PROGRESS REPORT ON ANL ADVANCED ACCELERATOR TEST FACILITY

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Introduction

A group at Argonne National Laboratory is constructing a facility for use in a program to experimentally study a variety of advanced acceleration mechanisms. Many new methods of particle acceleration have been proposed in recognition of the requirements for the next generation of colliders. Some of these ideas are well enough developed to warrant experimental studies.

There are several active programs at various laboratories directed toward specific methods, such as FEL rf sources, plasma beat wave, and switched power linacs. The facility at Argonne is particularly well suited for use in the study of wake field acceleration in a variety of structures and media.

Recognition that Argonne was in a unique position to address this study developed as a result of a several years experience using a 20 MeV, short pulse electron linac operated by the Chemistry Division. This is the same linac which was used for the Argonne beam signal pickup facility.[1,2] In the fall of 1984, plans were announced by the Chemistry Division to provide a pulse compression system to extend the study of chemistry experiments to the few picosecond range. This pulse compression system is described in a separate paper at this conference.[3] It was recognized that the new short bunch structure could be exploited for studies of wake field structures. At the same time, a group from the University of Wisconsin expressed interest in studying plasma wake fields using the beam.

Following a several month period of planning,[4] construction of the facility began in the summer of 1985. At a glance the design may appear quite simple, but many simultaneous constraints complicated the design considerably. The final design contains a number of subtle yet important features as will be described below.

Initial experiments will include wake field measurements using both structures and plasmas. These experiments are described in more detail below.

Description of Facility

The advanced accelerator test facility uses two beams, a 21 MeV, high intensity beam for driving wake effects, and a lower energy (~ 15 MeV), lower intensity witness beam for sampling the wake fields produced. The witness beam is produced by the driving beam from a small carbon target which degrades a small part of the driving beam by 5 - 6 MeV. The momentum and emittance bites accepted by the witness beam are determined by slits immediately following the first bending magnet. The witness beam flux is limited to a small fraction of the driving beam by multiple scattering effects in the energy loss target.

The beam line designs for both driving and witness beams were determined by constraints that both lines must have colinear, dispersion free foci at both ends, that the witness beam line must be able to delay the witness pulse by as much as 2.5 nsec, and that both driving and witness beams should have small time dispersion. Additional complications are caused by the large momentum bite of the driving beam (Ref. 3) and by the requirements that the beam lines should be magnetically isolated from each other while both beams should operate as close to the same energy as possible to maximize witness beam intensity. The resulting beam designs are shown in Fig. 1 and Fig. 2.

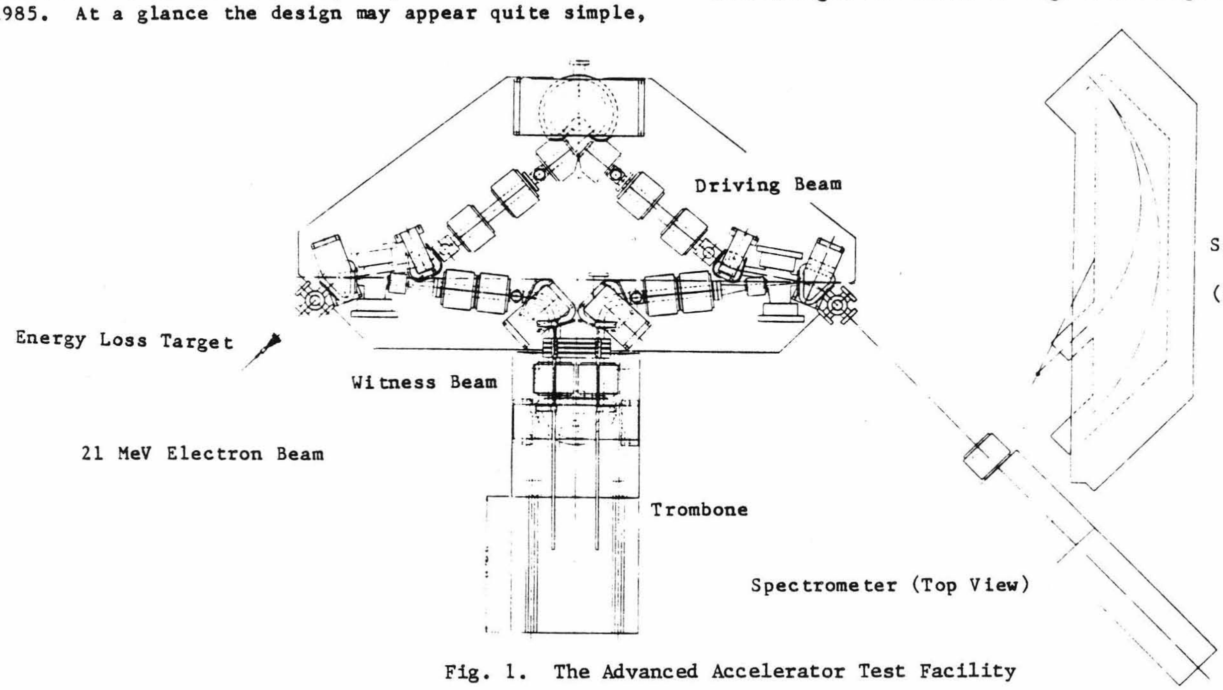

Fig. 1. The Advanced Accelerator Test Facility

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The beam lines have been designed with acceptances of about 10 π mmmr in x and y for the driving beam and about the same for the witness beam. We anticipate witness beam intensities of about 10^6 electrons for large acceptances and a linear relation between witness beam acceptance and intensity. Experiments can be accommodated in the indicated ~ 1 meter long straight section. In addition to the adjustable time delay, we will be able to control the relative positions of the two beams horizontally.

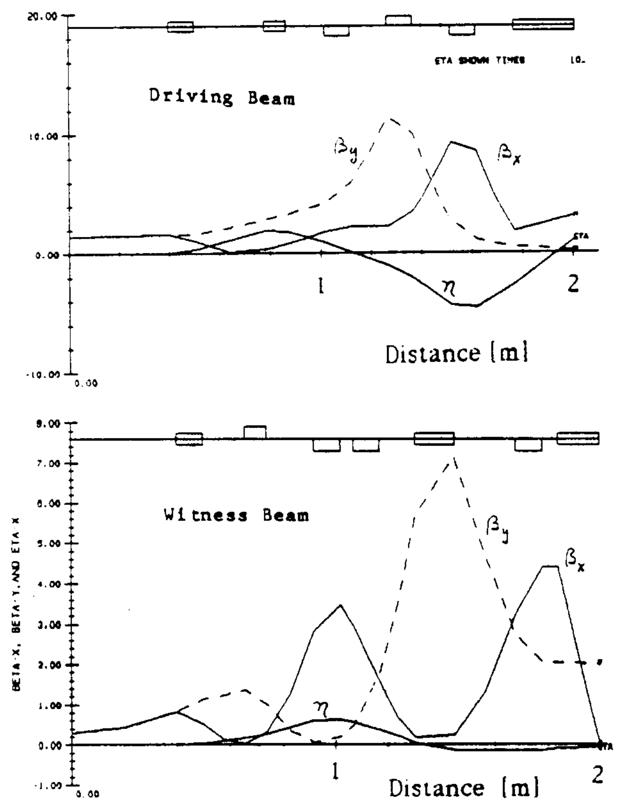

Fig. 2a and 2b. Twiss parameters of beamlines

The spectrometer design was determined by the requirements for high resolution and the ability to measure angular deflections in addition to momentum. The spectrometer consists of a quadrupole and a single large dipole bending 90°. The dispersion of the magnet is 1 meter and the angular resolution should be 2.5 mr/mm. The magnet will bend vertically to permit measurement of angular deflections of the witness beam caused by horizontal offsets of the driving beam.

All beam diagnostics will utilize scintillation screens viewed by CCTV cameras. These images will be digitized and manipulated by a Data Translation DT2803 frame grabber, and initial data analysis and monitoring will be done by a IBM PC/XT.

Construction Status and Schedule

Components for the facility are now being fabricated and assembled. All quadrupole and bending magnets have been constructed and tested, as have major support structures. Vacuum pipes and housings, complicated by the compactness of the facility, are now being fabricated. Power for magnets is provided by pulse width modulated power supplies operating at 15-20 KHz. All power supply systems have been completed and tested. Control systems, centered in the IBM-PC, use CAMAC and GPIB interfaces to communicate with power supplies, data acquisition, and diagnostic devices. The control system is essentially complete and software is being written.

Our present present schedule indicates that installation of facility components will be complete by late summer, 1986. Beam tuning is expected to begin in July.

Experimental Program

The facility will permit experiments on any structure or medium that can fit in the ~1 meter experimental region. The initial phases of the experimental program will study wake field acceleration in structures and in plasma.

The Wakeatron, which has been described elsewhere,[5] uses comparatively long bunches of protons traveling in a structure to accelerate short bunches of electrons which are colinear with the protons and follow closely. Initial experiments will be aimed at measuring energy loss within the driving beam as it traverses structures somewhat similar to accelerator waveguides, studying the dependence of measured quantities on the structure's geometry. The second phase will study acceleration and deflection of the witness beam. The goal of these experiments is to better understand the parameters of these structures to permit "next step" experiments, perhaps with high energy protons.

Plasma wake field acceleration will also be studied, initially using a small plasma source being built at the University of Wisconsin by Cline and Rosenzweig. This source, which will produce plasmas with densities on the order of $10^{13}/cm^3$, will be 10 - 20 cm long. We will study the acceleration and deflection of the witness beam as a function of driving beam current, plasma properties, relative longitudinal and transverse positions and bunch shape. In addition, measurements on the time development of the driving beam will be made. The linearity of transverse focussing of both driving and witness beams, for example, is critical in determining the properties of long accelerator systems. The ability to use triangular current pulse[3] allows tests of theoretical predictions by Chen and others for non-gaussian beams.[6] These calculations predict transformer ratios of triangular beams will be 3-4 times those of gaussion beams.

We plan to use this test facility to measure the rf properties of accelerator components such as bellows, kickers and pickups using the driving and witness beams to determine longitudinal and transverse wakes.

Summary

A facility is presently being constructed which can measure transverse and longitudinal wake fields in structures and media. Initial experiments with cavities and plasmas are being directed at systems which could be applied to a high energy linear collider, although other experiments should be possible. The facility will eventually operate as a user facility.

References

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