MR-Linac

Technical Details and Physics Developments

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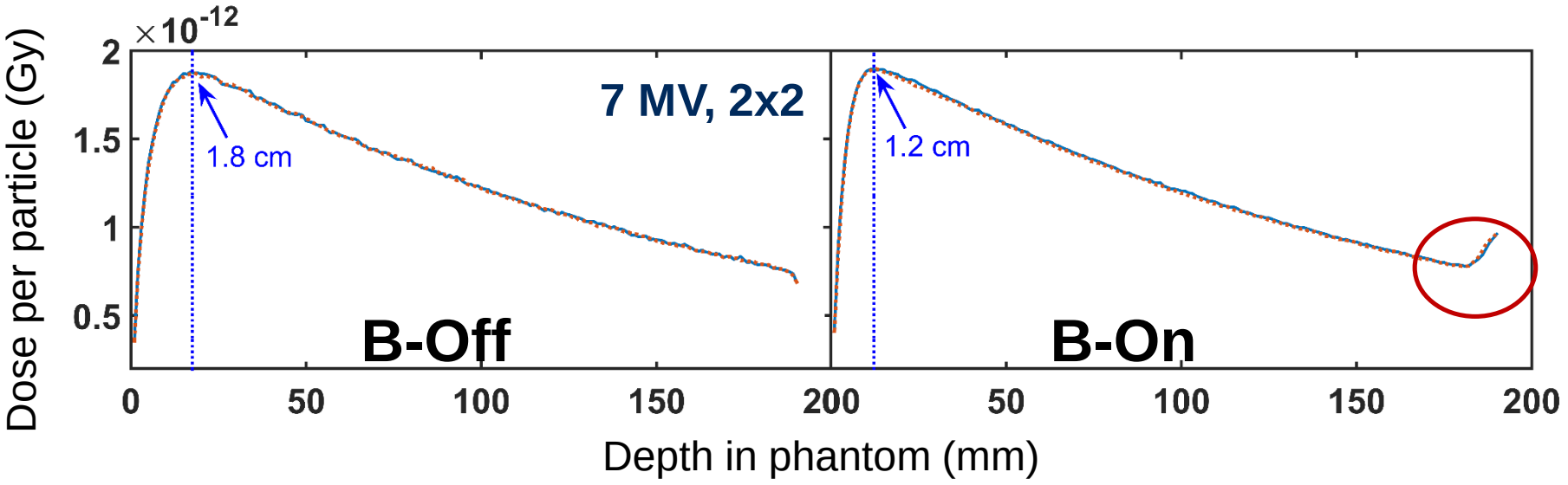
Radiation Oncology
UNIVERSITY OF TORONTO

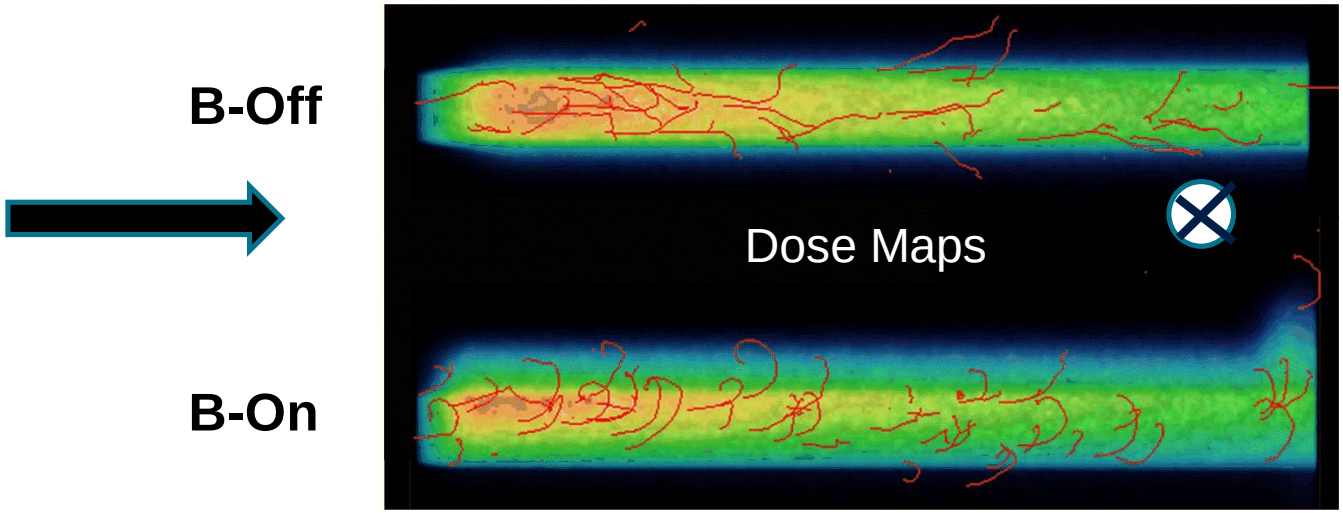
Sunnybrook
ODETTE CANCER CENTRE
A Cancer Care Ontario Partner

Objectives

- To address some of the dosimetric differences of the MR-Linac
- To outline some of the current physics related research and development

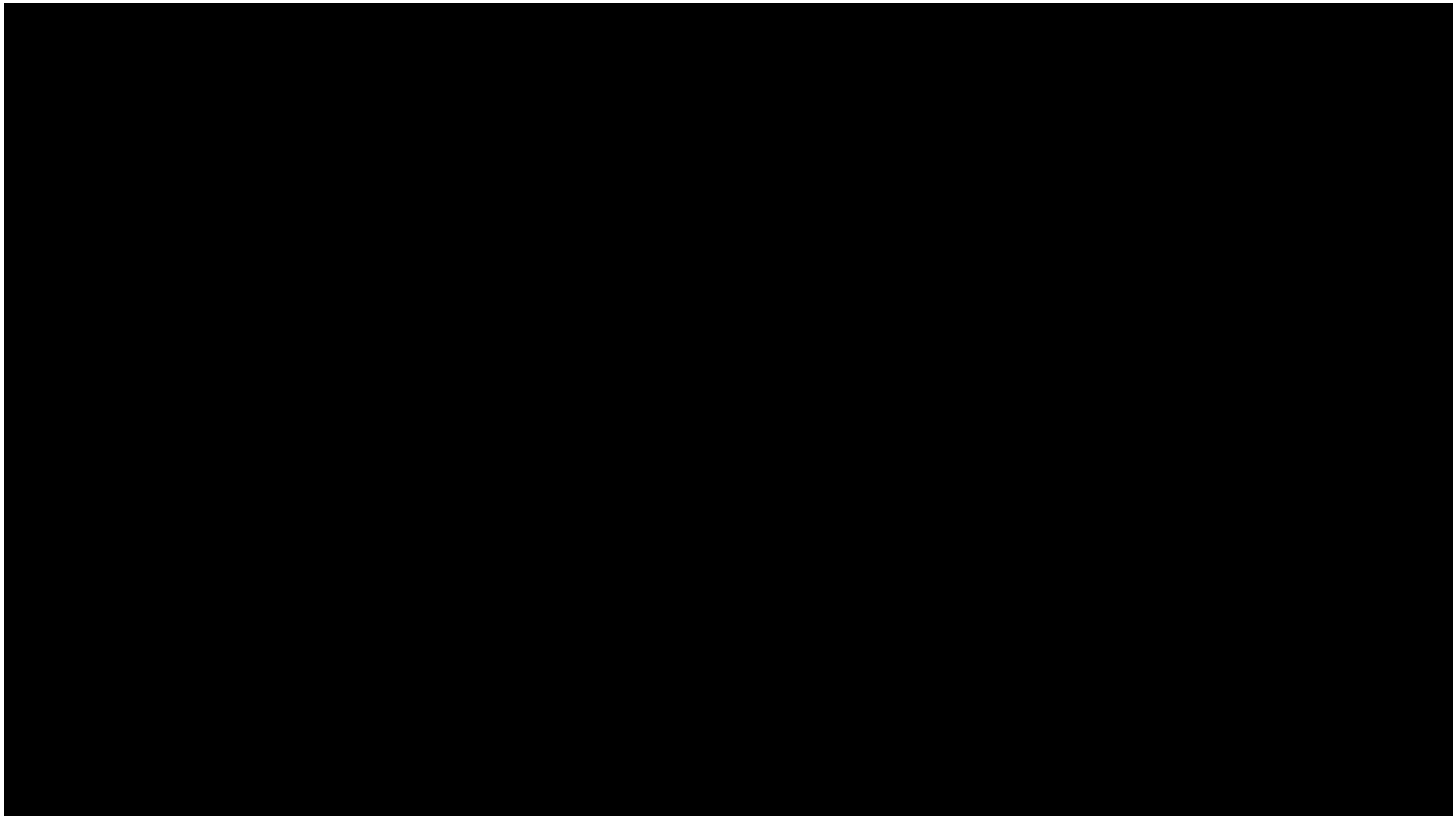
Validation of Monaco – With B-field





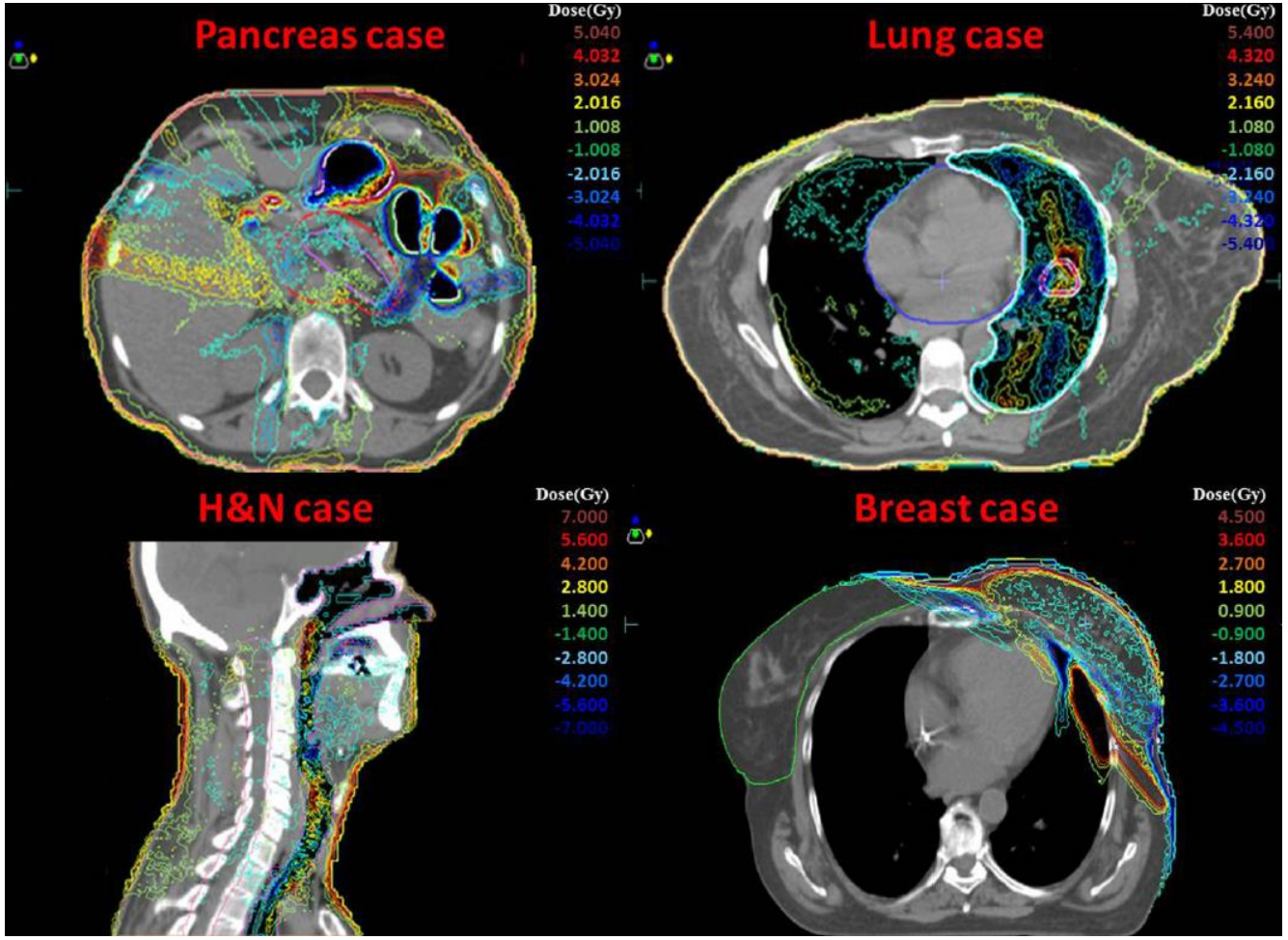
Ahmad S, Sarfehnia A, Paudel M, Kim A, Hissoiny S, Sahgal A and Keller B. Evaluation of a commercial MRI linac based Monte Carlo dose calculation algorithm with Geant4. Med Phys 43(2), 894 - 907, 2016.

Irradiating in a Magnetic Field



Ahmad S, Sarfehnia A, Kim A, Wronski M, Sahgal A and Keller B. Backscatter dose effects for high atomic number materials being irradiated in the presence of a magnetic field: A Monte Carlo study for the MRI Linac. Med Phys 43 (8), 4665-4673, 2016.

ERE Effects: Dose Difference Maps



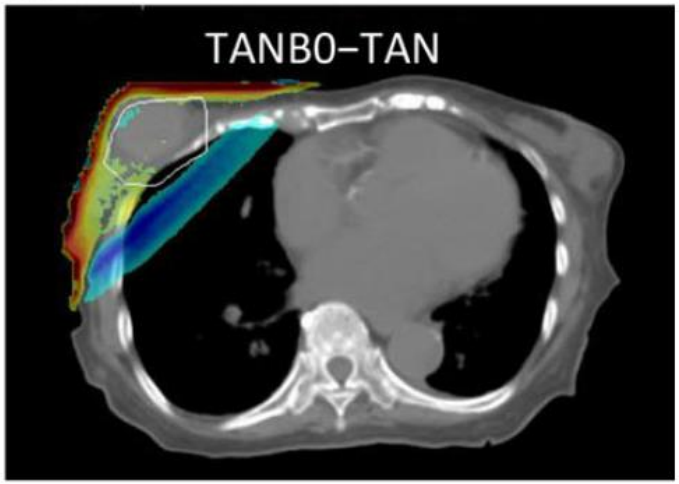
Chen et al. Dose effects of 1.5 T transverse magnetic field on tissue interfaces in MRI-guided radiotherapy. Med Phys 43(8), 4797, 2016

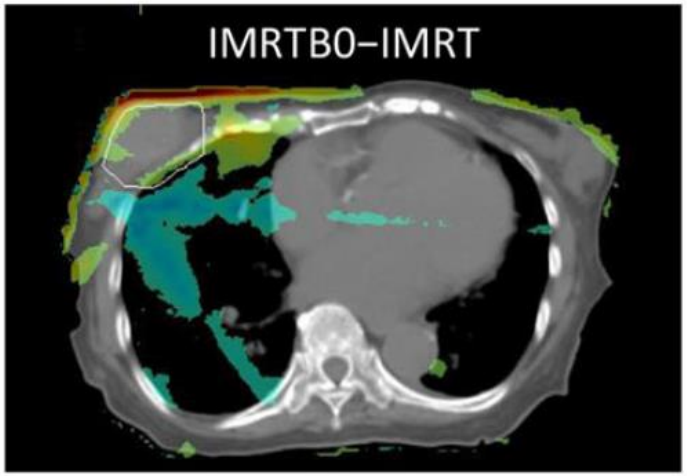
WILE

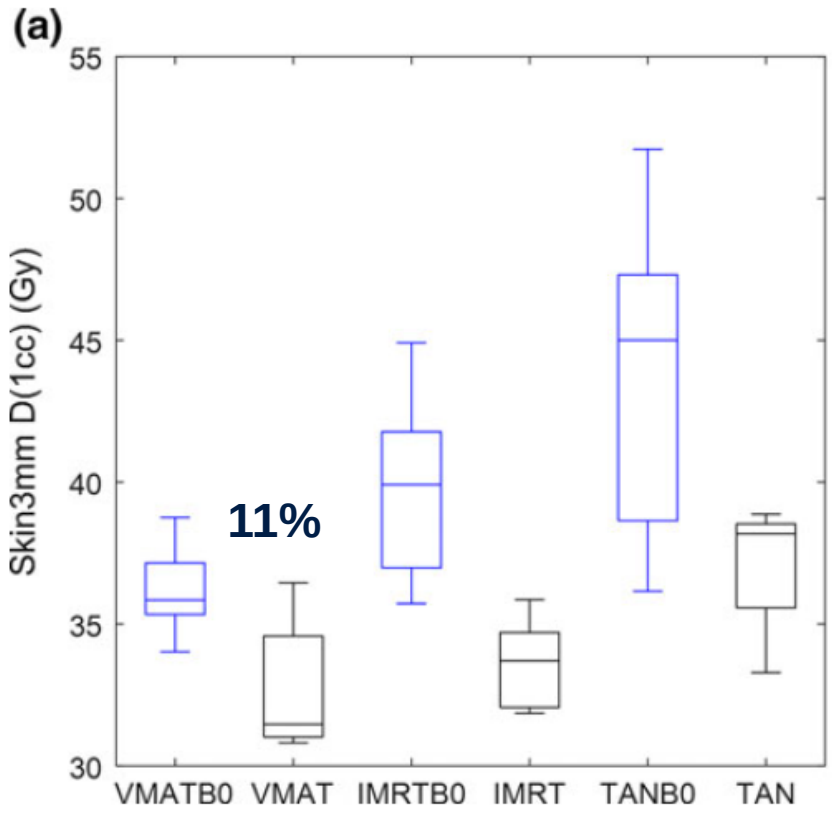
Magnetic field dose effects on different radiation beam geometries for hypofractionated partial breast irradiation

Anthony Kim[1,2] | Stephanie Lim-Reinders[1] | Claire McCann[1,2] | Syed Bilal Ahmad[1] | Arjun Sahgal[2,3] | Justin Lee[2,3] | Brian M. Keller[1,2]

J Appl Clin Med Phys 2017; 18:6: 62–70







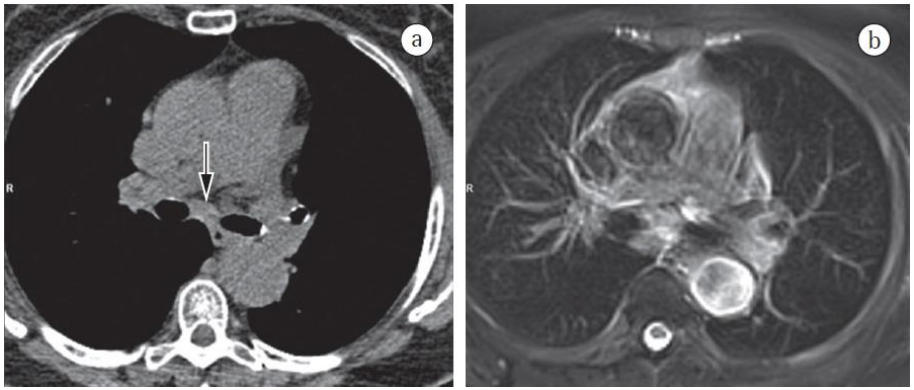
RADIATION ONCOLOGY PHYSICS

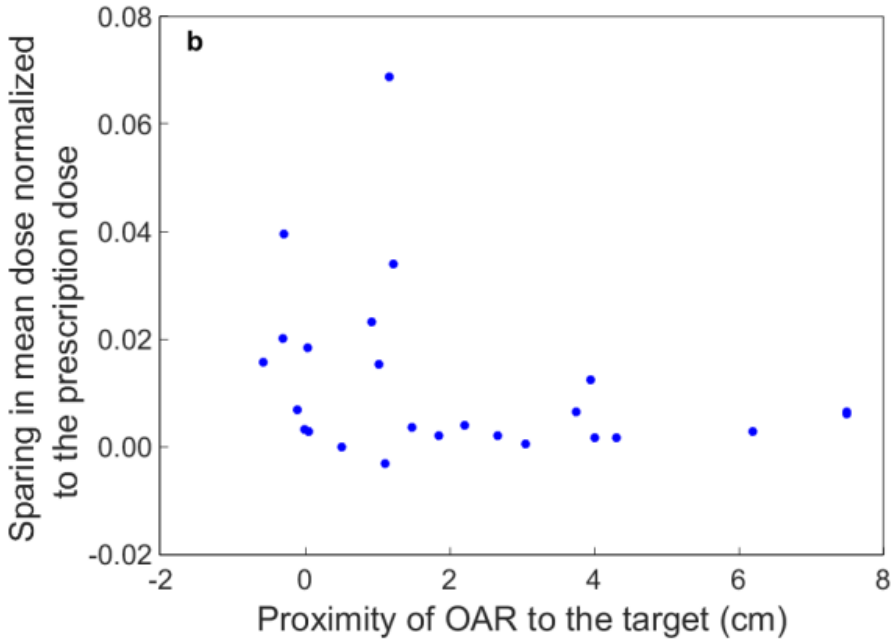
WILEY

The development of a 4D treatment planning methodology to simulate the tracking of central lung tumors in an MRI-linac

Shahad M. Al-Ward[1] | Anthony Kim[1,2] | Claire McCann[1,2] | Mark Ruschin[1,2] | Patrick Cheung[1,2] | Arjun Sahgal[1,2] | Brian M. Keller[1,2]

J Appl Clin Med Phys 2018; **19:1**: 145–155





On average, irradiated volume reduced by ~ 30%

OAR Sparing resulted from

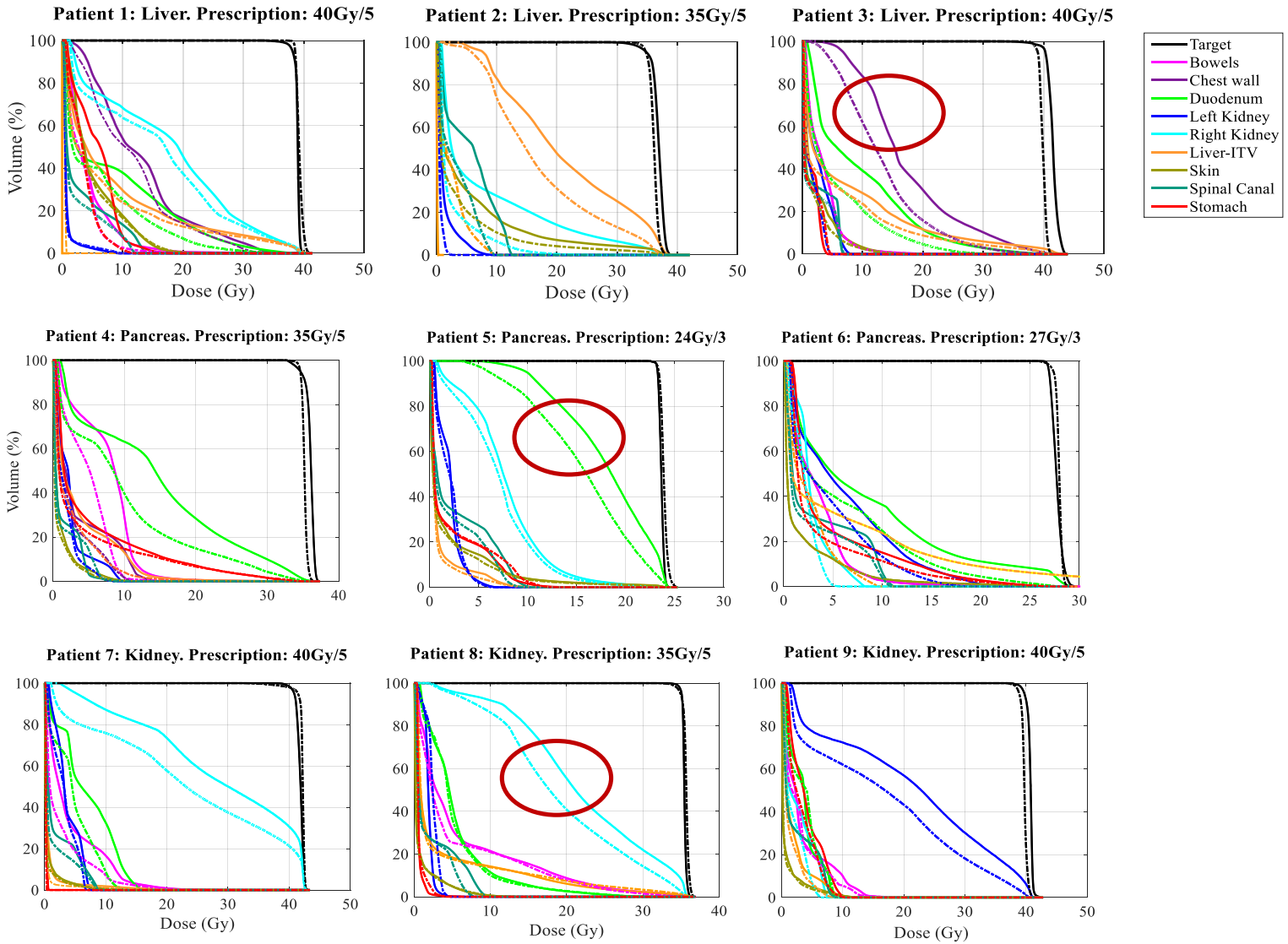
- Tumours with larger motions
- Close proximity of OAR to tumour

Simulated Tumour Tracking In a Magnetic Field : Liver, Pancreas, Kidney

Liver

Pancreas

Kidney



Physics in Medicine & Biology

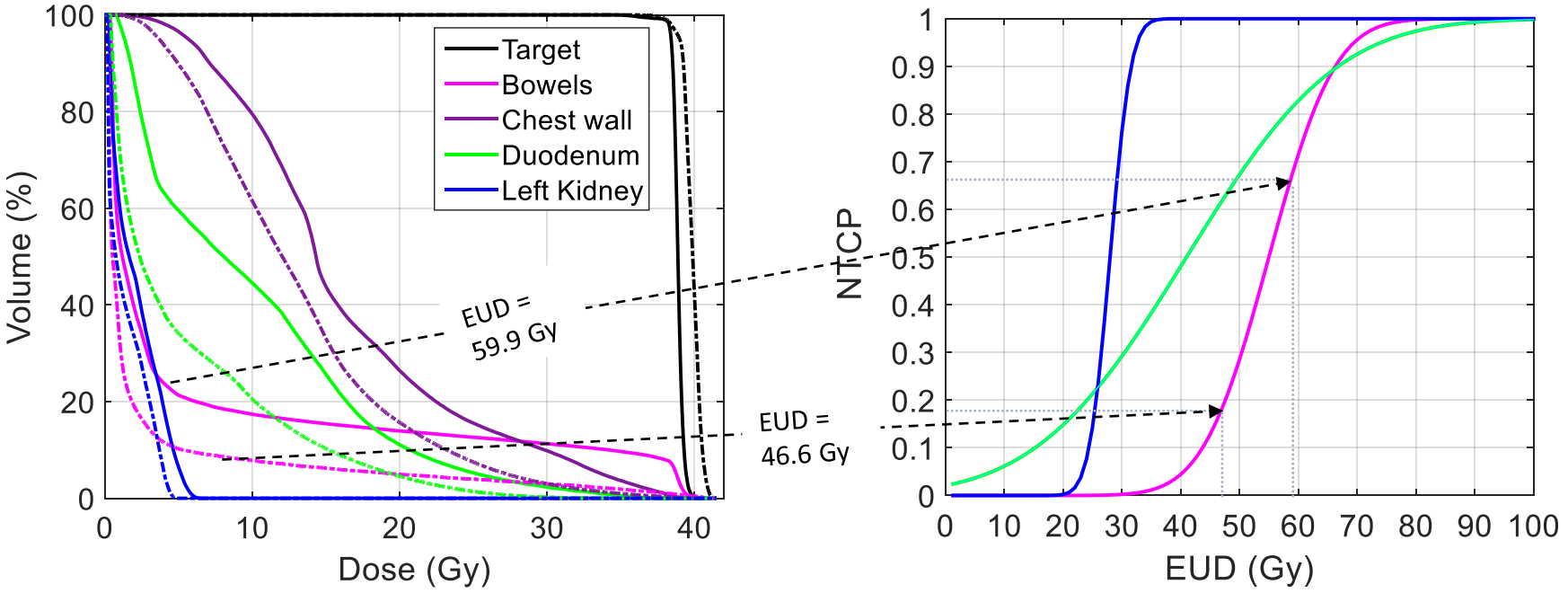
IPEM Institute of Physics and Engineering in Medicine

PAPER

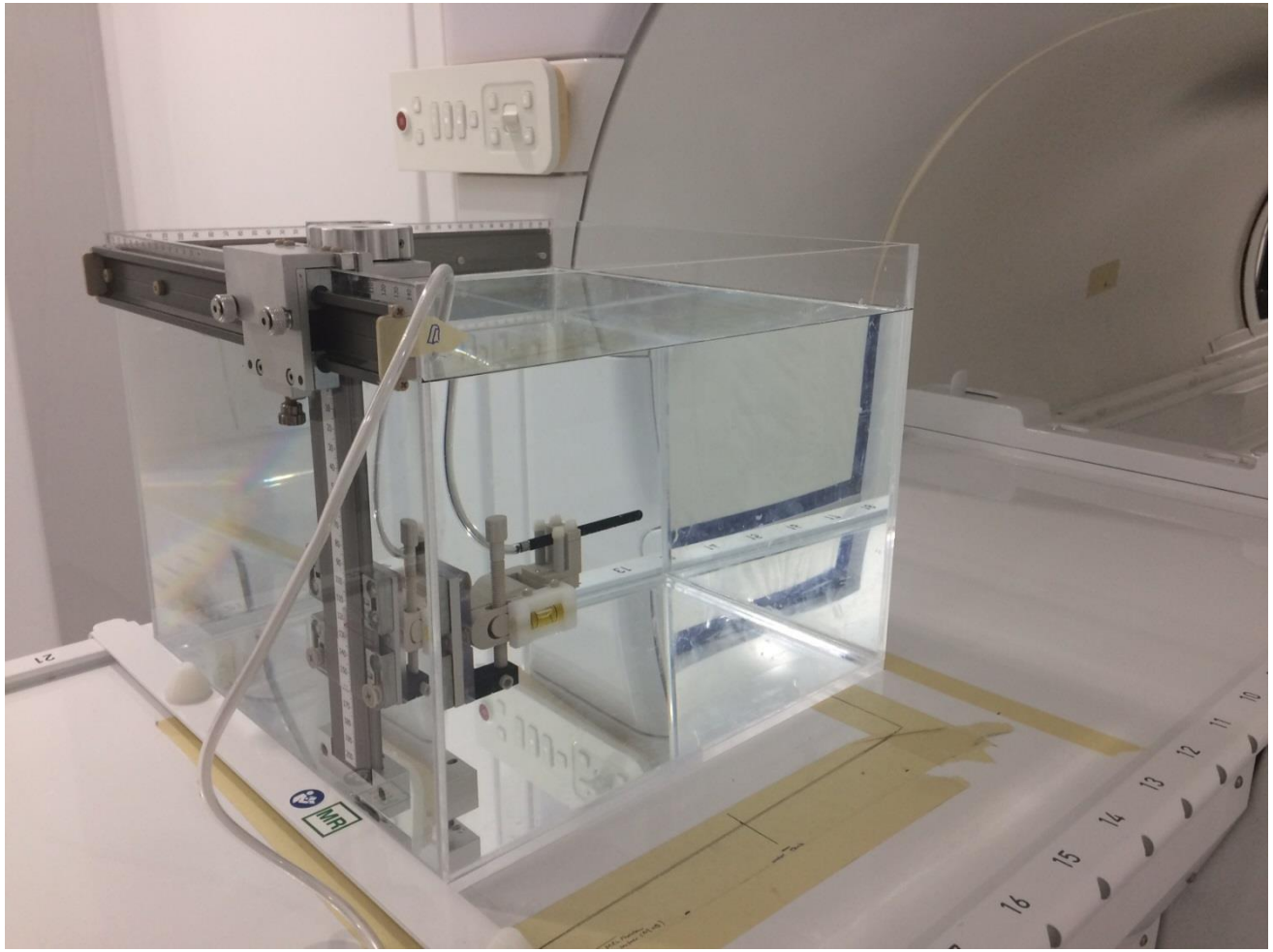
The radiobiological impact of motion tracking of liver, pancreas and kidney SBRT tumors in a MR-linac

Shahad Al-Ward[1], Matt Wronski[1,2], Syed Bilal Ahmad[1,2], Sten Myrehaug[1,2], William Chu[1,2], Arjun Sahgal[1,2] and Brian M Keller[1,2,3]

Phys. Med. Biol. **63** (2018) 215022 (11pp)

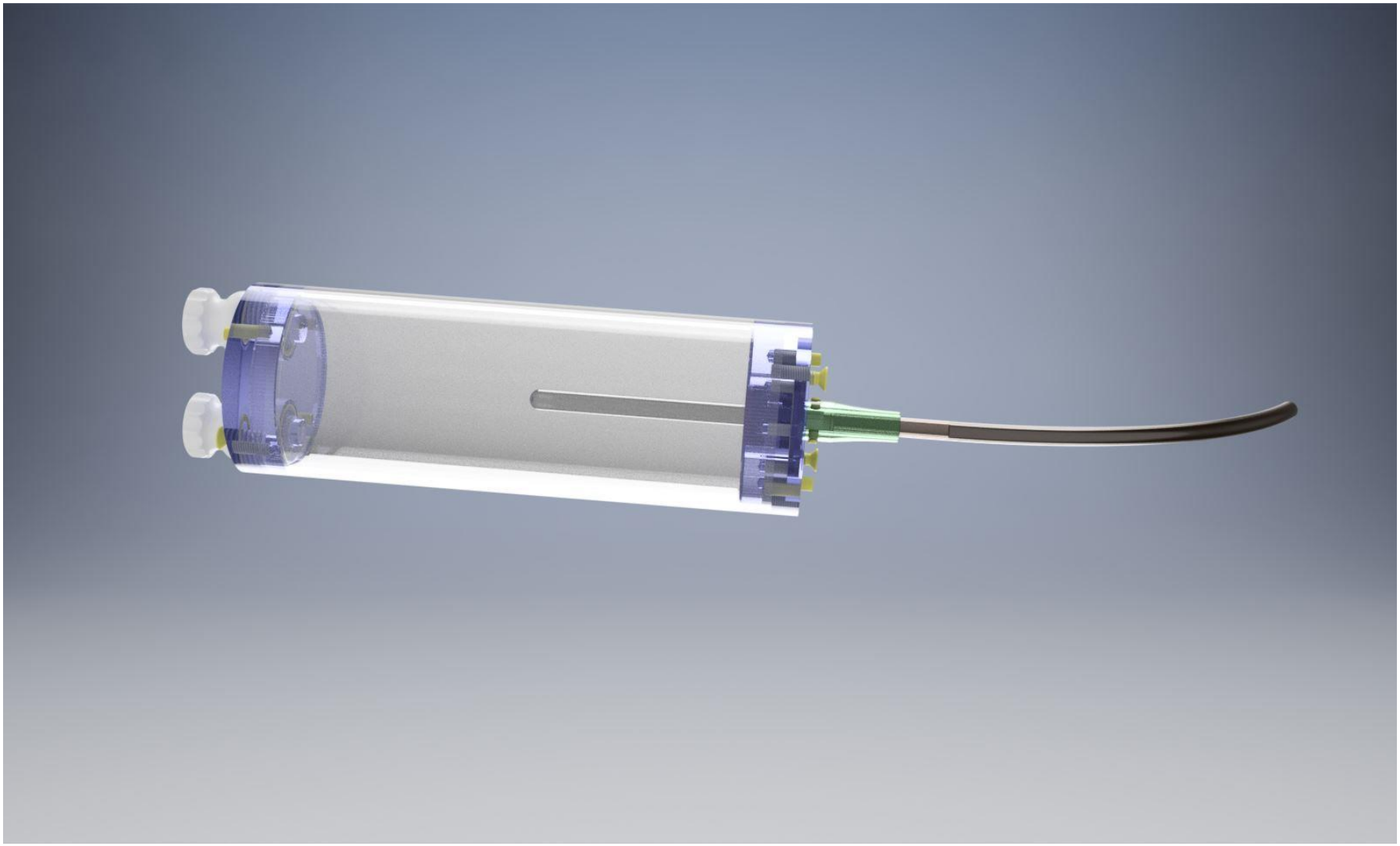


MR-linac Designed Water Tank



Harry Easton and Machine Shop

Daily Morning Output Measurements Device



Harry Easton and Machine Shop

Differences in NTCP values for ITV vs MLC Tracking

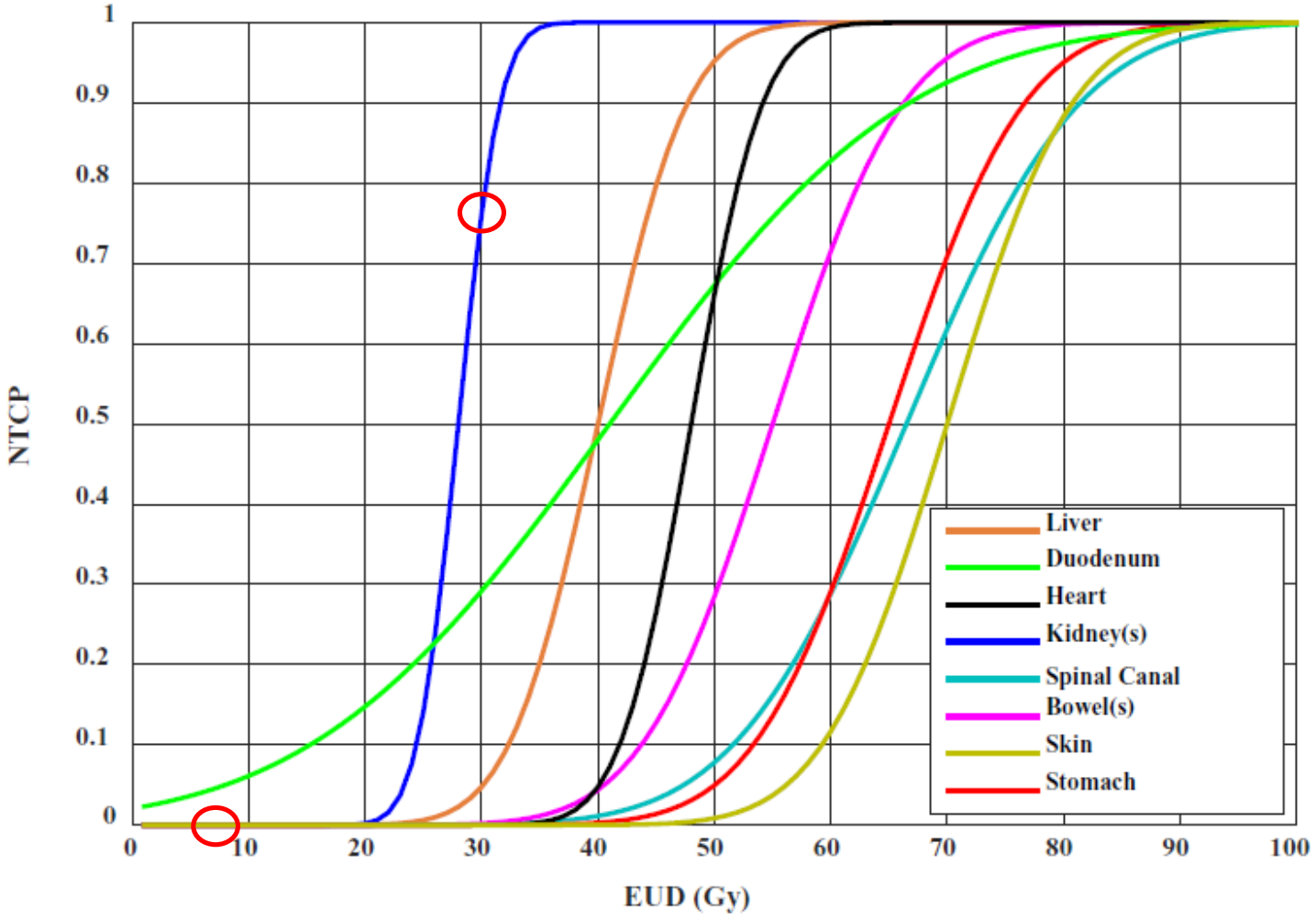


Figure 1. Plots of NTCP as a function of EUD for various organs at risk (OARs), where each OAR has its associated m and D_{50} values as listed in table 2.

The Radiobiological Impact of Motion Tracking of Liver, Pancreas and Kidney SBRT Tumors in a MR-linac

Treatment site: Liver

Patient 1	Tumor motion= 0.96 cm		Patient 2	Tumor motion= 2.57 cm		Patient 3	Tumor motion= 1.00 cm	
OAR	α	% NTCP difference	OAR	α	% NTCP difference	OAR	α	% NTCP difference
Liver-ITV	3	5	Liver-ITV	0.5	5	Liver-ITV	3	1
Right Kidney	0.5	2	Liver-ITV	1	17	Duodenum	4	13
Right Kidney	1	35	Liver-ITV	3	51	Duodenum	8	24
Duodenum	4	12	Right Kidney	3	79	Duodenum	15	25
Duodenum	8	15	Skin	8	1	Bowels	4	19
Duodenum	15	10	Skin	15	1	Bowels	8	44
Bowels	15	17				Bowels	15	9

Treatment site: Pancreas

Patient 4	Tumor motion= 0.80 cm		Patient 5	Tumor motion= 1.05 cm		Patient 6	Tumor motion= 0.81 cm	
OAR	α	% NTCP difference	OAR	α	% NTCP difference	OAR	α	% NTCP difference
Duodenum	4	17	Duodenum	4	10	Duodenum	4	6
Duodenum	8	7	Duodenum	8	7	Duodenum	8	1
Duodenum	15	2	Duodenum	15	5	Duodenum	15	-2
Small bowel	8	4						
Small bowel	15	67						
Large bowel	8	10						
Large bowel	15	69						
Stomach	8	-5						
Stomach	15	-16						

Treatment site: Kidney

Patient 7	Tumor motion= 1.21 cm		Patient 8	Tumor motion= 0.78 cm		Patient 9	Tumor motion= 1.17 cm	
OAR	α	% NTCP difference	OAR	α	% NTCP difference	OAR	α	%NTCP difference
Duodenum	4	2	Duodenum	15	1	Duodenum	4	4
Duodenum	8	3	kidney-ITV	0.5	77	Duodenum	8	4
Duodenum	15	3	kidney-ITV	1	48	Duodenum	15	5
kidney-ITV	0.5	15	kidney-ITV	3	1	kidney-ITV	0.5	69
			Large Bowel	8	4	kidney-ITV	1	56
			Large Bowel	15	18			