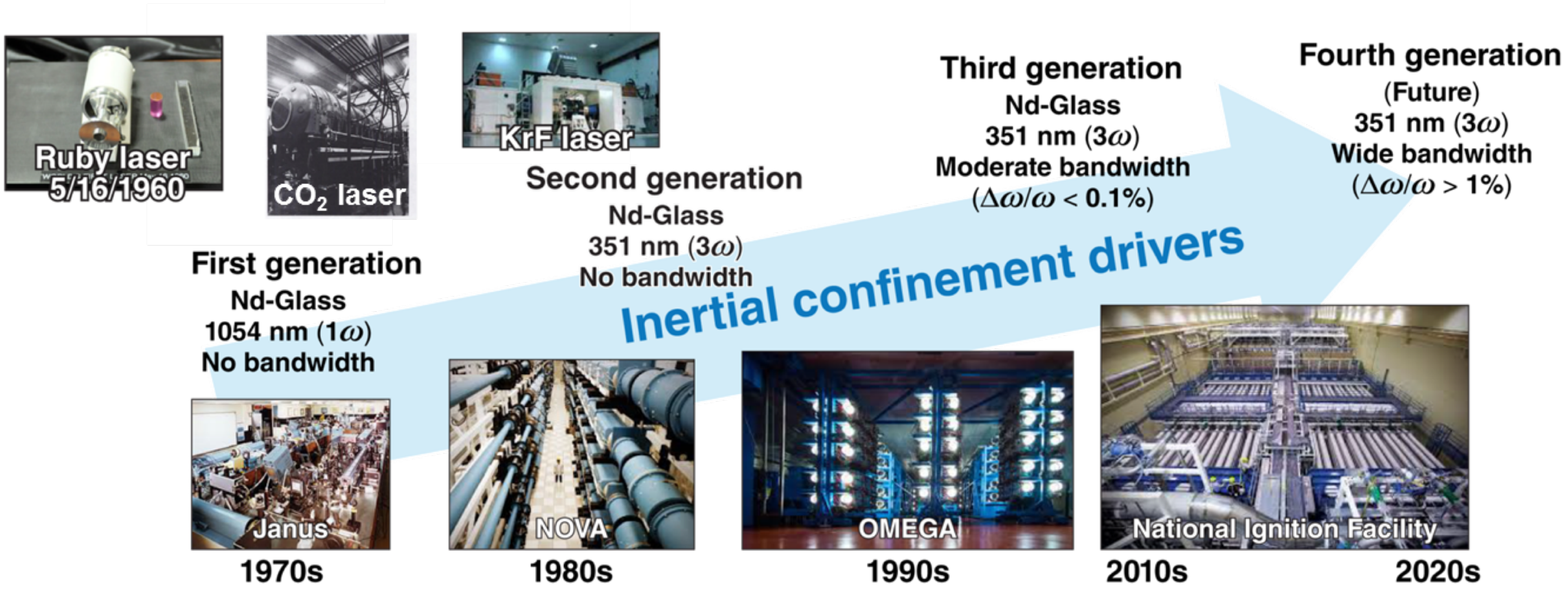
Fourth-Generation Laser for Ultra-Broadband Experiments—Expanding the ICF Design Space Through Mitigation of Laser Plasma Instabilities



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A Fourth-Generation Laser for Ultra-broadband eXperiments (FLUX) is being built to demonstrate the laser technologies at scale and provide a broadband beam on OMEGA for LPI studies

- Simulations predict $\Delta\omega/\omega>1\%$ laser bandwidth will mitigate LPI in direct-drive implosions

- An ultrawide bandwidth ($\Delta\omega/\omega>1\%$) UV long-pulse laser is being developed at LLE

- Efficient (>75%) amplification efficiency (narrow $1\omega \rightarrow$ broadband 1ω) has been demonstrated at high-powers

- Summed frequency generation (broadband 1ω + narrow band $2\omega \rightarrow$ broad band 3ω) is currently being tested as an efficient method to create broadband UV light

Collaborators

Laser Team:

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Plasma physics (Theory and Experimental) Team:

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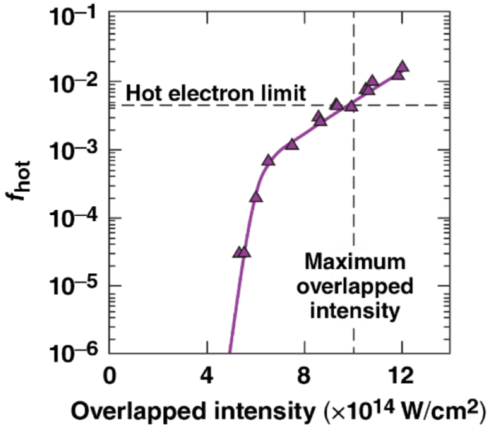
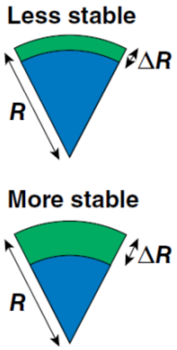
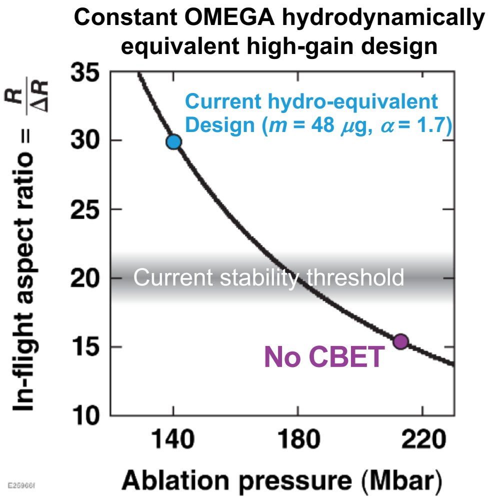
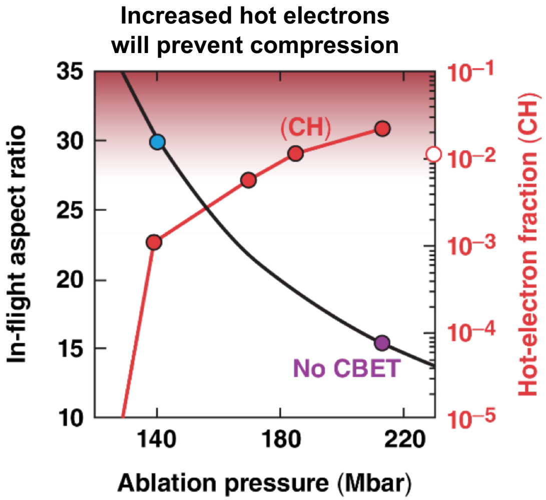
Los Alamos National Laboratory

For direct-drive experiments, the maximum drive pressure is set by the intensity threshold for hot-electron generation







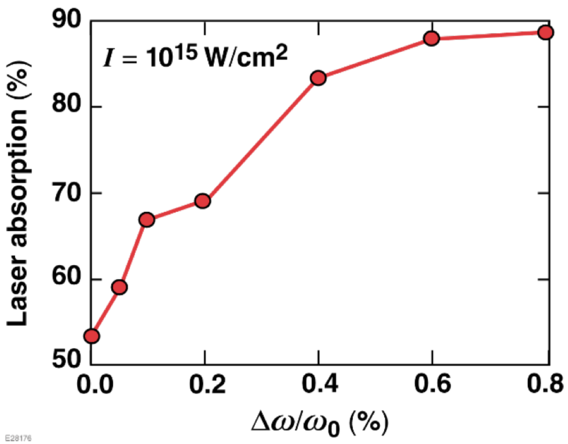


Solutions to expand the ICF design space by mitigating LPI must consider both CBET and TPD instabilities.

LPI modeling predicts that $\Delta\omega/\omega$ > 1% bandwidth can mitigate both CBET and hot-electron generation in hydrodynamic-equivalent ignition implosions on OMEGA

UR LLE

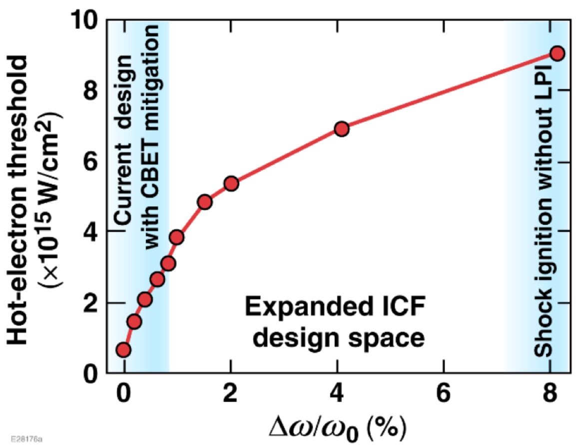
Cross-Beam Energy Transfer (Increased Drive Pressure)



Increasing $\Delta\omega/\omega$>0.5% will allow stable implosions on OMEGA (IFAR=15)

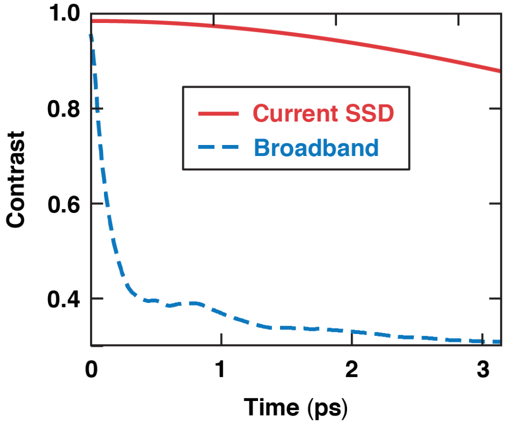
IFAR: in-flight aspect ratio

Two-Plasmon Decay (Hot-Electron Mitigation)



Increasing $\Delta\omega/\omega$>1% will mitigate both CBET and hot electrons and allow for hydro-equivalent ignition

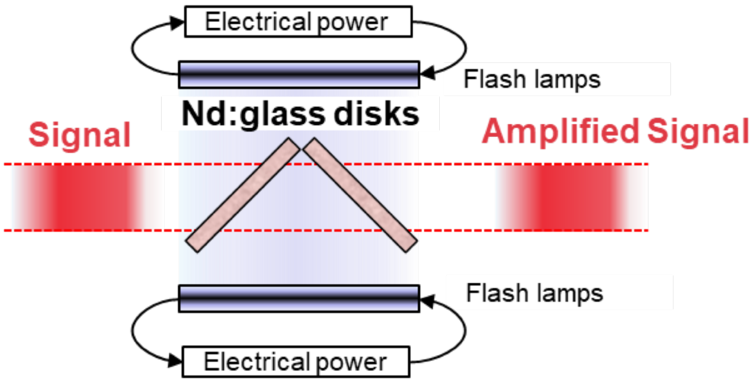
Improved Imprint (<1-ps asymptotic smoothing)



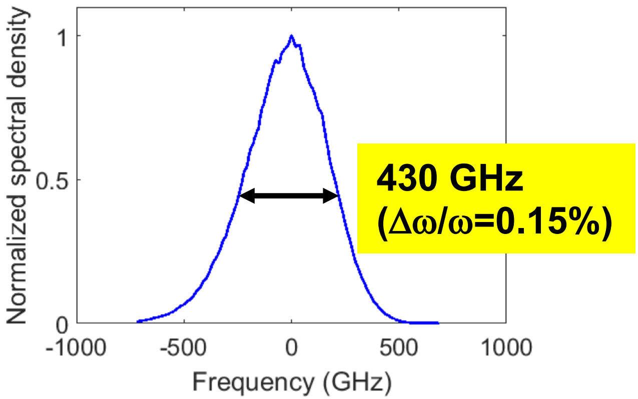
See J. Wilson NO5.00002 (Wed. 930A)

Improved imprint will further expand the direct-drive design space by increasing the hydro-stability threshold

From the beginning of laser-plasma instability research (1970s)*, theory showed that bandwidth could mitigate LPI, but glass lasers could not support it



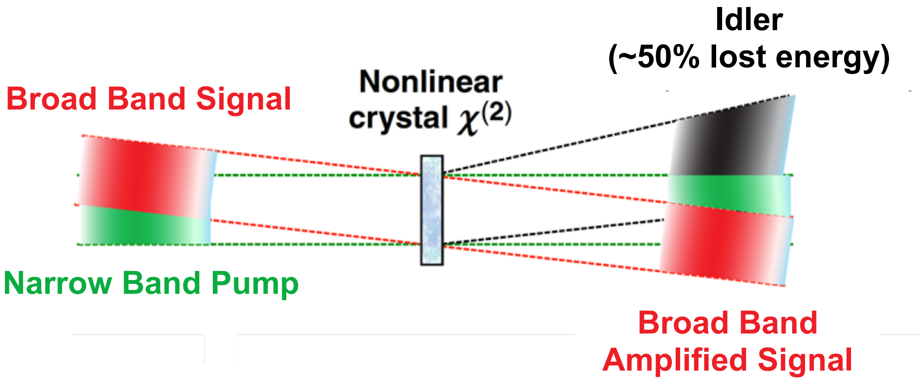
NIF-PAM fluorescence



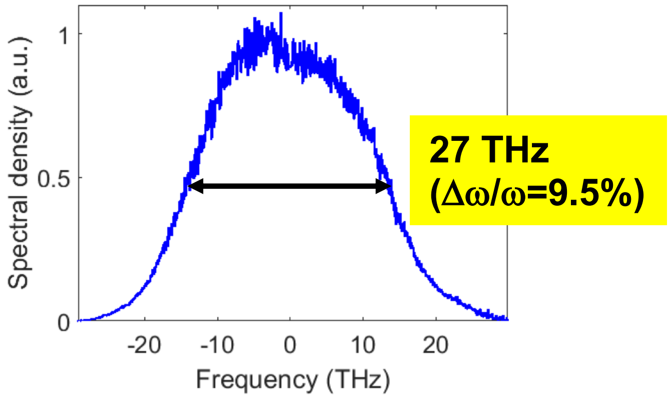
*J. Thomson & J. Karush, Phys. Fluids **17**, 1608 (1974); L. Lu Phys. Fluids B 1, 1605 (1985)

High-bandwidth technologies developed to support short-pulse lasers are being used at LLE to build the next-generation driver for ICF

Current Ultrashort Noncollinear Optical Parametric Amplifier Technology



LBO* OPA preamplifier

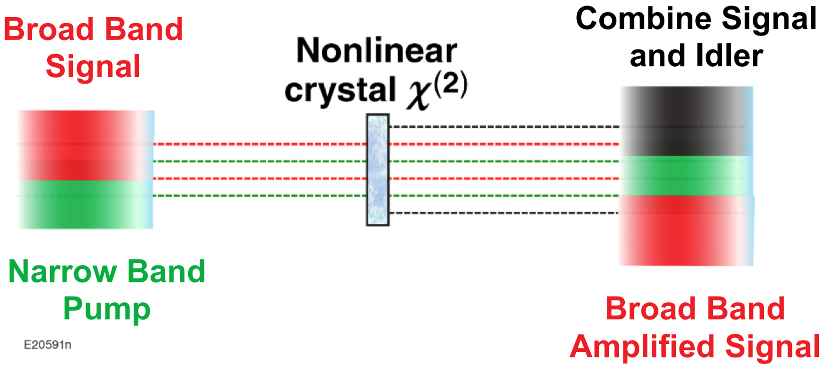


Noncollinear Optical Parametric Amplifiers are inherently inefficient

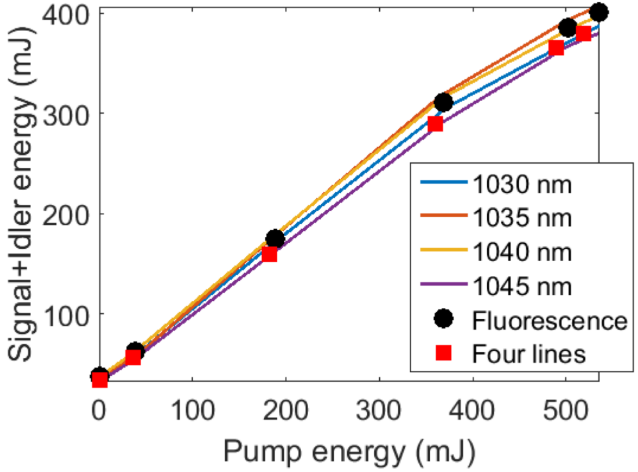
*** LBO: Lithium triborate***

Adapting the Noncolinear OPA provides an efficient broadband amplifier

Proposed Co-Linear OPA Amplifier Technology

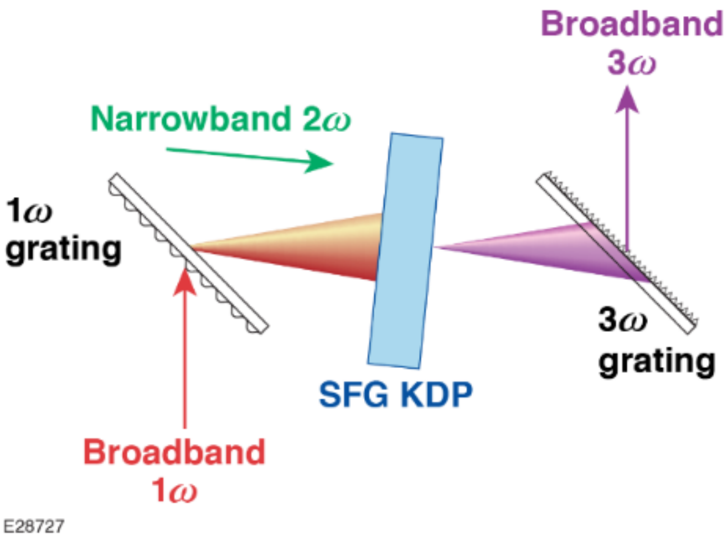


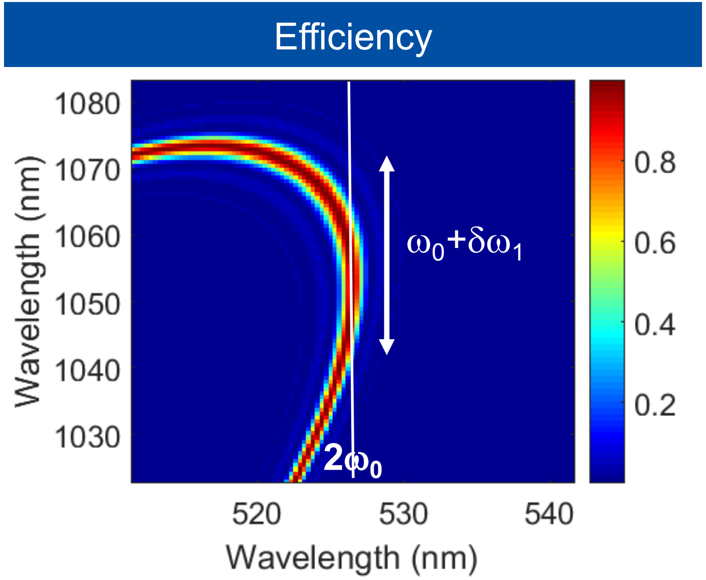
Joule level experiments demonstrate high efficiency amplification



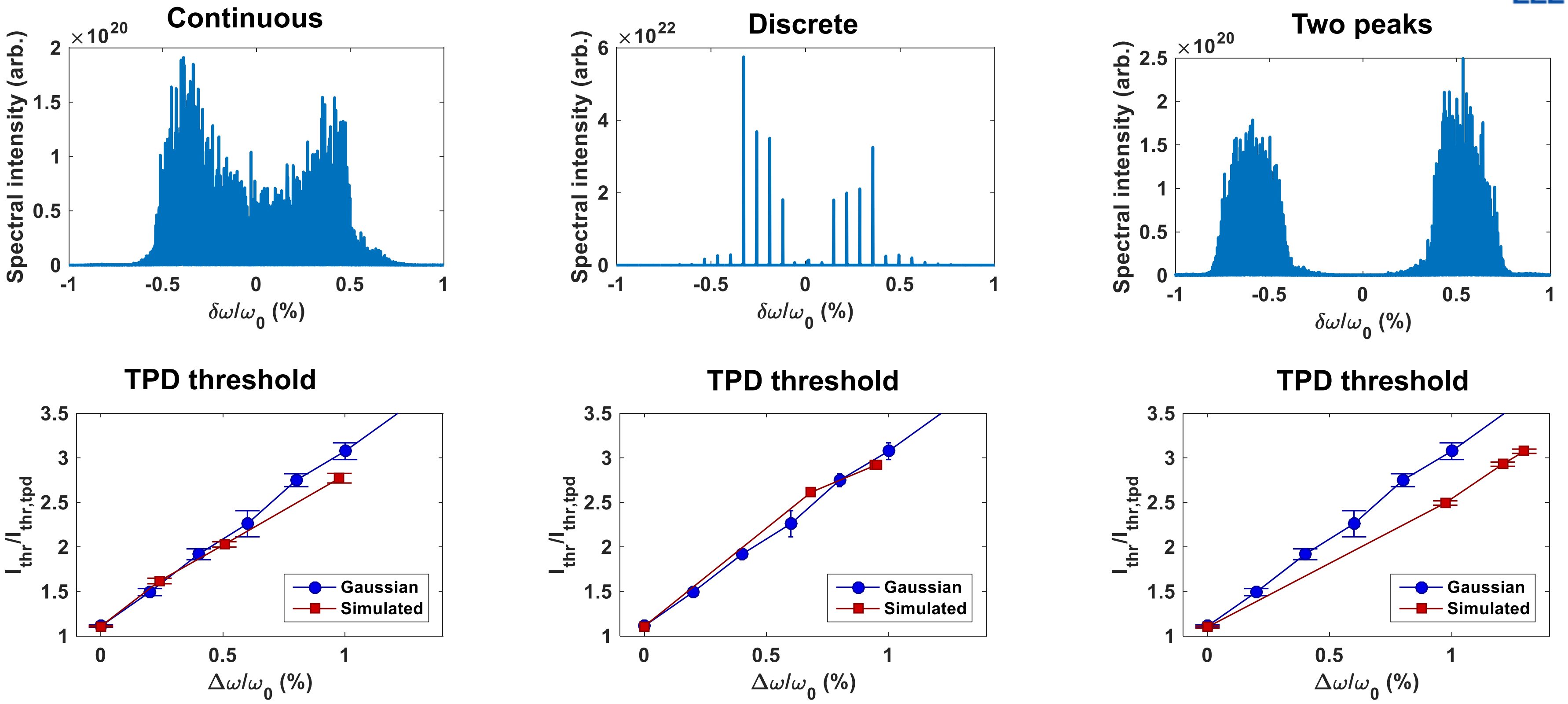
The co-linear OPA provides efficient conversion (>75%) of narrow band 2ω light to broadband 1ω

A novel summed frequency generation concept is being tested to efficiently produce broadband UV light

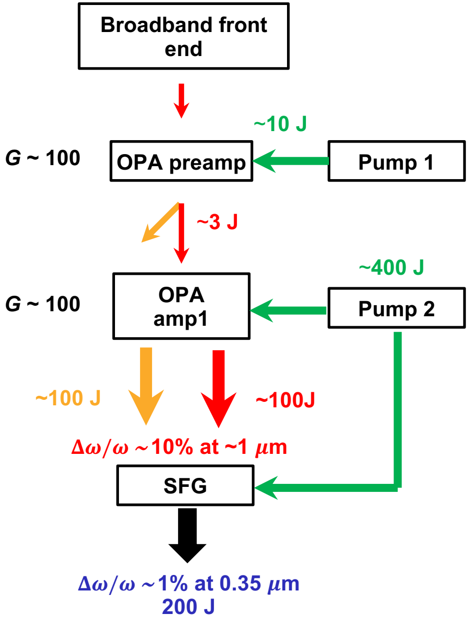




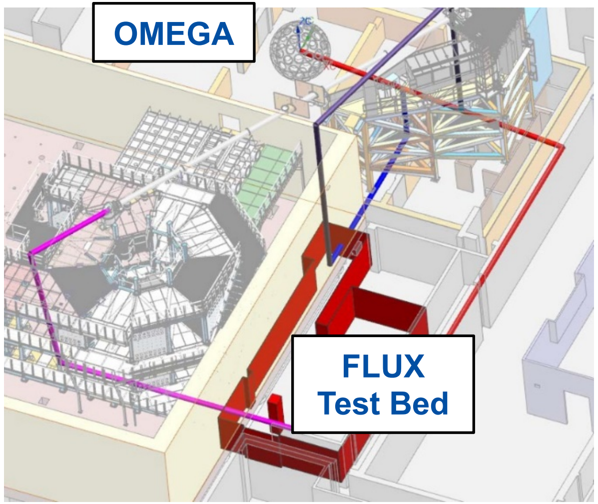
LPSE was used to determine the ideal bandwidth format when considering collinear optical parametric amplification



A Fourth-Generation Laser for Ultra-broadband eXperiments (FLUX) is being built as an additional laser beam on OMEGA

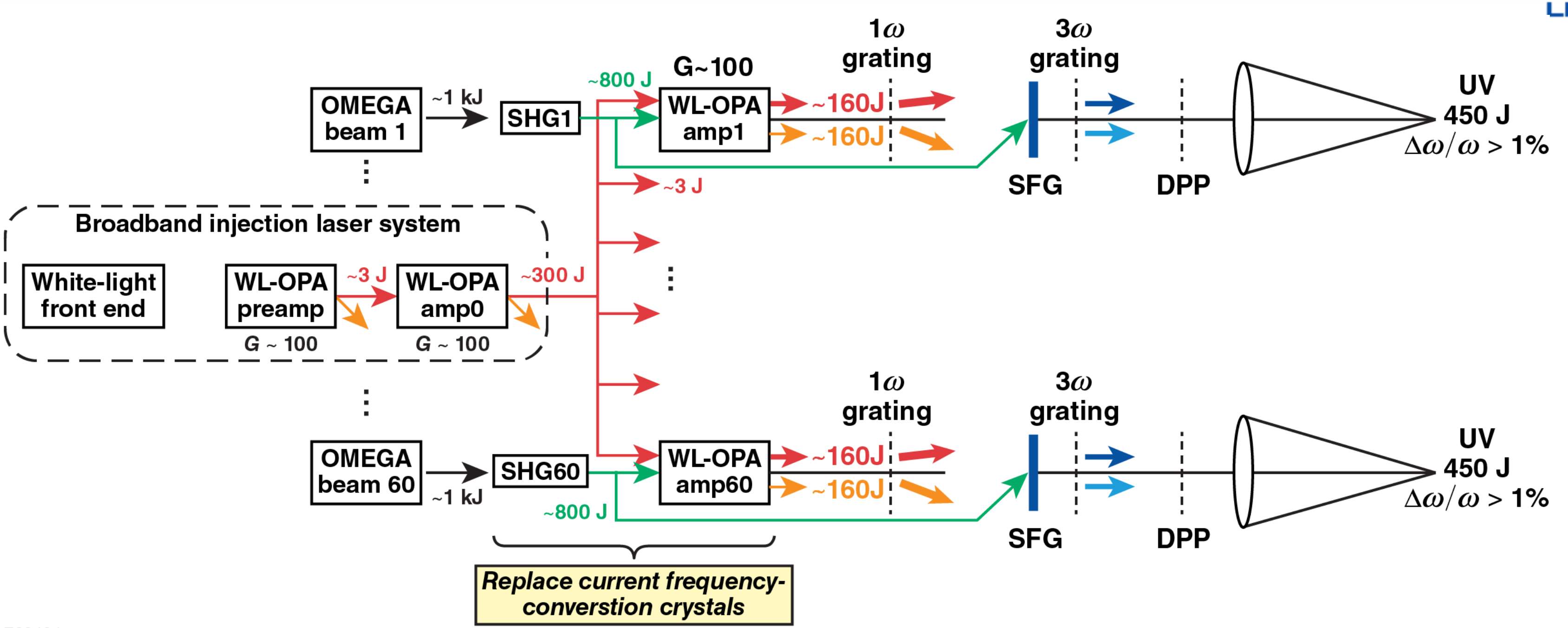


The FLUX laser will feed the OMEGA LPI Platform



The FLUX laser will be used with the LPI Platform on OMEGA to test the effects of bandwidth on CBET and hot electron generation

A successful technology demonstration (FLUX) will lead to a design for an upgraded OMEGA with ultra-wide bandwidth



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A conceptual layout for a "OMEGA FLUX-60" leverages the existing infrared laser system, target area, and diagnostics

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