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Nanoparticle-assisted electron minibeam radiotherapy

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Preclinical and clinical studies have shown that radiation delivery at ultra-high dose rate (UHDR, > 40 Gy/s) and sufficiently high total dose elicits the FLASH effect that maintains anti-tumor efficacy and spares normal tissue as compared with conventional dose rate (0.05 Gy/s), used in RT clinical practice. The 22 MeV electron PITZ beam delivers radiation at both UHDR up to unique 10^14 Gy/s and conventional dose rate. FLASH-lab@PITZ –a multidisciplinary R&D platform in collaboration with Technical University of Applied Sciences Wildau opens new territory of UHDR radiation with high bunch charges and bunch lengths in the picosecond time range, single bunch doses and dose rates up to extremely high levels and flexible choice of bunch timing structure and beam manipulation.

The concept of electron radiation combination with fullerene/cisplatin/gold nanoparticle-assisted near infrared (NIR)-luminescence imaging is being proposed. A generic multifunctional stimuli-responsive nanomedicine proposes chief attraction in high selectivity, imaging and switchable toxicity under exposure to electron radiation. The PITZ electron beam is very well controlled, its flexible single bunch charge and beam energy allows electron spot sizes from a few centimeters down to about ~100 µm. A kicker system distributes single bunches to different transverse locations, thus can "paint"the tumor within 1 ms. The dose per bunch can be freely adjusted in the range from 0.02 to 1000 Gy in 1 mm^3 volume that gives an opportunity to run a diagnostic imaging of tumor tissue location to guide its irradiation. For that first low-charged diagnostic bunch train can be used to scan the tumor for NIR-luminescence signal, based on which second high-charge therapeutic bunch train can be used to irradiate positive areas within 0.1-1 s. Combined imaging-guided UHDR dose delivery and tissue radiosensitization has a potential to improve cancer treatment efficiency.

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