WEPP28

HIGH-ACCURACY DIAGNOSTIC TOOL FOR BEAM POSITION MONITOR TROUBLESHOOTING IN SSRF BASED ON CLUSTERING ANALYSIS

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Abstract

Beam position monitors (BPMs) are important to monitor the beam moving steadily. In spite of some data is viewed and analysed, a large fraction of data has never been effectively analyzed in accelerator operation. It leads to some useful information not coming to the surface during the beam position monitor troubleshooting processing.

We will describe in this paper our efforts to use clustering analysis techniques to pull out new information from existing beam data. Our focus has been to look at malfunction of BPMs, associating basic running data that is β oscillation of X and Y directions, energy oscillation and doing predictive analysis. Clustering analysis results showed that 140 BPMs could be classified into normal group and fault group. The abnormal BPMs could be separated and the potentially damageable BPMs (boundary BPMs) also be detected. Based on the results, the algorithm could locate fault BPM and it could be an effective supplement for data analysis in accelerator physics.

Background

- Beam Position Monitor (BPM) system is an essential diagnostic tool in storage ring of a light source.
- A typical BPM system consists of the probe (button-type or stripline-type), electronics (Libra Electronics/Brilliance in SSRF) and transferring component (cables and such).
- BPM have occurred all kinds of malfunction. They were permanently damage of individual probe or corresponding cable, misaligned (position/angle) probes, high-frequency vibrations, electronics noise. Meanwhile, the ageing BPMs could result in poor performance in monitoring beam conditions.
- It is essential to find an effective method to detect the faulty BPM and the potentially damageable BPMs .

Beam experiment

Experiment data

- The experimental data were collected from the BPM turn-by-turn (TBT) data under the different beam intensity.
- Beam intensity, respectively, are 69 mA 73 mA 78 mA 88 mA 90 mA 96 mA 100mA 104mA 108 mA 111 mA 115 mA 120 mA 124 mA 130 mA 134 mA 140 mA 144 mA 157 mA.

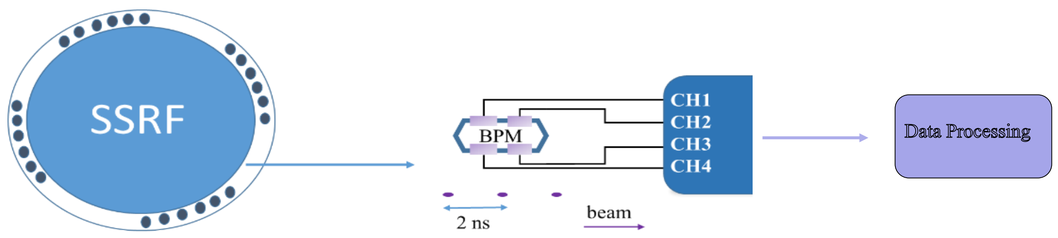


Figure 1: Architecture of data acquisition

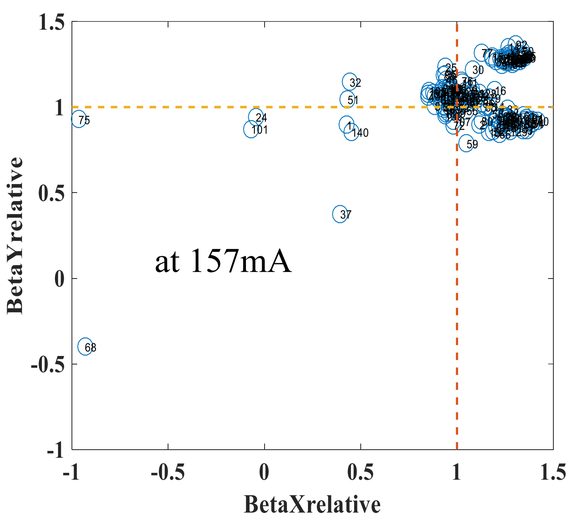


Figure 2: Scatter diagram based on transverse oscillation of X and Y direction

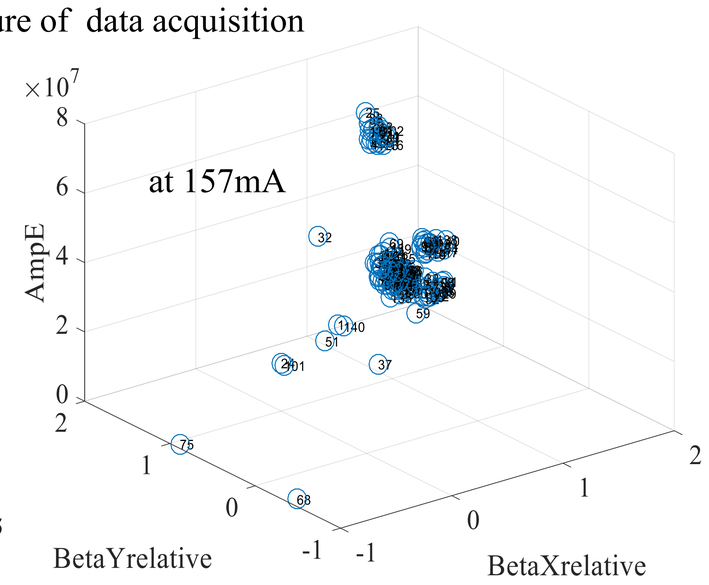


Figure 3: Scatter diagram based on transverse oscillation of X， Y direction and energy oscillation

Multi-dimensional clustering analysis model

- High δ and relatively High ρ are the cluster centers
- High δ and relatively low ρ is abnormal value
- The boundary BPMs may be the potentially damageable BPMs .

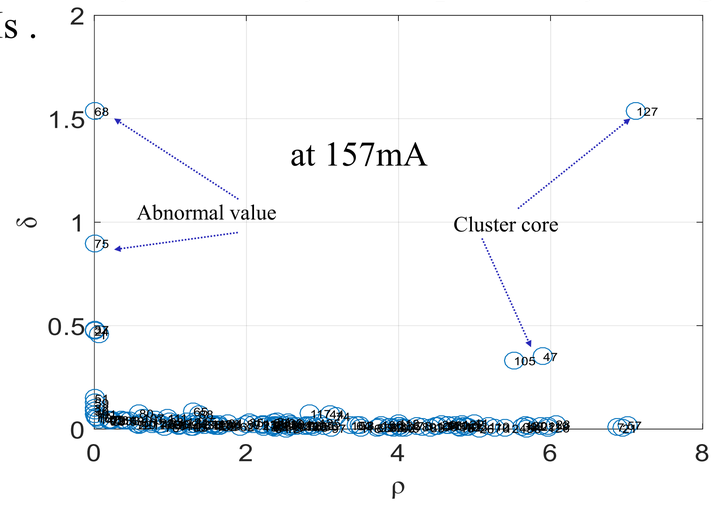


Figure 4: Decision graph

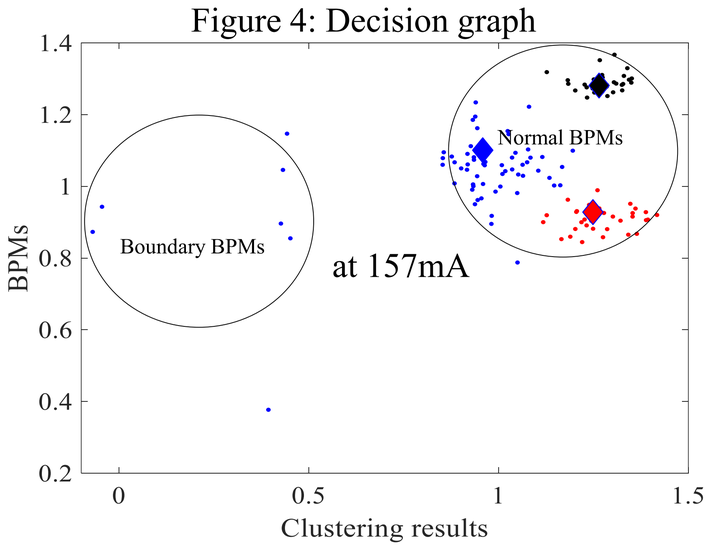
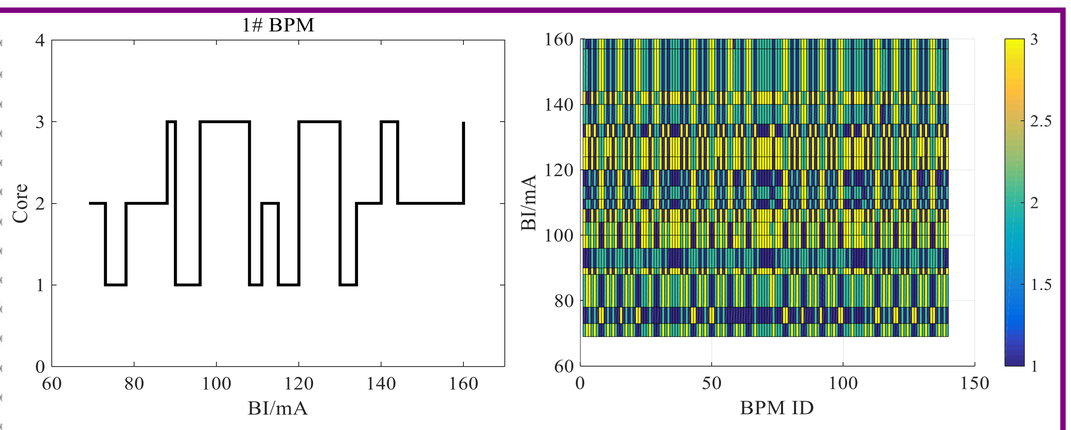


Figure 5: Clustering results for all BPMs

The performance differences of different BPMs

BI/mA	Faulty BPMs		Cluster Cores			Boundary BPMs						
157mA	68#	75#	47#	105#	127#	1#	24#	32#	37#	51#	101#	140#
144 mA	68#	75#	108#	118#	119#	1#	24#	32#	37#	51#	101#	140#
140 mA	68#	75#	42#	38#	105#	1#	24#	32#	37#	51#	101#	140#
134 mA	68#	75#	70#	91#	47#	1#	24#	32#	37#	51#	101#	140#
130 mA	68#	75#	76#	78#	110#	1#	24#	32#	37#	51#	101#	140#
124 mA	68#	75#	40#	77#	97#	1#	24#	32#	37#	51#	101#	140#
120 mA	68#	75#	47#	49#	70#	1#	24#	32#	37#	51#	101#	140#
115 mA	68#	75#	53#	110#	126#	1#	24#	32#	37#	51#	101#	140#
111 mA	68#	75#	5#	6#	133#	1#	24#	32#	37#	51#	101#	140#
108 mA	68#	75#	6#	47#	57#	1#	24#	32#	37#	51#	101#	140#
104 mA	68#	75#	5#	8#	71#	1#	24#	32#	37#	51#	101#	140#
100 mA	68#	75#	29#	73#	83#	1#	24#	32#	37#	51#	101#	140#
96 mA	68#	75#	29#	31#	106#	1#	24#	32#	37#	51#	101#	140#
90 mA	68#	75#	26#	126#		1#	24#	32#	37#	51#	101#	140#
88 mA	68#	75#	26#	29#	118#	1#	24#	32#	37#	51#	101#	140#
78 mA	68#	75#	8#	53#	89#	1#	24#	32#	37#	51#	101#	140#
73 mA	68#	75#	35#	38#	126#	1#	24#	32#	37#	51#	101#	140#
69 mA	68#	75#	57#	106#	122#	1#	24#	32#	37#	51#	101#	140#

Table 1: Clustering results for all BPMs



- The 68# and 75# are faulty BPMs.
- The boundary BPMs are the same at different Beam intensity, means may be the potentially damageable BPMs
- Normal BPM belongs to which clusters depending on the beam intensity

Conclusion

- The method could depict the faulty BPMs and find the number of clusters.
- Boundary BPMs may be the potentially damageable BPMs
- Whether the three categories belong to one big category, it needs to further study..

[1] Rodriguez et al., Clustering by fast search and find of density peaks. Science, vol.344, no.6191, pp. 1492, 2014.
[2] Leng Y B et al., Beam position monitor system for SSRF storage ring, Nucl Sci Tech, vol.33, no.6, pp.401–404, 2012
[3] Cheng Z C et al., Performance evaluation of BPM system in SSRF using PCA method. CPC, vol.38, no.6, pp. 112-116, 2014.