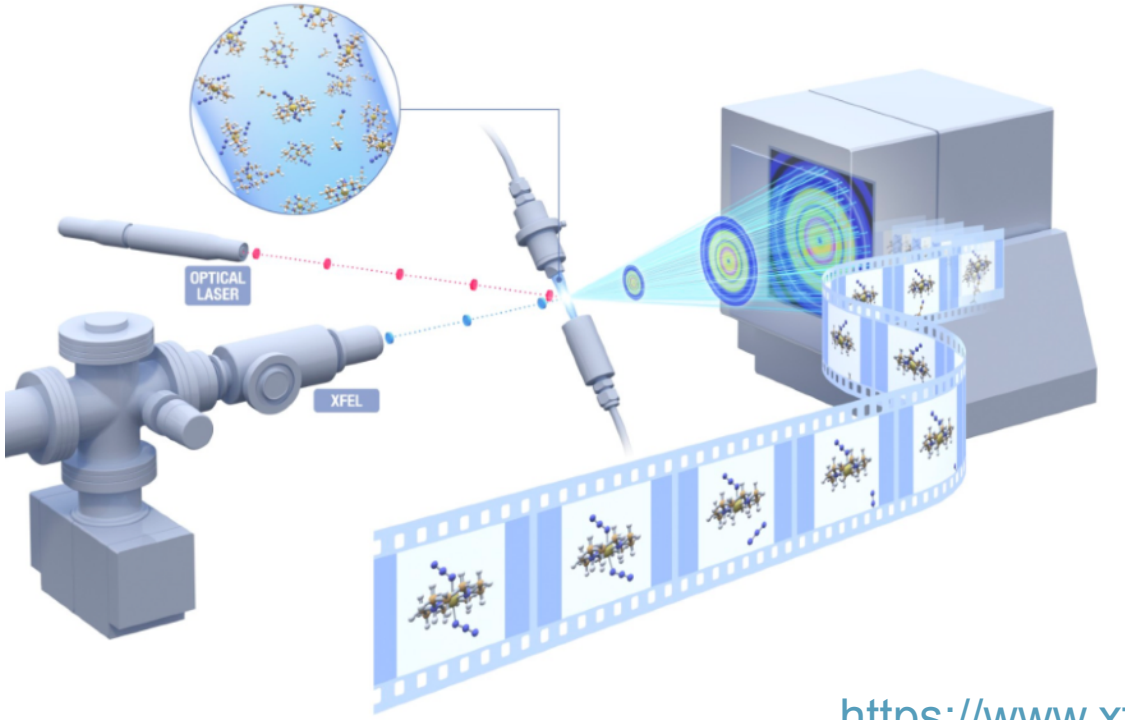
Run 9 @ Femtosecond X-ray Experiments

Chris Milne on behalf of FXE

European XFEL
FXE – Femtosecond X-ray Experiments



European XFEL Town Hall
12.5.2022

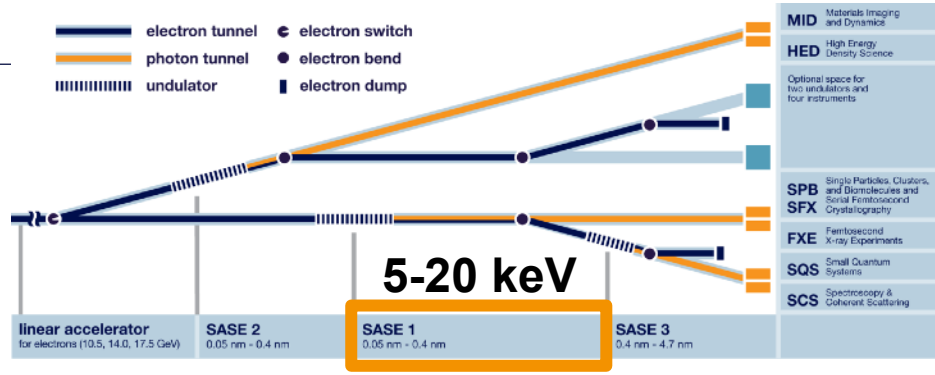
https://www.xfel.eu/

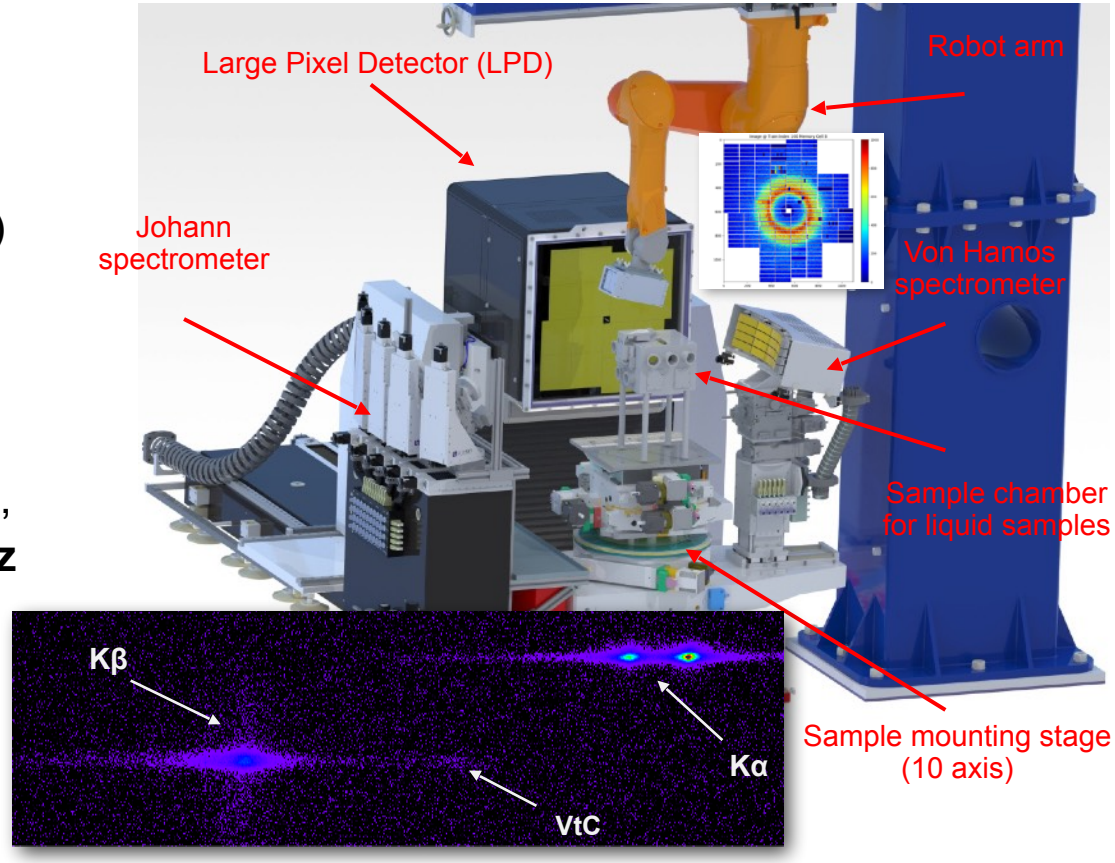
christopher.milne@xfel.eu

FXE: Femtosecond Hard X-ray Experiments

A Suite of **Simultaneous** X-ray Tools combined with flexible Laser Excitation Sources

- **Single-shot** dispersive resonant and non-resonant **XES**: von Hamos
- **Wide**(Small)-**angle X-ray Scattering**: Large Pixel Detector (LPD) and Jungfrau
- Huber sample motion, goniometer for **single-crystal X-ray diffraction** with Jungfrau detector motion using the robot arm
- Tuneable laser excitation covering 1030, 515 nm (1 ps), 800, 400, 266 nm (15 or 50 fs) and an **OPA** (50 fs, 240 nm to 3 um) with **THz** in development ($LiNbO_3$, 0.2-0.3 THz)
- **X-ray absorption spectroscopy** (5-20 keV): **scanning** (Si(111) 4-bounce mono) and **single-shot** (Spectrum analyzer)
- **Scanning** resonant and non-resonant **XES** (RXES): Johann spectrometer





"Scientific instrument Femtosecond X-ray Experiments (FXE): instrumentation and baseline experimental capabilities" A. Galler , et al., *J. Synch. Rad., 26, 1432 (2019)*
"Ultrafast X-ray Photochemistry at European XFEL: Capabilities of the Femtosecond X-ray Experiments (FXE) Instrument" D. Khakhulin, et al., *Appl. Sci., 10, 995 (2020)*

FXE group members

Leading Scientist

Chris Milne

Engineering team

Martin Knoll

Paul Frankenberger

June 1

Electronics engineer

Postdocs

2022

VALENCE postdoc

Xinchao Huang

Doriana Vinci

Hao Wang

Diana Bregenholt Jakobsen

PhD students

Florian Otte

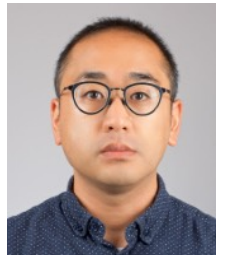
Sharmistha Paul Dutta

Scientists

Dmitry Khakhulin

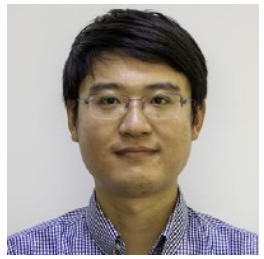
Frederico Alves Lima

Mykola Biednov



Yohei Uemura

Peter Zalden



Yifeng Jiang

Fernando Ardana Lamas

2022

Instrument scientist

Detector Scientist

Hazem Yousef

XFEL Collaborators

Wajid Ehsan (Controls)

Mohammed Vakili, Marco Kloos (SEC)

Jia Liu, Theophilos Maltezopoulos, Jan Grünert, Wolfgang Freund (XPD)

Marco Ramilli (Detectors)

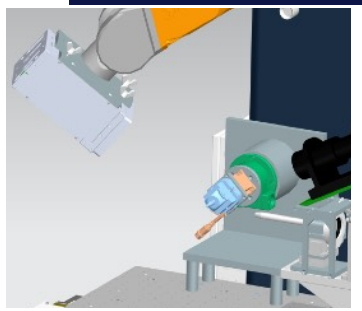
Kai Erik Ballak (EEE)

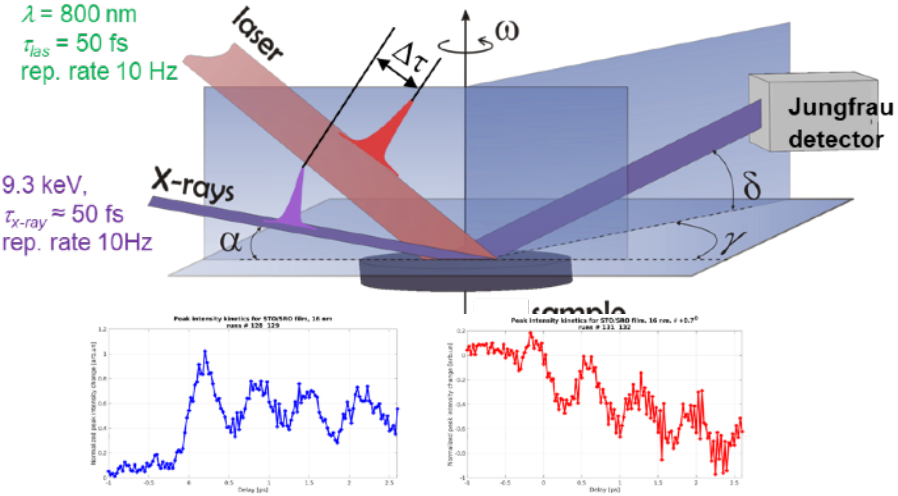
Liuba Samoylova (XRO)

https://www.xfel.eu/facility/instruments/fxe/group_members/

Standard sample environment and geometries: Liquid & solid state experiments

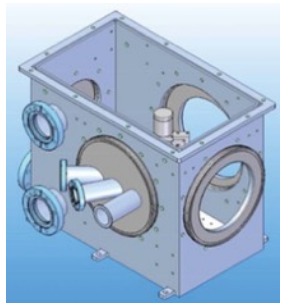
Fixed target 10-300 Hz diffraction experiment

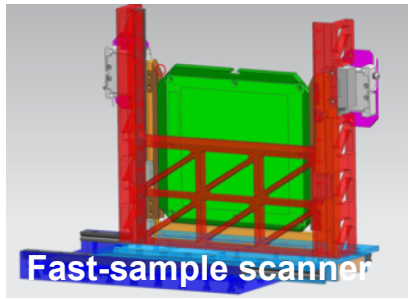


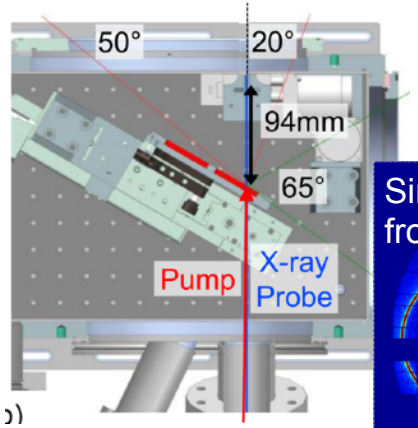


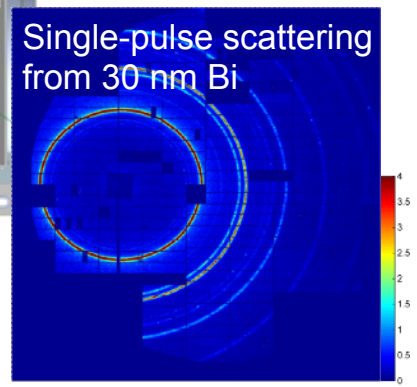
- Vertical and horizontal geometry
- Grazing and symmetric Bragg diffraction
- Flexible tracking of Bragg peak with detector on Robot arm
- Cooling and heating of samples supported
- Compatible with von Hamos XES for vertical sample geometry

Destructive single-shot diffraction experiment (<10 Hz)



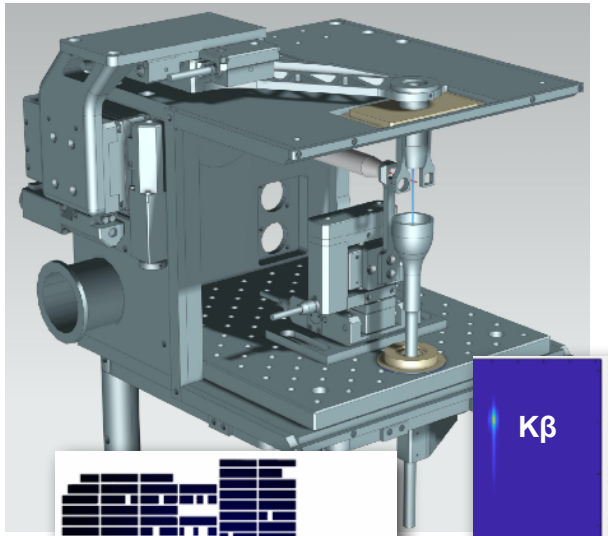


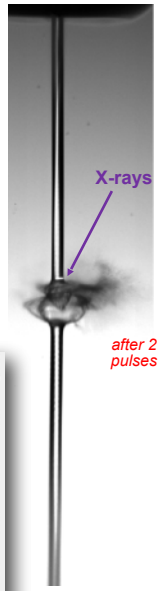


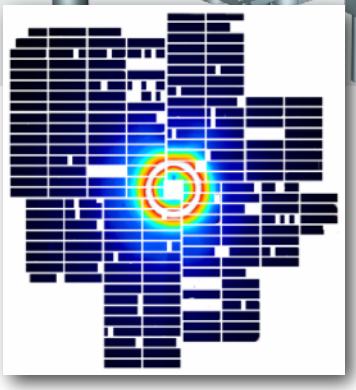


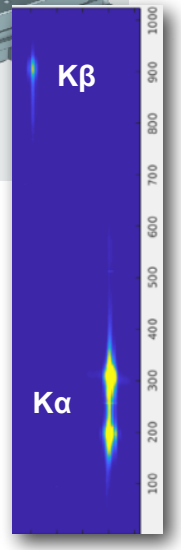
- Vacuum environment (1e-5 mbar)
- X-ray probe in transmission geometry
- Parallel X-ray emission and scattering compatible
- Diffraction up to 8.8 Å^{-1} at 16.5 keV and $2\theta_{max}$=63°

Liquid jet chemistry chamber (0.125-0.5 MHz)







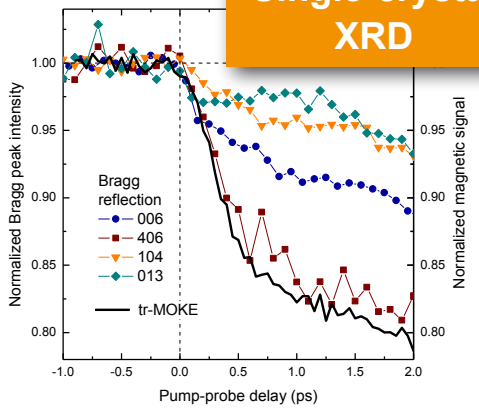


- He environment
- Open on 3 sides (XES, XAS, WAXS compatible)
- Parallel UV-Vis flow loop to monitor sample
- Jet diameter 25-200 µm
- XES Bragg angle range 67-83°
- WAXS maximum Q up to 10 Å^{-1}

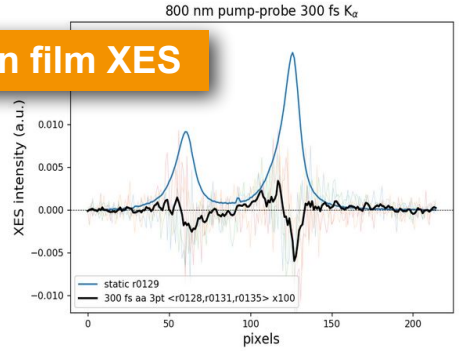
Scientific Scope of FXE: Measuring ultrafast dynamics with hard X-rays

Ultrafast solid-state dynamics

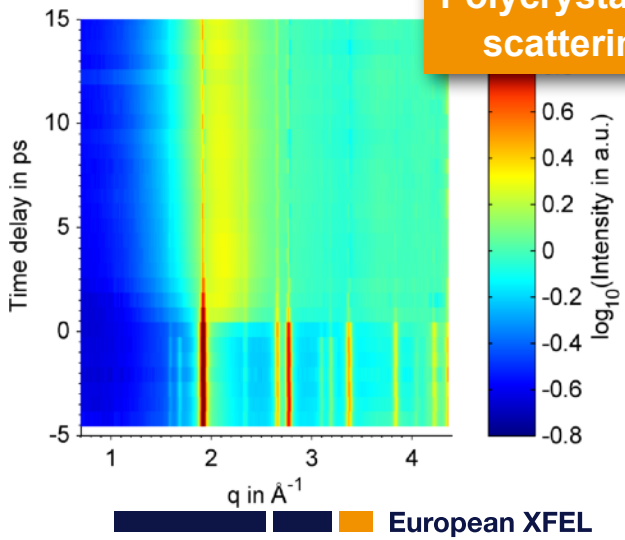
Single-crystal XRD

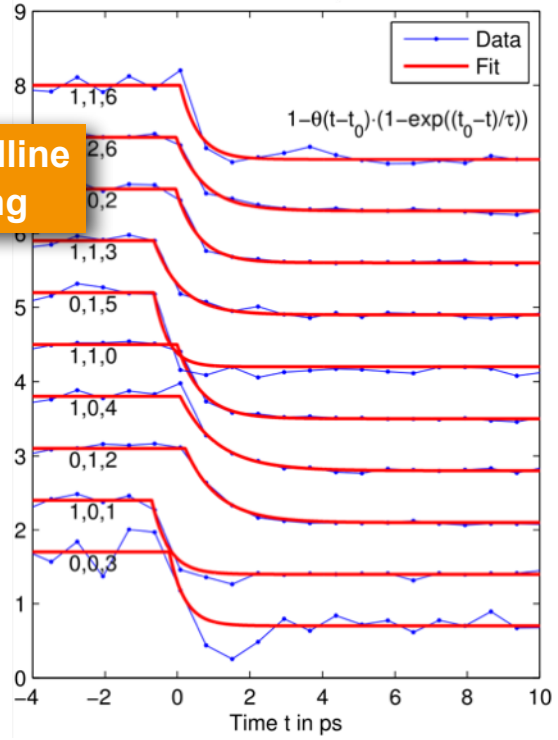


Thin film XES



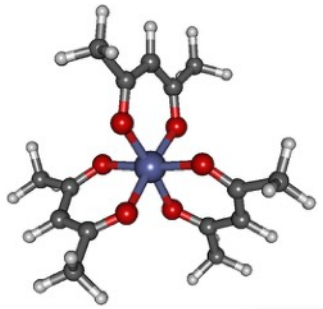
Polycrystalline scattering

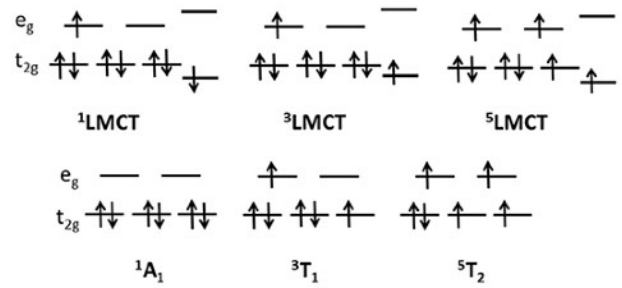




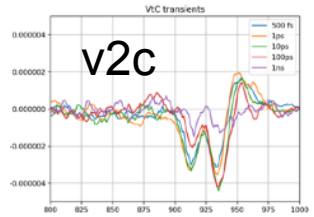
European XFEL

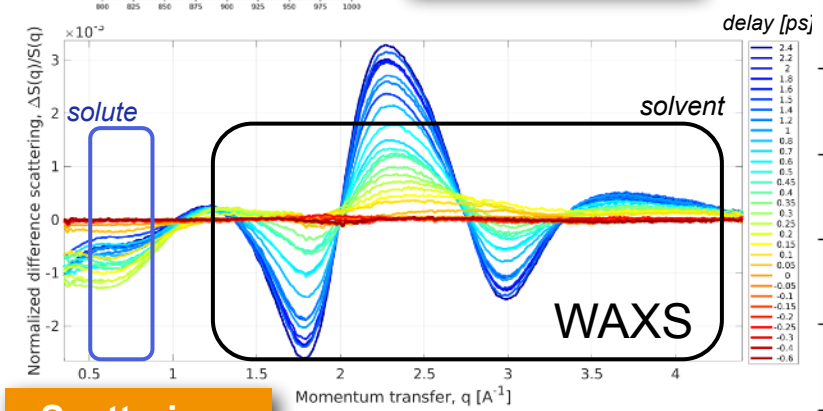
Ultrafast (bio)chemical dynamics

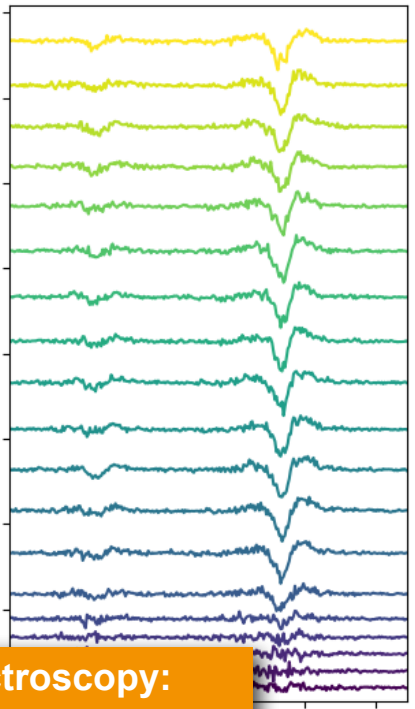




Excited-state electronic and structural dynamics





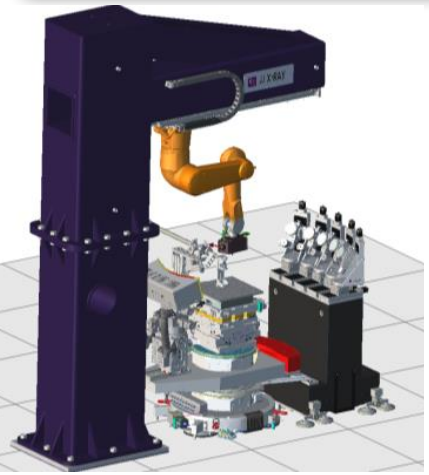


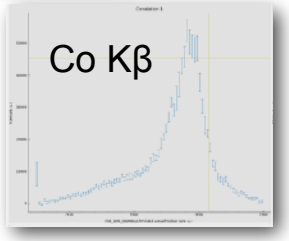
Scattering: structural information

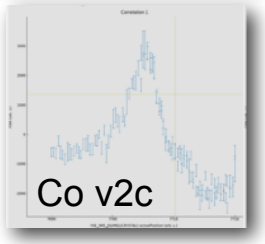
Spectroscopy: electronic information

FXE Status Update 5.2022

Johann XES spectrometer







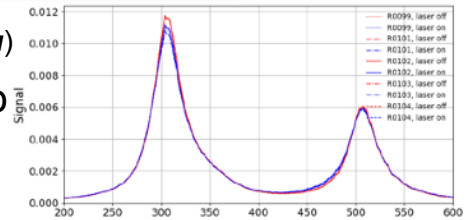
F. Lima (***frederico.lima@xfel.eu***)

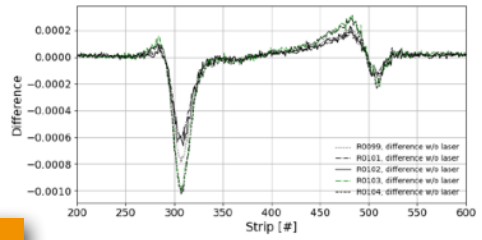
- **Johann spectrometer** commissioned and can be requested in proposals

Gotthard II detector

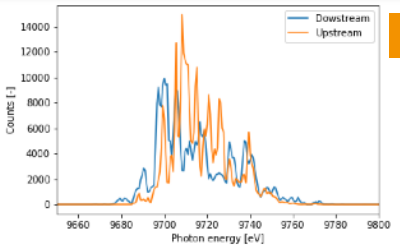
D. Khakhulin (***dmitry.khakhulin@xfel.eu***)

- Gotthard II integrated into robot support and used for pulse-resolved XES with the von Hamos
- Detector calibration ongoing





Single-shot spectrometers

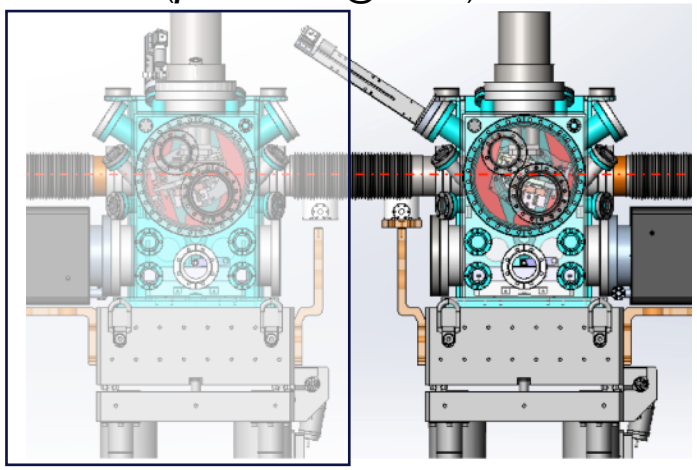


- Better understood and can be used for experiments

Fernando Ardana Lamas (**fernando.ardana@xfel.eu**)

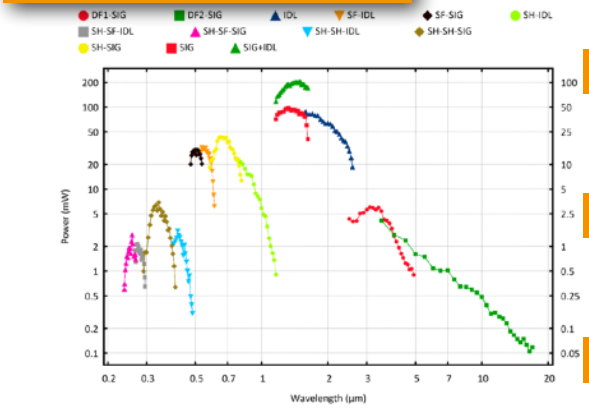
2-bounce monochromator

P. Zalden (***peter.zalden@xfel.eu***)



- Si(111) monochromator in a **two-bounce mode can be scanned** and operated reliably
- Stable delivery of **30 pulses per train in range 6-15 keV** is possible

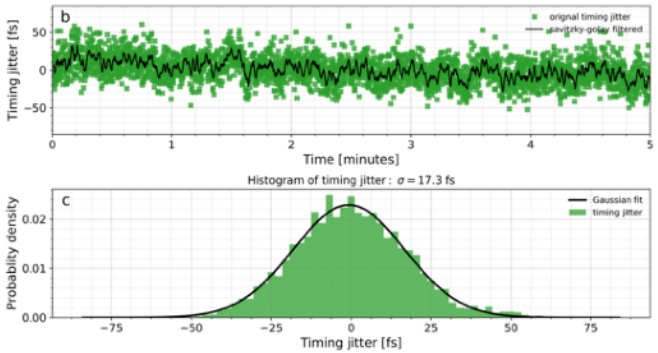
Optical excitation



- OPA used in the visible and near IR for experiments (400-600 nm)
- **282 kHz operation** planned for summer maintenance period
- Proposals using **240 nm to 2000 nm** are feasible

M. Biednov (***mykola.biednov@xfel.eu***)

Pulse-arrival monitor



- Timing jitter = 41.1 fs FWHM
- Tested at 9.3 keV and 12.3 keV, 5-50 pulses @ 282 kHz
- PP laser
  - 50 fs, 10-100 pulses @564 kHz
  - interleaved signal and reference
  - detectable signal for nearly all pulses in trains (95%)
  - 1.5 ps time window

Y. Jiang (***yifeng.jiang@xfel.eu***)