Laser Pulse Profile effects on target performance

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Outline

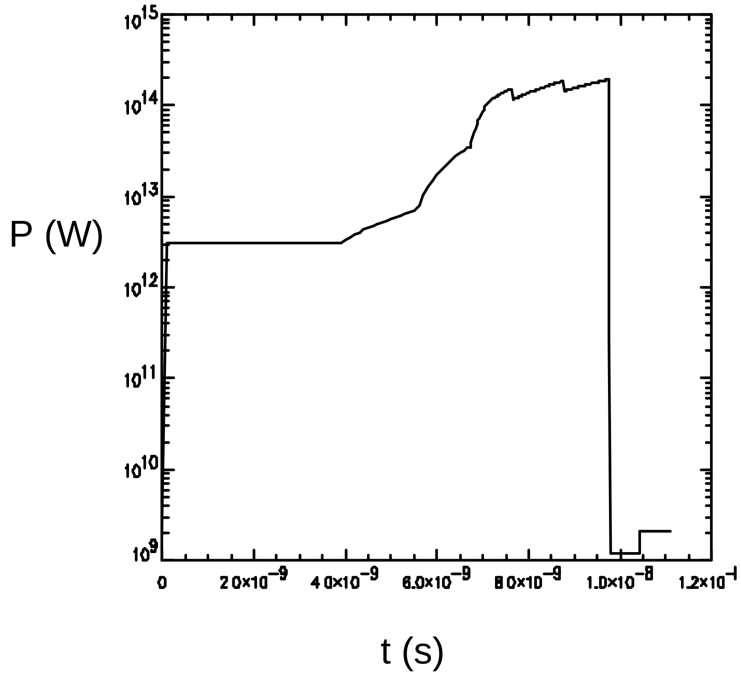
* Flat-top vs. rising pulse

* Hot electrons effects on gain

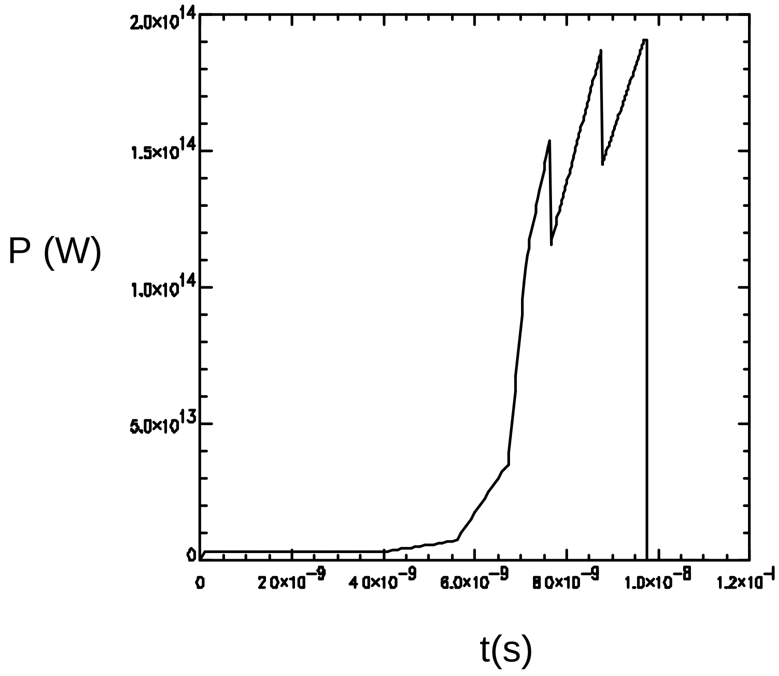
* Comparison between 1/4 and 1/3 μ light

1/2 MJ target, KrF   Old laser pulse (rising)

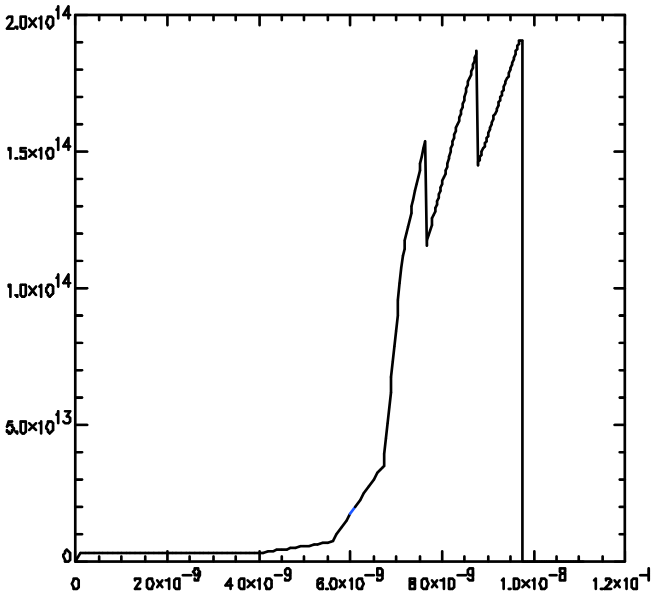
semi-log scale



linear scale



Old pulse



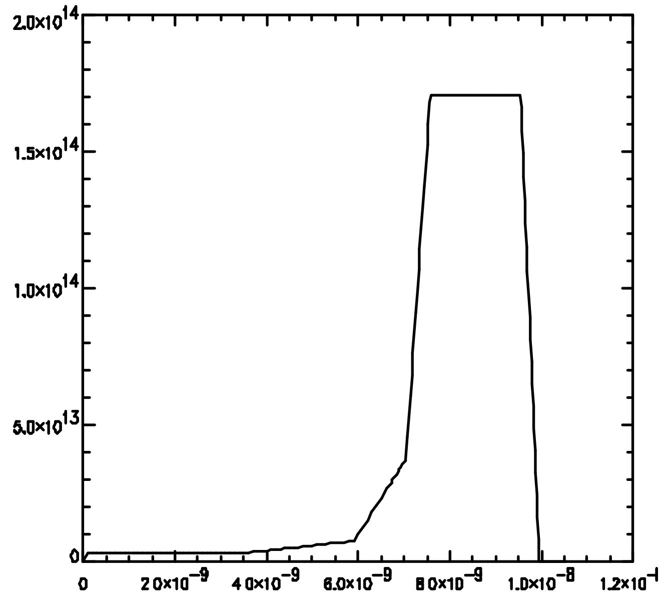
Gain= 58.8

max. v= 4.06×10^{7} cm/s

max. I = 2.5×10^{15} W/cm^2

E = 480 kJ

New flat-top pulse



Gain = 61.2

max. v = 4.04×10^{7} cm/s

max. I = 1.6×10^{15} W/cm^2

E = 480 kJ

Zooming now occurs without laser pulse power change

So, what changes?

Laser intensity on target since radius changes.

Changes small enough that they don’t affect target performance (no significant change in fuel adiabat).

Flat-top pulse

Lower peak Intensity (1.6 vs. 2.5×10^{15} W/cm^2) but ....

$I > 9 \times 10^{14}$ W/cm^2 for longer time (2.15 vs. 1.4 ns)

so depending on the threshold and growth rates of LPI,

this may or may not be an advantage but flat-top is easier

to make.

However, max. $I \lambda^2$ drops from 1.56×10^{14} to 1×10^{14} W-μ^2/cm^2

Hot-electron deposition model

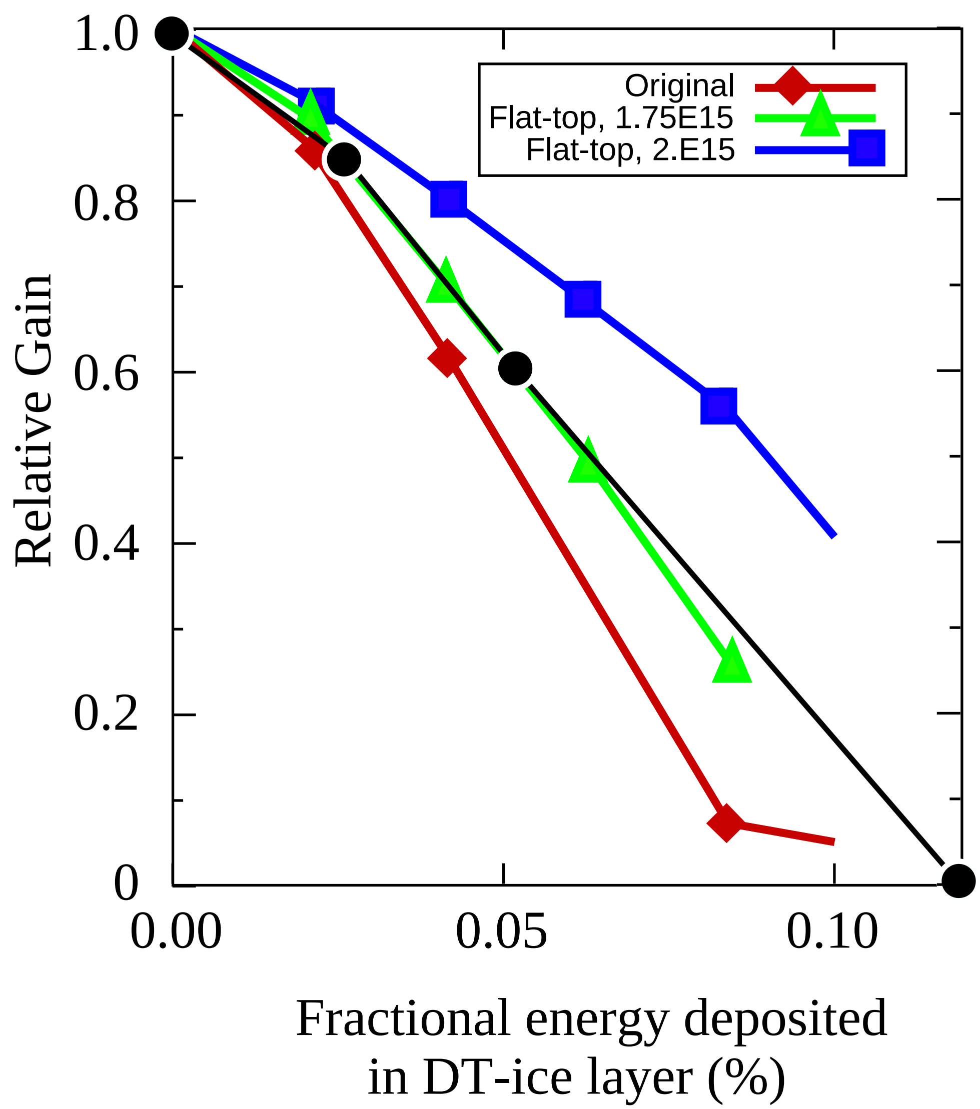
Simple model for hot-electron deposition

_ assume a given fraction of energy deposited goes into hot electrons

_ assume laser intensity above which hot electrons are generated

_ deposit hot electrons proportionally to density (since ~ 40% of total mass is fuel, 40% of hot electrons generated are deposited into fuel)

Degradation of gain due to arbitrary fraction in hot-e$^-$



Comparison between 1/4 and 1/3 micron targets (revisited)

Not very meaningful to make an exact comparison (same pellet, same laser pulse) because the 1/4 μ case will ignite and the 1/3 μ case will not.

Looking at various efficiencies:

- hydrodynamic eff. drops to 8.8% (from 10.1%)

- max. implosion velocity drops to 3.65×10^7 cm/s (from 4.06×10^7 cm/s)

- laser absorption eff. drops to 79% (from 90%) with 2-step zooming included

- $I\lambda^2$ increases to 1.89×10^{14} (from 1.56×10^{14})

- max. e-folds is 5.1 (vs. 5.4)

Comparison between 1/4 μ and 1/3 μ targets (continued)

Next best comparison: optimize laser pulse keeping the same pellet

Higher intensity (in order to get same pressure), so higher energy.

At “0" margin,

E_{inc} = 590 kJ (vs. 480 kJ for same pellet,1/4 μ)

v_{max} = 3.74 x 10^7 cm/s (vs. 4.06x10^7)

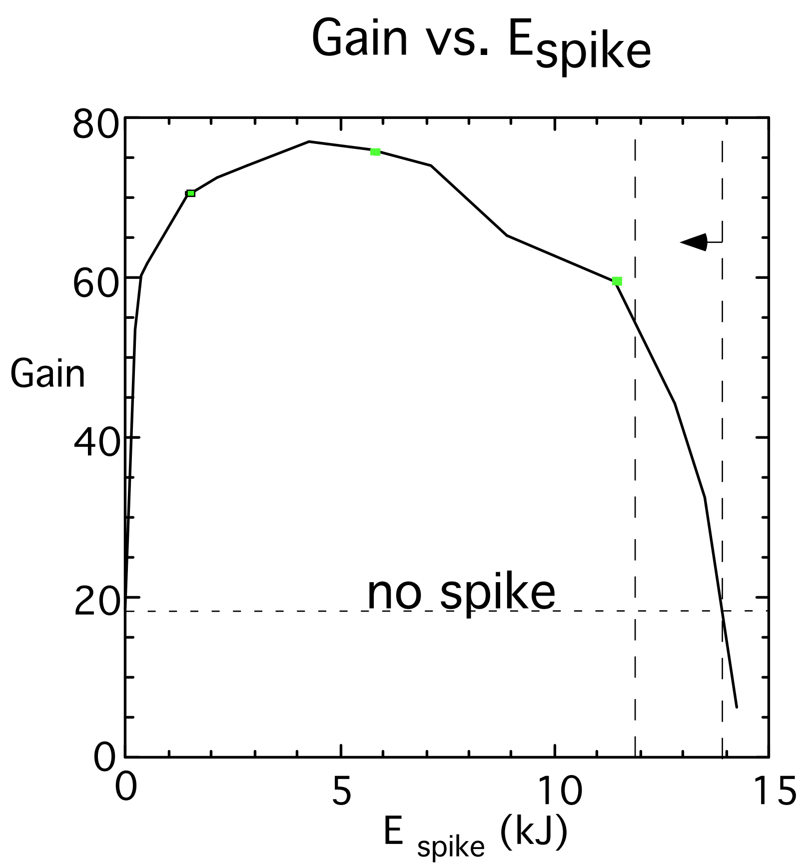
Gain = 40.7 (vs. 58 for 1/4 μ)

Max. no.of e-folds = 5.73 (vs. 5.41)

$I\,\lambda^2 = 2.22\text{x}10^{14}$ (vs. $1.56\text{x}10^{14}$ for rising pulse
$1.\text{x}10^{14}$ for flat-top)

So, in every aspect, performance of 1/3 μ target is less.

Spike main effect may be due to gain recovery in the presence of a strong stabilizing foot.



Conclusion

* Flat-top allows reduction in peak intensity.

* Effects of fast electrons similar to previous studies.

* 1/4 μ designs better at lower laser energies.