Excitation Functions of the 164Dy(p,xn) Reactions

I. 8   Excitation Functions of the ^{164}Dy(p,xn) Reactions

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Information of the excitation functions of nuclear reactions is of practical importance in many purposes, especially in isotope production, and it is preferable to have a reliable method of calculation of the excitation functions. For the production of ^{163}Ho with intent of determination of the electron neutrino mass, we were forced to evaluate the excitation function of the ^{164}Dy(p,2n)^{163}Ho reaction using the ALICE code. To confirm the applicability of the ALICE code in this mass region, we have measured the excitation functions of the ^{164}Dy(p,xn) reaction with x = 1, 3 and 4, and compared them with predictions of the ALICE code.

The excitation function measurements were made by the stack foil method. Metallic targets of ^{164}Dy 5 mg/cm^2 thick and Al energy absorbers of known thicknesses were alternately piled up, and bombarded with a proton beam from the cyclotron. The bombardments were made at beam energies of 25, 30, 35 and 41 MeV. The isotopic purity of the ^{164}Dy targets was 95.68 %. The targets were prepared by rolling ^{164}Dy metal, which was obtained by heating a mixture of ^{164}DyF$_3$ and granular Ca metal to 1600°C in Ar atmosphere.

After bombardment, intensities of the following γ-rays emitted from each target were measured as a function of time with a large-volume Ge(Li) and a small-volume Ge(HP) detector:-

1) The 91.4 keV γ-ray from the 91.4 keV state in ^{164}Er populated by the β$^-$ decay ($T_{1/2}$=29 m) of the ground state in ^{164}Ho.

2) The 37.3 keV γ-ray from the 37.3 keV state in ^{164}Ho populated by the de-excitation of the 140 keV isomeric state ($T_{1/2}$=37 m) in ^{164}Ho.

3) The 1319.6 keV γ-ray from the 1400.3 keV state in ^{162}Dy populated by the β$^+$ decay ($T_{1/2}$=15 m) of the ground state in ^{162}Ho.

4) The 1220.0 keV γ-ray from the 1485.7 keV state in ^{162}Dy populated by the β$^+$ decay ($T_{1/2}$=68 m) of the 110 keV isomeric state in ^{162}Ho.

5) The 25.7 keV γ-ray from the 25.7 keV state in ^{161}Dy populated by the EC decay ($T_{1/2}$=2.48 h) of the ground state in ^{161}Ho.

Using known decay schemes, we have deduced from these measurements the total production cross sections of ^{161}Ho, ^{162}Ho and ^{164}Ho via the (p,xn) reactions on ^{164}Dy as a function of proton energy.

Figure 1 shows the results of the present experiment in comparison with theoretical ones calculated with the ALICE code. The calculation succeeds in

reproducing the shapes and peak cross sections of the experimental excitation functions, but fails in predicting the peak positions; the peaks of the experimental excitation functions occur about 2 MeV higher in proton energy than the corresponding calculated ones, respectively.
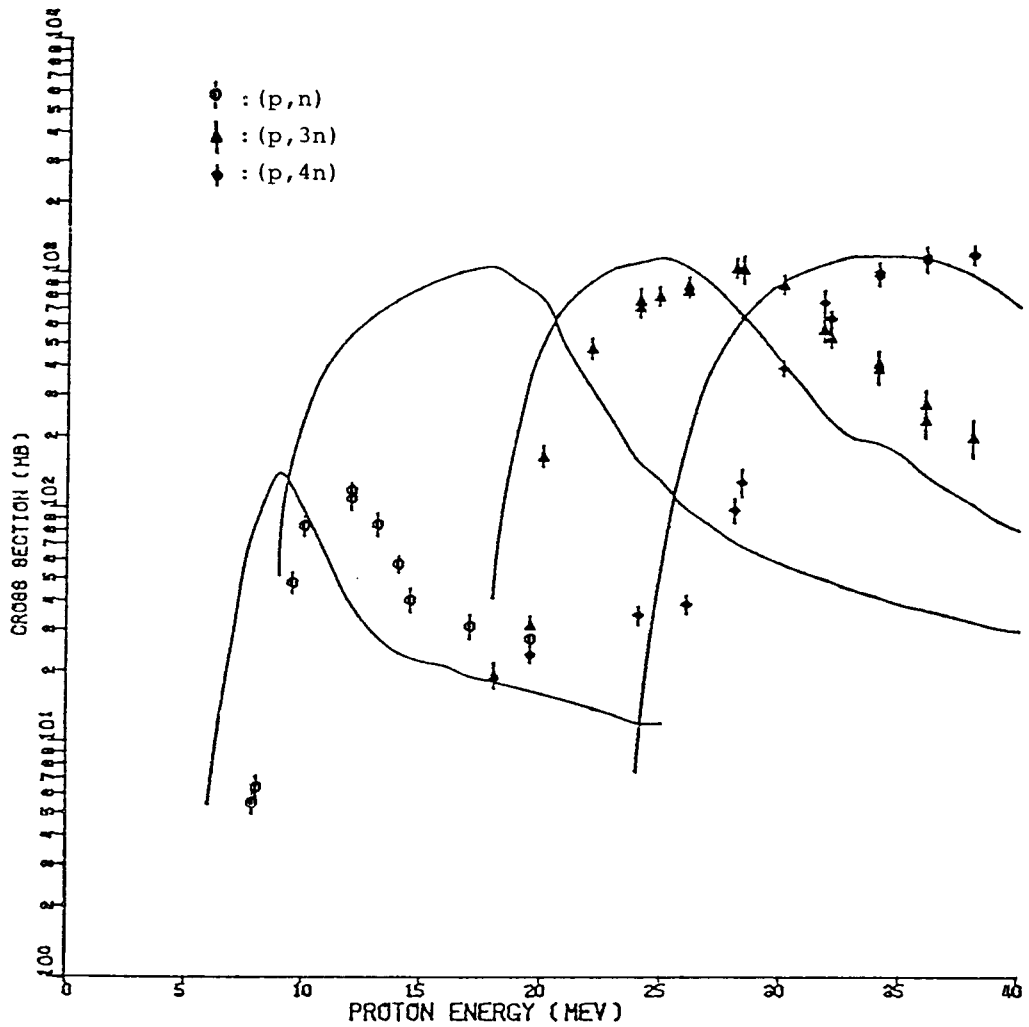

Fig. 1. Excitation functions of the ^{164}Dy(p,xn) reactions. Solid curves are theoretical excitation functions calculated with the ALICE code.