## FORMATION EXPERIMENTS : T REGION

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1. Evidence for a boson resonance of mass about 2200 MeV was first reported by the CERN M.M.S. group[1], that measured the missing mass distribution in the reaction $\pi^- + p \longrightarrow p + MM^-$ at small t, and found a five standard deviation peak, the T-meson, at a mass of 2195 $\pm$ 15 MeV with a width $\Gamma \lesssim 13$ MeV. Since then, many formation and production experiments have been performed, in the attempt to verify the existence of the T-resonance and possibly to measure its quantum numbers.

Although I am not going to discuss in detail production experiments, it is probably worthwhile to present a table showing a listing of the peaks seen in production experiments in the mass range 2000 to 2300 MeV.

Table 1

| Authors | Reactions | M (MeV) | $\Gamma$(MeV) | Decay modes observed |
|---|---|---|---|---|
| Chikovani et al. (1966) | $\pi^- p \to p\ MM^-$ at 12.0 GeV/c (small t) | 2195 $\pm$ 15 | $\lesssim$13 | 3 charg.(+ poss. neutr.) $\sim$94% |
| Anderson et al. (1969) | $\pi^- p \to p\ MM^-$ at 16.0 GeV/c (small u) | 2086 $\pm$ 38<br>2260 $\pm$ 18 | 150<br>$\lesssim$25 | |
| Alles-Borelli et al. (1967) | $\bar{p}p \to 2\pi^- 2\pi^+ \pi^\circ$ at 5.7 GeV/c | 2207 $\pm$ 13 | 62 $\pm$ 52 | $\pi^+\pi^-\pi^\circ$ |
| Clayton et al. (1967) | $\bar{p}p \to 3\pi^- 3\pi^+ \pi^\circ$ at 2.5 GeV/c | 2190 $\pm$ 10 | 130 | $A_2\,\omega$ |
| Caso et al. (1970) | $\pi^- p \to p\,\pi^+ \pi^- \pi^- \pi^\circ$ at 11.2 GeV/c | 2207 $\pm$ 22 | 130 | $\rho^- \pi^+ \pi^-$ |
| Kramer et al. (1970) | $\pi^+ p \to p \pi^+ \pi^\circ$ at 13.1 GeV/c | 2157 $\pm$ 10 | 68 $\pm$ 22 | $\pi^+\pi^\circ$ |
| Dagan et al. (1971) | $\bar{p}p \to 3\pi^- 3\pi^+(\pi^\circ)$ at 6.94 GeV/c | 2140 $\pm$ 20<br>2210 $\pm$ 40 | < 30<br>100$\pm$80 | $f^\circ\pi$<br>$g^\circ\pi$ |

The first entry in the table refers to the CERN missing mass experiment just mentioned. Later on, Anderson et al.[2] studied the production of high mass bosons in the same reaction at small u and observed enhancements at masses consistent with the R and U masses, but not with the S and T masses. Actually, the masses and widths corresponding to the peaks closest to the T-meson mass are (2086 $\pm$ 38, 150) MeV and (2260 $\pm$ 18, $\lesssim$ 25) MeV.

The other five entries refer to bubble chamber experiments. The peak seen by Alles-Borelli et al.[3] in the negative G-parity state $\pi^+\pi^-\pi^0$ is about two standard deviations above the over-all phase space and five standard deviations above the adjacent regions. Mass and width are consistent with the values found by Chikovani. Clayton et al.[4] saw a structure at 2190 MeV in the $(6\pi)^\pm$ effective mass distribution, where a $\pi^+\pi^-\pi^0$ combination in the $6\pi$ state was required to be in the $\omega$ region and the remaining $(3\pi)^\pm$ were required to have an effective mass in the $A_2$ region. Another positive G-parity structure was observed by Caso et al.[5], who reported a four-standard deviation peak at about the T mass in the $2\pi^-\pi^+\pi^0$ mass distribution with at least one $\pi^-\pi^0$ combination in the $\rho$ region. Events with a $\pi^+\pi^-\pi^0$ combination in the $\eta$ or $\omega$ region, as well as events with a $\pi^+p$ combination in the $\Delta^{++}(1236)$ region, were excluded from the plot. Next in the list, we have an $I^G = 1^+$ peak reported by Kramer et al.[6] at a smaller mass. Besides the mass shift with respect to the CERN M.M.S. experiment, also the 1 charged/3 charged ratios disagree. Assuming they are observing a new boson resonance (T'-meson), the authors put an upper limit $J^P \leqslant 5^-$ to its spin. Finally, Dagan et al.[7] reported some indications of structures in the $f^0\pi^\pm$ and '$g^0$' $\pi^\pm$ channels, where '$g^0$' really stands for a peak at 1650 MeV.

2. The $\bar{p}N$ total cross section measurements by Abrams et al.[8] also give evidence for an I = 1 structure at 2190 $\pm$ 10 MeV. Additional structures were observed at 2350 and 2375 MeV, respectively in the I = 1 and I = 0 cross sections.

This experiment has a high statistical accuracy and great care was exercised to avoid energy-dependent errors larger than $\pm$ 0.1%. The data points in the T-region were taken at momentum settings corresponding to mass intervals of 18 MeV, the mass resolution of the apparatus being 15 MeV full width at half-height.

The height of the enhancement at 2190 MeV is about 5.5 mb: if interpreted as a boson resonance it would have approximately: $\Gamma$ = 85 MeV, $\frac{1}{2}(J + \frac{1}{2})x = 0.36$, where $x$ is the elasticity of the resonance (the statistical uncertainty being smaller than $\pm$ 15% for the height and $\pm$ 30% for the width, with that particular choice of the background).

As pointed out by the authors, an alternative explanation of the bump could be a sharp rise of the $N\bar{\Delta}$ (1236) ($\bar{N}\Delta$) cross section, whose threshold is near the energy of the observed structure. To investigate this possibility, single $\pi$ production in hydrogen[9,10,11] and deuterium[12,13] was studied by several groups. The reactions involved, in hydrogen and deuterium, are:

$$\begin{aligned} \bar{p}p \rightarrow\ & \bar{p}\ p\ \pi^{\circ} && a)\\ & \bar{p}\ n\ \pi^{+} && b)\\ & p\ \bar{n}\ \pi^{-} && c)\\ & n\ \bar{n}\ \pi^{\circ} && d) \end{aligned} \qquad (1)$$

$$\begin{aligned} \bar{p}n \rightarrow\ & \bar{p}\ p\ \pi^{-} && a)\\ & \bar{n}\ n\ \pi^{-} && b)\\ & \bar{p}\ n\ \pi^{\circ} && c) \end{aligned} \qquad (2)$$

Reactions 1d), 2b) and 2c) cannot be measured in a bubble chamber. The analysable final states, however, are in agreement with the assumption that the one pion production is dominated by a $N\bar{\Delta}$ + $\bar{N}\Delta$ intermediate state, which allows to correct for the unseen reactions. In this case, only the I = 1 amplitude contributes to the one pion production so that

$$\sigma(\bar{p}n \rightarrow N\bar{N}\pi) = 2\sigma\ (\bar{p}p \rightarrow N\bar{N}\pi)$$

where the factor 2 takes into account the isospin normalization of the initial state. Fig. 1 shows the $\bar{p}n \rightarrow N\bar{N}\pi$ cross section and the $\bar{p}p \rightarrow N\bar{N}\pi$ cross section multiplied by 2 as functions of total energy. (In comparing the two sets of data, one should consider the fact that the deuterium data of ref. 13 are not corrected for the screening effect inside the deuterium nucleus). The one pion production cross section rises with nearly constant slope after threshold. This excludes that the bump observed by Abrams et al. in the $p\bar{N}$ cross section at 1.3 GeV/c is mainly due to the isobar threshold effect.

3. If it is assumed that the bump is due to the formation of a boson resonance lying, as conjectured, on the normal Regge trajectory $\rho$, $A_2$, with constant slope 1 GeV $^{-2}$, it would have spin J = 5. From the known value of $(J + \frac{1}{2})x$, we can expect an effect of about 200 $\mu$b in the $\bar{p}p$ elastic cross section. This is very difficult to see in the total elastic cross section [9,14-17] (Fig. 2), which is dominated by the large forward diffraction peak.

Cline[18] has suggested that backward scattering should be more sensitive to the presence of direct channel resonances.

A CalTech-B.N.L.-Rochester collaboration[19] has performed a counter experiment to measure the $\bar{p}p$ elastic scattering for $\cos\theta_{C.M.}$ between -0.98

and -1.0 and incident momenta between 0.70 and 2.16 GeV/c, at approximately 100 MeV/c intervals. The momentum dependence of the cross section exhibits a sharp dip at 0.9 GeV/c and a broad maximum at about 1.4 GeV/c (Fig. 3). No evidence for the narrow peaks observed in the CERN M.M.S. experiment was found, but the energy resolution might not be sufficient to resolve them. On the other hand, the authors were able to obtain, on the basis of three resonances corresponding to the Abrams peaks, a 180° $d\sigma/d\Omega$ which approximately reproduces their data. Alternatively, a diffraction model too gives an over-all view in agreement with data.

Bubble chamber data are also available, both for $\bar{p}p$[9,10,11,20,21] and $\bar{p}n$ backward scattering[22]. Fig. 4 presents a compilation by Vallet et al.[21] of the $\bar{p}p$ average differential cross sections in the interval $-1.0 < \cos\theta_{C.M.} < -0.8$. Fig. 5 presents preliminary results on the $\bar{p}n$ backward scattering in the interval $-0.95 < \cos\theta_{C.M.} < -0.8$. The momentum dependence of the deuterium data looks similar to that observed by Yoh et al. in their $\bar{p}p$ experiment in the same energy interval, and an interpretation in terms of an optical model is being tried.

In conclusion, most backward scattering data may be interpreted in terms of optical models, although it is probably not possible to exclude resonant effects.

The charge-exchange reaction $\bar{p}p \to \bar{n}n$ has been also studied. Bricman et al.[23] measured the cross section for this reaction at various incident momenta between 1 and 3 GeV/c. Although the over-all normalization is somewhat uncertain, the detection of a structure over a small momentum interval should not be impaired. No significant enhancement in the T-region was observed, but the presence of a resonance of spin as high as 5 or more is compatible with the data.

Recently, a Stony-Brook-Wisconsin collaboration[24] has measured total and differential cross sections for the same reaction. The total cross section presents some structures which rensemble the Abrams peaks (Fig. 6). The results of this experiment are however still preliminary and the authors do not claim at present that these structures are real effects. If confirmed, these results would favor a resonant interpretation of the Abrams peaks.

4. If the Abrams peak at 2190 MeV corresponds to a resonance, it must have small elasticity (and correspondingly high spin), and should show up in some inelastic channel. The $\bar{p}p$ topological cross sections[10,16,25] (Fig. 7) do not give clear indications about where to look for it. Various annihila-

tion channels have been or are being studied in the attempt to find specific channels where an effect is present over a relatively small background.

4.1 A counter-wire chamber experiment to study the reactions $\bar{p}p \rightarrow \pi^- \pi^+$ and $\bar{p}p \rightarrow k^- k^+$ between 0.7 and 2.4 GeV/c has been performed by a CalTech-Rochester-B.N.L. collaboration[26]. By combining these data with the ones obtained from a previous CalTech-B.N.L. collaboration[27], it was possible to obtain folded differential cross sections $\frac{d}{d\Omega}(\theta_{C.M.}) + \frac{d}{d\Omega}(\pi - \theta_{C.M.})$ at 13 different momenta. Figs. 8 and 9 show respectively the folded differential cross sections at some momenta and the coefficients $a_1$ of their expansion in terms of (even) Legendre polynomials.

The two pion angular distributions seem to be dominated by one set of states below 1 GeV/c and by another set above 1.7 GeV/c with interference in between. Therefore they have been fitted with two direct channel resonances and constant background. The results of the fit, shown in fig. 9, are obtained with a J = 3 resonance with M = 2.12 GeV, $\Gamma$ = 0.249 GeV and a J = 5 resonance with M = 2.29 GeV, $\Gamma$ = 0.165 GeV.

Both resonances, decaying into two pions, must have I = 1, P = -1, G = = +1. The position of the enhancements found by Abrams et al. are about 70 MeV away from these values and the widths are quite different. As for the narrow T and U resonances found by the M.M. spectrometer group, it is possible that the energy resolution was not good enough to reveal their presence.

The two pion(and two kaon)annihilation has been also studied in bubble chamber by T.C. Bacon et al.[28] in the more restricted C.M. energy range 2150 to 2240 MeV (Figs. 10 and 11). No structure in the T-region is observed.

In the region of overlap between the counter experiment mentioned above and this experiment, the $a_4/a_0$ and $a_6/a_0$ ratios are in reasonable agreement, but $a_2/a_0$ is somewhat smaller in the latter. This experiment yields also the odd Legendre coefficients. It is interesting to note that the forward and backward hemisphere have very different distributions and the low order odd coefficients are non-zero. Unfortunately, the statistical significance of this data does not allow a detailed direct channel analysis, but more high statistics counter data are forthcoming[29].

4.2 In the same bubble chamber experiment mentioned above, the channel $\pi^+\pi^-\pi^\circ$ has been studied. In particular, the amount of production of $\rho^\circ$, $\rho^\pm$, f° has been determined. With the possible exception of a relatively small $\rho^\pm$ cross section at 1.36 GeV/c, the resonance fractions and cross sections are approximately constant (Table II) and do not show evidence of direct channel effects. A compilation of the 3-pion cross section is given in Fig. 12[26,28].

Table II

3-pion cross sections in microbarns

| P(GeV/c) | 1.23 | 1.30 | 1.36 | 1.43 | Mean value |
|---|---|---|---|---|---|
| $\bar{p}p \rightarrow \pi^- \pi^+ \pi^\circ$ | 2019 ± 75 | 1894 ± 78 | 1719 ± 72 | 1742 ± 71 | 1843 ± 46 |
| $\rho^\pm \pi^\mp$ | 313 ± 84 | 308 ± 85 | 151 ± 82 | 215 ± 78 | 260 ± 39 |
| $\rho^\circ \pi^\circ$ | 255 ± 61 | 304 ± 71 | 216 ± 64 | 251 ± 61 | 264 ± 32 |
| $f^\circ \pi^\circ$ | 356 ± 71 | 300 ± 78 | 290 ± 76 | 295 ± 73 | 313 ± 38 |

The process $\bar{p}p \rightarrow \pi^+ \rho^-$ has been studied by Yoh et al.[30] at several incident momenta between 1 and 2 GeV/c in the angular range of $\cos\Theta_{C.M.}(\bar{p}\pi^+)$ between 0.96 and 1.0. Forward emitted positive particles were momentum analyzed by a magnet-wire spark chamber spectrometer. A Cherenkov counter and a time-of-flight system allowed the identification of these particles. From the missing mass distributions, the amount of $\pi^+ \rho^-$ production was evaluated at the various momenta. Fig. 13 shows the differential cross sections at an average value of $\cos\Theta_{C.M.}(\bar{p}\ \pi^+)$ of 0.99. The broad peak could suggest the existence of a G =-1 resonance near 2.25 GeV with a width of about 200 MeV. The peak covers both the T and U regions and might have been caused by more than one resonance.

4.3 No s-channel effect in the final state $\bar{p}p \rightarrow 2\pi^- 2\pi^+$ has been reported. Cooper et al.[10] fitted the $4\pi$ annihilation to an incoherent superposition of phase space and sums and products of Breit-Wigner cross sections for $\rho^\circ$, $f^\circ$ and $\rho^\circ f^\circ$. About 1/3 of the cross section was attributed to $\rho^\circ f^\circ$ production, but it stays approximately constant with momentum.

4.4 On the contrary a bump of about 0.8 mb at about the T mass was reported by Kalbfleisch et al.[16,31] in the channel $\bar{p}p \rightarrow 2\pi^- 2\pi^+ \pi^\circ$. Among the substates of the five-pions, $\rho^\circ$ was found in particular to show an enhancement and to be accompanied by a second $\rho^\circ$ at 1.33 GeV/c, but not at the other momenta (1.11 and 1.52 GeV/c). The significance of these data and a comparison between them (Fig. 14) and the analogous data from a A.N.L. group[32] (Fig. 15) were discussed extensively by Kalbfleisch in his report on the T-region at the 1970 Philadelphia Conference[31]. His conclusion was that the $\bar{p}p$ system is forming a meson state $\pi(2190)$ of width between 20 and 80 MeV, which decays into $\rho^\circ\rho^\circ\pi$ .

The $\rho^\circ\rho^\circ\pi^\circ$ cross section at the peak was estimated to be about 0.4 mb. No signal was seen in the $\rho^\circ\rho^\pm\pi^\mp$ channels but the $\pi^+\pi^-$MM cross section was reported to give probable evidence for a $\rho^+\rho^-\pi^\circ$ decay of the $\pi(2190)$. The same cross section was measured by Bacon et al.[28] at 1.23, 1.30, 1.36 and 1.43 GeV/c. Fig. 16 shows a comparison between the two sets of data. According to Bacon et al., the difference between them might be due to a different treatment of events with identifiable k-mesons. They concluded that in the $\pi^+\pi^-$ + neutrals cross section there is no significant evidence of structure in the T-region.

4.5 Before turning to the $\bar{p}n$ annihilation, let me recall the results for the reactions $\bar{p}p \rightarrow k_1 k_1 \omega$ and $\bar{p}p \rightarrow k^+ k^- \omega$[33] (Fig. 17). If the excess of events at 1.3 GeV/c is attributed to resonance formation, a fit through the $k_1k_1\omega$ points gives $M = 2176 \pm 5$ MeV, $\Gamma = 20^{+16}_{-2}$ MeV. This state would correspond to $I^G = 0^-$ or $1^+$: both assignments are incompatible with a $\rho^\circ\ \rho^\circ\ \pi^\circ$ state.

4.6 The data which will be discussed in this section are preliminary results on $\bar{p}d$ interactions at seven momenta between 1.0 and 1.6 GeV/c, from the Lawrence Berkeley Laboratory-Padova-Pisa-Torino collaboration. The results relative to one-pion production and $\bar{p}n$ backward elastic scattering have been presented in sects. 2 and 3 respectively.

Fig. 18 gives some topological cross sections. The odd prong topologies have been fitted to a background of the form a + b/p plus two Breit-Wigner functions which represent the Abrams et al. bumps in I = 1. The smearing effect of the Fermi momentum of the neutron and of the beam momentum spread have been taken into account. The BW (2190) contribution to the topological cross sections results to be $5.1 \pm 2.4$ mb for the 1-prong events, $2.3 \pm 1.0$ mb for the 3-prongs and $3.0 \pm 1.4$ for the 5-prongs (all 2-standard deviation effects). If we look at the physical channels (fig. 19) we get: $0.2 \pm 0.09$ mb for the $3\pi$ state and $0.5 \pm 0.2$ mb for the $5\pi$ state, whereas the $4\pi$ and $6\pi$ states do not show appreciable effects. Although these effects are probably not meaningful by themselves, they may provide some insight into the nature of the statistically much more meaningful peak found by Abrams et al. at 2190 MeV.

The $4\pi$ , $5\pi$ and $6\pi$ final states have been studied in some detail to determine the amount of production of the various $2\pi$ and $3\pi$ resonances.

Figs. 20 and 21 show some distributions relative to the $5\pi$ final sta te, relevant for the $\rho\rho\pi$ problem discussed in sect. 4.4. Since a background subtraction, as made by Kalbfleisch et al., is difficult to make objectively, a maximum likelihood fit to the data of combinations of amplitudes representing the various intermediate states has been performed. The results are shown in Table 3. Each amplitude has been symmetrized incoherently with respect to the exchange of like pions, but a coherent symmetrization does not alter the energy dependence of the $\rho\rho\pi$ percentage. It is impossible to draw from these data alone definite conclusions about the existence of the $\rho\rho\pi$ effect.

Table 3

$\bar{p}n \to 3\pi^- 2\pi^+$. Estimated channel percentage. With the particular parametrization used, the errors are about 0.05.

| $E_{c.m.}$ (MeV) | 2130-2150 | 2150-2165 | 2165-2185 | 2185-2210 | 2210-2240 | 2240-2290 |
|---|---|---|---|---|---|---|
| $\rho 3\pi$ | 0.25 | 0.21 | 0.19 | 0.11 | 0.26 | 0.00 |
| $f 3\pi$ | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.14 |
| $\varepsilon 3\pi$ | 0.01 | 0.07 | 0.00 | 0.00 | 0.00 | 0.03 |
| $\rho\rho\pi$ | 0.04 | 0.02 | 0.05 | 0.17 | 0.06 | 0.06 |
| $\varepsilon\varepsilon\pi$ | 0.22 | 0.08 | 0.00 | 0.00 | 0.09 | 0.15 |
| $\varepsilon\rho\pi$ | 0.05 | 0.24 | 0.45 | 0.20 | 0.19 | 0.06 |
| $f\rho\pi$ | 0.01 | 0.00 | 0.03 | 0.00 | 0.04 | 0.06 |
| $f\varepsilon\pi$ | 0.23 | 0.20 | 0.18 | 0.27 | 0.19 | 0.09 |
| $A_2^+ 2\pi$ | 0.00 | 0.02 | 0.03 | 0.10 | 0.05 | 0.15 |
| $A_2^- 2\pi$ | 0.05 | 0.00 | 0.07 | 0.00 | 0.00 | 0.26 |
| $A_2 \varepsilon$ | 0.00 | 0.08 | 0.00 | 0.00 | 0.02 | 0.00 |
| $A_2^- \rho$ | 0.14 | 0.08 | 0.00 | 0.15 | 0.08 | 0.00 |

As for the $4\pi$ and $6\pi$ channels, the various percentages are roughly constant.

5. In conclusion, the situation in the T-region, as it results by the various formation experiments, is not yet clarified, but some progress has been made. Backward elastic scattering has not given so far conclusive results. The new data on the $\bar{p}p \to \bar{n}n$ reaction are more promising, but we ha

ve to wait for the final results. The momentum dependence of the one-pion production cross section leads to exclude that the Abrams et al. enhancement at 2190 MeV is mainly due to a $\Delta$-threshold phenomenon. It is a difficult task to interpret without much ambiguity the various annihilation channels. Annihilation in deuterium, however, indicates that G = -1 states are probably important in this region. Finally, there are indications, both from production and formation experiments, for more than one resonance in the T-region, but they need confirmation.

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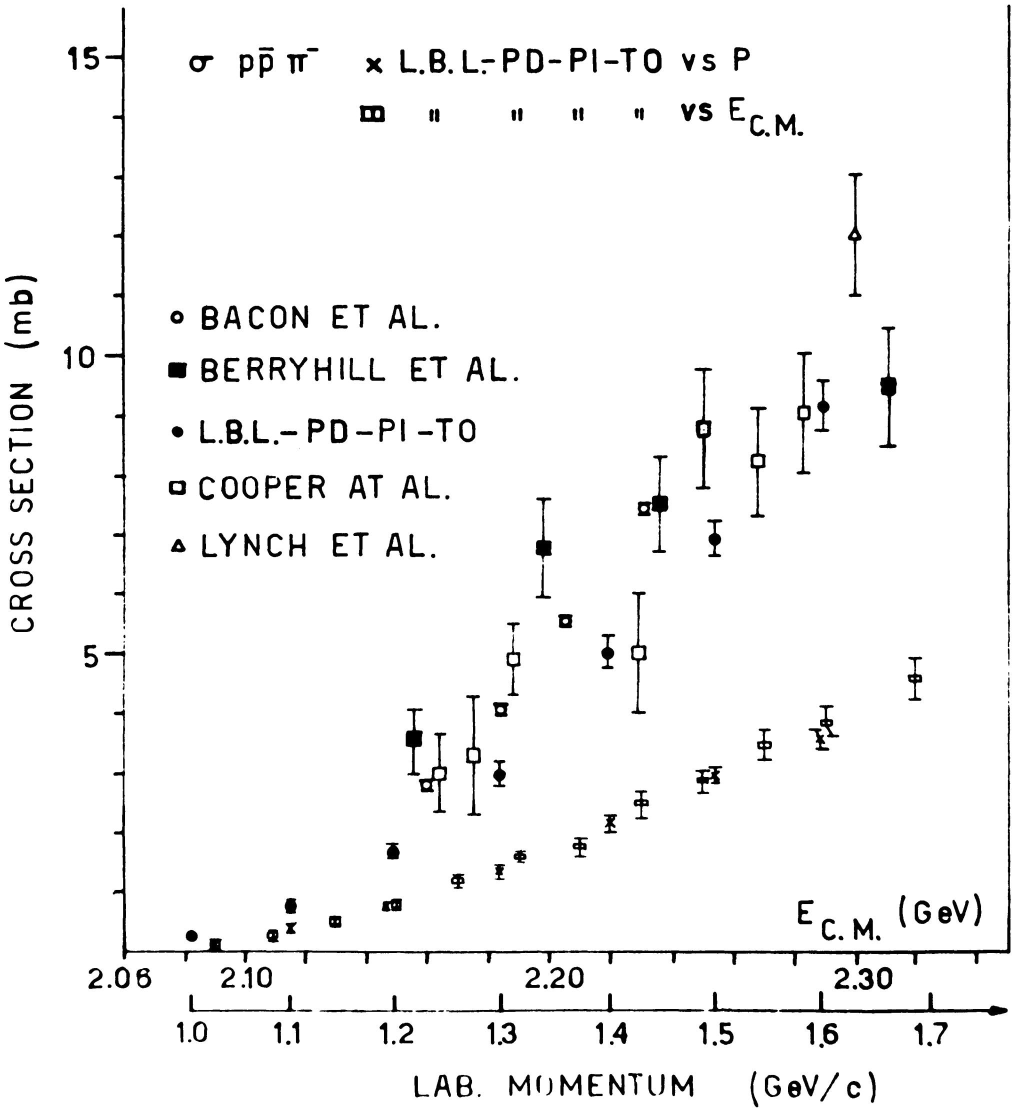


Fig. 1 Cross sections for $\bar{p}n \to \bar{p}p\pi^-$, $\bar{p}n \to N\bar{N}\pi$ (closed symbols) and $\bar{p}p \to N\bar{N}\pi$ (open symbols). The $\bar{p}p$ cross sections have been multiplied by two.

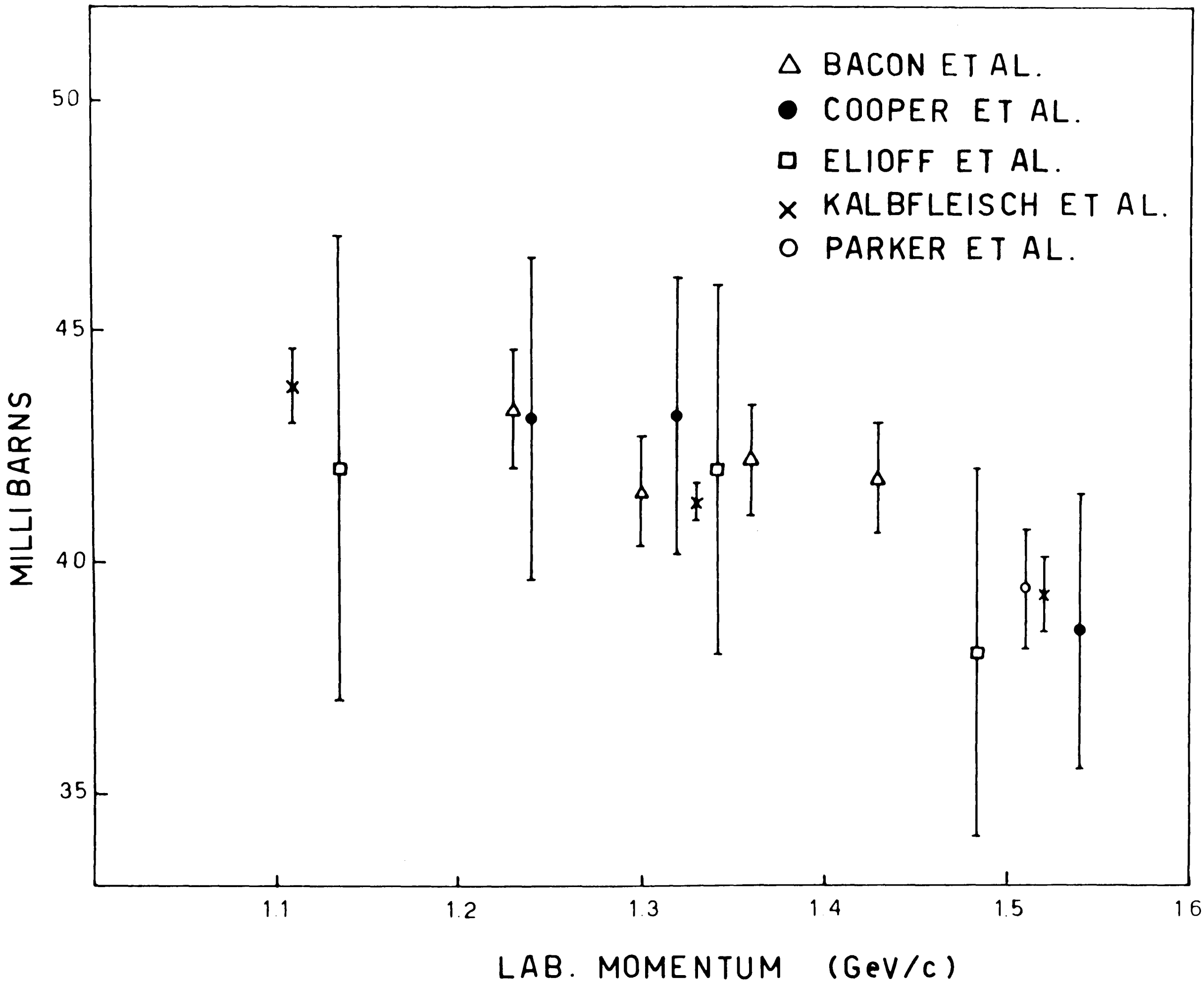


Fig. 2 p̄p elastic cross section.

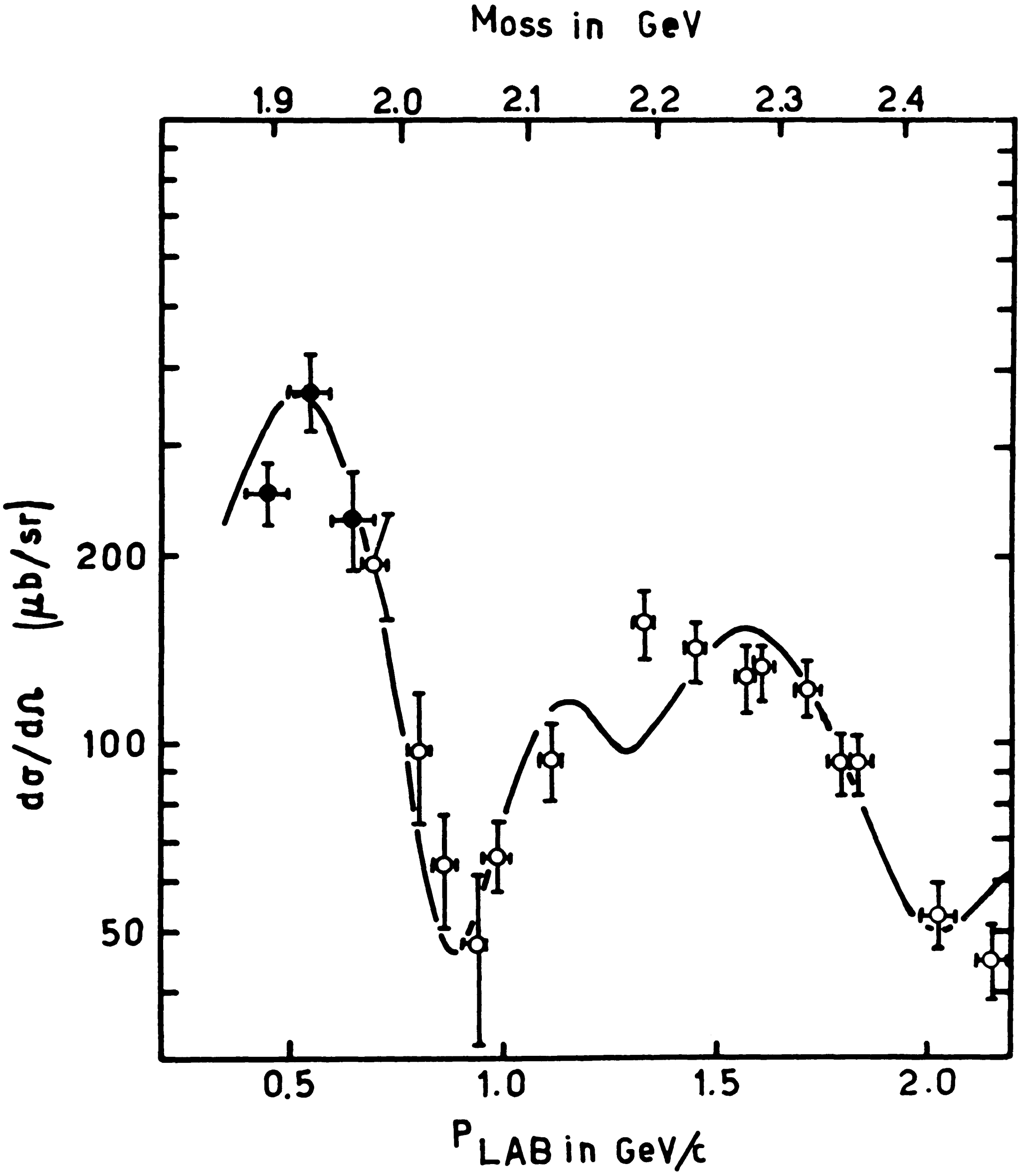


Fig. 3 $\bar{p}p$ elastic differential cross section for cos $\theta_{C.M.}$ between -1.0 and -0.98. Open circles: data from Yoh et al.; closed circles: data from Cline et al.. The curve represents the predictions of a diffraction model.

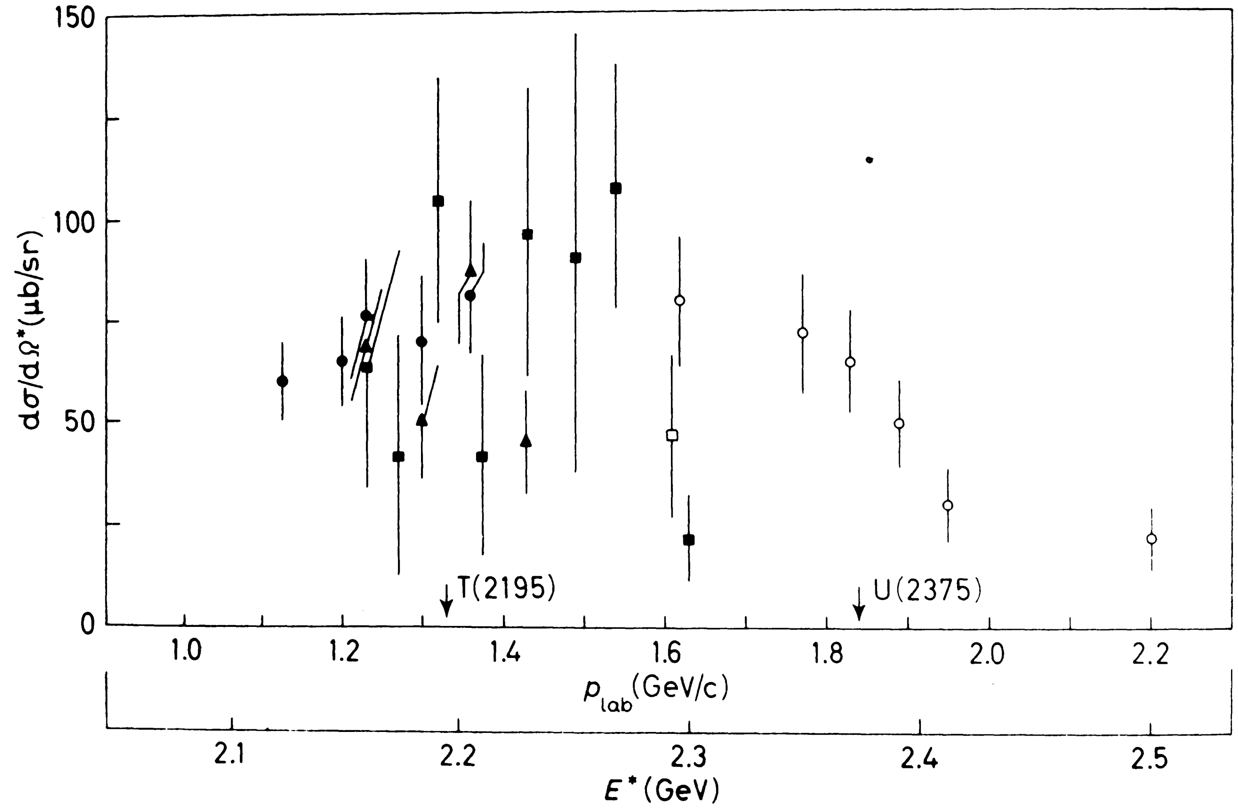


Fig. 4 A compilation of bubble chamber data on $\bar{p}p$ elastic scattering for cos $\theta_{C.M.}$ between -1.0 and -0.8.

▲ ref. 9, ■ ref. 10, □ ref. 11, ○ ref. 20, ● ref. 21

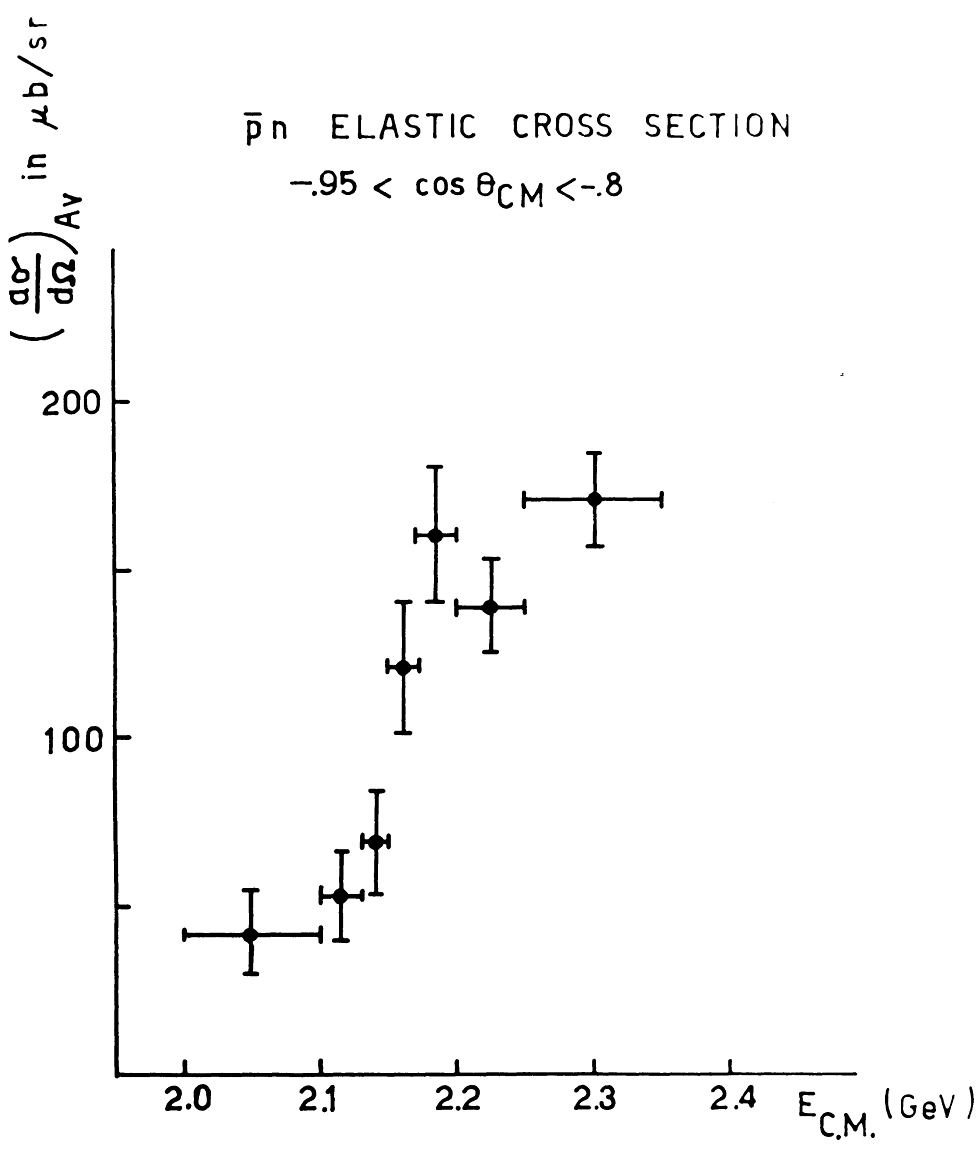


Fig. 5 $\bar{p}n$ elastic differential cross section for cos $\theta_{C.M.}$ between -0.95 and -0.8.

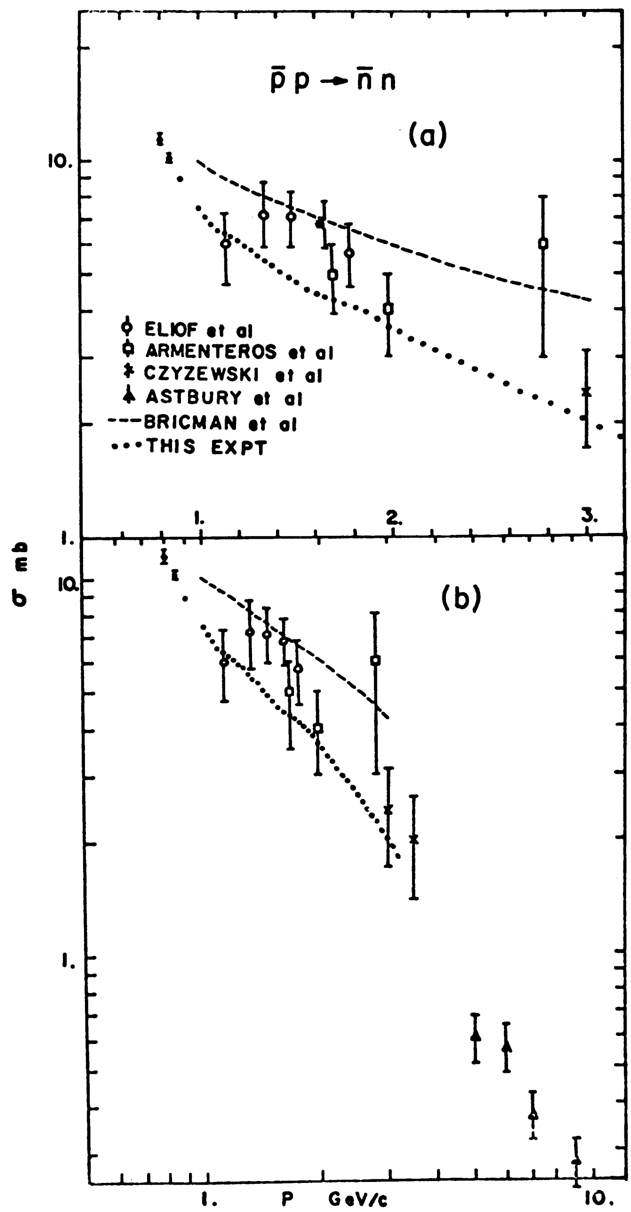


Fig. 6 Total cross section for the reaction p̄p—>n̄n, from the Stony Brook-Wisconsin collaboration.

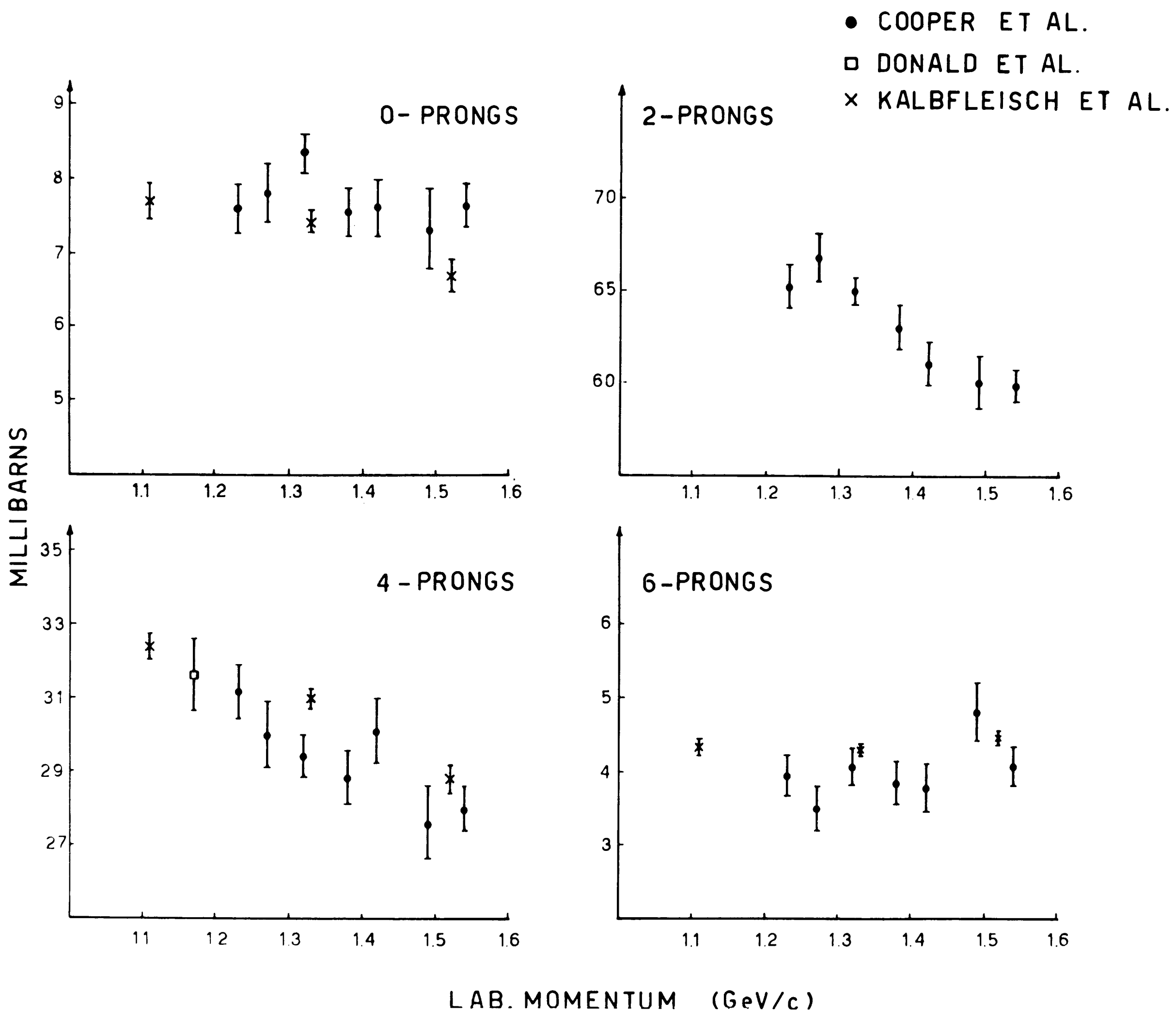


Fig. 7 $\bar{p}p$ topological cross sections.

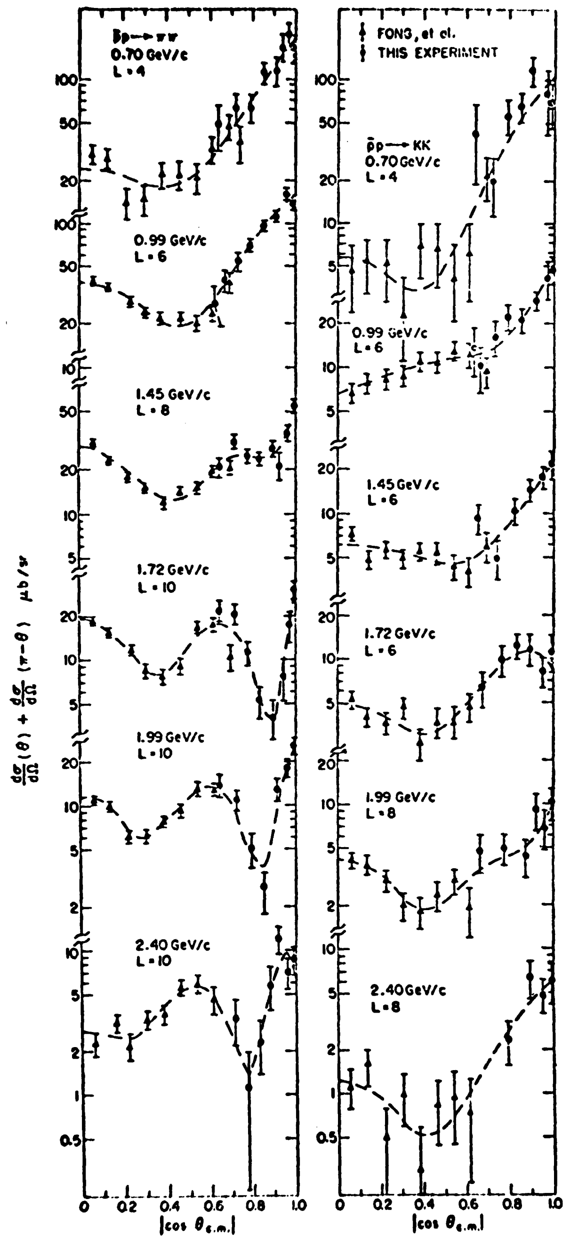

Fig. 8 Folded differential cross sections for $\bar{p}p \rightarrow \pi^- \pi^+$ and $\bar{p}p \rightarrow k^- k^+$ from ref. 26. The curves represent Legendre polynomial fits.

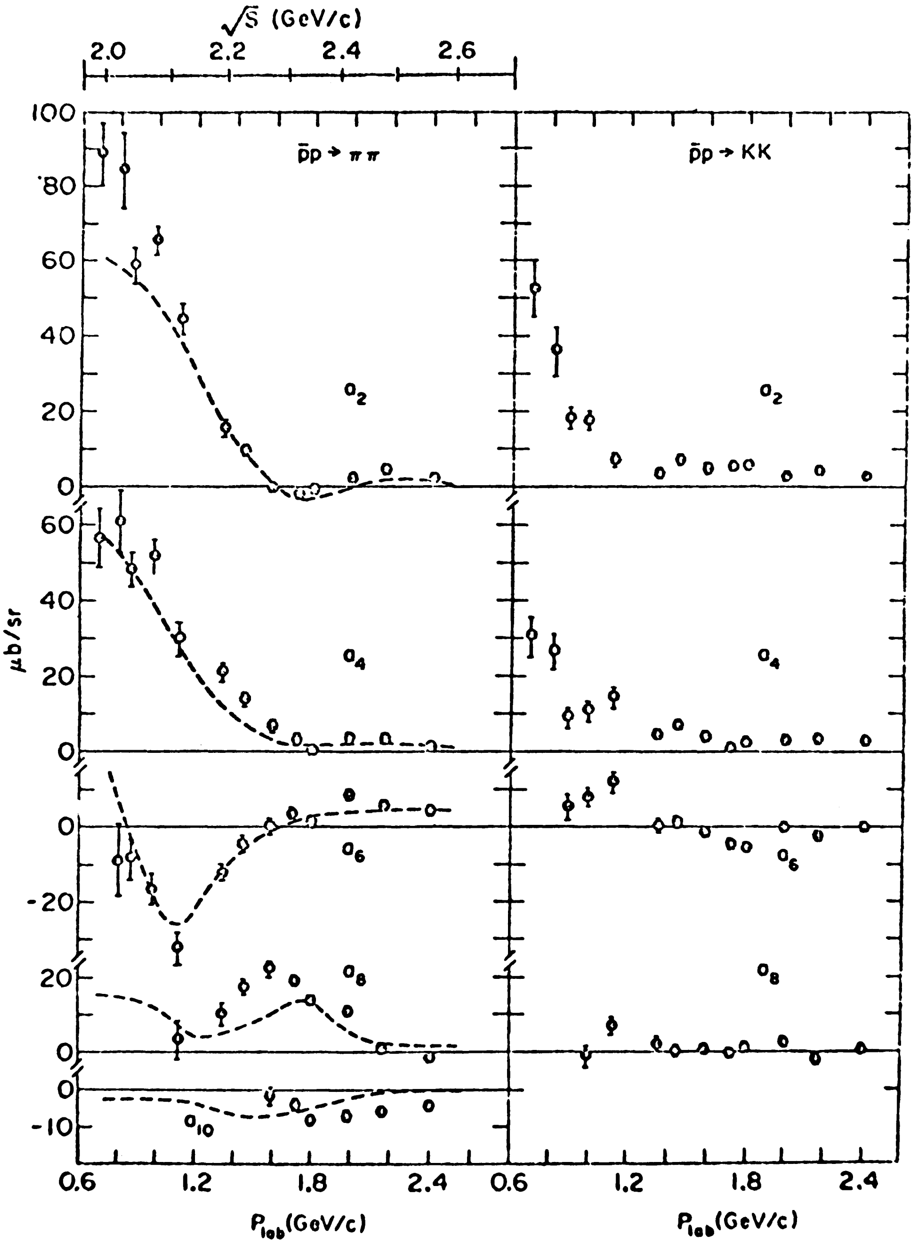


Fig. 9 Legendre coefficients from fits to the folded differential cross sections of fig. 8. The curves represent the resonance fit reported in the text.

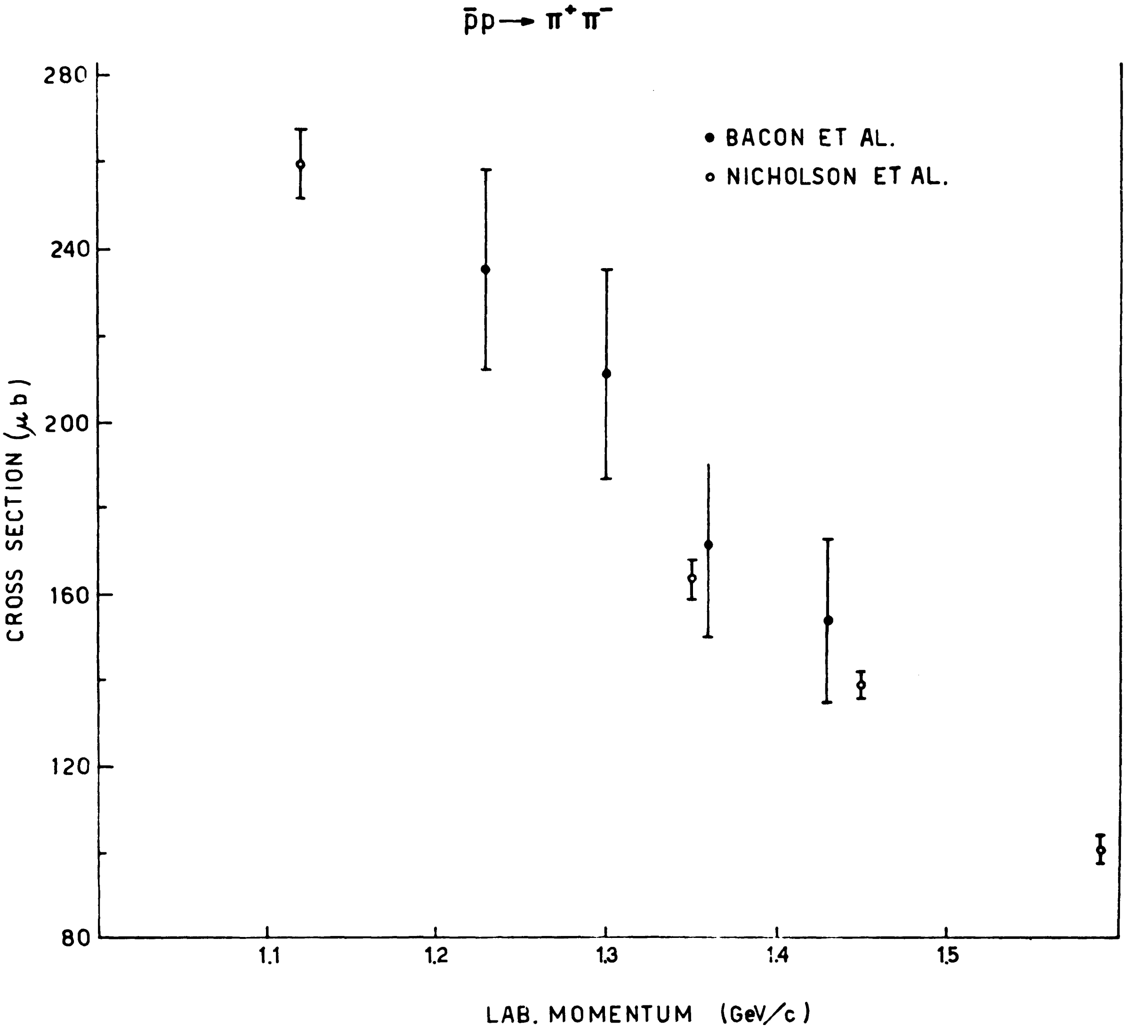


Fig. 10 Cross section for $\bar{p}p \rightarrow \pi^- \pi^+$

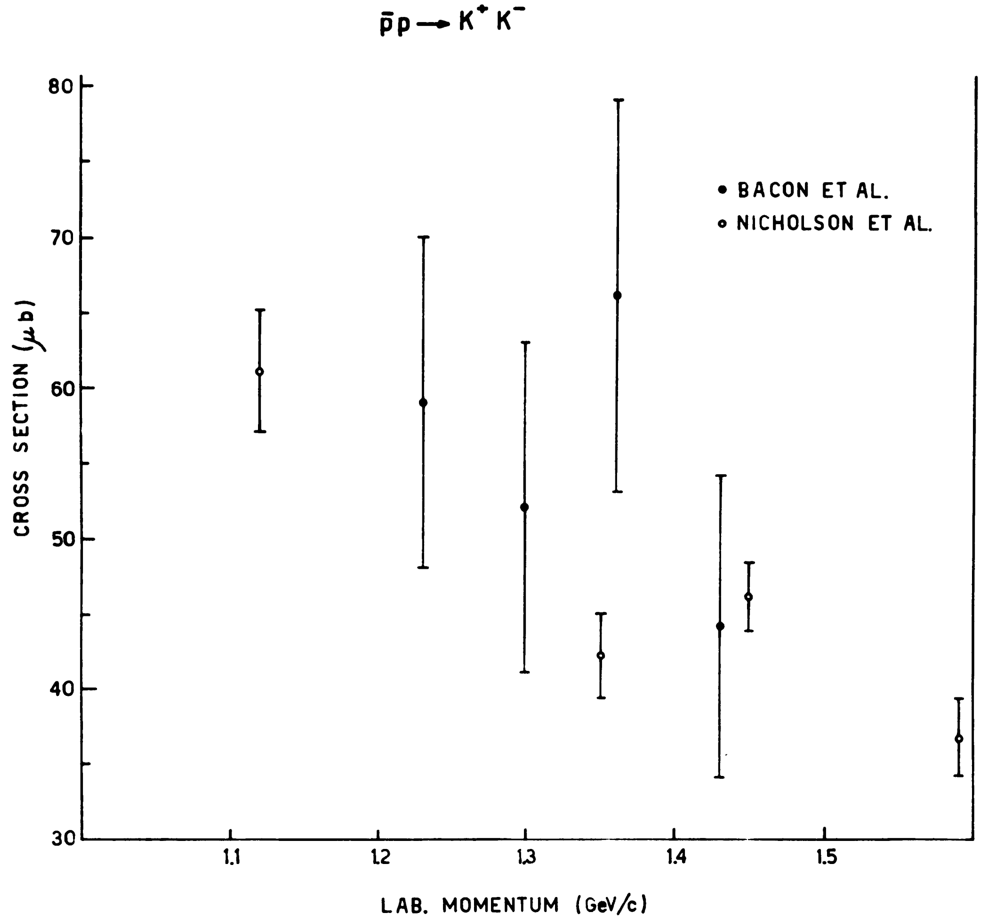


Fig. 11 Cross section for $\bar{p}p \longrightarrow k^- k^+$

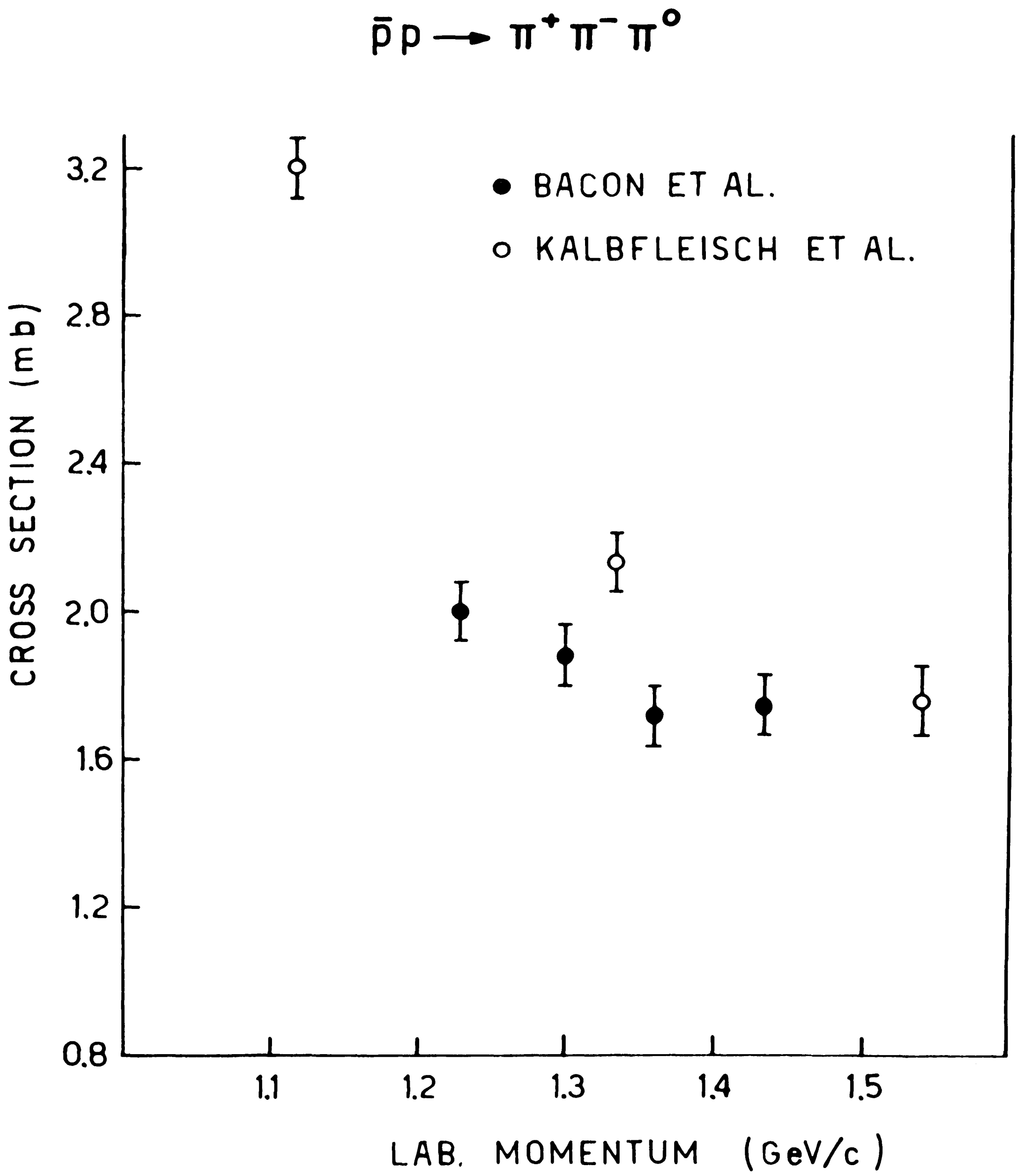


Fig. 12 Cross section for $\bar{p}p \rightarrow \pi^-\pi^+\pi^0$

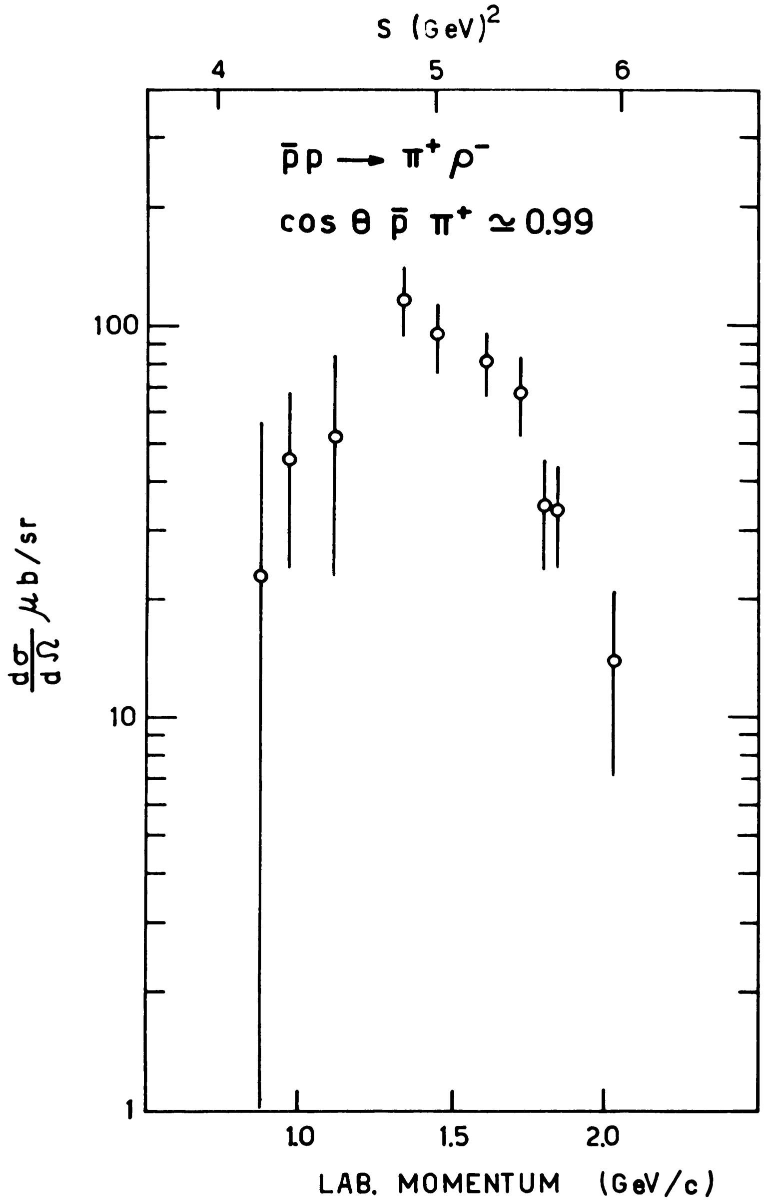


Fig. 13 Differential cross section for $\bar{p}p \rightarrow \pi^+\rho^-$ at $\cos\theta_{C.M.}(\bar{p}\pi^+) = 0.99$ from ref. 30.

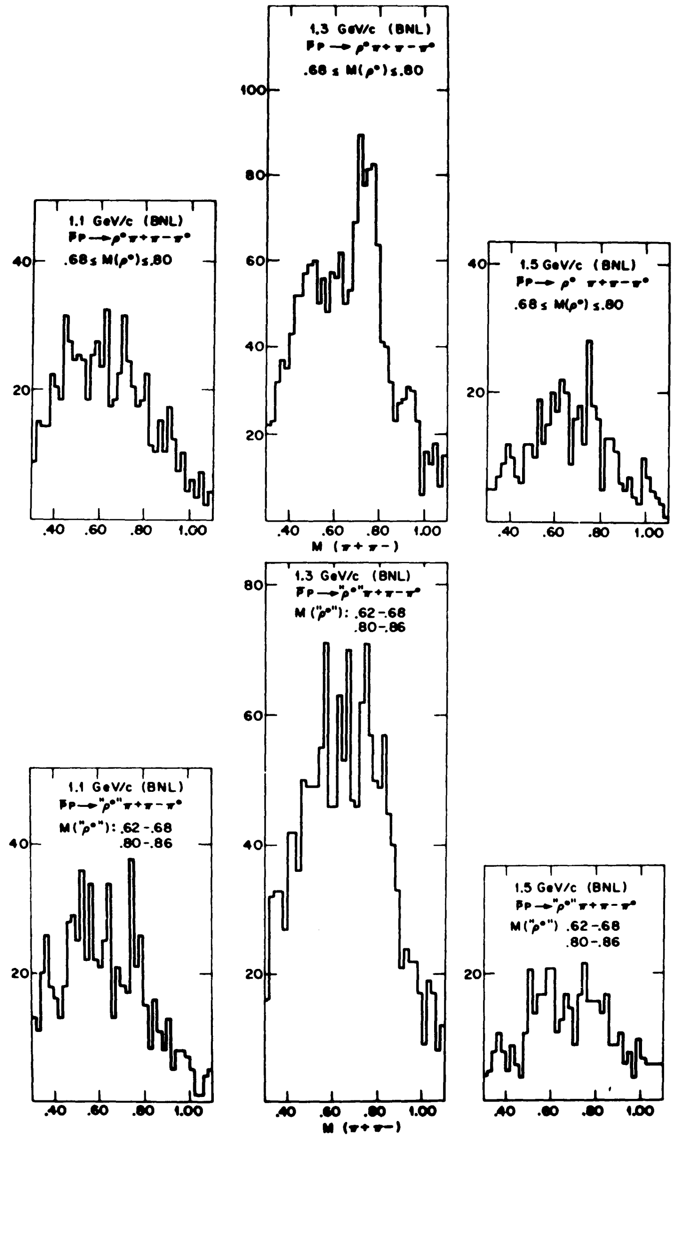

Fig. 14 $\pi^+\pi^-$ effective mass distribution for the reaction $\bar{p}p \rightarrow \rho^\circ\pi^+\pi^-\pi^\circ$ (Kalbfleisch et al. data). In the upper graphs the $\rho^\circ$ is in the $\rho$ band; in the lower graphs the '$\rho^\circ$' is in mass regions adja cent to the $\rho$ band.

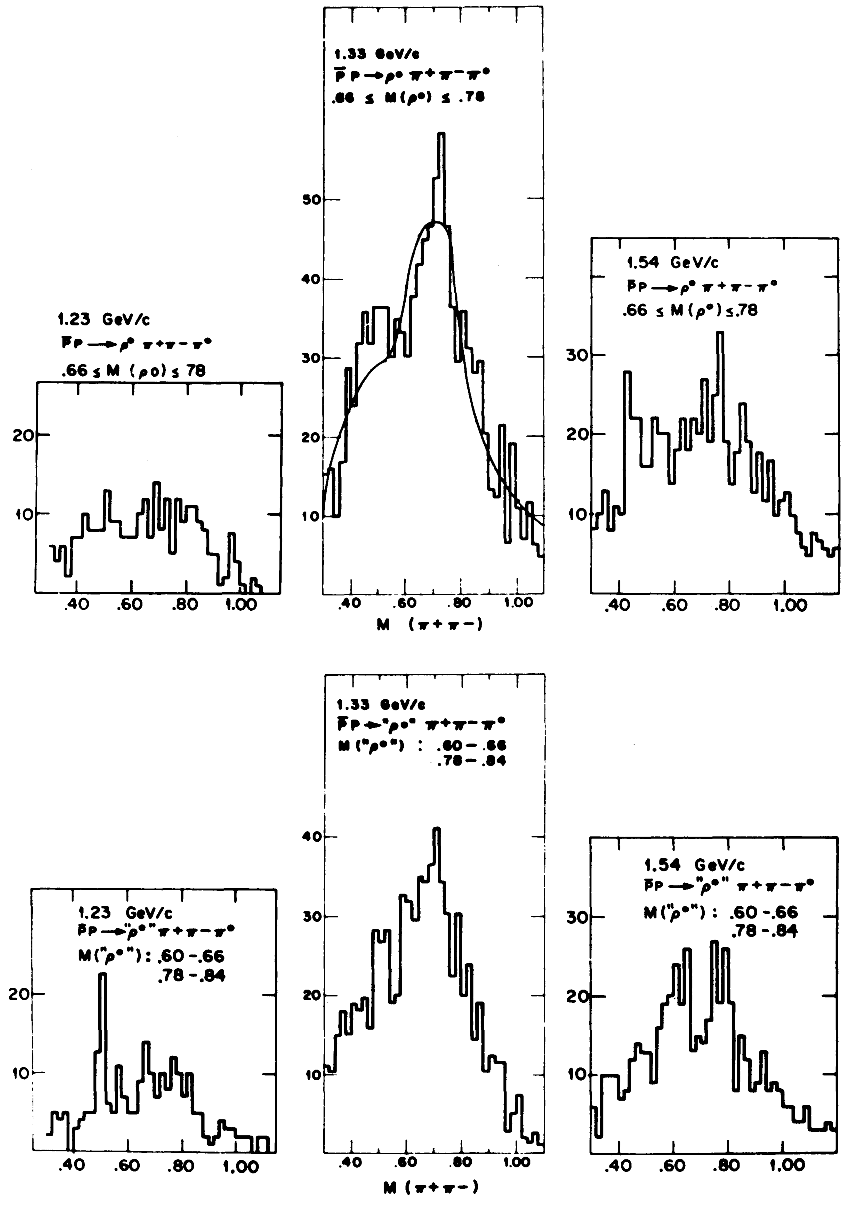


Fig. 15 $\pi^+\pi^-$ effective mass distribution for the reaction $\bar{p}p \to \rho^\circ\pi^+\pi^-\pi^\circ$ (Cooper et al. data). In the upper graphs the $\rho^\circ$ in the $\rho$ band; in the lower graphs the '$\rho^\circ$' is in mass regions adjacent to the $\rho$ band.

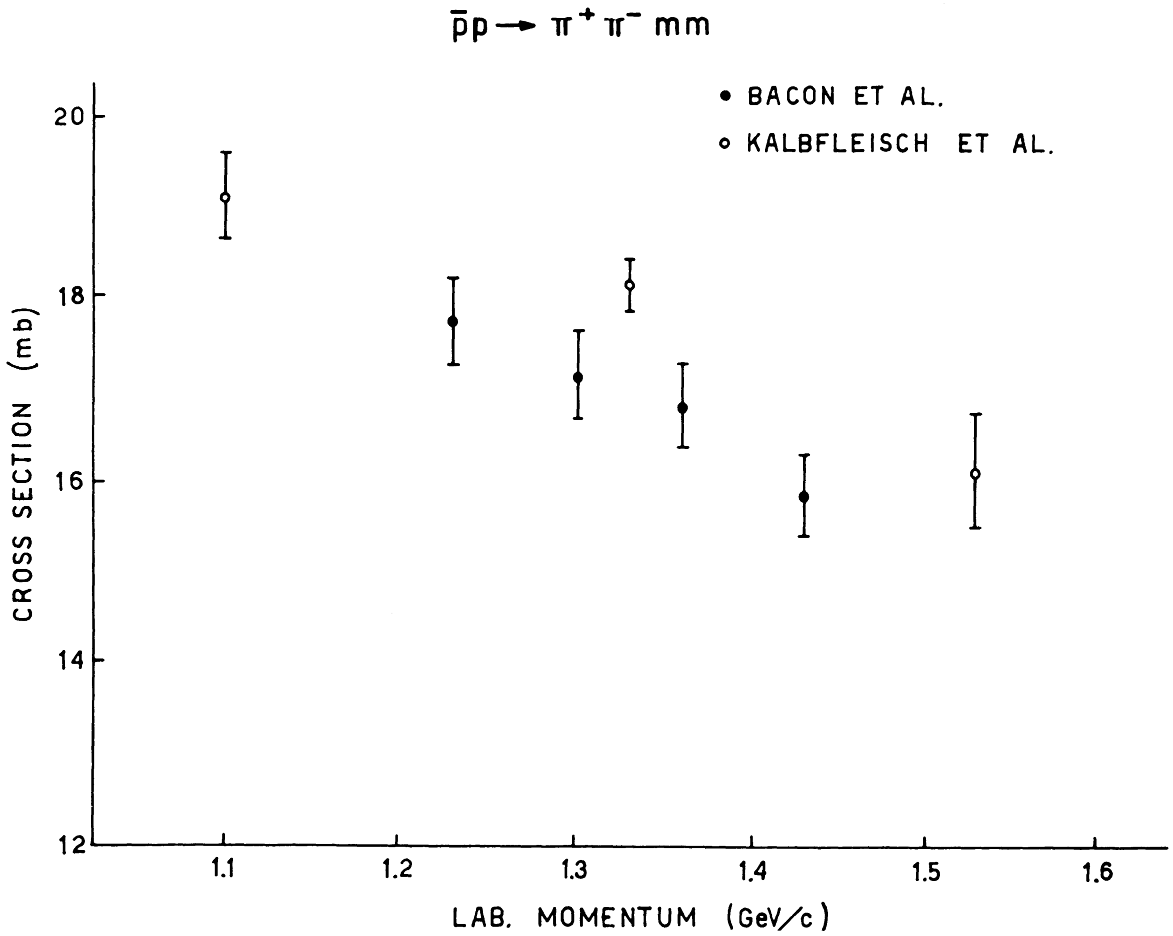


Fig. 16 Cross section for $\bar{p}p \to \pi^-\pi^+$ + neutrals.

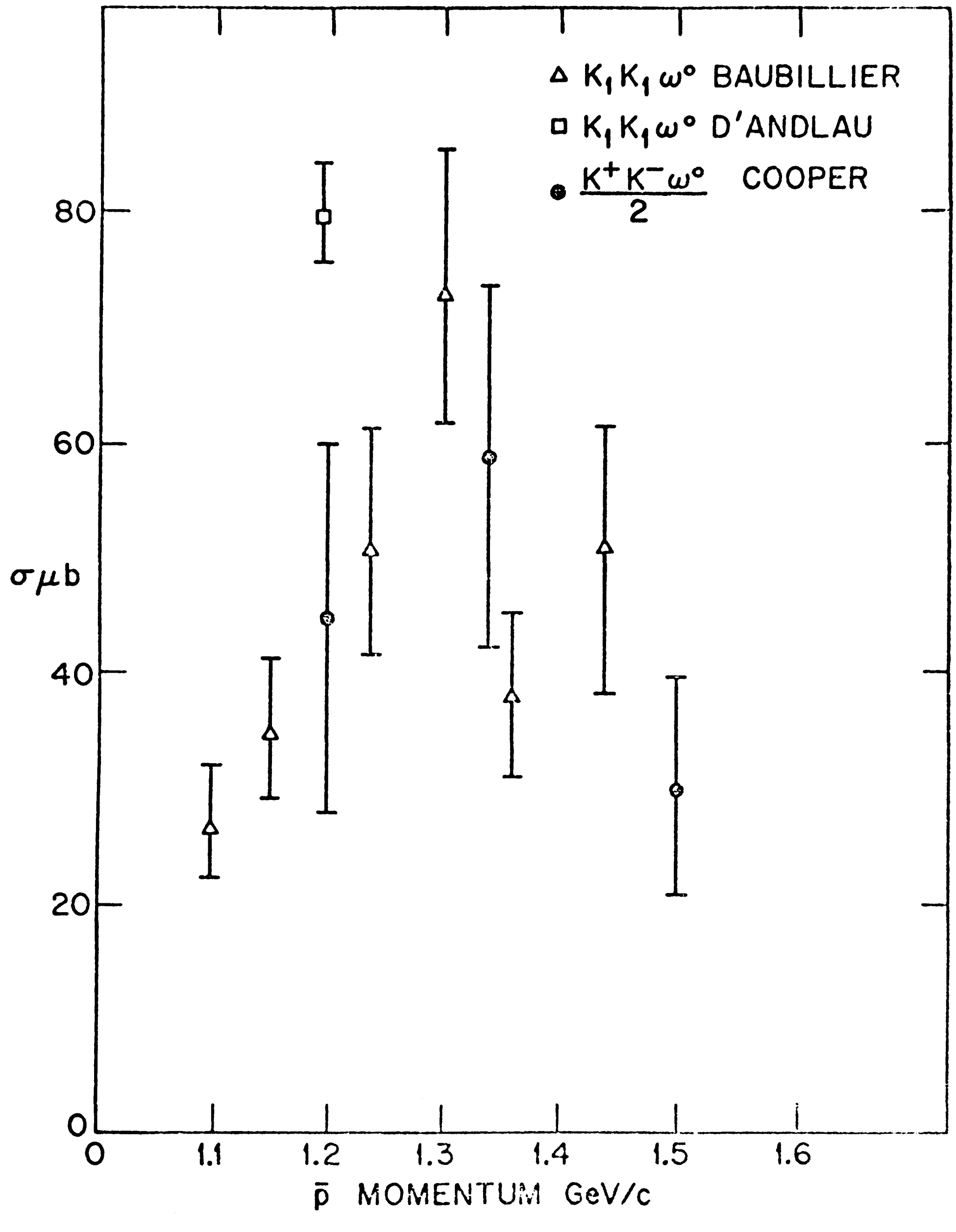


Fig. 17 Cross sections for $\bar{p}p \longrightarrow k_1 k_1 \omega$ and $k^- k^+ \omega$ .

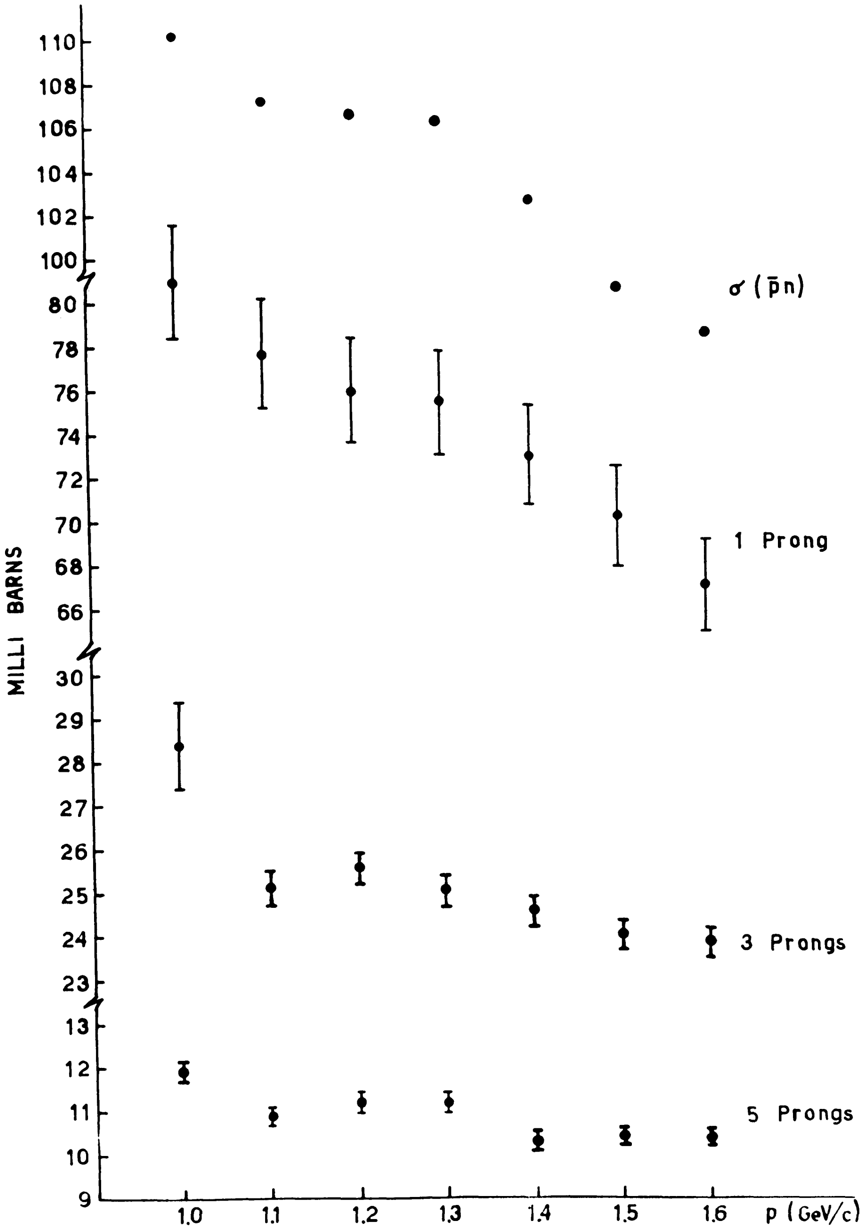


Fig. 18 Cross sections for the one, three and five prong topologies (with and without spectator proton). $\sigma(\bar{p}n)$ is the total $\bar{p}n$ cross section from Abrams et al..

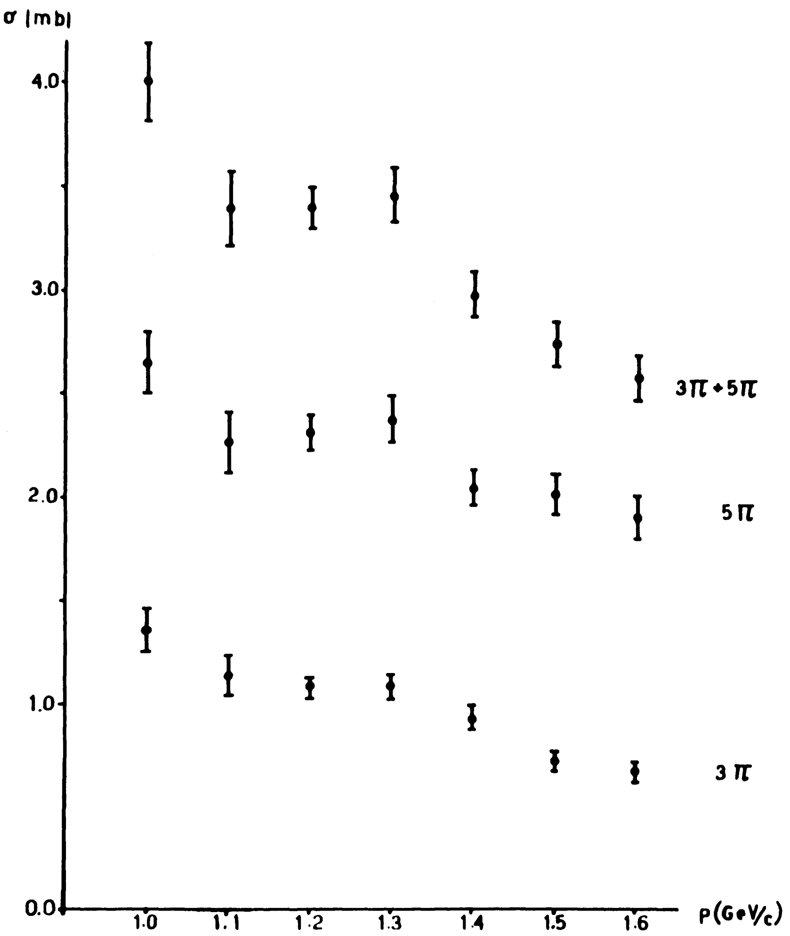


Fig. 19 Cross sections for $\bar{p}n \to 2\pi^-\pi^+$ and $3\pi^- 2\pi^+$ and their sum.

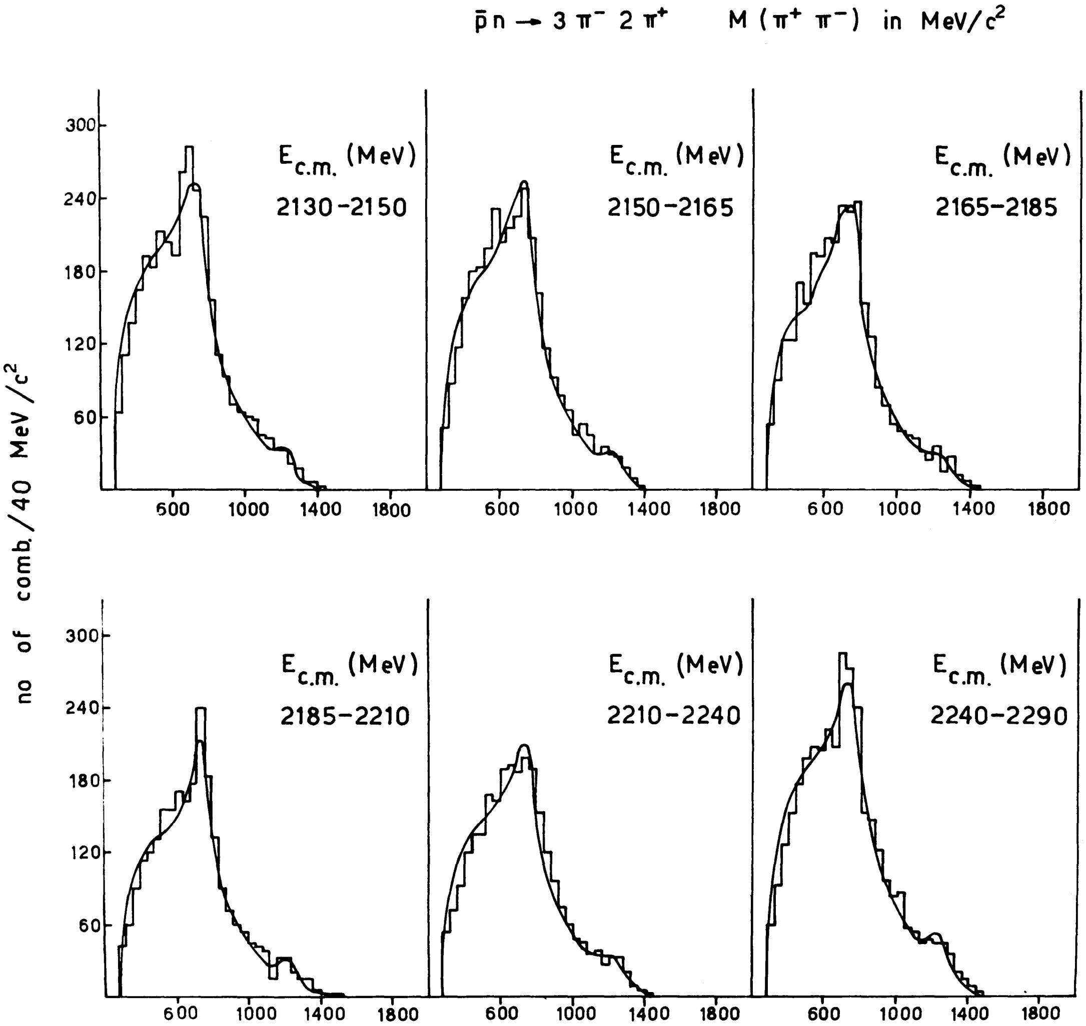


Fig. 20 $\pi^+\pi^-$ effective mass distributions from $\bar{p}n \rightarrow 3\pi^- 2\pi^+$.

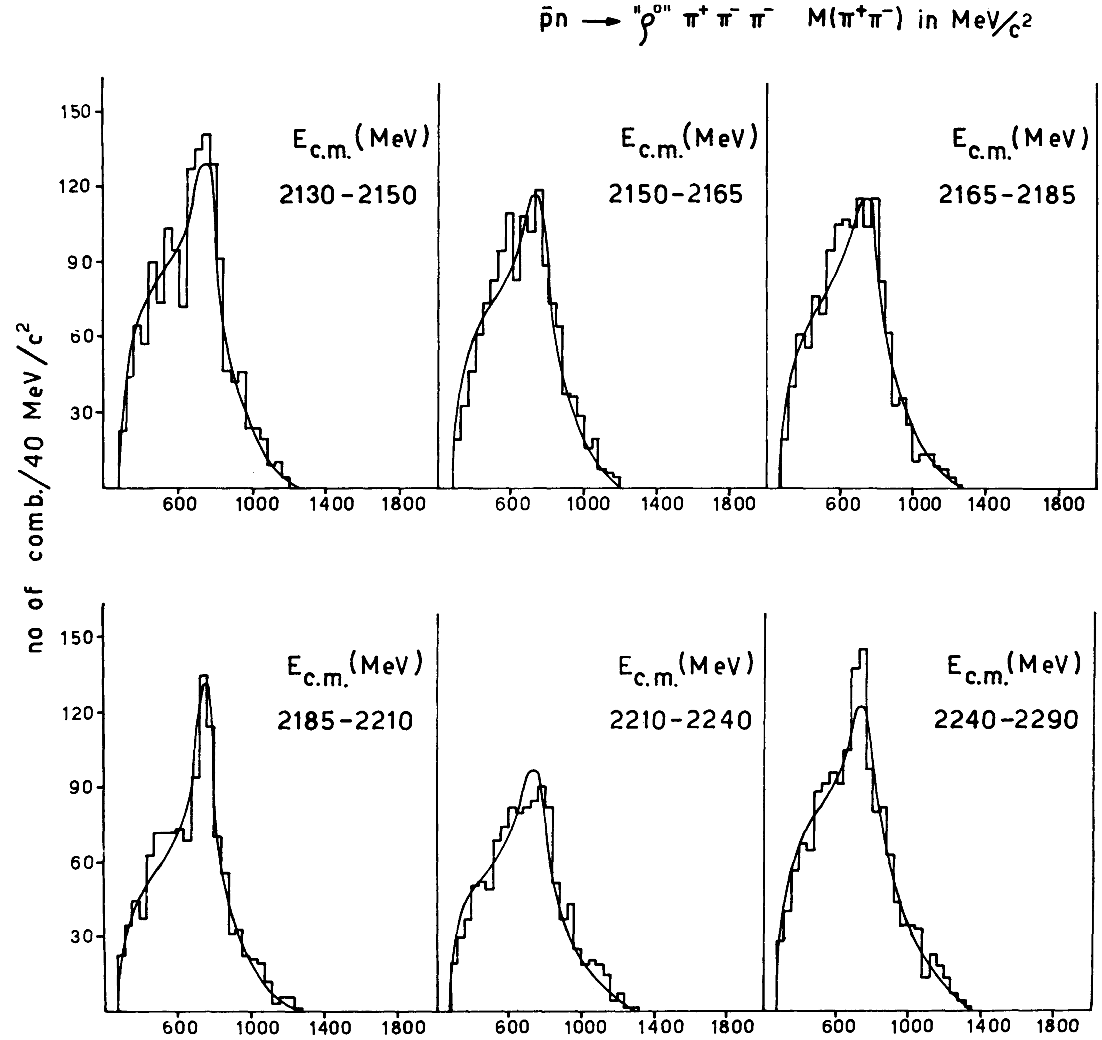


Fig. 21 $\pi^+\pi^-$ effective mass distributions from $\bar{p}n \rightarrow \rho^\circ\ 2\pi^-\ \pi^+$. The $\rho^\circ$ is in the mass region 700-820 MeV.