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A Thermionic Electron Gun for the Preliminary Phase of CTF3

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A dedicated electron gun has been designed and built for the preliminary phase of the CLIC Test Facility 3 (CTF3). The gun is based on a thermionic gridded cathode and operates at 90 kV in the intensity range of 50 mA to 2A. The specific time structure of the beam is characterized by a burst of up to seven pulses of variable pulse width (4 to 10 ns) each separated by 420 ns, the revolution time of the former EPA (Electron Positron Accumulator) ring. The mechanical conception was specifically designed to be compatible with the existing front-end of the former LIL (LEP Injector Linac). We will describe the experimental results obtained with the beam on CTF3

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A dedicated electron gun has been designed and built for the preliminary phase of the CLIC Test Facility 3 (CTF3). The gun is based on a thermionic gridded cathode and operates at 90 kV in the intensity range of 50 mA to 2A. The specific time structure of the beam is characterized by a burst of up to seven pulses of variable pulse width (4 to 10 ns) each separated by 420 ns, the revolution time of the former EPA (Electron Positron Accumulator) ring. The mechanical conception was specifically designed to be compatible with the existing front-end of the former LIL (LEP Injector Linac). We will describe the experimental results obtained with the beam on CTF3.

1 INTRODUCTION

The Compact Linear Collider (CLIC) scheme is based on the production of a 30 GHz RF pulse that requires electron bunch frequency multiplication [1]. The goal of the new CLIC Test Facility CTF3 is to demonstrate the feasibility of such a scheme. The so-called preliminary phase aims at testing the bunch combination scheme at low charge. The principle relies on the injection of short electron bunches into an isochronous ring using RF deflecting cavities in order to achieve frequency multiplication. A specific gun should be designed in order to fulfil the constraints described below.

2 CLIO GUN

The CLIO gun is a thermionic electron gun derived from the gun built at Orsay for the Free Electron Laser CLIO [2], hence the name. The CLIO gun is a conventional Pierce type gun with a gridded cathode of 1 cm² (EIMAC, Y646B type) emitting a burst of up to seven pulses of variable width (2 to 10 ns) with a rise time shorter than 1 ns. Each pulse is separated by 420 ns, the revolution time of the EPA ring. The intensity is in the range of 50 mA to 2 A. The nominal HV operation is 90 kV but 100 kV is used for the conditioning. The voltage stability is 1%. The inner geometry of CLIO design has been practically conserved. However EGUN simulations have been performed to ensure electron laminar flow, in the range of intensity and with the specific output of this new gun. The external geometry has been adjusted to be compatible with the existing front-end of the former LIL.
A bucking coil, allows reduction of the residual magnetic field at the cathode. The beam parameters at the gun exit are given in Table 1.

Table 1: Beam parameters at gun exit

Nominal beam energy	90	keV
Pulse width	2 to 10	ns
Intensity	0.05 to 2	A
Number of pulses	1 to 7	
Repetition rate	50	Hz
Emittance (rms)	<15	mm.mrd

2.1 Mechanical design

The vacuum chamber of the CLIO gun has been designed to fit existing CERN equipment, in particular the gun is fully compatible with the «CERN plug-in system» and an existing pair of ion pumps. All inner elements have been baked under vacuum (400 ºC, 10^{-5} mbar, 12 h) and assembled under clean laminar airflow. With these precautions a pressure of 10^{-9} mbar was obtained very quickly and the HV processing reduced to a few hours.

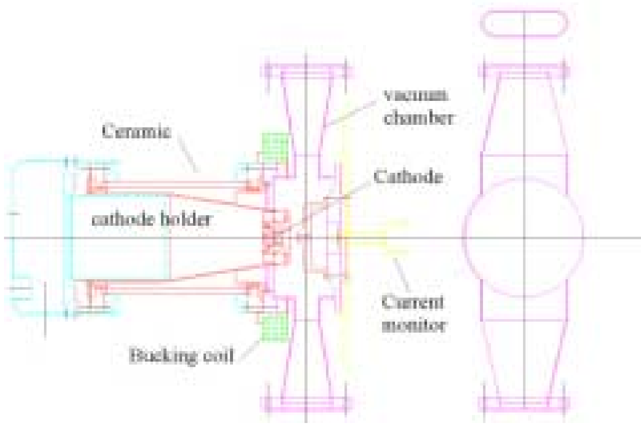


Fig.1 Mechanical scheme of CLIO GUN

2.2 Electronics

i) High Voltage: The gun high voltage is provided by a standard 100 kV, 5mA supply. For simplicity the buffer capacity - 2 nF - is provided by a 20 m length of the HV coaxial cable. The electronic earth is floating and the electronic cards are imbedded in a metal cabinet - the "hot deck" - connected to the HV. The gun anode is at earth potential.

Figure 3: Beam line set-up for measurements

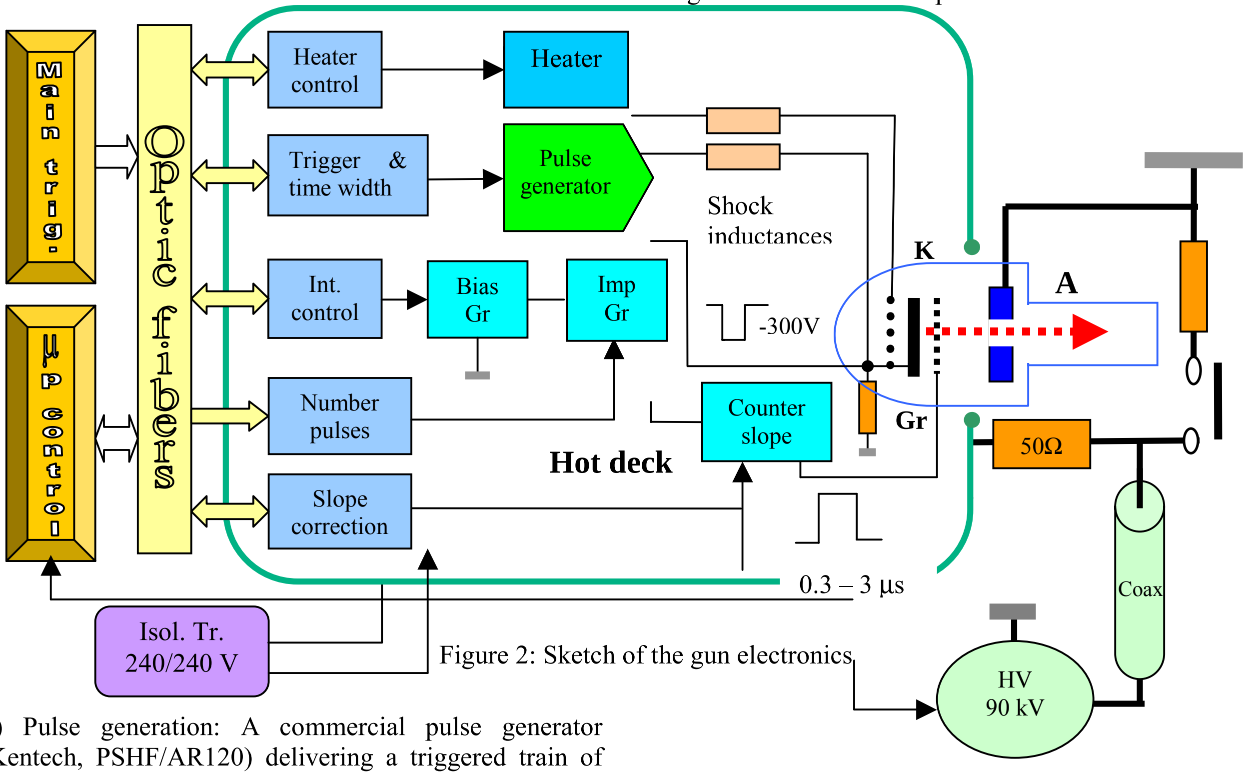


Figure 2: Sketch of the gun electronics

ii) Pulse generation: A commercial pulse generator (Kentech, PSHF/AR120) delivering a triggered train of 300V/50 Ω (with reference to cathode) elementary pulses of adjustable time width, feeds the gun cathode. The grid is used as a gate to select the number of desired pulses as well as to control intensity and correct the slope due to the buffer capacity discharge. A positive pulse produces the gate function, an adjustable voltage source is used to set the intensity and a counter-slope generator assures the flatness of the macro pulse.

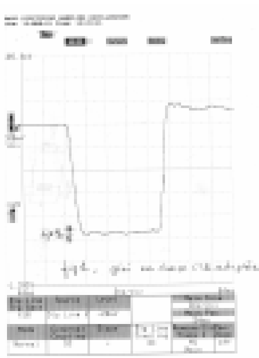
iii) Remote control: The remote control (provided by CERN) is done by a dedicated microprocessor. In this way it is possible to easily set all parameters of the gun. Logic protects the gun from wrong commands and assures the security of the interlocks. All connections of the remote control to the deck are make by optic fibres.

3 EXPERIMENTAL RESULTS

3.1 At LAL

For measurements of beam characteristics, the gun was connected to a beam line consisting of a set of magnetic field coils and two WCM (Wall Current Monitors) as shown in the Figure 3.

The pulse driving the cathode, and the pulse measured on it, are displayed on Figures 4 and 5.



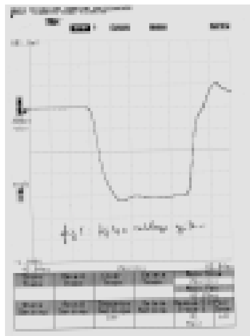
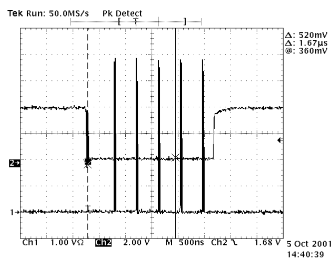


Fig.4 Signal from generator. Fig.5 Signal on the cathode

Figure 6 shows, inside a gate, a burst of five pulses as applied to the cathode grid.



3.2 At CERN

The commissioning of the gun started in September 2001. Conditioning was done by increasing the HV in small steps recording vacuum and HV leakage current. During a few hours the HV was ramped up to the conditioning value of 100 kV without any major problems. The vacuum descended slowly to about $3x10^{-9}$ Torr. After the vacuum was stabilised, HV was set to the nominal value 90 kV. The current was 20 µA. The pulse generator was switched on. The settings of the focusing system at the gun exit were set to the theoretical values. The grid voltage was increased in order to get the nominal current of 1 A. Figure 7 shows the signal as recorded by the capacitive electrode (ECM) just downstream of the anode. The capacitance of the ECM is 1.8 nF. For the nominal HV, one obtains 90 mV/A and with a 500 MHz amplifier, the calibration factor becomes 594 mV/A.

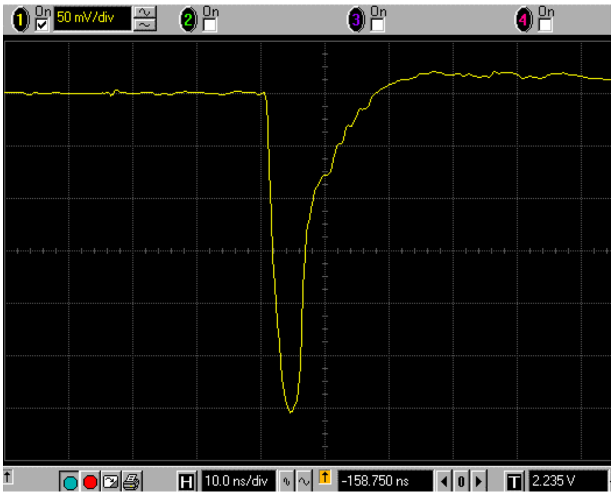


Figure 7: Electron pulse for 1 A at the gun exit.
The pulse length is 5 ns (FWHM)

The gun pulser was set up to provide a burst of 5 pulses to the cathode spaced by 420 ns. Then the timing was adjusted in order that the burst of 5 pulses arrived properly in the bunching system. Figure 8 shows the burst synchronized with the RF pulses of the bunching system (of the first and the second klystron of the linac).
The amplitude stability is ± 2.5 % per pulse and for a current of 1 A.

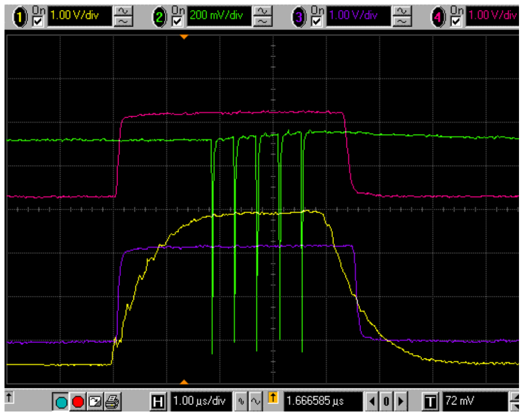


Figure 8: A burst of 5 pulses together with the RF pulses of the bunching system and accelerating cavities

5. CONCLUSION AND OUTLOOK

A thermionic electron gun has been “ redesigned” with specific electronics devoted to the preliminary phase of CTF3 [3]. This gun gives a beam in accordance with the specifications, and it has allowed the commissioning of the preliminary phase [4].
For the future, it is planned to build a new gun operating at 140 kV for the initial phase of CTF3 using an existing triode provided by SLAC.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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