

# The $pp \rightarrow pp\pi^0\pi^0$ Reaction and its Limiting Case, the Fusion to Quasibound ${}^2\text{He}$ , in Search of the ABC Effect\*

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The  $\pi\pi$  production in proton-proton collisions has been studied [1] from threshold up to  $T_p = 1.4$  GeV by exclusive and kinematically complete measurements at CELSIUS-WASA. The analysis of the data shows that the near-threshold region is governed by Roper excitation, whereas at energies  $T_p > 1$  GeV the  $t$ -channel  $\Delta\Delta$  process takes over.

It is this latter process, which has been suggested as cause for the ABC effect [2]. This effect stands for a peculiar high low-mass enhancement in the  $\pi\pi$  invariant mass distribution observed in double-pionic fusion processes, if the produced pion pair is of isoscalar nature like, *e.g.*, in the most basic reaction of this kind, the  $pn \rightarrow d\pi\pi$  reaction [3].

In order to shed more light onto this peculiar ABC effect we concentrate in this contribution on the  $\pi^0\pi^0$  production in the  $\Delta\Delta$  region. The observed  $\pi^0\pi^0$  invariant mass ( $M_{\pi^0\pi^0}$ ) spectra are qualitatively close to phase space distributions, at most tiny low- and high-mass enhancements relative to phase space may be recognized. However, no pronounced low-mass enhancement as seen in fusion processes is observed.

Next we follow an idea of the ANKE collaboration, which finds an ABC-like effect by restricting the  $pp \rightarrow ppX$  reaction to very small  $M_{pp}$  masses [4]. This way only protons in relative s-wave are selected. In the limiting case this restriction leads to the observation of the double-pionic fusion to quasi-bound  ${}^2\text{He}$ . In order to approach this limiting case in our measurements, we impose the condition  $M_{pp} < 2m_p + 10$  MeV on the data. As a consequence we find only slight indications for low- and high-mass enhancements for this “ ${}^2\text{He}$ ” case. In particular it lacks the strong ABC enhancements seen in cases, where the fusion reaction is completely isoscalar.

The differential data both for the constrained and the unconstrained case are surprisingly well described by the simple  $t$ -channel  $\Delta\Delta$  ansatz of Risser and Shuster [2]. This ansatz simultaneously describes also the ANKE data in their restricted phase-space coverage.

We see that the only modest low- and high-mass enhancements (“theoretical” ABC effect) observed here appear to be well understood in contrast to the ABC effect in isoscalar double-pionic fusion reactions, which has not yet found any conventional interpretation.

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