TRASCO RFQ DESIGN

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Abstract

In this paper, we describe the design of the 5 MeV 30 mA proton CW RFQ, of the Italian research program TRASCO (TRAsmutazione SCOrie). The first third of this structure is under construction.

1 INTRODUCTION

We describe the design of the RFQ (Radio Frequency Quadrupole) of the Italian research program TRASCO (TRAsmutazione SCOrie) [1]. This research program is aimed to test the critical components of a high intensity proton linac to be used in an ADS (Accelerator Driven System) for nuclear wastes transmutation or energy production following the Energy Amplifier scheme.

Other CW proton RFQs at 352 MHz have been built or designed recently, and in particular, LEDA RFQ at LANL is necessarily a point of comparison [2]. The main difference respect to LEDA design is the lower beam current (30 mA instead of 100 mA), dictated by the lower beam power requirement for our ADS applications. Moreover, in our linac architecture, keeping the same frequency in the accelerator (DTL or ISCL) that follows the RFQ, we can accept 5 MeV as RFQ output energy [3]

As a result, respect to LEDA, we could relax some parameters. Most relevant in our opinion are the possibilities of using a single klystron and of keeping a constant intervane voltage along the structure. The first point has a considerable impact in the cost of the RFQ, while the second point allows a "reasonable" power dissipation density of 850 W per structure cm length.

Table 1 RFQ specifications

Particle	p	
Input Energy	80	KeV
Output Energy	5	MeV
Frequency	352.2	MHz
Current	30	mA
Max Surface Field	33	MV/m
RF Power consumption	<800	kW
Duty factor	100	%

2 RFQ BEAM DYNAMICS

The RFQ is divided in the four traditional sections, the radial matching section, the shaper, the gentle buncher and the accelerator. In the last section, that corresponds to more than ¾ of the total structure length, the voltage is kept constant, while the average aperture R_0 is increased so to allow a higher electrode modulation keeping the necessary aperture *a*. This choice allows to safe about half a meter in RFQ length (i.e. 40 kW RF power) without a ramp of the voltage.

The main parameters are listed in Tab. I, and their evolution along the structure are shown in Fig.1.

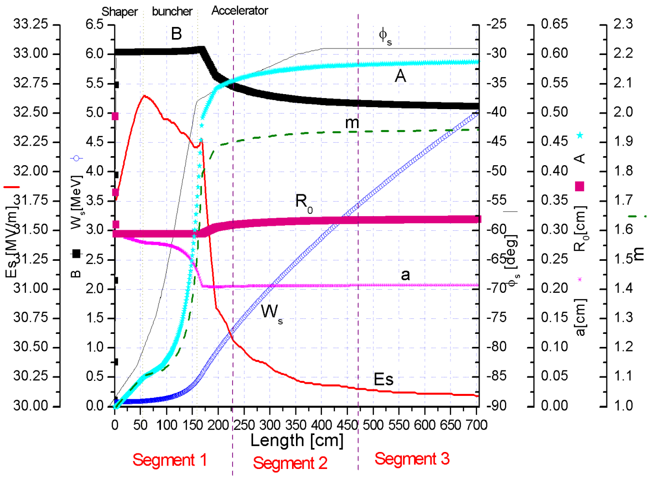

Figure 1: RFQ parameters as a function of length.

Table II:RFQ parameters

Emittance T RMS in/out	0.2/0.2	mmmrad normalised
Emittance L RMS	0.18	MeVdeg
RFQ Length	7.13	m
Intervane voltage	68	kV
Transmission	96	%
Modulation	1 ÷ 1.943	
Average aperture R_0	2.93÷ 3.19	mm
Minimal aperture	2.05	mm
Synchronous phase	-90 ÷ -29	deg
Dissipat power (SF*1.2)	0.579	MW
Beam loading	0.1476	MW
Q	8261	

The RFQ has been extensively simulated with PARMTEQM [4] (Fig. 2), while crosschecks have been done with TOUTATIS [5] made by CEA/Saclay and LIDOS.RFQ made by lidos team [6]. The results are: 97.41 % accelerated and 98.52 % transmitted protons by TOUTATIS and, 98.66 % accelerated and 98.66 % transmitted particles by LIDOS.RFQ, all runs are at

50 mA. The transmission as obtained by PARMTEQM is 96 % at 50 mA (Fig. 3), with losses mainly located below 2 MeV (Fig. 4), so to minimize the activation problems of the copper structure.

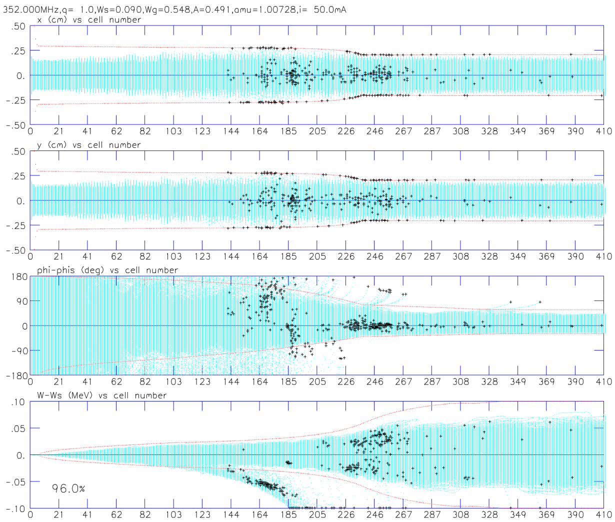

Figure 2: RFQ Beam dynamics in the RFQ for a current of 50 mA, 10000 particles.

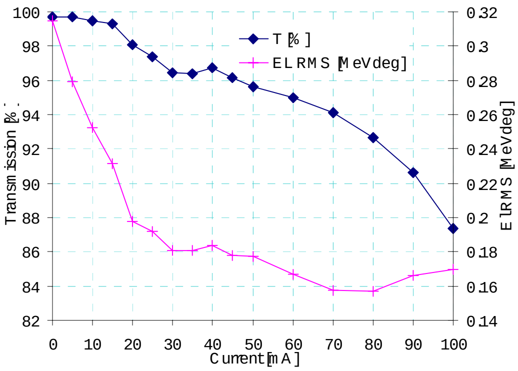

Figure 3: Transmission and longitudinal emittance in th RFQ as function of beam current.

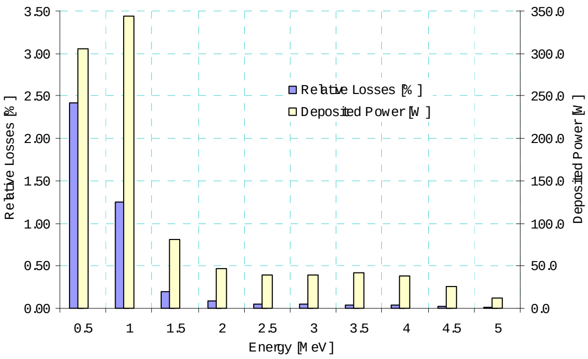

Figure 4: Particles losses and power deposited in the RFQ as function of energy; the total power deposited is 1 kW and above the 2 MeV is 210 Watts.

3 THE RESONATOR

The resonator, of four vanes kind (Fig.5), is divided in three segments, resonantly coupled, following LANL technique. In this way, the operating mode is about 2 MHz distant respect to the closest quadrupole modes, and the dipole modes are outside the range of the main quadrupole band (Fig. 6). This approach was checked with extensive simulations (SUPERFISH, MAFIA and HFSS codes) and by comparison with the measurements on the cold model, performed with bead pulling system.

The modulation will be milled with a single tool, with transverse radius 2.93 mm. The homogeneous voltage along the RFQ is obtained by increasing the transverse section dimensions as R_0 increases. It results in a constant local cut-off frequency due to inductance compensation.

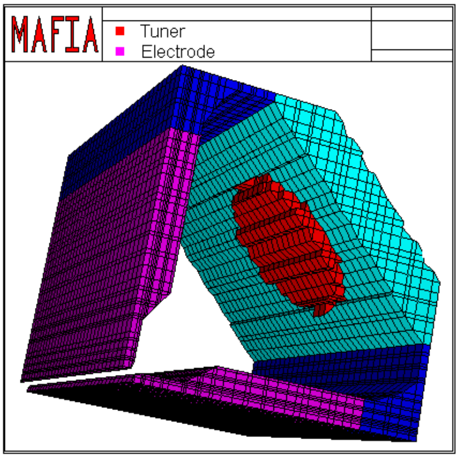

Figure 5: Mafia representation of one sector of the RFQ transverse section with a tuner.

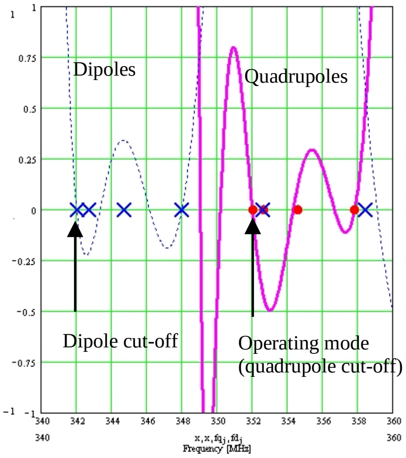

Figure 6: The eigenfrequencies correspond to the zeros the plotted functions for quadrupole and dipole modes for the stabilized RFQ. For comparison, the thick dots and crosses correspond to the quadrupole and dipole modes of the unstabilized RFQ.

4 RFQ ERROR STUDY

A 50 mA proton beam has been simulated under various conditions, in order to test the tolerances to errors; in all cases we plot the beam transmission and the final longitudinal emittance, that are both sensitive deign parameters.

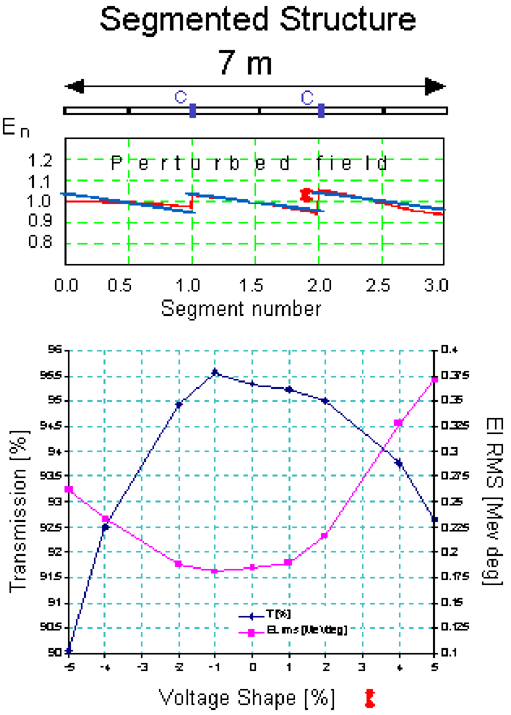

Figure 7: Transmission and Longitudinal emittance in a three segments RFQ (50 mA). The Voltage in PARMTEQM is shaped as indicated in the upper figure (blue line).

In fig.7 is plotted the effect of field dishomogeneity. In the upper part we show the characteristic field pattern of a segmented RFQ, where construction errors make non null the component of the two neighborhood quadrupolar modes. This determines a tolerance in field homogeneity of about ±1%, that is compatible with our mechanical tolerances and field adjustment procedure.

In fig. 8 we plot the calculated sensitivity to initial beam alignment, mismatch, emittance and vane voltage variation. For example a beam misalignment of 1 has almost no effect. From the previous results we can conclude that a high beam transmission is preserved in case of different error sources and that the beam dynamics is well estabilished.

At present the main choices for the machining and welding are taken, and we are completing the construction drawings. A technological model of this RFQ, corresponding to the first third of the structure, will be built during 2001.

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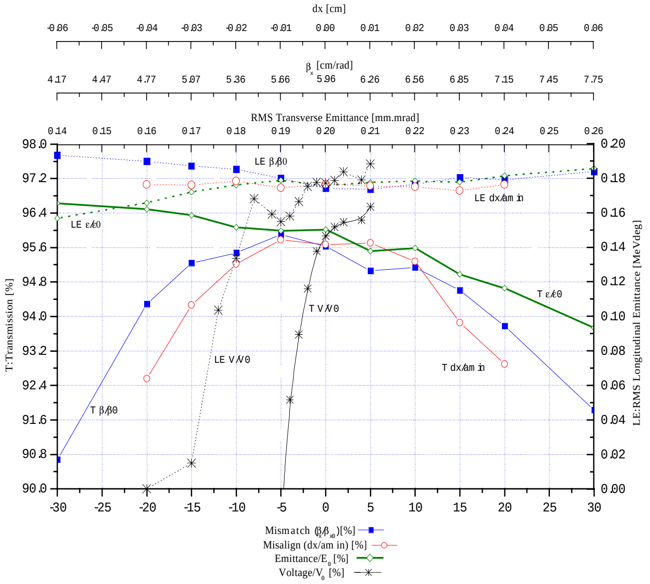

Figure 8: Errors sensitivity for a 50 mA proton beam

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