Ultrasound Guided HIFU Ablation (USgFUS)

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SonaCare Medical
AAPM 2013

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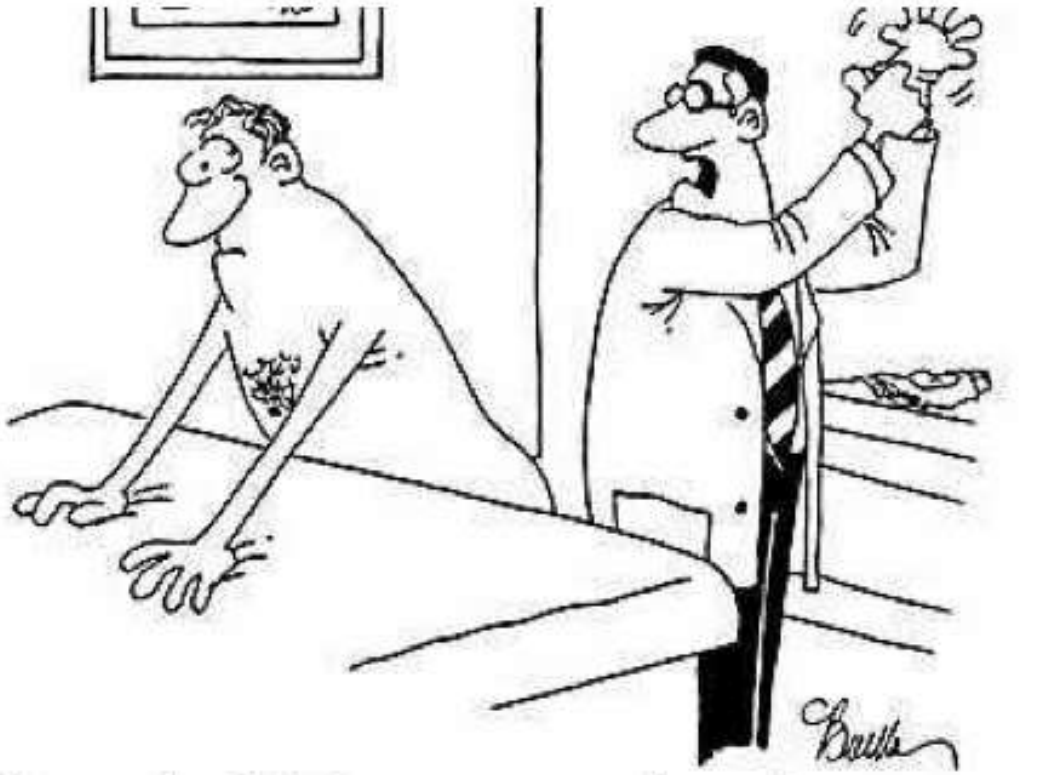
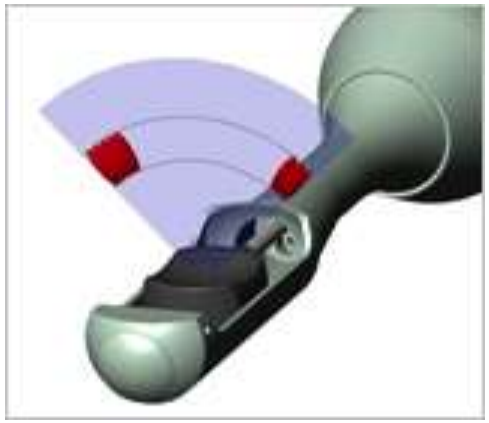


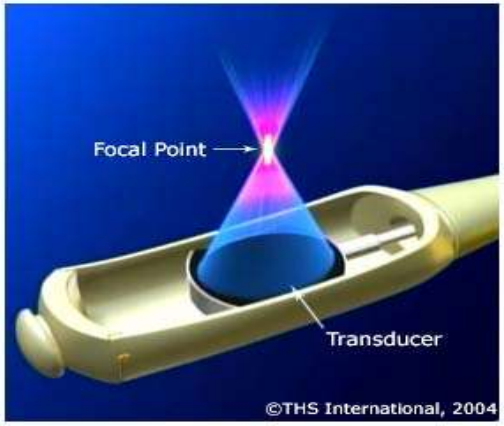
Honestly, if there was a virtual prostate exam, don't you think I'd want to be the first to know?"

Multi-Functional HIFU Probe
"See, Treat, and Track"

See



Treat



Track

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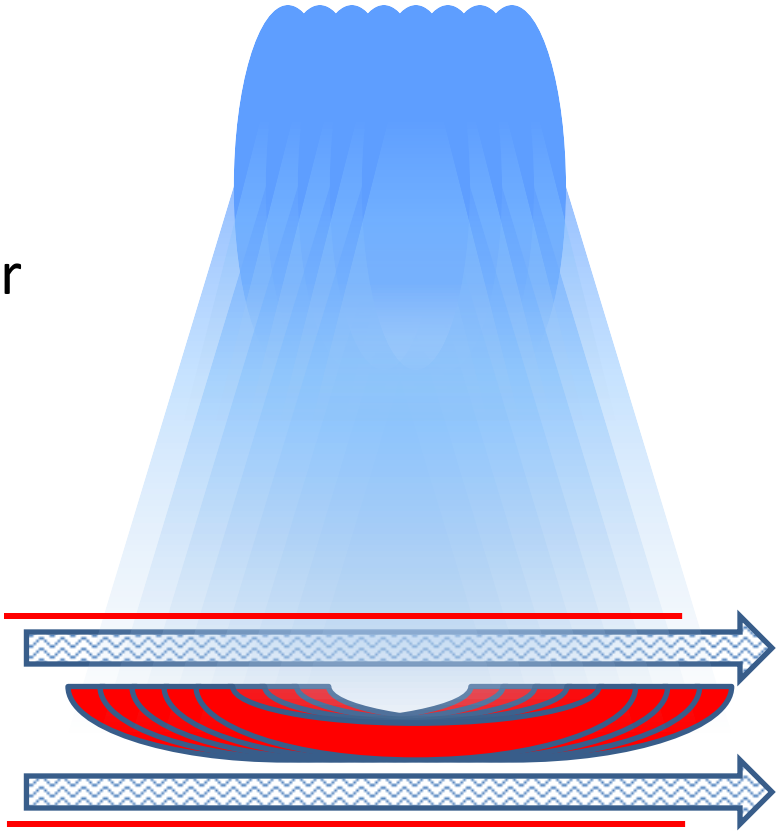
HIFU

Discrete Delivery

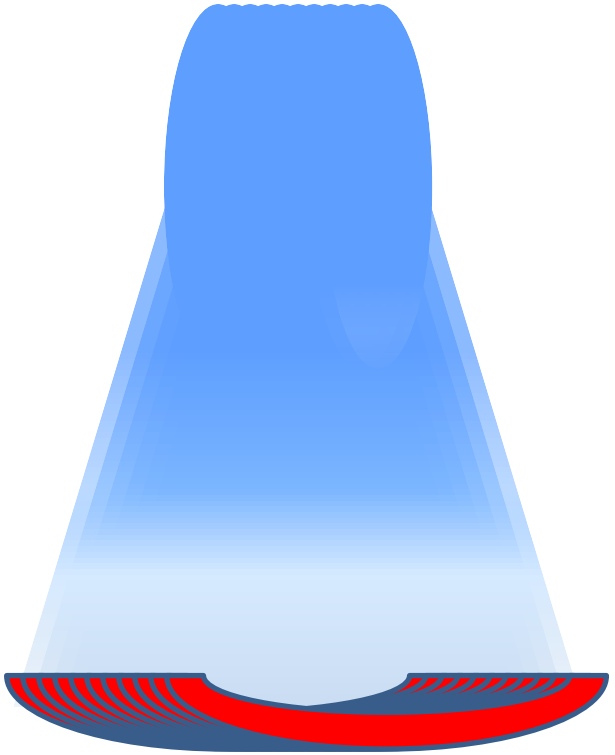
- **M**ost HIFU systems deliver a series of discrete ablations or “shots”
- Each shot is delivered in 3 seconds
- 3 - 6 second pause after shot allows for imaging and tissue cooling
- Staggered pattern of shot dispersion allows cooling of tissue
- Probe cooled with chilled water



HIFU

Continuous Delivery

- It is possible to deliver heat continuously, moving the focal point over volume of tissue to be ablated
- Tissue back to surface of the probe is destroyed eliminating need for probe cooling and pauses for cooling
- Elimination of “active” cooling results in a more efficient treatment delivery (3 – 6x)



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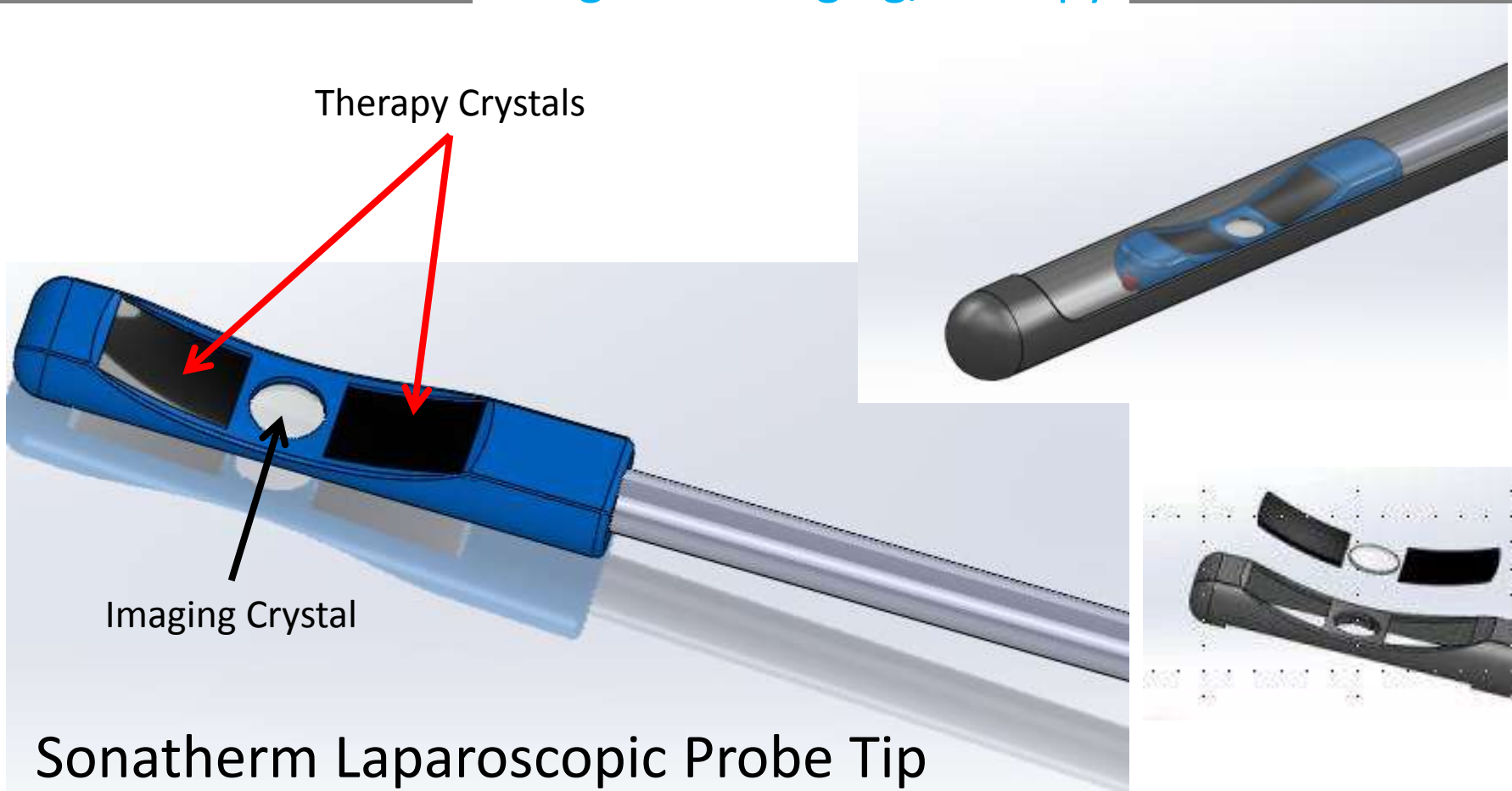
Integrated Imaging/Therapy



Sonatherm Laparoscopic Probe Tip

- Three (3) distinct operating crystals (one imaging and two therapy)
- Robotic scanning of transducers for volumetric imaging & ablation

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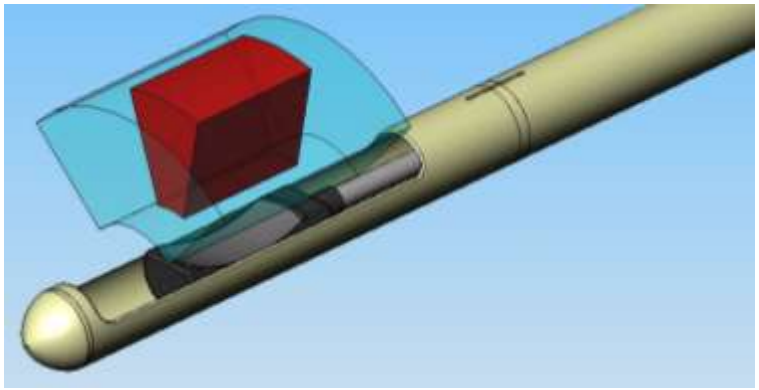
Characteristics

Focal Length:	35 mm
Lesion Depth:	30 mm (maximum)
Lesion L/W:	30 x 7 mm (maximum)
Imaging f:	**6.5 MHz**
Therapy f:	4 MHz
Max Output:	35 watts
Lesion Shape:	Sector
Treatment Times:	10 min for 12 cc lesion (2 cm x 2 cm x 3 cm)
	30 min for 35 cc lesion (Sonablate = 180 min)



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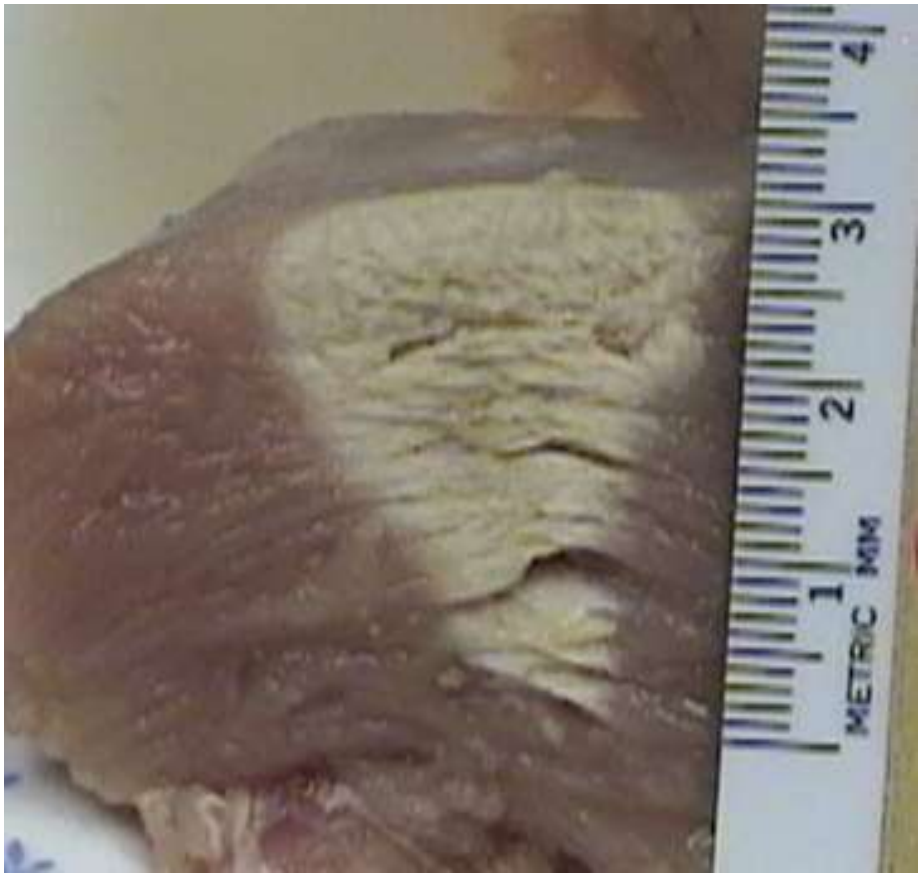
Ex-Vivo



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Role of US

HIFU Ablation

- **Image Fusion for localization and targeting**
- Treatment Planning
- Treatment Delivery
- Temperature Monitoring
- Tissue Typing

Road Runner
Localization

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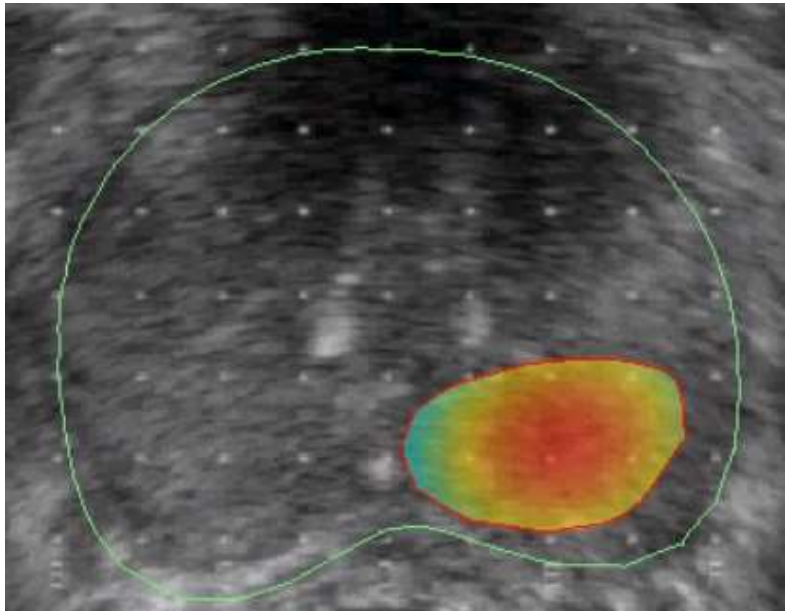
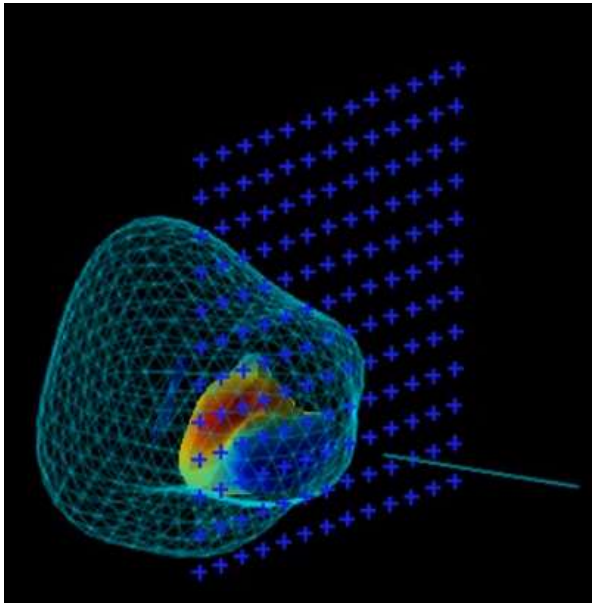
IMAGE FUSION

SmartTarget





University College London (UCL), United Kingdom

UCL Centre for Medical Image Computing

UCL Department of Medical Physics & Bioengineering

UCL Division of Surgery & Interventional Science

cmic
Centre for Medical Image Computing

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IMAGE FUSION

SmartTarget

- Automatic, deformable image registration/fusion
  - Compensates for shape changes due to ultrasound probe pressure and gland swelling
- Accuracy
  - Error of 2.4mm
  - >90% hit rate for a 0.5cc spherical tumour

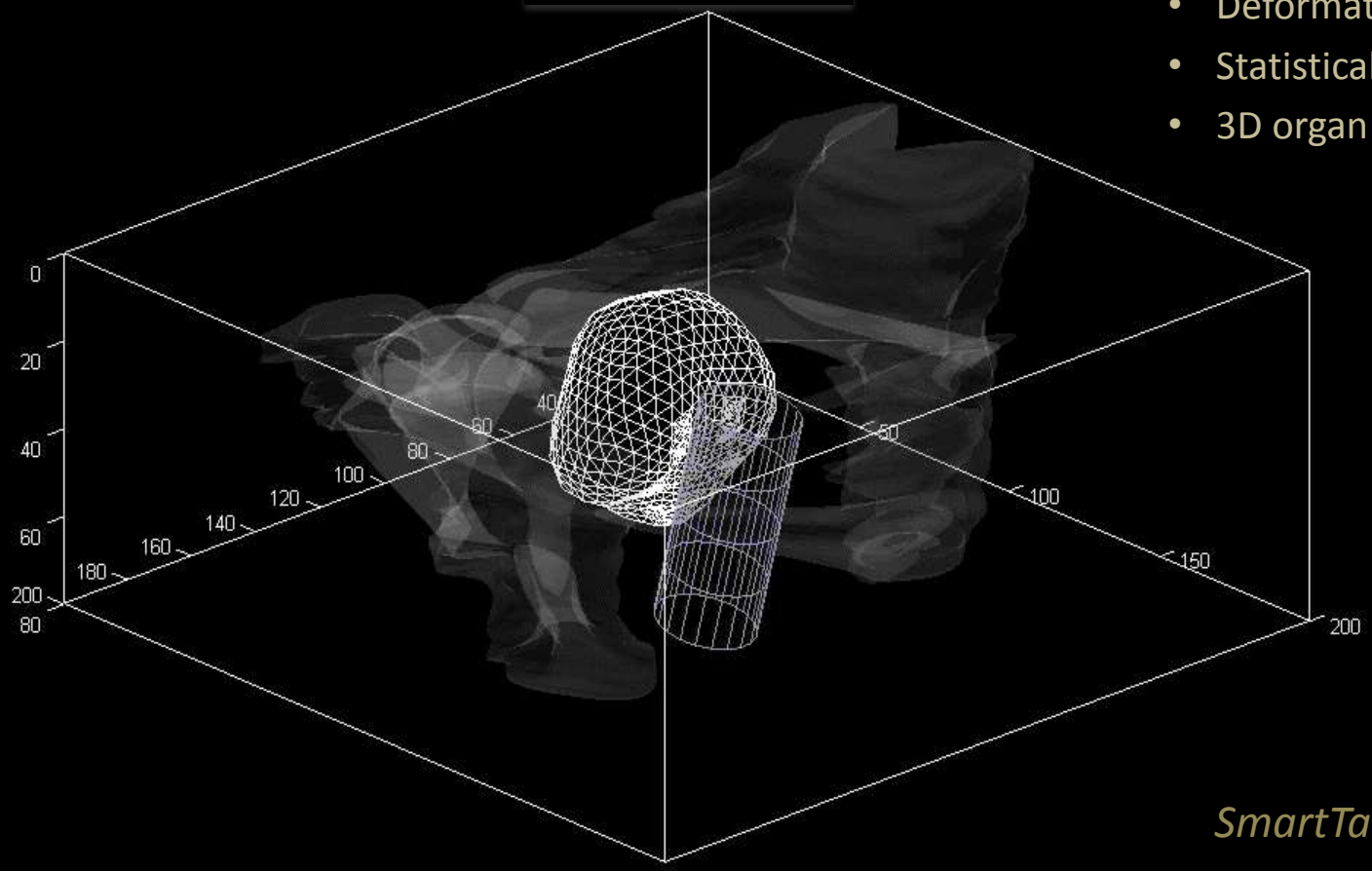
    *Hu et al. *Medical Image Analysis* (2012)
- Simple workflow
  - Minimal user interaction during a surgical procedure
- Versatility
  - Configurable for use with biopsy and all minimally-invasive therapies including HIFU

*Patent Pending

Sonablate® New Software Development

3D Deformable Model

- Volumetric model
- Deformation aspects
- Statistical shape analysis
- 3D organ models



SmartTarget

Courtesy of Professor Mark Emberton, M.D., University College London

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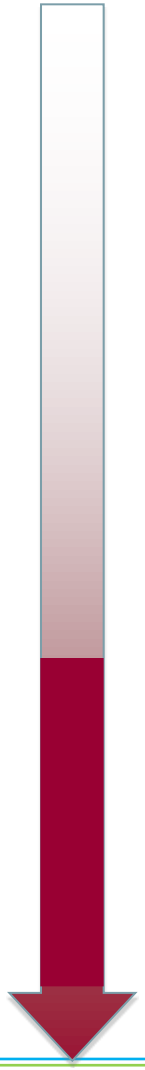
IMAGE FUSION

SmartTarget

Before Procedure (Steps 1-3)

During Procedure (Steps 4-5)



1. MR Analysis & Contouring
2. Deformable Model Generation
3. Acquire 3D TRUS Image
4. Register Model to 3D TRUS Image
5. Targeted Therapy Planning & Delivery

4a. Load 3D US volume file
4b. Load Deformable Model
4c. Define Volume Points in US Image
4d. Register Model to 3D US Image
4e. Export Tumor Data File

SonaCare Medical

IMAGE FUSION

Sonaplan

Export image volume to SmartTarget

IMAGE FUSION

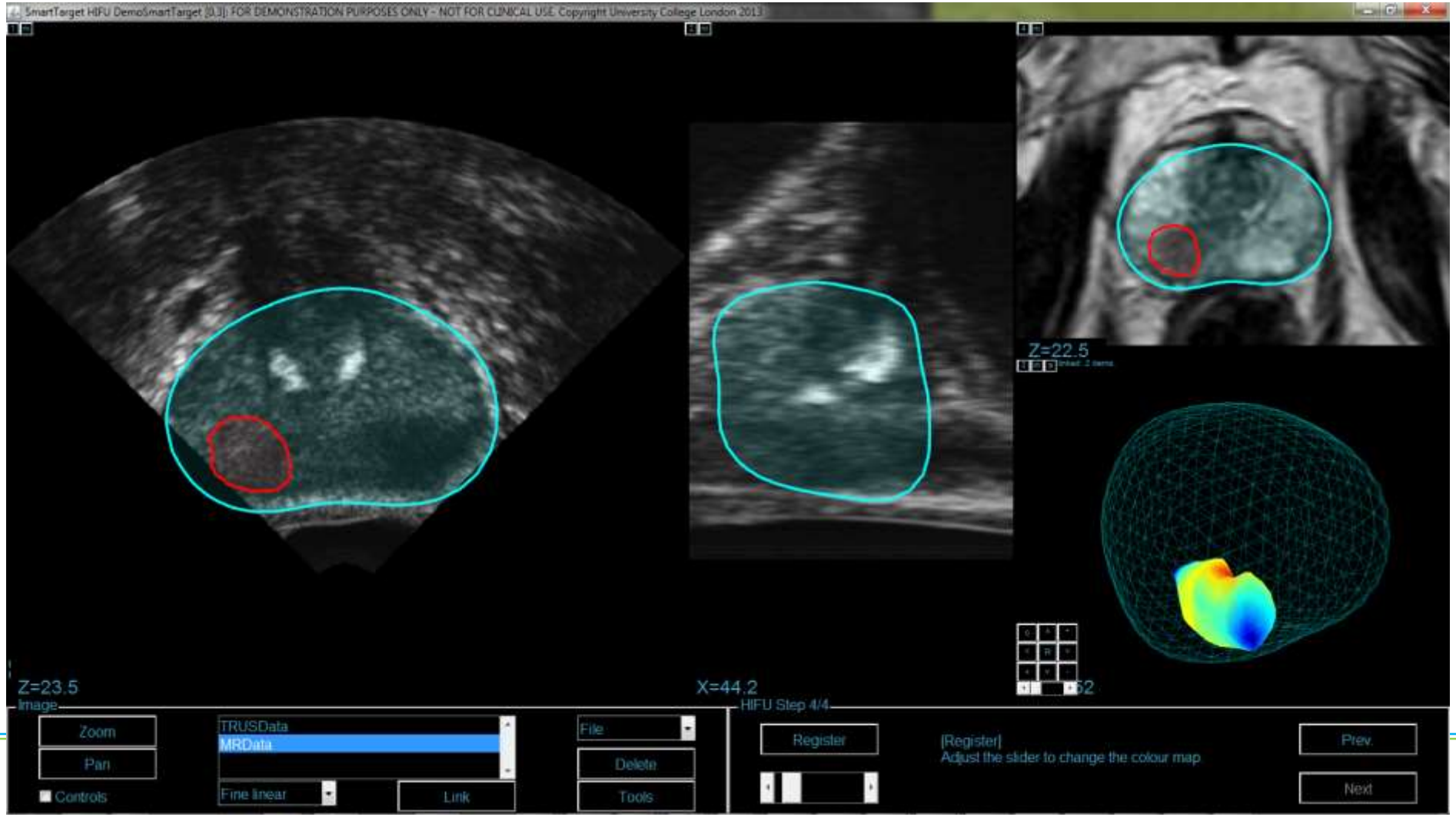
Sonaplan

Mark positions on prostate capsule

IMAGE FUSION

Sonaplan

Register MRI to US with SmartTarget



Role of US Imaging

HIFU Ablation

- Image Fusion for localization and targeting
- **Treatment Planning**
- Treatment Delivery
- Temperature Monitoring
- Tissue Typing

IMAGE FUSION

Sonaplan

Import structures into SonaPlan

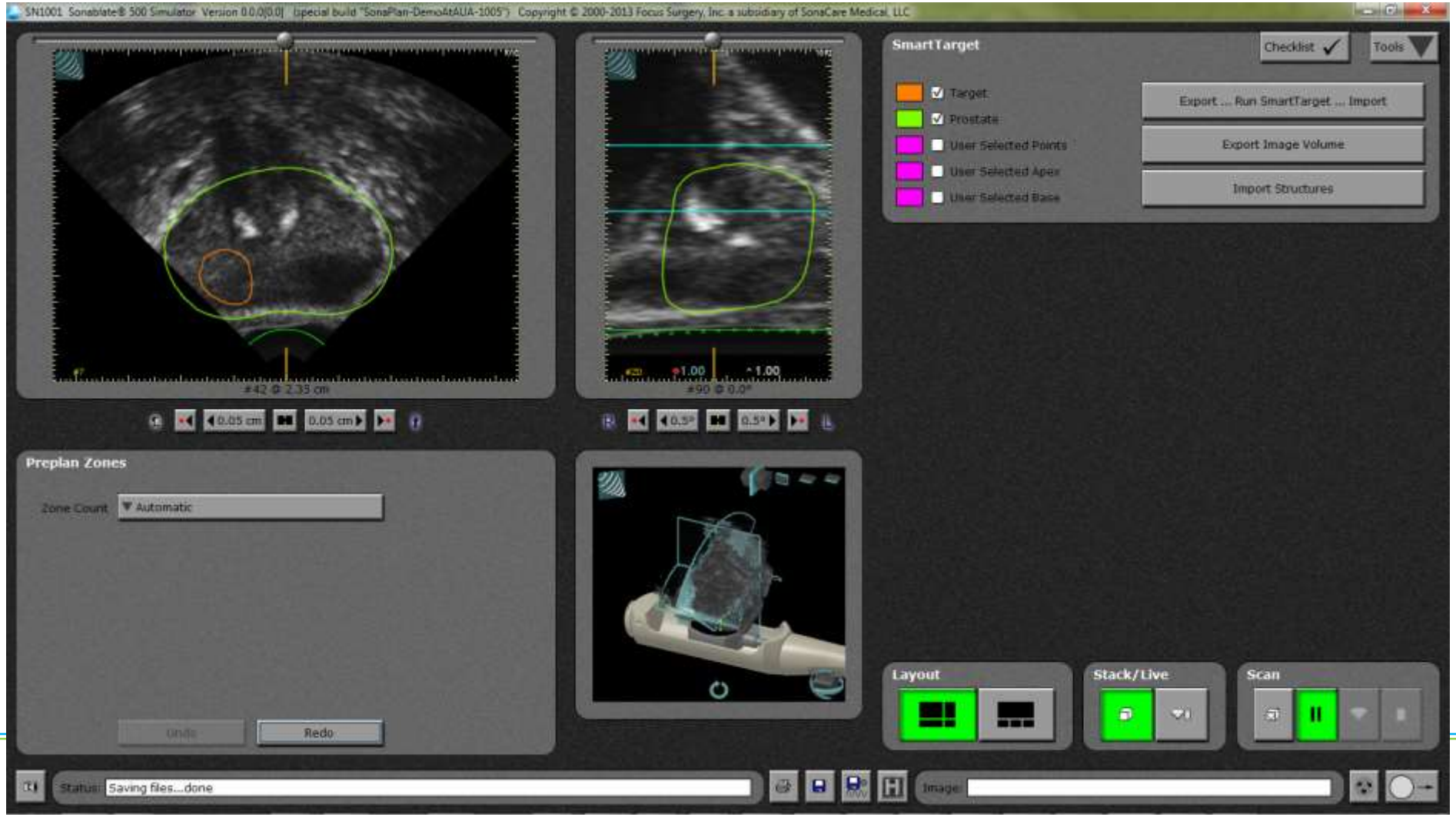


IMAGE FUSION

Sonaplan

View of target on planning screen

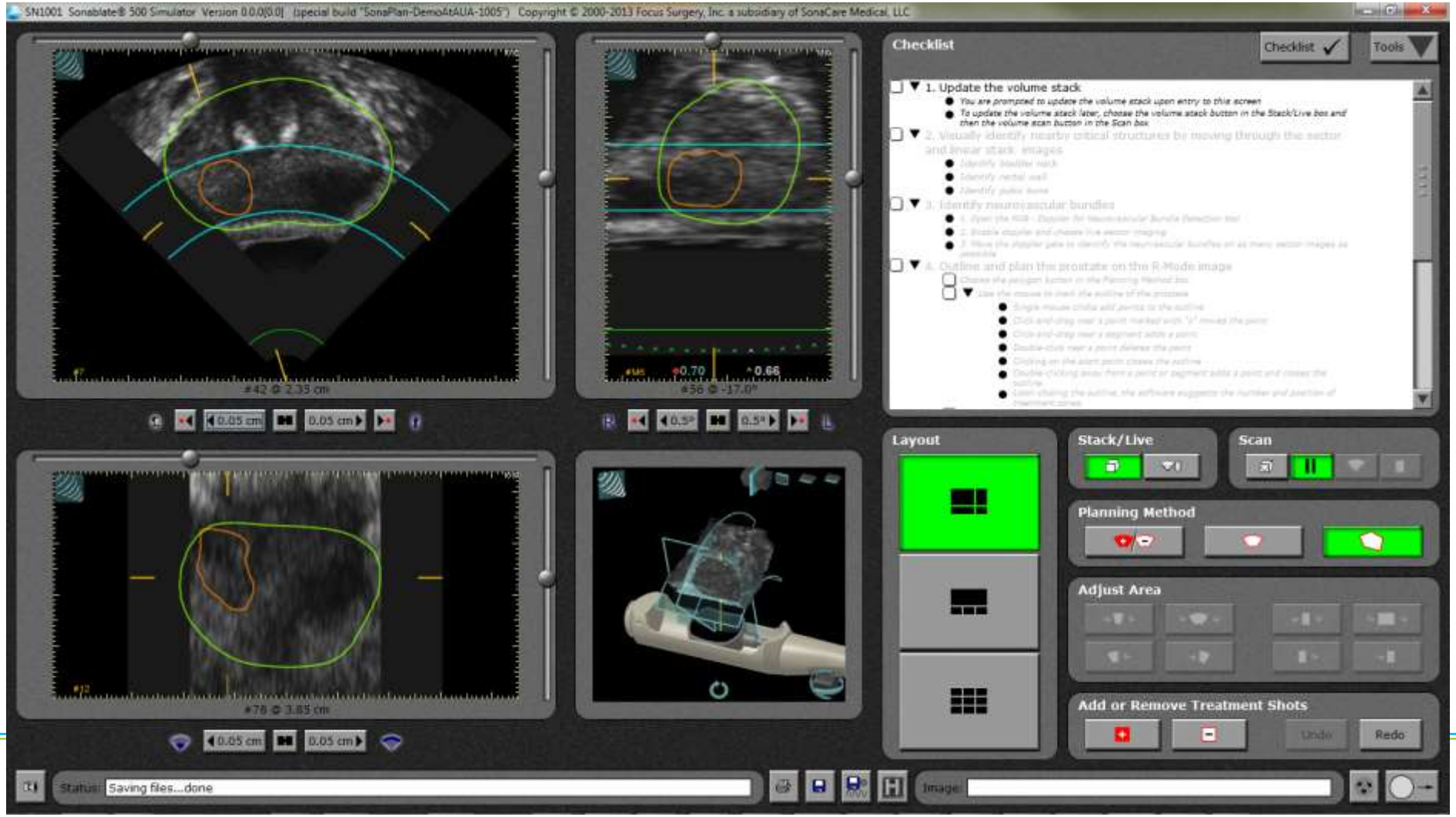


IMAGE FUSION

Sonaplan

Outline with desired margin

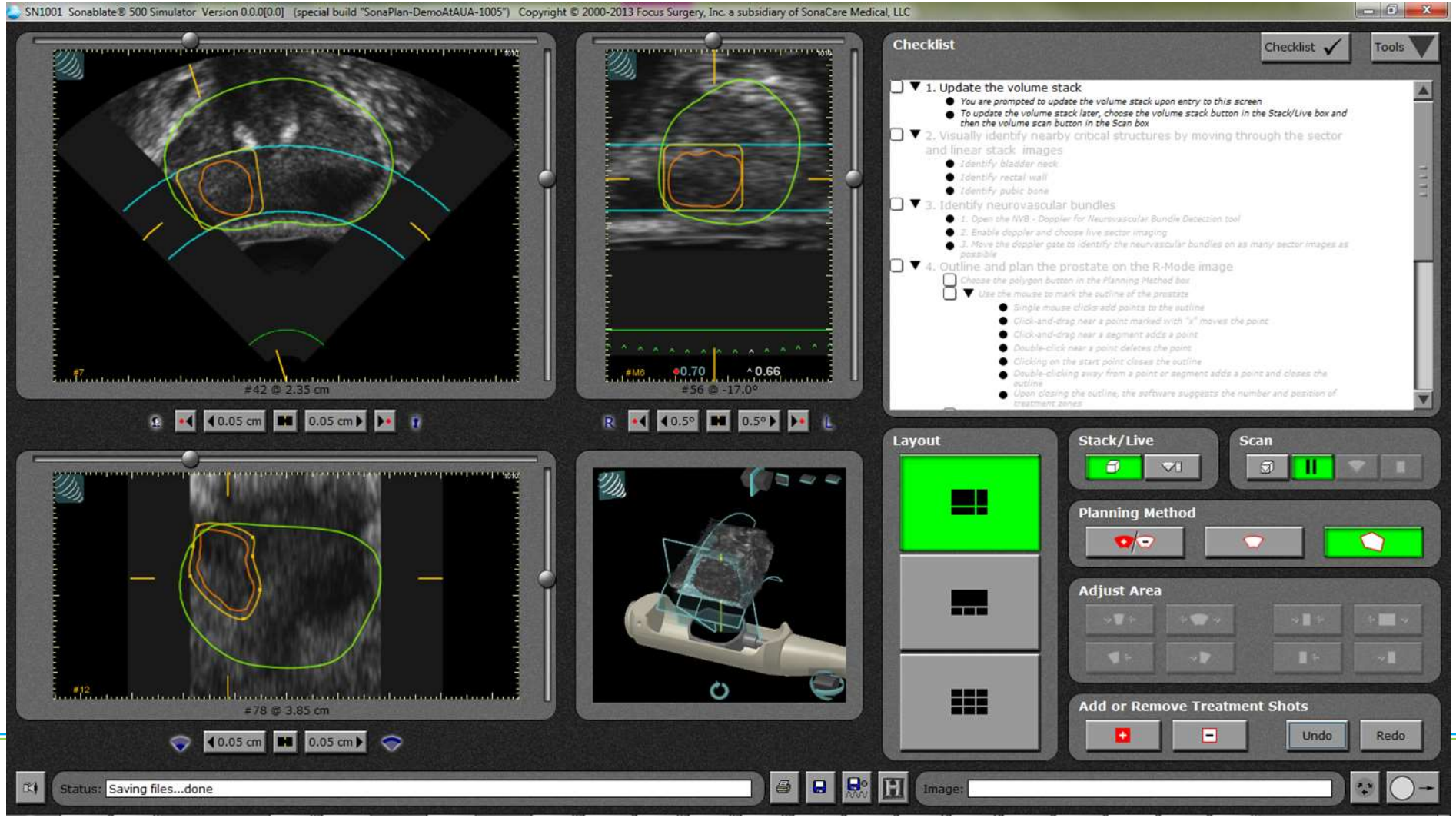
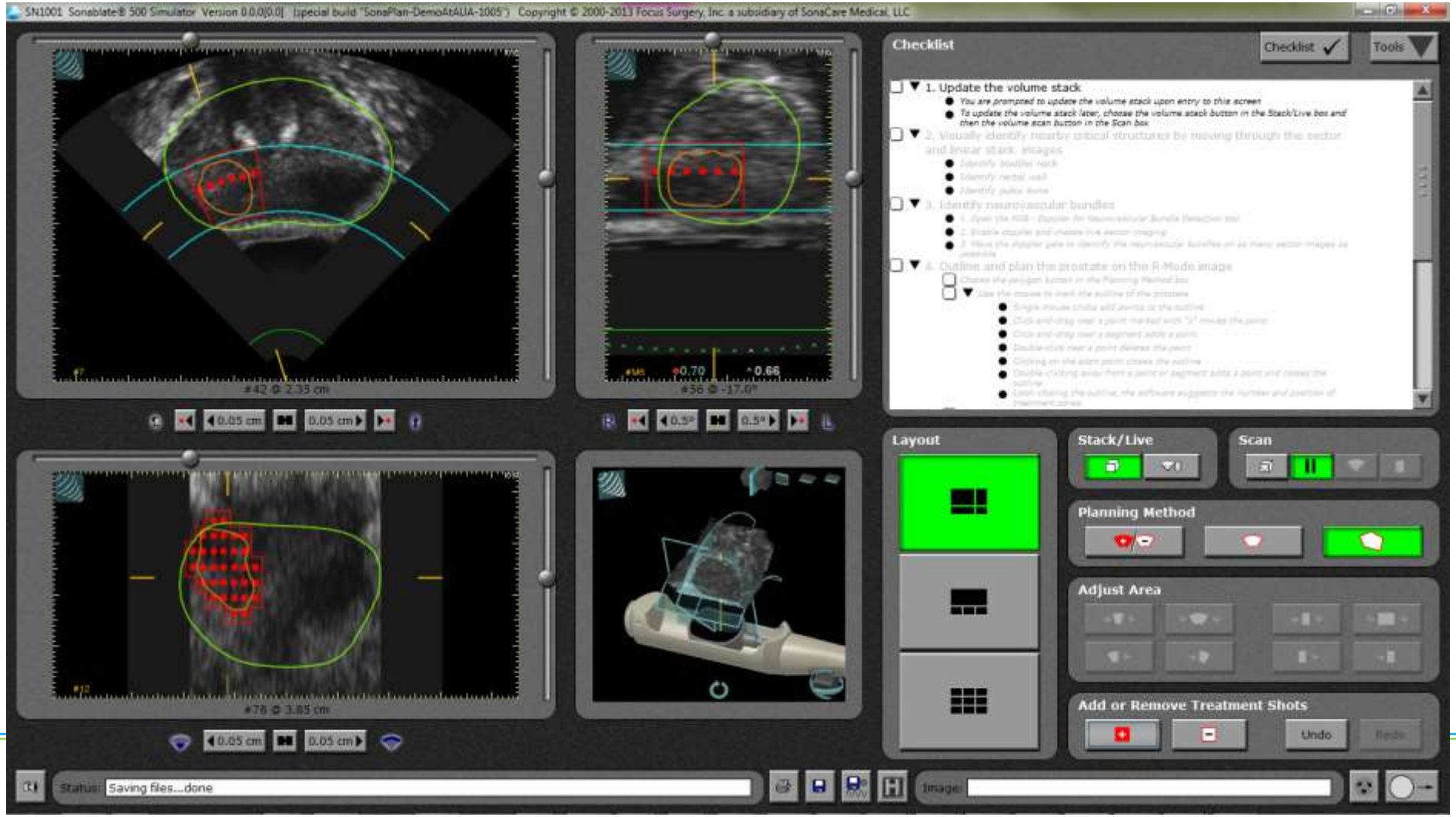


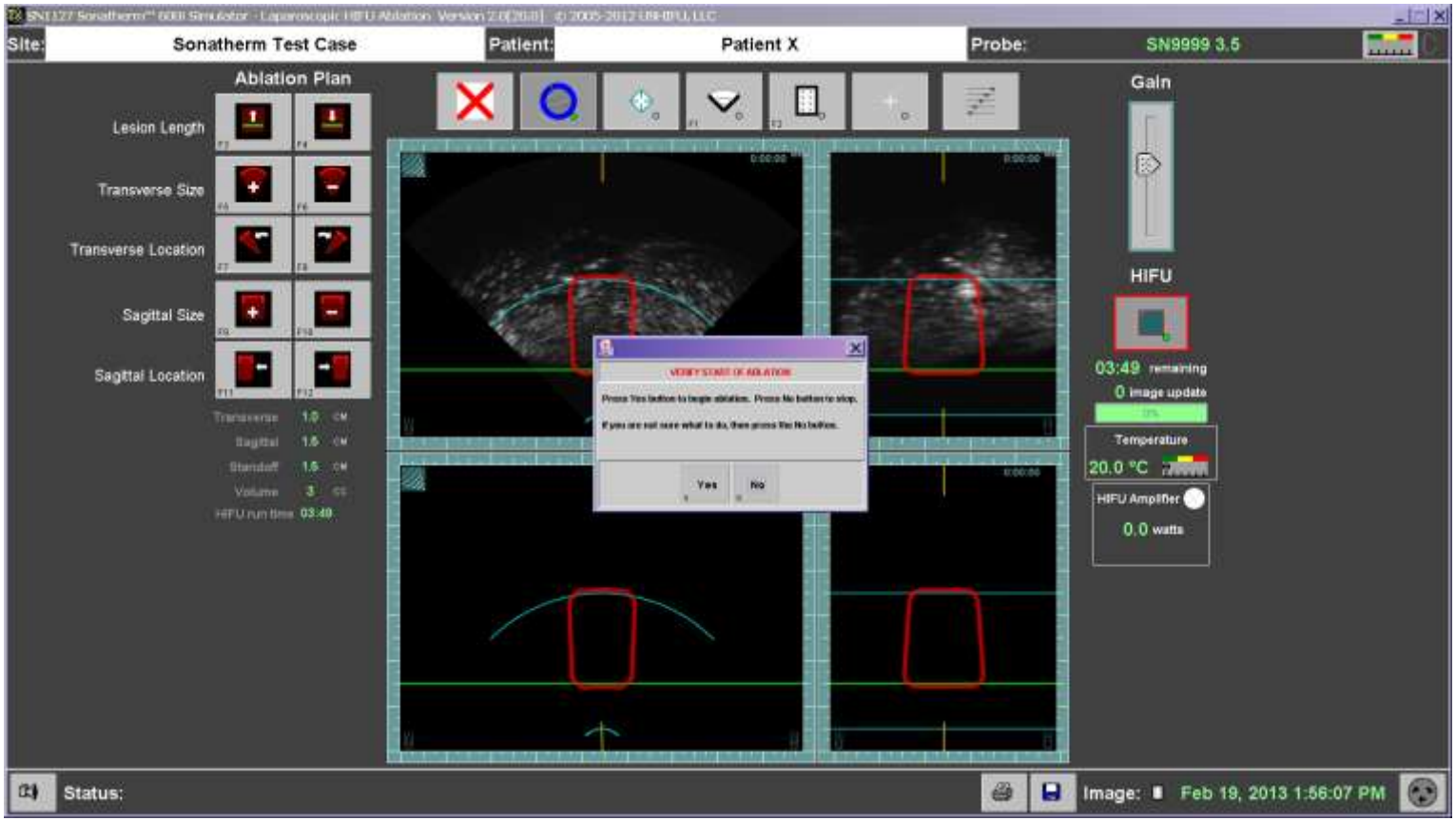
IMAGE FUSION

Sonaplan

Complete treatment plan



US-based
Planning



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Role of US

HIFU Ablation

- Image Fusion for localization and targeting
- Treatment Planning
- **Treatment Delivery**
- Temperature Monitoring
- Tissue Typing

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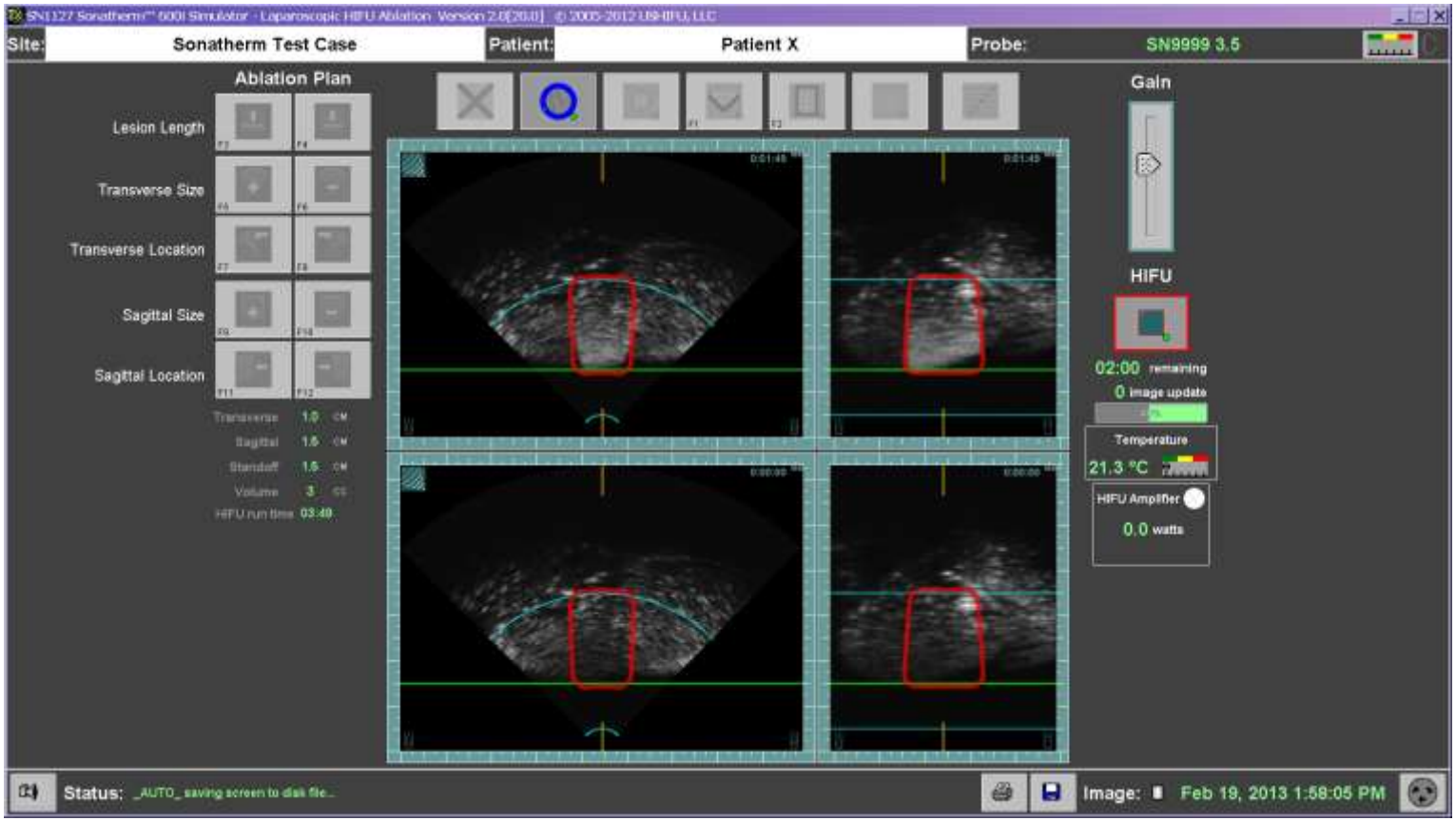
Treatment

Image update during HIFU



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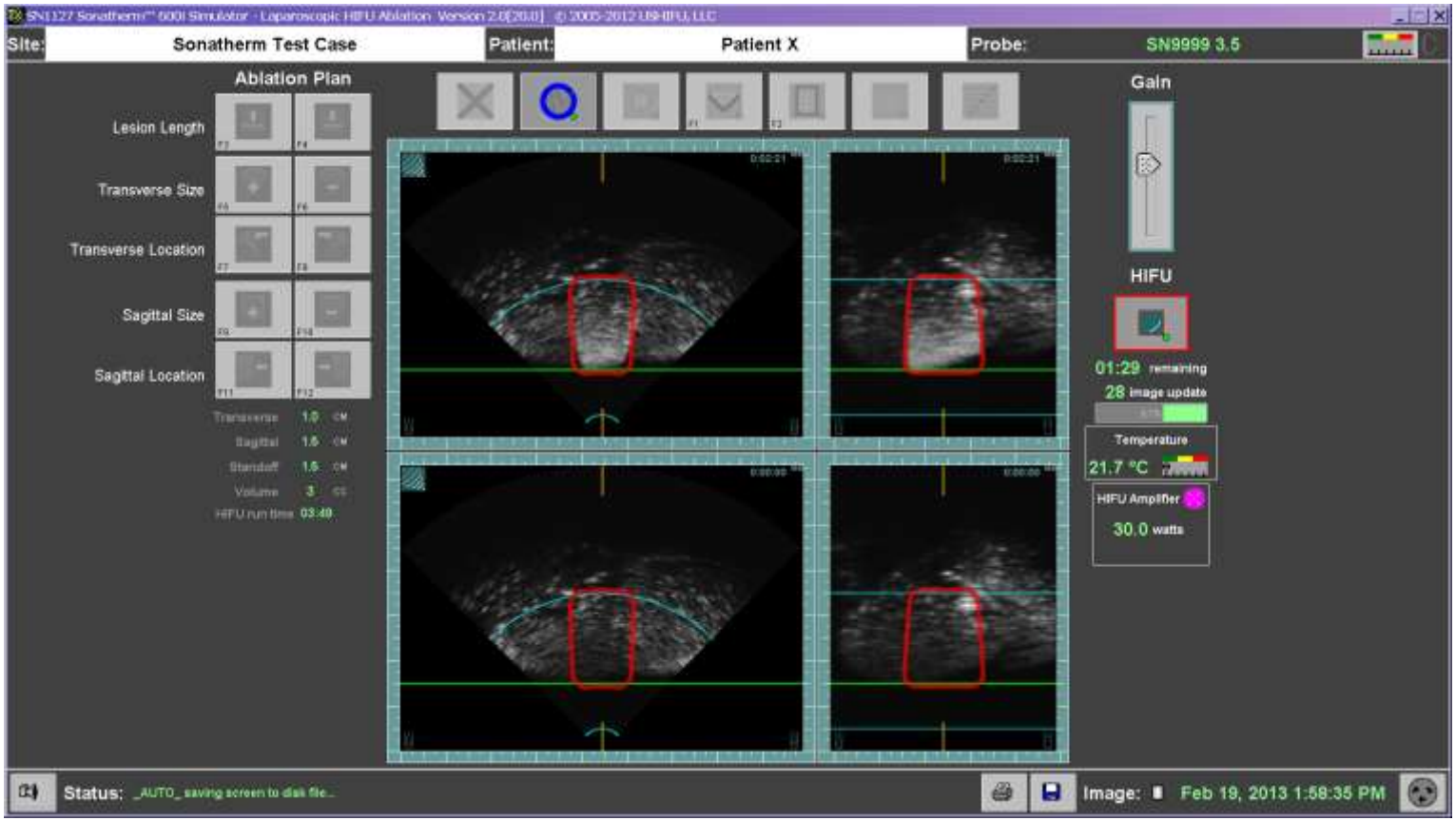
Treatment

Image update during HIFU



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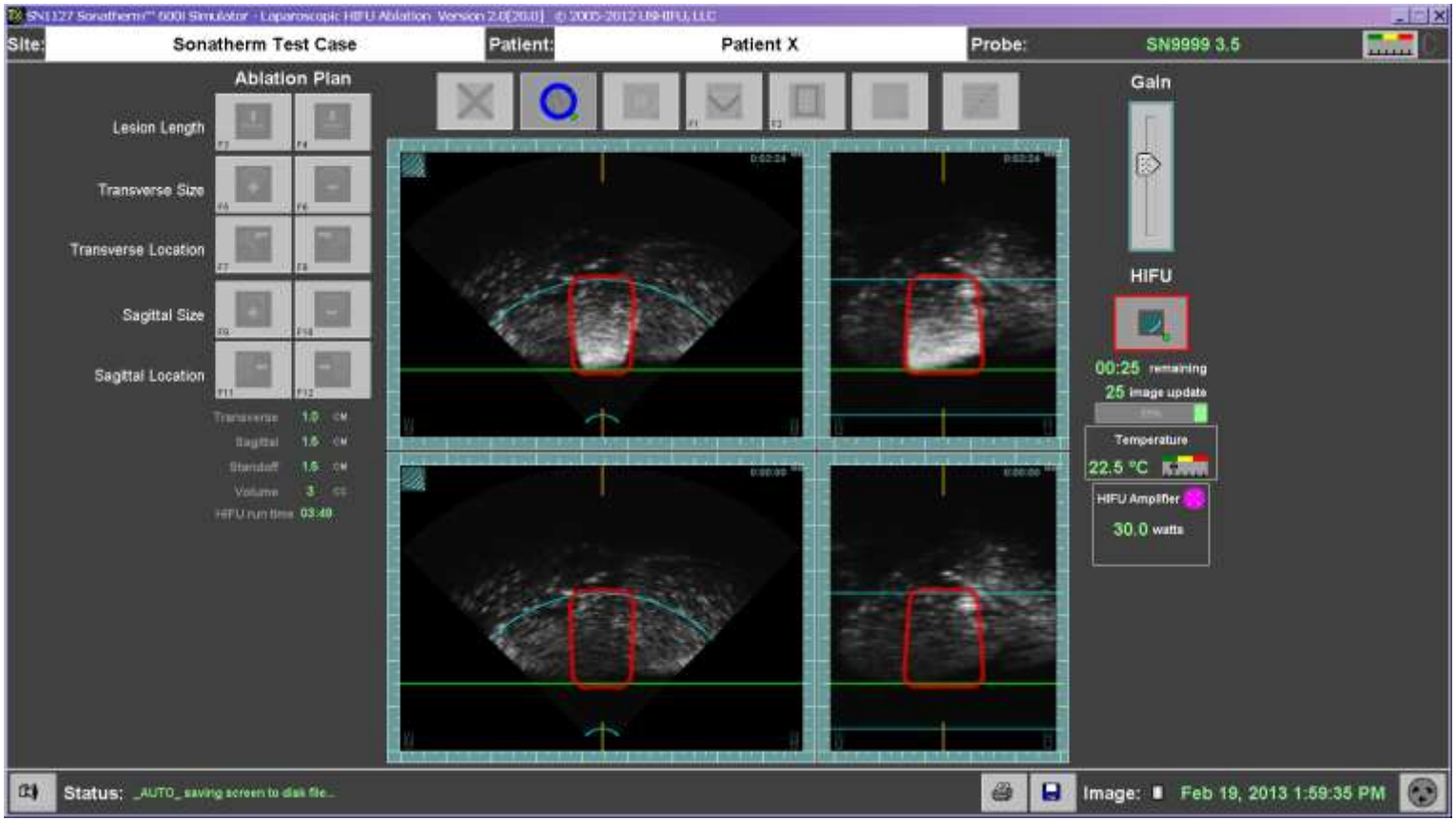
Treatment

Image update during HIFU



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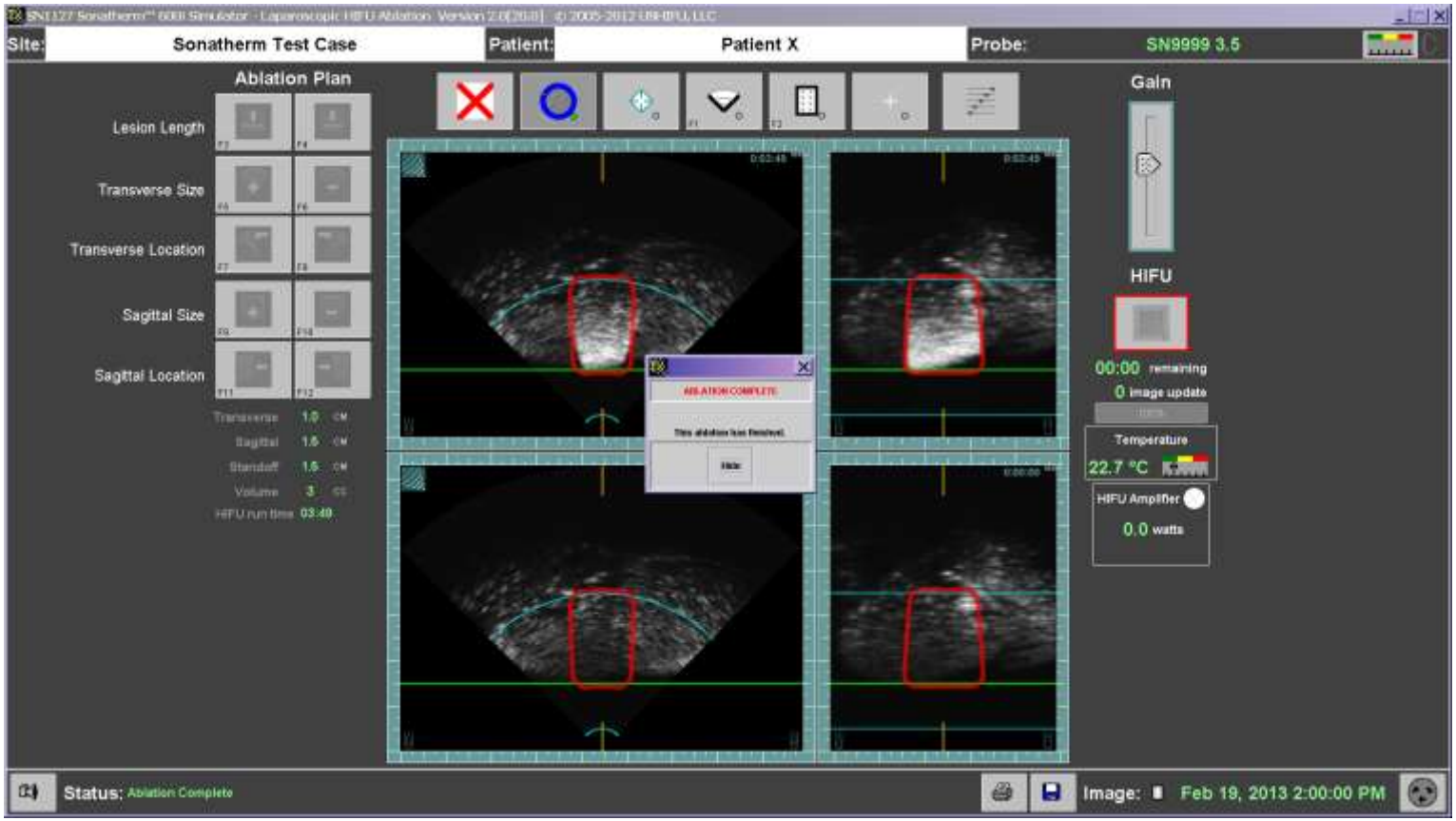
Treatment

Ablation Complete



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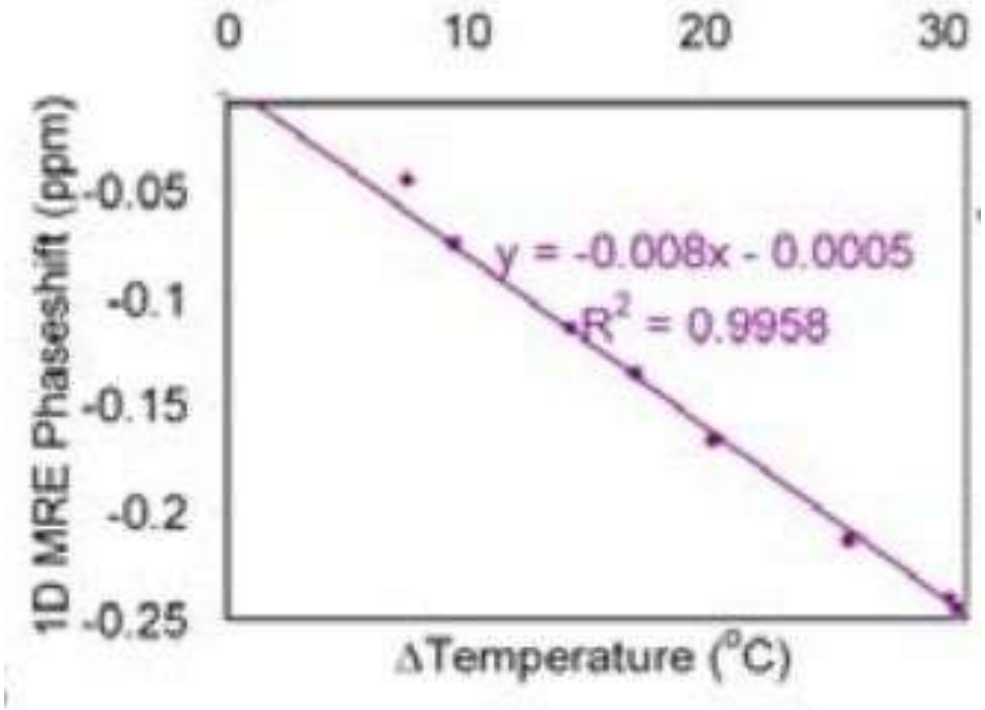
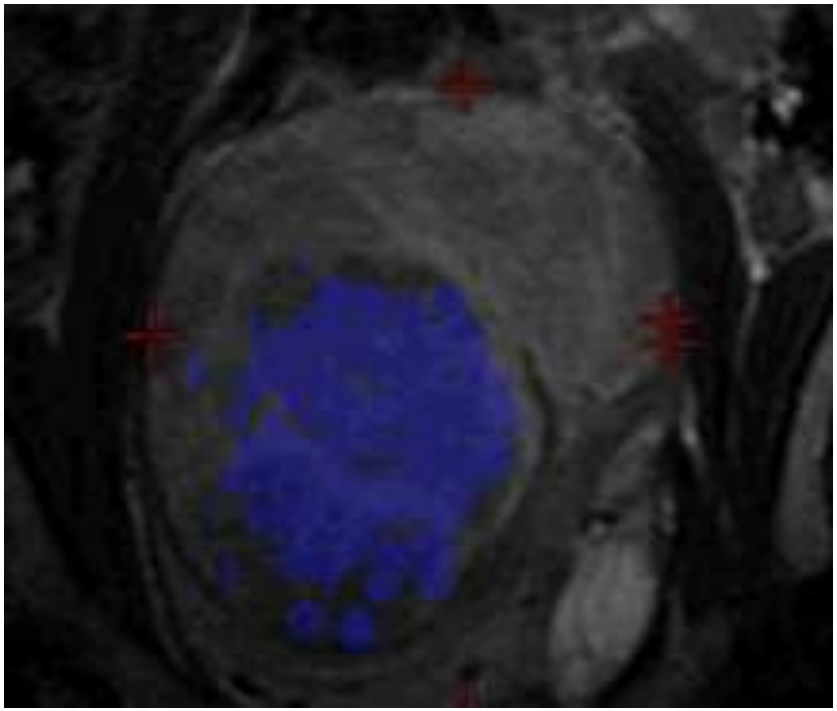
Role of US

HIFU Ablation

- Image Fusion for localization and targeting
- Treatment Planning
- Treatment Delivery
- **Temperature Monitoring**
- Tissue Typing

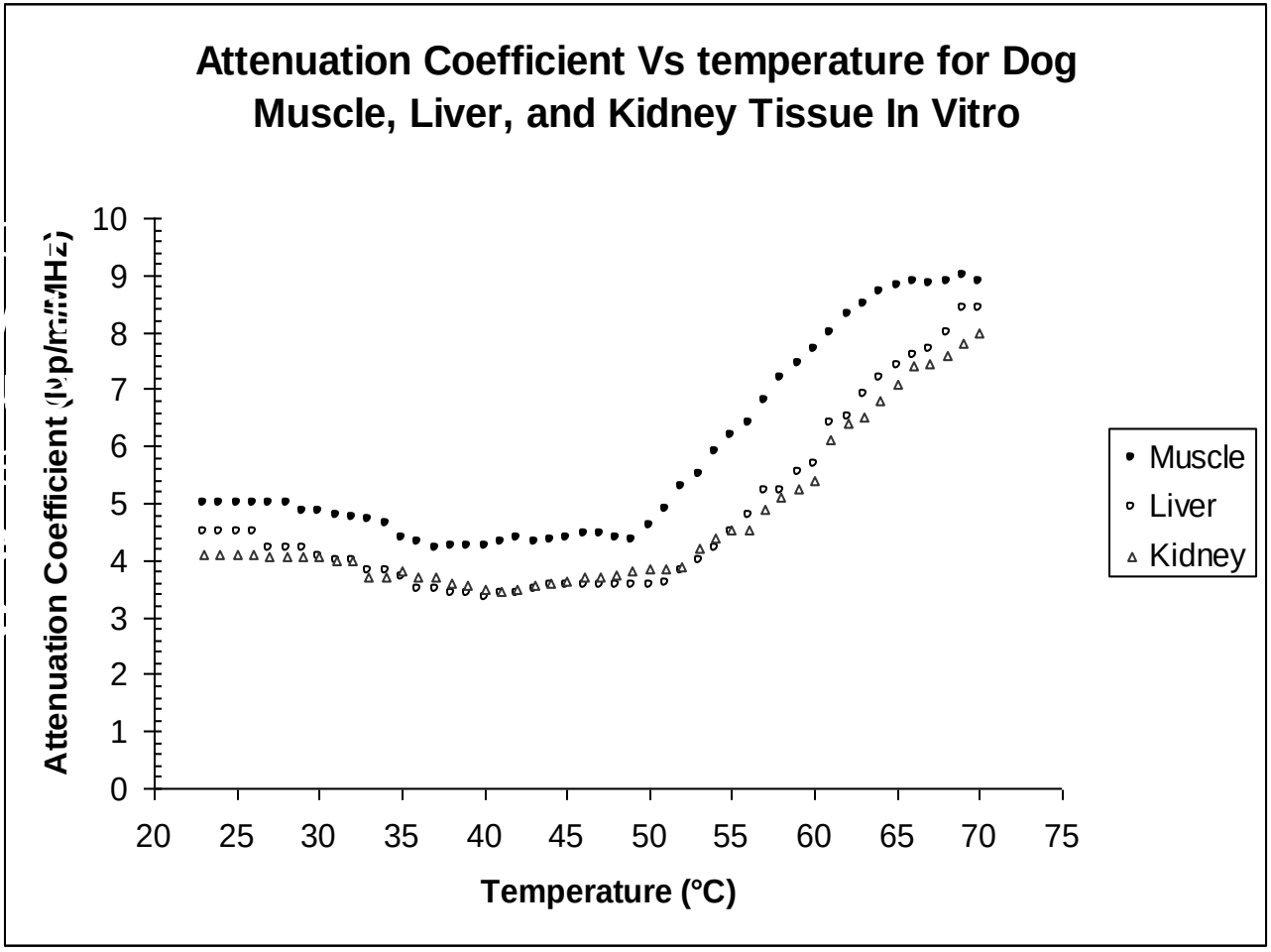
MR thermometry for continuous temperature feedback





Temperature Change Monitoring
(T C M)

INCREASED ATTENUATION DUE TO TISSUE TEMPERATURE ELEVATION



C. DAMIANOU & N.T. SANGHVI – 1994 JASA – 102, 1997

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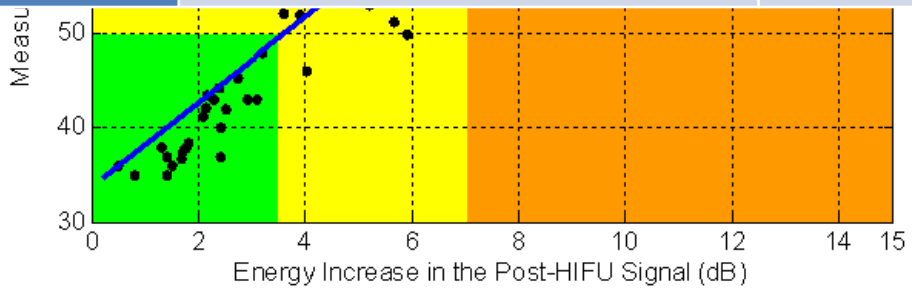
Temperature Change Monitoring (T C M)

- Spectral analysis on RF backscattered (pulse-echo) **ultrasound** signals acquired before and immediately following HIFU exposure
- Analysis generates energy spectra of signals
- Difference used as estimator for changes in tissue temperature

TCM Zones	Average Temperature Difference between Calculated (linear fitted) and Measured (°C)	Standard Deviation Difference between Calculated (linear fitted) and Measured (°C)
Green	2.8	2.0
Yellow	5.2	4.7
Orange	7.7	6.7



*Patented

Not Cleared For Use

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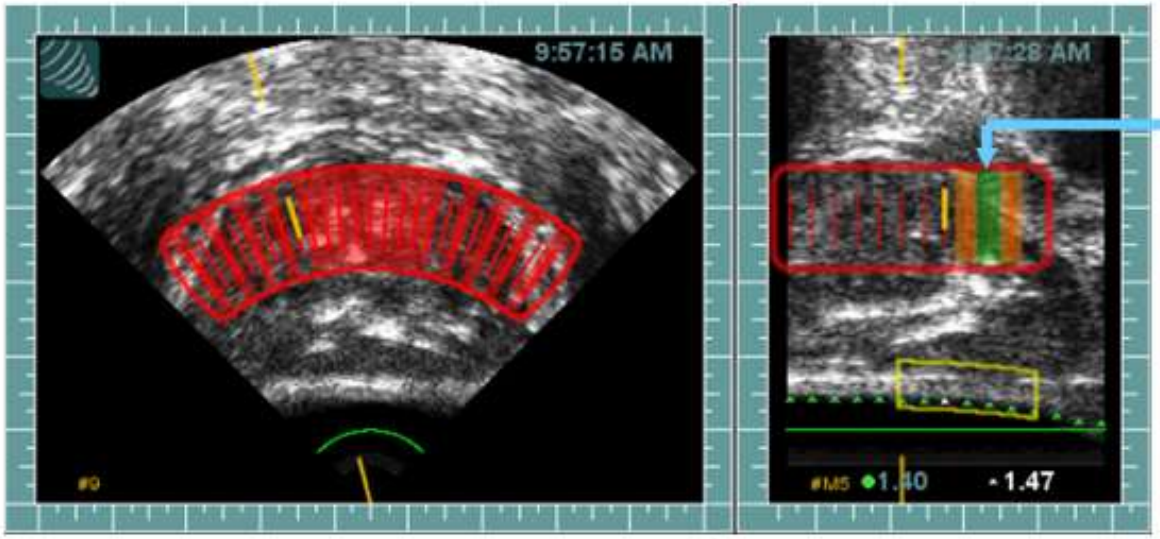
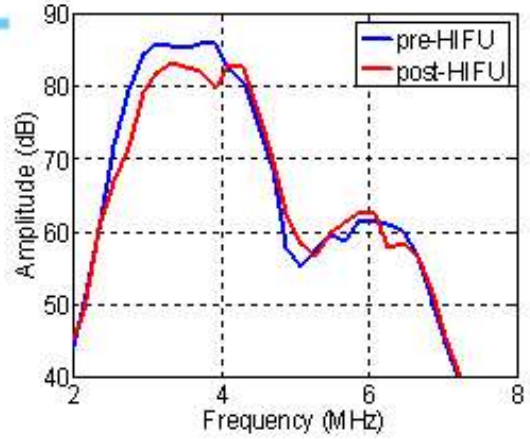
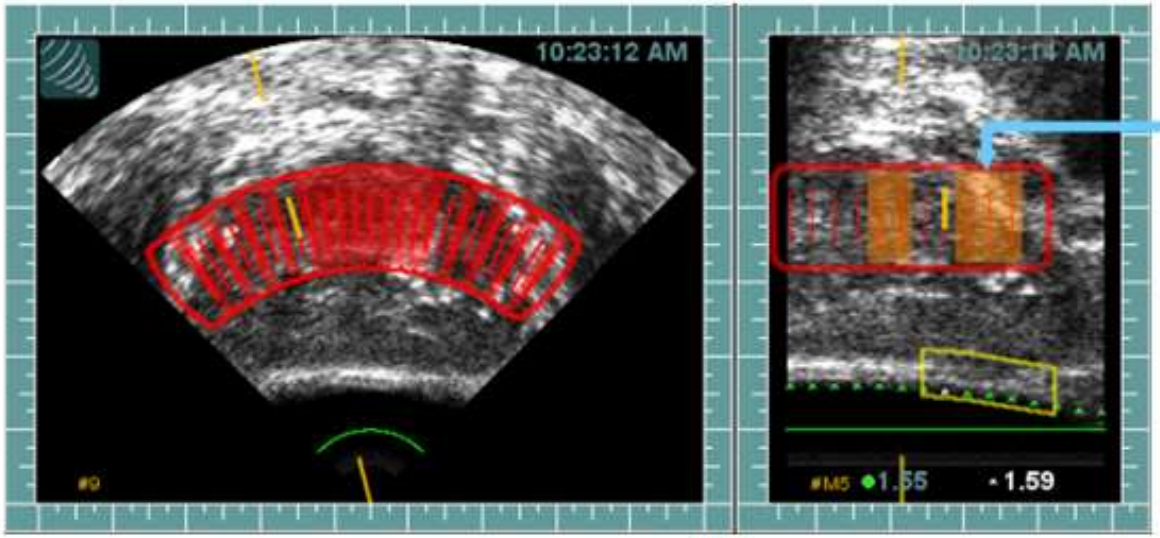
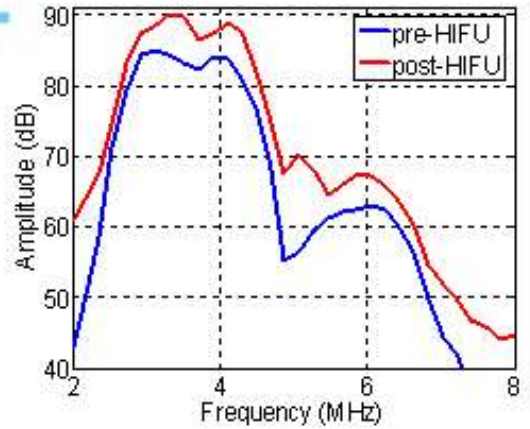
Temperature Change Monitoring (T C M)





(a)



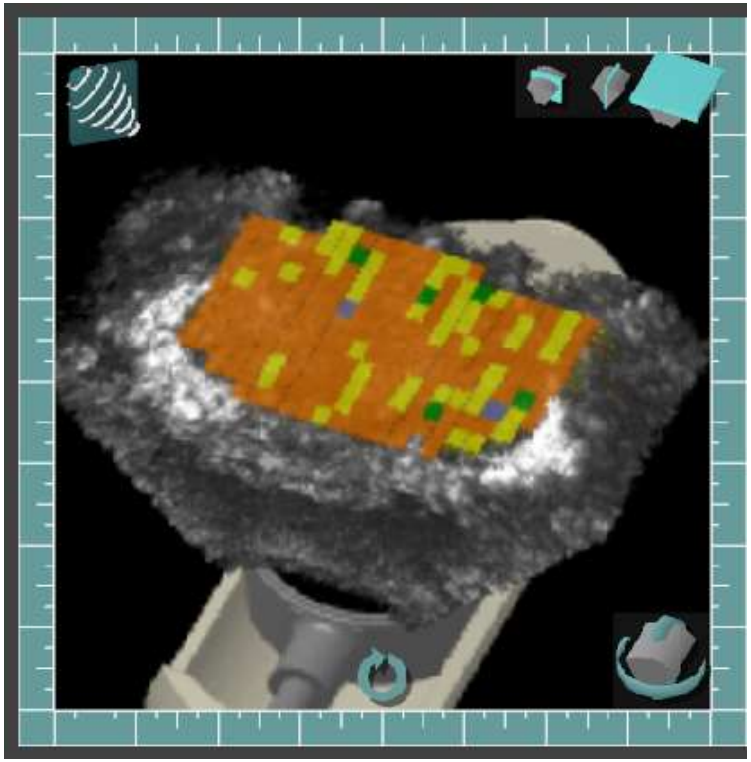


(b)

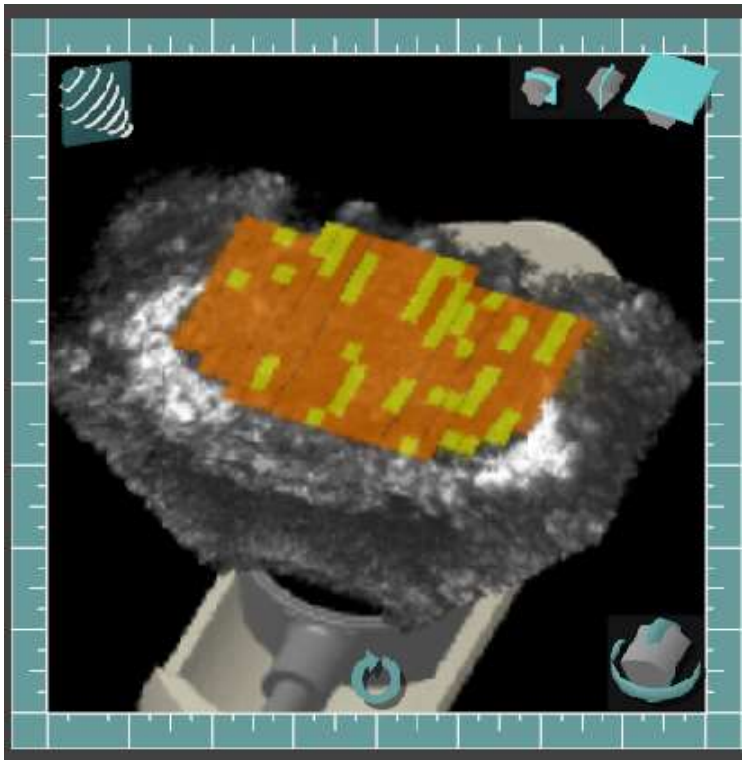
Temperature Change Monitoring (T C M)

Clinical Example of Second “Pass“ with HIFU

Replacing “Greens“ with “Yellow/Orange“



First Pass



Second Pass

Courtesy – Dr. G. M. Suarez, MD

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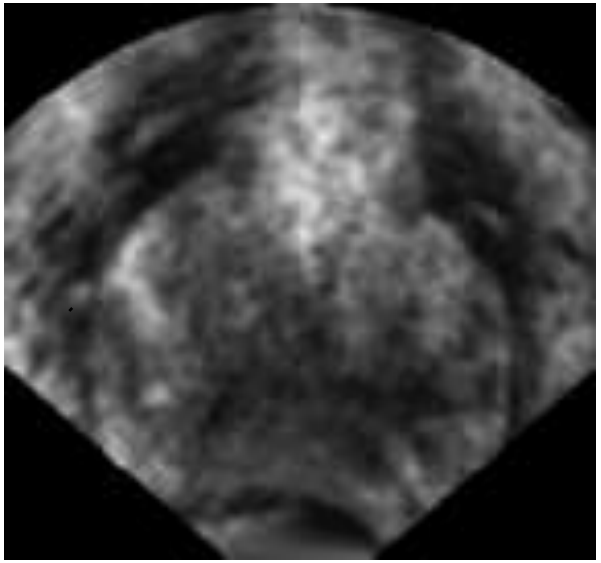
Role of US

HIFU Ablation

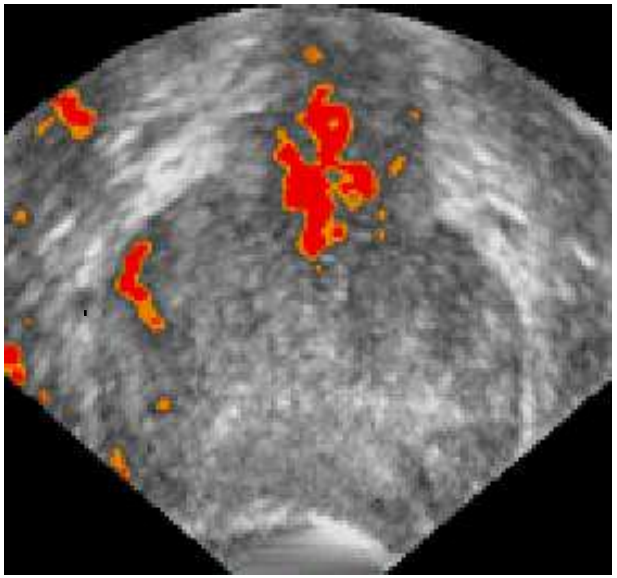
- Treatment Planning
- Image Fusion for localization and targeting
- Treatment Delivery
- Temperature Monitoring
- **Tissue Typing**

"Well, yes, we could fix it in Photoshop, but your arm would still be broken."

Use of Ultrasound Pulse-Echo (RF) data for Quantitative Features Analysis



Parametric Image

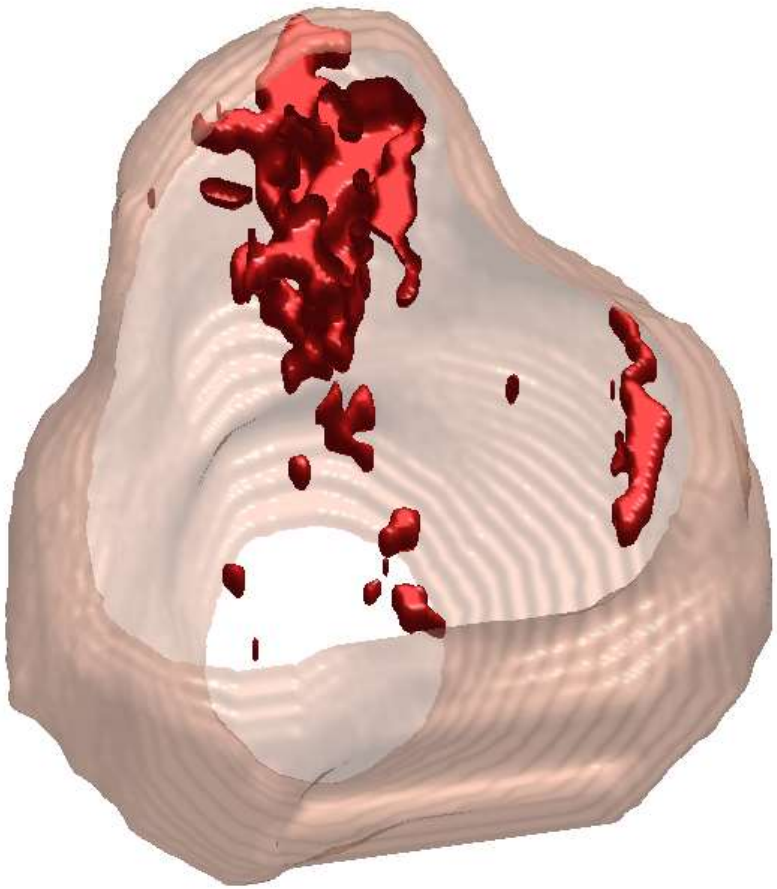


Display of PCa in Real Time

Histology of the same prostate

Anterior Tumor: 3-D Image

(base view)



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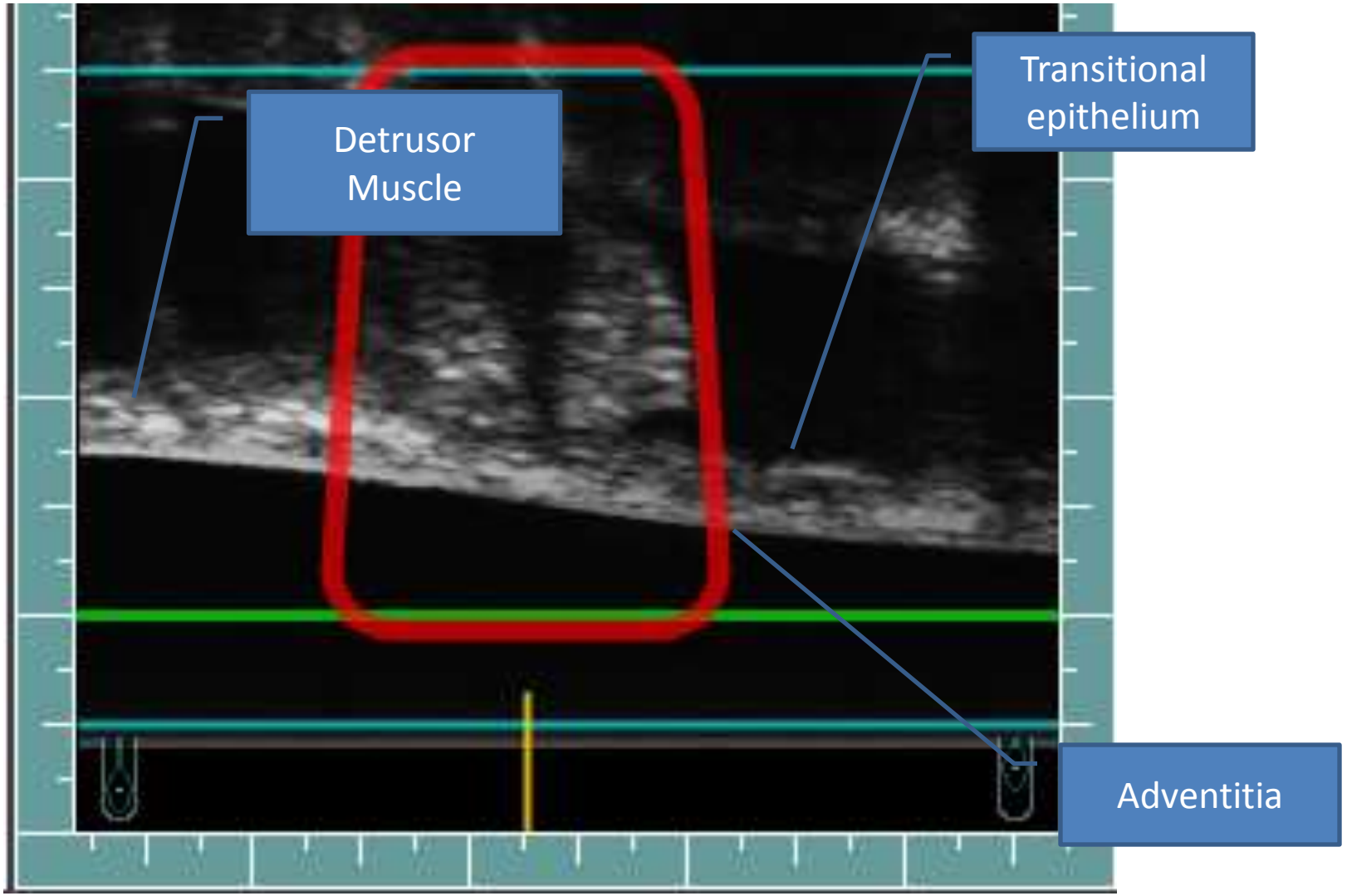
Use of Ultrasound for Anatomic Feature Analysis



USgFUS

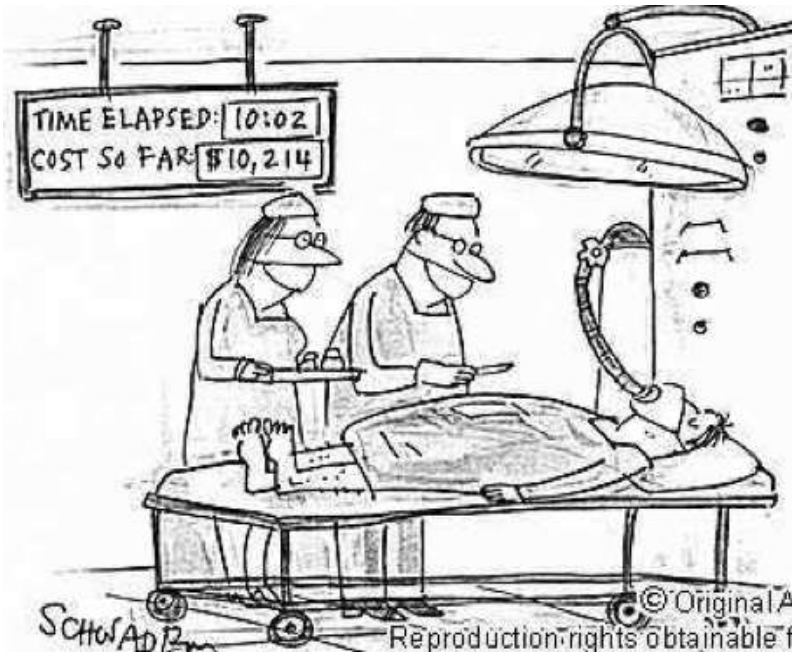
Complementary to Existing Approaches

"Judging by your X-rays, I'd say you've been exposed to too much radiation."

"Hi, I'll be performing your surgery tomorrow."

Final Thoughts

Cost of Health Care



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