Target Production in Support of Z-Machine Experiments

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April 23-26, 2019

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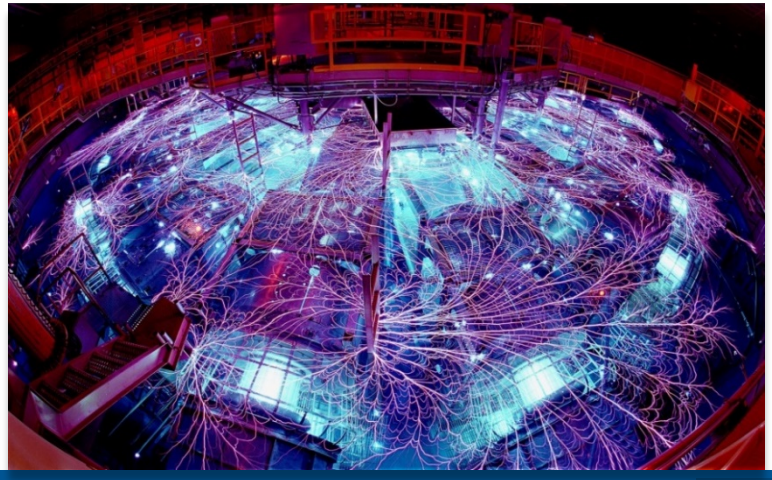
SNL Target Fabrication for Z and Z-beamlet / PECOS Experiments

- **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)
  - LEH window development
  - Coatings

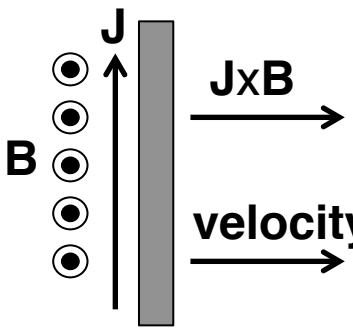


FY18 GA was involved on 97% of the targets shot on Z

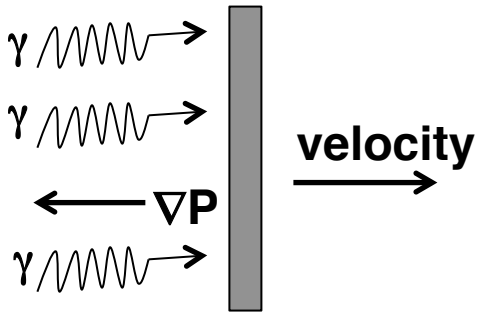
Large currents are used to drive experiments on pulse power machines

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

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 FY18, 40% of Z machine shots used beryllium

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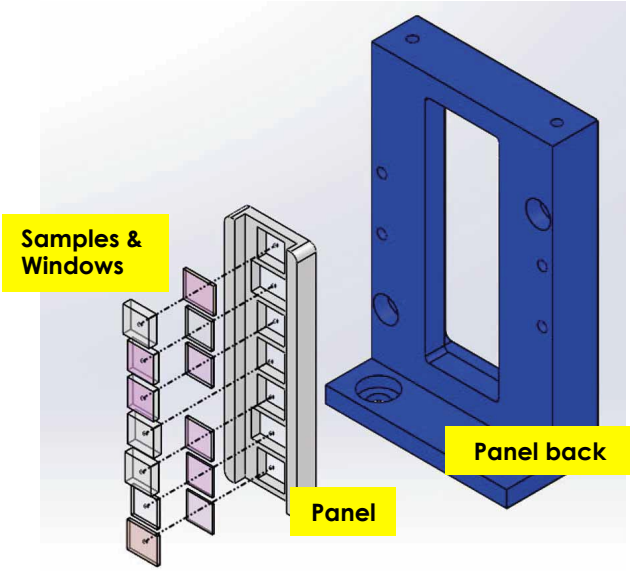
Dynamic Material Property (DMP) experiments study material behavior

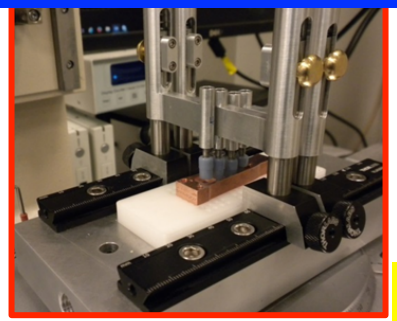
- Experiments achieve MPa pressures
- 90% of DMP experiments are planar

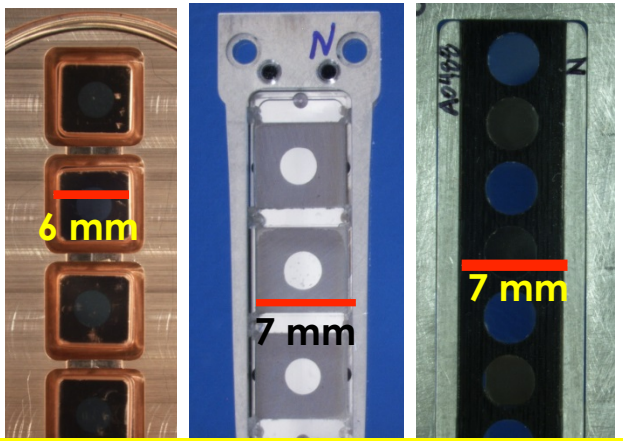
- DMP panels contain various sample materials
  - metals, plastics, aerogels, foams, lithium

- Increase fabrication efficiency
  - Multi Press Assy tool
  - Machining fixtures innovation
  - DFM (Design for manufacture)
    - Collaborate Between TF/Designers/PI



Multi Press Assy Tool to increase Fabrication efficiency





Various Panels for DMP Targets

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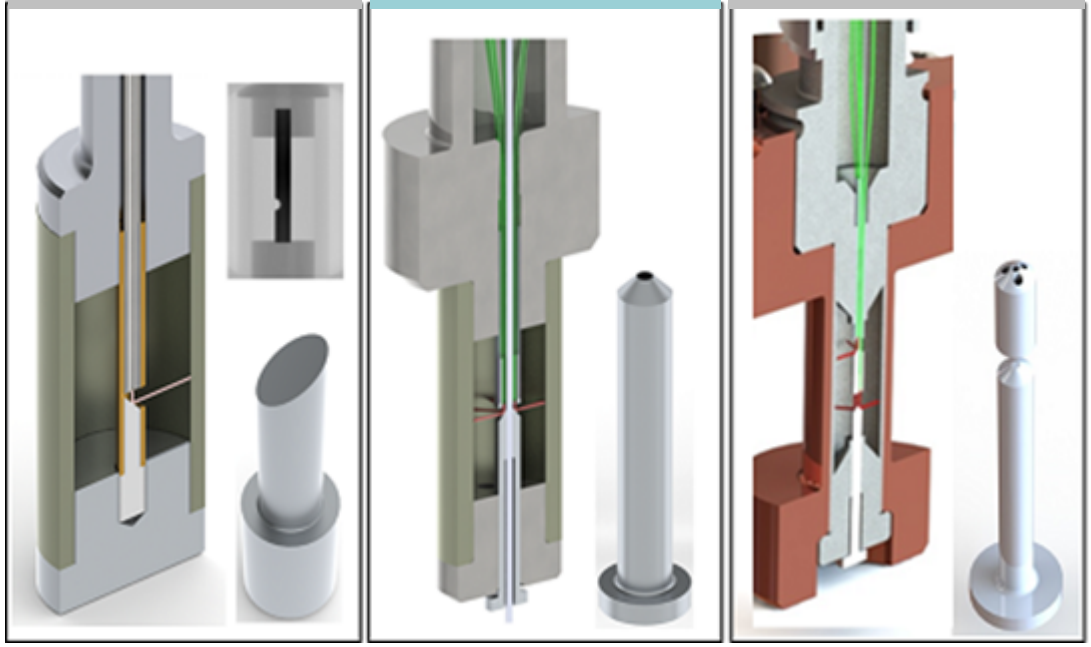
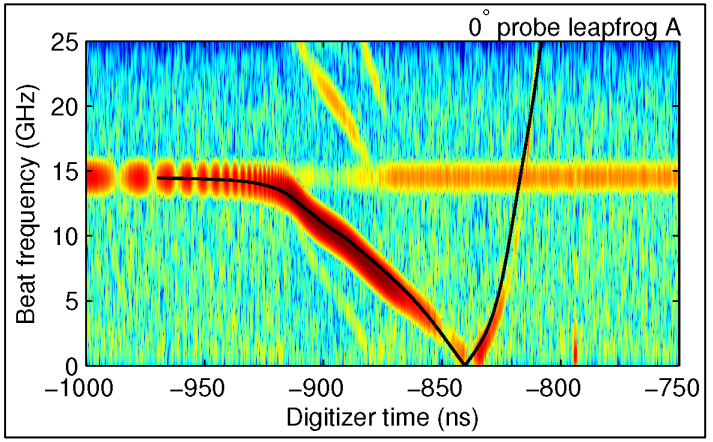
Cylindrical Photonic Doppler Velocimetry (PDV) diagnostic evolution*

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

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

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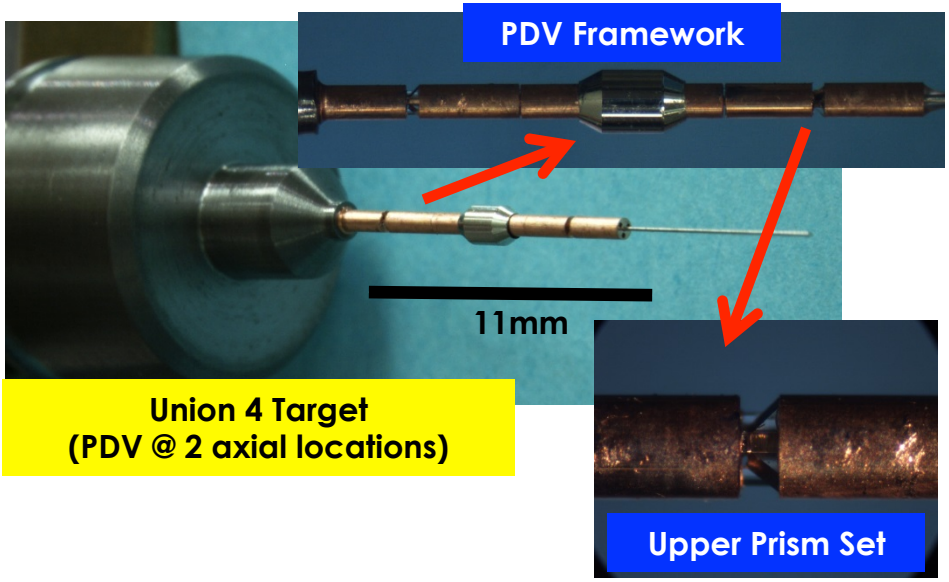
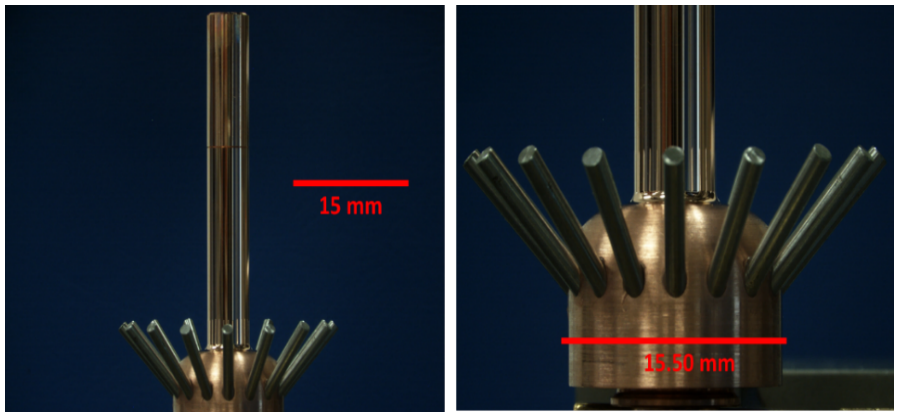
Targets that use the PDV diagnostic have continued to evolve

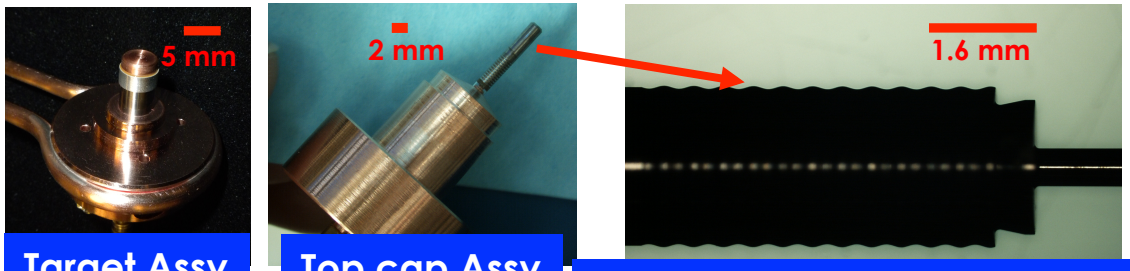


Union 4 Target
(PDV @ 2 axial locations)

Current Union
Cylindrical PDV Targets



Machined Patterned Be Rods for Decel
PDV Targets (ICF style targets)



Target Assy

Top cap Assy

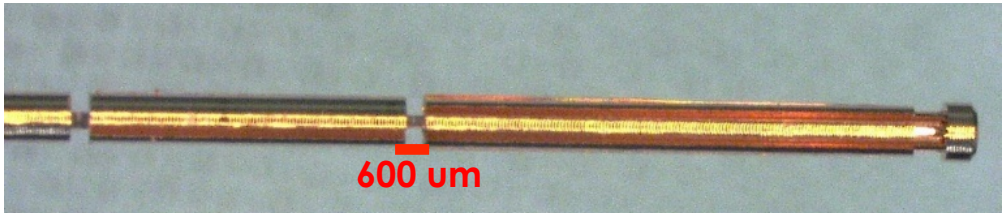
Patterned Be rod machined at
La Jolla

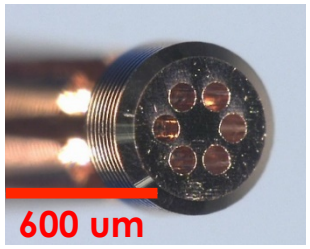
Union (HED) PDV concepts were transitioned to MagLIF (ICF) targets

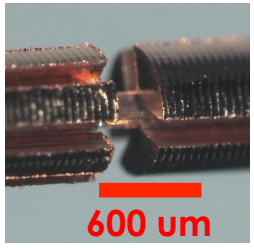
* R. W. Lemke, et al., J. Appl. Phys. 119, 015904 (2016)

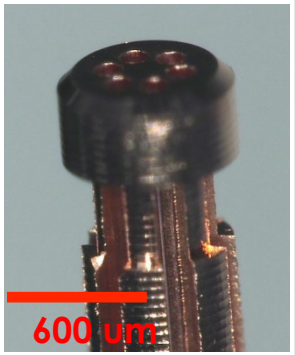
Key part in the PDV diagnostic is the PDV guides

Multi level PDV Guides







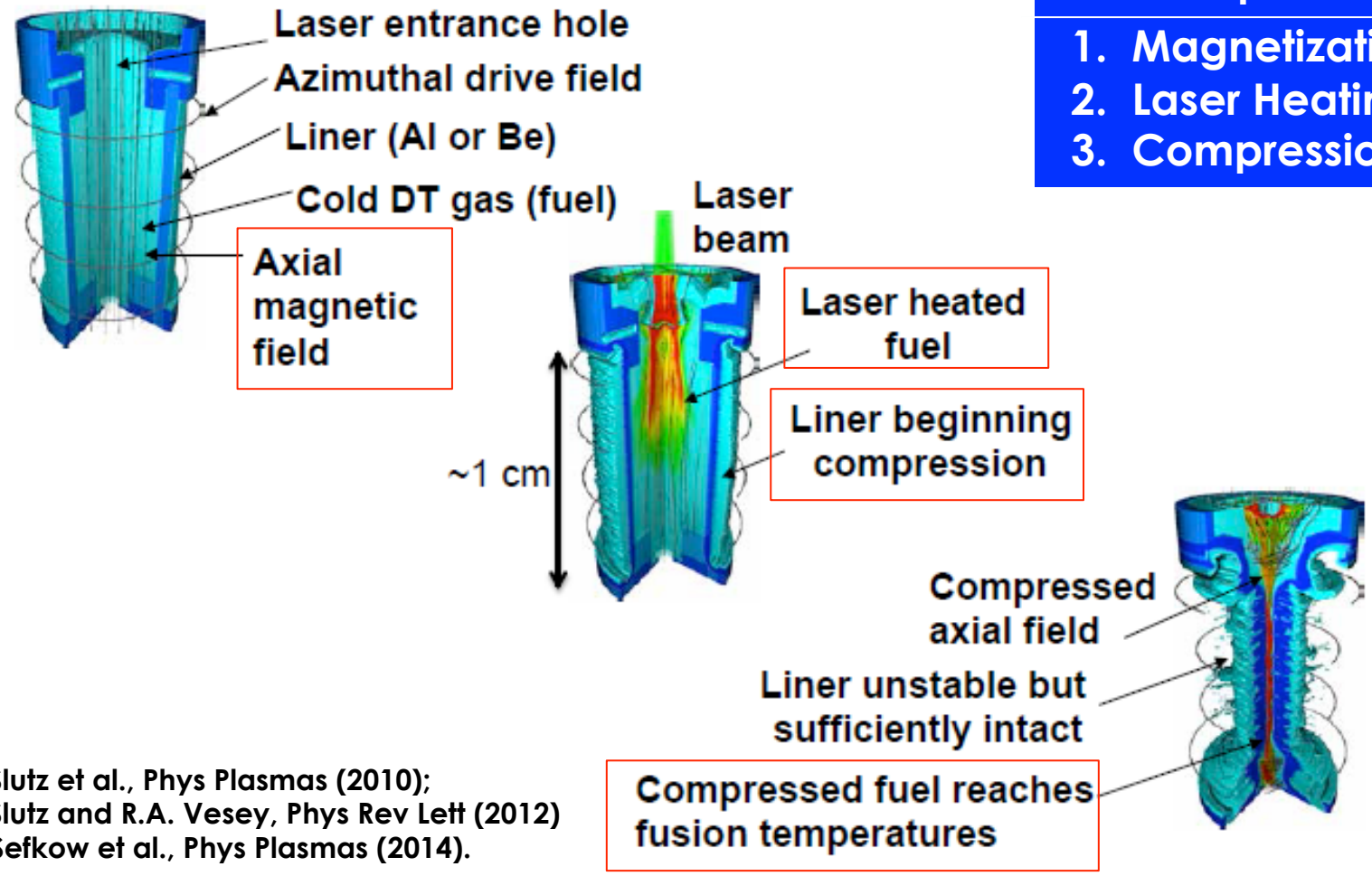


- **Very challenging & time consuming to machine**
  - Due to 20:1 length/diameter ratio & Tiny features (+/- 5um)
- **Local & machine shops across the country have no bid this part**
  - Most Shops that have the necessary equipment and experience
  - Don't feel they can charge enough to guarantee a profit.
- **GA is currently the only source to fabricate the part**
- **Currently working with PI & Target designers to simplify the part to make it more manufacturable**

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).

* E. Harding Talk

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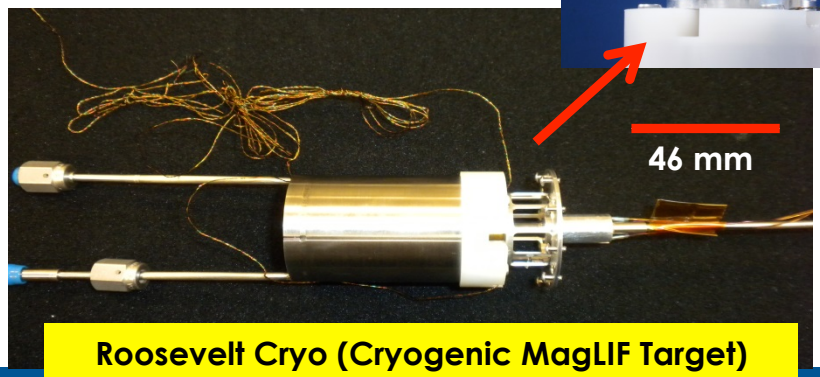
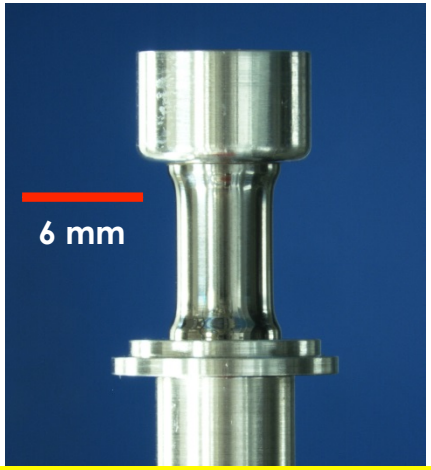
Variations of targets are used to study the MagLIF concept

- **Cryogenic experiments:** Roosevelt Cryo
- **Helical MagLIF Target:** Rayleigh Taylor instabilities
- **Thick End Targets:** Study implosion instabilities
- **StagMix Targets:** Target impurities & affects on implosion mix

Standard MagLIF Target



Roosevelt Cryo (Cryogenic MagLIF Target)



Thick Ends MagLIF Target

Helical MagLIF Target

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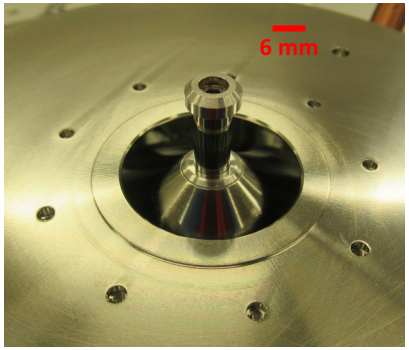
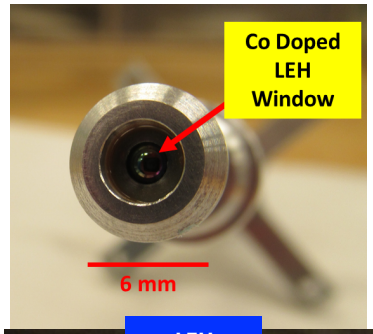
R&D developed for current & future targets

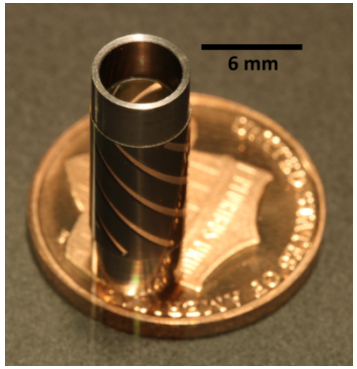
LEH Development for MagLIF Targets*

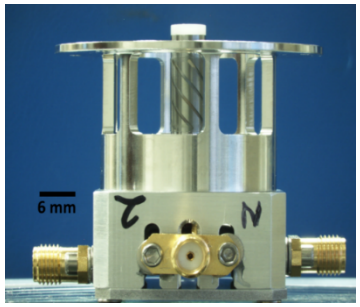




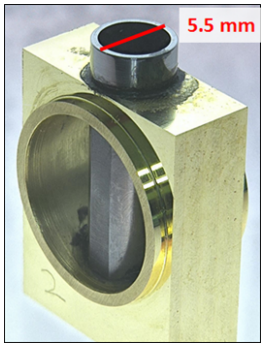
LEH Window holder for Pressure Testing

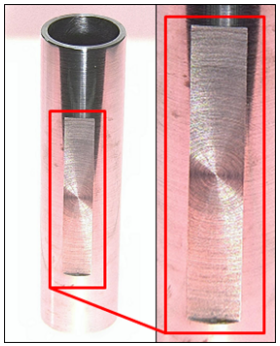
Auto-Magnetizing Liner ~150 T axial B field





Cryogenic R&D Test Targets





- **LEH Dev:** Higher pressure Mag LIF targets
- **Auto Mag:** Gen Magnetic Field W/O using external field coils
- **Cryo Test Target:** Study temperature gradients at cryo conditions

*A. Harvey Thompson et al., Phys Plasmas (2018)
* B. Zeiger Poster

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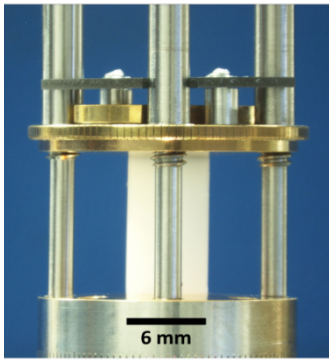
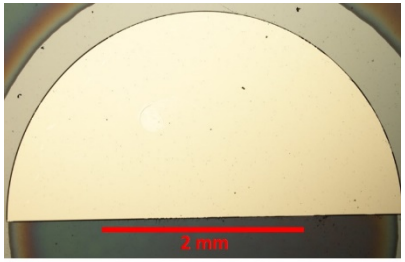
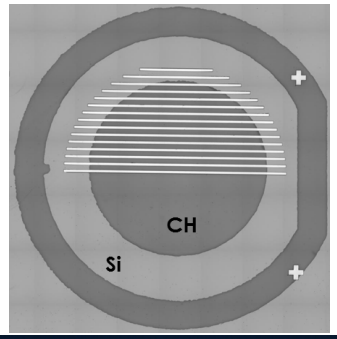
R&D developed for current & future targets

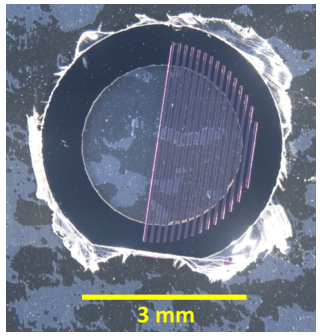
Opacity Foils GACH Foam

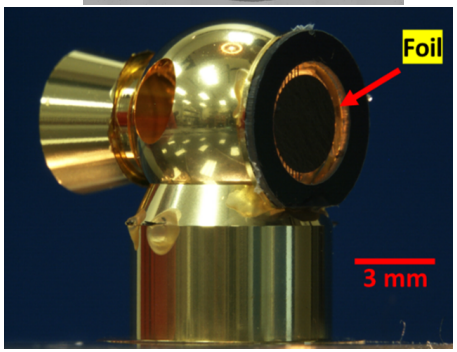




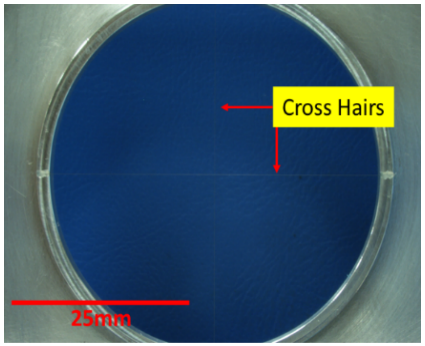
Hi-Z/Low-Z Plasma Transport Platform







Cross Hairs for Wolter Diagnostic



Opacity

- GACH Foam replaced TPX Foam (Fabrication efficiency)
- Produce Ni/Mg & Fe/Mg Half Moon foils with integrated frame (Assy efficiency)

Plasma Transport

- "Kenny" Holraum design Structure
- Developed process to produce Al doped Vanadium Foil

Wolter Diagnostic

- New optic diagnostic
- Collab-LLNL/NASA and Harvard)
- GA mounted the crosshairs for this diagnostic

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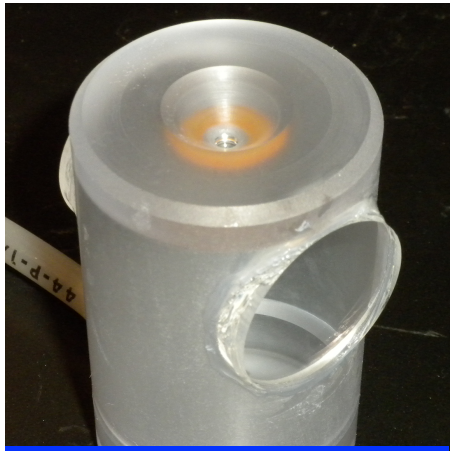
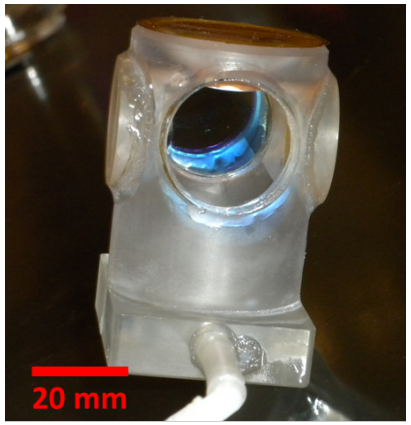
Advanced gas cell targets support MagLIF laser pre-heat studies with Z-Beamlet at PECOS target area

- **Gen 1 gas cell target: 15 PSI**
  - Mylar LEH
- **Gen 7 gas cell target: 90-120 PSI**
  - Utilize polyimide* windows
  - Tested new LEH design windows
  - In-house assembled LEH windows
    - Provides flexibility and faster response
- **New Generation 8**
  - Copper Body
  - Incudes Cryogenic testing

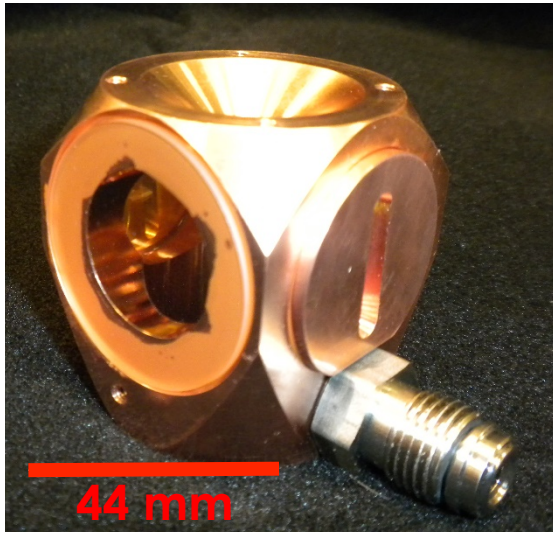


PECOS 1st gen Gas Cell



PECOS 7th gen Gas Cell

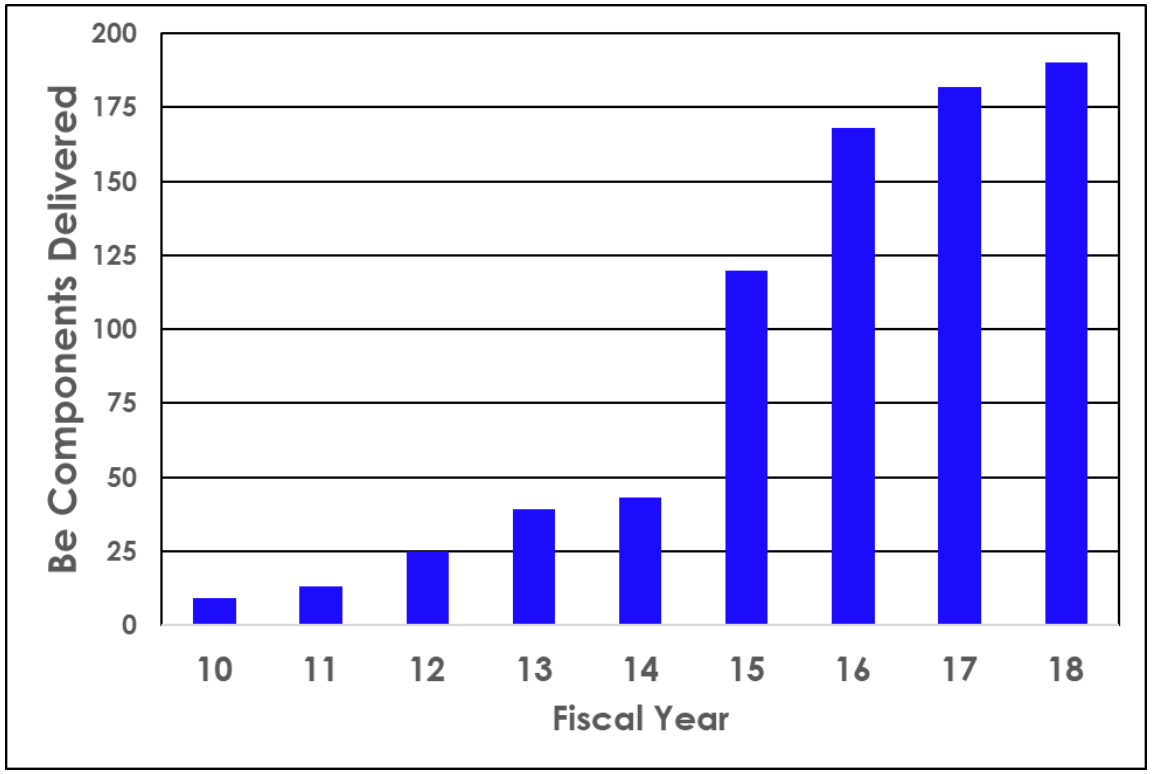
New PECOS Target



These targets help inform current & future MagLIF experiments

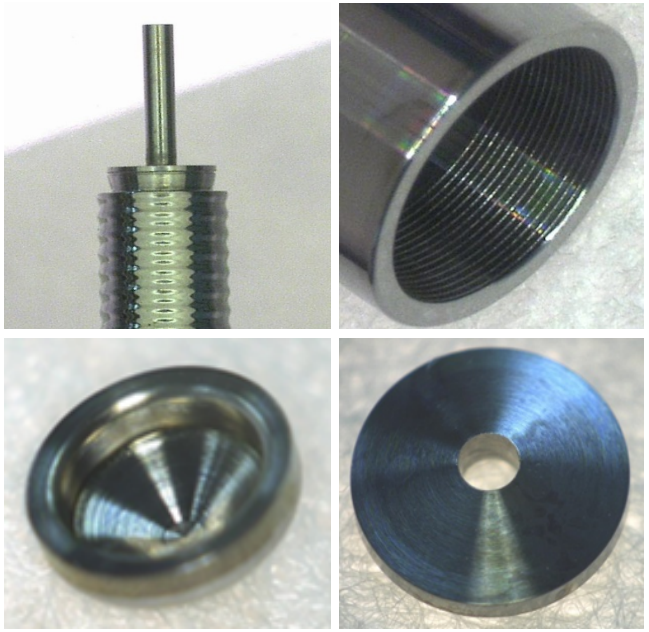
* LUXFilm® polyimide

Beryllium use on Z has increased 21 fold from 2010 to 2018



Shots that use Be on Z

CY 2018: 40%
CY 2017: 43%
CY 2016: 37%
CY 2015: 20%
CY 2014: 15%



Demand of Be components has increased year over year with new target designs

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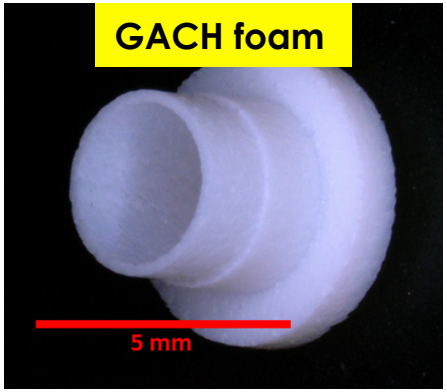
Conducted Foam R&D and machining for various projects

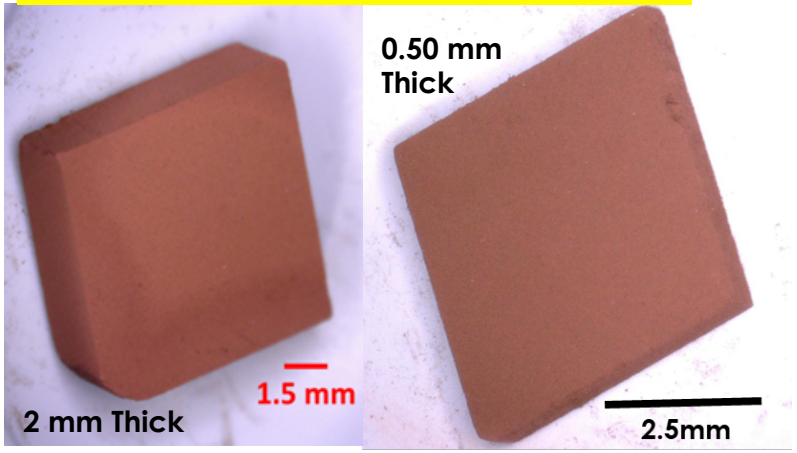
Foam fabrication & machining components

CH Cl foam

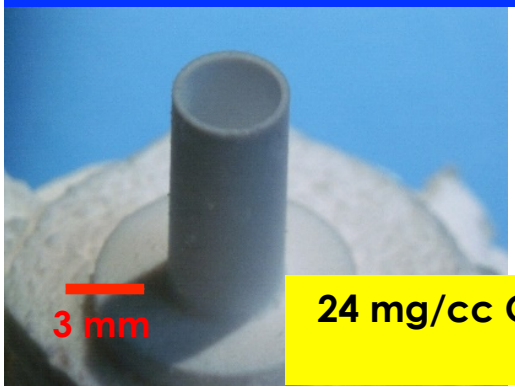
GACH foam



1g/cc Cu foam for DMP Experiments



Sierra: CHBr (Fabricated at GA/SNL)
Foam Machining



24 mg/cc CHBr HIPE foam loaded with 0.10 Atm% Br

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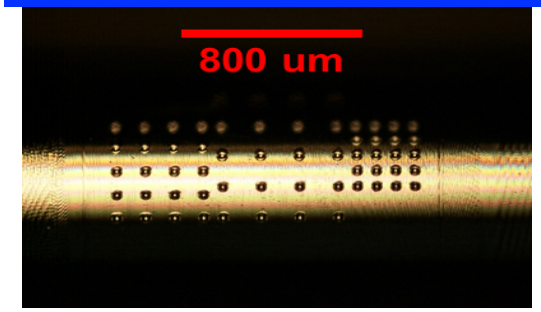
Collaboration with SNL PI's for future designs

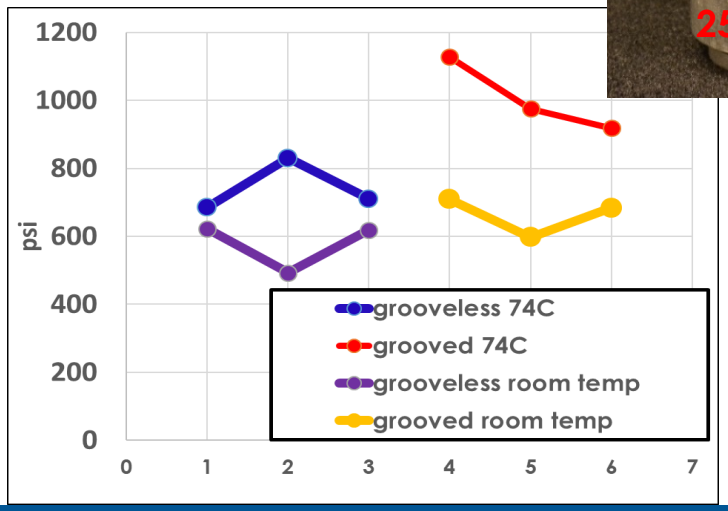
Development of Engineered Defect Targets*



- Targets on SNL's Mykonos Pulse Powered machine
  - Defects are hemispherical (24um Diameter/6um depth)
  - ~ 60 defects per rod
  - Evaluate various theories of plasma plume generation & filament evolution

High Pressure Testing Target

- Determining if grooves help target hold at higher pressures
  - **Found**- **Glue grooves & oven curing help-increase pressures**
  - Led to the use of glue grooves in higher pressure targets



Other Collaboration Projects

- **Floating Endcap for future gas fill targets**
- **Glueless stack DEV for DMP targets**
- **CoBe Parts (Materion/SNL/GA)**
- **Coining of Patterned Ta Foils**
- **New Opacity & Plasma Transport foils**
- **Tritiated plastics**

* K. Tomlinson Talk

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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 science campaigns

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