



## Experimental station Bernina :: SwissFEL :: Paul Scherrer Institut

# Bernina - status and objectives

SwissFEL Performance Workshop

# Who we are - now

Group for

**Beyond-equilibrium ultrafast Phenomena in condensed Matter**

within Laboratory for Condensed Matter (LSC, head: Frithjof Nolting)

Scientists



**Roman Mankowsky**



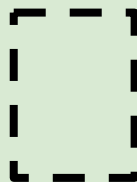
**Paul Beaud**



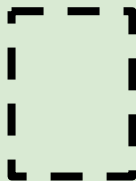
**Mathias Sander**  
from 1.3.

**HL**

Postdocs



open position



open position  
*SNF/ANR project*

Aramis  
diagnostics



**Christopher  
Arrell**

Technicians



**Alex Oggenfuss**



**Robert Kälin**  
20% from Feb

# Who we are, Matrix



**Yunpei Deng**

- Laser system design
- Attosecond physics



**Pirmin Böhler, Renzo Rontundo**

- Mechanical engineers

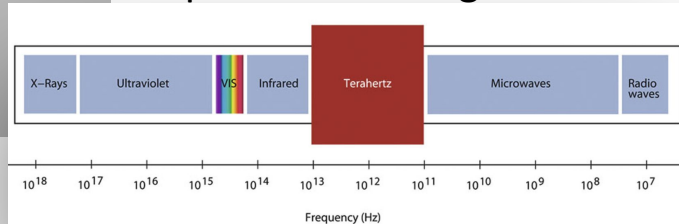


**Thierry Zamofing**

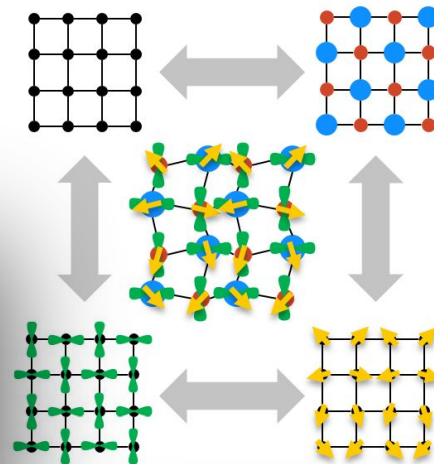
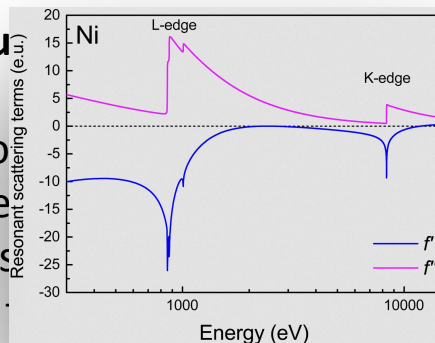
- Motion control

# What is our goal?

## Experimental insight into material function

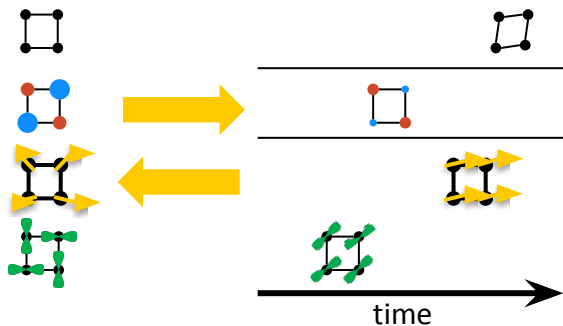


ations of  
time re  
: ~50 fs  
Step \*: 10fs



### Selective pump

### Selective probe

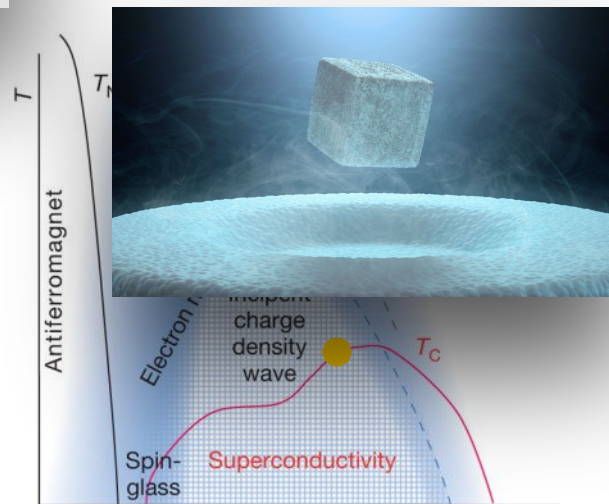


Bragg diffraction

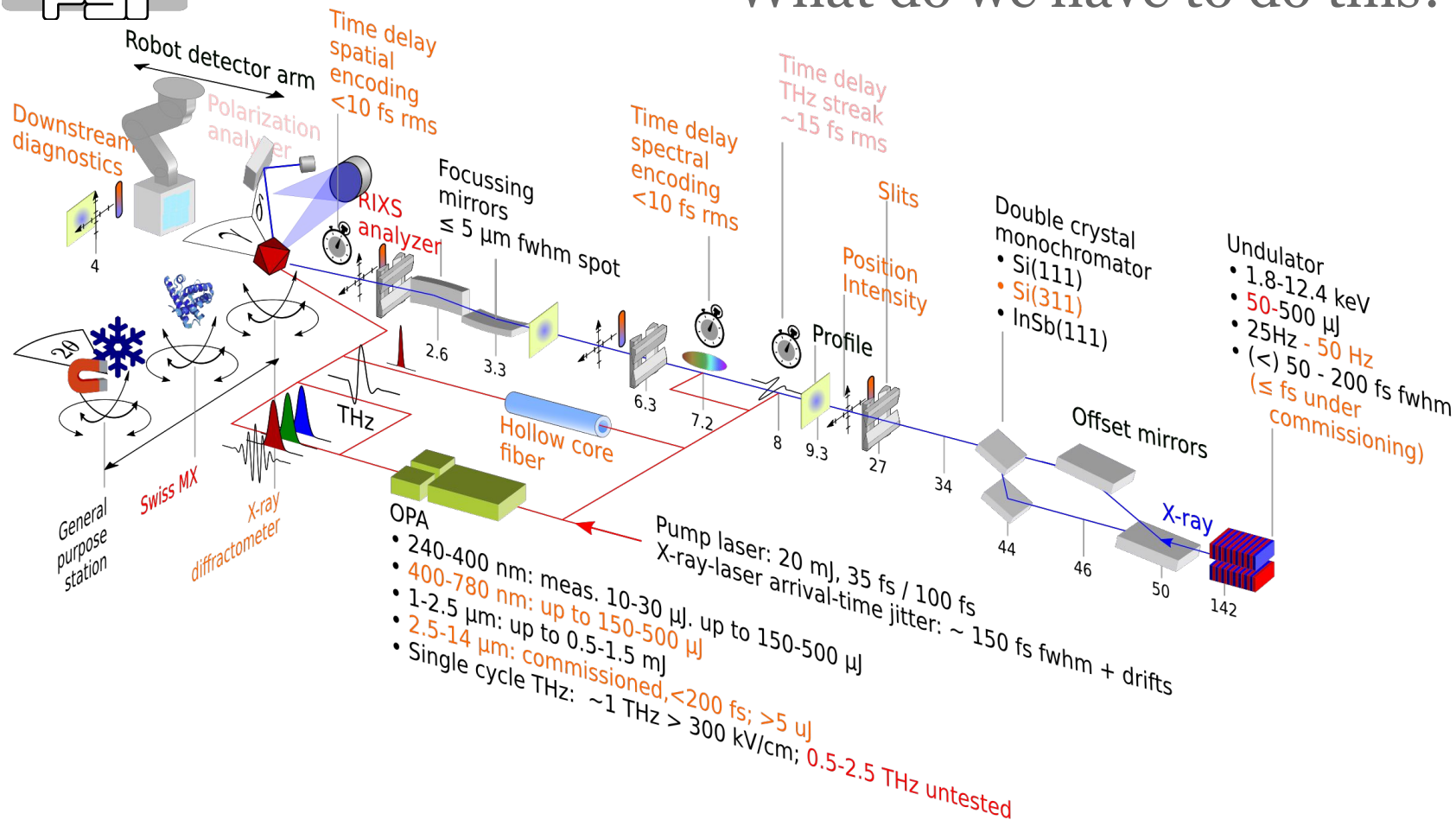
Resonant diffraction

+ Polarisation transfer

high brilliance  
(monochromatic)



# What do we have to do this?





# Experiments in 2020

## User run 3

Jan Feb Mar Apr May Jun

- Covid lock down before all 3 scheduled user experiments → cancellation
- Lockdown used for assembly of so far postponed **upstream diagnostics chamber**
  - profile monitor
  - timing tool
  - attenuator
  - beam defining and cleanup apertures
  - *intensity monitor.*

### Tender X-ray commissioning of new sample chamber

#### **Bernina group, PSI**

First commissioning of new low T, high THz field, tender X-ray sample chamber.

Test experiment on resonant diffraction at Ru edge (2.97 keV) using

#### **first SwissFEL in-vacuum Jungfrau detector.**

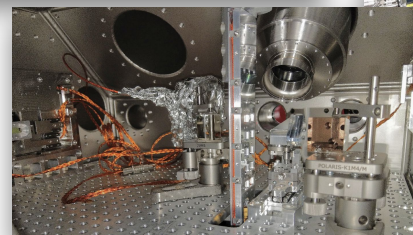
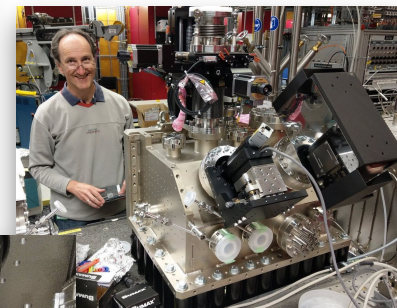
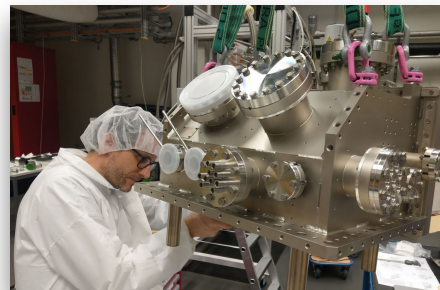
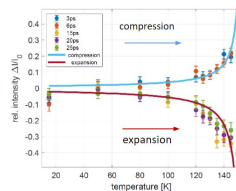
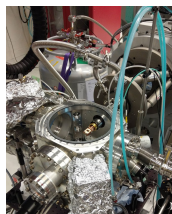
First setup and usage of a spectral timing tool near sample provided new results of orbital and magnetic dynamics.



### Low T and grazing geometry commissioning of new sample chamber

#### **Bernina group, PSI**

Commissioning of low Temperature in a pump probe geometry. Reached **<5K** with no noticeable effect of optical pump beam block by condensates on sample surface. Results from strain-induced interface effects in nano-structured STO films were obtained.

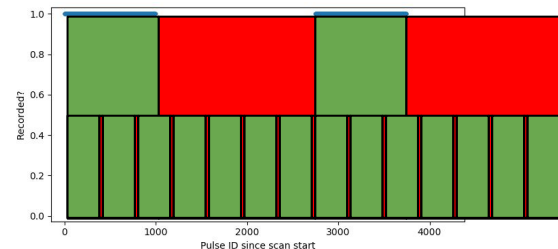


@ 100 Hz !

User run

Jul Aug

10% Si111  
Transmission

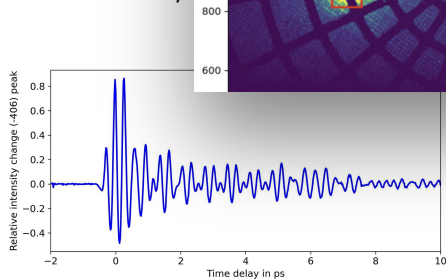


## Coherently driven electro-orbitons in

a quantum spin

*R. Mankowsky et al.*

Technically challenging THz excitation and temperature. Observation of direct excitation of field levels in a Pyromagnetic

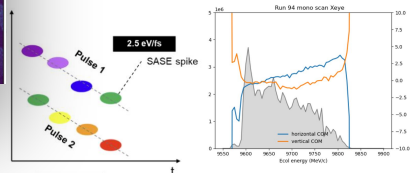


## Destruction of electronic order by

rays in a model magnet

*Pedrin et al., PSI*

Development and use of special single FE FEL pulse pump/probe technique taking advantage of large chirp mode at Aramis.

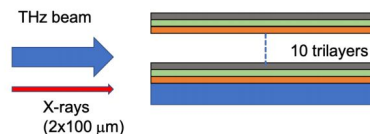


Several systems were tested, careful analysis is ongoing to distinguish systematic signal artefacts from single pulse pump/probe signals.

## Ultrafast injection of electrons through an interface

*U. Staub et al., PSI*

Excitation of charge and magnetic properties of a device-like heterostructure exciting with a polarization field in direction of the interface normal.

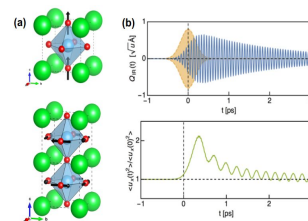


The cross-section for the process appeared very challenging as no obvious signal was found in the tested geometries.

## Diffuse x-ray scattering probe of a Brillouin zone edge soft mode in cubic SrTiO3 driven by high-order nonlinear phononics

*M. Först, Trigo et al., CFL Hamburg/SLAC*

Soft mode excitation direct excitation of a coupled phonon mode by mid-IR light excitation. Observation of phonon modes at Brillouin zone edge by diffuse scattering using Jungfrau area detector.



# Technical milestones enabling new experiments

## **Selective pump**

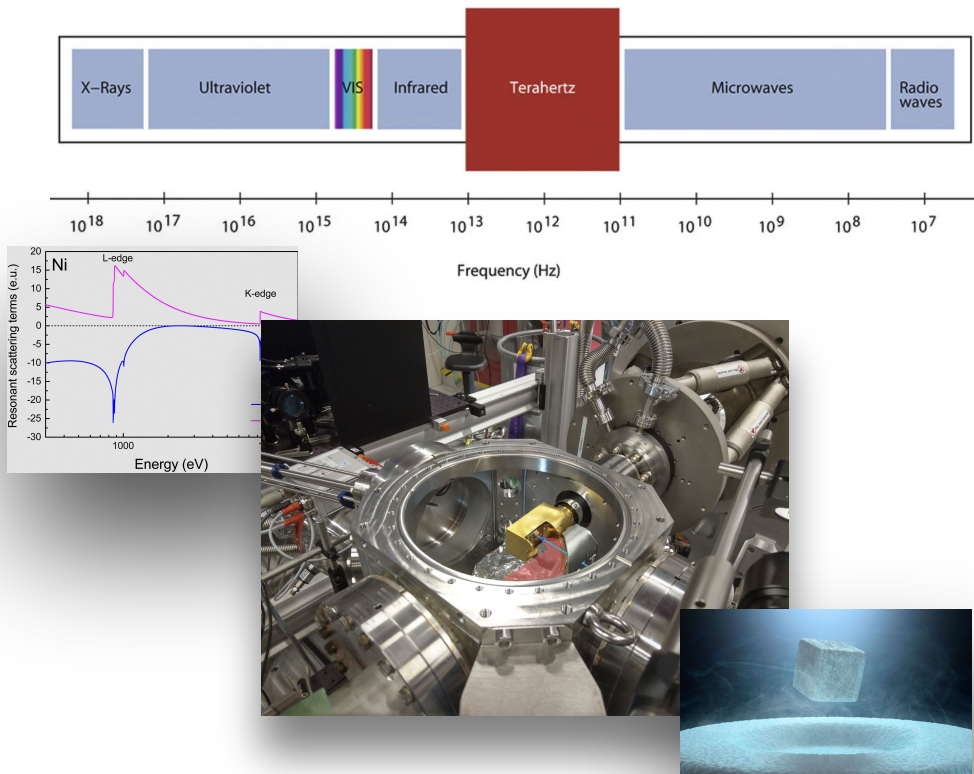
- Lowest excitation frequency so far (~0.5 THz)
- First user experiment in challenging range 15-20 THz
- new high field THz setup
- Gained more experience in 1-3 THz pulses

## **Selective probe**

- new setup for all in vacuum resonant tender x-ray measurements
- Multiple experiments taking advantage of resonant diffraction

## **Sample environment**

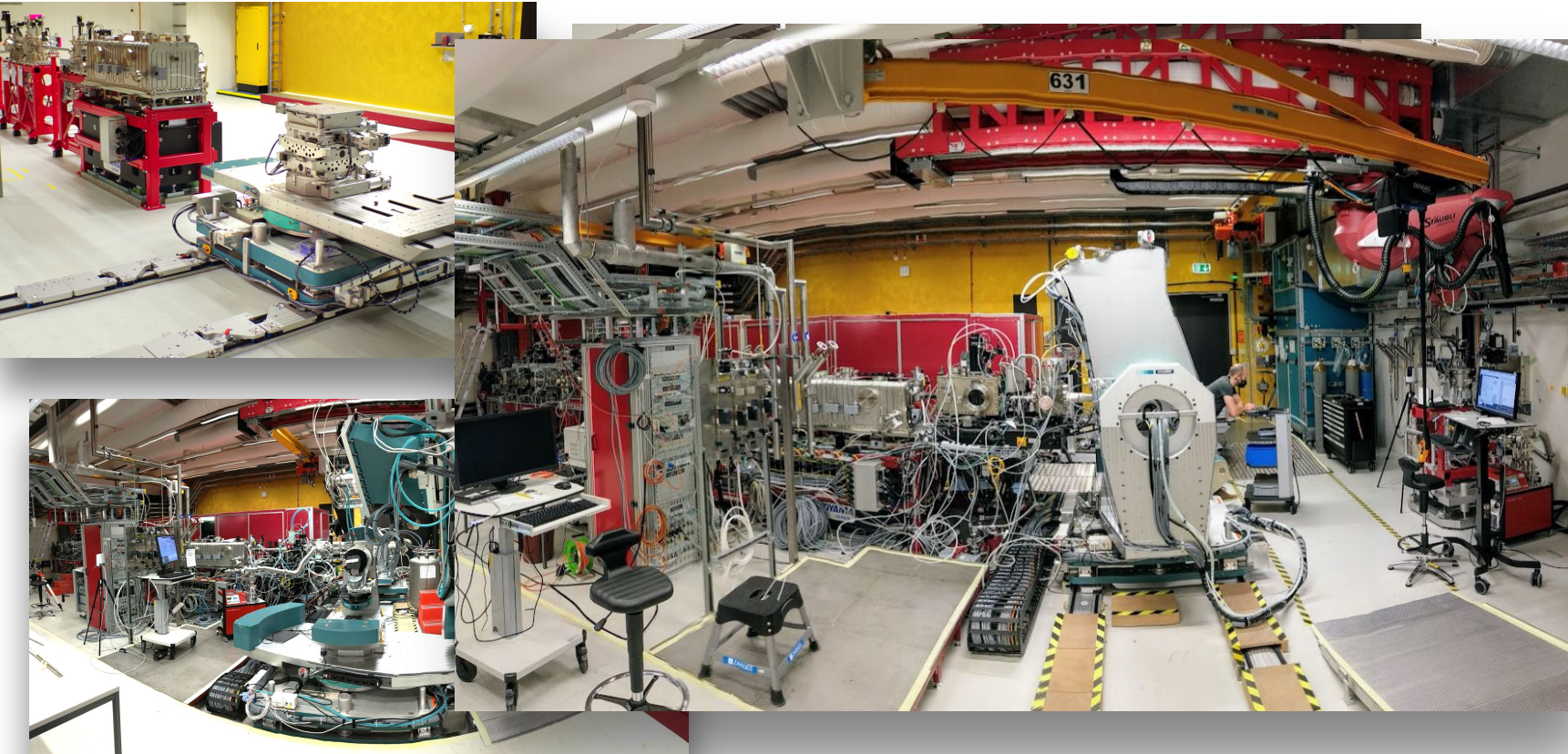
- routine setup for low sample temperature just below 5 K





# Performance status Bernina

**Baseline HW components slowly reaching completion**



# Challenges for the coming year

## Data & controls

- split of architecture for online data viewing
- long lag in configuration updates and removal of workarounds
- sustainable data storage and archiving
- versatile scalable online data processing framework
- data acquisition recording all relevant data
- finalisation of implementations for 100 Hz operation.
- **Robustness and support of centralized daq systems.**

## Da FEL

- pointing stability often insufficient / spatial chirp
- systematic parameter changes at 50 Hz
- reproducibility and robustness of tuning results
- incorporation and standardisation of optimisation to more diagnostics and single pulse data
- better understanding of the FEL
- better understanding of pulse duration

## FEL/Laser timing

- rediscussion of timing status and timing/sync. distribution systems
- Understanding and closing of a gap between expected and yet established time resolution

## All

- grinding out long known issues with various devices and procedures
- **Work towards better collaboration and goal-orientation, solve ever lasting conflicts**

# Parallel Operation between Athos Aramis

- Goals
  - independent operation
- Limits
  - Unclear if there are limits and what they are, are the temporary or not
- Requirements
  - Experiment defines BW and pulse duration within portfolio.
    - optimize and control/diagnose the parameters during experiment.
  - Change photon energies during experiments
  - Change of BW and pulse duration during the experiment should be possible at least for special experiments.
  - beam parameter stability should not depend on parallel operation or machine rep rate.
    - rep rates might need to be controlled with pulse pickers.
  - independence
    - data acquisition/storage, hardware
    - machine parameters
- Problems/current limitations
  - Data infrastructure of Aramis is used by Athos at the moment, which is a bottleneck and a solution is not in sight

# Reliable operation

- Goals
  - small spread of operation performance over months and years
    - <30% variation of important beam parameters over weeks / months.
      - pulse energy (also monochromatic)
      - pointing jitter
      - bandwidth
      - pulse length
      - energy jitter
      - timing jitter
  - Continuous Improvement in operation towards 1 mJ
- Limits
- Requirements
  - fast parameter switches (daytime independent), for instance between Aramis instruments
- Problems/current limitations
  - 100 Hz not fully supported as designed.
    - Cameras
  - data and data acquisition systems are slowly evolving from temporary to sustainable tools.
  - data archiving tool is not fully developed yet.
  - instability of data and data acquisition systems

- ***Increased attention to solving longstanding issues with PSI support***
- New sample chamber finalisation
  - High THz field excitation
  - Low Temperatures
  - Tender X-rays
- first user experiments using LiNbO3 THz generation.
- Upstream diagnostics with additional timing option
- Pushing forward ongoing projects
  - RIXS spectrometer
  - Grazing incidence exp. chamber
  - Beamline fixes (Opt. hutch)
  - Wavefront sensor

