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CALCULATION OF ELECTRON BEAM DYNAMICS IN FOUR ACCELERATING STATIONS FOR JINR ELECTRON ACCELERATOR LINAC-200

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Abstract

In the Joint Institute for Nuclear Research a Test Stand with an electron beam generated by the linear accelerator LINAC-200 with the energy up to 200 MeV is being constructed to investigate properties of accelerating and semiconducting structures for advanced detectors, a radiation resistance of detectors based on gallium arsenide semiconductor, to study a free electron laser and to do other applied work. The technical characteristics of the LINAC-200 accelerator make it possible to create an advanced system of test beams for scientific and methodological studies of detectors on its basis.

Four accelerating stations with maximum beam energy up to 200 MeV are put into operation. The work is being carried out for experiments with electron test beams with energy up to 800 MeV

This work presents the calculation results of the magnetic field of the focusing solenoidal system and electron beam dynamics in accelerating stations A00 – A04. In addition, the results on the formation of the electron beam with optimal parameters to be captured in further accelerating sections.

DESCRIPTION OF LINAC-200

Linear electron accelerator LINAC-200 is created on the basis of the accelerator MEA (Medium Energy Accelerator), brought from Dutch National Institute for Subatomic Physics to Dubna in 1999-2000 [1].

Linac-200 consists of 4 accelerating stations A01 – A04 with the maximum energy of about 200 MeV.

Injection station A00 consists of injector, prebuncher and buncher. The buncher is a short acceleration section with the length 1.654 m.

The focusing and transporting systems along the accelerator path includes solenoids, quadruples and beam correction elements. The buncher and short acceleration sections (A0BB, A1AA, B2AA) with the length 3.67 m have a constant solenoidal magnetic field from 100 to 500 Gauss generated by lenses (L1, L2) and solenoidal. After exiting the gun, the beam is picked up by a thin solenoidal magnetic lens 1, which focuses the beam on the chopper collimator. The second thin solenoidal lens focuses the beam on the input to the buncher. The long sections (A3A, B4A, B5A, A6A) with the length 7.35 m have no magnetic field, it contains quadruples Q1 and Q2 (Fig. 1). All quadruple lenses are identical. The internal radius of the channel is 2.5 cm, the field gradient is 7.6 kGauss/m.

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THE RESULTS OF CALCULATIONS ON THE FORMARTION OF THE MAGNETIC FIELD

For calculations on the formation of the magnetic field was used POISSON program [2]. The layout of the magnetic system for accelerating stations A00 – A02 is illustrated In Figure 2. Figure 3 shows a distribution of longitudinal and radial components of the magnetic field in accelerating stations A00 – A02.

Summarizing the calculation results, a Table 1 with the optimum values of the magnetic field was made.

The obtained results are used for further beam dynamics calculations of the electron beam.

Table 1: Optimal magnetic field for different elements of the accelerator

Element	B_{max}, Gauss
Lens 1 (L1)	200
Lens 2 (L2)	100
Buncher	200
A0BB	300
A1AA	400
B2AA	500

THE RESULTS OF ELECTRON BEAM DYNAMICS CALCULATIONS USING PARMELA PROGRAM [3]

The initial distribution of the particles was determined according to the Vladimirsky-Kapchinskii. The number of particles: 10 – 1000.

The goal of a prebuncher and a buncher is to compress the length of the bunch to a value suitable for capturing in the first accelerating section A0BB. Preference was given to variants with phases with a maximum energy of the high-frequency field in the section A0BB. The final choice of the optimal variant was made according to the results of the analysis for the maximum number of particles in the required phase range.

Beam cross-sections along the accelerator are illustrated in Figure 4 (sizes are in cm). Figure 5 shows beam spot (on the left) and energy-phase distribution (on the right). Energy gain along the LINAC-200 is demonstrated in Figure 6.

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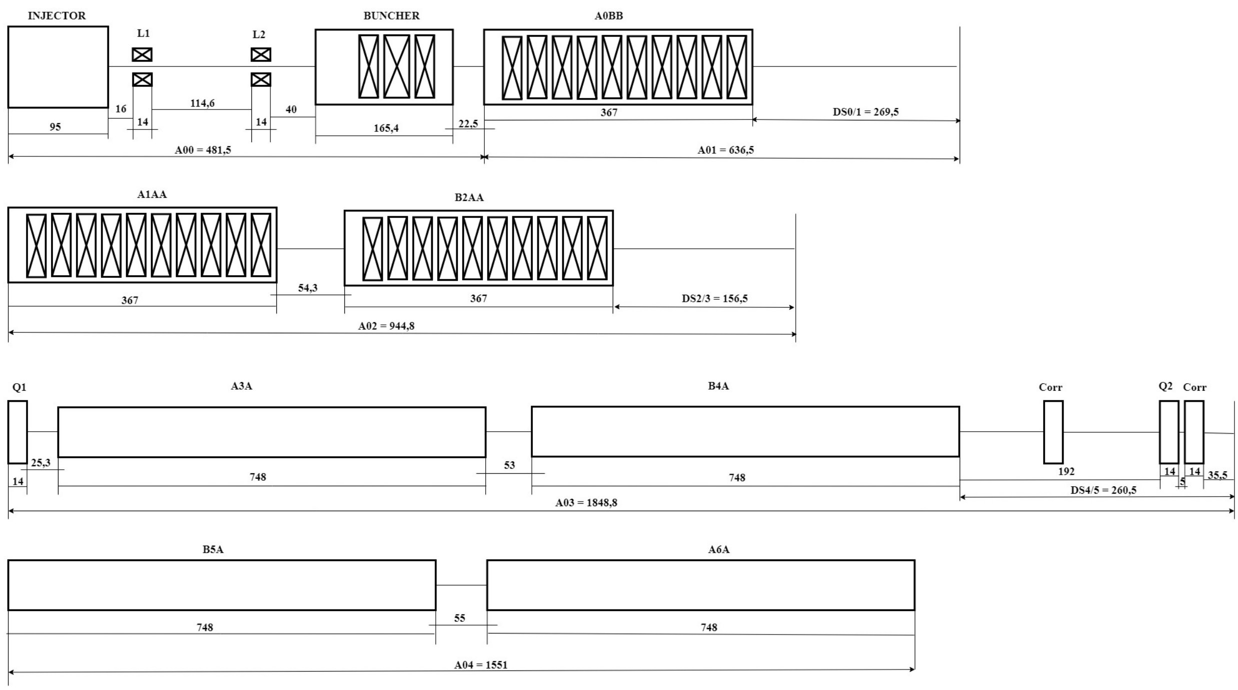

Figure 1: The layout of the magnetic system (sizes are in cm).

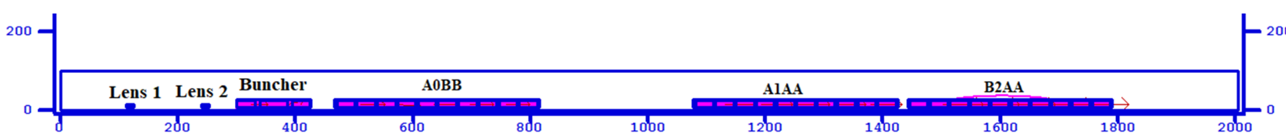

Figure 2: The layout of the magnetic system for accelerating stations A00 – A02 in POISSON program interface (sizes are in cm).

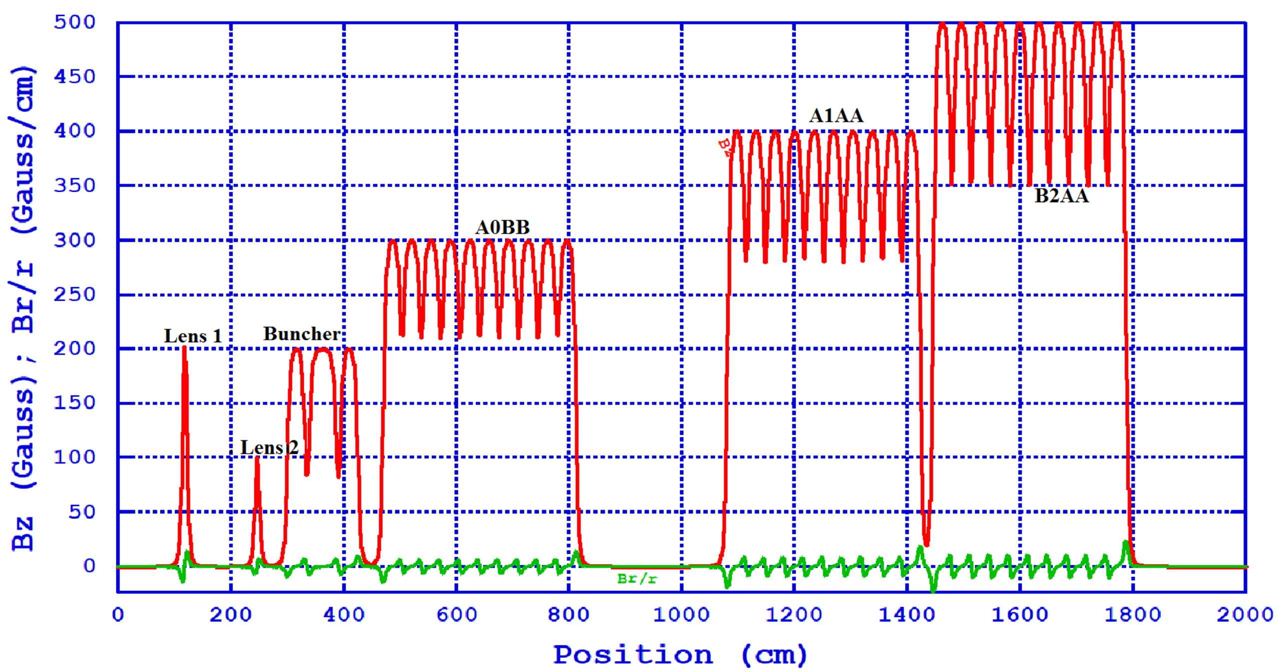

Figure 3: Distribution of longitudinal and radial components of the magnetic field in accelerating stations A00 – A02.

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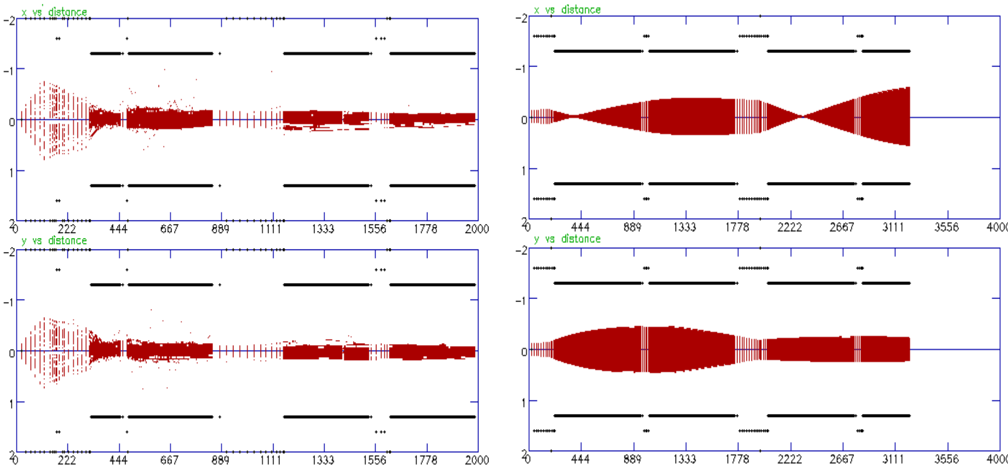

Figure 4: Changes of the transverse dimensions of the beam during acceleration and transport of the beam in accelerating stations A00 – A02 (on the left) and A03 – A04 (on the right).

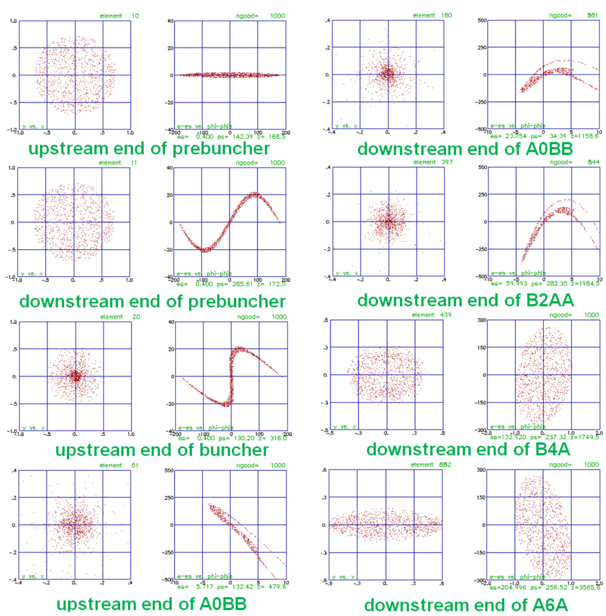

Figure 5: Beam spot (cm), energy-phase distribution (keV, degree).

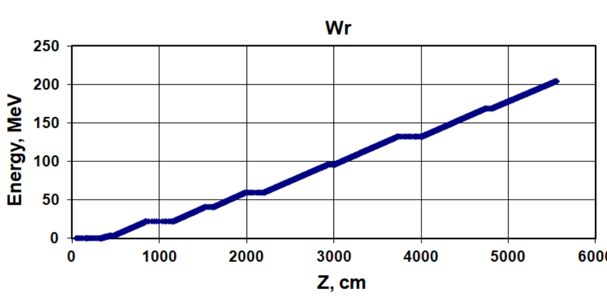

Figure 6: Energy gain along the LINAC-200.

Finally, a Table 2 with energy after each accelerating station was done.

Table 2: Energy after Each Accelerating Section

Accelerating station	Wr downstream end of element, MeV
A00	5.7
A01	23.7
A02	60
A03	133
A04	206

CONCLUSION

The electronic version of A00 - A04 was created. The magnetic field for A00 - A02 was formed. The beam with an X-dimension of about 1mm by a Y-dimension of about 12 mm was obtained behind the station A04. The maximum energy of about 200 MeV was formed behind the station A04.

TODAY'S STATUS/FUTURE

Comparison of data to be obtained with calculation data is to be done. The work is being carried out to measure energy at the exit of the second accelerating station (A02). Modernization by increasing the number of sections to get the energy of 800 MeV and later of 2 GeV is to be done. A free-electron laser is to be constructed.

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