Observation of the ABC Effect in the First Exclusive Measurements of $pn \to d\pi^0\pi^0$

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The ABC effect, first observed by Abashian, Booth and Crowe [1] stands for an surprising enhancement at low masses in the $\pi\pi$ invariant mass ($M_{\pi\pi}$) spectrum. Follow-up experiments revealed this effect to be of isoscalar nature and to show up in two-pion production processes leading to a bound nuclear state. With the exception of low-statistics bubble-chamber measurements at DESY [2] and JINR Dubna [3] 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, missing momentum spectra from inclusive measurements have been in support of such predictions.

In order to shed more light on the nature of the ABC effect we have carried out exclusive measurements of the quasi-free reaction $pn \to d\pi^0\pi^0$ on the deuteron as target at an incident proton energy of 1.05 GeV using the WASA detector at the CELSIUS ring. This reaction provides the most basic ssss production process leading to a bound nuclear system in the final state. In addition the $\pi^0\pi^0$ channel being free of any I=1 contributions is purely isoscalar.

The differential spectra exhibit features very similar to those observed for the ^{3}He case. In particular, the $M_{\pi^0\pi^0}$ spectrum exhibits a low-mass enhancement but no high-mass enhancement - in contrast to the predictions based on the $\Delta\Delta$ process and also in constrast to the impression obtained from the inclusively measured deuteron lab momentum spectra [4, 5]. The missing high-mass enhancement in our data, however, is in accord with bubble chamber results [2] for the $d\pi^+\pi^-$ production and also with the assumption in Ref. [5] that the high-mass bump in inclusive spectra is due to $\pi\pi\pi$ production.

The data can be reasonably well described, however, if we assume the $\Delta\Delta$ process to proceed via a quasi-bound $\Delta\Delta$ system.

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