Scintillating Fiber Array Characterization and Alignment for Neutron Imaging using the High Energy X-ray (HEX) Facility

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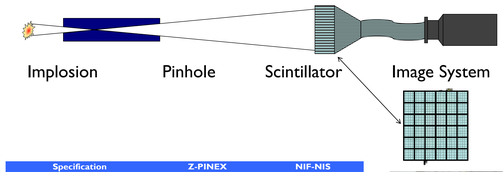
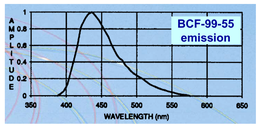
Neutron Imaging for Z and NIF

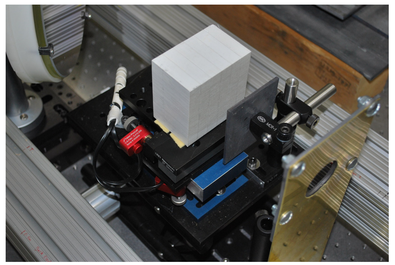
The Neutron Imager diagnostic at the National Ignition Facility (NIF) located at Lawrence Livermore National Laboratory (LLNL) will produce high-resolution, gated images of neutron-generating implosions.*✣§ A similar pinhole imaging experiment (PINEX) diagnostic was recently deployed at the Z facility at Sandia National Laboratories (SNL). Both the SNL[1] and LLNL[2] neutron imagers use similar fiber array scintillators (BCF-99-55[5]). Despite diverse resolution and magnification requirements, both diagnostics put significant onus on the scintillator spatial quality and alignment precision to maintain optimal point spread.

Characterization and alignment of the Z-PINEX scintillator and imaging system were done at NSTec/Livermore Operations in 2009, and is currently underway for the NIF Neutron Imager.



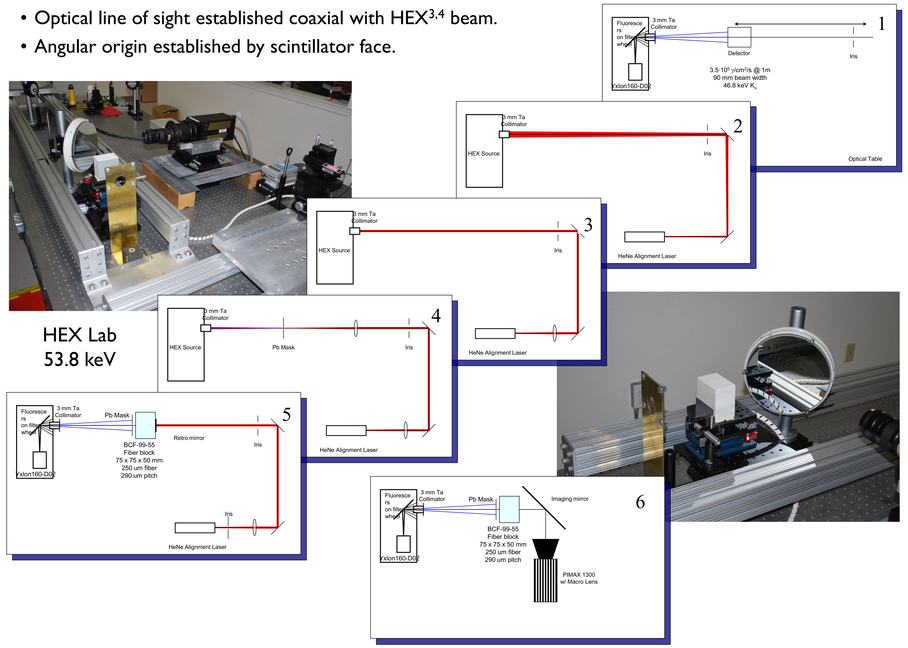


Specification	Z-PINEX	NIF-NIS
Yield	5×10^{13} (DD)	10^{14} - 10^{16} (DT)
Dynamic range	24 (point) @ peak 6 (uniform)	22 @ peak 10 @20%
Resolution on target (calculated)	320 µm	10 µm
Field of view	50 mm	> 100 µm
Pinhole type	slit or round	multiple, hybrid
Pinhole size	200 µm	5 µm (0-200 µm)
Pinhole taper	13.5 mrad, 15 mrad	1 mrad
Magnification	4.6	100
Pinhole distance from target	54 cm	27 cm
Pinhole pointing accuracy	±6.5 mrad (3.5 mm)	±100 µrad (25 µm)
Resolution on scintillator (calculated)	<1.5 mm	<1 mm
Scintillator distance from target	3 m	28 m
Scintillator pointing accuracy	<5 mrad	<5 mrad
Scintillator dimensions	75mm x 75 mm x 50mm	16cm x 16cm x 5cm
Neutron absorption	~40% (DD)	~ 40% (DT)
Deposition radius	~400 µm	~300 µm
Scintillator fiber size	250 µm	250 µm
Scintillator fiber pitch	290 µm	290 µm

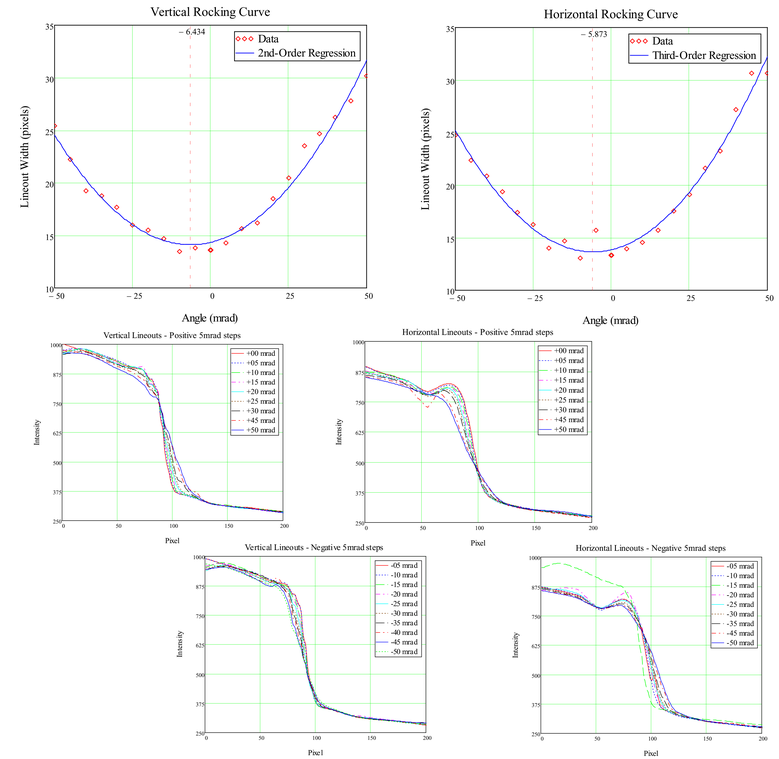


Alignment Setup

- Optical line of sight established coaxial with HEX[3,4] beam.
- Angular origin established by scintillator face.

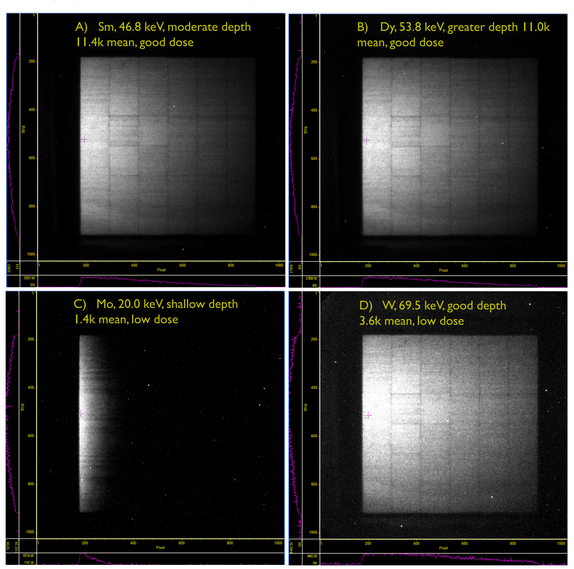


Rocking Curves



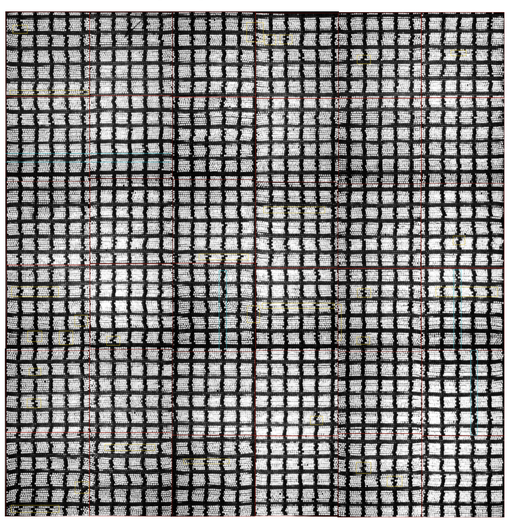
Side-Illuminated X-ray Penetration

- Dysprosium chosen for alignment.



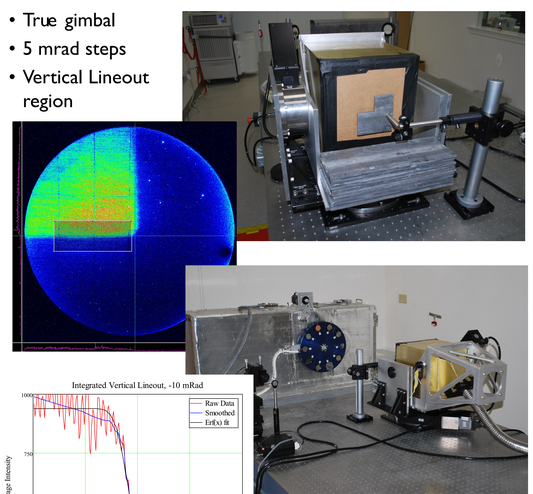
Observed Coherency of SFA

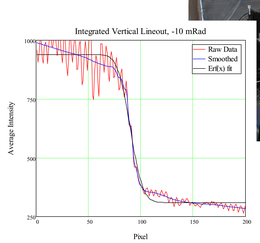
- Backlit regular grid: 600 µm lines, 2400 µm spacing
- Local and long-range distortion: 1–2 fiber diameters



Line Spread Function

- True gimbal
- 5 mrad steps
- Vertical Lineout region





- Lineout smoothed and centrally weighted
- Erf width obtained

Summary of Results

- Z-PINEX scintillator coherency was characterized.
- SFA incoherency on order of 1–2 fibers.
- Line spread functions could be obtained with penetrating X-rays ~ 55 keV for 5 cm depth.
- Optimal axis of fiber could be located with gimbal stage, to high accuracy.
- Centrally weighted lineout fits well with Erf.
- Rocking curve shows optimal axis is > 5 mrad from machined face. (~ 1 fiber pitch).
- MTF and PSF will be degraded by both incoherency and misalignment.
- NIF-NIS scintillator is being characterized now.
- Tight resolution and PSF requirements should demand scintillator alignment and improved SFA fabrication.

References

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Poster Information

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