New Gantry Beam Optics Solution for Minimising Treatment Time in Cyclotron-based Proton Therapy Facilities

Conference Poster

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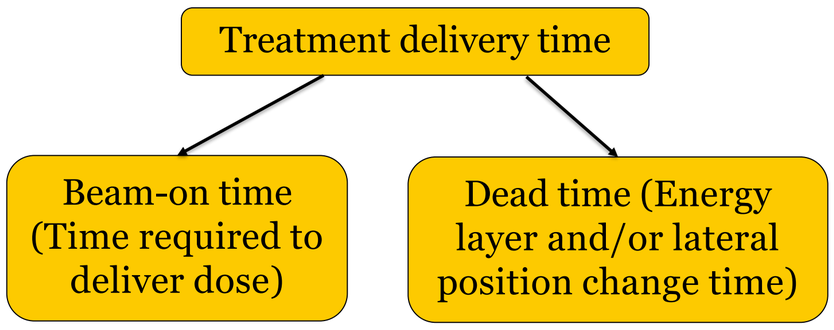
Introduction:



PSI's Gantry 2:

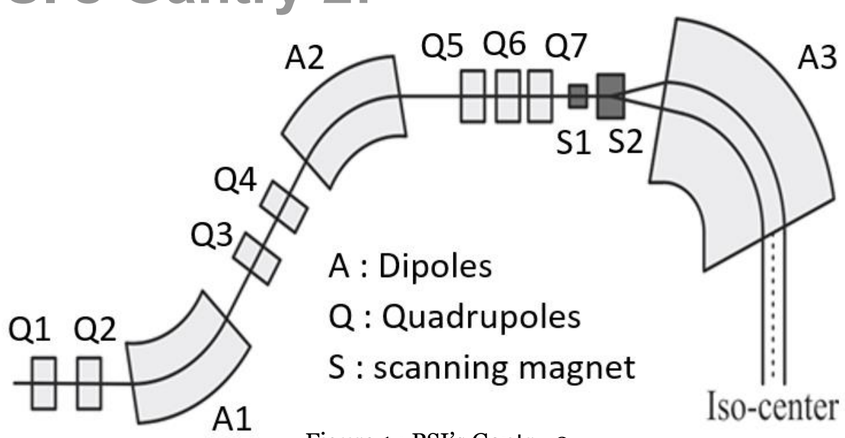


Figure 1 : PSI's Gantry-2

Why do we have large beam-on time?

Conventional gantry beam optics [1]:

- 1:1 imaging from gantry entrance to isocenter
- Beam size at gantry entrance: 3 mm (2σ)
- Beam divergence at gantry entrance: 10 mrad (2σ)
- Emittance transport through gantry: 30 pi*mm*mrad (2σ)
- Transmission through gantry: 57%

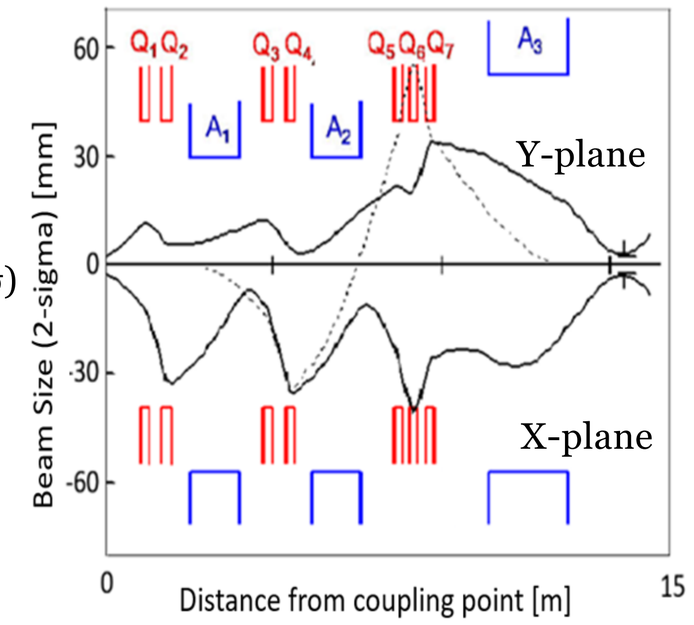


Figure 2 : Clinically used beam optics

- For low energy beams, the emittance after the degrader is very large (~400 pi*mm*mrad), and we lose most of the beam in emittance selection collimators to select 30 pi*mm*mrad (2σ) emittance.
- This limits the transmission of low energy beams and increases the beam-on time significantly.

Proposed new gantry beam optics

- Transport higher emittance through gantry and beamline (90 pi*mm*mrad (2σ))
- Beam size at gantry entrance: 16 mm (2σ)
- Beam divergence at gantry entrance: 5.6 mrad (2σ)
- To maintain a small beam size at the isocenter, we also modified the imaging to de-magnify the beam width by factors of 2:1
- Transmission through gantry: 60%

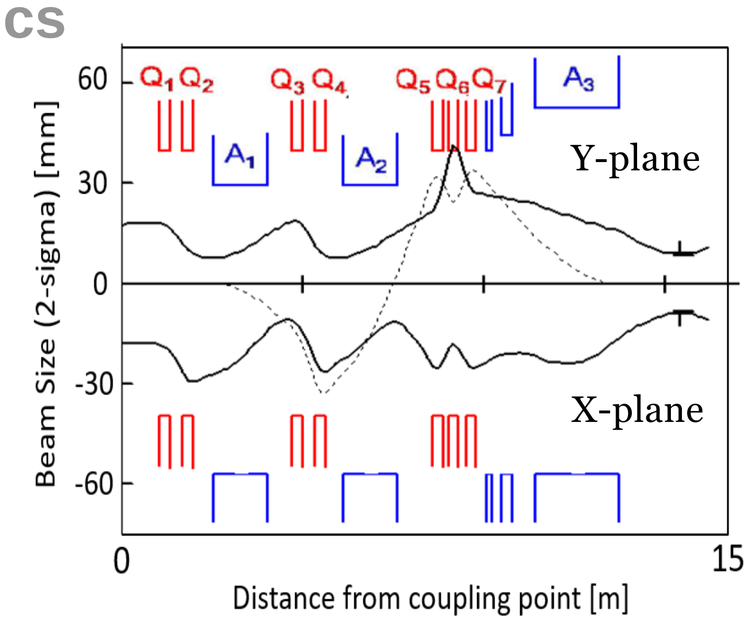


Figure 3 : Proposed beam optics

Effect on beam–on time:

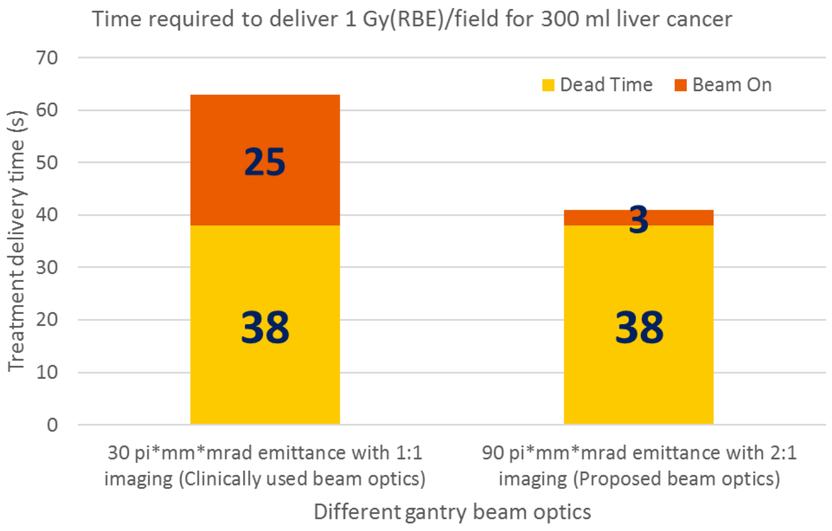


Figure 4 : Treatment delivery time comparison

Clinical Example

- Liver tumor (CTV: 403 ccm)
- Two field plan (1 Gy(RBE)/field)
- Number of spots/field: 12665
- Number of energy layers/field: 43
- Treatment planning optimizer: PSI plan

Conclusion:

- PSI's gantry 2 beam optics adopted to transport three times high emittance and managed to reduce the beam-on time by factor 8.
- Since the optics of PSI's Gantry 2 are comparable to other gantries, the here presented improvement could also be of advantage in other gantries.
- This will open the option of faster treatments in proton therapy.

Outlook:

Shortening Dead-time

- Treatment planning optimization with spot and/or energy layer reduction algorithm
- Use of ridge filter
- Improvement in electronics and control system

Reference:

[1] E. Pedroni, et el. Eur. Phys. J. Plus (2011) 126: 66

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