SINGLE-PION PRODUCTION NEAR THRESHOLD

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(Presented by J. Schultz)

We report results on single pion production from an exposure of 220,000 pictures of antiprotons in the BNL 30" HBC at six laboratory momenta between approximately 0.7 and 1.1 GeV/c. Approximately 2/3 of the flux was above the production threshold. The reactions studied are:

$$\bar{p}p \to \bar{p}p\pi^0 , \quad (1)$$

$$\bar{p}n\pi^+ , \quad (2)$$

$$\bar{n}p\pi^- . \quad (3)$$

A recent analysis by Ma et al.[1] in terms of an incoherent sum of isospin amplitudes, corresponding to the diagrams of Fig. 1, shows that in the region from 1.1 to 1.5 GeV/c the process is dominated by $I = 1$, $I' = 3/2$. This is perhaps to be expected, since this region is precisely the threshold region for producing $\Delta(1236)$ [and $\bar{\Delta}(1236)$]. In their analysis $I' = 3/2$ is characterized by a value of 2 for the ratio:

$$R \equiv \frac{\sigma(\bar{p}p\pi^0)}{\frac{1}{2}\left[\sigma(\bar{p}n\pi^+) + \sigma(\bar{n}p\pi^-)\right]} .$$

It seems clear that at low energies, particularly near threshold, interferences between the two diagrams of Fig. 1 may be very important, and the ratio R may be sensitive not just to isospin channels but to dynamical mechanisms as well.

Our data are shown in Figs. 2, 3, and 4 in comparison with some higher energy data. We note that the charged pion production in Fig. 2 is consistent with requirements of charge conjugation invariance, and that below 1.1 GeV/c R appears to fall clearly below 2, even though the statistical accuracy is somewhat limited.

Since the energy region studied is very near threshold, it is attractive to attempt to compare the results with current algebra predictions of soft-pion emission, which relate the single-pion production to $\bar{N}N$ elastic scattering. Although there are some inevitable kinematic ambiguities in such a calculation (connected with treating soft pions in the real world), the model has the appealing feature that there are intrinsically no free parameters. Results may be expected to be good to $\sim$ 15-20%.

For simplicity we calculate the amplitude at threshold; in this case the final $\bar{p}$, p cannot emit soft pions. Assuming emission from only the initial state particles, then only the diagrams of Fig. 5 contribute. To avoid the necessity of dealing with the large number of undetermined elastic amplitudes, we make the simplifying assumption of spin independence. This is consistent with the small polarization observed in this exposure from a sample of double scattering events[2]. Finally, again for simplicity, we invoke the elastic cross-sections at the same p_{lab} (which approximation is perhaps subject to question) and assume that $\sigma_{elas}(\bar{p}n) = \sigma_{elas}(\bar{p}p)$. The results are given by the curves in Figs. 2 and 3, which are reasonable approximations to the data. A more detailed calculation is in progress.

One consequence of our calculation is that $R = \sigma_{elas}(\bar{p}p)/\sigma_{elas}(\bar{p}n)$. Our data tend to favour an average value of R of order unity, but a better fit to the data points of Fig. 2 would be achieved if $\sigma_{elas}(\bar{n}p)$ were consistently smaller than $\sigma_{elas}(\bar{p}p)$.

It should be noted that reasonable agreement has been reported between soft-pion calculations and single-pion production in low-energy nucleon-nucleon collisions[3].

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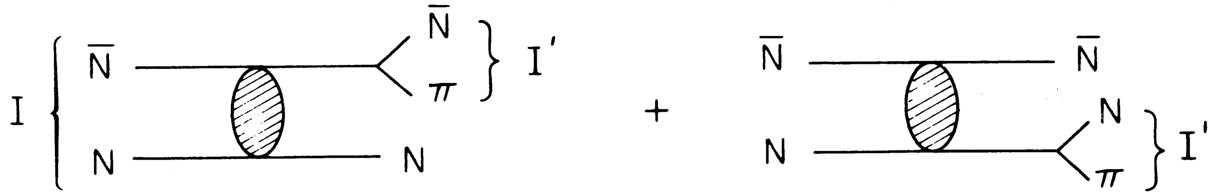
REFERENCES

1) Z. Ming Ma, J. Mountz, P. Zemany and G.A. Smith, Nuclear Phys. B68, 214 (1974).

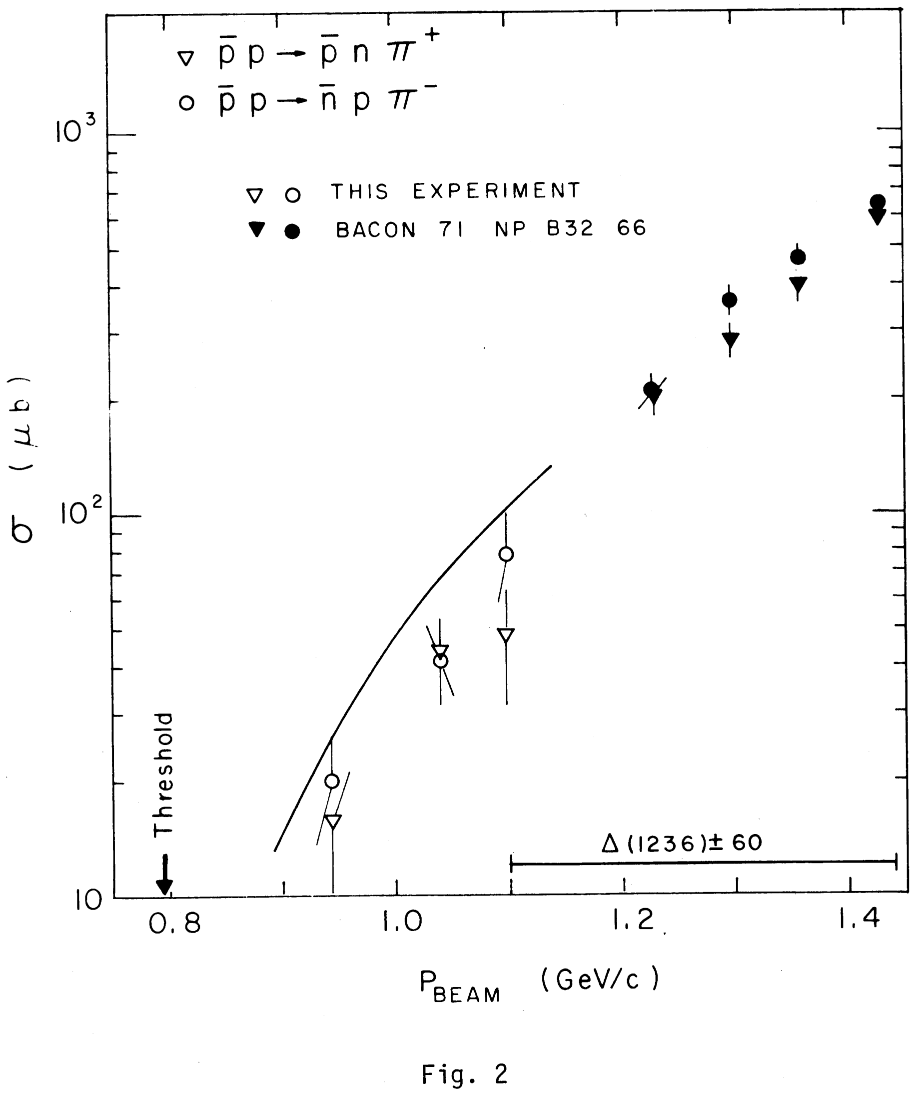
2) W. Tennyson (Thesis, unpublished).

3) M.E. Schillaci, R.R. Silbar and J.E. Young, Phys. Rev. 129, 1539 (1969). D.S. Beder, Nuovo Cimento 56 A, 625 (1968).



I
$\bar{N}$
N
$\bar{N}$
π
I'
N
+
$\bar{N}$
N
$\bar{N}$
N
π
I'

Fig. 1



▽ p̄ p → p̄ n π⁺
○ p̄ p → n̄ p π⁻
▽ ○ THIS EXPERIMENT
▼ ● BACON 71 NP B32 66
σ (μb)
10³
10²
10
Threshold
Δ (1236) ± 60
0.8
1.0
1.2
1.4
P_BEAM (GeV/c)

Fig. 2

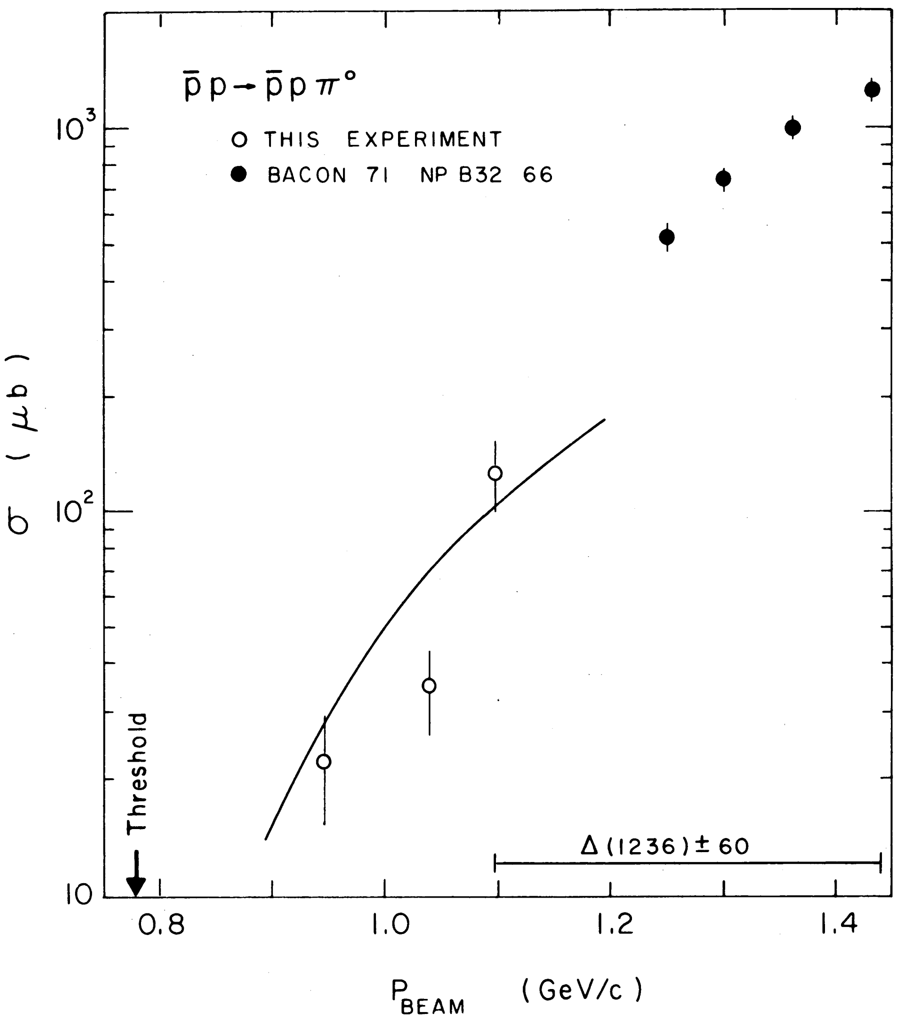

p̄p → p̄pπ°
○ THIS EXPERIMENT
● BACON 71 NP B32 66
σ (μb)
10³
10²
10
Threshold
Δ(1236) ± 60
0.8
1.0
1.2
1.4
P_BEAM (GeV/c)

Fig. 3

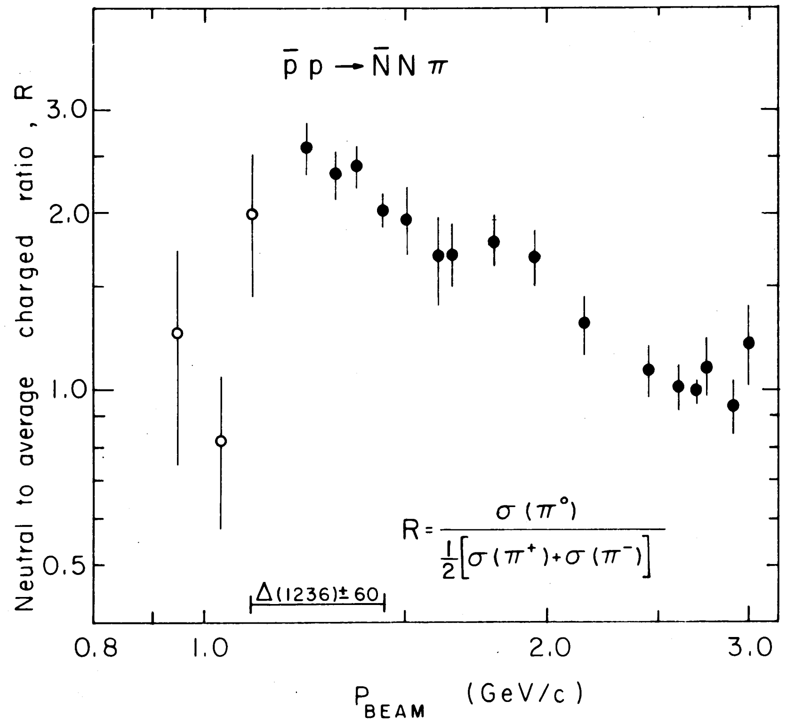

p̄p → N̄Nπ
Neutral to average charged ratio, R
3.0
2.0
1.0
0.5
0.8
1.0
2.0
3.0
R = σ(π°) / ½[σ(π⁺)+σ(π⁻)]
Δ(1236)±60
P_BEAM (GeV/c)

Fig. 4

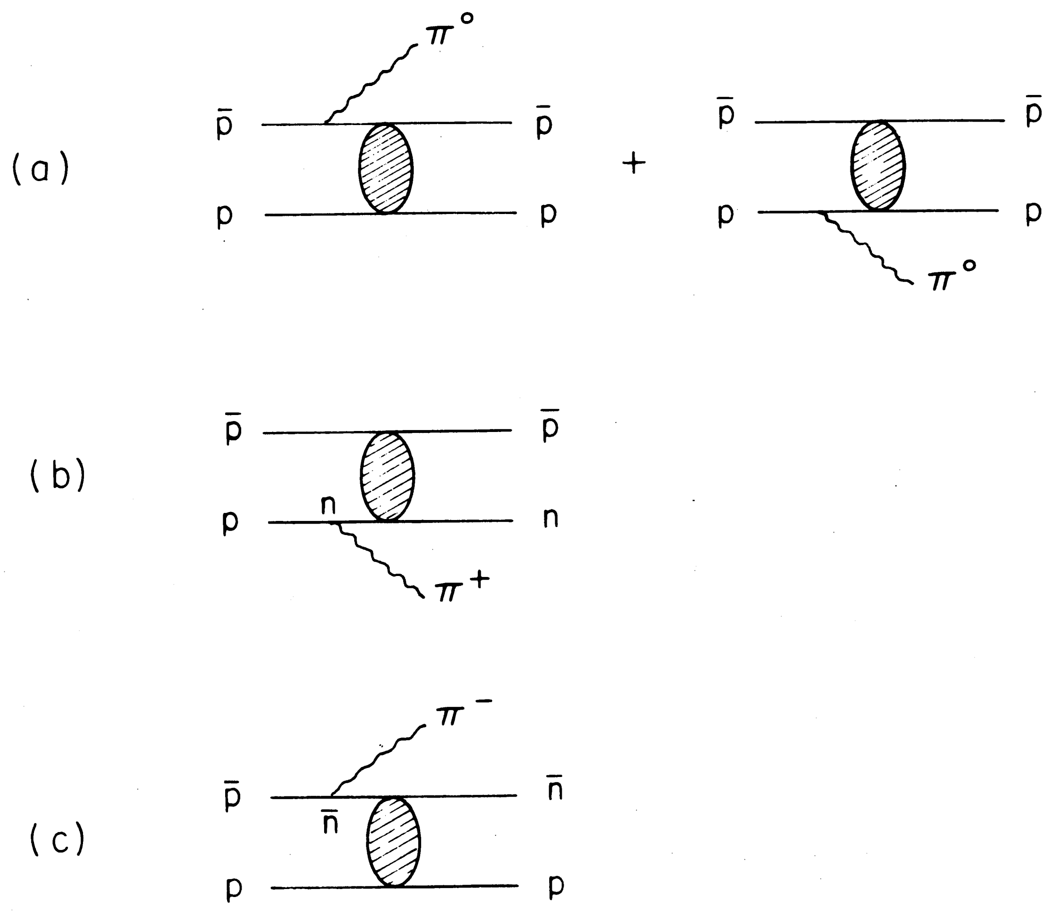


Fig. 5

D I S C U S S I O N

- *Flaminio:*

In your model the amplitude is a product of $p\bar{p}$ cross-section and the soft pion emission. Loosely speaking the energy dependence is too steep and it bends a little bit too much. Is it due to $N\bar{N}$ amplitude or to the soft pion emission?

- *Schultz:*

It is mostly due to phase space. What is most important is that the absolute value comes out right and there are no free parameters.

- *Rubinstein:*

I actually do not understand the basis of these calculations. In current algebra you have a pole. Here you have a lot of possible intermediate states which are not considered here as sources of pions.