Low-Mass $\pi\pi$ Enhancement in Baryonic $\pi\pi$ Production: ABC Effect Revised by Exclusive Measurements

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The ABC effect, first observed by Abashian, Booth and Crowe [1] in the double pionic fusion of deuterons and protons to ^{3}He, stands for an unexpected enhancement at low masses in the $M_{\pi\pi}$ spectrum. Follow-up experiments revealed this effect to be of isoscalar nature and to show up in cases, when the two-pion production process leads to a bound nuclear system. With the exception of low-statistics bubble-chamber measurements all experiments conducted on this issue have been inclusive measurements carried out preferentially with single-arm magnetic spectrographs for the detection of the fused nuclei.

Theoretically the ABC effect has been interpreted by $\Delta\Delta$ excitation in the course of the reaction process leading to both a low-mass and a high-mass enhancement in isoscalar $M_{\pi\pi}$ spectra. In fact, the missing momentum spectra from inclusive measurements have been in support of such predictions. It has been shown [2] that these structures can be enhanced considerably in theoretical calculations including ρ exchange.

In order to shed more light on this issue we have carried out exclusive measurements of the reactions $pp \to pp\pi\pi$, $pn \to d\pi\pi$, $pd \to ^3$He$\pi\pi$ and $dd \to ^4$He$\pi\pi$ at CELSIUS-WASA. The latter reaction - previously studied close to threshold with no enhancement seen - has been measured in the ABC region and just below and is currently analyzed by the Uppsala group. For the former reactions there are first results. In particular the $\pi^0\pi^0$ channel, which is free of isospin I=1 contributions, exhibits in all cases a low-mass enhancement in the $M_{\pi\pi}$ spectra, which is scalar in nature as assumed already previously, however, which is much larger than predicted in the $\Delta\Delta$ calculations. At the same time the data do not exhibit any high-mass enhancement as predicted by the same calculations and as suggested by the inclusive measurements. As anticipated already in Ref. [3] the high-mass bump observed in those spectra appears to be associated with $\pi\pi\pi$ production and I=1 contributions rather than with the isoscalar $\pi\pi$ production.

Since on the one hand the available $\Delta\Delta$ calculations obviously fail, but on the other hand the data clearly show the $\Delta\Delta$ excitation in their $M_{N\pi}$ spectra, a profound physics piece appears to be missing. One possibility is the assumption of a quasi-bound $\Delta\Delta$ state, which is able to describe the data leading to d and ^{3}He amazingly well.

[1] N. E. Booth, A. Abashian, K. M. Crowe, Phys. Rev. Lett. 7, 35 (1961); 6 (1960) 258; Phys. Rev. C132, 2296ff (1963).

[2] L. Alvarez-Ruso, Phys. Lett. B452 (1999) 207; PhD thesis, Univ. Valencia 1999 [3] F. Plouin, P. Fleury, C. Wilkin, Phys. Rev. Lett. 65, 690 (1990).

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