



Image guidance Strategies for Motion Management

4D and Couch Tracking Slides Courtesy of Prof. Matthias Guckenberger



Frank Lohr, Klinik für Strahlentherapie und Radioonkologie, Universitätsmedizin Mannheim

Disclosures

Research and Travel Grants from Elekta
Board Member of C-Rad

Overview

- Motion Compensation Strategies
- Breath Hold Imaging and Treatment
- Ultrasound-based positioning
- Does it work clinically?
- Where do we go from here

Overview

- Motion Compensation Strategies
- Breath Hold Imaging and Treatment
- Ultrasound-based positioning
- Does it work clinically?
- Where do we go from here

leonhard LENTZ

DER INDIANER

KEILNER



Motion Compensation Strategies

- 4D Treatment Planning, Individually Adapted Margins
- Breath Hold Treatment
- Gating
- Tracking
 - Robotic Tracking
 - Gimbal Tracking
 - Couch Tracking
 - Sequence Resorting

Imaging Modalities:

2D, 2D/3D, 3D X-ray based

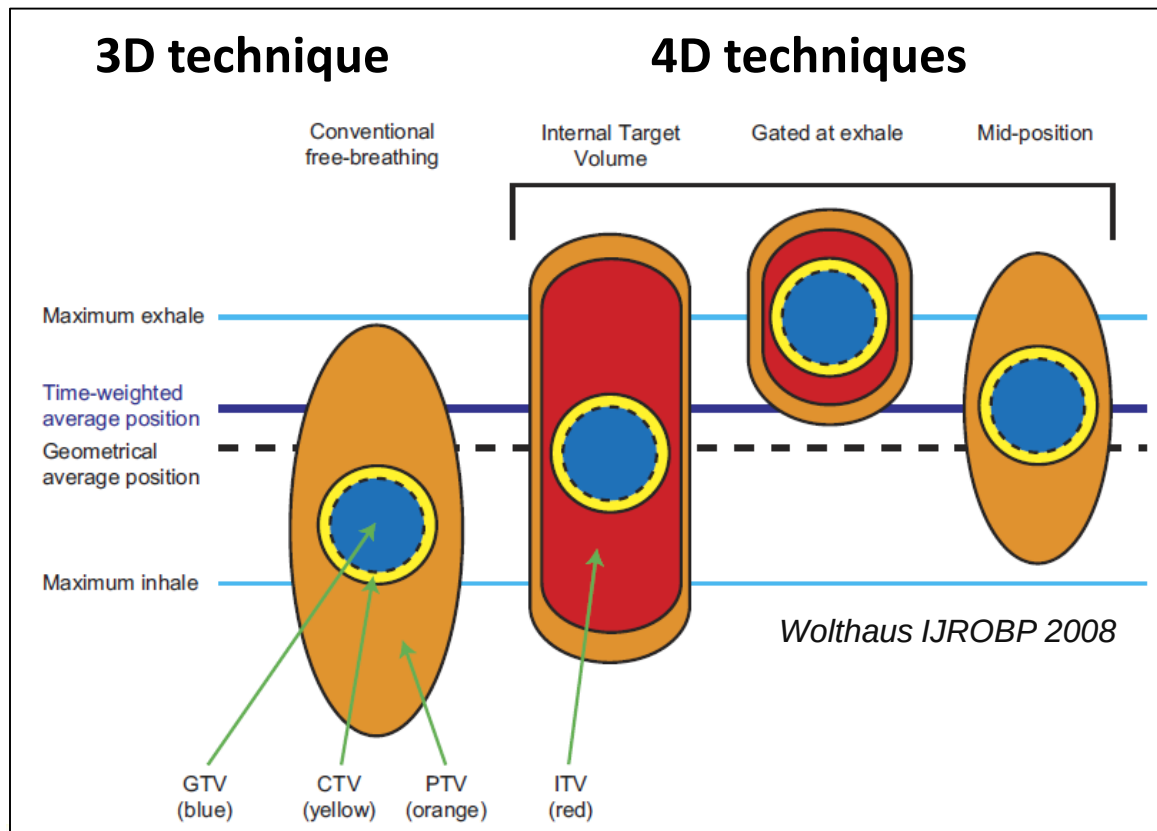
Transponder based

Ultrasound based

Motion compensation techniques: 4D IGRT

Treatment planning

Target volume definition: ITV concept



Pro:

- Large clinical experience
 - Low toxicity
 - High rates of LC
- Short RT delivery times
- Straight work-flow

Cons:

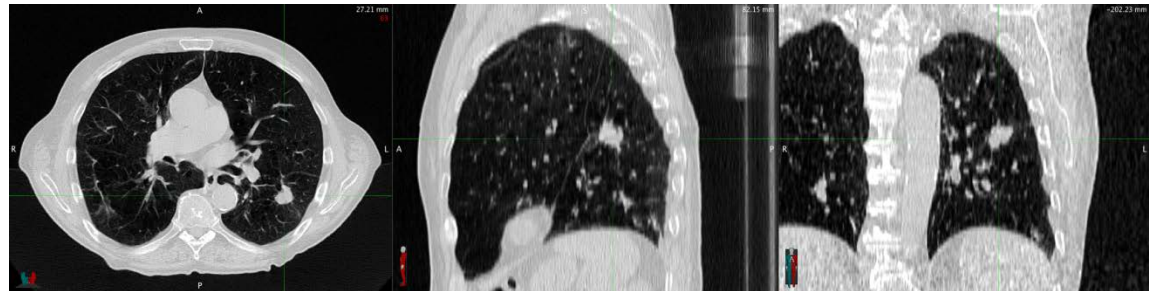
- Larger target volumes

Motion compensation techniques: 4D IGRT

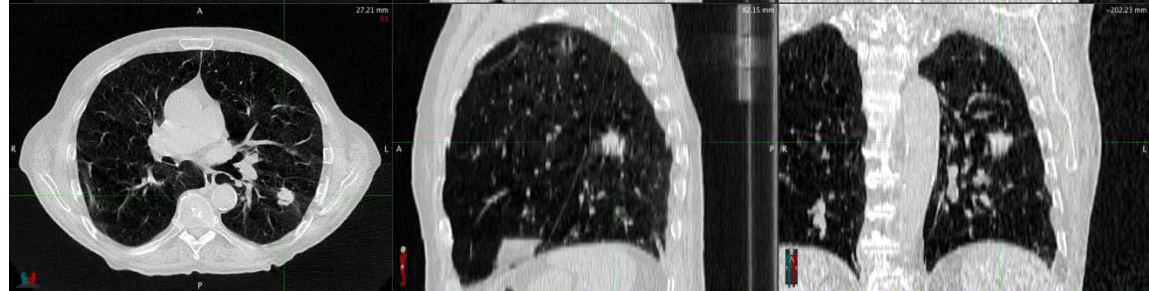
Treatment planning

Target volume definition: **respiration correlated 4D-CT**

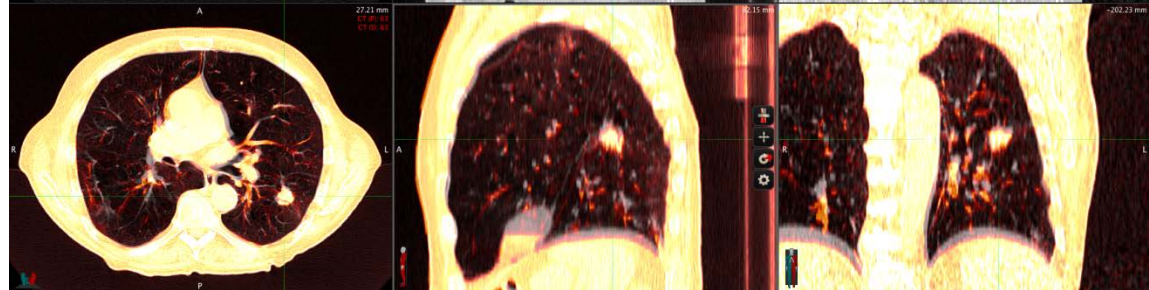
End-exhalation



End-inhalation



Fusion



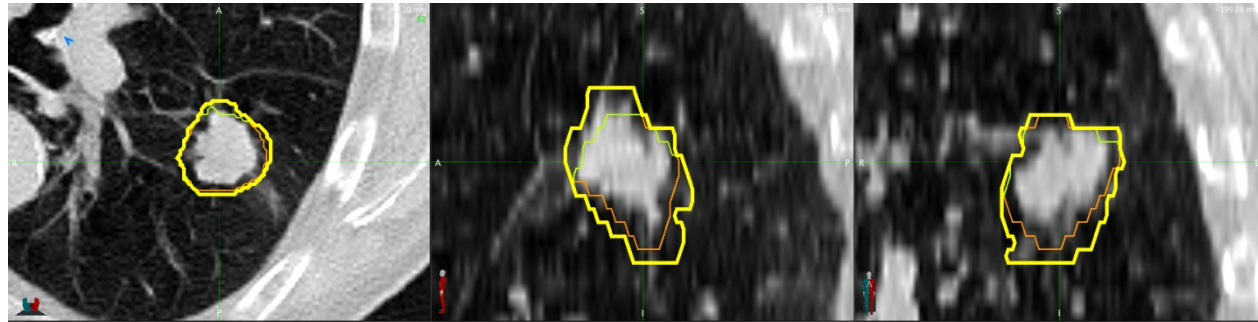
Motion compensation techniques: 4D IGRT

Treatment planning

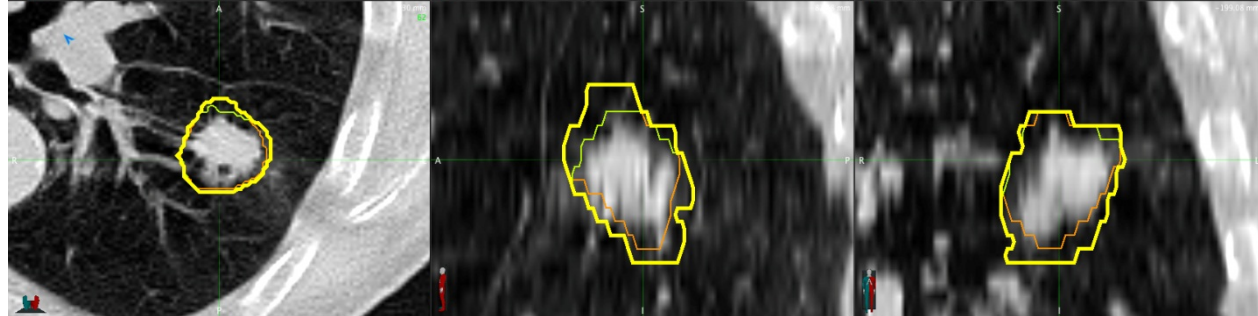
Target volume definition:

Motion compensation using the internal target volume (ITV) technique

End-exhalation



End-inhalation



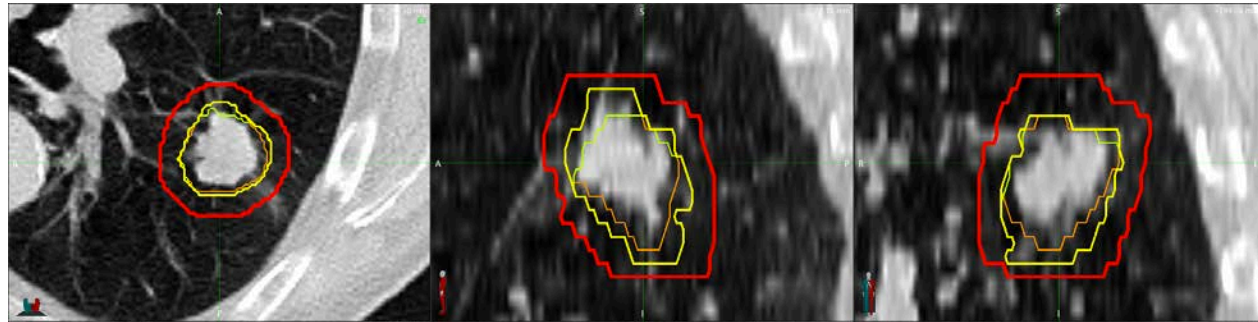
Motion compensation techniques: 4D IGRT

Treatment planning

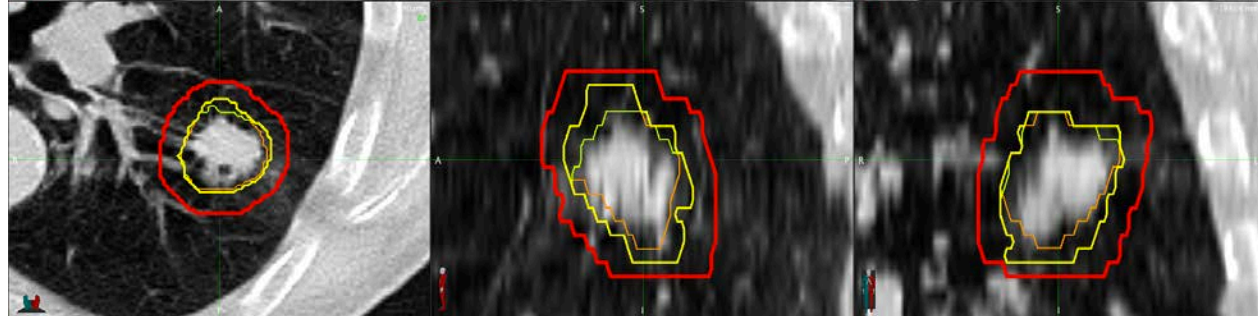
Target volume definition:

PTV = ITV + 5mm in all directions

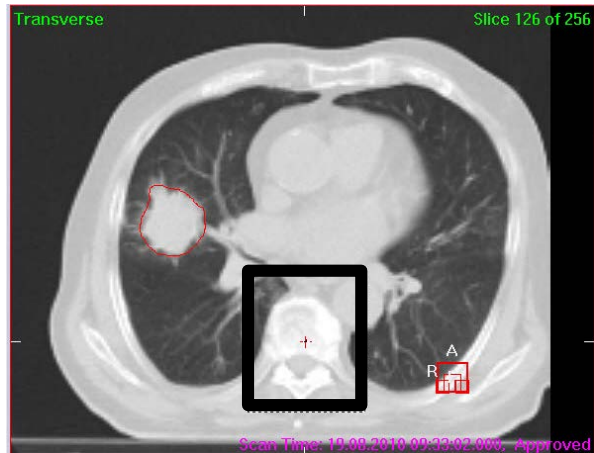
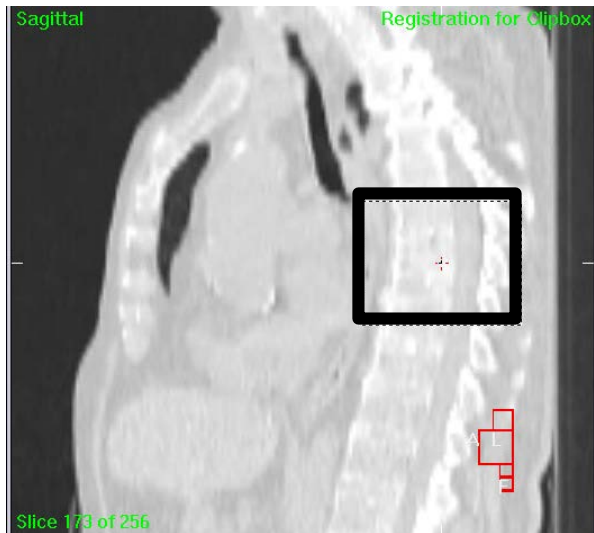
End-exhalation



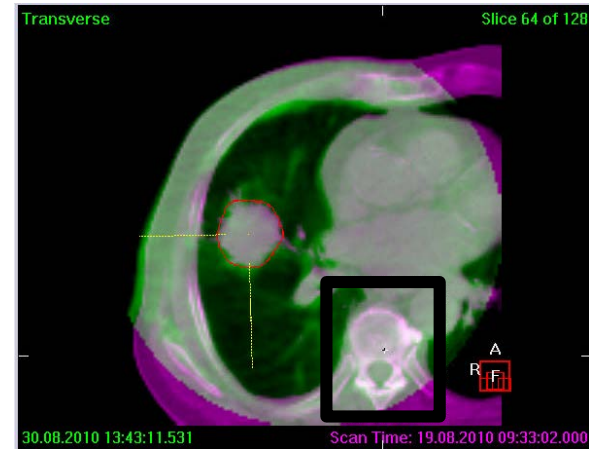
End-inhalation



Motion compensation techniques: 4D IGRT

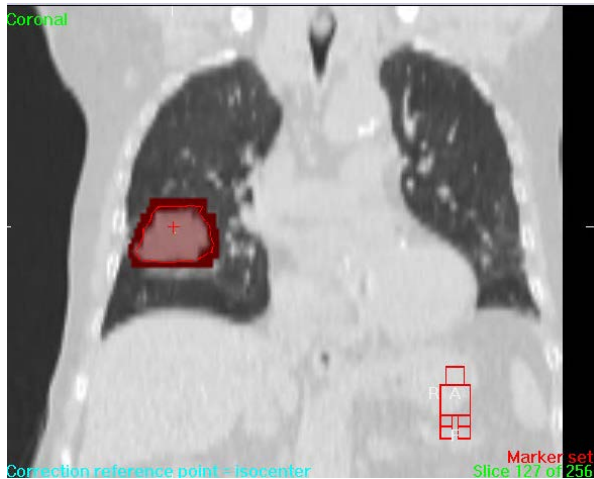
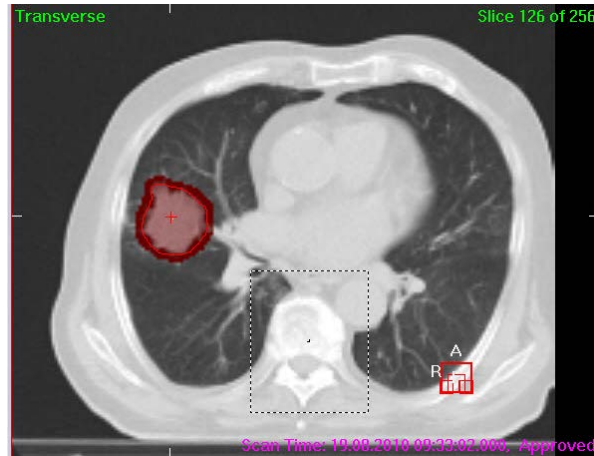


**Bony
registration**

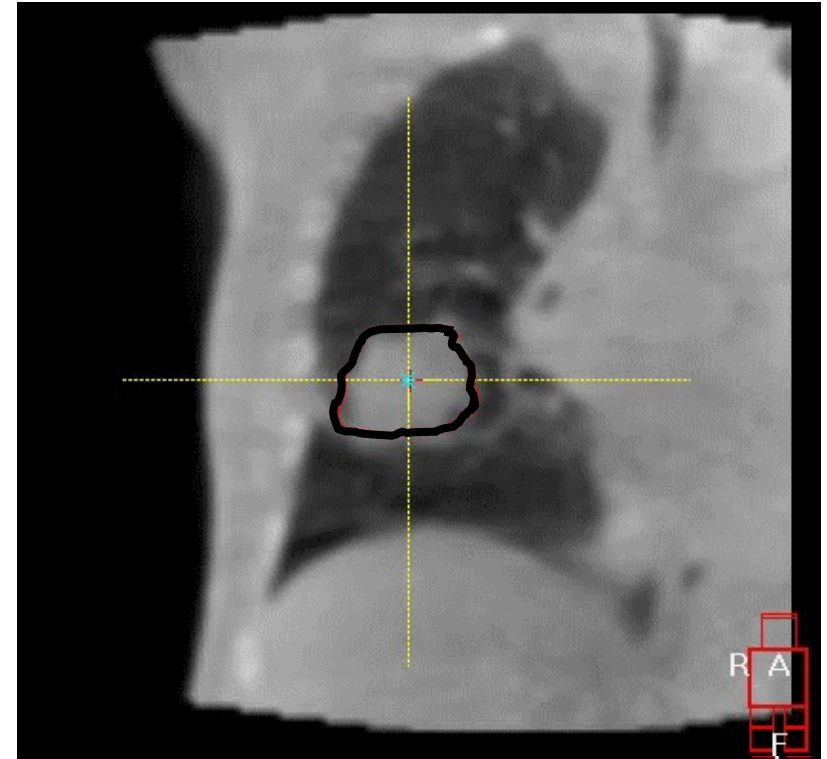


Evaluation of patient set-up error

Motion compensation techniques: 4D IGRT



Tumor
registration

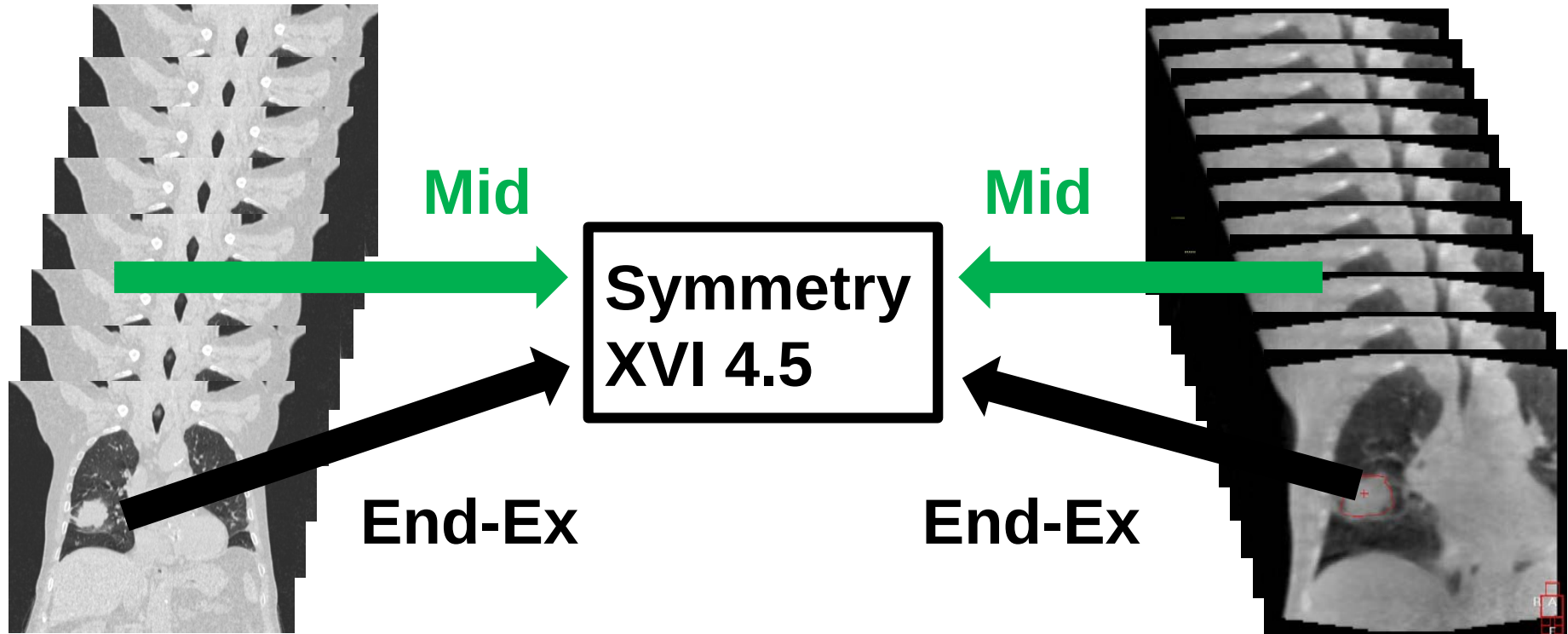


Evaluation of target position in each breathing phase

Motion compensation techniques: 4D IGRT

Treatment planning:
Reference Image

Treatment delivery:
Verification Image



4D IGRT: Registration of corresponding phases

Motion compensation techniques: 4D IGRT

Treatment planning:
Reference Image

Treatment delivery:
Verification Image

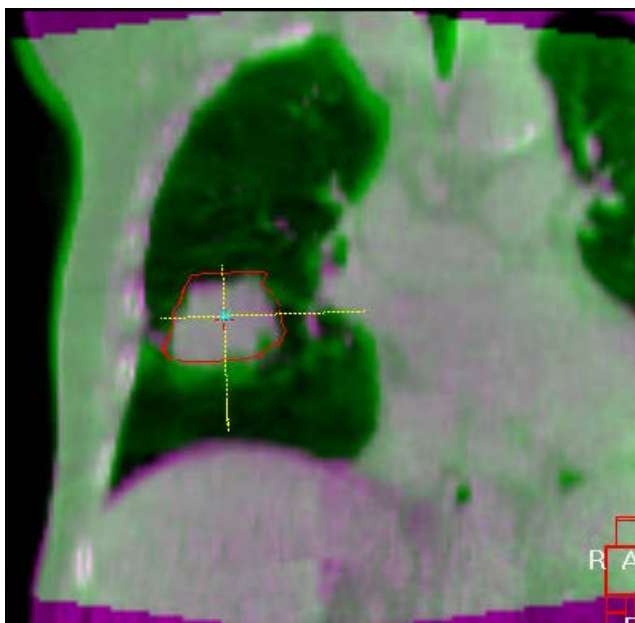


End-exhalation as reference: easy for visual verification

Motion compensation techniques: 4D IGRT

Bone set-up

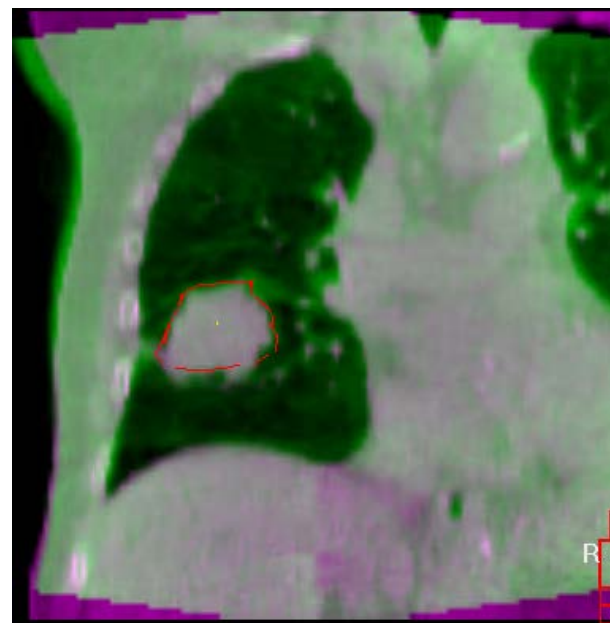
	Clipbox	Mask	Adjust
Tx (cm)	0.00	-0.21	☒
Ty (cm)	0.00	-0.47	☒
Tz (cm)	0.00	-0.38	☒



COMPROMISE

Tumor set-up

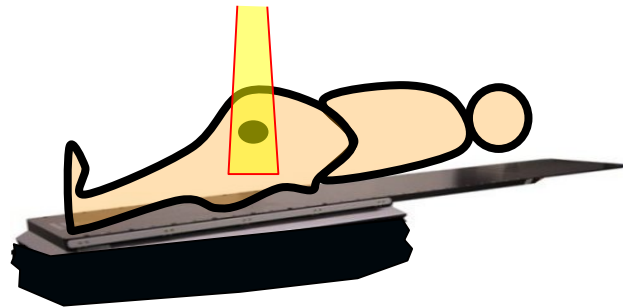
	Clipbox	Mask	Adjust
Tx (cm)	0.21	0.00	☒
Ty (cm)	0.47	0.00	☒
Tz (cm)	0.38	0.00	☒



Visualization of the effects of base-line shifts

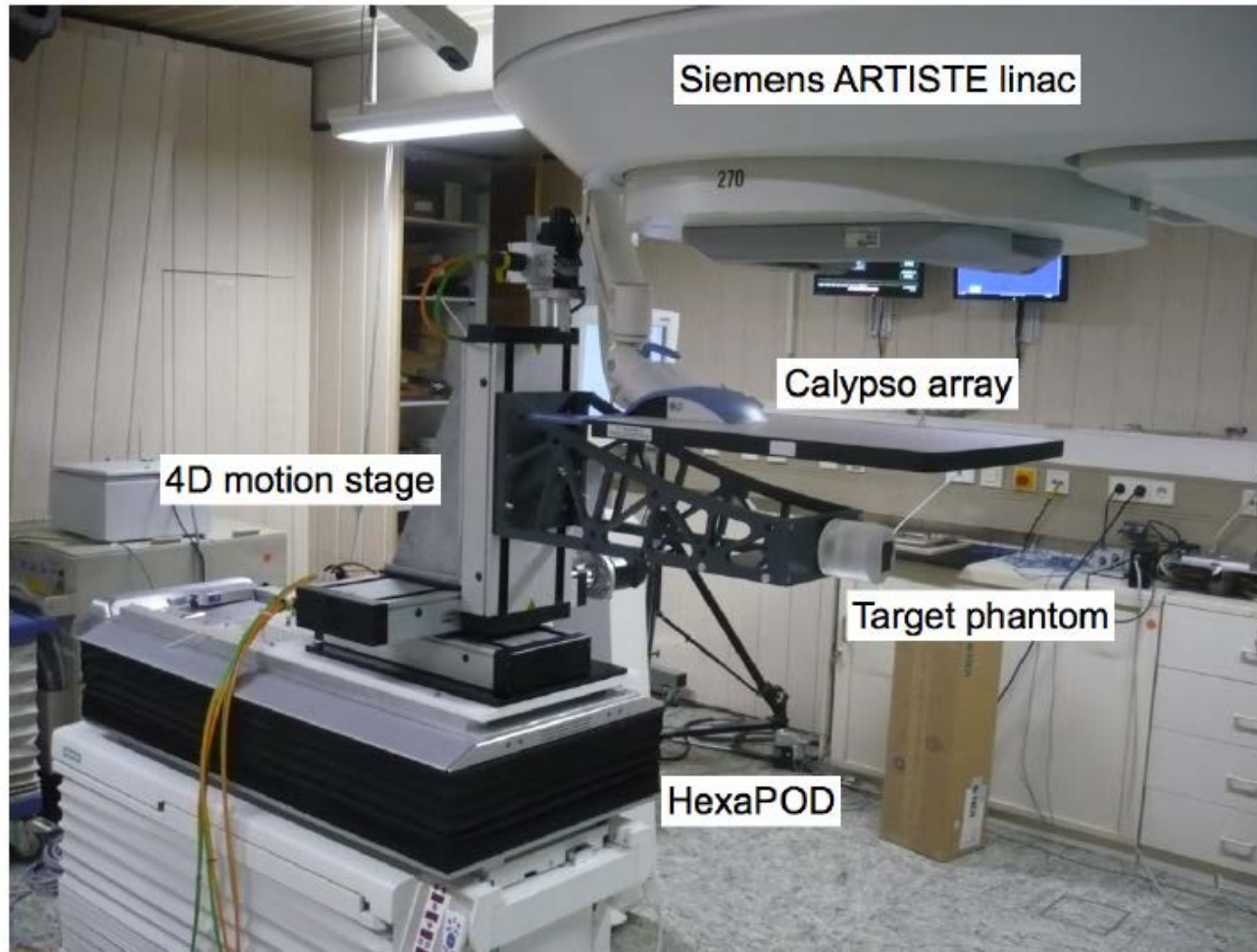
Motion compensation techniques

The concept of Couch and MLC tracking



Motion compensation techniques

Comparison of couch and MLC tracking



**Heidelberg:
Siemens 160 MLC**

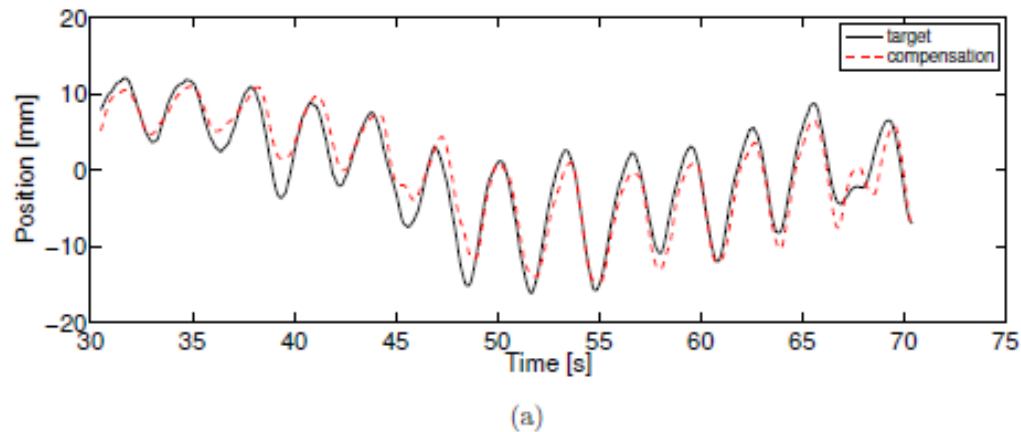
**Würzburg:
HexaPOD Evo**

Motion compensation techniques

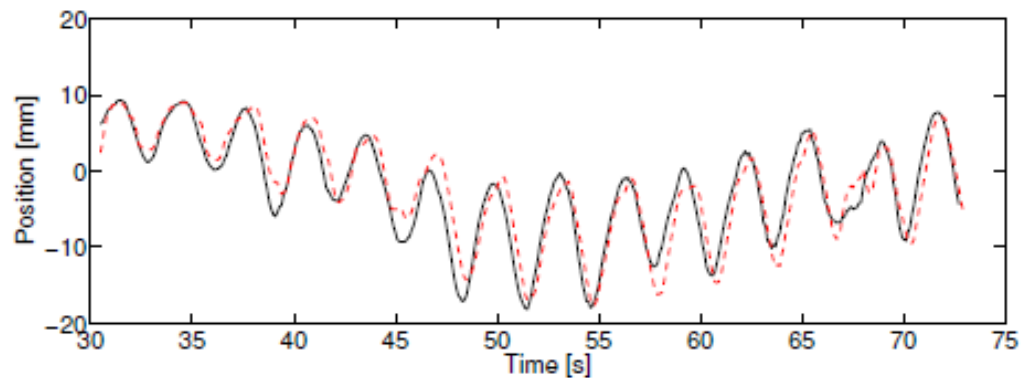
Comparison of couch and MLC tracking:

Geometrical accuracy in lung cancer

MLC



HexaPOD



Motion Compensation Strategies

- 4D Treatment Planning, Individually Adapted Margins
- **Breath Hold Treatment**
- Gating
- Tracking
 - Robotic Tracking
 - Gimbal Tracking
 - Couch Tracking
 - Sequence Resorting

Imaging Modalities:

2D, 2D/3D, 3D X-ray based

Transponder based

Ultrasound based

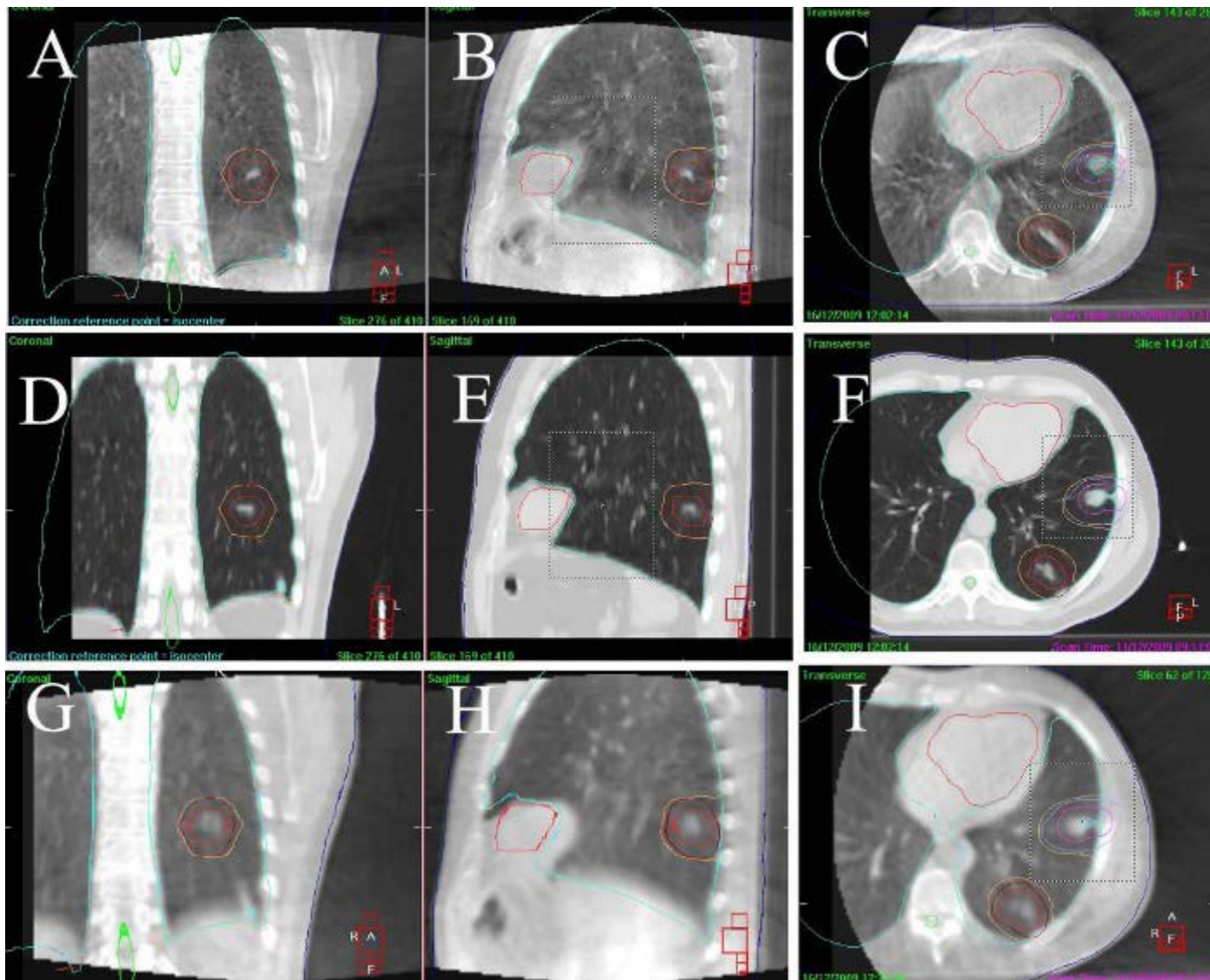
Guckenberger, Richter, Booda-Heggemann, Lohr, in press

Overview

- Motion Compensation Strategies
- **Breath Hold Imaging and Treatment**
- Ultrasound-based positioning
- Does it work clinically?
- Where do we go from here



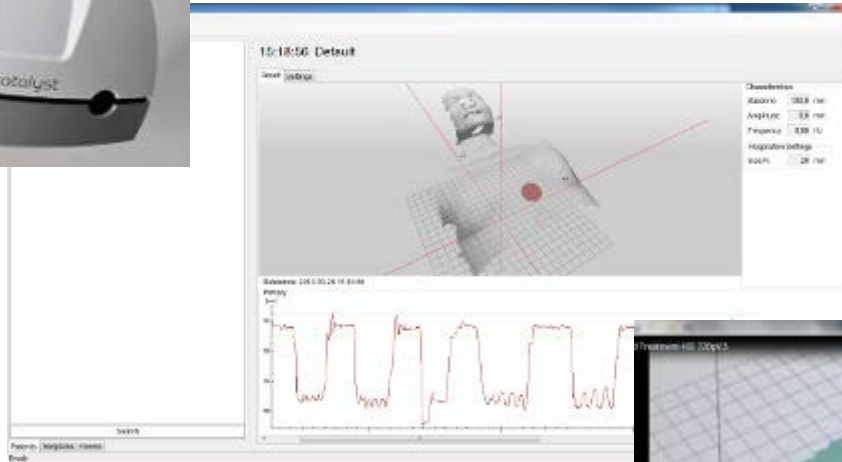
Active Breathing Control (ABC®)



Boda-Heggemann et al., Radiother Oncol, 2011

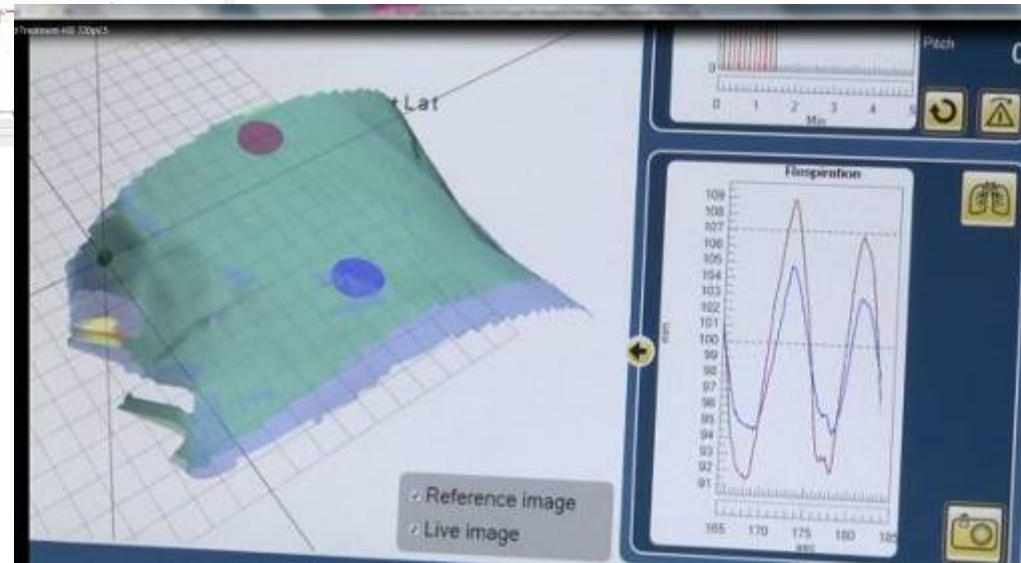
Clinical Setup:

2. Surface-based Surveillance

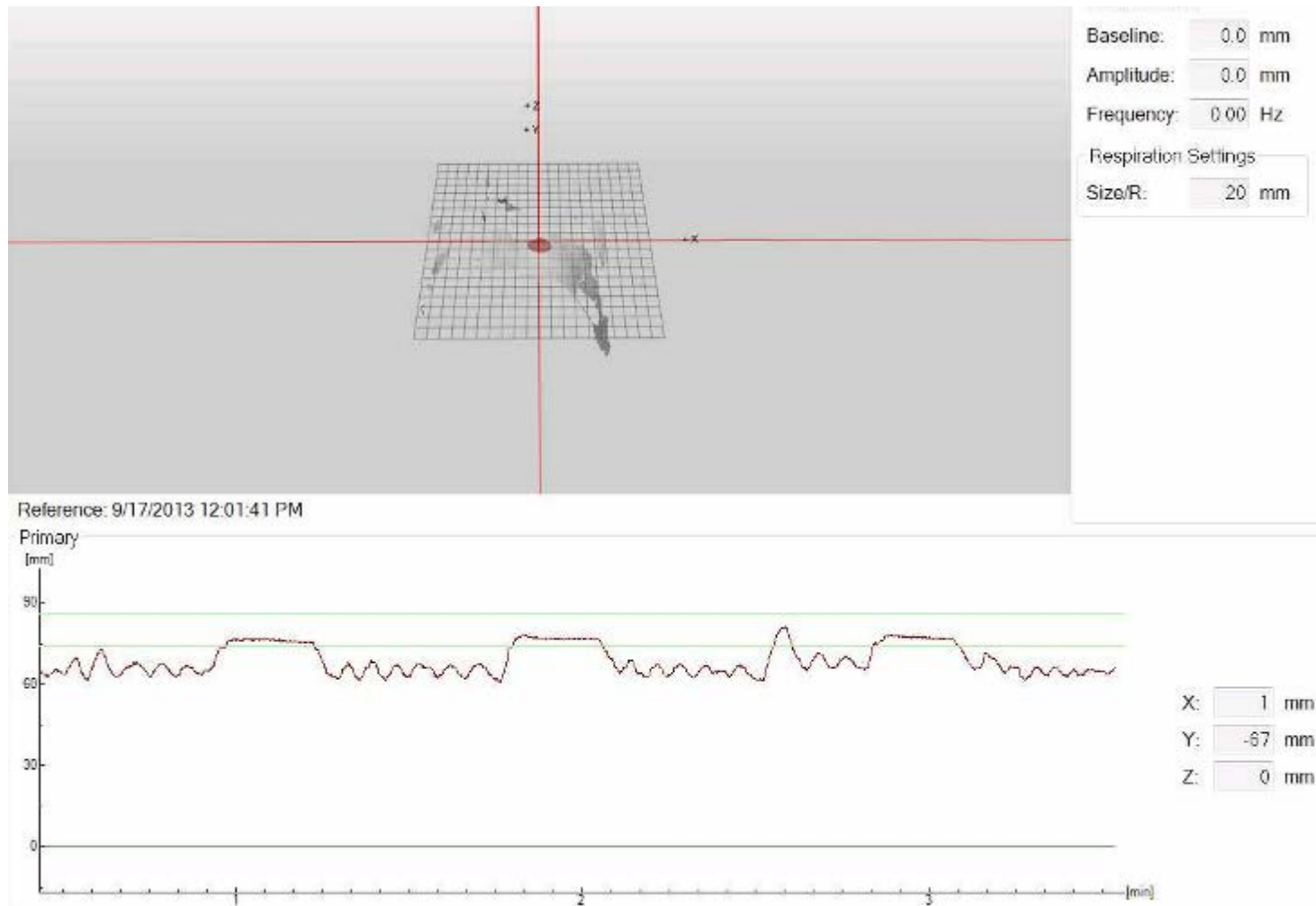


Stieler et al., SUON, 2012

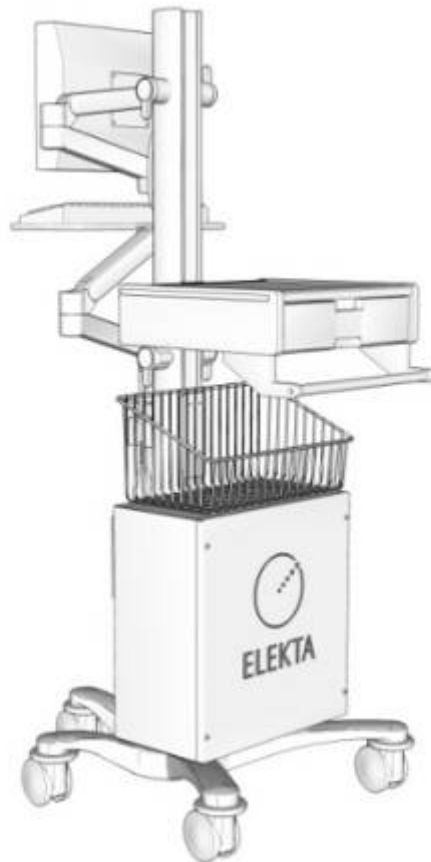
Stieler et al., SUON, 2013



Breath hold surveillance



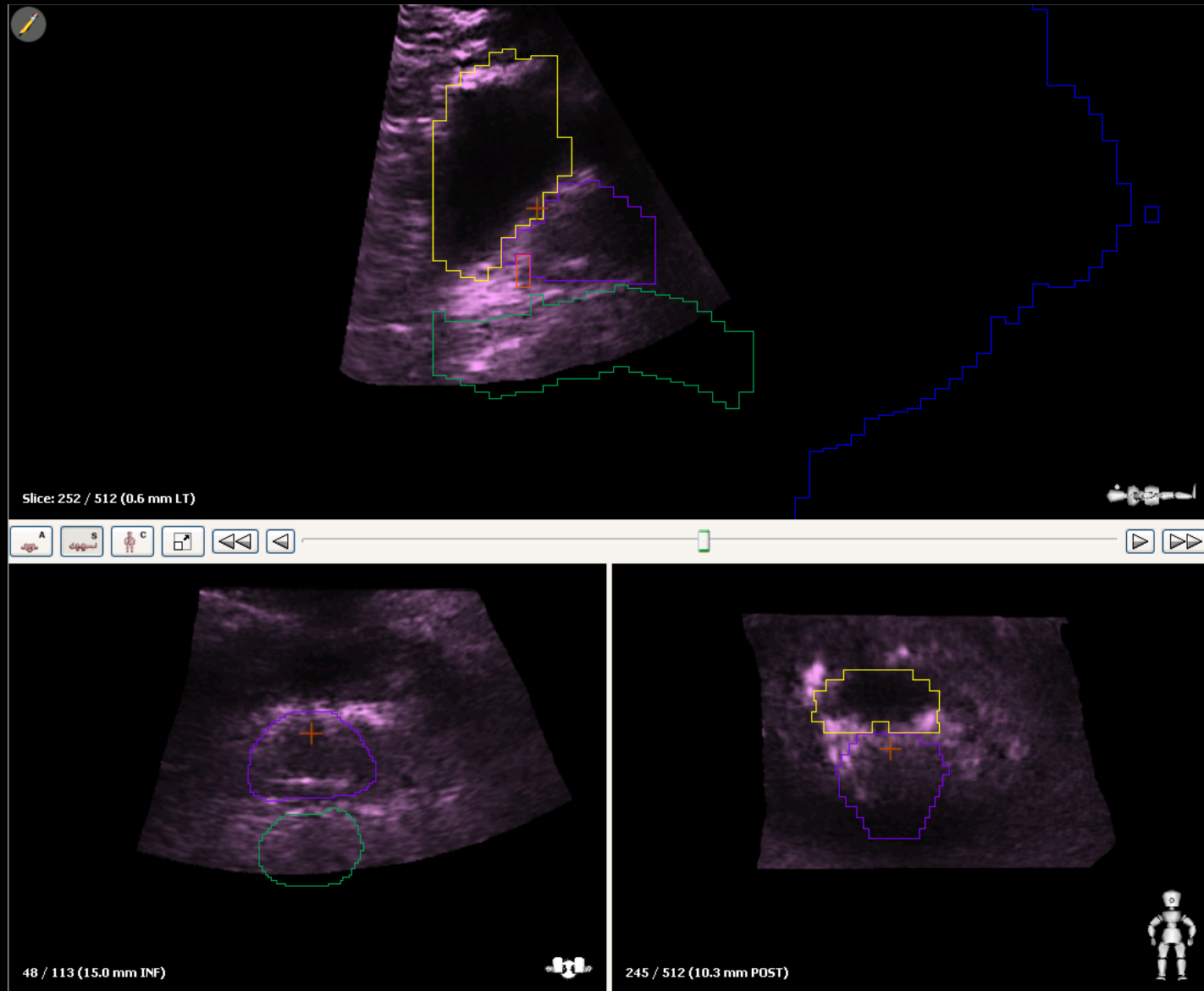
Clinical Setup: Flow-Based Breath Hold Triggering



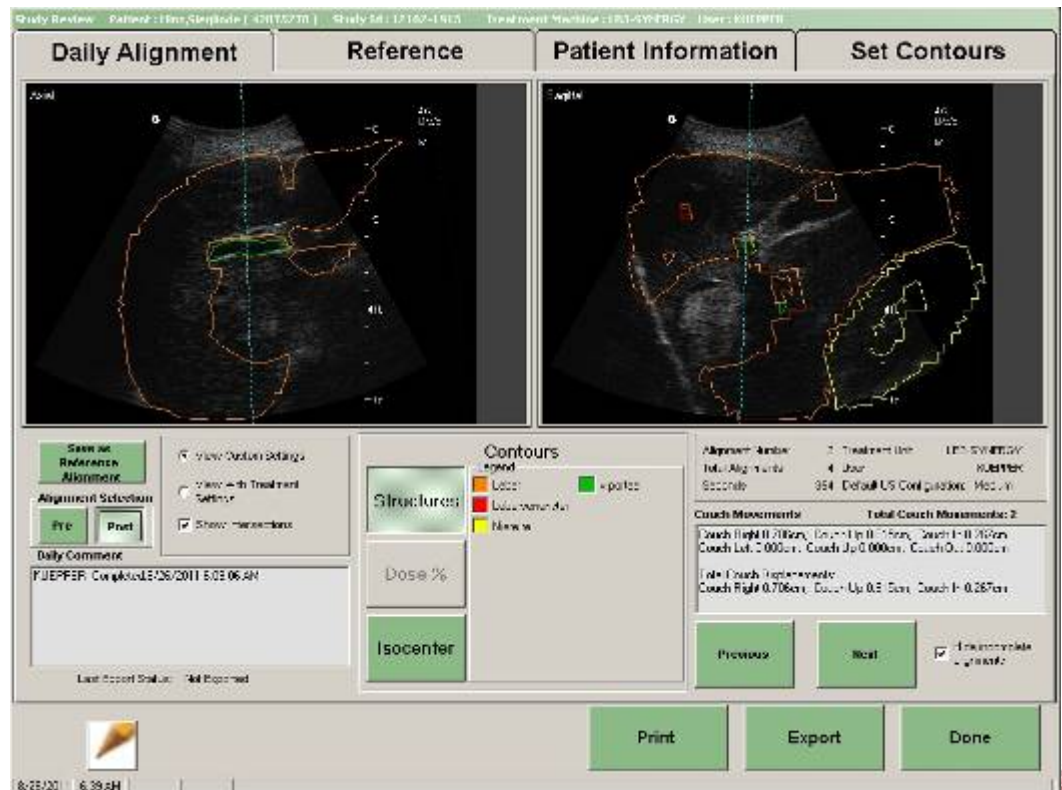
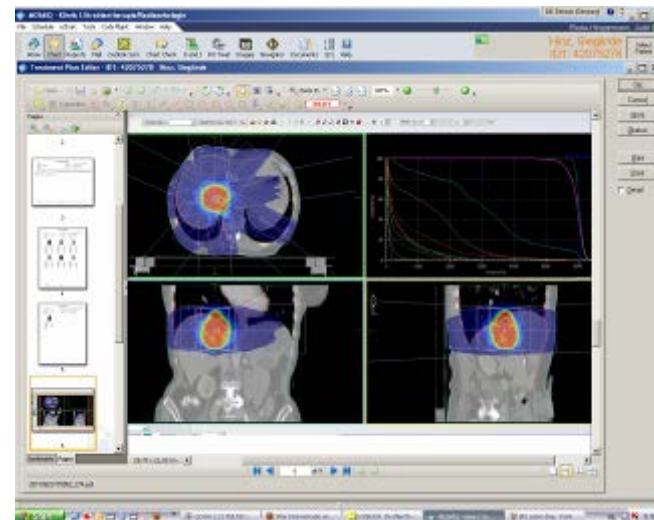
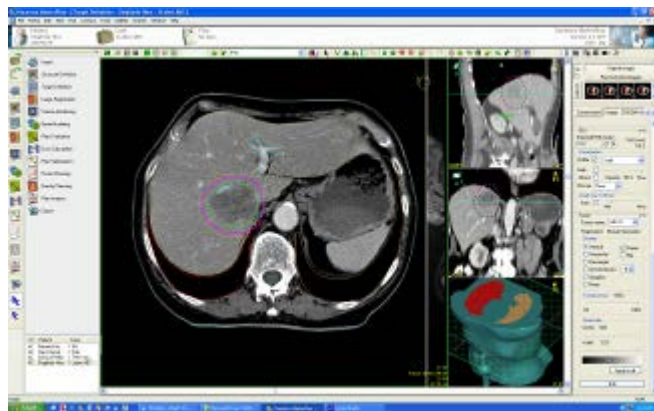
Overview

- Motion Compensation Strategies
- Breath Hold Imaging and Treatment
- **Ultrasound-based positioning**
- Does it work clinically?
- Where do we go from here?

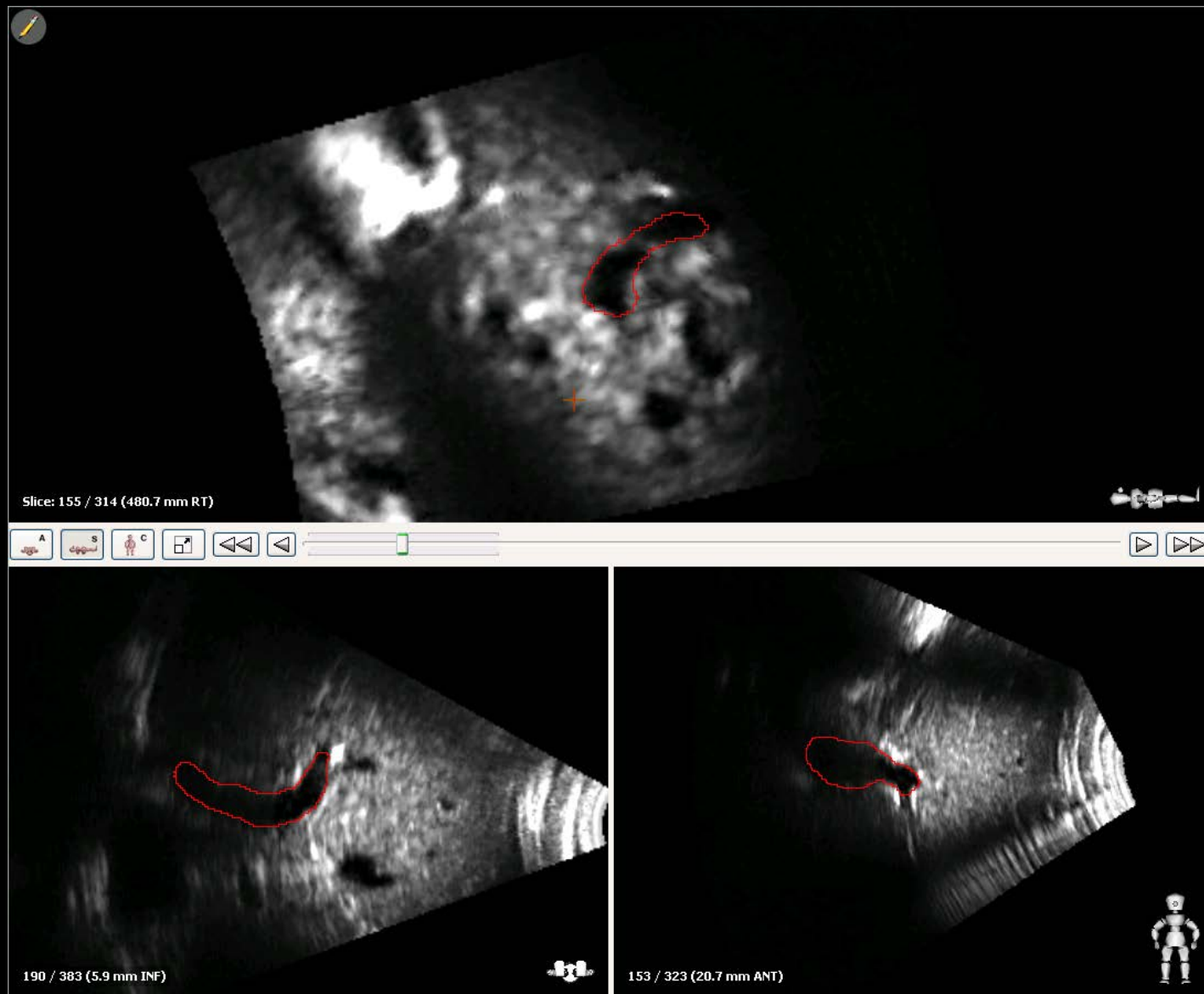
TPUS & TAUS Fused with CT



5 Clicks



Tracking Possibilities with the Portal Vein



Clinical Setup:

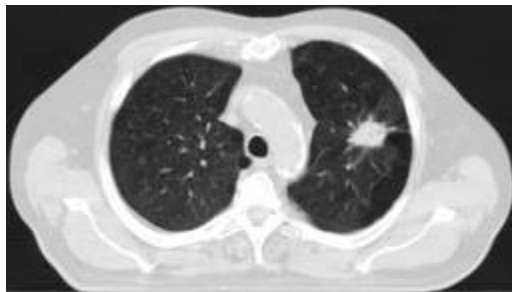
3. Direct Liver Tracking



Overview

- Motion Compensation Strategies
- Breath Hold Imaging and Treatment
- Ultrasound-based positioning
- Does it work clinically?
- Where do we go from here

Fallbeispiel hypofraktionierte Lungenbestrahlung

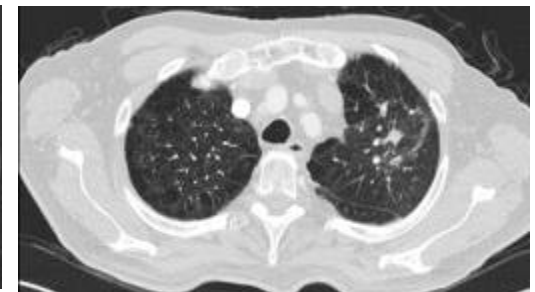


Planungs-CT: 02.09.09

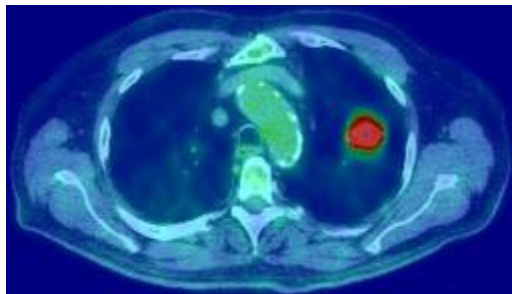
Radiatio
→
Sept 2009



Nachsorge-CT: 26.11.09



Nachsorge-CT: 06.10.10



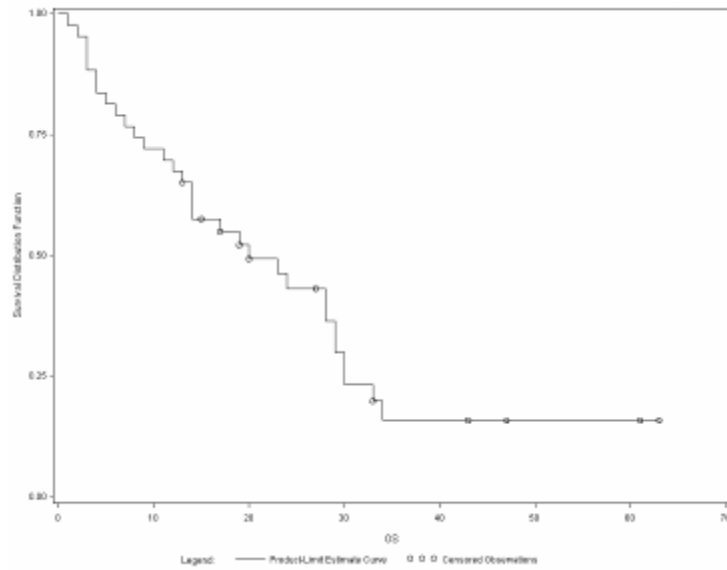
PET-CT: 31.08.09

80 jähriger Patient mit NSCLC Stadium I, T2aN0M0
Nebendiagnosen: COPD, Emphysem, KHK, art. Hypertonie
FEV1: 2,3l

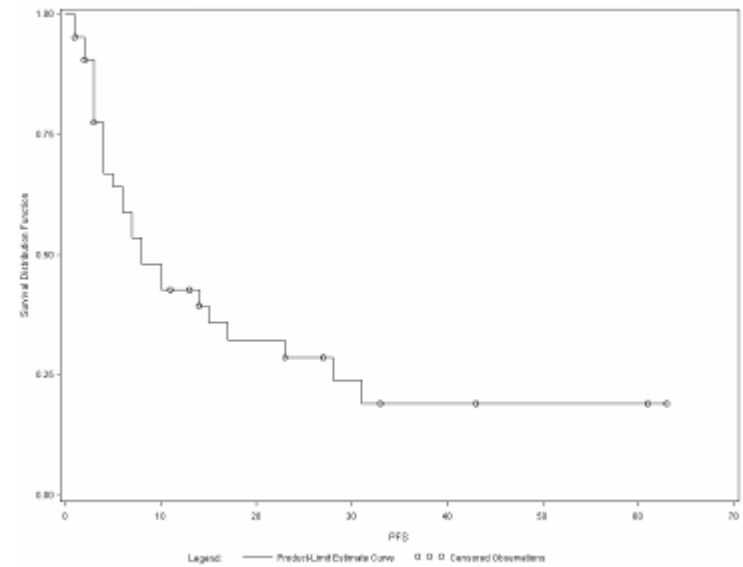
Zurzeit lokal kontrolliert und progressionsfrei

Lungen - Ergebnisse

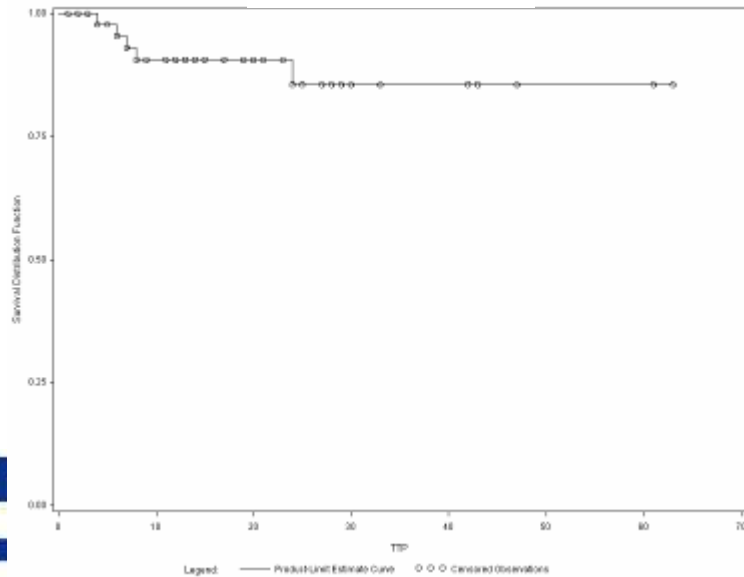
Overall Survival



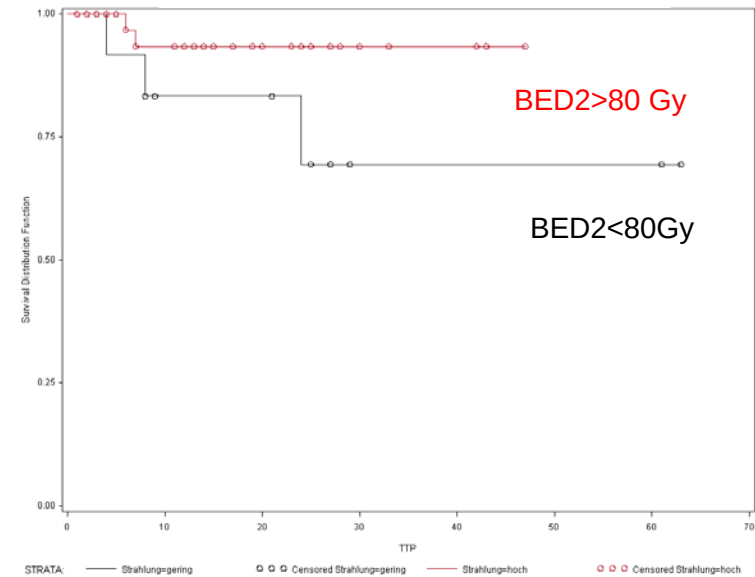
Progression Free Survival



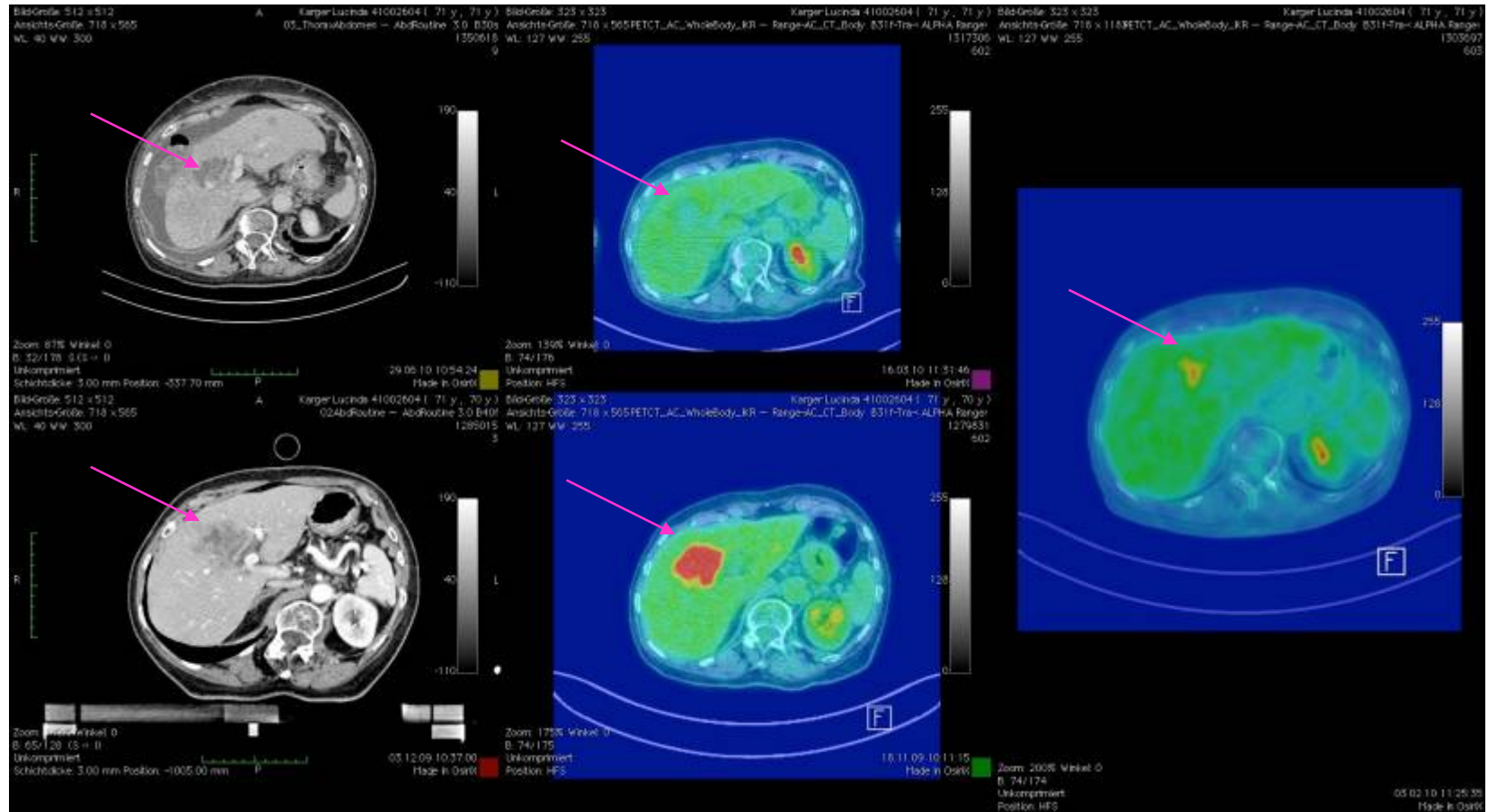
Local Control

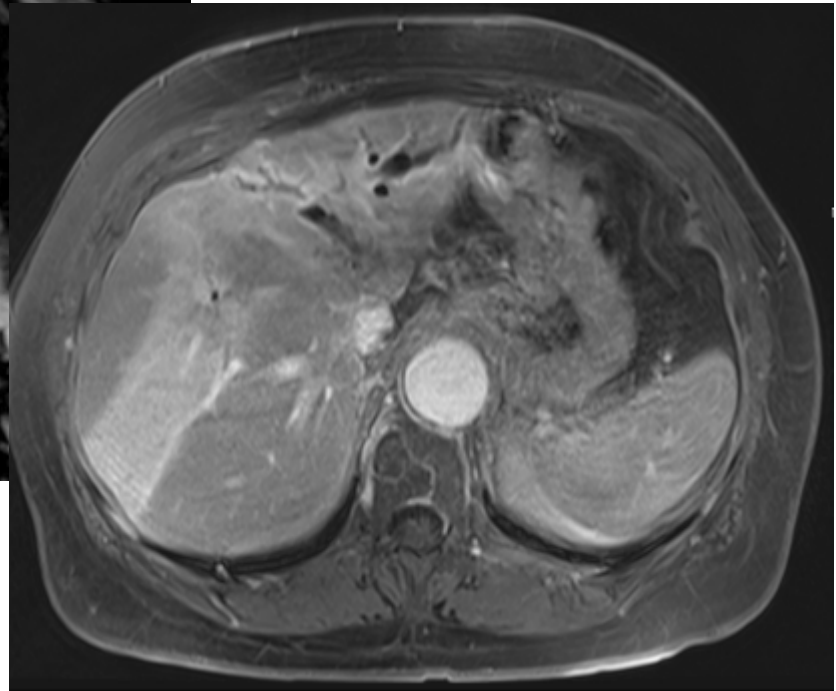
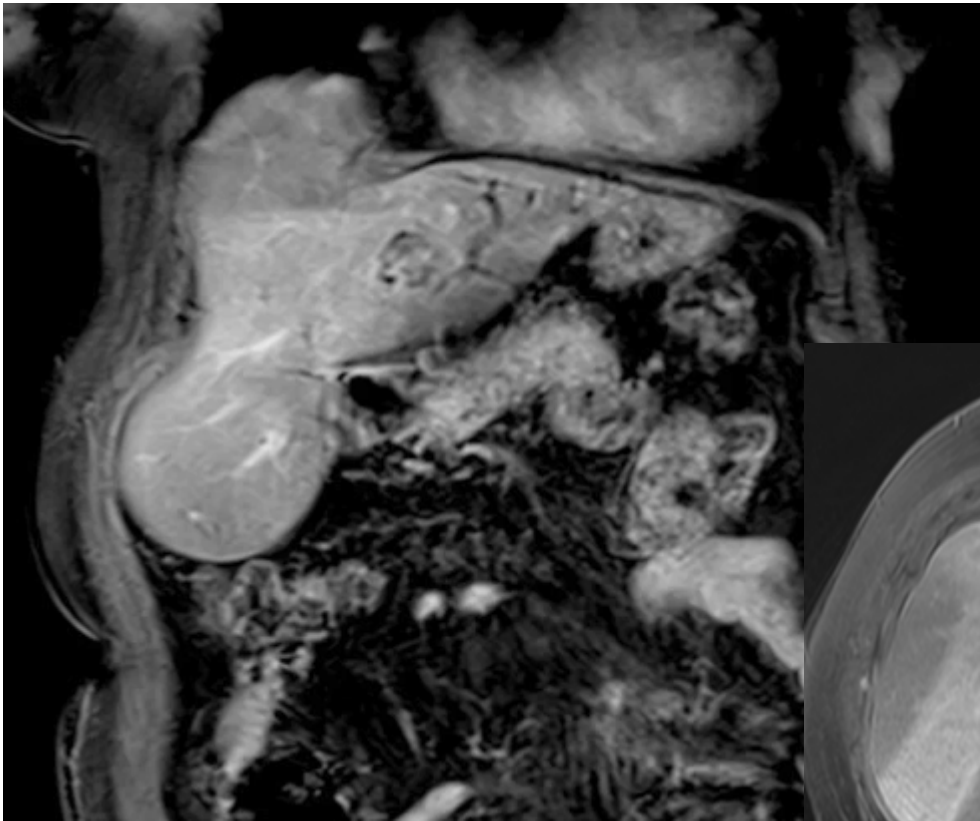


Local Control - abhängig von Dosis

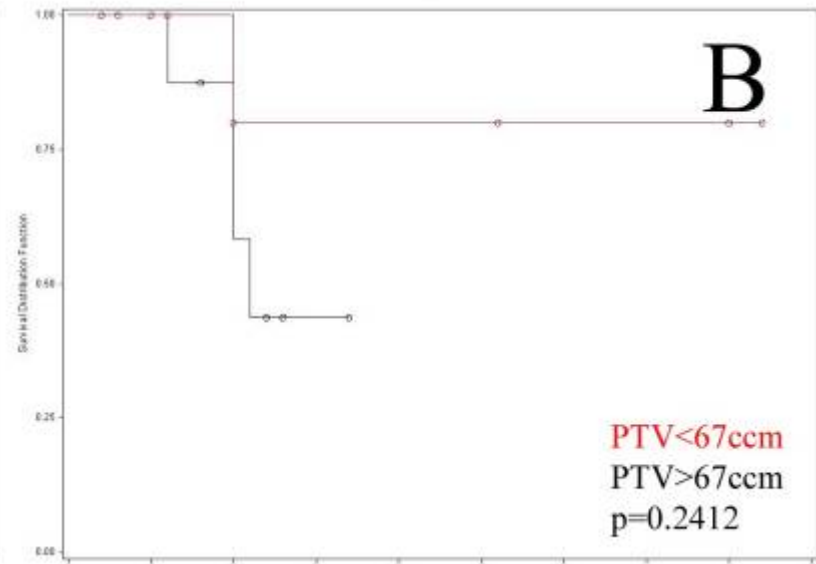
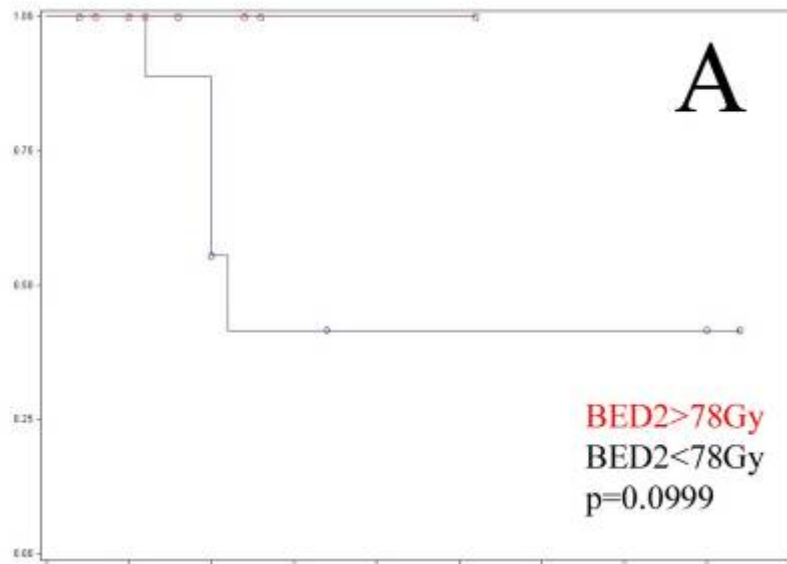


Functional imaging: PET -> complete remission





Local control



Overview

- Motion Compensation Strategies
- Breath Hold Imaging and Treatment
- Ultrasound-based positioning
- Does it work clinically?
- Where do we go from here

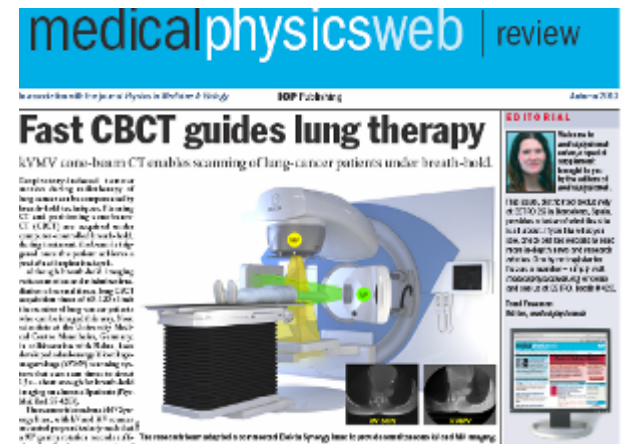
Fast kilovoltage/megavoltage (kVMV) breathhold cone-beam CT for image-guided radiotherapy of lung cancer

Hansjoerg Wertz^{1,5}, Dzmitry Stsepankou¹, Manuel Blessing¹, Michael Rossi², Chris Knox³, Kevin Brown³, Uwe Gros², Judit Boda-Heggemann¹, Cornelia Walter⁴, Juergen Hesser¹, Frank Lohr¹ and Frederik Wenz¹

kV



MV



Conclusion

Several motion compensation strategies successfully reduce motion effects in clinical radiotherapy

Breath hold treatments under IGRT control are easy to perform and precise

Ultrasound is a very precise positioning tool, particularly suited for breath hold liver radiosurgery and is ideal for noninvasive continuous target surveillance/tracking where applicable

Clinical results with these strategies are good