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Neural Network Approach for Determination of Neutron Beam Directionality in BNCT

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For accelerator-driven neutron sources applied in Boron Neutron Capture Therapy (BNCT), the directionality of the neutron beam is a critical characteristic, as it directly influences both the penetration depth of the therapeutic beam within tissues and the magnitude of undesired radiation.

We propose a method that combines the gold foil activation technique and the neural network to measure the statistical characteristics of neutron directionality. Firstly, using the Monte Carlo method, we calculate the (n, γ) reaction rates for the AuAl foils under certain spatial distribution by artificially setting different neutron flight direction distributions at the neutron exit. Subsequently, these simulation results are utilized as a training dataset, and a regression model is constructed using a neural network approach. Finally, a series of AuAl foils, placed in the aforementioned spatial configuration at the neutron exit of the target station, are irradiated by neutron beam for certain time. The activity data are then recorded. Based on these experimental data, we employ the regression model to determine the statistical characteristics of the neutron flight direction distribution at the neutron exit, such as the nth order moments of the distribution.

The validity and accuracy of above method are tested by Monte Carlo results based on a neutron target station structure designed for BNCT. Then, we apply this method to process experimental activation data obtained at the BNCT target station at the Compact Pulsed Hadron Source (CPHS) of Tsinghua University, and the results demonstrate a high degree of consistency with the simulation.

Email Address

Presenter if not the submitter of this abstract

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Primary authors: LUO, Yanzhong (Tsinghua University); Mr CHEN, Hongfei (Tsinghua University); Ms BAI, Pulin (Tsinghua University); Prof. WANG, Xuewu (Tsinghua University); Prof. WANG, Zhe (Tsinghua University)

Presenter: LUO, Yanzhong (Tsinghua University)

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