First Measurements of the Elettra 100 MeV Pre-Injector

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Abstract

The first part of the Elettra injector has been tested. The results of measurements in single and multibunch modes of operation are presented.

1. Introduction

The Elettra injector [1], made up of a 1.5 GeV linac, designed and built by GE CGR MeV, has had the 100 MeV pre-injector installed and tested. The operational specifications of this part of the linac are to be found in ref. [2]. The pre-injector has various modes of operation: single bunch and multibunch at 100 MeV and variable energy (30 to 75 MeV) FEL modes. For the two injection modes the energy, energy spread, current and/or charge and emittance have been measured. Table 1 gives a summary of the measurements.

2. General Description of the Pre-Injector

A detailed description can be found in ref. [2]. Figures 1 and 2 show the gun with the assembly of low energy bunching components and the accelerating sections installed in the tunnel. The low energy part of the pre-injector is made up of a 100 kV DC gun, followed by the bunching components: a 500 MHz rectangular cavity TM110 chopper, a 500 MHz TM010 cylindrical buncher, a 3 GHz prebuncher and a standing wave bunching section. Two 3.2 m long, 2/3 π travelling wave accelerating sections then increase the energy of the beam from 4 MeV at the exit of the s-band buncher up to 100 MeV. The whole machine is powered by a single 100 MW modulator that drives a TH2132 klystron, designed by Thomson to get 45 MW of rf power in a 4.5 µsec pulse. The rf output is split into two waveguides, one waveguide feeding the second accelerating section while the other waveguide is further split to feed both the first accelerating section and the appropriate s-band bunching modules. Two solid state amplifiers, 2.5 kW each, power the two 500 MHz cavities.

At the end of November 1991 the rf conditioning of the machine started, and the first beam was obtained at the beginning of 1992.

At present the injection modes (single bunch and multibunch) have been optimised for 100 MeV operation. The FEL mode is not yet in operation, although some preliminary tests have been performed in order to check the electronics driving the gun. We will test the pre-injector in the FEL mode at the end of the 1.5 GeV commissioning.

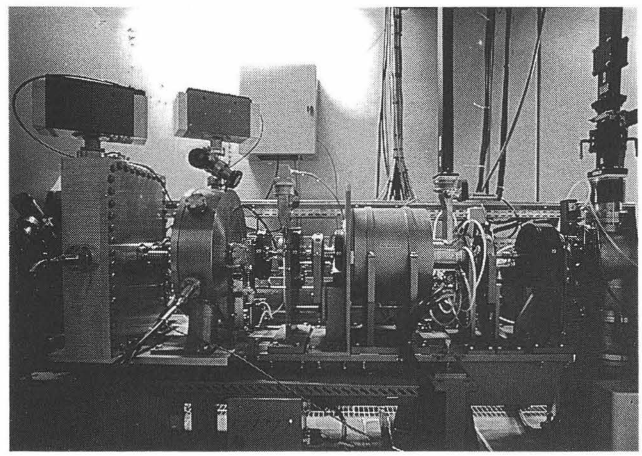

Figure 1. Gun and bunching sections.

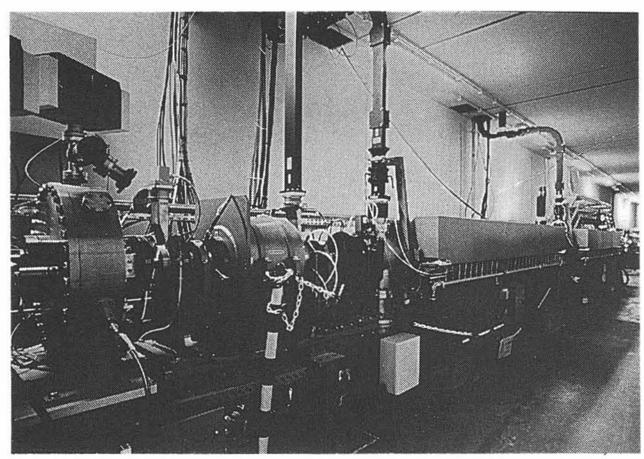

Figure 2. The two 3.2m long accelerating sections.

3. Measurements

3.1: Introduction

The principal linac parameters, energy, energy spread, current and transverse emittance were measured using the diagnostic line described in ref. [3]. The main components of the line being two quadrupole triplets, a bending magnet, three fluorescent screens, two Faraday cups, and an electrically isolated collimator. Furthermore, additional measurements of the current/charge were possible with use of toroids, gap and beam position monitors available along the linac [4].

Table 1: Results of first measurements in single and multi-bunch modes.

	Multi-bunch				Single bunch mode		
	Specified	Measured			Specified	Measured	
						Chopper off	Chopper on
Pulse length (ns)	10 to 300	300	150	10	< 1	≤ 0.25	≤ 0.25
Energy (MeV)	100	100.8	100.2	100.4	100	101	100
Current (mA) or	>10	13	16	17			
Charge/Pulse (nC)					≥ 0.16	0.19	0.17
Emittance (mm mrad)							
Horizontal	1.0	1.17	1.17	1.14	1.0	0.9	0.87
Vertical	1.0	0.81	0.76	0.66	1.0	0.76	0.93
Energy Spread (%)	≤±0.5	±0.5	±0.5	±0.5	≤±0.5	±0.5	±0.5

Substantial use was made of fluorescent screens [4]. The beam image on the screen is digitised by a frame grabber and analysed. The computed beam widths in both planes, the beam centre and the integrated intensity of the light signal are displayed on a television monitor and are also made available to various programs.

3.1: Energy Spread

The energy spread measurement was performed using a fluorescent screen positioned after a bending magnet. After ascertaining that all the beam was visible on the screen and/or correlating the integrated screen signal with a downstream Faraday cup, the average of a series of width measurements was calculated and used to define the relative energy spread. The beam current for all modes is defined to be that current contained in the specified energy spread. Figures 3 and 4 respectively show the energy spectra for a 300 and 150 ns linac pulse. For figure 4, 16 mA was found to be within ±0.5% relative energy spread.

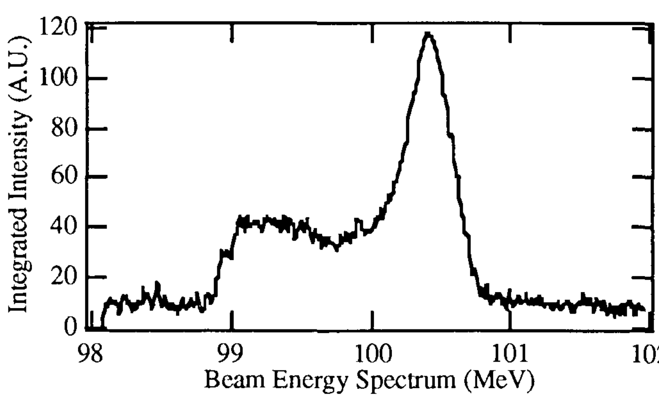

Figure 3: Energy spectrum for a long pulse 300 ns. Total charge in the pulse was 11.4 nC.

3.2: Emittance

The emittance measurements were performed by varying the strength of a quadrupole and measuring the resulting variation of beam size at a downstream fluorescent screen. A least squares fitting routine, using thick lens optics, was written to determine the emittance and the associated sigma matrix that characterises the electron beam. Figures 5 and 6 show the variation of the square of the beam size as a function of quadrupole current. The computed phase space ellipses at the exit of the linac (rf end) are shown in figures 7 and 8 respectively. Figure 9 shows the deviation from a Gaussian distribution of the electron pulse. Up to approximately 60% of two dimensional phase space electrons can be well described by a Gaussian distribution.

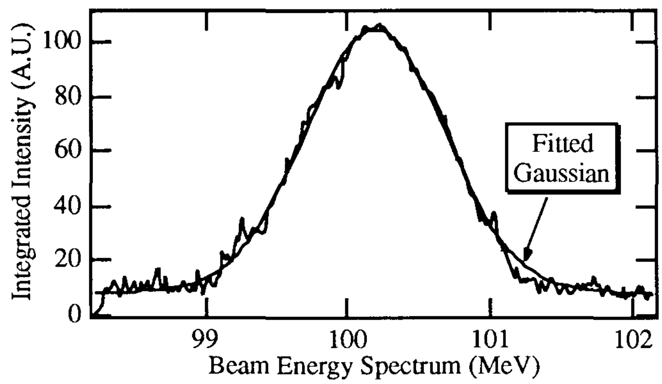

Figure 4: Energy spectrum of an optimised 150 ns pulse. Total charge in the pulse 3.45 nC. Also shown is a Gaussian function fitted to the data.

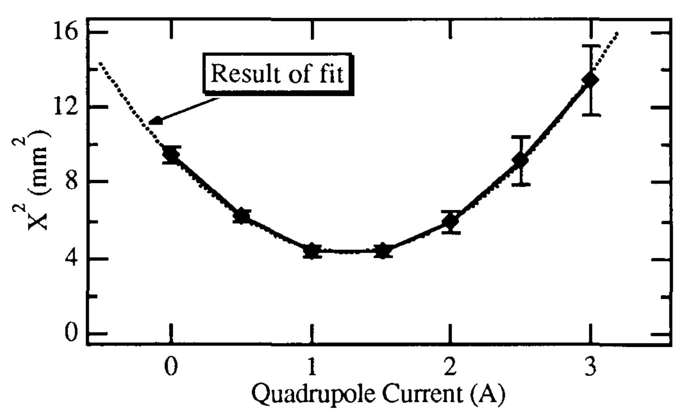

Figure 5: Variation of the square of the horizontal beam size as a function of quadrupole current.

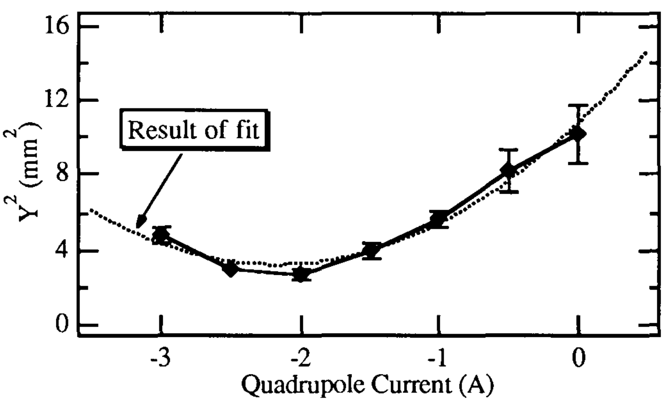

Figure 6: As in figure 4, but for the vertical plane

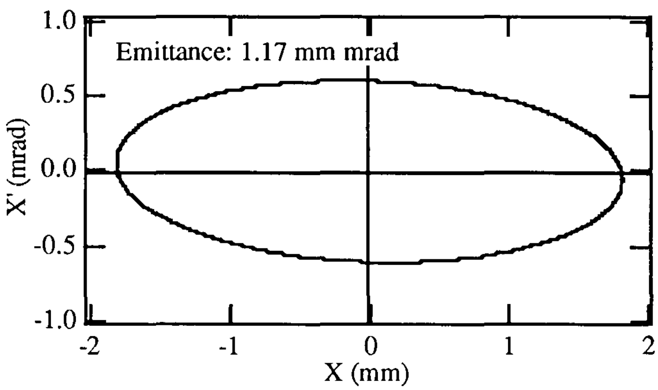

Figure 7: The beam ellipse in horizontal phase space. A result of the measurements in figure 5.

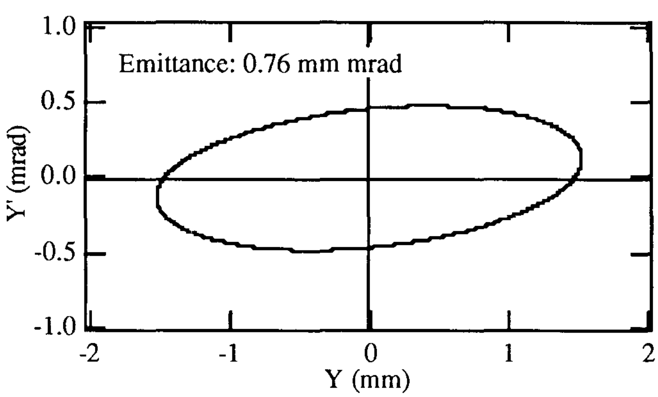

Figure 8: The beam ellipse in vertical phase space obtained by using the results of figure 6.

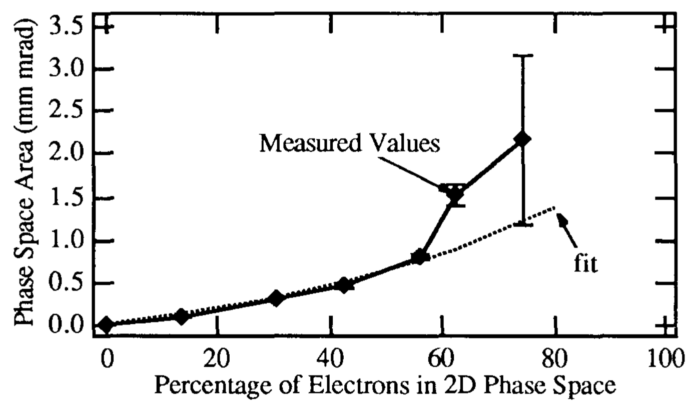

Figure 9: The diagram shows that approximately 60% the beam in two dimensional phase space can be considered to be distributed Normally. (The dotted line is the theoretical curve based on a Gaussian distribution normalised to the first four points. Multi-bunch mode 310 ns, 10 mA.)

4. CONCLUSIONS

In addition to the measured values satisfying the beam specification parameters, it is worth while to mention that the machine has accelerated more than 80 mA in a 300 ns pulse. This is of importance to the operation of the 1.5 GeV Elettra injector where it is preferable to have 100 mA in a 150 ns pulse at the exit of the pre-injector.

5. ACKNOWLEDGEMENTS

The authors gratefully acknowledge the following groups at Sincrotrone Trieste for their contribution: Alignment, Controls, Health Physics, Instrumentation, RF/Linac, Power Supply, Technical Office and Machine Shop, Vacuum and to the CGR MeV team who installed and operated the pre-injector.

6. REFERENCES

[1] D.Tronc, et al., "The Elettra 1.5 GeV Electron Injector", in IEEE Particle Accelerator Conference Proceedings, San Francisco, U.S.A., May 1991.

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[3] C.J.Bocchetta, et al., "The Diagnostic Line for the Acceptance Tests of the Elettra 100 MeV Pre-Injector", European Particle Accelerator Conference, Berlin, Germany, March 1992.

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