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Title: Implosion symmetry tuning with megajoule laser pulses on the National Ignition Facility

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Implosion symmetry tuning with megajoule laser pulses on the National Ignition Facility

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A key element for indirect drive inertial confinement fusion is tuning the implosion symmetry. Symmetric implosions maximize transfer of kinetic energy to the hot spot. One technique to measure the drive symmetry is the symcap. A symcap is a surrogate capsule that replaces the DT fuel layer by an equivalent mass of ablator material to mimic the hydrodynamic behavior of the capsule. The symcaps are filled with gas that provides an x-ray self-emission flash upon stagnation and is used to diagnose the radiation drive from based on the shape of the emission. Simulations indicate that the shape of the emission flash correlates well with an ignition capsule's core shape. Using this data, the radiation drive in the hohlraum can be tuned to achieve symmetric implosions. The current symmetry campaign sets the initial hohlraum conditions to provide symmetric implosions for the ignition campaign. Experimental results will be presented of the symmetry tuning with laser energies up to 1.3 MJ.

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Implosion shape is one of the requirements for the success of inertial confinement fusion

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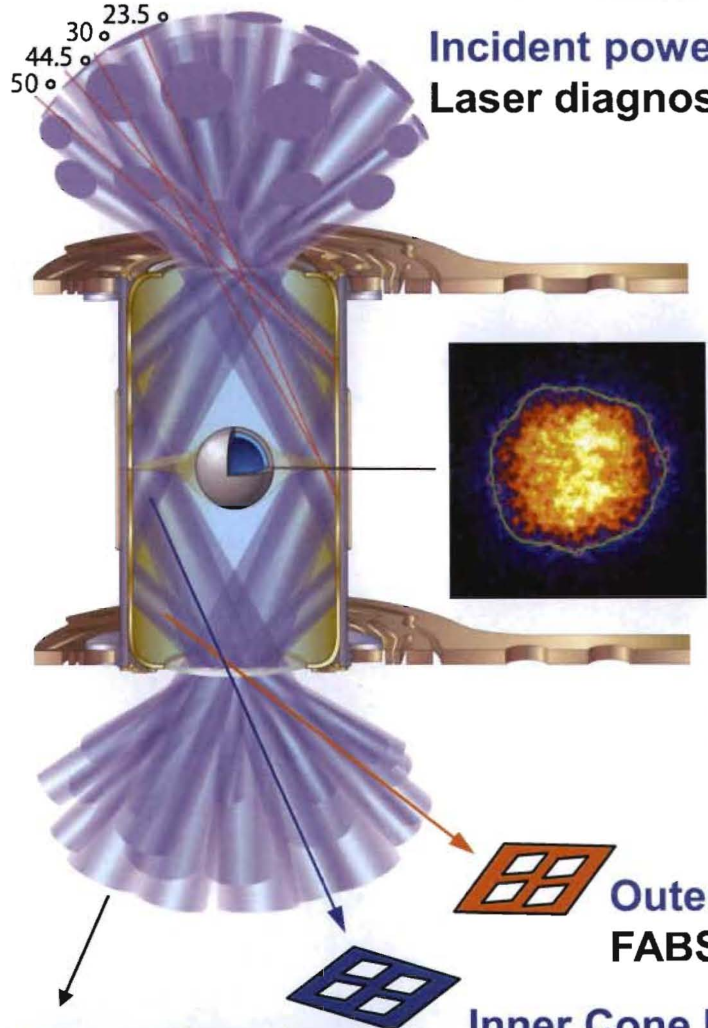
- Symmetric implosions using the ignition platform are required to effectively execute ignition tuning experiments such as convergent ablation, shock tuning, and THD.
- Due to the importance of inner beam propagation and crossing beam effects, hohlraum energetics and symmetry tuning are symbiotic experiments.
- **The goals of the symmetry tuning campaign is to measure and mitigate if necessary P2 & P4 core asymmetry for current hohlraum platform and assess reproducibility**
- Symmetry experiments have demonstrated the ability to achieve round implosion at 1 MJ laser energies as well as reproducible conditions

We use symcap experiments to measure hohlraum power balance and to tune implosion symmetry.

Measure incident laser power and energy

Measure backscattered power and energy

Measure x-radiation drive



Incident power and energy
Laser diagnostics

Imploded core shape
x-ray implosion time
Gated x-ray imager GXD

Measure and tune implosion symmetry.

Outer Cone backscatter
FABS & NBI Q36B

Inner Cone backscatter
FABS & NBI Q31B

X-ray drive and pre-heat
Soft x-ray detector DANTE

A model has been developed for tuning symmetry using cross beam transfer

Theoretical framework for calculating the effect of cross beams

↓

Experimental feedback supplementing the theory

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Application of the model with simulations

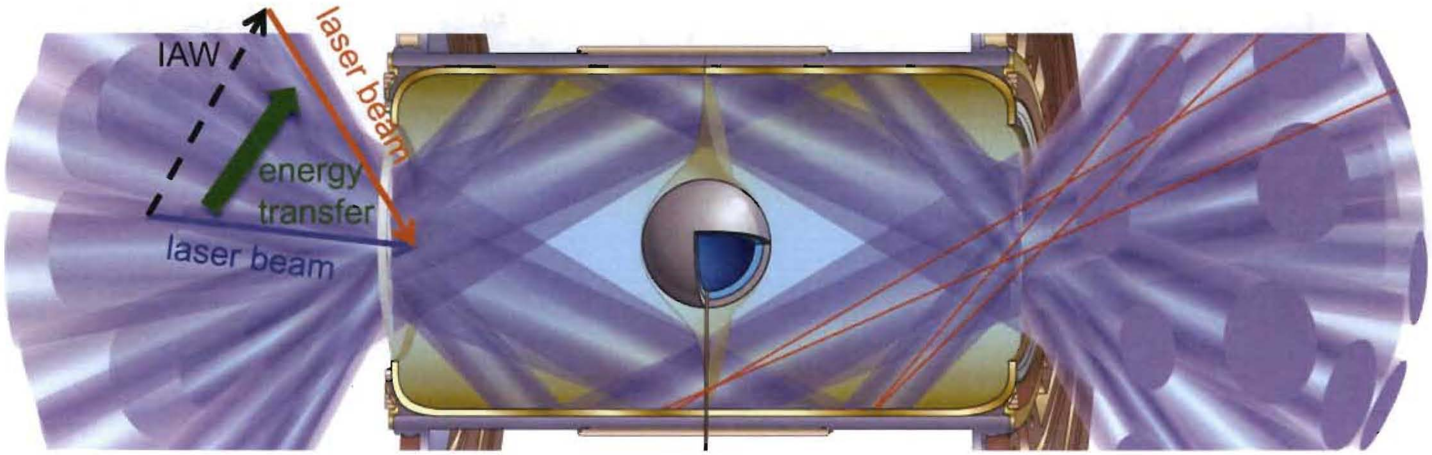
↓

Calculate tuning curves

↓

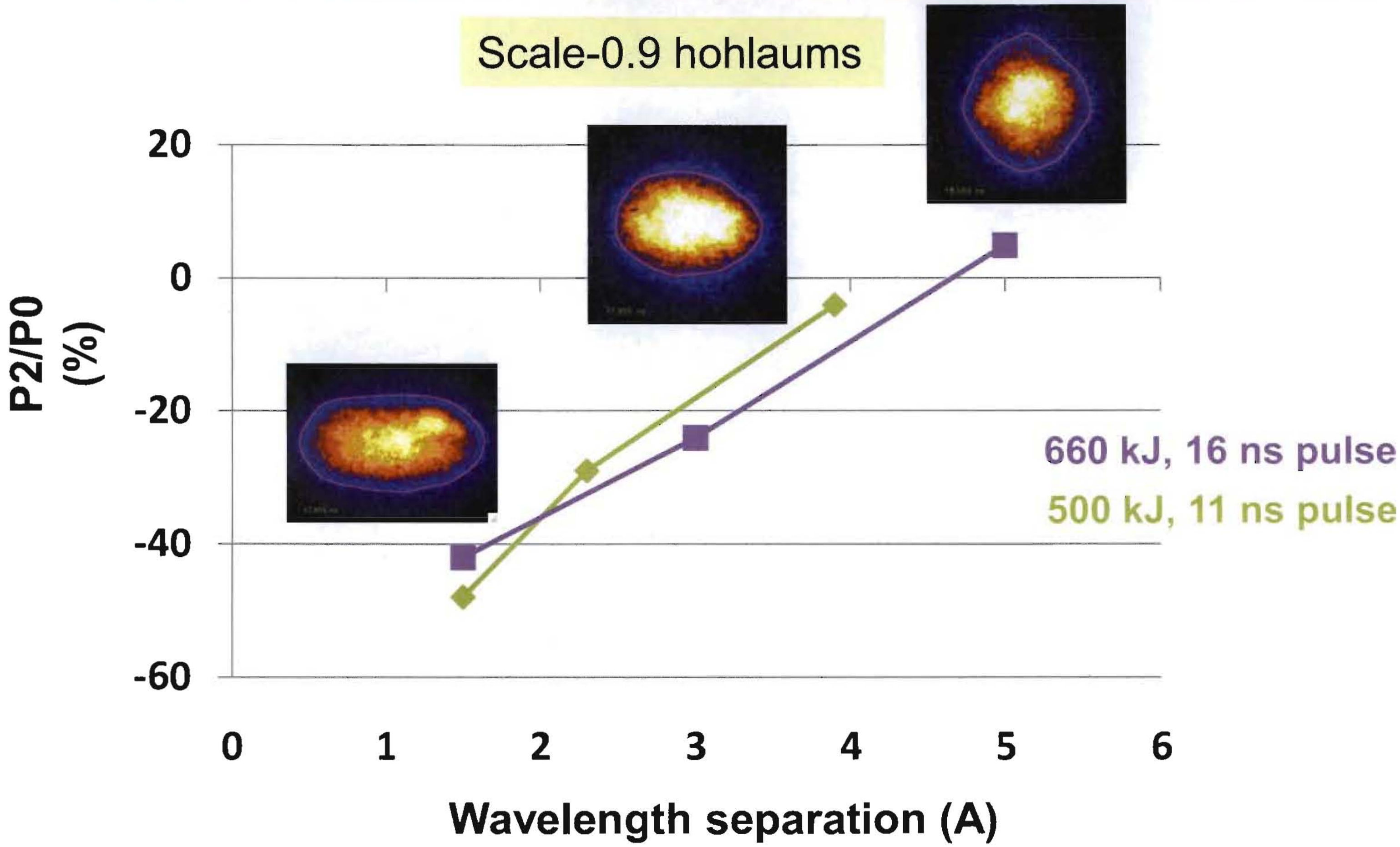
Validation of curves

Laser beams crossing in the LEH can transfer energy from one to another via induced scattering



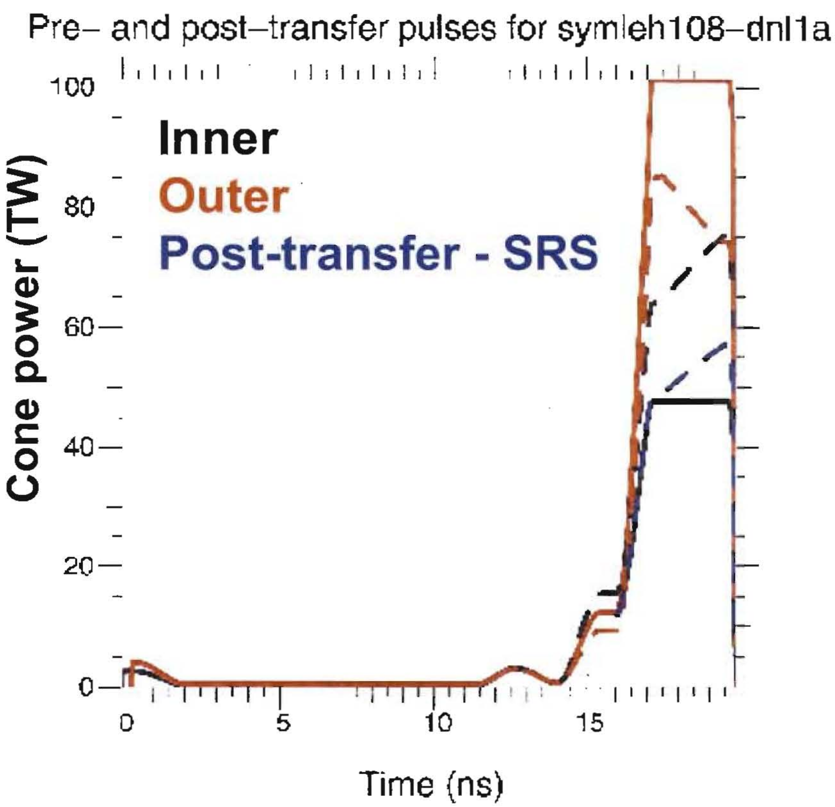
- By tuning the wavelength of inner cone vs outer cone, we can control the direction of the energy transfer – from outer to inner or vice versa

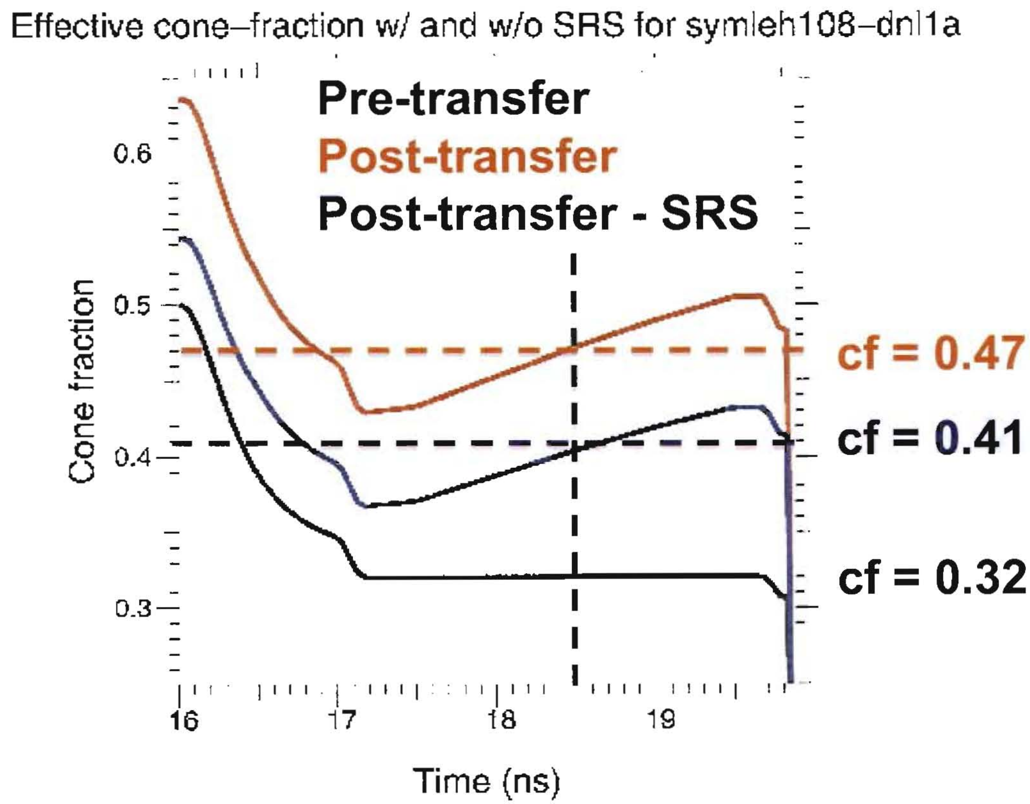
We have experimentally demonstrated the capability to tune P2 asymmetry using crossbeam transfer



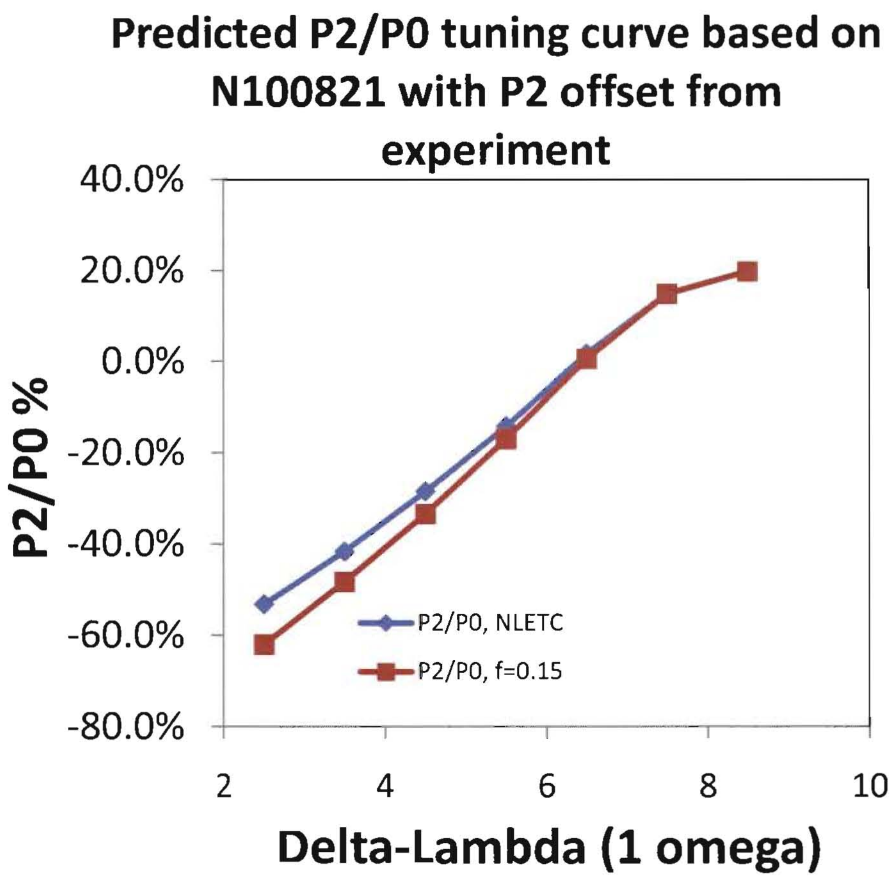
Laser has now delivered up to wavelength shift of 8.5 A.

Using the theory benchmarked by experiments, cross-beam transfer can be calculated with simulations

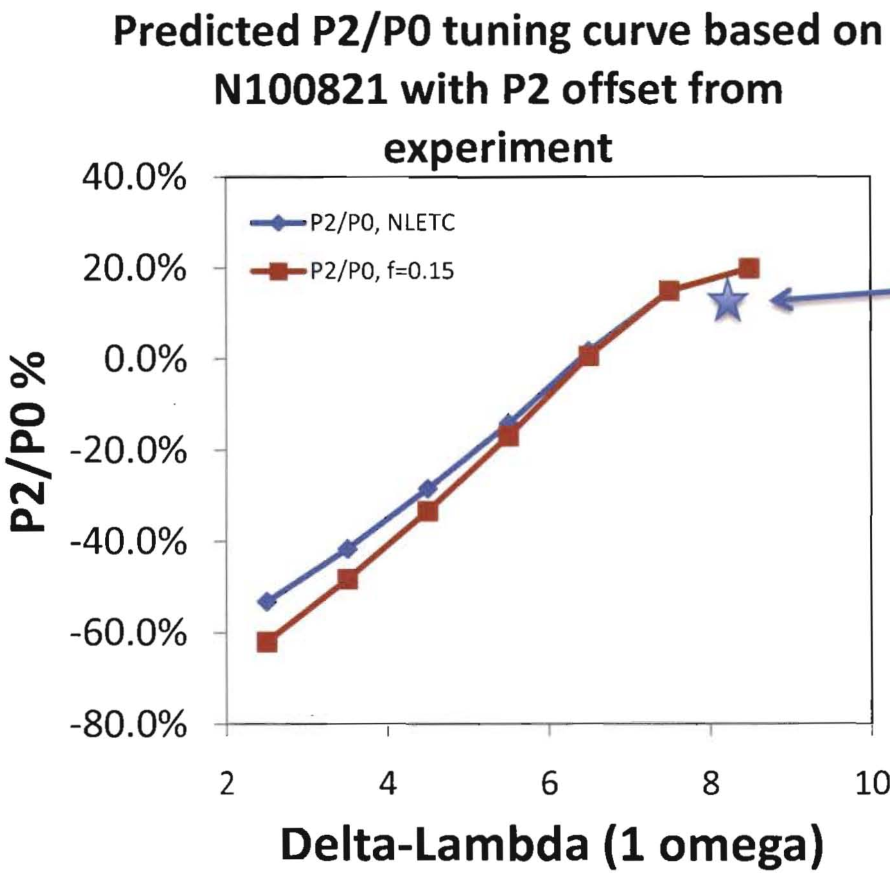


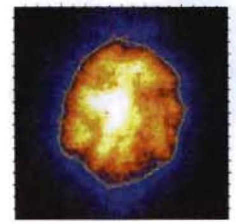


A series of simulations for different wavelength separations provides the expected change in symmetry



A 1 MJ experiment last Dec was used to anchor the simulated cross beam tuning curves





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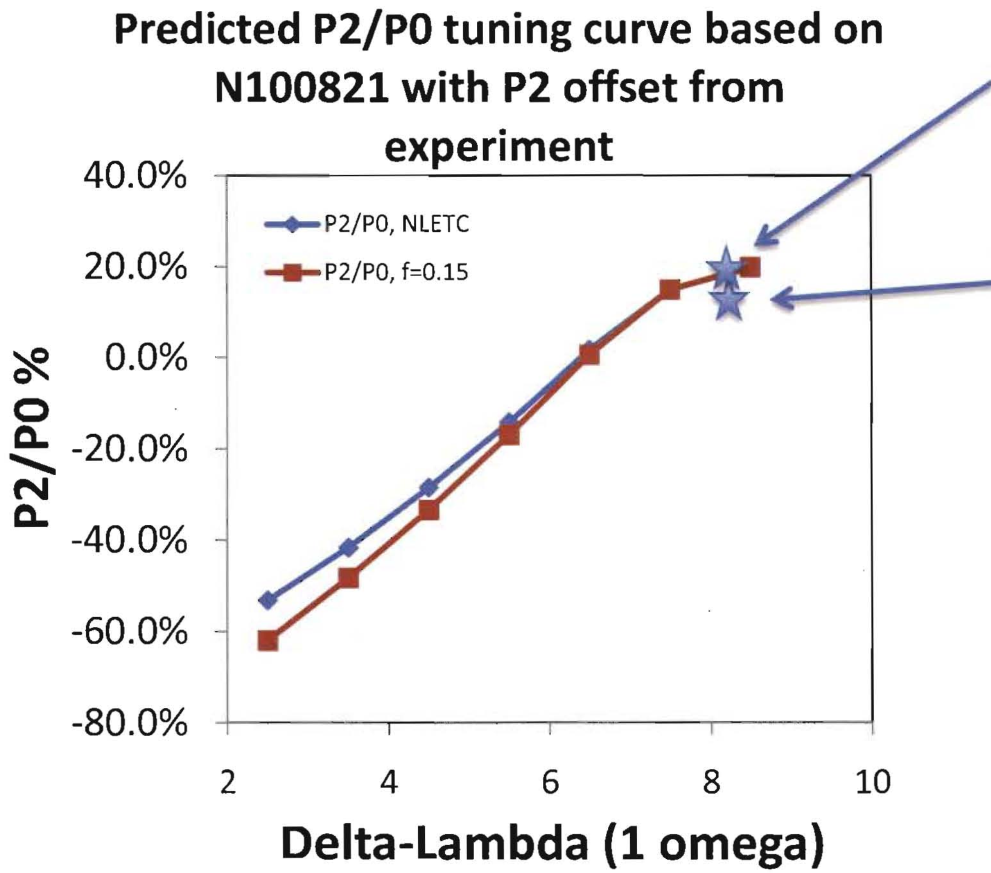
The first 1 MJ experiment this fall tested reproducibility benchmarking the tuning curves



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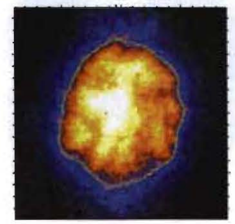

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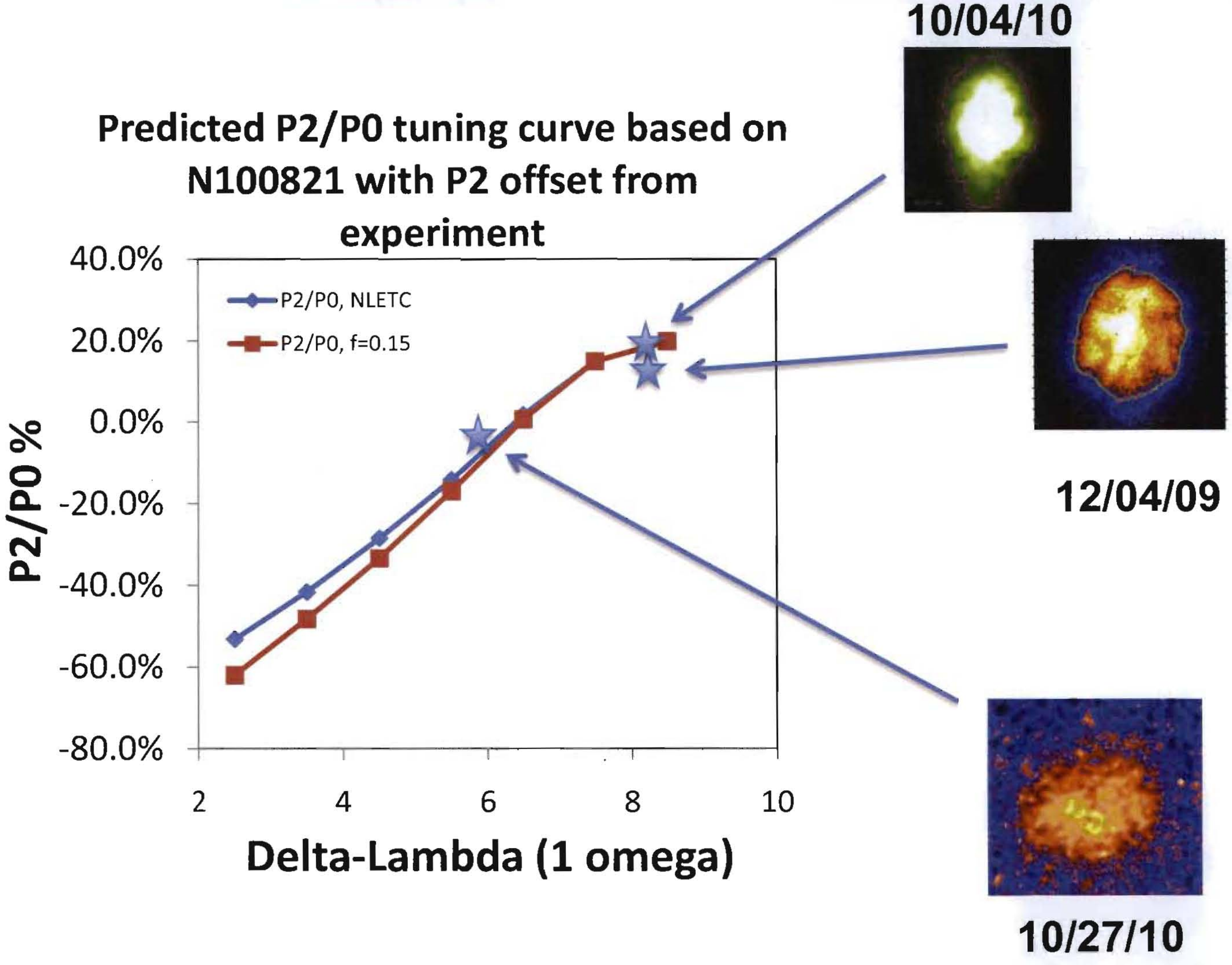
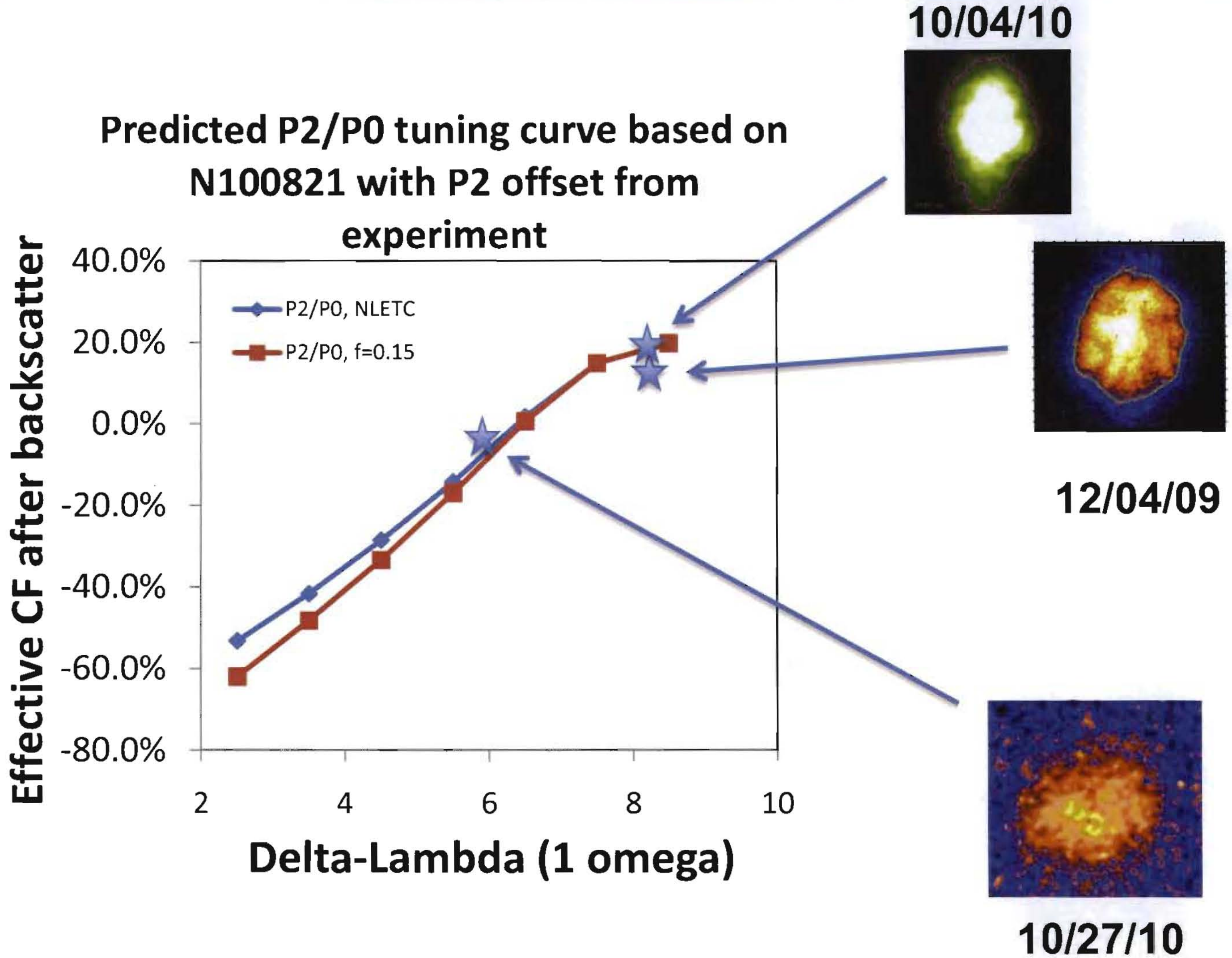
Using the calculations, the wavelength separation has been used to tune the symmetry validating the model



Experiments at 1 MJ show that we can tune ignition scale hohlraums and the conditions are reproducible



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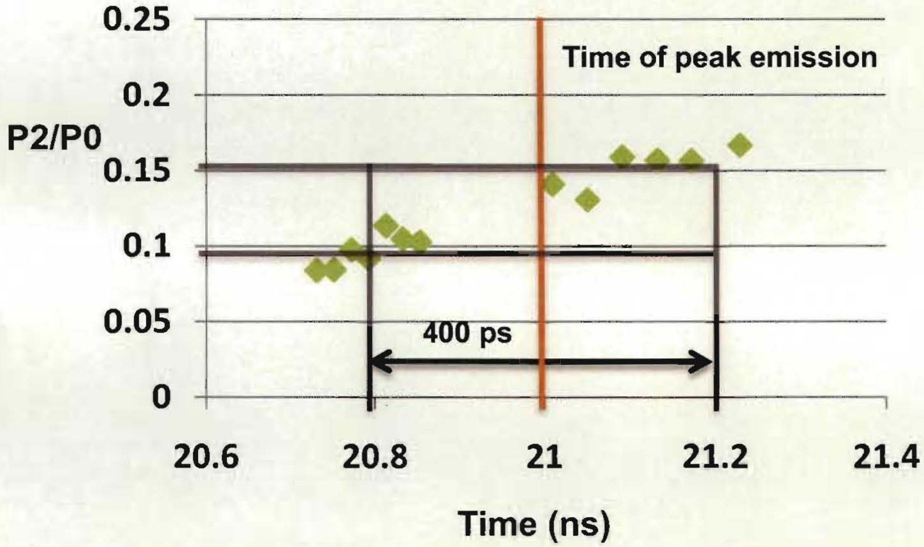
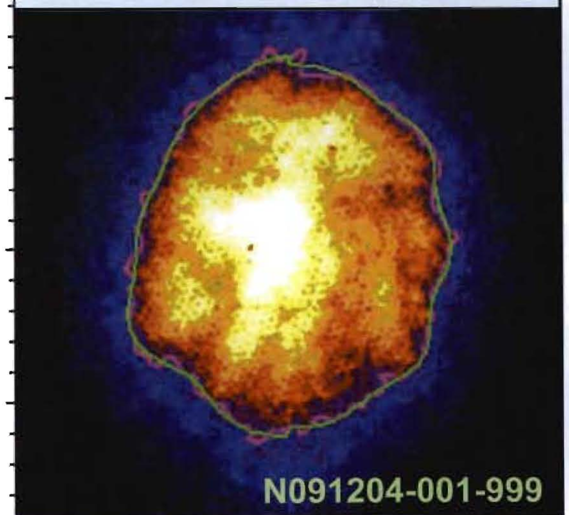
Plots of the time dependent symmetry for the two 1 MJ shots at 8.5A separation are reproducible

Time history of P2/P0



Although foot symmetry has not been tuned, core does not show large symmetry swings

Image at peak emission



P2/P0 = +14%
P4/P0 = 0%