CALCULATIONS ON BEAM FORMATION WITH TWO COUPLED RFQS FOR THE EHF INJECTION SCHEME

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Abstract

For the proposed European Hadron Facility (EHF)[1] a special method for injecting the beam from the linac into the booster ring was suggested: "Painting" of supsequent linac bunches into the same booster bucket during multiturn injection. Due to this painting procedure the time structure of the linac beam must be matched to the booster frequency. This can be done by a combination of RFQs, operating at different frequencies. Beam dynamic calculations for a combination of a 50 MHz and a 400 MHz RFQ are presented and results will be discussed.

Introduction

Over a period of about 3 years two international groups worked out a concept for a European Hadron Facility, an accelerator complex to produce a 30 GeV, 100 μA proton beam. The physics and the technical layout are described in two major studies[1,2] in detail. The proposed complex consists of four rings, a 1.2 GeV injector linac and adjacent transfer lines. While the rings operate at low radio frequencies, the linac should be operated at high frequencies for high efficiency and finite length. To fulfil both requirements a new injection scheme was proposed: A first RFQ, running at the booster frequency of 50 MHz, captures the beam from the ion source and compresses it such, that the bunch can be accepted by two buckets of a following 400 MHz RFQ. The beam is further compressed and accelerated for injection in a drift tube linac. Fig. 1 shows the scheme of the injector. Fig. 2 illustrates the "2 out of 8" buckets scheme: Only in the first RFQ all buckets are filled, later buckets are empty. Meanwhile more injector configurations were proposed[3], for example for bucket to bucket transfer with a smaller frequency jump. Such a system is better in beam quality and control of particle losses, but the peak current is higher. The comparison of all schemes has still to be done.

RFQ Design

The first RFQ has to form a bunch with well defined phase width and energy, which fits into the two buckets of the second RFQ both at design current of 12.5 mA and low current levels for polarized beams. First calculations demonstrated soon[4], that this could be achievable. Fig. 3 shows plots of longitudinal phase space. The main limitation of the first RFQ are space charge and small emittance growth at high phase advance. The second RFQ has a smaller aperture, lower phase advance at voltages near the sparking limit. Only direct coupling of the RFQs is considered[5], matching elements are the drift space and radial matching cells. Table I gives one example of parameters, fig. 4 plots of some RFQ parameters.

Table I

	RFQ 1	RFQ 2
φ_s	90 - 45^o	81 - 30^o
l	2.3 m	2.2 m
a	6 mm	3 mm
V	30 kV	140 kV
σ_{ot}	80^o	27^o

Computations and Results

The PARMTEQ code was used with some changes[6,7] made before: Implementation of space charge routines with image charges, handling of frequency jumps, addition of PARMILA transport routines and radial matching, new generation and dynamic routines. Calculations demonstrated the feasibility of the design. In case of low current beam transmission through RFQ1 is ~ 95 %, through RFQ2 ~ 80 %, total ~ 75 %, at design current total transmission is ~ 10 % lower due to the incomplete transverse matching at high phase advances[8]. Fig. 5 shows plots of beam behaviour and emittances for both RFQs, input current being 20 mA, output current 50.8 and 50 mA for both bunches. PARMTEQ calculates with 2000 particles, 1 particle represents $5 \cdot 10^{-3}$ part of the beam. Within this range the other buckets are empty.

At the time measurements at a 50/200 MHz RFQ combination are carried out[9], showing good agreement with the theoretical calculations. This arrangement allows also bucket to bucket transfer, which has some advantages.

Acknowledgement

The authors want to express their thank for the good and fruitful cooperation in the EHF design group.

References

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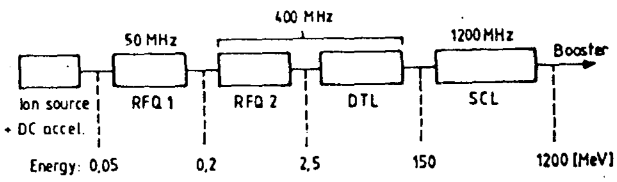


Fig. 1 Scheme of the linear accelerator complex

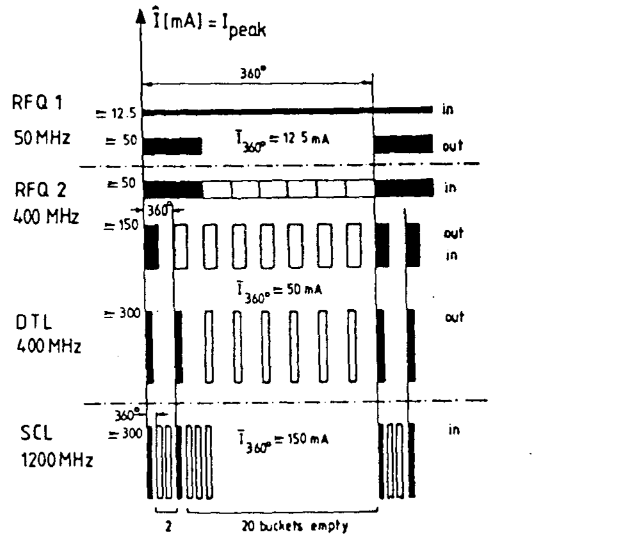


Fig. 2 The "2 out of 8" scheme and currents in the linac

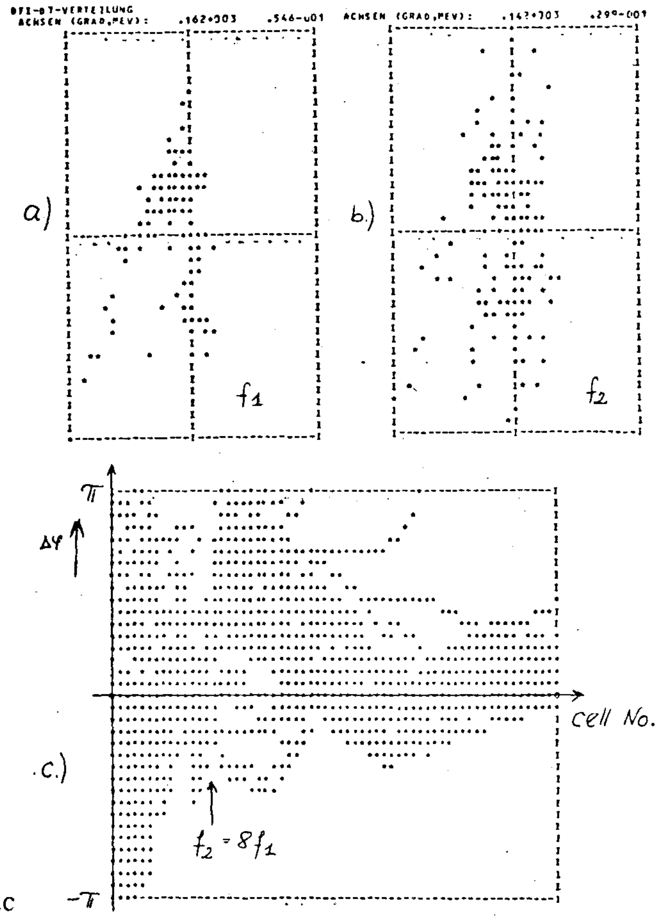


Fig. 3 Plot of longitudinal phase space
a) output of RFQ1 and RFQ2
b) plot of phase width along RFQ1 and for 1 bucket along RFQ2

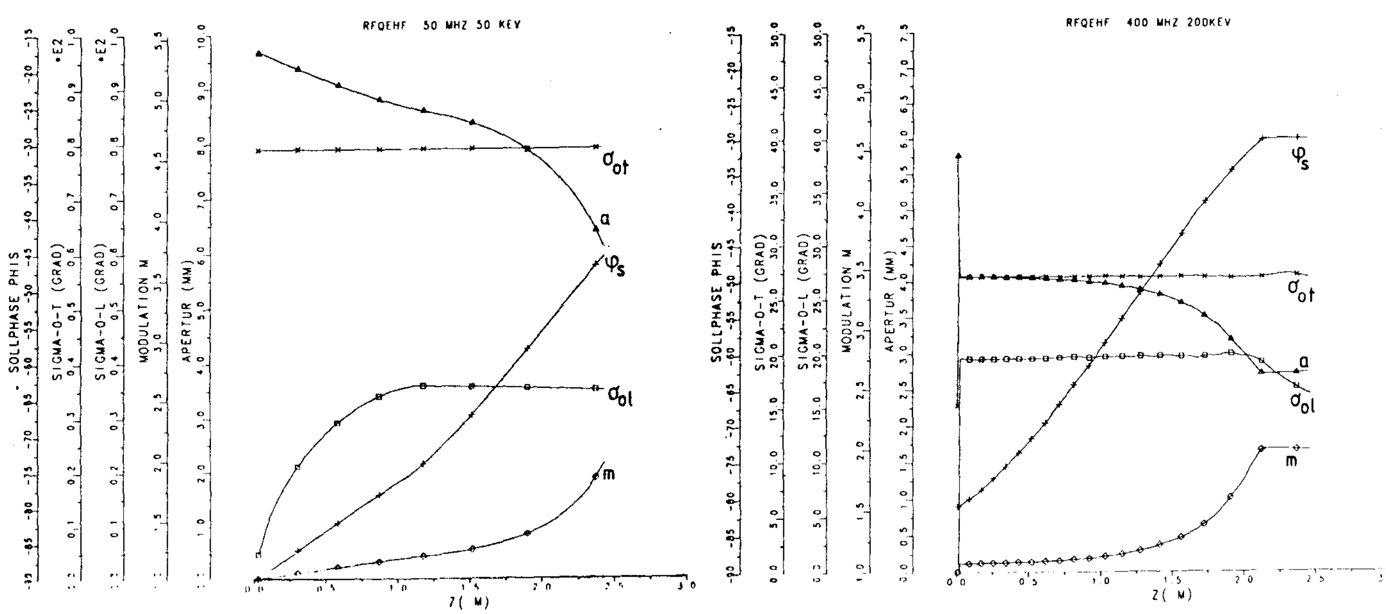


Fig. 4 Parameter plots for RFQ1 and RFQ2

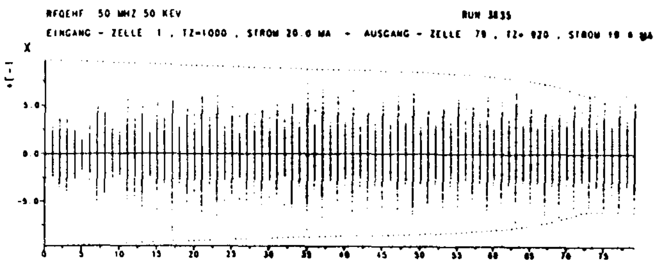
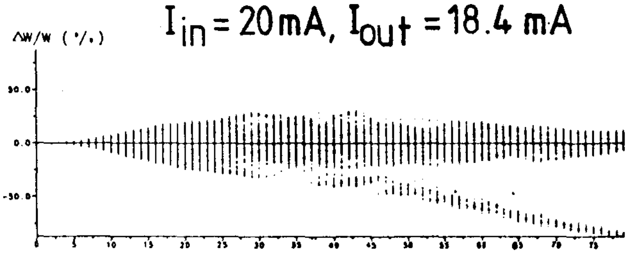
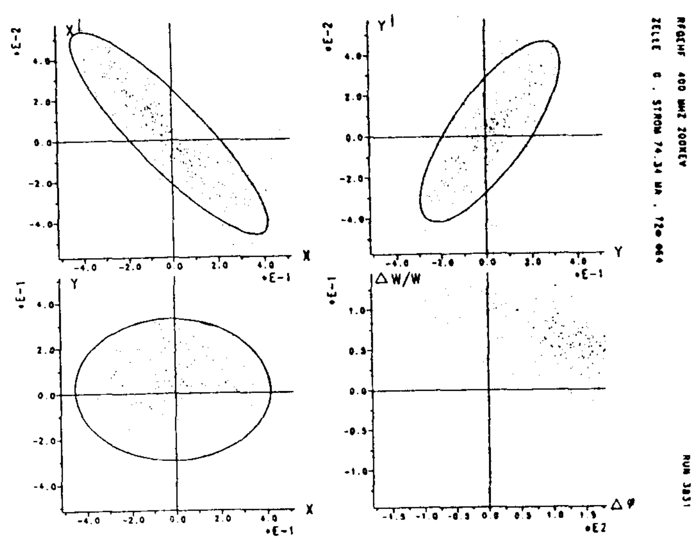


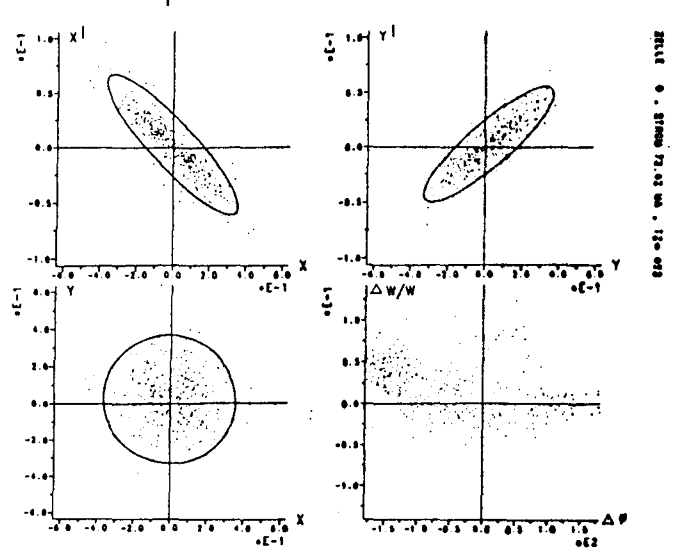
Fig. 5 RFQ 1

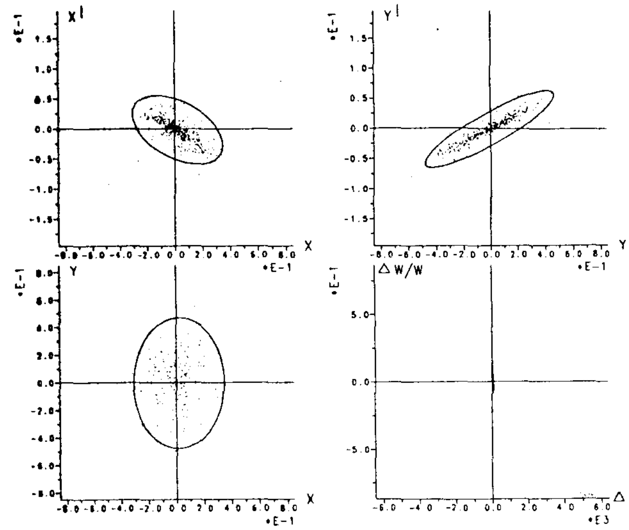
$I_{in} = 20\,mA$, $I_{out} = 18.4\,mA$



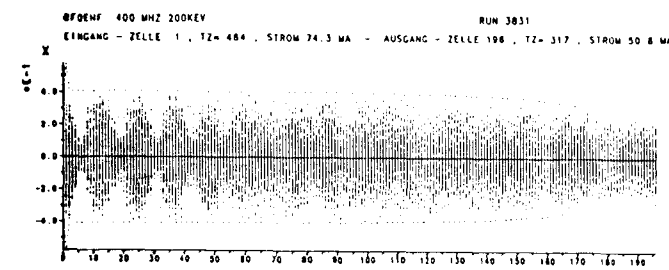


input emittances



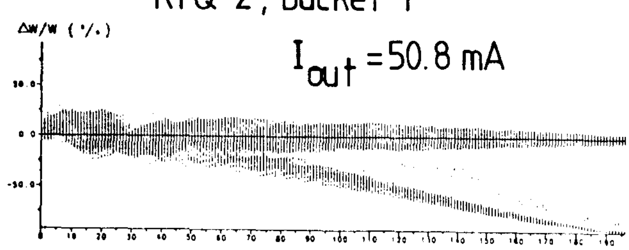


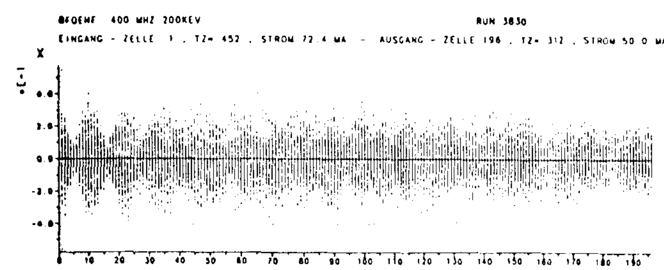
output emittances



RFQ 2, bucket 1

$I_{out} = 50.8\,mA$





RFQ 2, bucket 2

$I_{out} = 50\,mA$