

## SGRT: Overview and New Trends

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- AAPM Annual Meeting 2019 - San Antonio, Texas

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## Educational Objectives



- Discuss SI opportunities
- Review basic principles & systems
- Emerging results & applications
- New developments

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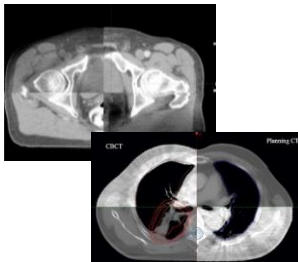
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## Role of Imaging in RT



- Volumetric, x-ray based imaging crucial for interfraction positioning due to highly conformal deliveries
- Limitations:
  - Additional dose
  - Temporal snapshot
  - No real-time monitoring
  - Motion management
  - Patient posture visualization



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## Why Surface Imaging?



- Goal: Improve the overall (temporal) accuracy of radiation delivery
  - Patient positioning
    - Improve inter-fractional set-up accuracy & precision
    - Visualize patient surface changes
    - Reduce set-up time
  - Patient monitoring
    - Monitor patient intra-fractionally (assess post CBCT/planar shifts)
    - Quantify inadvertent movements
    - Minimize re-imaging needs/reduce dose
  - Motion management tool for delivery
    - Efficient gating tool without extra patient devices
    - Simultaneously *monitor patient motion and acquire breathing trace*

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## Photogrammetry



- Method of extracting three-dimensional information from data acquired by means of multiple two dimensional images
- *Stereophotogrammetry* incorporates the known spatial geometry information
- Various techniques
  - Video-based
  - Laser-based
  - Optical-based

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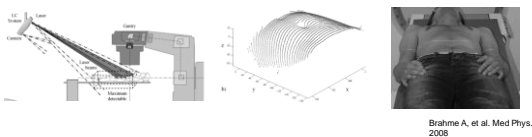
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## Evolution of SGRT




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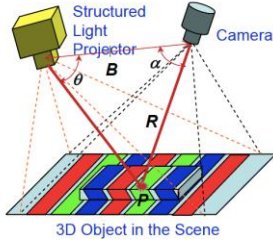
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## OPTICAL-BASED IMAGING

### Triangulation

$$R = B \frac{\sin(\theta)}{\sin(\alpha + \theta)}$$

B and  $\alpha$  are known,  
How to get the value of  $\theta$ ?



Courtesy of J. Geng




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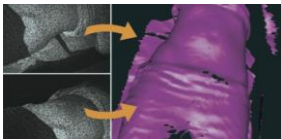
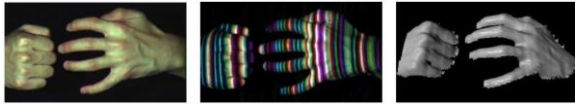
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### Structured Light Patterns



Zhang et al. 3DPVT (2002)

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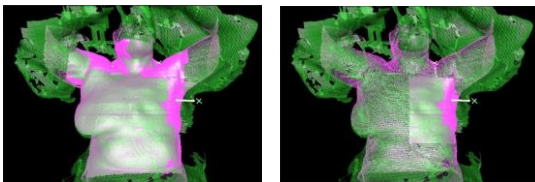
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### Selection of ROI



Courtesy of H. Al-Hallaq

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## Newer Generation: Systems



- VisionRT AlignRT
- C-RAD CatalystHD
- Varian IDENTIFY



Courtesy of VisionRT & Varian

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## SGRT Workflow Modules



Identification\*

- Ability to verify patients
- Identify immobilization devices

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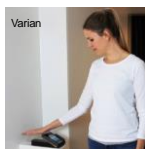
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## IDENTIFICATION

- Biometric identification
- Palm/RFID
- Facial
- Correct immobilization devices **and** location on treatment table verification



Courtesy of VisionRT, Varian & C-RAD

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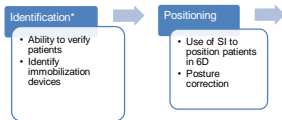
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## SGRT Workflow Modules



- Identification\***
- Ability to verify patients
  - Identify immobilization devices

- Positioning**
- Use of SI to position patients in 6D
  - Posture correction

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## SI: Set-up Accuracy & Efficiency



**COMPARISON OF INITIAL PATIENT SETUP ACCURACY BETWEEN SURFACE IMAGING AND THREE POINT LOCALIZATION: A RETROSPECTIVE ANALYSIS**

Dennis N. Stanley<sup>1</sup> | Kristen A. McCarron<sup>1</sup> | Neil Kirby<sup>2</sup> | Alanna N. Gutierrez<sup>1,3</sup> | Hsiao-Ping Lin<sup>2</sup> | Karl Rosenzweig<sup>2</sup>

**TABLE 1** Summary of post-CBCT 3D corrections calculated averages and standard deviations for a traditional three point localization with subcutaneous tattoos and surface imaging techniques.

	Three point localization		Surface imaging	
	Average(cm)	σ(cm)	Average(cm)	σ(cm)
Feet/lower extremities	0.9	0.4	0.6	0.3
Abdomen	1.0	0.5	0.5	0.3
Chest/upper extremities	0.9	0.6	0.5	0.3
Breast	1.4	0.7	0.6	0.2

### Can surface imaging improve the patient setup for proton postmastectomy chest wall irradiation?

Estelle Batin PhD<sup>1</sup>, Nicolas Depaew PhD, Shannon MacDonald MD, Hsiao-Ming Lu PhD

Dennis Stanley, Ph.D.

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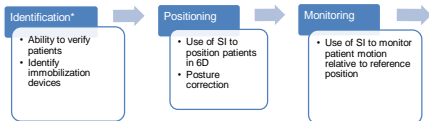
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## SGRT Workflow Modules



- Identification\***
- Ability to verify patients
  - Identify immobilization devices

- Positioning**
- Use of SI to position patients in 6D
  - Posture correction

- Monitoring**
- Use of SI to monitor patient motion relative to reference position

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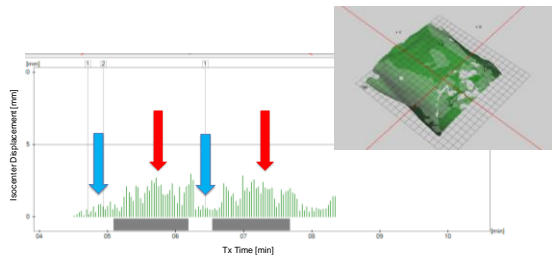
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## Patient Monitoring: Lung VMAT Case




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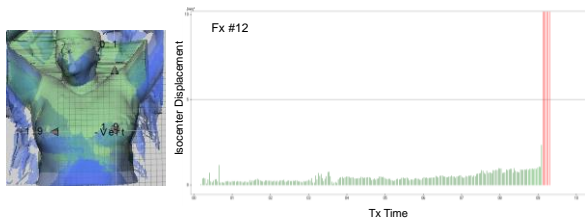
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## Patient Monitoring: Proton Breast Tx




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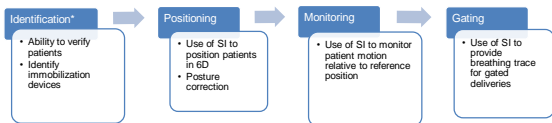
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## SGRT Workflow Modules




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## Motion Management: Gating



RADIATION ONCOLOGY PHYSICS Laaksomaa M, et al. JACMP. 20(3). 2019

AlignRT® and Catalyst™ in whole-breast radiotherapy with DIBH: Is IGRT still needed?

Marko Laaksomaa<sup>1</sup> | Sebastian Saradi<sup>2</sup> | Maija Rossi<sup>3,4</sup> | Turikka Lehtonen<sup>1</sup> | Jari Pekkonen<sup>5</sup> | Jenny Remes<sup>6</sup> | Heidi Loukkanen<sup>1</sup> | Tanja Skyyts<sup>1</sup> | Mika Kapanen<sup>1,3</sup>



Hanis A. Al-Hallaq, Ph.D.

RADIATION ONCOLOGY PHYSICS Xiao A, et al. JACMP 19(4). 2018

Single-institution report of setup margins of voluntary deep-inspiration breath-hold (DIBH) whole breast radiotherapy implemented with real-time surface imaging

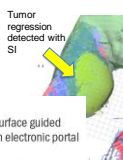
Aoife Xiao<sup>1</sup> | Jennie Crosby<sup>2</sup> | Martha Mallin<sup>2</sup> | Hyejoo Kang<sup>3</sup> | Maxine Washington<sup>1</sup> | Yassin Hasan<sup>2</sup> | Steven J. Chmura<sup>2</sup> | Hanis A. Al-Hallaq<sup>2</sup>



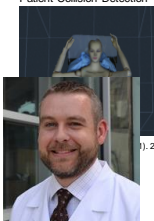
## Additional SI Opportunities



- New treatment sites
- Use to patient collision
- Use to monitor patient changes
- Use to facilitate machine QA



Patient Collision Detection



2015

Ryan Foster, Ph.D.



PAPER

Quality assurance of gating response times for surface guided motion management treatment delivery using an electronic portal imaging detector

Gary Barfield<sup>1</sup>, Edward William Burton<sup>1</sup>, Jonathan Stockart<sup>1</sup>, Mohamed Metwally<sup>2</sup> and Martin Gerard<sup>1</sup>
<sup>1</sup> Department of Radiotherapy Physics, United Lincolnshire Hospitals NHS Trust, Lincoln, United Kingdom
<sup>2</sup> Department of Radiotherapy Physics, Cambridge University Hospitals NHS Trust, Cambridge, United Kingdom
\* Author to whom any correspondence should be addressed.
© 2015 British Institute of Radiology

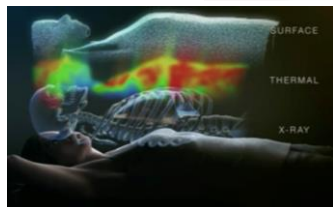
Keywords: surface-guided radiotherapy, treatment margins, gating, quality assurance, motion management, motion platforms



## Evolving SI Platforms



- BrainLAB ExacTrac Dynamic
- Combining imaging systems to synergistically improve accuracy
  - Surface
  - X-ray
  - Thermal
- Thermal imaging
  - Potentially enhances accuracy for select sites by using 3D heat map



Courtesy of BrainLAB



## Conclusions



- SI technology has evolved over recent years to improve quality and delivery efficiency of patient treatments
- Increasing adoption of SI technology in recent years
- Growing data emerging on the improved accuracy of radiation delivery for a number of disease sites
- Exciting future opportunities to further the use of SI

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## Thank you for your attention!



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