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Measurement of Electron Beam Transverse Sizes by Angular Distribution of Their Emission in a Thin Crystal

Based on the calculation method [1] of coherent electron radiation in Bragg direction elaborated for point-like beams we developed a technique taking into account the transverse beam size, which well described the experimental results [2]. The dependence of the angular distribution characteristics on the beam size on the crystal was calculated. The calculations show that the measurement of horizontal and vertical distributions does not allow to determine of the beam size in these planes because of their mutual influence.

A technique is proposed for determining beam sizes on a target by measuring two-dimensional angular distributions of radiation for two substantially different distances between the crystal where the radiation is generated and the coordinate detector. The required sizes are determined from the fitting results, where the adjustable function is the distribution for a shorter distance, and the fitting function is the convolution of the angular distribution for the larger distance with the two-dimensional Gauss distribution whose parameters are uniquely connected with the beam size on the target and the distances between the crystal and the detector.

The method can be realized under condition $\sigma \sim \Delta l$, where σ- characteristic beam size, Δl - pixel size of the detector.
The limits of the method applicability are the fulfilment of condition $\sigma' = \sigma/R >$0.1Θ_{ch}, where R distance between the crystal and the coordinate detector and Θ_{ch} is the characteristic emission angle of the detected radiation. For medium-energy electrons, where parametric X-ray radiation (PXR) yield significantly exceeds the diffracted transition radiation (DTR) one, as Θ_{ch} we can use Θ_{ph}- characteristic angle of PXR emission. For particle energies of the order of several GeV and
higher, where the DTR spectral-angular density is significantly larger than that of the PXR [3] the characteristic radiation angle is γ^{-1}. In the last case, the fitting area is limited to the central part of the emission spot. The method is model independent, does not require the constant temperature of the crystal and the perfection of its structure under the condition $\Theta_{ch} >> \sigma_{moz}$, where σ_{moz} is the crystal mosaicity factor. This work was supported in part by JSPS KAKENHI Grant Number JP26400304.

References

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