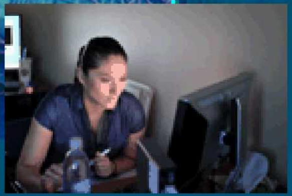
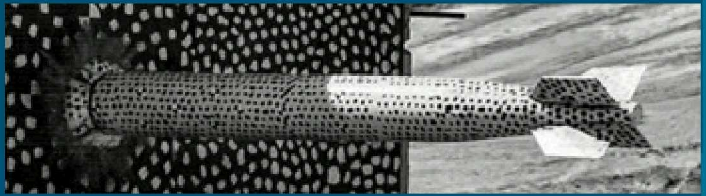
SAND2018-12211PE

Plasma Transport Platform: development, preliminary results and future directions





PRESENTED BY

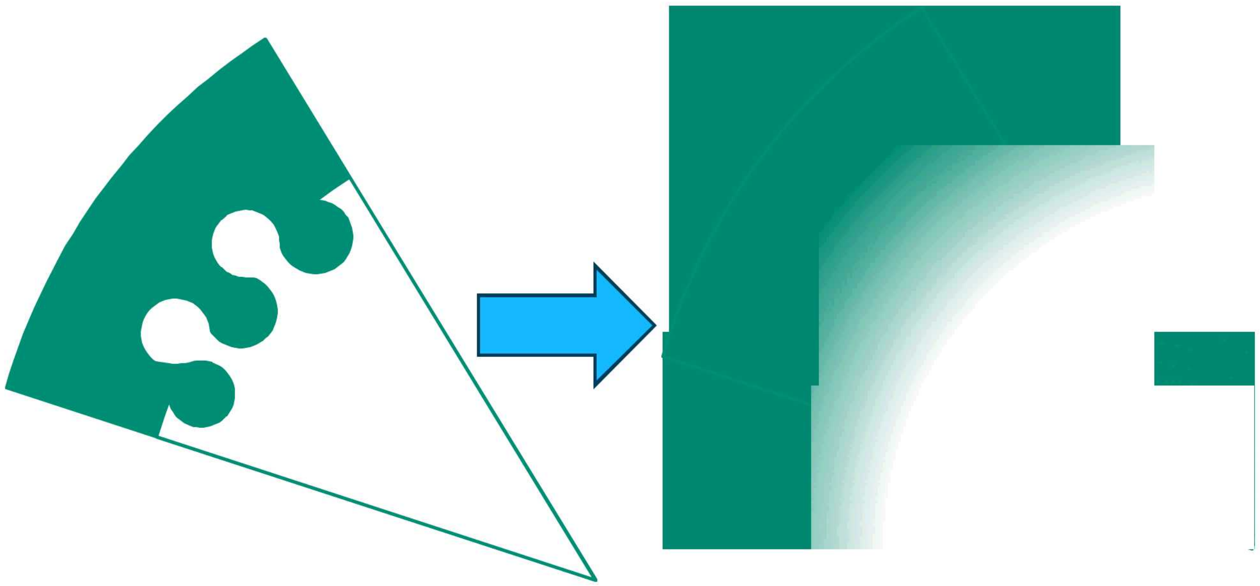
Patrick Knapp

Sandia National Laboratories, Albuquerque NM

This project has been a large interdisciplinary effort

- Diagnostic Development
  - E.C. Harding, M. Schollmeier, G.P. Loisel, S.B. Hansen
- Sample Development
  - S.B. Hansen, P.J. Christenson, P.F. Knapp
- Target Fabrication
  - Haibo Huang, Reny Paguio, Brian Stahl
  - *General Atomics, La Jolla, CA*
- Modeling and Source Development
  - Roger Vesey, P. J. Christenson, K. Beckwith

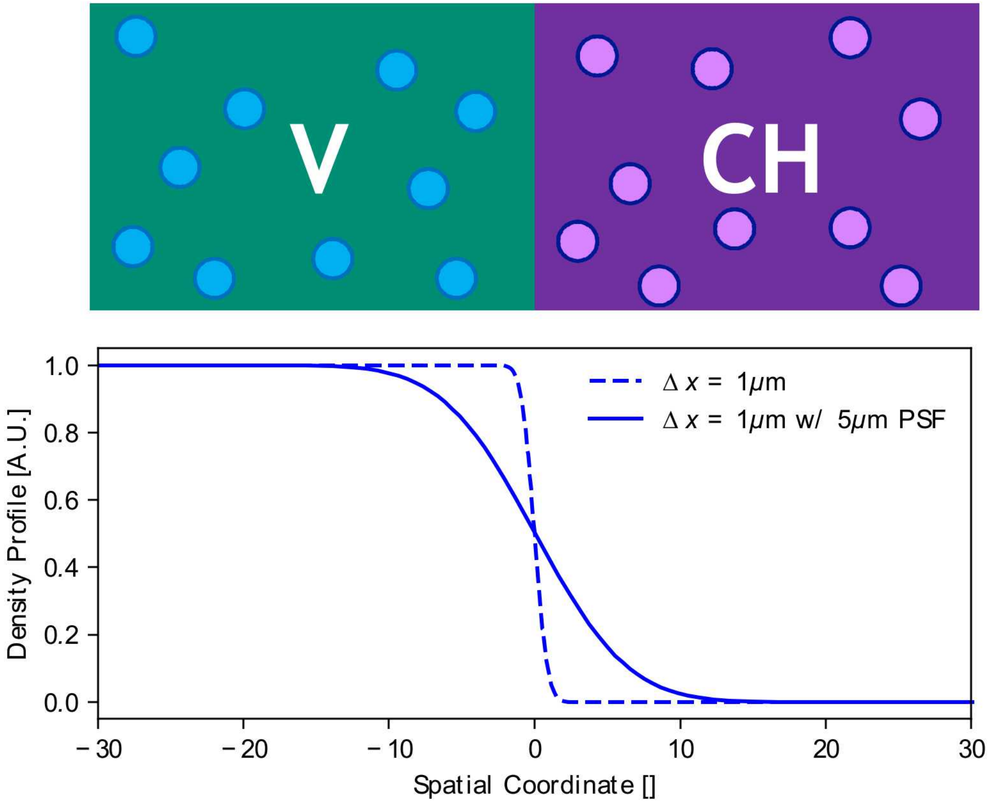
Understanding material transport across an interface is fundamentally tied to our understanding of mix

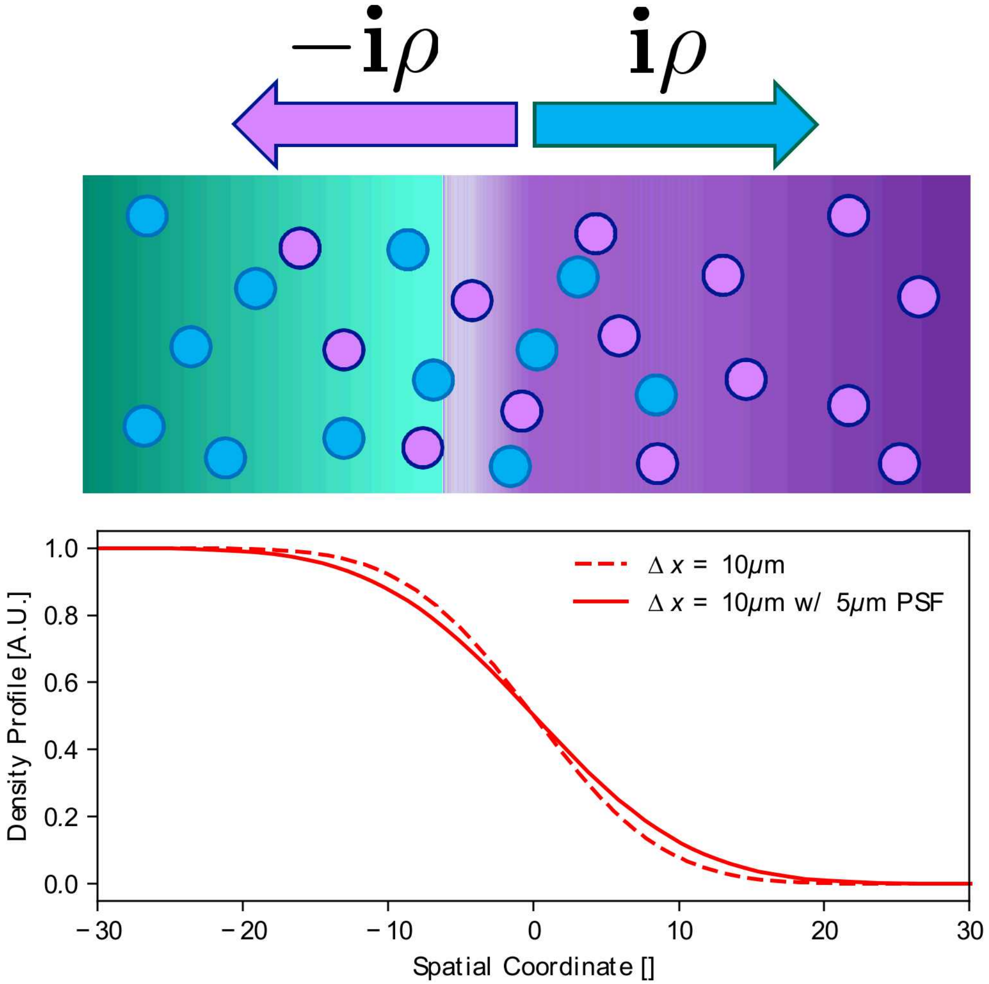


- In addition to distorting the hotspot shape and introducing vorticity, perturbations will
  - increase the surface area available for transport processes
  - decrease the scale length over which transport needs to operate to mix a volume
- Unfortunately fluid models don't account for transport processes well, particularly in strongly coupled plasmas

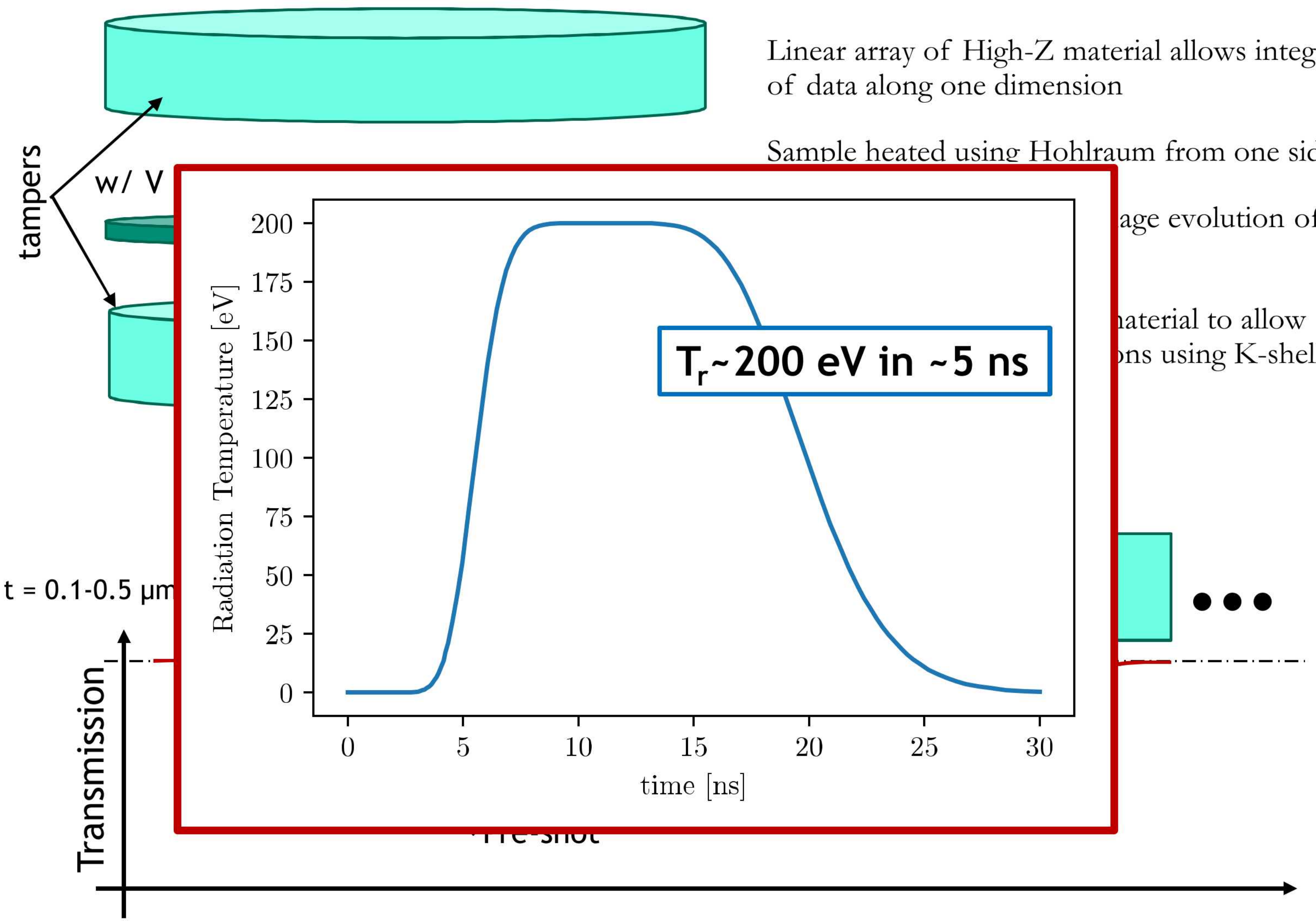
- How does an interface go from perturbed to mixed
- Is it just hydrodynamic stirring/turbulence?
- What role does diffusion play?

We want to measure the “blurring” of an interface between a strongly coupled mid-Z element and a low Z material





Plasma Transport Sample and Diagnostic Concept



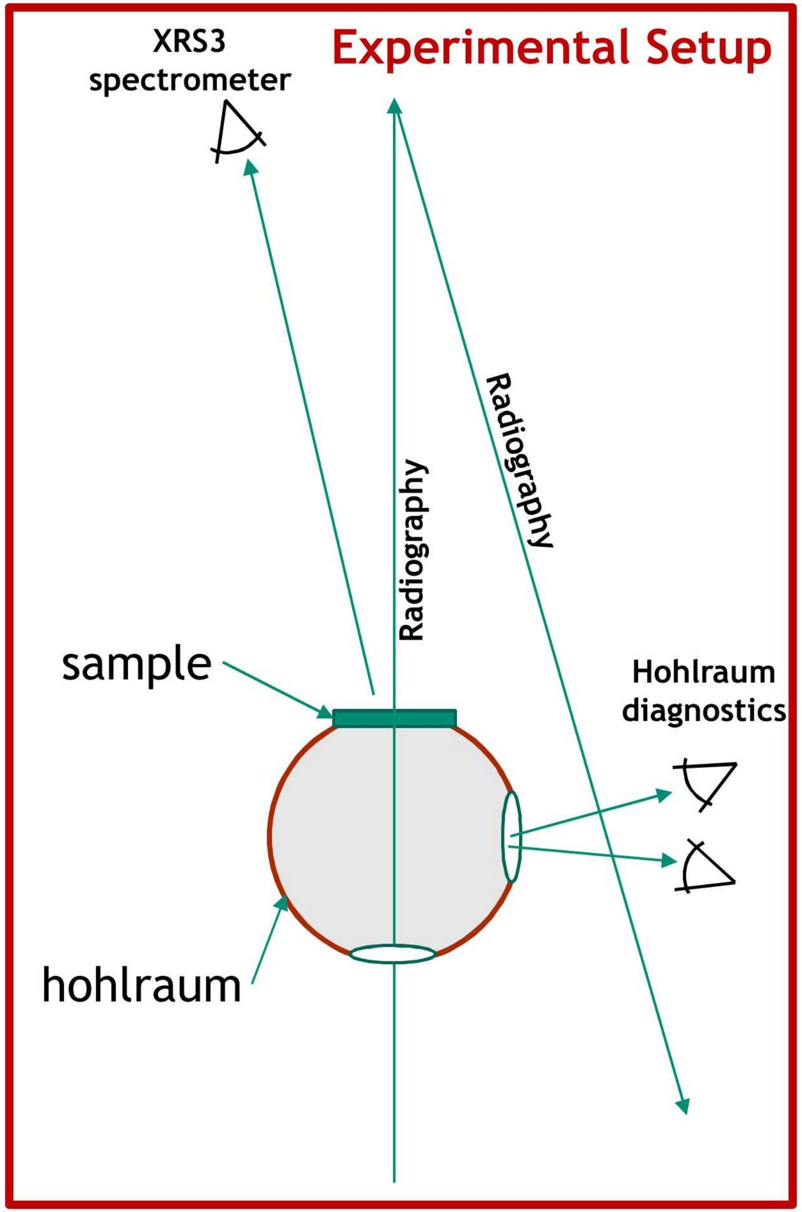
Half moon sample allows transmission to be obtained from the attenuation

Linear array of High-Z material allows integration of data along one dimension

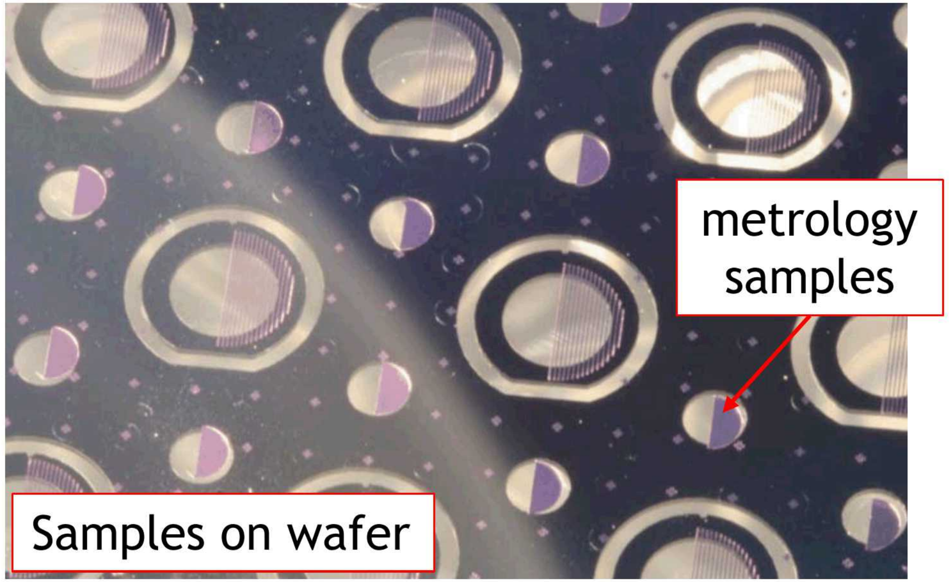
Sample heated using Hohlraum from one side

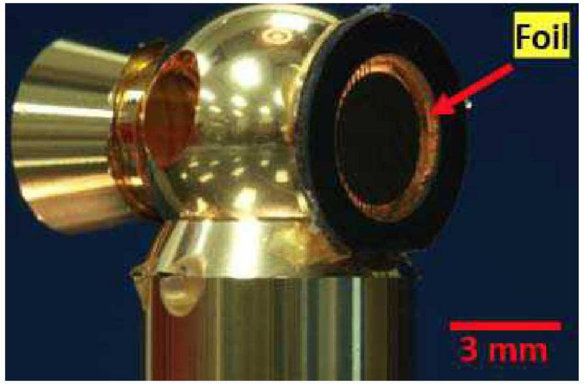
...age evolution of high

...aterial to allow ...ons using K-shell

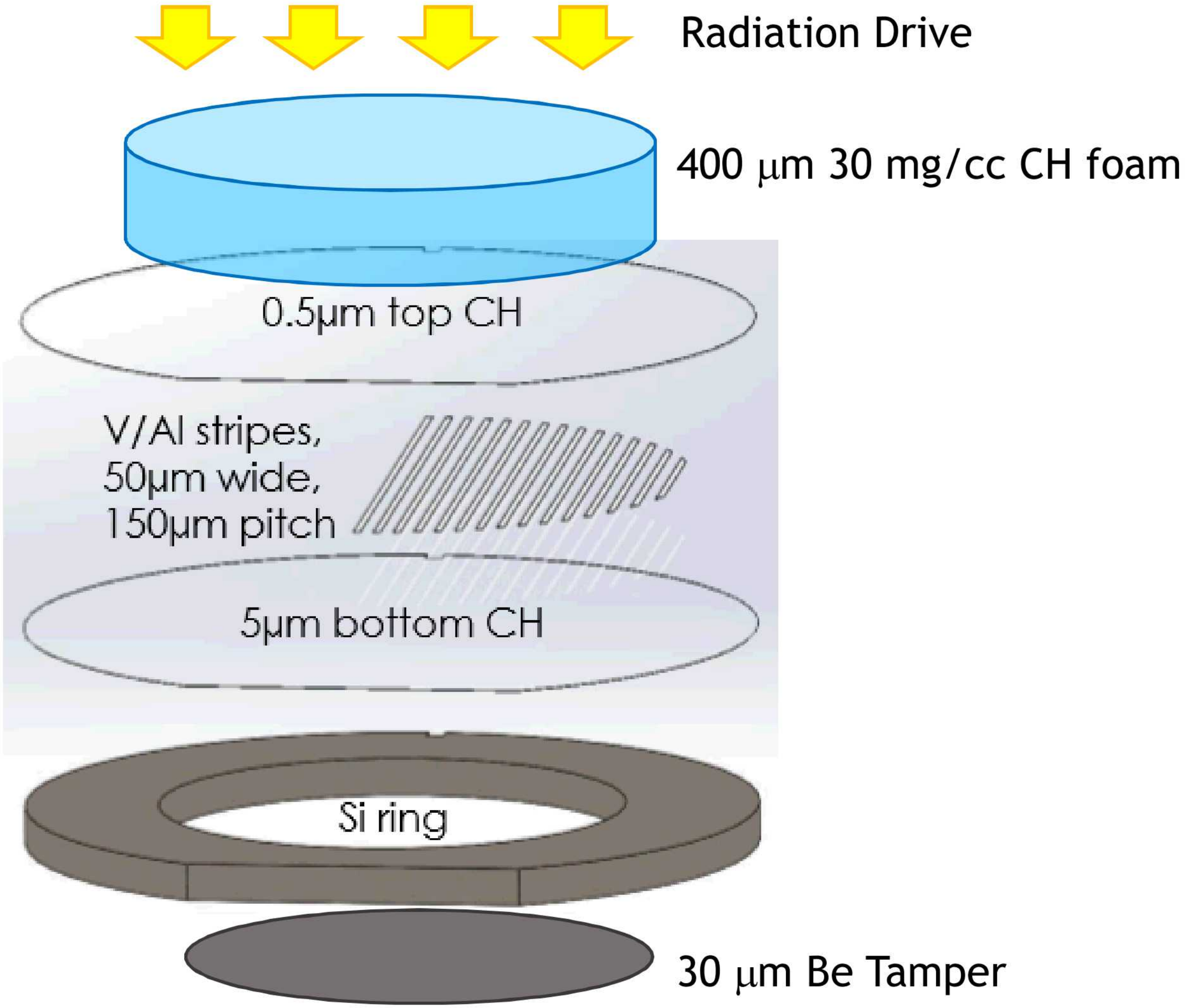


Fabrication of the sample required significant R&D by general atomics





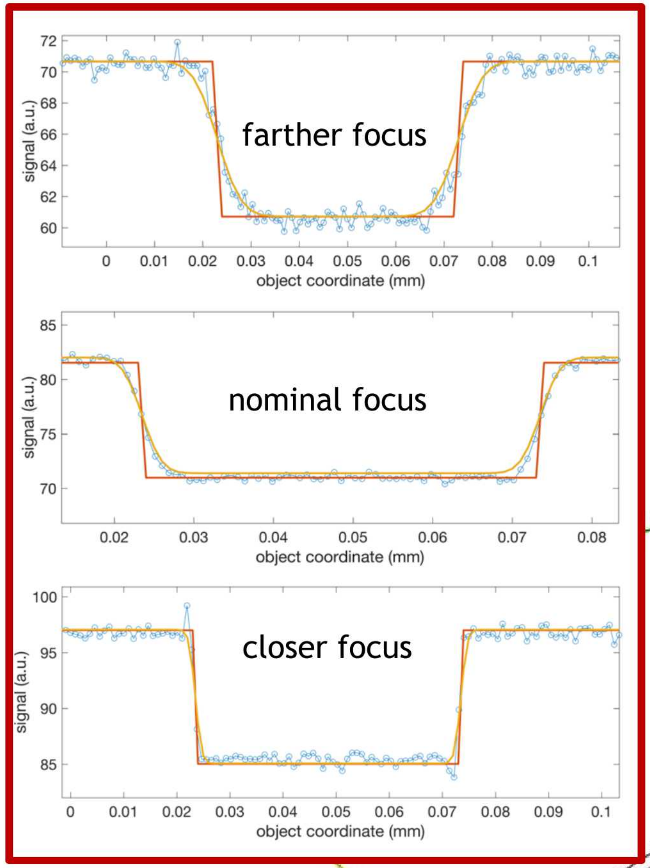
Sample on hohlraum w/ Be tamper attached

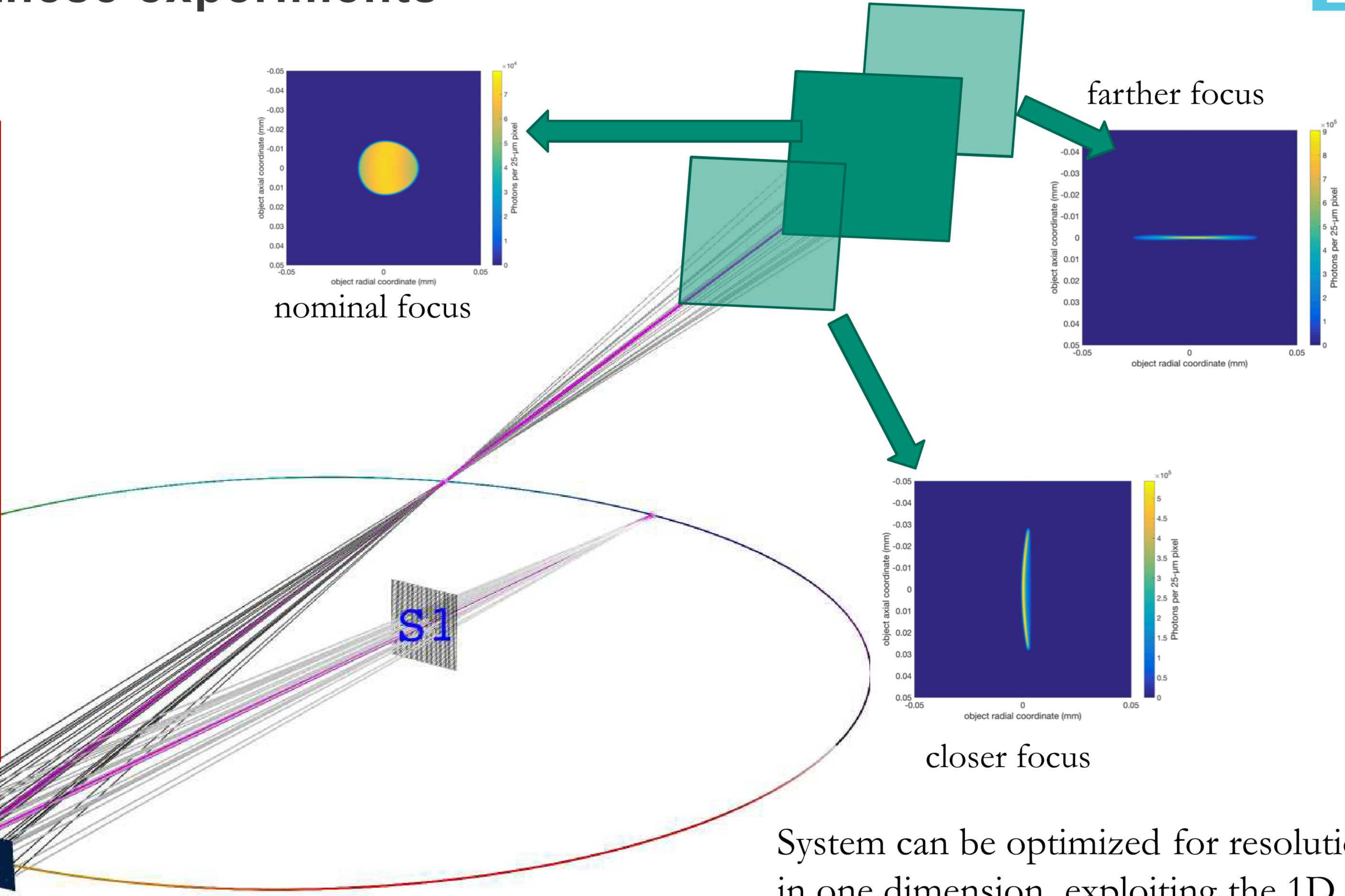


- Requirement of sharp interface led to use of lithographic technique
- Significant effort in metrology for areal density, mixture properties, and edge widths

Material provided by Haibo Huang, General Atomics

The Spherical Crystal Backlighter on Z is the primary diagnostic for these experiments



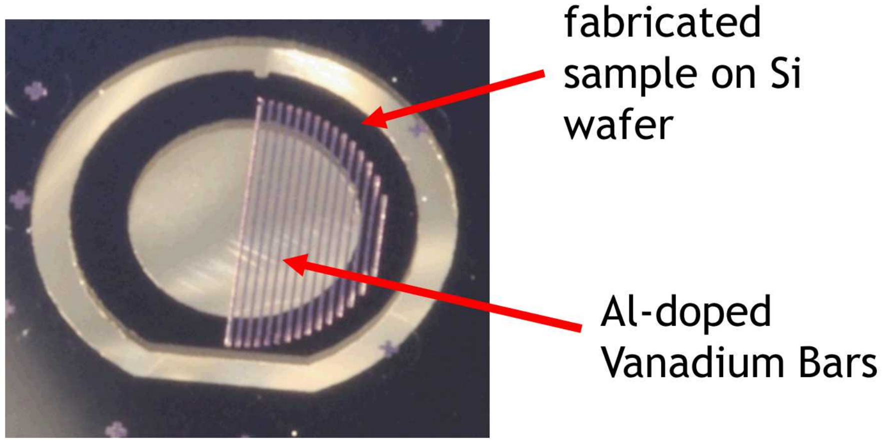


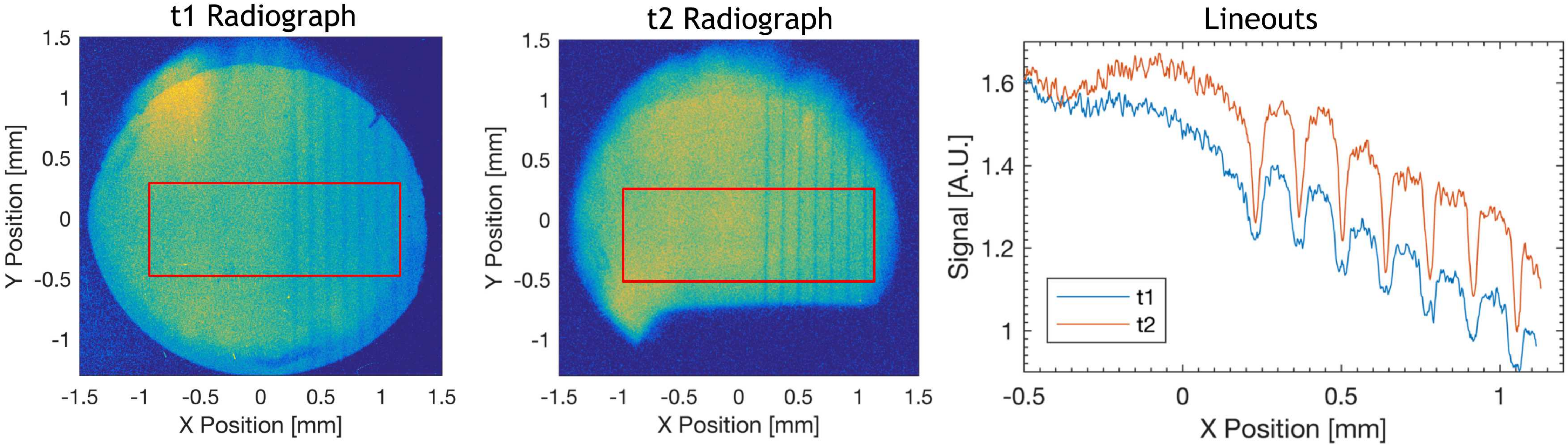
System can be optimized for resolution in one dimension, exploiting the 1D nature of the sample

Ray tracing performed by Marius Schollmeier

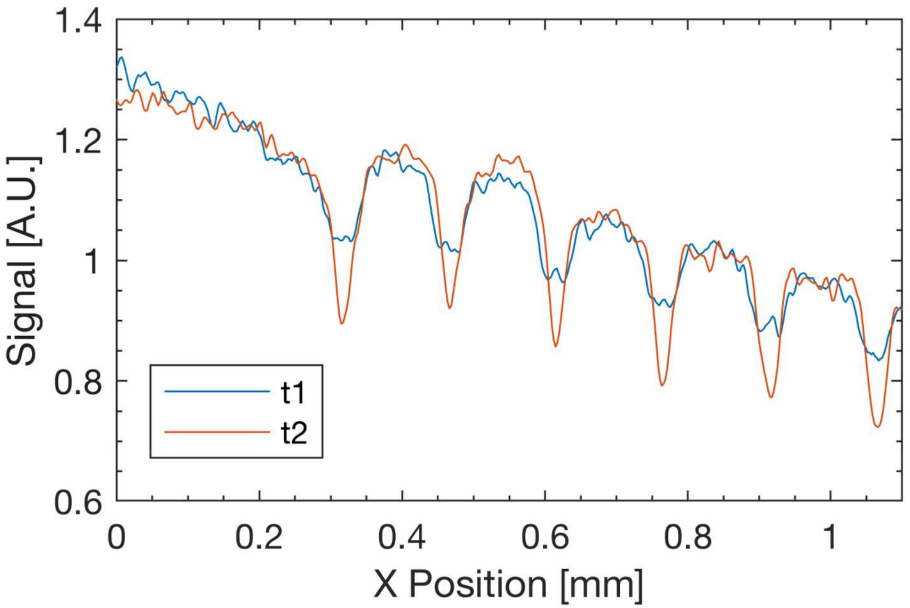
Shot z3220 was the first ever plasma transport experiments have been executed on Z demonstrating the feasibility of the proposed measurement

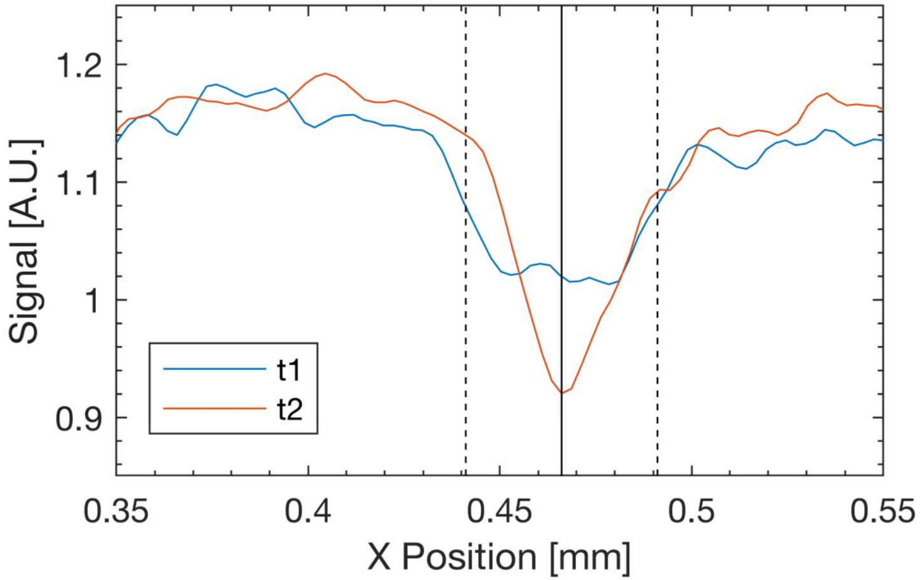
- Executed two experiments in March testing x-ray heating and diagnostics performance
- Demonstrated good contrast of the sample in the radiographs on shot z3220 (6.1 keV backlighter with detector placed at closer focal position)





A closer look



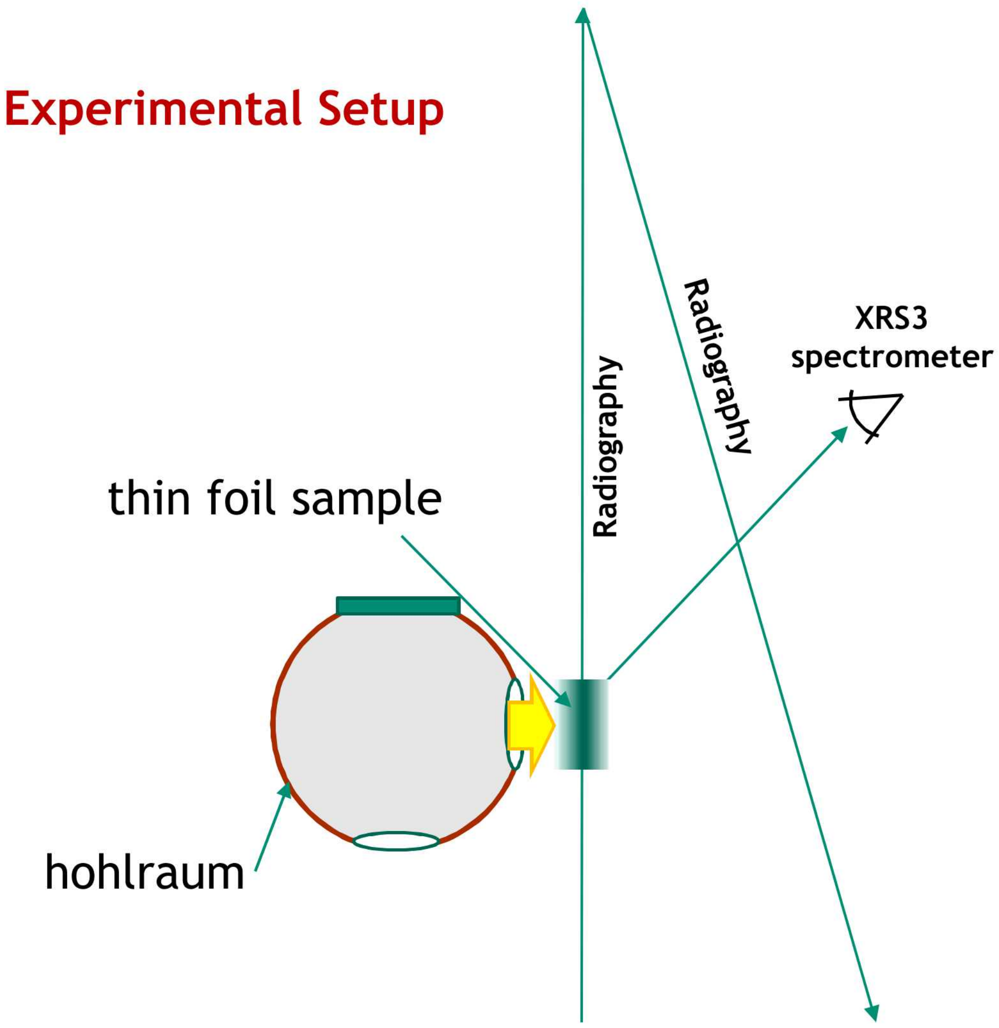


- There is a clearly visible difference between the two frames
- The V strips appear to get "squeezed" between the two frames
- There is a substantial absorption difference between the two frames (hohlraum emission makes it difficult to assess this)
- The width of the strips is approximately correct, though the resolution is as good as hoped

Future Work

- Need to perform offline "cold" radiography experiments to verify resolution and magnification
- We are pursuing alternate heating mechanisms to achieve higher heating rates (more impulse-like) and a more isochoric heating profile with less hydro-motion
- Looking at "simpler" validation experiments
- We are also pursuing alternate sample configurations that could allow new diagnostics to be used that don't have such stringent spatial resolution requirements
  - X-ray scattering techniques (Diffraction, SAXS, Thomson Scattering, etc.)
  - Fluorescence measurements (x-ray or e^- induced)
- This platform is well suited to development on other facilities to help bring the diagnostics and physics to a more mature state

Potential vacuum-expansion benchmark test

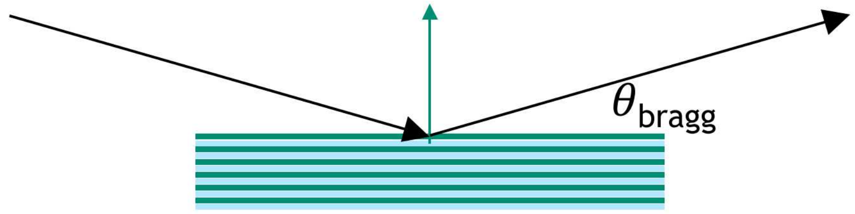


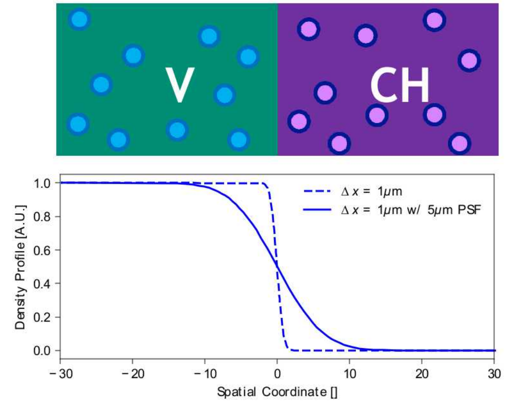
- We were asked by the HED council to try and conduct an experiment with more predictable observables to convince ourselves that the platform is behaving as intended
- Radiograph expansion and curvature of a thin foil
- Possibly use interferometry to see expansion velocity of low density plasma

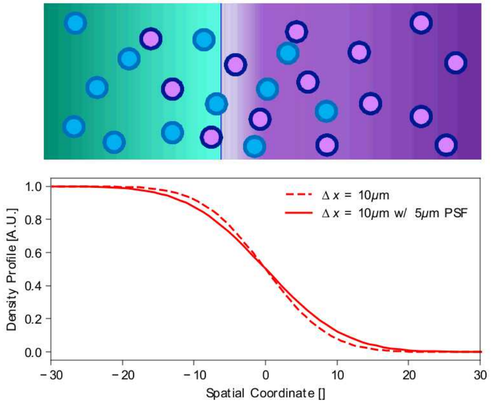
Thinking towards the future

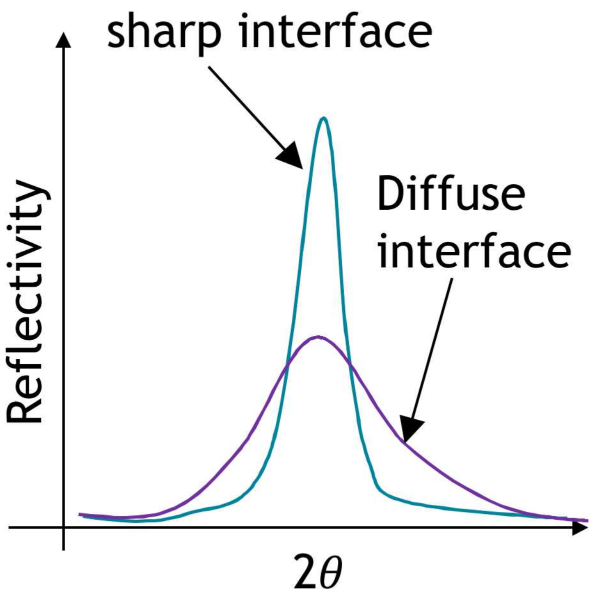
- Radiography is not the ideal diagnostic to do this
- Would prefer to probe the microphysics at the interface, not the bulk fluid signatures
- Using a betatron x-ray probe source, we could use multi-layers or 3D artificial crystal structure to create a sample geometry suitable for diffraction based measurements

1D multi-layer structure









3D "opal" structure