

Fetal Radiation Shield

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Outline

- Background
- Problem Statement
- Alternative Solutions
- Design Requirements
- Design Alternatives
- Design Matrix
- Future Work
- References
- Acknowledgments



Figure 1: Radiation suite

Background

- Radiation therapy for pregnant patients affects 4000 patients in the US each year [1]
- Want to limit radiation dose to the fetus [1]
- Primarily brain and breast cancer therapy [1]
- Best solution is altering treatment plan
- Leakage from the head of the radiation machine



Figure 2: Radiation suite, machine, and table [5]

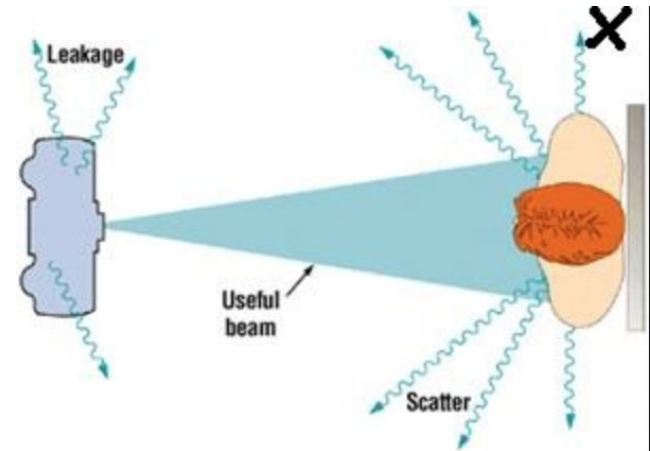


Figure 3: Radiation scatter explained [5]

Problem Statement

- A custom shield to physically block radiation scatter from the fetus during radiation treatment
- Must be:
 - Safe
 - Effective
 - Mobile
 - Adaptable to a variety of treatment delivery machines/techniques
- Budget is \$10,000 for final fabrication

Other Proposed Solutions

- University of Michigan's "U-Shield" design [2]
- Bridge over a patient [3]
 - Immediately rejected due to safety concerns
- Table over a patient [3]
 - Rejected due to the table not being able to support enough weight

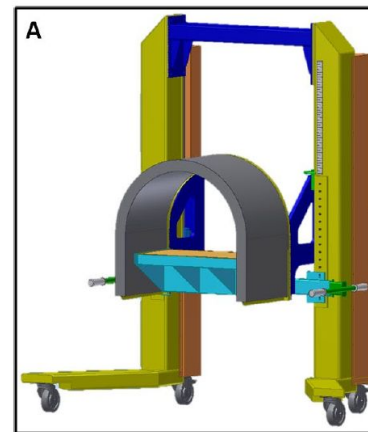


Figure 4: University of Michigan design

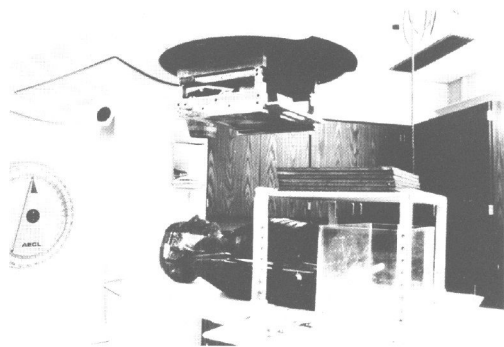


Figure 5: Bridge over patient

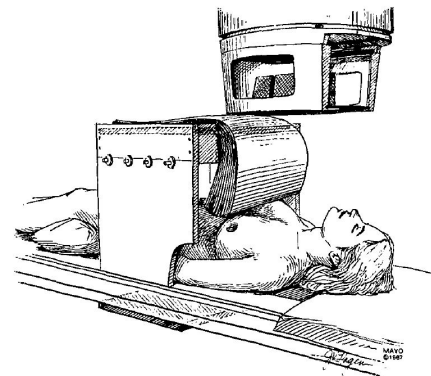


Figure 6: Table over patient

Design Requirements

- Block at least **50% of radiation** capable of reaching the fetus
- **5 cm** thick of lead
- **Safe** for patient and technicians to operate
- **Easy storage** when not in use
 - Must fit through a 1.2m x 1.8m opening
- Compatible with women of **all shapes and stages** of pregnancy
- **Easily transported** between treatment rooms
- Able to **move vertically** and **straddle a 53 cm wide treatment table**

Treatment Room and Storage

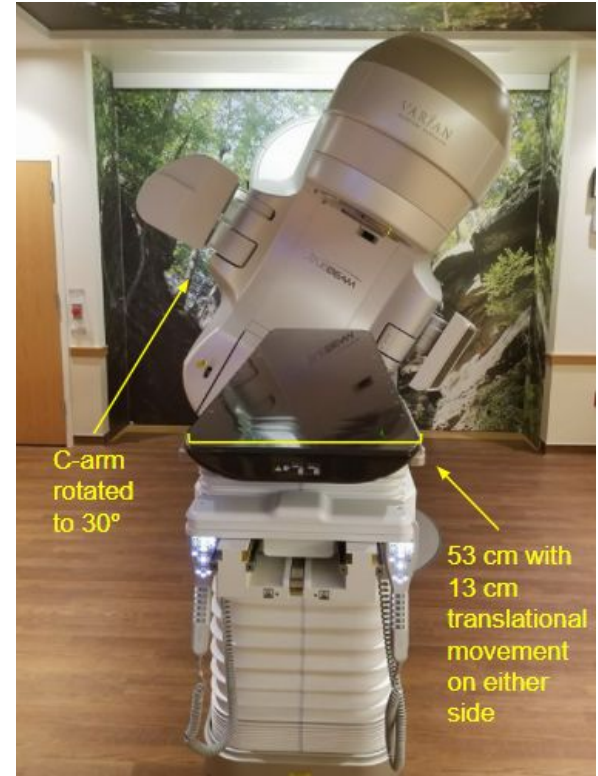
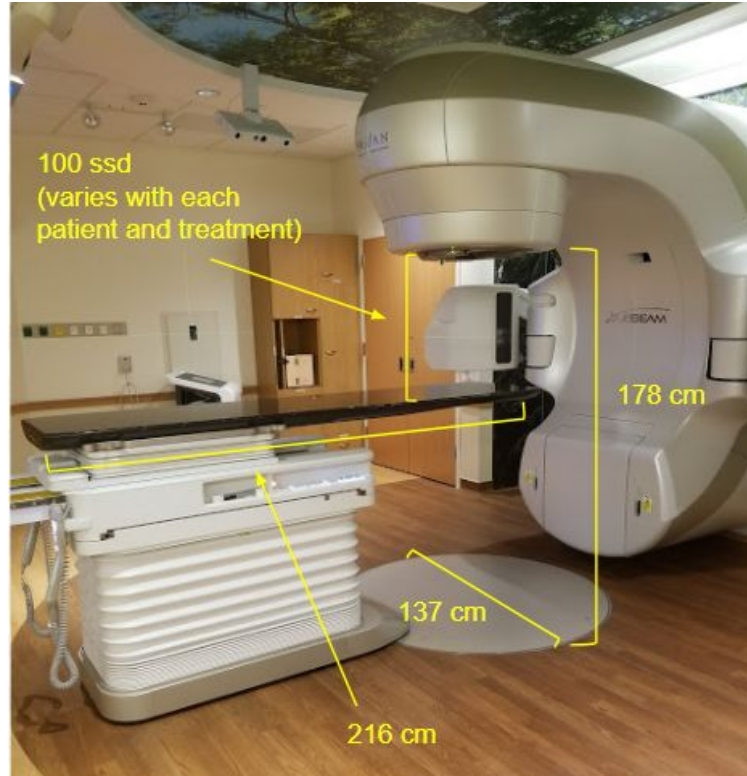


Figure 7&8: UW Hospital radiation therapy treatment suite

Design Alternatives

Shield Shape Idea 1

- **Helmet**
- Thick on the sides
- Added range of motion
- Pivots toward the abdomen

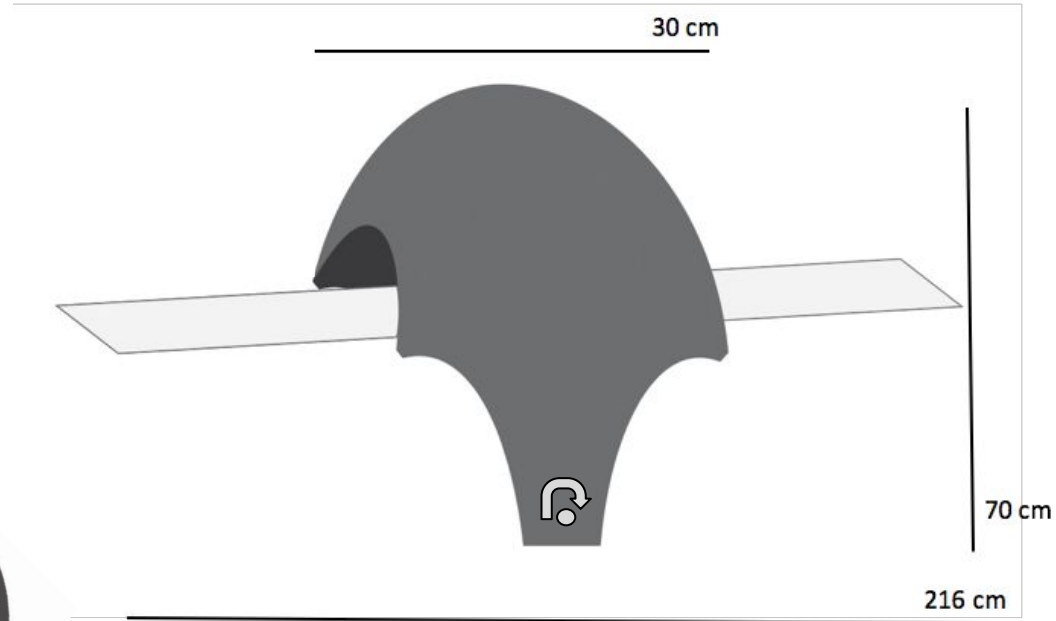
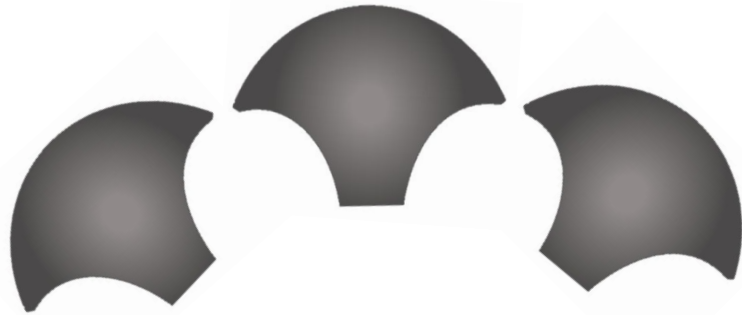


Figure 9&10: Design Idea 1

Shield Shape Idea 2

- **Modified-U**
- U-shaped with extended coverage on the superior side
- Ends extend past treatment table
- Mobile in the vertical direction

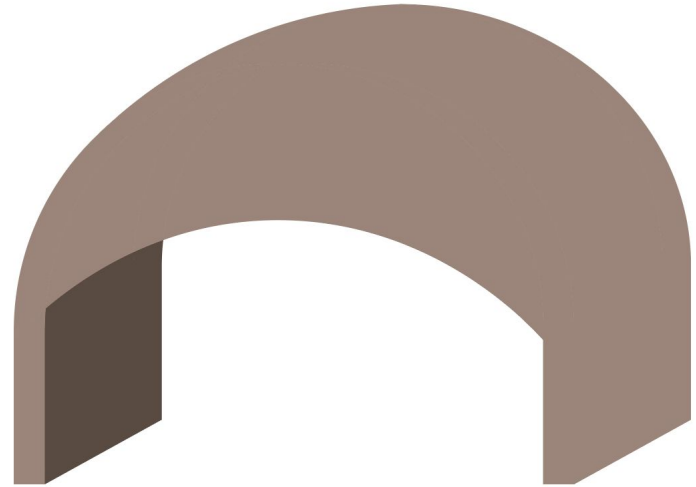


Figure 11: Design Idea 2

Shield Shape Idea 3

- **Wall Shape**
- Solid vertical sheet of lead
- Mobile in the vertical direction
- Focuses on deflecting leakage from head

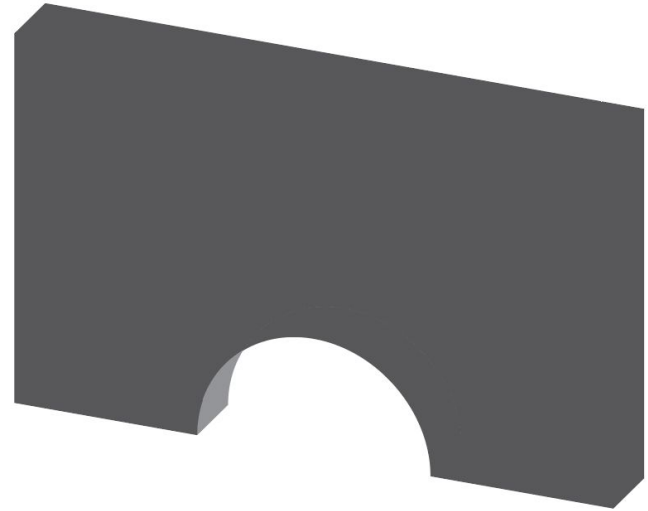


Figure 12: Design Idea 3

Support Mechanism

- Suspended vs. anchored
- Locking wheels
- Hydraulic lift system
- Frame will vary, based on which design is chosen



Figure 13, 14, 15: Support mechanism considerations

Design Matrix

	Modified U	Helmet	Wall
Cost - 5	(4/5) 4	(4/5) 4	(5/5) 5
Safety - 30	(5/5) 30	(4/5) 24	(4/5) 24
Ease of Use - 15	(5/5) 15	(4/5) 12	(5/5) 15
Weight - 15	(3/5) 9	(5/5) 15	(1/5) 3
Shielding - 25	(3/5) 15	(5/5) 25	(3/5) 15
Cleanliness - 10	(5/5) 10	(4/5) 8	(5/5) 10
TOTAL	83	88	72

What We Chose

Helmet (anchored)

- Anchored support = safer
- Pivot allows for adjustment to patient shape/size
- Dome-like shape allows for more superior and inferior coverage

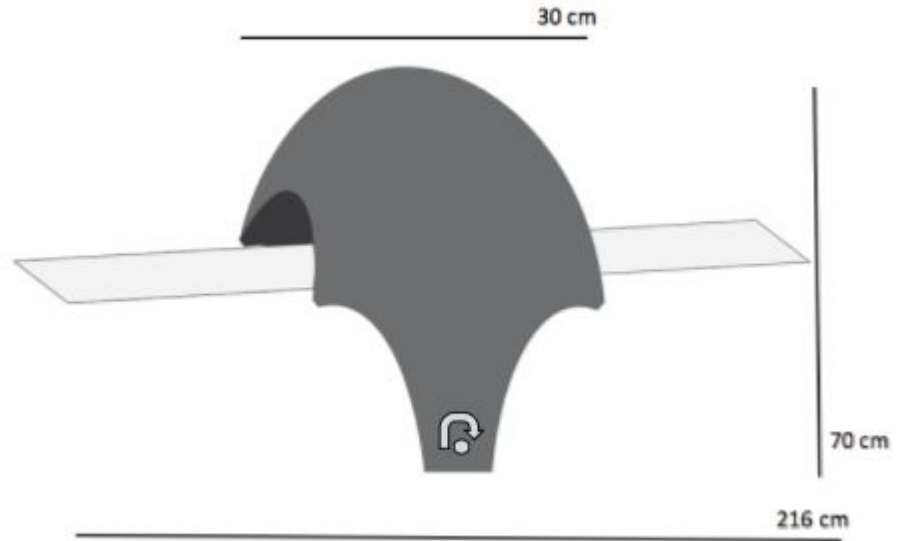


Figure 16: Final design idea and dimensions

Future Work

- Structure
- Prototype
 - Made of styrofoam or cardboard
 - CAD
- Testing
 - CAD
 - Phantom
- Fabrication Plan

References

- [1]P. Basta, A. Bak and K. Roszkowski, "Cancer treatment in pregnant women", *Współczesna Onkologia*, vol. 5, pp. 354-360, 2015.
- [2]A. Owrangi, D. Roberts, E. Covington, J. Hayman, K. Masi, C. Lee, J. Moran and J. Prisciandaro, "Revisiting fetal dose during radiation therapy: evaluating treatment techniques and a custom shield [JACMP, 17(5), 2016]", *Journal of Applied Clinical Medical Physics*, 2017.
- [3]M. Stovell and C. Robert Blackwell, "501 Fetal dose from radiotherapy photon beams: Physical basis, techniques to estimate radiation dose outside of the treatment field, biological effects and professional considerations", *International Journal of Radiation Oncology*Biophysics*, vol. 39, no. 2, p. 132, 1997.
- [4] McGeeney, M. (2016). *Replaced Linear Accelerator to start treating patients at SVMC*. [online] The Bennington Banner. [Accessed 5 Oct. 2017].
- [5]: "Radiation Protection For The X-Ray Technologist", 2017. [Online]. [Accessed: 05- Oct- 2017].

Acknowledgements

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Questions?