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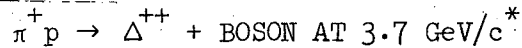
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THE ϕ/ω AND η/η' PRODUCTION RATIOS IN THE REACTION



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I. THE ϕ/ω RATIO

It is well known that the reaction $\pi p \rightarrow \Delta\phi$ is suppressed.¹ In a new high-statistics experiment with $\pi^+ p$ at 3.7 GeV/c we are getting data which indicates just how enormously the reaction

$$\pi^+ p \rightarrow \Delta^{++}\phi \quad (2_{-2}^{+3} \text{ events}) \quad (1)$$

is suppressed relative to the reaction

$$\pi^+ p \rightarrow \Delta^{++}\omega \quad (1324 \pm 100 \text{ events}) \quad (2)$$

Here the center-of-mass momenta are $p_\phi = 0.83 \text{ GeV}/c$ and $p_\omega = 0.96 \text{ GeV}/c$ so that phase space corrections are small. We thus obtain a cross section ratio of:

$$\rho = \frac{\sigma(\pi^+ p \rightarrow \Delta^{++}\phi)}{\sigma(\pi^+ p \rightarrow \Delta^{++}\omega)} = \frac{1}{662} = 0.0015_{-0.0015}^{+0.0023}$$

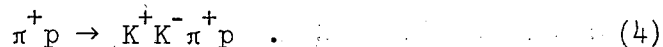
It is interesting to note that this ratio is in good agreement with the squared coupling constant ratio $g_{\phi\rho\pi}^2/g_{\omega\rho\pi}^2 \approx 1/600$ determined collectively from the experimental ω and ϕ widths, the $\phi \rightarrow \rho\pi$ branching fraction, and the ratio between the phase spaces available for $\phi \rightarrow \rho\pi$ and $\omega \rightarrow \rho\pi$.²

In our experiment we have analyzed about 60,000 four-prong events from an exposure of 180,000 pictures taken in the LRL 72-inch hydrogen bubble

chamber in a 3.7-GeV/c π^+ p beam at the Bevatron. These yielded 15,066 events fitted and identified as



and 353 events fitted and identified unambiguously as



In Fig. 1 we show a triangle plot of $M(K^+K^-)$ vs $M(p\pi^+)$. In Fig. 2 we show the projection on the $M(p\pi^+)$ axis. The K^+K^- spectrum, shown in Fig. 3, indicates clearly that we observe ϕ production (~ 18 events). However, there is no indication (see Fig. 4) that ϕ production occurs in association with Δ^{++} . Furthermore we note that ϕ production occurs at comparatively large t values (see Fig. 5), a result similar to that observed for π^-p interactions.³ We have examined the $\pi^+\phi$ and $p\phi$ mass distributions to find out whether the ϕ production here observed is associated with any higher mass meson or baryon system. No hint of any such effect is observed within our very limited ϕ data, which is consistent with uniform mass distributions. Thus the reaction $\pi^+ p \rightarrow \pi^+ \phi p$ appears to a nonperipheral process leading to three "particles" in the final state.

A. Mixing Angle Determination on a Quark Model

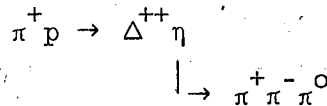
In the framework of the quark model the smallness of ρ can be interpreted in terms of the quark content of the ϕ and ω mesons; namely, they are almost entirely $\lambda\bar{\lambda}$ and $n\bar{n} + p\bar{p}$ respectively. Alexander et al.⁴ have related R to the $\omega\phi$ mixing angle θ_1 by:

$$\pm |R| = \frac{\langle \pi^+ p / \phi \Delta^{++} \rangle}{\langle \pi^+ p / \omega \Delta^{++} \rangle} = \frac{\cos \theta_1 - \sqrt{2} \sin \theta_1}{\sin \theta_1 + \sqrt{2} \cos \theta_1} = \tan (\theta_0 - \theta_1)$$

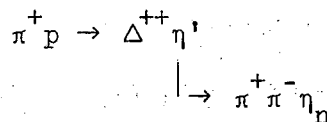
where $\theta_0 = \arctan(1/\sqrt{2}) = 35.26^\circ$ and $|R| = \sqrt{\rho}$. This relation gives a model-dependent determination of the mixing angle, but is independent of meson masses in the nonet. We find $|\theta_0 - \theta_1| = 2.2^\circ \begin{smallmatrix} +1.3^\circ \\ -2.2^\circ \end{smallmatrix}$. In principle this method could yield information on whether the quadratic or linear form of the Gell-Mann/Okubo mass formula is appropriate for the bosons.^{5,6} In practice however the values are sufficiently close; namely, $|\theta_1(\text{quadratic})| = 39.9^\circ \pm 1.1^\circ$ and $|\theta_1(\text{linear})| = 37.1^\circ \pm 1.1^\circ$, that our data cannot distinguish between them. Our results are: $\theta_1(R = +\sqrt{\rho}) = 33.1^\circ \begin{smallmatrix} +2.2^\circ \\ -1.3^\circ \end{smallmatrix}$ or $\theta_1(R = -\sqrt{\rho}) = 37.5^\circ \begin{smallmatrix} +1.3^\circ \\ -2.2^\circ \end{smallmatrix}$. This result is displayed graphically in Fig. 6.

II. THE η/η' RATIO

In this same experiment we have observed 139 ± 12 events ascribed to⁷



and 39 ± 10 events for



where we used a "narrow" Δ^{++} definition $M(p\pi^+) = 1160-1280$ MeV.

Using the Particle Data Tables,⁸ we find the 139 observed η events correspond to 594 ± 58 η events where all decay modes are taken into account. Using the data of Rittenberg,⁹ we find our observed η' events correspond to 127 ± 33 η' events where again all decay modes are taken into account. These two numbers give $\rho = 4.7 \pm 1.3$, where ρ is the ratio of $\Delta^{++} \eta$ events to $\Delta^{++} \eta'$ events.

Again, we have used the formula of Alexander et al.⁴ to evaluate the η/η' mixing angle. To make this comparison we multiply the above number of $\Delta^{++} \eta$

events by a factor such that the result corresponds to the same outgoing center-of-mass momentum in both cases, namely $p_{\text{cm}} = 0.853 \text{ GeV}/c$. The magnitude of this factor is obtained from the shape of the $\Delta^{++}\eta$ cross section as determined by Brown et al.¹⁰ Inclusion of the appropriate phase space and flux factors with this factor gives an overall correction factor of 0.93 to be applied to ρ . Thus we find from $R = \pm \sqrt{0.93} \rho = \tan(\theta_{\rho} - \theta)$ that $\theta(R = +\sqrt{\rho}) = -29.0^{\circ} \pm 3.3^{\circ}$ and $\theta(R = -\sqrt{\rho}) = -80.4^{\circ} \pm 3.3^{\circ}$. In this case the linear Gell-Mann/Okubo formula gives $|\theta| = 23.7^{\circ} \pm 0.3^{\circ}$ and the quadratic formula gives $|\theta| = 10.4^{\circ} \pm 0.2^{\circ}$. Thus our result is in agreement with the linear GMO formula, which is the conclusion obtained by Benson et al.⁶

Of course, this conclusion depends on the validity of the quark model⁴ and on the identification of the $\eta'(958)$ as the ninth member of the pseudo-scalar nonet rather than some other candidate such as the $E(1420)$.

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*Work supported by the U. S. Atomic Energy Commission.

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TRIANGLE PLOT W/ERRORS

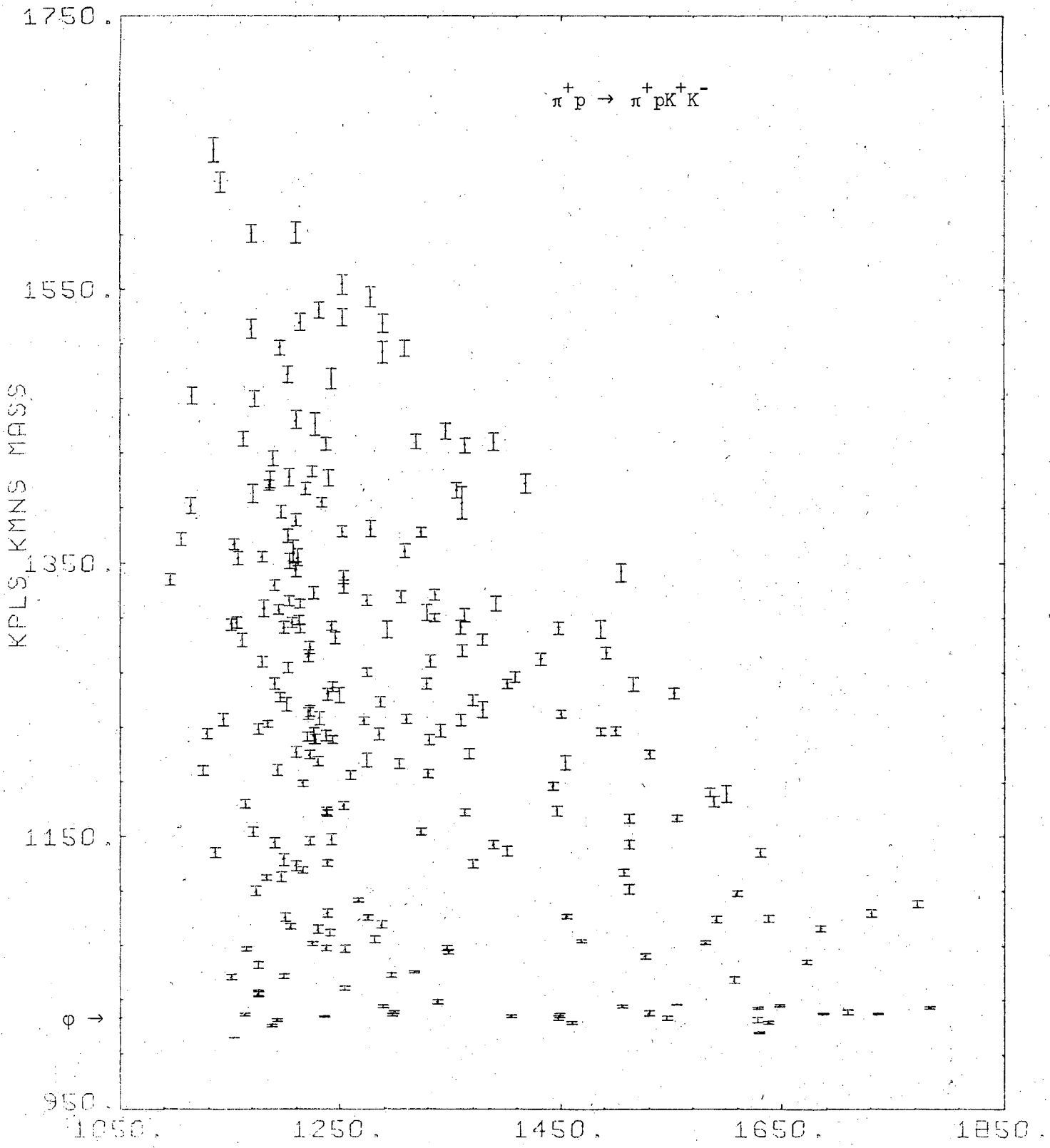


Fig. 1

P PIPLS MASS

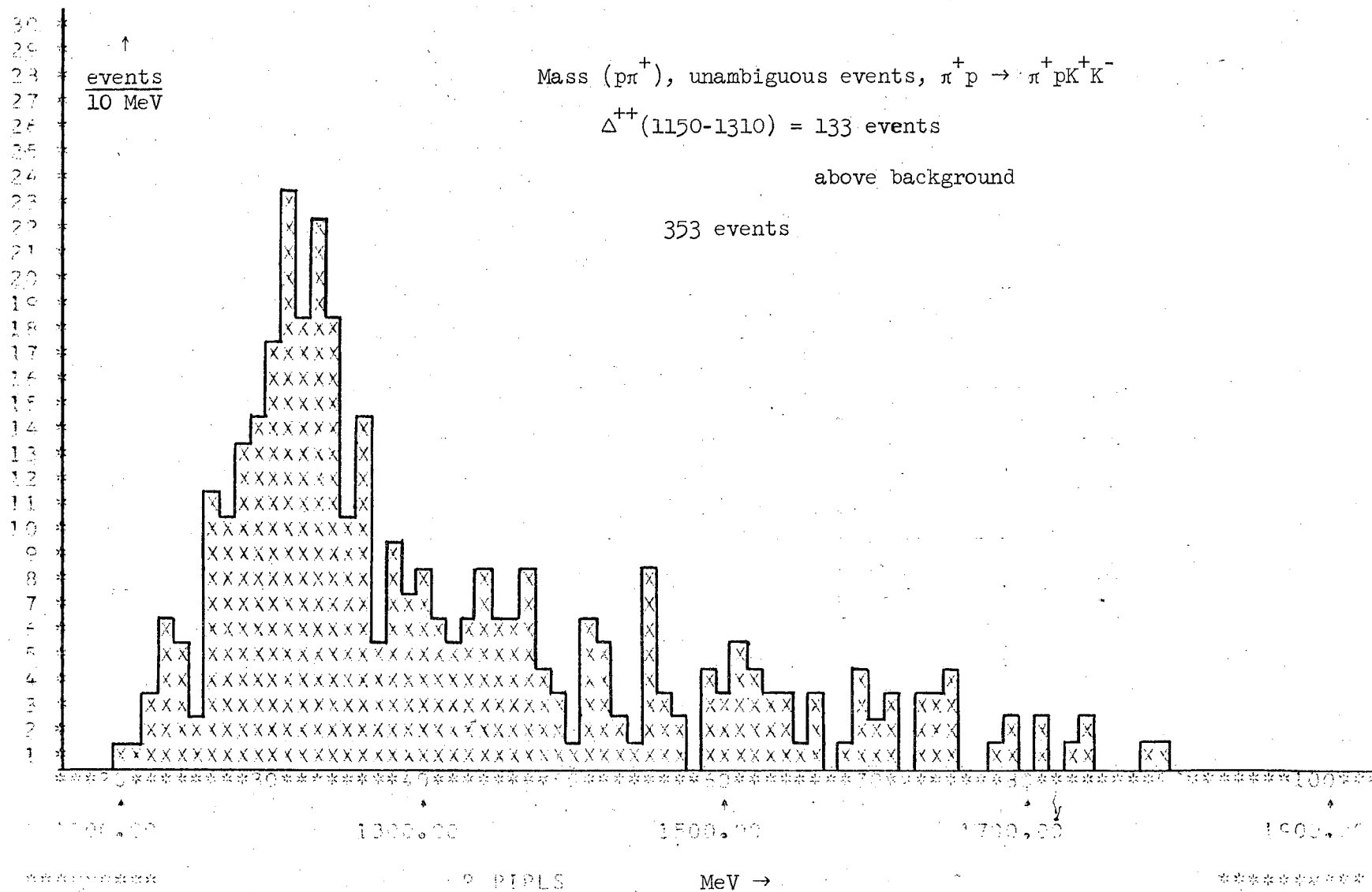


Fig. 2

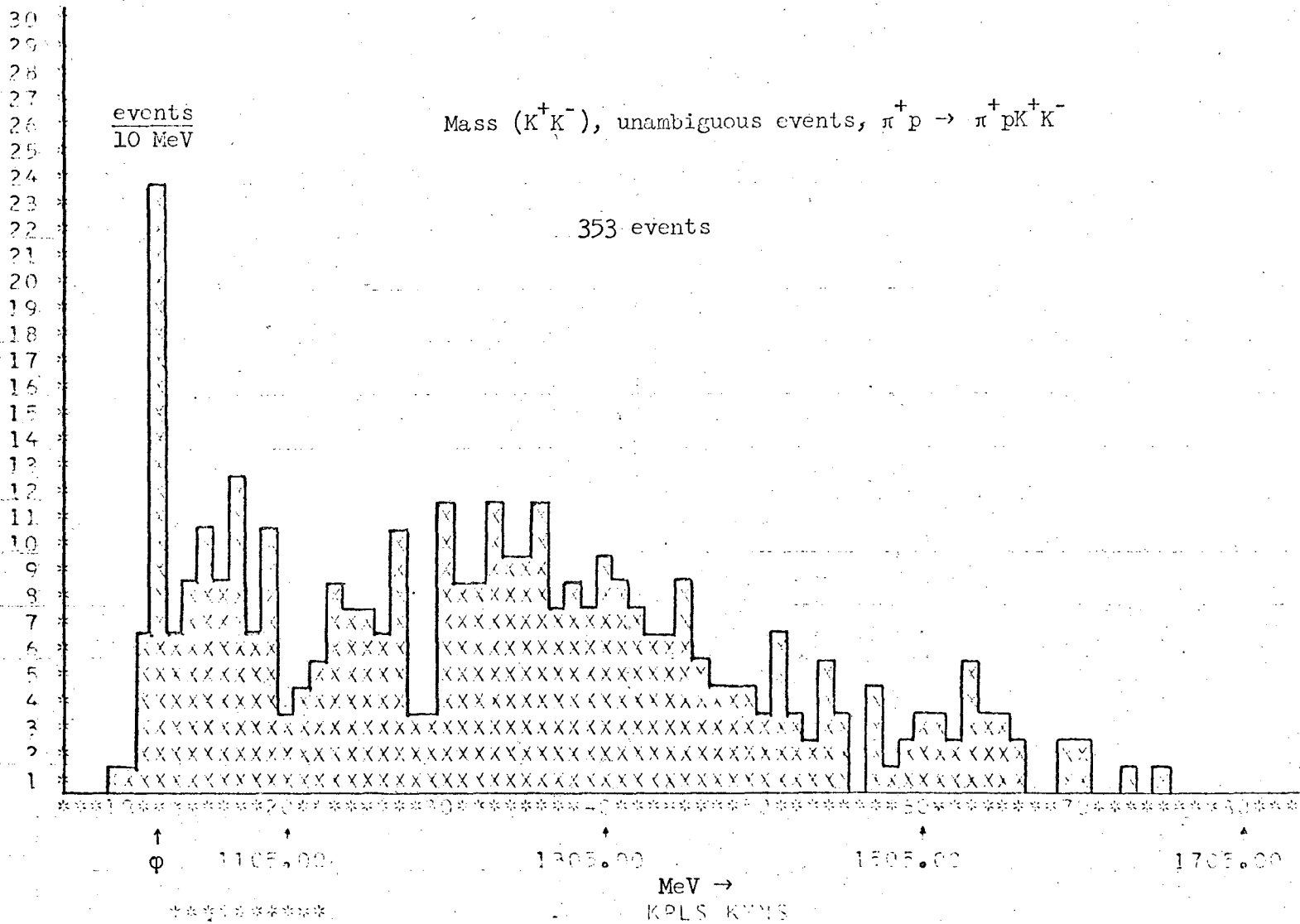


Fig. 3

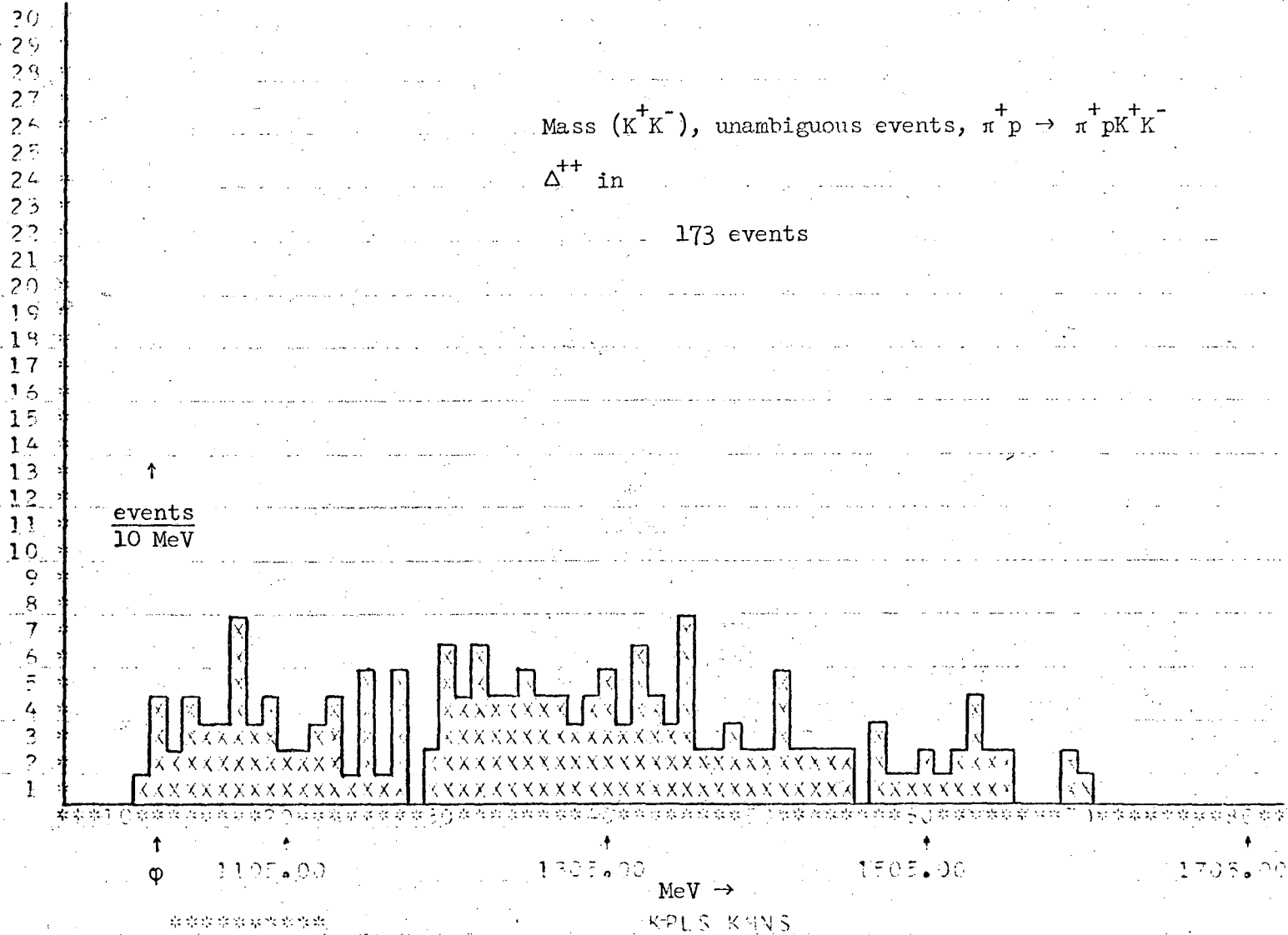


Fig. 4

CHEM-LQM PLOT

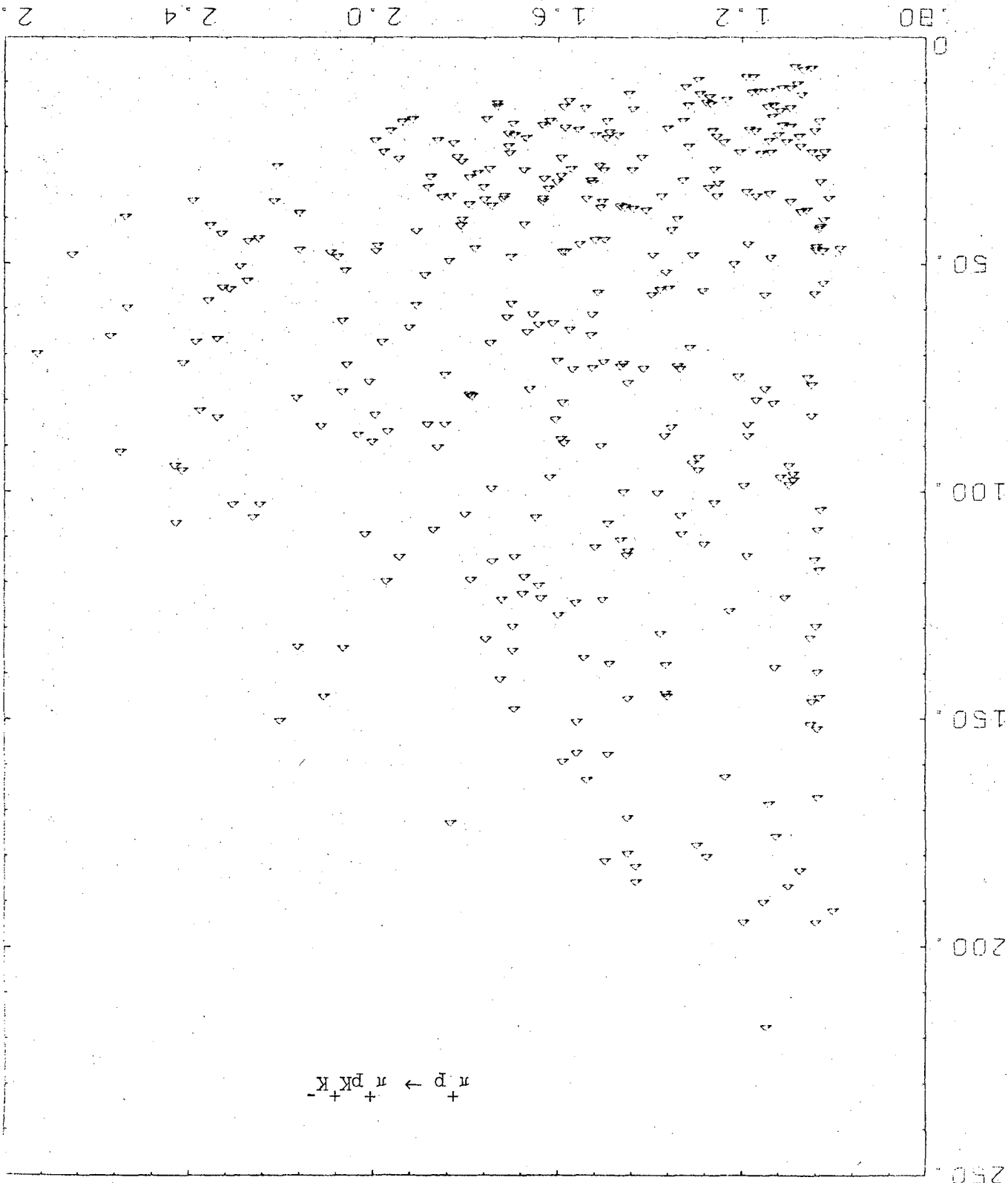


FIG. 5 K+K- MASS SQUARED

Determinations of θ_1 , the ϕ - ω mixing angle

$(R = \sqrt{P})$
33.1°

Our result

$(R = -\sqrt{P})$
37.5°

$\theta_0 = \arctan\left(\frac{1}{\sqrt{R}}\right) = 35.26^\circ$

37.1°
(linear mass formula)

39.9°
(quadratic mass formula)

32°

34°

36°

38°

40°

Fig. 6

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