Noninvasive Longitudinal Beam Profile Diagnostic Using Cherenkov Diffraction Radiation at CLARA Facility

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Production and diagnostics of short electron bunches in modern particle accelerators are fore-front issues. For example, in modern X-ray free-electron lasers the electron bunches are longitudinally compressed down to <100 fs to achieve high peak currents which is crucial to drive FEL process. Such a short bunch duration opens the possibility to use effect of coherent radiation for longitudinal beam profile diagnostics. In our work we focus on using the coherent Cherenkov diffraction radiation (ChDR) effect, which is, in comparison with others types of polarization radiation has relatively high intensity, allows us to perform noninvasive diagnostic, and is highly directional providing low background detection possibility.

Experimental part was performed at CLARA accelerator [1], where a 35 MeV, 70 pQ bunch with pulse repetition rate of 10 Hz was used to produced coherent Cherenkov radiation from teflon target. Inside the vacuum chamber we developed a multi-directional manipulation platform where ChDR and transition radiation (TR) targets were mounted. It allowed us to observe both effects during one accelerator run and make relevant comparisons. For spectral analysis we used Martin-Pupplet interferometer as it provides higher signal to noise ratio and allows us to perform self-normalisation.

Theoretical part consists of calculation of Cherenkov emission from a single particle. The model we used can be found in [2], Eq. 18. It takes into account angular acceptance of optical detection line, distance between target surface and electron beam, beam energy, target dimensions and its refractive index. Using this equation with experimental parameters from CLARA we can calculate ChDR single electron spectrum to extract bunch form-factor. Longitudinal charge distribution can be obtained as an inverse Fourier transform of a square root of the form-factor [3].

As a result we will demonstrate a selection of interferograms and spectra obtained during experiments at CLARA (both for TR and ChDR targets), products of single electron spectrum calculation for specific parameters we used, and reconstructed longitudinal beam profile for CLARA machine.

References

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