Target Fabrication at the University of Michigan for OMEGA Laser Campaigns

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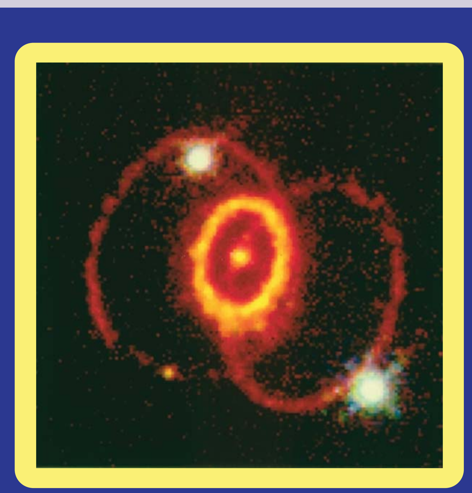
Overview - Laboratory Astrophysics

We produce processes relevant to astrophysical phenomenon, such as supernovae, in a laboratory setting.

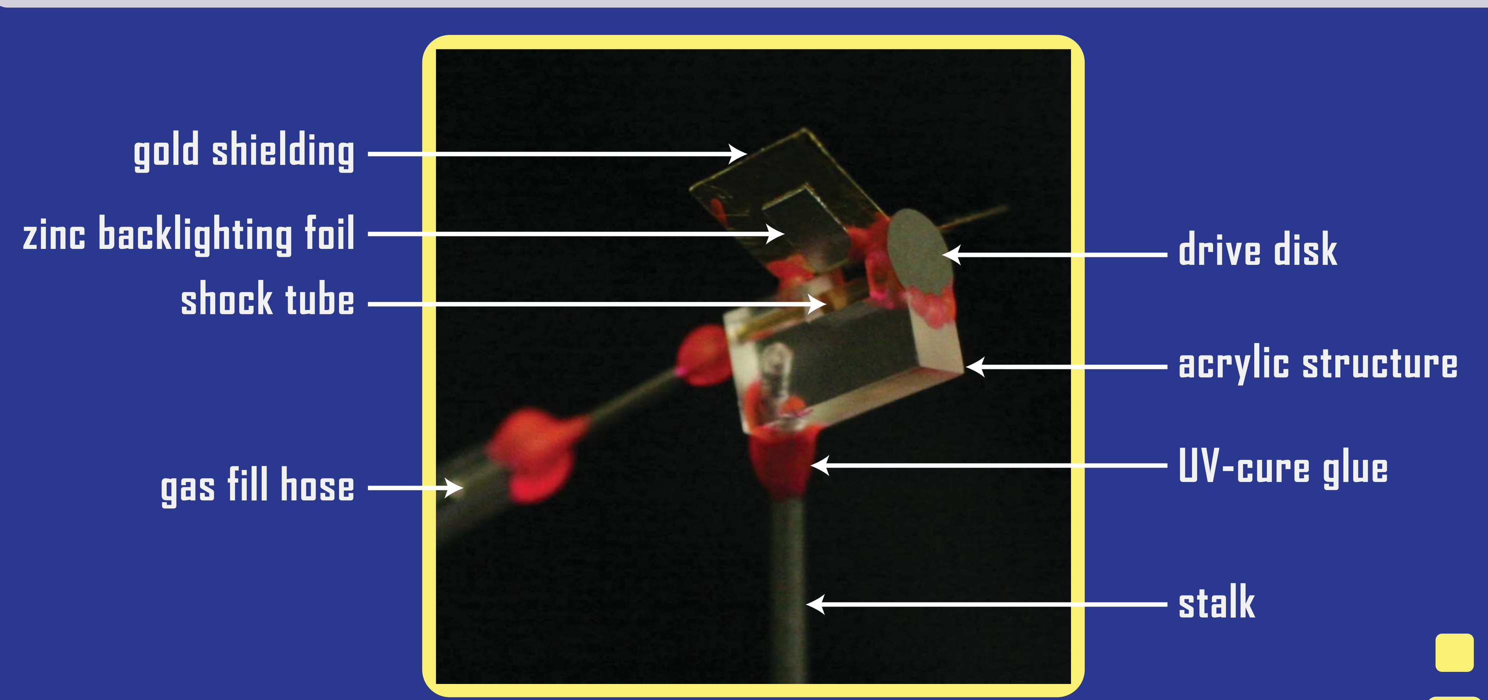
By precisely scaling our experiments to observed phenomena such as Supernova 1987a, we can create similar conditions as those found in the astrophysical systems.

This process allows laboratory data to improve our understanding of astrophysical phenomenon in a quantitative manner.



Supernova 1987a

Experimental Targets and General Components

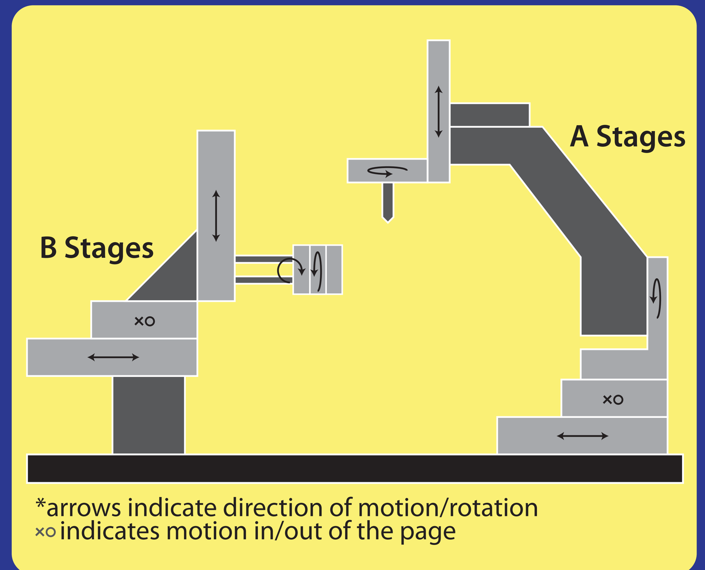


X-Ray Thomson Scattering Target, March 2010

Target Build Procedure

Each target is tailored to the specific experiment based on the hydrodynamics we plan to observe.

Parts are either purchased from vendors, such as General Atomics, machined on our microdrill/microlathe, or manufactured by our in-house machinist, Robb Gillespie.



The Target Fabrication System

For orientation and assembly of parts, we use the Target Fabrication System.

The Fabrication System contains two sets of stages and allows for both linear and rotational movement. These movements are highly precise, accurate to within tens of microns.

This setup is used in both building and metrologizing the targets.

A Machine-Based Design Approach

Previous targets were built using a stick-and-glue approach, where each component had its own separate geometry.

Current targets tend to have one large assembly or frame machined to a very specific geometry, into which many smaller components slide, lock, or press-fit, which has many advantages:

- The accuracy of a machine-built piece is significantly greater
- Designing insets, press-fit holes, and other features that relate the geometry of the frame to the other target components, decreases error in the assembly process

Examples of machined features:

stalk holes

drive disk inset

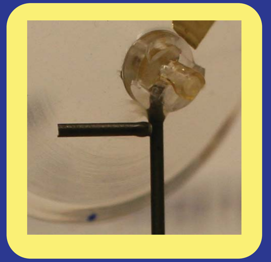
gold shield inset

Assembling targets with easily understandable geometry is a much faster and smoother process.

New Design Considerations

Combining multiple functions into a single piece whenever possible, so that increasingly complex experiments don't require increasingly complex geometry.

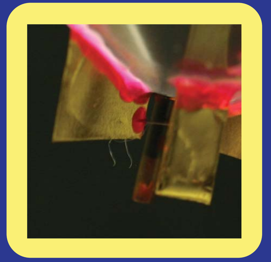
The acrylic cone (initially used for shielding diagnostics) has incorporated new features and become a general frame for holding the drive disk, tube, and stalk, among others



Hollow tungsten carbide tubes act as both a stalk and a gas-fill tube

Designs incorporate damage mitigation

- Using tilted pinholes, other tilted geometry when needed
- Ensuring surfaces of materials likely to become projectile debris are not normal to diagnostics or other important chamber equipment



Using built-in target features for alignment, instead of adding a separate wire

Improved Target Materials

Rigid, easily machinable material (acrylic) for bulk of target assembly

Working to replace all uses of beryllium

- Beryllium is low-z and rigid making it a convenient laboratory material, but is unfortunately toxic and expensive in both cost and time. For this reason we are looking into replacing beryllium with other safer, more easily available low-z materials.

Current alternate material testing is underway.

Colored, UV-cure glue

- Fast UV-curing allows pieces to be securely attached in 30 seconds with no risk of drooping, slumping, or other movement within the glue
- Pink coloration makes the gaps in glue easily visible, which eases the process of sealing targets to be gas-tight

Improvements Through OMEGA Facility Feedback

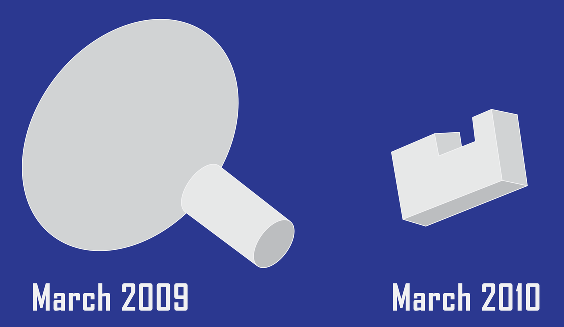
Target fabrication techniques and design considerations have also developed based on feedback from the OMEGA facility. Examples of these changes include:

Efforts to minimize possible shrapnel

Targets are also now designed to prevent the target or pieces of the target from becoming shrapnel, which include the efforts below, among others.

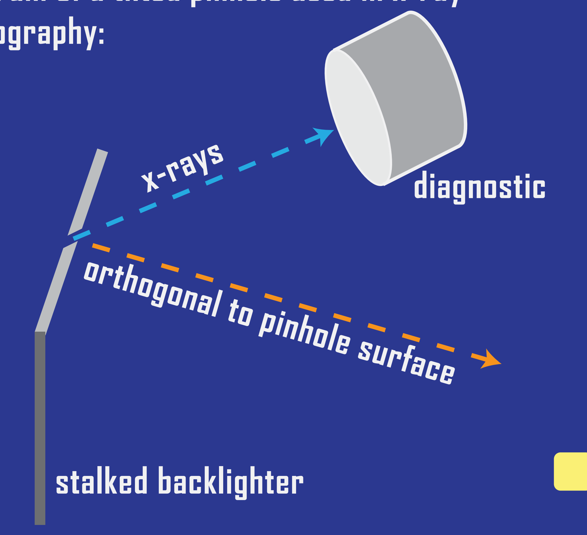
Minimizing the volume of our acrylic superstructure

Relative size of acrylic for X-Ray Thomson Scattering experiments:



Orienting surfaces away from diagnostics

Diagram of a tilted pinhole used in x-ray radiography:



Feedback for the OMEGA Facility from Users

Our gas fill targets are attached to pressure transducers, which often become unusable after the shot has been taken. We are aware that other experimentalists also have this problem. Is there a way to prevent transducers from failing during experiments?

We currently use the DS/DL lab space during experiments, particularly gas-fill experiments, to gas-test and gas-fill our targets on shot day. Having a dedicated lab space for us and other users would help shot day run more smoothly.

A thank-you: we appreciate that the OMEGA darkroom will have it's own IP scanner so we don't have to use the EP darkroom after each shot!

Summary of Improvements and Future Direction

Improvements in target materials used, the adoption of a predominantly machine-based design, simplifying target components, and streamlining the assembly process allow us to assemble complicated targets accurately and in a time-effective manner.

In recent shot campaigns, the early involvement of the target fabrication team in the design process and the continued involvement of the target designer throughout the build process have given greater foresight and procured a number of improvements in target fabrication; we hope to continue these innovations throughout future experimental campaigns.

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Target Timeline - Design Samples from the Beginning to Present

July 2003 | August 2005 | August 2006 | January 2008 | Present