Cornell University
Cornell High Energy Synchrotron Source

Cooper C. Hanley, August 2016

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Design of Downstream Slit Upgrades for White Beam X-ray Diffraction Experiments

Introduction

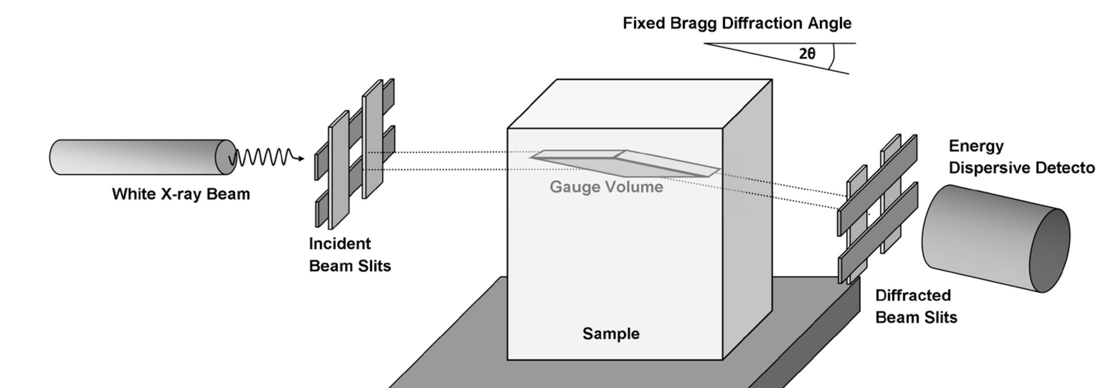
White beam x-ray diffraction experiments use a polychromatic beam with an energy spectrum of 40-100 keV. These high energies allow the x-rays to penetrate through real sized samples. The ability to watch a materials strain reactions to loading on an atomic level aids engineers in the design process of large scale projects. When looing at large samples using x-ray diffraction, it is important to have the ability to control what region of the sample you're looking at. Upstream and downstream slitting allow you to control the volume of diffracted x-rays seen by the detector. The ability to focus in on a specific volume of your sample and see how it reacts relative to other locations helps engineers learn how certain materials and shapes react to different loads. The current apparatus for downstream slitting used by Chris Budrow for his research in residual stress is intensive to set up and ultimately doesn't have the necessary abilities required for downstream slitting. The goal of this project was to design a downstream slitting apparatus that dramatically cut down on experiment set up time and has all the necessary attributes to provide effective downstream slitting for white beam x-ray diffraction experiments at the A2 beamline in CHESS.

Design Requirements

The goal of this project was to improve the downstream slitting in the A2 hutch at CHESS. The following is a list of objectives for the redesign:

- Rigid
- Light Weight
- Motorized Translation
- X-ray Shielding
- Cost Effective

X-ray Diffraction Experiment



https://en.wikipedia.org/wiki/File:EDXRD_Schematic.png#/media/File:EDXRD_Schematic.png

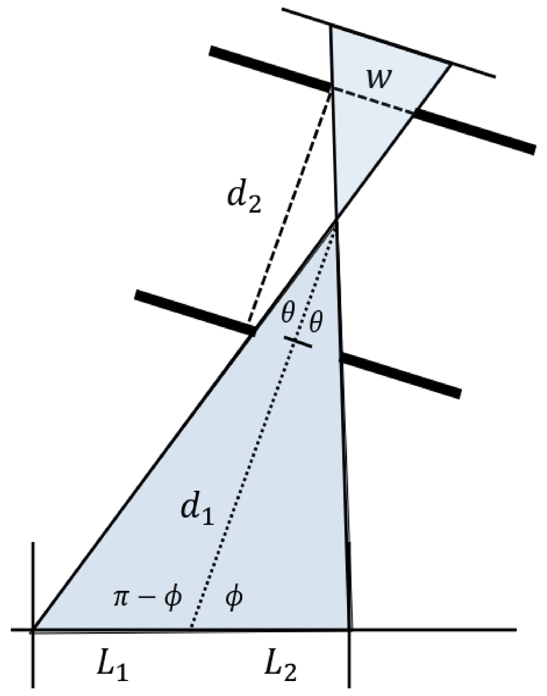
Energy Dispersive X-ray Diffraction

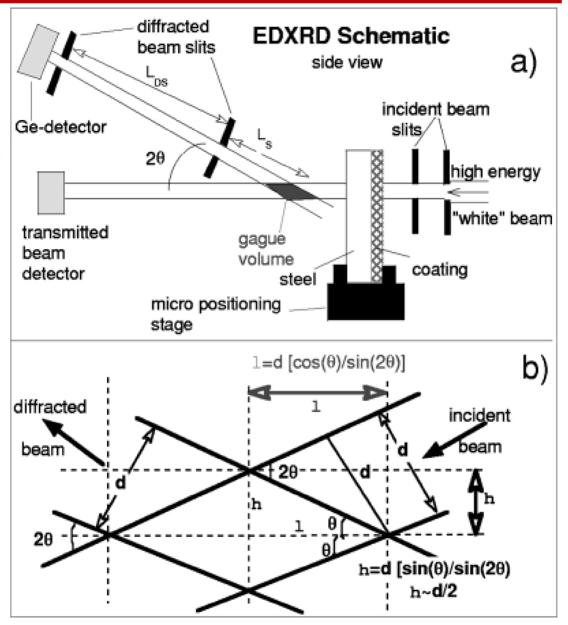
- Polychromatic beam
- Penetrates real sized samples

$$n\lambda = 2d\sin\theta$$ Bragg's Law

- *Fix θ, Measure λ*
- Solve for d spacing

Downstream Slitting





$$L_1 = \frac{\sin\theta}{\sin(\emptyset-\theta)}\left(d_1+\frac{d_2}{2}\right)$$

$$L_2 = \frac{\sin\theta}{\sin(\pi-\emptyset-\theta)}\left(d_1+\frac{d_2}{2}\right)$$

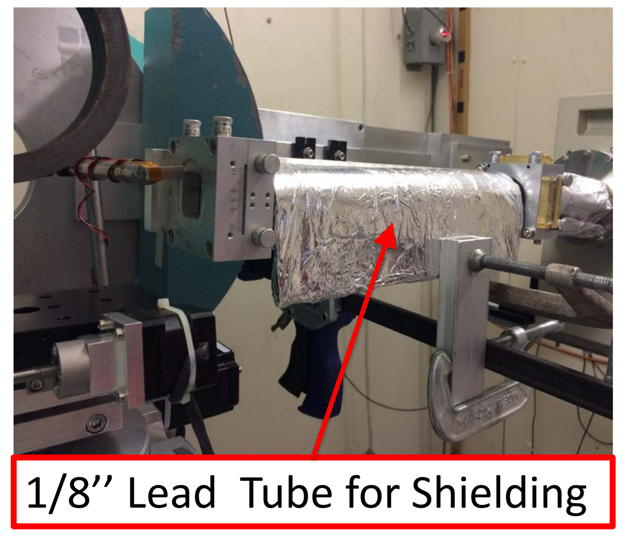
$$Res \cong L_1 + L_2, \quad \theta \cong \frac{W}{d_2}$$

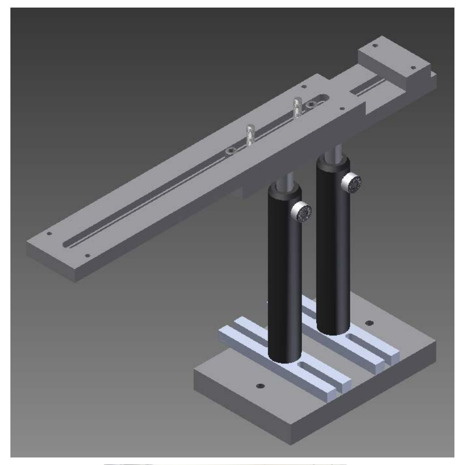
$$Res = w\left(\frac{d_1}{d_2}+\frac{1}{2}\right)\left(\frac{1}{\sin(\emptyset-\theta)}+\frac{1}{\sin(\pi-\emptyset-\theta)}\right)$$

Objectives:

- Smallest possible resolution.
- Maximize d_2 spacing.
- Motorized translation to change d_1 and d_2.

Existing Solution





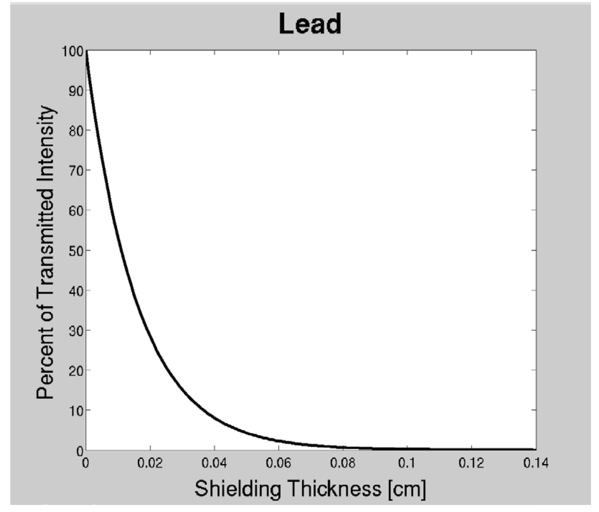
- Manual alignment and adjustments.
- Fixed spacing between slits.
- Pliant mounting system.

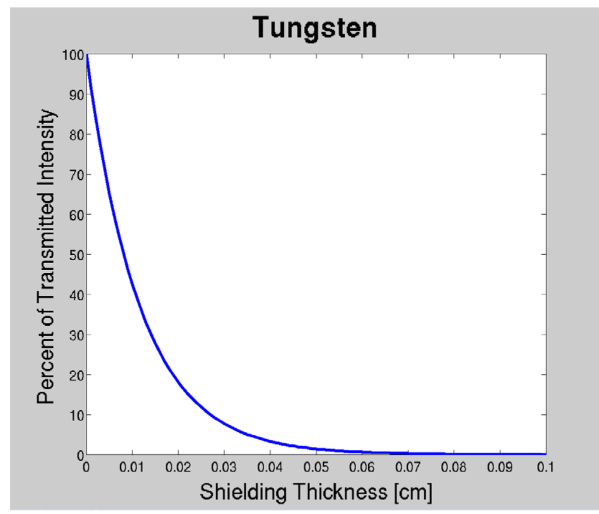
X-ray Shielding

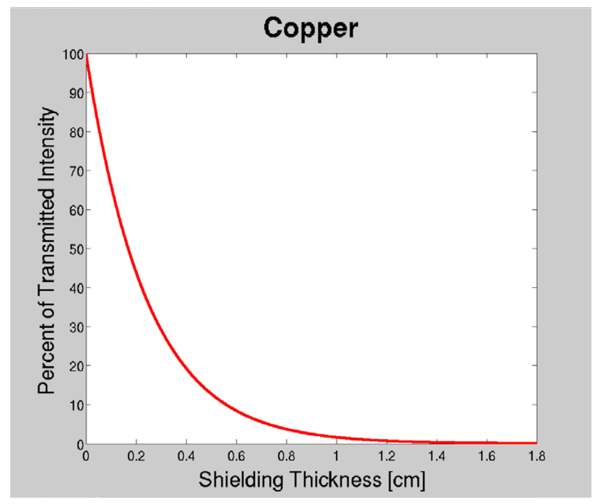
Shielding between slits reduces detector noise from background radiation.

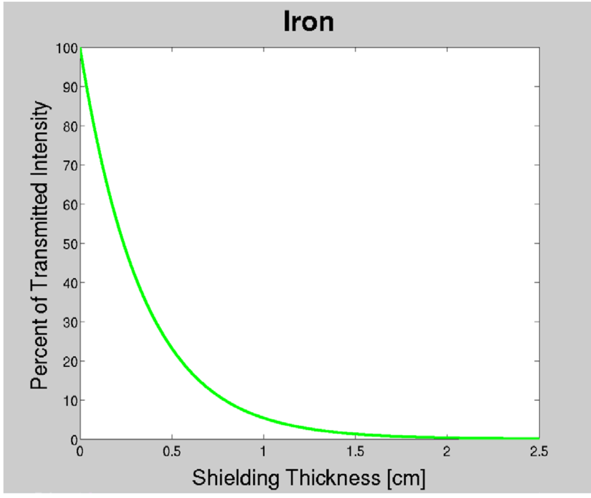
- Material Constraints

- Appropriate x-ray attenuation and absorption properties
- Structural and Machinable



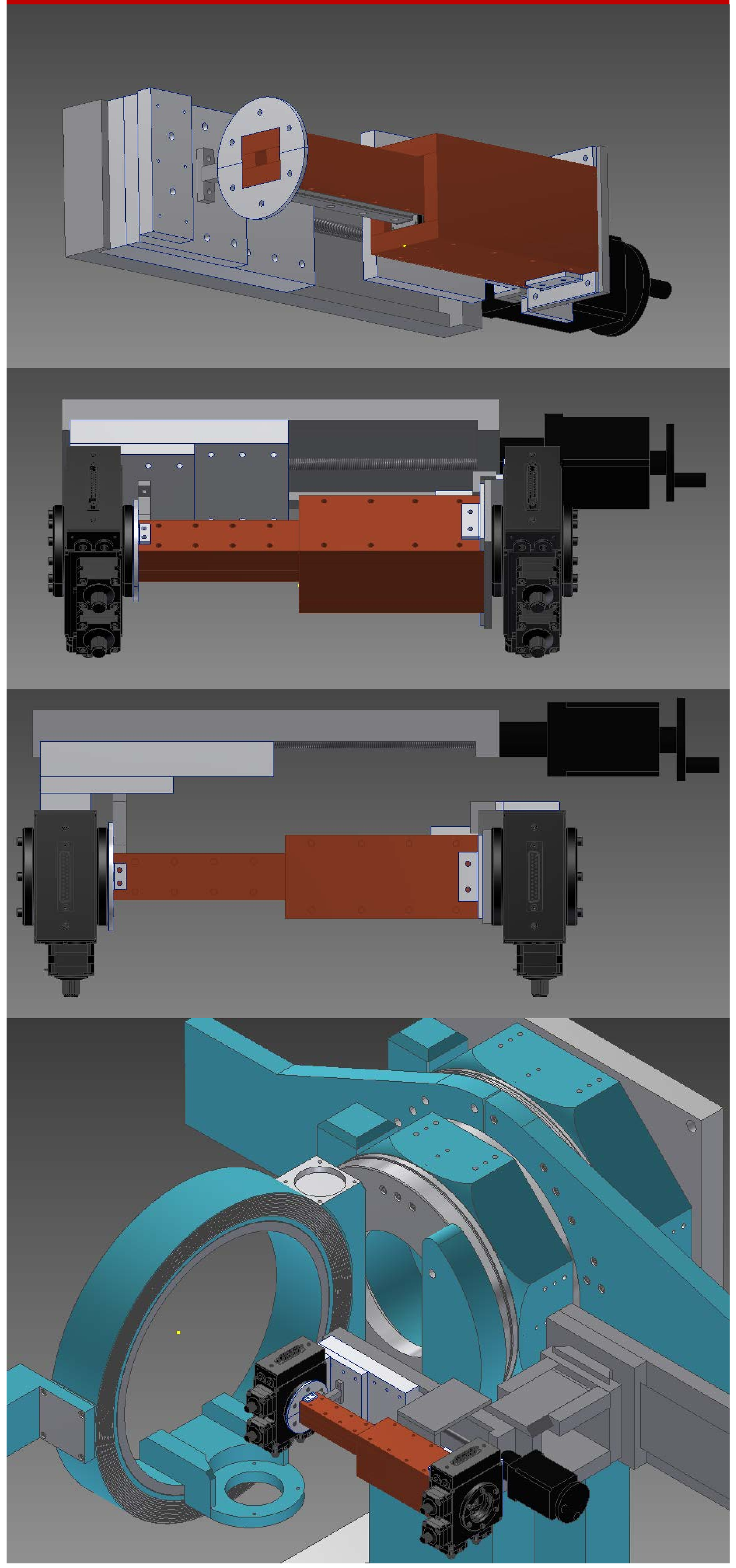






Figures: Percent of Transmitted Beam Intensity vs. Shielding Thickness for different elements at a beam energy of 100 keV.

Design



CHESS

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