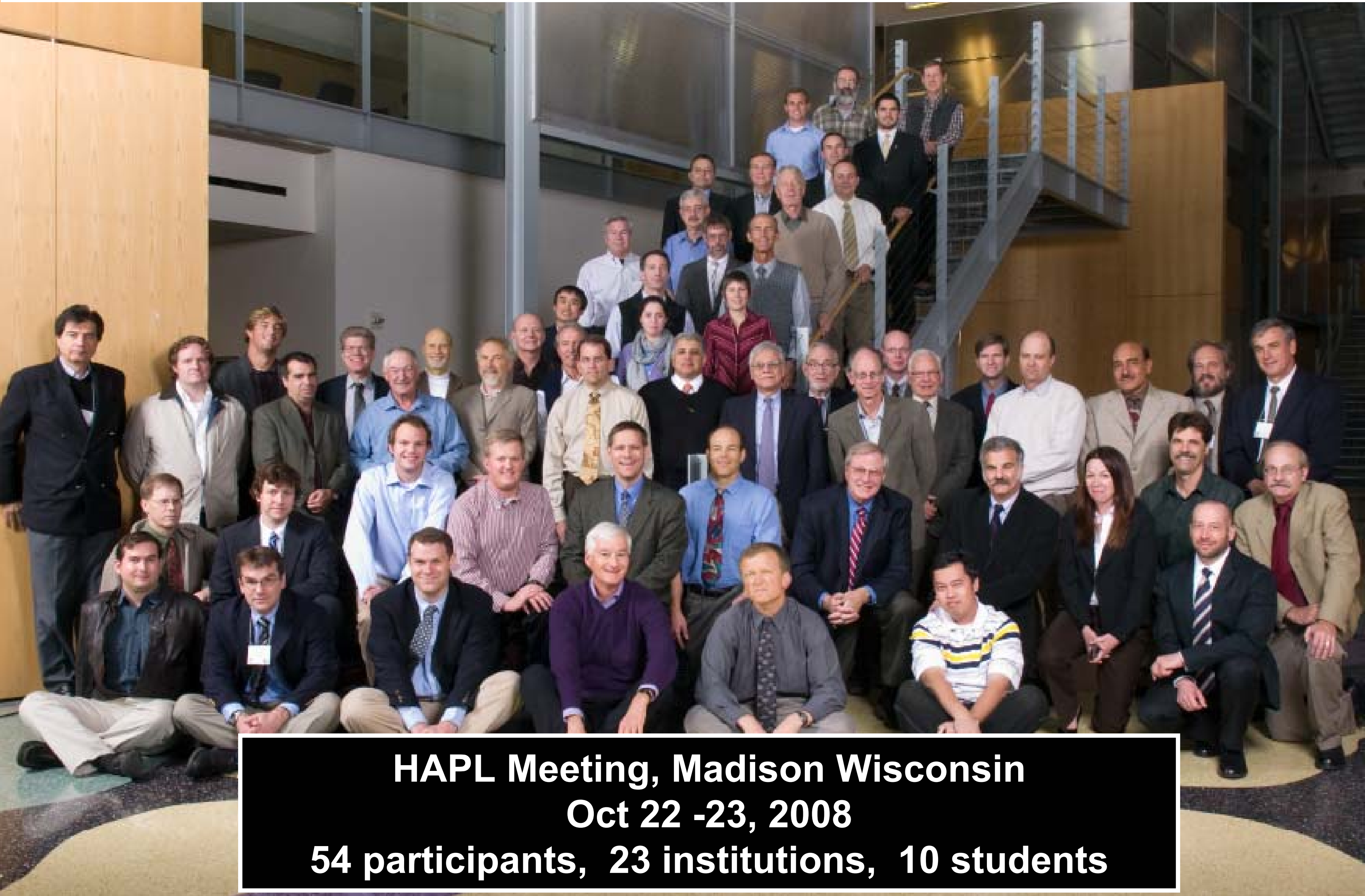
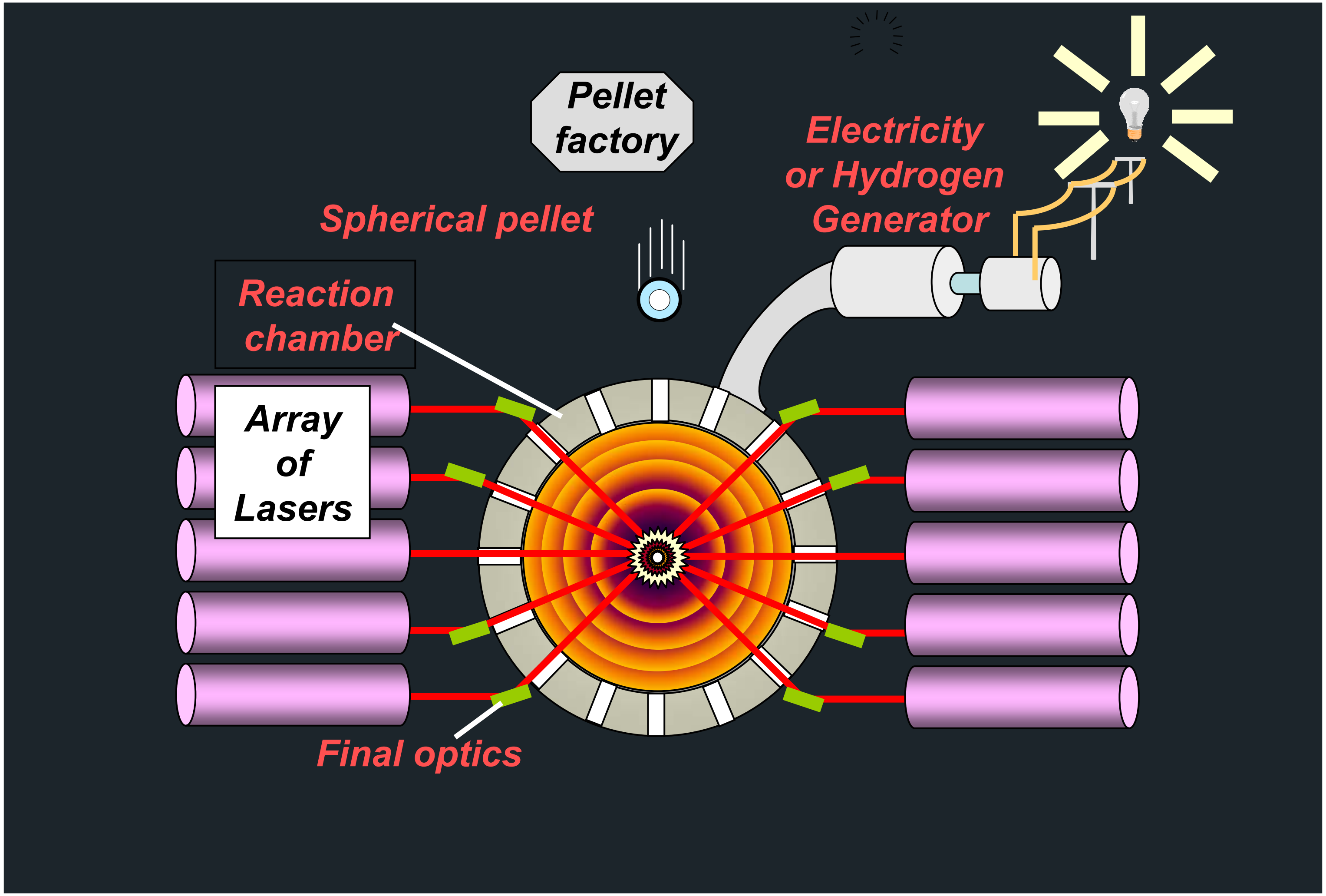
Advances in Laser Fusion Energy



HAPL Meeting, Madison Wisconsin
Oct 22 -23, 2008
54 participants, 23 institutions, 10 students

Fusion Energy with Lasers and Direct Drive



Major Advances this past year

Direct Drive Target Designs:

KrF Lasers:

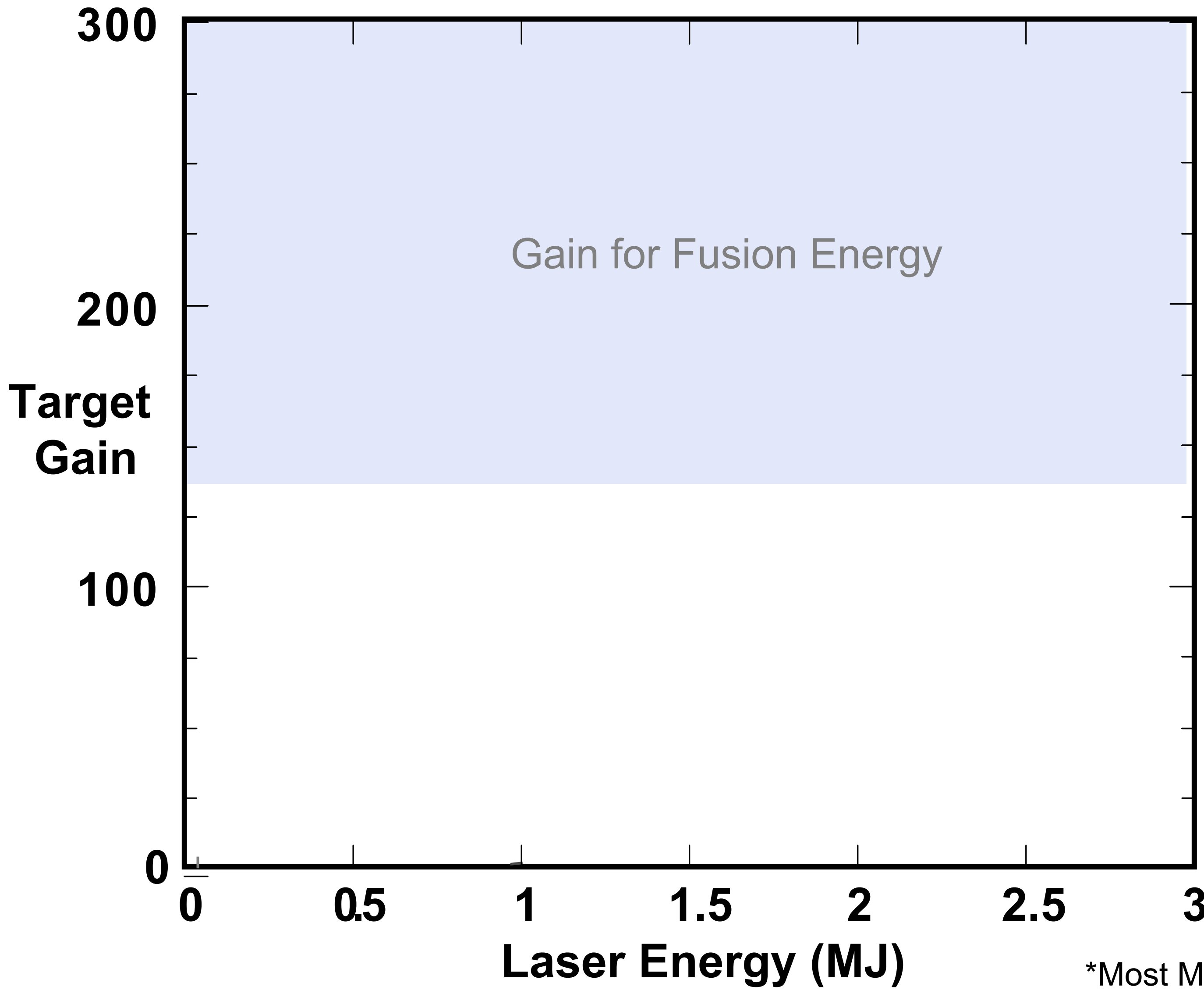
DPPSL Lasers: **discussed in LIFE talks**

Final Optics:

Target engagement:

First Wall:

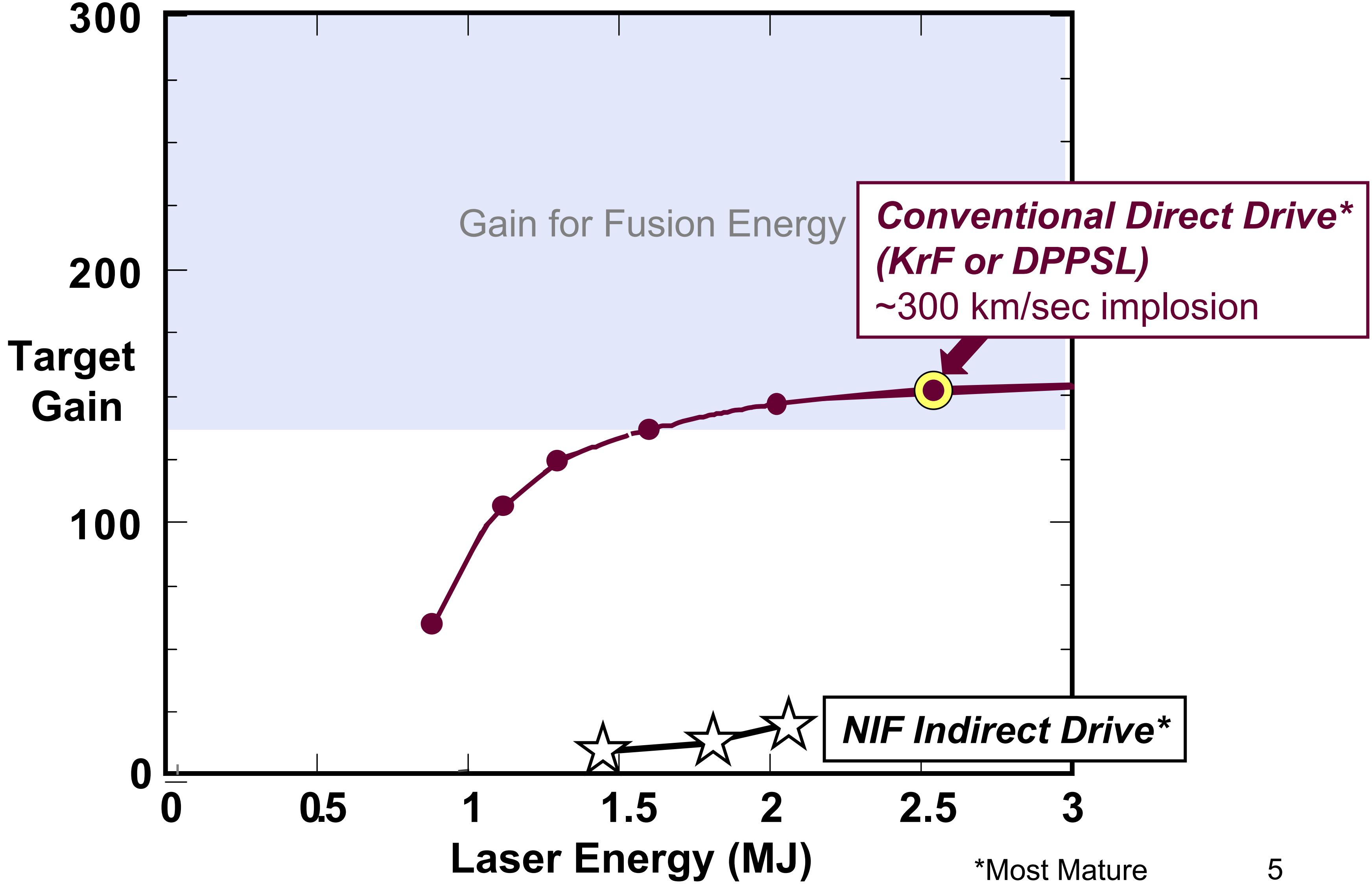
Advance #1: New Direct Drive Designs. Power plant gains, with much smaller laser



*Most Mature

M = 1/G

Advance #1: New Direct Drive Designs. Power plant gains, with much smaller laser



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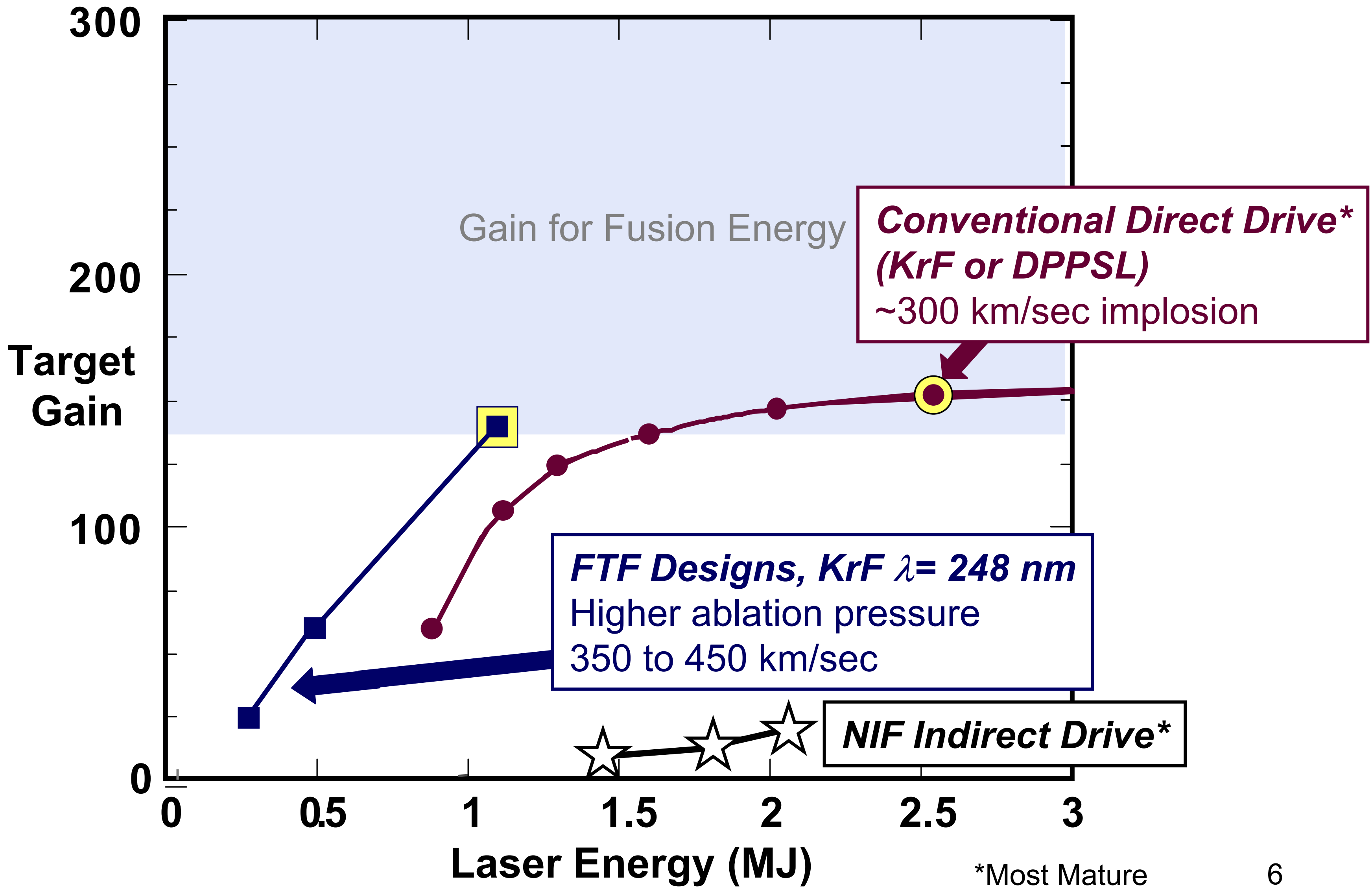

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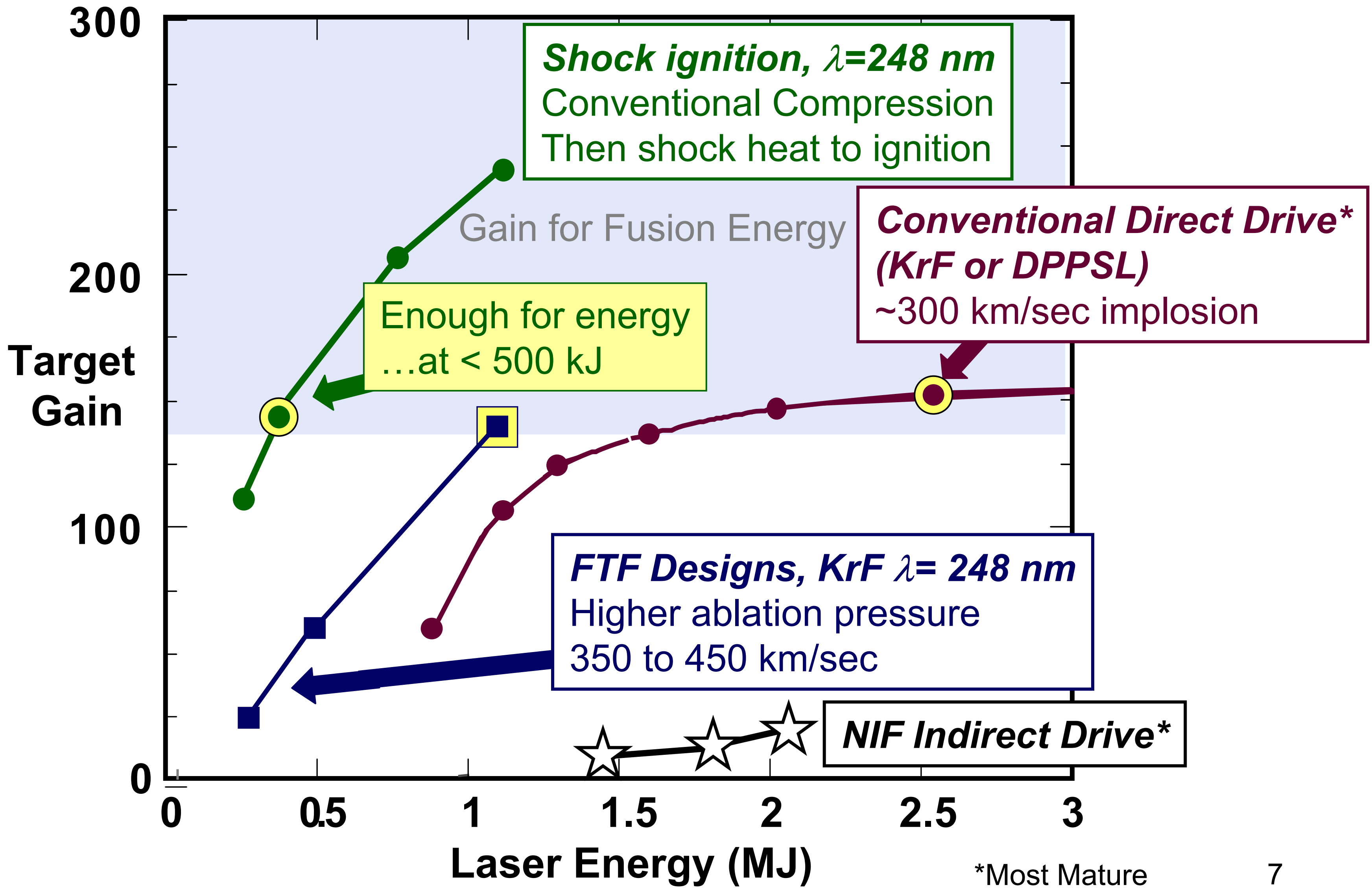
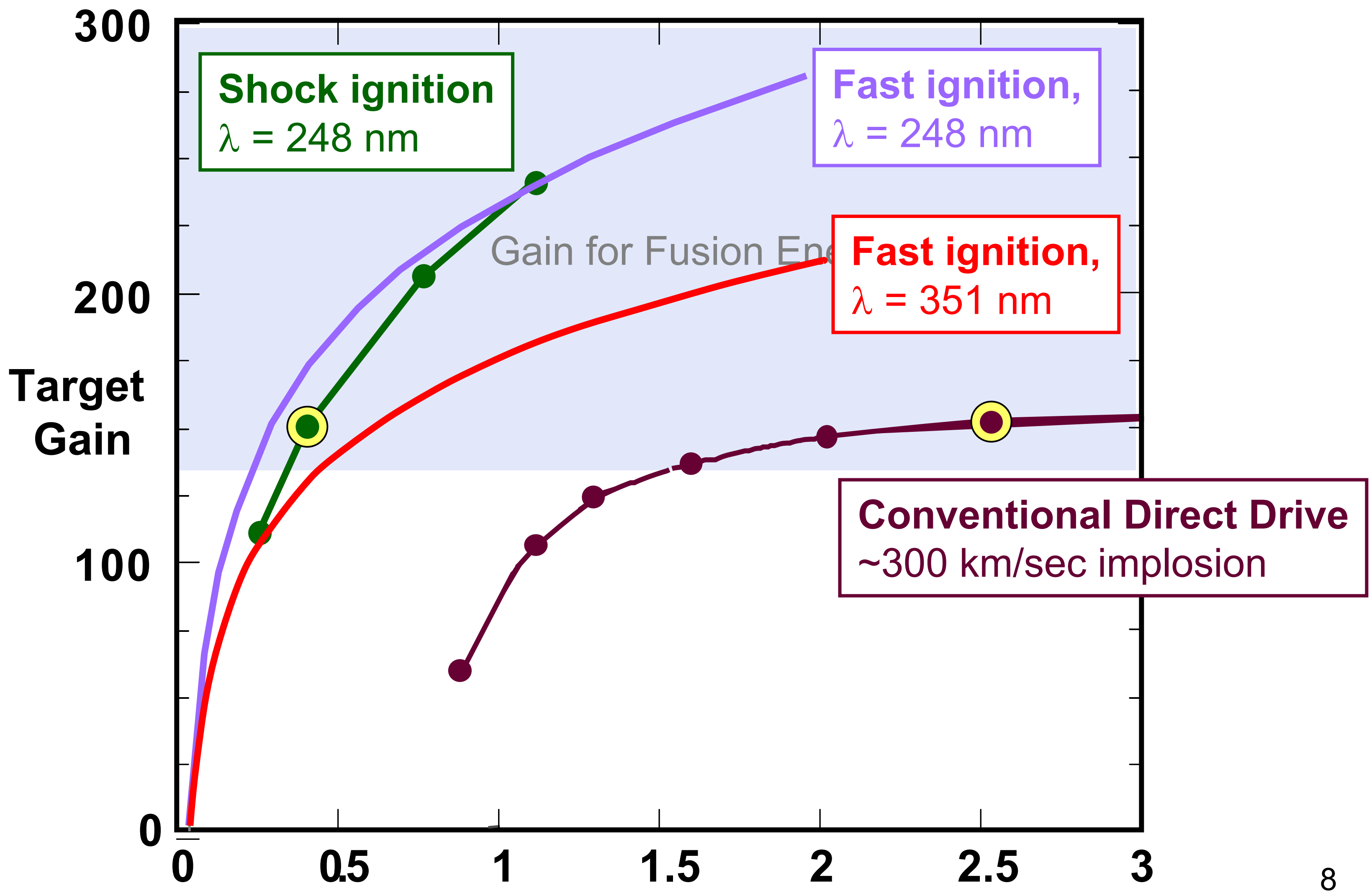
Advance #1: New Direct Drive Designs. Power plant gains, with much smaller laser



*Most Mature

M = 1/G

Shock Ignition predicts comparable gains as Fast Ignition… *without the complexities*



References for gain curves

Fast Ignition:
*Betti et al., Phys. Plasmas **13,** 100703 (2006).*

Shock Ignition Gain curves:
Schmitt, et al, 2008 TOFE

Shock Ignition Concept
Betti et al, Phys. Rev. Lett. 98, 155001 (2007).

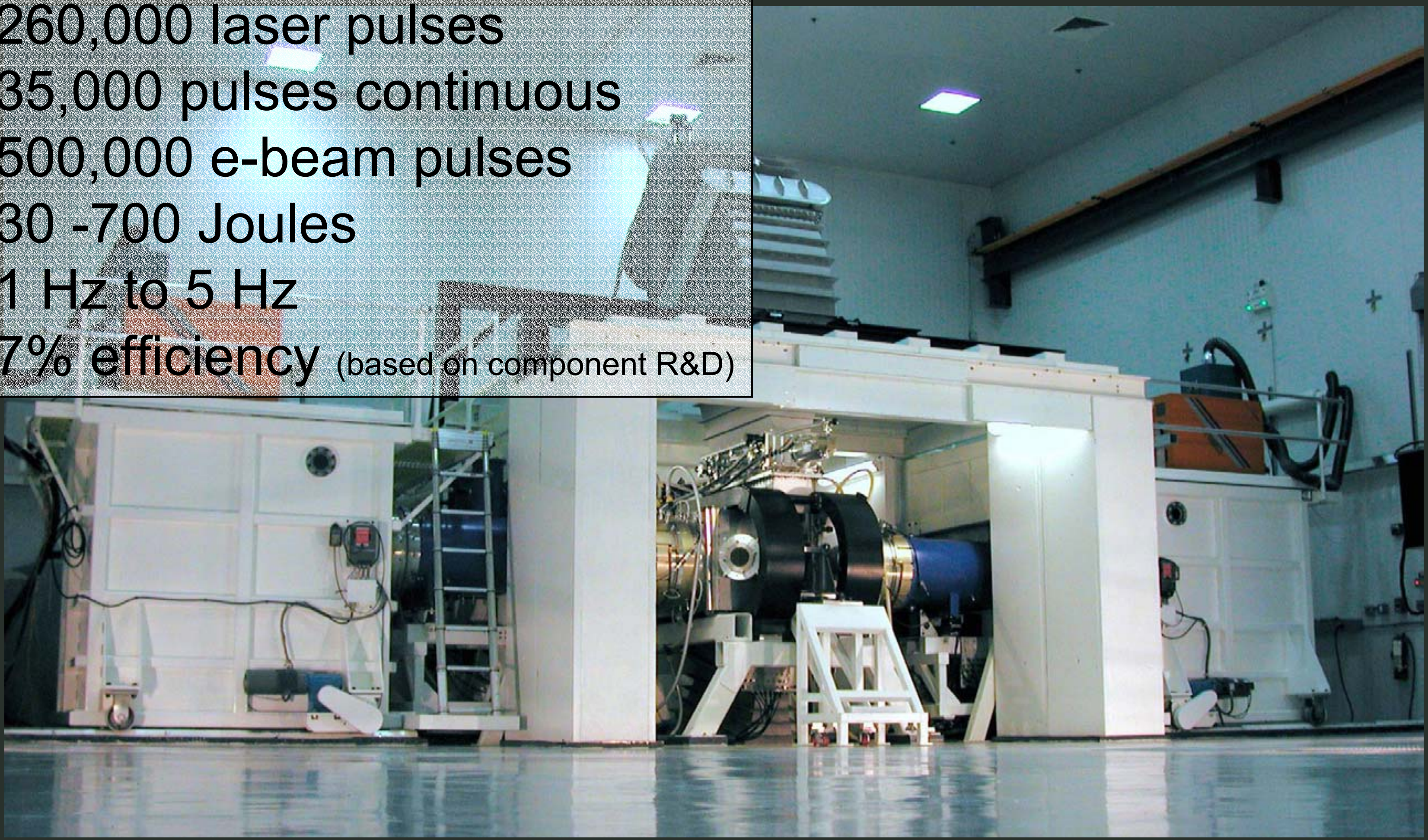
FTF Class:
Colombant et al., Phys. Plasmas 14 056317 (2007).

Conventional Direct Drive:
Bodner et al., IAEA Madrid meeting, June 2000.

Electra Krypton Fluoride (KrF) Laser
- electron beam pumped gas laser

<u>Electra Status to date</u>

- 260,000 laser pulses
- 35,000 pulses continuous
- 500,000 e-beam pulses
- 30 -700 Joules
- 1 Hz to 5 Hz
- 7% efficiency (based on component R&D)

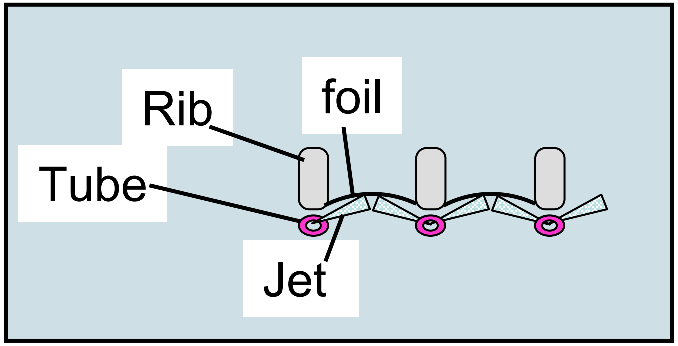


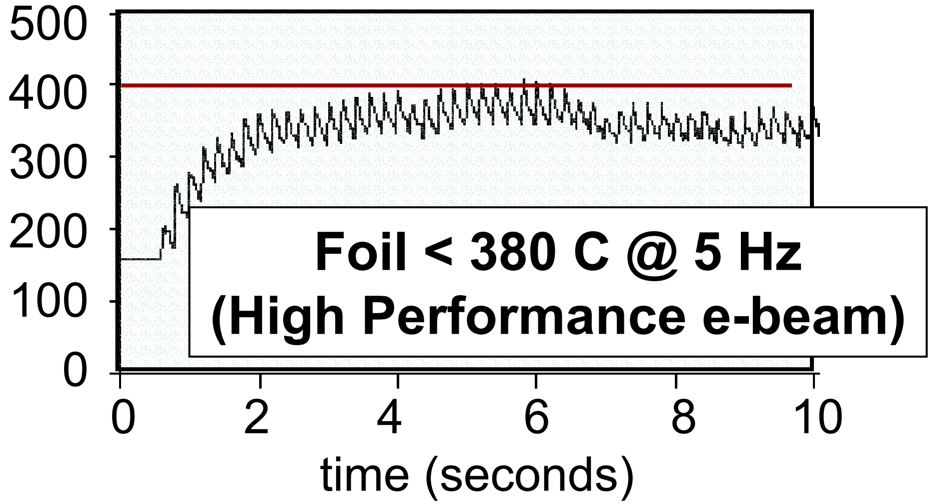
Advance #2: KrF Laser Pulsed Power. Solid state system demonstrates 1 M shots +

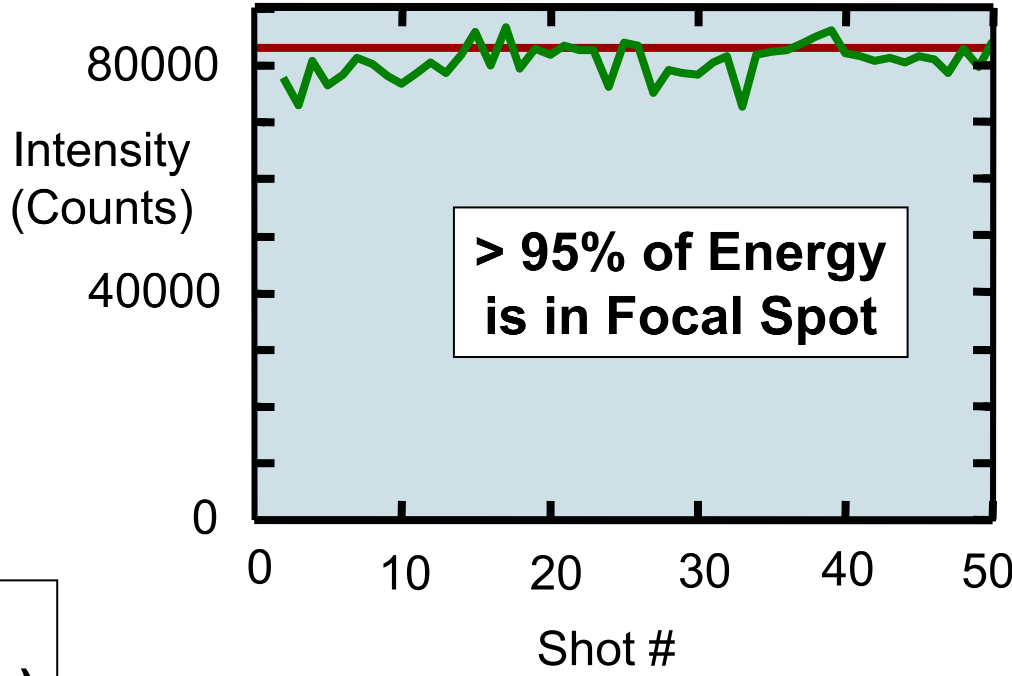
- Based on Commercial switches (component life > 300 M shots)
- Marx + PFL + Magnetic Switch (same as full scale driver)
- Marx: 1 M shots continuous at 10 Hz, > 80% efficiency
- Attractive cost: < $ 2 M for Electra (15 kJ)

Malcom McGeoch (PLEX)
Steve GIdden (APP)

Advance #3: KrF Foil Cooling.
Array of jets cools foil, maintains laser quality





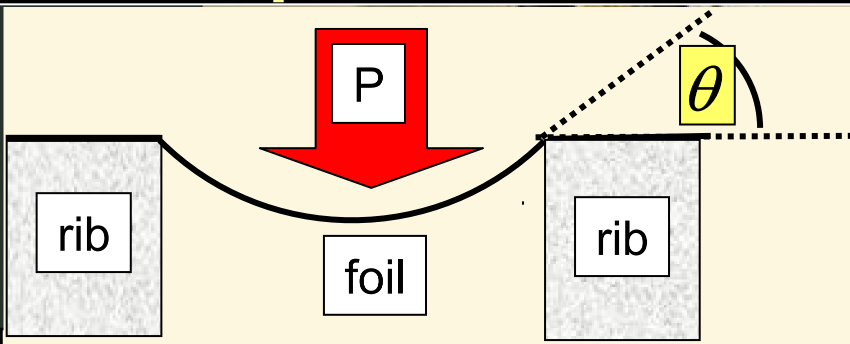


Said Abdel Kahlik (Georgia Tech)
Dennis Sadlowski (Georgia Tech)
Kevin Schoonover (SCI)
Matt Wolford (NRL)
Frank Hegeler (NRL/CTI)

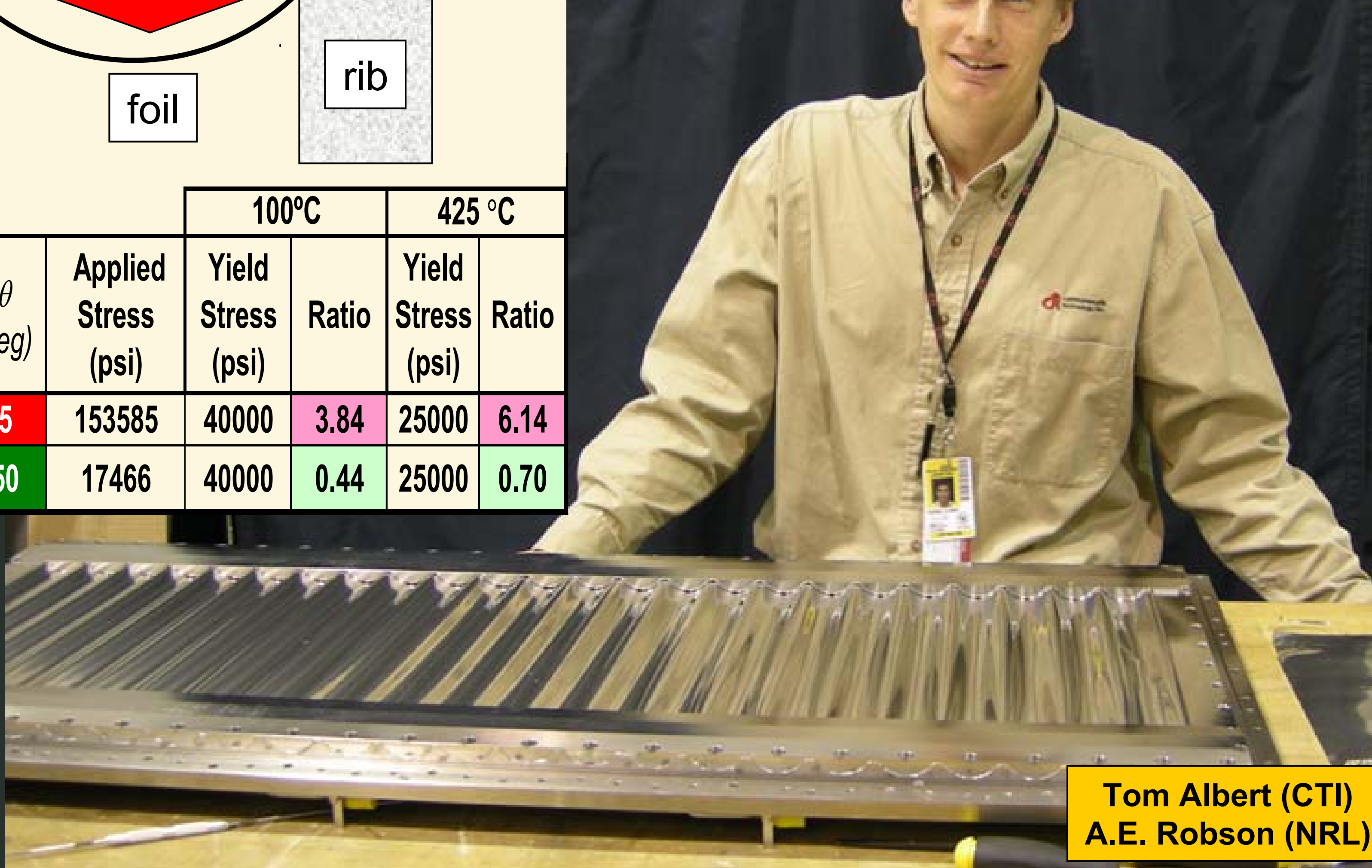
Advance #4: KrF Foil Support.

"Scalloped" hibachi reduces stress in foil 4 x

Module pressure tested to 1.4 M cycles

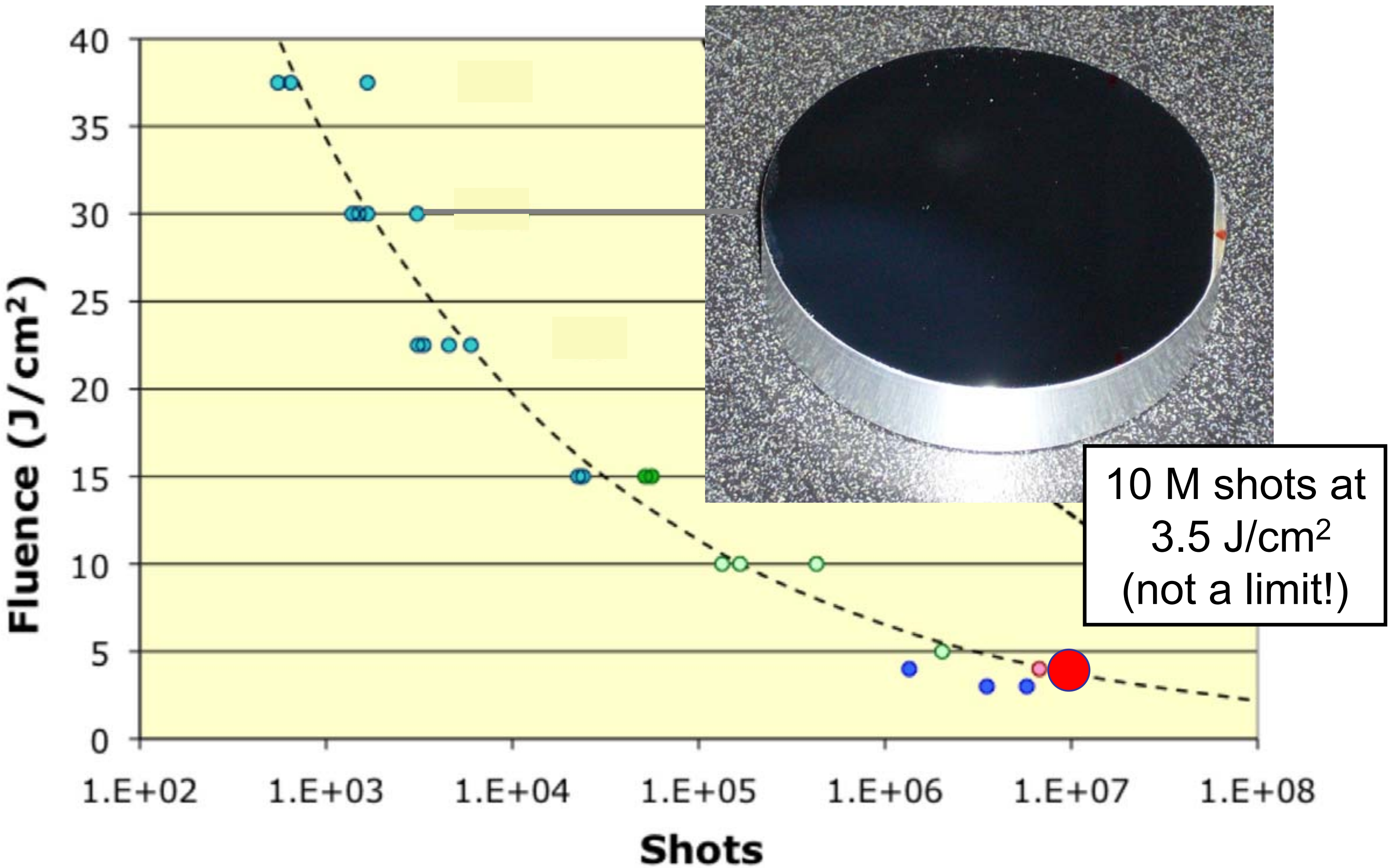


	θ (deg)	Applied Stress (psi)	100ºC Yield Stress (psi)	100ºC Ratio	425 °C Yield Stress (psi)	425 °C Ratio
Existing	5	153585	40000	3.84	25000	6.14
New	50	17466	40000	0.44	25000	0.70



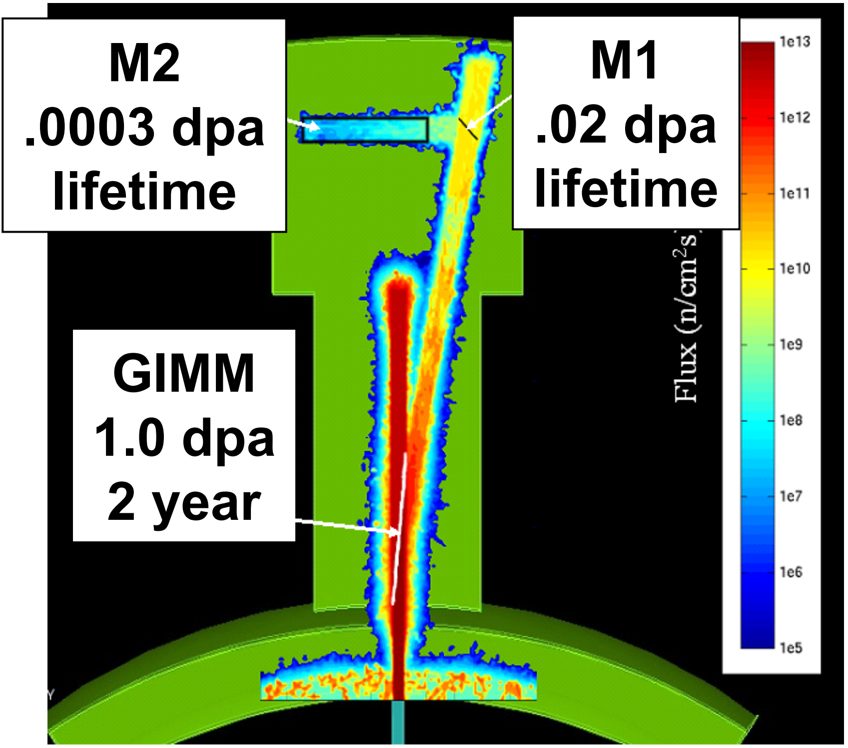
Tom Albert (CTI)
A.E. Robson (NRL)

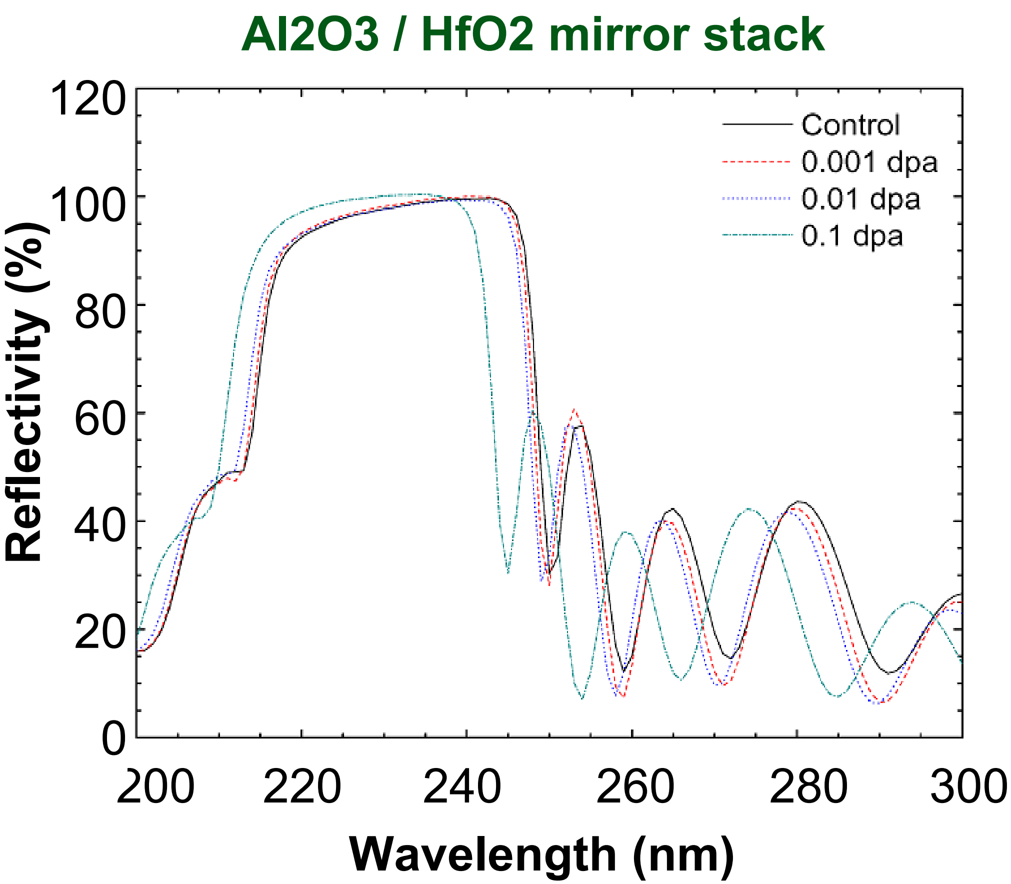
Advance #5: Grazing Metal Mirror (Final Optic)
Developing high cycle, high damage limit coating



Mark Tillack, UCSD

Advance #6: Dielectric Mirror.
Developed mirror that survives predicted dpa





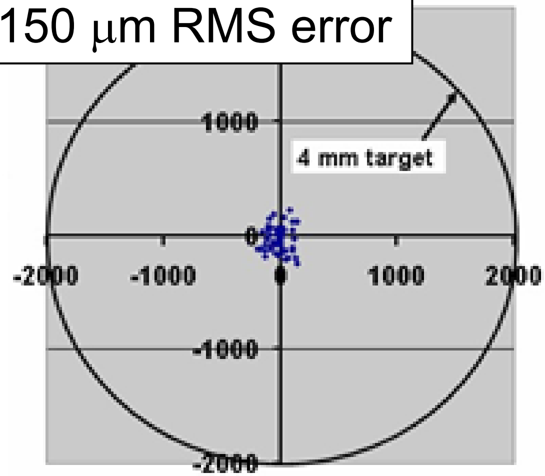
The "key"
Match irradiation-induced dimensional changes in substrate and mirror layers

Lance Snead (ORNL)
Tom Lehecka (Penn State)
Mohamed Sawan (Wisconsin)

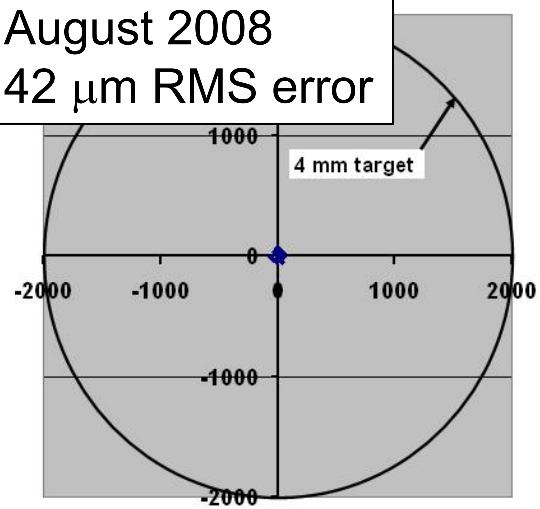
Advance #7: Target Engagement.

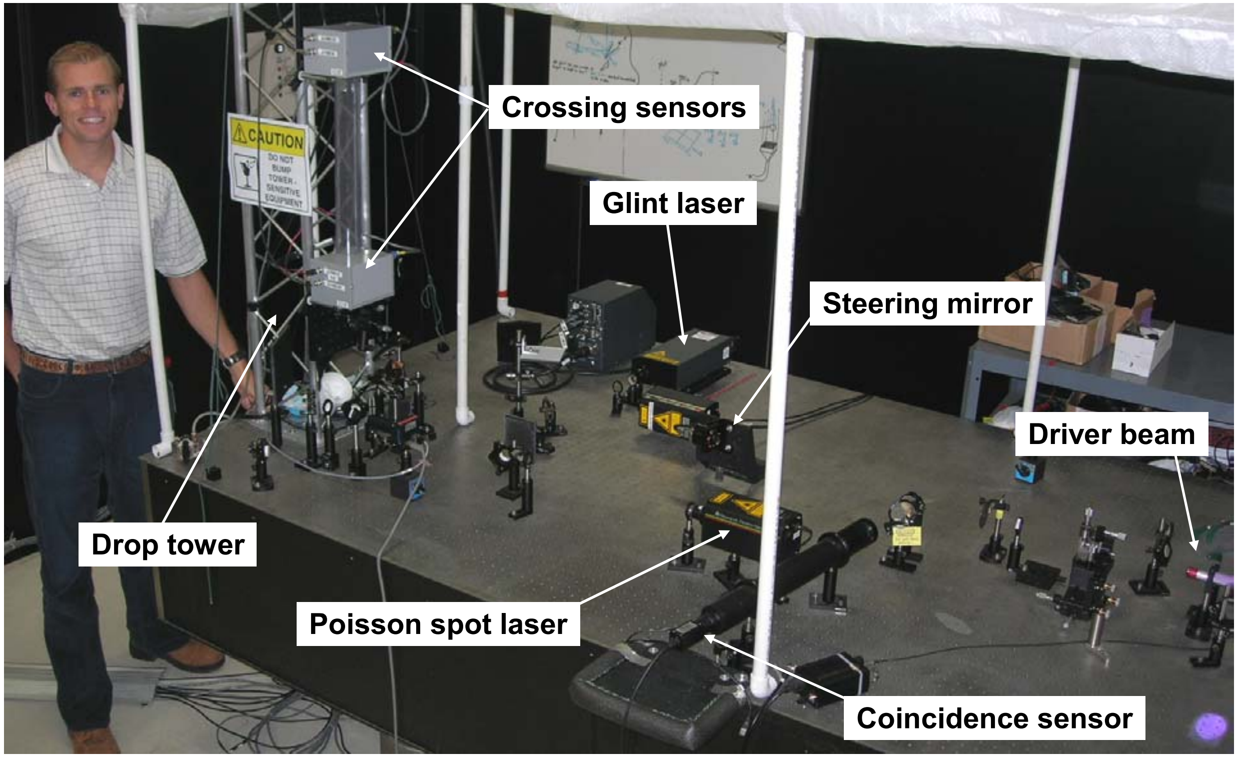
Bench test engages target within 42 um. Need ~20

August 2007
150 μm RMS error



August 2008
42 μm RMS error

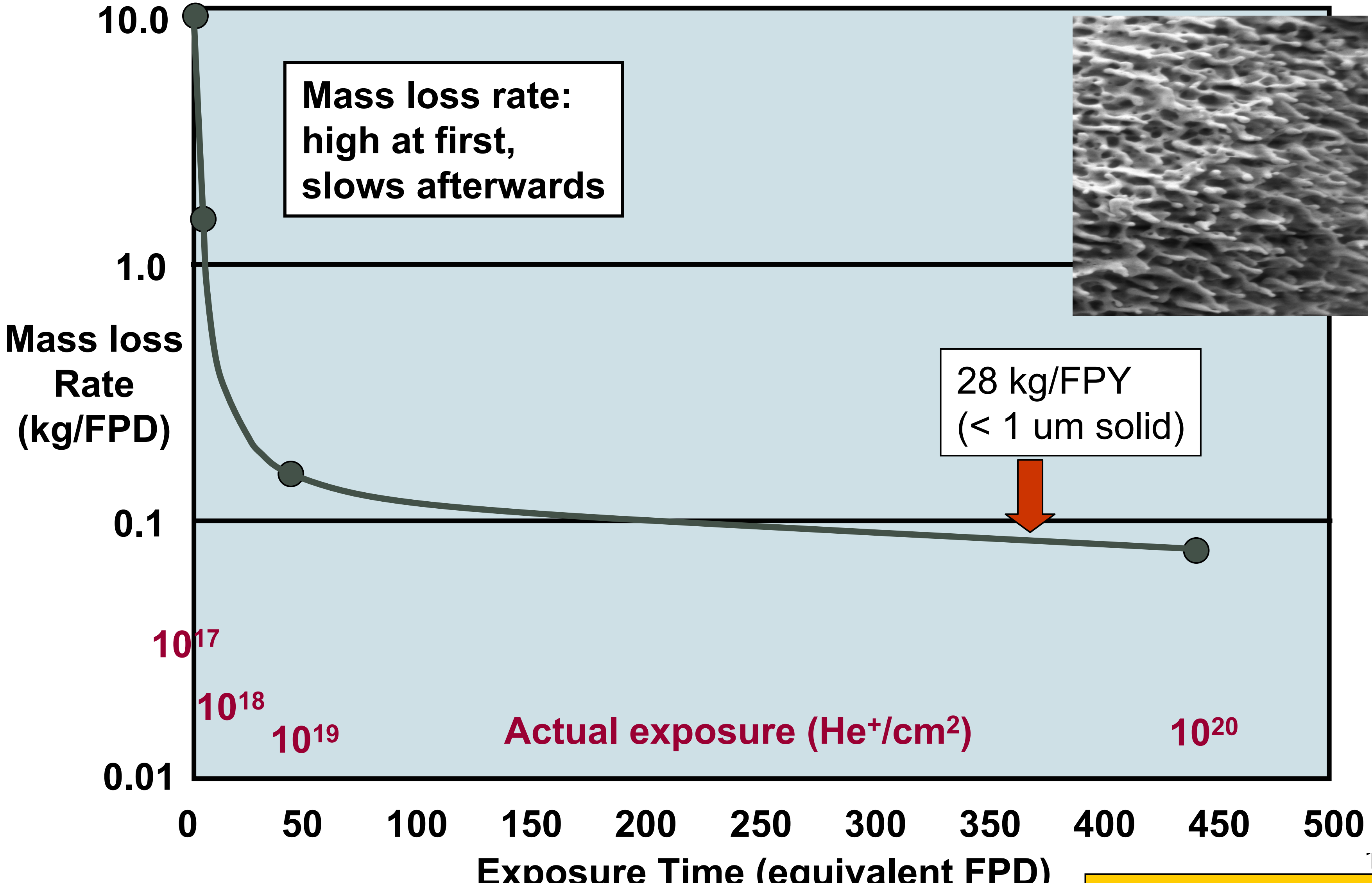




Lane Carlson (UCSD)

Advance #8: Chamber First wall material.

First "Nano-Engineered" Tungsten experiments encouraging



MI
heat cyc
dust

Sam Zenobia (Wisconsin)

Major Advances this past year

Direct Drive Target Designs: suggest gains > 140 @ < 1 MJ

KrF Lasers: Pulsed Power, Foil Cooling, Foil Support

DPPSL Lasers: Discussed in LIFE talks

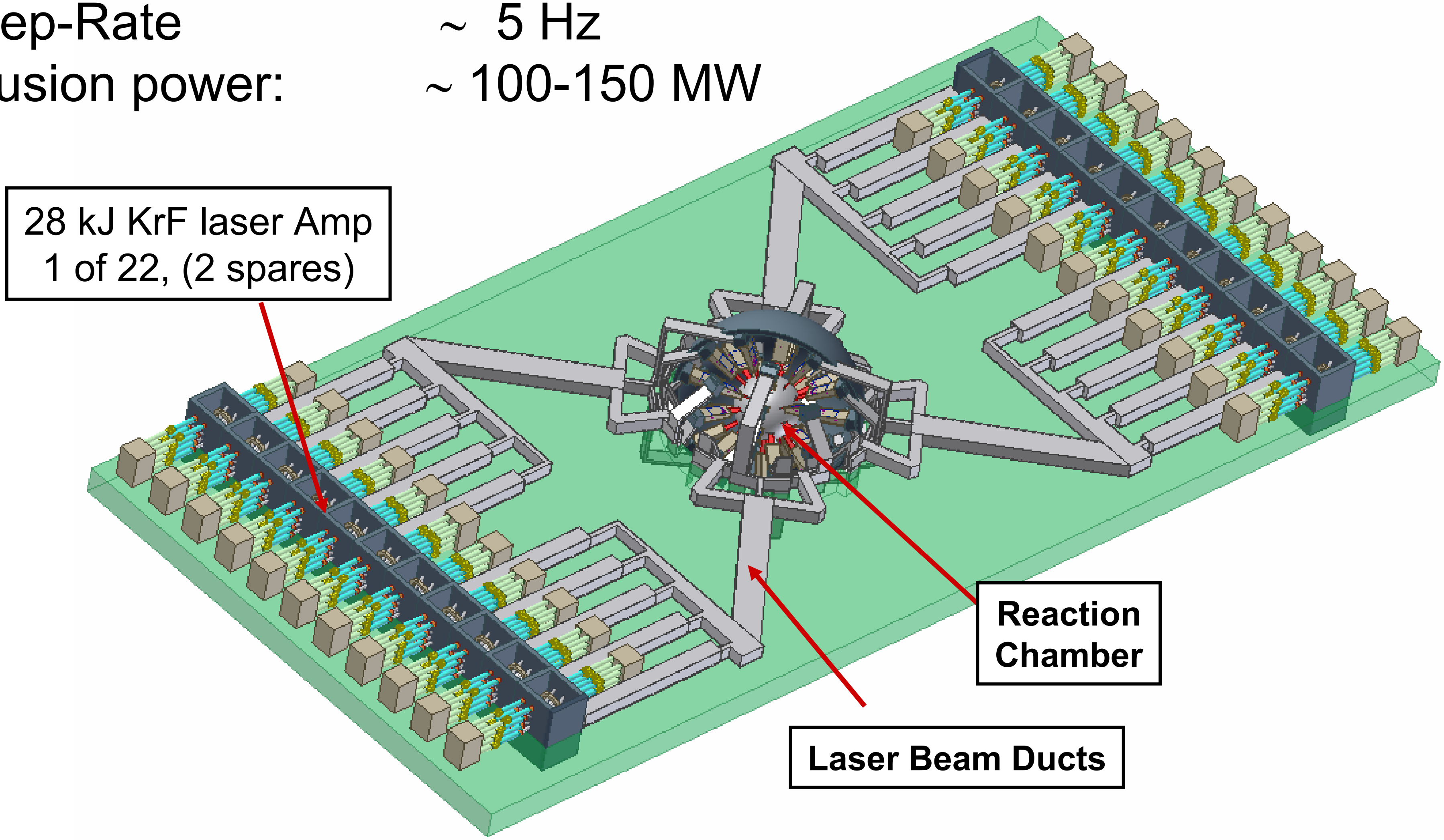
Final Optics: GIMMS: high cycle, high damage threshold
Dielectric Mirrors: Survive predicted dpa

Target engagement: almost met accuracy requirements

First Wall: Nano Engineered tungsten experiments
encouraging, may light path for solid wall

The Fusion Test Facility (FTF)

Laser energy: ~ 500 kJ
Rep-Rate ~ 5 Hz
Fusion power: ~ 100-150 MW



Objectives of the FTF

Develop key components, demonstrate they work together with the required precision and durability

Platform to evaluate and optimize pellet physics

Develop materials and full scale chamber/blanket components for a fusion power plant.

Provide operational experience and develop techniques for power plants.

Operating ~ 2022

The Vision…A plentiful, safe, clean energy source

A 100 ton (4200 Cu ft) ***COAL*** hopper runs a 1 GWe Power Plant for ***10 min***

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