Cross Section Measurements on ^{61}Cu for Proton Beam Monitoring above 20 MeV

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Introduction

All experimental studies involving charged particle induced nuclear reactions require a precise knowledge of monitor reactions. A number of well described proton induced monitor reactions exist in the lower energy range [1], which is covered by most medical cyclotrons. Concerning proton energies above 20 MeV, however, the accuracy of the monitor reactions declines as cross section data becomes scarcer. Furthermore, the growing interest in precise determination of projectile energies by comparing of ratios of monitor reaction cross sections demands new measurements and evaluations of known data for high threshold monitor radionuclides.

In this work cross section measurements on the formation of ^{61}Cu were done and energy dependent radionuclide ratios were calculated.

Material and Methods

For investigation of the ^{nat}Cu(p,x)^{61}Cu reaction copper foils of natural isotopic composition (Goodfellow Ltd.) were irradiated. The targets were of 10 and 20 µm thickness, having a diameter of 15 mm.

Proton bombardments up to 45 MeV incident energy were done in the stacked-foil arrangement at the accelerator JULIC of the Nuclear Physics Institute (IKP) of the Forschungszentrum Jülich. In addition to an internal irradiation possibility the cyclotron is equipped with an external target station which was used for most experiments. It can adapt standard and slanting solid target holders and is equipped with a water cooled four sector collimator and additional helium cooling of the entry foil. [2]

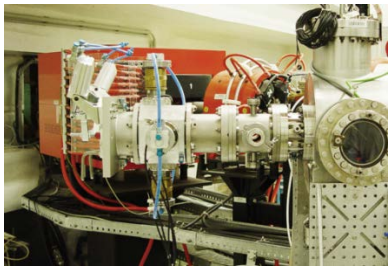

FIGURE 1. End section of the external beamline at the JULIC with target adapter and 4 sector collimator.

Several irradiations were executed. In each stack, besides copper samples, aluminium absorbers and additional nickel monitor foils were also placed, the latter for the determination of the respective beam current.

The produced radioactivity of ^{61}Cu was analysed non-destructively using HPGe γ-ray detectors (EG&G Ortec).

Results and Conclusion

Reaction cross sections of the ^{nat}Cu(p,x)^{61}Cu process up to 45 MeV were measured and compared with existing data from the literature (FIG. 2). Except for the data of Williams et al. our results are in good agreement, showing a maximum of about 165 mbarn at 37.5 MeV proton energy. The overall uncertainty of the new cross section data is between 8 and 10 %.

In FIG. 3, the excitation functions of the relevant monitor reactions on Cu are shown.

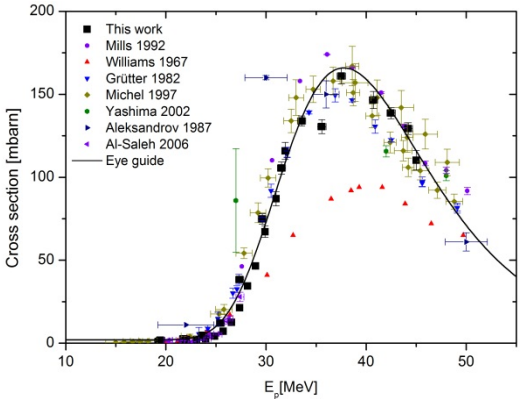

FIGURE 2. Experimental cross section data in comparison with data from the literature

In combination with the excitation function of the ^{nat}Cu(p,xn)^{62}Zn reaction, isotope ratios were calculated which can be used for determination of the proton energy within a target stack in the energy range of 22–40 MeV as described by Piel et al. [3]. FIGURE 4 shows the cross section ratio in dependence of the proton energy.

Above this energy, ^{65}Zn could be used to generate isotope ratios for energy determination, although the long half-life ($T_{½}$ = 244.3 d) of that radionuclide may be a problem.

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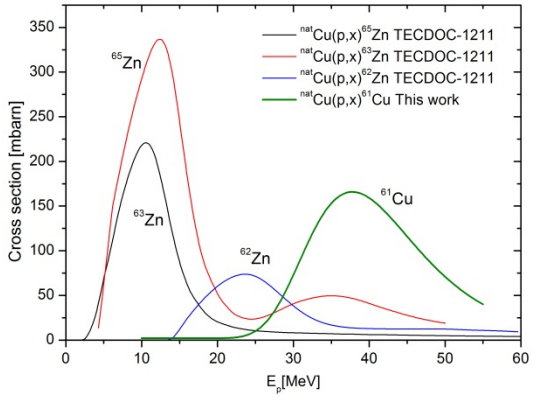

FIGURE 3. Excitation functions of proton induced monitor reactions on a natural Cu target.

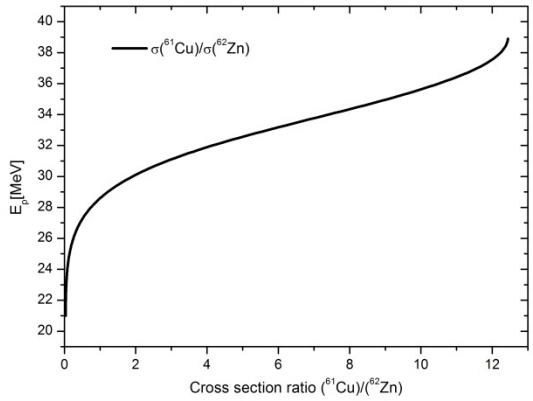

FIGURE 3. Ratio of the $^{nat}Cu(p,xn)^{62}Zn$ and the $^{nat}Cu(p,x)^{61}Cu$ reaction cross sections.

Additional cross section measurements are planned in order to further strengthen the data base of this potential monitor reaction. The results of this work shall be evaluated in the framework of an ongoing Coordinated Research Project of the IAEA.

References

1. F. Tárkányi, S. Takács, K. Gul, A. Hermanne, M. G. Mustafa, M. Nortier, P. Obložinský, S. M. Qaim, B. Scholten, Y. N. Shubin, J. Zhuang: *IAEA-TECDOC-1211*. IAEA, Vienna, 2001.
2. B. Scholten, S. Spellerberg, W. Bolten, H. H. Coennen: *Risø Report WTTC13* (S. Haroun, A. Givskov, M. Jensen, Editors), pp. 14–18, Risø, 2013.
3. H. Piel, S. M. Qaim, G. Stöcklin: *Radiochim. Acta* **57**, pp. 1–6, 1992.

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