The transform limited SXR monochromator, with ultra high resolution option, to open up new scientific capabilities for LCLS II

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The Linac Coherent Light Source (LCLS) of SLAC is upgrading the facility to a more flexible design, permitting both high energy per pulse mode and High Repetition Rate mode. Two independent sources, Soft and Hard X-ray, will serve five of the existing beamlines and three completely new ones. We present here one of the new beamlines (NEH2.2), mainly dedicated to Resonant Inelastic Scattering (RIXS) and Liquid Jet based experiments. Experimental techniques to study dynamic processes, correlated and uncorrelated systems and low-density matter will benefit from a higher pulse rate, making possible experiments not conceivable till today. The NEH2.2 beamline will operate in the 250 eV to 1600 eV photon energy range, and for the various experiments envisioned, the required spectral resolving power shall be between 5,000 and 50,000. In particular, at lower resolving power, the grating-induced pulse stretching shall be reduced to an almost transform limited level. In this work, we present the optical design of this monochromator.

In order to obtain transform-limited pulse stretching for a wide range of spectral resolving power configurations, the monochromator must meet the following requirements: on one hand, the source must be imaged onto the exit slit plane free of any wavefront distortion introduced by aberrations, diffraction at apertures, thermal bumps, figure error of mirrors or line density errors of gratings. On the other hand, it must provide control of the footprint size at the grating, so as to vary the energy resolution of the system between 5,000 and 50,000, using the same geometrical layout, and without clipping the beam. Finally, the monochromator must work under the intense photon flux and power emitted by the LCLS-II, keeping the optical elements below the radiation damage threshold, as well as the absorbed power within workable limits.

We present an optical design that meets all these requirements. The first optical element is a plane-elliptical bendable mirror which, for the high-resolution configuration, focuses the source at the exit slit plane. Downstream M1, there is the monochromator with a plane mirror and a plane VLS grating. The line density profiles of the gratings are chosen to compensate for defocusing and primary coma aberrations for the whole range of energies and included angles accessible to the monochromator. 240 mm long gratings, with a line density error better than 0.5E-5 are needed, as well as a vibration stability of 40 nrad for the pitch axis of the gratings.

For the low-resolution configuration, the bending curvature of M1 is increased so as to bring the focus of the source a few meters downstream the grating, way upstream the exit slit. In this case, the VLS parameters can correct the introduced defocus only for a fixed Cff value and require a precise setting of the included angle of the monochromator. For the low-resolution configuration, a single grating is used. It requires a very shallow blaze angle to provide enough efficiency and prevent the grating to be damaged by the radiation.

Details of the optical design and its limits of operation in terms of optical performance and reliability will be given. We will discuss the impact of the different mechanical parameters and manufacturing tolerances on the resulting performance, as calculated using analytical models and wavefront propagation simulation.