Accelerator Test Facility

Overview

- The ATF is a **proposal-driven, advisory committee reviewed USER'S FACILITY** for **long-term** R and D in Accelerator and Beam Physics
- We provide High-Brightness electron beams synchronized to high-power lasers
- We serve universities, industries and National Laboratories
- We provide for graduate education in Physics of Beams

What are our core capabilities?

- Record high-brightness electron beams from our laser photocathode RF gun
- 60 MeV linac (100 MeV upgrade this year)
- 5 GW 150 ps CO_2 laser synchronized to the e-beam to 1 picosecond, a 3 terawatt, 10 ps laser under commissioning
- Fully instrumented experiment hall, 3 beam lines (+1 in tunnel), state-of-the-art diagnostics, computer control
- Typically 1100 hours beam time delivered annually
- Typically 1-2 experiments approved annually - essentially steady-state

Making a better facility

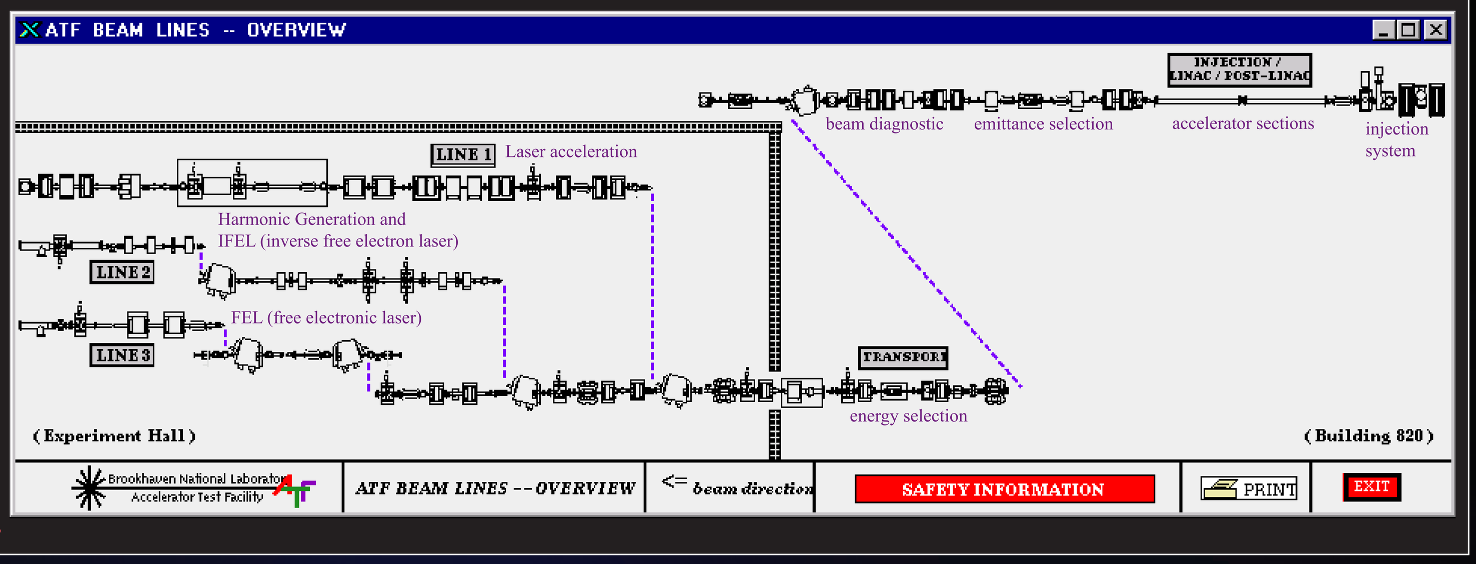
- Continuous brightness improvement
- Continuous stability improvement
- Computer control system upgrade
- New office and laboratory space
- Terawatt picosecond CO_2 laser
- Time resolved (~1 ps) ('Slice') emittance and high-resolution phase space tomography
- Ultra-short bunch generation and diagnostics
- Energy upgrade: Up to 72 MeV now, 100 MeV near future
- Improved communications with users: Long-range schedule, web information, e-mail newsletter, training...

Computer Control

The ATF computer control system is built around a single VAX 4200, manufactured by Digital Equipment Corporation of Maynard, MA. The CPU is a KA660-A (V3.7, VMB 2.12), operating with a clock rate of 114 MHz. The machine is equipped with 56Mb of RAM, a TK-70 streaming tape drive, a Cybernetics tape drive and 2GB of disk space, all housed in a BA215 cabinet. The system was purchased early in 1990 and, due to funding limitations, has remained in this original configuration since that time. The system operates continuously with it's usage divided into three main areas: 1) Primary function: Service outside experimenters. 2) Service in-house beam studies and maintenance operations. 3) Development and testing of improved hardware and software.

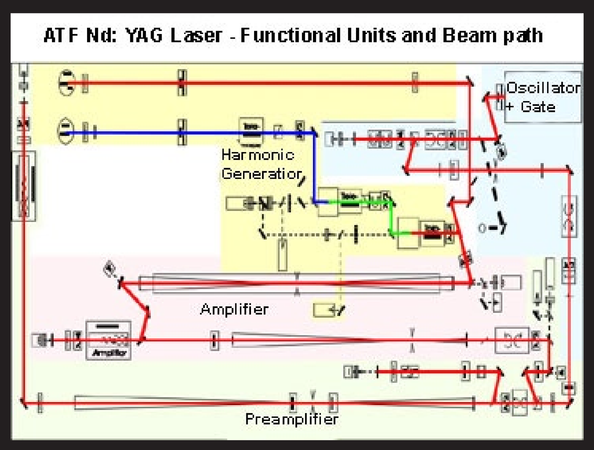
Using Vsystem (a commercial software tools package) combined with more than 60,000 lines of code written in-house, over 700 predefined windows have been developed for control, monitoring and data acquisition. Equipment accessible through the system includes magnet power supplies, beam position monitors, video camera signals and switching, timing generators, phase shifters and attenuators, stepping motors, laser joulemeters and analog diagnostics, optics stages, charge ADCs and stripline monitors.

All control system actions are done via through a graphic user interface. Operators working at X-Window terminals (or PC's with emulation) proceed through a set of drawings which capture the accelerator's topology in a top-down fashion.



Lasers: Nd: YAG laser

The Nd:YAG laser is located in a class 1000 clean room (the YAG Room) near the electron gun end of the ATF accelerator. It is operated in a linear amplifier mode, giving it a unique Pulse Train Mode. The Nd: YAG (abbreviated as YAG) serves as the illumination source for the ATF's photoinjector and also controls a semiconductor optical switch in the CO_2 laser. The YAG light can also be delivered to the experiment hall for use in experiments. This laser has an exceptionally high stability and a great versatility in generating variable length pulse trains with adjustable amplitude.



(top)The schematic of the Nd:YAG laser is shown in this YAG layout. (left)Photograph of Nd:YAG table

Energy: (dual pulse mode)	
UV on cathode	0-10 μJ
IR at CO2 table	5 mJ
Laser output: total IR	30 mJ
IR to gun	5 mJ / pulse
Green	1 mJ / pulse
UV	200 μJ
Repetition rate	1.5, 3 Hz
Pulse duration (FWHM):	
Oscillator IR	7 ps
Amplified IR	14 ps
Green	10 ps
UV	8 ps
Range of beam size on cathode (Ø)	0.2 - 3 mm
Top-Hat Beam Profile Modulation (P-P)	<20%
Shot-to-shot stability (rms):	
Timing	<0.2 ps
Energy	2 %
Pointing (fraction of beam Ø)	<0.3%
Drift (8 hour P-P)	
Timing	<1ps
Energy	<15 %
Pointing (fraction of beam Ø)	<1%

Demonstrated ATF YAG Laser performance

Lasers: CO2 laser

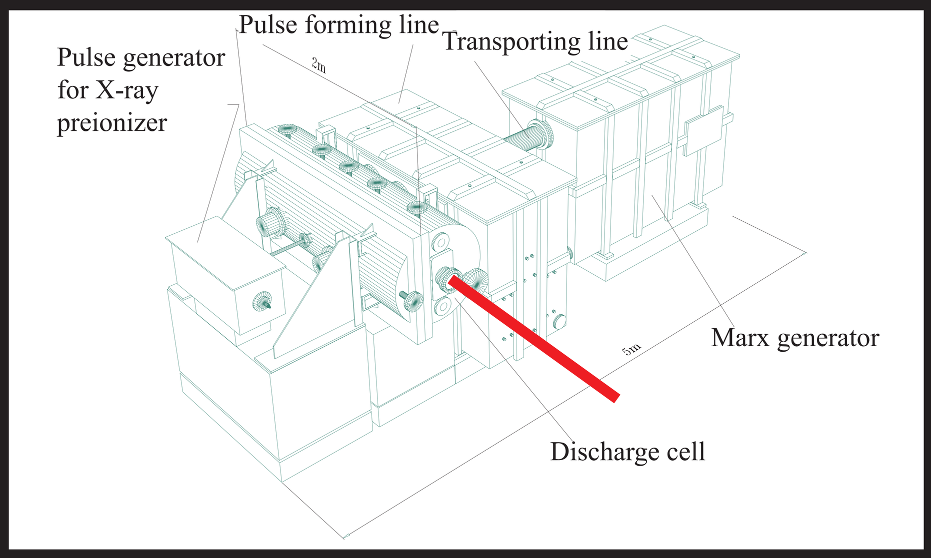
CO_2 laser status and perspectives

Until recently, operated at the 180 ps 30 GW level. The relatively long pulse duration was due to a narrow bandwidth of a preamplifier. Advisory panel (September 2001) outlined practical steps to attain ~1 TW primarily by shortening pulse duration:

- Generation of ~3 ps SH of YAG laser in a KD*P crystal
- Gate ~3 ps CO_2 pulse with a fast semiconductor or Kerr switch controlled by YAG SH
- Acquire 10-atm preamplifier

Presently, all these hardware upgrades are completed and integrated into the system that operates at 30 ps 0.5 TW (to be confirmed).

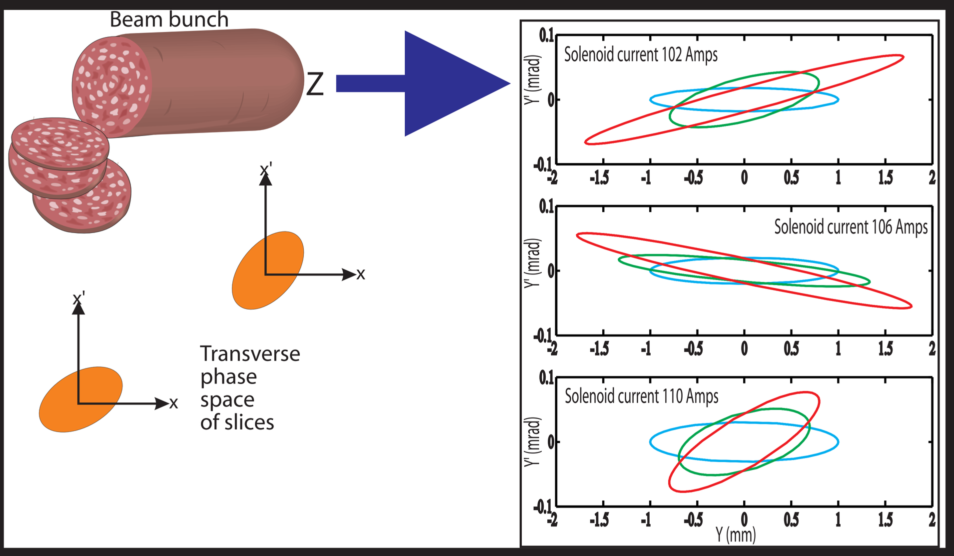
We will proceed with a gradual improvements leading to a shorter pulse and higher peak power by optimizing the YAG and CO_2 setup."



- The terawatt picosecond CO2 laser

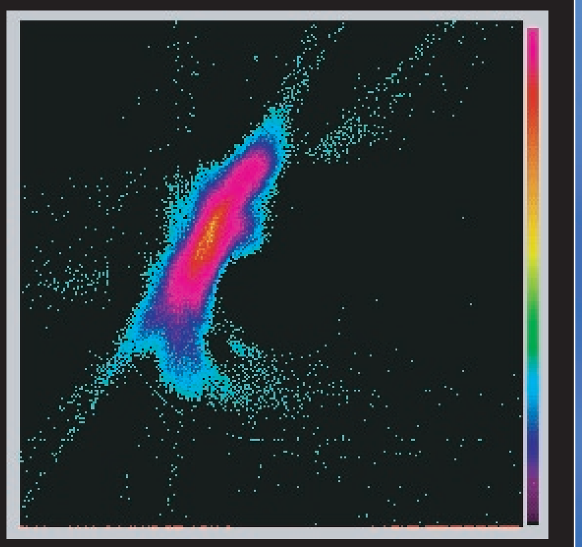
Diagnostics

- Slice-emittance measurement separates one longitudinal dimension.
- Phase-space tomography provides the distribution in the four transverse phase space dimensions.
- Control of phase space is possible through the laser intensity distribution on the photocathode.



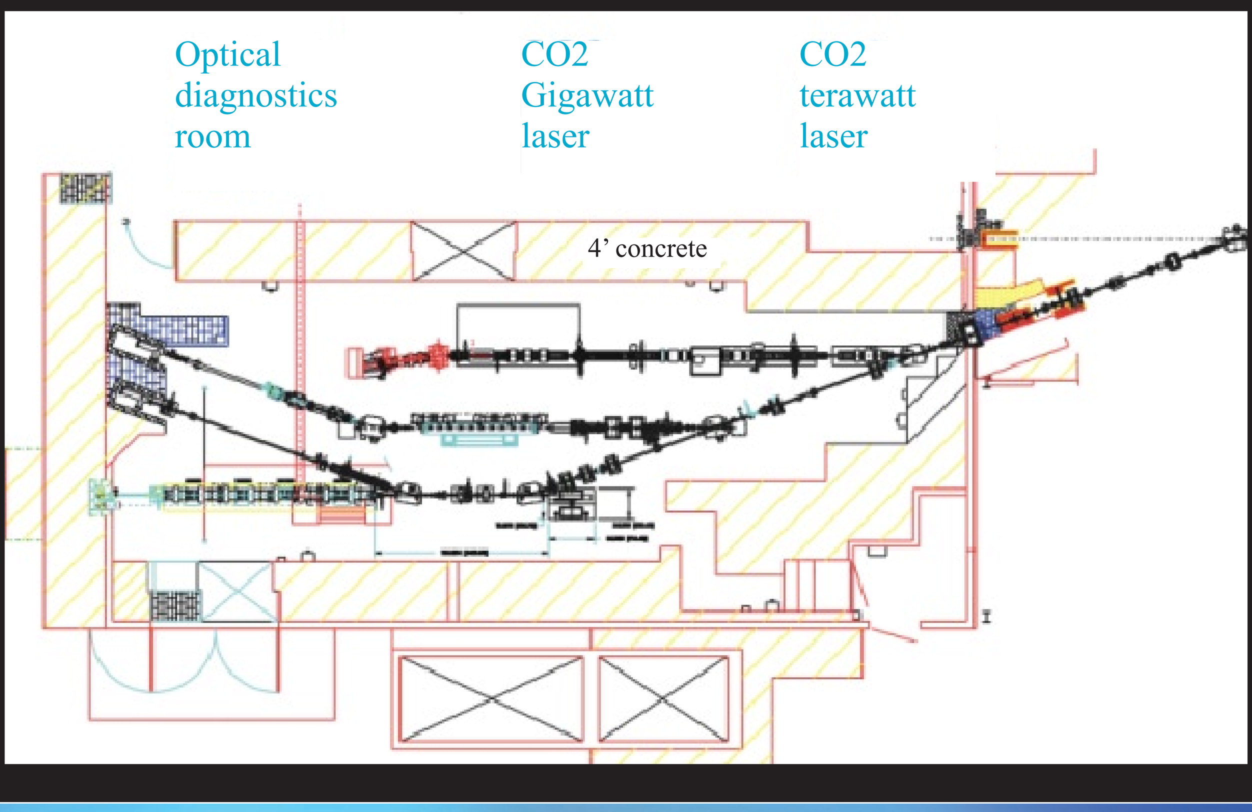
-Measuring the emittance of a 1 picosecond slice

-recovering the phase-space density distribution by tomographic techniques



Experiment Hall

3 beam lines, one beam line directly past linac. Spacious control area, set-up area, optical diagnostics area, offices and more.



Photoinjector R and D

The ATF Laser-photocathode RF gun series: State-of-the-art. The ATF runs a complete R&D program in photocathode RF gun injection system:

- High-duty RF gun (50 Hz) design and built by ATF is in operation at SDL, ANL and Japan. Closest to the LCLS 120 Hz design. (figure 1)
- A photocathode RF injection system including emittance compensation magnet, RF gun and beam diagnostics system. (figure 2)
- Drive laser system R&D on shaping, stability and reliability.
- Demonstrated technique of high QE Mg cathode with lifetime on the order of month.

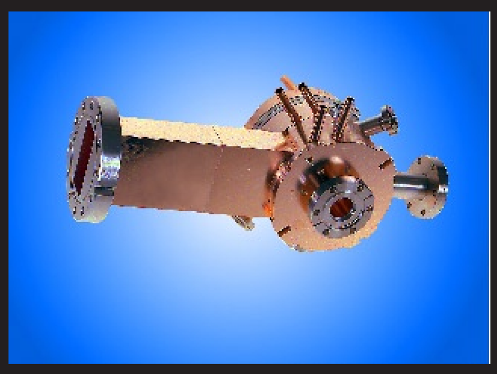


Figure 1: This gun was developed in collaboration with KEK and SHI. Copies of this gun can be found at the BNL Deep UV FEL Project, at Argonne National Laboratory LEUTL and the University of Tokyo.

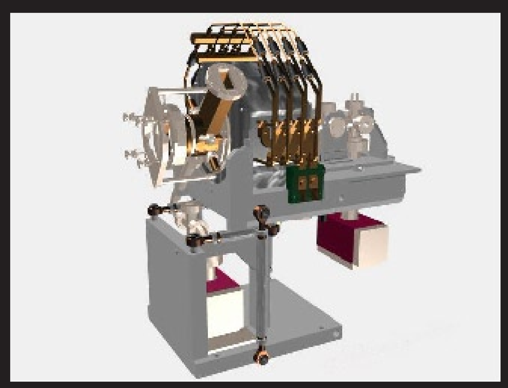


Figure 2: In collaboration with UCLA and SSRL, we have developed another version of the gun. This new gun, designated at BNL as Gun III and by the collaboration as 'The Next Generation Photoinjector', has been installed and tested at the ATF, at UCLA and at the Gun Test Facility at SLAC.