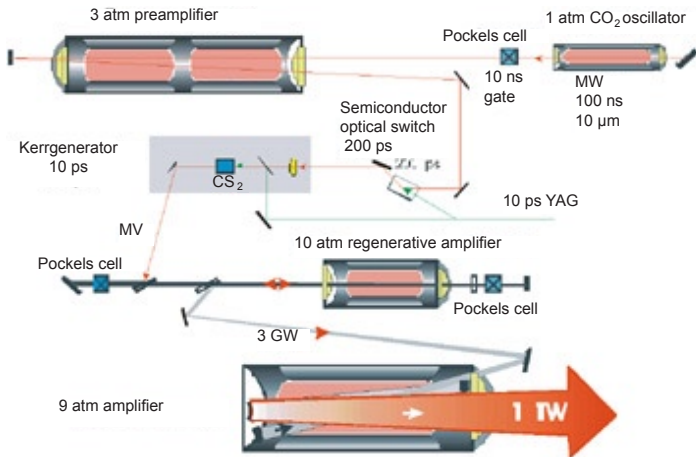


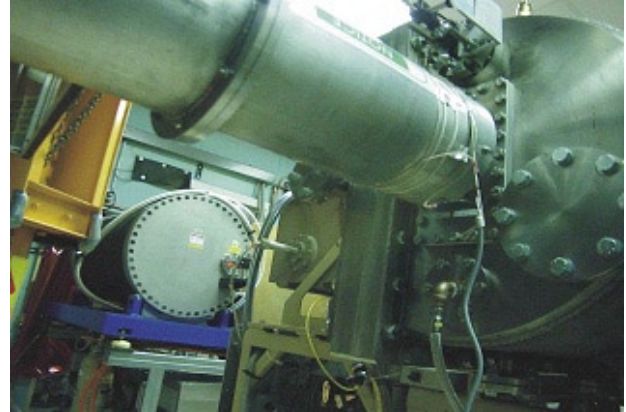
# Picosecond Terawatt CO<sub>2</sub> Laser



## Optical Scheme



High-pressure (10 atm) amplifiers are key components of the ATF picosecond CO<sub>2</sub> laser system.



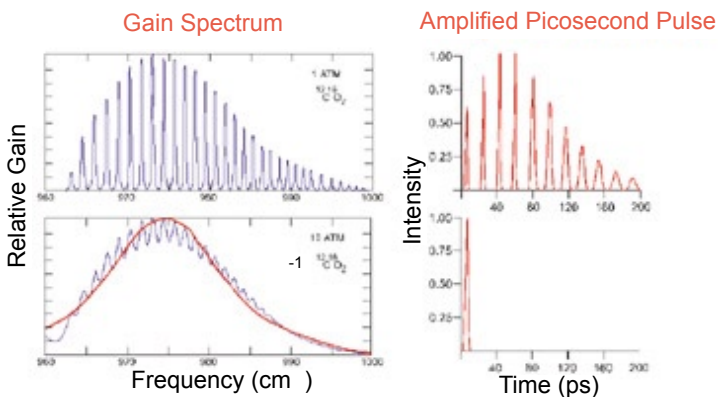
View on high pressure CO<sub>2</sub> amplifiers.

*Present Parameters:* 10J, 15ps, ~0.5TW, 0.05Hz

*Future Upgrade:* 10 - 15J, 3ps, 3TW

Higher repetition rate is possible with a stronger power supply and faster vacuum pumping of the amplifier x-ray preionizer.

## Bandwidth Limited Amplification of ps CO<sub>2</sub> Laser Pulses



Strongly modulated rotational line structure of the CO<sub>2</sub> gain spectrum modifies the frequency content of picosecond pulses, changing their temporal structure. At 10 atmospheres, collisional broadening produces overlap of the rotational lines into the 1 THz wide quasi-continuous gain spectrum, and pulses as short as 1 ps can be amplified without distortion.

## Fundamental benefits from using long-wavelength ( $\lambda=10\mu\text{m}$ ) CO<sub>2</sub> laser:

- Combines advantages of conventional high-finesse RF accelerators and prospective high-gradient optical ( $\lambda \approx 1 \mu\text{m}$ ) accelerators providing favorable phasing and structure scaling.
- Ponderomotive potential that controls plasma wake generation, production of x-rays, gamma-rays and particle beams (ions, protons, neutrons, electrons), and other strong-field phenomena is proportional to  $\lambda^2$ .

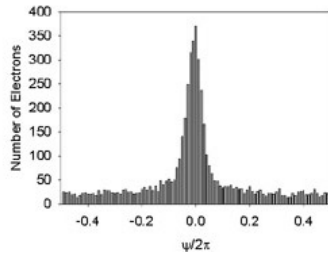
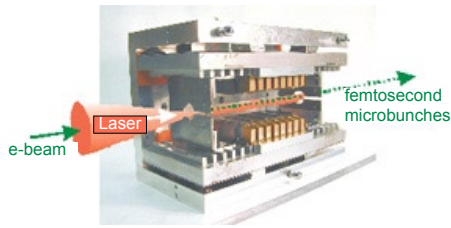
This makes effects from 3 TW, 10 J CO<sub>2</sub> laser equivalent to 300 TW, 1 kJ solid state laser. Then, technical considerations including robustness and high repetition rate of gas lasers come to play.



1.5 Meters

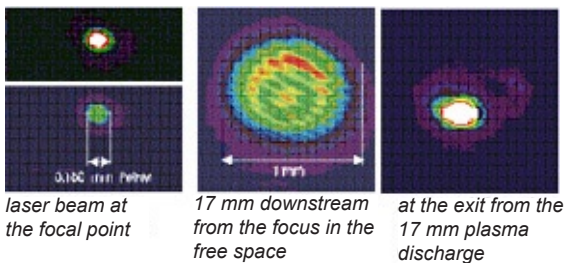
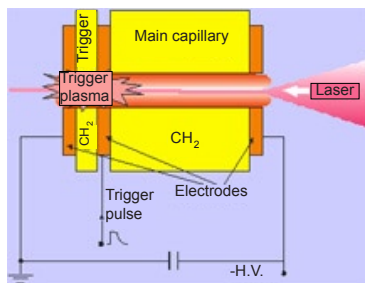
10-atm CO<sub>2</sub> laser operating at 5 Hz, 1 J/pulse.

Smart tools: plasma channel and “micro-bunch factory” enhance ATF capability to conduct strong-field experiments.



IFEL evolved into “micro-bunch factory” enabling a new generation of experiments: Resonance PWFA, PASER, STELLA-IFEL (completed), and Laser pulse length measurement.

CO<sub>2</sub> laser has been channeled in capillary discharge.



This enables a new generation of experiments on laser/e-beam interaction in plasma.

## ATF CO<sub>2</sub> Laser Success Story

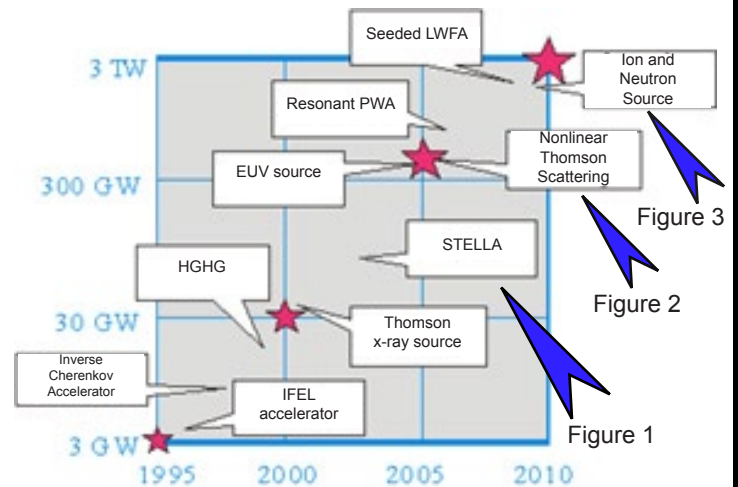


Figure 1

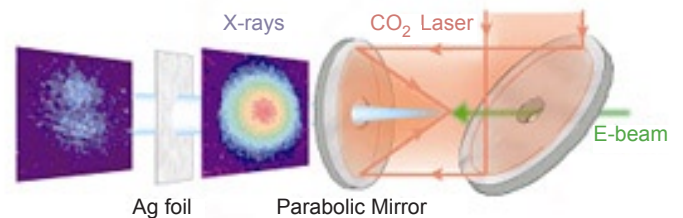


Figure 2

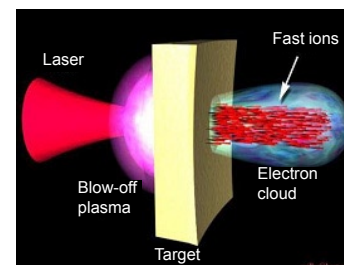


Figure 3

The Accelerator Test Facility  
Building 820M  
P.O. Box 5000  
Upton, NY 11973-5000

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CO<sub>2</sub> Laser Website: <http://www.bnl.gov/atf/systems/lasers/co2/co2sys.html>