LA-UR- 11-06559

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Title:	Symmetry tuning from analyzing the shape of x-ray self emission of Megajoule implosions at NIF
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Intended for:	Annual Meeting of the APS Division of Plasma Physics Salt Lake City, Utah November 8, 2011

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Symmetry tuning from analyzing the shape of x-ray self emission of Megajoule implosions at NIF

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Lawrence Livermore National Laboratory · National Ignition Campaign

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

Abstract

X-ray self-emission from imploding capsules driven by hohlraum radiation has been used to tune the symmetry of symcaps in the past. However as capsules have changed, new features have appeared in the x-ray images that have led us to re-examine the analysis and helped us tune the symmetry of different imploding cryogenically layered capsules as well. We had observed jets in the implosion and we tried identifying those jets, and avoid their effect on the observed time dependent symmetry. Since, we have tried to quantify the effect of these jets on the measured symmetry, x-ray history, and x-ray emission bang time. In this presentation we will show the effect of including the emission form the jets~~, show a correlation between the observations from different directions, give an estimate of the velocity of these features, as well as give a time history of their emission and size~~. We will also show how the time history have changed for the different laser conditions for the cryogenically layered targets, the implosion size was smaller than that for symcaps, and consequently the compression was larger.

We Measure Symmetry Parameters

To set intrinsic symmetry to meet requirements in the presence of all random components

- To successfully achieve inertial confinement fusion (ICF) in the laboratory with minimal energy, we require maximum compression to sizes a few times an alpha particle range in a central spot heated to an ion temperature close to 10 keV.

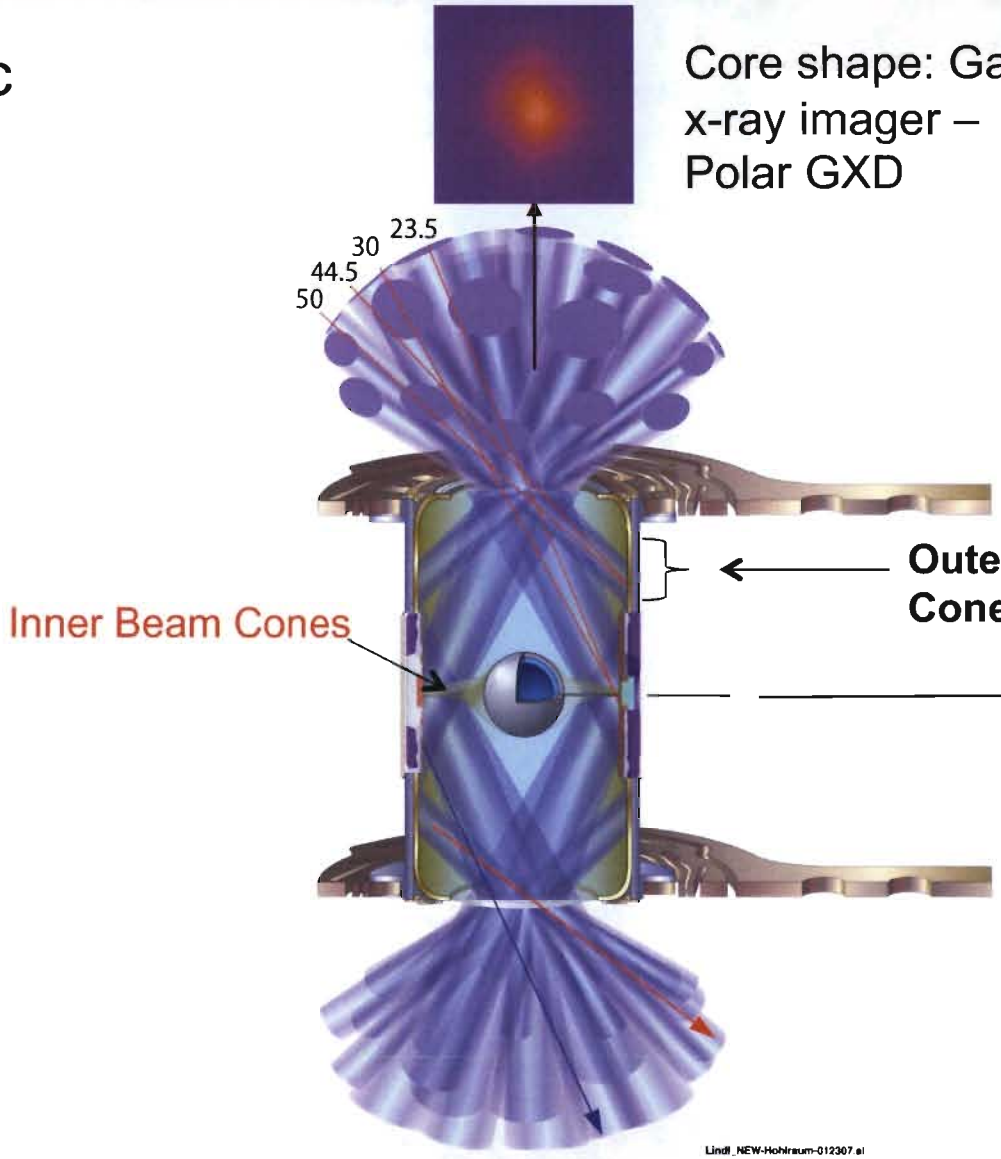
- These conditions necessitate the use of spherical implosions that have minimal surface losses for a given volume size, and require exquisite spherical symmetry so minimize the energy loss at the surface and to maximize the compression of an initial volume.

- These compressions must be achieved over a very short time comparable comparable to the sound speed propagation time across the hot core.

- To achieve the smallest core with the largest density, requires a large convergence ratio to use the least mass for a given alpha particle range. Thus the core must be as spherical as possible reducing yield-loss due to surface perturbations.

X-ray diagnostics are one of the suit of diagnostics That measure hohlraum and capsule conditions

Generic Target

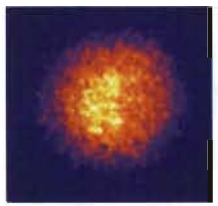


Core shape: Gated x-ray imager – Polar GXD

Previous Talk
Steve Glenn

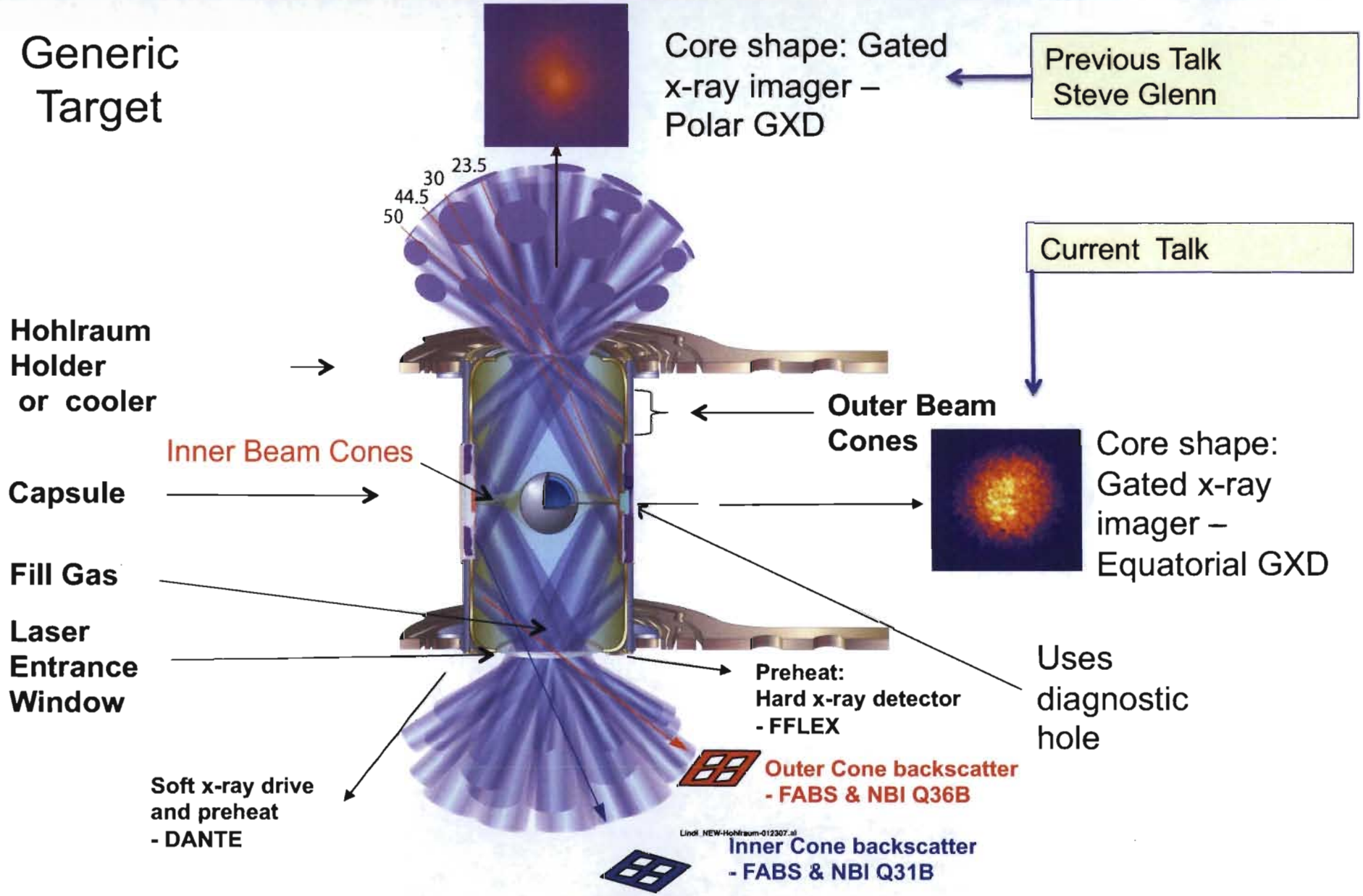
Current Talk

Outer Beam Cones

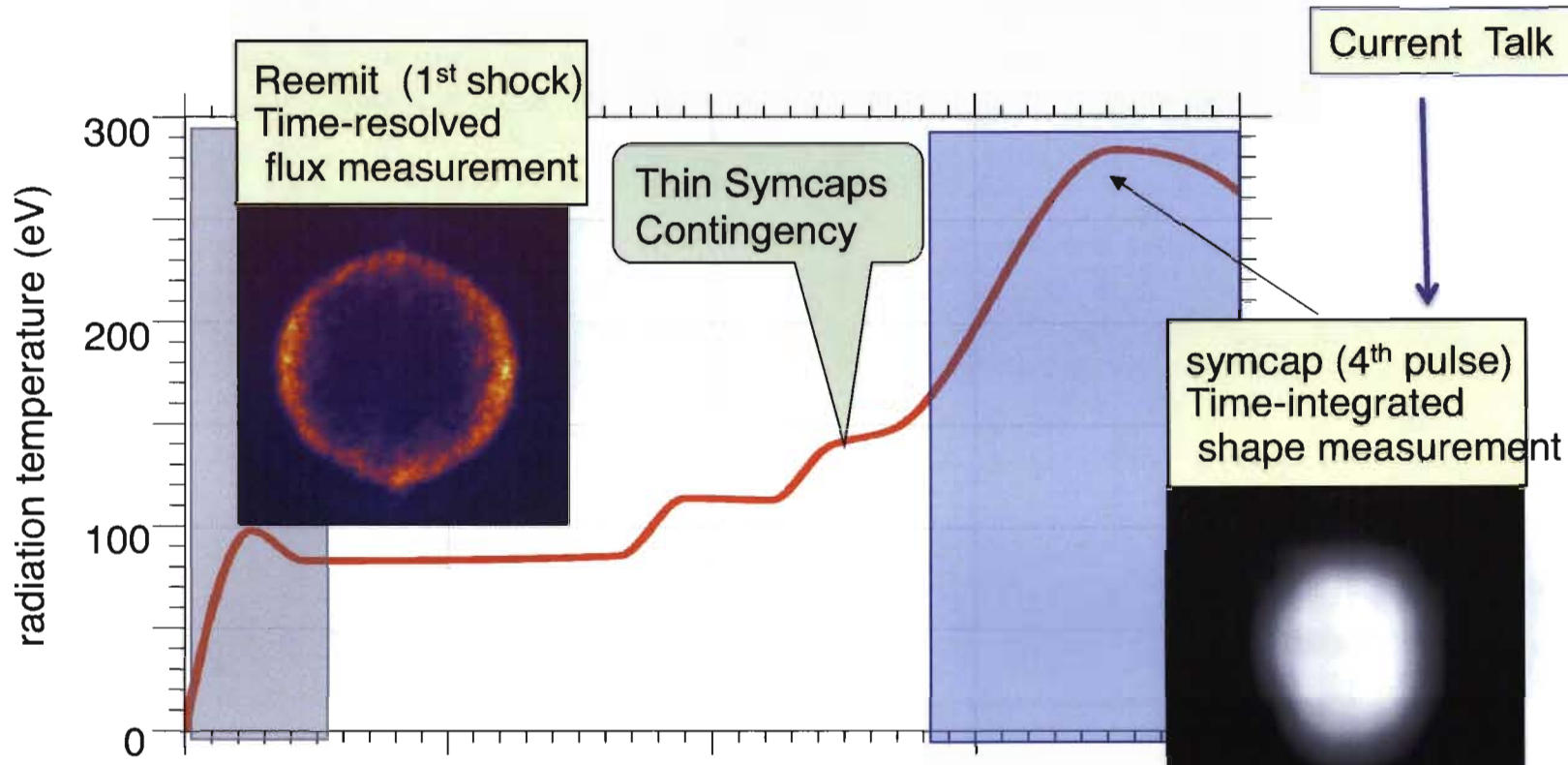


Core shape: Gated x-ray imager – Equatorial GXD

X-ray diagnostics are one of the suit of diagnostics That measure hohlraum and capsule conditions



The tuning strategy for symmetry relies on two types of measurement that emphasizes pulses 1 and 4



Reemit is used to set the early-time cone Imbalance, and Symcaps to set the late-time cone balance and hohlraum length

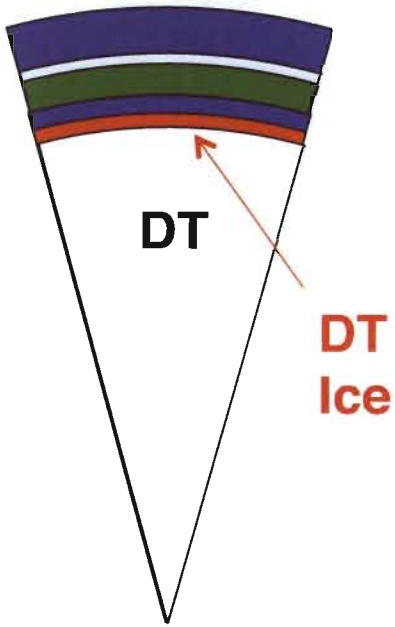
Reemit has been described in last High Temp by Edward Dewald. *RSI 97,10E903 (2008)*

We will present three sets of time dependent data showing equatorial symmetry variation

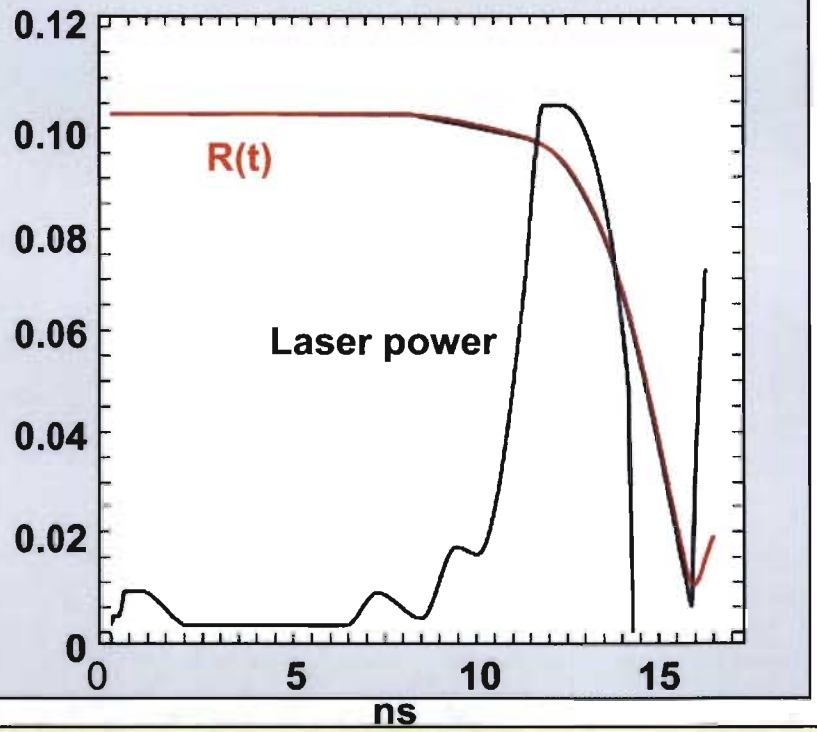
- Shape reproducibility using symcaps surrogates
- Variation of shape when changing from Ge-doped to Si-doped ablator shells.
- Variation of shape, surrogacy, using a symcaps Vs a cryogenically layered THD shot with similar rise time. [*THDs are ignition capsules used to reduce neutron yield allowing observations with gated x-ray detectors*]

Symcaps are good surrogate for the Ignition capsule inner [pusher fuel interface] surface trajectory and shape

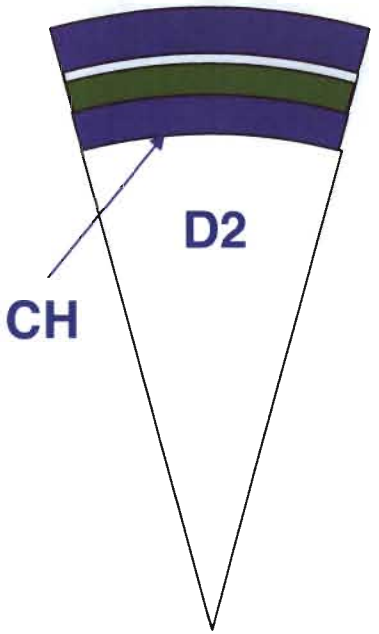
Ignition Capsule



Ignition fuel r(t) in 2D, rev 3.2
Red Symcap r(t) in 2D, rev 3.2



Symcap Capsule



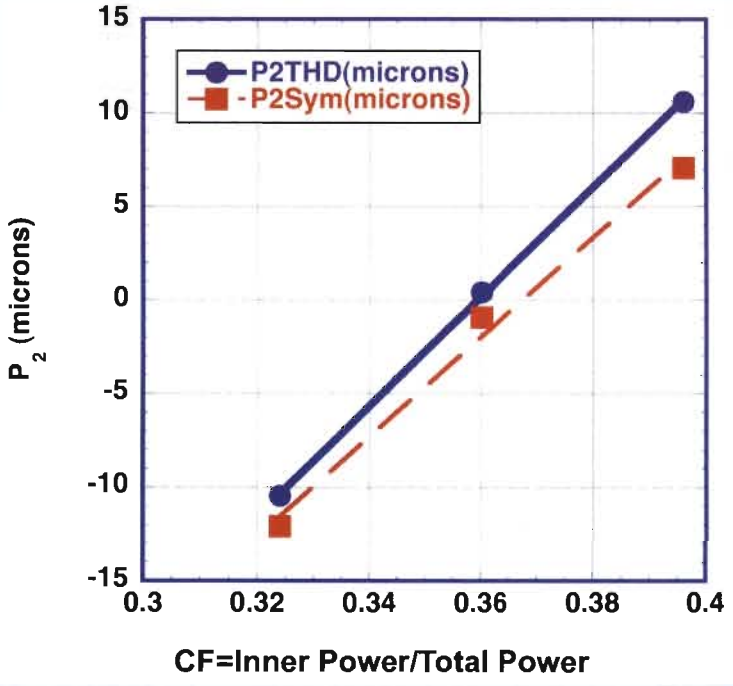
S. Weber, unpublished

The trajectory matches throughout the implosion –but the final implosion size is larger and the peak x-ray emission occurs later.

D[50]T[50] or THD are used for reduced neutron yield to allow diagnosis

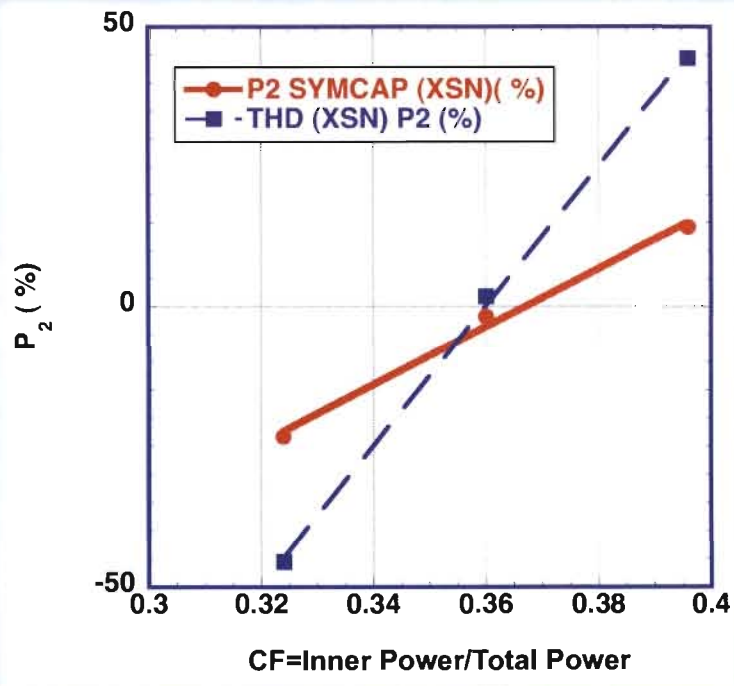
We adjust the symmetry by adjusting the power ratio between the inner and outer cones.

Calculations of P_2 at same cone fraction and at the 17% level



Absolute value of P_2 is close in calculations for both capsules

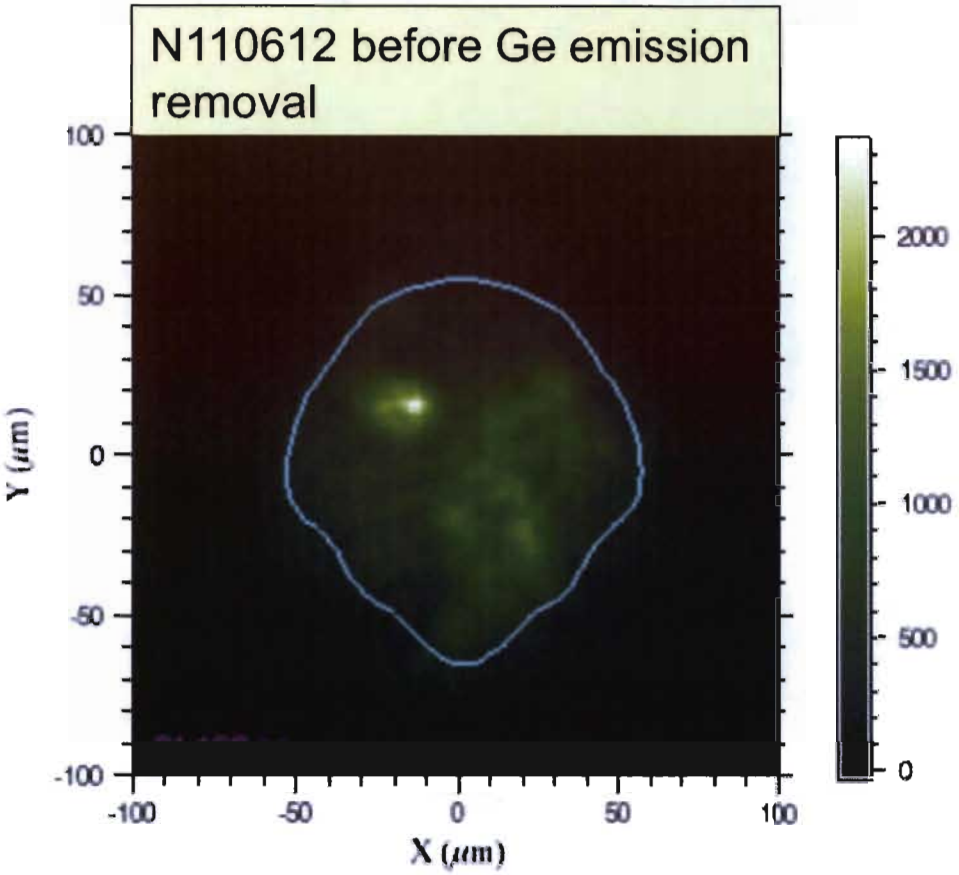
Calculations of P_2 at same cone fraction and at the 17% level



THD higher convergence increases and magnifies the asymmetry by 2x

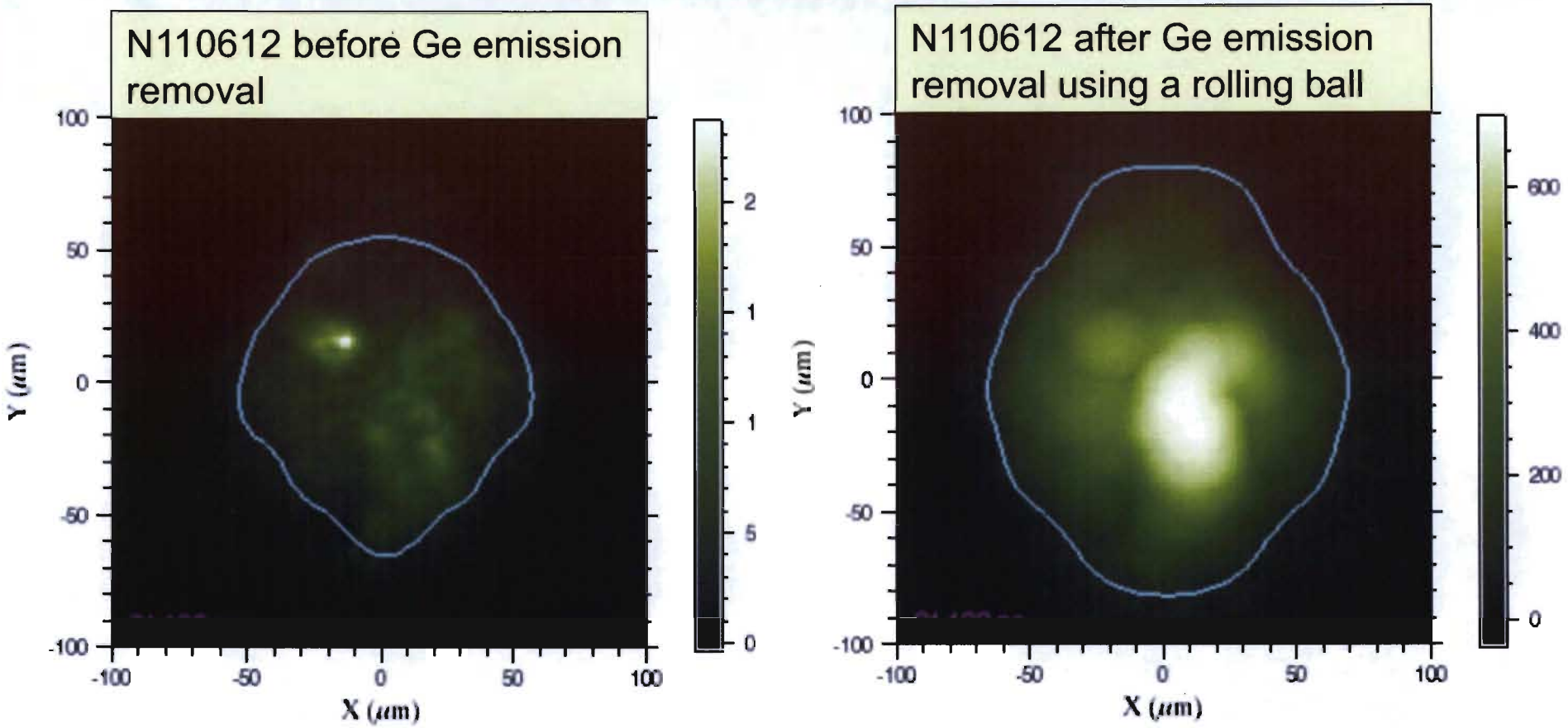
Symcaps reflect the symmetry of the inner ablator surface of a corresponding ignition implosion

Ge shell dopant mixed into the hot spot complicates analysis



The hot spot comes from Ge emission confirmed by Ross pair time-integrated imaging and x-ray spectroscopy.

Removing the Ge emission results in a more representative shape of the uncorrupted emission

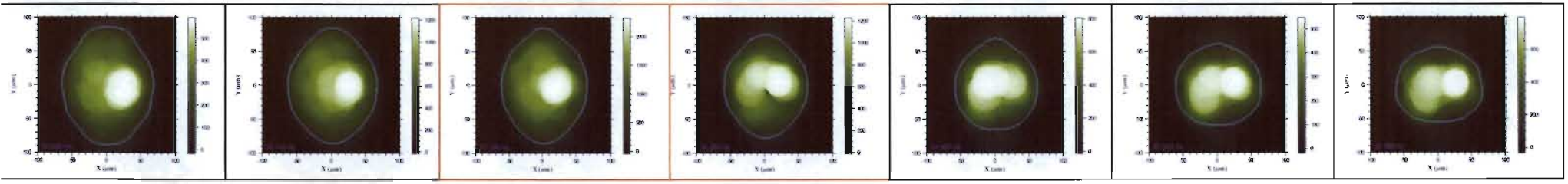


A rolling ball technique removes small features from the image, and changes the measured contour at the 17% level

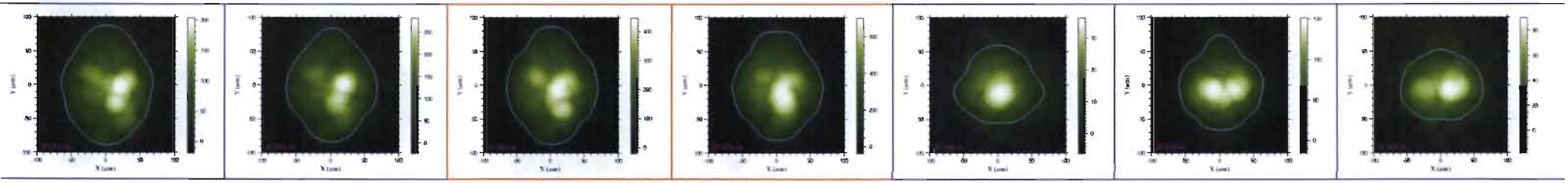
For a symcap, the time dependent symmetry was repeatable

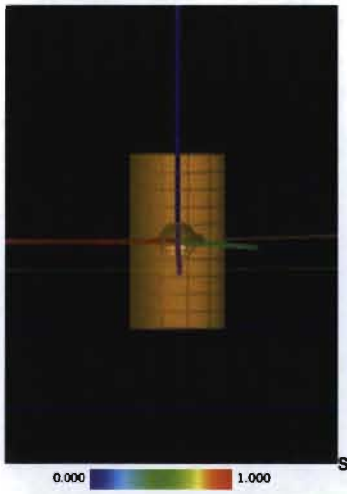
1.3 MJ, 6 A, Scale 544,Ge Symcaps

N110214 Equatorial, Foot CF=0.135,Peak CF=0.336



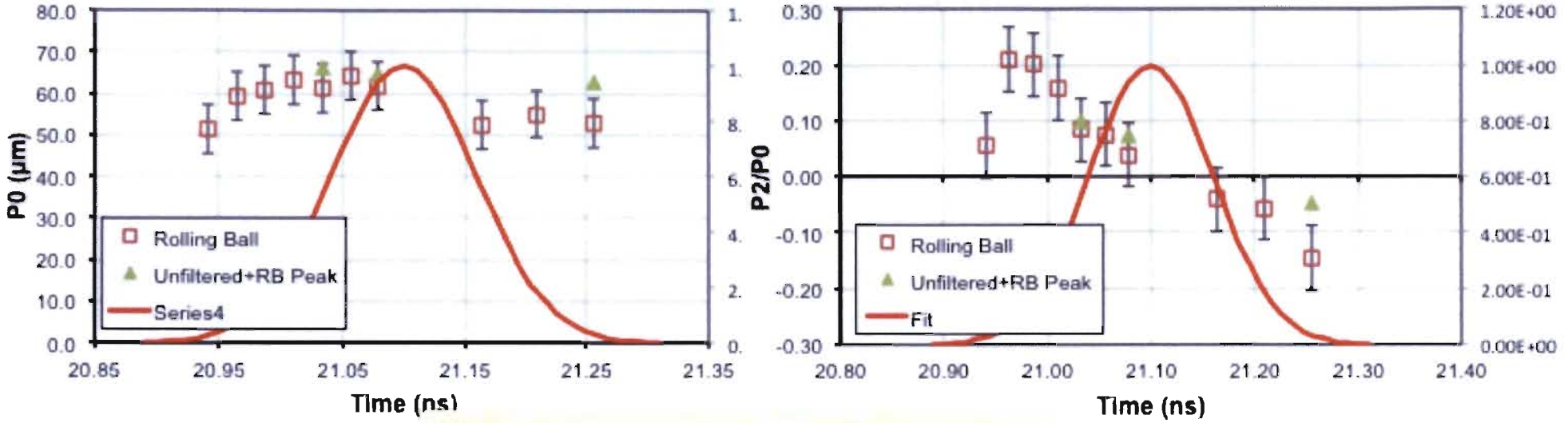
N110612 Equatorial, Foot CF=0.129, Peak CF=0.342



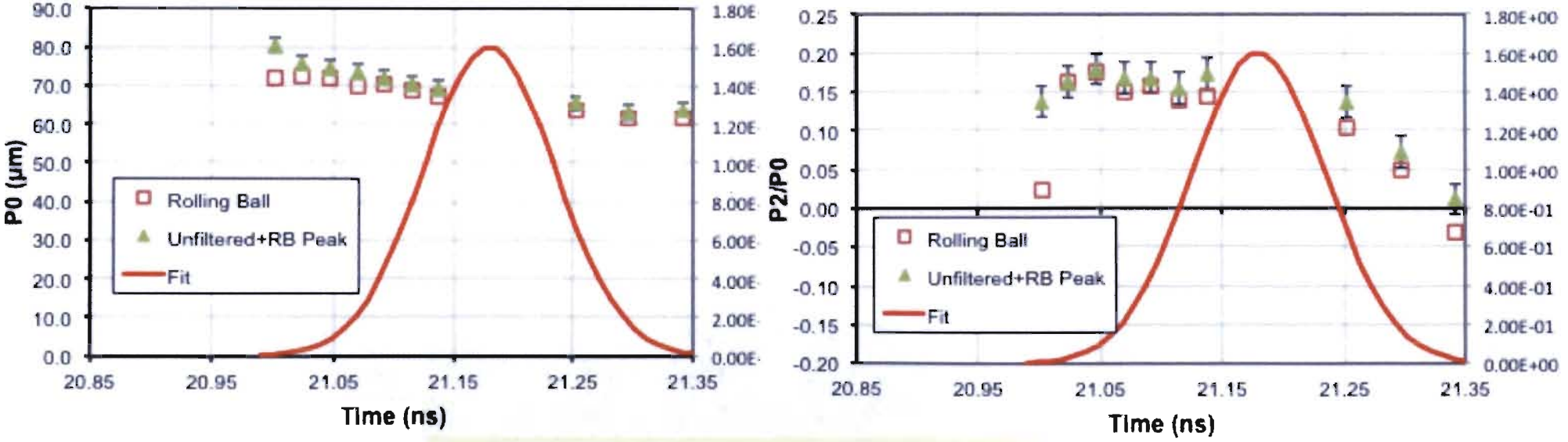


Symmetry about the same, slight variation due to various small laser variations in the foot cone fraction

ough the shape looks similar there is a difference in the measured values at the 17% level de to foot cone fraction being different



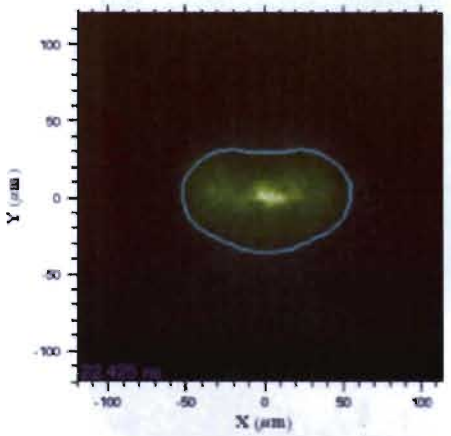
N110612, Bang Time=21.1(.07),FWHM=112 ps

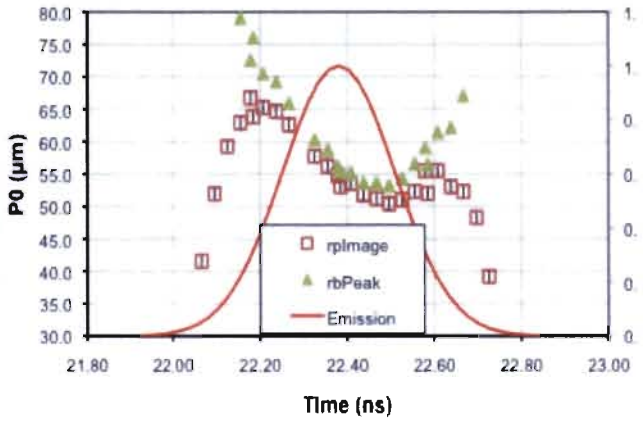


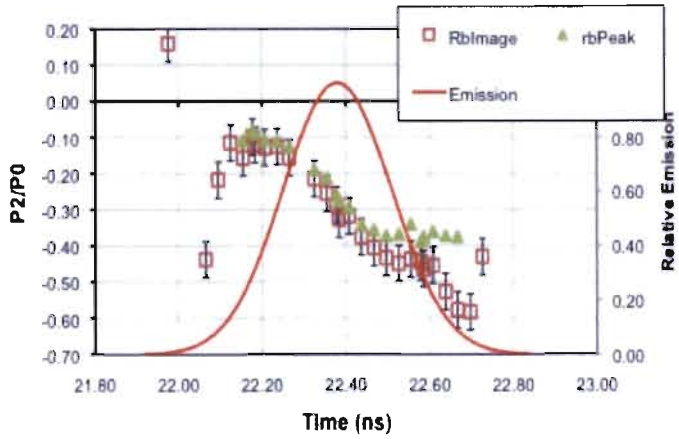
N110214 Bang Time 21.18(.07) FWHM=112 ps

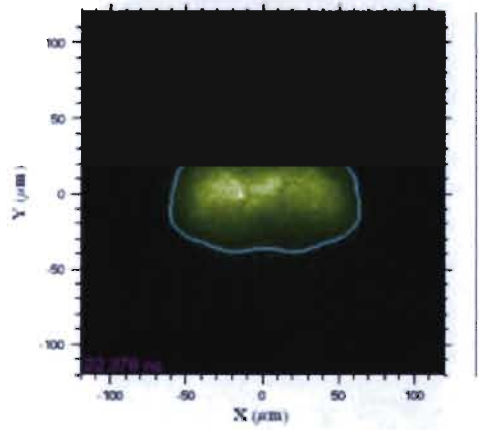
Jets and bright s pots are not visible when we used Si doped capsule

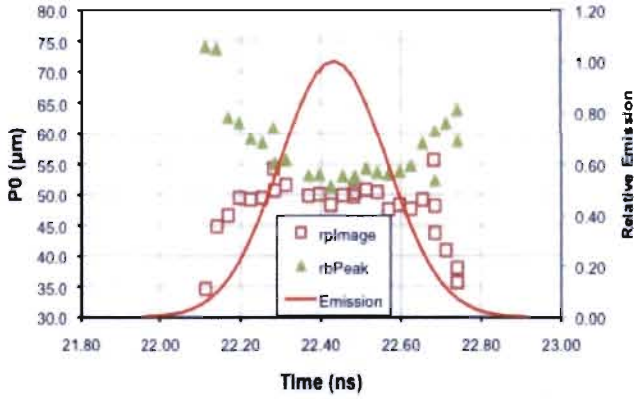
Symcap N110807 with Ge doping, 1.31 MJ, foot ECF 0.18 and peak ECF 0.35

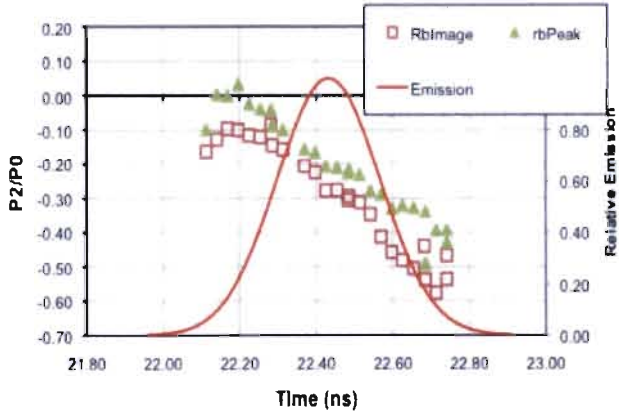










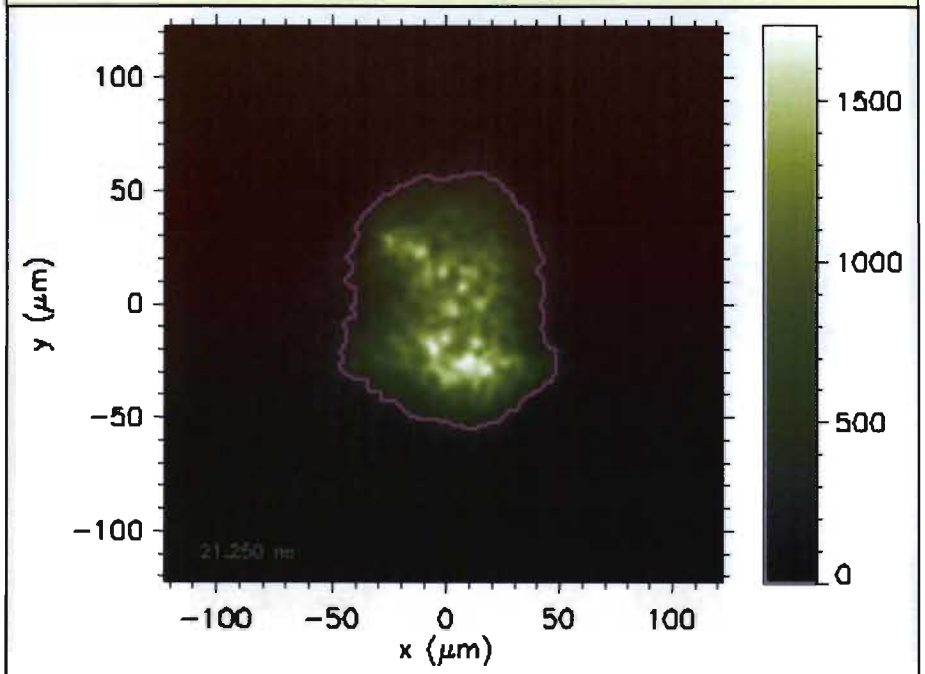


Symcap N110821 with Si doping, 1.326 MJ, foot ECF=0.1 and peak ECF=0.344

Analysis is easier with Si doped shell, but hides the underlying mix problem

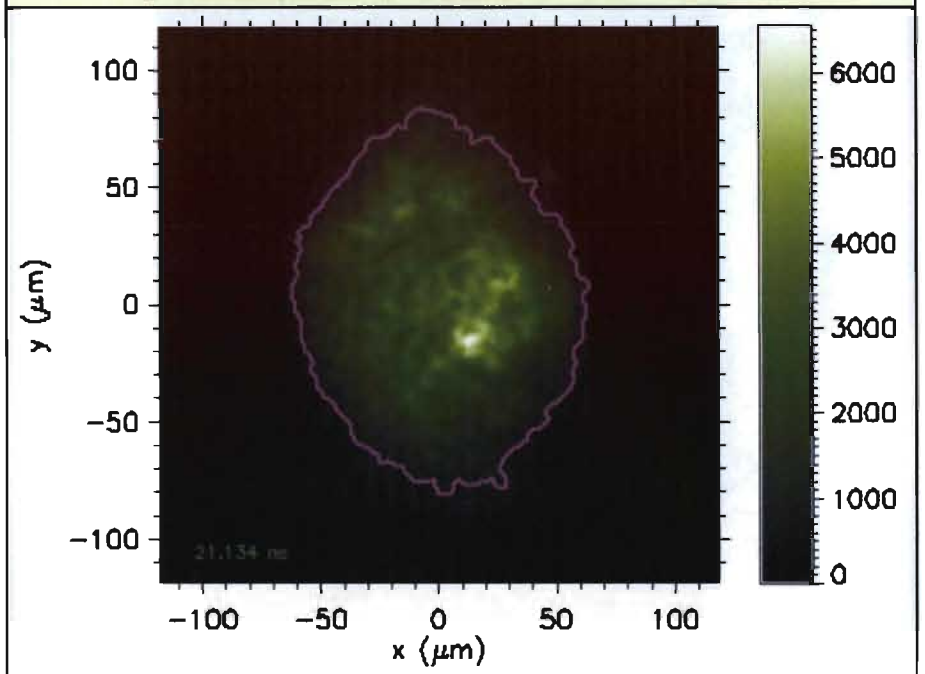
THD and a corresponding SYMCAP show similar sausage shapes, confirming surrogacy

THD implosion (N110212)



	N110212	Spec
P0	45 um	+/-3 um
P2/P0	13%	+/- 15%
P2	5.5 um	+/- 4.5 um
P4/P0	1.7%	+/- 10%
P4	1 um	+/- 3 um

Symcap implosion (N110214)

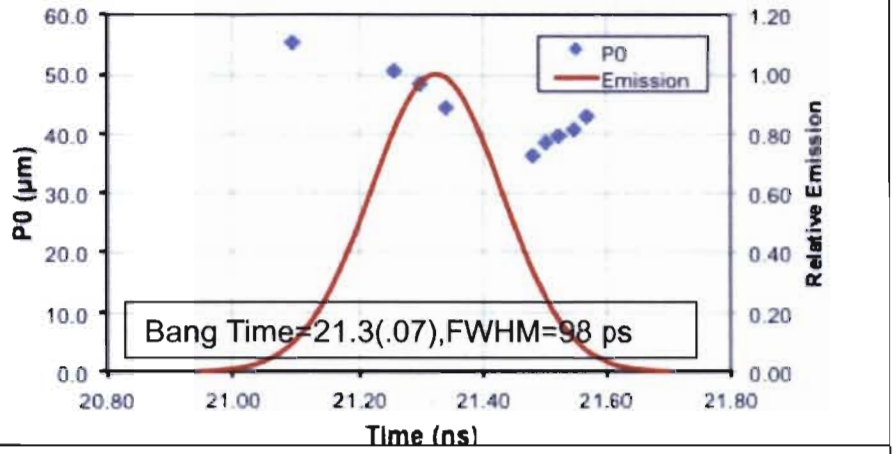


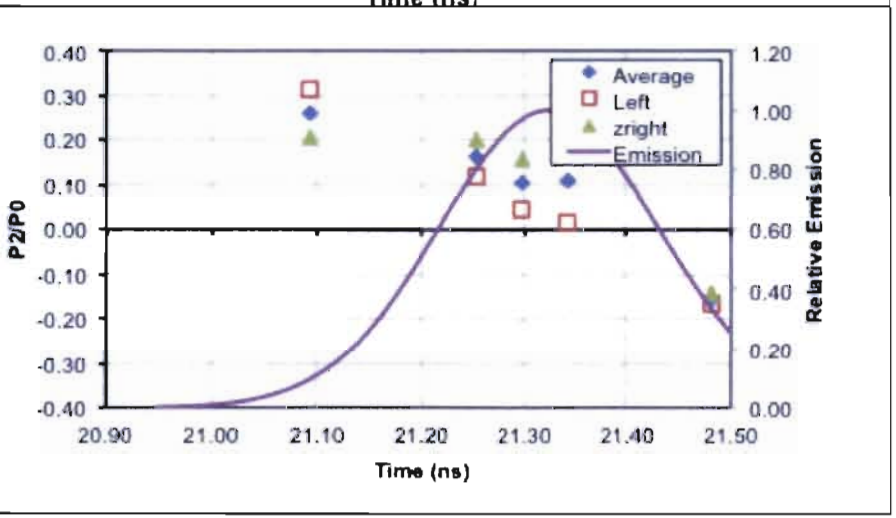
	N110214	Spec
P0	65.6 um	+/- 8 um
P2/P0	14%	+/- 7.5%
P2	9.5 um	+/- 4.5 um
P4/P0	5%	+/- 5%
P4	3.5 um	+/- 2.5 um

THD implodes to a smaller radius than a symcap

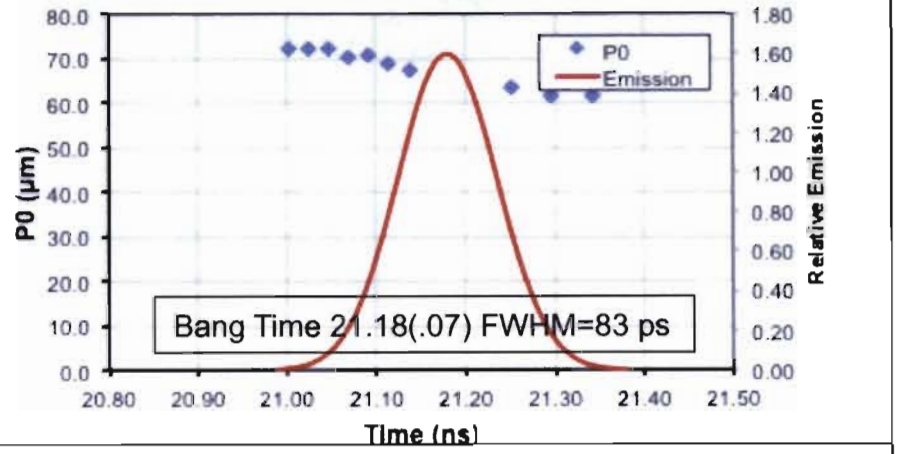
Although THD and Symcap equatorial shapes are similar at bang time, slight differences occur in the temporal dependence

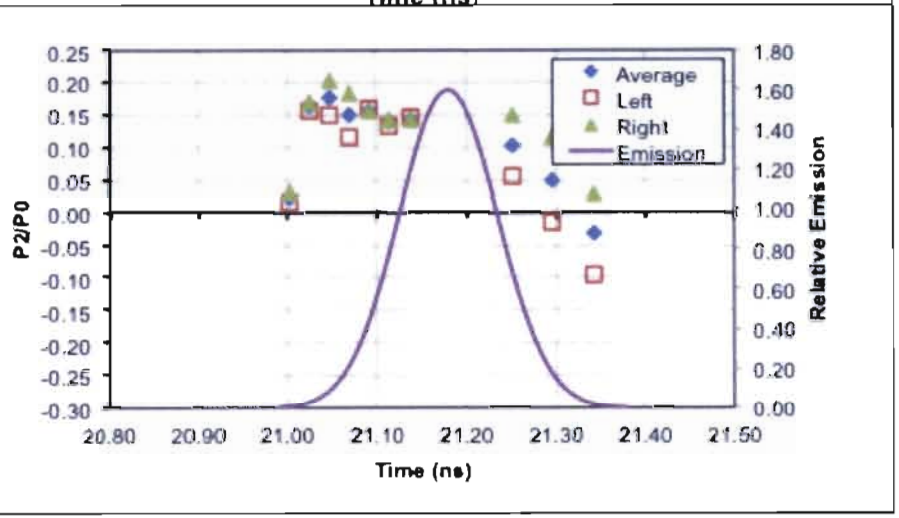
THD implosion (N110212)





Symcap implosion (N110214)





Implosions have a left right asymmetry that varies with time

We have demonstrated that various capsules behave similarly in the equatorial direction

- We developed an analysis technique in the presence of artifacts, from to Ge emission, a problem not observed in Si doped capsules.
- Symcap measurements using the same setup reproduce reasonably.
- At the same laser parameters, a THD ,as expected, converges more than a Symcap and have similar symmetry.