SIMULATION OF BEAM DYNAMICS IN THE EXTRACTION SYSTEM OF THE JINR PHASOTRON

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Abstract

Beam dynamics is studied in the extraction by the regenerative method from the JINR Phasotron (657 MeV, 3μA protons) using special complex of computer programs. Parameters of the beam at the deflector entrance are calculated. The beam extraction efficiency is found to be ~40%. The mean movement in the extraction channel is investigated. Calculated beam transverse parameters agree with the experimental ones to accuracy of~20%.

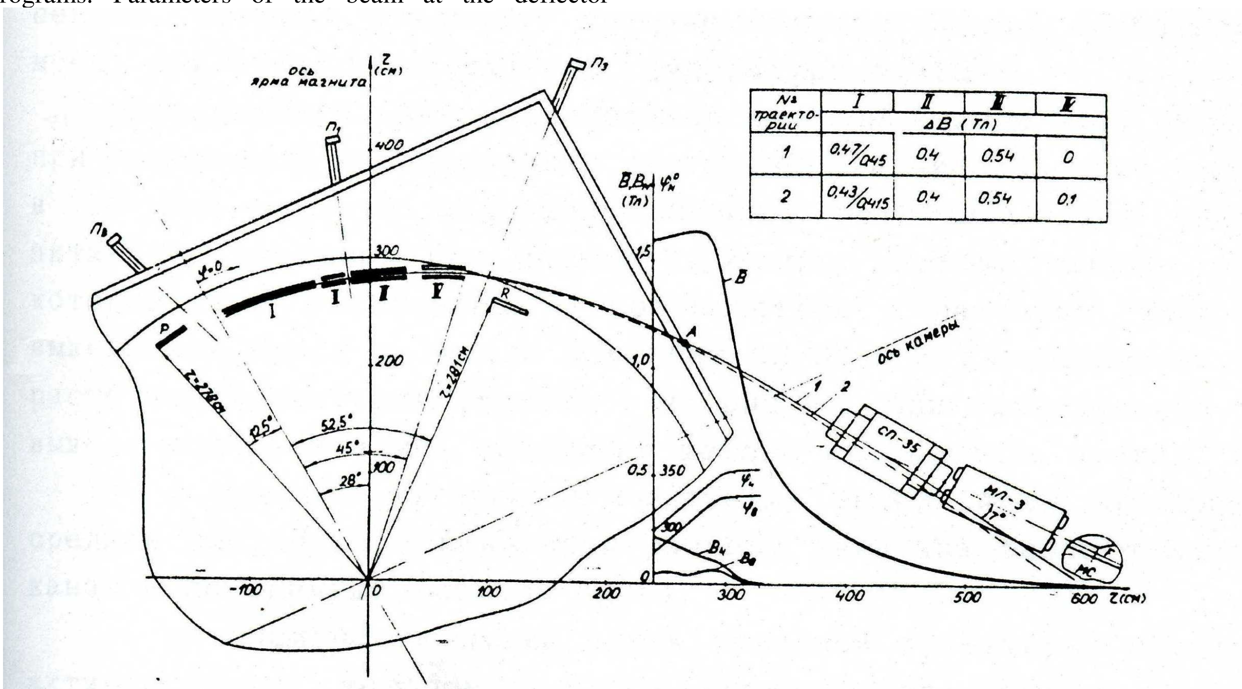

Figure 1: Layout of the Phasotron extraction system P is the peeler, R-regenerator, I, II, III, IV are the sections of the extraction channel.

EXTRACTION SYSTEM OF THE JINR PHASOTRON

The calculation of the beam acceleration in the JINR Phasotron ("F") and its throe to the extraction channel entrance is performed [1] with e special computer code for the beam dynamics simulation in the cyclotron-type accelerators. The regenerative method [2] is used for the beam extraction from "F". The extraction efficiency is ~40% and mainly depends on the beam losses at the entrance to the extraction system.

The position of the beam extraction system inside "F" vacuum chamber is shown in Fig. 1. System consists of peeler, regenerator and four channels. Each element has adjustable radial position. First of four channels is a current supplied channel with the thickness of the septum of 4mm. Other three sections are passive magnetic channels.

Figures 2-5 show portraits end energy distribution of the accelerated beam (2000-proton bunch) at the entrance to the extraction channel.

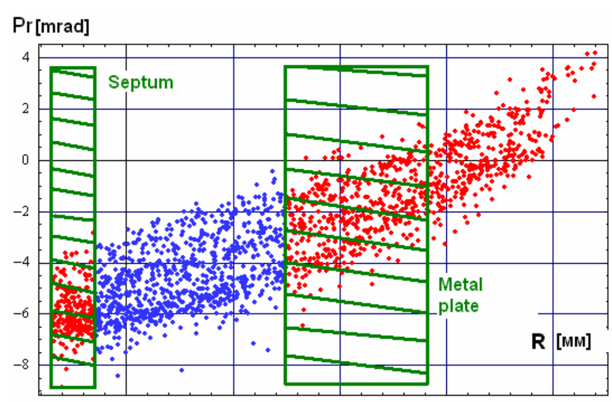

Fig 2: Position of the beam particles on the radial phase plane at the extraction channel entrance

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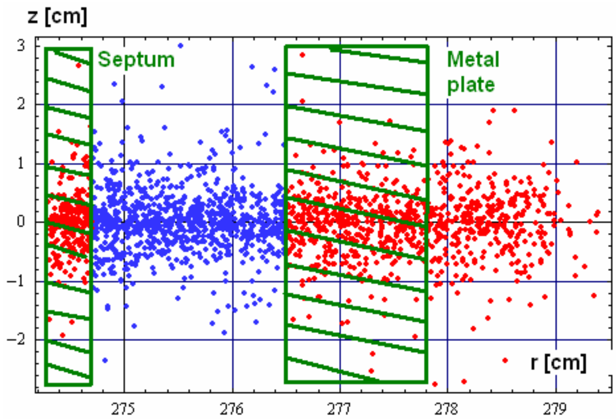

Fig 3: Position of the particles on *R-Z* plane at the extraction channel entrance

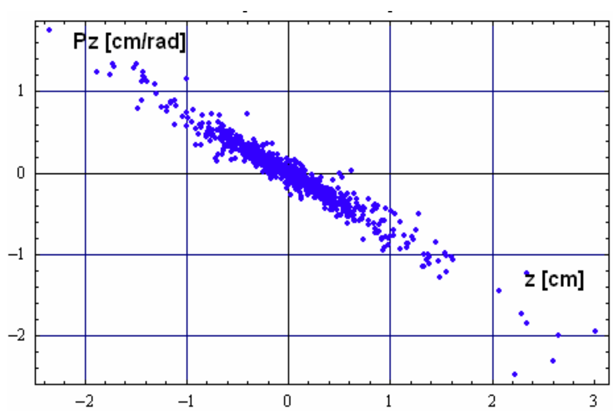

Fig 4: Position of the particles on the axial phase plane at the extraction channel entrance

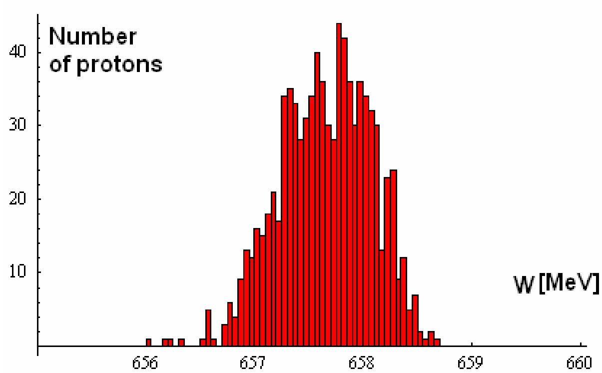

Fig 5: Energy distribution of the particles at the extraction channel entrance

Out of 2000 protons (which were injected from the ion source and came after 3000 turns to the radius of 80cm) 1951 (**98%**) protons were accelerated (37000 turns) to the extraction channel entrance. 49(**2%**) protons were lost due to large radial oscillation amplitudes. Out of 1951 particles which came to the extraction channel entrance (see Fig. 2) 857 (**43%** of 2000) particles were pushed inside the channel aperture, 241(**13%**) hit the septum tip, and 814(**42%**) were lost on the back wall of the current section. Transversal emitances of the beam that entered the channel aperture are $\varepsilon_r = 25\pi$ mm•mrad, $\varepsilon_z = 8\pi$ mm•mrad.

After the channel beam is extracted from the vacuum chamber and transported to the SP-35 magnet. The parameters of the extraction system elements are given in the Table 1.

Table 1: Parameters of the extraction system elements

Parameter	current supplied channel		passive magnetic channels			peeler	regenerator
	1	2	3	4	5	6	7
φ_1, °	1.0	9.8	20.0	25.2	36.5	348.0	50.7
φ_2, °	9.8	18.7	24.7	35.8	44.7	353.7	56.4
ΔB, kG	-4.7	-4.5	-4.0	-5.4	0.0	-2.48	2.16
dB/dX kG/cm	0.15	0.03	-0.1	-0.1	1.0	-0.31	0.27
Radial aperture, cm	1.8	1.8	2.2	2.6	5.0	11.0	13.0
R_1, cm	275.6	276.2	279.5	282.3	291.0	272.5	274.5
R_2, cm	276.2	279.0	282.0	290.5	299.0	272.5	274.5

In Table 1 R_1 and R_2 are axis entrance and exit radii of each element. ΔB is the magnetic fields drop at the central line of each element. dB/dX – additional gradient from the element.

2σ beam rms-envelopes inside the extraction system are shown in Figure 6.

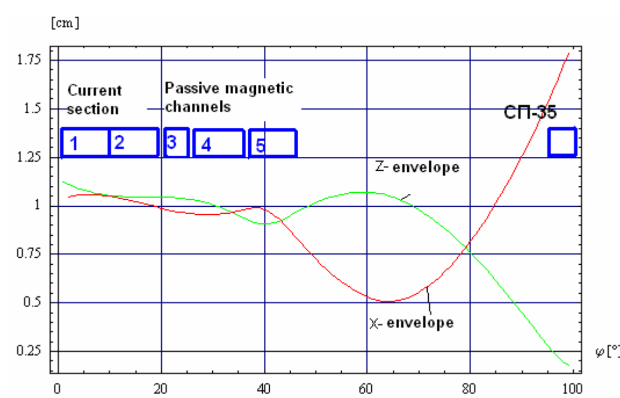

Fig 6: 2σ beam rms-envelopes inside the extraction system

The extracted beam profiles are shown in Figure 7 (calculated) and Figure 8 (experimental). One can see that both results agree with the accuracy of ~20%.

It is supposed that the developed code used in the calculations for the study of the beam dynamics can be helping for more careful investigation of the possibility of increasing the beam extraction efficiency at JINR Phasotron.

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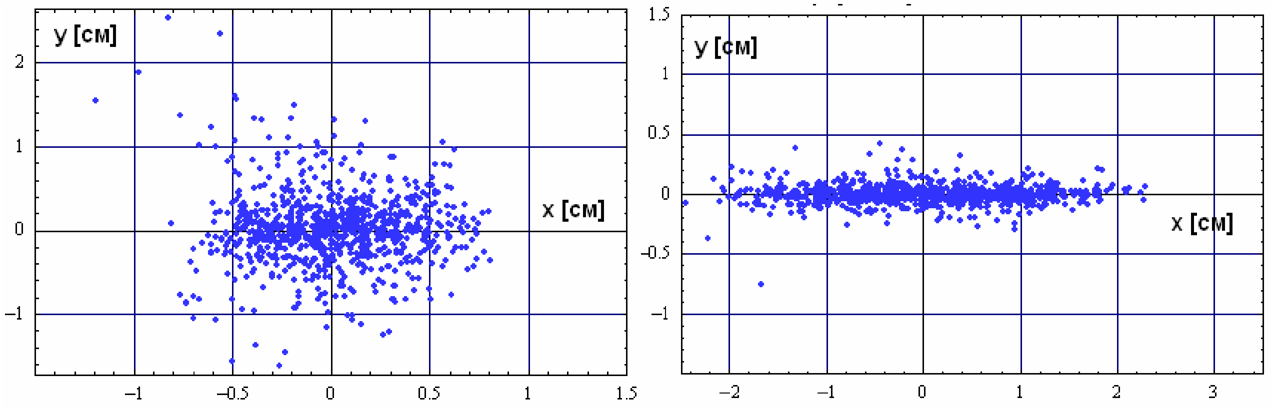

Fig 7: Beam profiles (calculated) at point A (see Figure 1) and at the entrance to the SP-35 magnet

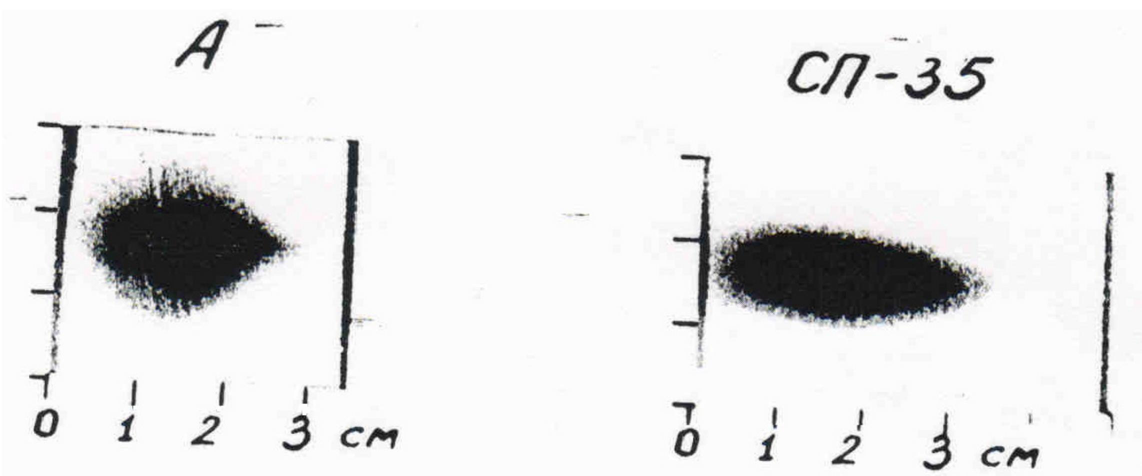

Fig 8: Beam signatures (experimental) at point A (see Figure 1) and at the entrance to the SP-35 magnet

CONCLUSIONS

Beam dynamics is studied in the extraction by the regenerative method from the JINR Phasotron using special complex of computer programs. Parameters of the beam at the deflector entrance are calculated. The beam extraction efficiency is found to be ~40%. The mean movement in the extraction channel is investigated. Calculated beam transverse parameters agree with the experimental ones to accuracy of 20%.

The developed code can be used for more careful investigation of the possibility of increasing the beam extraction efficiency.

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