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Wavefront tolerance analysis for the time-delay compensating monochromator (TDCM) beamline at FLASH2

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The design of the new monochromator beamline FL23 at FLASH, the Free-electron LASer in Hamburg, is made up of 7 optical elements: an elliptical mirror, 2 variable-line-spaced gratings in diffraction order compensation, a vertical slit, a plane mirror and a Kirkpatrick-Baez (KB) focussing system. The monochromotor is designed to work in the soft X-ray range covering a spectral range from 1-20 nm with a spectral resolution of approximately 2000. The two-grating time-delay compensating monochromator (TDCM) will provide a pulse duration in the range of 20 to 100 fs. The beamline FL23 may be used for a variety of experimental techniques such as EUV-spectrometry, to study molecular excitations, magneto-optics Kerr effects, or Extreme Ultraviolet magnetic circular dichroism.
The design process of such a beamline is complex. Simulations are needed to predict the limits on the radii of curvature of the mirrors, the effects of the substrate profile of the gratings and the threshold tolerances of misaligned angles. In order to have a good agreement between the calculations and the experiments, high accuracy simulation tools are required. Raytracing softwares, like SHADOW, are based on the geometry of the optics and the beam. One can introduce parameters in the simulation such as the surface roughness or the reflectivity of the mirrors. However, they neglect some effects like those due to the diffraction. To fully exploit all great features of FLASH2 and to transport parameters from the source, i.e, temporal and spatial coherence length, one can complement raytracing calculations with wavefront propagation. For this purpose the software WaveProgaGator (WPG) was developed at the European XFEL [L.Samoylova et al., J. of Appl. Crystallograpy (2016) 49,1347-1355]. It uses the Synchrotron Radiation Workshop (SRW) library [Chubar, O., and P. Ellaume. Synchrotron Radiation Workshop (SRW) code] and Python binding for wavefront propagation simulations. By taking into account factors like divergence, coherence time or pulse energy of the source, WavePopaGator calculates diffraction effects, interference due to the dimensions of the optics, etc.

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