Swedish neutron week

Grazing incidence small-angle neutron scattering (GISANS)

Opportunities for surface and interface science in Sweden

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Reflection from surfaces

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Content

Current situation

Scattering geometry
Instrumentation
Challenge

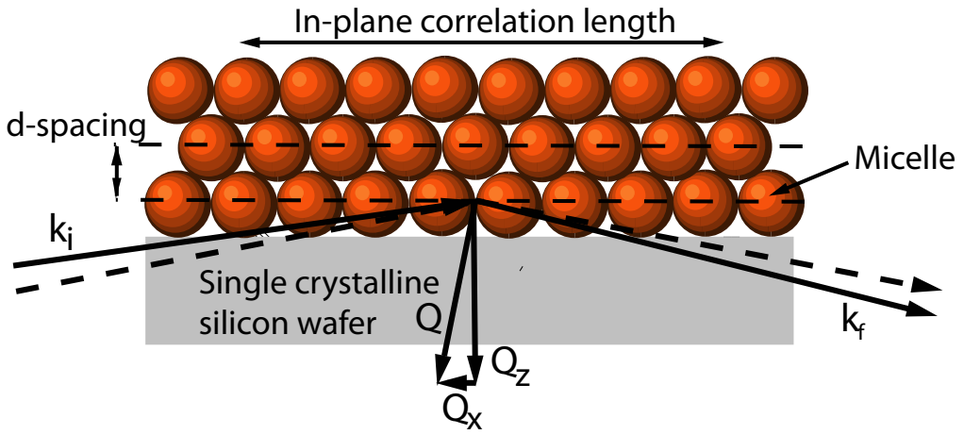
Examples

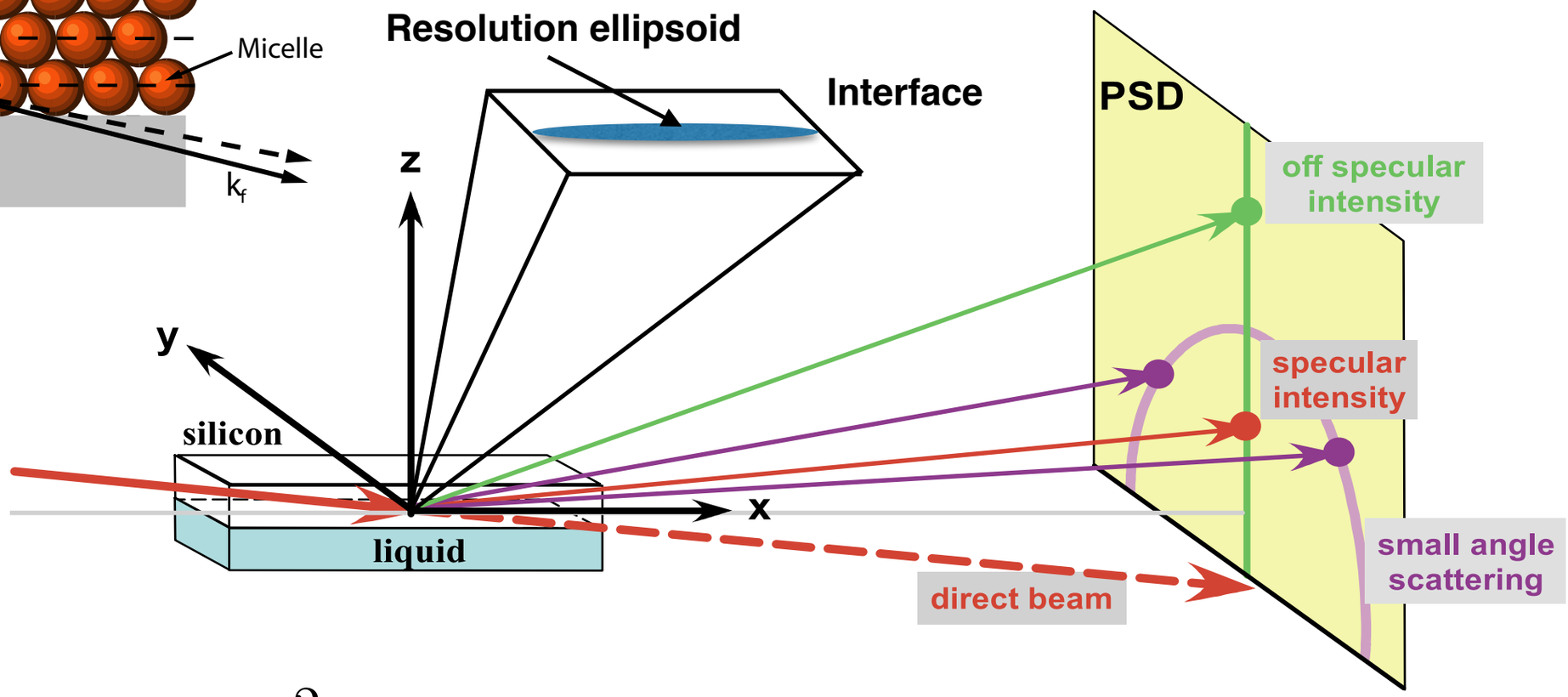
Hydration
Micro-phase separation
Micellar self assembly
Magnetic particles
Colloidal self assembly

Opportunities

Method developments
Research areas

Scattering from surfaces





Off-specular reflection: $Q_x = \frac{2\pi}{\lambda}[cos(\alpha_i) - cos(\alpha_f)]$ probes nm length scales

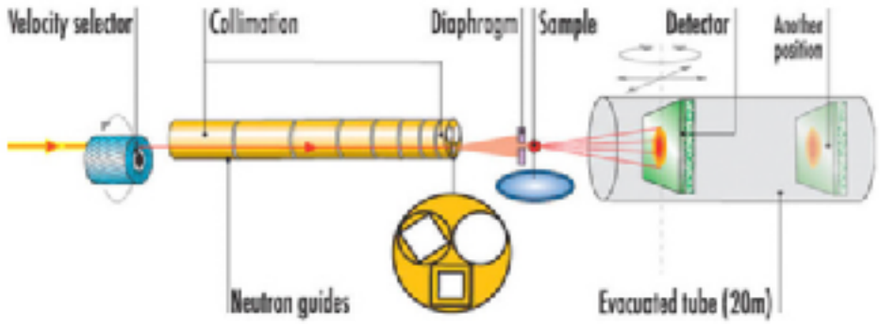
GISANS: $Q_y = \frac{2\pi}{\lambda}[sin(\phi_f) - 0]$ probes µm length scales

Specular reflection: $Q_z = \frac{2\pi}{\lambda}[sin(\alpha_i) + sin(\alpha_f)]$ probes nm length scales

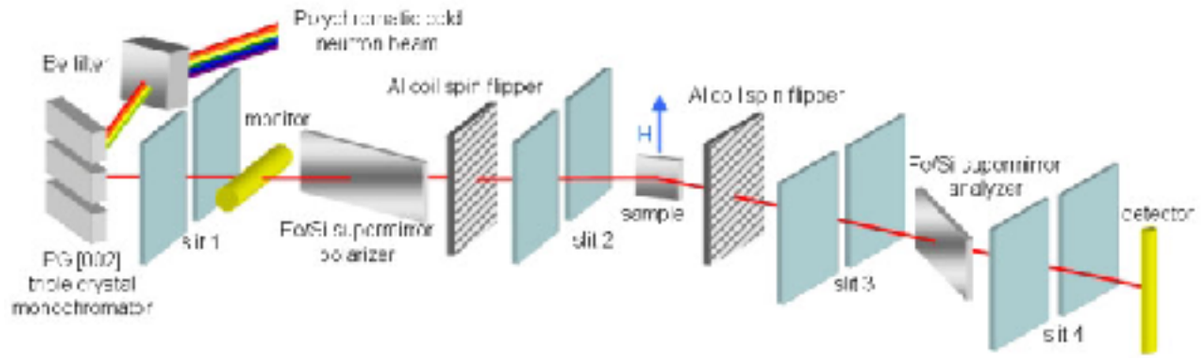
European Physical Journal: Web of Conferences **188**, 04002 (2018)

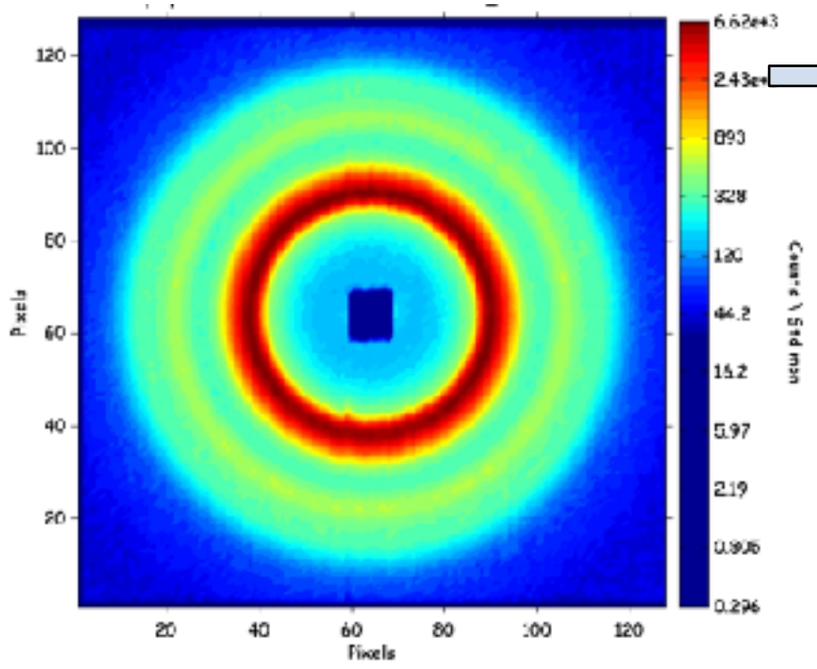
Instrumentation

SANS

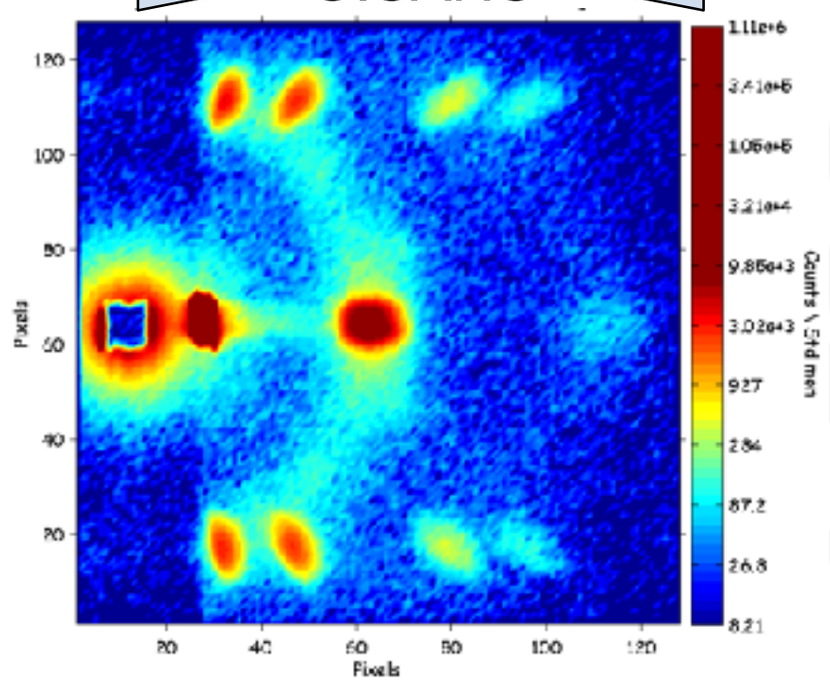


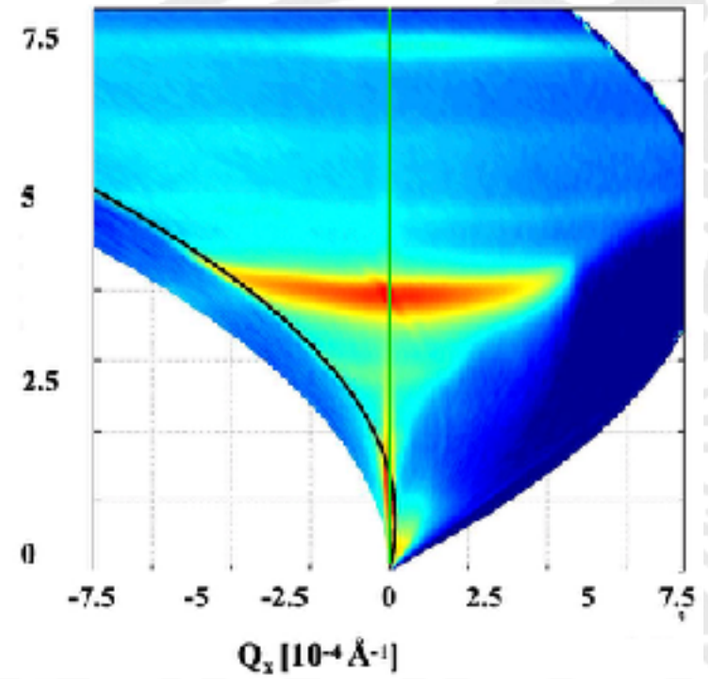
Reflectometry





GISANS





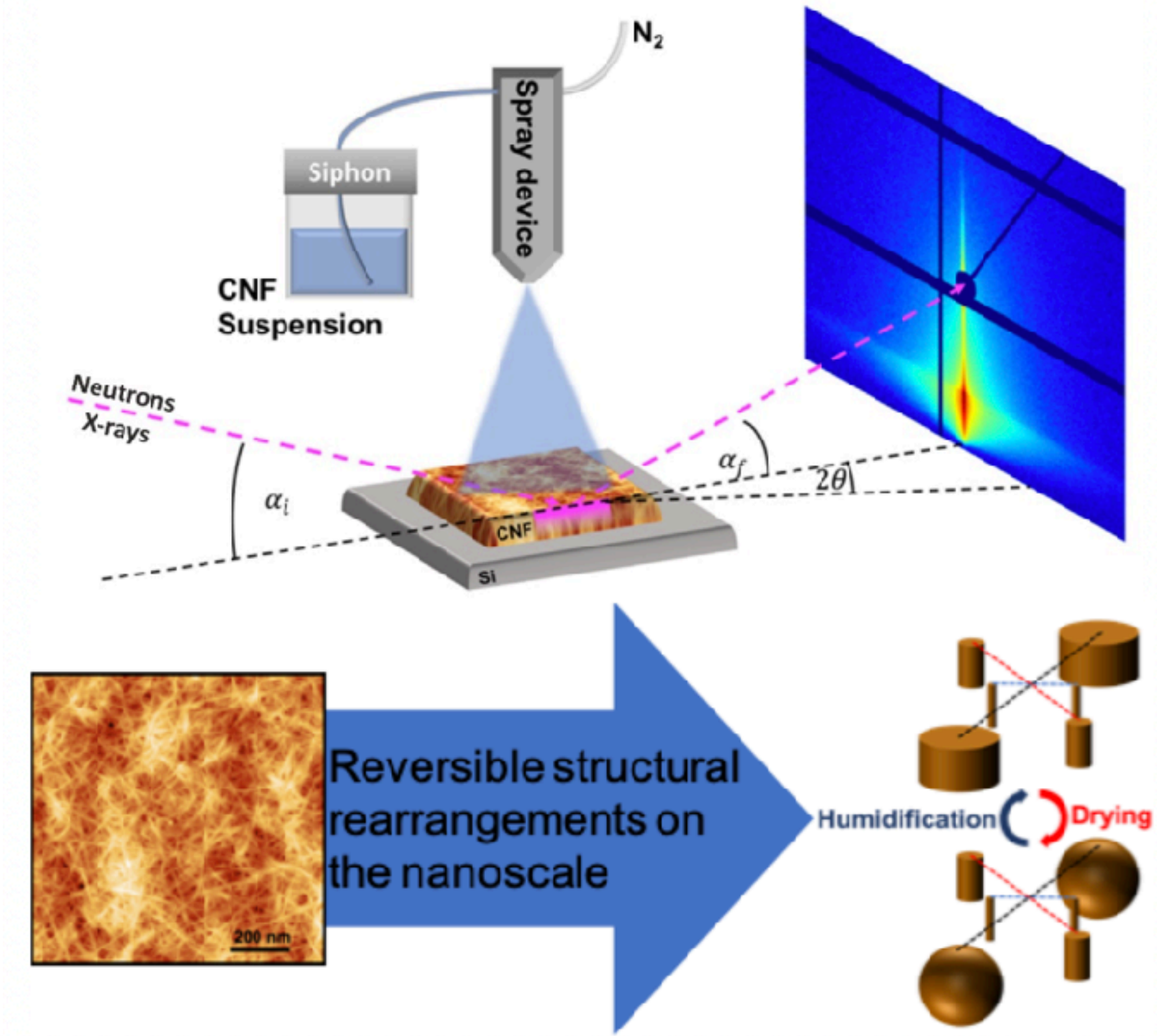
"No" dedicated GISANS instrument but about 30 GISAXS beam lines

Key challenge: Incident flux, Resolution, Background

Langmuir (Letter) **25 (1)**, 64 (2009)

Euro. Phys. J. E **16(2)**, 141 (2005)

Cellulose coatings - hydration



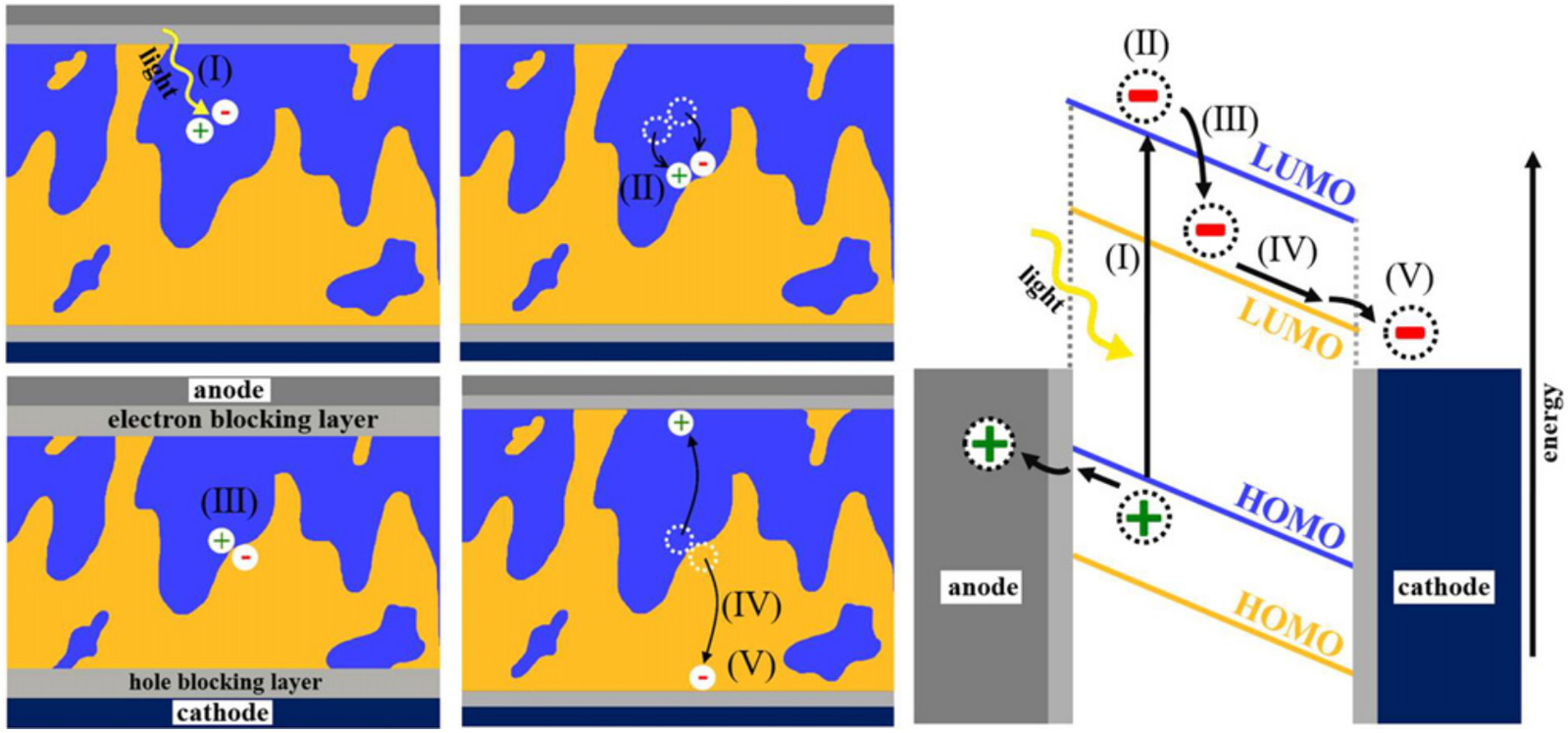
Reversible structural rearrangements on the nanoscale

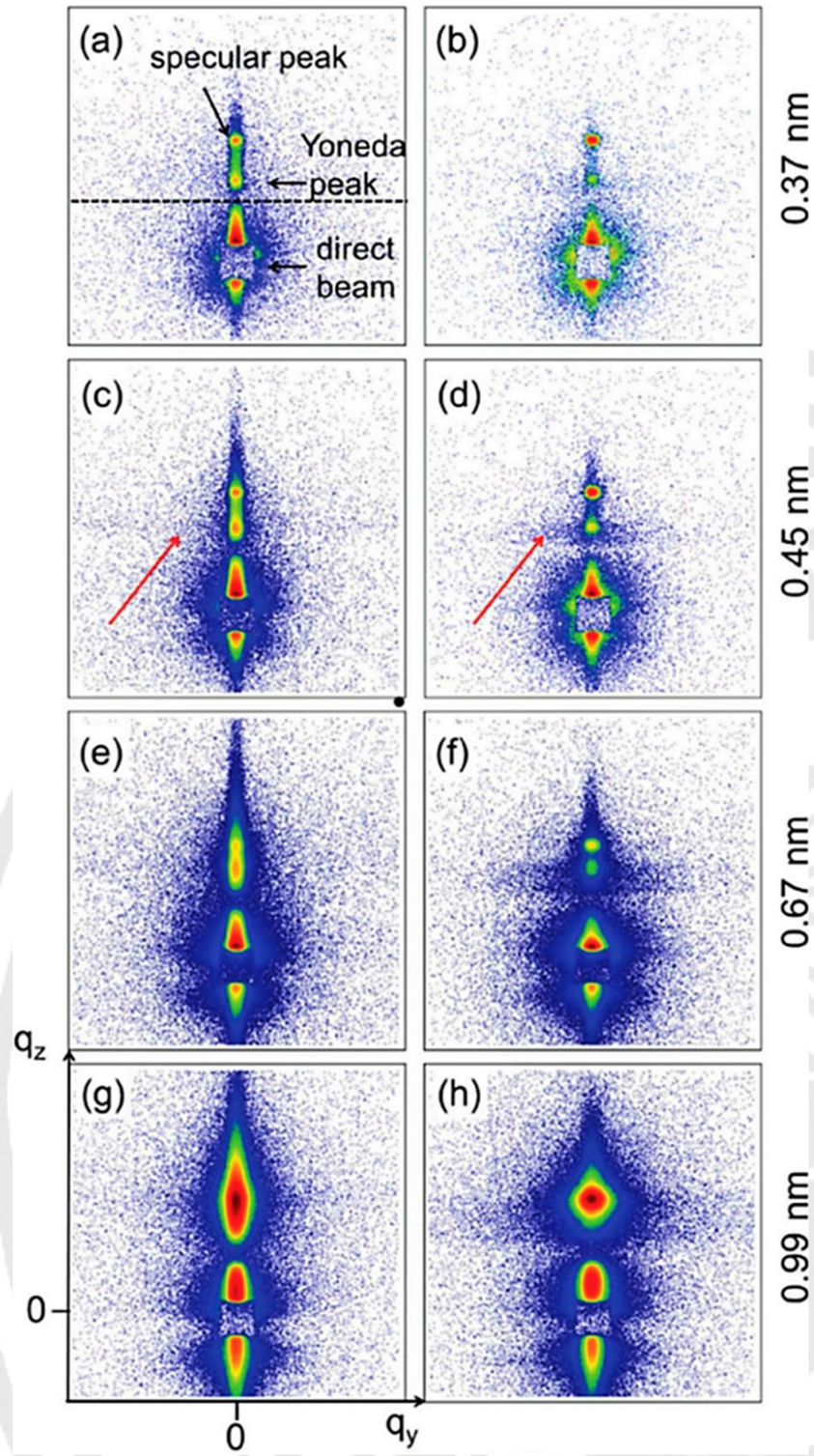
C. J. Brett, N. Mittal, W. Ohm, M. Gensch, L. P. Kreuzer, V. Körstgens, M. Månsson, H. Frielinghaus, P. Müller-Buschbaum, L. D. Söderberg, S. V. Roth.

Water-Induced Structural Rearrangements on the Nanoscale in Ultrathin Nanocellulose Films.

Macromolecules **52**, 4721-4728 (2019)

Solar cells - microphone separation





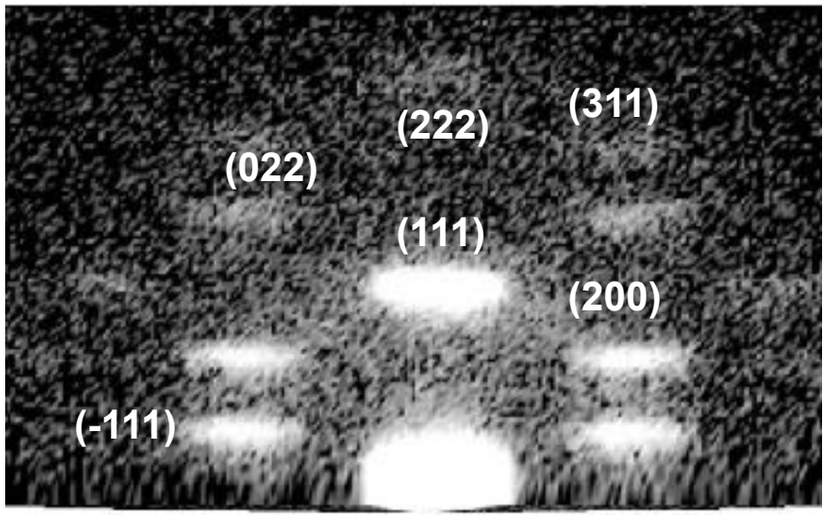
K. S. Wienhold, X. Jiang, and P. Müller-Buschbaum

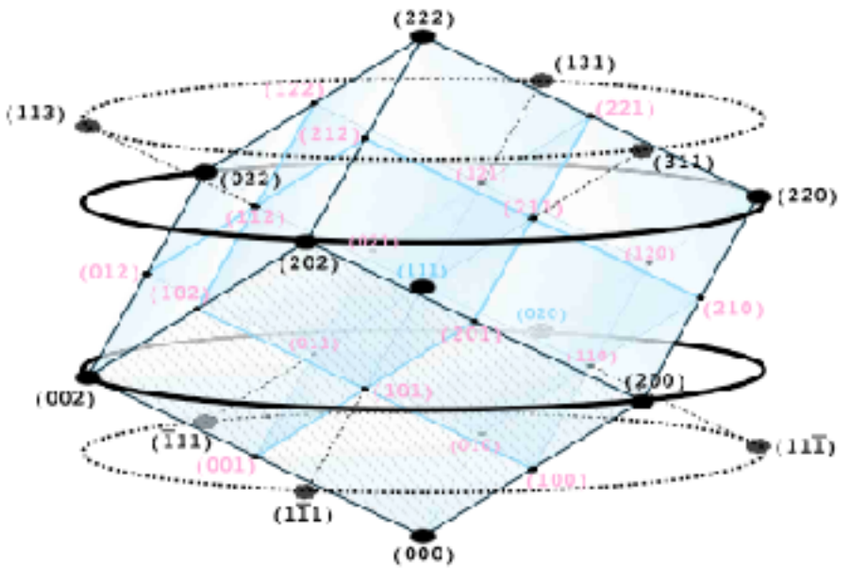
Organic solar cells probed with advanced neutron scattering techniques

Appl. Phys. Lett. **116**, 120504 (2020)

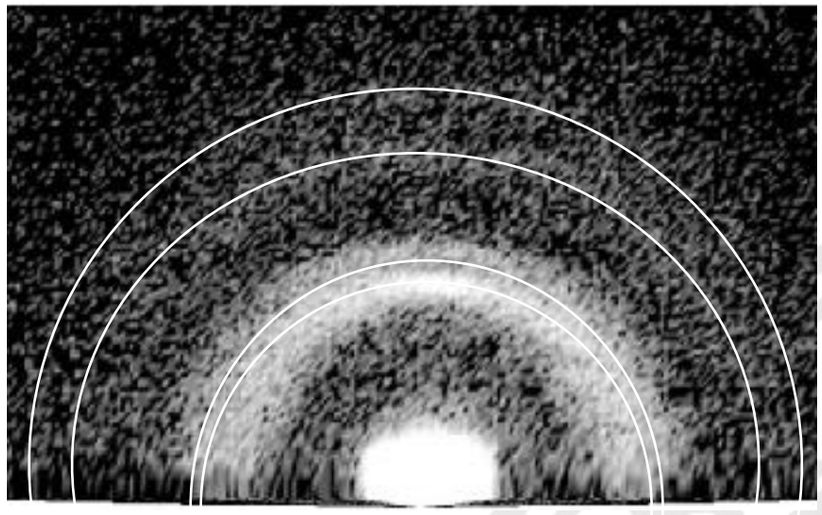
Micellar self assembly

Attractive interface



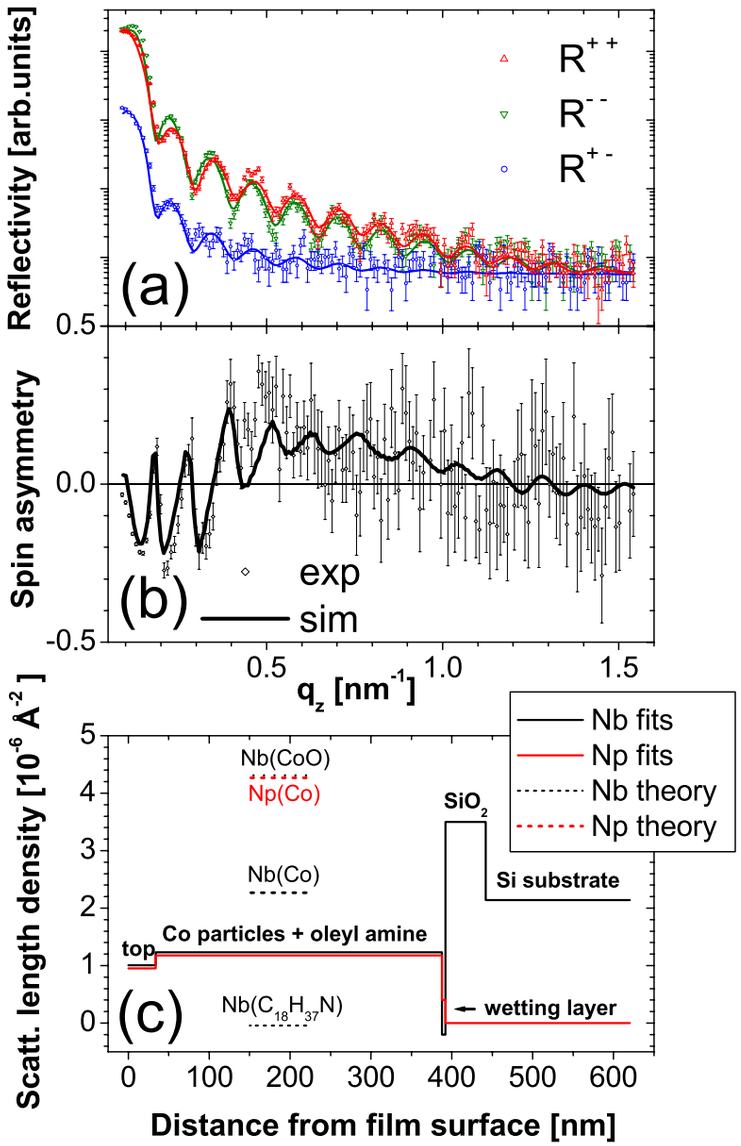


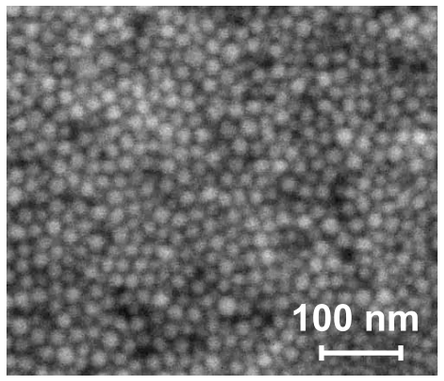
Repulsive interface

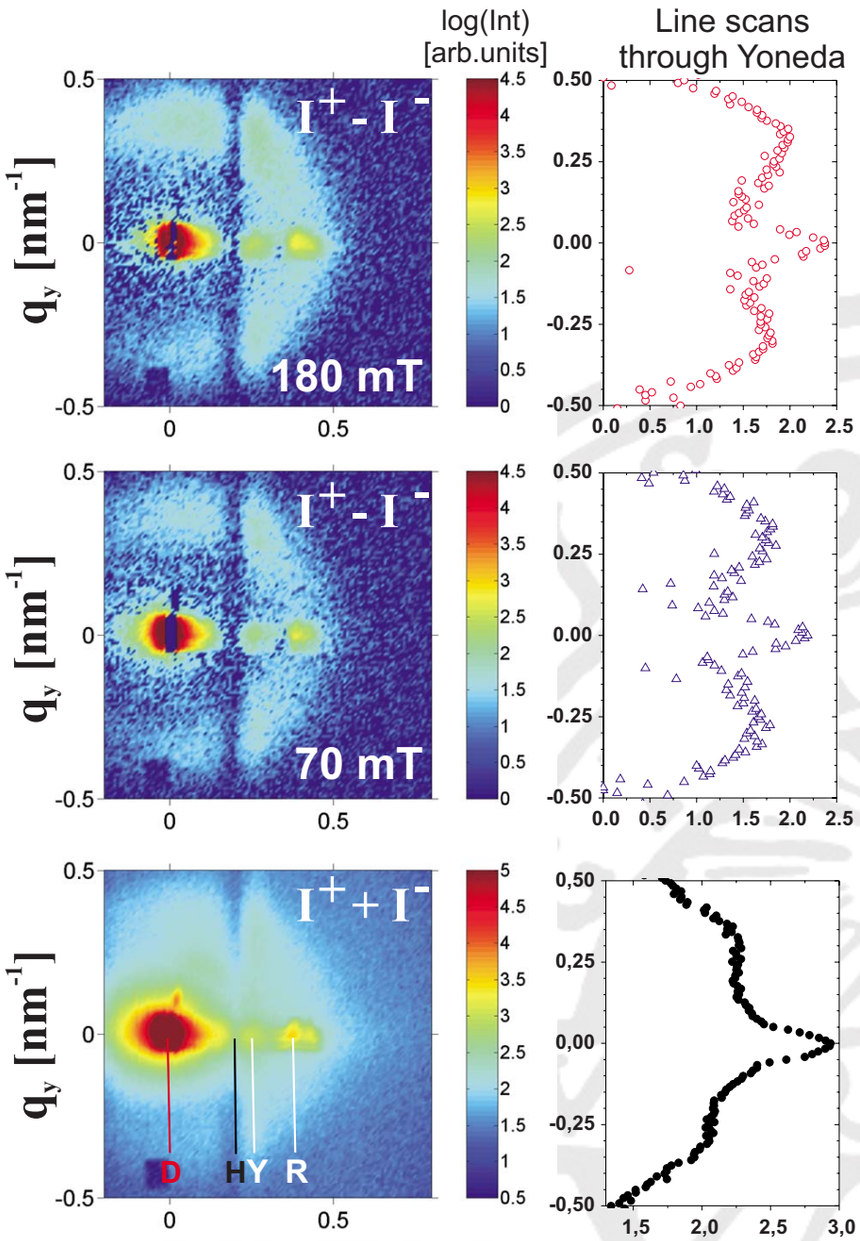


M. Wolff et al., Phys. Rev. Lett. **92**, 255501 (2004).

Magnetic colloids







Phys. Rev. B **78**, 134426 (2008)

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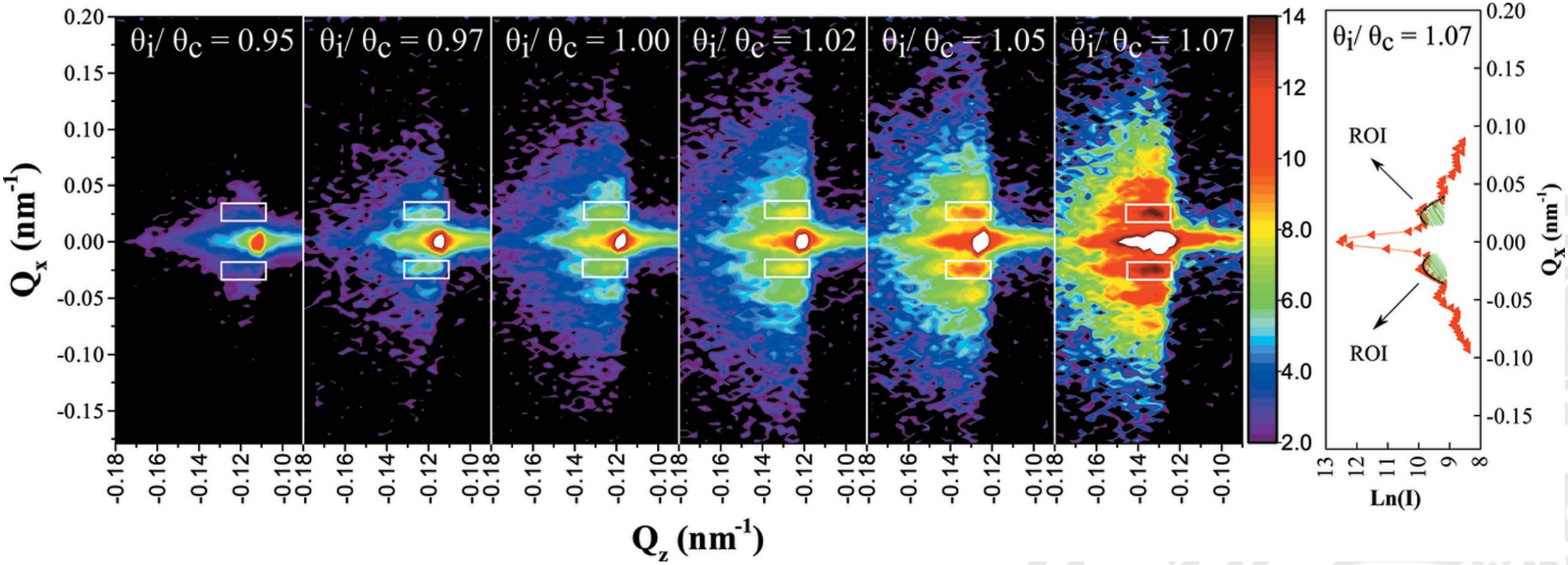
Colloidal self-assembly

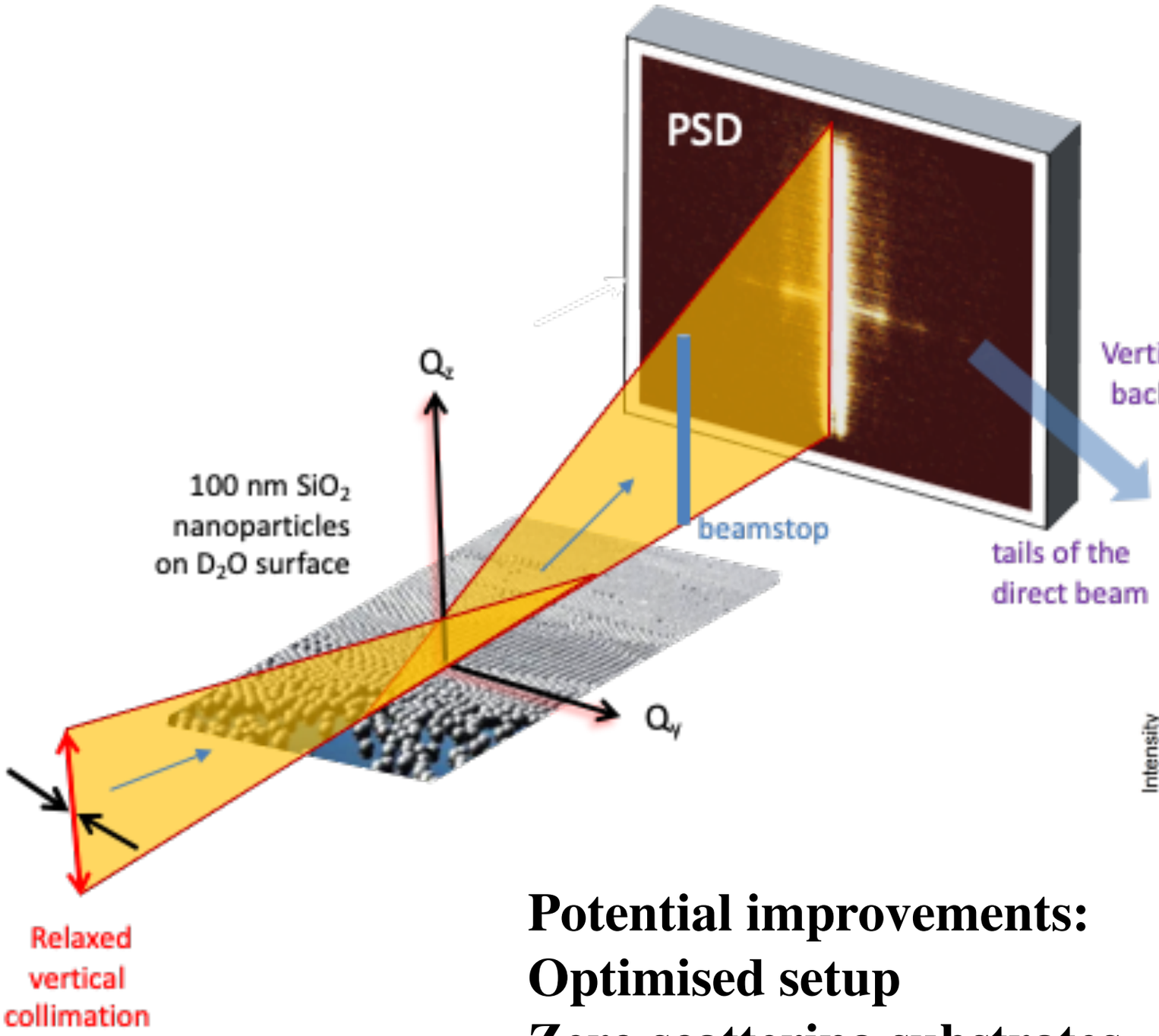


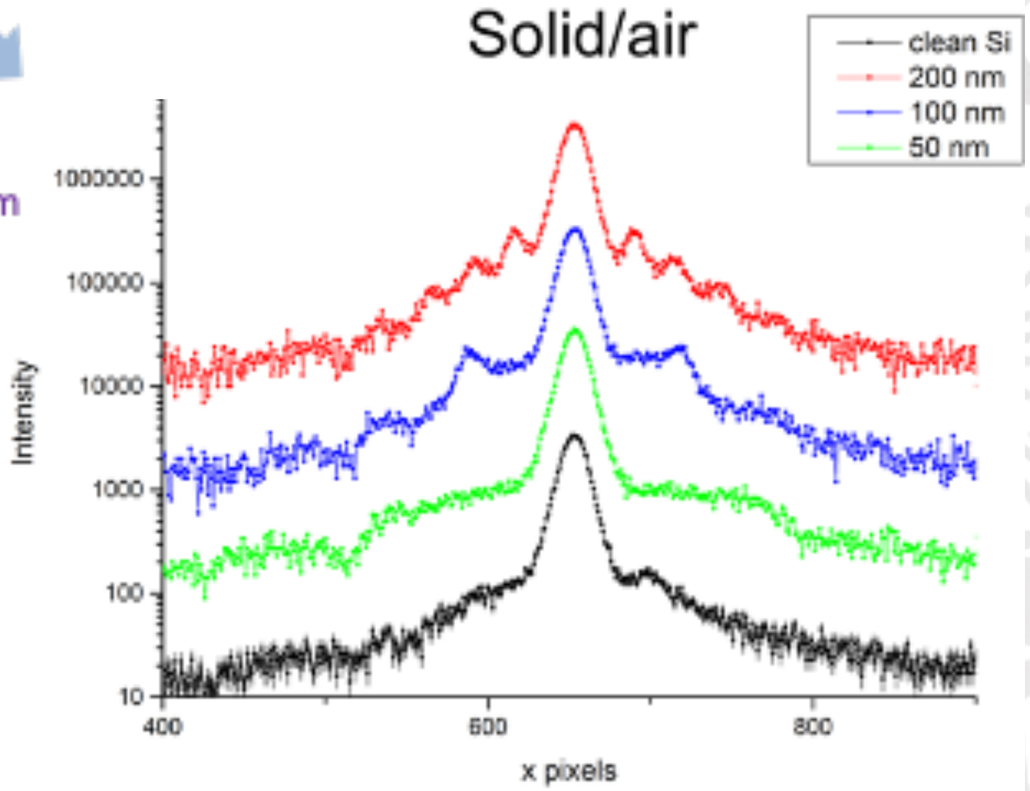
S. Nouhi, M. S. Hellsing, V. Kapaklis, A. R. Rennie

Grazing-incidence small-angle neutron scattering from structures below an interface

J. Appl. Cryst. (2017). 50, 1066–1074 (2017)

One dimensional GISANS

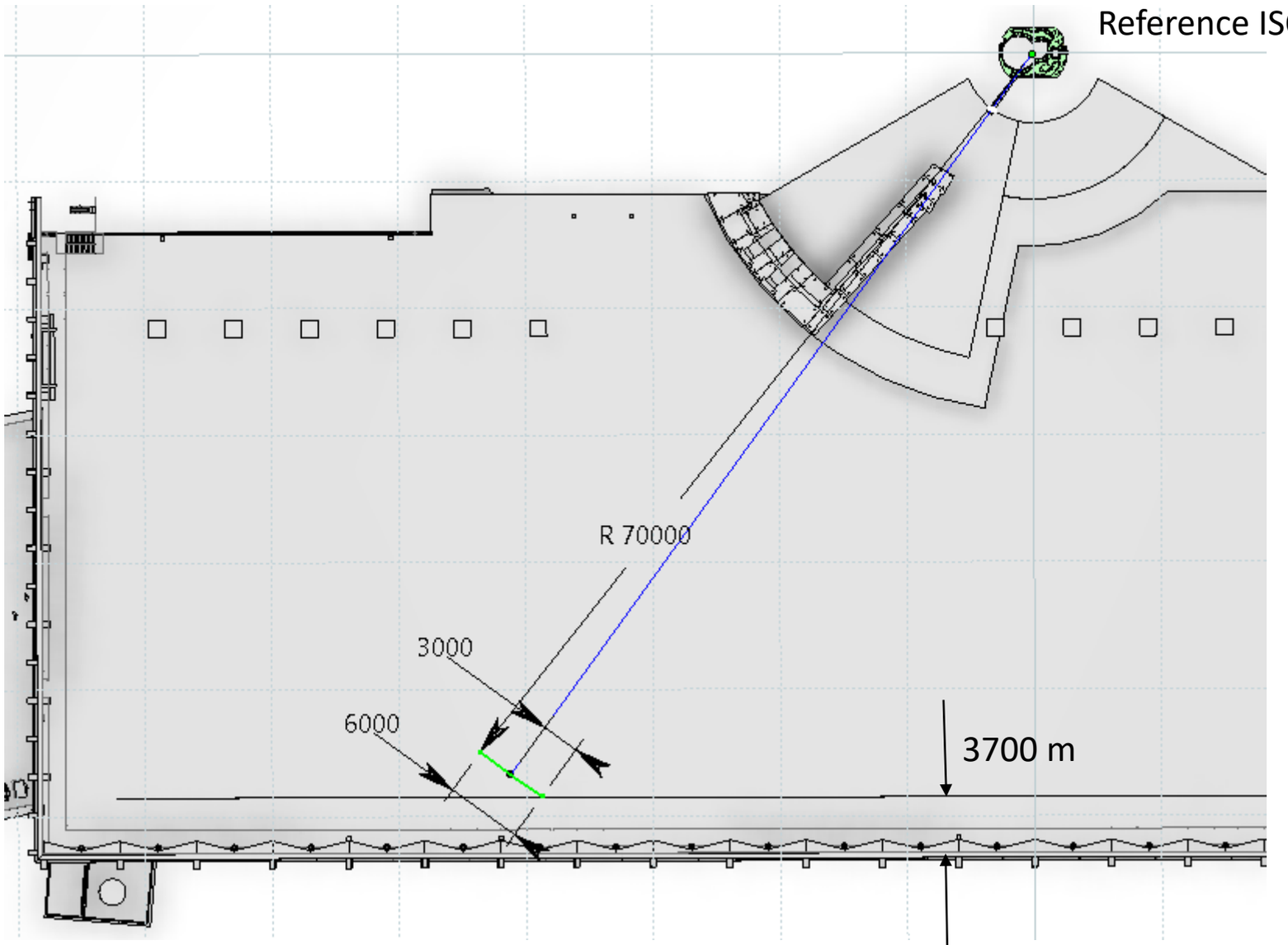




Potential improvements:
Optimised setup
Zero scattering substrates
Depth resolution, at least, challenging

Dedicated GISANS instrument SAGA

GISANS has been identified as capability gap of ESS
Opportunity for a dedicated GISANS instrument SAGA



High resolution instrument
Full brilliance of ESS

Beam port S5

Possible detector distance: 70m

6 Å minimum wavelength

Bandwidth: 4Å

Natural λ resolution: 2-3%

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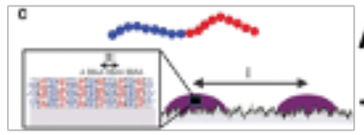
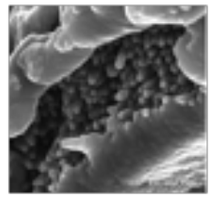
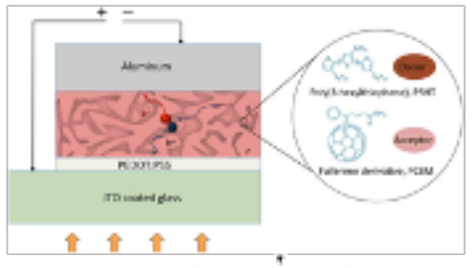
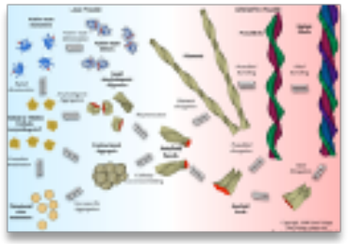
Unique opportunities for:

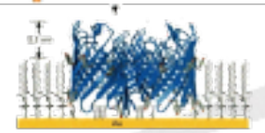


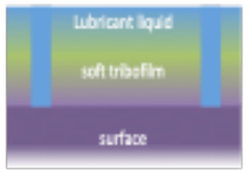
A Wide Range of Science involves
- gas, liquid, solid interfaces











Cell membranes

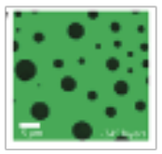
Organic Photovoltaics

Sustainable Biomaterials

Biosensors

Lubrication Tribology

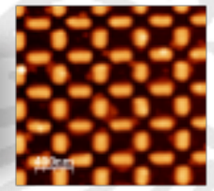
Ionic liquids



Surfactants & Polymers

Batteries and hydrogen storage

Drug delivery

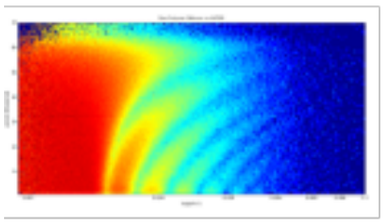


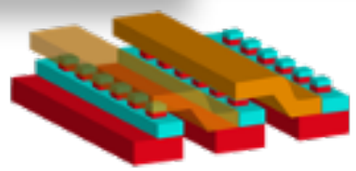
Magnetism & superconductivity

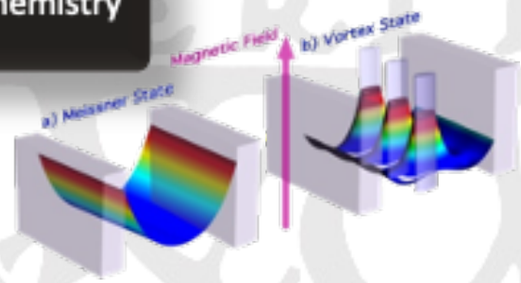
X-ray and neutron surface science

Inorganic templating

Electrochemistry





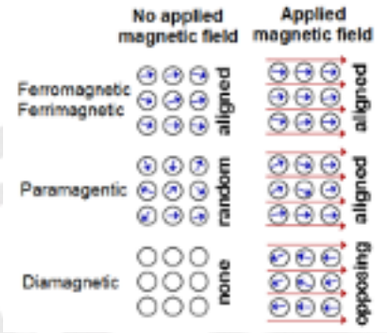


Provided by Hanna Wacklin Knecht, ESS

Summary

Instrumentation:

- Existing capabilities are limited/not optimised
- Ongoing developments:
  - One dimensional GISANS
  - Low background substrates
  - Resonance effects
- Opportunity for a **dedicated instrument (SAGA) @ ESS**



Opportunities for science (Sweden):

- Surfactant and lipid self-assembly
- Advanced polymer coatings
- Nanoparticle stability and deposition
- Materials science and energy
- Life sciences – food and medicine
- Hard condensed matter physics
- Quantum materials
- Magnetism