Amman, June 2, 2005
Note: CD-1

BPM PICK UP POSITIONING FOR SESAME VACUUM CHAMBER

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I Introduction

Accurate beam positioning simplifies machine tuning and enables accurate diagnostics of machine under normal and abnormal conditions. Beam position monitors (BPM) for SESAME [1] storage ring consists of four pick up buttons. The *difference/sum* method for converting BPM signals to position works well for beams centered in the beam pipe, while nonlinearities show up at large displacements from the center. In order to reconstruct accurately the beam transverse position, 2D electrostatic sensitivity analysis of the BPM has been carried out for horizontal and vertical planes and for different relative horizontal spacing of the BPM head in the vacuum chamber. The note will present this analysis in details.

II SESAME BPM System

Overall, there are 32 BPM sets, four BPMs in each cell of the storage ring [2, 3]. They will be placed at the exit and entrance of each bending magnet and between sextupoles and quadrupoles, to measure the closed orbit distortion all around the ring. Fig.1 shows the optical functions and BPM location for the unit cell.

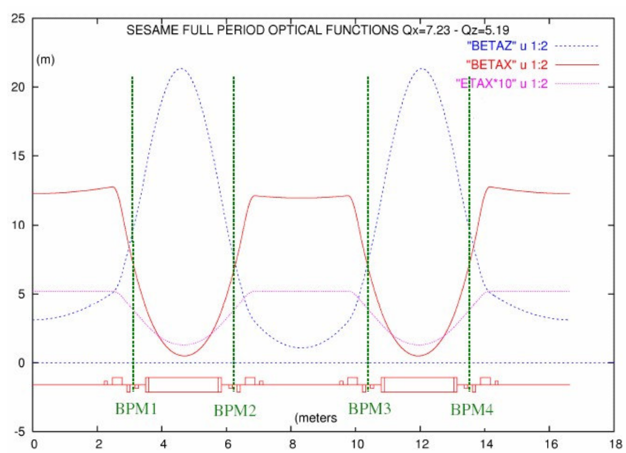

Figure 1: SESAME optical function and the BPM locations for the unit cell.

ESRF type capacitive buttons will be employed for SESAME BPM head. Each monitor consists of four button located symmetrically around the vacuum chamber. In order to reconstruct accurately the beam transverse position and recover the nonlinearity of transfer function, a sensitivity analysis has been carried out.

III 2D electrostatic Model

It can be shown that the determination of the signal induced by the beam on the button electrodes can be reduced, in case of relativistic beams, to a two dimensional electrostatic problem[4,5]. In this note we treat the charge and vacuum chamber in a 2D environment, furthermore the induced signals will have as DC electrostatic behavior. Vacuum chamber cross section and the BPM buttons position is shown in Fig. 2.

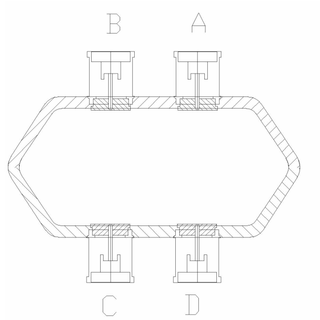

Figure 2: Vacuum chamber cross section and the BPM buttons position.

The electrical beam position in the horizontal/vertical plane is given by:

$$X = \frac{(Q_A + Q_D) - (Q_B + Q_C)}{(Q_A + Q_B + Q_C + Q_D)}$$

$$Y = \frac{(Q_A + Q_B) - (Q_C + Q_D)}{(Q_A + Q_B + Q_C + Q_D)}$$

where Q_A, Q_B, Q_C and Q_D are the induced charges on button electrodes. The physical beam position (x,y) is derived from a polynomial function of the electrical beam position (X,Y) by the following equation:

$$x = F_x(X,Y) = K_x(X,Y).X$$

$$y = F_y(X,Y) = K_y(X,Y).Y$$

where

$$K_x = \sum_{n=0}^{\infty}\sum_{m=0}^{\infty}\sum_{l=0}^{\infty} a_n.X^m.Y^l$$

and

$$K_y = \sum_{n=0}^{\infty}\sum_{m=0}^{\infty}\sum_{l=0}^{\infty} b_n.X^m.Y^l$$

Such functions allow, during machine operation, to reconstruct accurately the transverse beam position from the electrical position signals.

Fig. 3 shows the typical equipotential lines for a non-centered beam as given by a 2D POISSON simulation [6]. The data for each transverse position of electron beam has been collected and the electrical beam position has been obtained. The position sensitivity in each plane are obtained by the derivative (S_x and S_y) of the electrical position with respect to x and y.

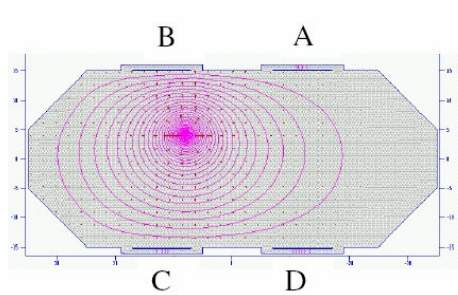

Figure 3: Poisson electrostatic analysis for a non-centered beam.

IV Results

Data obtained from electrostatic analysis, for many beam positions around the center with 2mm spacing between points, has been carried out. Fig. 4 shows the map position of the BPM configuration, when the horizontal distance between buttons (i.e. distance between A and B) is 30mm, while Fig. 5 shows the same analysis in case of a distance of 24 mm.

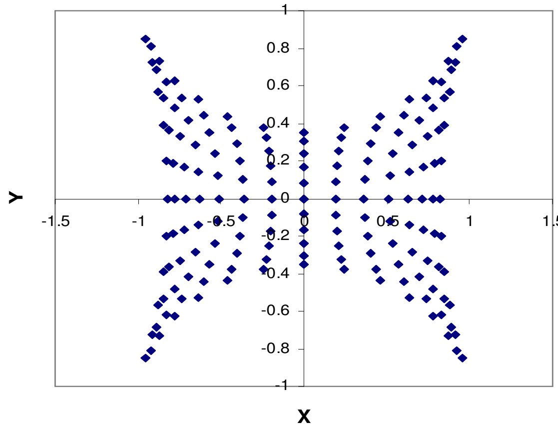

Figure 4: Position map with 30 mm Horizontal spacing (distance between dots is 2mm).

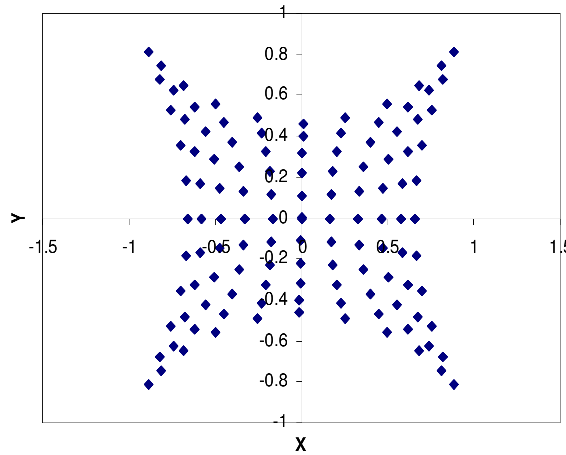

Figure 5: Position map with 24 mm Horizontal spacing (distance between dots is 2mm).

The sensitivity curves for x-direction and y-direction and for two different horizontal spacing of the buttons are given in Fig. 6 and Fig. 7.

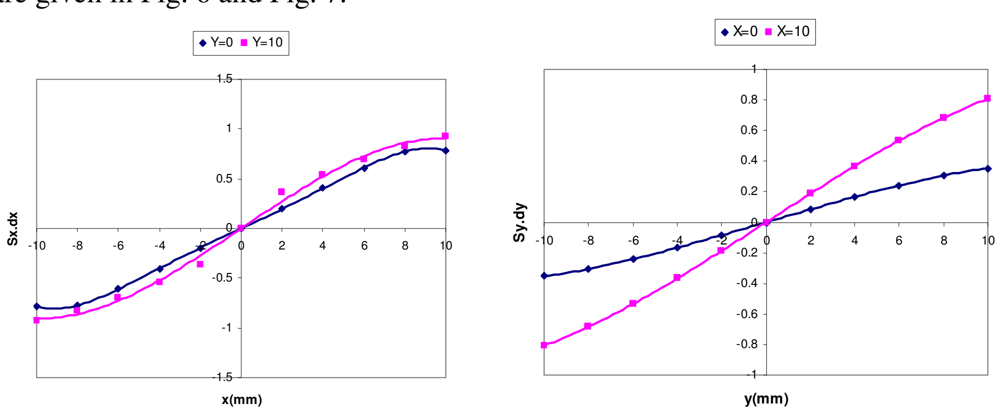

Figure 6: BPM sensitivity curves in the x and y directions for a horizontal spacing of 30 mm.

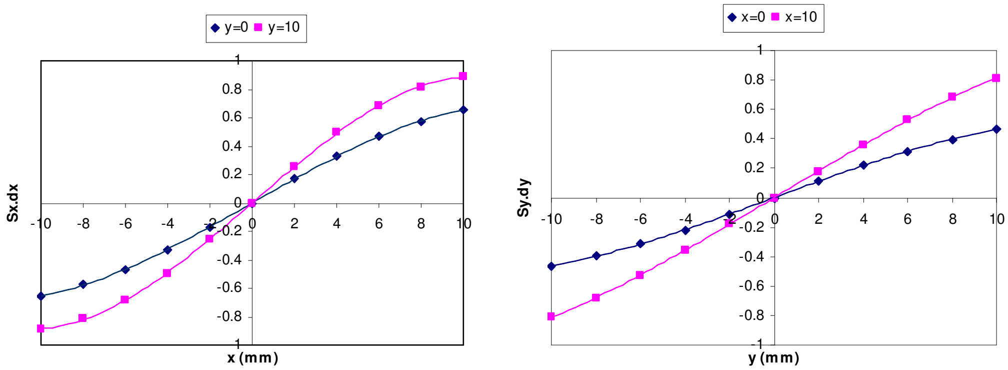

Figure 7: BPM sensitivity curves in the x and y directions for a horizontal spacing of 24 mm.

For a horizontal spacing of 24mm, the polynomial fitted to the analyzed points in the x-direction is given by:

$$F_x(X,Y)=11.73X+2.63X^3-19.66XY^3+12.35X^5+26.24X^3Y^2-2.03XY^4-13.77X^7-38.02X^5Y^2+32.07X^9$$

while in y-direction is given by:

$$F_y(X,Y)=17.64Y-21.17X^2Y+9.89Y^3+16.76X^4Y-25.29X^2Y^3+48.57Y^5-14.91X^4Y^3-48.55Y^7+33.94Y^9$$

The sensitivity at the center of the beam pipe is 8.5% per mm for the x-direction and 5.6% per mm for the y-direction.

VI Conclusion

The horizontal spacing of 24 mm has the best sensitivity between the many cases analyzed and it is the new proposed spacing for the BPM head.

VII References

[1] G.Vignola, et al. "SESAME in Jordan", PAC05, May 2005, US
[2] S.Varnasseri "The Beam Diagnostics for SESAME", DIPAC05, June 2005, France
[3] D.Einfeld et al. "SESAME Yellow Book" - May 2003
[4] A.Stella, "Analysis of the DAFNE Beam Position Monitor with a Boundary Element Method", DAΦNE Tech Note, Frascati, Dec. 97
[5] T.Shintake et al. "Sensitivity Calculation of Beam Position Monitor", Nuclear Instruments and Methods in Physical Research A254 (1987), pp146-150
[6] "Poisson Superfish Manual" LANL Document Server.