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ANTIPROTON-PROTON ELASTIC SCATTERING

IN THE BACKWARD HEMISPHERE

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ABSTRACT

This report presents the result of a comparison between the data of two experiments on the $\bar{p}p$ elastic scattering in the momentum interval ~ 300-700 MeV/c, that have recently been published.

Common data relative to the backward hemisphere $\bar{p}p$ elastic differential cross-section are compared showing significant discrepancies.

Conclusions are drawn about the eventual existence of bumps in this momentum region, corresponding to a 1900-1989 MeV/c^2 mass interval.

1. - INTRODUCTION

The possible existence of the narrow boson resonance S at the mass of ~ 1929 MeV/c^2 (1), has stimulated its search by studies of the $\bar{p}p$ interaction at low energies. If the S meson is coupled to the $N\bar{N}$ system, it should appear as a direct channel resonance at a momentum of ~ 460 MeV/ c for the incident antiproton. Furthermore, at these momenta the $\bar{p}p$ system allows a very high mass resolution, a very useful feature to study narrow resonances.

Since the $\bar{p}p$ elastic scattering cross-section is dominated by a conspicuous forward peak, apparently due to diffraction, the most sensitive way to detect the $\bar{p}p$ decay of narrow direct channel resonances, is to measure the energy behaviour of the backward elastic cross-section, although a direct channel resonance is not the only possible explanation for an eventual peak.

D. Cline et al. (2) have recently published the results of an analysis of 3934 $\bar{p}p$ backward elastic scatterings, giving the behaviour of the differential elastic cross-sections for $-1.0 \leq \cos \vartheta^* \leq 0.05$ ($\cos \vartheta^*$ being the $\bar{p}p$ c.m.s. angle cosine) in the 300-700 MeV/c momentum range. Henceforth this experiment will be referred to as A.

Earlier B. Conforto et al. (3) have measured 11000 $\bar{p}p$ elastic scatterings over the entire solid angle, in the momentum interval 350 - 600 MeV/c (their experiment will be referred to as B from now on). One of the aims of this high statistics experiment was the determination of the absolute cross-sections.

Limiting ourselves to the common angle and momentum interval ($-1.0 \leq \cos \vartheta^* \leq 0.05$; $350 \leq p \leq 600$ MeV/c), 3223 events are found in A and 690 in B. Although the two numbers of events differ by almost a factor 5, nevertheless a comparison between the two sets of data seems to be useful, mainly because of the different aims of the two experiments.

2. - CROSS-SECTIONS VERSUS MOMENTUM

In Fig. 1 we show plots of the cross-sections versus laboratory momentum for various $\cos \vartheta^*$ intervals. The dots refer to A data; B data are indicated by crosses.

The plot for the interval $-1.0 \leq \cos \vartheta^* \leq -0.8$ shows a good agreement between the A and B data. For the other cosine intervals, significant discrepancies are apparent: the cross-sections measured in B being generally higher. There appears to be a trend for this discrepancy to increase as cos ϑ* increases and to be more pronounced for lower momentum values.

It is difficult to understand the reasons for this discrepancy and an eventual misestimation of the total path length cannot explain it completely (see section 3).

Whilst no cuts were made in experiment B, in A the backward events were selected using an angle template and making cuts on the ranges of the outgoing particles. If it is true that in A there is a loss of events as cos ϑ* increases, this might be due to the use of too much restrictive selection criteria.

3. - DIFFERENTIAL CROSS-SECTIONS

The same data can be displayed as differential cross-sections $d\sigma/d\Omega$ as a function of cos ϑ*, for different beam momenta. In A this is done for four momentum intervals 100 MeV/c wide, starting at 300 MeV/c. In B data are divided into 9 momentum intervals of width decreasing with energy from 80 to 20 MeV/c. To make a comparison, the B data have been grouped in three intervals centered at about the same momentum as the three lowest A intervals. Details are given in the first three columns of Table I.

The resulting angular distributions are compared in Fig. 2. The effect observed in Fig. 1 is again apparent: the B cross-sections (full line) are higher than the A cross-sections (dashed line). The effect is particularly important at high cos ϑ* and low momentum. A χ^2 - test of

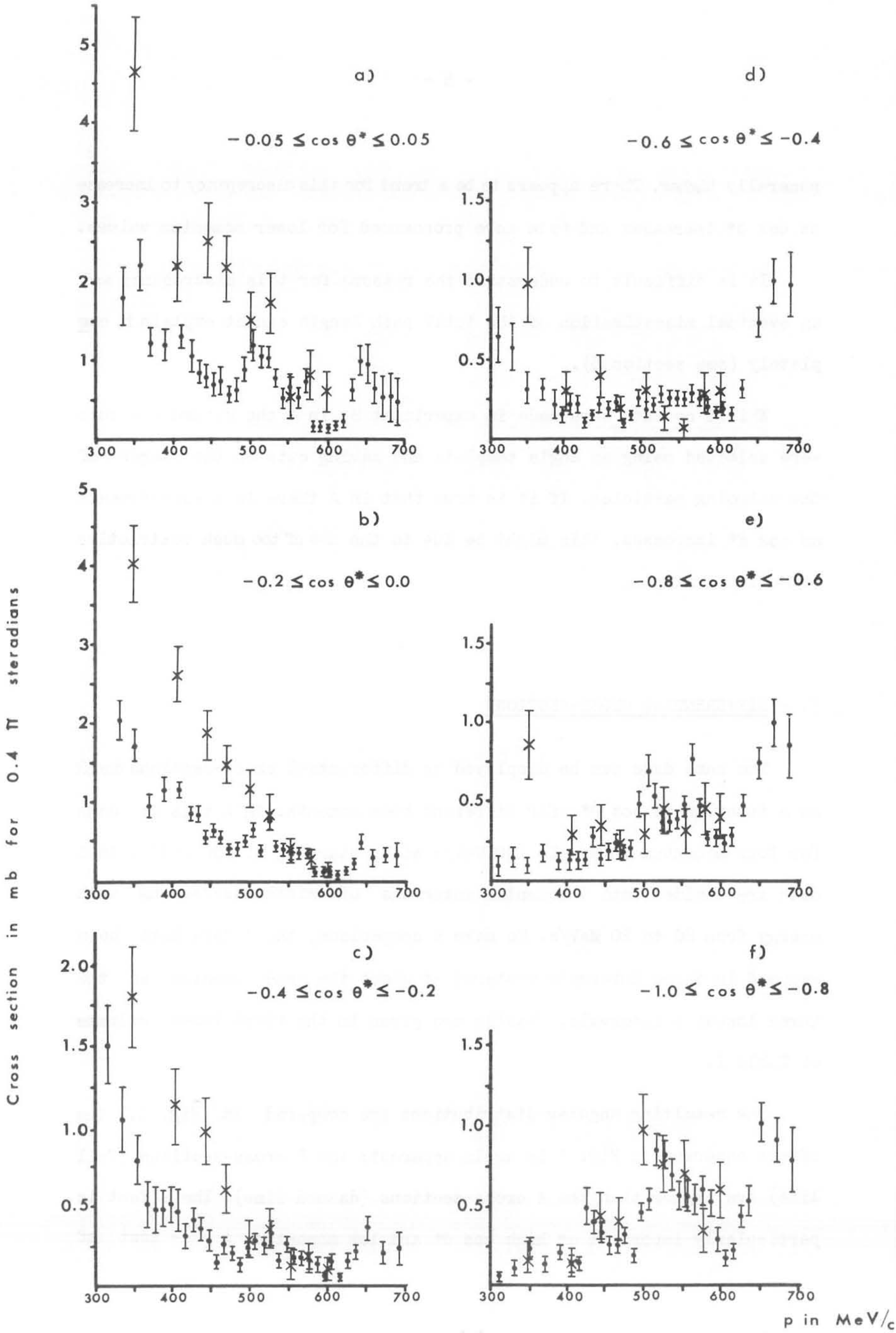
a)
−0.05 ≤ cos θ* ≤ 0.05
b)
−0.2 ≤ cos θ* ≤ 0.0
c)
−0.4 ≤ cos θ* ≤ −0.2
d)
−0.6 ≤ cos θ* ≤ −0.4
e)
−0.8 ≤ cos θ* ≤ −0.6
f)
−1.0 ≤ cos θ* ≤ −0.8
Cross section in mb for 0.4 π steradians
p in MeV/c
300
400
500
600
700

FIG. 1

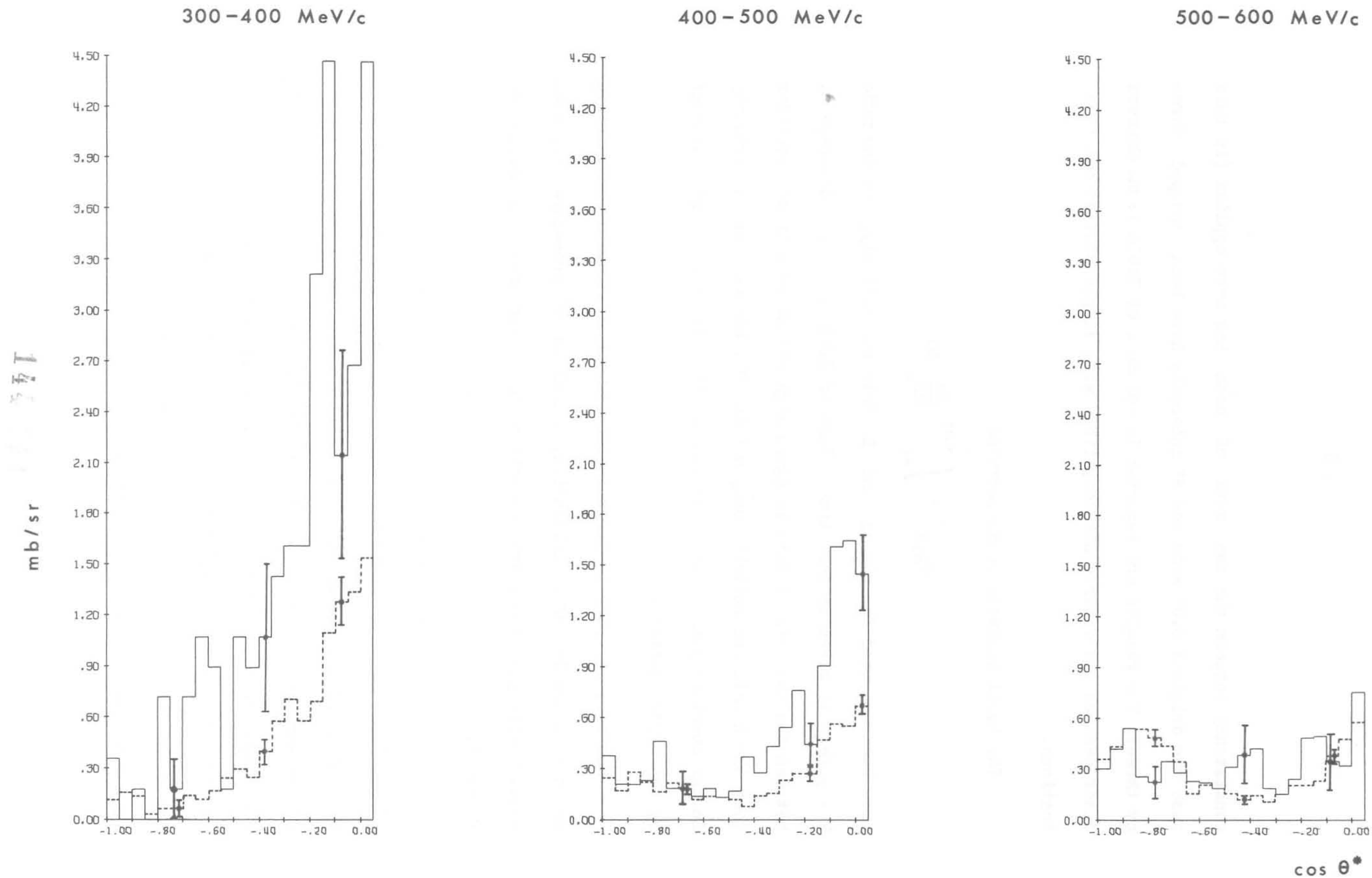
300-400 MeV/c
400-500 MeV/c
500-600 MeV/c
mb/sr
4.50
4.20
3.90
3.60
3.30
3.00
2.70
2.40
2.10
1.80
1.50
1.20
.90
.60
.30
0.00
-1.00
-.80
-.60
-.40
-.20
0.00
cos θ*

FIG. 2

consistency between the two sets of data has been applied (in this case the original 0.05 wide cos ϑ^* intervals have been grouped three by three). The results are reported in column 4 of Table 1: the observed discrepancies are clearly not compatible with simple statistical fluctuations.

The total backward cross-sections

$$\sigma_{A,B} = \int_{-1}^{0,05} \frac{d\sigma}{d\Omega}\, d\Omega$$

have been computed for the A and B data respectively, and the ratio $R = \sigma_A/\sigma_B$ is given in the fifth column of Table 1. The discrepancy between the two sets of data is again significant even if we consider that the A data are reliable only within 20%, because of uncertainty in the absolute path length measurement (this is taken into account by the errors quoted).

However, in order to further check if the discrepancy could be reduced to a problem of normalization, a minimum χ^2 procedure has been used, multiplying the B cross-sections by a variable normalization factor k.

The resulting values of the normalization factor and the associated $P(\chi^2)$ are given in columns 6 and 7 of Table 1, and seem to confirm that normalization is not the main question and that one must search for an explanation in the substantially different behaviours of the differential cross-sections. On the other hand, it should be noted that the use of a different normalization factor for every energy clearly influences the energy behaviour of the cross-sections, and this might have some consequences on the conclusions about the existence of peaks.

Table 1

1	2	3	4	5	6	7
Momentum interval (A) MeV/c	Momentum value (B) MeV/c	Mean momentum (B) MeV/c	$P(\chi^2)$	$R = \frac{\sigma_A}{\sigma_B}$	K	$P(\chi^2)$ if $\sigma_A = K\sigma_B$
300 - 400	349 ± 40	349	$< 10^{-3}$	0.345 ± 0.070	0.370 ± 0.034	0.015
400 - 500	405 ± 28 444 ± 22 467 ± 19 499 ± 15	465	$< 10^{-3}$	0.492 ± 0.099	0.518 ± 0.035	0.001
500 - 600	525 ± 14 553 ± 13 577 ± 12 599 ± 11	566	0.012	0.895 ± 0.180	1.130 ± 0.114	0.015
600 - 700						

4. - CONCLUSIONS

We have shown that there are significant discrepancies between the two existing sets of data on the $\bar{p}p$ low energy backward scattering.

The Wisconsin group (A) has reported two peaks in the 180° cross-section at ~440 and ~550 MeV/c. Moreover they see the ~550 MeV/c peak also in the 90° cross-section.

The data of the CERN-Roma-Trieste collaboration (B) are not in disagreement with the 180° cross-section reported by the Wisconsin group, but the two sets of data differ markedly in the energy dependence of the 90° cross-section. Pending a clarification of this discrepancy the existence of the ~550 MeV/c peak in this angular region should be considered with some caution.

A possible interpretation of the ~550 MeV/c peak at 180° is that it be due to a direct channel resonance with a mass of ~1945 Mev/c^2, but, as it has been recently shown (4), a simple diffractive model can also account for this backward bump.

ACKNOWLEDGMENTS

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FIGURE CAPTIONS

Fig. 1 - Momentum dependence of the backward $\bar{p}p$ cross-section for various $\cos \vartheta^*$ intervals.
The dots refer to A data, the crosses to B data.

Fig. 2 - $\bar{p}p$ differential cross-section in the region $-1.0 \leq \cos \vartheta^* \leq \leq 0.05$ for 3 momentum intervals. Full line refers to B data, dashed line to A data. Typical errors are also shown.

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