ENERGY SPREAD COMPENSATION IN AN ELECTRON LINEAR ACCELERATOR

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Abstract

Results are presented of experimental studies on beam parameters at the exit from an rf-injector and a single-section accelerator. It is demonstrated that owing to an assigned amplitude and electromagnetic field phase relationship in the rf-gun during the pulse, one can get in a position to optimize bunches inflight phases into the accelerating section during which compensation is observable of the beam energy spread induced by current loading of accelerating section.

1. INTRODUCTION

One of the well known techniques of an intense beam energy spread compensation, the spread being accounted for by current loading of accelerating structure, is the one of bunch inflight optimization into the accelerating field [1]. Simply put, this technique is such that, owing to an assigned variation of the current pulsehead bunch inflight, in other words, owing to variation of the accelerating field amplitude, governing the bunch behavior, from the initially assigned value up to very maximum, the pulsehead bunch energy increment becomes equal to the bunch energy increment during the steady-state acceleration mode of a loaded section. Below we will show that these conditions can be materialized in single-section accelerator that have rf-gun-based injectors and a magnetic compressor [2].

2. DESCRIPTION OF THE DESIGN

The electron beam whose phase-energy characteristics are shown in Fig.1 is formed in the rf-gun, then energy- separated (hatched region in Fig.1), while bunches passing through the magnetic compressor (α-magnet) and compressed along the longitudinal coordinate. It should be noted that on account of beam cavity loading the field amplitude temporal characteristic inside the cavity (oscillogram b, Fig.2). As shown from some auxiliary research [3], a substantial contribution is made by electron back-bombardment under rf-field and cathode heating.

As a result, due to field amplitude-phase variations inside the cavity, the integrated bunch phase width during the entire pulse exceed 17° FWHM. Fig.3 shows results of particle phase distribution measurements in a pulse-averaged bunch. The technique is based on the analysis of the amplitude of current passing through the slot collimator during the beam circular sweep in the cavity while transverse-type oscillations of the fundamental frequency field are present [4].

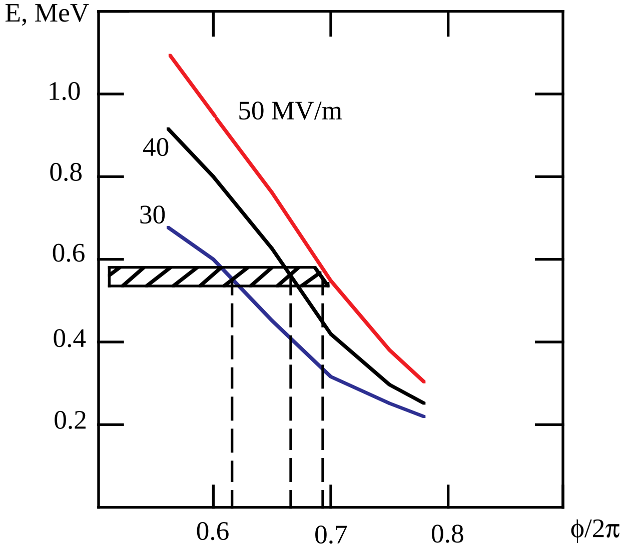

Figure 1. Particle phase-energy distribution per bunch at different rf-gun field strengths.

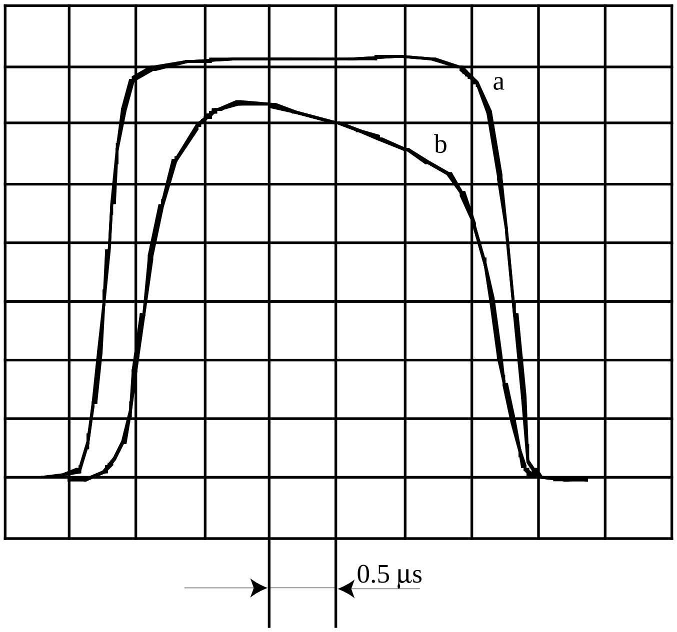

Figure 2. Oscillograms: a) rf-gun input rf-signal; b) rf-gun cavity field.

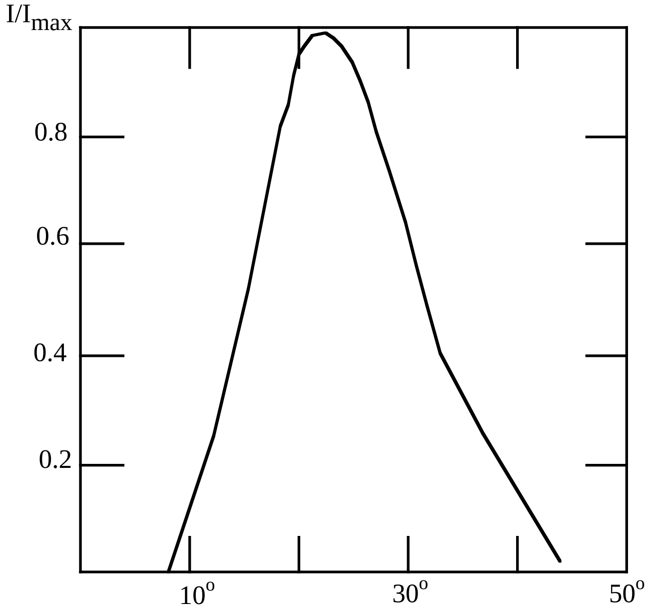

Figure 3. Pulse averaged particle phase distribution in bunches leaving the magnetic compressor.

Using the electrostatic deflector for selecting the current pulse in the downward field region of the cavity (oscillogram b, Fig.2) and by accelerating these 25-ns pulses at invariable field amplitude-phase characteristics of the accelerating section, we succeeded in determining the regularity of bunch inflight phase distribution such that bunch energy increment varied during 0.4 μs macropulse from 56 MeV to 59 MeV (Fig.4). This done, the current (0.1A) energy spectrum measurement spread for 90% particles does not exceed 2% which corresponds to the resolution limit of the spectrometer used. For this structure this value is 13%, the filling time being 1 μs, loading characteristic 80 MeV/A during the routine acceleration mode (some inflight phase for all bunches in the 1 μs pulse at 0.1 A current). In this manner, the conclusion can be made that there is observation of the energy spread compensation effect which occurs due to the bunch inflight phases optimization during current pulse.

3. CONCLUSION

Finally, a few words must be said about some possible techniques of monitoring the flow phase characteristic variations at the rf-gun exit. Evidently, for this purpose one could use various rf-devices, allowing to change rf-gun amplitude-phase and temporal characteristics. Yet, from our standpoint, of more practical interest shell be the technique of cavity load manipulations by using the back-bombardment electrons effect.

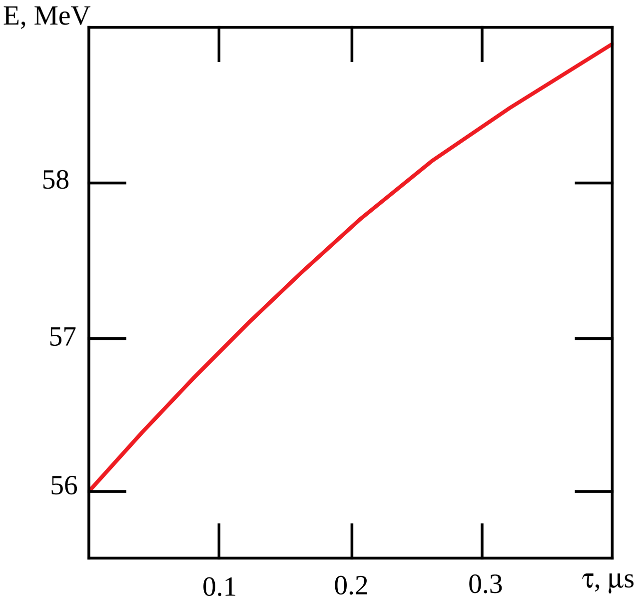

Figure 4. Relationship of energy increment of 25 ns select pulses vs. their temporal position inside the macropulse.

As shown in paper [5], application of a transverse magnetic field provides for the effective back-particles characteristic variations, i. e. cathode heat loads, and, accordingly, for those of emission currents and amplitude-temporal and phase characteristics of the cavity field. We have plans for more detailed study on this problem.

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