Thin Diamond Radiator Fabrication for the GlueX Experiment

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Outline

- Overview of GlueX
- UConn Laser Ablation Setup
- Analysis of Radiator Samples
The GlueX Experiment
Thin and Flat Diamonds

- Radiators restricted to 20μm thickness due to multiple scattering
- Must also have well defined crystal structure with whole crystal rocking curves less than 30μr
- Techniques for thinning diamond exist, but they leave samples stressed and “potato chipped”
- Laser ablation as a viable method for machining while keeping internal crystal structure unchanged
UConn Laser Ablation Facility

- CNC style XY translation and laser pulsing via LabView
- Ablation Chamber optimized to reduce amorphous carbon deposition on windows
- Enhanced optics to reduce spherical aberrations (sub micron beam spot)
X-ray assessment: S150

The surface of S150 was polished with the RCMP process.

The X-ray rocking curve analysis shows a peak centroid at 329.9 ± 0.0 and a peak rms width of 10.37 ± 0.00, limited by instrumental resolution.
X-ray assessment: S90

The surface of S90 was not treated after VPIE process and was not as flat as S150, but still in spec.
X-ray assessment: S30 – the *real* target

surface of S30 was not treated after VPIE process

challenge lies here!
new idea tested in 2012: *add a frame*

Diamonds appear to warp severely when thinned to 20 microns. Try to stiffen the diamond by leaving a thick outer frame around the 20 micron region. Frame around 20 micron is still part of the single crystal, maintains planarity. Warping is from combination of mounting and internal stresses.
First “picture frame” sample: U40

315 micron frame around outside edge

thinned inner rectangular window

residual raster pattern is from a coarse laser step size

DNP 2012
3D Zygo Images of U40

White-light interferometer gives surface and thickness profiles with sub-micron prec.

top surface measurements with Zygo
approximate bottom surface depth, Zygo measurement on next slide
3D Zygo Images of U40

White-light interferometer gives surface and thickness profiles with sub-micron prec.

average thickness 40µm

DNP 2012
X-ray rocking curve for U40

surface of U40 was not treated after ablation

excellent result for thinned diamond!
Observations on ablated sample

- Central region looks good
- Sharpness of the walls does not degrade with depth
- Pileup of amorphous carbon is not catastrophic
- So far no clouding of the ablation chamber window from residue

- **Excellent flatness of the central region**
- **So far no need for active correction to cutting rate**, but pulse-by-pulse recording of laser power is being collected, can be used to keep the milling rate even more uniform
- Exploring annealing techniques
Questions?
Extra Slides
New vs. Old Spot Profile

Wider spot size in $y$ allows for larger step sizes and faster rasterizing.