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$K^o_L p$ INTERACTIONS AND EXCHANGE DEGENERACY*

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INTRODUCTION

The idea of exchange degeneracy, EXD, goes back to a suggestion by Arnold(1) in 1965 -- long before duality was proposed. However, since 1968 the concept of EXD has always been used in conjunction with duality, since it provides the logical predictions for EXD.

According to duality, there is a close connection between the absence of exotic amplitudes in one channel and the degeneracy between exchanged trajectories in another channel.

Let us consider a simple example: a given process is exotic in one channel; in that channel the imaginary part of the amplitude has to vanish. The same imaginary part of the same amplitude should be described in terms of exchanges of trajectories in the crossed channel of this process. In this crossed channel the quantum numbers are not exotic. The total contribution to this crossed channel amplitude will vanish if, and only if, at least two

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trajectories will contribute such that they cancel each other. Such a cancellation can occur at all energies if, and only if, the two trajectories have the same value of $\alpha(t)$, and are therefore degenerate. Thus for the exotic channel the imaginary part of the amplitude is zero since there are no exotic resonances, and the other channel has zero imaginary amplitude since the two non-exotic exchanges cancel.

ABSENCE OF EXOTICS

What is the evidence for the non-existence of exotic states? We briefly summarize the situation.

a. Total K^+p, K^+n Cross Sections

There has been evidence of structure in the total K^+p, K^+n cross sections for several years -- structure which could be interpreted as evidence for the formation of exotic $S = +1$, $B = 1$ states called Z^*. Many investigations have tried to establish the resonant nature of these structures, but with little success. In general, they seem to be strongly associated with the opening up of inelastic thresholds. However, if they were to be interpreted as resonances, they are very strongly suppressed compared to usual resonances like N^*, or Y^*.

b. Backward K^-p, $\bar{p}p$ Elastic Scattering

The CERN-Orsay 5 GeV/c elastic scattering experiment[2] showed strong backward peaks for $\pi^{\pm}p$ and K^+p elastic scattering, but also showed clear evidence for small backward peaks for K^-p and $\bar{p}p$ scattering. The peaks are $\sim 10^{-2}$ of the strength of the allowed (or non-exotic) peaks, but are nevertheless quite distinct. The presence of these backward peaks for K^-p and $\bar{p}p$ implies the exchange of exotic quantum numbers in the u-channel.

The s-dependence of the backward cross section is very steep, being $\sim s^{-10}$ for the exotic processes. However, the 90^o cross section is falling even more rapidly, of the order $10^{-12} - 10^{-14}$, and so may be masking the real backward energy dependence. Michael[3] has calculated that the simultaneous exchange of two non-exotic Regge trajectories could explain the observed K^-p, $\bar{p}p$ backward peaks without the necessity of exotic Z^*. The energy dependence of the backward peaks would then be $\sim s^{-3}$ which is consistent with the present data (when allowance is made for the fast falling "background", or 90^o, cross section).

c. $\bar{p}p \rightarrow \bar{\Sigma}\Sigma$

An Oxford bubble chamber experiment[4] studying the following antiproton reactions at 3.6 GeV/c,

$\bar{p}p \rightarrow \bar{\Sigma}^-\Sigma^-$ forbidden ($\Delta Q = 2$)

$\bar{p}p \rightarrow \bar{\Sigma}^+\Sigma^+$ allowed ($\Delta Q = 0$)

The analysis found that the forbidden reaction, with charge two exchange, giving a forward $\bar{\Sigma}^-$, occured $(9 \pm 3)\%$ of the allowed reaction with $\bar{\Sigma}^+$ forward. They determined an s-dependence of s^{-4} for this process.

Again the data clearly imply the presence of exotic quantum numbers, but are also in fair agreement with Double Regge Exchange, (i.e. the exchange of two non-exotic particles).

d. Evidence for I = 3/2 Exchange

There is good evidence for the presence of a small amount of $I = 3/2$ meson exchange from studies of the ratios of SU_2 related reactions, e.g.

$$\pi^- p \rightarrow M^0 Y^0 \qquad\qquad K^- p \rightarrow M^+ Y^-$$
$$\phantom{\pi^- p \rightarrow{}} M^+ Y^- \qquad\qquad \phantom{K^- p \rightarrow{}} M^- Y^-$$
$$\pi^+ p \rightarrow M^+ Y^+ \qquad\qquad K^- n \rightarrow M^- Y^0$$
$$\phantom{\pi^+ p \rightarrow M^+ Y^+ \qquad\qquad K^- n \rightarrow{}} M^0 Y^-$$

These studies lead to $\left| f_{3/2}/f_{1/2} \right|^2 \sim$ few percent, around 5 GeV.[5]

Also studies of π^+, π^- ratios and Σ,Λ ratios in photoproduction from hydrogen and deuterium show similar effects.

Again, this few percent effect of exotic exchanges could be easily accounted for by Double Regge Exchange.

e. Forward K^+ in $\pi^- p \rightarrow K^+ Y^-$

First indications for the process, $\pi^- p \rightarrow K^+ Y$ ($Y = \Sigma^-$ or Y^-_{1385}), were given several years ago by a SUNY group. Recently two new experiments have confirmed the effect, firstly by Akerlof, et al.[6] and secondly by a BNL bubble chamber experiment.[7]

The differential cross sections are reported as (0.8 ± 0.2) μb/GeV^2 around 3 GeV/c, falling to $(0.11 \pm .11)$μb/GeV^2 at 5 GeV/c. An energy dependence of $s^{-3.5}$ is reported.

Once more these results are quite compatible with exchanges of a new exotic K* with I = 3/2 and with a mass of ~ 1 - 1-1/2 GeV, or with Double Regge Exchange (e.g. $(\rho^+ + K^{*+})$).

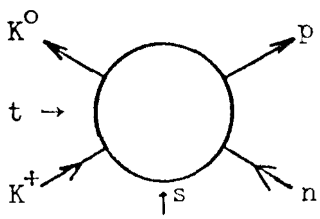
I apologize for the rapid review of the experimental evidence, but what can we conclude?

It is clear that exotic quantum numbers play a role in two body processes at intermediate energies. The magnitude of the exotic effects is of the order of (10-15)% in amplitude at around 5 GeV/c. However, all of the data, at present, is equally compatible with Double Regge Exchange. We may conclude that exotic states probably do not exist, or if they do they are strongly suppressed.

EXAMPLES OF EXCHANGE DEGENERACY

Let us consider a few examples:

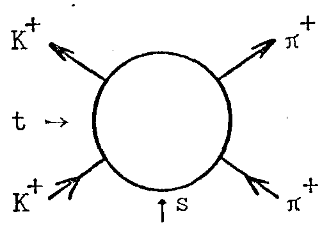
a. $K^+ n \to K^0 p$



s:	$K^+ n \to K^0 p$	Exotic
t:	$K^+ \overline{K}^0 \to \overline{n}\, p$	Y
u:	$\overline{K}^0 n \to K^- p$	ρ, A_2

The absence of resonances in the s-channel means that the net contribution of ρ, A_2 and Λ, Σ in the crossed channels to the imaginary part of the s-channel amplitude in zero. This implies exchange degeneracy between ρ, A_2 and between the hyperons exchanged in the t- and u-channels.

b. $\pi^+ K^+ \to \pi^+ K^+$



s:	$K^+ \pi^+ \to K^+ \pi^+$	Exotic
t:	$K^+ K^- \to \pi^+ \pi^-$	K^*, K^{**}
u:	$K^- \pi^+ \to K^- \pi^+$	ρ, f

implies the exchange degeneracy of K^*_{890} and K^{**}_{1400}, and of the ρ and f mesons. Similarly, by considering the exotic s-channel process $\pi^+ \rho^+ \to \pi^+ \rho^+$, one can show ω, A_2 exchange degeneracy.

TESTING EXCHANGE DEGENERACY

There are two kinematic regions in which we might test the idea of exchange degeneracy -- (a) $t > 0$, and (b) $t < 0$.

There has been good support from the $t > 0$ data for the idea of EXD for a long time, at least for the meson systems. The Chew-Frautchi plot (Fig. 1) shows clear degeneracy for the mesons.

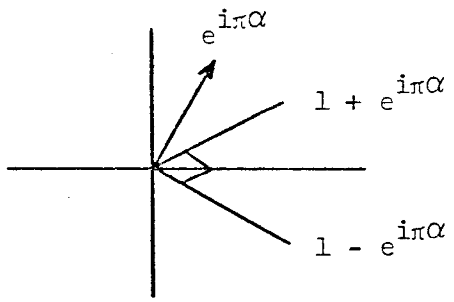
The situation is not so good for the baryons. The only convincing degenerate set seems to be Λ_{1115}, Λ_{1520} and Λ_{1815}.

What of the $t < 0$ region? One way to investigate this region would be to try to isolate Regge trajectories from the study of specific reactions and then compare the parameters and see if they are degenerate. For example, one could study $\pi^- p \rightarrow \pi^0 n$ and isolate the ρ trajectory, and $\pi^- p \rightarrow \eta^0 n$ and isolate the A_2 trajectory. In principle, comparison of the ρ, A_2 trajectories from these studies would allow comment on whether these two trajectories are EXD.

In practice, however, this would not be a good method of comparison. Apart from the problem that we do not have many processes in which the exchanges can be clearly isolated as in the above examples, the determination of the trajectory parameters are very model-dependent, (e.g. secondary trajectories to be included or not, and their specific form, parameterisation of residues, etc.).

A more positive way of testing exchange degeneracy is suggested by the following:

Consider a reaction with two exchanges -- one +ve and the other -ve signature. (The signatures are $1 \pm e^{i\pi\alpha}$ respectively.) The phase of the total amplitude depends on α, (in fact $\alpha/2$), but if



α is the same for both trajectories the angle between the two amplitudes is always 90° independent of the particular value of α. This implies that there cannot be interference between two opposite signature trajectories which are EXD (i.e. $\alpha = \alpha'$). Thus one test of EXD would be to look for presence of this interference term, which would show up as a difference between the cross sections of related reactions.

Or, more generally, the predictions of EXD are:

for the weak form

$$\left\{ \begin{array}{l} \alpha\text{'s are equal, } \alpha^{1}(t) = \alpha^{2}(t) \\ \Rightarrow \dfrac{d\sigma^{1}}{dt} = \dfrac{d\sigma^{2}}{dt} \\ \text{and } \pm P^{1} = \mp P^{2} \end{array} \right.$$

for the strong form

$$\left\{ \begin{array}{l} \alpha^{1}(t) = \alpha^{2}(t) \\ \beta^{1}(t) = \beta^{2}(t) \\ \Rightarrow \dfrac{d\sigma^{1}}{dt} = \dfrac{d\sigma^{2}}{dt} \\ \text{and } P^{1} = P^{2} = 0 \end{array} \right.$$

There are many possible tests of EXD and several examinations of these tests have been tried.(5,8) For the remainder of this talk we will consider various aspects of the SLAC $K_L^0 p$ bubble chamber experiment which allow tests of EXD.

SLAC $K_L^0 p$ EXPERIMENT

I will report data on several final states which allow tests of EXD. The data comes from analysis of about 800,000 pictures of the SLAC 40" HBC exposed to a K_L^0 beam. The momentum spectrum peaks around 5 GeV/c and provides a useful flux of K_L^0's in the range (1-12) GeV/c. The integrated path length for this experiment is ~ 40 events/μb cross section. These results are preliminary; the $\Lambda\pi^+$, $\Sigma^0\pi^+$ and backward $K_S^0 p$ data will all be available in final form shortly. The results being reported are the work of G. W. Brandenburg, W. B. Johnson, D. W. G. S. Leith, J. S. Loos, G. J. Luste, J. A. J. Matthews, K. Moriyasu, W. M. Smart, F. C. Winkelmann, and R. J. Yamartino.

a. $\overline{K}^0 p \rightarrow K^- \Delta^{++}$

The reactions $K^+ p \rightarrow K^0 \Delta^{++}$ and $\overline{K}^0 p \rightarrow K^- \Delta^{++}$ are related by line reversal and both involve the exchange of ρ and A_2 trajectories. The $K^+ p$ reaction being exotic in the s-channel, duality requires these two exchanges to be degenerate -- which should then imply equal cross sections.

We have data on the reaction $\overline{K}^0 p \rightarrow K^- \Delta^{++}$ from (1.5 - 8) GeV/c. Preliminary cross sections are shown in Fig. 2, together with data from the line reversal process. The cross section for $K^+ p \rightarrow K^0 \Delta^{++}$ is greater than the $\overline{K}^0 p \rightarrow K^- \Delta^{++}$ reaction, but seems to be falling faster with increasing energy, such that equality should be reached by 10 GeV/c.

The slopes for the differential cross section are already equal by 3 GeV/c and remain in good agreement throughout the momentum region considered here.

In summary, these reactions compare well for the slope of the differential cross section at intermediate energies, but the normalisation does not come into line until ~ 10 GeV/c.

b. $\overline{K}^o p \to \Lambda\pi^+$, and $\overline{K}^o p \to \Sigma^o \pi^+$

From the $K_L^o p$ HBC experiment we have almost completed our study of the $1pV^o$ events, which allow a study of the reaction $\overline{K}^o p \to \Lambda\pi^+$. The cross sections for this process are shown in Fig. 3, (preliminary). For comparison, cross sections for the related processes $K^- p \to \Lambda\pi^o$, $K^- n \to \Lambda\pi^-$ are shown.

In addition to the $\Lambda\pi^+$ final state, we can isolate the reaction $\overline{K}^o p \to \Sigma^o \pi^+$. The clean identification of the Σ^o events is shown in Fig. 4, where the effective mass of $\Lambda\gamma$ is plotted, showing the clear Σ^o peak at all beam energies. The cross section for the Σ^o reaction as a function of beam energy is shown in Fig. 5. Again, related $K^- p$, $K^- n$ cross sections are shown for comparison.

The ratio between the Σ^o and Λ cross sections as a function of momentum is shown in Fig. 6. The data show a slow rise of the (Σ^o/Λ) ratio from ~ 0.3 at low energies rising to ~ 0.6 at high energies.

The differential cross sections for three momentum intervals for these reactions are shown in Figs. 7 and 8. Both reactions show shrinkage of the forward peak from 2 GeV/c to 8 GeV/c and the the change of slope of the differential cross section as a function of momentum is shown in Figs. 9 and 10. The slopes of the differential cross sections for the line reversal process are shown for comparison.

In Fig. 11, the polarisation for the reaction $\overline{K}^0 p \rightarrow \Lambda\pi^+$ is shown for all momenta greater than 2.5 GeV/c, and also for the two regions $(2.5 < p_{K_L} < 3.8)$ GeV/c and $(p_{K_L} > 3.8$ GeV/c). The polarisation rises quickly from zero in the forward direction essentially to its maximum value at $t \sim .5$ GeV^2 and then falls rapidly to zero around $t \sim 2.5$ GeV^2.

These two reactions ($\overline{K}^0 p \rightarrow \Lambda\pi^+$, $\overline{K}^0 p \rightarrow \Sigma^0\pi^+$), are related through line reversal to the pion initiated reactions $\pi^- p \rightarrow K^0\Lambda$ and $\pi^- p \rightarrow K^0\Sigma^0$, respectively. If the K^*_{890} and K^{**}_{1400} are indeed exchange degenerate, the cross sections of the related processes should be equal and the polarisations either zero, or at least equal in magnitude and opposite in sign.

In our energy region, EXD does not seem to work. The K initiated cross sections are larger than the π initiated, and the polarisations are non-zero and even of the same sign for $t < 1.0$ GeV^2. However, we do observe that the difference between the cross sections seem to be reducing such that equality may be reached around 12 GeV/c. (Will they go on through equality and reverse roles, or will they remain equal?) The slopes of the differential cross sections, which are radically different for momenta ~ 3 GeV/c seem to become equal for momenta ~ 8 GeV/c for both Λ^0 Σ^0 reactions.

Preliminary data from a new experiment in $\pi^- p \rightarrow \Lambda K^0$ and $\pi^- p \rightarrow \Sigma^0 K^0$ at 3, 4, 5, and 6 GeV/c at ANL by Jovanovich et al. was presented at this meeting by Yokosawa.(9) The experiment has good missing mass resolution allowing clean separation of the Λ, Σ^0 final states. Good data also exist from (8-16)GeV/c from K. Foley et al.(10) of BNL. These experiments will provide good data for careful comparison with the $\overline{K^o}p$ data, and will allow a better study of EXD than has hitherto been possible. At present, all one can say is that EXD does not work in the 5 GeV/c region for these reactions, but that there are signs (for the optimist) that by (10-12) GeV/c it may be in fair shape.

c. Backward $K_L^o p \rightarrow p K_s^o$ Scattering

Let me remind you of another result of the CERN-Orsay wide angle elastic scattering experiment at 5 GeV/c.(2) They also published data on the two body antiproton annihilation cross sections into $\pi^+\pi^-$ and K^+K^-.

These reactions are related by line reversal to backward elastic scattering:

				u-channel exchange
(a)	$\pi^+p \rightarrow p\pi^+$	$\longleftrightarrow$	$\bar{p}p \rightarrow \pi^-\pi^+$	(N, Δ)
(b)	$\pi^-p \rightarrow p\pi^-$	$\longleftrightarrow$	$\bar{p}p \rightarrow \pi^+\pi^-$	(Δ)
(c)	$K^+p \rightarrow pK^+$	$\longleftrightarrow$	$\bar{p}p \rightarrow K^-K^+$	(Λ, Σ)
(d)	$K^-p \rightarrow pK^-$	$\longleftrightarrow$	$\bar{p}p \rightarrow K^+K^-$	(Exotic)

When doing these comparisons care has to be taken with respect to different phase space factors, allowance for spins, etc. However, the results show that reactions (a) are in good agreement with each other, reactions (b) share the same shape but are different in absolute scale by a factor of two and reactions (c) are in good agreement. (See Fig. 12.)

These results are surprising. Reactions (a) involve both the exchange of N and Δ in the u-channel and the presence of the backward dip is evidence that they indeed do both contribute. The fact that two kinds of unrelated trajectories are being exchanged (which do not show EXD behavior in $t > 0$ region) implies that EXD should not hold very well. But it does!

For reactions (b), the u-channel exchanges are simple, with only the Δ trajectory being exchanged -- so here one would expect EXD to work. However, it does not -- at least not in absolute scale.

Finally, for reactions (c), we again have a complicated situation with several unrelated trajectories being exchanged. In this case, the exchanges are $I = 0$, and $I = 1$ hyperons. However, the EXD comparison works out rather well.

Our K^o experiment can help throw some light on these puzzling agreements and disagreements, at least for the reactions (c).

In Fig. 13 we show the energy dependence of the backward cross section in K^+p and K^-p elastic scattering. The cross sections for both strangeness states fall off together through the low energy s-channel resonance region, and then split abruptly. The exotic exchange process, the backward K^-p cross section, falls off very much faster than the allowed Y^* exchange process, the K^+p scattering.

In Fig. 14 we show the same data, but also include the $K_L^o p \to pK_S^o$ from the SLAC 40" HBC experiment. The $K_L^o p$ data fall off with a cross section not much more than the K^-p reaction. Since the $K_L^o p \to pK_S^o$ contains contributions of both $S = +1$ and $S = -1$, and since the $S = +1$ can only contain contributions from $I = 1$ exchange, these data strongly suggest that the K^+p backward scattering is dominated by $I = 0$ exchange. This in turn helps explain why the reactions (c) seem to satisfy EXD so well, as the Λ trajectories

(Λ_{1115}, Λ_{1520}, Λ_{1815}) were one of the few examples of baryons showing EXD in $t > 0$ region (i.e. in Chew-Frautschi plot).

CONCLUSIONS

The lack of polarisation data at high energy makes it difficult to comment on Strong Exchange Degeneracy.

For simple cases, where two exchanges are dominant -- (ρ, A_2) or (K^*, K^{**}) -- there are some indications that Weak EXD may work in the energy region ~ 10-15 GeV/c. The slopes of differential cross section are becoming equal at even lower energies, but the cross sections are generally not in good agreement below 10 GeV/c, although they show trends which could bring equality by, say 15 GeV/c.

So we see a somewhat limited success for EXD in our energy region, with deviations by a factor of two being rather common. Why is it failing? Is EXD not a good idea? Are there other things going on?

Since we know for $t > 0$ that EXD works, and also, since we know from many sources that absorptive effects are important in the intermediate energy region, we might lay the blame on the neglecting of these absorptive corrections. I hope that in the near future we will see some attempts to include cuts, (absorptive effects) within the framework of the dual models and that then the EXD comparisons we have examined today will come into good agreement.

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FIGURE CAPTIONS

Fig. 1 Chew-Frautschi plot for several meson trajectories.

Fig. 2 Cross sections for $\overline{K}^0 p \to K^- \Delta^{++}$ as a function of beam momentum. Cross sections for charge symmetric and line reversal processes are shown for comparison.

Fig. 3 Cross section for $\overline{K}^0 p \to \Lambda\pi^+$ as a function of momentum.

Fig. 4 Effective mass of $(\Lambda"\gamma")$ in fit to the reaction $\overline{K}^0 p \to \pi^+ \Lambda"\gamma"$. The fits to the reaction $\overline{K}^0 p \to \Lambda\pi^+$ have been removed.

Fig. 5 The cross section for $\overline{K}^0 p \to \Sigma^0 \pi^+$ as a function of momentum.

Fig. 6 The ratio between cross section $\overline{K}^0 p \to \Sigma^0 \pi^+$ and $\overline{K}^0 p \to \Lambda\pi^+$ as a function of momentum.

Fig. 7 The differential cross section for $\overline{K}^0 p \to \Lambda\pi^+$ for (a) (2-3) GeV/c, (b) (3-5) GeV/c, and (c) (5-8) GeV/c.

Fig. 8 The differential cross section for $\overline{K}^0 p \to \Sigma^0 \pi^+$ for (a) (2-3) GeV/c, (b) (3-5) GeV/c, and (c) (5-8) GeV/c.

Fig. 9 Change of slope of differential cross section, b, (from $d\sigma/dt = Ae^{bt}$), as a function of momentum for $\overline{K}^0 p \to \Lambda\pi^+$.

Fig. 10 Change of slope of differential cross section, b, (from $d\sigma/dt = Ae^{bt}$), as a function of momentum for $\overline{K}^0 p \to \Sigma^0 \pi^+$.

Fig. 11 Polarisation of the Λ for $\overline{K}^{o}p \rightarrow \Lambda\pi^{+}$, for (a) all momenta greater than 2.5 GeV/c, and (b) the two momentum intervals (2.5-3.8) GeV/c, and (3.8 - 8.0) GeV/c.

Fig. 12 (a) Comparison between the differential cross sections for the reactions $\overline{p}p \rightarrow \pi^{-}\pi^{+}$ and $\pi^{+}p \rightarrow p\pi^{+}$ at $s = 11.3$ GeV^{2}. The backward elastic scattering $d\sigma/dt$ has been corrected for the statistical factor due to the different initial spins between the two line reversed reactions(2).

(b) Same as (a) for the reactions $\overline{p}p \rightarrow \pi^{+}\pi^{-}$ and $\pi^{-}p \rightarrow p\pi^{-}$.(2)

(c) Same as (a) for the reactions $\overline{p}p \rightarrow K^{-}K^{+}$ and $K^{+}p \rightarrow pK^{+}$.(2)

Fig. 13 Energy dependence of the backward cross section for $K^{\pm}p$ elastic scattering.

Fig. 14 Energy dependence of the backward cross section for $K^{\pm}p$ elastic scattering, and $K_{L}^{o}p \rightarrow pK_{S}^{o}$.

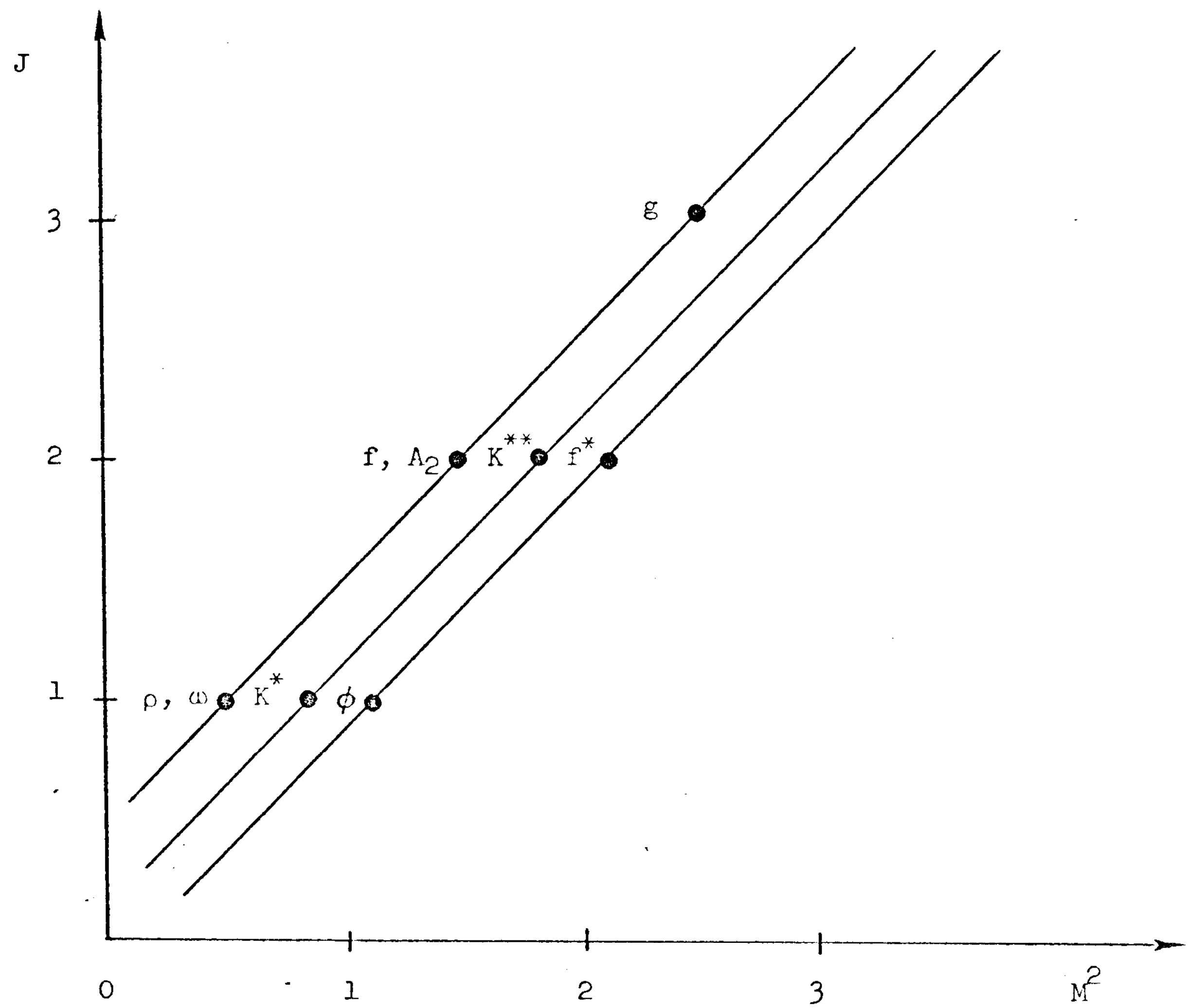
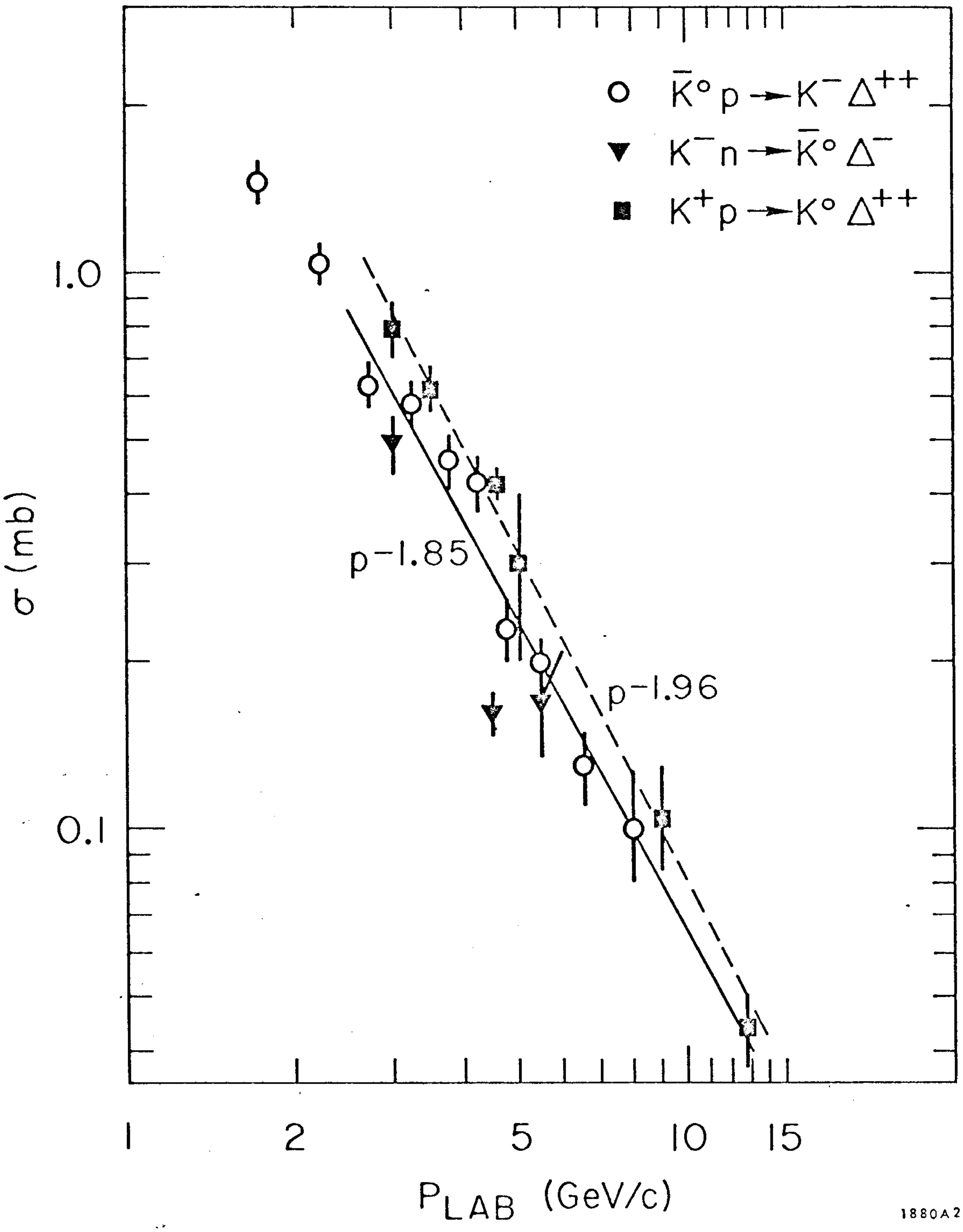


Fig. 1



$\bar{K}^\circ p \to K^- \Delta^{++}$
$K^- n \to \bar{K}^\circ \Delta^-$
$K^+ p \to K^\circ \Delta^{++}$
1.0
0.1
σ (mb)
$p^{-1.85}$
$p^{-1.96}$
1
2
5
10
15
P_{LAB} (GeV/c)
1880A2

Fig. 2

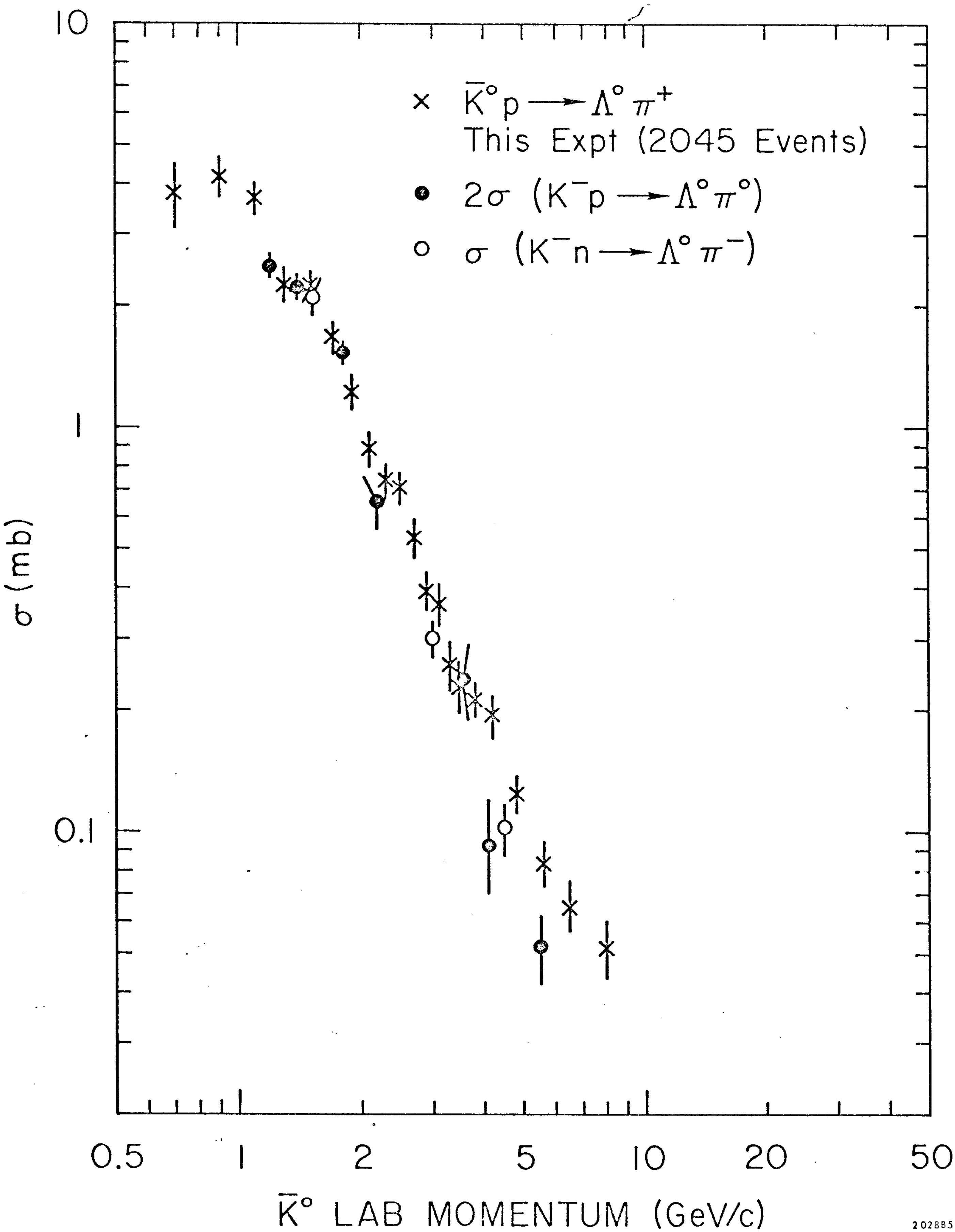
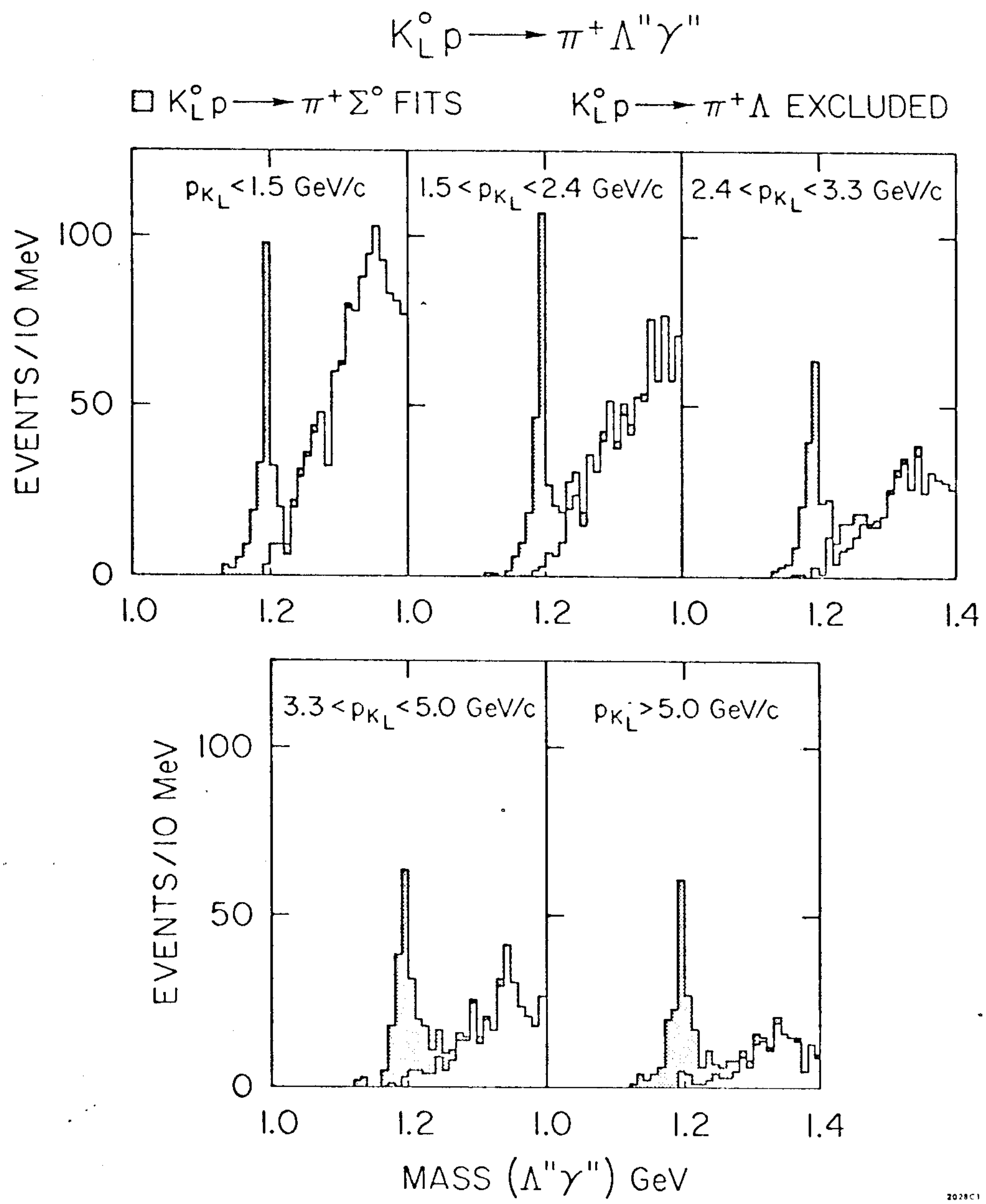
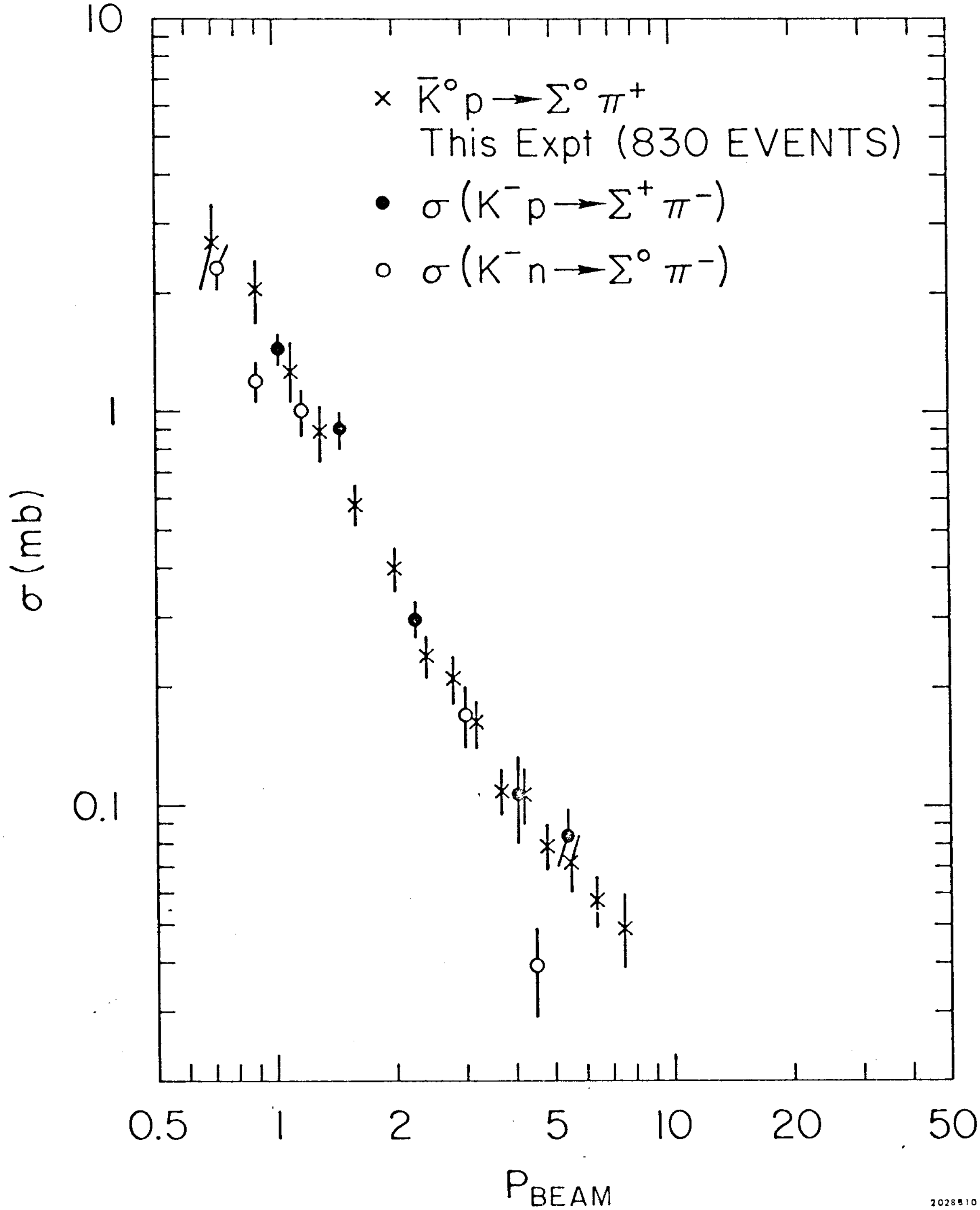

10
1
0.1
σ (mb)
× $\bar{K}^\circ p \to \Lambda^\circ \pi^+$
This Expt (2045 Events)
● $2\sigma\ (K^- p \to \Lambda^\circ \pi^\circ)$
○ $\sigma\ (K^- n \to \Lambda^\circ \pi^-)$
0.5
1
2
5
10
20
50
$\bar{K}^\circ$ LAB MOMENTUM (GeV/c)
202885

Fig. 3



$K_L^\circ p \longrightarrow \pi^+ \Lambda'' \gamma''$
□ $K_L^\circ p \longrightarrow \pi^+ \Sigma^\circ$ FITS
$K_L^\circ p \longrightarrow \pi^+ \Lambda$ EXCLUDED
$p_{K_L} < 1.5$ GeV/c
$1.5 < p_{K_L} < 2.4$ GeV/c
$2.4 < p_{K_L} < 3.3$ GeV/c
$3.3 < p_{K_L} < 5.0$ GeV/c
$p_{K_L} > 5.0$ GeV/c
EVENTS/10 MeV
0
50
100
1.0
1.2
1.4
MASS ($\Lambda'' \gamma''$) GeV

Fig. 4



10
1
0.1
σ (mb)
× $\bar{K}^\circ p \to \Sigma^\circ \pi^+$
This Expt (830 EVENTS)
● $\sigma(K^- p \to \Sigma^+ \pi^-)$
○ $\sigma(K^- n \to \Sigma^\circ \pi^-)$
0.5
1
2
5
10
20
50
P_{BEAM}
2028810

Fig. 5

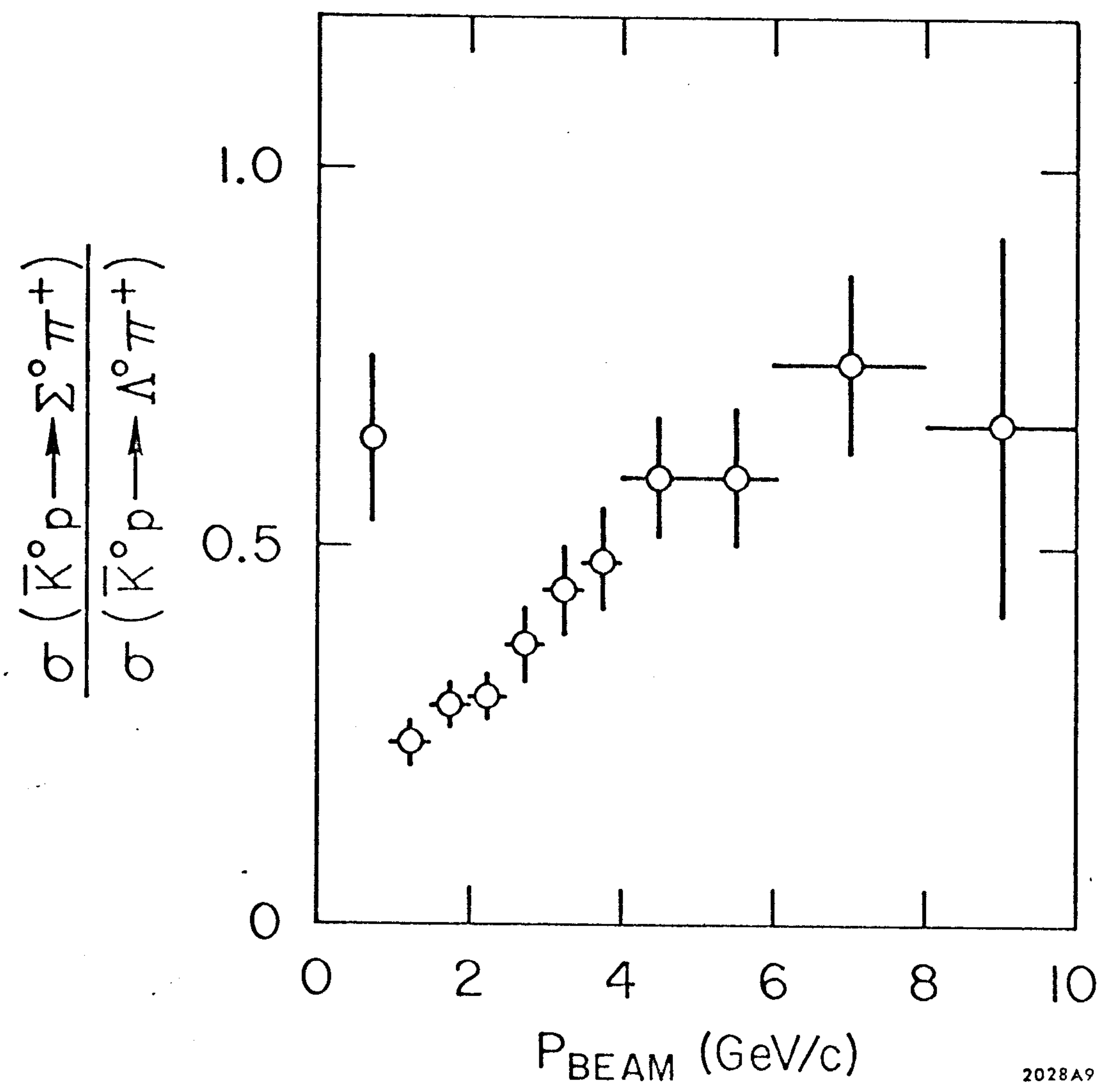
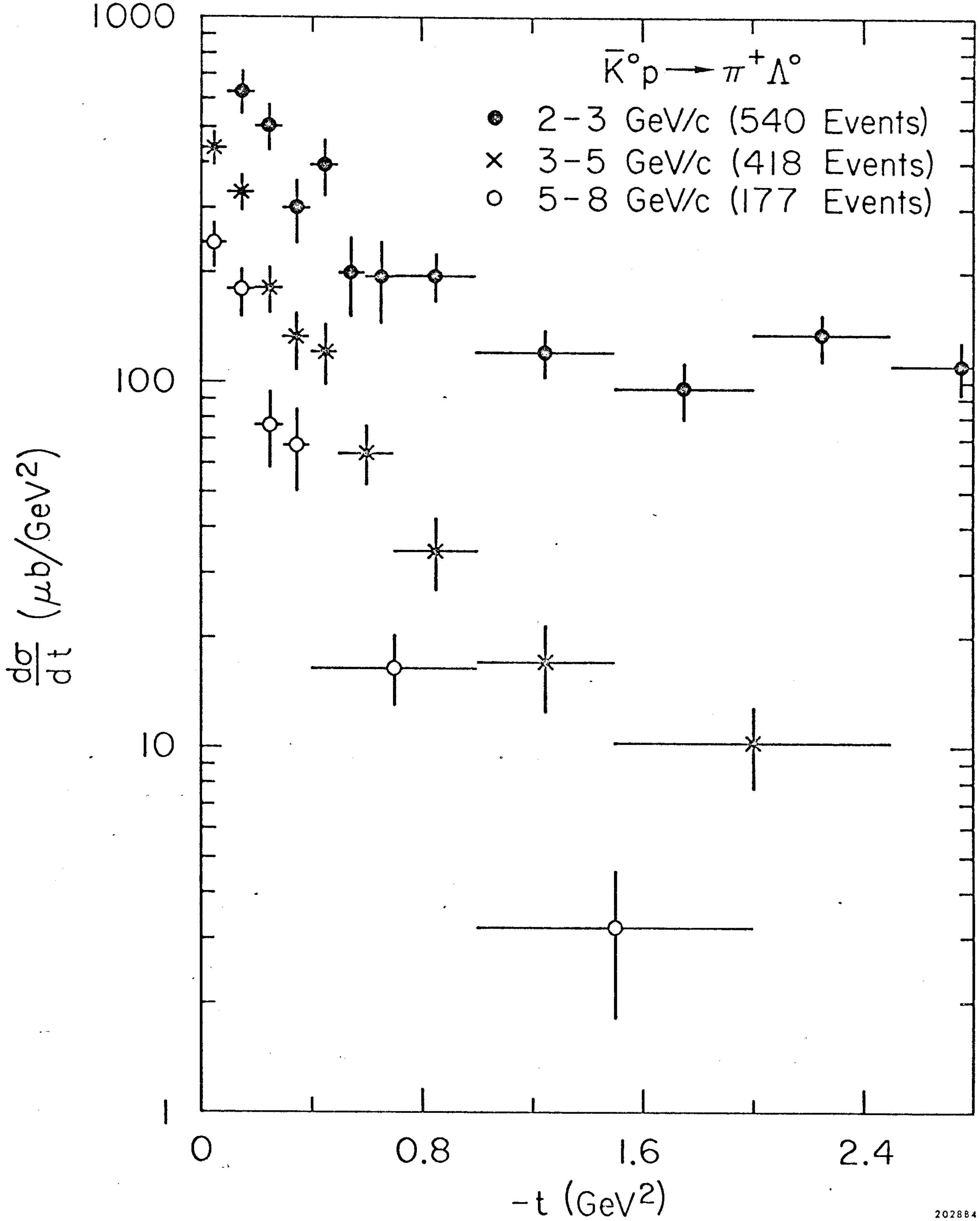
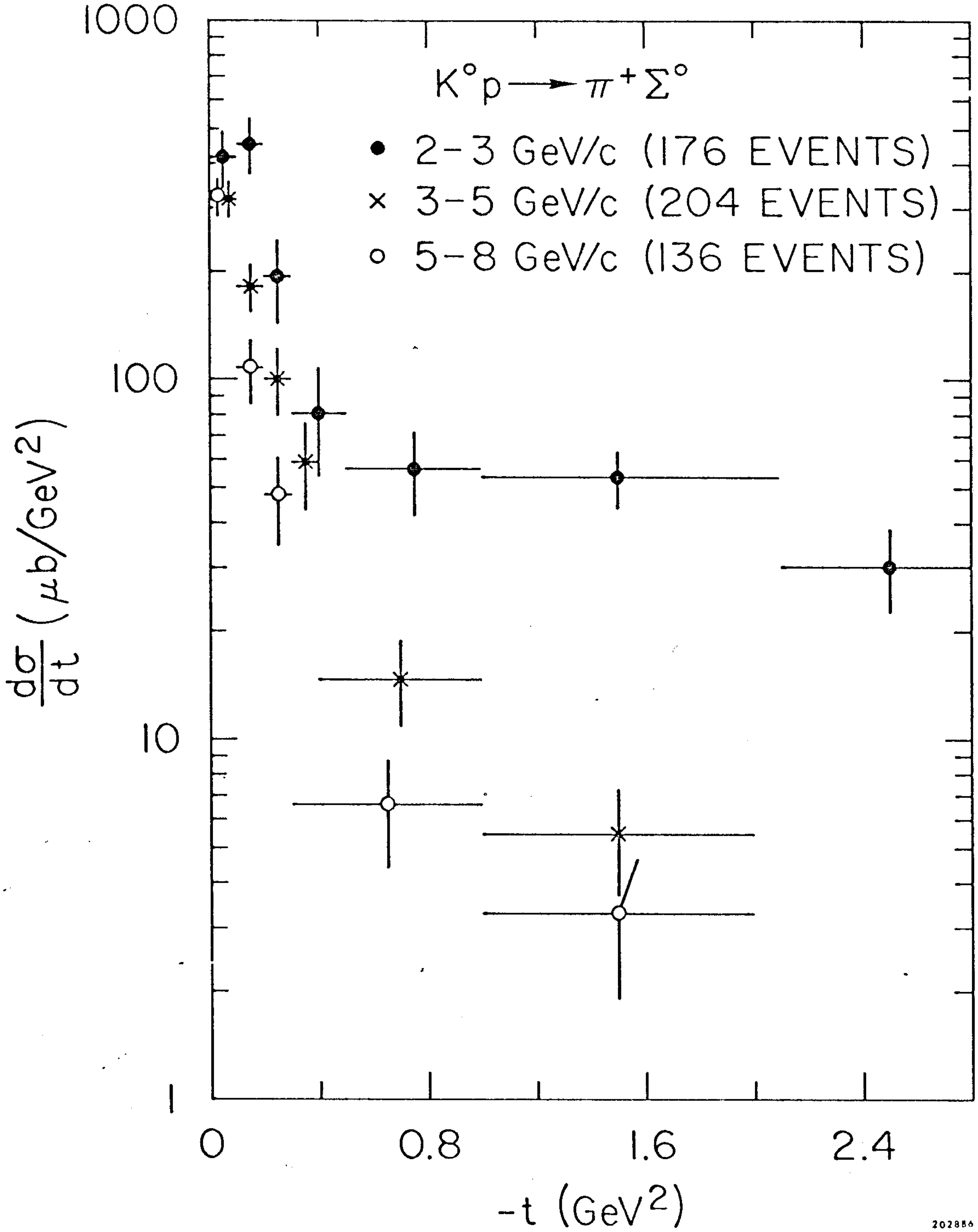


Fig. 6



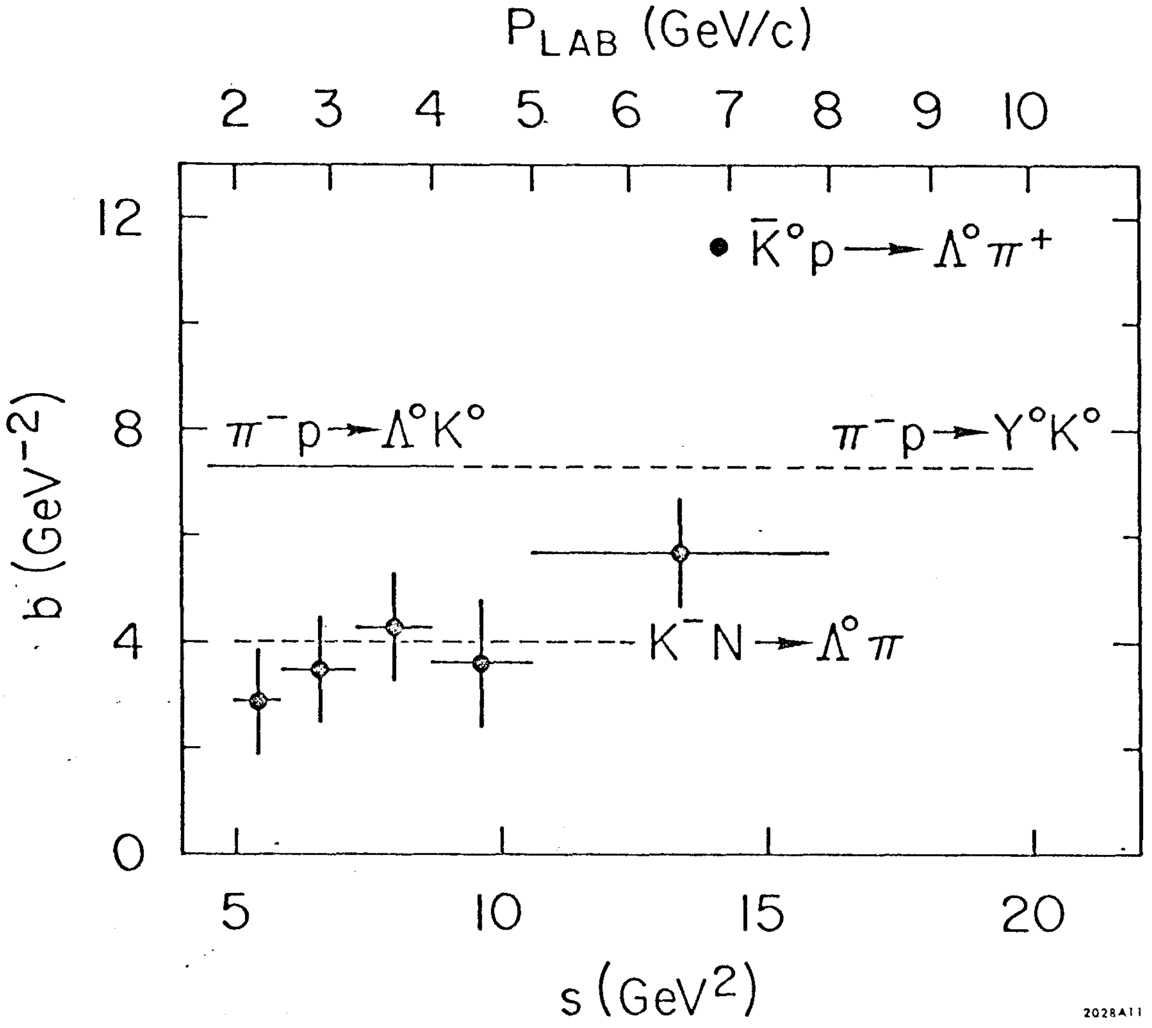
1000
100
10
1
0
0.8
1.6
2.4
$\frac{d\sigma}{dt}$ (μb/GeV^2)
$-t$ (GeV^2)
$\bar{K}^\circ p \rightarrow \pi^+ \Lambda^\circ$
2-3 GeV/c (540 Events)
3-5 GeV/c (418 Events)
5-8 GeV/c (177 Events)
202884

Fig. 7



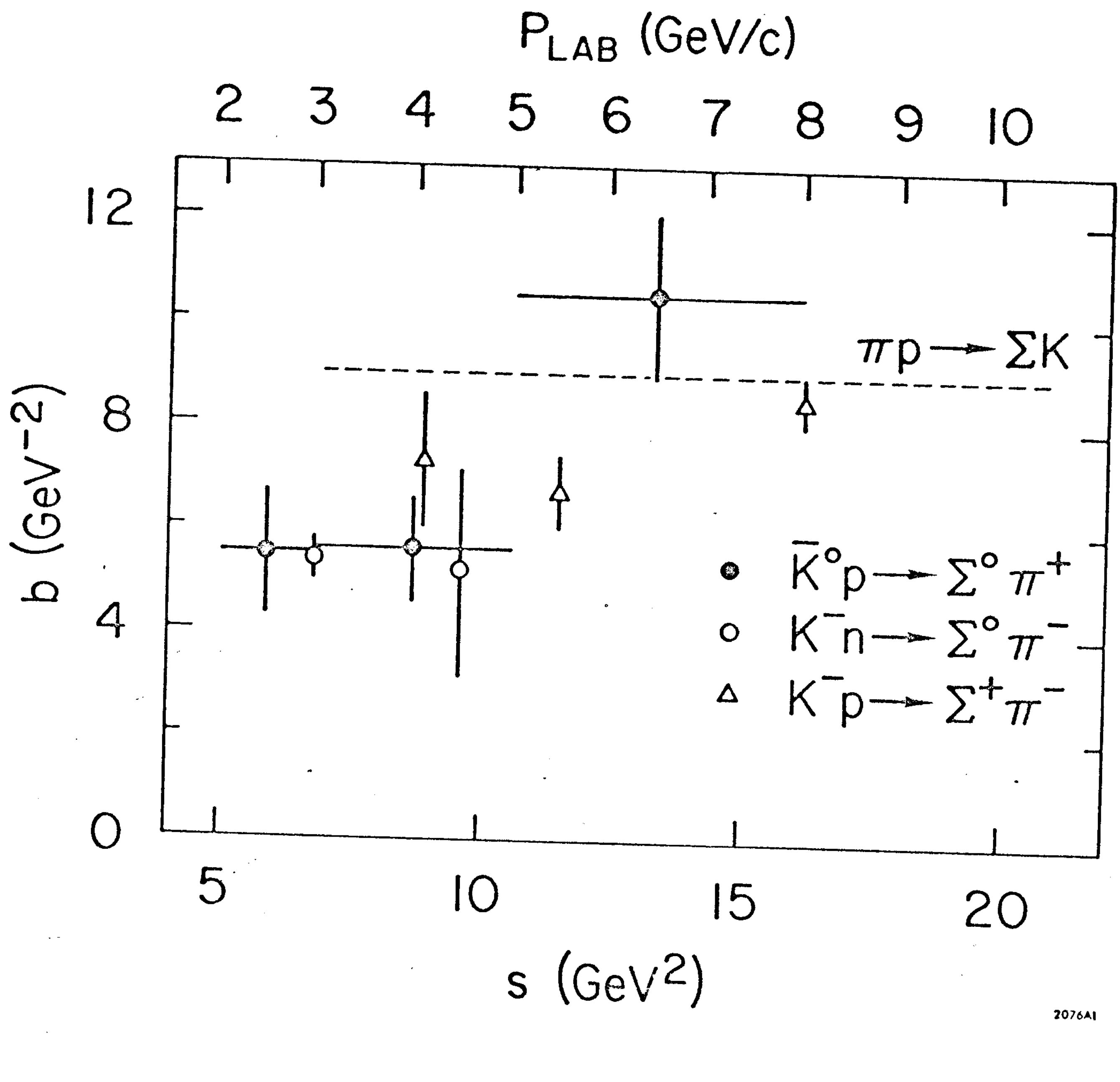
K°p ⟶ π⁺Σ°
2-3 GeV/c (176 EVENTS)
3-5 GeV/c (204 EVENTS)
5-8 GeV/c (136 EVENTS)
1000
100
10
1
dσ/dt (μb/GeV2)
0
0.8
1.6
2.4
-t (GeV2)
202886

Fig. 8



P_{LAB} (GeV/c)
2 3 4 5 6 7 8 9 10
12
8
4
0
b (GeV^{-2})
• $\bar{K}^0 p \to \Lambda^0 \pi^+$
$\pi^- p \to \Lambda^0 K^0$
$\pi^- p \to Y^0 K^0$
$K^- N \to \Lambda^0 \pi$
5 10 15 20
s (GeV^2)
2028A11

Fig. 9



P_{LAB} (GeV/c)
2
3
4
5
6
7
8
9
10
12
8
4
0
b (GeV^{-2})
$\pi p \rightarrow \Sigma K$
$\bar{K}^0 p \rightarrow \Sigma^0 \pi^+$
$K^- n \rightarrow \Sigma^0 \pi^-$
$K^- p \rightarrow \Sigma^+ \pi^-$
5
10
15
20
s (GeV^2)
2076A1

Fig. 10

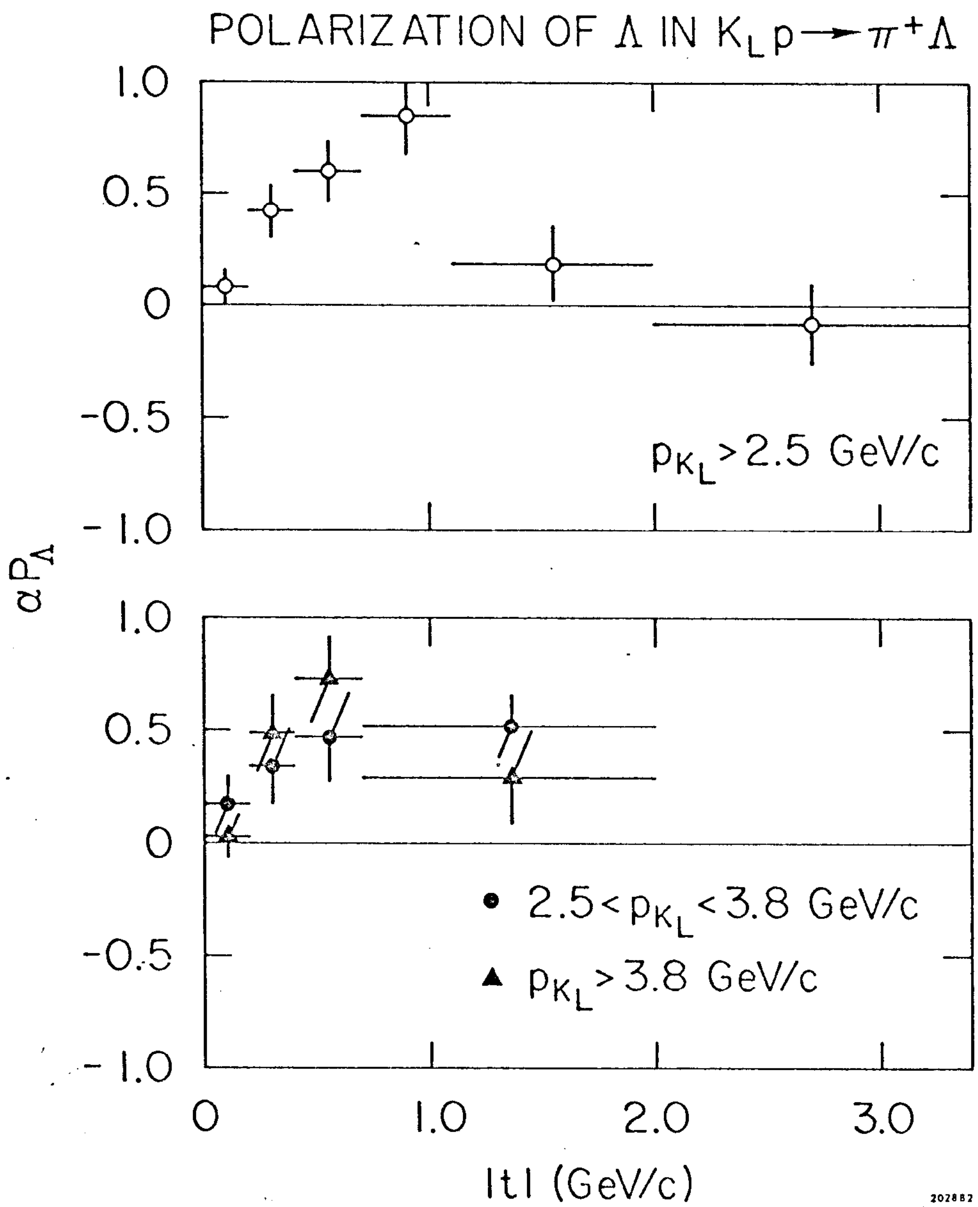

POLARIZATION OF Λ IN $K_L p \rightarrow \pi^+ \Lambda$
1.0
0.5
0
-0.5
-1.0
$p_{K_L} > 2.5$ GeV/c
αP_Λ
1.0
0.5
0
-0.5
-1.0
● $2.5 < p_{K_L} < 3.8$ GeV/c
▲ $p_{K_L} > 3.8$ GeV/c
0
1.0
2.0
3.0
|t| (GeV/c)
202882

Fig. 11

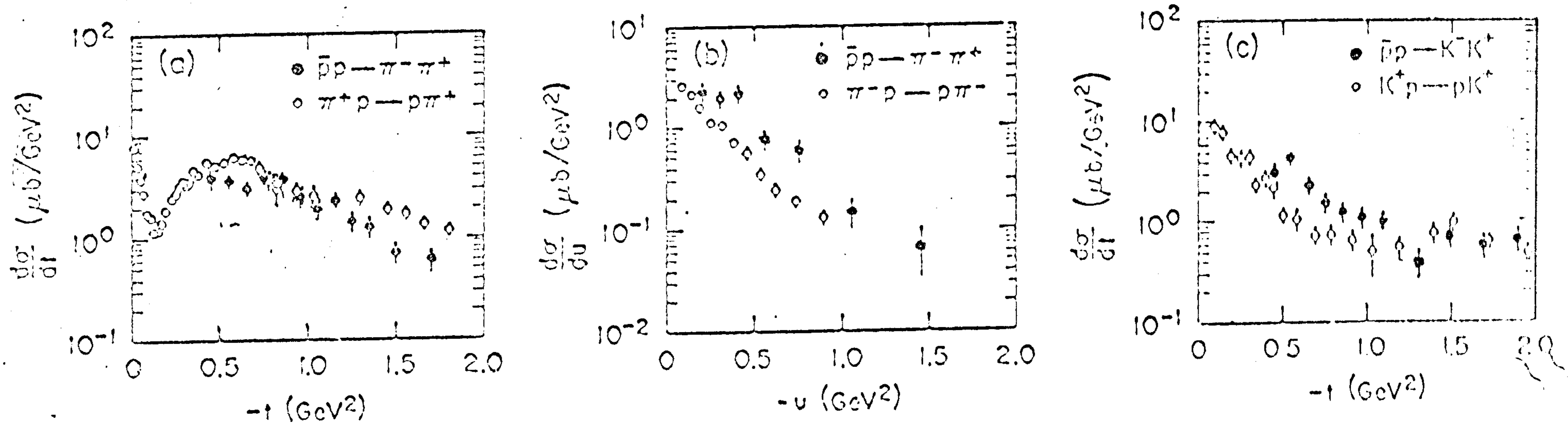
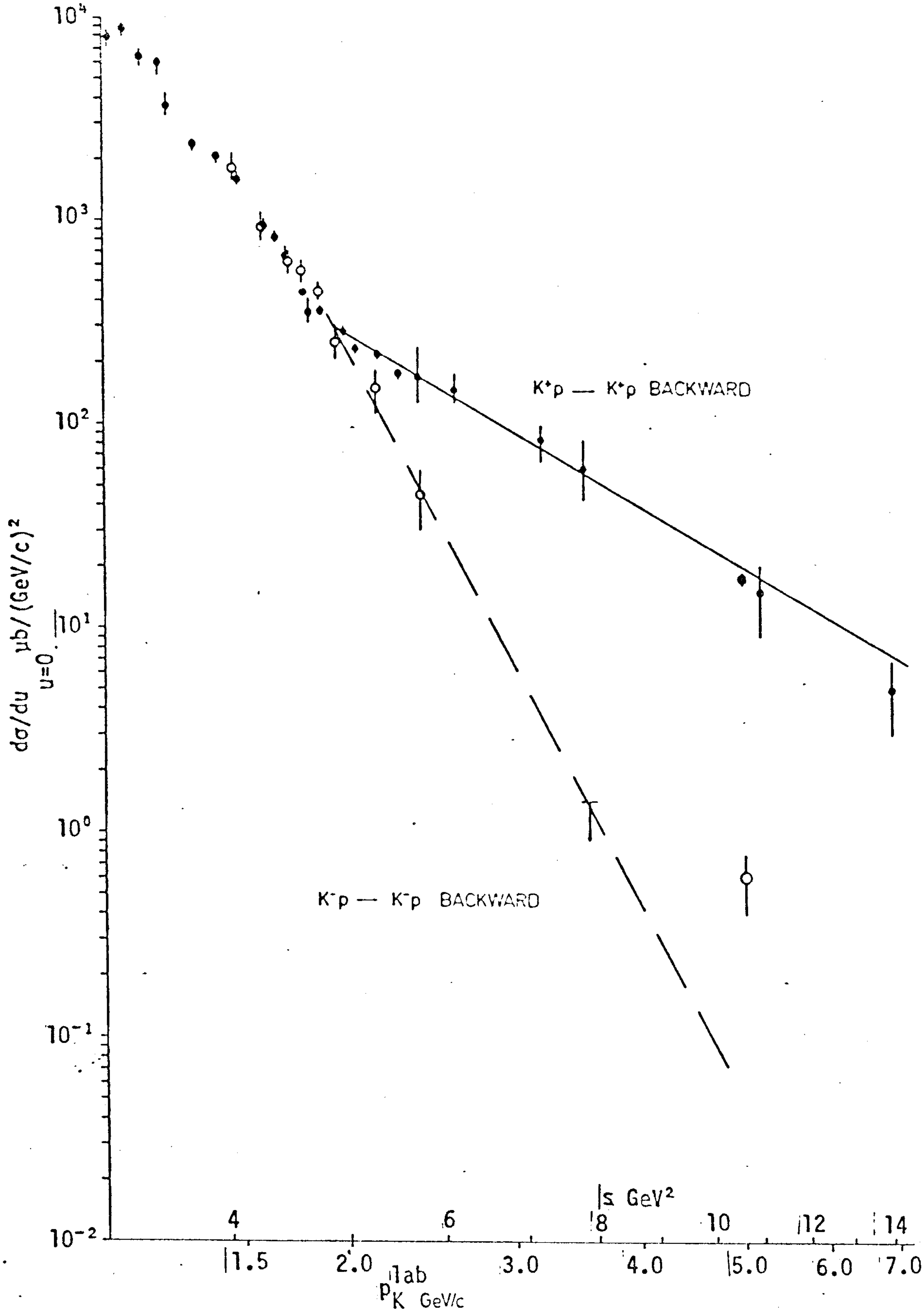
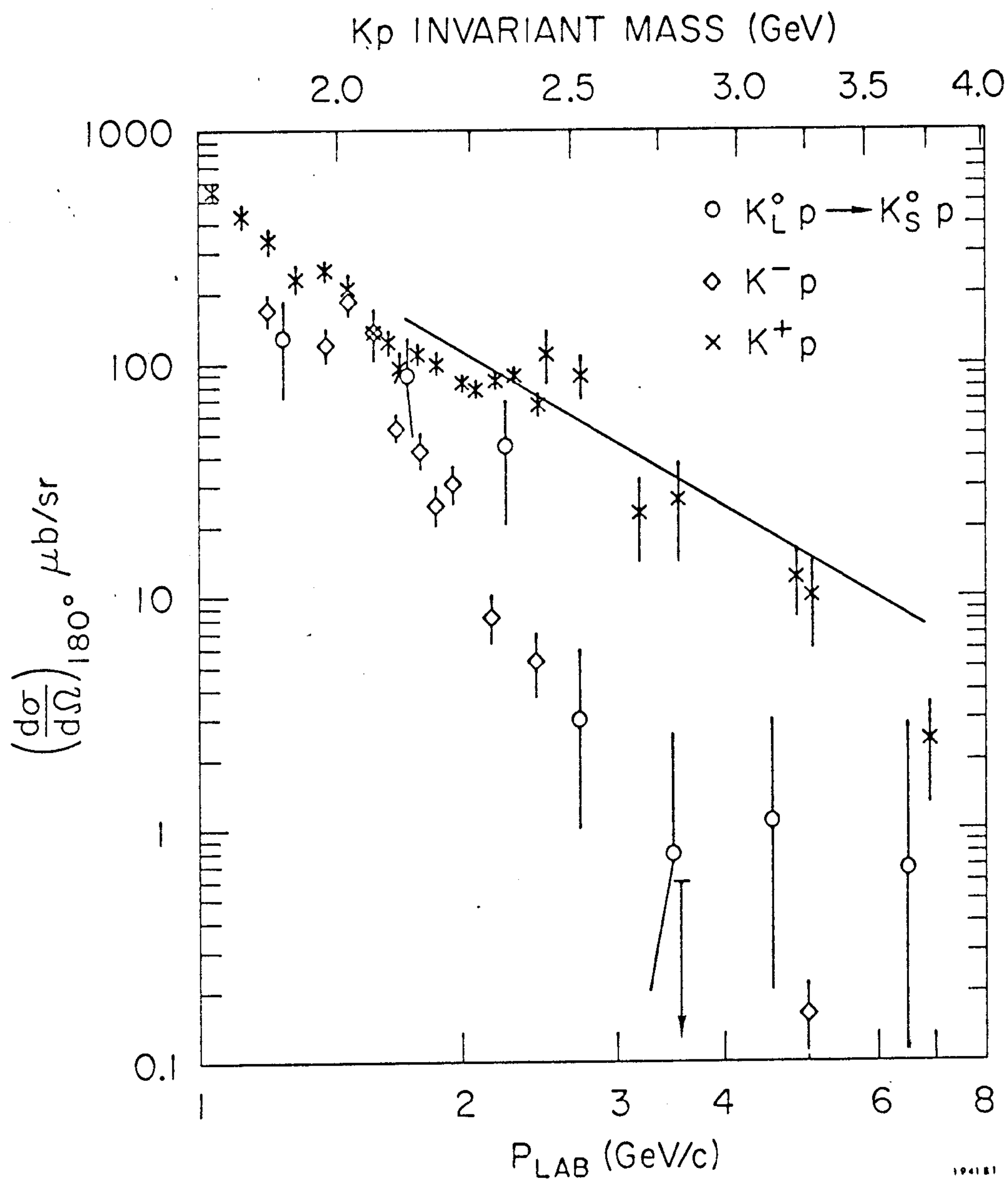

(a)
p̄p — π⁻π⁺
π⁺p — pπ⁺
dσ/dt (μb/GeV²)
-t (GeV²)
(b)
p̄p — π⁻π⁺
π⁻p — pπ⁻
dσ/du (μb/GeV²)
-u (GeV²)
(c)
p̄p — K⁻K⁺
K⁺p — pK⁺
dσ/dt (μb/GeV²)
-t (GeV²)

Fig. 12



10⁴
10³
10²
10¹
10⁰
10⁻¹
10⁻²
dσ/du u=0 μb/(GeV/c)²
K⁺p — K⁺p BACKWARD
K⁻p — K⁻p BACKWARD
s GeV²
4
6
8
10
12
14
1.5
2.0
3.0
4.0
5.0
6.0
7.0
p_K lab GeV/c

Fig.13



Kp INVARIANT MASS (GeV)
2.0
2.5
3.0
3.5
4.0
1000
100
10
1
0.1
$\left(\frac{d\sigma}{d\Omega}\right)_{180°}$ μb/sr
○ $K_L^\circ p \rightarrow K_S^\circ p$
◇ $K^- p$
× $K^+ p$
1
2
3
4
6
8
P_{LAB} (GeV/c)
194181

Fig. 14