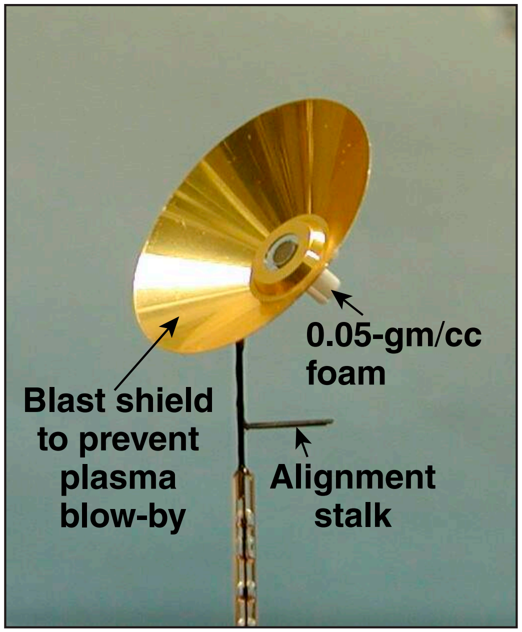
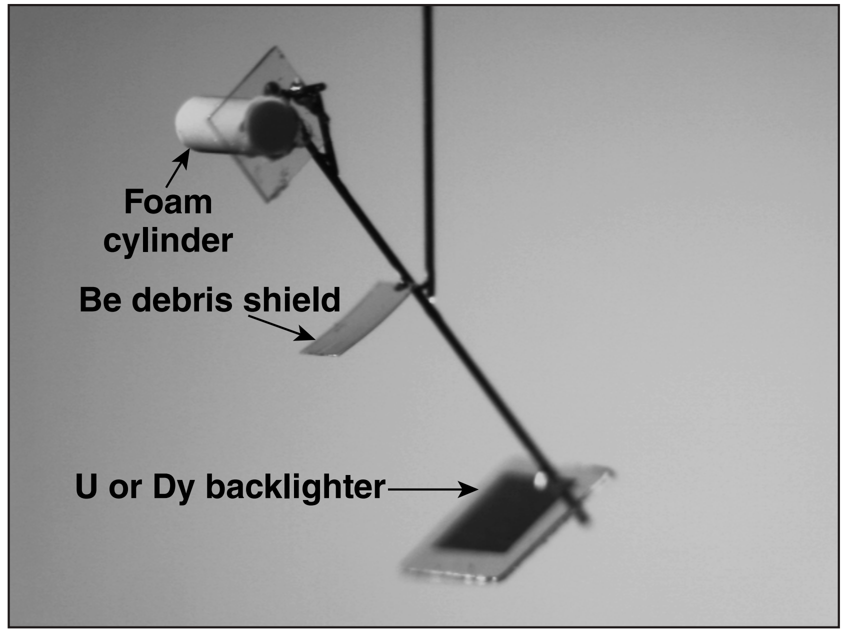
# Target Fabrication: Capabilities and the Ordering Process

Thin plastic foil with imposed perturbation
(provided by GA/Schafer)




Astrophysical target
for a NLUF campaign




Rayleigh–Taylor instability target
Produce 15 for a one-day campaign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Omega Laser Facility
Users' Group Workshop
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Summary

# Early involvement with the Target Fabrication Group is essential if any LLE/GA support is needed to make targets

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Target fabrication process

1. Conceptual design of the target to assess complexity
   - need approximate dimensions
   - need ~6 months before shot date
2. If this is a new design (i.e., different dimensions, shape, gas content compared to earlier targets), the development effort must be determined
3. Detailed target specifications/design are needed 3 months before the shot date, including
   - detailed assembly drawings to ensure adequate lead time to procure components from labs/vendors and interface assembly with other target orders
   - QA requirements defined by the target specifications, we quantify only parameters that are explicitly defined
   - avoid over-specifying (increases cost, time and feasibility of making the target)

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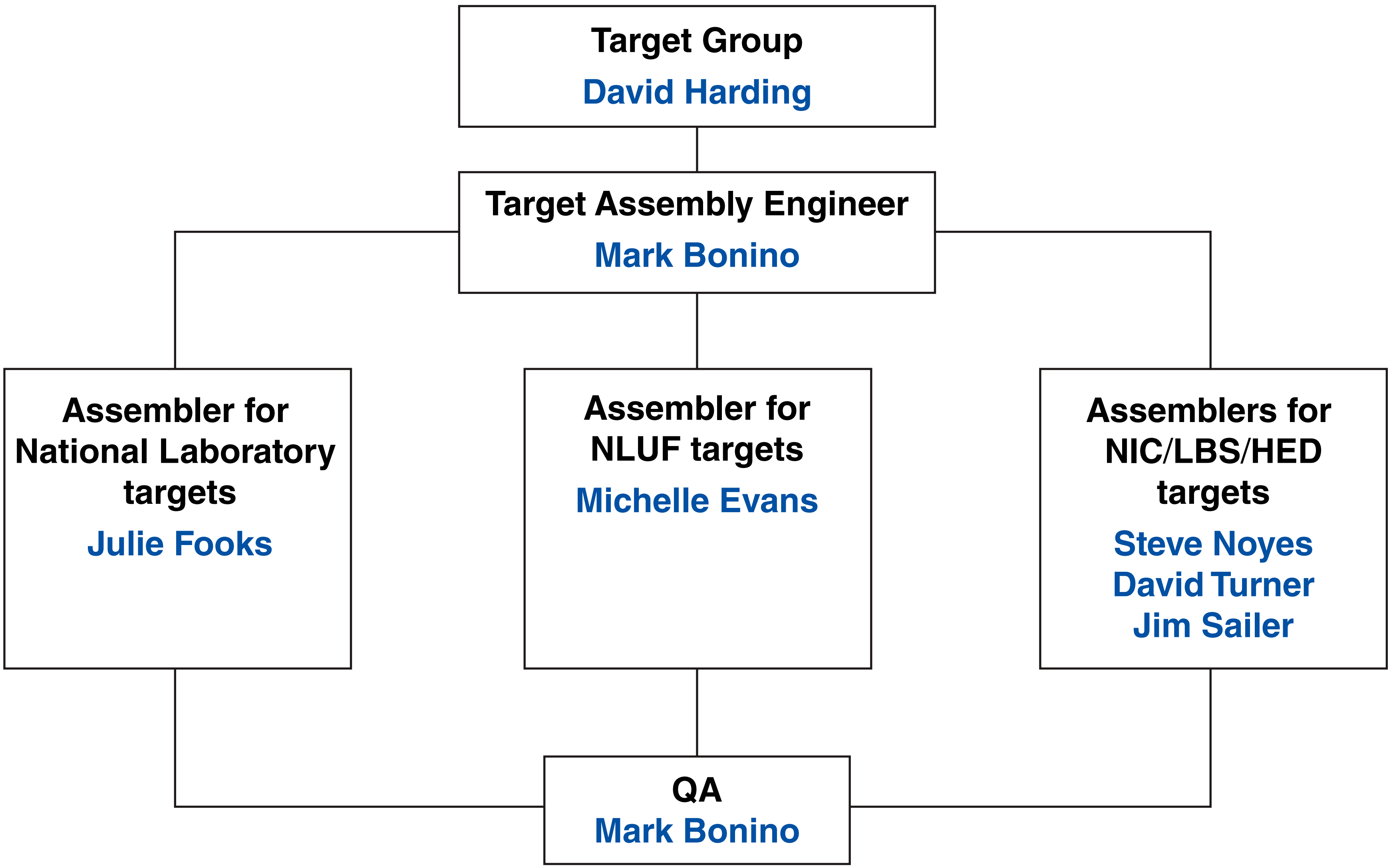
# Outline

1. Organization
2. Capabilities
3. Ordering and Assembly Process
    a. Target Request Form (TRF)
    b. suppliers
    c. internal assembly
3. Post processing
    a. QA
    b. gas permeation
    c. If DT or cryogenic conditions are required then the OMEGA Laser Operations Director (Sam Morse) must be contacted

# Organizational chart for target assembly




Primarily to support national laboratory targets

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# The following types of targets have been provided

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Target types

- Cryogenic spherical targets
  - contain $D_2$ or DT gas
- Cryogenic planar and hohlraum targets
  - contain liquid $D_2$
- Spherical targets
  - varied gas compositions and pressures
    $^3$He, $D_2$, DT, Ar, Kr
- Planar targets – single-foil experiments
- Hohlraum targets
- Complex targets

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# The most straightforward target assemblies are still labor-intensive because they require gas inside the shell

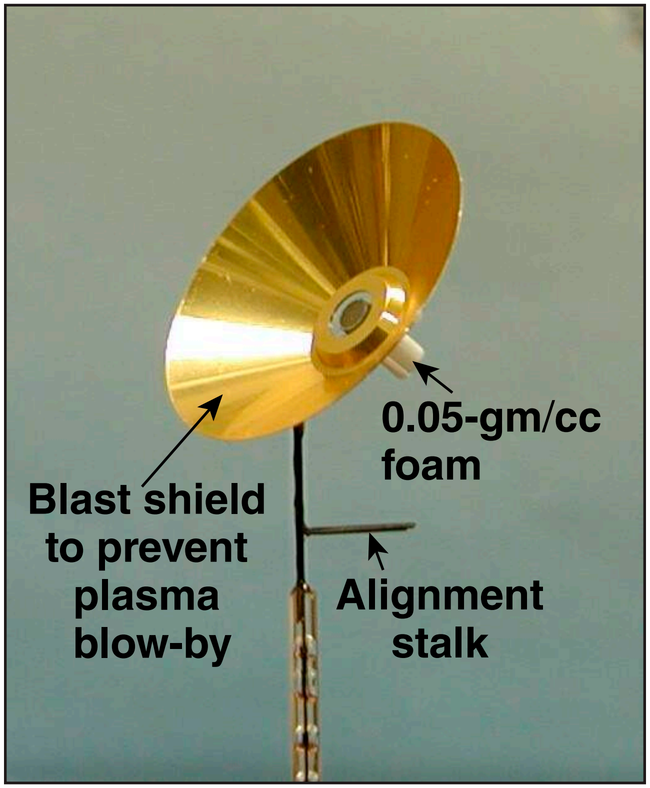
SiC fiber support stalk


17-$\mu$m stalk supporting a 1-mm-diam capsule

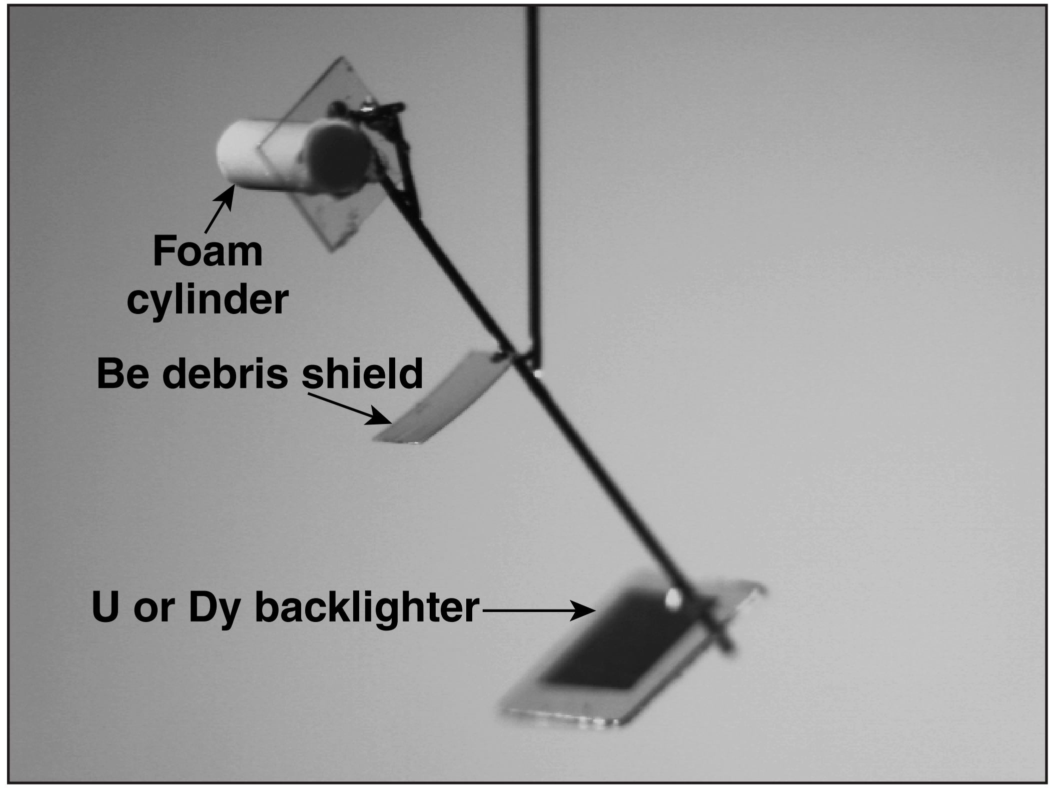
- Gas Pressures: 3 to 30 atm
- Gases:
  - $^{3}He:D_2$ (1:1 at. %)
  - DT
  - $D_2$
  - $Ar/D_2$ (0.05 to 1 at. %)
- Permeation-time constants: 20 s to 24 hr
- Knowing the gas pressure accurately is labor intensive
  - what uncertainty is acceptable

# Many targets consist of a flat foil with exotic structures to protect the foil; foils may contain perturbations

**Thin plastic foil with imposed perturbation**
(provided by GA/Schafer)




**Astrophysical target for a NLUF campaign**




**Rayleigh–Taylor instability target**
**Produce 15 for a one-day campaign**

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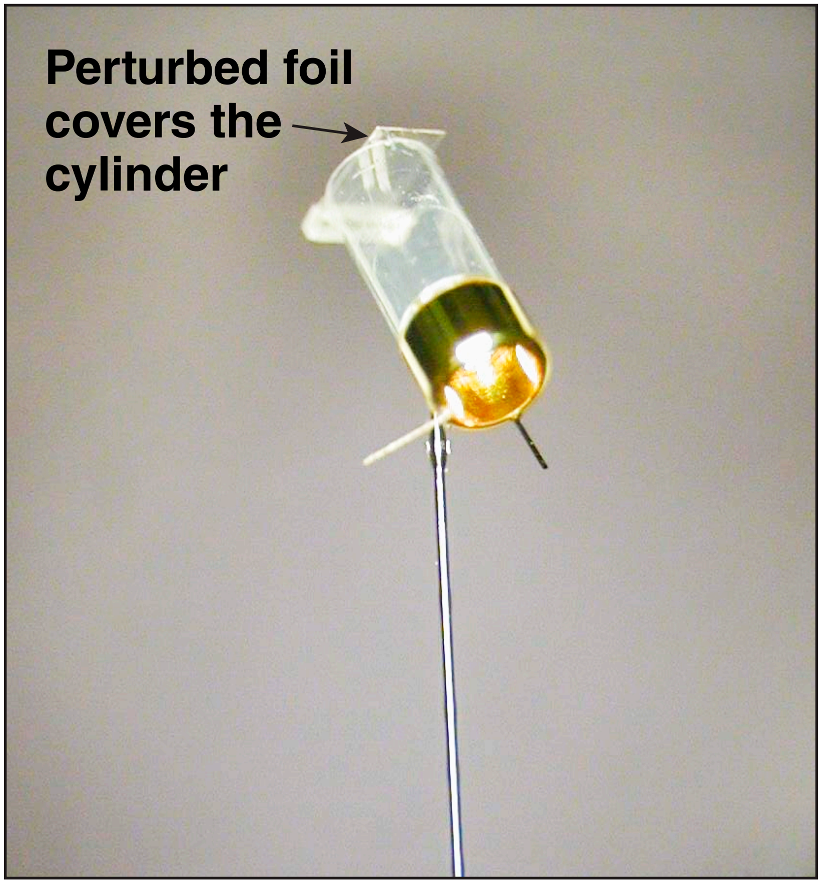
# We have the infrastructure and experience to assemble hohlraum and halfraum targets and to add gas to the hohlraum





Hohlraums provided by GA

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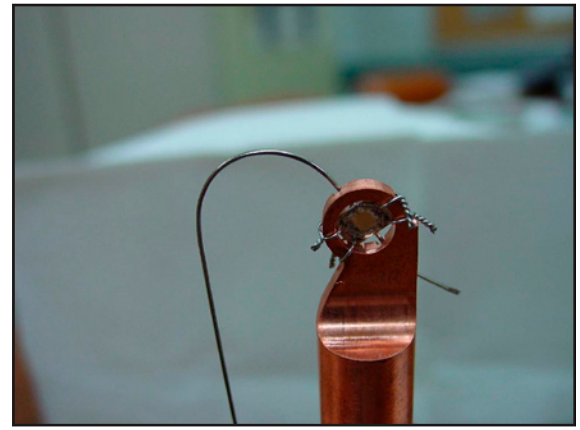
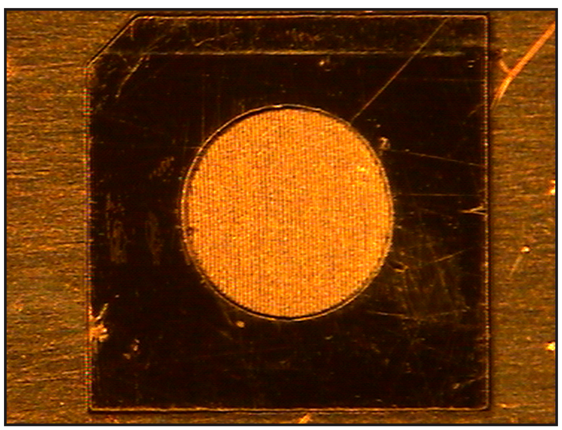
# We order target components from General Atomics whenever possible



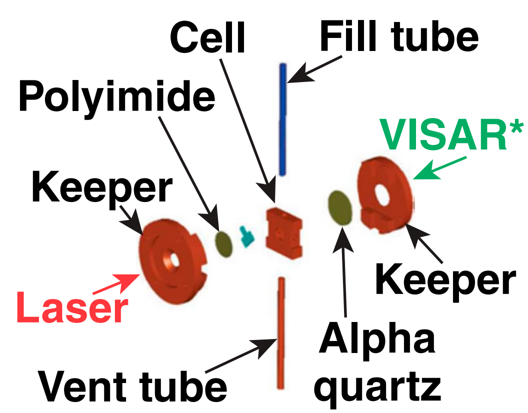
- Components not available from GA are sourced from other commercial suppliers
  - foams (GA, LLNL)
  - foils (Goodfellow, Luxel, GA, in-house)
    - list elements: U, Dy, Sm, Sc, Zn, Ti, Au, Fe, V, Ta
  - specialty components (i.e., pinholes, washers, cryo-pins: optimation, resonetics, AVKO)
  - planar cryogenic components (Van Thomas)





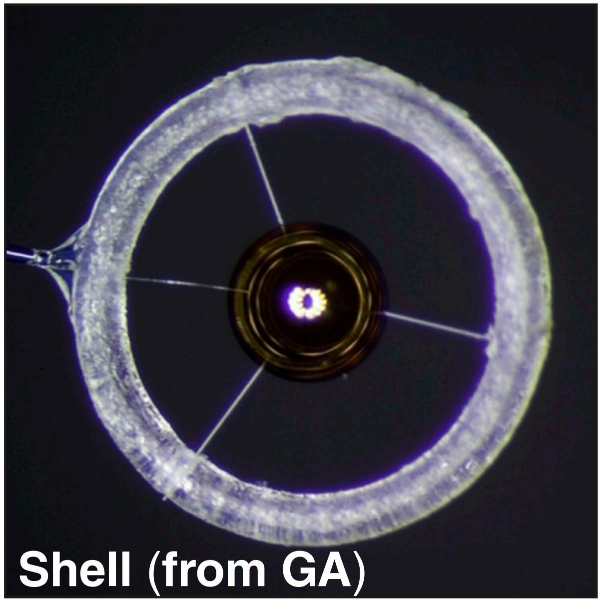
Modulated foils for RTI campaign, 20 × 3.3 $\mu$m (wavelength, amplitude)

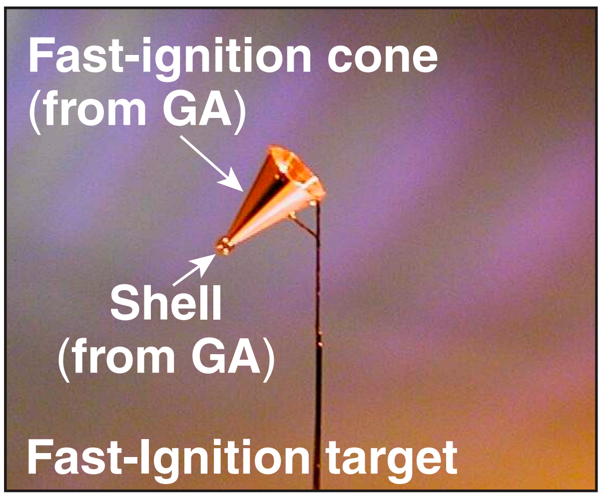
Planar cryo target




* Velocity interferometer system for any reflective surface

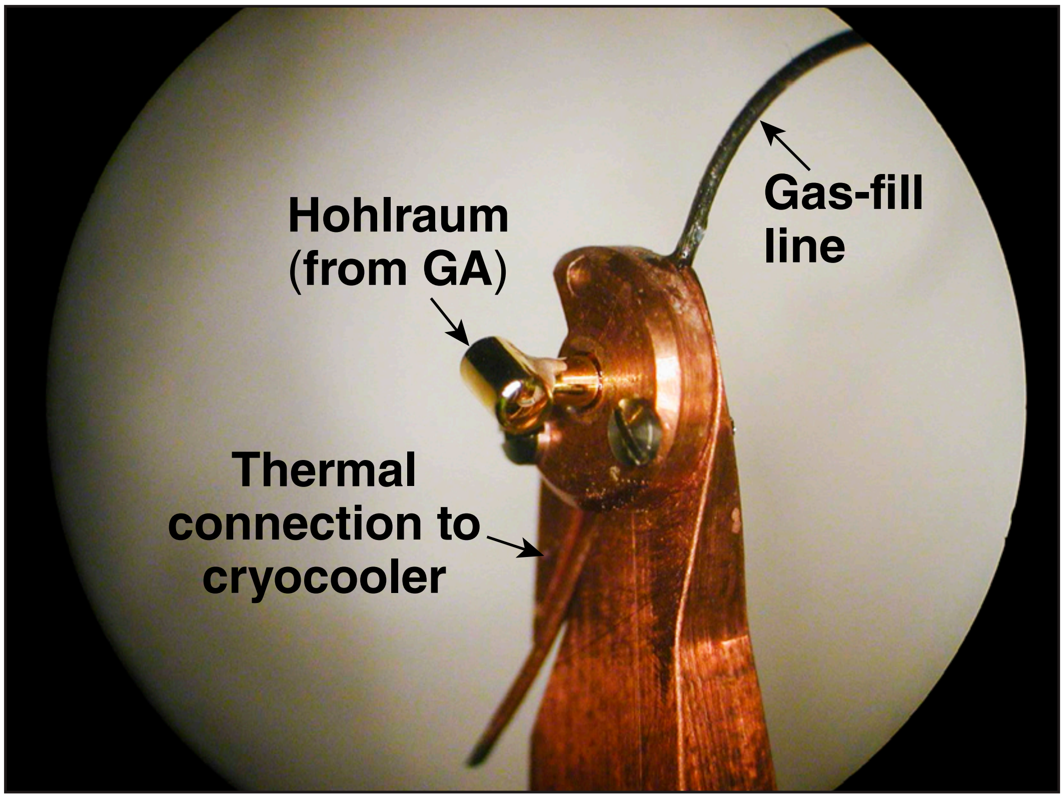
# New target support structures and new targets are developed to support new experimental campaigns

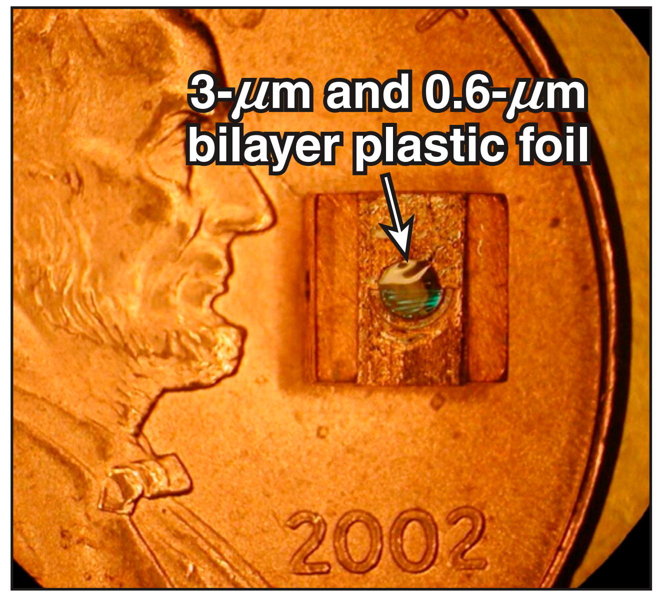



- Injection molded polystyrene ring uses 10-$\mu$m-diam alumina fibers to support the target
- Fill-tube fabrication and assembly (8-$\mu$m hole) completed in-house

# Planar cryogenic targets are delivered by a cryogenic system that consists of small, precision-machined components (foils and hohlraums)



# Eclectic target designs are possible, but extra time is needed to develop new assembly techniques and build the machine dies to assemble these targets to specification

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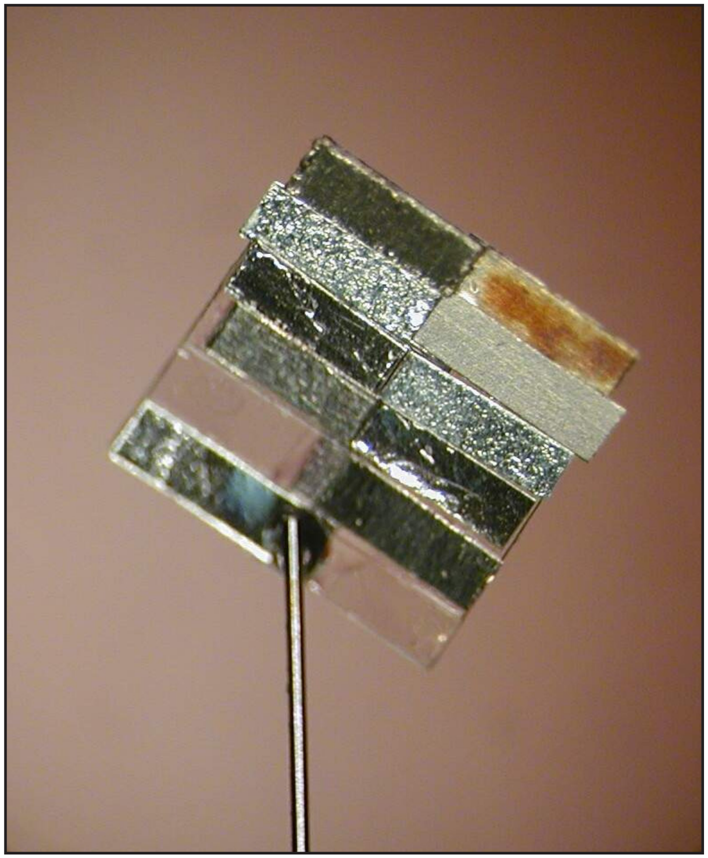
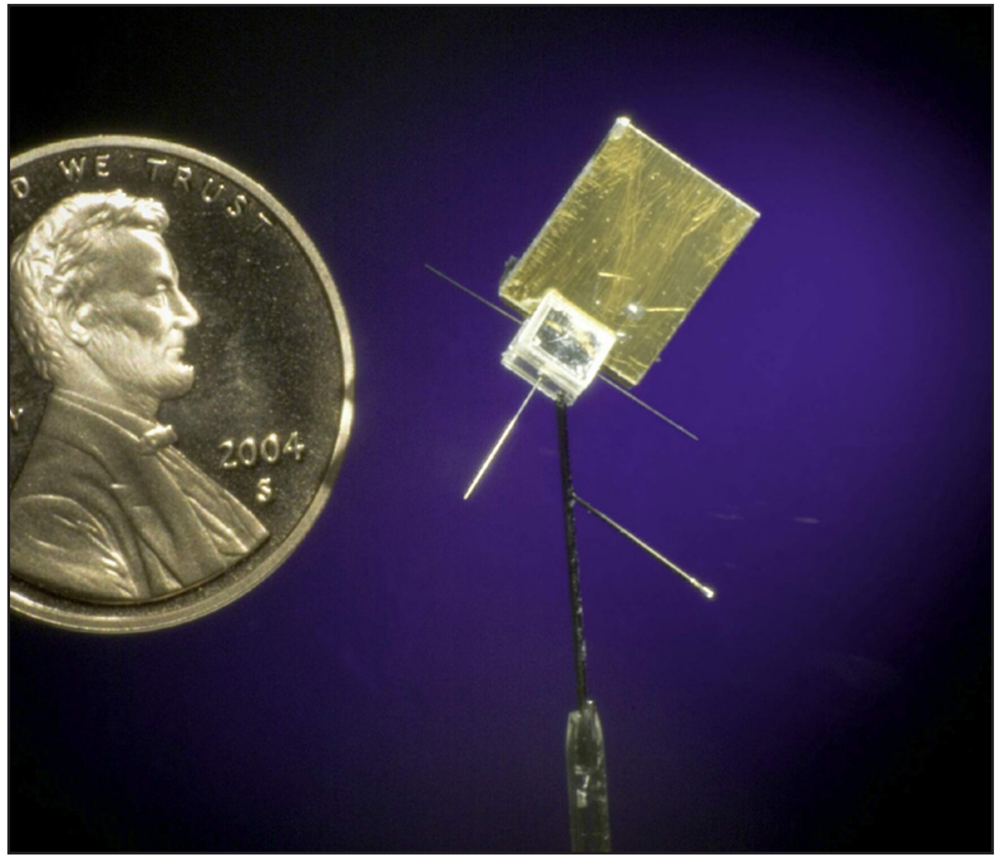


ROSS development target consisting of 12 separate thin films of 1.5 to 25 keV



X-ray Thomson-scattering targets

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# We developed and built equipment that is specific to the requirements of fabricating a wide variety of ICF targets

- On-site capabilities
  - 6 (5 standard, 1 LANL) target-assembly stations
  - 7 vacuum-coating systems
  - machining infrastructure (within the group and in the facility)
  - gas-permeation infrastructure
  - measure target roughness—Atomic Force Microscope
  - Measure dimensions and angles—Powellscope (5-axis device)
  - Measure vibration spectrum

# All target requests follow the same sequence: the complexity of each step varies for each campaign

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1. Evaluate target conceptual design (manufacturing feasibility)
   – finalize specifications with Principal Investigator and OMEGA Manager
2. Order components—GA is the principal vendor
3. Fabricate components not available from vendors
4. Manufacture assembly structures (design/build assembly fixtures)
5. Metrology—confirmed by PI
6. Prepare target (i.e., permeate gas into the shell)
7. Deliver target

Lead time

- 6 months for a new target design (requiring development)
- 3 to 4 months for a known target design
- 3 months: component orders to GA
- 2 months: outside vendors

**Flexibility to provide new targets at "the last minute" is a critical component of our work—to cover unforeseen changes in experimental plans.**

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# The Target Group works closely with the Principal Investigator and the OMEGA Operations Group

## Critical Issues

- Fragile design
  - robustness adds mass that compromises the experiment and damages the Target Chamber optics
- Short shelf-life because of gas fill
  - targets are pressurized until 1/2 h before the experiment
- Metrology immediately prior to the experiment
  - safeguard against alignment fiducial or component misaligned (endangering the laser and/or experiment)
- Exacting angular and dimensional tolerances
- Complex and developmental cryogenic systems
- Radiological issues associated with use of tritium

# The Target Request Form (TRF) is the basis for ordering all targets

- Specify a target with a drawing in the TRF, including a target normal ($\theta$, $\phi$ coordinates) and tolerances (±1° without special fixturing)
- Specify target positioner
  - OMEGA: TPS-2 (H2) or TIMS
  - OMEGA EP: TPS-7, TPS-83
  - targets can come from the same positioners, depending on experimental tolerances
- Specify metrology/characterization
  - metrology can dictate timeline
  - if timelines are not met, the metrology margin is reduced

# Target production timeline/checklist

- T–6 months:  Conceptual design (part of the LBS/NLUF proposal)
- T–3 months:  PI initiates TRF
  - reviewed by Target Group for feasibility/production scheduling
  - production review with vendor for feasibility/production scheduling
  - PI approval required
- T–2 months: OMEGA Scheduling Committee requires accurate drawings
- T–1 month: parts delivery
- 2 to 3 weeks for assembly (phased with other campaigns)
- 2 week brief: specify time required for Powellscope metrology
  - review “as-built” target with PI, confirm metrology requirements
- 1 week brief:  target completion status and “as-built”specifications to PI
- Metrology data due to XOPS 2 days prior to shot day
- Shot day
- Postmortem:  review with PI

# A three-month lead time is required to phase multiple campaigns on two systems per week

| Target Type | Component Fabrication and metrology, vendor | Assembly | Metrology | Campaign Examples |
|---|---|---|---|---|
| Capsules: gas fills at room temp. | 3 to 4 weeks, 30 man-h (GA) | 2 man-h/ 15 targets | Leak-rate measurements: 1 to 3 weeks, depending on quantity | ISE, DD, DIME, FI, NLUF (core imagining) |
| Cryogenic capsules | 3 to 4 weeks, 30 man-h (GA) | 1 man day/ 5 targets | Dimensions, photographs | Cryo, Cryo testing |
| Planar single foils | 1 to 5 weeks, depending on vendor availability | 1 h/10 targets (simple foils) | Powellscope, 2 man-h/10 targets (rotation fiducials) | OMEGA EP ISO Heating, System Sci, PRAD backlighters |
| Complex multiple foils | 80 man-h | 68 man-h/ 6 targets | Included in 68 man-h estimate | RTI, XRTS, PRAD |
| Hohlraums | 80 man-h (GA) 50 man-h (Luxel) | 120 man-h/ 12 targets | Included in 120 man-h estimate | Hohlraum energetics, PRAD |
| Planar cryo | 80 man-h, 3 month lead time (GA), 6 week outside vendor | 4 to 5 days, 10 to 12 man-h | Leak-rate measurements, 4 man-h/6 targets | NIC ST, Cryogenic XRTS |

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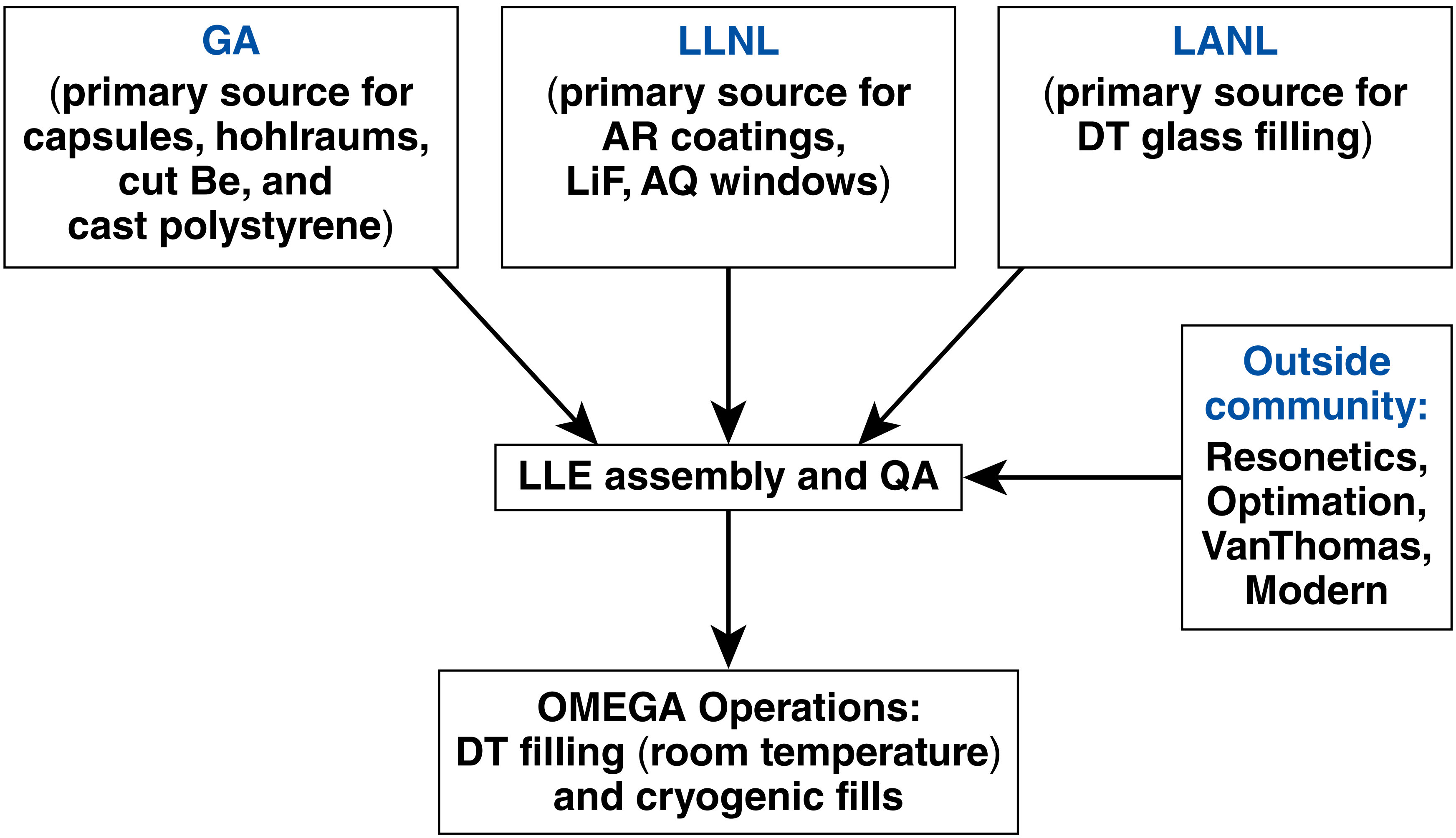
# Target process flow chart

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# Metrology capabilities

- Mach–Zehnder interferometer/Filmetrics unit: measures polystyrene 5 to 30 $\mu$m in thickness (0.1-$\mu$m accuracy)
- Powellscope metrology system: measures to ±0.2° accuracy, 6-$\mu$m resolution
- Nikon measuring microscope: optical resolution: 1 $\mu$m
- Zygo white-light interferometer: optical resolution: $<$10 nm
- Leak-rate measurements (capsules): accurate to ±5%
- AFM spheremapper

Summary/Conclusions

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