RAPPORTEURS TALKS

TWO-BODY HADRONIC REACTIONS

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TWO-BODY HADRONIC INTERACTIONS AND TOTAL CROSS SECTIONS

J. V. Allaby

Introduction

This report is somewhat less wide in scope than the title implies. Since there is a separate report to the Conference specifically on quasi two-body hadronic processes these will not be covered in this paper. Furthermore the analysis of two-body interactions at the lower energies falls more logically into the realm of strange or non-strange resonances which are also covered in separate reports to this Conference, so that generally speaking the resonance region will not be covered, although inevitably some overlap may occur.

The report is divided into the following topics:

1. Forward Elastic Scattering.
2. Forward Charge Exchange Scattering.
3. Backward Scattering.
4. Large-Angle Elastic Scattering; Structure in Differential Cross Sections.
5. Polarization in High Energy Scattering.
6. Inelastic Two-Body Reactions.
7. Total Cross Sections.
8. K^0 Regeneration.

1. Forward Elastic Scattering

The most fully explored region in high energy scattering is the forward elastic scattering. The established features of the differential cross section for $\pi^{\pm}p$, $K^{\pm}p$ and $\bar{p}p$, pp are shown in Fig. 1. This is a compilation due to Morrison and the curves shown for each reaction represent hand-drawn lines through

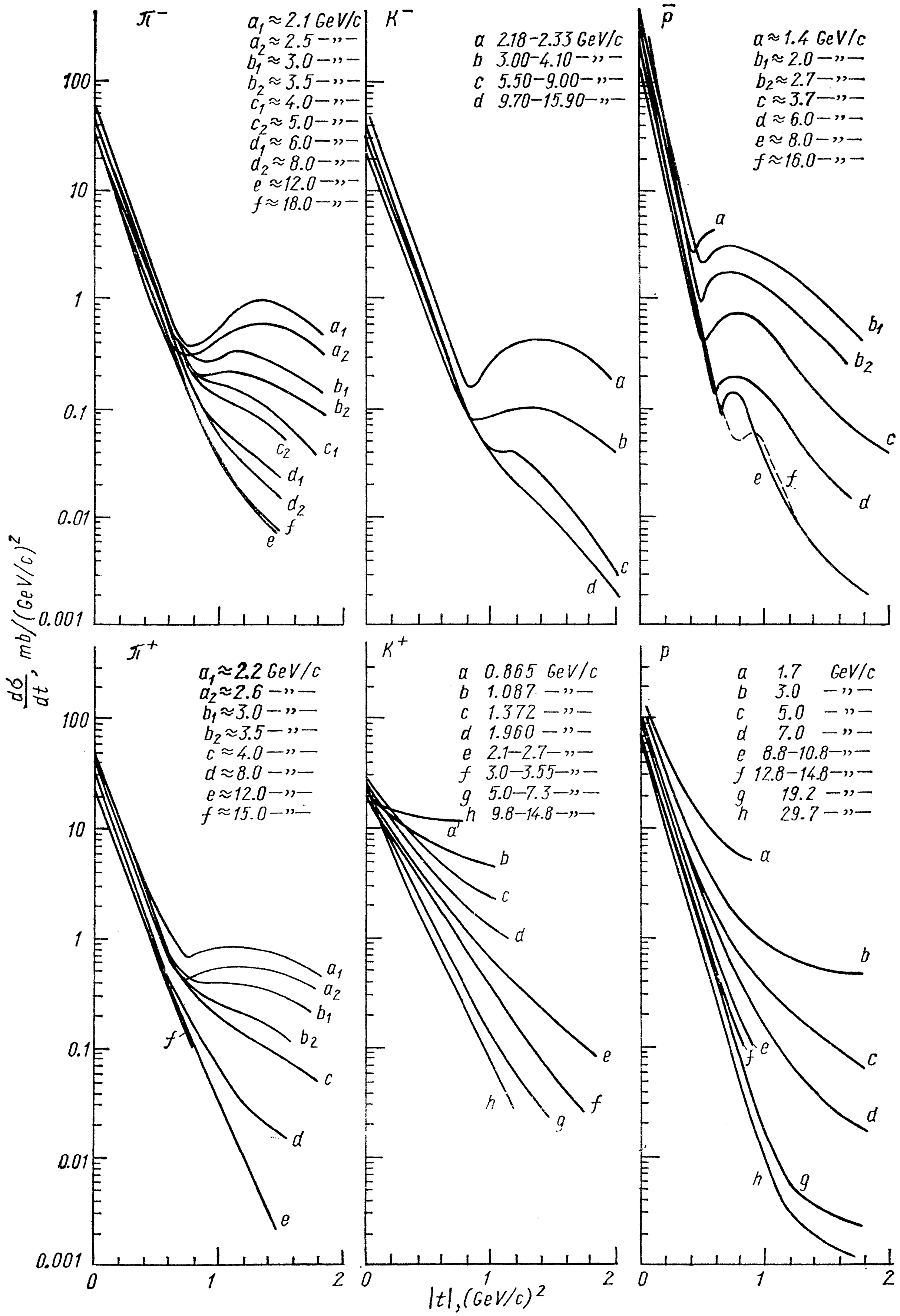


Fig. 1. A compilation showing the general features of forward elastic scattering. The lines are hand-drawn through the data available at various incident momenta.

the data of various incident momenta, out to four-momentum transfer squared, $|t|$, of about 1.5 GeV^2. The established features of the elastic scattering are

a) a sharp forward peak for all these reactions

b) for K^+p and pp: smooth behaviour for $|t| \leqslant 1.2$ GeV^2 and «shrinkage» of the forward peak

c) for K^-p, $\pi^+ p$, pp: the presence of a dip at $|t| \approx 0.6—0.8$ GeV^2 followed by a secondary maximum which decreases in size as the incident momentum increases.

New results on K^-p elastic scattering at high energies have been presented by the ABCLV Collaboration [1], who have studied 16,000 kinematically fitted K^-p elastic scattering events at 10.1 GeV/c, and by Miller et al. [2] who have analysed about 5500 events of K^-p elastic scatters at 14.25 GeV/c. The results of the ABCLV Collaboration are shown in Fig. 2, where the new data have been compared with data from counter experiments at nearly energies [3]. The fitted line is formed from the sum of two exponentials and the change of slope occurs near $|t| = 0.8$ GeV^2, corresponding to the dip seen at lower incident momenta. The fitted line shown extrapolates to a value below the optical point. The authors have studied the small $|t|$ data carefully and have fitted the data with both simple and quadratic exponential forms over different $|t|$ ranges, observing that the slope is dependent on the $|t|$ range used. Their best fit over the small $|t|$ range 0.06—0.22 GeV^2 using a quadratic exponential form leads to a value of $(d\sigma/dt)_{t=0} = 25.0 \pm 0.3$ mb/GeV^2, which is equal within errors to the optical point of 25.8 ± 0.5 mb/GeV^2.

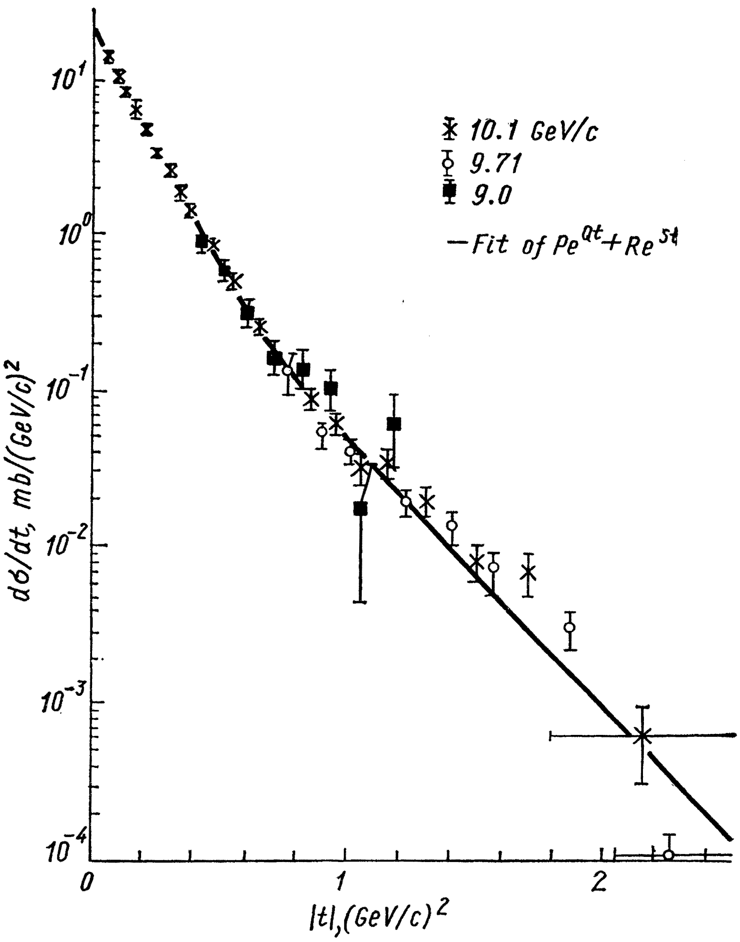


Fig. 2. K^-p elastic scattering at 10.1 GeV/c from the bubble chamber experiment of the ABCLV Collaboration [1] compared with results from counter experiments [3] at nearby momenta. The fitted line is the sum of two exponentials with slopes $Q = 8.2 \pm 0.1$ GeV^{-2} and $S = 3.7 \pm 0.1$ GeV^{-2}, respectively.

In a communication to this Conference, Lasinski et al. [4] have made a redetermination of the diffraction slopes of elastic scattering using all the data currently evailable. They have fitted the forward scattering with the conventional exponential form:

$$\ln\left(\frac{d\sigma}{dt}\right) = A(k) + B(k)t + C(k)t^2 \tag{1}$$

in order to determine the slope $B(k)$ in the region $0.02 \leqslant |t| \leqslant 0.15$ GeV^2, as a function of the incident momentum k. When the differential cross section data were sufficiently good in this $|t|$ range they have fitted without the quadratic term.

Whenever necessary to obtain a significant result, a larger range of $|t|$ was fitted but including the quadratic term. They claim to have studied carefully effects of variation of cut-off value of $|t|$ for the fits. The authors in their earlier work have related «bumps» in $B(k)$ to the known resonances. In the communication to this Conference they stress that the «background» in $B(k)$ under the resonances together with the higher energy data give indication for shrinkage of the diffraction peak. Their results for π^+p and π^-p are shown in Figs. 3*a* and 3*b*. Their argument is essentially that the minimum values of $B(k)$ between the «bumps» at low energies should be used in establishing the asymptotic behaviour of $B(k)$, since this is to be interpreted as «background» and in the duality picture equated to the contribution of the Pomeranchuk exchange. Within this assumption the argument is valid, but only data at higher energies, equivalent to that already produced for *pp* scattering can clarify the picture.

There have been several new results brought to this Conference on the measurement of the ratio α of real to imaginary scattering amplitudes in the forward direction. Results on the measurement of α for π^-p scattering between 1.95 and 5.65 *GeV/c* are shown in Fig. 4, from the contribution of Govorun et al. [5]. The new data are compared with older data at higher energies [6] and with dispersion relation calculations [7]. The new data show no deviation from the theoretically

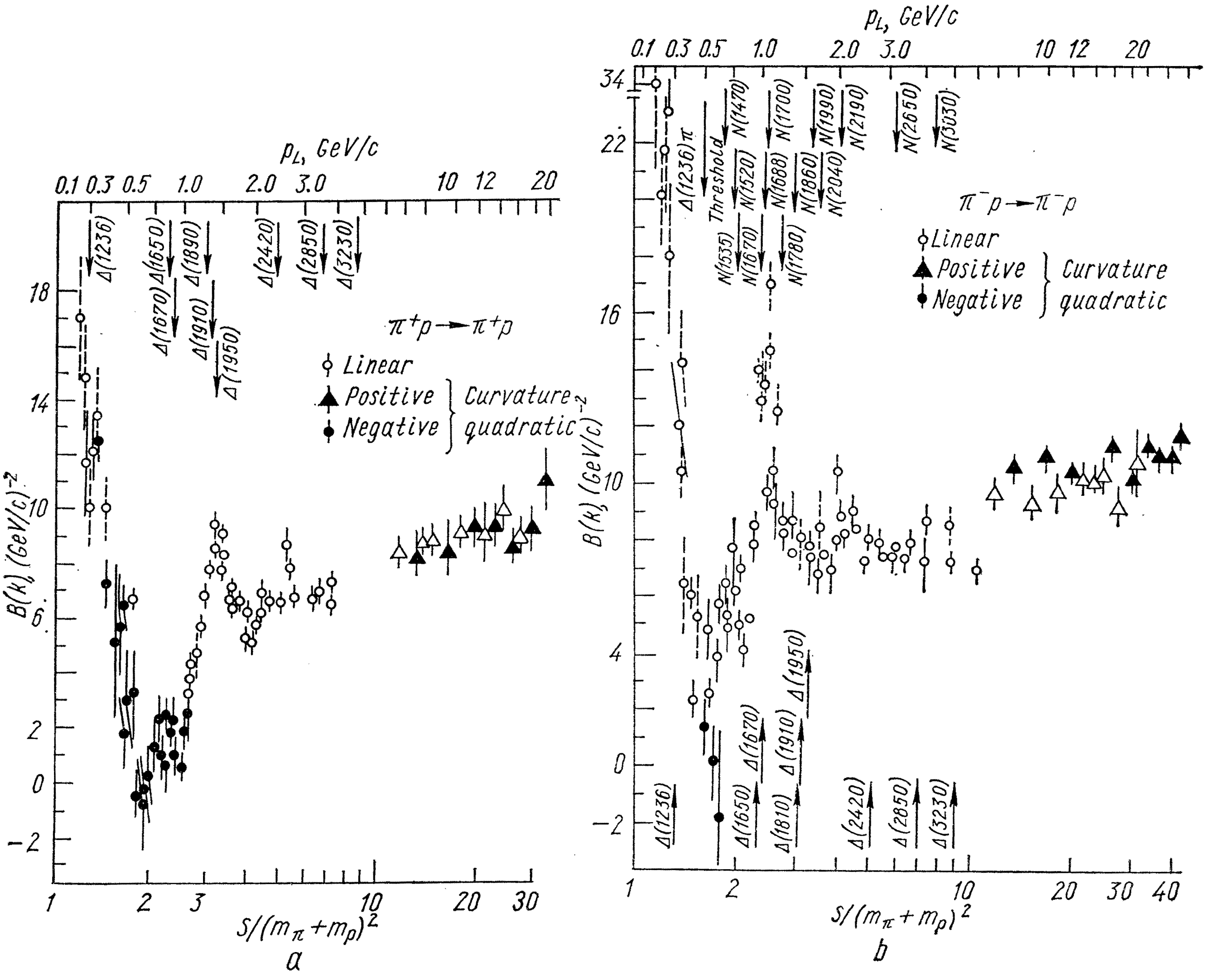


Fig. 3. Values of the coefficient $B(k)$, the logarithmic slope of $\pi^{\pm}p$ elastic scattering near the forward direction, from the analysis of Lasinski et al. [4]. The abscissa is the square of the centre-of-mass energy divided by the square of the sum of the pion and proton masses. 3*a* shows the results for π^+p and 3*b* shows the results for π^-p. (Dashed error flags for 3-points fits).

calculated values of α from dispersion relations, in agreement with the conclusion from the older data.

Fig. 5 shows the angular distribution, near the forward direction, for K^-p elastic scattering at 4.2 *GeV/c* communicated by Bellm et al. [8]. This is a bubble chamber experiment. By careful analysis of the Coulomb-nuclear interference region, they obtained a value for the ratio of real/imaginary amplitudes of $\alpha = 0.19 \pm 0.06$. Spin flip has of course been neglected.

Jain et al. [10] have obtained a value for $|\alpha|$ by a comparing extrapolated small-angle data for K^-p scattering at 12.7 *GeV/c* with the optical point. Although this method is not so reliable as the Coulomb-nuclear interference experiments they quote a value of $\alpha = 0.76^{+0.08}_{-0.21}$.

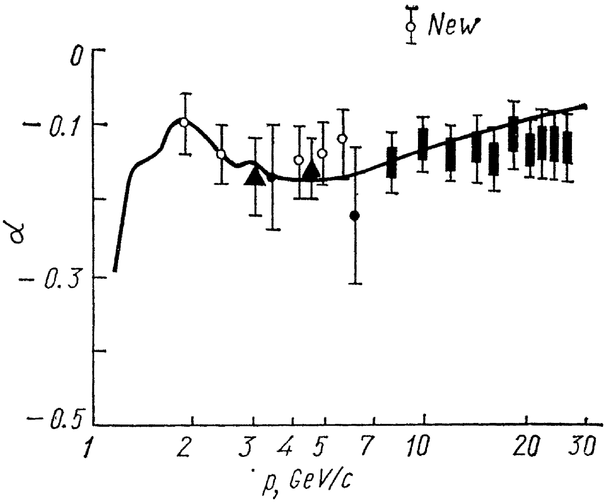


Fig. 4. New results from Govorun et al. [5] on the ratio of real to imaginary scattering amplitudes for π^-p elastic scattering compared with previous data [6]. The curve indicated is from the dispersion relation calculation of Höhler et al. [7].

The experiment of the Dubna group on *pp* and *pd* small-angle scattering in the range 8—70 *GeV/c* was described in an invited paper by Nikitin. Nevertheless, for the sake of completeness I include the results in this report. Fig. 6*a* shows the results of this experiment (Bartenev et al. [11]) on the value of α for proton — proton scattering compared with the results already known at lower energy [12] and with the dispersion relation calculation of Söding [13]. Since the value of the *pp* total cross section was assumed in the analysis, the broken line error bars indicate the change in α_{pp} produced by varying $\sigma_{tot}(pp)$ by $\pm$ 1 *mb*. Fig. 6*b* shows the results from the same group on *pd* scattering. The values of α_{pd} are compared with older data [14] and with the dispersion relation calculation of Bialkowski and Pokorski [15].

2. Forward Charge Exchange Scatte;ing

New data were presented on *np* charge exchange by Miller et al. [16] and Engler et al. [17]. The former experiment used a continuous spectrum neutron beam and used detection of the forward proton and time of flight on the slow recoil neutron to obtain its momentum and angle. This technique allowed simultaneous measurements for the range of momenta 3—12 *GeV/c*. The data at small angles are shown in Fig. 7 *. The forward peak is clearly seen at all momenta with the characteristic width $\approx m_\pi^2$. The data were fitted by the expression

$$\frac{d\sigma}{dn} = As^{2\alpha(u)-2} \tag{2}$$

The values of $\alpha_{eff}(u)$ are shown in Fig. 8. Note that $\alpha_{eff}(u)$ falls towards —0.5 but turns up sharply at small $|u|$.

* Miller et al. refer to the reaction $np \to pn$ as backward elastic scattering and thus use the variable u to describe the angular distribution. Other papers discussed use the variable t to describe the charge exchange. In both casses one is describing the reaction in which a neutron enters a hydrogen target and a proton comes out in the forward direction, and thus either terminology can be used.

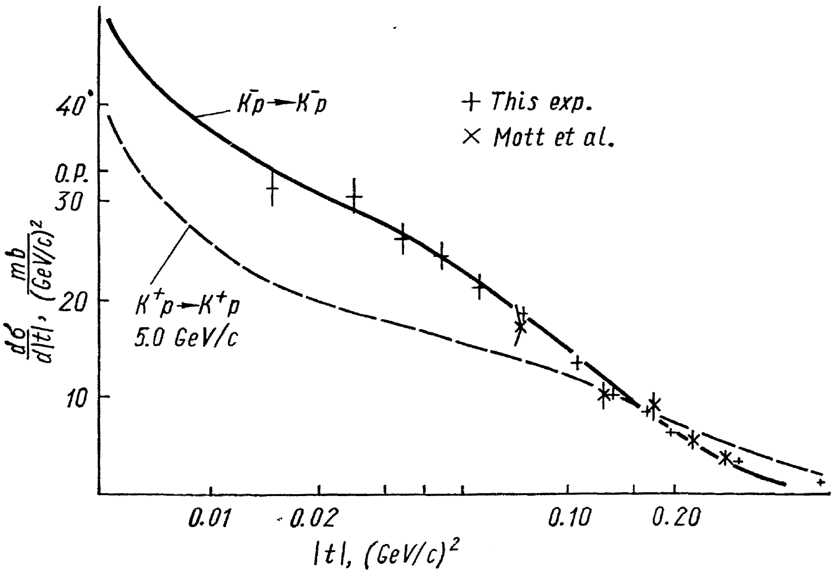


Fig. 5. The differential cross section for $K^{-}p$ elastic scattering in the Coulomb — nuclear interference region from the bubble chamber experiment of Bellm et al. [8] at 4.2 *GeV/c*. The other data are from Mott et al. [9]. The solid curve is the best fit leading to the quoted value of $\alpha = 0.19 \pm 0.06$. The broken line is the fit obtained by the same group for $K^{+}p$ elastic scattering at 5.0 *GeV/c* which gave a value of $\alpha = -0.58 \pm 0.11$.

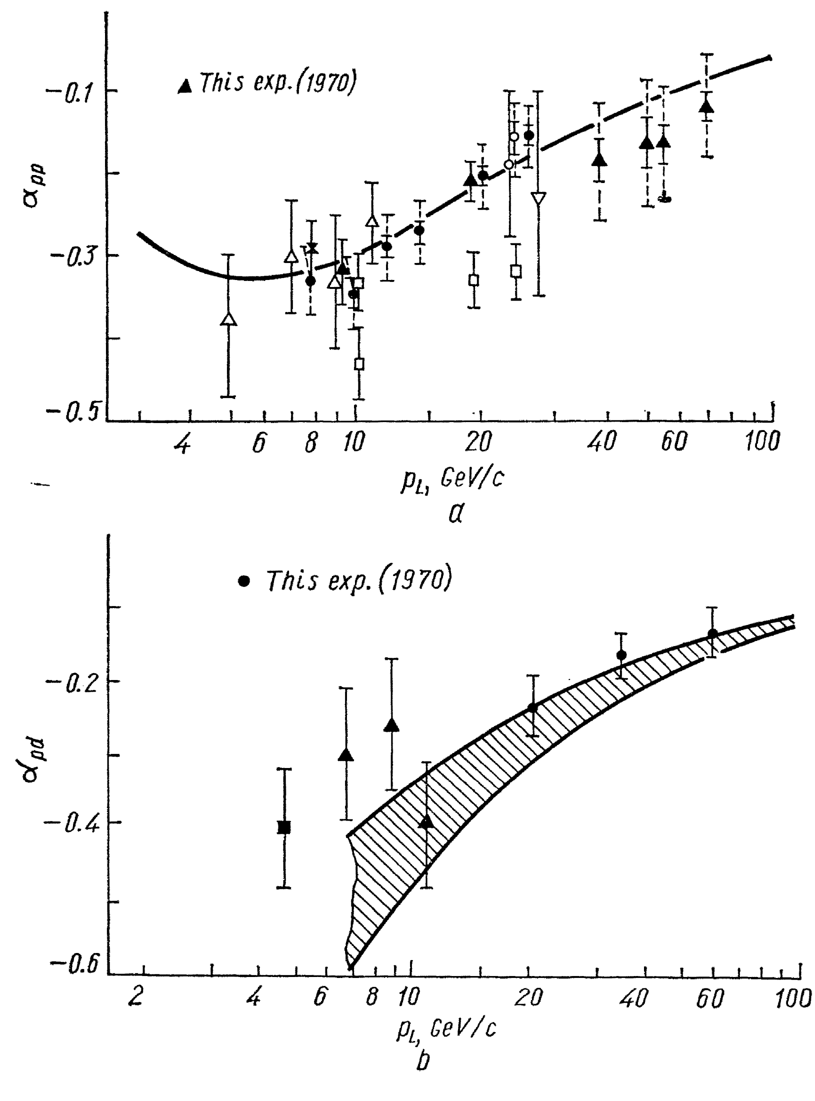


Fig. 6. *a*) Results on the ratio of real to imaginary scattering amplitudes for $p - p$ elastic scattering up to 70 *GeV/c*, including the new results of the Dubna group [11]. The broken line extension to the error bars on the new data represents the change in α caused by varying the assumed value of σ_{tot} (pp) by ± 1 *mb*. The curve is the result of the dispersion relation calculation of Söding [13].

b) Results on the ratio of real to imaginary scattering amplitudes for $p - d$ elastic scattering up to 60 *GeV/c*. The three high-energy points are the new results of the Dubna group [11]. The shaded area represents the theoretical prediction from the dispersion relation calculation of Bialkowski and Pokorski [15].

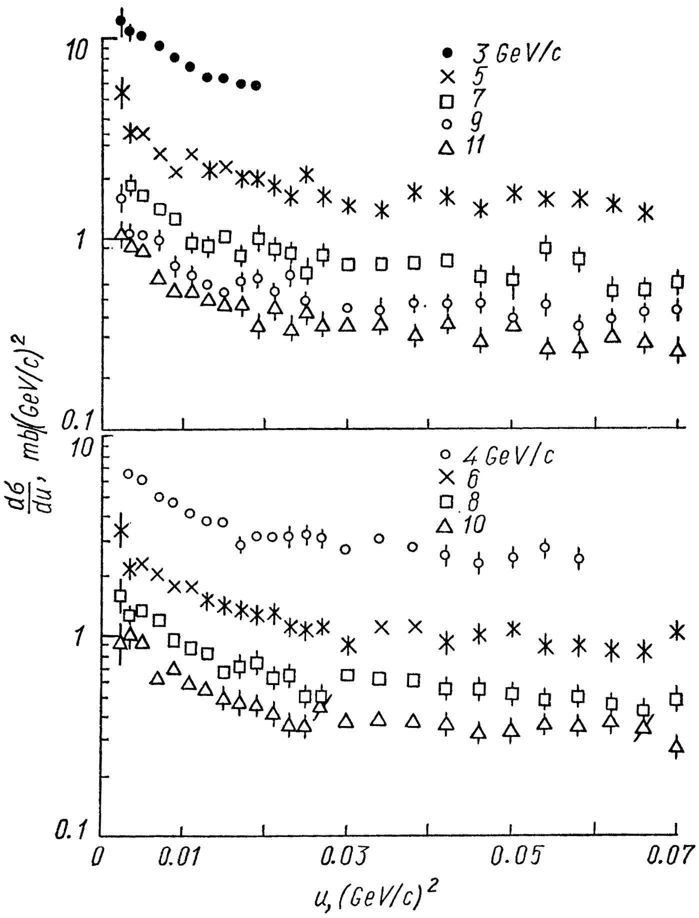


Fig. 7. Data on forward charge exchange scattering of neutrons on protons from 3—11 *GeV/c* by Miller et el. [16].

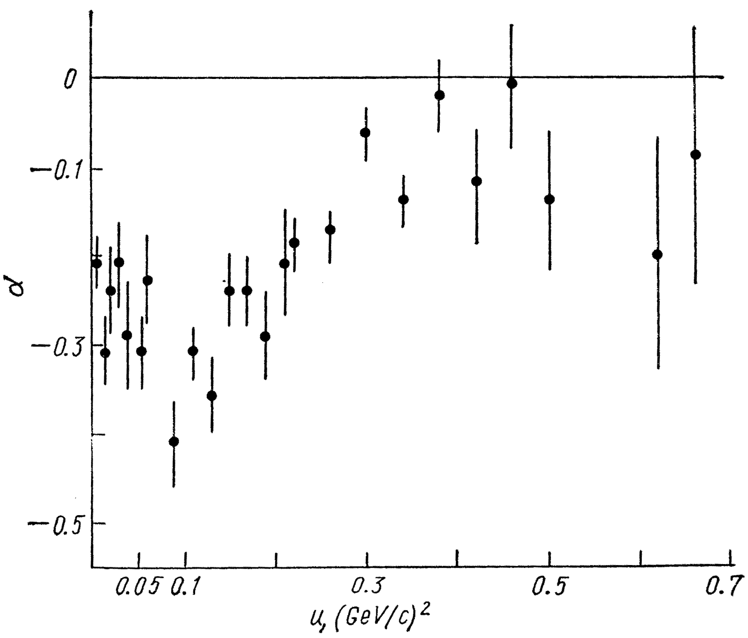


Fig. 8. The values of $\alpha_{eff}(u)$ from a fit to the *np* charge exchange data by Miller et al. [16].

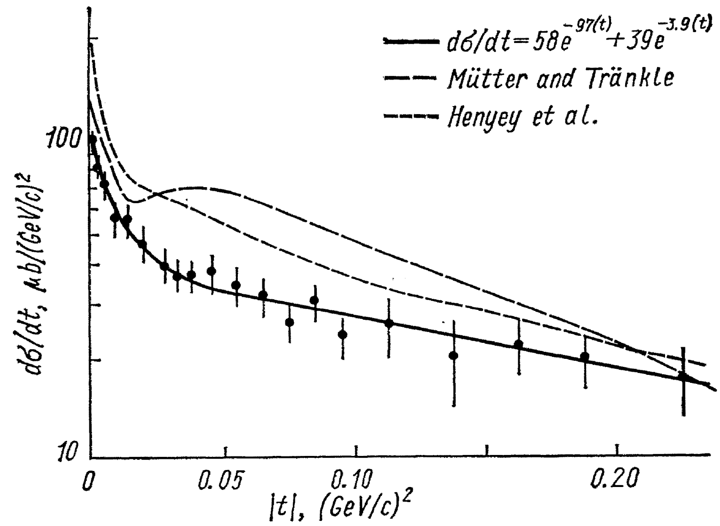


Fig. 9. The results on forward np charge exchange at 19 GeV/c from the experiment of Engler et al. [17]. The curves are theoretical predictions [19].

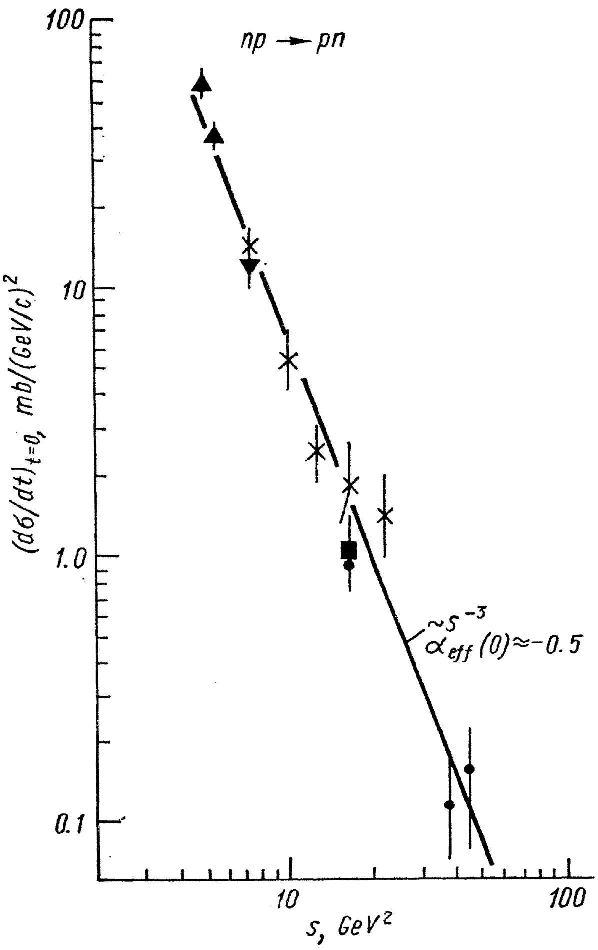


Fig. 10. A compilation of $(d\sigma/dt)_{t=0}$ for np charge exchange scattering [16, 18, 20] showing an s^{-3} dependence (where s is the square of the centre-of-mass energy).

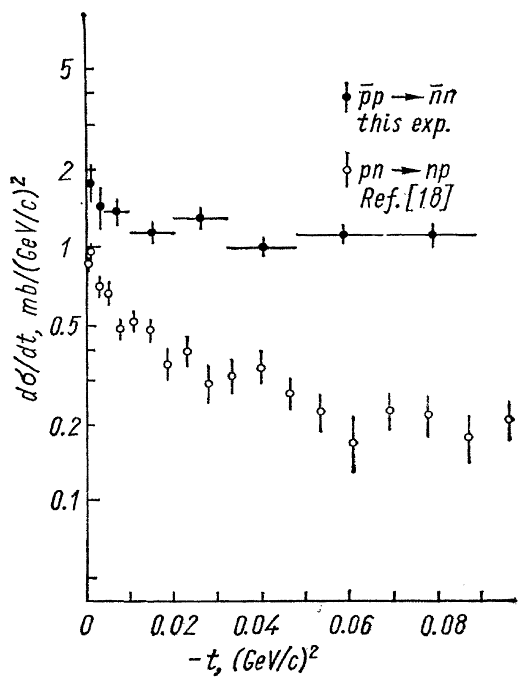


Fig. 11. The results from Beusch et al. [21] on the reaction $\bar{p}p \to \bar{n}n$ at 8 GeV/c compared with the data of Manning et al. [18] on np charge exchange at the same momentum.

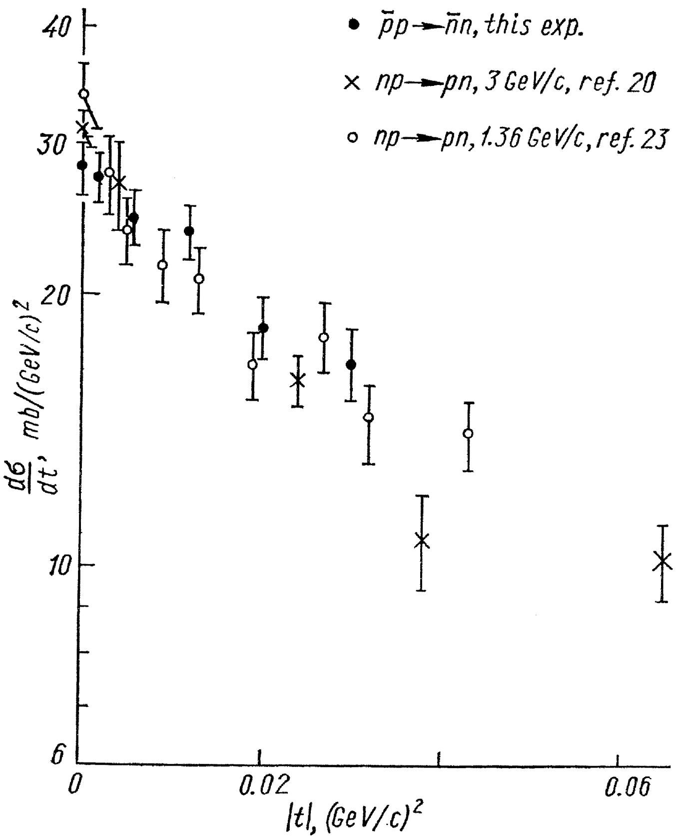


Fig. 12. The results from Atwood et al. [22] on the reaction $\bar{p}p \to \bar{n}n$ at 1.80 GeV/c compared with data on np charge exchange at nearby momenta [20, 23].

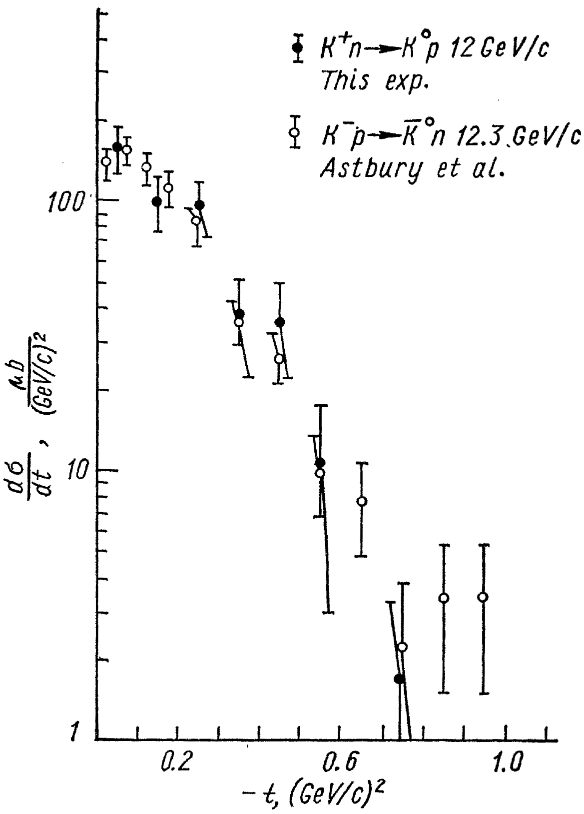


Fig. 13. A comparison between $K^+n \to K^0p$ at 12 GeV/c from the experiment of Firestone et al. [24] and $K^-p \to \bar{K}^0n$ at 12.3 GeV/c from Astbury et al. [25].

The experiment of Engler et al. used the technique of double charge exchange scattering which was used earlier by Manning et al. [18], and data were taken at 8, 19 and 24 GeV/c. The results at 8 GeV/c are in agreement with Manning et al. Fig. 9 shows the data at 19 GeV/c, demonstrating a clear forward peaking which is essentially the same as at the lower energies. The data of both new experiments and of previous measurements [18, 20], for the value of $d\sigma/dt$ at $t = 0$ are shown in Fig. 10. Although there is some normalization difference in the data at 8 GeV/c it seems that the new results show an s dependence $\sim s^{-3}$, which corresponds to $\alpha_{eff}(0) = -0.5$.

The np charge exchange is closely related (by line reversal) to the charge exchange reaction $\bar{p}p \to \bar{n}n$. An interesting question is whether a similar sharp forward peak exists in this reaction. The CERN — ETH — Imperial College group (Beusch et al. [21]) have communicated data at 8 GeV/c shown in Fig. 11, compared with the np charge exchange data of Manning et al. [18]. The authors conclude that a peak of the same relative height as the forward peak in $np \to pn$ is absent but that rapid variations by as much as 0.5 mb/GeV^2 near $t = 0$ are not excluded. Atwood et al. [22] presented the data shown in Fig. 12 at 1.80 GeV/c compared with data on $np \to pn$ at nearby momenta [20, 23]. Here the data are more suggestive of a forward peak. The authors conclude that there is a forward peak but that it is relatively less prominent than the np charge exchange peak. One should stress perhaps that Beusch et al. have only analysed 10% of their data and so they should be able to draw a firm conclusion when the analysis is complete. I conclude myself that a small peak does exist and one must study why it is smaller in $\bar{p}p \to \bar{n}n$ than in $np \to pn$.

Interesting results were presented by Firestone et al. [24] on the charge exchange reaction $K^+n \to K^0p$ at 12 *GeV/c*. Their data are shown in Fig. 13 compared with $K^-p \to K^0n$ data at 12.3 *GeV/c* [25]. The similarity is impressive, and is evidence for strong exchange degeneracy. The optical theorem point for the $K^+n \to K^0p$ reaction is calculated to be $\frac{d\sigma}{dt}(\mathrm{Im}f)_{t=0} = 4.6 \pm 8.2$ $\mu b/GeV^2$ from the difference in K^+p and K^+n total cross sections. The extrapolated forward scattering cross section is 218 ± 18 $\mu b/GeV^2$. Thus the amplitude is dominated by its real part, in agreement with lower-energy data. This is supporting evidence for the strong exchange degeneracy of the ρ and A_2 trajectories.

3. Backward Scattering

Data on the backward charge exchange $\pi^-p \to n\pi^0$ were presented to the Conference by Chase et al. [26]. Preliminary results have already been published. The final data now agree at 6 *GeV/c* with the results from the Cornell group in the region of the dip at $u \approx -0.25$. The filling-in of the dip had been caused by a background effect which has been removed in the final analysis. The Cornell group, (Boright et al. [27]) have presented new data at 5.9, 10.1 and 13.8 *GeV/c* for the same reaction, which is shown in Fig. 14. The strong dip at $u \approx -0.25$ GeV^2 is followed by a broad maximum at $u \approx -0.7$ GeV^2. Boright et al. have also reported the backward cross section for the reaction $\pi^-p \to n\eta^0$ at 5.9 *GeV/c*. The result is $\sigma_{\text{backward}}(\pi^-p \to n\eta^0) = 0.91 \pm 0.27$ μb where the data have been integrated from $u_{\max}$ to $u = -2$ GeV^2. Treating the π^0 data in the same way the authors obtain the ratio

$$R = \frac{\sigma(\pi^-p \to n\eta^0)}{\sigma(\pi^-p \to n\pi^0)} = 0.45 \pm 0.11. \quad (3)$$

Assuming that N_α exchange dominates both backward charge exchange and backward eta production, pure *SU* (3) gives the ratio of the coupling constants as:

$$\frac{g^2_{\eta NN}}{g^2_{\pi NN}} = R = {}^1/_3(4\alpha - 1)^2, \quad (4)$$

where α is the fraction of *F* type coupling in pure *SU* (3). The above results then yield $\alpha = 0.54 \pm 0.04$.

New results have been communicated to the Conference on the backward scattering $\pi^-n \to n\pi^-$ by Babayev et al. [28], at 23, 30 and 40 *GeV/c*. The *u* range covered is small

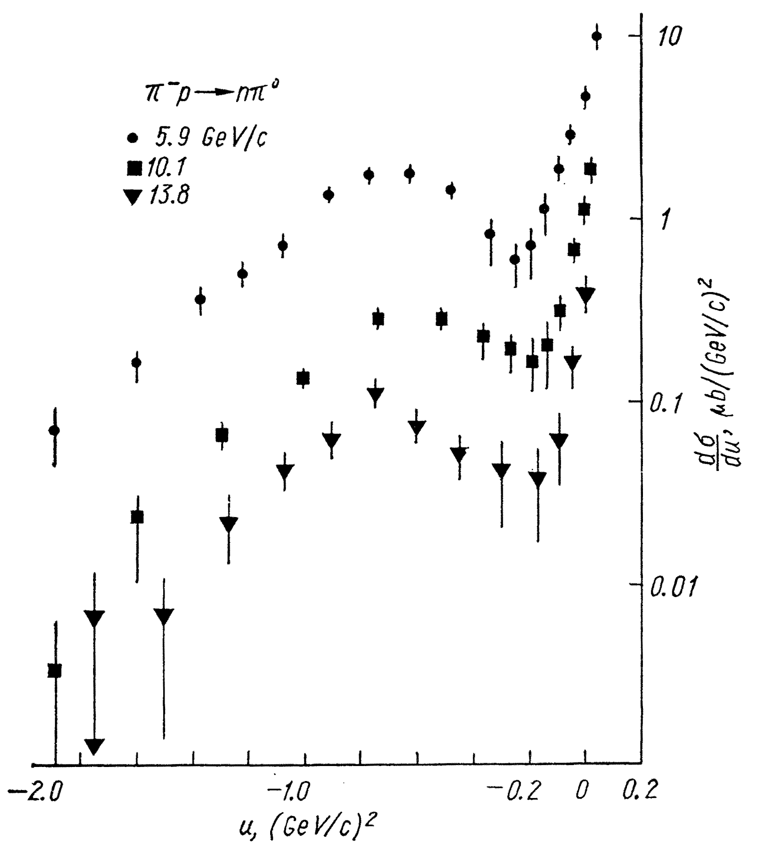
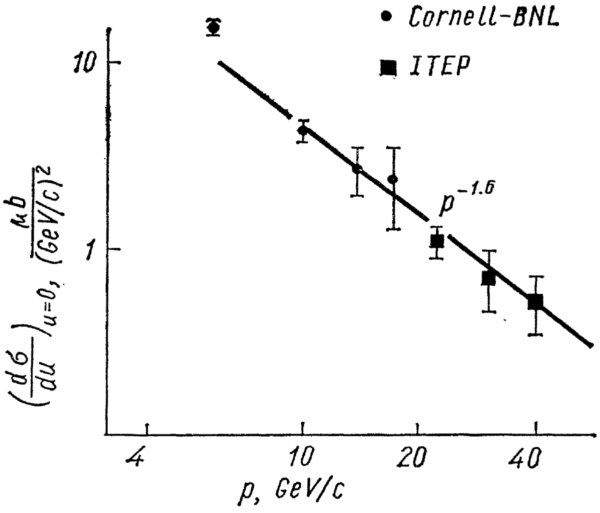


Fig. 14. Results from Boright et al. [27] on the backward charge exchange reaction $\pi^-p \to n\pi^0$ at 5.9, 10.1 and 13.8 *GeV/c*.

Fig. 15. Values of $(d\sigma/du)_{u=0}$ from the results of the ITEP experiment (Babayev et al. [28]) on backward π^-n scattering compared with the data of the Cornell — *BNL* group on π^+p backward scattering [29].



but there is a strong backward peak. The momentum dependence of $(d\sigma/du)_{u=0}$ is shown in Fig. 15 for the new results and the older data from *BNL* [29]. The straight line on this log-log plot represents the power law fall-off of $\sim p^{-1.6}$, which suggests that only Δ exchange is surviving at the highest energies.

4. Large Angle Scattering. Structure in Differential Cross Sections

In this section, data which extends beyond the diffraction peak will be discussed, although usually the forward diffraction peak is at least partially measured.

Fig. 16 shows the bubble chamber result, communicated to this Conference, by Baton and Laurens [30] on the full angular distribution of π^-p scattering at 2.77 *GeV/c*. For comparison, the polarization data of Andersson et al. [31] at 2.74 *GeV/c* for the same reaction is shown on the same figure. The dip in the differential cross section at $|t| \approx 0.8$ GeV^2 is the same as mentioned in the beginning of this report. The second dip at $|t| \approx 2.8$ GeV^2 is well established in both π^-p and π^+p and persists at higher energies. However, the third dip at $|t| \approx 3.6$ GeV^2 is new. The dip could be interpreted as a backward scattering phenomenon since the value of $|u|$ is ≈ 0.60 GeV^2 but there is no structure at such u value at higher energies. It is tempting to associate the two dips at $|t| = 2.8$ GeV^2 and $|t| = 3.6$ GeV^2 with the maxima of polarization seen in the Andersson data although, especially for the latter $|t|$ value, the statistical precision of P_0 is poor.

Fig. 17 shows the elegant new data communicated to this Conference by Rust et al. [32] on π^+p scattering at 5 *GeV/c*. Almost all the angular distribution has been covered. In the figure the backward data of Baker at al. and Chandler et al. [33] have been used to complete the full curve. Fig. 18 shows the same data compared with a Regge model due to Auvil et al. [34] which combines multi-Pomeron exchange for the forward peak and shoulder, u channel baryon exchanges for the backward peak-dip structure, and the fixed kinematic cut in the baryon exchange amplitudes proposed by Halzen et al. [35] to produce a fit to the data. The pronounced dip at $t = -2.8$ GeV^2 is explained as a $t - u$ channel exchange interference effect.

Fig. 19 shows new data covering most of the angular distribution for K^+p elastic scattering at 4 and 5 *GeV/c* communication to this Conference by Rust et al. [36]. Although the statistical precision is not quite good enough to discern any

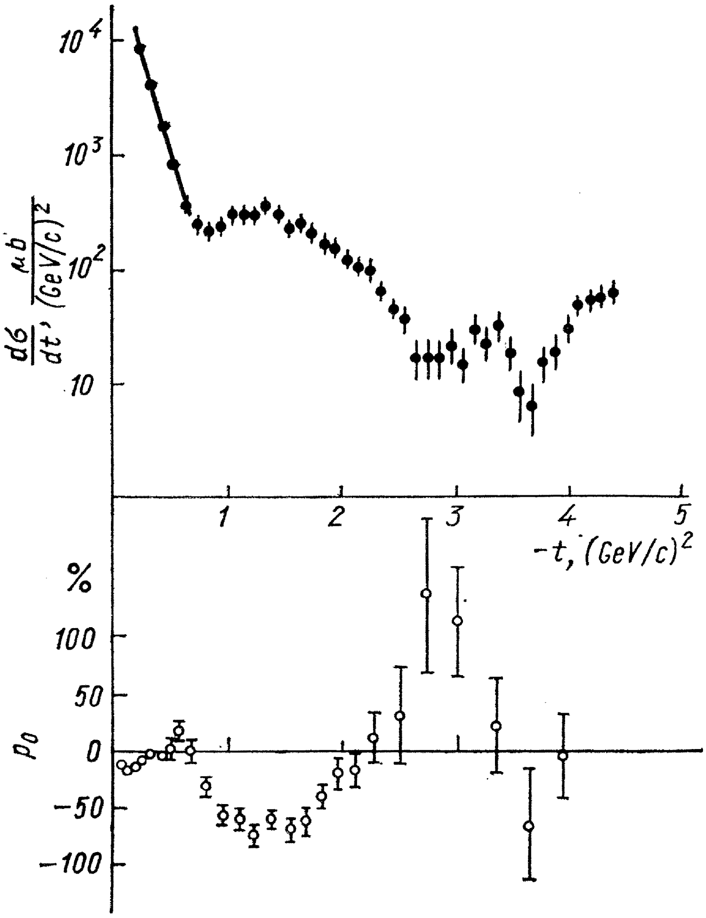


Fig. 16. The full angular distribution of $\pi^- p$ elastic scattering at 2.77 GeV/c from Baton and Laurens [30] compared with the polarization data at 2.74 GeV/c from Andersson et al. [31], on the same reaction.

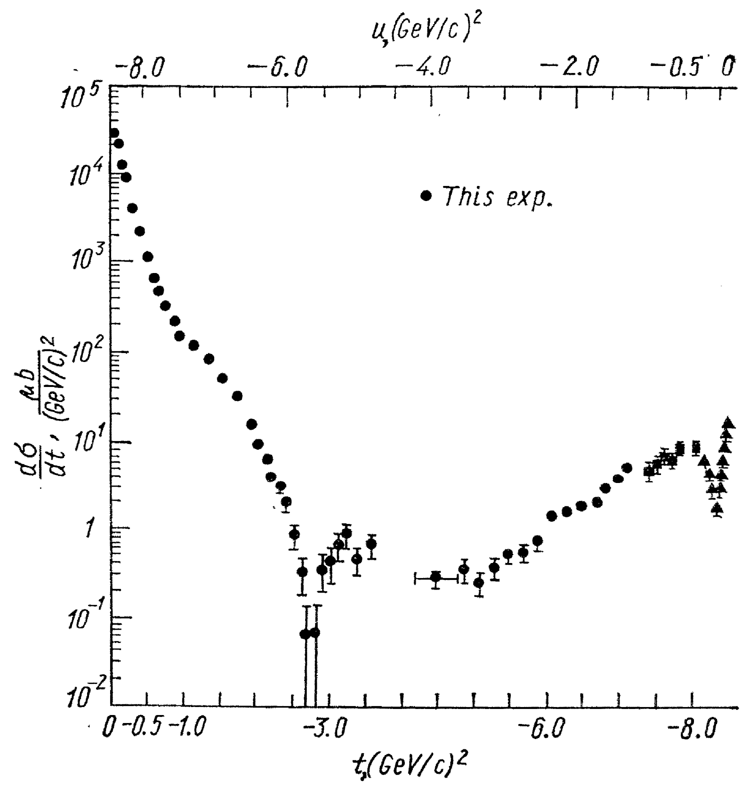


Fig. 17. The angular distribution of $\pi^+ p$ elastic scattering at 5 GeV/c. The new data are from Rust et al. [32]. The data near the backward direction are from Baker et al. and Chandler et al. [33].

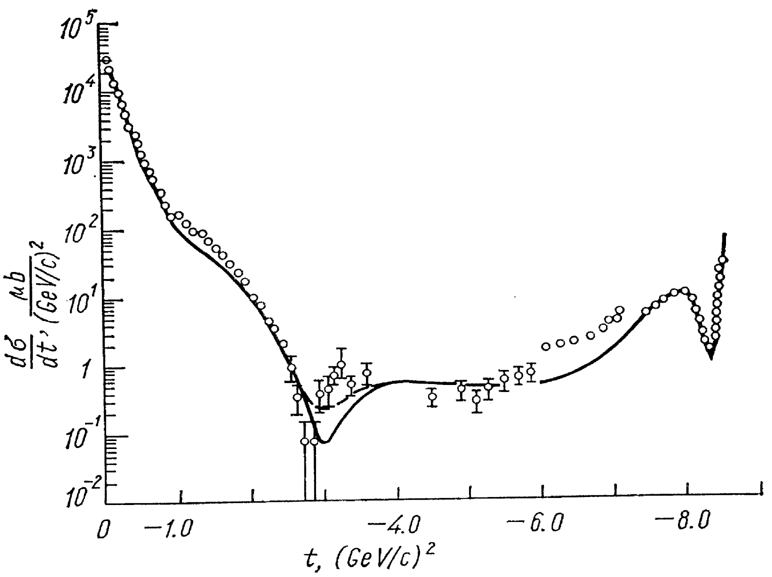


Fig. 18. A theoretical fit to the data shown in Fig. 17 by Auvil et al. [34].

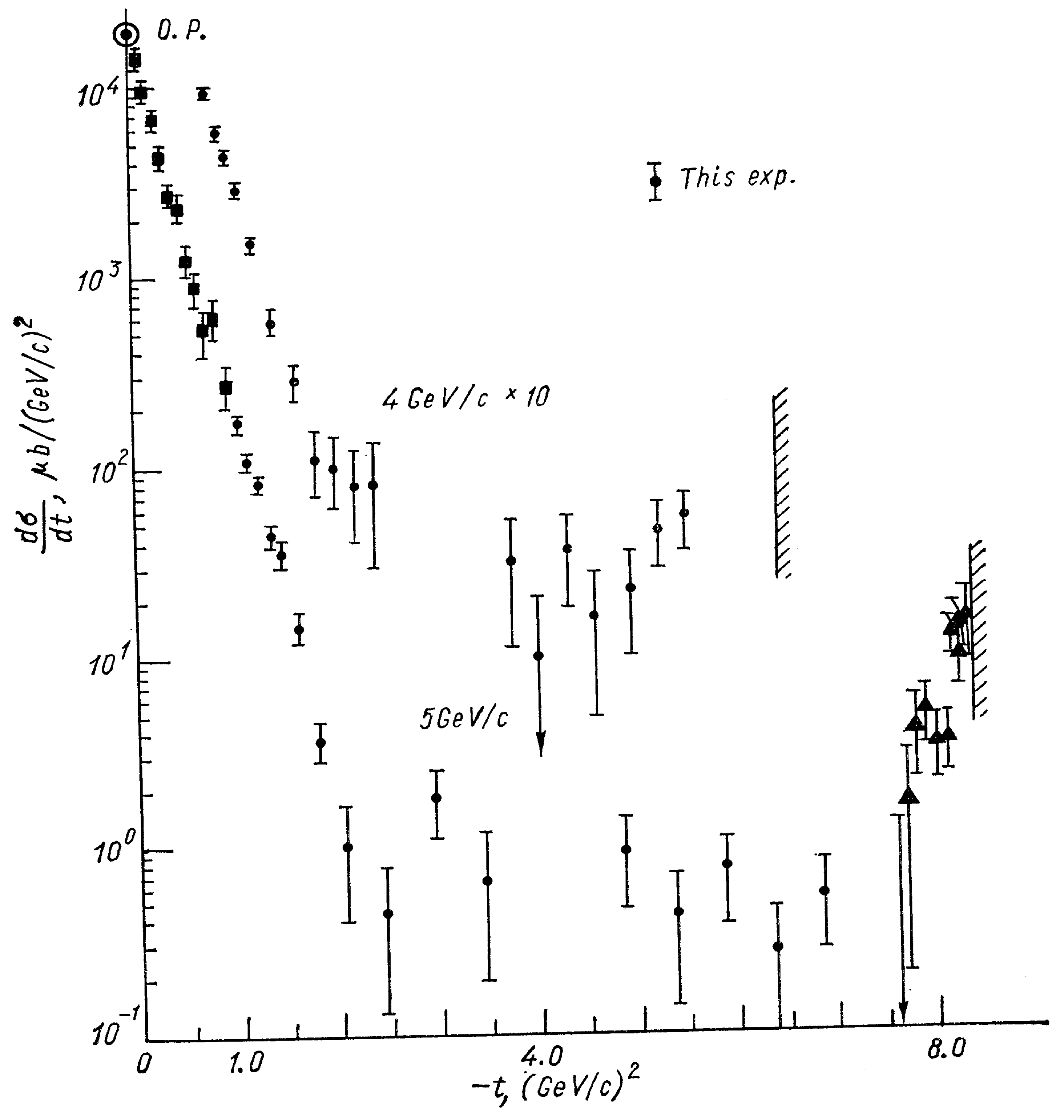


Fig. 19. New results on K^+p elastic scattering by Rust et al. [36] at 4 and 5 GeV/c. Note that the 4 GeV/c data have been displaced by one decade for reasons of clarity.

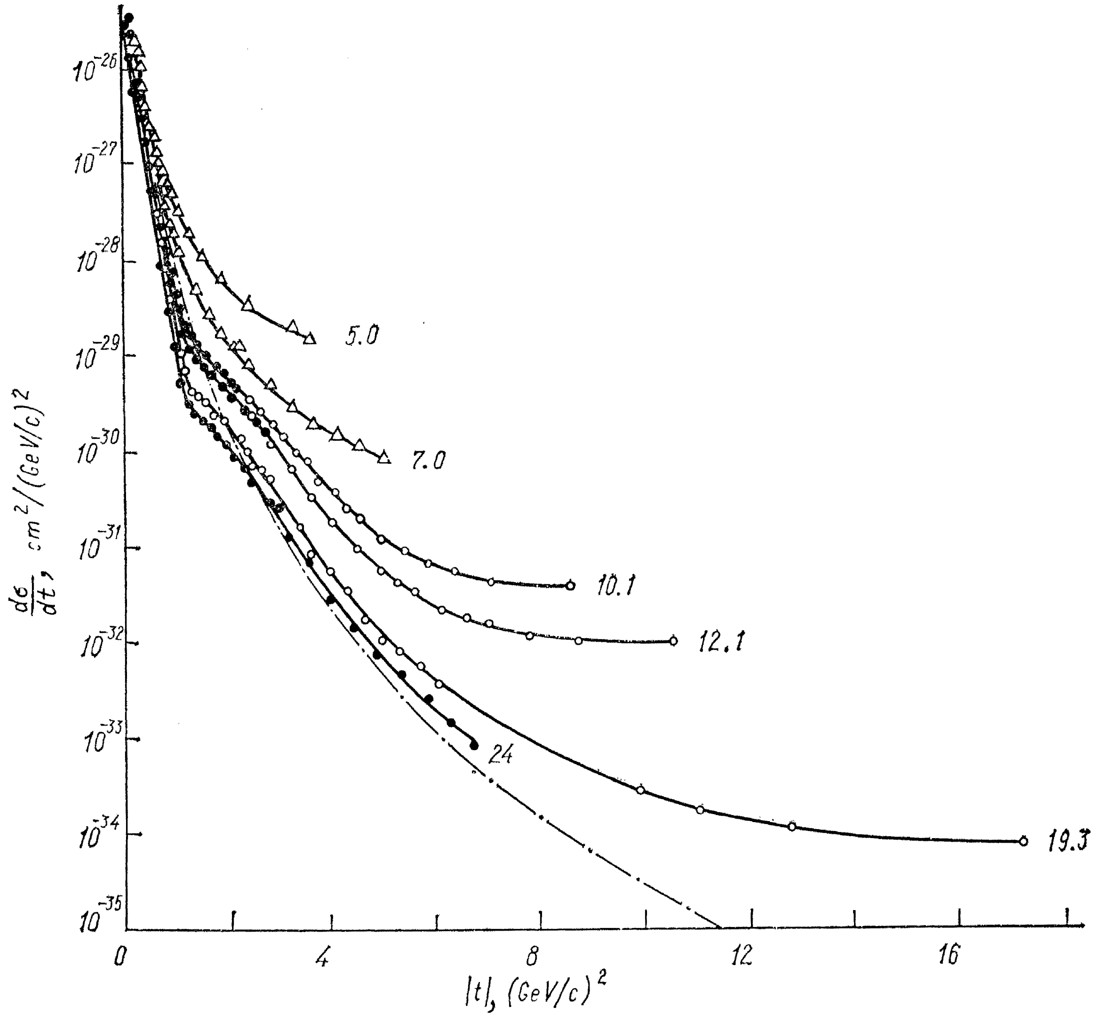


Fig. 20. Compilation of pp elastic scattering data. The new results communicated by Allaby et al. [37] are at 10, 12 and 24 GeV/c. For comparison, the broken line shows the behaviour of the fourth-power of the electromagnetic form-factor of the proton.

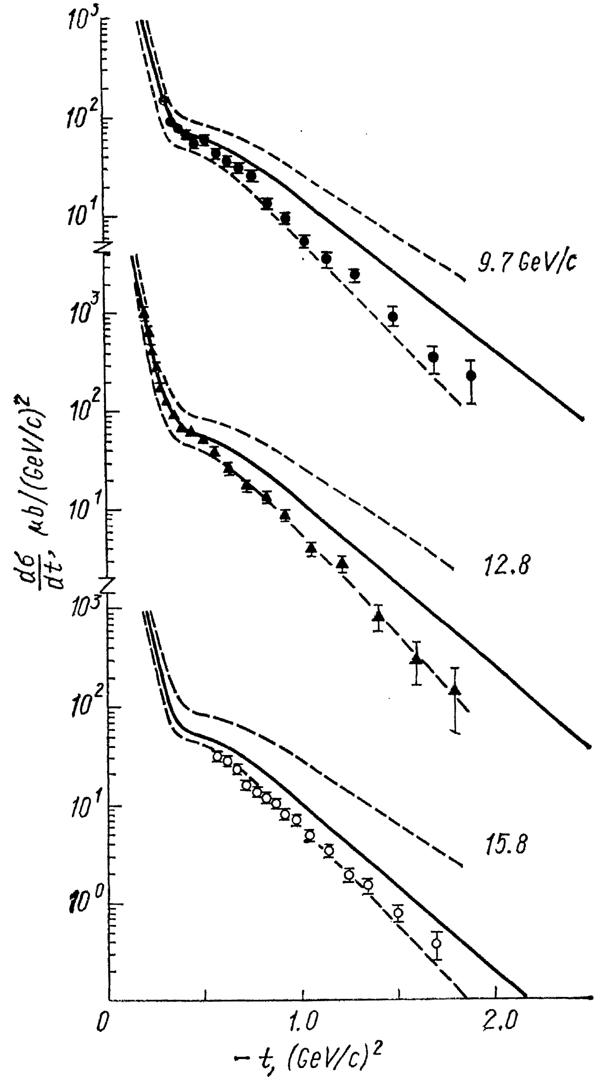


Fig. 21. Data on elastic scattering of protons on deuterons from Bradamante et al. [38]. The curves result from calculations using the Glauber multiple scattering model, with different assumptions on the pN amplitudes.

structure in the large angle region, this is certainly the best data that exist on large angle K^+p scattering at high energies and one hopes to see attempts to fit these results in the near future.

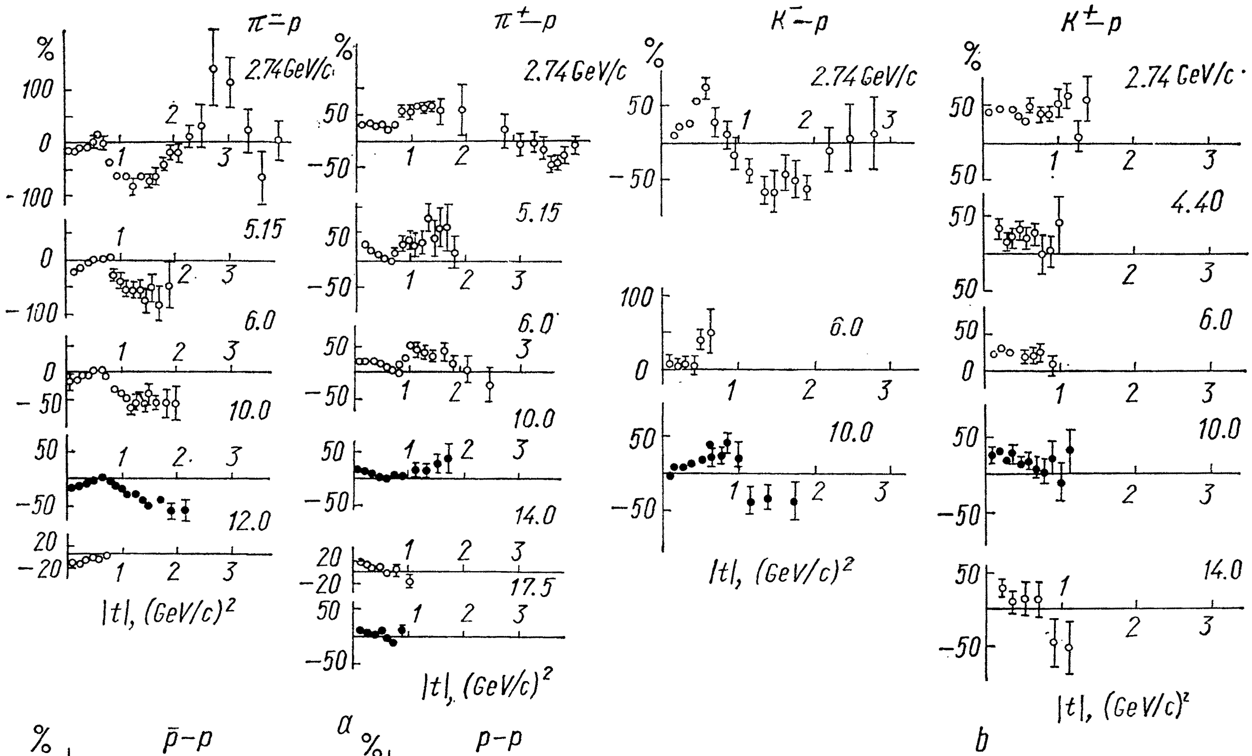
Fig. 20 shows new data on *pp* elastic scattering at 10, 12 and 24 GeV/c reported at this Conference by the CERN group [37] compared with previous results. The new data show that the structure at $|t| \approx 1.2$ GeV^2 observed at 19.3 GeV/c is also present at 10, 12 and 24 GeV/c. Although there is a tendency for the shoulder to become more pronounced at the higher energies, there is not a strong s-dependence as some models have suggested. Data at much higher energies would be very useful to study this structure, for instance at 70 GeV/c.

There seems to be a remarkable similarity in shape between the *pp* differential cross section and the *pd* differential cross section obtained by Bradamante et al. [38] and shown in Fig. 21. In this paper the data are well fitted by using the Glauber multiple scattering model, the shoulder resulting from interference between single and double scattering. I believe that this similarity is not coincidental but is indirect evidence for the composite nature of the proton; the shoulder in *pp* scattering resulting from interference between single and double scattering of the components of the protons.

5. Polarization in High Energy Scattering

New data on polarization in elastic scattering were communicated by Borghini et al. [39] at 10 GeV/c and 17.5 GeV/c. The new data on $\pi^{\pm}p$ has been compared with older data in Fig. 22*a*. The combined data show that the $|t|$ dependence of the polarization seems to be almost independent of s and that the s dependence is very weak especially for π^-p. The polarization near $t = 0$ for π^+p seems to fall from $\approx 30\%$ at 2.74 GeV/c to $\approx 10\%$ at 17.5 GeV/c. The equivalent comparison for $K^{\pm}p$ is shown in Fig. 22*b*. The new K^-p data at 10 GeV/c show the same striking cross-over as was seen at 2.74 GeV/c. Again the negative particle, K^-, shows very weak s dependence. The $\bar{p}p$ and *pp* polarization is shown in Fig. 22*c*. The statistics on *pp* at 10.0 GeV/c are poor but the polarization is small out to $t = -1.0$. The *pp* polarization at 10 GeV/c shows quite strong structure having $P_0 \approx 0$ at $t \approx -0.8$ GeV^2 rising again to a positive maximum at $t = -1.5$, falling through zero at $t = -1.9$ GeV^2 to a negative maximum at $t \approx -2.5$ GeV^2. The data at 17.5 GeV/c show the same structure but somewhat reduced in magnitude. Presumably this structure is related to the shoulder seen in the differential cross section above 10 GeV/c

Cozzika et al. [40] have reported results on the measurement of the triple scattering parameter R in π^-p scattering at 16 GeV/c, shown in Fig. 23, together with older results at 6 GeV/c on both A and R. R in the $|t|$ region 0.3—0.4 GeV^2 is seen to be negative around —.20. The new data are the circled points. The curves represent predictions [41, 42] from Regge model fits to other data in π^-p scattering, and both these predictions, which were made a long time before the data was available, are in fair agreement. I remark that even the sign of A and R is an important measurement for comparison with the theory.



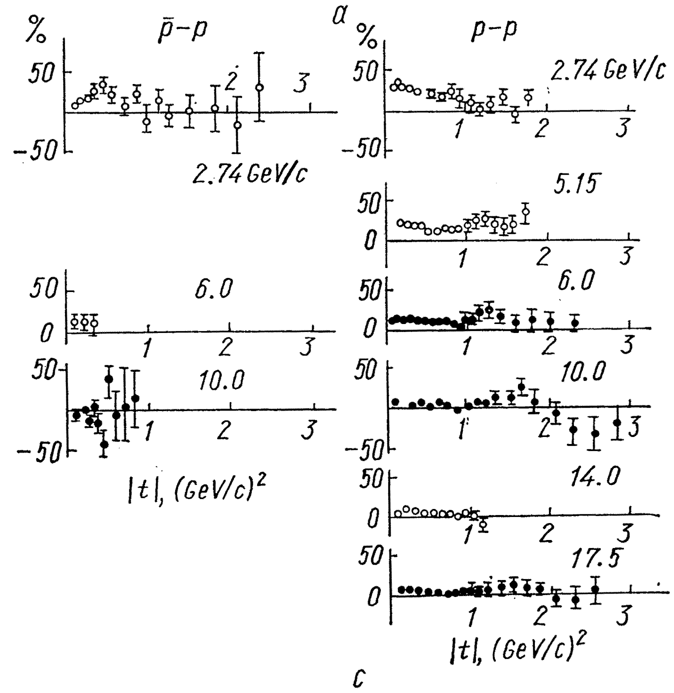


Fig. 22. Compilation of data on polarization in high energy elastic scattering from the contribution of Borghini et al. [39]. New data are the solid points, *a*) shows the data on $\pi^{\pm}p$, *b*) the data on $K^{\pm}p$ and *c*) the results for $\bar{p}p$ and pp.

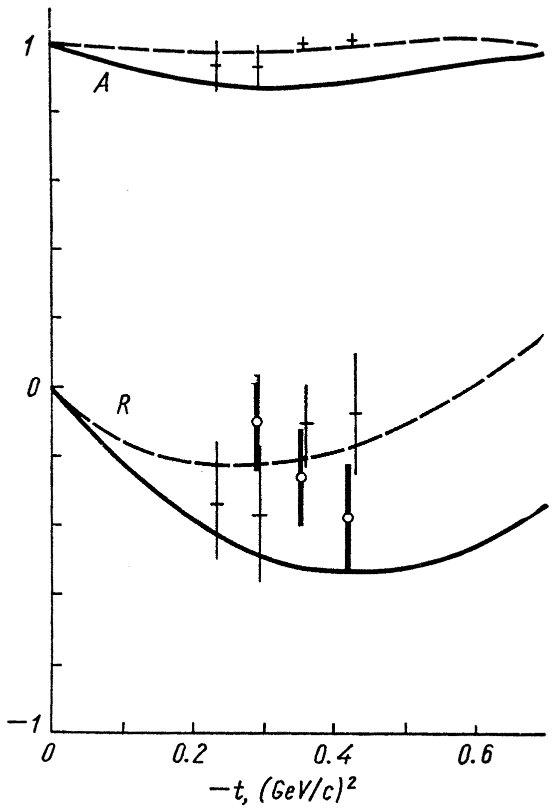


Fig. 23. The new results on the triple scattering parameter R in $\pi^{-}p$ scattering at 16 *GeV/c* from the experiment of Cozzika et al. [40]. The results from the same group on both R and A at 6 *GeV/c* are indicated by the crosses. The curves represent predictions obtained from Regge model fits to other $\pi^{-}p$ data. The broken line is a prediction of Barger and Phillips [41]. The solid line is the prediction of Cohen — Tannoudji et al. [42].

6. Inelastic Two-Body Reactions

New results were presented to the Conference on the reaction $\pi^+p \rightarrow K^+\Sigma^+$. Fig. 24 shows the data of Han et al. [43] at 3,4 and 5 GeV/c together with the earlier data of Pruss et al. [44]. The differential cross section shows similarities with the π^+p elastic cross section with a dip at $|t| \approx 0.5$ GeV^2 followed by a maximum which disappears with increasing energy. The data of Bashian et al. [45] at 6, 10 and 14 GeV/c on the same reaction are shown in Fig. 25. The dip at $|t| \approx 0.5$ GeV^2 degenerates into a «break» at the higher energies and the secondary maximum disappears just as in elastic scattering.

Fitting these combined results for the differential cross section with the usual single Regge-pole form:

$$\frac{d\sigma}{dt} = f(t) \cdot s^{2\alpha(t)-2} \tag{5}$$

the trajectory function was evaluated by Bashian et al. [45] to be

$$\alpha(t) = (0.61 \pm 0.04) + (1.14 \pm 0.06)\,t. \tag{6}$$

Evidence against the existence of a forward dip was presented by the Michigan group (Akerlof et al. [46]) and is shown in Fig. 26, where small angle data on the $\pi^+p \rightarrow K^+\Sigma^+$ at 5 GeV/c are compared with $\pi^-p \rightarrow \pi^0n$ and $\pi^-p \rightarrow \eta^0n$ data from the Saclay — Orsay group [47]. The forward dip in the charge exchange reaction $\pi^-p \rightarrow \pi^0n$ is well known and is attributed to the vanishing of the spin flip term in the forward direction. One might have expected a similar dip in the hypercharge exchange reaction $\pi^+p \rightarrow K^+\Sigma^+$ since this is thought to involve exchange of the

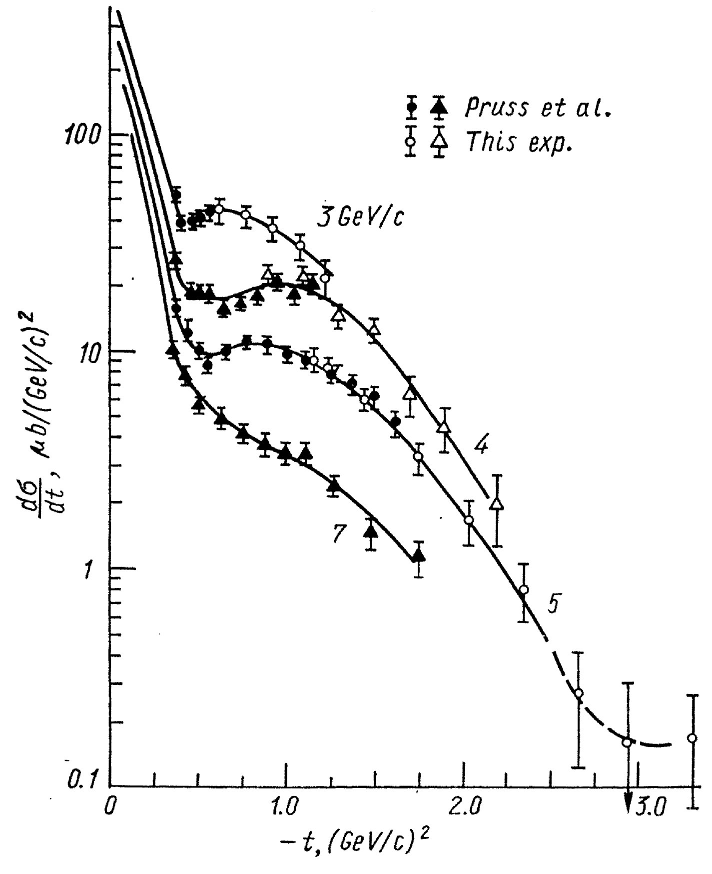


Fig. 24. The differential cross section for the reaction $\pi^+p \rightarrow K^+\Sigma^+$. The new data of Han et al. [43] are indicated by open symbols. Earlier data from Pruss et al. [44] are also shown on the figure.

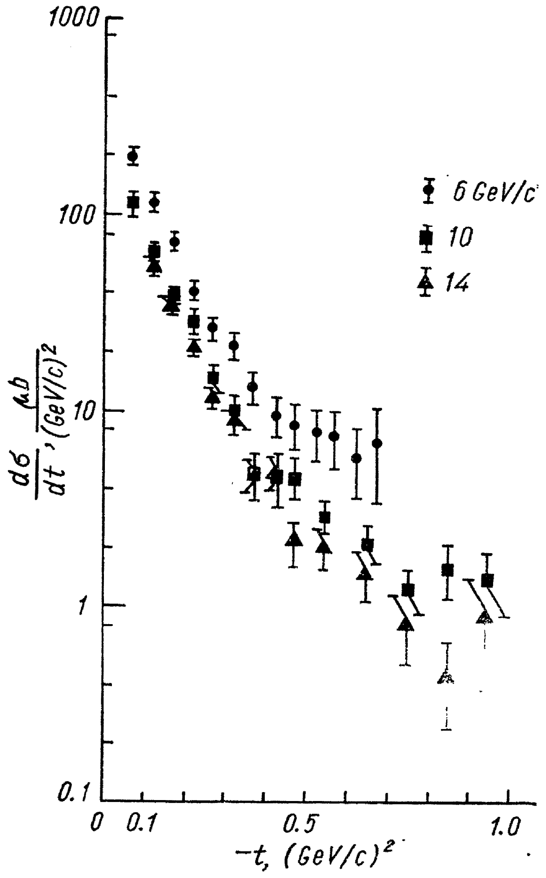


Fig. 25. The differential cross section for the reaction $\pi^+p \rightarrow K^+\Sigma^+$ from the data of Bashian et al. [45].

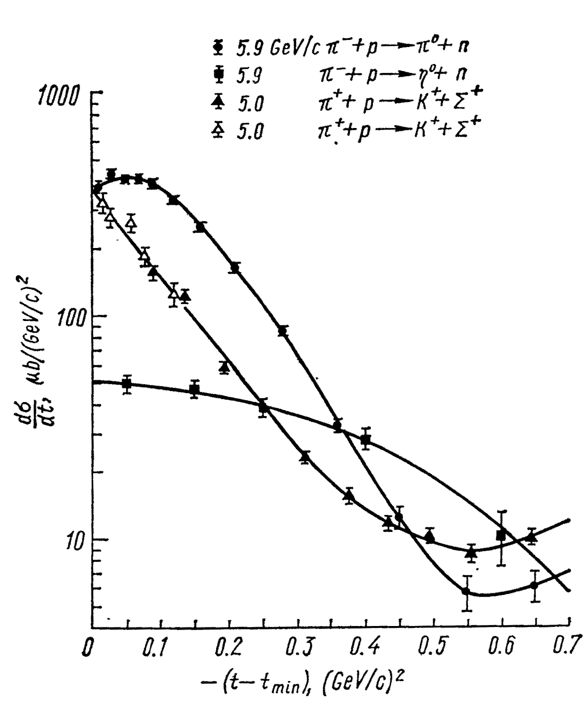


Fig. 26. Small angle differential cross sections for $\pi^+p \to K^+\Sigma^+$. The new data of Akerlof et al. [46] are indicated by the open triangles. For comparison the data of the Saclay — Orsay group on $\pi^-p \to \pi^0 n$ and $\pi^-p \to \eta n$ are shown [47].

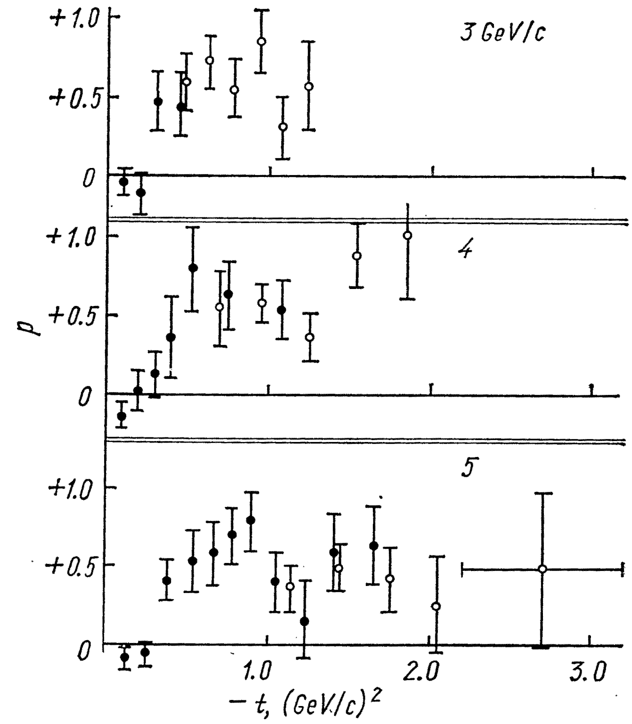


Fig. 27. Polarization of the Σ^+ from $\pi^+p \to K^+\Sigma^+$. The open points are the new data of Han et al. [43], the solid points are the data of Pruss et al. [44].

K^* (890), which is the strange counterpart of the ρ exchanged in $\pi^-p \to \pi^0 n$. The absence of a dip thus suggests that there is no significant spin flip contribution at small values of $|t|$, which is consistent with the small values of the Σ^+ polarization for $|t| \leqslant 0.3$ GeV^2 (see Fig. 27).

Finally, Fig. 27 shows the polarization of the Σ^+ from the communication of Han et al. [43] and the published results of Pruss et al. [44]. The polarization is

Table of Slopes

Reaction	*b*		
	8.0 *GeV/c*	10.7 *GeV/c*	15.7 *GeV/c*
$\pi^-p \to K^0\Lambda^0$	6.8±0.4	8.2±0.5	—
$\pi^-p \to K^0\Sigma^0$	11.5±0.6	9.9±0.7	—
$\pi^-p \to K^0(\Lambda^0, \Sigma^0)$	8.3±0.4	9.0±0.4	8.6±0.3

large and positive away from the forward direction. Neither the dip in $d\sigma/dt$ nor the change in sign of the polarization at $|t| = 1.8$ GeV^2 predicted by the Regge model of Reeder and Sarma [48] are seen in these data.

Ozaki et al. [49] have communicated preliminary results on the reactions $\pi^-p \to K^0\Lambda^0$, $\pi^-p \to K^0\Sigma^0$ at 8.0, 10.7 and 15.7 *GeV/c* near the forward direction. The slopes of these reactions and for $\pi^-p \to K^0$ (Λ^0 or Σ^0) were measured to be (see table). Although these data are preliminary there is evidence that $d\sigma/dt$ for $\pi^-p \to K^0\Lambda^0$ is shrinking whilst $\pi^-p \to K^0\Sigma^0$ has some antishrinkage.

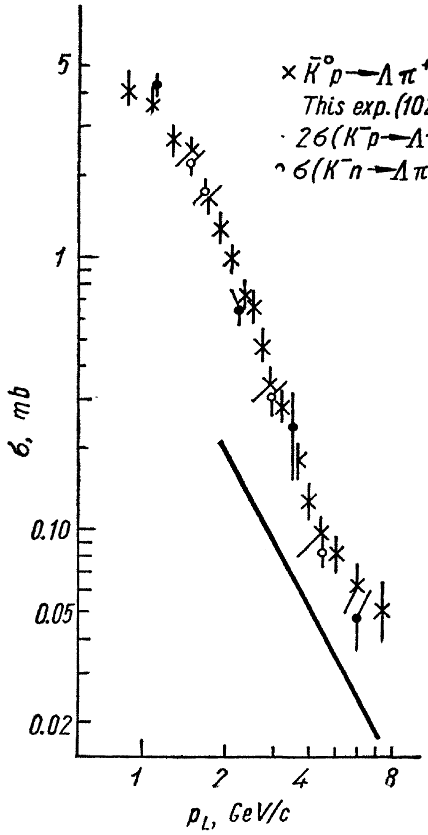


Fig. 28. Preliminary results from Brody et al. [50] on the reaction $\bar{K}^0_p \to \Lambda\pi^+$ compared with $K^-p \to \Lambda\pi^0$ and $K^-n \to \Lambda\pi^-$. The line is the prediction of the Sarma — Reeder model [48].

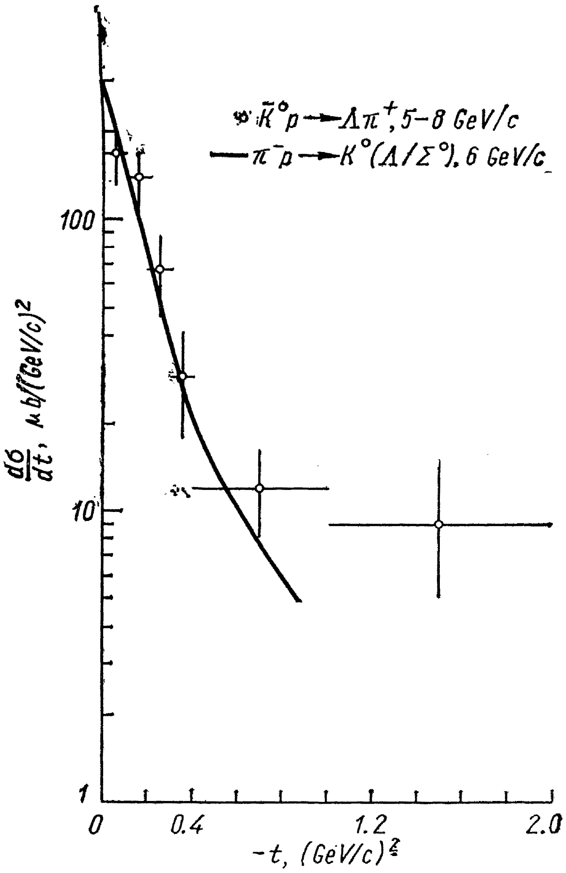


Fig. 29. Comparison between the differential cross section for $\bar{K}^0 p \to \Lambda\pi^+$ from Brody et al. [50] in the region 5—8 GeV/c compared with a fit to data on $\pi^-p \to K^0$ (Λ/Σ^0) at 6 GeV/c.

Preliminary results of a study of the reaction $\bar{K}^0 p \to \Lambda\pi^+$ between 1 and 8 GeV/c communicated by Brody et al. [50]. Fig. 28 shows this data on the cross section compared with the reactions $K^-p \to \Lambda\pi^0$ and $K^-n \to \Lambda\pi^-$ with the proper isospin factors, as well as the predictions of the Regge model of Reeder and Sarma [48], which is below the data by a factor of two. The angular distributions from this experiment near the forward direction exhibit shrinkage such that the slope for the 5—8 GeV/c data agrees with the slope of $\pi^-p \to Y^0K^0$ at equivalent s-values, which is necessary for exchange degeneracy of K^* (890) and K^* (1420). Fig. 29 shows the differential cross section for the 5—8 GeV/c data compared with a smooth fit to the data on $\pi^-p \to K^0$ (Λ^0, Σ^0) at 6 GeV/c. The close agreement indicates that exchange degeneracy in $\bar{K}^0 p \to \Lambda\pi^+$ and $\pi^-p \to K^0$ (Λ^0, Σ^0) may be good at momenta greater than 6 GeV/c.

7. Total Cross Sections

A Serpukhov group, Gorin et al. [51] have studied in detail the absorption and stripping cross sections for antideuterons. This has enabled them to measure correctly the total cross sections for $\bar{d}p$ and $\bar{d}d$. The total cross sections for $\bar{d}$ on protons and deuterons were measured at a momentum of 13.3 GeV/c and

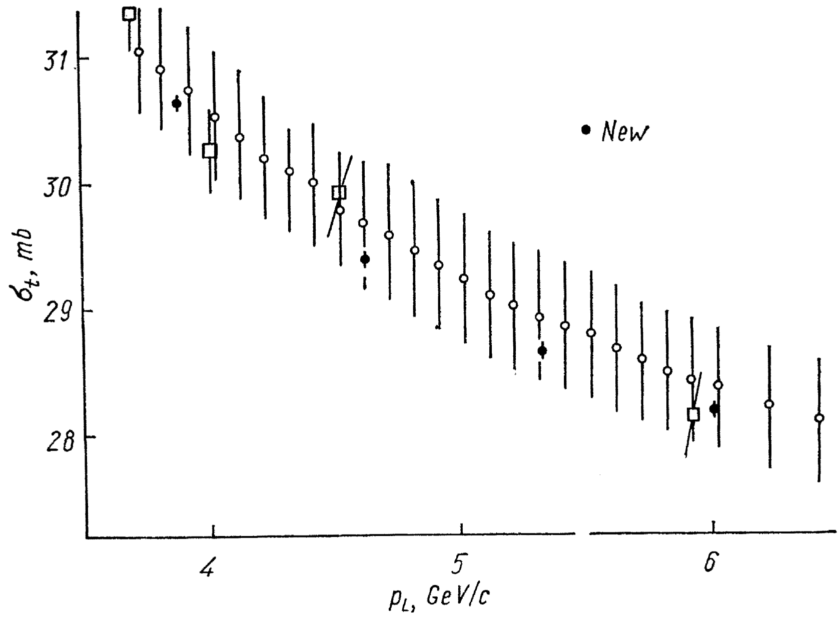


Fig. 30. Results of the experiment of Giordenescu et al. [52] on σ_{tot} for $\pi^- p$ scattering between 4 and 6 *GeV/c*. The other data are from ref. [53].

compared with data on σ_{tot} for $\bar{p}d$ measured at the same centre-of-mass energy, that is at a momentum of 6.67 *GeV/c*. The purpose of these measurements was to compare the total cross sections of $\bar{d}p$ and $\bar{p}d$ as a test of CPT invariance. The results on the differences are:

$$\sigma_{tot}(\bar{d}p) - \sigma_{tot}(\bar{p}d) = 0.2 \pm 2.6 \ mb \quad (7)$$

in agreement with CPT. Using the Glauber correction they also derived the difference:

$$\sigma_{tot}(\bar{n}p) - \sigma_{tot}(\bar{p}n) = 0.2 \pm 2.9 \ mb \quad (8)$$

which is also consistent with zero.

New measurements of σ_{tot} $(\pi^- p)$ between 4 and 6 *GeV/c* were communicated by Giordenescu et al. [52]. They have used a novel technique in which special differential Cerenkov counters were used to detect the incident and transmitted flux of π^-, and have used a target with flat end windows, enabling the target thickness to be measured very precisely. Fig. 30 shows their results compared with older data [53]. The error bars include systematic and statistical errors. I have not been able to understand completely their error analysis from the contribution to the Conference, but the quoted errors are extremely low, and perhaps this is an interesting utilization of a differential counter to minimize the geometrical effects of target length by measuring independently the particle direction after the scattering.

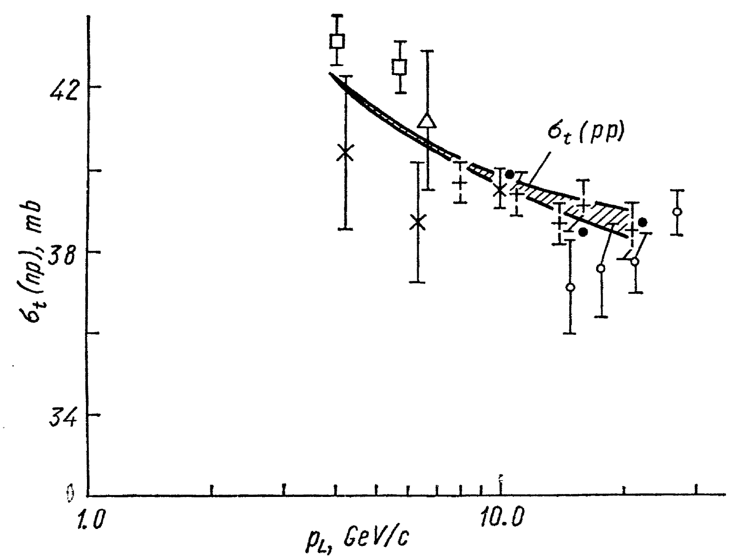


Fig. 31. Compilation of data on the total cross section for *np* scattering. The new results of McCorriston et al. [55] are the solid points. The other data are from previous experiments [56]. The shaded curve represents σ_{tot} (pp).

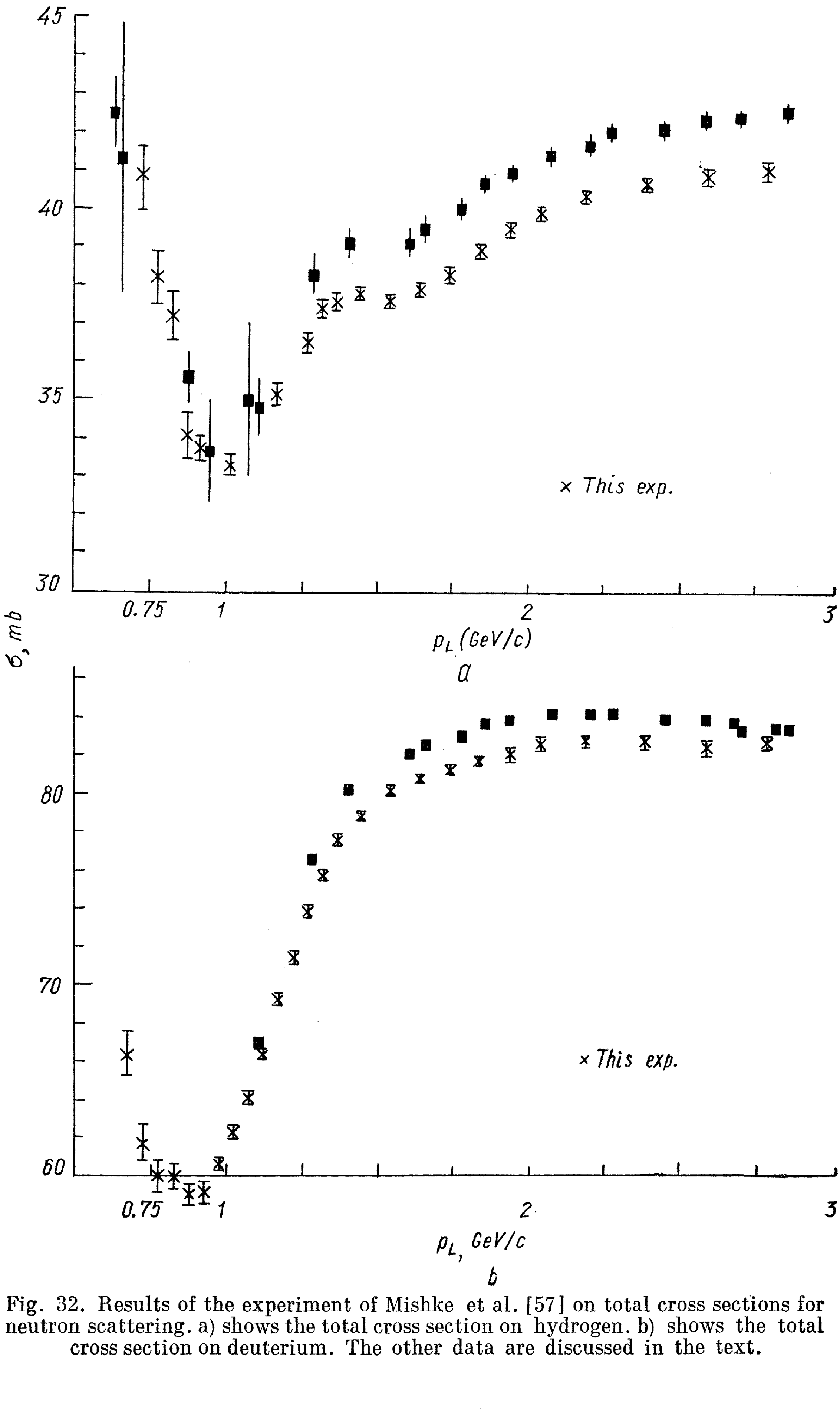


Fig. 32. Results of the experiment of Mishke et al. [57] on total cross sections for neutron scattering. a) shows the total cross section on hydrogen. b) shows the total cross section on deuterium. The other data are discussed in the text.

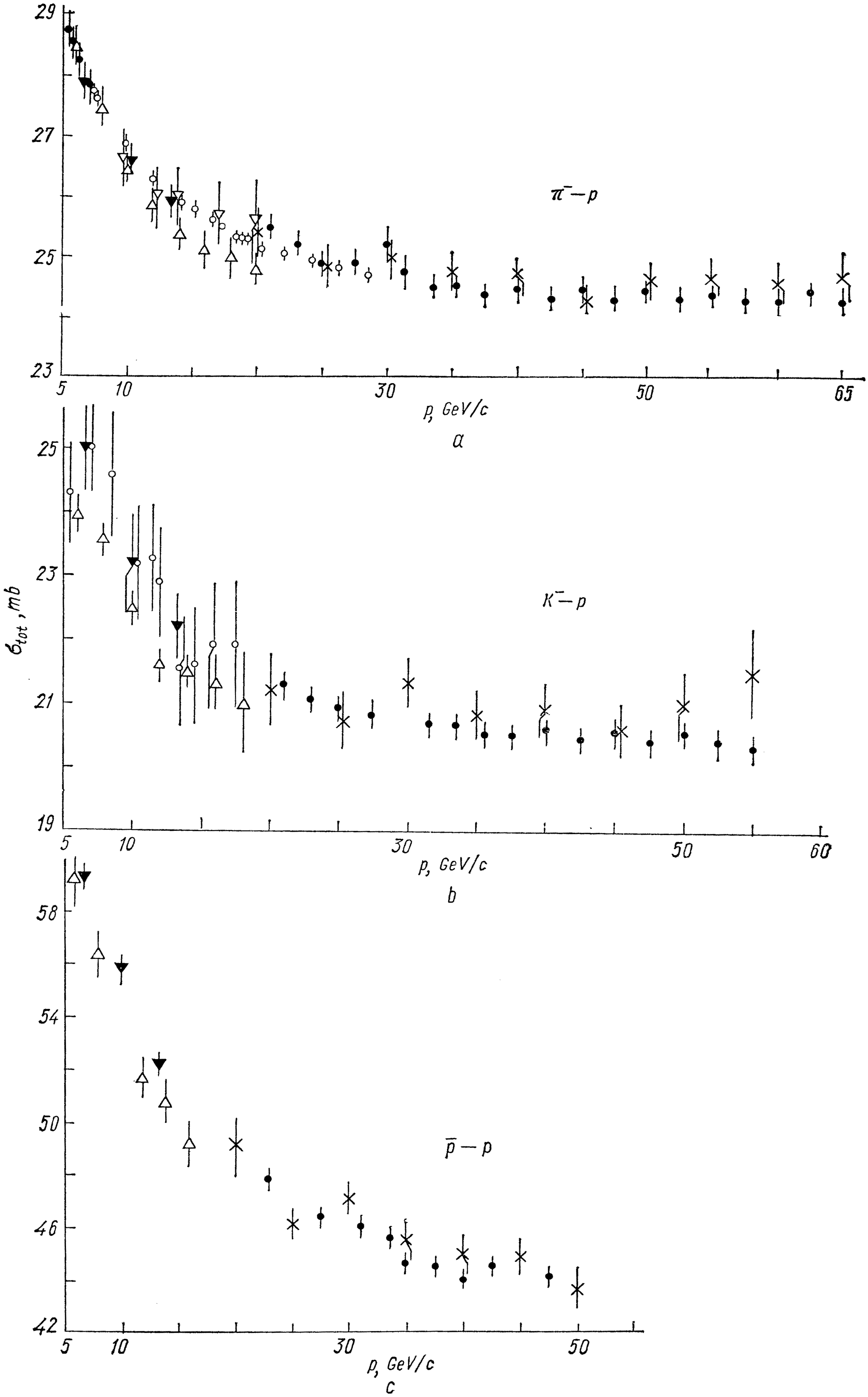


Fig. 33. New results from the IHEP (Serpukhov) group, Vasiljev et al. [60] on the total cross sections at high energies compared with published data [61]. The results of the CERN — IHEP collaboration are indicated by crosses, the new data by solid points. The results for $\pi^- p$ are shown in *a)* for $K^- p$ in *b)* and for $\bar{p}p$ in *c)*.

New data were presented to the Conference on *np* and *n*-nucleus total cross sections by Engler et al. [54] and McCorriston et al. [55]. The situation in *np* total cross sections about two years ago was anomalous in that data taken at Brookhaven by Kreisler et al. [56] suggested that the *np* cross section was below the *pp* cross section in the 15 *GeV/c* region and that there was a cross-over near 25 *GeV/c*. The new results have removed the anomaly as shown in Fig. 31. The communication of McCorriston et al. (which is essentially the same group as Kreisler et al.) reported that a source of error in the older data has been located. The *np* cross section now seems in good agreement with the *pp* cross section shown by the shaded area in the figure.

Mischke et al. [57] presented new results on *np* and *nd* total cross sections in the momentum range 0.70—2.90 *GeV/c*. In these measurements, carried out at the Princeton — Pennsylvania accelerator, the energy of the incident neutrons was determined by a time-of-flight system. The results on σ_{tot} (*np*) are shown in Fig. 32*a* compared with the σ_{tot} (*pn*) data from Bugg et al. [58], renormalized as indicated by Riley [59]. The new *np* results show clearly the «bump» interpreted as D^* (2180), but are in systematic disagreement with the *pn* results by much more than the quoted errors. The results on σ_{tot} (*nd*) are compared with data for σ_{tot} (*pd*) (Bugg et al., also renormalized following Riley) in Fig. 32*b*. If one assumes charge independence, again there is a similar systematic discrepancy between the new results on σ_{tot} (*nd*) and the σ_{tot} (*pd*) data.

New measurements on the total cross sections for π^-, K^- and $\bar{p}$ on hydrogen at high energies were presented to the Conference by the Serpukhov group (Vasiljev et al. [60]), which were the subject of an invited paper by Yu. D. Prokoshkin. For the sake of completeness the preliminary results are also included in this report. Fig. 33 shows the new results for π^-p (*a*), K^-p (*b*) and $\bar{p}p$ (*c*) total cross sections compared with the published results from previous measurements [61]. The error bars on the new data include both statistical ($\sim 0.3\%$) and systematic ($\sim 0.5\%$) errors. The error bars on the IHEP — CERN data also include the systematic scale error of $\approx 1\%$. In addition to the new measurements in the momentum range 20—65 *GeV/c*, the Serpukhov group have measured total cross sections at 6.65, 10.0, and 13.3 *GeV/c* using the high pressure gas target. These results are indicated by the solid triangles in Fig. 33, and are in agreement with earlier measurements.

As a whole the new data confirm the results of the previous experiment. There is, on average, a shift of about 0.3 *mb* towards lower cross sections which is within the errors of the old experiment. Beyond 35 *GeV/c* the π^-p and K^-p cross sections become essentially constant. If one approximates the energy dependence of σ_{tot} (π^-p) for $p \geqslant 35$ *GeV/c* by a straight line, the slope is found to be $(-0.005 \pm \pm 0.004)$ *mb*/(*GeV/c*). A similar straight line for σ_{tot} (K^-p) has a slope of $(0.005 \pm \pm 0.006)$ *mb*/(*GeV/c*). The new results on σ_{tot} ($\bar{p}p$) are in good agreement with the earlier results which showed no disagreement with theoretical expectations.

8. K° Regeneration

Vishnevsky et al. [62] have presented new experimental data on K^0 regeneration on copper between 0.8 and 3.8 *GeV/c*, from an experiment carried out on the 7 *GeV* ITEP accelerator using optical spark chambers and a magnetic spectrometer to detect both two-pion decays and leptonic decays following a 6 *cm* copper regenerator. The results of this experiment are shown in Fig. 34, compared with previously published data [63]. The average value of the regeneration phase was measured to be Φ_f (Cu) $= (-43 \pm 11)°$ over the momentum range covered.

The lines in Fig. 34 represent the calculated values of Nicolaev et al. [64] who have used dispersion relations and two assumptions about the asymptotic behaviour of the $K^{\pm}N$ total cross sections to predict the regeneration amplitude on copper within the framework of the optical model. The solid lines result from assuming that the Pomeranchuk theorem is violated and that specifically:

$$\begin{aligned} \sigma^{p}_{-}(\infty) - \sigma^{p}_{+}(\infty) &= 3\ mb \\ \sigma^{n}_{-}(\infty) - \sigma^{n}_{+}(\infty) &= 2\ mb \end{aligned} \tag{9}$$

for the asymptotic behaviour of the $K^{\pm}N$ cross sections. The broken lines result from assuming that the cross sections above 20 GeV/c follow the simple Regge-pole model predictions and thus do not violate the Pomeranchuk theorem. Although this is rather an indirect test of the asymptotic behaviour of the KN cross sections, the data certainly favour the latter assumption.

Results on the diffraction regeneration $K^0_Lp \to K^0_Sp$ on hydrogen between 0.8 and 8.0 GeV/c were presented by Brody et al. [65]. Fig. 35 shows the results for the integrated cross section as a function of the incident momentum of the K^0_L. The cross section is seen to fall from 1—8 GeV/c as $p_{lab}^{-2.5}$, although above 2.5 GeV/c this dependence might be more like p_{lab}^{-2}. The inset shows the cross section on a linear scale including the lowest momentum point. The authors conclude that in the momentum interval 0.8—1,3 GeV/c the cross section is dominated by Y_1^* (1765) formation. The open points show $(d\sigma/dt)_{t=0}$ evaluated over three momentum bands between 1.3 and 8.0 GeV/c. The forward differential cross section is seen to fall approximately as p_{lab}^{-1}. In addition the value of $|\alpha|$, the ratio of real to imaginary amplitudes was obtained by comparison with the optical point. Within errors $|\alpha|$ is constant over the three momentum values considered and the average value quoted

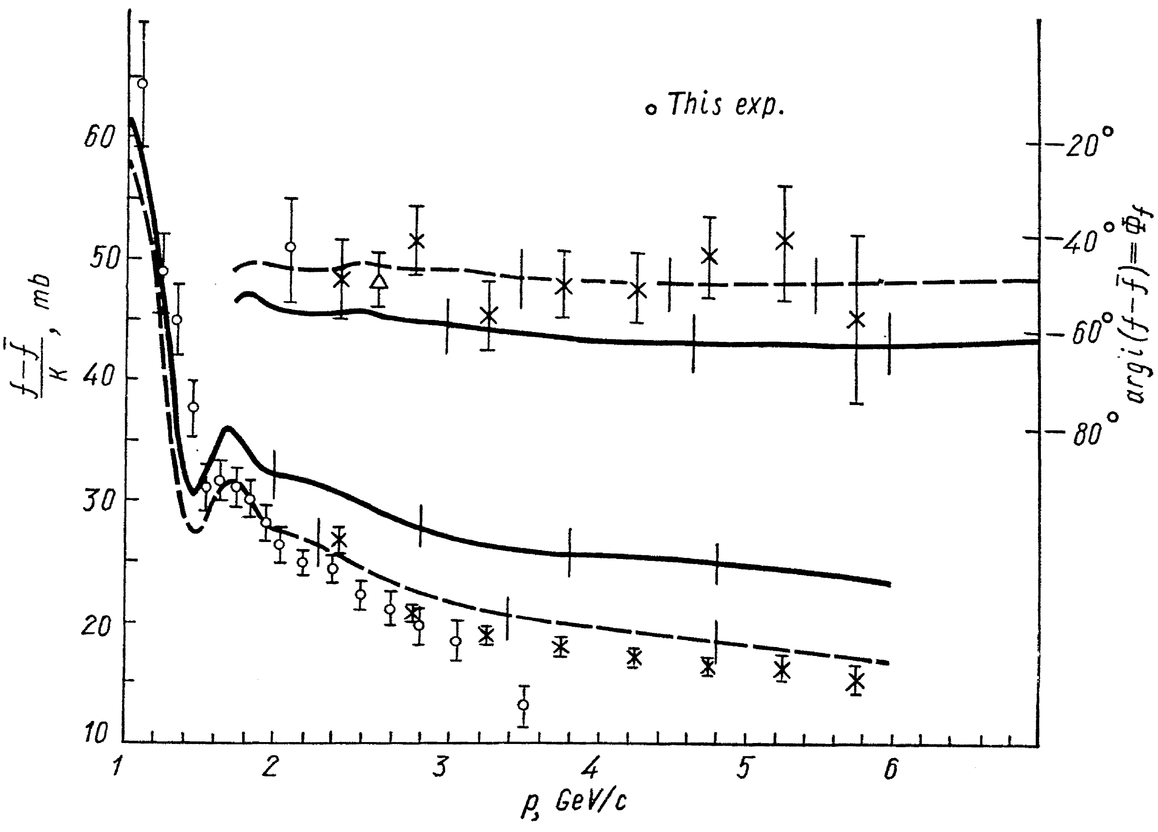


Fig. 34. Results of Vishnevsky et al. [62] on the amplitude and phase of K^0 regeneration on copper in the range 0.8—3.8 GeV/c, compared with earlier data at higher momenta [63]. The lines are discussed in the text.

is $|\alpha| = 0.92 \pm 0.15$. In order to evaluate the phase from $|\alpha|$, the authors assume the ω-exchange dominates the forward amplitude and use Regge theory to deduce that $\alpha > 0$; they use the optical theorem to tell them that $\operatorname{Im} A\,(K_L^0 p \to K_S^0 p) < 0$. This fixes Φ in the third quadrant. The result is then that the phase of the forward scattering amplitude is $\Phi_{21} = (-133.4 \pm 4.2)°$ The regeneration phase

$$\Phi_f = \arg\{iA\,(K_L^0 p \to K_S^0\, p)_{t=0}\} = \\ = \Phi_{21} + \pi/2 \qquad (10)$$

$\Phi_f = (-43.4 \pm 4.2)°$ which agrees well with the experimental values measured on carbon and copper.

Preliminary results have been reported by Darriulat et al. [66], Buchanan et al. [67] and the Dubna — Serpukhov collaboration, (Borisovskaya et al. [68]) on coherent regeneration in hydrogen. The techniques were essentially identical so that the results will be discussed together.

In these experiments the phase and magnitude of the amplitude $A\,(K_L^0 p \to K_S^0 p)$ were measured by observing the interference between the $\pi^+\pi^-$ decay of K_L^0 regenerated in a liquid hydrogen target and the *CP* violating decay of K_L^0 in the transmitted beam. Darriulat et al. measured over the range 3—6 *GeV/c*, Buchanan et al. have made measurements in the range 3—10 *GeV/c* whilst the measurements of Borisovskaya et al. covered the momentum range 16 — 36 *GeV/c*.

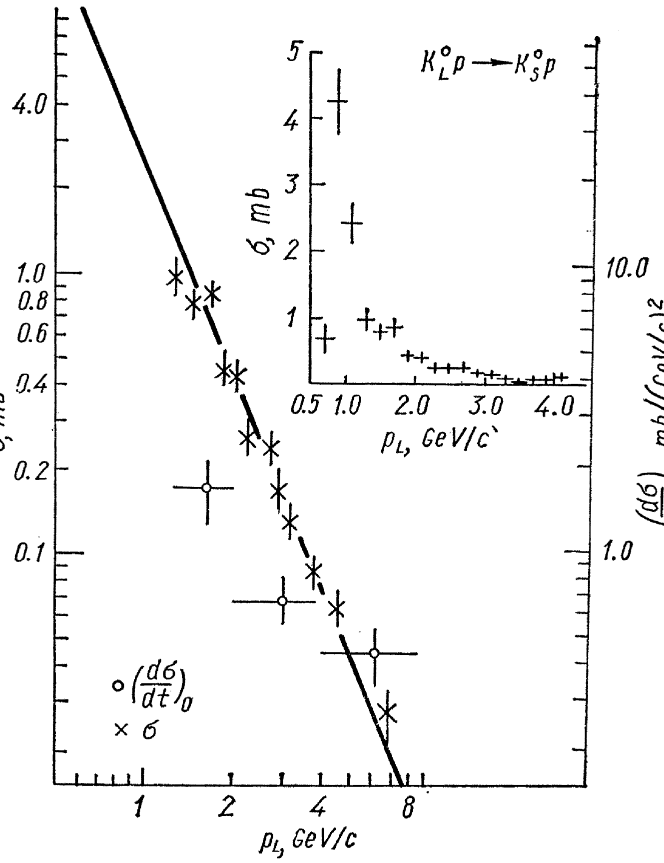


Fig. 35. Results on the diffraction regeneration $K_L^0 p \to K_S^0 p$ in hydrogen from the experiment of Brody et al. [65]. The crosses are the integrated cross section for this reaction, shows on a linear scale in the inset. The open points are values of $(d\sigma/dt)_{t=0}$ obtained by extrapolation.

The experimental results are presented in the form of a phase Φ_{21} and the imaginary part of the amplitude $\operatorname{Im} A\,[f(0) - \bar{f}(0)]$ which can be expressed as the cross section difference $\Delta\sigma = \sigma\,(K^- n) - \sigma\,(K^+ n)$ by the optical theorem, using isospin invariance:

$$\Delta\sigma = \sigma\,(K^- n) - \sigma\,(K^+ n) = - \\ - \frac{4\pi}{k} \operatorname{Im} A\,[f(0) - \bar{f}(0)]. \qquad (11)$$

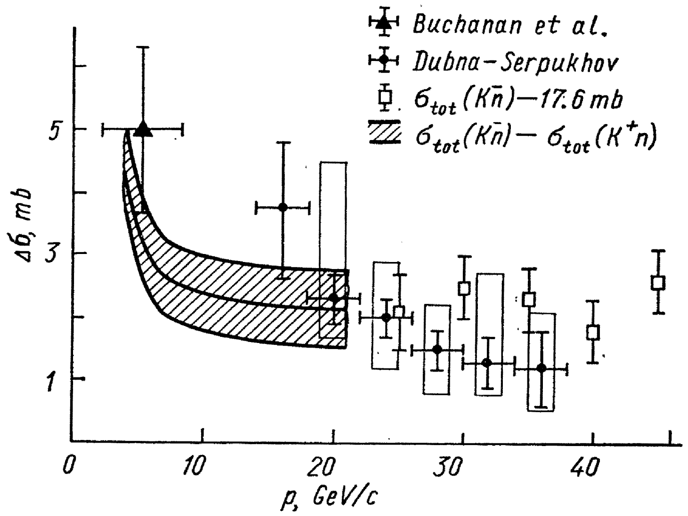


Fig. 36. Results from the Dubna — Serpukhov collaboration (Borisovskaya et al. [68]) and from Buchanan et al. [67] on the cross section difference $\Delta\sigma = \sigma\,(K^- n) - \sigma\,(K^+ n)$ obtained by K^0 regeneration on hydrogen. The other points and the curve are discussed in the text.

Darriulat et al. have fitted a common phase over their momentum

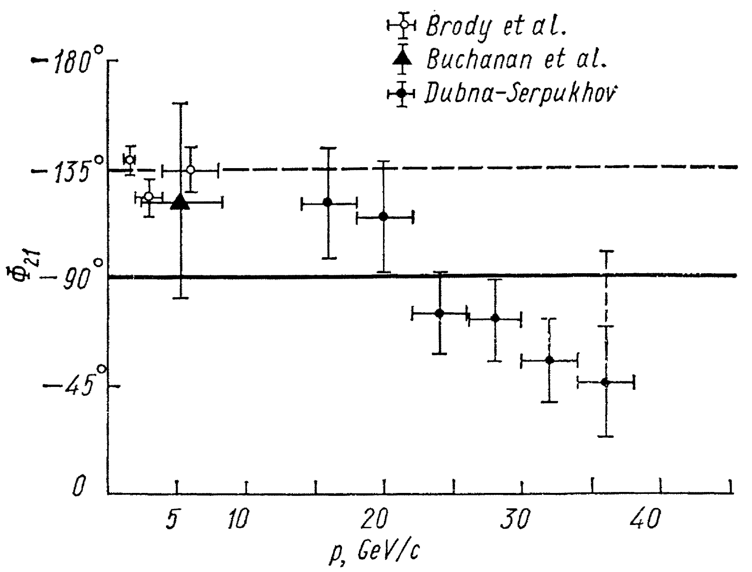


Fig. 37. Results from Brody et al. [65], Buchanan et al. [67] and the Dubna — Serpukhov [68] collaboration on the phase of the forward scattering amplitude $K_L^0 p \to K_S^0 p$.

range of 3 — 6 *GeV/c*. They obtained a value of the regeneration phase $\Phi_f = (-42 \pm 17)^\circ$ corresponding to $\Phi_{21} = (-132 \pm 17)^\circ$. They also evaluated $\Delta\sigma$ and compared with data from total cross section measurements finding good agreement within the errors.

The preliminary results from the Dubna — Serpukhov group and from Buchanan et al. on the values of $\Delta\sigma$ are shown in Fig. 36. The error bars represent statistical errors. The rectangles indicate the possible limits of systematic errors since these have not yet been estimated precisely For comparison, $\Delta\sigma$ has been derived also from total cross section data directly. Below 20 *GeV/c* the shaded region represents $\sigma_{tot}(K^-n) - \sigma_{tot}(K^+n)$ obtained using the smooth interpolated values tabulated by Giacomelli [69] and including the typical statistical error. Above 20 *GeV/c* the data of the IHEP — CERN collaboration have been used and have been converted to $\Delta\sigma$ by subtracting the constant value of 17.6 *mb*, which is the best fit value of $\sigma_{tot}(K^+n)$ in the region near 20 *GeV/c*. Only the point-to-point errors of the IHEP — CERN data have been included. An additional systematic error of about 0.5 *mb* exists for all the $\Delta\sigma$ values derived from total cross sections. Because of the large systematic and statistical errors it is hard to draw a conclusion, but the suggestion from the trend of the Dubna — Serpukhov result is that $\Delta\sigma$ is decreasing with increasing momentum, and thus that $\sigma_{tot}(K^+n)$ should increase above 20 *GeV/c* and not stay constant as has been assumed until quite recently.

The preliminary results from the same two experiments on the phase of the forward scattering amplitude Φ_{21}, are given in Fig. 37, together with the data of Brody et al. [65]. The error bars are statistical only. The broken line on the highest momentum point indicates an estimate of the possible limit of the systematic errors. The broken line at $\Phi_{21} = -135^\circ$ indicates the expected behaviour or Φ_{21}, if a single Regge-exchange model (ω-exchange) is used. Although the errors are too large to draw a definite conclusion one can at least say that this behaviour of Φ_{21} was highly unexpected. The data indicate that the phase rotates from —135° to —45° between 16 and 36 *GeV/c*. Even with the large errors on this preliminary data, it is difficult to avoid the conclusion that the phase changes dramatically above about 20 *GeV/c*, and thus that the simple Regge-pole picture must break down, as has been indicated by the total cross section results from the Serpukhov laboratory. It appears that several Regge mechanisms, notable ρ — ω pole cancellation, terms that violate the Pomeranchuk theorem, or complex trajectories, do predict a phase rotation, in the direction observed, and can be adjusted to give approximate agreement with the data [70]. It remains to be seen if the final results of the Dubna — Serpukhov experiment, which is by no means completed, will be sufficiently precise to allow one to discriminate between these various possibilities.

9. Conclusion

This Conference has seen a large amount of new data presented in the field of two-body hadronic interactions and total cross sections. The experiments at the energies below about 25 *GeV* are becoming more refined and are probing reactions with smaller and smaller cross sections or measuring to higher and higher precision to test the various theories of strong interactions. The data which is now being produced at the Serpukhov 76 *GeV* accelerator, although in some cases rather preliminary in nature is tending to bring surprises rather than fitting neatly into the picture viewed from the lower energies. This fact is very exciting for the future of high energy physics, with the possibilities of even higher energies to be available soon with the NAL 500 *GeV* accelerator, the CERN ISR (2000 *GeV* effective), the European 300 *GeV* project, and the Novosibirsk proton — antiproton colliding beam facility (VAP — NAP).

10. Acknowledgements

The task of the rapporteur at a Conference of this size is certainly not an easy one. The fact that for myself the burden was not intolerable was due to the help of the discussion leaders and secretaries of the parallel sessions covered by this report. I would like to thank my colleagues Yu. D. Prokoshkin, G. Giacomelli and L. van Rossum for their invaluable advice and to congratulate them for the smooth way in which they organized the parallel sessions. I wish to thank my secretaries at the Conference for their hard work and understanding, especially S. Mukhin, Yu. Galaktionov and M. Shafranova, without whose help this report would never have been prepared in time for presentation at the first plenary session.

DISCUSSION

Kane:

I have two comments I would like to make: The $np \to pn$ absolute normalization is very important because of the close relationship of the data to that of charged photoproduction. The interpretation of this relation is very difficult in the case of the two normalizations presented. The size of the $\bar{p}p \to \bar{n}n$ forward peak is about as expected in the absorption models (e. g. see the prediction in the paper we presented to the meeting). Essentially one finds a smaller peak than in $np \to pn$ be because of the larger cross section in $\bar{p}p \to \bar{n}n$ at larger angles; it is an interference effect so one must calculate to make predictions, but the relative size of the peak is expected to be about a factor 3—5 smaller in $\bar{p}p \to \bar{n}n$ than in $np \to pn$.

Allaby:

I will stress again that it is very difficult to obtain precise absolute normalization for $np \to pn$ measured by the double scattering technique, but that this technique allows one to go to the smallest values of four-momentum transfer and so gives a good angular distribution.

Moffat:

You have shown some slides of charge-exchange reactions which relate to the question of exchange degeneracy of (ρ, A_2) and (K^*, K^{**}) trajectories on the basis of line reversal of the reactions using s — u crossing. You seemed to imply that exchange degeneracy holds in nature. However, if you look at the world's data both the normalization and the t-dependence in several reactions indicate that exchange degeneracy is violated by a factor of ~ 2 in the cross sections at lower energies for (ρ, A_2) and between 3—15 *GeV/c* for (K^*, K^{**}) exchange. I refer to a recent publication by Kwan Lai and Louie on this question. Could you comment on this please?

Allaby:

I have not looked at the world data to make a detailed analysis of exchange degeneracy. I have tried to indicate where experimental results which I have presented have supported exchange degeneracy but I am well aware of other results in disagreement with this assumption, for example the non-zero polarization in *np* charge exchange which was recently published in Phys. Rev. Letters by a Berkeley group.

B e r g e r:

Twice you advertized fixed — kinematic — cut model fits to differential cross section data. You emphasized that the model fits both the deep $\pi^- p \to \pi^0 n$ backward dip of Boright et al. and the $t \simeq -3\,(GeV/c)^2$ dip in $\pi^\pm p$. I should like to comment that this model **does not** give dips naturally. In fact, for nucleon (N_α) exchange the cut contribution completely dominates the cross section. This cut has no dip. Therefore, $d\sigma/du$ has no natural dip in the model. The only way to fit data is to kill the cut term **artificially** by use of **contrived** residues. This is explained in detail in my paper (with G. C. Fox) (ANL/HEP 7013 and 7019) submitted to this conference (Session 11a, Paper 16). In my opinion, these remarks discredit the work of both Halzen et al. and Auvil et al. The fixed-cut model would prefer a world with no dips in $d\sigma/du$ and $d\sigma/dt$.

A second remark. In this age of duality, is it not antediluvian, to say the least, to use a sum of *t* channel and *u* channel exchange, as do Auvil et al.?

A l l a b y:

My reason for presenting the fit of Auvil et al. to the 5 *GeV/c* $\pi^+ p$ angular distribution was purely because it is the first time I have seen a Regge model predict a full angular distribution. I hope one will see more of this in the future. I certainly am not competent to discuss whether the model is artificial from the theoretical point of view, but from the experimental point of view, it fits the data.

W i n t e r:

I wish to point out a source of possible systematic error due to strong correlation of modulus and phase of the regeneration amplitude f_{21} over the short acceptance region ($3\Lambda_S$ at 40 *GeV/c*) in the $K^0_L - K^0_S$ regeneration experiment of the Dubna — Serpukhov group. Precise knowledge of the K^0_L momentum spectrum is needed for the analysis. An error in its slope gives a systematic error in the modulus of f_{21} and, through the above-mentioned correlation, also in its phase.

T e l e g d i:

What was the magnitude of the regeneration in the region 16—36 *GeV/c*?

A l l a b y:

Savin can probably quote an exact value but I seem to recall that ρ was in the range $1^1/_2$—2 times $\eta_\pm$.

S a v i n:

In the region of 16—36 *GeV/c*, ρ was about $(2.5—4) \times 10^{-3}$.

L i p k i n:

The value quoted for the *D/F* ratio obtained from π^0 and η backward production was calculated without taking into account the $\eta - \eta'$ mixing. This is very dangerous for couplings of the η to non-strange particles. Two-thirds of the η octet wave function is $(\lambda\bar{\lambda})$, which seems to be decoupled from the nucleon, as in the case of the Φ. Thus the η coupling depends only on a small component of the wave function and is sensitive to small admixtures. Assuming decoupling of the $\lambda\bar{\lambda}$ component the correction factor is $g_{\eta NN}/g_{n_8 NN} = (\cos\theta \pm \sqrt{2}\sin\theta)$ where θ is the mixing angle, η is the physical η, and n_8 is the pure octet state.

I suggest that experimentators quote errors on their experimental numbers only, and refrain from giving error limits on theoretical parameters extracted from the data by dubious theoretical procedures, unless they are ready also to include the «theoretical error».

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