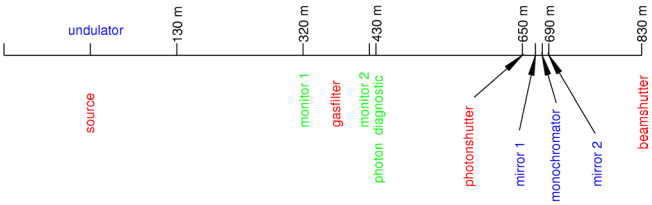
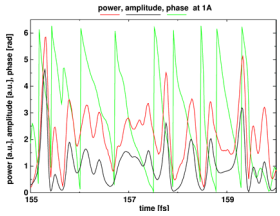
X-ray optics requirements

generic XFEL beamline

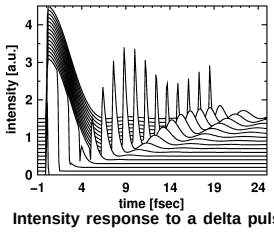
XFEL beamline with all elements located inside the tunnel building. Special optical elements, e.g. tight focusing optics, will be installed in the experimental area located inside the XFEL laboratory.



photon beam timing: intrinsic time scales

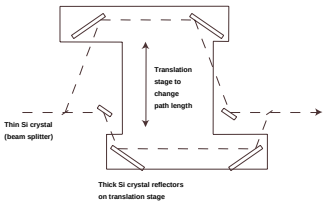


XFEL source time structure: "spikes" with a typical length of 0.1fs inside a single 1Å photon bunch with a total length of 100fs.



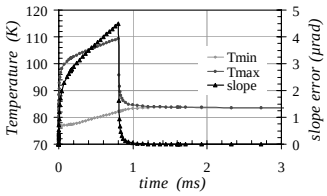
Intensity response to a delta pulse of Bragg crystals (diamond 111) with different thickness (from 0.1µm to 11.3µm) vs. time (W. Graeff).

photon beam timing: time-delay

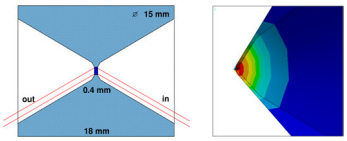


A single translation stage carrying four crystals changes the relative path lengths in this configuration by:
54 mm translation ~ 500 ps change in delay
1 µm resolution ~ 10 fs resolution
(J.Arthur, LCLS-CDR)

power: thermal management



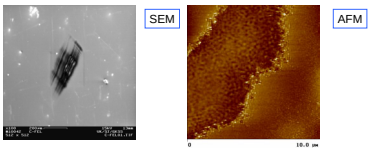
The challenge of cooling a diamond crystal (20mm³) with liquid N_2, absorbing 2J during a 0.8ms long XFEL photon bunchtrain (L. Zhang, A. Freund, Th. Tschentscher, H. Schulte-Schrepping)

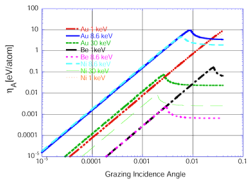


Temperature distribution in a cylindrical liquid nitrogen cooled diamond crystal hit by the beam in the thin central part (schematic and cut away FEM model from XFEL-TDR).

power: focused beams

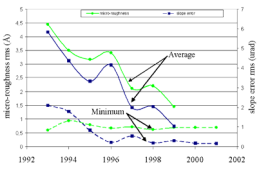
Deliberate Damage of C coatings in the focused TTF1 beam
R. Sobierajski et al., IFPAN, DESY, GKSS



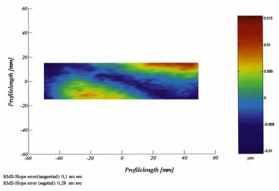


Dose per atom as function of the grazing incindence angle for various materials and photon energies in a focused XFEL beam. (LCLS-CDR)

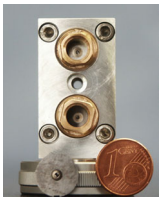
precision requirements



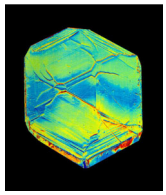
Development of micro roughness and slope error of synchrotron radiation mirrors over the last 10 years measured of a perfect mirror area of 160 and 400 mm



Ultra glancing angle (<1mrad) mirror setups have to be further evaluated. Damage thresholds from TTF-1 and estimated values for the VUV-FEL and XFEL indicate the need for novel coatings (C, Be) and manufacturing techniques.



Single Be-lens and lens assembly for the SLAC-SPPS beamline. Alternative materials will be C and B_4C, other configurations are KB-like decoupled devices etched in C or Si.
The effective opening at 1Å wavelength is 1.2mm. (lenses by B.Lengeler, Ch. Schroer)



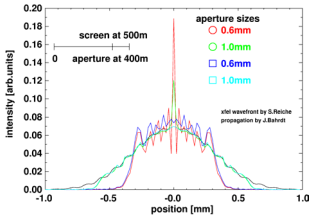
Distribution of lattice tilts of a 10x12mm² diamond (111) crystal (courtesy A. Freund ESRF)

coherence preservation

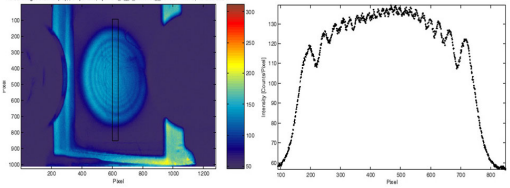
mirror with slope error ≤ 1µrad and roughness ~1Å RMS

perfect crystals

coherence aware slit design and guard slits



The effect of apertures on the XFEL photon beam.



Experiences at TTF-1:
5 mm aperture, 12m from source.
Ce:Yag screen 3m behind aperture. Beam diameter 3mm

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