

Horizontal Plane Computed Tomography

CT's in the seated position

Mark Pankuch PhD

AAPM MidWest Chapter

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Today's Discussion

- Define the potential capacity issues as we implement Pencil Beam Scanning in the Gantry room 4
- Introduce a potential solution : the Horizontal Plane CT scanner
- Share some design concepts
- Reach out for potential collaborations

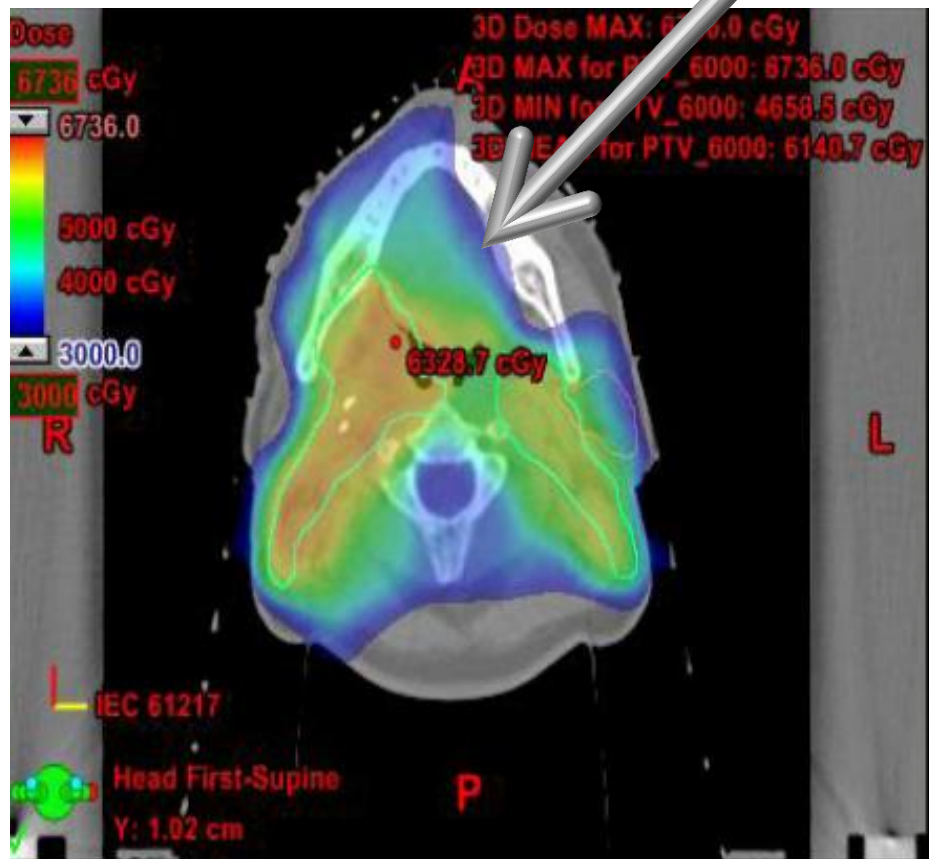
Proton Center Beam Delivery System



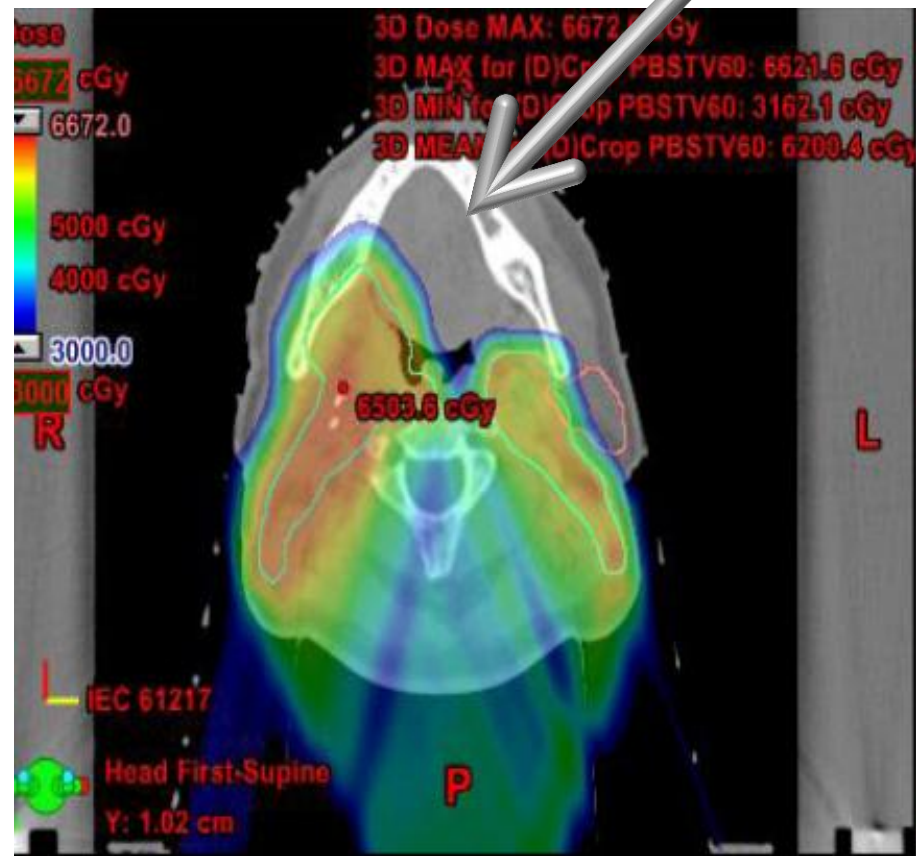
PBS in the Gantry

- In late stages of installation of PBS
 - All Hardware in place
 - Beam Optics optimization
- Acceptance testing to begin late May/June
- Plans are to dedicate this room to PBS
 - Head / Neck
 - Breast
 - Cranial Spinal Irradiations (CSI)

Head / Neck with PBS

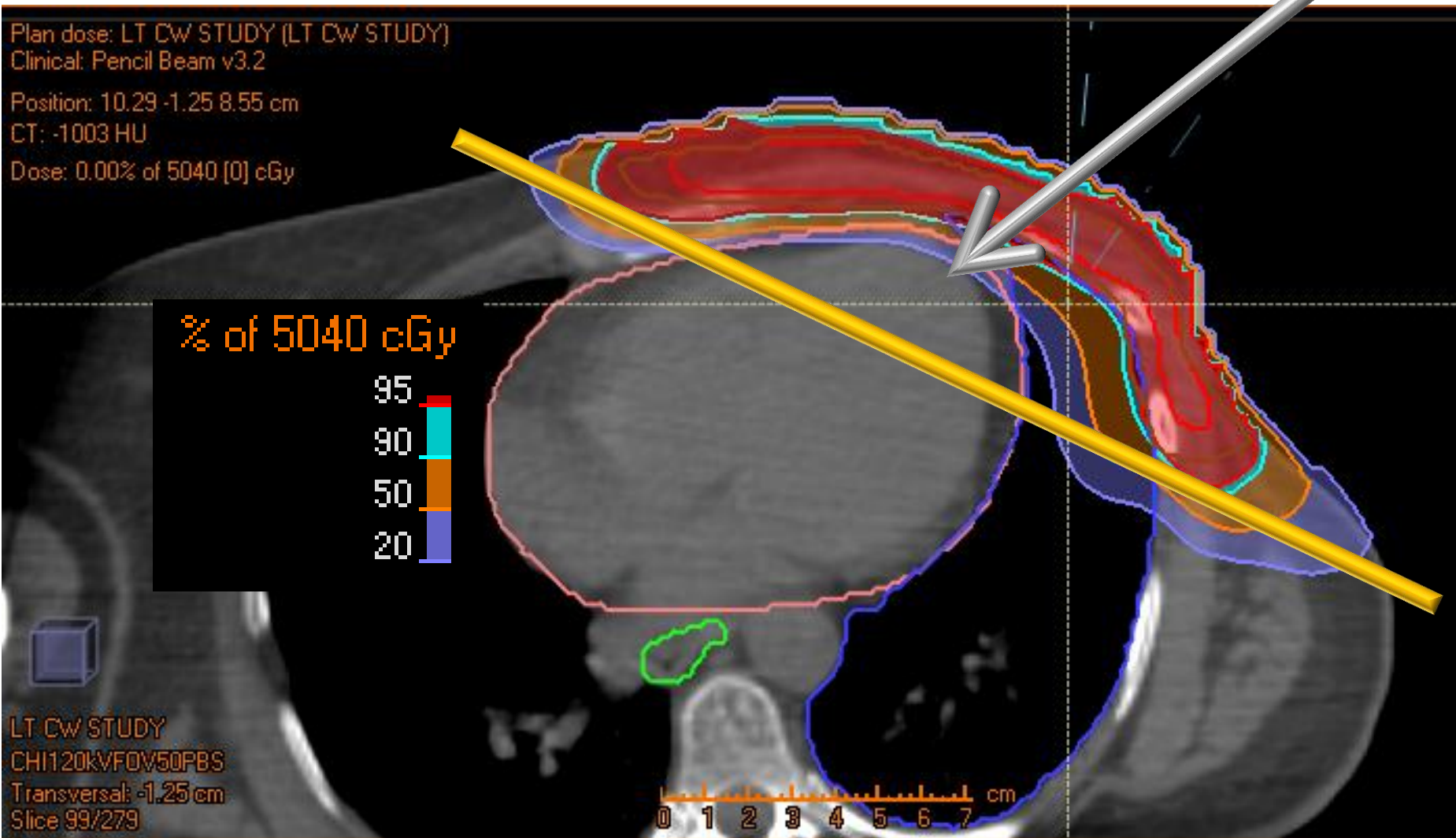


Photon IMRT



Proton PBS

Stage 3, Left Breast/Chestwall + IMN

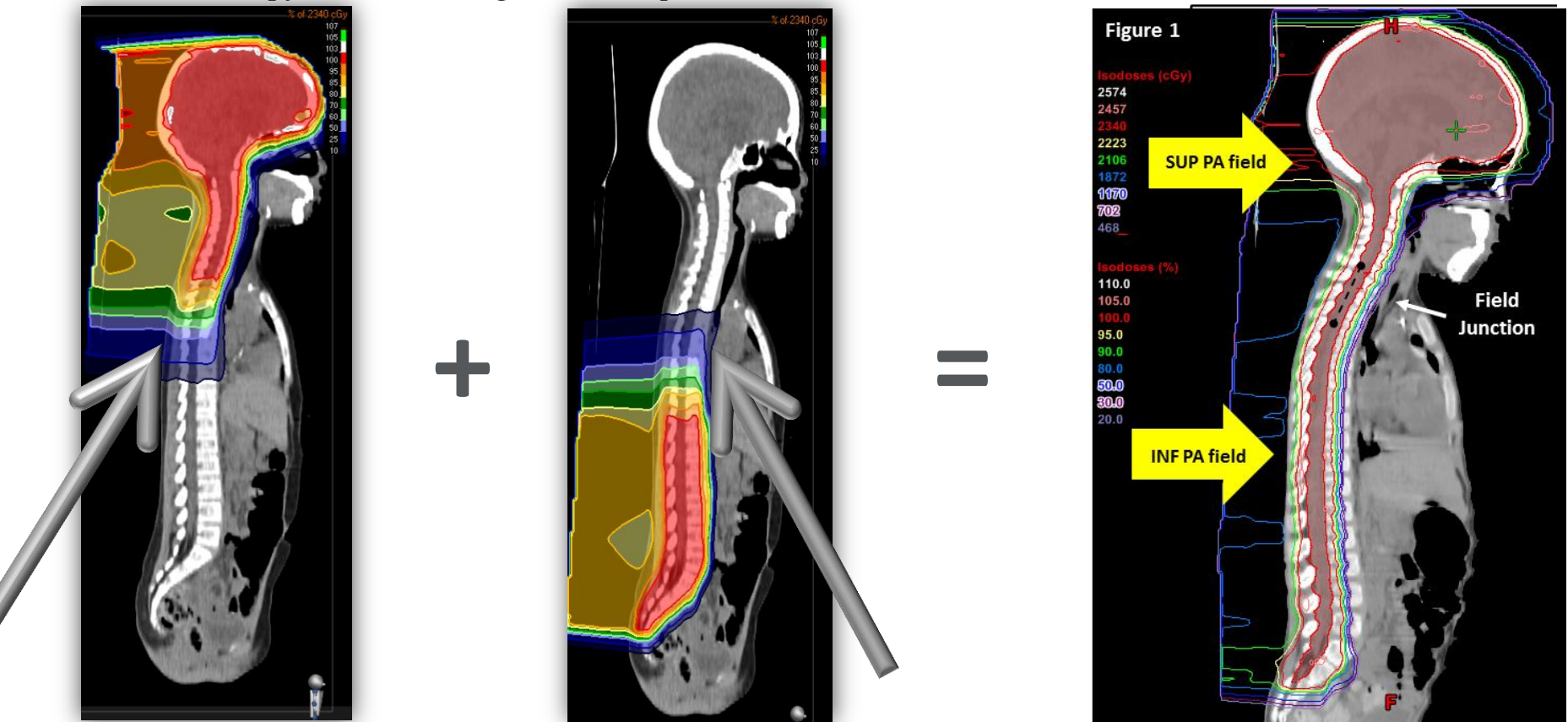


A Simple Scanning Beam Treatment Technique for CSI

Annelise Giebeler, Andrew Chang, Luis Perles, Lei Dong, and Atmaram S. Pai Panandiker

Affiliations of Authors: Scripps Proton Therapy Center, San Diego, CA

Purpose: Proton therapy is an ideal radiation modality for craniospinal irradiation (CSI). The majority of new proton therapy centers in development exclusively utilize pencil beam scanning (PBS); other centers in operation and in development are incorporating PBS as an additional proton delivery method. We present a simple, gradient-focused intensity modulated proton therapy (IMPT) planning approach as an alternative to the junction shifts utilized in passively scattered and uniform scanned proton therapy. We assess dosimetric advantages as well as effectiveness in the initial 6 patients treated at Scripps Proton Therapy Center utilizing this technique.



How will the addition of PBS to the Gantry room effect Gantry Capacity



Improves Capacity



Decreases Capacity

- Head / Neck

- New treatment site not currently treated



- Lt Breast

- Reduce 2-4 Fields/day to 1-2 Fields/day
- Expected increase in volume due to better distributions with PBS



- CSI

- Reduce from 4-5 fields/day to 2-3 fields/day
- Reduce from 3 match lines to 1 match line
- Volume expected to remain constant



- Gantry is currently at capacity at 16hours/day



- Net increase of H/N and breast is be greater than increased efficiencies gained



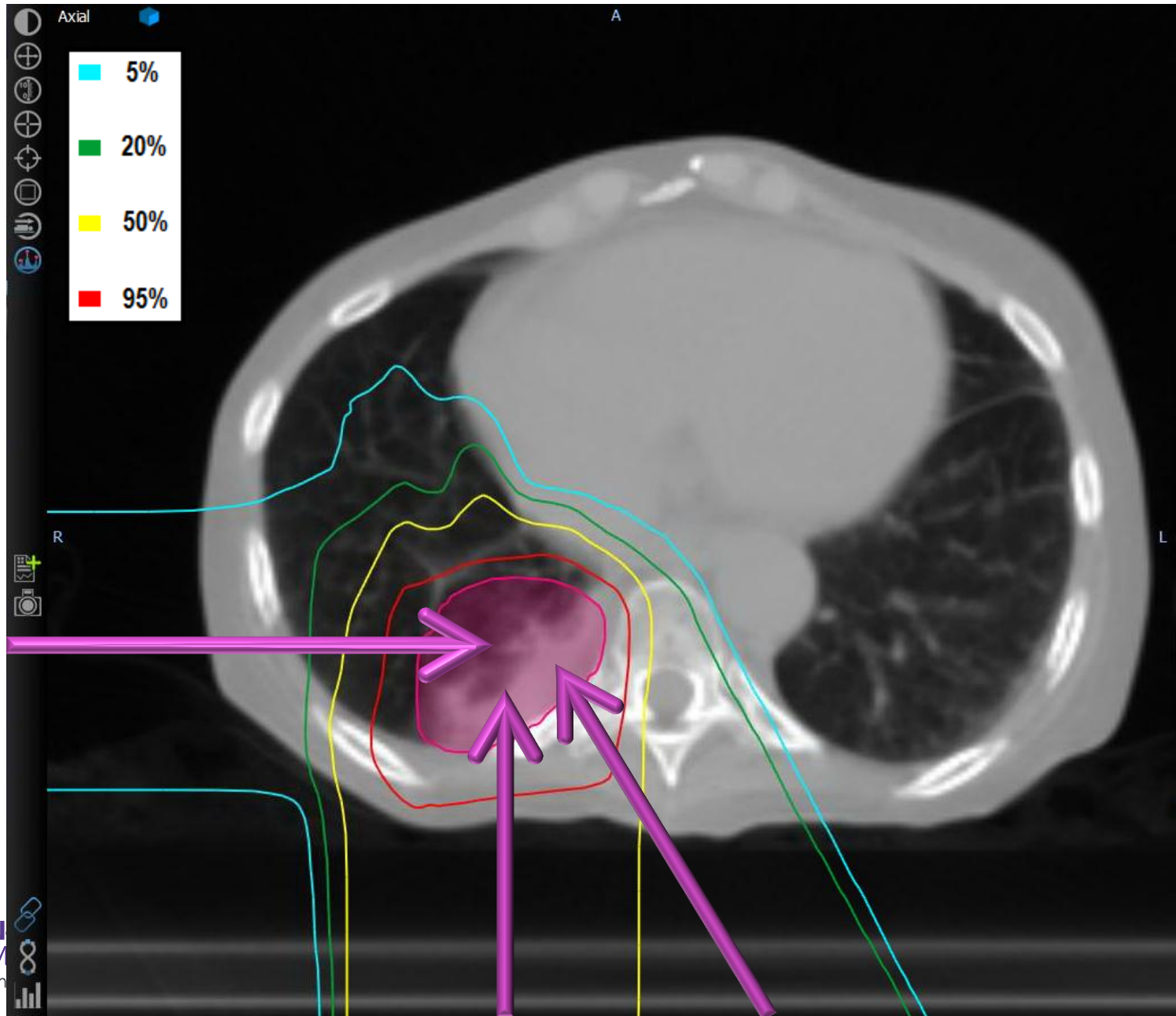
How will the addition of PBS to the Gantry room effect Gantry Capacity (Continued)

- Switching from PBS to US requires ~ 30-40 minutes

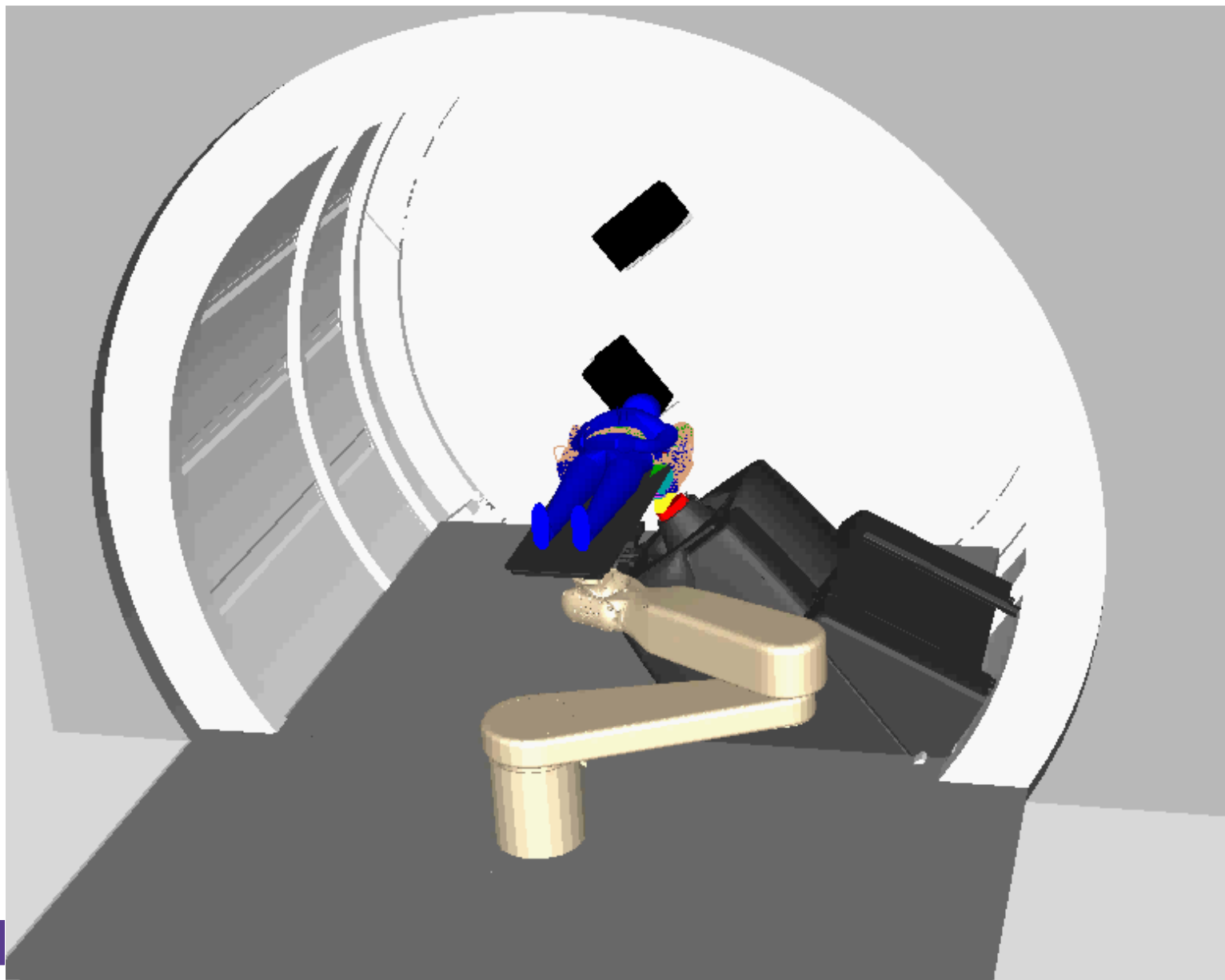


- The solution : Dedicate Gantry Room to PBS
- **But what about our Lung patients???**
 - Use of proton has tremendous potential for Stage III Lung
 - Two protocol already out to determine proper dosing and effectiveness in a randomized format
 - Using PBS may present interplay effects caused by the slow layer switching time
 - Many lung plans greatly benefit from posterior angles of incidence

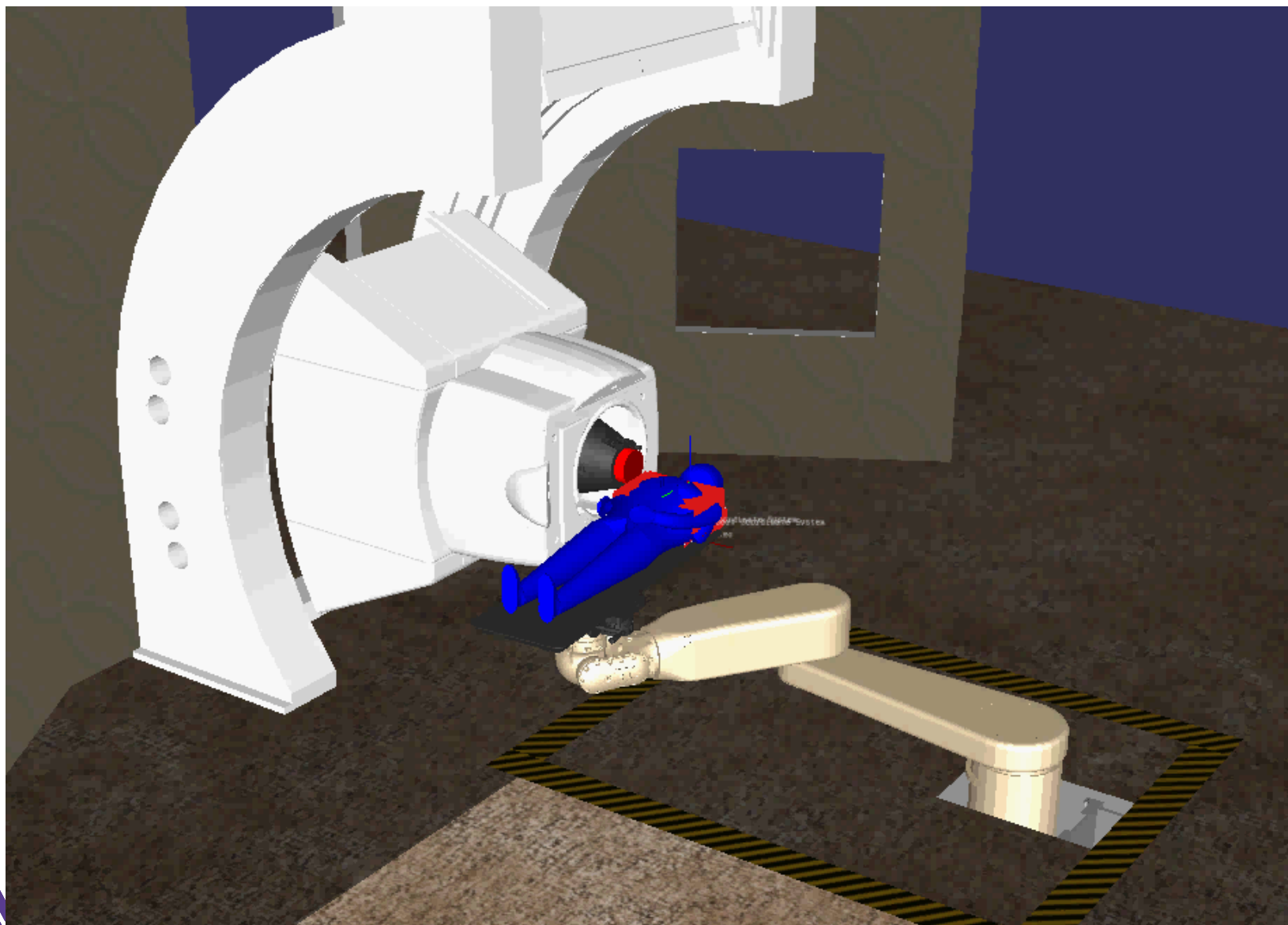
Lung Treatments with Protons



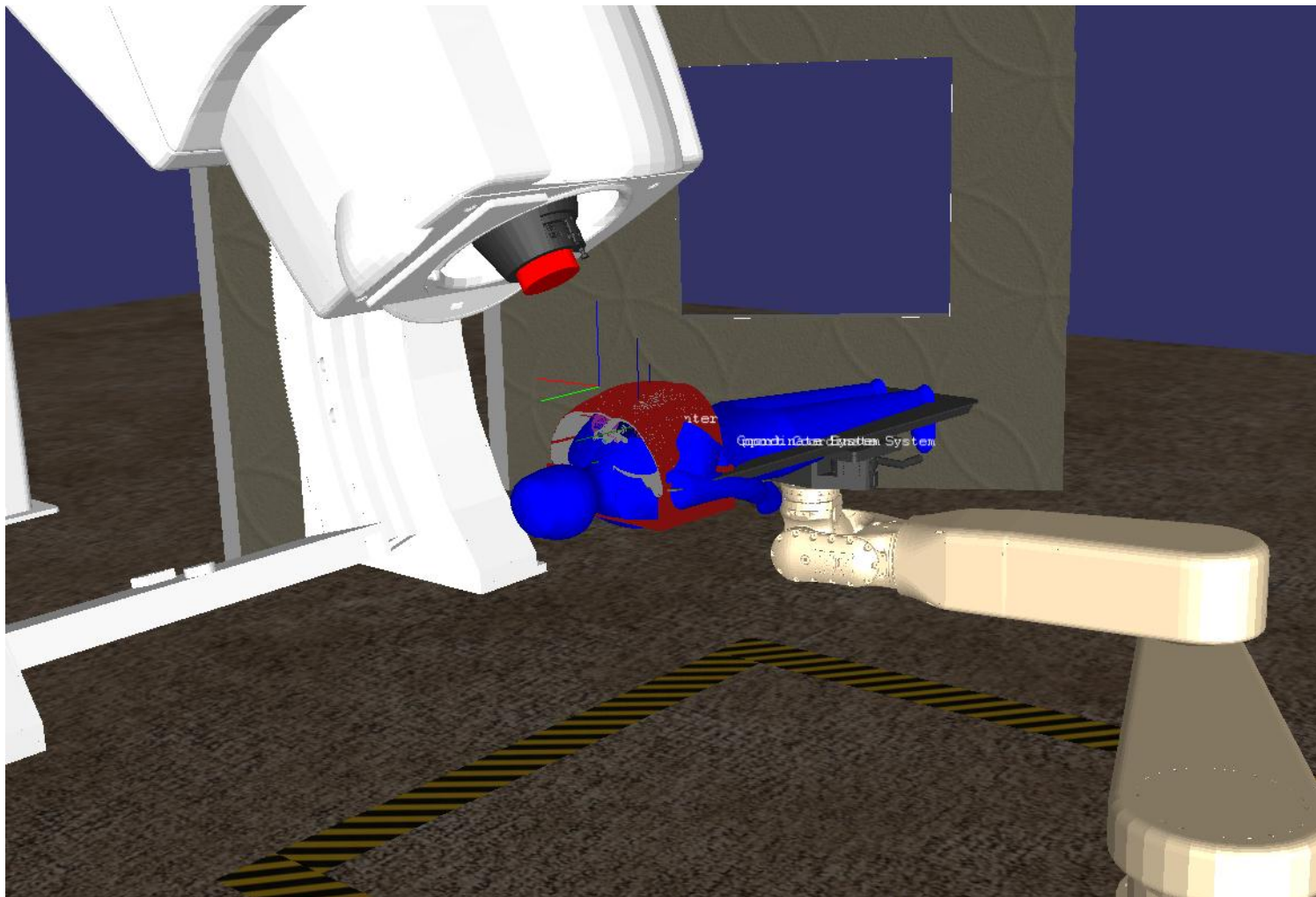
Posterior Fields in a Gantry Room



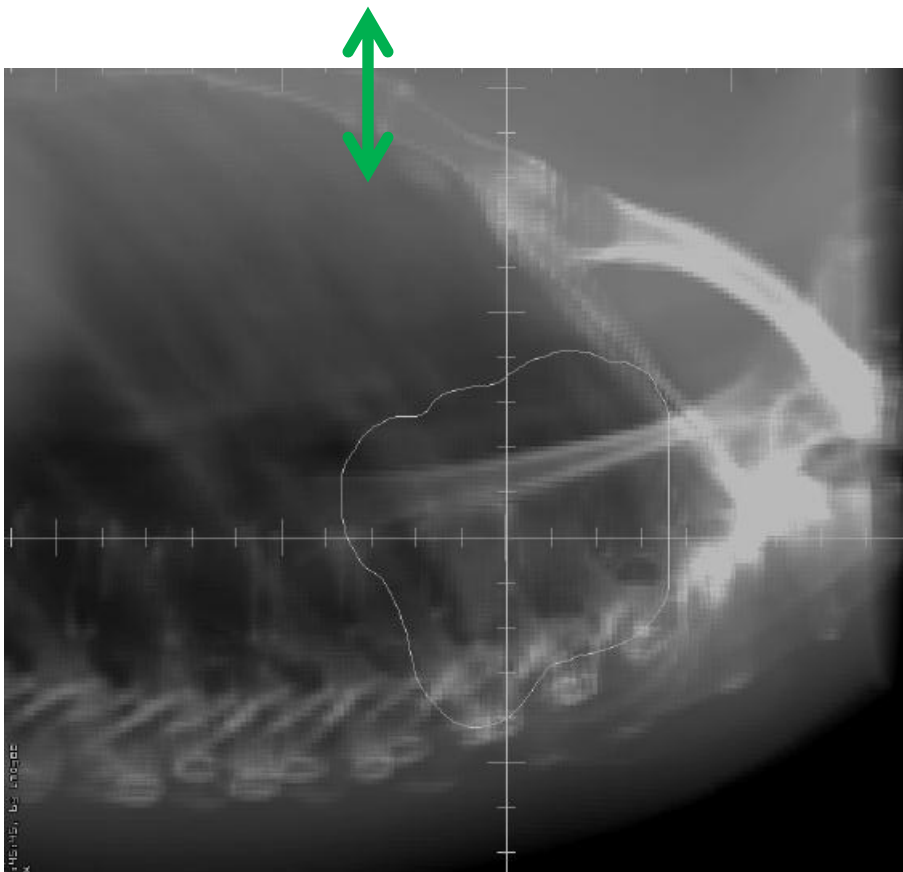
Treatment angle options in the Inclined Beam Room



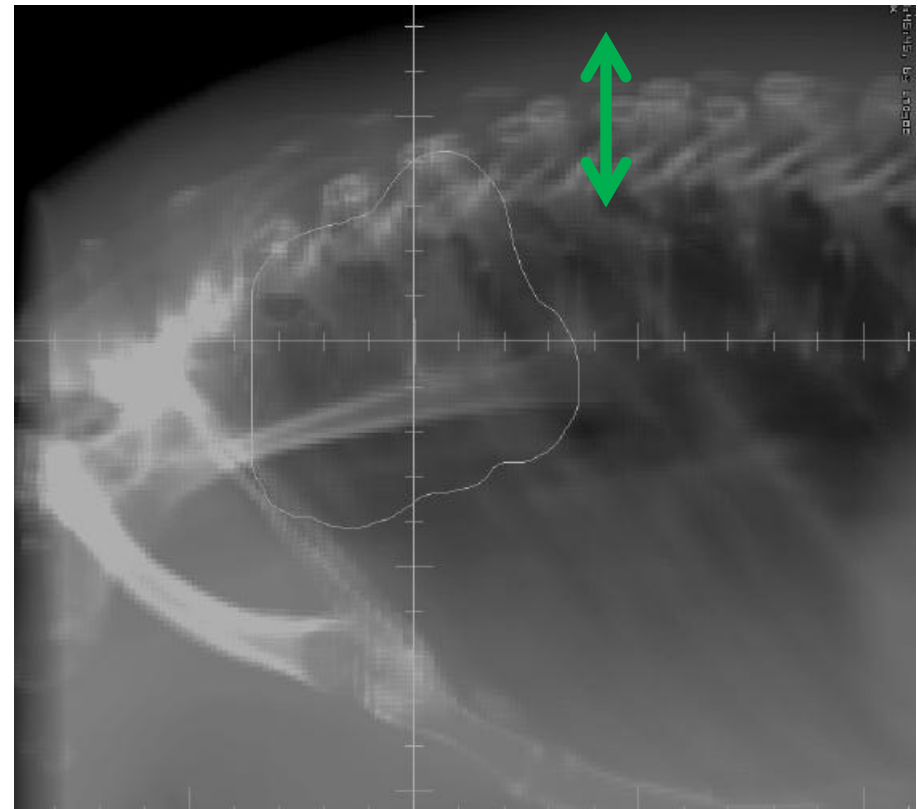
Lung Treatments in the Incline Beam Line



Supine vs. Prone : Areas of motion

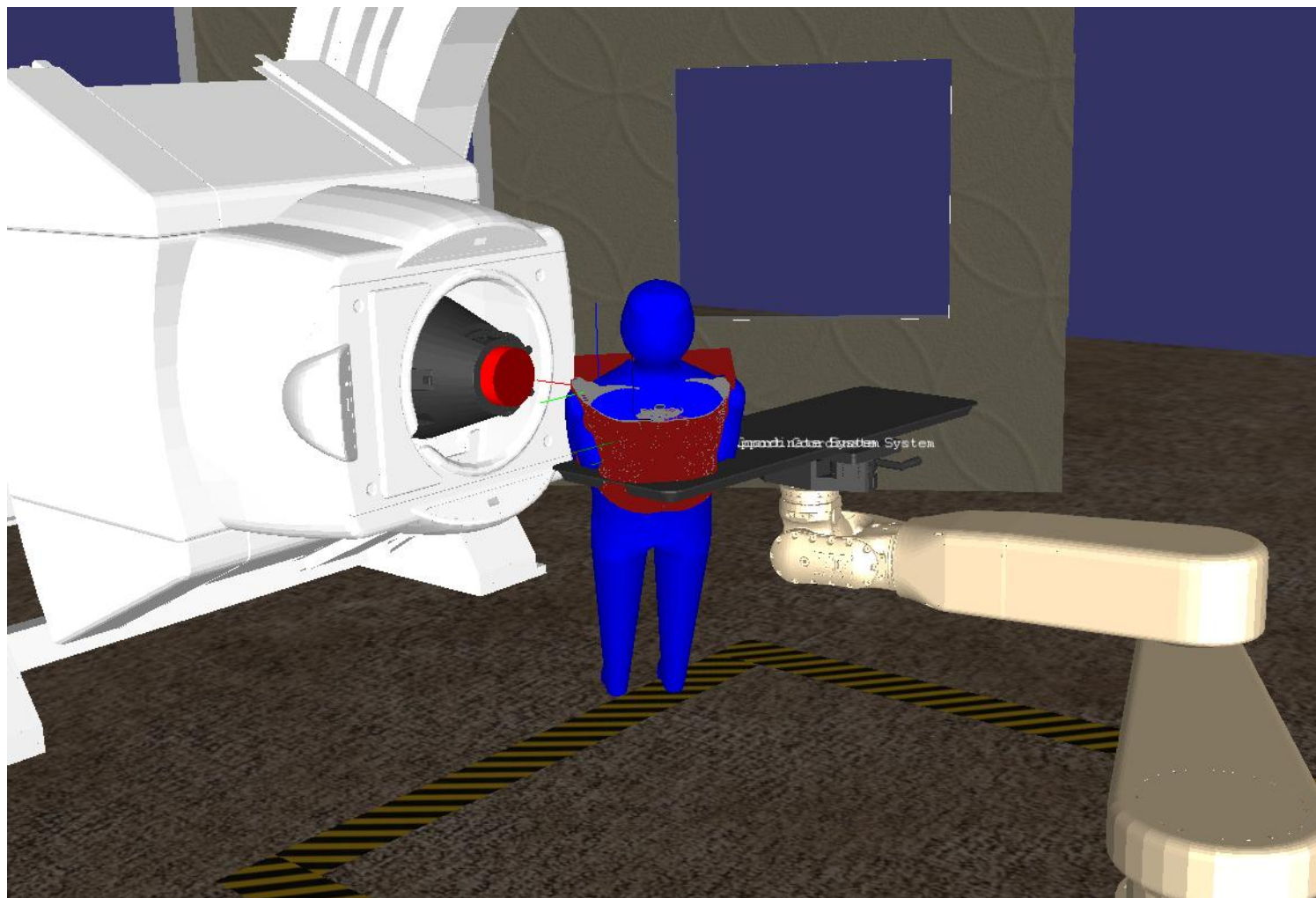


Supine Treatment



Prone Treatment

Consider treatment is seated position



Original Report

Advantages of simulating thoracic cancer patients in an upright position

Jinzhong Yang PhD^a, David Chu PhD^b, Lei Dong PhD^{a, c}, Laurence E. Court PhD^{a, *}

^a*Department of Radiation Physics, The University of Texas MD Anderson Cancer Center, Houston, Texas*

^b*Fonar Corporation, Melville, New York*

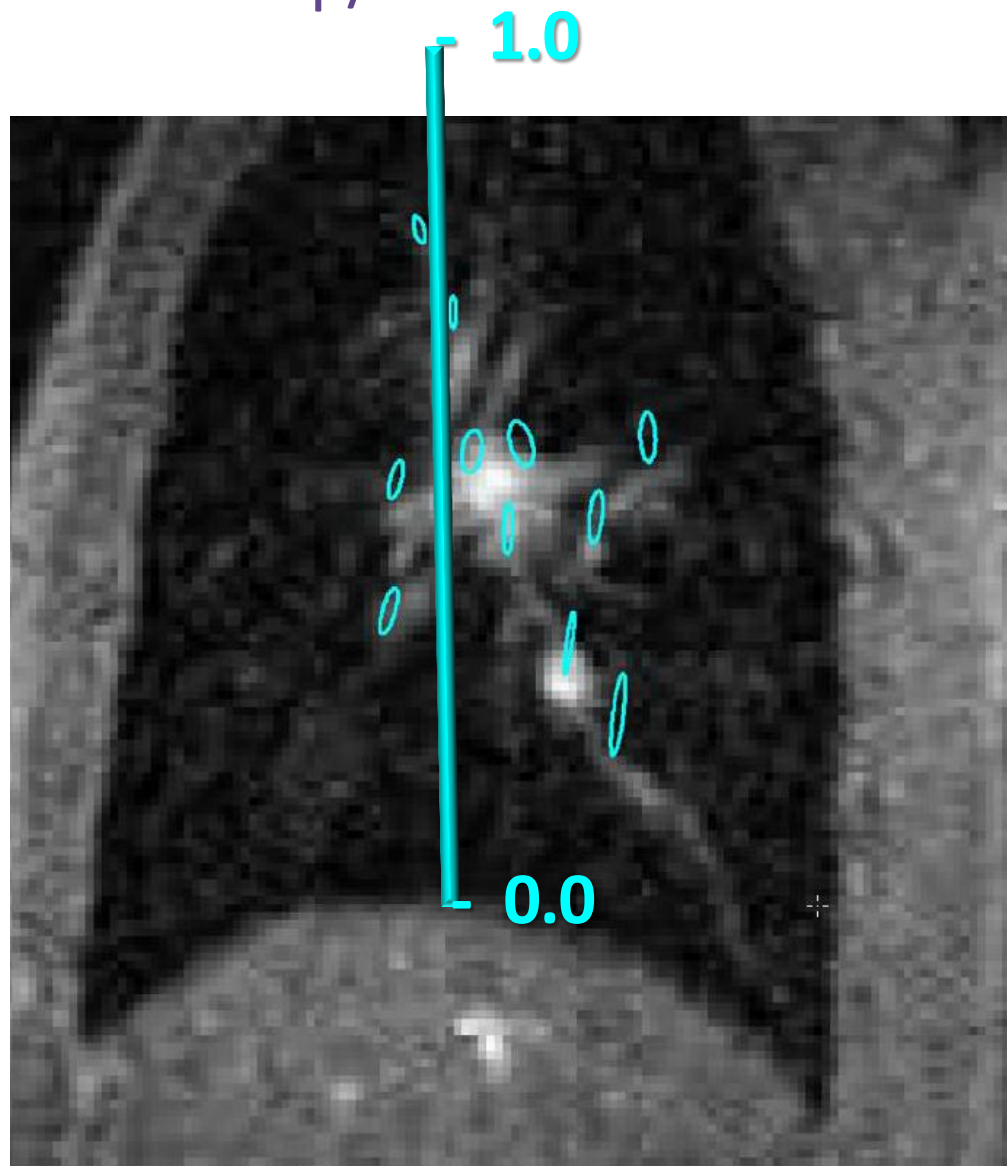
^c*Scripps Proton Therapy Center, San Diego, California*

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- MRI of 5 healthy, male volunteers in seated and supine position
- 6 to 8 sagittal cine images obtained to cover the most visible structures in the Rt Lung
- 3-D axial images obtained in a single breath hold to obtain lung volume

Determination of Magnitude of Sup/Inf Motion

- Sagittal cine MRI
- Trajectory of clear landmarks were determined
- Magnitude of internal breathing obtained for several points with >2mm of motion
- Positions normalized to distances from the diaphragm
 - 0.0 at diaphragm
 - 1.0 at lung apex



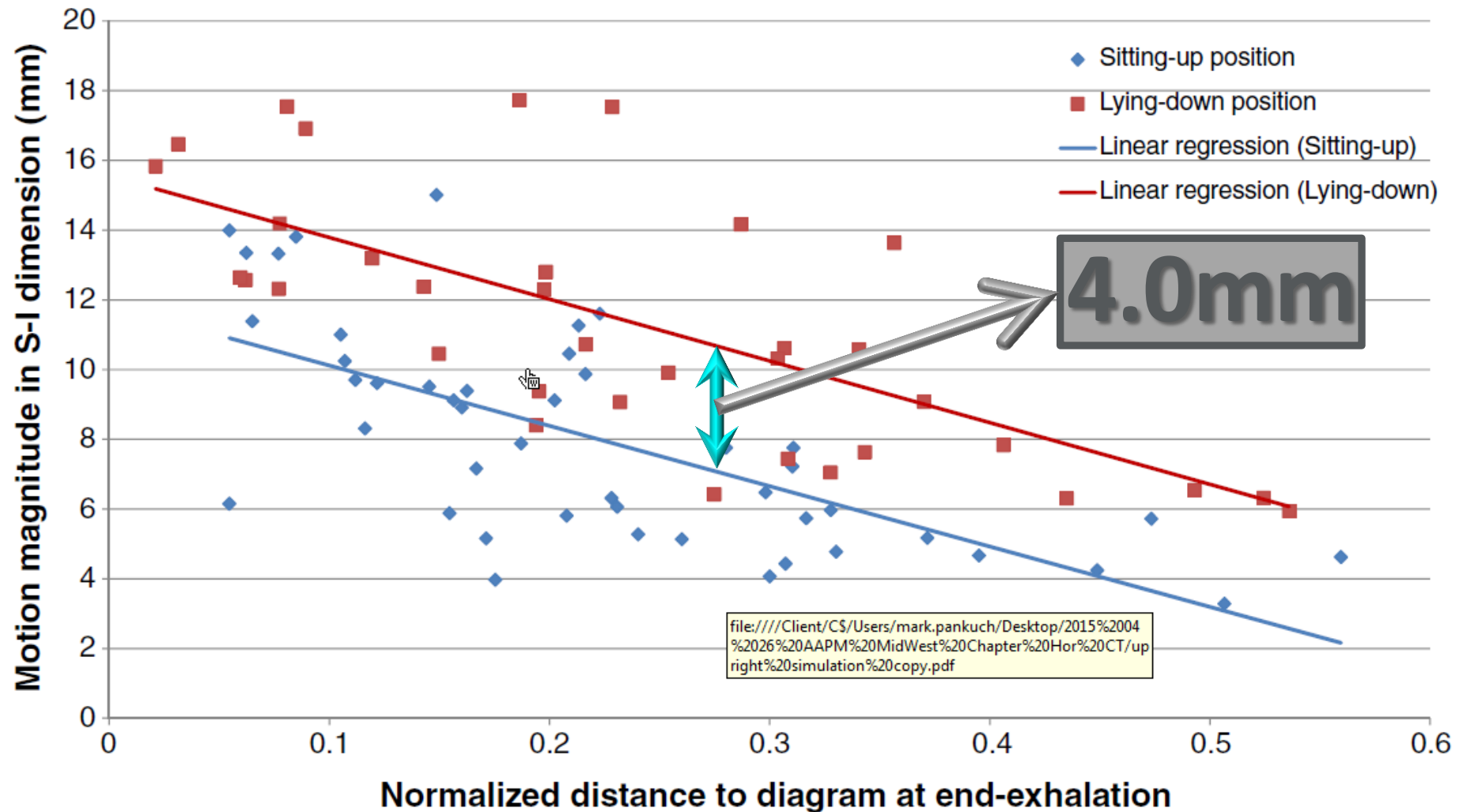


Figure 2 The amplitude of motion in the superior-inferior (S-I) direction for landmark points was plotted as a function of normalized distance to the diaphragm at end-exhalation for 1 volunteer. The vertical distance between the apex of the sagittal lung and the diaphragm was set to 1. A linear regression to these data indicated that the motion when the participant was in the upright position was around 4 mm less than when the participant was in the supine position.

Average Motion Magnitude Difference

Table 1 Average motion magnitude differences in scans done with participants in supine and upright setup positions

Volunteer no.	1	2	3	4	5	Average
Difference (mm)	3.6	2.8	2.9	1.0	4.0	2.9

For each volunteer, the result was calculated from the average of motion difference at different distance to diaphragm using Eq ($\Delta = \frac{1}{0.6} \int_0^{0.6} [f(x) - g(x)] dx$) defined in the context.

Total Lung Volume Differences

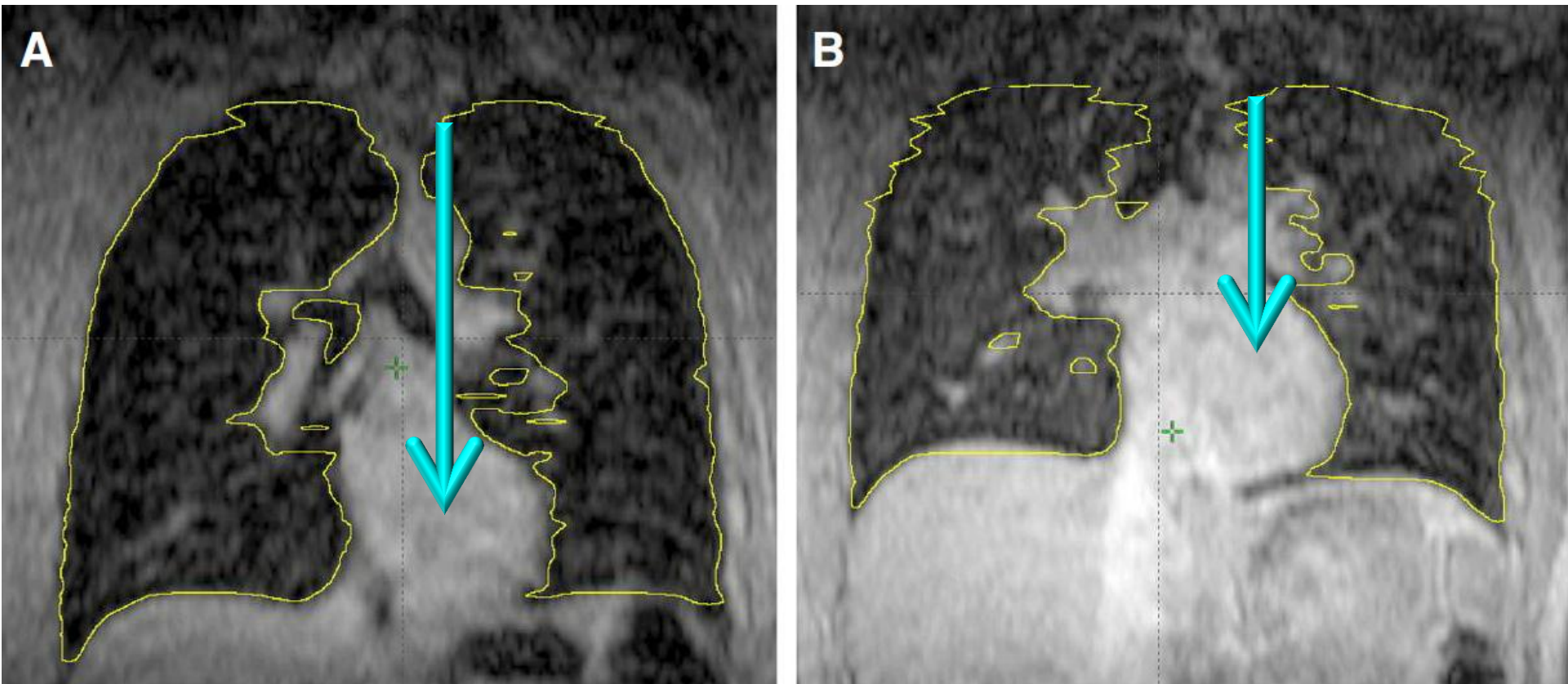


Figure 3 Illustration of the lung volume difference on a coronal slice for upright and supine setup positions. The lung volume at end-exhalation in the upright position (A) is much larger than in the supine position (B).

	1021	2051	1550	52.8
Average	3548	2797	751	26.9

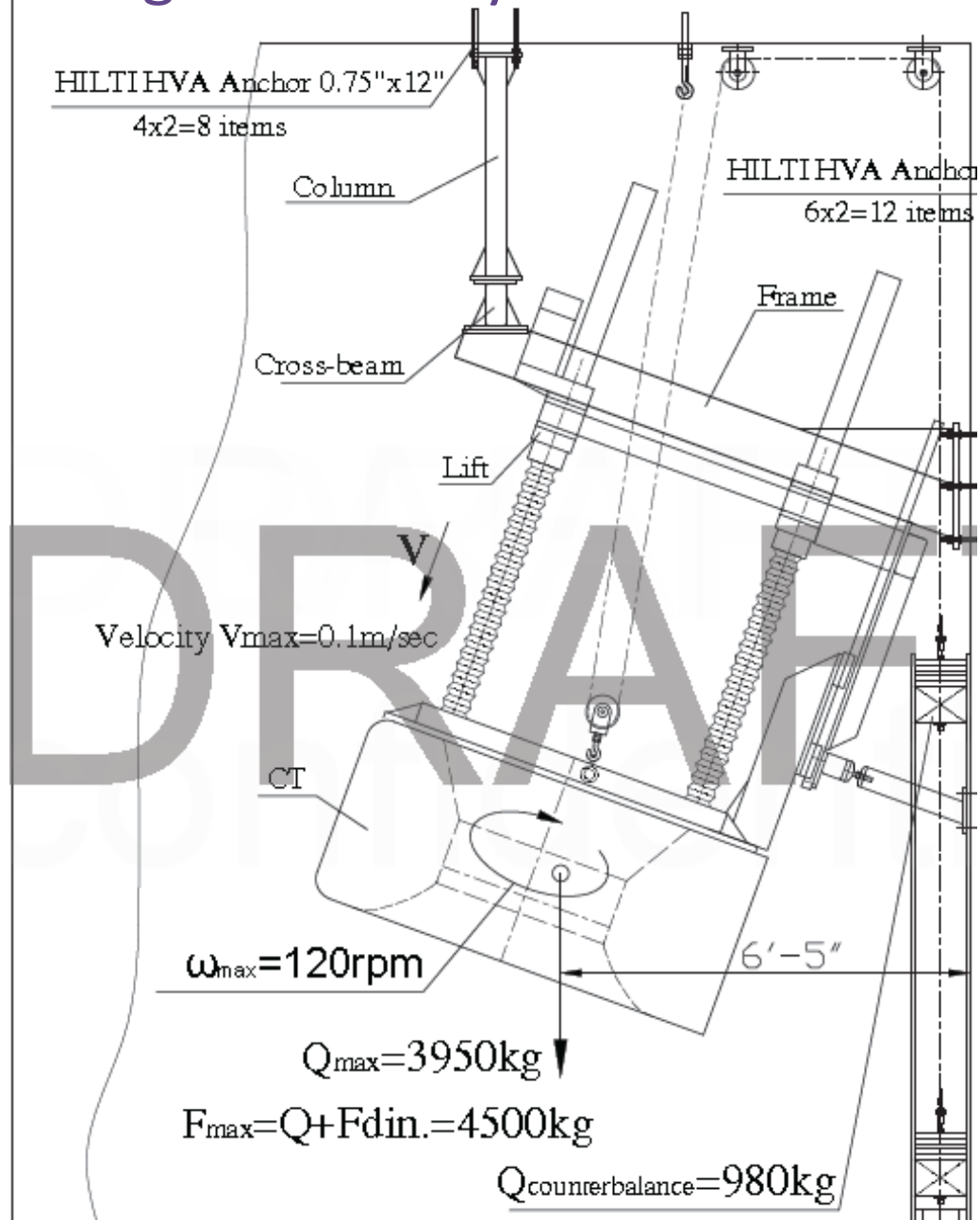
Treatment In the seated position has potential benefits

- Increase Lung volume
- Decrease lung motion
- Displaces the heart
- Provide us the opportunity to treat with US in IBL with Gantry-like field arrangements
 - Less sensitive to interplay effects
- The answer for us :
 - Treatment in the seated position
 - Horizontal Plane scanner

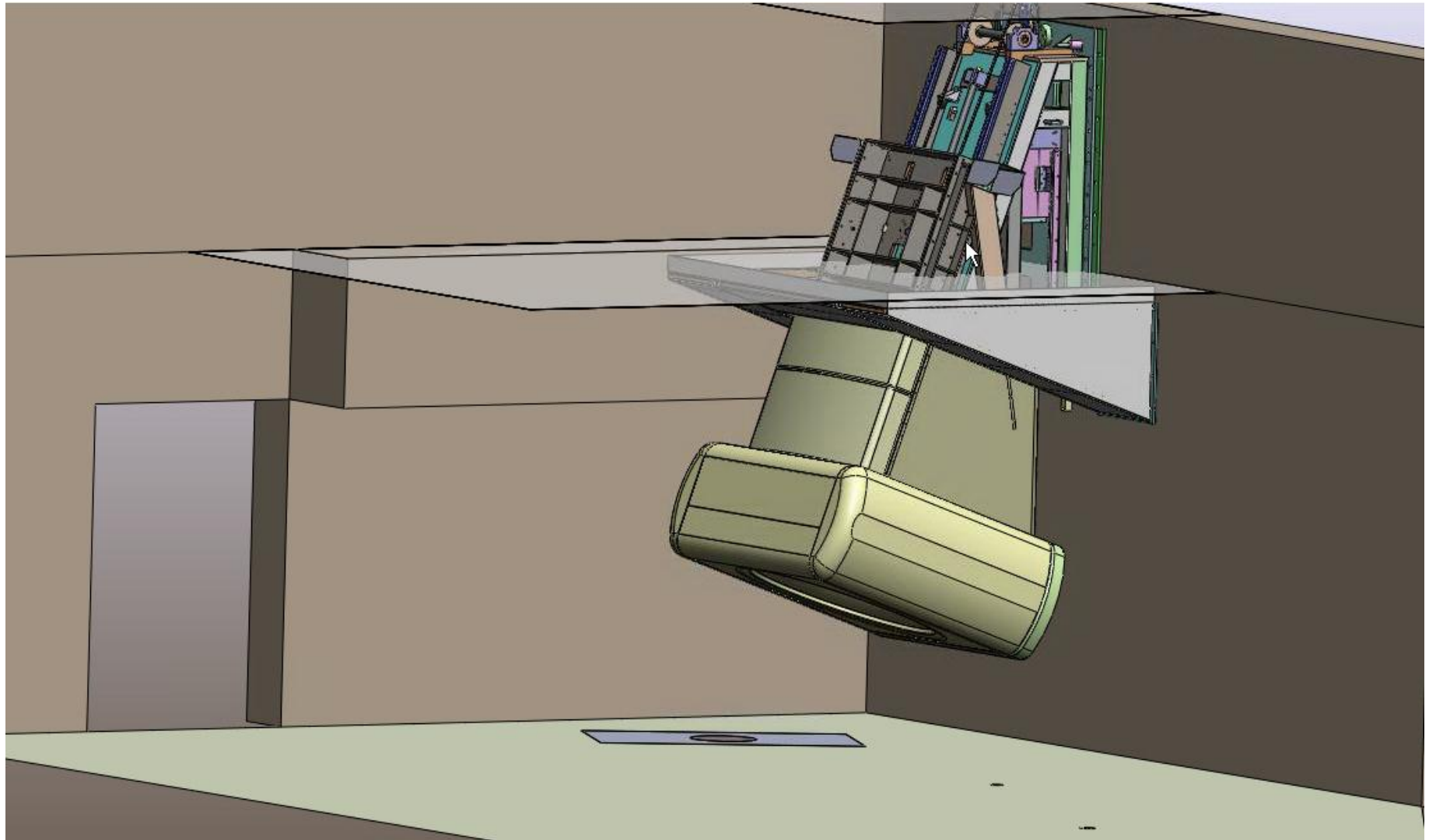
P-Cure Solution \ Phillips Large Bore CT Scanner



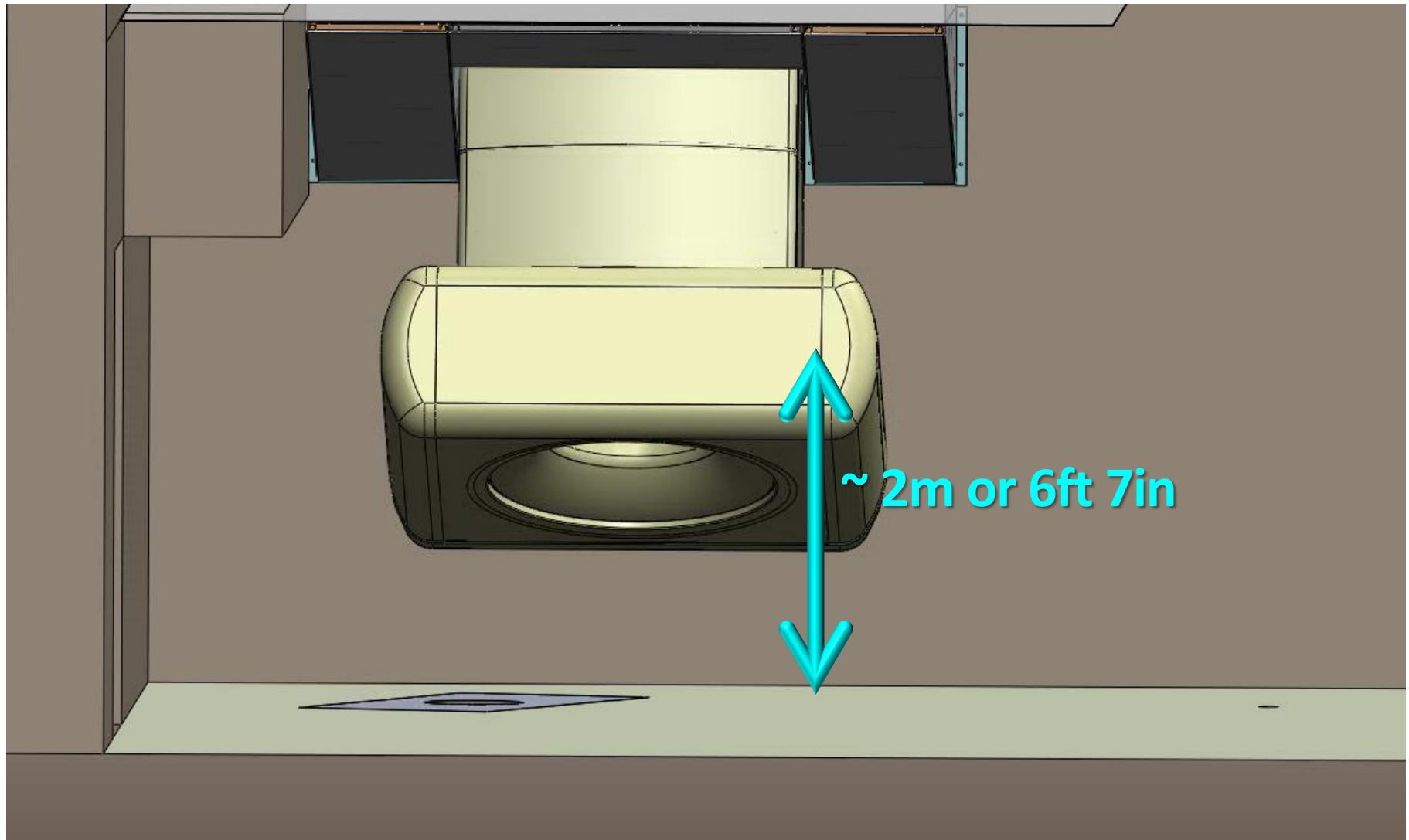
Wall and Ceiling mounted system



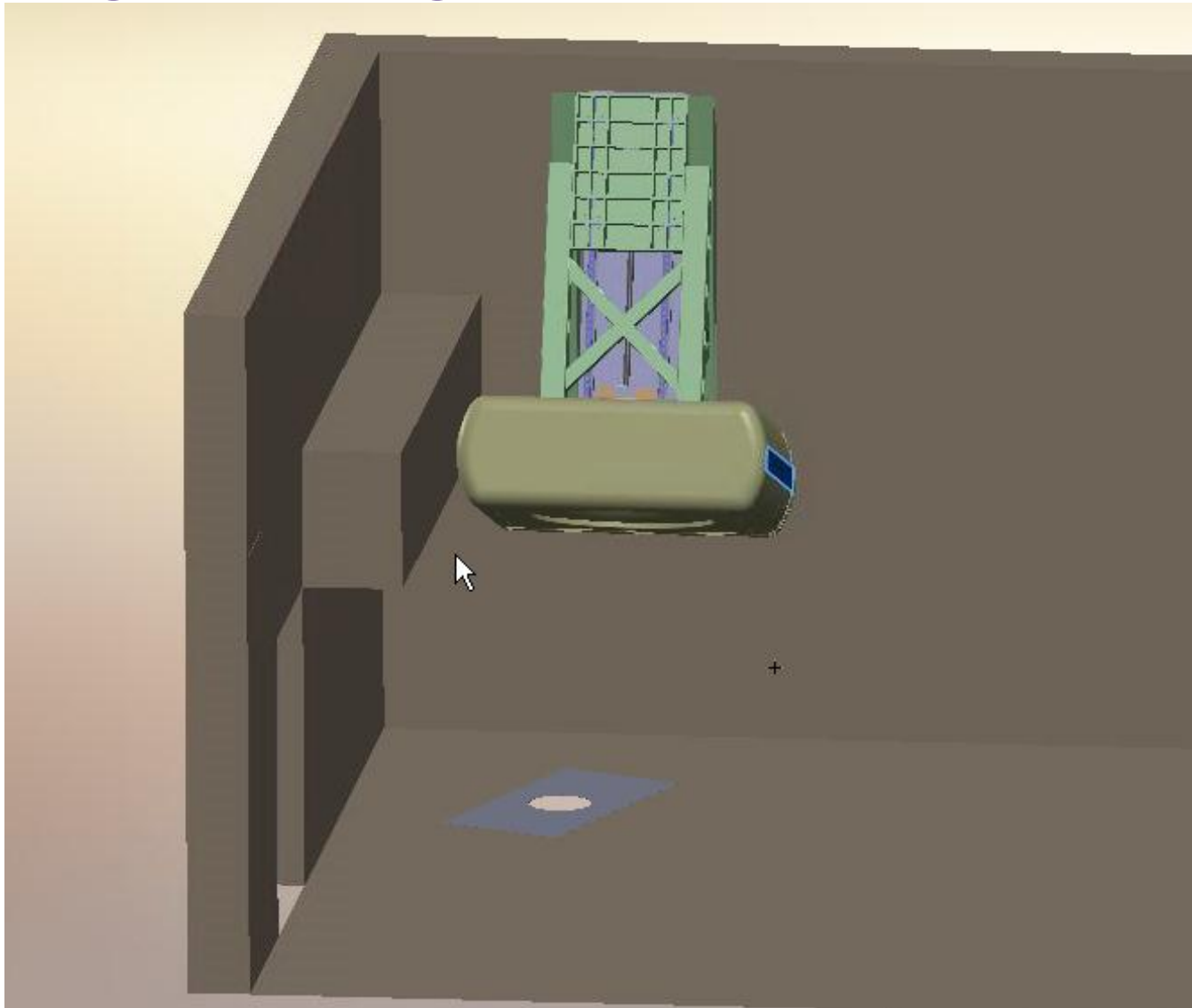
Wall Mounted System in IBL3



Wall Mounted System in IBL3



Existing Air handling ductwork



In-room Mock-up



Functional system with collision guard



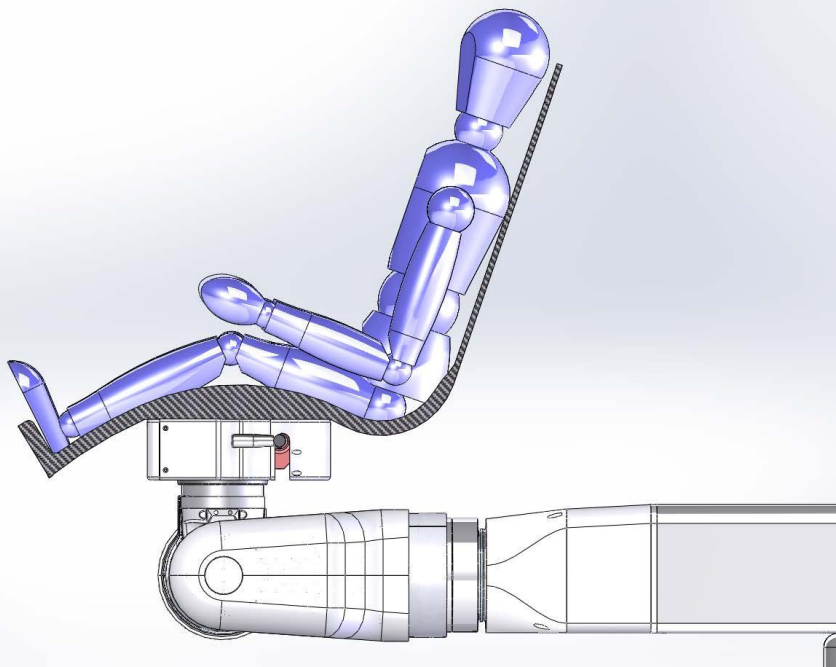
Functional system with collision guard



Thoracic chair - requirements

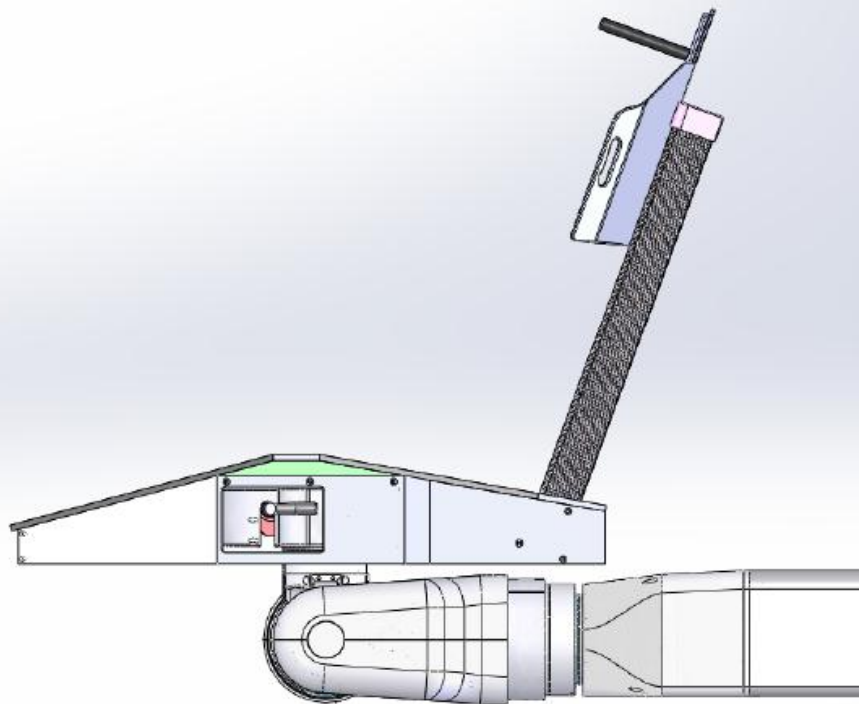
- Patient comfort
- Must be able to treat through the backrest
- Must attach to the top of the PPS wrist – full 360 degree rotation
- Weight limit – 400 lbs
- Interchangeable backrest with Unique IDs
- Must be able to scan below the diaphragm

Beach Chair concept



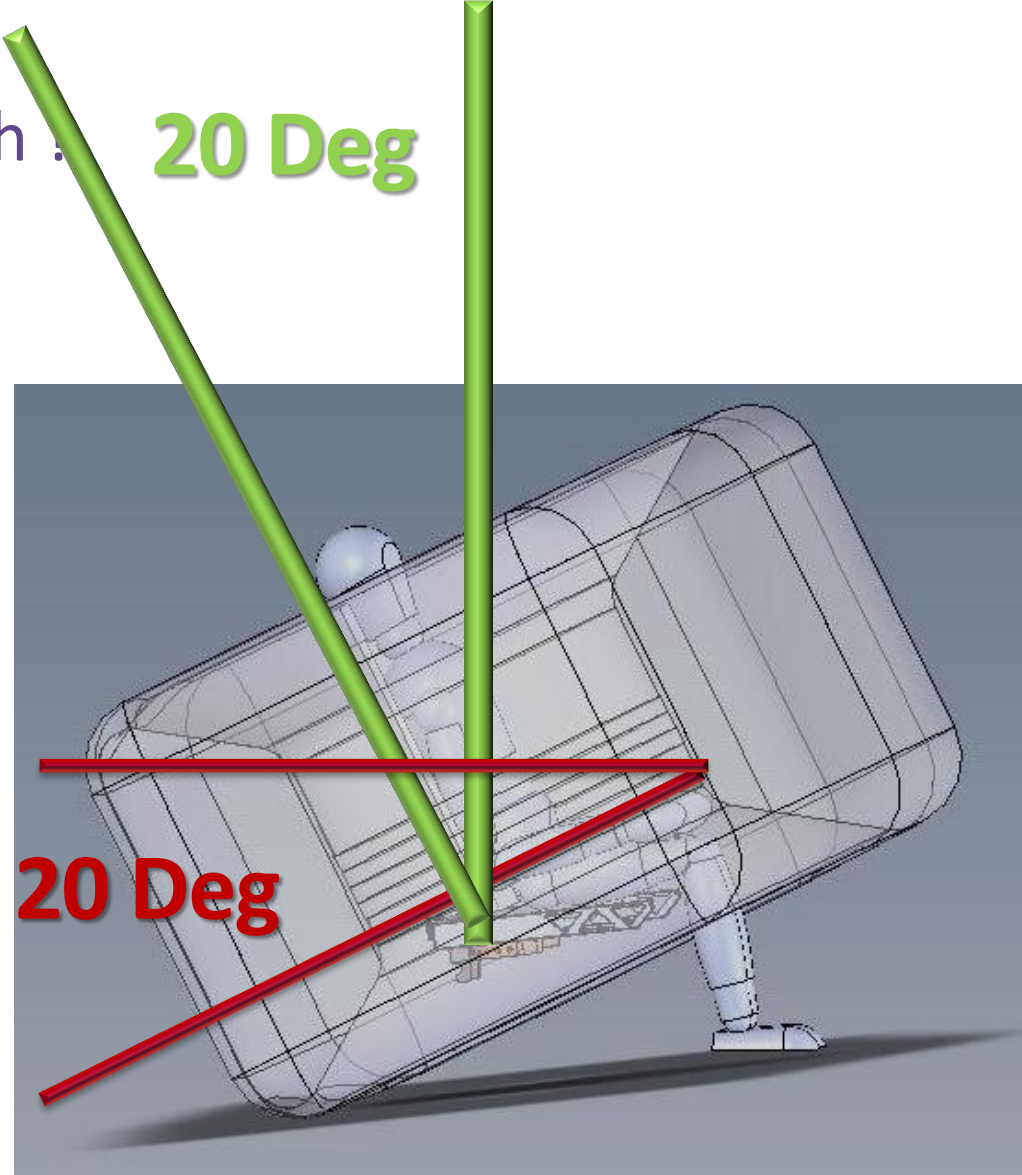
PPS attaches to the chair under the knees

Wing Board Attachment

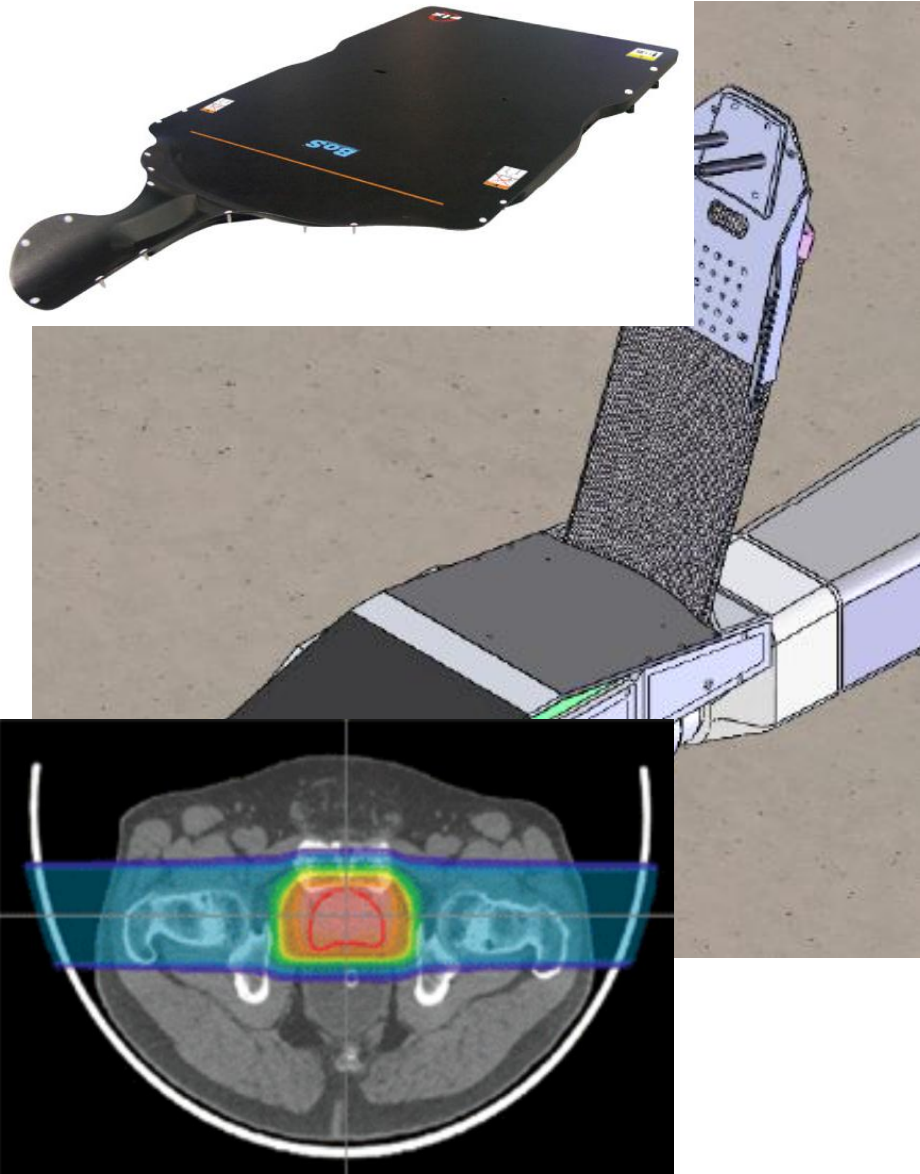


Can we scan low enough : **20 Deg**

- Scan at an inclined, 20 deg angle
 - Patient comfort
 - Can scan lower down
 - Patient's COG is above hips



Beach Chair concept

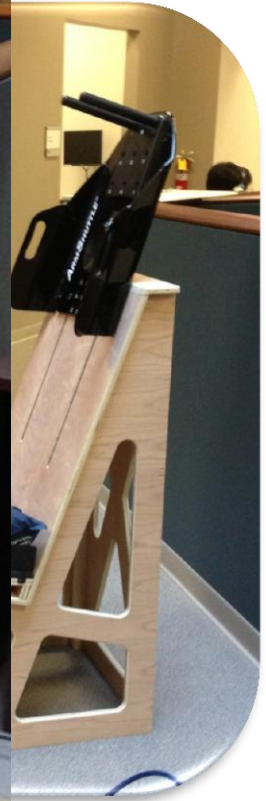


- Interchangeable Backrests
 - Thorax
 - H&N patients
- May use a curved backrest
 - Allow for a better thoracic immobilization shell
- A need for arm supports
 - Arms up or down
- A potential need for Chin / Head Straps

Beach C



den chair



Horizontal CT : Additional Acceptance Testing

- **Axial geometry accuracy**

- A geometric phantom with clearly identifiable objects of known separations will be imaged. Distances between objects within an axial slice will be measured using the scanner software and compared to the known distances of the phantom.
- Expected tolerance: The measured distance should not deviate from the known distance by more than one pixel length.
-

- **Longitudinal geometry accuracy**

- A geometric phantom with clearly identifiable objects of known separations will be imaged. Distances between objects obtained on axial slices of differing longitudinal positions will be measured using the scanner software and compared to the known distances of the phantom.
- Expected tolerance: The measured distance should not deviate from the known distance by more than the axial slice thickness.
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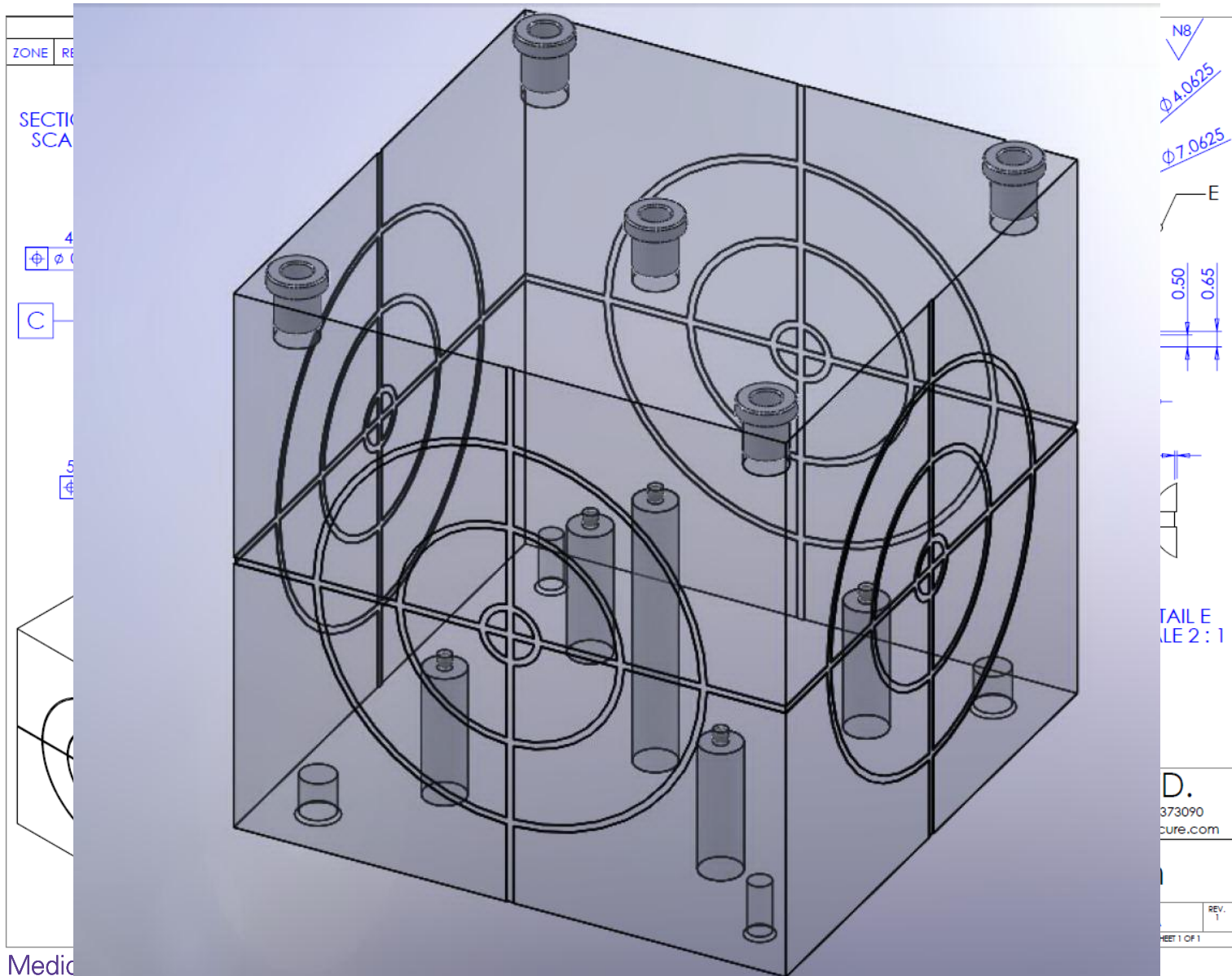
- **Orientation of the chair base with respect to the imaging plane**

- A series of images will be obtained of the treatment chair through a 30cm portion of the back support.
- Expected tolerance:
- On the axial image, the back of the chair should not deviate from the image plane in the Left/Right direction by more than ± 1 mm across the entire length of the treatment chair back.
- On consecutive images, the back of the chair should not deviate in the anterior/posterior direction by more than ± 1 mm over the entire length of the acquired images.
-

- **Orientation of lasers with respect to the imaging plane**

- The CDH Proton Center's CT laser phantom will be indexed to the treatment chair, aligned to the external lasers and imaged.
- Expected tolerance: Laser positions obtained from the phantom image shall coincide with the expected position on the image by ± 2 mm

Geometry Phantom for Horizontal Plane Scanner



Implementation plan

- 1) Use for treatment planning CT only
 - Respiratory monitoring?
- 2) On treatment CT in treatment position
- 3) Volumetric Localization

Potential Future Options (From “Rock” Mackie)





Thanks for your attention !!!

- Comments / Questions
- Are you interested???
- We are welcoming potential collaborators!
- Contact me at
– mark.pankuch@cadencehealth.org