



RESPIRATORY MODULE

Dr. Torsten Moser
SGRT Meeting Berlin

Wie funktioniert es?

Motion Management with AlignRT®



Projektion eines infraroten **Speckle-Musters** auf die Patienten-Oberfläche



Stereo HD Kamera-Pods prozessieren das Muster in 3D



Software rekonstruiert die gesamte **Oberfläche**



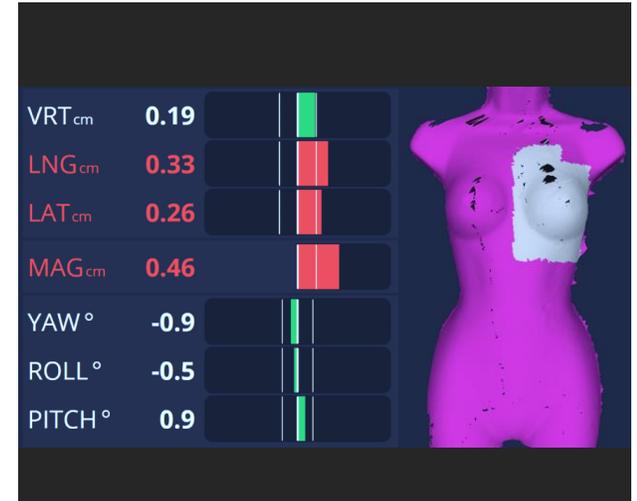
Live-Bild der Oberfläche wird in Echtzeit auf die **Referenzoberfläche** aus dem CT oder AlignRT gematched (Framerates: **10-20 fps**)



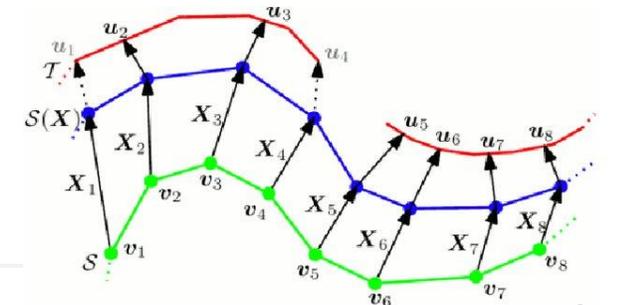
Depth



Projektor/stereoskopische Kameras → 3D-Oberfläche



Rigide Registrierung 6DoF
Setup und Monitoring





A phantom evaluation of a stereo-vision surface imaging system for radiotherapy patient setup

Christoph Bert
*Biophysics, Gesellschaft für Schwerionenforschung, Planckstrasse 1, 64291 Darmstadt, Germany;
 Department of Radiation Oncology, Massachusetts General Hospital, Boston, Massachusetts 02114*

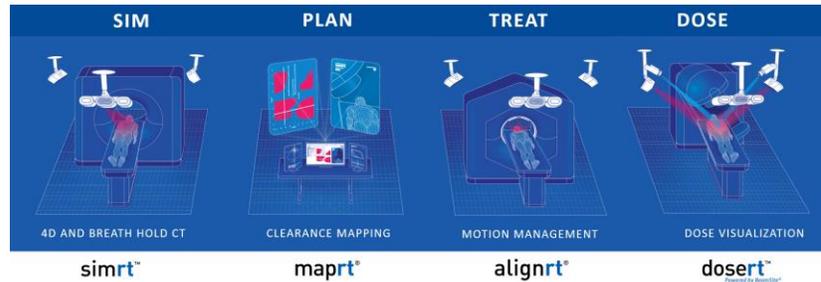
Katherine G. Metheany
Department of Radiation Oncology, Massachusetts General Hospital, Boston, Massachusetts 02114

Karen Doppke and George T. Y. Chen
Department of Radiation Oncology, Massachusetts General Hospital & Harvard Medical School, Boston, Massachusetts 02114

(Received 14 December 2004; revised 20 April 2005; accepted for publication 2 June 2005; published 17 August 2005)

Unser Ziel:

Accuracy und precision über die ganze Strahlentherapie Kette



	Accurate	Inaccurate (systematic error)
Precise		
Imprecise (reproducibility error)		

source: <http://academics.wellesley.edu>

Vision RT hat die Oberflächenbildführung mittlerweile vor über 20 Jahren erfunden.

Jedoch erst durch DIBH hat sich die SGRT klinisch etabliert

→ bewegten Zielvolumina



Int. J. Radiation Oncology Biol. Phys., Vol. 64, No. 4, pp. 1265-1274, 2006
 Copyright © 2006 Elsevier Inc.
 Printed in the USA. All rights reserved
 0360-3016/06/\$-see front matter

doi:10.1016/j.ijrobp.2005.11.008

PHYSICS CONTRIBUTION

CLINICAL EXPERIENCE WITH A 3D SURFACE PATIENT SETUP SYSTEM FOR ALIGNMENT OF PARTIAL-BREAST IRRADIATION PATIENTS

CHRISTOPH BERT, M.S.,*† KATHERINE G. METHEANY, B.S.,† KAREN P. DOPPKE, M.S.,†
 ALPHONSE G. TAGHIAN, M.D., Ph.D.,† SIMON N. POWELL, M.D., Ph.D.,†
 AND GEORGE T.Y. CHEN, Ph.D.†

TAKING MOTION INTO ACCOUNT

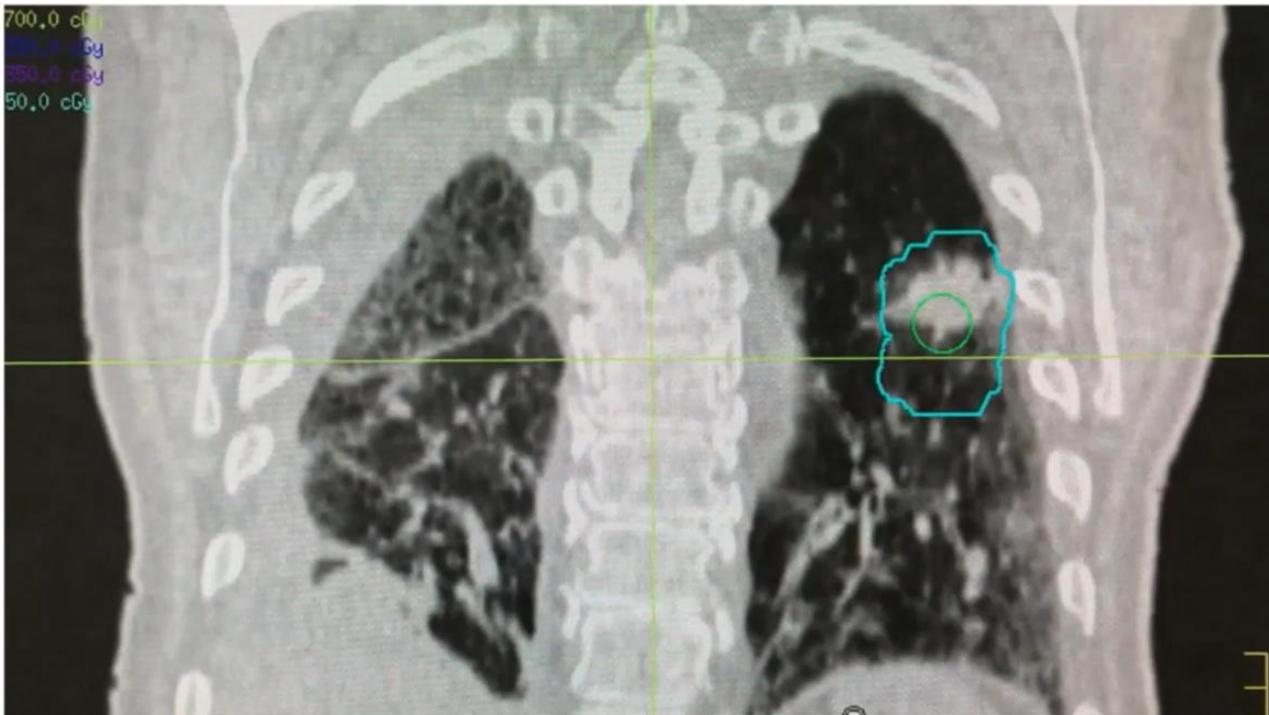
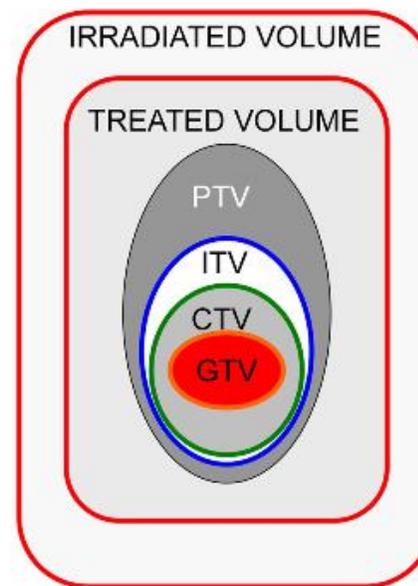


Figure 2: Orange and its peel representing a target volume and its margin. A 6.5 mm thick margin (peel) consists of the same volume as a 5 cm diameter target (orange), taken from Verellen et al. 2007.

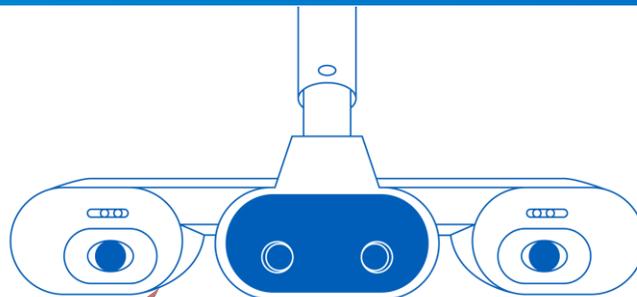


ICRU 50/62/83



- **Gross tumor volume (GTV):** Tumor visible on (CT, MRI, PET, clinical etc.)

Motionmanagement



**Passe den Patienten der
Behandlung an**

- *Atemanhaltetechniken*

1

DIBH

2

EEBH



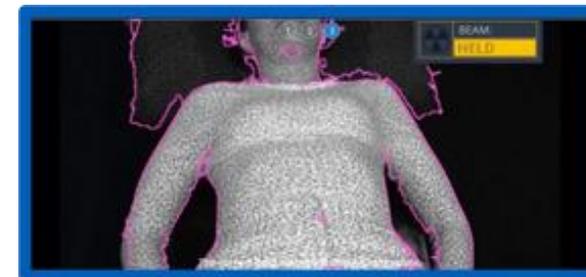
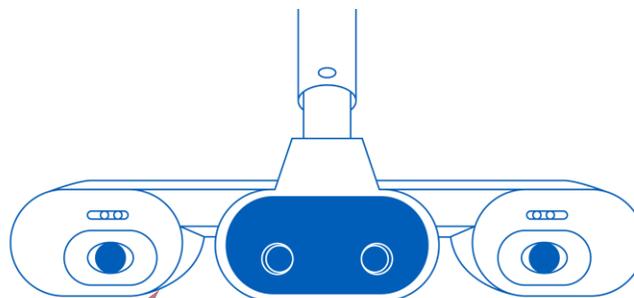
Nicht-periodische Bewegung Beam Gating

The screenshot displays a medical software interface for beam gating. The top left shows a pause button and the patient name 'Brain ISO 1'. The top center shows 'SGRT BODY' and 'ROI1'. The top right has a 'Beam Control' toggle and a 'BEAM: HELD' status indicator.

The central panel displays motion data for various parameters:

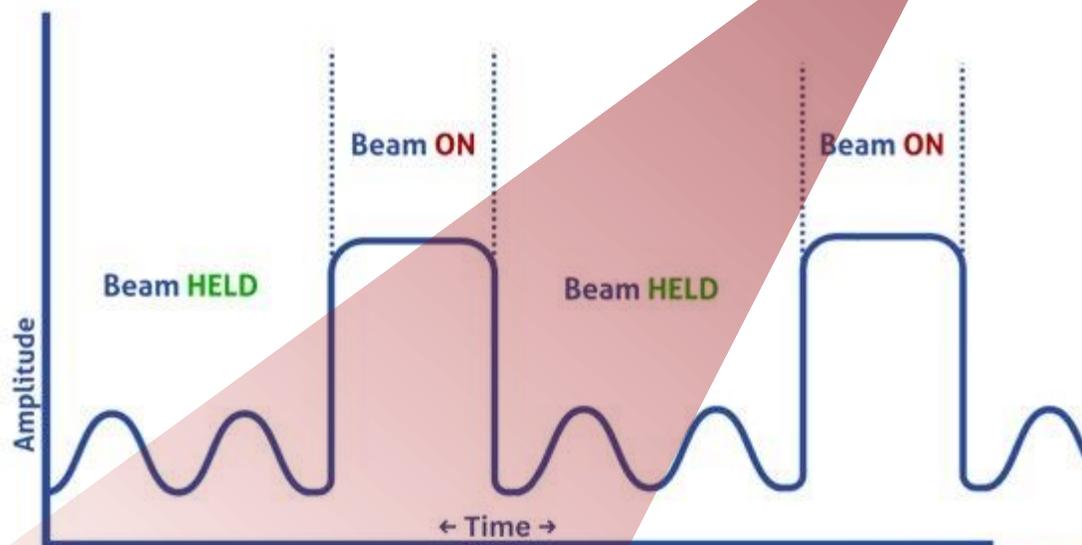
Parameter	Value	Visual Indicator
VRT _{cm}	0.17	Green bar
LNG _{cm}	0.31	Red bar
LAT _{cm}	0.24	Red bar
MAG _{cm}	0.43	Red bar
YAW°	-0.8	Green bar
ROLL°	-0.5	Green bar
PITCH°	0.9	Green bar

The right side of the interface shows a video feed of a patient's head with motion contours. Below the video is a timeline with a yellow bar indicating the beam status. The bottom right has tabs for 'Surface', 'Deformation', and 'Video'.



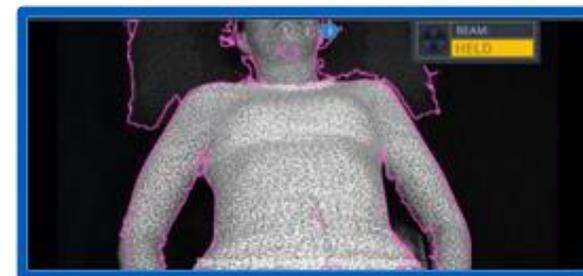
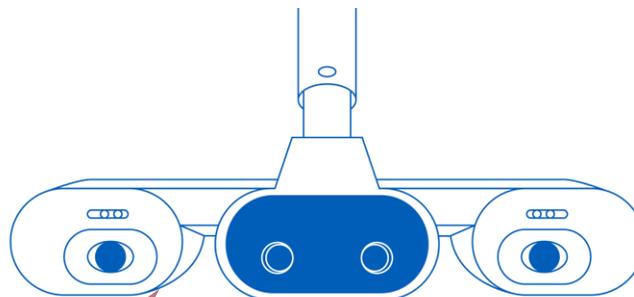
DIBH

Deep Inspiration Breath Hold (DIBH) a well-recognized technique used in radiotherapy treatments for the breast, thorax and abdomen. The patient takes a deep breath in and holds whilst the radiation is delivered.



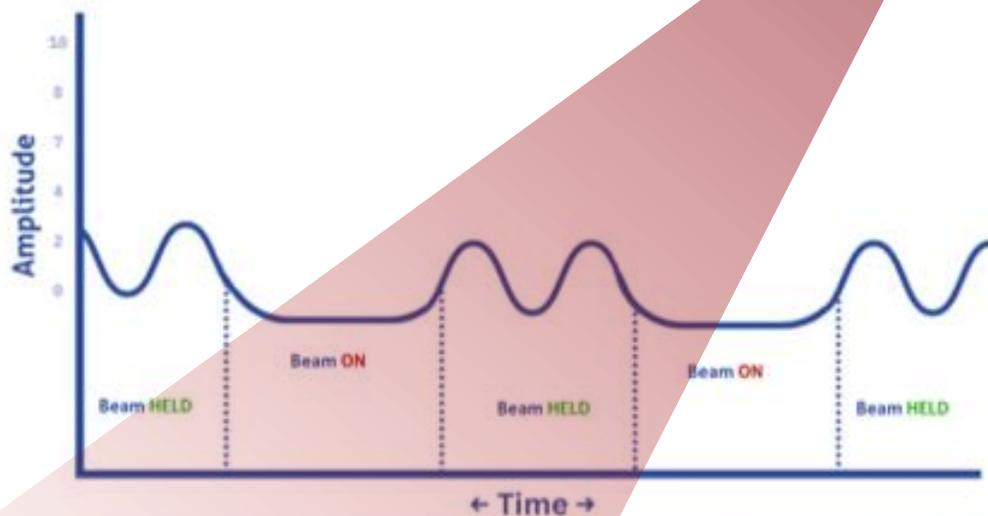
- Atemanhalt in tiefer Einatmung
- Effektive und unkomplizierte Methode die Bewegung zu reduzieren
- Für viele Brustbestrahlungen bereits state-of-the-art.
- Nicht von allen Patienten gut toleriert.

VRT _{cm}	0.04	
LNG _{cm}	0.07	
LAT _{cm}	0.04	
MAG _{cm}	0.09	
YAW [°]	-0.2	
ROLL [°]	0.0	
PITCH [°]	-0.3	



EEBH

End Expiration Breath Hold (EEBH) a technique sometimes used in SBRT treatments to the abdomen. The patient will hold their breath at the end point of their expiration cycle whilst the radiation is delivered.



- Viele Kliniker glauben, dass EEBH besser toleriert wird als DIBH.
- End-expiration repräsentiert die längste statische Phase im Atemzyklus und kann für Atemanhaltetechniken geeigneter sein.

VRT _{cm}	0.04		
LNG _{cm}	0.07		
LAT _{cm}	0.04		
MAG _{cm}	0.09		
YAW [°]	-0.2		
ROLL [°]	0.0		
PITCH [°]	-0.3		

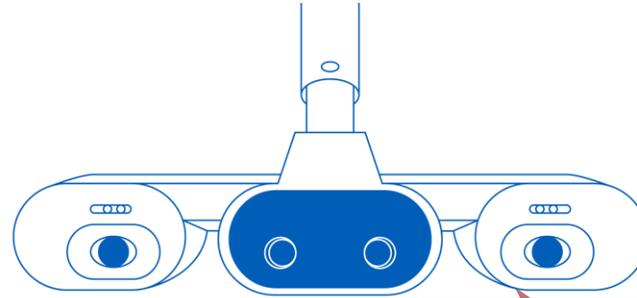
Periodische Bewegung Beam Gating

The screenshot displays a medical software interface for beam gating. The top left shows a pause button and the patient name "Brain ISO 1". The top center shows a patient icon and "SGRT BODY". The top right shows a patient icon and "ROI1", along with a "Beam Control" toggle switch and a "BEAM: HELD" indicator.

The left panel displays movement metrics with corresponding bar charts:

Metric	Value
VRT _{cm}	0.17
LNG _{cm}	0.31
LAT _{cm}	0.24
MAG _{cm}	0.43
YAW°	-0.8
ROLL°	-0.5
PITCH°	0.9

The right panel shows a 3D model of a patient lying on a couch, with a pink outline representing the body. Below the model is a video player with a yellow progress bar. The video player has tabs for "Surface", "Deformation", and "Video".

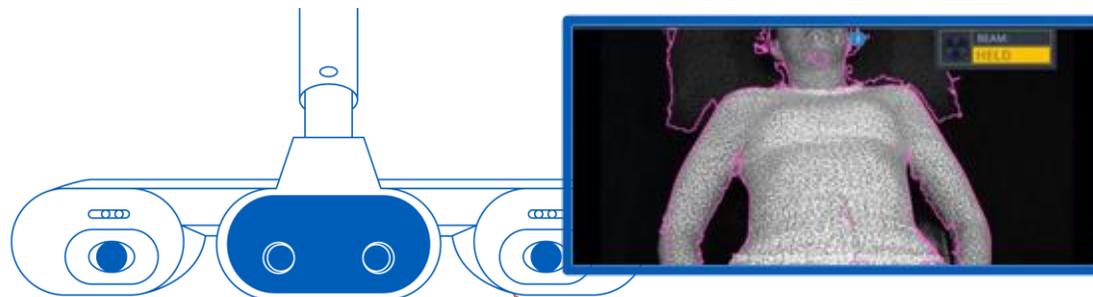
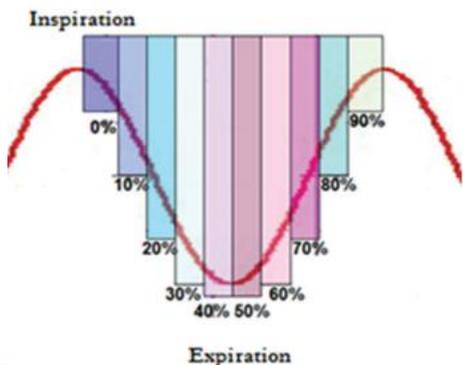


Passe Behandlung dem Patienten an

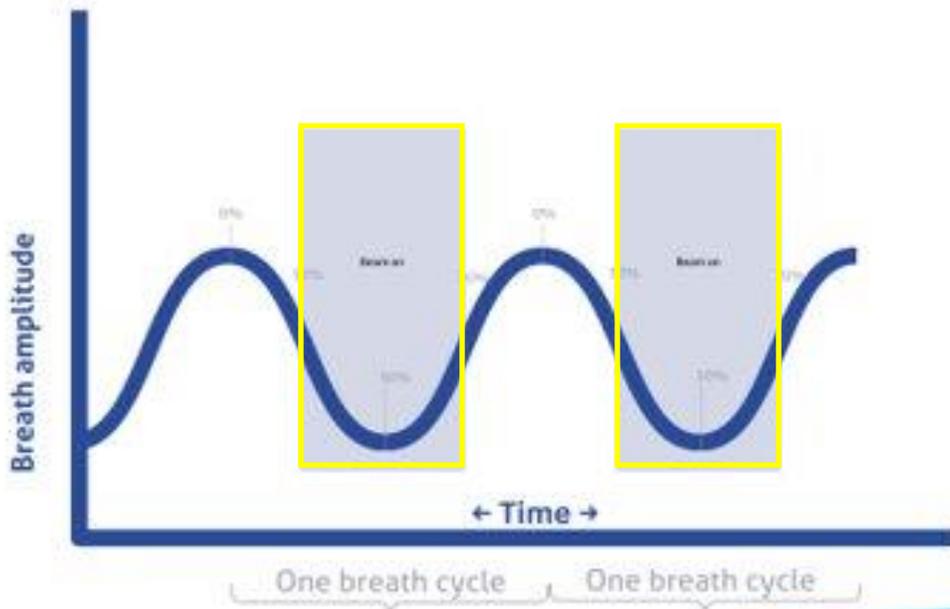
- *Rx in freier Atmung*

3

Phase

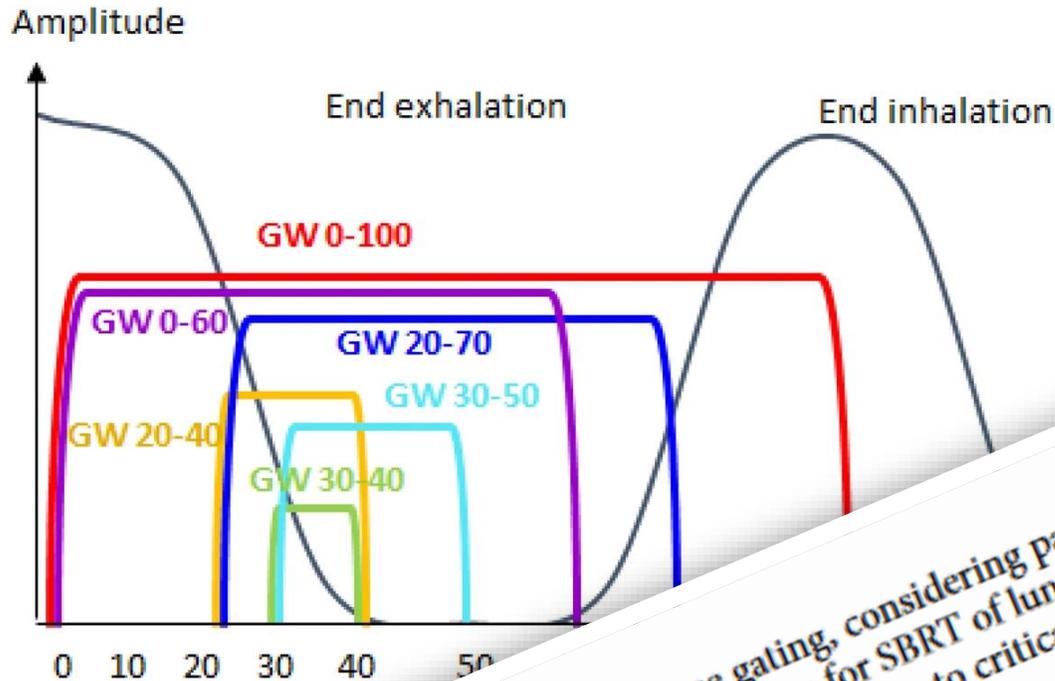


In **PHASE-based gating**, the beam is on during a prescribed phase of the breathing cycle. The **timing** of the cycle is the trigger.



- Behandlungsstrahl nur während der gewählten **Phase**
- Niedriger Duty Cycle

VRT _{cm}	0.04		
LNG _{cm}	0.07		
LAT _{cm}	0.04		
MAG _{cm}	0.09		
YAW°	-0.2		
ROLL°	0.0		
PITCH°	-0.3		



Conclusion
 Patient-individual phase gating, considering patient individual tumor position and location, can considerably improve the dose distribution for SBRT of lung tumors. This can be of particular importance for the treatment of central tumors in close proximity to critical organs with high radiation doses.

Schematic drawing of amplitude vs. phase showing end exhalation and end inhalation curves. Several gating windows (GW) are overlaid: GW 0-100 (red), GW 0-60 (purple), GW 20-70 (blue), GW 20-40 (yellow), GW 30-50 (cyan), and GW 30-40 (green). The x-axis is labeled from 0 to 50.

Kraus, K.M., Oechsner, M., Wilkens, J. et al. Patient individual phase gating for stereotactic radiation therapy of early stage non-small cell lung cancer (NSCLC). Sci Rep

Case number and case location peripheral	GW (phase)	PTV (cm ³)	PTV reduction		Max GTV motion (mm)	PTV		V _{20Gy} [lung] (%)	V _{20Gy} [lung] red. (%)	D _{mean} [lung] (Gy)	
			(%)	(cm ³)		D _{50%} (Gy)	D _{95%} (Gy)				
1 RLL	30-50	44.7	-	-	-	22.1	46.7	7.5	11.8	6.6	
						47.7	8.5	7.0			
						68.4	55.6	42.8	5.5	3.5	4.4
						70.3	56.1	45.3	5.7	4.6	
	30-50	22.1	35.5	12.2	5.8. Ir	58.8	50.6	40.5	4.6	33.8	4.1
	0-100	34.3				59.2	50.5	39.0	7.1		5.5
4 RLL	30	40.7	38.4	39.1	17.8. cc	71.1	56.8	45.6	6.0	68.3	5.7
	20-40	61	18.2	18.8		69.1	55.8	42.5	8.0	20.8	7.1
	0-60	69.6	9.9	10.2		70.6	52.8	35.2	8.5	15.8	7.4
	0-100	79.8	-	-		69.6	56.4	42.9	10.1		8.2

Respiratory Gating

PHANTOM, VRT01
1/1/1950, PHY0013

Programs Treatment

NOT FOR CLINICAL USE

Non_Gated ISO 1

SGRT BODY

ROI1

VRT_{cm} 0.02

LNG_{cm} 0.01

LAT_{cm} 0.00

MAG_{cm} 0.02

YAW° 0.0

ROLL° 0.0

PITCH° 0.0

Reference

10/23/2023 6:17:29 PM

Gated Capture

Beam Control

BEAM: **ENABLED**

Respiratory Module Patch Movement
Amplitude Based
8.8 BPM PHASE 51%

Amplitude (cm) 4.0 0.0 -8.0

Time (s) 10 20 30 40 50 60 70 80 90 100

Surface Deformation Video Patch

alignrt® ROI 8.2 fps | Field Status | System Status | 10/23/2023 6:22 PM

PHANTOM, VRT01
1/1/1950, PHY0013

Programs Treatment

NOT FOR CLINICAL USE

Gated ISO 1

SGRT BODY

ROI1

VRT_{cm} -0.36

LNG_{cm} 0.00

LAT_{cm} 0.02

MAG_{cm} 0.37

YAW° 0.1

ROLL° -0.1

PITCH° -0.4

Reference

10/23/2023 6:04:36 PM

Gated Capture

Beam Control

BEAM: **HELD**

Respiratory Module Patch Movement
Phase Based
9.1 BPM PHASE 48% Start 70% Stop 30%

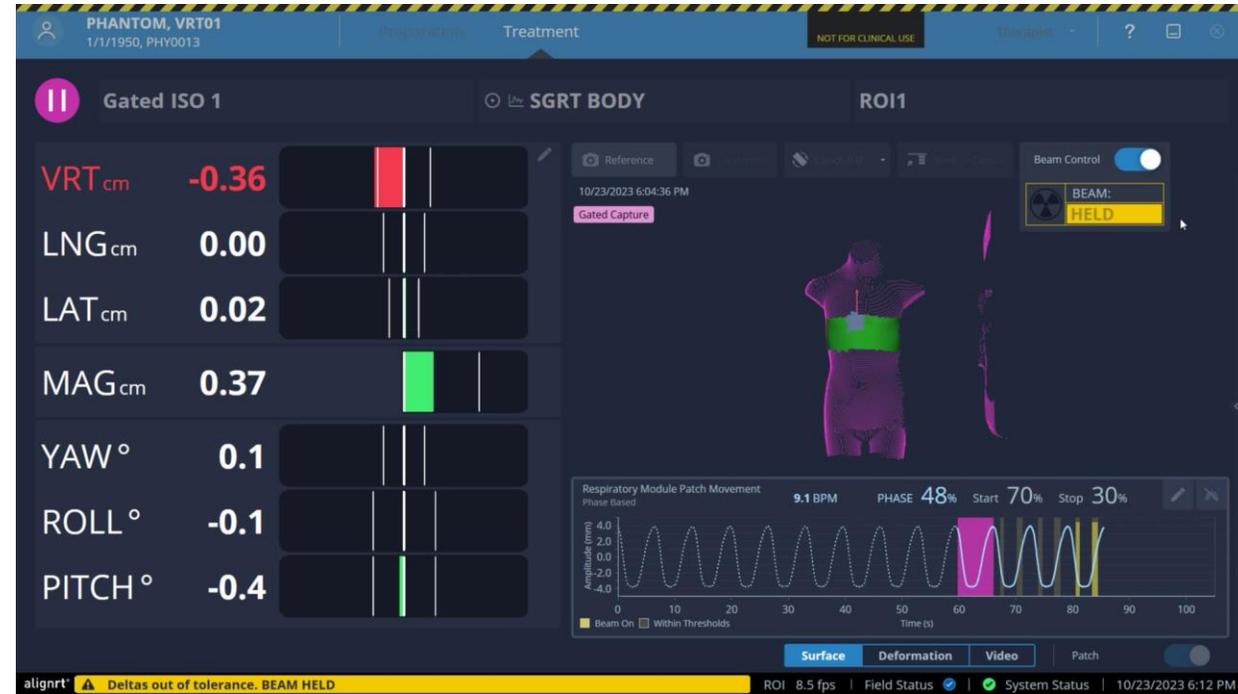
Amplitude (cm) 4.0 2.0 0.0 -2.0 -4.0

Time (s) 0 10 20 30 40 50 60 70 80 90 100

Surface Deformation Video Patch

alignrt® **⚠ Deltas out of tolerance. BEAM HELD** ROI 8.5 fps | Field Status | System Status | 10/23/2023 6:12 PM

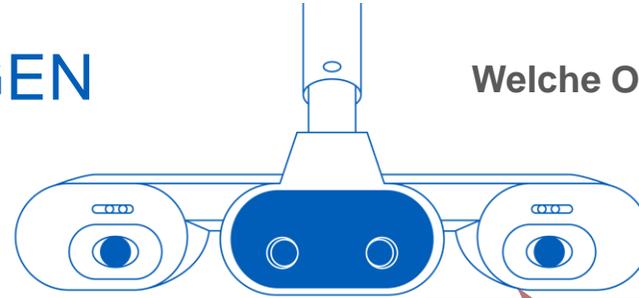
Respiratory Gating



Phasenbasiert

KLINISCHE ANFORDERUNGEN

Welche Optionen für Atembewegungsmanagement gibt es?



**Passe Behandlung
dem Patienten an**

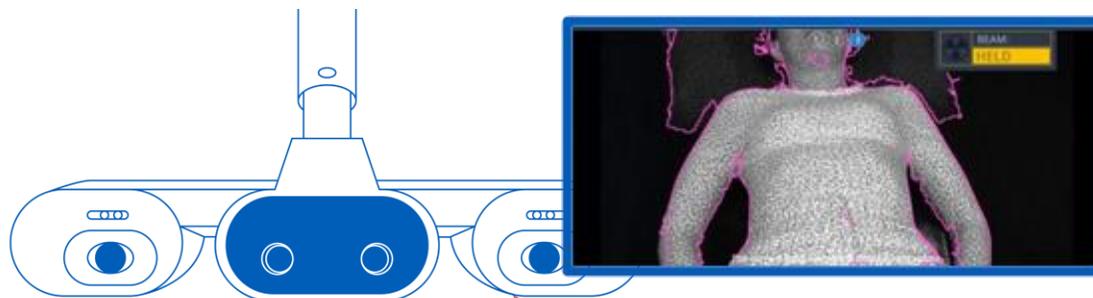
- *Rx in freier Atmung*

3

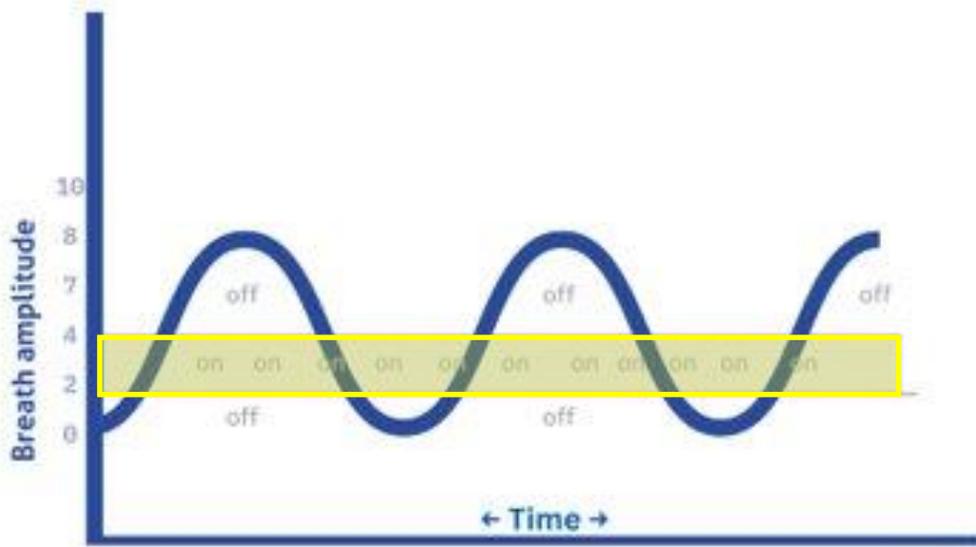
Phase

4

Amplitude



In **AMPLITUDE**-based gating, the beam is on during a specific amplitude, regardless of where the patient is in the breathing cycle.



- Behandlungsstrahl nur während einer bestimmten **Amplitude**
- Üblicherweise höherer Duty Cycle als phasenbasiert
- Niedrigere Konformität

VRT _{cm}	0.04	
LNG _{cm}	0.07	
LAT _{cm}	0.04	
MAG _{cm}	0.09	
YAW [°]	-0.2	
ROLL [°]	0.0	
PITCH [°]	-0.3	

Respiratory Gating

PHANTOM, VRT01
1/1/1950, PHY0013

Preparation Treatment

NOT FOR CLINICAL USE

Non_Gated ISO 1

SGRT BODY ROI1

VRT_{cm} 0.02

LNG_{cm} 0.01

LAT_{cm} 0.00

MAG_{cm} 0.02

YAW° 0.0

ROLL° 0.0

PITCH° 0.0

Reference

10/23/2023 6:17:29 PM

Gated Capture

Beam Control

BEAM: **ENABLED**

Respiratory Module Patch Movement
Amplitude Based
8.8 BPM PHASE 51%

Amplitude (cm) 4.0 0.0 -8.0

Time (s) 10 20 30 40 50 60 70 80 90 100

Beam On Within Thresholds

Surface Deformation Video Patch

alignrt® ROI 8.2 fps | Field Status | System Status | 10/23/2023 6:22 PM

PHANTOM, VRT01
1/1/1950, PHY0013

Preparation Treatment

NOT FOR CLINICAL USE

Gated ISO 1

SGRT BODY ROI1

VRT_{cm} -0.36

LNG_{cm} 0.00

LAT_{cm} 0.02

MAG_{cm} 0.37

YAW° 0.1

ROLL° -0.1

PITCH° -0.4

Reference

10/23/2023 6:04:36 PM

Gated Capture

Beam Control

BEAM: **HELD**

Respiratory Module Patch Movement
Phase Based
9.1 BPM PHASE 48% Start 70% Stop 30%

Amplitude (cm) 4.0 2.0 0.0 -2.0 -4.0

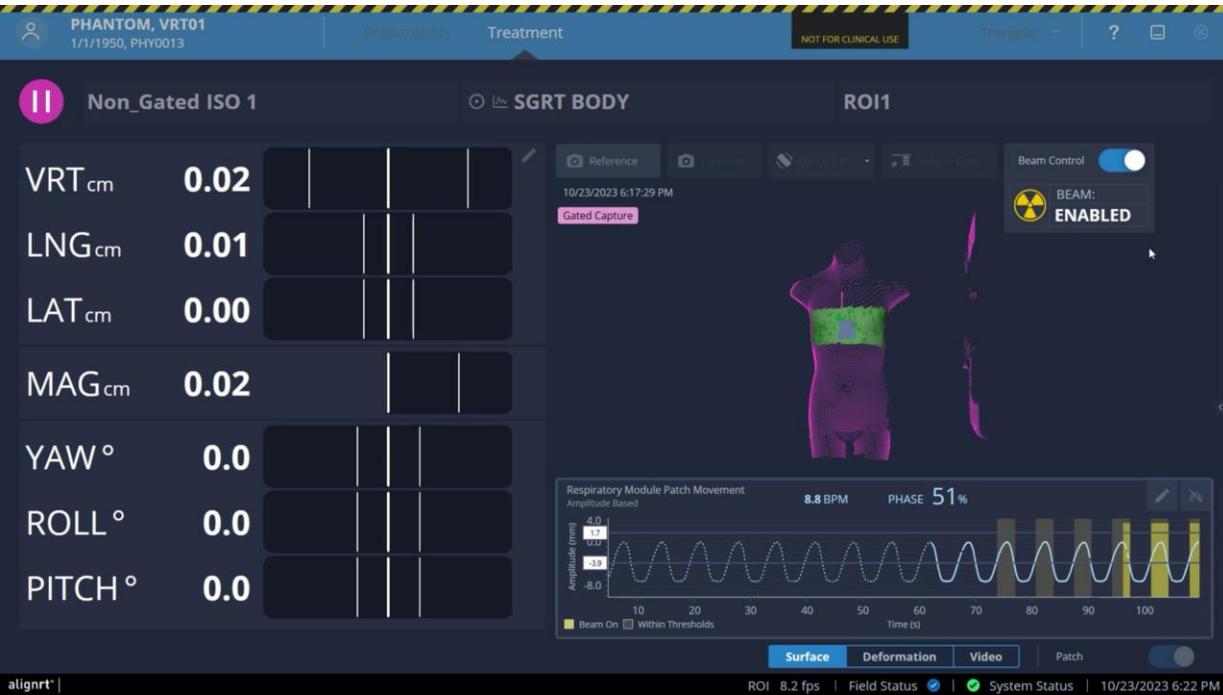
Time (s) 0 10 20 30 40 50 60 70 80 90 100

Beam On Within Thresholds

Surface Deformation Video Patch

alignrt® **⚠ Deltas out of tolerance. BEAM HELD** ROI 8.5 fps | Field Status | System Status | 10/23/2023 6:12 PM

Respiratory Gating



Amplitudenbasiert

mouse, minnie
01/01/1920, 1231

Preparation Treatment www.BANDICAM.com Logged in as Service user NOT FOR CLINICAL USE

Lung1 SGRT Surface ROI1

VRT _{cm}	0.02	
LNG _{cm}	0.05	
LAT _{cm}	0.03	
MAG _{cm}	0.06	
YAW [°]	-0.1	
ROLL [°]	0.0	
PITCH [°]	-0.1	

Reference Treatment Couch 0.0° Beam Control

23/11/2023 11:38:25

Gated Capture
Treat Without Plan

Respiratory Module Patch Movement
Phase Based BPM PHASE -- % Start 30% Stop 70%

Amplitude (mm) vs Time (s)

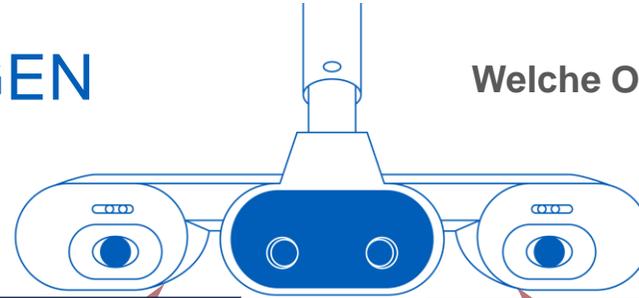
Legend: Beam On (yellow), Within Thresholds (green)

Surface Deformation Video Patch

aliant® | Patch 23.3 fns ROI 12.0 fns | TreatmentMonitoringState | 1838.69 MB | System Status | 23/11/2023 11:39

KLINISCHE ANFORDERUNGEN

Welche Optionen für Atembewegungsmanagement gibt es?



**Passe den Patienten der
Behandlung an**

- *Atemanhaltetechniken*

1

DIBH

2

EEBH

**Passe Behandlung
dem Patienten an**

- *Rx in freier Atmung*

3

Phase

4

Amplitude

**Respiratory Module
in AlignRT
erfüllt alle**

Klinische Anforderungen

Questions and Discussion
