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Investigation of the hybrid electron linac with negative group velocity

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Abstract. Hybrid accelerator, incorporating travelling wave (TW) and standing wave (SW) structures is proposed and discussed. Accelerator can sum up an RF focusing in the SW buncher and lower losses in the TW accelerating structure walls. Moreover, the structure without dumping load is proposed. Input power and beam loading are chosen to minimize power reflection from buncher maintain travelling wave regime in the accelerating structure while beam loading is on. In this case SW buncher operates as a dumping load, so all input power either goes to beam or dissipates in the wall losses, it increases structure efficiency. RF characteristics and beam dynamics simulations have been performed.

1. Accelerating and bunching cells geometry

Well studied [1, 2] magnetic coupled diaphragm loaded structure (DLS-M) has been chosen as a TW part of the accelerator (Fig. 1). It operates on the $2\pi/3$ mode at 2856 MHz. Magnetic coupling provides a higher group velocity (i.e. structure filling time) compared to the conventional DLS structures and also allows to control it without changing an aperture radius. One of the aspects of using such a structure is it having a so-called negative dispersion curve, which corresponds to power flow and wave phase velocity travelling in opposite directions. For this project DLS-M has been tuned to the 1% group velocity.

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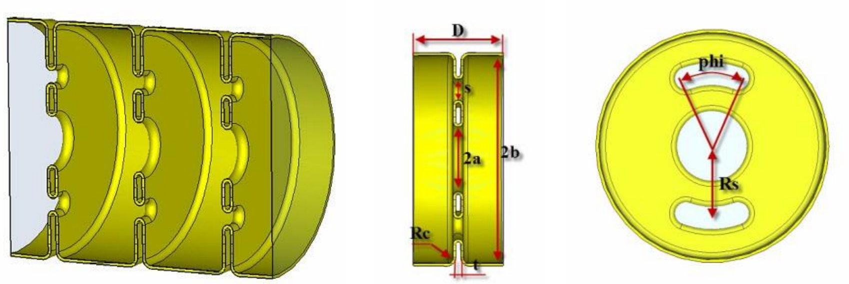


a) b) c)

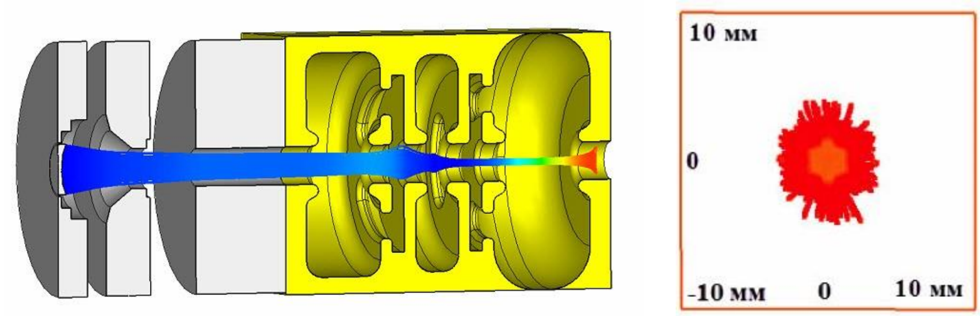
Figure 1. DLS-M geometry

1.1. Buncher

Bi-periodic accelerating structure (BAS) [3] has been chosen to bunch an electron beam, injected from the 30 kV electron gun. Three bunching cells and on-axis accelerating field distribution are presented in Fig. 2c. To obtain maximum capture and minimal energy spread, in according to beam dynamics study, it appears that $E_{z1}/E_{z2}/E_{z3}$ should be as shown in the Fig. 2c. Beam dynamics simulation model with the 1 MW RF input power and current of 0.5 A is presented in Fig. 3.

a) b) c)

Figure 2. (a) Buncher cells geometry; (b) generator-accelerator buncher cells; (c) on-axis accelerating electric field distribution



a) b)

Figure 3. (a) Beam dynamics in the buncher cells; (b) electron beam cross section at the end of the buncher

2. Hybrid structure

DLS-M is connected to the BAS via the rectangular waveguide as shown in Fig. 4. The main difference between this structure and ones, utilizing electrically coupled DLS, is that the RF power flows through such a system ”backwards”, deriving the TW part and the SW part of the accelerating structure. With the optimized number of cells in both parts, the excessive power from the TW part if fully absorbed by the SW part, thus eliminating the need for the dumping loads and circulators. In the Fig. 5 transient process of filling of the structure with RF power (without beam) is presented.

3. Beam dynamics

In this paper beam dynamics was calculated for the stationary RF fields. Output beam parameters structure, incorporating 3 BAS and 40 DLS-M cells are presented in the Table 1 and in the Fig. 6.

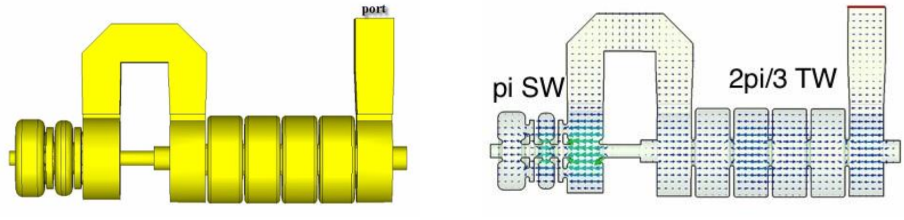


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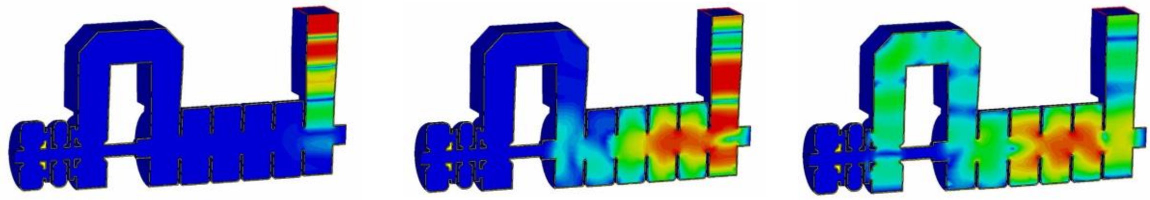
Figure 4. Geometry and fields in the hybrid linac

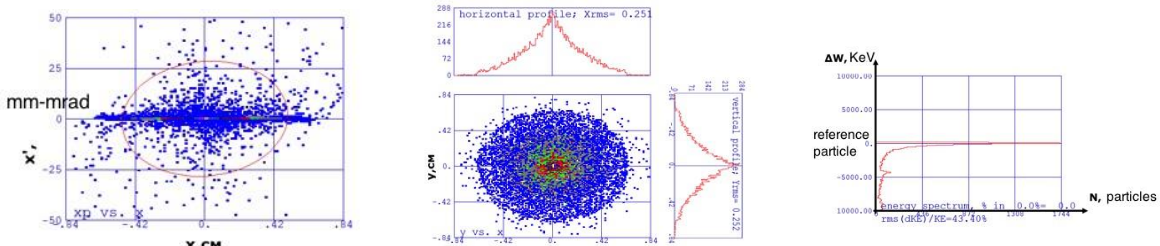


a) b) c)

Figure 5. Transient processes in the hybrid linac

Table 1. Output beam parameters

Maximum energy, MeV	Average en- Beam Capture co- Efficiency, ergy, MeV radius, mm efficient, % %				Beam curre nt, A
13.1	10	3	58	57	0.3



a) b) c)

Figure 6. (a) Beam transverse emittance; (b) beam cross section; (c) energy spectrum

4. Conclusion

Hybrid accelerating structure with magnetic coupled DLS-M cells has been investigated. SW and TW parts of the accelerating structure were tuned to achieve high efficiency and captivity coefficients. Beam dynamics has been simulated. In result the possibility of developing an accelerating structure without the dumping loads was provided.

Acknowledgement

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