Contribution ID: **54** Type: **Poster**

Design, Simulation, and Offline Testing of a Fast Neutron Moderator for AD-BNCT

Saturday 1 November 2025 11:45 (1 hour)

abstract: The Cotton University Particle Accelerator Centre and North East (CUPAC-NE)[1] is developing the first particle accelerator facility in Northeast India, a region with the nation's highest cancer incidence. This work focuses on Accelerator-Driven Boron Neutron Capture Therapy (AD-BNCT), an emerging cancer treatment based on the ^{10}B(n,α)^{7}Li reaction that selectively destroys boron-loaded tumor cells. Clinical efficacy depends on neutron energy: thermal neutrons (0.025 eV) are suited for superficial tumors, while epithermal neutrons (1 eV - 10 keV) penetrate deeper tissues and subsequently thermalize. Optimized moderation is therefore critical to maximize epithermal flux while ensuring patient safety.

The p(^{7}Li,^{7}Be)n reaction[2] at 28 MeV in inverse kinematics is employed at the HIRA facility (IUAC)[3] as the neutron source. Geometric constraints restrict moderator placement to 33°–50° and ≤ 200 mm to avoid overlap with the first quadrupole (Q1) as shown in Fig.1, thereby fixing the beam energy. The primary neutron branch (1 - 5 MeV) is kinematically correlated with a satellite ^{7}Be branch (17 - 19 MeV), detectable at HIRA.

As current GEANT4/TOPAS models are unreliable above 23 MeV in inverse kinematics, a transformation code was developed to convert direct to inverse kinematics at equal center-of-mass energy, validated against GEANT4 within its reliable range. Moderator optimization was conducted with CAD-integrated GEANT4 simulations. Conical moderators, commonly employed in AD-BNCT, were found to be inefficient. After several iterations, an optimized design with 14$\times$ higher efficiency was achieved as shown in Fig. 2. The system uses water as moderator, Teflon as cone material (chemically inert, providing additional fast-neutron absorption via ^{19}F(n,α)^{16}O and favorable scattering), and Bi as a gamma shield. Simulations predict $\sim 3 \times 10^4$ thermal neutrons per hour from a 28 MeV, 5 pnA ^{7}Li beam on a 20 μm polypropylene foil, further enhanced by a Pb collimator. The spectrum exhibits a thermal peak at $\sim$ 48 meV with FWHM $\sim$ 147 meV.

A scaled moderator prototype was 3D-printed in PLA (Polylactic Acid), with simulations indicating that a gypsum coating achieves efficiencies comparable to Teflon. A preliminary test is planned at the medical cyclotron of the State Cancer Institute, Guwahati. For thermal neutron detection, a novel and cost-effective method using LR115(II) solid-state nuclear track detectors is proposed. In this method, moderated thermal neutrons interact with ^{10}B compounds, producing α-particles that generate observable tracks under an optical microscope. The technique was validated using a ^{241}Am α-source, which produced well-defined tracks. Using this technique, the thermal neutron flux at the moderator exit can be determined. The medical cyclotron is also equipped with a BF_3 neutron detector, which allows evaluation of the moderator's efficiency by comparing the incident-to-exit flux ratio. Following optimization, the final experiment will be conducted at HIRA (IUAC, AUC:71368), where accelerator-driven monochromatic neutrons will be moderated to produce a well-characterized thermal neutron beam.

Acknowledgement: We extend our heartfelt gratitude to Prof. G. C. Wary, Prof. M. Patgiri, HIRA group, Dr. S. Santra, Dr. P. C. Rout, Jibon Sharma, Achuyt and Abhilash for their help and guidance.

References

[1] G. C. Wary, et al., "Developing a Discovery Class Particle Accelerator Facility at Cotton University by CUPAC - North East Collaboration,"in Proc. DAE Symp. Nucl. Phys., vol. 65, pp. 5–14, 2021.
[2] J. J. Das, et al., "Production of light radioactive ion beams (RIB) using inverse kinematics,"Nucl. Instrum. Methods Phys. Res. B, vol. 241, pp. 953–958, 2005.
[3] A. K. Sinha, et al., "Heavy ion reaction analyzer (HIRA): a recoil mass separator facility at NSC,"Nucl. Instrum. Methods Phys. Res. A, vol. 339, pp. 543–549, 1994.

Author: GOGOI, Monuj (Cotton University)

Co-authors: Ms SAIKIA, Dimpal (Cotton University); Mr GOGOI, Hritik (Cotton University); Ms BARUAH, Rasna (Cotton University); Mr BORUAH, Bhargab (Cotton University); Mr KUMAR KALITA, Naba (Cotton University); Mr PANDIT, Nabajyoti (Cotton University); Dr BARTHAKUR, A (Cotton University); Prof. DAS, J J (Cotton University); Dr BARO, M (Cotton University); Dr DEVI, M M (Tezpur University)

Presenter: GOGOI, Monuj (Cotton University)

Session Classification: Poster Presentations

Track Classification: Track 04: Astronomy & Astrophysics, Space & Atmospheric Physics, Plasma Physics, Nuclear Physics and Non-linear Dynamics