Universitätsklinikum Würzburg

Motion monitoring - IGRT - ART
What can we learn from IGRT for photons?

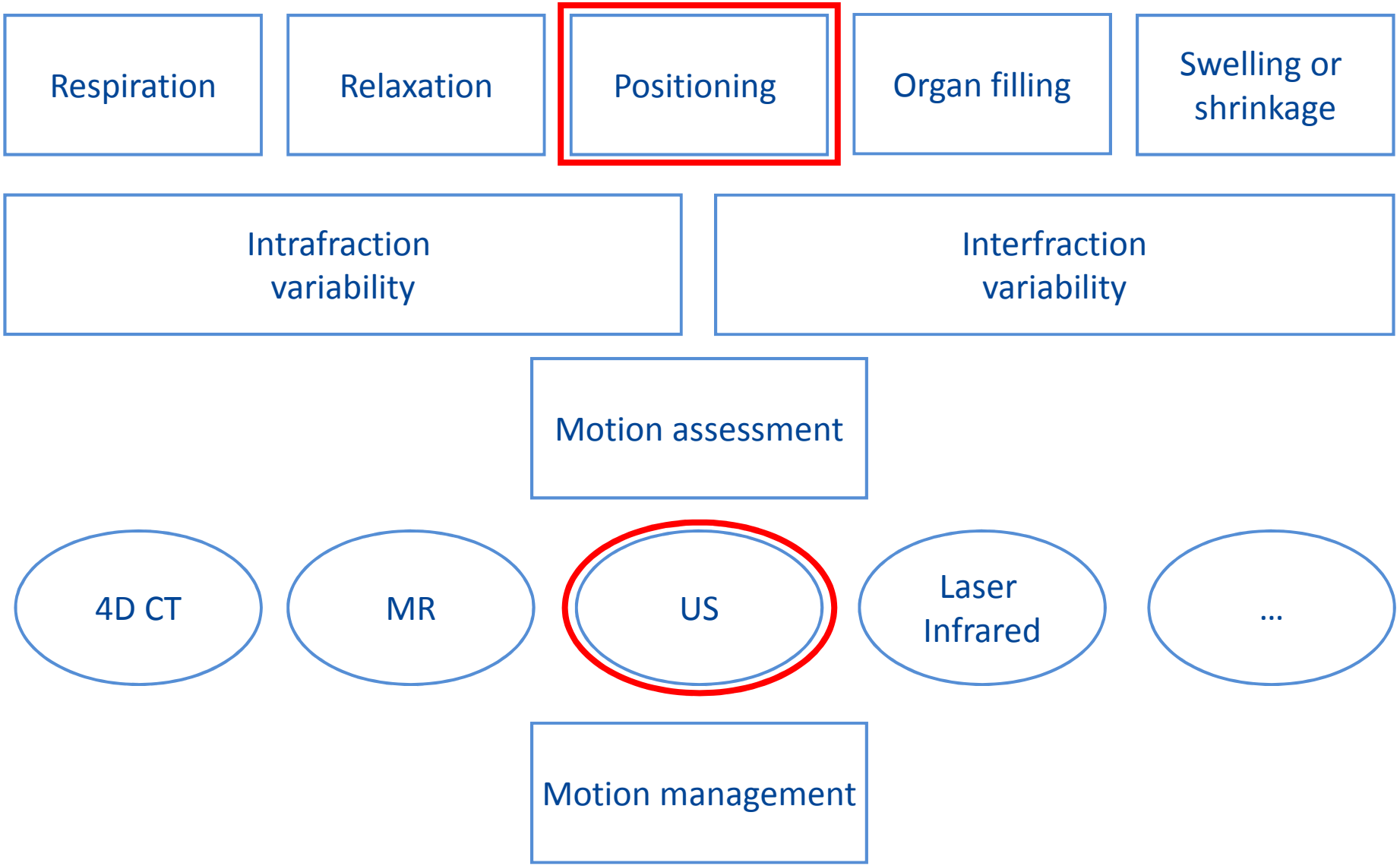
Dr. Anne Richter
Universitätsklinikum Würzburg

Klinik und Poliklinik für Strahlentherapie
Direktor: Prof. Dr. Dr. M. Flentje

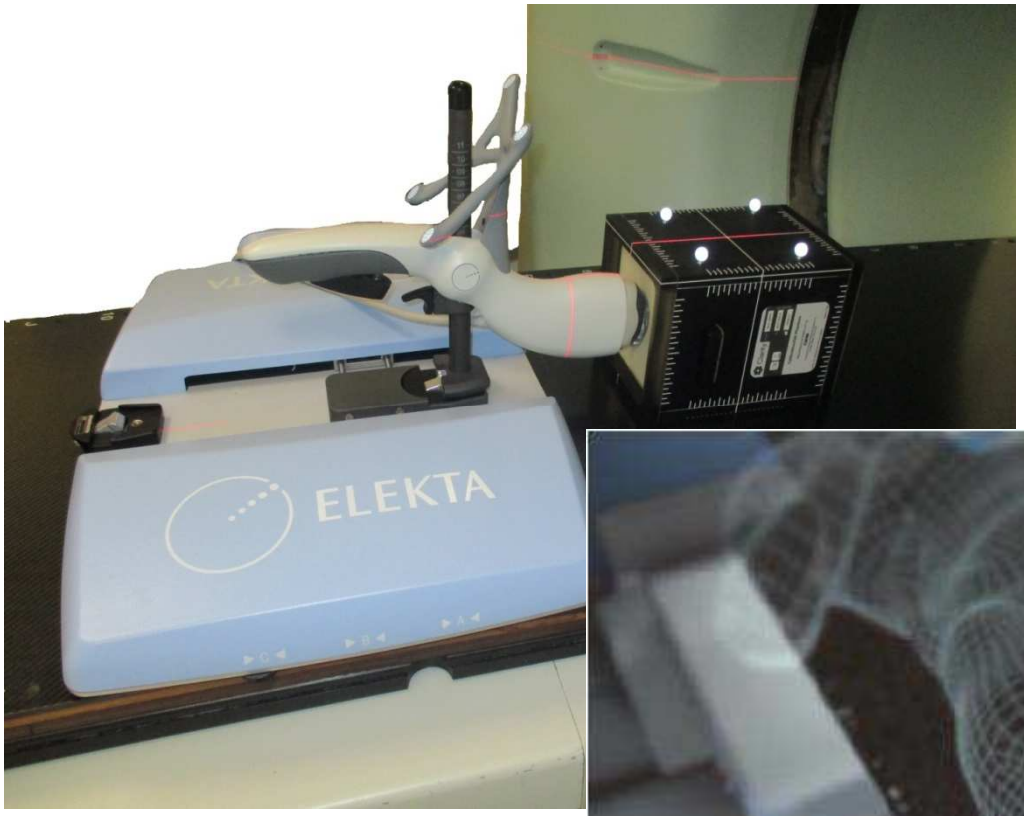
Outline

- Motion assessment
- User variability
- Multi-center study: protons or photons
- 4D MR

Organ motion



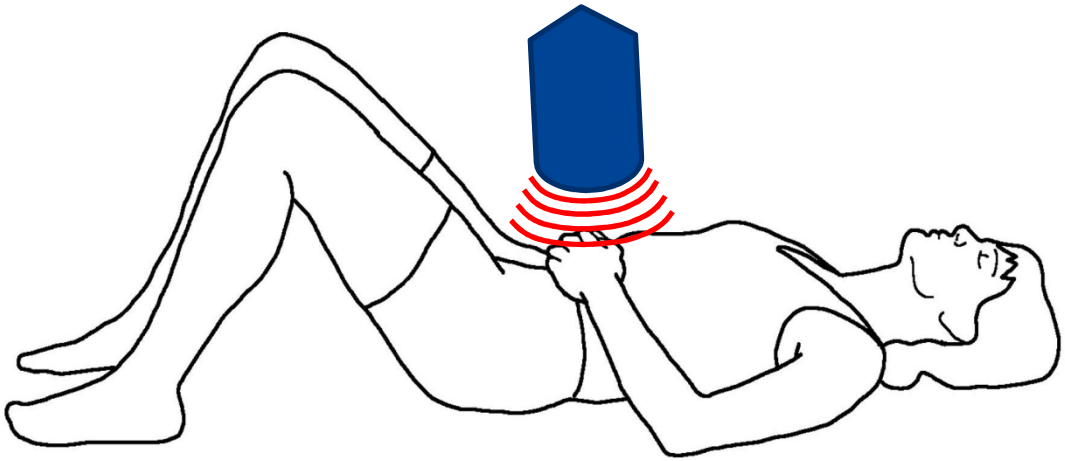
Ultrasound imaging



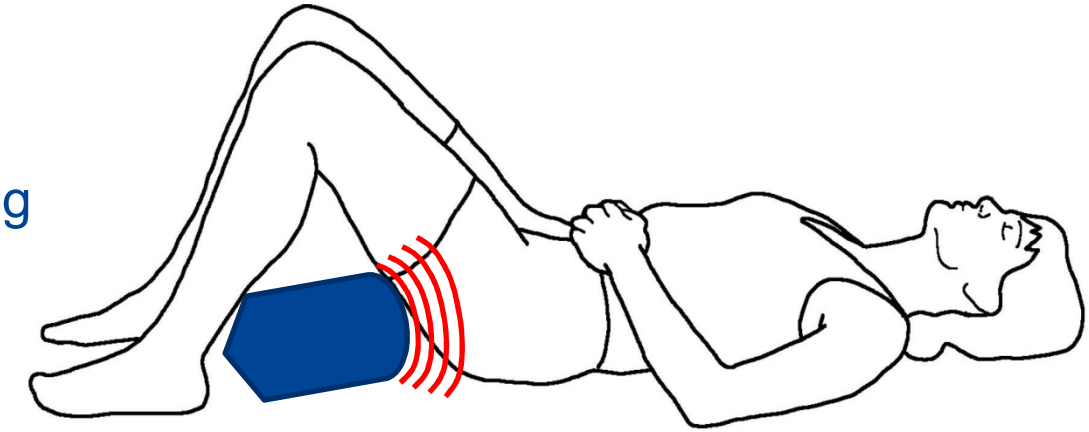
- Elekta Clarity system
- Positioning and monitoring
- Breast, liver, prostate …
- Abdominal or transperineal

Ultrasound imaging

- Transabdominal
  - Probe pressure on bladder
  - Patient comfort

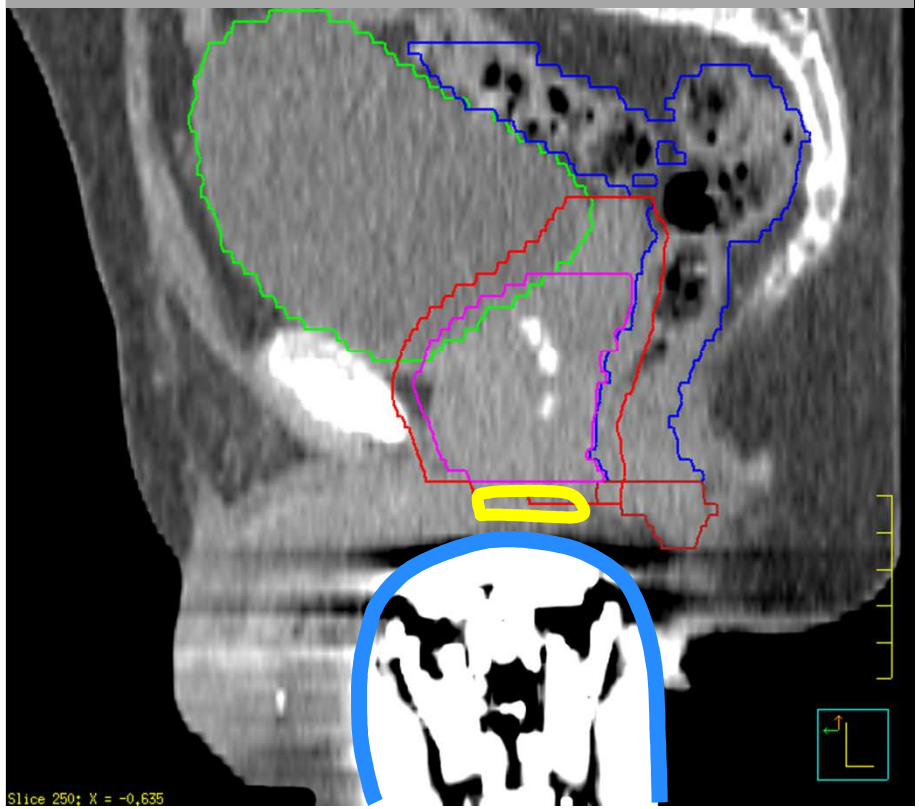


- Transperineal
  - Setup suitable for intrafraction monitoring

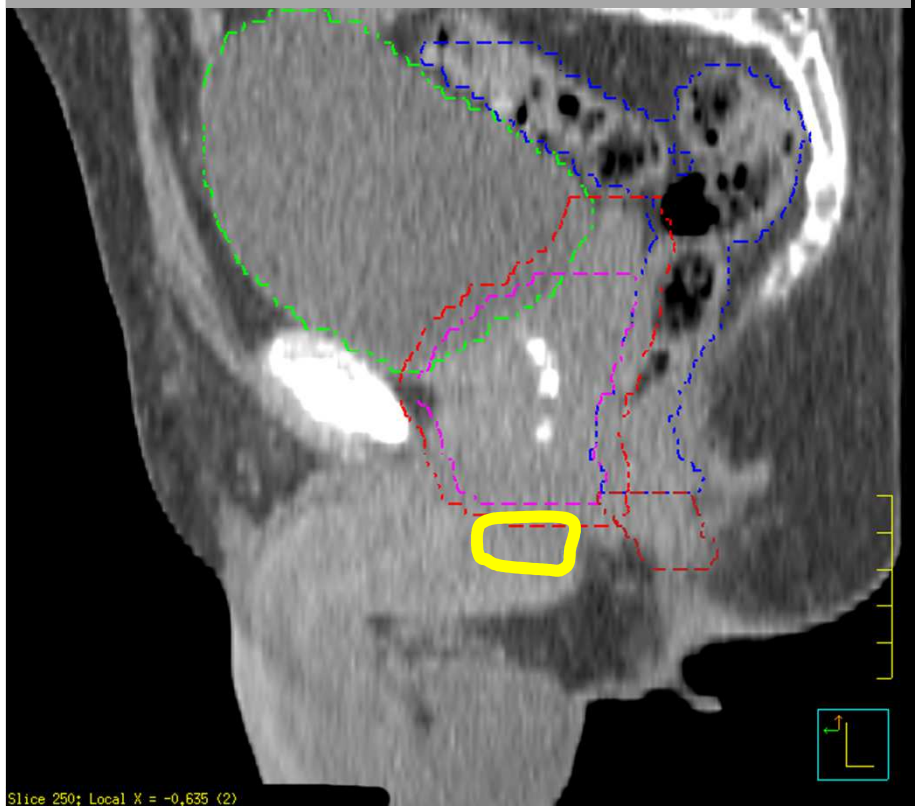


Transperineal ultrasound imaging

With probe



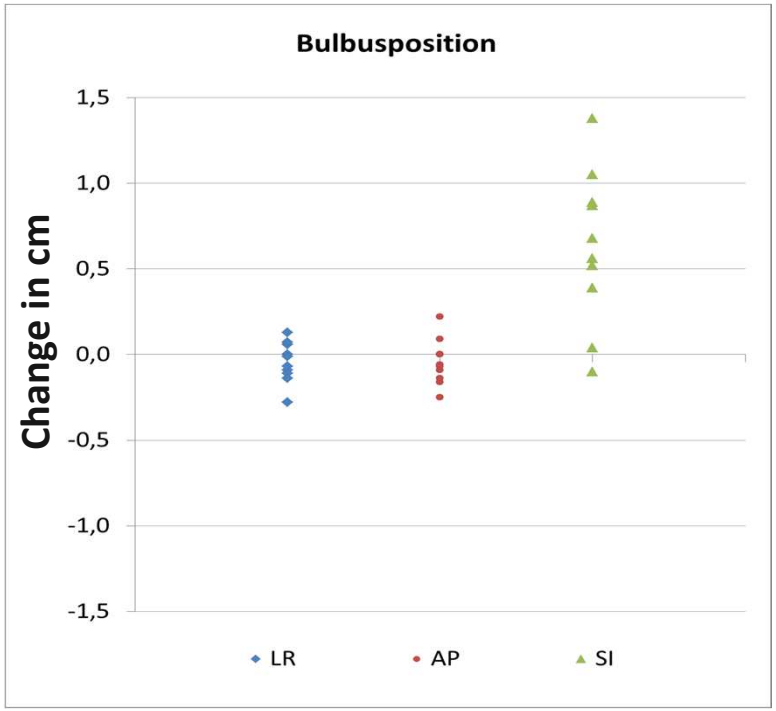
Without probe



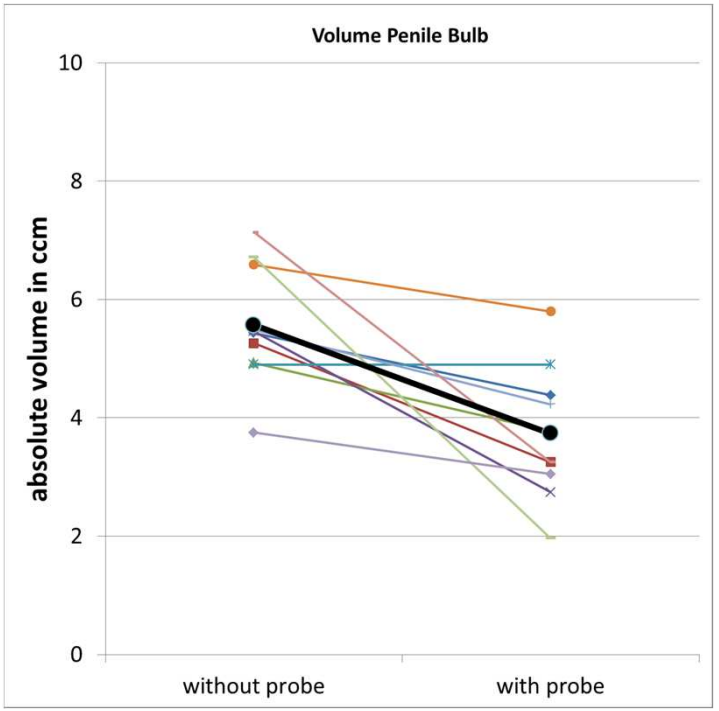
- Tissue compression and organ shift
- Influence on dose (penile bulb)

Influence of probe pressure on penile bulb

- Position change

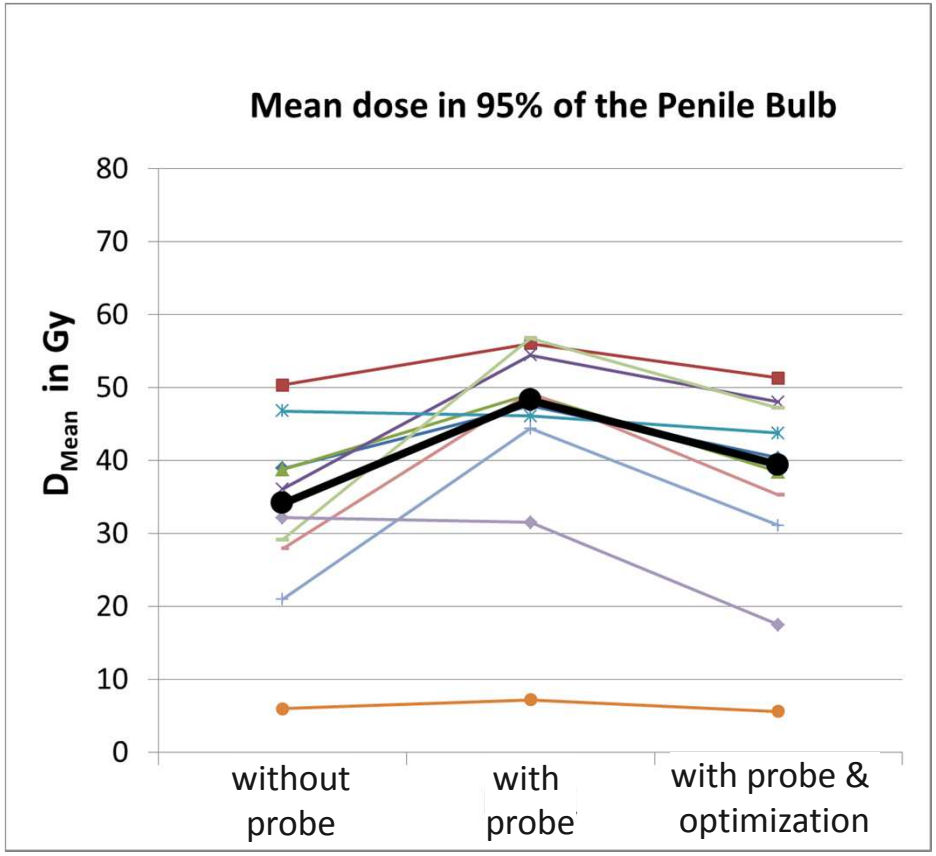


- Volume change



- Organ shift and tissue compression due to probe pressure

Influence on dose

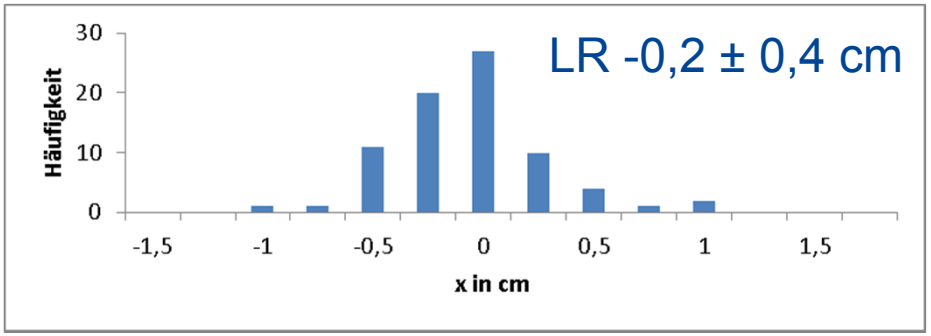


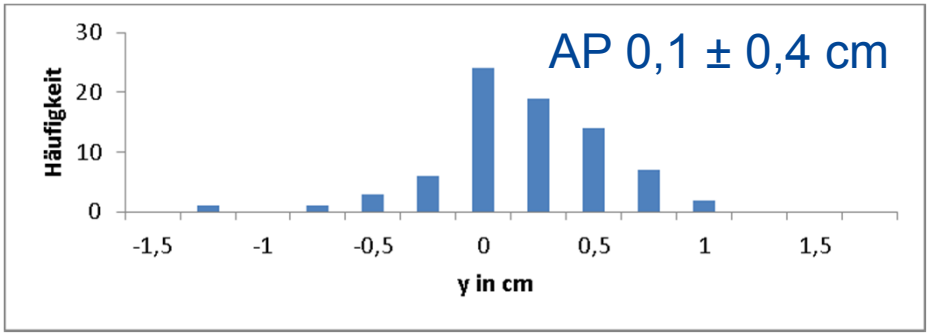
- Dose in the penile bulb increased due to probe pressure
- Penile bulb sparing possible
- Dose below QUANTEC thresholds

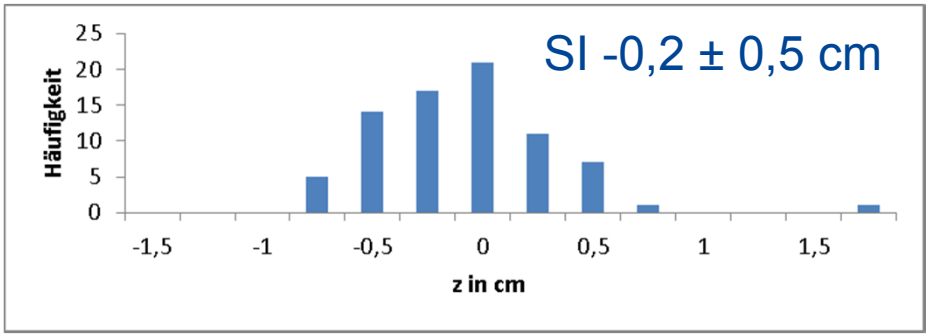
Setup verification via Conebeam or Ultrasound imaging ?

Setup verification

- 5 Patients, 77 fractions
- Clarity ™ & Conebeam CT
- Difference of setup errors







Setup verification

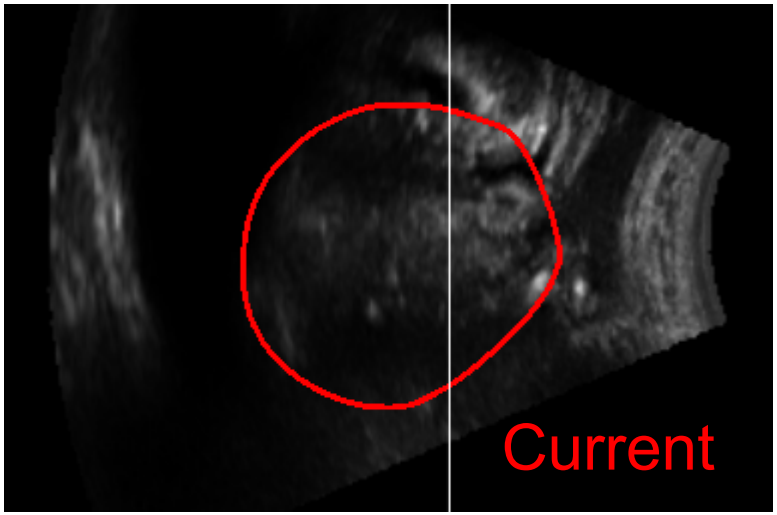
Table 3 Difference between setup errors measured in US vs seed-match in CBCT, compared to other published data, presented as mean ± SD

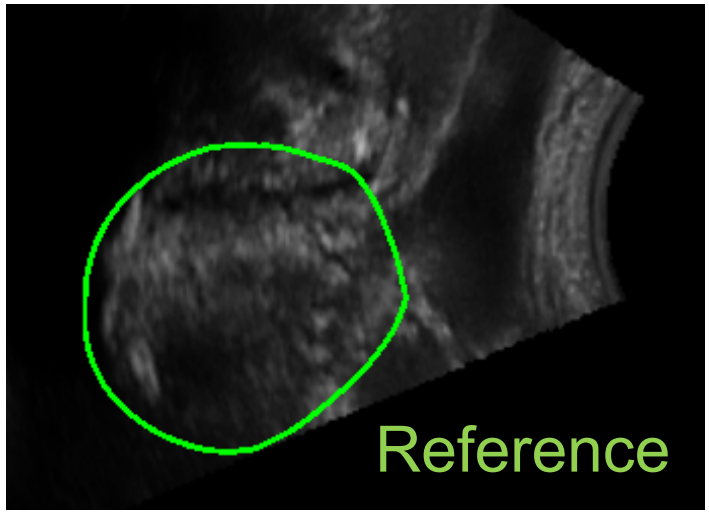
Reference	lateral	longitudinal	vertical
Bodda-Heggemann (2008) [37]	0.6 ± 1.7	0.9 ± 3.2	−1.7 ± 3.5
McNair (2006) [32]	−2.2 ± 3.7	3.2 ± 3.2	−3.3 ± 3.5
Van der Meer (2013) [26]	2.5 ± 4.0	0.6 ± 4.9	−2.3 ± 3.6
this paper **Li (2015)**	−0.2 ± 2.7	−1.9 ± 2.3	0.0 ± 3.0
Data from Wuerzburg	**-1.7 ± 3.9**	**-1.9 ± 4.5**	**-0.5 ± 3.9**

- Large deviation between Conebeam CT and US imaging
- Idea:
  - use CBCT for setup verification
  - Use Ultrasound for intrafraction monitoring

Interobserver variability

- Verification of treatment setup
  - High interobserver variability for US (Fontanarosa et al 2015)
  - Reproducibilty of probe pressure





- Make US imaging user-independent and automatic
  - Automatic image fusion
  - Automatic registration

Interobserver variability

- Variability in target volume delineation
  - Lung 2.1 mm Peulen et al. RO 2015
  - Cervix 40 mm Eminowicz et al. RO 2015
  - H&N 4 mm Brouwer et al. BMC RO 2012
  - Prostate 2 mm Nyholm et al. BMC RO 2013
  - …
- High interobserver variability in general

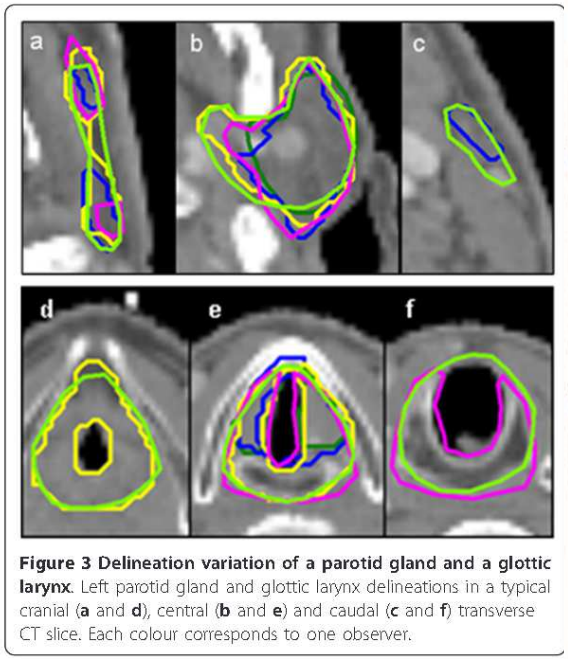
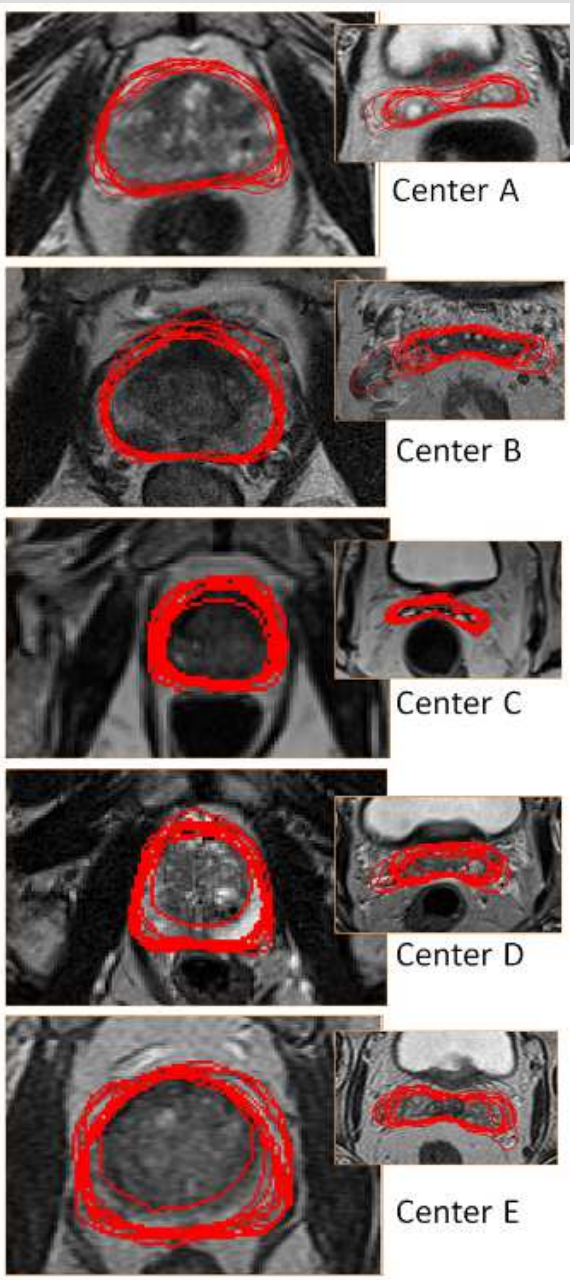
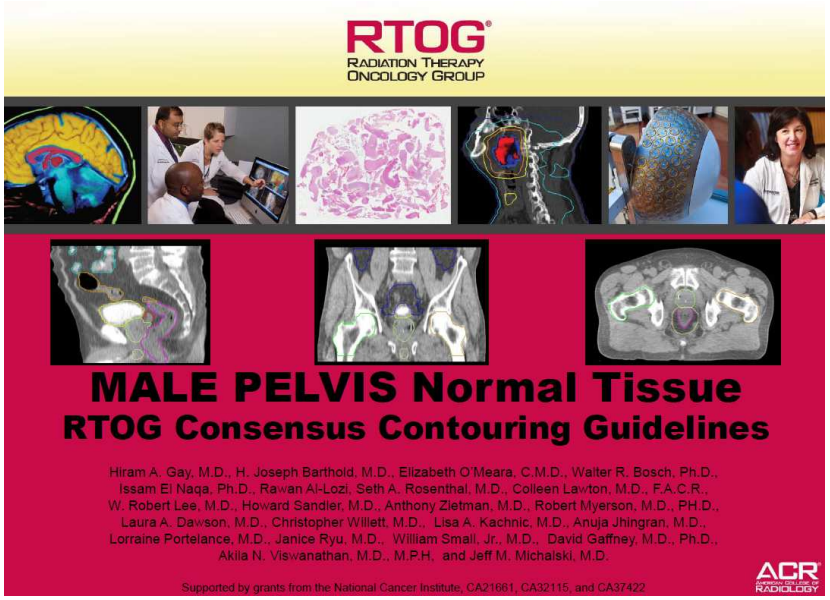


Figure 3 Delineation variation of a parotid gland and a glottic larynx. Left parotid gland and glottic larynx delineations in a typical cranial (**a** and **d**), central (**b** and **e**) and caudal (**c** and **f**) transverse CT slice. Each colour corresponds to one observer.



Interobserver variability

- Improve consistency of contouring by
  - Education
  - Consensus guidelines
  - Multi-institutional collaborations



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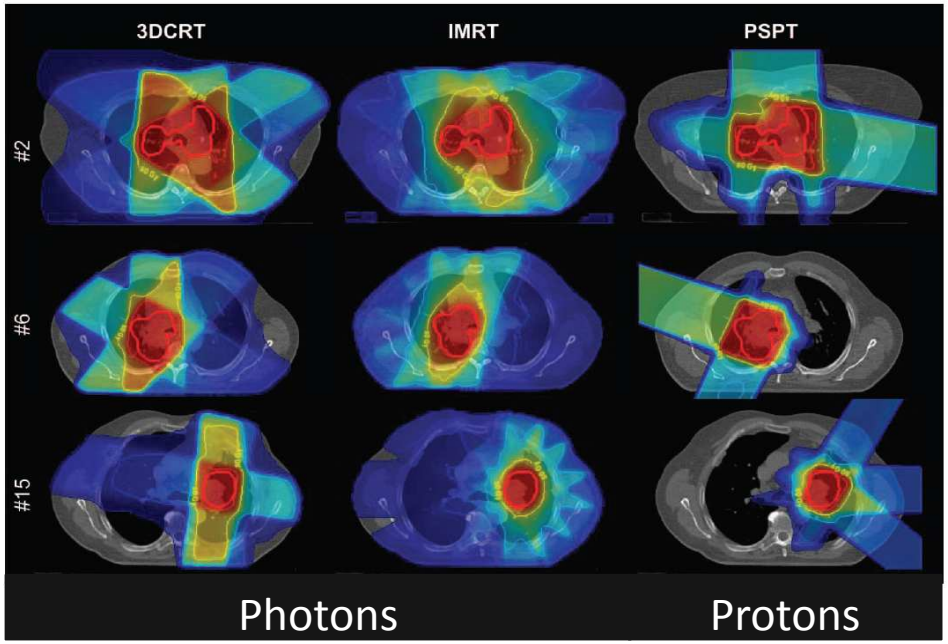
Advanced Technology Radiation Therapy

Contouring Atlases

- Anorectal
- Brachial Plexus Contouring Atlas
- Breast Cancer Atlas
- Female RTOG Normal Pelvis Atlas
- GYN
- H & N Atlases
- Hippocampal Sparing
- Male RTOG Normal Pelvis Atlas
- Pancreas Atlas
- Prostate Pelvic Lymph Nodes
- Prostate Post-Op
- RTOG Extremity Soft Tissue Sarcoma Atlas
- Lung Atlas
- Upper Abdominal Normal Organ Contouring Consensus

Protons or photons

- Multicenter study (Roelofs 2012)
- NSCLC, protons or photons, integral dose



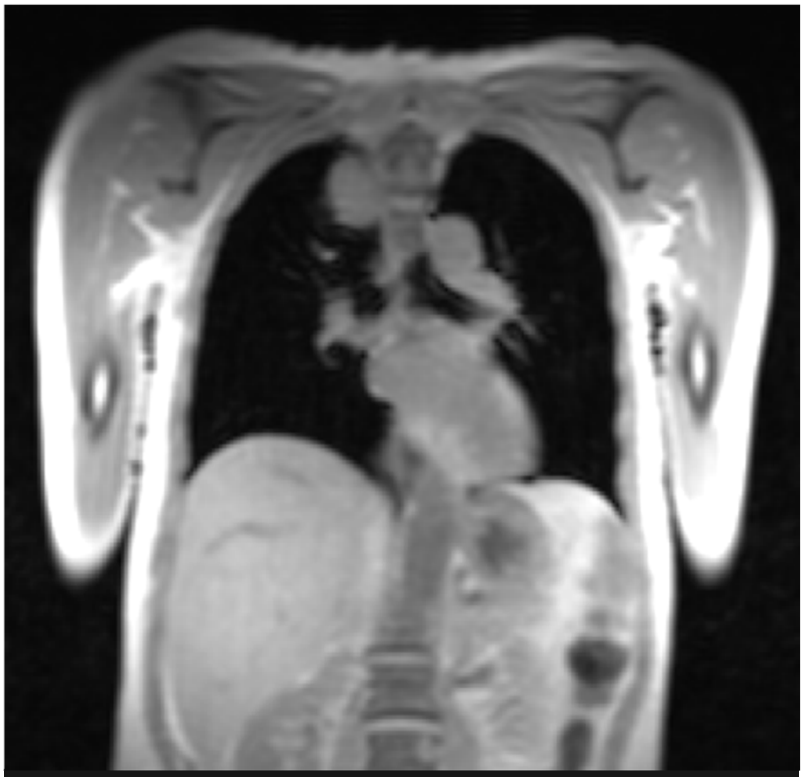
- Protons less integral dose
- Integral dose also depends on treatment technique
  - dynamic/static, beam angle …

4D MR = 3D + 1D time

- MR, mGRE
- free breathing
- MR coil near diaphragm as navigator signal
- Retrospective self gating

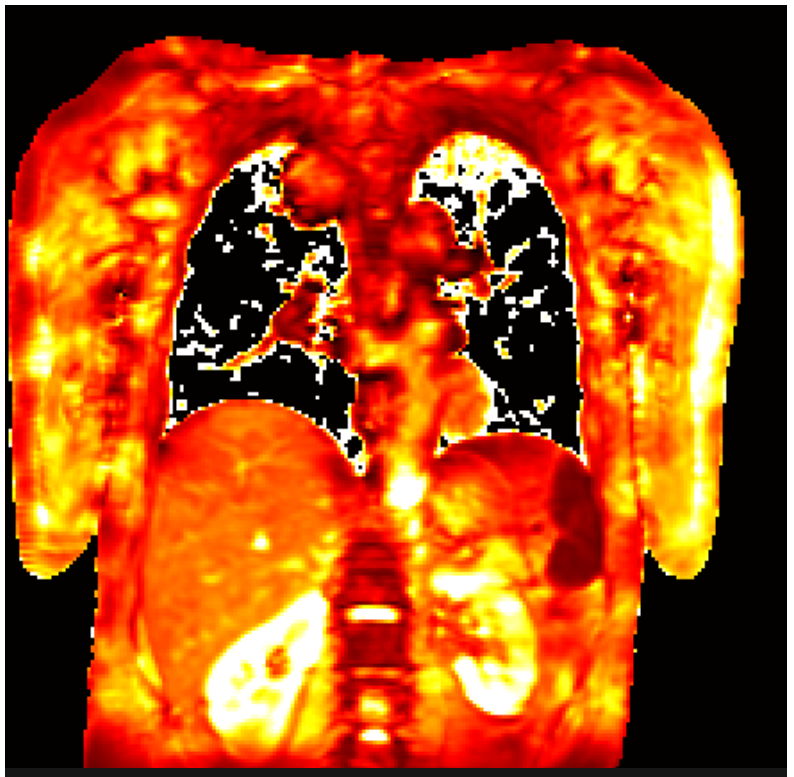
[1] Weick et al. MRM (in Revision) [2] Weick et al., JMRI 37(3):727-32 (2013)

5D MR



4D MR
3D + Time

+



1D T2*

5D MR

Summary

- Transperineal ultrasound imaging
  - Probe pressure shifted penile bulb cranial
  - Consideration of bulb contour during IMRT optimization
- High user variability
  - Ultrasound image registration and target delineation (CT/MR/US)
  - Education and consensus guidelines
  - Multi-institutional collaborations
- Protons or photons
  - Protons: less integal dose and improved OAR sparing
- Combine 4D imaging and biological imaging
  - 4D MR → 5D MR

"Precision in radiation therapy comes not only from image guidance, but also from patient comfort," Dr. van Herk observes.

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