Real-Time Imaging of the Stopping Distribution for Antiprotons in Biological Targets

Purpose: To keep the normal tissue complication probability (NTCP) as low as possible, real-time imaging of the irradiation process is highly desirable to detect and correct any deviation from the treatment plan. Using a simple detector setup, the one-dimensional annihilation vertex distribution was reconstructed by evaluating the tracks of charged pions resulting from antiproton annihilation in a water phantom.

Methods and materials: A spare ladder of 10 silicon pixel detector chips, normally used as part of the vertex detector in the ALICE experiment at CERN, was used. Each chip has 256 x 320 pixels with 50 µm width and 425 µm height, and a thickness of 200 µm. It was mounted unconventionally, allowing charged particles, especially pions, to traverse it more or less tangentially to the front surface, depending on their place of generation. By interacting with a line of pixels, they leave tracks with a specific length and slope, which are used to back-calculate their origin. FLUKA 2008.3c.0 was used to simulate this set-up and to generate Monte Carlo data to improve the understanding and analysis of real events collected during a run with 500 MeV/c antiprotons at the antiproton decelerator facility at CERN.

Results: Reconstruction of the annihilation vertex was achieved with a resolution of 4 cm in the axial direction, limited by the present detector mounting. Based on Monte Carlo simulations, alternative detector orientations and optimized detector geometries are proposed.

Conclusion: The principal applicability of the described method was demonstrated. Further investigation needs to be done to improve on the resolution. Rotating the detector by 90 degrees seems beneficial, but might introduce too much material so that the pions interact significantly, disabling a track reconstruction.