Evolution of Compton Radiography Targets

23rd Target Fabrication Meeting

Annapolis, Maryland

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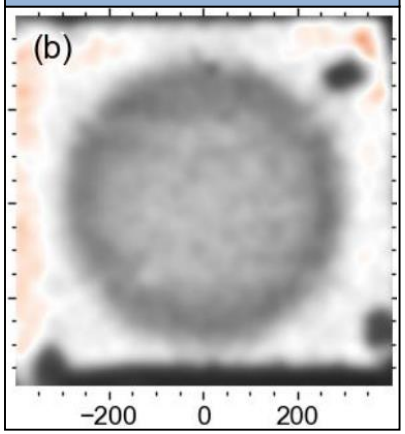
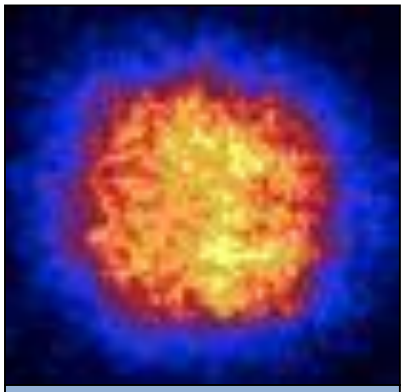
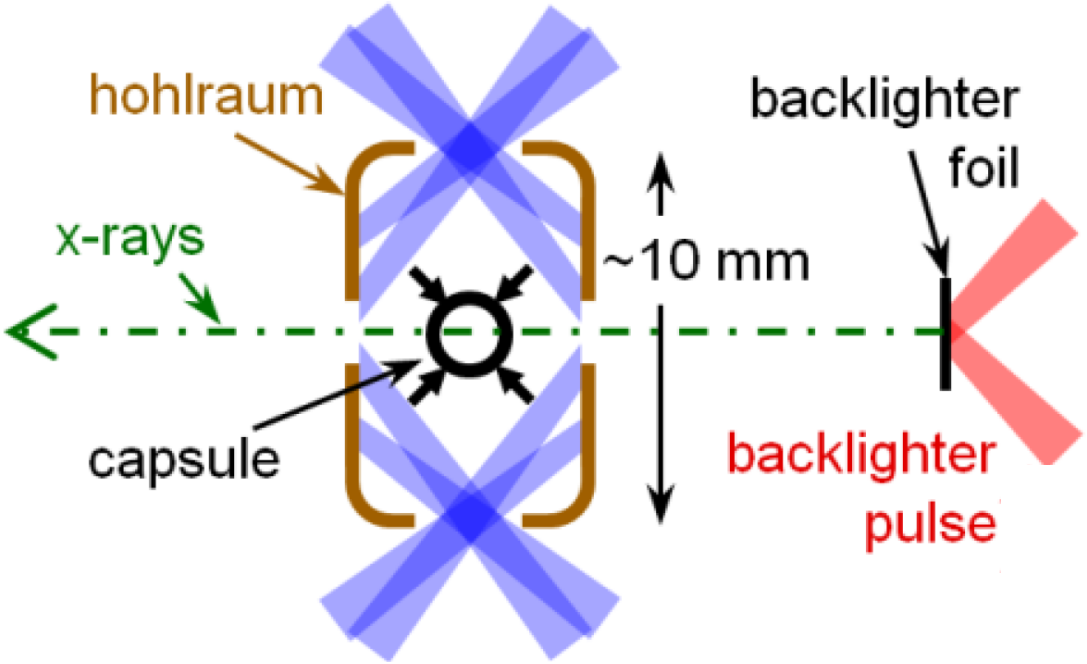
Compton radiography relies on backlit imaging

Backlit Radiograph at 200um radius and lower density





20um radius core



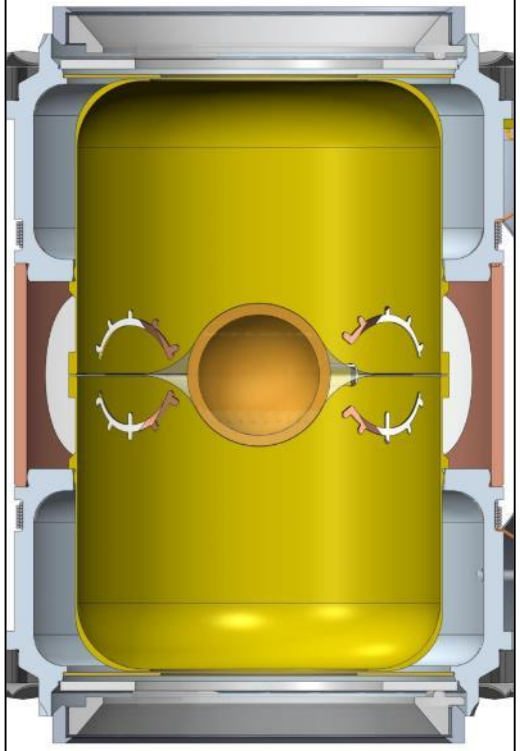
- Compton radiography is required to image the dense DT core at 20um radius
- Core is opaque below ~15keV
- Self emission overwhelms backlighter brightness below ~70keV

Transmission Compton radiography can obtain images of the dense cold DT fuel at stagnation

Gold microwire backlighters for high-energy Compton scattering

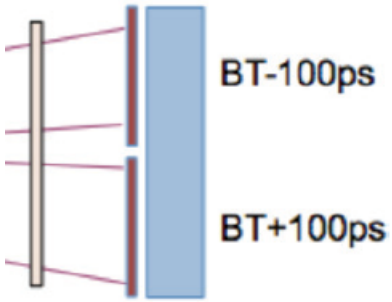
Microwires must be shielded from NIF unconverted light

Ignition target platform



Layered target requires cryogenic shroud

Framing camera

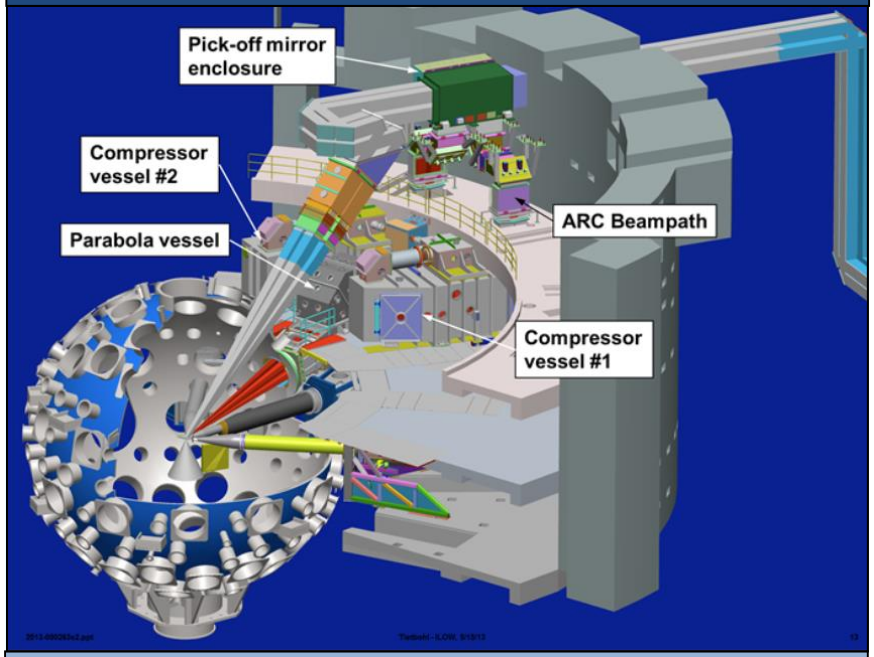


Record Compton radiographs of DT fuel at peak compression

Compton Radiography experiments require the Advanced Radiographic Capability (ARC) And ARC X-ray Imaging System (AXIS)

Advanced Radiographic Capability, ARC

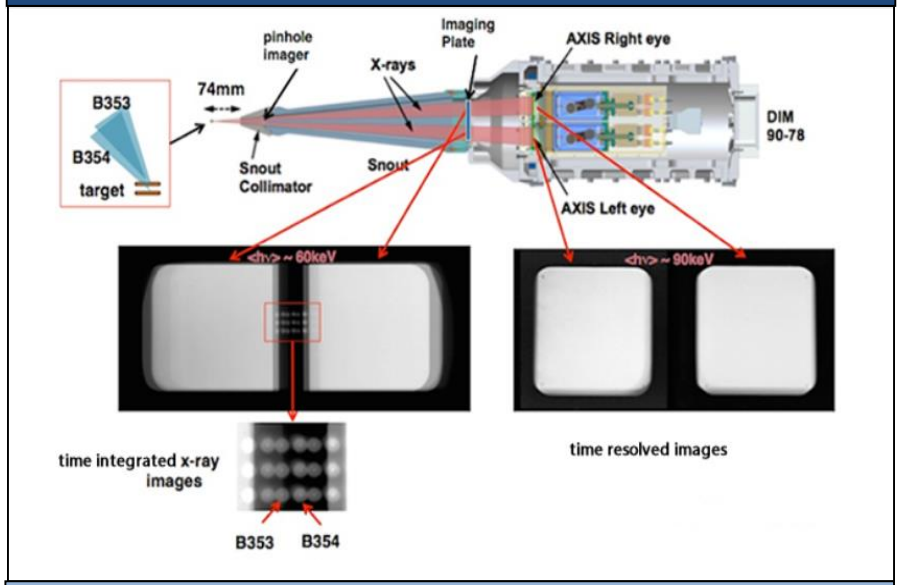
Image from https://lasers.llnl.gov



Used to produce Bremsstrahlung X-ray backlighter sources over the range of 50 keV-200 keV

ARC X-ray Imaging System, AXIS

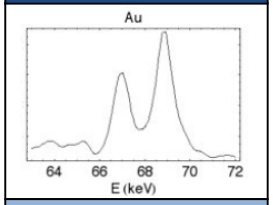
Image from https://lasers.llnl.gov



Provides high detection quantum efficiency at the 40-200 keV x-ray range required for Compton radiography

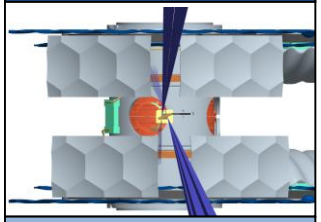
Development of Compton radiography of inertial confinement implosions has been ongoing for more than a decade

TITAN Laser



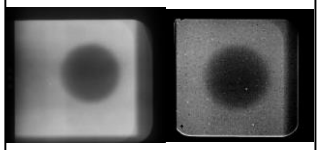
Backlighter tests

NIF (no ARC)



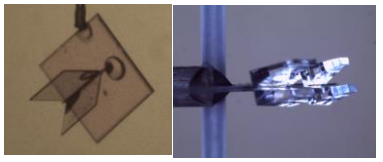
Cryogenic without ARC or AXIS

NIF w/ ARC



RT images with shielding and BL alignment

BL improvements

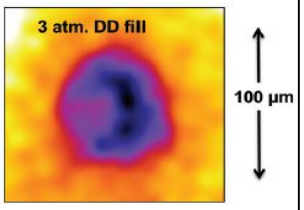


OMEGA EP and NIF BL testing

2007 — 2012-2015 — Mid 2016 — Early 2018

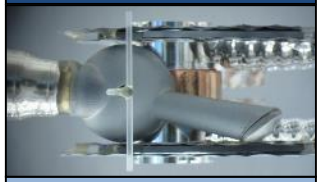
2010-2012 — Early 2016 — Late 2016 — Mid 2018

OMEGA Laser



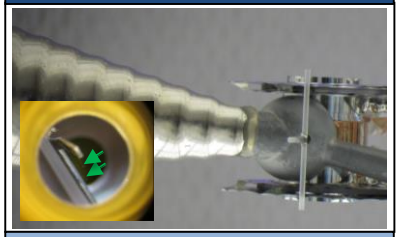
Microwire backlit imaging sphere or capsule

NIF w/ ARC



ARC BL shielding and shroud development

NIF w/ ARC



RT images of HDC bead in TMP target

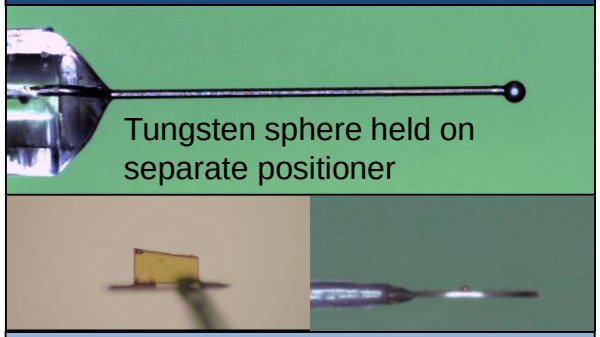
NIF, ARC and AXIS

Cryogenic HDC implosion imaging

The OMEGA laser was instrumental in validating the Compton scattering high energy microwire backlighter concept

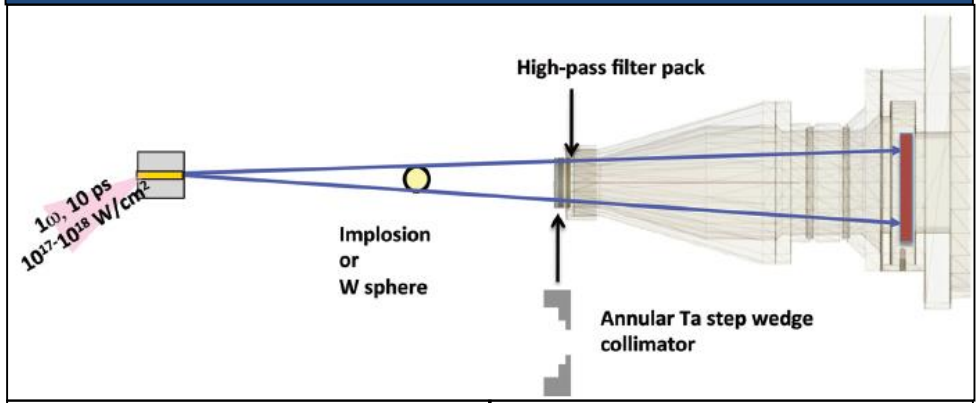
2010-2012

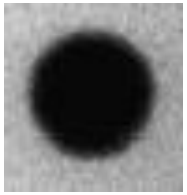
OMEGA BL development



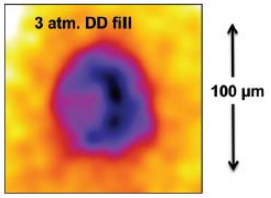
25um and 10um diameter microwires

Experimental Setup





2D radiograph of backlit W-sphere

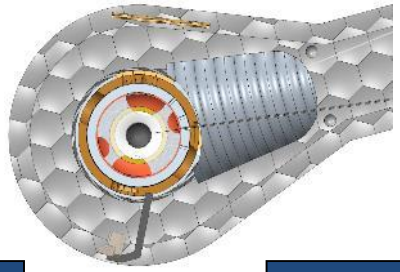


Compton Radiograph of imploding CH shell

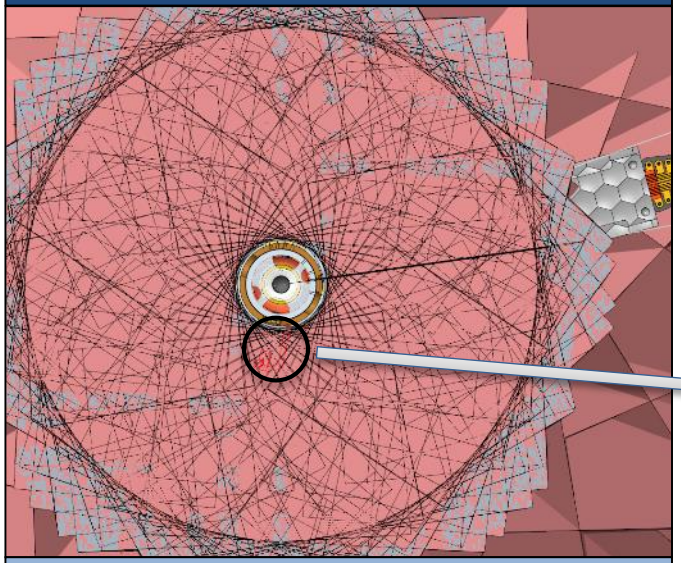
Relatively simple targets could be built and many experiments could be run to test backlighter energy and resolution (See Kelly Youngblood's poster)

Compton radiography backlighter must be shielded due to NIF unconverted light

2012-2015

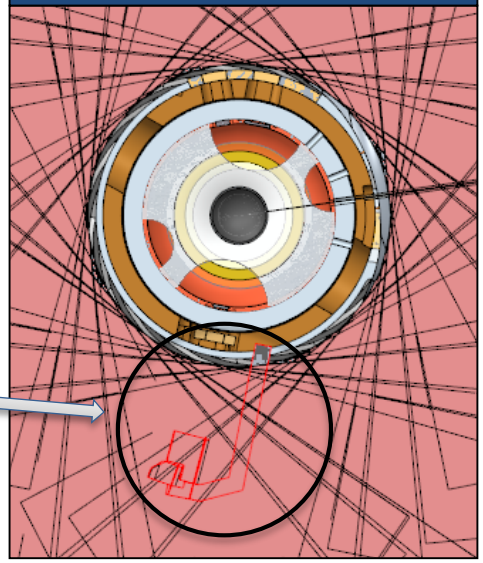


Compton radiography target within NIF 1ω unconverted light



1ω unconverted light starts at 4.75 mm radius and extends to 37.5 radius

Backlighter closeup

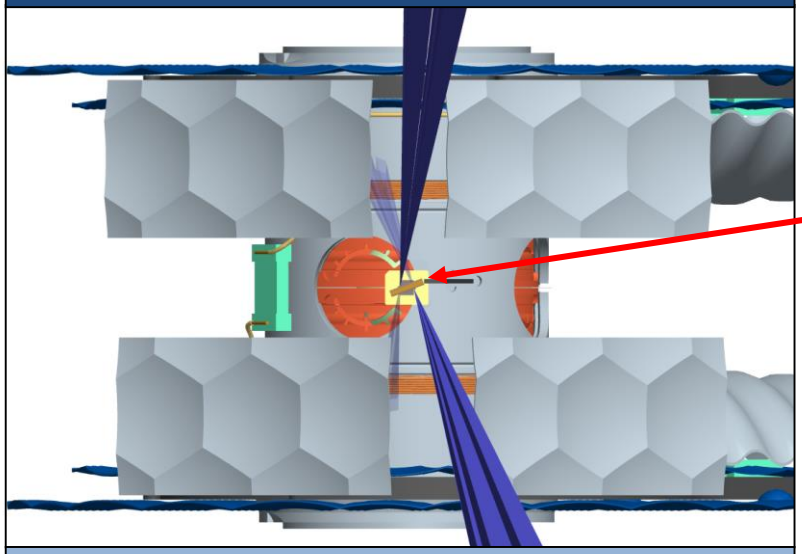


Compton radiography backlighter is completely within the unconverted light and must be shielded to mitigate preheating of the backlighter microwires

Initial NIF experiments showed that ARC was required to obtain sufficient backlighter energy for Compton radiographs of DT fuel

2012-2015

ARC BL unconverted light shielding



Shielding for NIF beam backlighter fit in standard cryogenic shrouds

Dual microwire backlighter

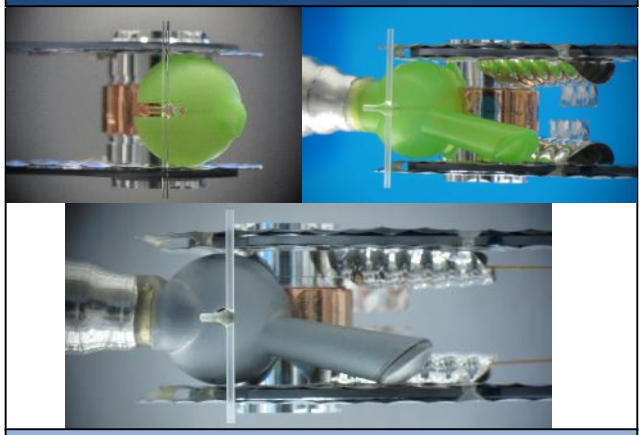
30 micron square microwires illuminated with NIF beams

Several backlighter only targets were designed and fielded to test wires at the bottom plastic V-shaped grooves to help get more laser energy on the wires.

Targets compatible with ARC and AXIS required development of unconverted light shielding and backlighter alignment to allow fielding of Compton targets

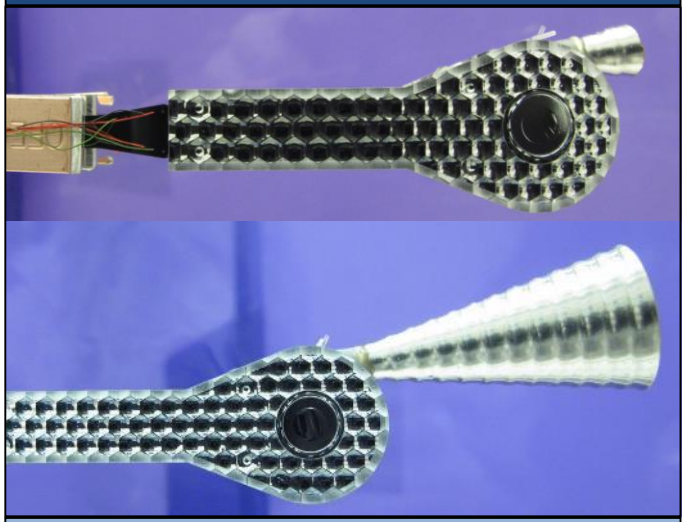
Early 2016

BL unconverted light shielding



Solution to preheating due to insufficient shielding

ARC unconverted light shielding



ARC shielding tests confirmed that a new cryogenic shroud would be required

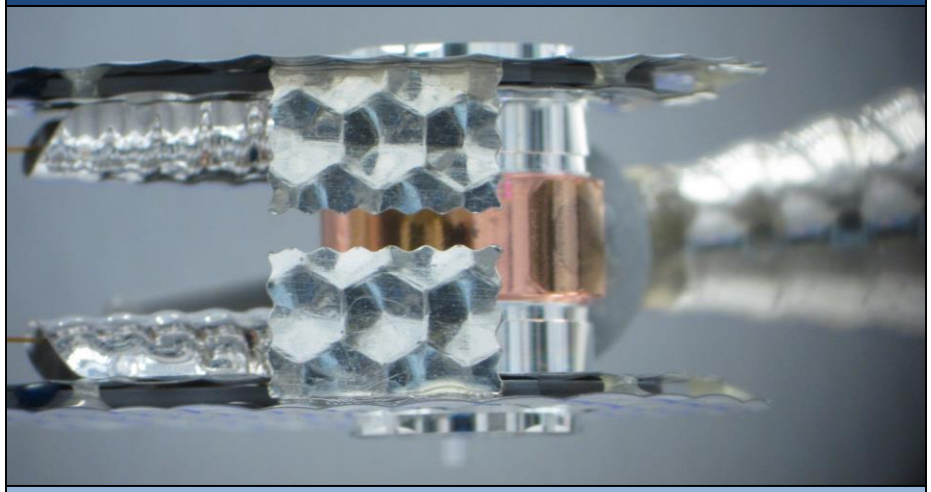
Backlighter Alignment Fiducial

- Validated target metrology
- Facilitated ARC alignment procedure development
- Fiducial alignment is not possible for a shrouded cryogenic experiment

A room temperature shot of a TMP-based target confirmed acceptable unconverted light shielding with a successful AXIS image using ARC illuminated microwires

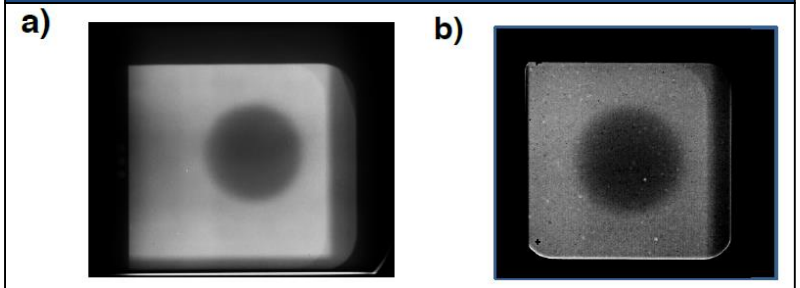
Mid 2016

Warm TMP-based target for integrated platform backlighter shield testing



View from 90-78.75 showing diagnostic shielding

Experimental radiographs of a 200um diameter WC sphere

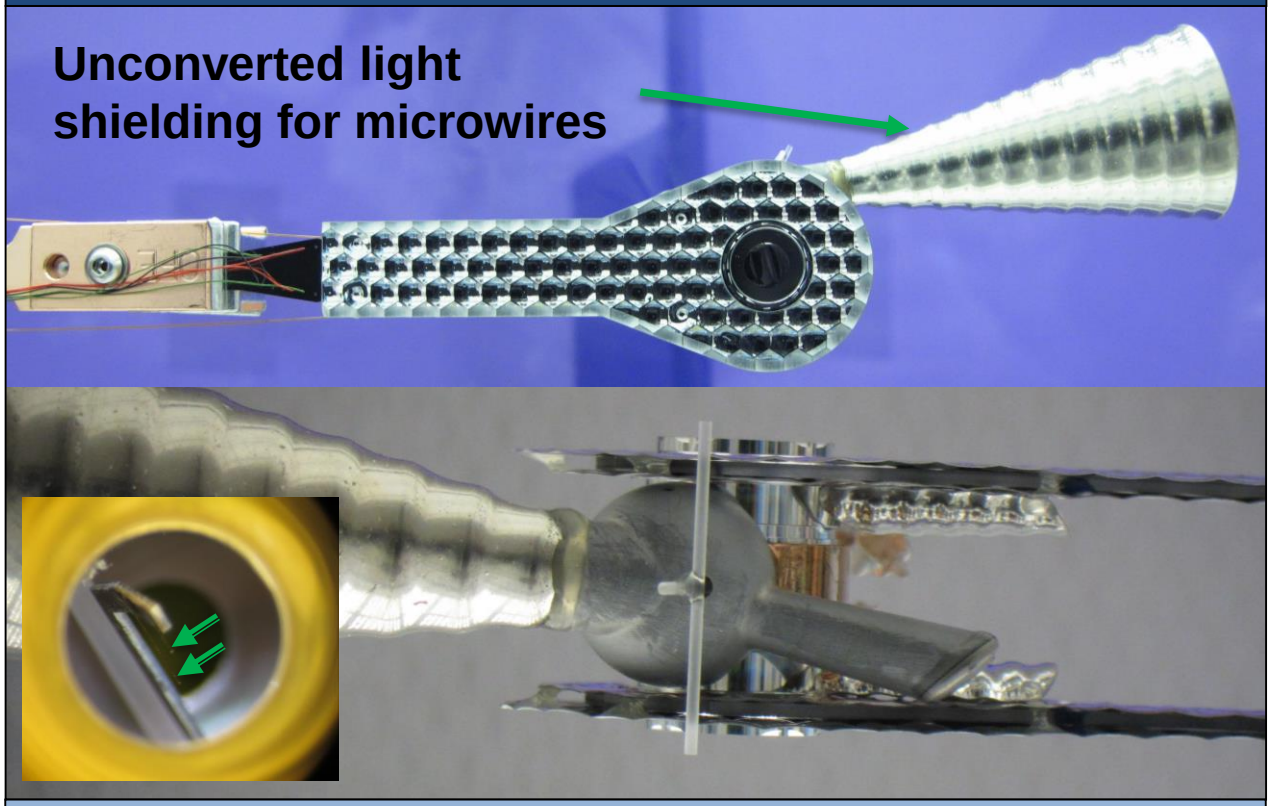


Au microwire backlighter, recorded on Image Plate, a), and on one of the two AXIS framing cameras, b). Credit: Riccardo Tomassini

An integrated room temperature experiment successfully imaged a solid HDC bead in a driven hohlraum

Late 2016

Warm hohlraum target containing a CH coated HDC

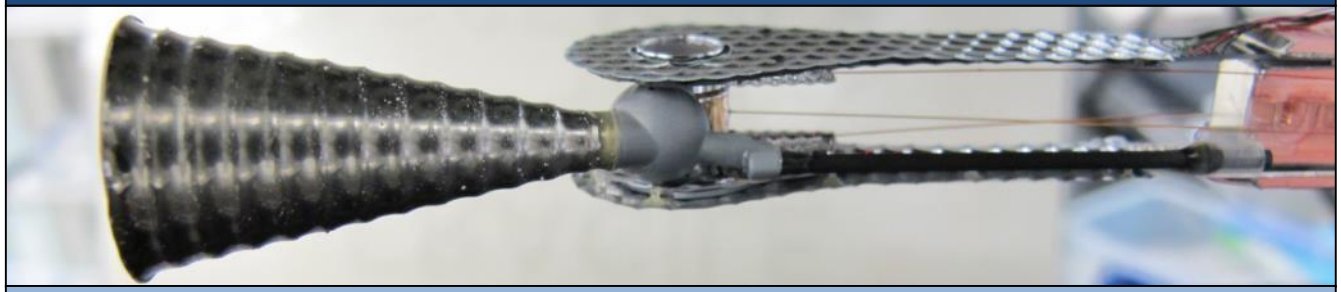


Platform facilitated first imaging using ARC illuminated microwire backlighter with full hohlraum and backlighter shielding and apertures

A new cryogenic shroud and BL unconverted light shield was required to support layered Compton radiography targets

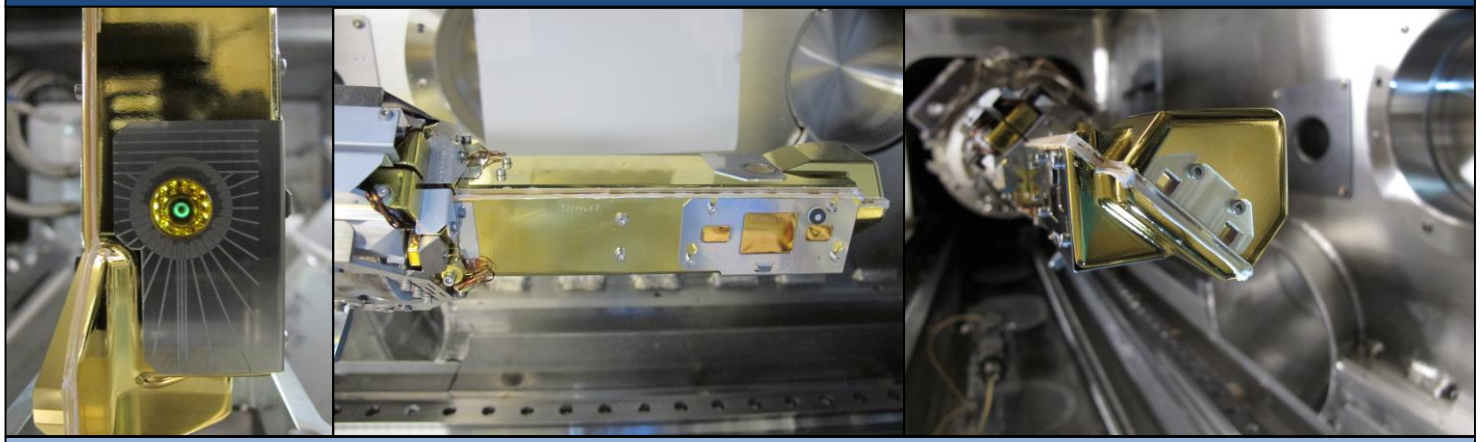
2017

Cryo-compatible ARC unconverted light shielding



Layering requires that unconverted light shield have no contact with TMP

New cryogenic shroud to support large unconverted light cone



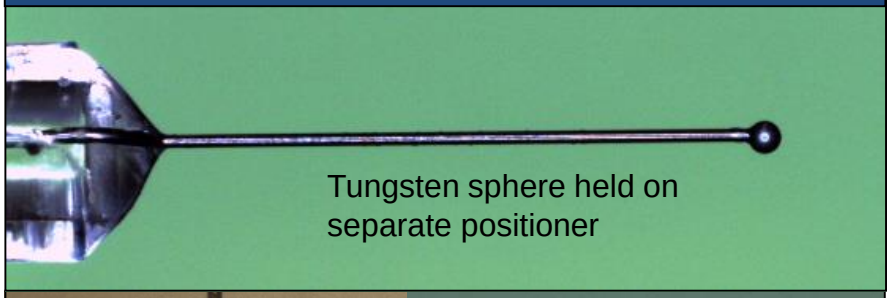
Shroud validated with an existing layering target retrofitted with ARC shield

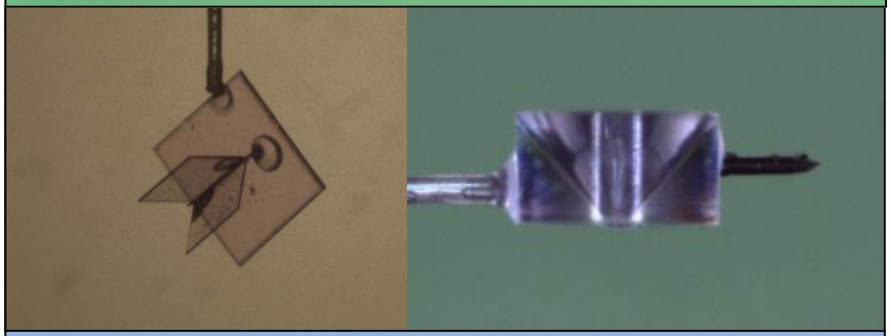
An ignition specification layer was produced, which validated the new shroud design

Experiments on both OMEGA EP and NIF optimized backlighter designs using plasma mirrors and smaller wires

Early 2018

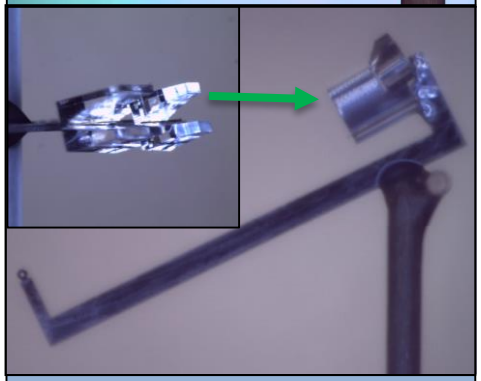
OMEGA EP BL development





V-shaped and parabolic plasma mirrors

NIF BL development



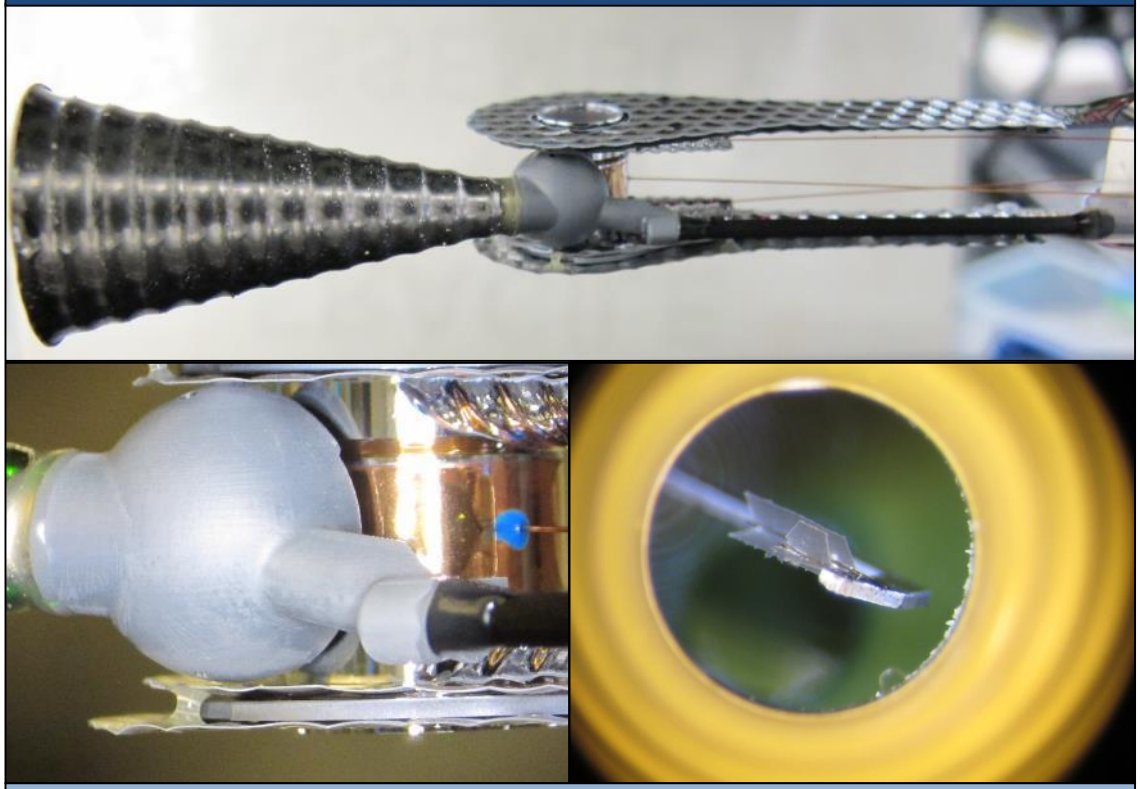
V-shaped and parabolic plasma mirrors with 10um microwires

- Please see Kelly Youngblood's poster

A successful integrated cyrogenic platform has been fielded at the NIF using both ARC and AXIS, producing Compton radiographs of the compressed DT fuel

Mid 2018

Integrated high-yield HDC with DU hohlraum platform

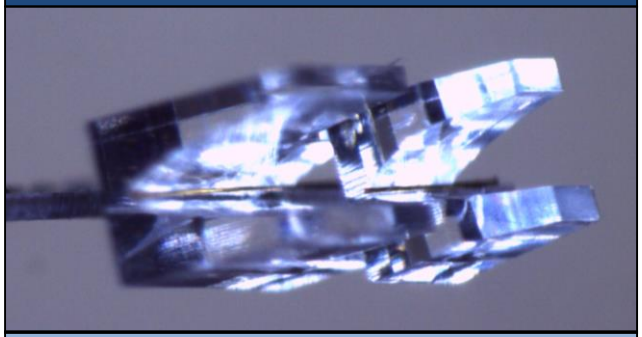


V-shaped plasma mirrors were used to increase the ARC energy that is incident on the 25um microwires

Radiographs will be published soon

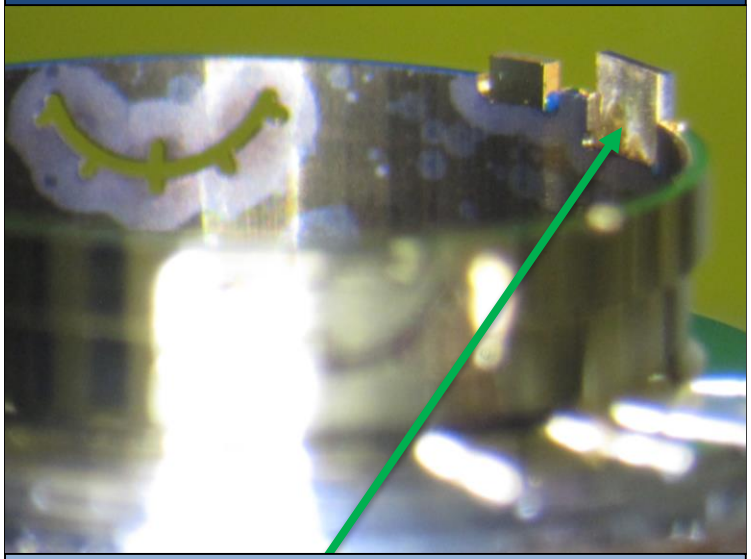
Another cryogenic target, with parabolic concentrators around the backlighter wires, is currently planned to be shot in late April 2019

Parabolic concentrators



Higher resolution 10 micron diameter microwires with parabolic plasma mirrors

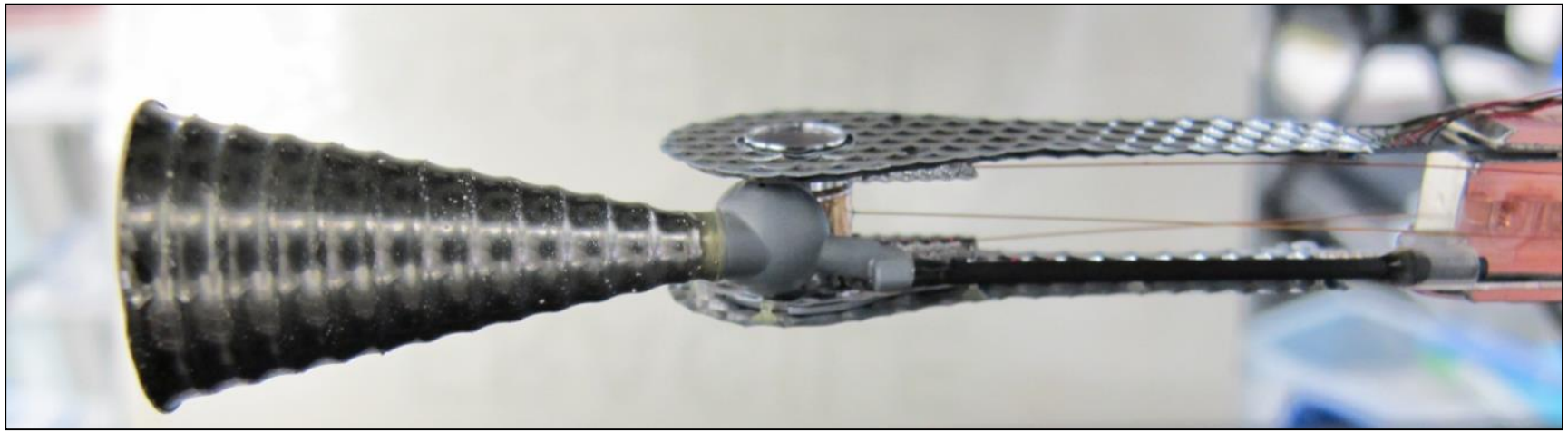
Imaging through hohlraum wall



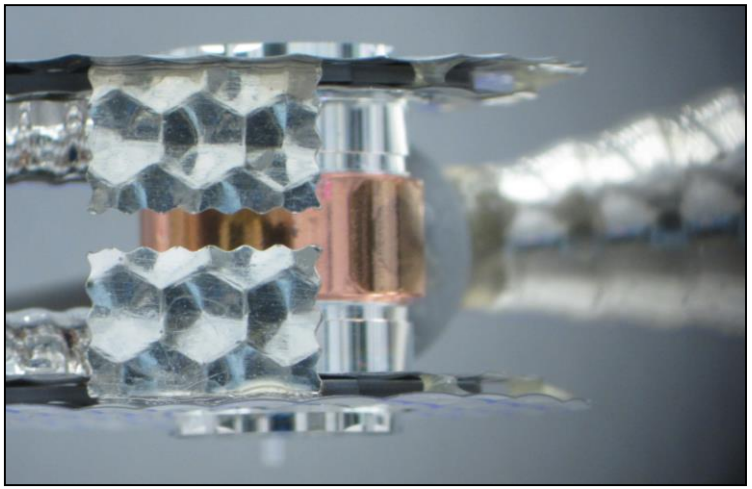
15 micron thick gold foil bonded to standard hohlraum diagnostic windows will confirm Compton platform imaging capability

There is a concern that the hohlraum imaging windows contribute to non-uniformity, so removal of these windows will allow comparison of cold fuel images with and without windows

The Compton radiography platform has been successfully fielded due in part to the close communication of multiple NIF teams



- Physics
- Target Fabrication
- Diagnostics (AXIS team)
- ARC IPT (Advanced Radiographic Capability)
- NIF Facility (Cryo operations and engineering)
- Alignment
- TaLIS (Target and Laser Interaction Sphere)
- Debris and Shrapnel

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