PAUL SCHERRER INSTITUT

PSI

Εστια

Estia

EUROPEAN SPALLATION SOURCE

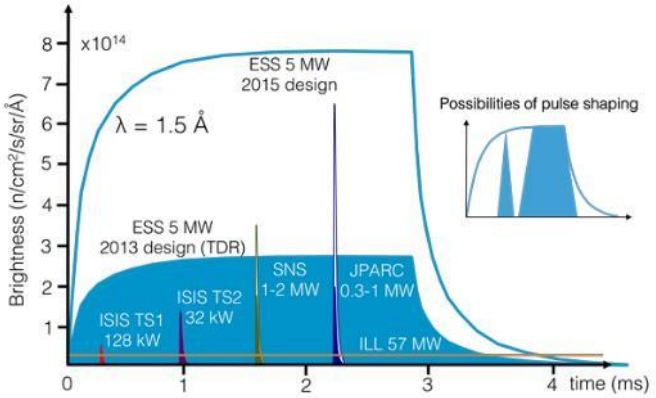
Sven Schütz :: Paul Scherrer Institut :: 29.10.2018

ESTIA – Science Case and SEE Priorities

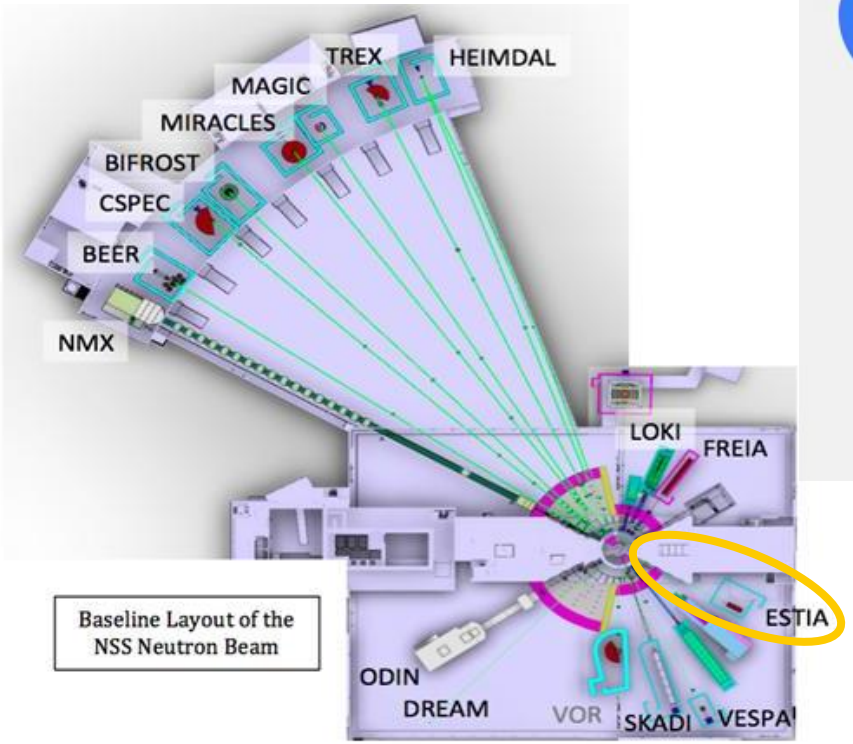
LSS SEE Workshop

27.11.2018 – ISIS

The European Spallation Source (ESS)

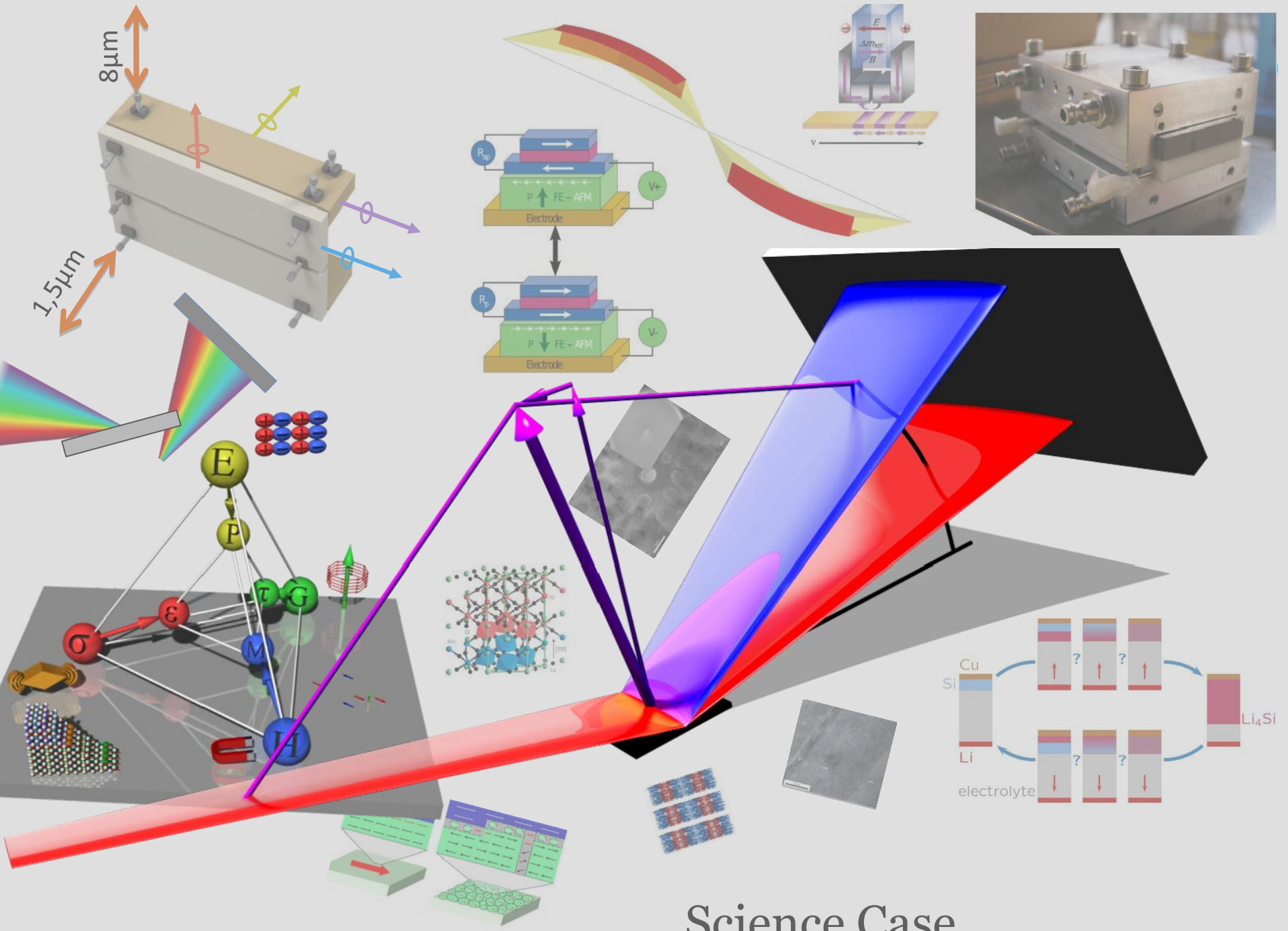


- 1st ESS reflectometer
- Polarization analysis
- Truly focusing guide



Baseline Layout of the NSS Neutron Beam

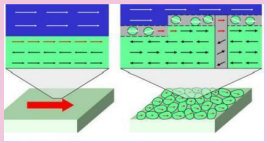
- Installation at ESS: 2021/2022
- Hot commissioning: 2022/2023
- User operation: 2024

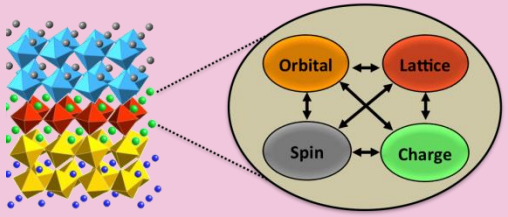


Science Case

ESTIA Science Case I

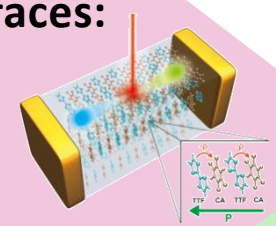
Fundamental understanding of condensed matter





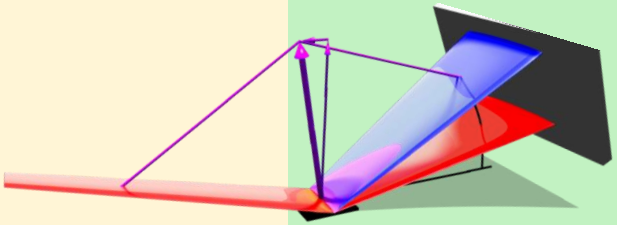
Emergent Properties at Interfaces:

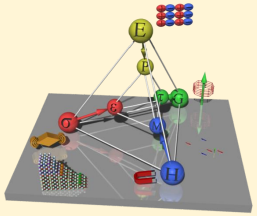
- Exchange Bias
- Electronic reconstruction
- Magnetic interface layers
- 2DEG and Superconductivity



Ordering Phaenomena:

- Multiferroics
- Skyrmions
- Frustrated Dipole Systems
- Ordered Nanoparticles

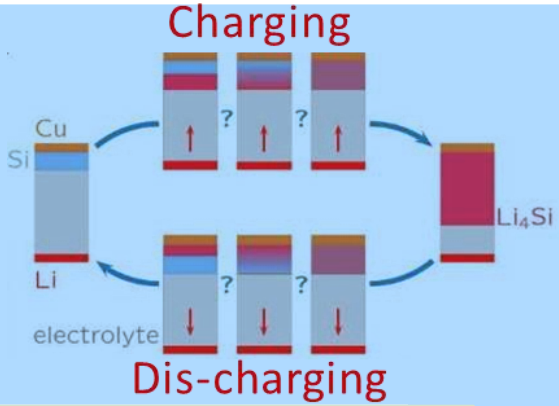




Health - Bio-membrane function:

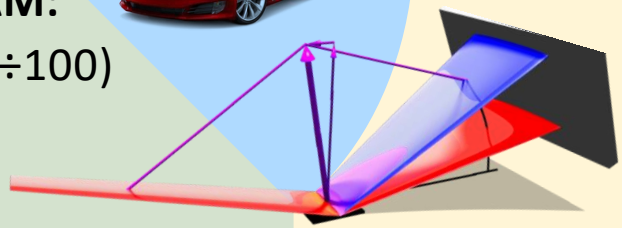
- Structure of cell membrane in equilibrium
- Reaction to external stimuli (E-field)
- Dynamics of interaction w/ other molecules

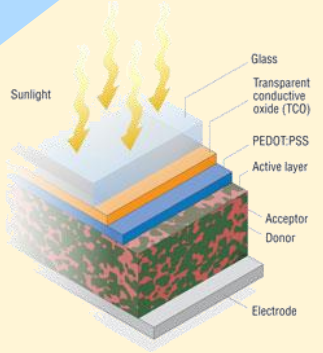
Help to solve societies great challenges



Energy - Battery materials:

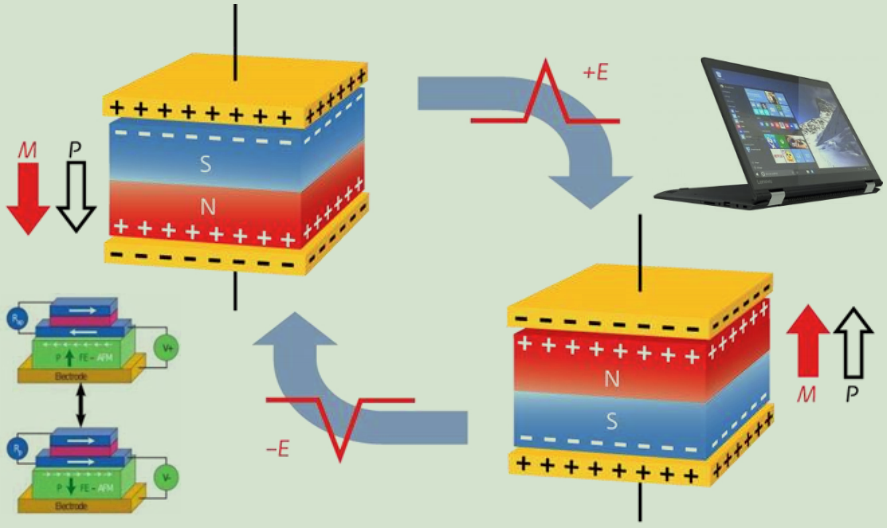
- In-situ insight in ion transport
- Understand underlying surface chemistry
- Improve structure of electrodes
- Investigate new material systems

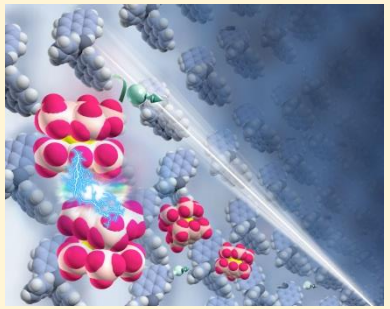




Information - Multiferroic RAM:

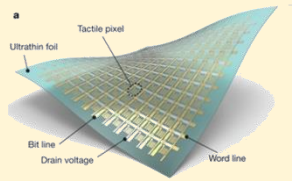
- Low energy consumption (÷100)
- Non-volatile
- 4 distinct memory states





Functional soft-matter:

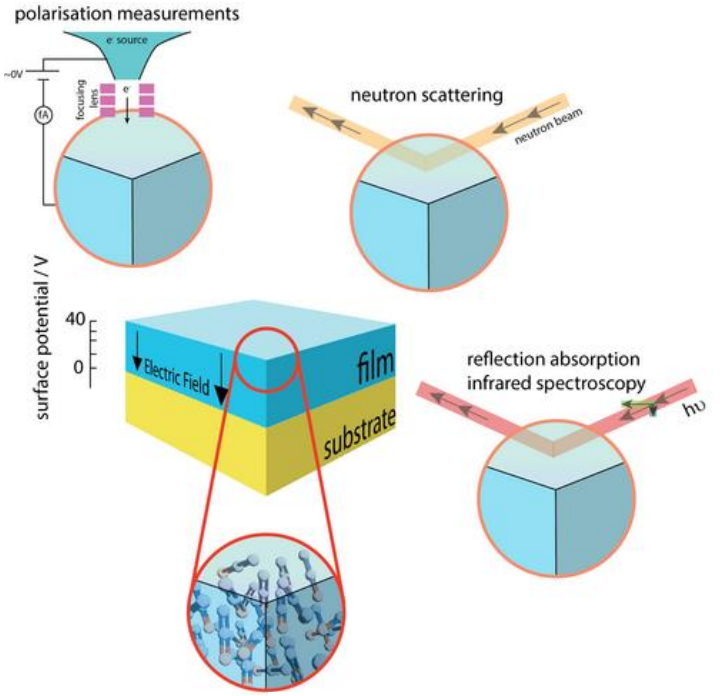
- Semi-conductors
- Organic photovoltaics (OPV)
- OLEDs
- Sensors

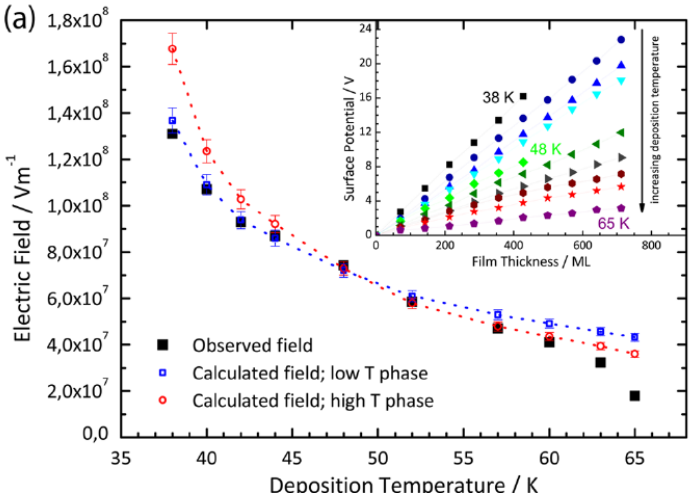


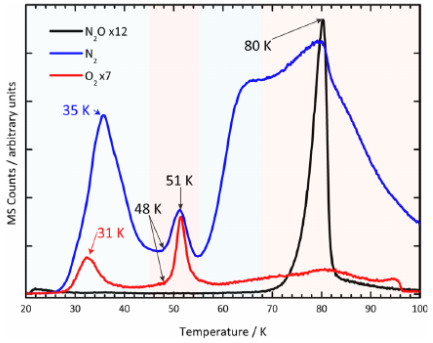
E1: Spontelectric thin films

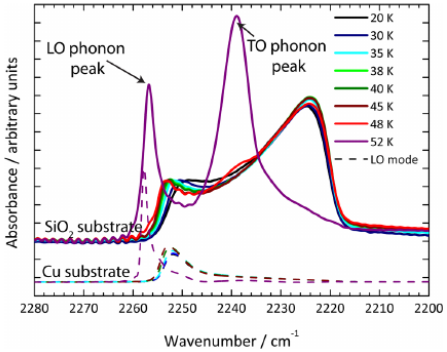
- Films of N_2O/Methyl formate deposited in HV and low T
- Molecules assemble with preferred orientation
- Spontaneous electric field is developed

- What is the structure in the film?
- What happens at transitions?



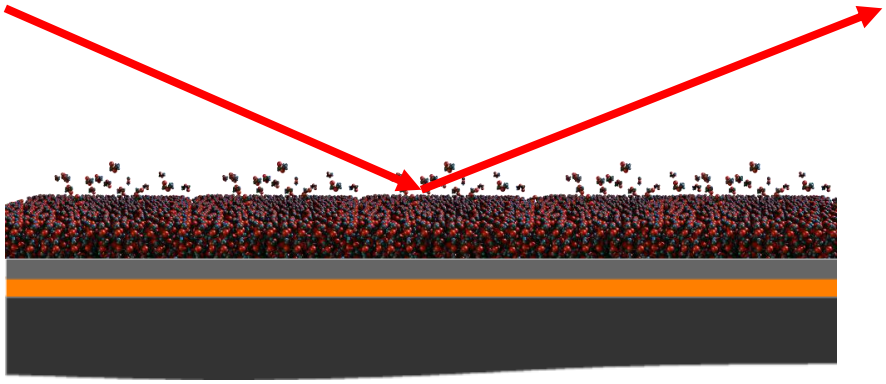


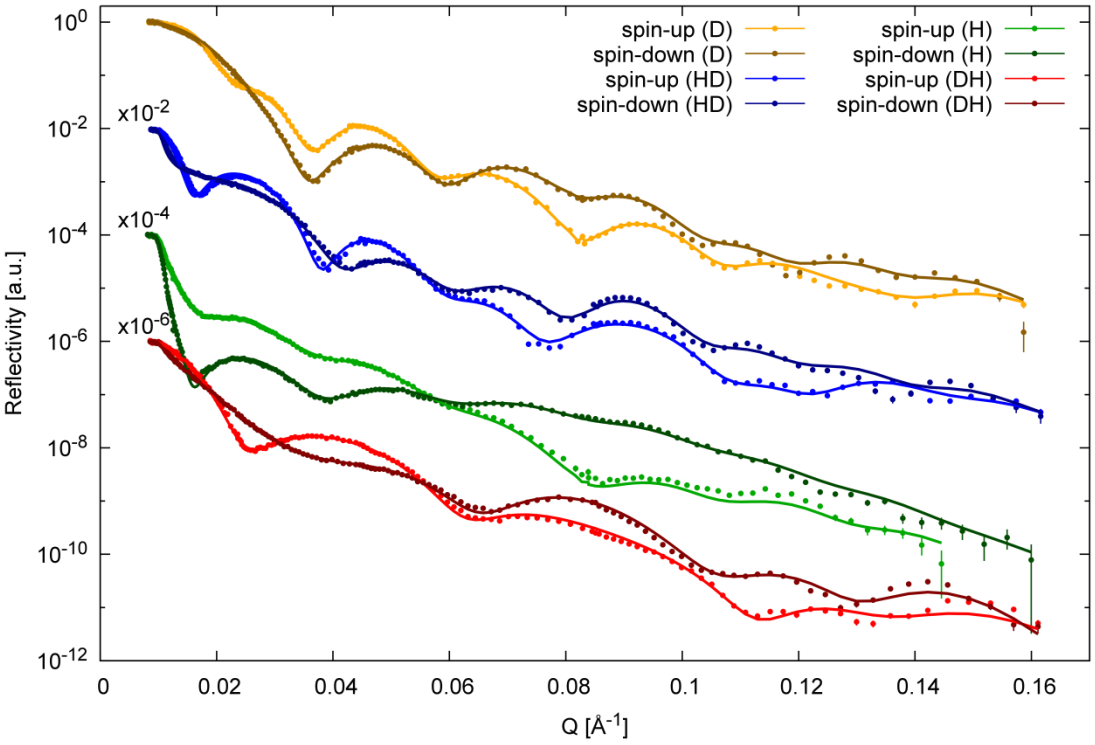


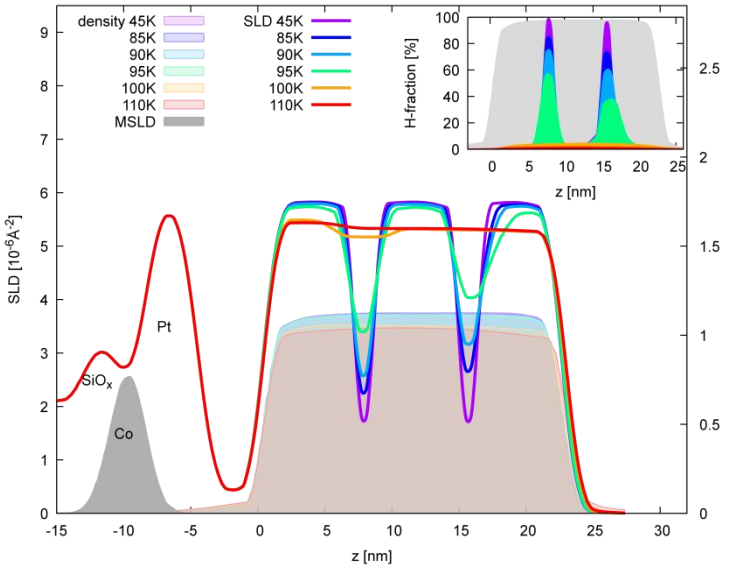


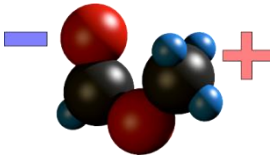
Cassidy, A.; Jørgensen, M. R. V.; Rosu-Finsen, A.; Lasne, J.; Jørgensen, J. H.; Glavic, A.; Lauter, V.; Iversen, B. B.; McCoustra, M. R. S. & Field, D.
Dipole-Oriented Molecular Solids Can Undergo a Phase Change and Still Maintain Electrical Polarization
Journal of Physical Chemistry C, 2016

E1: Spontelectric thin films









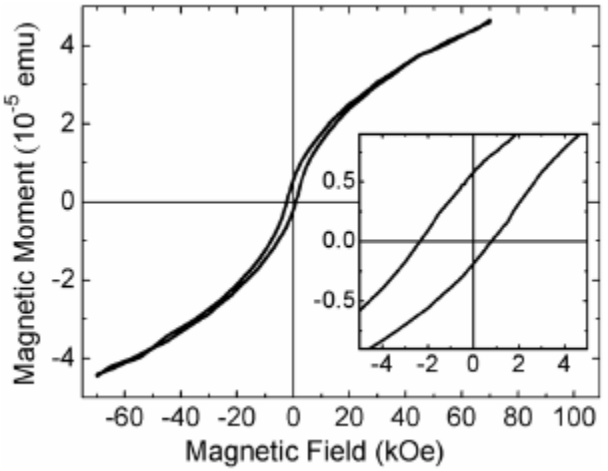
Methyl Formate
$C_2H_4O_2$

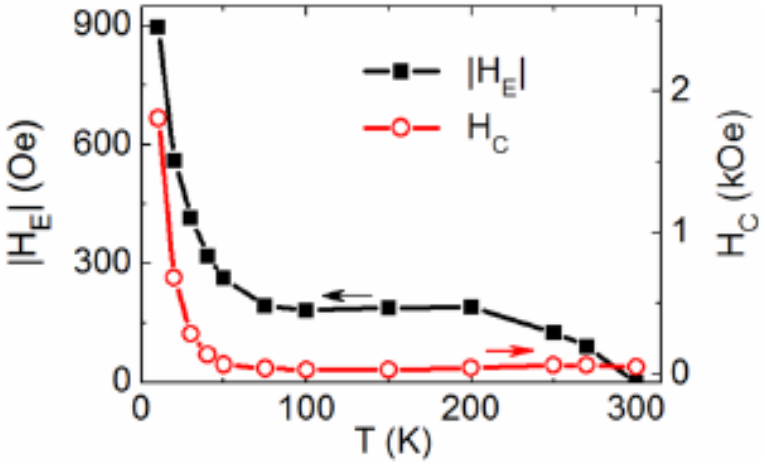
- Deposit on substrate with magnetic reference layer
- Protonated and deuterated gases for multilayer deposition
- Observe self-diffusion when approaching glass transition temperature

E2: Exchange-Bias at Cu/FeMn Interface

- Heterostructure with FeMn sandwiched between Cu layers
- SQUID shows EB
- No FM/AFM interface

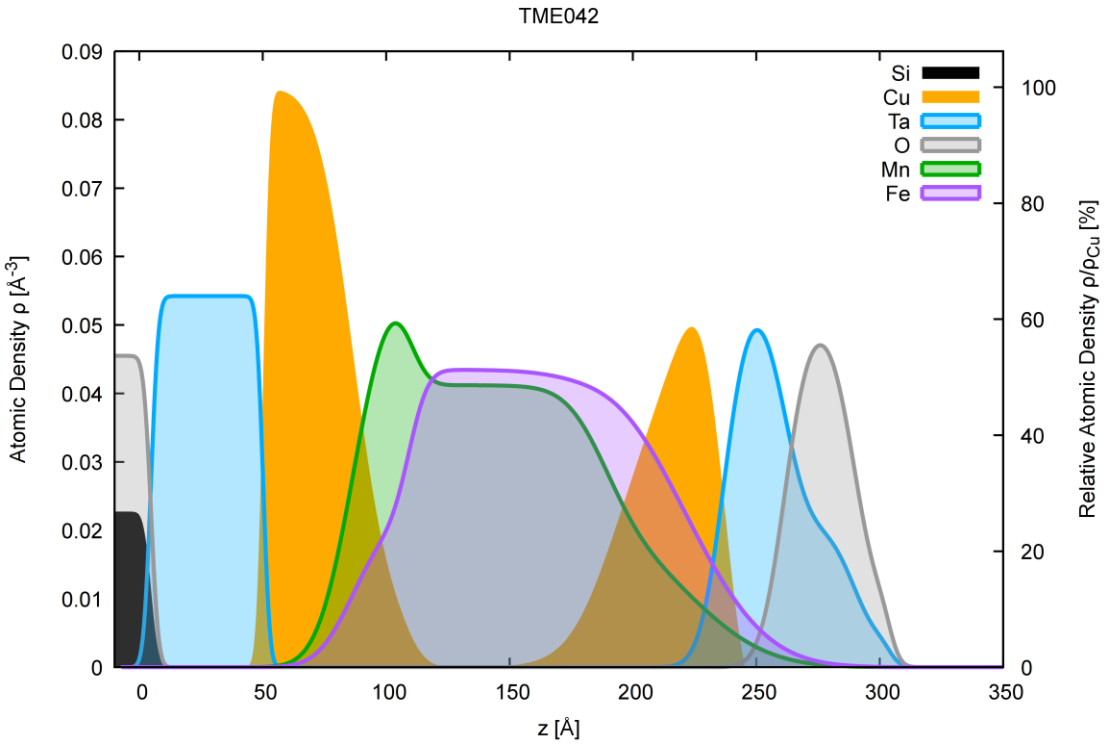
- Where is the magnetization?
- What "pins" the moments (AFM)?

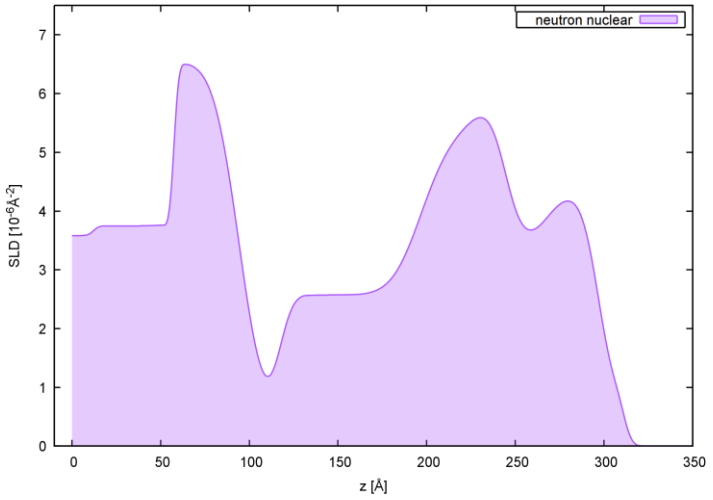


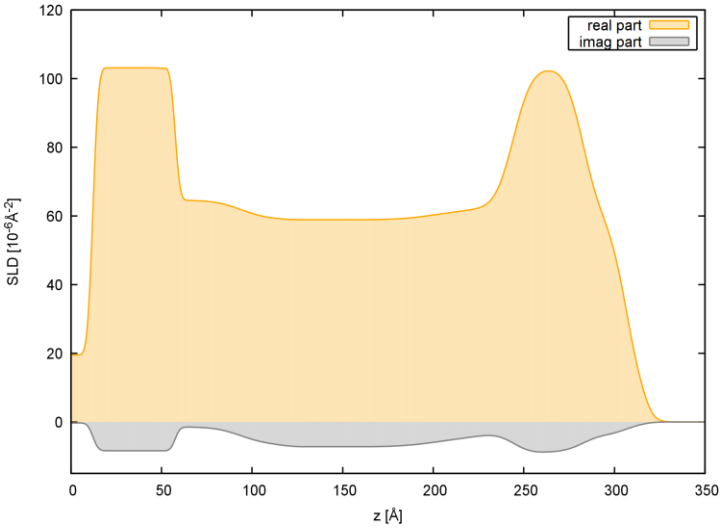


Roshchin, Igor V.; Lapa, Pavel N.; Glavic, Artur; Ambaye, Haile; Lauter, Valeria; Eggers, Tatiana M.; Miller, Casey W.; Belashchenko, Kirill

E2: Exchange-Bias at Cu/FeMn Interface







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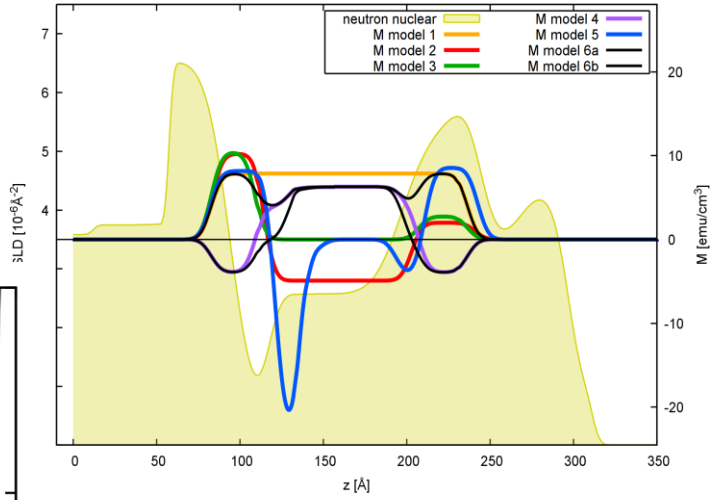
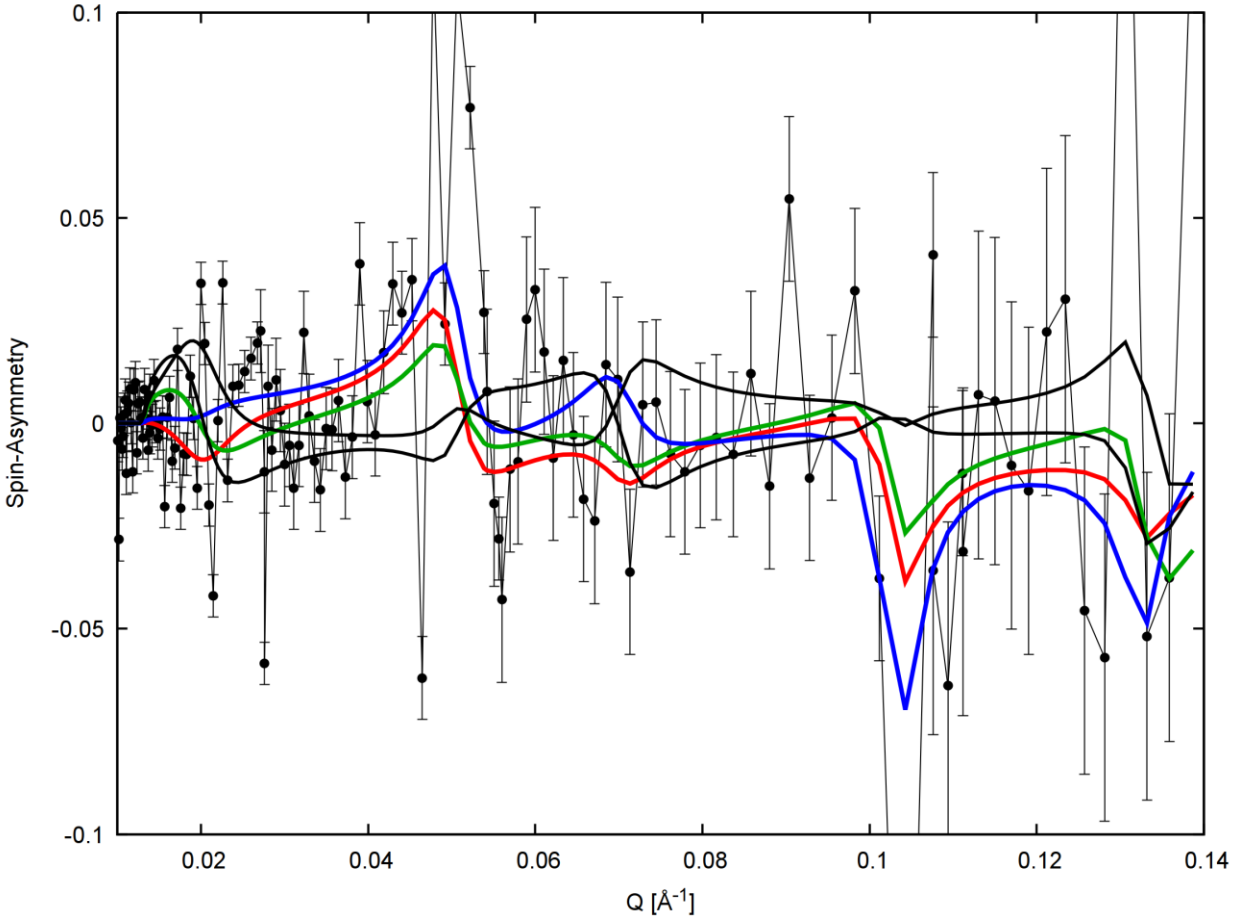
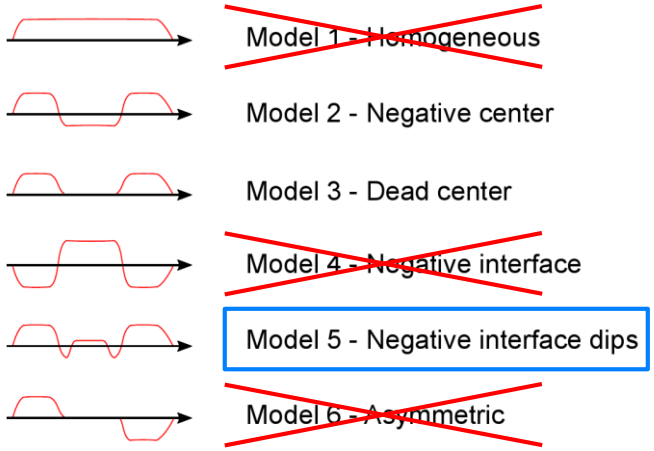
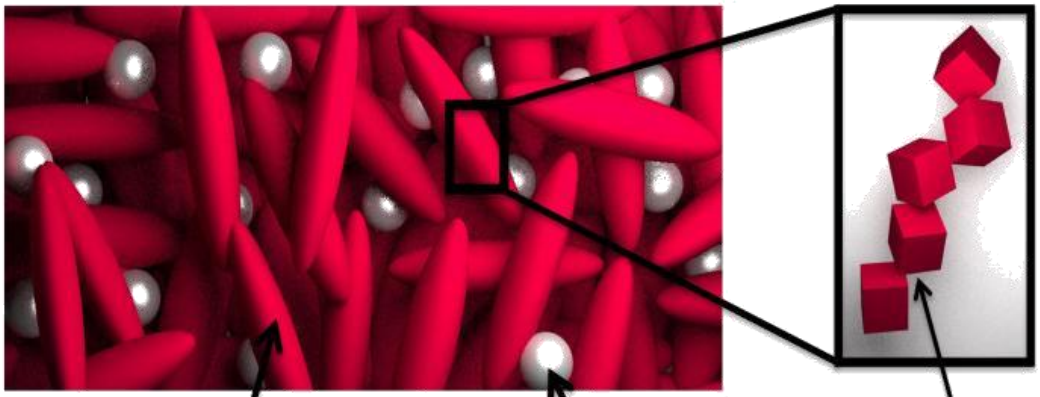


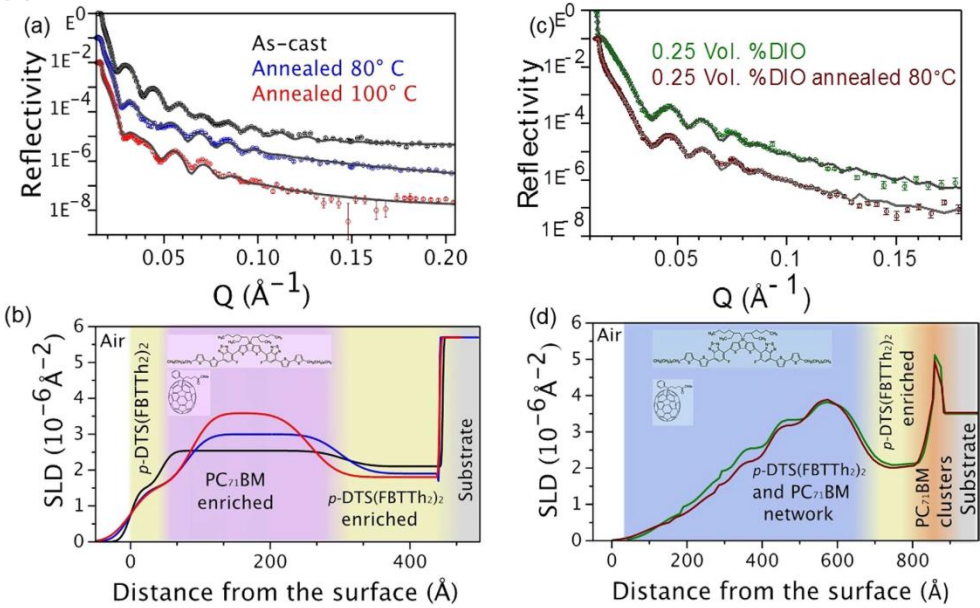




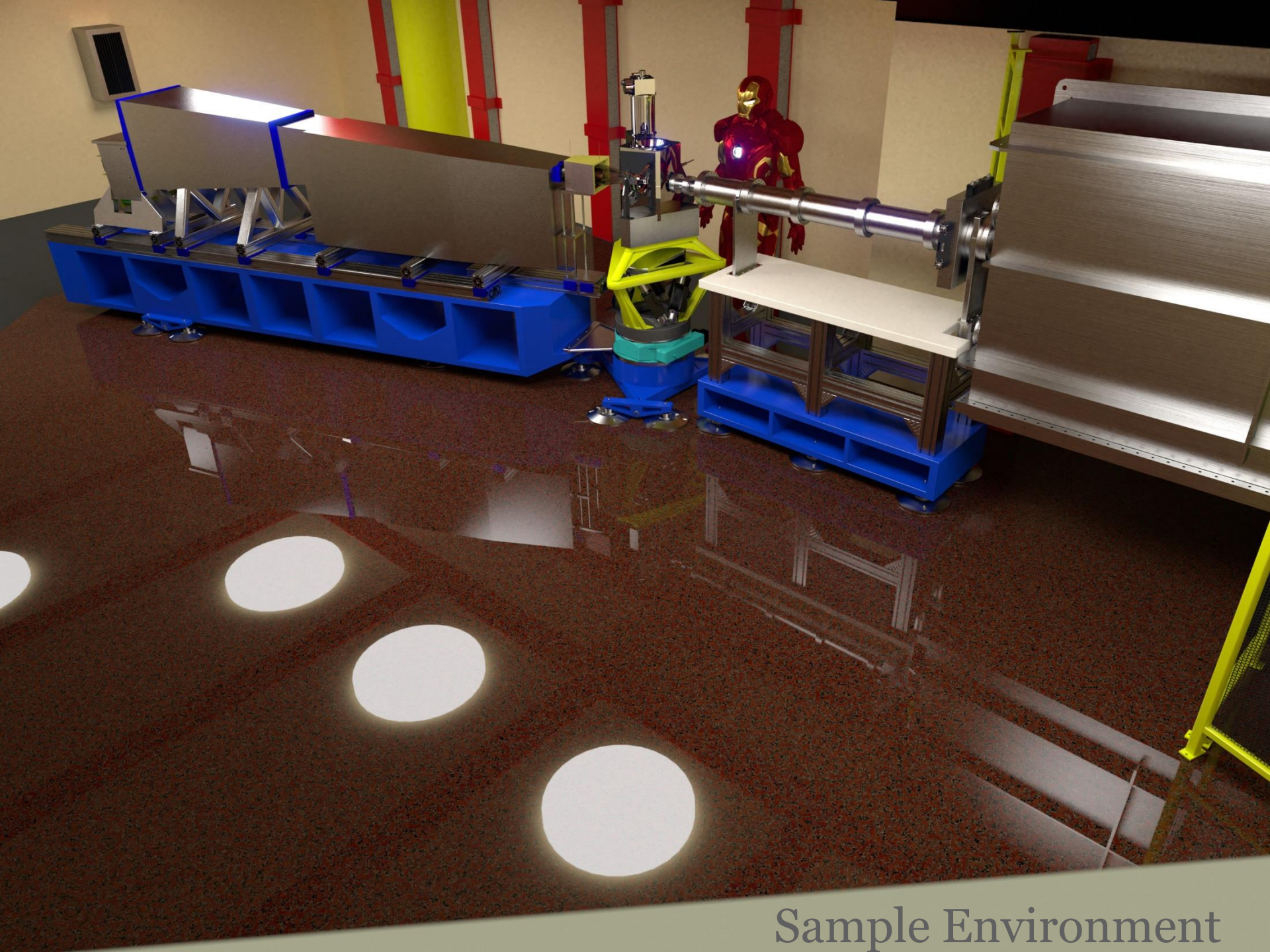
E3: Organic photovoltaics



- Performance of devices strongly depends on morphology of functional layers
- Neutron reflectometry allows insight into buried layers and allows to understand the influence of deposition parameters
- Deuteration can be used to label organic molecules



N. Herath, et al., Scientific Reports 5:13407 (2015)



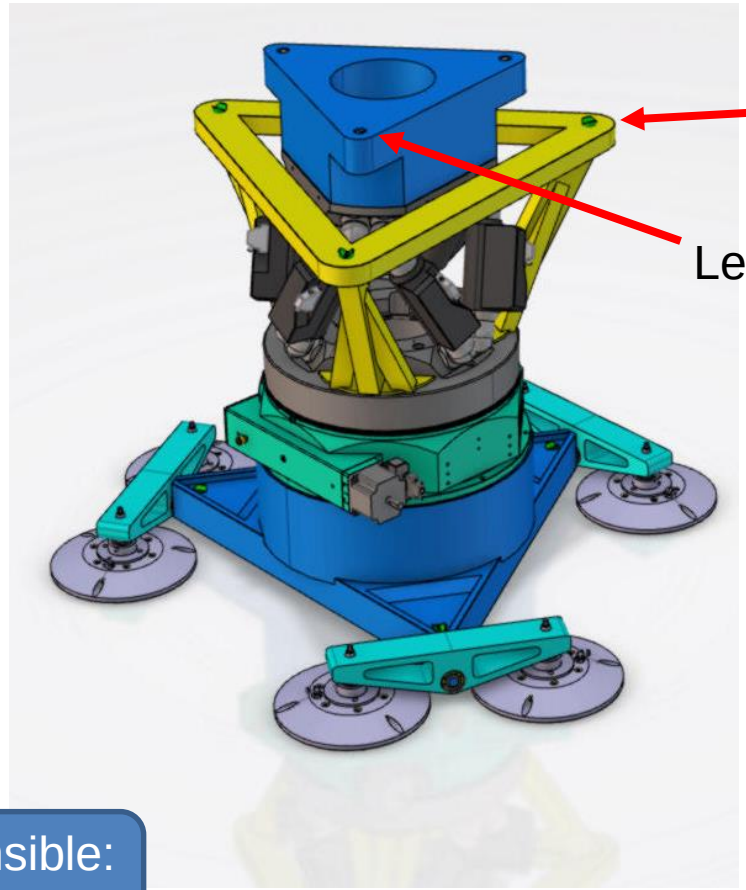
Sample Environment

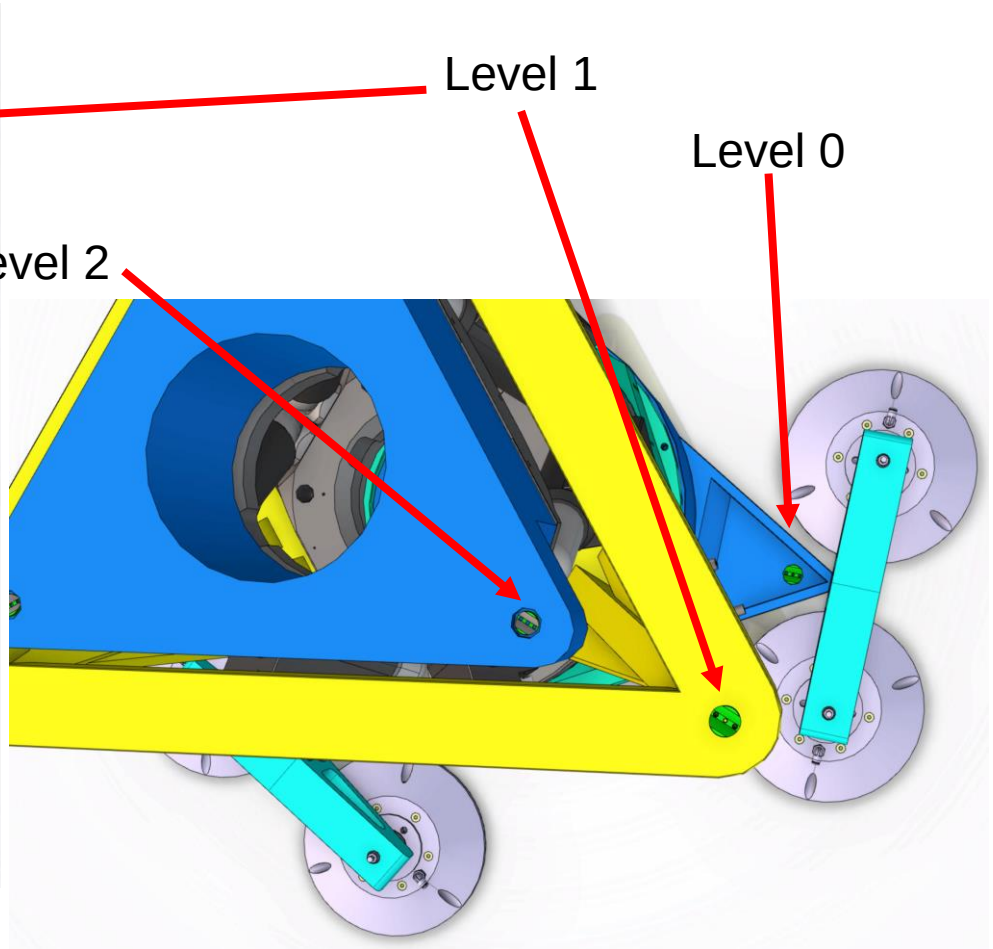
Sample stage

Interfaces with ESS standard KM

- Sample stack on airpads for alignment to beam
- No current use case for L0
- L1 and above rotate with omega

Hot Comm.





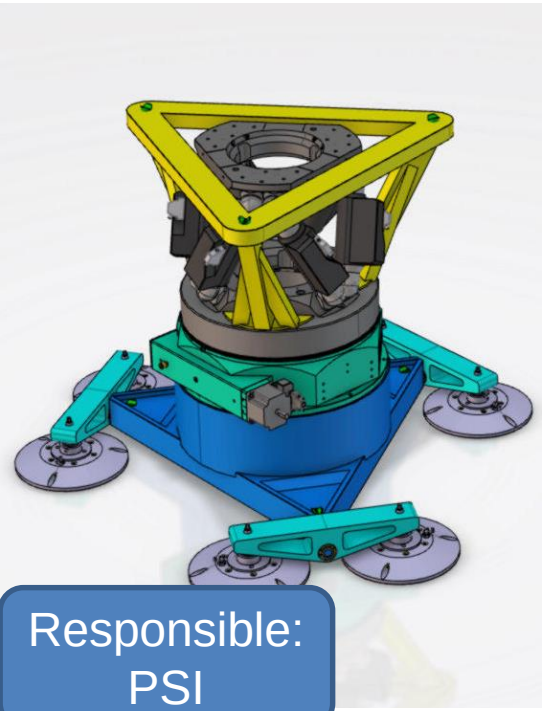
Responsible: PSI

Sample stage

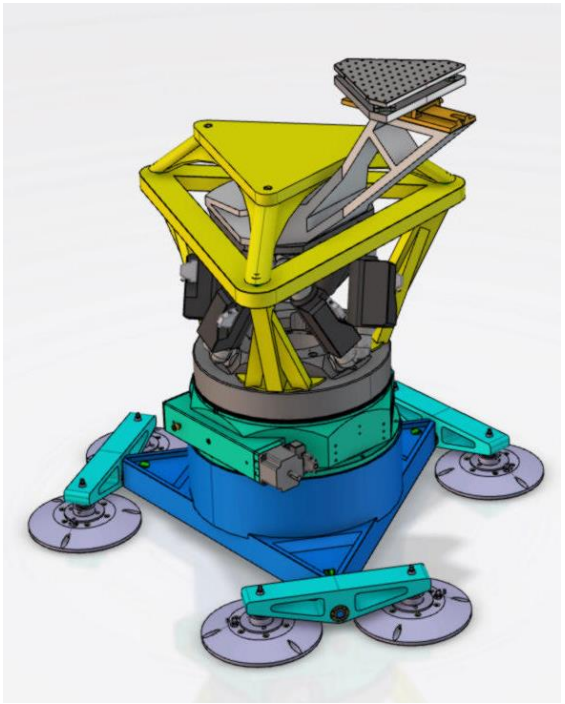
Modular setup depending on SEE weight

Hot Comm.

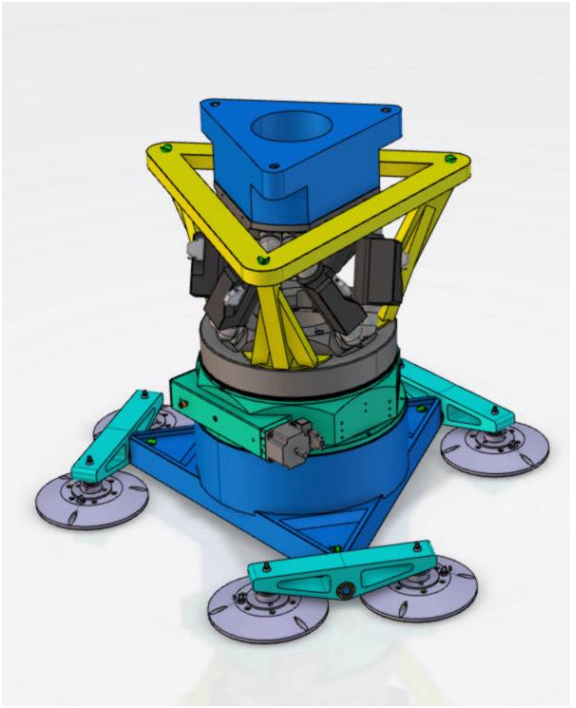
- No adapter
- L1 w/ rotation
- Hexapod unused
- ~350kg-1000kg



- L1-L2 adapter omega
- Custom cryostat stage on Hexapod
- L2 rotates, stage 6 DOF
- L2 ~500kg, stage ~50kg



- Hexapod to L2 adapter
- Rotates + 6 DOF
- ~350kg



Responsible: PSI

RT bore cryomagnet & cryostat

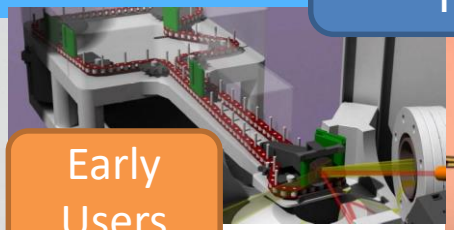
Setup 1

- Magnet on omega
- Cryostat w/ sample adjusted with Hexapod inside magnet
- Laser setup for sample alignment w/o beam
- Geometry allows reflectivity and diffraction
- Cryostat is light weight and can be removed
- Optional: RT sample holder or changer

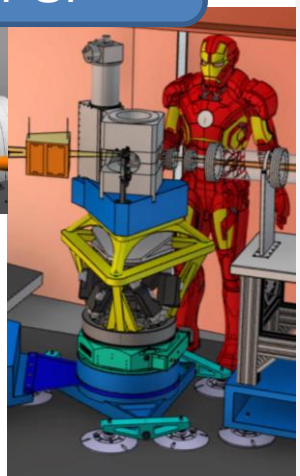
Hot Comm.

Hot Comm.

Responsible: PSI

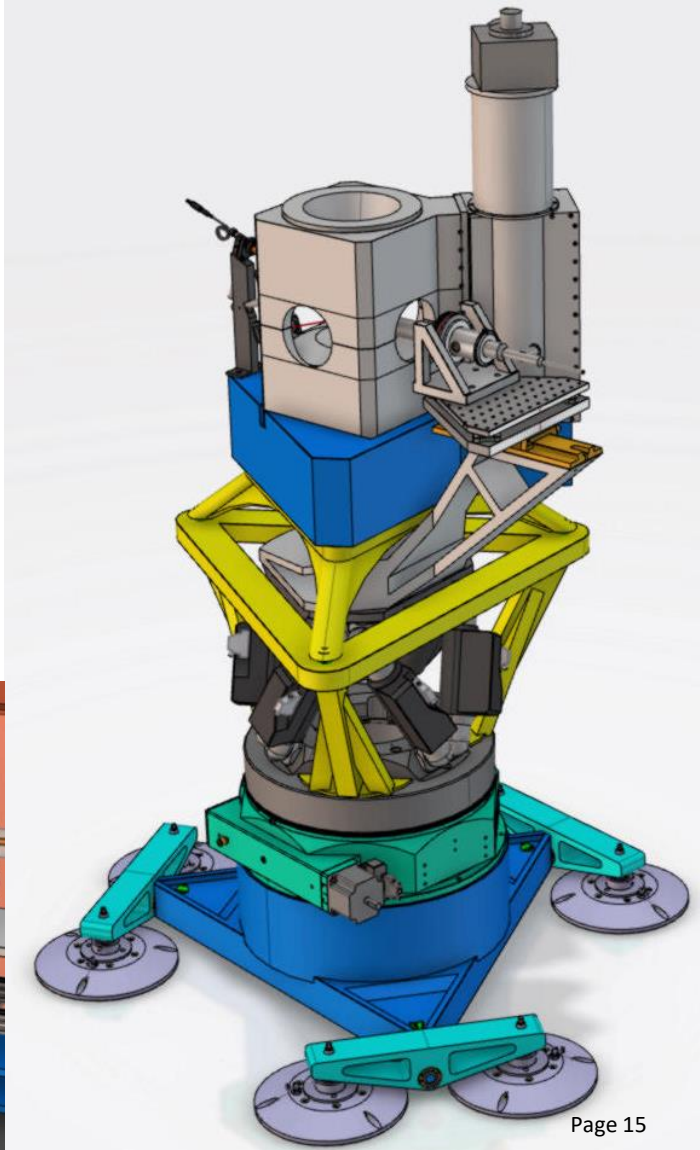


Early Users



Similar system used at MLZ (2.3 T)

Responsible: ESS

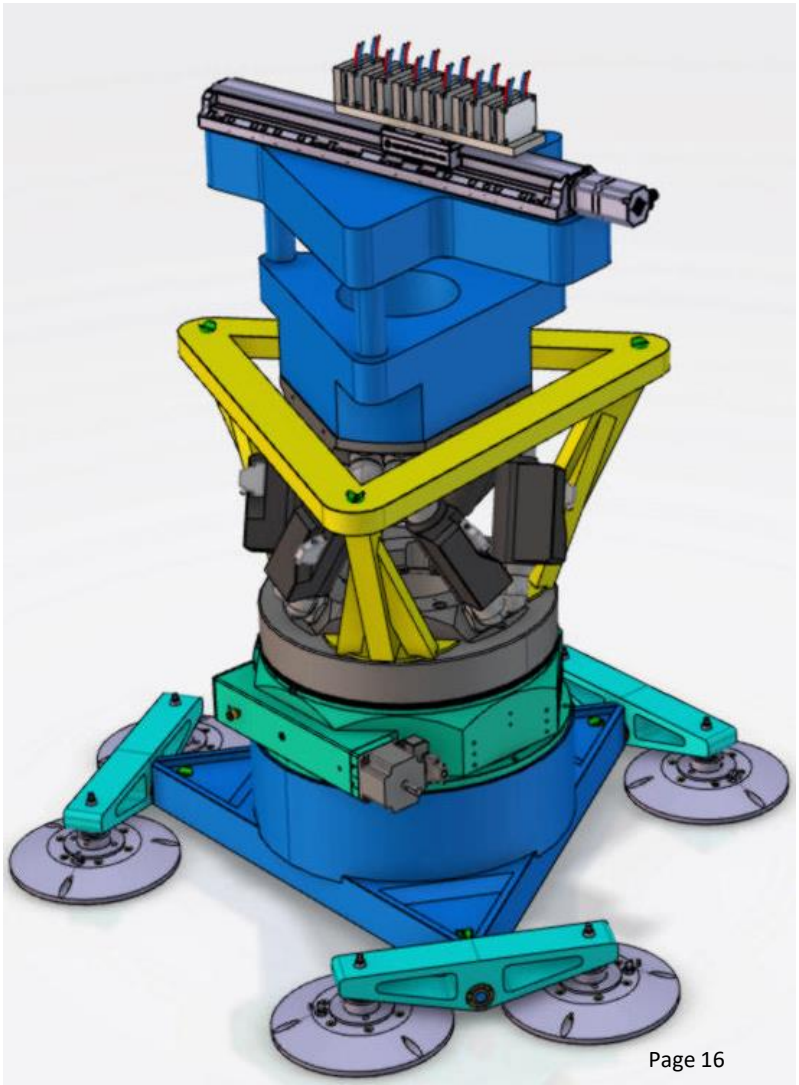


Solid-liquid cells & changer

Setup 2

- Horizontal sample changer
- Free access from all sides
- High precision alignment with Hexapod
- Whole system can quickly be removed and reinstalled on kinematic couplings (<50µm repeatability)
- Dedicated Estia Solid-liquid cells
- Liquids handling equipment

Hot Comm.



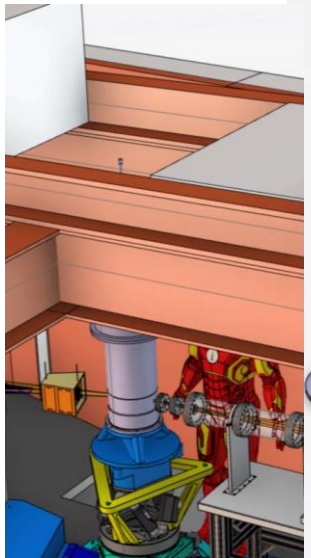
Responsible: PSI

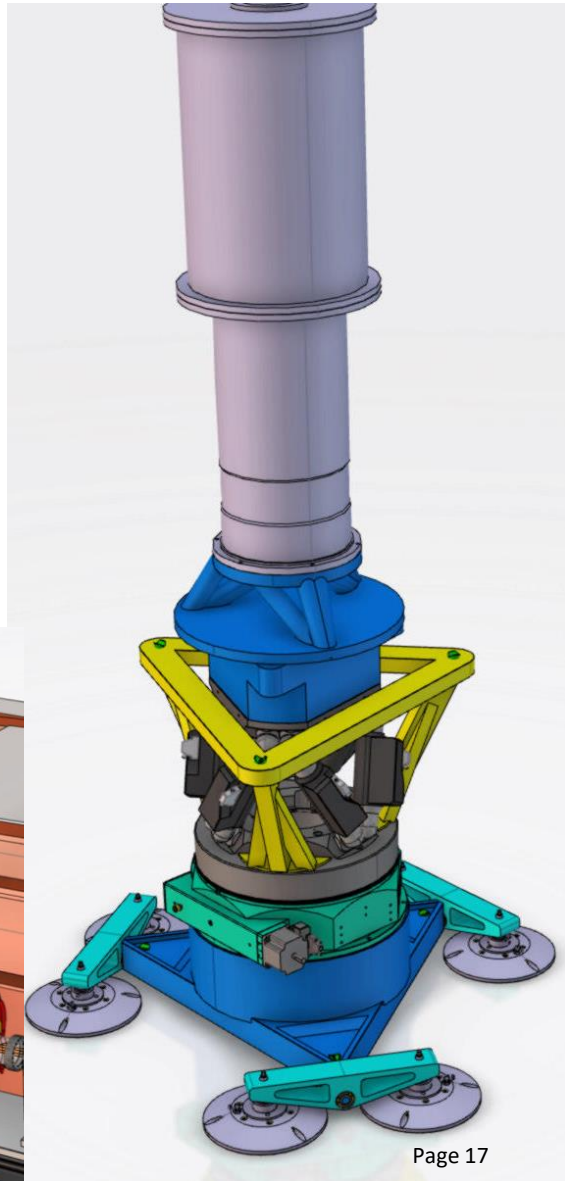
High field magnet

Setup 3

- ~5T magnet will be light enough for Hexapod (<350kg)
- Full adjustment range and precision
- Sample access directly from roof

Early Users





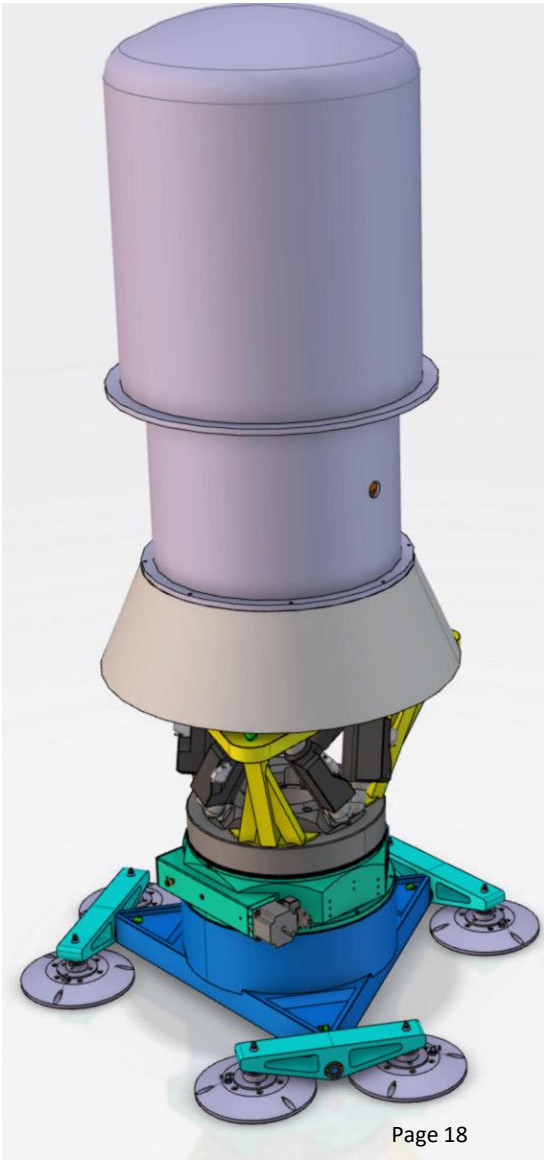
Responsible: ESS

Heavy high field magnet

Setup 4

During Operation

- Very high field possible with magnet on L1
- Only omega motion possible
- Alignment given by kinematic mounts (~0.1mm)
- Need larger beam size horizontally by opening VS
- Vertical beam position can be adjusted by VS +/- 5mm

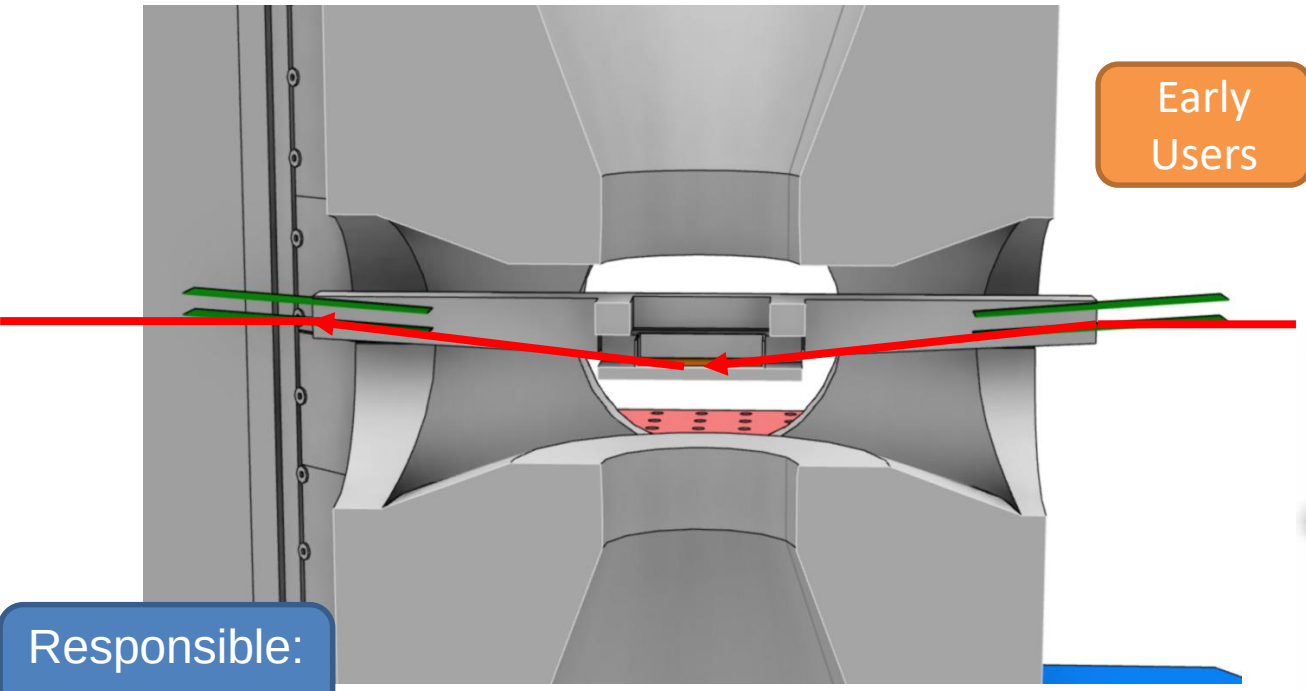


Responsible: ESS

Free liquid surfaces

Setup 5

- Collimate vertically with slit and VS
- 1.2° - 2.7° incident angle available from guide
- Extent q-range with double-mirror option (m=2,5) to 4.0° and 6.0° for q_{max}>0.3 $Å^{-1}$
- Provide additional capability while FREIA is not yet in the user program

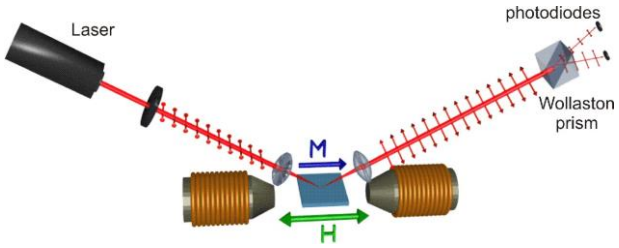


Early Users

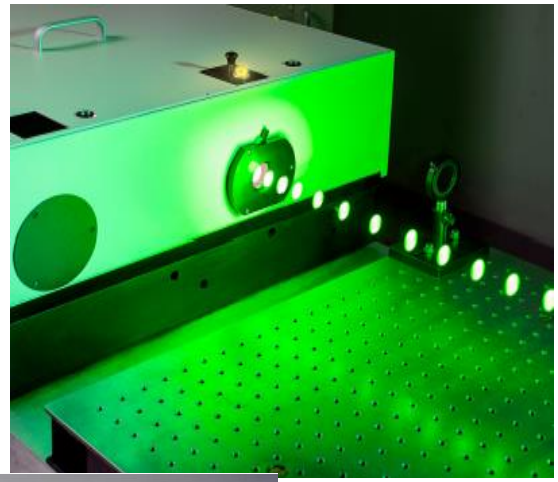
Responsible: open

Later upgrades

Setup X

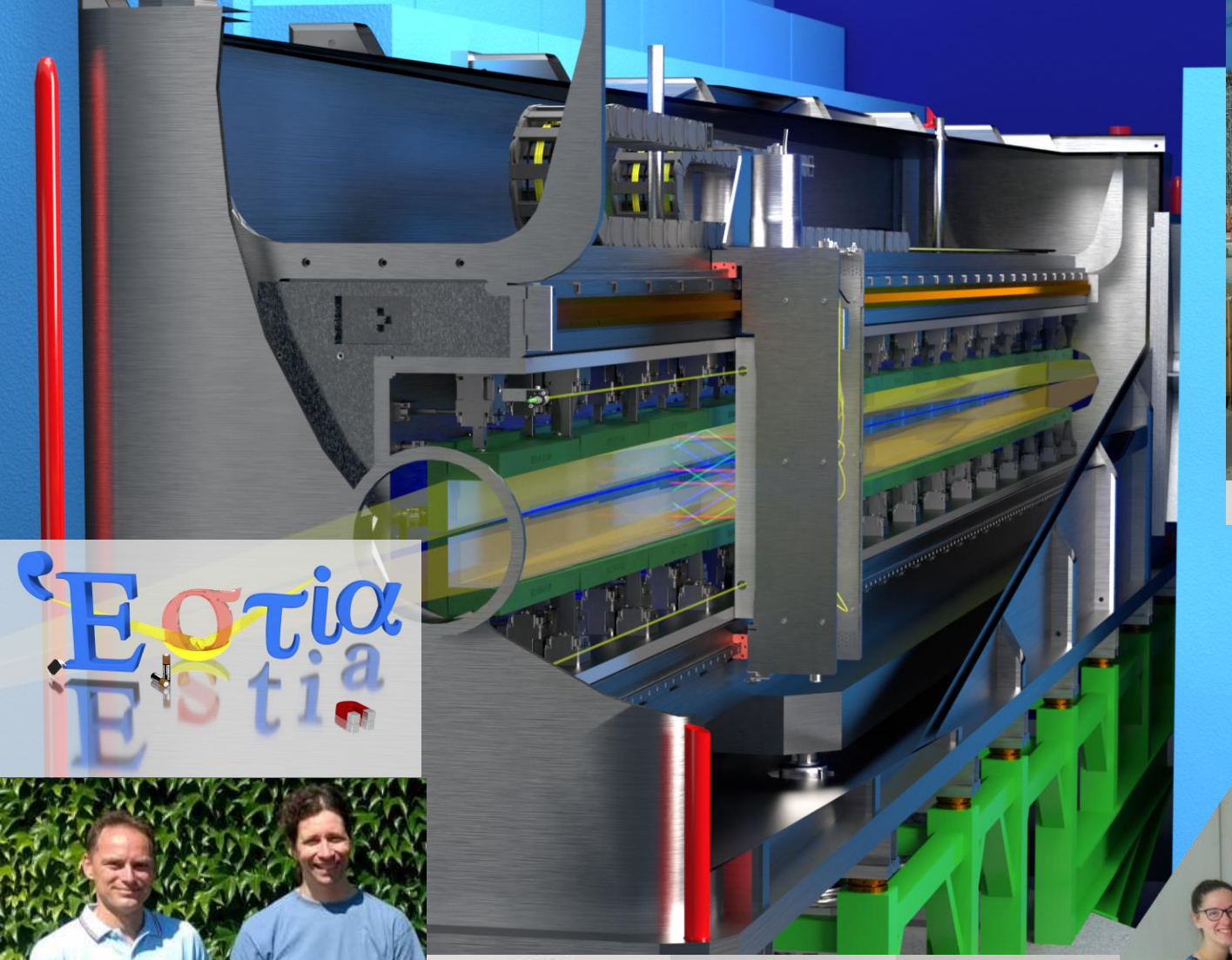


- Kerr-effect add-on
- Additional cryostats for fast sample changes (cooling new sample while measuring old)
- Pump laser for dynamic experiments
- Helmholtz coils for XYZ-polarization analysis
- Pressure cell for low-T as advised by STAP
- Bending rig
- Potentiostat
- High E-field
- High-T for cryo



Responsible: open

During Operation



Sven Schütz

Artur Glavic

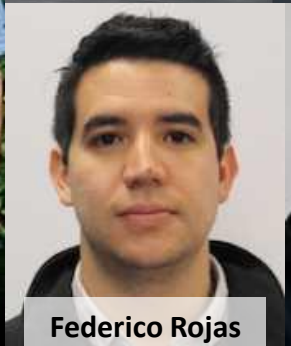
Εστία

Estia

Francesco Piscitelli

Uwe Filges

Jochen Stahn



Federico Rojas

Andre Schwarb

Peter Heimgartner

Katharina Liefert

Elisa Maslowski

Fabian Cortesi