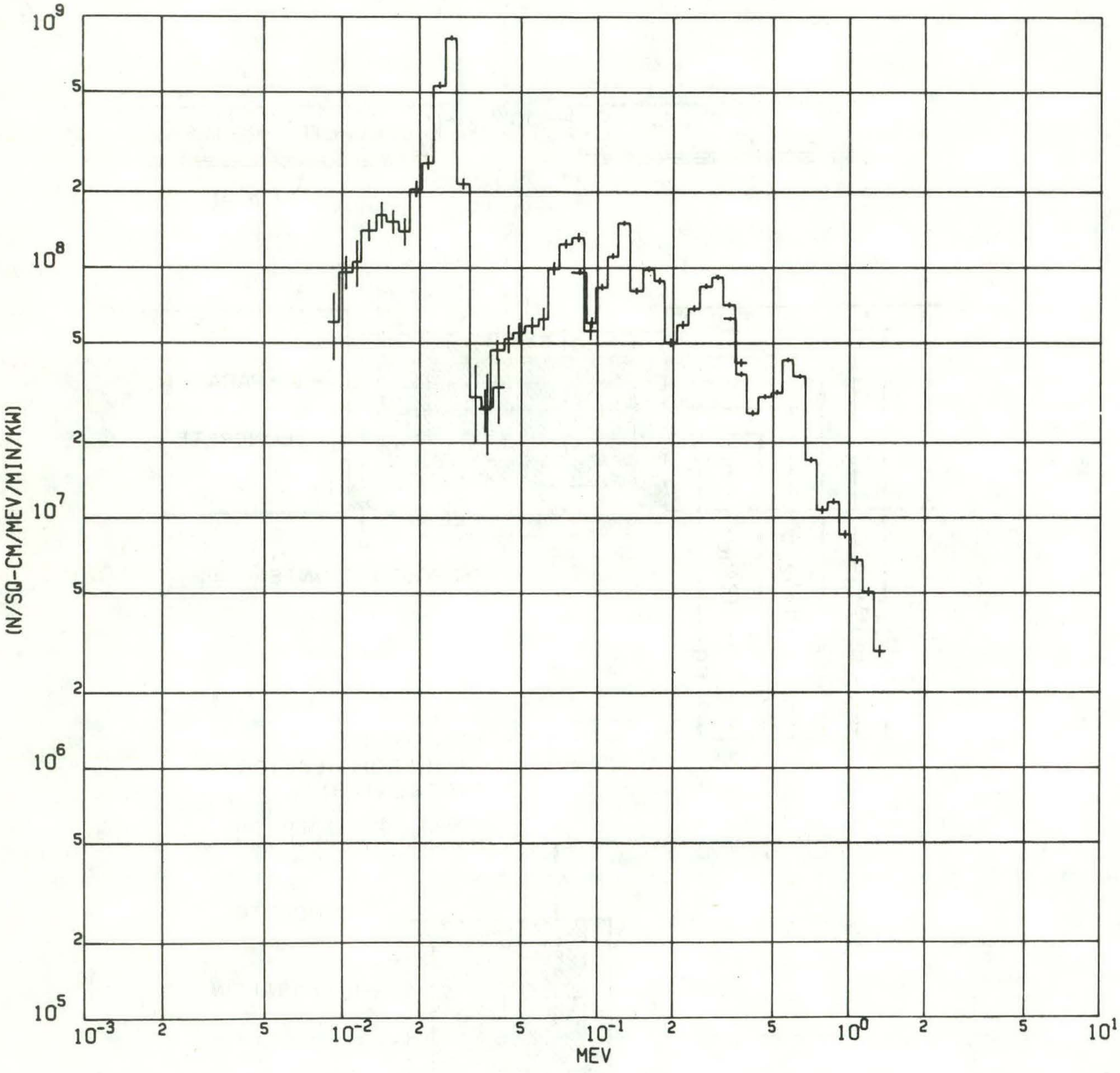

Fig. 8. The Spectrum of Neutrons from 8 keV to 1.4 MeV Transmitted by 12 in. of Iron at 9 ft 9 3/16 in. from Core Center

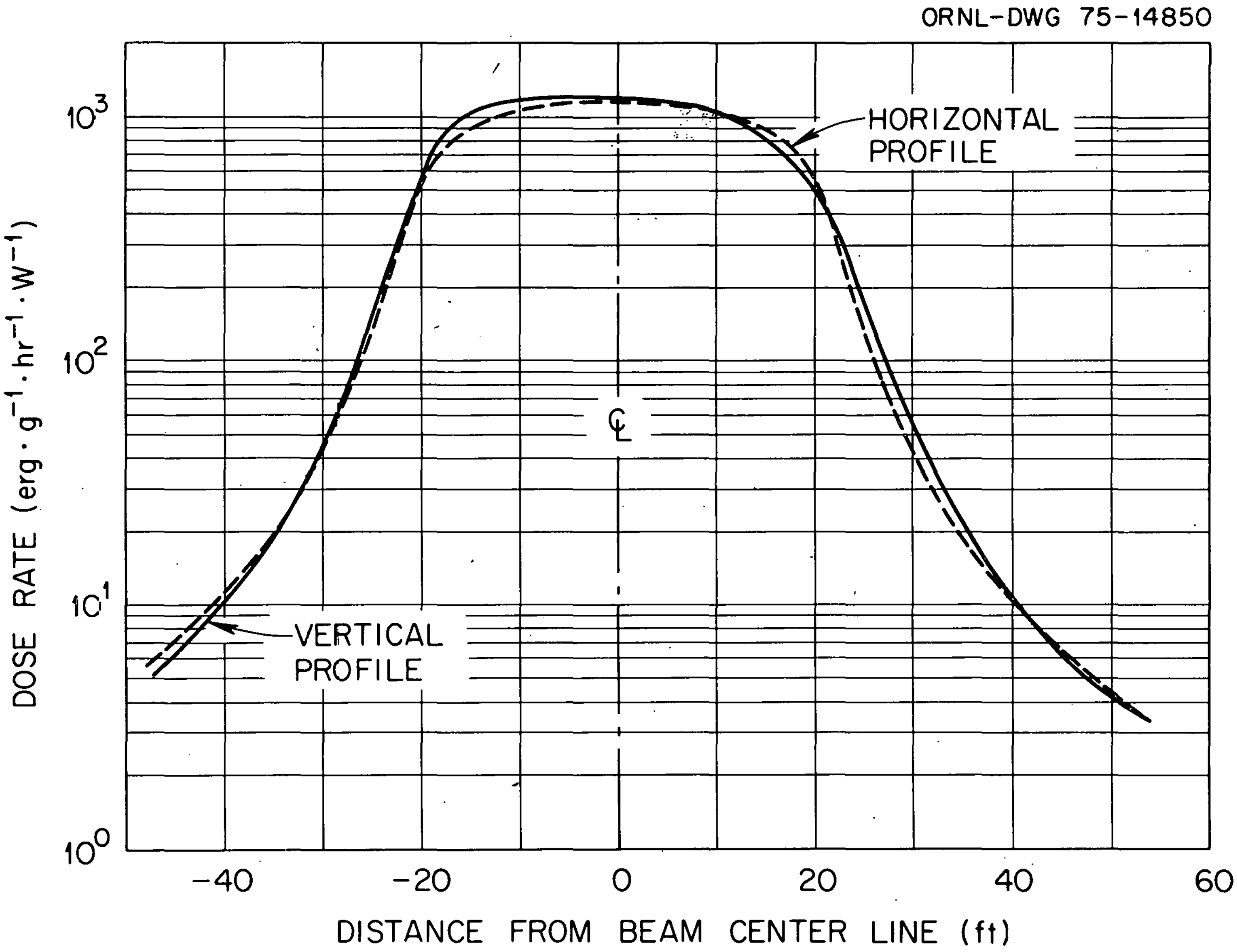

Fig. 9. Fast-Neutron Dose Rate Profiles Horizontally and Vertically Through the Beam Axis in a Plane 3 ft 2 3/4 in. from Reactor Core Center

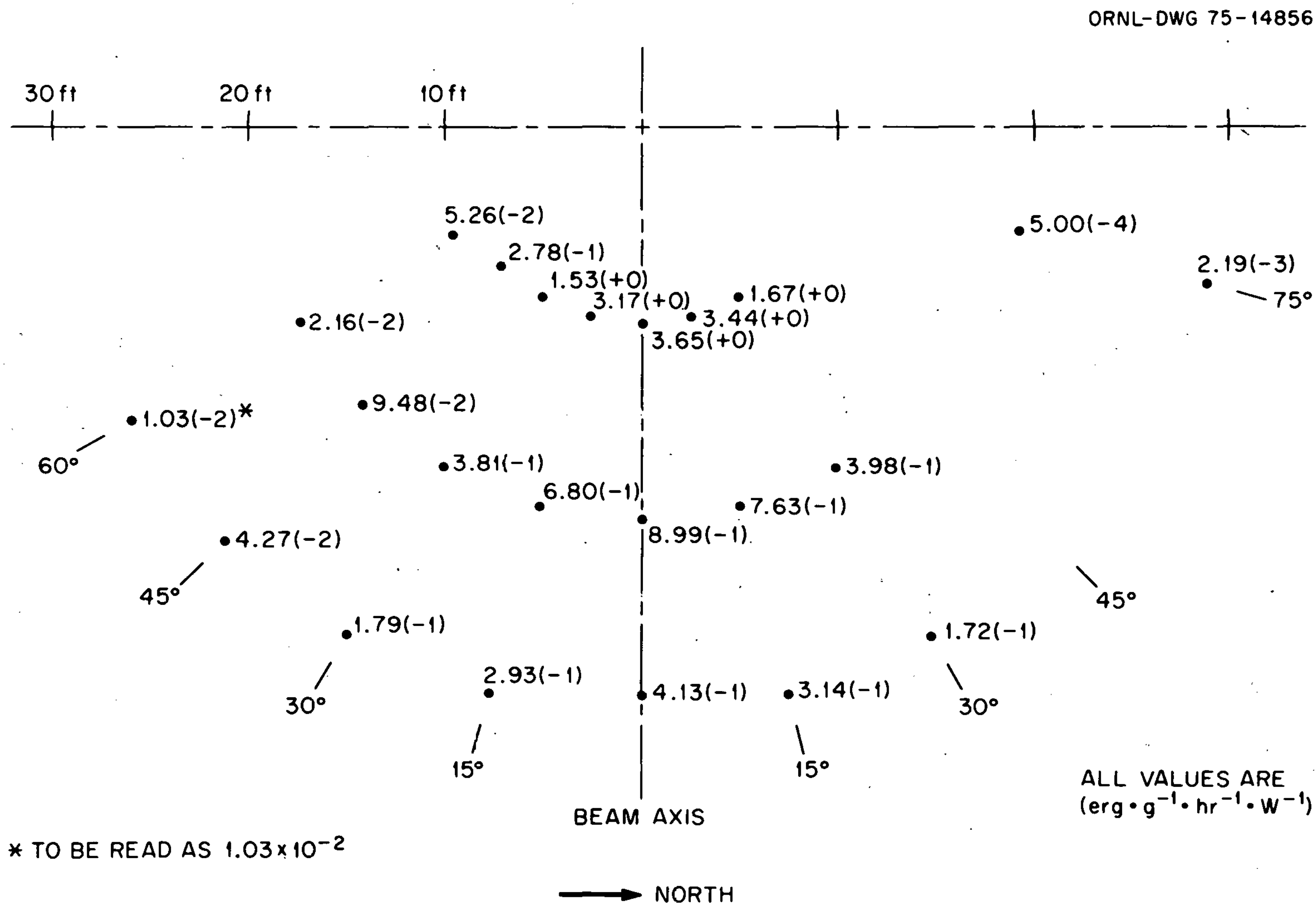

Fig. 10. Fast-Neutron Dose Rates in the Horizontal Plane Through the Beam Axis

TABLE 1. HIGH-ENERGY NEUTRON SPECTRUM OF THE TSR-II BARE BEAM AT 40 FT. FROM CENTER OF REACTOR. A 4.5 IN. SLAB OF 238 U WAS IN BEAM AT 20 FT. RUN NO. 1694A.

ENERGY (MEV)	FLUX (NEUTRONS/SQ-CM/MEV/MIN/W) LOWER BOUND	UPPER BOUND	MEAN VALUE	RUNNING INTEGRAL
0.80	0.117E 03	0.140E 03	0.129E 03	0.0
0.90	0.905E 02	0.117E 03	0.104E 03	0.104E 02
1.00	0.764E 02	0.945E 02	0.854E 02	0.189E 02
1.10	0.957E 02	0.109E 03	0.102E 03	0.292E 02
1.20	0.968E 02	0.108E 03	0.102E 03	0.394E 02
1.30	0.731E 02	0.833E 02	0.782E 02	0.472E 02
1.40	0.715E 02	0.816E 02	0.766E 02	0.549E 02
1.50	0.737E 02	0.844E 02	0.791E 02	0.628E 02
1.60	0.703E 02	0.808E 02	0.755E 02	0.703E 02
1.70	0.677E 02	0.773E 02	0.725E 02	0.776E 02
1.80	0.674E 02	0.767E 02	0.721E 02	0.848E 02
1.90	0.651E 02	0.727E 02	0.689E 02	0.917E 02
2.00	0.631E 02	0.694E 02	0.662E 02	0.983E 02
2.10	0.630E 02	0.684E 02	0.657E 02	0.105E 03
2.20	0.620E 02	0.669E 02	0.645E 02	0.111E 03
2.30	0.611E 02	0.650E 02	0.630E 02	0.118E 03
2.40	0.593E 02	0.629E 02	0.611E 02	0.124E 03
2.50	0.567E 02	0.601E 02	0.584E 02	0.130E 03
2.60	0.539E 02	0.568E 02	0.554E 02	0.135E 03
2.70	0.502E 02	0.528E 02	0.515E 02	0.140E 03
2.80	0.454E 02	0.478E 02	0.466E 02	0.145E 03
2.90	0.402E 02	0.422E 02	0.412E 02	0.149E 03
3.00	0.349E 02	0.369E 02	0.359E 02	0.153E 03
3.20	0.265E 02	0.286E 02	0.276E 02	0.158E 03
3.40	0.215E 02	0.237E 02	0.226E 02	0.163E 03
3.60	0.192E 02	0.212E 02	0.202E 02	0.167E 03
3.80	0.195E 02	0.212E 02	0.204E 02	0.171E 03
4.00	0.198E 02	0.214E 02	0.206E 02	0.175E 03
4.20	0.193E 02	0.206E 02	0.200E 02	0.179E 03
4.40	0.192E 02	0.206E 02	0.199E 02	0.183E 03
4.60	0.176E 02	0.189E 02	0.182E 02	0.187E 03
4.80	0.149E 02	0.161E 02	0.155E 02	0.190E 03
5.00	0.139E 02	0.150E 02	0.144E 02	0.193E 03
5.20	0.140E 02	0.151E 02	0.145E 02	0.195E 03
5.40	0.128E 02	0.138E 02	0.133E 02	0.198E 03
5.60	0.111E 02	0.121E 02	0.116E 02	0.200E 03
5.80	0.105E 02	0.115E 02	0.110E 02	0.203E 03
6.00	0.101E 02	0.110E 02	0.105E 02	0.205E 03
6.20	0.952E 01	0.103E 02	0.993E 01	0.207E 03
6.40	0.900E 01	0.977E 01	0.939E 01	0.209E 03

BOUNDS ARE 68 PER CENT CONFIDENCE LIMITS.

TABLE 1. (CONT.)

FLUX
(NEUTRONS/SQ-CM/MEV/MIN/W)

ENERGY (MEV)	LOWER BOUND	UPPER BOUND	MEAN VALUE	RUNNING INTEGRAL
6.60	0.816E 01	0.891E 01	0.854E 01	0.210E 03
6.80	0.712E 01	0.781E 01	0.746E 01	0.212E 03
7.00	0.618E 01	0.683E 01	0.651E 01	0.213E 03
7.20	0.566E 01	0.630E 01	0.598E 01	0.214E 03
7.40	0.529E 01	0.589E 01	0.559E 01	0.215E 03
7.60	0.463E 01	0.519E 01	0.491E 01	0.216E 03
7.80	0.385E 01	0.438E 01	0.412E 01	0.217E 03
8.00	0.340E 01	0.388E 01	0.364E 01	0.218E 03
8.20	0.316E 01	0.360E 01	0.338E 01	0.219E 03
8.40	0.283E 01	0.326E 01	0.305E 01	0.219E 03
8.60	0.252E 01	0.292E 01	0.272E 01	0.220E 03
8.80	0.225E 01	0.262E 01	0.244E 01	0.220E 03
9.00	0.205E 01	0.240E 01	0.223E 01	0.221E 03
9.20	0.185E 01	0.218E 01	0.202E 01	0.221E 03
9.40	0.152E 01	0.183E 01	0.167E 01	0.221E 03
9.60	0.121E 01	0.151E 01	0.136E 01	0.222E 03
9.80	0.104E 01	0.133E 01	0.118E 01	0.222E 03
10.00	0.926E 00	0.119E 01	0.106E 01	0.222E 03
10.20	0.818E 00	0.107E 01	0.943E 00	0.222E 03
10.40	0.756E 00	0.991E 00	0.874E 00	0.222E 03
10.60	0.776E 00	0.997E 00	0.886E 00	0.223E 03
10.80	0.764E 00	0.988E 00	0.876E 00	0.223E 03
11.00	0.625E 00	0.846E 00	0.735E 00	0.223E 03
11.20	0.453E 00	0.658E 00	0.555E 00	0.223E 03
11.40	0.366E 00	0.561E 00	0.463E 00	0.223E 03
11.60	0.352E 00	0.541E 00	0.446E 00	0.223E 03
11.80	0.339E 00	0.514E 00	0.426E 00	0.223E 03
12.00	0.290E 00	0.450E 00	0.370E 00	0.223E 03
12.20	0.210E 00	0.364E 00	0.287E 00	0.223E 03
12.40	0.116E 00	0.268E 00	0.192E 00	0.224E 03
12.60	0.417E-01	0.186E 00	0.114E 00	0.224E 03
12.80	0.176E-01	0.146E 00	0.816E-01	0.224E 03
13.00	0.380E-01	0.157E 00	0.974E-01	0.224E 03
13.20	0.763E-01	0.188E 00	0.132E 00	0.224E 03
13.40	0.113E 00	0.211E 00	0.162E 00	0.224E 03
13.60	0.134E 00	0.217E 00	0.175E 00	0.224E 03
13.80	0.127E 00	0.201E 00	0.164E 00	0.224E 03
14.00	0.935E-01	0.165E 00	0.129E 00	0.224E 03
14.20	0.567E-01	0.120E 00	0.885E-01	0.224E 03
14.40	0.332E-01	0.877E-01	0.604E-01	0.224E 03

BOUNDS ARE 68 PER CENT CONFIDENCE LIMITS.

TABLE 1. (CONT.)

FLUX
(NEUTRONS/SQ-CM/MEV/MIN/W)

ENERGY (MEV)	LOWER BOUND	UPPER BOUND	MEAN VALUE	RUNNING INTEGRAL
14.60	0.222E-01	0.737E-01	0.480E-01	0.224E 03
14.80	0.158E-01	0.680E-01	0.419E-01	0.224E 03
15.00	0.101E-01	0.589E-01	0.345E-01	0.224E 03
15.20	0.475E-02	0.484E-01	0.266E-01	0.224E 03
15.40	0.338E-02	0.428E-01	0.231E-01	0.224E 03
15.60	0.836E-02	0.439E-01	0.261E-01	0.224E 03
15.80	0.145E-01	0.498E-01	0.322E-01	0.224E 03
16.00	0.159E-01	0.554E-01	0.357E-01	0.224E 03
16.20	0.109E-01	0.560E-01	0.335E-01	0.224E 03
16.40	0.151E-02	0.508E-01	0.261E-01	0.224E 03
16.60	-.698E-02	0.398E-01	0.164E-01	0.224E 03
16.80	-.104E-01	0.245E-01	0.706E-02	0.224E 03

BOUNDS ARE 68 PER CENT CONFIDENCE LIMITS.

TABLE 2. HIGH-ENERGY NEUTRON SPECTRUM OF THE TSR-II BARE BEAM AT 40 FT. FROM CENTER OF REACTOR. A 4.5 IN. SLAB OF 238 U WAS IN BEAM AT 20 FT. RUN NO. 1695A.

	FLUX (NEUTRONS/SQ-CM/MEV/MIN/W)			
ENERGY (MEV)	LOWER BOUND	UPPER BOUND	MEAN VALUE	RUNNING INTEGRAL
0.80	0.116E 03	0.139E 03	0.128E 03	0.0
0.90	0.951E 02	0.121E 03	0.108E 03	0.108E 02
1.00	0.721E 02	0.900E 02	0.811E 02	0.189E 02
1.10	0.755E 02	0.897E 02	0.826E 02	0.272E 02
1.20	0.824E 02	0.946E 02	0.885E 02	0.360E 02
1.30	0.840E 02	0.947E 02	0.894E 02	0.450E 02
1.40	0.813E 02	0.915E 02	0.864E 02	0.536E 02
1.50	0.768E 02	0.871E 02	0.820E 02	0.618E 02
1.60	0.724E 02	0.821E 02	0.773E 02	0.695E 02
1.70	0.678E 02	0.765E 02	0.722E 02	0.768E 02
1.80	0.635E 02	0.719E 02	0.677E 02	0.835E 02
1.90	0.621E 02	0.692E 02	0.657E 02	0.901E 02
2.00	0.621E 02	0.687E 02	0.654E 02	0.966E 02
2.10	0.628E 02	0.687E 02	0.657E 02	0.103E 03
2.20	0.634E 02	0.688E 02	0.661E 02	0.110E 03
2.30	0.626E 02	0.673E 02	0.649E 02	0.116E 03
2.40	0.600E 02	0.642E 02	0.621E 02	0.123E 03
2.50	0.562E 02	0.598E 02	0.580E 02	0.128E 03
2.60	0.520E 02	0.550E 02	0.535E 02	0.134E 03
2.70	0.476E 02	0.502E 02	0.489E 02	0.139E 03
2.80	0.431E 02	0.456E 02	0.443E 02	0.143E 03
2.90	0.388E 02	0.411E 02	0.400E 02	0.147E 03
3.00	0.346E 02	0.367E 02	0.356E 02	0.151E 03
3.20	0.267E 02	0.284E 02	0.276E 02	0.156E 03
3.40	0.211E 02	0.229E 02	0.220E 02	0.160E 03
3.60	0.191E 02	0.207E 02	0.199E 02	0.164E 03
3.80	0.195E 02	0.210E 02	0.202E 02	0.168E 03
4.00	0.204E 02	0.218E 02	0.211E 02	0.173E 03
4.20	0.205E 02	0.216E 02	0.211E 02	0.177E 03
4.40	0.194E 02	0.204E 02	0.199E 02	0.181E 03
4.60	0.174E 02	0.184E 02	0.179E 02	0.184E 03
4.80	0.156E 02	0.165E 02	0.160E 02	0.188E 03
5.00	0.138E 02	0.146E 02	0.142E 02	0.191E 03
5.20	0.117E 02	0.124E 02	0.120E 02	0.193E 03
5.40	0.102E 02	0.110E 02	0.106E 02	0.195E 03
5.60	0.108E 02	0.115E 02	0.111E 02	0.197E 03
5.80	0.113E 02	0.121E 02	0.117E 02	0.200E 03
6.00	0.109E 02	0.116E 02	0.113E 02	0.202E 03
6.20	0.104E 02	0.110E 02	0.107E 02	0.204E 03
6.40	0.983E 01	0.104E 02	0.101E 02	0.206E 03

BOUNDS ARE 68 PER CENT CONFIDENCE LIMITS.

TABLE 2. (CONT.)

FLUX
(NEUTRONS/SQ-CM/MEV/MIN/W)

ENERGY (MEV)	LOWER BOUND	UPPER BOUND	MEAN VALUE	RUNNING INTEGRAL
6.60	0.875E 01	0.927E 01	0.901E 01	0.208E 03
6.80	0.757E 01	0.802E 01	0.780E 01	0.209E 03
7.00	0.650E 01	0.690E 01	0.670E 01	0.211E 03
7.20	0.560E 01	0.600E 01	0.580E 01	0.212E 03
7.40	0.490E 01	0.527E 01	0.509E 01	0.213E 03
7.60	0.434E 01	0.469E 01	0.452E 01	0.214E 03
7.80	0.378E 01	0.411E 01	0.394E 01	0.215E 03
8.00	0.326E 01	0.356E 01	0.341E 01	0.215E 03
8.20	0.292E 01	0.320E 01	0.306E 01	0.216E 03
8.40	0.267E 01	0.293E 01	0.280E 01	0.216E 03
8.60	0.255E 01	0.279E 01	0.267E 01	0.217E 03
8.80	0.242E 01	0.264E 01	0.253E 01	0.217E 03
9.00	0.210E 01	0.232E 01	0.221E 01	0.218E 03
9.20	0.175E 01	0.196E 01	0.185E 01	0.218E 03
9.40	0.153E 01	0.173E 01	0.163E 01	0.219E 03
9.60	0.142E 01	0.161E 01	0.151E 01	0.219E 03
9.80	0.125E 01	0.143E 01	0.134E 01	0.219E 03
10.00	0.102E 01	0.119E 01	0.110E 01	0.219E 03
10.20	0.847E 00	0.100E 01	0.924E 00	0.220E 03
10.40	0.770E 00	0.913E 00	0.841E 00	0.220E 03
10.60	0.728E 00	0.868E 00	0.798E 00	0.220E 03
10.80	0.696E 00	0.836E 00	0.766E 00	0.220E 03
11.00	0.620E 00	0.758E 00	0.689E 00	0.220E 03
11.20	0.470E 00	0.602E 00	0.536E 00	0.220E 03
11.40	0.337E 00	0.465E 00	0.401E 00	0.220E 03
11.60	0.302E 00	0.426E 00	0.364E 00	0.220E 03
11.80	0.309E 00	0.422E 00	0.366E 00	0.221E 03
12.00	0.287E 00	0.392E 00	0.340E 00	0.221E 03
12.20	0.250E 00	0.351E 00	0.300E 00	0.221E 03
12.40	0.207E 00	0.308E 00	0.257E 00	0.221E 03
12.60	0.154E 00	0.251E 00	0.202E 00	0.221E 03
12.80	0.109E 00	0.191E 00	0.150E 00	0.221E 03
13.00	0.823E-01	0.157E 00	0.119E 00	0.221E 03
13.20	0.681E-01	0.140E 00	0.104E 00	0.221E 03
13.40	0.652E-01	0.128E 00	0.967E-01	0.221E 03
13.60	0.728E-01	0.126E 00	0.993E-01	0.221E 03
13.80	0.807E-01	0.127E 00	0.104E 00	0.221E 03
14.00	0.774E-01	0.120E 00	0.989E-01	0.221E 03
14.20	0.615E-01	0.103E 00	0.825E-01	0.221E 03
14.40	0.426E-01	0.844E-01	0.635E-01	0.221E 03

BOUNDS ARE 68 PER CENT CONFIDENCE LIMITS.

TABLE 2. (CONT.)

FLUX
(NEUTRONS/SQ-CM/MEV/MIN/W)

ENERGY (MEV)	LOWER BOUND	UPPER BOUND	MEAN VALUE	RUNNING INTEGRAL
14.60	0.308E-01	0.708E-01	0.508E-01	0.221E 03
14.80	0.299E-01	0.653E-01	0.476E-01	0.221E 03
15.00	0.353E-01	0.661E-01	0.507E-01	0.221E 03
15.20	0.387E-01	0.672E-01	0.529E-01	0.221E 03
15.40	0.351E-01	0.631E-01	0.491E-01	0.221E 03
15.60	0.253E-01	0.533E-01	0.393E-01	0.221E 03
15.80	0.125E-01	0.419E-01	0.272E-01	0.221E 03
16.00	-.908E-03	0.342E-01	0.166E-01	0.221E 03
16.20	-.126E-01	0.322E-01	0.980E-02	0.221E 03
16.40	-.195E-01	0.338E-01	0.715E-02	0.221E 03
16.60	-.182E-01	0.337E-01	0.773E-02	0.221E 03
16.80	-.798E-02	0.277E-01	0.984E-02	0.221E 03
17.00	-.428E-02	0.278E-01	0.118E-01	0.221E 03
17.20	-.223E-01	0.473E-01	0.125E-01	0.221E 03
17.40	-.401E-01	0.640E-01	0.119E-01	0.221E 03
17.60	-.470E-01	0.676E-01	0.103E-01	0.221E 03
17.80	-.409E-01	0.576E-01	0.836E-02	0.221E 03
18.00	-.269E-01	0.398E-01	0.645E-02	0.221E 03
18.20	-.124E-01	0.222E-01	0.491E-02	0.221E 03
18.40	-.173E-01	0.249E-01	0.383E-02	0.221E 03
18.60	-.332E-01	0.395E-01	0.317E-02	0.221E 03
18.80	-.551E-01	0.609E-01	0.287E-02	0.221E 03
19.00	-.855E-01	0.912E-01	0.288E-02	0.221E 03
19.20	-.130E 00	0.136E 00	0.321E-02	0.221E 03

BOUNDS ARE 68 PER CENT CONFIDENCE LIMITS.

TABLE 3. HIGH-ENERGY NEUTRON SPECTRUM OF THE TSR-II BARE BEAM AT 40 FT. FROM CENTER OF REACTOR. A 4.5 IN. SLAB OF 238 U WAS IN BEAM AT 20 FT. RUN NO. 1695C.

ENERGY (MEV)	FLUX (NEUTRONS/SQ-CM/MEV/MIN/W) LOWER BOUND	UPPER BOUND	MEAN VALUE	RUNNING INTEGRAL
0.80	0.118E 03	0.142E 03	0.130E 03	0.0
0.90	0.908E 02	0.117E 03	0.104E 03	0.104E 02
1.00	0.753E 02	0.930E 02	0.842E 02	0.188E 02
1.10	0.756E 02	0.892E 02	0.824E 02	0.271E 02
1.20	0.805E 02	0.925E 02	0.865E 02	0.357E 02
1.30	0.833E 02	0.938E 02	0.886E 02	0.446E 02
1.40	0.815E 02	0.914E 02	0.865E 02	0.532E 02
1.50	0.772E 02	0.873E 02	0.823E 02	0.614E 02
1.60	0.721E 02	0.820E 02	0.770E 02	0.691E 02
1.70	0.670E 02	0.762E 02	0.716E 02	0.763E 02
1.80	0.639E 02	0.730E 02	0.684E 02	0.831E 02
1.90	0.629E 02	0.703E 02	0.666E 02	0.898E 02
2.00	0.622E 02	0.686E 02	0.654E 02	0.964E 02
2.10	0.619E 02	0.675E 02	0.647E 02	0.103E 03
2.20	0.617E 02	0.667E 02	0.642E 02	0.109E 03
2.30	0.615E 02	0.656E 02	0.636E 02	0.116E 03
2.40	0.601E 02	0.637E 02	0.619E 02	0.122E 03
2.50	0.571E 02	0.604E 02	0.588E 02	0.128E 03
2.60	0.533E 02	0.563E 02	0.548E 02	0.133E 03
2.70	0.488E 02	0.516E 02	0.502E 02	0.138E 03
2.80	0.438E 02	0.464E 02	0.451E 02	0.143E 03
2.90	0.387E 02	0.410E 02	0.398E 02	0.147E 03
3.00	0.337E 02	0.357E 02	0.347E 02	0.150E 03
3.20	0.260E 02	0.278E 02	0.269E 02	0.156E 03
3.40	0.210E 02	0.230E 02	0.220E 02	0.160E 03
3.60	0.189E 02	0.207E 02	0.198E 02	0.164E 03
3.80	0.195E 02	0.211E 02	0.203E 02	0.168E 03
4.00	0.203E 02	0.219E 02	0.211E 02	0.172E 03
4.20	0.195E 02	0.208E 02	0.202E 02	0.176E 03
4.40	0.187E 02	0.198E 02	0.192E 02	0.180E 03
4.60	0.179E 02	0.189E 02	0.184E 02	0.184E 03
4.80	0.165E 02	0.175E 02	0.170E 02	0.187E 03
5.00	0.147E 02	0.156E 02	0.151E 02	0.190E 03
5.20	0.126E 02	0.135E 02	0.131E 02	0.193E 03
5.40	0.115E 02	0.123E 02	0.119E 02	0.195E 03
5.60	0.112E 02	0.120E 02	0.116E 02	0.197E 03
5.80	0.107E 02	0.114E 02	0.111E 02	0.200E 03
6.00	0.987E 01	0.106E 02	0.102E 02	0.202E 03
6.20	0.910E 01	0.973E 01	0.941E 01	0.204E 03
6.40	0.883E 01	0.940E 01	0.911E 01	0.205E 03

BOUNDS ARE 68 PER CENT CONFIDENCE LIMITS.

TABLE 3. (CONT.)

FLUX
(NEUTRONS/SQ-CM/MEV/MIN/W)

ENERGY (MEV)	LOWER BOUND	UPPER BOUND	MEAN VALUE	RUNNING INTEGRAL
6.60	0.859E 01	0.911E 01	0.885E 01	0.207E 03
6.80	0.774E 01	0.817E 01	0.795E 01	0.209E 03
7.00	0.666E 01	0.704E 01	0.685E 01	0.210E 03
7.20	0.593E 01	0.632E 01	0.612E 01	0.211E 03
7.40	0.521E 01	0.557E 01	0.539E 01	0.212E 03
7.60	0.437E 01	0.470E 01	0.454E 01	0.213E 03
7.80	0.378E 01	0.409E 01	0.394E 01	0.214E 03
8.00	0.345E 01	0.373E 01	0.359E 01	0.215E 03
8.20	0.320E 01	0.346E 01	0.333E 01	0.216E 03
8.40	0.288E 01	0.313E 01	0.300E 01	0.216E 03
8.60	0.260E 01	0.283E 01	0.272E 01	0.217E 03
8.80	0.237E 01	0.258E 01	0.247E 01	0.217E 03
9.00	0.204E 01	0.225E 01	0.214E 01	0.218E 03
9.20	0.169E 01	0.189E 01	0.179E 01	0.218E 03
9.40	0.145E 01	0.164E 01	0.155E 01	0.218E 03
9.60	0.138E 01	0.155E 01	0.146E 01	0.219E 03
9.80	0.131E 01	0.148E 01	0.139E 01	0.219E 03
10.00	0.111E 01	0.126E 01	0.118E 01	0.219E 03
10.20	0.900E 00	0.105E 01	0.973E 00	0.219E 03
10.40	0.846E 00	0.979E 00	0.913E 00	0.219E 03
10.60	0.877E 00	0.101E 01	0.942E 00	0.220E 03
10.80	0.819E 00	0.951E 00	0.885E 00	0.220E 03
11.00	0.613E 00	0.744E 00	0.678E 00	0.220E 03
11.20	0.387E 00	0.509E 00	0.448E 00	0.220E 03
11.40	0.291E 00	0.411E 00	0.351E 00	0.220E 03
11.60	0.310E 00	0.429E 00	0.369E 00	0.220E 03
11.80	0.299E 00	0.408E 00	0.354E 00	0.220E 03
12.00	0.218E 00	0.322E 00	0.270E 00	0.220E 03
12.20	0.157E 00	0.254E 00	0.206E 00	0.220E 03
12.40	0.154E 00	0.252E 00	0.203E 00	0.220E 03
12.60	0.168E 00	0.261E 00	0.214E 00	0.220E 03
12.80	0.154E 00	0.232E 00	0.193E 00	0.220E 03
13.00	0.112E 00	0.187E 00	0.150E 00	0.220E 03
13.20	0.850E-01	0.155E 00	0.120E 00	0.221E 03
13.40	0.864E-01	0.145E 00	0.116E 00	0.221E 03
13.60	0.945E-01	0.145E 00	0.120E 00	0.221E 03
13.80	0.906E-01	0.138E 00	0.114E 00	0.221E 03
14.00	0.743E-01	0.118E 00	0.962E-01	0.221E 03
14.20	0.540E-01	0.948E-01	0.744E-01	0.221E 03
14.40	0.368E-01	0.758E-01	0.563E-01	0.221E 03

BOUNDS ARE 68 PER CENT CONFIDENCE LIMITS.

TABLE 3. (CONT.)

FLUX
(NEUTRONS/SQ-CM/MEV/MIN/W)

ENERGY (MEV)	LOWER BOUND	UPPER BOUND	MEAN VALUE	RUNNING INTEGRAL
14.60	0.262E-01	0.658E-01	0.460E-01	0.221E 03
14.80	0.249E-01	0.633E-01	0.441E-01	0.221E 03
15.00	0.299E-01	0.636E-01	0.467E-01	0.221E 03
15.20	0.331E-01	0.623E-01	0.477E-01	0.221E 03
15.40	0.291E-01	0.573E-01	0.432E-01	0.221E 03
15.60	0.207E-01	0.487E-01	0.347E-01	0.221E 03
15.80	0.107E-01	0.399E-01	0.253E-01	0.221E 03
16.00	-.598E-03	0.336E-01	0.165E-01	0.221E 03
16.20	-.130E-01	0.303E-01	0.863E-02	0.221E 03
16.40	-.226E-01	0.285E-01	0.298E-02	0.221E 03
16.60	-.229E-01	0.266E-01	0.182E-02	0.221E 03
16.80	-.114E-01	0.236E-01	0.607E-02	0.221E 03
17.00	-.154E-02	0.293E-01	0.139E-01	0.221E 03
17.20	-.106E-01	0.537E-01	0.215E-01	0.221E 03
17.40	-.235E-01	0.751E-01	0.258E-01	0.221E 03
17.60	-.307E-01	0.813E-01	0.253E-01	0.221E 03
17.80	-.306E-01	0.723E-01	0.208E-01	0.221E 03
18.00	-.227E-01	0.513E-01	0.143E-01	0.221E 03
18.20	-.126E-01	0.279E-01	0.763E-02	0.221E 03
18.40	-.182E-01	0.219E-01	0.185E-02	0.221E 03

BOUNDS ARE 68 PER CENT CONFIDENCE LIMITS.

TABLE 4. THE SPECTRUM OF NEUTRONS FROM 8 KEV TO 1.4 MEV TRANSMITTED BY A 12-IN.-THICK IRON SLAB LOCATED AGAINST THE BEAM SHUTTER. DETECTOR 12 IN. BEHIND SLAB.

ENERGY BOUNDARY (MEV)		FLUX (N/SQ-CM/MEV/MIN/KW)	ERROR (PERCENT)
0.0077	0.0091	0.5701E 09	16.70
0.0091	0.0105	0.8821E 09	12.43
0.0105	0.0124	0.1134E 10	8.38
0.0124	0.0147	0.1354E 10	6.42
0.0147	0.0171	0.1457E 10	6.80
0.0171	0.0203	0.1829E 10	4.21
0.0203	0.0241	0.3503E 10	2.08
0.0241	0.0283	0.5559E 10	1.17
0.0283	0.0330	0.1681E 10	3.46
0.0326	0.0384	0.2198E 09	11.53
0.0330	0.0390	0.2817E 09	16.85
0.0384	0.0460	0.2692E 09	8.45
0.0390	0.0460	0.5739E 09	8.07
0.0460	0.0537	0.2779E 09	9.64
0.0537	0.0633	0.3207E 09	7.71
0.0633	0.0748	0.5807E 09	4.03
0.0748	0.0863	0.5742E 09	4.59
0.0863	0.1017	0.4296E 09	4.96
0.1017	0.1209	0.6068E 09	3.04
0.1033	0.1231	0.8112E 09	1.47
0.1209	0.1420	0.9499E 09	1.84
0.1231	0.1429	0.1002E 10	1.34
0.1429	0.1684	0.7665E 09	1.44
0.1684	0.1996	0.6370E 09	1.53
0.1996	0.2335	0.4453E 09	2.24
0.2335	0.2760	0.5736E 09	1.47
0.2760	0.3241	0.6669E 09	1.17
0.3238	0.3785	0.4720E 09	0.71
0.3241	0.3835	0.4799E 09	1.31
0.3785	0.4515	0.2416E 09	1.07
0.3835	0.4515	0.2307E 09	2.49
0.4515	0.5244	0.2453E 09	1.16
0.5244	0.6156	0.3011E 09	0.75
0.6156	0.7251	0.2169E 09	0.81
0.7251	0.8528	0.9843E 08	1.42
0.8528	1.0078	0.7365E 08	1.49
1.0078	1.1902	0.4827E 08	1.79
1.1902	1.4000	0.2692E 08	2.52

TABLE 5. THE SPECTRUM OF NEUTRONS FROM 8 KEV TO 1.4 MEV TRANSMITTED BY A 12-IN.-THICK IRON SLAB LOCATED 9 FT. 9 3/4 IN. FROM THE CORE CENTER. DETECTOR 12 IN. BEHIND SLAB.

ENERGY BOUNDARY (MEV)		FLUX (N/SQ-CM/MEV/MIN/KW)	ERROR (PERCENT)
0.0088	0.0097	0.6065E 08	29.67
0.0097	0.0110	0.9604E 08	14.65
0.0110	0.0119	0.1057E 09	20.58
0.0119	0.0136	0.1409E 09	9.08
0.0136	0.0149	0.1625E 09	11.43
0.0149	0.0166	0.1525E 09	10.03
0.0166	0.0183	0.1393E 09	11.97
0.0183	0.0205	0.2056E 09	6.97
0.0205	0.0226	0.2613E 09	5.91
0.0226	0.0252	0.5309E 09	2.49
0.0252	0.0278	0.8198E 09	1.59
0.0278	0.0313	0.2147E 09	4.32
0.0313	0.0347	0.3028E 08	33.45
0.0342	0.0377	0.2711E 08	18.97
0.0347	0.0386	0.2758E 08	35.42
0.0377	0.0429	0.4703E 08	8.69
0.0386	0.0429	0.3332E 08	28.70
0.0429	0.0464	0.5226E 08	12.25
0.0464	0.0517	0.5506E 08	9.04
0.0517	0.0587	0.5881E 08	7.19
0.0587	0.0639	0.6260E 08	9.89
0.0639	0.0709	0.9909E 08	5.15
0.0709	0.0797	0.1244E 09	3.55
0.0794	0.0906	0.9582E 08	1.79
0.0797	0.0884	0.1320E 09	3.63
0.0884	0.0990	0.5589E 08	7.67
0.0906	0.0990	0.6014E 08	4.16
0.0990	0.1101	0.8354E 08	2.48
0.1101	0.1213	0.1110E 09	2.03
0.1213	0.1352	0.1506E 09	1.27
0.1352	0.1519	0.8051E 08	2.09
0.1519	0.1686	0.9867E 08	1.86
0.1686	0.1854	0.8832E 08	2.23
0.1854	0.2077	0.5011E 08	3.07
0.2077	0.2300	0.5915E 08	2.87
0.2300	0.2551	0.6868E 08	2.33
0.2551	0.2857	0.8441E 08	1.58
0.2857	0.3164	0.9162E 08	1.52
0.3164	0.3526	0.7078E 08	1.64
0.3196	0.3556	0.6257E 08	0.96

TABLE 5. (CONT.)

ENERGY BOUNDARY (MEV)		FLUX (N/SQ-CM/MEV/MIN/KW)	ERROR (PERCENT)
0.3526	0.3916	0.4156E 08	2.67
0.3556	0.3916	0.3737E 08	1.68
0.3916	0.4367	0.2604E 08	2.06
0.4367	0.4907	0.3046E 08	1.56
0.4907	0.5447	0.3166E 08	1.59
0.5447	0.5987	0.4283E 08	1.19
0.5987	0.6707	0.3669E 08	0.96
0.6707	0.7428	0.1694E 08	2.00
0.7428	0.8238	0.1068E 08	2.82
0.8238	0.9138	0.1156E 08	2.34
0.9138	1.0129	0.8525E 07	2.79
1.0129	1.1299	0.6742E 07	2.83
1.1299	1.2559	0.5020E 07	3.35
1.2559	1.4000	0.2903E 07	4.71

Table 6. Bonner Ball Count Rates Along the Beam Axis

Distance from Core Center (ft)	Bonner Ball Count Rate ($c \cdot min^{-1} \cdot W^{-1}$)			
	Bare	Cd-Covered	3 in.	6 in.
20	8.9802+4[a]	2.6310+3	2.8241+4	9.1858+4
20 (Background)[b]	2.8504+4	7.869+2	8.734+3	1.9634+4
21	8.1225+4	2.3842+3	2.5629+4	8.4297+4
22	7.4805+4	2.1840+3	2.3522+4	7.6064+4
24	6.1798+4	1.8184+3	1.9582+4	6.4479+4
26	5.1841+4	1.5417+3	1.6805+4	5.4316+4
28	4.5090+4	1.3301+3	1.4478+4	4.6767+4
28 (Background)[b]	1.7402+4	4.801+2	5.034+3	1.1592+4
30	3.8923+4	1.1462+3	1.2613+4	4.0834+4
32	3.554+4	1.0015+3	1.1225+4	3.5129+4
34	2.9440+4	8.818+2	1.0109+4	3.1389+4
36	2.6027+4	8.146+2	8.704+3	2.8584+4
36 (Background)[b]	1.2627+4	3.268+2	3.455+3	7.854+3
38	2.3167+4	7.497+2	7.4880+3	2.5680+4
40	2.0393+4	6.674+2	6.6314+3	2.3480+4
42	1.8222+4	6.043+2	5.9957+3	2.0663+4
44	1.6793+4	5.513+2	5.4606+3	1.8583+4
44 (Background)[c]	1.723+3	2.624+3	2.6480+2	5.984+3
46	1.5525+4	4.937+2	5.0025+3	1.7173+4
48	1.3933+4	4.507+2	4.6057+3	1.5687+4
50	1.2919+4	4.526+2	4.3333+3	1.4410+4
52	1.2133+4	3.877+2	4.1289+3	1.3234+4
52 (Background)[c]	1.273+3	1.980+2	1.9840+3	5.210+3

[a]To be read as 8.9802×10^4

[b]Background measured with 36 x 36-in. 16-in. thick lithiated paraffin slab at 16-ft point.

[c]Background measured with 36 x 36-in. 16-in. thick lithiated paraffin slab at 25-ft point.

Table 7. Bonner Ball Count Rates along a Vertical Line Through the Beam Axis and 20 ft from the Reactor Center Line

Distance Above Pad (in.)	6-in. Bonner Ball Count Rate $(c \cdot min^{-1} \cdot W^{-1})$
20	9.3273+4[a]
32	9.4706+4
44	9.6000+4
56	9.6073+4
68	9.4874+4
80	9.2578+4
92	9.1140+4
104	8.8168+4
116	8.2380+4
128	7.7719+4
140	7.3700+4
152	6.6487+4
164	6.0837+4
176	5.4890+4
188	5.0064+4
212	3.9299+4

[a]To be read as 9.3273×10^4

Table 8. Bonner Ball Count Rates along a Horizontal Line Through the Beam Axis and 20 ft from the Reactor Center Line

Distance South of Center Line (in.)	Bonner Ball Count Rate ($c \cdot min^{-1} \cdot W^{-1}$)			
	Bare	Cd-Covered	3 in.	6 in.
0	9.2362+4[a]	2.6905+4	2.9003+4	9.3748+4
0 (Background)	2.8504+4	7.869+3	8.734+3	1.9623+4
12	9.0684+4	2.6302+4	2.9067+4	9.2582+4
24	8.9803+4	2.5874+4	2.8689+4	9.1064+4
36	8.5954+4	2.5059+4	2.7880+4	
42				8.6330+4
48	8.1460+4	2.4058+4	2.6317+4	
60	7.6800+4	2.2832+4	2.5058+4	7.8476+4
72	7.0962+4	2.1413+4	2.3543+4	
78				7.0177+4
84	6.5195+4	2.0038+4	2.2364+4	
96	6.0739+4	1.8411+4	1.9927+4	6.1765+4
96 (Background)	2.4228+4	7.029+3	7.389+3	1.6829+4
108	5.5479+4	1.6994+4	1.8610+4	
114				5.2928+4
120		1.5685+4	1.6992+4	
126	4.7845+4			
132		1.4273+4	1.5680+4	4.7888+4
144	4.0805+4	1.2916+4	1.4039+4	
150				3.7616+4
156		1.1699+4	1.2686+4	
162	3.5196+4			
168		1.0485+4	1.1305+4	3.1494+4
180	2.9962+4	9.585+3	1.0352+4	
186				2.6201+4
192	2.6748+4	8.558+3	9.603+3	2.4672+4
192 (Background)	1.4725+4	4.352+3	4.491+3	9.782+3

[a]To be read as 9.2362 x 10^4

Table 9. Bonner Ball Horizontal Traverses in the Plane of the Beam at 30 and 45 Degrees South from the Beam Axis

Distance from Core Center (ft)	Bonner Ball Count Rate ($c \cdot min^{-1} \cdot W^{-1}$)			
	3-in. Ball		6-in. Ball	
	30°	45°	30°	45°
20	1.9095+4[a]	1.0873+4	5.6137+4	2.7200+4
20 (Background)	6.089+3	4.746+3	1.3392+4	9.782+3
22	1.5896+4	9.021+3	4.6153+4	2.3250+4
24	1.3517+4	7.852+3	3.9569+4	1.9879+4
26	1.1542+4	6.811+3	3.3852+4	1.7185+4
28	9.903+3	5.922+3	2.9573+4	1.5334+4
28 (Background)	4.150+3	3.066+3	9.009+3	6.487+3
30	8.903+3	5.343+3	2.5323+4	1.3594+4
32	7.683+3	4.768+3	2.2418+4	1.2083+4
34	6.938+3	4.158+3	1.9817+4	1.0909+4
36	6.244+3	3.808+3	1.7691+4	9.681+3
36 (Background)	2.936+3	2.112+3	6.077+3	4.479+3
38	5.423+3	3.323+3	1.5672+4	8.626+3
40	4.965+3	3.072+3	1.4179+4	7.697+3
42	4.447+3	2.781+3	1.2919+4	7.172+3
44	4.047+3	2.577+3	1.1543+4	6.563+3
44 (Background)	2.134+3	1.601+3	4.476+3	3.298+3
46	3.669+3	2.400+3	1.0556+4	6.070+3
48	3.376+3	2.210+3	9.659+3	5.487+3
50	3.150+3	2.029+3	8.961+3	5.125+3
52	2.926+3	1.925+3	8.340+3	4.823+3
52 (Background)	1.628+3	1.253+3	3.445+3	2.582+3

[a]To be read as 1.9095×10^4

Table 10. Fast-Neutron Dose Rates along the Beam Axis

Distance from Core Center (in.)	Dose Rate ($erg \cdot g^{-1} \cdot hr^{-1} \cdot W^{-1}$)	Distance from Core Center (in.)	Dose Rate ($erg \cdot g^{-1} \cdot hr^{-1} \cdot W^{-1}$)
20 3/4*	2.00+3[a]	227 1/8	1.05+0
23 3/4	1.36+2	239 1/8	9.76-1
26 3/4	1.02+2	251 1/8	8.60-1
29 3/4	8.01+1	263 1/8	7.75-1
32 3/4	6.51+1	275 1/8	7.09-1
35 1/8	5.80+1	287 1/8	6.51-1
35 3/4	5.38+1	287 1/8 (Background)	5.12-2
41 1/8	4.06+1	299 1/8	6.00-1
41 3/4	3.69+1	311 1/8	5.63-1
47 1/8	2.94+1	323 1/8	5.23-1
48 1/2	2.59+1	335 1/8	4.83-1
53 1/8	2.19+1	347 1/8	4.53-1
59 1/8	1.78+1	359 1/8	4.21-1
71 1/8	1.16+1	359 1/8 (Background)	3.22-2
83 1/8	8.23+0	383 1/8	3.69-1
95 1/8	5.92+0	407 1/8	3.35-1
107 1/8	4.70+0	419 1/8	3.13-1
119 1/8	3.69+0	419 1/8 (Background)	3.77-2
131 1/8	3.11+0	431 1/8	2.97-1
143 1/8	2.55+0	455 1/8	2.64-1
155 1/8	2.22+0	455 1/8 (Background)	3.45-2
167 1/8	1.99+0	469 1/8	2.51-1
167 1/8 (Background)	1.16-1	481 1/8	2.38-1
179 1/8	1.69+0	503 1/8	2.17-1
191 1/8	1.51+0	503 1/8 (Background)	2.80-2
203 1/8	1.35+0	527 1/8	1.91-1
215 1/8	1.18+0	551 1/8	1.78-1
215 1/8 (Background)	9.14-2	551 1/8 (Background)	2.36-2

*Edge of detector can was touching aluminum shroud over pressure vessel at this location

[a]To be read as 2.00×10^3

Table 11. Fast-Neutron Dose Rates along a Vertical Line through the Beam Axis and 3 ft 2 3/4 in from the Reactor Center

Distance Above Pad (in.)	Dose Rate (erg·g^{-1}·hr^{-1}·W^{-1})	Distance Above Pad (in.)	Dose Rate (erg·g^{-1}·hr^{-1}·W^{-1})
35	2.05-1[a]	90 3/4	4.16+1
37	2.48	91 7/8	4.28
40	3.30	93 3/4	3.80
43	4.52	94	3.82
46	6.72	94 7/8	3.84
49	1.03+0	96	3.53
52	1.73	96 3/4	3.37
55	3.30	97 7/8	3.40
57 3/4	7.32	98	3.29
58	7.08	99 3/4	2.72
60	1.36+1	100	2.82
62	2.35	100 7/8	2.74
64	3.20	102	2.20
64 7/8	3.84	102 3/4	1.84
66	3.99	103 7/8	1.72
67 7/8	4.48	104	1.54
68	4.44	105 3/4	8.64+0
70	4.50	106	9.12
70 7/8	4.80	106 7/8	7.96
72 3/4	4.64	108 3/4	3.60
73 7/8	5.12	109	4.00
75 3/4	4.72	109 7/8	3.52
76	4.84	111 3/4	1.85
76 7/8	5.08	112	1.97
78 3/4	4.80	114 3/4	1.14
79 7/8	5.16	115	1.20
82 (Axis)	4.84	117 3/4	7.68-1
82 7/8	5.04	118	7.88
84 3/4	4.72	120 3/4	5.04
85 7/8	4.88	121	5.40
87 3/4	4.48	124	3.61
88	4.44	127	2.62
88 7/8	4.56	136	1.32

[a]To be read as 2.05 x 10^{-1}

Table 12. Fast-Neutron Dose Rates along a Horizontal Line Through the Beam Axis and 3 ft 2 3/4 in from the Reactor Center

Distance from Beam Axis (in.)	Dose Rate ($erg \cdot g^{-1} \cdot hr^{-1} \cdot W^{-1}$) North of Axis	Dose Rate ($erg \cdot g^{-1} \cdot hr^{-1} \cdot W^{-1}$) South of Axis
0	4.48+1[a]	
6	4.40+1	4.44+1
12	3.99	3.88
14	3.84	3.66
16	3.50	3.04
18	2.92	2.73
20	2.11	1.96
22	1.26	1.20
24	7.04+0	6.92+0
27	3.08	3.09
30	1.66	1.67
33	1.03	1.04
36	6.84-1	7.00-1
39	4.72	4.88
42	3.57	3.50
45	2.56	2.43
48	1.97	2.23
54	1.38	1.43

[a]To be read as 4.48×10^{1}

Table 13. Fast-Neutron Dose Rates at the NE213 Spectrometer Location (40 ft from the Core Center, in Concrete Block Shelter)

Energy Deposition Rate ($erg \cdot g^{-1} \cdot hr^{-1} \cdot W^{-1}$)	
Foreground	Background
5.79-6[a]	3.12-7
5.92-6	3.11-7
5.84-6	3.13-7
5.88-6	
5.80-6	2.85-7[b]

[a]To be read as 5.79 x 10^6

[b]The lower background rate in the last pair of measurements reflects a decrease in reactor power of about 19X

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