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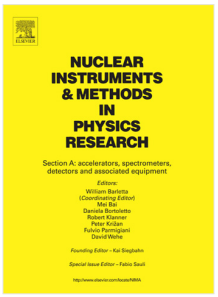

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Absolute laser-intensity measurement and online monitor calibration using a calorimeter at a soft X-ray free-electron laser beamline in SACLA

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Abstract

This paper reports measurement of the absolute intensity of free-electron laser (FEL) and calibration of online intensity monitors for a brand-new FEL beamline BL1 at SPring-8 Angstrom Compact free-electron LAser (SACLA) in Japan. To measure the absolute intensity of FEL, we used a room-temperature calorimeter originally developed for FELs in the hard X-ray range. By using the calorimeter, we calibrated online intensity monitors of BL1, gas monitors (GMs), based on the photoionization of argon gas, in the photon energy range from 25 eV to 150 eV. A good correlation between signals obtained from the calorimeter and GMs was observed in the pulse energy range from 1 μJ to 100 μJ, where the upper limit is nearly equal to the maximum pulse energy at BL1. Moreover, the calibration result of the GMs, measured in terms of the spectral responsivity, demonstrates a characteristic photon-energy dependence owing to the occurrence of the Cooper minimum in the total ionization cross-section of argon gas. These results validate the feasibility of employing the room-temperature calorimeter in the measurement of absolute intensity of FELs over the specified photon energy range.

1. Introduction

In the past decade, rapid progress has been achieved in the development of free-electron lasers (FELs) based on the self-amplified spontaneous emission (SASE) principle [1-8], and seeded FELs [9-11]. FEL sources generate intense and short femtosecond-duration laser pulses, thereby facilitating novel investigations concerning photon–matter interactions under extreme conditions. In Japan, the SPring-8 Compact SASE Source (SCSS) has demonstrated its proof-of-principle as a compact source of FEL radiation in the extreme-ultraviolet (EUV) range [2]. Additionally, the SPring-8 Angstrom Compact free-electron LAser (SACLA), has been greatly successful at generating X-ray FELs at wavelengths less than 0.1 nm [5]. After successful completion of research and development activities performed on SCSS, its accelerator components were moved to the undulator hall at SACLA to transform a wide-range spontaneous radiation beamline BL1 into an SASE-FEL beamline. Therefore, the operation of BL1 is independent of the other beamlines: BL2 and BL3 (i.e., hard X-ray FEL beamlines) at SACLA. Recently, user operations of BL1 have resumed, wherein it is utilized as a soft X-ray FEL beamline that operates over a photon energy range of 20 eV to 150 eV [12].

In terms of FEL facilities and beamlines, the absolute intensity of an FEL is a fundamentally important parameter. For SASE-FELs in particular, intensity monitoring of each FEL pulse is indispensable, because the statistical nature of SASE causes intensity