Title
THE HELD OF NEUTRAL MESONS FROM PROTON BOMBARDMENT OF LIGHT NUCLEI

Authors
Hales, R.W.
Hildebrand, R.H.
Knable, N.
et al.

Publication Date
1951-11-05

UNIVERSITY OF CALIFORNIA – BERKELEY

RADIATION LABORATORY

DISCLAIMER

UCRL-1543
Unclassified-Physics Distribution

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

THE YIELD OF NEUTRAL MESONS FROM PROTON BOMBARDMENT OF LIGHT NUCLEI

R. W. Hales, R. H. Hildebrand, N. Knable and B. J. Moyer

November 5, 1951

Berkeley, California

THE YIELD OF NEUTRAL MESONS FROM PROTON BOMBARDMENT OF LIGHT NUCLEI

R. W. Hales, R. H. Hildebrand†, N. Knable‡, and B. J. Moyer

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

November 5, 1951

This experiment was planned in order to study the relative cross sections of various light nuclei for the production of neutral pions by 340 Mev protons.

In particular we wished to measure the yield of π°s in p-p collisions in order to obtain information about the symmetry properties of the π° meson.

If the π° is a pseudo scalar meson it cannot be emitted in a P angular momentum state from a p-p collision in an even orbital state since parity and angular momentum cannot be conserved simultaneously in this case. If the π° is emitted in an S state, then, in analogy with π^{+} production for which the S state yield is about one-eighth of the P state yield, we should expect the numbers of π°s from p-p collisions to be about one-eighth of that from p-n collisions. If the π° is a scalar meson no such large ratio would be expected.

No direct comparison of the p-p and p-n π° yields could be made using a proton beam but relative p-p and p-d yields were obtained by subtractions utilizing targets of carbon, polyethylene, heavy water, ordinary water and liquid oxygen. The series Be^{9}, B^{10}, B^{11}, C^{12} was also studied.

A unique method of indentifying a neutral pion would be to detect

---

† Now at the University of Chicago

‡ Now at the University of Illinois

both of the decay γ-rays in coincidence in the manner used for detection of neutral photomesons[1] but the unfavorable neutron background conditions associated with proton bombarded targets makes the method infeasible for this experiment. Hence it was necessary to depend on single γ detection. This is probably a valid measure of the neutral meson yield since the photon spectrum from proton-bombarded targets, which has been measured by Bjorklund, Crandall, Moyer, and York[2] and by Crandall and Panofsky[3], is nearly consistent with a pure π^{o} decay spectrum. The possible reabsorption of a charged or neutral meson within the nucleus in which it is created seems to be not more than a few per cent.

The pair spectrometer method of Bjorklund et al[2] was not suitable for comparing yields from different targets because of the uncertainties involved in multiple traversals when viewing interval cyclotron targets.

The photon detector used for this experiment was of the type developed by Hildebrand, Knable, and Leith[4] in which multiple scattering in a thick converter is used to separate the electron pairs. In this device two scintillation counter telescopes are placed behind the converter and connected in coincidence as shown in Fig. 1 so that whenever the electron and positron are scattered into separate telescopes the event is recorded. The phosphors were thick so that only photons above 20 Mev could produce pairs with sufficient energy to cause a coincidence of all four counters. This detector has good discrimination against neutrons and charged particles and was thus suitable for use with the external beam in the presence of a high background.

The detector was placed at an angle of 135^{o} to the direction of the proton beam for all these measurements in order to avoid the large flux of neutrons from the target which is present at small angles. The results obtained at this one angle should be a fairly good measure of relative total yields of π^{o}s since the angular distribution of photons in the meson's rest frame is isotropic so that the photon yield at one angle in the lab frame receives contributions from mesons emitted in any direction. That the photon yield in a given direction in the laboratory is not strongly affected by conceivable meson angular distributions can be shown by straightforward calculations.

The results are shown in Table 1 and Fig. 2. The yields shown are relative to the carbon yield which has arbitrarily been given the value 6.00.

The yield from H^1 appears to be suppressed in accordance with the selection rule discussed above for a pseudo-scalar meson. Further measurements using a liquid hydrogen target in place of the carbon and polyethylene targets will be necessary to establish a positive yield from hydrogen or to lower the present upper limit appreciably. The yields from the series Be^9, B^{10}, B^{11}, C^{12} which differ by the successive addition of a proton, a neutron and a proton suggest that only the neutrons in light nuclei contribute appreciably to π^o production in proton bombardment. However differences in the nuclear structure of these nuclei may modify this simple inference.

This work was performed under the auspices of the Atomic Energy Commission.

---

[1]Steinberger, Panofsky, Steller, Phys. Rev. 78, 802 (1950).

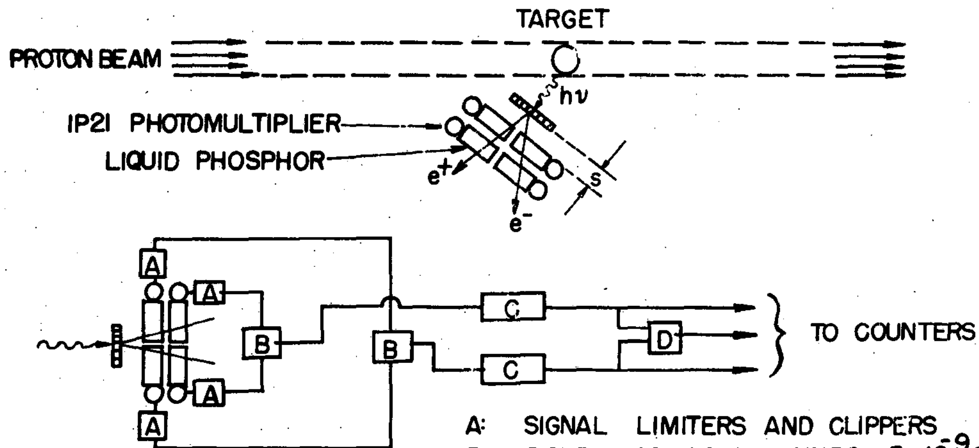
[2]R. Bjorklund, W. Crandall, B. Moyer, and H. York, Phys. Rev. 77, 213 (1950).

[3]W. Crandall, and W. Panofsky. Private communication. Crandall, Crowe, Moyer Panofsky, Phillips, Walker -- to be published in Phys. Rev.

[4]R. H. Hildebrand, N. Knable and C. E. Leith, UCRL-1517. To be published in R. S. I.

TABLE I

Nucleus	Relative cross sections for neutral meson production by 341 Mev protons
H^1	0.07 ± 0.06
H^2	0.85 ± 0.20
Be^9	5.01 ± 0.12
B^{10}	4.99 ± 0.11
B^{11}	5.95 ± 0.13
C^{12}	6.00 ± 0.16
O^{16}	7.46 ± 0.28



A: SIGNAL LIMITERS AND CLIPPERS
B: DOUBLE COINCIDENCE UNITS, 5×10^{-9} SEC. RESOLUTION
C: AMPLIFIERS, 10Mc BAND WIDTH
D: DOUBLE COINCIDENCE UNIT, 10^{-6} SEC. RESOLUTION

APPARATUS AND CIRCUIT FOR DETECTION OF HIGH-ENERGY PHOTONS

MU 1724

Fig. 1

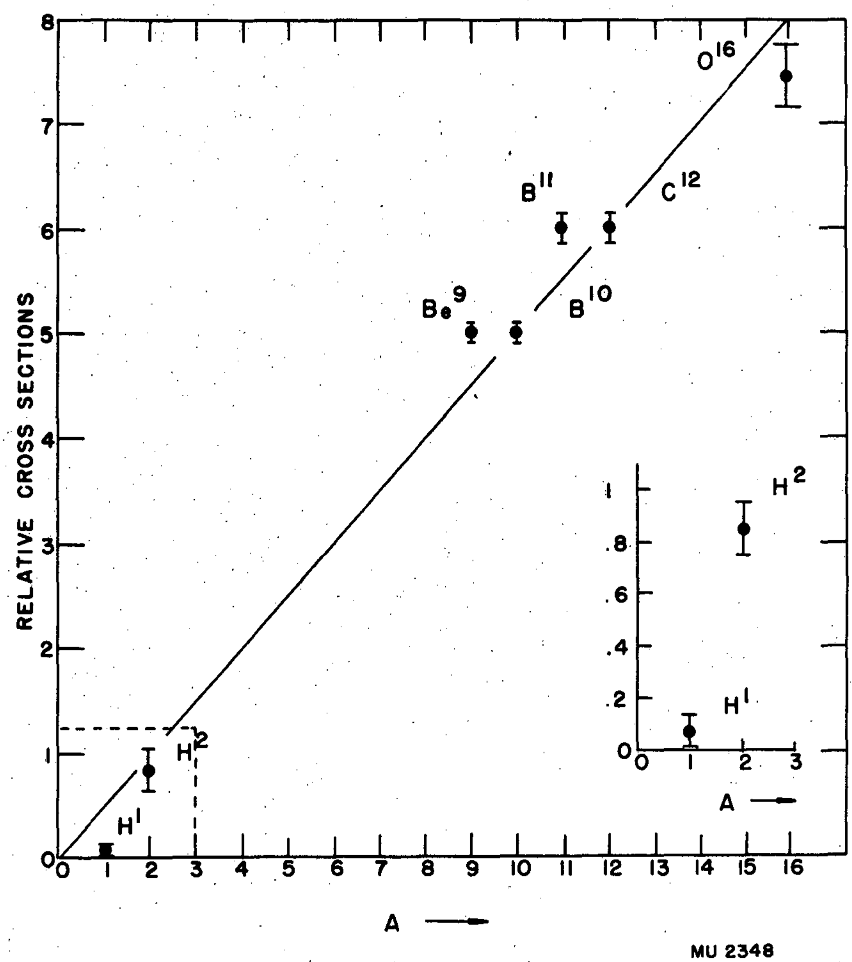


Fig. 2. Relative neutral meson yields.