MR Linac and prostate cancer

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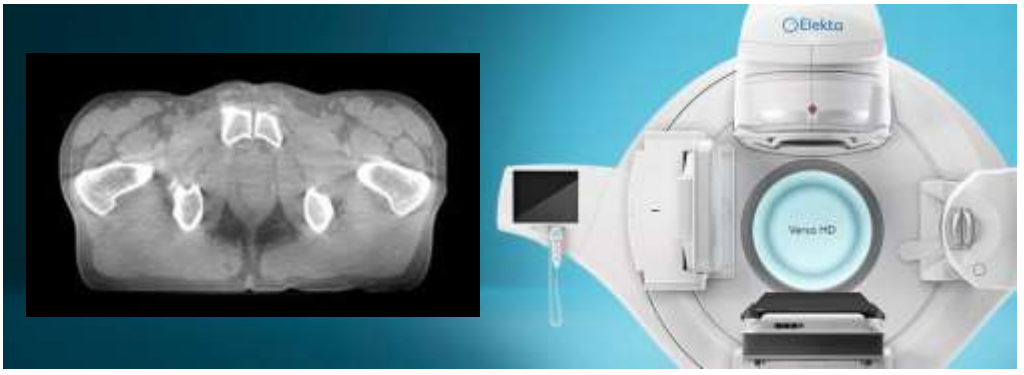
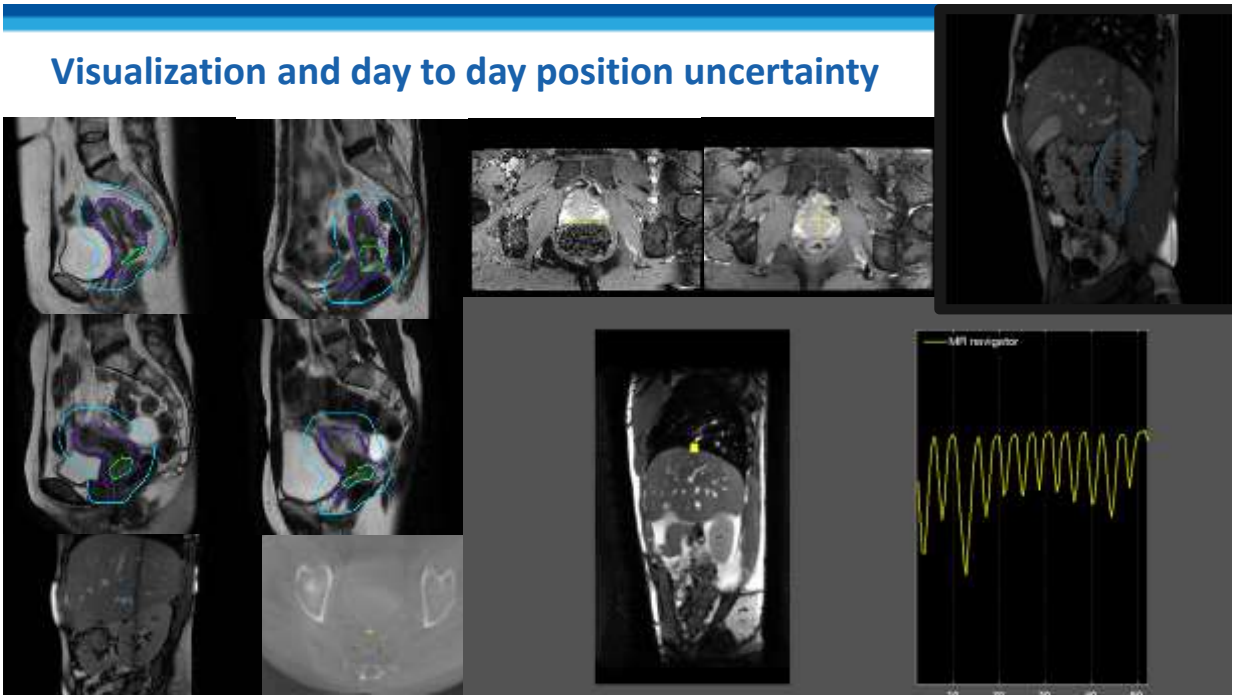
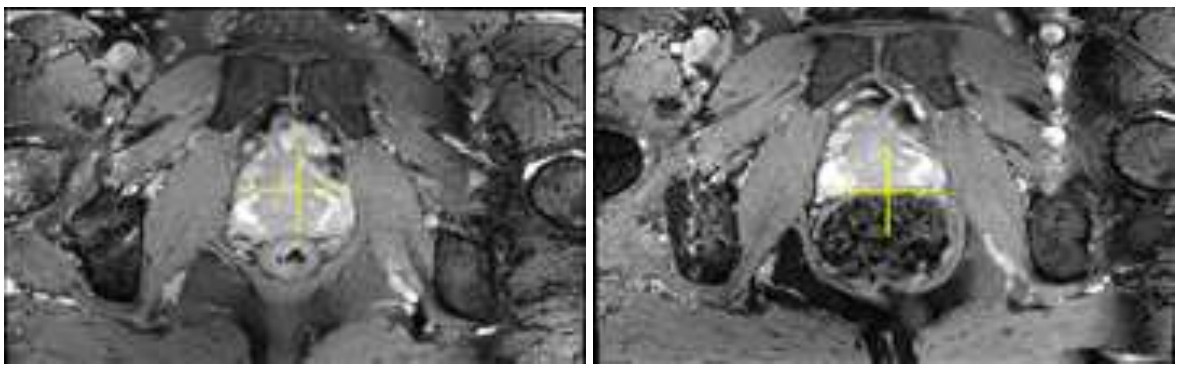
Conventional Radiotherapy: Cone-beam CT



Visualization and day to day position uncertainty



Prostate day to day position uncertainty



Uncertainty kills dose painting

Courtesy Dirk Verellen

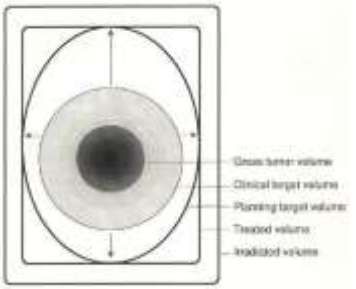
Uncertainty results in:

- Wide margins, large treatment fields, homogeneous dose
- Normal tissue complications which limit tumour dose
- Fractionated treatments
- Often the combination with surgery to remove local gross tumour volume

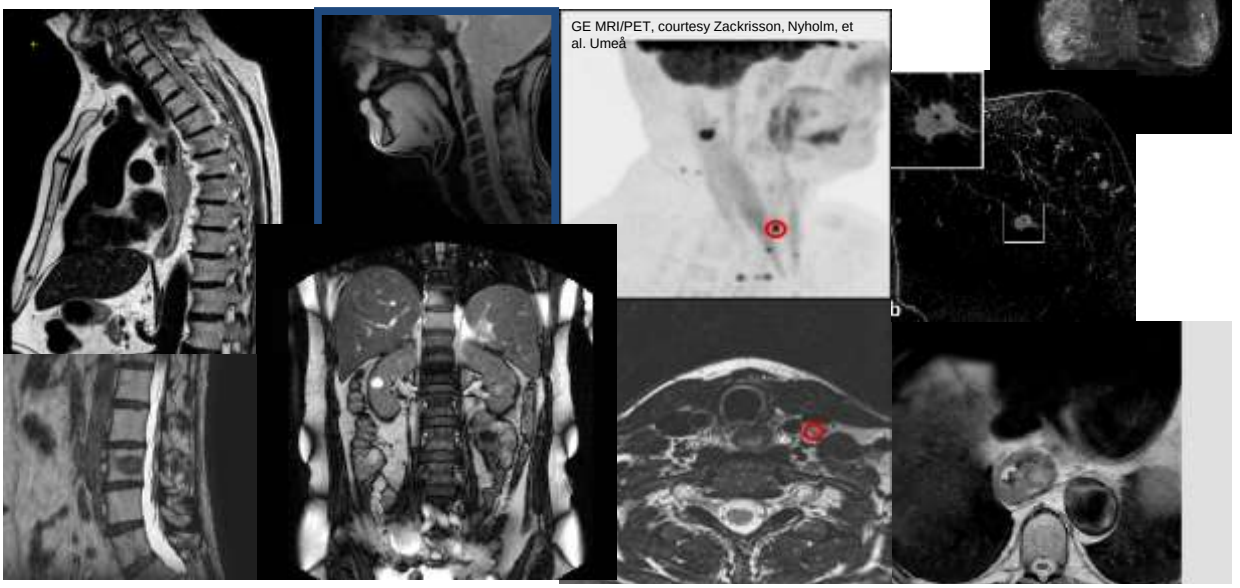
Continuous effort to improve positioning

- Implanted gold fiducials
- CBCT, bony structures

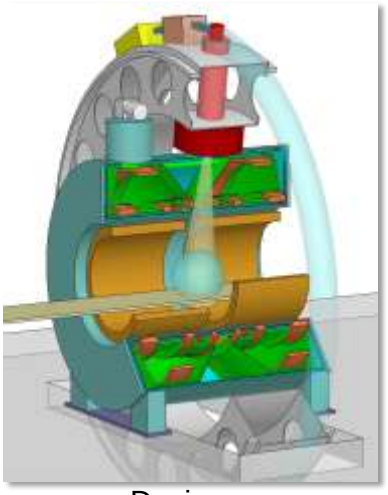
ICRU-50



MRI guided Radiotherapy, see what you treat



MR linac system: combination
1.5T MRI and 7MV accelerator

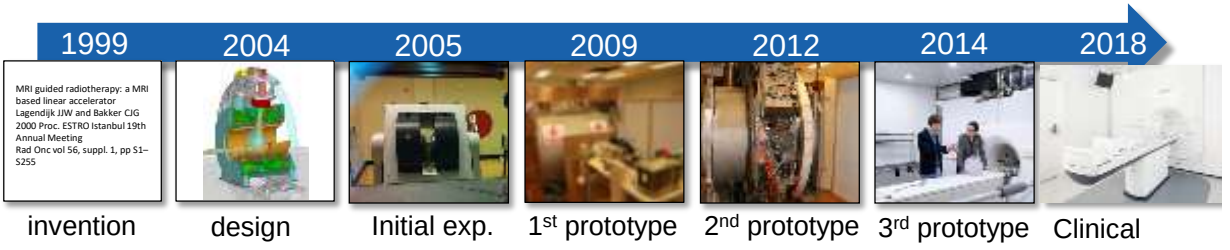


Design

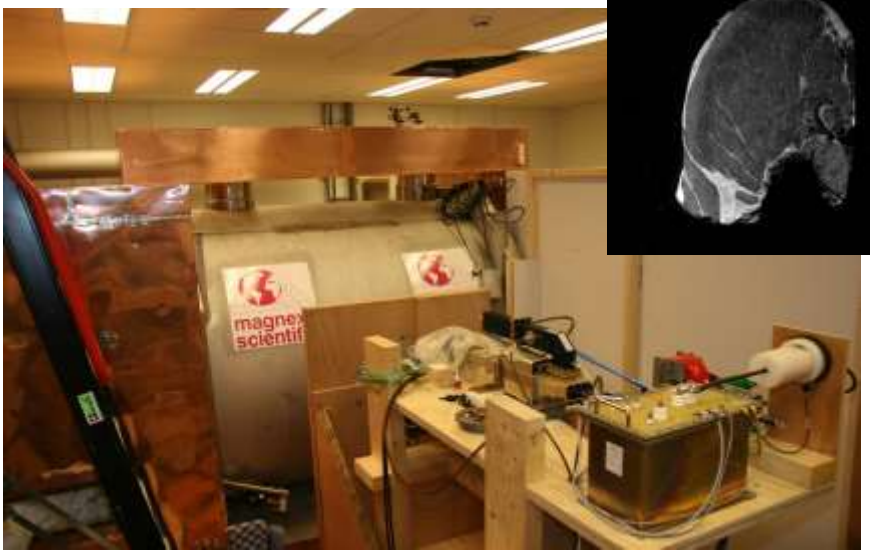
Design team MR-linac: UMCU, Elekta, Philips

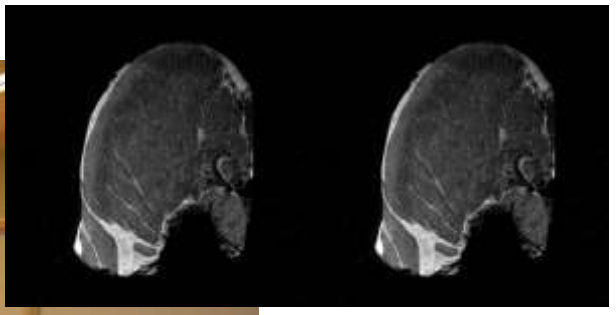
Active shielding, decoupling MRI and linac

MR Linac development timeline



2009 MRL 'proof of principle'





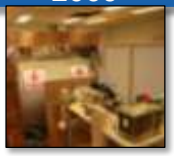
Beam-on – Beam-off

STW connecting innovators

PHILIPS

Elekta

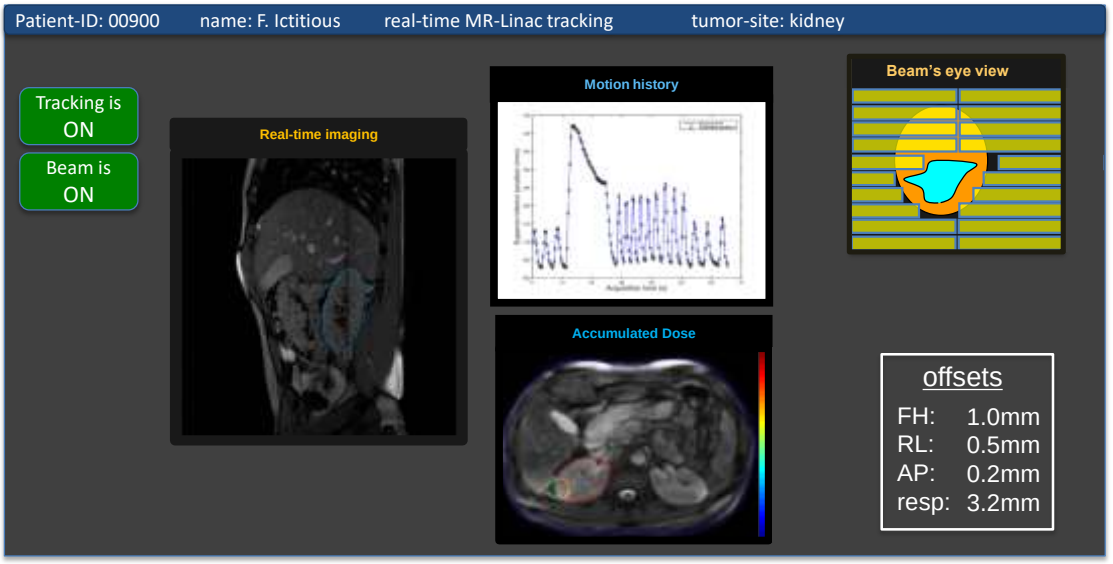
MR Linac development timeline

1999	2004	2005	2009	2012	2014	2018
MRI guided radiotherapy: a MRI based linear accelerator Lagendijk JJW and Bakker CJG 2000 Proc. ESTRO Istanbul 19th Annual Meeting Rad Onc vol 56, suppl. 1, pp S1–S255						
invention	design	Initial exp.	1st prototype	2nd prototype	3rd prototype	Clinical

Installation at the UMC Utrecht summer 2018

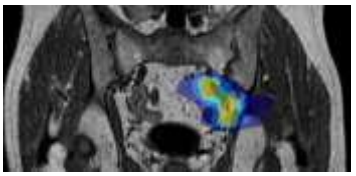
Stereotactic accuracy (3D): ***0.3 mm***

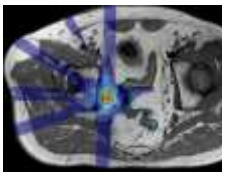
At the UMCU we are developing: Real-time motion tracking & dose accumulation

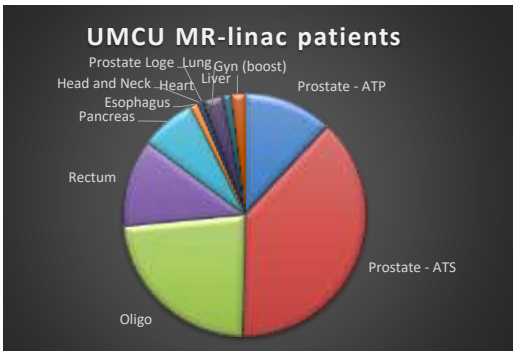


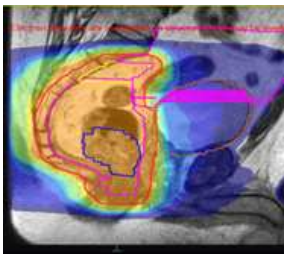
Current status Unity April 2022 UMC Utrecht

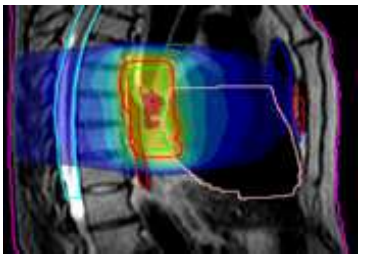
- So far >1000 patients treated, ≈10 new patients a week on two Unity systems
- Third system entering the clinic
- Focus on hypo-fractionated treatments (prostate, oligo and rectum)
  - Oligo lymph nodes, single and multiple, SBRT 5x7/3x10Gy
  - Rectal cancer pre-operative, 5x5Gy
  - Esophageal cancer palliation, 5x4Gy
  - Prostate low/intermediate risk, 5x7.25Gy
- All patient on-line treatment planning





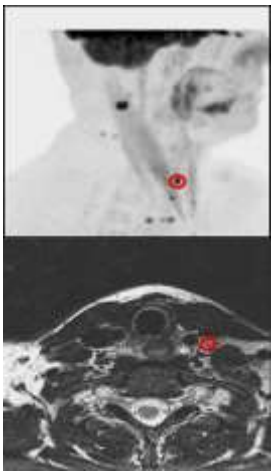






Development MRI/PET → Unity MR-linac pipeline
Wide bore 1.5T MRI/PET RT simulator

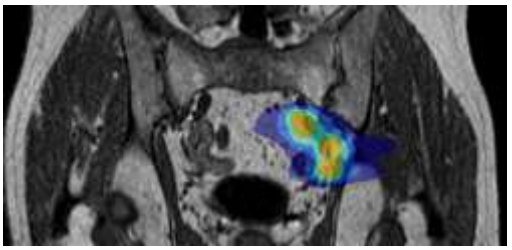
- Intrinsic registration between MRI and PET
- Use of MRI based motion registration in the PET reconstruction (search for small tumours)
- Common platform Unity and MRI/PET
- Alternative for the RefleXion system

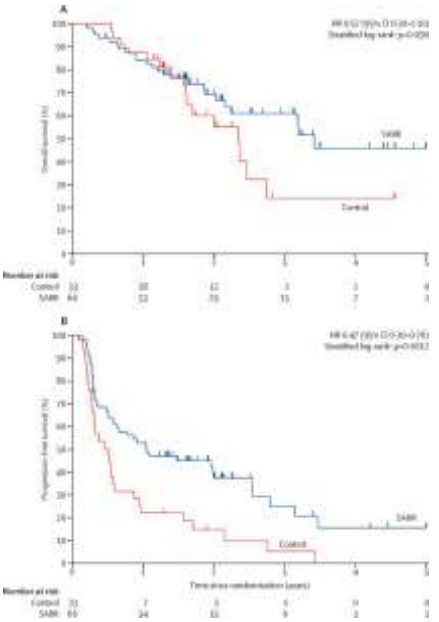


GE MRI/PET, courtesy Zackrisson, Nyholm, et al. Umeå

MR-Linac for metastatic disease: Potential breakthrough technology

- Oligo-metastases (Palma et al. 2019, Lancet)





Poly-metastases: Bauman et al., Arrest trial, BMC Cancer 2021

Acknowledgements UMC Utrecht MR-linac project

Over 70 PhD students

All UMC Utrecht RT staff members