Project name Beam Test Proposal of an Optical Diffraction Radiation Beam Size Monitor at the SLAC FFTB

Classification Accelerator

Institutions and Personnel

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Project Overview

The Optical Diffraction Radiation is generated when a charged particle bunch passes by an inhomogeneous boundaries, and is considered as the wakefield of a beam bunch. By using a tilted conducting slit, we can observe the interference pattern of the backward scattered optical diffraction radiation, which gives the transverse beam size information. Because the aperture of the slit is 10 times or more larger than the transverse beam size, this beam size monitor is non-invasive, which is essential to minimize the beam loss in beam size monitoring. The ratio of the photon intensity peak of the interference pattern of the optical diffractive radiation and that at the valley of the photon intensity gives the information of the transverse beam size.

Most of the experiments on the optical diffractive radiation has been done only recently with electron beams up to around 1 GeV at TTF(Tesla), and at ATF(KEK). The γ factor of 5.8×10^4 allows us to use larger aperture size, with the 29 GeV e^-/e^+ at the SLAC FFTB(Final Focus Test Beam) which contributes to reduce the background photons significantly. The test of the beam size monitor with the optical diffraction radiation at the SLAC FFTB provides a unique condition for a non-invasive beam size monitor with the highest beam energy and with the positron beam size measurement. The beam size and the beam intensity of electron and positron beam at a focal point of the SLAC FFTB are 1-10 μm in horizontal and vertical, 0.7 mm in the length, and 1-3 $\times 10^{10}$ particles/pulse. The normalized transverse emittances are 3-5 $\times 10^{-5}$ m-rad in horizontal and 0.3-0.6 $\times 10^{-5}$ m-rad in vertical.

The international collaboration with researchers who have done significant R&D on the optical diffractive radiation at the KEK ATF in Japan with the 1.3 GeV electron beam allows us to understand the beam energy dependence of the beam size measurement by using the optical diffractive radiation.

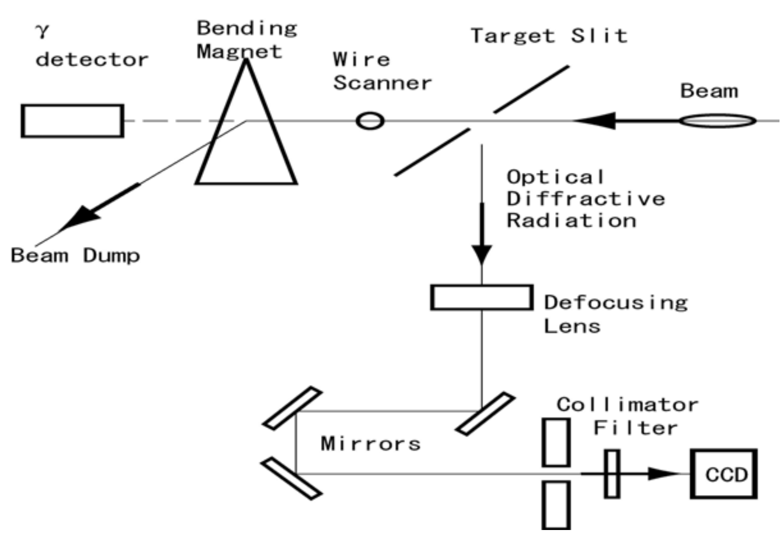
Description of the project activities

A schematic diagram of the beam size monitor and a conventional wire scanner is shown in the figure. Because the wavelength of the diffracted optical photon is much longer than the beam bunch length, the observed optical diffractive radiation is incoherent, where a CCD camera can be used.

The goals of the beam test for the beam size monitor with optical diffractive radiation at the SLAC FFTB are :

1. optimization of the slit plate angle, gap size, and the bandwidth of the optical diffractive radiation for a precise non-invasive beam size monitor,
2. study on the background radiations due to:
   - i) optical transition radiation which is generated by the transverse tail particles,
   - ii) scattered optical photons associated with the beam halo, and
   - iii) synchrotron radiation at the upstream bending magnets,
3. cross-calibration of the beam size by using:
   - i) conventional wire scanners for transverse beam size,
   - ii) transition radiation for transverse beam size, and
   - iii) streak camera for the longitudinal beam size.

The key issues are to use conventional wire scanners and the optical transition radiation for cross-calibration of the beam size measurement, and to understand the background optical photons at the SLAC FFTB. The challenges of this beam test are to achieve the required flatness of the conductive slit surface, and to resolve the small opening angle between the interference pattern peaks within a reasonable distance.



A Schematic Diagram

Budget

Institution	Item	Cost
UCLA	Vacuum chamber modification	$ 5,000
	Remote controlled precision slit	$ 6,000
	CCD camera/Filter	$ 25,000
	Phototubes	$ 3,000
	Optics parts/Calibration System	$ 12,000
	Indirect costs	$ 8,000
	UCLA total	$ 59,000
SLAC	Slit/Vacuum chamber alignment	$ 1,000
	Vacuum system installation	$ 2,000
	SLAC total	$ 3,000
	Grand Total	$ 62,000

References

1. Y. Dnestrovskii, et al.,
   "Radiation from Charged Particles Passing Near a Perfect Conductor"
   Sov., Phys., Dokl. 4(1959)132.
2. A. P. Kazantsev, et al.,
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   Sov., Phys., Dokl. 7(1963)990.
3. T. Muto, et al.,
   "First Stage Experiment on Optical Diffraction Radiation at KEK-ATF"
   ICFA Laser Beam Interaction Workshop, NY, Stony Brook, June 2001.