

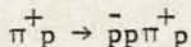
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PRODUCTION OF NARROW  $\bar{p}p$  STATES BY MESON EXCHANGE IN 10 GeV  $\pi^+p$  INTERACTIONS \*

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The possibility of producing narrow baryonium states in  $\pi^+p$  collisions in the forward direction is interesting for a variety of reasons. There is, of course, the whole controversy surrounding the S meson; any information regarding narrow  $\bar{p}p$  states around 1935 MeV will be helpful. In addition, indications of production of narrow low mass  $\bar{p}p$  states come from two inclusive reactions, the ACCMOR 90 GeV  $pp$  experiment and a 70 GeV photoproduction study in the Omega spectrometer. Finally there is the result of the Toronto-York-Purdue collaboration, reported at the last meeting of this conference, in which a  $\bar{p}p$  state was observed at 1955 MeV with  $\Gamma \sim 10$  MeV and produced with  $\sigma \sim 300$  nb at 11.5 GeV in the reaction.



From a theoretical viewpoint Jaffe has proposed that production of narrow six quark states might occur copiously at moderate energies as a result of baryonium exchange. This, he suggests, would provide a production mechanism consistent with the observed narrow  $\bar{p}p$  decay width of the states claimed as baryonium.

Our experiment was carried out at the BNL Multiparticle Spectrometer

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(see Fig. 1 of the following paper). The data reported here were obtained using a trigger which required only one fast ( $> 4$  GeV/c) forward negative track which did not fire an atmospheric Cherenkov counter ( $\bar{p}$  or  $K^-$ ). The trigger also required that three or more particles emerge from the target. At low  $\bar{p}p$  masses the tendency of both  $\bar{p}$  and  $p$  to go forward causes some reduction of triggering efficiency because of the single fast requirement. This effect is straightforwardly calculable and is included in our Monte Carlo acceptance calculations.

Our events are characterized by having two or more long tracks with well measured momenta and one or more short tracks for which only an estimate of momentum is possible. We select our sample of four prong events by testing all events kinematically. First the short tracks are assigned momenta which achieve overall momentum balance for the event assuming no missing particles. Then we assign the trigger track a  $\bar{p}$  mass and a  $\pi^+$  mass to the track which results in the best overall energy balance for the event assuming it is  $\bar{p}p\pi^+$ . This results in the distribution of energy imbalance shown in Fig. 1.

As expected Fig. 1 shows a clear peak at zero associated with the  $\bar{p}p\pi^+$  final state. It also indicates a second peak due to the  $K^+K^-\pi^+p$  reaction as well as a general background of events with missing neutrals. From the known shape of the energy imbalance for  $K^+K^-\pi^+p$  events treated as  $\bar{p}p\pi^+p$  we estimate the background within a 0.2 GeV cut around 0 GeV to be  $\sim 30\%$ .

As a check on our sensitivity we have measured the topologically similar process  $\pi^+p \rightarrow \rho^0\Delta^{++}$  by triggering separately on events producing a forward  $\pi^-$ . We agree within  $\lesssim 30\%$  with other measurements of this reaction. To check our effective mass scale and resolution we observe the shape of the  $\Lambda^0 \rightarrow \pi^-p$  decay as observed in our apparatus. The mass agrees well and the observed FWHM = 9 MeV is the value predicted by our Monte Carlo program.

Our Monte Carlo simulation of  $\pi^+ p \rightarrow \bar{p} p \Delta^{++}$  is able to predict correctly:

- 1) geometric quantities - distance of closest approach at the vertex,  $\chi^2$  for individual track fits, the shape of hydrogen target ends, etc.
- 2) kinematic quantities - distributions of momentum and energy imbalance.
- 3)  $\Lambda^0$  width from forward  $\pi^- p$ .
- 4)  $K^0$  width from  $\pi^+ p \rightarrow K_f^+ Y^* \rightarrow K_f^+ p K^0$ , which checks our handling of the backward produced, slow, short  $\pi$  tracks from the  $K^0 \rightarrow \pi^+ \pi^-$  decay.

We predict from the same Monte Carlo that our  $\bar{p} p$  effective mass measurements for states in the 1.9 - 2.5 GeV range should have  $\sigma \sim 2-5$  MeV.

Fig. 2a displays the  $\bar{p} p$  mass distribution obtained. It shows no evidence for narrow peaks. A fifth order polynomial fit to the spectrum gives a  $\chi^2/\text{d.f.}$  of 1.42. The 300 nb production measured by the Toronto-York-Purdue for a state at 1955 MeV would appear as a 260 event excess in Fig 2a. If allowed to distribute itself over two bins (40 MeV) it would stand on a smooth background of  $\sim 600 \pm 24$  events - a fluctuation of more than 10 standard deviations!

We indicate also in Fig. 2b the  $\bar{p} p$  distribution for events with a  $\Delta^{++}$  formed by the  $\pi^+$  and the slower p. Again no peaks appear;  $\chi^2/\text{d.f.}$  for a polynomial fit is 1.27.

From the spectra in Fig. 2 we can obtain upper limits at each mass for production of states with width less than our resolution at that mass. Fig. 3 shows the 95% confidence level limits obtained. We conclude that no narrow  $\bar{p} p$  states are produced in  $\pi^+ p \rightarrow \bar{p} p \pi^+$  in the mass range 1.9 - 2.5 GeV with cross sections above  $\sim 20$  nb.

\* Work supported in part by the U.S. Department of Energy and the U.S. National Science Foundation.

Figure Captions

FIG. 1. Energy imbalance for four prong events when fitted to  $\bar{p}p\pi^+p$  hypothesis.

FIG. 2.  $\bar{p}p$  effective mass spectra for the  $\bar{p}p\pi^+p$  final state. (a) all events, (b) events with a  $\Delta^{++}$  formed by the  $\pi^+$  and slower p.

FIG. 3. 95% confidence level upper limits for production of  $\bar{p}p$  states with width less than our resolution at each mass. (a) all  $\bar{p}p\pi^+p$  events, (b)  $\Delta^{++}$  formed by  $\pi^+$  and slower p.

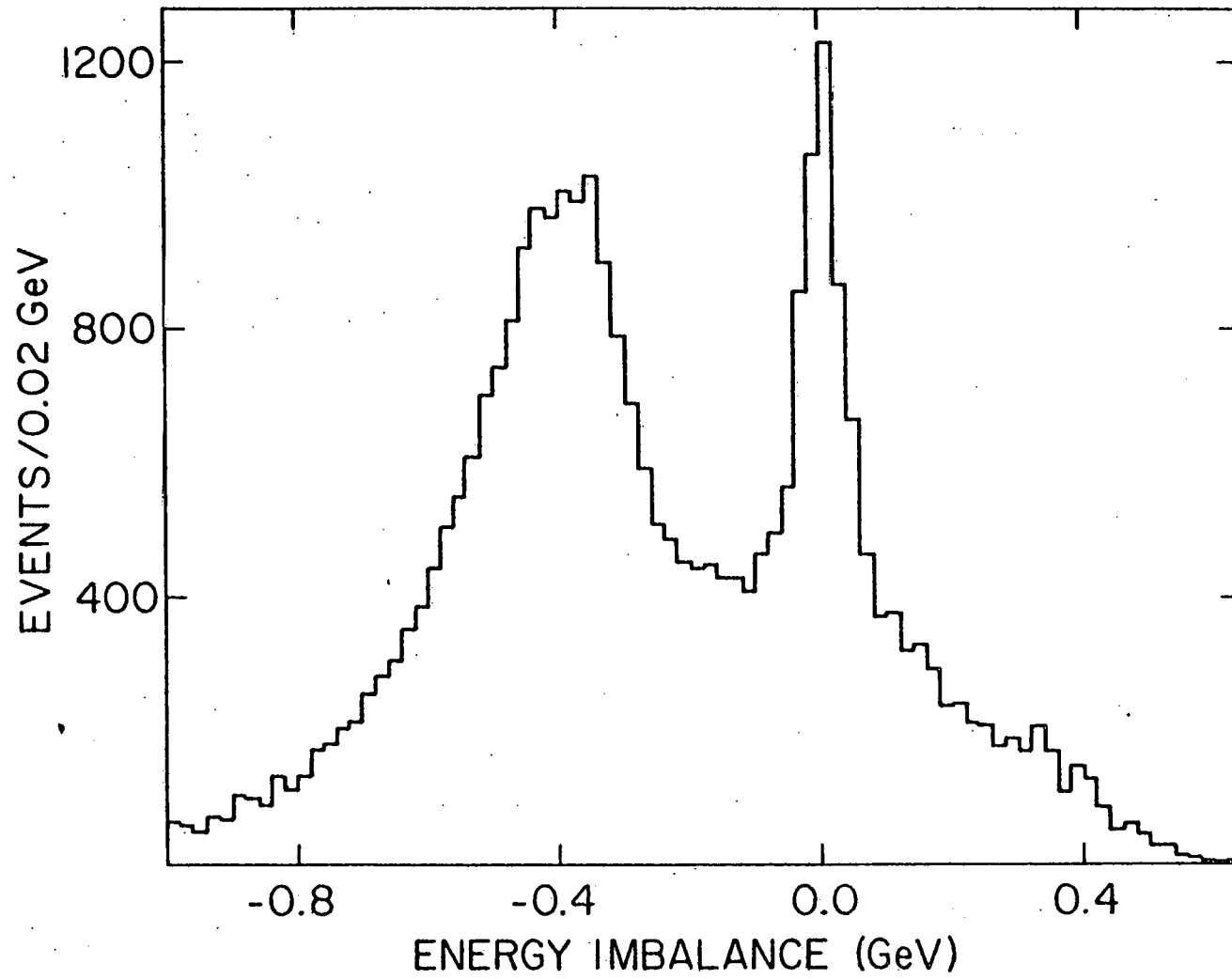


FIG. 1

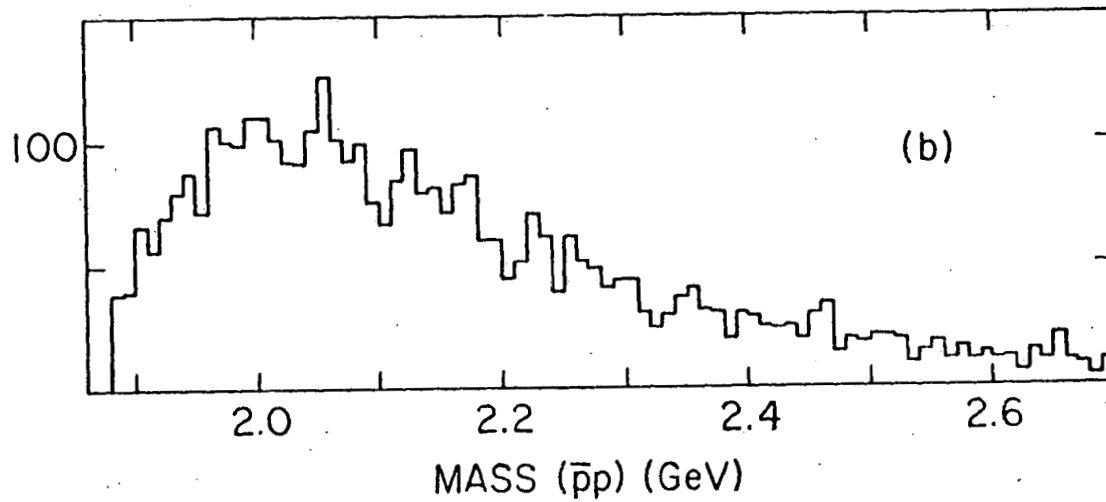
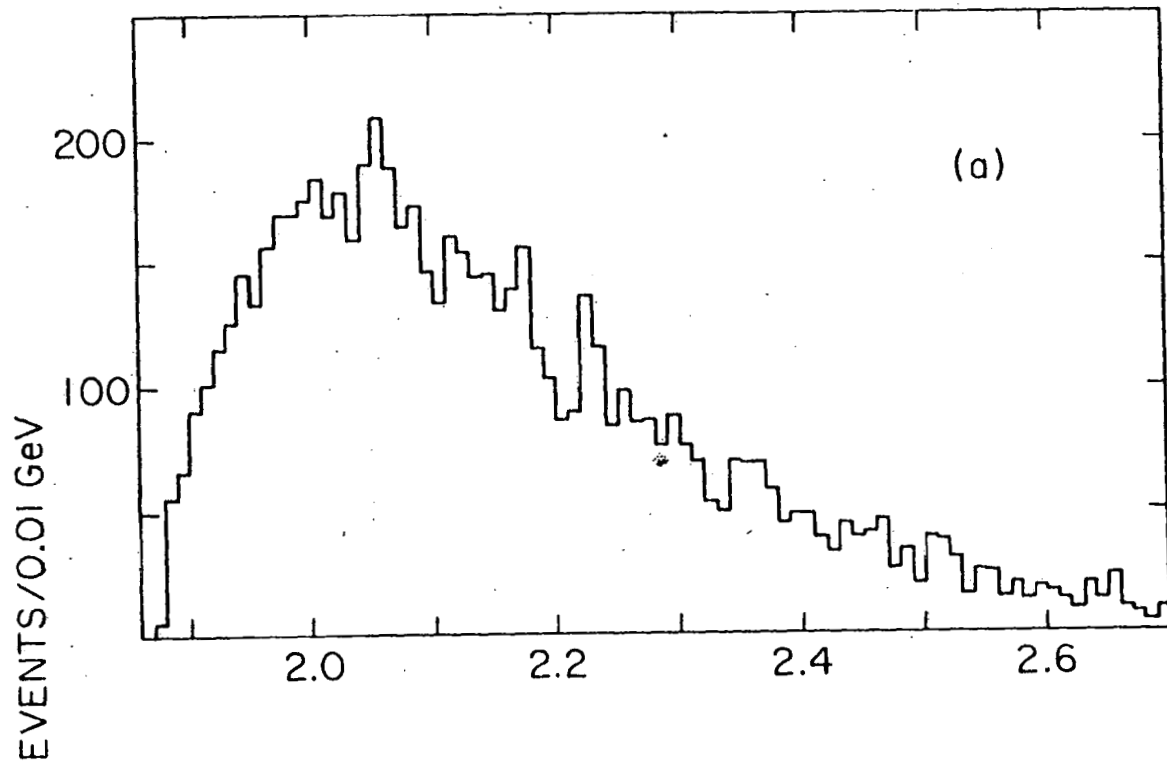


FIG. 2

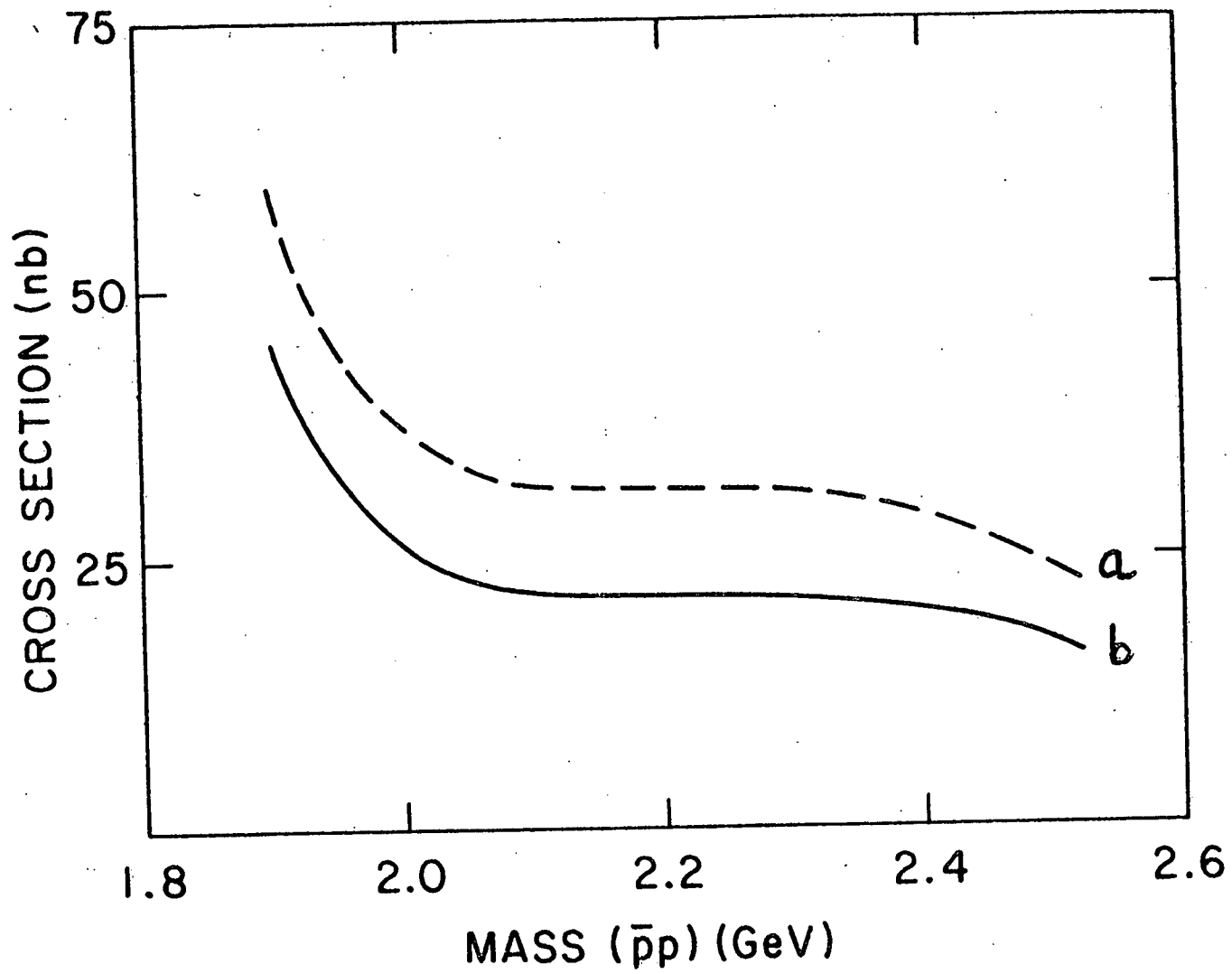


Fig. 3