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NIF Ignition Target 3D Point Design

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This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

We have a 3D model of the ignition point design and are using it to answer various questions

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- We have developed an input file for running 3D NIF hohlraums that is optimized such that it can be run in 1-2 days on parallel computers

- We have incorporated increasing levels of automation into the 3D input file
  - Configuration controlled input files
  - Common file for 2D and 3D, different types of capsules (symcap, etc.)
  - Can obtain target dimensions, laser pulse, and diagnostics settings automatically from NIF Campaign Management Tool

- Using 3D Hydra calculations to investigate different problems
  - Intrinsic 3D asymmetry
  - Tolerance to nonideal 3D effects (e.g. laser power balance, pointing errors)
  - Synthetic diagnostics

Have optimized calculation so that it can finish in 1-2 days on parallel computers

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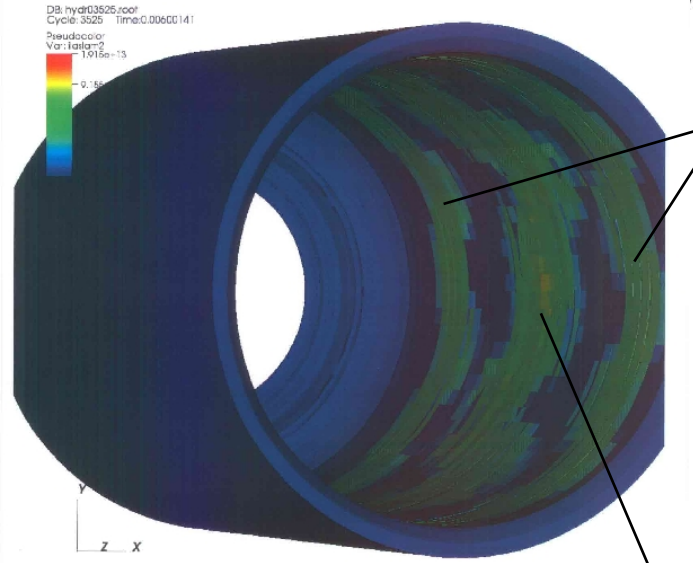
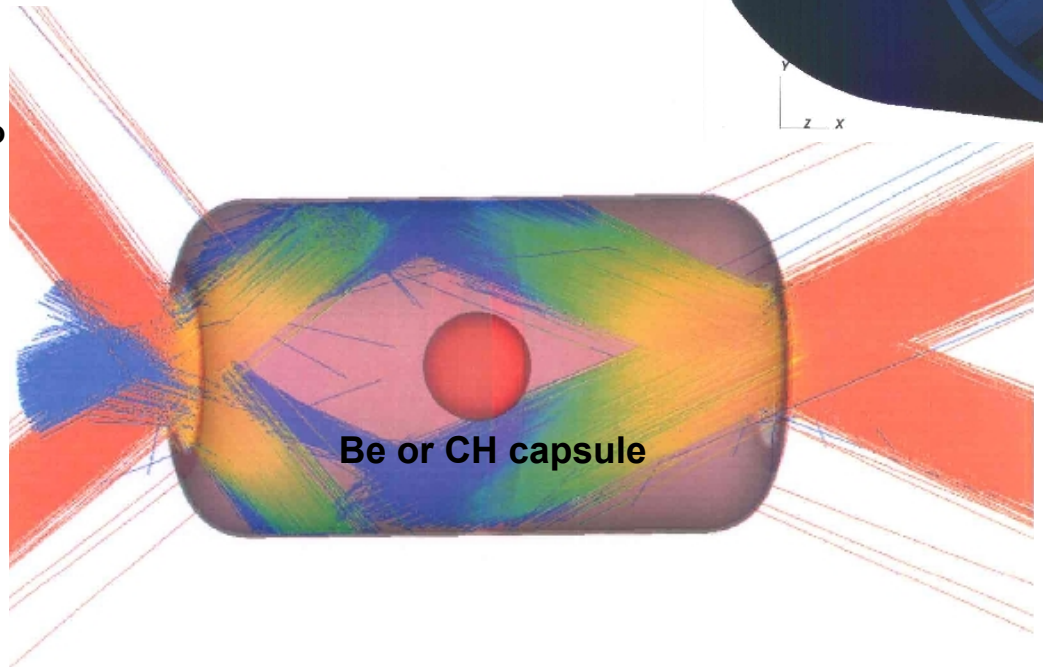
- Using Hydra code
- 3 million zones
- 1024 CPUs
- 30 million photons



Outer cone spots

Inner cone spots



There are three areas where the Hydra calculation process has been automated

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- **Configuration control on input files**
  - Allows designers to compare code settings to a reference case
  - Allows improvements in settings to propagate quickly to all users
- **Use of a common input file for 2D and 3D calculations of ignition capsules, symmetry capsules, re-emission capsules, etc.**
  - Eliminates zoning and physics parameter differences that can contaminate results of sensitivity studies
  - Allows systematic study of surrogacy for diagnostic capsules
- **Obtaining target, laser power, and diagnostics settings directly from NIF Campaign Management Tool**
  - Will be essential when pre-calculating real NIF shots
  - Capability already being exercised in simulated campaigns

The NIF point design is Cu-doped Be capsule inside uranium hohlraum with 285 eV peak drive

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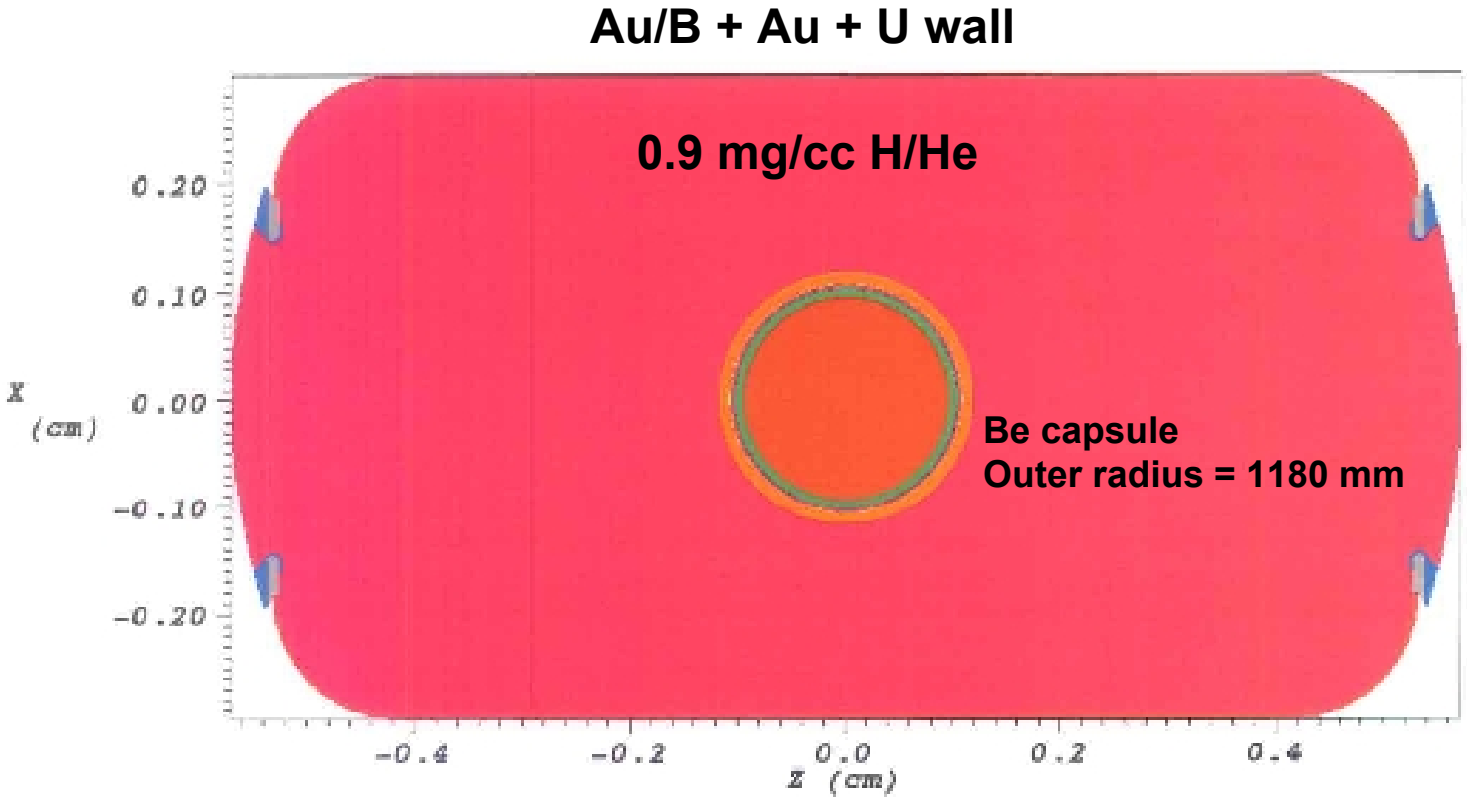

Inner cone beams form a pattern on the hohlraum wall that leads to an m=4 modal structure

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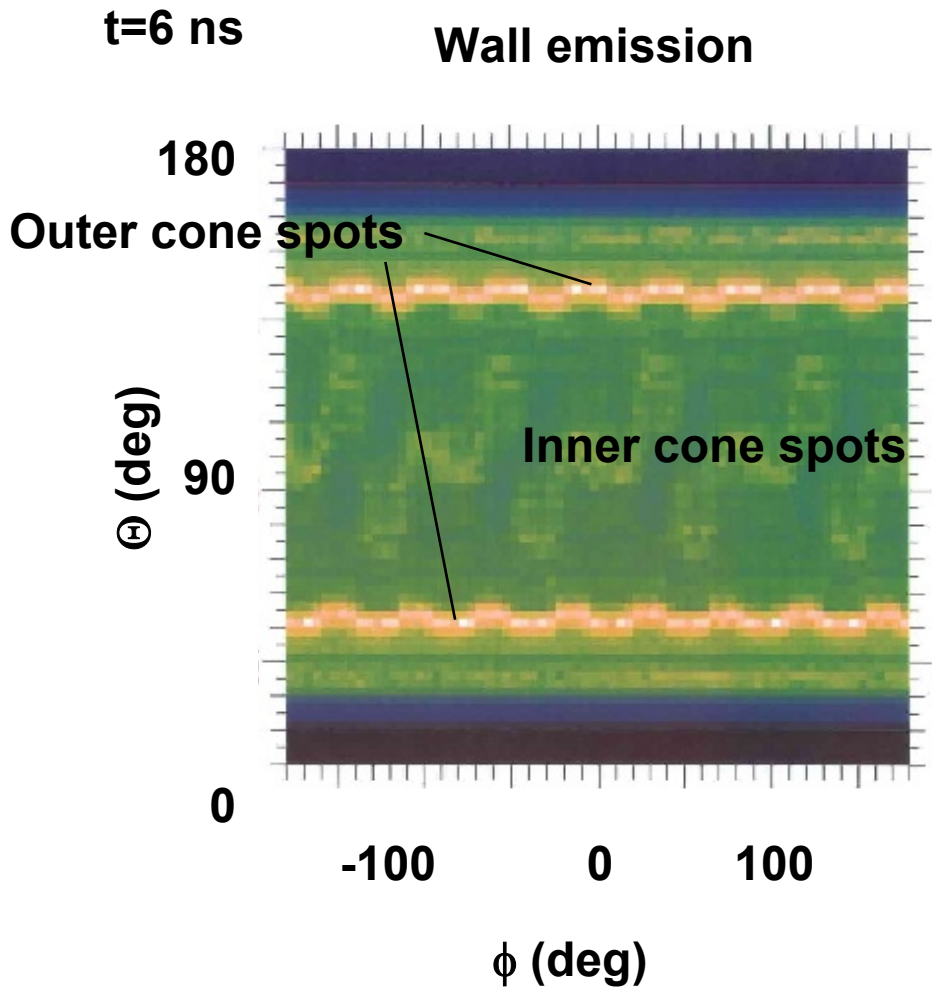

At ignition time, density contours show some features that are not axisymmetric

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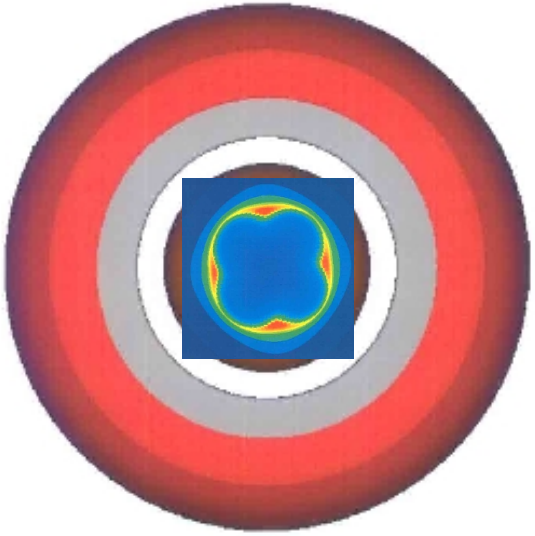
Equatorial view

Axial view



Density contours at ignition time

Density slices of core at various ϕ angles show evidence of small m=4 mode

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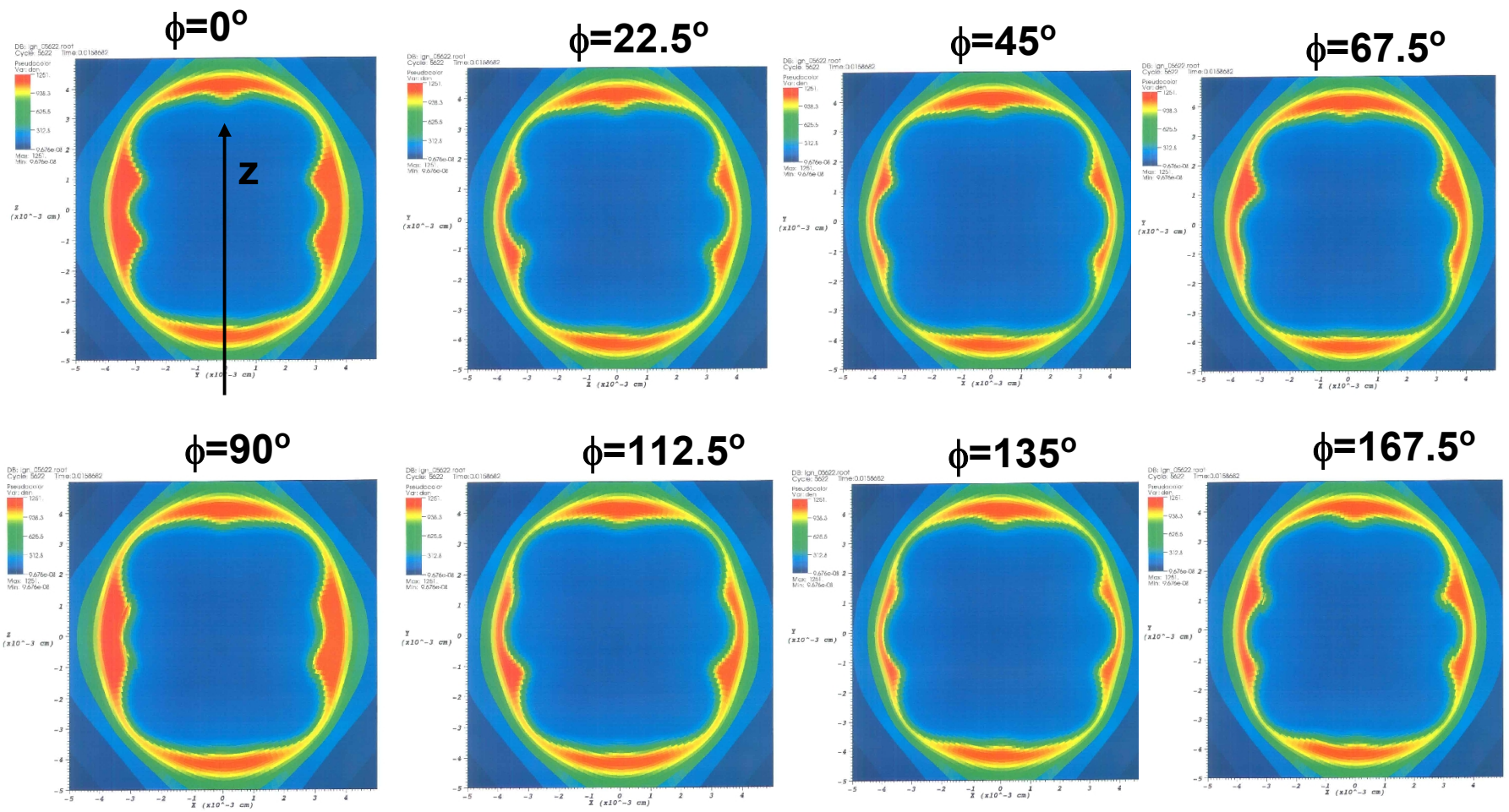

Plots of electron density show subtle differences between 2D and 3D calculation

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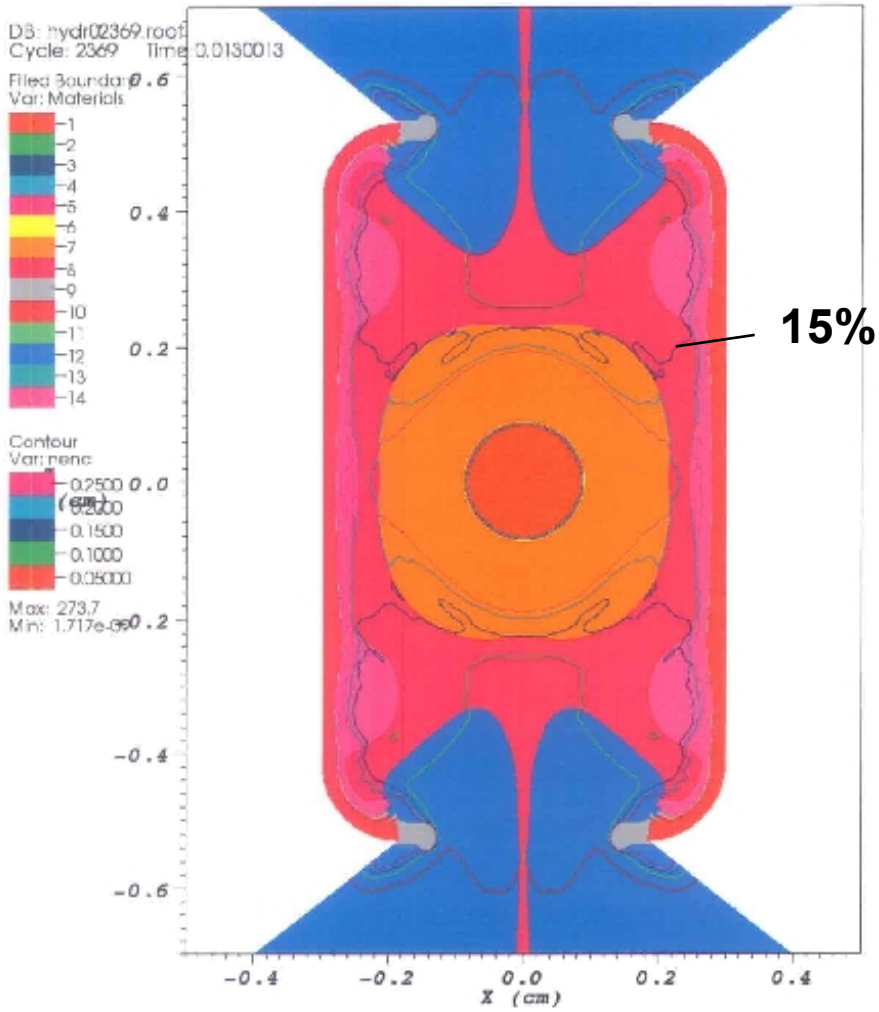
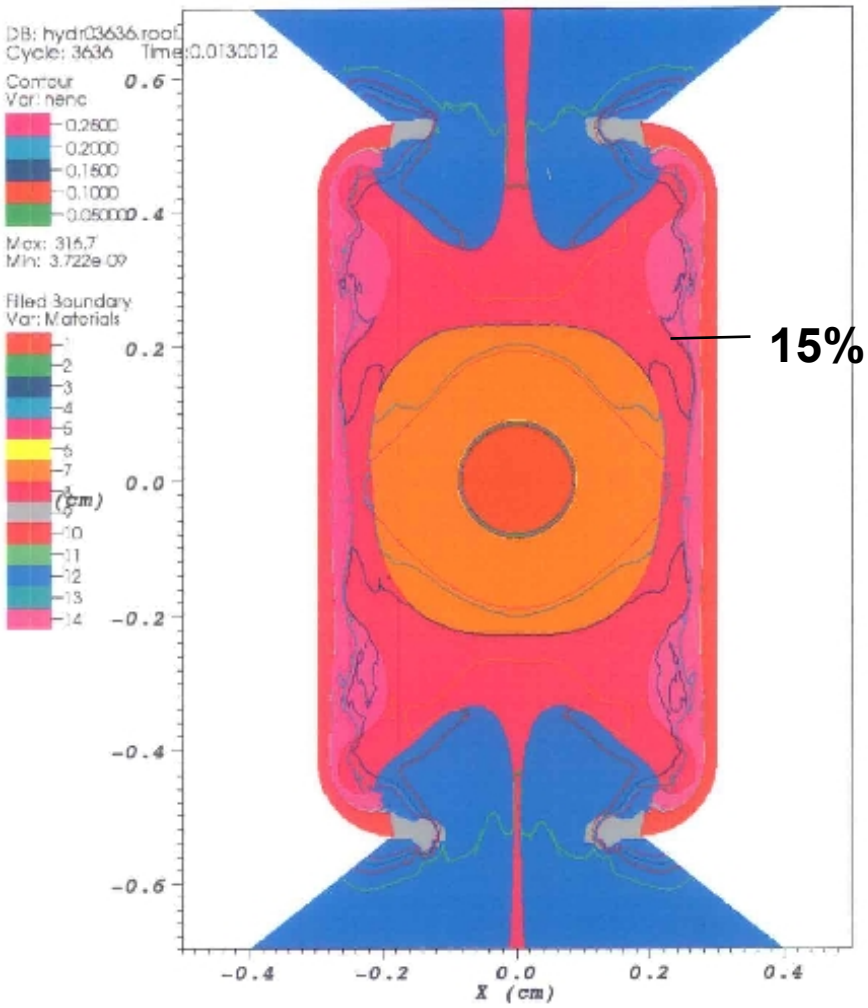
2D, 13 ns



3D, 13 ns, ϕ=67.5°



Intensity of inner cone ring varies with ϕ as you pass through individual beams

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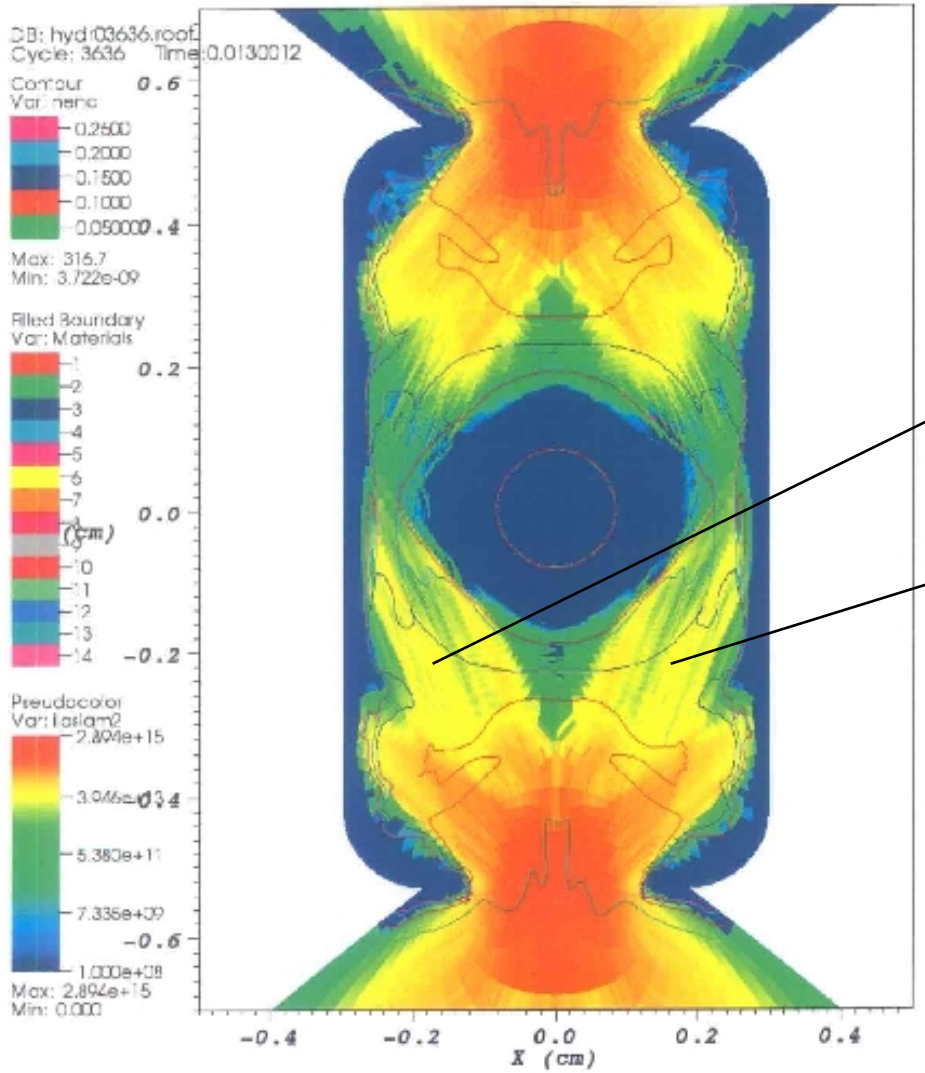

z

Q42B (NIF ϕ=281.25°)

Q24B (NIF ϕ=101.25°)

View from NIF ϕ=191.25°

To assess sensitivity to laser power balance we obtained power from NIF power balance model

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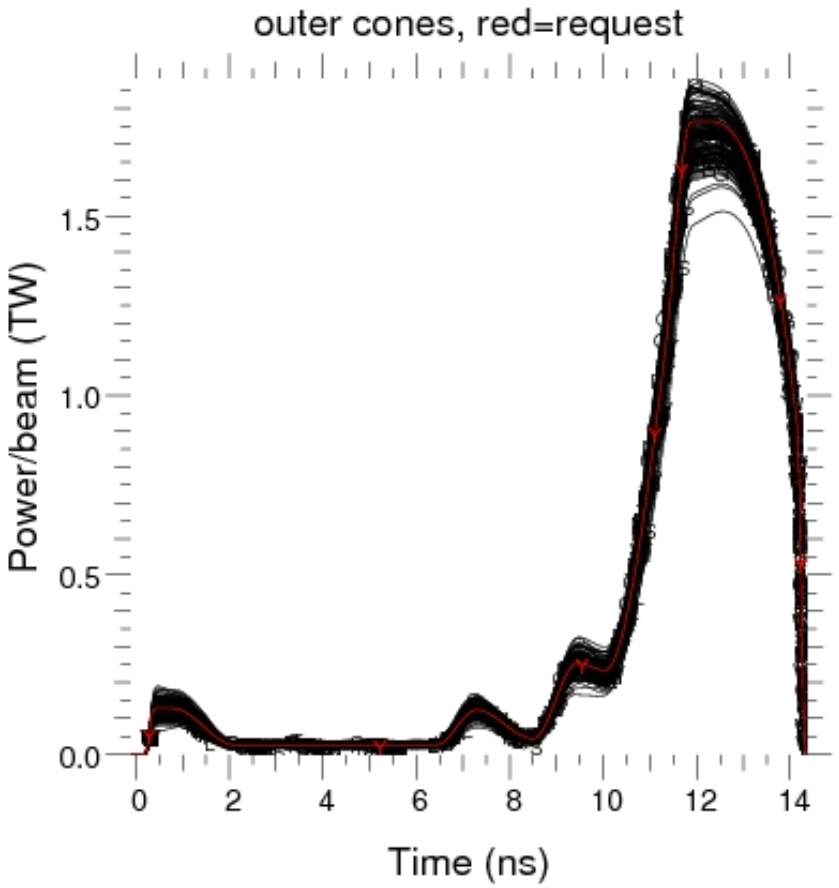

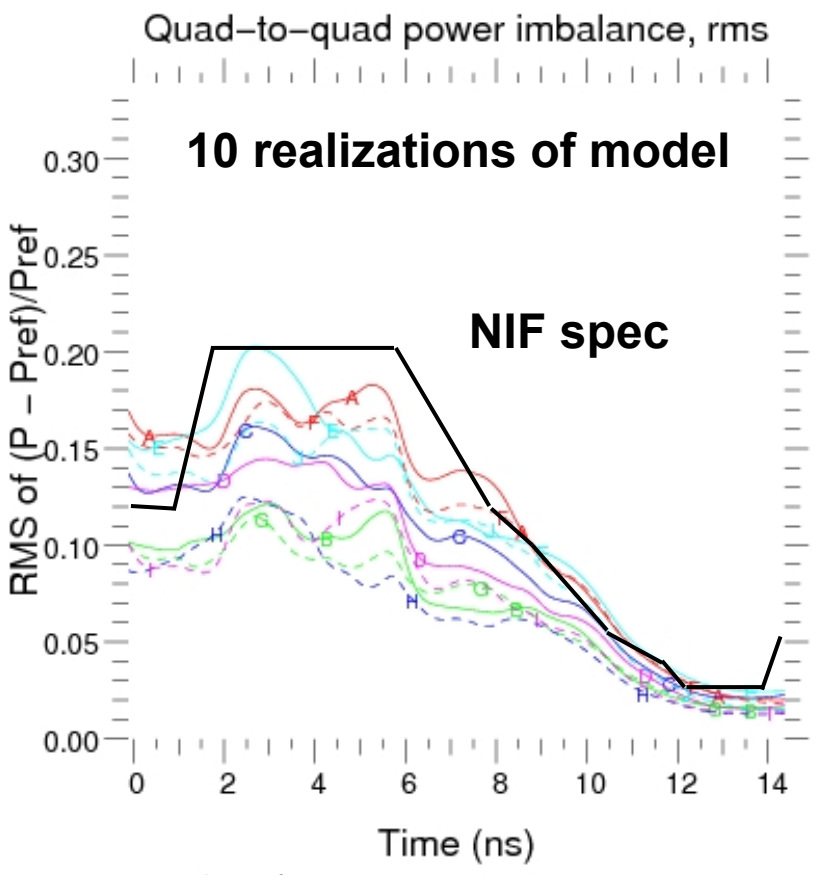

Rms power imbalance was increased beyond specification until core highly distorted

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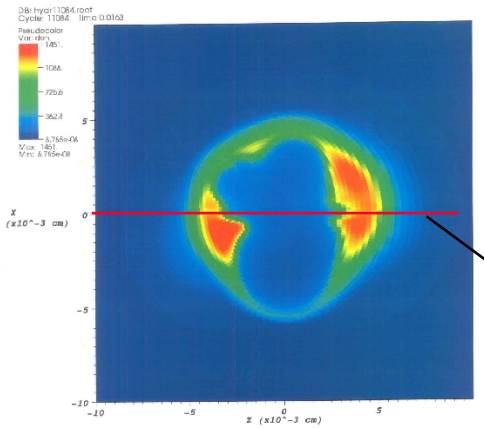
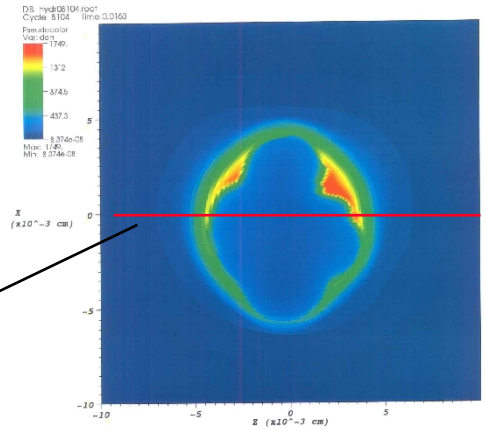
Equatorial view

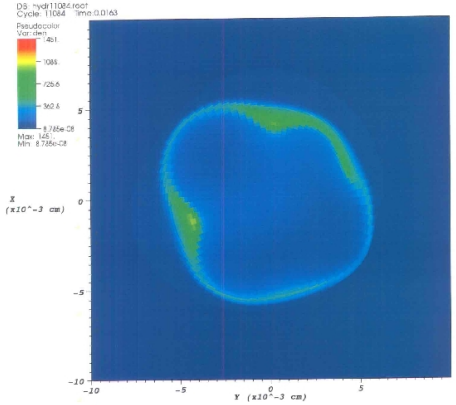


Equatorial view

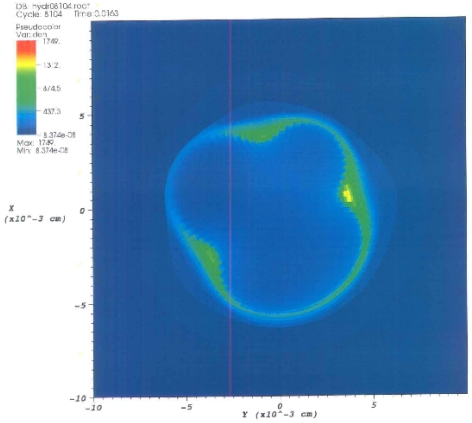


Hohlraum axis

Axial view



Axial view



Start to see some yield degradation with power imbalance at 2 times the specification

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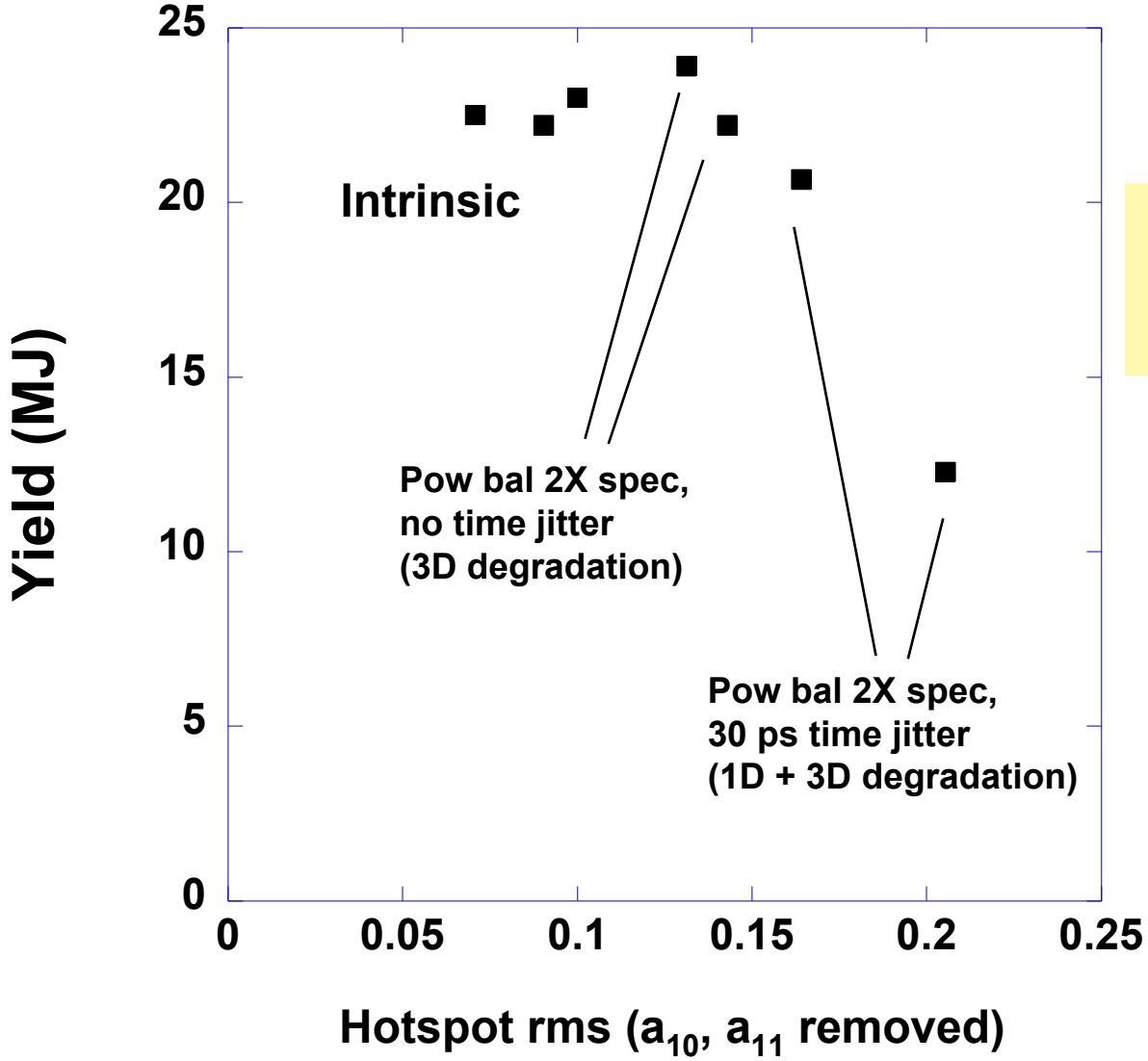
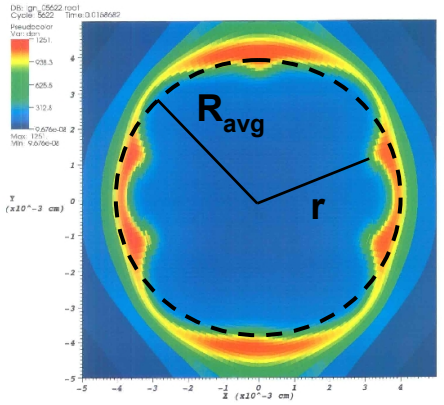


Hotspot rms:

$$\xi = \sqrt{\frac{\iint \left(r - R_{avg}\right)^2 d\Omega}{4\pi}} \frac{1}{R_{avg}}$$



Random power balance also leads to top-bottom imbalance, shifting capsule centroid (a_{10})

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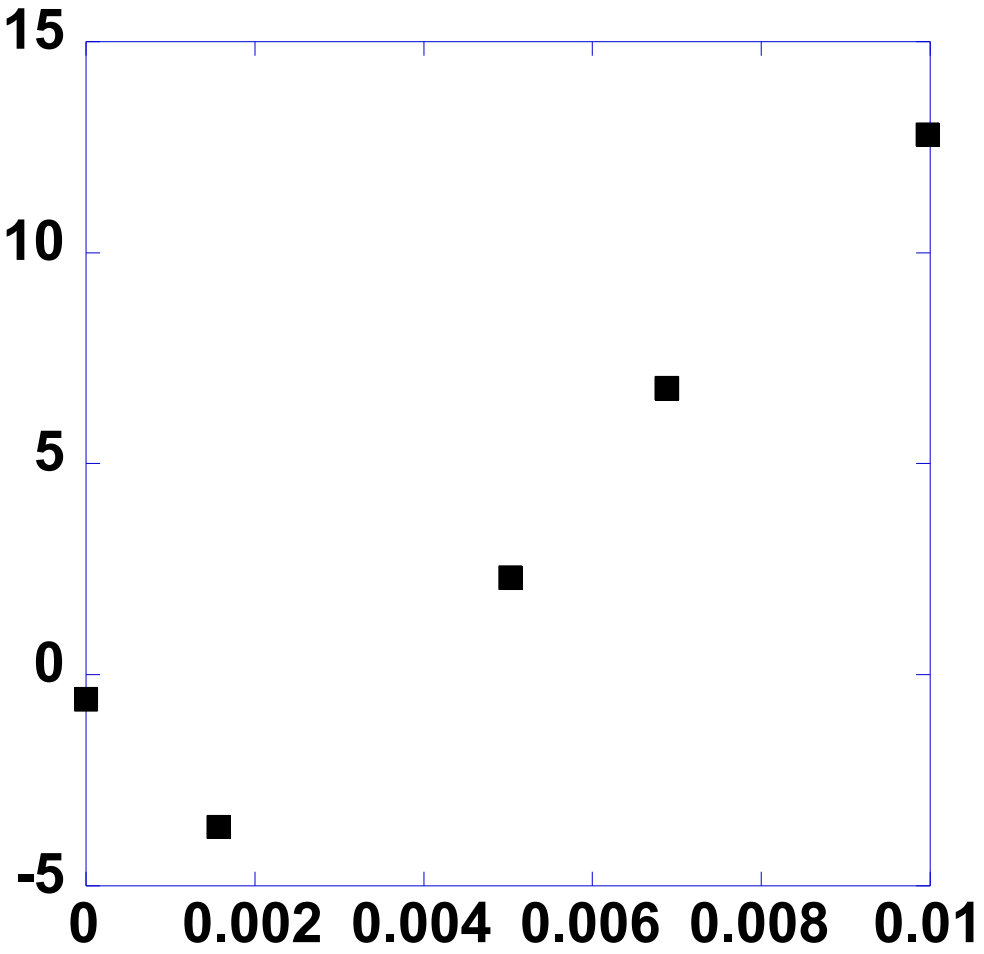

$$balance = \frac{E_{outer,bot} - E_{outer,top}}{E_{outer}}$$

Capsule hotspot rms distortion most sensitive to laser power balance during 4th step (peak power)

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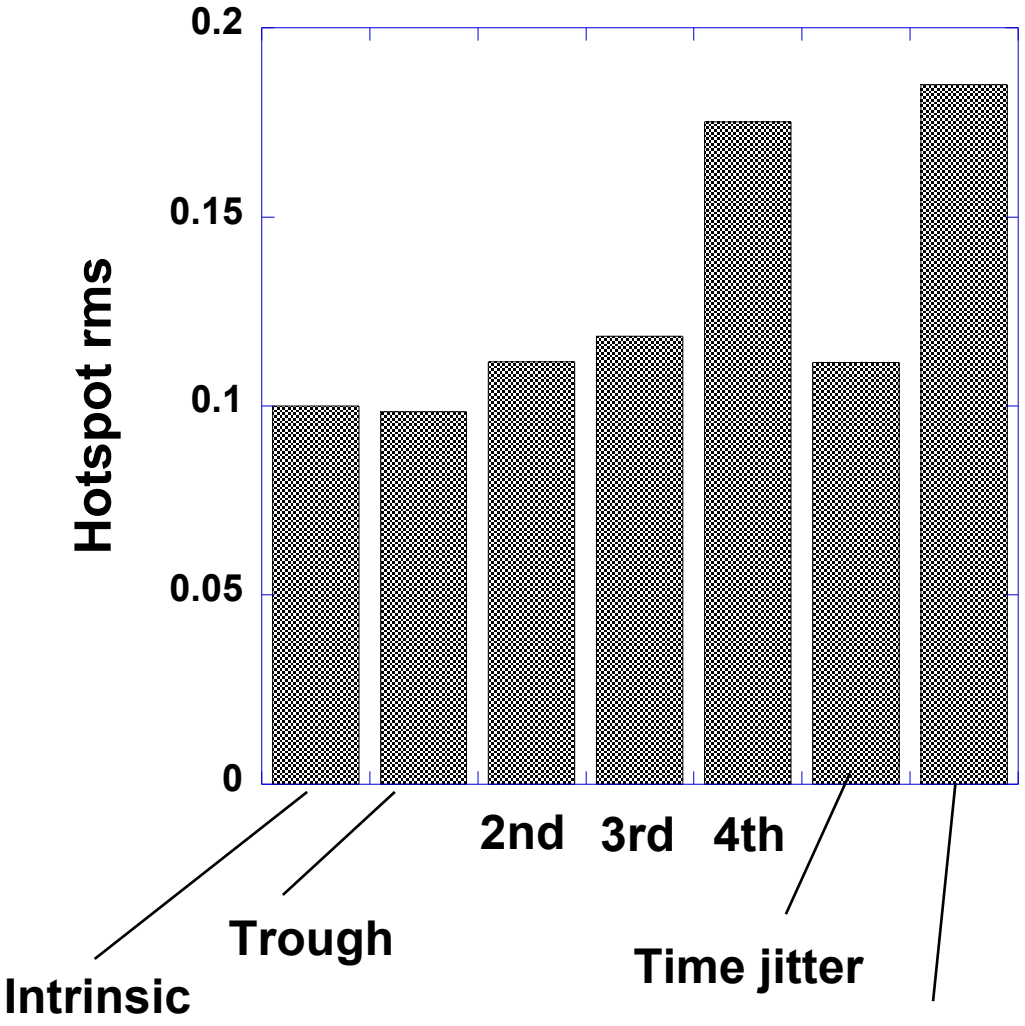

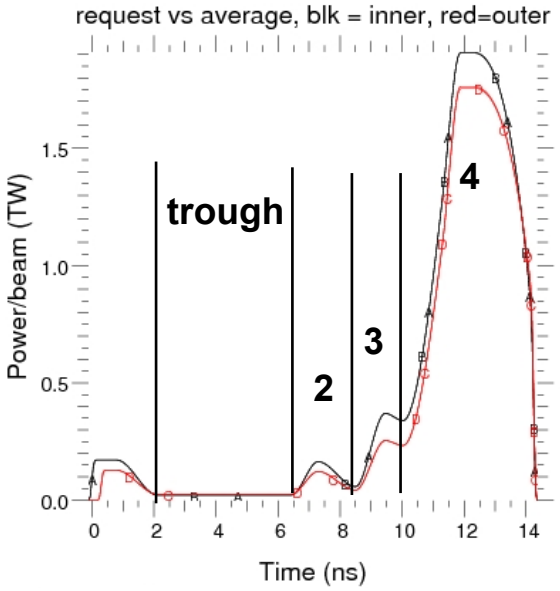

Series of calculations with 2X spec power balance applied during different parts of pulse

For one set of calculations a random pointing error was introduced

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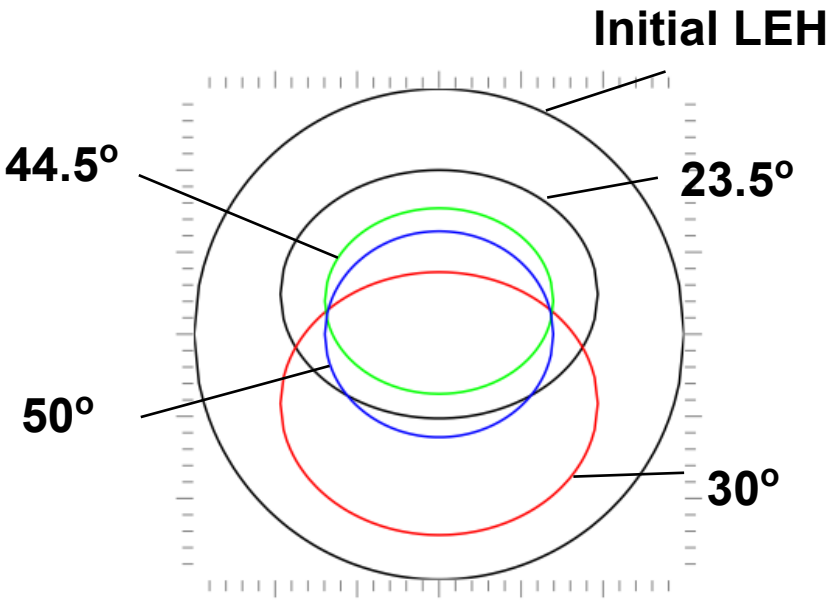
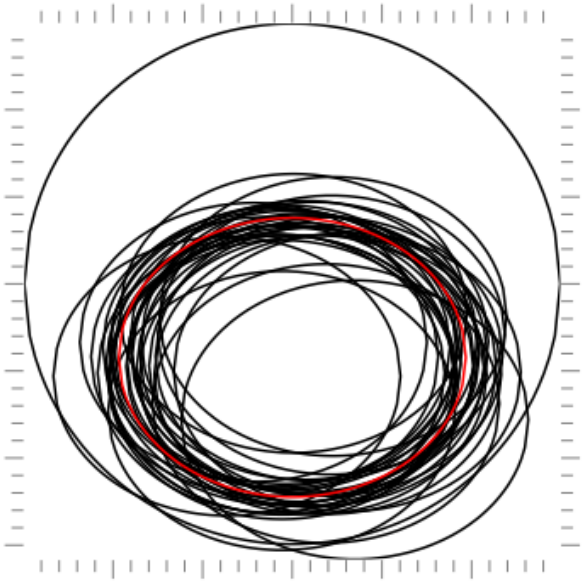
Beam spots projected onto LEH plane





200 μm rms pointing error (2.66 x spec)

Found that 200 μm rms pointing error would decrease peak Tr by 5 eV

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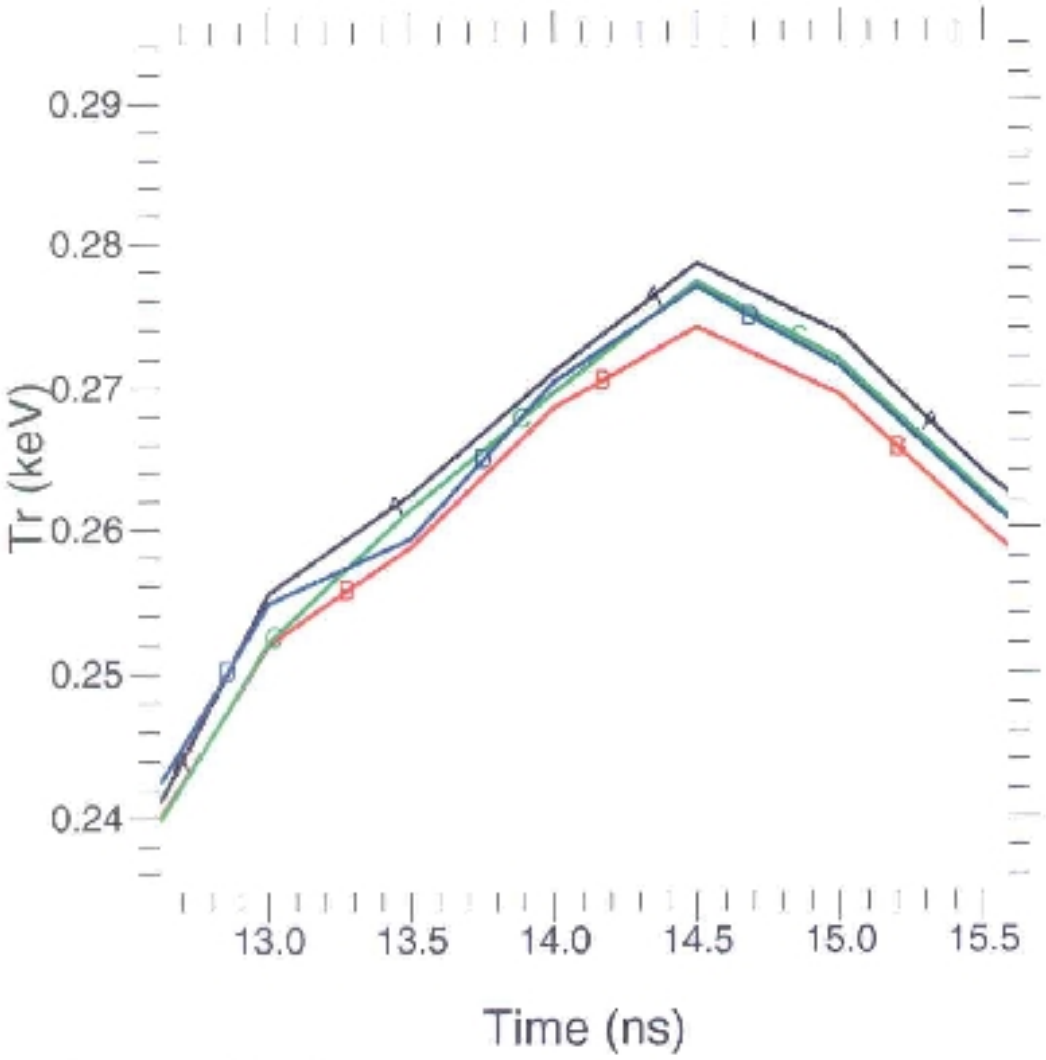

For 285 eV Be design
A = ideal pointing
B = 200 μm rms
C = 200 μm rms inner only
D = 200 μm rms outer only

NIF spec: 75 μm rms

For 100 μm rms pointing error (1.33 x spec), change in peak drive temperature is negligible

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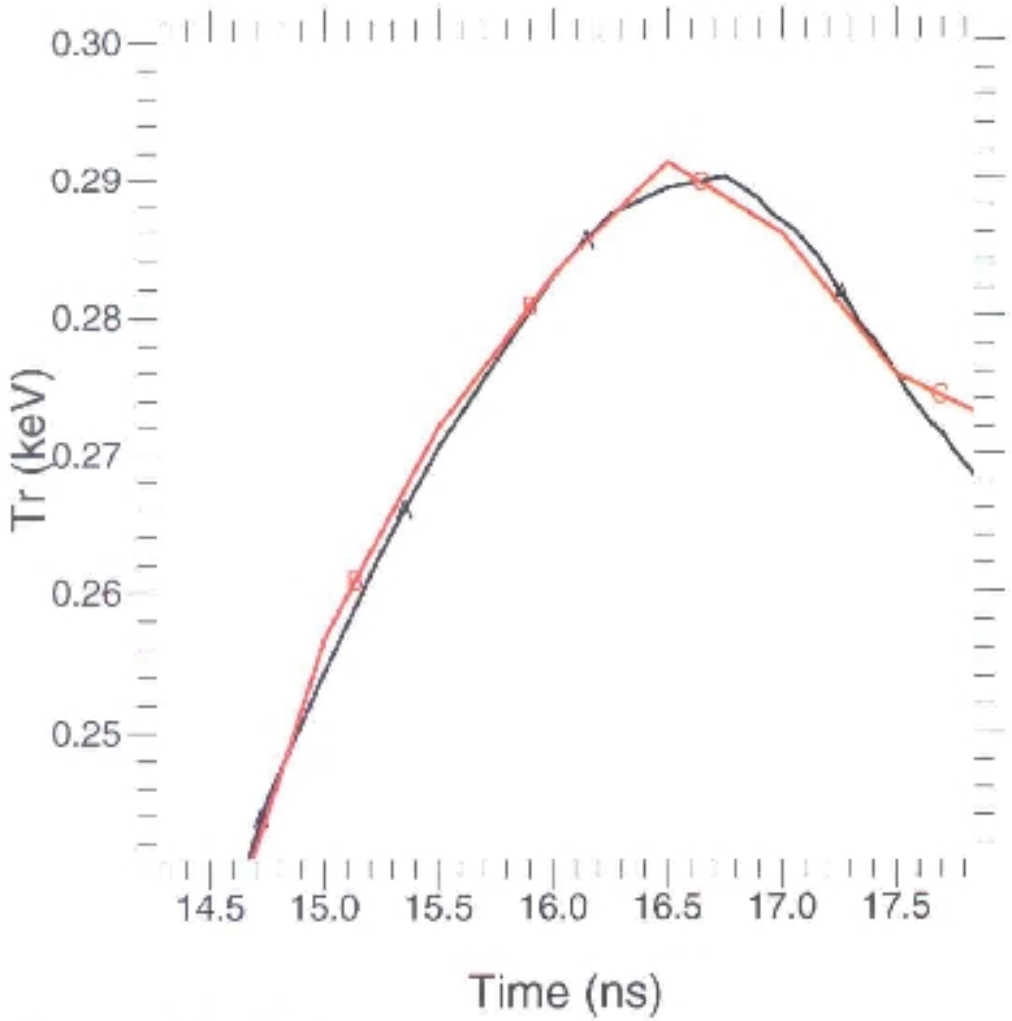
Zoom near peak drive



This calculation for CH capsule with "300 eV" drive

3D calculations enable us to make synthetic images from actual NIF diagnostic port angles

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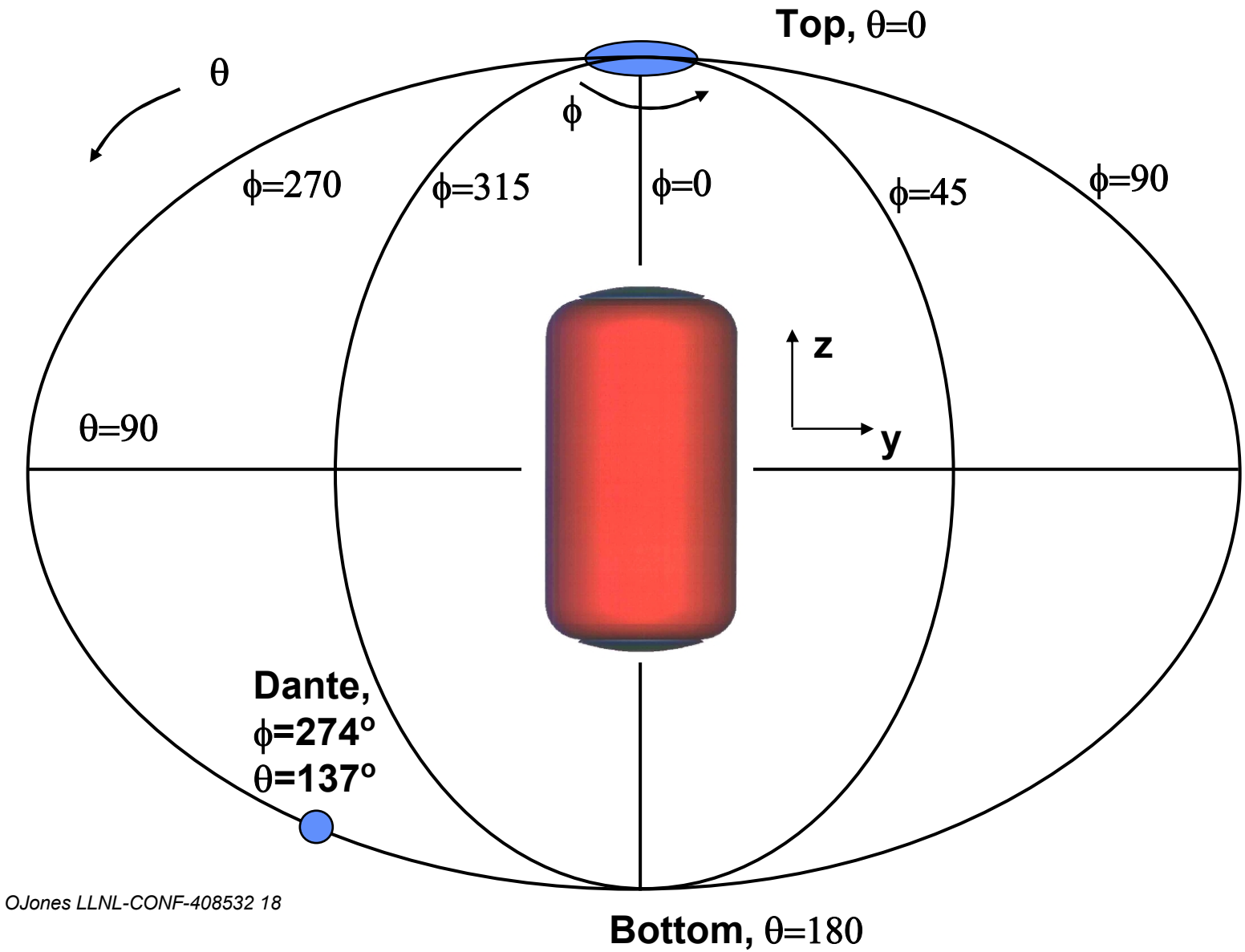

For example, we can calculate the Dante emission from the NIF Dante port view

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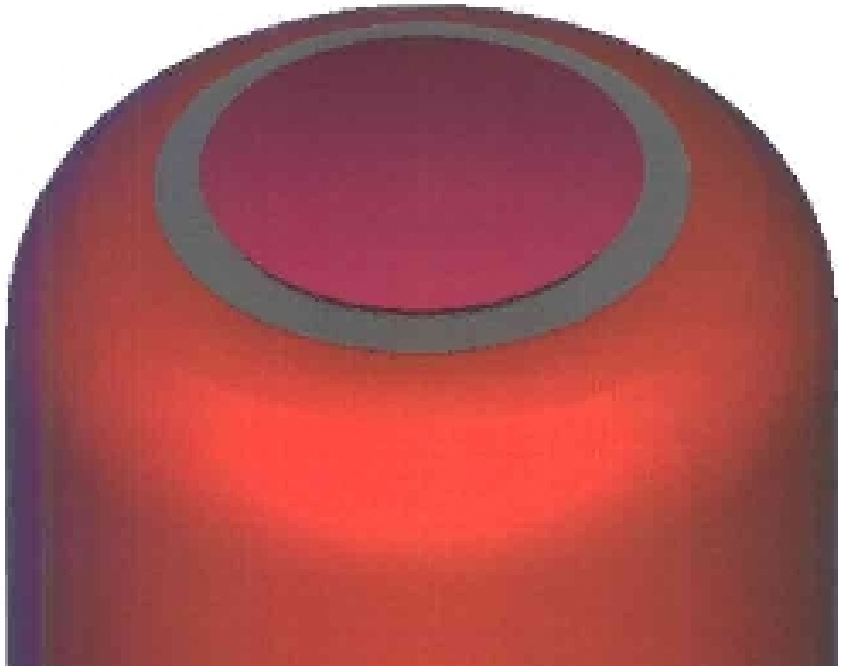

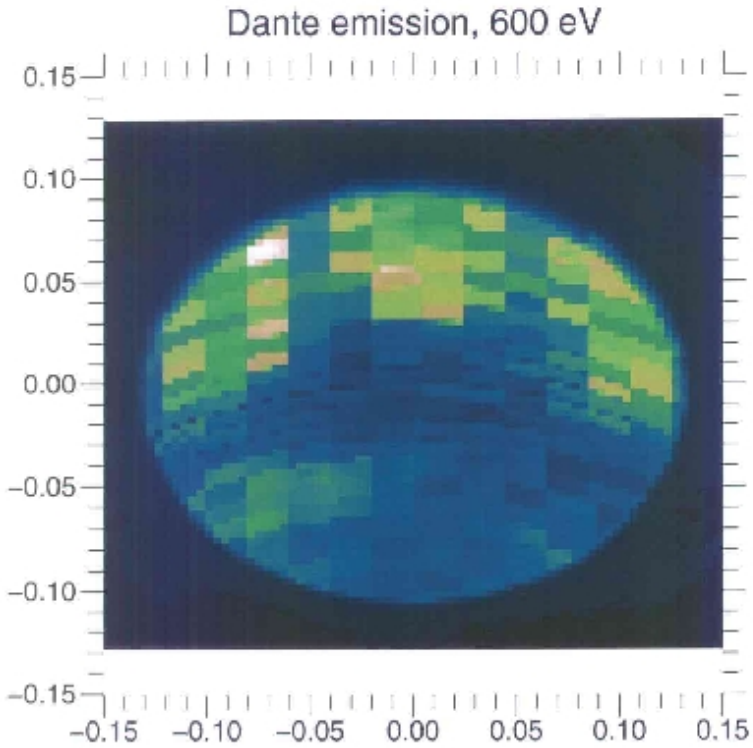

This example is a synthetic backlit image of a THD capsule with random laser power balance

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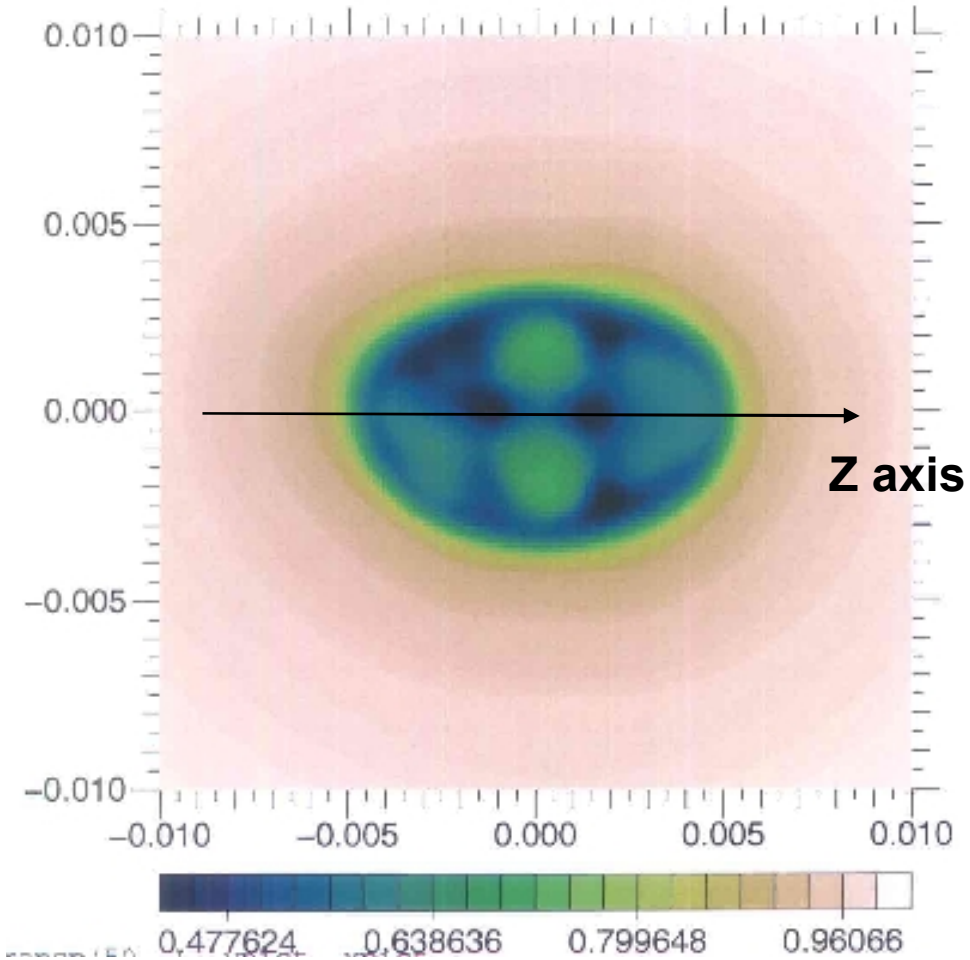

Image of THD capsule at max compression

Transmission at ARC backlighter energy of ~80 keV

THD capsule:

24.75% H
0.5% D
74.75% T

Same mass as 50/50 DT

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