Research Plans for OMEGA EP

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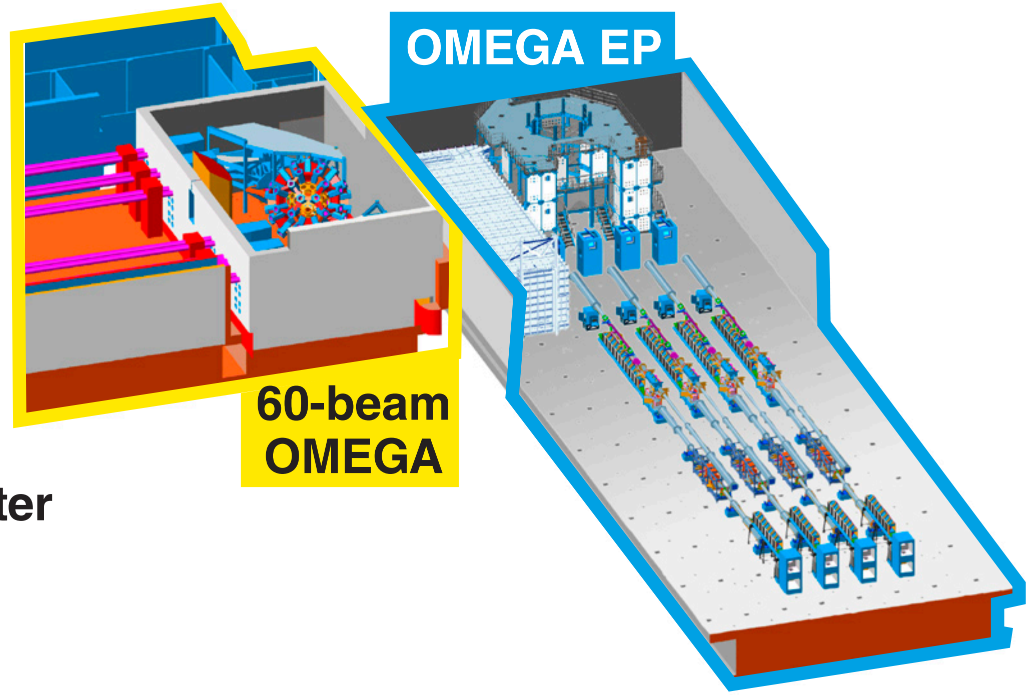
Summary

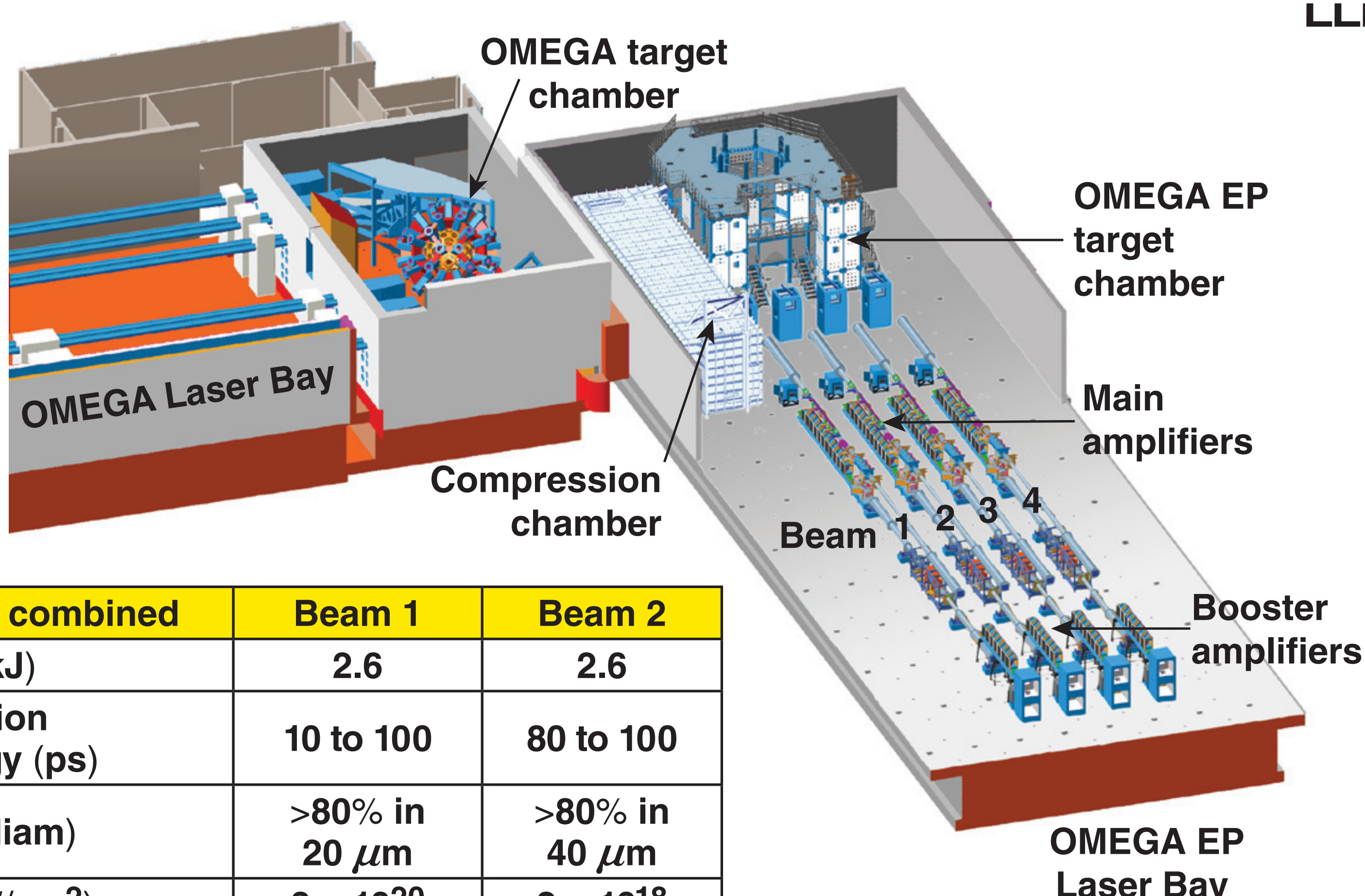
OMEGA EP has five primary missions

1. Extend HED research capabilities with high-energy and high-brightness backlighting
2. Perform integrated advanced-ignition experiments
3. Develop advanced backlighter techniques for HED physics
4. Staging facility for the NIF to improve its effectiveness
5. Conduct ultrahigh-intensity laser–matter interactions research



OMEGA EP will be completed in Q3 FY08

OMEGA EP beams has four NIF-like beams; two of these can be operated with ps pulses



Short pulse combined	Beam 1	Beam 2
IR energy (kJ)	2.6	2.6
Pulse duration at full energy (ps)	10 to 100	80 to 100
Focusing (diam)	>80% in 20 μm	>80% in 40 μm
Intensity (W/cm^2)	3×10^{20}	2×10^{18}

- Each beam duration can be as short as 1 ps at reduced energy (grating damage and *B*-integral)
- Beam 2 can produce 2.6 kJ in 10 ps when propagating on a separate path

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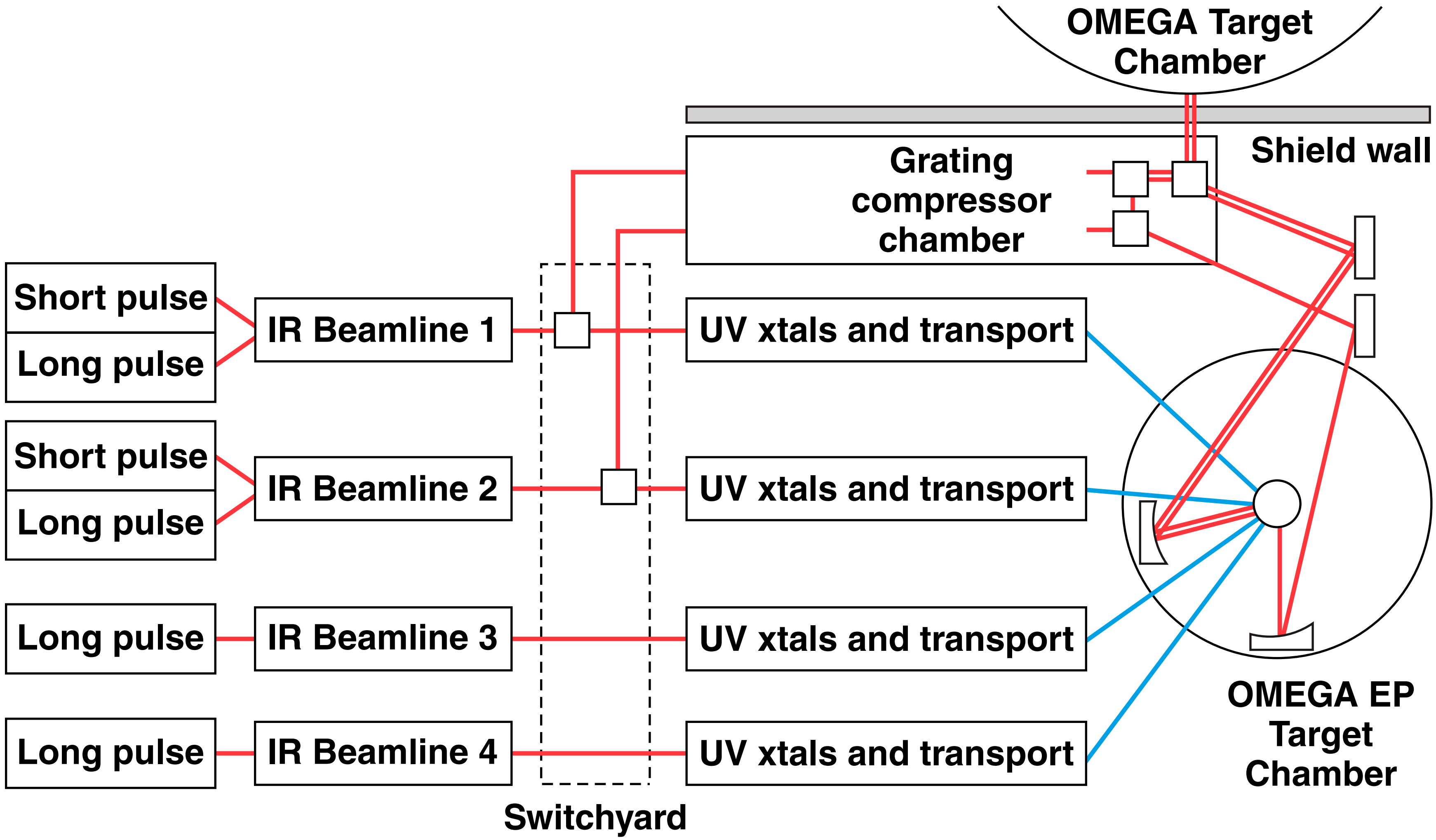
The OMEGA EP architecture is based on multi-configurable beam paths



Short-pulse OMEGA EP beams can be directed either to OMEGA or to the OMEGA EP target chamber

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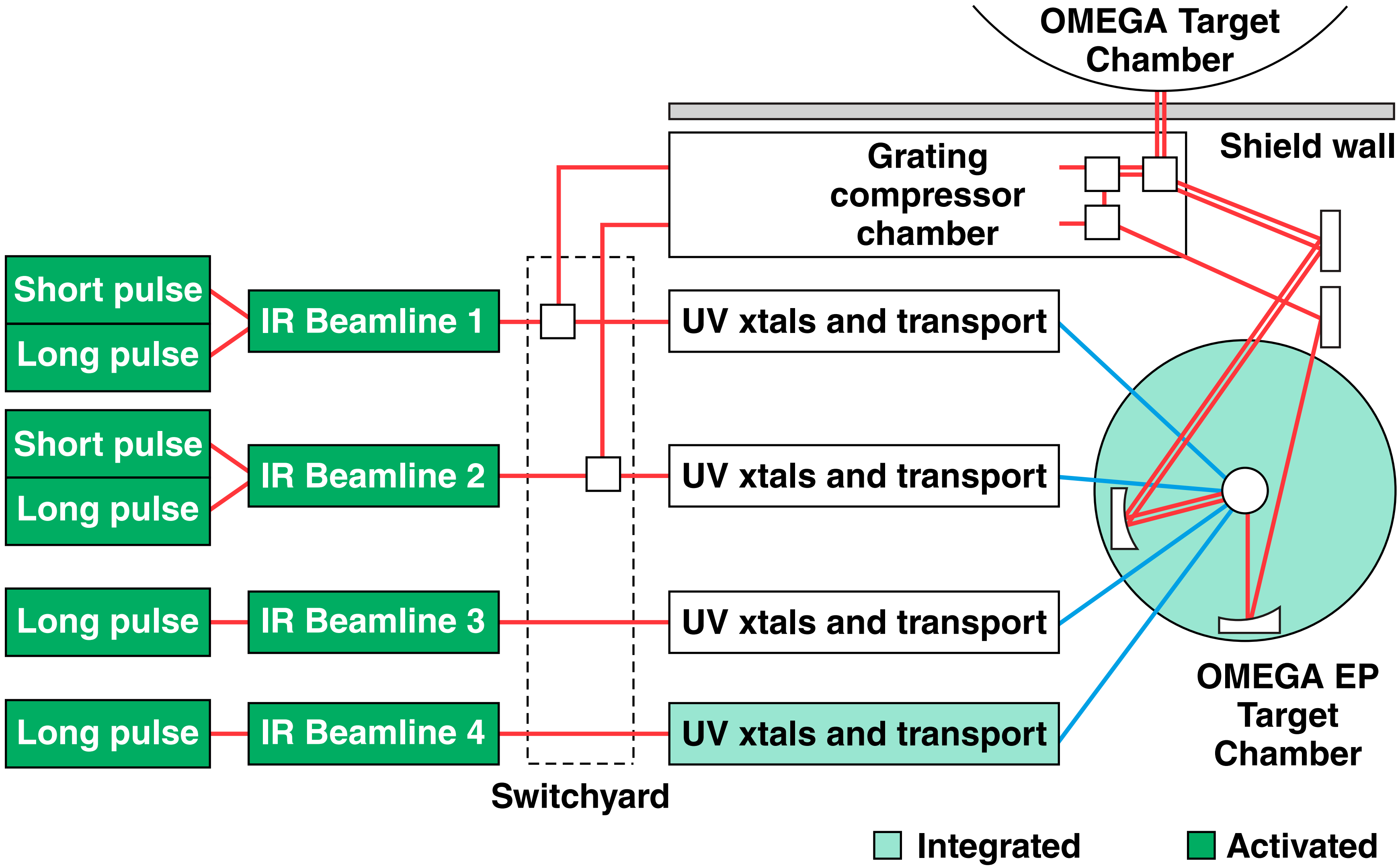
Initial activation has been completed up to the switchyard



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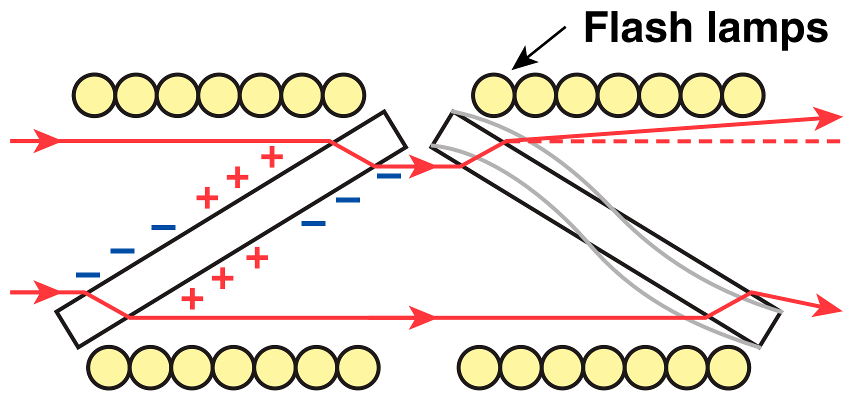
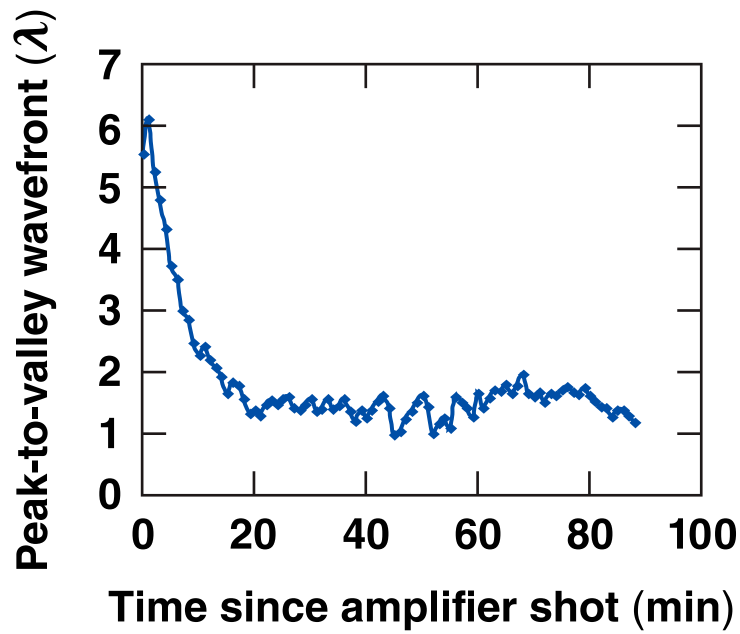
Recovery from amplifier thermal distortion supports 1-h repetition rate

- Nonuniform heating of amplifier disks causes an S-bend, leading to an astigmatic defocusing of the beam.

- Water cooling allows rapid recovery of wavefront.





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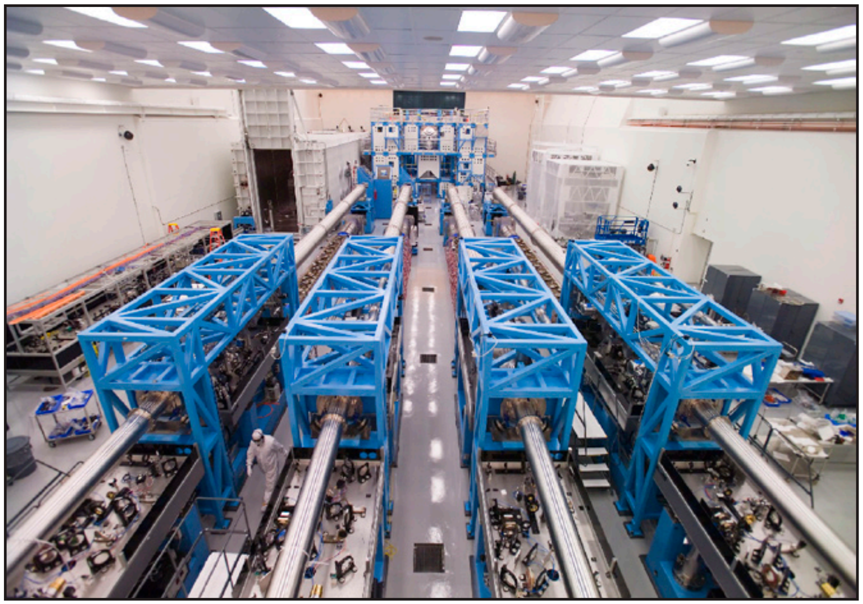
OMEGA EP integration is nearly complete and commissioning is scheduled for Q3 FY08



IR activation to 3 kJ	Completed
Grating Compressor alignment	June–October 2007
Short-pulse alignment to target chamber	November–January 2008
UV activation	November–January 2008
Short-pulse activation	February–April 2008

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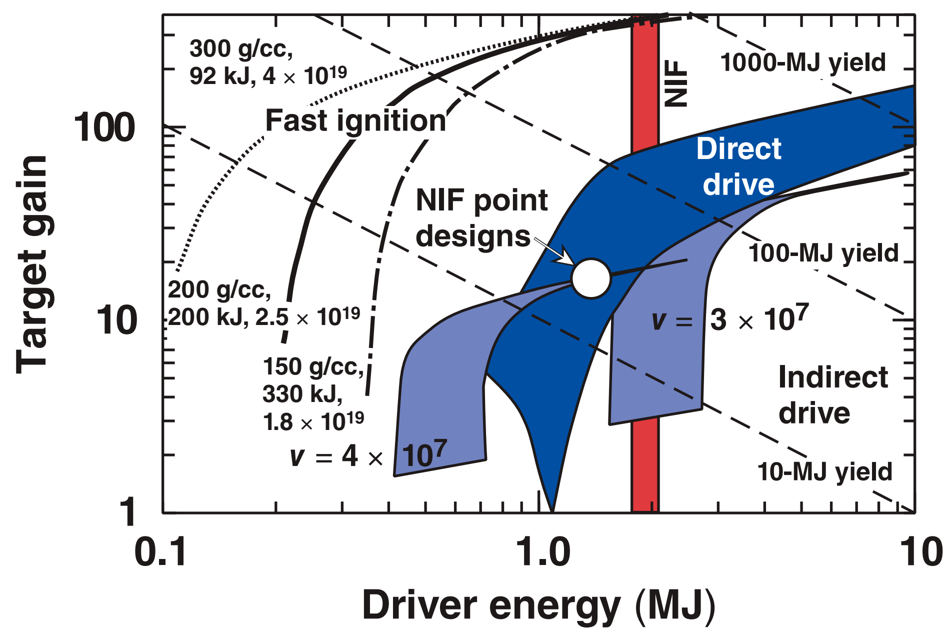
OMEGA and OMEGA EP will be operated as user facilities as part of NNSA's Complex 2030

- LLE has implemented a new facility governance plan.
- All users participate in the governance plan.
- The LLE Director approves a facility schedule that supports NNSA requirements.
- LLE hosted OMEGA EP Users' Workshops in January 2006 and May 2007.
- LLE will host a third OMEGA EP Users' Workshop in February/March 2008.

OMEGA facilities are essential for supporting ICF/NIC and HED/SSP campaigns, and basic science.

The fast-ignition concept reduces the compression energy required by providing external heating of the hot spot

- The basic fast-ignition concept*
  - – assemble fuel to high densities without creating a hot spot
    - - requires 50% less driver energy
  - – use an external heating source to heat a $\rho R \sim 0.3\ g/cm^2$ region to 10 keV
- This reduces the required driver energy for similar gain to conventional ICF.



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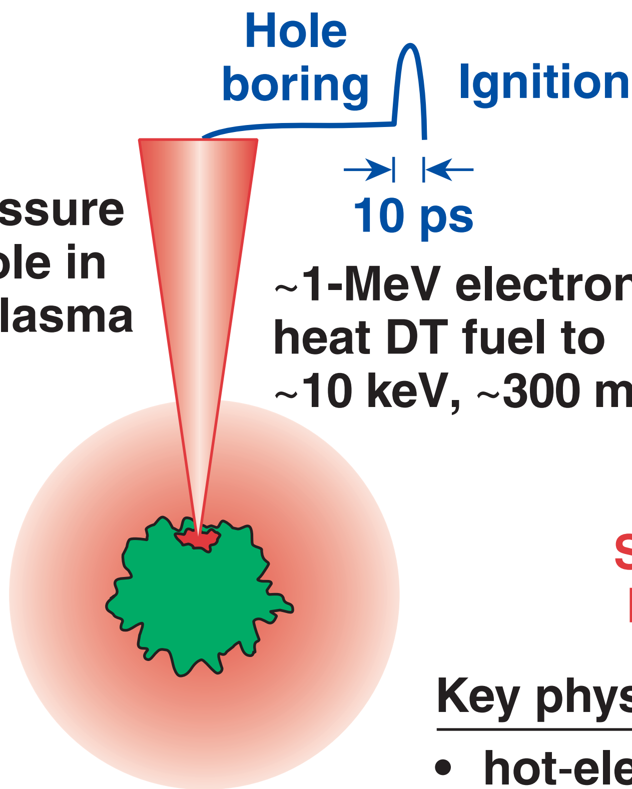
*M. Tabak *et al*., Phys. Plasmas 1, 1626 (1994).

Fast-ignition research with cryogenic fuel will be conducted on OMEGA with the high-energy-petawatt OMEGA EP

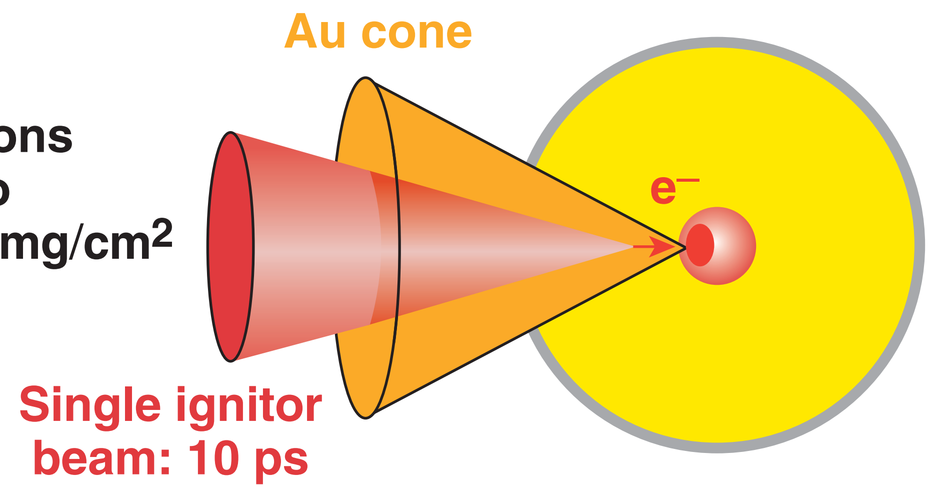
Channeling Concept[1]



Light pressure bores hole in coronal plasma

~1-MeV electrons heat DT fuel to ~10 keV, ~300 mg/cm^2

Cone-Focused Concept[2]



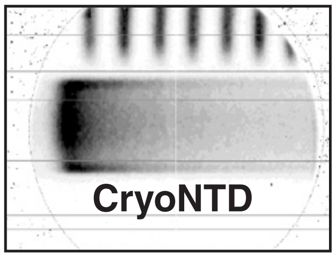
Key physics issues

- hot-electron production
- transport to the core
- core formation

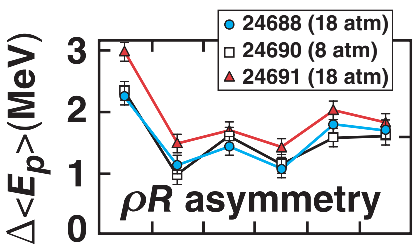
[1]M. Tabak *et al.*, Phys. Plasmas 1, 1626 (1994).
[2]R. Kodama, Nature 418, 933 (2002).

E11710m

Integrated cryogenic DD FI experiments on OMEGA will validate/compare both channeling and cone concepts on a single facility

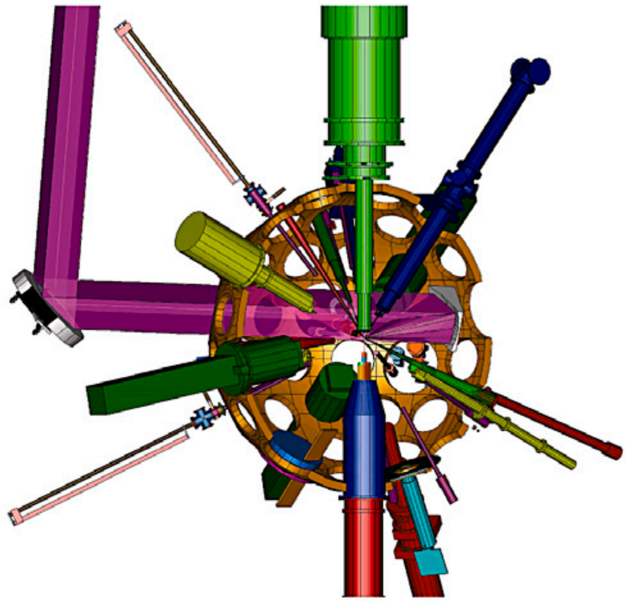


Neutronics

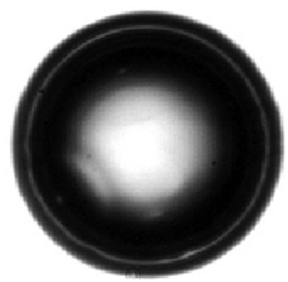


Charged-particle spectroscopy

Cone targets

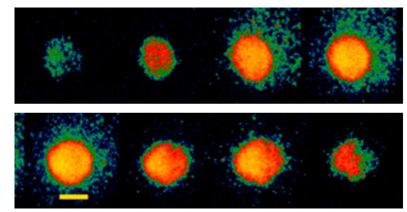


Petawatt beam - OMEGA EP

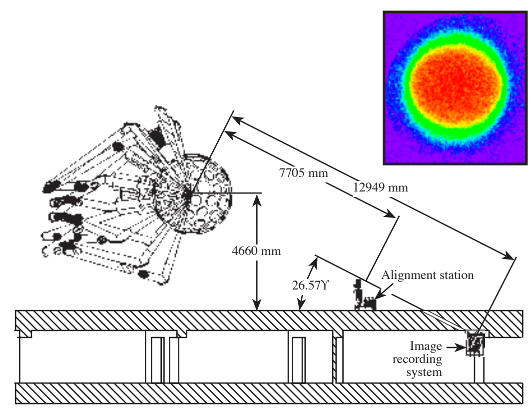


Direct-drive DD and DT cryo capsules

- High throughput
- Proven diagnostics
- Proven cryogenics



X-ray imaging



Neutron imaging

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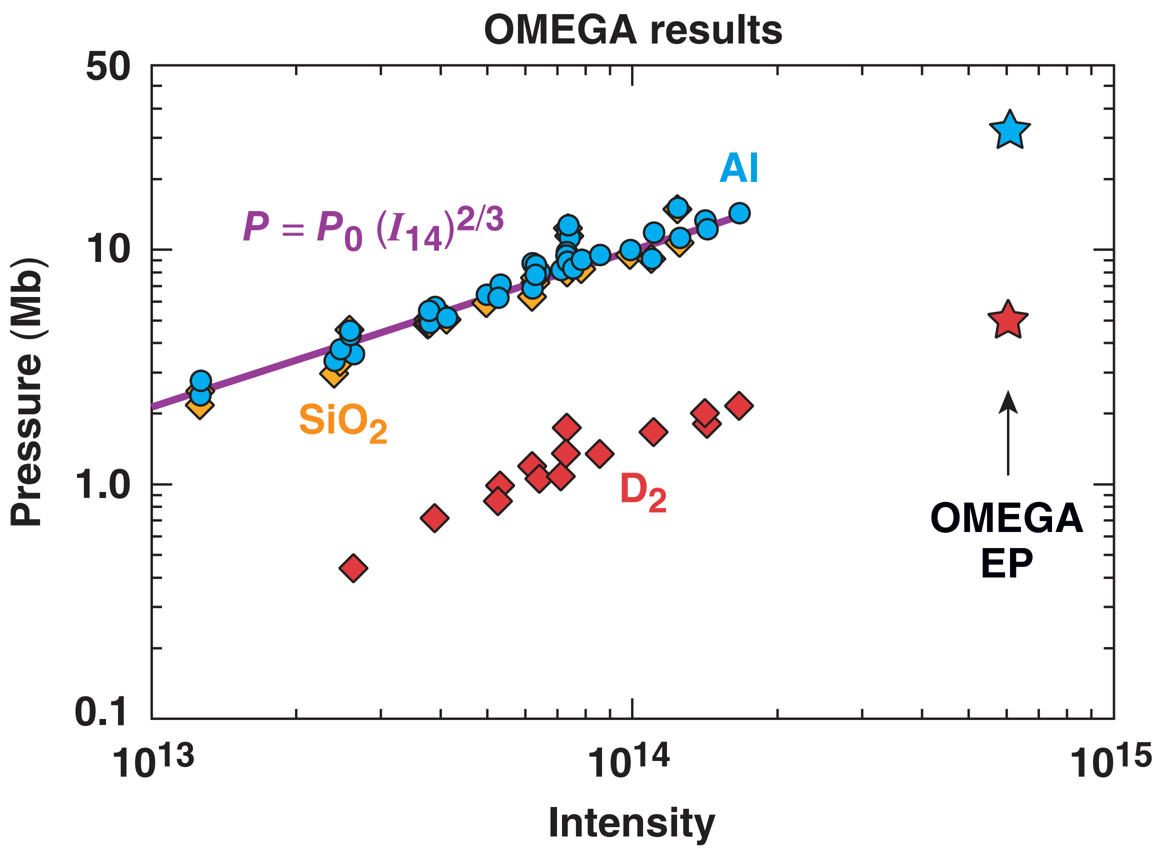
OMEGA EP will have 2 ~ 3 higher drive pressures for EOS experiments than available on OMEGA

- The long-pulse UV OMEGA EP beams will drive shock waves of ~30 Mbar in Al and 5 Mbar in D_2.
- OMEGA EP will be equipped with a VISAR/SOP and planar cryogenic target handling for EOS studies.



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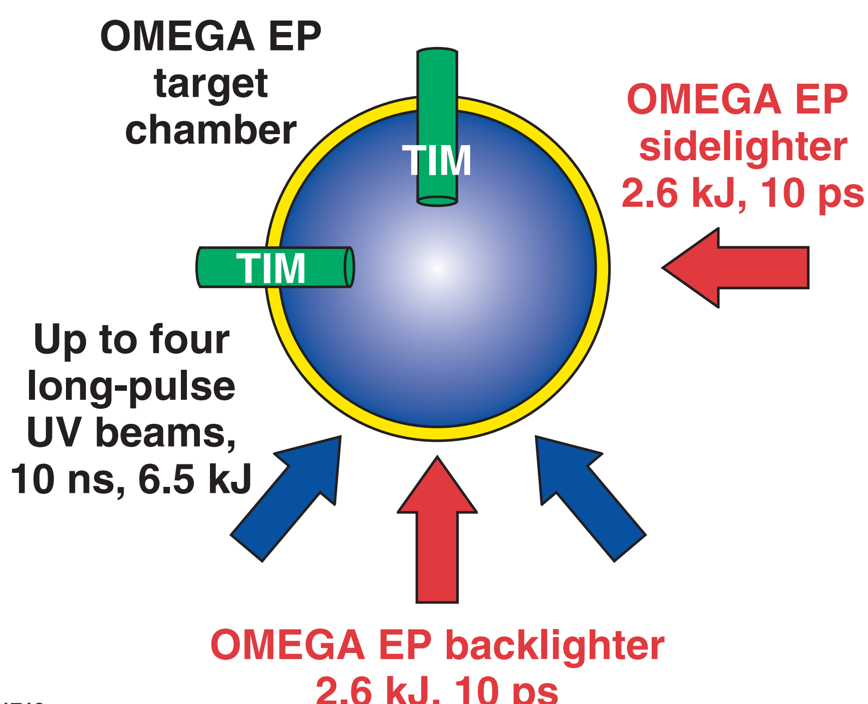
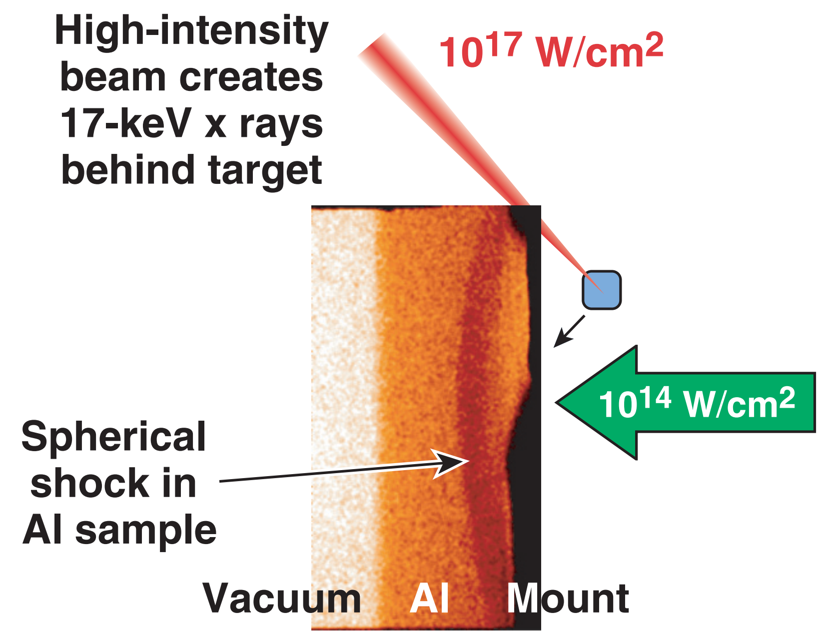
The combination of long- and short-pulse beams on OMEGA EP will allow high-photon-energy backlighting of compressed materials

- High-photon-energy backlighting of shock-compressed materials has been demonstrated at RAL.
- Backlighting in underground experiments allowed increased understanding.
- Higher pressures and photon energies are available on OMEGA EP.





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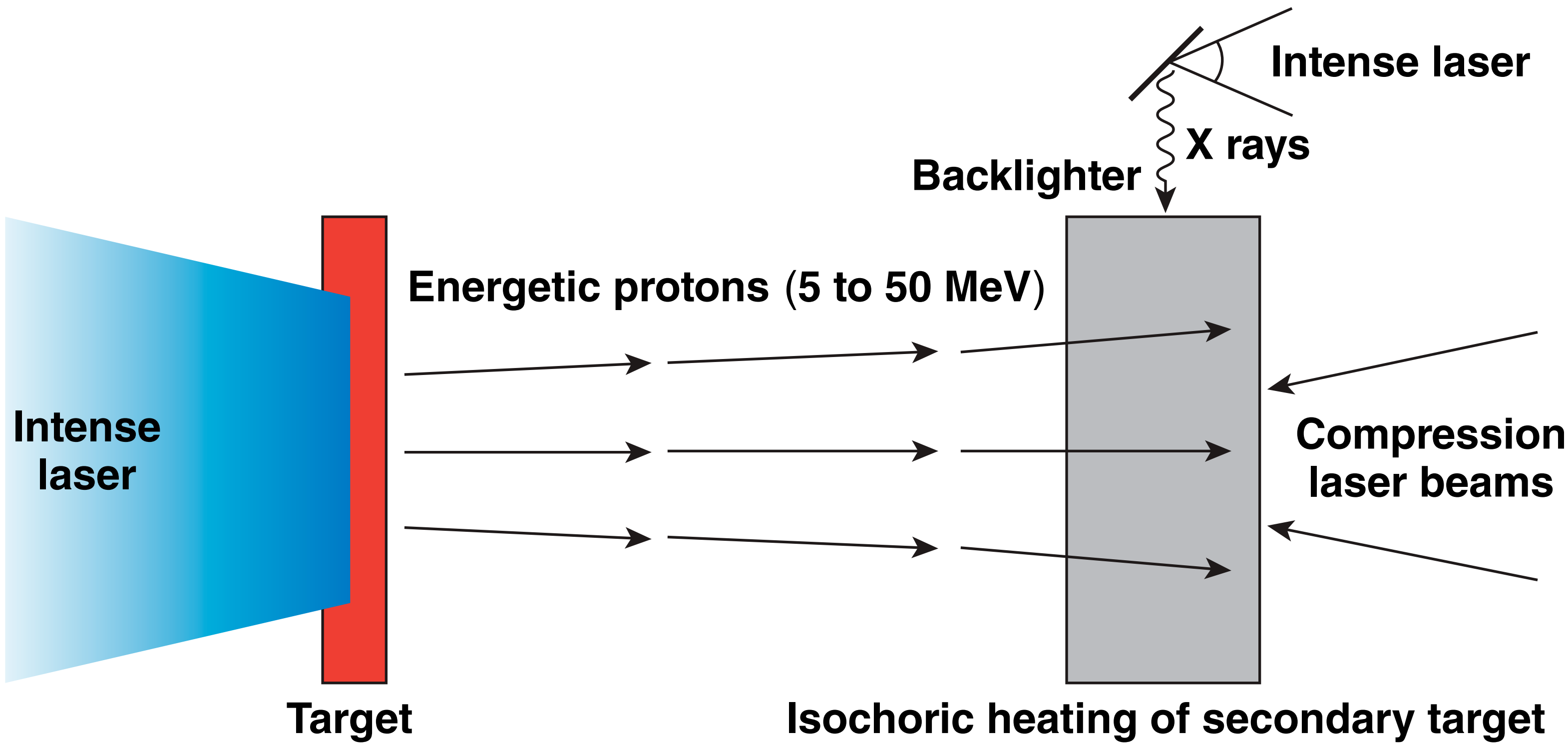
Joint experiment at RAL by M. Koenig *et al.*

High-energy PW systems can be used to isochorically heat solid-density matter to high temperatures

High-energy PW lasers produce an intense beam of high-energy protons.

High-energy PW lasers can heat solid-density matter with electrons, protons, or photons.



Applications: Radiography, measuring fields, heating

Applications: Fast-ignition opacity of high-density, high-*Z* matter; access otherwise unreachable regions of phase space

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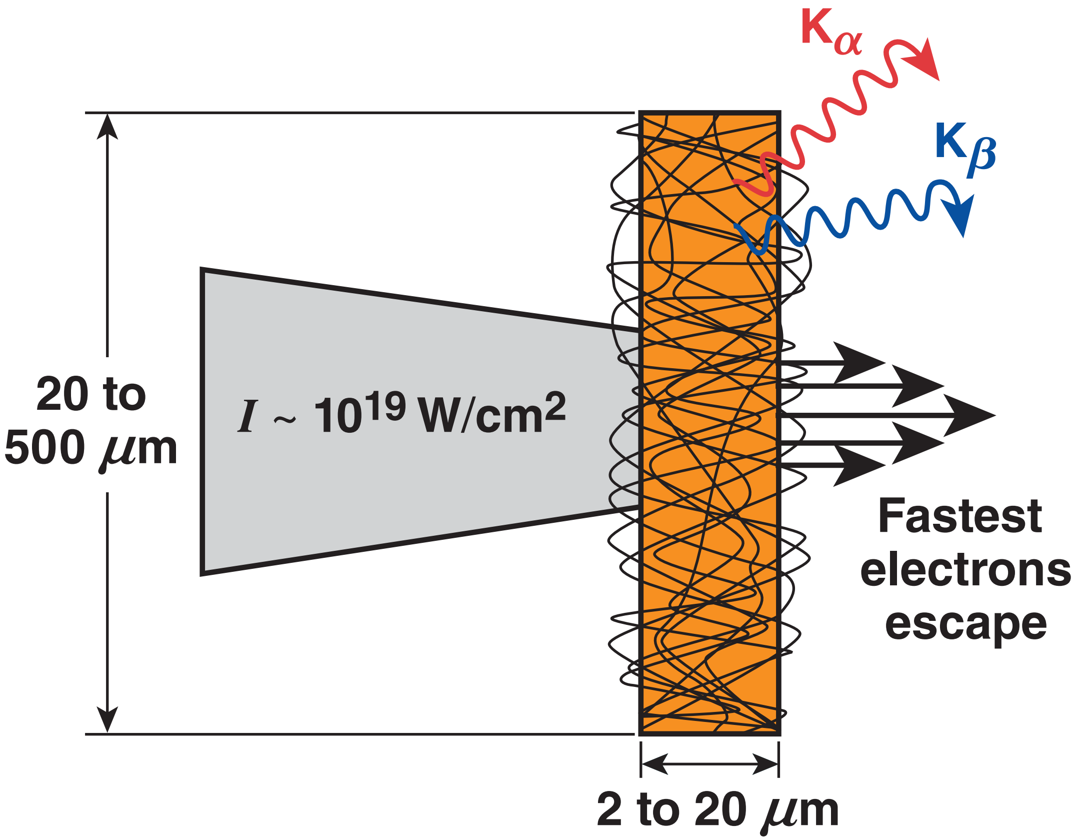
Fast-electron refluxing in small-mass targets allows access to high-energy-density phenomena



- Refluxing is caused by Debye sheath field effects[1,2]
- Majority of fast electrons are stopped in the target
- Provides a simple geometry for testing laser-coupling, electron-generation, and target-heating models[3,4]

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[1]S. P. Hatchett *et al.*, Phys. Plasmas 7, 2076 (2000).
[2]R. A. Snavely *et al.*, Phys. Rev. Lett. 85, 2945 (2000).
[3]W. Theobald *et al.*, Phys. Plasmas 13, 043102 (2006).
[4]J. Myatt *et al.*, Phys. Plasmas 14, 056301 (2007).

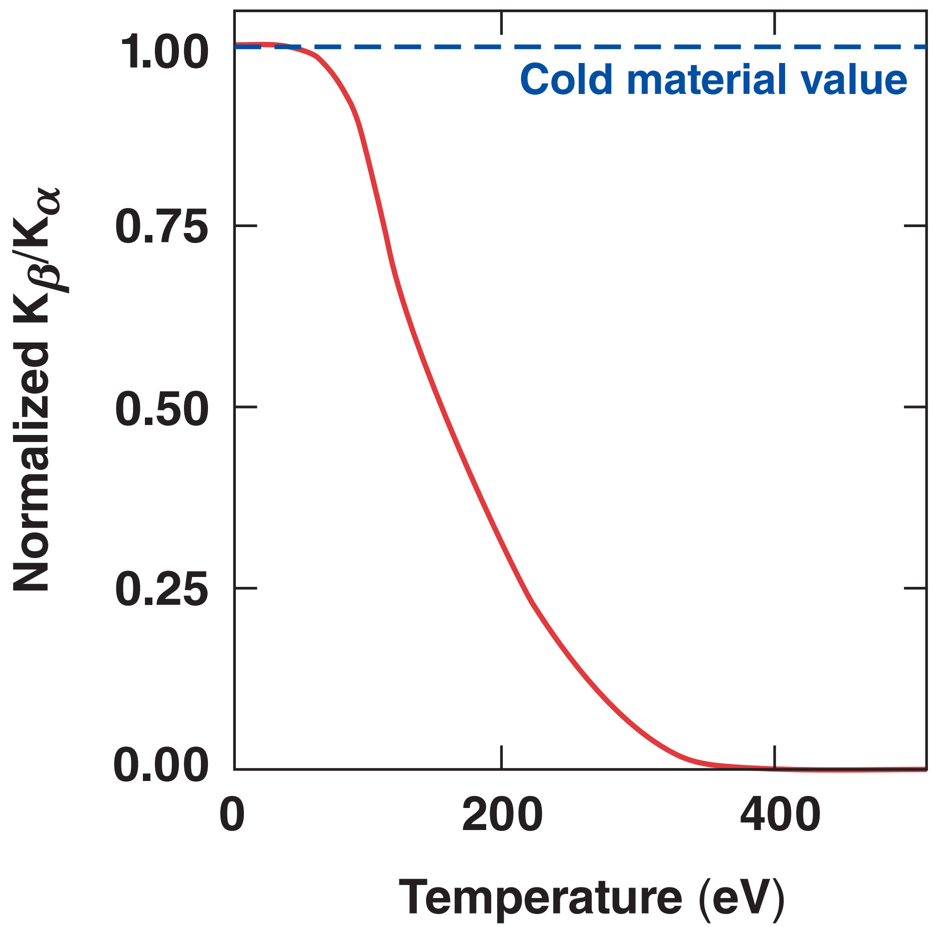
E16142

The K_β/K_α ratio is sensitive to the bulk-electron temperature

FSC

UR LLE

- In the cold limit $K_\beta/K_\alpha \approx 0.14$
- For T_e = 400 eV, the copper M-shell is completely depleted
- K_β/K_α variation with temperature can be studied experimentally using various mass targets (for fixed laser conditions)



Decreasing target volume →

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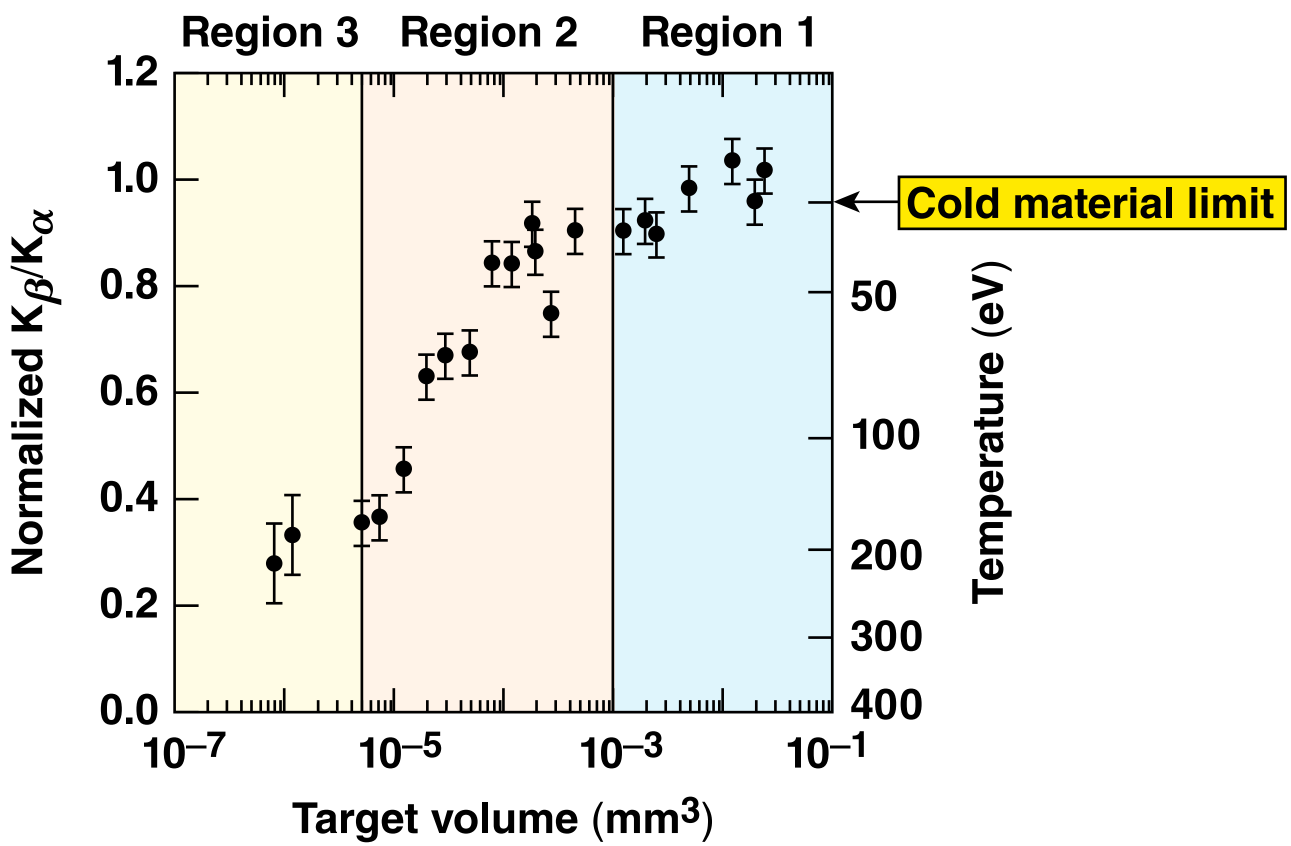
A 3.5× reduction of K_β/K_α for target volumes $V = 10^{-6}$ mm^3 is consistent with bulk-electron temperatures $T_e \gtrsim 200$ eV



Increasing energy density ←

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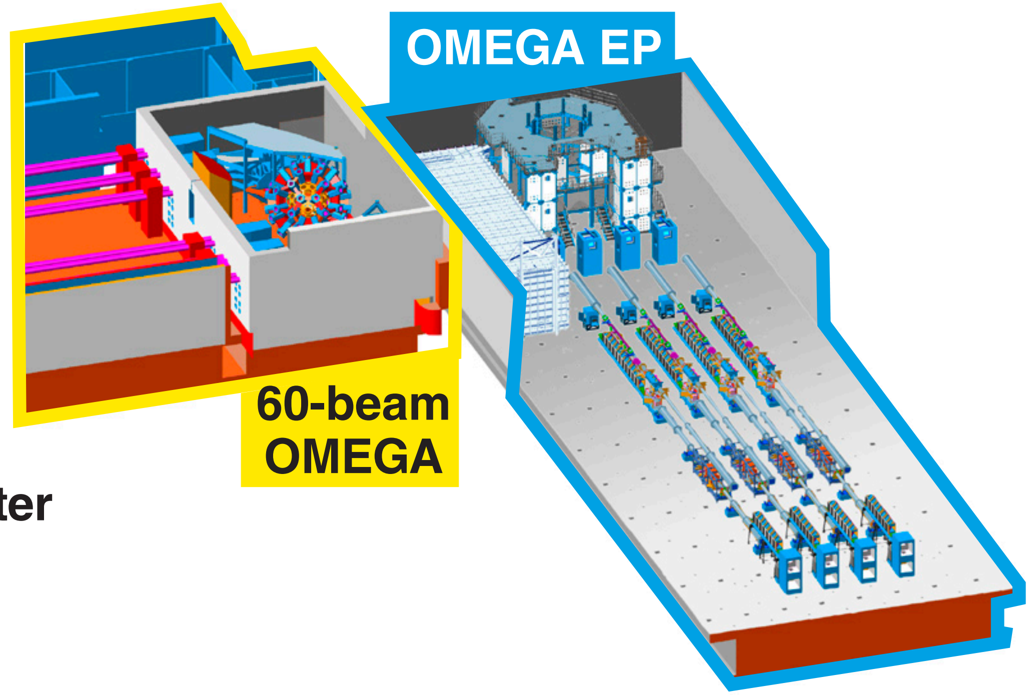

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