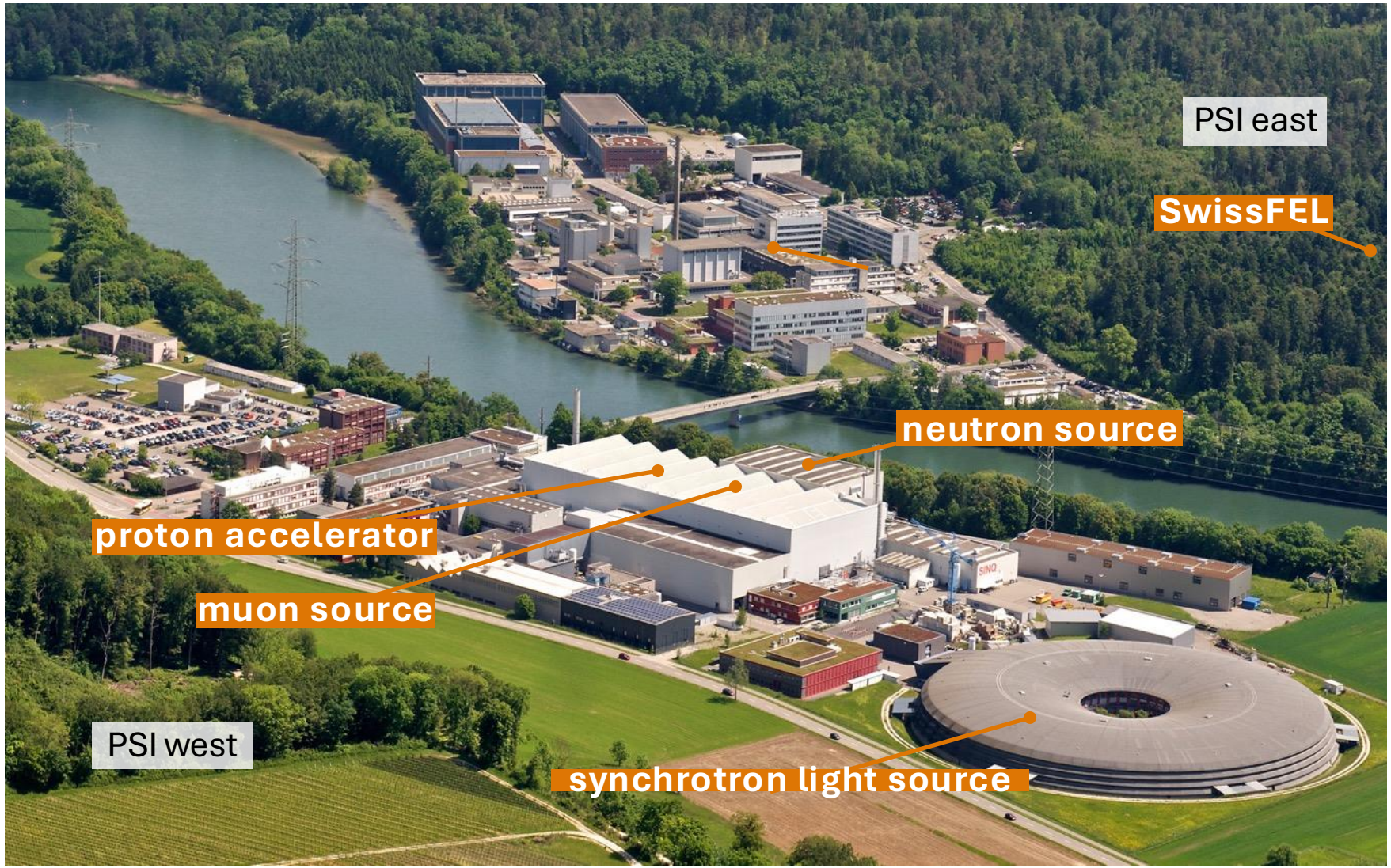
Sample Environment

for the User Facilities SINQ and SμS

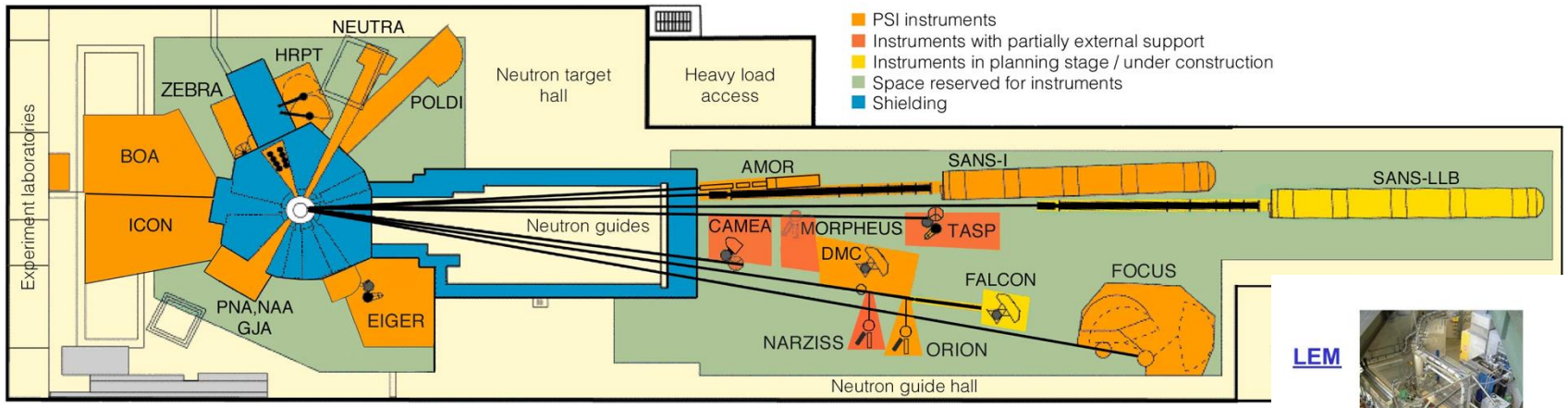
Marek Bartkowiak

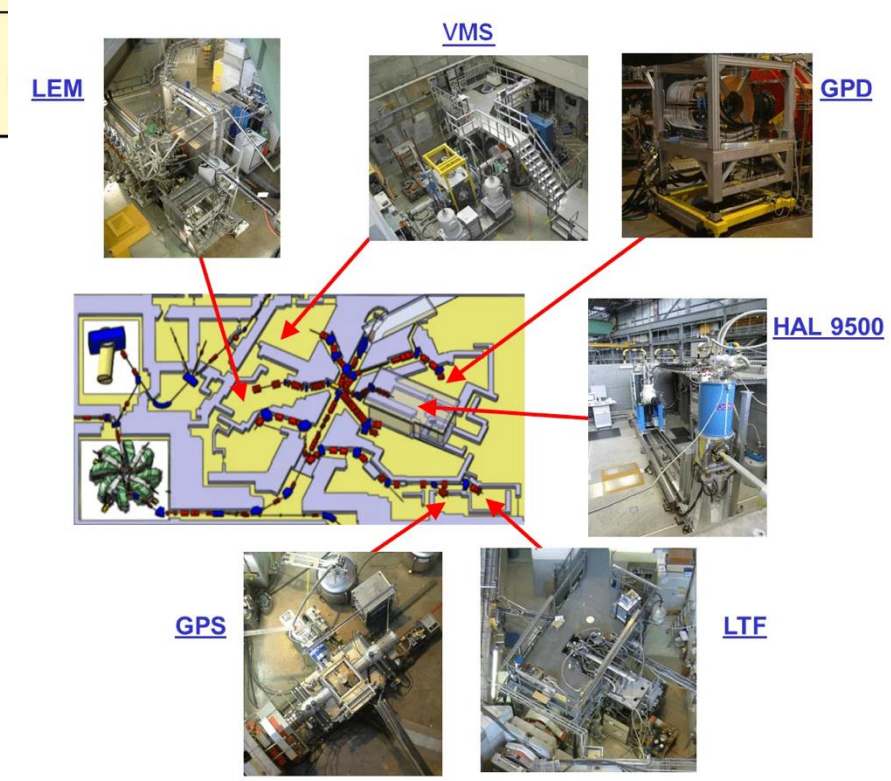
BRIDGE2025, University of Tokyo 22-22 Oct 2025

Overview


PSI east
SwissFEL
neutron source
proton accelerator
muon source
PSI west
synchrotron light source

SINQ & SμS





SINQ

- 18 Instruments
- 12 in user operation

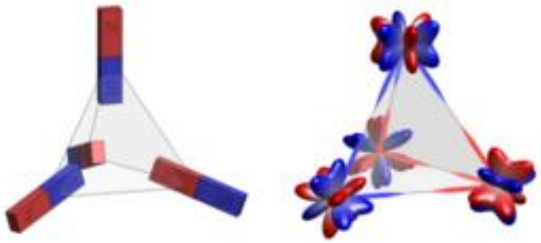
SμS

- 6 instruments in user operation

Scientific landscape at our facilities

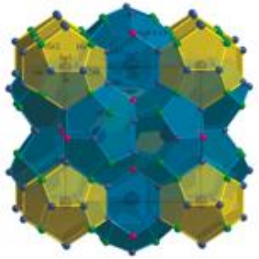
PSI

Solid state phenomena



Quantum Spin ices
Strongly correlated materials
Superconductors

Material science

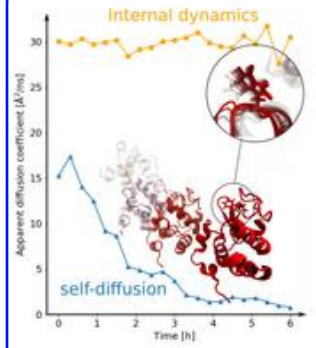


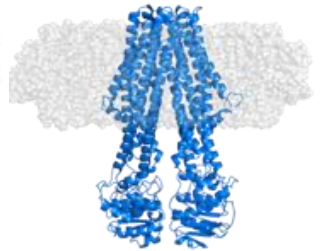
Energy Storage
Catalysts
Functional Materials

Devices science

Batterie research
Additive manufacturing processes

Life science





Biological processes
Bio interfaces

Cultural heritage

Fundamental science

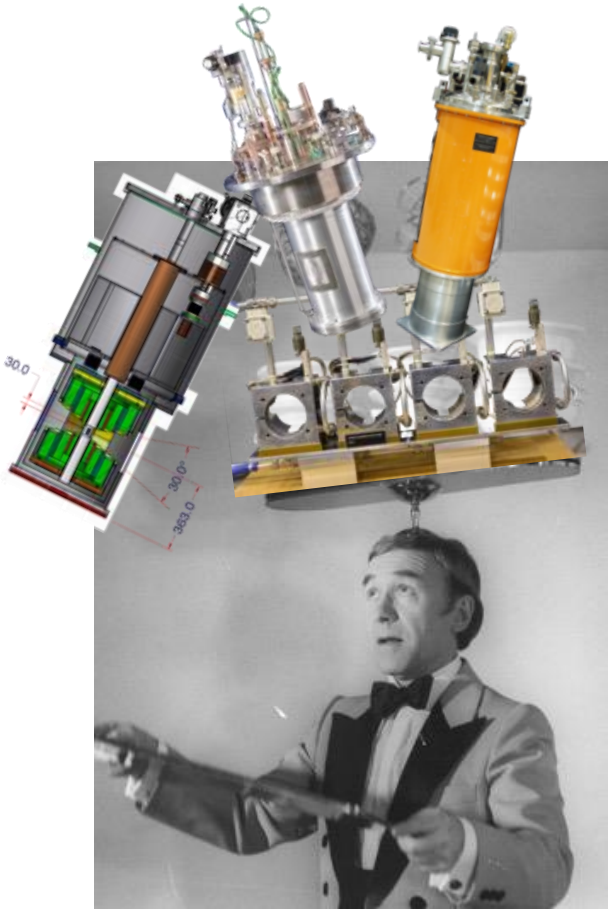
Mission of Sample Environment

- Provide **control** over the ambient conditions of a sample such as temperature, magnetic field, pressure, etc
- support a **variety** of equipment
- Provide **reliable** equipment
- **Development** of new devices
- push the boundaries in parameter space

Challenges

- Provide **control** over the ambient conditions of a sample such as temperature, magnetic field, pressure, etc
- support a **variety** of equipment
- Provide **reliable** equipment
- **Development** of new devices
- push the boundaries in parameter space

Growing & diversifying user base
Increasing complexity of scientific questions
Increasing complexity of tech. solutions



https://www.juggle.org/cups-and-spoons/

..and how to manage them

Support of user program

Development of new capabilities

Active role in research

automation

- full control of SEE with FRAPPY
- Automatic LN2 filling…

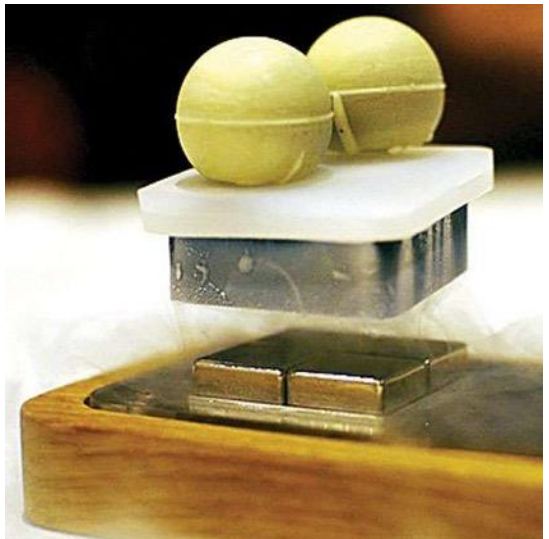
standardisation

- Fleet policy for equipment
- Standard pinouts

collaboration

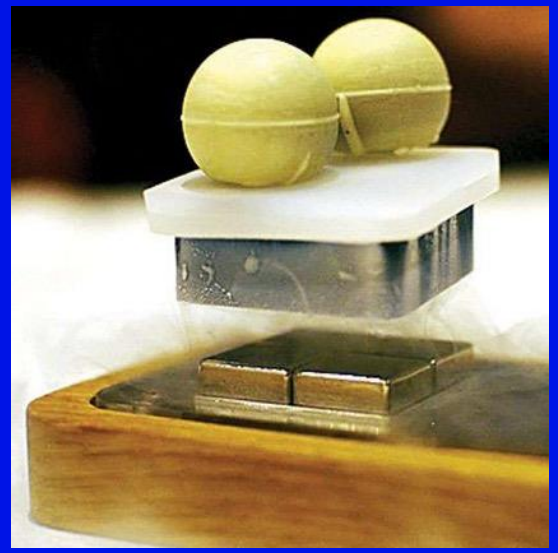
SE@PSI What's on the menu?

soft matter	temperature & magnetic field	pressure



… and limited support for SµS, the µSR-facility

Temperature and Magnetic Field



Sample Environment Equipment
Temperature and Field

PSI

T_{max} : 1800K

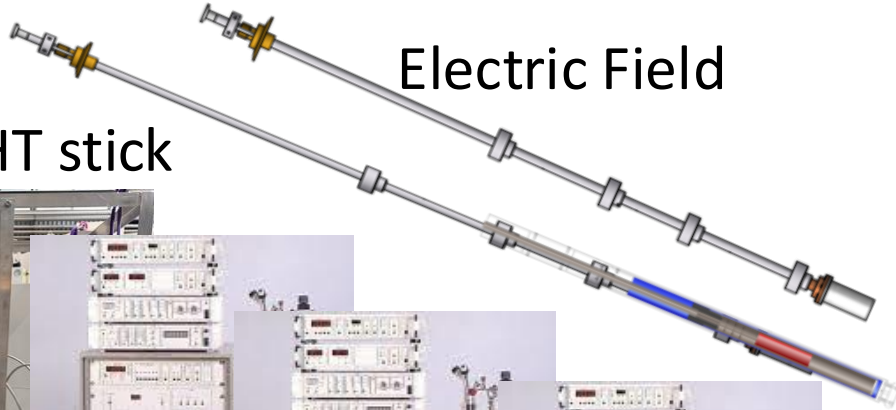
T_{min} : 35mK

B_{max} : vertical 15T

horizontal 11T

P_{max} :

100kbar



Sample Environment support for SµS

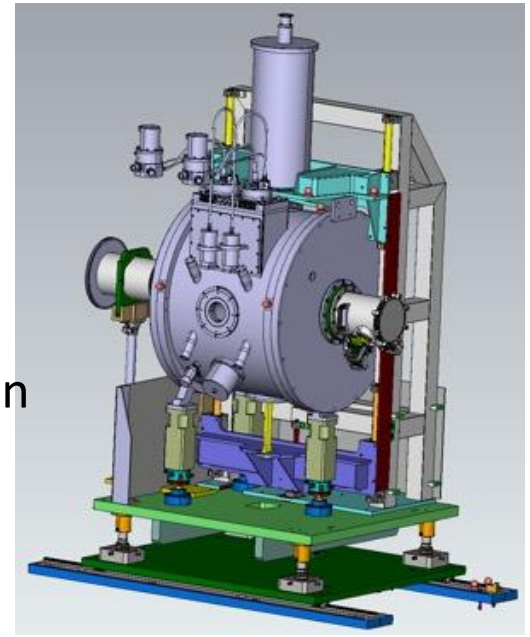
Sample Environment Equipment for FLAME

Technical support in the purchase process for

- Main magnet
- He-cryostat
- Dilution refrigerator

Provide support in system integration (control software)

Design of ULT sample holders and thermometry



Support for HAL

Cryogenic support

maintenance of dilution and magnet

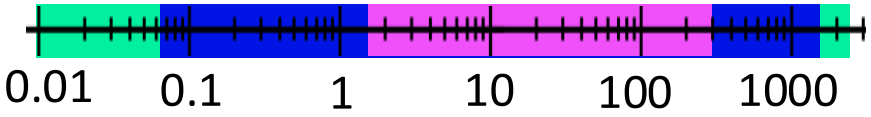
Software control

High Pressure

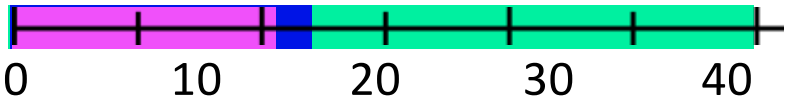
Extending the parameter space

From simply pushing the boundaries

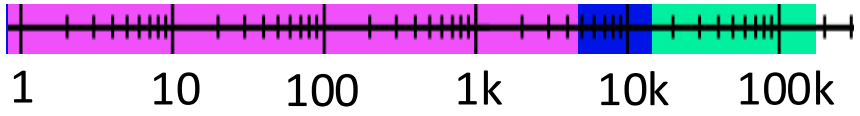
Temperature (K)



Magnetic Field (T)

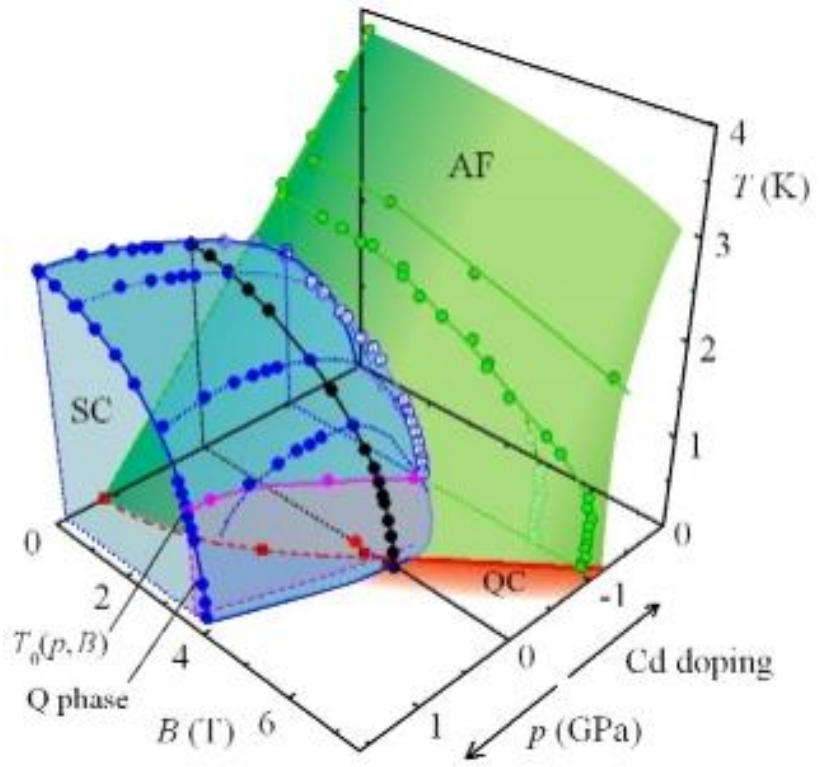


Pressure (bar)



Standard SE
with restrictions
Not commonly available

.. To multiparameter experiments



Time dependent

In situ

In operando

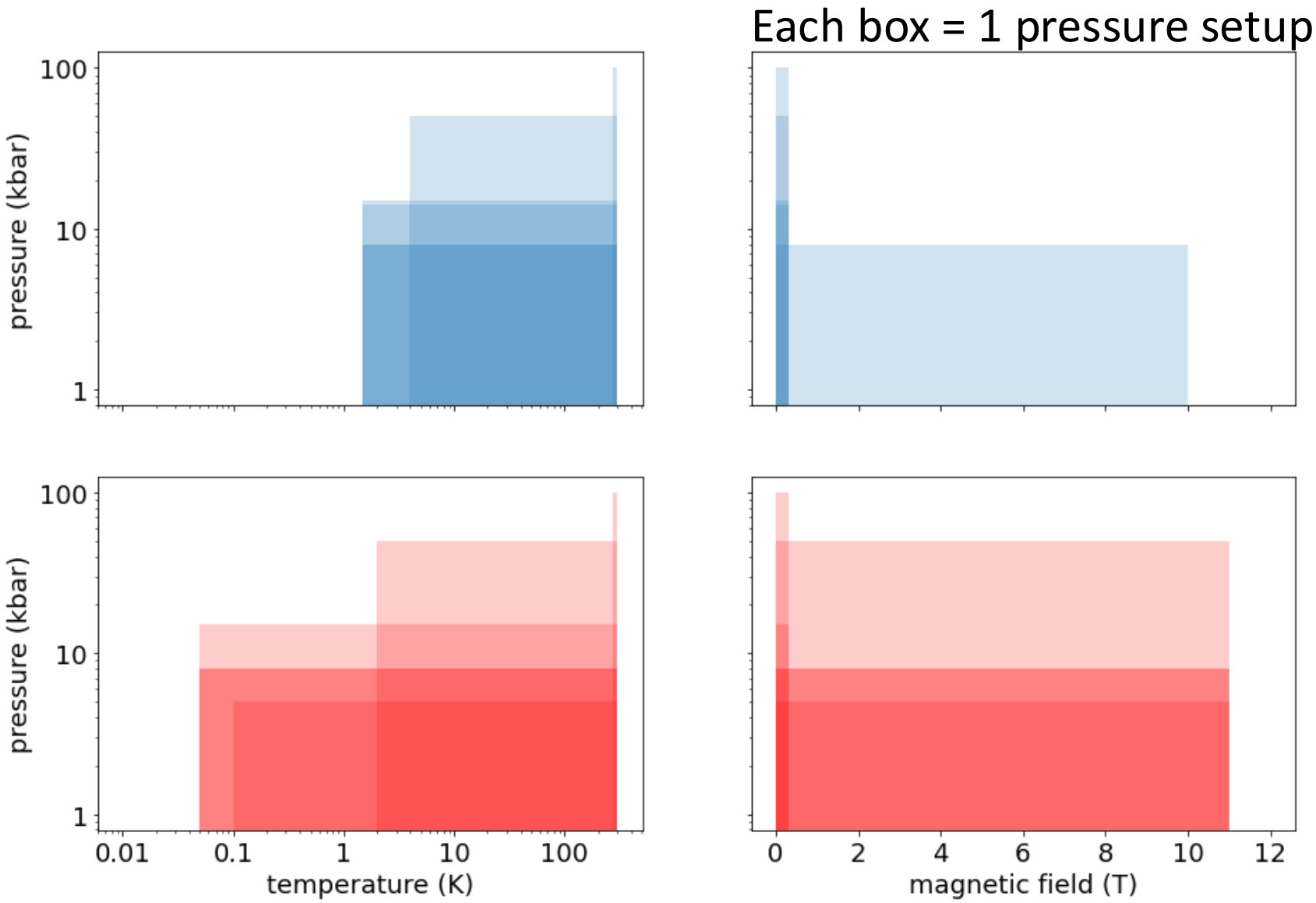
Hydrostatic Pressure

Current situation

- Most p-cell are magnetic
- Cells are to large for normal cryostats

Planned extensions

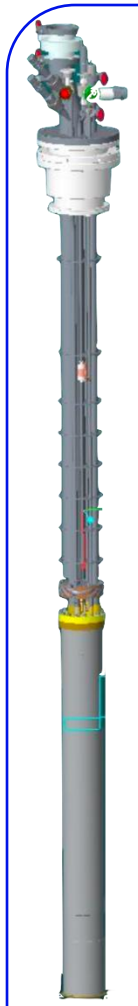
- Extend to sub-K
- Non-magnetic clamp cells
- non-magnetic anvil cells (ExtremeP)



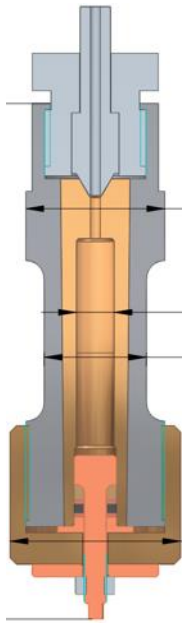
Pressure activities at PSI

rapid cooling large cryo-magnet

Vertical field 11T
Ø100mm sample space

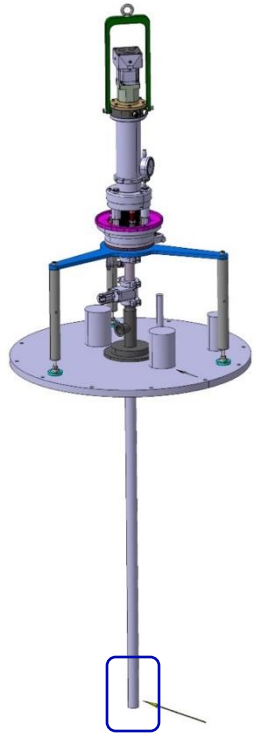


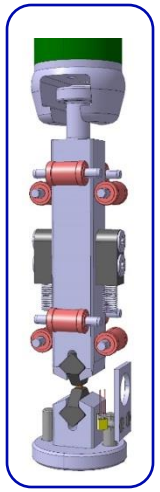
10kbar cell
40mK; 11T



10kbar He gas stick
fast pressure changes

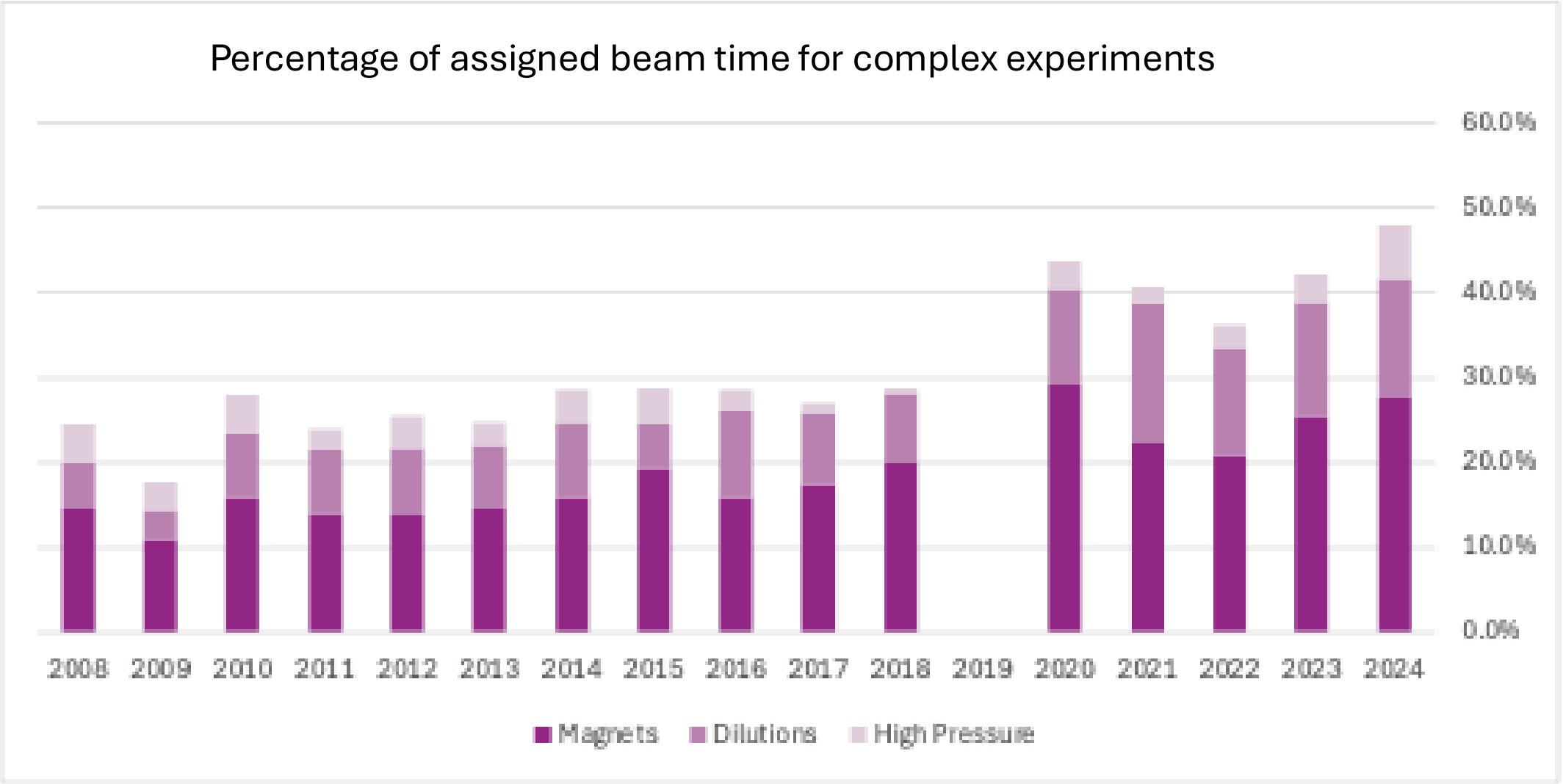
Uniaxial pressure device





Precission control of compressive
and tensile forces

User Demand at SINQ



Sample Environment Control – FRAPPY

PSI

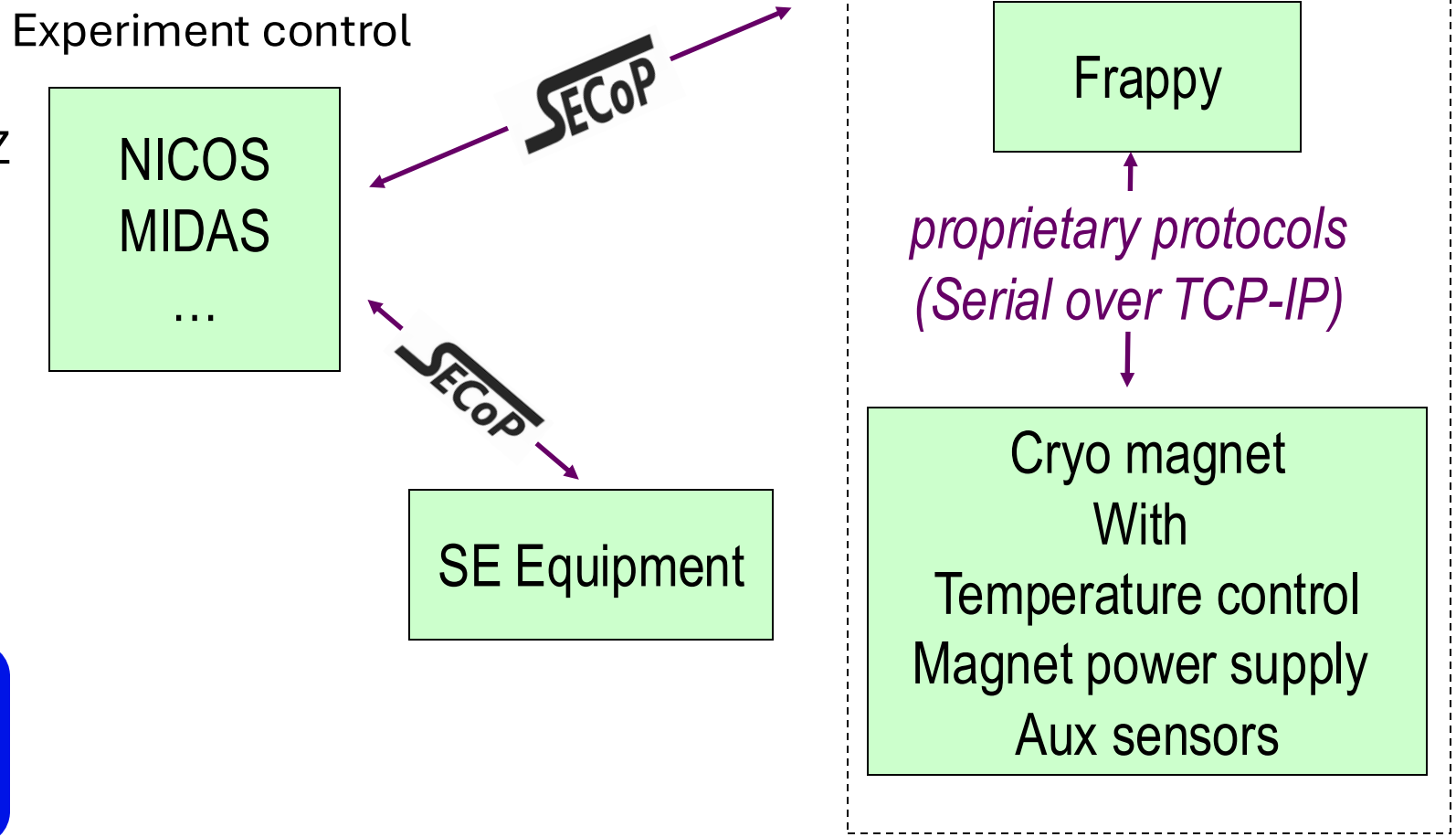
- FRAPPY is a Python framework
- Developed in collaboration with MLZ
- Uses SECoP for communication

SECoP

standard protocol for interfacing sample environment equipment to experiment control software.

Easily move equipment between facilities
FOSS for users and companies
minimize software integration effort

Governed and developed by ISSE SINE2020



SE-group members

Patrick Hautle
DNP & NMR
Pressure safety

Gediminas Simutris
Pressure support

Marek Bartkowiak
Cryogenics
And magnets

Markus Zolliker
Software & electronics

Paul Schurter
SINQ support & cryogenics

Silvan Stamm
SINQ support & materials lab

Anik Stark
Student 20%
Soft Matter Projects

Tina Arh
PostDoc
High pressure
w. G. Simutis

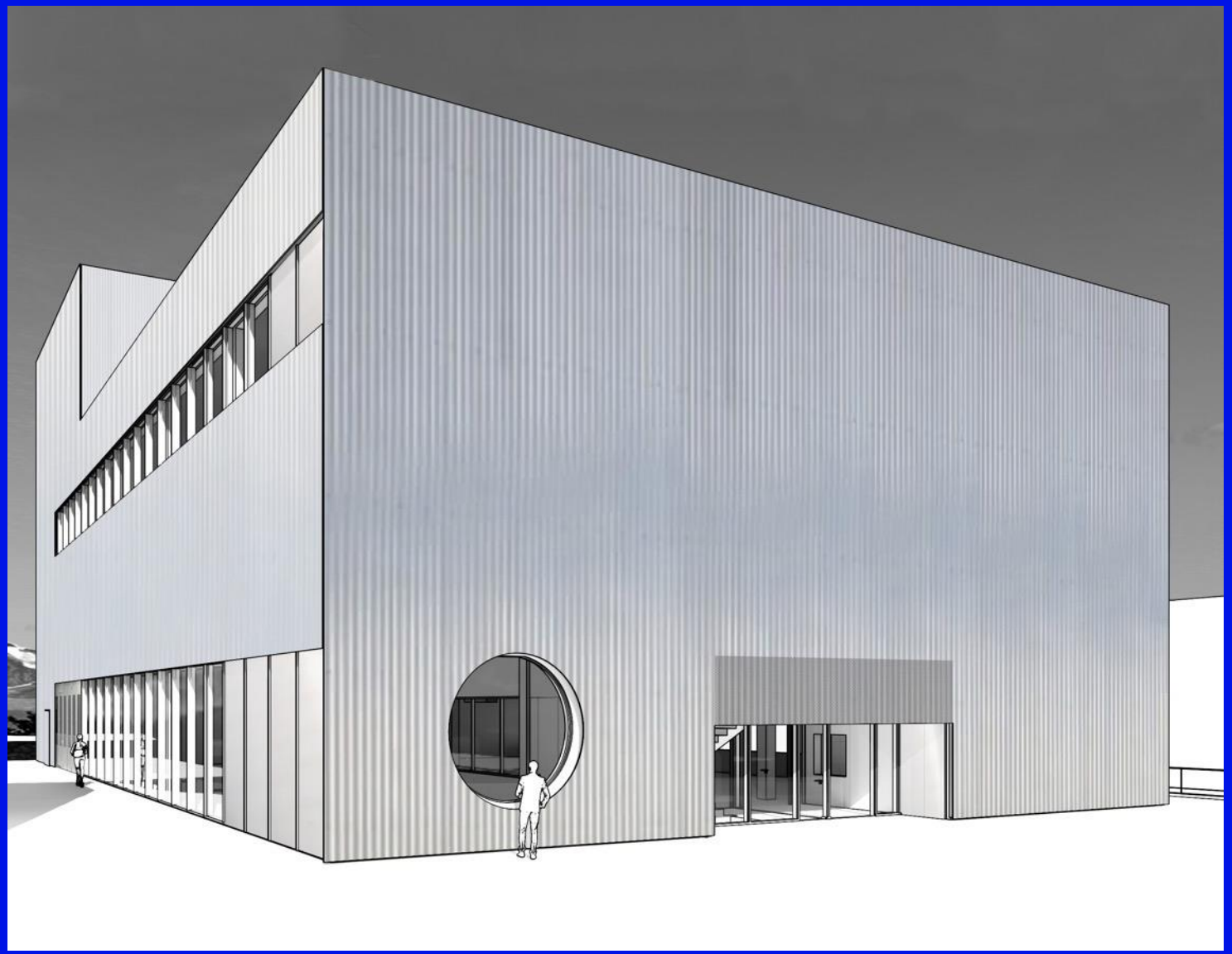
Dang Xuan Dang
Ph.D. Student
RUS with M. Janoschek

Ilaria Villa
PhD Student
QSL
With R. Sibille LNS

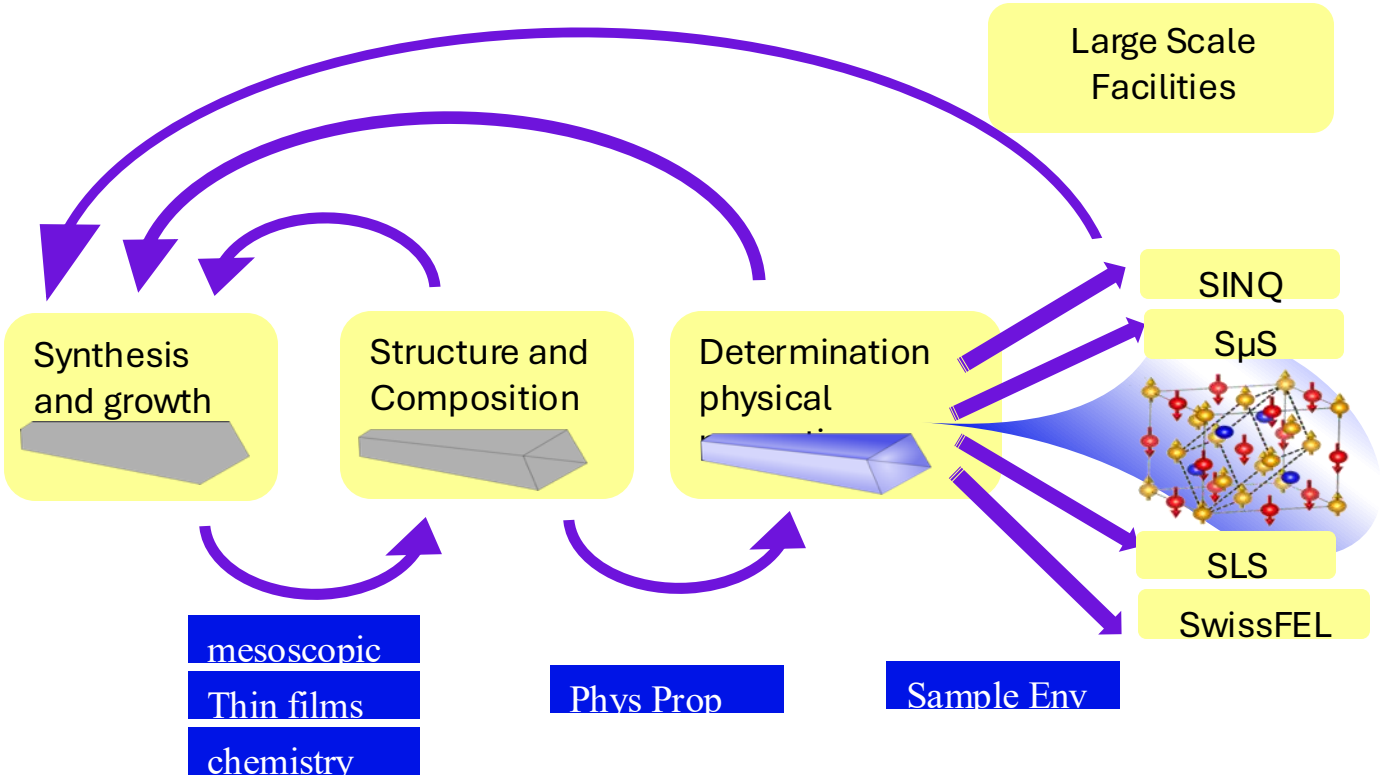
Marcel Fuchs
Softmatter support
Support for sputterlab

Florian Fautz
SINQ support

Quantum Matter and Materials Discovery Center



Motivation



Tighter interaction between sample growth and characterization speeds up materials discovery

Lab based characterization methods complement and motivate large scale facility experiments

Experiments at extreme conditions (ultra-low temperatures, High pressure and magnetic field) help to reveal new states of matter

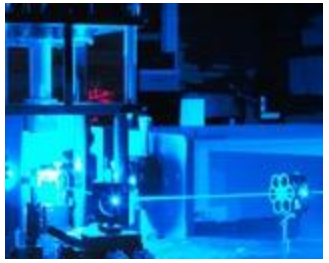
Groups involved

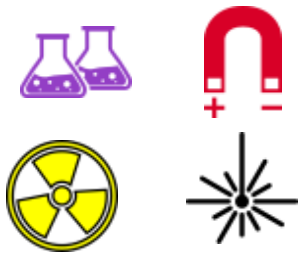
mesoscopic

- magnetic und multi-ferroic films and nanostructures
- From basic research to device physics

Thin films

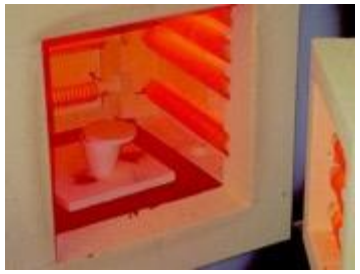
- Thin films of functional materials
- Materials for energy applications (Li-ion batteries, catalysis …
- multiferroic thin films
- Provide characterisation methodes

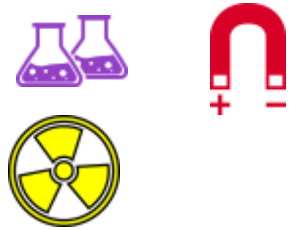




chemistry

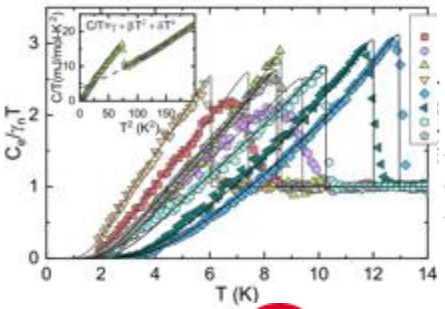
- Synthesis of materials with novel elektronic and magnetic properties
- superconductors
- magnetic oxides
- Contibution of samples to LSF research
- characterisation methodes

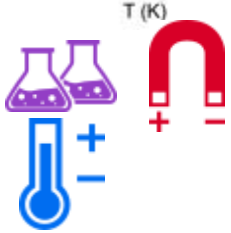




Phys Prop

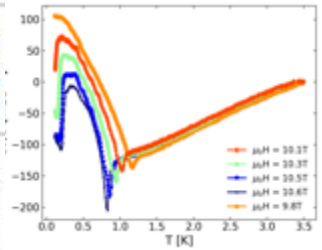
- Synthesis of novel materials
- Investigation of materials with competing interactions
- Contribution
- Provide characterisation methodes





Sample Env

- Development of new measurement techniques
- Strongly correlated electron systems



Structure of the Building

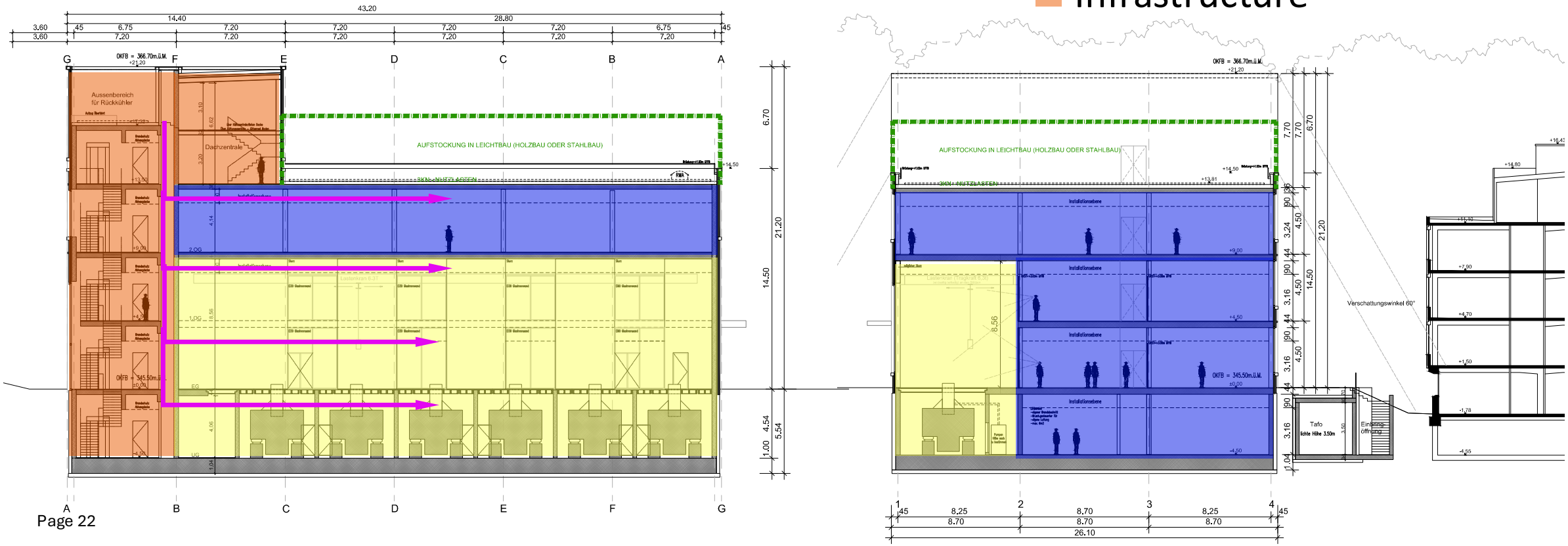
Labs: 1200m^2 assigned

850m^2 reserve

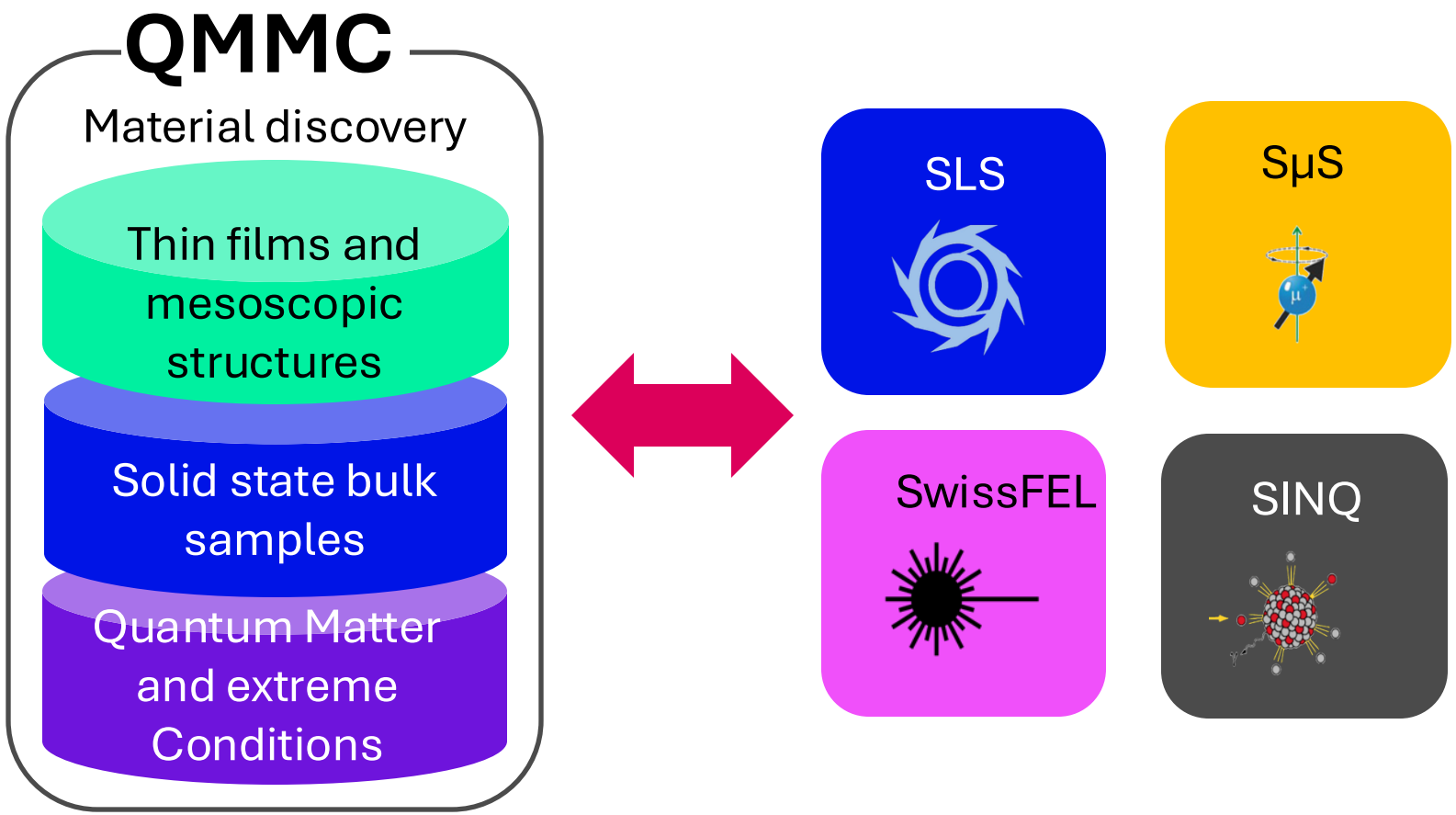
based on modules 60m^2

height 4 m

- Ultra Low Noise
- Lab space
- Infrastructure



Materials Discovery Vision



MIC Materials Innovation Cluster

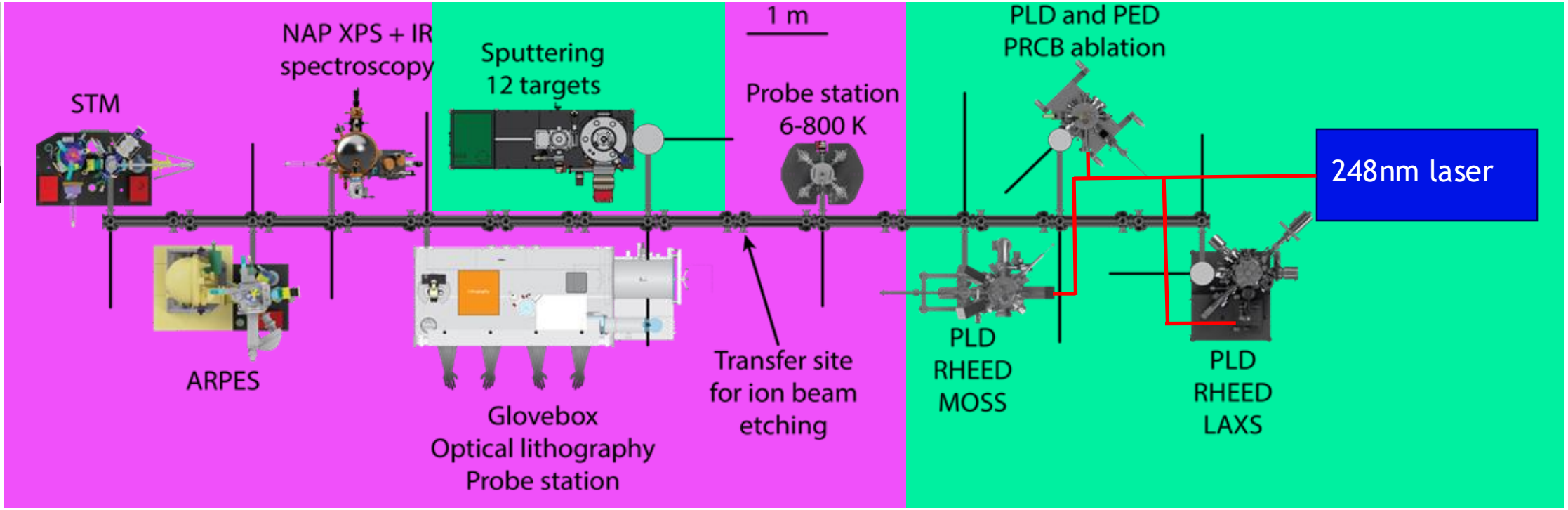
PSI

all-in-one setup
- sample preparation
- Characterization
- measurement

***in situ* micro-patterning and characterizations**
(AFM, lithography), Ion etching, electrical transport, dielectric, ferroelectric characterization; (NAP)-XPS; STM, ARPES

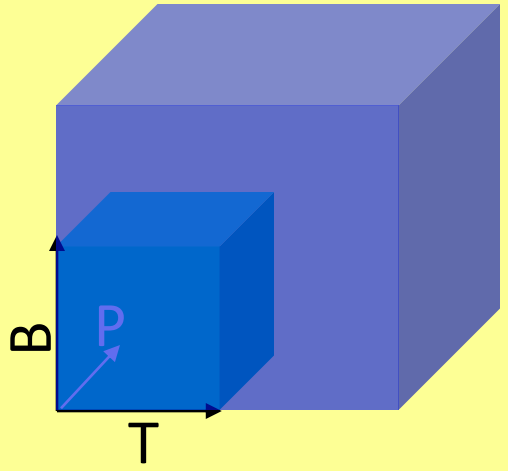
Sample preparation and operando characterizations
PLD with RHEED&MOSS
PLD/PED with impedance set-up
Sputtering set-up

Daniele Pergolesi

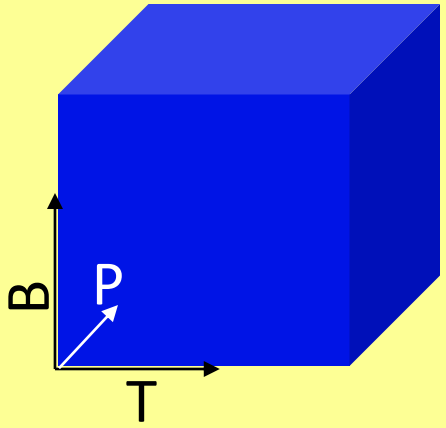


New labs for new capabilities

parameter space for lab-based characterization at PSI



parameter space for experiments at SINQ/SµS



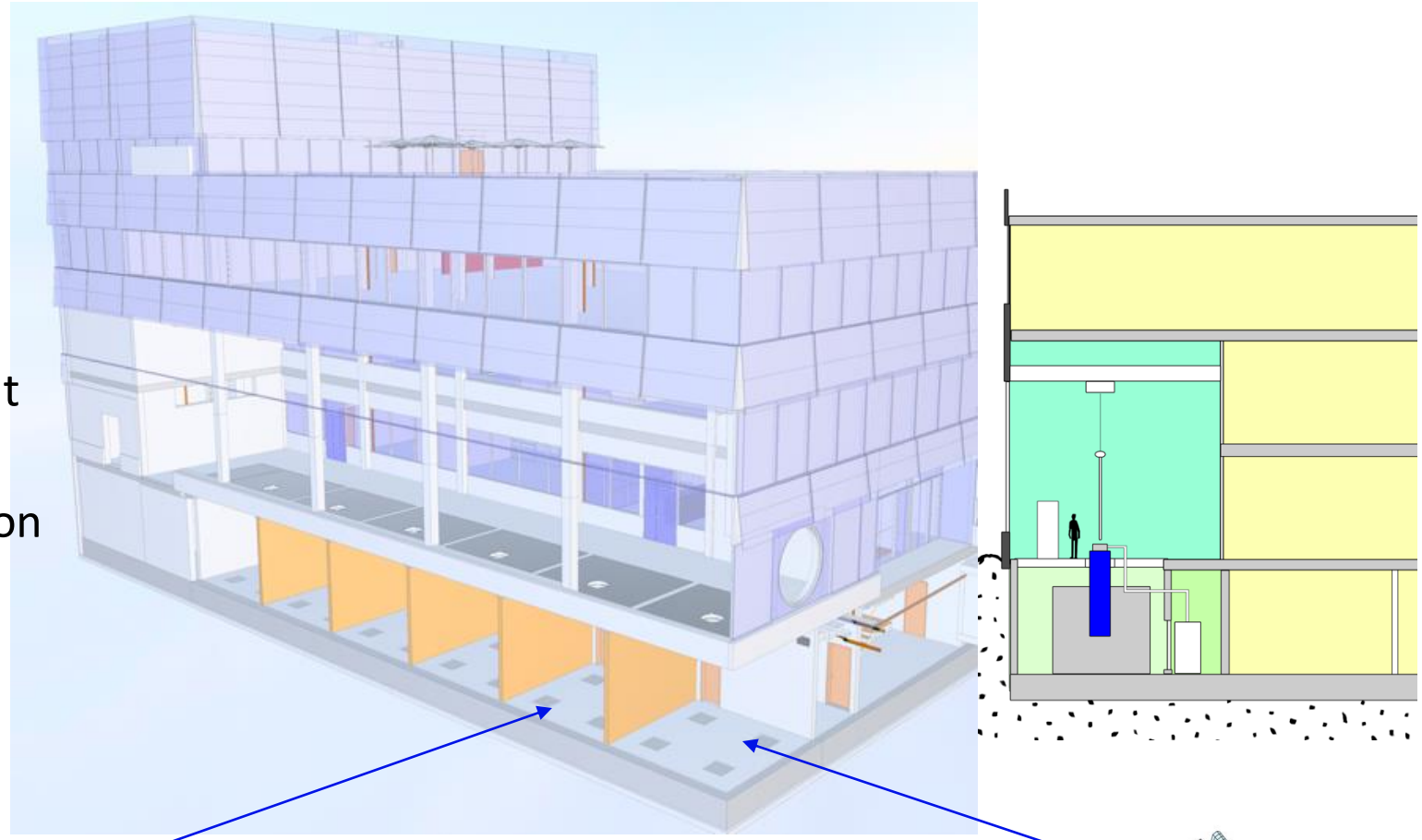
expand to lower temperatures, high magnetic fields and high pressures

The current pressure activities at SµS and SINQ will be expanded into QMMC

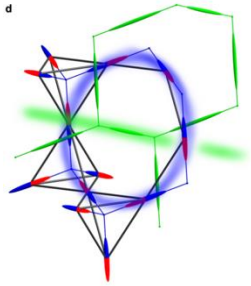
- provide complementary information
- ➔ increases the quality of the scientific results
- Drive expansion of the parameter space at the large scale facilities

“Ultra-Low Noise Lab” for Quantum-Matter Research

- Separated experimental areas for 6 experiments
- Non-magnetic rooms suitable for high magnetic fields
- Experiments are grounded to basement
- User access at groundfloor level ➔ separation between setup and operation
- A crane is available for logistics



First two instruments in construction

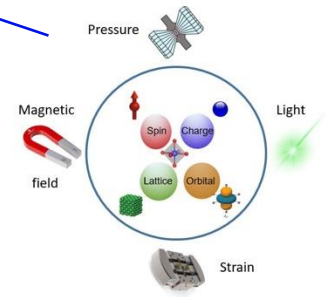


Emergent electrodynamics in quantum spin ices materials

R Sibille

advanceNMR
NMR Spectroscopy for quantum material research

G. Simutis



Thank you for your attention