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Optical Cherenkov Diffraction Radiation as a Tool for Non-invasive Charged Particle Beam Diagnostics

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Transverse beam diagnostics is a key sub-system in any accelerator facility enabling to evaluate its performance. Invasive techniques such as optical transition radiation (OTR) or wire scanners are not good enough because high power beam can destroy the OTR target or a thin wire so quickly that the diagnostics equipment will become useless for a long period of time required to repair it. Moreover, a solid target can distort beam parameters such that the distorted beam can damage expensive accelerator components.

Recent years have witnessed an intense development of non-invasive techniques for charged particle beam diagnostics. Physicists and engineers together were searching for physics phenomena which can give information about the beam without direct interaction with matter. The state-of-the-art in non-destructive transverse beam diagnostics is a so-called laser-wire [1], when a thin laser beam is scanned across a particle beam and the secondary particles are detected downstream. This technique has micron scale resolution and is recognised as a primary equipment for future linear colliders. However, this method is not a turn-key device. It is expensive and requires a team of experts looking after it. Optical diffraction radiation [2] appearing when a charged particle moves through a slit in a conducting screen has been rigorously investigated as an alternative to the laser-wire technique. However, contribution of synchrotron radiation (SR) background into ODR [3] significantly complicates its use for beam diagnostics, because it requires special settings of the beam parameters.

Recently we have proposed to use Cherenkov Diffraction Radiation (ChDR) as a promising technique for transverse beam diagnostics. ChDR appears when a fast charged particles moves in the vicinity of and parallel to a dielectric interface. The polarized interface emits radiation along the direction defined by Cherenkov radiation propagation angle ($\cos\theta = 1/\beta n$, where β is the speed of particles in units of the speed of light and n is the refractive index of the medium) away from the particle trajectory. Due to very high directionality ChDR can be separated from SR generated upstream and ODR generated from the any accelerator components or incoming edge of the target itself. On the other hand the ChDR parameters can be used to diagnose the beam size, emittance, position, and direction. Due to very short wavefront along the Cherenkov direction, a fast detector can give information about the beam arrival time.

In this report we shall present the first observation of ChDR in optical wavelength range in Cornell University, its basic experimentally observed characteristics and their comparison with simulations performed by polarization current approach, and demonstration of ChDR feasibility for charged particle beam diagnostics. Our future plans for experimental work at KEK-ATF (Japan) and Diamond LS (UK) facilities.

References

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