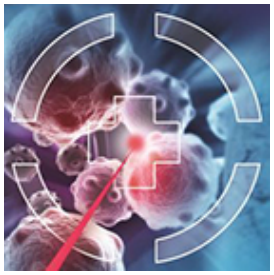

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Advances in the FLUKA Particle Therapy Tool and its extensions for ion therapy optimization.

This work presents the recent developments of the FLUKA [1,2,3] Particle Therapy Tool [4]. FLUKA is a general-purpose Monte Carlo (MC), particle transport code, used for an extended range of applications including medical physics. Together with the support of its graphical user interface Flair [5,6], an easy-to use platform was developed for MC simulations in particle therapy. It has already proven its use in applications such: patient specific treatment plan quality assurance and biologically-oriented dose scoring in clinical and research scenarios.

Two novel additions to the FLUKA Particle Therapy Tool will be presented here: an extended validation of the tool for complex clinical carbon ion irradiation scenarios and an extension of the FLUKA Particle Therapy Tool for multiobjective optimization based on dose and dose-averaged Linear Energy Transfer (LET_D) distributions.

Four multi-field clinical carbon ion treatment plan scenarios from CNAO were studied, i.e. head and neck, liver, prostate and pancreas, of which two include range shifter. Together with their validation against commissioned clinical Treatment Planning System (TPS) results and analysis of the discrepancies, RBE-weighted dose (DRBE) distributions using clinical radiobiological models (LEM I [7], MKM [8]) were calculated. Uncertainties in predicting D_RBE using such models make the optimization of LET_D distributions as additional descriptor for estimating the biological tissue response a promising approach to improve clinical outcome. This idea was then used in a treatment planning re-optimization.

The extension of the FLUKA Particle Therapy Tool provides optimization functionalities with the support of the MC-based treatment planning tool [9]. An upgraded tool is now compatible with the standardized FLUKA functions and the current modular design allows to easily test new optimization algorithms. In order to cope with the multiobjective optimization problem (physical dose and LET_D distributions), various evolutionary algorithms were implemented and tested. Preliminary optimization results provide a reduction of the hight LET_D distribution in organs at risk (OAR), while still satisfying the clinical requirments on the Dose-Volume-Histograms for planned target volume (PTV). Results using MultiObjective Evolutionary Algorithm based on Decomposition (MOEA/D) algorithm [10] for optimizing carbon ion treatment plans will be presented.

Obtained results shows that FLUKA Particle Therapy Tool is suitable for clinical and research application in particle therapy. Moreover, it can be easily extended to other ion species such as helium ions, planned to be used at HIT clinically in close future.

References:

1. Ferrari A, Sala P, Fasso A and Ranft J 2005 FLUKA: a multi-particle transport code Technical Report CERN-2005-10, INFN/TC 05/11, SLAC-R-773

2. Böhlen T T, et al. 2014 The FLUKA code: developments and challenges for high energy and medical applications Nucl. Data Sheets 120 211–4

3. Battistoni G et al. 2006 Recent Developments in the FLUKA nuclear reaction models Proc. 11th Int. Conf. on Nuclear Reaction Mechanisms pp 483–95

4. Kozłowska W et al 2019 Phys. Med. Biol. 64 075012

5. Vlachoudis V 2009 FLAIR: a powerful but user friendly graphical interface for FLUKA Proc. Int. Conf. on Mathematics, Computational pp 1–11

6. Vlachoudis V and Sinuela-Pastor D 2014 Numerically robust geometry engine for compound solid geometries SNA + MC 2013—Joint Int. Conf. on Supercomputing in Nuclear Applications + Monte Carlo pp 1–6

7. 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
8. Inaniwa T et al. 2010 Treatment planning for a scanned carbon beam with a modified microdosimetric kinetic model Phys. Med. Biol. 55 6721
9. Mairani A et al. 2013 A Monte Carlo-based treatment planning tool for proton therapy Phys. Med. Biol. 58 2471–90
10. Q. Zhang, H. Li, "MOEA/D: a multiobjective evolutionary algorithm based on decomposition", IEEE Trans. Evol., vol. 11, no. 6, pp. 712-731, 2007

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