AN ELECTRON GUN TEST STAND TO PREPARE FOR THE MAX IV PROJECT

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Abstract

The MAX IV facility [1], currently under construction, will include a 3 GeV linac injector [2] with two RF guns providing beams for the two operation modes: ring injection and the Short Pulse Facility (SPF) [3]. The ring injection will be done by a thermionic 3 GHz RF gun developed from the current MAX-lab RF gun [4]. The SPF gun will be a laser driven photo cathode 3 GHz RF gun based on the 1.6 cell BNL/SLAC type for FERMI@Elettra [5]. The guns will be operated with short (0.7 μs) RF pulses from a SLED system.

A gun test stand to fine tune the operation of the two different systems has been assembled at the MAX IV laboratory (former MAX-lab).

INTRODUCTION

The MAX IV laboratory has over the years developed several RF guns. The MAX injector [6] is utilising a thermonic RF gun which is operated also in photo cathode mode for the MAX-lab test FEL activities [7].

For the MAX IV project two RF guns are envisaged; one photo cathode structure for the Short Pulse Facility (SPF) and one thermionic RF gun for injection into the storage rings. For the development of these a gun test stand has been constructed. This facility has been used for the first commissioning of the photo cathode gun for the FERMI@Elettra project [5] and is now operated for the tests of the MAX IV guns.

Table 1: Electron Source Specifications for the MAX IV Pre Injector

Rep rate	10-100	Hz
Energy	~4	MeV
Emittance (norm)	3/10	mm mRad (SPF/injection)
Charge	< 0.5	nC

THE MAX IV PRE-INJECTOR

The MAX IV pre-injector, see fig 1, consists of two RF gun structures mounted to be operational in parallel, though not at the same time. In line in front of the linac is a photo cathode RF gun system placed to allow low emittance and controlled short pulses to be injected into the linac [2]. The thermionic gun is placed at a 120 deg angle and the beam is injected through a magnetic energy filter (EF). This is similar to the solution on the current MAX-lab injector [6]. The gun-to-EF transport now carries a double solenoid system to allow an intermediate focus. This focus (at 90 cm from the cathode) allows for an aperture which is used to chop the electron beam. The beam displacement is done by a fairly weak kicker immediately after the first gun solenoid supplying a 100 MHz modulation to suit ring injection. The additional transport is sensitive to space charge and thus only suitable for ring injection. The optics is shown in figure 2.

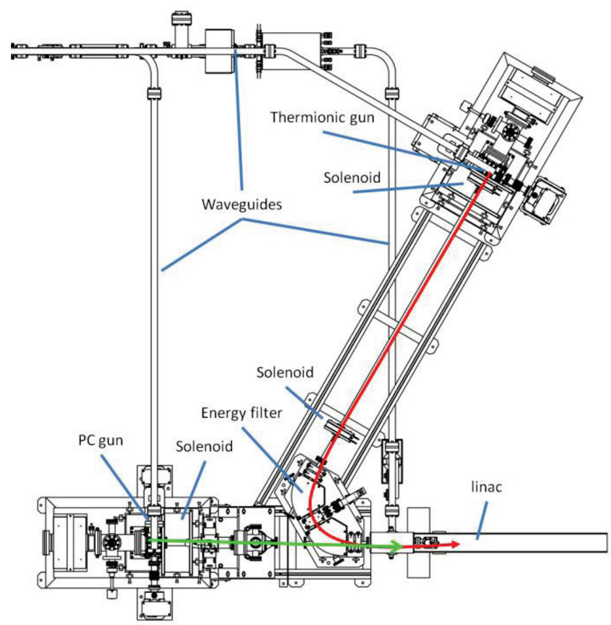

Figure 1: The MAX IV pre-injector layout with two RF guns injecting into the first linac.

THE GUN TEST STAND

In a radiation controlled area close to the current MAX injector the gun test stand has been set-up (see figure 3). Guns can here be driven by one of the klystron-modulator chains for the MAX injector which can deliver up to 35 MW at 10 Hz repetition rate. In addition the gun laser system for the MAX injector is available for photo cathode tests. The gun laser can deliver >150 uJ (on the cathode) in 2-10 ps pulses synchronised to the 3 GHz RF. Further an emittance meter built by Massimo Ferrario [8] for the EUROFEL collaboration in FP6 is currently in place at MAX-lab. The photo cathode gun for FERMI@Elettra was tested and commissioned using this facility [5].

The system is also equipped with a magnetic spectrometer, screens, current transformers and charge monitors.

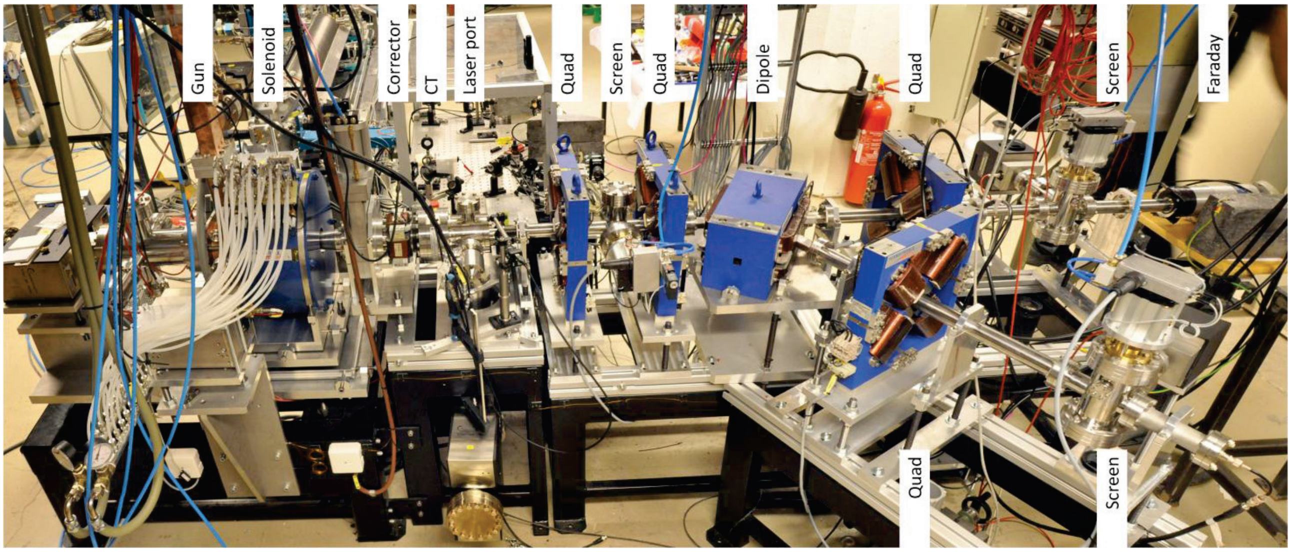

Figure 3: The MAX-lab gun test stand with the 1.6 cell RF gun and solenoid mounted.

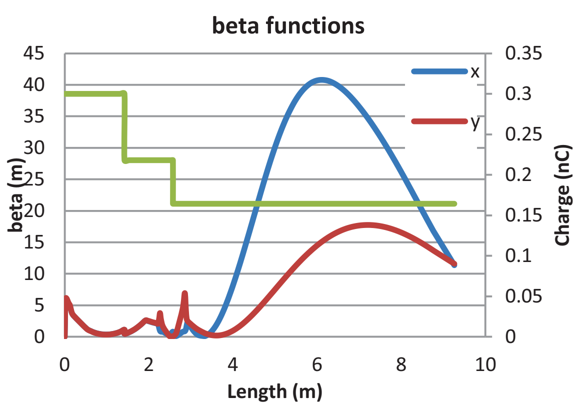

Figure 2: Optical functions and charge for the thermionic gun injection through the first linac. The chopper aperture is placed at 1.4 m from the cathode, the energy filter starts at 2m from the cathode and the linac entrance is at 3.5 m.

RF GUNS DESIGNS

On the way to the MAX IV RF guns several structures have been developed. Below the two structures to be used on the MAX IV are described.

Photo Cathode Structures

The structures are based on Fermi@ELETTRA gun experiences of the SLAC/BNL 1.6 cells structures modified to European 3 GHz. To allow operation with the short pulses provided by the SLED system (0.7 µs) the coupling has to be refined. Also the cooling of the gun has to be enhanced to allow operation at 100 Hz. Cooling is added in the intermediate wall between the two cells. The thermal load is reduced significantly by the operation with SLED pulses due to the reduced RF pulse length.

The first structure built has a coupling of 1.3 and traditional cooling. This structure has been operated on the test stand which proves that the manufacturing process and the simulation results are correct.

A second structure has been produced with coupling ~1.8 (design), matched to the RF pulse length. The field geometry in all structures will be identical. This gun has so far only been tested at low power (see table 2).

Table 2: 3 GHz Photo Cathode Gun (Low Power Measurements)

Rep rate	10-100	Hz (design)
Energy	~4	MeV (design)
Frequency	2998.5	MHz
Mode separation	14.3	MHz
Q	12 150	
Coupling	1.76	

Thermionic Structures

The thermionic structure is based on the gun in operation at the current MAX-lab. The model to be used in the MAX IV pre-injector has been enhanced mainly with additional cooling to be able to operate up to 100 Hz. The improved cooling channels have also influenced the ½-lambda couplers around the cathode. The coupling has been increased to allow operation with the short SLED pulses and finally the local radiuses at the main cell and close to the cathode have been enlarged to allow higher RF power.

The design of the system is completed (see figure 4 and table 3) and the structure is in production. A copy of this gun will be installed at the SOLARIS [9] in Krakow, Poland.

Table 3: 3 GHz Thermionic Cathode Gun (Design)

Rep rate	10-50	Hz
Energy	1.5-3	MeV
Frequency	2998.5	MHz
Mode separation	17.9	MHz
Q	12 500	
Coupling	1.85	

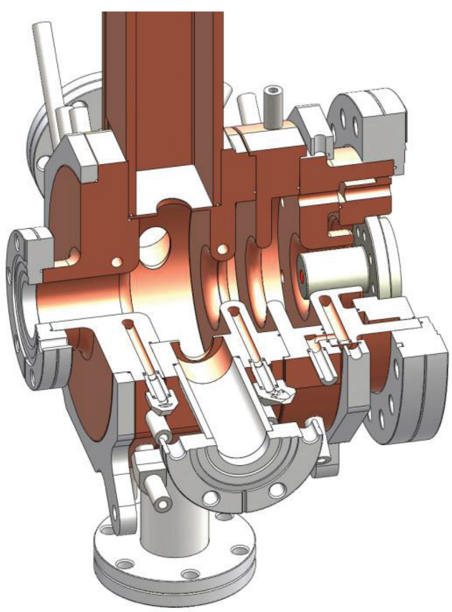

Figure 4: The thermionic RF gun with improved cooling in between the cells and around the cathode, increased coupling and changed geometry of the ½ wavelength choke for the cathode mount.

RESULTS

In the new gun series for the MAX IV injector two structures have been produced and tested. One at low power and one at high power in the gun test stand. Operation producing photo electrons up to 3.3 MeV kinetic energy and 0.25 nC has thus been achieved.

The quantum efficiency of the Cu cathode has been measured to 1.5 10^{-5}. (see figure 5). Saturation can be seen already below 100 uJ in laser energy which can be accounted to the small laser spot (0.4 mm rms). Further measurements are being prepared.

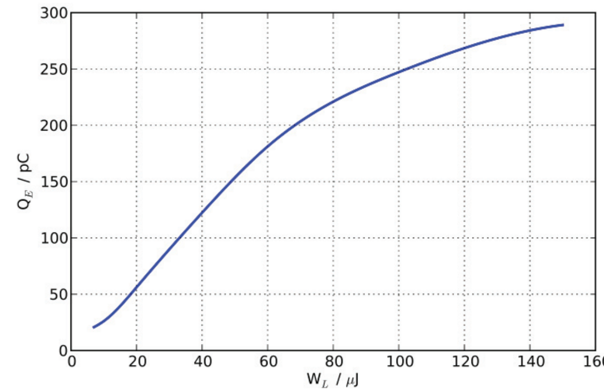

Figure 5: Emitted charge as a function of laser energy.

SUMMARY

A gun test stand has been built-up and used for the development and commissioning of RF guns. The RF gun structures necessary for the MAX IV pre injector have been designed and a first structure produced and initial measurements performed. The two final structures, photo cathode and thermionic, are designed and in production.

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