

BEAM POSITION MEASUREMENT SYSTEM FOR THE VEPP-2000 COLLIDER

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Abstract

A beam position measurement (BPM) system for VEPP2000 collider has been developed in BINP. 4 electrostatic pickups with diameter of vacuum chamber of 40mm have been installed in ring. BPM system is able to measure the position of each of 2 bunches at every turn for beam current range 1-100mA. The resolution of measurement of the single bunch is about 100 microns for beam current of 10mA. The features of system design, the main parameters and results obtained in VEPP2000 ring are presented.

1 INTRODUCTION

VEPP-2000 electron-positron collider has been constructed in the Budker INP at the beginning of 2007 year [1]. Some parameters of the collider are given in Table 1.

Table 1. Parameters of VEPP-2000 collider.

Circumference	24.4 м
RF frequency	172.1 МГц
Revolution frequency	12.29 МГц
Number of particles per bunch	$1 \cdot 10^{11}$
Energy	2 GeV
Beam current	100 mA

Developed at BINP simple and cheap beam position measurement (BPM) system gives the possibility to measure separately positions of two electron and two positron bunches. The system although provides turn-by-turn measurements.

SYSTEM DESCRIPTION

BPM system includes 4 electrostatic Beam Position Monitors (BPMs), front-end electronics located near BPMs and readout electronics in CAMAC standard. Beam Position Monitor (Fig 1) consists of four button electrodes at the angle of 45 degrees to horizontal plane. Button diameter is 17 mm.

The structure of the BPM electronics is given in Fig 2. This structure is similar to FEL BPM electronics structure [2]. The signals from four BPM electrodes are simultaneously processed with four channels of processing electronics. Each channel consist of LPF with cut-off frequency of 110 MHz, programmable gain amplifier with range of 45 dB and 12 bits ADC. Time interval between electron and positron bunches is about 20 ns for each BPM. Analog electronics bandwidth of 110 MHz allows us to decrease the crosstalk of electron and positron bunches signals at level of 0.5 dB. Timing circuit

provides ADC samples at the top of BPM signal. It is achieved by means of programmable delay of reference pulses with revolution frequency F_{REV} . Delay range covers all revolution period. Delay step is 0.25 ns.

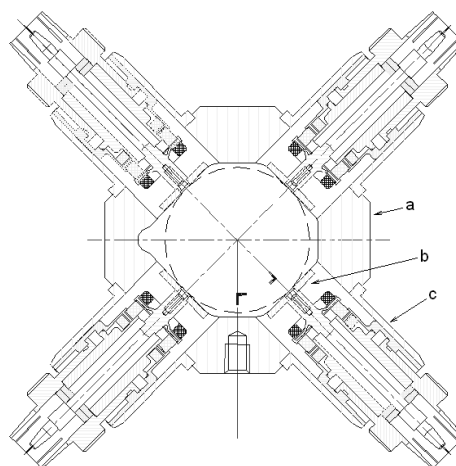


Fig 1. Electrostatic Beam Position Monitor.

- a. vacuum chamber
- b. pickup electrode
- c. vacuum feedthrough

Beam position is measured for each turn. Measurements results are written to Memory. Slow data are obtained with averaging of results for any chosen number of turns.

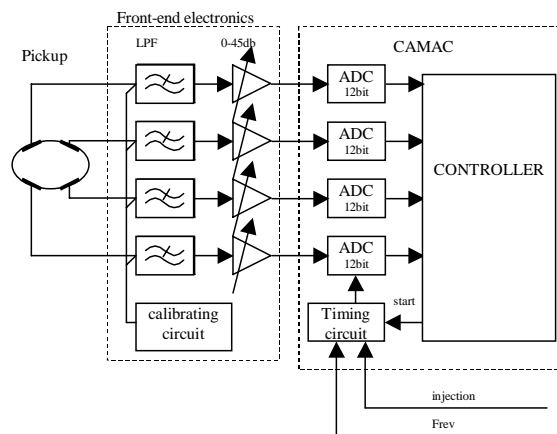


Fig 2. The structure of the BPM electronics.

The compensation of BPM electrical zero in all signal processing channels is provided with using of calibrating signals.

Synchronization of the system with beam injection gives the possibility of the beam position measurements for the first turn and measurements of the betatron frequencies after injection. The system although allows measurements of the betatron frequencies with kicking method.

IMPLEMENTATION FOR STORAGE RING COMMISSIONING

During storage ring commissioning precision of the BPM system has been measured.

Resolution of measurements for beam currents above 5 mA with averaging of data for 256 turns is about 2-3 microns (Fig 3). Parameters of the system are given in Table 2.

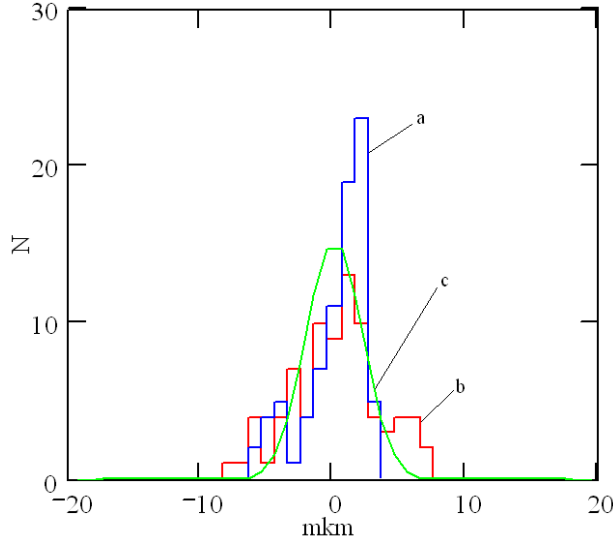


Fig 3. Beam position measurements histogram for beam current of 6 mA and for measurement time of 256 turns:

a - vertical position ($\sigma=3$ microns)

b - horizontal position ($\sigma=2$ microns)

Table 2. Parameters of the BPM system.

Bunches current	0.1-100 mA	
Resolution, turn by turn measurements	0.1-1 mA	150-500 μm
	1-10 mA	50-150 μm
	>10 mA	<50 μm
Resolution, data averaged with 256 turns	0.1-1 mA	10-30 μm
	1-10 mA	3-10 μm
	>10 mA	<3 μm
Long time stability	30-40 μm	
Temperature stability	2 $\mu\text{m}/^\circ\text{C}$	

During storage ring commissioning the system had been used in turn-by-turn mode for injection tuning. Injection errors can be defined by amplitude and phase of synchrotron oscillations. In Fig.4,5 examples of injection errors are shown. The phase of synchrotron oscillations for the case of energy mismatch and for the case of phase mismatch differs at 90° . In case of correct injection synchrotron oscillations are minimal.

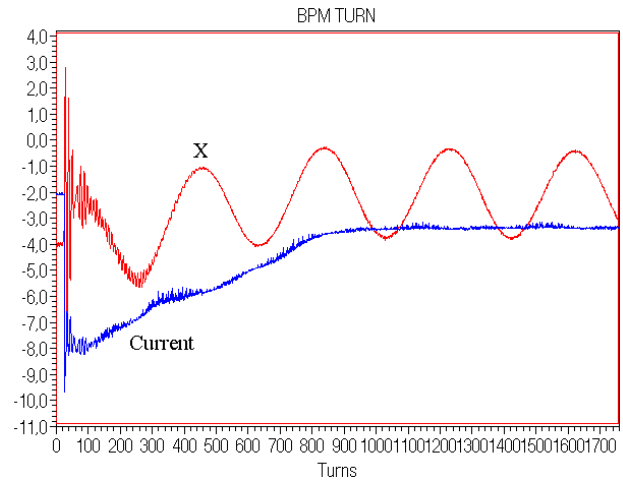


Fig 4. Injection at energy error

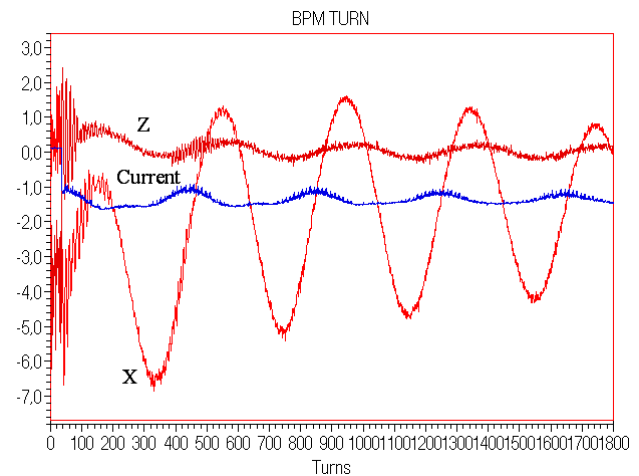


Fig 5. Injection at phase error

CONCLUSION

Developed at Budker INP simple and cheap BPM system satisfies nevertheless to all requirements of VEPP-2000 operation. Precision of measurements is sufficient for VEPP-2000 experiments. Possibility of turn-by-turn measurements for each electron and positron bunches gives the powerful instrument for storage ring study and adjustment.

REFERENCES

- [1] D.E.Berkaev et. al., VEPP-2000 ELECTRON-POSITRON COLLIDER COMMISSIONING AND FIRST RESULTS OF ROUND COLLIDING BEAM TESTS // Proc. of EPAC08, Genoa, Italy, 2008.
- [2] E.N. Demytyev et. Al., FREE ELECTRON LASER FOR THE SIBERIAN CENTRE FOR PHOTOCHEMICAL RESEARCH: SOFTWARE AND CAPABILITIES OF BEAM POSITION MEASUREMENT SYSTEM // Proc. of RuPAC XIX, Dubna 2004.