Pulse Shapes and Beam Smoothing for OMEGA and the NIF

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Direct-drive implosions on the NIF require maximum uniformity of laser irradiation on the capsule, which in turn requires maximum laser bandwidth. We have calculated the input IR laser pulse shape and energy necessary to produce frequency-tripled pulse shapes on target specified by target designers. These calculations take into full account the small but unavoidable conversion losses expected when using an additional tripler crystal to enhance the laser bandwidth to ~1 THz, and include the time dependence of these losses. Designs for both OMEGA and the NIF are presented. For possible 2-D SSD schemes on the NIF, the tradeoff between conversion and smoothing for deflections in the doubler-sensitive direction is evaluated. We have considered the possibility of time-dependent bandwidth on the NIF, in particular a reduction with time of the angular spread of the beam in one direction. For each SSD scenario, fully consistent IR and UV pulse shapes and smoothing parameters are calculated. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority.

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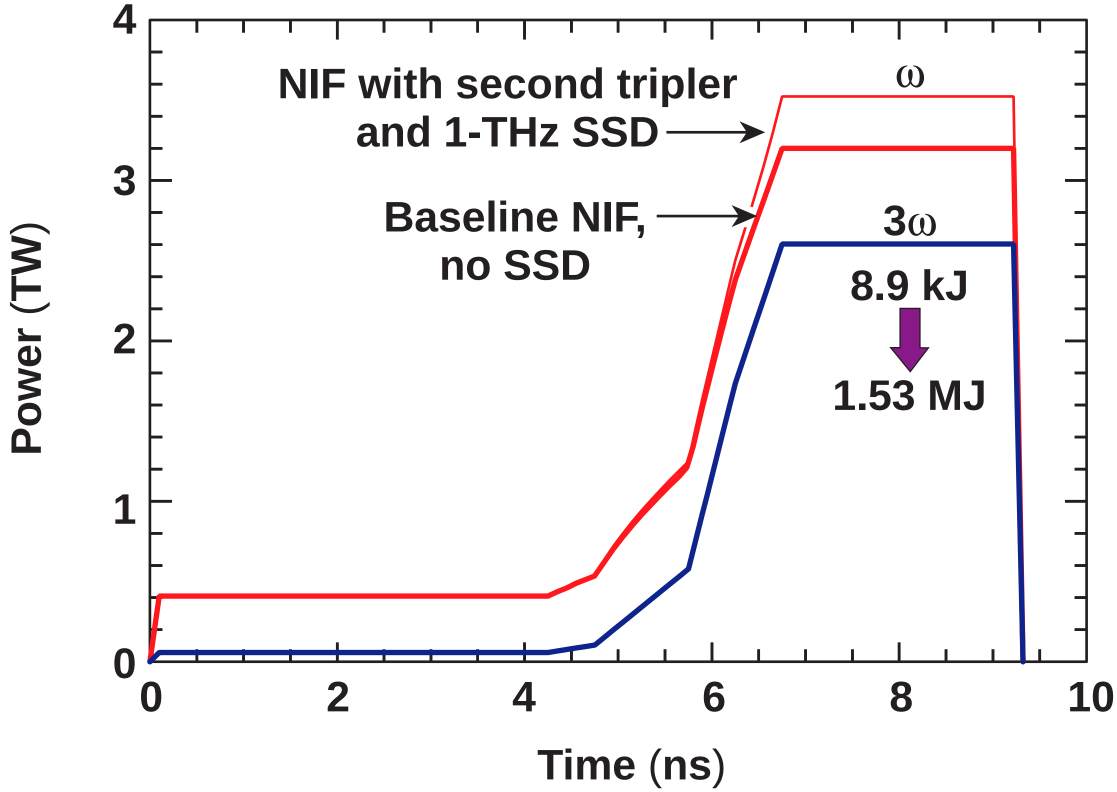

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Summary

The shaped pulses required for direct drive on OMEGA and the NIF with 1-THz, 2-D SSD can be generated with only a modest IR energy penalty

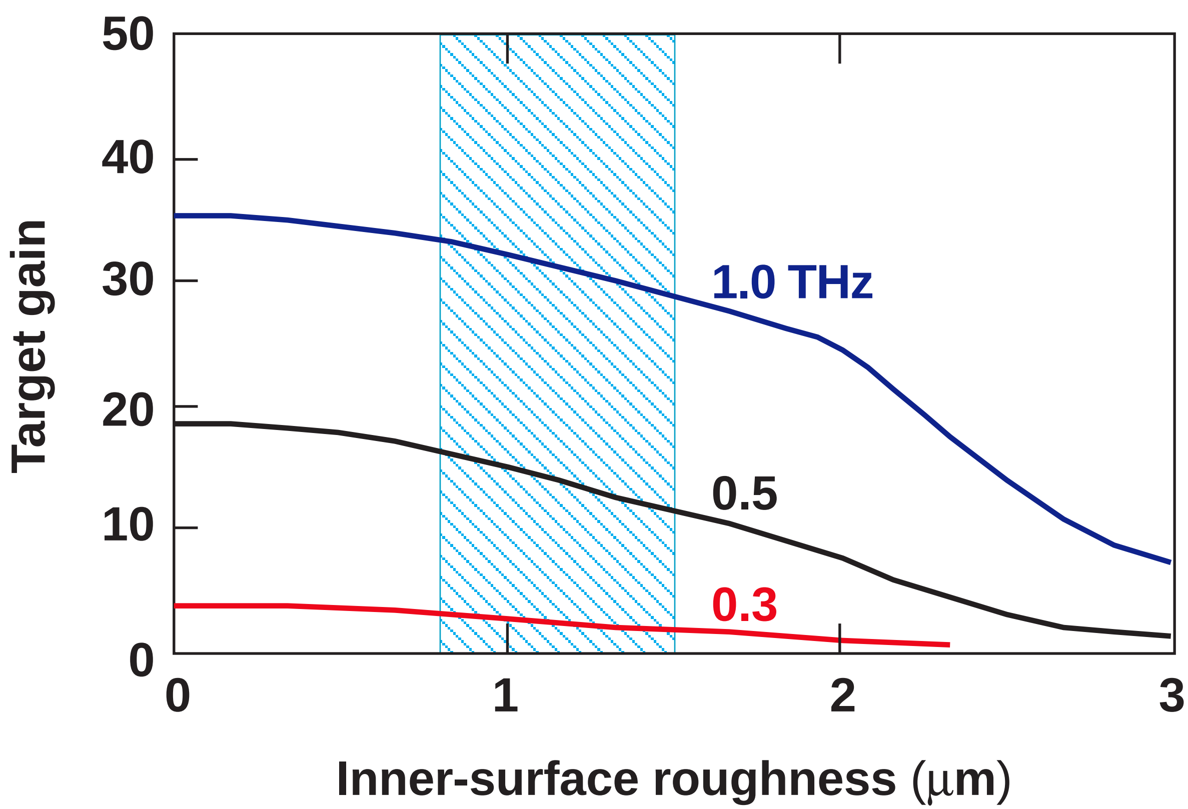
UR LLE

- A target gain of 30 is predicted for the NIF with 1-THz SSD.
- 1019 J (not 857 J) per beam (IR) is needed on OMEGA to make 31.6 kJ of UV on target.
- 14.2 kJ (not 13.2 kJ) per beam (IR) is needed on the NIF to make 1.53 MJ of UV on target.

Outline

- Direct-drive target design
  - gain, uniformity
- Conversion model including 2-D SSD
- Conversion results
  - How much IR do we need?

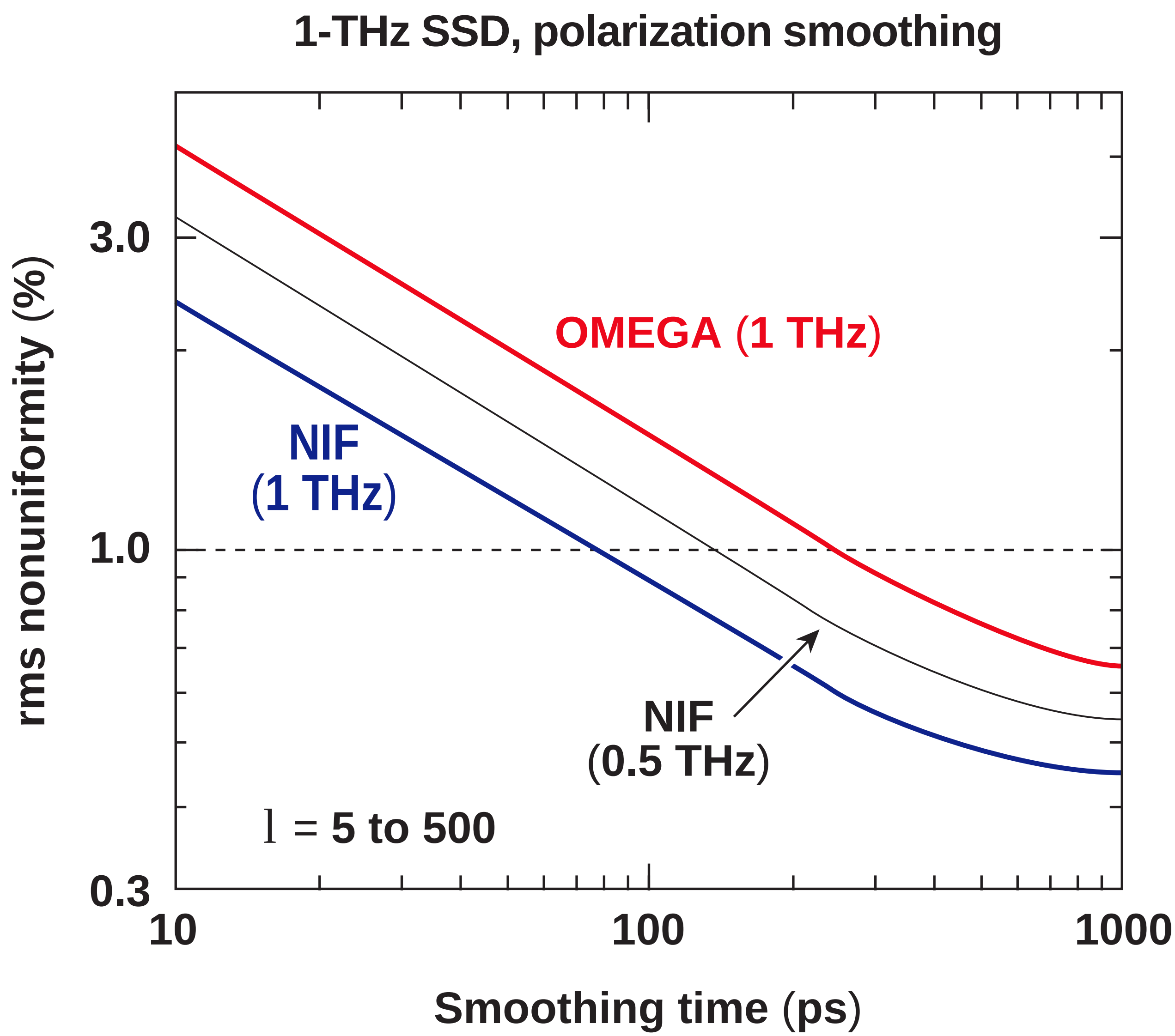
Higher SSD bandwidth produces increased target gain on the NIF*



Target: 2 μm CH on 340 μm DT, diameter 3.4 mm

*V. Goncharov *et al.*, Proc. IFSA, Bordeaux, France (September 1999).

The rms nonuniformity on NIF will be lower than on OMEGA in proportion to the square root of the number of beams



TC4896a

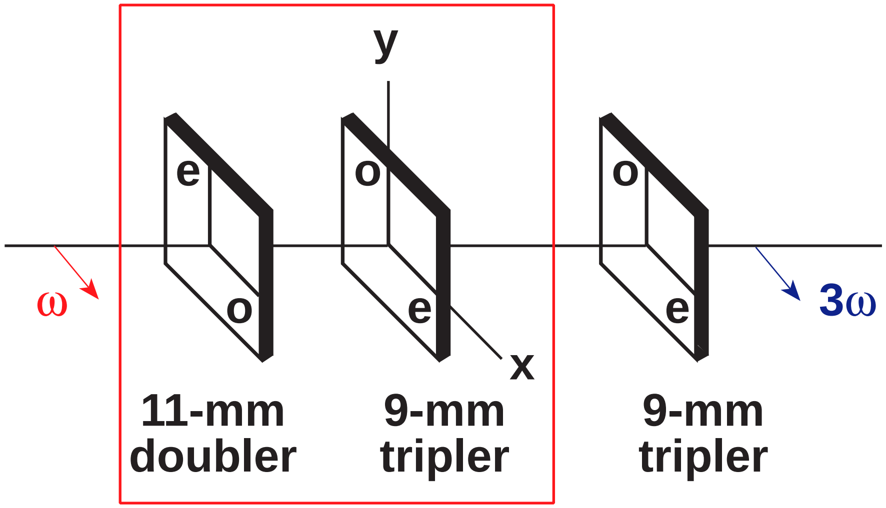
All conversion calculations include a realistic treatment of SSD

- For each ray in the beam the frequency conversion depends on

  $I\ (x,y,t)$

  $\Delta\lambda\ (x,y,t) = \Delta\lambda_x\ (x,t) + \Delta\lambda_y\ (y,t)$

  $\Delta\theta_x\ (x,t),\ \Delta\theta_y\ (y,t)$

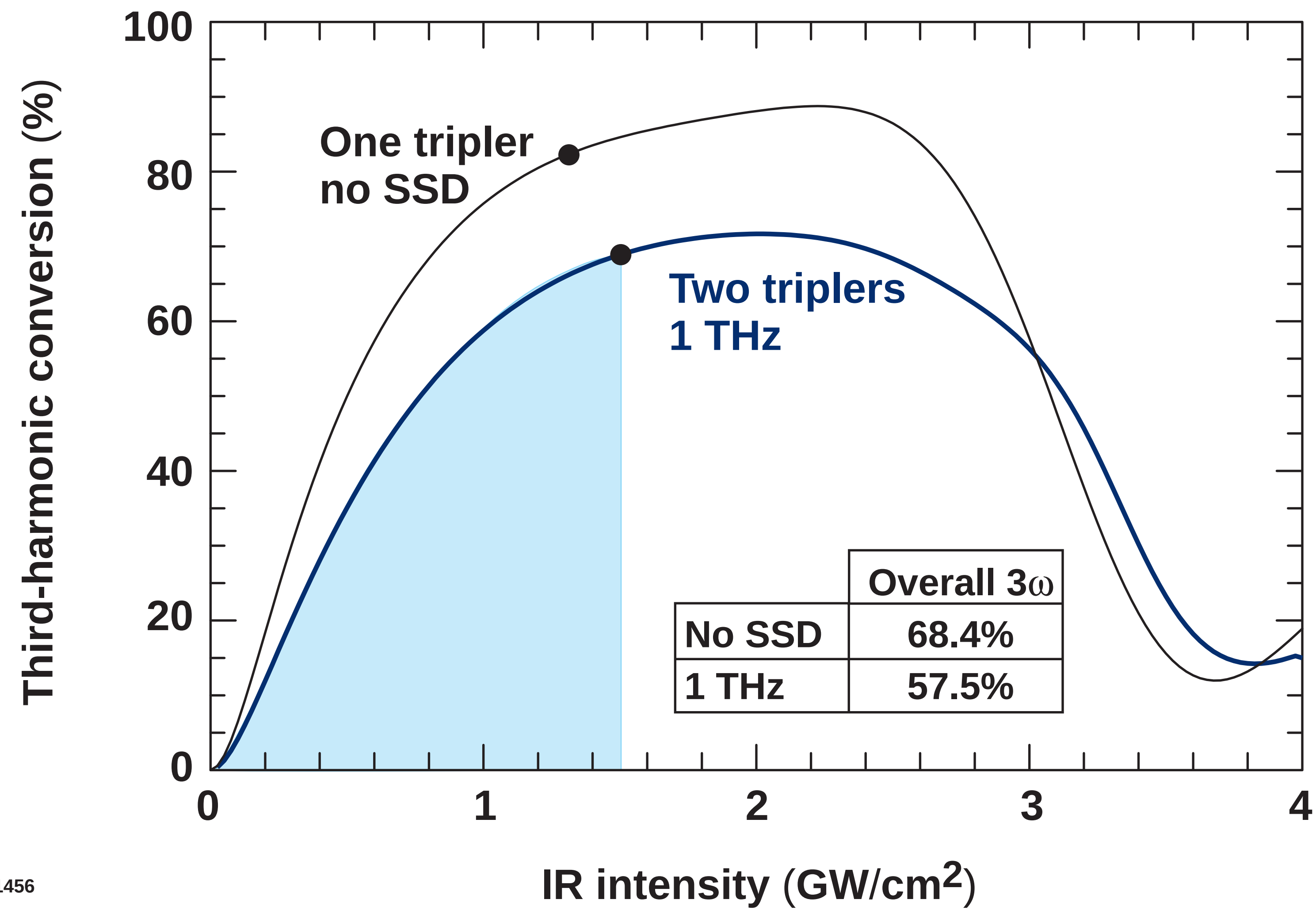


- Realistic coating and transport losses are used.
- The same 1-THz parameters are used on both OMEGA and the NIF:

	X	Y
Bandwidth (full width)	11.0	1.5 Å
Modulation frequency	10.5	3.3 GHz
Deflection (full width)	100	50 μrad

TC5203

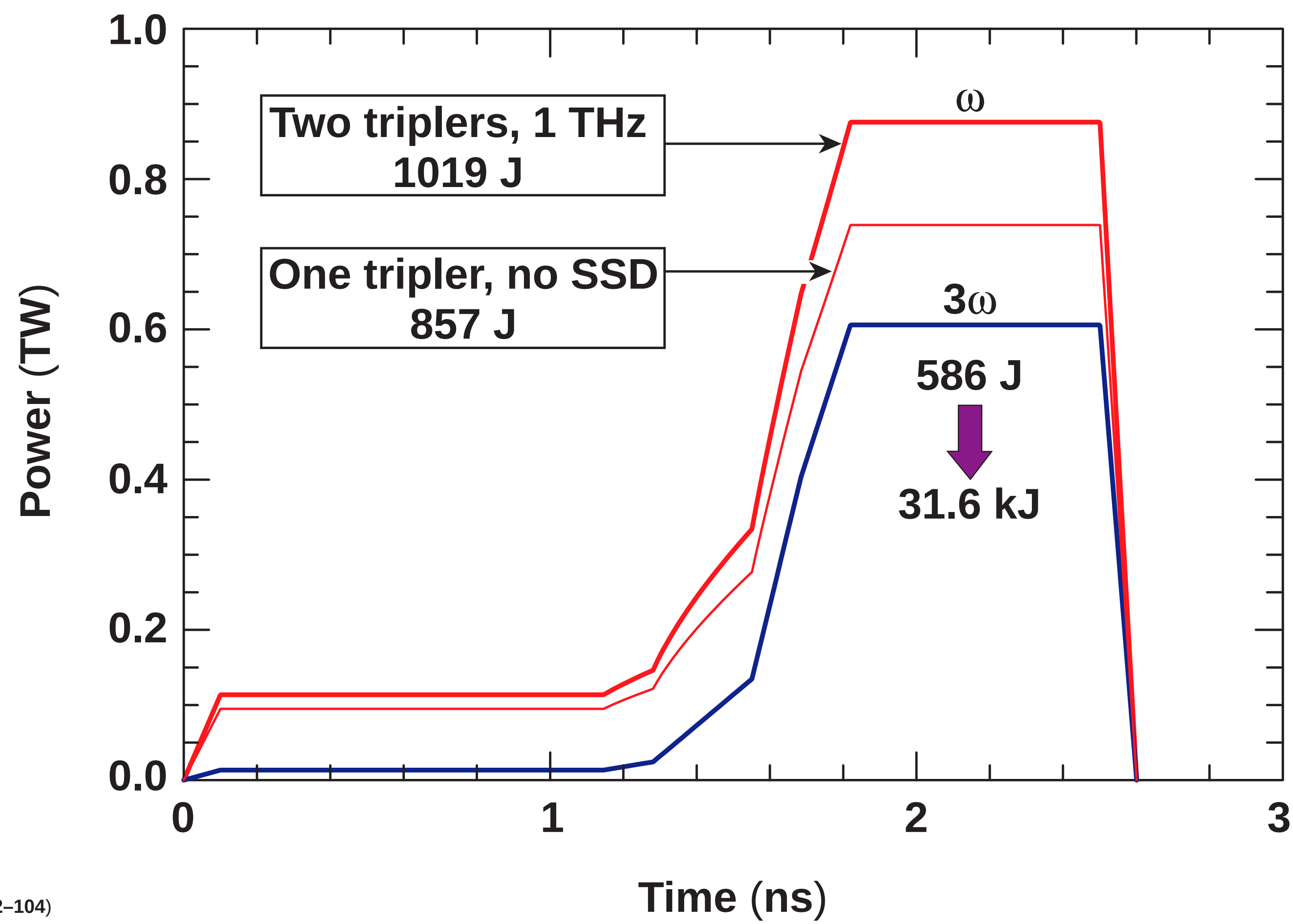
With 1-THz bandwidth, the conversion efficiency on OMEGA is reduced at all intensities



	Overall 3ω
No SSD	68.4%
1 THz	57.5%

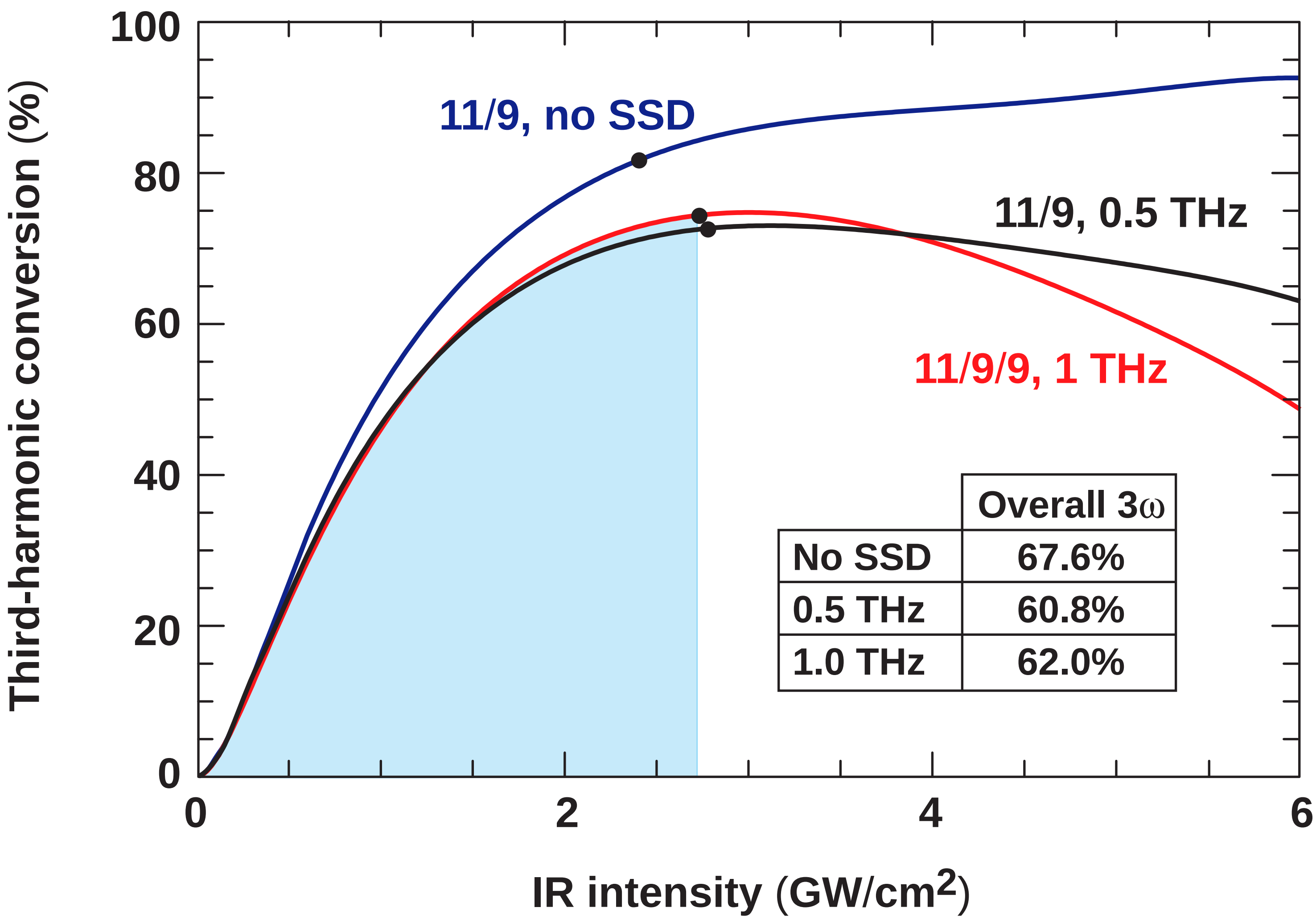
Run MI1456
TC5204

19% extra IR energy is needed to create 1-THz bandwidth on OMEGA



Run Sub12(102–104)
TC5205

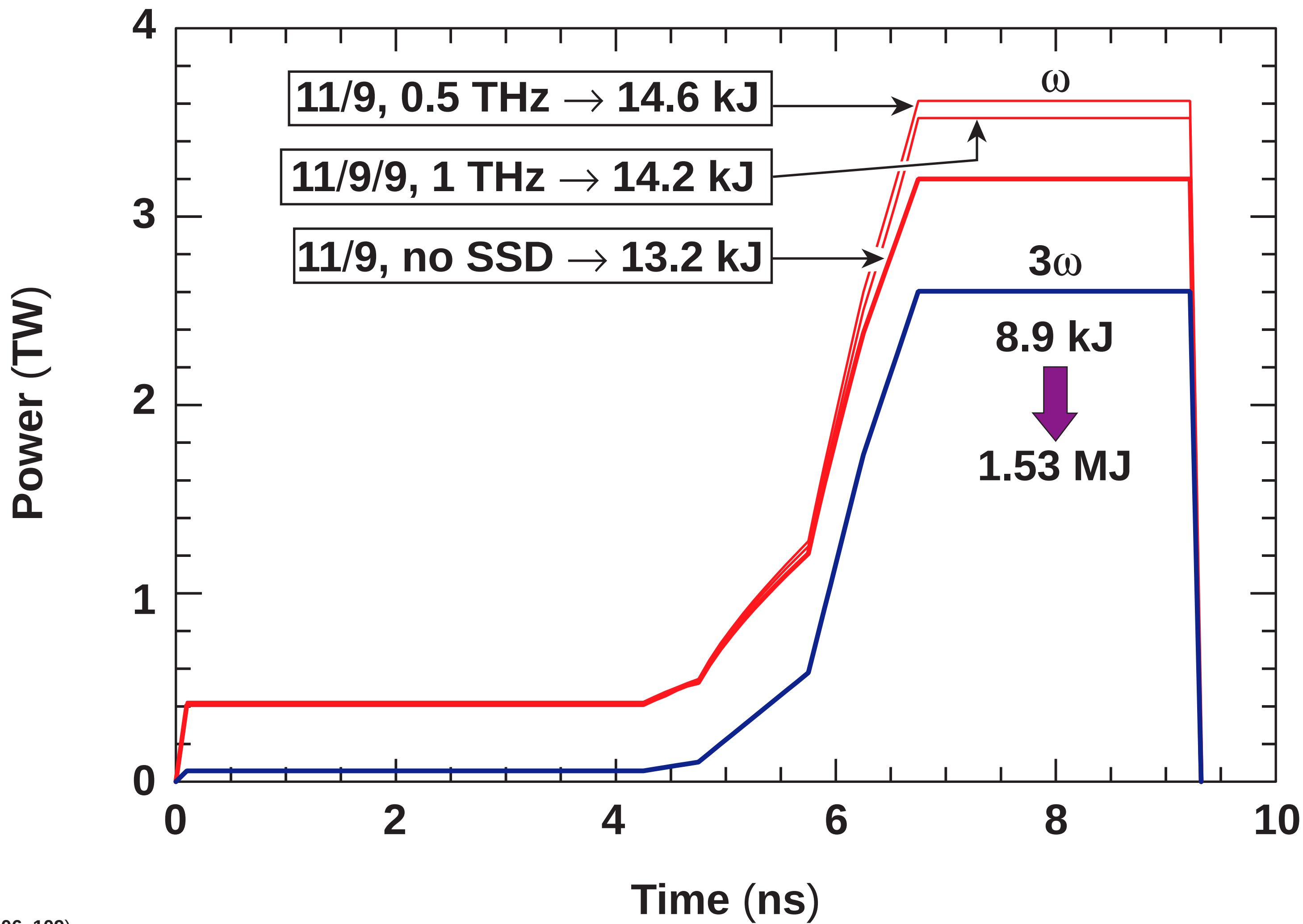
Frequency-conversion losses are small for both NIF SSD options



	Overall 3ω
No SSD	67.6%
0.5 THz	60.8%
1.0 THz	62.0%

Run MI14S5
TC5206

Only 8% extra IR energy is needed on the NIF to permit 1-THz bandwidth



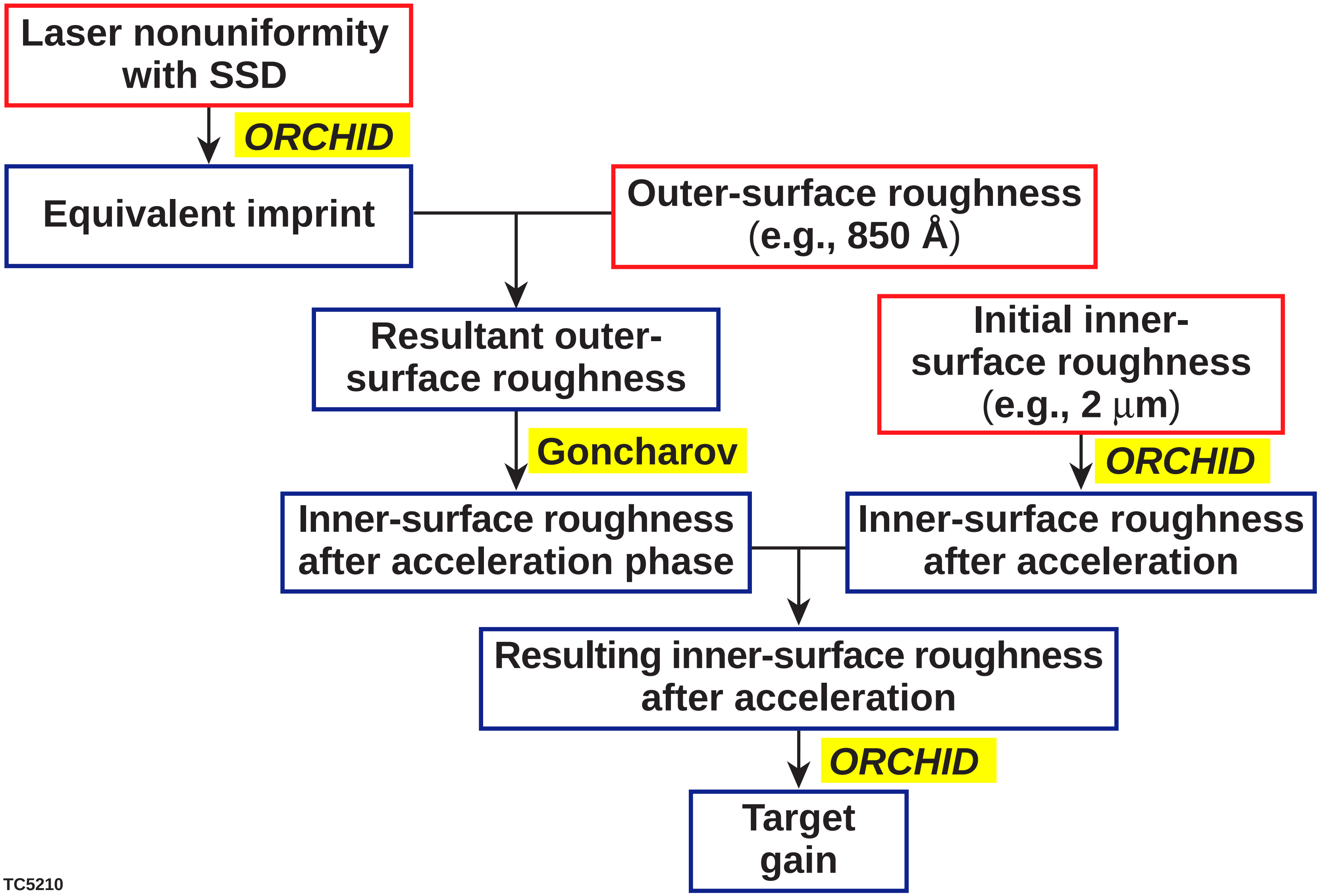
Run Sub12(106–109)
TC5207

The small extra IR energy needed for direct drive with 1-THz bandwidth appears to be within the NIF's capabilities

UV pulse shape	SSD?	UV on target	IR/beam
Former*	—	1.59 MJ	15.0 kJ
Current	1.0 THz (2 triplers)	1.53 MJ	14.2 kJ
	0.5 THz	1.53 MJ	14.6 kJ
	—	1.53 MJ	13.2 kJ

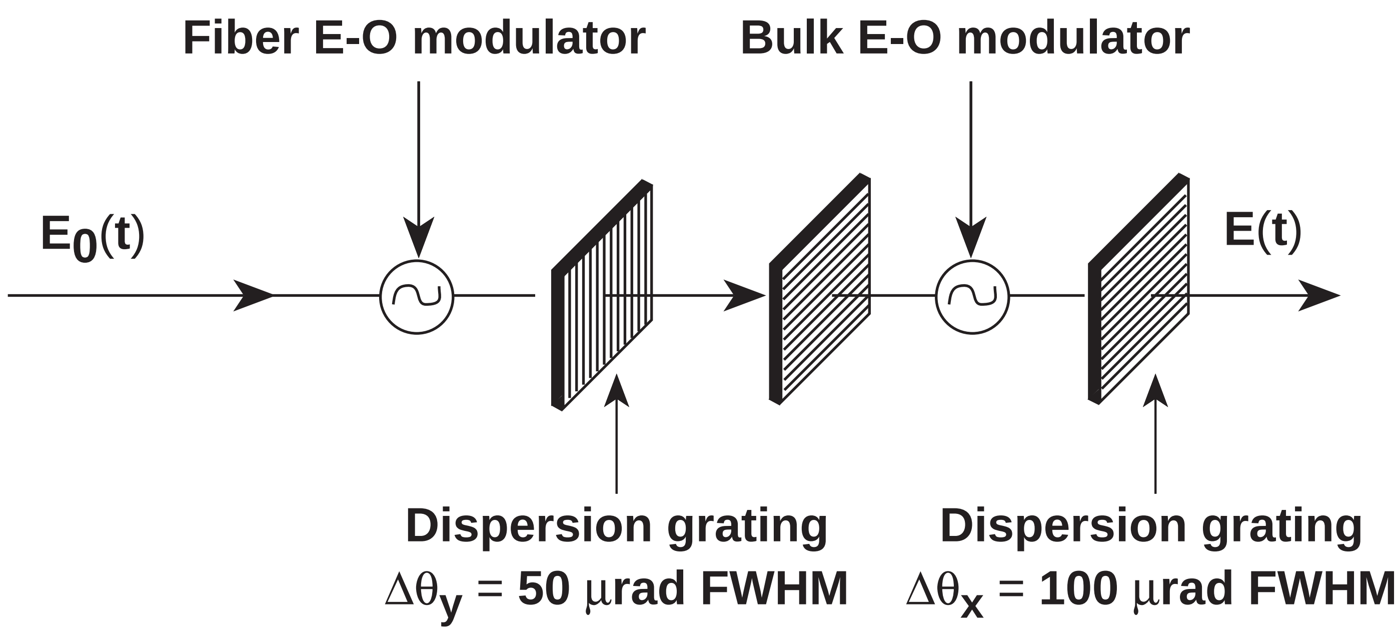
*O. S. Jones *et al*., SPIE Proceedings 3492, 49 (1998).

The gain calculations used multiple stages



TC5210

2-D broadband SSD is proposed for the NIF



"11/9/9" crystal design → 1-THz UV bandwidth

TC4851a

Summary/Conclusions

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