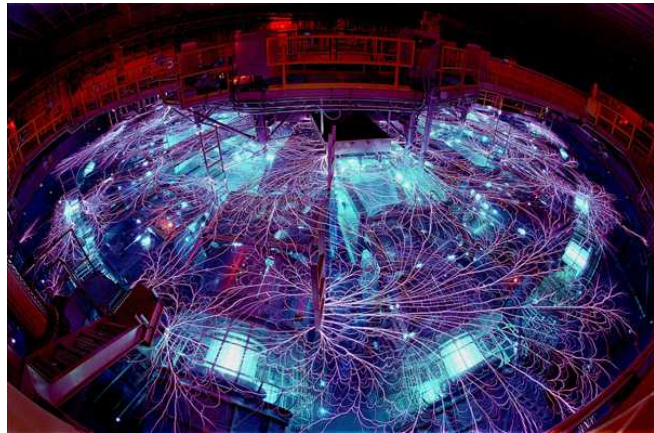
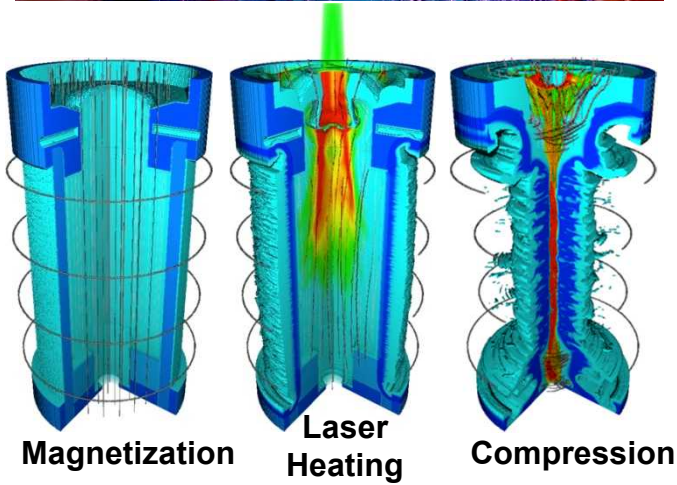


Exceptional service in the national interest



Stagnation & Burn

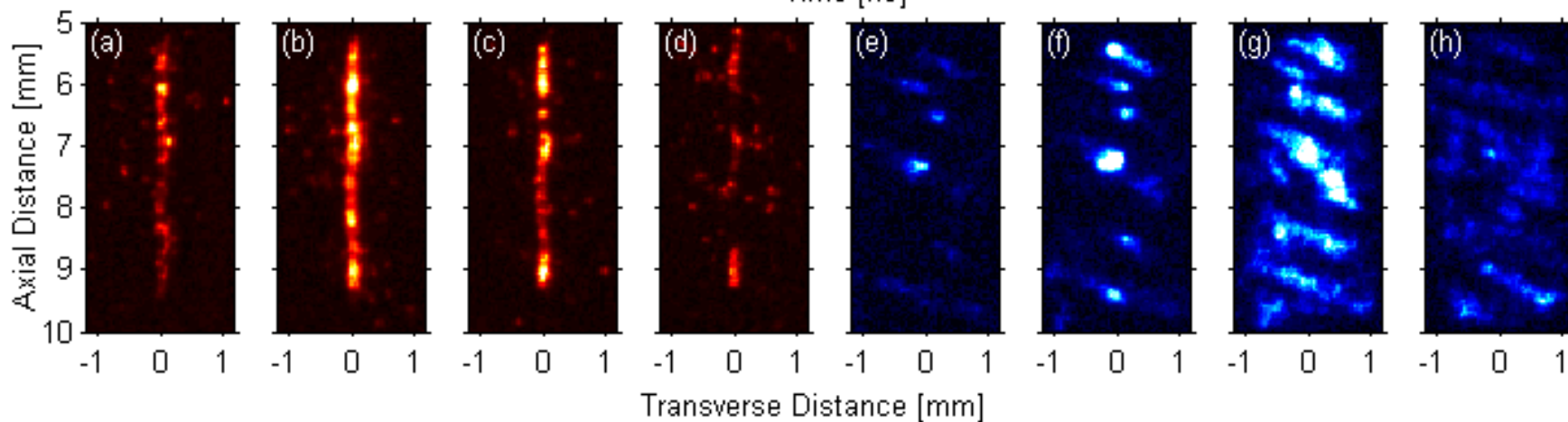
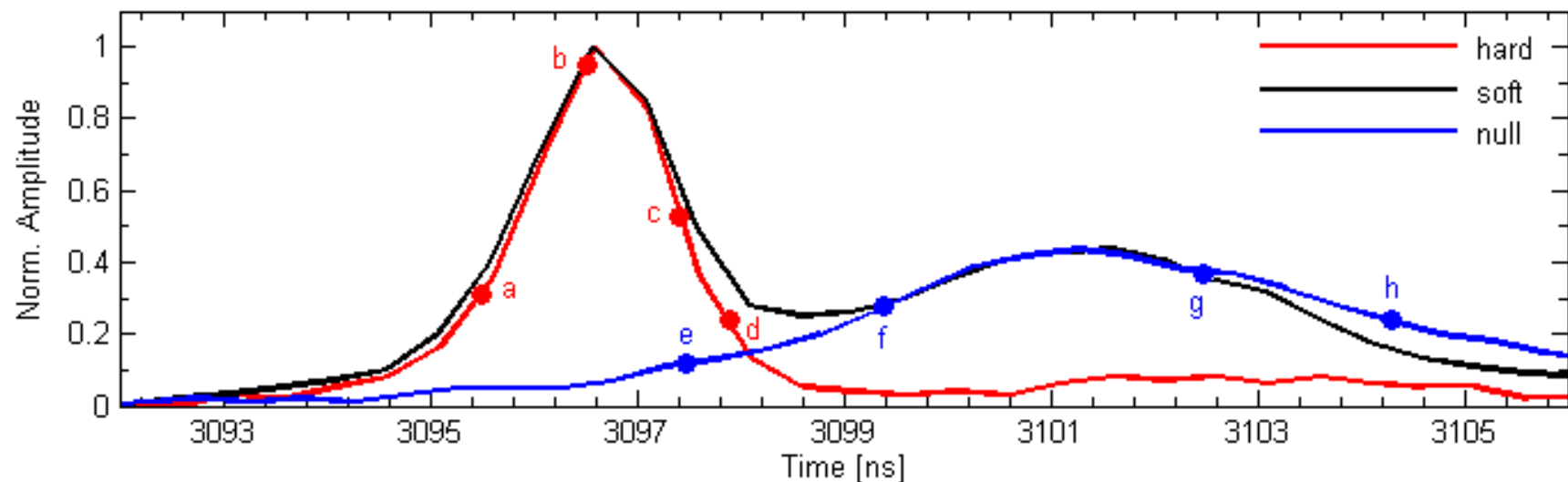
MagLIF Stagnation morphology



Time-resolved x-ray imaging diagnostic requirements

- Sensitive enough to measure $\sim 1\text{-}10$ GW x-ray powers distributed over 10 mm axial height and 0.1 mm diameter in the > 5 keV photon energy range
 - ~ 10 J radiated over 2 ns, escapes from liner (~ 1 g/cm² Be)
- Able to resolve 10-50 μm scale transverse spatial structure
- Able to spatially resolve 0.5-1 mm scale axial spatial structure
- Temporal resolution of approximately 0.25 ns
 - 1 order of magnitude less than the x-ray pulse duration
- Sufficient number of frames and interframe spacing to cover at least ± 2 ns for machine jitter plus 2 ns pulse width
 - 6 ns coverage with 0.5 ns spacing requires 12+ frames

We have had some success with a time-resolved filtered x-ray pinhole camera



Info on our existing pinhole camera

- ✓ Sensitive enough to measure $\sim 1\text{-}10$ GW x-ray powers distributed over 10 mm axial height and 0.1 mm diameter in the > 5 keV photon energy range
- ✗ Able to resolve 10-50 μm scale transverse spatial structure
 - Resolution is limited to approximately 150 μm
 - Stagnation emission width is ~ 100 μm
- ✓ Able to spatially resolve 0.5-1 mm scale axial spatial structure
- ✓ Temporal resolution of approximately 0.25 ns
- ? Sufficient number of frames and interframe spacing to cover at least ± 2 ns for machine jitter plus 2 ns pulse width
 - Only have 4 ns coverage with 0.5 ns spacing (8 frames)
 - It may take several experiments to capture the entire signal of interest

Developing a high-resolution version of the filtered x-ray pinhole camera

- Switch to Gen 2 MCP with strip lines aligned vertically
 - Allows for approximately 3x magnification (change from 0.5x)
- Use 15 μm pinholes (change from 50 μm)
 - In the geometric limit for photons above 5 keV
 - 3x mag \Rightarrow 20 μm resolution
 - 60 μm spot at the image is well matched to 50 μm MCP camera pixel size
- Sensitivity calculation
 - $\frac{1}{2}$ x mag to 3x mag drops signal per pixel by 36x
 - Moving pinholes from 3546 mm to 170 mm increases signal by 435x
 - Decreasing pinhole size from 50 μm to 15 μm drops signal by 11x
 - Approximately 10% more sensitive than existing diagnostic
- Temporal resolution and coverage
 - Same as existing diagnostic, 8 frames, 0.25 ns gate

Geometric vs Diffraction limit

- Geometric limit if $a^2/\lambda \gg f$
 - a = pinhole diameter, λ = x-ray wavelength
 - $1/f = 1/p + 1/q$
 - p = object to pinhole distance, q = image to pinhole distance
- Assuming mag = 3x
 - $a \gg \sqrt{\frac{3}{4} p \frac{hc}{E}}$
- Simplifying
 - $a[\mu m] \gg 30.5 * \sqrt{\frac{p[m]}{E[keV]}}$
- For $p = 0.17$ m and $E > 5$ keV
 - $a \gg 5.6 \mu m$
 - We choose $a = 15 \mu m$