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COHERENT PRODUCTION OF INTERMEDIATE BOSONS FROM M

By

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Lee and Yang have considered the production of the intermediate boson W by the process

$$\nu + p \rightarrow W^{+} + \mu^{-} + p$$
$$\rightarrow W^{-} + \mu^{+} + p \qquad (1)$$

This process can presumably occur also from a nucleus, either coherently or incoherently. If the cross section per unit momentum transfer q to the proton in process (1) is $d\sigma_p/dq$, then the total cross section for a nucleus of Z protons is approximately:

$$\sigma_t = Z \int \left[1 - F^2(q)\right] \left(\frac{d\sigma_p}{dq}\right) dq + Z^2 \int F^2(q) \frac{d\sigma_p}{dq} dq \qquad (2)$$

where the first term is the inelastic and the second term is the elastic contribution, and where F(q) is the usual form factor. Equation (2) has been plotted by Yang for the assumed values of the W mass m_W in units of the proton mass m_p; the result is given in Fig. 1, plotted for iron (Z = 26).

Figure 2 shows this cross section multiplied by the differential neutrino spectrum $I(p_\nu)$ as defined in Project M Report 200-17.

Let us consider a target detector of mass M grams covering a distance from L_0 to L from the primary target (see Fig. 3, Project M Report 200-17). The yield of W bosons per incident electron is then

$$Y = \frac{(0.041)\ L_0}{L^2}\ MN \times \frac{Z}{A} \int_0^{25\ \text{Bev}} I(p_\nu)\ \sigma_t\ dp_\nu \qquad (3)$$

where N = Avogadro's number, and $(Z/A) = 0.47$ for iron. Numerically, for $L = 30$ m, $L_0 = 15$ m,

$$\frac{Y}{M} = \frac{0.041 \times 15}{(30)^2} \times 6 \times 10^{23} \times 0.47 \times 7.2 \times 10^{-44}$$

$$= 1.39 \times 10^{-23} \quad \text{W particles/primary electron-gram.}$$

If we assume a beam of 4×10^{14} e^-/sec and measure M in tons (10^6g), we obtain an interaction rate of about

$$5.5 \times 10^{-3} \text{ W particles/ton-sec}$$

or (4)

$$20 \text{ W particles /ton-hour}$$

for a W-particle mass of 0.6 proton masses and an electron energy of 25 Bev.

This calculation should be fairly reliable since the principal contribution to the yield would come from neutrinos of 3 Bev and above; these would originate primarily from pions of high energy, where the Drell* calculations of photopion production of peripheral collisions are presumably applicable.

The predicted counting rate according to Eq. (4) is extremely high as projected neutrino experiments go. If the W mass is higher, the rates would decrease very rapidly, as can be seen by inspection from Fig. 1.

A possible method of detection of the boson would be a large spark chamber. Detection might be feasible in a large liquid

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*S. D. Drell, M-200-7A, August 1960; and J. Ballam, M-200-8, August 1960.

scintillator using a pulse sequence of the machine, the muon, and the decay electron from the μ-decay mode of the boson:

$$W^+ \rightarrow \mu^+ + \nu \qquad \mu^+ \rightarrow e^+ + \nu + \bar{\nu}$$

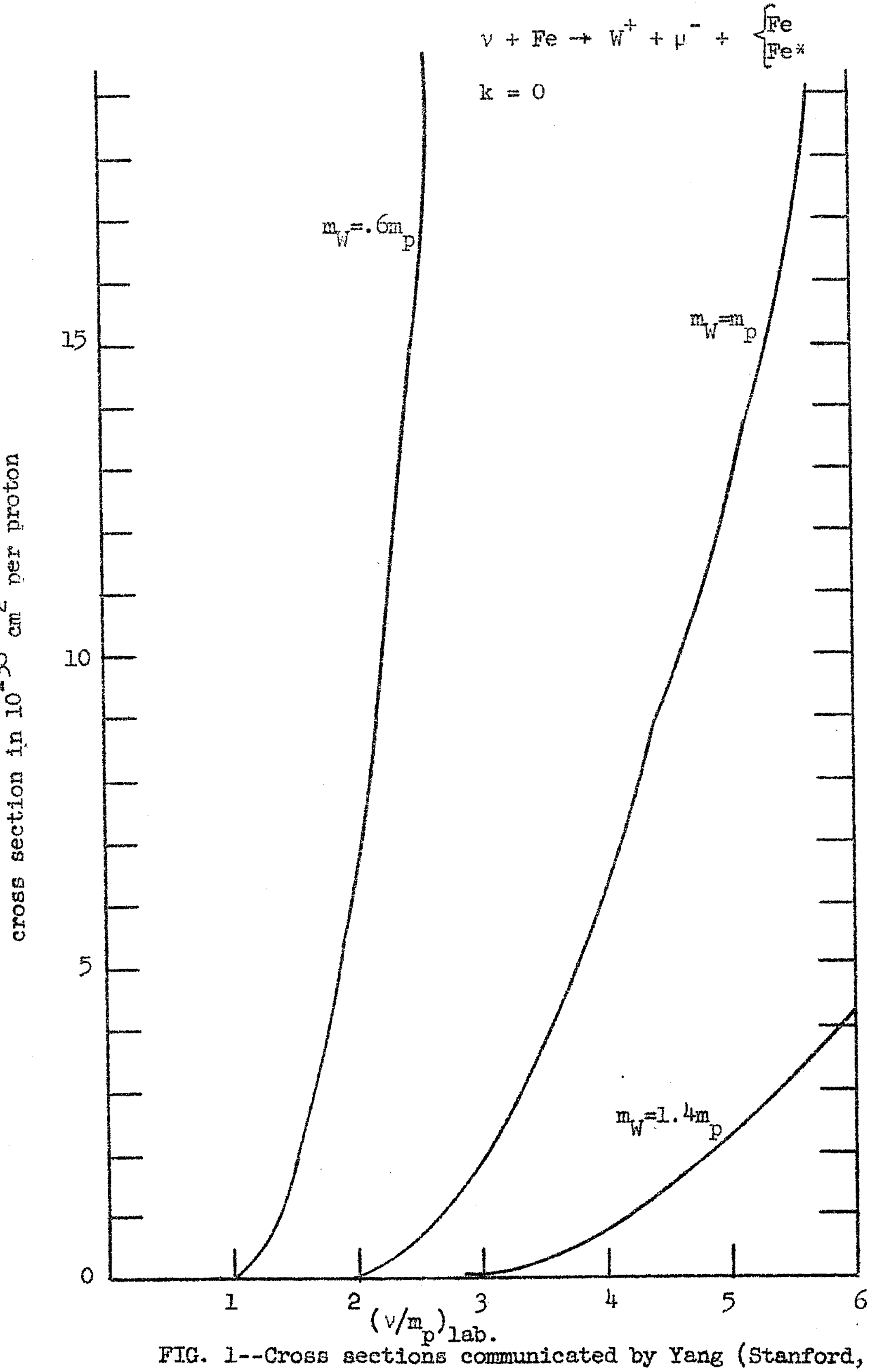

FIG. 1--Cross sections communicated by Yang (Stanford, June 1961) for the sum of coherent and noncoherent production cross sections of W particles of zero magnetic moment and various masses in iron.

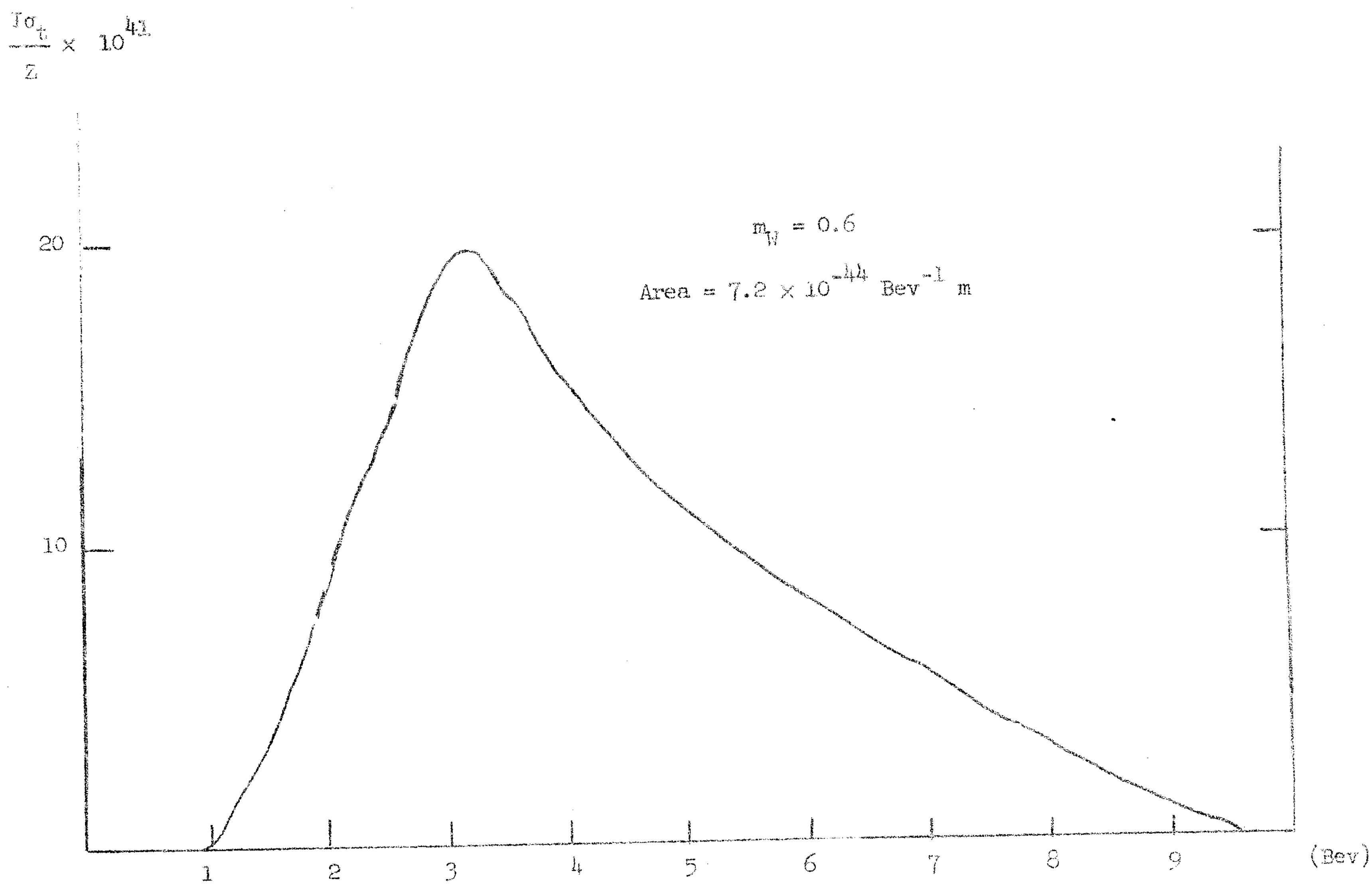

FIG. 2--Product of the cross sections of Fig. 1 and the neutrino spectra computed in Project M Report M-200-17 from pions produced by 25 Bev electrons.