Diagnostic of Forward Bragg Diffraction Hard X-ray beams for Self-Seeding applications SwissFEL

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New photon sources based on linear accelerators, known as X-ray free-electron lasers (XFELs), which rely on the self-amplified spontaneous emission in the hard X-ray regime, and exhibit peak brightnesses many orders of magnitude larger than those from insertion devices at third-generation synchrotron sources [1]. X-FELs open new avenues for investigations of phenomena at the femtosecond time scale. Geloni et al. [2] have proposed to exploit features of Forward Bragg Diffraction (FBD) process for self-seeding FELs in the hard X-ray regime to clean up the spectrum. The FBD process produces time-delayed beam of well-defined wavelength and reduced bandwidth [3], which are used to seed a second FEL stage. This self-seeding scheme is foreseen also for the hard X-ray branch (2.0 – 12.4 keV) of the Swiss free electron laser (SwissFEL) currently in commissioning at PSI [4]. Although this self-seeding approach has been demonstrated experimentally [5], a detailed study of the fine-tuning possibilities is still lacking.

In this contribution we present a detailed study in space-, time- and frequency domain aspects of the FBD process. Both the transverse displacement and the time-delay of the FBD signal are key parameters that have to be understood in view of possible optimizations. Such investigations are essential for facilities as SwissFEL, where the optimization of the coupling between electron bunch and narrow-bandwidth photon echo would increase the final brilliance of the seeded X-ray pulses. Simulations based on the dynamical diffraction theory Fourier transform model described by Bushuev [6], were compared with experimental data obtained at the beamline MicroXAS at the Swiss Light Source, Fig 1. The results will help in the optimization of the self-seeding design at SwissFEL.

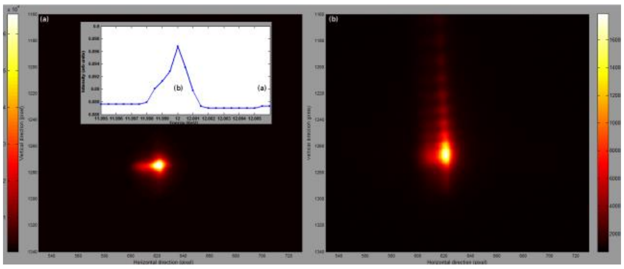

Figure 1: (Left) Image collected at the forward detector 6 eV away from the Bragg condition, (inset) Reflectivity curve for the energy scan performed, and (Right) at the Bragg condition for the reflection (220) of a 400 µm thick diamond single crystal at 12 keV.

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