TetraCage Cryogenic Targets for Alternate Capsule Support

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It takes a village! In particular:

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	A. Nikroo, M. Stadermann & S. Schlaffino		
TFAB Production:	K. Bigelow, B. Butlin, C. Choate, A. Fabyan		
NIF Operations:	T. Briggs, T. Kohut		
Cryo Group:	S. Bhandarkar, J. Sater, C. Walters		
Physics:	J. Ralph		





Traditional formvar tent support significantly degrades implosion resulting in lower performance





Best results achieved with "Polar tent" that has reduced capsule contact.

Want to improve with further reduction in capsule support



TetraCage support replaces tent with four Carbon Nano Tubes (CNT) micro-wires with much lower contact

Perturbations originate from discontinuities along contact lines

Support	Contact length , mm	Lift off length, mm	Mass, µg
Standard Formvar Tents	10.6	10.6	2.8
Polar Tents	3.8	3.8	3.6
TetraCage Wires	1.0	~ 0	0.1





Carbon nanotube yarns: small, robust & with adjustable diameters. Not commercially available, developed by TFAB S&T group. Stronger and more reproducible than spider silk.

Grown by pulling and twisting from a CNT forest



For more details see "Carbon Nanotube Yarns" Talk by X. Lepro et al, Wed. 4/24/19 2:10pm Poster by C. Aracne et al, Tue 4/23/2019 3:10pm



We maintained compatibility with existing manufacturing at GA and targets at LLNL, as well as alignment and DT layering features for fielding on NIF





- Slots machined in Hohlraums to "drop" wires at pre-determined position.
- Need to be designed in conjunctions with several other features around equator
- Starburst cut-outs slightly modified for yarns but still allowed to x-ray ice during layering

Allowed rapid component fabrication and assembly without interfering with production



New tooling developed to handle and place the CNT wires during assembly



For more details see also poster presentations: "TetraCage" by J. Bigelow et al, Tue 4/23/2019

Laboratory "Layered Cryogenic Targets" by S. Diaz et al, Wed 4/24/2019



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Three fully functional targets succesfully tested on NIF in 2018 Early prototypes

- Initially, several prototypes were designed and built for characterization and developing handling procedure
- Cryo targets were used to develop
 - Production processes in cleanroom
 - Fielding procedures at NIF
 - DT layering
 - Endurance sequences with multiple insertions and shroud open/close
- All three targets survived up to simulated shot time



Cryo target layered with uniform DT layer on NIF



Very careful handling was required through all the steps including new procedures at NIF



Capsule centering and risk of laser damage due to catastrophic failure of wires are two remaining challenges

- More robust than other capsule support designs (fishing pole or supported FT)
- But more fragile and capsule position less stable than regular tents
- Capsule position can be off by ~ 100 μm vs 20um spec



• There is concern regarding catastrophic failure of wires displacing capsule and leading to laser damage via backscattered light



'Safety Net' membrane positioned just below capsule is first risk mitigation

- Membrane does not contact capsule directly
- Catch capsule and keep it in center position in case of wires failure
- Limit sag

Also considering

- Stronger wires
- Different tensioning and positioning of wires





Smaller than polar tent contact of ~300-400um





'Light curtain' is developed for capsule presence/position sensing, as an additional option Light source and detector

15

0.5

-0.5

-1.5

-2

-2.5

- Detect transmission of light pulse through capsule
- Tested and characterized proof of concept in mockup configuration
- Functional target designed
- Need testing at Cryo
 - Thermo-mechanical stability
 - Impact on ice formation (simulations indicate negligible impact)











Conclusions

- TetraCage targets can improve implosion performances by reducing perturbations
- CNT wires that meet size and capsule support requirements have been developed at LLNL
- Cryo targets have been designed, fabricated, fielded and layered on NIF
- There are two remaining challenges:
 - 50-100um shifts in capsule position
 - Risk of laser damage from a wire catastrophic failure
- Additional improvements are under development
 - 'Safety Net'
 - 'Light Curtain'





