STATUS REPORT ON THE 2.3 GEV/C $\bar{p}p$ EXPERIMENT*

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This experiment is the work of a number of people, D.S. Rhines, T. Fields, Y. Oren, J. Whitmore (Argonne), W.A. Cooper (formerly Argonne now at the Open University), W.W.M. Allison (formerly Argonne now at Oxford).

The data were taken in the ANL 30" chamber and 340,000 events were automatically scanned and measured by POLLY II[1]. The normalisation of the experiment was provided by the integrated track length scanned by POLLY and yielded a total cross section after correction:

$$\sigma_{tot} = 87 \pm 4 \text{ mb at } 2.32 \text{ GeV/c}$$

in agreement with the transmission experiments of Abrams et al[2]. The V^o events were scanned by hand and measured by POLLY later - these data are preliminary.

We have already published our data[3] on ρ/ω interference. They suggest that the production amplitudes for the states $\rho^o\pi^+\pi^-$ and $\omega^o\pi^+\pi^-$ are approximately equal and in phase at this momentum and others where data is available above 1.2 GeV/c. In particular the relationship applies to the pure I-spin states $\rho^o f^o/\omega^o f^o$, $\rho^o\rho^o/\omega^o\rho^o$.

Figure 1 shows the elastic angular distribution. The data cover the range +0.97 to -0.98 corresponding to minimum lab. momenta of 210 MeV/c and 170 MeV/c for proton and anti-proton respectively. In addition to the statistical errors shown there is a 4% normalisation uncertainty which applies to all channels. The forward peak shows some evidence for curvature. Extrapolating from various regions of the forward peak (as shown) we get:

$$d\sigma/d\Omega\,)_o = 98 \pm 15 \text{ mb/sr.}$$

and

$$\sigma_{el} = 30 \ (\pm 2) \text{ mb}$$

At this point it is normal practice to ignore the difference between singlet and triplet scattering and attribute the difference

$$\frac{d\sigma}{d\Omega}\Big)_o - \frac{k^2\sigma^2_{tot}}{16\pi^2}$$

to the real part of the forward scattering amplitude. One must remember however that the non-linearity of the optical theorem will destroy this argument if singlet and triplet scattering differ in either total cross section or ratio of real to imaginary parts. With this reservation we have

$$\text{modulus } \frac{\text{Ref}}{\text{Imf}}\Big)_o = 0.28 \ \left(\begin{smallmatrix}+0.15\\-0.28\end{smallmatrix}\right) \text{ i.e. consistent with zero.}$$

In the backward region we have no peak at all - the distribution as a whole certainly does not <u>suggest</u> the presence of s-channel resonances, although, as has been pointed out before at this meeting, quantitative models of diffraction which can be reliably extended into the backward region do not exist. As a result no firm conclusion may be drawn.

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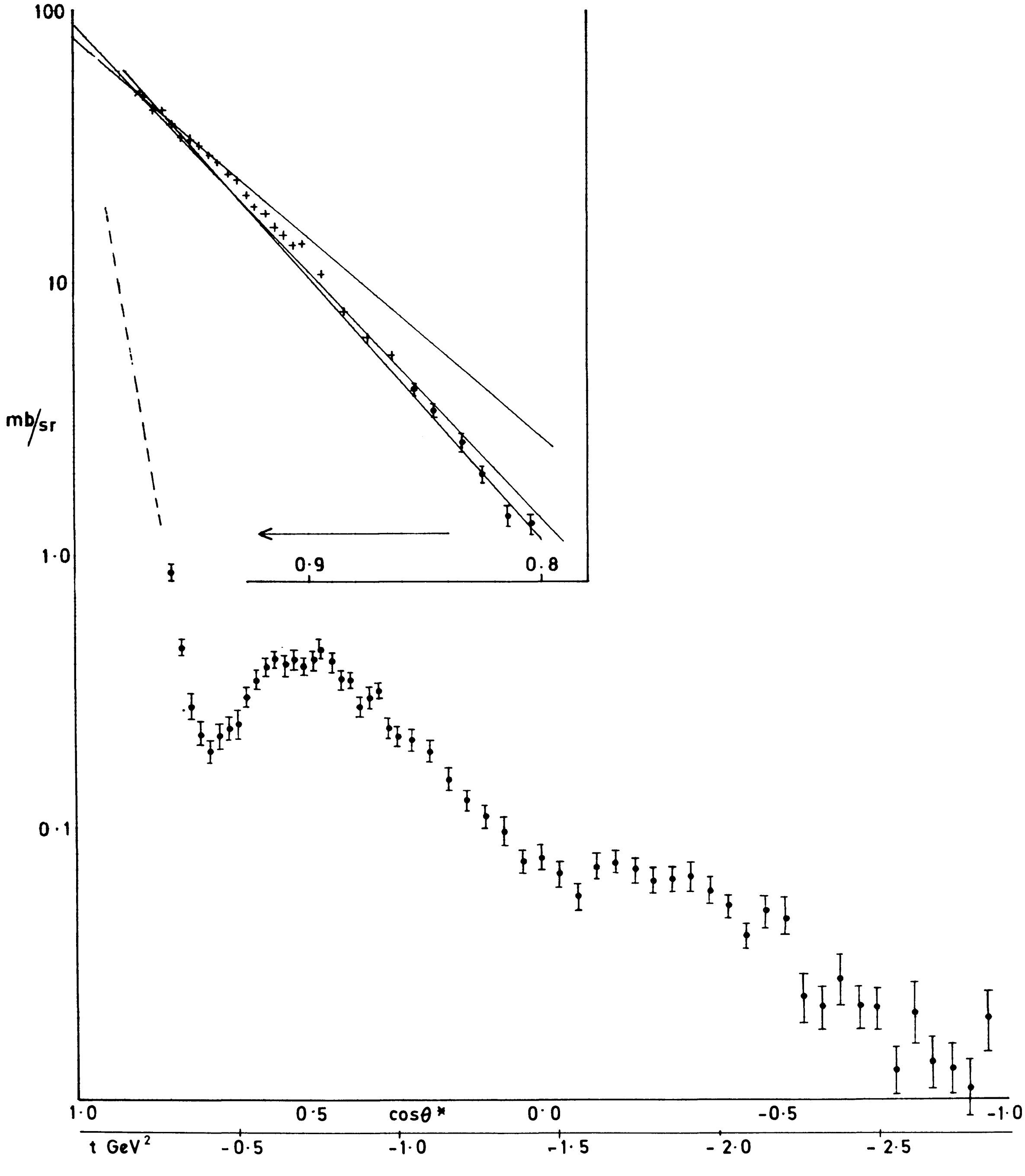


Fig. 1 pp elastic scattering at 2 · 32 GeV/c (79,255 events).

We have searched our data very carefully for exotic mesons. None has been found. Other aspects of the multibody data will be published in a series of papers in the near future.

I would like to spend the rest of the time discussing the 2 body channels shown[4]:

channel	events	cross section (μb)	
$\pi^+\pi^-$	223	45(±3)	
K^+K^-	91	18(±2)	
$\pi^o f^o$		72(±19)	Background subtracted; $f^o \to \pi^+\pi^-$
$\pi^o \rho^o$		51(±15)	" "
$\pi^-\rho^+$ / $\rho^-\pi^+$		119(±40)	" "
$K_1^o K_1^o$	0	< 0.3	No events seen; $K_1^o \to \pi^+\pi^-$
$K_1^o(K_2^o)$	2	∿ 0.3	2 events seen; $K_1^o \to \pi^+\pi^-$

Figure 2 shows the relevant angular distributions. The K^+K^- data is consistent with hyperon exchange and indeed agrees quite well with backward KN scattering under line reversal (dotted curve)[4]. There is no backward peak due to Z^{*++} exotic exchange. The small ratio $K^o\bar{K}^o/K^+K^-$ may be interpreted as the result of either

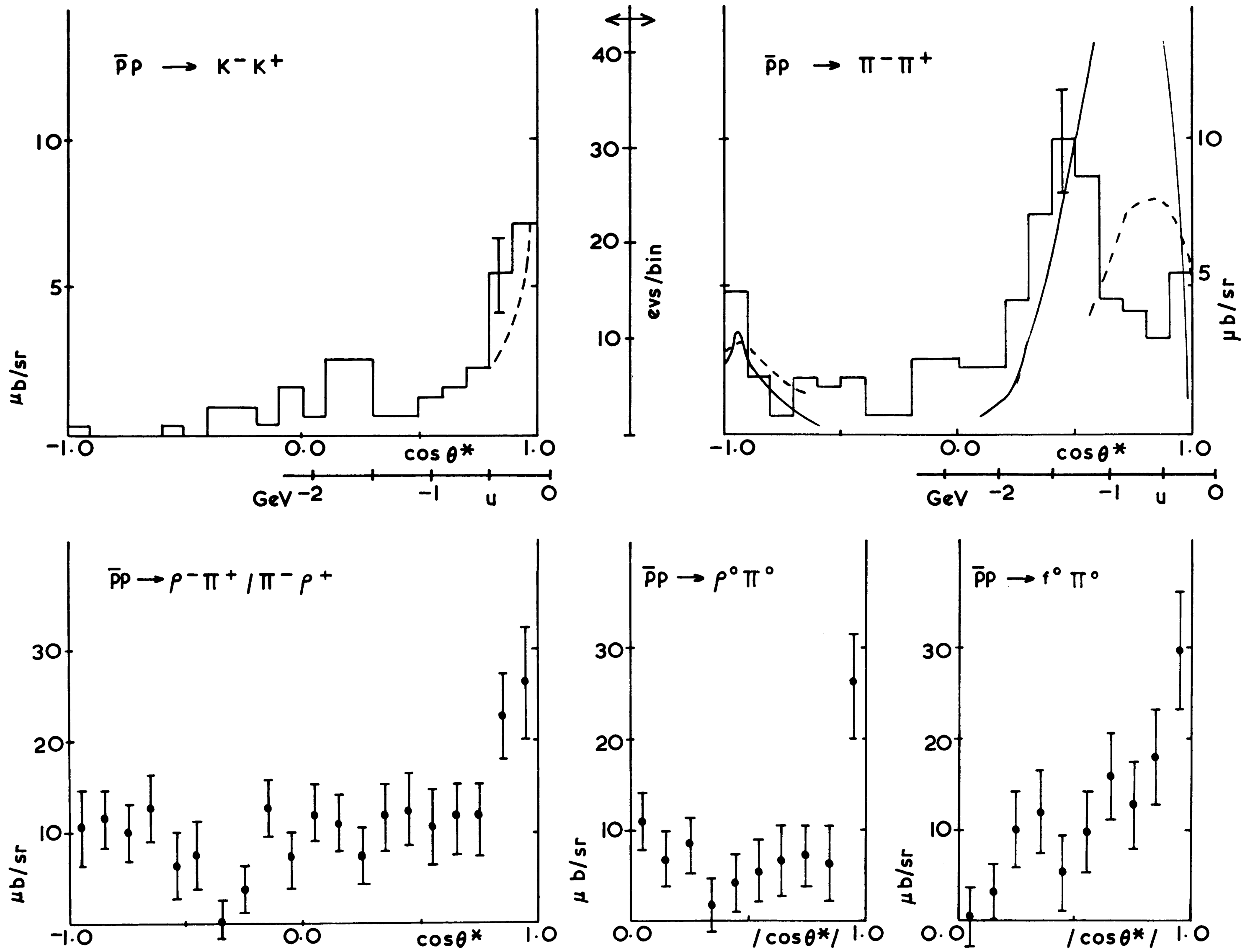
a) I = 0 exchange or

b) equal in phase I = 0 and I = 1 s-channel amplitudes.

While these two descriptions are "dual" to one another, it is particularly interesting to notice that the same relative amplitude and phase of the I = 0 and I = 1 channels was found in the ρ/ω interference[3]. Furthermore both effects appear more or less independent of incident momentum above ∿ 1 GeV/c suggesting either an absence of s-channel resonances or a strong degeneracy of resonances with respect to I-spin.

A very different situation appears to obtain in the 2π channel. The angular distribution shows a major peak corresponding to a 4-momentum transfer of 1.2 GeV^2 or a transverse momentum of 1 GeV/c! This suggests spatial structure of order 0.2 fermis in the interaction region. We have compared our data with those of other experiments and get moderate to good agreement[4,5,6]. The line reversal predictions of the models of Barger & Cline[7] (dashed curve) and Berger & Fox[8] (solid curve) do not fit the data at all. We have also considered a simple diffractive model[9] involving 2 body production in the surface of the annihilation region. While this can give a peak at ∿ 1 GeV/c in transverse momentum the primary peak near zero should be twenty times higher. We are forced to the conclusion that an s-channel resonance interpretation of data in this region is not only possible (as shown by Nicholson et al[6]) but necessary[10].

Why do these resonances only couple to $\pi^+\pi^-$? Is the observation of this extraordinary resonance phenomenon to be associated with the equally unique combination of selection rules and absorption which constrains the s-channel amplitudes for $\pi^+\pi^-$? It is only reasonable to conclude that other states also couple to s-channel resonances but that the large angle interference structure are washed out by the many different helicity and I-spin states.



Center of mass angular distributions. For the charged states the right hand side represents the 'no-charge-exchange' direction; neutral final states are folded about 90°. For ρ and f° channels each point represents an independent resonance + background fit to the mass spectrum for that angular bin. The errors shown are statistical.

From these results we find positive support for a dual picture of towers of resonances with strong degeneracies such that s and t channel descriptions are equivalent. However only when there are a small number of amplitudes allowed in the s-channel does the resonance structure manifest itself.

REFERENCES

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(4) T. Fields et al., to be published. Also Oxford preprint "The reaction $\bar{p}p \to \pi^-\pi^+$ and K^-K^+ at 2.3 GeV/c" (October 1971)
(5) J.W. Chapman et al., Phys. Rev. Lett. 21, 1718 (1968)
(6) H. Nicholson et al., Phys. Rev. Lett., 23, 603 (1969)
(7) V. Barger & D. Cline, Phys. Lett., 25B, 415 (1967)
(8) E. Berger & G. Fox, Nucl. Phys., B26, 1 (1971)
(9) The word diffraction means different things to different people. Here we mean that the phases of the different partial waves are all relatively real and positive. This is discussed further in ref. 4.
(10) We do not imply that the details of the Nicholson analysis are necessarily unique, only that some such resonance interpretation is required.

DISCUSSION AND COMMENTS

Mr. Armenteros : How much time did you need for the measurements ?

Mr. Allison : One year, 100 hour a week.

Mr. Butterworth : What is your scanning efficiency for backward elastic scattering and for V^o ?

Mr. Allison : At 2.3 GeV/c, the angular range for backward elastic scattering with an unvisible antiproton is small. We introduce a cut at cos $\theta^* = -0.97$. Our results on channels with strange particle are preliminary. In this experiment, emphasis was put on channels with large cross-sections.

Mr. Butterworth : Underlines that the strange behaviour of the $\pi^+\pi^-$ angular distribution is not specific of the 2.3 GeV/c but is also absurd at other energies (1.2 to 1.5 GeV/c).