SCS instrument

European XFEL Virtual User Information Meeting
9th Call for Proposals

Andreas Scherz
Spectroscopy and Coherent Scattering
(SCS instrument)

12. May 2022

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Scientific Instrument SCS

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9th Call for Proposals: FFT and CHEM

We are happy to accept proposals for two experiment stations in this call: the forward-scattering fixed target (FFT) experiment station and the CHEM experiment station with liquid jet environment. FFT station can be combined with detectors for Small-Angle X-ray Scattering (SAXS), Coherent diffraction imaging (CDI), X-ray photon correlation spectroscopy (XPCS) as well as X-ray Absorption Spectroscopy (XAS). The afterburner Apple-X is in commissioning this year and will offer to users of this call circular and linear polarizations with basic functionality for instance for ultrafast magnetic studies exploiting magnetic CDI or X-ray Magnetic Circular Dichroism (XMCD) methodologies. The CHEM station holds a liquid-jet sample environment for Resonant Inelastic X-ray Scattering (RIXS) in back-scattering geometry. While other configurations are accepted, we have a standard configuration for the CHEM-RIXS.

9th-Call-for-Proposals: FFT & CHEM

SCS instrument and beam parameters
9th Call-for-Proposals, scheduled for the first half of 2023
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9th-Call-for-Proposals: Standard Configuration

SCS standard configuration CHEM
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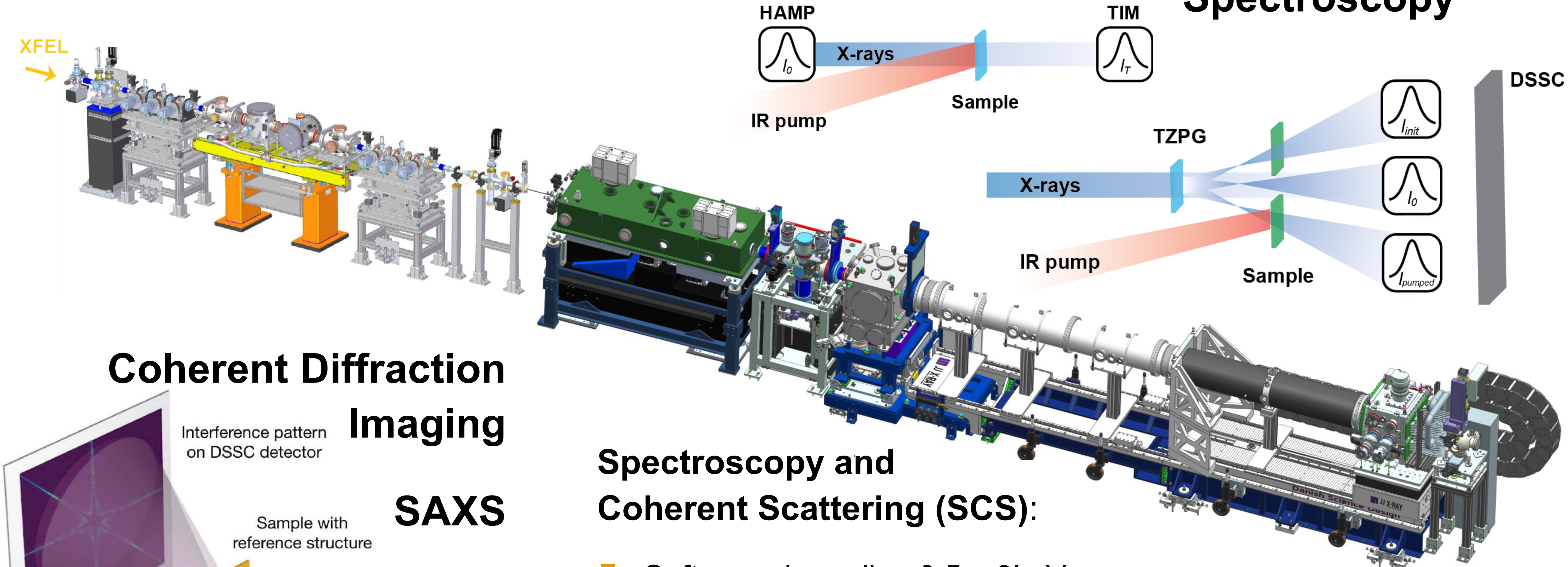
Please contact the **SCS team** for further technical information about instrumentation in operation and discuss your experiment plans before submitting your proposal.

contact us:
scs@xfel.eu

SCS instrumentation for forward scattering geometries

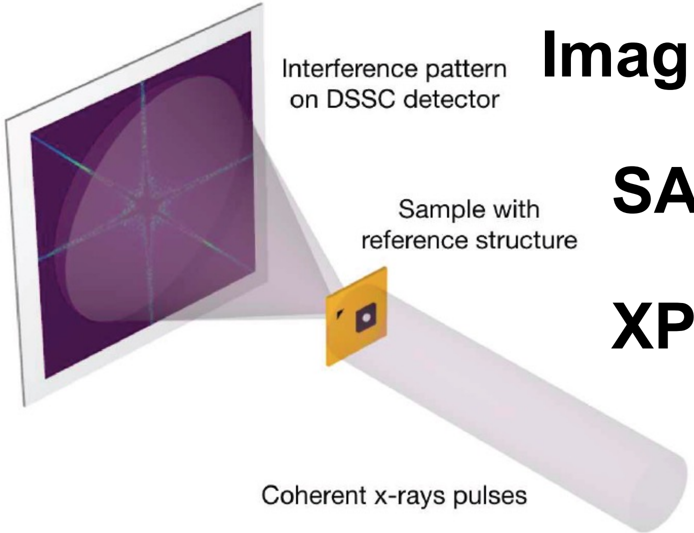
Spectroscopy



Coherent Diffraction Imaging

SAXS

XPCS

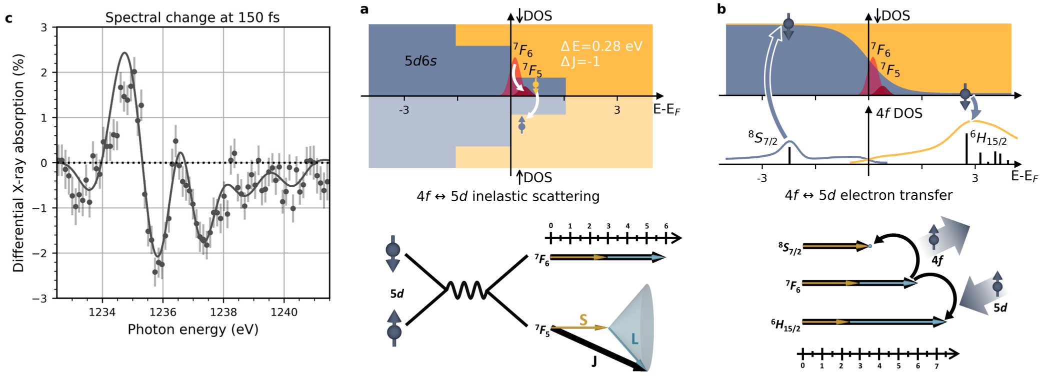


Spectroscopy and Coherent Scattering (SCS):

- Soft x-ray beamline 0.5 – 3keV
- Time-resolved/ non-linear x-ray spectroscopies
- Time-resolved/ non-linear x-ray diffraction
- Forward- / small-angle scattering geometries

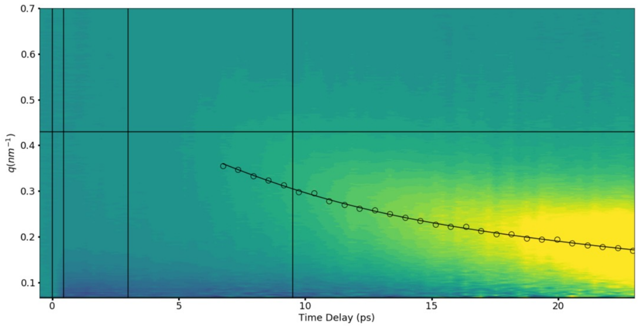
Science at SCS with FFT

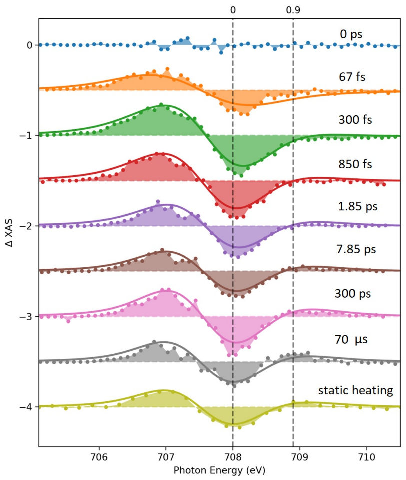
Study of electron and spin dynamics



Thielemann-Kühn, et al.., arXiv:2106.09999

Laser-driven phase transitions

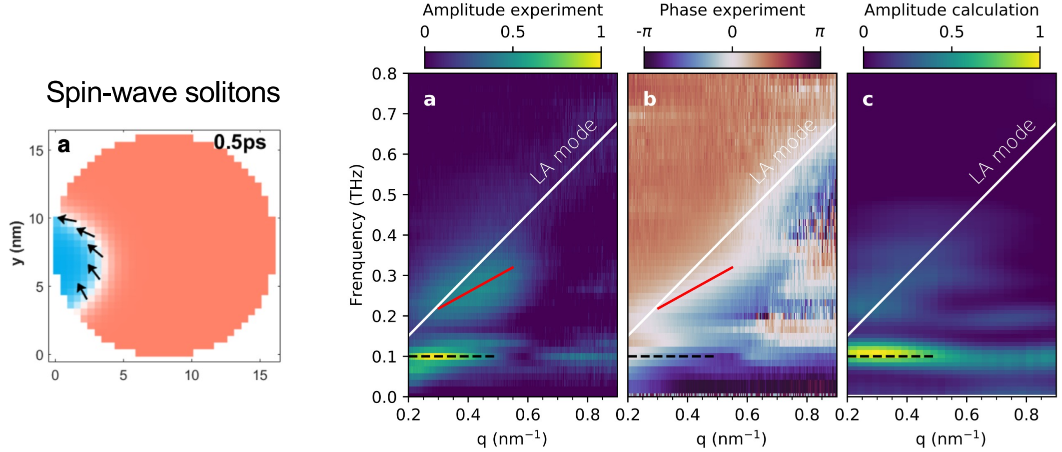




Agarwal, PhD thesis UHH (2022)

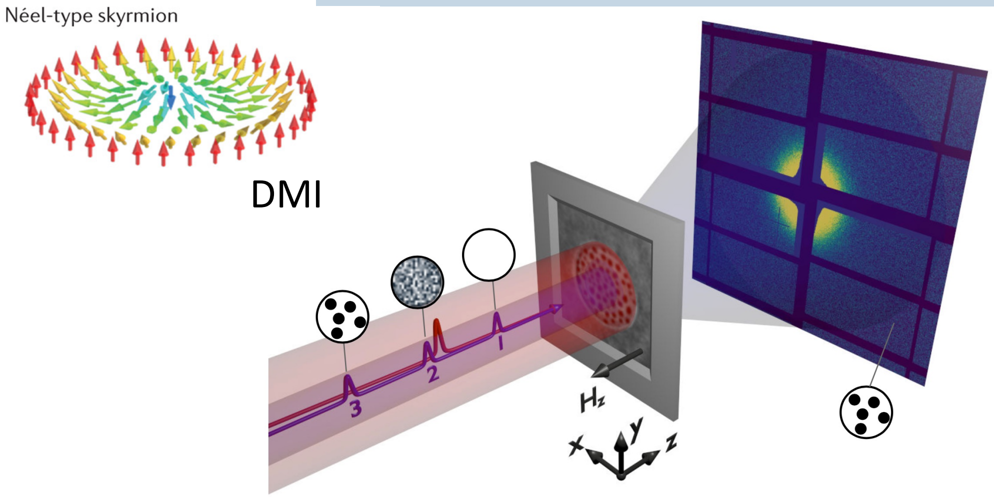
Spin-lattice coupling in nanostructures

Turenne et al., Science Advances (2022)

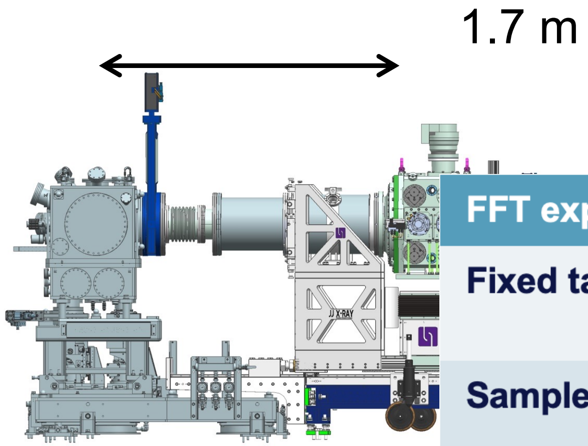


Spin-orbit-driven topological systems

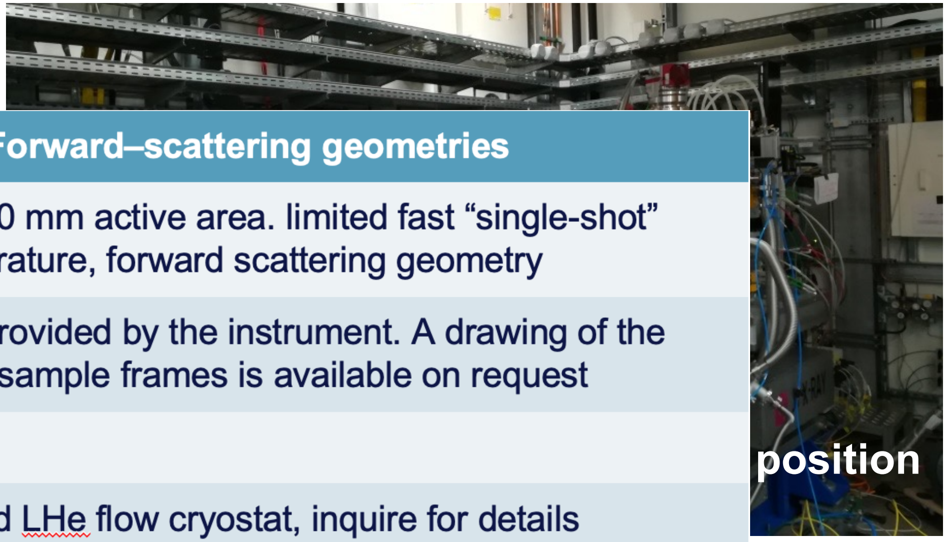
Büttner, et al.., Nature materials (2021)

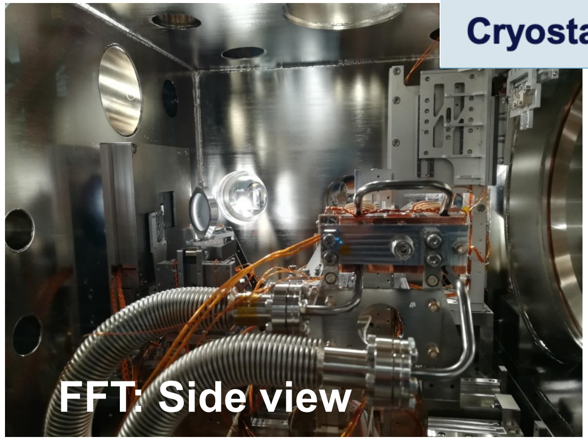


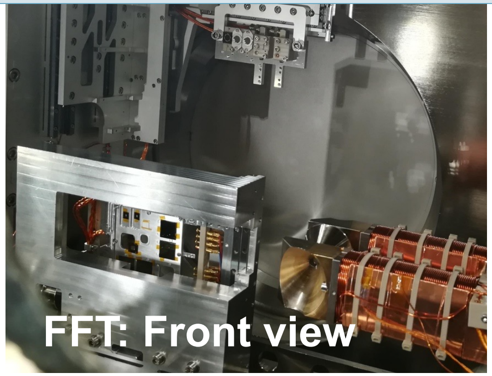
FFT Experimental apparatus for XAS and SAXS / CDI

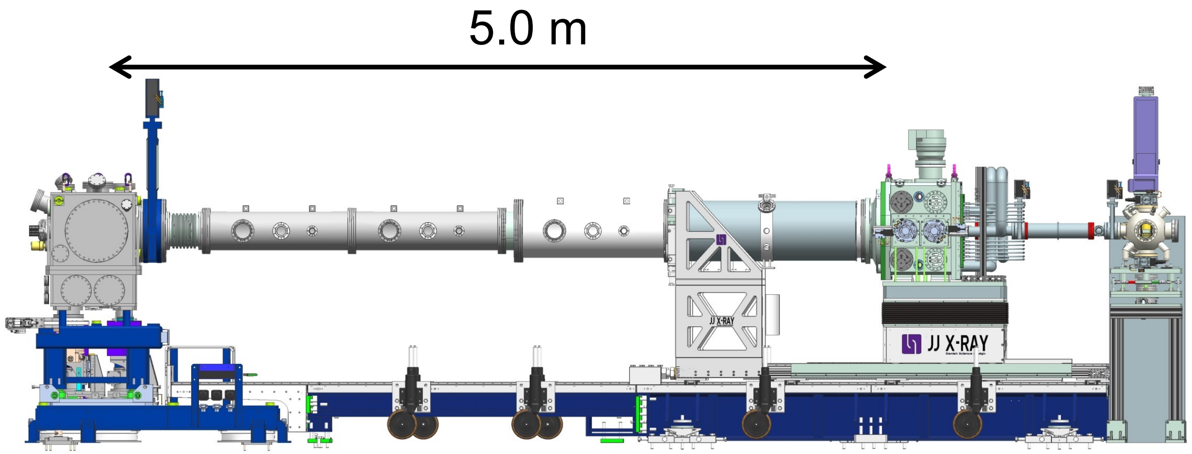


FFT experiment station - solid sample environment, Forward–scattering geometries	
Fixed target sample holder	Frame with 50 mm x 50 mm active area. limited fast "single-shot" scanning, room temperature, forward scattering geometry
Sample Frame	Standard frames are provided by the instrument. A drawing of the frame to produce own sample frames is available on request
DC electromagnet	≤ 0.35 T
Cryostat sample holder	15 – 300K, top-inserted LHe flow cryostat, inquire for details







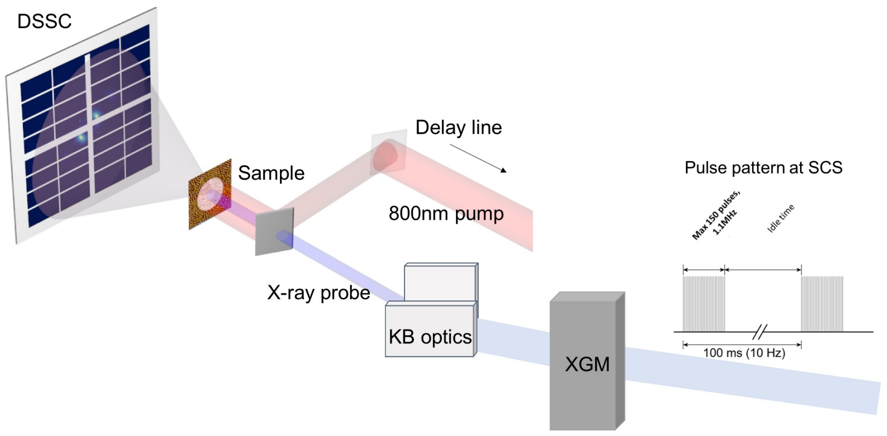


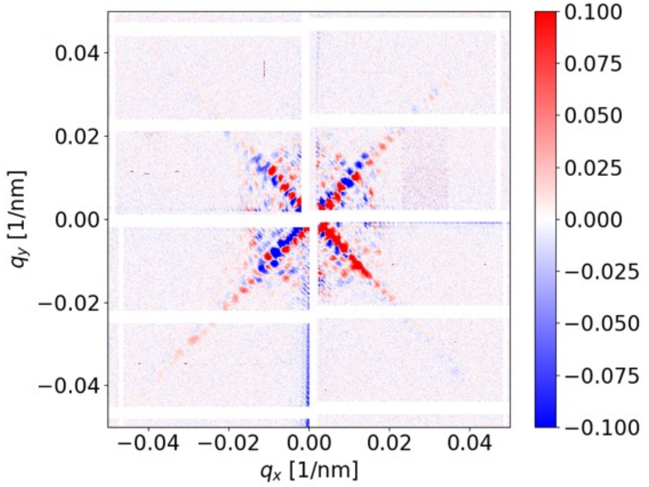
DSSC Detector for CDI, SAXS, XPCS

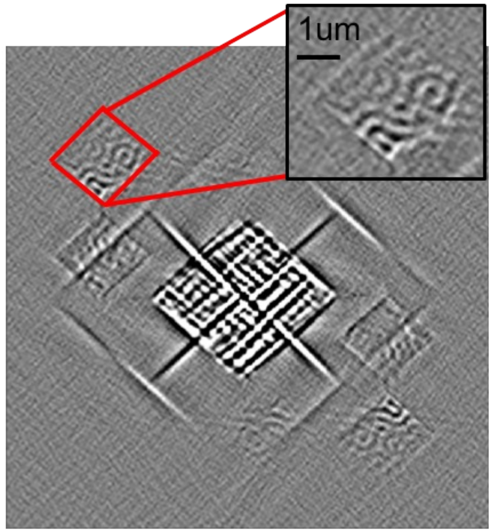
DSSC detector	SAXS, CDI, BOZ-XAS/XMCD, XPCS	
Number of pixels	1024 x 1024	
Pixel coordinates	Hexagonal	Detector quadrants in windmill configuration
Pixel size	204 µm x 236 µm	
Max frame rate	4.5 MHz	
Beam hole size	Default: 4.75 mm (windmill)	The diameter of the central dead area is 8mm.
Standard detector-to-sample distance	Min: 1.24 m Max: 5.40 m Travel range: 1.5 m (under vacuum)	

Megahertz-rate Ultrafast X-ray Scattering and Holographic Imaging

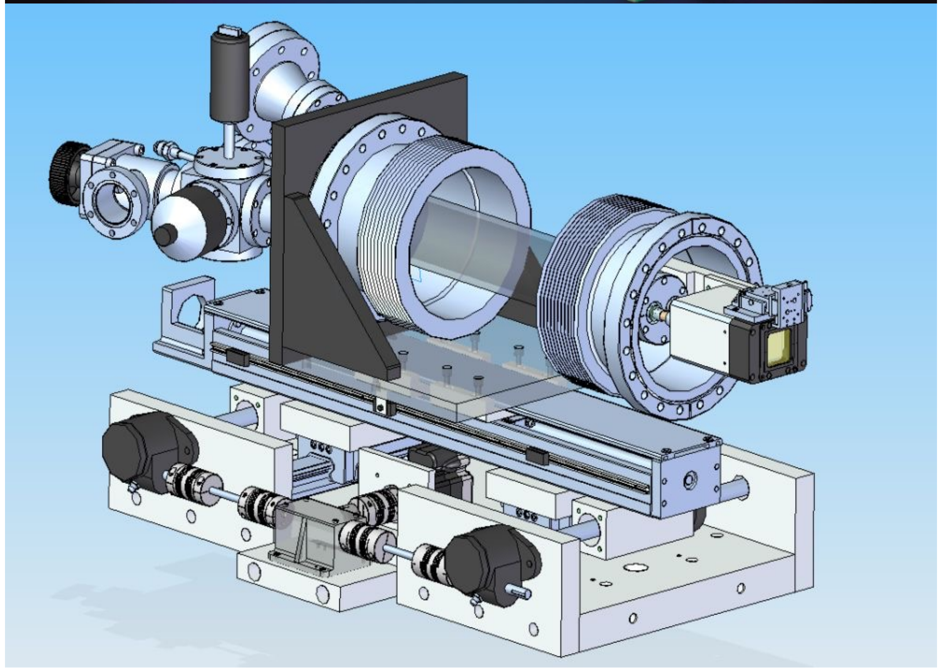
Hagström, et al.., arXiv:2201.06350(2022)



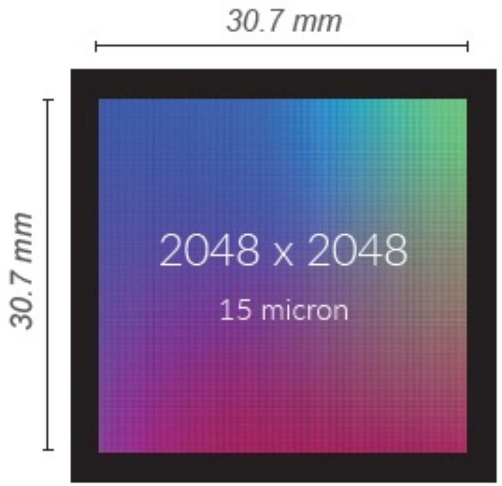


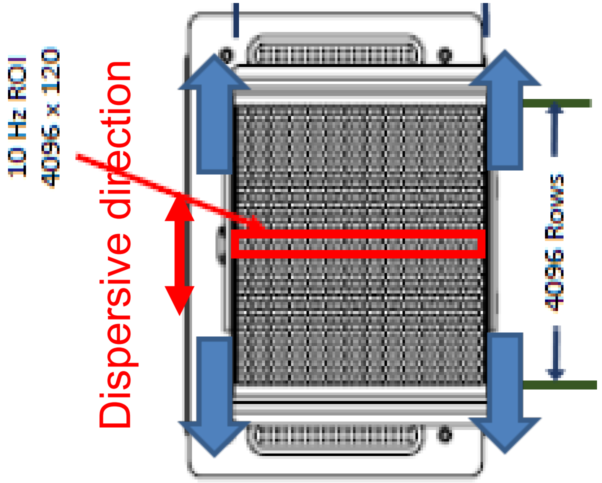


Pi-MTE3 commercial detector option

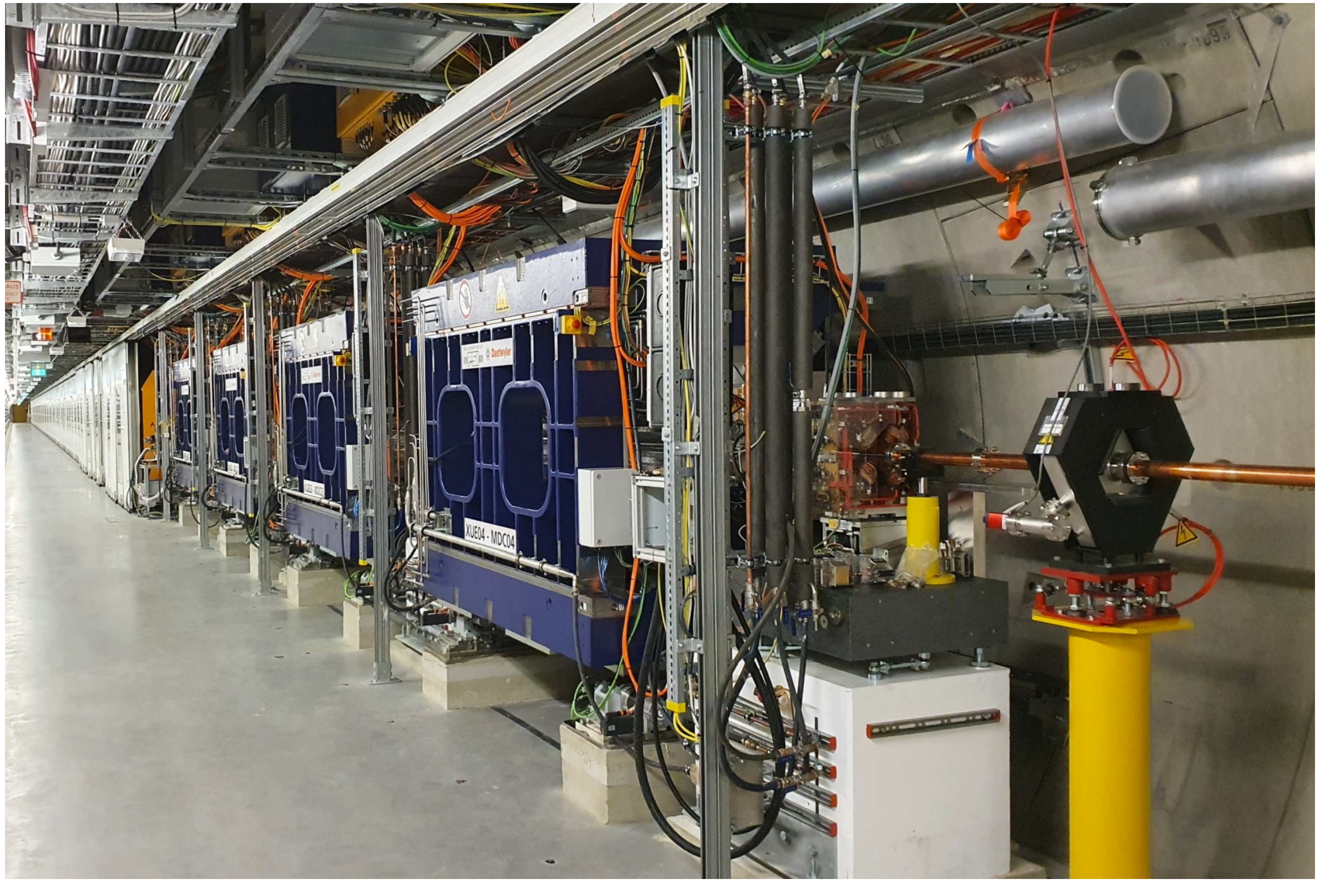


PI-MTE3 Detector		
Number Pixels / Size	2048 x 2048, 15µm x15µm	Cartesian coordinates, 30.7 x 30.7 mm imaging area
Frame rate	up to 1Hz	4 port readout, inquire for details
detector-sample distance	55 - 820 mm	





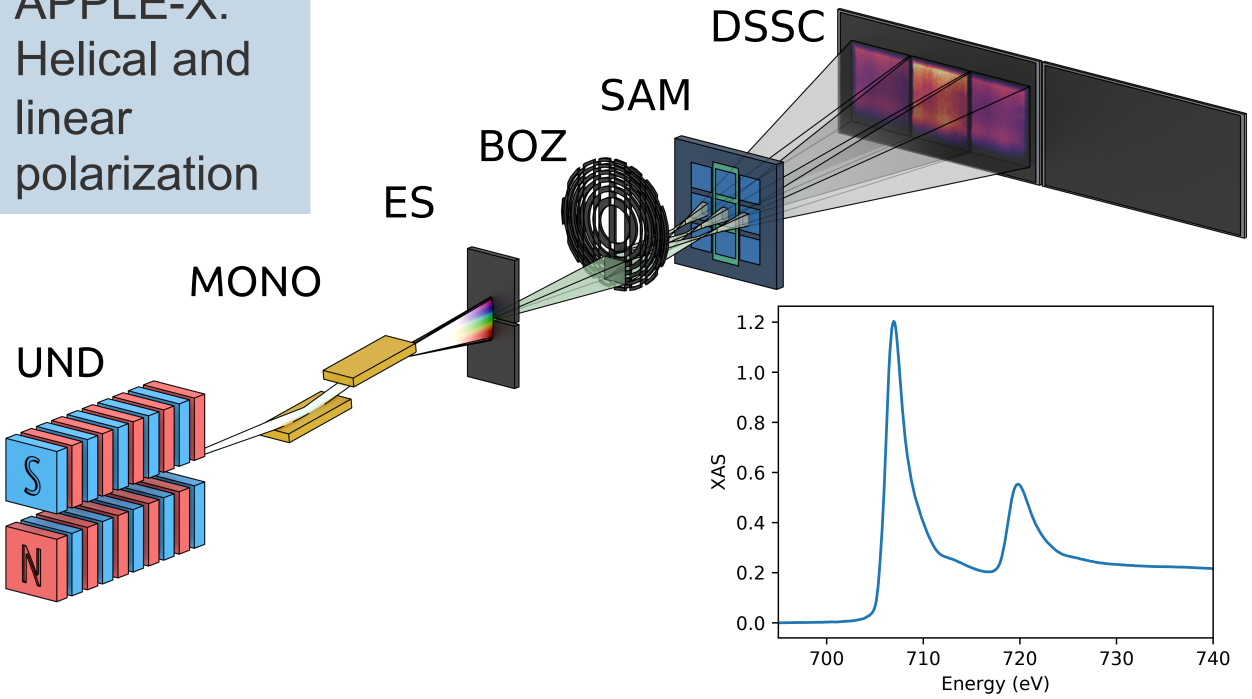
EuXFEL APPLE-X (UE90) Variable Polarization at SA3:
Linear horizontal, linear vertical, left and right circular Polarizations

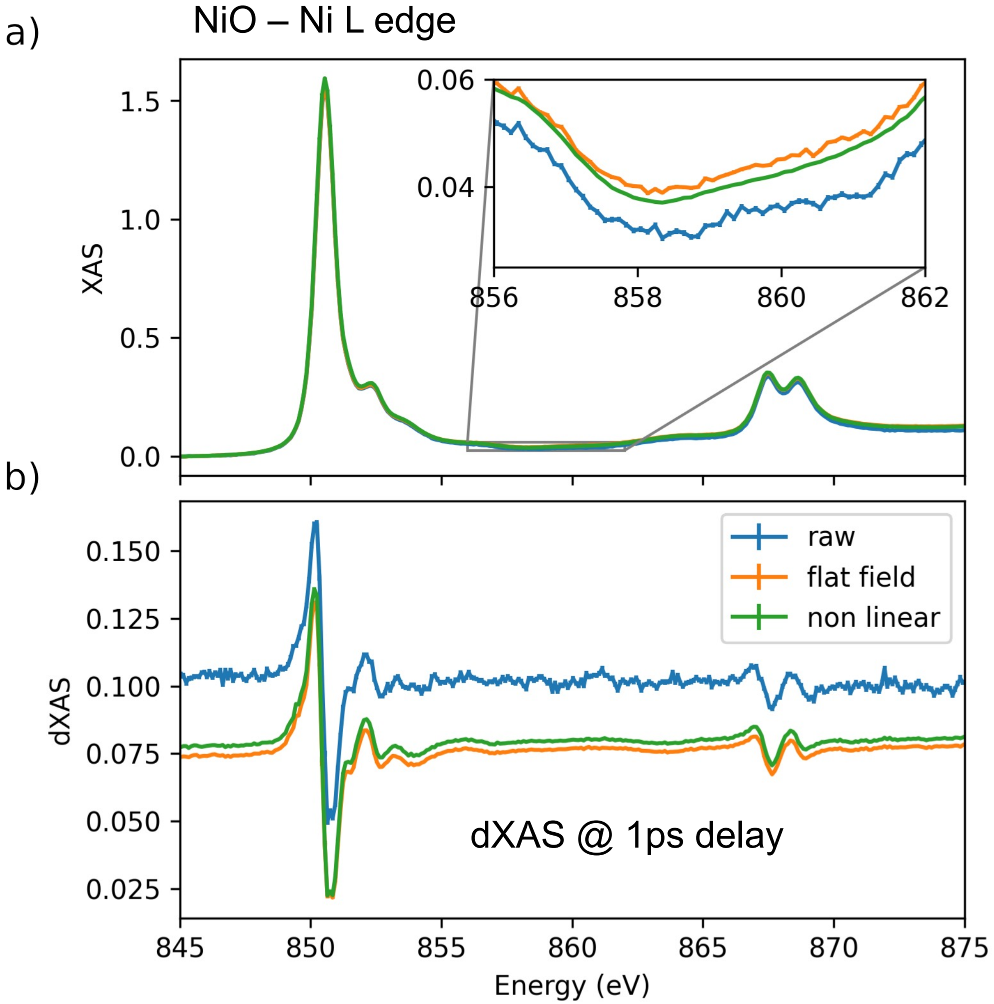


- Installed during winter shutdown 21/22
- Commissioning in 2022
- Basic Functionality in 2023

Beam-splitting off-axis zone plate for shot-noise limited MHz transient absorption spectroscopy with the DSSC detector

APPLE-X:
Helical and linear polarization

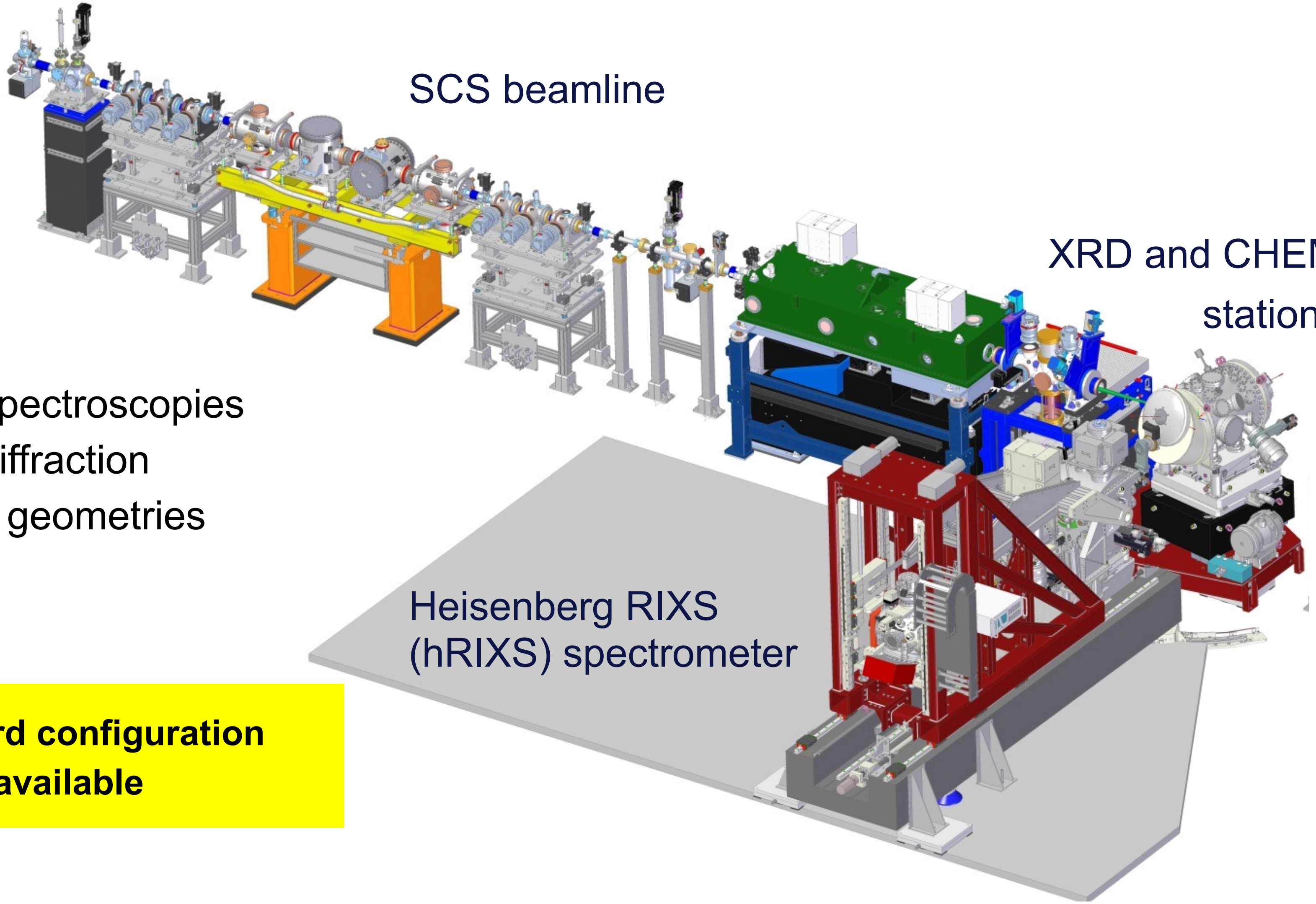




Le Guyader, et al., in preparation (2022)

UP 2589, Eschenlohr et al., in preparation (2022)

CHEM-RIXS at the SCS Instrument, 9th Call for Proposals



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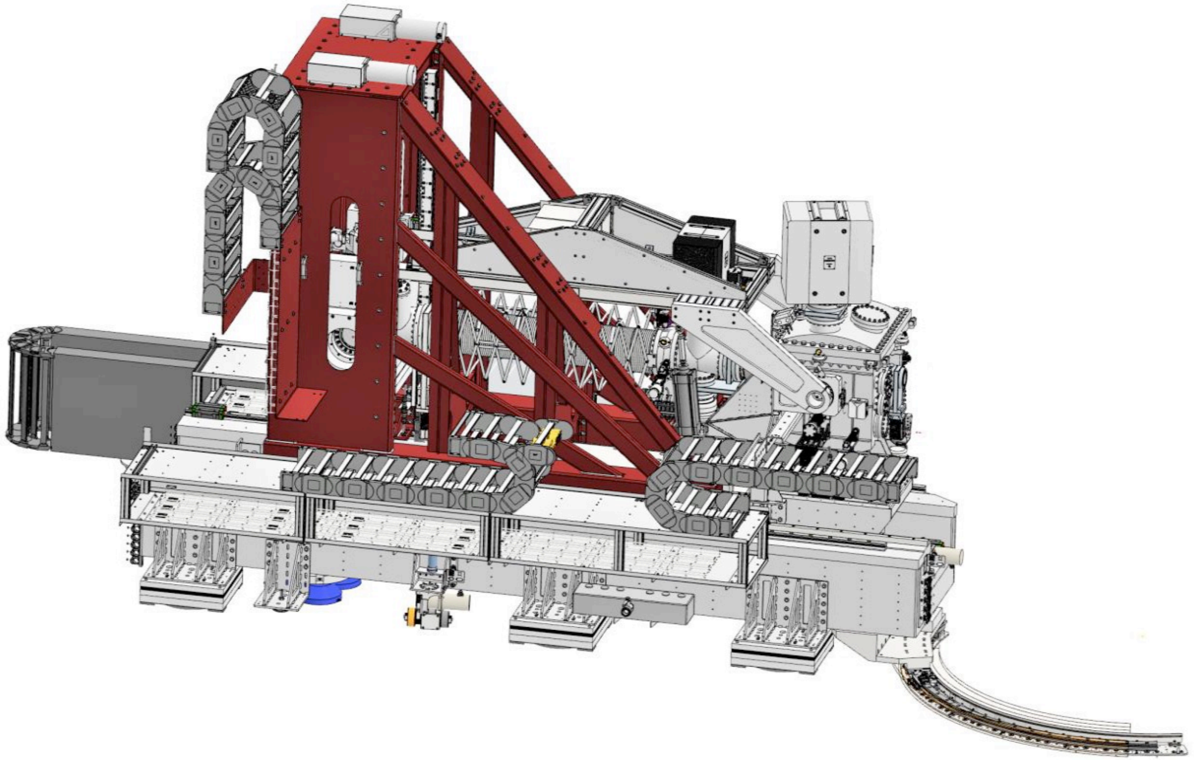
- **RIXS**
- **Solid samples**
- **Liquid-jet samples**

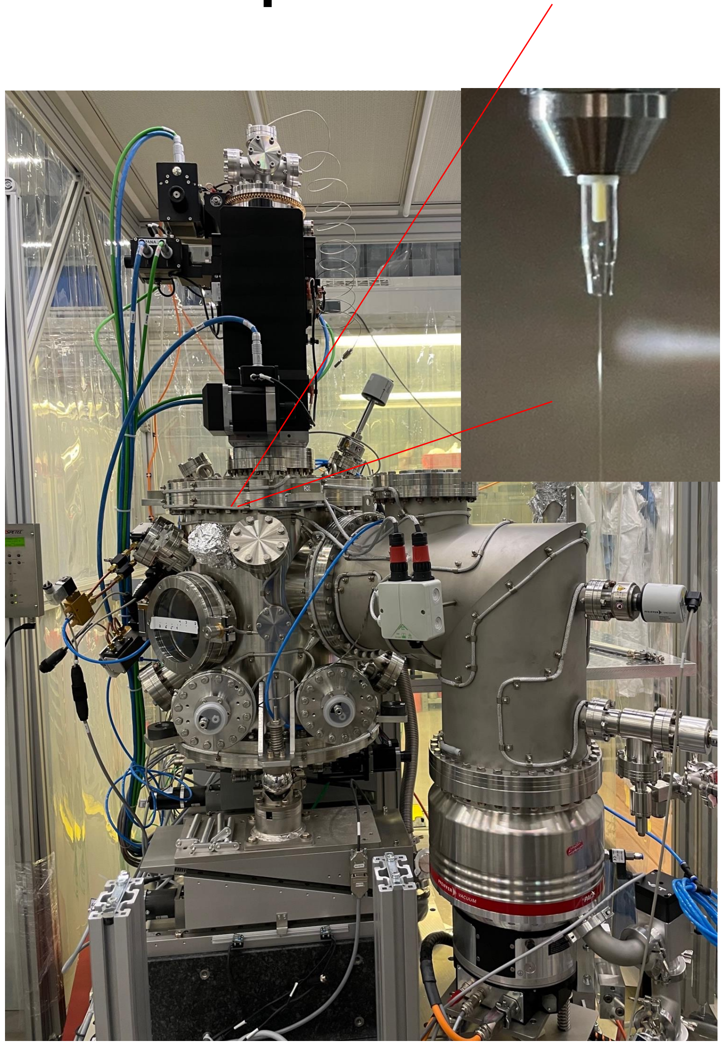
Standard configuration available

hRIXS parameters for run 9th



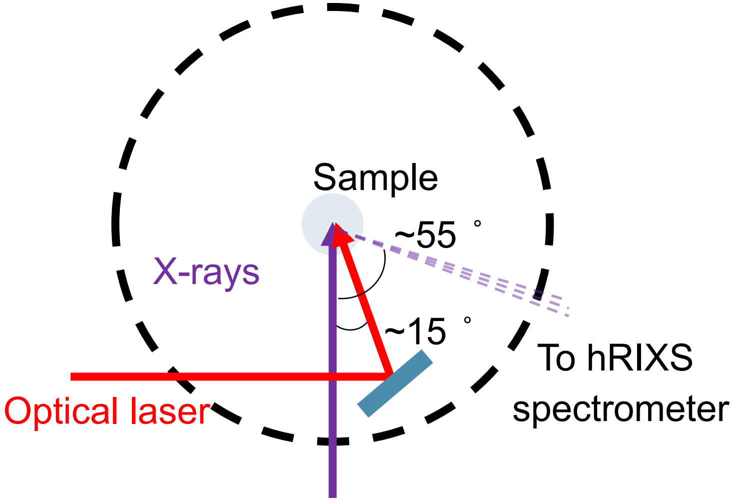
hRIXS parameters	
Photon energy	0.5 – 1.5 keV
Combined resolving power	Up to 10.000 (mono HR) 3.000 (mono LR)
Transmission	~10^{-6}
Time resolution	Limited by mono: 80-150 fs (mono HR) 30-50 fs (mono LR)
Scattering angle -> CHEM	90 deg, 125 deg

CHEM experiment station with liquid-jet sample environment



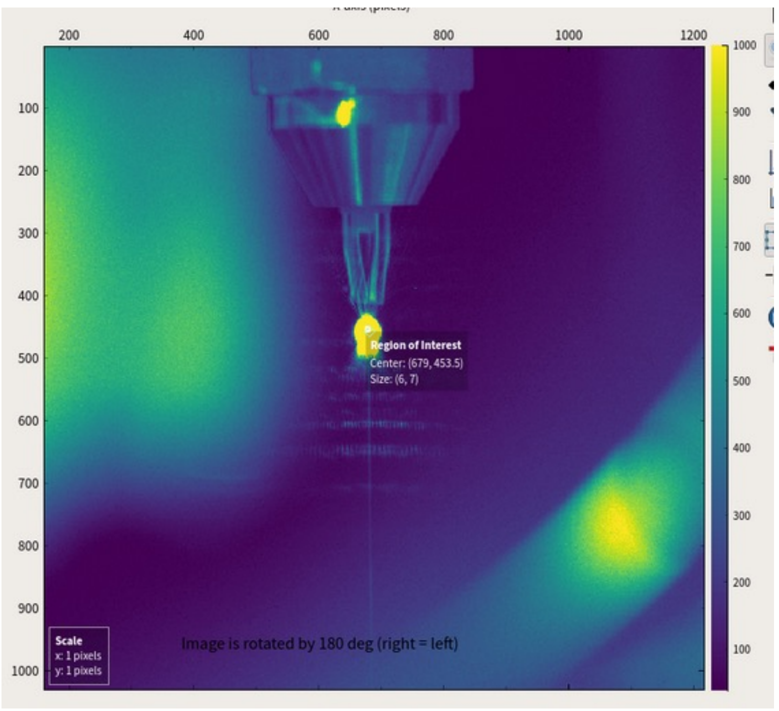
CHEM station is optimized for time-resolved high-resolution RIXS studies of chemical samples in the liquid phase

CHEM chamber, top view



CHEM / Liquid sample environment		
Sample delivery	Liquid jet, single cylinder, 20-50µm	Standard configuration
RIXS scattering angle	125 deg, 90 deg	Standard configuration: 125 deg
Solvents	Water, Ethanol, Isopropanol*	Standard configuration. *) Inquire for alternative solvents

Time-Resolved RIXS: Standard Configuration



Focal spot size at sample, tunable	10-30 µm x 10 µm hor. & ver. tunable	10µm vertical is used for RIXS
Sample delivery	20 – 50 µm liquid jet, single cylinder	
Solvents	Water, Ethanol, Isopropanol	
RIXS scattering angle	125 deg	
Optical laser	800nm: 0.2mJ (1.1MHz) – 2mJ (0.113kHz), 400nm (SHG), 266nm (THG) via conversion from 800nm; spot size ~100µm; Linear, circular polarization	

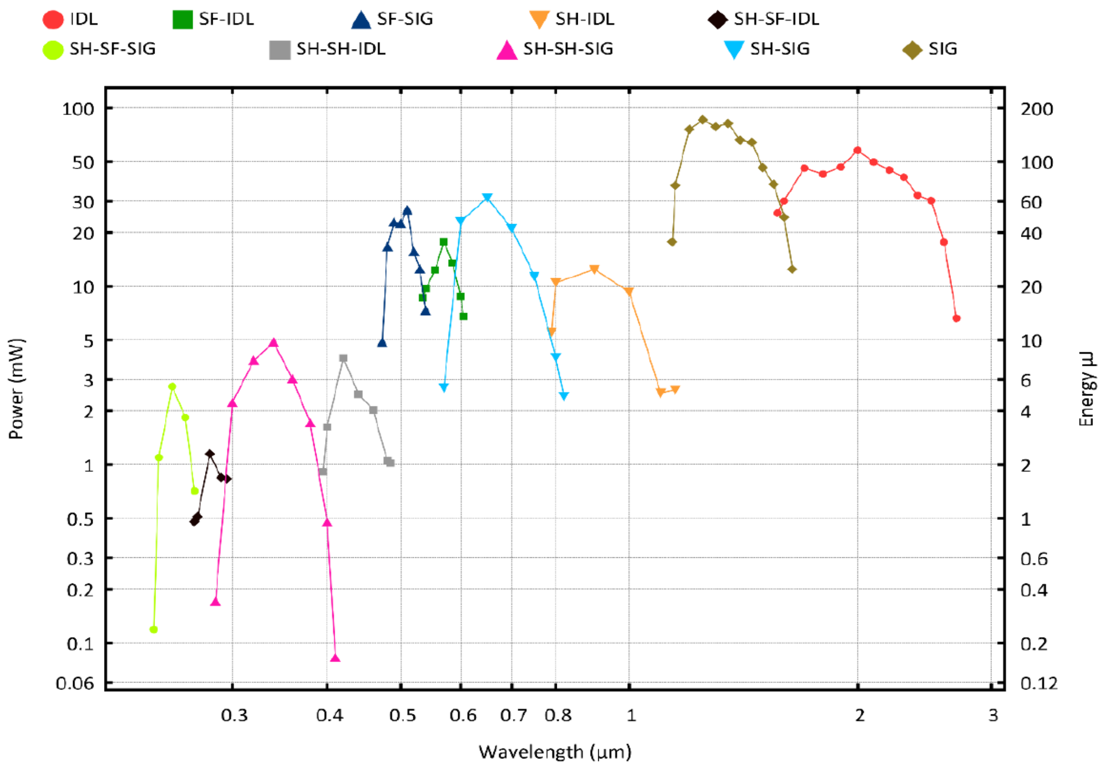
- RIXS on transition metal complexes in solution (water and alcohols)
- Concentration 10's of mM and greater
- Laser In-coupling with 800, 400, or 266 nm laser excitation

Optical delivery

- Pump-Probe laser (fundamental 800 nm)
  - Up to 2 mJ/pulse @ 113 kHz, up to 0.2 mJ/pulse @ 1.1 MHz
  - 15 or 50 fs
  - SHG (400 nm) and THG (266 nm) available
  - TOPAS (Tunable OPA pumped by PP laser): 250 nm – 10 µm up to 0.2 mJ/pulse
  - **Successful experiments so far:**
    THG (266 nm), SHG (400 nm),
    500 nm, 633 nm, 800 nm, 1100 nm, 1300 nm, 2500 nm
  - 1030 nm long pulse (>800 fs), 40 mJ/pulse also available

- Temporal stability
  - New feedback on Beam Arrival Monitors (BAM)

- Spatial stability
  - Focused beam monitored every train



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