BNL--46385

DE91 015841

The Brookhaven Accelerator Test Facility

K. Batchelor, I. Ben-Zvi, R.C. Fernow, J. Fischer, A.S. Fisher, J. Gallardo,
Xie Jialin, H.G. Kirk, Z. Parsa, R.B. Palmer, T. Rao, J. Rogers, J. Sheehan,
T.Y.F. Tsang, S. Ulc, A. Van Steenbergen, M. Woodle, R.S. Zhang
Brookhaven National Laboratory
Upton, NY 11973

K.T. McDonald D.P. Russell
Princeton University
Princeton, NJ 08544

Z.Y. Jiang
SUNY, Stony Brook
Stony Brook, NY 11794

C. Pellegrini X.J. Wang
UCLA
Los Angeles, CA 90024

Presented by D.P. Russell

Abstract

The Accelerator Test Facility (ATF), presently under construction at Brookhaven National Laboratory, is described. It consists of a 50-MeV electron beam synchronizable to a high-peak-power CO_2 laser. The interaction of electrons with the laser field will be probed, with some emphasis on exploring laser-based acceleration techniques.

I. Introduction

The present generation of charged-particle accelerators, based on RF-cavities, is rapidly approaching the limits set by size and technology. Significant increases in beam energy and quality will likely require new acceleration techniques. One possibility is to make use of coherent electromagnetic radiation of shorter wavelength than radio-frequency waves. Optical and infrared lasers are natural candidates for supplying such accelerating fields.

The Accelerator Test Facility is being constructed by the Center for Accelerator Physics at Brookhaven to provide electron and laser beams of sufficient quality for the study of their interaction. A major theme is to be the demonstration of certain laser-based acceleration schemes. Central to the construction of the ATF is the production and transport of a high-brightness (low-emittance) electron beam, an important issue for present and future accelerators. The ATF is to be a user facility at which experiments can be performed in several different beamlines.

II. The Facility

The Accelerator Test Facility consists of the following components:

1. 50-MeV high-brightness electron beam
   a. 4.5-MeV high-brightness photocathode RF gun
   b. 50- to 100-MeV S-band linac
2. Synchronizable laser system
   a. Nd:YAG laser with 6-picosecond pulse length
   b. CO_2 laser with 6-psec pulse length and 20-GW peak power.

A schematic diagram of the ATF is shown in Figure 1.

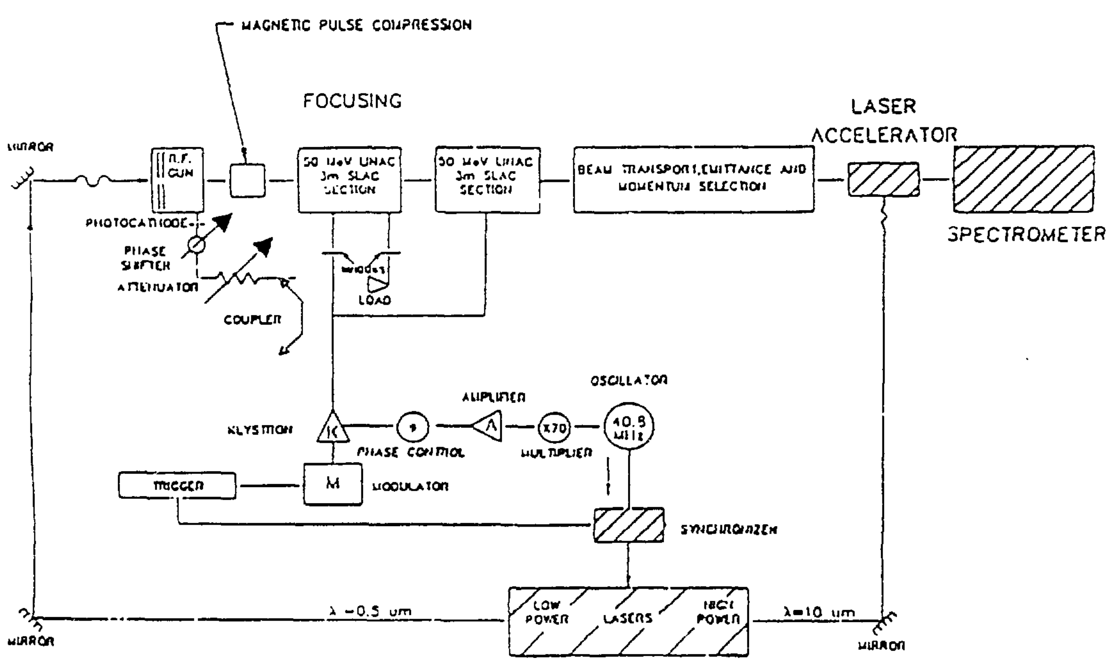

Figure 1. Schematic diagram of the ATF.

The RF gun[1] is shown in Fig. 2. It is based on a design[2] in which a photocathode is incorporated into the end wall of an RF cavity. The Yttrium photocathode is illuminated by a YAG laser pulse which is synchronized with the RF system. The transverse and longitudinal phase spaces of the resulting electron pulse can then be altered by varying the laser spot size and duration. A small invariant transverse emittance may be achieved in this manner. The gun was first operated during the Summer of 1989, during which time an emittance of about 8π mm-mrad was measured.

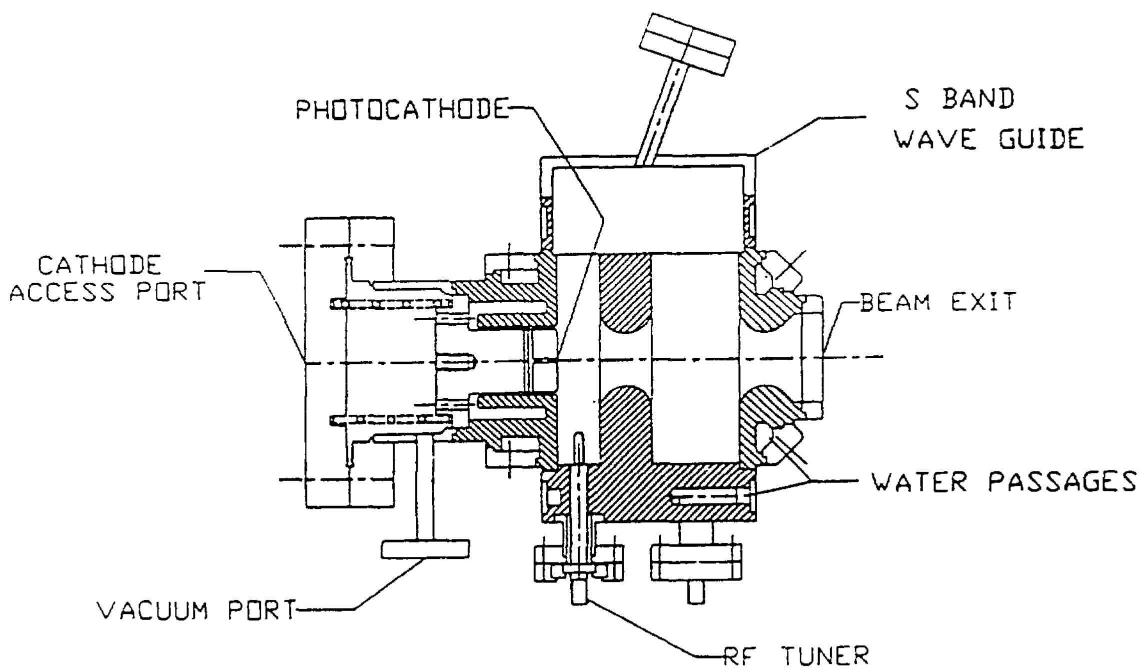

Figure 2. The RF gun of the Brookhaven Accelerator Test Facility.

The line transporting the beam from the gun for injection into the linac, as well as the post-linac transport to the experimental stations must be designed and constructed so as to minimize emittance growth. This is a major challenge, and the initial running phase at the ATF is concentrated on diagnosing the beam quality at various points along the beamline. A beam-profile monitor[3] is used to measure transverse emittances, and in conjunction with an RF kicker and dipole bending magnet, should allow diagnosis of the longitudinal phase space as well.

Another challenge is the synchronization of the electron beam with the laser beams on the picosecond scale. The RF system and YAG laser are driven by a common master oscillator. The pulse from the mode-locked YAG is shortened to 6 picoseconds by fiber-optic chirping[4] and then drives the photocathode. Part of this pulse also trims the CO_2 laser pulse to 6 picoseconds for use with experiments.

Experimental Program

The following is a partial list of experiments to be run at the ATF.[5]

- Smith-Purcell radiation.
- Laser-grating accelerator experiment.
- Inverse Čerenkov accelerator experiment.
- Visible free-electron laser.
- Nonlinear Compton scattering experiment.

Beam through the linac is expected by Spring, 1990. The first experiments are planned for Fall, 1990.

References

1. K. Batchelor *et al.*, in Proceedings of the European Particle Accelerator Conference, 1988; K.T. McDonald, IEEE Trans. Elec. Dev. **35**, 2052 (1988).
2. J.S. Fraser and R.L. Sheffield, IEEE Jour. Quant. Elect. **23**, 1489 (1987).
3. D.P. Russell and K.T. McDonald, in Proceedings of the 1989 IEEE Particle Accelerator Conference, p. 1510.
4. T. Shimada *et al.*, contributed to the Conference on Lasers and Electrooptics, 1989.
5. Proposals presented at the ATF User's Meeting, Brookhaven National Laboratory, November, 1989.