Ignition Target Baseline Design for Indirect Drive Ignition Experiments on the National Ignition Facility (NIF)

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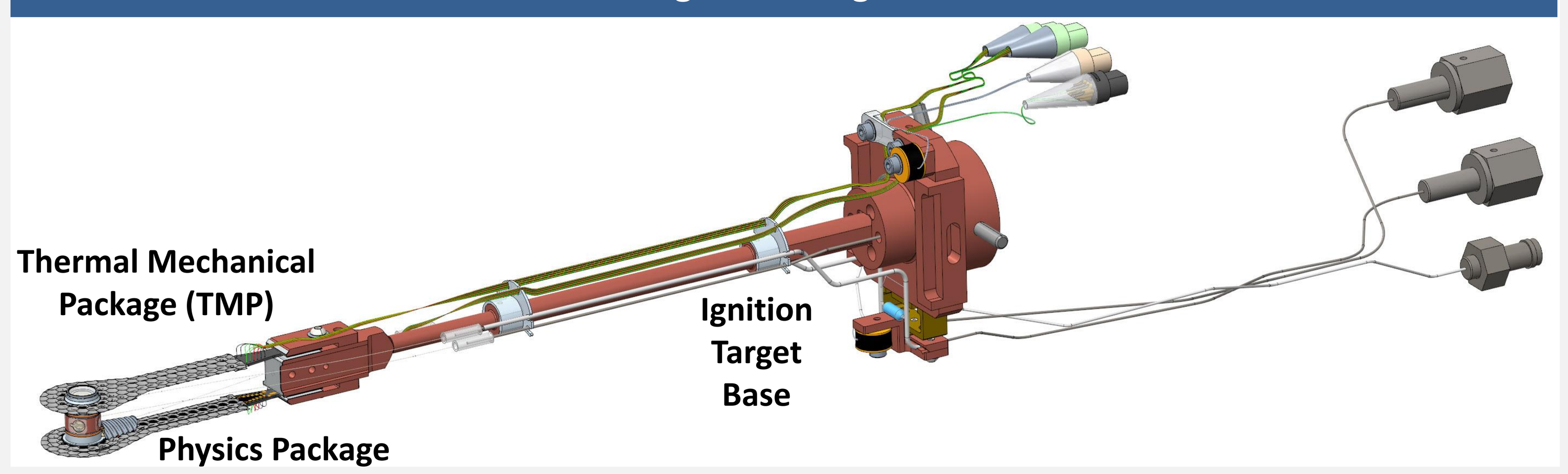
The ignition target has undergone many design updates over the years

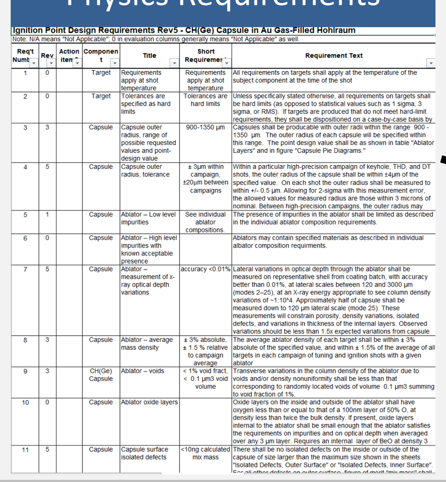
- Changes to physics requirements, production processes and optimizations have led to many updates to the current ignition target design
- Updates allow us to satisfy changing requirements and strive to increase reliability

Ignition Target



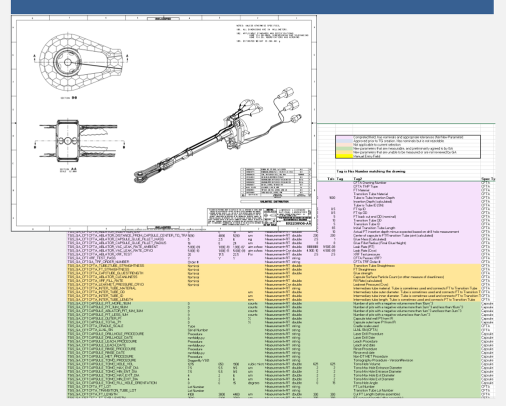
- A clear set of physics requirements including the associated flow down to engineering details is crucial for tracking drivers of target evolution

Physics Requirements



Engineering Requirements

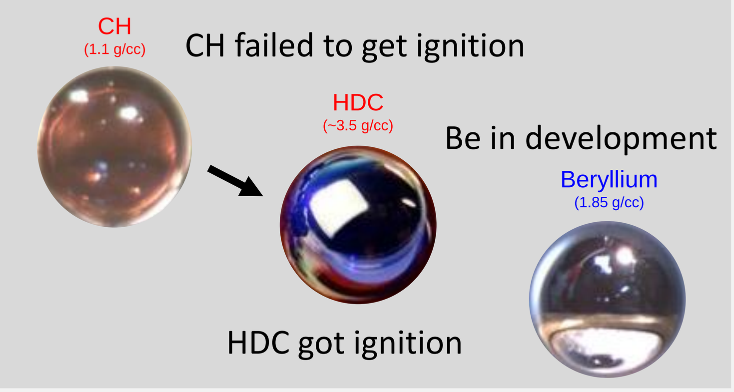
Drawings & Specifications

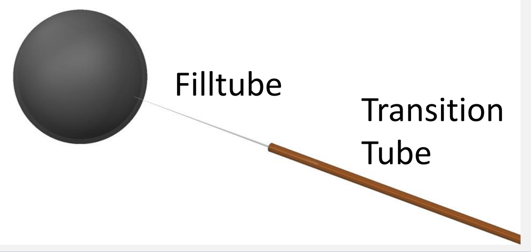


Evolving physics requirements drive physics package development

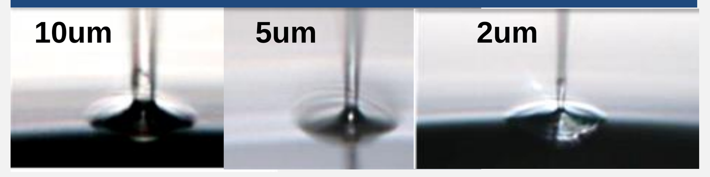
Capsule and Capsule filltube assembly (CFTA) are continuously improved

Three ablator materials used on NIF ICF experiments; all 3 need to meet near-perfect smoothness, roundness & homogeneity





Filltubes to deliver hydrogen have gotten continually smaller to minimize impact on the implosion



Capsules and CFTAs represent many requirement and process changes which drive innovation and are captured in many posters and talks

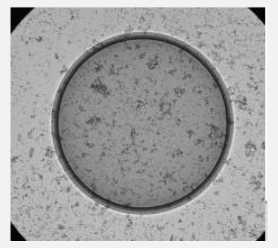
DU hohlraums are preferred for additional X-ray drive

Gold

Linerless Uranium

Gold Lined Uranium

Manufacturing difficulty



DU hohlraum slivers require new process development

DU Hohlraum requirements drive many production challenges

Capsule support must be minimized to reduce implosion influence

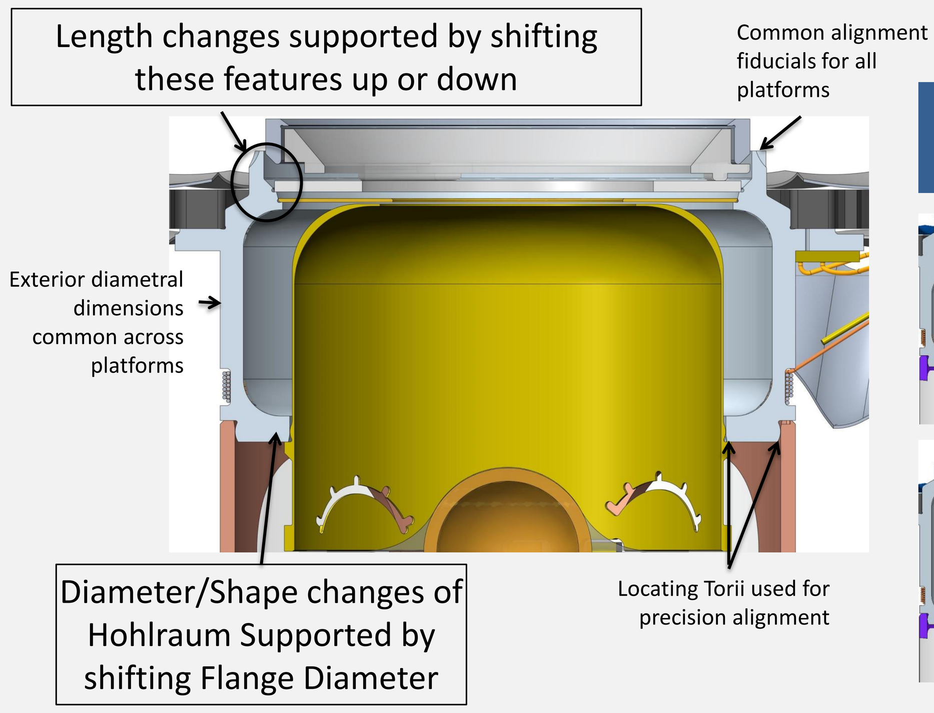
Tent thickness is currently at 45nm but its impact is still noticeable for CH capsules

Tent alternatives such as polar tents (minimize tent contact) and tetracage (carbon nano yarns) have been explored

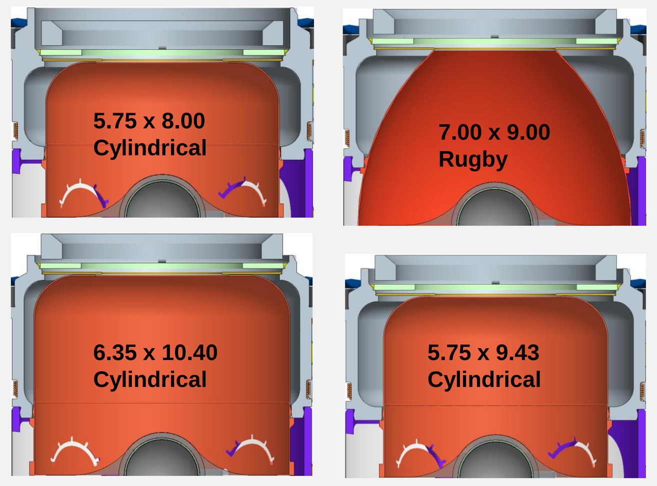
Tent thickness evolution: 110nm → 300nm → 110nm → 15nm → 45nm (HDC is less susceptible)

The Thermal Mechanical Package (TMP) positions the physics package, supports gas fill and facilitates thermal control

Hohlraum scale changes drove the need for an agile TMP which could easily be modified to support many hohlraum sizes and shapes

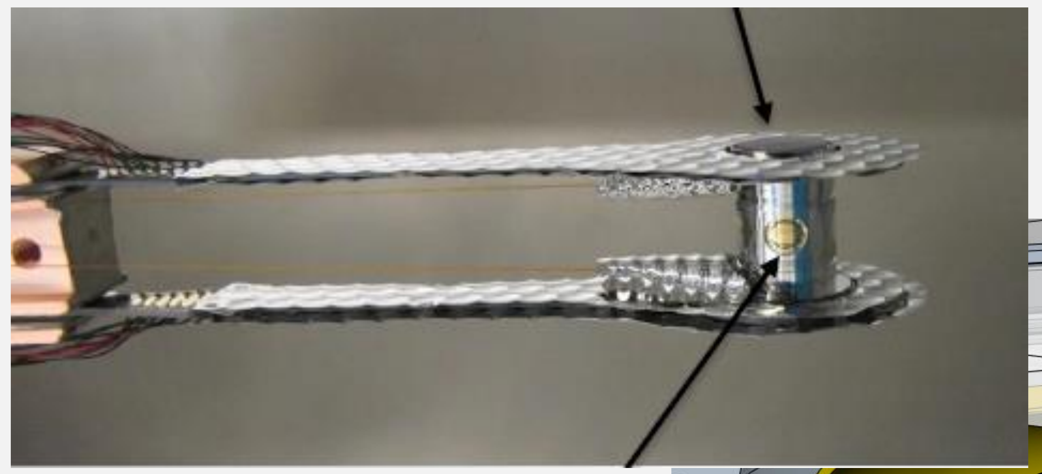


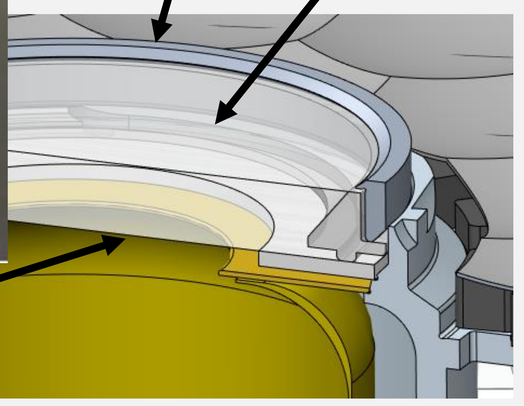
TMP versions support dozens of hohlraum sizes



The TMP has proven to be a robust design which facilitates rapid design changes

Storm windows reduce air ice buildup on the laser entrance hole (LEH) window



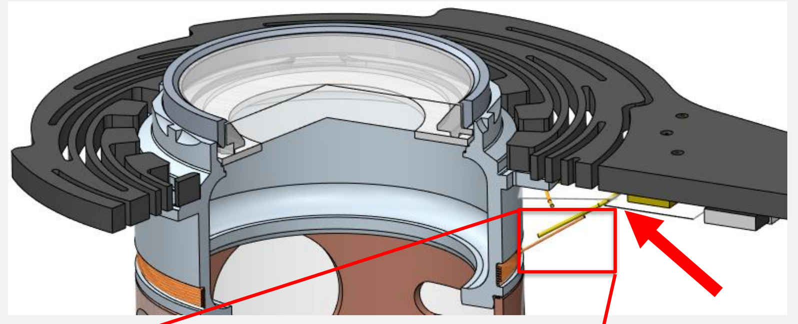


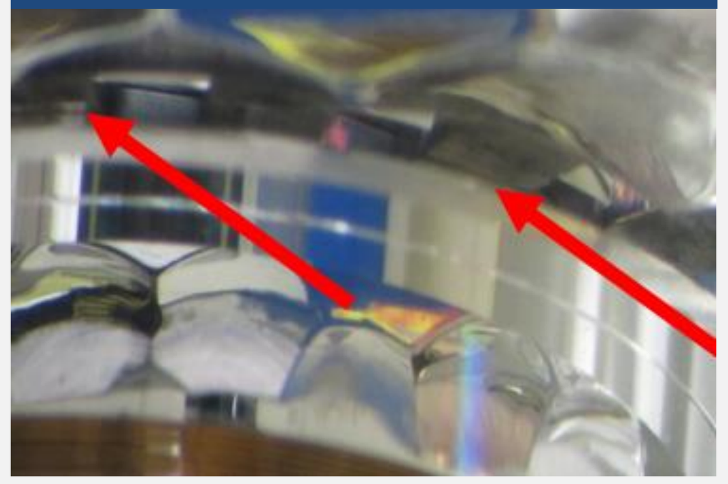
The storm window was the response to a requirement of less than 100nm of ice on the LEH window

Silver filled epoxy obsolescence drove production changes to continue to meet requirements

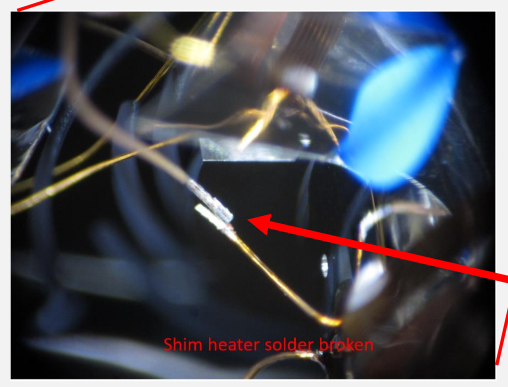
- The thermal performance of the bond between the silicon arm and the aluminum TMP shell is critical to cryogenic performance of the ignition target
- Epoxy is also used to provide electrical connections for heaters and temperature sensors

The bonding of silicon cooling arm to TMP shell is critical to thermal uniformity





Red arrows show debonded regions



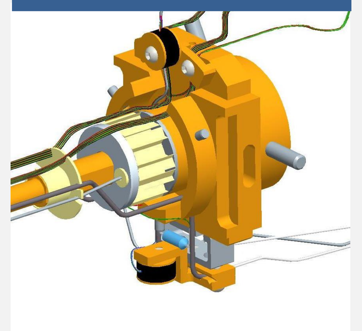
Poor wetting of glue causing electrical shorts

Process updates allowed similar performance, but require careful monitoring

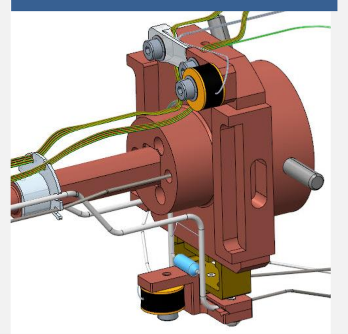
Ignition Target Base optimizations have also resulted from updated requirements and process improvements

Production process simplification removing blast shield, wiring support and temperature sensor mount

Old with blast shield



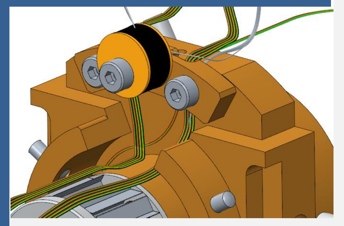
New no blast shield



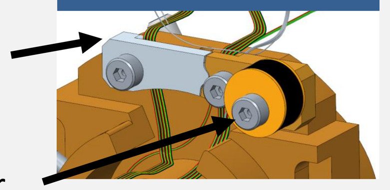
NIF after shot target images showed no evidence of blast shield damage

- Wire support with sensor showed sporadic readings
- Copper wire support caused abrasion of wires

Old Design



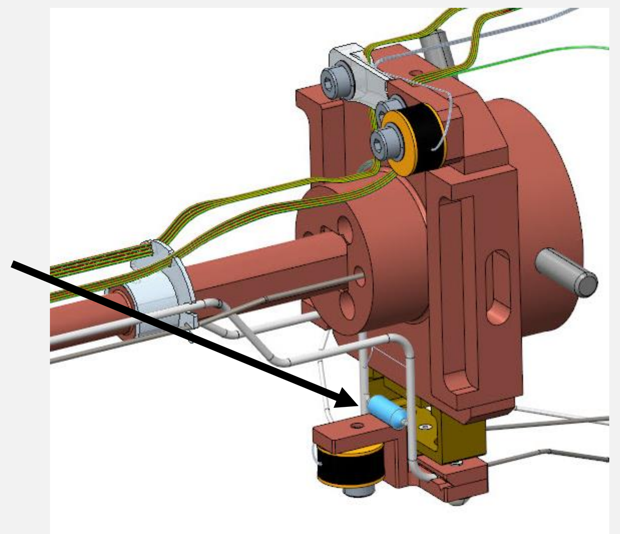
New Design



Some design changes are driven by simplification of process while still meeting existing requirements

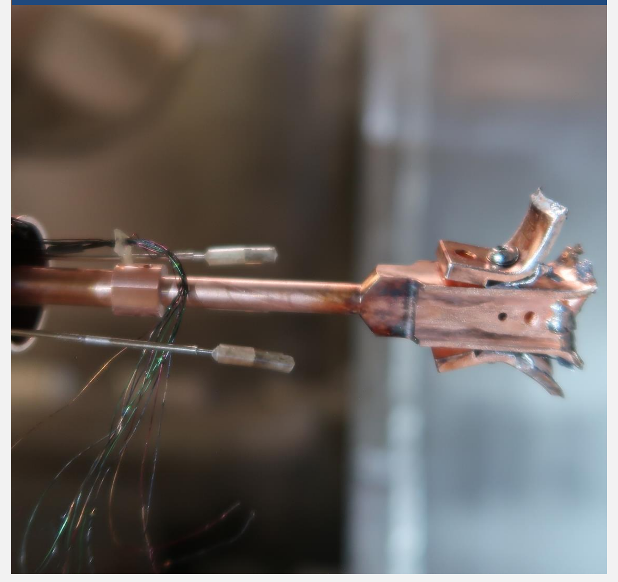
Gasline heater requirements updated from gasline temperature control to cryo trap

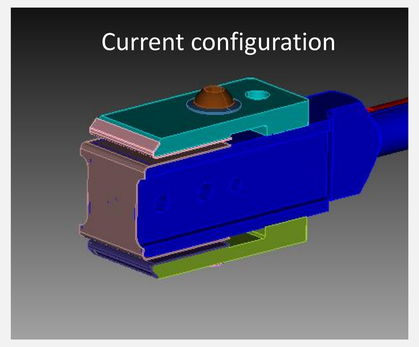
- Initial target design used a higher resistance thermal standoff to allow heating of the gaslines to stop gas condensation or freezing
- The thermal standoff was changed from plastic to brass to decrease thermal resistance and allow cryogenic trapping of hohlraum gas contaminants

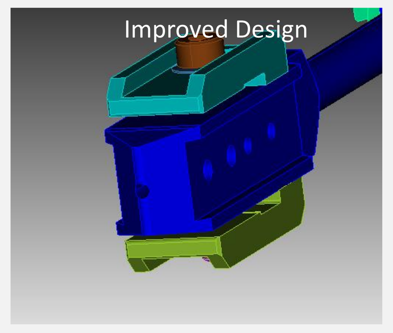


Experiment debris requirements also generate design change requests

Post shot image from first ignition







Bolt stress is 40% of original design

Higher yield targets may require base requirements changes to reduce debris risk

The ignition target has evolved into a robust platform for ICF experiments

- Changes are driven by:
  - Updated physics requirements
  - Production process improvements
  - Engineering optimization

LLNL has achieved fusion ignition on NIF five times to date

As we explore higher ignition yields, the target requirements and design will continue to evolve

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