mediate use.

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EVIDENCE THAT THE f^0 HAS ISOTOPIC SPIN ZERO*

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We have analyzed 50 000 pictures of 3.65-BeV/c π^+ in deuterium from the BNL 20-inch chamber. The results of this analysis, along with results of a similar π^--p exposure, show that the f^0 is $(J=\text{even})^{++}(T=0)$ and cannot, therefore, be identified with the ω-π resonance (B meson), as suggested by Frazer, Patil, and Xuong.[1]

The arguments presented here are based on observation of the following reactions.

$$\pi^+ + n + (p) \to (p) + p + \text{neutrals}, \qquad (1)$$

$$\to (p) + p + \pi^+ + \pi^-, \qquad (2)$$

$$\to (p) + p + \pi^+ + \pi^- + \text{neutrals}, \qquad (3)$$

where (p) stands for the spectator proton and "neutrals" in Reaction (3) stands for something besides a single π^0. We have selected events in which the spectator proton is measurable (range between 1 mm and 8 cm and stops in the chamber), and the other proton has a momentum less than 1.7 BeV/c. This allows us to positively identify both protons by ionization. We chose to have a low track density (~10 tracks/picture) in an effort to obtain bias-free samples of (1), (2), (3) and also to facilitate the differentiation of π, K, p by bubble counting.

The invariant-mass distribution of the "neutrals" from Reaction (1) is shown in Fig. 1(a). There is a definite peak in the region of the f^0 (1250 ± 80 MeV) mass. We note first that this cannot be due to the neutral decay of the B^0, since the $B^+ \to \omega^0\pi^+$ decay, if it proceeds via a strong interaction, requires that the B have $T=1$, $G=+1$, and $C=-1$. This means that $B^0 \to n\pi^0$ ($n=2, 3, 4, \cdots$) is forbidden by C and hence $B^0 \to$ neutrals must contain an odd number of γ's and proceed via the electromagnetic interaction. The most likely process of this kind would be $B^0 \to \omega^0 + \pi^0 \to \pi^0 + \gamma + \pi^0$, which would have a branching ratio of 10%[2] relative to $B^0 \to \omega^0 + \pi^0 \to \pi^+ + \pi^- + \pi^0 + \pi^0$. By looking at the mass of the ($\pi^+ + \pi^-$ + neutrals) from Reaction (3), we see [Fig. 1(b)] that there is no evidence for a strong $B^0 \to \pi^+ + \pi^- + \pi^0 + \pi^0$ peak, so that $B^0 \to \omega^0 + \pi^0 \to \pi^0 + \gamma + \pi^0$ in Reaction (1) must be completely negligible.[3]

We now look at the $\pi^+\pi^-$ mass distribution from Reaction (2), shown in Fig. 2(a). The ρ^0 and f^0 peaks stand out clearly. The mass spectrum of Reaction (2) is actually well known from the charge-symmetric process $\pi^- + p \to n + \pi^+ + \pi^-$, which we have investigated at the same energy.[4] We show these data in Fig. 2(b) for comparison. Since the peak in Fig. 1(a) cannot be due to the B^0, we interpret it as $f^0 \to$ neutrals and obtain a branching ratio [we include a correction based on the fact that the events in Reaction (2) are

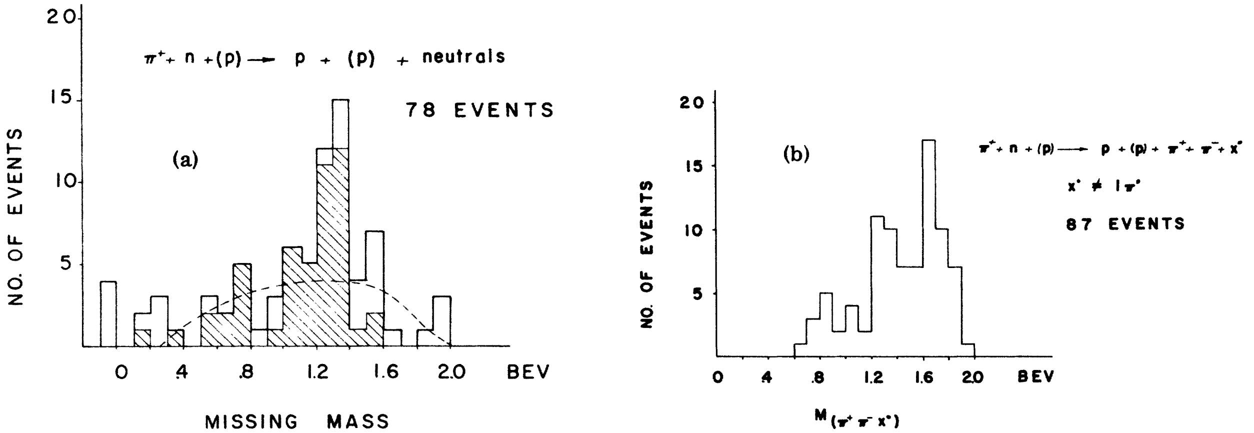

FIG. 1. (a) Invariant mass spectrum of the "neutrals" from Reaction (1). The $2\pi^0$ phase space taking into account the Fermi momentum of the target neutron is shown for comparison. The shaded area is the subsample of events with $\Delta^2 \leq 20\ \mu^2$. The four events with negative masses represent cases for which small negative values [$< 0.04\ (\text{BeV})^2$] were obtained for the mass squared. (b) Invariant mass spectrum of ($\pi^+ + \pi^- +$neutrals) from Reaction (3). See reference 3.

taken from 75% of the sample from which the events in Reaction (1) are taken]

$$R = \frac{f^0 \rightarrow \text{neutrals}}{f^0 \rightarrow \pi^+ + \pi^-} = 1.0 \pm 0.4.$$

The $f^0 \rightarrow \pi^+ + \pi^-$ decay via a strong interaction proves that the f^0 must be either $(J = \text{even})^{++}(T = 0, 2)$, or $(J = \text{odd})^{-+}(T = 1)$. The latter possibility has $C = -1$ which, again, allows no strong $f^0 \rightarrow$ neutrals decay; hence $T = 1$ is ruled out by the existence of the peak in Fig. 1(a). The $T = 2$ possibility is then also <u>definitely ruled out</u> by the observation of the cross-section ratio

$$\frac{\sigma(\pi^- + p \rightarrow f^- + p \rightarrow \pi^- + \pi^0 + p)}{\sigma(\pi^- + p \rightarrow f^0 + n \rightarrow \pi^- + \pi^+ + n)} \leq 0.3 \text{ (observed)},$$

which we find from an analysis of data of reference 4 for events with di-pion masses in the f^0 region. If the outgoing pions in the reactions above are in a $T = 2$ state, then this ratio must be 4.5. <u>This prediction is independent of the assumption of one-pion exchange and is based only on isotopic-spin invariance</u>. Hence if there is any strong neutral decay of the f^0, it must have $T = 0$ and the value of R must be equal to 0.5 (neglecting $4\pi^0$ decay and the $\pi^0 - \pi^+$ mass difference). (The value $R = 0.6 = \pm 0.17$ was obtained by Gelfand <u>et al.</u>[5])

We conclude that the f^0 is $(\text{even})^{++}(T = 0)$ and that the f^0 and B cannot be the same particle. We point out that if $f \neq B$, then the lack of any ev-

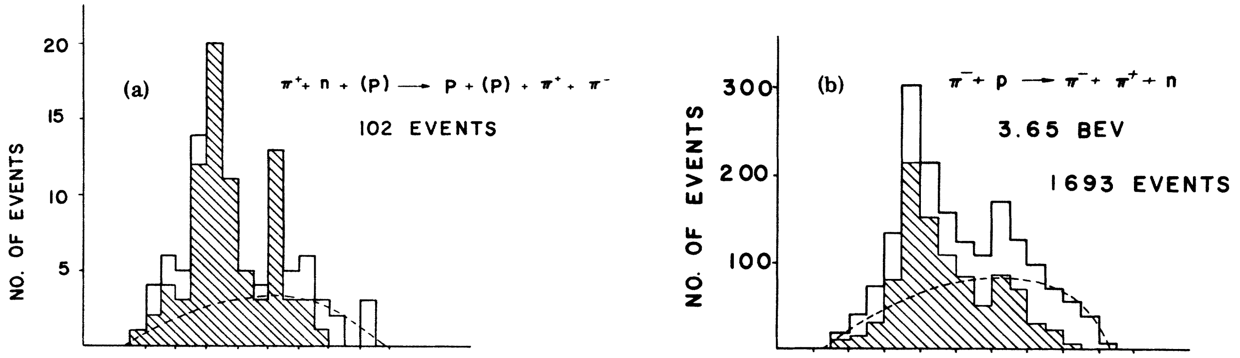

FIG. 2. (a) Invariant mass spectrum of $\pi^+\pi^-$ from Reaction (2). The shaded area is the subsample of events with $\Delta^2 \leq 20\ \mu^2$. (b) $\pi^+\pi^-$ mass spectrum from $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ taken from the data of reference 4.

idence for $B^\pm \to \pi^\pm + \pi^0$ seems to rule out $(J=\text{odd})^-$ for the B. This would disagree with the experimental indication[6] of 1^-, but allows the theoretical predictions[7,8] of 2^- or 1^+.

On the basis of the data presented here, we cannot rule out the possibility that the peak in Fig. 1(a) is entirely due to a third resonance at this mass which is neither the f^0 nor the B. If this were the case, then one might still argue that $f=B$.

There are, however, two more independent pieces of evidence that the f^0 does not have $T=1$ and, therefore, in favor of $f \neq B$. These are the value ≥ 2 found for the f^0 spin[4] and the triangle relations for the production processes. Using our $\pi^- p$ data[4] at 3.65 BeV/c for $\sigma(\pi^- + p \to f^0 + n)$ and the La Jolla upper limit[9] at 3.5 BeV/c for $\sigma(\pi^+ + p \to f^+ + p)$, these triangle relations (based only on isotopic spin invariance) predict $\sigma(\pi^- + p \to f^- + p) \geq 0.25$ mb for an f^- with $T=1$. Our observed upper limit for this process is 0.1 mb. This seems to be strong evidence against $T=1$ for the f^0.

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SOME REMARKS ON THE LIFETIMES OF THE MASSIVE TRIPLETS*

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The unitary symmetry[1] model of the strong interaction, together with the assumption that the (strong) violating part of the interaction between mesons and baryons transforms like a component (F_8) of the eight-dimensional representation of SU(3), has received an impressive amount of experimental confirmation.[2] Concurrently, a model which seeks to explain these properties of the strong interactions on a more fundamental basis has been proposed by Gürsey, Lee, and Nauenberg.[3] In this model, the existence of two massive triplets α, β of massive bosons and fermions is postulated. These particles belong to three-dimensional representations of SU(3), and from their interaction with each other the main properties of the strong interaction follow in a natural way. As an experiment searching for such particles has already been proposed,[4] we felt it interesting to discuss what additional information can be inferred from the properties of such particles if they are to be found.

It has been suggested, moreover,[5,6] that the electromagnetic and weak interactions also transform like some components of the eight-dimensional representation of SU(3). If this is the case, then the α and β triplets can only undergo β decay among themselves, and ultimately the lightest α and β should be absolutely stable. In the following we will discuss the consequences of abandoning the above-mentioned hypothesis, and show that the lifetime for α and β decays is extremely sensitive to the nature of the interaction.