Nonobservation of Heavier J Particles from p-N Reactions*†

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After the discovery of the J particle at 3.1-GeV mass we have made an extensive search for heavier J particles in the mass region 3.2 to 4.0 GeV. To a level of 1% of J (3.1 GeV) yield, and with 90% confidence, no heavier J particles were found.

We report an extensive search for heavier J particles from p-nucleon reactions at the pair spectrometer at Brookhaven National Laboratory's alternating gradient synchrontron. The design of the spectrometer has been described previously[1] where production of J was found with mass 3.1 GeV, width consistent with zero, and a production cross section of $\sim 10^{-34}$ cm^2/nucleon [where we assumed $d\sigma/dp_\perp \propto \exp(-6p_\perp)$, independent of $p_{\parallel}$]. The production of J has also been detected by groups at SPEAR and Frascati.[2,3] Following the detection of J, we have gone to a higher-mass region to search for heavier J particles. This was done in two ways:

(1) We compiled all the old data where we used a 28.5-GeV proton beam on a beryllium target and detected the $90° \pm 4°$ decay of J particles produced almost at rest in the center of mass system (c.m.s.) (see Fig. 1). For a total incidence of 1.2×10^{17} protons on nine pieces of 0.070-in. beryllium, with the exception of the sharp peak at mass 3.1 GeV, no additional structures in the region 3.2–4.0 GeV were found. *We set an upper limit of 1% (with 90% confidence) of J (3.1 GeV) yield for the production of heavier J's.* Since the spectrometer has a mass acceptance of 2 GeV, the acceptance in the mass region 3–4 GeV varies very slowly with the mass. We note this upper limit is independent of any assumption of production mechanisms. If we assume a production mechanism of $d\sigma/dp_\perp \propto \exp(-6p_\perp)$, independent of $p_{\parallel}$, we obtain a corresponding upper limit of $\sim 10^{-36}$ cm^2 in production cross section for heavier J's, also with 90% confidence.

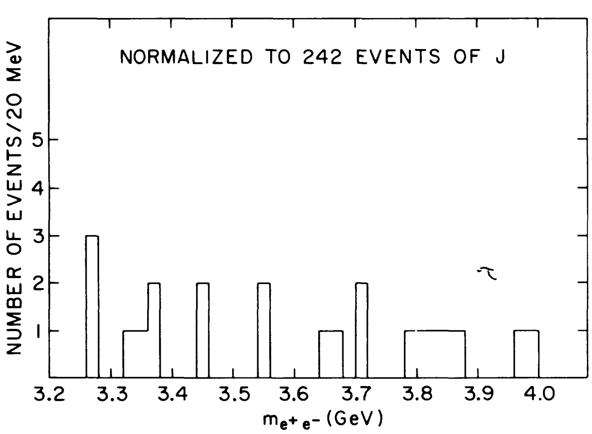

FIG. 1. Yield of e^+e^- in the mass region 3.2 to 4.0 GeV. The acceptance in this region is a smooth function and is constant within a factor of 2. The observed events are consistent with the random accidental counts.

(2) We ran the alternating gradient synchrontron at its highest possible energy (30.59 GeV), where we detected $90^{+2°}_{-6°}$ (c.m.s.) J decay and used a nickel target composed of eighteen pieces each 0.010-in. thick to provide larger Fermi energy of target nucleons.[4] An exposure of 2.2×10^{16} protons yielded no structures in the 3.2- to 4.9-GeV mass interval. This corresponds to an upper limit of $\sim 6\times10^{-36}$ cm^2/nucleon in production cross section with the same assumptions made above.

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[1]J. J. Aubert *et al.*, Phys. Rev. Lett. 33, 1404 (1974).

[2]J.-E. Augustin *et al.*, Phys. Rev. Lett. 33, 1406 (1974). Professor B. Richter has informed us that SPEAR has observed a 3.7-GeV particle.

[3]C. Bacci *et al.*, Phys. Rev. Lett. 33, 1408 (1974).

[4]D. E. Dorfan *et al.*, Phys. Rev. Lett. 14, 995 (1965).

Evidence for a Non-Hulthén Impulse-Model Component in $K^+d \to K^{*0}(890)pp$ at 2.0 GeV/c*

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In a study of $K^+d \to K^{*0}(890)pp$ at 2.0 GeV/c, evidence is found for the occurence of the single-pion virtual state $d \to \pi^-(pp)$ associated with the high-momentum tail of the deuteron.

Attempts to use deuterium as a source of quasi-free neutrons in high-energy scattering experiments have been surprisingly successful. The impulse model, wherein the interacting nucleon is regarded as free with a momentum distribution given by the internal wave function for the deuteron, is able to account for most of the events in such experiments. In these events, the momentum distribution of the slowest nucleon (i.e., the "spectator") closely resembles the momentum transform of this wave function. However, about 8% of the events in such experiments have a slow-proton momentum $p_{slow} > 300$ MeV/c, compared with 1–2% expected from a typical wave function (e.g., Hulthén). The production mechanism of this class of events is not fully understood. The presence of these events is generally attributed to one or the other (or both) of the following hypotheses: (a) Initial- or final-state particles scatter on the spectator nucleon; or (b) the Hulthén wave function is inadequate, especially in the high–spectator-momentum region.

In the present Letter we report a study of the properties of the events with $p_{slow} > 300$ MeV/c in the reaction

$$K^+d \to K^{*0}(890)pp\,, \tag{1}$$

at 2.0 GeV/c.[1] In particular, we investigate the question of whether these events result from double-scattering processes or whether, as seems to be the case, they arise predominantly from a simpler, more direct, production mechanism.

A sample of 24 000 events of $K^+d \to K^+\pi^-pp$ with $\lesssim 3\%$ background was obtained in a 780 000-picture exposure of the Lawrence Berkeley Laboratory 25-in. deuterium-filled bubble chamber to a 2.0-GeV/c K^+ beam. Details of the exposure and data reduction are to be found elsewhere.[2] From fits to the $K^+\pi^-$ invariant-mass spectrum, we find that $\sim 55\%$ of the events contain $K^{*0}(890)$. A working sample of Reaction (1) is selected by using the criterion $0.84 < m_{K\pi} < 0.94$ GeV. This cut yields 11 885 events, of which 85% are examples of Reaction (1); in the remaining 15%, the $K\pi$ system is in a $J^P = 0^+$ state.[2]

A convenient representation of these data is the Chew-Low plot shown in Fig. 1(a). The momentum transfer t between the incident K^+ and the outgoing K^* is plotted as a function of the pp invariant mass M_{pp}. The striking diagonal band of events is due to the fact that the incident K^+ scatters only on a component of the deuteron (the neutron). It can be shown that if the deuteron Fermi motion is ignored, and the incident K^+ scatters only on the neutron, then t and M_{pp} are uniquely related by $-t = M_{pp}^2 - 4m_p^2$. This equation passes through the center of the diagonal band in Fig. 1(a) (not plotted to avoid obscuring the data). The