For a "pure" V-A interaction ($C_V = -C_A \equiv F/\sqrt{2}$, $B_V = B_A = 0$) formula (5) simplifies into

$$d\sigma = \frac{d(-Q^2)F^2}{4\pi E m_p}(\varepsilon^2 - m_\Lambda^2); \quad \sigma = \frac{F^2}{2\pi}\varepsilon^2\left(1 - \frac{m_\Lambda^2}{\varepsilon^2}\right)^2. \quad (6)$$

The second of these formulas is valid to the extent that the Q^2 dependence of F may be ignored. This dependence will become important, presumably, at $-Q^2 \sim m_K^2$.[6] In any case the magnitude of the form factors should fall off rapidly for $-Q^2 \gg m_K^2$. Therefore, at high energies the effective range of variation of $-Q^2$ is smaller than is given by Eq. (4). One may suppose that in effect $0 \leq -Q^2 \leq Q_0^2$, $Q_0^2 \sim m_K^2$. If at the same time $E \gg m_\Lambda$, and consequently $m_p E \gg -Q^2$, then only the first term in Eq. (5) is important so that

$$d\sigma = \frac{d(-Q^2)}{2\pi}(C_V^2 + C_A^2). \quad (7)$$

For $C_V^2 + C_A^2 \equiv F^2 \approx \text{const}$ $(0 \leq -Q^2 \leq Q_0^2)$

$$\sigma \sim \frac{F^2}{2\pi}Q_0^2 \sim \frac{F^2}{2\pi}m_K^2 \sim \frac{F^2}{G^2}\cdot 2\cdot 10^{-39}\ \text{cm}^2 \quad (8)$$

where $G = 1.41 \times 10^{-49}$ erg cm^3 is the Feynman–Gell-Mann constant.[2] If $F^2/G^2 \sim 1/20$ then $\sigma \sim 10^{-40}$ cm^2. In a similar fashion we find

$$\sigma \approx (F/G)^2\cdot 7\cdot 10^{-40}\ \text{cm}^2 \approx 0.35\cdot 10^{-40}\ \text{cm}^2, \quad (9)$$

for E = 400 Mev, when the upper limit on the range of variation of $-Q^2$ in Eq. (4) is of order m_K^2 and we may use for estimate purposes the second of the formulas (6).

With a cross section of the order of 10^{-40} cm^2 the probability for the process (1) is equal to 10^{-17} for a 10 cm path length of an electron in liquid hydrogen of density $\sim 10^{22}$ atoms/cm^3. Consequently, approximately $10^{18} - 10^{19}$ electrons are needed to observe the reaction. With accelerator intensities of 10^{13} electrons per second this figure is not so fantastic. If instead of hydrogen heavier elements are used then for the same number of atoms in 1 cm^3 the necessary number of electrons is decreased by a factor Z. Theoretically, however, the analysis of the experimental results becomes in this case much more complicated since the proton is initially bound. We only remark that in the case of a nucleus some of the reactions $e^- + p \rightarrow \Lambda + \nu$ will result in the formation of Λ hyperfragments.

The experimental study of the process (1) presents, naturally, a number of difficulties, connected in part with the necessity of observing a Λ hyperon in the presence of considerable background. Nevertheless such a study is of interest particularly since by varying the energy E it is possible in this way to directly investigate the Q^2 dependence of the form factors.

Along with the reaction (1) it is possible to study the reactions $e^- + p \rightarrow \Sigma^0 + \nu$ and $e^- + n \rightarrow \Sigma^- + \nu$. In view of the absence of intense μ^--meson beams the corresponding processes involving μ^- mesons in place of e^- are hardly possible experimentally.

The author is grateful to I. M. Shmushkevich for pointing out the feasibility of studying process (1) and for discussions.

*If one neglects the mass difference between the Λ hyperon and the proton (in which case, according to Eq. (3), $-Q^2 = 2m_pW$) as well as the "magnetic" form factors of the type B_V and B_A, then the expression for the cross section with all covariants of the 4-fermion interaction taken into account is the same as the expression describing the cross section for electron-neutrino scattering.[4] (In formula (1) of reference 4 g_S^2 should stand next to $W^2 + 2WE$ and not $W^2 + WE$, and $(2g_Vg_A + g_Sg_T + g_Pg_T)$ next to $W^2 - 2WE$, not $W^2 - WE$).

For $B_A = 0$, $m_\Lambda \approx m_p$, expression (5) coincides with the result obtained by Berestetskiĭ and Pomeranchuk[5] for the cross section for the process $e^- + p \rightarrow n + \nu$.

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INELASTIC INTERACTIONS OF 9 Bev PROTONS WITH FREE AND BOUND NUCLEONS IN EMULSION

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In an emulsion stack exposed to the proton synchrotron of the High-Energy Laboratory of the Joint Institute for Nuclear Research, 243 cases of inelastic interactions (140 pp and 103 pn) of

9-Bev protons with free and bound nucleons of the emulsion were recorded by scanning along the tracks. The selection of the events was made according to the criteria enumerated in reference 1 and described earlier in greater detail.[2]

To obtain the energy and angular characteristics of the secondary particles, measurements of multiple Coulomb scattering and ionization were carried out on all tracks inclined at an angle no greater than 5° to the plane of the emulsion. There were 144 such tracks of pp events and 108 of pn events. The method of measurement and analysis of the results was described in reference 3. The mean value of spurious scattering in pellicles in which momentum measurements were made was 0.3μ for a 1000μ cell and 0.7μ for a 2000μ cell, which corresponds to the Coulomb scattering of a singly charged particle with $p\beta = 5$ Bev/c. All secondary tracks with $p\beta \leq 1.6$ Bev/c were identified; in the region of higher $p\beta$ values the ionization vs $p\beta$ curves for π mesons and protons overlap. After allowance for the geometric correction[3] it was found that particles with $p\beta \leq 1.6$ Bev/c constituted 78% of the total number of particles.

All secondary particles whose angle of emission with reference to the direction of the primary proton in the laboratory system was greater than 20° were identified. This means that all π^- mesons emitted in the center-of-mass system (c.m.s.) of the colliding nucleons in the backward hemisphere were identified. The proportion of unidentified protons emitted in the backward hemisphere in the c.m.s. can be estimated by making use of the symmetry of the angular distribution of secondary particles from pp interactions with respect to the 90° direction in the c.m.s. The corresponding value did not exceed 6% of the number of identified protons in the backward hemisphere in the c.m.s. Hence, practically only identified particles fall in the backward hemisphere in the c.m.s.

For the pp interactions, the angular distributions of the charged π mesons and protons emitted in the c.m.s. in the backward hemisphere are shown in Fig. 1 (N is the number of particles in relative units). The median angle of emission in the c.m.s. was $(16 \pm 6)°$ for protons and $(38 \pm 10)°$ for π mesons. Thus the angular distributions of the protons and π mesons are anisotropic, as has also been observed[4] at 6.2 Bev. This is in contradiction to the statistical theory assumption of isotropy of the secondary particle distribution in the c.m.s., at least in its variant in which the influence of the conservation of angular momentum is not taken into account.

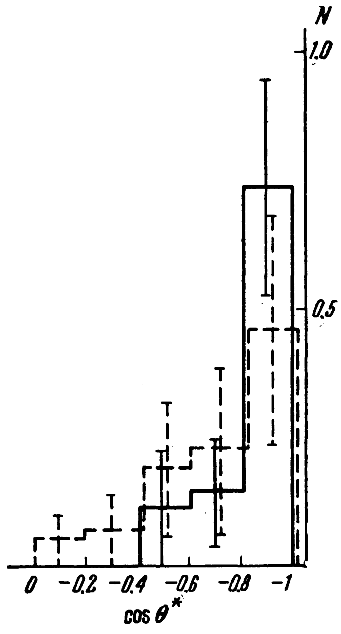

FIG. 1. C.m.s. angular distribution of protons and charged π mesons from pp interactions. Solid line – protons (43 tracks); broken line – π mesons (20 tracks).

The mean numbers n_p and n_π of protons and charged π mesons for one act of inelastic pp interaction found from the number of protons and π mesons in the backward hemisphere in the c.m.s. are $n_p = 1.3 \pm 0.3$ and $n_\pi = 1.9 \pm 0.3$. The corresponding values calculated from statistical theory[5] are $n_p = 1.2$ and $n_\pi = 2.3$. The number of negative π mesons in each pp event, if the production of antiprotons and strange particles is neglected, is determined from the law of charge conservation. Thus, knowing the total number of charged π mesons, one can estimate the number of π^+ and π^- mesons for one act of interaction. The values found are $n_{\pi^+} = 1.3 \pm 0.3$ and $n_{\pi^-} = 0.61 \pm 0.06$.

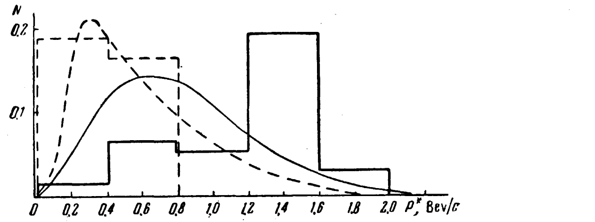

FIG. 2. C.m.s. momentum spectra of protons and charged π mesons from pp interactions. Histograms – experimental data; smooth curves – according to statistical theory.[5] The areas under all four curves are the same. Solid lines – protons (43 tracks); broken lines – π mesons (20 tracks).

The momentum spectra for protons and charged π mesons emitted in the c.m.s. in the backward hemisphere is shown for pp interactions in Fig. 2. It is seen from the figure that the π-meson and proton spectra are displaced, with respect to the theoretical spectrum, towards the lower and higher momenta, respectively. The same is also observed[4]

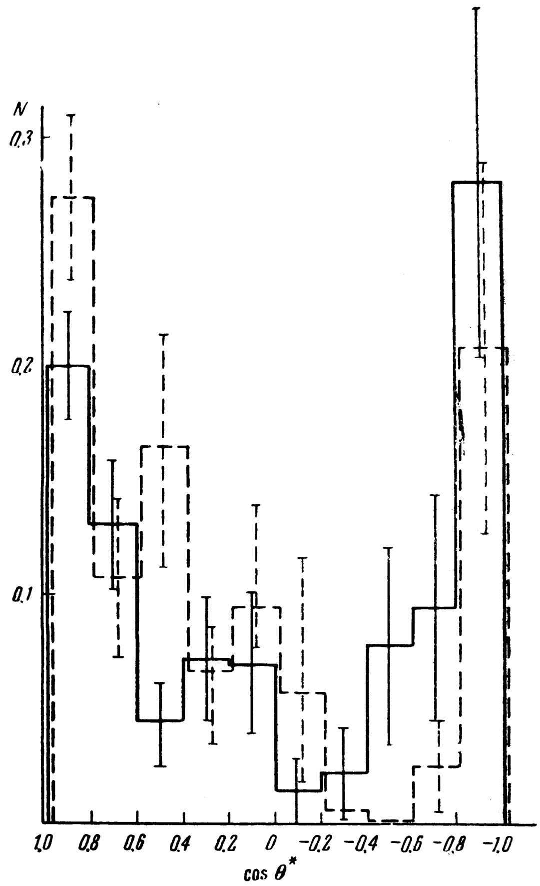

FIG. 3. C.m.s. angular distributions of secondary particles from pp interactions (solid line) and pn interactions (broken line).

at 6.2 Bev. The mean momenta in the c.m.s. for protons and charged π mesons are $P_p^* = (1.2 \pm 0.1)$ Bev/c and $P_\pi^* = (0.4 \pm 0.1)$ Bev/c, and according to statistical theory,[6] $P_p^* = 0.79$ Bev/c and $P_\pi^* = 0.51$ Bev/c.

The energy lost by the primary proton in the production of π mesons (charged and neutral) in pp collisions in the laboratory system is $(36 \pm 2)\%$, and the coefficient of inelasticity, i.e., the ratio of the energy expended on the production of π mesons in the c.m.s. to the total kinetic energy in the c.m.s. is 0.52 ± 0.03. Calculations based on statistical theory[6] give for the energy loss in the laboratory system a much greater value (58%). Even if the contribution from peripheral collisions is taken to be 20%, the theoretical energy loss in the laboratory system will not drop below 50%.

For pp and pn interactions the angular distributions in the c.m.s. were constructed for secondary charged particles on whose tracks scattering and ionization measurements were made (Fig. 3). A geometric correction here was introduced in accordance with reference 3. It was assumed that the velocity of the unidentified particles in the c.m.s. was equal to the velocity of the center of mass. The angular distributions of the secondary particles in the c.m.s. for pp interactions are symmetric. In contrast to the pp interactions, the angular distributions of the secondary particles from pn interactions are asymmetric. The respective coefficients of asymmetry are $\Delta_{pp} = 0.08 \pm 0.36$ and $\Delta_{pn} = 1.05 \pm 0.32$, which confirms the results obtained earlier.[2] Here $\Delta = (N_F - N_B)/C$, where N_F and N_B are the numbers of particles emitted forward and backward in the c.m.s. and C is the number of interactions. The existence of an asymmetry in the c.m.s. angular distributions of secondary charged particles from pn interactions cannot, in general, be explained from the point of view of statistical theory.

Hence the experimental results obtained in the present work and earlier[2,3] indicate that the nucleon-nucleon interaction at energies of 6 — 9 Bev are not described by the statistical theory of multiple production. The data of the present article on the momentum and angular distributions of secondary protons and mesons do not contradict the conclusion as regards the important role of collisions with a small momentum transfer (peripheral collisions).[7]

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