Update on MJ Laser Target Physics

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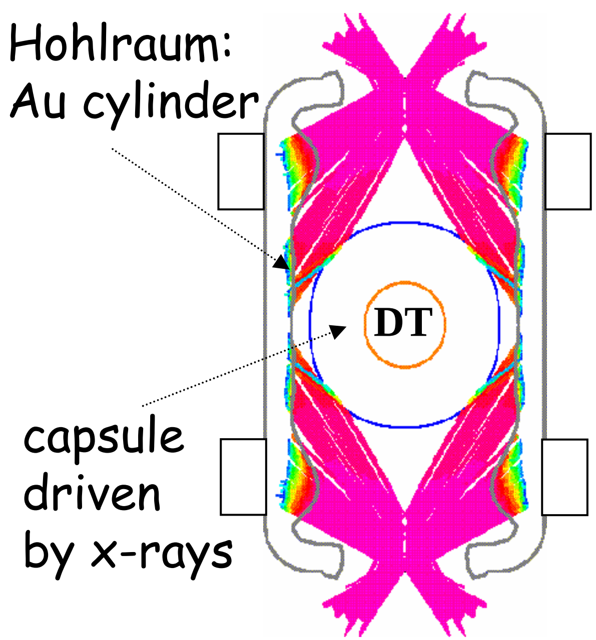
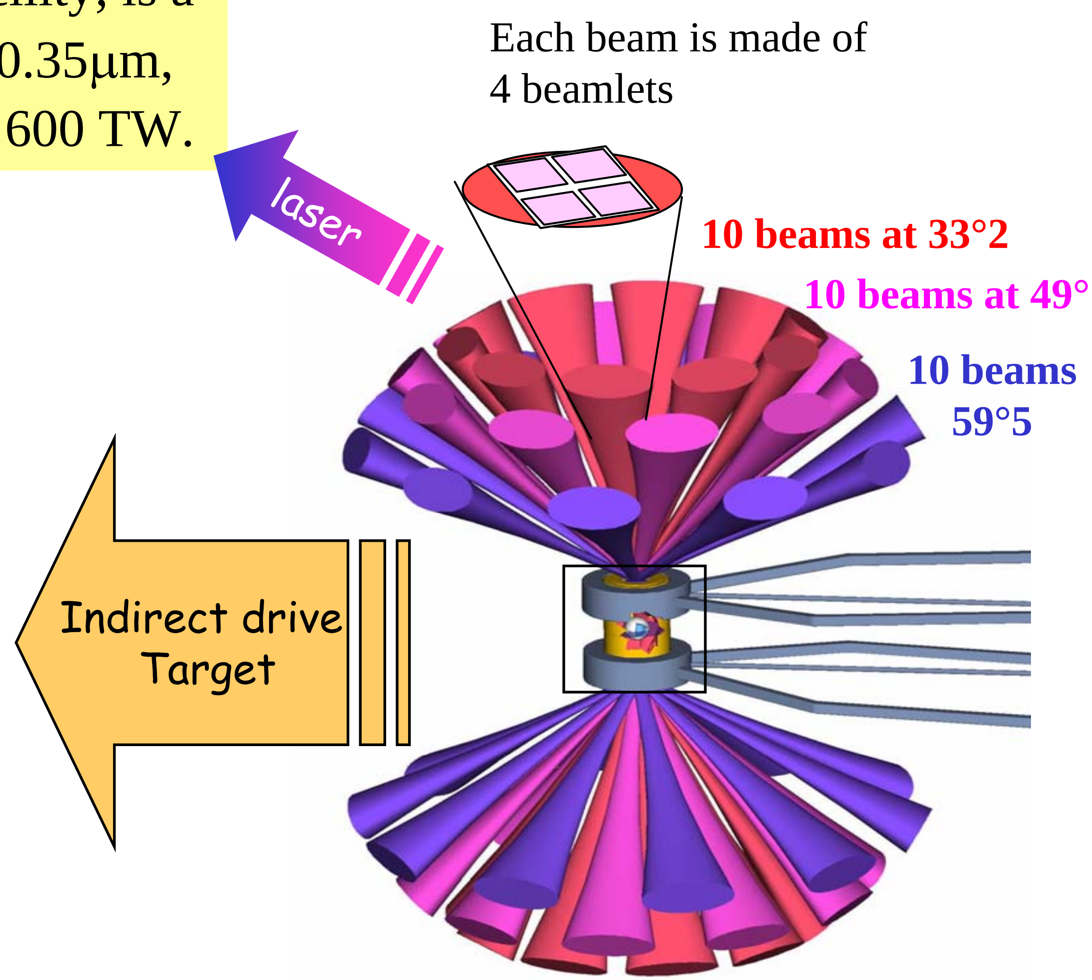
Update on LMJ Target Physics

The Laser Megajoule facility, is a 240 beamlet laser at λ=0.35µm, delivering up to 2 MJ or 600 TW.





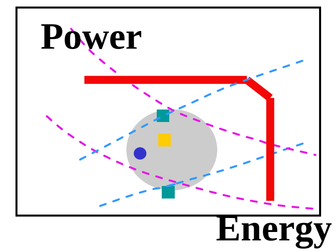
LMJ is under Construction (site in sept. 2004)

Target chamber (10m diameter) will be installed in june 2006

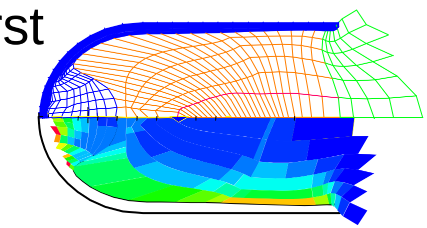
Concrete & steel framework slabs of the laser

Summary

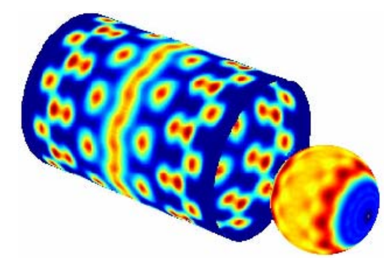
- We have designed several targets in the {Energy $_{laser}$,Power $_{laser}$} domain.



- LIL (4 beamlets) is the LMJ prototype and the first experiments are planned for 2005.

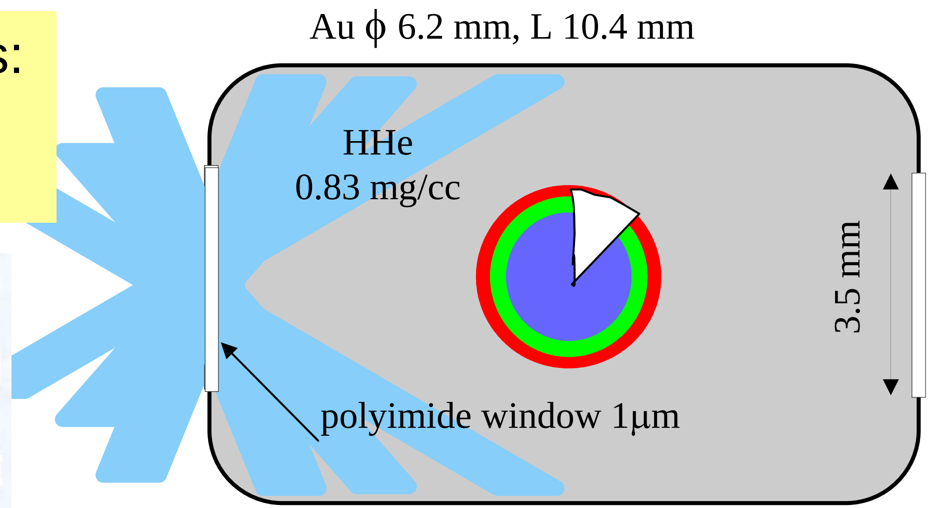


- We have estimated the effect of radiation non-uniformities around the capsule due to laser imbalance and mispointing.

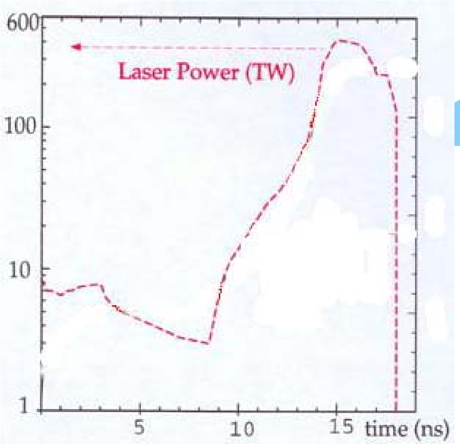


Indirect drive ignition target with cryogenic DT capsule

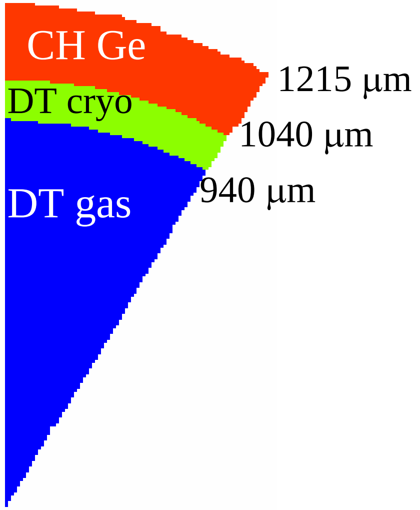
integrated 2D simulations: capsule in hohlraum for the symmetry



1.4 MJ
440 TW
Tr=300 eV
190 kJ on capsule,
25 MJ fusion



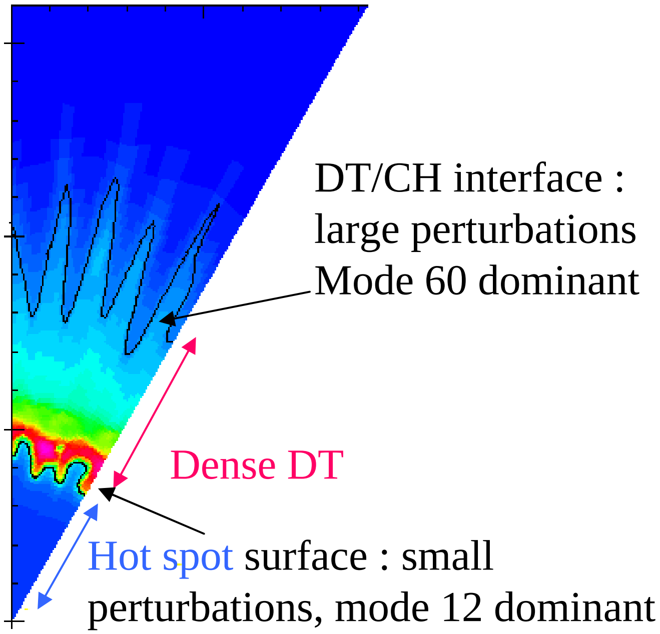
capsule-only 2D simulations for the Rayleigh-Taylor instabilities



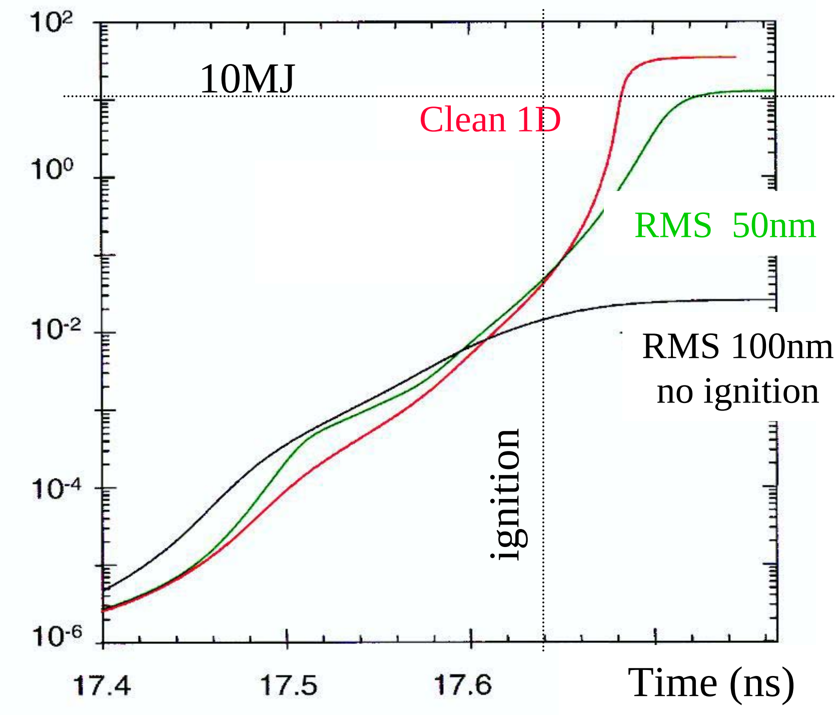
1 The integrated 2D simulations don't deal with 2 major issues:

- The risk connected to Rayleigh-Taylor instabilities:
our capsule can tolerate 50nm ablator roughness and 1µm DT ice roughness.

Density contours at ignition (modes 12 to 60)

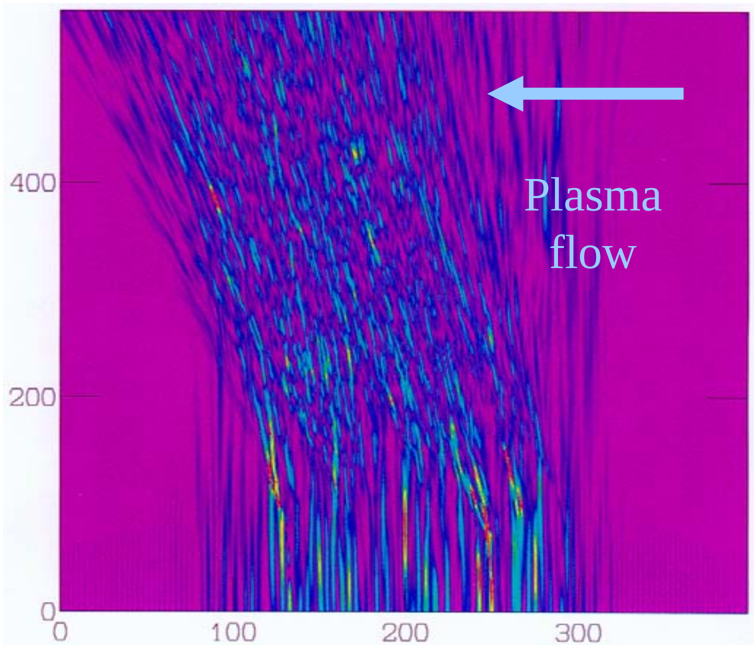


Fusion yield (MJ) with different ablator roughness

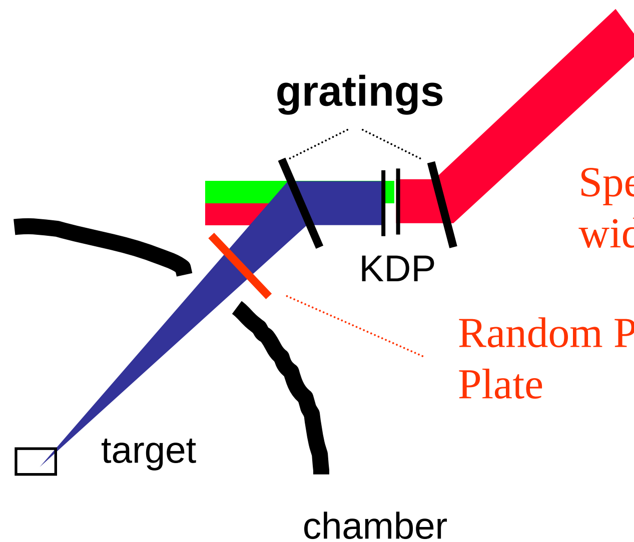


D. Galmiche, C. Cherfils

1 - The risk connected to Laser Plasma Interaction is controlled by beam smoothing



Filamentation of the beam leads to
-beam deflection: the figure shows the simulation by a **paraxial propagation code** in LMJ conditions.
-backscattering out of the hohlraum (Brillouin and Raman)

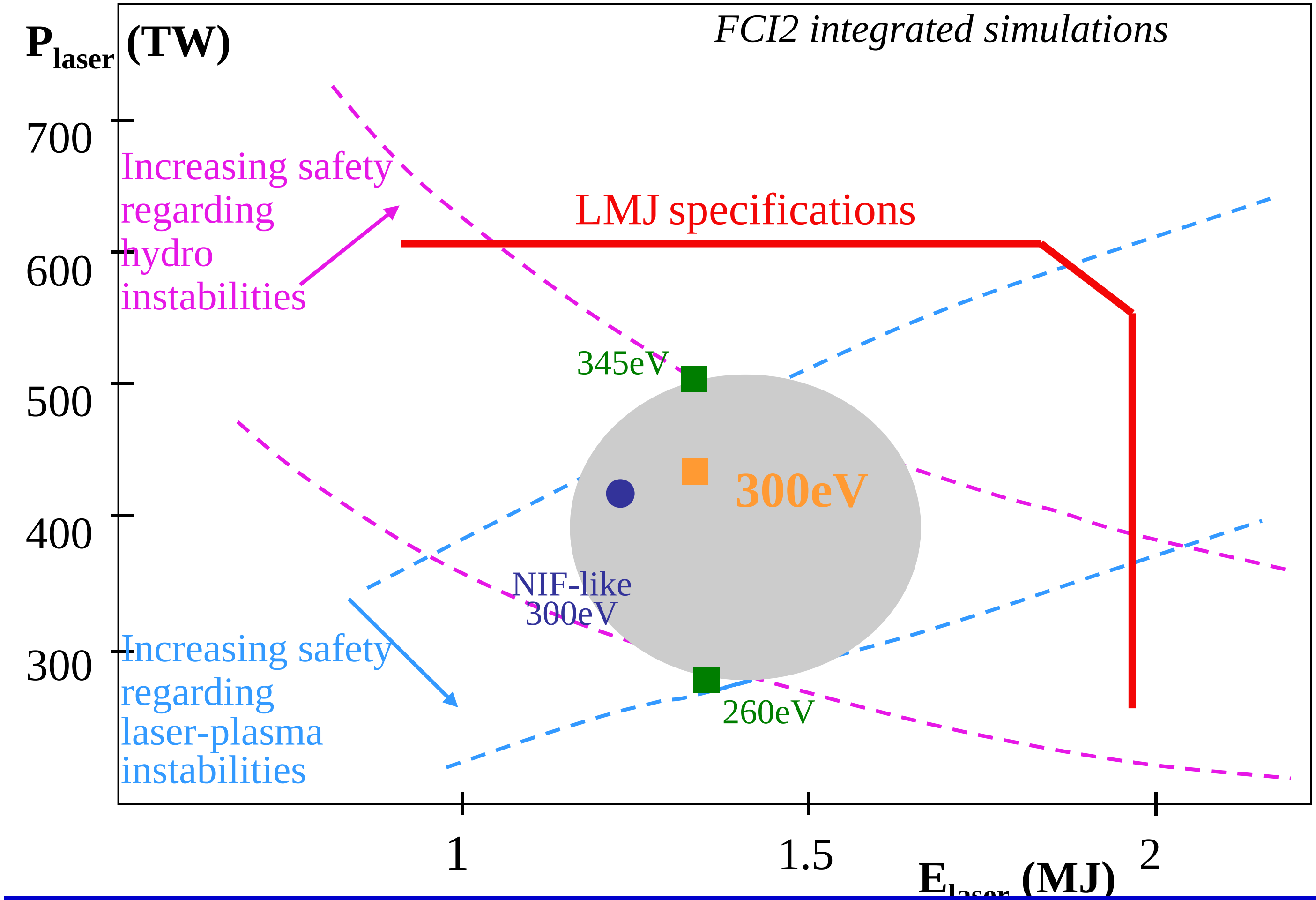


LMJ focusing-&-smoothing system

• control of filamentation by breaking the laser coherence (laser smoothing or SSD)

• electronic density
Ne / Ncritic < 10%

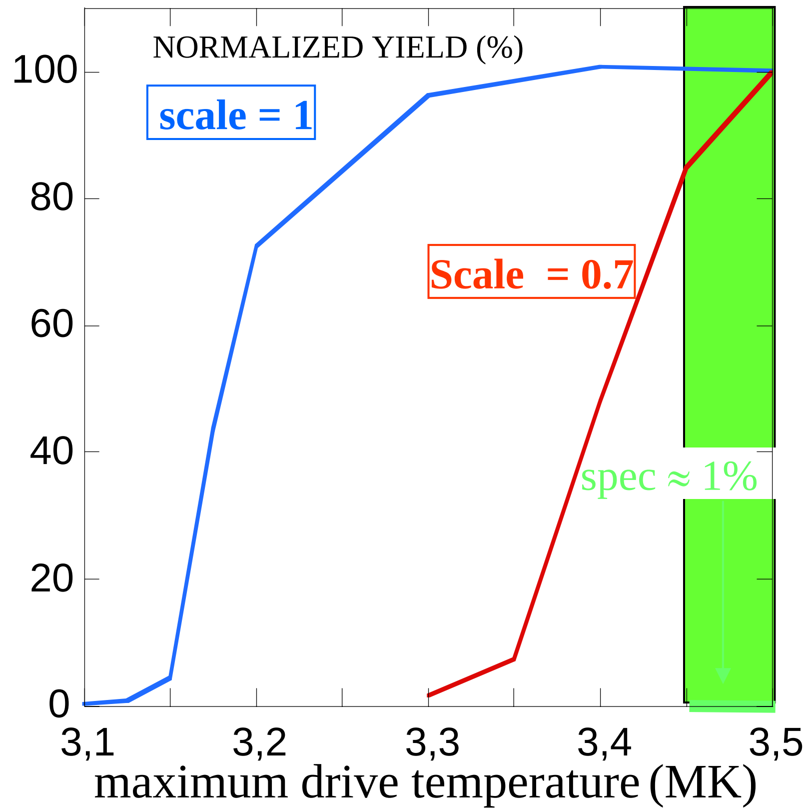
1 Ignition may be achieved in a large (E_{las}, P_{las}) region.



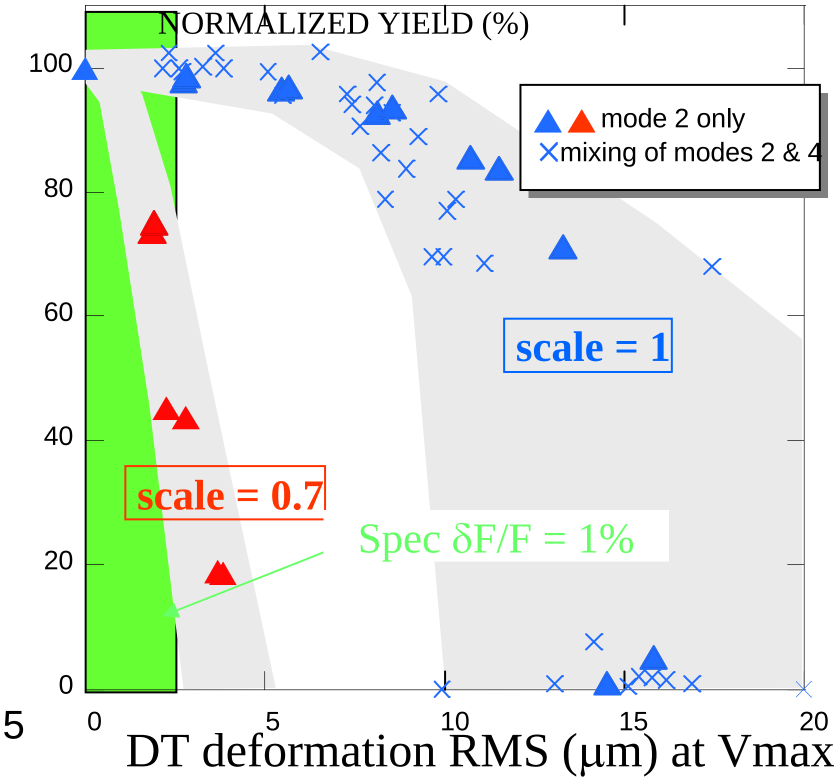
Our baseline target is a trade-off between hydro-instability and Laser Plasma Interaction risks.

1 A scale 0.7 capsule of our baseline target is not robust enough: the yield is divided by 5 (burn efficiency 31% -->14%).

The sensitivity to radiation Temperature alone (1D sim)



Sensitivity to DT deformation from low modes alone (2D sim)

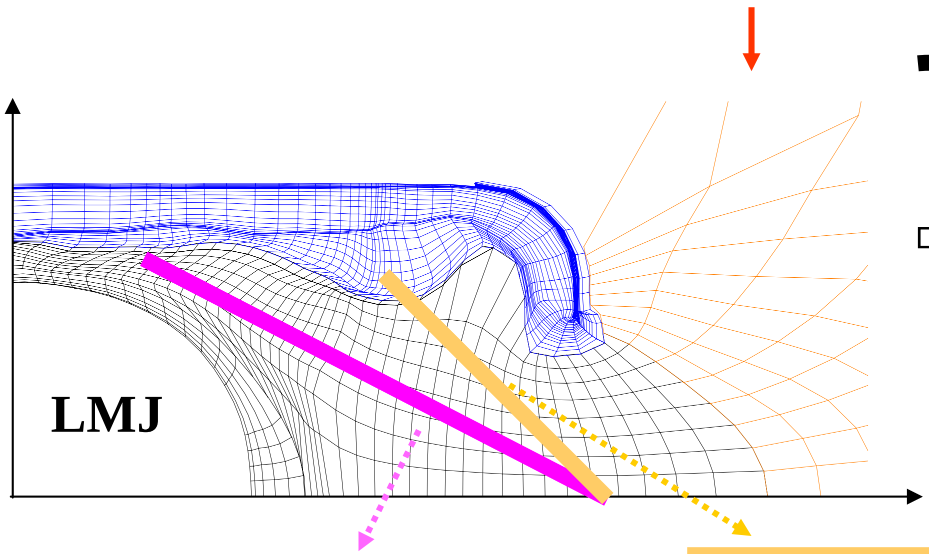


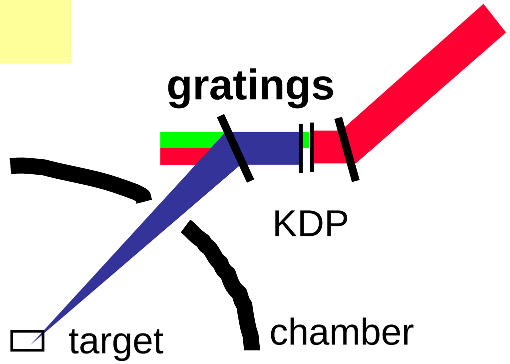
No margin for the other sources of gain drop

2

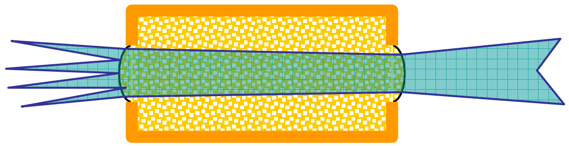
First **LIL** experiments will be devoted to **L**aser-**P**lasma **I**nstabilities & radiation measurements, with a longitudinal smoothing

In 2005, one beam will be available with longitudinal SSD on LIL (up to 30 kJ) .

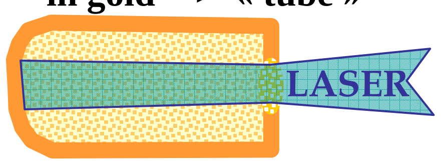




inner beams: Raman (SRS) dominant in gas => « open cylinder »



outer beams: Brillouin (SBS) dominant in gold => « tube »

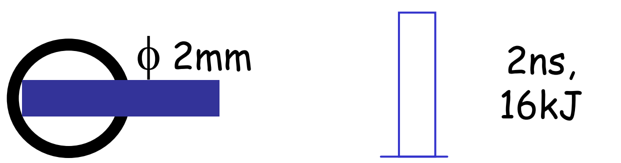


The **LIL** experimental program ranges from **NOVA** to **LMJ** conditions (Ne, Te, Tr)

2

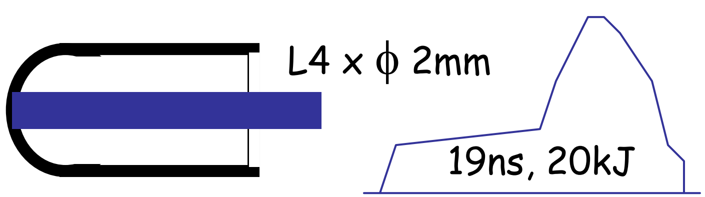
Reproduce Nova conditions

* *CEA shots on Nova [1994-1999]*



~ 10 shots

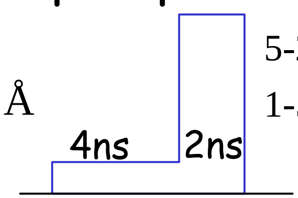
Reproduce LMJ with long pulse



~ 10 shots

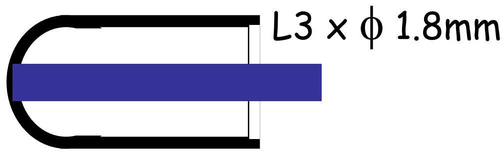
Reproduce LMJ with shaped pulse

$\Delta\lambda$ = 1 / 2.5 / 5 Å

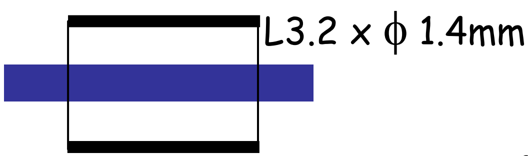


5-20 kJ,

1-5 10^{15} W/cm^2

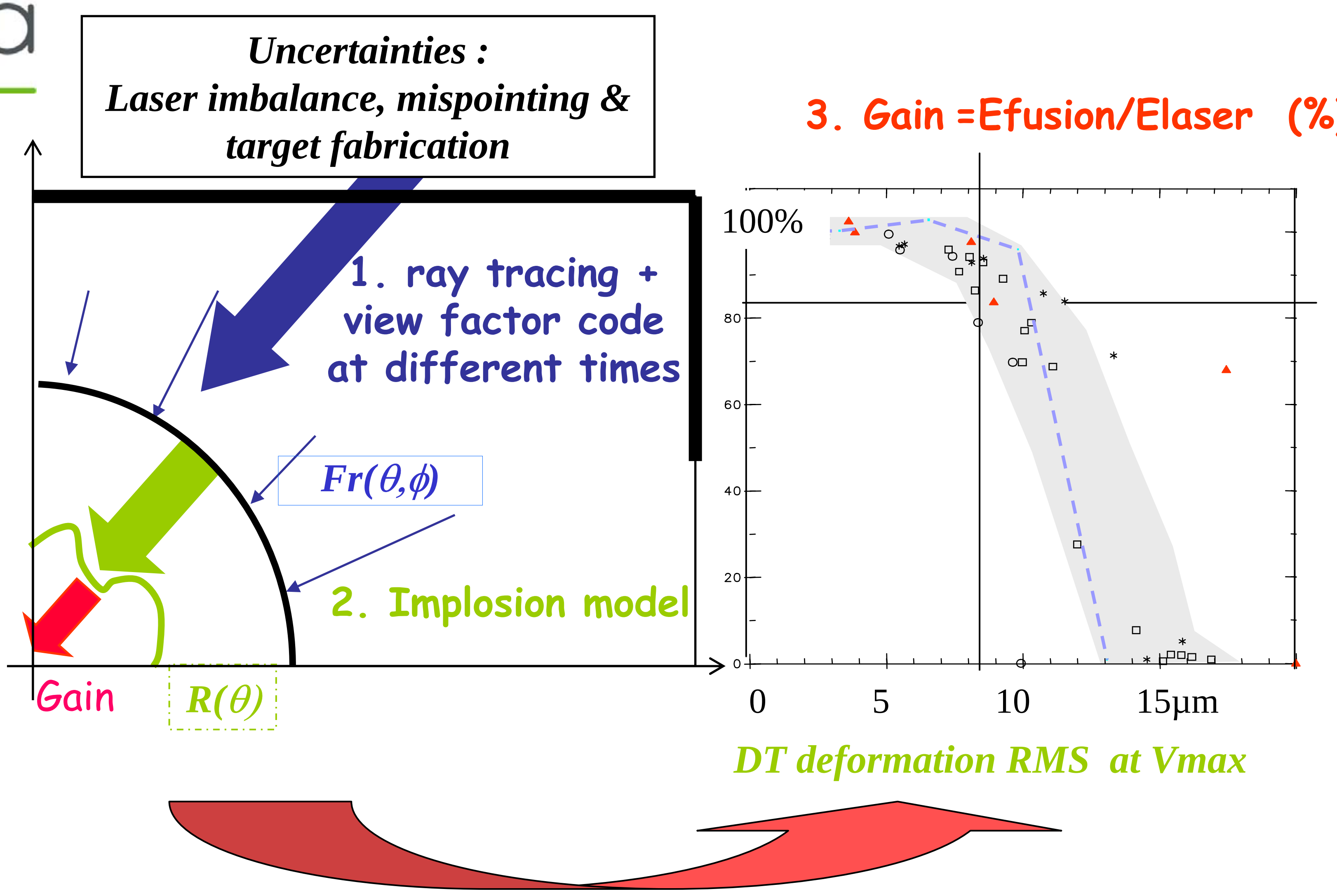


~ 10 shots



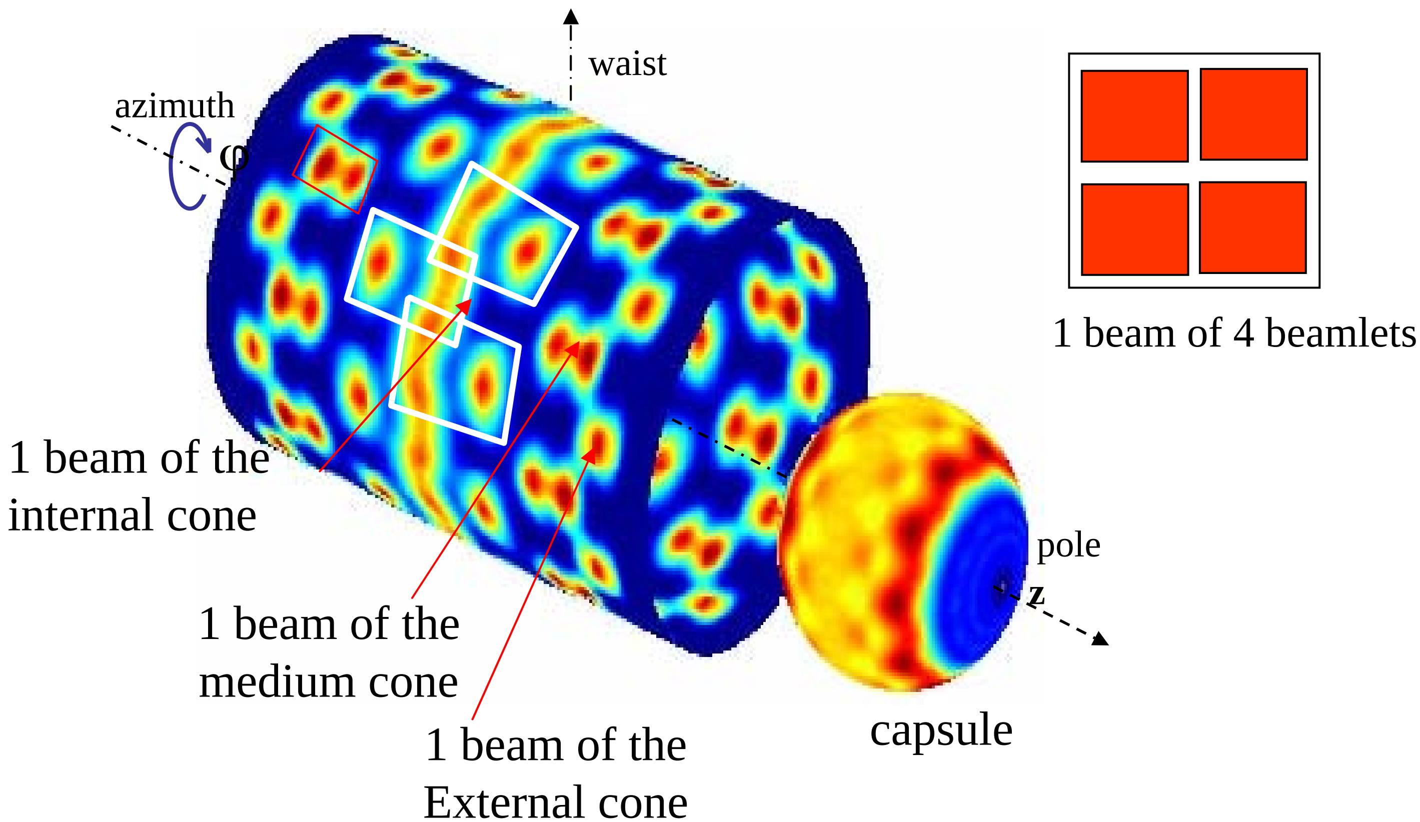
~ 10 shots

3 The Robustness against uncertainties is studied with a chain of 3 models fitted on bidimensionnal FCI2 simulations.



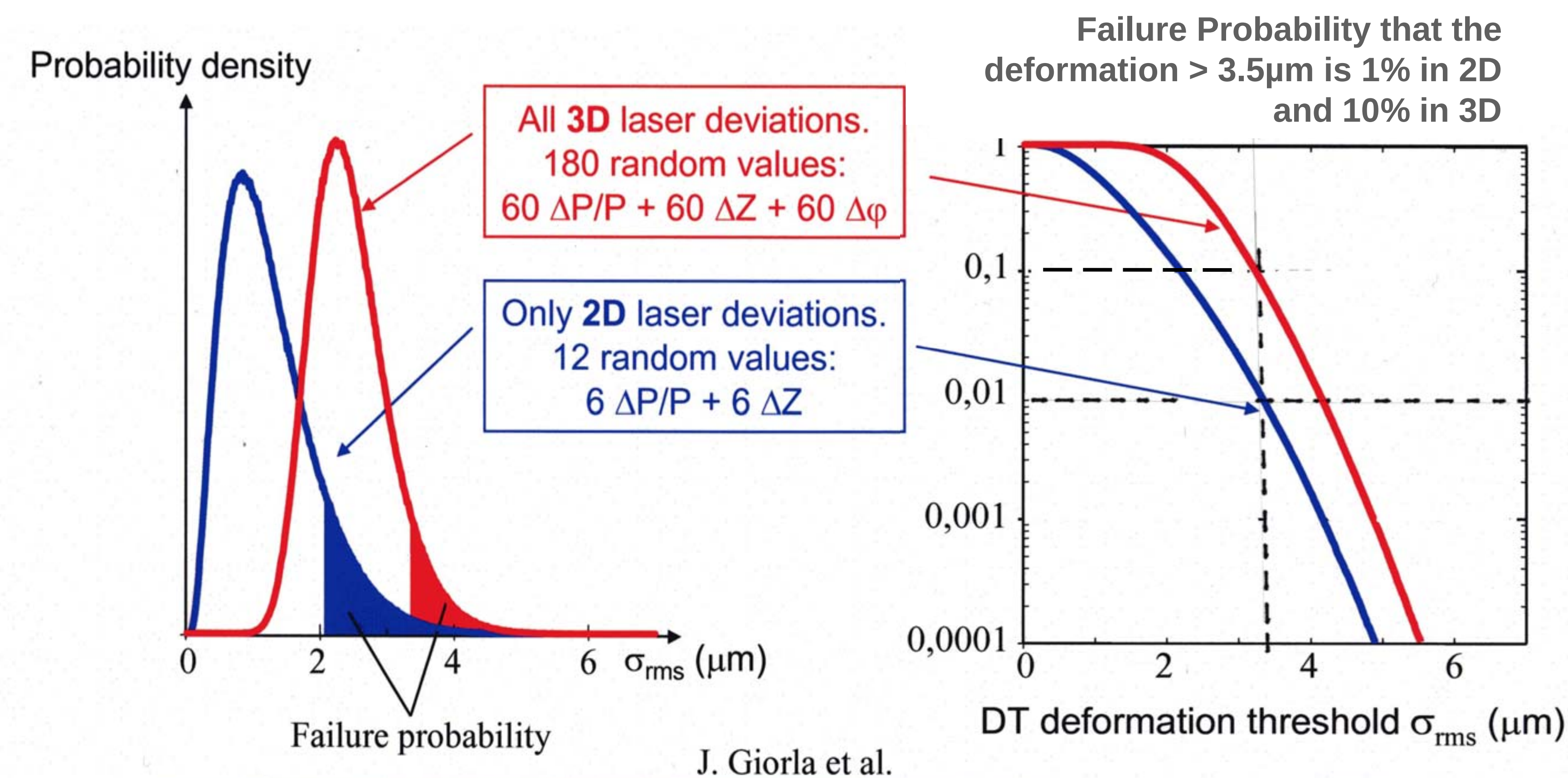
3 The Robustness against uncertainties is studied with the same chain of 2 models in 3D, up to the deformation.

Map of laser illumination with 60 beams on the hohlraum



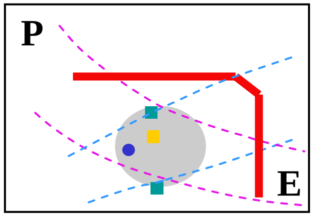
3 Regarding final DT deformation, 3D laser errors increase slightly the threshold obtained for only 2D errors.

The random variations within the specifications induce a random distribution of deformation σ by using a Monte Carlo model.
The spec. are **50μm RMS in pointing and 5% RMS in laser peak power**



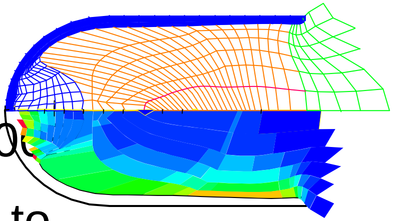
Summary of LMJ target physics

1



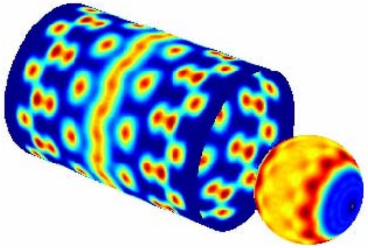
- A whole $\{E_{laser}, P_{laser}\}$ domain of targets was determined with different safety factors regarding hydrodynamic instabilities and laser-plasma instabilities .

2



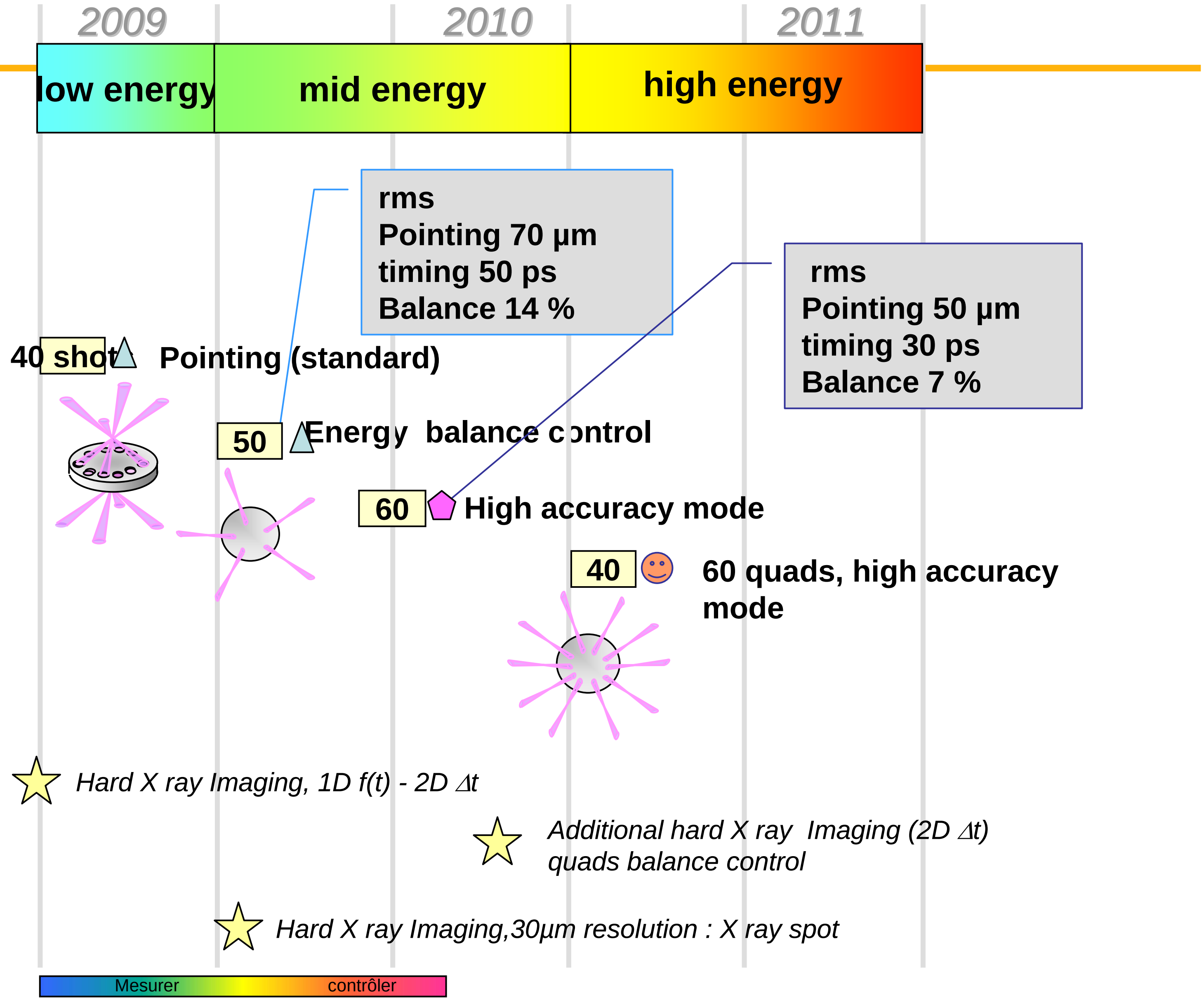
- About 40 shots representative of LMJ Laser-Plasma Instabilities and radiation conditions are planned in 20 on the LIL facility. The first goal of LIL experiments is to validate the laser beam smoothing.

3



- 3D laser errors don’t change dramatically the DT deformation threshold obtained for only 2D ones.

Strategy : 1-Reaching accuracy specifications



Differences NIF /LMJ

- Laser : A lot of features are very close because of the collaboration CEA-DOE since the beginning, but

- NIF = 192 beamlets, LMJ = 240 beamlets
- NIF focusing by lenses, LMJ focusing by gratings (➔ diff smoothing)
- Angles of the cones NIF 24-30°/ 45-50, LMJ 33° / 49 / 59.5

- Baseline targets very close, except

The inner beam crossing
Lining of the entrance holes / hole diameter
Ablator (but still 3 choices)

- New alternatives (for both):

2w/3w,
Capsule filling with DT by a micro-tube Diam ~ 10μ,
graded-dopant in the ablator