Beam Loss Monitoring in HIMAC with Fiber Optic Radiation Monitor

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Abstract

Beam loss was measured in HIMAC with Fiber Optic Radiation Monitor. Fiber Optic Radiation Monitor can measure the radiation distribution continuously along the sensor cable made of scintillation fiber. Position and intensity of beam] loss were measured in various operating condition and time structure of beam loss was consistent with the signal wave form from ripple monitor.

1 Introduction

It is very important for an accelerator operation to reduce a beam loss as low as possible. The beam loss monitor has been developed with Fiber Optic Radiation Monitor[1,2], which continuously detects the beam loss position along the beam duct . The sensor of the monitor is a scintillation fiber with cable structure. It is installed on the outer beam duct, and detects the radiation generated when the beam hits the duct surface. The preliminary experimental result in HIMAC[3] is reported in this paper.

2 Fiber Optic Radiation Monitor

2.1 Principle of detection

Fiber Optic Radiation Monitor can measure the radiation distribution along the sensor. Time of Flight Method is applied for distribution measurement, i.e., for the detection of incident position of radiation. Figure1 shows the principle of detection in Fiber Optic Radiation Monitor.

When radiation enters the scintillation fiber, the interaction between core material and the radiation causes scintillation within the core. Scintillation light pulse is propagated towards both ends of the fiber, and received by each photo-multiplier. As the propagation time depends on the distance between the incident point of the radiation and the photo-multiplier, it is possible to determine the incident point of the radiation by measuring the propagation time difference. [This method is known as the Time of Flight (TOF) method]. In addition, by counting all the optical pulses, the radiation dose rate can be computed.

2.2 Features and Specification

Beam loss monitoring with Fiber Optic Radiation Monitor has following features.

(1) Reduction of beam adjustment time

With the detection of the beam loss position along the beam duct, the magnet which has to be adjusted is easily identified and the result of adjusting is measured on real-time.

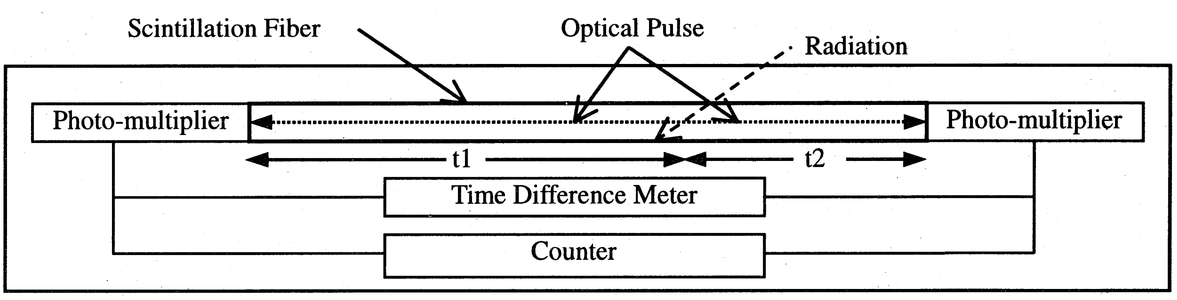

Fig.1 Principle of Fiber Optic Radiation Monitor

(2)Reduction of activation in facility

As beam duct is activated by high energy beam, the reduction of beam loss leads to the reduction of activation in the facility and of the exposure of operators.

(3)Non-destructive monitoring

The beam loss monitor is installed along the outside of beam duct and gives no influence to beam condition.

(4)Applicable to high-voltage and high frequency facility

Signals are transmitted in light pulse, so electromagnetic noise immunity allows this monitor to be applied in high-voltage or high-frequency facility.

Specification of the monitor is summarized at Table.1.

Table.1 Specification

Item	Specification
Type of radiation	X-ray or Gamma-ray
Measuring Range	1 to 10^4uSv/h
Energy Range	600KeV to 1.3MeV
Operating Temperature	0 to 50 degree Celsius
Effective sensing length	20m
Sensor radius	15mm
Sensor cable length	60m

3 Experiment

The sensor was installed along the beam extraction line in HIMAC synchrotron. It was chosen as the monitoring position of the beam loss, as shown in Fig.2, because a beam is lost at the septum of the electrostatic deflector(ESD).

The sensor and measuring unit were placed in the accelerator area, the data processing unit in control room, and each unit were connected with co-axial cable.

Following tests were carried out in various operating conditions with 290MeV/u Carbon beam.

(1) Beam loss detection with the insertion of ripple monitor(RMON) or profile monitor(PRN).

(2) Beam loss detection in the adjustment of steering magnet and focusing magnet.

(3) In maximum beam intensity

(4) Time structure of beam loss

4 Results and discussions

4.1 Insertion of Profile monitor

Back ground level shows the peak at ESD position in Figure.3 and this means that the wall has been activated by the beam at ESD position.

The position and intensity of beam loss is shown in Figure 4 in normal operation.

Beam loss was observed at the ESD position in normal operation, because a part of the beam was lost (cut) inevitably by the septum of the ESD due to the resonant-extraction process.

The position and intensity of beam loss in the insertion of profile monitor in normal operation is shown in Figure 5. Beam loss was observed at near downstream of profile monitor. Profile monitor has two aluminum-windows with thickness of 300um and two lattice-structure electrodes with diameter of 20 and 50 um, respectively. Thus beam scattered by the profile monitor hits the beam duct at various magnet positions and X-ray and gamma-ray are emitted.

4.2 Adjustment of Focusing magnet

Figure 6 shows the beam loss in the condition of focusing magnet's power turning off.

Focusing magnet(QF) is designed to adjust the beam profile. By turning Focusing magnet's power off, the beam spreads out as it goes downstream; and beam loss was detected at about 4m downstream position in Fig.6.

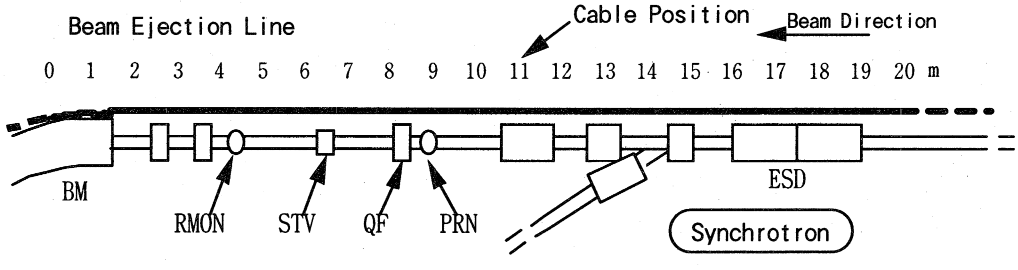

Fig.2 Installing position of sensor

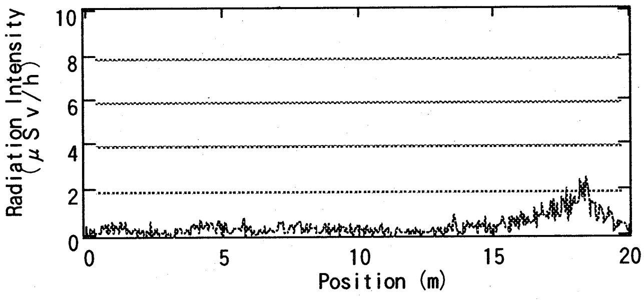

Fig.3 Background

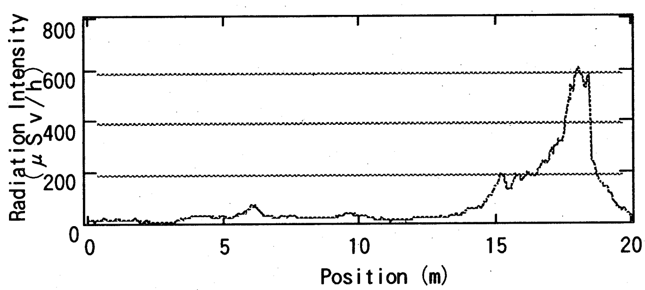

Fig.4 Beam loss in stable condition

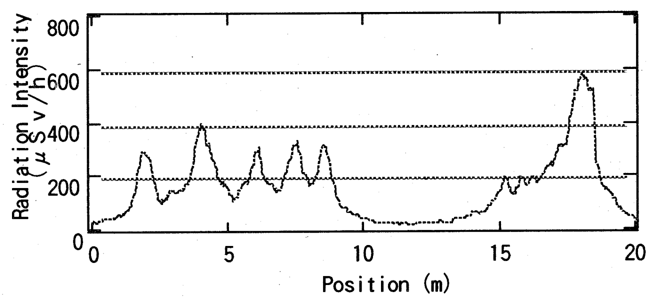

Fig.5 Insertion of profile monitor

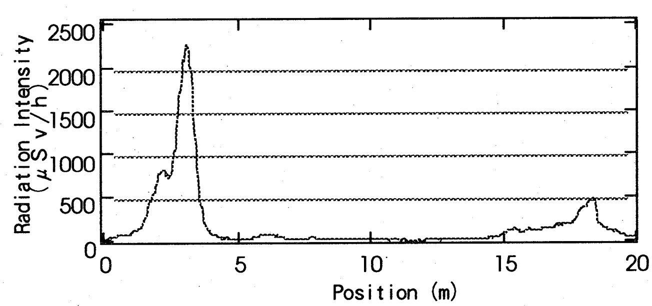

Fig.6 Focusing magnet turning off

4.3 Time structure of beam loss

The time structure of beam loss is shown in Fig.7.

The beam was extracted at a cycle of 3.3 second. The amount of beam loss was measured at an interval of 150ms synchronizing with the extraction. The measurement of time structure was consistent with the signal wave form from the ripple monitor.

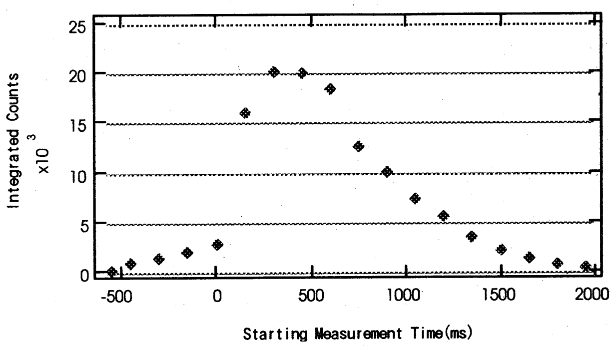

Fig.7 Time structure of beam loss

5 Conclusion

Fiber Optic Radiation Monitor with the detection length of 20m was installed on the beam extraction line in HIMAC synchrotron and the beam loss was measured.

It was possible to detect the position and intensity of beam loss by detecting the radiation emitted when the beam hits the beam duct.

Time structure synchronizing with the beam extraction signal was also measured and consistent with the signal wave form from ripple monitor.

Thus it was found that the beam loss monitor was useful tool for beam tuning.

References

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[3]E.TAKEDA et al., PROC. 5th EPAC, BARCELONA, 1996, p.2659-2661