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Experiment for double-differential cross section measurement with the emission of light charged particles from high energy neutrons on carbon at n_TOF

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In hadron therapy for cancer treatment, secondary neutrons with energies up to about 200 MeV are produced by beam interaction with tumor cells and other surrounding materials. The risk assessment of secondary tumors induced by these neutrons requires double-differential cross sections (DDX) data for the emission of light charged particles (p, d, t, 3He and α). Experimental DDX data for tissue constituents are still rather scarce for neutron energies above 20 MeV and mostly measured for discrete neutron energies at mono-energetic neutron beam facilities. There are only very few DDX data available for discrete neutron energies close to and above 100 MeV for carbon.

Therefore, a proof-of-principle measurement of DDX on carbon at continuous neutron energies from 20 MeV to 250 MeV was carried out between September and October 2024 at the neutron time-of-flight facility n_TOF at CERN. This facility offers a white neutron spectrum up to several GeV which is unique in Europe. Two carbon targets were irradiated inside a new dedicated vacuum chamber, and the ΔE-E technique was used to identify secondary particles emitted at several measurement angles with combinations of silicon transmission detector (ΔE) and organic/inorganic scintillators as stop detector (E). Furthermore, the time-of-flight technique was exploited for the determination of the neutron incident energy on the target.

Preliminary results have shown our valid experimental approach for some combinations of ΔE-E telescopes. Some experimental inconsistencies with theoretical expectations still emerged and have provided useful insights for optimisations of the experimental setup. An analysis of the overall performance including first results will be presented. In the end, DDX data with uncertainties comparable to data from mono-energetic neutron sources are expected for the final validation of this proof-of-principle experiment with continuous energy coverage, which can then be extended in future experiments to tissue elements beyond carbon.

Author: DIETZ, Mirco (Physikalisch-Technische Bundesanstalt (PTB))

Co-authors: Mr BEYER, Roland (Helmholtz-Zentrum Dresden-Rossendorf (HZDR)); Mr DI CHICCO, Augusto (Physikalisch-Technische Bundesanstalt (PTB)); Mr JUNGHANS, Arnd (Helmholtz-Zentrum Dresden-Rossendorf (HZDR)); Mr NOLTE, Ralf (Physikalisch-Technische Bundesanstalt (PTB)); Ms PIROVANO, Elisa (Physikalisch-Technische Bundesanstalt (PTB)); N_TOF COLLABORATION, the (European Laboratory for Particle Physics (CERN))

Presenter: DIETZ, Mirco (Physikalisch-Technische Bundesanstalt (PTB))

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