Helium ion beam modelling

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Cross Sections

Soft tissue is mainly water, so cross sections for the collisions ^{4}He+p and ^{4}He+O are required in order to perform transport calculations for radiotherapy [1]. Dedicated experiments to obtain data over the whole energy range are time consuming, thus we rely on nuclear reaction models. We investigated the semiempirical models of Tripathi [2] and Sihver [3], Figure 1. The gross properties are similar, however, we currently prefer the Tripathi model, giving better agreement with experimental data.

Transport Calculation

One of the most important observables is the attenuation of the primary beam, which is usually easier to measure than pure cross sections. Figure 2 shows the result of our deterministic transport calculation compared with experimental results obtained at HIT [4]. At maximum penetration depth, about 50% of the beam is lost due to nuclear reactions.

Radiobiology

Although ^{4}He ions are considered low-LET radiation, their RBE, in particular in the stopping region, is all but negligible. In Figure 3 we show the relevant quantities for a model system (CHO, α/β=8.6Gy, LEM IV) for a typical target depth and a target dose of $\approx$ 3Gy(RBE). RBE rises steeply towards the distal edge and thus cannot be neglected in treatment planning.

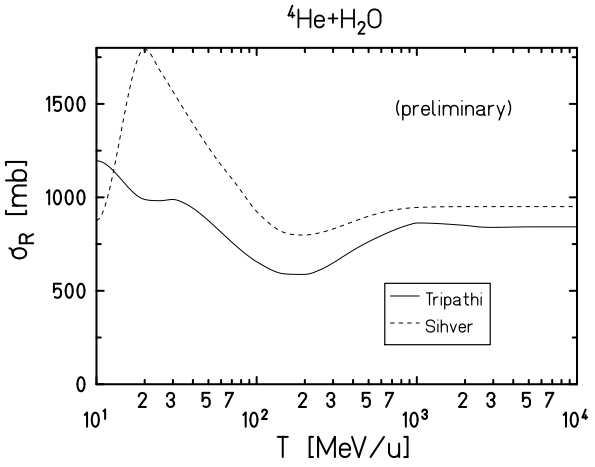

Figure 1: Nuclear reaction cross sections.

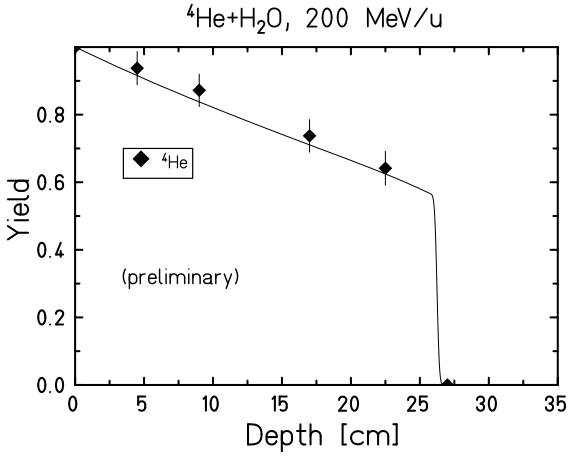

Figure 2: Primary beam attenuation.

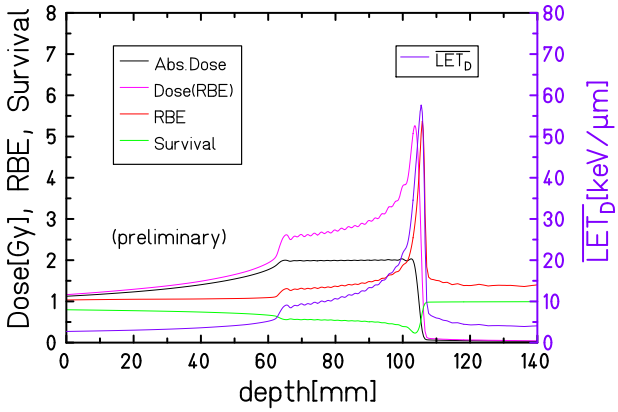

Figure 3: Depth profiles, including dose-mean LET.

References

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