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NEW GUN IMPLEMENTATION AND PERFORMANCE OF THE DAΦNE LINAC

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Abstract

A new electron gun system has been developed for the DAΦNE LINAC, and put into operation since January 2014. Several elements of the system were upgraded, including a new grid pulser, an improved bias voltage system and a renewed cathode socket.

The new LINAC gun has now a wider range of parameters, i.e. the emission pulse length spans from 1.4 ns up to 40 ns, while the better control of the grid and bias voltage allows a maximum peak current of 5 A with a pulse repetition rate of 50 Hz. This paper describes the details of the pulser, the power supply, the socket, all the service components of the upgraded gun and its integration in the main LINAC control system. A report on the performance of the LINAC with the new gun will follow.

INTRODUCTION

The injector of the DAΦNE accelerator complex is an S band (2856 MHz) LINAC that alternately produces and accelerates the electron and positron beams up to the collider operation energy of 510 MeV. Before injection into the Main Rings the beams are stored into the Accumulator ring for phase space damping. The LINAC has been designed, built, and installed by TITAN BETA (USA); the system checking has been done jointly by TITAN BETA and LNF personnel, while the commissioning with both beams has been entirely performed by the LNF staff. The commissioning phase started on April 1996 and was concluded on February 1997.

Since November 2002 the LINAC also delivers beam to Beam Test Facility (BTF)[1] at a maximum repetition rate of 50 Hz: electrons with energy up to 750 MeV, with a typical current of 180 mA/pulse, or positrons with energy up to 510 MeV, with a typical current of 85 mA/pulse. The Beam Test Facility (BTF) is a beam transfer line optimized to produce single electrons and positrons mainly for high-energy detectors calibration in the energy range between 25 MeV and the maximum LINAC energy, and can provide beam in a very wide range of intensities, up to 10^{10} electrons/pulse.

LINAC GUN DESCRIPTION AND PARAMETERS

The electron source consists of a gridded electron gun with replaceable cathode, high voltage deck 150 kV power supply, isolation transformer and sufficient corona shielding to be processed up to full voltage in air.

The deck contains all the necessary electronics to operate the electron gun, and includes fiber optical links to the low level control chassis. Typical operation values are 6 A 120 kV in the positron mode, and 0.5 A 120 kV in the electron one. In normal operation (DAΦNE injection at 510 MeV) the gun is pulsed at 50 Hz with a rectangular waveform of 10 ns.

Up to this date, two different type of cathode grid assembly (HWEG-1227[2] and EIMAC Y796[3]) have been used to provide electron/positron beams during the DAΦNE LINAC operation. The difference between the two types is the size and current capabilities of the planar cathodes. The main specifications of the EIMAC Y796 installed in May 2010 are summarized in Table 1.

Table1: Cathode Grid Assembly Data Sheet

Conflat Size	3-3/8"
Grid-Cathode Spacing (DGK)	170 microns (cold)
Emission, typical	12 A @ Ec=100V
Cathode Area	2.0 cm²
Cathode Heater Voltage	6.0/7.5 V
Cathode Heater Current, typ.	5.8 A @ 6.0 V
Cathode Type	Planar Dispenser

UPGRADE OF ELECTRON GUN

In order to increase the efficiency of the DAΦNE LINAC, a complete upgrade of the electronic control chassis of the electron gun has been performed, starting in January 2014.

A new socket cathode has been installed to obtain the best electrical connection between the high voltage deck and cathode (see Figure 1).

Inside the isolated high voltage station, the old custom TITAN BETA electronics has been replaced, and the new gun electronics (grid pulser and multiple outputs DC Power Supply System) was installed (see Figure 2).

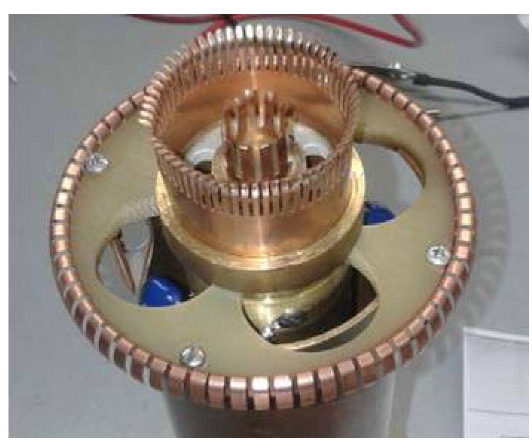

Figure 1: New cathode socket.

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Figure 2: Isolated high voltage station, with new electron gun system.

The new grid pulser, Kentech Instruments PG750[4], generates a pulse of adjustable length and amplitude with fast (<1ns) edges. The output is designed to drive 50Ω and is AC coupled. The AC coupling will allow DC biases of ± 1kV maximum to be applied to the output.
The main parameters of the pulser are listed in the table below:

Table 2: Kentech Instruments PG750 Main Specifications

Polarity	Negative AC coupled
Pulse shape	Rectangular
Pulse width	1.5 to 40 ns, step 0.5 ns
Jitter	~ 20 ps
Amplitude	300 to 750 V, step 30 V
Maximum rep rate	50 Hz
Flatness	±10%

The TESTRON 2400 made by Horizon Electronics[5] is a programmable multiple output DC Power Supply System. Each 19" by 5 1/4" chassis is user configurable by selecting up to eight power modules. Modules of different power ratings can be combined in the same chassis. It can continuously monitor the voltage and current to stay within programmed levels, offloading the controller from routine checks (ramp up or down and set level).
The gun injector floating deck is controlled by fiber-optical coupled link (ETH fiber+GPIB), and the new electronic devices (pulser and DC power supply) have been completely integrated in the LINAC control system.

OPERATION AND PERFORMANCE

In standard operation, the e+/e- beam from the LINAC is stacked and damped in the accumulator ring for being subsequently extracted and injected into the Main Rings of DAΦNE collider. When the injector is not delivering beam to the accumulator, the LINAC beam can be transported into the Beam Test area by a dedicated transfer line (BTF line).
As a consequence of this particular operation mode, we can divide the gun operational set-up in different configurations: standard operation (DAΦNE+BTF) or BTF operation (BTF in dedicated mode).The parameters of the gun in DAΦNE+BTF configuration are listed in the table 3.

Table 3: DAΦNE-LINAC Gun Parameters for Collider Injection

Particle	electron	positron
Cathode Heater Voltage	5.66 V	5.66 V
Cathode Heater Current	5.50 A	5.50 A
Pulse width	10 ns	10 ns
Pulse Amplitude	300 V	540 V
Grid bias	200 V	140 V
High Voltage	90 kV	90 kV
Extracted gun current*	0.5 A	5.5 A
Final current**	180 mA	85 mA
Energy**	510 MeV	510 MeV

*Current measurement at current monitors (resistive type) placed at the gun output, and
**at the LINAC end with final energy value.

LINAC New Gun Tuning

In the BTF operation mode[6] the gun parameters can be varied by using the dynamic range of the pulser (width and amplitude) and the grid bias power supply.
In order to test the performance of the new electron gun system, a dedicated experimental measurement has been done.
In this dedicated configuration we have preliminarily investigated the capabilities of the system in terms of stability and performance. The emission current of the gun has been measured by four beam current monitors (resistive type) placed at the gun output, at the positron converter, at the separator output and at the LINAC end. Nevertheless, to obtain the best correlations between the gun parameters and the beam charge emitted, we have considered the value measured at the LINAC end where a calibrated BCM (type Bergoz ICT 122-070-10-1) is installed. With the same LINAC setup (RF and magnets at the same value), the beam charge at the BCM monitor has been acquired as a function of the pulse (width and amplitude of the pulser) and grid potential, without any transport optimization. The results are shown in the following figure 3–5.

Experimental Data

During the data acquisition a beam charge in the range from 2 to 9 nC has been measured at the end of the LINAC, at the repetition rate of 1 Hz. The heater voltage of the filament was at constant value of 5.66 V with a heater current of 5.5 A.
The typical gun characteristics are shown in figure. 2, which shows the beam charge as a function of the pulse width with pulse amplitude fixed at 330 V and grid voltage at 192 V.
The figure 3 shows the beam charge as a function of pulse voltage with the pulse width fixed at the default value of 10 ns and grid voltage at 192V.

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The figure 5 shows the beam charge as a function of grid voltage, with the pulse amplitude fixed at 330 V and the pulse width at the default value of 10 ns.

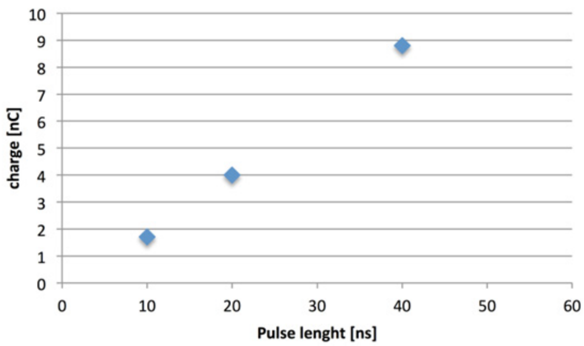

Figure 3: Measured beam charge (nC) vs width, for 10, 20 and 40 ns pulses, for typical gun settings.

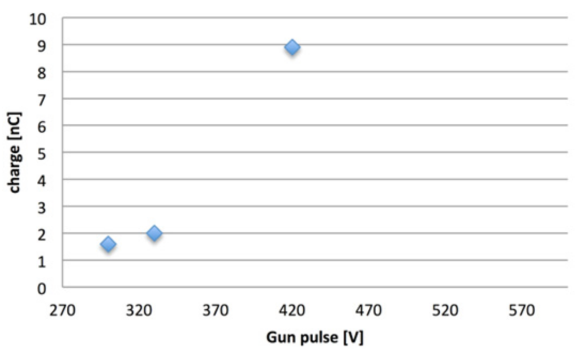

Figure 4: Measured beam charge (nC) vs pulse amplitude (V), for 10 ns pulses.

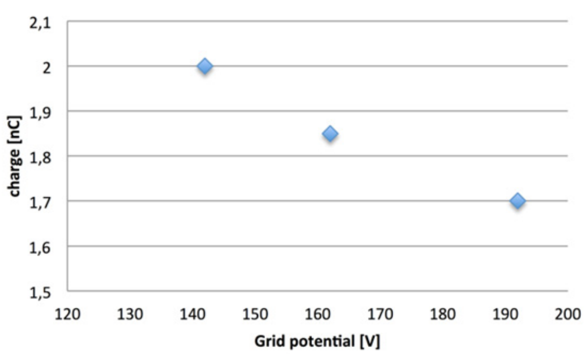

Figure 5: Measured beam charge (nC) at different grid voltages, for default values of pulse voltage and width.

CONCLUSION

The new electron gun showed very good performance, both from the point of view of operation reliability, and flexibility. At this moment, the implementation and routine running shows that the design, manufacturing and operation of the new electron system were successful.

We are planning more experimental measurements in dedicated mode to explore the whole range of the emission the cathode. Finally we are studying the possibility for the installation of new pulser for further extending the pulse width, both to increase the beam charge at the end of DAΦNE-LINAC, and for possible experiments requiring long-pulse extracted beams.

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[4] http://www.kentech.co.uk
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