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UHN Princess Margaret Cancer Centre

Effect of Varying Lateral Spot Size and Beam Energy Spread on Proton Therapy Treatment Plans

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Related posters:

SU-315-GPD-T-924
SU-315-GPD-T-301

References

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Introduction

- The **dielectric wall accelerator (DWA)** is proposed as a low-cost, compact system for proton therapy[1,2,3] that can provide unique control over spot size and energy spread.
- We evaluate the effect of **lateral spot size and longitudinal spot size** (i.e, beam energy spread) on clinical proton treatment plans to:
  - Identify desirable beam characteristics
  - Help inform our DWA design

Methods

- A linear beam optics model of the DWA[3] was developed and validated using the **TRANSOPTR**[4] code.
  - Beam parameters exiting the DWA were subsequently passed through components of a generic nozzle model in **TOPAS**[5].
- **Lateral spot size** (1σ in air at isocenter) was varied across **0.6, 0.8, 1, 3, 5, 7, and 10 mm**.
- **Beam energy spread** (% ratio of energy variation to the nominal energy) was varied over **0.05%, 0.5%, 1%, and 5%**.
- **RayStation (2023B)** treatment plans were generated for 5 **pediatric central nervous system (CNS)** cases.
- All results were benchmarked against reference data from a conventional cyclotron-based proton therapy machine[6].

Results

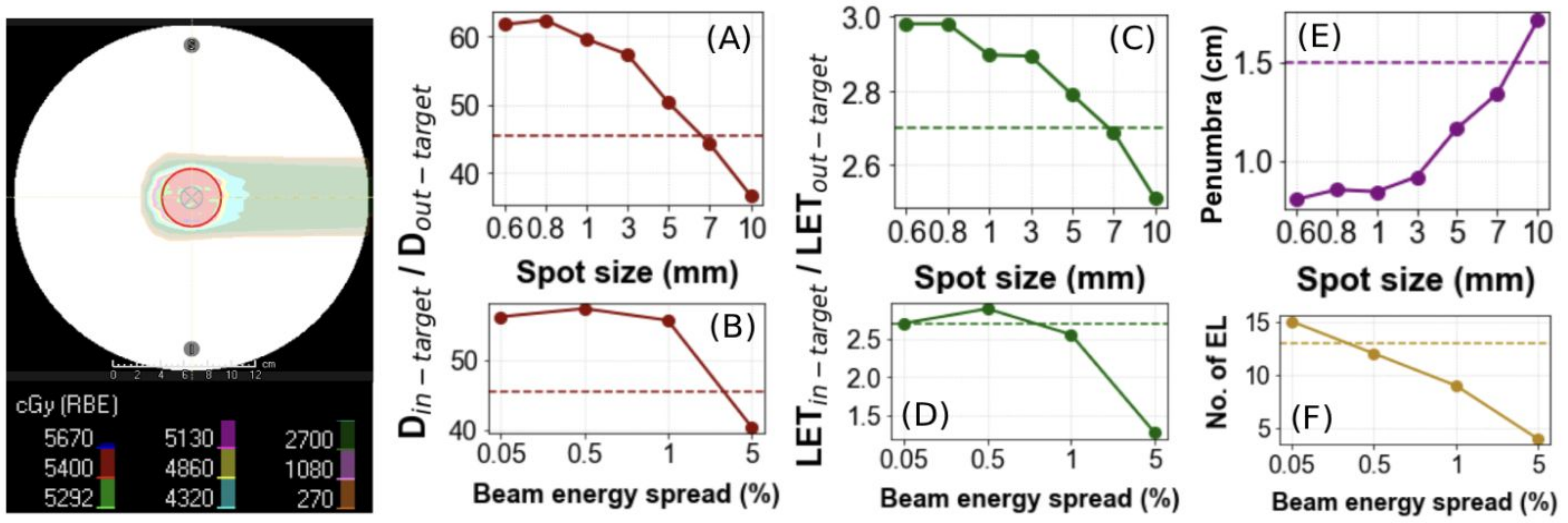

Figure 1. *A 5-cm diameter target located at the center of a 30-cm oval water phantom is shown as a sample case. A sagittal slice* ***(left)*** *illustrates the target (red) and dose distribution for a 1-mm spot size plan. Results* ***(right)*** *are presented across lateral spot sizes of 0.6, 0.8, 1, 3, 5, 7, and 10 mm and energy spreads of 0.05%, 0.5%, 1%, and 5%:* ***(A)*** *and* ***(B)*** *show the ratio of mean dose inside versus outside the target;* ***(C)*** *and* ***(D)*** *the ratio of mean LET_d inside versus outside the target;* ***(E)*** *penumbra; and* ***(F)*** *the number of energy layers. The horizontal dashed line shows a reference conventional proton beam. Data for 11 other targets (varying in size and location) are demonstrate similar overarching trends.*

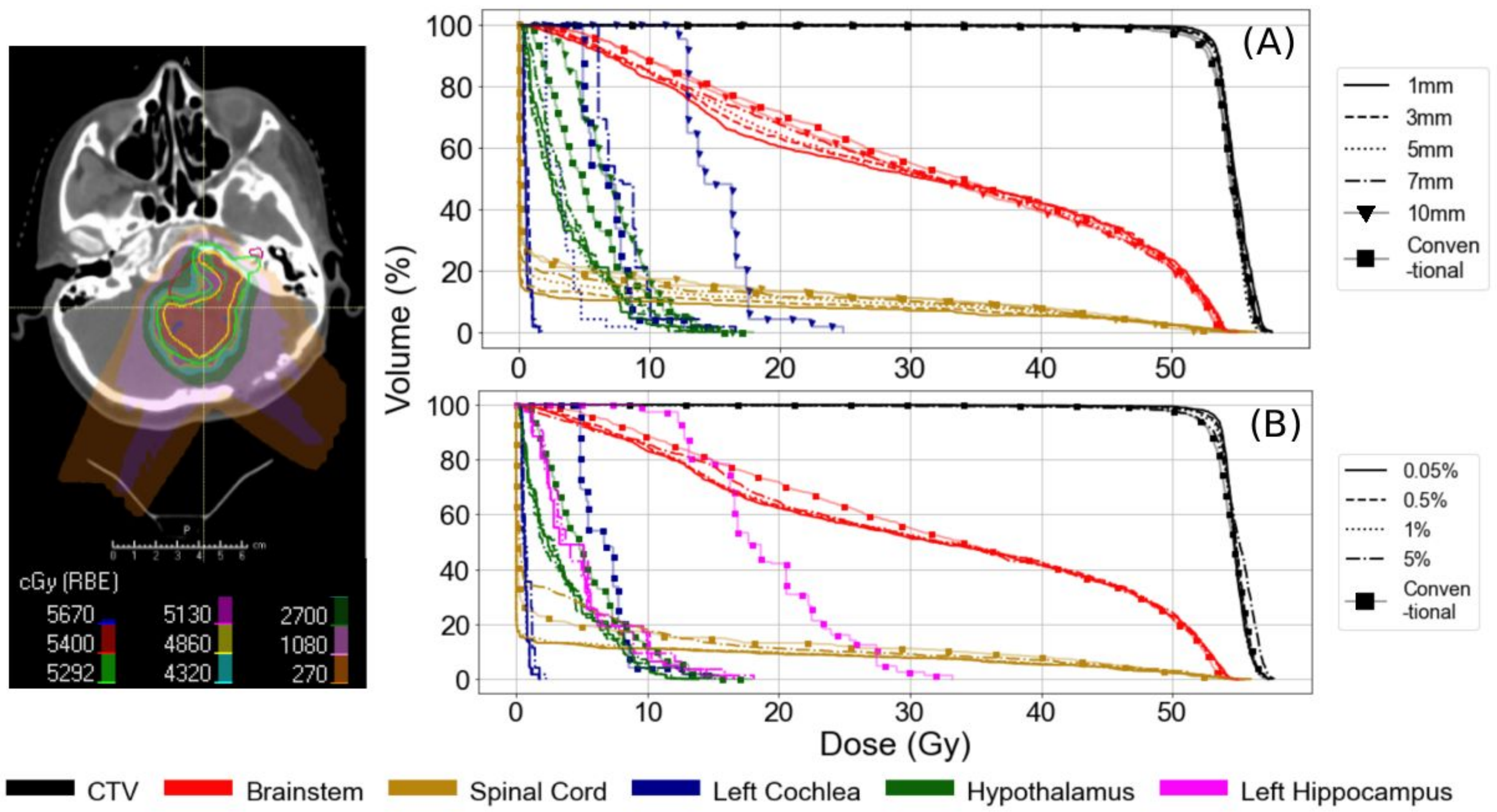

Figure 2. *For a pediatric CNS patient (infratentorial ependymoma), an example axial slice (left) illustrates the brainstem (red), CTV (yellow), and dose distribution for a 1-mm spot size plan. The DVHs (right) for the CTV and various OARs are shown for* ***(A)*** *lateral spot sizes from 1 to 10 mm and* ***(B)*** *beam energy spreads from 0.05% to 5%. Data for 4 other CNS patients demonstrate similar trends.*

Conclusion

Decreasing lateral spot size and beam energy spread resulted in greater OAR sparing while maintaining target coverage. For optimization of the DWA system, the most favourable beam parameters were a lateral spot size of ~**1 mm** and an energy spread between **0.1% – 0.5%** for **20 to 230 MeV**.