MASTER

Evidence Against an $n\bar{n}\pi^0$ Enhancement at a Mass
of $1.627 \text{ GeV}/c^2$ in $K^+d \rightarrow p_s \pi^+\pi^-\pi^0 n \bar{K}^0$ at $4.48 \text{ GeV}/c$

A. C. Ammann, D. D. Carmony, A. F. Garfinkel,
L. J. Gutay and D. H. Miller

Physics Department
Purdue University
Lafayette, Indiana 47907, U.S.A.

and

W. L. Yen

Physics Department
Indiana University-Purdue University at Indianapolis
Indianapolis, Indiana 46205 U.S.A.

ABSTRACT

Recently evidence has been presented for the production of an $n\bar{n}\pi^0$ enhancement of mass $1627 \text{ MeV}/c^2$ in the reaction $K^+d \rightarrow p_s \pi^+\pi^-\pi^0 n \bar{K}^0$. With greater statistics, our data for the same reaction at nearly the same energy fail to show any evidence for such a resonance.

LEGAL NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

124

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

In a recent letter Price et al [1] have reported 4.7 standard deviation evidence for a narrow $n\bar{n}\pi^-$ enhancement with a mass of $1.627 \text{ GeV}/c^2$ and a width of less than 0.03 GeV . They identified 468 events of the reaction (Here p_s denotes a spectator proton.)

$$K^-d \rightarrow p_s \pi^+ \pi^- \pi^- n K^0 \quad (1)$$

at an incident momentum of $4.91 \text{ GeV}/c$.

We have analyzed 789 events of reaction (1) at $4.48 \text{ GeV}/c$. The data were obtained from a $5 \text{ event}/\mu\text{b}$ per nucleon exposure of the Argonne National Laboratory thirty inch deuterium filled chamber [2]. Fig. 1 shows the invariant mass distribution for the $n\bar{n}\pi^-$ combination. The background curve is obtained from the Reggeized multipheral model of Chan et al [3] as modified by Plahte and Roberts [4] to include resonance production. The fraction of events that we observe to contain Δ^- (1238) and K^* (890) are input to the model [2,5]. Our center of mass energy is only 120 MeV lower than reference (1) where a 27 event $n\bar{n}\pi^-$ enhancement is observed including a background of 11 counts. Thus we should observe roughly $16 \times 789/468 = 27$ events above background. Even allowing for possible systematic mass shifts of $\sim 15 \text{ MeV}/c^2$ [6] we find 0 ± 5 events. Thus we see no evidence for an $I = 5/2$ enhancement.

Price et al mentioned that the $3.9 \text{ GeV}/c$ K^-d experiment of Lai et al [7] does not observe the $n\bar{n}\pi^-$ enhancement but speculate that this could be due to energy dependence of the production of isospin $5/2$ baryon enhancements. The histogram in the inset to Fig. 1 shows the center of mass energy spread in our experiment due to the Fermi motion of the target neutron. The curve is the center of mass energy distribution for Price et al's data. In order to approximately reproduce their experimental conditions the shaded histogram in Fig. 1 is the $n\bar{n}\pi^-$ effective mass distribution for the 352 events in our experiment which have a center of mass energy $> 3.1 \text{ GeV}$. We again see no enhancement. Price et al also suggested the $n\bar{n}\pi^-$ enhancement may share a π^- with the K^* (890). We see no evidence of this either.

Finally we would also like to discuss the statistical significance of the observation of reference (1). Firstly, they apparently estimated the statistical significance assuming Gaussian distributed errors,

since $(27-11)/\sqrt{11} = 4.7$ standard deviations. This implies the impressive betting odds against a random fluctuation of this size or bigger of 700 000 to 1. In order to correctly estimate the probability of observing 27 or more counts when 11 are expected the Poisson distribution must be utilized.

$$P = \sum_{m=27}^{\infty} \frac{11^m e^{-11}}{m!} = 0.000033 \quad (2)$$

Thus the betting odds against such a random fluctuation are 30 000 to 1 in any one bin and, since a typical experiment may have 100 plots with 100 bins, one experiment in three will see such a fluctuation. Secondly, the solid curve in Fig. 1(a) of Reference (1) may underestimate the background of the bin in question. We believe that a smooth background of 13 events can be drawn and then the (Poisson calculated) odds against observing 27 or more events are only 2200 to 1 per bin (a probability equivalent to 3.5 standard deviations for Gaussian distributed errors).

In conclusion with 1.7 times as many events at nearly the same energy as reference (1) we see no evidence for the reported isospin $5/2$ $n\bar{n}\pi^+\pi^-$ state at a mass of $1.63 \text{ GeV}/c^2$.

One of the authors (W.L.Y.) wishes to thank Purdue Research Foundation for a XL Grant during the summer of 1970. We would like to thank the accelerator and bubble chamber staffs at Argonne National Laboratory and our programmers and scanners at Purdue, without whose assistance this experiment would not have been possible.

References

1. R. R. Price, R. E. Berg, E. O. Salant, J. W. Waters, M. S. Webster, and A. Weinberg, Phys. Letters 33B (1970) 533.
2. W. L. Yen, A. C. Ammann, D. D. Carmony, A. F. Garfinkel, L. J. Gutay, and D. H. Miller, Final States with Three Charged Particles and a Visible K^0 from K^-d Interactions at 4.5 GeV/c (To be published).
We demanded that the spectator proton have a momentum less than 300 MeV/c and less than the neutron momentum. Our sample consists of 249 four prong plus Vee and 540 three prong plus Vee events in good agreement with the spectator model. If the positive secondary had a momentum less than 1.2 GeV/c, the ionization was checked visually by a physicist. We estimate that about 10% of the events are ambiguous with $K^-d \rightarrow pp\pi^+\pi^-\pi^0 K^0$.
3. Chan Hong-Mo J. Loskiewicz, and W. W. M. Allison, Nuovo Cimento 57A (1968) 93.
4. E. Plahte and R. G. Roberts, Nuovo Cimento 60A (1969) 33.
5. There are 205 Δ^+ (1238) and 175 K^{*-} (890) above background.
6. We have compared the width of the ω signal in the reaction $K^-n \rightarrow \Lambda \pi^+\pi^-\pi^0$ and conclude that our resolution is the same as reference (1).
A. Weinberg, Private Communication.
7. K. W. Lai, private communication to R. R. Price et al [1].

Figure Caption

1. Invariant mass distribution for 789 $n\bar{n}\pi^-\pi^-$ events from reaction (1). The shaded histogram shows the $n\bar{n}\pi^-\pi^-$ mass distribution of those 352 events with center of mass energy $E^* > 3.1$ GeV. A histogram of the E^* distribution of this experiment is given in the inset to the figure along with a curve representing the E^* distribution of reference 1.