Mechanism of the Reaction $^{11}B(p,\alpha)2\alpha$ below and in the Vicinity of the 675-keV Resonance

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In preceding papers all the kinematical details of the reaction $^{11}B(p, \alpha)2\alpha$ have been described. Therefore we want to concentrate only on those properties that are important in the chosen range of energies. There are two proton resonances at 675 keV ($J^{\pi}=2^{-}$, $T=1$) and 1388 keV ($J^{\pi}=1^{-}$, $T=1$), which are in the available energy range of the 2-MV cascade generator (PHILIPS) at Marburg University. Since in the 163 keV resonance the breakup of the compound nucleus ^{12}C (16.1 MeV) can no longer be described as a cascade via $^{8}Be^{*}$ (2.9 MeV) (see preceding paper by D. Dehnhard) it was of interest to investigate the reaction at higher energies with essentially the same aim and similar experimental setup.

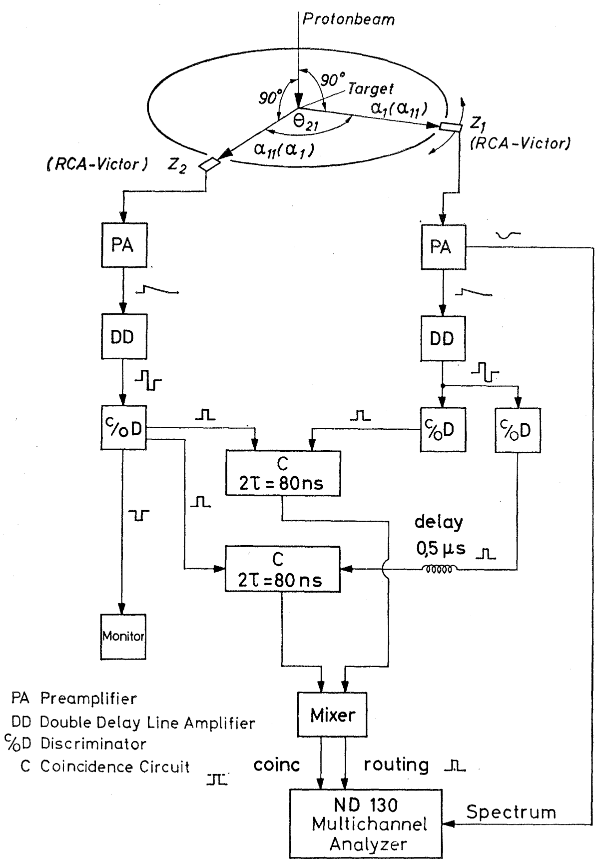

FIG. 1. Block diagram of the electronics setup.

Within a target chamber of 180-mm diameter two semiconductor particle detectors (subtended angle 4° each) were placed in the plane perpendicular to the incoming proton beam. The angle θ_{21} (laboratory system) between the two detectors could be varied. Corresponding to the variation of this angle there is a variation of the α energies (α_{11} or α_{12}) of the ^{8}Be breakup particles. It was the aim of the experiment to show whether or not the α_1 and $\alpha_{12}(\alpha_{11})$ lines showed up as distinct lines, thereby giving indication for cascade or three-particle decay, respectively.

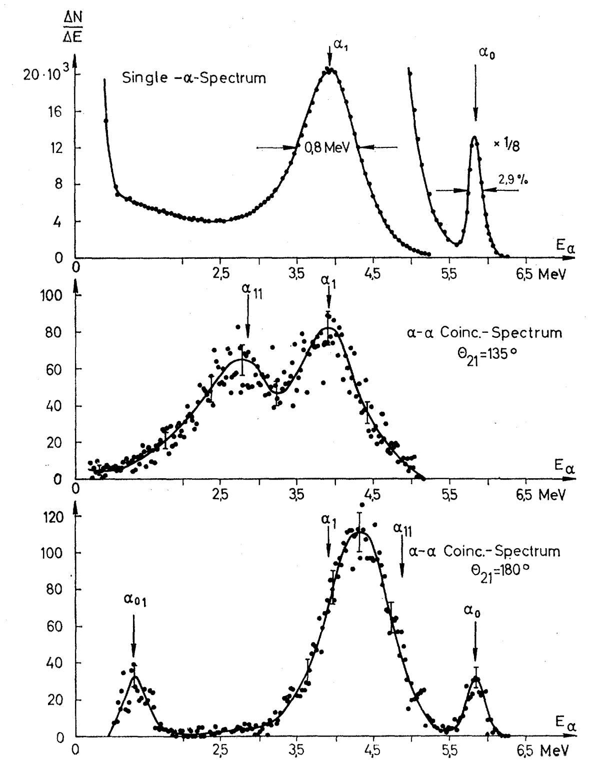

FIG. 2. Single α -spectrum and α–α-coincidence spectra for $E_p=250$ keV taken at angles θ_{21} between the two detectors of 135° and 180° in the plane perpendicular to the p beam.

An experimental problem arose because the scattered protons (1...2 MeV, target thickness 25 $\mu g/cm^2$ natural boron on 200 $\mu g/cm^2$ Al) obstructed the low energy part of the α spectrum. In order to suppress them Ni foils of suitable thickness (1.8 mg/cm^2 and up) were inserted before the detectors. By this measure, producing also a shift of the α's, a low-energy cutoff was produced which was unavoidable. For this reason

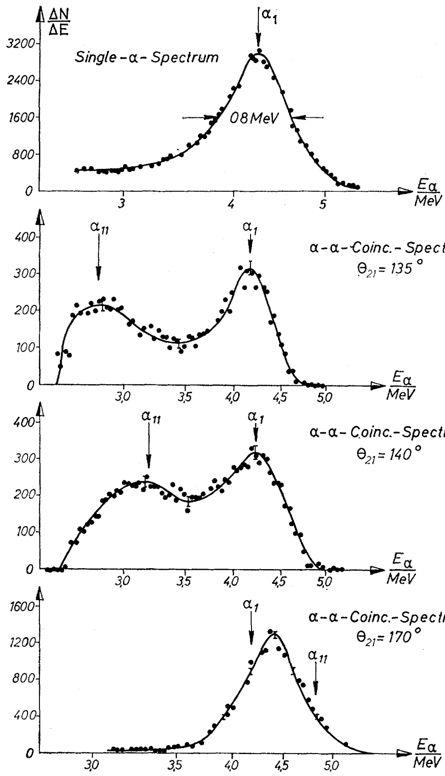

FIG. 3. Same as in Fig. 2, but $E_p=675$ keV and $\theta_{21}=135°$, 140°, and 170°.

coincidence spectra only up to 800 keV could be measured, thereby missing the 1388-keV resonance.

Figure 1 shows the experimental and electronics setup used in the experiment. By use of routing technique the total and random coincidence spectra could be measured simultaneously (coincidence resolving time $2\tau=80$ nsec).

The following figures give a series of experimental results. Figure 2 shows singles and coincidence spectra at 250 keV where no foils before the detectors were necessary and the lower energy threshold was at about

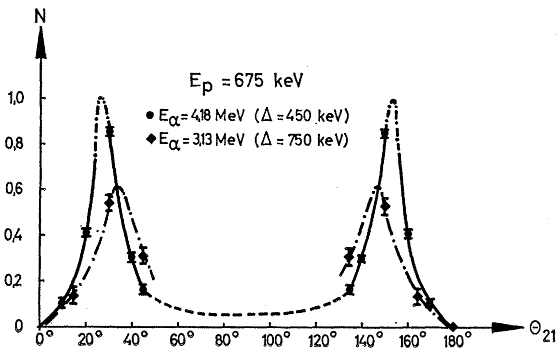

FIG. 4. Population on two stripes across the Dalitz plot at the 675-keV resonance. Δ channel width corresponding to the width of the stripe. The points above 90° have been measured, they have been plotted also below 90° on reasons of symmetry.

$E_\alpha=1$ MeV. Figure 3 gives the single and coincidence spectra at 675 keV.

The singles' spectra are interesting insofar as their shapes are identical with the ones below 163 keV. In that low-energy region the deformation of the singles' spectra when going into the 163-keV resonance gave the first indication for a changed mechanism. At 675 keV one does not observe such a deformation. The corresponding coincidence spectra support the cascade mechanism of the reaction: the pattern is well separable into the two components α_{I} and α_{II}, and when changing the angle θ_{21} between the two counters the line α_{II} moves across the energy scale as it should in a sequential decay, whereas the α_{I} does not move. On the other hand, one cannot make an estimate for the three-particle participation unless one measured exactly the density of coincidences on a Dalitz plot as shown in the preceding paper. In order to do that still another test at 675 keV was performed. Instead of recording coincidences between the total α spectra an energy window was set for one of the detectors. By this means one fixes a cut through the Dalitz plot parallel to one side of the energy triangle. By changing the position of this energy window one changes the position of the cut through the Dalitz plot and can measure the population of the diagram at certain positions of interest. This procedure can be advantageous because then the coincidence spectrum consists of only one line, the intensity of which can be determined easily. Figure 4 shows two measured distributions along such cuts, one of which lies exactly on the α_{I} line, the other passes almost through the center of the Dalitz plot. Maxima occur at positions where α_{I} lines cross the chosen energy stripe. The pattern shows no such increase in density at the center of the plot as has been found at 163 keV. Thereby again leading to the conclusion that the reaction proceeds at 675 keV as a sequential decay via ^{8}Be ground and first excited state.

Combining the results of the preceding and of this paper the conclusion is, that from the resonances at 675 and 1388 keV the decay is via ^{8}Be, from the 163-keV resonance a sequential decay takes place only via ^{8}Be ground state, the remaining disintegrations of the ^{12}C state being a three-particle decay. It should be emphasized that all three states of ^{12}C that have been reached are $T=1$ states.

Finally, it should be remarked that the coincidence spectra for an angle of $\theta_{21}=180°$ show an appreciably narrower distribution as expected from simple addition of two Breit–Wigner distributions according to the 2.9-MeV state in ^{8}Be. This is observed also at lower energies (see preceding paper) and might be explained as an interference effect.

ACKNOWLEDGMENTS

Thanks for discussions on the problem are due to Dr. D. Dehnhard and Dr. P. Kramer.