Deutsche Gesellschaft für Medizinische Physik e.V.

DGMP

AK IMRT der DGMP am 19. und 20. März 2015 in Erlangen

Dr. Franco Canestri
C-RAD GmbH

Title : *Medizinische Anwendungsmöglichkeiten durch präzise C-RAD Patientenlagerungsüberwachung während der Strahlentherapie :*

erste Erfahrungen mit dem 3-Kamera System und die Flexibilität der Lösung.

C-RAD

Agenda

Background

First Fraction OK, but what happens afterwards ?

Clinical Benefits : 3-Camera System and Flexibility
on all following Fractions.

Videos

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 31 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

C-RAD

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*

Ziel :

Mehr Patienten pro Tag,

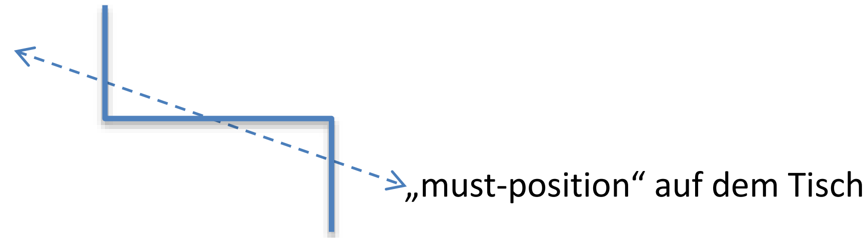
besser, komfortabler und

sicherer behandeln.

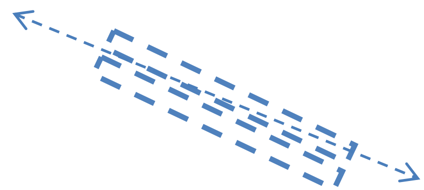
C-RAD

Strahlentherapie : Herausforderungen

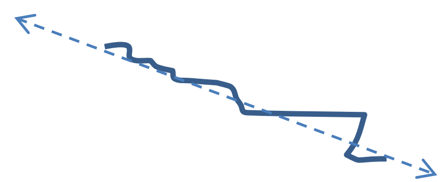
”Posture Errors”



Genauigkeit



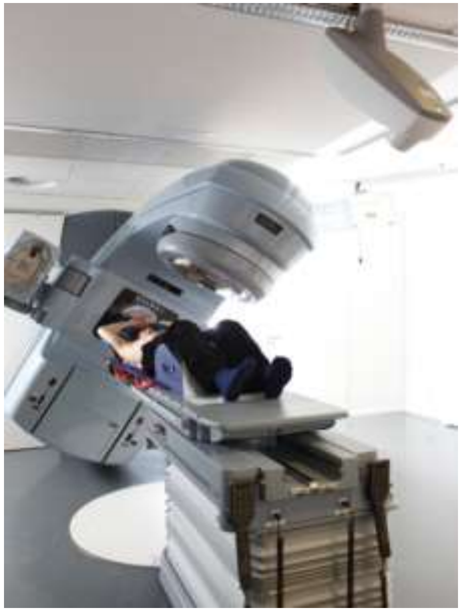
Bewegungen



”Respiratory Gating (DIBH)” vs. ”Free Breathing”

C-Rad Solutions with Interfaces to **CT** and **Linacs** (Siemens, Toshiba, GE, Philips + Elekta and Varian)

Covering the full treatment chain : from the CT to the Linear Accelerator, <u>including room Lasers</u>

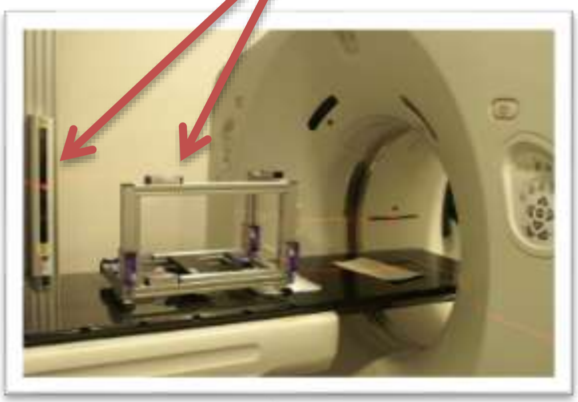


C-RAD Approach to precise patient positioning

C-RAD ultra-precise (0.1 mm at isocenter) Room Lasers :
-) with dual-diode (red + green)
-) and automatic calibration (< 9 Min.).

Camera

Projector



For CT + RT Rooms

For RT Room

For CT Room

„Installed base“ C-RAD Systeme in DACH – 2012 bis Heute

„Sentinel“ (CT Raum) : **11**

„Catalysts“ (Linac Raum) : **13**

„Catalysts HD“ (Linac Raum) : **8** **(*)**

C-RAD „HIT“ Raum Lasers : **7**

Gesamt : 39 C-RAD Systeme - Deutschsprachige Länder

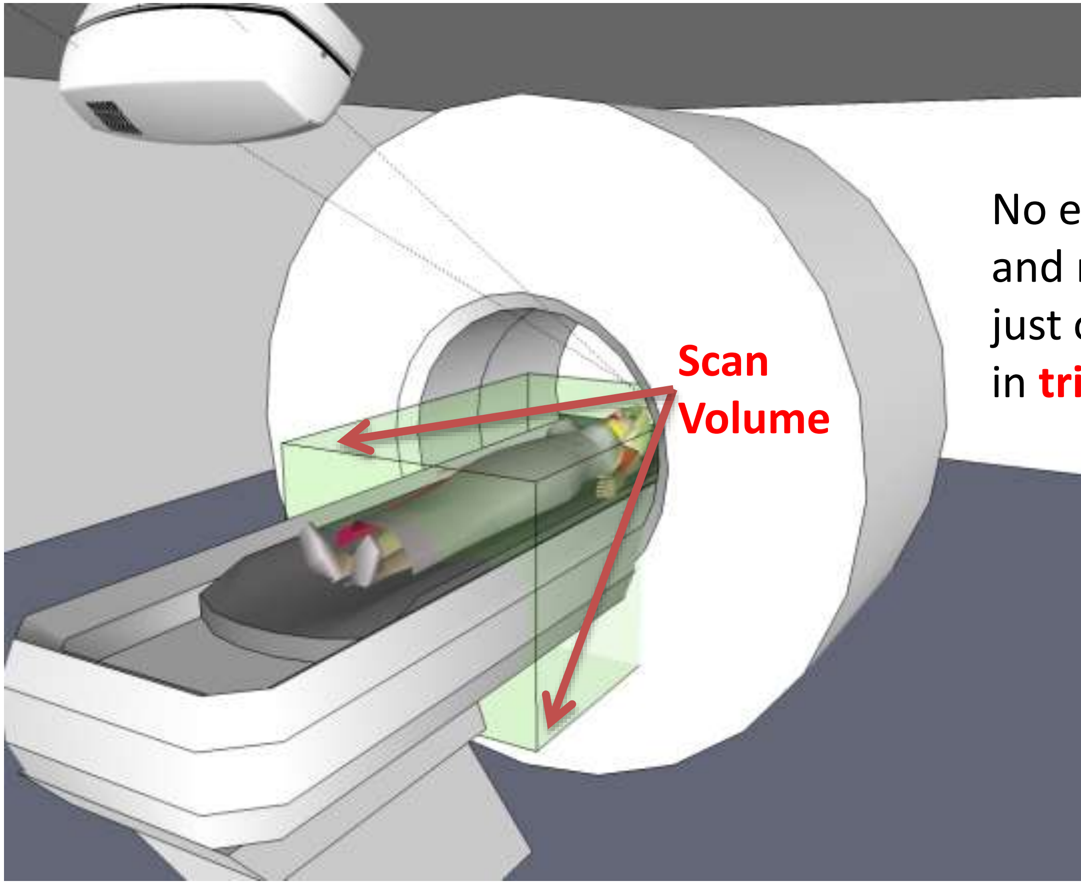
Kliniken nur in DE. : 15 mit C-RAD Lösungen im Einsatz in BRD
Publikationen : 16 aus LMU, UMM, Uni Mainz, Gelsenkirchen, etc.

Wachstum 2013 → 2014 : 60% in € (→ Siehe WEB; C-RAD Press Release)

(*) : 3-Kamera Version

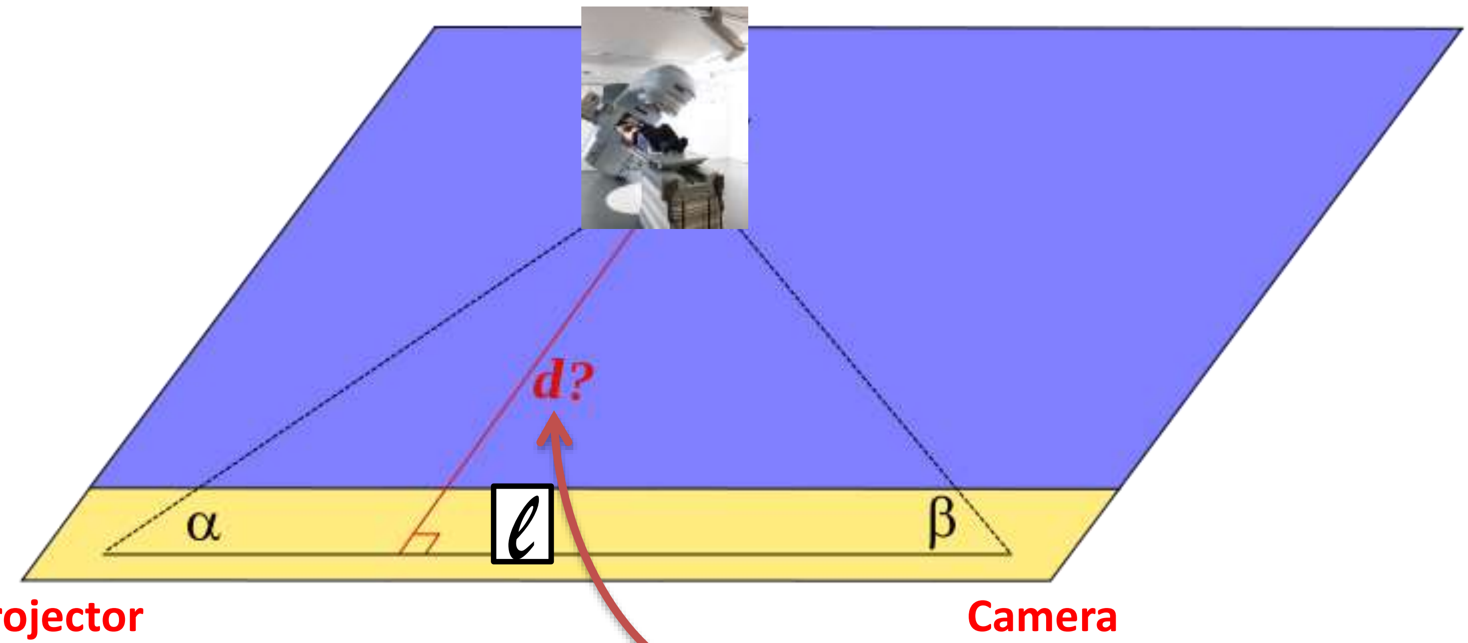
Measurement Principles

Projector **Camera**



No extra ionizing radiation
and no lasers,
just optical LED cameras
in **triangulation**

Triangulation Method



$$\ell = \frac{d}{\tan\alpha} + \frac{d}{\tan\beta}$$

therefore :

$$d = \ell \,/\, \left(\frac{1}{\tan\alpha} + \frac{1}{\tan\beta}\right)$$

We know that :

tan α = sin α / cos α

and that :

sin(α + β) =
sin α cos β + cos α sin β

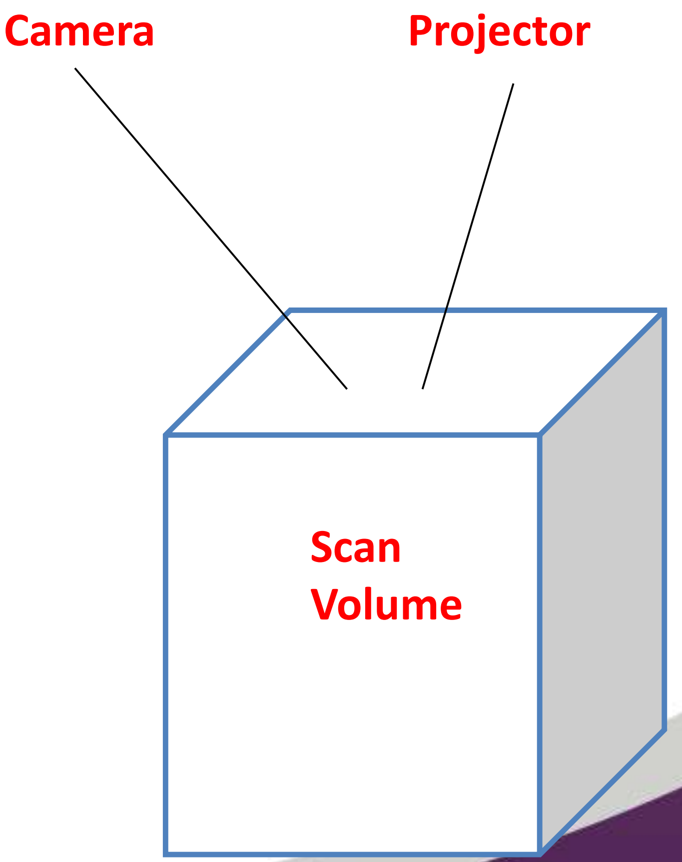
$$d = \frac{\ell \sin\alpha \sin\beta}{\sin(\alpha+\beta)}$$

Technical performances

Scan volume: up to 80cm x 130cm x 70cm

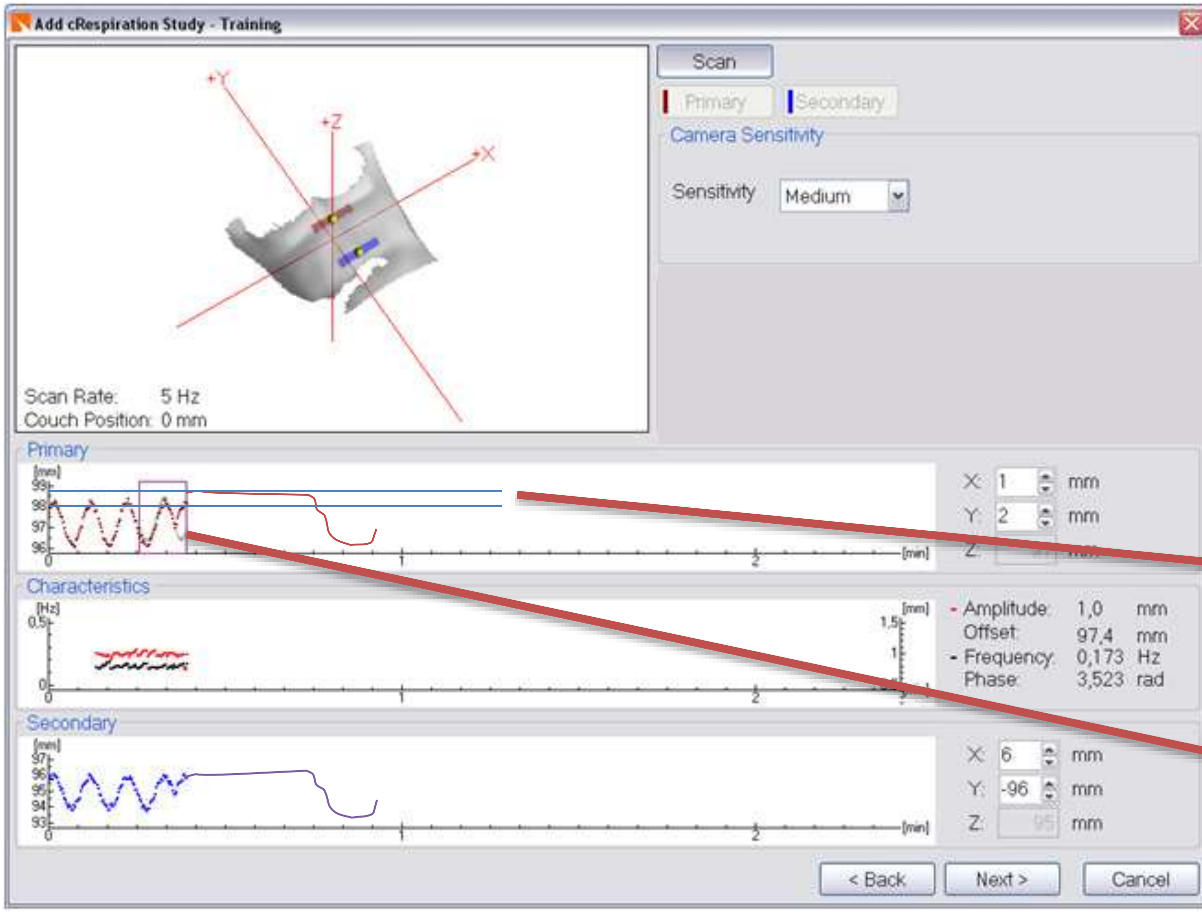
Position accuracy: <1mm

Motion detection accuracy: <1mm



Workflow : Step 1 - CT

SENTINEL



- **4DCT prospective gating** (when you know where the tumor is located and you want to perform DIBH mainly for left breast cancer)

- **4DCT retrospective gating** (when the areas are too spread and there is no acute need of DIBH)

It will be sent to the Catalyst in Linac room for DIBP …

… or for free breathing

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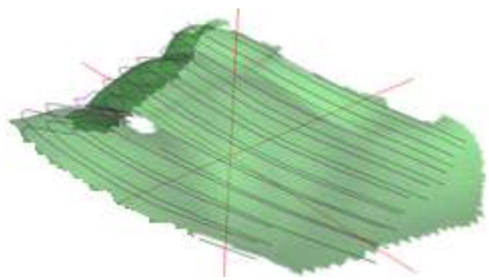
Workflow : CT →RT (first Fraction)

from CT Room

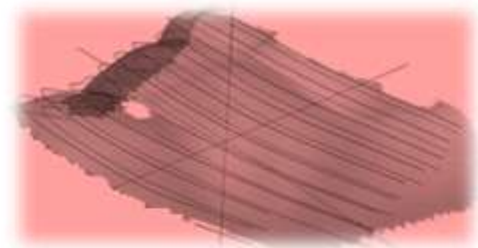
- Patient‘s Surface (time of the first CT)
- Tumor‘s isocenter info
- 4DCT
- Therapy plans (TPS)



SENTINEL

in RT Room

- Patient‘s Surface (now, first fraktion at the Linac)



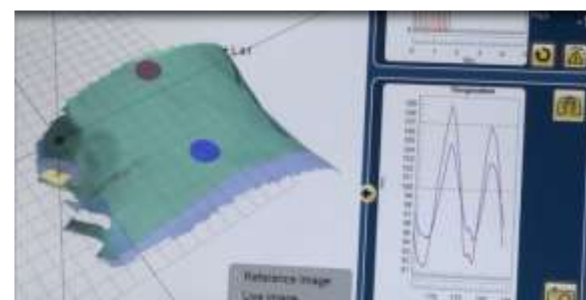
catalyst

Delta = 0
Delta > 0

Delta < 0

Isocenter and red areas

Yellow areas



Gating

Geometrical corrections via couch and Intefaces to Linacs

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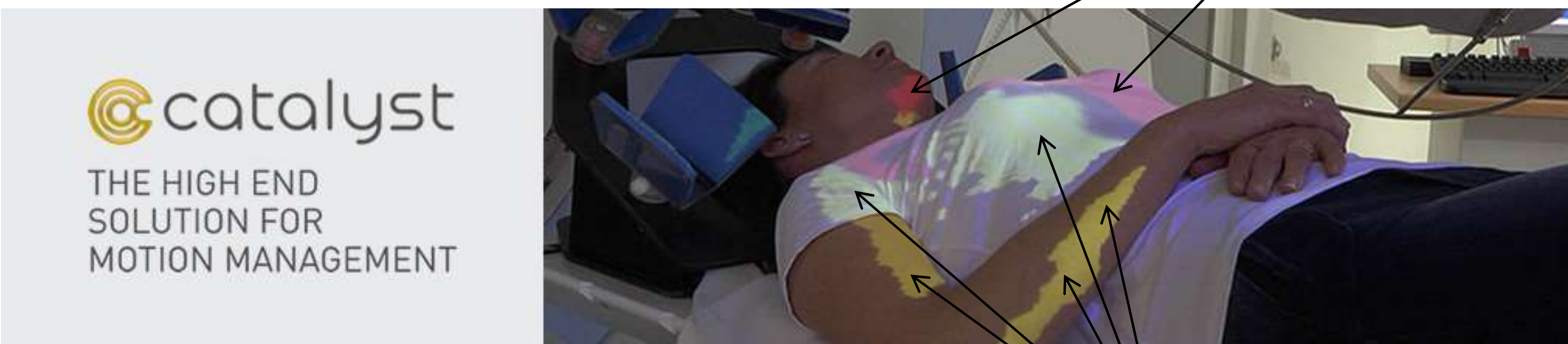
Rückprojektion : Torso Rotation

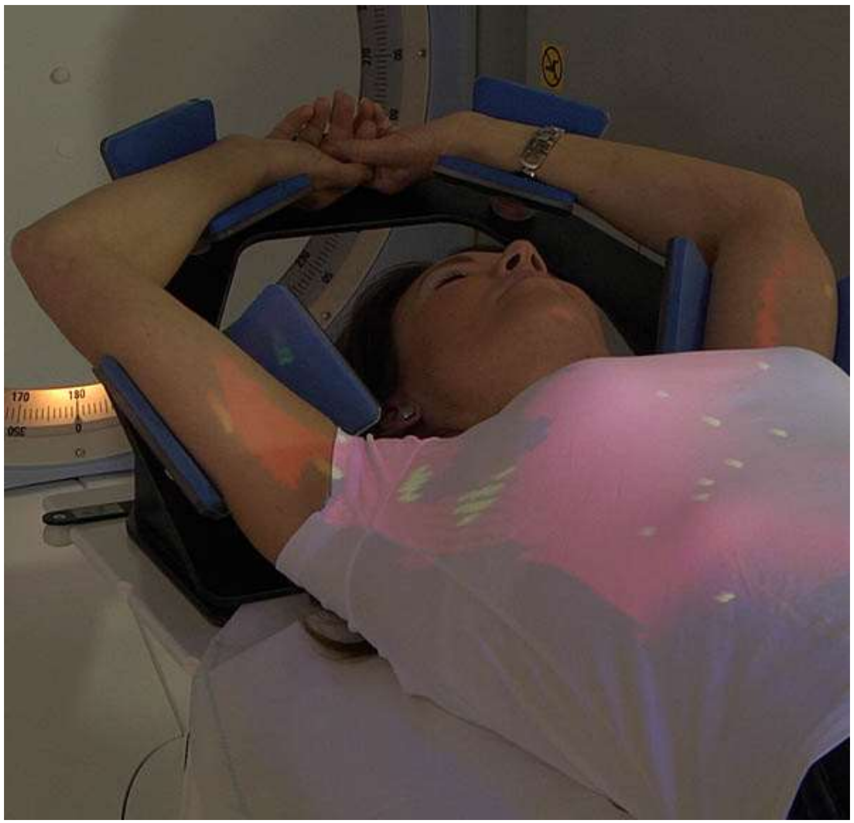
Muss nach **unten** (weil Rot)



Muss nach **oben** (weil Gelb)

catalyst

Modules



- Patient setup and Positioning
- Motion detection
- Respiratory gating

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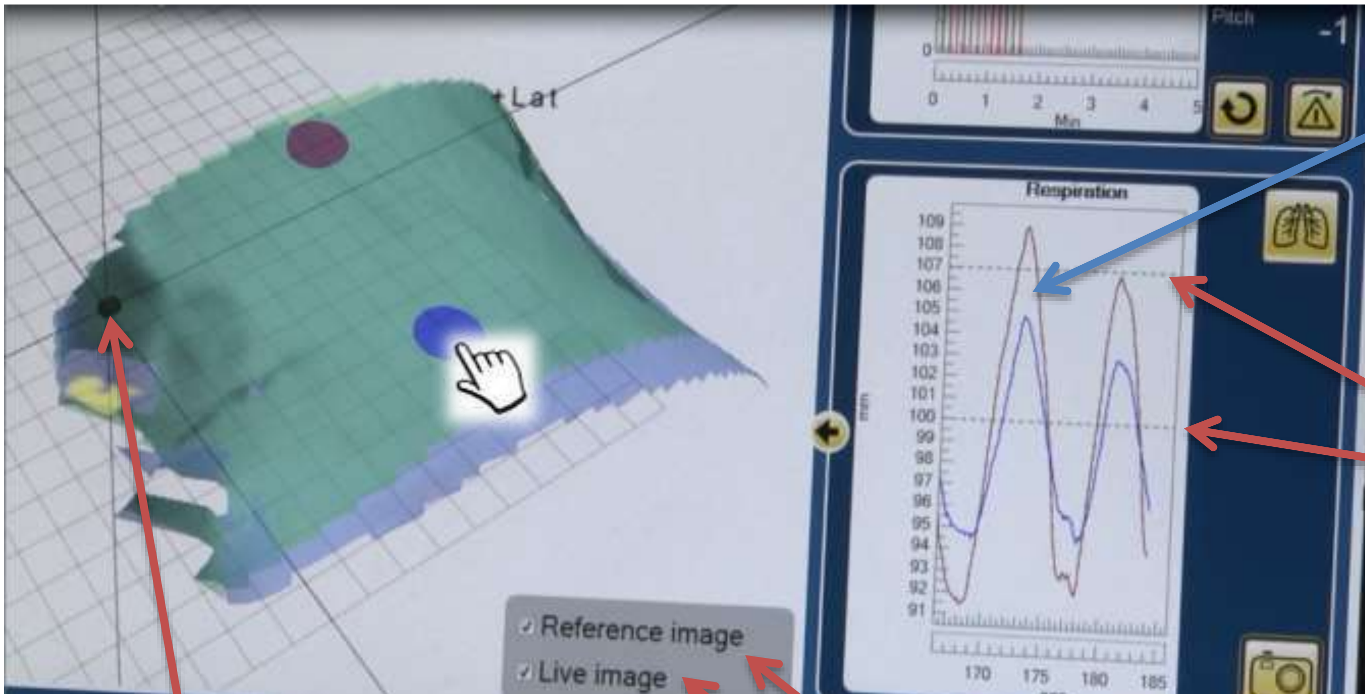
Respiratory Gating with the Catalyst in Linac Room (with Touch Screen Option)



Real-time Measurements (free breathing) in Linac Room

From CT for free-breathing

From Sentinel - CT

From Catalyst - Linac

1) Tumor's Isocenter
2) Linac = Catalyst Isocenter

Innovation und Flexibilität

Respiratory gating / coaching (DIBH)

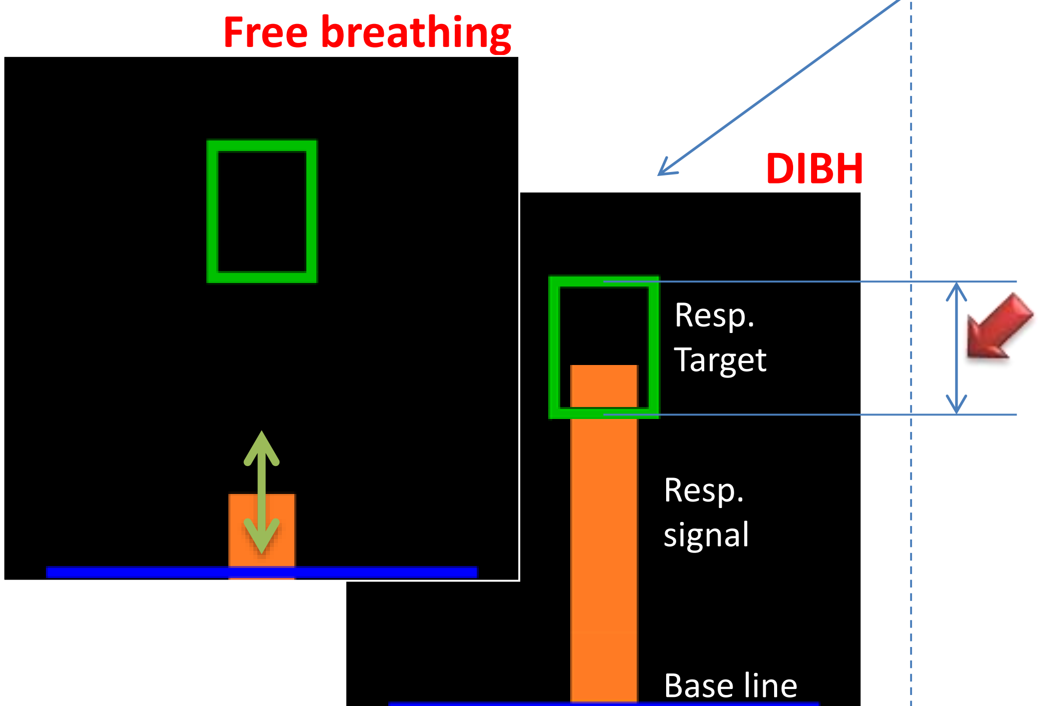
„Catalyst" „Sentinel"

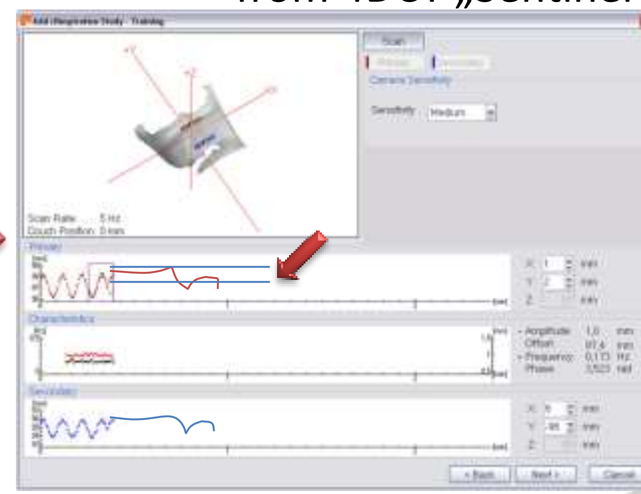
RT ← CT

Patient's Visual feedback

Exported via DICOM

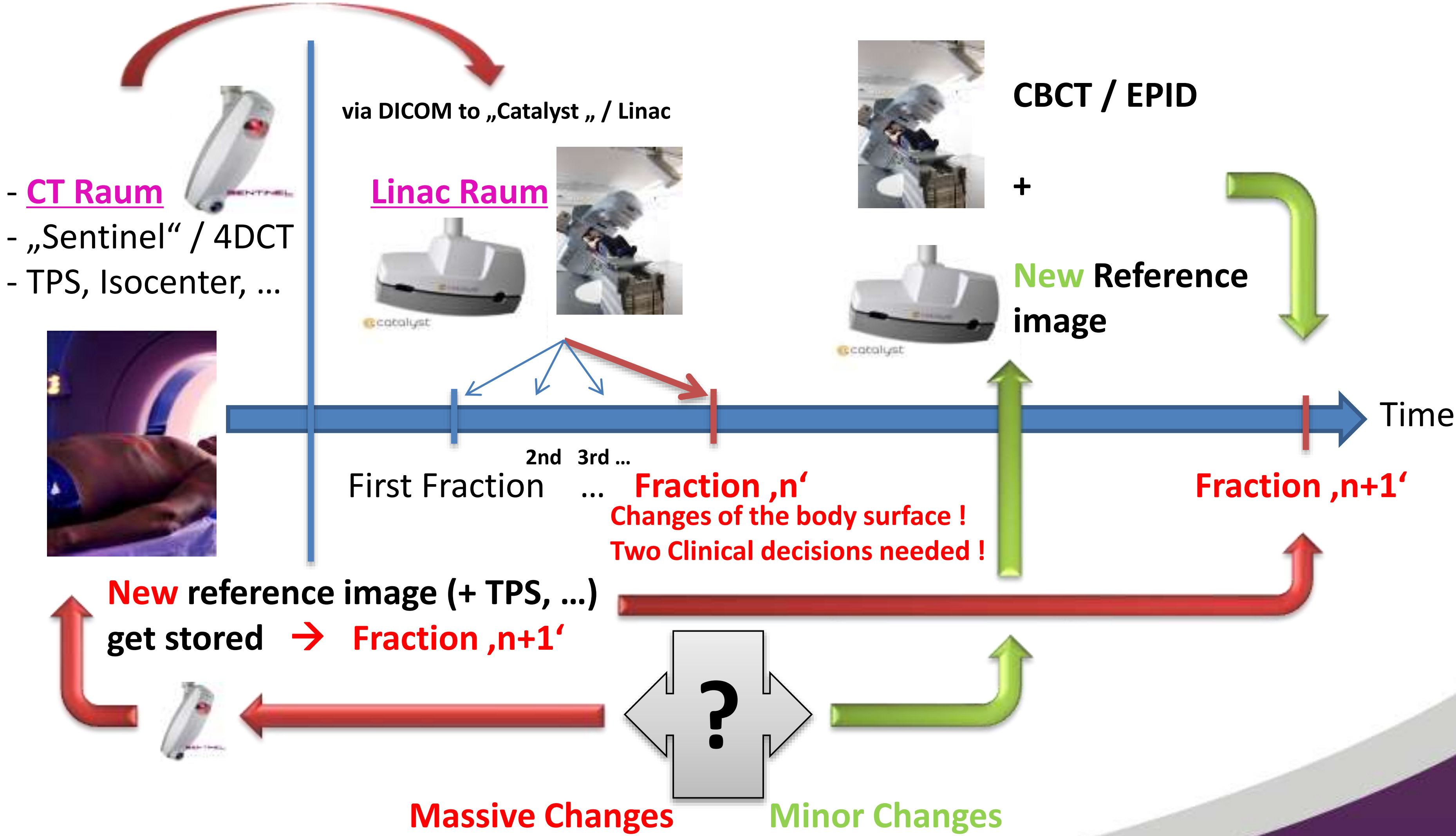
from 4DCT „Sentinel"





Has the patient‘s surface changed after the first fractions ?

Always a dynamic Workflow :



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

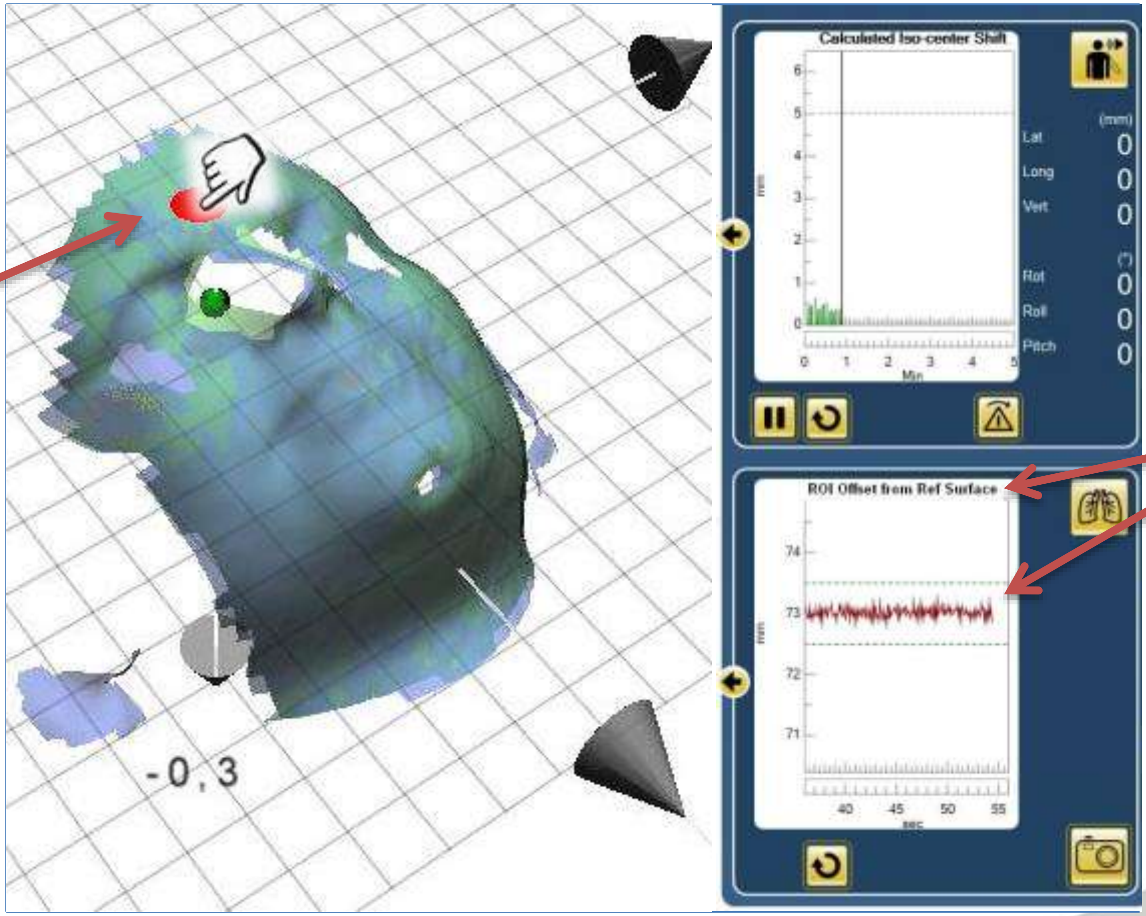
Malin Kügele1, Charlotte Thornberg1, Elisabeth Kjellén2, Fredrik Nordström1, Silke Engelholm2

1 Radiation Physics, Skåne University Hospital, Lund, Sweden

2 Skånes Oncology Clinique, Section of Radiation Therapy

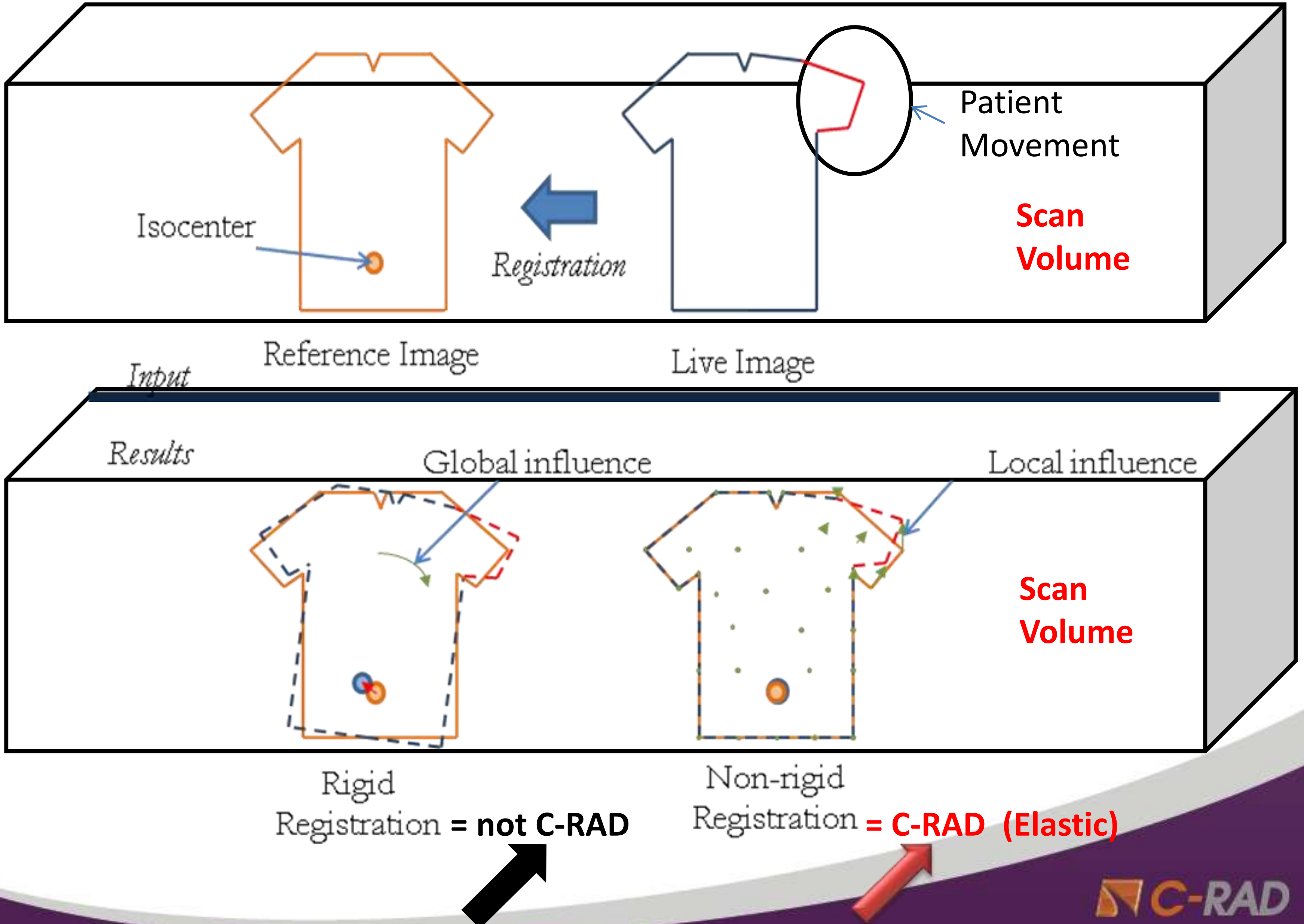
„Head & Neck“ … ohne Masken … (Uni Lund, SE)

„Gating“ spot …



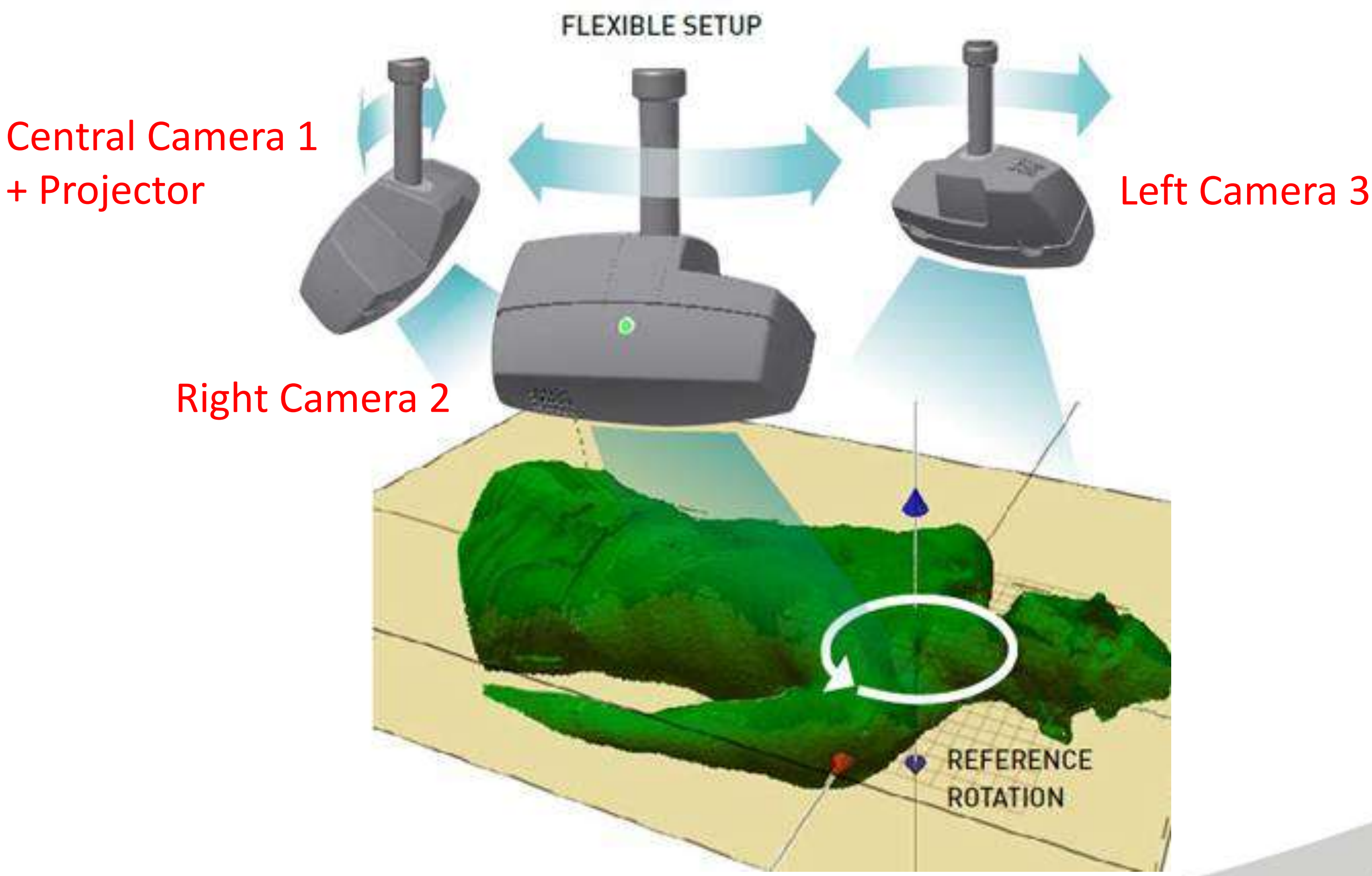
C-RAD

Non-rigid algorithm for isocenter calculation :



C-RAD

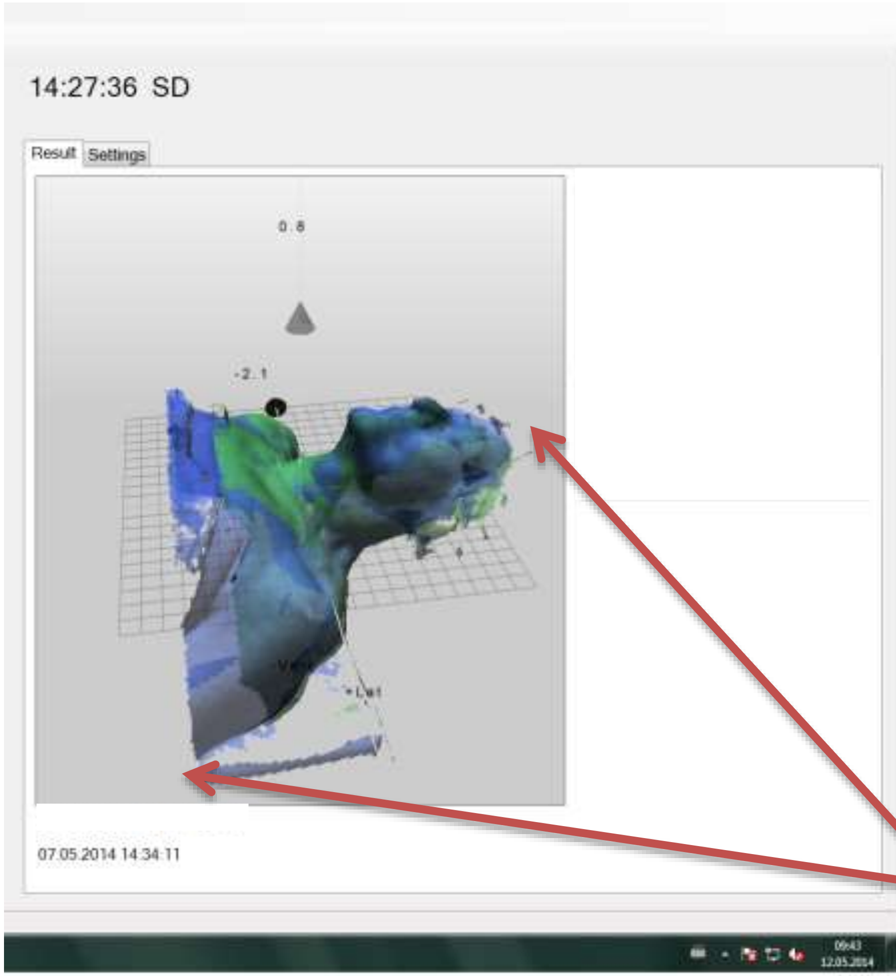
3-Camera Solution



3-Camera Solution
KFJ Spital – Wien –

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

3-Camera Catalyst Stereotactic Report with Screen View



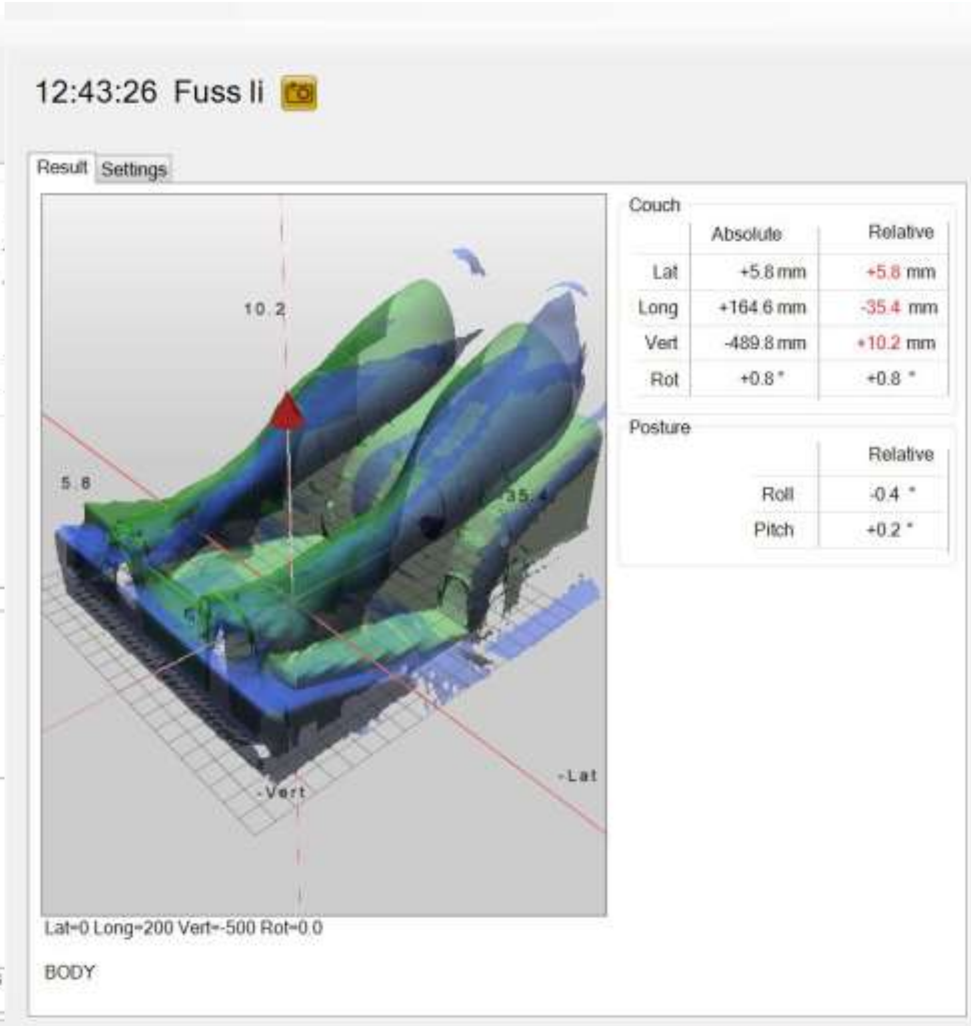
Benefits for Stereotactic Appications :

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

Critical Angles / Views

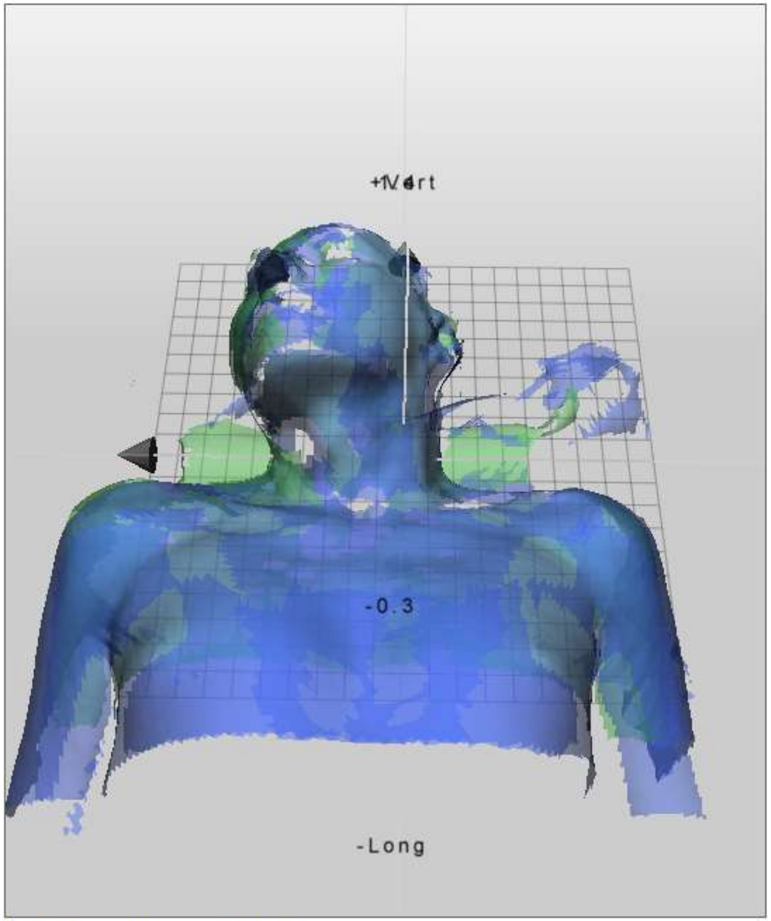
→ Instant verification of postural errors (shoulder and head rotation)

Three more examples :



13:51:27 Hals li

Result | Settings



Lat=0 Long=0 Vert=0 Rot=0.0

06.05.2014 13:33:17

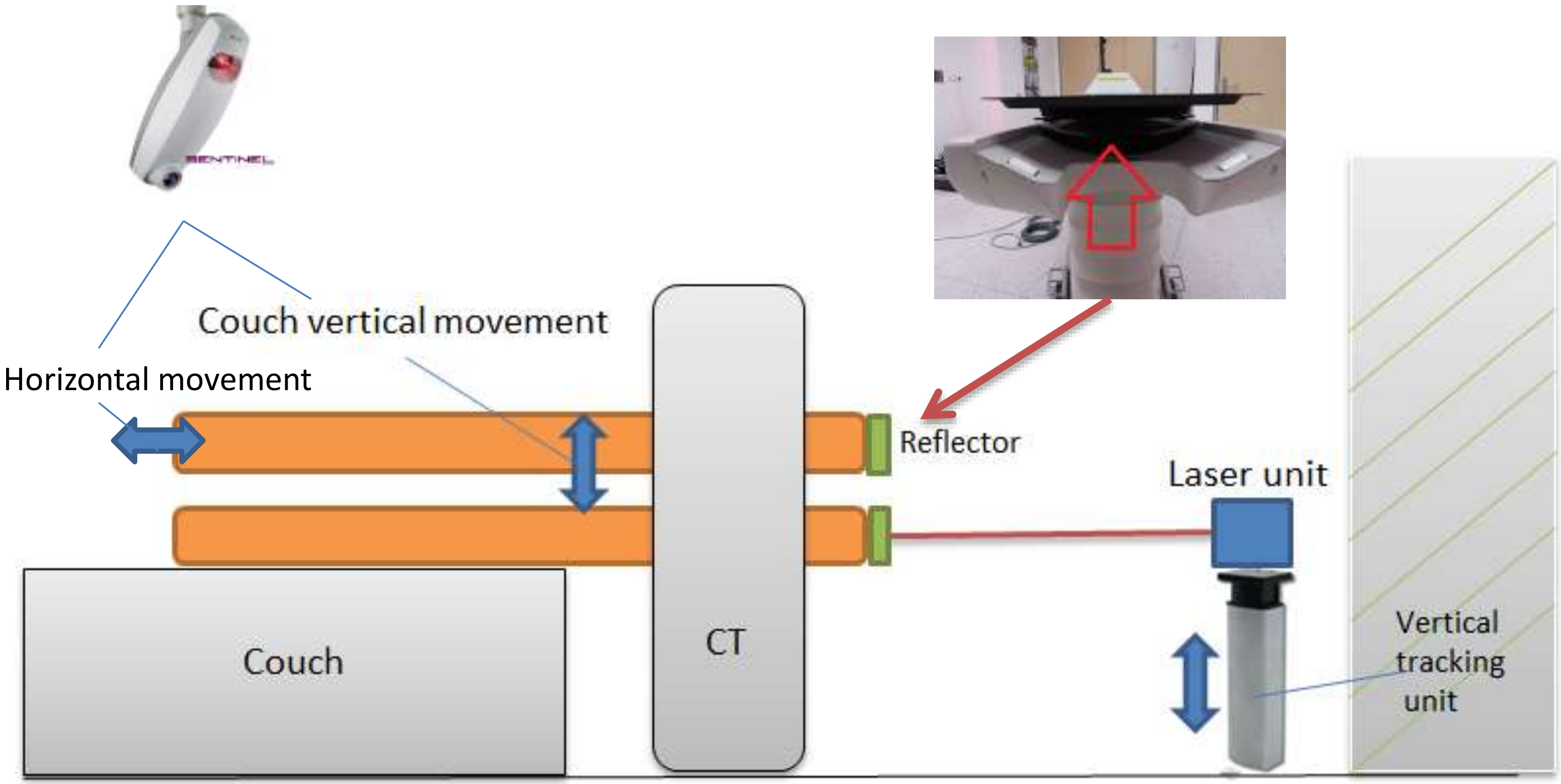
Couch

	Absolute	Relative
Lat	-2.0 mm	-2.0 mm
Long	+1.4 mm	+1.4 mm
Vert	-0.3 mm	-0.3 mm
Rot	+359.2 °	-0.8 °

Posture

	Relative
Roll	-0.6 °
Pitch	+0.4 °

New : Table Tracking for "Sentinel" in CT Rooms



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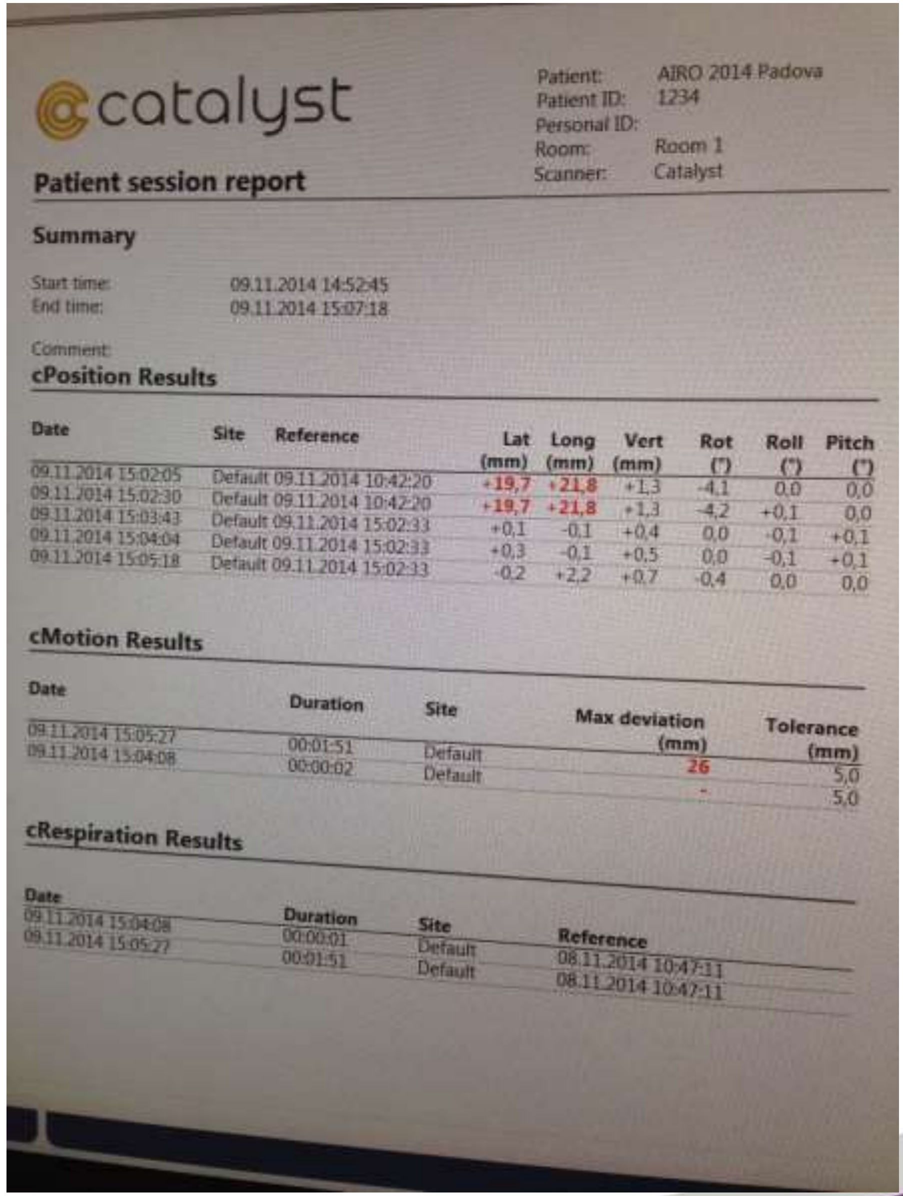
Reporting

(on screen and in .pdf)



catalyst

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

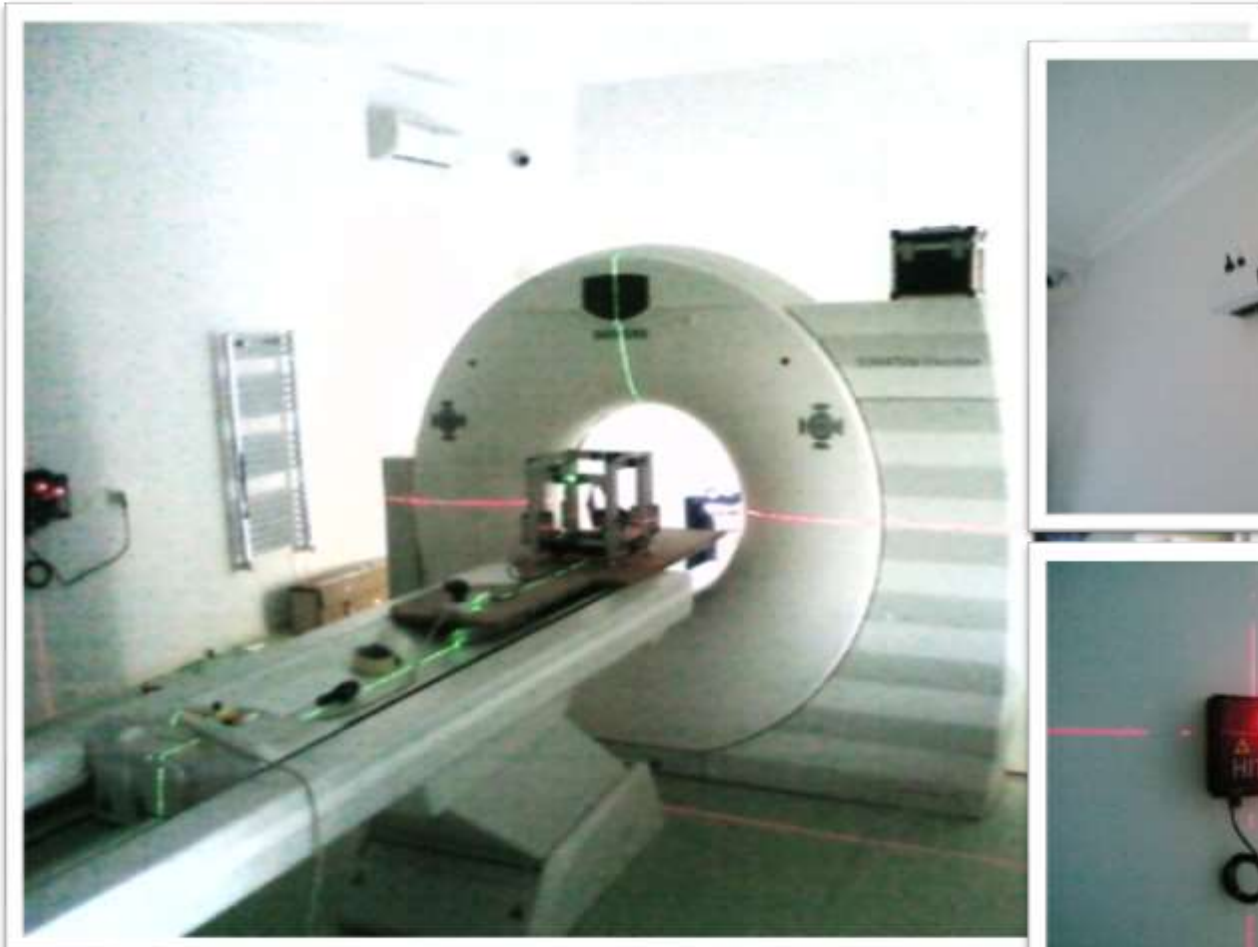
cMotion Results

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

Room Lasers : View of a mobile and a fixed laser with the SmartPhantom



Klinische Vorteile : Überblick

- **Patientenlagerung sowie Patienten Auto-Setup →**
  mit Tischinterface sowie Schnittstelle zum Bestrahlungssystem, interessant ist die Möglichkeit der **Rückprojektion**, d.h. Lagerungsfehler werden während des Setups direkt auf den Patienten projiziert (plus Screen im Kontrollraum) : **Vorteil** für die MTRA's, bei Positionierung, Gating und Bewegungsmanagement, ohne Markers, Belts und Fiduciary Points = mehr Komfort für alle.

- **Patientenüberwachung nach der Positionierung und während der gesamten Bestrahlung →**
  dies ist insbesondere dann interessant, wenn entweder lange Bestrahlungszeiten vorliegen oder mit einer **hohen Dosisrate** bestrahlt wird.

- **Respiratory Gating →**
  Durch die Erfassung der Oberfläche und der Tatsache, dass **keine Marker** angebracht werden müssen, ergeben sich große Vorteile für die Bestrahlung linker Mammen und Lungentumoren.

- **Tisch und Linac autom. Steuerungen →** via Interfaces.

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Results

catalyst

AT SKÅNE UNIVERSITY HOSPITAL, SWEDEN

Skåne University Hospital has a deep experience in respiratory gating. The clinical implementation of respiratory gated treatments was in 2006 based on the Varian RPM System.

Since 2011 the Skåne University Hospital has been involved in the evaluation and implementation of clinical workflows for the new functionalities based on the unique features of the Catalyst system. The installations are on Varian 2100 Clinacs and on Siemens Somatom Definition CT scanner.

Markerless and accurate solution

The respiratory gating solution is based on deep inspiration breath hold used on left sided breast patients with prospective CT image acquisition on the Siemens scanner. The aim of this technique is to save organs at risk (heart, coronary artery) for the breast patients and therefore minimize the side effects of the treatment. A gated CT scan is performed and gated treatment is delivered only when the separation between the target and organs at risk is as planned.

It is important that the breathing is reproducible from day to day, therefore it is valuable that the respiratory signal is expressed in absolute coordinate system indicating if there is a base shift in the signal. The patient is guided with audio and visual coaching in order to ensure that the breathing has the same pattern as during the CT acquisition.

"One of the many strengths with the C-RAD's gating solution is that we are able to gather one or two respiratory signals directly on the skin, with no need for markers and without constraints on the location for signal acquisition."

Charlotte Thornberg, PhD.

In parallel with the gated treatment delivery the patient is monitored in real time and the beam will be turned off via the MMI interface if the movements are outside allowed intervals.

Interactive adjustment for posture errors

Especially for breast patients it is important that the arms are placed in the same position in every fraction since their position may affect the target placement. If an arm is not in the correct position the system is projecting a clear indication of the magnitude and direction of the adjustment that need to be done. This indication is updated in real time with the remaining adjustment. When the posture errors have been corrected the couch is moved to the correct position with automatic couch adjustment.

Overall the system is very intuitive and easy to use.

Ensure that treatment is not delivered when patient is moving

"The patient monitoring application shows clearly if the patients are moving during treatment delivery. This is something that was not easy to see before, because the supervision was done visually by the treatment personnel. Using the beam hold function on the Linac we can make sure that treatment is not delivered when the patient movements exceed the thresholds.

We have also used the recorded results to show to anxious patients that the treatment went well and that they did not move, with the positive outcome that they felt more relaxed the following fractions."

(Charlotte Thornberg, PhD.)

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Results

Increased patient throughput for treatment with helical tomotherapy

K. Petersson,[1] C. Ceberg,[1] T Knöös,[1,2] and M. Enmark[2]

[1] Medical Radiation Physics, Lund University, Lund, Sweden [2] Radiation 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 linac. 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 unwanted 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 dosimetric 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 (2-5 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 it took to MVCT scan the patient and the time it took to match the MVCT scan to the planning KVCT 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 use of MVCT imaging (scan + match) took in average 15 minutes to perform. The total treatment time was in average 35 minutes (with a standard deviation of 15 minutes) when the MVCT system was utilized and 15 minutes in average (with a standard deviation of 4 minutes) when the laser scanning system was used. A box plot of total treatment times can be seen in Figure 1. Reduced MVCT scans according to the imaging protocol would result in an increased patient throughput of about 50%.

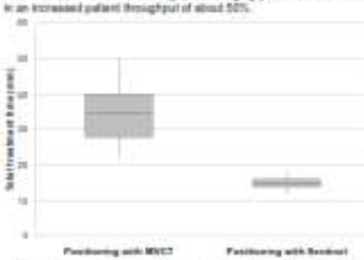

Figure 1. Box-and-whisker plot illustrating the total treatment time (from that a patient enters the treatment room until they leave) when positioned with the MVCT system or with the Sentinel system, for patients treated with helical tomotherapy. Boxes represent the inter-quartile range (25th to 75th percentile), and whiskers indicate the 5th and 95th percentiles. The line represents the mean values.

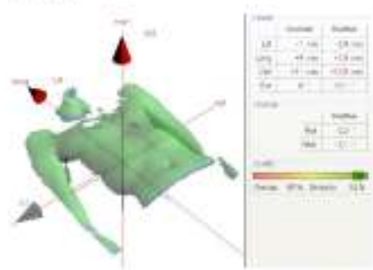

Figure 3. Proposed positioning corrections from the Sentinel system software after a laser surface scan, in preparation for helical tomotherapy treatment in the thoracic region.

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

Mattias Jönsson[1*], Sofie Ceberg[1], Charlotte Thornberg[2], Sven Bäck[2]

[1] Medical Radiation Physics, Department of Clinical Sciences, Malmö, Lund University

[2] Radiation Physics, Skåne University Hospital, Malmö, Sweden

Aim

The aim of this pilot study was to evaluate the optical scanning system Catalyst™ (C-Rad, Uppsala, Sweden) for pre-treatment patient positioning for external beam radiotherapy.

Background

The Catalyst™ system is intended to serve as a complement to x-ray imaging with the potential benefit of detecting misplacement of for example the arms during breast cancer treatment.

Incorrect arm positions might affect the tumour position due to skin stretching and contraction of muscles such as the pectoralis muscles. Changes in the soft tissues, where the tumour is located, would not be detected using x-ray imaging.

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

Figure 2. Reference (blue) and second scan (red) of a patient overlapping. The scanning system detected a difference in arm position.

Materials and Methods

A Catalyst™ system was installed in the ceiling above the couch 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-mesh. Using the LED-projector, deviations between the body contour and the contour reconstructed from the CT-scan will be coloured giving the therapy personnel instant feedback during the patient positioning (Figure 1).

A total of 32 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.

Results

In the sagittal plane, the arm position was within ±2 degrees from the median value in 62 % of the treatment sessions and within ±3 degrees in 72 % of the treatment sessions. The maximum observed deviation was 8 degrees from the median value.

In the coronal plane, the arm position was within ±2 degrees from the median value in 61 % of the treatment sessions and within ±3 degrees in 90 % of the treatment sessions. The maximum observed deviation was 6 degrees from the median value.

Conclusions

After patient setup using planar x-ray 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 contour with a direct guidance projected on the patient is a helpful tool during patient setup with the potential of increasing both workflow and patient safety.

LUND UNIVERSITY Faculty of Medicine

Presented at Estro 31, 9-13 May 2012, Barcelona, Spain

*corresponding author: mattias.jonsson@med.lu.se

C-RAD

Ziel erreicht !

Mehr Patienten pro Tag,

besser, komfortabler und

sicherer behandeln.

C-RAD

Thank you for your attention !

→VIDEOS !

www.c-rad.se

franco-canestri@c-rad.com
Mobile : 0176.10023655

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