Calculation of Electron Beam Dynamics in Four Accelerating Stations for JINR Linear Electron Accelerator LINAC-200

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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 [1] is being constructed for:

- Research of properties of accelerating and semiconducting structures for advanced detectors.
- Investigation of the radiation resistance of gallium arsenide semiconductor-based detectors.
- Creation of a free electron laser.
- Other applied investigations.

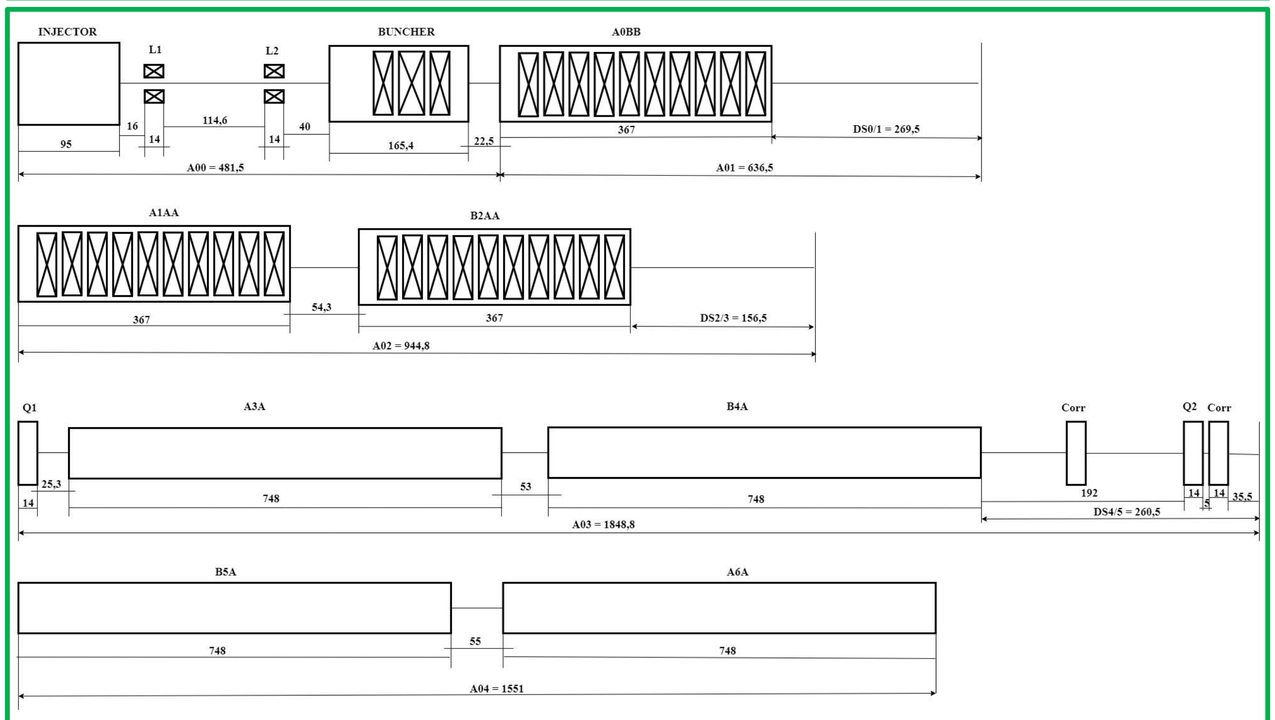
GOALS

- Calculation of the electron beam dynamics in accelerating stations A00 - A04.
- Formation of the electron beam with optimal parameters to be captured in further accelerating sections.

LINAC-200

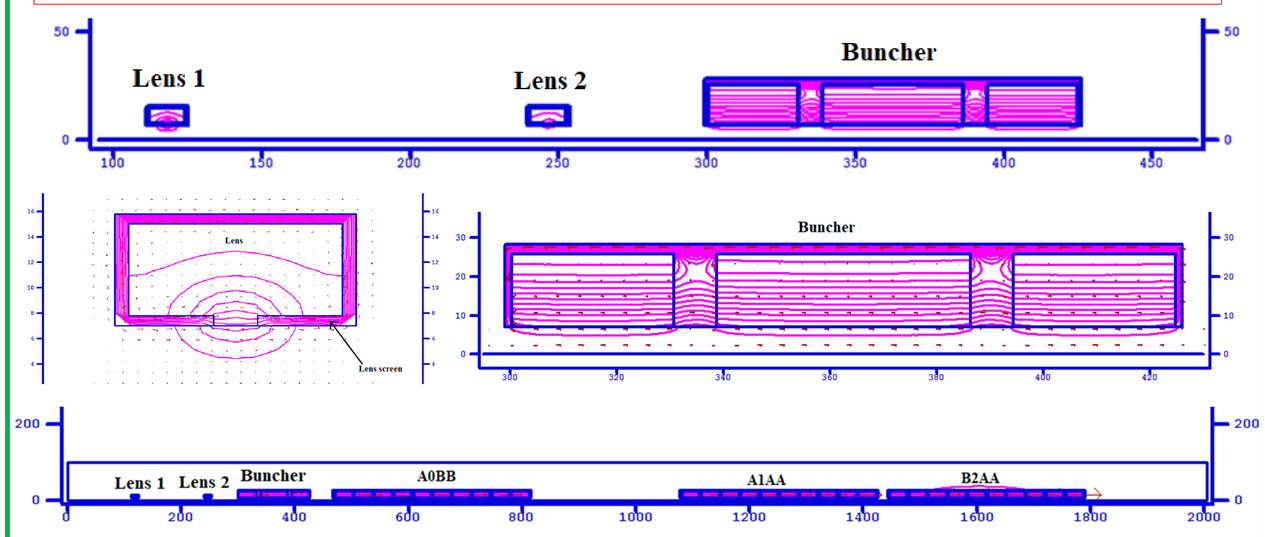
OBJECTIVES

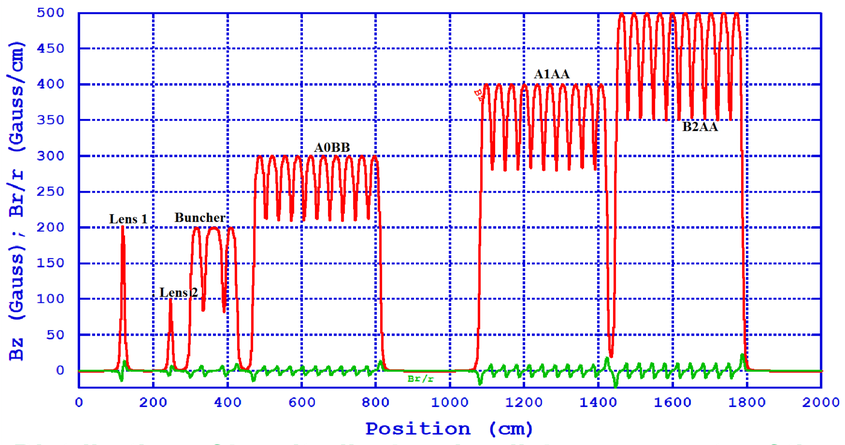
- Creation of the electronic version of stations A00 - A04.
- Calculations for the formation of the magnetic field of the solenoidal focusing system for A00 - A02 stations using the POISSON program [2].
- Optimization of an RF field phases.
- Calculations of the electron beam dynamics for A00 - A04 stations using the PARMELA program [3].
- Formation of a bunch suitable to be captured in further accelerating sections.
- Optimization of the electron beam parameters.



The layout of the magnetic system

THE RESULTS OF CALCULATIONS ON THE FORMATION OF THE MAGNETIC FIELD



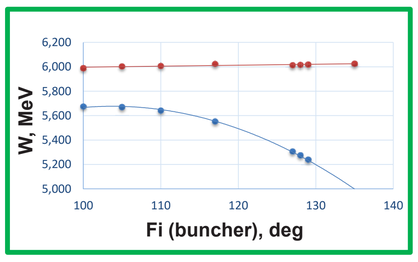


Distribution of longitudinal and radial components of the magnetic field in accelerating stations A00 – A02

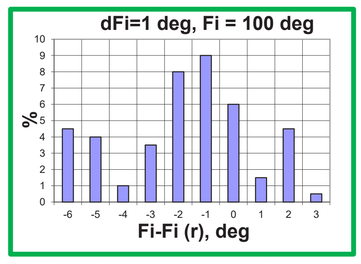
Element	B_{max}, Gs
Lens 1 (L1)	200
Lens 2 (L2)	100
Buncher	200
A0BB	300
A1AA	400
B2AA	500

THE RESULTS OF ELECTRON BEAM DYNAMICS CALCULATIONS

- 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.
- The process of finding an optimal phase:

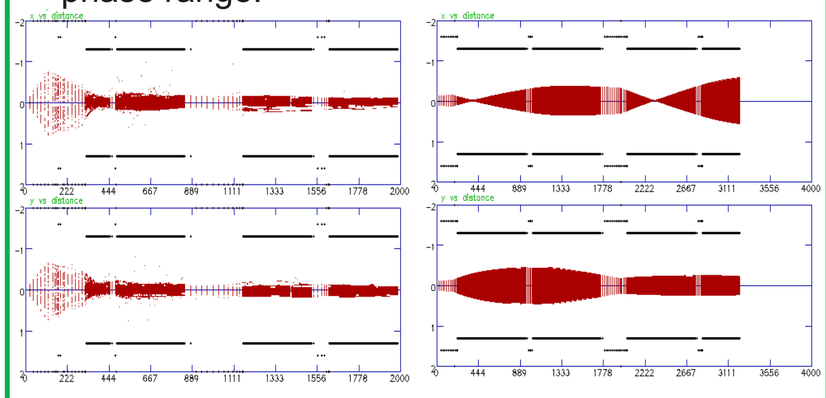


The dependences of the maximum energy of particles and the energy of the central (reference) beam particle on the phase of the field in the buncher



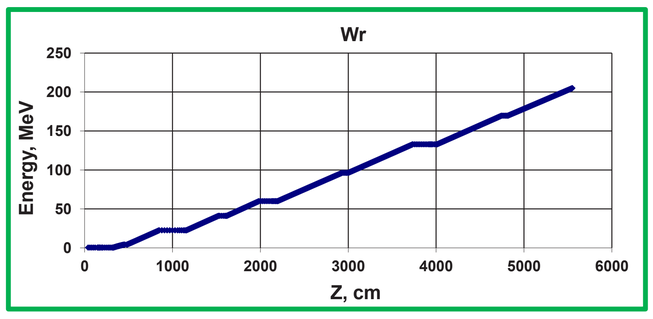
The dependence of the number of particles in the phase range (2°) on the phase of the reference particle

- 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.



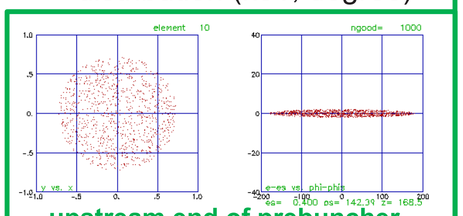
Changes along the transverse dimensions of the beam during acceleration and transport of the beam in accelerator stations A00 – A02 and A03 – A04

Element	Wr downstream end of element, MeV
Prebuncher	0.4
Buncher	5.7
A0BB	23.7
A1AA	42
B2AA	60
A3A	96.3
B4A	133
B5A	170
A6A	206

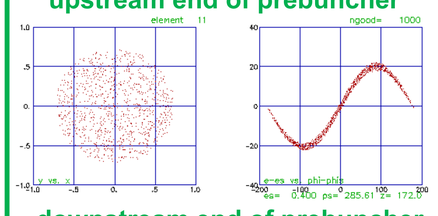


Energy gain along the LINAC-200

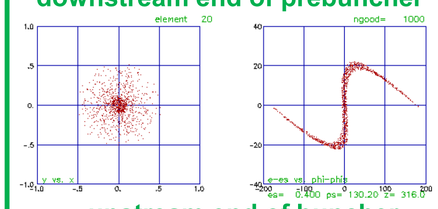
On the left: beam spot (cm)
On the right: energy-phase distribution (keV, degree)



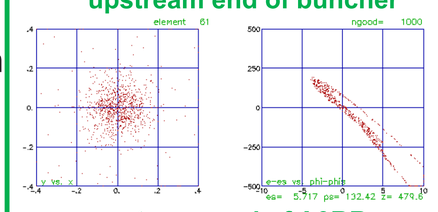
upstream end of prebuncher



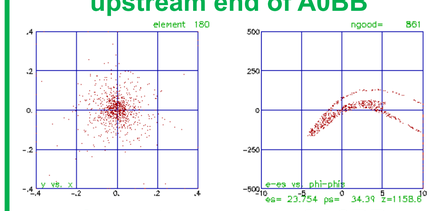
downstream end of prebuncher



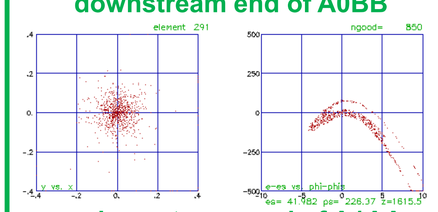
upstream end of buncher



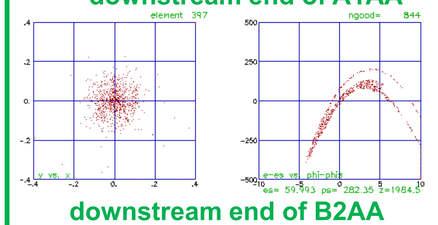
upstream end of A0BB



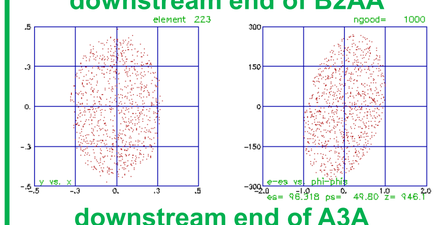
downstream end of A0BB



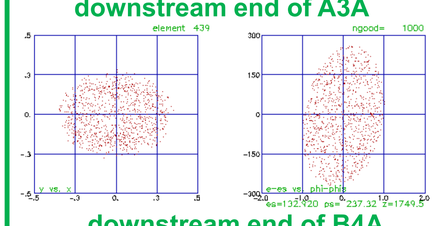
downstream end of A1AA



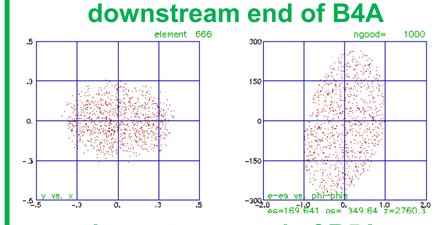
downstream end of B2AA



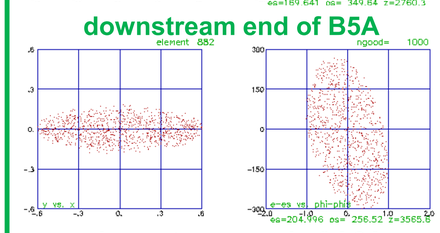
downstream end of A3A



downstream end of B4A



downstream end of B5A



downstream end of A6A

CONCLUSIONS

- 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 vs. FUTURE

- Comparison of data to be obtained with calculation data is to be done.
- The work is being carried out to measure energy behind 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.

REFERENCES

[1] V.V. Kobets. et al., Physical Startup of the First Stage of the Electron Linear Accelerator LINAC-800, RuPAC 2012 Conf., S.-Peterburg.
[2] POISSON Program, Los Alamos Acc.Group, LA-UR-87-115, 1987.
[3] The PARMELA Program, B.Mouton, LAL/SERA 93-455, Orsay, 1993.

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