New experimental data for $^{12}\text{C}(n,\alpha)^9\text{Be}$ reaction.
Khryachkov Vitaly, Bondarenko I., Khromyleva T., Prusachenko P. and G.Giorginis*

Institute for physics and power engineering (IPPE) Obninsk, Russia
*Institute for Reference Materials and Measurements (IRMM), Geel, Belgium
Justification for the $^{12}\text{C}(n,\alpha)^{9}\text{Be}$ reaction cross section measurement

- Reactor criticality (graphite moderator, carbide fuel)
- Dosimetry
- Gas production
- Astrophysics
- Organic scintillator response function.
Current status of $^{12}\text{C}(n,a)$ data

Cross section, barn

En, MeV
Experimental methods for \((n,\alpha)\) reaction investigation

- Activation method;
- Direct measurement of \(\alpha\) – particle yield;
Activation method

\[ n + \frac{Z}{M}A \rightarrow \alpha + \frac{Z-2}{M-3}D \]

\[ \frac{Z-2}{M-3}D \rightarrow \frac{Z-1}{M-3}N^* + \bar{\nu} \quad , \quad T_{1/2} \]

\[ \frac{Z-1}{M-3}N^* \rightarrow \frac{Z-1}{M-3}N + \gamma \]

Diagram:

- 1-st stage
- 2-st stage
- Sample
- Gamma-ray
- Gamma-detector
Limitations of the activation method

- Residual nuclear must by radioactive!
- Half-life time for residual nuclear must be convenient!
- Energy of gamma-ray must be convenient!
- Yield of gamma-ray must be significant!

For stable residual nuclear activation measurement can not be done at all!
Why is it difficult to measure light elements?

- It is difficult to prepare a clean target
- Low reaction cross section
- The kinematical effect – dependence of anode pulse amplitude from the emission angle.
- Negative Q – value. Background from \((n,\alpha), (n,p)\) reaction, elastic recoil at working gas.
- Background of a detector.
- Light elements from the air (O, N) are present on the electrodes surface.
- Fine structure in cross section.
Scheme of the experimental setup

1-monitor chamber; 2-main chamber.
Geometry of the gaseous target

\[ V = \frac{\pi h}{3} \left( R_1^2 + R_1 R_2 + R_2^2 \right) \]

\[ N_{\text{Oxygen}} = 2.464 \times 10^{20} \text{ nuclei at } V=5.6346 \times 10^{-5} \text{ m}^3 \]

\[ N_{\text{Carbon}} = 1.232 \times 10^{20} \text{ nuclei at } V=5.6346 \times 10^{-5} \text{ m}^3 \]

\[ N(^{238}\text{U}) \text{ atoms in the monitor} = 6.831 \times 10^{18} \text{ (solid target } \sim 500 \mu \text{g/cm}^2) \]
Examples of signals of the main chamber and monitor chamber

DSP allows you to analyse:

1) Amplitude of anode pulse;
2) Amplitude of cathode pulse;
3) Time when anode signal appeared;
4) Time when anode signal reached the satiation;
5) Time when cathode signal appeared;
6) Time when cathode signal reached the satiation;
7) Ionisation distribution along the particle track. (Anode signal shape).
Two-dimensional spectrum of the end of the particle track drift time versus the anode pulse amplitude. The dashed rectangle defines the region of interest for final analysis. The drift time window $\Delta T_d$ determines the height of the effective volume of the gaseous target $\Delta x$. 

![Diagram of two-dimensional spectrum](image-url)
$\Delta t$ distribution for $^{12}\text{C}(n,\alpha) \alpha$-particles
Method of type of particle determination
Two-dimensional spectrum of rise time versus anode pulse amplitude with the dashed line separating $\alpha$ particles from background.
Experimental spectra
Spectrum decomposition

En=8.24 MeV
Peak position dependence

\[ Pa = 20.66 \times En - 119.3 \]
\[ Q = -\frac{119.3}{20.66} = -5.77 \text{ MeV} \]

\[ Q_{C(n,\alpha)}^2 = -5.702 \text{ MeV} \]
Result

Cross section, barn

En, MeV

- ENDF/B-VI
- JENDL 4
- Davis-63
- Dietze-82
- Pillon-11
- Brede-91
- IPPE-IRMM 2007
- IPPE 2017
- (JENDL 4)^0.8
Conclusion

- A new data for $^{12}\text{C}(n,\alpha)$ reaction was obtained for neutron energy range 7.5 – 9.6 MeV.
- Obtained data is more close to JENDL 3 evaluation (shape of excitation function).
- Normalization 20% is need to have detailed agreement between JENDL 3 and new data.
- Data for neutron energy more then 9.4 MeV have to be analyzed additionally.