

**Dr. Franco Canestri
C-RAD GmbH**

C-RAD Patientenlagerungsüberwachung und Atem Gating
während der Strahlentherapie :

→ die Erfahrungen aus Gelsenkirchen, Dresden, Weiden, Lund, Seattle und Stockholm

Für :

**Treffen von AK IMRT und AK Klinische Festkörperdosimetrie
03. + 04.04.2017 - Münster**

Agenda

Background

C-RAD methods used in optical triangulation

Workflow CT → RT

Clinical Benefits and Published Results : Videos.

New Products !

Discussion

Background of the Presenter

- Ph.D in Medical Physics from University of Genoa and National Cancer Institute of Milan - Italy („Lasers in Surgery and Oncology“)
- Since 33 Years in Germany
- Professional Experiences with Hewlett-Packard Medical and Agilent Technologies Optical Division in Böblingen (Product Design). With C-RAD since beginning 2013.
- Scientific Publications : www.franco-canestri.de

Background of the Company



- *Product ideas based on specific studies about patient positioning and monitoring during radiation therapy at the :*

Karolinska Institutet, Stockholm



- *Research and first developments by Anders Brahme started back in 1997*
- *C-RAD company was founded in 2003, now with Main Subsidiaries in USA, Germany, France and China plus 20+ Distributors world-wide.*



→ C-RAD GmbH in Germany : 3 Offices in Berlin, Karlsruhe and Landau (Pfalz).

End-to-end treatment solution

Sentinel 4DCT
in CT room



For all CT
Manufacturers



Catalyst/HD/PT in
RT room



SETUP AND
POSITIONING
OF PATIENTS



INTRA-FRACTION
MOTION DETECTION



RESPIRATORY
GATING



Multi Vendor
Support



Siemens

„Installed base“ C-RAD Systeme in DACH :

„Sentinel“ (CT Raum) : 18

„Catalysts“ (Behandl. Raum) : 35 alle (1-Kamera + 3-Kamera HD (*))

(„Catalysts HD“ (Behandl. Raum) : 18 (*))

C-RAD „HIT“ Raum Lasers : 12

Gesamt : 65 C-RAD Systeme - Deutschsprachige Länder
(Status ende März 2017) in 29 Kliniken.

Publikationen : aus LMU, UMM, Uni Mainz, Gelsenkirchen, etc.

Uni Kliniken mit C-RAD : Aachen, Mainz, LMU x 2, UMM, Bonn, Köln, Essen.

(*) : Catalyst HD 3-Kamera Version

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NEW ! C-RAD SGSRT solution

*Stereotactic radiation therapy including
frameless SRS and SBRT workflow*



**Visit our Stand at ESTRO in
Vienna 2017**



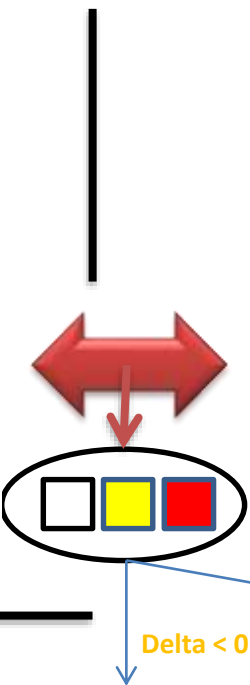
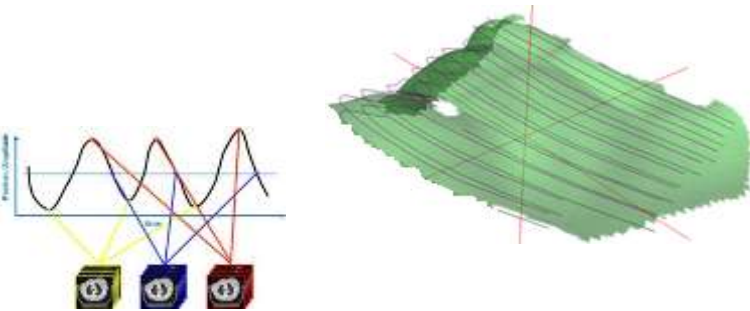
**All-in-one solution
for SRS and SBRT!**

Workflow : Step 2 – RT (first Fraction)

from CT Room
SENTINEL

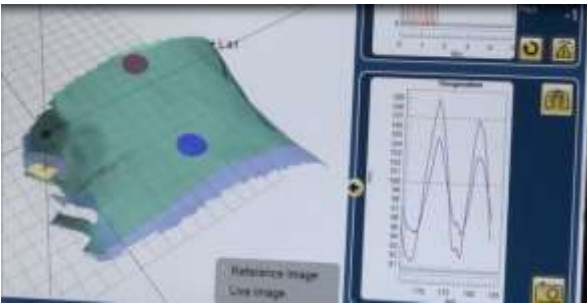
in RT Room
@catalyst

- **Again** : Patient's Surface (now, first fraction at the Linac)
+ local Gating



$\Delta < 0$

$\Delta = 0$
 $\Delta > 0$



Gating at Linac

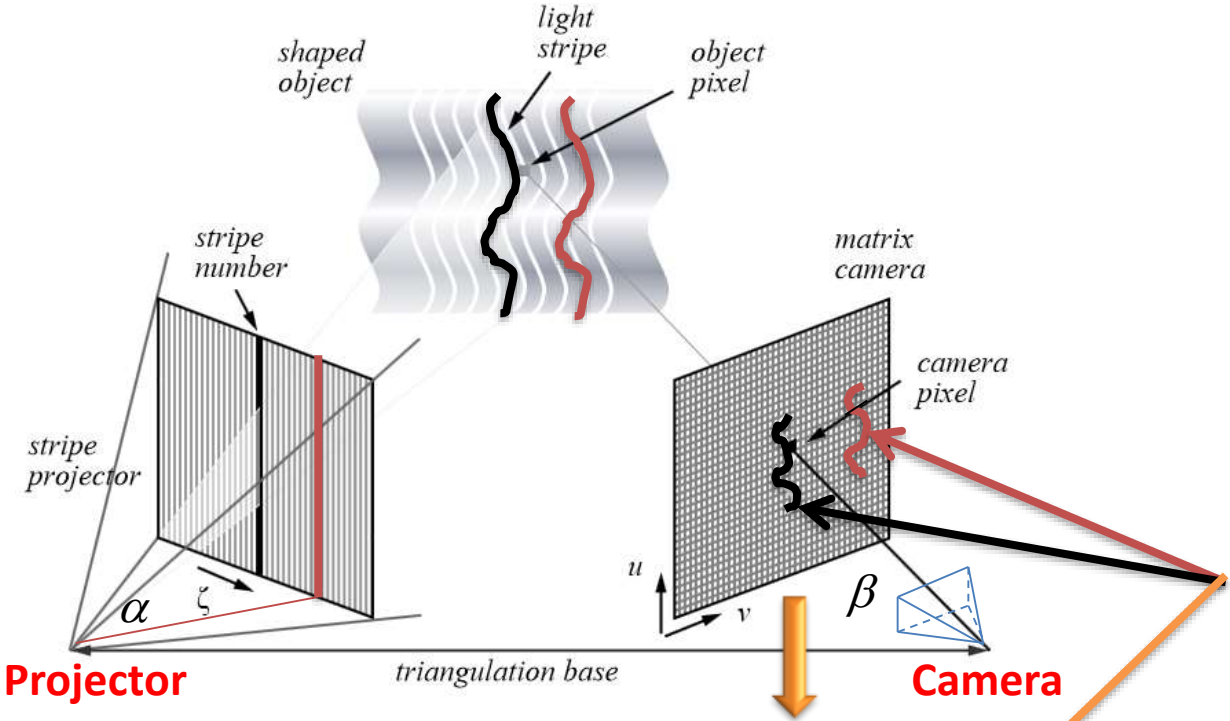


Back-projection,
Patient Vicinity & Safety



Isocenter

3D surface capturing with one unit, up to 80 times per second

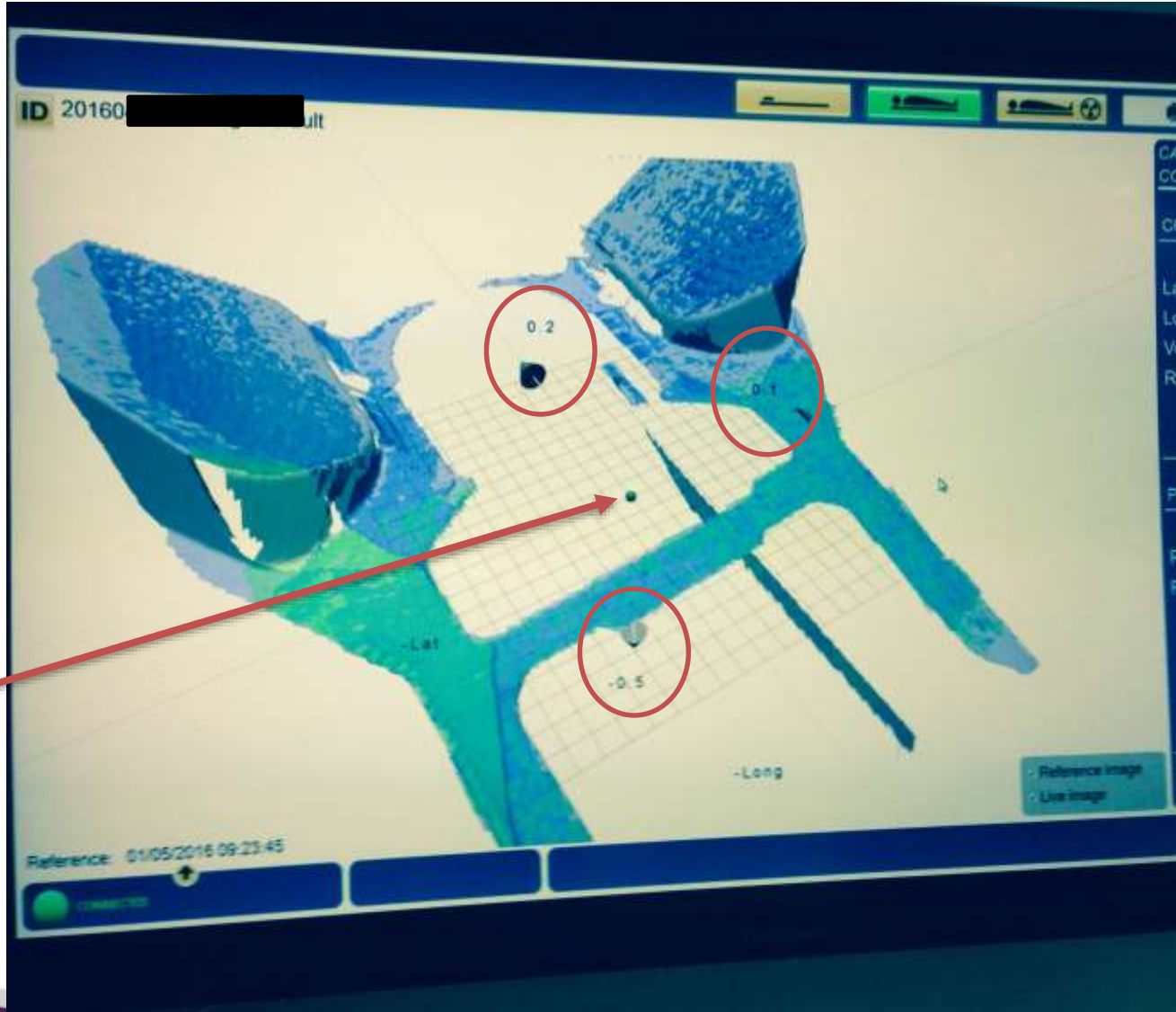


Patient's „signature“



Workflow in RT : Lagerungshilfe Check am Linac (Genauigkeit < 1 mm. – konfigurierbar)

Isozentrum

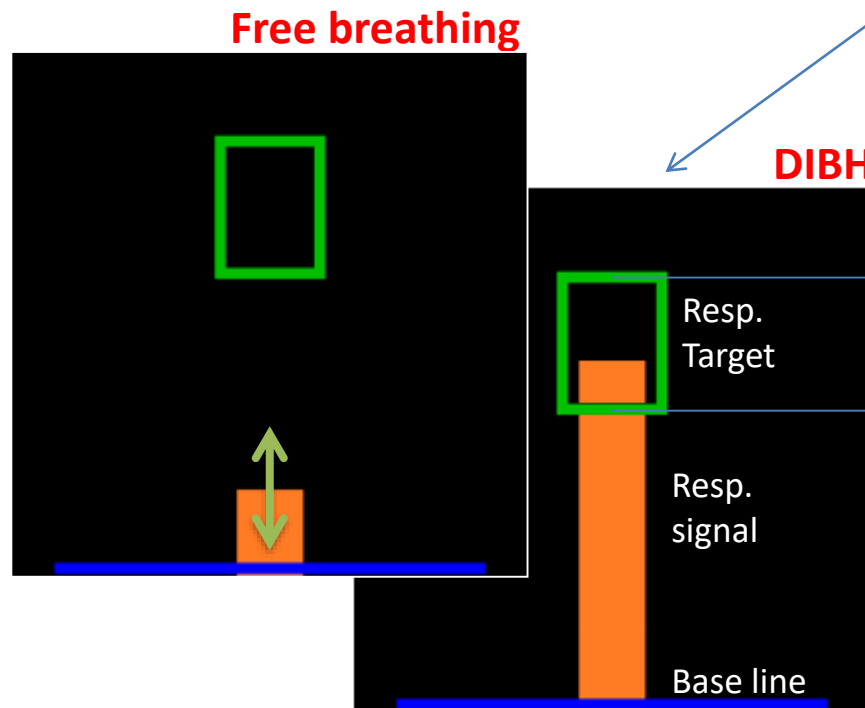


Respiratory gating / coaching for "Deep Inspiration Breath Hold" (DIBH)



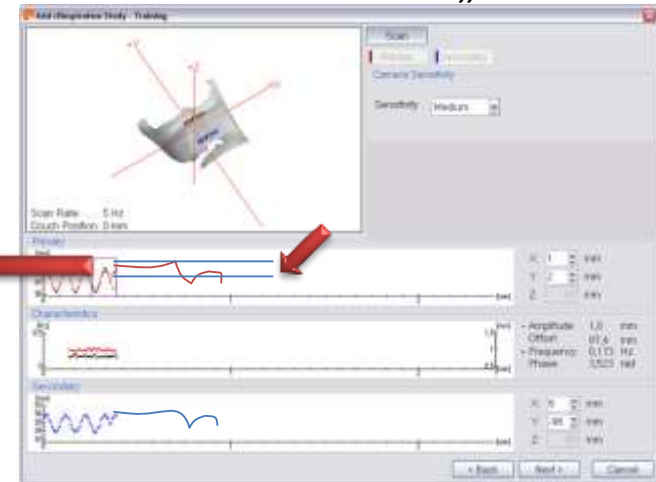
„Catalyst“
RT ← CT
„Sentinel“

Patient's Visual feedback



Exported via DICOM

from 4DCT „Sentinel“

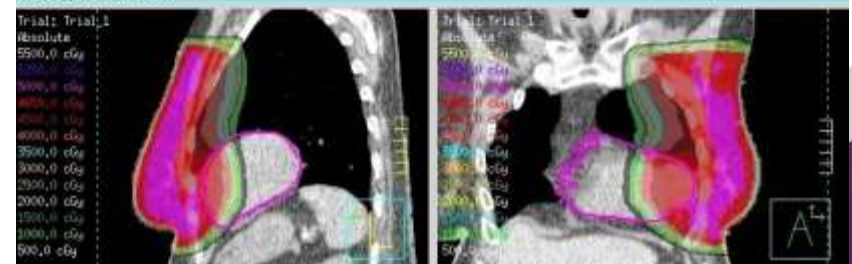
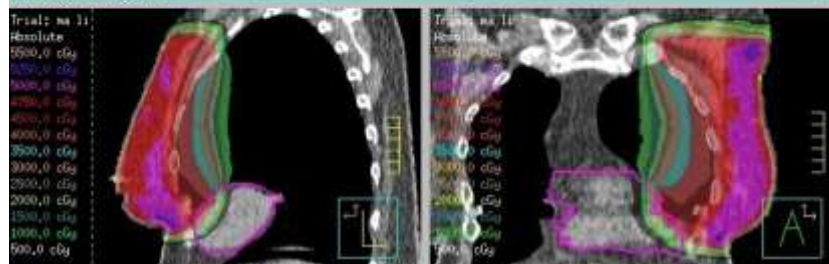


Neue C-RAD Bluetooth Patientenbrille



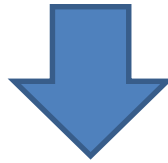
- 4DCT im CT Raum (Sentinel)
- Gating im Linac Raum (Catalyst)

Dosimetrical comparison between Plans in DIBH and free breathing via C-RAD Goggles.



Results (Hepp, R. – Galalae, R. - 2015)

- **Lung** (DIBH vs. Free Breathing) :
 - $V_{20\text{Gy}}$: 12% vs. 17% (p:0.0003)



- Reduction of lung complication probability >20%*

*Zurl et al, Strahlenther Onkol 2010

Results (Hepp, R. – Galalae, R. - 2015)

- **Heart** (DIBH vs. NB):
 - $V_{10\text{Gy}}$: 0,3 % vs. 3 % (p:0.0002)
 - $D_{2\text{cm}^3}$: 21,4 Gy vs. 45,7 Gy (p<0.0001)



- Mean Dose to the heart halved
- In 80% long-term cardiac mortality risk below 1%*
 - In Free Breathing: 30% of the patients !!!

*Pili et al, Int J Radiat Oncol Biol Phys 2011

1-camera vs. 3-camera Upgrade and final Installation

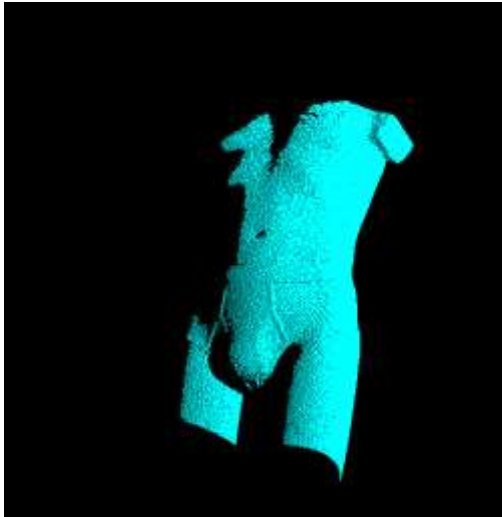


3-Camera Solution KFJ Spital – Wien –

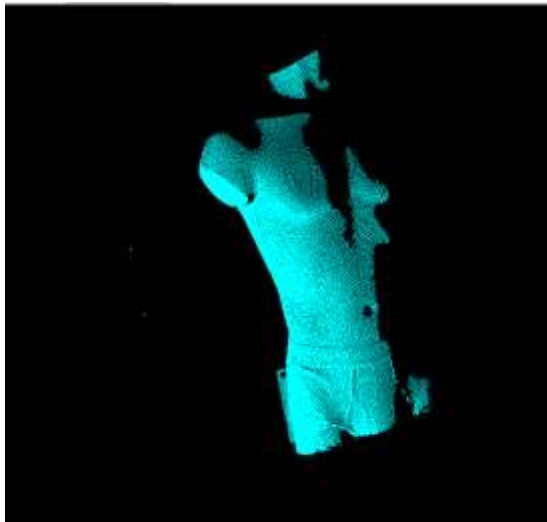


- Also for Stereotactic and PT Treatments
- Full Patient Surface coverage
- Monitoring independent from couch kicks

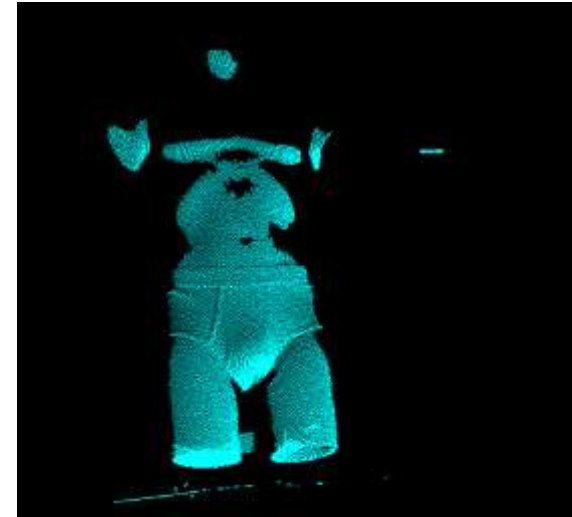
Right Camera 2



Left Camera 3



Central Camera 1

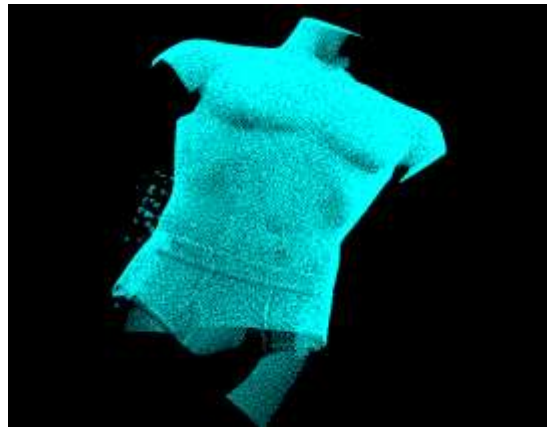


Camera
Shots

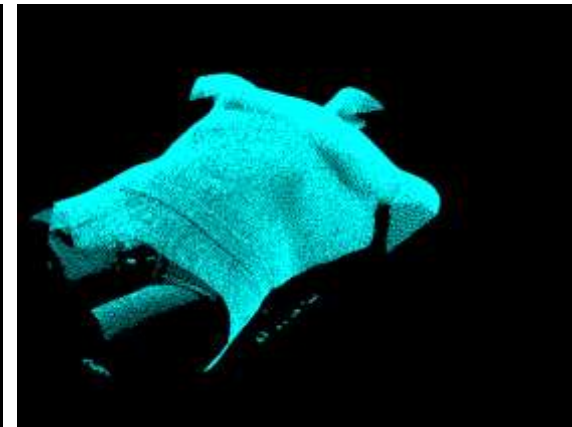
Composite
Global
Views
(**R2+L3+C1**
Camera Shots
Super-
impositions)



Right View

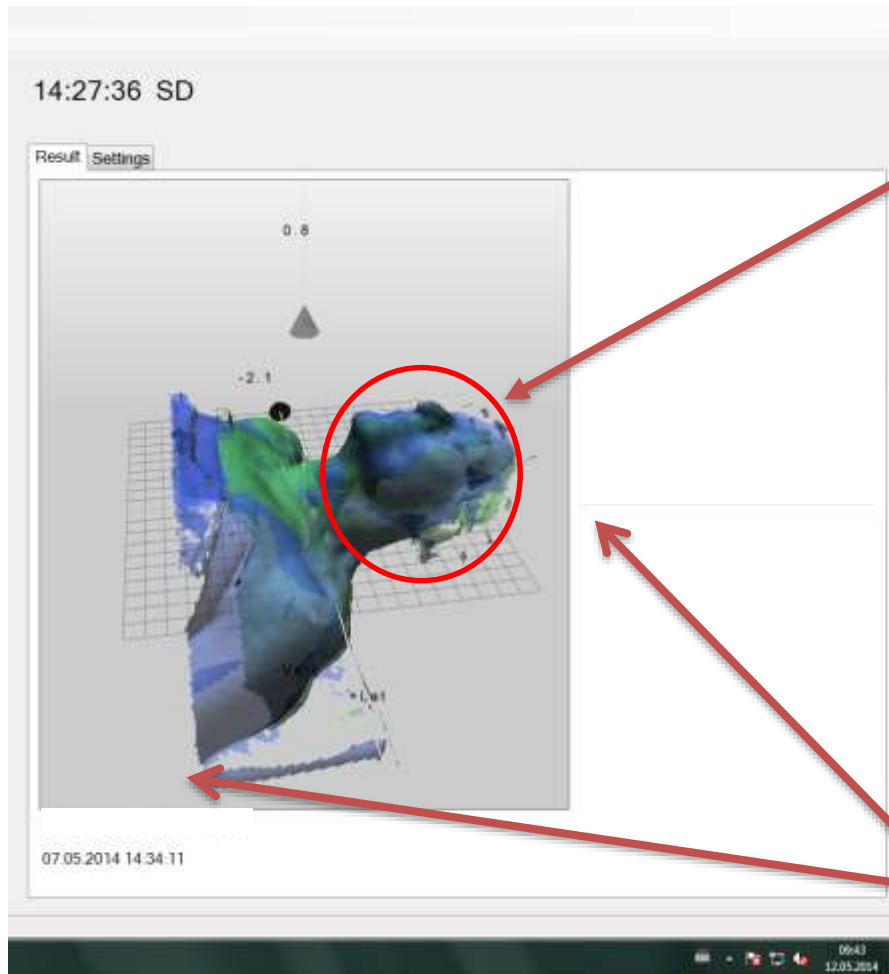


Central View



Left View

3-Camera Catalyst Stereotactic Report with Screen View



Patient Vicinity Recognition

Benefits for Stereotactic Applications :

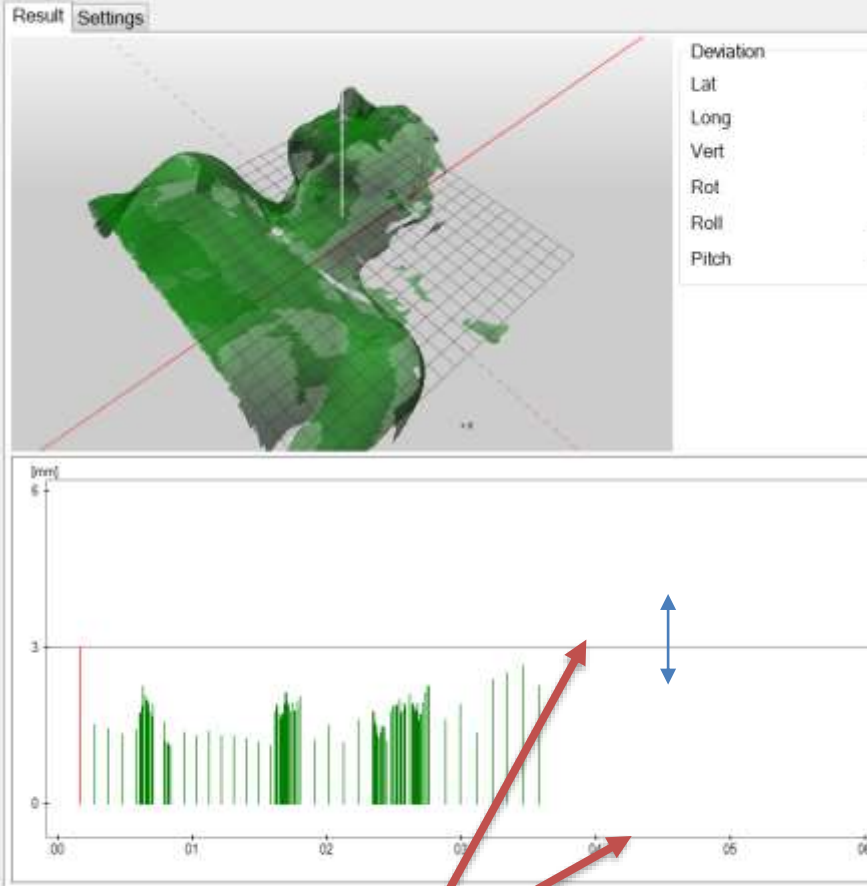
- 1) Full patient coverage indep. from couch kicks
- 2) Positioning, Patient Vicinity
- 3) Motion
- 4) Gating
- 5) Audio/Vidual (Googles)
- 6) Non-rigid Algorithm

Critical Angles / Views

→ Instant verification of postural errors (shoulder and head rotation)

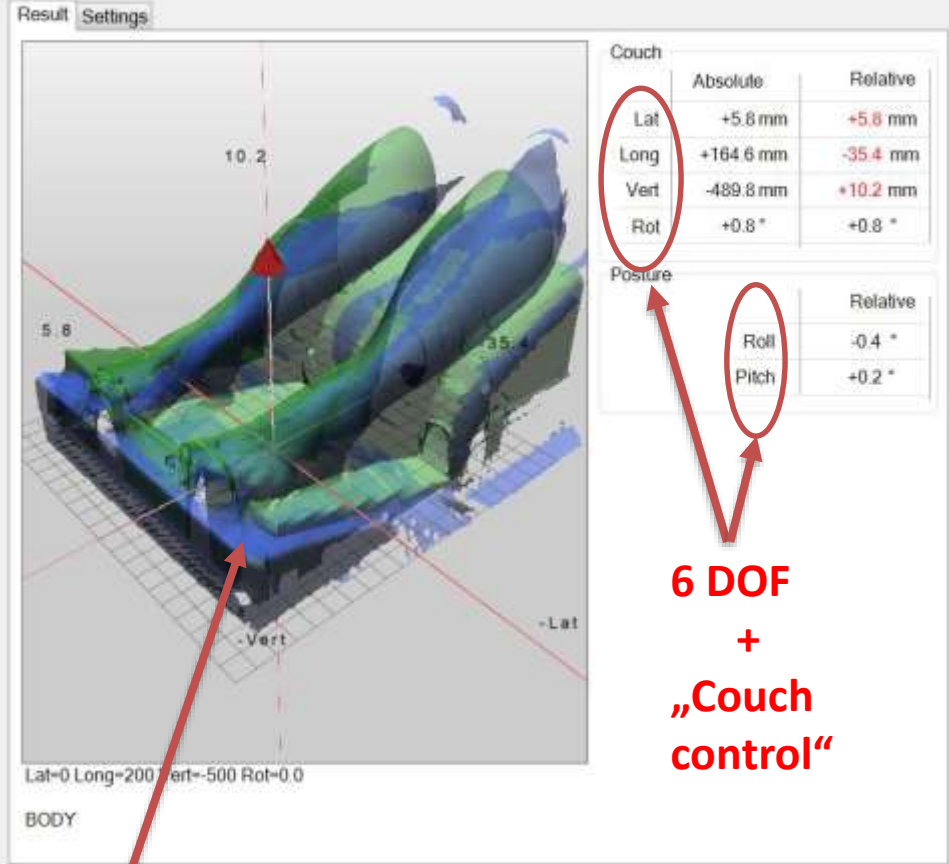
„Patient Vicinity“ und Sicherheit :

13:51:38 Hals li



Sicherheitsfenster
(konfigurierbar)

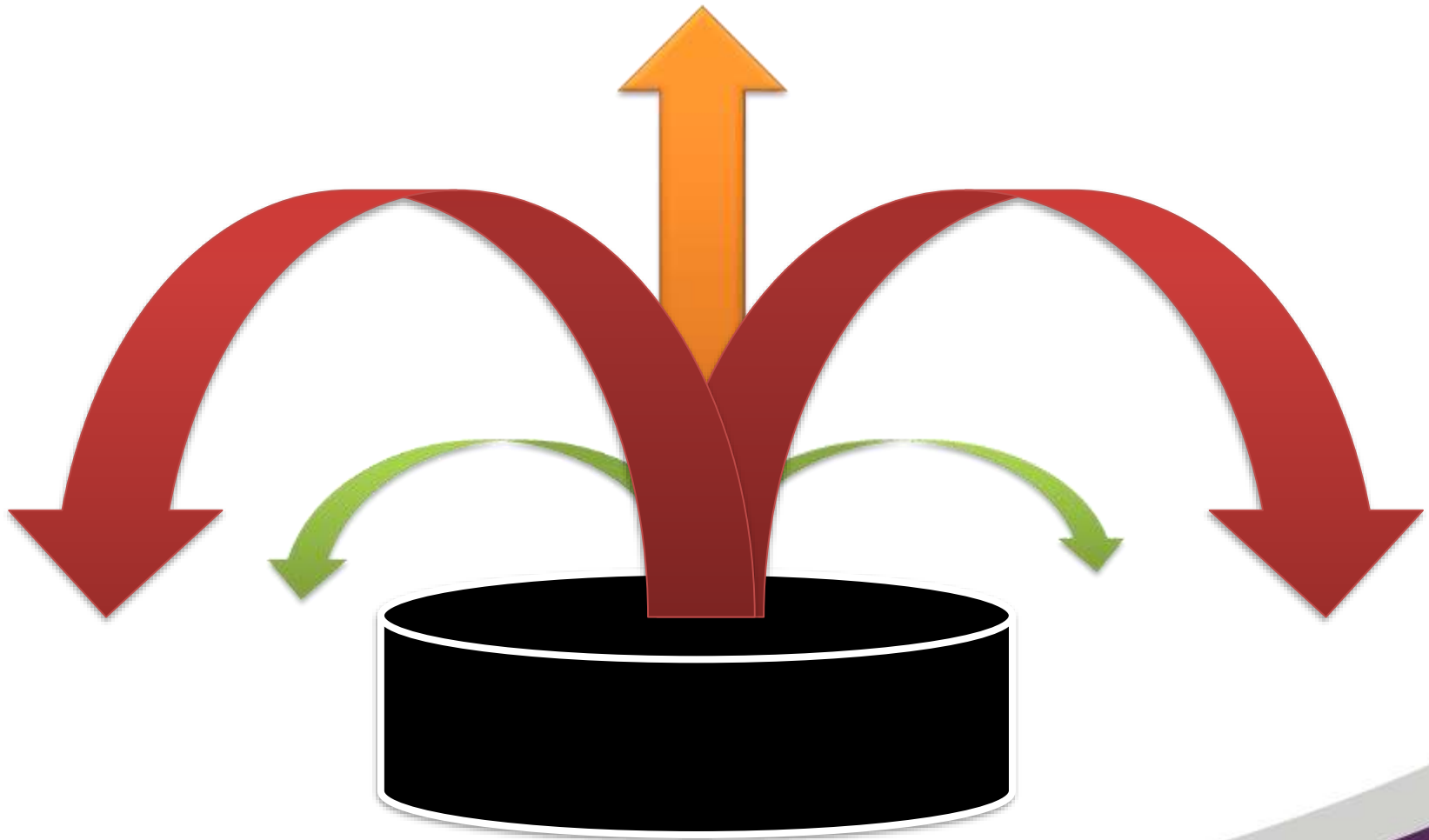
12:43:26 Fuss li



Lagerungshilfe Informationen ...

6 DOF
+
„Couch control“

... and now ... let us think „out of the box“



Flexibilität des Systems ... mit / ohne Brille



Respiratory
Gating spot (traditional use)

The screenshot displays the C-RAD software interface. At the top, there is a control bar with a 'Select Field' dropdown, a patient icon, a radiation icon, a camera icon, and a refresh icon. Below this, the main 3D view shows a green anatomical model with a red dot indicating a 'Respiratory Gating spot'. A red arrow points to this spot from the text 'Respiratory Gating spot (traditional use)'. The model is overlaid with a grid and labeled with '+Long' and '+Lat'. To the right, there are two data panels. The top panel, titled 'Calculated Iso-center Shift', shows a histogram of shift values over 5 minutes. The bottom panel, titled 'Respiration', shows a graph of respiratory signal over time (65-80 seconds). A status bar at the bottom left shows a green 'CONNECTED' indicator. A legend at the bottom right lists: cMotion Ref, Live image, and cRespiration Ref.

Parameter	Value	Unit
Lat	+0.1	(cm)
Long	-0.1	
Vert	-0.2	
Rot	0	(°)
Roll	0	
Pitch	0	

Head & Neck ... ohne Masken ... (Sweden)

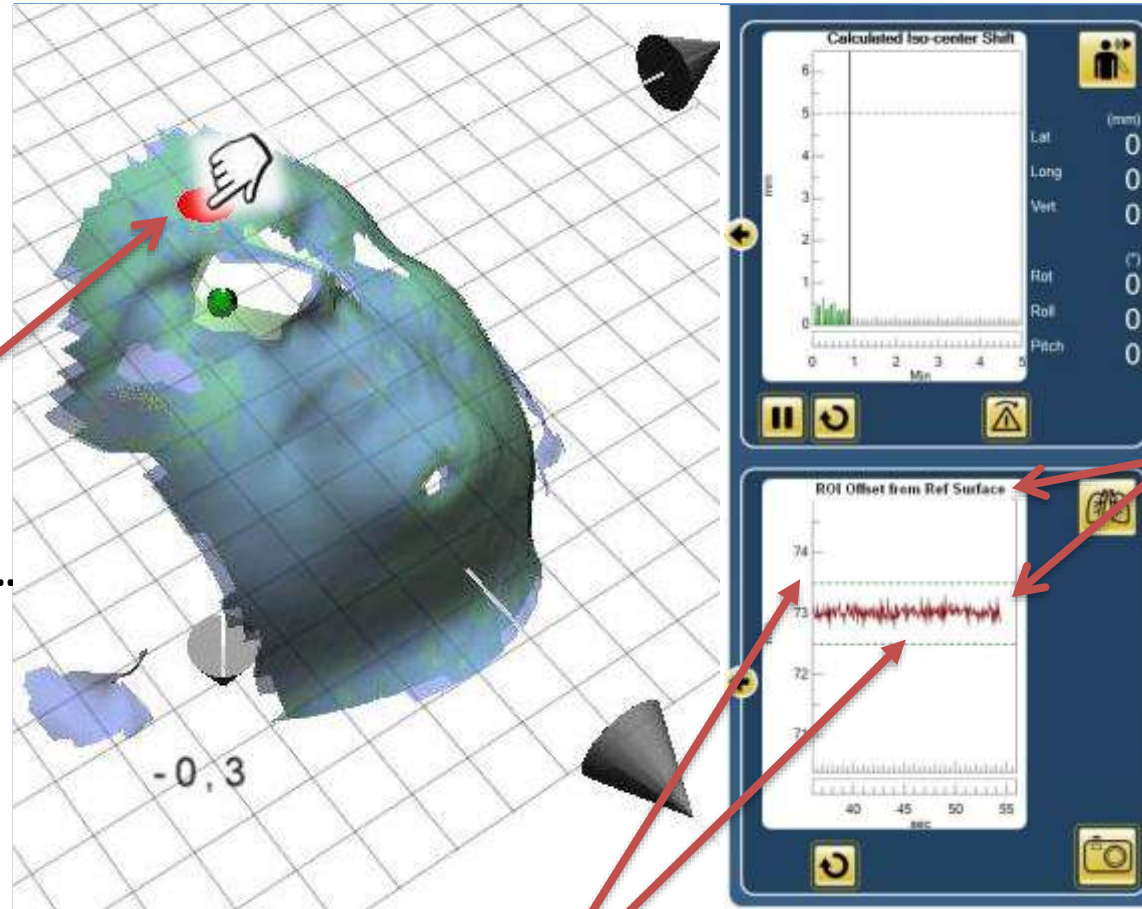
“Reduced fixation with optical monitoring for palliative whole brain radiotherapy treatment”.

Silke Engelholm at al.

Radiation Physics, Skåne University Hospital, Lund, Sweden

„Gating“ primary spot ...

Secondary spot also available.



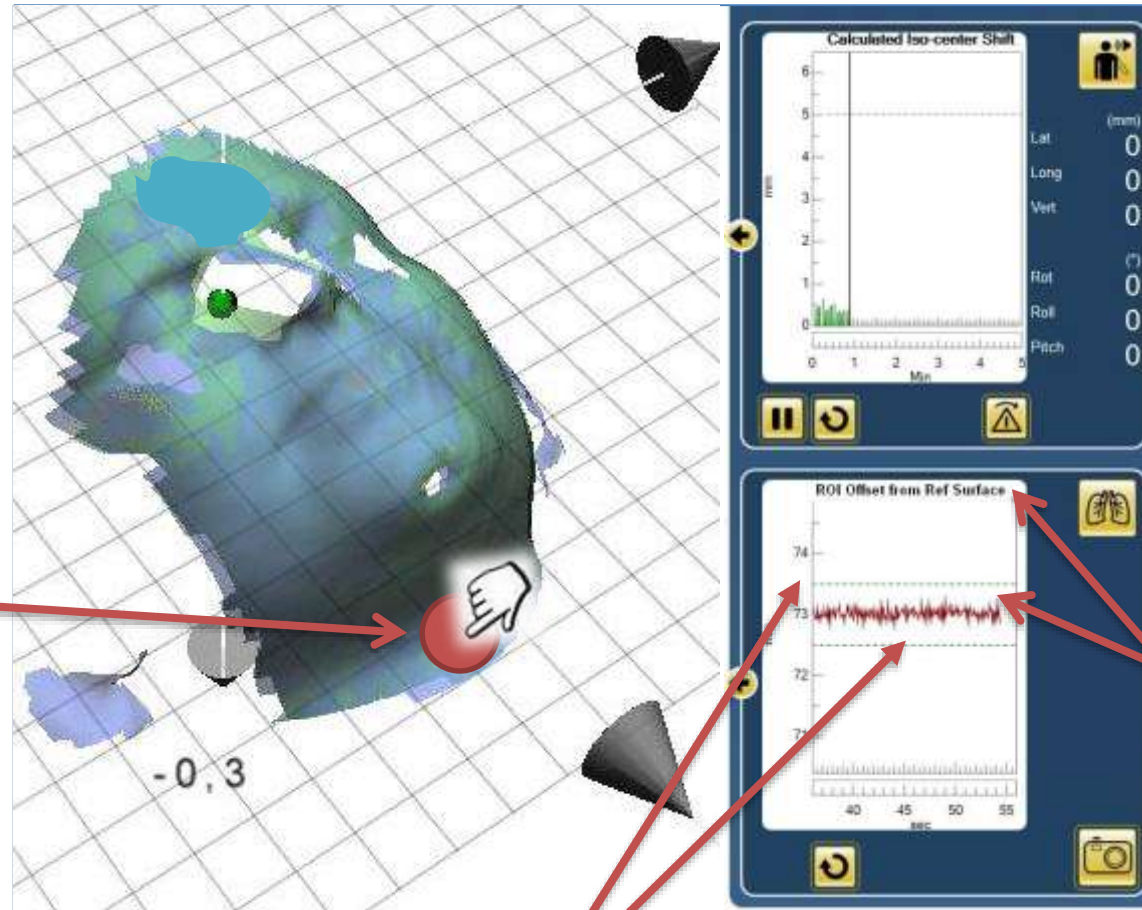
Sicherheitsfenster

Head & Neck ... ohne Masken ... (USA)

“Application of Surface Mapping in detecting Swallowing for Head & Neck Cancer”

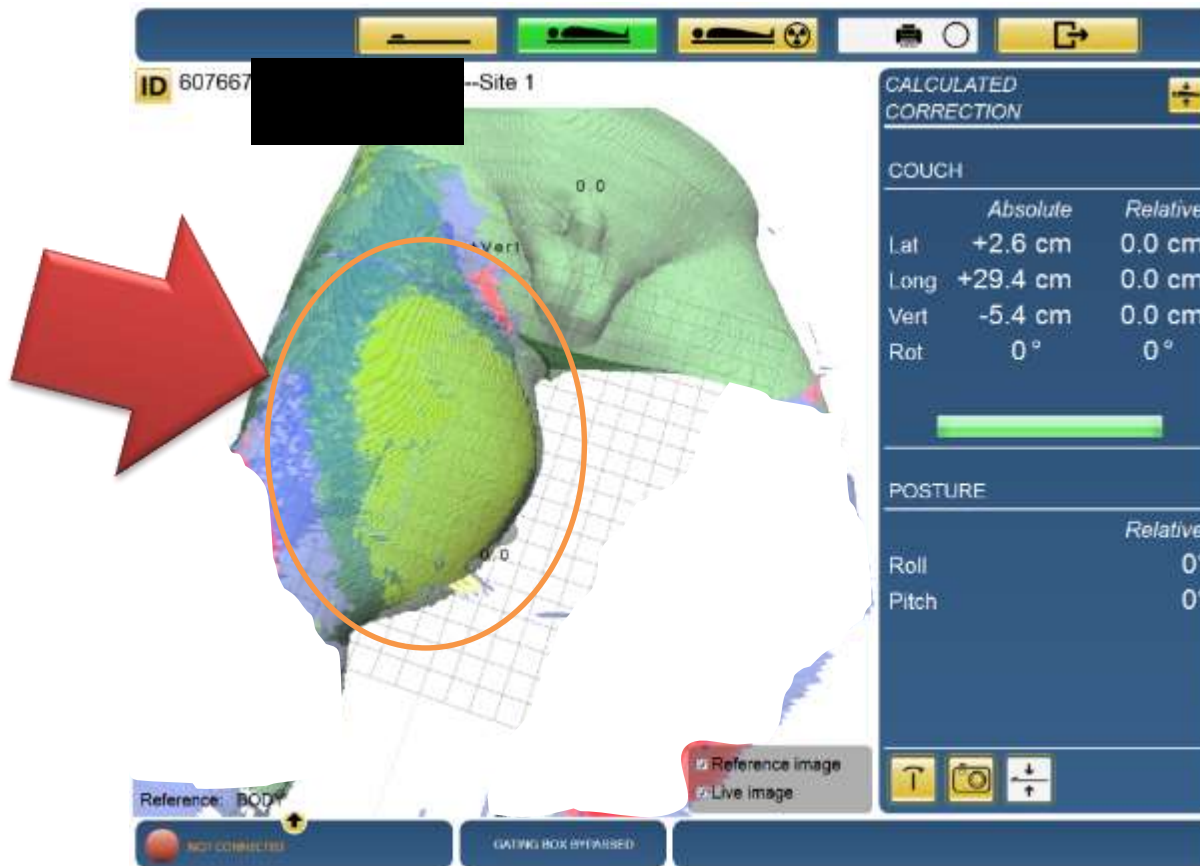
David Shepard et al. - Swedish Hospital Seattle, USA

„Gating“ spot ...



Sicherheitsfenster

Sarcoma Positioning after / during Pharmaceutical Treatment (with “crop” function)



C-RAD Catalyst's „cPositioning“ shows fraction-by-fraction surface changes ...

NEW ! C-RAD SGSRT solution

*Stereotactic radiation therapy including
frameless SRS and SBRT workflow*



**Visit our Stand at ESTRO in
Vienna 2017**



**All-in-one solution
for SRS and SBRT!**

Clinical Training Process

Technical Training as part of the Installation

Target group: Physicist and Lead Therapist

Performed by: C-RAD Installation Engineer

4 hours

On-Site Clinical Application Training

Target Group: Physicians, Physicists and all therapists

Performed by: C-RAD Clinical Application Specialist

3 days

Optional: C-RAD Training center

Target group: "Super user"

2 days

Follow up On-Site Clinical Application Training

Target Group: Physicians, Physicists and all therapists

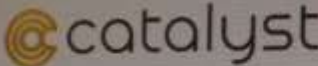
Performed by: C-RAD Clinical Application Specialist

2-3 days

Training and support on demand

Reporting

(on screen and in .pdf)

 Patient: AIRO 2014 Padova
 Patient ID: 1234
 Personal ID:
 Room: Room 1
 Scanner: Catalyst

Patient session report

Summary

Start time: 09.11.2014 14:52:45
 End time: 09.11.2014 15:07:18
 Comment:

cPosition Results

Date	Site	Reference	Lat (mm)	Long (mm)	Vert (mm)	Rot (°)	Roll (°)	Pitch (°)
09.11.2014 15:02:05	Default	09.11.2014 10:42:20	+19,7	+21,8	+1,3	-4,1	0,0	0,0
09.11.2014 15:02:30	Default	09.11.2014 10:42:20	+19,7	+21,8	+1,3	-4,2	+0,1	0,0
09.11.2014 15:03:43	Default	09.11.2014 15:02:33	+0,1	-0,1	+0,4	0,0	-0,1	+0,1
09.11.2014 15:04:04	Default	09.11.2014 15:02:33	+0,3	-0,1	+0,5	0,0	-0,1	+0,1
09.11.2014 15:05:18	Default	09.11.2014 15:02:33	-0,2	+2,2	+0,7	-0,4	0,0	0,0

cMotion Results

Date	Duration	Site	Max deviation (mm)	Tolerance (mm)
09.11.2014 15:05:27	00:01:51	Default	26	5,0
09.11.2014 15:04:08	00:00:02	Default	-	5,0

cRespiration Results

Date	Duration	Site	Reference
09.11.2014 15:04:08	00:00:01	Default	08.11.2014 10:47:11
09.11.2014 15:05:27	00:01:51	Default	08.11.2014 10:47:11

Publications :

Hepp R, Ammerpohl M, Morgenstern C, Niolinger L, Erichsen P, Abdallah A, Galalae R. Deep inspiration breath-hold (DIBH) radiotherapy in left-sided breast cancer : Dosimetrical comparison and clinical feasibility in 20 patients. *Strahlenther Onkol.* 2015 Apr 18. [Epub ahead of print]

Deep inspiration breath-hold (DIBH) Radiotherapy in left-sided breast cancer: Dosimetrical comparison and clinical feasibility in 20 patients

Bestrahlung der linken Brust in tiefer Inspiration und Atemhaltetechnik (DIBH) bei linksseitigem Brustkrebs: Dosimetrischer Vergleich und Prüfung der klinischen Durchführbarkeit in 20 Patientinnen.

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Sentinel/Catalyst surface tracking system for respiratory gating. Tests performed at Skåne University Hospital, SUS, Malmö.

Charlotte Thornberg, Mattias Jönsson, Sofie Cederberg, Malin Kugler, Fredrik Nordström

Introduction

In radiation treatment, gating can be used in different ways to minimize the absorbed dose to risk organs. A positive correlation has been observed between cardiac dose-volume and the level of excess risk of cardiac mortality from ischemic heart disease [1] as well as between the irradiated lung volume and radiation pneumonitis [2]. Respiratory gating for breast cancer patients is a simple and straightforward way to reduce the absorbed dose to the heart and lungs [3]. In Malmö, gating of left-sided breast cancer patients has been in use clinically since 2007 (Varian Real-time Position Management (RPM) system). A Sentinel system was installed in 2009 for evaluation and development of gating functionalities. In 2011, the Sentinel system in the treatment room was moved to the CT room and replaced by a Catalyst system.

This report describes some of the initial tests performed in the implementation of the gating functionality, as well as comparisons with the RPM system.

Material and methods

Catalyst

The Catalyst system is installed in connection with two treatment machines (Varian X 2100 Clinac), and there is also a system in a training room for gating evaluation. Measurement in the Catalyst system is based on the principle of optical triangulation. A rapid and near-invisible sequence of patterns is projected onto the surface of the object to be measured. At the same time, images are captured by a camera, which is mounted at an angle from the projector. By analyzing the recorded image sequence, a high-resolution 3D surface model can immediately be reconstructed. A complete surface can be captured in fractions of a second, with an accuracy of a few tenths of a millimeter – measured at a distance of several meters away.



Fig. 3. The Catalyst system

Application of Surface Mapping in Detecting Swallowing for Head-&-Neck Cancer

Daliang Cao, Xin Xie, Vivek Mehta, David M. Shepard
Swedish Cancer Institute, Seattle, WA

Introduction	Methods & Materials	Results	Conclusions
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Swallowing (also involuntary or voluntary) during radiotherapy may introduce tumor or normal tissue motion that is not accounted for in standard radiation treatment plans. VMAT and IMRT plans may be more prone to suboptimal treatment results if swallowing motion is significant. Future evidence suggests that long-term swallowing recovery after head and neck radiotherapy may be improved if the dose to the swallowing structures can be limited. Head-&-Neck cancer radiotherapy typically uses a mask to immobilize the patient. The mask does not restrict either voluntary or involuntary swallowing. In some respects, the mask may limit the observation/measurement of this event. CBCT or portal film cannot effectively monitor such a target motion. While fluoroscopy images may detect the swallowing motion, it introduces extra radiation dose. Surface mapping techniques provide an opportunity for continuous high-resolution motion monitoring without using ionizing radiation. We therefore carried out the study of using C-RAD Catalyst surface mapping system to test the feasibility of monitoring patient swallowing during treatment. We also evaluated the accuracy of the method.

The C-RAD Catalyst system and track volometer lying outside the patient Catalyst system to create any invasive skills. The Catalyst system is very close to it made the volometer more accurate to show in Figure placed on the posterior side. The independence of mapping table placement, we inventors, can be other one is possible.

The actual patient was not in use the system in motion.



Figure 1: The Catalyst system and track volometer lying outside the patient Catalyst system.

Original article

Strahlenther Onkol. 2015; 188:538–544
DOI 10.1007/s00066-015-0991-z
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Published online: 22 September 2015
© Springer Verlag Berlin Heidelberg 2015

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Department of Radiation Therapy, University Medical Center
Munster, University of Münster, Münster

A novel surface imaging system for patient positioning and surveillance during radiotherapy

A phantom study and clinical evaluation

Image-guided radiotherapy (IGRT) reduces setup errors and thus minimizes the margin between clinical target volume (CTV) and planning target volume (PTV). Two-dimensional (2D) image guidance with the therapy beam enables matching/positioning relative to bony structures only [1]. Cone-beam computed tomography (CBCT) has been widely adopted and provides the most accurate patient positioning with a relatively low cost imaging dose to the patient [1, 2]. A re-positioning strategy based on target motion during dose delivery in the treatment of lung and liver metastases. Multiple strategies have been developed to compensate for the manufacturing tolerances [3].

An alternative positioning strategy is based on surface tracking. The patient surface scan is compared to the reference surface (based on planning CT) and a shift vector is calculated [4, 5, 6, 7]. These systems may reduce the number of CBCT scans and thus limit the imaging dose to patients. The system described in this study uses a new scanning method with a non-visible light projector and a charge-coupled device (CCD) camera. It projects the calculated regional patient shift directly onto the patient's surface in order to simplify the patient positioning process. It also permits a non-visible function to detect patient movement or breathing during treatment (introduction movement): a functional mobility that can also be used to drive the gating surface of a linear accelerator.

The surveillance function, the new scanning approach and gating may further improve the accuracy of liver and lung treatments [4], provided that the inherent accuracy of the system is sufficient. As a first step, we investigated the basic performance and accuracy of the new scanning method of the Catalyst (C-RAD, Uppsala, Sweden) system in a non-guided environment. These issues were addressed in both phantom experiments mimicking different clinical situations and in a prospective clinical study covering three anatomical regions.

Materials and methods

Phantom and clinical studies were performed on an Elekta Synergy (Elekta AB, Stockholm, Sweden) accelerator with CBCT. The Catalyst optical system is mounted to the ceiling above the foot end of the treatment table (Fig. 1). Instead of using laser light to scan the surface,

Catalyst employs three high-power LEDs to project light with wavelengths of 495 (blue), 538 (green) and 634 nm (red) onto the object. The blue component in the measuring light (the object scanning and is detected by a monochrome CCD camera with an acquisition speed of 200 frames per second. The green and red light project surface structures (actual vs. reference) onto the area where the measurement is directed to aid patient positioning. Two custom settings, gate and integration time (IT), made the Catalyst software can influence scan quality. The gate is the quantity of captured electrons required on a pixel of the CCD camera to convert light into electronic charge and a digital readout. IT defines the time of light absorption. The maximal scan volume is 60 cm wide, 20 cm long and 70 cm high. An individual region of interest relative to the paradigm can be defined. The phantom part of the study analyzed scanning quality, reproducibility



Fig. 1. A Catalyst system Catalyst left and set up to linear accelerator room right

Publications :

Increased patient throughput for treatment with helical tomotherapy

K. Petersson,¹ C. Ceberg,¹ T Knöds,^{1,2} and M. Enmark²

¹Medical Radiation Physics, Lund University, Lund, Sweden ²Radiation Physics, Skåne University Hospital, Lund, Sweden

1. Purpose

Treatment with helical tomotherapy is beneficial for many patients compared to treatment with a conventional C-arm beam. To be able to treat more patients with tomotherapy the total treatment time per fraction for every patient has to be shortened.

One way of doing this is to replace the time-consuming use of MVCT imaging for positioning of the patient with a faster laser scanning positioning system, for most fractions in a treatment. The Sentinel system (C-Rad AB, Uppsala, Sweden) is such a system and it has been used for a year for patients receiving treatment with helical tomotherapy at our hospital. A time study has been performed to quantify how much time the system can save per fraction and subsequently how much the patient throughput can increase.

2. Conclusions

This study shows that significant amount of time can be saved if using the Sentinel system as an alternative method to MVCT imaging for positioning the patient, when treating with helical tomotherapy. The time saved can be used for a substantial increase in the number of patients treated with this technique.

Another benefit with limiting the number of MVCT scans is the reduction of the scattered dose from MVCT scans received by the patients. The disadvantage with Sentinel system is that it scans and positions the surface of the patient but we almost always treat internal structures. This means that the surface positioning must correlate with the correct positioning of the treated internal structures for the system to be useful. The diagnostic consequences of not using the MVCT for the positioning of the patients needs to be investigated in future studies.



Figure 2. The Sentinel system hardware consisting of a laser and a camera in a single unit.

3. Methods

The Sentinel system was used for the positioning of the patients when the MVCT imaging system was not utilized. The study was performed for 20 patients (2-3 fractions). In the study, the time when the patient entered the treatment room was registered as well as the time when the patient left. The time from MVCT scan to the patient and the time it took to match the MVCT scan to the planning MVCT scan was registered.

The total treatment time (patient entering treatment room until patient leaving) was compared for fractions when the laser scanning positioning system was used vs. fractions when the MVCT imaging system was used. The increased patient throughput was calculated based on an imaging protocol that stipulates that the MVCT imaging system is used for positioning of the patients for the first three

4. Results

The positioning of the patient with the Sentinel system took on average 15 minutes to perform in average 20 minutes (with a stand when the MVCT system was utilized and standard deviation of 4 minutes) when it was used. A time plot of total treatment time (Patient MVCT scans according to the 1) vs. an increased patient throughput of this

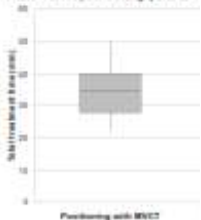


Figure 3. Box and whisker plot showing the patient time in the treatment room with the MVCT system or with the Sentinel system. 1. tomotherapy. Boxes represent the interquartile range and whiskers indicate the 5th and 95th percentiles.

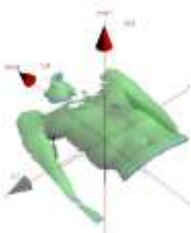


Figure 4. Prepared positioning coordinate system for the Sentinel system.



Klinische Erfahrungen mit dem Einsatz des Catalyst™-Systems zur Beurteilung der Lagerungsgenauigkeit bei Patientinnen mit Mammakarzinom

F. Walter, S. Schönecker, Dipl.-Ing. P. Freudenberger, Dr. E. Nikielaj, Dipl.-Phys. A. Triller, Dr. rer. nat. M. Sobin, Prof. Dr. C. Belka

Hintergrund

Die Positionierung von Patientinnen mit Mammakarzinom erfolgt in der Strahlentherapie mittels orthogonalen Röntgenaufnahmen, anhand deren kreisförmige Strukturen des Thorax bzw. der Lungenkontur beurteilt werden können. Das Catalyst™-System (RAD AB, Schweden) bietet die Möglichkeit die Oberfläche des Patienten zu scannen und die Patientenpositionierung zu beurteilen.



Abb. 1. 3D-Modell einer Brustoberfläche, die mit dem Catalyst-System gescannt wurde.

Methoden

Die Lagerung der Mammakarzinompatienten erfolgte standardmäßig anhand der Röntgenaufnahmen und wurde anschließend mittels Catalyst™ dokumentiert. Die korrekte Patientenlagerung wurde mittels orthogonalen Röntgenaufnahmen verifiziert und ggf. korrigiert. Bei allen Patientinnen erfolgte die subkutanen Beurteilung der Lagerung mittels Catalyst™ und EPD (ViewCT™, Elekta AB, Schweden) mindestens fünfmal im Verlauf der Bestrahlungstherapie.



Abb. 2. Abweichung der Lagerung nach Kollimator (oben) und nach Catalyst™ (unten) verglichen mit EPD-Aufnahmen, aufgetragen pro Patientin.

Ergebnisse

Für die Lagerung nach Kollimator zeigte die Kontrolle mit ViewCT™ eine mittlere Abweichung in lateraler Richtung von $-0,1 \pm 1,4$ mm, longitudinal $0,7 \pm 1,2$ mm und vertikal $1,0 \pm 1,6$ mm. Die Abweichung der Catalyst™-Messung von den aus den Röntgenbildern errechneten Verschiebewerten nach ViewCT™ ergab eine Abweichung von $1,5 \pm 1,5$ mm in lateraler, $0,9 \pm 2,5$ mm in longitudinaler und $1,2 \pm 2,4$ mm in vertikaler Richtung. Die Mittelwerte wurden mit dem Wilcoxon-Signifikanz-Test verglichen und ergaben keine signifikante Abweichung (laterale p=0,55, longitudinal p=, vertikale p=1).

Parameter	Unit	Median	5th	95th	p-Value
laterale	mm	0,2	-1,1	1,1	0,87
longitudinal	mm	0,7	-1,1	1,1	0,87
vertikal	mm	1,0	-1,1	1,1	0,87

Diskussion

In der Einzelbildbeurteilung zeigt sich, dass lokale Abweichungen der Lagerung insbesondere der Arme und des Kopfes einen deutlichen Einfluss auf die von der definierten Registrierung des Catalyst™ errechneten Verschiebewerte hat. Diese lokalen Abweichungen lassen sich mit der aus Standard angebotenen Bildgebung mittels EPD nicht beurteilen. Es handelt sich bei der vorliegenden Auswertung um eine retrospektive Beobachtung der Werte in einer Klinik erhebenen Daten zur Lagerungsgenauigkeit mittels Catalyst™. Die Präzision der lokalen Abweichungen ist daher bei der Systembeurteilung nicht statistisch beurteilt werden. Trotzdem zeigt sich ein signifikanter Unterschied im Vergleich der Mittelwerte.



Abb. 3. 3D-Modell einer Brustoberfläche, die mit dem Catalyst-System gescannt wurde.

A pilot study of breast cancer patient positioning using optical surface scanning and reprojection

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Aim
 The aim of this pilot study was to evaluate the optical scanning system for breast cancer patient positioning.



Figure 1. Mispositioned arm highlighted in red by the projector.

As a complement to a ray tracing reconstruction of the treatment room, the Sentinel system was used for patient positioning. The aim of this pilot study was to evaluate the optical scanning system for breast cancer patient positioning.



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Materials and Methods
 A Catalyst™ system was installed in the waiting room in the treatment room. The Catalyst™ consists of a LED projector projecting a mesh pattern onto the patient. A CCD-camera registers the projected pattern and reconstructs a surface 3D-model. Using the LED-projector, deviations between the body contour and the contour reconstructed from the CT scan will be coloured giving the therapy personal instant feedback during the patient positioning (Figure 1).

A total of 12 treatment sessions (four patients) were analysed in this study. After patient setup and position correction based on planar kV-imaging of the thorax wall and spine, the thorax region was scanned and registered using the Catalyst™ system. At each treatment session a new surface image was acquired after patient positioning (Figure 2).

Interfractional changes in arm position were observed by measuring the angle of the upper arm (humerus) in the sagittal and coronal plane. To find misplacements, each measured arm position was compared to the median value of all treatment sessions of the same patient.

Conclusions
 After patient setup using planar kV-imaging, interfractional changes in the patient's arm position were observed using optical scanning. The misplacements were not detected using planar kV-imaging of the thorax region. An optical scanning of the patient's contour with a direct patient feedback during the patient positioning may improve the accuracy of the patient positioning.

Thank you for your attention !

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