CHESS Rocking Curve Measurements of Thin Diamonds for the GlueX Experiment

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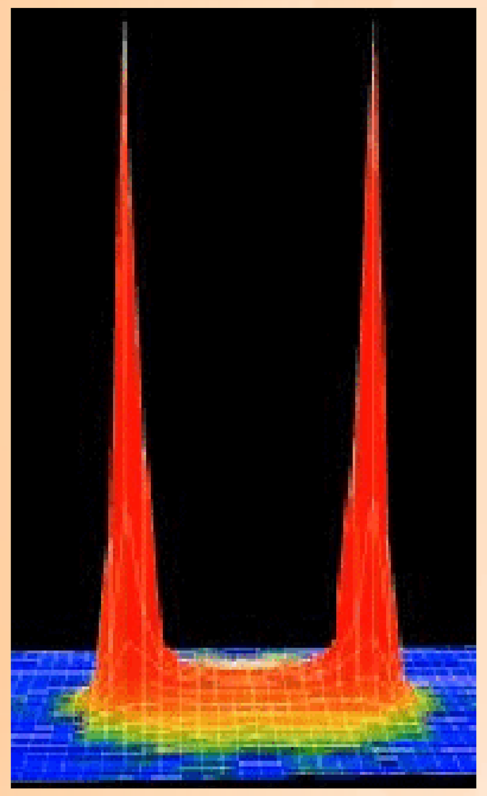
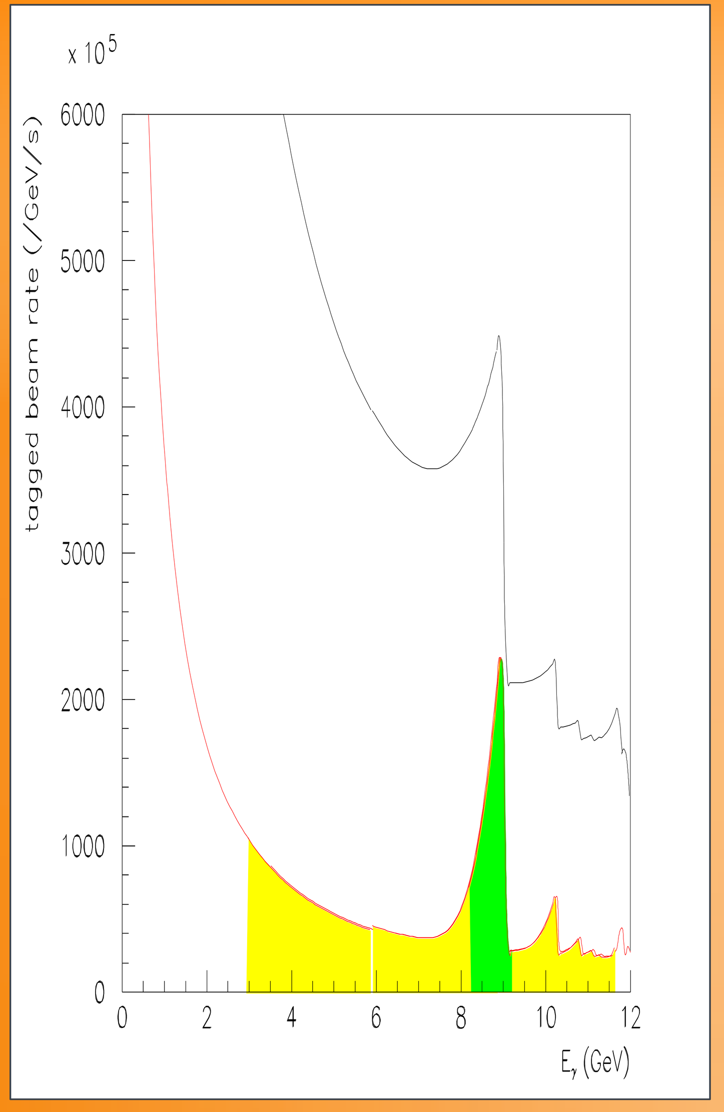
Abstract

The GlueX experiment at the Thomas Jefferson National Lab in Newport News, Virginia is a photonuclear experiment designed to explore the excited gluonic bonds between quarks. The excitation of the bonds is induced by the absorption of a polarized high energy photon by a proton in a liquid hydrogen target. To create a well collimated polarized photon beam, coherent bremsstrahlung radiation was chosen. A 12GeV electron beam will pass through a 20μm thick diamond wafer and undergo the bremsstrahlung process. The spread of photon production is not only a function of the thickness of diamond, but also of its planarity.



The lattice structure of an ideal diamond makes it a good choice, however modern machining techniques tend to leave the diamonds curved and stressed resulting in a wide bremsstrahlung peak. The collaboration group at UConn has developed a laser ablation process to create 20μm CVD diamond radiators free from strain and warping. Rocking curve measurements taken at CHESS and surface profiles are presented which demonstrate that this process results in diamond radiators which meet the GlueX criteria for thickness, flatness, and crystal mosaic spread.

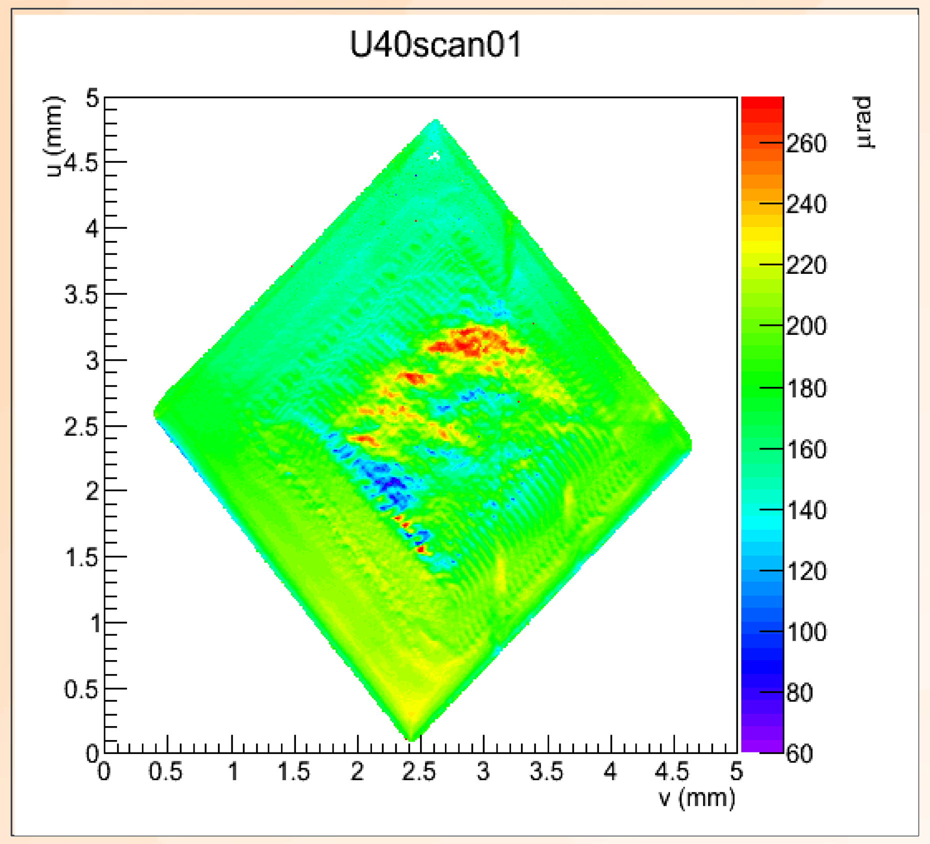
Coherent Bremsstrahlung

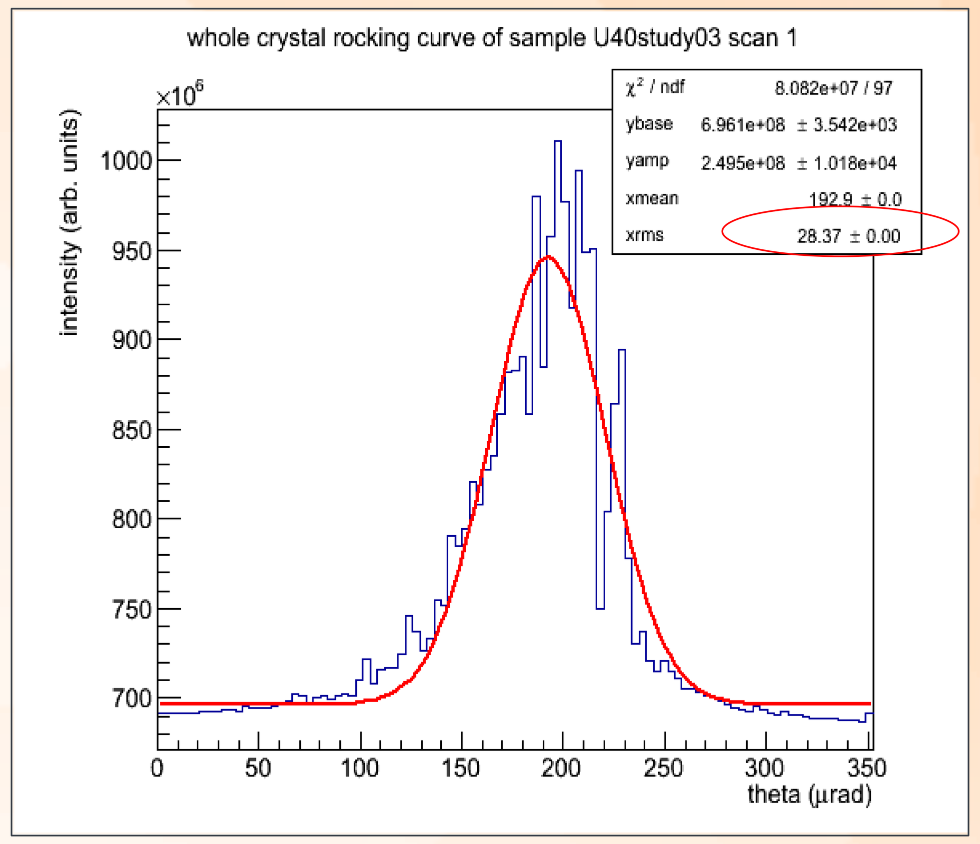


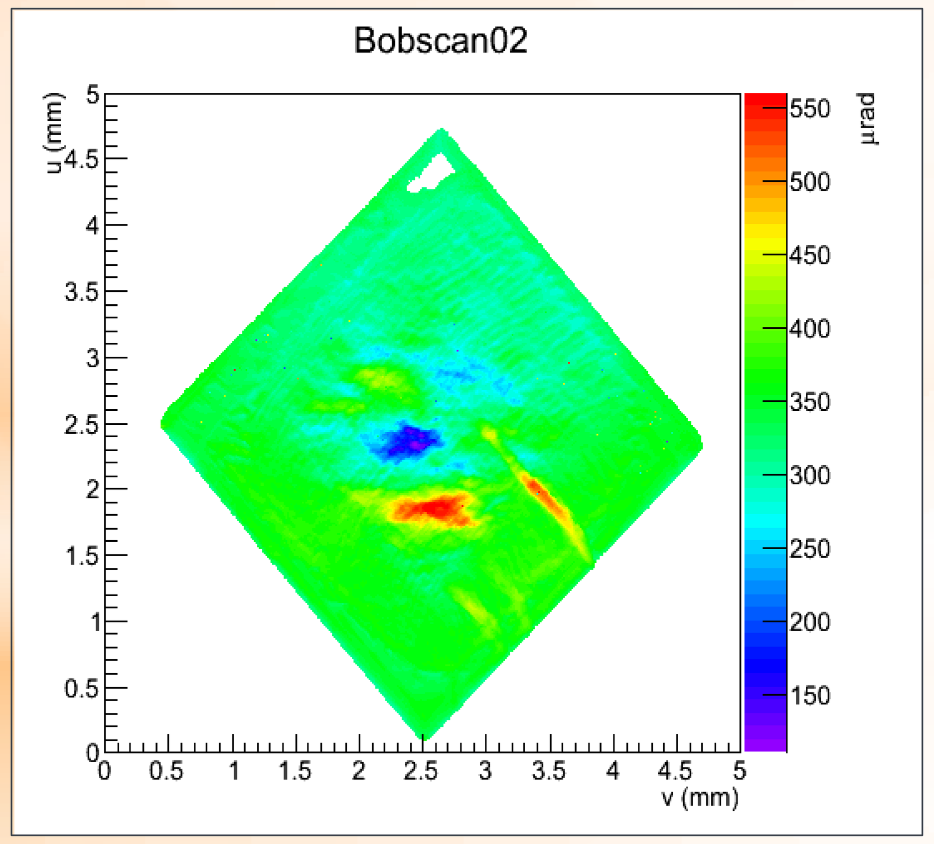
In the figure above, the black and red lines represent bremsstrahlung and coherent bremsstrahlung, respectively. The green area is the usable beam and the yellow is there for contrast.

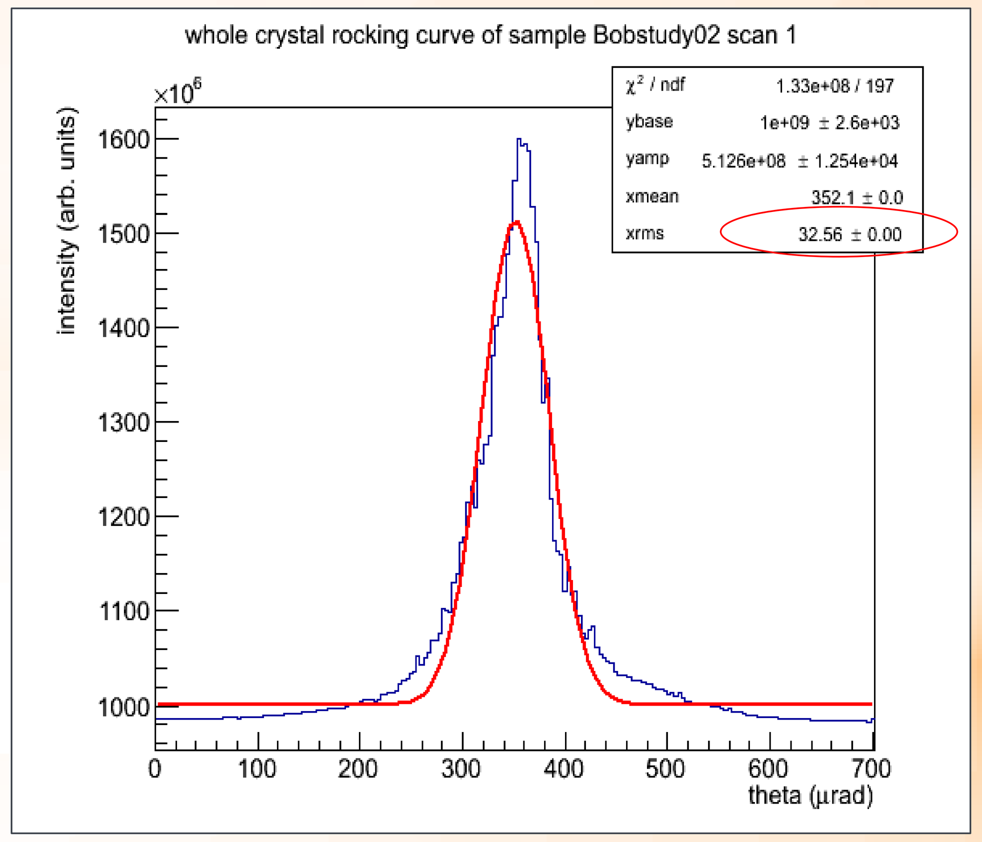
Bremsstrahlung produces electro-magnetic radiation when a charged particle is deflected by another particle. In the GlueX experiment, a 12GeV electron will decelerate when it passes through a diamond radiator producing photons with about 9GeV. In order to create the sharp peak in the otherwise smeared brems-strahlung radiation energy spectrum, the resulting photon beam will be collimated. Coherence occurs when the atoms in the radiator recoil together from the radiating electron. Compton scattering was also considered for GlueX photo-production and although this process achieves nearly 100% polarization and has very low background, it was not chosen due to its insufficient energy and flux.

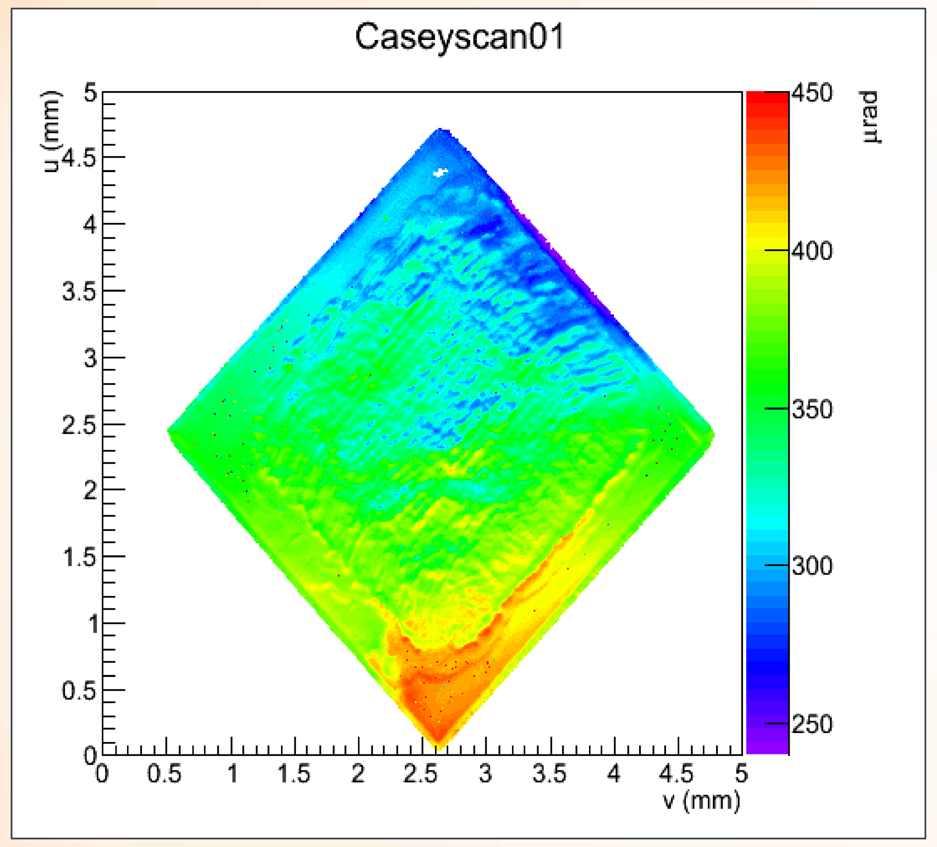
X-Ray Rocking Curves Taken at CHESS of UConn Samples

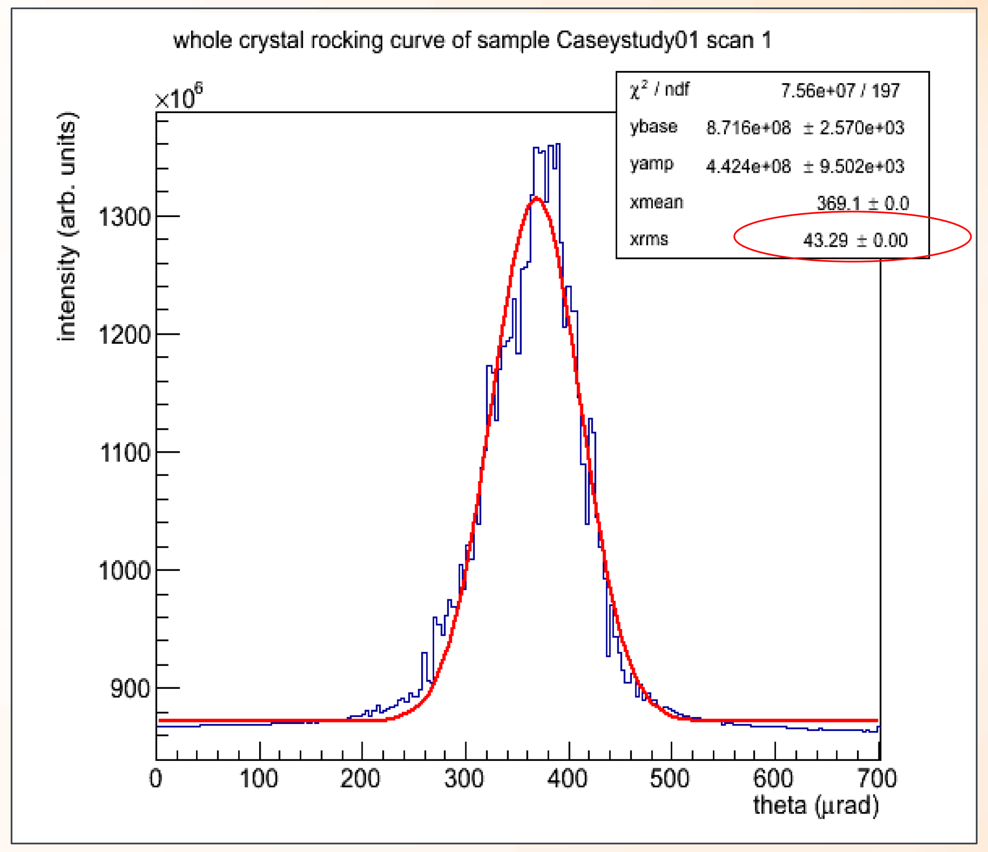










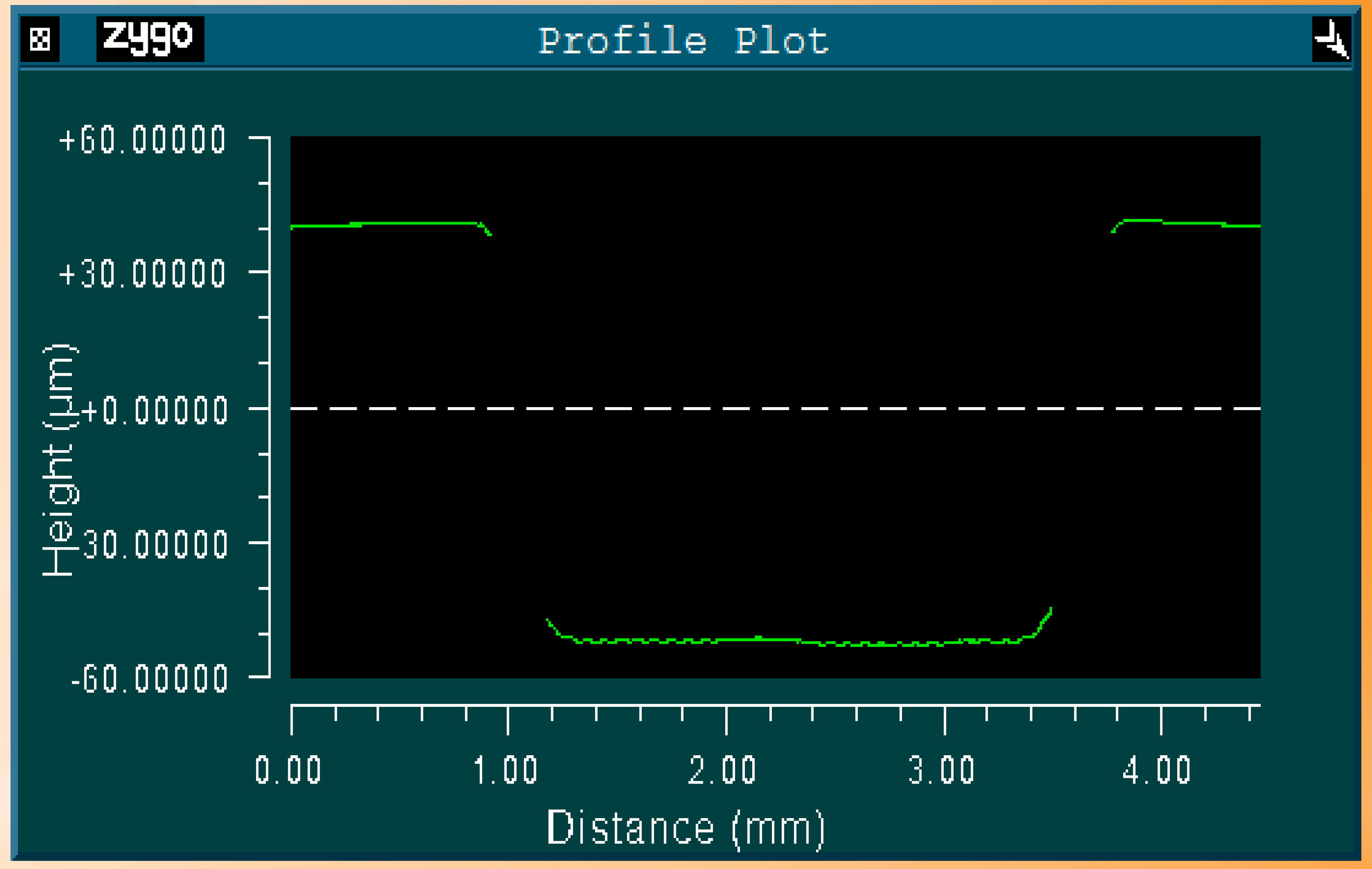


The first diamond produced that was thin and flat enough was U40, seen at the top. Using the data from CHESS, the rocking curves were analyzed and we could measure x_rms which we found to be 28.37 urad. We require x_rms to be between 20 and 30 urad which is less than or equal to the original divergence of the electron beam. U40 is a proof of concept but took 2-3 days to mill with the laser.

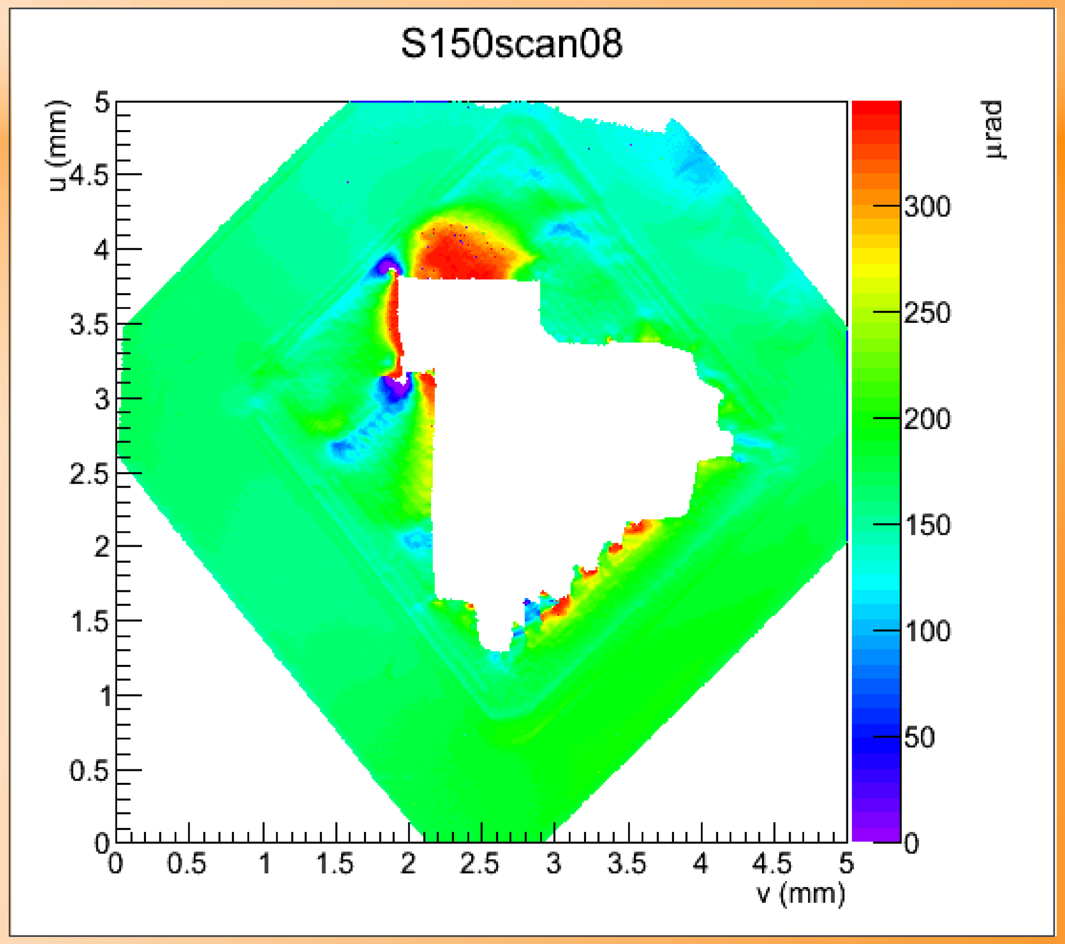
Bob, middle, and Casey, bottom, each took approximately 8 hours to mill with a rocking curve of 32.56 and 43.29 urad, respectively. These were the first attempts at increasing our ablation rate while keeping our x_rms low.

Promising Results

The plot below shows a cross section of sample S150 taken with a Zygo white light profilimeter. After 100μm was removed from the central region, the interior surface remained exceptionally flat and the vertical walls steep; both of which are crucial requirements for the GlueX experiment.



Oops



During the last milling pass of S150, the laser power proved too high and cut through the crystal. Learning from this, an energy meter has been integrated in our procedure so that laser power can be adjusted and monitored during the entire milling process.

Citations

1. The GlueX Experiment, (http://www.gluex.org).
2. Richard T. Jones, *Diagnostics of Deformation in Thin Diamonds for Coherent Bremsstrahlung Radiators*
3. http://zeus.phys.uconn.edu/wiki/