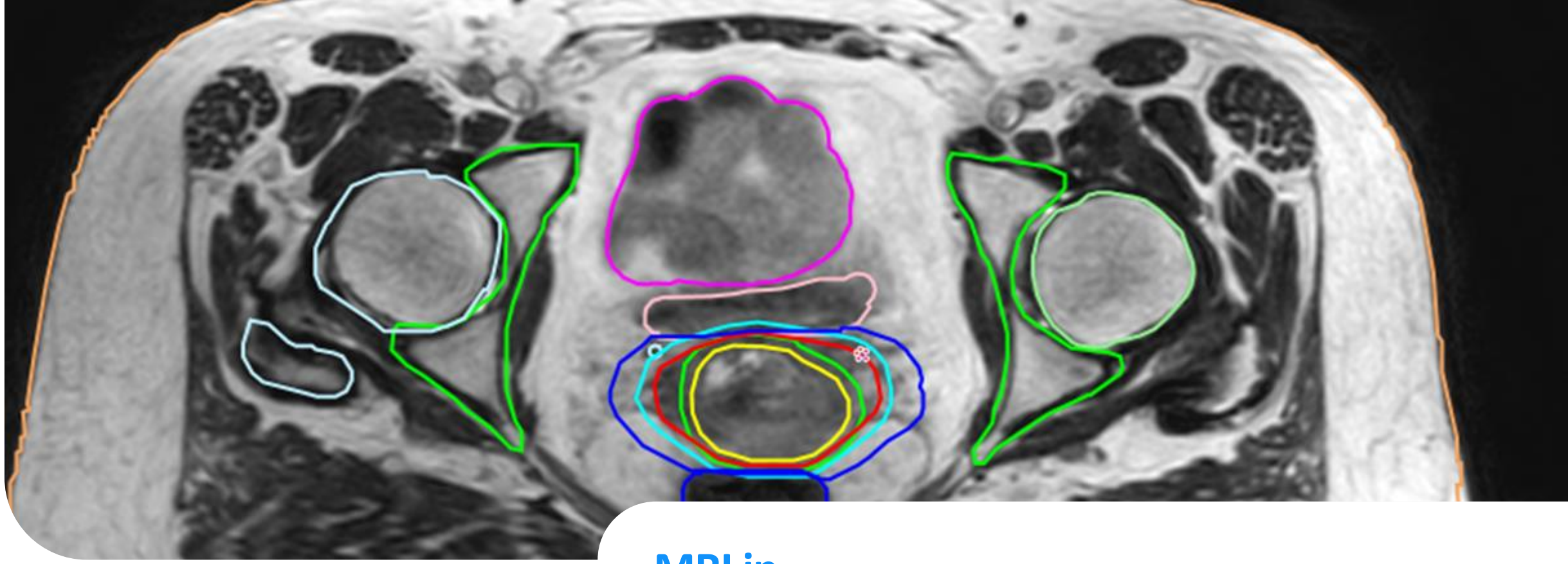


MRI in de voorbereiding en behandeling van gynaecologische tumoren op de MRL

Dr. Ir. Astrid van Lier

UMC Utrecht

Dept. of Radiotherapy

Themadag 2025 – RT bij gynaecologische tumoren
Catharina

Overview

- **When** is MRI used?
  - EBRT
  - Brachytherapy
  - MRLinac

- **Why** do we use MRI for gyn treatments? And why not CT?
- **Which** types of MRI scans are used? For what purpose?

- **How** is MRI expected to be used in the future for gyn radiotherapy?

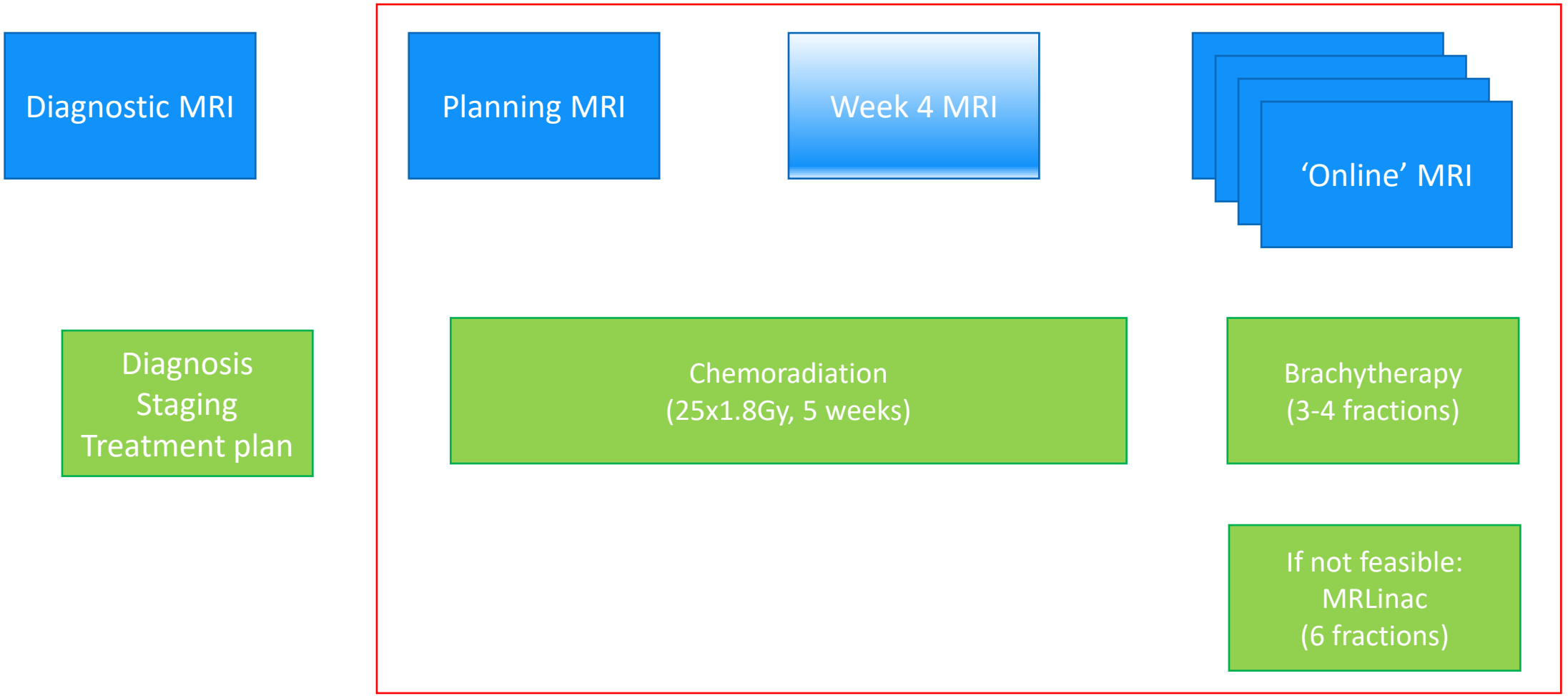
Indications for radiotherapy

Cervical cancer
800 cases/year in NL
Nearly half < 45 years old

51 % early stage	39% locally advanced	7% metastatic 3% unknown
9% radiotherapy	82% radiotherapy (chemoradiation, primary radiotherapy, radiotherapy + hyperthermia)	31% radiotherapy
	Often: EBRT + Brachytherapy boost	

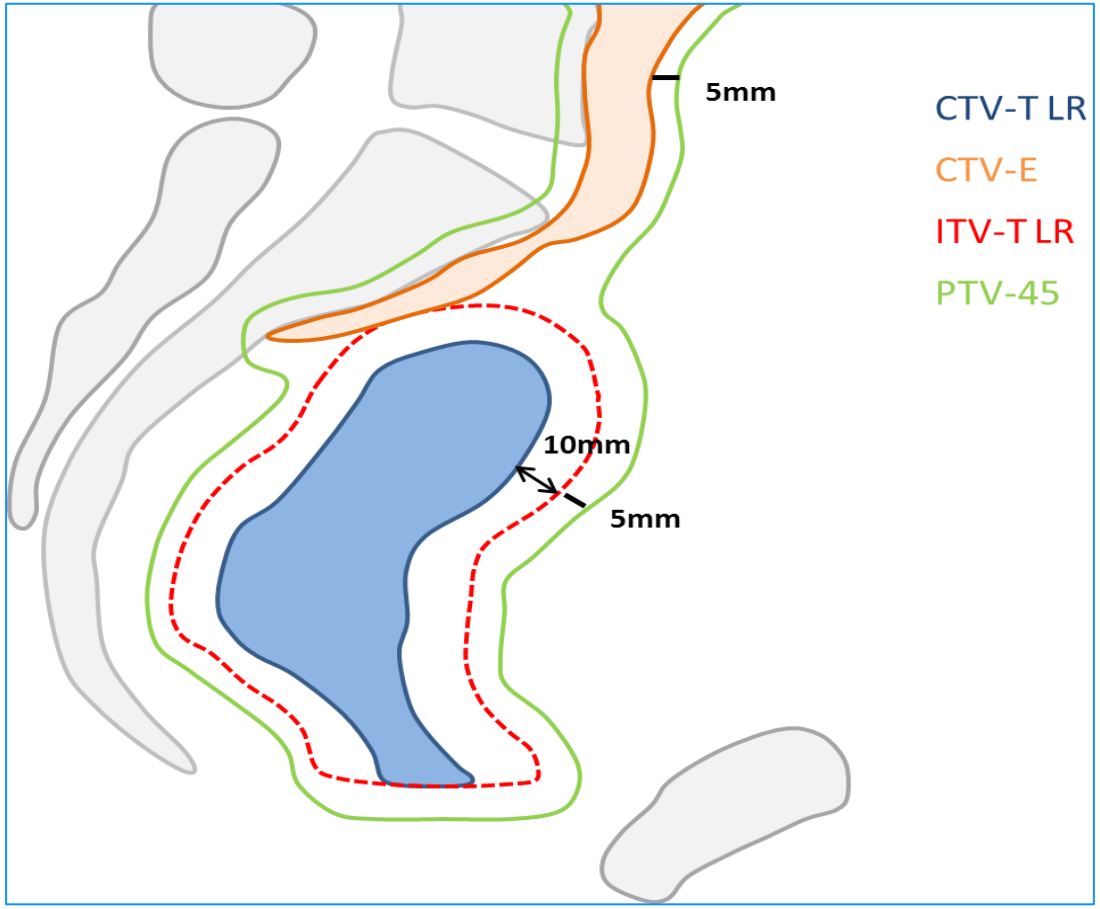
Source: IKNL – cervixcarcinoom in Nederland (2024)

When is MRI used?



Planning MRI:
Which targets are treated with EBRT radiotherapy?

Classic ITV approach



Which types of MRI scans are used?

Planning MRI

GTV	Intermediate/high signal **T2-weighted MRI signal** + clinical examination
CTV-LR Table 2. CTV components GTV: Entire GTV; intermediate/high signal seen on T_2-weighted MR images Cervix: Entire cervix; if not already included within GTV contour Uterus: Entire uterus Parametrium: Entire parametrium, including ovaries; include entire mesorectum if uterosacral ligament involved Vagina: Minimal or no vaginal extension: upper half of the vagina Upper vaginal involvement: upper two-thirds of the vagina Extensive vaginal involvement: entire vagina	**T2-weighted MRI**
CTV-E *Nodes and relevant draining nodal groups (common, internal, and external iliac and obturator and presacral lymph nodes).* *Inclusion of para-aortic lymph nodes will depend on the extent of disease and results of staging investigations.*	**T2-weighted MRI + CT**

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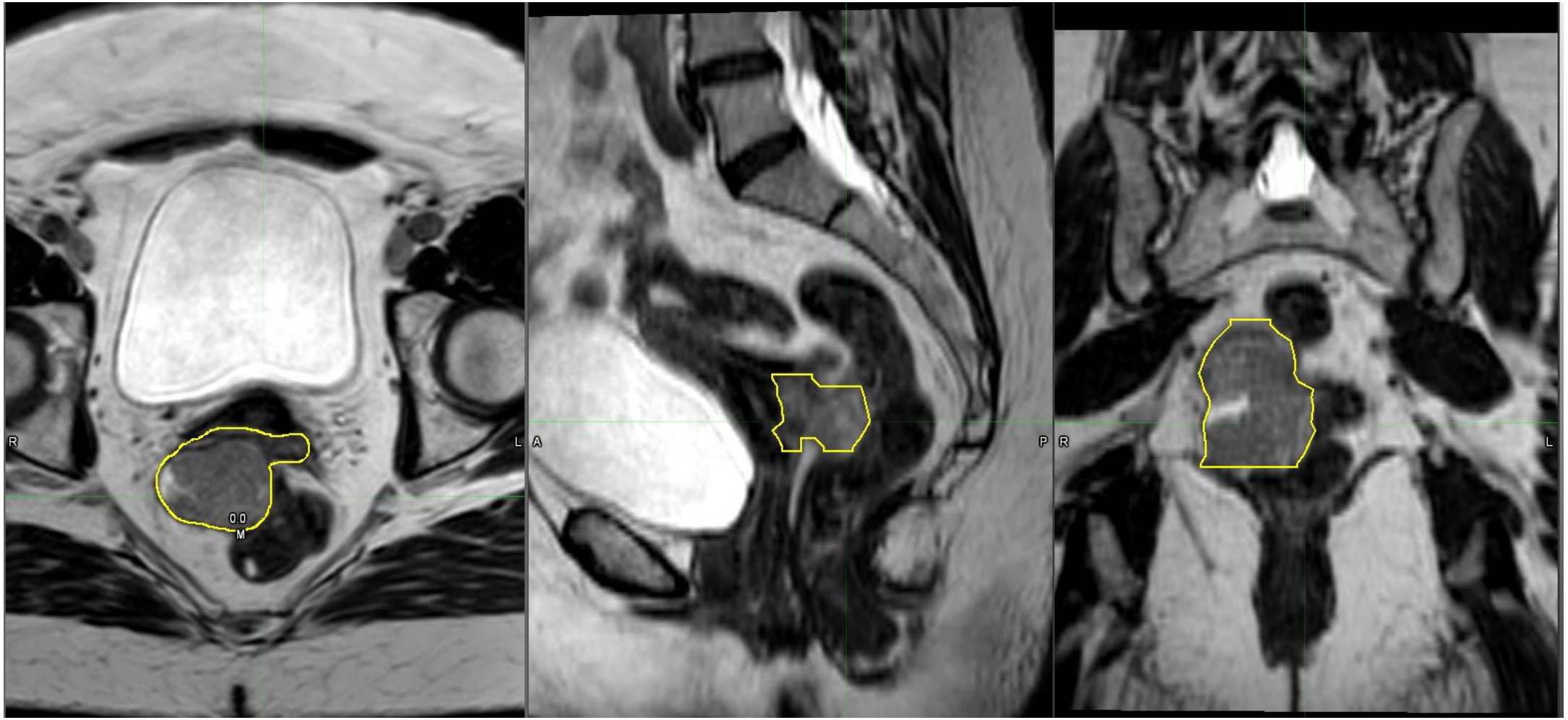
https://doi.org/10.1016/j.ijrobp.2009.10.075

Example images MRI - GTV

Planning MRI



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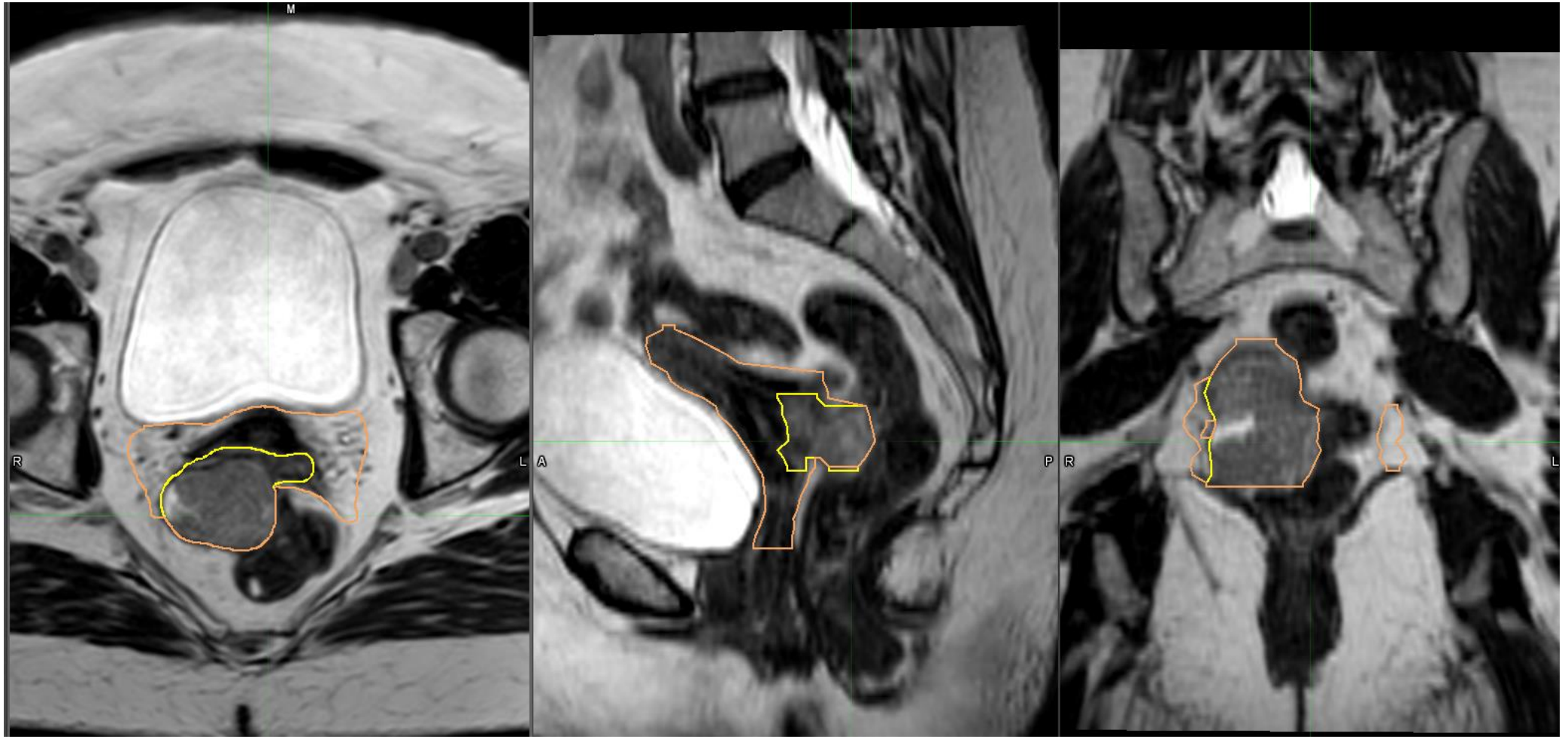
Example images MRI – CTV-LR

Planning MRI



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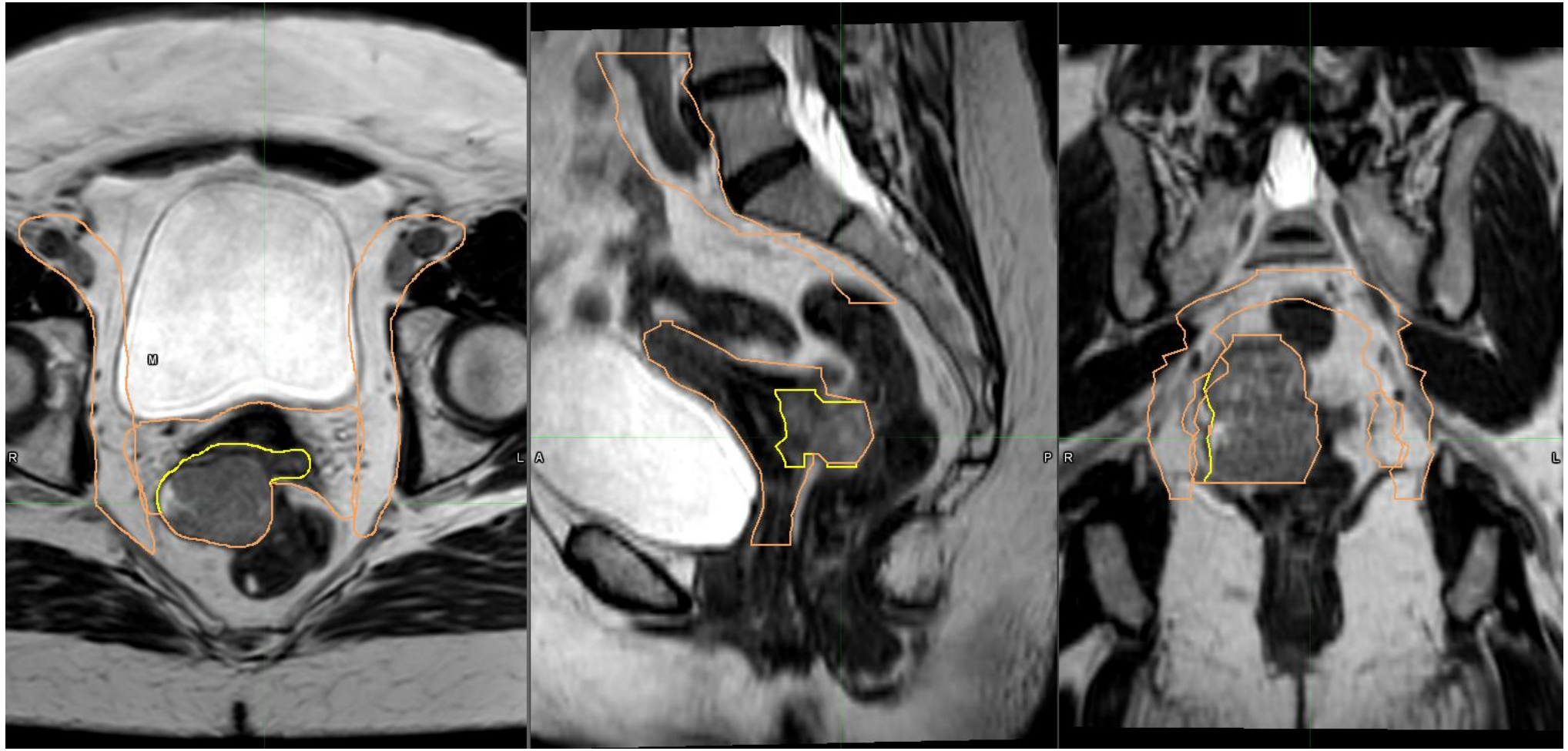
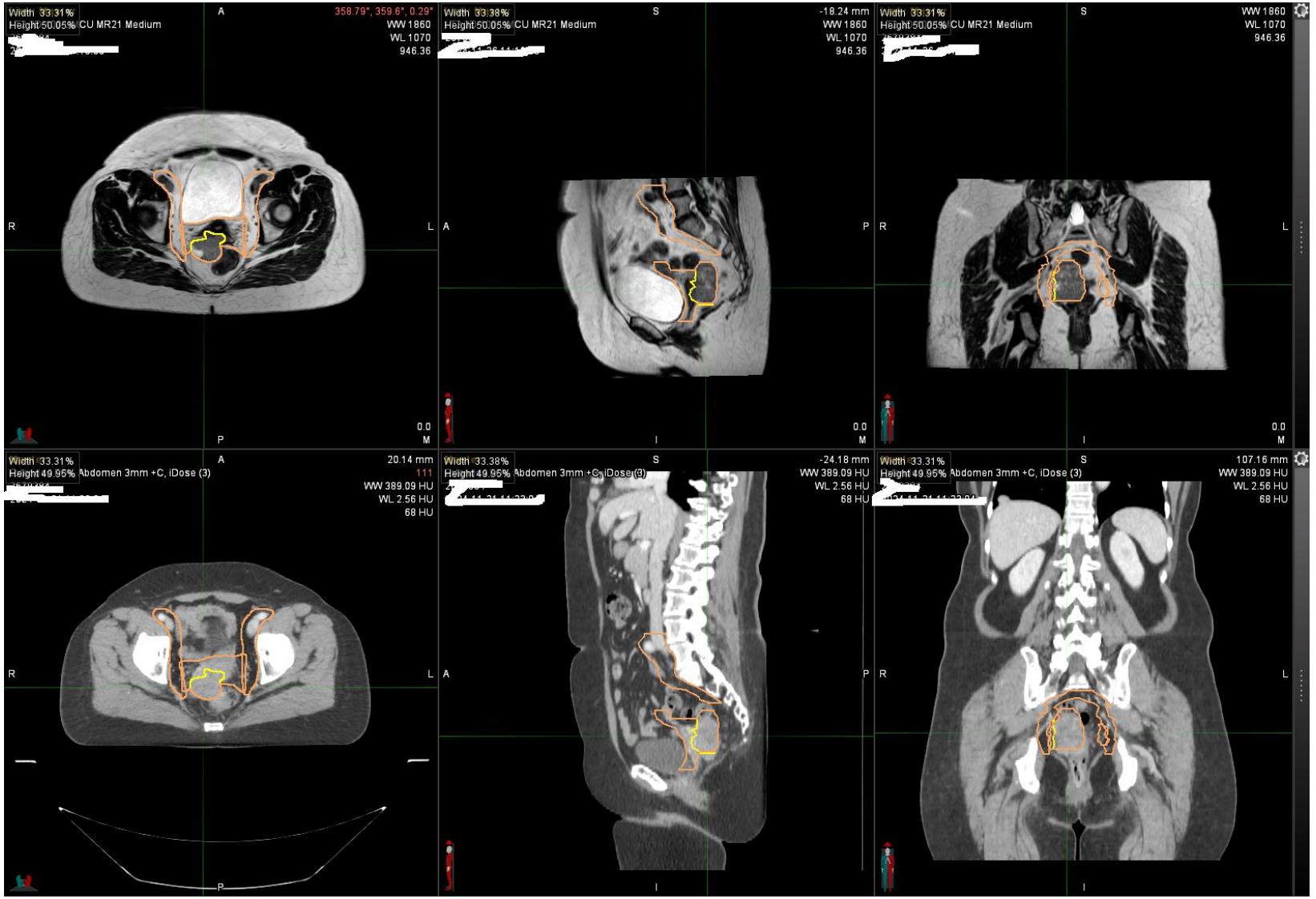
Example images MRI – CTV-E

Planning MRI



Example images MRI & CT –CTV-E

Planning MRI



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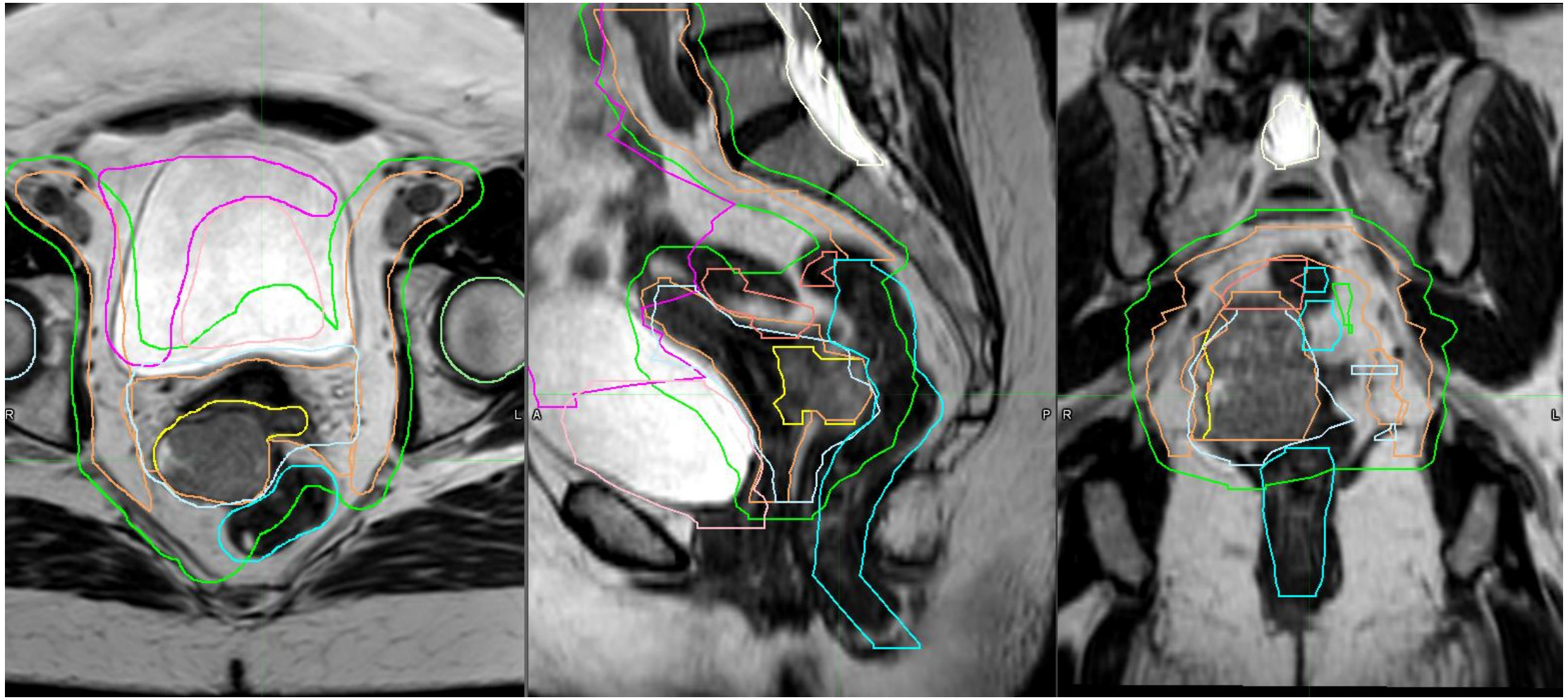
Complete delineation set

Planning MRI



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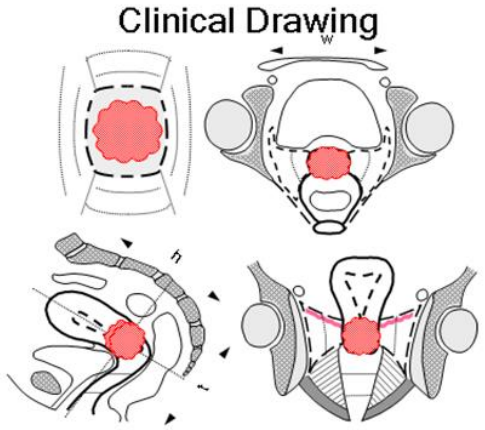
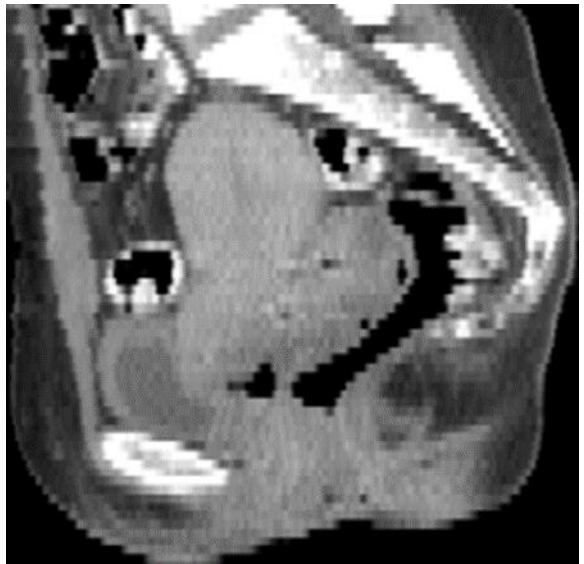
Why is MRI used, and not CT?



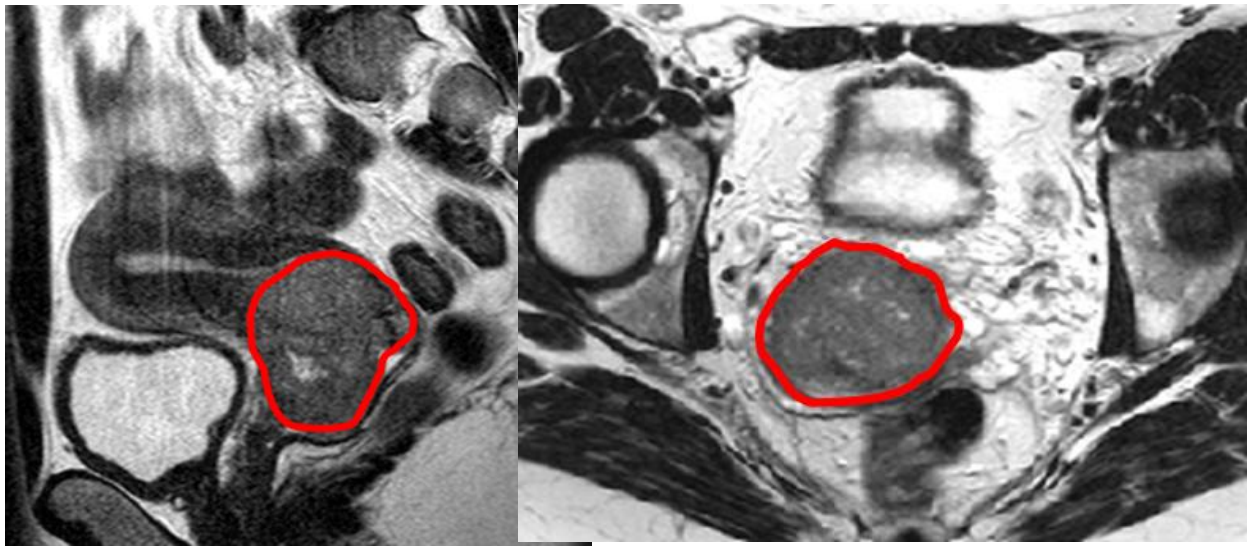
FIGO IB2, cT4a uterine corpus, rectum and bladder wall



Why is MRI used, and not CT? (2)

Advantage of MRI to define primary GTV - superior to clinical investigation and CT

- parametrial infiltration
- infiltration into the uterus
- infiltration into bladder and rectum



More MRI possible without radiation burden

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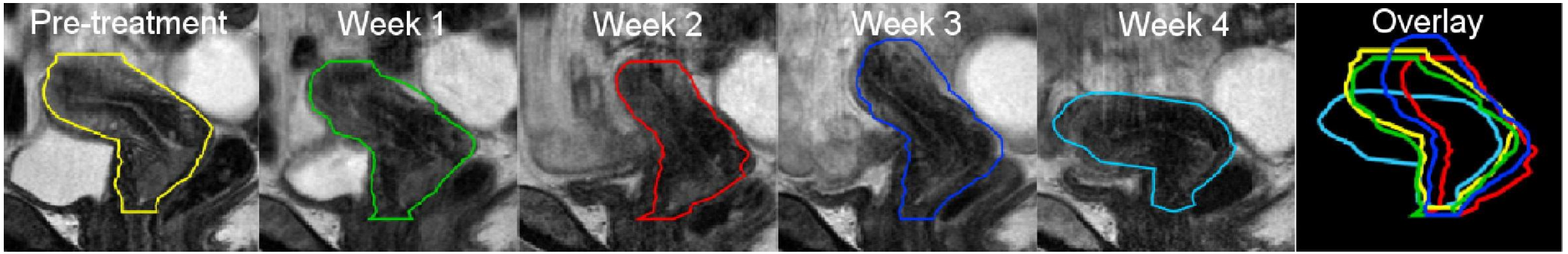
13

GTV = intermediate or high signal on T2 weighted MR images

Using MRI to estimate interfraction motion

Planning MRI

Uterus position is changes considerably from fraction to fraction



Radiotherapy and Oncology
Volume 88, Issue 2, August 2008, Pages 241-249

IMRT in cervical cancer

Online MRI guidance for healthy tissue sparing in patients with cervical cancer: An IMRT planning study

Ellen M. Kerkhof, Bas W. Raaymakers, Uulke A. van der Heide, Linda van de Bunt, Ina M. Jürgenliemk-Schulz, Jan J.W. Lagendijk

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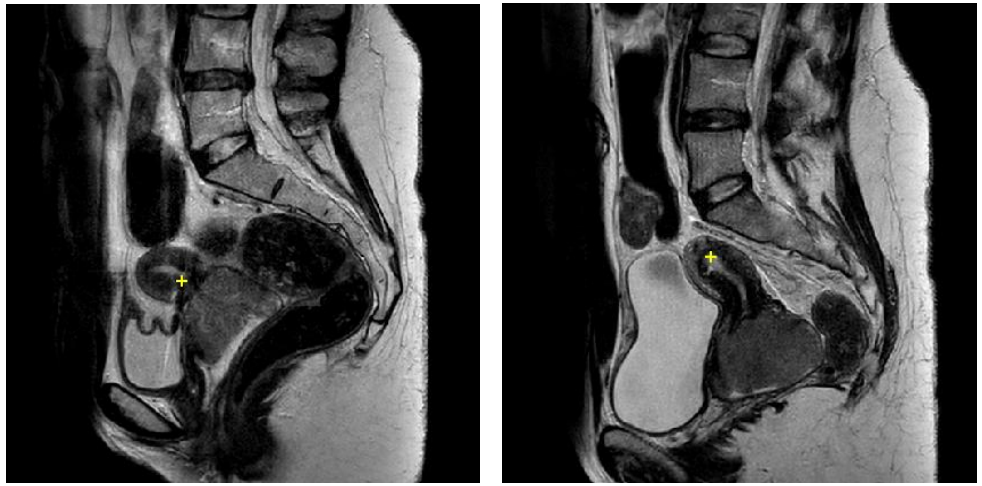
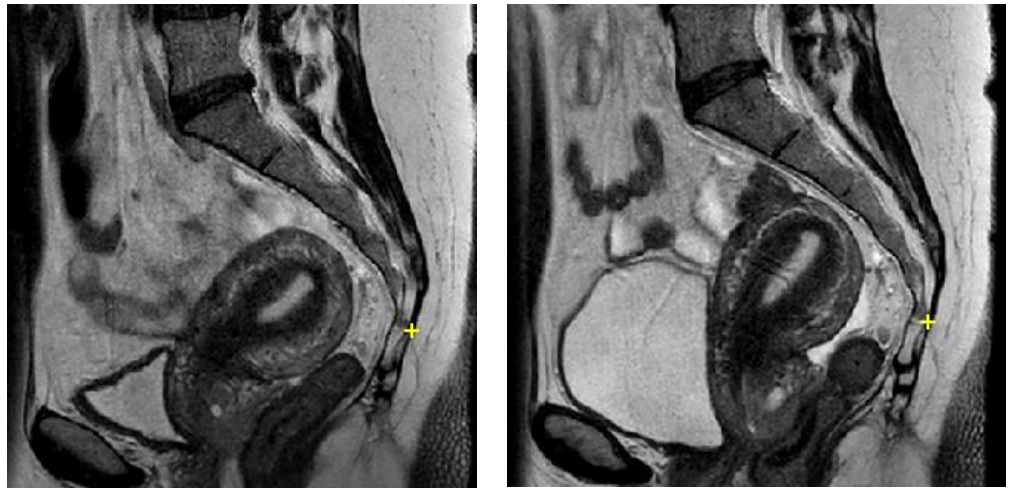
Simulating interfraction motion

Planning MRI

MRI scan with different bladder filling - sagital T2w MRI or high resolution 3D



Example 1



Example 2

MRI and interfraction motion - ITV

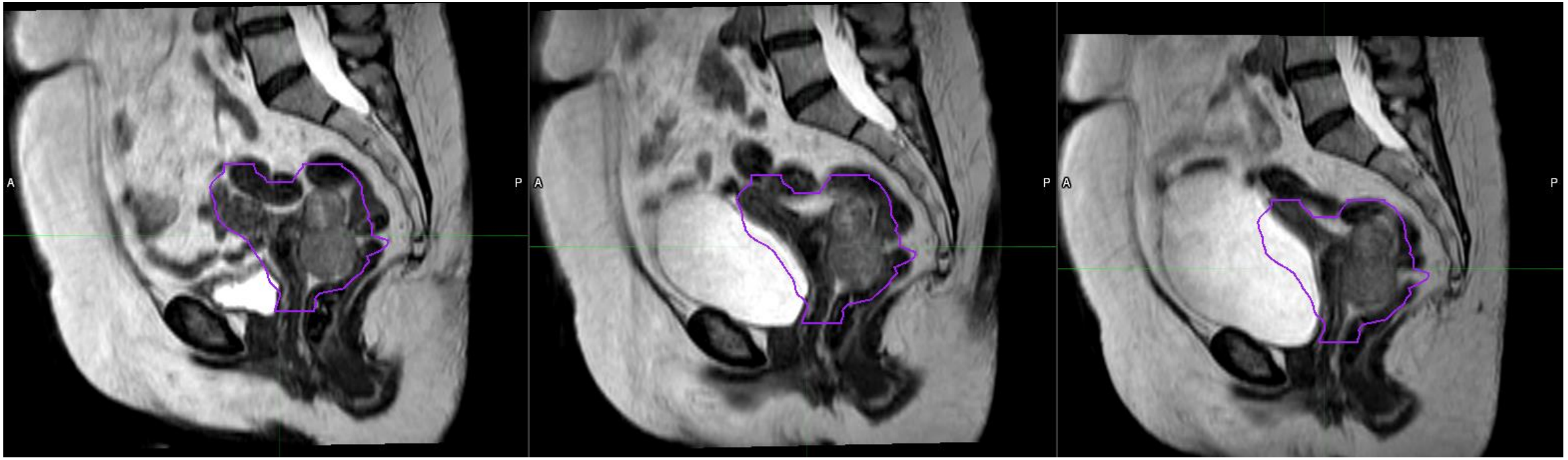
Planning MRI

Three bladder filling

Empty

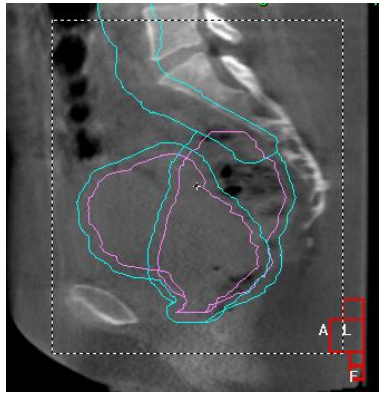
Medium

Full



MRI and interfraction motion - LoP

Planning MRI



Example 2a

Week 4 MRI

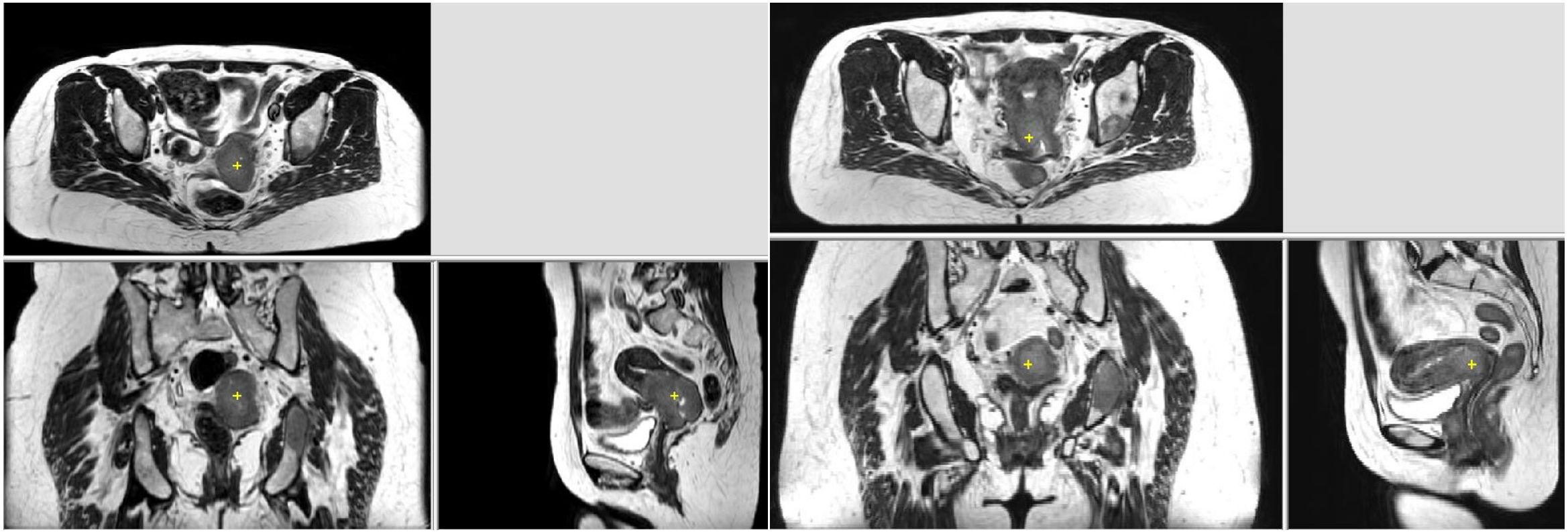
Initial treatment response

Tumor response

Week 4 MRI

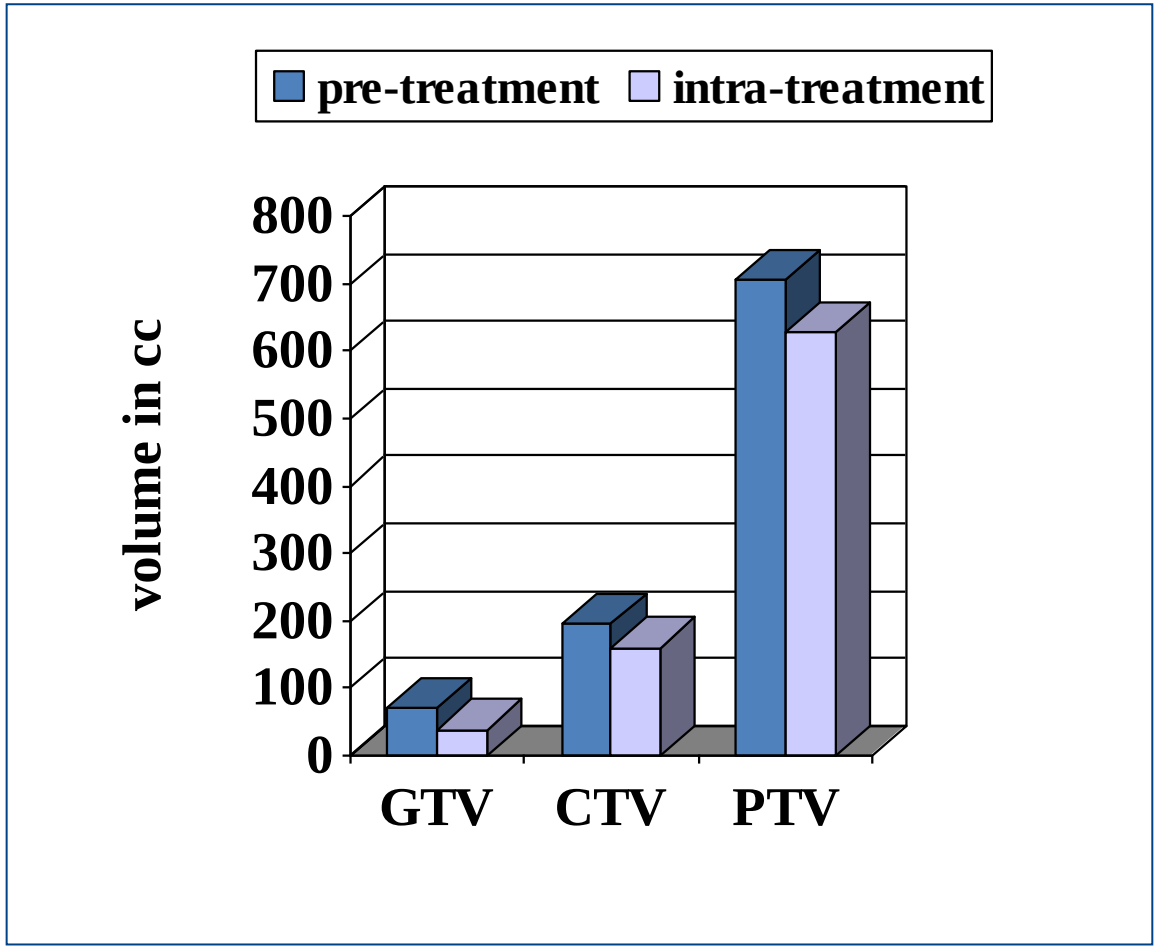
Pre-treatment

Week 4 Chemoradiation



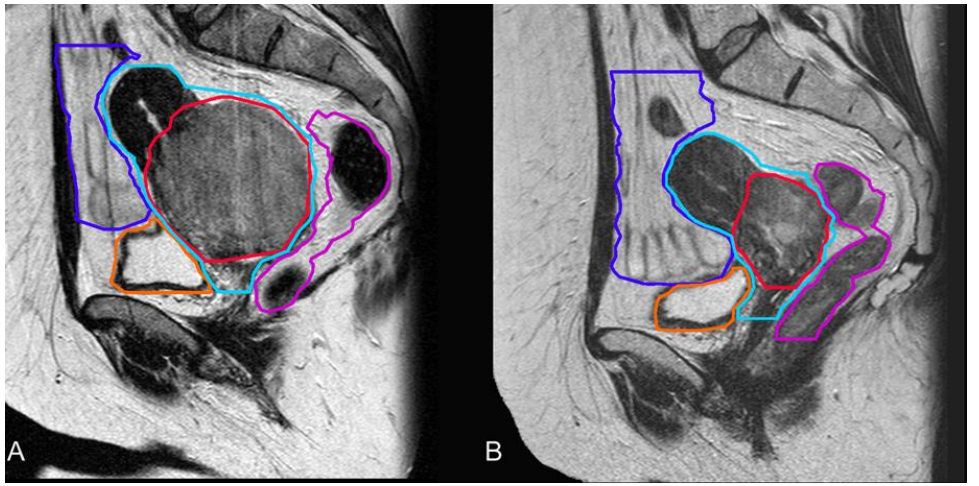
Tumor response = volume reduction

Week 4 MRI



Before treatment

After 30 Gy EBRT



Average decrease in volume after 30 Gy

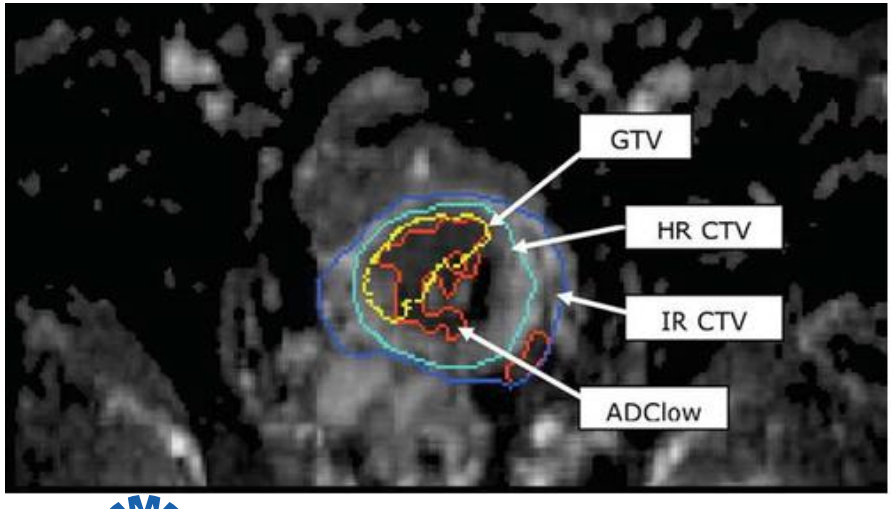
GTV	49.2%
CTV	13.4%
PTV	9.7%

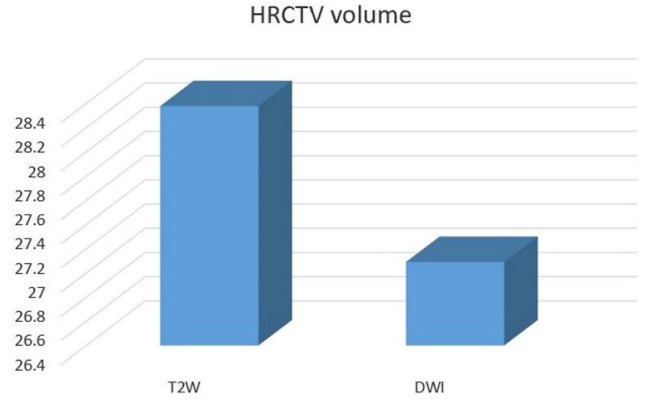
Data: Ina Schulz

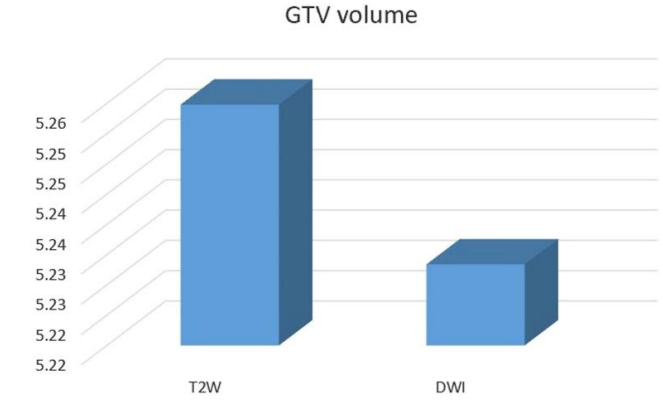
Role of Diffusion Weighted imaging

Week 4 MRI

- Highlights suspicious regions @ time of BT
  - Additional information for grey zone boundaries on T2 weighted MRI
- Cannot be used as stand alone image
  - No anatomical information of OARs
  - Geometrically less accurate due to acquisition method
  - Different volumes are visualized







Haack et al, Acta Oncol 2010
https://doi.org/10.3109/0284186X.2010.500619

https://doi.org/10.1016/j.rpor.2020.08.008

Accounting for treatment response

Week 4 MRI

CT for EBRT

RED per structure

Expected technical challenges

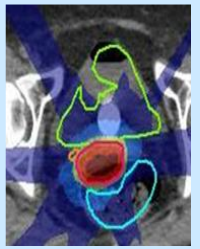
MRI scan @ week 4 concomitant chemoradiotherapy

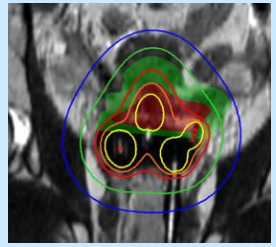
MRL planning (*offline*)

Ineligble for brachy

Plan comparisson

Brachy test plan





MAGENTA
MRL versus BT dose planning

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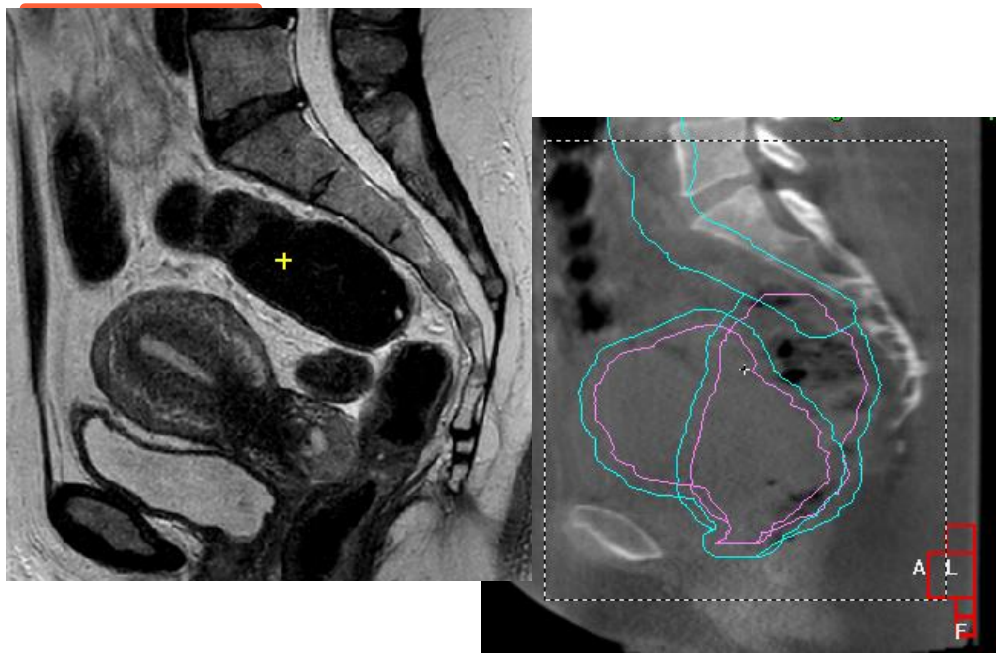
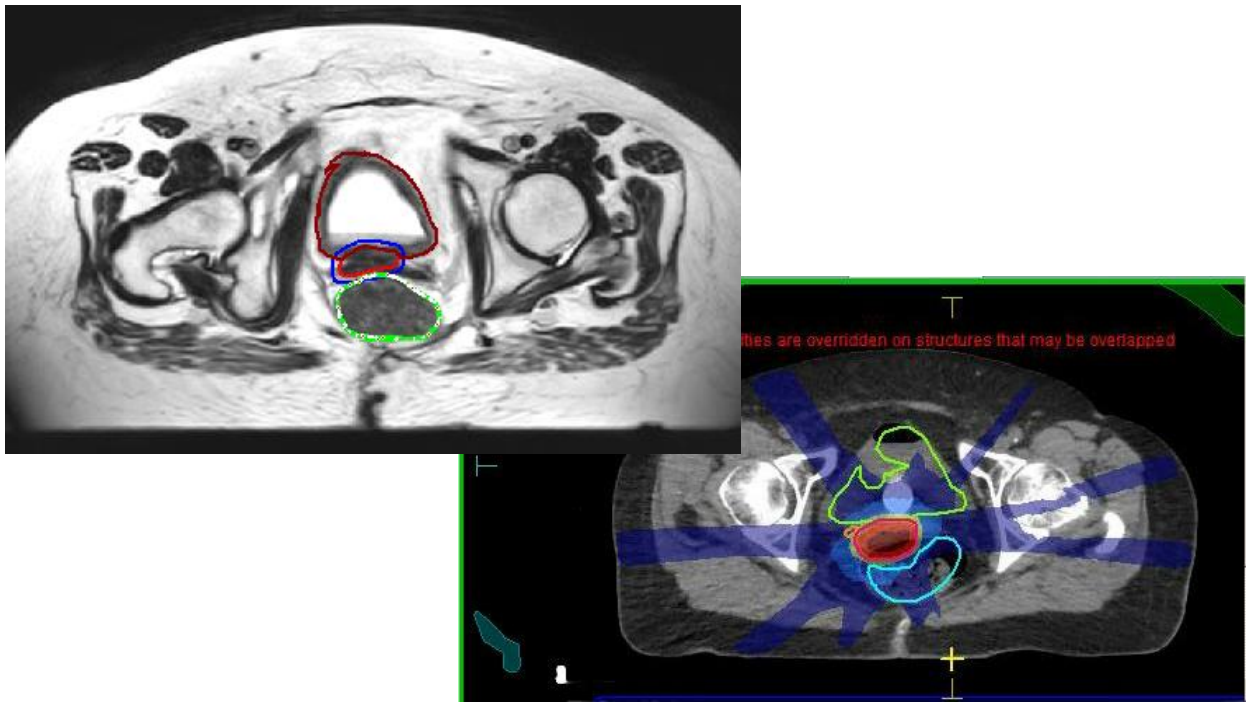
Why move to MRL and not CBCT-Linac?





CBCT-linac
- Visualization of tumor and OARs very limited
- Dose distribution cannot be adapted precisely

Large field required

Achievable dose to tumor is limited to prevent toxicity
E.g. 12x2 Gy, <70 Gy EQD2

MR-linac
- Good visualization of tumor (GTV) and remaining microscopic tumor (CTV-HR)
- Good visualization of surrounding OARs
- Dose distribution can be adapted to daily anatomy
- Intrafraction motion monitoring and adaption

Dose levels close to brachytherapy **may** be achievable

MRLinac treatments: accounts for all online changes

MR-guided brachytherapy & MRLinac

Interfraction motion	✓
Tumor regression during radiotherapy	✓
Delineation guidelines for MR imaging	✓

MRLinac specific

Intrafraction motion	✓

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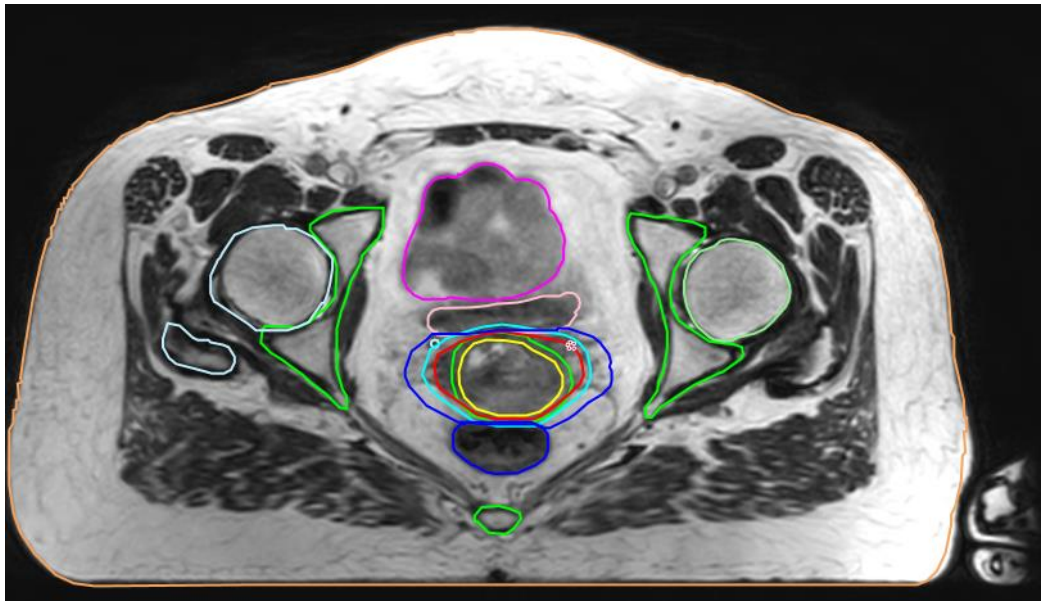
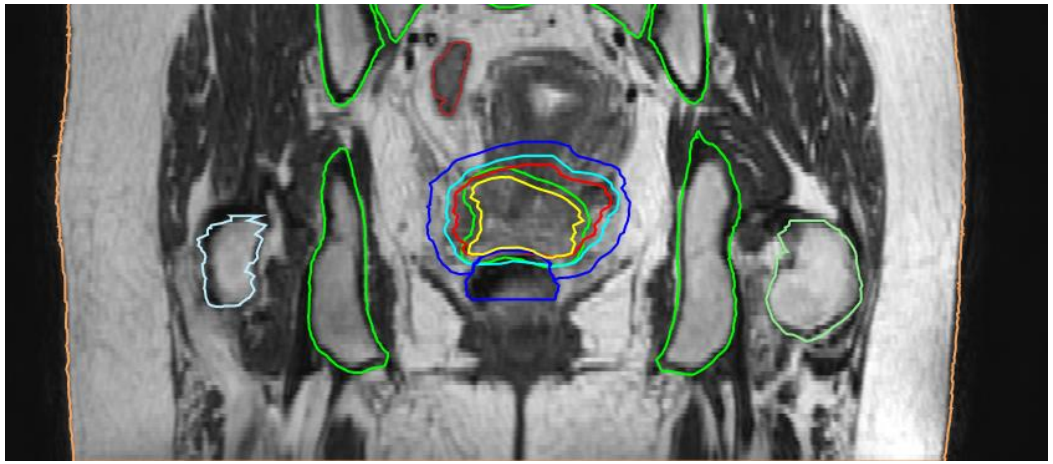
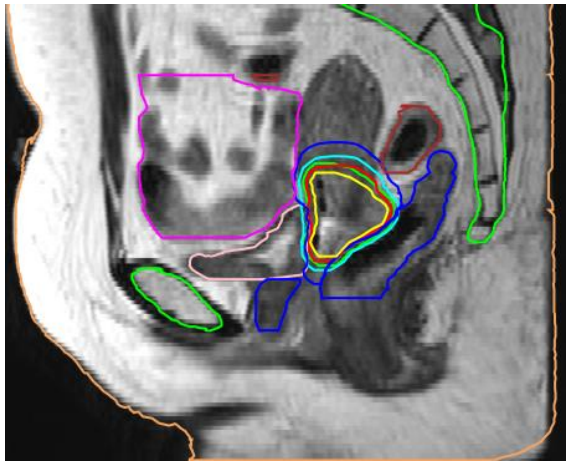
Pretreatment delineation



3D T2 weighted scan
FOV in RL should be large (often > 450 mm)

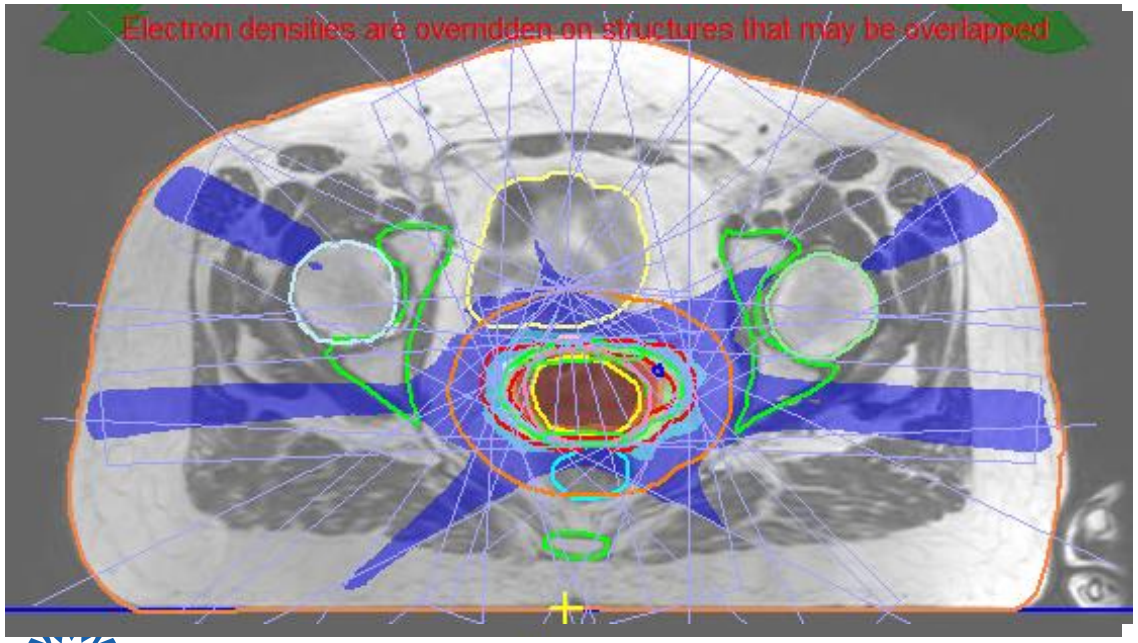
Obtain additional scans if needed (e.g. DWI)
-> not possible to use online





Online delineation

Only T2w scans available
Good contrast for targets and OARs



Intrafraction motion: BT vs. MR

	BT	MRL
Applicator	✓	✗
Target-to-radiation source/beam motion	✗	✓

Intrafraction motion

T2 weigthed cine scan
New image every 2 seconds
(sagital + coronal)

Enables **base line shift** only when needed!

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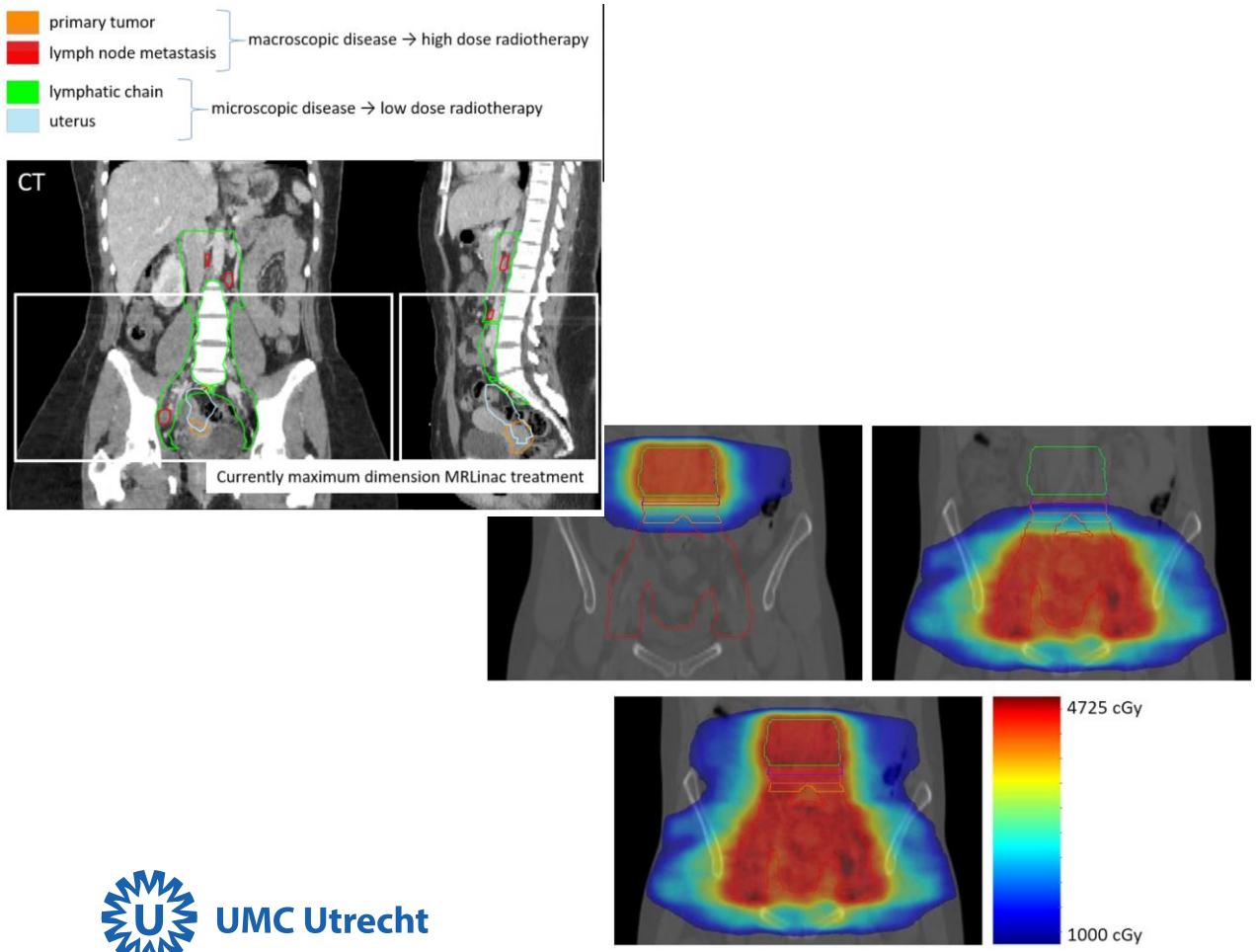
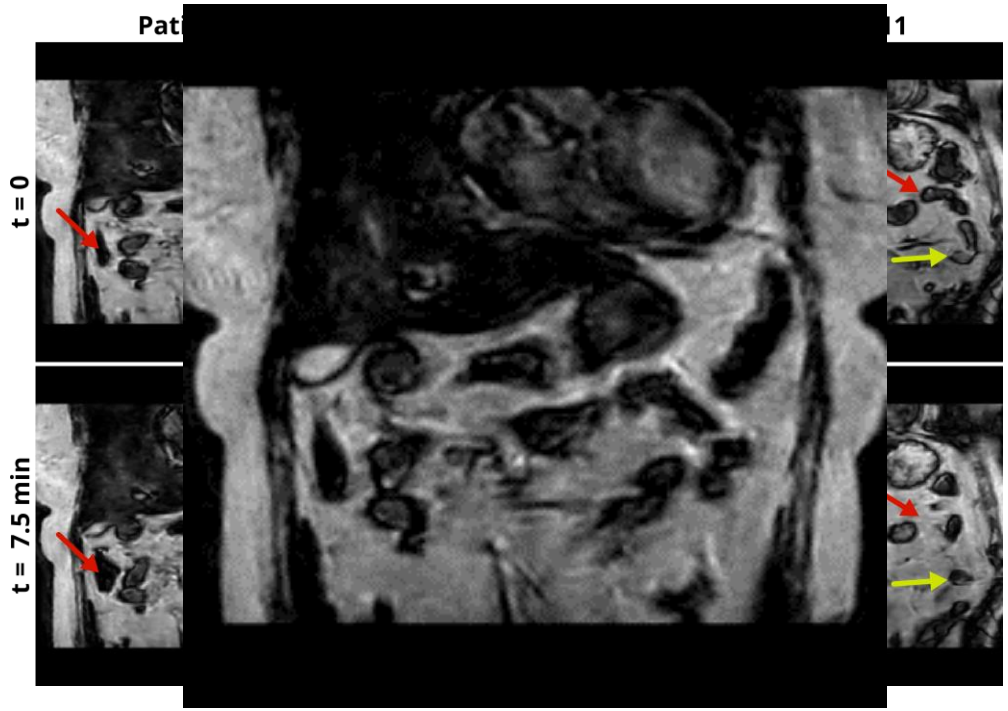
Future MRI challenges

MRLinac for complete treatment?



1. *Chuter et al., 2017*
2. *Chuter et al., 2023*

Bowel imaging – dynamic behaviour



ACCEPTED MANUSCRIPT • OPEN ACCESS

Bowel tracking for MR-guided radiotherapy: simultaneous optimization of small bowel imaging and tracking

Saskia Laura Corry Damen, Astrid L H M W van Lier, Cornel Zachiu and Bas W Raaymakers

Accepted Manuscript online 28 February 2025 • © 2025 The Author(s). Published on behalf of Institute of Physics and Engineering in Medicine by IOP Publishing Ltd

What is an Accepted Manuscript?

DOI 10.1088/1361-6560/adbbac

Summary

Planning MRI

Week 4 MRI

'Online' MRI

Follow up

T2w	GTV CTV-LR OAR
Repeated T2w (bladder filling)	ITV or LoP delineation
Large FOV	*CTV-E* *LN+*

T2w	GTV CTV-HR OAR
DWI	GTV CTV-HR

T2w	GTV CTV-HR OAR
Cine	Intrafraction motion tumor
Cine – 3D	*Bowel motion*
Larger FOV	*CTV-E, LN+*

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Cursive = to be developed/evaluated

Questions

Acknowledgements:
Femke van der Leij
Ina Schulz
Saskia Damen

and the gyn team @ UMC Utrecht