Performance Evaluation of GAGG+ and Tungsten Carbide Blades in an X-ray Pinhole Camera

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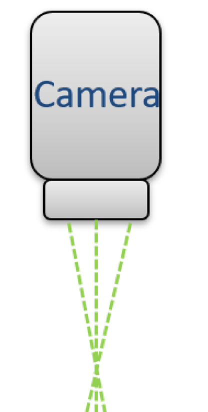
ABSTRACT

At Diamond Light Source two X-ray pinhole cameras are used to measure the transverse profile of the 3 GeV electron beam [1]. The current pinhole assembly is formed using tungsten blades with chemically etched shims to produce a 25 µm x 25 µm aperture and the imager incorporates a 0.2 mm LuAG:Ce scintillator. Tungsten carbide is a machinable high-Z material which at millimetre thicknesses is opaque to X-rays. With a slight change in pinhole design, similar to that already in place at the ESRF [2], tungsten carbide blades could offer a well-controlled aperture size for the pinhole camera with simpler assembly. Further to this, improvements to the photon yield of scintillators mean that the new scintillator GAGG+ has an almost two-fold increase in yield compared to the current LuAG:Ce scintillator [3]. An evaluation of the tungsten carbide blades and GAGG+ scintillator is presented.

X-RAY PINHOLE CAMERAS AT DIAMOND

Table 1: X-ray pinhole camera systems at Diamond.

PINHOLE CAMERA	DESCRIPTION
1	Used in the vertical emittance feedback system.
2	
3	Used for research and development.



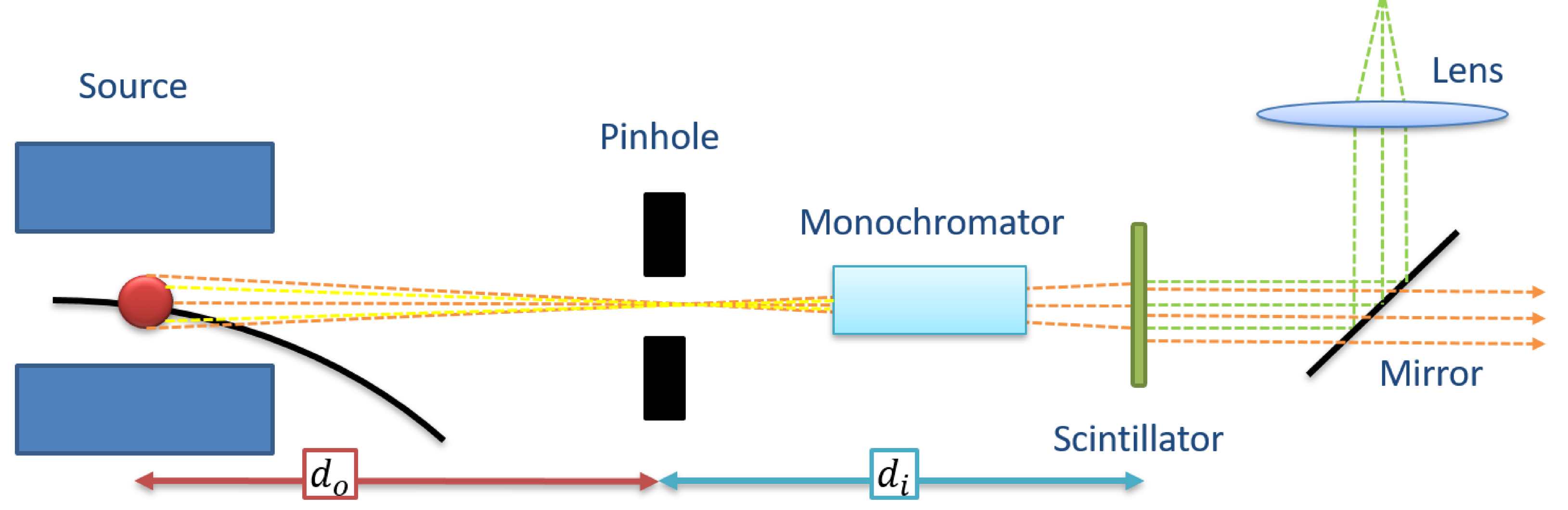


Figure 1: Schematic of the monochromatic X-ray pinhole camera system [1,4].

PINHOLE BLADES AND DESIGNS TO FORM REQUIRED APERATURES

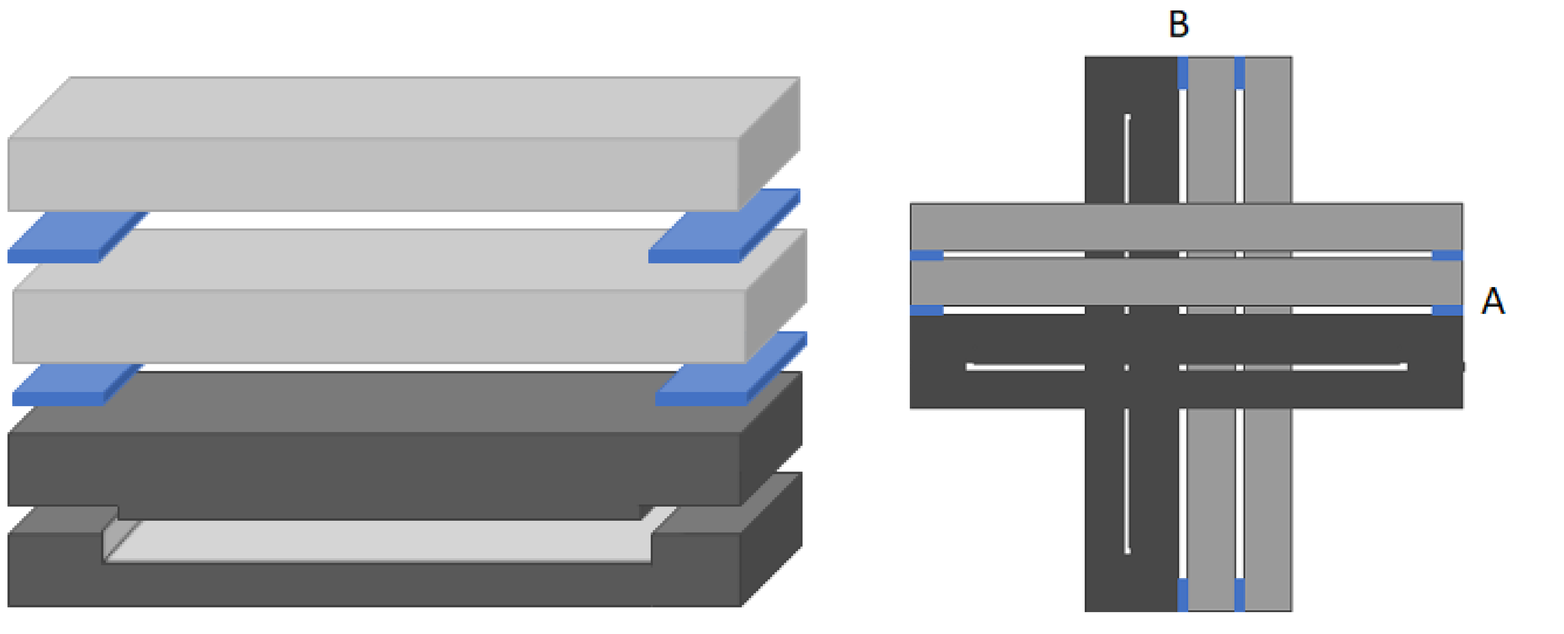


Figure 2: Schematic of the traditional tungsten blade – shim – tungsten blade design (light grey and blue) and the tungsten carbide C-D design (dark grey) [2].

The tungsten carbide blades were manufactured by Midland Carbides, UK [5]. Microscope images measurements of these new tungsten carbide C-D apertures have found them to be larger at around **35 µm, when they should be 25 µm**.

TUNGSTEN AND TUNGSTEN CARBIDE APERTURE SCANS USING X-RAY FAN

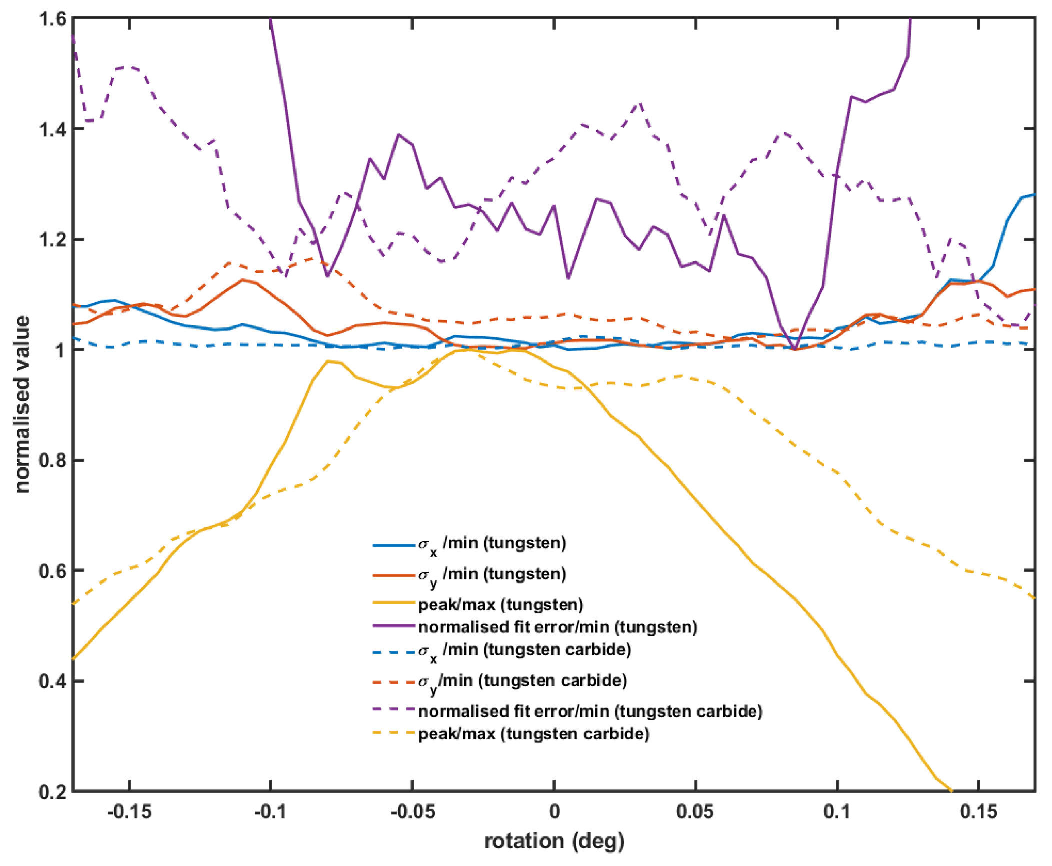


Figure 3: Horizontal aperture scan with fitted beam size (σ_x,σ_Y), peak intensity, and normalised error of tungsten and tungsten carbide aperture.

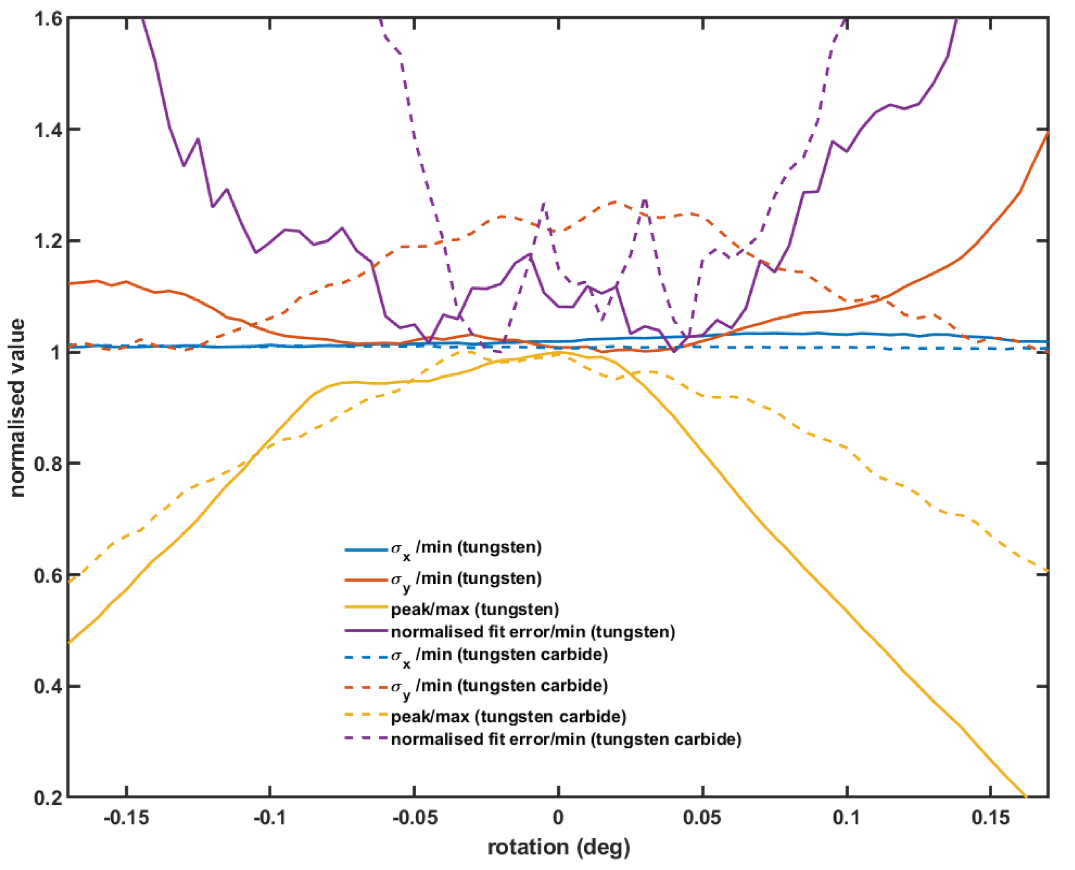


Figure 4: Vertical aperture scan with fitted beam size (σ_x,σ_Y), peak intensity, and normalised error of tungsten and tungsten carbide aperture.

LuAG:Ce VS GAGG+ MODULATION TRANSFER FUNCTIONS

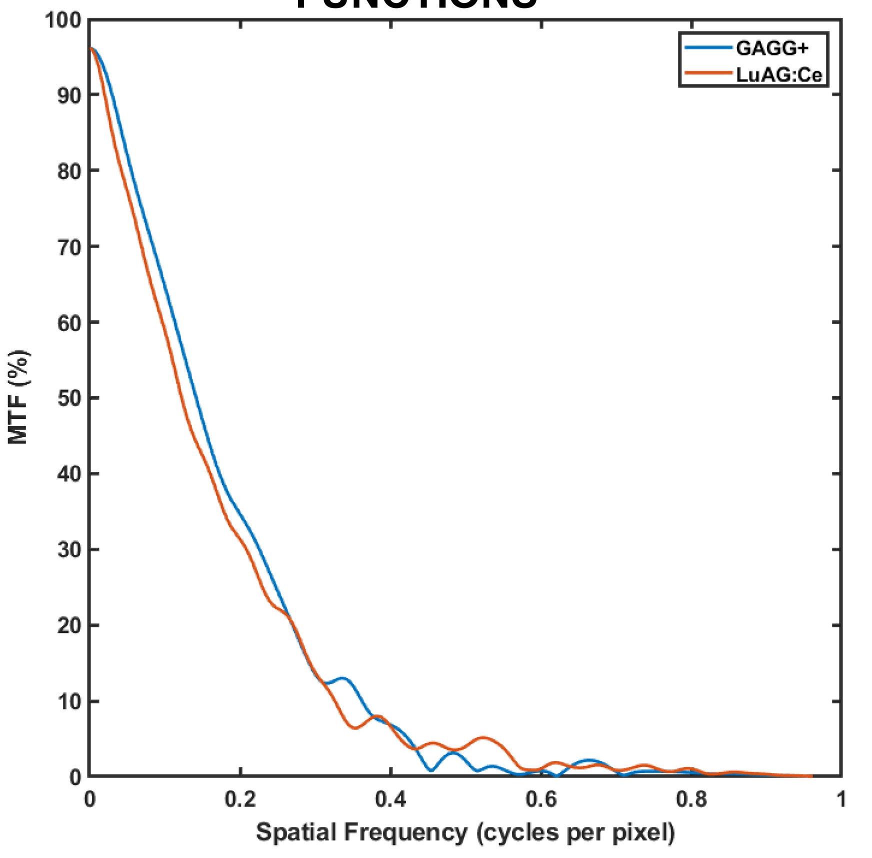


Figure 5: A comparison of the knife edge experiments of LuAG:Ce and GAGG+ scintillators.

MTF	LuAG:Ce	GAGG+
MTF50 (lp/mm)	27.8	32.0
MTF10 (lp/mm)	70.7	78.6

Table 2: MTF values for LuAG:Ce and GAGG+

PHOTON YIELD COMPARISON BETWEEN LUAG:CE AND GAGG+

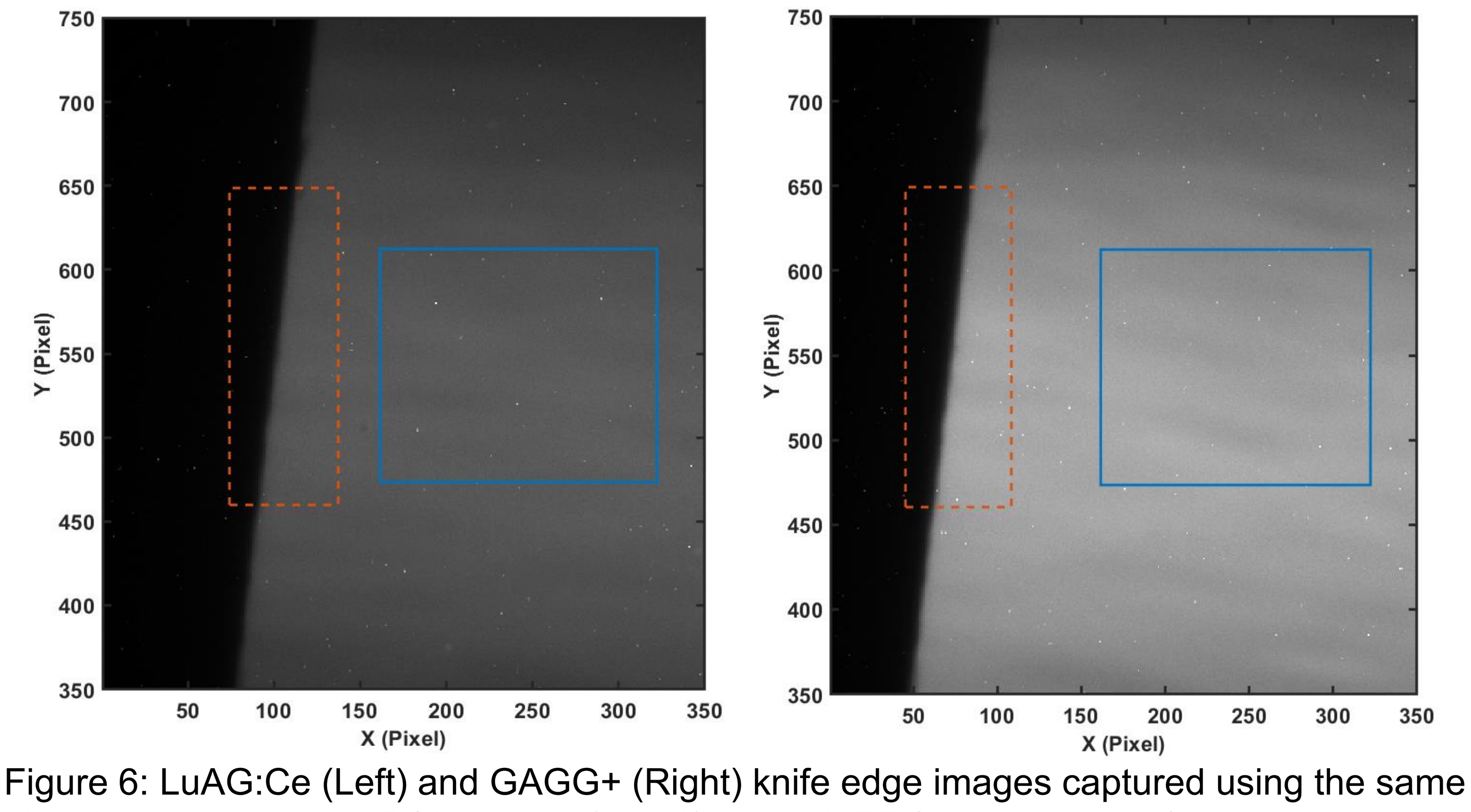


Figure 6: LuAG:Ce (Left) and GAGG+ (Right) knife edge images captured using the same pinhole camera setup. ROIs shown for knife-edge MTF (dashed orange) and photon yield measurements (solid blue).

For a beam only section (solid blue ROI), the average intensity per pixel for LuAG:Ce was **88 a.u/pixel** and GAGG+ was **157 a.u/pixel** which is an increase of **78%**. This improvement can help provide reliable vertical emittance measurements, even with the synchrotron at lower currents. This can also help reduce jitter by allowing for shorter exposure times.

CONCLUSIONS

It has been demonstrated that the new tungsten carbide blades are **larger by around 10 µm,** which was confirmed by microscope images. The blade scans have shown they still produce good attenuation of the beam, though the vertical scan shows an increase in vertical beam size, attituded to its larger size.

GAGG+ has been demonstrated to have around an **78% increase in photon yield** and produce similar MTF values. This means replacement of LuAG:Ce with GAGG+ would improve the photon yield of the pinhole cameras without any loss of spatial resolution, even at low currents.

Further investigations are planned to record the PSF values of these pinhole cameras with the new tungsten carbide blades and GAGG+ scintillator using the Touschek calibration method.

ACKNOWLEDGEMENTS

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