

A High Stability Nd:YAG Photocathode Drive Laser*

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A versatile, highly stable, and reliable Nd:YAG laser is in operation at the Brookhaven Accelerator Test Facility(ATF) for illumination of a metal photocathode RF electron gun. This system addresses the stringent requirements on pulse duration, pulse timing jitter, pulse energy, spatial profile, and pointing imposed by electron accelerator experiments¹.

A commercial, diode-pumped, actively mode-locked Nd:YAG oscillator produces an 81.6 MHz train of 15 ps FWHM output pulses phase locked with the electron gun's RF power. A timing stabilizer circuit controls a piezoelectric cavity length adjustment to reduce phase jitter between the 81.6 MHz optical train and RF to <1 ps.

The oscillator pulse train is gated and amplified in a four pass preamplifier and two pass amplifier, both flashlamp pumped. A Pockels cell and polarizer after the first two passes allow the preamplifier loss to be modulated up to the 60MHz bandwidth of the Pockels cell. An arbitrary waveform generator drives the Pockels cell with a ramping voltage which exactly compensates for gain depletion caused by significant energy extraction in the amplifiers. A feedback system reduces shot to shot variations, and in combination with the arbitrary waveform generator allows the generation of trains of up to 250 pulses with envelopes flat to within 2%. In this pulse train regime up to 1.5 mJ per micropulse is generated at 1 μ m and subsequently frequency quadrupled.

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A second mode of operation allows for generation of a single pulse of 30 mJ which is split to drive not only the photocathode, but also to simultaneously control a picosecond semiconductor switch for the ATF's high power CO₂ laser. In both modes, the system repetition rate is variable from 1.5 to 3 Hz. This flexibility in pulse formats allows a wide range of experiments to be carried out.

A significant factor in beam position stability is the Fourier relay imaging used to transport the beam through the amplifiers and to the cathode. The system employs collimated Keplerian telescopes with apertures at the Fourier transform plane. These spatial filters are chosen to easily pass a diffraction limited beam, and filter mainly higher spatial frequencies generated by scattering or diffraction in the system. Using this technique in the multi-pass amplifiers greatly reduces the energy lost into undesirable modes while allowing the rods to be well filled for good extraction. Space constraints at the ATF require that the laser system be located in a separate room 30 m from the photocathode. From the laser room, the beam is relay imaged through a vacuum pipe to an optics hutch near the photocathode. Variable magnification and optics to tailor the beam for oblique incidence on the photocathode allow circular spots from 0.5 to 1.5 mm diameter to be formed. A final relay onto the photocathode is through an overfilled aperture at an image plane. This reduces any remaining motion and RMS centroid jitter of 3% of beam diameter has been achieved on the cathode.

1. Proceedings of the Conference on Lasers for RF Guns, Anaheim, CA, May 14-15, 1994.

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