SAND2020-2063PE

X-RAY DIFFRACTION ON THOR

PRESENTED BY

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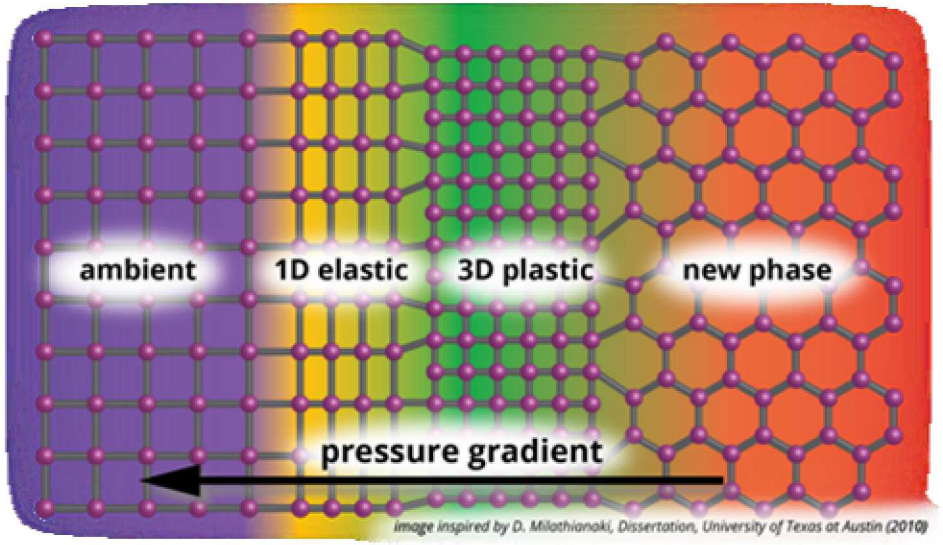
X-ray diffraction to infer dynamic material properties

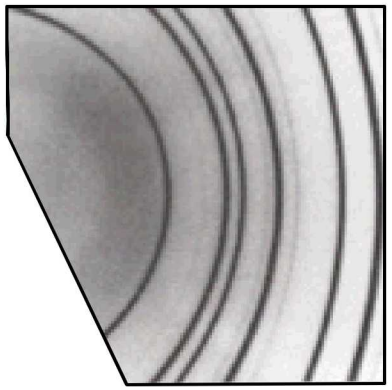
Goals

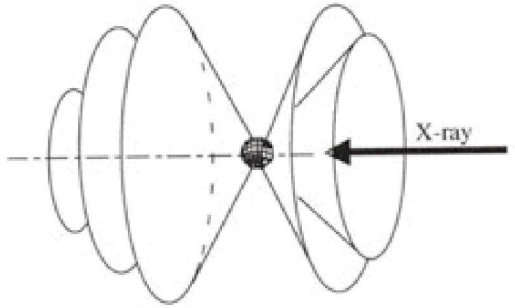
- Characterize both phase transitions and their kinetics that occur in dynamically compressed condensed matter on ns time scales and nm spatial scales
- Determine at atomic scale how materials behave under extreme pressure & temperature conditions; velocimetry gives only continuum scale information



Approach

- Produce source x-rays with flash x-ray diode
- Generate high-pressure state with Thor pulsed power driver
- Detect diffracted x-ray pattern with image plate

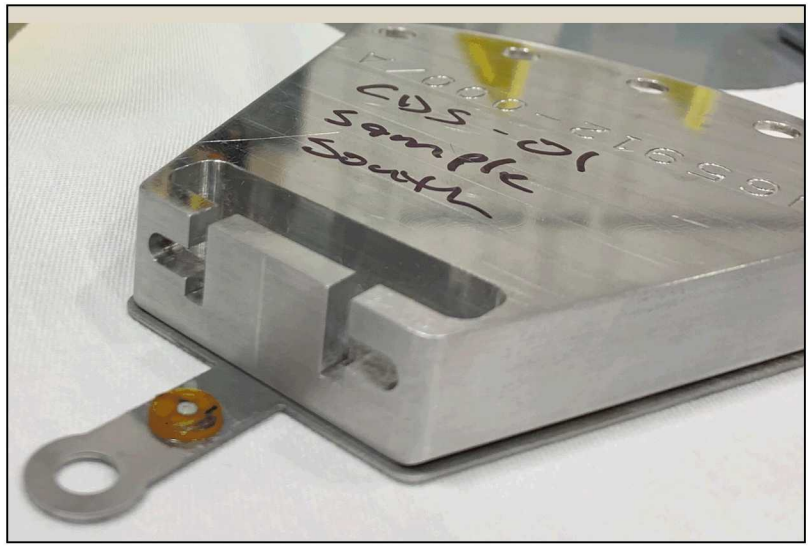


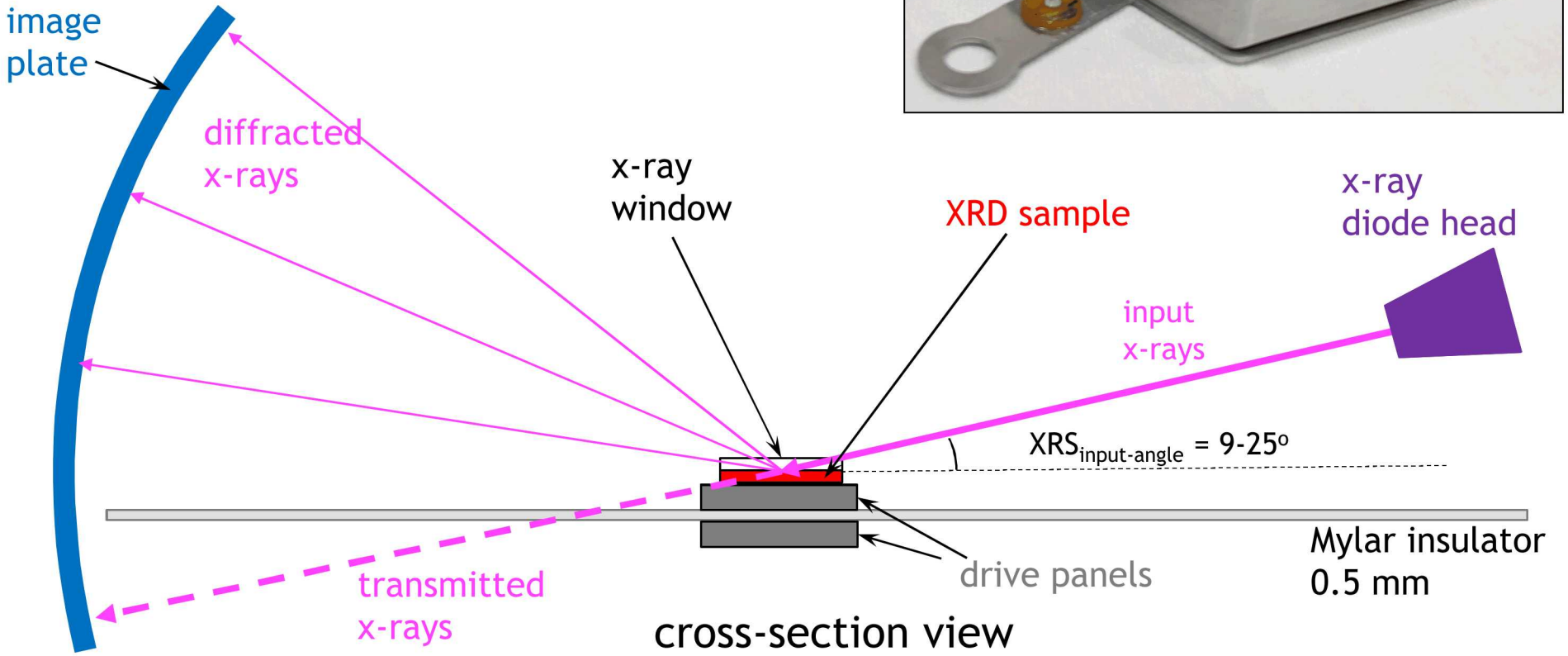


Experimental design of Thor-XRD

New Thor panels for input and output of x-rays

- Drive panels: Al, 1 mm
- XRD sample: CdS, 1 mm; Zr, 0.5 mm
- X-ray window: TPX, 0.5 mm

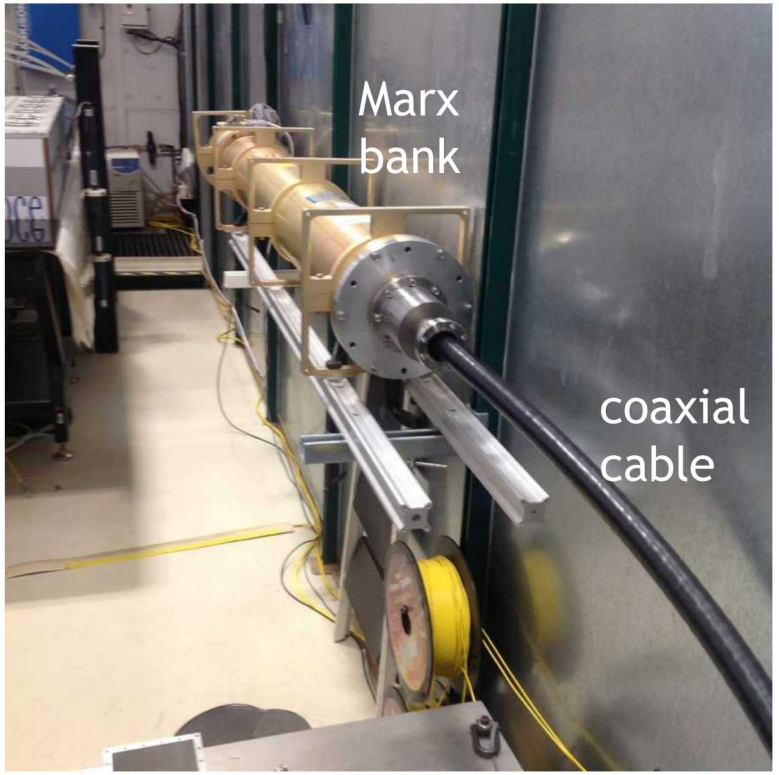




Flash x-ray diode system

Combination of existing and new hardware

- 35-stage Marx bank high-voltage pulsed power generator charged to 30 kV
- Needle-and-washer electron beam diode via high-voltage coaxial cable
- Select anodes to produce various K_α emission
  - e.g. Cu: 8.0 keV; Mo: 17.4 keV, Ag: 22.1 keV
- Line and bremsstrahlung x-ray emission within 30 ns pulse

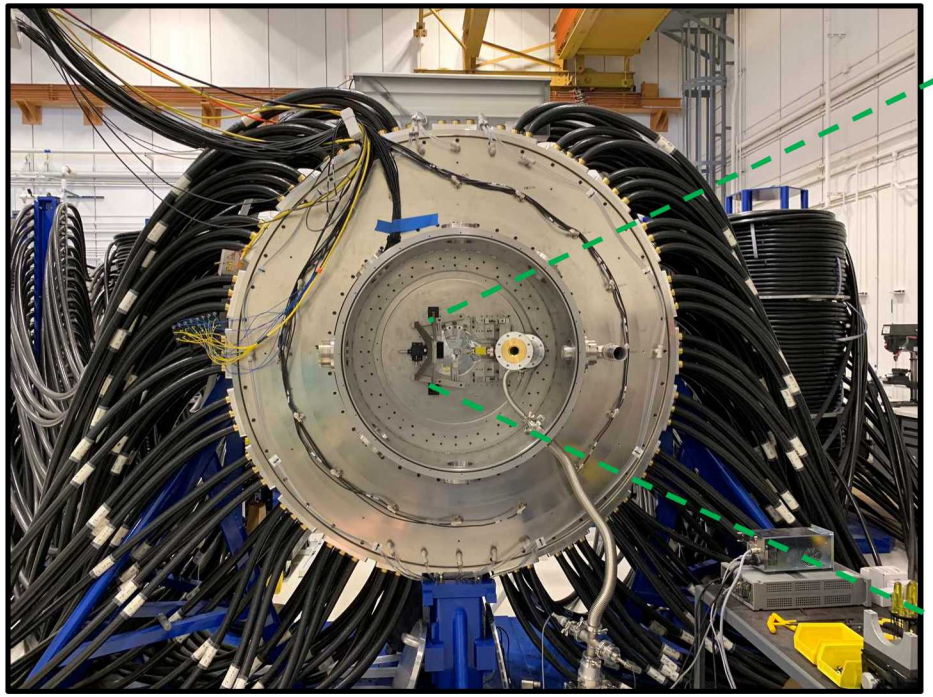


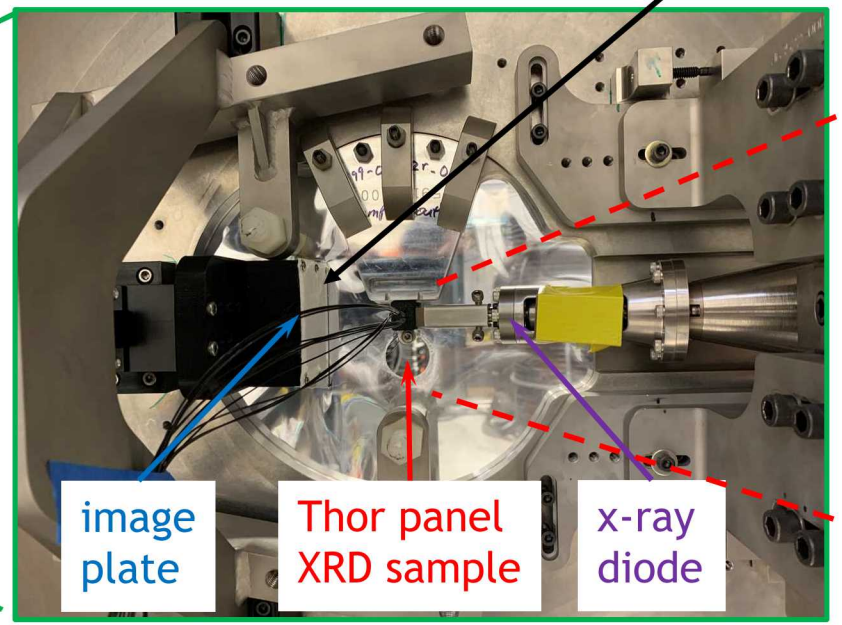
Morgan *et al.*, RSI **79**, 113904 (2008)

Implementing x-ray diode onto Thor

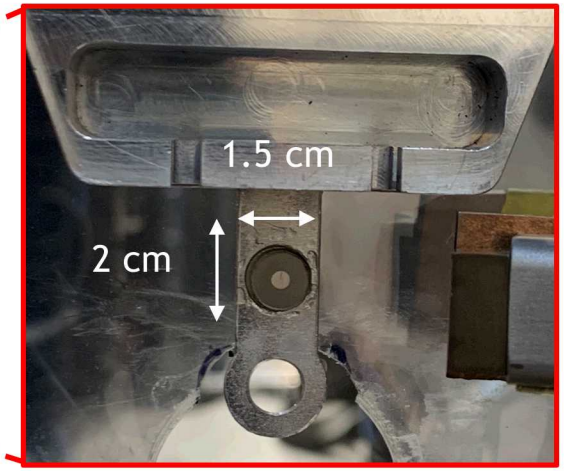
New hardware to accommodate x-ray diode, load panel, and image plate

- Modified center power flow plate
- Larger load chamber with opening x-ray diode
- Conical x-ray diode head with 90° turn

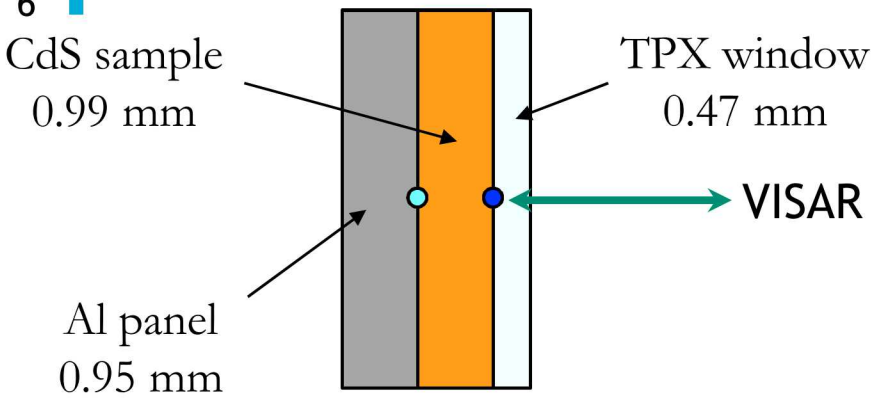


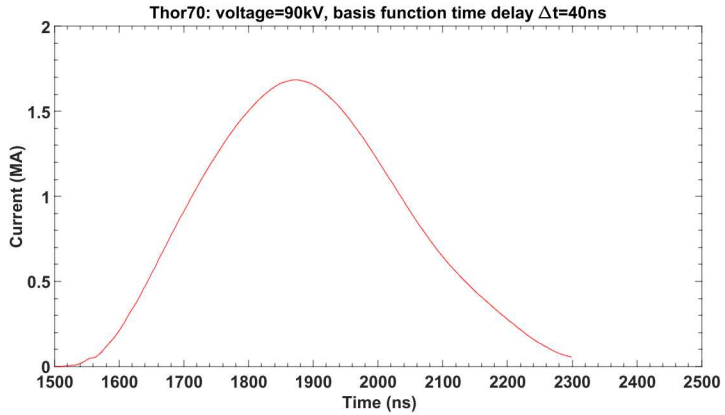


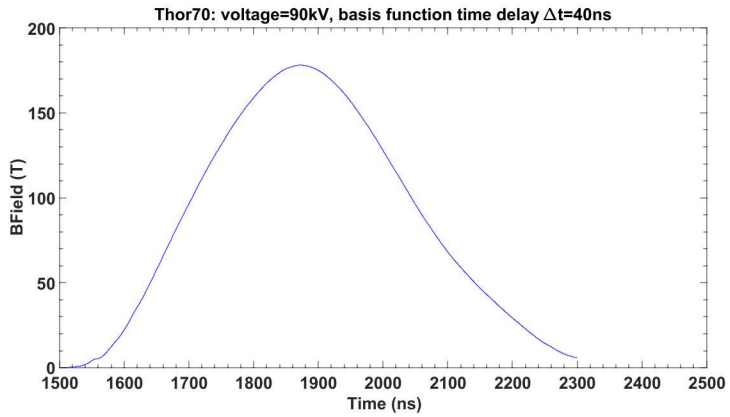
post-shot image plate shield

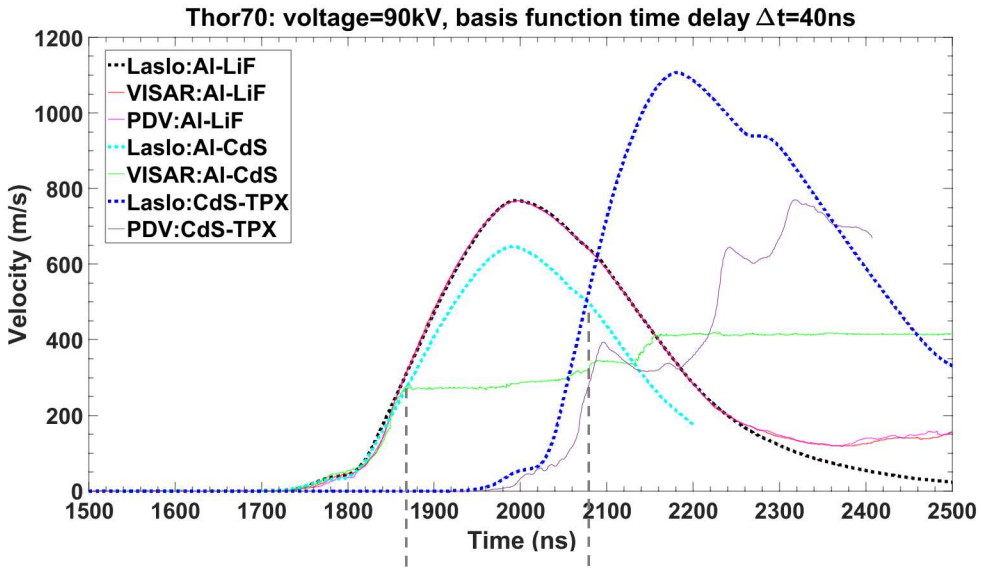


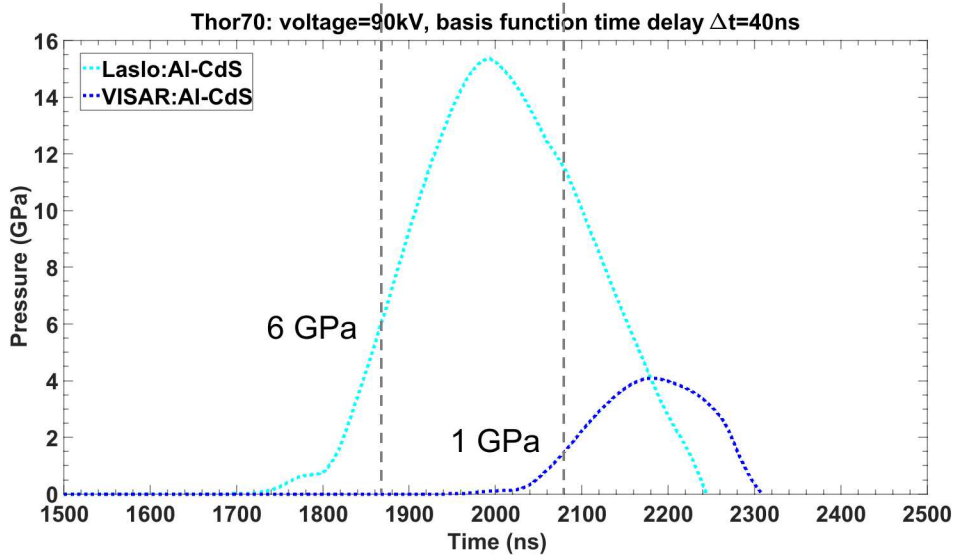
Thor #70 - Laslo simulations and VISAR of Al panel, CdS sample, TPX window







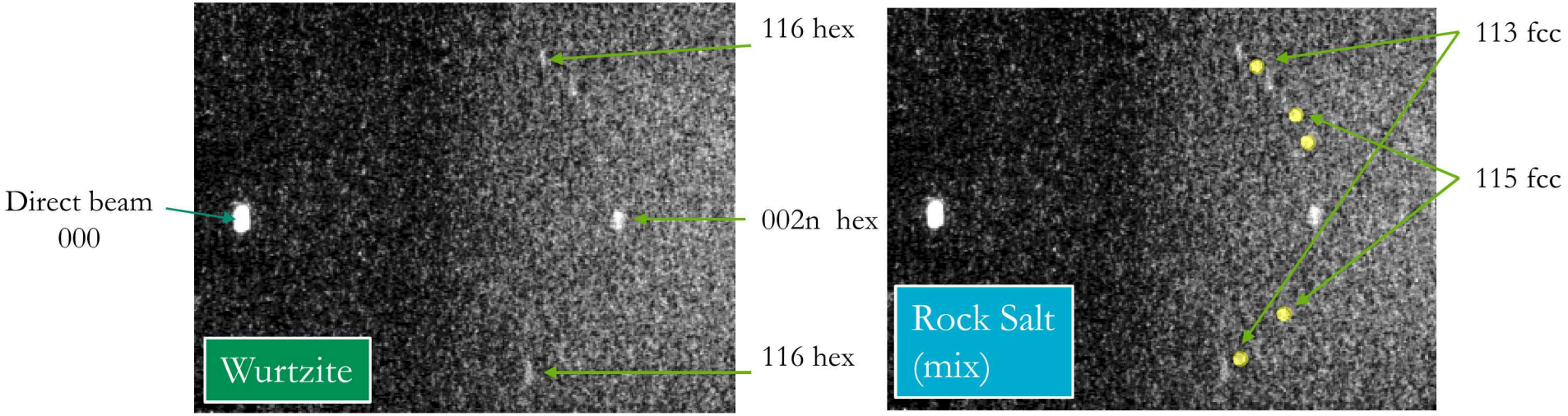




Thor #70 – XRD prediction of CdS phase transition Laue pattern with beam along a-axis +30°

hex phase (Wurtzite)

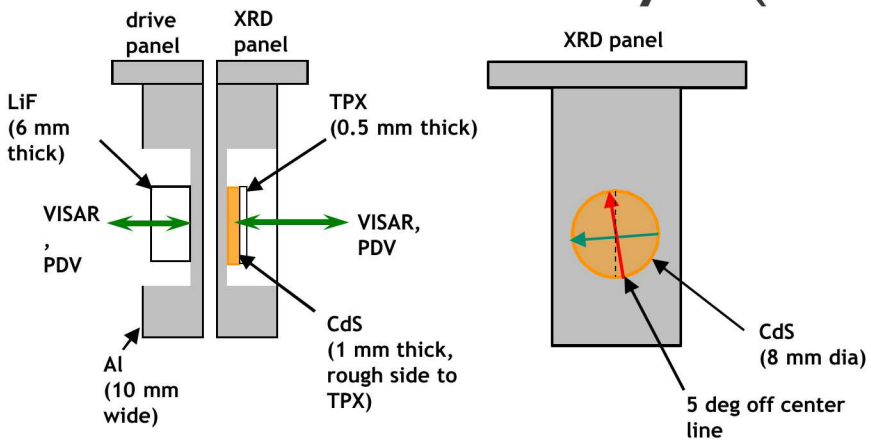
ψ = 17.0°	h k l	α (°)	d (Å)	θ_B (°)	E (keV)
	1 1 4	39.06	1.303	13.12	21.0
	1 1 6	28.41	0.984	14.90	24.5
	1 1 8	22.09	0.778	15.72	29.4

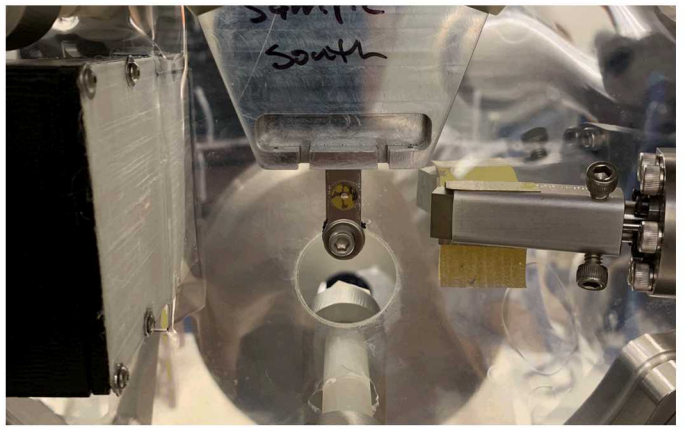


fcc phase (rock salt)

ψ = 17.5°	h k l	α (°)	d (Å)	θ_B (°)	E (keV)
	1 1 3	25.24	1.749	15.33	13.4
	1 1 5	15.79	1.120	16.34	19.7
	1 1 7	11.42	0.815	16.65	26.6

Thor #70 – Laue XRD pattern of single-crystal CdS with broadband x-rays (W anode)





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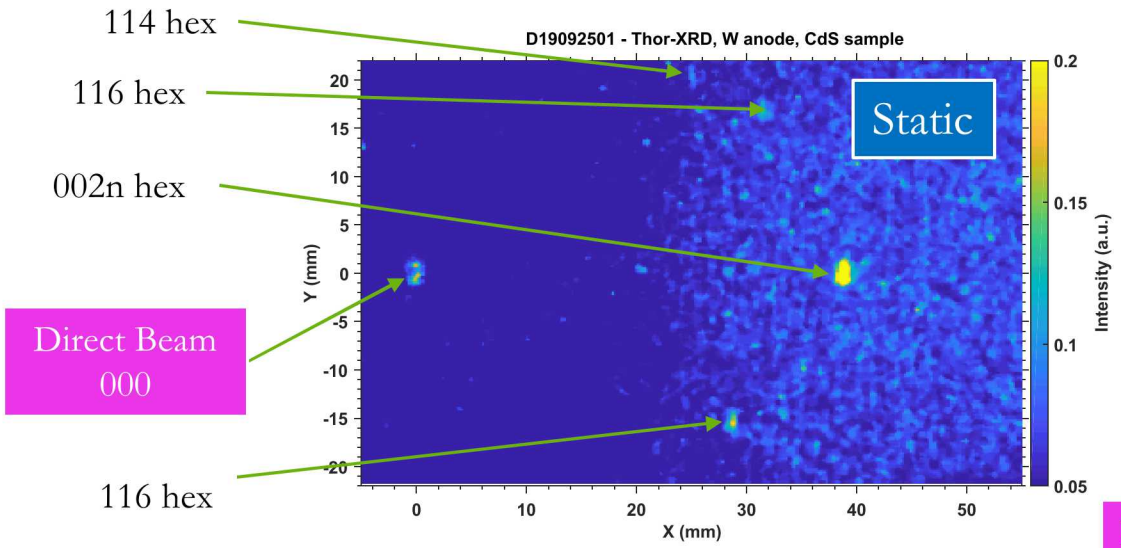
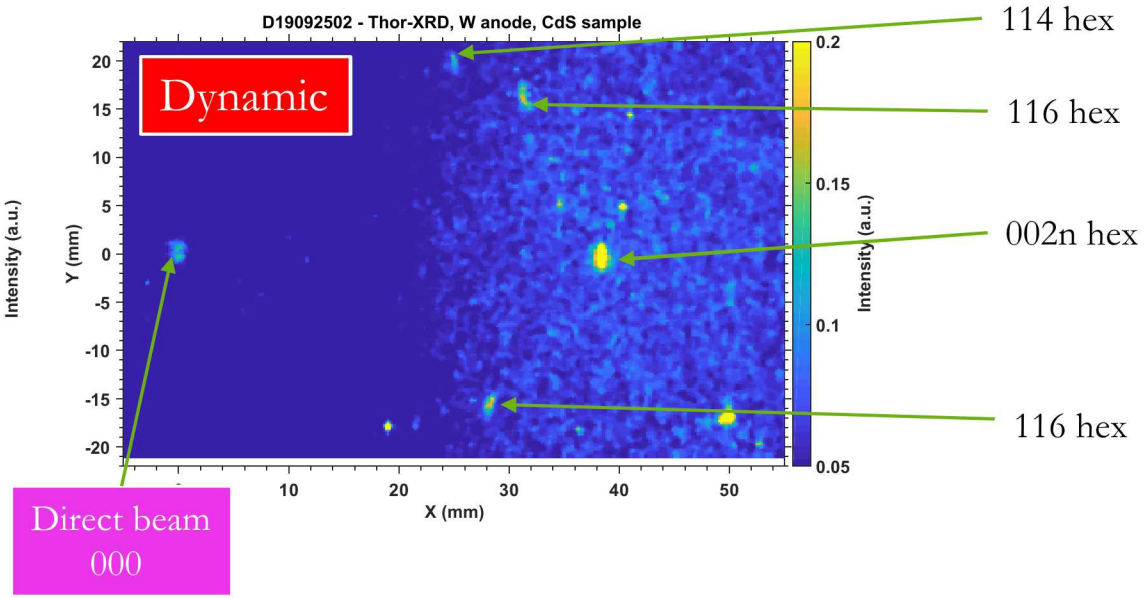
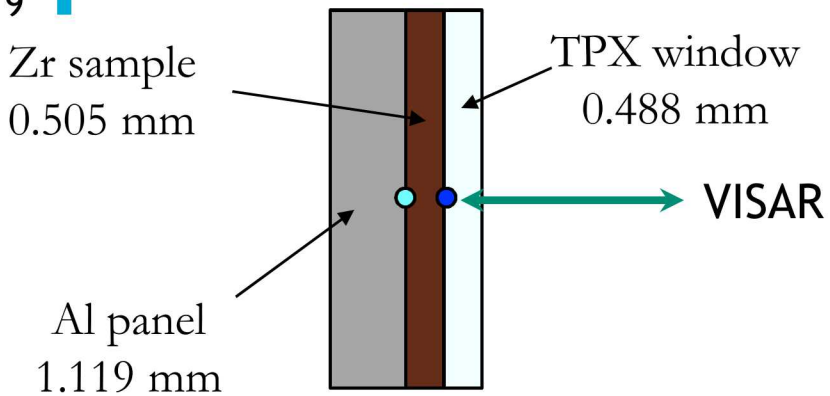
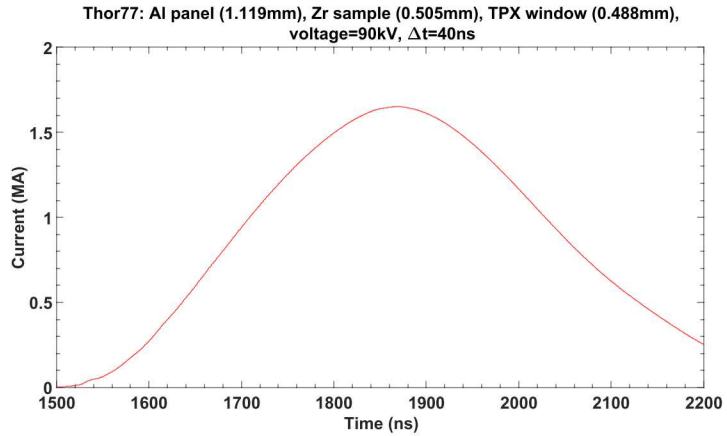
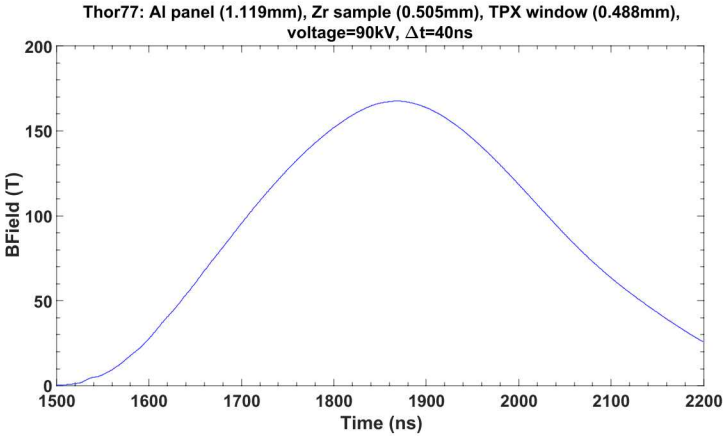


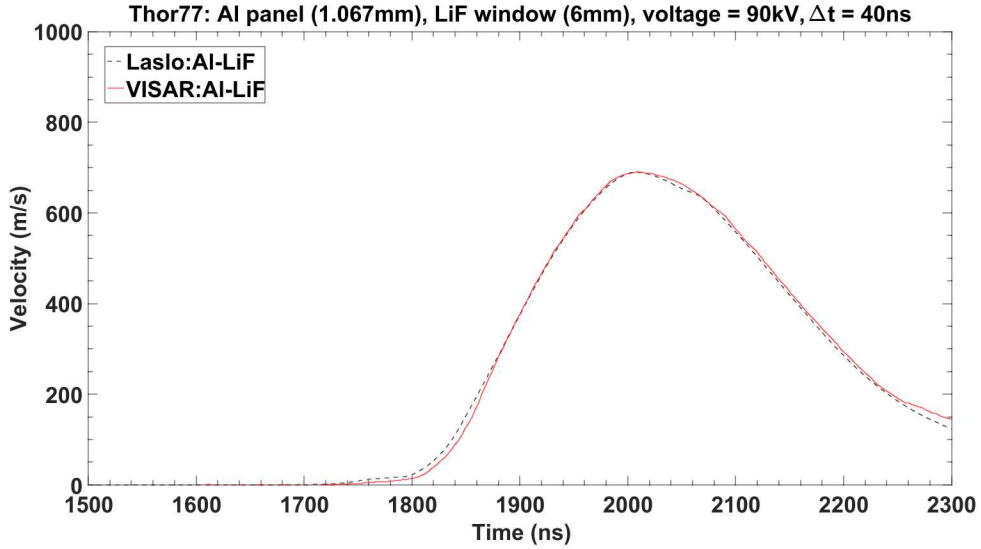


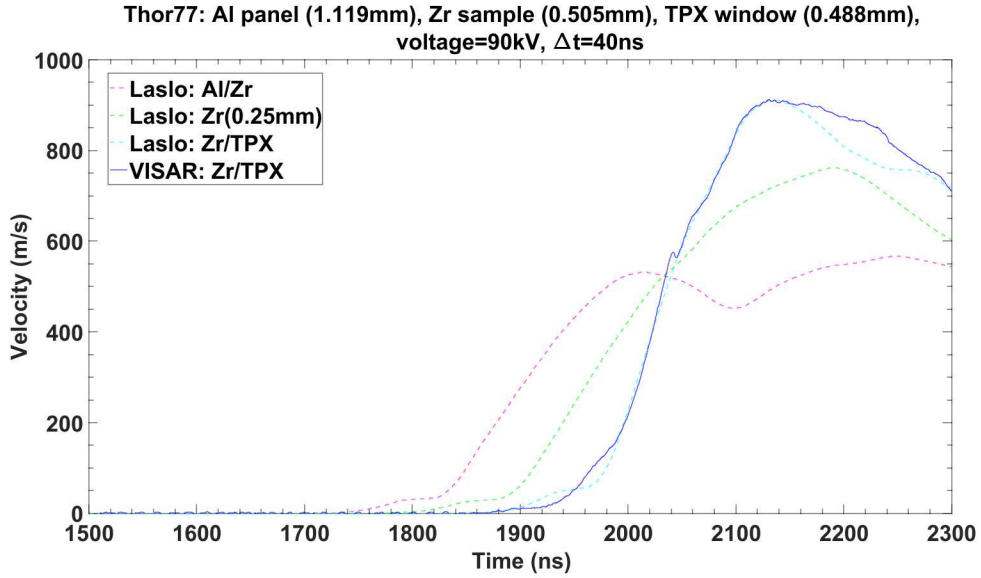
Thor #77 - Laslo simulations and VISAR of Al panel, Zr sample, TPX window



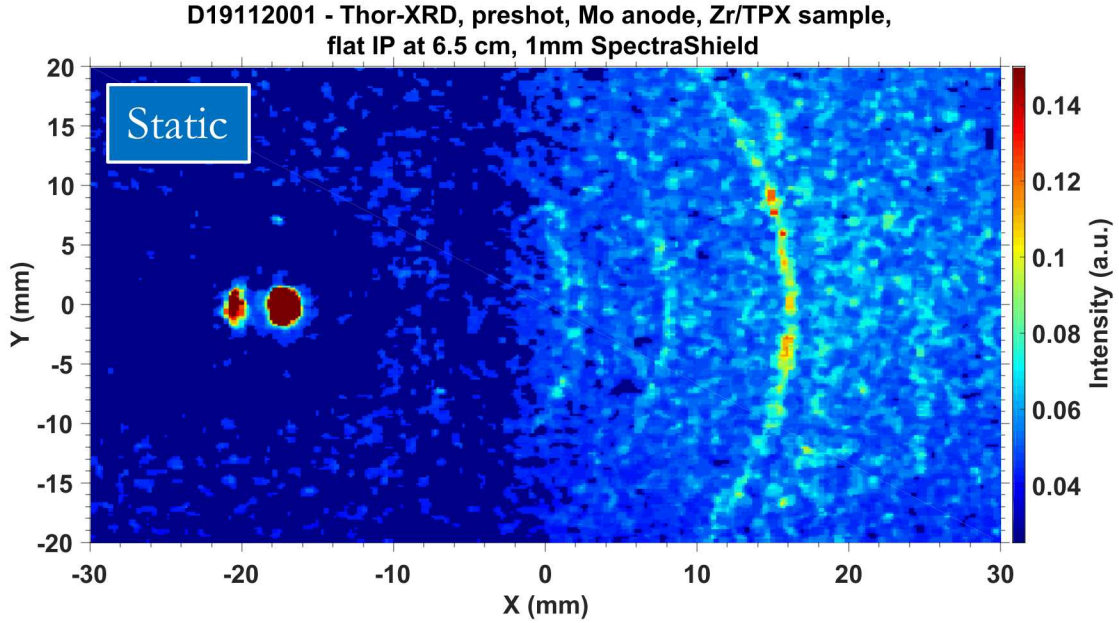


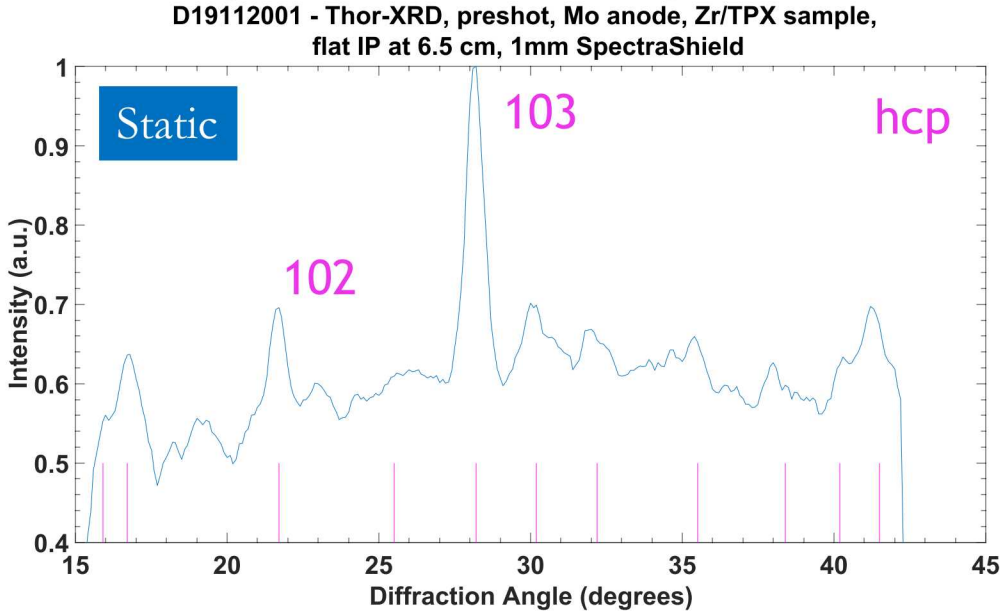


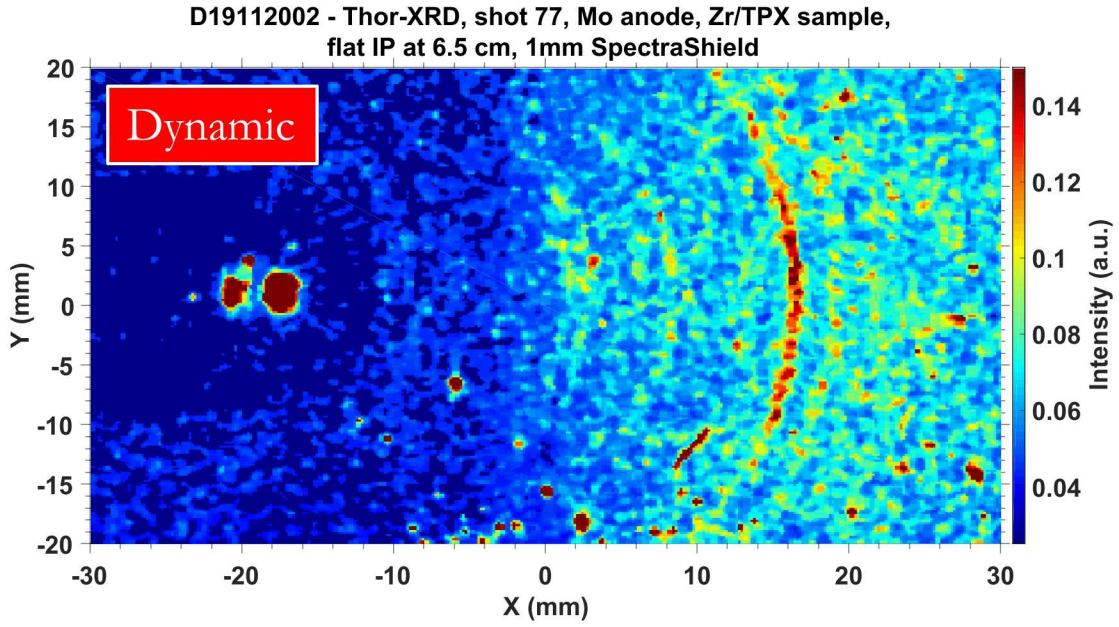


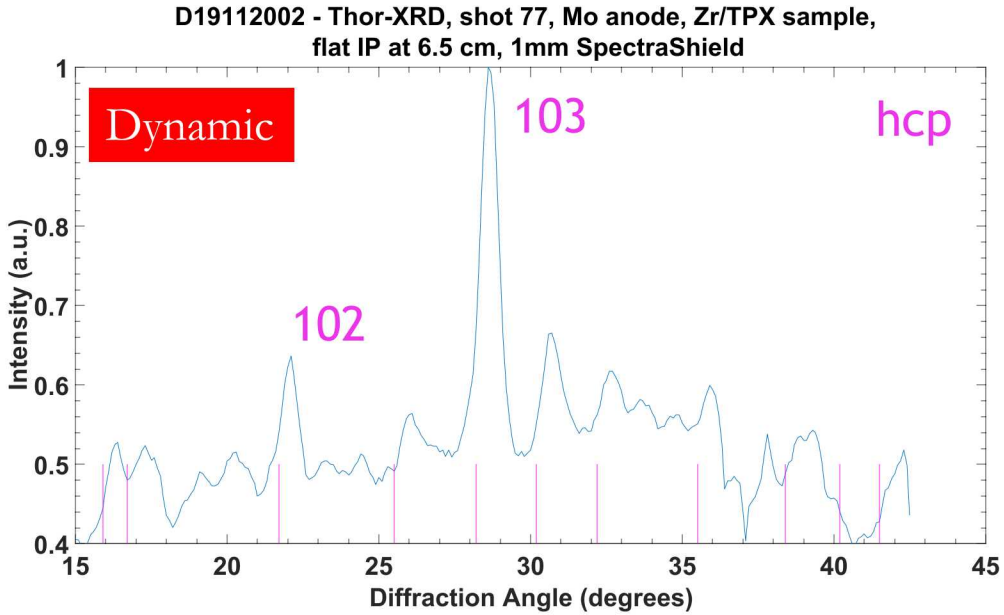


Thor #77 – XRD of Zr with 17.4 keV x-rays (Mo anode)









On-going developments

Issues

- Timing of Thor and x-ray diode
- Damage to Rexolite ring
- Reaching higher pressures to access phase transitions

Solutions

- Internal Rogowski coil within Marx to reduce interference from Thor
- Minimum inductance load panels to alleviate voltage discrepancies
- Install jacks to Thor-XRD chamber to provide strain relief
- Higher impedance windows to maintain pressure
  - e.g. vitreous carbon and LiF111