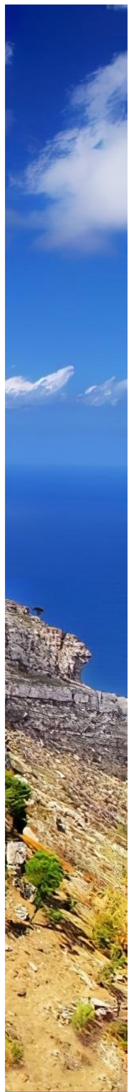
Physics for Health:

New perspectives in medical applications and radiation safety



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BOOK OF ABSTRACTS
AND CONFERENCE PROGRAMME

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"Monte Carlo Geant4–Based Assessment of Microdosimetric Spectra for Proton Minibeam Radiotherapy"

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Currently, one of the primary limitations of radiotherapy lies in the maximum dose that can be safely tolerated by surrounding healthy tissues, often making treatments ineffective for advanced lesions located in critical organs such as the lungs and brain. Spatially fractionated radiotherapy (SFRT) delivers alternating high- and low-dose regions, reducing normal tissue toxicity while maintaining tumor control. Minibeam radiotherapy (MBRT) is an SFRT approach using parallel 0.5–1 mm beam separated by similar gaps, producing a peak-and-valley dose pattern. The use of proton beams, known for their low scattering and maximum energy deposition at the end of their path (Bragg peak), combined with the unique properties of spatial modulation, makes proton minibeam radiotherapy (pMBRT) a potentially more effective and safer treatment option for cancer patients in the future clinical perspective of this technique.
The presented study was performed in the framework of the INFN MIRO (MInibeam RadiOtherapy) project, financed by the Committee 5 of the INFN, with the goal to address key questions related to the radiobiological minibeam effect with both electron and proton beams and explore potential clinical implications through the correlation with the dosimetric and physical quantities.
At this aim, the quality of proton minibeam radiation at a clinical energy and its variation along the peak-to-valley pattern and in depth was evaluated by means of Monte Carlo Geant4 simulations. In particular, the microdosimetric spectra and the related average quantities have been estimated for specific minibeam configurations and compared to the ones obtained simulating an equivalent homogeneous proton beam, i.e. without the spatial modulation. Microdosimetry is, in fact, particularly relevant for minibeams where spatial modulation in the dose distribution requires a micrometric-scale description to further investigate their biological effect.
The "exp_microdosimetry" Geant4 advanced example developed by the INFN Catania division was used to perform Montecarlo simulations of 100 MeV gaussian proton beam impinging on a tungsten 5 mm thick collimator with different geometrical configuration (width and center-to-center distance). An array of silicon microdosimeters was simulated to simultaneously acquire the microdosimetric spectra at different positions along the minibeam pattern and reduce as much as possible the computation time. In particular, the single microdosimeter simulated was the simplified silicon detector already implemented in the code and developed at the Centre for Medical Radiation Physics (CMRP), University of Wollongong.
Results regarding the microdosimetric spectra (in frequence and in dose) and the average quantities yF and yD between the peak and the valley and at different water depths for the most relevant minibeam configuration will be presented in this contribution.
This preliminary study lay the groundwork for future calculations of the RBE in radiobiological models and open the way to a more complete microdosimetric and radiobiological characterization of pMBRT.