Advanced Intraundulator Electron-Beam Diagnostics Using COTR Techniques*

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Abstract

One of the standard means of imaging electron beams is the use of optical transition radiation (OTR) as the conversion mechanism. Its inherently good spatial resolution and ultrafast time response must be balanced with its lower conversion efficiency in some applications with bright beams. However, in the case of microbunched beams, we report a significant advance in intraundulator electron-beam diagnostics based on the signal enhancements observed in coherent optical transition radiation (COTR). The longitudinal microbunching of the electron beam as it copropagates with the emitted synchrotron radiation results in significant signal enhancements (up to 4-5 orders of magnitude) at the fundamental wavelength. In the case of our self-amplified spontaneous emission (SASE) free-electron laser (FEL) operating in the UV-visible regime, we have used standard CCD imaging cameras to obtain near-field, far-field, and spectral information on the COTR. A thin A1 foil inserted 63 mm upstream of the 45 degree A1 pickoff mirror at each station was used to block the stronger SASE signal and generate COTR. We actually observed interference between the foil and mirror surface COTR sources and obtained effective beam size data for the 217-MeV beam through both the near-field images and analysis of the fringes and features seen in the COTR interference patterns. We also tracked the z-dependent microbunching evolution and performed a series of experiments at 530 nm and 265 nm that illustrate e-beam match and beam coalignment issues as well, which relate directly to optimization of the FEL performance. In summary, the COTR diagnostics provide a unique view of the critical e-beam microbunching phenomena.

* Work supported by the U.S. Department of Energy, Office of Basic Energy Sciences, under Contract No. W-31-109-ENG-38.