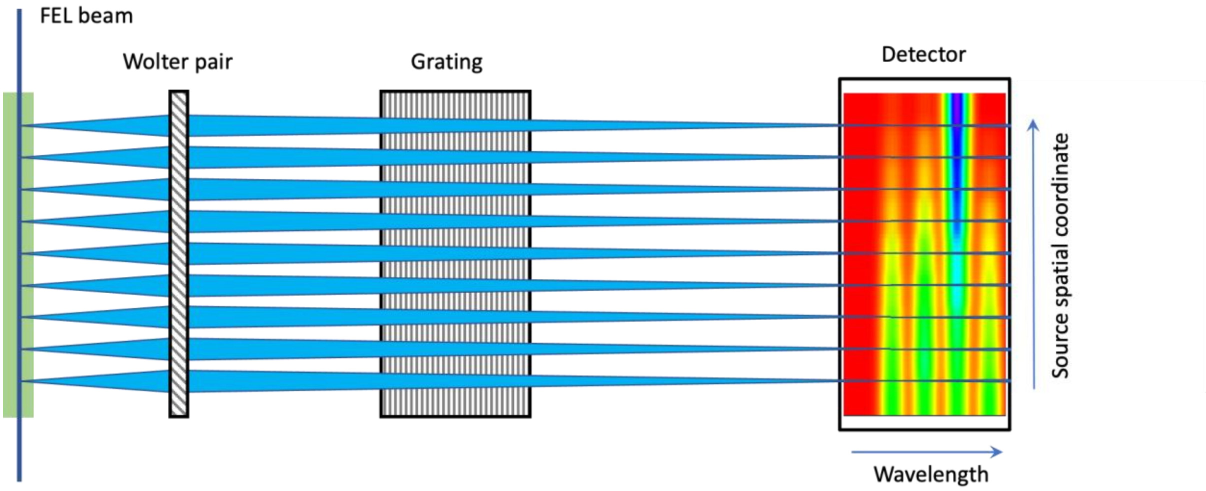
A brief introduction to the imaging X-ray spectrometer

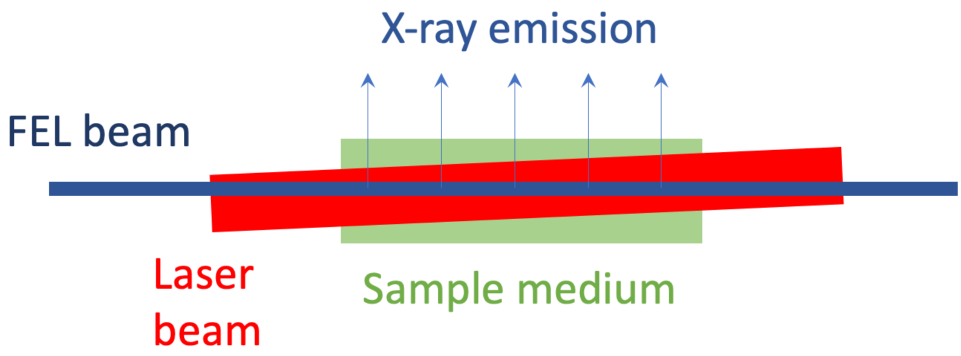
The imaging RIXS spectrometer employs a cylindrical Wolter mirror pair to allow for 1D imaging of an extended source. A cylindrical grating mounted in the perpendicular plane provides energy dispersion so that the detector records an image with wavelength dispersion in one direction and spatial resolution in the other. In order to comply with the fixed focal length of the Wolter mirror pair, wavelength range selection is made by repositioning the grating.
The design offers the possibility to study ultra-fast processes with femtosecond time resolution by encoding the spatial coordinate through the light propagation speed. The envisaged 15 micron spatial resolution corresponds to 50 fs at vacuum speed of light. The primary features of the imaging RIXS spectrometer is schematically shown in the figure (the Wolter optics is represented by the slanted pattern object). The green box indicates the sample, e.g. a gaseous medium (liquid flat jet, molecular beam and cluster source also envisaged), and the dark blue line represents the FEL beam.



The grey vertical lines represent the ruling of a cylindrical grating, and the light blue horizontal lines represent the scattered radiation, 10-fold enlarged and imaged by the Wolter optics and wavelength dispersed by the grating onto the detector. The detector image shows a made-up example where a new feature appears at a certain time, when the incident FEL pulse has propagated through the medium. The length of the source is limited to 2 mm by the size of the detector and the spatial resolution at the source is 15 micron.

In order to allow detection of the FEL photon burst every 220 ns the spectrometer will be provided with a novel 128 channel delay-line detector that allows one count per pulse per delay line to be detected. At the SQS instrument[1] around 10^{14} photons per pulse can be delivered to the sample, and considering the solid-angle acceptance, and the efficiency of optics and detector we expect the luminosity of the instrument to be 10^{-8} for an angularly isotropic source.

[1] https://www.xfel.eu/facility/instruments/sqs/index_eng.html



It will also be possible to couple in an optical laser nearly collinear with the X-rays, as shown above. Since the two beams are at an angle with respect to each other pump-probe measurements can be performed without the need to operate a delay stage. The delay will be inherently imprinted in the spatial position where the scattered photons originate – since the relative speed of light along the propagation direction of the X-rays will be different for the two pulses.
The angle is set to 15 degrees in the original setup. If both beams propagate at vacuum speed of light, this corresponds to consecutive delays of 1.7 fs between each 15-micron segment, and a full range of 0.23 ps for the 2 mm path length. In principle the angle can be varied to reach the desired temporal delay.

In addition, effects of varying delay between pulses due to differences in propagation speed in media can be examined, including combination with optical lasers as well as multiple-color X-ray pulses, which are available at the SQS station.

The spectrometer will cover the energy range 140 – 1150 eV using two gratings with 280 lines/mm or 950 lines/mm. We estimate that the energy resolution is about 70 meV at 250 eV and 100 meV at 540 eV.

For further information about the spectrometer, please contact
marcus.agaker@physics.uu.se.
For information about the SQS instrument, please contact
michael.meyer@xfel.eu