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PROPERTIES OF THE ω MESON

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Properties of the ω meson have been studied in almost 2000 events of the type $K^- + p \rightarrow \Lambda + \omega$ obtained at six different K^- momentum settings from 1.2 to 1.75 BeV/c; these events were identified in pictures taken at the Bevatron with the 72-inch hydrogen bubble chamber. The mass of the ω is found to be 782 MeV. The width of the ω manifested by the predominant three-pion mode of decay is estimated to be less than 4 MeV. Branching ratios for ω decay into $\pi^+\pi^-\pi^0$, neutrals (presumably $\pi^0\gamma$), $\pi^+\pi^-$, and e^+e^- have been determined; relative rates of these modes are 1.0: (0.11 ± 0.03) : (0.045 ± 0.016) : (0.005 ± 0.003) , respectively, as determined from approximately 1000 $\Lambda\omega$ events at 1.5 BeV/c incident momentum. Further studies made with the ~ 2000 $\Lambda\omega$ events from all momentum settings indicate the $\pi^+\pi^-\gamma/3\pi$ branching ratio to be 0.032 ± 0.013 . Also, from the complete $\Lambda\omega$ sample, the two-pion mode of decay appears somewhat better established, with a branching ratio of 0.034 ± 0.010 . ~~The width of the three pion decay is found from the complete data to be $\leftarrow 5$ MeV.~~

ABSTRACTED IN NSA

The mass spectrum for the three pions in events fitted as $\Lambda\pi^+\pi^-\pi^0$ is shown in the accompanying figure; the center-of mass energy for these events ranges from 1890 to 2130 MeV. About 40 per cent of all events are in the $\Lambda\omega$ peak. (At 1.5 BeV/c, almost 50 per cent of all $\Lambda 3\pi$ events were $\Lambda\omega$.) To find the true width of the $\omega \rightarrow 3\pi$ decay, it was necessary to discard events having program-estimated errors in the 3π mass which were greater than 10 MeV. Classification of the remaining events into several samples according to the estimated $M(3\pi)$ error, ranging from 3 to 10 MeV, allowed an extrapolation to be made to zero error for an evaluation of the true three-pion width. (This method was checked by determining the near-zero lambda width in a similar manner and was found fairly reliable.)

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Details on the neutral mode of decay and other work at 1.5 BeV/c incident momentum are to be found elsewhere.¹ Recent studies have extended the analysis for the e^+e^- mode of decay; in 4000 events processed of the type $K^- + p \rightarrow \Lambda + 2$ charged prongs, three excellent candidates for $\omega \rightarrow e^+e^-$ and at least 2 more fairly probable candidates were identified on the basis of various fitting and kinematic considerations. As a check, colinearity of the charged particles, interpreted as e^+e^- and as $\pi^+\pi^-$, was examined in the rest frame of the total mass recoiling from the fitted lambda.

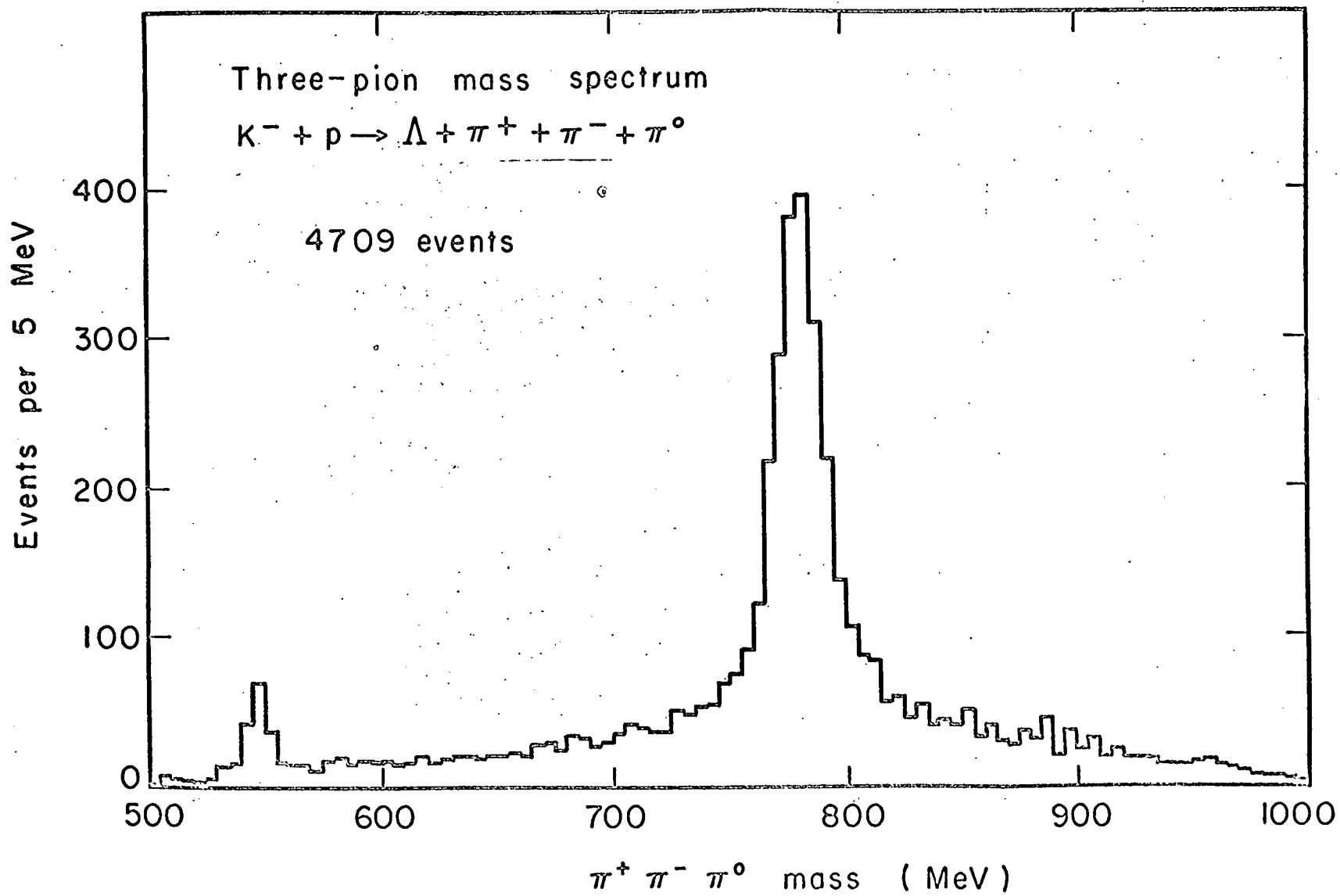
To find the two-pion decays of the ω , events fitting $\Lambda\pi^+\pi^-$ were examined. It was necessary to exclude those with a $\Lambda\pi^\pm$ mass near that of the (1385-MeV) Y^0 . At 1.5 BeV/c, a very narrow peak (with a width of 13 MeV, comparable to the measurement error) appeared in the two-pion mass spectrum at approximately 780 MeV, above the broad peak of the ρ meson. (The ρ was produced only 35 to 40 per cent as abundantly as the ω meson.) Although possibly a statistical fluctuation, the 15 ± 5 events in the peak fit very well in a comparison of the total spectrum with assumed distributions for the $\omega \rightarrow 2\pi$, the ρ , and background events. Study of the larger data sample has not been completed as to the detailed fitting of distributions; however, it is clear that about 32 ± 9 events are found in a narrow peak in the two-pion mass at the energy of the ω .²

To study the rare $\pi^+\pi^-\gamma$ decay mode of the ω , a "scatter plot" was made of the square of the mass recoiling against the lambda versus the square of the neutral mass for events fitting $\Lambda\pi^+\pi^-\pi^0$ or $\Lambda\pi^+\pi^-\gamma$. The events heavily populated a band corresponding to the ω mass; further, a cluster was evident near the neutral mass corresponding to the π^0 . After appropriate cut-offs were made to exclude events having large mass errors or those fitting well the interpretation $\Sigma^0\pi^+\pi^- \rightarrow \Lambda\pi^+\pi^-\gamma$, about 12 $\pi^+\pi^-\gamma$ events were peaked at zero mass above a background of $6\pi^+\pi^-\pi^0$ events in the π^0 tail. Further restriction of measurement errors gave 7 $\pi^+\pi^-\gamma$ events with ~ 1 $\pi^+\pi^-\pi^0$ events. The energy spectrum of the γ in the sample of 12 events was similar to the rather flat phase-space prediction.

Comparison of the above experimental results shows fair consistency with the decay rates estimated by Gell-Mann, Sharp, and Wagner for the modes $\omega \rightarrow \pi^+\pi^-\pi^0$, $\pi^0\gamma$, $\pi^+\pi^-$, and e^+e^- ; this approximate agreement is indicative of the validity of such models as $\omega \rightarrow \rho + \pi \rightarrow 3\pi$ and also of the assumptions (from unitary symmetry) for coupling constants, namely $\gamma_\omega = \gamma_\rho = \gamma_{\rho\pi\pi}$. However, similar calculations by P. Singer with the coupling constants of reference (3) give an estimate of the $\pi^+\pi^-\gamma/3\pi$ ratio (2×10^{-5}) which is far below the experimental number above.⁴ Failure of the model $\pi^0 \rightarrow \rho + \omega \rightarrow 2\gamma$ utilized by Gell-Mann et al to calculate $f_{\rho\omega\pi}$ could explain the discrepancy in the results; however, it would not explain the fact that the Singer prediction for the γ -ray spectrum is very different from the experimental spectrum. Comparison of the three-pion decay width with various theoretical estimates shows significant disagreement only with that of 10 to 20 MeV made from dispersion-relation calculations by Frazer and Wong.⁵

The experimental data above give upper or lower limits on several coupling constants involved in strong or electromagnetic interactions of the ω , ρ , and π mesons. Within the experimental limitations, these do not disagree with the estimates from unitary symmetry theory.

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4. P. Singer, Northwestern University pre-print
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