Creating a Cavity-Dumped Helium Neon Laser

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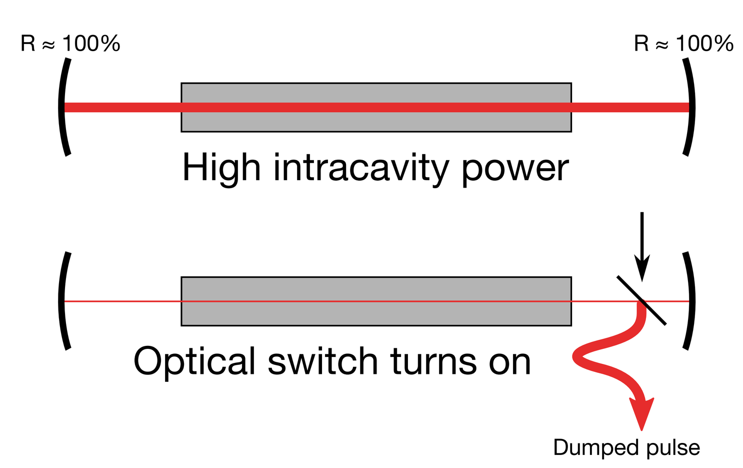
Abstract

We use an acousto-optic modulator to quickly dump circulating power from a 1.4 m open-cavity HeNe laser. We can extract 100 ns pulses with peak power ~2 mW at a repetition rate of 100 kHz. Peak power increases at lower repetition rates.

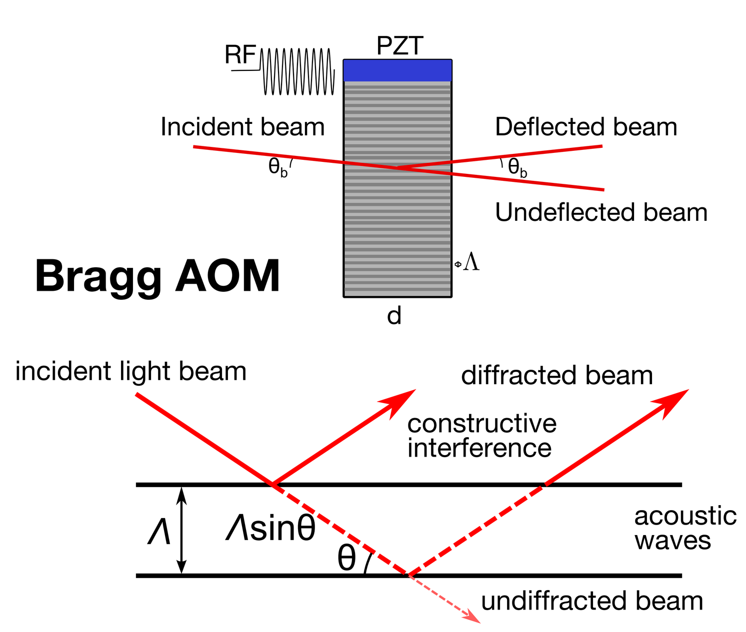
Background

Pulsed lasers are created by modelocking or energy modulation. In energy-modulated lasers, energy is built up in one component of the laser, and then released quickly. Pulsed pumped lasers store energy in the pump. Q-switched lasers store energy in the gain medium. Cavity dumped lasers store energy in the intracavity optical beam.



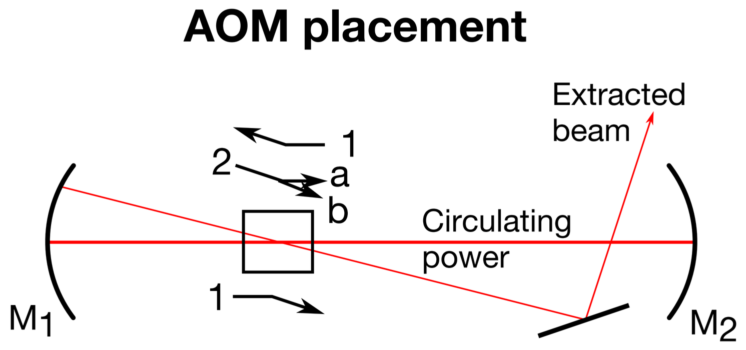
With cavity dumping, the OC is replaced with an HR to enable high intracavity power. Intracavity power is repetitively deflected out of the cavity by a high speed optical switch like an acousto-optic modulator or electro-optic modulator.

Acousto-optic modulator



A Bragg AOM diffracts an incident beam into a single first order beam.

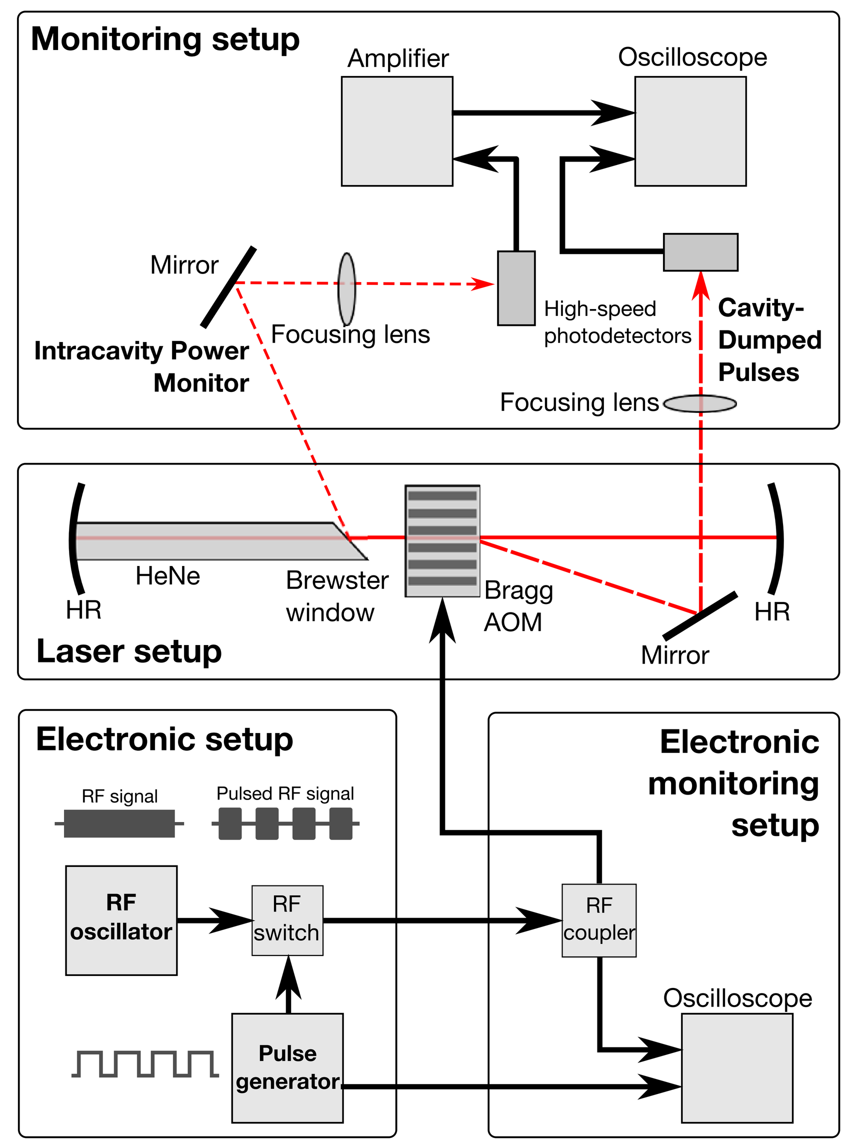
AOM placement



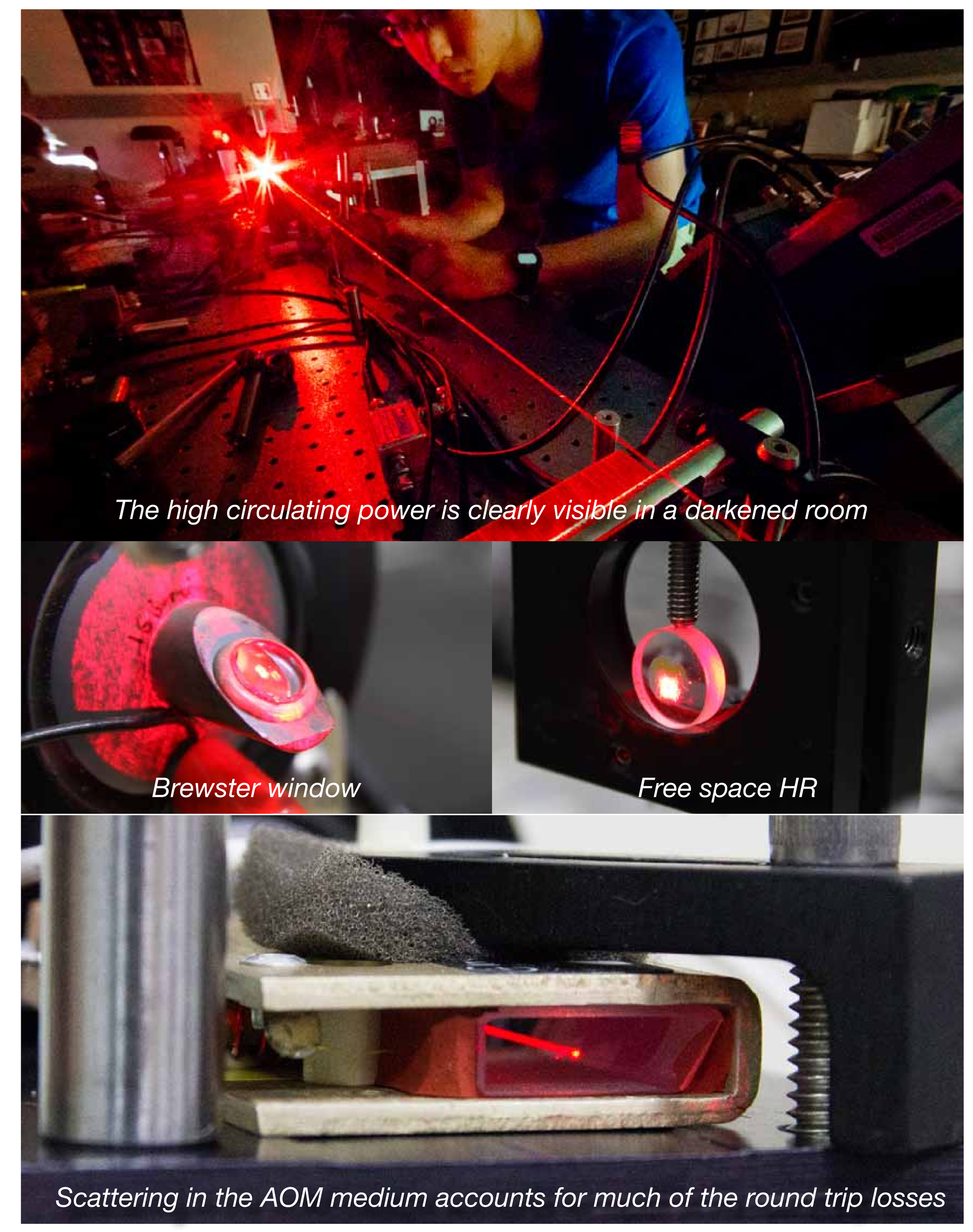
$$\eta' = 2\eta - \eta^2$$

For an AOM placed at the cavity beam waist, double-pass diffraction efficiency (η') depends on single-pass diffraction efficiency (η). We were, however, not able to recapture the return beam.

Experimental setup



The cavity is 1.4 m in length. Clipping the cavity-dumped beam out of shorter cavities was not possible without blocking the intracavity beam.



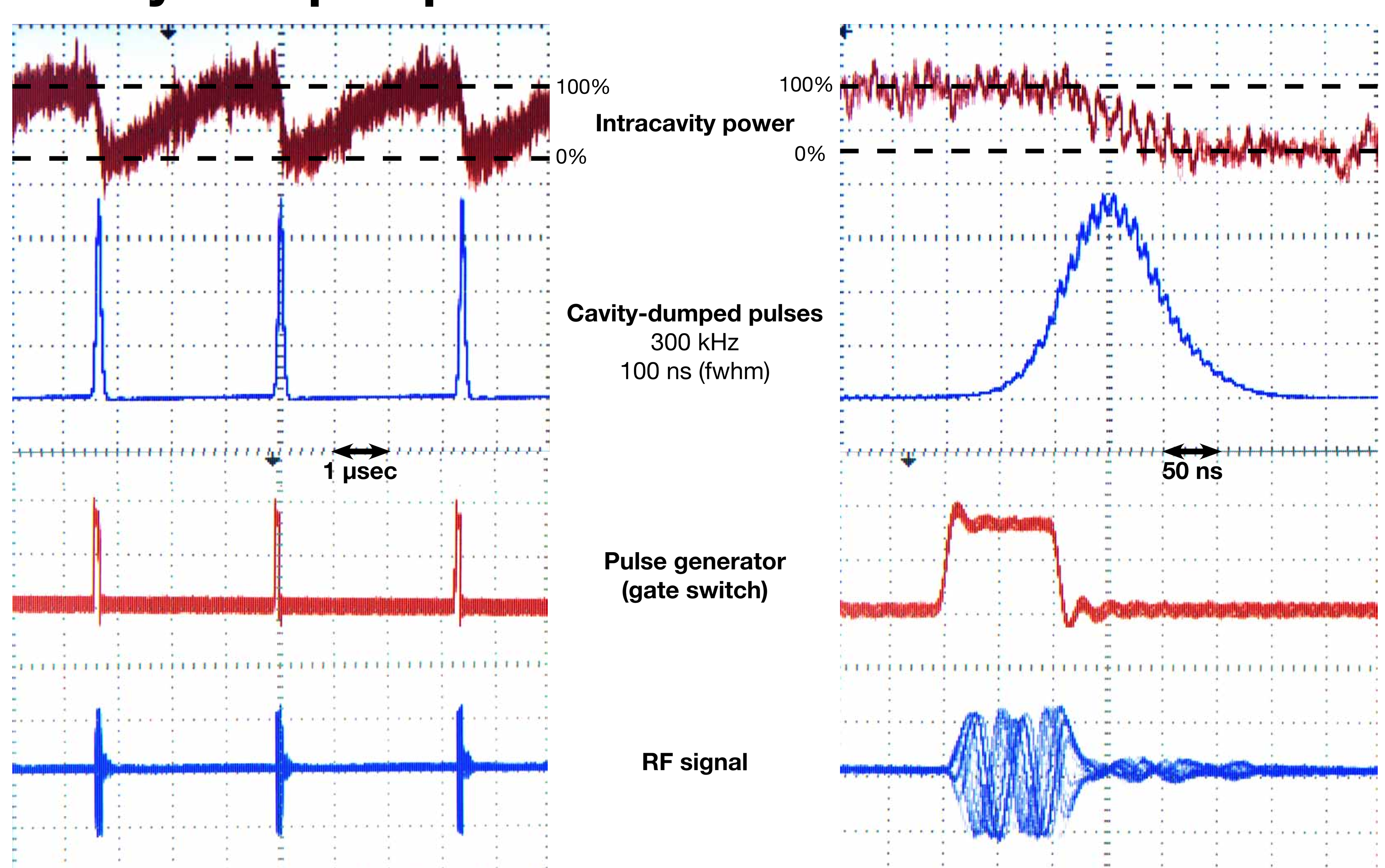
The high circulating power is clearly visible in a darkened room

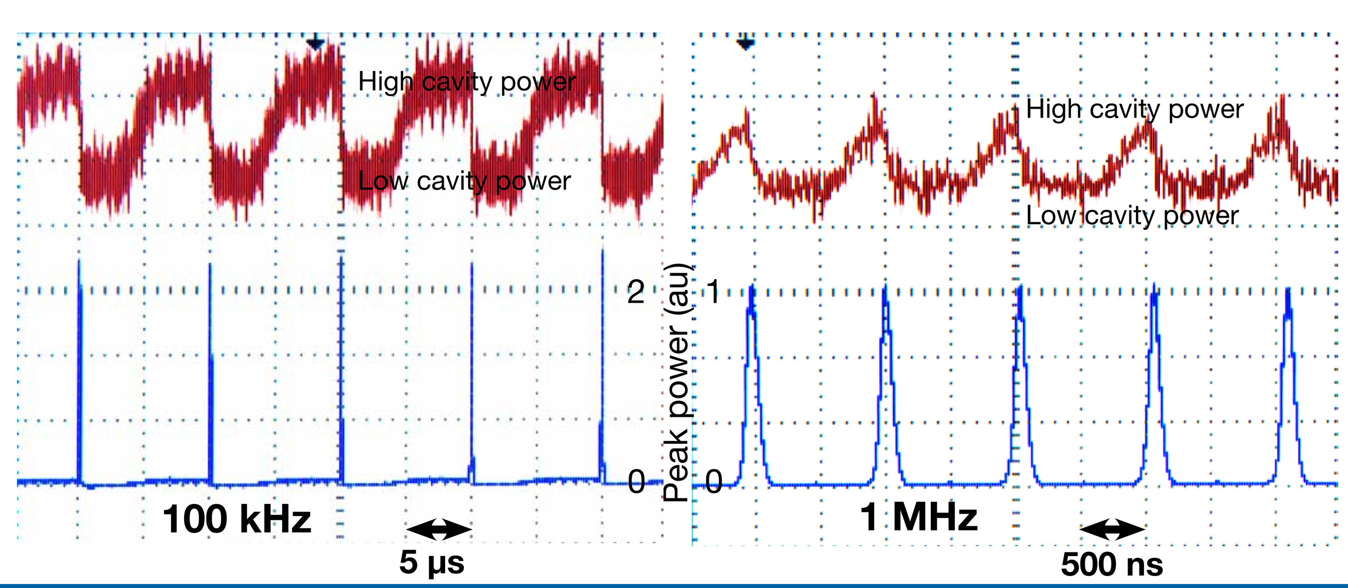
Brewster window

Free space HR

Scattering in the AOM medium accounts for much of the round trip losses

Cavity dumped pulses





Higher repetition rates do not allow the cavity to fully recover, resulting in lower peak powers.

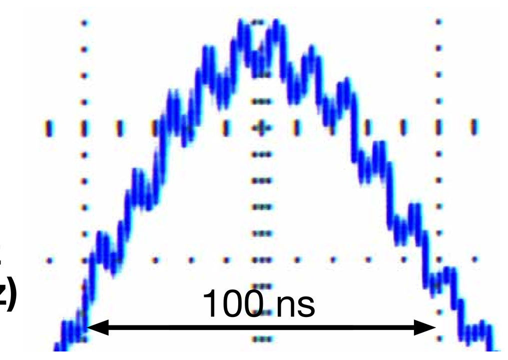
Characterization

Optical power limitations

- High losses of AOM medium (1.6% per pass)
- Slight Raman-Nath characteristics of AOM (multiple higher order diffracted beams)
- Low diffraction efficiency of AOM ($\eta \approx 15\%$)

Mode beating

An amplitude modulation on the pulse at 107 MHz is observed, in exact agreement with axial mode separation (c/2L) in the cavity.



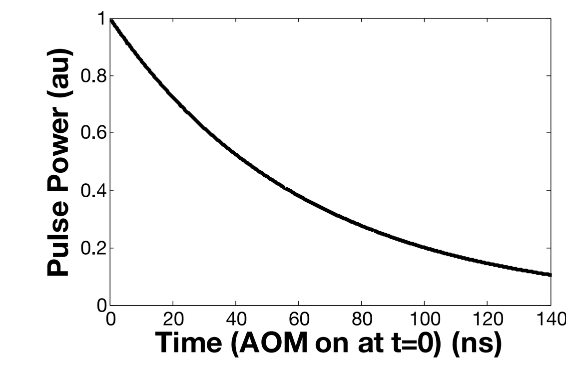
Cavity-dumped pulses

Pulse duration	**100 ns**
Repetition rate	**Tunable to >1 MHz**
Average power	**0.016 mW (100 kHz)**
Peak power	**2 mW (100 kHz)**

Pulse shapes

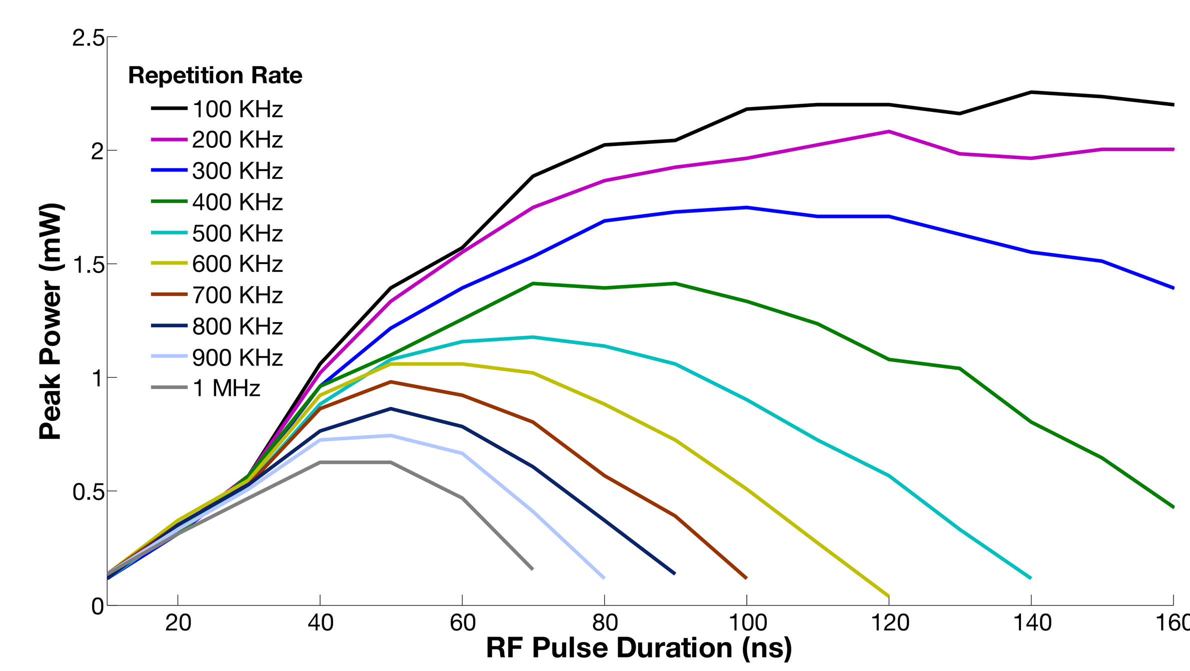
The shape of a cavity-dumped pulse is given by:

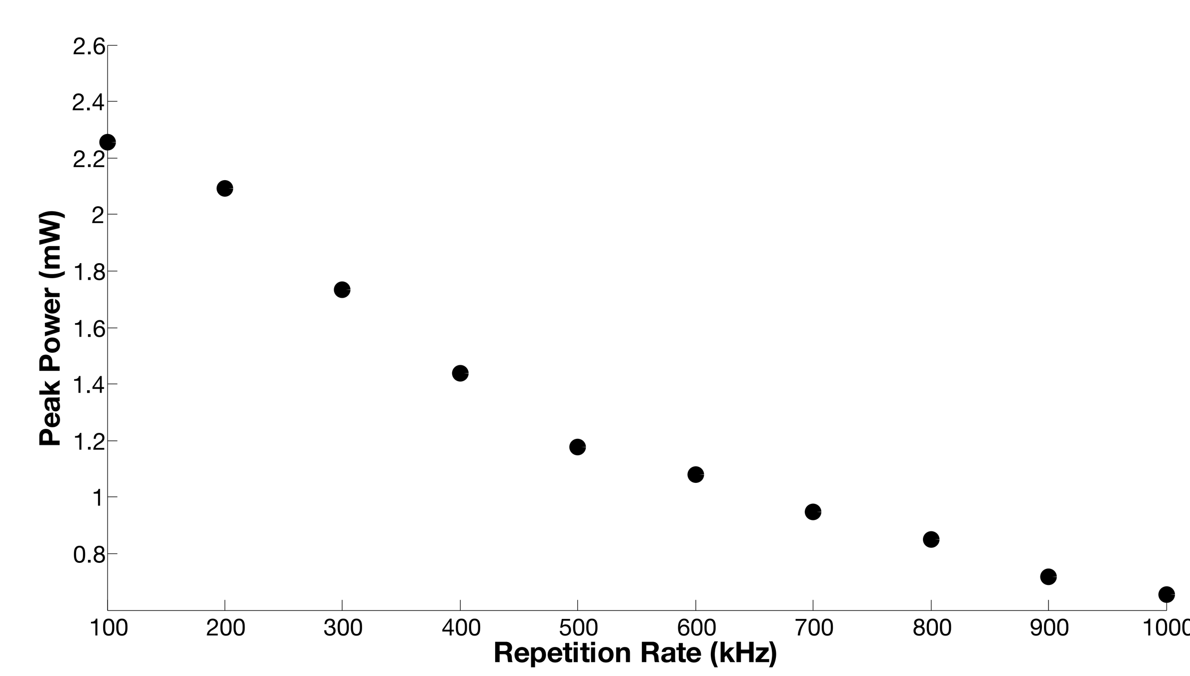
$$P = P_0 \exp\left(-\frac{\eta' t}{2L/c}\right)$$



This model predicts a pulse duration (fwhm) of ~50 ns. Pulse broadening and the symmetrical shape were caused by the rise/falltime of the RF pulse, and the acoustic beam transit time across the laser beam.

Peak power characteristics





Peak power per pulse is related to RF signal duration and repetition rate. Output pulse duration stays constant at about 100 ns.

References

D. Maydan, "Fast modulator for extraction of internal laser power," J. Appl. Phys. 41, 1552–1559 (1970).

We would like to acknowledge Sam Goldwasser for providing key equipment. This work was supported by the Laser Teaching Center and the Simons Foundation.