301 - Excellence - 42 - Fetal Radiation Shield - Executive Summary

Approximately 4,000 pregnant U.S. women will be diagnosed with cancer requiring radiation therapy and will face with the difficult decision to either pursue treatment or delay treatment until after the birth. Many patients will choose to delay treatment to minimize risks to the developing fetus. However, in some cases, the risk of the cancer to the patient will outweigh the potential risk of radiation exposure to the fetus, therefore precautions must be taken to reduce radiation leakage and scatter that could harm the fetus.

Despite the very low incidence of pregnant women undergoing radiation therapy, the risks posed to a patient by foregoing critical treatment or to the fetus by radiation exposure, in addition to the dearth of established protocols to minimize fetal radiation, warrant a solution. The aim of this project is to create a fetal radiation shield that: 1) is capable of consistently blocking 50% of fetal radiation, 2) can be moved between treatment room and storage place, 3) can be raised and lowered, and above all, 4) is safe for the patient and all medical personnel involved. The total budget is $10,000.

Current efforts to reduce fetal dose are limited to altering the treatment parameters such as angle and direction of the beam. Lead “shields” were previously fashioned during the 1990’s by manually stacking lead bricks or sheets on a bridge or table placed over the treatment couch, which has been discontinued due to safety risks posed to patients and medical personnel. Placing a Cerrobend brick against the head of the treatment machine to block radiation leakage to the fetus at the source has been proposed, but was discontinued due to safety concerns and inefficiency. In 2010, the University of Michigan’s Medical Innovation Center developed a mobile, U-shaped shield with a sophisticated locking system and hydraulic motors. Despite its efficacy, the design led to the bankruptcy of the manufacturing company due to cost. Hence, there currently exists no safe, commercially-available product to minimize fetal radiation dose.

We have worked with our client, Dr. Zachariah Labby, an assistant professor in the Department of Radiation Oncology at the University Hospital of the University of Wisconsin-Madison, to first devise the “High-waisted Skirt” lead radiation shield design. This shield shape was designed with multiple design components in mind. We evaluated the projectile motion of radiation photons towards the fetus, the dimensions of a pregnant as they vary both throughout pregnancy and between different patients, and the physical constraints of the treatment room. In doing so, we came up with the “High-Waisted Skirt.”

The second component to this project is the support and movement of this shield we designed. Expected to weight roughly half a ton, the shield will need a mechanism to be safely supported over the patient and table, raised and lowered to accommodate treatment, and then moved in and out of the various treatment rooms. We came up with a support design that includes two linear actuators and a threaded rod on either side of the shield. Each of these components is capable of lifting the shield individually, thus incorporating a fail-safe mechanism into the support. Additionally, a steel casing will be designed around the lead shield in order to ensure the integrity of the shield, but also to attach the supporting system.

The team has modelled the the shield and support structure in Solidworks as our current prototype. This has been vital to mechanical testing of the support for the shield structure weighing roughly half a ton. Additionally, a fabrication plan has been devised with Vulcan Manufacturing of Milwaukee, WI, who will manufacture the lead shield.