4He dose- and track-averaged Linear Energy Transfer: Monte Carlo algorithms and experimental verification

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Background: In the present hadrontherapy scenario, there is a growing interest in exploring the capabilities of different ion species other than protons and carbons. The possibility of using different ions paves the way for new radiotherapy approaches, such as the multi-ions treatment, where radiation could vary according to target volume, shape, depth, and histologic characteristics of the tumor. For these reasons, in this work, the study and understanding of biological-relevant quantities was extended for the case of 4He ion.

Material and Methods:
Geant4 Monte Carlo based algorithms for dose- and track-averaged LET (Linear Energy Transfer) [Petringa2020, Cirrone2011] calculations, were validated for $_4$He ions and for the case of a mixed field characterised by the presence of secondary ions from both target and projectile fragmentation.
The simulated dose and track averaged LETs were compared with the corresponding dose and frequency mean values of the lineal energy, yd and y_F, derived from experimental microdosimetric spectra.
Microdosimetric experimental campaigns were carried out at the Italian eye proton therapy facility of the Laboratori Nazionali del Sud of Istituto Nazionale di Fisica Nucleare (INFN-LNS, Catania, I) using two different microdosimeters: the MicroPlus probe and the nano-TEPC (Tissue Equivalent Proportional Counter)

Preliminary results:
The corresponding set-ups were entirely simulated and the depth dose deposition and LET curves derived and compared with the LET values experimentally derived by microdosimetric measurements. Figure 1 reports the case of a "modulated" Helium beam. Microdosimetric spectra (colored curves) were acquired at different depths in water (corresponding dots) while the continuous curve represent the experimental and simulated depth dos deposition curves. In Figure 2 the correspondent experimental (crosses) and simulated LETs are reported. The blue curve is the LET_total where the contribution from the generated secondaries is also considered.

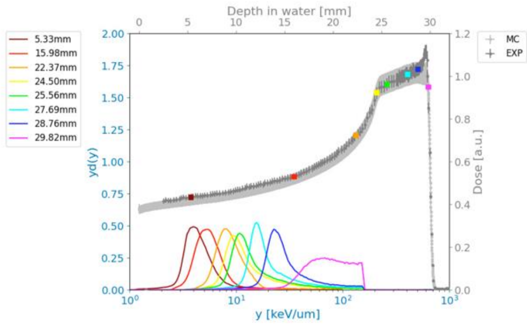

Figure 1: depth dose curves and microdosimetric spectra of a modulated 4He beam.

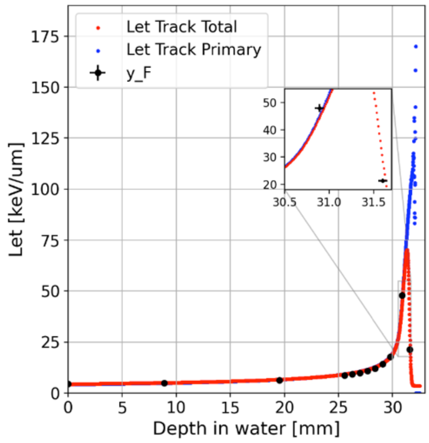

Figure 2:experimental and simulated LETs corresponding to the beam of Figure 1

Petringa, G. et al. (2020). Monte Carlo implementation of new algorithms for the evaluation of averaged-dose and -track linear energy transfers in 62 MeV clinical proton beams, Physics in Medicine and Biology 65: 235043.

Cirrone, G. et al. (2011). Hadrontherapy: a Geant4-Based Tool for Proton/Ion-Therapy Studies,Progress in Nuclear Science Technology 2: 207-212.