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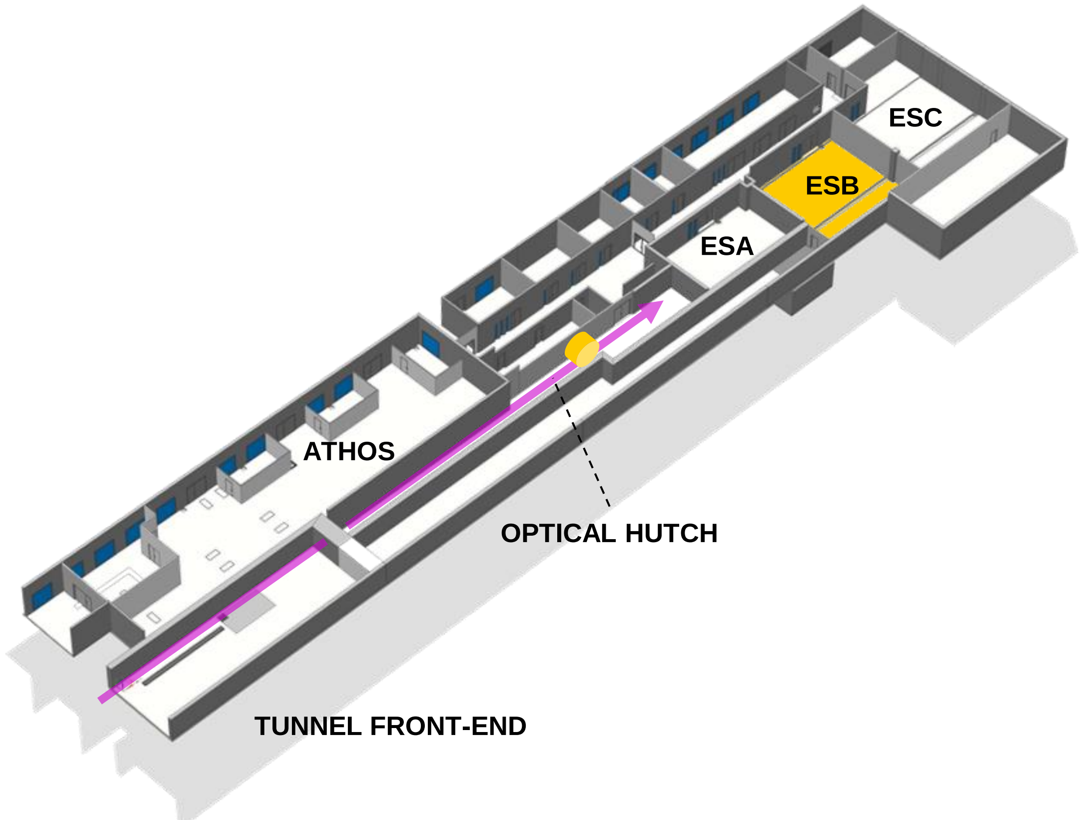
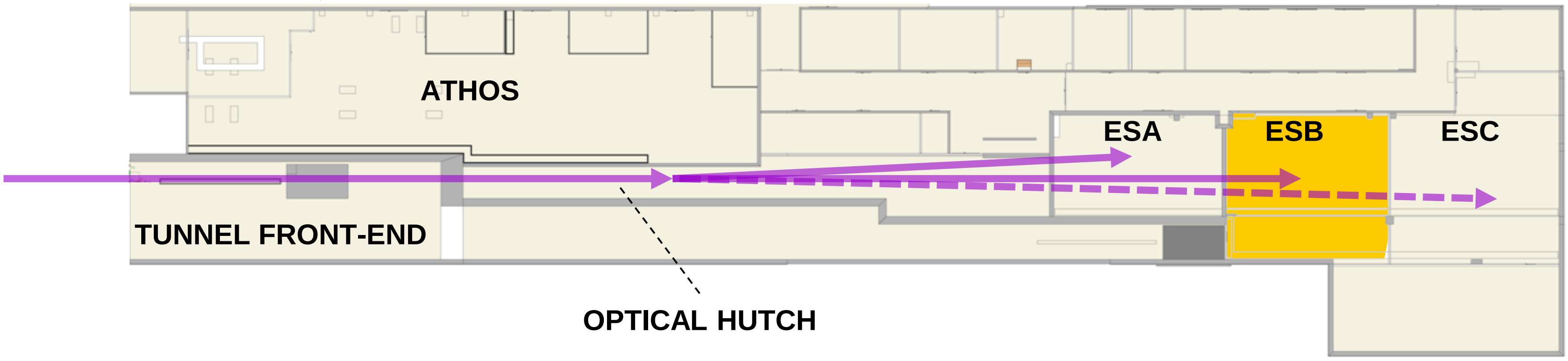
Henrik Lemke :: SwissFEL :: Paul Scherrer Institut

Experimental Station B
Ultrafast Diffraction

SwissFEL User Kick-off Meeting, 06.12.2016

ESB location in ARAMIS Experimental area





ESB Instrument: Team

Team (ESB Endstation)

G. Ingold: BL Scientist / FEMTO group leader
P. Beaud: Senior Scientist (50% FEMTO)
H. Lemke: BL Scientist (formerly: LCLS)
A. Oggenfuss: Technician
J. Rittmann: Postdoctoral Researcher

P. Böhler: Mech. Design/Engineering (PSI AMI)
A. Keller: Mech. Design/Engineering (PSI AMI)
Y. Deng: Laser Scientist (SwissFEL Laser Group)
T. Zamofing: Software (PSI Controls Group)

In collaboration (ESB Instrument):

SwissFEL Management
R. Abela
B. Patterson
L. Patthey

X-ray Diagnostics
P. Juranic
J. Rehanek

DAQ
L. Sala
S. Ebner

X-ray Optics Group
U. Flechsig
R. Follath
A. Jäggi

Beamline
Claude Pradervand
Christoph Hess

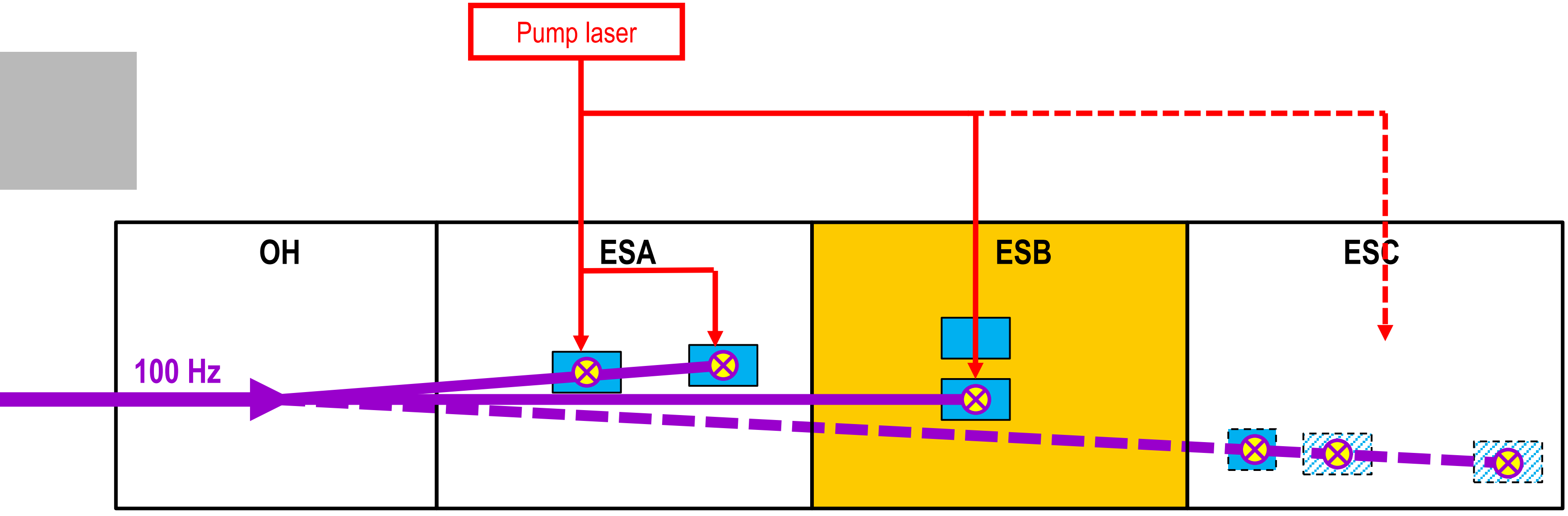
Laser Group
Ch. Erny
Ch. Hauri
M. Divall

Detectors
A. Mozzanica
B. Schmidt

Mech. Engineering
P. Wiegand

Synchronization
S. Hunziker

Beam trajectories



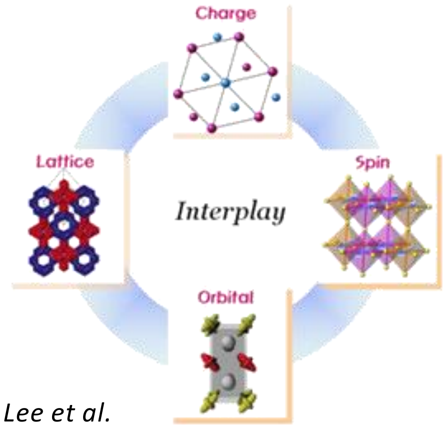
Conclusions

The ESB station is …

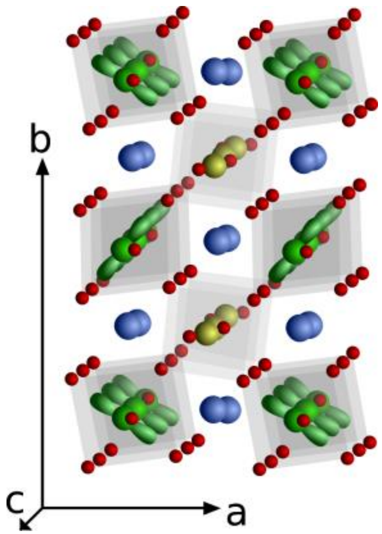
… specialized for solid **state pump/probe experiments**

… **flexible** for implementation of larger equipment (e.g. ESB-MX/Pedrini).

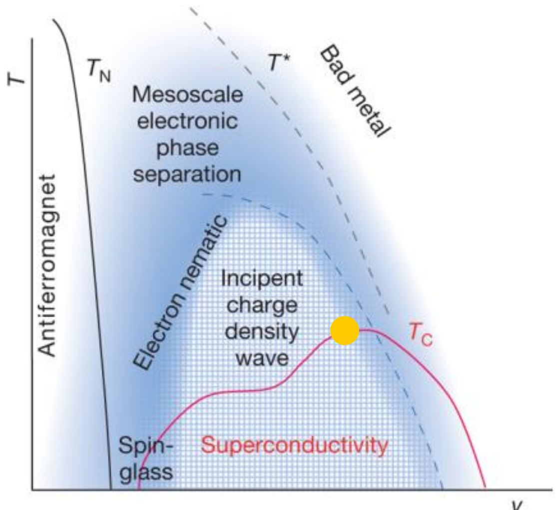
Example: Correlated electron systems



Lee et al.
SSRL highlight



Beaud et al. PRL 103, 155702 (2009).

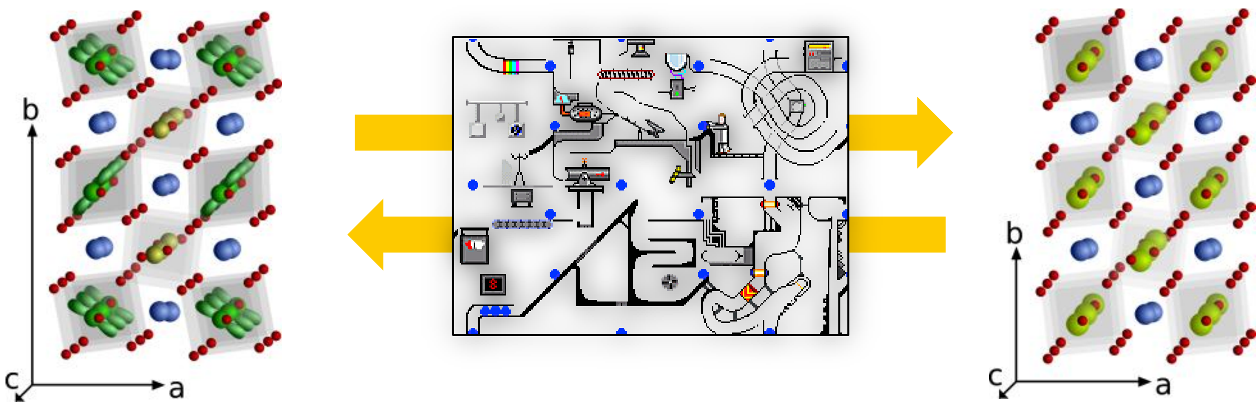


Nature Physics 8, 864–866 (2012)

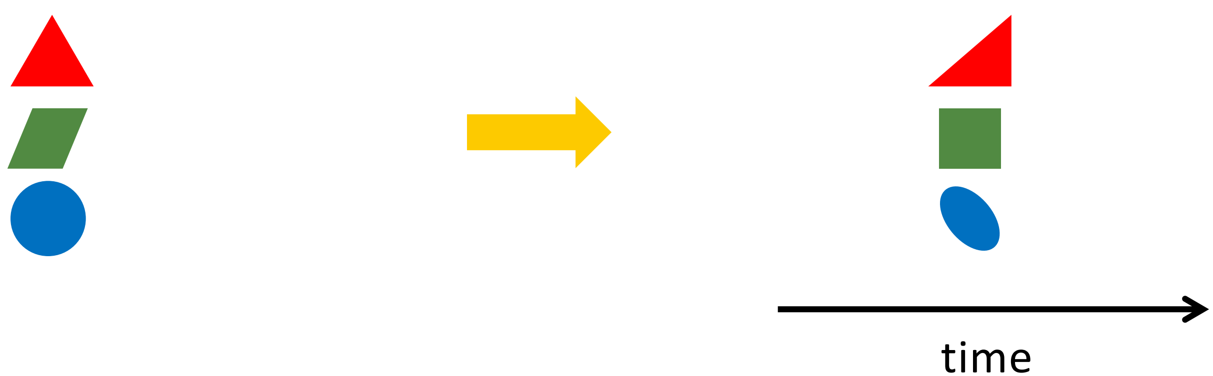
Material phases with very different electronic and magnetic properties through complex interplay of electronic and ionic structure.

Correlated material → correlated Mechanism

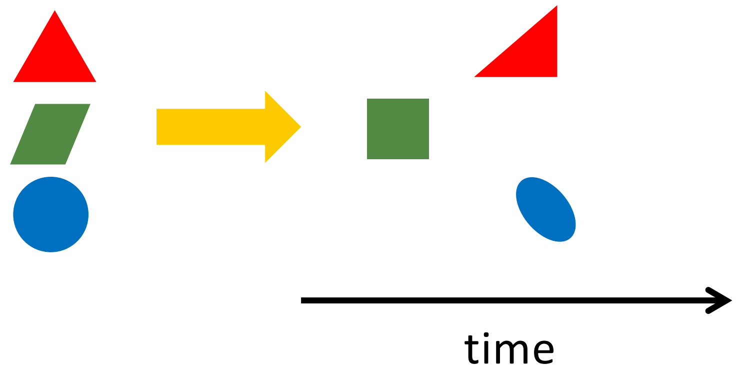
Correlated Structure suggests switching mechanism through interaction between degrees of freedom

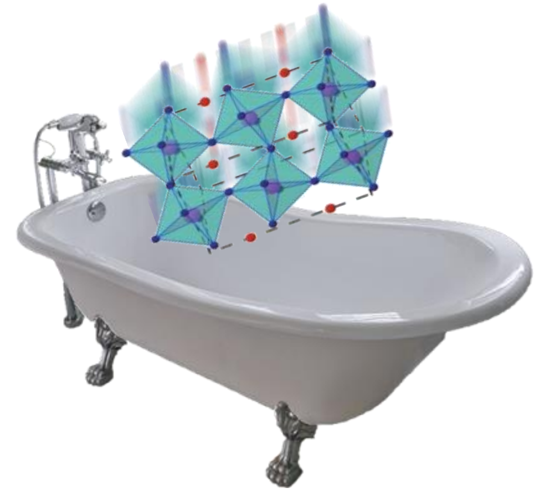


Time information can unravel process cascades/dependencies

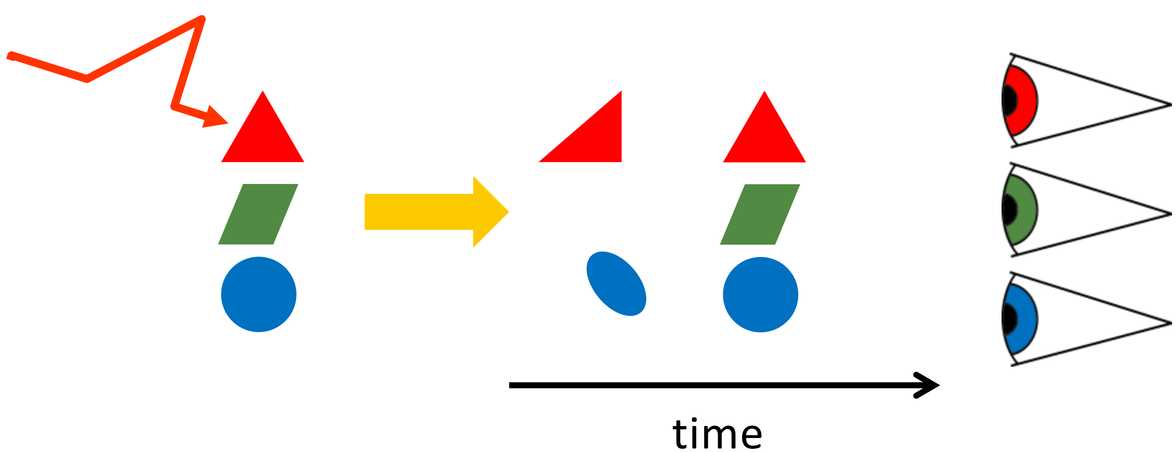


Selective switching / selective sensitivity





Causality in mechanism cascade can be detected by selective excitation and probing of specific DOFs



X-ray diffraction

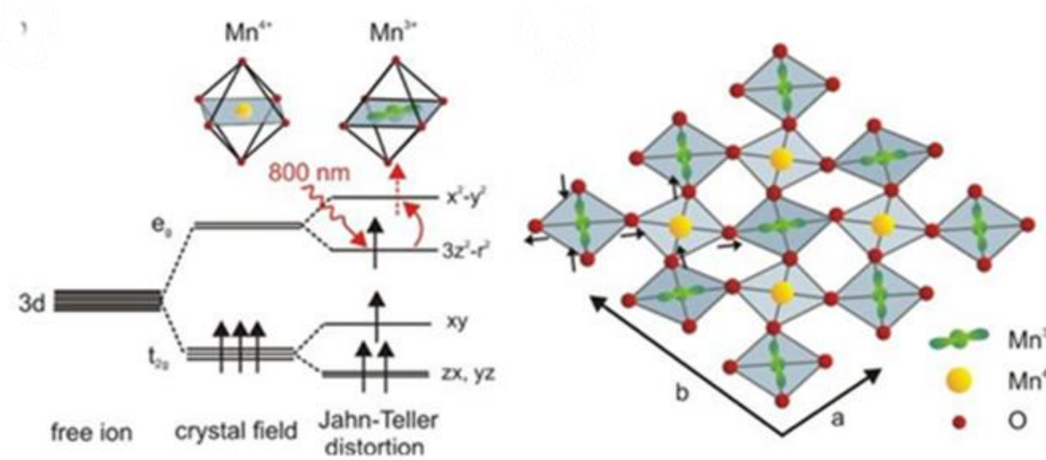
Resonant diffraction

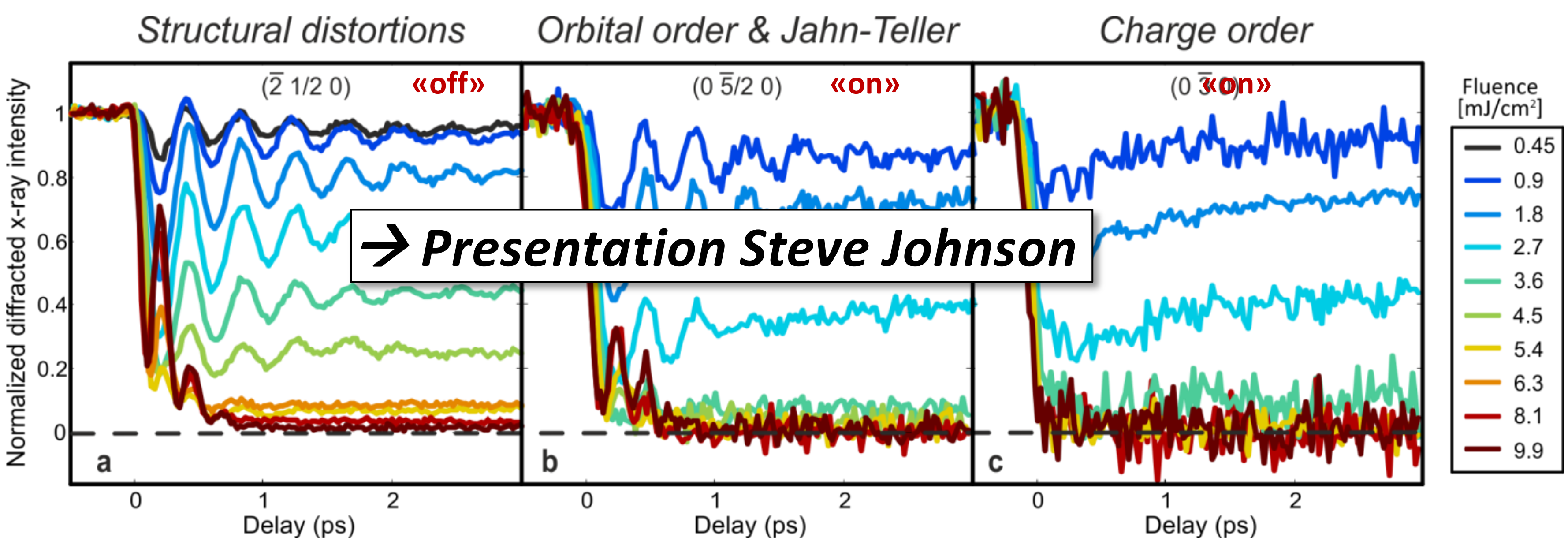
Diffuse and inelastic scattering

Example Manganite – resonant diffraction

Manganite $Pr_{0.5}Ca_{0.5}MnO_3$ close to Mn Absorption Edge (6.5 keV)

→ **Selective Sensitivity**

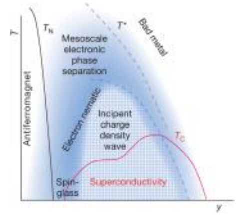




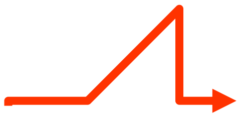
→ ***Presentation Steve Johnson***

Beaud et al., Nature Materials 13, 923–927 (2014)

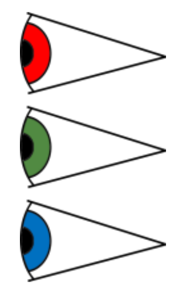
Experimental requirements



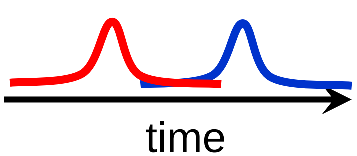
- Conditioning of sample system



- Selective manipulation of different DOFs
- Selective sensitivity to different DOFs



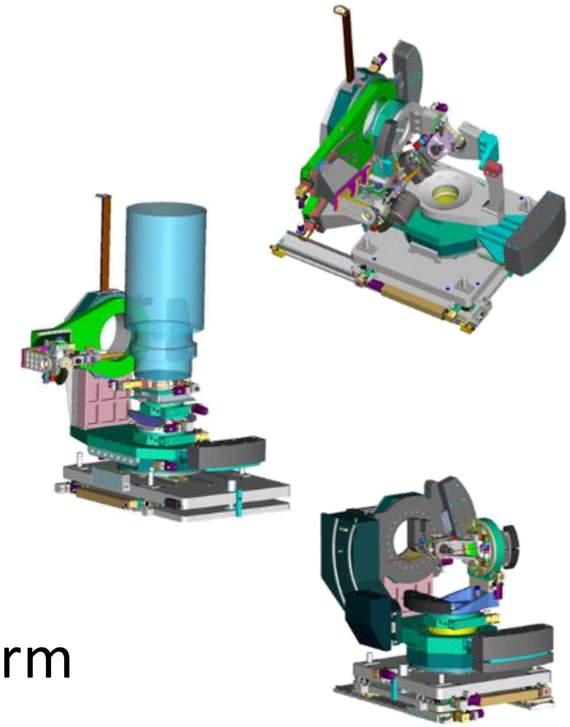
- Sufficient time resolution to separate process cascades



Controlling sample Condition: T, P, B

Compromise between sample degrees of freedom and sample environment

- Cryostats
- High B-field superconducting magnets
- Vacuum chambers
- High-P setups



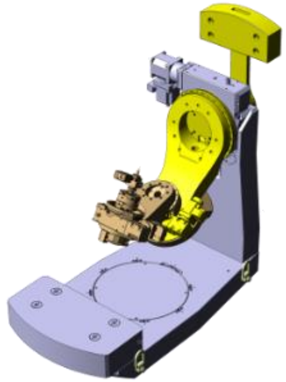
⇨ Requirement of flexible platform

Examples from

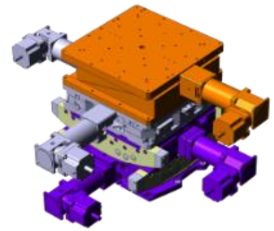
P09 and P01, PETRA III (DESY)

Flexible Diffractometer options

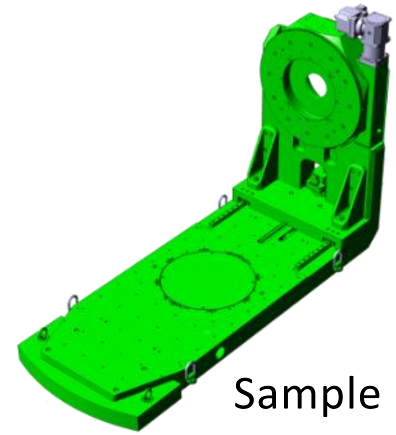
Exchange Modules



κ sample arm

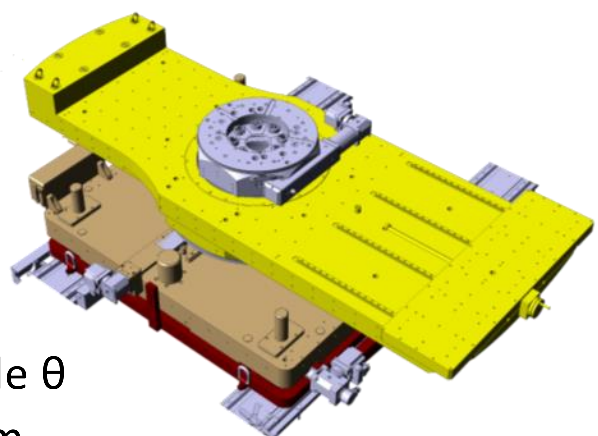


High load goniometer non-magn.

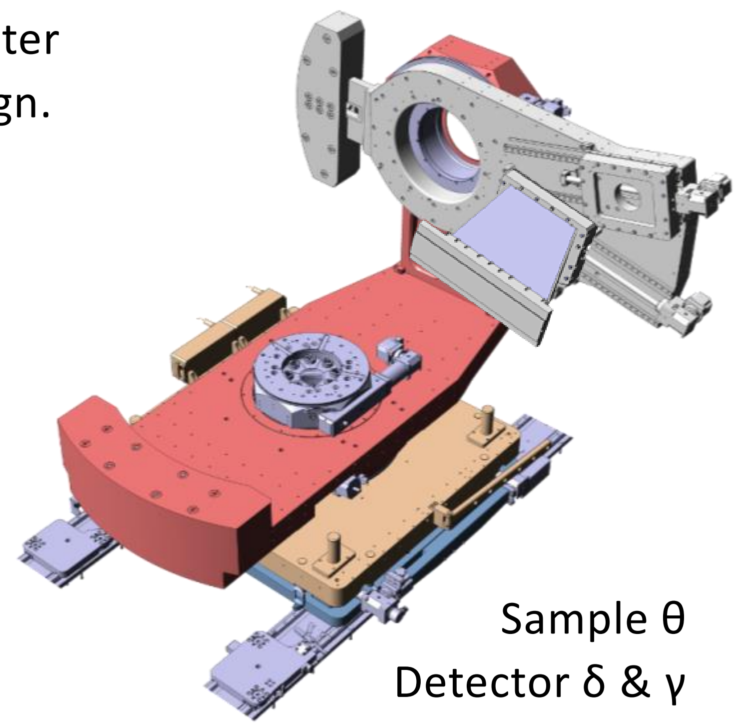


Sample μ rotation

Base Platforms



Sample θ
2θ arm
Beam positioning table (3 DOF)



Sample θ
Detector δ & γ
Beam positioning table

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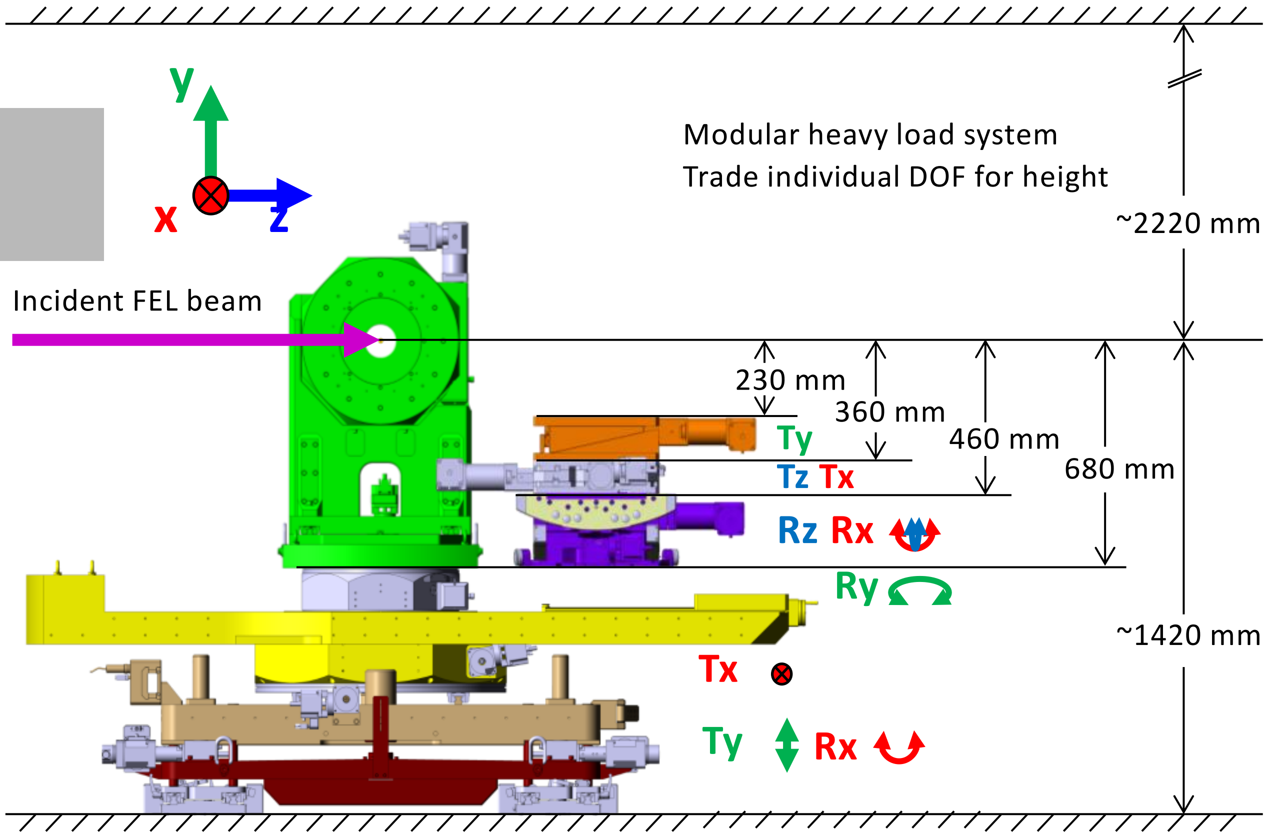
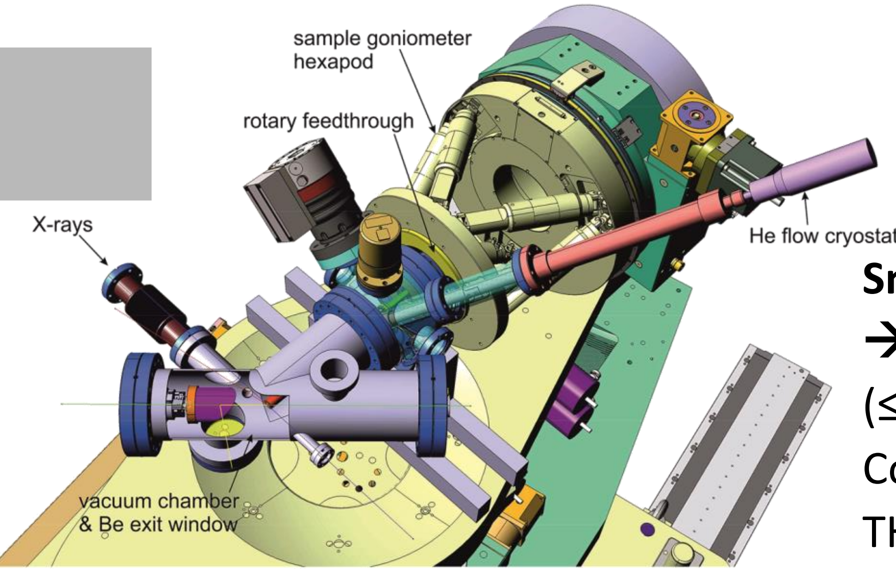
Base heights



Andreas Keller

Thierry Zamofing

Infrastructure for resonant diffraction at low Temperatures



Small cryo diffraction chamber

→ Large solid angle accessibility

(≤ 20 K, $5 \cdot 10^{-9}$ mbar)

Collinear opt/IR excitation

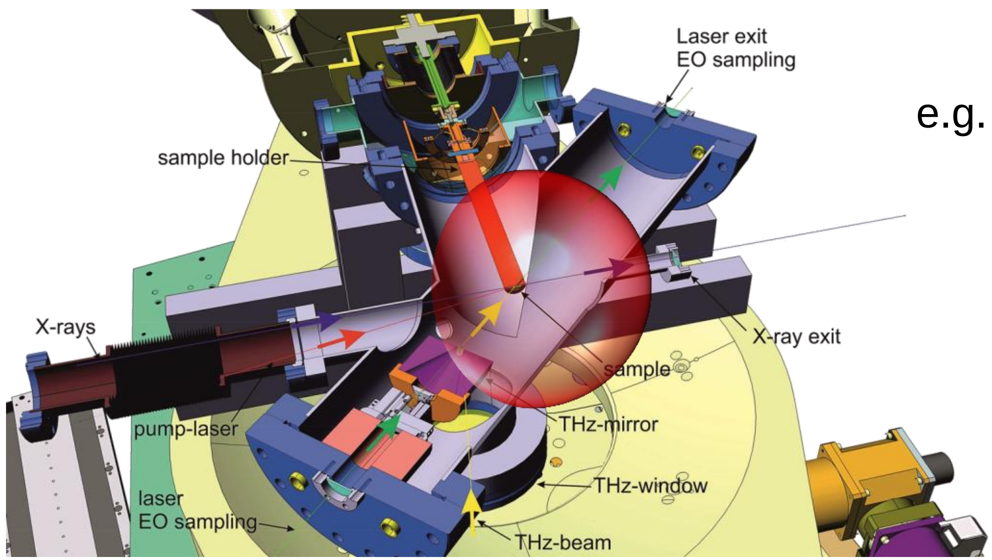
THz at 45/90 deg.

LN2 / He cryo blower (30-100 K)

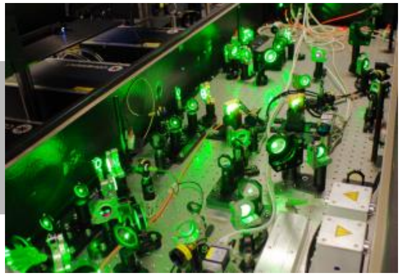
e.g. with Kappa arm

Gerhard Ingold

Alex Oggenfuss



Pump laser: wide range of excitation conditions



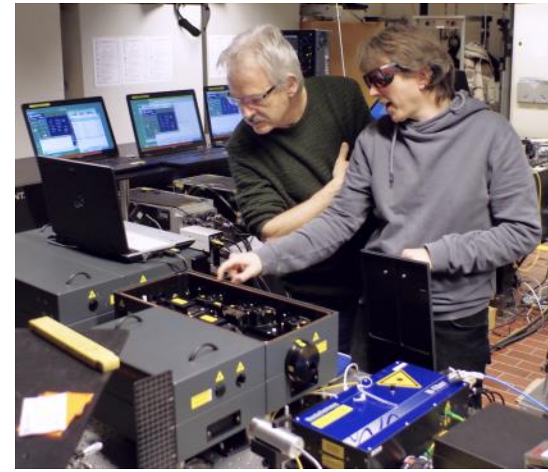
Ti:Sa laser System

> 20 mJ, < 30 fs @ 100 Hz

~ 50/50 Timing/experiment

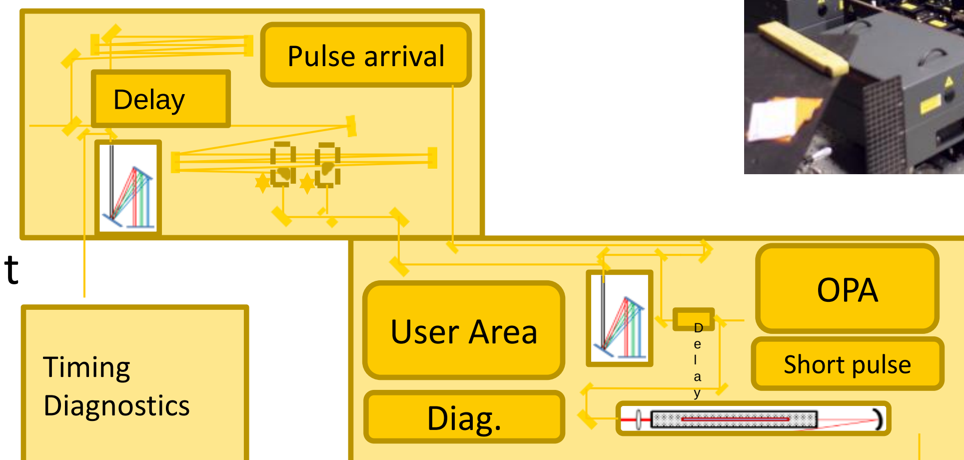
OPA: Topas HE

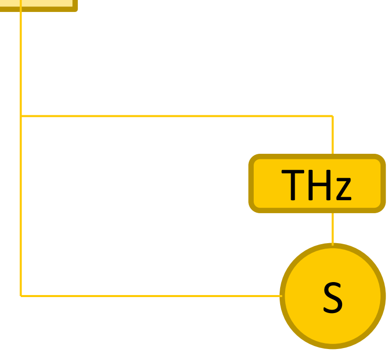
1100 nm	- < 15’000 nm
ca. 1 mJ	- ca. 10 µJ
ca. 40 fs	- < 100 fs

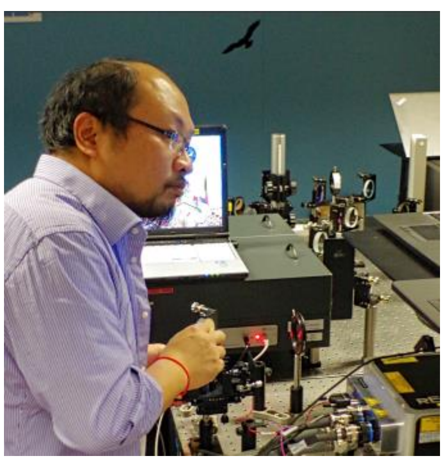


Paul Beaud

Christian Erny



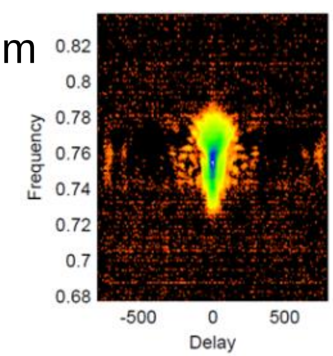




Short pulse

< 10 fs @ 800 nm

ca. 500 µJ



Yunpei Deng

Single cycle THz source

1 – 10 THz

> 1 MV/cm, ca. 10 µJ

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X-ray optics – Probe

Optimized Energy range:	4.5-12.4 keV
Pink pulse energy, BW (expected):	1 mJ / pulse, <1% BW
Beam profile:	300-600 µm (FWHM)

Single X-ray beam trajectory

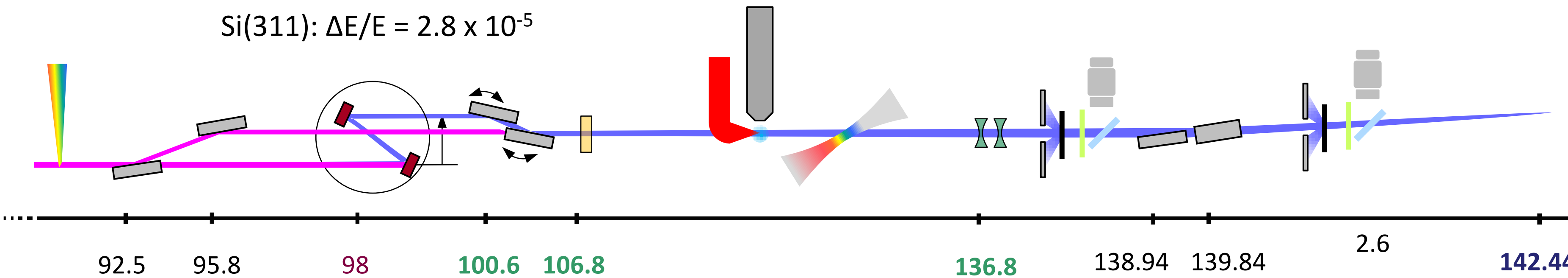
Double crystal Monochromator

Si(111): $\Delta E/E = 1.3 \times 10^{-4}$

Si(311): $\Delta E/E = 2.8 \times 10^{-5}$

KB focusing Optics

2-200 µm spot size (FWHM)



Distance from end of undulator (m)

Rolf Follath

Uwe Flechsig

Upgrades

1. Refractive optics
2. Harmonic rejection
3. Phase retarder

R. Follath et al. Proc. SRI (2015)

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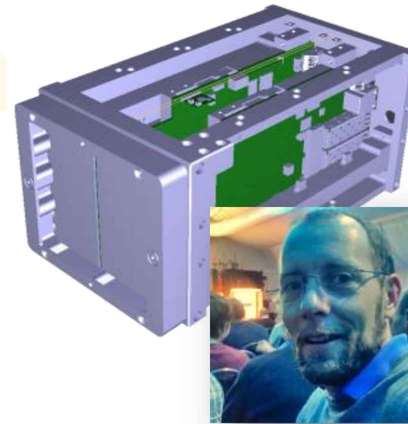
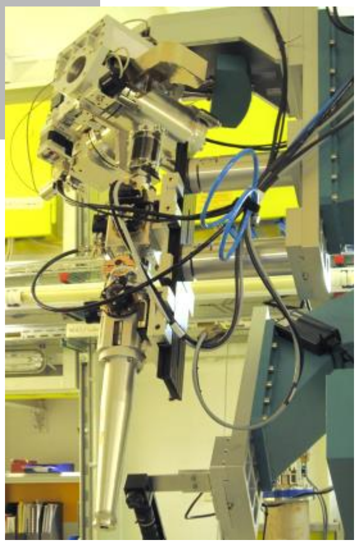
Detection



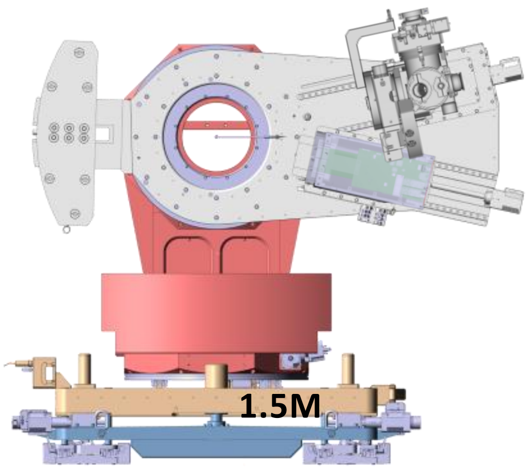
Aldo Mozzanica

Module size	80x40 mm^2
Px size	75x75 μm^2
Dyn. Range	10^4 @ 12 keV



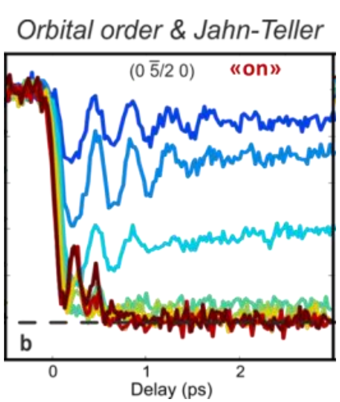
Polarisation analyzer

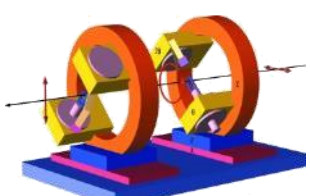
Diffractometer with double detector arm



16M

Sample - detector distances: -0.5 – 3 m

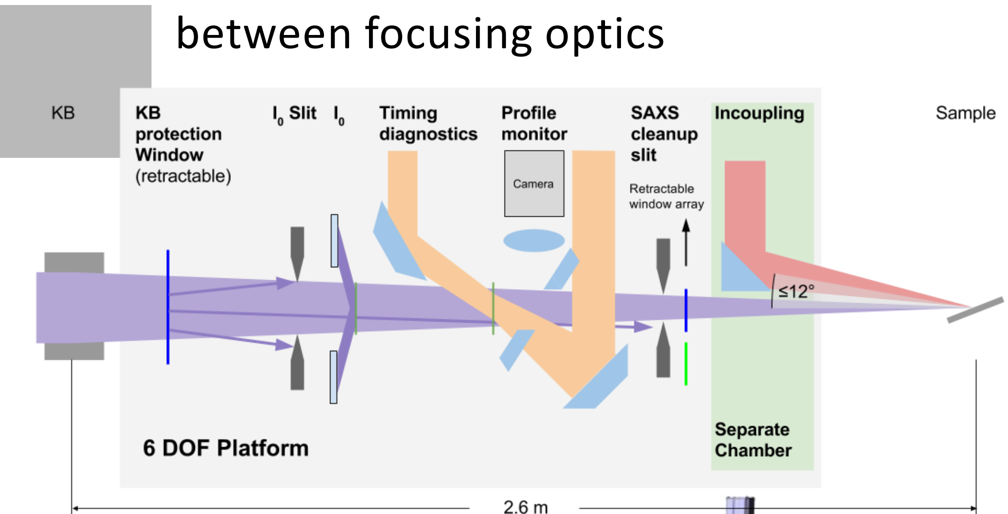




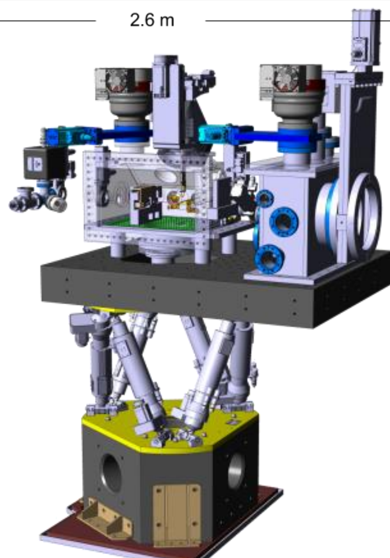
Patrick Suter
Pirmin Böhler

Pump/probe geometry / Timing diagnostics

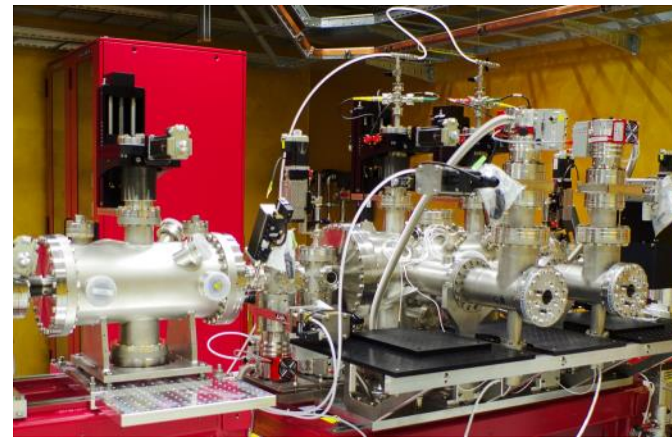
6 DOF Diagnostics table
between focusing optics

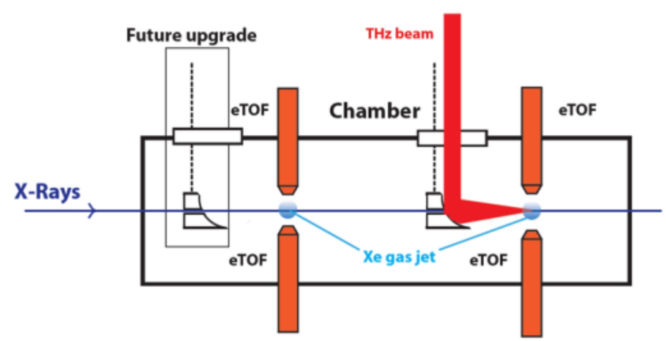


Jochen
Rittmann



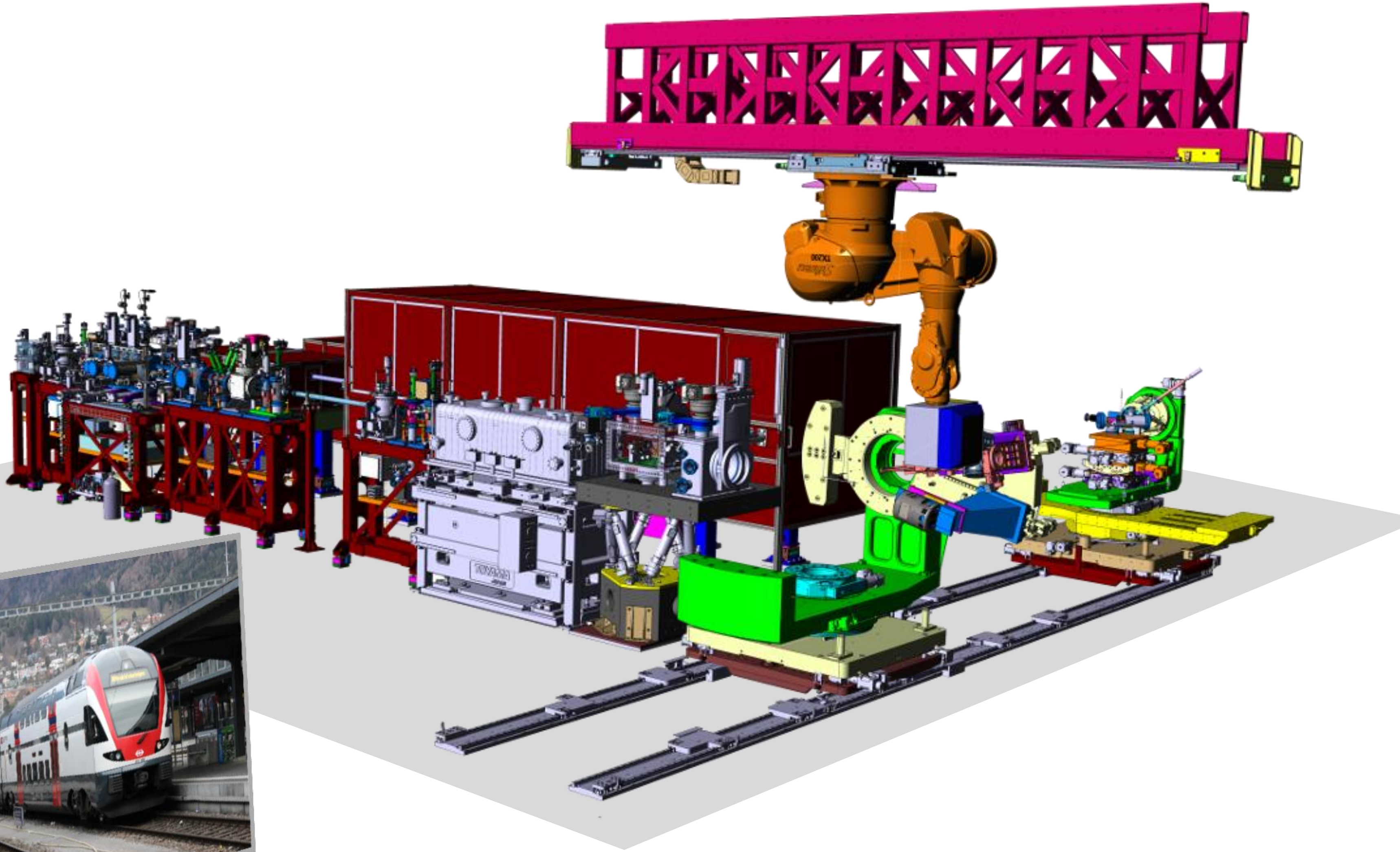
THz streak camera / Spectral encoding





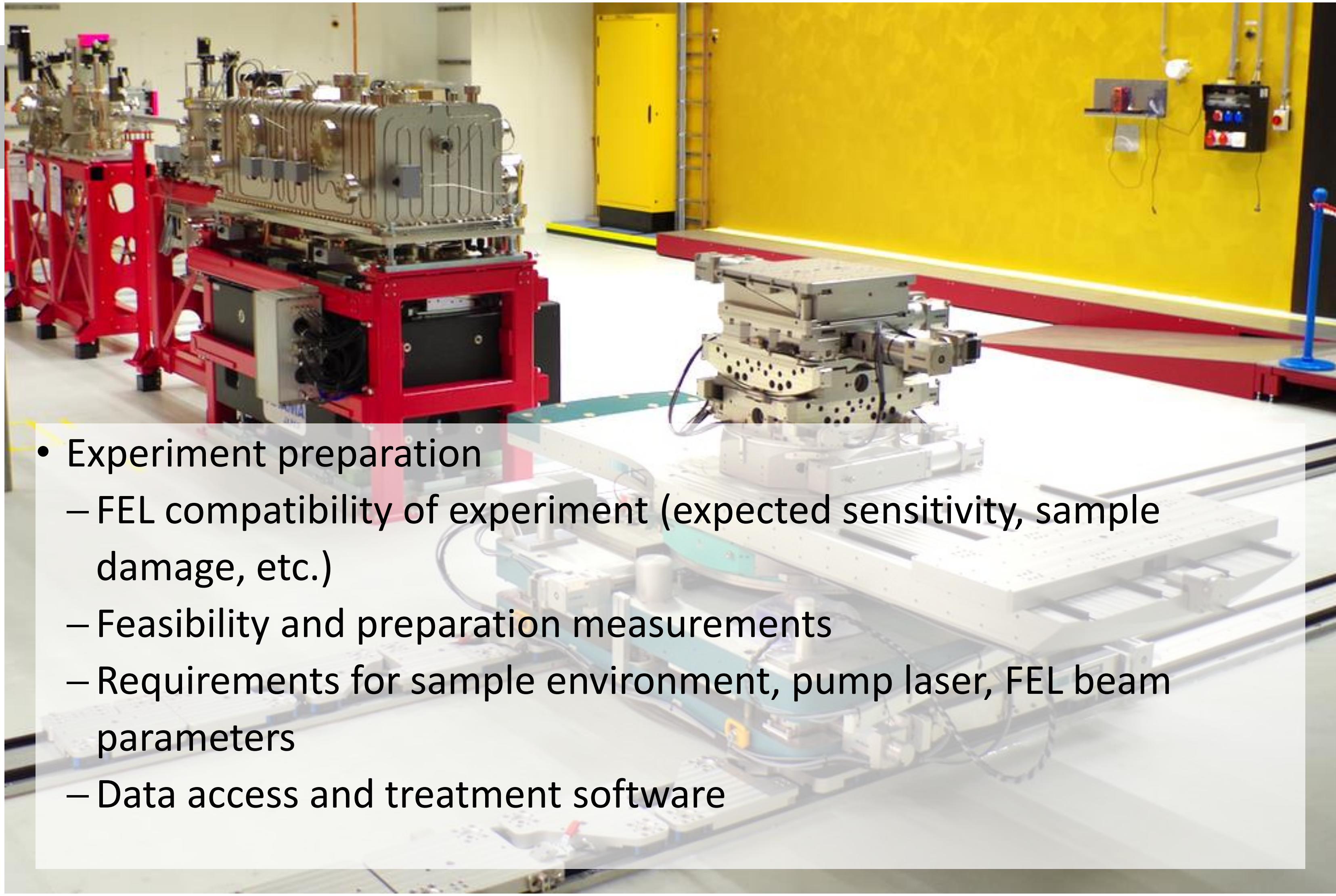
Pavle Juranic

Instrument overview



SBB CFF FFS

Let's go!



- Experiment preparation
  - FEL compatibility of experiment (expected sensitivity, sample damage, etc.)
  - Feasibility and preparation measurements
  - Requirements for sample environment, pump laser, FEL beam parameters
  - Data access and treatment software