PSR-2000. Beam Extraction to SP-103

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Abstract

This paper discribes the channel structure for electron beam transport from PSR-2000 to spectrometer SP-103 with the system controlling electron spin orientation. Problems of slow extraction of electron beams at resonance m/3 and the parametric one are discussed.

1. INTRODUCTION

A pulse stretcher ring (PSR-2000), intended for producing a quasi-continuous electron beam with an energy up to 3 GeV, has been designed for the Kharkov 2 GeV electron linear accelerator [1]. The report briefly describes the extraction system and the channel structure for beam transport to the existing experimental halls with the spectrometer SP-103.

A slow beam extraction from the PSR-2000 under achromatic operation conditions is to be performed in the horizontal plane at the third-order resonance (ν_x =16/3) or at the parametric resonanse (ν_x =11/2). At beam energies between 2 and 3 GeV, when the damping time of betatron oscillations is comparable or shorter than the time of extraction, the extraction efficiency at the third-order resonance falls. In view of this, it appears reasonable to extract the beam in this energy range at the parametric resonance [2].

2. BEAM EXTRACTION TO SP-103

2.1 Slow extraction at m/3 resonance

During beam extraction at the third-order resonance, the resonance harmonic of the sextupole field is produced by four conventional and four pulsed sextupole magnets which are located in achromatic straight sections. The magnets compensate the deviation of the particle extraction angle. The tuning to resonance is done by using three pulsed quadrupole magnets. To choose the parameters for the slow extraction system and to calculate the beam characteristics, we have used the DeCA package [3].

For injection of the beam with a radial emittance ε_x=3·10^{-7}mrad and a betatron oscillation amplitude of 1cm, for detuning $\delta_{init}=\nu_x$-16/3=-1.33·10^{-2} and δ_{fin}=-0.8·10^{-2} and a distance of 4cm from the electrostatic septum to the reference orbit, the pitch is δx_s=2cm, and the beam divergence is $\delta x'$=1.4·10^{-4}rad. The extracted beam emittance is ε_x=1.87·10-6. The undertaken studies have demonstrated the possibility of reducing the angle deviation (by means of pulsed sextupole magnets) and obtaining the extracted beam emittance ε_x=1.·10^{-7}mrad. Fig.1 shows the phase portrait of the beam on the azimuth of the electrostatic septum in the slow-extraction mode at the third-order resonance.

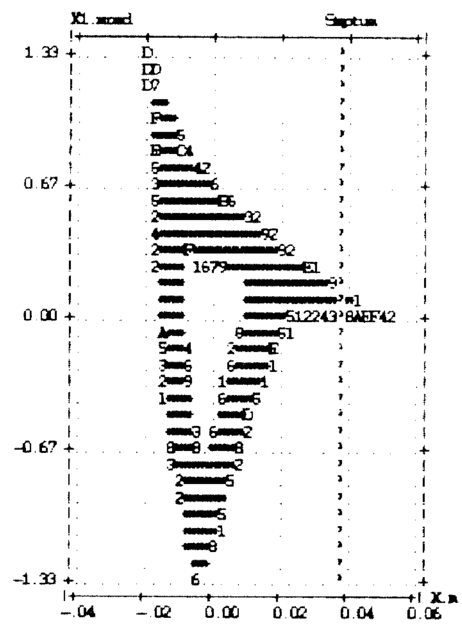

Fig.1 Phase portrait of the beam in the slow extraction mode at the third-order-resonance.

2.2 Slow extraction at a parameteric resonance.

With the parametric-resonance extraction the resonance harmonic and the separatrix are generated by three pulsed quadrupole magnets and two octupole magnets. This system permits the extraction at both positive and negative detuning relative to the resonance. The numerical estimates have shown that for the particle extraction at an optimum angle with an initial detuning $\delta_{int}=\nu_x-11/2=4\cdot10^{-2}$ the pitch is 1cm (the electrostatic septum being at 4cm from the reference orbit). For the tuning to the resonance by the use of one pulsed quadrupole, the extracted beam emittance is $\varepsilon_x=5\cdot10^{-7}$mrad. A large divergence of the extracted beam (0.15mrad) is due to the variation of the extraction angle with a decreasing amplitude of oscillations in the separatrix. By varying the phases and amplitudes of the resonance quadrupole perturbation it is possible to reduce essentially the deviation of the particle extraction angle[2]. For this purpose, it is necessary to have two pulsed quadrupole magnets with the force of one magnet growing, while the force of the other decreses. In this case the extracted beam emittance is about $1\cdot10^{-7}$mrad. Fig.2 shows the phase portrait of the beam on the azimuth of the electrostatic septum in the mode of parametric-resonance slow extraction.

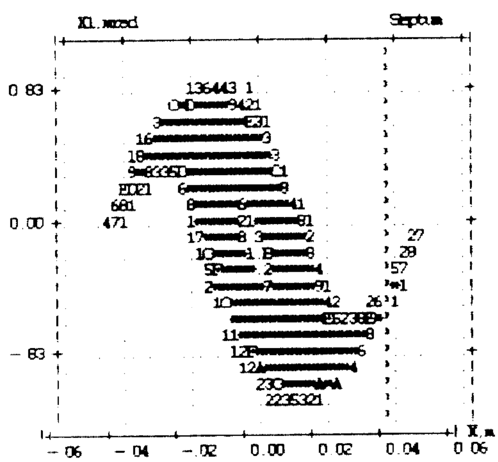

Fig.2 Phase portrait of the beam in the mode of parametric-resonance slow extraction.

2.3. Transport to the SP-103.

To transport the beam to the SP-103 experimental halls, we use the magnets, the main characteristics of which are given in Table 1.

Table 1. Parameters of magnets in the PSR-2000-SP-103 channel.

	Dipole	Quadrupole
Quantity required	8	18
Field induction at 3GeV	1.124T	20T/m
Effective length	1.773m	0.52m
Gap or diameter	53mm	75mm

The main parameters of the septa employed to extract particles are presented in Table 2.

Table 2. Main septum parameters in the extraction system.

	Electrostatic septum	Magnet septum 1	Magnet septum 2
Field value at 3 GeV	50 kV/cm	0.25T	0.9T
Effective length	1.42m	1.15m	1.4m
Septum thickness	0.1mm	1.5mm	14mm

The influence of multipole field components in the magnet components of the ring

$$\Delta H=\frac{1}{n!}\frac{d^nH}{dx^n}$$

on the extracted beam parameters was studied analytically and by computer simulation using the DeCA program package. Tolerances for multipole components in the dipole and quadrupole magnets of the ring, viz.,

$$\sum\left[\frac{\Delta H_n}{H}\right]=0.4\cdot10^{-3} \quad \text{for dipoles}$$

$$\sum\left[\frac{\Delta H_n}{G}\right]=1.3\cdot10^{-3} \quad \text{for quadrupoles}$$

correspond to a 15% variation in the uniformity of extraction and the extracted beam emittance (this value is within the tuning value of the extraction system).

Fig.3 shows the layout of the equipment and the envelopes of the extracted and circulating beams for the extraction section.

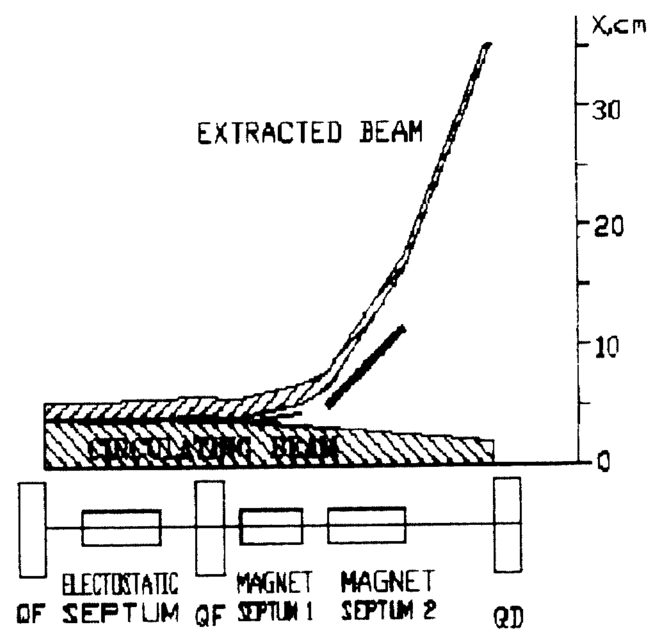

Fig.3 The layout of the equipment for the extraction section

The focusing structure of the transport channel was chosen with the help of the TRANSPORT program[4], taking into account the necessity of controlling the orientation of the beam polarization vector so that to produce in the SP-103 the longitudinally polarized beam in the whole energy range of the PSR complex (0.5 - 3 GeV)[5].

The structure of the PSR-SP extraction channel and the beam envelopes in this channel are shown in Fig.4. The channel for beam transport from the PSR to the SP-103 comprises diagnostic facilities providing for quasicontinuous beam intensity, position and profile measurements, as well as 10 two-coordinate dipole correctors. The total length of the beam transport channel from the PSR-2000 to the SP-103 is about 130. To compensate quadratic effects, six sextupole magnets should be set in the extraction channel. An aluminum-alloy chamber is supposed to be used as an electron guide.

The chosen scheme of extraction and the channel focusing structure would allow the production of a quasicontinuous electron beam with required parameters in the experimental SP-103 halls.

3. REFERENCES

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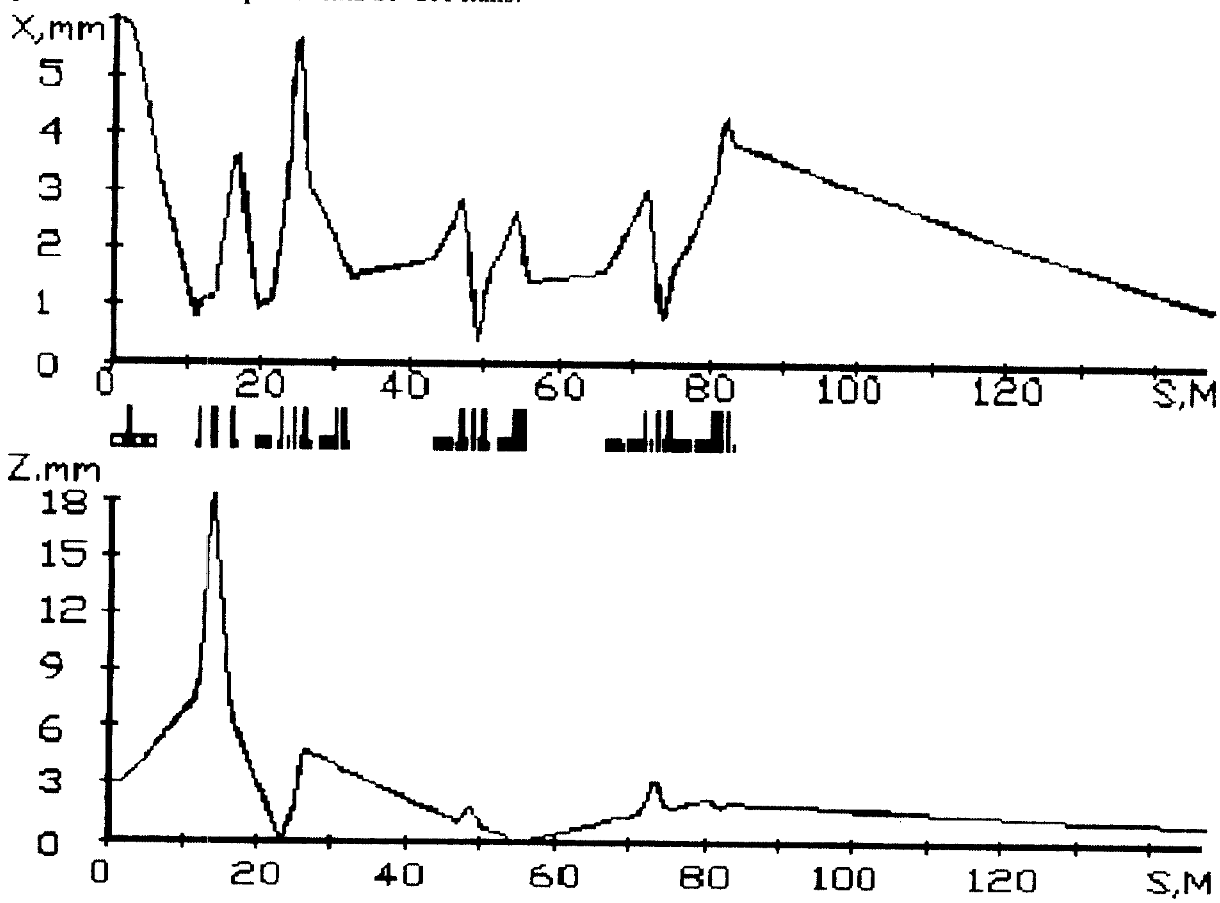

Fig.4 The beam envelopes in PSR-SP channel