On the way to automatized optics adjustment
at FEL sources

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In recent years, the Institut für Nanophotonik Göttingen e.V. (formerly Laser-Laboratorium Göttingen) has successfully developed several Hartmann wavefront sensors in collaboration with DESY. These sensors have been designed for the precise focus characterization and optics alignment of the FEL FLASH in the soft X-ray spectral range, with a wavelength of approximately 5 - 40 nm. Even when using those wavefront sensors, the optimal adjustment of optics is very time-consuming and can only be successfully carried out by experienced beamline scientists. This is especially true for the often used so-called Kirkpatrick-Baez (KB) optics with up to 14 strongly coupled degrees of freedom. Furthermore, the optics adjustment process must be repeated frequently due to changing beam requirements of the users and occasionally varying beam characteristics of the SASE FELs during user experiments. Consequently, there is a high level of interest in the automation of fine-tuning of the focusing optics using rapid "machine learning" algorithms. This is the scope of the BMBF project FELFocus.

We will present first results of automated focus alignments using the KB-optics system at FL23/FLASH2. In order to test the automation, the focus of the KB optics system was optimized by bending the two KB mirrors with initially 4 actuators, whereby the wavefront sensor measures the wavefront and the intensity distribution in real-time at the location of the sensor. Using Fresnel-Kirchhoff integration of these data, the focus size and the intensity distribution at the focus position are calculated. Both the wavefront shape (Zernike coefficients) and the computed focal characteristics are used for an automated control of the actuators of the motorized KB optics. In addition to conventional minimization also advanced machine learning methods based on multi-objective optimization were employed. The latter can significantly speed up the automated focus alignment.