DESIGN AND FACTORY TEST OF THE e^+/e^- FRASCATI LINEAR ACCELERATOR FOR DAΦNE

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Introduction

The electron-positron accelerator for the DAΦNE[1] project has been built and the first half is in test at Titan Beta in Dublin, CA. This S-Band RF linac system utilizes four 45 MW sledded[2] klystrons and 15-3 m accelerating structures to achieve the performance. It delivers a 4 ampere electron beam to the positron converter and accelerates the resulting positrons to 550 MeV. The converter design uses a 4.3T pulsed tapered flux compressor, a 12 kG tapered field solenoid, along with a pseudo-adiabatic tapered field to a 5 KG solenoid over the first two positron accelerating sections. Quadrupole focusing is used after 100 MeV. The system performance is given in Table 1. This paper briefly describes the design of the various subassemblies in this system and gives the initial factory test data.

Table 1. DAΦNE Linac Parameters

General

RF Frequency	2856 MHz
Klystron Power	45 MW
No. of Klystrons	4
No. of SLED Cavities	4
No. of Sections	45 + Buncher
Repetition Rate	50 Hz
Beam Pulse Width (FWHM)	10 nsec

High Current Electron Linac

No. of Accelerating Sections	5 + Buncher
Input Current	up to 10.0 A
Input Energy (nominal)	120 kV
Output Current	>4.0 A
Output Energy	250 MeV
Output Emittance (geometric)	$\leq 1\pi$ mm·mrad
Energy Spread	± 5%
Focused Beam Spot	~1 mm radius

Positron Linac Mode

No. of Accelerating Sections	10
Output Energy	$\geq$510 MeV
Input Energy (mean)	8 MeV
Resolved Output Current	36 mA
Emittance (geometric)	$\leq 5\pi$ mm mrad
Energy Spread	± 1%

High Energy Electron Linac Mode

Full Beam Energy	510 MeV
Peak Current	150 mA
Energy Spread	±0.5%
Emittance (geometric)	$\leq 1\pi$ mm·mrad

System Description

The linac system consists of:

1. A high current linac designed to produce 250 MeV with 4 amperes of beam current with a 1 mm radius focus spot on the positron target. This section includes the electron gun and injector which is useable in both the electron and positron modes. This linac utilizes a series of discreet solenoid coils over the first section and quadrupole focussing over the remaining 4 sections. A final focus triplet brings the beam to the 1 mm radius spot on the positron target.

2. An electron to positron converter based on the SLAC design.

3. A low current accelerator designed to produce 550 MeV for accelerating either the positron beam or a low current (150ma) electron beam. This section includes a 5 kG solenoid over the first two sections followed by an electron-positron separator prior to the remaining eight sections.

4. A distributed control system operating thru a CAMAC based IEEE-488 Buss computer system. An Apple Macintosh Quadra 700 computer running National Instruments LabView II control and data acquisition software is used to control the entire Linac system. An additional Apple Macintosh computer is employed for a stand-alone data acquisition system to gather pulse waveform data from the beamline diagnostics.

The system design has been described in reference 3.

System Status

The present status of the project is as follows. Earlier status was reflected in reference 4.

Construction Status

Half of the system has been assembled in a 120 foot long shielded test cell at Titan Beta. The e-gun, injector, buncher, and sections 1-8 along with appropriate magnets, and support systems have been assembled and are under test. Figure 1 shows the beamline as assembled at Titan Beta. The second half of the system is being mechanically assembled and tested up to but not including RF and beam prior to shipment. The modulators and klystrons are being electrically tested. The positron converter has been assembled and the flux concentrator operated for many hours at full power. Figure 2 shows the positron coverter assembly. It has a 4.3 Tesla pulsed coil (flux concentrator), target assembly, and a 12 kG DC solenoid included. Pulse Sciences Division of Titan built this assembly.

The 5 Kg, 6 M uniform field solenoid has been designed and is in fabrication. Parts of it have been tested and are at Titan Beta.

Figure 1

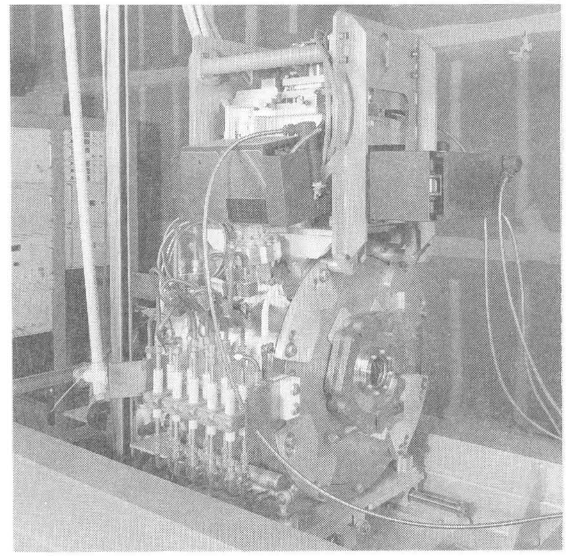

Figure 2

Test Status

Modulator and Klystron Tests

At this point in the project all of the four modulators and klystrons have been tested extensively at full power: 45 MW, 4.5 μs flattop, 50 pps. Figure 3 shows one of the four modulator assemblies.

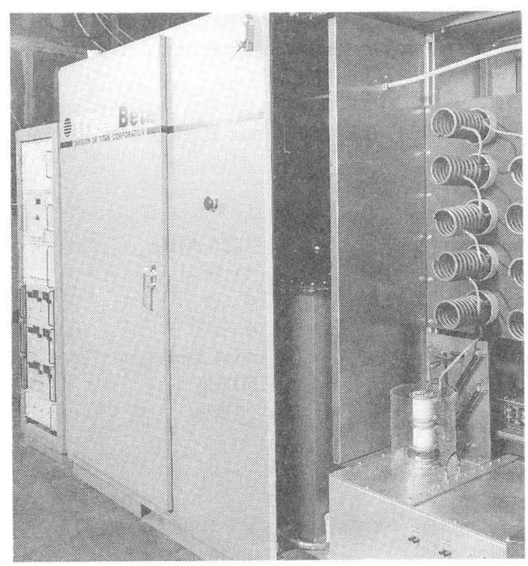

Figure 3

RF Tests

Two of the four SLED cavities have been installed, tuned and operated at full power. The peak power reaches about 200

MW at the start of the SLED pulses. The SLEDDED pulse width is about 900 ns. Figure 4 shows one of the SLED assemblies. It is placed adjacent to the klystron that powers it. We RF conditioned the eight accelerating sections in test to full power. The conditioning took approximately two weeks. Thenominal maximum gradient is 26 MeV/M in the positron capture section. The water systems operated as designed and provided ±.1°C regulation.

Beam Tests

Beam tests have been performed. We achieved 4 amps of beam at the position of the positron target as desired within the 2 mm required spot diameter. The actual spot size measured is .94 mm in one plane and 1.56 mm in the other FWHM. A Spirocon beam analyzer is used to obtain spot size and position information.

The positron converter is not assembled in the beamline at the factory so as not to make it radioactive and create problems in shipping and customs.

Energy was measured using steering coils to deflect the beam on a phosphor coated aluminum plate placed in the beam. The Spirocon is used to observe spot deflection with nearby steering coil magnetic field and the energy is calculated from this. Nominal values have been observed.

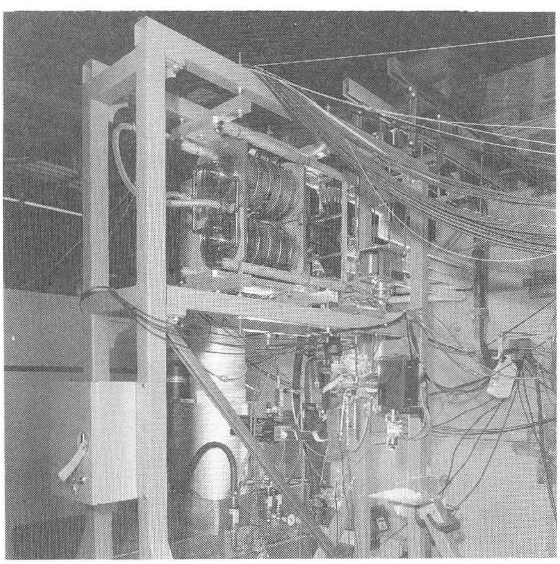

Figure 4

Completion Schedule

We will complete beam tests on the half-system shortly. The uniform field solenoid is being assembled and when the system is ready for shipment we plan to use 10-12 sea vans to ship via ship in September 94. Assembly and commissioning in Italy will take place this fall through next spring.

Conclusion

The DAΦNE accelerator is under construction at Titan Beta. It is expected to be delivered in 1994 and commissioned in the Spring of 1995.

References

[1] G. Vignola, INFN-LNF; "DAΦNE, The Frascati Φ-Factory", PAC '93 Conference Ib4, May 17-20, 1993.

[2] Z.D. Farkas, H.A. Hogg, G.A. Loew and P.B. Wilson, "SLED: A Method of Doubling SLAC's Energy", IXth Int'l Conf on High Energy Accelerators, SLAC, May 2-7, 1974.

[3] K. Whitham, H. Anamkath, S. Lyons, J. Manca, et. al., "Design of the e^+/e^- Frascati Linear Accelerator For DAΦNE", 1992 Linear Accelerator Conference Proceedings, Ottawa, Ontario, Canada, August 24-28, 1992.

[4] K. Whitham, et. al., "Design adn Factory Test of the e^+/e^- Frascati Linear Accelerator for DAΦNE", EPAC, London, UK, June 1994.