Energy-differential measurement of the $^{12}\text{C}(n,p)$ reaction

Proposal to the INTC


08. February 2017.
Importance of the $^{12}\text{C}(n,p)$ reaction:

- dose estimation in radioprotection and hadrontherapy
- design of shields and collimators at accelerator facilities, spallation sources and irradiation facilities for fusion materials
- response of the diamond detectors to fast neutrons
- understanding of the nuclear structure of light nuclei

Subject also under investigation by Pillon et al. (shown with kind permission by M. Pillon)

- continuation of work from M. Pillon et al., NIMA 640 (2011) 185
- the latest results presented at the ND2016 conference
Status overview

- highly uncertain cross section throughout evaluated libraries, experimental data and between different models
- the latest integral measurement from n_TOF* indicates that existing data and evaluations may not be reliable

*P. Žugec et al., EPJA 52 (2016) 101
Proposed experimental apparatus

Detector features

- in vacuum
- out of beam
- telescope
- very thin Si-layers (20+300 µm)
- (limited) angular discrimination

7Be(n,p) campaign
Intended use of neural networks for maximum efficiency in particle discrimination.
Expected \((n,p)\) discrimination: up to 25 MeV

Above 25 MeV the proton yield from the \(^{12}\text{C}(n,np)\) reaction is expected to start mixing with the \(^{12}\text{C}(n,p)\) yield.
Detected counts reduced due to the limited solid angle, i.e. the geometrical efficiency. (discontinuities: an artifact of the Binary cascade, selected purely for the integral yield closest to the n_TOF value)
Sample thickness: 0.2–0.3 mm

0.2–0.3 mm: the optimum between the detected reaction yield up to 25 MeV and the background induced by the secondary reactions.
Excited states and angular distribution

Excited states of $^{12}\text{B}$ are known! Branching ratios may be taken either from other experiments or from the calculations.

Strategy: expansion of efficiency over partial contributions:

$$\varepsilon_{\text{tot}}(E_n) = \sum_{x,\ell} c_{x,\ell} \cdot \varepsilon_{x,\ell}(E_n)$$

$x =$ excited state
$\ell =$ partial wave
Proposed number of protons: $2 \times 10^{18}$

(Binary cascade)

Expected counts

$E_n$ [MeV]

Petar Žugec et al.
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Conclusions

• the data on the $^{12}$C($n,p$) reaction are, at present, largely discrepant, between experiments, models and evaluations

• the latest integral measurement from n_TOF suggests that none of them are quite reliable

• we propose an energy-differential measurement up to 25 MeV, to be performed by detecting the protons from the $^{12}$C($n,p$) reaction

• the challenges will be met by using a high-end stripped Si-telescope, in combination with the advanced data analysis

• we ask for the total of $2 \times 10^{18}$ protons on target
Thank you for your attention!
Most modern fast neutron therapy facilities use a $^9\text{Be}(p,n)$ source reaction, which produces a broad spectrum of neutrons with energies up to 70 MeV. (...) With the exception of hydrogen, sufficiently accurate nuclear data do not yet exist in this energy range to allow neutron therapy to reach its full potential. Because "standard man" consists (by mass) of hydrogen (10%), carbon (18%), nitrogen (3%), oxygen (65%), and various trace elements (4%), an accurate understanding of neutron nuclear reactions on carbon is essential.

M. B. Chadwick et al.