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## **A Novel Ultra-High Dose Rate Proton Therapy Technology: Spot-Scanning Proton Arc Therapy FLASH (SPLASH)**

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**Objectives:** To introduce a novel optimization and delivery technique, the spot-scanning proton arc therapy (SPArc)+FLASH (SPLASH), to take full advantage of FLASH dose rate (40Gy/s) and high dose conformity.

**Methods:** SPLASH framework was implemented in an open-source proton planning platform (MatRad, Department of Medical Physics in Radiation Oncology, German Cancer Research Center-DKFZ). It optimizes with (1) the clinical dose-volume constraint based on dose distribution and (2) the effective dose-average dose rate by minimizing the monitor unit (MU) constraint on spot weight and accelerator's beam current sequentially, enabling the first dynamic arc therapy with voxel-based FLASH dose rate. This new optimization framework is able to minimize the overall cost function value combined with plan quality and voxel-based dose rate constraints. Three representative cases (brain, liver and lung cancer) were used for testing purposes. Dose-volume histogram (DVH), dose rate volume histogram (DRVH) and dose rate map were compared among intensity-modulated proton radiotherapy (IMPT), SPArc and SPLASH.

**Results:** Results: SPLASH/SPArc could offer superior plan quality than IMPT in terms of dose conformity. The DRVH results indicated SPLASH could significantly improve V40Gy/s in target and region of interest (ROI) for all tested cases in comparison with SPArc and IMPT. The optimal beam current per spot is simultaneously generated, which is within the existing proton machine specifications in the research version (< 200nA).

**Conclusion(s):** SPLASH offers the first voxel-based ultra-dose-rate and high-dose conformity treatment using proton beam therapy. Such a technique has the potential to fit the needs of a broad range of disease sites and simplify clinical workflow without applying a patient-specific ridge filter, which has never been demonstrated before.



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