A New Spectrally Tunable Narrowband Front-End Source for Cross-Beam Energy Transfer Mitigation Experiments

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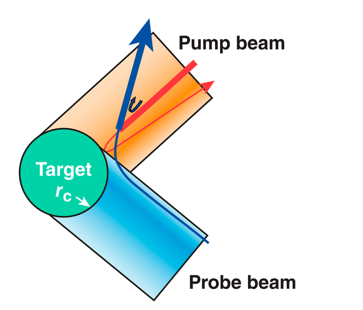
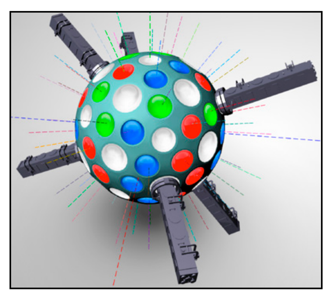
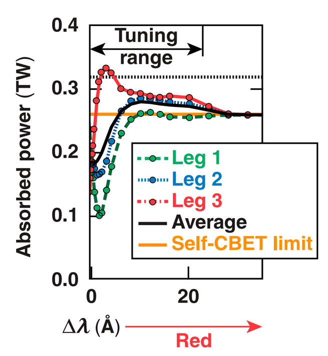
A tunable UV beam is being developed to study cross-beam energy transfer (CBET) mitigation



CBET is the transfer of laser energy from ingoing (pump) rays to outgoing (probe) rays, and it reduces the energy absorbed by the target



A three-color OMEGA front end is proposed because wavelength detuning can help minimize the energy losses



Wavelength detuning is predicted to recover much of the drive power currently lost to CBET

The system will enable robust tests of integrated CBET hydro models and demonstrate CBET mitigation using wavelength shifting.

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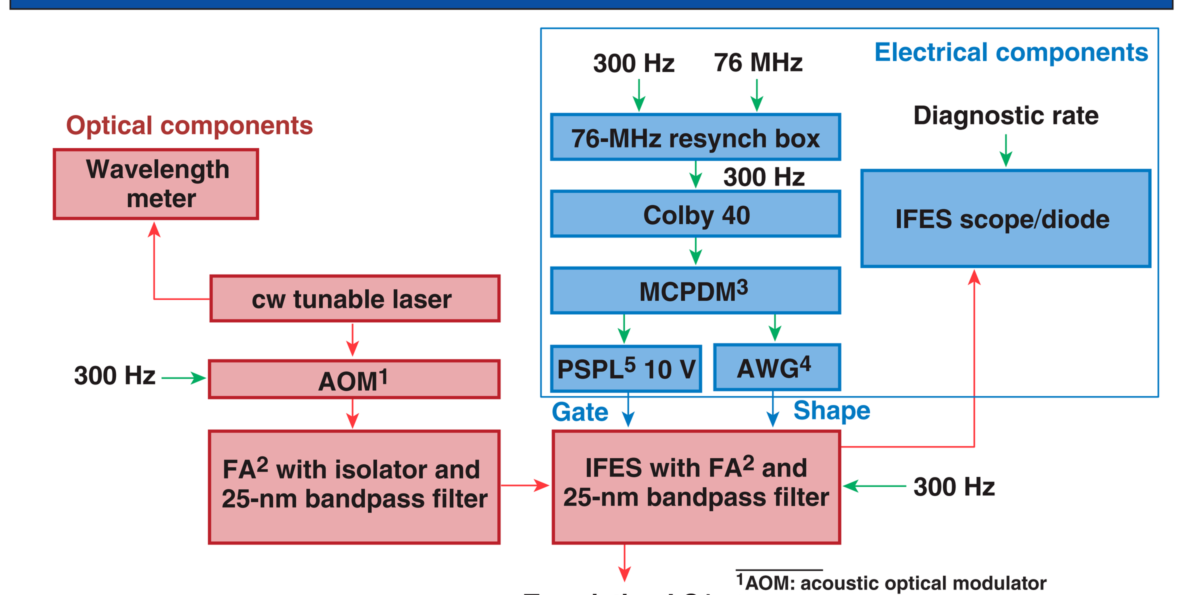
D. H. Edgell *et al.*, Phys. Plasmas 24, 062706 (2017).

A new fiber front end has been installed in the OMEGA EP Laser Sources Bay to feed the OPA system with a narrowband tunable seed



[1]AOM: acoustic optical modulator
[2]FA: fiber amplifier
[3]MCPDM: multichannel picosecond delay module
[4]AWG: arbitrary waveform generator
[5]PSPL: picosecond pulse labs

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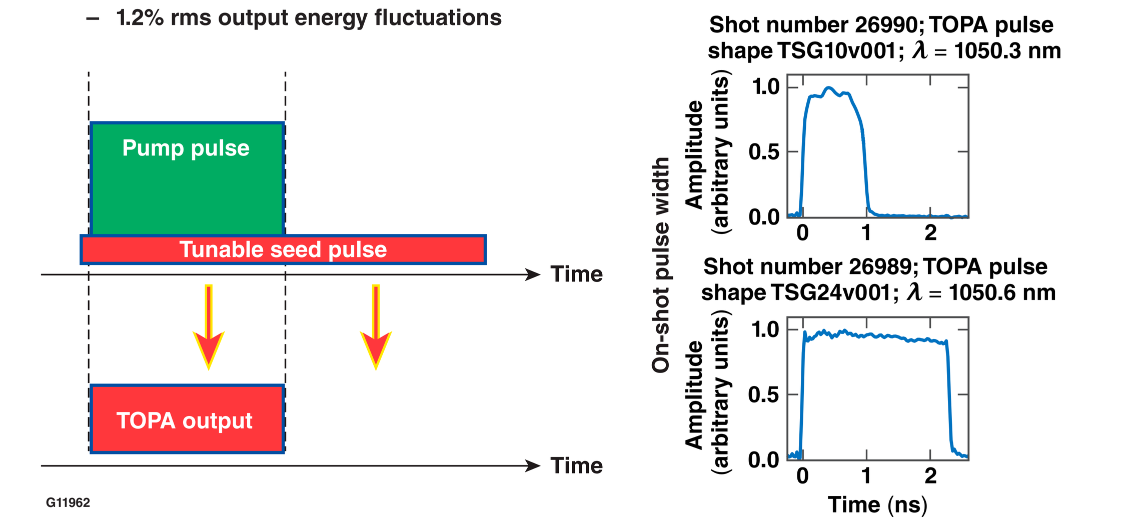
Varying the duration of the OPA pump pulse supports signal pulse lengths from 1.0 ns up to 2.4 ns while minimizing fluorescence

- Operate with temporally square signal and pump pulses
  - output pulse length is set by adjusting the length of the pump pulse
  - timing of the pump pulse is set ~50 ps following the seed pulse to minimize ASE/fluorescence
  - wavelength tunability in <0.03-nm steps from 1050.6 nm to 1060.2 nm (in the IR)
  - 1.2% rms output energy fluctuations



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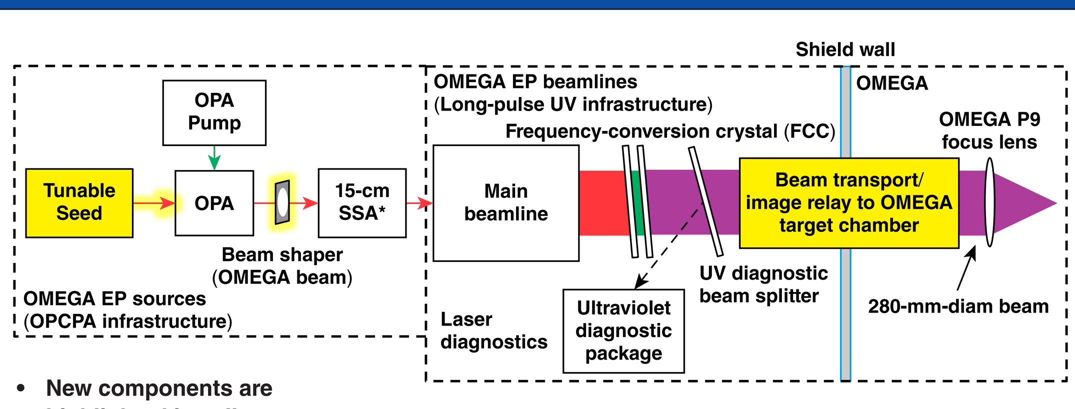
The preferred concept uses existing elements of OMEGA EP Beamline 1 with a tunable seed



- New components are highlighted in yellow
- The tunable optical parametric amplifier (OPA) source utilizes the OMEGA EP short-pulse optical parametric chirped-pulse amplifier (OPCPA) system with a narrowband tunable seed laser injected into the preamplifier (bypassing the stretcher)

Top-level requirements

Parameter	Minimum requirement	Goal
Tuning range	351 to 352.6 nm	350.2 to 353.4 nm
Wavelength step	<0.01 nm	
Power on target	0.1 TW (351 to 352.6 nm) 0.01 TW (350.2 to 353.4 nm)	0.5 TW for $\tau \leq$ 1 ns 0.1 TW for $\tau >$ 1 ns (full spectrum)

*SSA: single-segment amplifier

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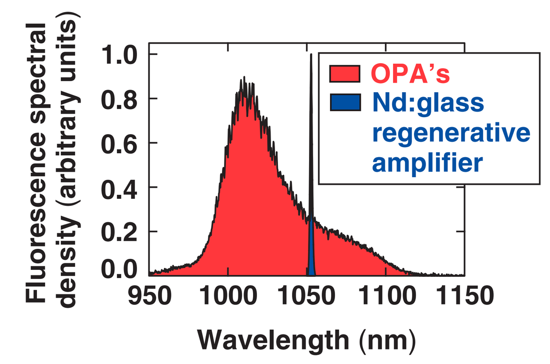
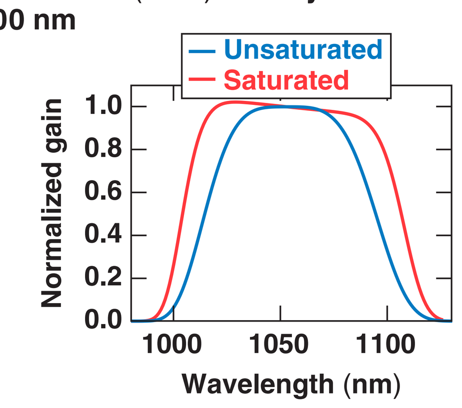
The existing optical parametric amplifiers used for short-pulse operations theoretically provide more than 100 nm of bandwidth

- The Nd-doped amplifiers used in the OMEGA EP main beamline have a very limited gain bandwidth compared to an OPA
  - the bandwidth of the OMEGA EP main beamlines has been measured to be ~3.5 nm
- The OMEGA EP two-stage, lithium triborate (LBO) OPA system has a bandwidth of greater than 100 nm





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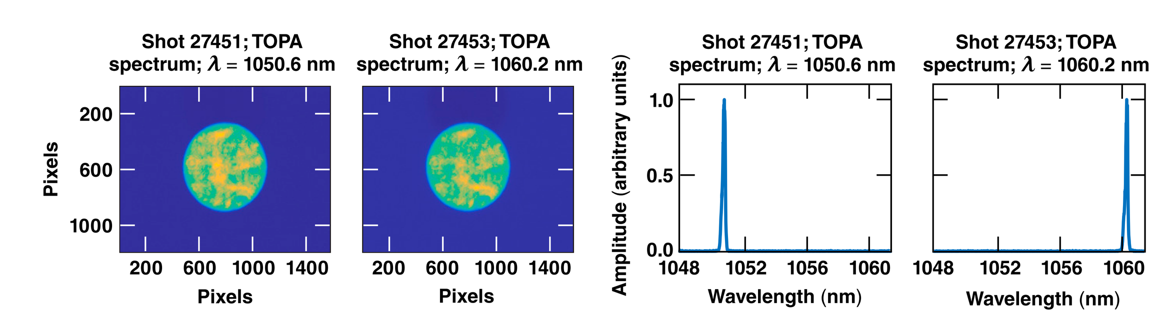
The tunable front end has been fully characterized across the full range of required IR wavelengths



- Operational parameters and procedures have been developed and tested to ensure ideal OPA operation across the full range of required IR wavelengths
  - IR range 1050 to 1060 nm in 0.03-nm steps
- Pump-energy set points for each pulse length were chosen to maintain intensity levels
- A correction factor is applied to energy diagnostics to compensate for wavelength-dependent sensitivity

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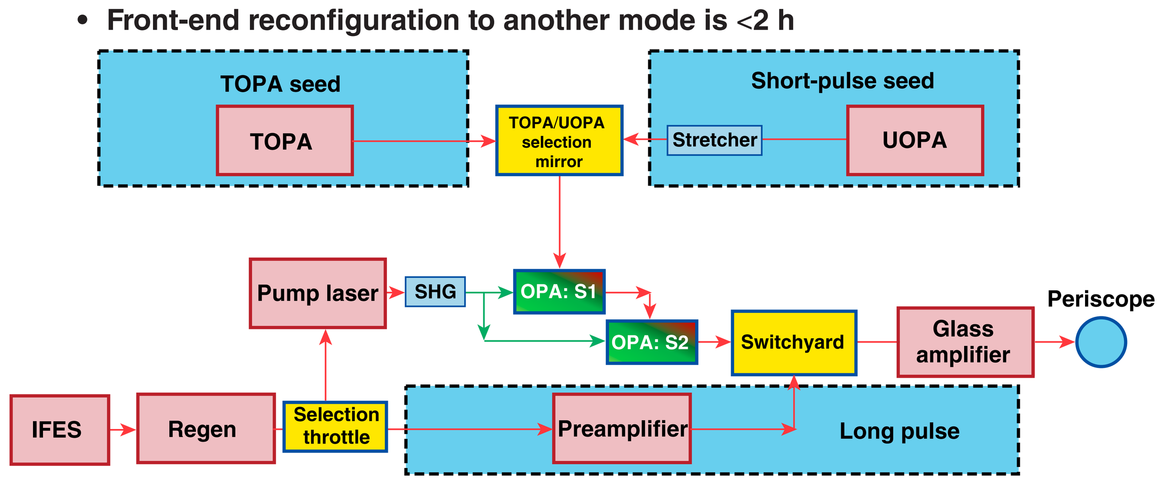
Beamline 1 can now support short pulses, shaped long pulses, and spectrally tunable square long pulses

- A series of kinematic mirrors allow the front-end configuration to be easily switched between long-pulse, short-pulse, and the new tunable OPA (TOPA) mode
- Front-end reconfiguration to another mode is <2 h



IFES: integrated front-end system
SHG: second harmonic generation
UOPA: ultrafast optical parametric amplifier

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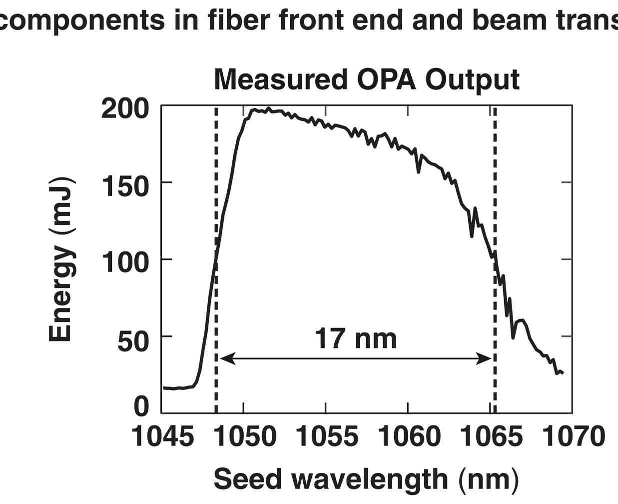
The tuning range available is limited by the need to suppress the broadband amplified spontaneous emission (ASE) of the fiber front end

- The TOPA is limited to a range of 17 nm; this is limited by
  - ASE filters in fiber amplifiers (<1050 nm)
  - fiber amplifier gain
  - components in fiber front end and beam transport



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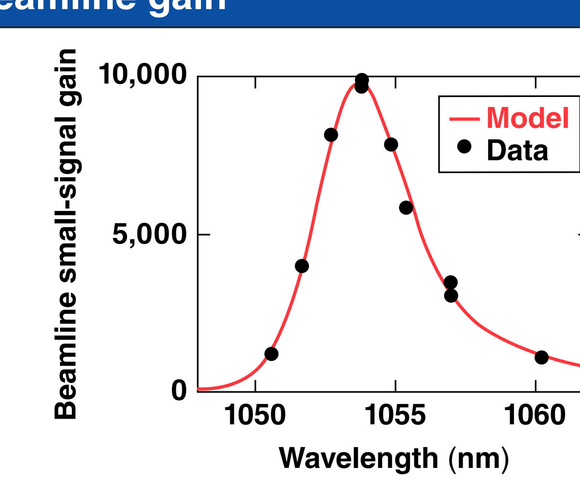
Fail-safe systems ensure that the on-shot seed wavelength is set consistently with the expected beamline gain



- Wavelength is actively monitored at two locations
  - a wavelength meter measures the tunable seed laser to a 0.005-nm accuracy
  - OPA output is sampled by the shared OPCPA/TOPA IR spectrometer

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