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Secondary fragment production in ion Beam therapy: experimental measurements for nuclear model improvement

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Accurate modelling of nuclear fragmentation is essential in ion beam therapy, where secondary ions contribute significantly to dose deposition and biological effects. However, the predictive capabilities of current Monte Carlo models remain limited in the energy range of therapeutic beam, especially for light fragment production ($Z = 1-6$), due to a lack of experimental data.

Within the CLINM (Cross-sections Light Ions and Neutron Measurements) project, we performed detailed measurements of secondary charged particles produced by carbon beams (120–400 MeV/u) on thick RW3 targets at the CNAO facility, using a $\Delta E-E$ scintillation telescope. This telescope enabled particle identification and energy reconstruction over multiple emission angles and irradiation configurations.

The measured yields and energy spectra were benchmarked against Geant4 simulations using the INCL++ physics list. Systematic discrepancies were observed across all ion species, particularly for helium and beryllium fragments, where both yield and spectral shape were misestimated. In several cases, model predictions underestimated light ion production by more than 30%, or failed to reproduce the angular dependence of energy distributions.

These results highlight the limitations of current hadronic models for therapy-relevant ion beams, and provide new statistics data to guide their refinement. This work reinforces the need for dedicated experimental campaigns to ensure the reliability of Monte Carlo simulations in clinical contexts.

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