BNL-28263

OG 559

CONF-800724--27

Search for Narrow $B\bar{B}(\pi)$ States in 16 GeV/c $\pi^- p$ and 5 GeV/c $\bar{p}p$ Interactions

S. U. Chung

Brookhaven National Laboratory
Upton, New York 11973

MASTER

Presented at the XXth International Conference on High Energy Physics

University of Wisconsin, Madison, Wisconsin

July 17-28, 1980

The submitted manuscript has been authored under contract DE-AC02-76CH00016 with the U.S. Department of Energy. Accordingly, the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or allow others to do so, for U.S. Government purposes.

Presented at the XXth International Conference
on High Energy Physics, University of Wisconsin, Madison
July 17-28, 1980

Submitted 9/2/80 OG 559

SEARCH FOR NARROW $B\bar{B}(\pi)$ STATES IN 16 GeV/c π^-p AND 5 GeV/c $\bar{p}p$ INTERACTIONS

S. U. Chung*
Physics Department, Brookhaven National Laboratory
Upton, New York 11973

INTRODUCTION

We report here on the searches for narrow baryon-antibaryon ($B\bar{B}$) bound states from two recent experiments carried out at the BNL Multiparticle Spectrometer. First, we present the results of a search for narrow states in the $\bar{p}p$, $\Lambda p\pi^{\pm}$ and $\bar{p}p\pi^+$ systems from π^-p interactions at 16 GeV/c. The data come from an experiment carried out by physicists from BNL, Brandeis, CCNY, Southeastern Massachusetts, University of Massachusetts.[1] Next, we show results of a search for narrow $\bar{p}p$ states from $\bar{p}p$ interactions at 5 GeV/c, an experiment with collaborators from BNL, Brandeis, University of Cincinnati, Florida State University, and Southeastern Massachusetts University.[2]

π^-p DATA AT 16 GeV/c

This experiment was conceived in part to further study the two $\bar{p}p$ states with widths less than 25 MeV and masses 2020 and 2200 MeV seen in a CERN Ω-spectrometer experiment by Benkheiri, et al.[3] Although a number of experiments looked for these states in formation as well as production processes, ours is the first to have searched for them in the same reaction as that of the CERN experiment with similar trigger techniques and acceptance.

The reaction studied is

$$\pi^- p \to (p_f \pi^-)\ (\bar{p} p_s) \tag{1}$$

where $p_f(p_s)$ refers to a fast (slow) proton in the laboratory. The trigger for this study required detection of a fast forward proton with momentum between 8 and 12 GeV/c, implemented via two three-dimensional coincidence-matrix (RAM) logic systems and two gas Čerenkov counters.[4] A total of 3.4×10^6 proton triggers were recorded, and ~80% of them have been analyzed to date, corresponding to a raw sensitivity of 62 ev/nb.

The events have been processed through our chain of data-reduction programs, yielding finally a total of ~7 K events with acceptable four-constraint kinematic fits to reaction (1). We estimate that the contamination from non-4C background in this final

*Research supported by the U. S. Department of Energy under contract DE-AC02-76CH00016.

sample is less than 3... In Fig. 1a we present the $M(p_f\pi^-)$ spectrum showing clear $\Delta^o(1238)$ and $N^o(1520)$ peaks in our data. Fig. 1b shows the spectrum $M(\bar{p}p_s)$ of the recoil system. There is no evidence for the production of 2020 and 2200 MeV states in our data. We have gone to considerable lengths in an attempt to enhance the baryon-exchanged production of the $\bar{p}p_s$ system, but no significant peaks have been observed in the entire $\bar{p}p$ mass range.

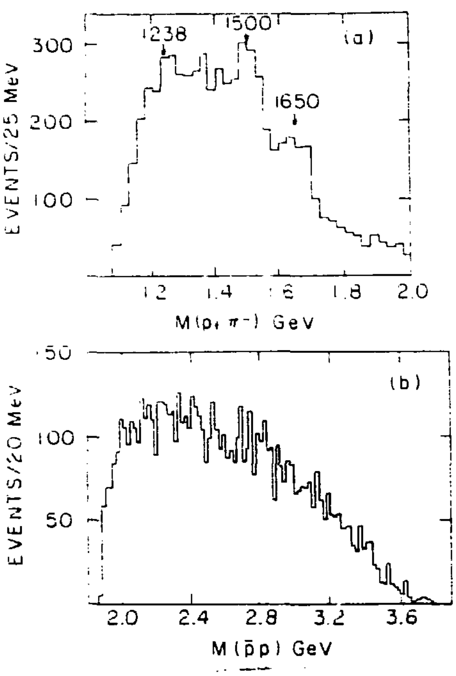

Fig. 1(a,b). $M(p_f\pi^-)$ and $M(\bar{p}p)$ spectra for reaction (1).

Using the calculated acceptance and the experimental and data-reduction losses, we estimate that the overall visible sensitivity of our present data ranges from 8 ev/nb at $M(\bar{p}p_s) = 2.02$ GeV with $\Delta^o(1238)$ to 5 ev/nb at $M(\bar{p}p_s) = 2.20$ GeV with N^o (1520). From these we conclude that the 2 σ upper limit cross sections are 3.0 nb for the 2020-MeV state (obtained from the $\bar{p}p$ spectrum with Δ^o and N^o selections) and 2.0 nb for the 2200-MeV state (from Δ^o events alone). These values are to be compared to the corresponding cross sections quoted in Benkheiri, et al.[3]: 36 ± 9 nb for 2200-MeV state and 21 ± 5 nb for 2200 MeV state at 12 GeV/c. The rms mass resolution of our data is better than 7(11) MeV at 2020 (2200) MeV, sufficient for observation of narrow $\bar{p}p$ states, if produced in our data.

We have in addition searched for narrow states in the meson-exchange reactions

$$\pi^- p \to (\Lambda\bar{p}\pi^+)X^o \;(2); \quad (\Lambda\bar{p}\pi^-)X^{++} \;(3); \quad (\bar{p}p\pi^+)X^- \;(4);$$

where X denotes the recoiling system off that being studied. Note that the $\Lambda\bar{p}\pi^-$ system is explicitly exotic, whereas the $\Lambda\bar{p}\pi^+$ and $\bar{p}p\pi^+$ systems require $I = 3/2$ and $Q = 2$ exotic meson exchanges. The protons in (4) and those from the Λ decay in (2) and (3) are the triggered particles, identified by two Cerenkov counters, and the $\bar{p}$'s in (2), (3) and (4) were required off-line to go through one Cerenkov counter without yielding light. The latter requirement eliminated π^-'s, but some K^-'s do remain in our sample, contributing to the general background in the mass spectra being studied.

No significant narrow peak is observed in any of the spectra (not shown). At 2.5 GeV the 2 σ upper limits for $\Lambda\bar{p}\pi^+$ ($\Lambda\bar{p}\pi^-$) states with width less than 40 MeV are ∿25 nb (30 nb), and for $\bar{p}p\pi^+$ with width less than 20 MeV it is ∿25 nb. The rms mass resolution at 2.5 GeV is estimated to be less than 20 MeV for all three mass spectra.

$\bar{p}p$ DATA AT 5 GeV/c

We have investigated the $\bar{p}p$ system produced in the baryon-exchange process

$$\bar{p}p \to p_f \bar{p}\pi^0 (\text{or } \rho^0) \quad (5)$$

at 5 GeV/c. The p_f is the fast forward proton ($p \gtrsim 1.2$ GeV/c), triggered with the aid of the RAM logic system and a high-pressure Cerenkov counter.[6] Both p_f and $\bar{p}$ were required to have momenta greater than 1.8 GeV/c for the maximum efficiency of the Cerenkov counter.

The advantages of this experiment over previous experiments for narrow $B\bar{B}$ searches are two-fold: first, our beam momentum at 5 GeV/c favors baryon-exchange process compared to a meson beam at 12 GeV/c, where Benkheiri, et al.[3] saw two narrow $\bar{p}p$ states at 2.0 and 2.20 GeV. Second, the four-momentum transfer squared from the $\bar{p}$ beam to the $\bar{p}p$ final state can become positive, thus allowing for closer approach to the baryon poles. We estimate that the combined effects amount to an enhancement factor of $\sim$30 compared to the experiment of Benkheiri, et al.

The sample of data presented here corresponds to a raw sensitivity of 6.5 nb^{-1}. The missing mass spectrum recoiling off $\bar{p}p$ (not shown) shows clear peaks at π^0 and ρ^0, respectively, demonstrating our substantial acceptance for the reaction (5). We estimate that non-π^0 (or non-ρ^0) background in our data is less than 50%. Figs. 2a and b show the $\bar{p}p$ mass spectra for the π^0 and ρ^0 events. No significant peak with width $\lesssim$ 20 MeV are seen in our data. The superposed curves are our estimate of the overall acceptance, obtained via MC events.[5] The rms mass resolution at 2.20 GeV is estimated to be less than 15 MeV. We obtain a 2 σ upper-limit cross section of 130 nb (75 nb) for a $\bar{p}p$ state at 2.0 GeV (2.2 GeV) with width less than 20 MeV for π^0 events. For ρ^0 events the corresponding upper limits are $\sim$50% higher than those of the π^0 events.

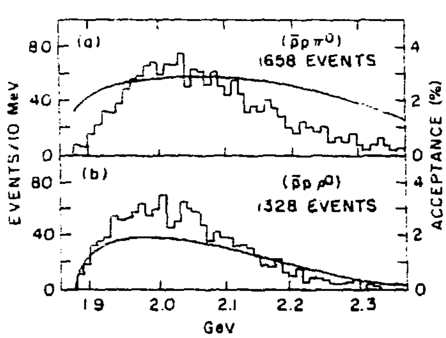

Fig. 2(a,b). M($\bar{p}p$) spectra for reaction (5).

SUMMARY AND CONCLUSIONS

We have presented here the latest results of a systematic search for narrow $B\bar{B}$ states in two BNL MPS experiments requiring fast forward protons in the trigger. We have found no significant narrow peaks with widths less than 40 MeV in all the spectra we have examined so far.

In the experiment with $\pi^- p$ interactions at 16 GeV/c, we obtain 2σ upper limits of less than 3 nb for $\bar{p}p$ states at 2.0 to 2.2 GeV with widths less than 20 MeV. Based on the cross sections for 2.02 and 2.20 $\bar{p}p$ states quoted by Benkheiri, et al.[3] and assuming baryon-exchange processes for production of these states, we should have seen better than 5 σ signals at our energy. We have in addition searched for narrow states in $\bar{\Lambda}p\pi^{\pm}$ and $\bar{p}p\pi^{+}$ systems; 2 σ upper limits are $\lesssim$ 30 nb for the states with widths less than 40 MeV.

In the experiment with $\bar{p}p$ interactions at 5 GeV/c, we have looked for narrow $\bar{p}p$ states produced by baryon-exchange with either π^0 or ρ^0 as recoiling particles. Given an enhancement factor of ~30 for our experiment and the cross section of ~30 nb quoted in the paper by Benkheiri, et al.,[3] we should have seen the $\bar{p}p$ states with cross sections of the order of ~1 μb. Instead, we find that 2 σ upper limits are $\lesssim$ 130 nb for a $\bar{p}p$ state with less than 20 MeV and mass below 2.2 GeV.

REFERENCES

1. Z. Bar-Yam, J. Bensinger, J. Button-Shafer, S. Dhar (Present address: Raytheon Corp., Wayland, MA 01420), J. Dowd, A. Etkin, R. Fernow, K. Foley, J.H. Goldman (Present address: Florida State University, Tallahassee, FL 32306), W. Kern, H. Kirk, J. Kopp, M.A. Kramer, A. Lesnik (Present address: Fairchild Republic Co., Farmingdale, NY 11735), R. Lichti (Present address: Texas Tech University, Lubbock, TX 79409), S.J. Lindenbaum, W. Love, U. Mallik, T. Morris, W. Morris, S. Ozaki, E. Platner, S.D. Protopopescu, A. Saulys, D.P. Weygand, C.D. Wheeler, E. Willen, M. Winik.
2. J. Albright, Z. Bar-Yam, J. Bensinger, R. Diamond, J. Dowd, H. Fenker, R. Fernow, J.H. Goldman, V. Hagopian, S. Hagopian, M. Jenkins, W. Kern, H. Kirk, L. Kirsch, A. Lesnik, B.T. Meadows, W. Morris, R. Poster, S.D. Protopopescu, P. Schmidt, D.P. Weygand, M. Winik.
3. P. Benkheiri et al., Phys. Lett. 68B, 483 (1977); Phys. Lett. 81B, 380 (1979). A marginal signal was also seen in e^-p interactions by Gibbard et al., Phys. Rev. Lett. 42, 1593 (1979).
4. For the experimental layout and other experimental details, as well as for the references to relevant experiments, see S.U. Chung, et al., BNL preprint OG 548 (submitted to Phys. Rev. Lett.).
5. The curves do not include additional losses due to trigger efficiency, impurities in the beam, absorption in LH_2, etc.
6. For the experimental layout and other experimental details, as well as for the references to relevant experiments, see S.U. Chung, et al., BNL preprint OG 545 (submitted to Phys. Rev. Lett.)