IBIC 2020 International Beam Instrumentation Conference

Newly designed Inclined X-ray Beam Position Monitors to Reduce Influence of Filling Pattern for the SPring-8 Photon Beamlines

SPring-8

2020/09/15

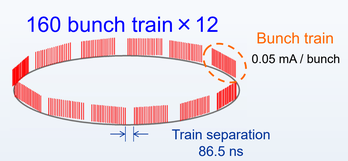
TUPP06

Hideki Aoyagi , Yukito Furukawa , Sunao Takahashi
Japan Synchrotron Radiation Research Institute (JASRI/SPring-8)

Abstract

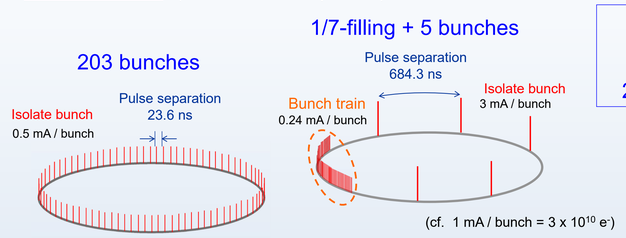
The X-ray beam position monitors (XBPMs) at SPring-8 operate in photoemission mode equipped with blade-shaped detecting elements. **Influence of bunch filling patterns** on XBPM performance increased year by year as bunch current in the storage ring increased. We have performed a systematic evaluation of the influence of the filling patterns. We found that the cause of the influence is suppression of the XBPM current signal due to the **space charge effect**, and that it can be quantified by observing the behaviour of the current signal while changing the voltage of a photoelectron collection electrode. We have designed and manufactured **new blade-shaped detecting elements in inclined configuration** for the purpose of mitigation the space charge effect. It has been demonstrated that the influence of filling patterns is reduced to a few μm. We also report that, as a result of a series of efforts against existing XBPMs for all ID beamlines, the influence has been reduced to approximately 5 μm RMS.

Multi bunch (Long life, CW beam)



Multi-bunch mode is a filling pattern that places the least load on the accelerator beam operation.

Several Bunch (for Time-resolved experiment)



Other SeveralBbunches

- 11 bunch train × 29
- 11 / 29 - filling + 1 bunch
- 2 / 29 - filling + 26 bunches

Circumference:	1,436 m
RF frequency:	508 MHz
Harmonic number:	2,436
Shortest pulse interval:	2.0 ns
Ring current:	100 mA

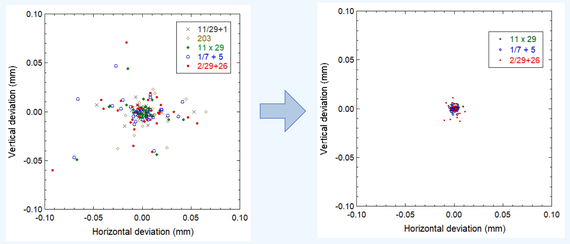
Introduction

The X-ray beam position monitors (XBPMs) in SPring-8 are **photoemission type** that is equipped with four blade-shaped detection elements made of tungsten as photocathodes.

SPring-8 constantly provides various **several-bunch mode operations**, which combine single bunches (isolated bunces) and train bunches (partial full-filling). The **influence of filling patterns** on XBPM performances increased year by year.

Influence of Filling Pattern with Existing Parallel-XBPMs

We evaluated the XBPM readouts in five types of several-bunch modes systematically using that in **multi-bunch mode as the reference data**.

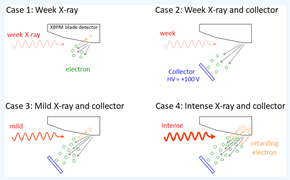


(a) Before the series of measures (b) After the series of measures

Figure 1: Deviations of XBPM readouts from the reference positions (multi-bunch) due to variations of five different filling patterns of the storage ring.

Space Charge Effect

We presumed that the cause was **space charge effect** of photoelectrons near the surface of blade detectors.



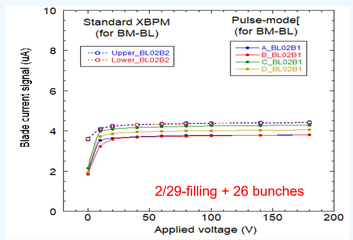
Therefore, we changed the operating points to confirm whether the influence of filling pattern can be reduced.

Major changes:
(1) Applied voltage of the photoelectron collecting electrodes.
(HV = +100V -> +500V)
(2) Insertion devise (ID) gaps for fixed point observations (FPO).

Table 1: Bunch Current and the Deviation of the Readouts of Existing XBPMs and New XBPM

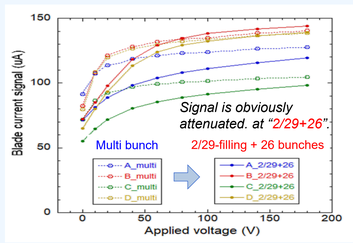
Filling pattern	Bunch train (mA/bunch)	Isolated bunch (mA/bunch)	ID-BL (μm RMS) before		ID-BL (μm RMS) after		BM-BL (μm RMS)		Inclined XBPM (μm)	
			Horizontal	Vertical	Horizontal	Vertical	Vertical		Horizontal	Vertical
Multi	0.05	—	3.6	2.0			1.3			
11/29 + 1	0.10	5.0	13.9	5.8			3.0			
203	—	0.5	17.6	12.6			6.0			
11 x 29	0.31	—	27.7	14.6	2.7	2.0	4.3	→ 2.2		
1/7 + 5	0.24	3.0	33.5	15.2	2.4	2.1	5.4	→ 2.7		
2/29 + 26	0.38	1.4	40.3	20.5	4.3	5.6	8.0	→ 6.0 → 3.0	3.4	1.1

Applied Voltage Curve of Collecting Electrodes with Existing Parallel-XBPMs



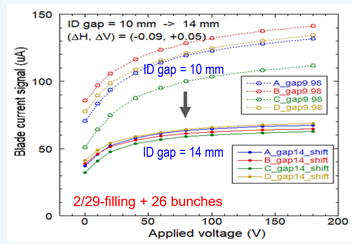
BM-BL (BL02B1, 02B2)

If the current signal is small, the lower limit of the plateau region is sufficiently low.



ID-BL (16XU)

Several bunch (2/29 + 26) clearly has a higher lower limit of the plateau region compared to multi-bunch.

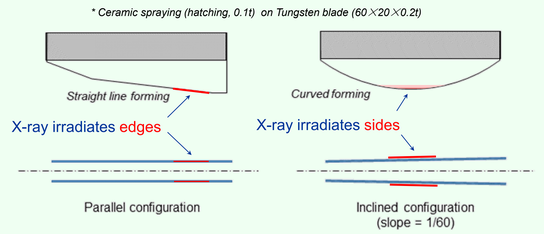


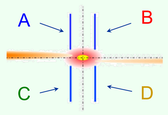
ID-BL (BL22XU)

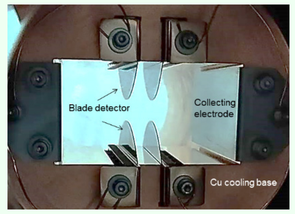
When the ID gap is widened, the influence of the space charge effect is suppressed.

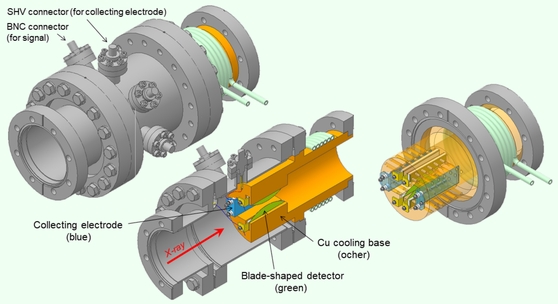
Insertion Devise (ID)
Bending Magnet (BM)
Beam Line (BL)

Structure of New Inclined-XBPM



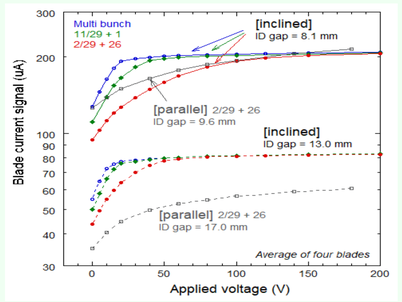






Applied Voltage Curve of Collecting Electrodes with New Inclined-XBPM

The lower limit voltage of the plateau region becomes higher as the operating mode (several-bunch) has a greater influence or the ID gap is further closed to increase the blade current signal.



New inclined-XBPM has greater effect than the existing parallel-XBPMs in reducing the influence of filling pattern.

Table 2: Deviation of the Readouts of New Inclined-XBPMs

Condition		Deference of readouts from Multi bunch	
ID gap (mm)	XBPM HV (V)	Dx (μm)	Dy (μm)
13.0 (FPO gap)	100	4.5	1.0
	500	-1.5	1.0
8.1 (min. ID gap)	100	-5.0	-1.5
	500	0.0	1.0

3.4 μm RMS 1.1 μm RMS

Influence of the filling pattern is sufficiently small when the applied voltage is +500V.

Conclusion

- Using the existing **parallel-XBPM**, we succeeded in suppressing the influences of the filling pattern ("space charge effect") to less than several μm in RMS after taking a series of measures.
- **Inclined-XBPM** was newly designed and manufactured to solve the problem fundamentally. We performed evaluation tests and demonstrated that the influence of filling pattern can be sufficiently reduced.