The RFQ2 Complex : the Future Injector to CERN Linac 2

M. Weiss
CERN, PS Division
CH - 1211 Geneva 23

Abstract

In the January-February shut-down of 1993, the conventional 750 kV HT generator and the low energy beam transport (including three bunchers) of CERN Linac 2 will be replaced by the RFQ2 complex which, with its main part the RFQ2, is to be considered as a unit. Indeed, all its elements, from the ion source upstream to the buncher (matching cavity) downstream are mounted and aligned on a unique support, which will then be installed and aligned to Linac 2. The overall design of the RFQ2 complex and its interesting features are outlined.

1. INTRODUCTION

The RFQ2 complex has been developed in view of replacing the present injecton system of Linac 2 with one of higher performance. It makes part of the improvements required by the future Large Hadron Collider.

The advantages of RFQs compared to high voltage electrostatic equipment and classical bunching schemes have been discussed and recognized many times. However, it is not the RFQ alone which makes an injection system into a linac, where a correct 6-dimensional beam matching is required, in particular when dealing with high beam intensities. The RFQ2 makes part of a complex and it is the description of the features of this complex, which makes the subject of this paper.

It is considered worthwhile to introduce the subject by briefly recalling the present Linac 2 injection system and then compare it to the new RFQ2 complex.

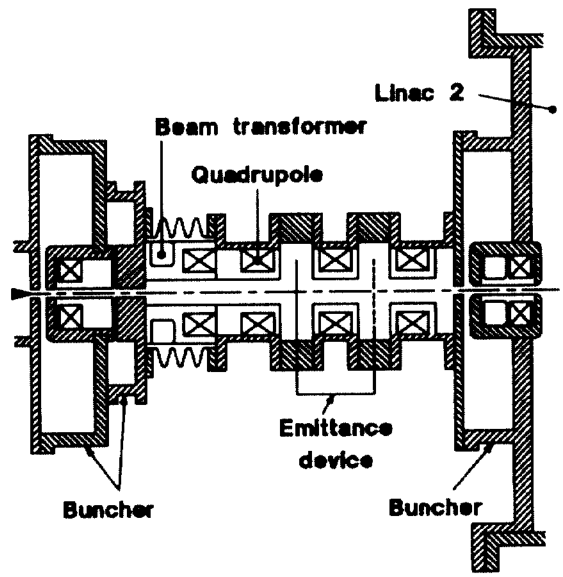

Figure 1. Bunching section of the present LINAC 2 system.

2. PRESENT INJECTION SYSTEM OF LINAC 2

The present injection system is divided into two parts, the unbunched beam part, about five meters long and the bunching part, about one meter. The length of the first part is non-critical and is determined by various considerations, including civil engineering ones. The second part, on the contrary, is of a critical length and disposition of elements, as it is here where the beam is matched in six dimensions to the Linac 2 acceptance.

Figure 1 shows schematically the bunching part of the injection system, a rather compact and "crowded" section.

A 750 keV proton beam of about 200 mA is matched transversally with six quadrupoles (the last one being in the first half drift-tube of tank 1) and longitudinally with three bunchers, one of them operating at the second harmonic of the fundamental 201.56 MHz frequency. The third buncher, operating at the fundamental frequency, is mechanically incorporated into the front end cover of tank 1. An excellent trapping efficiency of 80% has been computed and measured, which nevertheless means that 20% of the beam is lost in tank 1, perturbing the beam dynamics in the beginning .

For measurement purposes, apart from the beam transformers, the bunching section contains the second emittance measurement device, the first one being in the unbunched beam part. It must, however, be stated that after the commissioning period, when beam emittances have been extensively analyzed, no such measurements were made any more for Linac 2 operation. The steering of the beam, due to lack of space in the bunching section, is accomplished in the unbunched beam section.

3. THE RFQ2 COMPLEX

The essential characteristic of the RFQ2 complex is that it represents a compact assembly, a unit, mounted on a single support as shown in Figure 2. Prior to dealing with its mechanical features, we shall briefly describe the RFQ2 complex from the beam optics point of view.

The RFQ2 is preceded and followed by matching sections, the first, matching the 90 keV beam into the RFQ2, the second, matching the 750 keV beam into Linac 2. The 200 mA (up to 250 mA) beam from the RFQ2, already bunched, is transversally and longitudinally matched into tank 1 of Linac 2 by four quadrupoles and two bunchers, respectively. The bunchers act here merely as lenses in the longitudinal phase plane. The disposition of elements, rather crowded, follows beam dynamics considerations. It should be noted that the trapping losses already occurred in the RFQ2 (trapping efficiency > 90%) and, in principle, all the particles of the 200 mA beam to be injected into Linac 2 are inside its acceptance.

Mechanically, the RFQ2 complex will be aligned to tank 1 of Linac 2 as a whole, via the three adjustment feet of the main support. As in the present situation, a buncher (buncher 2) will be a rigid part of tank 1. The flexible joint (bellows), separating RFQ2 and Linac 2, is situated between the bunchers. On the main support, one has essentially two subassemblies :

a.) the low energy (90 keV) beam transport, comprising the ion source, accelerating column and two solenoids

b.) the RFQ2 proper, with buncher 1 being a rigid part of it.

At first, all the elements of the subassembly "a" are aligned mechanically with respect to the ion source, which can only pivot around a vertical axis; the solenoids, which follow, are in contrast equipped with adjustment tables. Once all the elements are aligned, the whole subassembly can change position via a common adjustment table, see Figure 2. Prior to the installation of subassembly "b", an emittance measurement device is mounted in place of RFQ2 and subassembly "a" is tested with beam and realigned, if necessary. At the same time, the matching into RFQ2 is studied and input emittances are measured for various operating conditions.

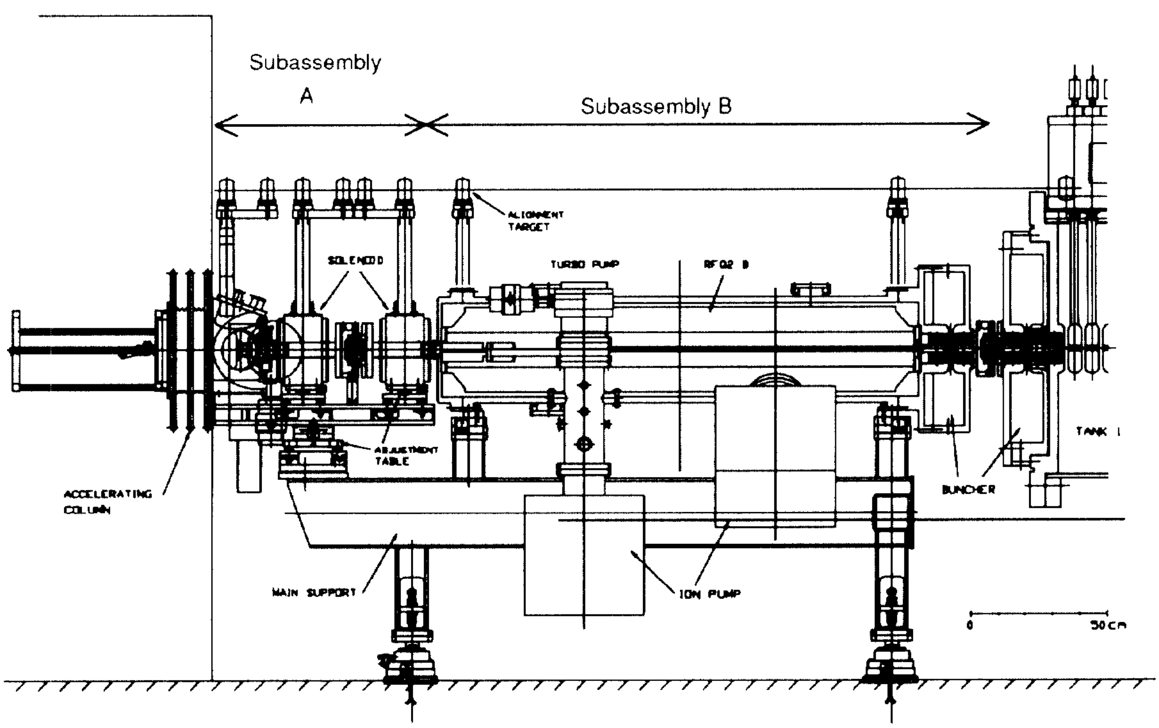

Figure 2. The RFQ2 complex

After the installation and alignment of subassembly "b", the emittance device is again installed, this time downstream of RFQ2, and the whole complex is tested with beam. If a beam steering is found necessary, the subassembly "a" is moved as a whole via its common adjustment table. At the end, the beam characteristics and matching conditions, which will exist at the input of Linac 2 are known. Once the RFQ2 complex is installed at Linac 2 and aligned, it can still be moved for steering purposes, but only as a whole, via the already mentioned adjustment feet of the main support.

4. THE RFQ2

For the sake of completeness, the RFQ2 parameters are presented in Table 1.

Table 1
Main RFQ2 design parameters

RF frequency	202.56 MHz
Input energy	90 KeV
Output energy	750 KeV
Output current	200 mA
Trapping efficiency	~90 %
Vane voltage	178 KV
Final synchronous phase	-35 °
Modulation factor(max)	1.62
Mean aperture radius	7.87 cm
Cavity length	178.5 cm
Vane length	175.2 cm
Cavity diameter	35.4 cm

The rf fields in the RFQ2 have been adjusted with great care and they should remain unchanged during operation. It is particularly important that the vanes do not deform due to heating or aging . Therefore, they are installed in the RFQ2 cavity in an isostatic way. The vane sits on three spacers, positioned so as to minimize the sag of the vane. The spacers serve also to adjust the vane vertically and to tilt the vane tip transversally, provided symmetrization of the rf fields requires it. The longitudinal vane position is determined by a pin and a key. The vane is free to extend due to heating up.

The electric contact between the vane and the cavity is ensured by elastic copper strips, see Figure 3. The strips are welded on the vane and on rails, previously brazed in the tank. The strips serve at the same time as bulk tuners: varying their shape along the RFQ2, one can compensate the inherent tilt of the rf field , caused by the modulation of vane tips [1].

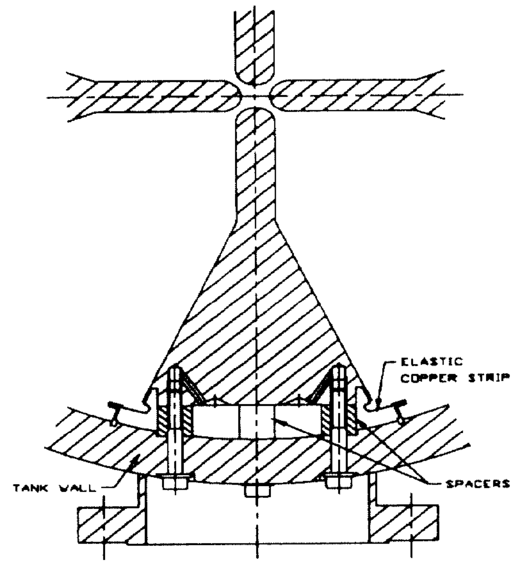

Figure 3. Fixation of vanes in the RFQ2 cavity.

5. CONCLUSION

The RFQ2 complex is a prealigned and tested assembly, which will be installed at Linac 2 as a unit. For beam diagnostics, only beam transformers are foreseen, with an option for a beam profile device to be installed in the box between the bunchers, see Figure 2. As for the beam emittances, they have been measured in the experimental area, when the performance of the RFQ2 complex was analyzed [2].

6. ACKNOWLEDGMENTS

The basic idea for the mechanical layout of the RFQ2 complex is due to E. Boltezar. The actual design was made by P. Bourquin and W. Fritschi of the MT design office. The construction has been done by the mechanics of the MT main workshop. Many thanks go to them all for their excellent work.

7. REFERENCES

[1] J.L. Vallet, M.Vretenar and M.Weiss, "Field Adjustment, Tuning, and Beam Analysis of the High-Intensity CERN RFQ", Proceedings of the 1990 European Particle Accelerator Conference, Nice, France, 12-16 June 1990, pp. 1234-1236.

[2] E. Tanke, M. Vretenar and M. Weiss, "Measurements of the CERN high intensity RFQ" , This conference.