Two-Pion Production $pp \to NN\pi\pi$ - Do We See a Sign of $\Delta(1600)$ Excitation in the $nn\pi^+\pi^+$ Channel?

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At CELSIUS-WASA the two-pion production in pp-collisions has been measured from threshold up to $T_p = 1.36$ GeV. Total cross sections have been obtained for the channels $pn\pi^+\pi^0$, $pp\pi^+\pi^-$, $pp\pi^0\pi^0$ and also $nn\pi^+\pi^+$. Two surprising features emerge from these measurements for intermediate incident energies $T_p > 1$ GeV, i.e. in the region, which is beyond the Roper excitation but at the onset of $\Delta\Delta$ excitation :

- The $pp\pi^0\pi^0$ cross section agrees well with theoretical predictions [1] up to $T_P = 1$ GeV. Whereas the predicted cross section keeps rising smoothly with increasing T_P, our data level off for $T_p > 1.0$ GeV, falling behind the predictions by an order of magnitude near 1.2 GeV and exhibiting then by a sharp rise at $T_p > 1.2$.
- The observed $nn\pi^+\pi^+$ cross section on the contrary is a factor of 5 larger than the theoretical predictions[1].

Our findings, however, are in good agreement with previous bubble chamber results.

In order to be independent of model assumptions we have carried out an isospin decomposition of the total cross sections. As a result we obtain an amplitude for the isoscalar $\pi\pi$ configuration, which is in good agreement with the theoretical predictions for the isoscalar parts of Roper and $\Delta\Delta$ excitations, but not for the isotensor part. As evidenced by the surprisingly large $nn\pi^+\pi^+$ cross section the isotensor amplitude is more than twice as big (and of opposite phase) as expected from the $\Delta\Delta$ process. Note that the Roper excitation can not contribute to the isotensor amplitude directly.

Since only I = 3/2 resonances can contribute directly to the isotensor $\pi\pi$ amplitude, the next higher-lying candidate resonance would be $\Delta(1600)$, which due to its large width of about 350 MeV is not unlikely to contribute already at the energies of interest. Since $\Delta(1600)$ preferably decays via $\Delta(1232)$, it contributes strongly to the isotensor cross section and also to the isovector part. With the aid of this excitation we obtain a good description of all available $pp \to NN\pi\pi$ total cross section data up $T_p = 1.5$ GeV.

The feature that Roper, $\Delta\Delta$ and $\Delta(1600)$ excitations contribute very differently to isoscalar, isovector and isotensor channels provides a powerful tool to disentangle the different resonance contributions.

[1] L. Alvarez-Ruso et al., Nucl. Phys.. **A633** (1998) 519

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