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Construction of a proton minibeam beamline for preclinical experiments in small animals –Minibee Project

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Proton minibeam radiotherapy (pMBT) is a novel radiotherapy method that deploys proton beams, combined with spatial fractionation, intending to broaden the therapeutic window while protecting healthy tissues. Pre-clinical studies have already highlighted the potential of pMBT in sparing healthy tissues and achieving better tumor control compared to conventional proton therapy. Constructing a proton minibeam beamline for pre-clinical experiments (Minibee) at the Helmholtz Zentrum Berlin (HZB) will facilitate in-depth and systematic research.

The cyclotron at HZB extracts a 68 MeV proton beam, which is suitable for studies in small animals. If necessary, the beam energy can be degraded right after the cyclotron and a range shifter can further adjust the beam energy to generate a spread-out Bragg peak (SOBP). A quadrupole triplet, close to the isocenter, creates magnetically focused minibeam and scanning magnets will offer the possibility to scan a field of 50x50 mm². FLASH irradiation mode can be supported at the beam entrance in single energy mode, with an average dose rate of kGy/s and local peak dose rates up to several MGy/s. Switching times of 6 μ s are needed to preserve a dose error <2%, bringing forth challenges for dose monitoring. These can be resolved by a resonant beam monitor for ultra-fast signal transmission. The beamline also includes small animal imaging, positioning tools, and a microscope, allowing live-cell imaging for 2D and 3D culture experiments. The simulation studies have shown that the proposed facility can generate minibeam with a σ of ~50 μ m in both directions and transmission of ~2.5%. The opening of the beamline took place last year.

The pMBT facility will intensify the research in the field while offering the opportunity to develop new technologies and better understand the underlying mechanisms.

Author: ROUSSETI, Aikaterini (Universität der Bundeswehr München)

Co-authors: NEUBAUER, Jessica (Universität der Bundeswehr München); Dr KOURKAFAS, Georgios (Helmholtz-Zentrum Berlin (HZB)); KANG, Minkyu (Helmholtz-Zentrum Berlin (HZB)); DITTWALD, Alina (Helmholtz-Zentrum Berlin (HZB)); BUNDESMANN, Jürgen (Helmholtz-Zentrum Berlin (HZB)); Dr DENKER, Andrea (Helmholtz-Zentrum Berlin (HZB)); Prof. DOLLINGER, Günther (Universität der Bundeswehr München); Prof. REINDL, Judith (University of Oslo, Universität der Bundeswehr München)

Presenter: ROUSSETI, Aikaterini (Universität der Bundeswehr München)

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