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NEUTRON CROSS-SECTION MEASUREMENTS AT 4.5 Bev

John H. Atkinson, Wilmot N. Hess, Victor Perez-Mendez, and Roger W. Wallace

January 19, 1959

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In this letter we report the results of a series of measurements on the total and reaction cross sections for 4.5-Bev neutrons on carbon, copper, and lead.

The experimental arrangement is shown in Fig. 1. The neutron flux is taken at 0° relative to the proton beam incident on an internal target in the Bevatron. The beam-defining collimator is 5 ft long and is located 50 ft from the target; the aperture in the collimator is 2×2 in., and hence the emerging neutron beam has an angular spread of less than 0.1 degree. Two lead filters placed in the collimator serve to eliminate photons present in the neutral beam.

The energy distribution of the neutrons is known[1] to be peaked at about 4 Bev and to extend up to the beam energy of 6.2 Bev. The neutron detector described below has a threshold detection efficiency for neutrons starting at 3.5 Bev, hence the mean energy of the detected neutrons is ~4.5 Bev with an energy spread of $^{+1.5}_{-1.0}$ Bev.

Figure 1 shows the neutron detector schematically. It is a counter telescope with three scintillators and a gas Cherenkov counter.[2] First in the beam line is a scintillator connected in anticoincidence to the remaining three counters. This is followed by a 12-in. long Be converter, a

*Work done under the auspices of the U.S. Atomic Energy Commission.

scintillator, a Pb electron filter, a sweeping magnet, the gas Cherenkov counter, and a final scintillator. Neutrons are detected by the charged pions produced in the beryllium converter and recorded by the triple coincidence of the two scintillators and Cherenkov counter. The threshold energy of 3 Bev for detecting pions is set by the gas pressure in the Cherenkov counter. The Pb electron filter and the sweeping magnet serve to deflect out of the telescope the conversion electrons, originating from decaying π^0 mesons of all energies produced in the beryllium converter. Protons made in the converter have too low a β to count in the Cherenkov counter.

The neutron-counter telescope is placed at a fixed distance of 30 feet from the collimator. A similar telescope at the rear of the collimator monitors the neutron flux by detecting charged pions produced in the lead filter. Absorption measurements in "good" and "poor" geometry were done by placing the sample at various distances from the neutron detector. Figure 2 shows the results of such a series of measurements on Pb. Similar measurements have been performed on carbon and copper. The limiting values of the cross section for "good" and for "poor" geometry yield the total and reaction cross sections listed in the table. The most interesting feature of the data is that the elastic cross sections, especially for the heavy elements, are considerably smaller than at lower energies, whereas the absorption cross sections remain essentially constant from 300 Mev up to our energy.

	σ_t (in mb)	σ_{r_i} (in mb)
Pb	2320 ± 130	1660 ± 90
Cu	1088 ± 22	638 ± 24
C	354 ± 11	218 ± 8

The following letter discusses the interpretation that can be placed on these values, in relation to the Brookhaven measurements performed at a mean energy of 1.4 Bev, and lower-energy data.[3]

We should like to acknowledge the support of Professors A. Carl Helmholz and Burton J. Moyer for this experiment. We should also like to thank Dr. Edward J. Lofgren and the Bevatron crew for their help and unfailing courtesy in the performance of this experiment.

References

1. Fred N. Holmquist, Pion Production in Neutron-Proton Collisions at Bevatron Energies (Thesis), UCRL-8559, Dec. 1958.
2. V. Perez-Mendez and J.H. Atkinson, Gas Cherenkov Counters, UCRL-8570, Dec. 1958.
3. Coor, Hill, Hornyak, Smith, and Snow, Phys. Rev. 98, 1369 (1955).

Figure Captions

Fig. 1. Schematic of the experimental arrangement, showing the collimator, monitor telescope, and neutron-detector telescope. The absorber is placed in various positions between the monitor and neutron telescopes.

Fig. 2. Cross section of neutrons in lead as a function of the half angle subtended by the neutron detector. The solid curve is a least-squares fit to the data according to an opaque-nucleus calculation for a mean neutron energy of 4.5 Bev.

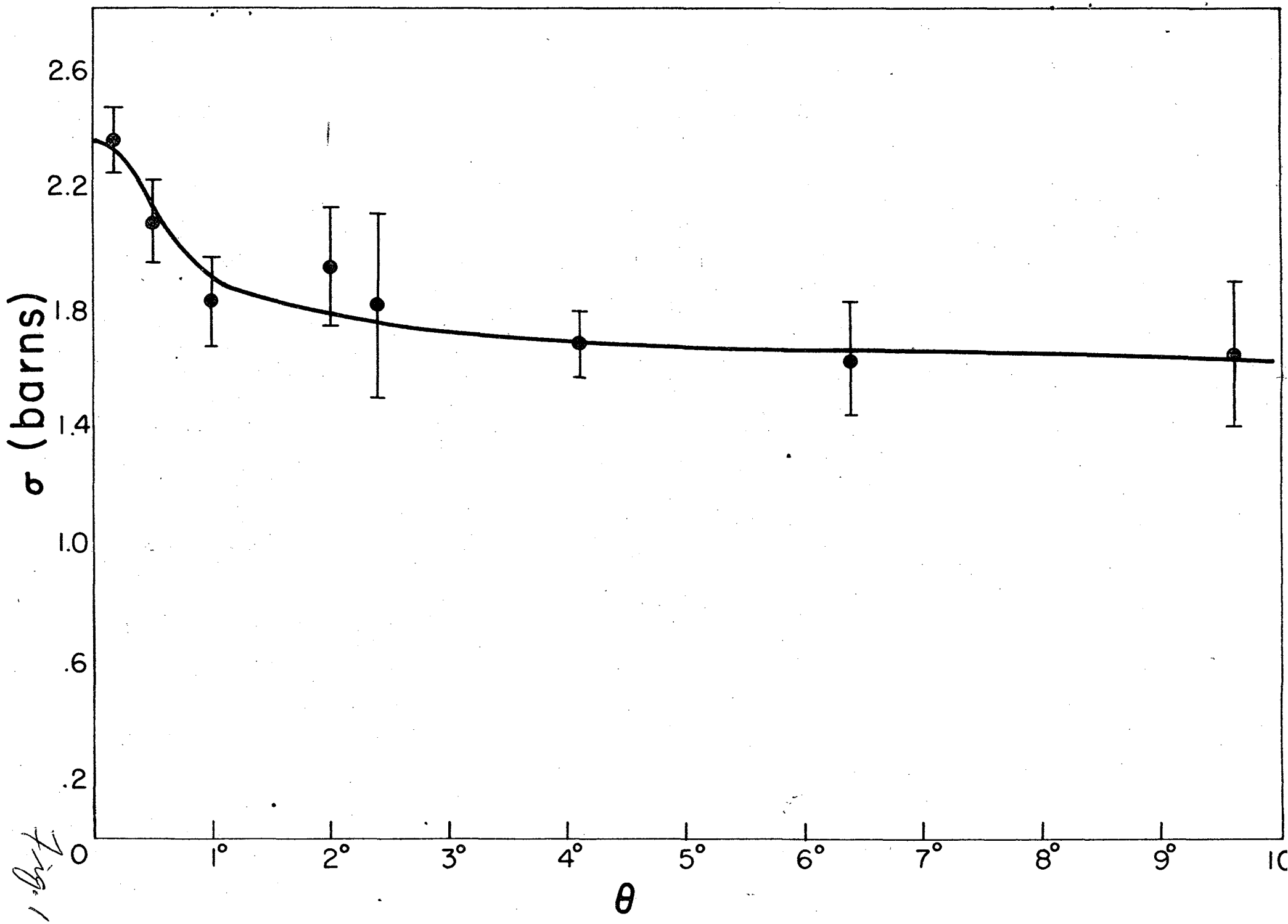

Fig. 1

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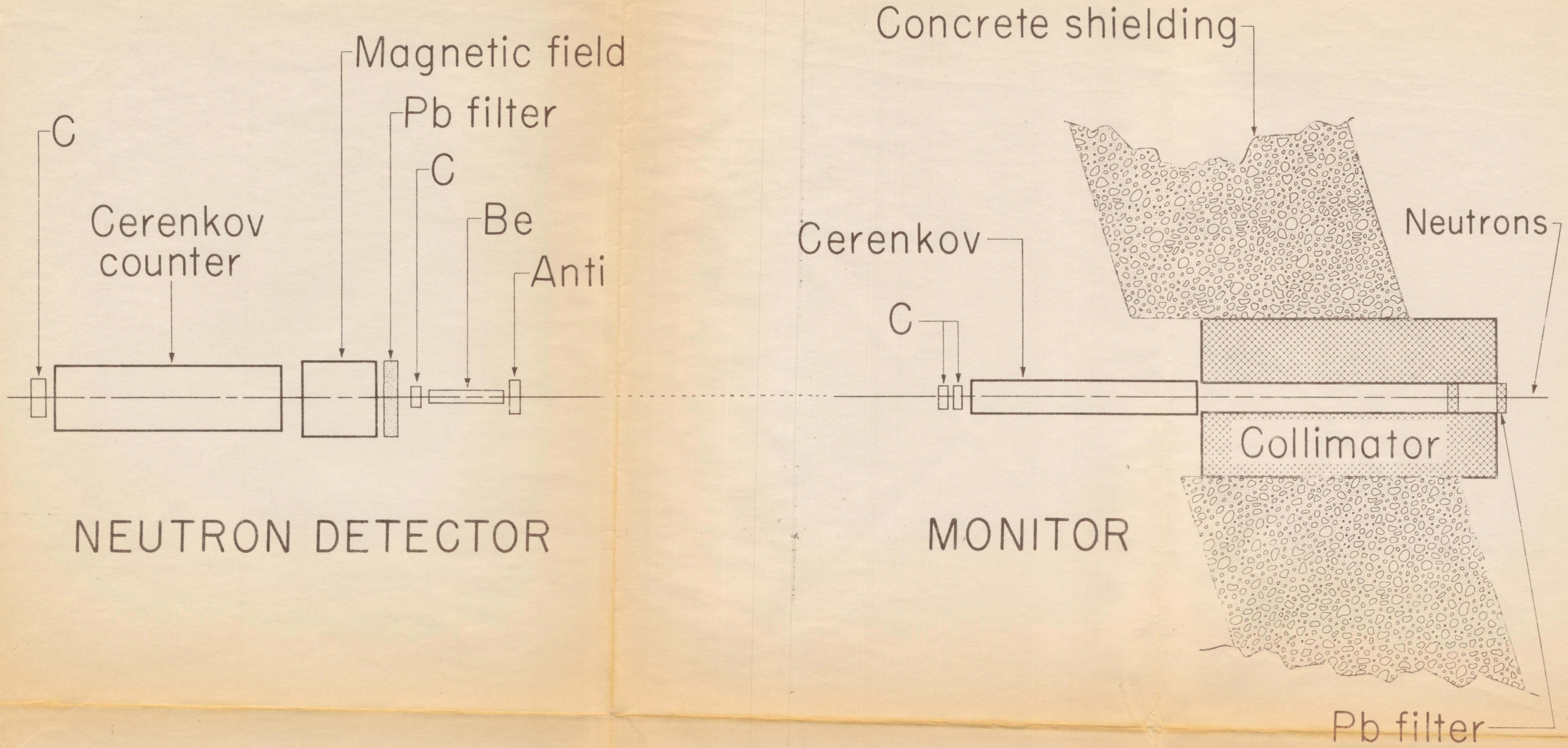
Magnetic field
Pb filter
C
C
Be
Anti
Cerenkov
counter
NEUTRON DETECTOR
Concrete shielding
Cerenkov
C
Neutrons
Collimator
MONITOR
Pb filter

Fig. 2