Design of Button Beam Position Monitor for the ILSF Booster

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Abstract

The Iranian Light Source Facility Booster is under de-sign with a 504 m circumference and will accelerate the electron bunches from 150 MeV to 3 GeV. the 50 button-type beam position monitors (BPMs) are considered the non-destructive tools to measure the beam position in the ILSF booster. In this paper, the design of the BPM for the ILSF booster is studied. The BPM blocks have 4 buttons (electrodes) that are placed at 45 degrees to the beam axis. to choose the best geometry, The BPMs with differ-ent button diameters and gaps are simulated by the CST Microwave Studio and BpmLab.

About the Design

In this design 4 electrodes are placed in the 45,135,225, and 315 degree in the housing that has the same diameter as booster vacuum chamber (diameter=33mm). 4 electrodes are isolated by ceramic (alumina). This system is matched with 50Ω impedance of the coaxial feed-throughs cables.

When the beam passes through the vacuum chamber, the image charge is induced on the electrodes. By determining the induced voltage on every electrode can obtain the beam position in the horizontal and vertical plane via the following formulas:

$$x = \frac{1}{S_x}\frac{U_{right}-U_{left}}{U_{right}+U_{left}} = \frac{1}{S_x}\frac{\Delta U_x}{\sum U_x} \quad (1)$$

$$y = \frac{1}{S_y}\frac{U_{up}-U_{down}}{U_{up}+U_{down}} = \frac{1}{S_y}\frac{\Delta U_y}{\sum U_y}$$

And button capacitance is given by:

$$C_b = \frac{2\pi\varepsilon_0 t}{\ln(\frac{d+g}{d})} \quad (2)$$

Where d is electrode diameter, t is button thickness and g is upper gap.

In this paper the BPMs with different electrode diameters and thicknesses, gap between the electrodes and housing (gap side) are simulated by the BpmLab with delta over sum approach and the CST Microwave Studio and to compare and choose the best design. (Although the Wakefield problem is not important in the Booster but can choose the best design).

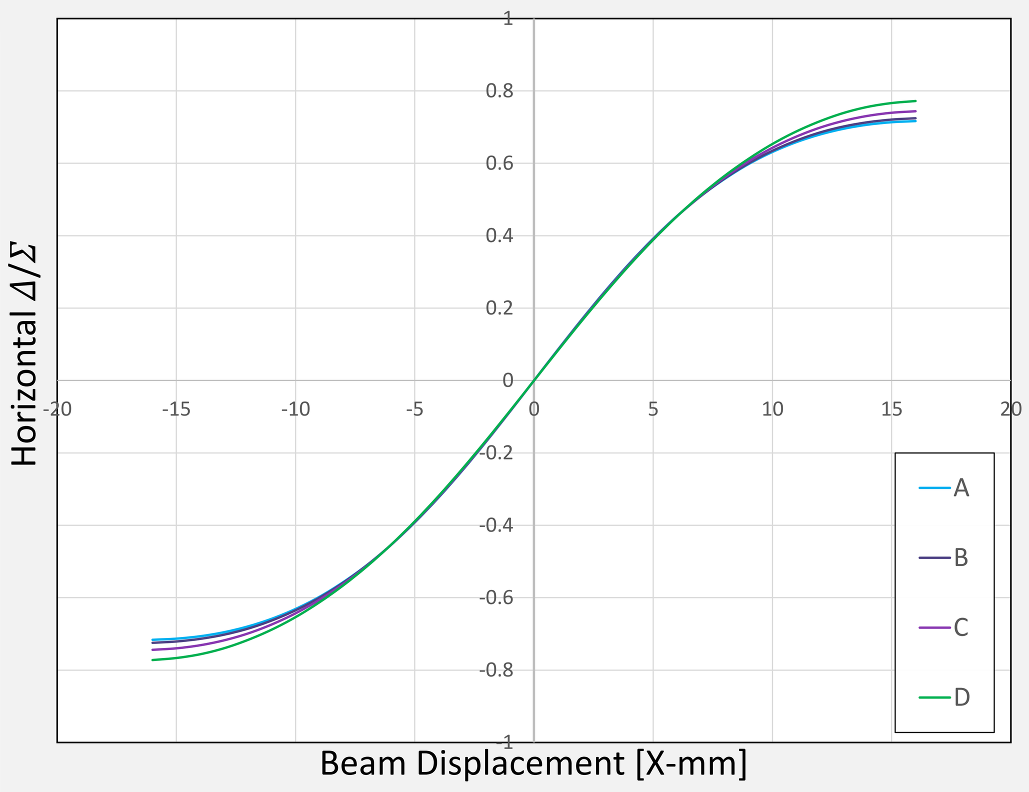


Figure 1: Position detection and BPM sensitivity by BPMlab.

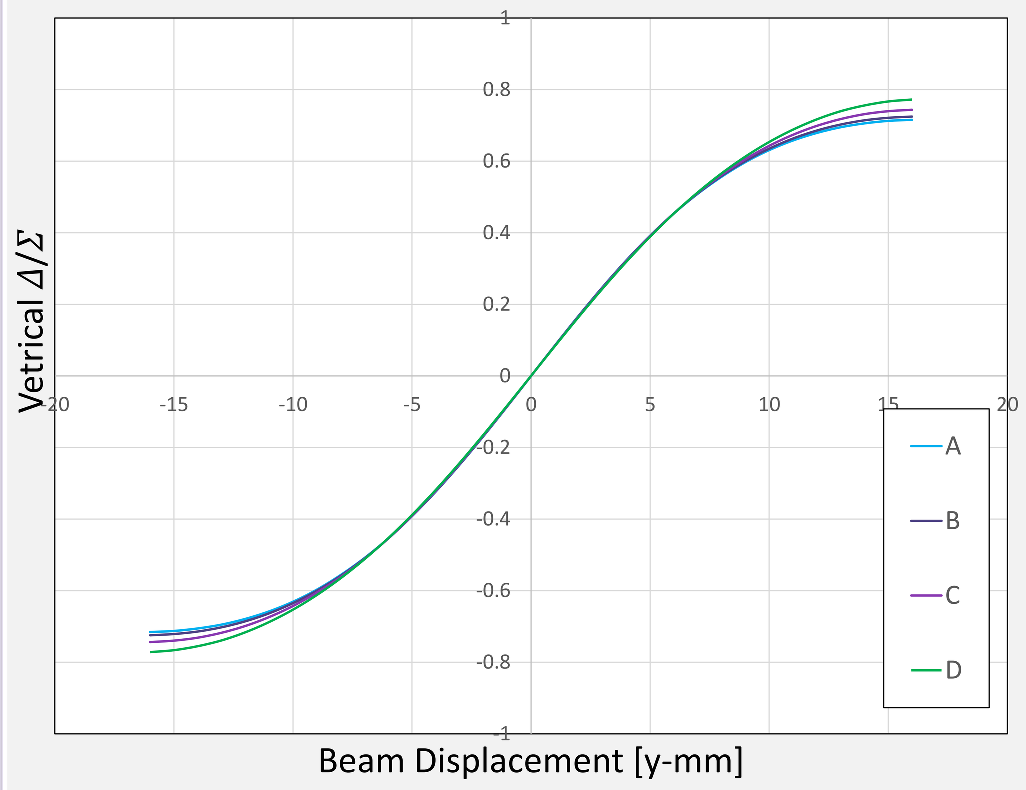


Figure 2: Position detection and BPM sensitivity by BPMlab.

Table 1: Design of button BPM for the ILSF booster with different button diameter

geometry	Design			
	A	B	C	D
Button diameter(mm)	5	7	10	13
Button thickness (mm)	4	4	4	4
side gap (mm)	0.3	0.3	0.3	0.3
upper gap (mm)	0.5	0.5	0.5	0.5
button capacitance (pF)	1.963	2.707	3.823	4.934

Table 2: Design of button BPM for the ILSF booster with different button thickness

geometry	Design		
	C	C2	C3
Button diameter(mm)	10	10	10
Button thickness (mm)	4	3	5
side gap (mm)	0.3	0.3	0.3
upper gap (mm)	0.5	0.5	0.5
button capacitance (pF)	3.823	2.864	4.773

Table 3: Design of button BPM for the ILSF booster with different side gap

geometry	Design			
	C	C4	C5	C6
Button diameter(mm)	10	10	10	10
Button thickness (mm)	4	4	4	4
side gap (mm)	0.3	0.2	0.4	0.5
upper gap (mm)	0.5	0.5	0.5	0.5
button capacitance (pF)	3.823	5.673	2.891	2.334

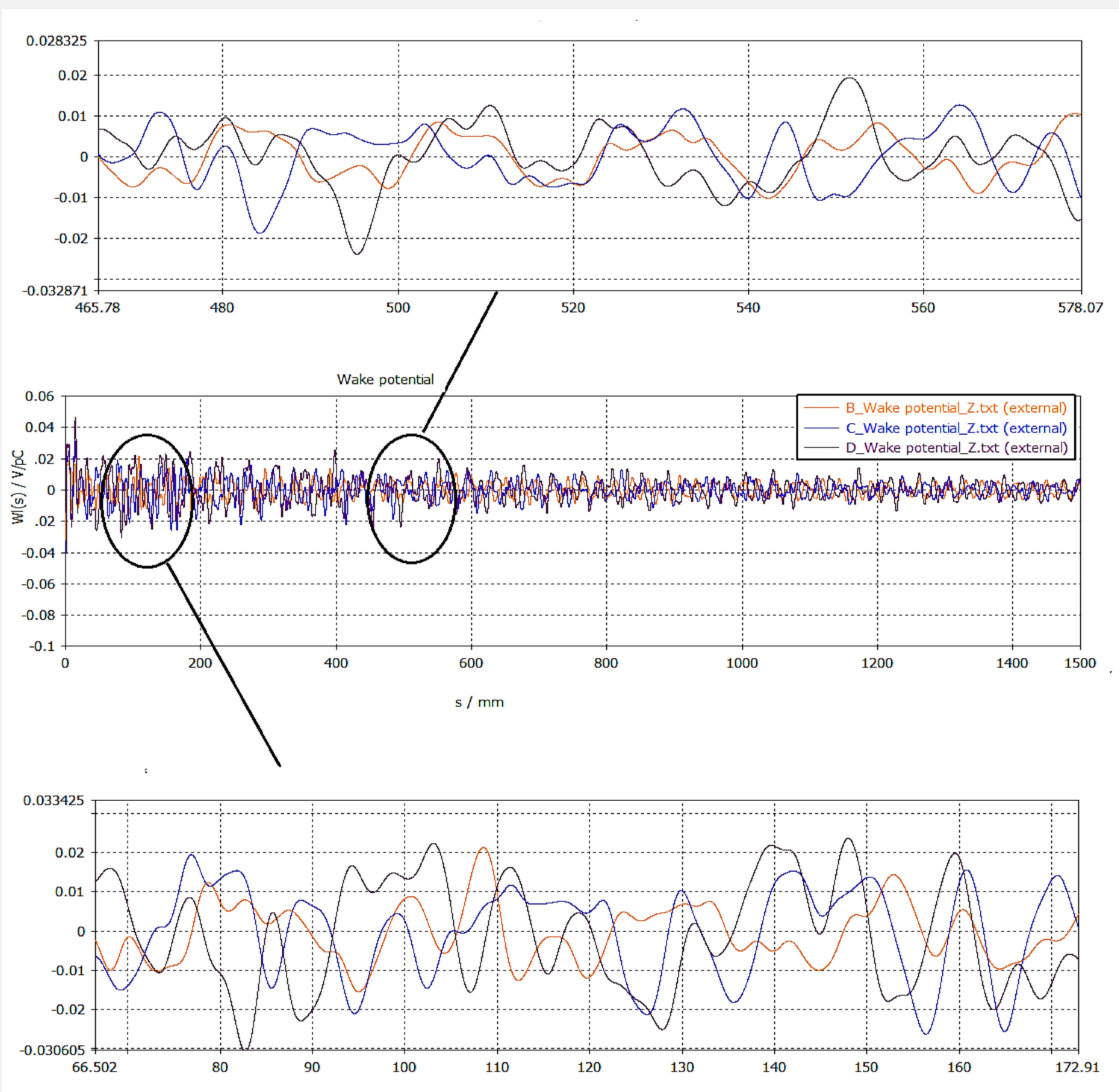


Figure 3: Wake potential for buuton bpm with table 1 parameter.

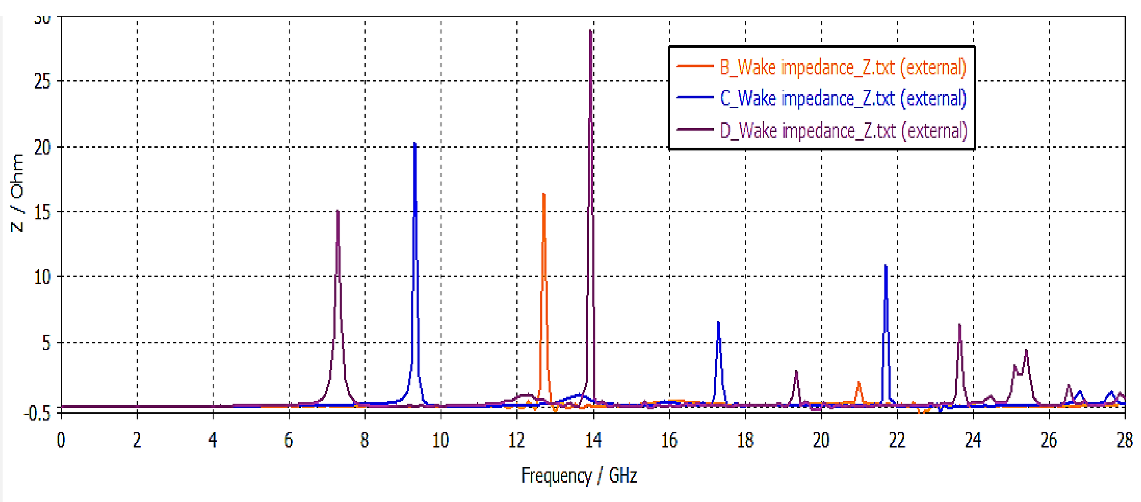


Figure 4: Longitudinal wake Impedance for button bpm with table 1 parameter.

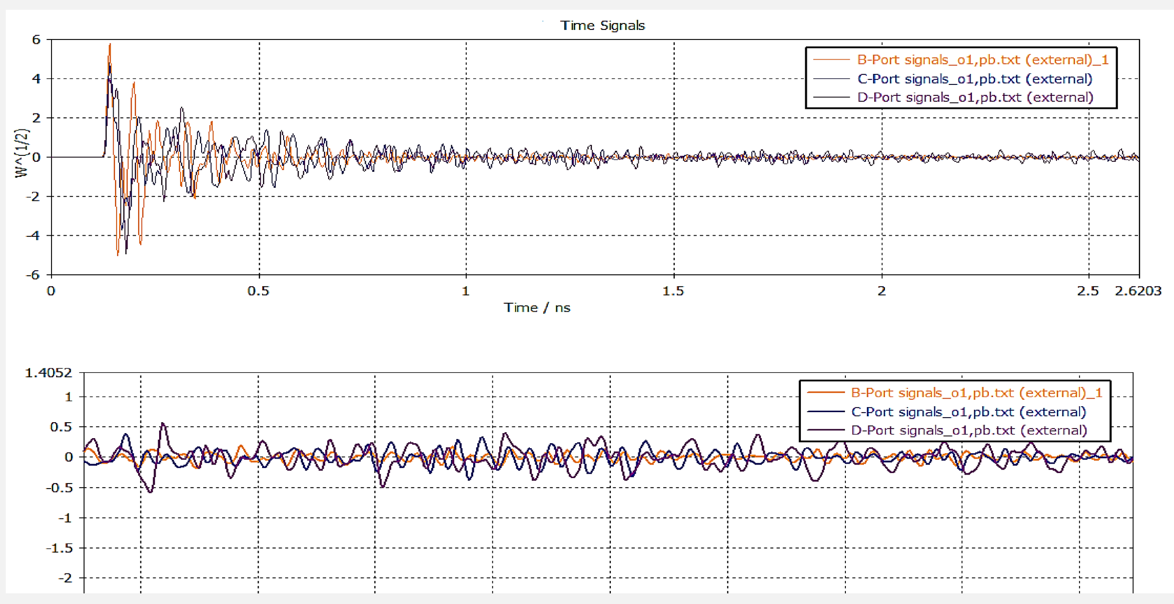
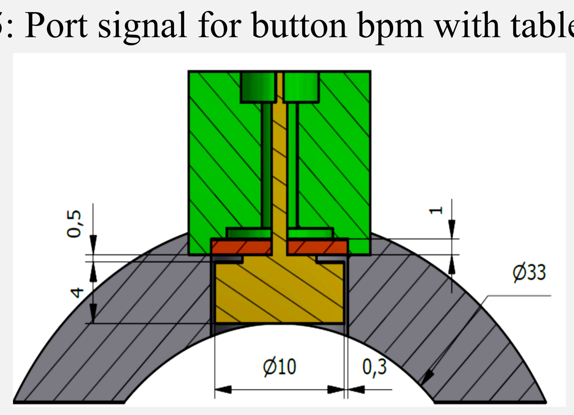


Figure 5: Port signal for button bpm with table 1 parameter.

The best design

The greater the thickness of the button, the higher the capacitance, and consequently, the lower the losses. The larger the radius, the higher the sensitivity. The smaller the gap, the lesser the effects related to HOM (higher capacitance and lower losses).

According to the mentioned points and the results of calculations and simulations. Design (C) is the chosen design for the ILSF booster



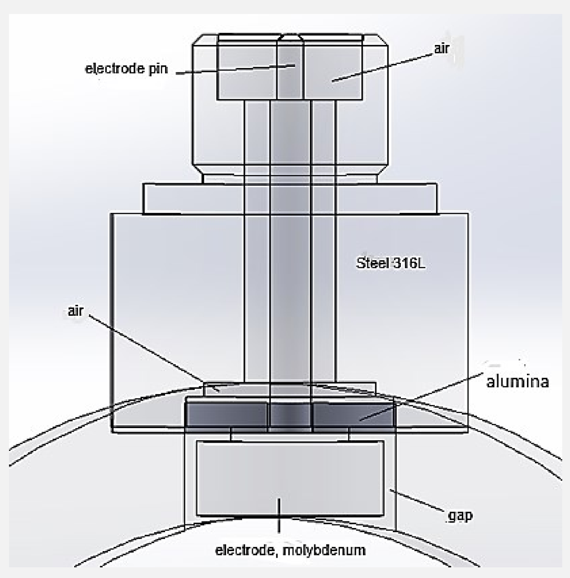


Figure 6: Overview of a Button BPM

Table 4: Geometry and Physical parameters of the ILSF button BPM

Design	Geometry parameters				
	Button diameter(mm)	Button thickness (mm)	side gap (mm)	upper gap (mm)	
C	10	4	0.3	0.5	
	Physical parameters				
	$S_x(0,0)$ $[\frac{1}{mm}]$	$S_y(0,0)$ $[\frac{1}{mm}]$	$K_x(0,0)$ $[mm]$	$K_y(0,0)$ $[mm]$	button capacitance (pF)
	0.0823	0.0822	12.45	12.546	3.823

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