

Targets, Enabling Ignition & High Yield Research

Presented at
42ND ANNUAL FUSION POWER ASSOCIATES MEETING
Virtual/Remote Meeting

Presented by
Mario Manuel

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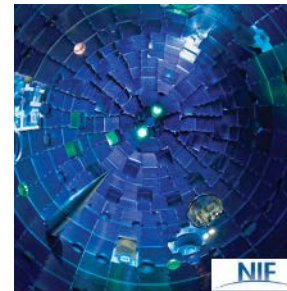


Advances in Targets Manufacture & Metrology are Enabling Higher Yields

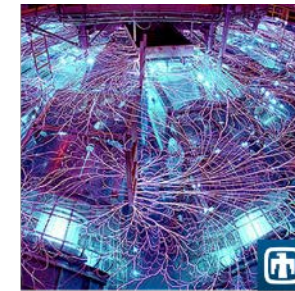
- Ignition “Focus” remains on target details
- Metrology, Metrology, and more Metrology
- Expanding spherical target design space
- Higher adoption of Additive Manufacturing
- Rep-rated research efforts



Targets for experiments at



National Ignition Facility

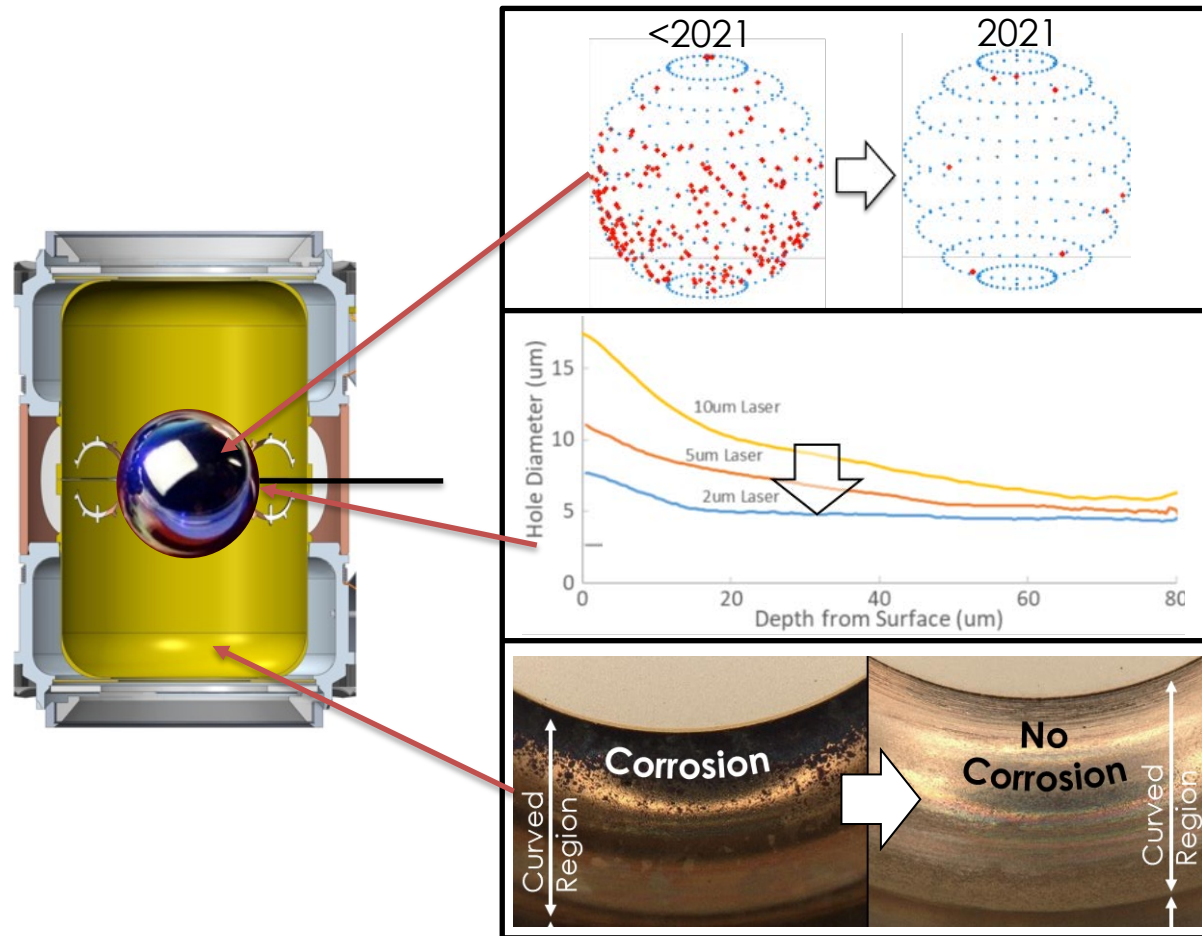


Z pulse power machine



OMEGA Laser Laboratory
for Laser Energetics

Improvements in the Target



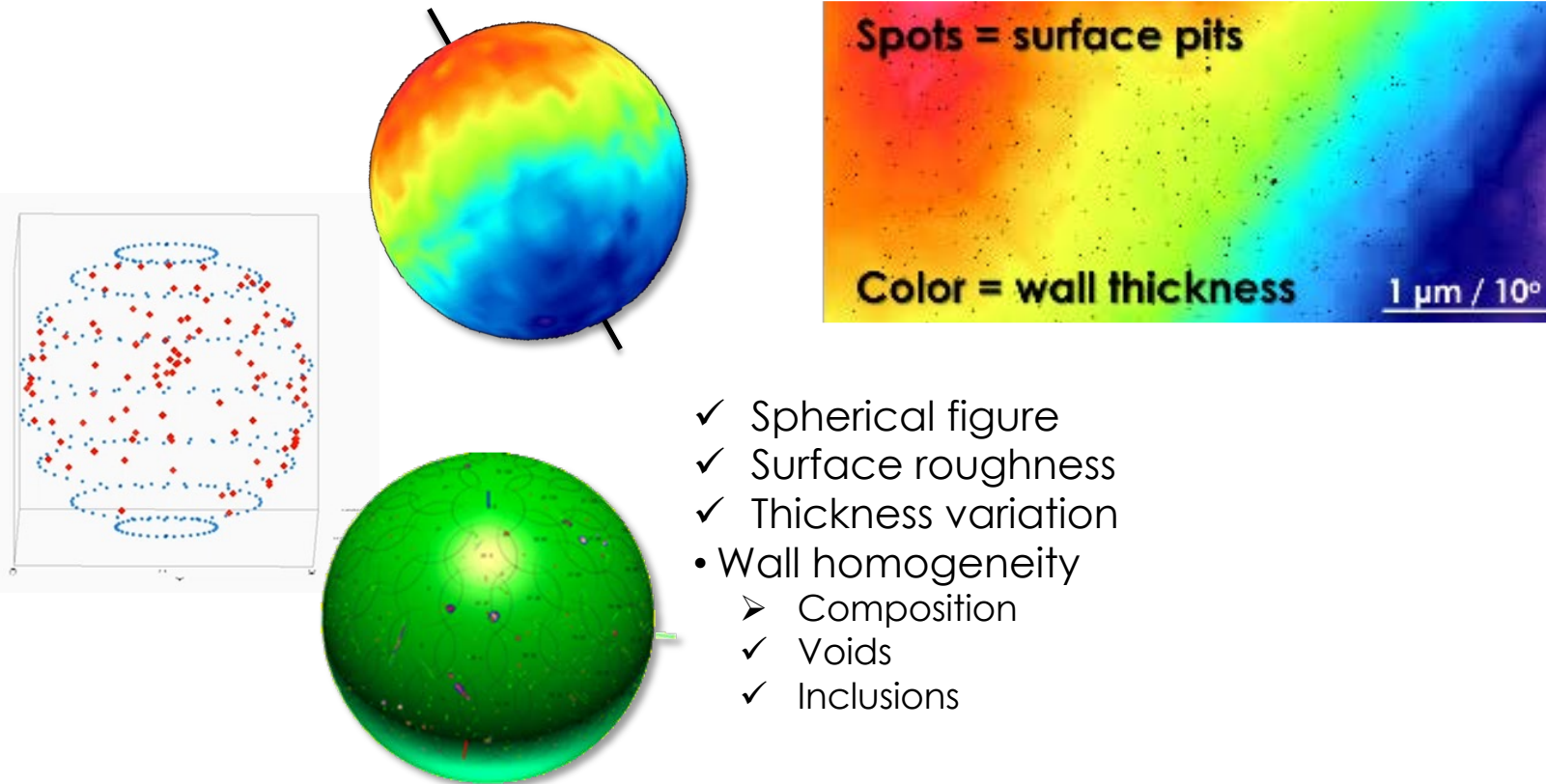
**4pi Characterization!
Make & Select the best capsule!
Surface, Point nonuniformities,
Spherical uniformity**

Smaller fill-tubes

Improved hohlraums

Improvements in the target enabled this 1.3MJ result!

Micron and Nanometer understanding of the Three Dimensional Shell

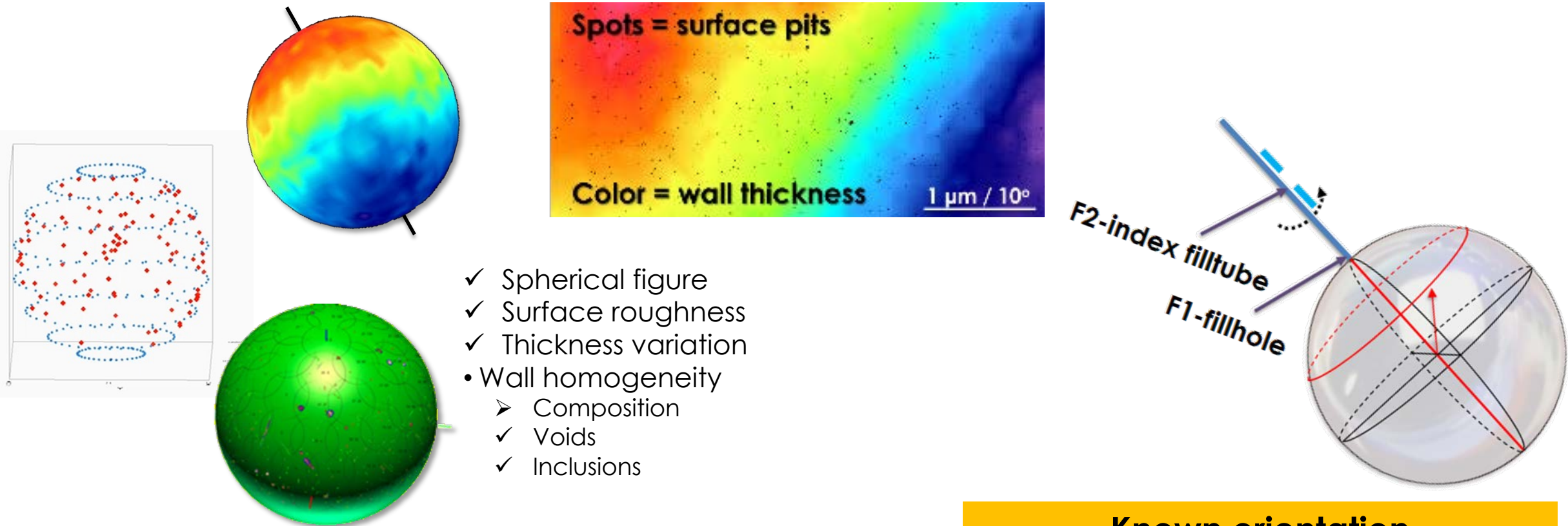


The Metrology

Spherical (3D) TARGET DATA is increasingly important to physics understanding

Correlating data with fiducials enables known positioning of shell imperfections

Micron and Nanometer understanding of the Three Dimensional Shell



The Metrology

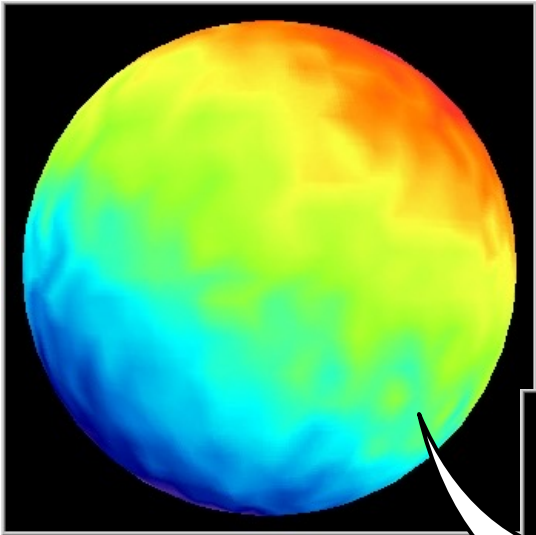
Known orientation at shot time

Spherical (3D) TARGET DATA is increasingly important to physics understanding

Correlating data with fiducials enables known positioning of shell imperfections

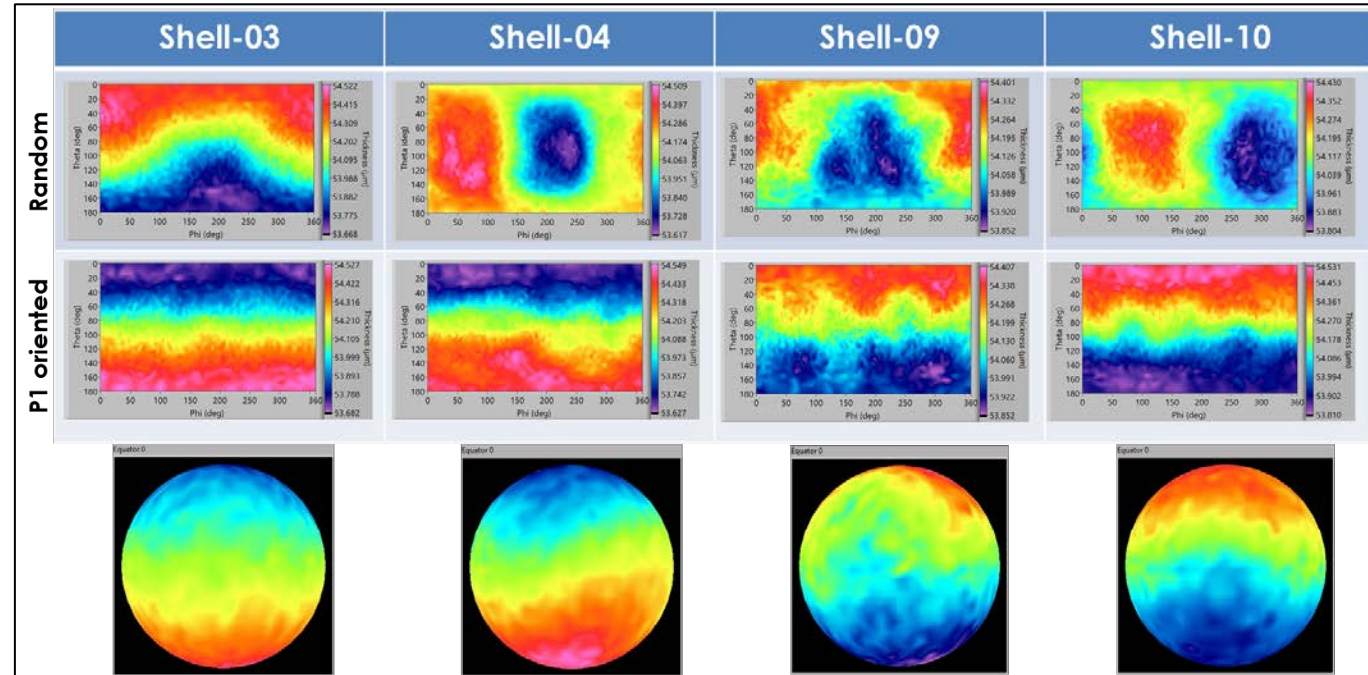
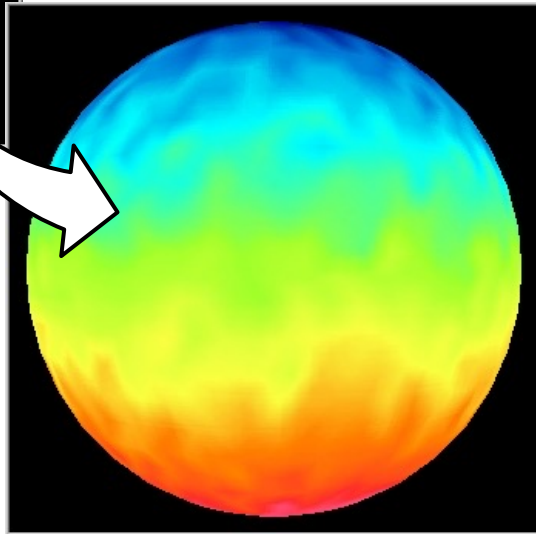
Controlling Capsule P1 spherical nonuniformity location within the target

Randomly Oriented

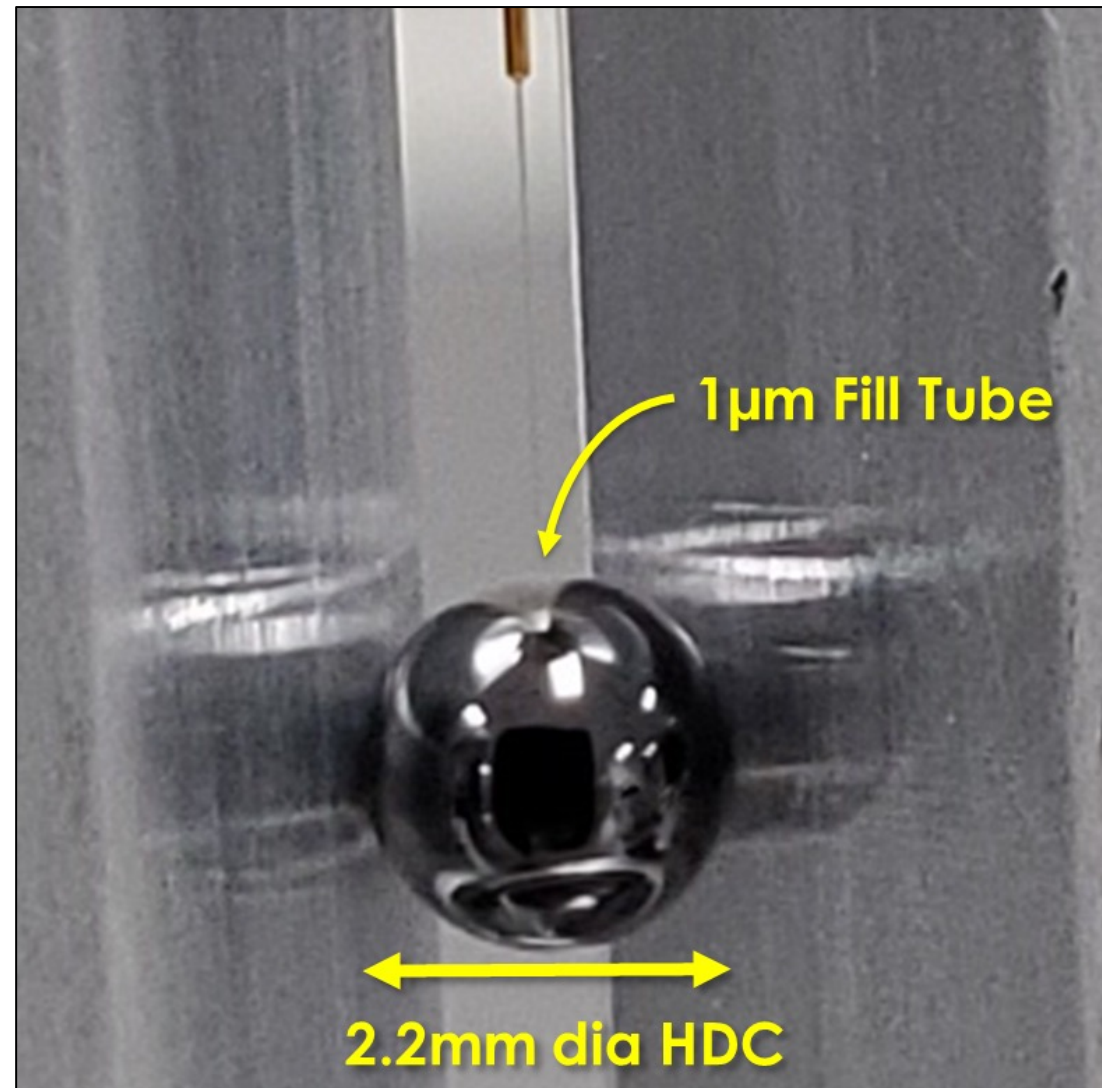


Drill fill tube hole
in thinnest region

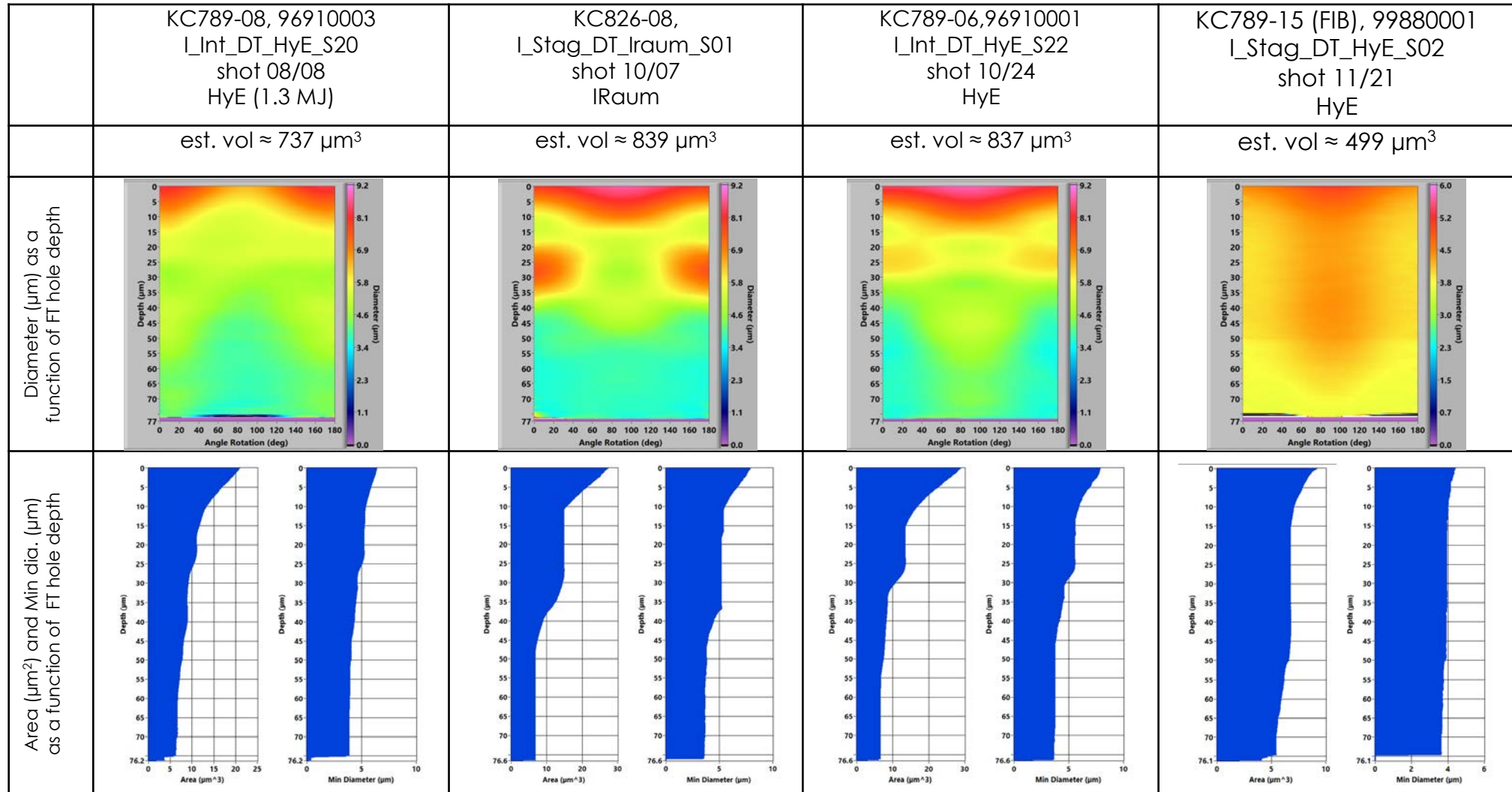
Re-orient
coating



Advancing the state-of-the-art in ICF targets

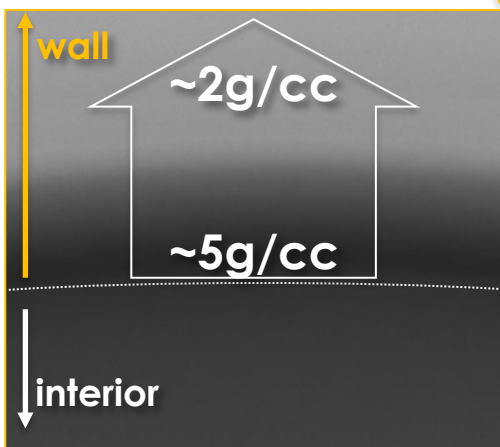
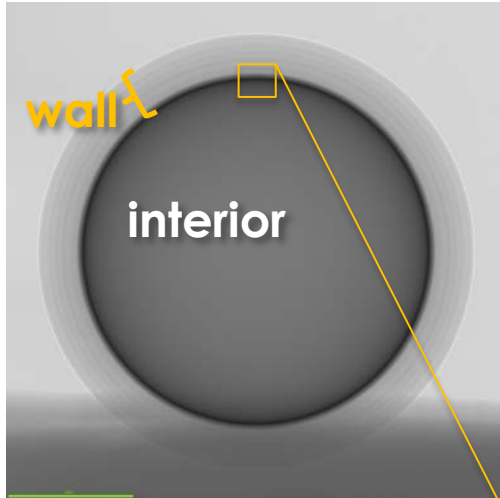


Understanding and controlling the fill tube hole shape



Other R&D Supporting Laser Indirect Drive

Gradient Density Metal Shells

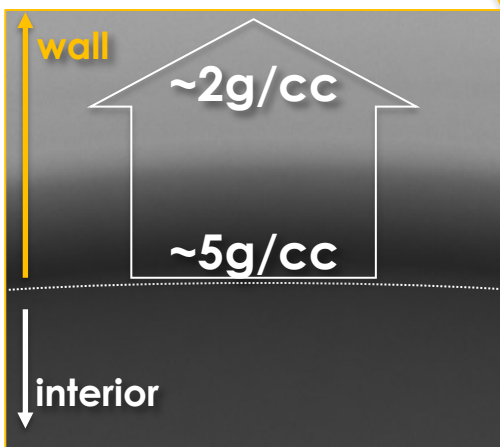
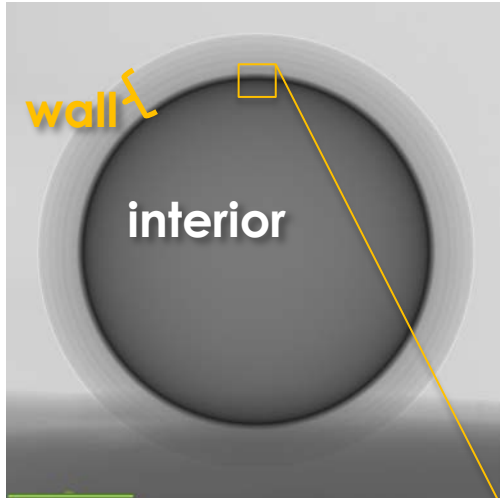


✓ ✓
Cr Mo W
24 → 42 → 72

Engineered Alloys

Other R&D Supporting Laser Indirect Drive

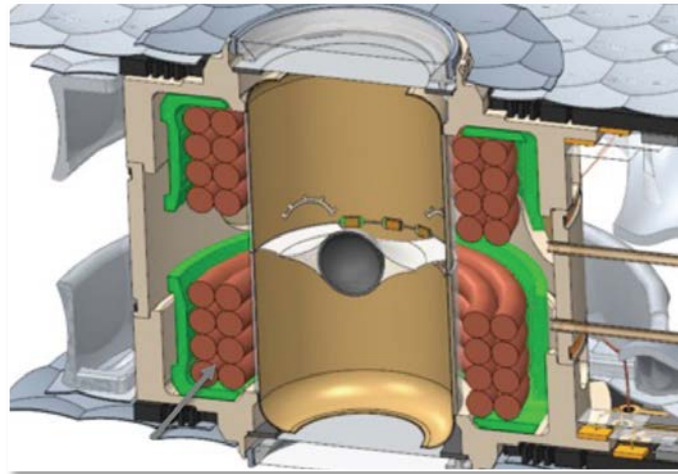
Gradient Density Metal Shells



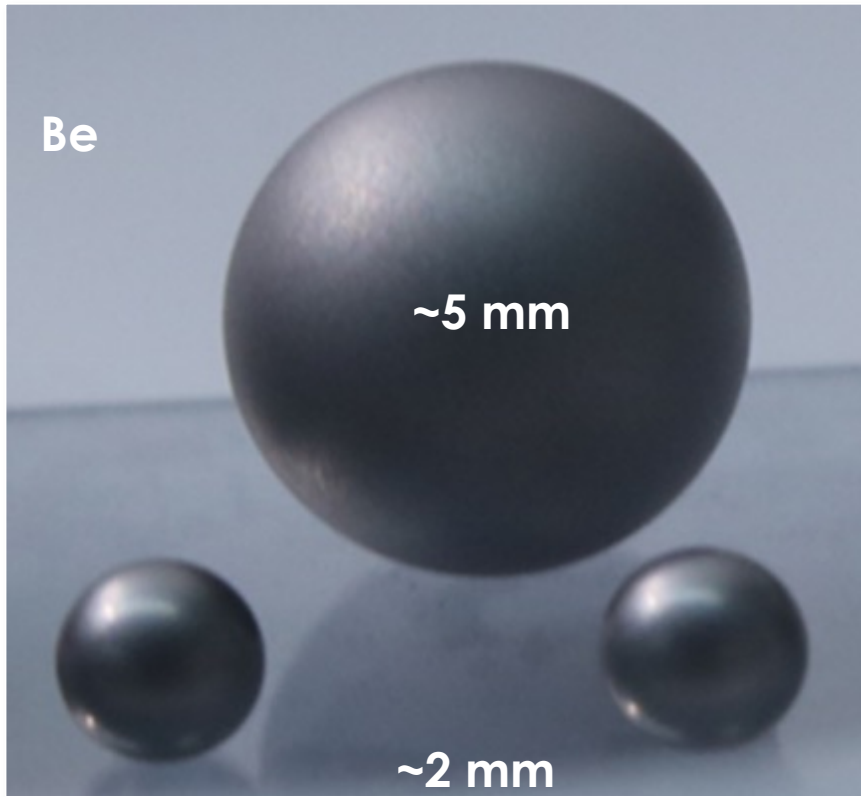
✓ Cr ✓ Mo W
24 → 42 → 72

Engineered Alloys

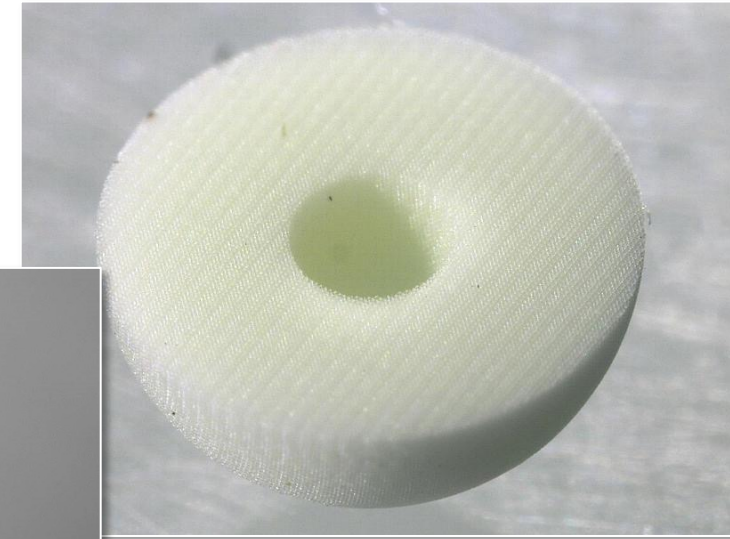
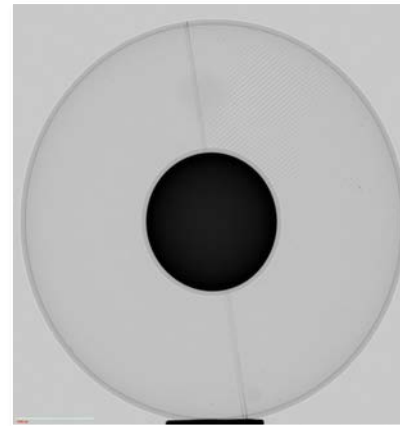
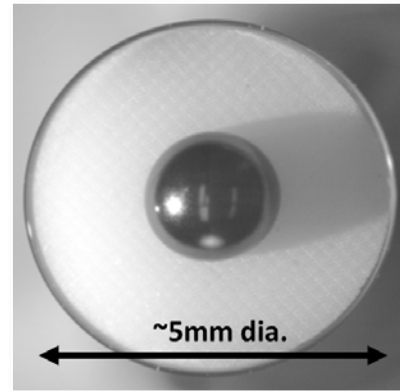
Enabling B-fields on Indirectly Driven Cryogenic Implosions



Expanding Spherical Target Design Space



4.4 mm diameter Be shell holds
direct drive neutron record @
 1.6×10^{16}

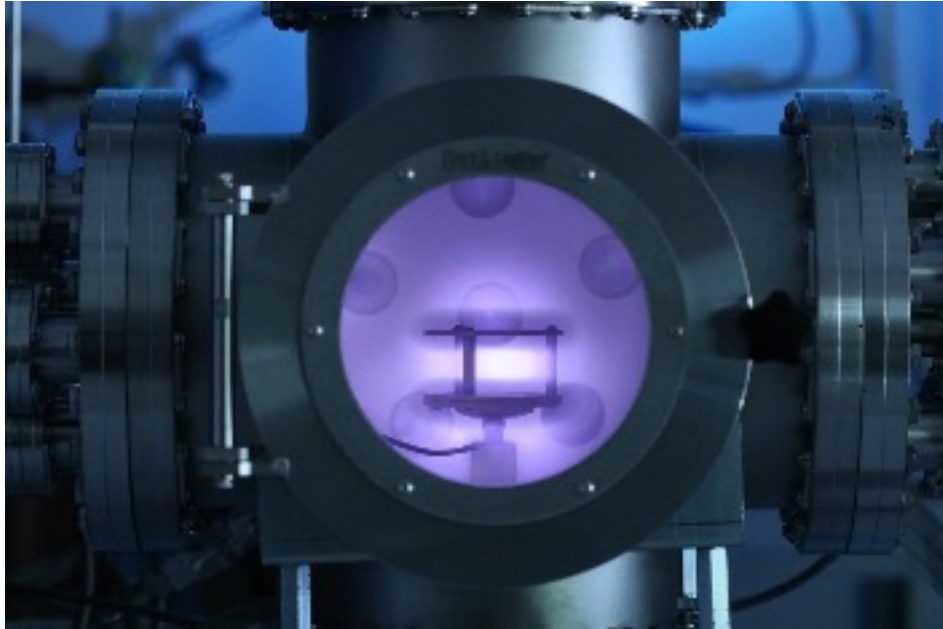


Additively manufactured targets
(Double Shell cushion)

Amorphous Ablator Material Research

(Eliminate crystalline microstructure inherent in High Density Carbon & Be shells)

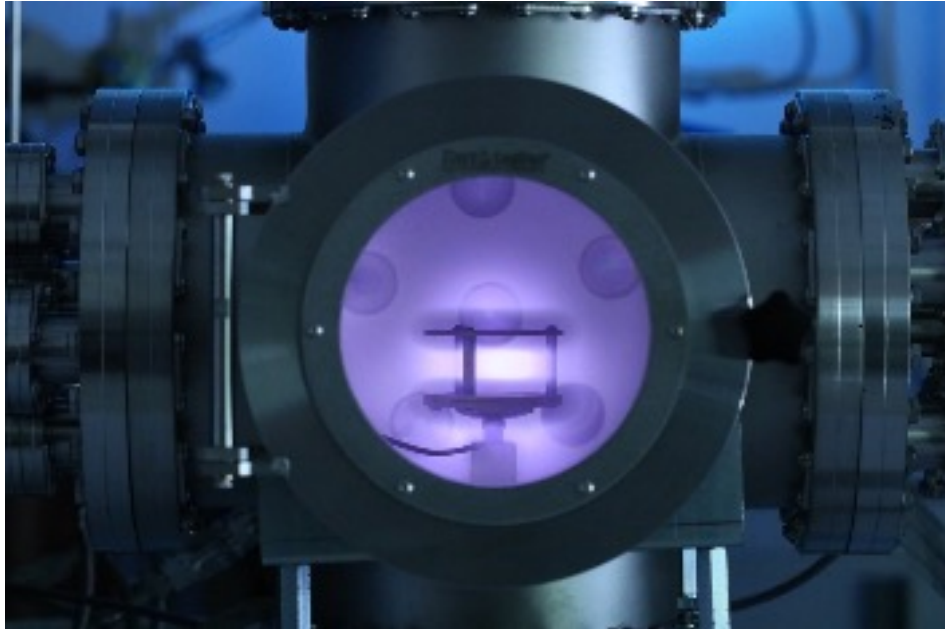
Developed custom coater



Amorphous Ablator Material Research

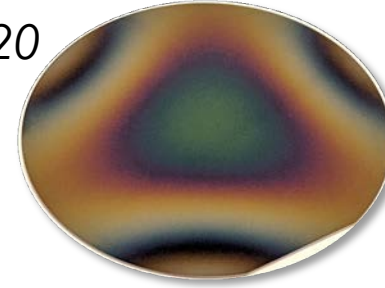
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Developed custom coater



Spherical coatings

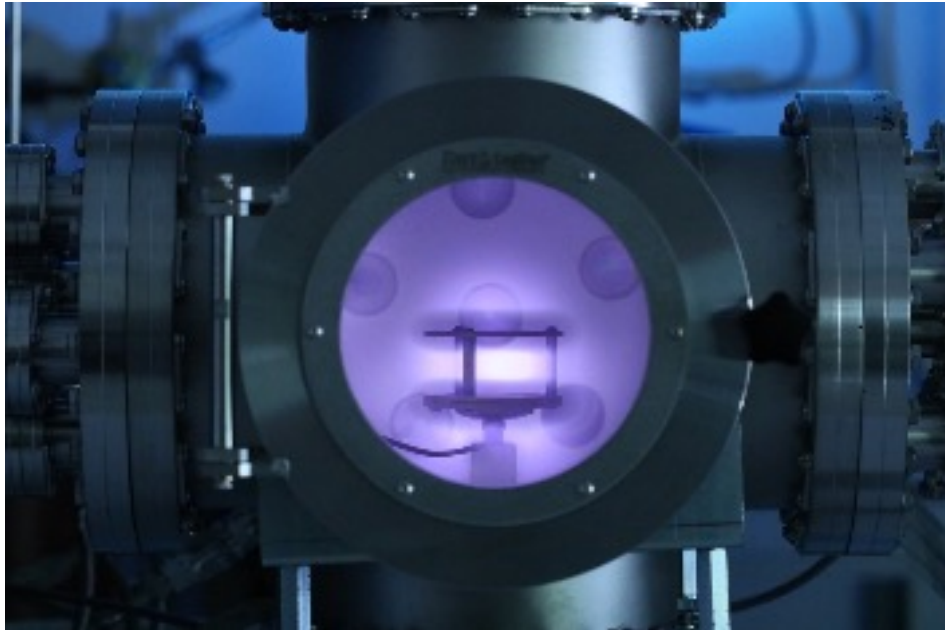
~nm planar in Dec 2020



Amorphous Ablator Material Research

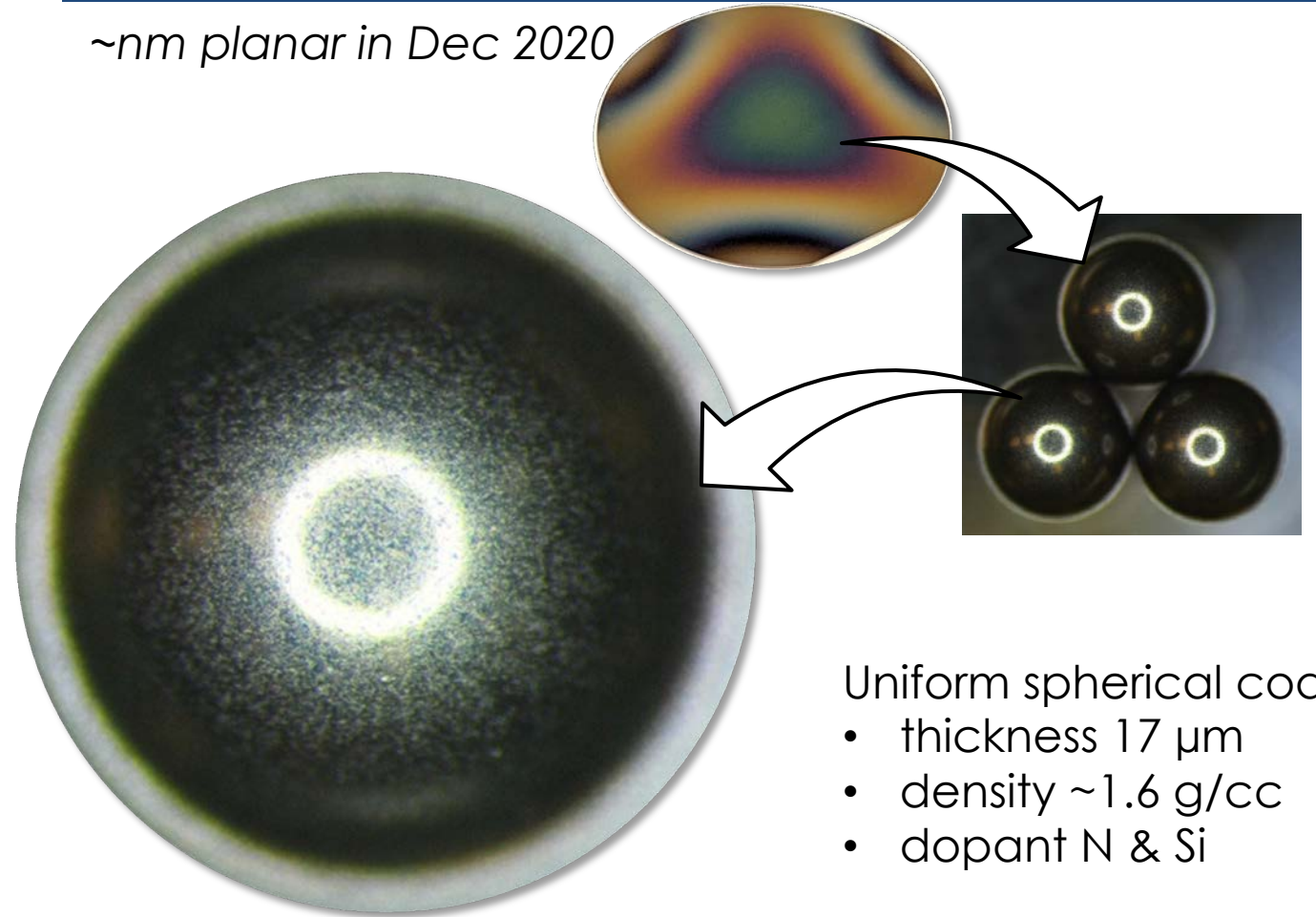
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Spherical coatings

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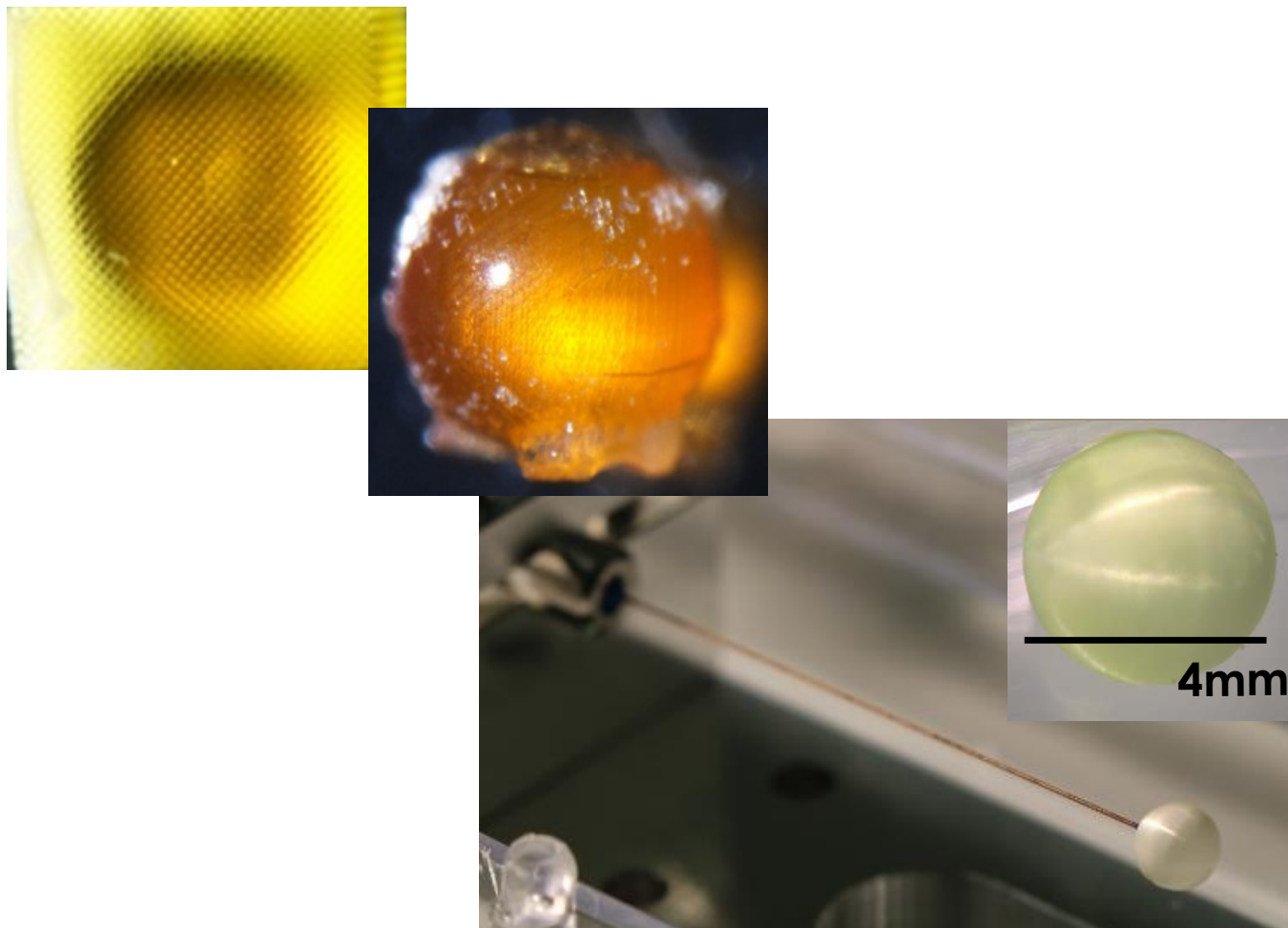
Uniform spherical coatings

- thickness 17 μm
- density $\sim 1.6 \text{ g/cc}$
- dopant N & Si

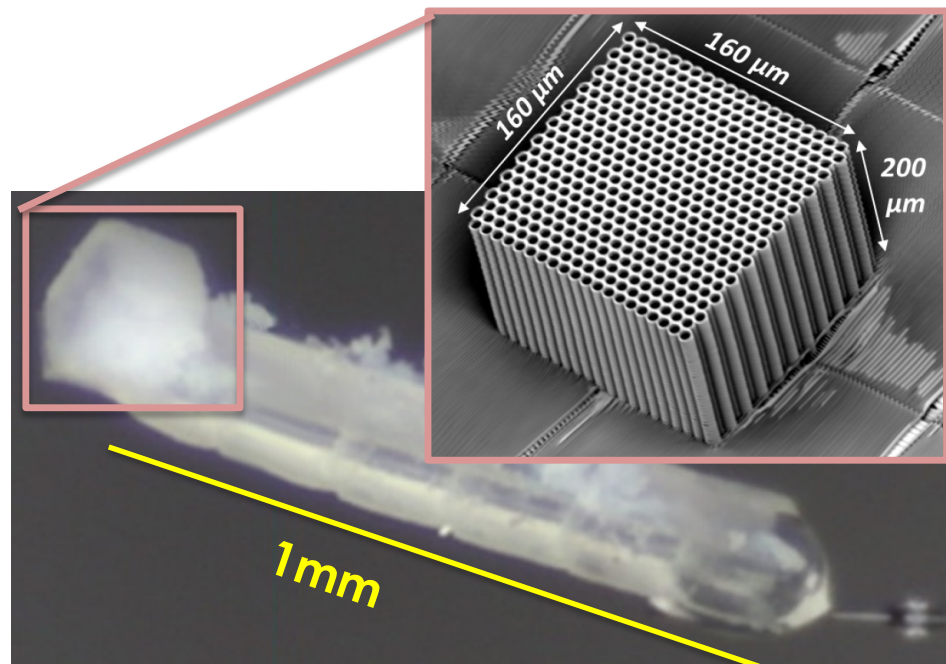
Increasing the use of Additively Manufactured Targets

(Enabling efficient design variation studies)

Advancing Two Photon Polymerization Adoption



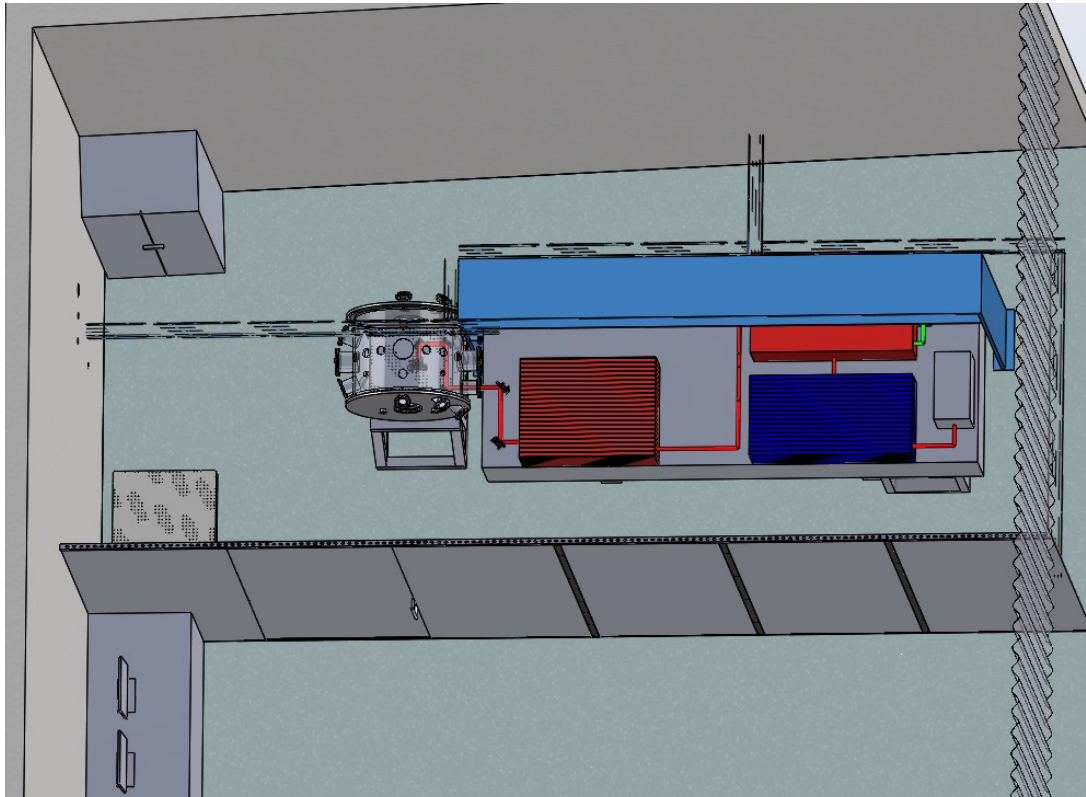
Foam filled Microtubes



Developing a Facility to Support Rep-rated HEDP and IFE Research: Target fielding, Diagnostics, and Control-feedback Systems



GA Laboratory for Developing Rep-rated Instrumentation and Experiments with Lasers

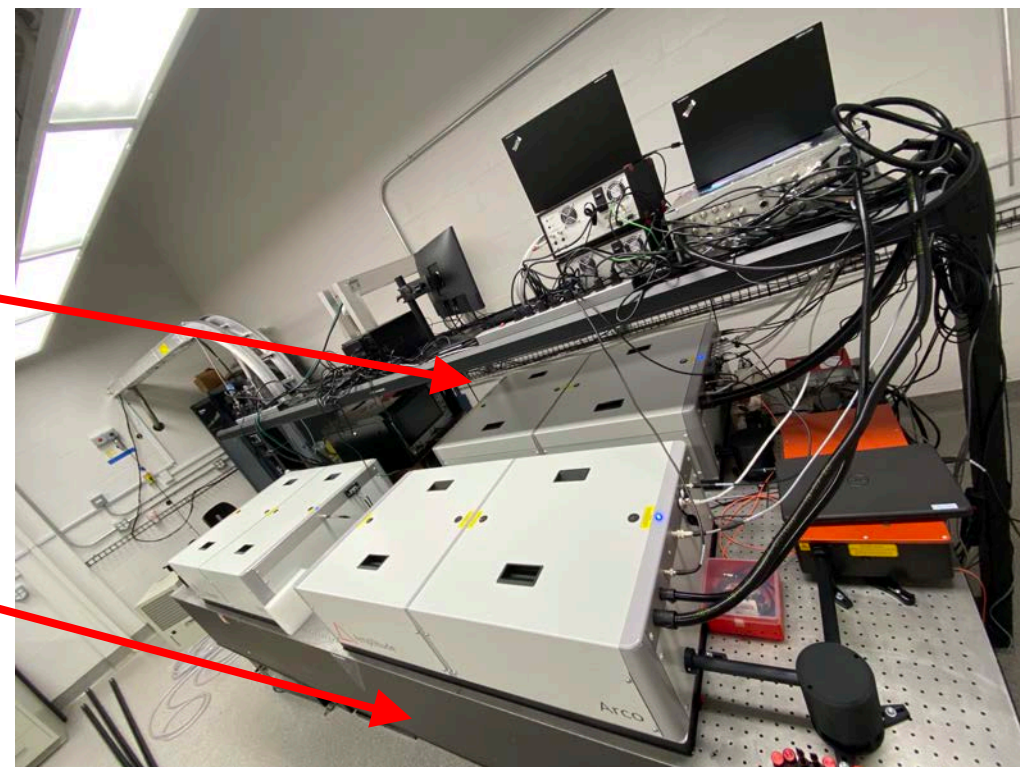
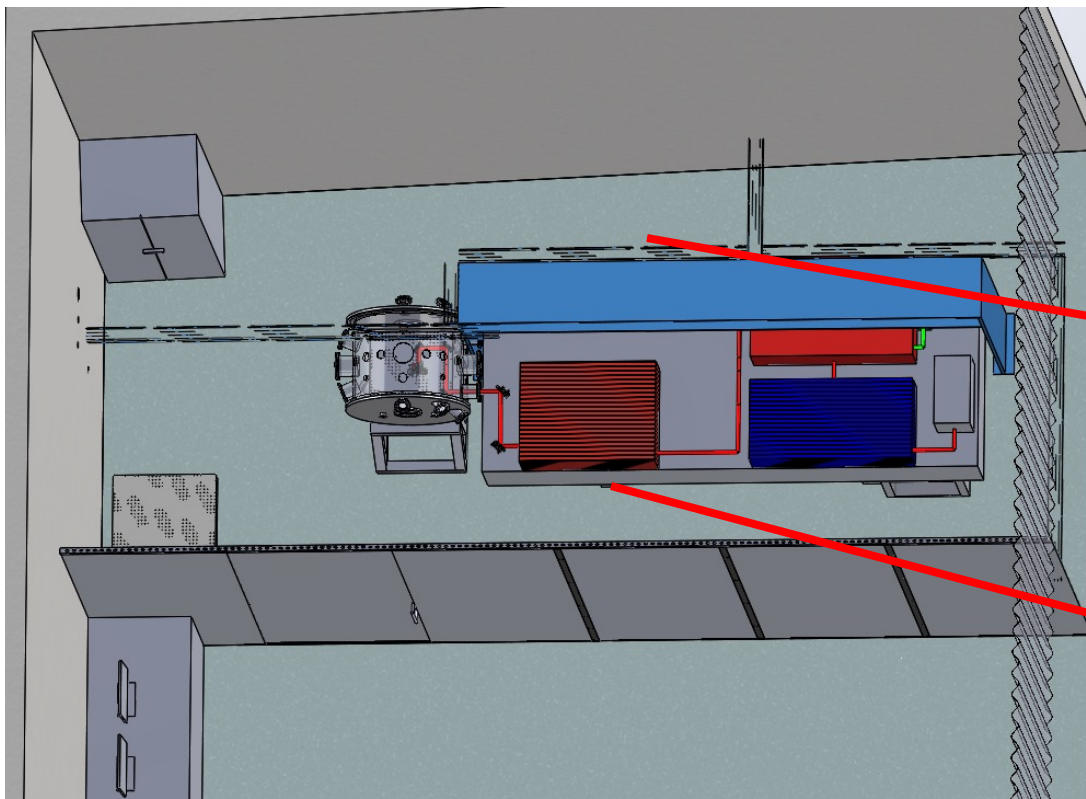


- Target Fielding
 - mass production
 - delivery systems
 - robotics and metrology
- Diagnostics
 - Optical, x-ray, particle
- Controls
 - mass data analysis
 - machine learning
 - feedback systems

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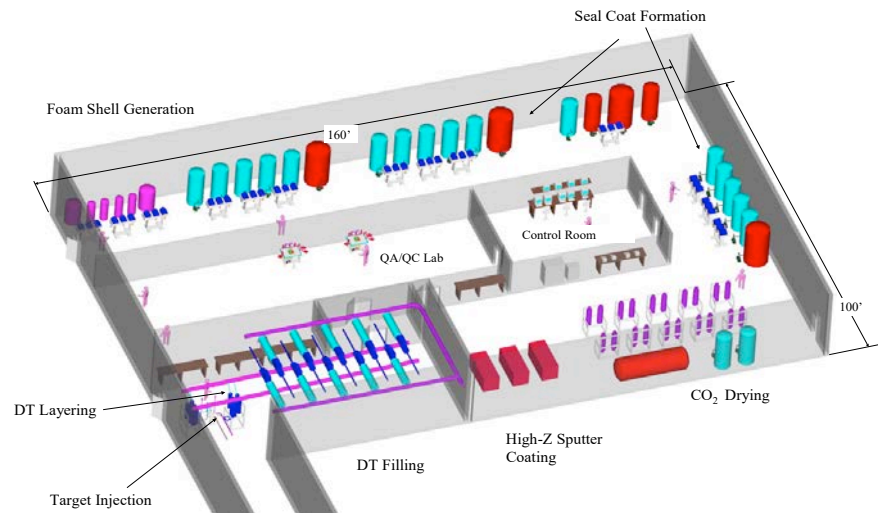


Highlights of prior R&D projects relevant to IFE

Capsule Production

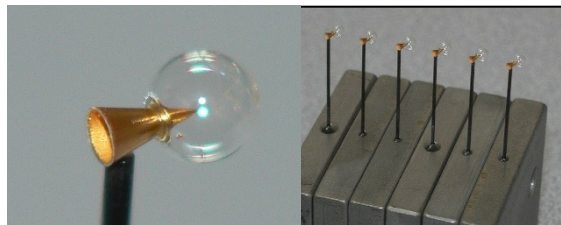
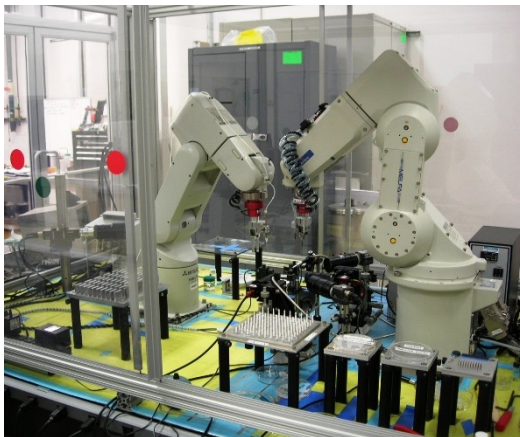


Mass production: example
Direct drive target factory study;



Goodin, D.T., et al, "A cost-effective target supply for inertial fusion energy", *Nuclear Fusion* 44 (2004).

Automated Assembly



Cone-in-shell targets
assembled with $\pm 10 \mu\text{m}$
accuracy

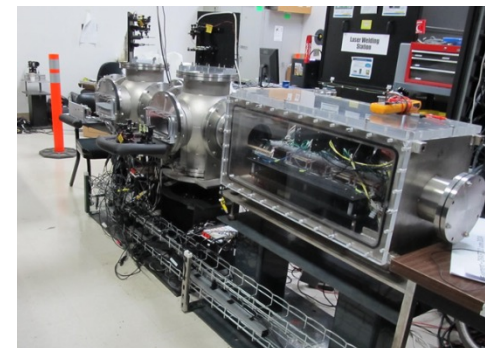


Electro-
formed
gold
cones

Target Injectors and Tracking



Gas gun with sabot:
400 m/s with 0.59 mrad accuracy,
50 m/s with mrad accuracy 0.24



Linear Induction Accelerator with
post launch trajectory correction;
57 m/s, 0.14 mrad accuracy

Ronald Peitzolt, et al (2015) Linear Induction Accelerator with Magnetic Steering for Inertial Fusion Target Injection, *Fusion Science and Technology*, 68:2, 308-313, DOI: 10.13182/FST14-915

Advances in Targets Manufacture & Metrology are Enabling Higher Yields

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- Metrology, metrology, & more metrology!
- Expanding spherical target design space
- Higher adoption of Additive Manufacturing
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- Partnering in Science-Based Stockpile Stewardship and ICF & HED Research

