

FXE Instrument Parameters for Early User Operation

All parameters are subject to change, pending the commissioning process.

Note in particular that for grey parameters/devices availability has to be cross-checked with the FXE instrument scientists.

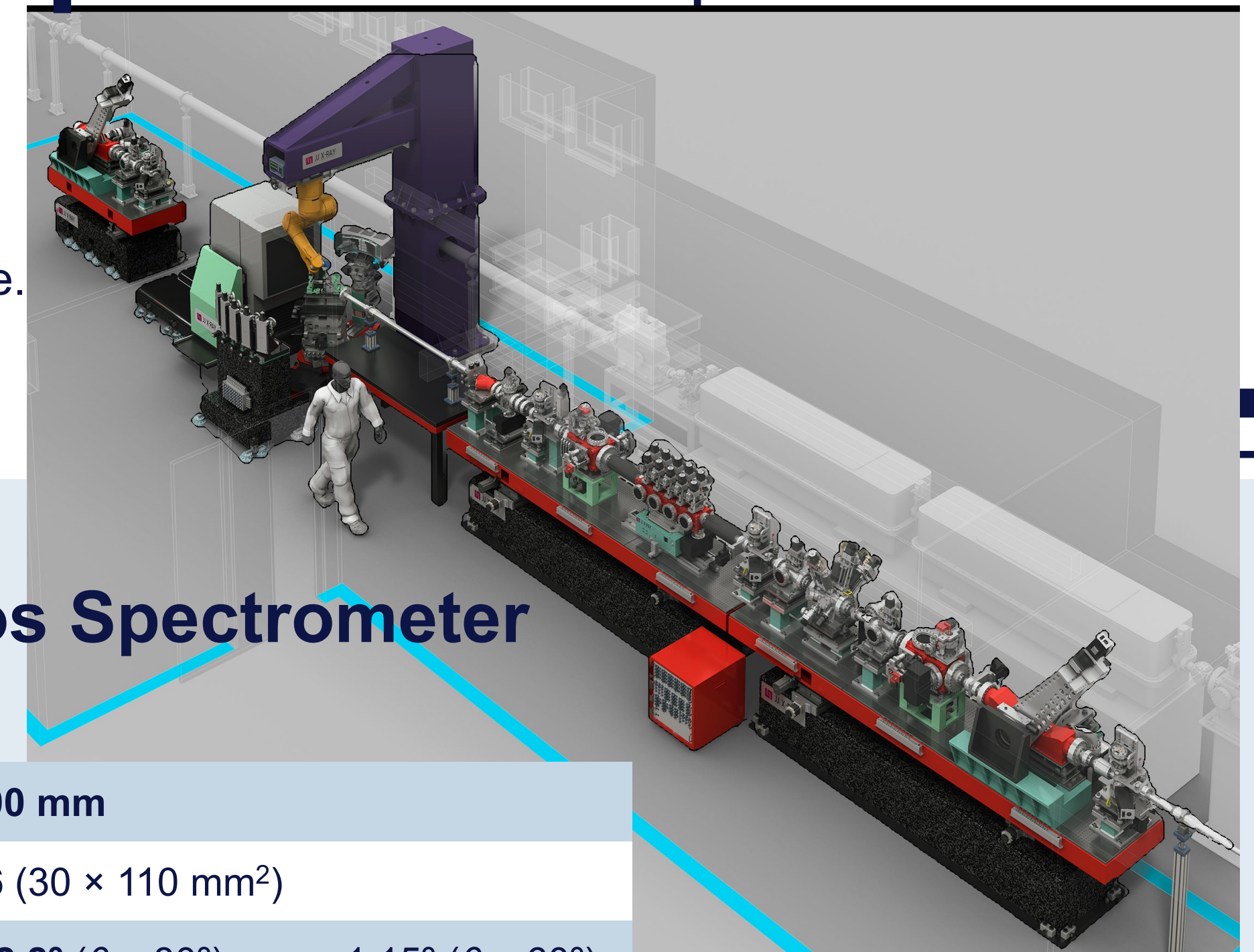
Please always discuss your experimental plans with an FXE instrument scientist before submitting your proposal.

They can help you with any details that may have been updated, assist with evaluating the experiment feasibility, and much more.

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Photon Beam Parameters (*see also "beam parameters" for this run*)

| | | |
|--|----------------------------|--|
| Photon energy | 6-18 (5-10) keV | potentially changeable |
| Pulse energy | 1 mJ | measured, (0.35 mJ calculated, at saturation) |
| Electron bunch charge | 0.25 nC | |
| Photons per pulse | 3.6×10^{11} | calculated for 0.5 nC at 8.979 keV |
| Pulse duration | 25 fs | calculated from e- beam properties (50 fs at 0.25 nC) |
| Spot size on sample | ~ 15 μm (focus) | calculated (2 μm), variable up to ~100 μm |
| Photons/ μm^2 on sample | ca. 10^{10} | derived |
| Train repetition rate | 10 Hz | fixed |
| Intra-train repetition rate | 1.1 MHz | possibly changeable to 4.5 or 0.1 MHz |
| No. of bunches per train | 200 | possibly variable between 1 and 200 |
| Pointing stability | 2 μrad | possibly drifting over entrance apertures |
| $\Delta E/E$ | < 0.2% | calculated |
| Primary Si(111) 4-bounce monochromator | $\Delta E/E = 10^{-5}$ | Calculated, currently under commissioning |

Beam and Timing Diagnostics

(Technical Design <http://www.xfel.eu/research/instruments/fxe>)

| | |
|-------------------------------|--|
| Spectrum analyzer | Spectral fingerprint of beam using crystal diffraction |
| Post-sample diagnostics bench | Beam position, intensity, spectrum |
| Timing tool | RF synchronization: ~ 300 fs (measured); Optical synchronization: ~ 50 fs (measured) |

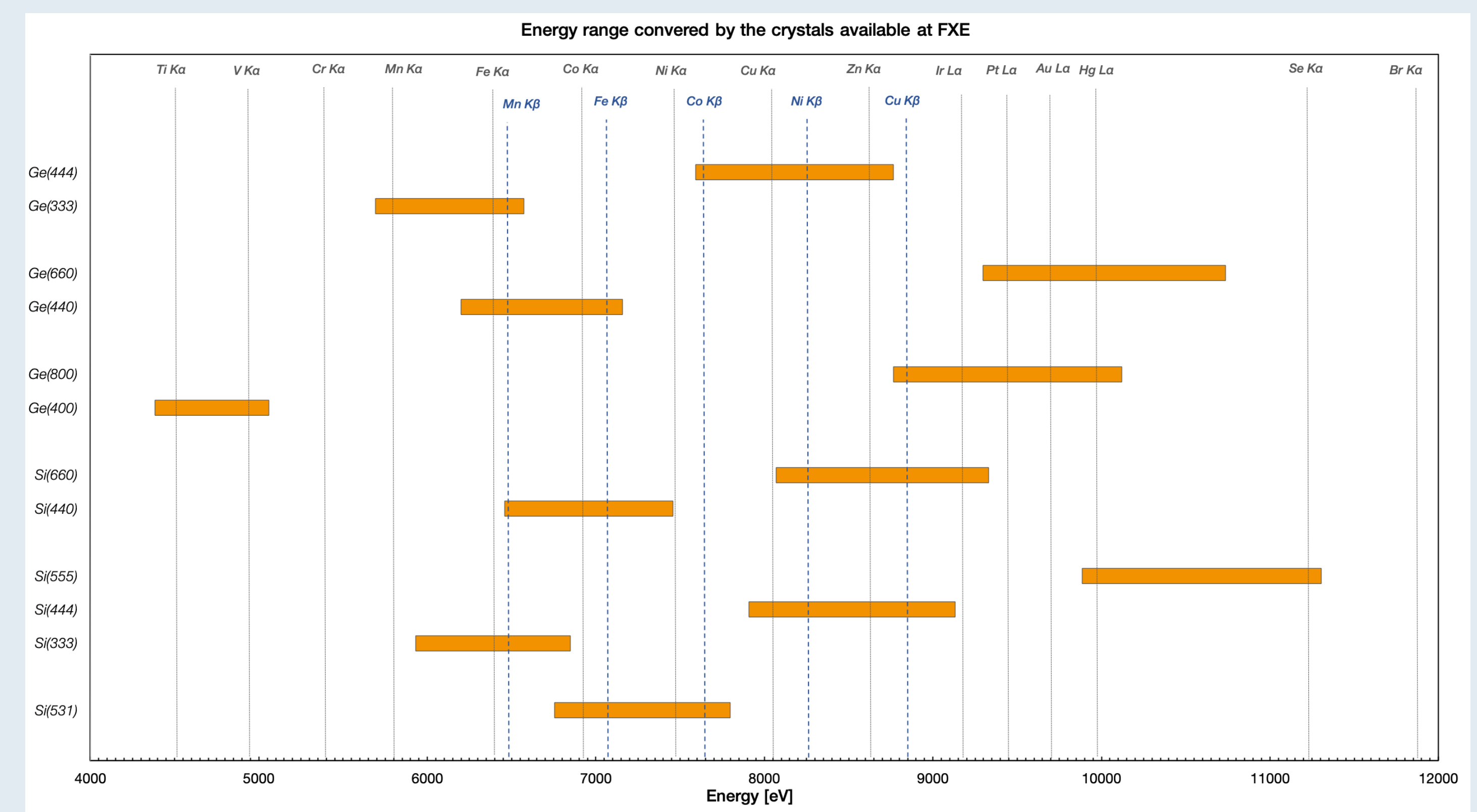
Sample Delivery System

| | | |
|---|---|--|
| Liquid flat-sheet jet/ Cylindrical jet | 100 μm , 300 μm / 50-300 μm | fixed, for wide range of viscosities |
| Pumping of liquids | Up to 60 m/s | HPLC, micro gear pumps |
| Swivel/translation sample stack | | more details at http://www.xfel.eu/research/instruments/fxe |

XES: von Hamos Spectrometer

| | |
|---------------------------|--|
| Crystal bending radius | 500 mm |
| Total number of tiles | 16 (30 \times 110 mm ²) |
| Angular range (1 crystal) | ~ 2.8° ($\theta = 80^\circ$) ~ 1.15° ($\theta = 60^\circ$) |

Available Crystals and Energy Coverage in 60° – 90° Geometry



XES: Johann Spectrometer

Under commissioning. Check status with FXE staff.

Detectors and online data analysis

| | GreatEyes (2D) | Jungfrau (2D) | Photon III | GOTTHARD (1D) |
|----------------------------|--|---|---|---|
| Technique | XES | XES & SAXS | | XES |
| Energy range | 0.5-10 keV | 5-30 keV | 5-30 keV | 3.5-15 keV |
| Detector efficiency | ~ 90% (5 keV), > 25% (10 keV) | 90% (5 – 10 keV), > 50% (15 keV) | 95% @25keV | 90% (5 – 10 keV), > 50% (15 keV) |
| Detector frame rate | 10 Hz | 10 Hz | 10 Hz | 40 kHz – 0.8 MHz |
| No. of pixels (pixel size) | 1024 \times 256 (26 \times 26 μm^2) | 1024 \times 1024 (75 \times 75 μm^2) | 1536 \times 1024 (135 \times 135 μm^2) | 1280 \times 1 (50 $\mu\text{m} \times$ 8 mm) |
| Pixel dynamic range | ~ 350 at 7 keV | 10^4 at 12 keV | 10^4 at 18 keV | 10^4 at 12 keV |

Online data inspection capabilities:

X-ray Emission: Online visualization of pump-probe difference spectra from Jungfrau data (10 Hz intertrain currently)

X-ray Scattering on LPD: Online azimuthal integration of one train (up to 64 pulses) every 2 sec. and visualization of pump-probe differences (intratrain)

All techniques: Online visualization of pump-probe intensity differences from ROIs of one train (accumulate up to 64 bunches) every 0.5 sec on LPD, 10 Hz on Jungfrau

Scattering: Large Pixel Detector (LPD) Parameters

| | | |
|--------------------------|----------------------------------|---|
| No. of pixels | 1024 \times 1024 | 4 quadrants, each 512 \times 512 pixels |
| Pixel size | 500 \times 500 μm^2 | |
| Sensor | Si, 500 μm | |
| Max. frame rate | 4.5 MHz | |
| Memory depth | 510 images | per pulse train (with vetoing capability) |
| Sample-detector distance | 80 – 1500 mm | on motorized stage |
| Central hole diameter | 10 mm | $Q_{\min}(9 \text{ keV}, 100 \text{ mm distance}) = 0.32 \text{ 1/\AA}$ |
| Max. Q range at 9 keV | ~ 5.1 1/\AA | at edge of detector for hole-centred beam (100 mm) |
| Max. Q range at 14 keV | ~ 7.9 1/\AA | at edge of detector for hole-centred beam (100 mm) |
| Dynamic range | 10^5 at 9 keV | |
| Quantum efficiency | 98% at 9 keV | 89% at 12 keV, 38% at 20 keV |

Optical Laser Systems Parameters

Three synchronised femtosecond to picosecond laser systems will be available. All laser pulses can be time delayed with respect to the X-ray pulse over a range of 4.6 ns in steps of 2.5 fs. Optical parametric amplification, white light generation schemes, laser system II and THz pulses are available upon request. In these cases, feasibility needs to be discussed with instrument staff prior to submission.

| | pump-probe laser system I | | pump-probe laser system II | | pump-probe laser system "Tangerine" | |
|--|---|------------------------------------|----------------------------|------------------------------------|---------------------------------------|---------------------------|
| wavelength | 800 nm | | 1030 nm | | 1030 nm | |
| pulse duration | 15, 50 fs | | 0.8 – 500 ps | | 350 fs | |
| train repetition rate | 10 Hz | | 10 Hz | | N/A no burst mode operation; quasi cw | |
| intra-train repetition rate | 1.1 MHz (4.5 MHz) | Stepwise variable, down to 100 kHz | 4.5 MHz | Stepwise variable, down to 100 kHz | 4.5 MHz | variable, down to 100 kHz |
| wavelength conversion | SHG, THG | OPA | SHG, THG, FHG, THz | | SHG, THG, FHG | |
| pulse energy (fundamental) | 200 μJ at 1.1 MHz | up to 1 mJ at 100 kHz | 1 mJ at 4.5 MHz | up to 40 mJ at 100 kHz | 5 μJ | |
| efficiency of 2 nd harmonic gen | 12% / 24% | @ 15fs input / @ 55fs input | t.b.d. | | ~ 40% at 400 kHz | |
| efficiency of 3 rd harmonic gen | t.b.d. | | t.b.d. | | ~ 10% at 400 kHz | |
| efficiency of 4 th harmonic gen | N/A | | t.b.d. | | ~ 5% at 400 kHz | |
| arrival time jitter w.r.t. X-rays | 350 fs fwhm (RF synchronization); 75 fs (optical synchronization) | measured | t.b.d. | | t.b.d. | |

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Parameters may change at any time