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Nuclear Physics applications in Medicine: State of the Art

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Medical applications of nuclear physics started to be part of INFN activities in the last couple of decades, and nowadays represent an important portion of funded research projects, especially in CSN V. In this context, the continuous development of charged particle therapy (CPT) represents a prolific scenario for the birth of a number of initiatives. On the one hand, CPT demands for innovative technologies, ranging from accelerator-related aspects to devices for beam monitoring, dosimetry and imaging. On the other hand, a deepened knowledge of radiation-matter interactions on multiple physical scales is required for allowing efficient treatments. This is needed in order to improve the accuracy of treatment plan calculations, as well as to understand the radiobiological response of cells and tissues exposed to different radiation qualities compared to photons, which is finally responsible for treatment outcomes.

Proton therapy is currently the most widespread solution for charged particle treatments, with few clinical centers operating in Italy, and a number planned for the near future. While proton therapy is considered an established approach for the treatment of specific cancer types (e.g. those in the brain, head-and-neck districts), research efforts are ongoing, aiming at further improving the potential of this technique. INFN provided several contributions to this field in the last few years, not only from the technological point of view, but also with more basic research dedicated to the understanding of target fragmentation processes, as well as to the use of boron nuclei as radiosensitizers, due to the alpha emitted by the proton-boron reaction.

The talk will provide an overview of the main activities carried out in the framework of INFN on the topics introduced above. Future perspectives and starting initiatives will also be discussed. From this point of view, a special focus will be dedicated to the ultra-high dose rate radiotherapy, also called FLASH. This stems from the experimental observation that the delivery of a therapeutic amount of dose to the target in a very narrow time window in the typical range of 1-200 milliseconds, allows reducing significantly treatment-related toxicity, while preserving the same treatment effectiveness. Extensive research is developing worldwide in this field, since the potential of an unprecedented paradigm shift in RT treatments is attributed to FLASH. Activities in this direction started already in INFN, which will thus have the chance to contribute to this rapidly developing field.

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