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EXPERIMENTAL LIMIT ON ϕ MESON PHOTOPRODUCTION FROM HYDROGEN AT 15 GeV*

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The results of several experiments[1-5] have shown a dominant diffractive-like mechanism for ρ^0 photoproduction in the region from 2 to 6 GeV. Such a mechanism is expected in the vector dominance model; assuming SU(3) symmetry and the SU(6) $\omega\phi$ mixing angle, this model predicts that at high energies the photoproduction cross sections should be in the ratio $\rho^0/\omega/\phi = 9/1/2$.[6] Although the hydrogen bubble chamber data[7,8] on ω production seems consistent with this prediction, the ϕ cross section is measured to be 0.2 ± 0.1 μbarn (averaged over the region 3.5 to 6 GeV)[9] giving $\phi/\rho \approx 0.012 \pm 0.006$, more than an order of magnitude below that predicted by the simple model. The quark model has been used to introduce symmetry breaking and to partially alleviate this discrepancy.[10,11]

It is clearly of great interest to extend the experimental information to higher energies where the theoretical models can be applied with a greater certainty. One speculation, for example, might be that the ϕ is anomalously suppressed at the intermediate energies thus far studied, but that at high energies the ϕ/ρ ratio will approach the symmetry value of 2/9.

Tsai, et al.,[12] have obtained a limit on ϕ photoproduction at high energies by measuring the 5.5 GeV/c K^- flux produced near 0^0 by a 16-GeV electron beam in a 1.8-radiation length beryllium target. Any ϕ's contributing to this K flux

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are kinematically constrained to have an energy between 9 and 15 GeV. Unfortunately, the analysis relating the production from beryllium to that from hydrogen is not unambiguous. Assuming the ϕ scattering from beryllium to have the same t distribution as p-beryllium scattering[13,14] and that the elastic cross sections are in the ratio $\phi p/\phi Be = pp/pBe$ they obtained an upper limit of 0.9 ± 0.3 μbarn (the error reflects only the 30% systematic uncertainty in the K flux measurements).

In this paper we examine the momentum dependence of the π^- and K^- fluxes produced by a bremsstrahlung beam in a hydrogen target. The SLAC 20-GeV/c spectrometer system[15] was used to measure the fluxes of particles produced at a lab angle of 1.45° by bremsstrahlung with end points of 14 and 16 GeV. The difference of the yields at the two energies was subtracted to give an effective photon beam of energy 15 ± 1 GeV.

As a check of the method we first consider results for the π yields, shown in Fig. 1a as a function of laboratory momentum. Also shown in the figure is the result of a calculation made with the Tsai-Whitis computer program[16] for the pion yield coming from ρ^0 decay, assuming that ρ^0 photoproduction at 15 GeV is similar to that observed[2,3] in the region 3 to 6 GeV. The data indicates that roughly half the π^- yield comes from ρ^0 decay. This seems qualitatively reasonable in that we do observe enough π's to account for the ρ^0 cross section expected in the diffraction model and that this process contributes a sizeable fraction of the π yield.

The K^- yields are shown as a function of lab momentum in Fig. 1b. The Tsai-Whitis[16] computer program was used to calculate the K^- flux coming from ϕ decay under the assumptions that

$$\frac{d\sigma}{dt}(\gamma p \rightarrow \phi p) \propto e^{-At} ,$$

with $A = 3$ or $7\ (\mathrm{GeV})^{-2}$, a total ϕ cross section of 1.0 μbarn, ϕ helicity = ± 1, and $(\phi \rightarrow K^+K^-)/(\phi \rightarrow \mathrm{all}) = 0.48$; the results of the program are also shown in Fig. 1b.

The ϕ cannot contribute to the K yield at 10 GeV/c and the yield at this momentum is a measure of the background from other processes such as the Drell mechanism,[17] Y* decay, etc. The yield from these background processes might be expected to increase as the momentum is lowered. Indeed, a straight line can be drawn through the points and the data do not show a need for a peak in the distribution corresponding to ϕ production. If, however, we assume that the K^- yield from other processes at 8 GeV/c is just that given by the point at 10 GeV/c, a total $\gamma p \rightarrow \phi p$ cross section of (0.38 ± 0.18) μbarn is obtained if the ϕ's are produced with an e^{-7t} distribution; this becomes (0.52 ± 0.25) μbarn for e^{-3t}. If the K^- yield from the other processes falls off rapidly going from 10 to 8 GeV/c, then an upper limit for $\gamma p \rightarrow \phi p$ can be obtained by assuming that all the K^- yield at 8 GeV/c comes from ϕ decay; this drastic assumption results in upper limits (95% confidence) of 1.0 and 1.4 μbarns for e^{-7t} and e^{-3t} distributions, respectively.

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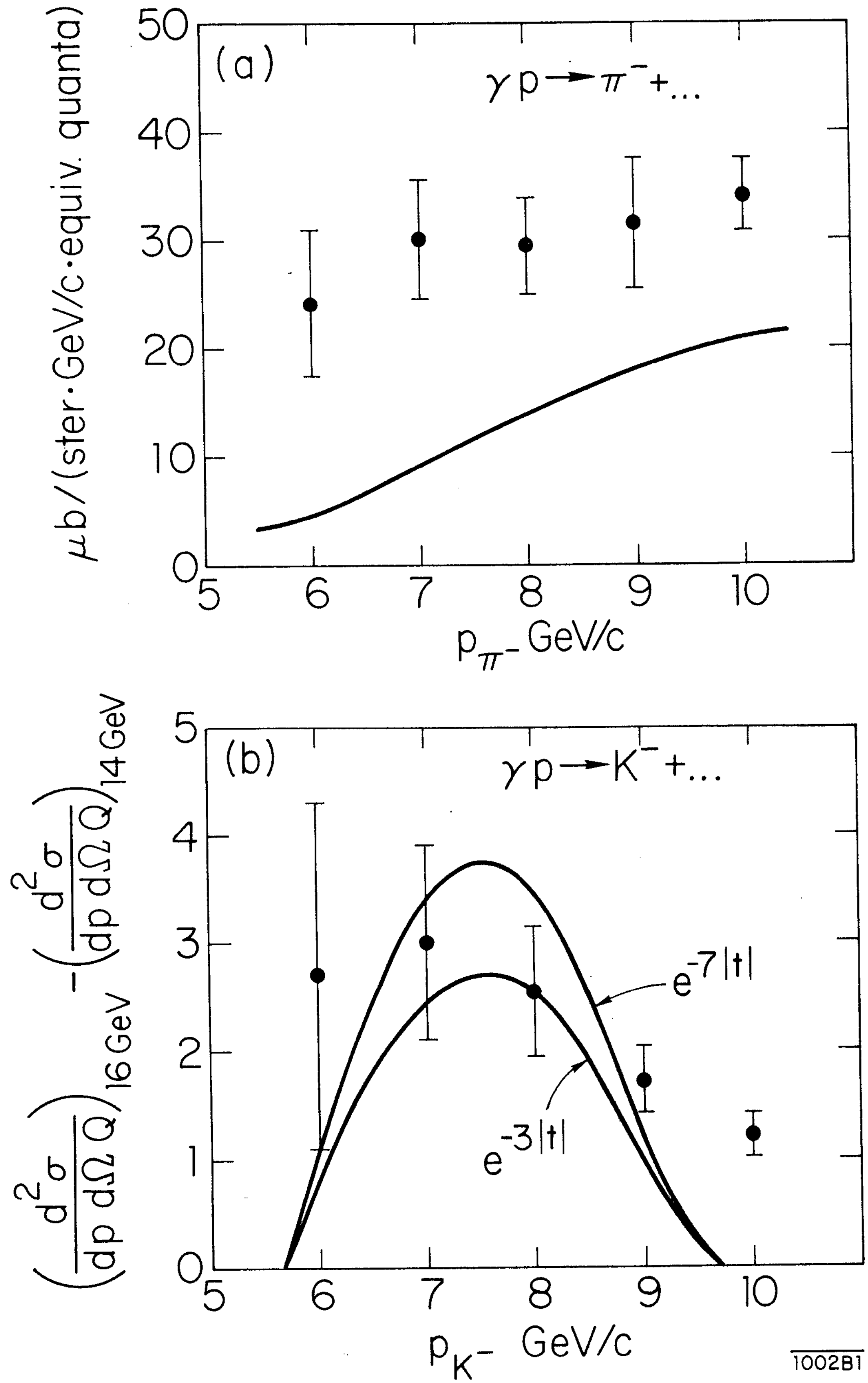
FIGURE CAPTION

1. The differences of 1.45° yields obtained from hydrogen with bremsstrahlung beams of end point energies 16 and 14 GeV. The error bars indicate the statistical and monitoring uncertainties; not shown is the 10% overall systematic uncertainty.

   a. π^- yields. The curve gives the π^- yield expected from $\gamma p \rightarrow \rho^o p$ assuming a t dependence for ρ^o production of e^{-7t}, a total ρ^o cross section of 16 μbarns and ρ helicity ± 1 (see Refs. 2 and 3).

   b. K^- yields. The curves give the K^- yields expected from $\gamma p \rightarrow \phi p$ assuming a t dependence for ϕ production of e^{-3t} or e^{-7t}, a total ϕ photoproduction cross section of 1 μbarn and ϕ helicity ± 1.



(a)
$\gamma p \to \pi^- + \ldots$
$\mu b/(\mathrm{ster}\cdot\mathrm{GeV/c}\cdot\mathrm{equiv.\ quanta})$
p_{π^-} GeV/c
(b)
$\gamma p \to K^- + \ldots$
$\left(\frac{d^2\sigma}{dp\, d\Omega\, Q}\right)_{16\,\mathrm{GeV}} - \left(\frac{d^2\sigma}{dp\, d\Omega\, Q}\right)_{14\,\mathrm{GeV}}$
$e^{-7|t|}$
$e^{-3|t|}$
p_{K^-} GeV/c
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