

Accelerator and RF System Development for NLC*

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Abstract

An experimental station for an X-band Next Linear Collider has been constructed at SLAC. This station consists of a klystron and modulator, a low-loss waveguide system for rf power distribution, a SLED II pulse-compression and peak-power multiplication system, acceleration sections and beam-line components (gun, pre-buncher, pre-accelerator, focussing elements and spectrometer). An extensive program of experiments to evaluate the performance of all components is underway. The station is described in detail in this paper, and results to date are presented.

I. INTRODUCTION

In order to test new high-gradient accelerator structures for a Next Linear Collider (NLC), an experimental test area is required to study the detailed properties of these devices. Such a facility must be capable of measuring the energy and energy distribution of a tightly bunched accelerator beam as well as that of dark current produced by electron emission from accelerator cavity walls. We have completed the construction of an accelerator structure test area (ASTA) that consists of a gun/beam focussing section, and a spectrometer section capable of analyzing up to 200 MeV electrons. The gun assembly and accelerator structures are mounted on precision rails to permit the testing of structures up to 4 m in length. Part of ASTA but external to the housing is a high-power X-band klystron and a SLED II rf pulse-compression system. The facility itself is constructed from

concrete with wall thicknesses 1.22 m and ceiling thickness 0.61 m. Extensive lead shielding (up to 20 cm thick) is incorporated in the spectrometer area to keep the expected radiation to a safe level.

II. GUN AND BEAM FOCUSING

A schematic of the accelerator beamline is shown in Figure 1. The electron gun consists of a planar Pierce triode operating at a nominal beam voltage of 80 kV. The design-beam current is 25 mA with a pulse width of 10 ns. The rise and fall times of this pulse will be <1 ns. The pulse width and rise times will be determined by a grid pulser. The beam will be first focussed to an "alpha" magnet by means of a thin-lens solenoid. The alpha magnet effectively bends the beam 105° so that its trajectory will coincide with the main accelerator axis after passing through the magnet. The purpose of this magnet is to prevent the gun from viewing the accelerator structure directly. If the thermionic cathode faces the accelerating structure directly, Barium, boiling off the cathode surface, could contaminate the structure. The accelerator could also bombard the cathode with reverse-accelerated electrons. A second thin lens, positioned after the alpha magnet, will focus the beam through a pre-buncher. This single cavity pre-buncher is used to improve the capture efficiency of the beam. The pre-buncher will be driven by a TWT driver. Following the pre-buncher, a third thin lens is positioned to focus the beam through a pre-accelerator, into the accelerator. The pre-accelerator, identical in design to the

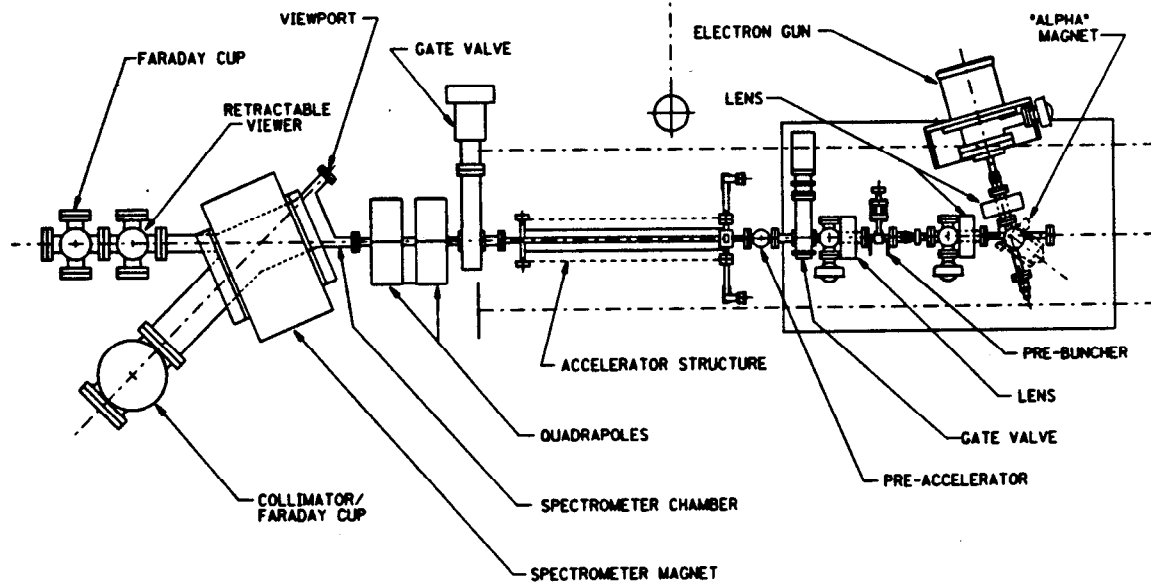


Figure 1. ASTA beam line.

* Work supported by Department of Energy contract DE-AC03-76SF00515, and grants DE-FG03-92ER40695 and DE-FG03-92ER40759.

pre-buncher and located directly in front of the accelerator, will be used to accelerate the beam to energies high enough that beam capture is possible even at low injector voltages and accelerator drive powers. The rf power for this pre-accelerator will be derived from the main accelerator drive power through a 20 dB coupler. Control of power and phase will be accomplished by a magic Tee and moveable shorts arrangement (see Figure 2). The complete gun and focussing system is mounted on a metal plate which slides on a pair of precision rails. This will permit the testing of accelerator sections of various lengths with a minimum of redesign or alignment to the support structure. The beam current can be measured at three positions along the beamline by means of beam-gap monitors.

III. SPECTROMETER

The spectrometer is designed to measure the total beam current through an exit port aligned along the accelerator axis or to measure a momentum analyzed beam through an exit port positioned at 45° to the accelerator axis. A 1.6 T analyzing magnet is capable of bending a 200-MeV electron beam 45° through the analyzing beam line and into a Faraday cup. Detailed measurements of the magnetic-field profile in the vicinity of the beam trajectory have been performed and calibration curves of current versus field strength have been made. In addition, a precision hall probe has been positioned within the spectrometer for accurate field determination. A

pair of collimating slits in front of this Faraday cup permits $\pm 0.5\%$ energy resolution. A second Faraday cup, positioned at the end of the 0° exit path measures the total beam current. A moveable scintillating viewport in this beam line also permits the viewing of the beam. Using this viewport and a pair of quadrupoles at the entrance of the spectrometer, the beam profile can be optimized.

IV. RF POWER

The source of rf for ASTA is a high-power X-band klystron which feeds power to a SLED II pulse-compression setup. The general layout of this setup is shown in Figure 3. The initial design goal is to obtain a 50 MW, 1 μ s rf pulse from a klystron. This will be pulse compressed with SLED II, resulting in a 225-MW pulse having a pulse width of 150 ns. Currently, a reduced pulse-width SLED II scheme has been completed (pulse width of 70 ns) and initial high-power testing has been performed [1]. The klystron (XC-2) currently used is capable of generating 35–40 MW rf power at 1 μ s which is sufficient for initial accelerator testing. A great deal of rf component development work has gone into the construction of SLED II. Since X-band power is rather lossy in rectangular waveguide and since the SLED II pulse-compression scheme requires rf power to travel long distances in its storage waveguides, the use of the low-loss TE₀₁ mode in circular waveguides is required. This, in turn has required the development of new high-power components

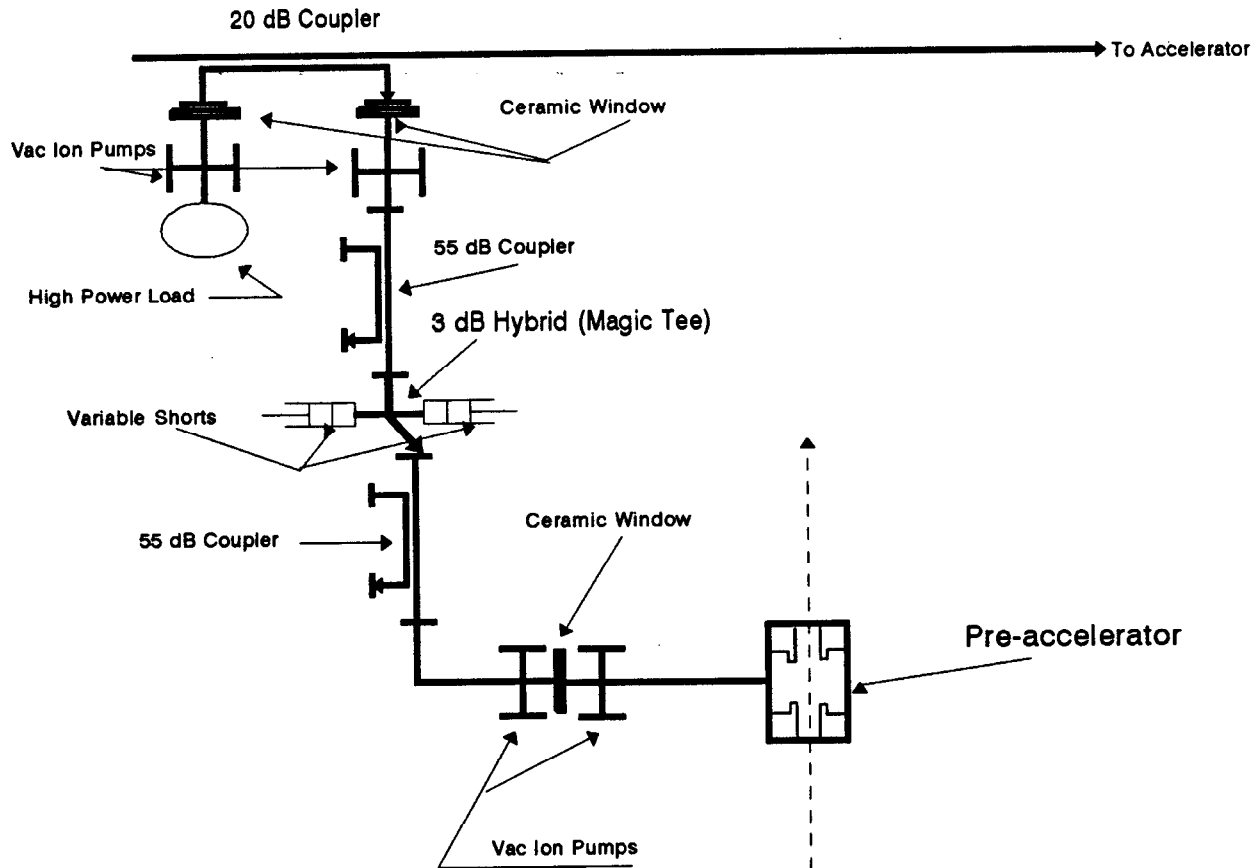


Figure 2. Pre-accelerator rf line.

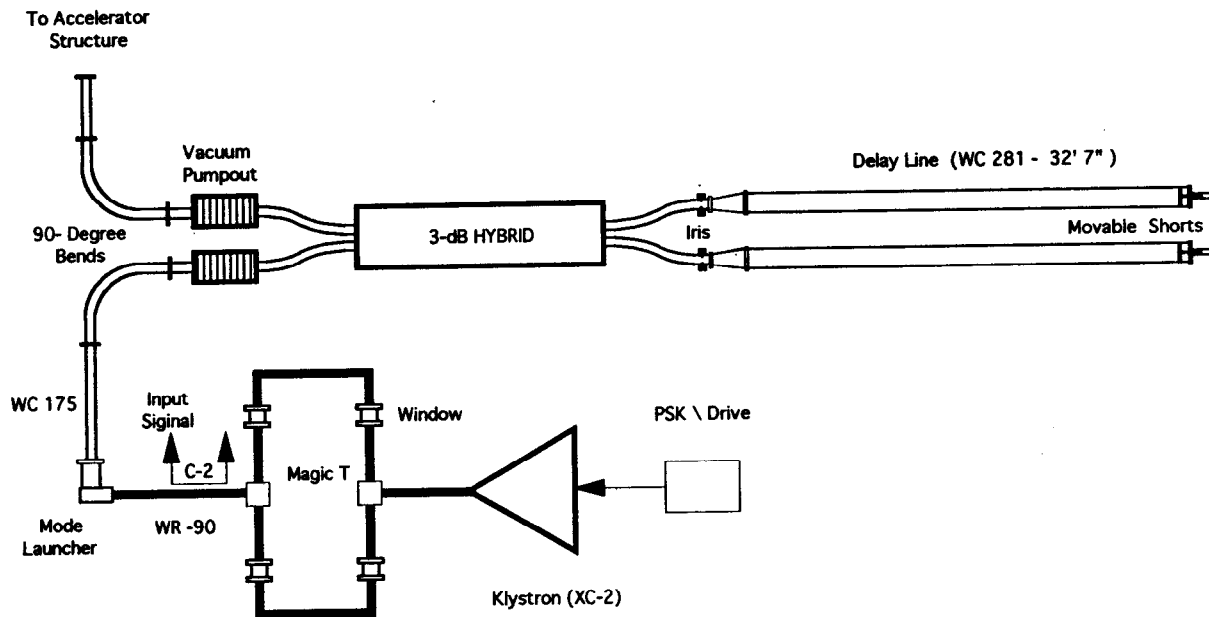


Figure 3. SLED II pulse compression for ASTA.

to transport the rf power. We have recently designed and tested a flower petal mode converter [2] that converts rf power from the rectangular TE_{10} mode to the circular TE_{01} mode with less than 0.7% loss (reflection plus spurious mode conversion). This device has recently been successfully tested in a traveling-wave resonant ring to 150 MW. In addition, low-loss circular 90° bends and nonlinear tapers (purchased from General Atomics Corp.), pumpout/mode filters, and directional couplers [3] were developed and are being tested.

V. TESTING PROGRAM

In the next year several additional high-gradient structures will be tested. Currently the facility is being readied to test a .75 m constant-gradient structure. Initially, only dark-current measurements will be performed. The peak accelerating gradients to be measured will be 100 MV/m. The next series of tests will be with a 1.8-m, detuned structure. In these tests both dark-current measurements and bunched-beam tests will be performed at accelerating gradients up to 100 MV/m. A third series of tests will then be performed with two 1.8-m structures operated at peak

accelerating gradients of 50 MV/m. In addition to testing accelerator structures, different types of high-power waveguide component will be tested by being incorporated into the rf transport line. New, reduced sized 90° bends, 3 dB hybrids, and pumpouts/mode filters will be the first components to be tested in the next few months.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the considerable support and assistance of J. K. Cobb of SLAC's Magnetic Measurements group for mapping out the magnetic field profile of the spectrometer magnet used in ASTA.

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