

TG 147: QA for non-radiographic localization and positioning systems

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Quality assurance for nonradiographic radiotherapy localization and positioning systems: Report of Task Group 147

Medical Physics, Vol. 39, No. 4, April 2012



Objectives

- Be able to identify types of localization systems addressed in TG147
- Be able to list several tests that should be performed daily, monthly, and annually on these localization systems.
- Be able to describe a localization accuracy test
- Now where to look for resources and references to set up a QA program for localization.

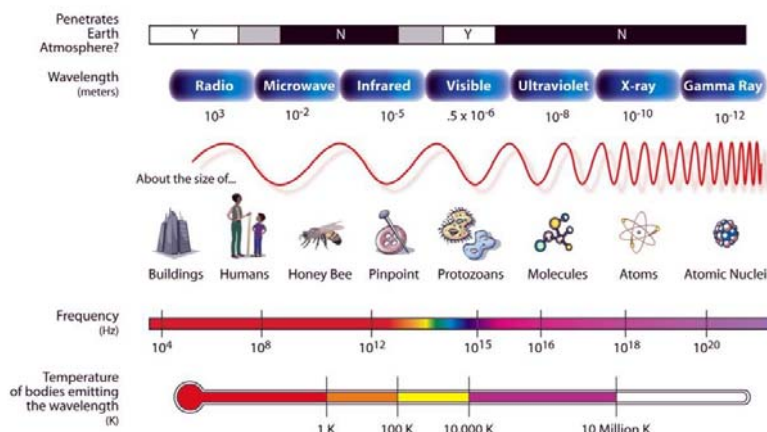


Radiotherapy Localization Systems

- Ultrasound: Soft tissue alignment – mostly prostate
- Orthogonal MV x-rays: Bony anatomy or implanted markers
- Orthogonal kV x-rays: Bony anatomy or implanted markers
- Cone-beam CT:
- MV CT:
- In room CT:
- **Non-Radiographic: Video, RF, and laser alignment systems**



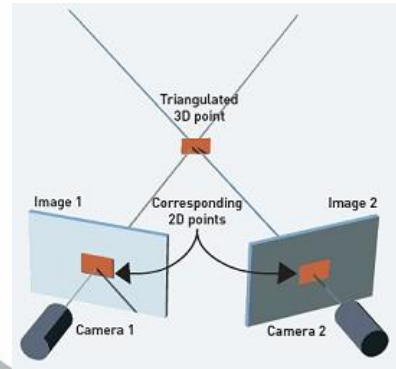
THE ELECTROMAGNETIC SPECTRUM



Pros and Cons of this type of system

- Pro:
 - Very quick response
 - Can be used for Tracking and/or Gating (quick response, etc.)
 - No additional Dose to patient
- Cons:
 - Not typically internal anatomy
 - Use of Surrogates
 - Possible interference (noise) or in the room or blocked views

Stereo Correspondence



Specifications

- FOV & Volume of View
- Update Rate / Refresh Rate
- Camera accuracy

Camera Based Systems

Optical Tracking Infrared and Visible light

- Optical tracking is a means of determining in *real-time* the position of an object by tracking the positions of either active or passive infrared markers attached to the object. The position of the point of reflection is determined using a camera system.



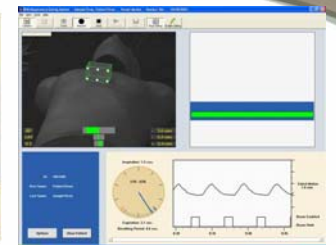
Active markers



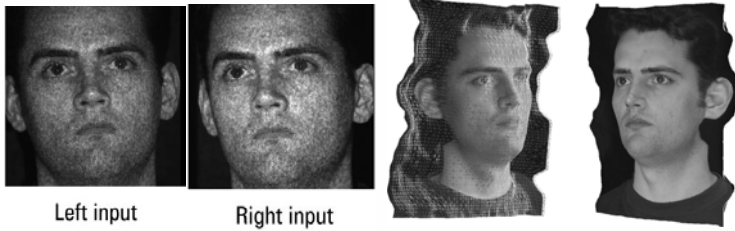
Passive markers



Camera



Stereo Correspondence (Image Feature Correspondence)



- Use of projection of patterned or structured light onto the scene.

Images from: Siebert et al, "Human body 3D imaging by speckle texture projection photogrammetry," Sensor Review 20:3, p 218, 2000.

Patterned Light Projection Stereo Example VisionRT Ltd., ALIGNRT

- RT Vision sensor system arranged in pods, each is capable of stereo "vision".



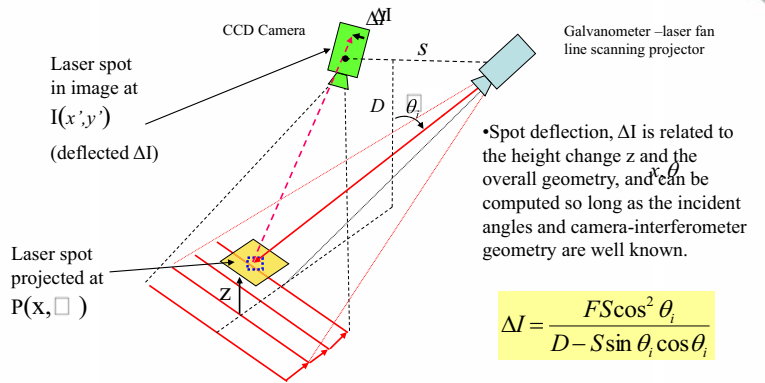
- A pod contains 1 stereo pair of cameras and a speckle pattern projector.

- A texture camera, white flash, and speckle flash projector are also present.



Laser Systems

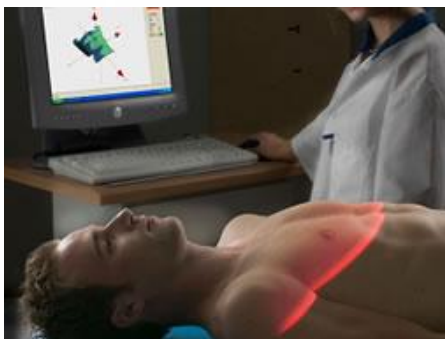
Laser Line Projection Methods



Moore et al, "Opto-electronic sensing of body surface topology changes during radiotherapy for rectal cancer," IROBP 56:1 p248, 2005.

C-Rad Sentinel™

LAP Galaxy



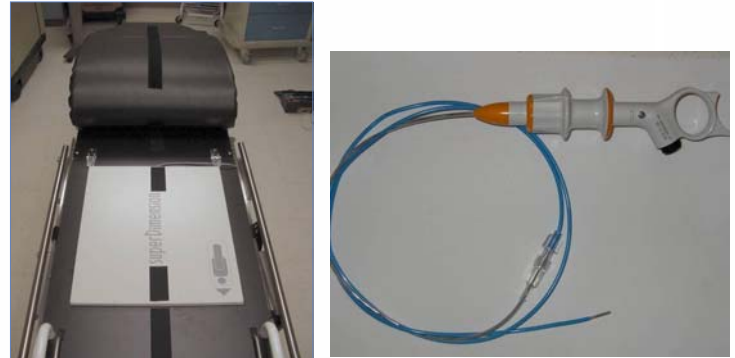
RF Systems

Ascension Technology



Ascension Technology products use RF sensors to track the position and orientation in real-time of instruments including ultrasound probes. Tracking accuracy is unaffected by the nearby presence of conductive metals including aluminum, titanium and stainless steel 300

SuperDimension Bronchoscopy



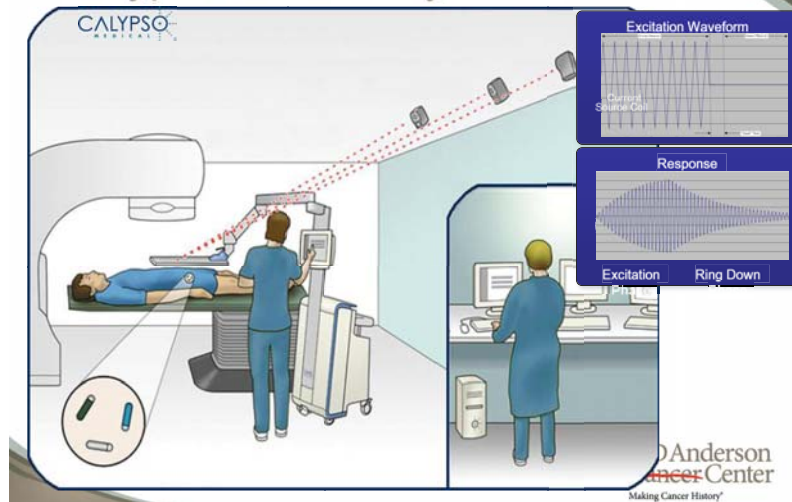
Micropos Medical



TO USE RAYPILOT® TOGETHER WITH IGRT



Calypso Medical System



QA of Localization System

Installation

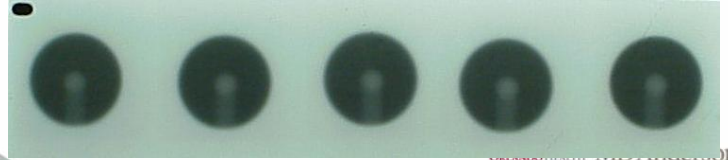
- Machine isocenter and in-room laser accuracy (per customer ATP / TG40)
- Linac interference with localization system
- Localization system interference Linac (and collision space)
- Establish Localization Volume (Volume of View)
- Establish Tracking volume (VOV for Tracking)
- System Performance

Installation

- Machine isocenter and in-room laser accuracy (per customer ATP / TG40)
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Installation

- Recommend the use of a Winston/Lutz film process for establishing machine isocenter / laser QA documentation prior to installation of add-on equipment



Installation

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Installation

- Machine isocenter and in-room laser accuracy (per customer ATP / TG40)
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- Localization system interference Linac (and collision space)
- Establish Localization Volume (Field of View)
- Establish Tracking volume (Field of View for Tracking)
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System Performance

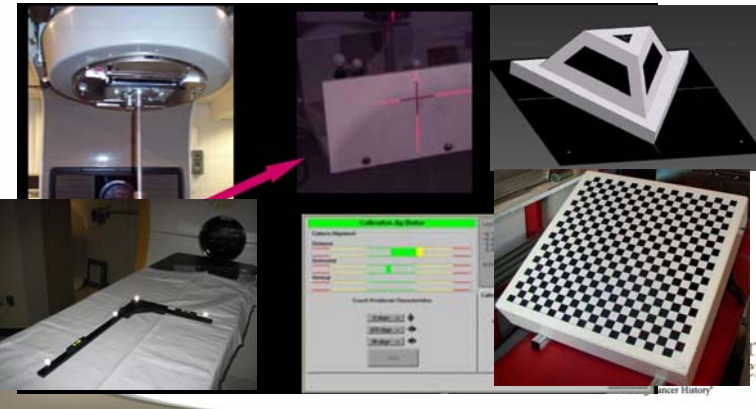
- Calibration Procedures
- Overall Localization Accuracy (End to End Test)
- System Drift
- Reproducibility
- Tracking Accuracy
- Response Time (latency)

System Performance

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■ Calibration

All peripheral devices for localization will be correlated to the machine isocenter: Vendor typically supplies phantoms for this.



■ System Performance

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■ End to End test

CT scan - Treatment plan - Data Transfer - Localize - Portal films of Radiographic Target - Analysis

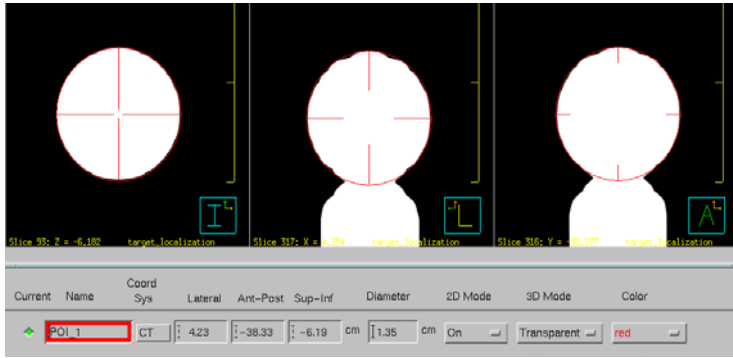
Phantoms: Any phantom that had a radiographic target

■ Example 1: Infrared Camera End to End test

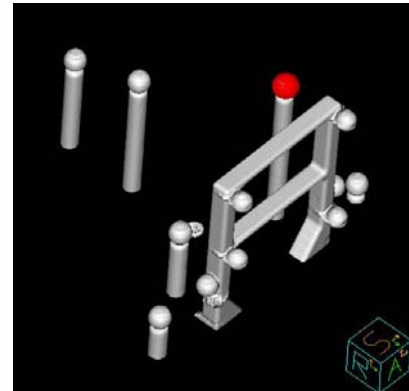
■ Target Localization Accuracy and Overall Positional Accuracy (End to End Test)



Localization on Treatment Planning System



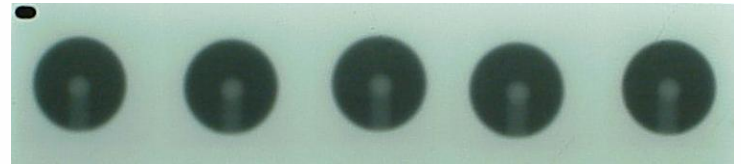
Localization on Treatment Planning System



Setup of "Patient" under Optical Guidance



Resulting Film: Measure of Total Accuracy of System



Results:

Z: 0.49 mm to T

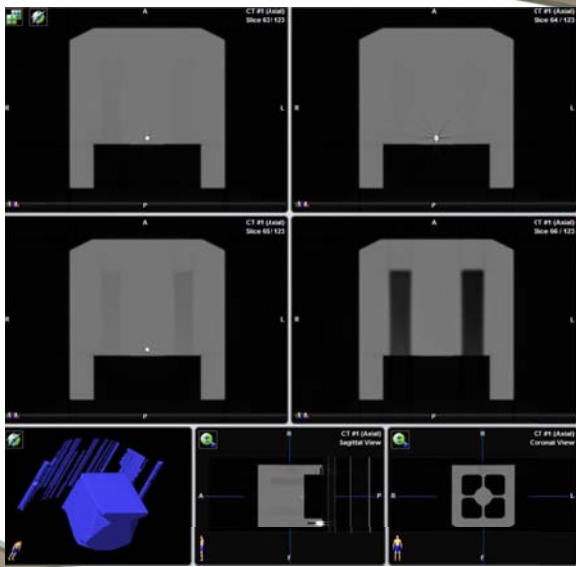
X: 0.35 mm to A

Y: 0.50 mm High

Overall error = 0.789mm

Example 2: Calypso™ Phantom End to end test

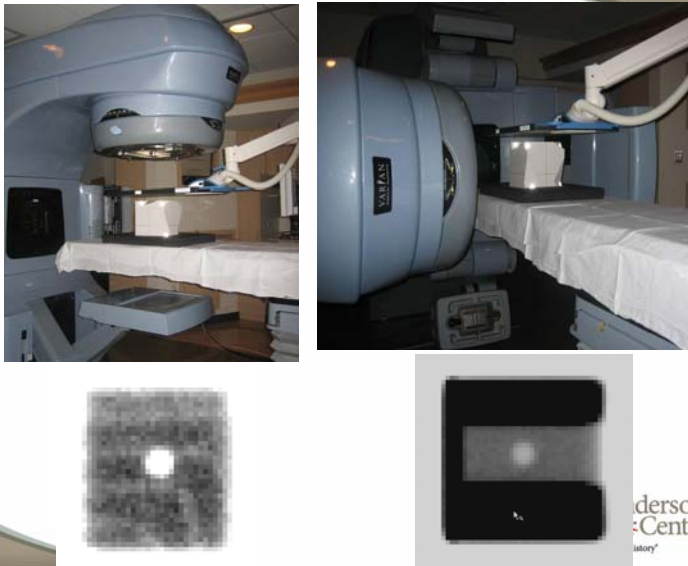




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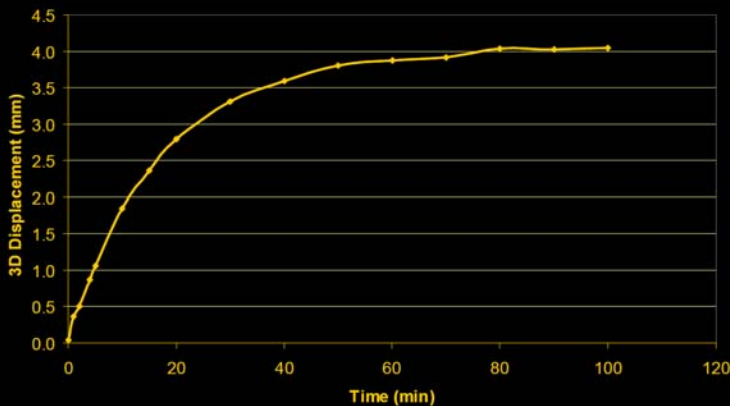
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System Performance

- Calibration Procedures
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- Response Time (latency)

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Thermal Drift



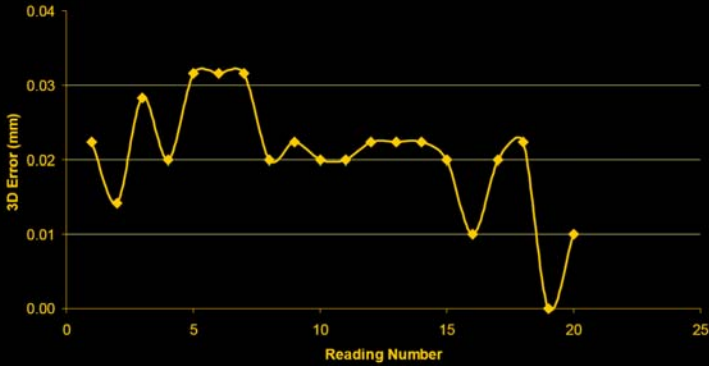
Meeks RSNA 2002

System Performance

- Calibration Procedures
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Reproducibility



Meeks RSNA 2002

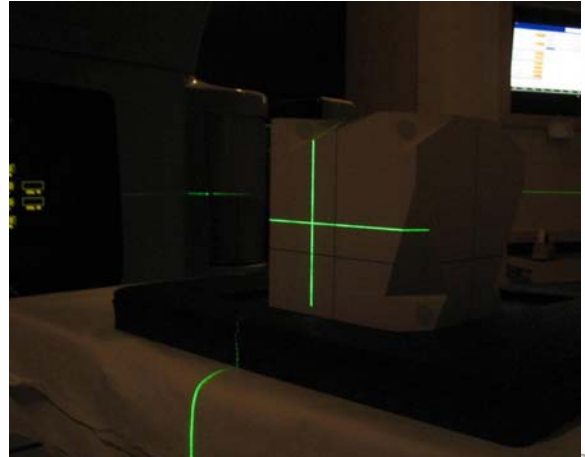
System Performance

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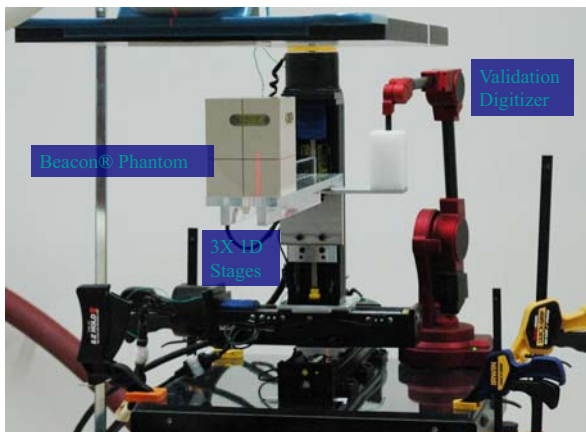
Tracking Accuracy



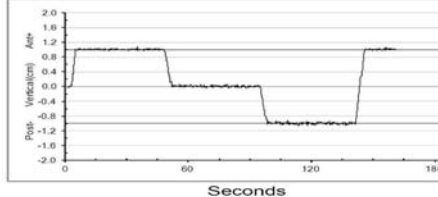
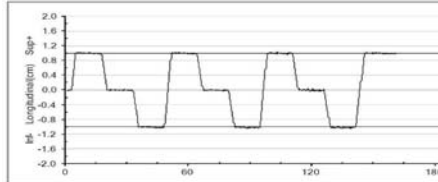
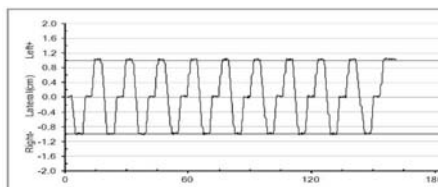
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Phantom



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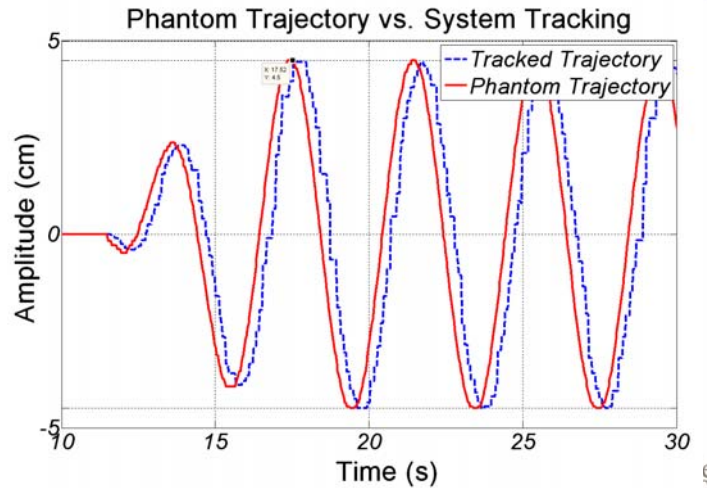
Tracking accuracy measured by a 4D motion phantom

Programmed to move locations up to + 1cm to - 1cm for set second intervals

Tracking report reveals the tracking accuracy over this range.

System Performance

- Calibration Procedures
- Overall Localization Accuracy (End to End Test)
- System Drift
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Timeline

- A Work in progress
- Preliminary report to be submitted end of September
- Depending on review process, a publication will follow (late 2009/early 2010?)

Thank-you.

Which of these waves has the Highest Frequency?

- 20% 1. kV X-Ray
- 20% 2. Ultrasound
- 20% 3. Video Tracking system
- 20% 4. Infrared Camera System
- 20% 5. Radiofrequency Tracking

From TG147- How frequently should localization accuracy be checked?

- 20% 1. Before each patient
- 20% 2. Daily
- 20% 3. Weekly
- 20% 4. Monthly
- 20% 5. Yearly

■ From TG147: What is the primary test used to check the localization

- 20% 1. Thermal Drift
- 20% 2. End to End test
- 20% 3. Star Shots
- 20% 4. Calibration test
- 20% 5. Latency Test

■ The introduction of a Speckle pattern is used to improve SNR for which system?

- 20% 1. RF systems
- 20% 2. X-ray systems
- 20% 3. Visible light system
- 20% 4. Infrared Marker systems
- 20% 5. Laser scanning system

■ Which of the following is NOT true of camera or RF localization systems?

- 20% 1. Near Real-Time
- 20% 2. Can be used for Gating
- 20% 3. Decreased Dose to patient
- 20% 4. Accurate patient positioning
- 20% 5. Visualize internal anatomy

Thank-you.