Commissioning of the LNLS Injector LINAC

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Abstract

A 50 MeV LINAC designed and built at LNLS the first part of the injector for a 1.15 GeV storage ring, is now under commissioning. Its performance has fully achieved design specifications. The design characteristics and measured beam parameters are presented.

1 Introduction

The LNLS was created with the purpose of designing, building and operating a dedicated synchrotron radiation facility[1]. Activities started with staff hiring and training in June 1987, after five years of discussions among the scientific community. The initial setup of this facility will be based upon an 1.15 GeV electron storage ring[2], scheduled for operation in 1994.

Injection will be at low energy by a 100 MeV linear accelerator. In order to train people it was decided to build this LINAC in house, in two phases: a first 50 MeV accelerator, to be followed by an upgrading to 100 MeV when the LNLS buildings are finished. The accelerating structures and the first electron gun were provided by the Institute of High Energy Physics, Beijim. In parallel, LNLS developed another e-gun with higher current yield[3].

The LINAC was designed[4] and built by a team of LNLS physicists and engineers in a period of 2 1/2 years. Construction of phase one was completed by the end of 1989.

2 LINAC Characteristics

A standard traveling-wave accelerator design was adopted, using two SLAC-type, disc-loaded, constant gradient accelerating structures, operating at a frequency of 2856 MHz. Its main parameters are indicated in Table 1 and the main components in Figures 1, 2 and 3.

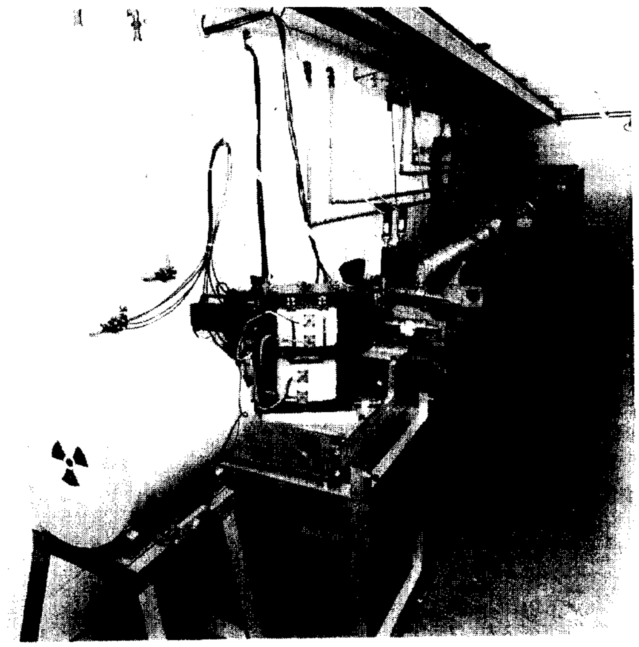

Figure 2: The LINAC tunel as seen from the beam stopper

Table 1: Phase-one LINAC Design parameters.

Output energy	50	MeV
Macropulse current	200	mA
Pulse length	100	ns
Repetition rate	0.5 to 33	Hz
Gun voltage (maximum)	80	kV
Gun current (maximum, peak)	1.0	A

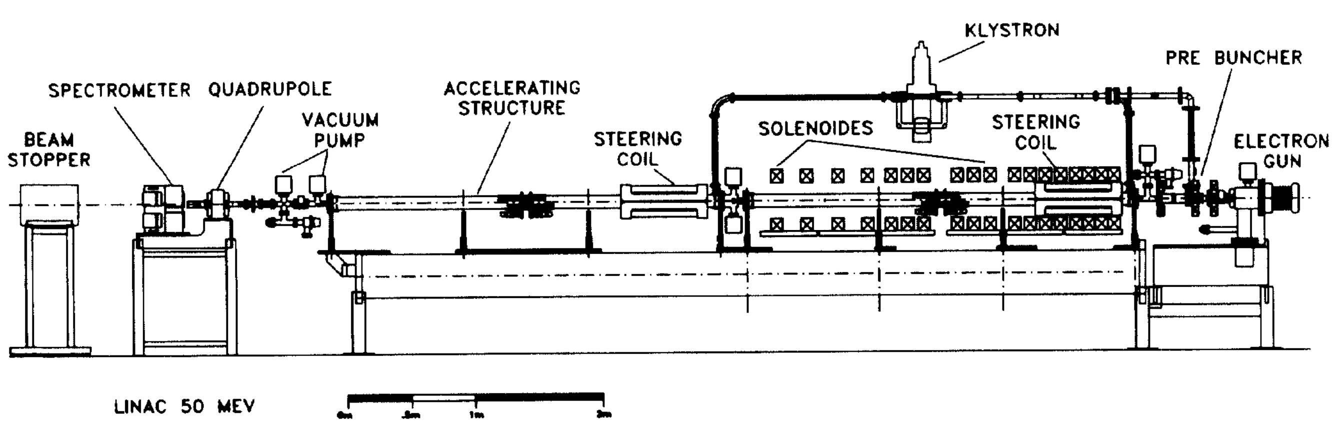

Figure 1: Main components of the 50 MeV LINAC.

The injector is composed by a Pierce-type triode gun, steering coils, magnetic lenses, beam current transformer and a single-cavity pre-buncher. No buncher was used.

Microwave power is generated in three stages: one high stability 2856 MHz time-base system, a pulsed 1 kW klystron amplifier and a 25 MW klystron with a 65 MW, 3 μs modulator. Transmission to the accelerating structures is made by a waveguide system including couplers, for power and VSWR measurements, and arc detectors. The system has been working with aluminum waveguides pressurized with SF_6. The pre-buncher power network has remote controlled phase-shifter and attenuator.

Beam transport components include a solenoide made of 18 coils over the first structure, fed by six independent power supplies and two pairs (horizontal and vertical) of steering coils.

Beam diagnostics is provided by beam current transformers, optimized for 100 ns, and screen monitors between structures and at the end of the LINAC. Also at the end, there is an energy analyzer composed of a quadrupole and a short rectangular bending magnet (up to 1.1 Tesla). The quadrupole is also used for emittance measurements.

Under steady operation, accelerating structures are temperature stabilized within $(318.2 \pm 0.1)K$.

The vacuum system uses eight $20l/s$ sputtering-ion- pumps, two ion-gauges and two sector valves.

3 Operation and Performance

The assembly of the LINAC parts started in November 1989. The first electron beam at the output screen monitor was observed on December 1989. After a few weeks of adjustment the LINAC achieved the design current and energy specifications.

The gun normally operates at $3 \cdot 10^{-8} mbar$ and the LINAC average pressure is about $1 \cdot 10^{-7} mbar$. The corresponding static pressures are $6 \cdot 10^{-9}$ and $6 \cdot 10^{-8} mbar$, respectively.

At maximum klystron output power, 25 MW, the measured input RF power to each accelerating structure is 11 MW. Under this condition, the macropulse current at the end can be varied continuously up to 220 mA, corresponding to a total capture efficiency of $\sim 25\%$. Figure 4 shows the beam current just after the gun and at the end of the LINAC.

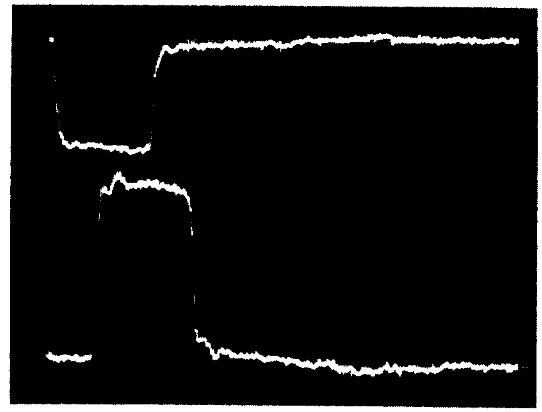

Figure 4: Beam current from the e-gun (above; 350 mA/div.) and at the end of the LINAC (bellow; 50 mA/div.). Horizontal scale: 50 ns/div.

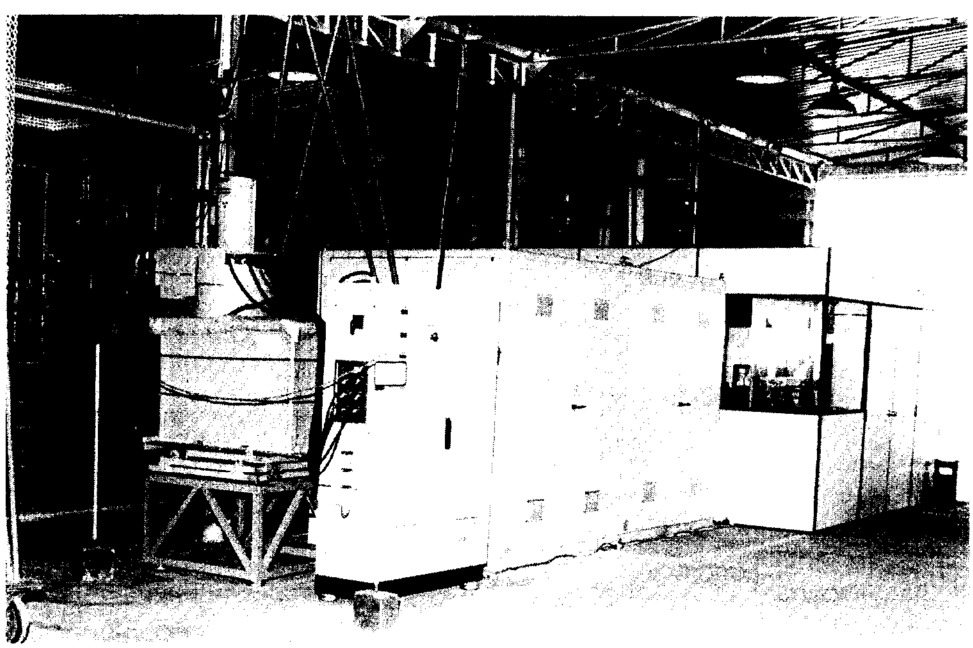

Figure 3: Equipment installed outside the tunel. From left to right: klystron over pulse-transformer tank, klystron coils power supply, high power modulator and control room.

Measured values of the beam energy, for different beam currents and maximum RF power, are shown in Figure 5. The measured energy dispersion was 2% (one standard deviation).

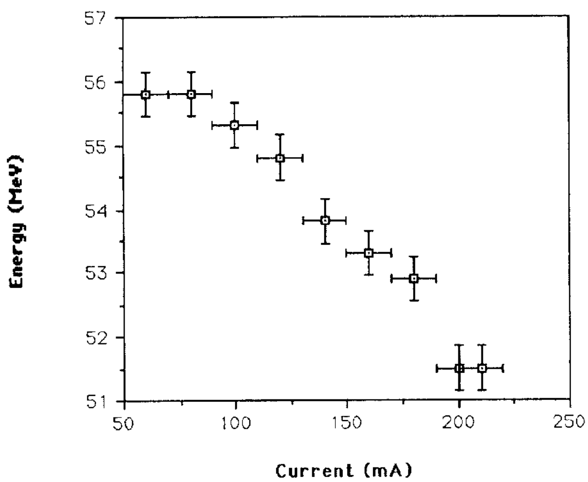

Figure 5: Measured beam energy versus beam current for maximum RF power.

Experimental beam emittance was determined by measuring the horizontal beam-width on the output screen-monitor for various values of the quadrupole gradient. The best fitted *rms* value was found to be $(1.4 \pm 0.3) \cdot 10^{-6}\pi \cdot mm \cdot mrad$, for beam currents in the 80 to 180 mA range and normalized to an energy of 50 MeV, close to the calculated value, $1.3 \cdot 10^{-6}\pi \cdot mm \cdot mrad$ given by the code PARMELA[4]. Figure 6 shows a typical set of measured envelope standard deviation for various values of quadrupole field gradient.

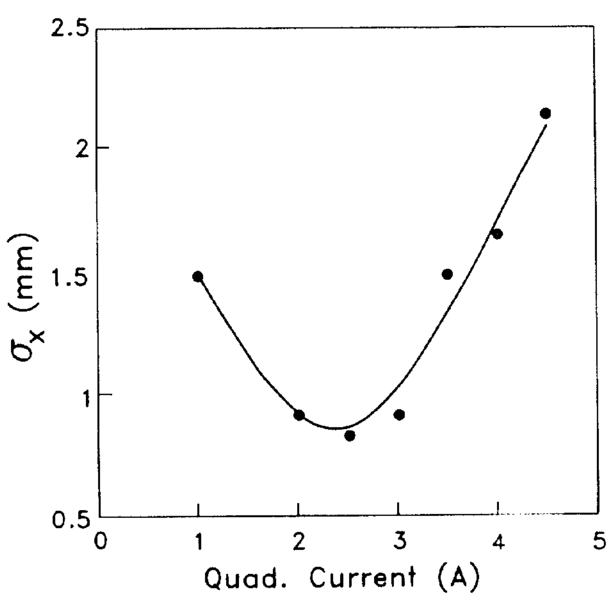

Figure 6: Set of measured beam envelope (standard deviation) at the output screen monitor as a function of the quadrupole gradient.

References

[1] C.E.T. Gonçalves da Silva, A.R.D. Rodrigues and D. Wisnivesky, LNLS: The Brazilian Synchrotron Light Laboratory, PAC-IEEE (1989).

[2] L.Liu, L.Jahnel and P.Tavares, A Magnet Lattice for the LNLS UV Synchrotron Light Source , presented at this conference.

[3] O.R.Bagnato, A.C.Lira, L.Jahnel and P.Tavares , An Electron Gun for the LNLS pre-Injector, presented at this conference.

[4] L.Liu, L.Jahnel and P.Tavares, The Injection System for the LNLS Synchrotron Light Source: The Linear Accelerator., PAC-IEEE (1989).

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