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THE CHANGING $\Sigma(1660)$ BRANCHING RATIO*

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ABSTRACT

Three new experimental results have been reported about the branching ratio $\Sigma\pi\pi/\Sigma\pi$ of the $\Sigma(1660)$ resonance produced in K^-p production experiments. One of them contradicts, and the two others corroborate statements published years ago, according to which this branching ratio changes with production angle. Overwhelming evidence is still in favor of the changing branching ratio, which can be simply explained by the existence of two $\Sigma(1660)$ with different branching ratios and different production distributions.

INTRODUCTION

For those who like controversies, the $\Sigma(1660)$ has certainly been a source of enjoyment. In the past the controversy was about its parity assignment. Today, it's the behavior of its branching ratio upon which most but not yet all experimentors agree. Here, I want to summarize the present situation concerning the $\Sigma(1660)$ branching ratio into $\Sigma\pi\pi$ and $\Sigma\pi$.

To compare experimental results, it is misleading to quote branching ratios and their errors, because such errors are not Gaussian-distributed quantities in general. We would rather represent the data on a plot, where the amount of decay of a resonance into one mode is plotted versus the amount of its decay into the other mode. On such a plot, the errors on each ordinate are sensibly Gaussian and are represented conveniently by a one-standard-deviation ellipse sur-

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rounding the measured point. The branching ratio is the slope of the line joining the point to the origin. Two measurements of the branching ratio agree when they line up on a straight line passing through the origin.

DATA REPORTED BEFORE THE CONFERENCE

In the reaction

$$K^- p \to \Sigma(1660)^+ + \pi^- \qquad (1)$$

several experimentors have selected different intervals of production angle Θ at different momenta and measured the amounts of $\Sigma(1660)^+$ decay into $\Sigma^\pm \pi^\mp \pi^+$ and $\Sigma^+ \pi^0$.[1-4] We plotted their results and their errors on the plot of Fig. 1 with non-shadowed ellipses.

Since a branching ratio is represented in Fig. 1 by the slope of the straight line joining a measured point to the origin, one does not alter the information of a given measurement by scaling both its coordinates and its error ellipse by a given ratio. We have taken advantage of that property to scale the coordinates in such a way that the measurements are ordered according to the K^- beam momentum in reaction (1) from smaller to larger distances from the origin. The measurements at the same momentum are connected by a dashed curve labeled with that momentum. The label, in the middle of the error ellipse of a measurement, is the interval of cos Θ used for that measurement, Θ being the angle between the $\Sigma(1660)$ and the K^- in the CMS of reaction (1). We also show the range of slopes that are compatible with the branching ratio ≤ 0.28 measured in formation experiments.[5]

Before this conference, we knew about the data shown for 2.1, 2.25, 2.6 GeV/c and a mixture of 3.9- and 4.6-GeV/c data.[1-4] We can see a general pattern. In these production experiments, the branching ratio $\Sigma\pi\pi$ to $\Sigma\pi$ decreases systematically when cos Θ increases and, in the forward direction, it resembles the value obtained in formation experiments. No single straight line through the origin can be drawn that would accommodate all measurements of the branching ratio within their errors. It has been concluded[2] that there are two objects with different production distributions, either two resonances with similar masses and widths or two overlapping resonances of the same spin parity that could produce the varying branching ratio effect by interference. In the latter case there is no need for having two resonances with very similar masses and widths. All that is needed is for one of them to be broad enough to overlap the other. There is also evidence that the two objects have the same spin parity.[5,6]

DATA REPORTED AT THIS CONFERENCE

From a Nymegen-Amsterdam collaboration,[7] we got new measurements of the $\Sigma^+\pi^+\pi^-$ to $\Sigma^o\pi^+$ branching ratio at 4.2 GeV/c, for cos Θ intervals (-1.0, -0.8) and (-0.8, 1.0) and we plotted their result in Fig. 1, assuming $\Sigma^+\pi^o$ decay mode of the $\Sigma(1660)$ to be the same as the $\Sigma^o\pi^+$ mode and assuming that the $\Sigma^-\pi^+\pi^+$ decay mode is the same as the $\Sigma^+\pi^+\pi^-$. The experimentors observe the same pattern as in the afore-published data: they see favored $\Sigma\pi\pi$ production at very negative cos Θ and favored $\Sigma\pi$ production for less negative cos Θ.

There is still a dissonant note. At 2.9 GeV/c, the Brandeis-Maryland-Syracuse-Tufts collaboration (BMST)[8] has analyzed reaction (1) in the same cos Θ intervals as reported at 2.6 GeV/c in Ref. 2. Using twice the $\Sigma^o\pi^+$ decay rate as the $(\Sigma\pi)^+$ decay rate, I plotted their points for $-1.0 < \cos\Theta < -0.95$ and $-0.90 < \cos\Theta < -0.70$ in Fig. 1. In both intervals the measured branching ratios are compatible with one another and with our value measured at 2.6 GeV/c for $\cos\Theta \sim -0.8$. For $\cos\Theta < -0.95$, their value is in disagreement with ours at 2.6 GeV/c. It is unlikely that the behavior of the $\Sigma(1660)$ production changes so rapidly between 2.6 and 2.9 GeV/c. It seems more appropriate to present these two measurements at $\cos\Theta < -.95$ as conflicting experimental results.

Another point of disagreement is worth mentioning. At 2.1, 2.25, and 2.6 GeV/c, the decay rate of the $\Sigma(1660)^+$ into $\Sigma^+\pi^o$ and $\Sigma^o\pi^+$ has been measured to be the same within statistical error,[1,2,4] in agreement with predictions based in isospin invariance. In the BMST experiment, no $\Sigma^+\pi^o$ decay mode of the $\Sigma(1660)$ was detected, and the upper limit is inconsistent with the $\Sigma^o\pi^+$ decay mode. If this last result turns out not to be an experimental fluke, it could have farther reaching consequences than the disagreement on the $\Sigma\pi\pi/\Sigma\pi$ branching ratio in the backward direction.

Actually, since the number of $\Sigma^+\pi^o$ and the number of $\Sigma^o\pi^+$ are not the same in the BMST analysis, you can reasonably question which one should be used to estimate the $(\Sigma\pi)^+$ amount. If $\Sigma^+\pi^o$ is chosen instead of $\Sigma^o\pi^+$, then the upper limit for $\Sigma^+\pi^o$ makes all three BMST measurements of the branching ratio compatible with the branching ratio with our point at 2.6 GeV/c and $\cos\Theta < -0.95$ and not with the point at $\cos\Theta \sim -0.8$. If BMST turns out to be right, it is inconvenient to consider the $(\Sigma\pi)^+$ decay mode as a whole and one should refer to $\Sigma^o\pi^+$ and $\Sigma^+\pi^o$ separately, as the authors did in their paper.

Since this talk has been given, I was informed that reaction (1) was analyzed at 3.2 GeV/c in Oxford (England).[9] I have just received their data with a representation of the errors that does not make it easy to plot an error ellipse on Fig. 1. I plotted their central value of the measured branching ratios for different cuts in cos Θ, inside an arc of circle representing the range of values within about one standard deviation. It is clear that their measurements at 3.2 GeV/c are all in agreement with ours at 2.6 GeV/c and do not confirm the BMST measurement at 2.9 GeV/c for cos $\Theta < -0.95$.

Another point worth mentioning is that there is a clear signal of $\Sigma(1660)$ decaying into $\Sigma^+\pi^o$ as well as into $\Sigma^o\pi^+$ in the Oxford data.

In conclusion, all production experiments (except one)[8] see the $\Sigma(1660)$ branching ratio $\Sigma\pi\pi/\Sigma\pi$ changing as a function of cos Θ over a wide range of K^- beam momenta.[2,3,4,7,9] The simplest explanation of this phenomenon is the existence of two resonances with different branching ratios and different production angular distributions.

REFERENCES

1. G. W. London et al., Phys. Rev. *143,* 1034 (1966).

2. P. H. Eberhard, J. H. Friedman, M. Pripstein, and R. R. Ross, Phys. Rev. Letters *22,* 200 (1969).

3. M. Aguilar-Benitez et al., Phys. Rev. Letters *25,* 58 (1970).

4. R. D. Estes, J. Duboc, P. H. Eberhard, J. H. Friedman, M. Pripstein, and R. R. Ross, in *Proceedings of the Hyperon Resonances,* edited by E. C. Fowler (Moore Publishing Co., Durham, North Carolina), p. 279.

5. R. Armenteros et al., Phys Letters *24B,* 198 (1967) and *28B,* 521 (1969); Nucl. Phys. *B14,* 91 (1969).

6. P. H. Eberhard, M. Pripstein, F. T. Shively, V. E. Kruse, and W. P. Swanson, Phys. Rev. Letters *163,* 1446 (1967); see also Ref. 8.

7. R. T. Van de Walle, private communication.

8. S. P. Apsell, P. Ford, S. Gourevitch, L. E. Kirsch, P. E. Schmidt, C. Y. Chang, A. R. Stottlemyer, G. B. Yodh, S. Glickman, M. Goldberg, S. M. Jacobs, B. Meadows, G. C. Moneti, J. Brenner, J. Schneps, and G. Wolsky, communication at this conference.

9. D. Radojicic, private communication after the conference.

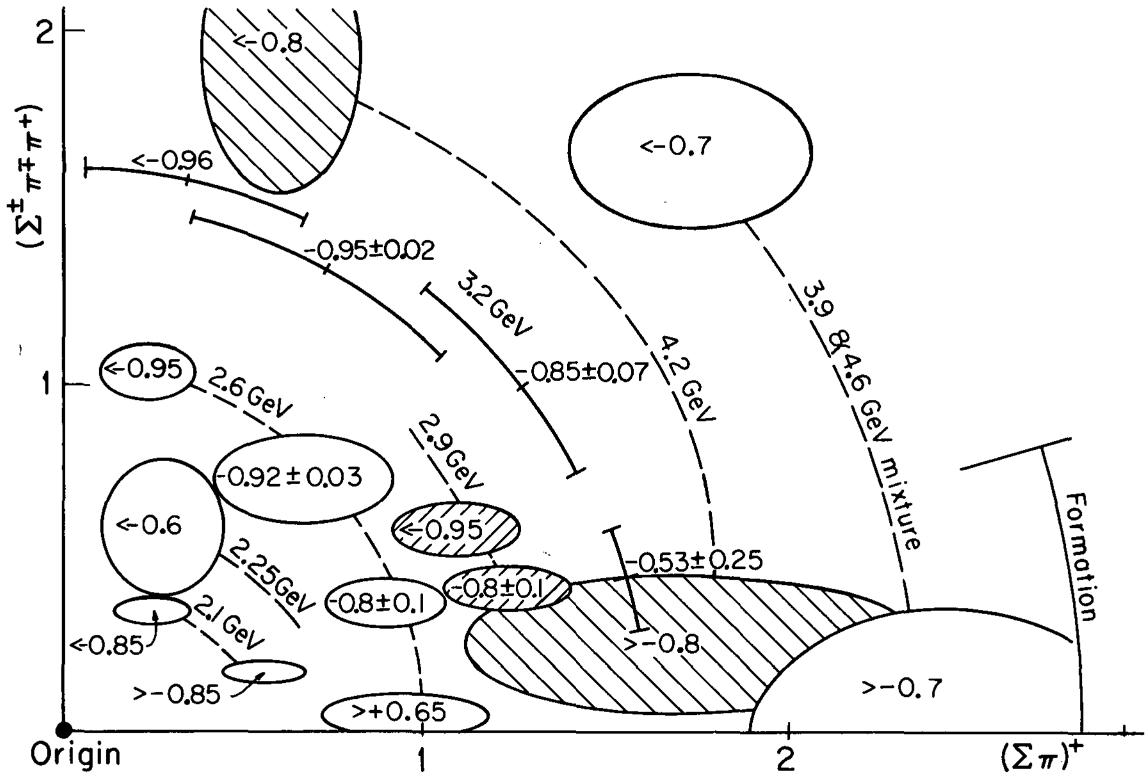

FIGURE CAPTION

Fig. 1. Plot of measured amounts of $\Sigma(1660)$ decay into $\Sigma\pi\pi$ versus $\Sigma\pi$ in arbitrary units. The ellipses represent one-standard-deviation errors. The label inside each error ellipse is the interval of cos Θ used for the measurement. The measurements at 2.1 GeV come from Ref. 4, at 2.25 GeV from Ref. 1, at 2.6 GeV from Refs. 2 and 4, at 3.9 and 4.6 GeV from Ref. 3. The range of branching ratios compatible with the results of formation experiments is deduced from Ref. 5. The shadowed ellipses correspond to results reported at this conference: 2.9 GeV from Ref. 8, 4.2 GeV from Ref. 7. The arcs of circle represent the measurements and an estimation of the errors of Ref. 10, as they were communicated after this talk was given.

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