DOE/ER/40693--1

DE92 040333

PROGRESS REPORT

DOE Grant No. DE-FG03-92ER40693

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The work supported by the above referenced grant is a broadly based research program on advanced accelerator physics concepts. Specific areas of research include: i) non-linear beam dynamics studies; ii) development of low emittance, high brightness electron sources; iii) development of RF accelerating structures; and iv) studies of laser acceleration, in particular the inverse free electron laser. The research involves both theoretical and experimental studies and is carried out in collaboration with faculty and students in the UCLA Electrical Engineering Department.

Substantial progress was made last year on the construction of the RF photocathode electron source and compact 20 MeV linear accelerator. The photoinjector was commissioned for routine operation with RF power levels of up to 5 megawatts. The laser system is now running at 50 picosecond pulses on a day to day basis and some fine tuning is underway for stable 4 picosecond pulse operation at the wavelength 266 nanometers. During May, 1992, the first photoelectron beam was observed. Measurement of the beam characteristics were performed or are planned to be performed on the following parameters: 1) beam energy and energy spread by the use of a magnetic dipole; 2) transverse emittance by correlation of the beam size and the quadrupole magnet strength; 3) quantum efficiency of the copper cathode at 266 nanometers by measuring the photon energy and beam charge by a Faraday cup, beam position monitor and pickup probe; 4) pulse lengths of the laser and particle beam by using a streak camera and optical transition radiation.

Diagnostics for the above were designed and built for measurements of the following parameters: 1) angle of incidence, either 2 or 70 degree; 2) pulse length, either 4 or 50 picoseconds; 3) spot size on the cathode by varying the focusing; 4) polarization, either sigma or pi; and 5) the phase of the laser pulse with respect to the RF.

During the last year a plane wave transformer (PWT) linac was tested. A second unit, with improvements, is currently under construction implementing design techniques investigated during simulation studies.

Tuning and calibration of an undulator, which was furnished by our collaborators at the I.V. Kurchatov Institute of Atomic Energy in Moscow, was also completed. Measurements of the field distribution indicate excellent field uniformity and electron beam trajectory, sufficient for the generation of coherent infrared radiation.

A substantial amount of time and effort went this past year into the planning and design of the shielding (x-ray and neutron shielding) for the 20 MeV linac and beam lines. A design for the construction of the concrete bunker is now complete and a contractor for the work has been selected.

The drive laser is a critical component of the RF photocathode electron source and compact linac. Since the laser pulse determines both the pulse length and the total charge of the electron beam, its performance is paramount for achieving a high brightness beam. Because of the high peak power required to produce 1 nC of charge from a copper photocathode, chirped pulse amplification and compression is used to achieve less than 3 picosecond pulse duration and 4 mJ of energy per pulse at 1.064 micrometers. This technique utilizes self-phase modulation (SPM) and group velocity dispersion (GVD) to increase the spectrum of the pulse in a time correlated fashion so that it may be compressed to its new transform limit using an anomalously dispersive element. Limits on pulse compression are due to the non-linearity of the spectral bandwidth increase from SPM and the power threshold for other nonlinear effects such as Stimulated Raman Scattering (SRS). The pulse is amplified after passing through the optical fiber but before the compression stage.

The laser oscillator, a Coherent Antares YAG, produces 80 picosecond pulses in a mode-locked pulse train at 76 MHz. Pulse compression from 80 picoseconds to 3 picoseconds is achieved using a fiber-grating compressor. A silicate glass regenerative amplifier from Continuum provides amplification of 10^6 between the fiber and the grating pair. This system will provide 4 mJ pulses of less than 3 picosecond duration operating at 5 Hz. The amplified and compressed pulses are then frequency upconverted to 266 nanometers using two KD*P doubling crystals.

The threshold for SRS was determined as 800 mW for 500 meters of fiber. At 500 mW, the pulse spectrum was measured to be 40 Angstroms. The optimum grating separation was found to be 8 inches. This produced a compressed pulse with a FWHM of 3 picoseconds assuming a Gaussian pulse shape.

These results, however, where achieved prior to the introduction of the regenerative amplifier which is necessary for the extraction of 1 to 10 nC of charge at the cathode. A Nd:glass amplifier is required to maintain the pulse bandwidth. Measurements of the pulse bandwidth after amplification show no significant distortion. The amplified and compressed pulse width was measured with a streak camera whose resolution is 10 picosecond. A single shot autocorrelation diagnostic with better than 1 picosecond resolution is currently under construction.

Computational studies of the plane wave transformer linac were performed as part of the theoretical research activity. In designing a high power RF-accelerator, it is necessary to examine any field disturbances created by the asymmetries in the structure. A study was undertaken of the disturbance of the modes using the three-dimensional frequency domain solver "MAFIA". Particular attention was given to perturbations in the accelerating mode and also to higher order modes which can be excited by the electron beam itself. These perturbations in the accelerating mode and off axis kicks due to the higher order modes give rise to emittance growth. Ways to redesign the support structure in order to minimize accelerating mode perturbation effects and ways to damp out unwanted higher order modes were studied. The results of the study and corresponding simulations give hope that the coaxial modes and quadrupole components can be dealt with in a way without radical modifications of the PWT. The results from these studies are being incorporated in the second PWT being built at UCLA.

More general to the program this last year was the establishment of a local area network for the group's personal computers. This network is also interfaced to the University's computer network. An IBM RISC 6000 computer, which runs various simulation programs, was installed and made operational. Other computers were interfaced for control, data acquisition and diagnostic monitoring of the RF photocathode electron source and compact linac. A general purpose software library was completed which allows users to easily write control codes and a significant portion of the control software was also completed. A staging laboratory to assemble and test components was established and outfitted this last year as well.

Ongoing work will include improvements to the stability and reliability of the laser and RF systems and an upgrading of the photoinjector and diagnostic systems.

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