Target Production in Support of Z-Machine Experiments

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Sandia National Laboratories

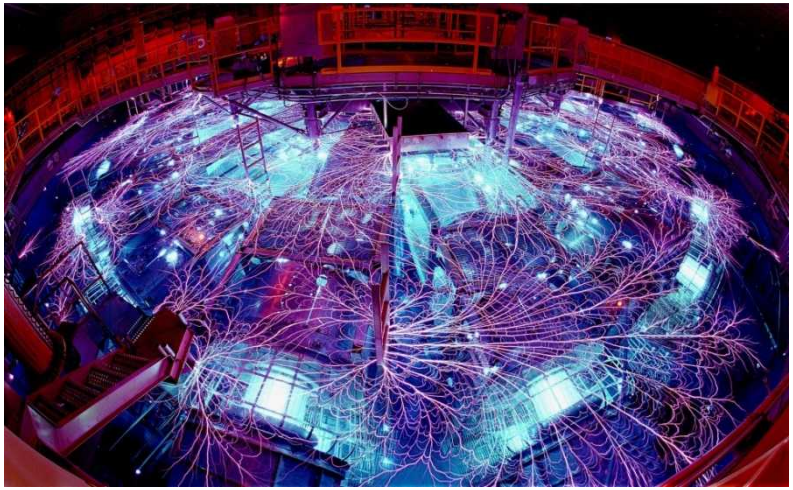
GENERAL ATOMICS

SNL Target Fabrication supports a variety of experiments on Z and Z-beamlet / PECOS

- **Z generated multi-Megabar pressures have been used to study the equation of state of materials relevant to ICF and HED Science**

- **Includes Various Programs: ICF/Radiation Effects Science (RES), Dynamic Material Property (DMP), Fundamental Science (FS), Z100**
  - Planar & Cylindrical Targets

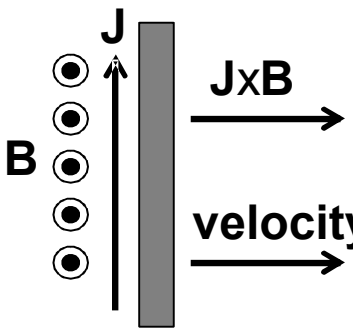
- **R&D & collaborative efforts for current & future experiments**
  - PDV (Photonic Doppler Velocimetry) Diagnostics
  - Various materials for machining & Assy (Be, Pr, Ge, Ir, Rh, Li, LiH & Foams)
  - Coatings



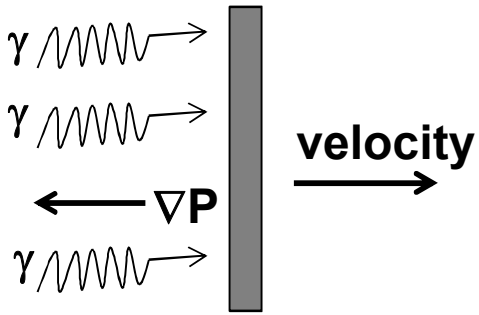
Large currents are used to drive experiments on pulse power machines

$$\rho\left(\frac{\partial \mathbf{u}}{\partial t}+(\mathbf{u}\cdot\nabla)\mathbf{u}\right)=\frac{\mathbf{J}\times\mathbf{B}}{c}-\nabla P$$

Magnetic Drive – 2D



Photon Drive – 3D



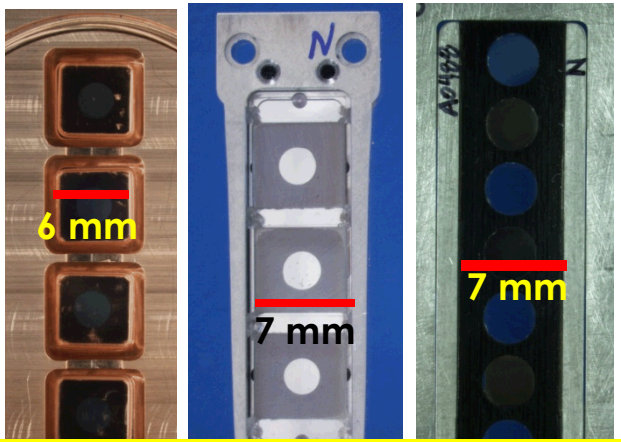
SNL targets compared to OMEGA/EP/NIF Targets

- Similar assembly tolerance requirements
- 2D: Cylindrical or Planar versus 3D: Spherical or Sphere in a hohlraum
- Larger: 10's of mm versus ≤ 10 mm
- In FY16, 40% of Z machine shots used beryllium

Dynamic Material Property (DMP) experiments study material behavior

- Experiments achieve MPa pressures
- 90% of DMP experiments are planar configuration

- DMP panels contain various sample materials
  - metals, plastics, aerogels, foams



Various Panel for DMP Targets

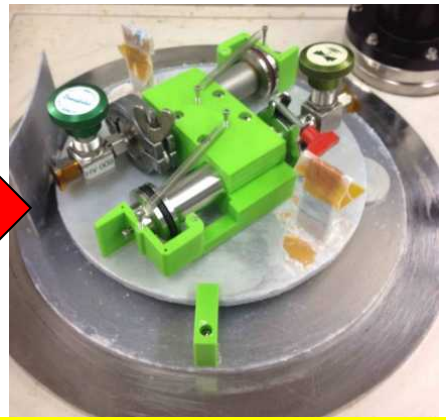
first-of-a-kind lithium target

- Made in argon glovebox
- LiF window protects Li
- For Li without window: parylene-N protects Li

Li Panel DMP Target

Transfer from glovebox to coater to Jack in a box Device

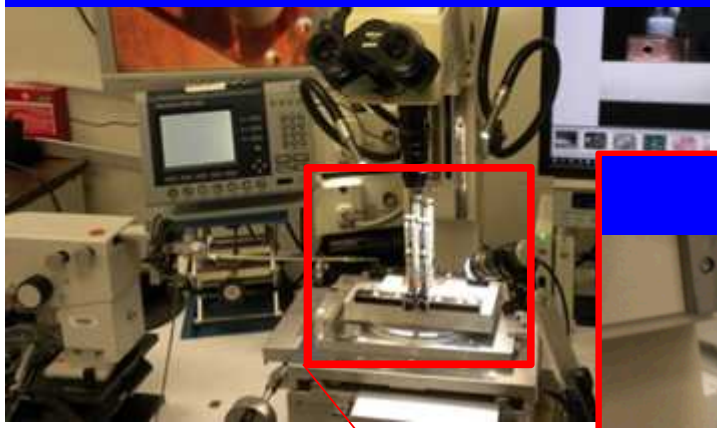
Once coater is under vacuum- Jack in a Box opens up



Jack in a Box Device

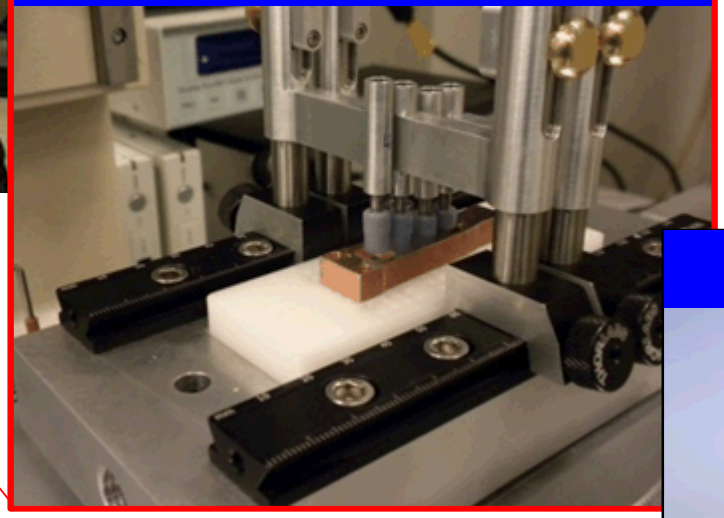
Investment in multi-press tool development improved fabrication efficiency for planar DMP targets*

Assembly station with multipress

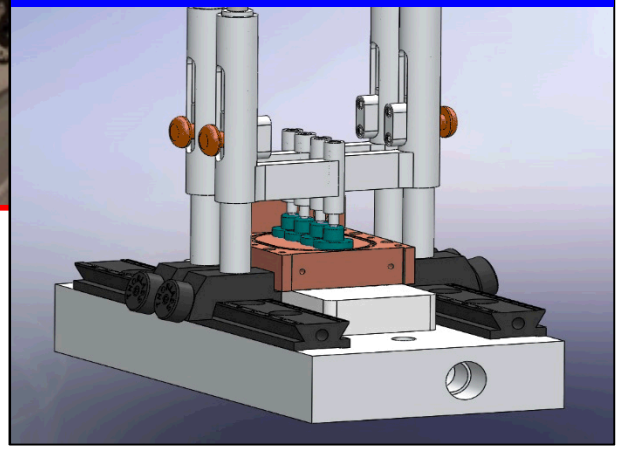


Assembly time reduced by 2-5X

Closeup on Press

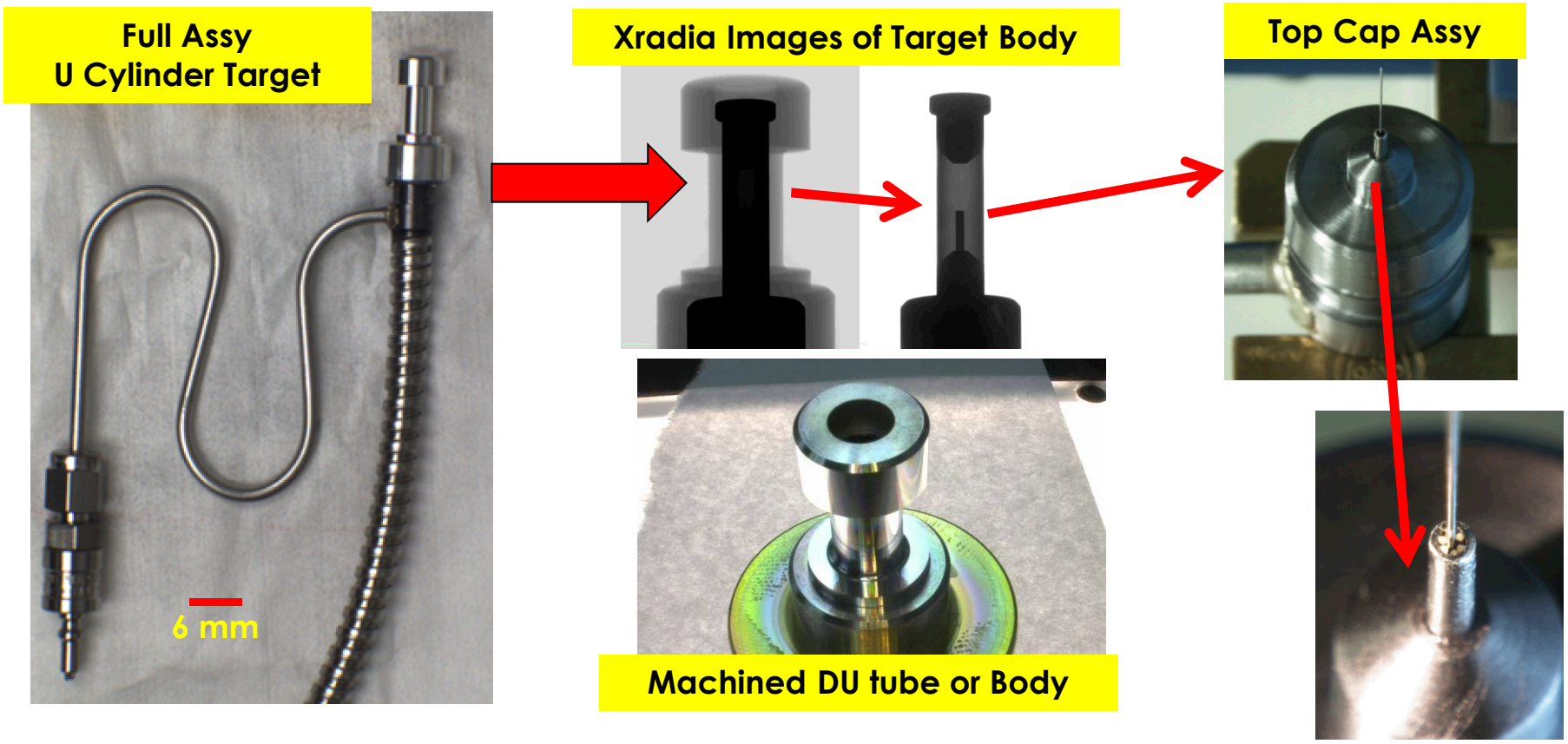


Multipress model



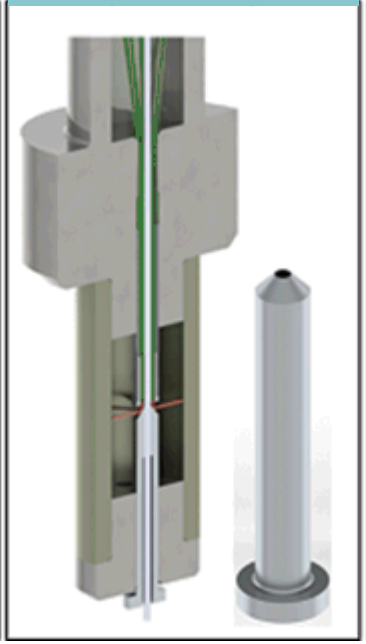
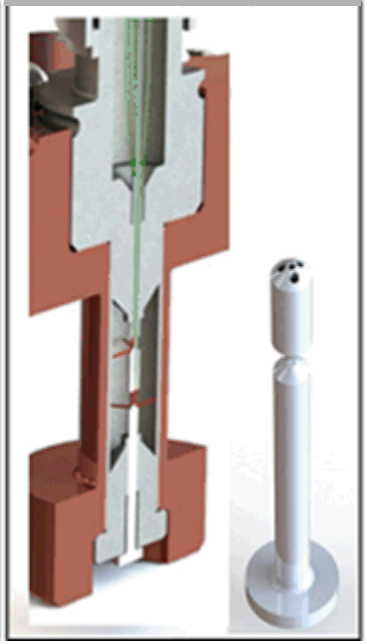
* Tatum et al. (Poster)

A multi-facility effort produced a cylindrical DMP depleted uranium (DU) target shot on Z

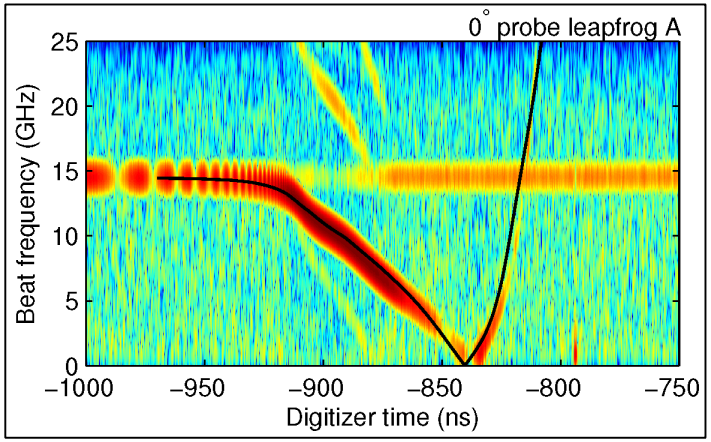


LANL: Provided near net shape DU cylinder
GA-La Jolla: Finish machined DU liner and other target component
GA-SNL: Target assembly and metrology (La Jolla)
SNL: Shot time containment

Improvements in the cylindrical Photonic Doppler Velocimetry (PDV) diagnostic*

Single point (2012)	Multipoint (2013-2014)	2-level Multipoint (2015-2016)
		

Measures material properties at significantly higher pressures (3-4X) VS. planar target

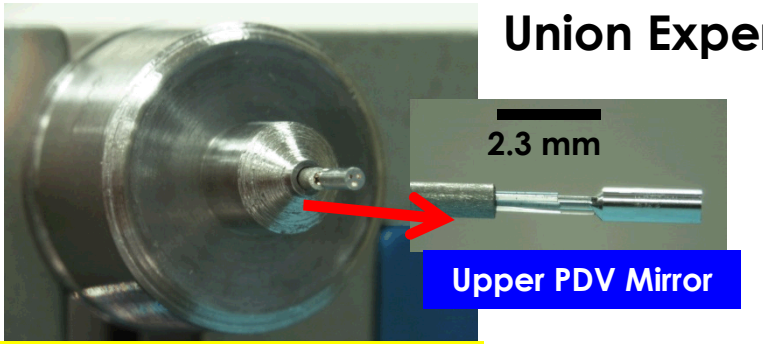


Continuously measure wall motion during implosion versus a single time point measurement

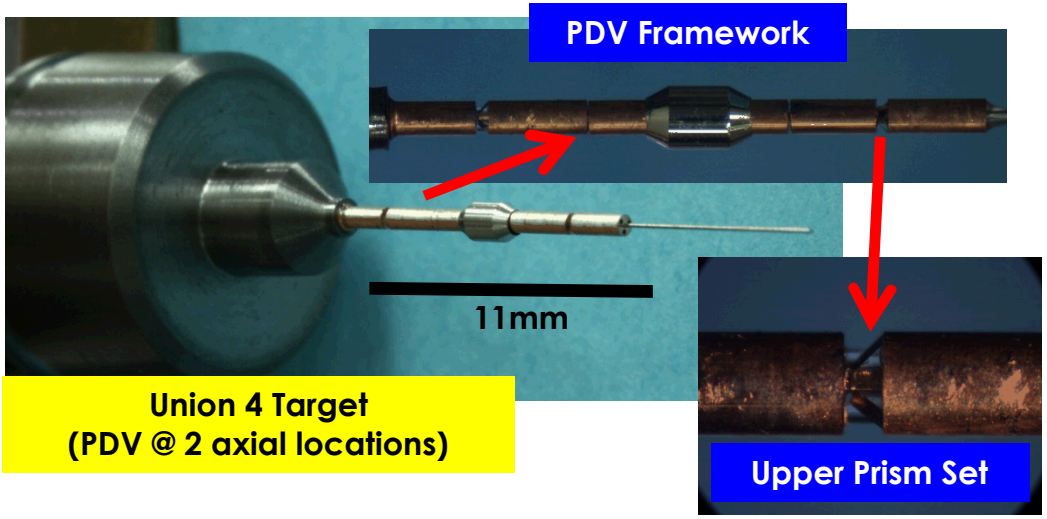
* Tomlinson et al. (Talk)
* R. W. Lemke, et al., J. Appl. Phys. 119, 015904 (2016)

Teamwork led to first of it's kind 2-level PDV diagnostic

Union Experiments*



Union 3 Target
(PDV @ 2 axial locations)

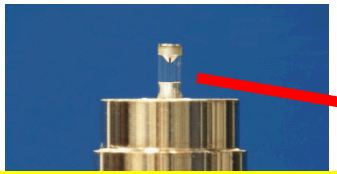


Union 4 Target
(PDV @ 2 axial locations)

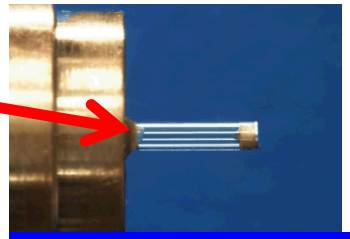
* Tomlinson et al. (Talk)
* R. W. Lemke, et al., J. Appl. Phys. 119, 015904 (2016)

Union (HED) PDV concepts were transitioned to MagLIF (ICF) targets

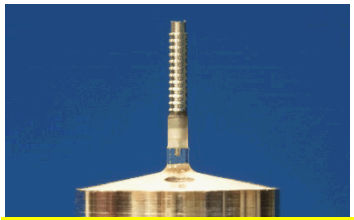
~4-5 ICF campaigns per year use PDV



Eddy Target with single Axis PDV



PDV Quartz Assembly

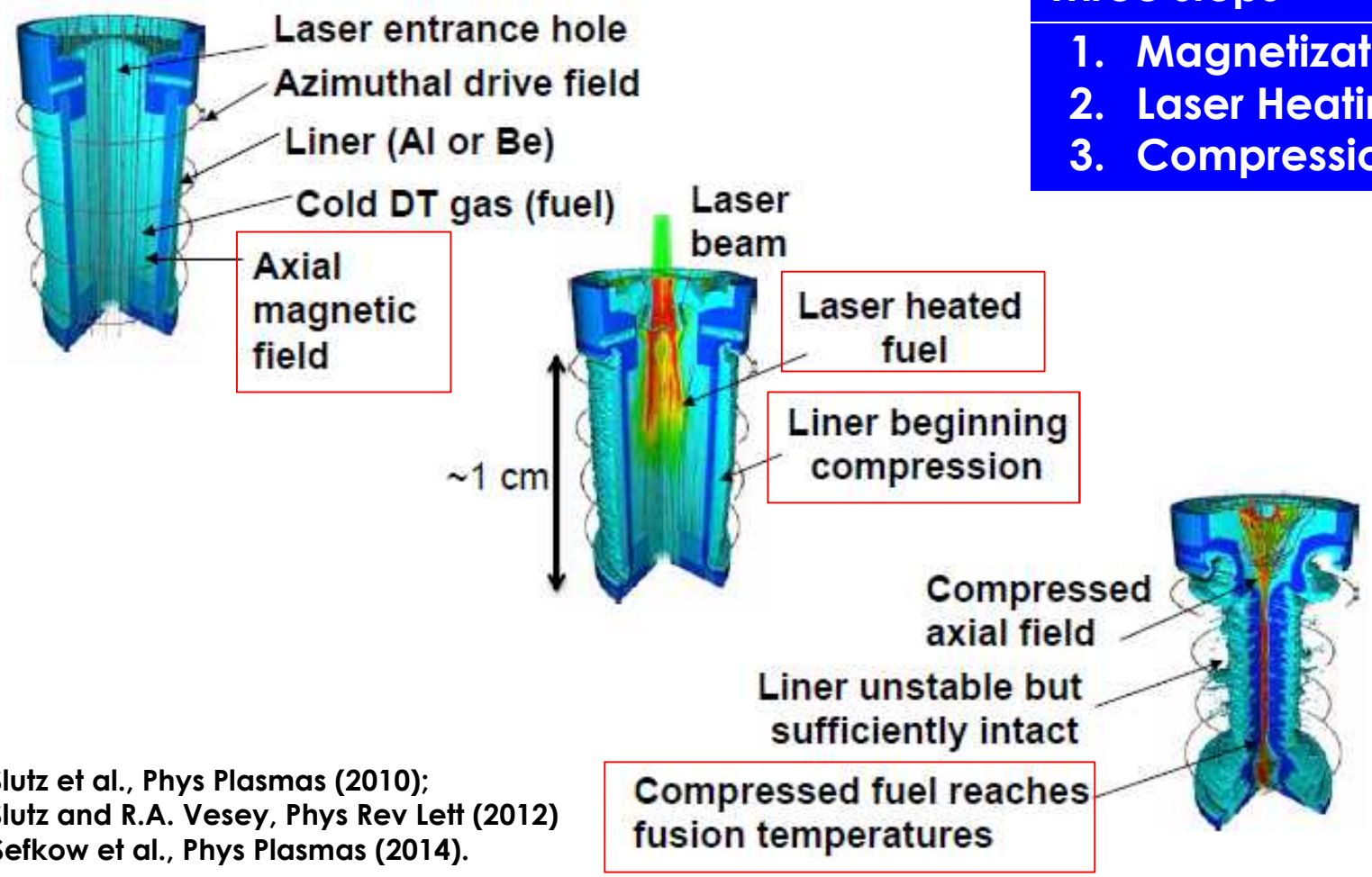


IMP DRT Eddy Target with single Axis PDV

Magnetized Liner Inertial Fusion (MagLIF)

Three steps

1. Magnetization
2. Laser Heating
3. Compression

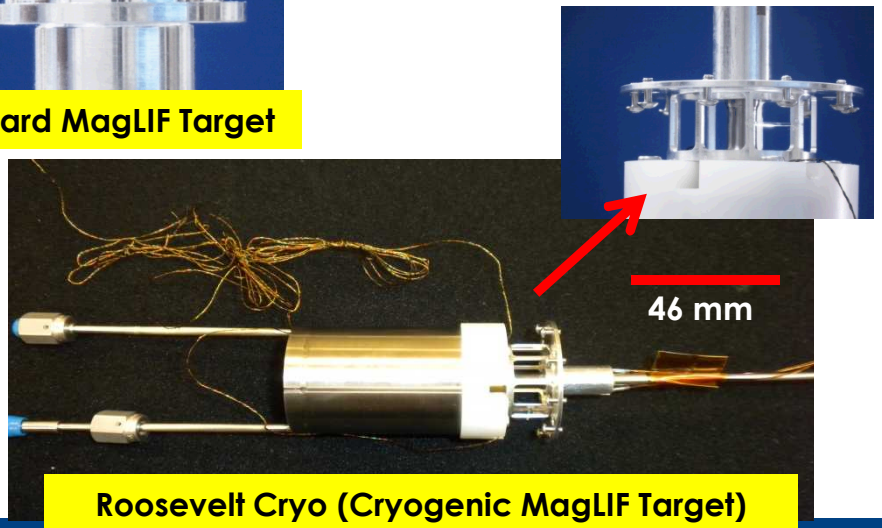


- S.A. Slutz et al., Phys Plasmas (2010);
- S.A. Slutz and R.A. Vesey, Phys Rev Lett (2012)
- A.B. Sefkow et al., Phys Plasmas (2014).

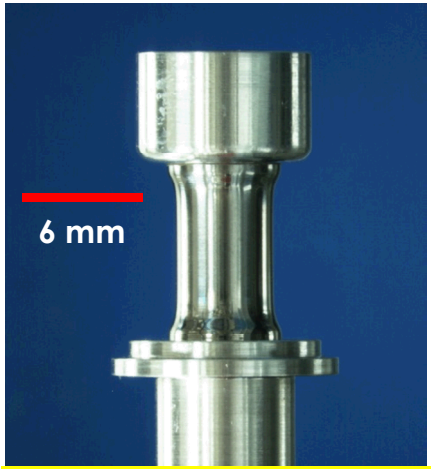
A variety of targets are used to study the MagLIF concept

- **Cryogenic experiments:** Roosevelt Cryo
- **Helical MagLIF Target:** Rayleigh Taylor instabilities
- **Thick End Targets:** Study implosion instabilities
- **StagMix Targets:** Target impurities and how they affect the implosion mix

Standard MagLIF Target



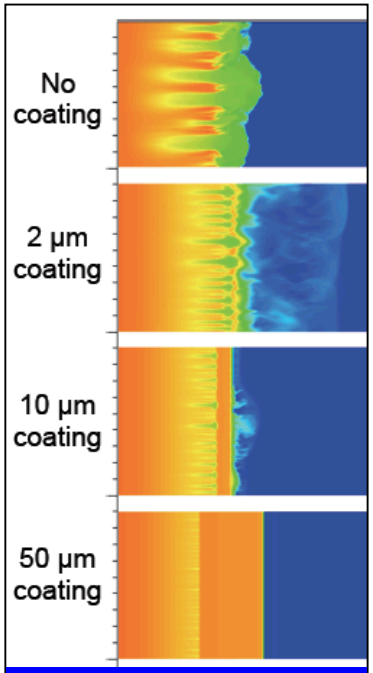
Roosevelt Cryo (Cryogenic MagLIF Target)



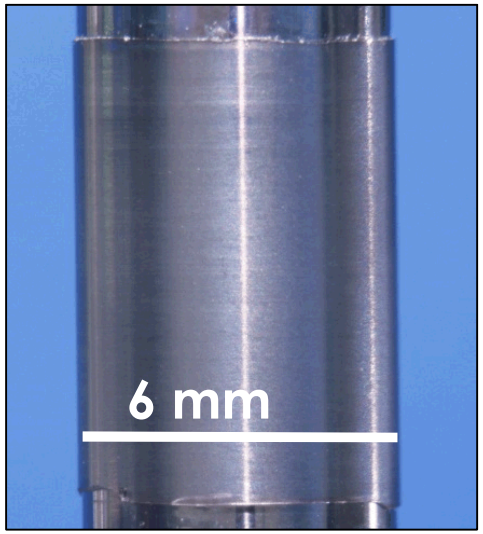
Thick Ends MagLIF Target

Helical MagLIF Target

Thick dielectric coatings suppress liner instabilities *

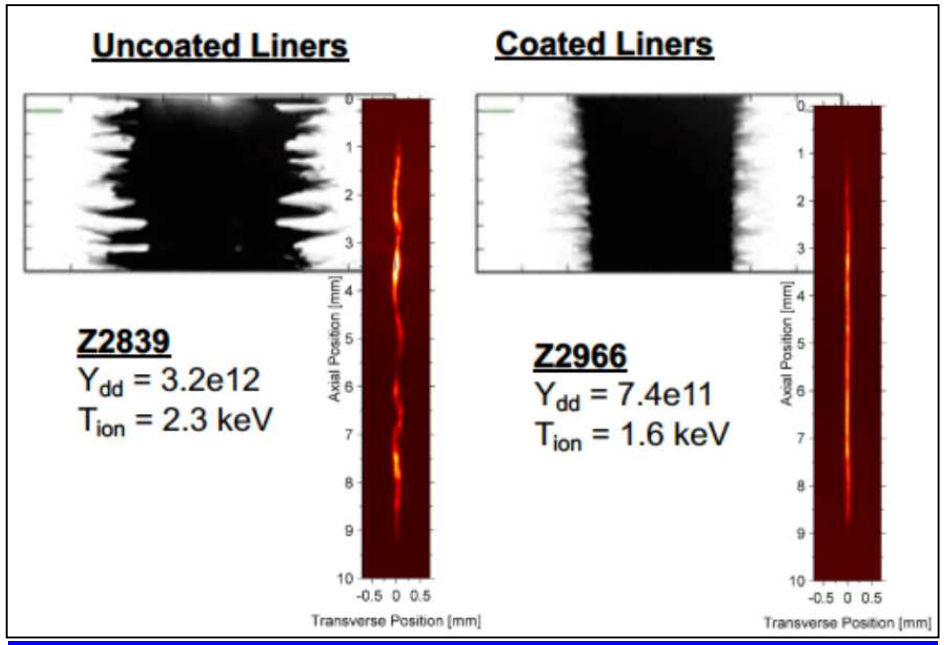


Model



75 μm dielectric coating on a liner

Resulting in improved stagnation morphology



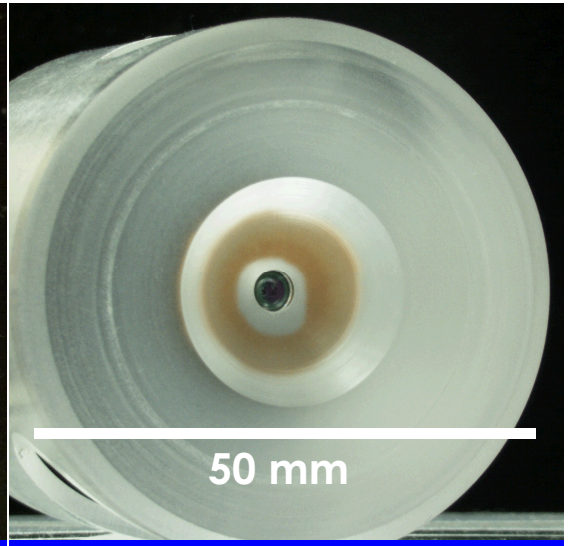
Experimental Results

* T. Awe et al.

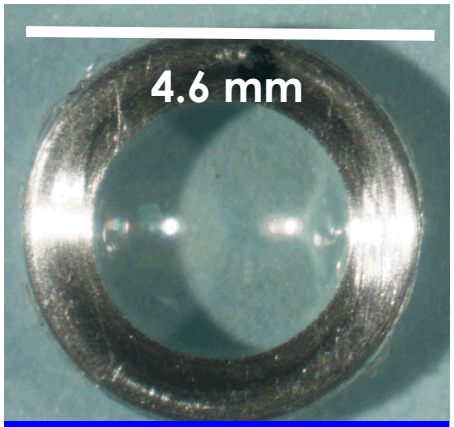
Advanced gas cell targets support MagLIF laser pre-heat studies with Z-Beamlet at PECOS target area

- **Gen 1 gas cell target: 15 PSI**
  - Mylar LEH
- **Gen 2 gas cell target: 60 PSI**
- Mimic MagLIF target pressures
  - Utilize polyimide* windows
  - Improved component bond strength robustness
- **In-house assembled LEH windows**
  - Provides flexibility and faster response
  - Various coating on polyimide* provided evaluation of window mix

PECOS Gas Cell



LEH Window region



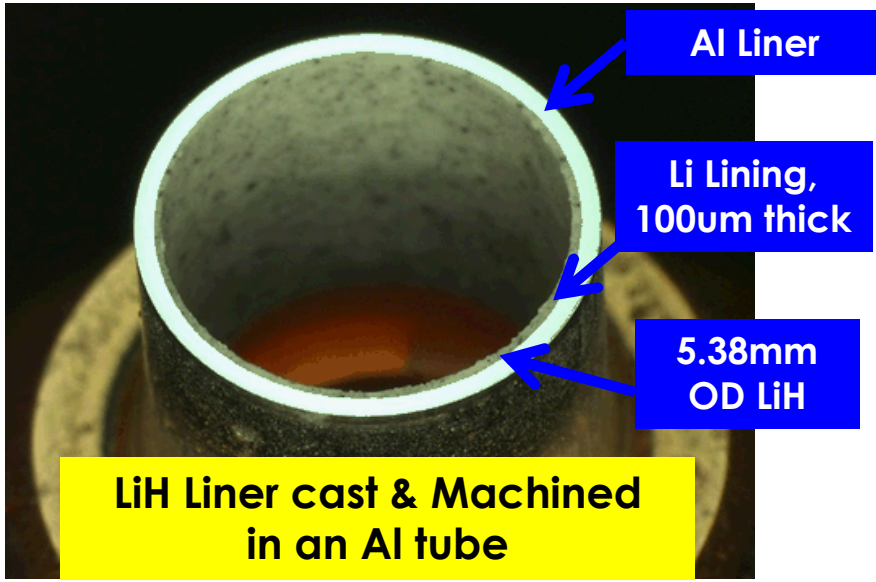
LEH Window

These targets help inform an integrated MagLIF experiment conducted on January 2017

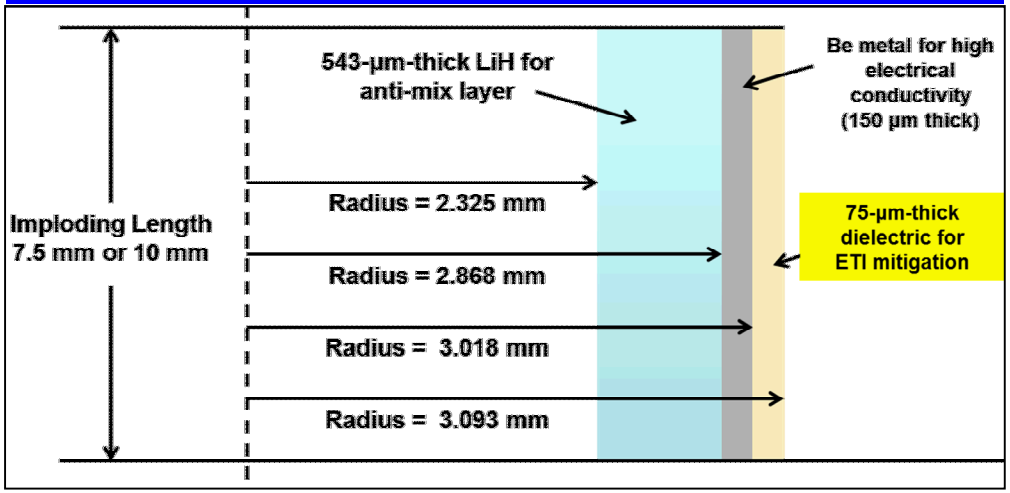
* LUXFilm® polyimide LUXEL

R&D work on lithium hydride liners for future MagLIF experiments

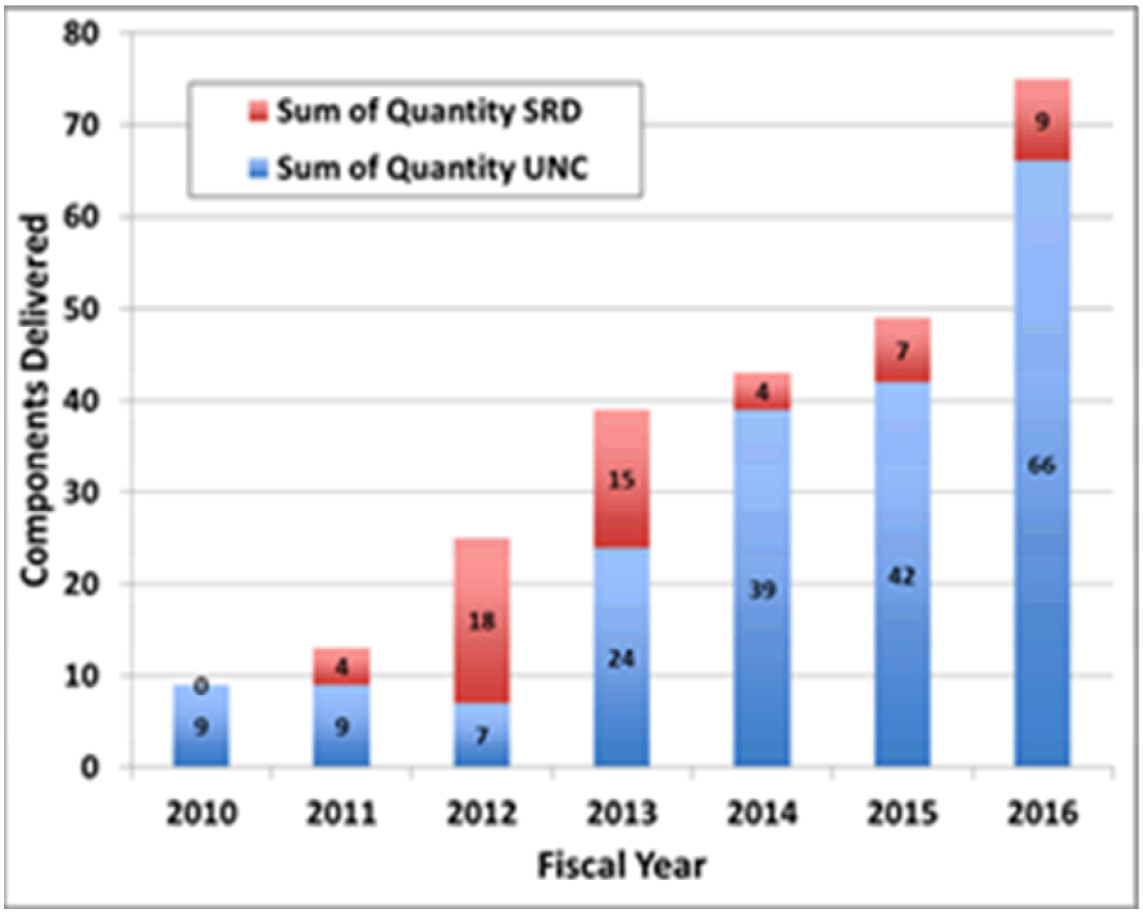
- **Fabricated Proof of principle liners 2 ways**
  1. LiH Liner cast and machined to thickness in an Al tube
     - LiH wall thickness 100 um
  2. Machined Free Standing Liner
     - 100um thick wall



MagLIF design for LiH Liner

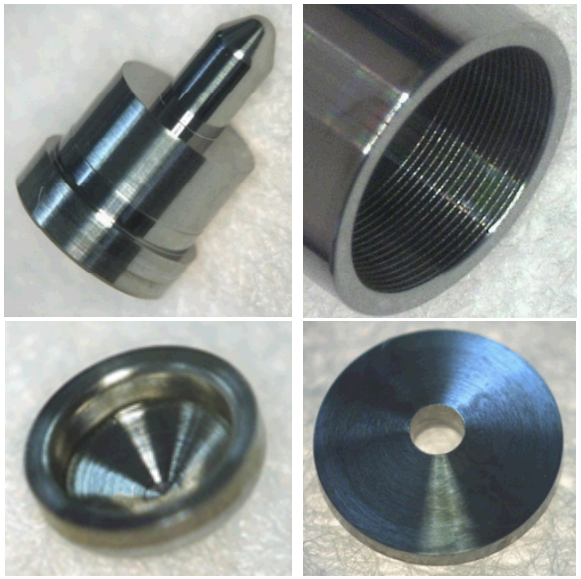


Beryllium use on Z has increased two fold in four years



Shots that use Be on Z

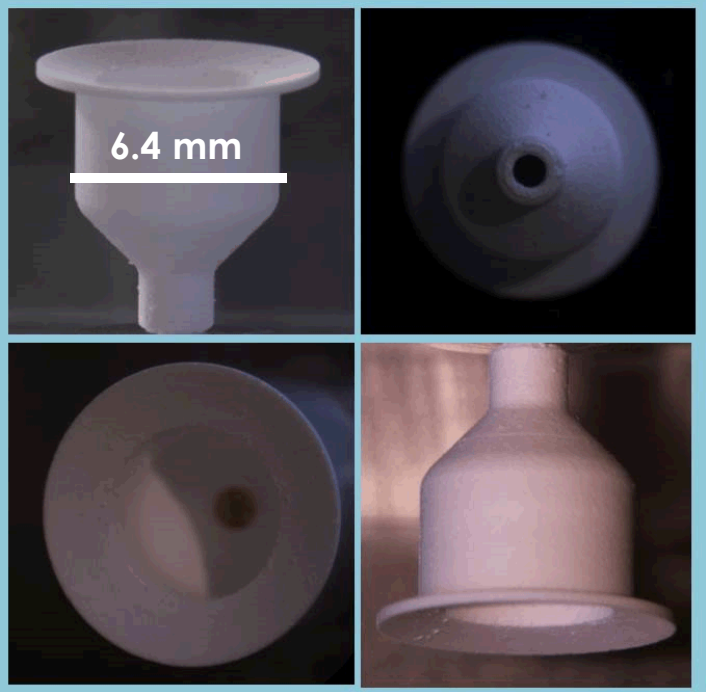
CY 2017: 40%
CY 2016: 37%
CY 2015: 20%
CY 2014: 15%

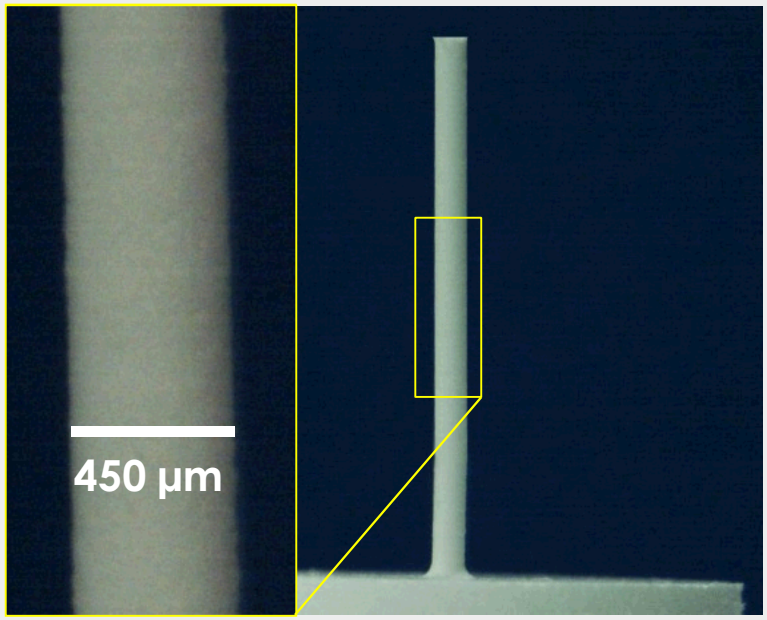


Demand & complexity of Be components has increased year over year

New complex foam components are being developed for wetted foam type experiments

- Thin wall cavity
  - 6.4 mm major diameter with ~200 µm wall
  - 50 mg/cc (0.10 at% Br)-CH HIPE foam





- High aspect ratio rod
  - ~450 µm diameter rod, 8 mm long
  - 50 mg/cc CH HIPE foam

SNL Target Fabrication team supports Sandia's Science-base Stockpile stewardship experimental program

- **Z facility is capable of megabar pressures to study HED and ICF conditions**
- **Multiple experimental thrusts / campaigns are supported**
- **Target development is ongoing to support these experimental campaigns**

G. Smith (Poster)-Target Assy