Finding a Model for an X-Ray System: Explosives Detection for Airport Baggage Scanners

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Introduction: The detection of explosives in baggage is very important to aviation security. Baggage scanners can use X-ray technology to both determine the shape of the objects inside a bag, but also to determine what kind of material is inside the bag. In order to use the X-ray system to determine what type of material is inside the bag, one method requires you to know almost everything about the X-ray system. We studied an X-ray system at the Transportation Security Laboratory (TSL) and created a model. This model could be used in future studies to detect explosives better.

Theory: Objects cast shadows on the screen caused by X-rays in the same way normal shadows work. If the object is very dense or thick, then the object will block or absorb the X-rays and the screen will be dark. If an object is not very dense or thick, then the object will not absorb all of the X-rays and the screen will be brighter.

We measured the:

Transmission: how much of the X-rays reach the screen
Absorption: how much of the X-rays are absorbed

Different materials will have different transmissions and absorptions of X-rays. It is possible to calculate a theoretical value based on the material and the system. Because we know the material, we are instead trying to understand the system.

Figure 1: An example X-ray.

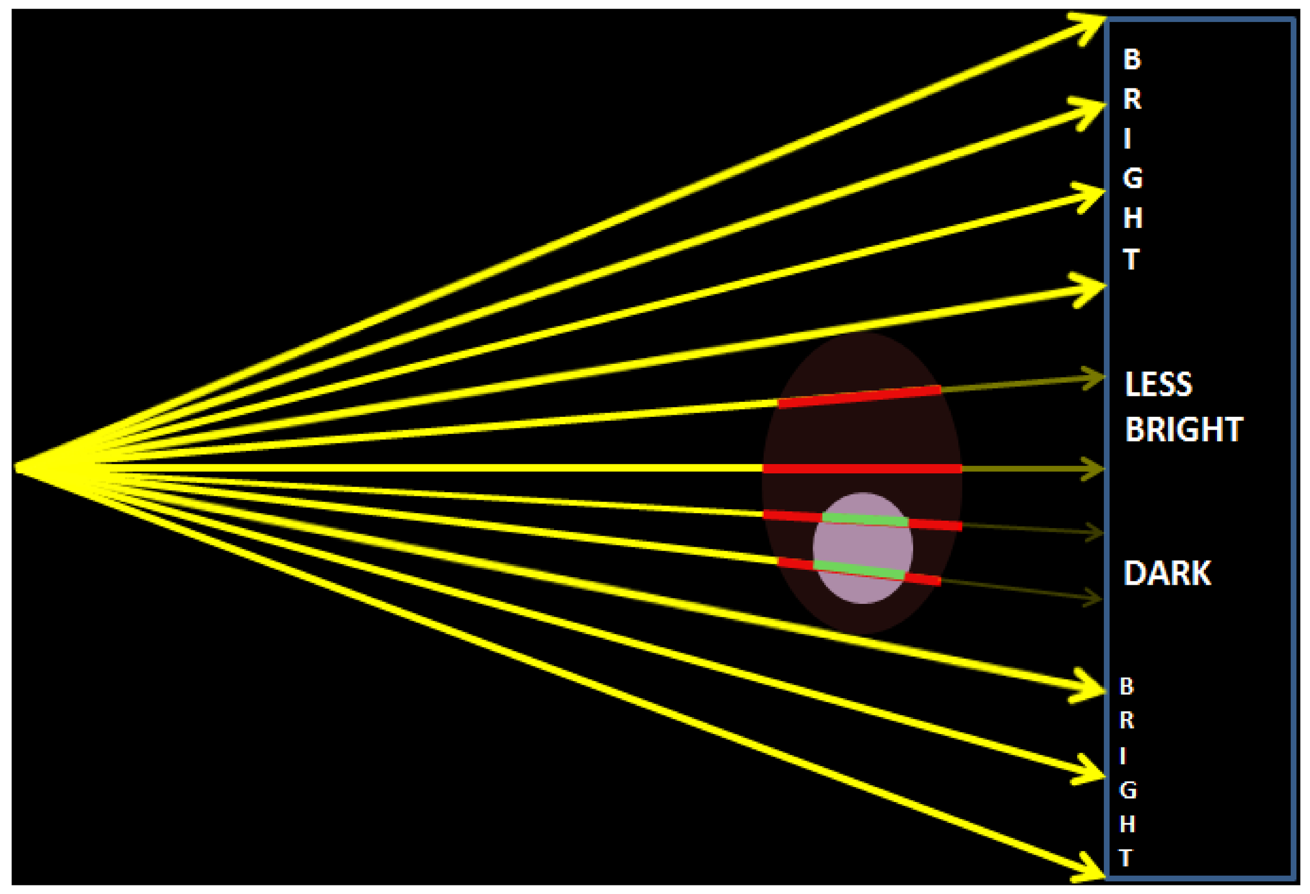


Figure 2: A schematic of how an X-ray image is produced.

Data Collection: Data was taken using the TSL High Energy X-Ray (HEX) system. There were six samples shaped like step wedges. The materials were Aluminum, Delrin, Teflon, Propylene Glycol, and Water. Software was written to determine the transmission and absorption for all the data.

The HEX System:

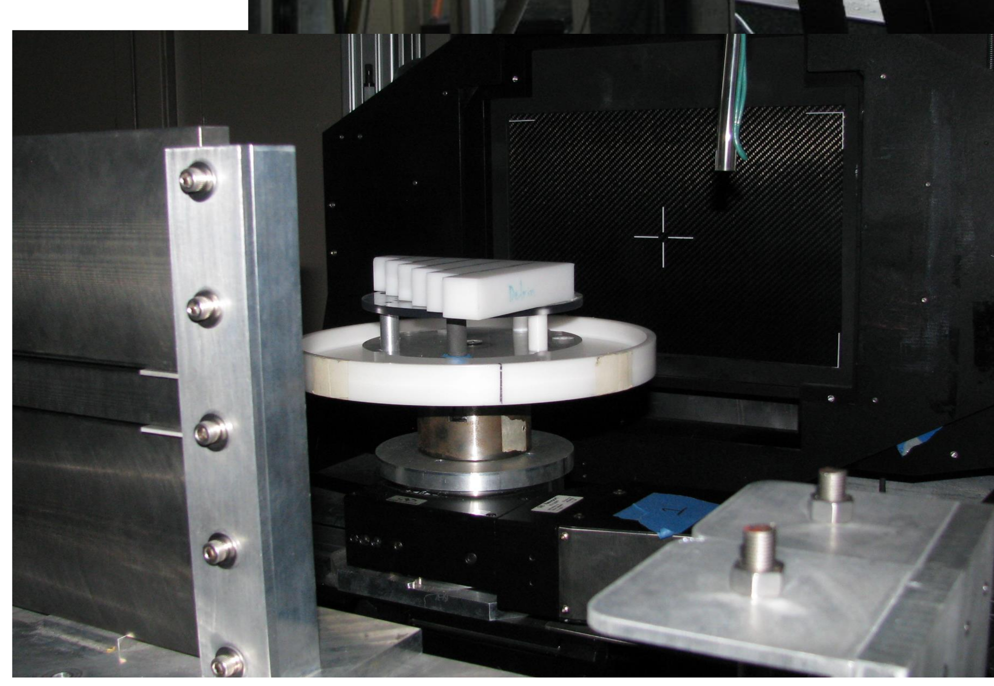
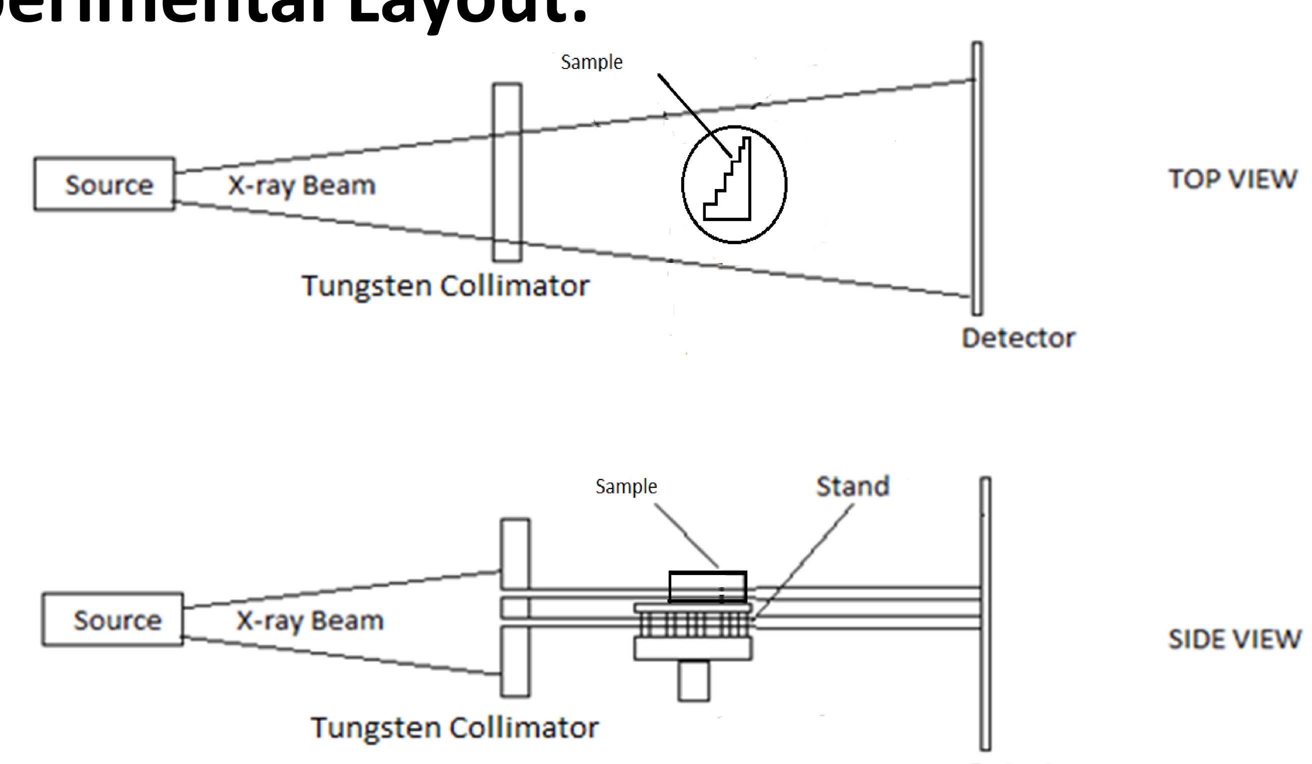
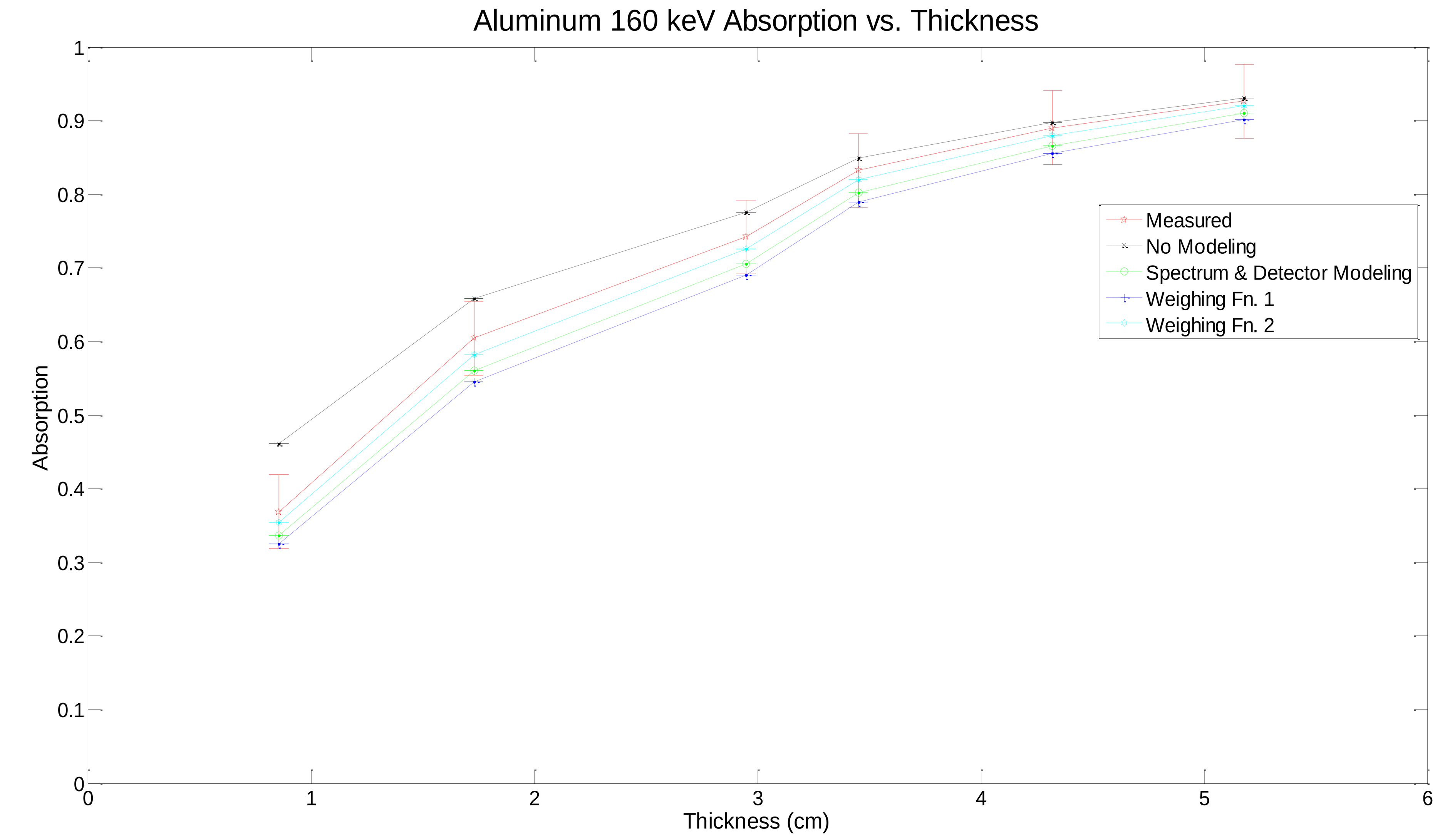
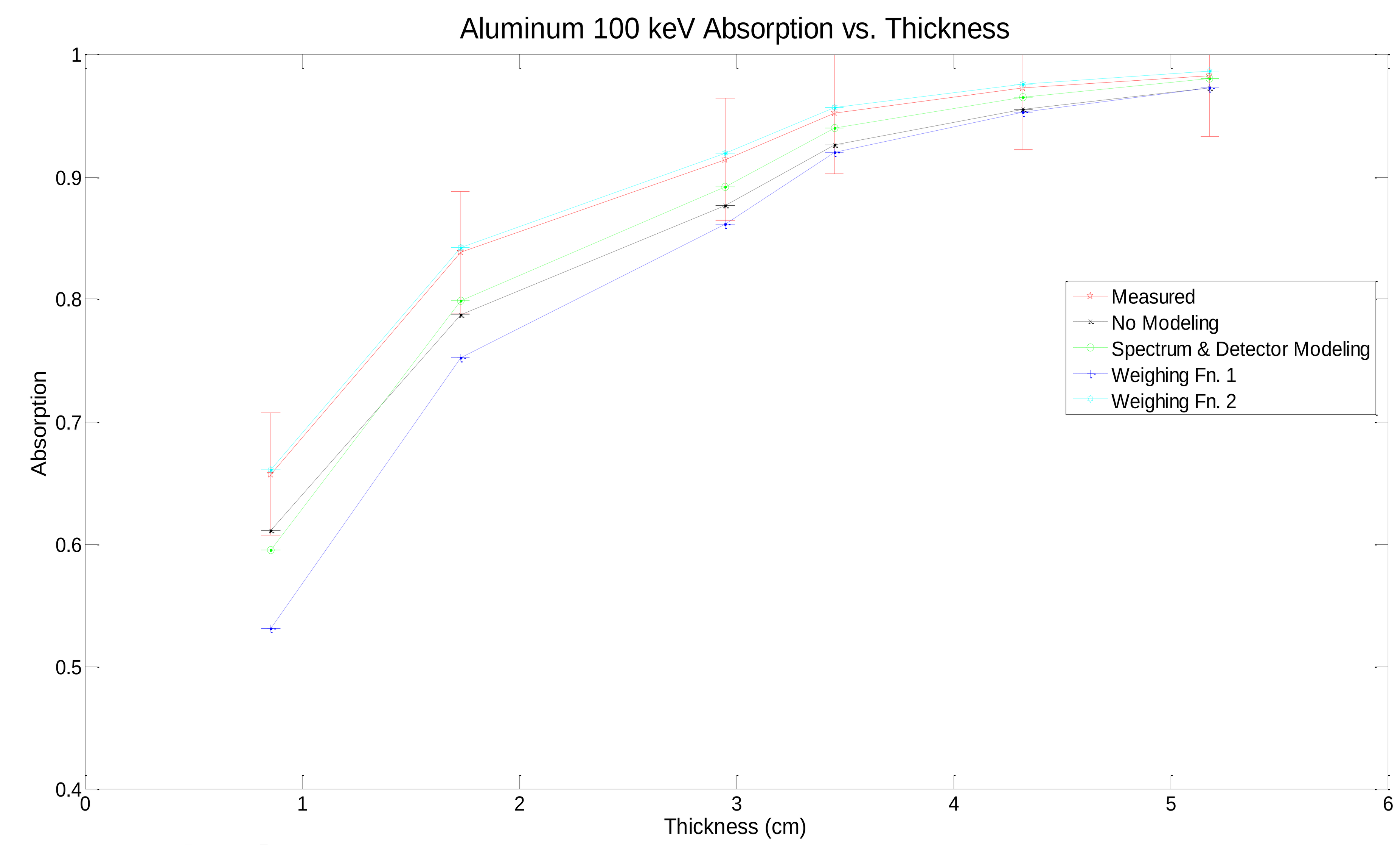


Figure 3: Photographs of the experimental set up.

Experimental Layout:







Data Analysis: Using known values about the materials we were able to calculate different theoretical values with different models for the system. The theoretical value for the absorption had to be close to the measured value from the data. We tried a lot of different models for the system until we were able to match the measured values for all of the materials used at two different energy scans.

Figure 4: Examples of airport baggage scanners.

Conclusion: We measured the X-ray absorption of six different materials at two different energy scans and varying thicknesses. The X-ray absorption of a material depends on what type of material it is and the X-ray system model. We determined the best X-ray system model for all of the data. This X-ray system model can be used in future studies at the TSL for baggage scanners in order to better detect explosives for aviation security.