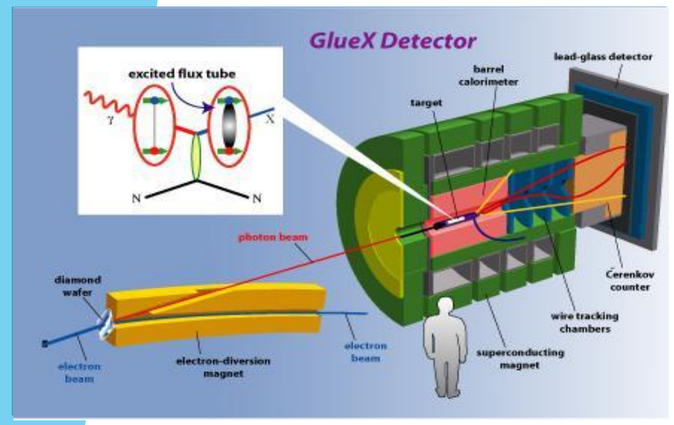
Diamond Radiator Fabrication and Characterization for the GlueX Experiment

Brendan Pratt, Richard Jones

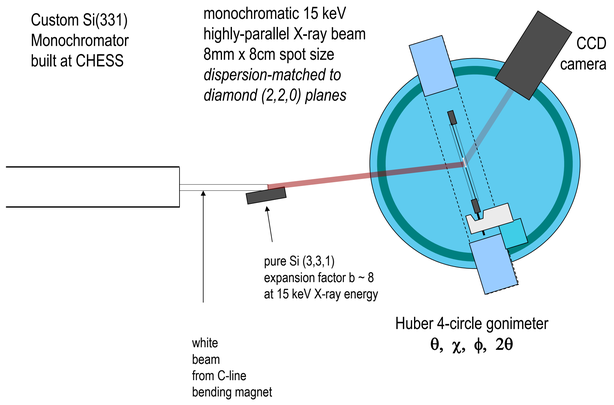
Experimental Nuclear Physics, *University of Connecticut*

Abstract

The GlueX experiment at the Thomas Jefferson National Lab in Newport News Virginia uses a polarized beam of 9GeV photons incident on a liquid hydrogen target to explore the excitations of gluonic bonds between quarks. 9GeV photons are generated by a 12GeV electron beam passing through a 20μm thick diamond wafer and undergoes coherent bremsstrahlung.
Optimum polarization requires that the mosaic spread of the diamond be negligible, but experience with thin diamond wafers has shown that internal stress caused by defects produce large scale warpage. The GlueX group at UConn has developed a laser ablation process to create 20μm CVD diamond radiators free from strain and warping.



Setup for Diamond Diffraction at CHESS



CHESS
Cornell High Energy Synchrotron Source

Laser Ablation Facility

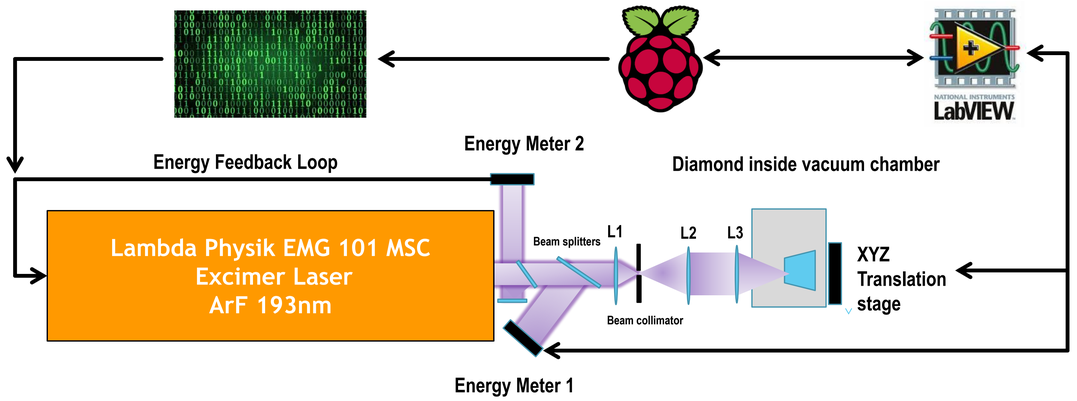


Figure: Diagram of laser ablation facility used for thinning diamond plate to 20 microns. The laser beam passes through two beam splitters for energy monitoring and laser energy regulation before it hits the first of three fused silica lenses. Lens 1 and 2 (L1 and L2 respectively) have overlapping focal points, creating an expanded, parallel beam which is then focused onto the diamond which is held under vacuum (500-700 mtorr). LabView controls the motor position of the diamond to within one micron precision, and computes the overlap of the laser's beam spot over each row (which is how we control cut depth). The Raspberry Pi reads the desired milling pattern and tells the laser when and where to fire.

Laser Focus Characterization

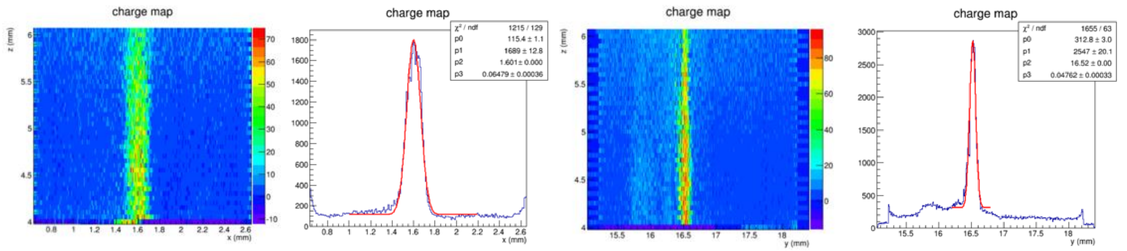


Figure: Color maps of the two orthogonal scans of the beam focal region, where the color represents the charge per pulse seen on the wire in arbitrary units. Projections of the wire charge maps onto the transverse axis with Gaussian fits to the central peak over a flat background.

Raster Pattern from White Light Interferometry Images

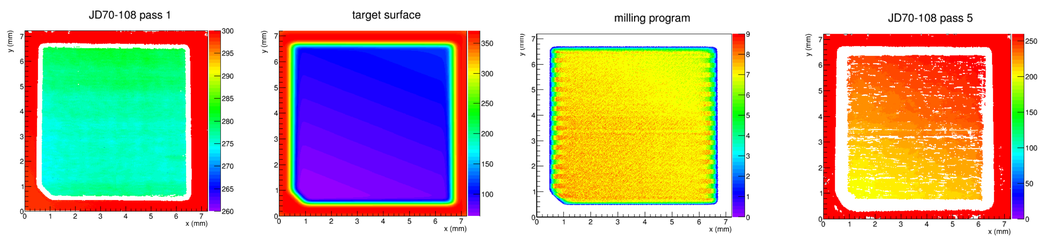


Figure: Color map images showing the progression of how raster patterns are created for diamond (JD70-108). The first image shows an image of the diamond after the first milling attempt. The next image is called the "target surface" and is the desired profile of the final crystal. The third image is called a "milling program" and each pixel represents a pulse of the laser at that specific position of the diamond. The final image shows the diamond after a series of these rasters have been implemented over the diamond.

20 microns!

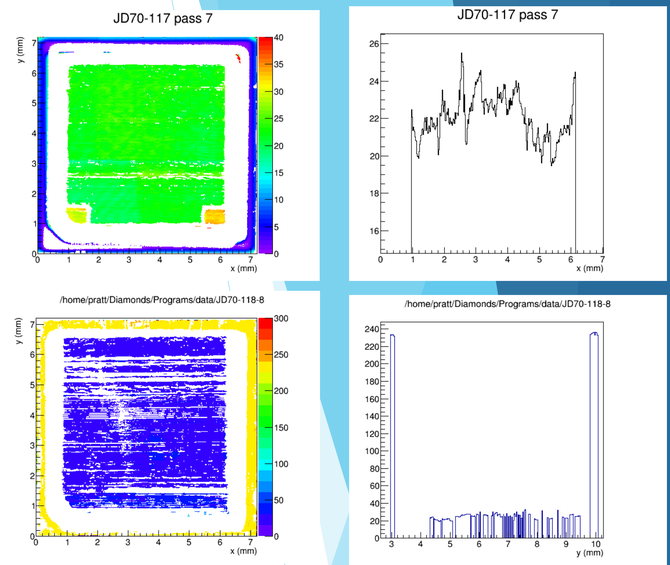


Figure: Zygo image of JD70-117 cut to 23 microns. The plot on the right is a cross section through y = 3.5mm

Initial Coherent Bremsstrahlung Results from GlueX

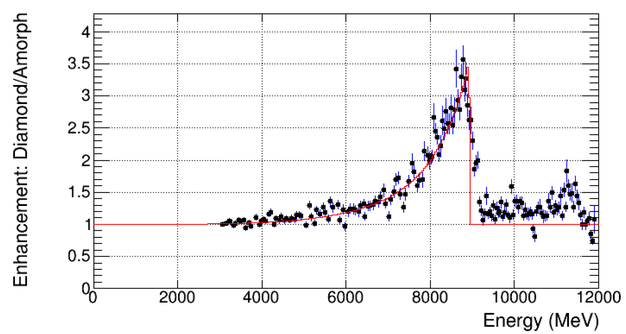


Figure: Initial data taken during Hall D Spring 2016 run using diamond JD70-118. The results show the photon beam enhancement of the diamond radiator when compared to an amorphous radiator.

Citations

1. **The GlueX Experiment, ((http://www.gluex.org).**
2. **http://zeus.phys.uconn.edu/wiki/**
3. **This work is supported by the U.S. National Science Foundation under grant 1207857**
4. **"This work is based upon research conducted at the Cornell High Energy Synchrotron Source (CHESS) which is supported by the National Science Foundation and the National Institutes of Health/National Institute of General Medical Sciences under NSF award DMR-1332208."**