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THE $K^+p \rightarrow K^+\pi^-\Delta^{++}$ INTERACTION AT 4.6 AND 9 BeV/c*

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It is well known that the reaction $K^+p \rightarrow K^*(890) + \Delta^{++}(1238)$ is dominated by one pion exchange as modified by absorption effects. The present note represents an attempt to test the extent to which the entire reaction $K^+p \rightarrow K^+\pi^-\Delta^{++}(1238)$ can be understood in this fashion. We find that we need at least three and possibly four distinct effects to interpret our experimental results. These are:

1. $K^*(890) + \Delta^{++}$, where the $K^*(890)$ exhibits the well-known p-wave $K\pi$ scattering features with some s-wave interferences.
2. $K^*(1420) + \Delta^{++}$, where the $K^*(1420)$ shows the features corresponding to d-wave $K\pi$ scattering and thus $J^P = 2^+$.
3. A $\pi^-\Delta^{++}(1238)$ enhancement in the mass region 1400 to 1700 MeV. This is associated with low four momentum transfer squared, $\Delta^2(K^+)$, to the K^+ and may correspond to the diffraction dissociation of the proton into some of the many N^*'s known in this mass region--a phenomenon which is well known from other reactions. This channel has an important bearing on the other three in that, if interpreted as $K\pi$ scattering, the events occur strongly peaked in the forward direction in $\cos\alpha$ and hence introduce an additional asymmetry in $\cos\alpha$ as well as an anisotropy in ϕ, the Treiman-Yang angle.
4. The most vital question--and also the most difficult to answer--is: is there any evidence for a 0^+ $K\pi$ resonance? There is clear evidence for

strong asymmetry in the Kπ scattering angle α (in the $K^+\pi^-$ c.m. system). (See Fig. 9.) This asymmetry drops to a minimum in the mass region ~ 1100 MeV and rises sharply again beyond this mass. If all the data could be ascribed to Kπ scattering this effect could be due to an s-wave Kπ state, as for example the 1080 enhancement indicated by the CERN group at the 1966 Berkeley Meeting. The difficulty with this interpretation lies in the presence of the πΔ enhancement effect which gives rise to a strong asymmetry in the high mass region, but as can be judged from the Dalitz plots in Fig. 2 still persists in the region of the two K^*'s. What is more, this effect persists even after a $\Delta^2(K\pi) < 0.5$ $(\text{BeV/c})^2$ cutoff as Fig. 3 shows. We are thus faced with the dilemma: which effect causes the asymmetry, or even whether the two represent alternative descriptions of the same physical phenomenon. The latter point of view is currently expressed in terms of the Multiperipheral Model. A partial answer which favors the Kπ s-wave interpretation is given by the following points.

a) The reaction $K^+p \rightarrow K^0\pi^0\Delta^{++}$ gives no $\pi^0\Delta^{++}$ enhancement (Fig. 5); however, an asymmetry in cos α is present (Fig. 9).

b) There is an indication of a shoulder in the $K^+\pi^-$ mass distribution above the $K^*(890)$ which becomes more apparent when the $\pi^-\Delta^{++}$ enhancement is removed, or cut for $\cos\alpha < 0.8$ is taken (see Fig. 10).

c) A study of the $\Delta^2(K^+)$ distribution as a function of $M(K^+\pi^-)$ as in Fig. 4 shows the feature that whenever $M(K^+\pi^-)$ hits a resonance the $\Delta^2(K^+)$ distribution exhibits a second bump. This is the consequence of backward decay in the resonance region. Such a second bump is clearly visible for $K^*(890)$, $K^*(1420)$, but what is possibly relevant here, also for $M(K^+\pi^-) \cong 1100$ MeV (see Fig. 4).

This work is based on two exposures in the BNL 80-inch hydrogen bubble chamber at 4.6 GeV/c and 9 GeV/c as described earlier. All measurements were performed with the LRL Flying Spot Digitizer. At 4.6 GeV/c of the 4-prong events measured 2651 events gave the 4c fit corresponding to $K^+p \rightarrow K^+\pi^-\pi^+p$. The corresponding results at 9 GeV/c are 2947 events which gave the 4c fit.

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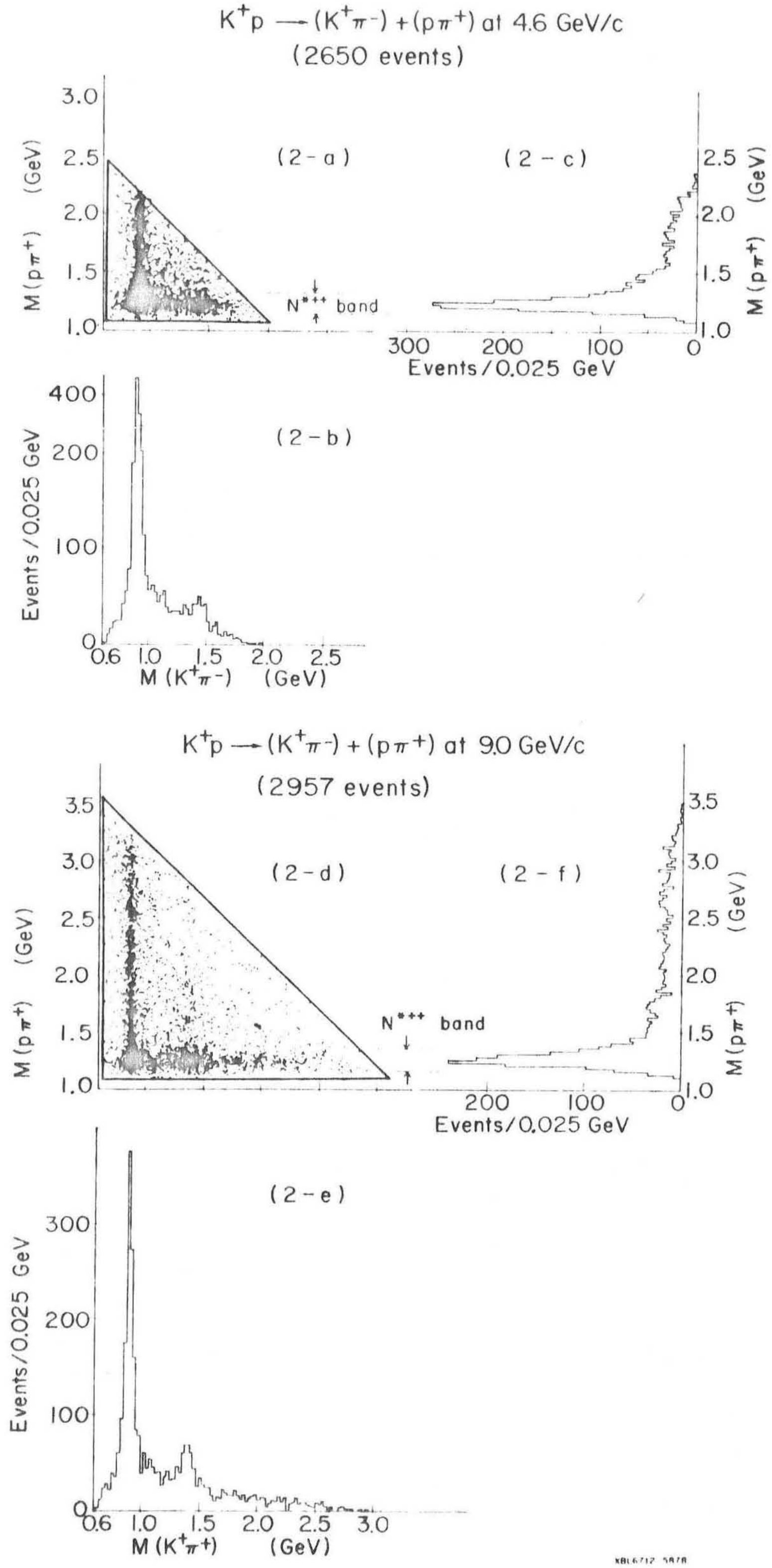

$K^+p \longrightarrow (K^+\pi^-) + (p\pi^+)$ at 4.6 GeV/c
(2650 events)
(2-a)
(2-c)
(2-b)
$M(p\pi^+)$ (GeV)
N^{*++} band
Events/0.025 GeV
$M(K^+\pi^-)$ (GeV)
$K^+p \longrightarrow (K^+\pi^-) + (p\pi^+)$ at 9.0 GeV/c
(2957 events)
(2-d)
(2-f)
(2-e)
$M(K^+\pi^+)$ (GeV)
XBL 6712-5878

Fig. 1

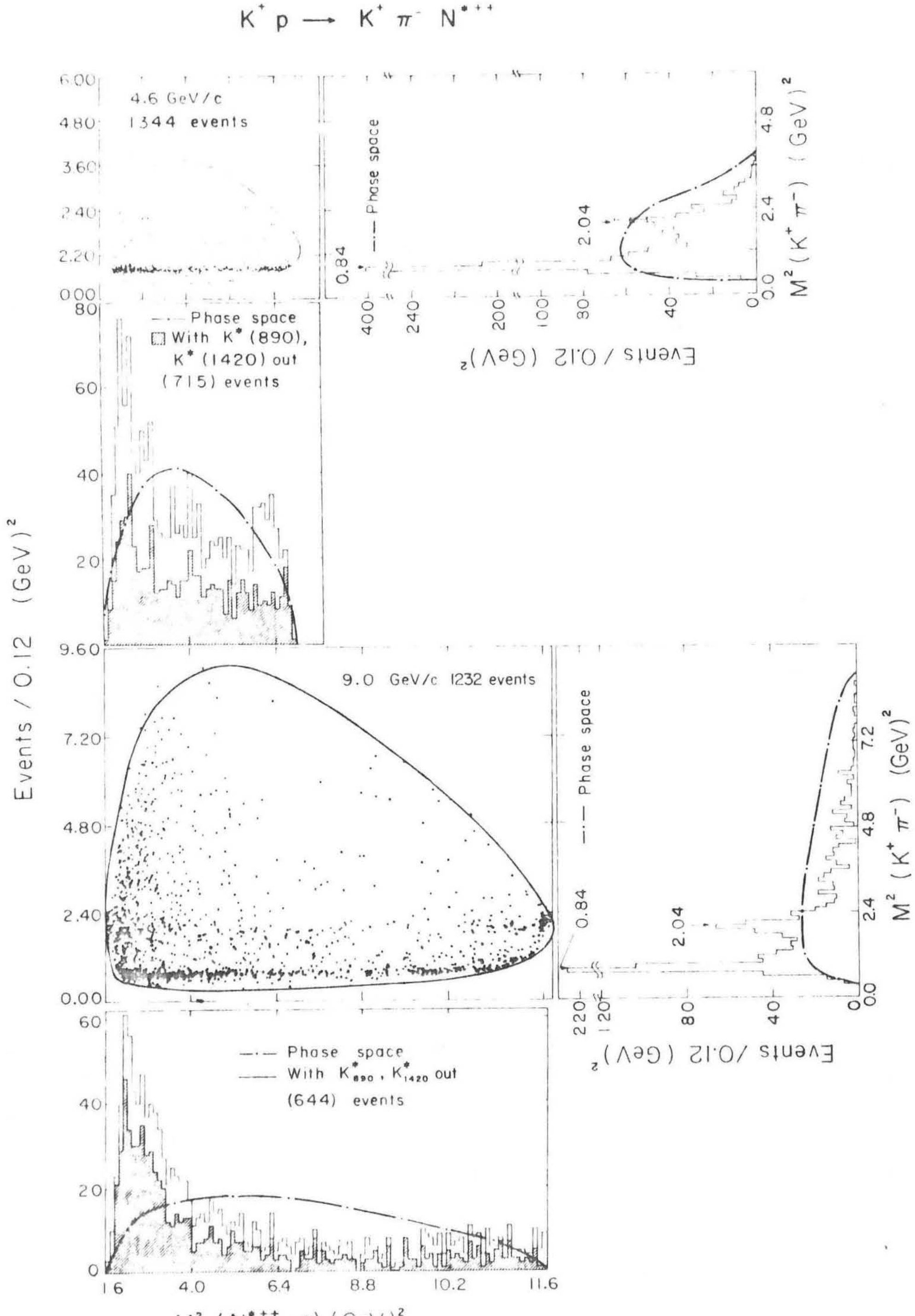

$K^+ p \longrightarrow K^+ \pi^- N^{*++}$
4.6 GeV/c
1344 events
Phase space
With K* (890), K* (1420) out
(715) events
9.0 GeV/c 1232 events
Phase space
With K^*_{890}, K^*_{1420} out
(644) events
Events / 0.12 (GeV)²
M^2 ($K^+ \pi^-$) (GeV)²
M^2 ($N^{*++} \pi^-$) (GeV)²
0.84
2.04

Fig. 2

Same Dalitz plots as Fig. 2 with Δ^2 (Δ^{++}) cut.

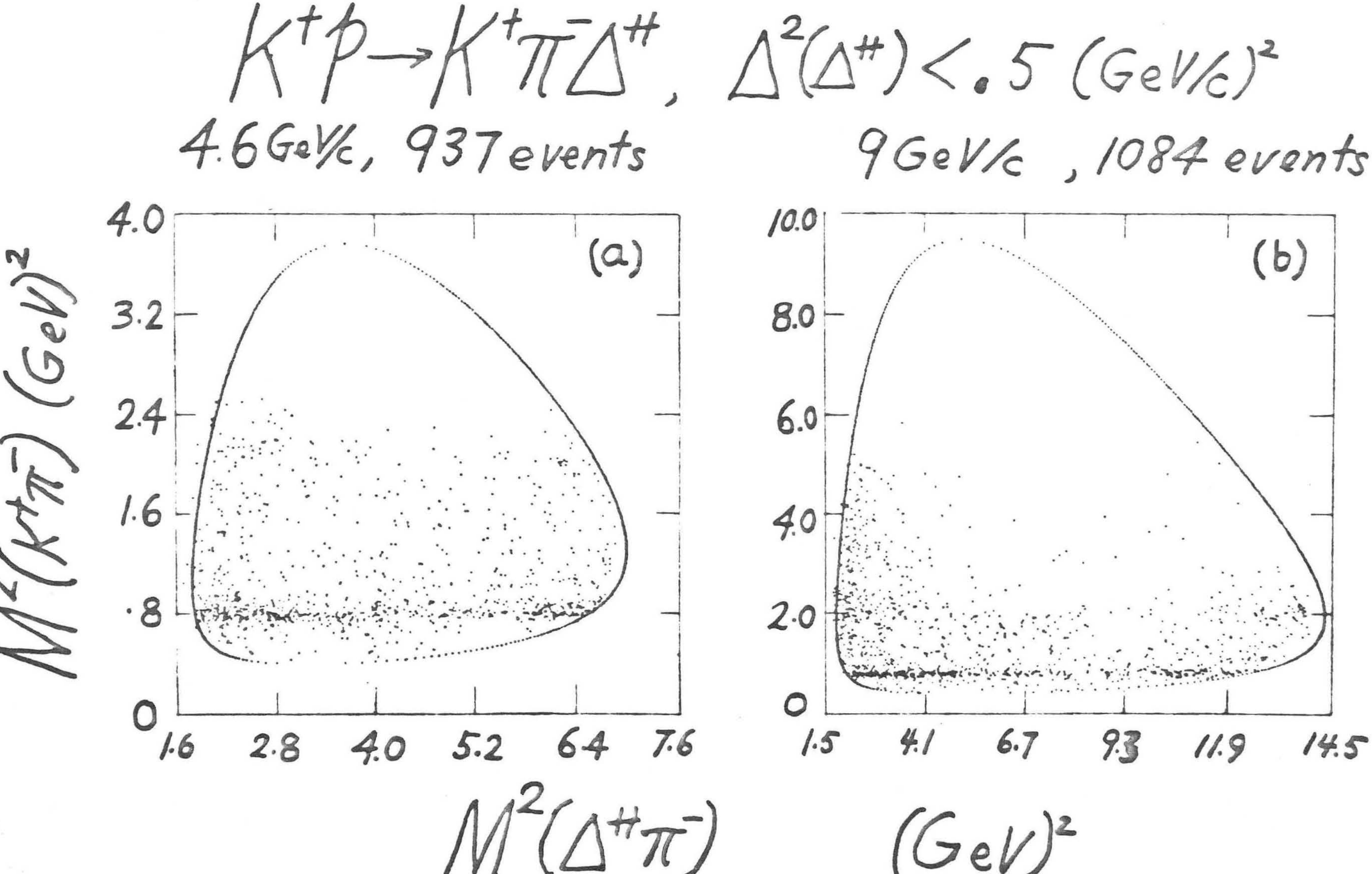


Fig. 3

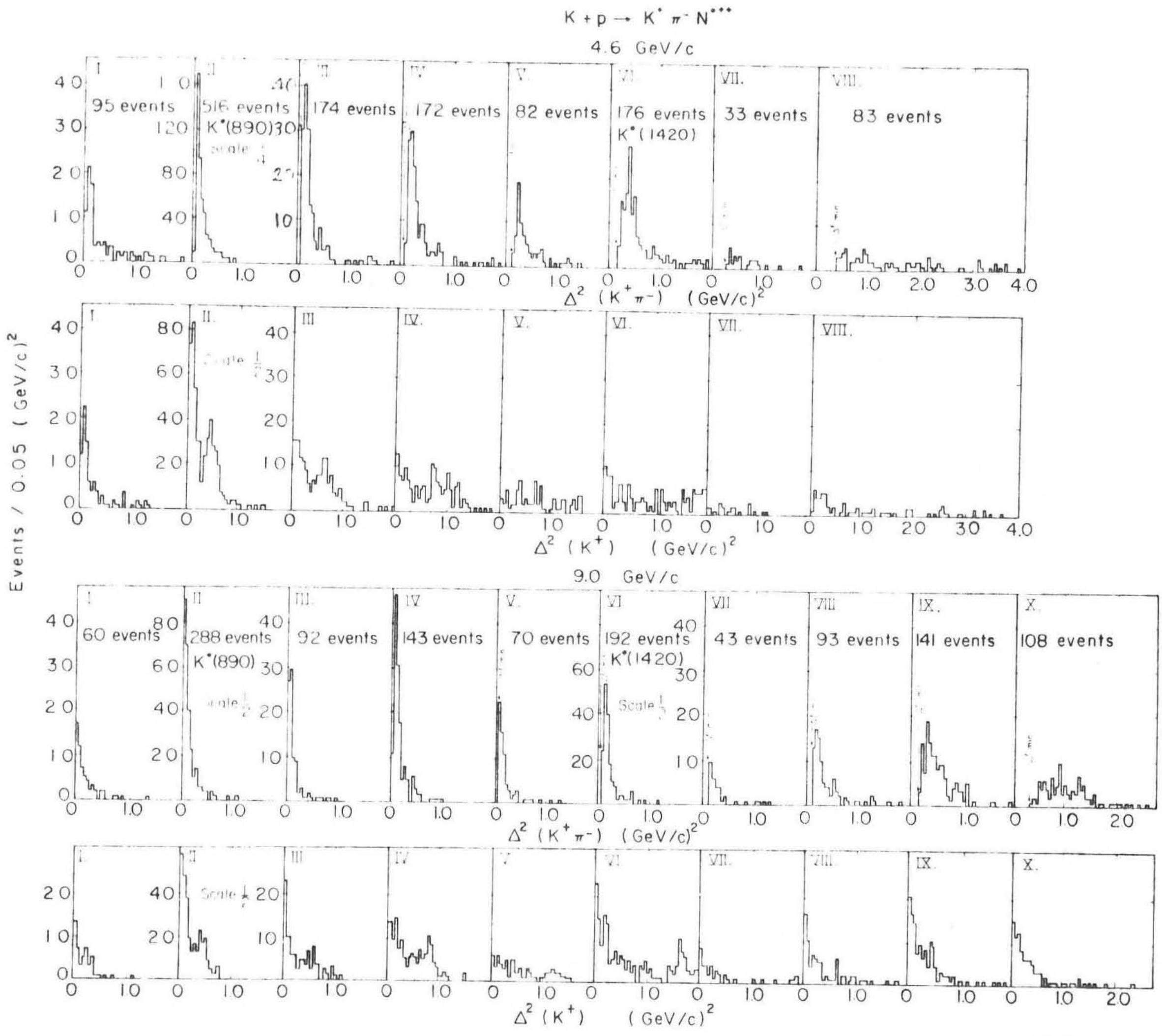


Fig. 4. $\Delta^2(K^+\pi^-)$ and $\Delta^2(K^+)$ for the mass cuts in $K^+\pi^-$ as indicated below: I. 600-840; II. 840-940; III. 940-1040; IV. 1040-1240; V. 1240-1340; VI. 1340-1500; VII. 1500-1560; VIII. 1560-1800; IX. 1800-2200; X. 2200-4200. (a) $\Delta^2(K^+\pi^-)$ for the 4.6-GeV/c data. (b) $\Delta^2(K^+)$ for the 4.6-GeV/c data. (c) $\Delta^2(K^+\pi^-)$ for the 9.0-GeV/c data. (d) $\Delta^2(K^+)$ for the 9.0-GeV/c data.

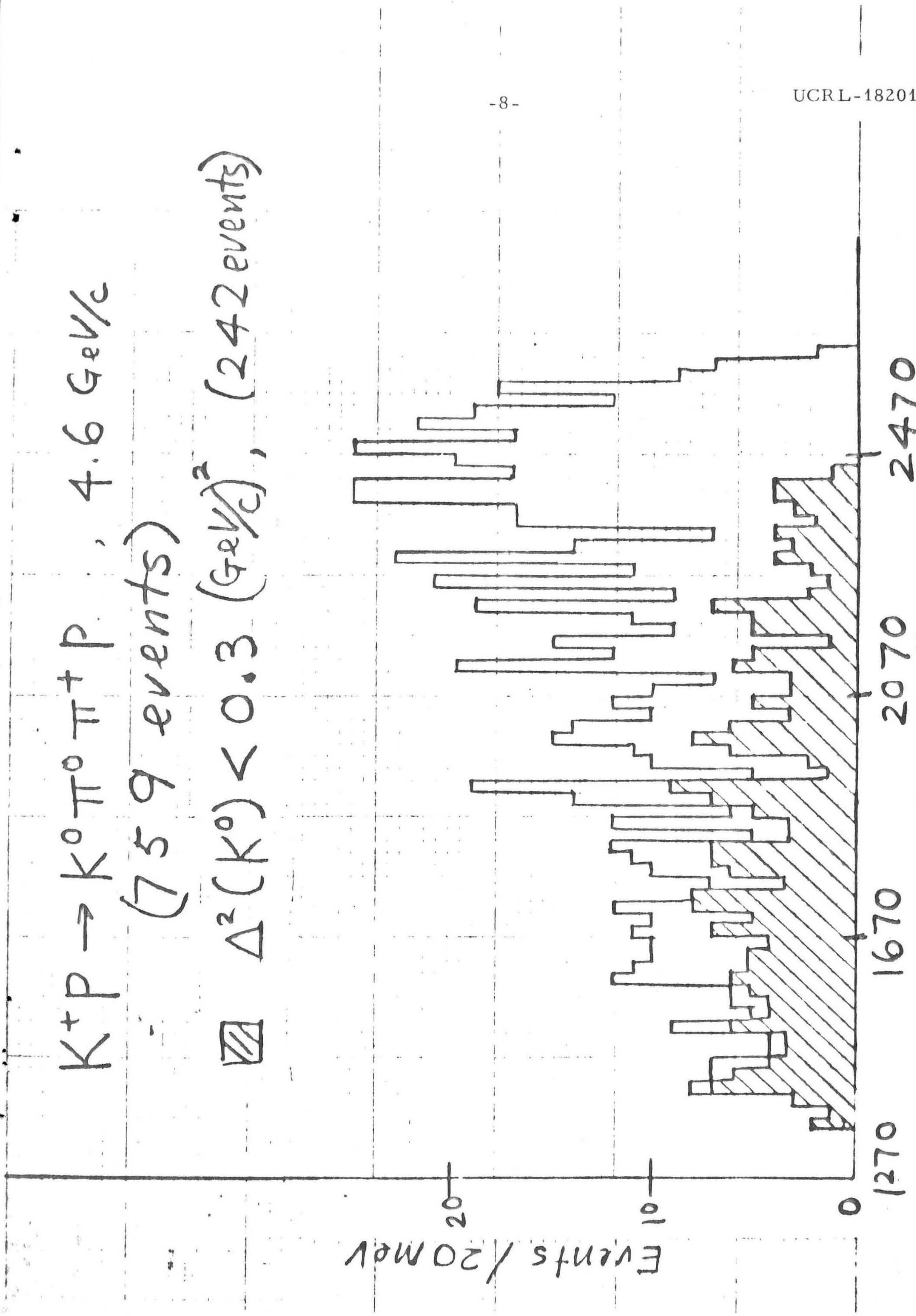
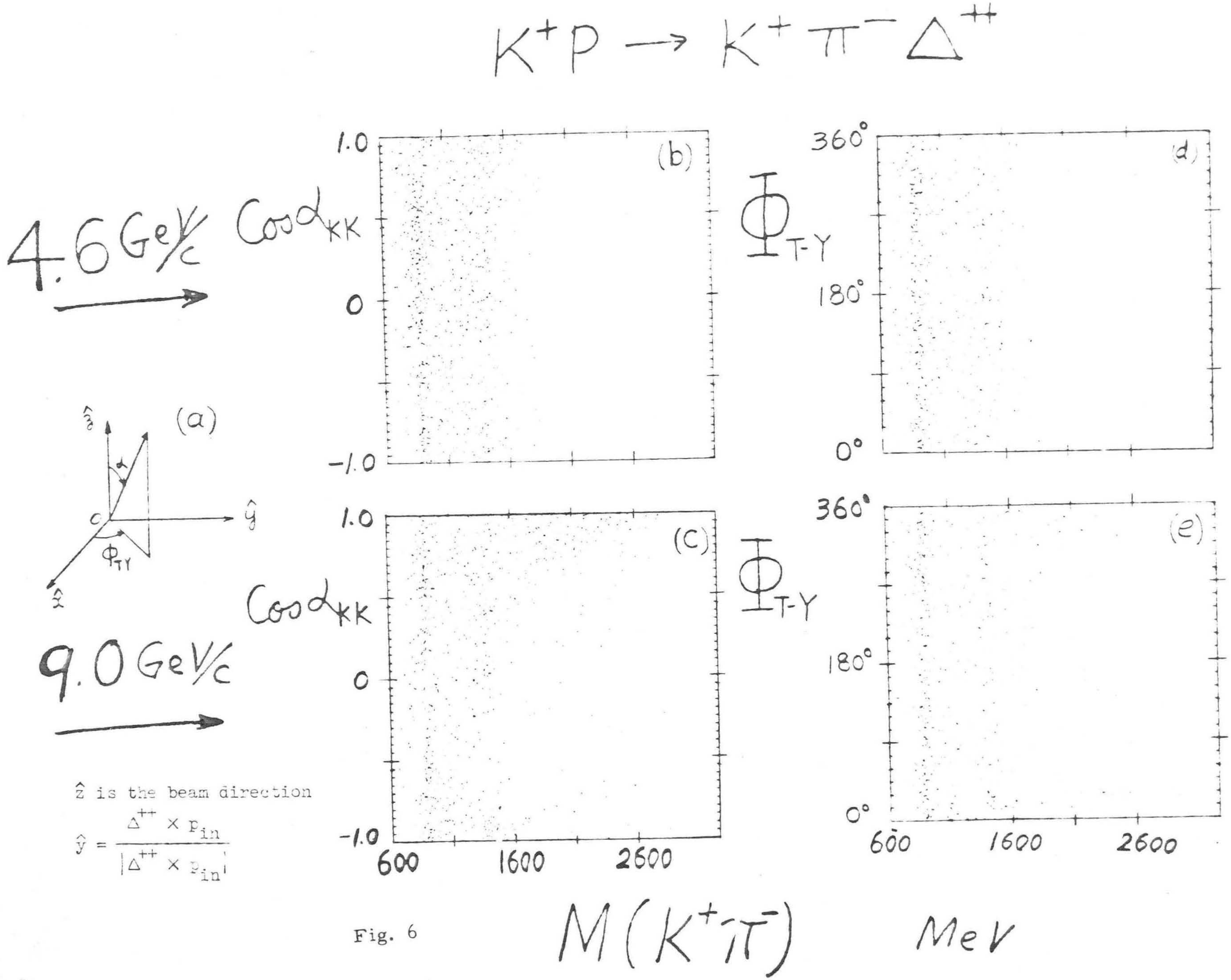

K⁺P → K⁰π⁰π⁺P , 4.6 GeV/c
(759 events)
Δ²(K⁰) < 0.3 (GeV/c)², (242 events)
Events / 20 MeV
0
10
20
1270
1670
2070
2470
MeV
M (pππ)⁺⁺

Fig. 5



K+P → K+ π− Δ++
4.6 GeV/c
9.0 GeV/c
Cos α_KK
Φ_T-Y
(a)
(b)
(c)
(d)
(e)
1.0
0
-1.0
360°
180°
0°
600
1600
2600
ẑ
ŷ
x̂
α
Φ_TY
ẑ is the beam direction
ŷ = Δ++ × p_in / |Δ++ × p_in|
M(K+π−) MeV

Fig. 6

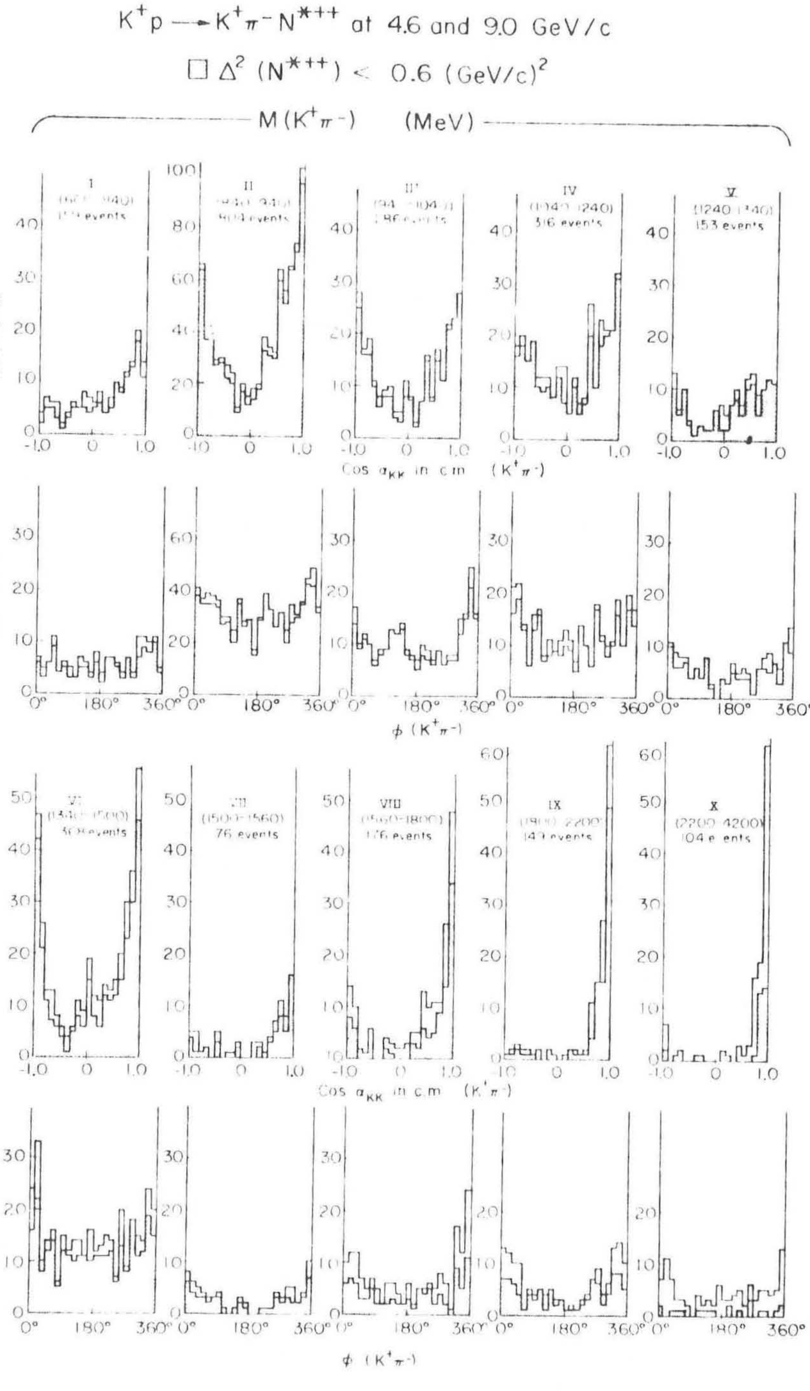


Fig. 7. Distributions of the cosine of the scattering angle α and the Treiman-Yang angle ϕ_{TY} for the $(K^+\pi^-)$ mass regions (in MeV) as indicated on the figure.

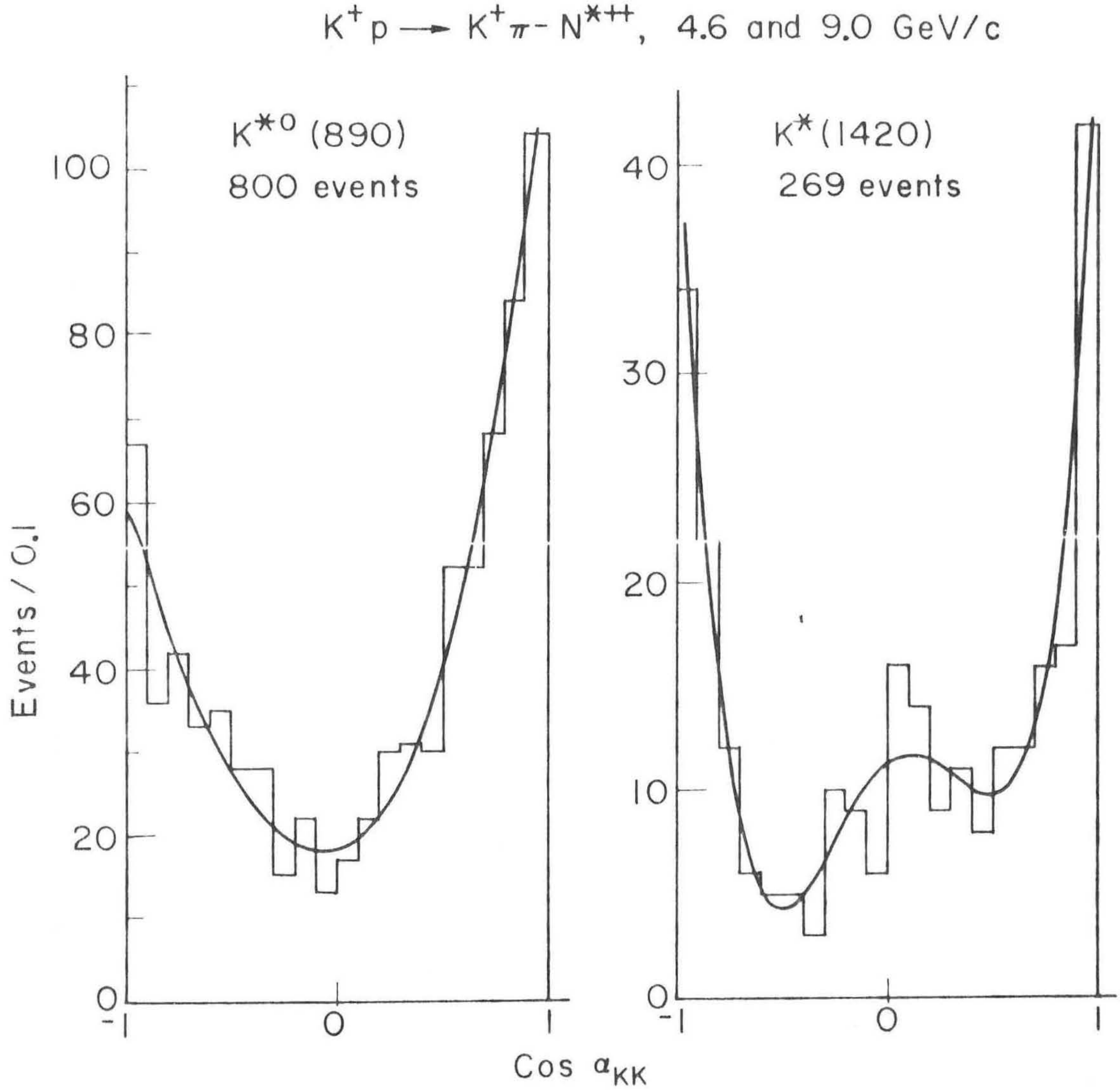
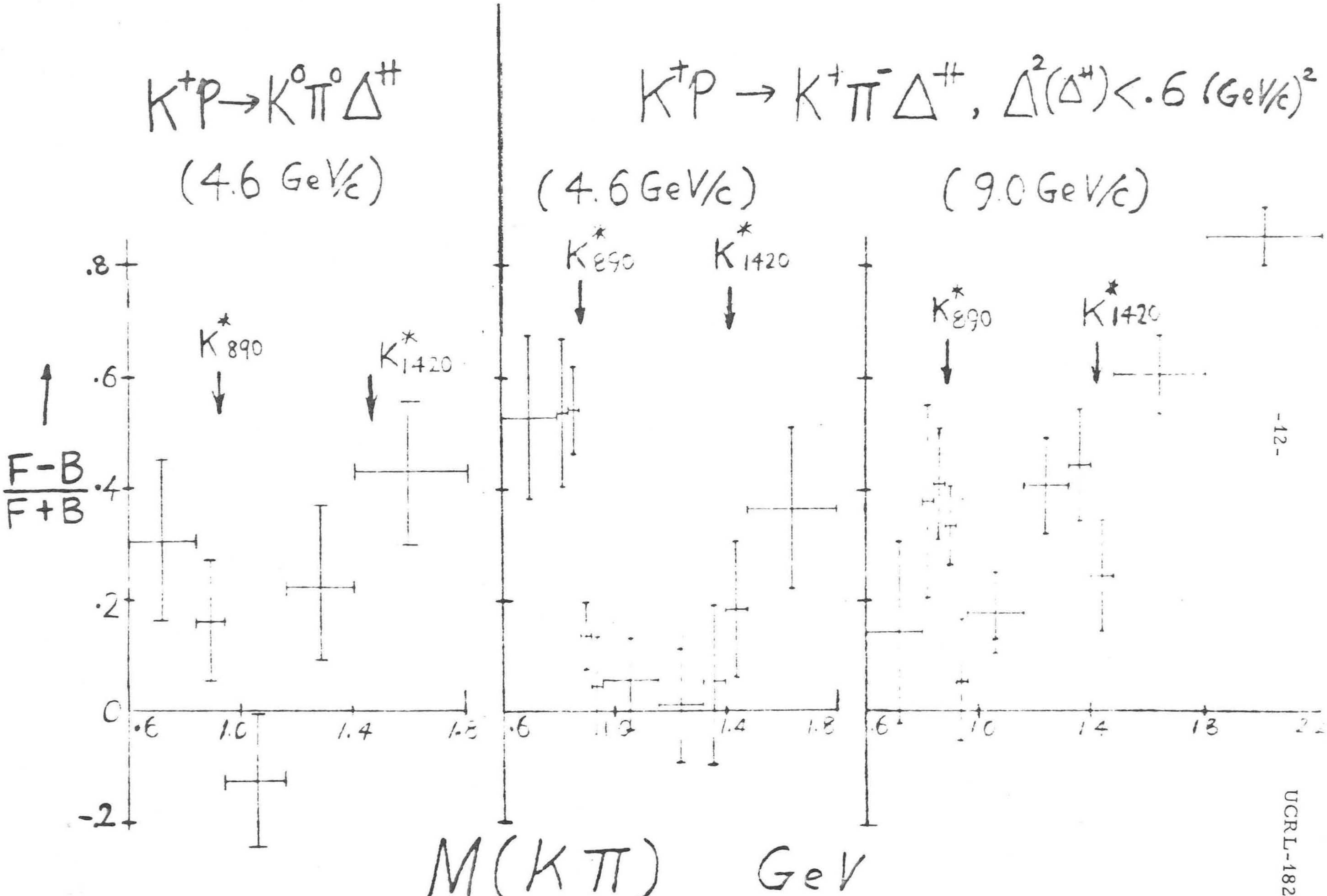
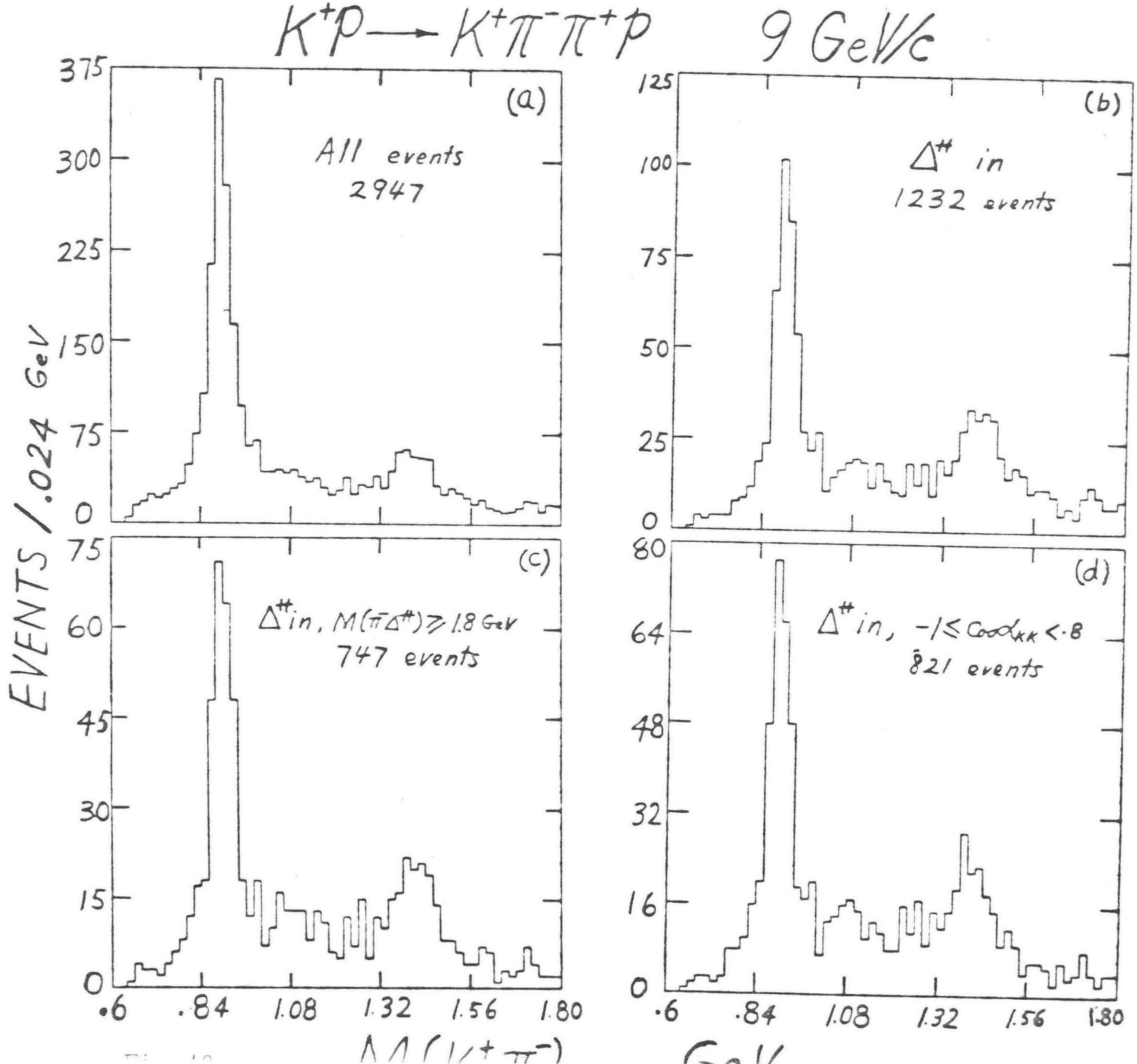


Fig. 8. Decay angular distribution for the $K^*(890)$ and $K^*(1420)$ for the reaction shown. The curves are expansions in Legendre polynomials: $\sum_\ell a_\ell P_\ell(\cos\theta)$ with $a_1 = 0.46\pm0.07$, $a_2 = 1.12\pm0.08$, $a_3 = 0.18\pm0.10$, $a_4 = 0.04\pm0.11$ for the $K^*(890)$ and $a_1 = 0.19\pm0.12$, $a_2 = 1.20\pm0.15$, $a_3 = -0.25\pm0.17$, $a_4 = 1.16\pm0.18$ for the $K^*(1420)$ with a_0 normalized to 1.0.



$K^+p \to K^0\pi^0\Delta^{++}$
(4.6 GeV/c)
$K^+p \to K^+\pi^-\Delta^{++}$, $\Delta^2(\Delta^{++}) < .6\ (GeV/c)^2$
(4.6 GeV/c)
(9.0 GeV/c)
K^*_{890}
K^*_{1420}
$\frac{F-B}{F+B}$
.8
.6
.4
.2
0
-.2
.6
1.0
1.4
1.8
2.2
M(Kπ) GeV

Fig. 9


K+P ⟶ K+π−π+P   9 GeV/c
EVENTS / .024 GeV
(a)
All events
2947
(b)
Δ++ in
1232 events
(c)
Δ++ in, M(π−Δ++) ≥ 1.8 GeV
747 events
(d)
Δ++ in, −1 ≤ Cosα_KK < .8
821 events
.6 .84 1.08 1.32 1.56 1.80
M(K+π−) GeV

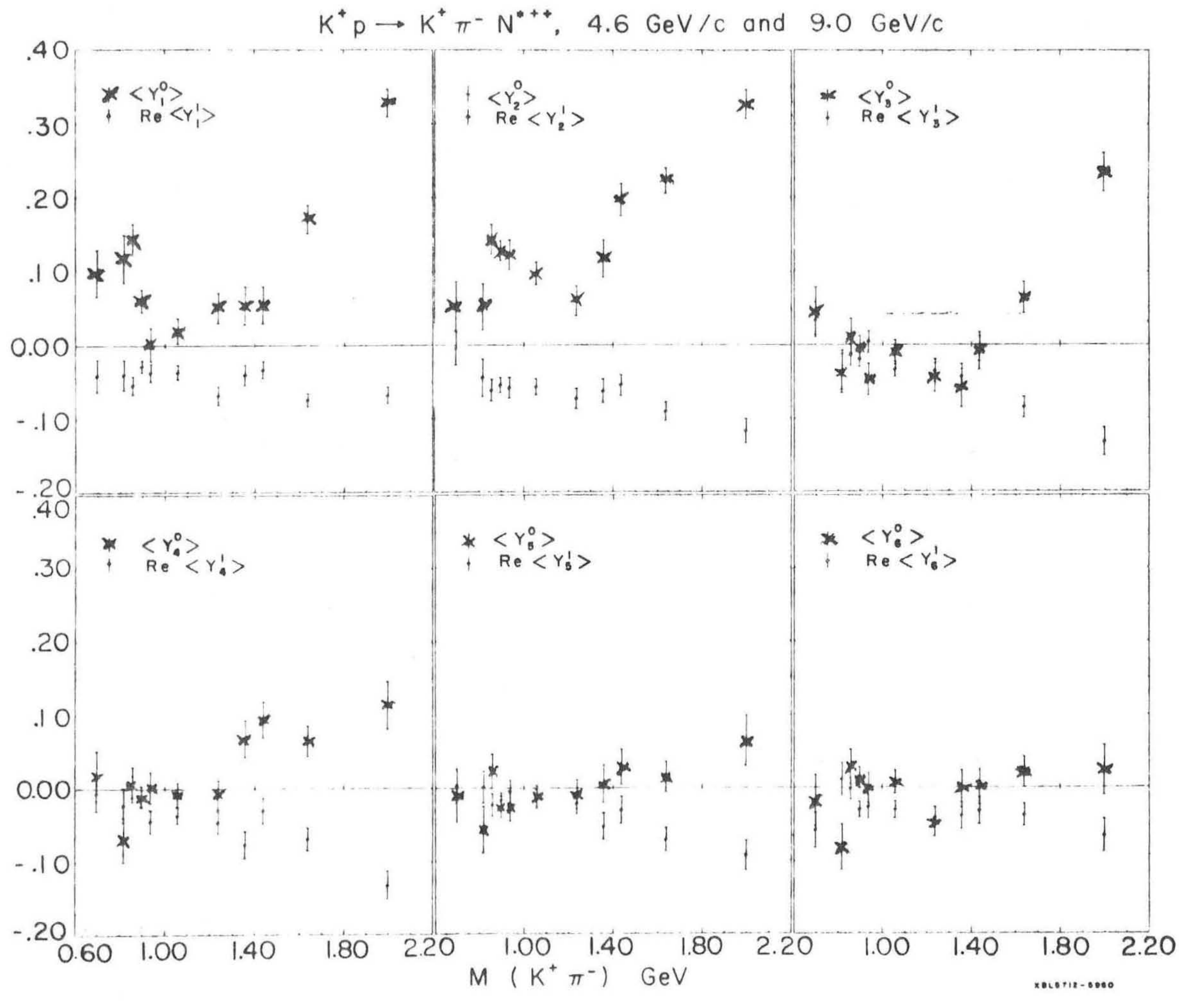


Fig. 11. Moments of spherical harmonics $\langle Y_\ell^0 \rangle$ and Re$\langle Y_\ell^1 \rangle$ vs M($K^+\pi^-$) for ℓ = 1, 2, 3, ..., 6. $\langle Y_\ell^m \rangle$ is defined by

$$\langle Y_\ell^m \rangle_{N_J} \equiv \frac{1}{N_J} \sum_{i=1}^{N_J} Y_\ell^m(i)$$

where N_J is the number of events in a ($K^+\pi^-$) mass region J and $Y_\ell^m(i)$ is the value of Y_ℓ^m for the <u>ith</u> event in that region.