Symmetry in a 48 beams Direct Drive configuration

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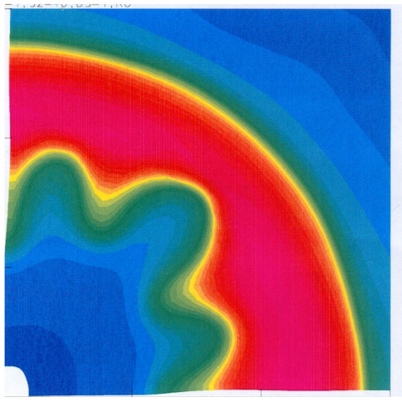


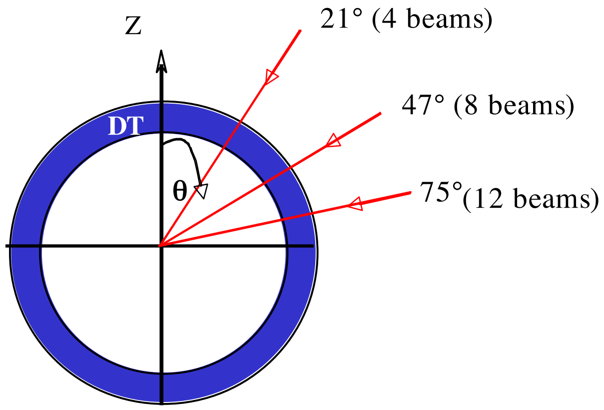
The objective is

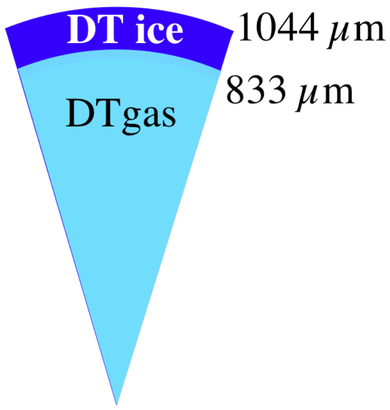
(1) to try to assess the impact of laser intensity asymmetries on implosion asymmetries: intrinsic asymmetry in a 48 beams configuration

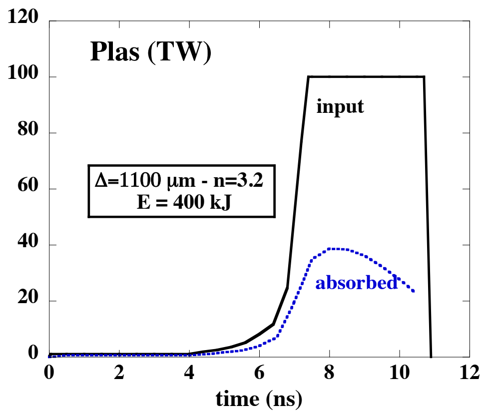
(2) to determine the more sensitive parts of the pulse, as a support to the PDD optimization: mono-mode asymmetry in case of normal incidence

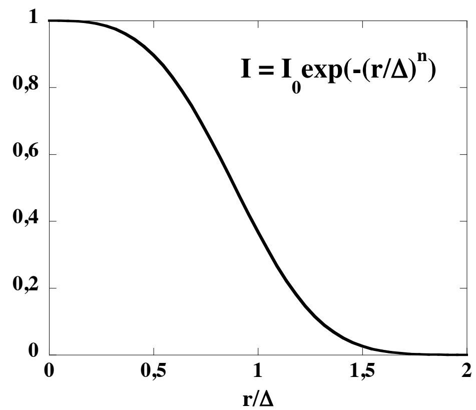
Intrinsic asymmetry
48 beams config.

As a starting point, we use the target designed by *Atzeni et al* *(POP, 14, 2007)*



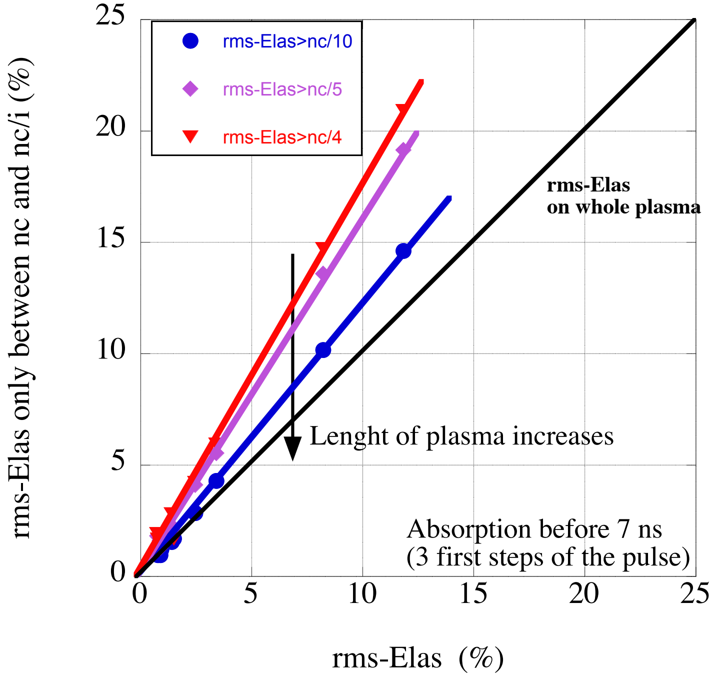






Intrinsic asymmetry
48 beams config.

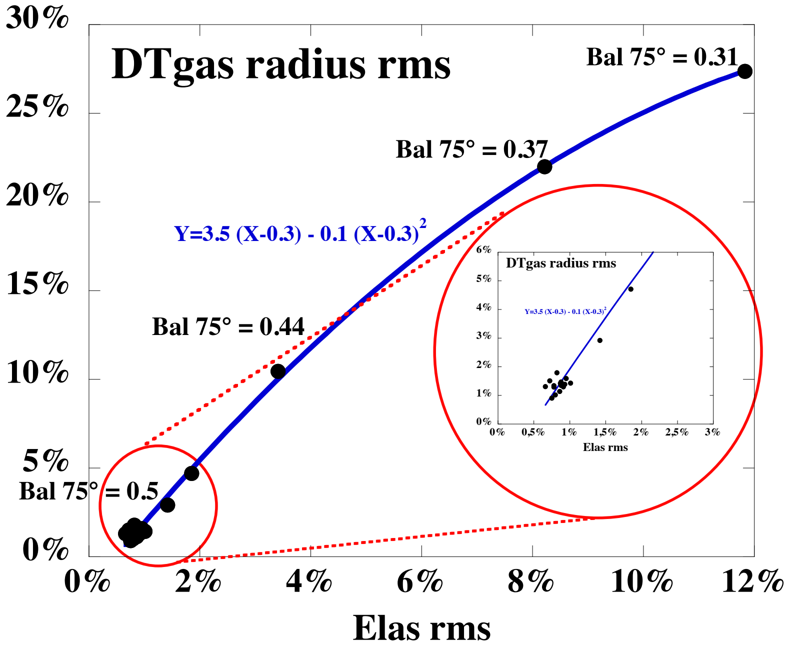
Where asymmetries on laser absorption (here before 7 ns) have to be estimated ?



- Laser asymmetries are generated by varying focal spot (n and Δ parameters) or power balance.
- We compare asymmetries on laser absorption between nc and nc/4, nc/5 or nc/10, with asymmetry on laser absorption along the whole plasma
- Levels are clearly different. But the trends are exactly the same: when incident laser asymmetry increases, all the metrics exhibit a linear increase of the asymmetry.

Intrinsic asymmetry
48 beams config.

How initial laser asymmetry translates in end-of-implosion asymmetry ?

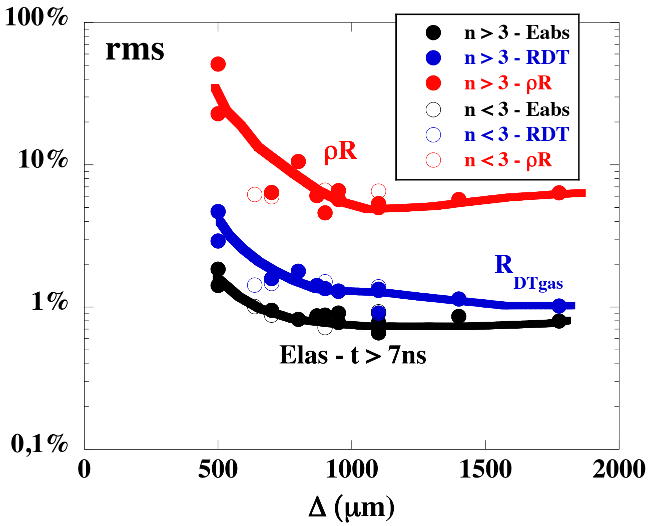


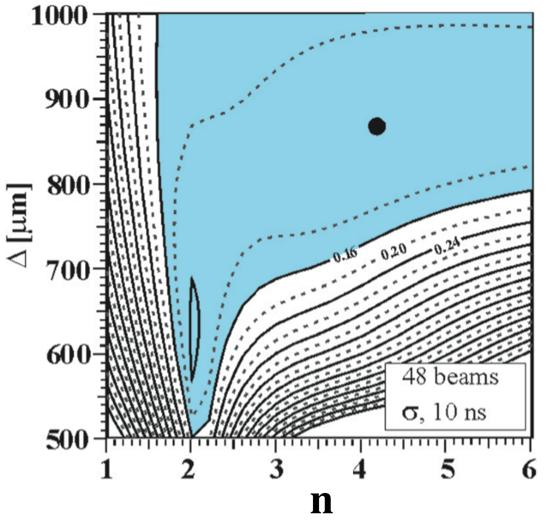
- Here, two metrics are compared: the rms deviation of the DT gas radius at peak implosion velocity, and the rms of energy absorbed per unit of solid angle, during the first 3 laser steps (< 7ns).
- Correlation is readily observable: rms_R_{DT} is about 3 times rms_Elas

$V \sim (I\lambda^2)^{1/3}$ *(Lindl 1995, p. 3959)*

$\Rightarrow \Delta R/R \approx R_c\, \Delta v/v \approx R_c/3\, \Delta I/I \approx \mathbf{3}\, \Delta I/I$

As expected, enlarging the focal spot improves symmetry, at least for half-width (Δ) lower than 800 µm

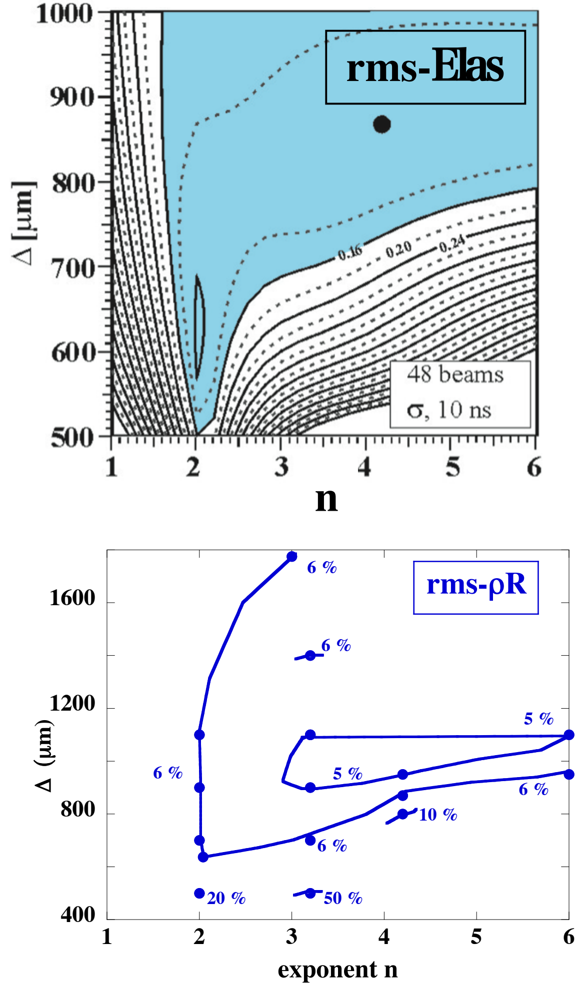




- Each result comes from an optimized 2D simulation where the implosion velocity is maintained to 2.9 10^7 cm/s.
- Here, symmetry is assessed from three metrics: the Root Mean Square (rms) deviation of the DT gas radius at peak implosion velocity, the rms of ρr, and the rms of laser absorption before 7 ns.
- Correlations between the three metrics are observable
- Same trends than in Ray-tracing model (*M. Temporal*)

Intrinsic asymmetry
48 beams config.

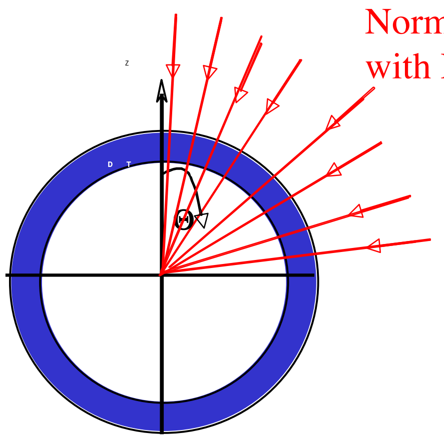
Similarities are observable between 2D simulations and ray-tracing model from *(M. Temporal and B. Canaud, EPJD 2009)*

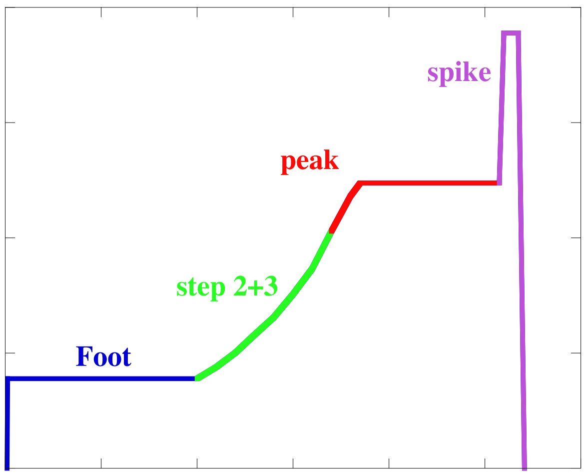


- In the (n, Δ) space, contour lines of (up) rms_Elas from model and (down) rms_ρr from 2D simulations, are plotted.
- Although both metric are calculated at different moments and places, iso-contour asymmetry are similar:
  - for n >2, symmetry depends mainly on the width of the focal spot
  - for n< 2, symmetry depends mainly on the exponent

After having studied the effect on implosion of intrinsic asymmetries created by the laser irradiation, we address the impact of mono-mode asymmetries (P2 or P4) in case of normal incidence

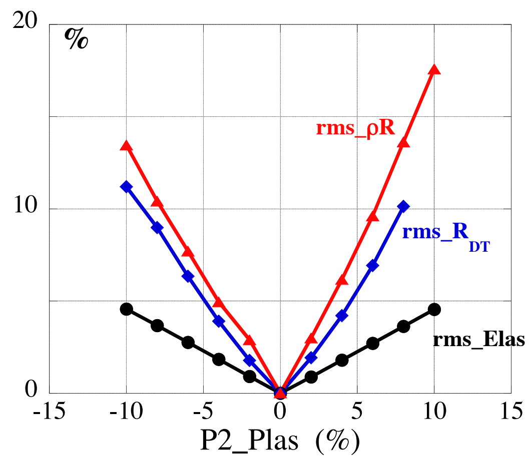
Mono-mode asymmetry normal incidence

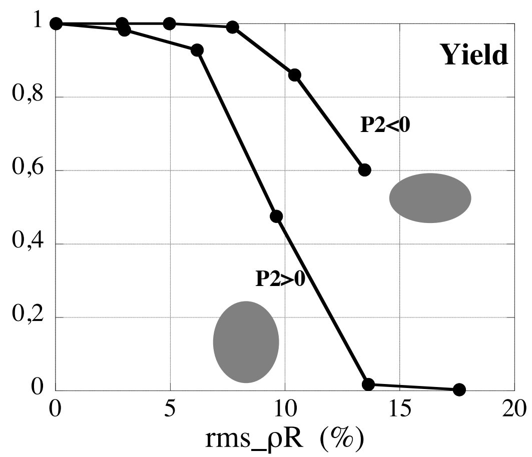




- We performed 2D calculations with normal incidence (no focal spot).
- A spike is added at the end of the main pulse, to ignite the capsule
- For some calculations, P2 or P4 are applied on part of the laser pulse (either foot / or (2nd + 3rd) steps / or peak / or the spike)

How mode 2 applied on the whole pulse is amplified ?





- We found that (not in the figure)

incident laser power asymmetry = absorbed laser energy asymmetry
(normal incidence)

- We checked that (see figure)

  rms_Elas = 1/√(2l+1) P2_Elas ≈ 4.5 P2_Elas

  rms_R_{DT} ≈ 3 rms_Elas

- Capsule fails when rms on ρR exceeds 10-15 % (P2 incident mode only)
- A negative P2 leads to a more effective compression, thus to more yield

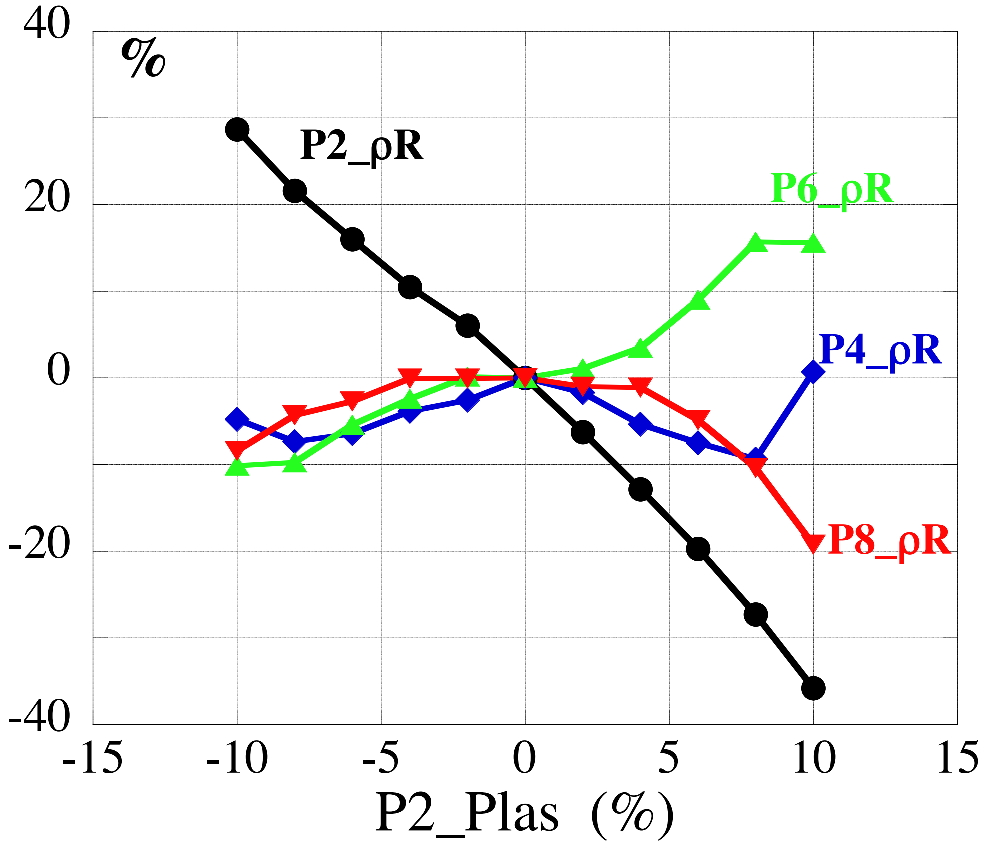
  (it's easier to compress a "sausage" than a "pancake")

  (see also S. Pollaine et al, IFSA 2002, for the same results in NIF calculations)

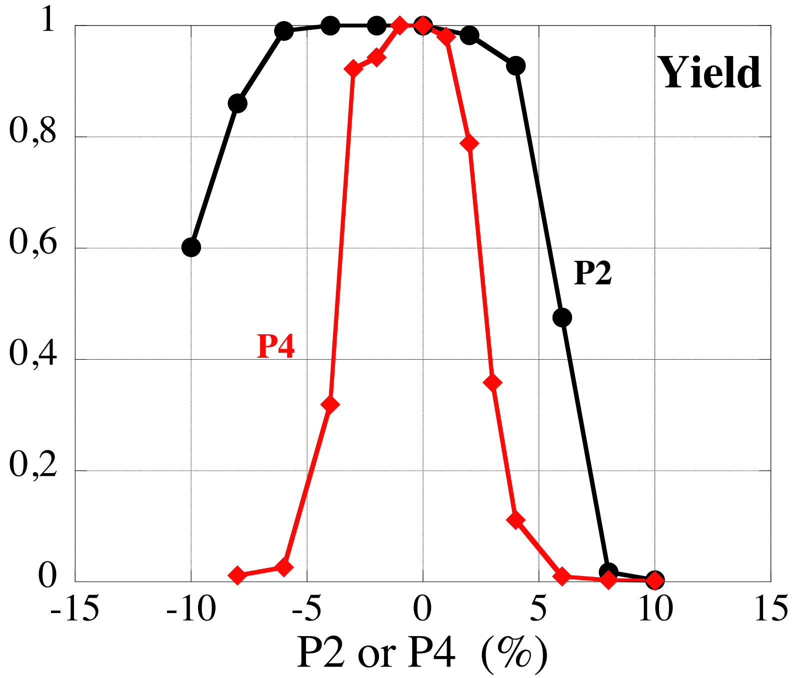
Mono-mode asymmetry
normal incidence

Mode 2 on ρR varies linearly with incident P2. The third harmonic (mode 6) is important

P2_ρR ≈ 3 P2_Elas



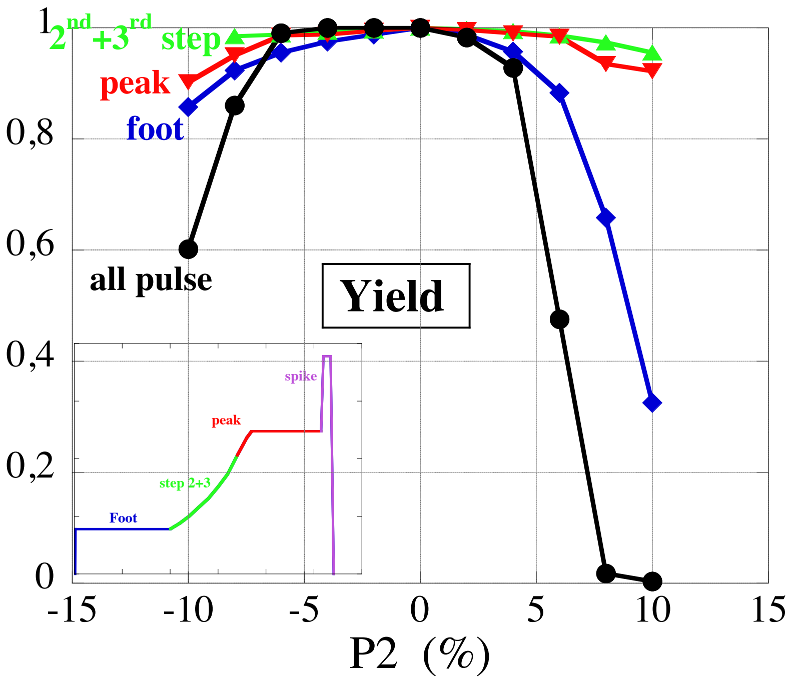
Constant P2 (P4) causes the capsule to fail when the amplitude exceeds 6 % (3 %)



- A P4 mode appears to be more deleterious than P2
- We plan to run higher mode calculations

Mono-mode asymmetry
normal incidence

Which part of the pulse is essential ?

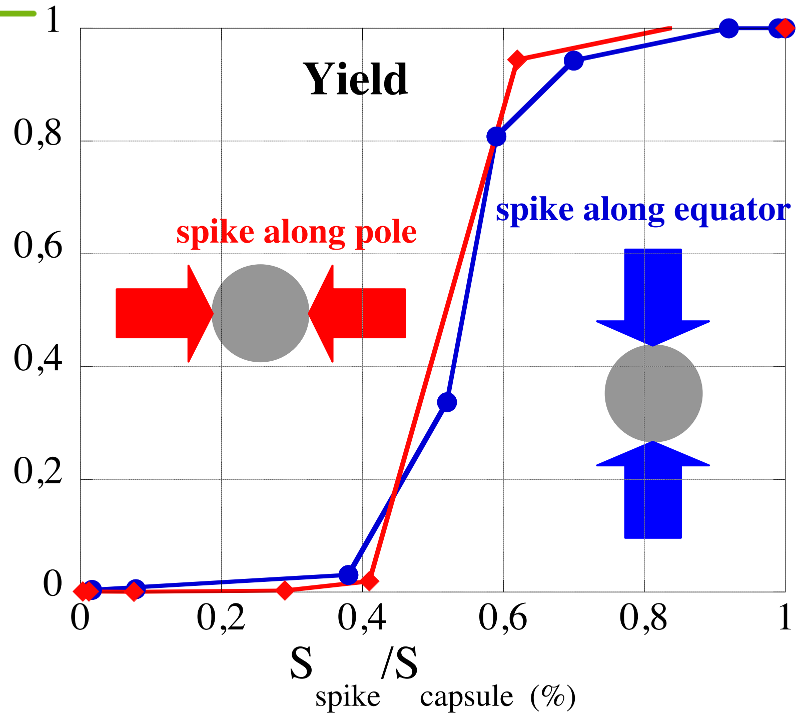


- The foot is clearly more sensitive to low mode asymmetries than the following of the pulse: imprint effect

(homogeneous spike, here)

Mono-mode asymmetry
normal incidence

A huge asymmetry is acceptable on the spike



- The capsule still ignites with P2 applied on the spike, between P2=-100 % and P2=200 % (with an homogeneous assembly pulse)
- We remove spatial part of the spike, without changing the laser power (see figure).

The capsule fails when $S_{spike} < S_{capsule}/2$

(see also X. Ribeyre, PPCF, 2008)

Conclusion

- We performed 2D simulations . in case of a 48 beams direct-drive configuration, with variations of the focal spot

  . in case of normal incidence and single mode (P2 or P4)

- We correlated absorption asymmetries and end-of-implosion asymmetries.

- We have provided evidence of similarities between results from 2D hydrodynamic simulations and ray-tracing model from M. Temporal.

- We found that the yield is more sensitive to a P4 mode than a P2 mode.

- We found that foot asymmetries are essential (imprint). Huge asymmetries on spike are acceptable.