A PULSE COMPRESSION SYSTEM FOR THE ANL 20 MeV LINAC

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Introduction

This paper describes the pulse compression system being built on the Argonne 20 MeV electron linac (ref). The system is designed to rotate the bunch from the present measured pulse length of 38 psec FWHM, to pulse lengths of 5 to 6 ps with the large instantaneous currents (1-4 kA) possible instantaneous current. This system was necessary to extend the study of reactive fragments of molecules to the time scale of a few picoseconds, in particular to examine the chemistry of electrons and ions before and during relaxation of the surrounding media. These experiments are not sensitive to the beam energy spread. High Energy Physics experiments studying wake fields have also been proposed using the short bunches and the facility was designed so that the wake field experiment could share the beam bunching system.

The 20 MeV electron linac uses a double gap, 12th subharmonic prebuncher together with a one wavelength 1.3 Ghz prebuncher to produce a single pulse of 38 ps from one occupied rf bucket.[1] Beam emittances of 15.7 mmmr have been measured for 40 nC of accelerated charge and 8 mmmr at 10 nC. The energy spread of dE/E = 1% (FWHM) has been measured at 40 nC. Thus the accelerated beam has excellent time structure, high current, and good emittance.

Description

The pulse compression system shown in Fig. 1 consists of a 1.3 GHz cavity together with a transport line to two experimental areas. The voltage in the cavity is such that the beam executes one fourth of a synchrotron period between the accelerator and the experimental areas. The two experimental areas are accommodated by the use of two optical systems between the bending magnets. The betatron phase advance between the centers of the bending magnets is π when the magnets bend the same way and 2π when they bend the opposite way, thus the time dispersion, which is equal to the integral of (eta/rho), will add in both cases. The twiss parameters for the two lines are shown in Fig. 2. An additional isochronous section capable of transporting the beam from a Cerenkov radiator to a test cell will be built for the chemistry users as shown. Tracking of the beam line using TURTLE was done to evaluate the contributions of chromatic and second order effects. Sextupoles placed between the 90° bending magnets significantly improve the beam quality through the wake field beam lines.

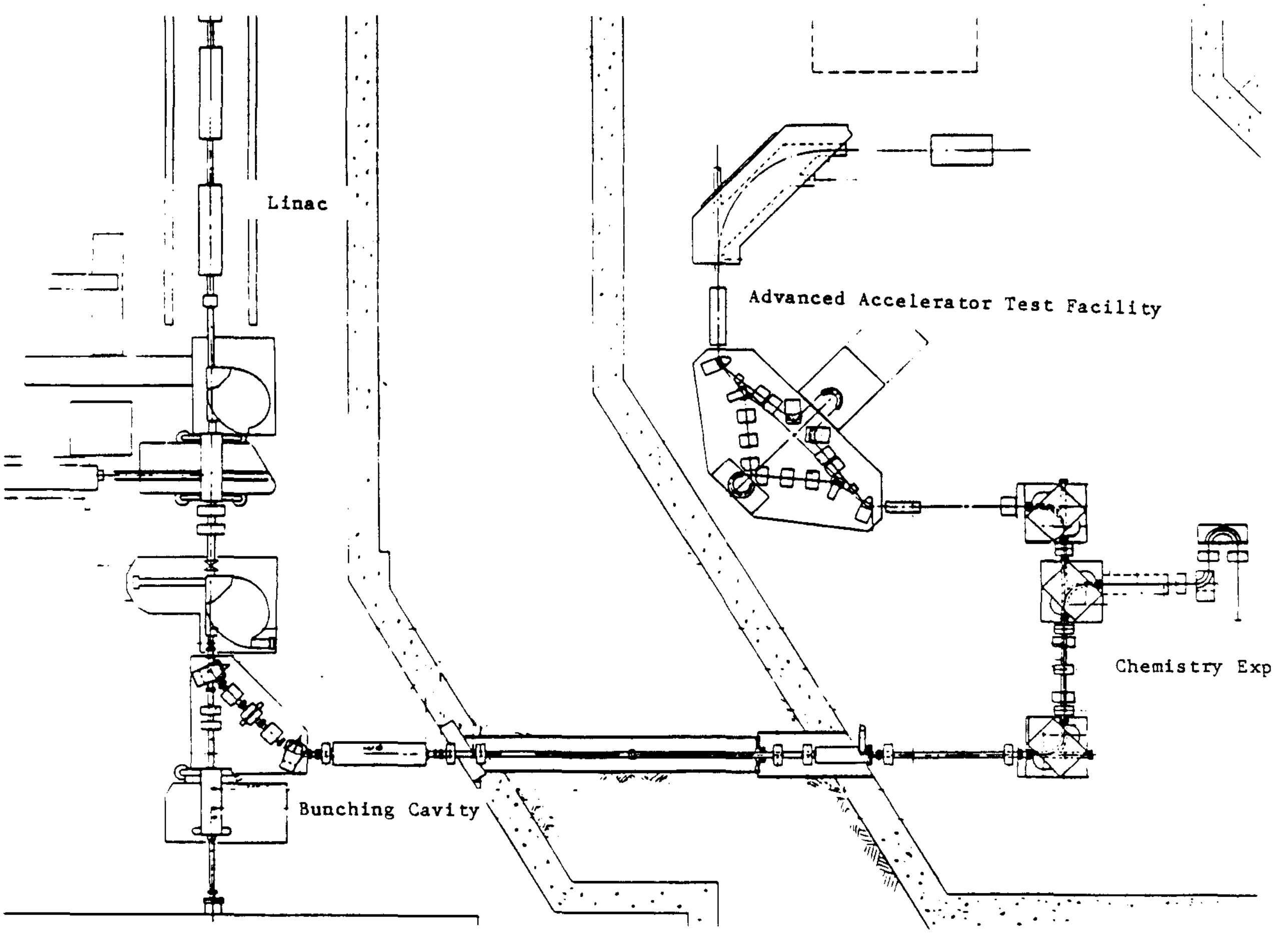

Fig. 1. The pulse compression system

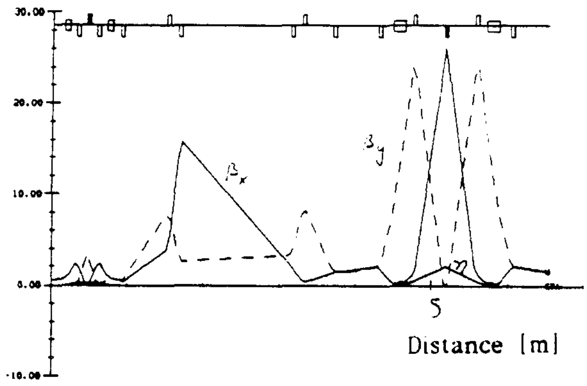

Fig. 2 Twiss parameters for the beam line

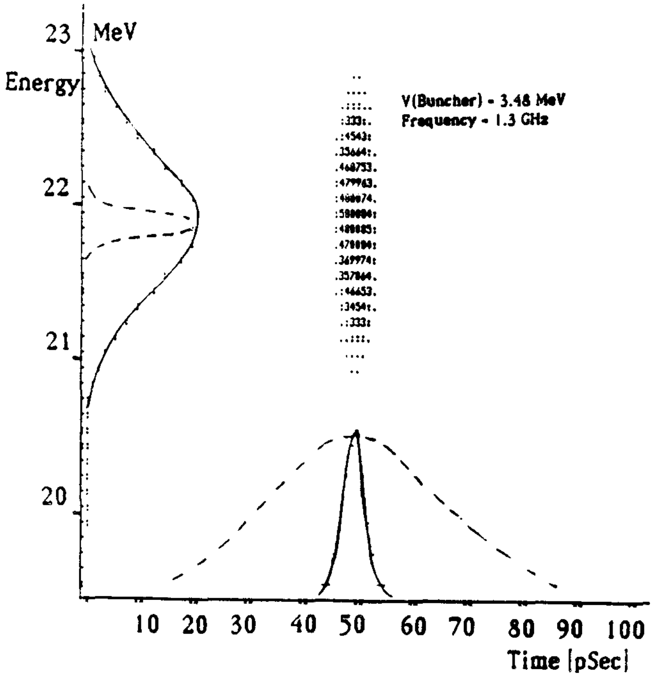

Fig. 3 Bunch rotation synch phase space

The energy spread of the beam before and after the bunch compressor is shown in Fig. 3. The pulse length produced depends on the energy spread of the beam into the bunching cavity. In principle reducing the momentum bite into the system should allow the bunch length to be arbitrarily small, however beam loading in the linac may limit the minimum pulse length that can be produced. Adjustable slits are provided between the first two bending magnets to control the energy spread at this point. Time slewing introduced by the 45° degree magnets is negligible.

Options

Although this system is designed to compress pulses, a variety of other pulse shapes can be produced. By changing the phase of the bunching cavity by π, the system can be made to double the pulse length to about 80 ps and further increases in cavity voltage would produce further increases in pulse length. Lengthening the pulse in this way increases the energy spread, however it is possible to reduce the energy spread with the addition of another cavity if this is necessary.

A potentially more interesting modification to the beamline is the possibility of bunching with a high frequency cavity with variable phase, which permits control over the pulse shape. Since wake fields are highly dependent on the shape of the driving bunches, pulse shape is an important variable. For example, recent theoretical results have shown that triangular current profiles can accelerate particles more than three times as effectively as gaussian beams.[2] For this reason we have studied the possible effects of bunching with a high frequency cavity at various arbitrary phases. The results, shown in Fig. 4, show how beam pulses with a triangular shape can be produced. The high frequency cavity, as well as the cavity for reducing the energy spread of long bunches can be accommodated in the straight sections immediately before and after the two 90° bends in Fig. 1.

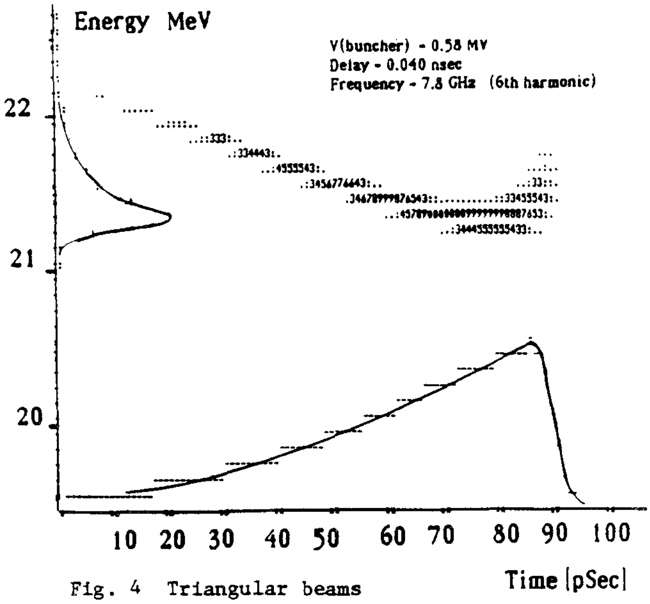

Fig. 4 Triangular beams

Status

Construction of the facility is well underway. The beam line should be completed around mid summer and tune up and operation will take place soon after so that full operation will be possible in the early fall, when the isochronous line for chemistry experiments should also be ready.

Acknowledgements

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