UMC Utrecht

Image guided brachytherapy: HDR treatments in the MR room

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UMC Utrecht:
HDR treatments in the MR room, or an MR scanner in the Brachy suite

- Since 2010
- 1.5 T MR system at department Radiotherapy
- MR guided intervention
  - Brachytherapy
  - HIFU

Contents

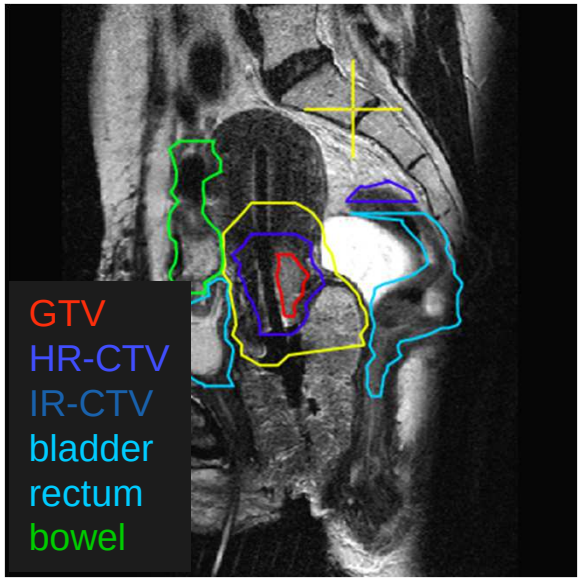
- Why MR and
  why MR in Brachy treatment room
- MR safety
- MRI guided brachytherapy in
  - Focal HDR prostate brachytherapy
  - Robotic prostate brachytherapy
  - oesophagus, head & neck
  - Gynaecology
- Workflow HDR for cervical cancer

IGABT for cervical cancer: GEC-ESTRO recommendations:

Target definition

MR based

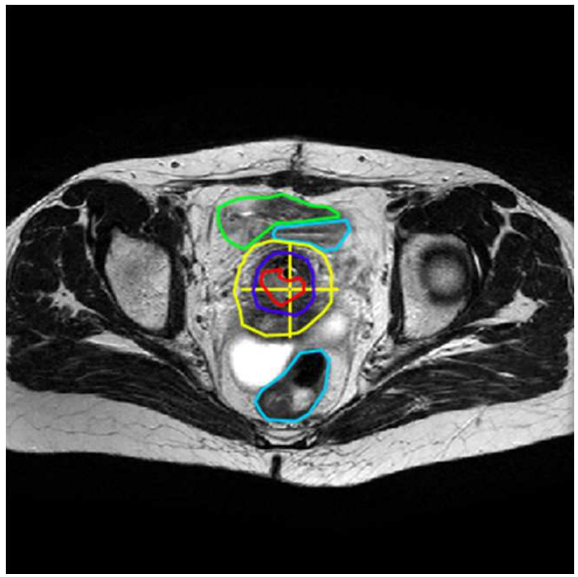
- GTV (macroscopic tumor)
- **HR-CTV** (GTV + suspected microscopic tumor)
- IR-CTV (pre-treatment extension)



Reporting Dose Volume parameters

DVH: aims and constraints on total dose: EBRT + Brachytherapy

DVH analysis based on EQD2 with :	α/β(target)	=10 Gy
	α/β(OAR)	=3 Gy
	$T_{1/2}$	=1.5 h
Dose volume parameters:	target:	D90 and D98
	OAR:	D2cc

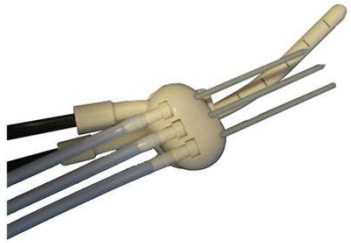


Common Language!!

Haie-Meder et al. Radiother Oncol 2005
Pötter et al. Radiother Oncol 2006

UMC Utrecht: since 2006 MR guided treatment

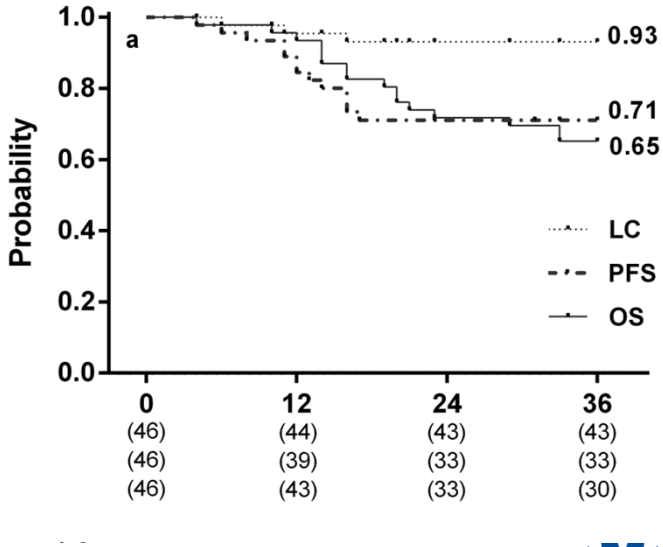
PDR in two applications, 2* 31 hours
MR scans with applicator in situ
MR at department radiology
Optimization, combination Intracavitary/interstitial



Utrecht applicator

Clinical results **2006-2008 RETRO-Embrace**

3 yrs outcome	All n=46 %	Node positive n=20 %	Node negative n=26 %	*P*
Overall survival	65	50	77	**0.032**
Local Control	93	94	92	0.799
Pelvic control	84	78	88	0.370



EMBRACE

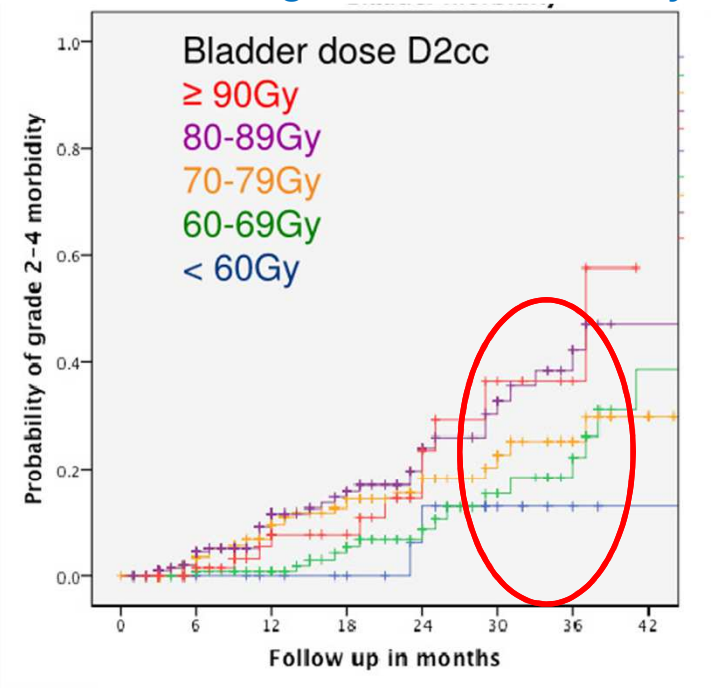
An intErnational study
on MRI-guided BRachytherapy
in locally Advanced CErvical cancer

>1100 patients, from >24 centers

Preliminary Dose Effect analysis OAR

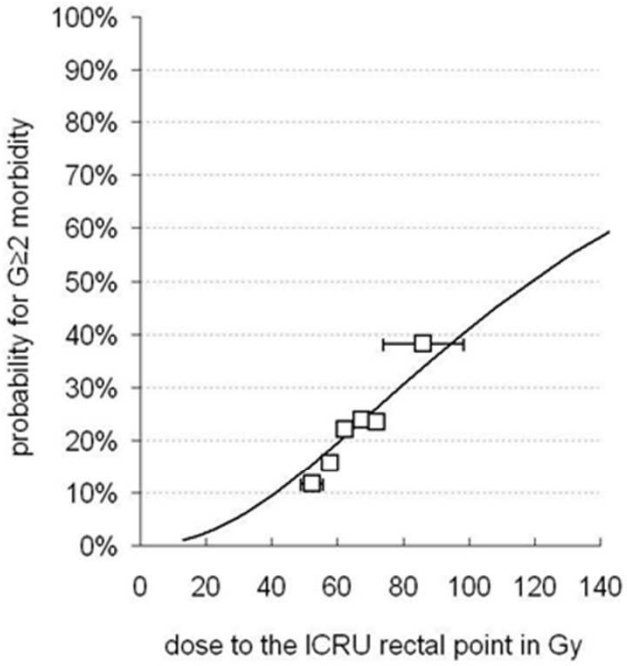
Bladder

Dose effect grade 2-4 morbidity



Vagina

Dose effect grade ≥ 2 morbidity



Strong rationale to decrease OAR dose

Fokdal et al. 2013

Kirchheiner et al 2013

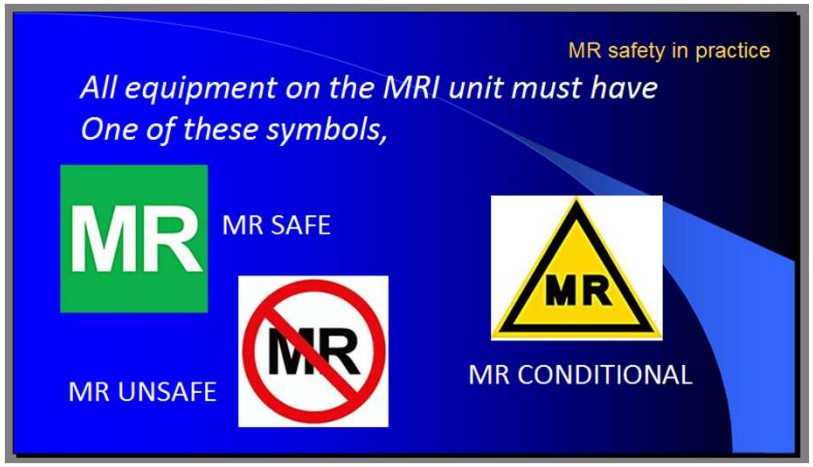
Brachy treatment suite
With 1.5 T MR scanner and HDR afterloader

Radiation Shielded treatment room with
- MR scanner 1.5 T
- **non** MR compatible HDR afterloader

MR compatible applicators, needles, tubes

MR compatible instruments/robotics

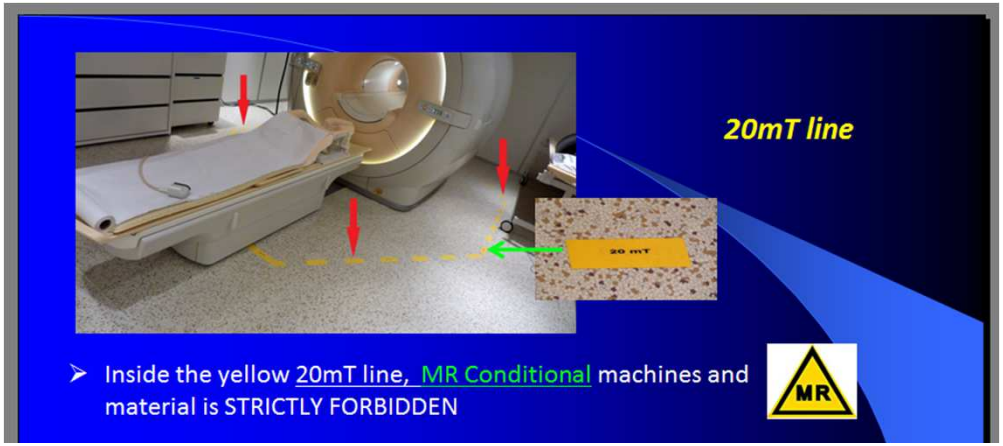
MR safety issues



Need for:
MR compatible instruments and applicators

Effort: Once before start

MR safety issues



5 Gauss marking on the floor for MR conditional equipment

Securing **non MRI compatible** equipment:
HDR afterloader with double ropes.

MR safety issues: Training

Most experienced RTT's are trained/educated in operating MR scanner as well.

MR Safety procedures and –training developed

MR Safety training: conform hospital protocol:
yearly for all staff,
as well for anesthesia staff!!

HDR emergency procedure in MR:
regularly trained: RTT's, physicians
5 minutes movie available

Combination training

Continuous effort!!

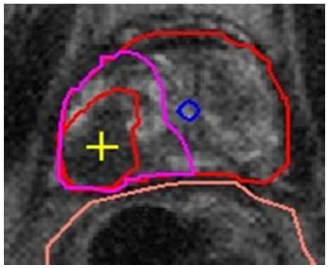
MRI guided brachytherapy: HDR prostate

Focal HDR brachytherapy for localized cancer

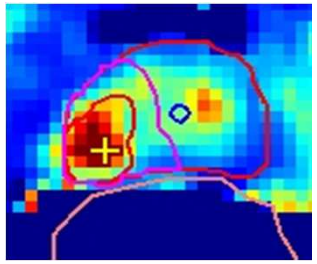
- 19 Gy on focal tumors in single fraction(GTV+5mm margin)
- **ONLY IF:** Dose plan meets stringent constraints: Rectum and bladder: D1cc < 12 Gy, Urethra: D10% < 21 Gy

Procedure

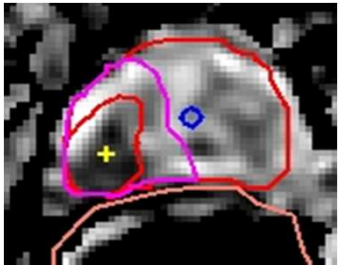
- Pre brachy multi parametric MRI



low signal onT2



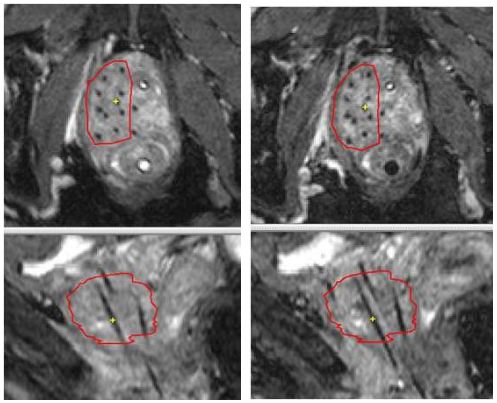
high Ktrans



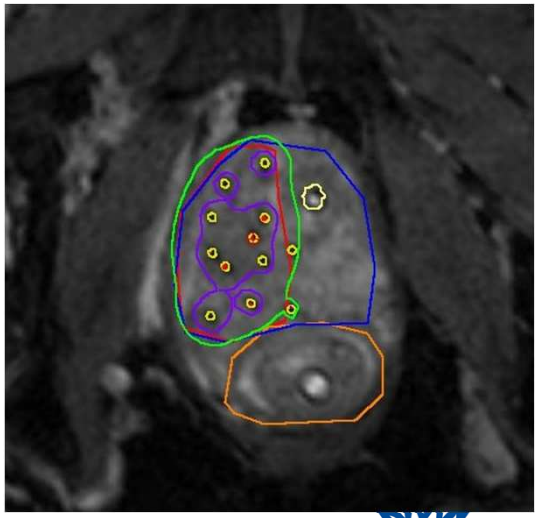
low ADC

- US guided insertion of catheters
  - Fusion with pre brachy MRI

- MRI
- Reconstruction
- Contouring Fusion with pre brachy MRI
- (Inverse) dose planning



Plannings MRI with PTV



- MRI (position verification)

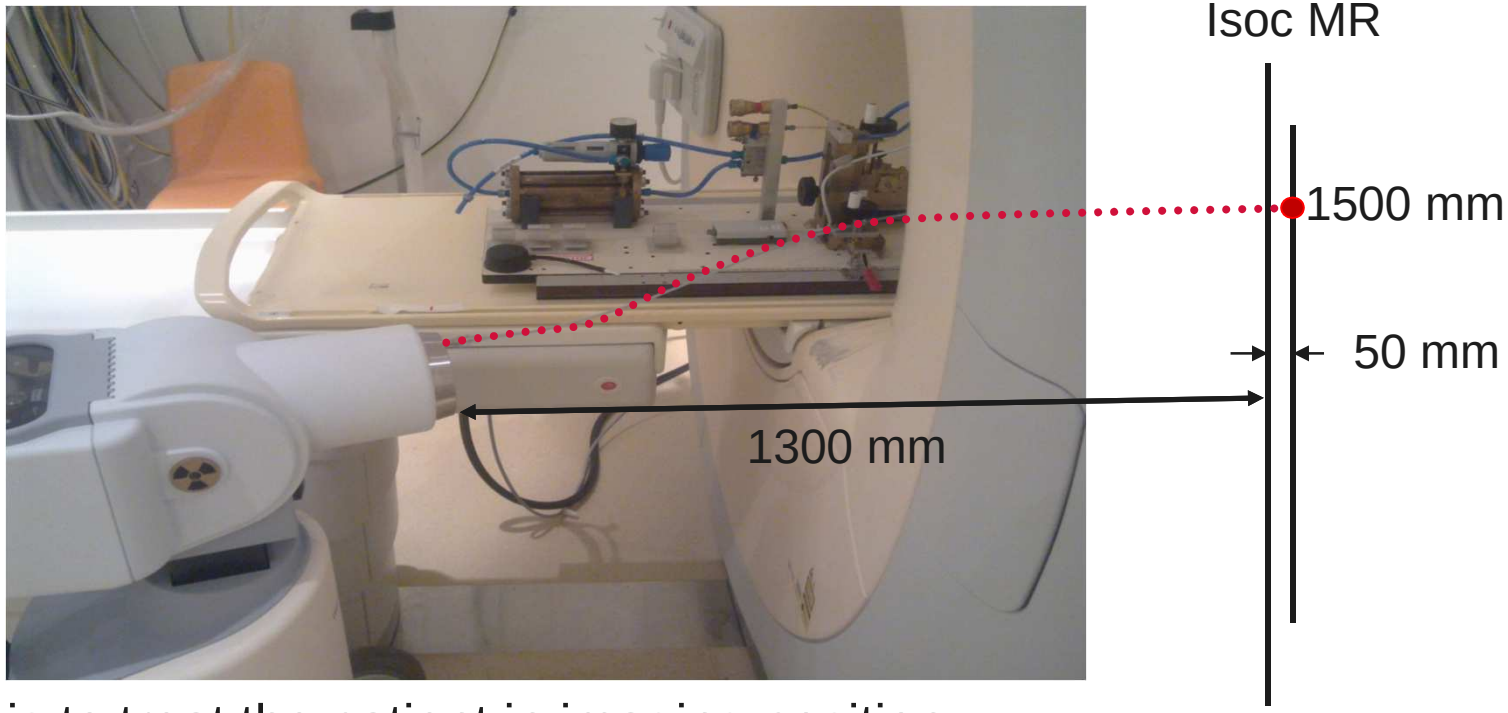
- Irradiation

Position verification

Groenendaal et al. IJROBP 2012;82:537-44

Development of robot and MR compatible afterloader

Setup with treatment length 1500 mm at 50 mm beyond isocenter MR; position test with film: source position within spec (error <0.5 mm)



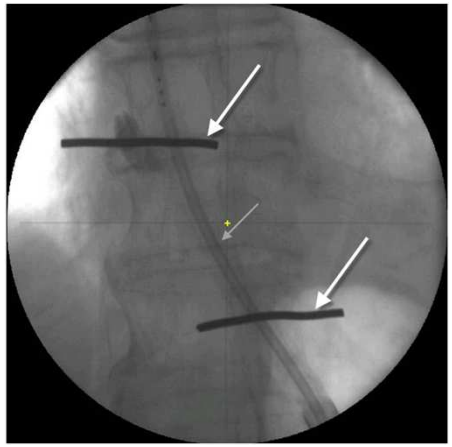
The aim is to treat the patient in imaging position
This is feasible,

- with longer treatment cable
- and breaking the RF waves

Courtesy Moerland 2013

MRI guided brachytherapy: Studies

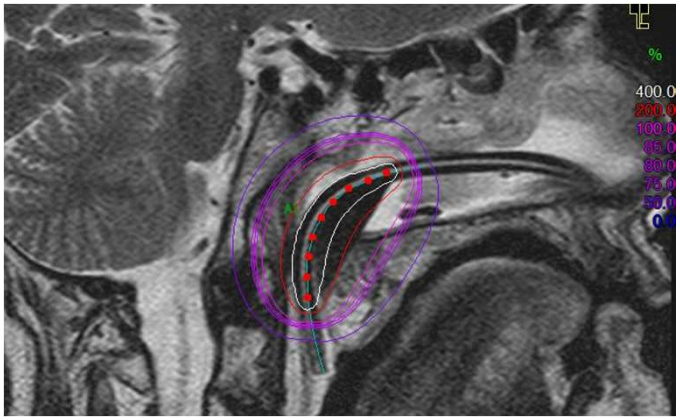
Esophageal cancer

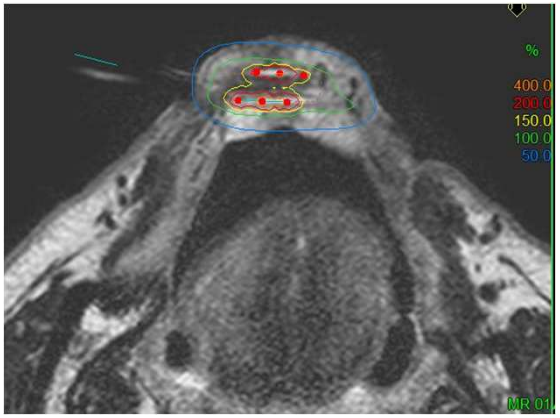


a) Delineation of the esophageal tumor on a T2 MR image
b) Markers indicate the tumour borders as determined with standard X-ray guided endoscopic procedure

Applicator tube with inner MR marker tube

Head & Neck

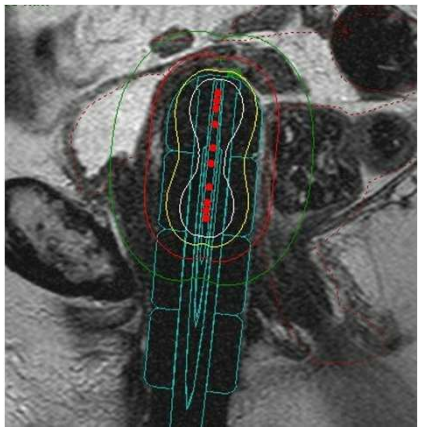




Potential benefit of MRI-guided brachytherapy for nasopharynx, lip, vestibulum nasi tumours

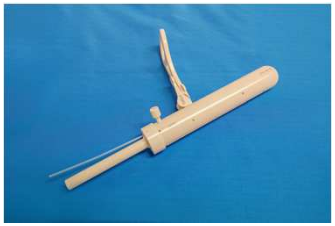
MRI guided brachytherapy: Gynecology

- Vaginal cylinders, endometrium cancer



Application, MR scan, visual inspection,
irradiation standard plan, dose calculation

- ➢ adaptation necessary?



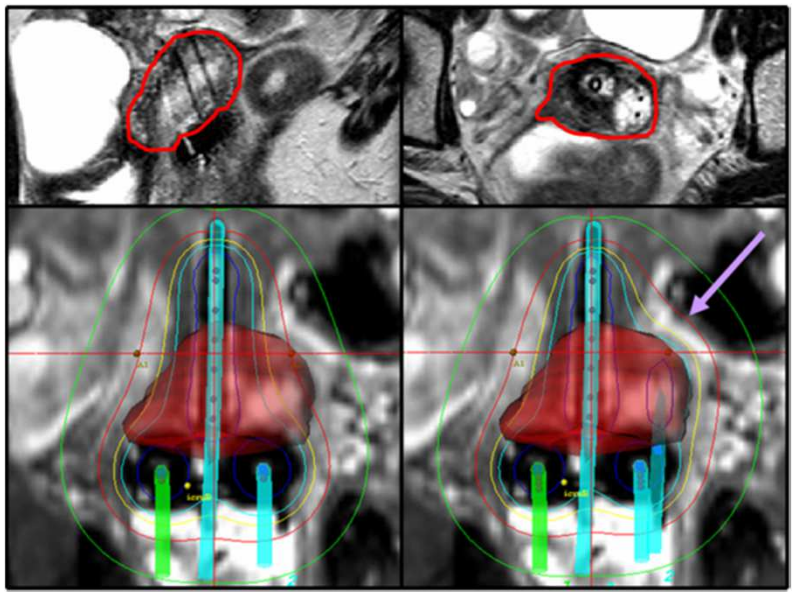
- Advanced cervical cancer

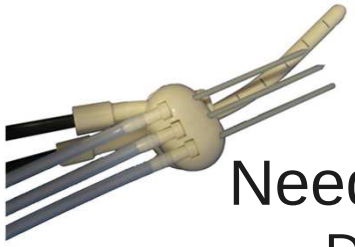
MRI guided brachytherapy: Advanced Cervical cancer

MRI guidance

- Accurate delineation of target volumes
- Additional needles help to increase target dose

- Adequate organ sparing
- Moderate morbidity rates
- Improvement of local control and cancer specific survival





Need for: MR scans with applicator and needles in situ

Direct reconstruction on MR using models in TPS

Direct delineation on MR

Uncertainties IGART cervix cancer BT

- Special issue Radiotherapy and Oncology

Radiotherapy and Oncology 107 (2013) 1–5

Contents lists available at SciVerse ScienceDirect

Radiotherapy and Oncology

journal homepage: www.thegreenjournal.com

Editorial

Uncertainties in image guided adaptive cervix cancer brachytherapy: Impact on planning and prescription

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- Intra- inter fraction dose variation

Radiotherapy and Oncology 107 (2013) 20–25

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Image guided brachytherapy

A multicentre comparison of the dosimetric impact of inter- and intra-fractional anatomical variations in fractionated cervix cancer brachytherapy

Nicole Nesvacil [a,*], Kari Tanderup [b], Taran P. Hellebust [c,d,e], Astrid De Leeuw [f], Stefan Lang [a], Sandy Mohamed [b,j], Swamidas V. Jamema [g], Clare Anderson [h], Richard Pötter [a,i], Christian Kirisits [a,i]

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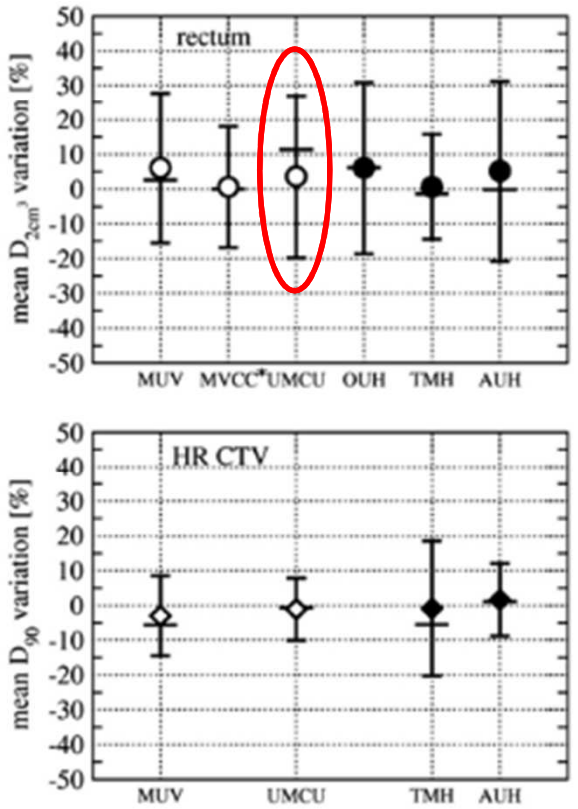


Intra-fraction dose variation UMC Utrecht:

PDR

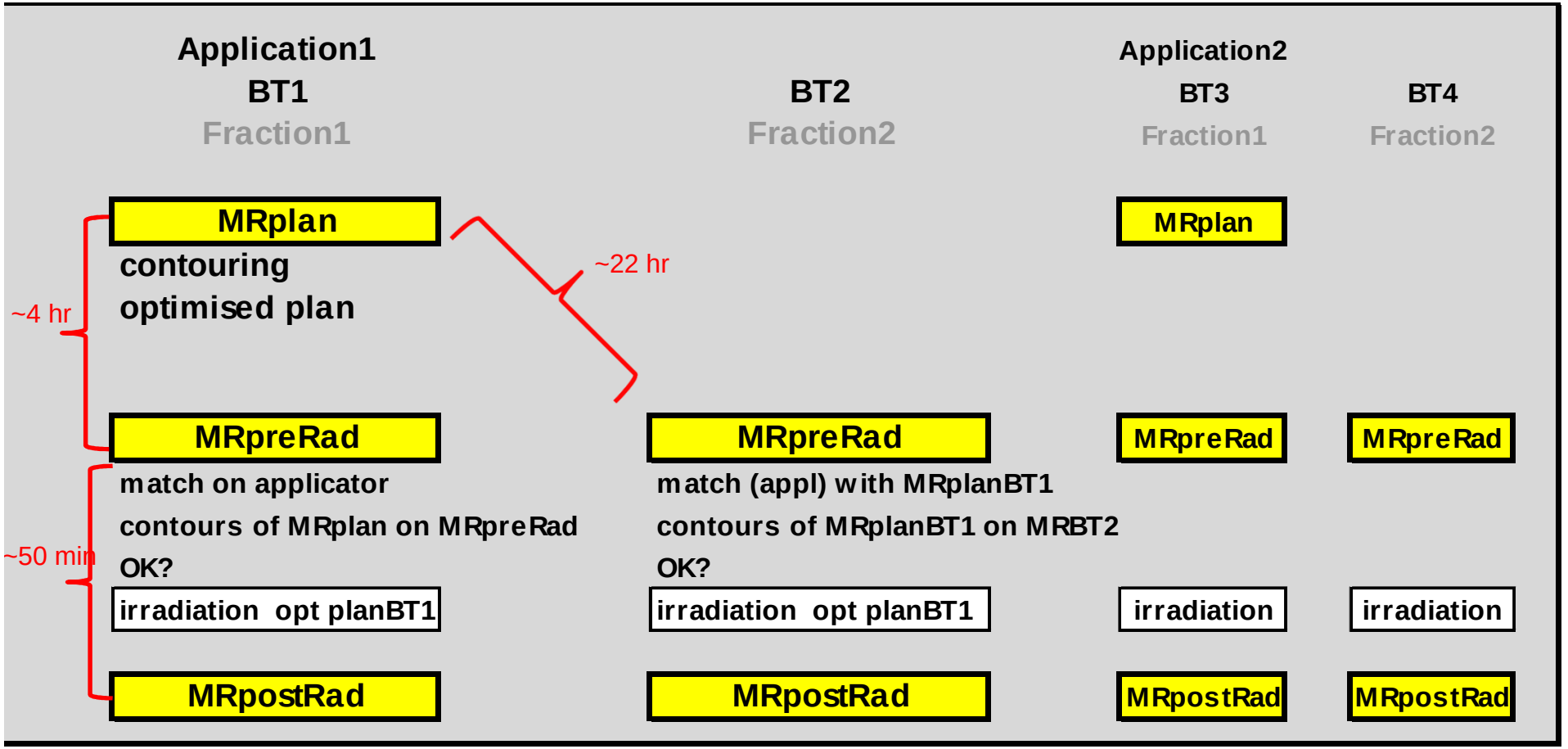
- One fraction: ~30 hours treatment, one pulse every hour
- Dose variation during fraction due to OAR changes
- Systematic increase of rectum D2cc dose

Therefore change to:

HDR 2*2 fractions of 7 Gy (since brachy suite with MR)

Imaging workflow HDR patients (study: n=15)

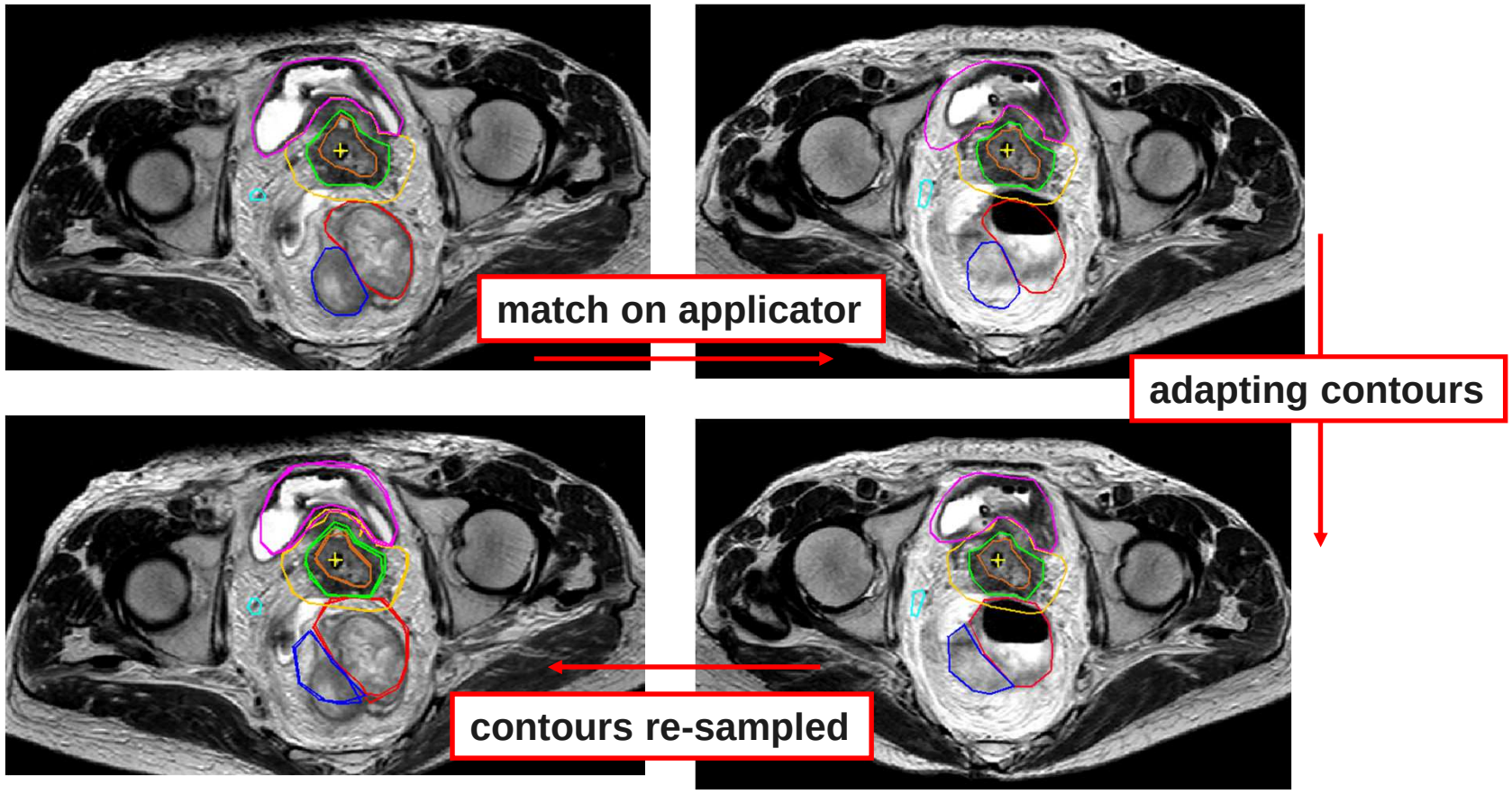
Brachytherapy schedule HDR : 4*7Gy: 2 applications, with 2 fractions each



HDR workflow: image registration and calculation of DVH parameters on ‘real’contours

MRplan

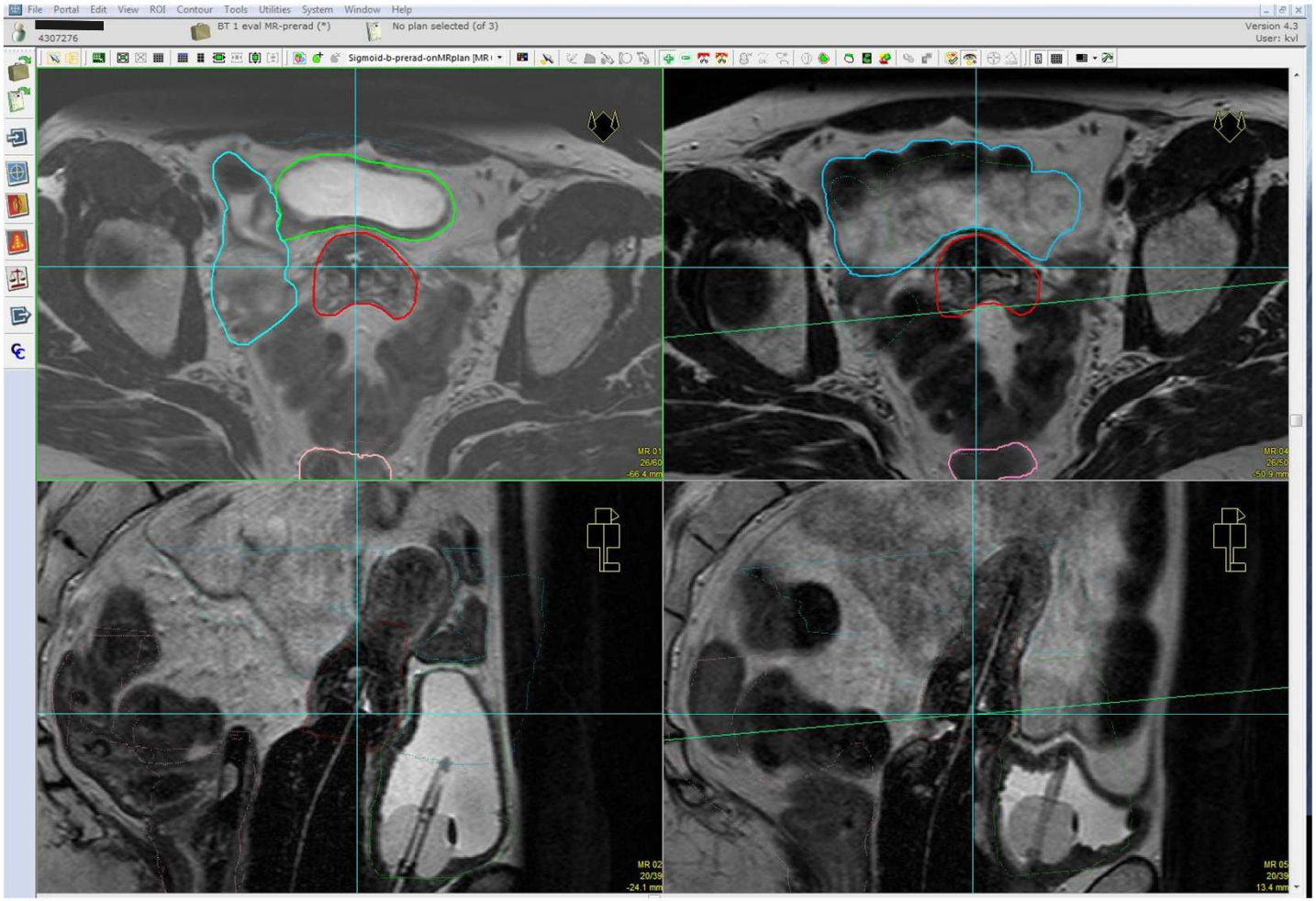
MRpre-/postfraction



DVH parameters on new contours

D2cc rectum 4.2 ➔ 5.8 Gy

Treatment planning system: Oncentra/Elekta

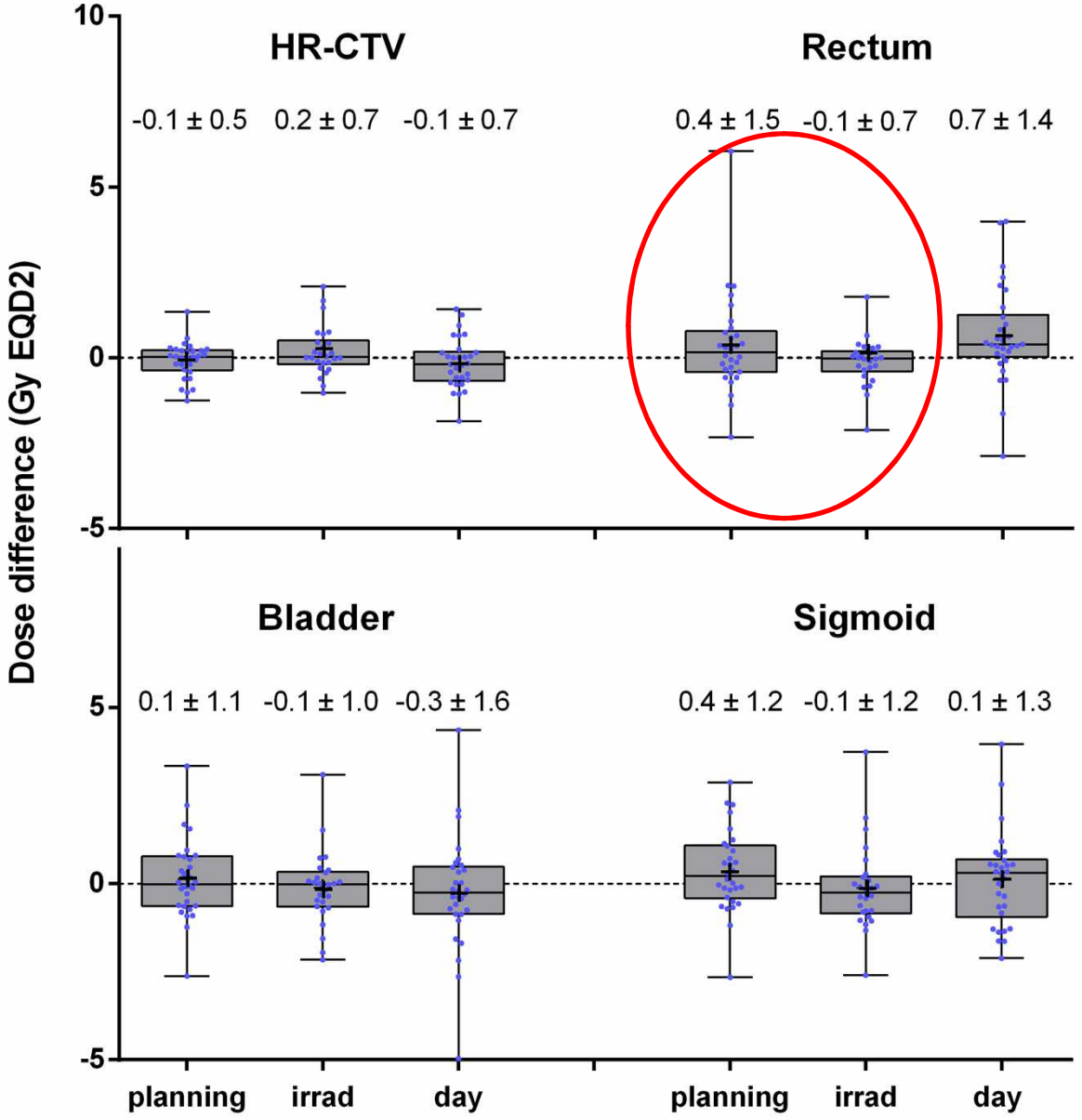


Results: dose differences for 3 time intervals

Planning (~4 hours)

irrad=radiation+MR (50 minutes)

day (~22 hours)

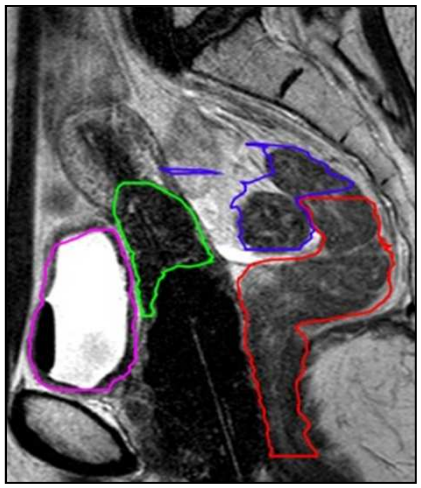


Important: detect outliers

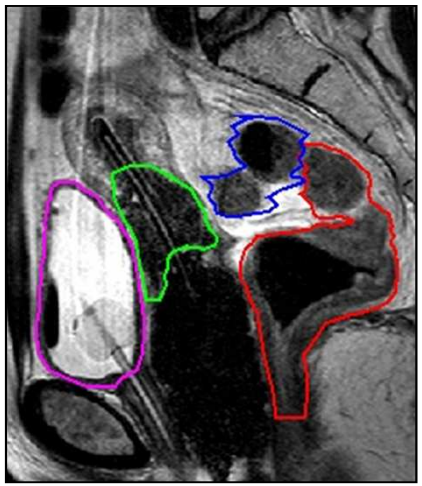
Christel Nomden et al 2014

Example from first patients

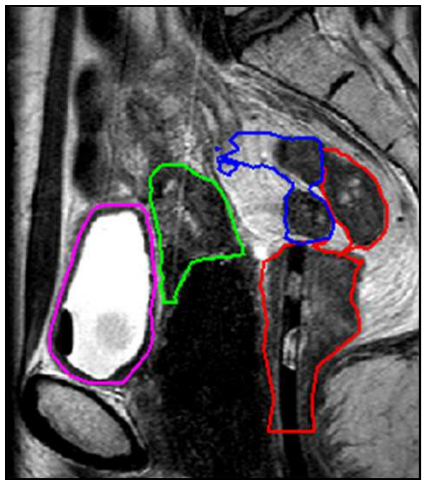
MRI for treatment planning



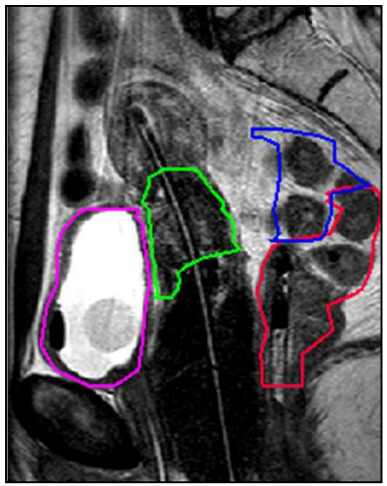
MRI pre-radiation about 4 hours later



MRI after insertion of rectal probe

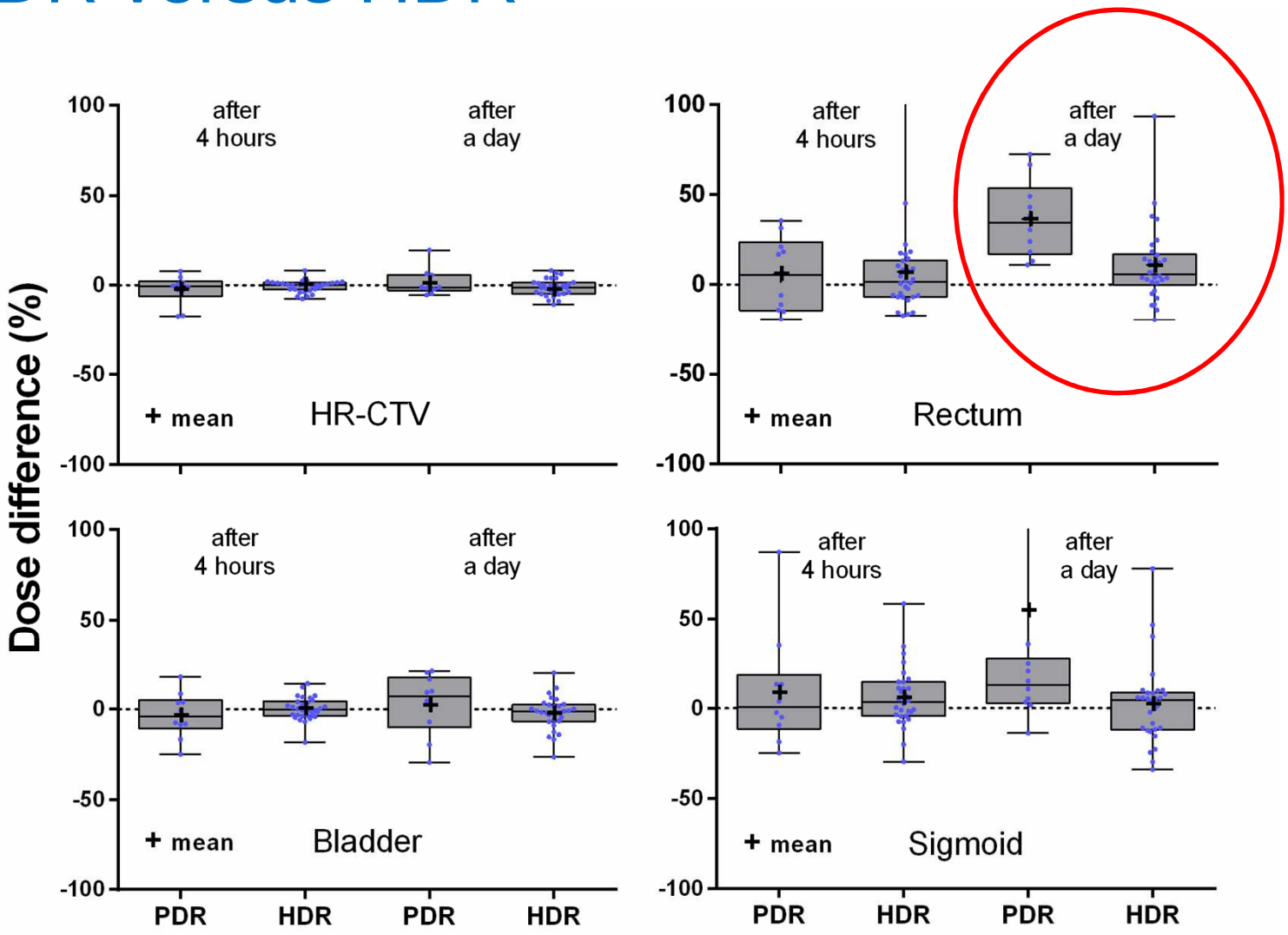


MRI post-radiation about 40 min later



- Difference in rectal filling: Increase of **gas!**
- Therefore:
    - **Rectum catheter in all HDR patients**
- Adapt when necessary (de-gassing)

Comparison intra-fraction dose variation PDR versus HDR

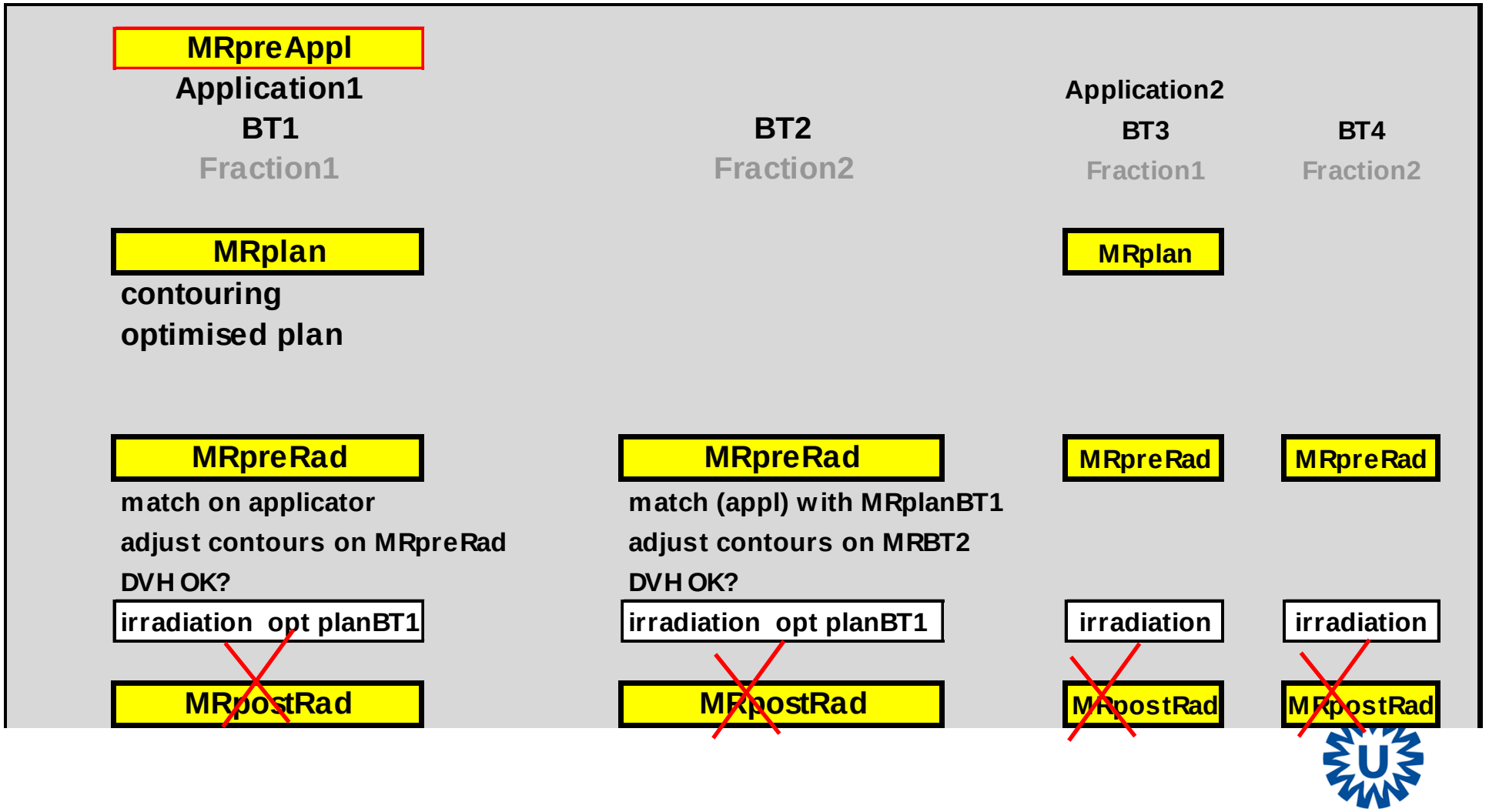


Unfavourable systematic increase during PDR

Christel Nomden et al. 2014

Imaging workflow HDR patients: clinical practise

Brachytherapy schedule HDR : 4*7Gy: 2 applications, with 2 fractions each



Clinical practise: workflow first application

- **MR scan**

  (MRpreApp)
- Application
- MR scan
- Planning
- MR scan
- Irradiation

MR scan immediately before start application
(T2 TSE sagital, transversal, coronal) :

replacement of MR in week 4

- Tumor regression?
- Needles necessary?

BT1preAp

Clinical practise: workflow first application

- MR scan
- **Application**
- **MR scan**

  (MRplan)
- Planning
- MR scan
- Irradiation

Application in MR room

- If needles necessary:
  - MR guided placement
  - short sagital/transversal sequence (~2*1min)

After application:

- MR scan: T2 TSE sagital, transversal, coronal, DWI (~13 min)

BT1 preApp

BT1 nld

BT1 plan

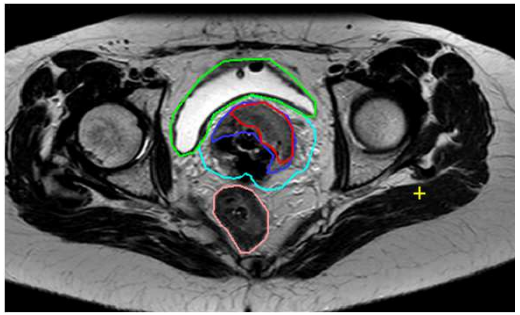
Clinical practise: workflow first application

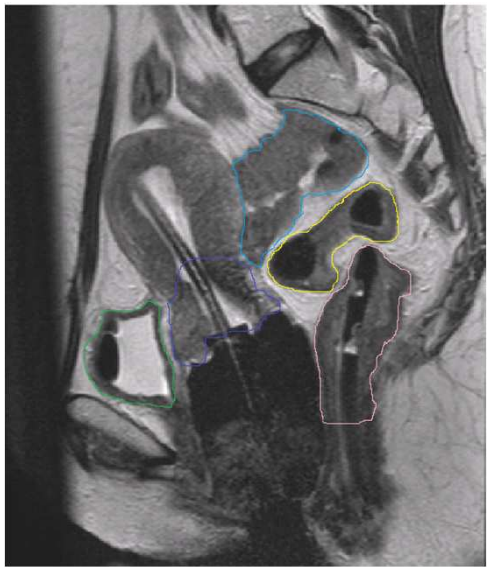
- MR scan
- Application
- MR scan
- **Planning**
- MR scan
- Irradiation

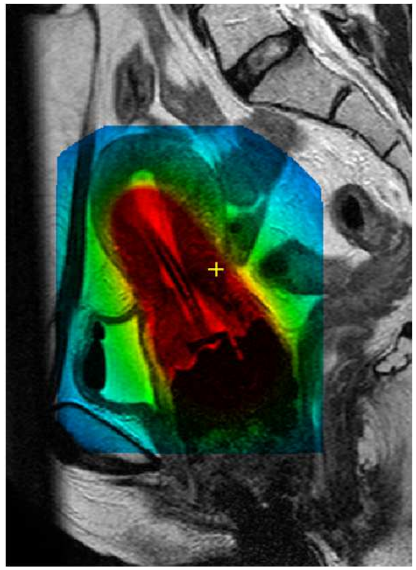
Contouring
by radiation oncologist

Applicator reconstruction
by RTT

- DVH analysis standard plan
- Optimization of plan (with needles)
- DVH analysis optimized plan
- if approved by doctor and physicist:
  next step:







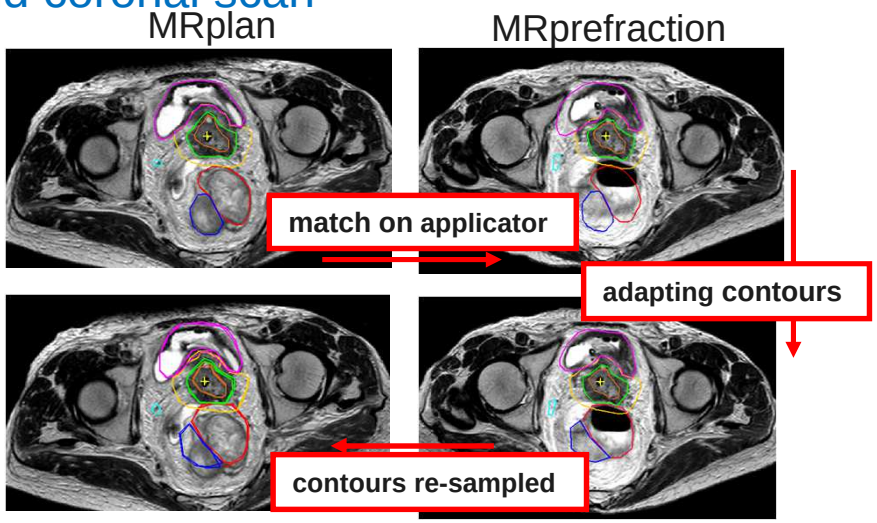
Clinical practise: workflow first application

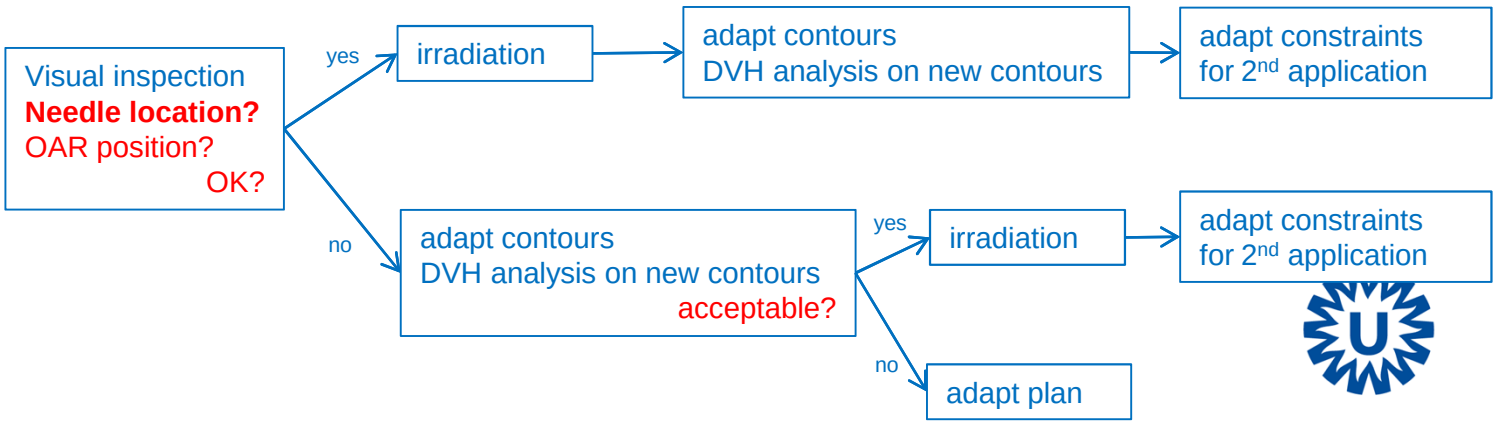
- MR scan
- Application
- MR scan
- Planning
- **MR scan (MRprefract)**
- **Irradiation**

Patient on MR trolley

MR scan: sagittal scan, visual inspection, **adaptation?**
and transversal and coronal scan

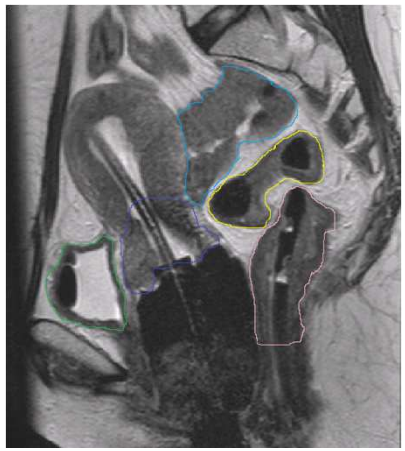
Registration of transversal scan with MRplan
(Mutual Information
on box around applicator)





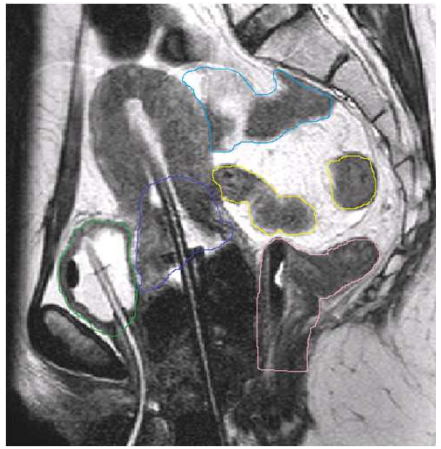
Example 1 No special adapation

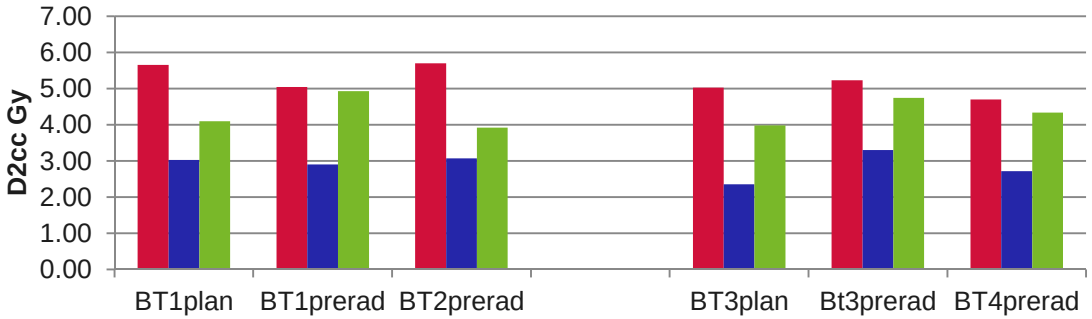
BT1plan



BT1prerad

BT2prerad





BT3plan

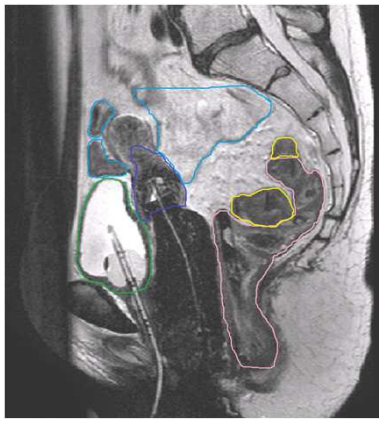
BT3prerad

BT4prerad

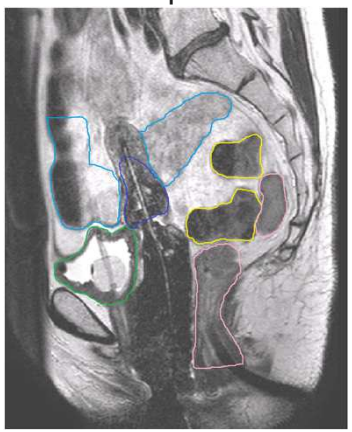
	total EQD2 in Gy	
	estimated deliverd	planned
bladder	77.1	79.0
rectum	57.6	55.4
bowel	70.1	66.0

Example 2 changing bladder filling

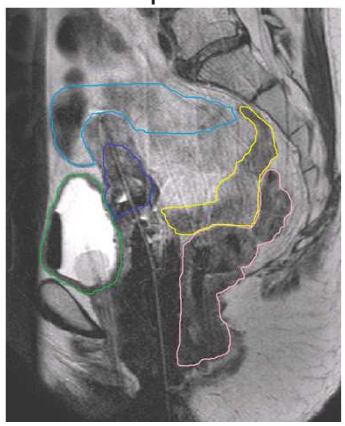
BT1plan



BT1prerad



BT2prerad

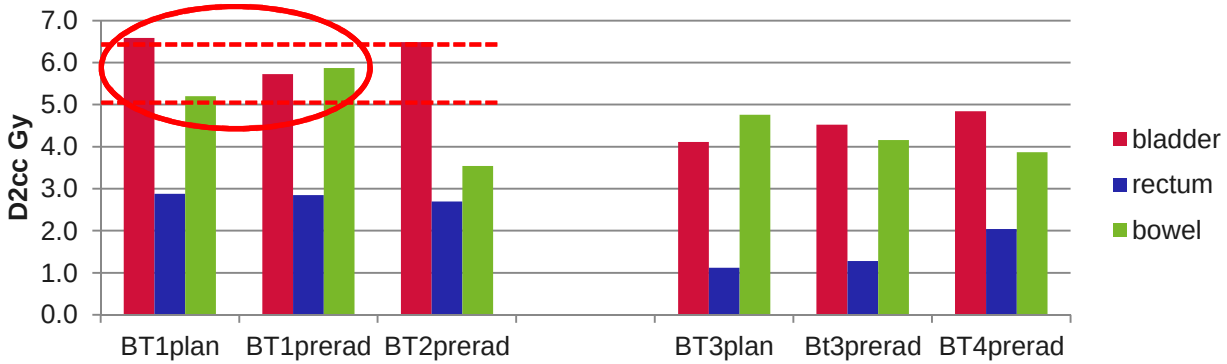


’wrong’ (not empty) bladder filling at first MR

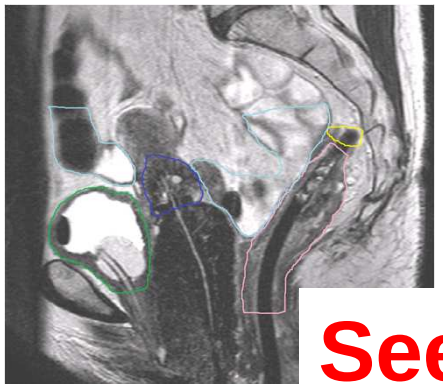
→ lower bladder, higher bowel dose for first fraction

→ Next fraction 100 cc bladder filling

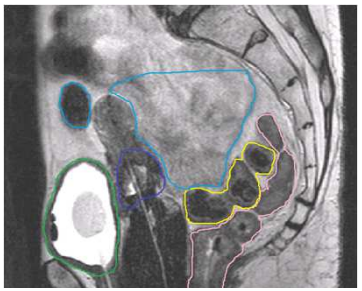
→ adaptive



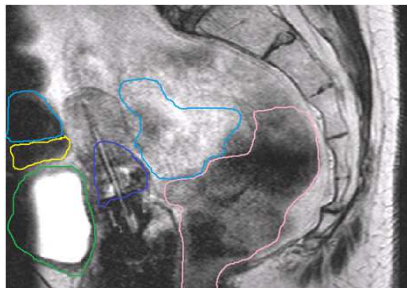
BT3plan



BT3prerad



BT4prerad



	total EQD2 in Gy	
	estimated delivered	planned
bladder	79.9	80.0
rectum	52.8	51.8
bowel	69.5	75.0

See, manipulate, adapt dose!

Controlling total dose, using spreadsheet

EMBRACEnr UTR065

		Brachy fysische dosis in cGy				EQD2 Gy				EB+Brachy EQD2 Gy	
α/β target	10	BT1	BT2	BT3	BT4	BT1	BT2	BT3	BT4		
α/β OAR	3	10-Mar-14	11-Mar-14	17-Mar-14	18-Mar-14						
Date		BT1planning		BT3plan							
Case name		optimized		optimized							
Plan name		700	700	700	700						
Aim (referentie) dose											
hr-ctv-b											
	Volume(cm3)	22.4	22.4	16.3	16.3						
	D50	1198	1198	1147	1147	21.9	21.9	20.5	20.5	129.2	
	D90	784	784	755	755	11.7	11.7	11.0	11.0	89.6	>85 of 90
	D98	658	658	657	657	9.1	9.1	9.1	9.1	80.6	
	V100 (%)	95.9	95.9	95.0	95.0						
gtv-b											
	volume (cm3)	0.3	0.3	0.6	0.6						
	D90%	765	765	1936	1936	11.3	11.3	47.4	47.4	161.5	
	D98	712	712	1609	1609	10.2	10.2	35.0	35.0	134.5	
ir-ctv-b											
	volume(cm3)	62.2	62.2	49.6	49.6						
	D90%	449	449	431	431	5.4	5.4	5.1	5.1	65.4	>70
	D98	323	323	345	345	3.6	3.6	3.9	3.9	59.1	
OAR											Constraint
bladder-b	ICRU	262	262	157	157	2.9	2.9	1.4	1.4	52.0	
	D0.1	843	843	537	537	19.3	19.3	9.0	9.0	99.7	

		Brachy fysische dosis in cGy				EQD2 Gy				EB+Brachy EQD2 Gy	
		BT1	BT2	BT3	BT4	BT1	BT2	BT3	BT4		
bowel-b	D0.1	751	751	662	662	15.8	15.8	12.7	12.7	100.2	
	D2	520	520	476	476	8.5	8.5	7.4	7.4	75.0	<75 of 70
bowel-prera	D2	587	354	416	387	10.4	4.6	6.0	5.3	69.5	

- Adaptive workflow, adaptation rectum/bladder filling
- better estimation delivered OAR dose

Conclusions

MR Imaging directly before HDR dose delivery:

-results in a more accurate estimate of delivered dose

-helps identifying situations that ask for individual adaptations

(e.g. rectal de-gassing)

But .....MR safety training is essential

Thanks to UMCU Team

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