Dynamic Beam Attenuator

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Clients:

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Advisor:

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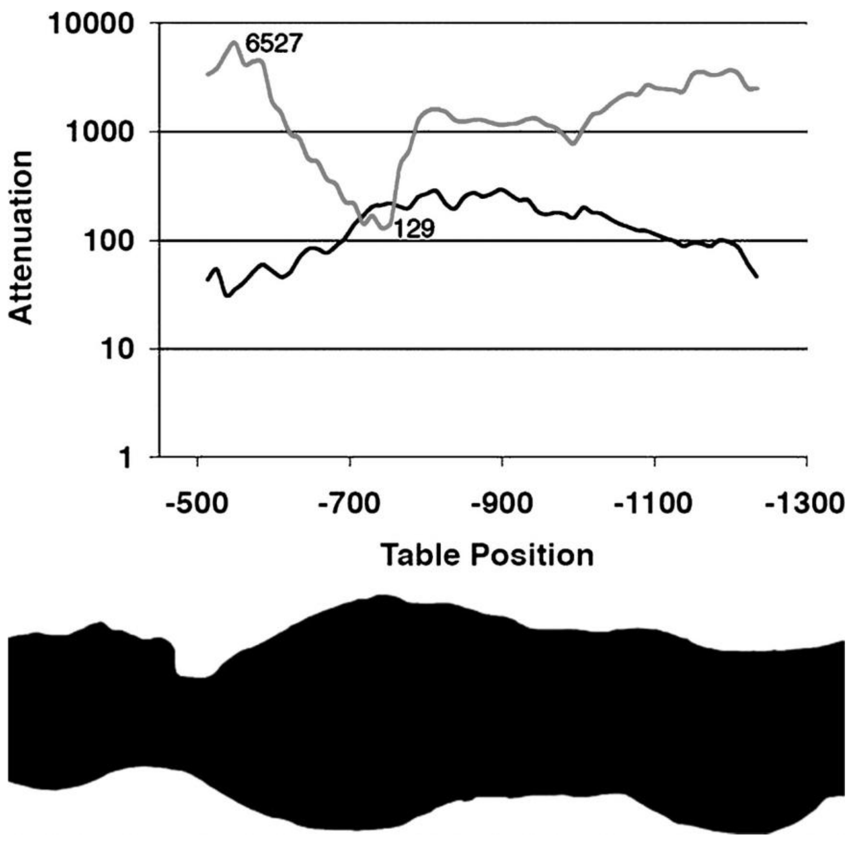
Background

- Clients: Dr. Mistretta and Tim Szczykutowicz
- X-Ray Computed Tomography[1,2] (CT)
  - X-Rays to image multiple planes in body
- Uses:
  - Diagnostic Imaging[3,4]
  - CT-Guided Procedures[5]

C-arm CT[6]

Problem Definition

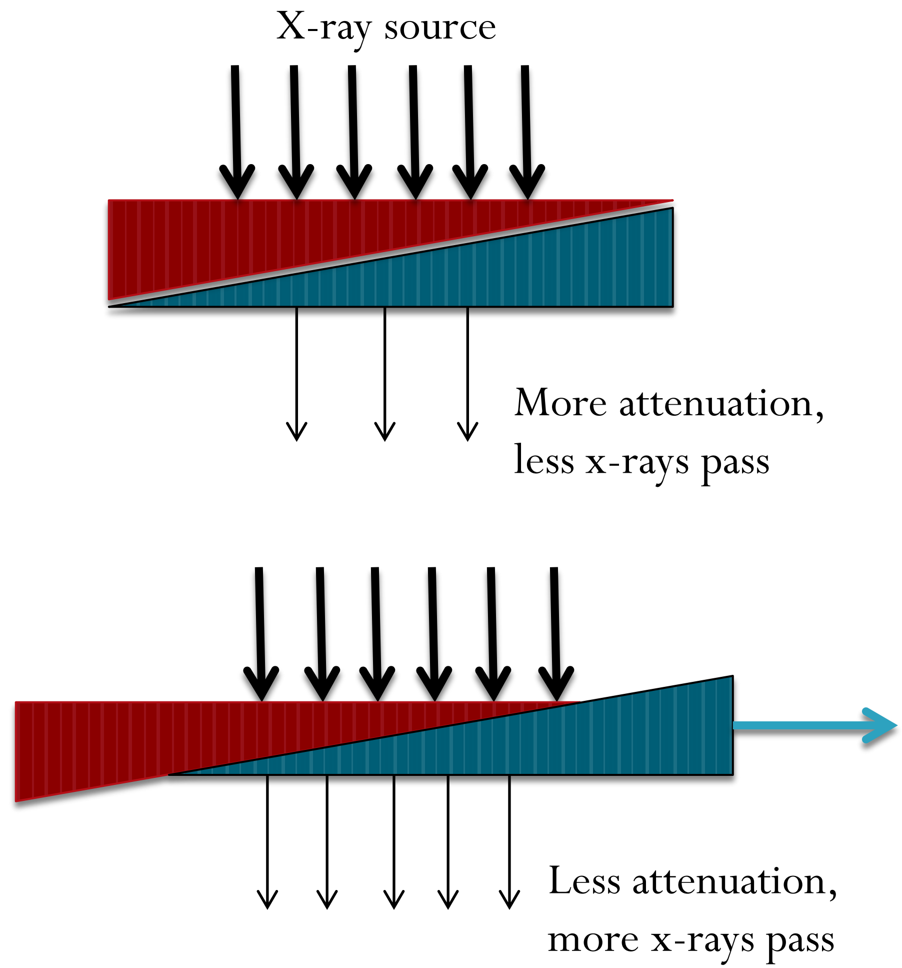
- Current CT scans lack dynamic dose modulation[7,8]
  - High x-ray doses
  - Low quality images
- Competing devices:
  - Bowtie filters
  - kVp modulation
  - No dynamic filters



Attenuation heterogeneity across the body

Design Criteria

- Client Proposal: Attenuate X-Ray dosages[7]
  - Wedge thickness
  - Changes over time
  - Improve signal to noise uniformity
- Budget: ~$5000
- Goal:
  - Proof of concept
  - Design new wedges with actuation



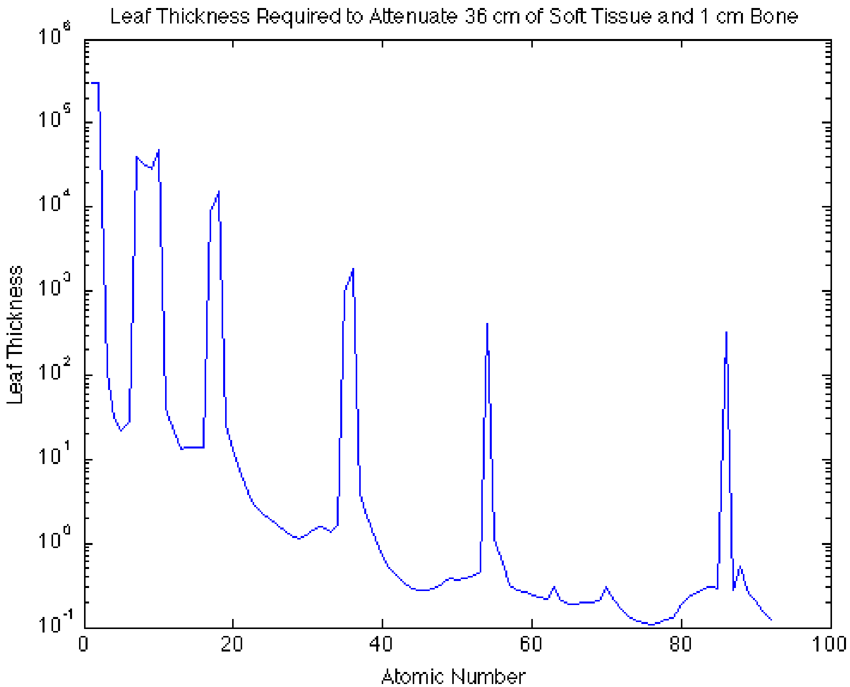
Current Prototype

- 10 steel wedges
- Fixed wedge plate on the top
- Very heavy
- Cannot optimally attenuate
- One wedge attached to one motor

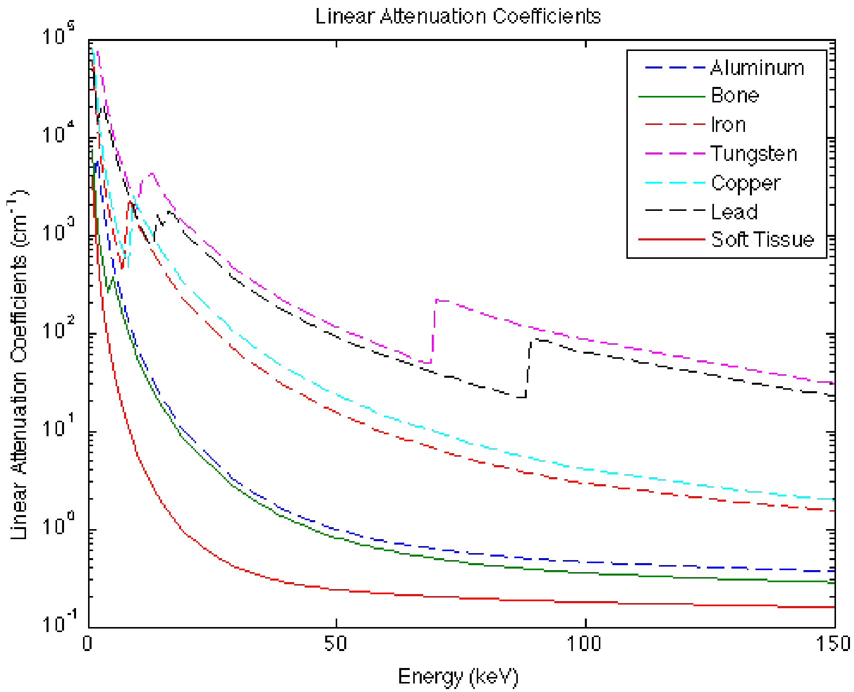
Current prototype with 10 steel wedges[7]

Material thickness & Beam Hardening

- Matlab simulations to model the wedge thickness required to attenuate 36 cm of soft tissue and 1 cm of bone
- Beam hardening: Energy change of x-rays as it passes through the material

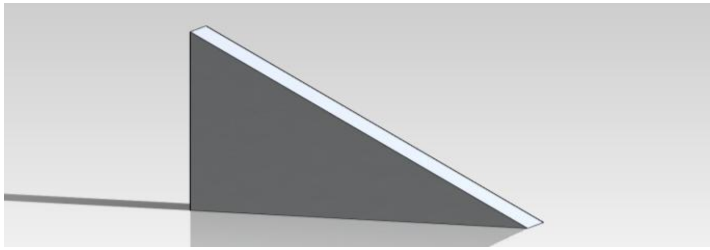
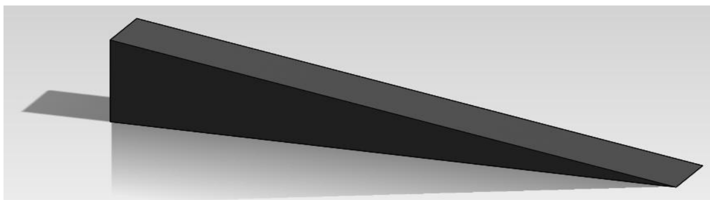
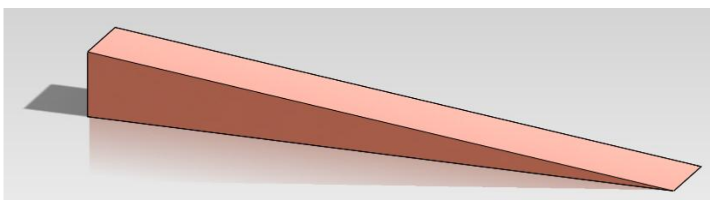
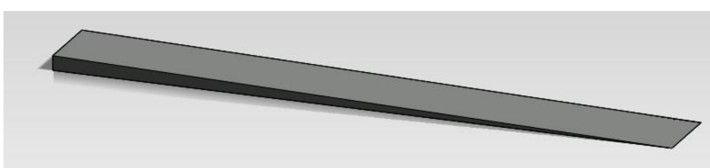
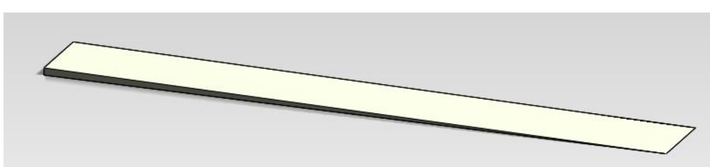


Thickness required for every element



Linear attenuation coefficients

Wedge Material

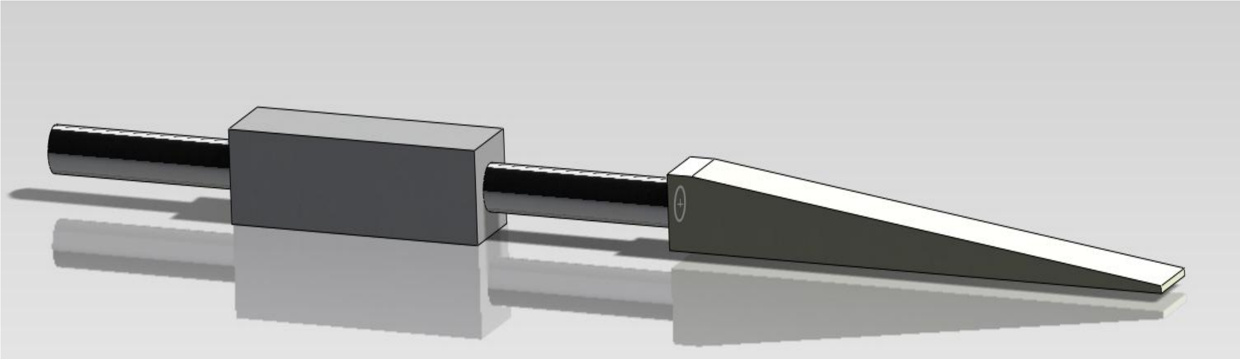
		Heel Thickness (mm)
	**Aluminum**	129.7
	**Iron**	16.3
	**Copper**	11.4
	**Lead**	2.5
	**Tungsten**	1.2

Materials Design Matrix

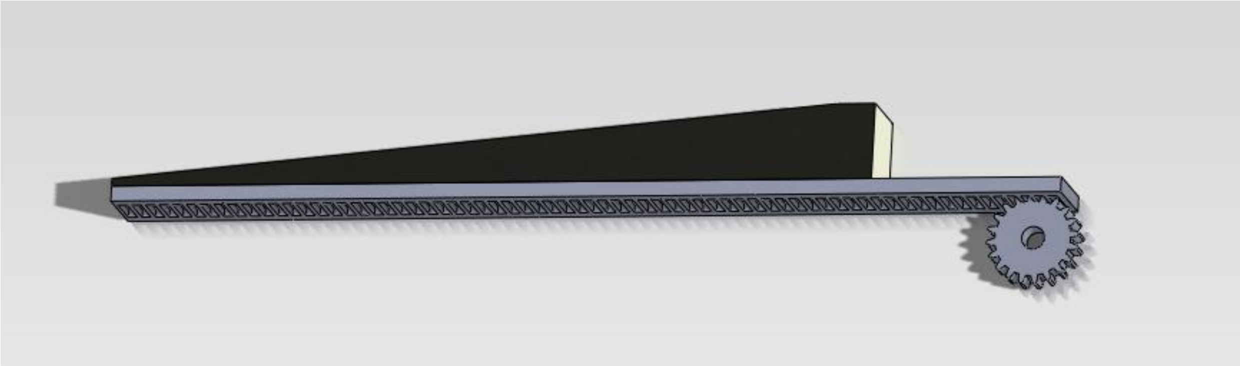
Criteria	Weight	Lead	Tungsten	Copper	Iron	Aluminum
Leaf Thickness	**4**	4.91	10	1.06	0.74	0.09
Beam Hardening	**2.5**	7.96	10	7.36	7.4	8.23
Machinability	**2**	6	2	6	8	10
Cost	**1**	2.33	0.10	1.36	4.27	10
Weight/Heaviness	**0.5**	8.33	10	2.27	1.80	0.66
Total (out of 100)		**58.0**	**74.1**	**37.1**	**42.6**	**51.3**

Note: Values quantitatively determined and normalized to a scale from 1 to 10. Each criteria was weighted so that the grand total was from 1 to 100.

Wedge Actuation



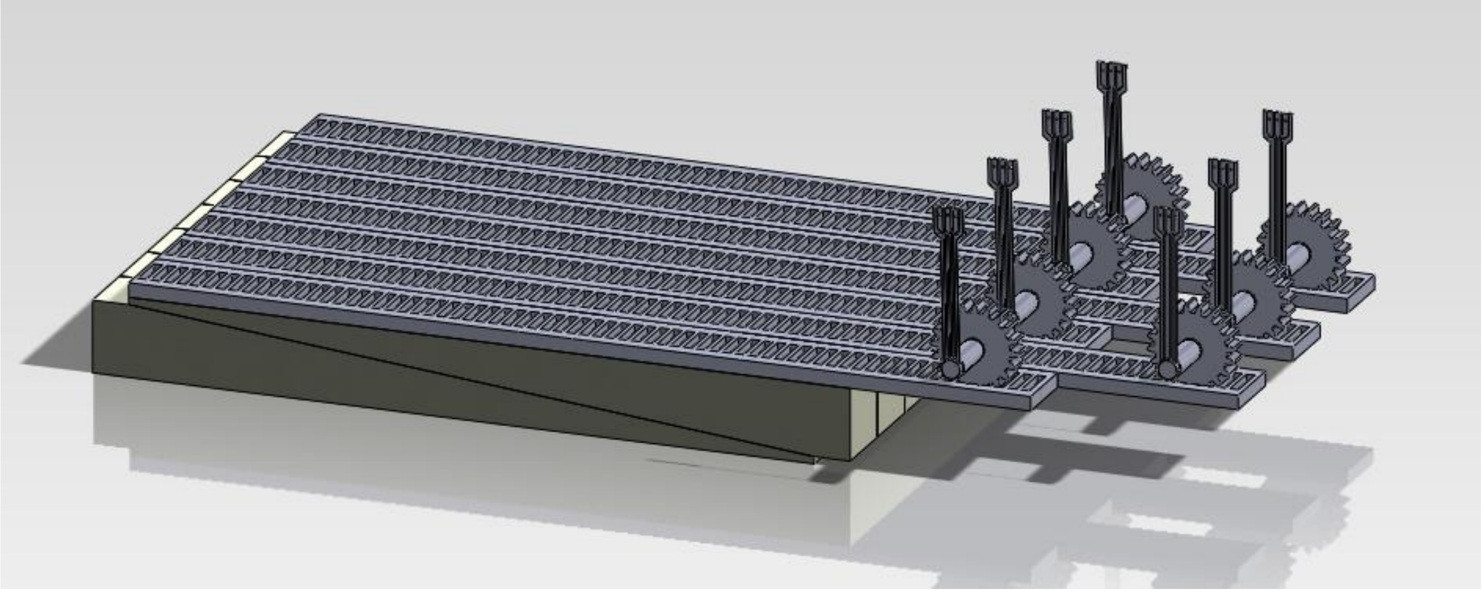
Wedge with linear actuator



Wedge with rack and pinion

Preliminary Design

- Tungsten wedges with rack and pinion actuation in flush configuration
- Motors placed on same side with alternating positions
- Actuation and configuration may not be the final design



Proposed design based on size restraints
(Wedge thickness not drawn to scale)

Future Work

- Machine wedges and housing
- Select, purchase, and implement actuation mechanism
- Assemble entire device
- Program the device
- Test with phantoms

Acknowledgements

- Clients: Chuck Mistretta and Tim Szczykutowicz
- Advisor: Dr. Paul Thompson
- Siemens engineer: Kevin Royalty
- Erick Oberstar

References

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[2] Goldman, L., *Principles of CT and CT Technology*. J. Nucl. Med. Technol, vol. 35, no. 3, pp. 115-128, 2007.

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