

Proton Versus Photon Radiotherapy Treatment Planning

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Introduction

Project Goals: Conduct a comparative evaluation of photon and proton therapy treatment modalities by developing various treatment plans for the prostate.

Photon Therapy:

- Uses X-rays to deliver radiation to cancerous tissue.
- Can be implemented using Intensity-Modulated Radiation Therapy (IMRT).
- Intersects multiple beams with tailored intensities and varying beam angles to maximize damage to cancer cells.

Proton Therapy:

- Delivers increasingly precise, targeted radiation to tumours using protons.
- Utilises Bragg Peak effect to deposit maximum energy to cancerous tissue, allowing for highly localised radiation delivery.

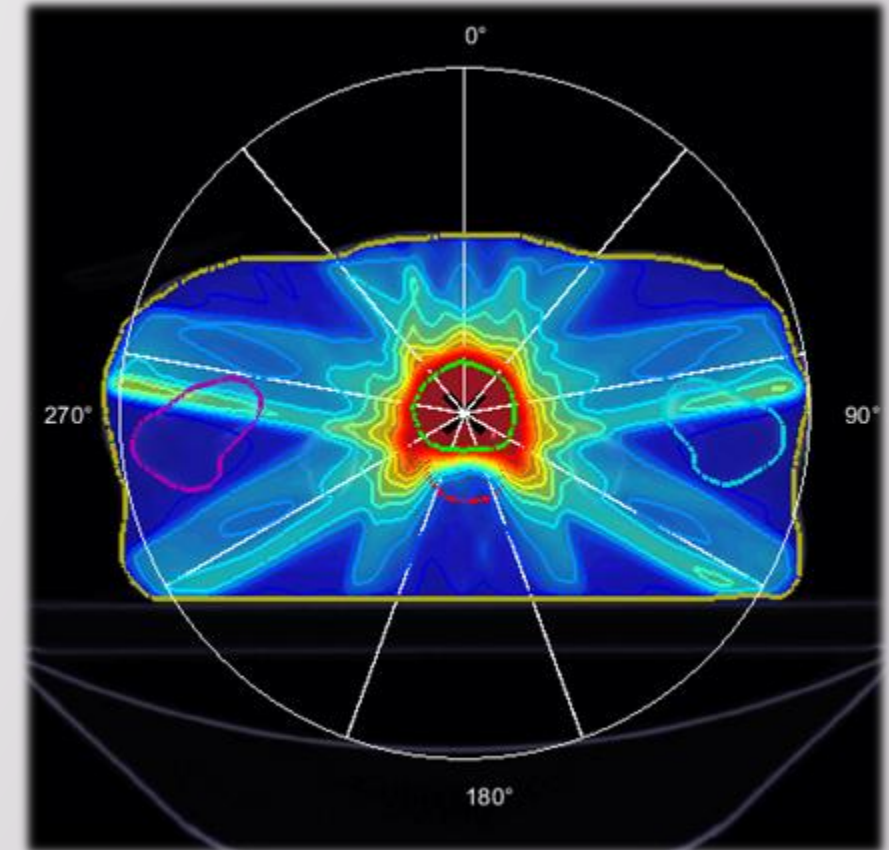


Figure 1: 9 Field (Beam) IMRT Photon Therapy Treatment Plan Applied to Prostate

Materials and Methods

Workflow

Refresh Load *.mat data Calc. influence Mx Optimize Save to GUI
Load DICOM Recalc Export
Import from Bin... Import Dose

Status: plan is optimized

Plan

pixel width in [mm] 5
Gantry Angle in ° 90 270
Couch Angle in ° 0 0
Radiation Mode protons
Machine Generic
IsoCenter in [mm] 207.4 200.9 116.5 ☒ Auto.
Fractions 37
Type of optimization const_RBExD

Objectives & constraints

VOI name	VOI type	OP	Function	p	Parameters
Bladder	OAR	2	Max DVH	100	d: 40 V_{max}^{ref} : 50
Bladder	OAR	2	Max DVH	100	d: 65 V_{max}^{ref} : 25
Prostate	TAR...	1	Squared Deviation	1000	d: 74
Rectum	OAR	2	Max DVH	100	d: 40 V_{max}^{ref} : 35
Rectum	OAR	2	Max DVH	100	d: 65 V_{max}^{ref} : 17
Rectum	OAR	2	Max DVH	100	d: 75 V_{max}^{ref} : 10
Femur_Head	OAR	3	Max DVH	100	d: 50 V_{max}^{ref} : 5
Femur_Head	OAR	3	Max DVH	100	d: 50 V_{max}^{ref} : 5

Visualization

Slice Type of plot inten... GoT lateral ☐ plot CT ☐ plot contour ☐ plot isolines ☐ plot dose ☐ plot isolines labels ☐ plot iso center ☐ visualize plan / be
Beam Selection Plane axial
Offset Display option RBExDose

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Viewing

axial plane z = 117 [mm]

Y [mm] 50 100 150 200 250 300 350

X [mm] 50 100 150 200 250 300 350

RBExDose [Gy/RBE]

Set IsoDose Levels

Viewer Options

Result (i.e. dose) Window Preset Custom Window Center: 1.13 Window Width: 2.26 Range: 0 2.261 jet Lock Settings ☐ Dose opacity: 0 1

Structure Visibility

- ☒ Bladder
- ☒ Prostate
- ☒ Rectum
- ☒ Femur_Head_L
- ☒ Femur_Head_R
- ☒ External

Info

v2.10.1 "Blaise"

www.matRad.org

About

Beam Adjustment

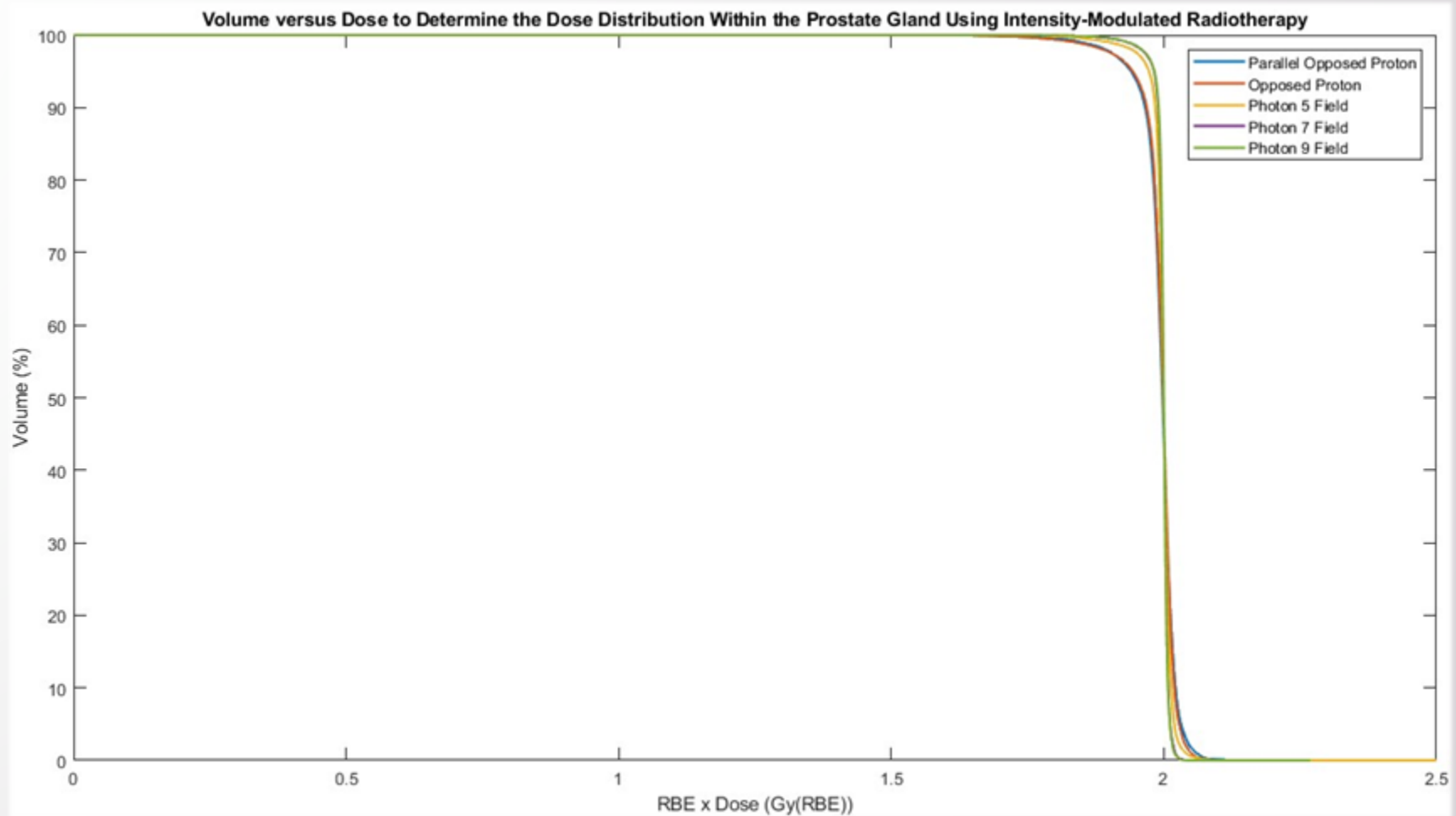
Overlap Priority

Optimisation Penalty

Results

Prostate (PTV) 74 Gy (2 Gy Per Fraction)	Parallel Opposed IMPT Proton	Opposed IMPT Proton	5 Field IMRT Photon	7 Field IMRT Photon	9 Field IMRT Photon
D _{98%} (Gy)	1.94 Gy	1.91 Gy	1.94 Gy	1.95 Gy	1.96 Gy
D _{2%} (Gy)	2.05 Gy	2.04 Gy	2.02 Gy	2.02 Gy	2.02 Gy
Rectum					
V _{40Gy} <35% (1.08 Gy / Fx)	(15.7 ± 0.5) %	(9.1 ± 0.5) %	(33.3 ± 0.5) %	(30.0 ± 0.5) %	(29.6 ± 0.5) %
V _{65Gy} <17% (1.76 Gy / Fx)	(1.5 ± 0.5) %	(1.3 ± 0.5) %	(6.1 ± 0.5) %	(3.2 ± 0.5) %	(3.1 ± 0.5) %
V _{75Gy} <10% (2.03 Gy / Fx)	(0.0 ± 0.5) %	(0.2 ± 0.5) %	(0.0 ± 0.5) %	(0.0 ± 0.5) %	(0.0 ± 0.5) %
Bladder					
V _{40Gy} <50% (1.08 Gy / Fx)	(5.5 ± 0.5) %	(7.5 ± 0.5) %	(12.0 ± 0.5) %	(12.9 ± 0.5) %	(13.2 ± 0.5) %
V _{65Gy} <25% (1.76 Gy / Fx)	(1.5 ± 0.5) %	(1.9 ± 0.5) %	(4.1 ± 0.5) %	(4.3 ± 0.5) %	(4.3 ± 0.5) %
Femoral Heads					
L V _{50Gy} <5% (1.35 Gy / Fx)	(0.1 ± 0.5) %	(0.0 ± 0.5) %	(0.0 ± 0.5) %	(0.0 ± 0.5) %	(0.0 ± 0.5) %
R V _{50Gy} <5% (1.35 Gy / Fx)	(0.0 ± 0.5) %	(0.0 ± 0.5) %	(0.0 ± 0.5) %	(0.0 ± 0.5) %	(0.0 ± 0.5) %

Results



	Parallel Opposed IMPT Proton	Opposed IMPT Proton	5 Field IMRT Photon	7 Field IMRT Photon	9 Field IMRT Photon
Mean Dose	1.99 Gy	1.99 Gy	2.00 Gy	2.00 Gy	2.00 Gy
Homogeneity Index	1.04	1.04	1.03	1.02	1.02

Discussion

Proton Therapy:

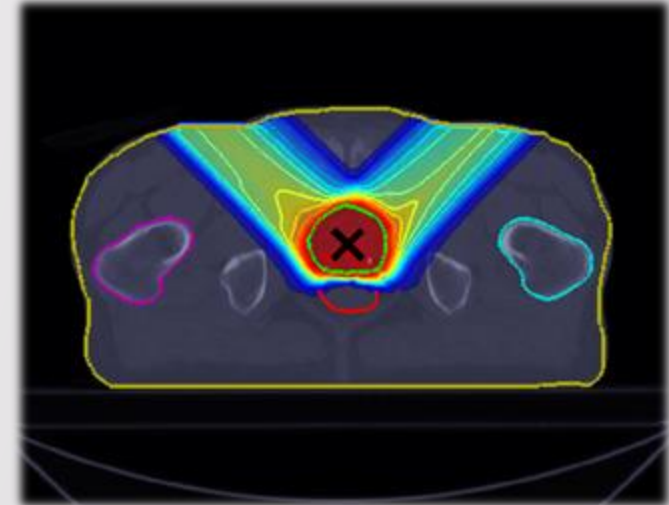
- Less damage to organs at risk.
- Highly conformal.
- High cost & low availability.

Photon Therapy:

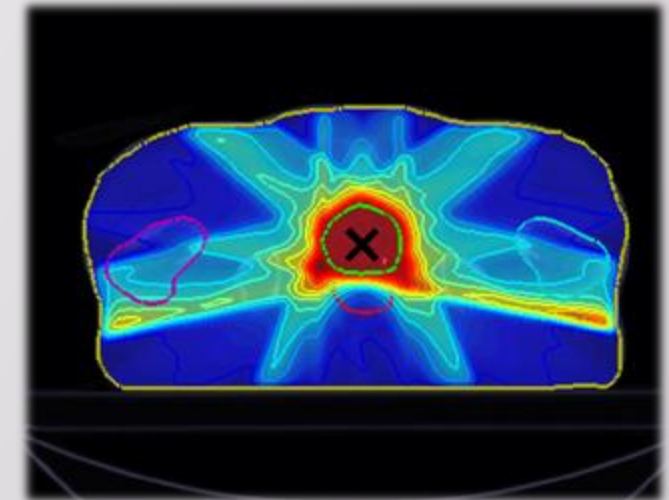
- Established treatment option.
- Enhanced uniformity.
- Exit dose contributes to increased damage to organs at risk.

Clinical Considerations:

- Tumour size and shape.
- Proximity to critical structures.
- Cost and availability.



Opposed (45/315 Degree) Proton Therapy Treatment Plan Applied to Prostate



7 Field (Beam) IMRT Photon Therapy Treatment Plan Applied to Prostate