

Treating prostate cancer with passively scattered and intensity modulated proton beams: A comparative planning study

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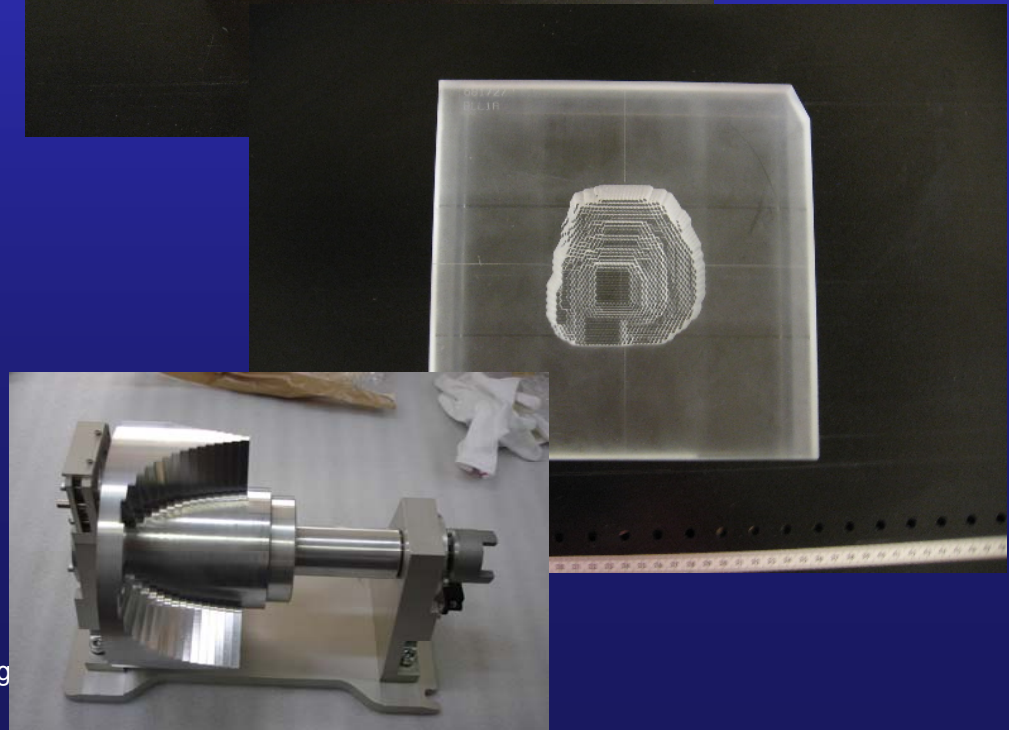
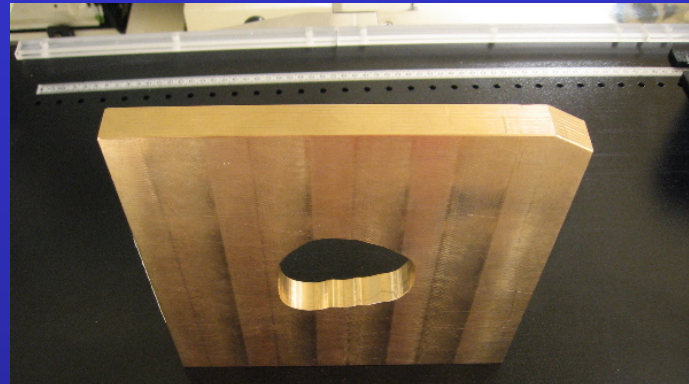
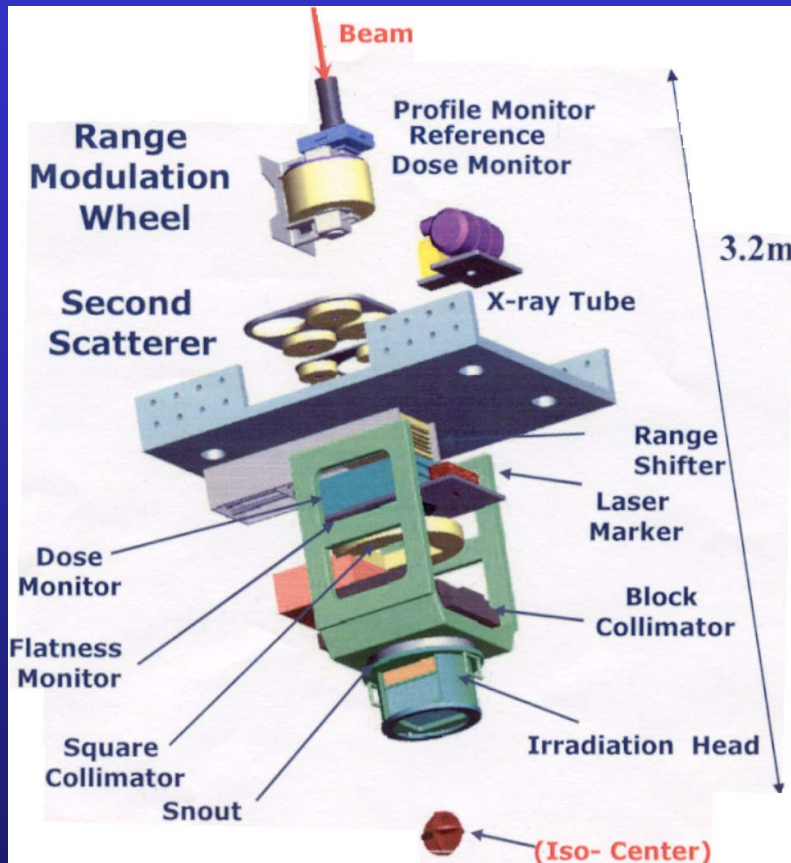
Purpose of study

- To evaluate the potential benefit of intensity modulated proton therapy (IMPT) in the treatment of prostate cancer, when compared with passive scattering proton therapy (PS).

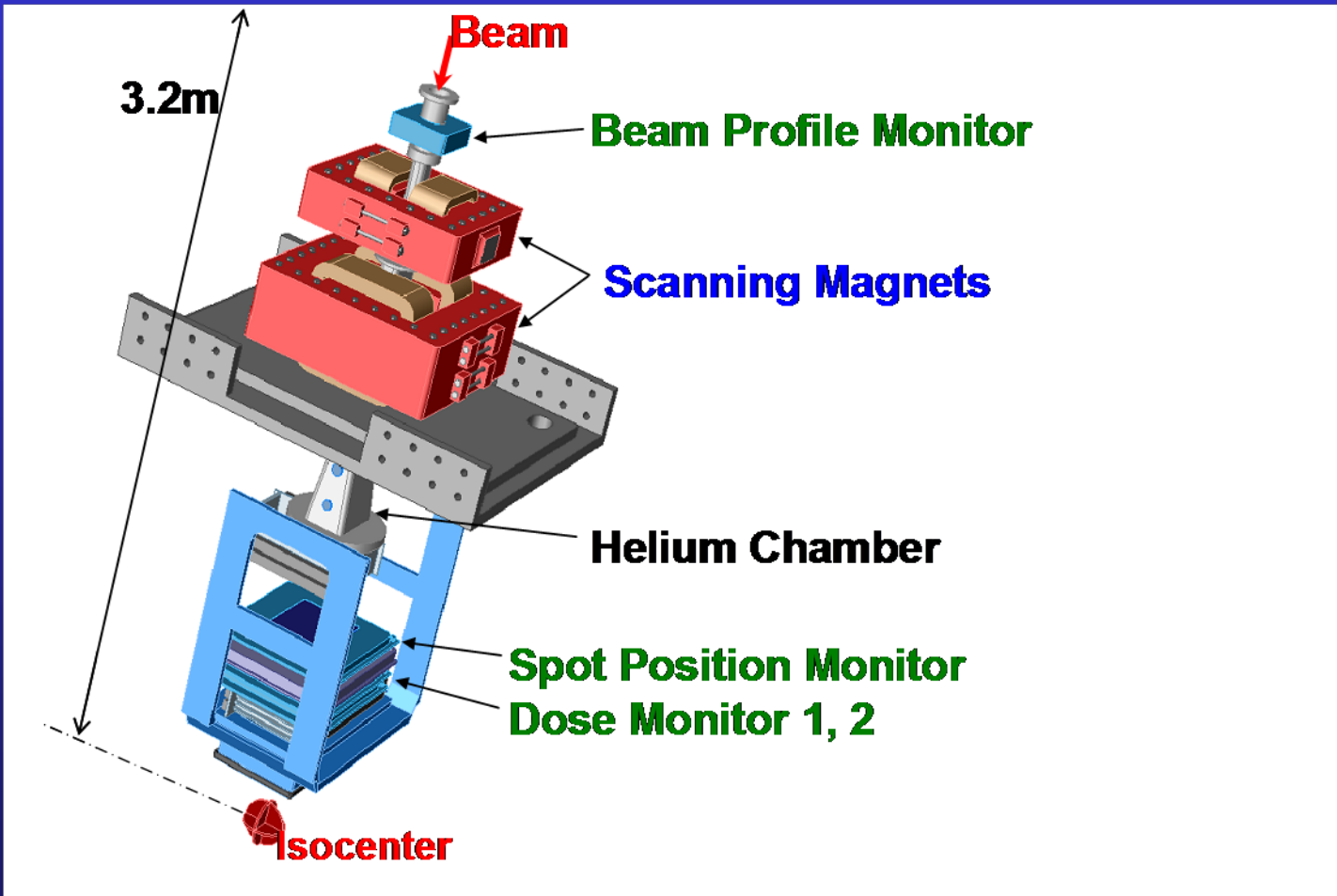
Methods

- Varian Eclipse Proton Treatment Planning Software was commissioned for PS (measured data) and PBS (Monte Carlo)
- Commissioning data models Passive scattering nozzle and PBS nozzle of the Hitachi PROBEAT proton therapy system, at MD Anderson Cancer Center in Houston

Beam delivery hardware for PS



Beam delivery hardware for pencil beam scanning and IMPT



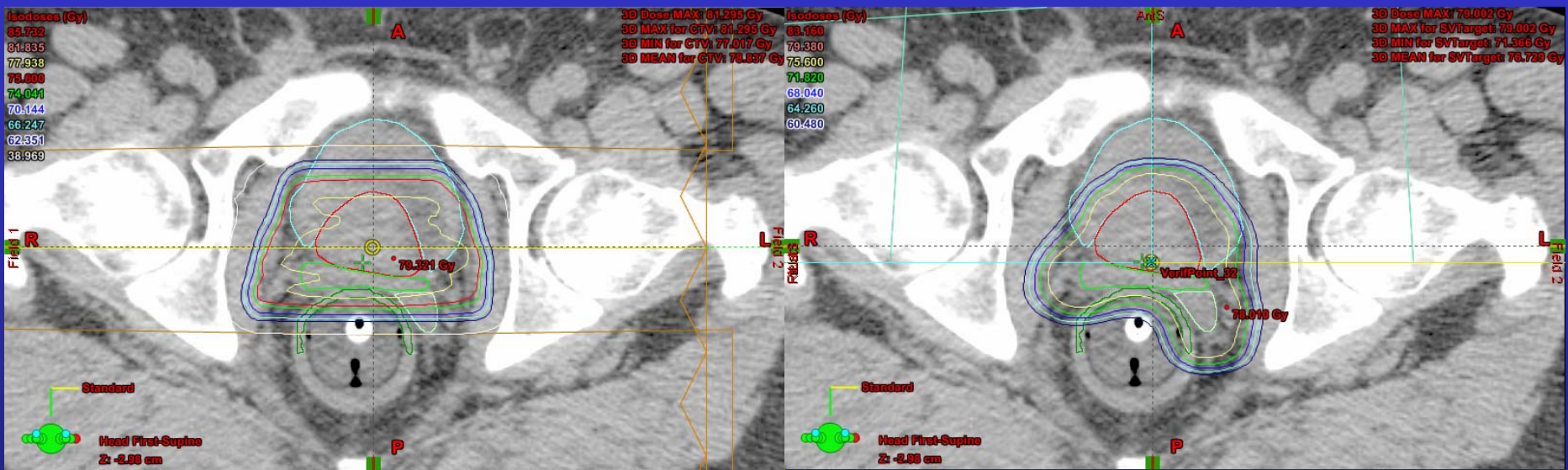
Methods (cont.)

- 10 patients were planned using PS and IMPT modules of Eclipse
- PS planning parameters:
 - 75.60 CGE prescribed to an isodose line (typically 97% – 98%) encompassing the CTV
 - Lateral opposed beams treated with rectal balloon
 - CTV includes entire prostate and proximal seminal vesicles
 - Distal Margin = $(0.035 \times \text{distal CTV depth}) + 3 \text{ mm}$
 - Proximal Margin = $(0.035 \times \text{proximal CTV depth}) + 3 \text{ mm}$
 - Smearing Radius approximately 9 mm

- IMPT planning parameters:
 - 75.60 CGE prescribed to 100 % line encompassing the CTV
 - Lateral opposed beams treated with rectal balloon
 - CTV includes entire prostate, proximal seminal vesicles, and distal seminal vesicles
 - Extended CTV (ECTV), 8mm distal and proximal, 5mm superior and inferior, 8mm anterior, 5mm posterior
 - 5mm isotropic margin surrounding ECTV

Plan robustness analysis

- All PS plans and all IMPT plans were evaluated for robustness of the dose distribution under misalignment of the patient
- Patient misalignment was simulated in TPS by rotating gantry +/- 3 degrees and re-computing dose for both PS and IMPT plans
- (For IMPT plans a robustness analysis was carried out using +/- 3mm shifts in AP and Superior-Inferior direction.)



PS plan

IMPT plan

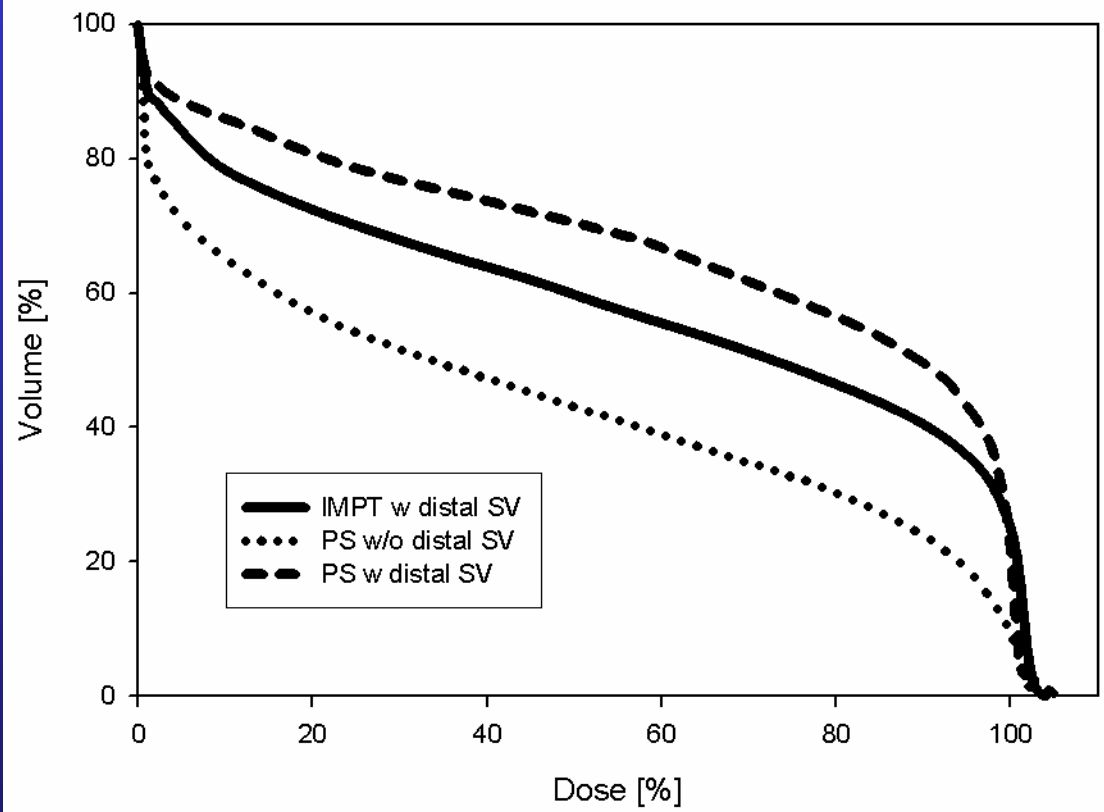
Target coverage

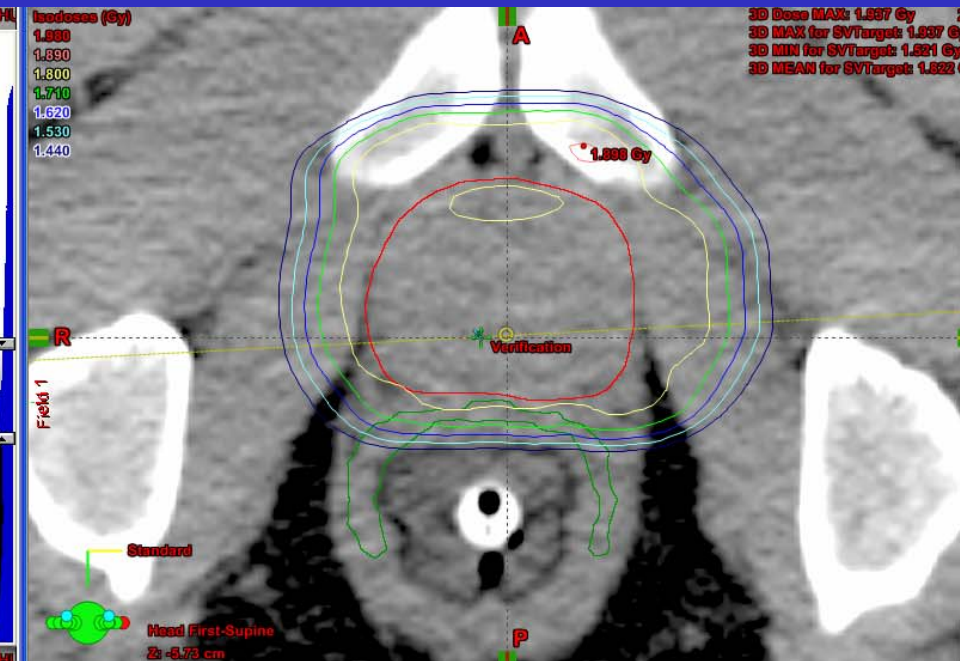
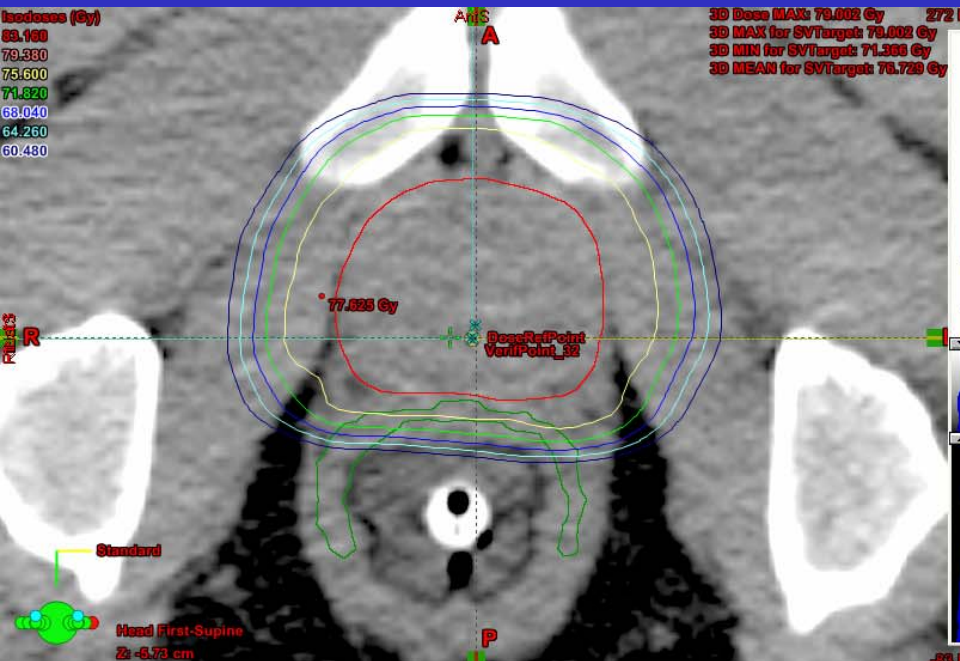
Patient	Min. dose to Prostate and prox. SV [%]		Max. dose to Prostate and prox. SV [%]		Min. dose to distal SV [%]	
	IMPT	PS	IMPT	PS	IMPT	PS
1	99.9	98.7	104.2	102.8	99.7	N/A
2	100.0	98.9	103.9	105.1	99.1	
3	99.8	97.6	104.6	102.6	99.3	
4	100.4	99.0	104.2	103.5	99.5	
5	100.4	98.6	104.1	103.3	99.5	
6	100.1	97.9	104.3	102.3	99.4	
7	100.1	98.9	103.8	103.2	100.1	
8	100.2	98.7	103.7	104.3	99.4	
9	99.6	97.5	104.3	102.3	99.3	
10	100.0	98.5	103.7	102.5	100.0	

Healthy tissue involvement

Patient	Anterior Rectal Wall V_{60CGE} [%]		Mean Dose to Femoral Heads [%]	
	IMPT	PS	IMPT	PS
1	45	42	29.0	33.4
2	55	45	37.1	39.4
3	63	43	29.1	31.9
4	41	42	29.5	32.8
5	56	54	34.5	38.3
6	53	49	31.7	34.6
7	58	55	29.8	32.8
8	45	31	33.7	38.6
9	46	39	33.2	34.8
10	41	41	27.4	30.2

Rectal Wall DVHs for Patient 8





Unperturbed IMPT plan

IMPT plan with 3° patient roll

Results of plan robustness analysis

- For IMPT cold spots of perturbed plans were increased by 2%. (4% in worst case)
- For IMPT hot spots of perturbed plans were increased by 2%. (3% in worst case)
- PS plans did not show any significant change under perturbation.

Conclusion

- In the treatment of prostate cancer with protons, IMPT may offer the possibility of treating distal seminal vesicles while keeping rectal involvement at tolerable levels.
- However, IMPT plans are more sensitive to errors in patient positioning than PS plans.
- A plan robustness analysis should be part of the IMPT planning process.

Thank you!