

- Development of an -  
MRI-Compatible, Dynamic, and Deformable  
**Imaging Phantom**

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Mentors: **Dr. Parag Parikh, Dr. Olga Green**

# MRI in Radiation Therapy



[www.viewray.com](http://www.viewray.com)

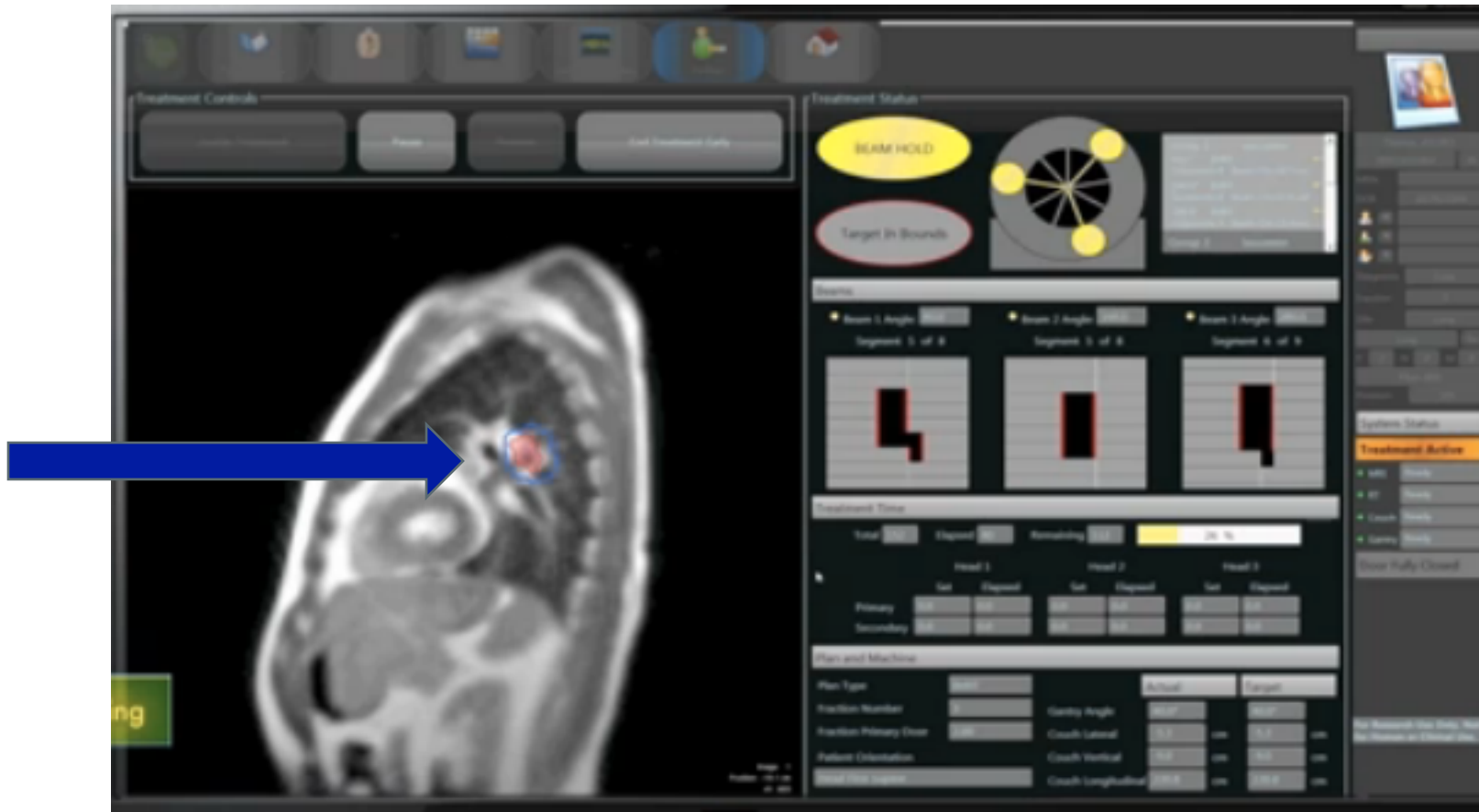
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# ViewRay



[www.viewray.com](http://www.viewray.com)

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# Project Scope

Design an **imaging phantom**  
that can be used to **assess the accuracy**  
of the **ViewRay software** in  
**calculating deformation** of moving organs  
in an **MRI scanner**, i.e.,

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# Project Scope

...design a phantom capable of:

- **Translating** in 3 dimensions,
- **Deforming** in 3 dimensions, and
- **Rotating** continuously in time

in a way that is:

- (Binary) **controllable**,
- Precisely **known**,
- Able to **operate in an MRI** environment, and
- Able to be **imaged by an MRI**.

# Specifications

## Translation

x, y, and z  
directions

$5 \pm 0.5$  cm

## Deformation

x, y, and z  
directions

$2 \pm 0.5$  cm

## Rotation

About  
x, y, and z axis

$\pm 0.5^\circ$

## Volume Change

Known pre- and  
post- deformation  
volumes

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# Specifications

## Translation

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### Motion must be:

- Reproducible and stable
- Precisely known
- (Binary) controllable

### Physical Characteristics:

- Weight:  $\leq 150$  lbs
- Dimensions:  $\leq 50 \times 30 \times 50$  cm
- Maximum price: \$10,000 - \$30,000

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Materials

Motion Mechanism

Motion Tracking

Imageable

[www.aplmedident.com](http://www.aplmedident.com)



Drangova (1996), Kahn (2003), Key (2010)

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Materials

Motion Mechanism

Motion Tracking

Imageable



Koichi (2003), Huber (2010)

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Materials

Motion Mechanism

Motion Tracking

Imageable

Non-Interfering

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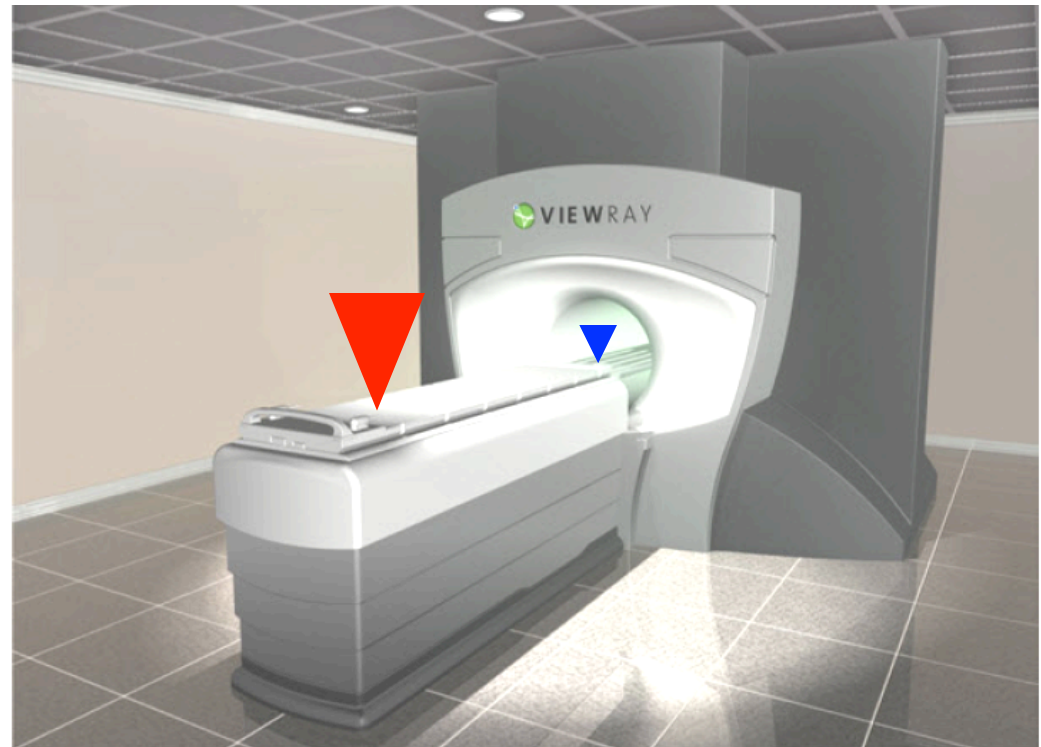
Materials

Motion Mechanism

Motion Tracking

Imageable

Non-Interfering



Drangova (1996), Kee (2010), Zhou (1999)

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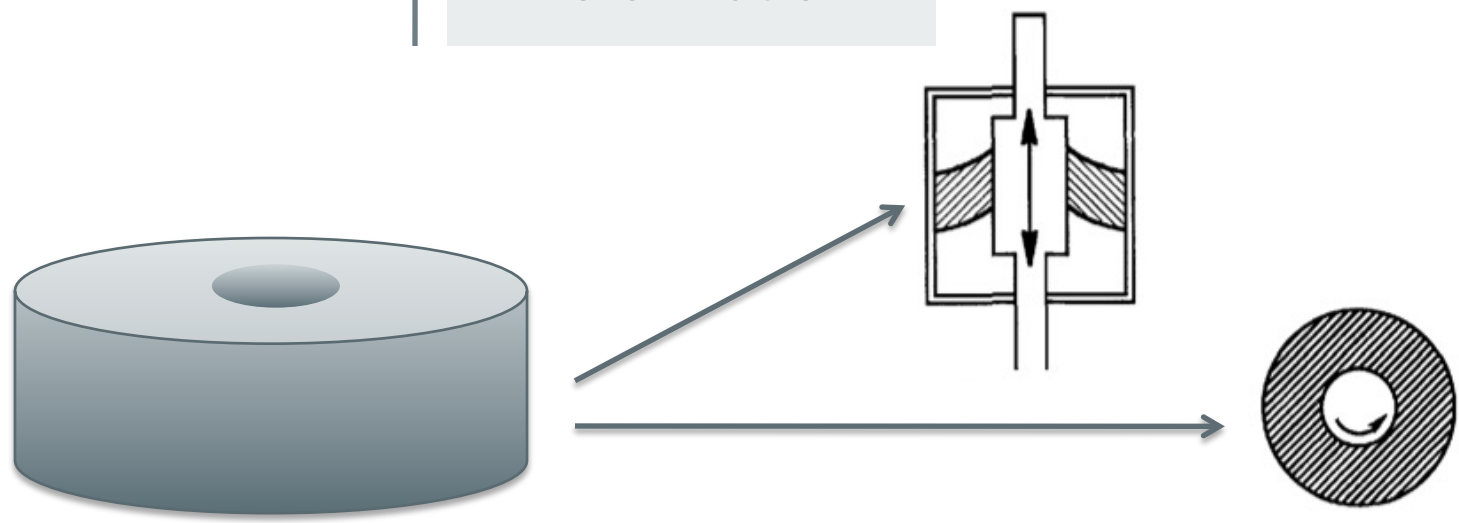
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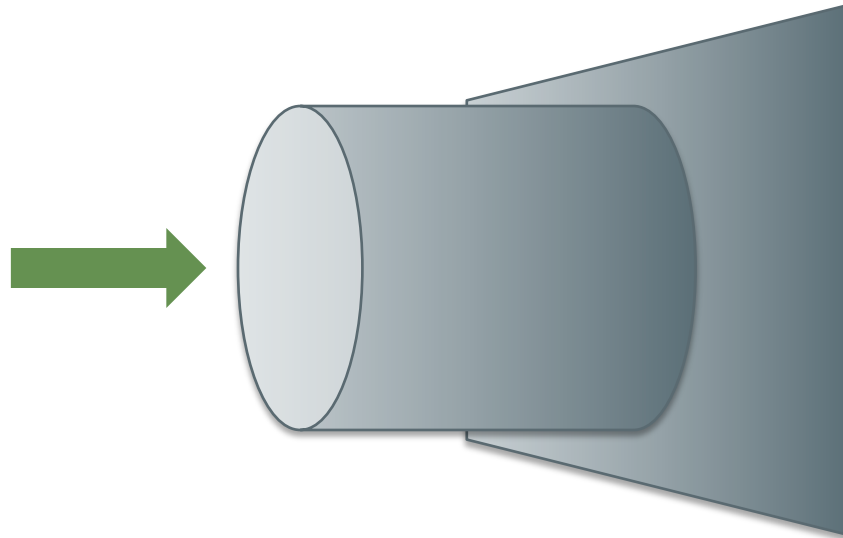
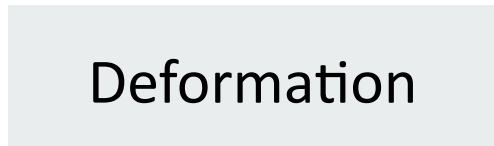
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Materials      **Motion Mechanism**      Motion Tracking

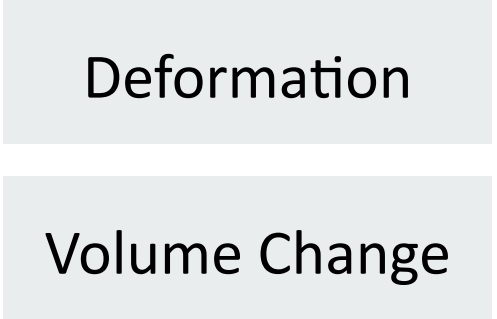
Deformation



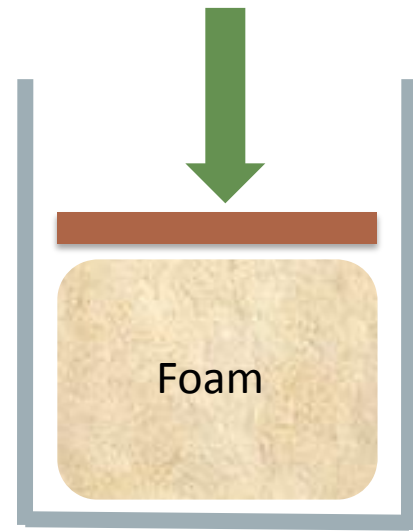
Drangova (1996)



Kee (2010)



Kashani (2006)



Materials

Motion Mechanism

Motion Tracking

- Video or sensor monitoring
- Mathematical modeling of system movement

Precisely Known  
Position

Precisely Known  
Volume

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Materials

Motion Mechanism

Motion Tracking

Koichi (2003)

Chang (2009)

Kashani (2007)

Zhou (1999)

Gassert (2006)

Gullans (2009)

Huber (200)

Drangova (1996)

Kee (2010)

Kahn (2003)

Take-Home Message:  
Failure in one of three modes

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# Phantom Motion Frequency

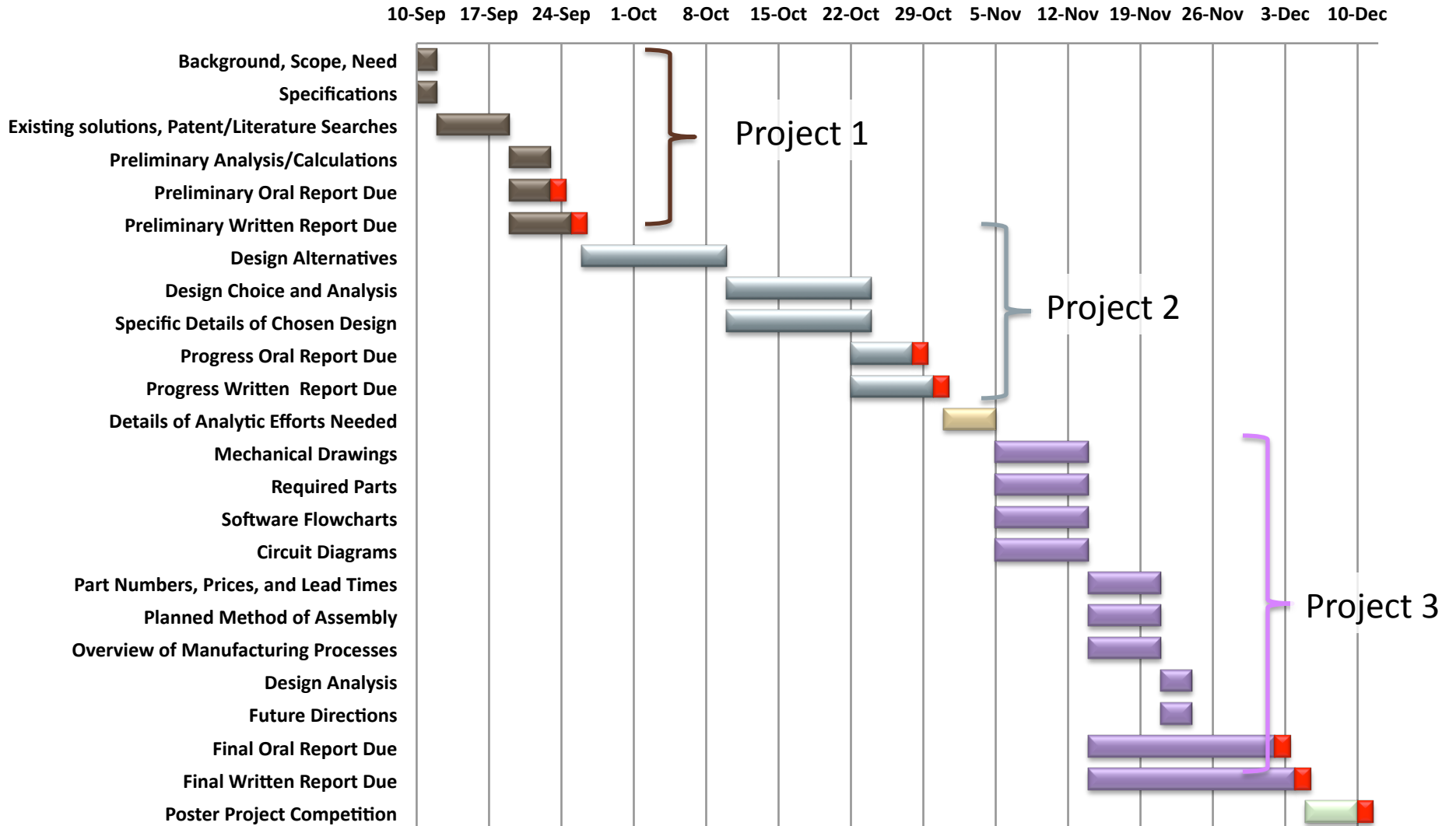
- Respiratory Rate: 10-25 cycles/min

$$10 \frac{\text{cycles}}{\text{min}} * \frac{1 \text{ min}}{60 \text{ sec}} = .17 \text{ Hz}$$

$$25 \frac{\text{cycles}}{\text{min}} * \frac{1 \text{ min}}{60 \text{ sec}} = .42 \text{ Hz}$$

- Challenge: Motion mechanism operating at low frequencies

# Preliminary Design Schedule



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# Questions?

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