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SUMMARY OF THE RESEARCH PROGRESS MEETING OF APRIL 24, 1952

Sergey Shewchuck

April, 1952

Berkeley, California

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I. Photoproduction of π^0's from Deuterium. W. Heckrotte.

The talk was essentially based on report UCRL-1611 by W. Heckrotte, L. R. Henrich and J. V. Lepore, December 13, 1951. A summary is quoted as follows together with a concluding remark:

"The cross sections for neutral meson production was calculated when a dueteron particle was formed in the final state. The pseudoscalar meson theory with pseudovector coupling was assumed and the process treated according to the perturbation theory. It was found that the principal contribution to the cross section is proportional to the square of the interaction energy."

It apparently may be concluded that one can determine the sign of the proton - neutron - meson coupling constant from a study of the elastic scattering.

II. Absolute Yield of π^0 Mesons in the Proton Bombardment of Carbon. B. Moyer.

The work of W. E. Crandall and others on the photon spectra received at various angles from targets bombarded with 340 Mev protons allows one to infer the angular distribution of both the photons and the π^0 mesons. However, in that work it was not possible to use an absolute proton beam monitor, since for reasons of intensities the target was placed within the cyclotron tank and multiple passage of the beam rendered a confident measurement of its current impossible. The relative numbers of photons received at various angles were measured by the use of thin aluminum foils or thin polystyrene foils fastened to the carbon target. The activities of sodium 24 or of carbon 11, respectively, served to give relative normalization.

The present report deals with an absolute evaluation of the photon yield received at 90° from a carbon target bombarded by the external proton beam, whose current could be precisely measured. Comparison with the 90° spectrum received from internal targets then made it possible to place the data upon an absolute scale of intensity. In the table which follows, there are listed the results for the various angles of observation in the laboratory system. The first column gives the differential cross section presented by the carbon nucleus for the production of photons at the peak of the spectrum seen at the angle specified. The second column gives the total photon yields in terms of the cross sections for the delivery of high-energy photons into unit solid angle in the direction specified. The third column gives the amount of solid angular space to be associated with each of the spectra at the various angles of view. The last column consists of the products of the preceding two columns which, when summed, will give the total cross section of the carbon nucleus for the production of high energy photon radiation.

TABLE

ANGLE	$\frac{d\sigma}{dE\,d\Omega}$	$\frac{d\sigma}{d\Omega}$	$\Delta\Omega$	$\frac{\sigma}{\Delta\Omega}$
0	4.31×10^{-30}	6.91×10^{-28}	0.84	5.80×10^{-28}
47°	3.59 "	4.58 "	2.30	10.53 "
90°	2.26 "	2.02 "	6.28	12.70 "
133°	2.42 "	2.36 "	2.30	5.43 "
180°	1.99 "	1.83 "	0.84	1.54 "
	cm^2/sterad. Mev	cm^2/sterad.	sterad.	$36.0 \times 10^{-28} cm^2$

$$\sigma_{photon} = (3.6 \pm 0.8) \times 10^{-27} \ cm^2$$

$$\sigma_{\pi^0} = (1.8 \pm 0.4) \times 10^{-27} \ cm^2$$

(Error estimated from basic data.)

If all the high energy photons are considered to arise from neutral mesons then neutral meson cross sections are one half of that for photon production, or 1.8 ± 0.4.

In Figure 1 is shown a plan view of the experimental arrangement. The pair spectrometer is located where it can first view the internal cyclotron target, for the purpose of receiving sufficient gamma radiation to allow the adjustment of counting conditions to provide satisfactory plateaus, subsequently the pair spectrometer is turned upon its base so as to view through the side wall aperture a carbon target placed in the external proton beam. Final collimation and an electron clearing field preceding the pair spectrometer gave satisfactorily low converter-out counting rates.

In Figure 2, are displayed sample data from one run showing the dependence of photon counting rate upon tantalum converter thickness. The abscissa is expressed in terms of "effective thickness" which is calculated from actual thickness by taking account of the photon attenuation by the tantalum up to the depth of the point of pair creation and the possibility of electron energy loss to energies below detectability for the pair electrons emerging from that point. From this curve the photon yield per unit thickness of tantalum is obtained.

III. π^0 Yield vs. Z. R. W. Hales.

In the experimental setup for the detection of π^0 yield there was used instead of liquid scintillators anthracene crystals which gave better results. Yields were obtained on a number of elements in four series run as follows:

Series 1; Carbon, polyethylene, water, heavy water, Cl.

" 2; Water, heavy water, liquid O_2.

" 3; (1in.diameter cylinders) Li, Be, B^{10}, $B^{natural}$, C, Na, Ca, K.

" 4; C, Al, Cu, Pb.

The Na and K targets due to their low melting points were able to be cast in one inch centrifuge tubes. The tubes were afterwards broken off and the metals re-immersed in oil. The gasses D_2, He, N_2, and A are going to be used as targets later, employing a high pressure gas chamber designed by R. Stephen White.

Figure 3 shows the relative yield of high energy photons from 340 Mev proton bombardment of the lighter nuclei up to Al^{27} plotted against the atomic number. It is to be noted that the yield is approximately the same for certain pairs of elements having the same number of neutrons as B^{11} - C^{12} and Be^9 - B^{10}; and, in general, the yield is proportional to the number of neutrons. Figure 4 gives the relative yield including the heavier elements up to Pb. For elements above Al the yield ceases to be proportional to the number of neutrons N but goes rather according to the number of neutrons per unit volume on the surface of the nucleus, i.e.

$$\sigma \propto \frac{N}{A} A^{2/3} \quad \text{or}$$

$$\sigma/N \propto A^{-1/3} \qquad \text{(As shown in Figure 3)}$$

By comparison, Panofsky, Steinberger and Steller in the case of photon produced π^0's from the synchrotron found a yield of π^0's per nucleon vs. atomic number which fits $\sigma \sim A^{-1/3}$ in the region Li to Pb. This means that the mesons are strongly reabsorbed. Panofsky et al.

confined themselves to meson energies of over 85 Mev by their detection scheme.

A calculated curve for proton absorption cross sections following the method of Fernbach, Serber and Taylor shows good agreement in shape with the π^{o} cross section being only slightly higher toward the heavy elements (Figure 3). This is an indication of little meson absorption and might be due to a lower meson energy than those observed by Panofsky et al.

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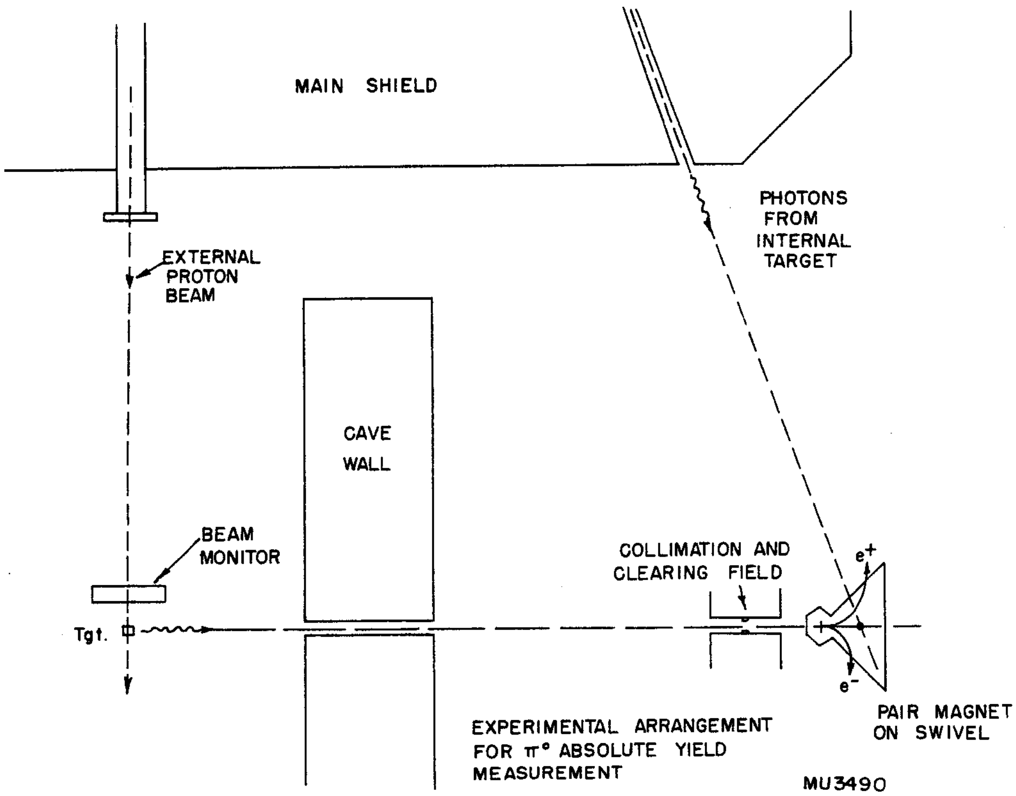
MAIN SHIELD
PHOTONS FROM INTERNAL TARGET
EXTERNAL PROTON BEAM
CAVE WALL
BEAM MONITOR
Tgt.
COLLIMATION AND CLEARING FIELD
e+
e−
PAIR MAGNET ON SWIVEL
EXPERIMENTAL ARRANGEMENT FOR π° ABSOLUTE YIELD MEASUREMENT
MU3490

Fig. 1

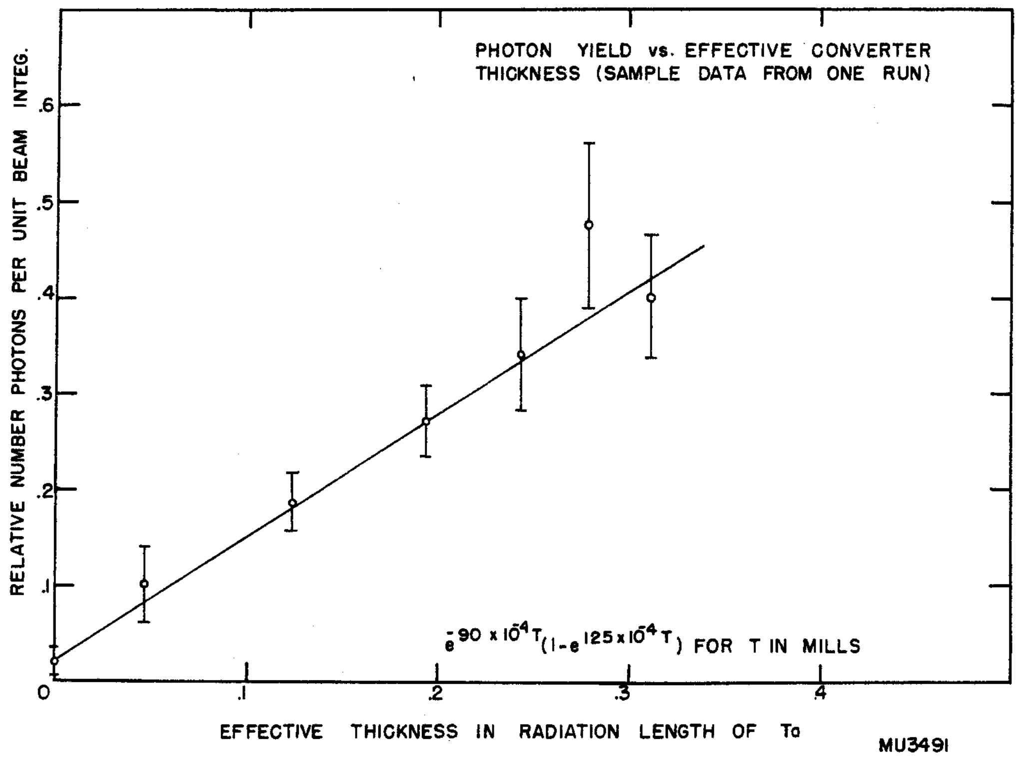
PHOTON YIELD vs. EFFECTIVE CONVERTER
THICKNESS (SAMPLE DATA FROM ONE RUN)
RELATIVE NUMBER PHOTONS PER UNIT BEAM INTEG.
.6
.5
.4
.3
.2
.1
0
.1
.2
.3
.4
$e^{-90 \times 10^{-4} T}(1-e^{125 \times 10^{-4} T})$ FOR T IN MILLS
EFFECTIVE THICKNESS IN RADIATION LENGTH OF Ta
MU3491

Fig. 2

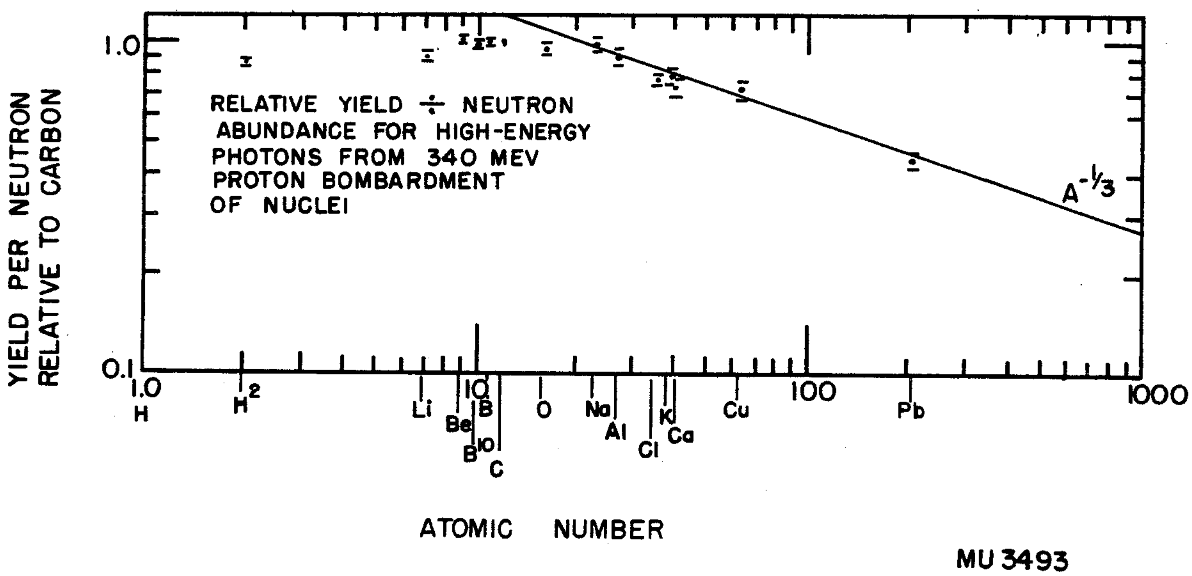
YIELD PER NEUTRON RELATIVE TO CARBON
1.0
0.1
RELATIVE YIELD ÷ NEUTRON
ABUNDANCE FOR HIGH-ENERGY
PHOTONS FROM 340 MEV
PROTON BOMBARDMENT
OF NUCLEI
A-1/3
1.0
10
100
1000
H
H2
Li
Be
B10
B
C
O
Na
Al
Cl
K
Ca
Cu
Pb
ATOMIC NUMBER
MU 3493

Fig. 3