

Universitätsklinik für Radioonkologie

Sektion Biomedizinische Physik

# Neue Möglichkeiten der MR-geführten adaptiven stereotaktischen RT

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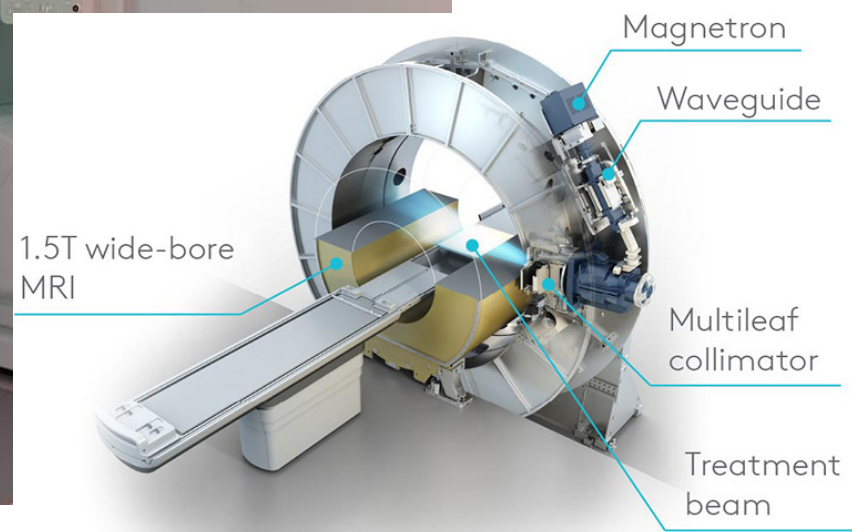
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# Online MR-geführte adaptive RT mit dem 1.5 T MR-Linac



Unity, Elekta AB, Sweden



Source: [www.elekta.com](http://www.elekta.com)





# Online MR-geführte adaptive RT mit dem 1.5 T MR-Linac



**Unity**, Elekta AB, Sweden



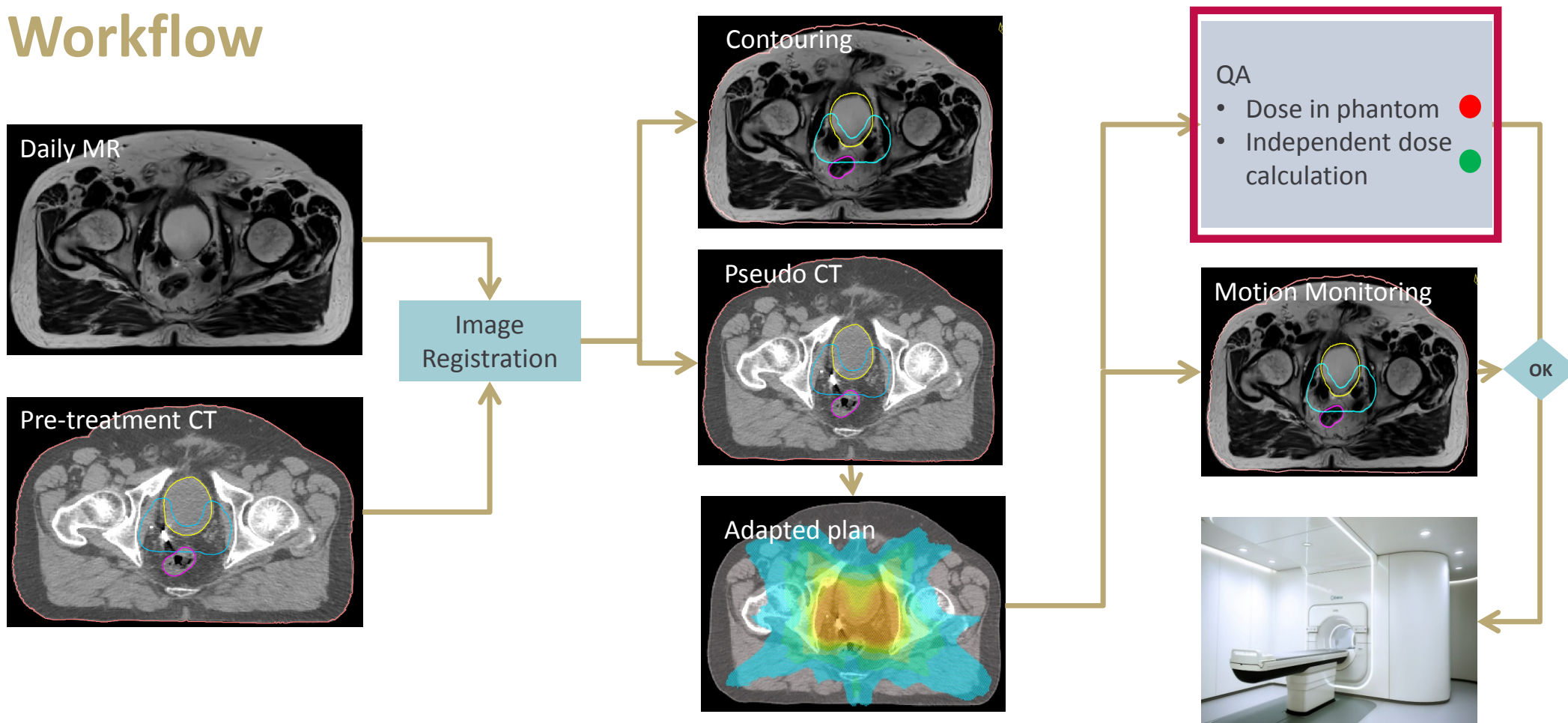
# Technical Performance of the MR-Linac

	<b>Elekta Versa HD</b>	<b>Elekta MR-Linac</b>
Distance focus – IC (cm)	100	144
IMRT technique	VMAT	Step and Shoot
Photon energies (MV)	6 / 15	7
Flattening filter	FF and FFF	FFF
Leaf width (mm in IC)	5	7.2
Leaf travel direction	Arbitrary	Cranio-caudal
Field size (cm in IC)	40 × 40	22 (cranio-caudal) × 56
Rotation	+/- 180° (1 RPM)	Continuous (6 RPM)
IC position	Arbitrary	Limited
On-board imaging	CBCT / PI	MRI / PI

IC: Isocenter  
 FFF: Flattening Filter Free  
 CBCT: Cone-beam CT  
 PI: Portal Imaging



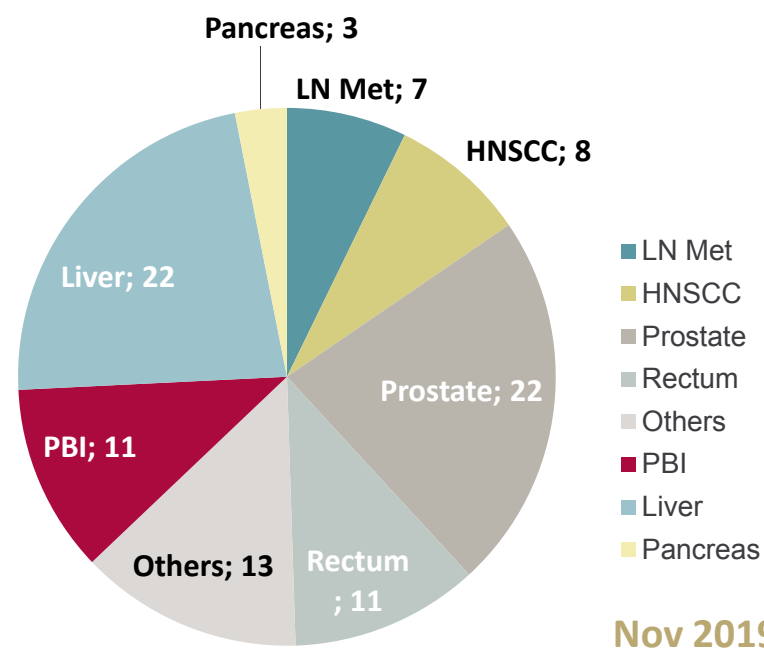
# MR-guided adaptive RT: Workflow



# More than 1 year of clinical experience with online MRgRT



July 2019

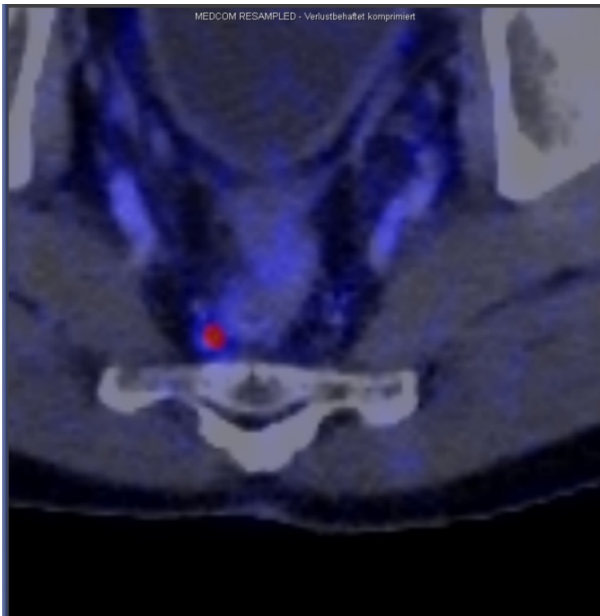




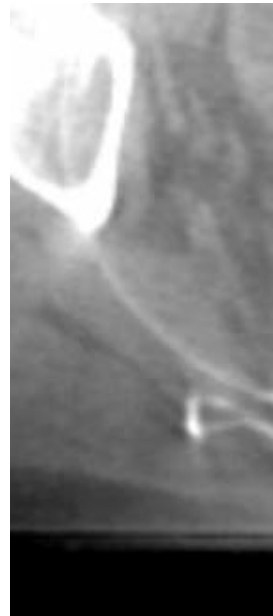
# Key advantages of MR-guided RT:

## 1. High resolution MRI with excellent soft tissue contrast

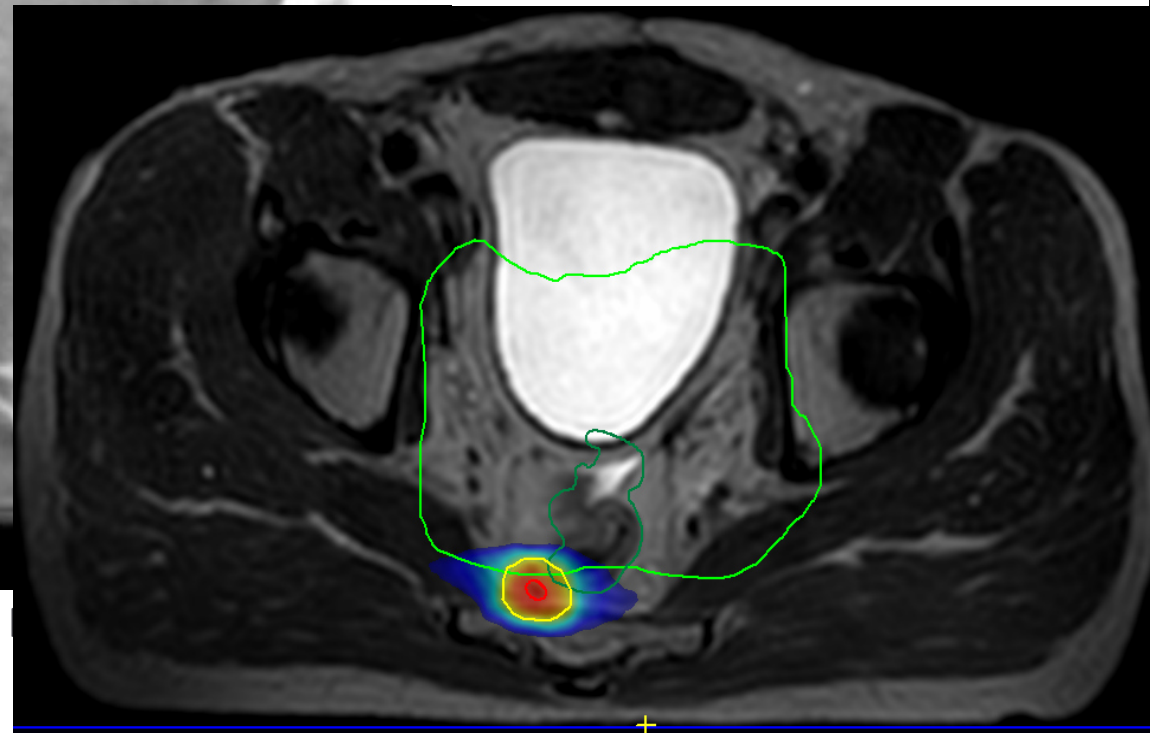
Online MR-based RT adaptation  
SBRT, 7 Gy/ fraction



Diagn. PSMA PET/CT



X-ray guided



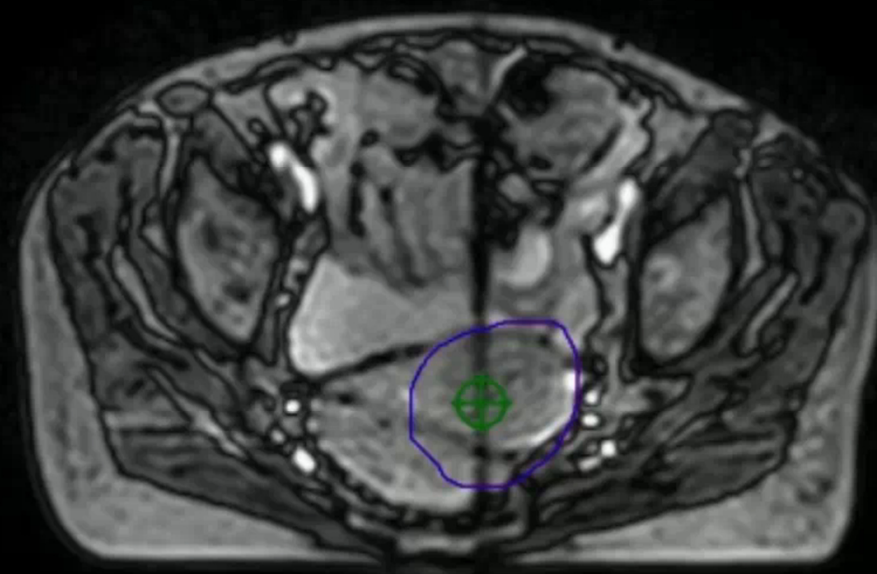
## Key advantages of MR-guided RT: 2. Intra-fraction motion assessment



*manual gating*



**Beam on!**  
Treatment interrupted  
Ready to treat



courtesy M. Nachbar



# Future perspectives: stereotactic RT of primary PC

Widmark A, et al. Lancet 2019; 394(10196):385-395.

- HYPO-RT PC
- Randomized, non-inferiority, phase 3 trial
- N=1180 patients
- Conventional fractionation (39 fx) vs. ultra-hypofractionation (7 fx)
- No difference in 5y PSA control

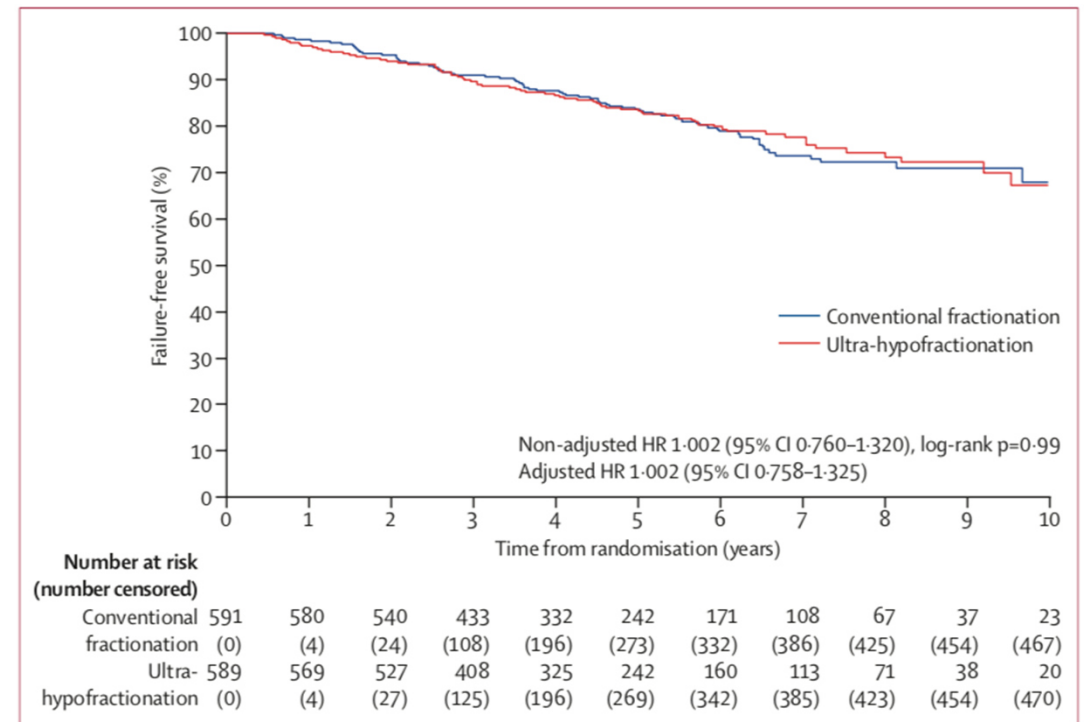
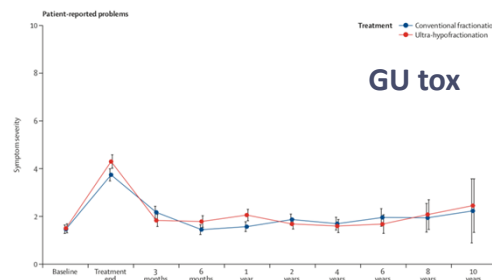
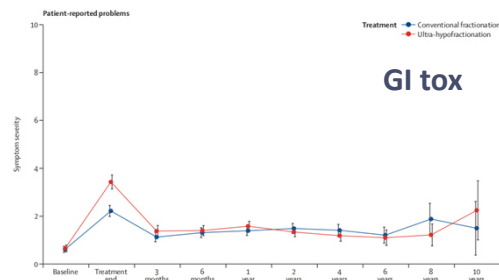


Figure 2: Failure-free survival  
HR=hazard ratio.

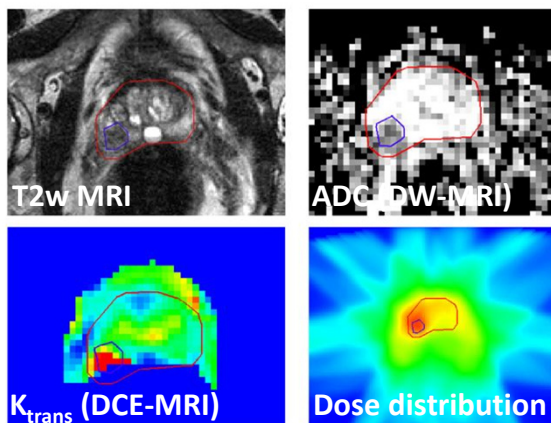




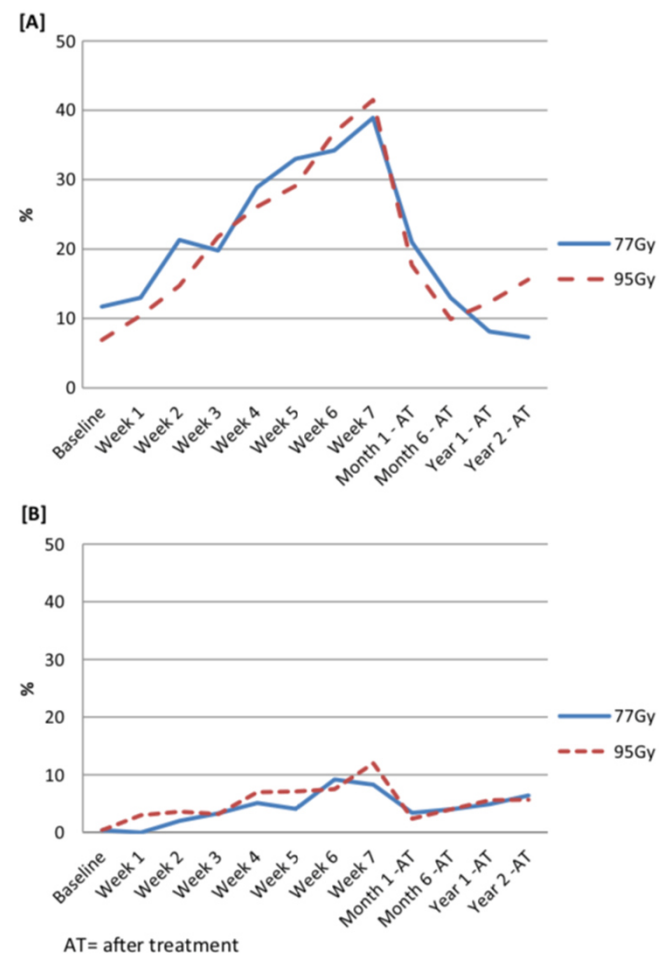
# Stereotactic boost /dose escalation to intraprostatic lesion

Monnikhoff EM, et al. Radiother Oncol 2018;127(1):74-80.

- FLAME trial
- Conventional treatment (77 Gy) vs. Boost of up to 95 Gy to dominant lesion
- No increase in toxicity



Lips IM, et al. Trials 2011;12:255.



# Technical requirements for MR-guided adaptive SBRT

## MR-guided adaptive SBRT

- High geometrical accuracy of MRI data (<1mm)
- Accurate dosimetry in B-field
- Methods for fast online plan-QA

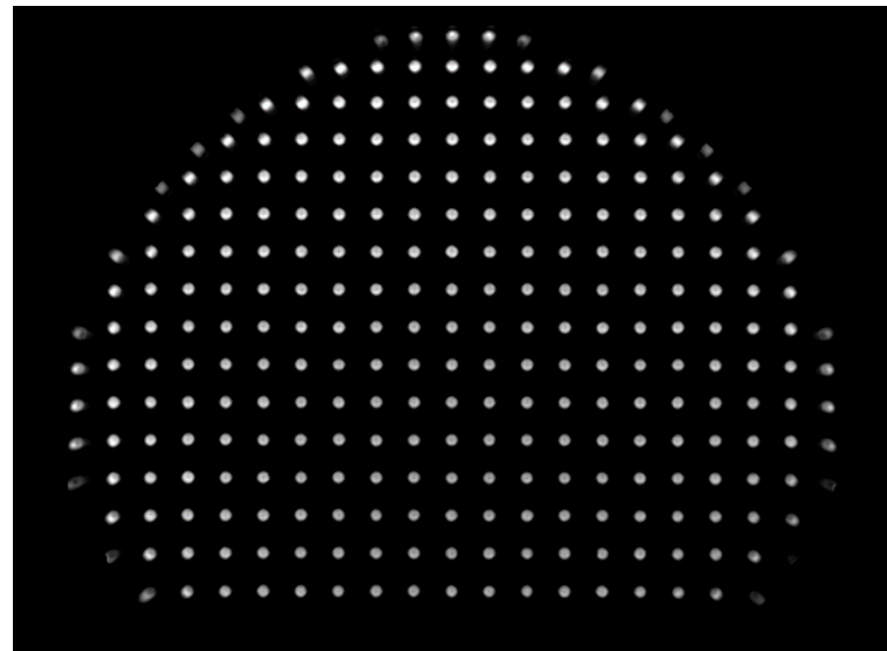
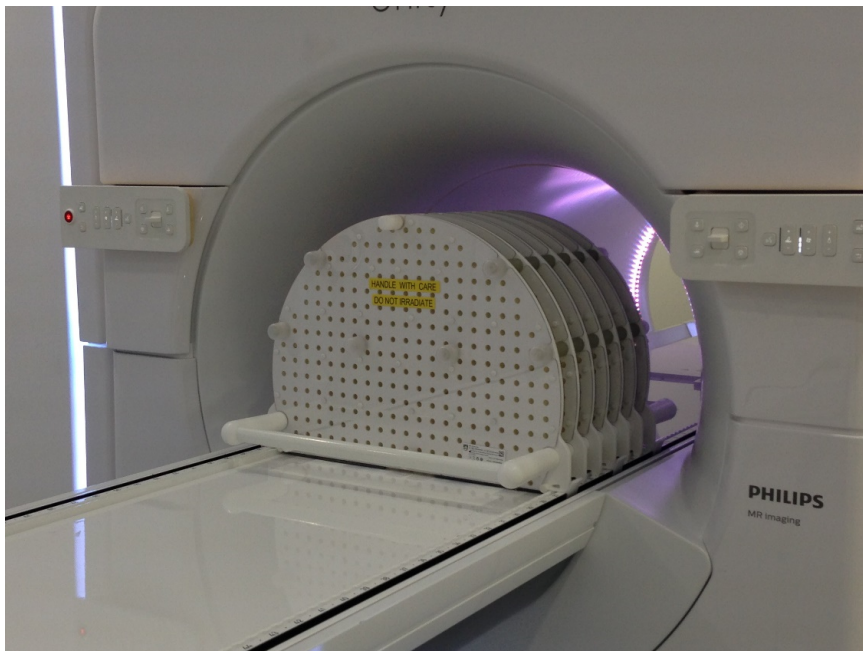
## Functional MR-based dose escalation to dominant lesion

- Robust and reproducible quantitative MR imaging



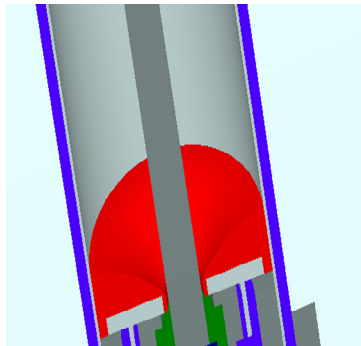
# Assessment of geometrical distortion and MR-QA at the 1.5T MR-Linac

- Geometry / Distortions
- Homogeneity
- Signal-to-noise



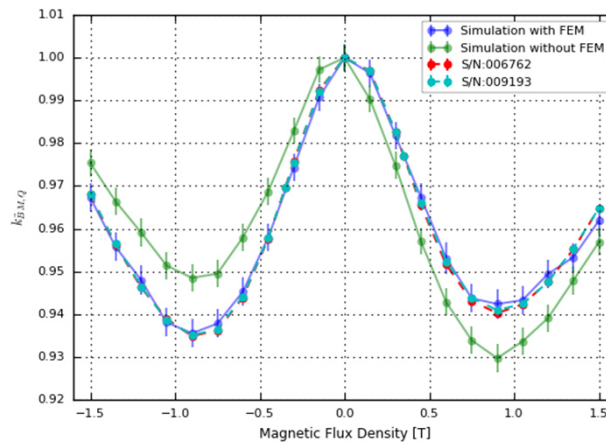
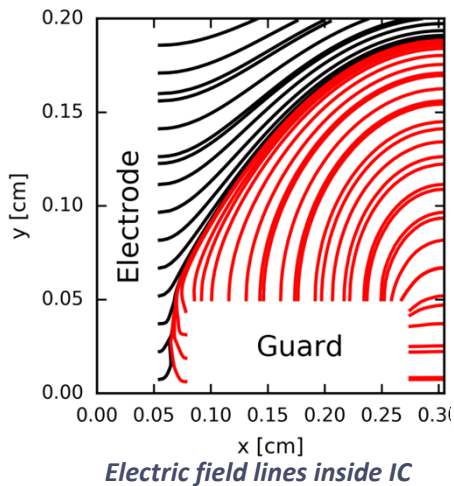
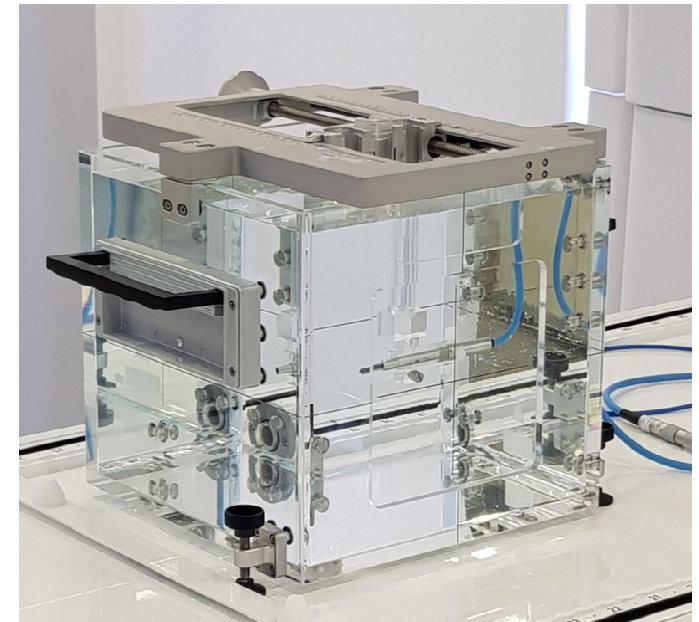


# Absolute dosimetry in MR-guided RT



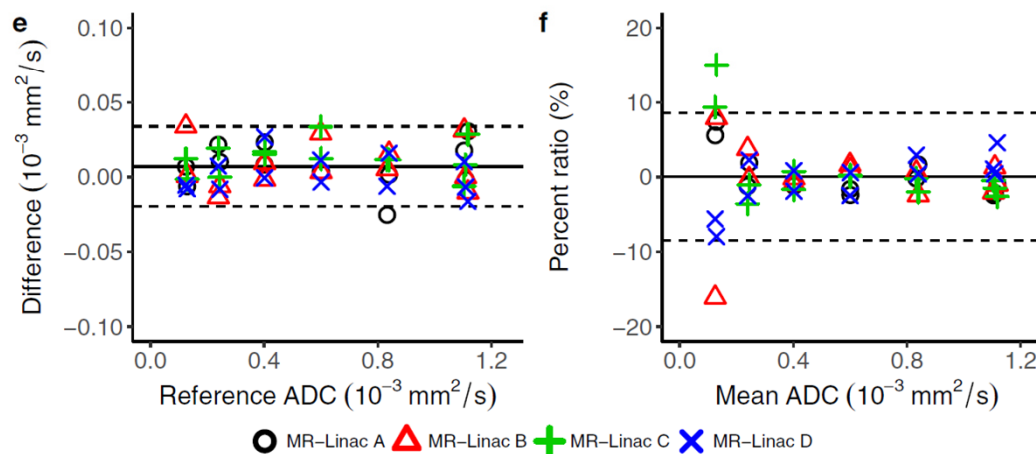
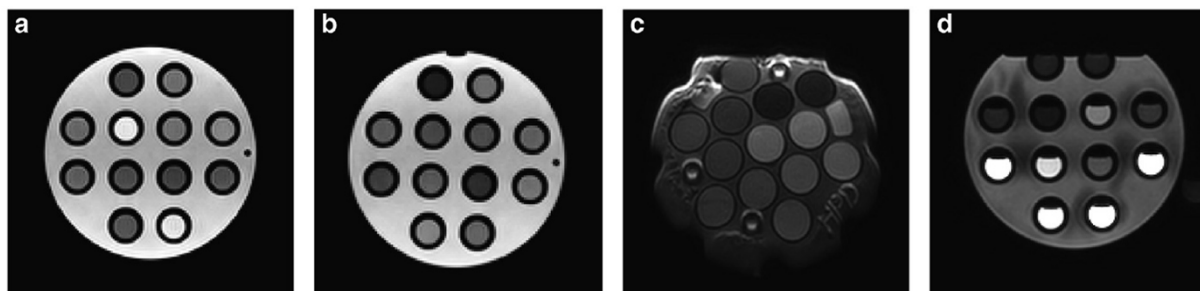
Dead volume inside IC

- Simulation of correction factors for ionization chambers
- Validation measurements for different chambers (PTB Braunschweig)



# Quantitative MR-Bildgebung (qMRI) am MR-Linac

- Untersuchung der quant. MR-Bildgebung (qMRI) an MR-Linac Systemen
- Ermittlung von Genauigkeit, Wiederholbarkeit und Reproduzierbarkeit von **T1**, **T2**, **ADC** und **DCE**
- qMRI am MR-Linac ist möglich



QIBA-Phantom

Kooreman E, et al. Radiother Oncol 2019; 133:156-62.



# Conclusion

## Promising new opportunities of real-time MR-guided adaptive RT

- > excellent MR image quality: better visualisation of target and OAR
- > real-time workflow for MR-guided adaptation, MRI for motion monitoring
- > functional imaging
- > dose-accumulation in target and OAR

## High potential as a facilitating technology for SBRT

- > fraction number reduction
- > margin reduction: lower OAR dose or higher target dose
- > individualized dose concepts through repeated anatomical and functional imaging (response-adaptive MRgRT)





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