Calibration Procedures for Beam Position Monitors on the SPring-8 Storage Ring

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The SPring-8 storage ring has 288 beam position monitors (BPM's) to measure beam positions with respect to sextupole magnets. Each BPM consists of four button pickup electrodes that are welded into straight section vacuum chambers made of extruded aluminum alloy (Fig. 1). To measure the beam position with the BPM's, it is necessary to know precisely the location of the electrical center of each BPM and the relation between imbalance of four signals and the deviation of the electron beam from the center. The imbalance is expressed by position sensitivities U and V which are defined as,

$$U = \frac{1}{2}\left(\frac{V_1 - V_2}{V_1 + V_2} + \frac{V_4 - V_3}{V_3 + V_4}\right)$$

$$V = \frac{1}{2}\left(\frac{V_1 - V_4}{V_1 + V_4} + \frac{V_2 - V_3}{V_2 + V_4}\right)$$

where V_1, V_2, V_3, and V_4 stand for the output signal voltages of each pickup. All the BPM's are calibrated by a scanning rf antenna before installation in the storage ring. To refine and establish the calibration procedures, we have optimized and qualified the rf antenna [1].

The rf antenna is made of a straight semi-rigid cable with an inner conductor bared at a tip. The outer diameter of the cable is 3.6 mm. The length of the coaxial cable is 295 mm that is a half wavelength of 508 MHz sinusoidal wave fed to the antenna. The rf antenna is supported by a long rod that is fixed to the three dimensional moving stage. Three ferrite rubber sheets are wound around the rod to suppress the effect of external disturbance. The longitudinal position of a BPM along the antenna is experimentally determined to be at 130 mm from the end of the coaxial cable [1].

A precision BPM chamber with the ideal elliptical cross section of the real beam chamber has been used to verify that the antenna well simulates an electron beam. The experimental position sensitivity measured with the antenna has been compared with the theoretical sensitivity for an electron beam. Open circles in Fig. 2 represent sensitivities U and V measured with the antenna by 1 mm step in a central square of 10 mm by 10 mm. Crosses in Fig. 2 represent beam sensitivities calculated by the boundary element method at the same points [2]. Small systematic errors were found in antenna sensitivities, + 2.7 % in horizontal sensitivity U and - 2.2 % in vertical sensitivity V. After correction of systematic errors, residual error in sensitivity measurement is smaller than 1 % [1].

To measure the offset of an electrical center of a BPM, we have to locate the rf antenna precisely at the reference point. The reference point for offset measurement has been defined as the mechanical center of another BPM chamber with circular cross section. Owing to its rotational symmetry, the mechanical center is definitively identified. The accuracy of offset measurement is experimentally determined to be ± 54 μm (full error) [1].

References

[1] K. Tamura *et al.* , 1995, in preparation.

[2] S. Sasaki 1995, private communications.

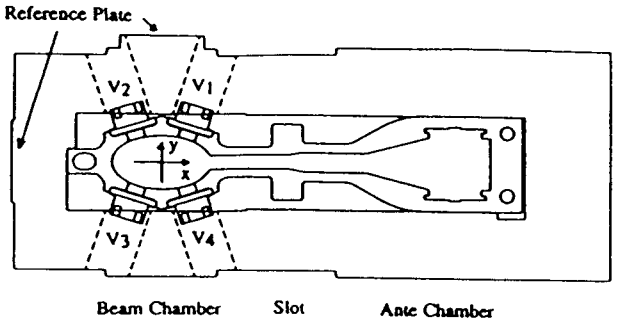

Fig. 1. The cross section of the storage ring vacuum chamber at a BPM.

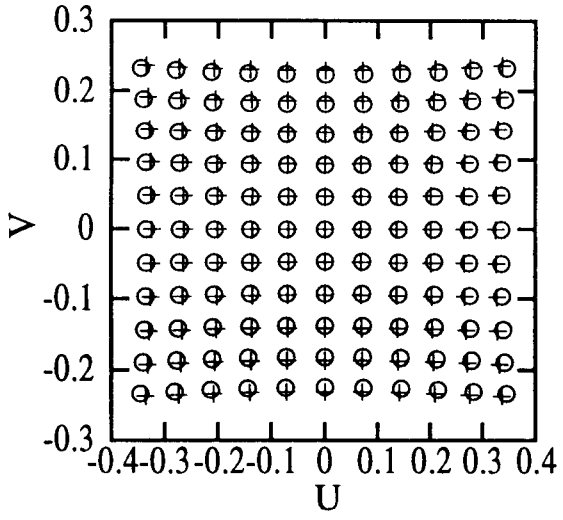

Fig. 2. The position sensitivities U and V measured with the antenna (open circles) and calculated theoretically (crosses).