Associazione Italiana Radioterapia e Oncologia clinica

Società Italiana di Radiobiologia

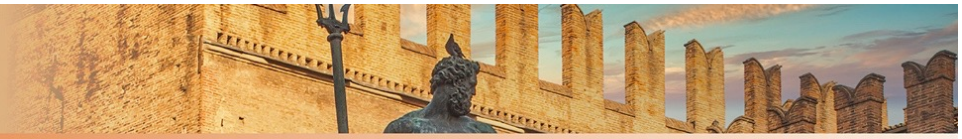
Dosimetric impact of intrafraction prostate motion in dose-escalated linac-based SBRT

Sistema Socio Sanitario
Regione Lombardia
ASST Monza

Dr.ssa Valeria Faccenda

UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

Associazione Italiana Radioterapia e Oncologia clinica
Società Italiana di Radiobiologia



DICHIARAZIONE

Relatore: Valeria Faccenda

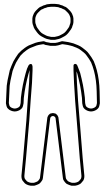
Come da nuova regolamentazione della Commissione Nazionale per la Formazione Continua del Ministero della Salute, è richiesta la trasparenza delle fonti di finanziamento e dei rapporti con soggetti portatori di interessi commerciali in campo sanitario.

- Posizione di dipendente in aziende con interessi commerciali in campo sanitario **(Niente da dichiarare)**
- Consulenza ad aziende con interessi commerciali in campo sanitario **(Niente da dichiarare)**
- Fondi per la ricerca da aziende con interessi commerciali in campo sanitario **(Niente da dichiarare)**
- Partecipazione ad Advisory Board **(Niente da dichiarare)**
- Titolarità di brevetti in compartecipazione ad aziende con interessi commerciali in campo sanitario **(Niente da dichiarare)**
- Partecipazioni azionarie in aziende con interessi commerciali in campo sanitario **(Niente da dichiarare)**

Purpose

1. To investigate the effects of **intrafraction motion** on dose metrics

2. To assess the dosimetric benefit of **employing continuous monitoring, beam gating and motion correction** strategies

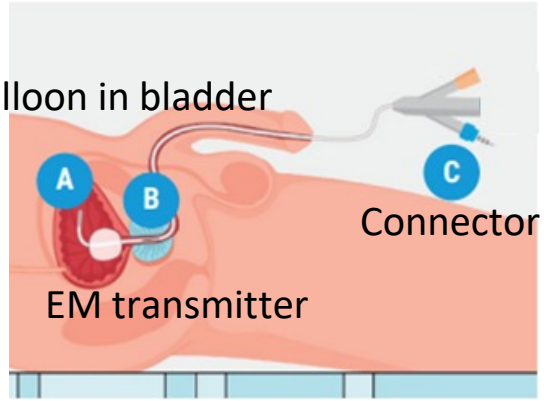


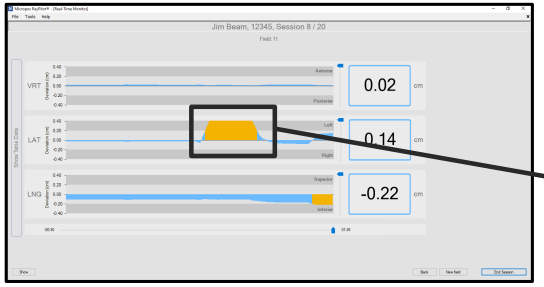
13 patients with pCa

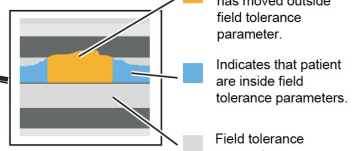
Dose-escalated linac-based **SBRT**

N.	Dose	Fx	BED
4	40 Gy	5	253 Gy
9	38 Gy	4	278 Gy

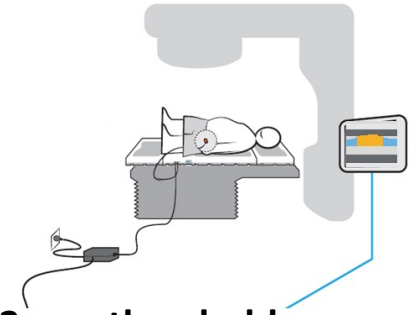
Intra-fraction prostate motion data







Real Time Tracking



2 mm threshold

The shift of the transmitter was used as a **surrogate for the prostate motion**

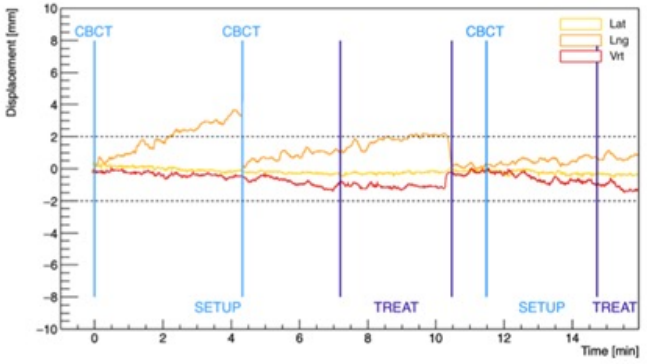
BEAM INTERRUPTION

Non re-entering motion > **2 mm**?

- YES ❌ — patients **repositioned** by a new CBCT
- NO ✅

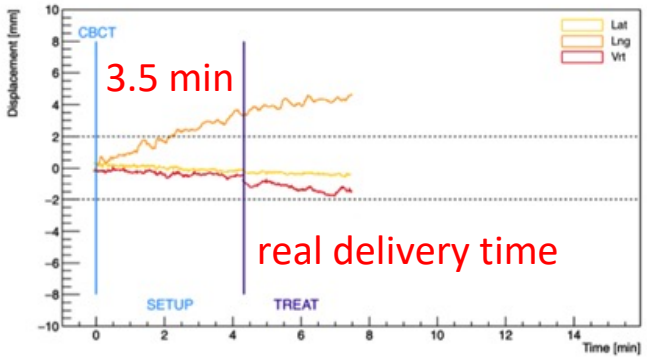
Prostate trajectories

CASE A



Clinical implemented strategy of beam gating and motion correction

CASE B



Simulation of treatments without any organ motion management

Motion-encoded plans

A method of dose reconstruction for moving targets compatible with dynamic treatments

Per Rugaard Poulsen[a)]
Department of Oncology, Aarhus University Hospital, Nørrebrogade 44, 8000 Aarhus C,
Institute of Clinical Medicine, Aarhus University, Brendstrupgaardsvej 100, 8200 Aarhus N, Denmark

Mai Lykkegaard Schmidt
Department of Physics and Astronomy, Aarhus University, Ny Munkegade 120, 8000 Aarhus C, Denmark

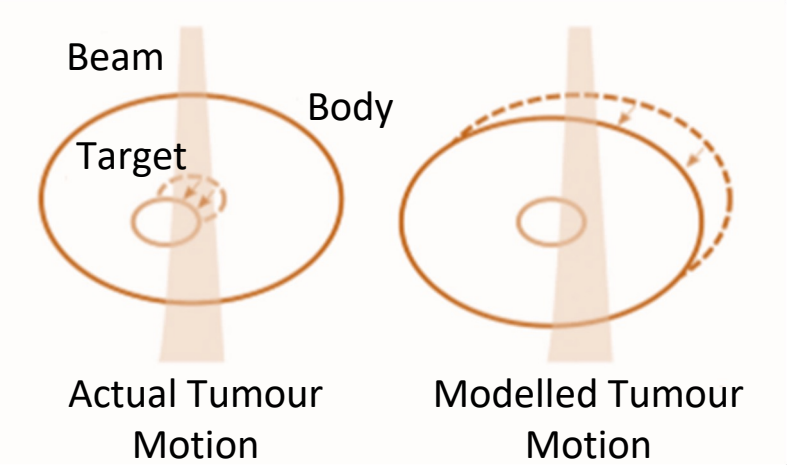
Paul Keall
Radiation Physics Laboratory, Sydney Medical School, University of Sydney, NSW 2006, Australia

Esben Schjødt Worm
Department of Oncology, Aarhus University Hospital, Nørrebrogade 44, 8000 Aarhus C,
Department of Medical Physics, Aarhus University Hospital, Nørrebrogade 44, 8000 Aarhus C, Denmark

Walther Fledelius
Department of Oncology, Aarhus University Hospital, Nørrebrogade 44, 8000 Aarhus C, Denmark

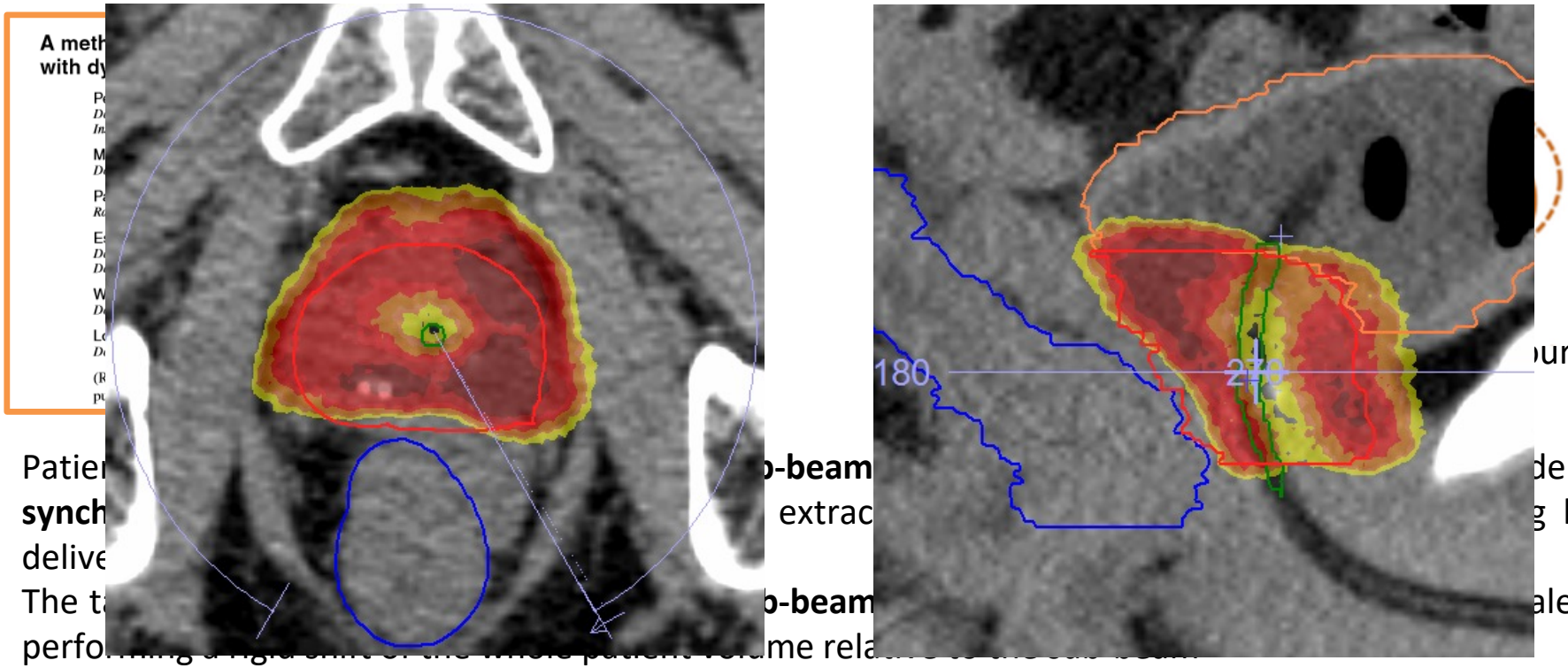
Lone Hoffmann
Department of Medical Physics, Aarhus University Hospital, Nørrebrogade 44, 8000 Aarhus C, Denmark

(Received 6 May 2012; revised 22 August 2012; accepted for publication 31 August 2012; published 25 September 2012)

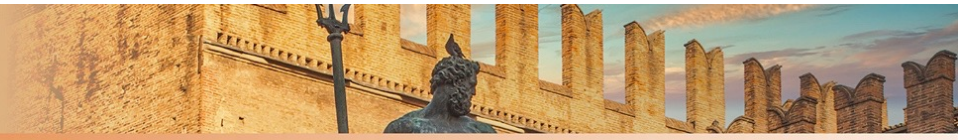


- Patient **Dicom RT plan divided into several sub-beams** to represent the part of the treatment delivery **synchronized with each prostate position** bin extracted from the trajectories recorded during beam delivery
- The target shift was modeled **by shifting the sub-beam isocenter** in the opposite direction, equivalent to performing a rigid shift of the whole patient volume relative to the sub-beam

Motion-encoded plans



- Patie **b-beam** delivery **synch** extrac g beam delive
- The t **b-beam** alent to perfo me rela

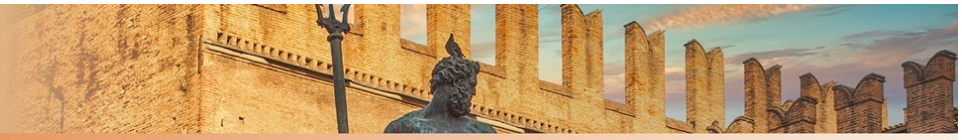


Dosimetric Analysis (1): case A

	Metrics	Mean [range]
CTV	Dmean	-0.1% [-0.7 – 2.3]
	D99%	-0.2 % [-5.1 – 5.1]
	D2%	+0.3 % [-0.4 – 4.4]
PTV	Dmean	-0.0% [-0.7 – 2.0]
	D95%	-0.4 % [-3.7 – 1.4]
	D2%	+0.4 % [-0.4 – 4.3]
PTV - CTV	Dmean	-0.1 % [-1.5 – 1.0]
	D95%	-1.0 % [-12.1 – 7.1]

	Metrics	Mean [range]
Urethra PRV	D0.035cc	+0.7 % [-0.8 – 6.4]
	D10%	+0.6 % [-0.9 – 5.4]
Rectum	D5%	-1.7 % [-14.4 – 11.5]
	D10%	-2.3 % [-16.7 – 14.2]
	D20%	-2.9 % [-39.8 – 13.6]
	D50%	-1.3 % [-12.5 – 6.2]
Rectum wall	D0.035cc	-0.6 % [-7.9 – 5.3]
Rectum mucosa	D0.035cc	-1.1 % [-13.5 – 14.0]
Bladder	D0.035cc	+0.3 % [-1.9 – 3.3]
	D10%	+0.2 % [-11.7 – 11.4]
	D40%	+1.4 % [-18.7 – 37.7]

*significant differences ($p < 0.05$) according to Wilcoxon-Mann-Whitney test



Dosimetric Analysis (2): case B vs case A

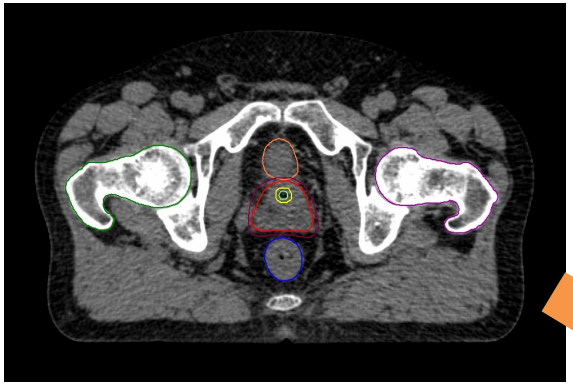
	Metrics	Mean [range]
CTV	Dmean	-0.2 % [-2.3 – 1.1]
	D99%*	**-2.8 % [-16.3 – 1.1]**
	D2%	-0.1 % [-4.2 – 0.6]
PTV	Dmean	-0.4 % [-2.1 – 0.8]
	D95%*	**-2.4 % [-11.9 – 0.9]**
	D2%	-0.4 % [-4.1 – 0.6]
PTV - CTV	Dmean	-0.8 % [-3.6 – 0.6]
	D95%*	**-5.6 % [-23.7 – 1.9]**

	Metrics	Mean [range]
Urethra PRV	D0.035cc	+0.4 % [-5.3 – 2.9]
	D10%	+0.6 % [-5.0 – 6.3]
Rectum	D5%	-4.3 % [-30.8 – 13.0]
	D10%	-4.6 % [-33.8 – 27.5]
	D20%	-4.8 % [-31.2 – 38.0]
	D50%	-1.9 % [-22.1 – 25.1]
Rectum wall	D0.035cc	-3.0 % [-25.2 – 4.7]
Rectum mucosa	D0.035cc	-3.9 % [-30.3 – 8.6]
Bladder	D0.035cc	+0.3 % [-6.3 – 3.0]
	D10%	**+3.1 % [-13.8 – 24.6]**
	D40%	**+11.6 % [-22.8 – 83.5]**

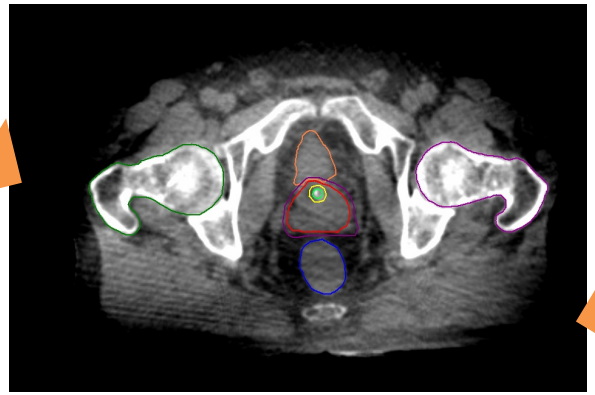
*significant differences ($p < 0.05$) according to Wilcoxon-Mann-Whitney test

Daily Anatomy

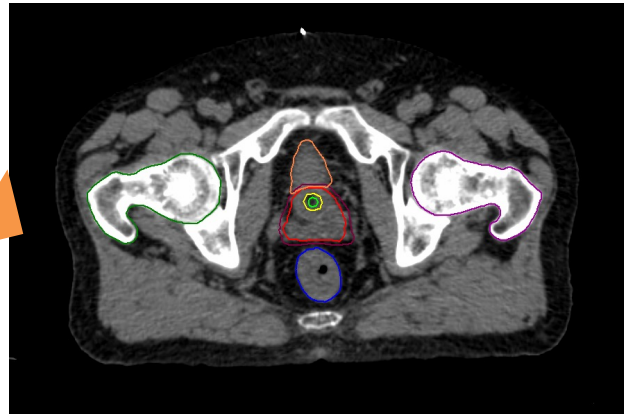
CTV
Urethra
Rectum
Bladder
Femoral heads



CT



CBCT



dCT

Advanced Medical Imaging Registration Engine ADMIRE, research version 3.13, Elekta AB, Stockholm, Sweden

Dosimetric Analysis (3): delivered

	Metrics	Mean [range]
CTV	Dmean	-0.5 % [-2.0 – 1.2]
	D99%*	**-3.0 % [-18.5 – 2.8]**
	D2%*	-0.4 % [-1.6 – 2.8]
PTV	Dmean	-0.7 % [-2.9 – 1.2]
	D95%*	**-2.6 % [-17.8 – 1.0]**
	D2%	-0.4 % [-1.5 – 2.7]
PTV - CTV	Dmean	-1.2 % [-5.8 – 1.3]
	D95%*	**-4.8 % [-27.3 – 6.4]**

	Metrics	Mean [range]
Urethra PRV	**D0.035cc***	**+1.0 % [-1.6 – 5.6]**
	D10%	+0.7 % [-1.2 – 4.9]
Rectum	D5%	-4.7 % [-35.9 – 24.6]
	D10%	-5.0 % [-41.7 – 31.7]
	D20%	-3.6 % [-38.4 – 39.0]
	D50%	-1.5 % [-24.1 – 38.8]
Rectum wall	D0.035cc	-0.8 % [-13.5 – 12.6]
Rectum mucosa	D0.035cc	+0.8 % [-27.1 – 33.9]
Bladder	D0.035cc	-0.8 % [-7.0 – 1.2]
	D10%	-4.6 % [-44.6 – 38.0]
	D40%*	**+2.6 % [-74.0 – 319.9]**

*significant differences ($p < 0.05$) according to Wilcoxon-Mann-Whitney test

Conclusion

- The intrafraction prostate motion marginally contributed in the scenario of gated treatments with a 2 mm threshold
- Non-gated treatments would have resulted in larger target dose deficits and bladder overdoses in some fractions → continuous monitoring, beam gating and motion correction are recommended to safely deliver such extreme hypofractionated treatments
- Major discrepancies to both target and OARs with respect to planning were observed including the interfraction anatomical deformations in the dose recalculations
- The strict patient preparation regimen, along with current CTV to PTV margins, robustness of original treatment plans, soft-tissue matching and fast FFF beam delivery, ensured no significant degradations of dose metrics for target and OARs

@valefacc22
valefacc22@gmail.com