BEAM TEST PROPOSAL OF AN ODR BEAM SIZE MONITOR AT SLAC FFTB

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Abstract

ODR(Optical Diffraction Radiation) transverse beam size measurement at the SLAC FFTB at 28.5 GeV is a challenge and it requires special target and optics system, which is much difficult than the conventional ODR beam size measurement. We propose to use a curved disphased conductive slit target to recover the sensitivity in the measurement of the single bunch transverse beam size by using ODR photons from a conductive slit. In order to cancel the effect of the beam divergence, the conductive slit target surface must be curved. Also, we can obtain the focused interference pattern of the ODR photons at the detector at the shorter distance from the target than the $\gamma^2\lambda$, by using lens optics system.

INTRODUCTION

Methods have been proposed to obtain the beam size information by using diffraction radiation. [1-3] Transverse beam size can be measured simply by letting beam bunch passing through a vacuum space, an opening of conductive slit, without any magnetic field by using the ODR. The ODR is generated when a charged particle bunch passes by inhomogeneous boundaries, and it is considered as the optical component of the wake field of a beam bunch. By using a tilted conducting slit where a beam bunch passes through the center of the slit aperture, we can observe the interference pattern of the backward scattered ODR from two edges of the conductive slit. This beam size monitoring is non-invasive and provides the transverse beam size of a single beam bunch. Detection of the diffraction radiation in the optical wave length can be done simply using a CCD camera.

Single bunch measurement of the transverse beam size by using the incoherent ODR has been reported in relatively low beam energy region at around 1 GeV or lower at TTF (Tesla), and at ATF (KEK), for example. [4-6] With the 28.5 GeV e^-/e^+ beam at the SLAC FFTB (Final Focus Test Beam), the γ factor of 5.8×10^4 allows us to use much larger aperture size (slit opening) than those with lower beam energy, which contributes to reduce the background photons significantly. But, because of the same large γ factor, the ratio of the photon intensity at the valley of the interference pattern of the ODR to that at the peak of the photon intensity is expected to be below the detector sensitivity by using the conventional conductive slit target. Because of the small $1/\gamma$, which is the typical opening angle of the ODR photon yield, the beam divergence at the focal point of the FFTB can not be neglected. Also without using the special lens optics system, the interference pattern of the ODR photons from the conductive slit target is deformed significantly due to the pre-wave zone effect, which is parameterized by a fraction of the distance between the slit target and a detector $\gamma^2\lambda$, where λ is the ODR wave length. The $\gamma^2\lambda$ is 1.6 km at the SLAC FFTB. So the detector at around 20 m from the target slit is extremely in the near-field zone.

ADVANTAGE AND DISADVANTAGE AT HIGHER BEAM ENERGY

The advantages and disadvantages (and solutions for those) of the ODR beam size measurement at the SLAC FFTB are the following: (1) Because of the larger $\gamma\lambda$, the slit opening can be much larger, which reduces the beam halo background. (2)Because of the larger $\gamma\lambda$, conventional method of measuring the ratio of ODR photons in the valley and that in the peak with a simple slit opening does not work, because the ratio is too small to measure. A solution to this disadvantage is to use the disphased target, which has two rotated half conductive planes. (3) Because the $\gamma^2\lambda$ is much larger than the distance of the detector from the target, so-called near field effect distorts the ODR photon yield as a function of the opening angle. A solution to this disadvantage is to use an lens optics system which restores the relation of the photon emitting angle to the offset at the detector.
(4) Because the $1/\gamma$, the typical peak opening angle of the ODR photon, is small and is comparative to the beam divergence at the SLAC FFTB, the opening angle distribution of the ODR photons is distorted/smeared. A solution to this disadvantage is to use the curved slit target surface and make the ODR emitting angle larger than the beam divergence.

These solutions are under the beam test at the KEK ATF by using the existing set-up of the ODR transverse beam size measurement experiment.

EXPERIMENTAL PLAN

Figure 1 shows a schematic diagram of the experiment at the SLAC FFTB. In the initial stage of detecting the ODR photons, a movable mirror and a photo multiplier

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0-7803-8859-3/05/$20.00

tube behind a collimator is planned to be used by using multiple beam bunches to complete a scanning of the ODR photon yield as a function of the opening angle. In the later stage of the measurement, a CCD camera will be used for a single bunch beam size measurement.

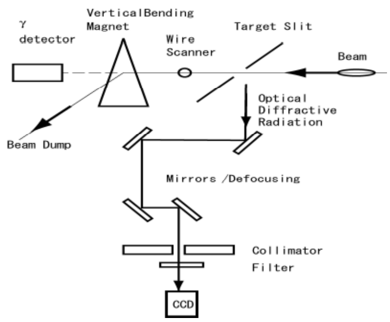

Figure 1: A Schematic Diagram of the Experiment.

Figure 2 shows a schematic of a conducting slit target where the left part and the right part are rotated by the vertical axis by $\alpha/2$ to opposite direction. This target set-up is to measure the vertical transverse beam size. The average tilting angle to the beam direction is 45 degrees. The target slit is made of crystalline wafer/block with 1-2 μm thick Au conductor coating on the top plane. The minimum slit aperture is around 1 mm.

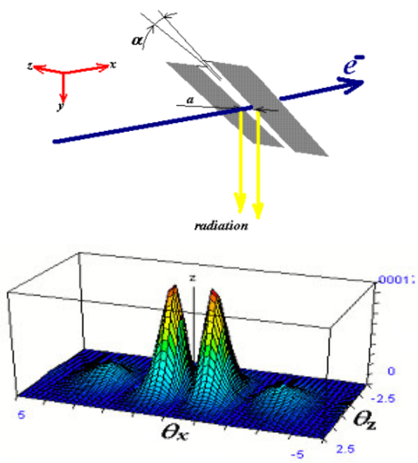

Figure 2: A schematic diagram of a disphased target slit to measure the vertical beam size and the ODR photon yield in the far field zone.

Figure 3 shows the curved disphased slit target which makes the opening angle of the ODR photons induced on the conductive target larger than the beam divergence. At the SLAC FFTB, beam divergence is comparative to the $1/\gamma$, the typical opening angle of the ODR photons at the peak

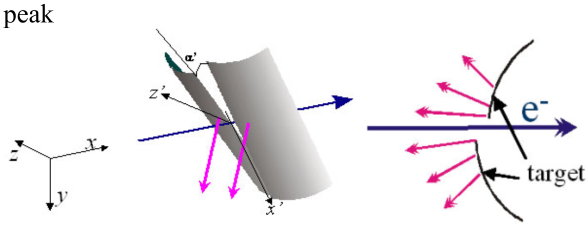

Figure 3: A disphased conductive slit target with curved surface.

Figure 4 shows the lens optics system which can restore the relation of the ODR photon opening angle at the target to the offset at the detector, for the curved disphased target. Figure 5 shows the min/max ratio of the ODR photon yield as a function of the transverse beam size with this target and the lens optics system. [7-12]

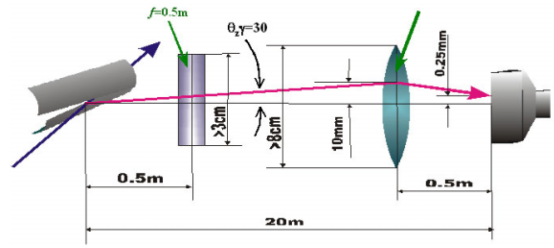

Figure 4: Lens Optics system for a disphased conductive slit target with curved surface.

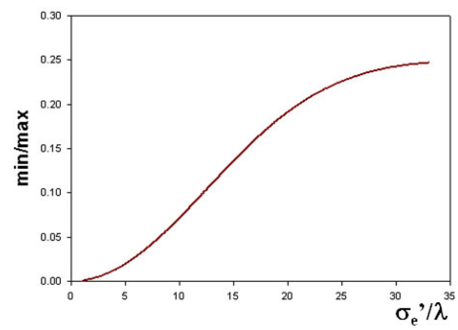

Figure 5: min/max ODR photon yield ratio as a function of the transverse beam size with the curved disphased target.

We studied the recoil effect of the beam bunch due to the beam's passing through conductive slit target and generating/inducing diffraction radiation, and we concluded that the recoil effect was negligible and it was too small to measure in the ODR beam size monitoring at the SLAC FFTB. [13]

The SLAC FFTB beam line is scheduled to be converted into an injection beam line for the LCLS project in the calendar year 2006. The SLAC beam has been off due to the stand-down since the end of 2004, but it will resume the FFTB operation in May 2005. Currently three experiment groups at the FFTB, STTS, E166 and E167, are scheduled to use the beam time. And the procedure is going on to obtain the beam time for this ODR beam size monitor test experiment before the shutdown of the FFTB beam line.

CONCLUSION

Measuring the transverse beam size incoherently at the SLAC FFTB is a challenge but it provides a non-destructive beam monitoring device for the higher energy beam bunches in the future linear collider. We developed a plan to experiment the ODR beam size measurement with a special target slit and optics system.

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