OPTICAL PROFILE MONITOR FOR KEKB INJECTOR LINAC

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Abstract

In order to measure a two-dimensional beam profiles at the injector linac for KEKB, two optical-profile monitors using visible synchrotron radiation (SR) are installed in the last bending magnet of 180°arc section and third bending magnet of the ECS. The monitor consists of a quartz SR-extraction mirror, focusing lens and CCD camera. The entire setups of two monitors are set inside the accelerator tunnel. The obtained images of the beam are relayed back to the control room for continuous non-destructive measurements of beam profiles.

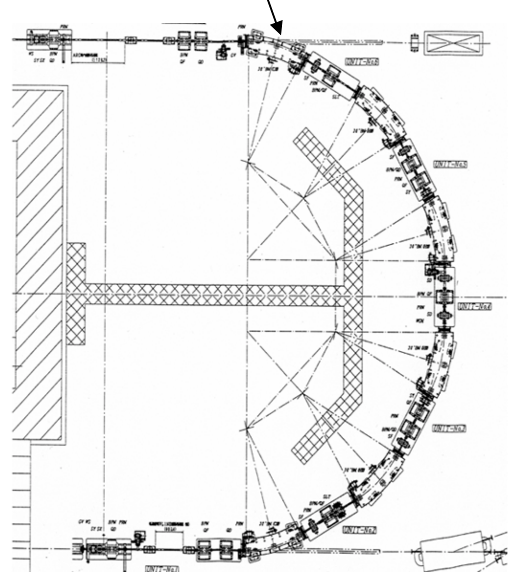
1 INTRODUCTION

The observation of beam profile improve the efficiency of the commissioning of the injector linac of KEKB project. Especially, it is important to know that the beam profile at 180° arc section for the regulation of the energy spread of primary electron beam for the generation of positron beams [1]. For this purpose, we installed wire scanners [2] at 180°arec section. But with the wire scanner, we can only observe a profile of a projection of the beam profile. Since in the wire scanner measurement needs scanning of the wire, we cannot measure a pulse by pulse beam profile. To observe a pulse by pulse two-dimensional beam profile, we installed a beam profile monitor based on an imaging the synchrotron radiation. Two optical-profile monitors are installed in the last bending magnet of 180°arc section and third bending magnet of the ECS. Since the dispersion function at these source points are m and m. We can estimate the energy spread of the beam from the beam profiles taken at these source points. The visible-SR beam from bending magnet is extracted by a quartz mirror. Then extracted visible SR beam is relayed to focussing lens by mirror. An image of the electron beam is observed with a CCD camera. The obtained images of beam are relayed back to the control room for continuous non-destructive measurements of beam profiles.

2 MONITOR LOCATION AND EXTRACTION OF VISIBLE SR

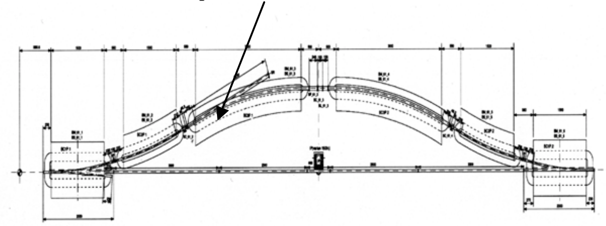
Two optical-profile monitors are constructed and installed in the last bending magnet of 180°arc section and third bending magnet of the ECS. The locations of source points for the monitors are shown in Fig 1. The parameters of source points are listed in Table 1. The SR beam is extracted through a special vacuum duct for the bending magnet which has a branch beam duct. An extraction mirror chamber is set at the end of the branch duct. Due to the pulse operation of linac, the mean powers for the extraction mirror are only 3.9 μW and 3.2 μW. Since the power of the SR is so small, it is no need to use a water-cooled extraction mirror such as used in conventional optical-profile monitor in the storage ring. By this reason, we applied an aluminium-coated quartz mirror having a optical quality of λ/10. The one extraction mirror set at 1340mm from the source point in the bending magnet of 180°arc section and another mirror set at 2990mm from the source point in the bending magnet of the ECS.

Source point of monitor for 180°arc section



(a) Monitor for180°arc section.

Source point of monitor for ECS



(b) Monitor for ECS.

Figure 1: Locations of SR source points for monitors.

The visible SR beam is reflected down by extraction mirror, and it relayed to a focussing lens system by another mirror as shown in Fig.2. The optical path is closed by aluminium tube (not evacuated) to eliminate the fluctuation of the air density.

Table 1: Parameters of the source points

	180°arc	ECS
Bending radius	3.57m	8.0m
Beam energy	1.6GeV	3.5GeVT
Mean power of SR	3.9μW	3.2μW
β-function	0.36m	9.4m
η-function	0.36m	0.85m

3 IMAGING SYSTEM

A beam profile monitor [3] based on a focusing system is set inside of a dark box which is fixed on the accelerator floor. The focussing system consists of a diffraction limited doublet lens as an objective lens. The diameter and the focussing length of objective lens are 80mm and 300mm, respectively. The conjugation ratios of the objective lenses are set 0.154 in the monitor for the 180°arc section and 0.103 in the monitor for the ECS. A quadrant slit is applied just in front of the objective lens to define the entrance aperture. A band-pass filter having a band width of 10nm is applied to obtain a quasi-monochromatic lay at the wavelength of 550nm. A dichroic-sheet polarizer is applied to choose a σ-polarization component. A variable ND filter is applied to optimize the intensity of the image. The expected beam size at the both source points are order of 1-2cm. The conjugation ratio of objective lens is large enough for this beam size, and we do not need further magnification of the beam image. An outline of the optical layout is shown in Fig. 2.

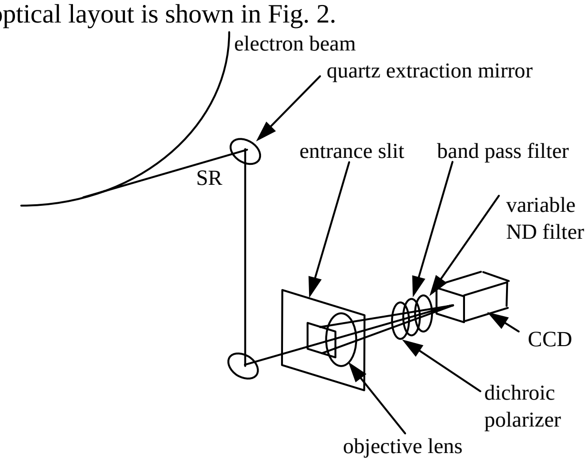


Figure 2: Outline of the optical layout.

For the observation of beam image, a CCD camera is set on a linear stage at the direct focussing point of objective lens. The CCD camera can move ± 25mm for the purpose of the adjustment of focus.

The obtained images of the beam profile are relayed back to the control room for continuous non-destructive measurements of beam profiles. A closed dark box (not evacuated) is applied to contain the imaging optics. The dark box is shielded by lead blocks to avoid the damages to optical components and CCD camera from strong radiation inside the accelerator tunnel.

4 OBSERVATION OF BEAM PROFILES

The two-dimensional beam profiles are observed at two source points in the last bending magnet of 180°arc section and third bending magnet of the ECS. The linac is operated with 5Hz. The results are shown in figures 3 and 4.

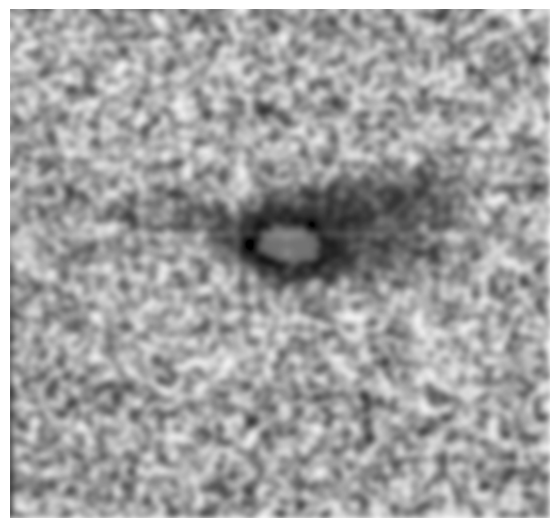


Figure 3: Observed beam profile at the source point in the last bending magnet of 180° arc section.

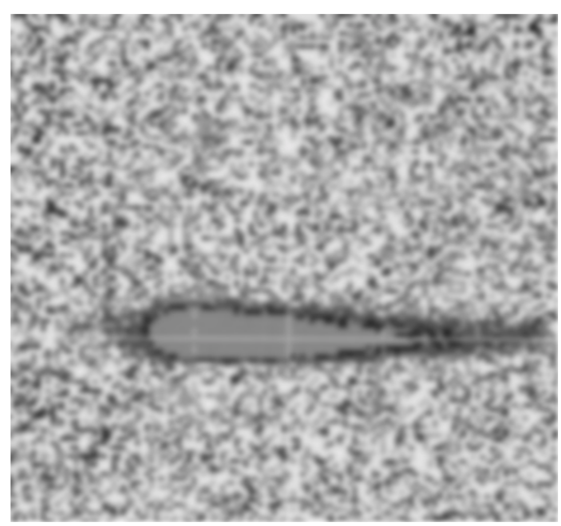


Figure 4: Observed beam profile at the source point in the third bending magnet of ECS.

From Fig.3, we can clearly see a two-dimensional distribution of beam tail at the source point in last bending magnet of 180°arc section. At the source point in third bending magnet of the ECS, a long beam-profile in horizontal direction due to energy spread is observed.

5 COMPARISON WITH RESULTS OF WIRE SCANNER

We compare the observed beam profile and a result of the wire scanner at 180°arc section. Figure 5 shows one result of beam profile and horizontal distribution of the profile.

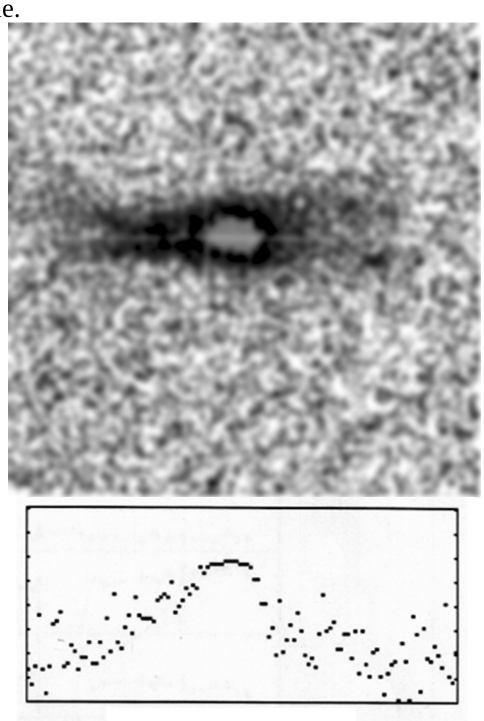
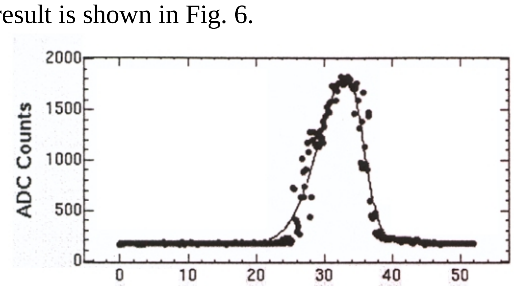


Figure 5: Result of beam profile and horizontal distribution of the profile. The side length of plot is 18mm.

The size of beam core is about 5mm in tail to tail. At the same time, we measure the wire scanner data. The result is shown in Fig. 6.



wire position$\times\sqrt{2}$ (mm)

Figure 6: A result of horizontal distribution of beam by wire scanner

The size of beam core is about 10mm in tail to tail. The β and η-function at source points are listed in Table 2.

Table 2 β and η-function at the source points

	180°arc	wire scanner
β-function	0.36m	1.8m
η-function	0.36m	0.9m

Taking into account of β and η-function at the source points, two results of beam sizes are in good agreement. But two-dimensional distribution of beam tail in beam profile is only observed with the optical profile monitor.

6 CONCLUSIONS

In order to measure a two-dimensional and pulse by pulse beam profiles at the injector linac for KEKB, the optical-profile monitor is constructed. The monitor is successfully operated as a non-destructive profile monitor. The obtained images of the beam are relayed back to the control room for continuous non-destructive measurements of beam profiles. With this monitor, we can observe instantaneous beam profile such as double-peaked profile of the beam as shown in Fig. 7.

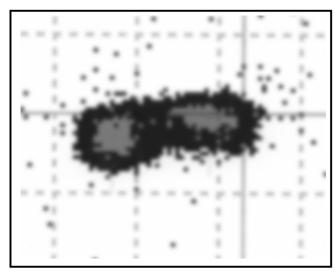


Figure 7: Double-peaked profile of the beam

With the wire scanner, we cannot measure the beam profile instantaneously. We cannot distinguish double-peaked profile or energy fluctuation of the beam by use of wire scanner. Optical profile monitor is very useful to know instantaneous beam profile due to accelerating conditions.

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