X-Ray Shielding

SLAC NATIONAL ACCELERATOR LABORATORY

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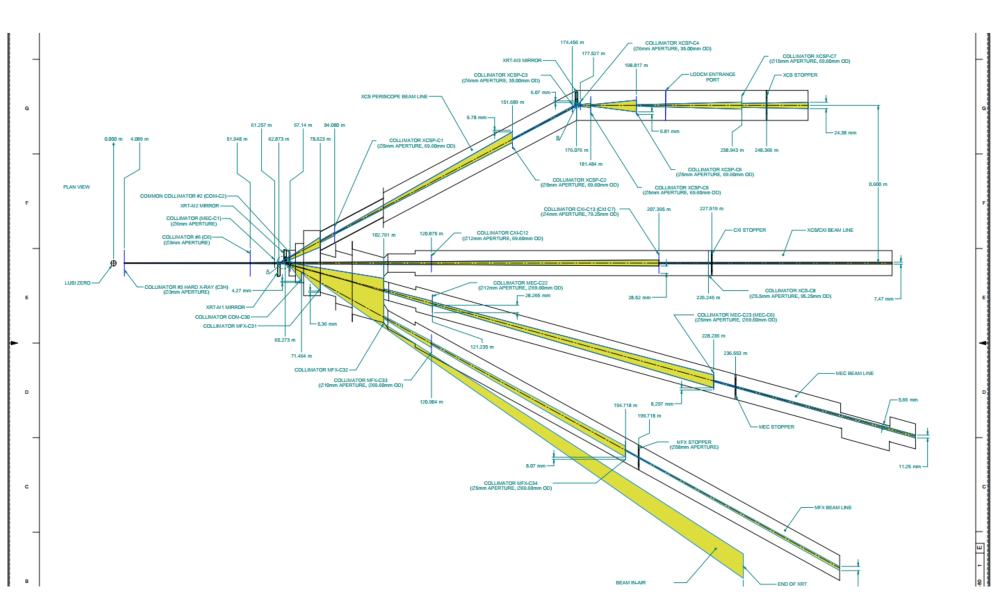
Introduction

X-Ray shielding is a necessary part of safety at SLAC. As X-Rays are diffracted off of materials in a sample chamber, radiation may escape and damage materials in the hutch or personnel. In this project we will explore how sheetrock (calcium sulfate dihydrate) is used as a cheap and effective shielding material.

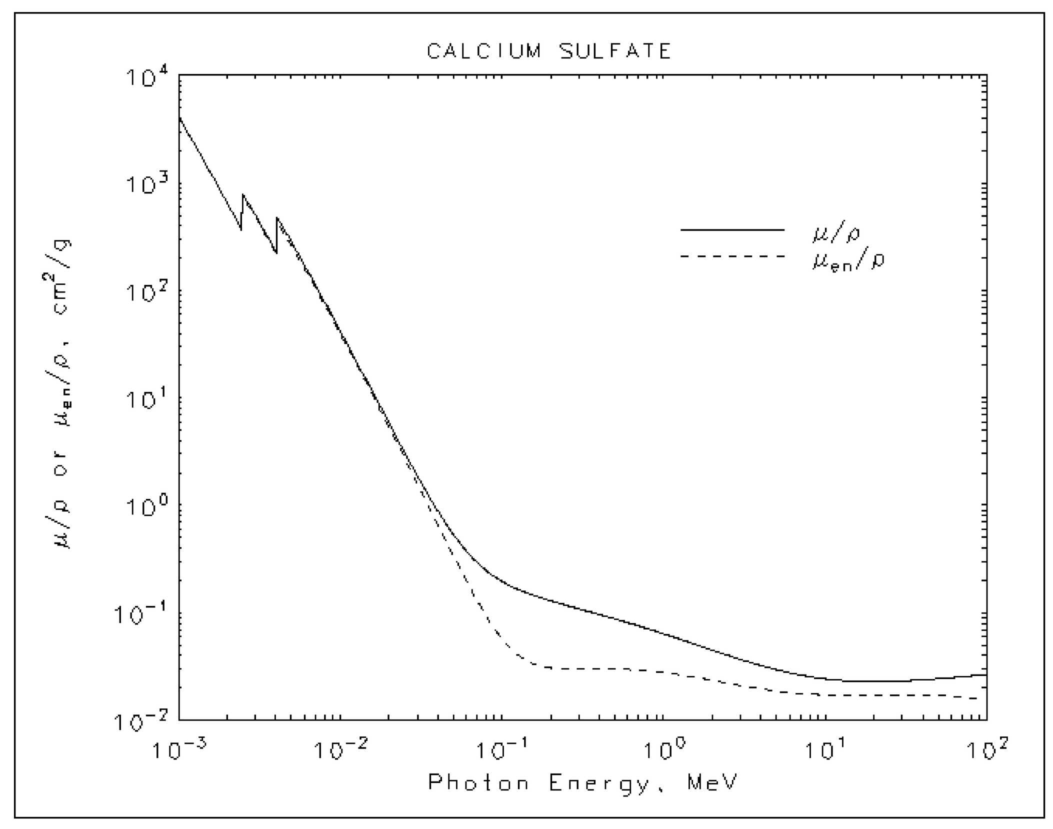
Research

Beam Energies: The Free Electron Laser (FEL) produces an X-Ray laser ranging from 280 eV to 11.2 KeV and pulses around 120 Hz. FEL is unique when it comes to shielding because the energy, 1 to 6mJ per pulse, is focused into a diameter from 1 mm to 100 nm and the pulse duration is 10 to 100 femtoseconds. This combination of practically instantaneous energy deposit causes the beam to exceed the vaporization thresholds of many materials.



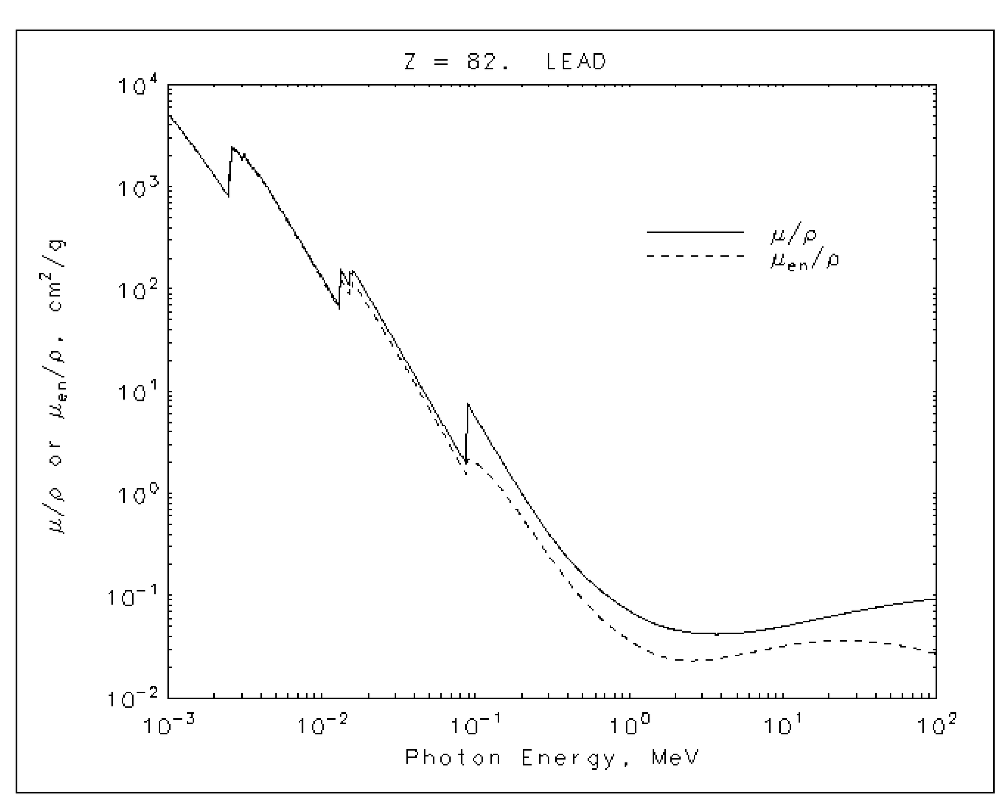
The ray trace above shows the possible reflections of the beam in the yellow highlighted areas. This specific trace comes from the splitting of the beam in the XRT.

Calcium Sulfate Dihydrate: After an initial attenuation provided by air, sheet rock is used to absorb reflected beam energy. Sheet rock has a low density which allows it to effectively spread the energy through the volume of the material which minimizes risk of melting or vaporization.

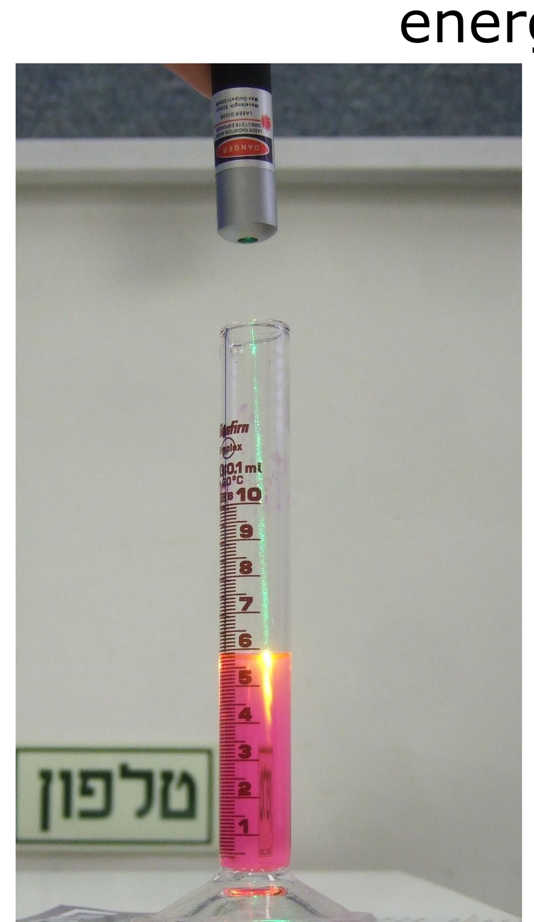


The graph shows that the mass absorption coefficient decreases as energy increases.

Lead: Lead is not used for shielding directly surrounding the radiation source because of its high atomic number, high density, and low melting point. If exposed to high energy beam, lead would concentrate the energy in its surface and melt or vaporize.



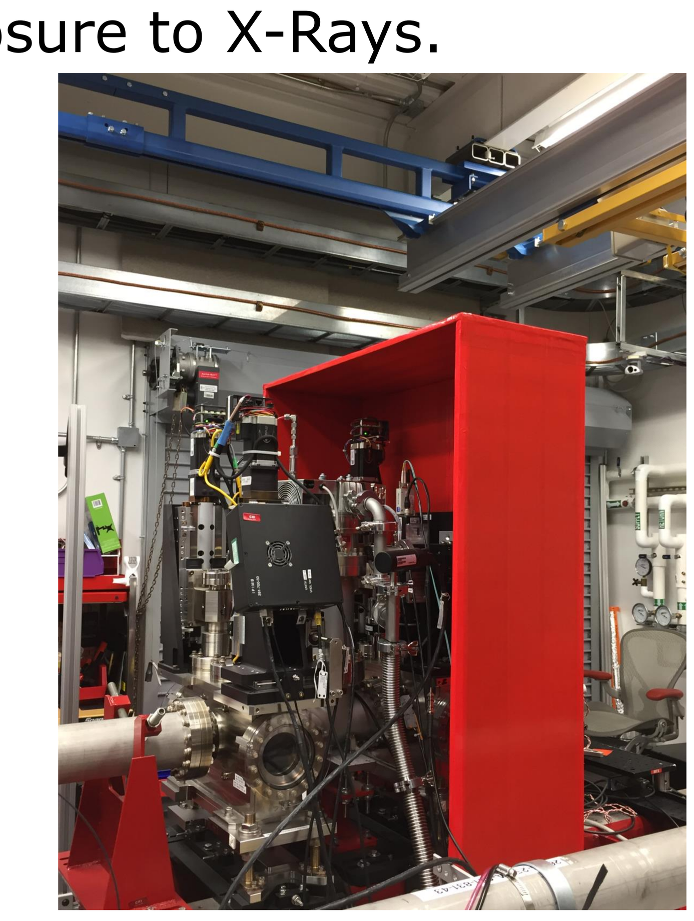
Despite higher mass absorption coefficients on almost every beam energy, lead is less practical than sheetrock at absorbing highly concentrated energy.

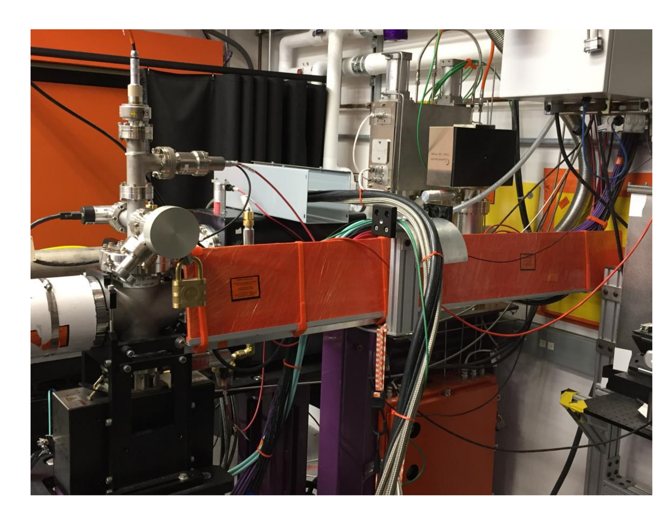


Representation of attenuation using green laser light passing through Rhodamine 6B solution.

Application

Shield Placement: The LUSI Wavefront Monitor holds a YAG crystal with the potential for diffraction of the beam. The red sheet rock box surrounding the LUSI stops radiation from entering areas like vents and roll up doors that could fail to stop personnel exposure to X-Rays.





Sheet rock is placed along the sides of the beam to shield any possible diffracted rays.

Conclusions

Lead is still necessary as a final “mop” for x-rays but sheet rock is an effective and cheap solution for X-Ray shielding. It can absorb more concentrated bursts of energy better, is less toxic, and easier to install than lead. In the future I hope to experimentally test the attenuation abilities of sheet rock under extremely concentrated energy. This will allow us to understand the physical limitations of sheet rock’s use for shielding and improve the safety of the facility as LCLS II is built.

Acknowledgments

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