Investigation of $^{50}Cr(n,\alpha)^{47}Ti$ reaction cross section for neutron energy less than 7.2 MeV

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Abstract

$^{50}Cr(n,\alpha)^{47}$ reaction cross section experimental investigation results is presented in this work. An ionization chamber with Frisch grid allied with wave form digitizer was used for this investigation. The developed investigation method of information accumulation and processing allowed significantly decrease background from parasitic reactions and select signals from investigating reaction. The $^{50}Cr(n,\alpha)^{47}Ti$ cross section measurements for 4.7 – 7.2 MeV neutron energy region is presented in this work.

Introduction
Construction materials radiation resistance is considerably defined by gaseous products (such as helium or hidrigen) of (n_{fast},α) nuclear reactions. The carried out analysis made it clear the lack of experimental data for a few elements (though of their great practical importance), for example, chromium is investigated for 14 MeV only [1-3]. And even these data differ from author to author in tens of percents (fig.1). There is total data absence for neutrons from reactor energy region. The consequence of such situation is wide dispersion in theoretical estimations of $^{50}Cr(n,\alpha)^{47}$ reaction cross section, shown also on Fig. 1. Comparison of ENDF/B VII to JENDL 3 $^{50}Cr(n,\alpha)$ ^{47}Ti reaction cross section data is shown on Fig. 2. The difference between them raise up to 27 times for low energy neutrons! This difference can only be solved by appearance of new experimental data.

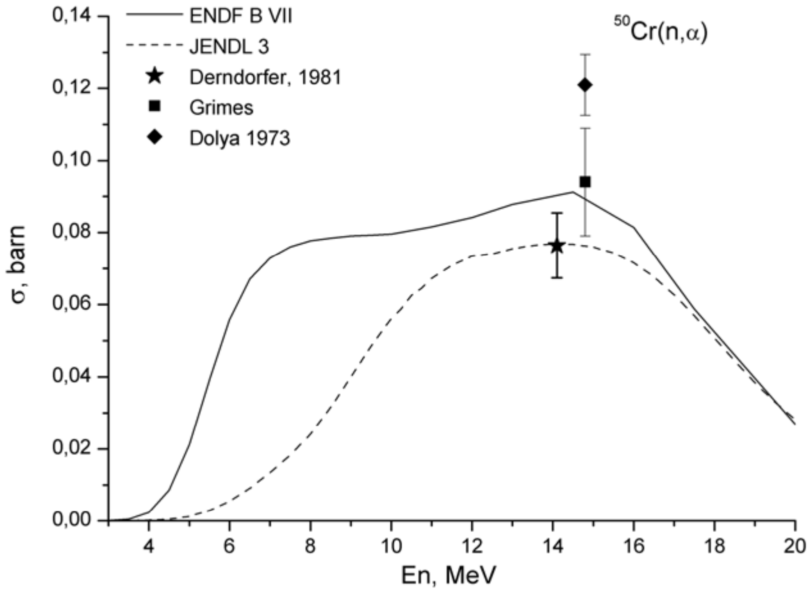

Figure 1. $^{50}Cr(n,\alpha)^{47}Ti$ cross section experimental data and theoretical estimations known for today.

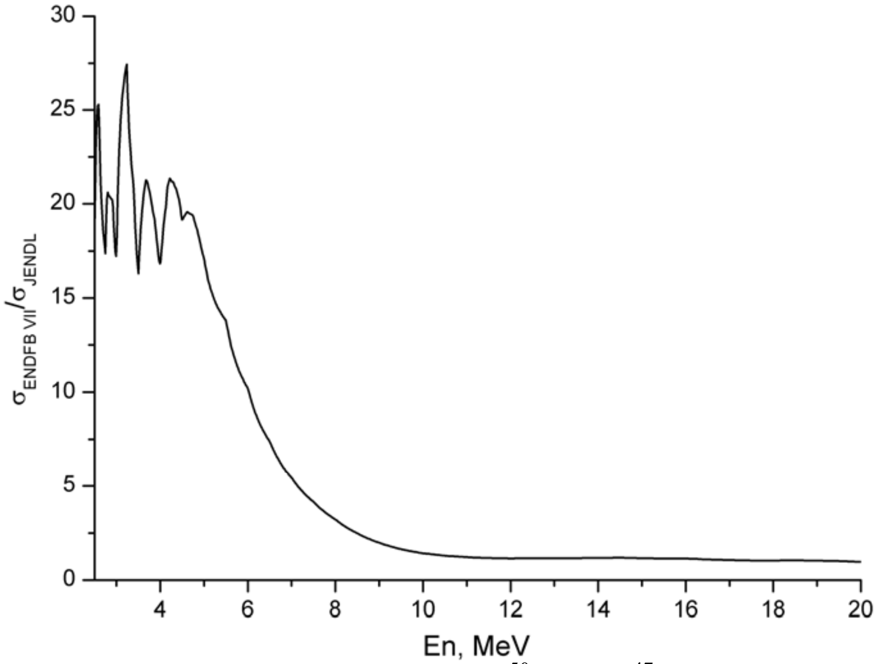

Figure 2. Comparison of ENDF/B VII to JENDL 3 $^{50}Cr(n,\alpha)$ ^{47}Ti reaction cross section data.

Experimental method

The solid cromium target with 96,8% of ^{50}Cr isotop was used in this work. The other isotopes were: ^{52}Cr (2.98%), ^{53}Cr (0.18%), and ^{54}Cr (0.04%). Target's full mass is 5.15 mg. The target was spread on golg foil with 84 mg/sm^2 thickness. The target was plased in ionization chamber with Frsch grid filled up with 97%Kr+3%CH_4 gas mixture wich pressure was 3 atmospheres. Great background to investigation effect arise from recoil protons registration that appears due to usage of hydrogen reach methane. Still, an attempt to use carbon dioxide has brought almost the same level of background, this time from oxygen. We found out that signal digital processing is easier for working with recoil protons background than oxygen α-particles.

First attempt of placing the target on the cathode showed that its material components became intensive source of α-particles appearing from (n, α) reaction. The authors have great experience of (n, α) reaction investigation in case of gaseous targets [4-5]. So, using this experience, the target was placed in the cathode – Frisch grid interval (Fig. 3). This approach allowed us to separate α-particle signals of different origin: from target surface, from cathode or that appeared in working gas. It is important that such a detailed analysis can be made with signal digital processing only.

Signals from anode and cathode were digitized separately, resulting numerical matrix with their amplitudes in different moments of time. This digitized signals were kept on PC hard drive for further processing. So we could get amplitudes of signals and their start and end time moments. Information joint analysis for each event allowed us to get detailed information about registered particle – energy, place of birth and her type. Every of determining parameters allow to reduce background and so, to increase number of investigating events determination reliability.

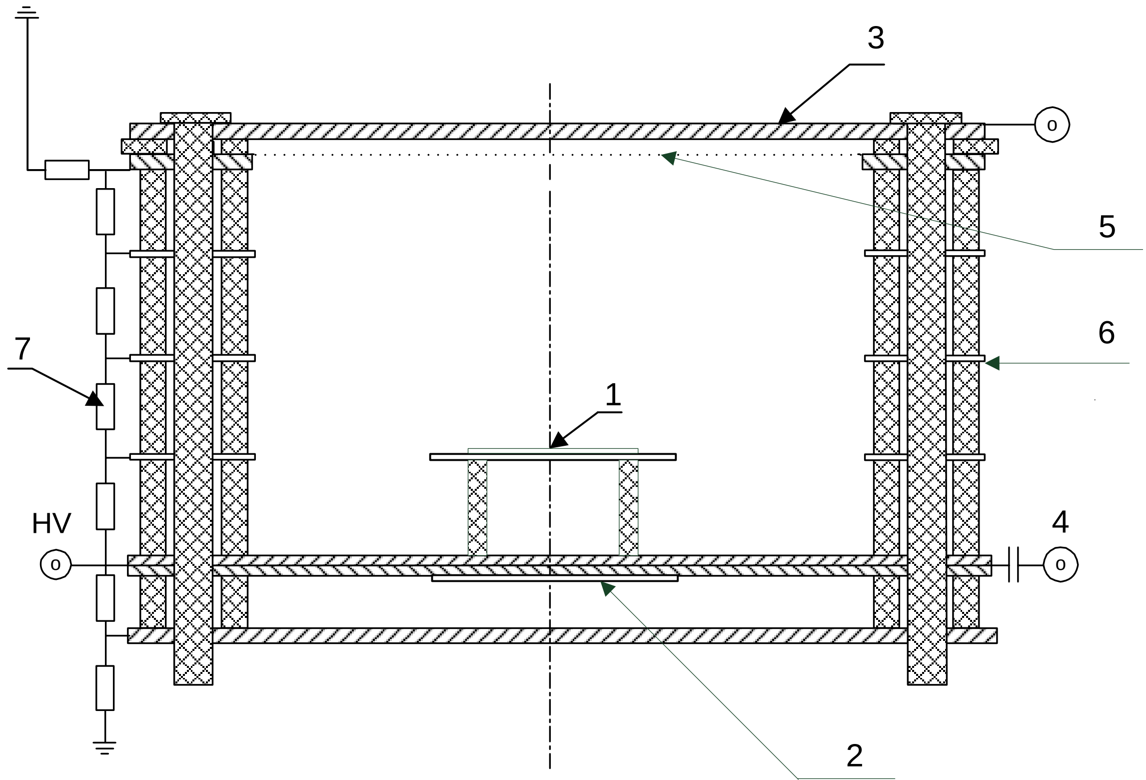

Figure 3. Detector construction scheme. 1 – ^{50}Cr target; 2 – ^{238}U target; 3 – IIC Anode; 4 – common cathode; 5 – Frisch grid; 6 – guard electrodes; 7 – divider.

All described investigations were carried out on EG-1 accelerator of IPPE. Neutrons were get from D(d,n) reaction on solid titanium target wich thickness is 1 mg/sm^2. Investigations is made for 4,7 to 7.2 MeV neutron energy region.

Flat double ionization chamber was used in our investigations. The second, made in back-to-back geometry, ionization chamber with ^{238}U target (99,99% enrichment) was used as α-particle source for neutron flux monitoring. Uranium target is 4,60 mg (determined by mass-spectrography). The describing methode allowed us to make the same dead time for both reaction channels – in main and monitor chambers. So we can record signals from common cathode not depending what sterted it – event from main or monitor chamber (fission fragments and α-partiles of ^{238}U).

Results obtained

Results of our investigatins are shown on Fig. 4. Совершенно очевидно что результаты наших измерений полностью противоречат оценке даваемой ENDF/B VII. В ряде точек отношение сечения даваемого ENDF/B VII к эксперименту достигает 50. В заметно лучшем согласии экспериментальные данные находятся с предсказаниями даваемыми библиотекой JENDL. Однако и в этом случае можно отметить, что в целом полученное экспериментально сечение систематически находится ниже оценки. Кроме того в экспериментальных данных отчетливо прослеживается некоторая структура в области энергии нейтронов ~ 6 МэВ которая отсутствует в оценке даваемой JENDL.

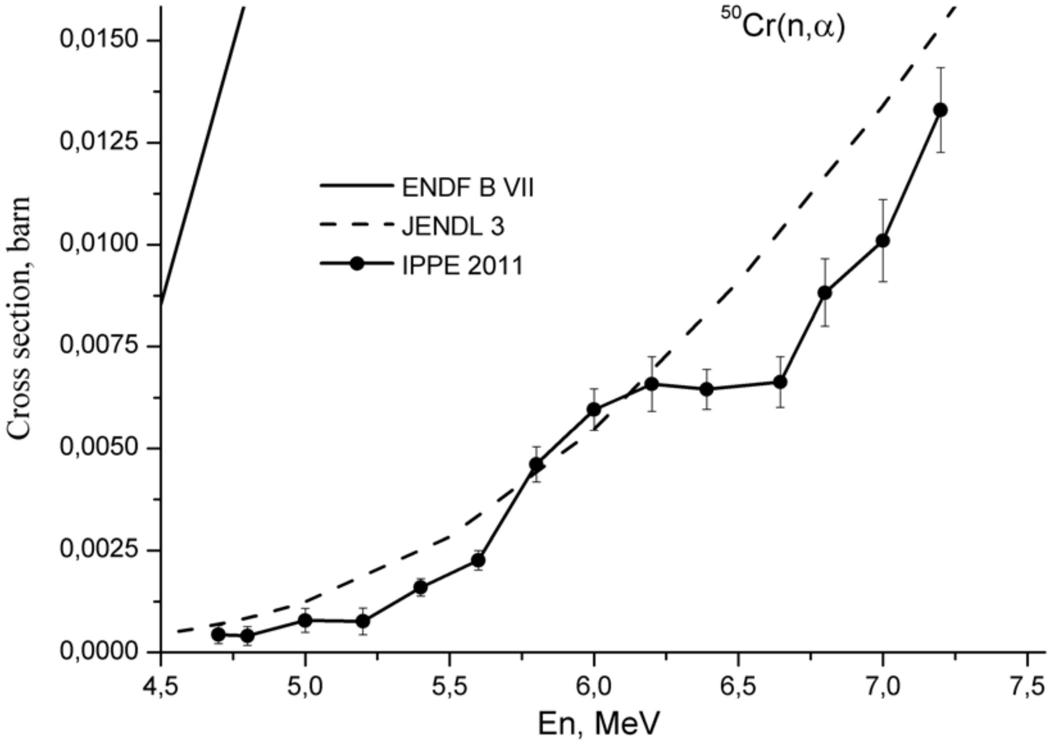

Figure 4. 50Cr(n,α)47Ti reaction cross section experimental data.

Conclusion

New digital spectrometer with a solid target for (n, α) reaction cross section investigation was developed. Its reliability of working in heavy parasitic reactions background was proved. Digital algorithms for background suppression was found. $^{50}Cr(n,\alpha)^{47}Ti$ reaction cross section in neutron energy region from 4,7 to 7,2 MeV was measured. Big discrepancy (up to 400%) with ENDF/B VII was found. Though JENDL data is much closer to experimental data, its average cross section and its excitation function tendency is not match with experimental data.

References

1. C. Derndorfer, R. Fischer, P. Hille, H. Vonach and P. Maier-Komor. Investigation of the 50Cr(n,α)47Ti reaction at En=14.1 MeV Zeitschrift für Physik A Hadrons and Nuclei Volume 301, Number 4, 327-334.
2. Dolja G.D. et al. 1973, Kiev conf, v.3, 131 (1973).
3. Grimes S.M., et al;. Phys.Rev. C19, 2127 (1979).
4. G.Giorginis, V.Khryachkov et al. The cross section of the 16O(n,α)13C reaction in the MeV energy range. In Proc. Of Int. Conf. NDST 2007 conference. Nice, 2007, pp.525-528.
5. Khryachkov V.A., Bondarenko I.P., Kuzminov B.D., Study of (n,α) reaction cross section on a set of light nuclei. Proc. Of XVIII Int. Seminar on Interaction of Neutrons with Nuclei, ISINN-18.