A NEW 3 GHz RF-GUN STRUCTURE FOR MAX-LAB

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Abstract

A new 1/2+1/2+1 cell RF-gun structure has been developed and produced at MAX-lab. Zero power measurements of the performance have been done with excellent results. The main frequency is reproduced with dp/p<0.06% and the field distribution within 4%.

The first gun structure will be operated as a thermionic RF-gun, while other cathode principles are regarded for future copies. The gun will be installed on the new MAX-lab injector system.

1 INTRODUCTION

The national laboratory MAX-lab is currently replacing its old electron source (a triode DC gun) and injector (a 100 MeV Racetrack Microtron) with a thermionic RF-gun and a linac system [1]. The new electron source will produce electrons for injection at 250 MeV into the MAX I storage ring, 500 MeV into the storage rings MAX II and MAX III, which is in production. The MAX I storage ring is also operated as a pulse stretcher and will raise its energy from 100 to 250 MeV. The source should also provide electrons for future possible installations of FELs in the Infrared and/or VUV.

2 THE GUN STRUCTURE

2.1 General Layout

The basic idea behind the design is a gun which removes the demands for a buncher cavity and a pre accelerator linac, thus the choice has fallen on an RF-gun. Further, the operation should be simple and thus a thermionic cathode was chosen.

By the choice of a thermionic cathode, back bombardment has to be considered. The gun is not designed to operate at outmost bunch charges (currents) and the demands for emittance are not too demanding. In addition the energy spread will be defined by the linac system as a direct consequence of the electron bunch length from the gun.

Several gun designers [2,3 among others] have addressed the problem of back bombardment and a common solution has been to introduce an extra "zero field" cavity to elongate the gun and to operate the excitation of the gun such that the first cavity has around 40% of the field amplitude of the main accelerating one. Thus a design with ½+½+1 cell has been chosen with a field relation of 2.6 operating in $\pi/2$ mode. This solution is similar to [3].

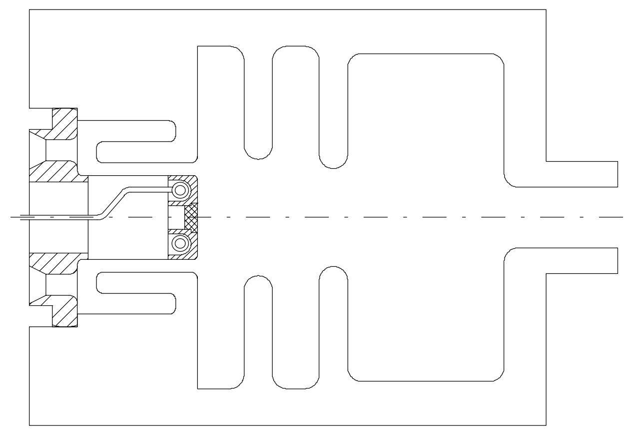

Figure 1: Layout of gun, RF-choke and cathode.

2.2 Cathode

As the cathode is heated to around 1000 C a proper insulation has to be made between it and the gun structure. At the same time a proper electrical contact has to be assured. One choice is a solution using thin springs of bad heat conductors. These are complicated to mount though. A better solution is what was chosen for the Thermionic gun at SLS [4]. Here the cathode is mounted via an RF-choke ($\lambda/2$ termination) (Figure 1). The choke is terminated in the end and the $\lambda/2$ "moves" the termination to the entrance hole of the choke.

2.3 Tuning

The gun will be tuned during production and tests by a fixed plunger. This will move us within 1 MHz from the operating frequency and the fine tuning will be made by temperature.

3 ENERGY FILTER

An RF-gun with a thermionic cathode also suffers from having a long low energy tail in the electron bunch. To remove this tail and to give opportunities to shape the bunch length an energy filter has been designed. The filter consists of two 60 degree bending magnets and 5 quadrupole magnets [5]. Between the two bending

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magnets the dispersion allows filtering of the low energy electrons by a slit.

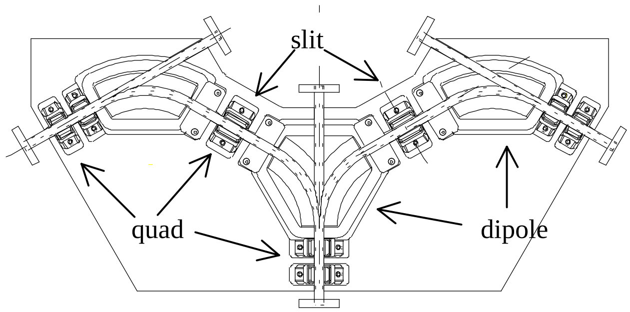

Figure 2. The energy filter. Entrance from gun at left and right. Exit to linac at middle bottom.

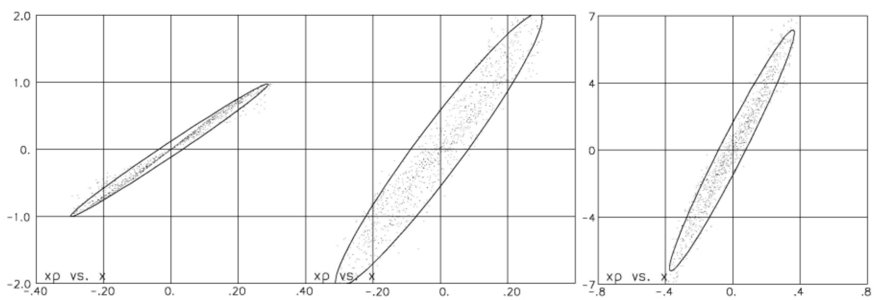

Figure 3. Phase space (x' v. x) at the gun exit (horizontal and vertical direction are identical). (x in cm, x' in mRad) (I = 0 / 100 / 600 mA, E = 2.3 MeV).

3 SIMULATIONS

The simulations for the gun have been presented earlier [5] and are summarised in Table 1 and figure 4.

4 ACHIEVED PERFORMANCE

The achieved performance is unfortunately limited to "zero power" measurements. A prototype gun has been brazed together in full with waveguide, plunger, Vacuum connections and connections for RF-pickups. Unfortunately the waveguide showed a vacuum leak which after several attempts proved fatal. Thus two new structures have been machined. They are right now in the brazing process and thus no results exist from them.

The "zero power" measurements were successful though (table 2 and figures 2 &3). ("zero power" means using a Network analyser and not a klystron for excitation). The field profile and the relative field strength between the cavities excellently reproduced the simulated values (figure 4). The frequency of the gun was around 2 MHz lower than excepted, but as Superfish (the simulation code used) only uses axially symmetric cases, this is well acceptable while considering waveguide and plunger which are not axially symmetric.

Table 1. Gun performance

	Simulations				Achieved
Power dissipation	2.02			MW	
Q	15030				13600
Maximum electric field on axis	81.4			MV/m	
Maximum electric field on boundary	97.4			MV/m	
Frequency	2999.15			MHz	2997.6
Beam kinetic energy	2.3			MeV	
Rise time	0.42			μs	
Input coupling	3				
Coupling between cavities	2.64				2.6
Current from cathode	**0 mA**	**100 mA**	**600 mA**		
Beam power	0	0.23	1.38	MW (@ dE=2.3 MeV)	
Energy spread (nucleus of bunch)	0.13	1.1	18	KeV (RMS)	
Bunch length (nucleus of bunch)	0.06	0.08	0.26	ps (RMS) ≈ deg (RMS)	
Emittance	0.03	0.85	2.0	π mm mRad (@ E=2.8 MeV) (RMS)	
Emittance, norm	0.16	4.6	11	π mm mRad (RMS)	

5 SUMMARY

The production of the RF-gun is delayed due to a a vacuum failure. The measurements that have been done so far on the prototype are very encouraging and we can from these results not see anything that is worrying. The agreement between simulations (axially symmetric) and the produced structure is "scaringly" correct.

A new structure is right now under production and will be mounted during the late summer on the "hot position" on the new system. Test will therefore be a little bit more demanding. High power RF-tests are planned for during the fall 2000.

REFERENCES

1 The 500 MeV injector for MAX-lab using a recirculated linac; S. Werin et al, these proceedings

2 V.V. Mitrochenko, PAC 97

3 E. Tanabe et al. LINAC98

4 SLS, priv. comm.

5 S. Werin et al. FEL-99

Figure 4. Field profiles of the RF-gun structure.