Divinylbenzene Foam Shell Studies: Non-Concentricity Issues

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High Average Power Laser Program

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IFE Target Fabrication Goals at GA…

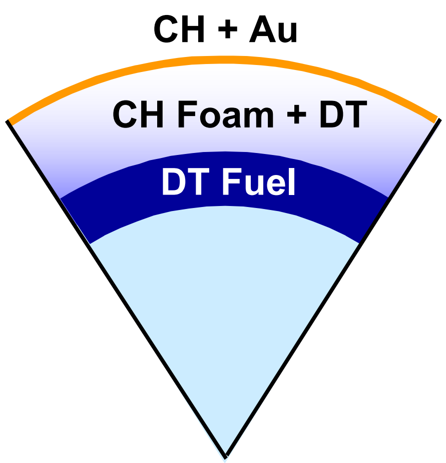
Overall objectives:

- Develop mass production methods for IFE targets, identifying the processes necessary to increase from laboratory scale to 500,000 plus targets per day
- Assist in the process development of the IFE target to achieve ignition quality specifications

Focus since last HAPL meeting:

- Developing a new theoretical model that uses *rotational shear* to provide increased control of non-concentricity, NC
- Assembled and bench tested an apparatus which maximizes the rotational shear applied to the shells, decreasing average NC to 2-3% in an initial trial
- Installed and brought into operation equipment for characterization of large (4-5 mm) opaque foam shells, improving measurement to +/- 0.5% NC

Particular specifications for laser-driven IFE ignition quality targets are challenging…



Direct Drive NRL Laser Fusion Target

- ✓ Diameter: 4-5(4.1*) mm ± 0.2 mm
- ✓ CH foam wall: 250-300(290*) µm
- ✓ High-Z coat: 500 Å
- ✓ Density: 20-120(100*) mg/cc
- ✓ Pore size: ~ 1 µm
- × CH full density overcoat: 1-5 µm
- × Non-concentricity: <1%*

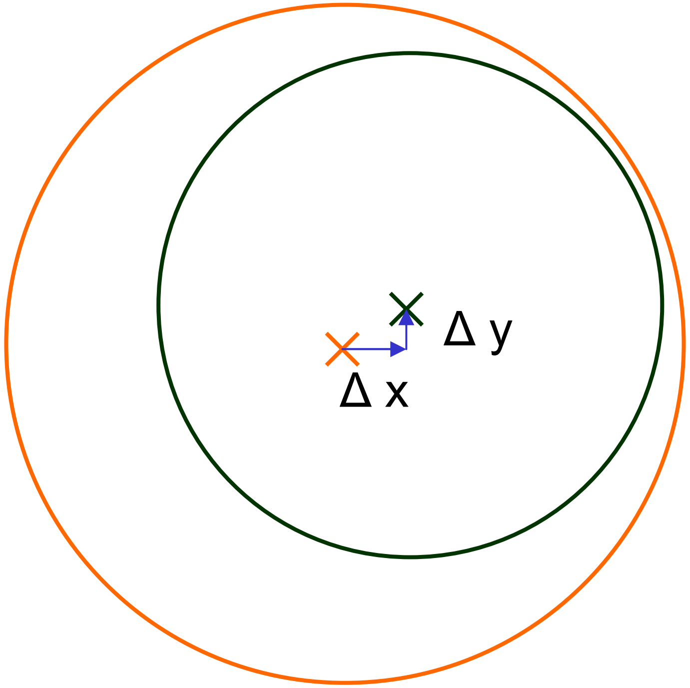
* *working specification*

- GA's ICF program currently produces made to order foam shells in small "boutique material and quantity", however, generally with ~ 3-5% NC
- The IFE program currently specifies an NC goal of <1% for ignition quality targets
- We are working towards achieving the NC specification by re-examining forces that control shell centering…

Let’s define how we calculate non-concentricity…

Better NC, < 5%

Poor NC



Additional orthogonal view provides Δ z

Current IFE ignition specification: < 1% NC

- Our definition of non-concentricity:

$$NC \equiv \frac{\sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2}}{\overline{wall}}$$

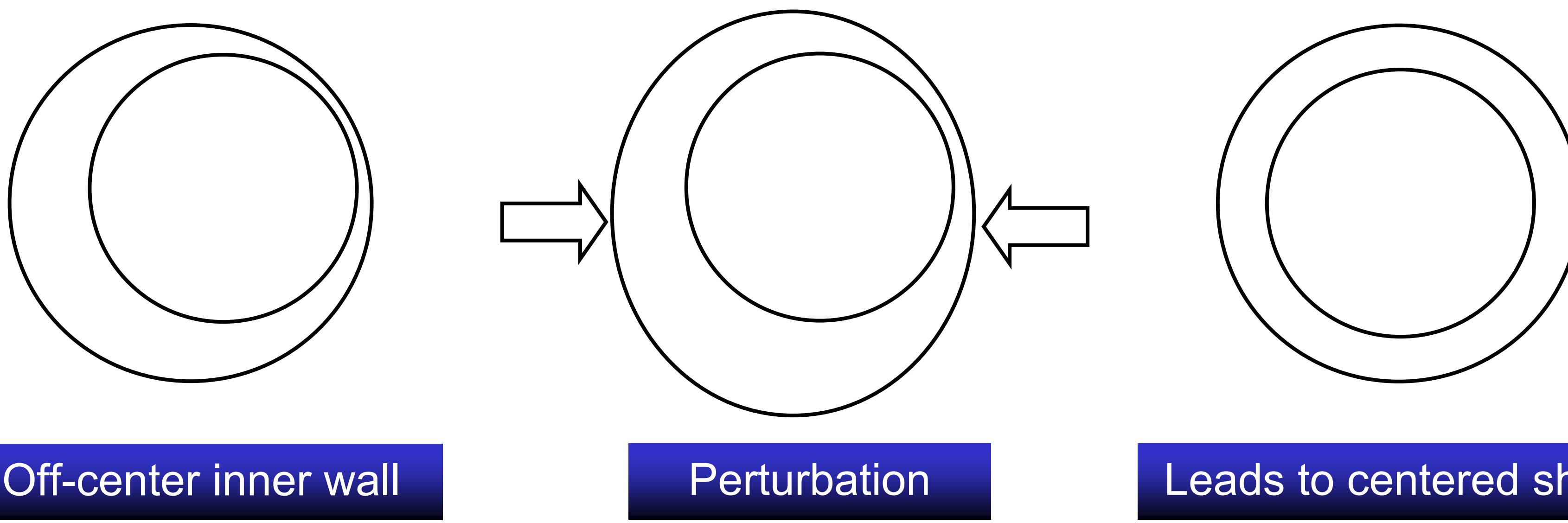
- What are the forces that help center the shell?

GENERAL ATOMICS

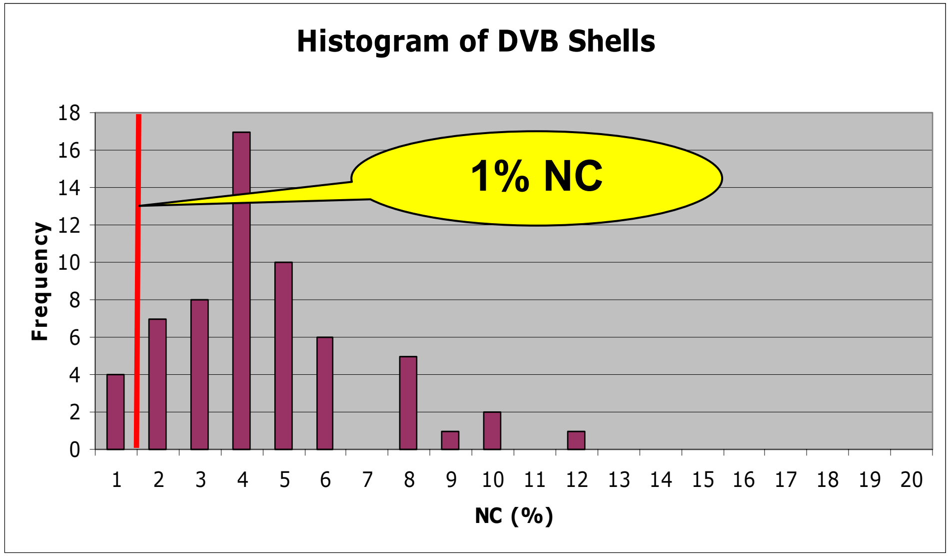
Many variables may affect non-concentricity, there are two models of centering force…

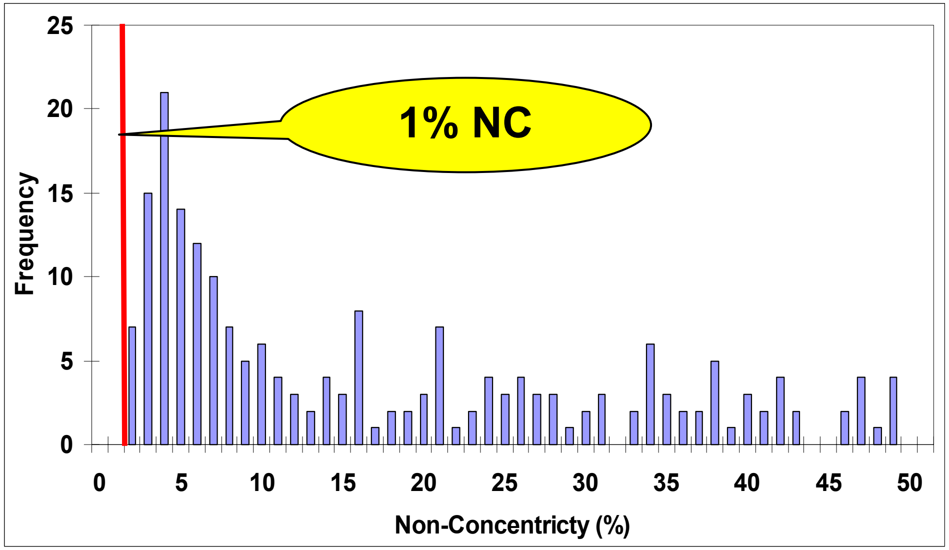
Standard technique, considered "Conventional Wisdom"

- Perturbation applied to the outside of the shell *deforms the shape* from a sphere, the shell then reverts to a centered uniform wall when perturbation force is removed
- Rotary evaporators rotate a beaker "roto-beaker" full of shells in fluid to affect this perturbation
- Technique perfected over many years (Takagi) and provides for best reported NC's of DVB shells: average 3 to 5 percent NC, (Streit, Paguio)



Typical results with the roto-beaker technique…





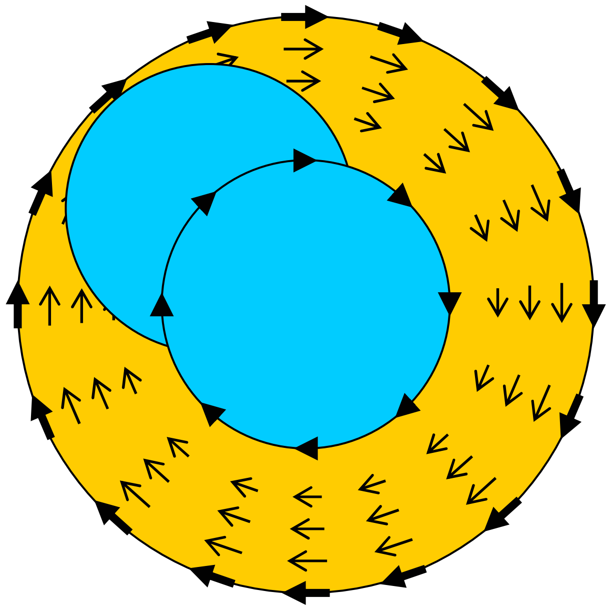
75% < 5 % NC at smaller than 4 mm dia. (ICF, Paguio)

Qualitative screening of nearly all experiments with roto-beaker, 17% < 5 % NC ~ 4.1 mm dia. (IFE)

- We have achieved NC below 5%, with a occasional shells below 1%
- Desire is to get to, then increase yield of DVB shells meeting the <1% NC specification

New theory presents that *rotational shear* may also affect centering the shells…

- Applying tangential shear increases the centering force within the thinner wall of the shell
- This model predicts the force minimizes as the shell either achieves full body rotation or as it approaches the center
- Requires enough density matching and rotation so force can overcome gravity
- Details available in "GA internal memo, IFT05/011(Flint)"



Conceptual bench testing!

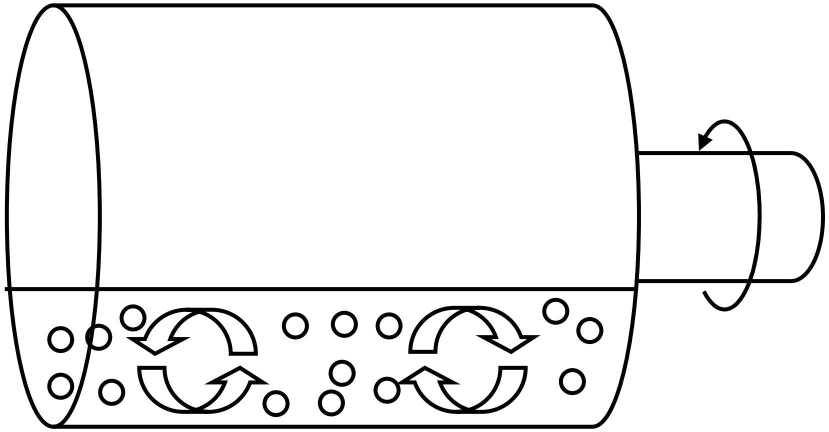
…We now have a mechanism by which concentricity can be modeled and have "knobs to turn" in the laboratory

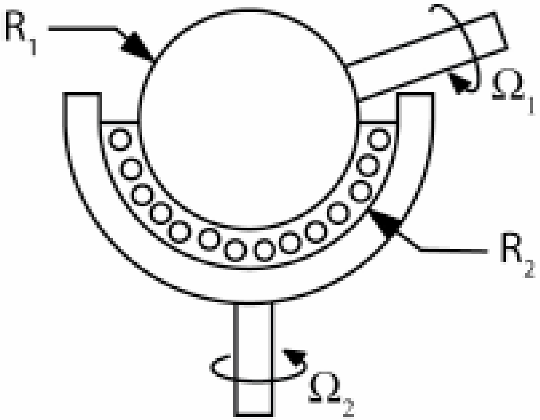
GENERAL ATOMICS

We have built an apparatus to provide control of increased rotational shear…

Roto-Beaker

Rotational shear device

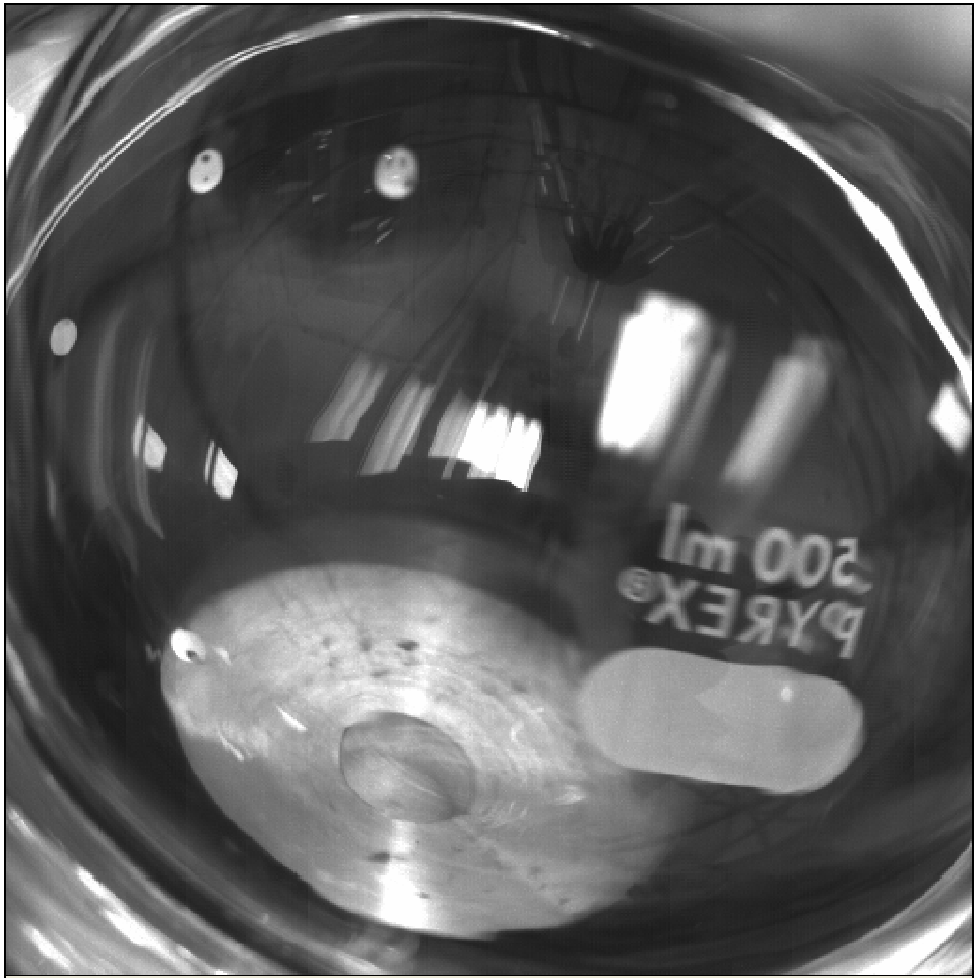




Apparatus is undergoing bench testing, with the first successful batch recently collected…


rotobeaker1

Test run with hard DVB shells added to roto-beaker

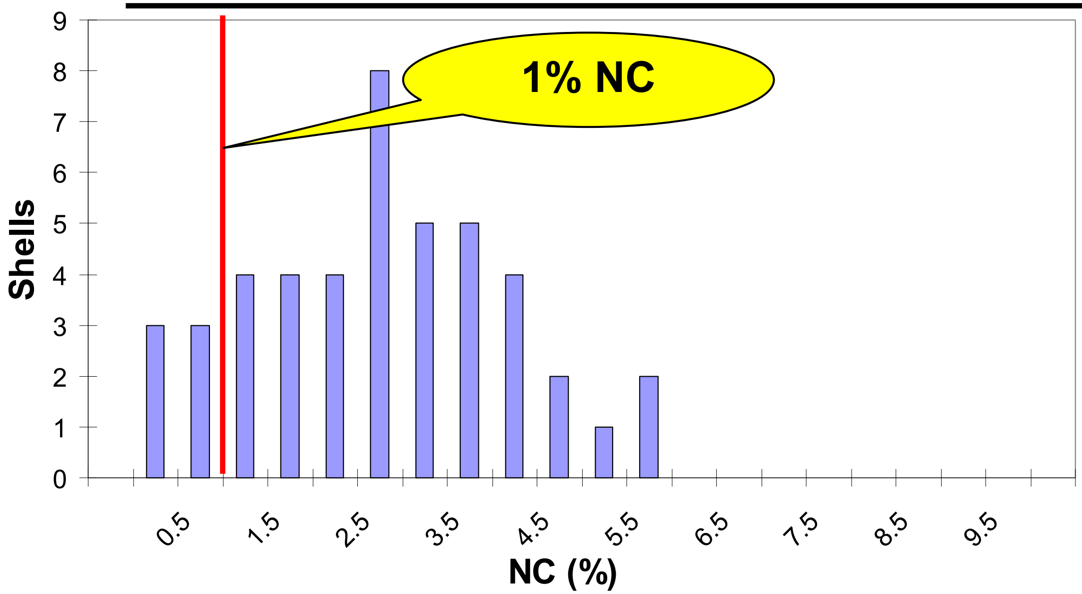


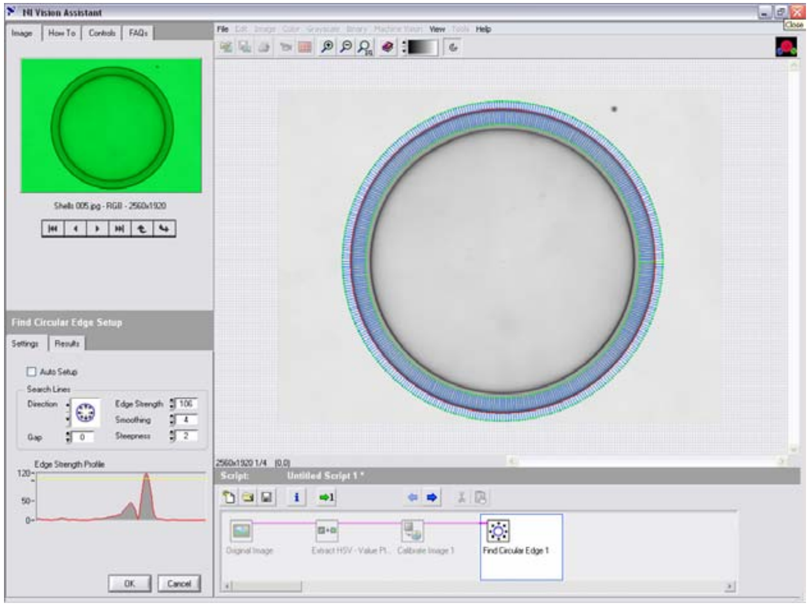
12-13-04 - ball 4.2s bowl 3.8s_C001S0001

Bench Testing with hard DVB shells

- Question: Might we be serendipitously applying rotational shear in roto-beaker?

First parametric test explicitly controlling tangential shear resulted in reduced average NC…





Screen shot of characterization in progress with new software

Average OD	4047
Average Wall	282
Average NC	**2.72**
NC Stdev	1.43
Shells <5% NC	93%

- Note shells now below 1% NC, and ALL 45 shells sampled (50% population) below 6%
- We can now measure wet shell wall thickness down to 0.5 μm utilizing our new characterization station employing a pixel averaging scheme (e.g. 1% +/- 0.5% NC)

GA IFE Target Fabrication Recap

We are developing the techniques and processes necessary for producing 500,000 IFE laser fusion targets per day

Current focus includes:

- Reducing non-concentricity to < 1% at increased yield

Achievements:

- We now have a theoretical model by which mechanisms for shell centering can be identified and tested, allowing us to exploit system parameters for improved NC
- We built and bench tested an apparatus to apply controlled tangential shear to DVB shells
- First experiment with new apparatus provided enticing results, parametric testing will begin to see if we can get to and consistently produce < 1% average NC
- We installed a new characterization system enabling faster measurements with improved measurement quality of wet DVB shells