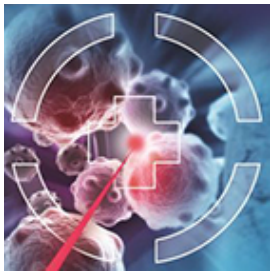

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Review of the improved nuclear physics models in FLUKA for helium and carbon ion therapy

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FLUKA (Ferrari et al. 2005, Böhlen et al. 2014) is a multi-purpose Monte Carlo code for particle transport, developed by a CERN-INFN collaboration. In hadron therapy it is used to generate the basic input data for the treatment planning systems (e.g. at CNAO in Italy, and at HIT and MIT in Germany), to validate the dose calculations, and for research purposes (Battistoni et al. 2016).

Besides proton and carbon ions, already in use in several facilities worlwide, HIT is planning to exploit helium ions for cancer treatments in the near future. In order to provide accurate dose calculations in FLUKA, as a support for the treatment planning system at HIT, refinements of the total and non-elastic cross section models embedded in FLUKA were carried out. Experimental data acquired at HIT (Horst et al. 2017, Horst et al. 2019) were used to benchmark the code. A better agreement between FLUKA and experimental measurements of depth-dose profiles was achieved, especially in the Bragg peak. The dose distributions predicted by the previous and revised FLUKA versions were compared in realistic clinical cases. This work is crucial in view of the use of helium ions for hadron therapy at HIT.

For estimation of the cell lethal lesions induced by the radiotherapy treatments, accurate calculations of the RBE-weighted dose are needed. Different radiobiological models have been developed, among which there are the local effect model I (LEM I) (Scholz et al. 1997, Krämer and Scholz 2006) and the microdosimetric kinetic model (MKM) (Inaniwa et al. 2010), both used in clinics. LEM IV (Grün et al. 2012, Krämer et al. 2016) is a revised version of LEM I, which has been optimized particularly for heavy ions. In addition, the biophysical analysis of cell death and chromosome aberrations (BIANCA) model (Carante et al. 2018) has been developed at the University of Pavia and INFN-Pavia (Italy).
In our research we interfaced the FLUKA code with the four above-mentioned radiobiological models. For a given physical dose, the resulting RBE-weighted dose distributions obtained using different models were compared. Real clinical cases treated at the CNAO facility were used for studies with primary carbon ions. Comparisons between simulations and in-vitro experimental data were performed for helium ion and carbon ion beams. The most relevant achievements will be presented.

References:

Battistoni G et al. 2016 The FLUKA Code: An Accurate Simulation Tool for Particle Therapy Front Oncol. 6: 116

Böhlen TT et al. 2014 The FLUKA Code: Developments and Challenges for High Energy and Medical Applications, Nuclear Data Sheets 120 211-14

Carante MP et al 2018 BIANCA, a physical model of a cell survival and chromosome damage by protons, C-ions and He-ions at energies and doses used in hadrontherapy, Phys. Med. Biol.63(7) 075007

Ferrari A et al. 2005 FLUKA: a multi-particle transport code, CERN-2005-10, INFN/TC-05/11, SLAC-R-773

Horst F et al. 2017 Measurement of charge- and mass-changing cross sections for 4He+12C collisions in the energy range 80–220 MeV/u for applications in ion beam therapy, Phys. Rev. C 96, 024624

Horst F et al. 2019 Measurement of 4He charge- and mass-changing cross sections on H, C, O, and Si targets in the energy range 70–220 MeV/u for radiation transport calculations in ion-beam therapy, Phys. Rev. C 99, 014603

Krämer M and Scholz M 2006 Rapid calculation of biological effects in ion radiotherapy, Phys. Med. Biol. 51 1959–70

Krämer M et al. 2016 Helium ions for radiotherapy? Physical and biological verifications of a novel treatment

modality, Med. Phys. 43 1995
Grün R et al. 2012 Impact of enhancements in the local efffect model (LEM) on the predicted RBE-weighted target dose distribution in carbon ion therapy, Phys. Med. Biol. 57 7621-74
Inaniwa T et al. 2010 Treatment planning for a scanned carbon beam with a modified microdosimetric kinetic model Phys. Med. Biol. 55 6721
Scholz M et al. 1997 Computation of cell survival in heavy ion beams for therapy. The model and its approximation, Radiat Environ Biophys 36(1) 59-66

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