Mitglied der Helmholtz-Gemeinschaft

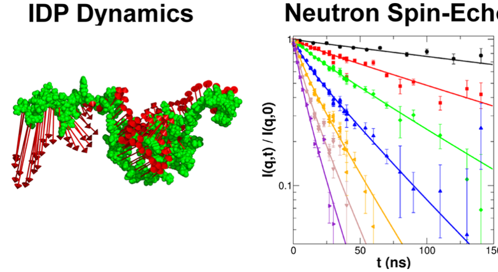
The neutron spin echo spectrometer J-NSE

July 2017 | Olaf Holderer

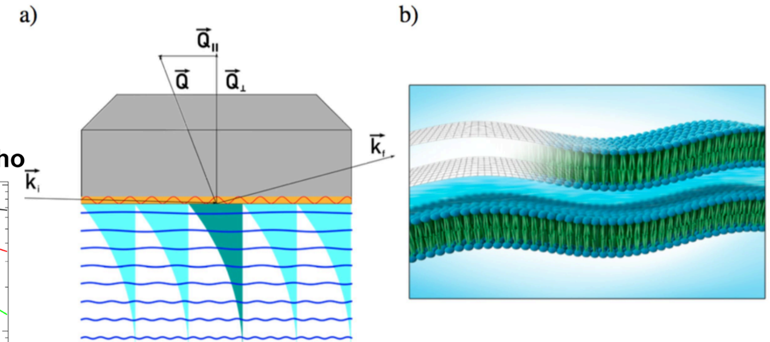
Examples of slow dynamics

https://de.wikipedia.org/wiki/Antikörper
Julian Voss-Andreae Angel of the West, 2008 Height 12' (3.70 m)
Stainless steel Location:
The Scripps Research Institute Florida

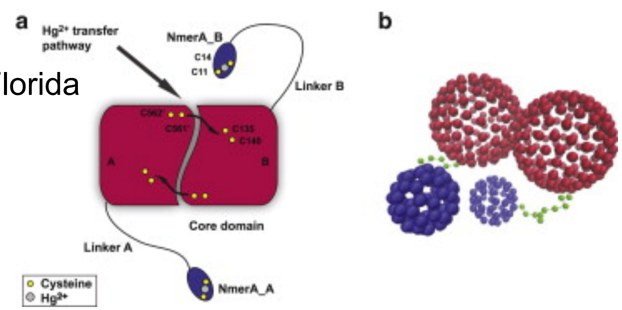
Immunoglobuline and NSE:
→ L. Stingaciu et al.,
Scientific Reports (2016)



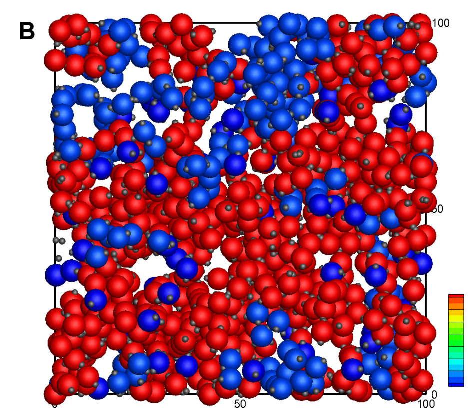
A. Stadler et al., JACS (2015)



S. Jaksch et al., Scientific Reports (2017)



L. Hong et al., Biophysical Journal 2014
https://doi.org/10.1016/j.bpj.2014.06.013

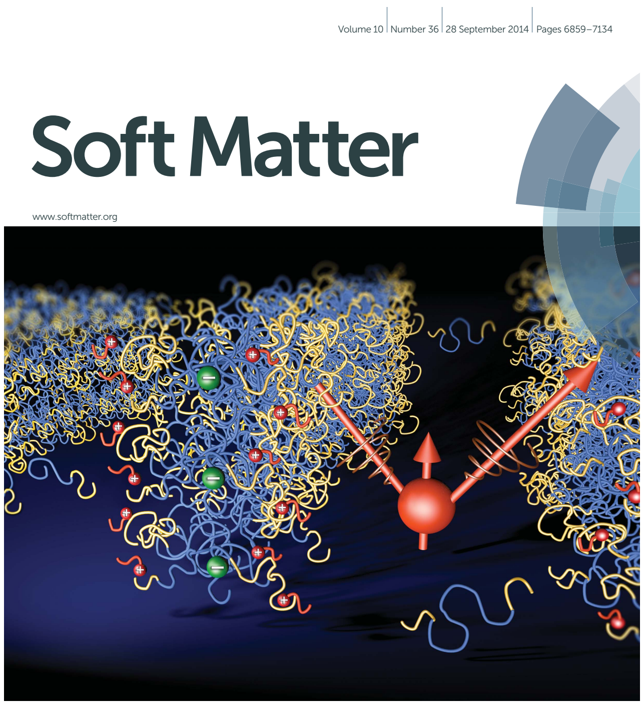


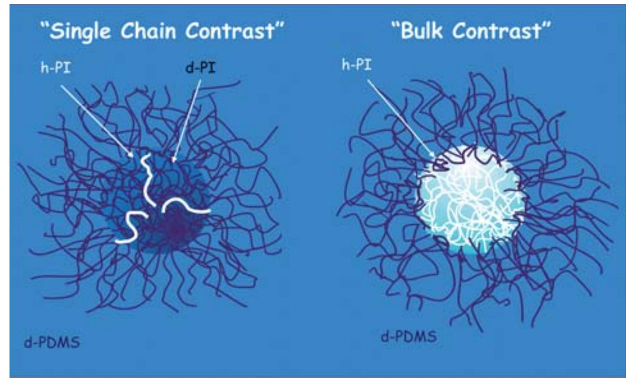
S. Bucciarelli et al., Science Advances (2016)

Jülich Centre for Neutron Science

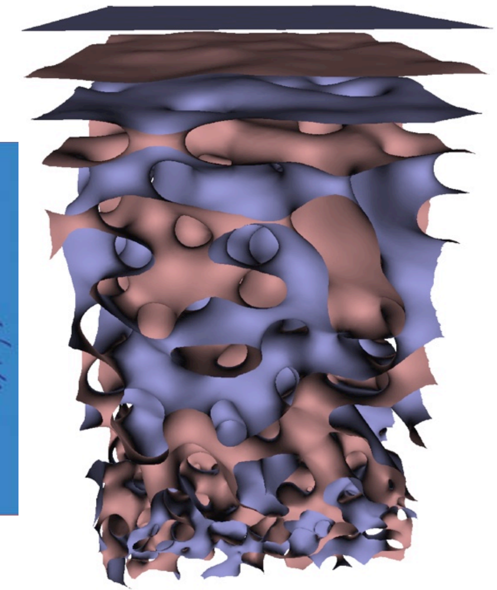
JÜLICH FORSCHUNGSZENTRUM

Examples of slow dynamics





L. Willner, et al., Soft Matter (2010)



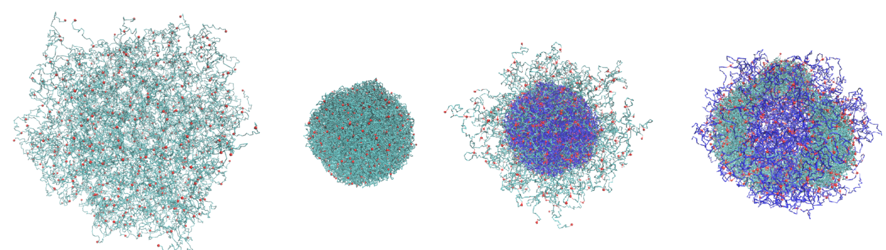
Kerscher M. et al., Phys. Rev. E (2011)

CrossMark

Cite this: *Soft Matter*, 2014, **10**, 6926

Bending elastic properties of a block copolymer-rich lamellar phase doped by a surfactant: a neutron spin-echo study†

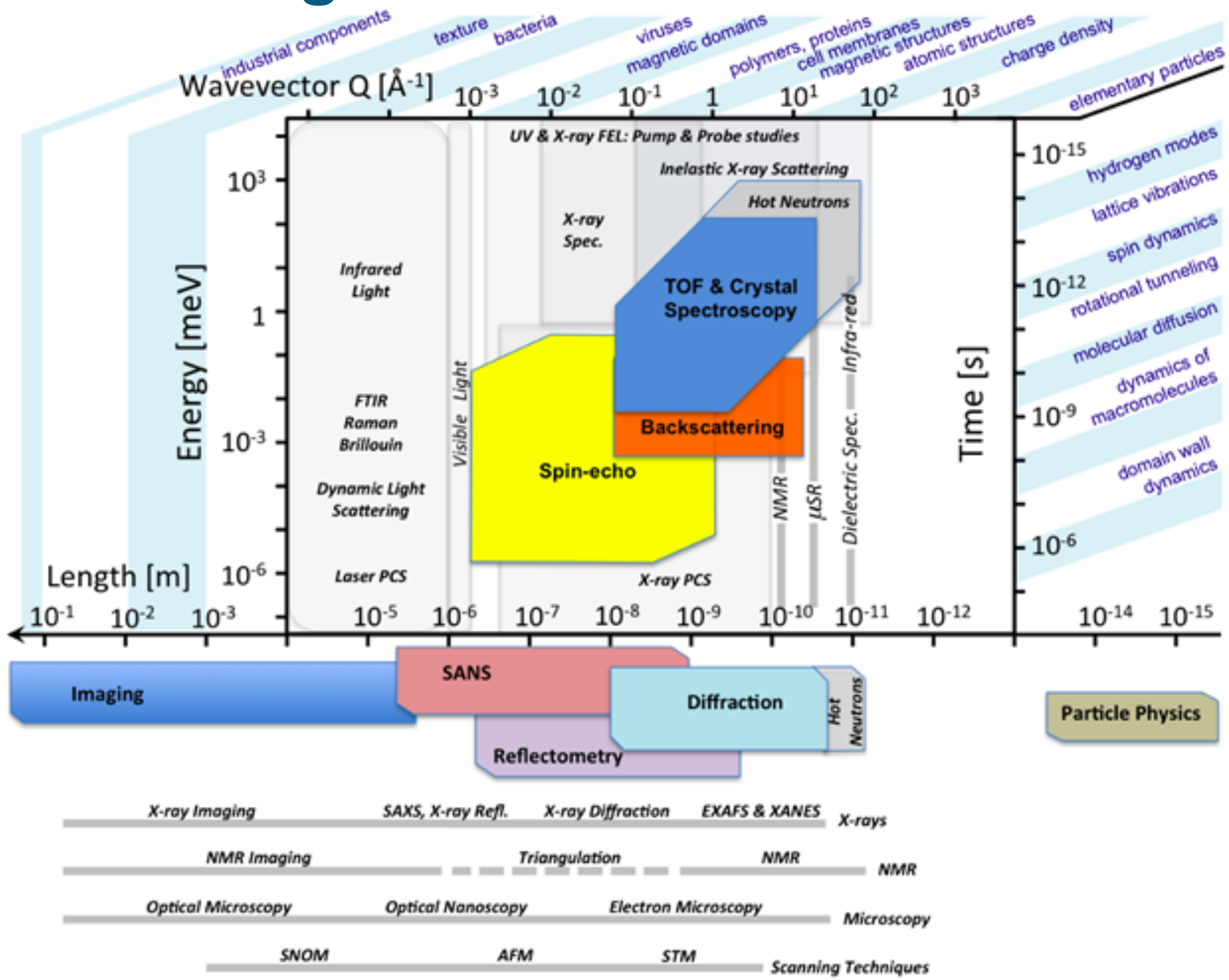
H. Egger,‡[a] G. H. Findenegg,*[a] O. Holderer,[b] R. Biehl,[c] M. Monkenbusch[c] and T. Hellweg*[d]



Swollen | Collapsed | Collapsed-core-swollen-shell | Swollen-core-collapsed-shell

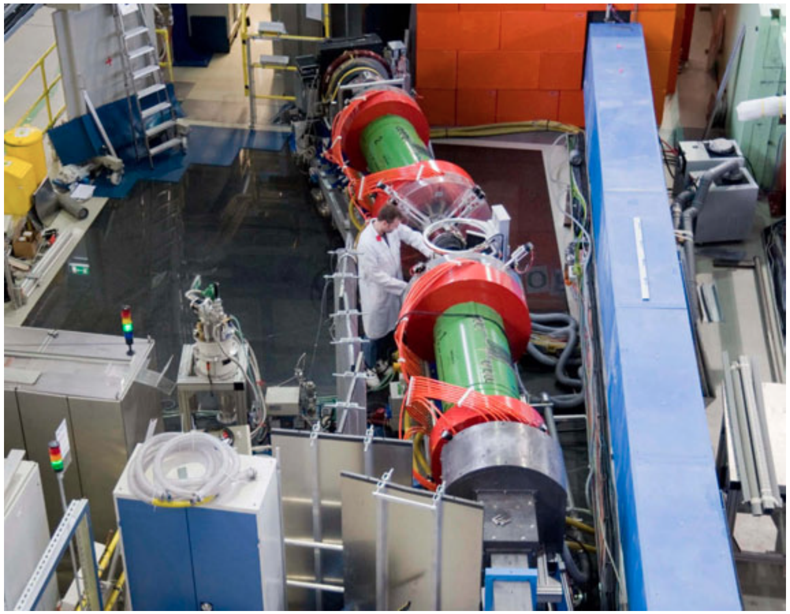
S. Maccarrone et al., Macromolecules (2016)

Time- and lengthscales

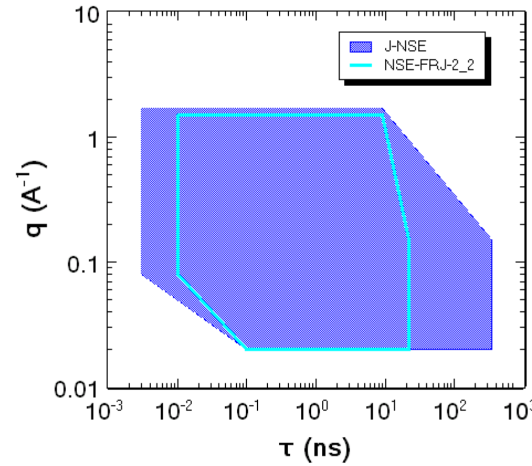


http://europeanspallationsource.se/feature-series-ess-instrument-suite

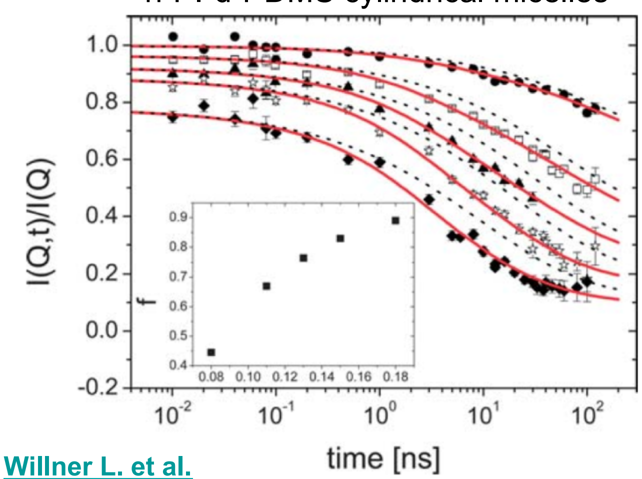
Instrument State of the Art

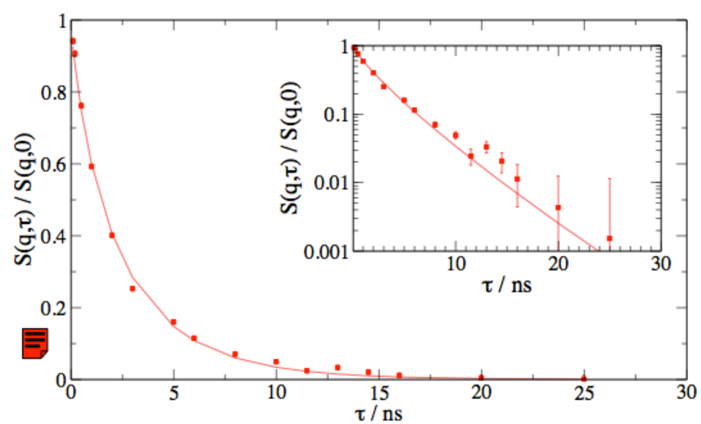


- High stability
- Low background
- Large dynamic range (more than 4 decades)



h-PI-d-PDMS cylindrical micelles



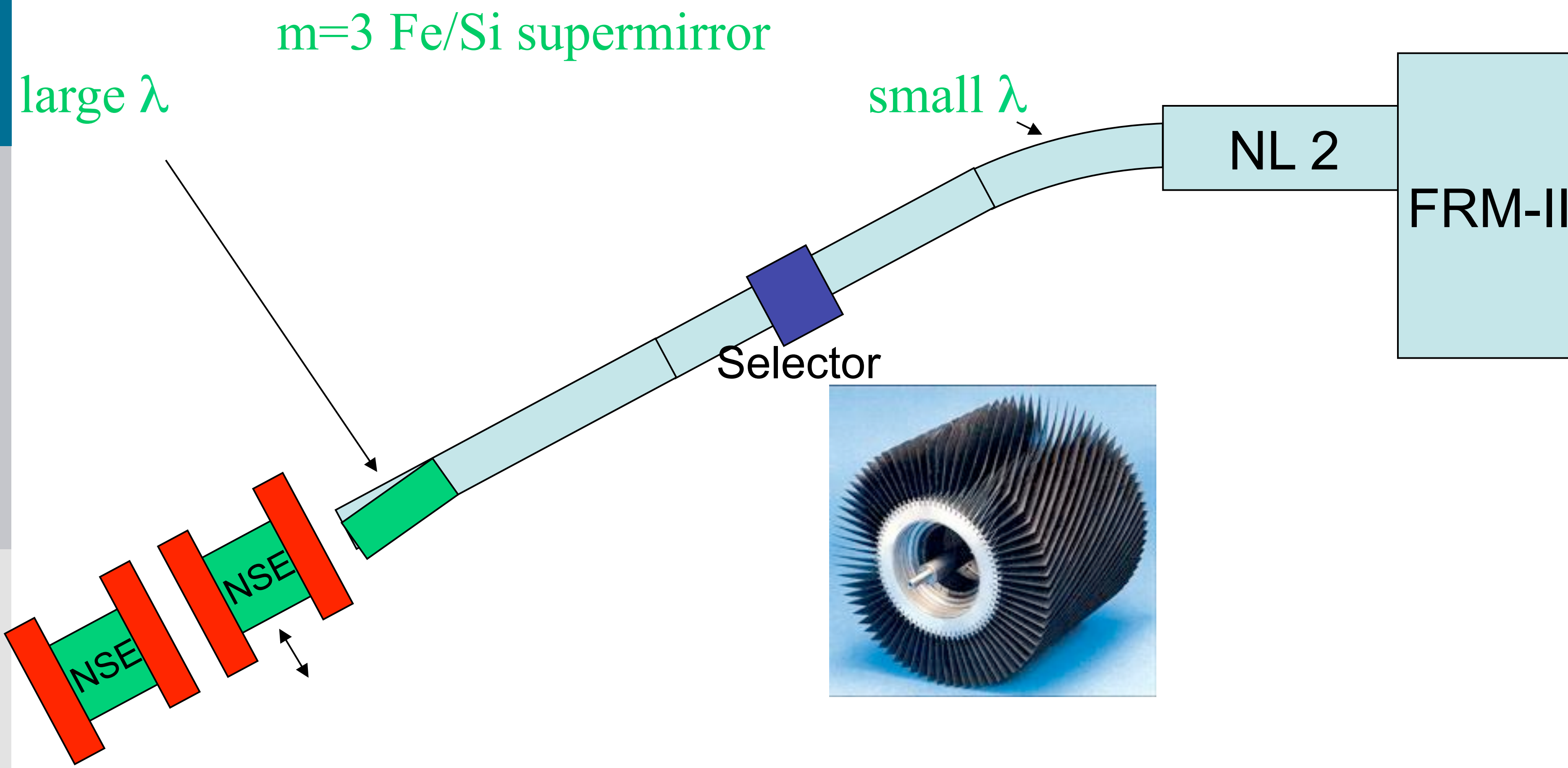


Polymer in solution (PEP in d-decane)

Willner L. et al. Soft Matter (2010)

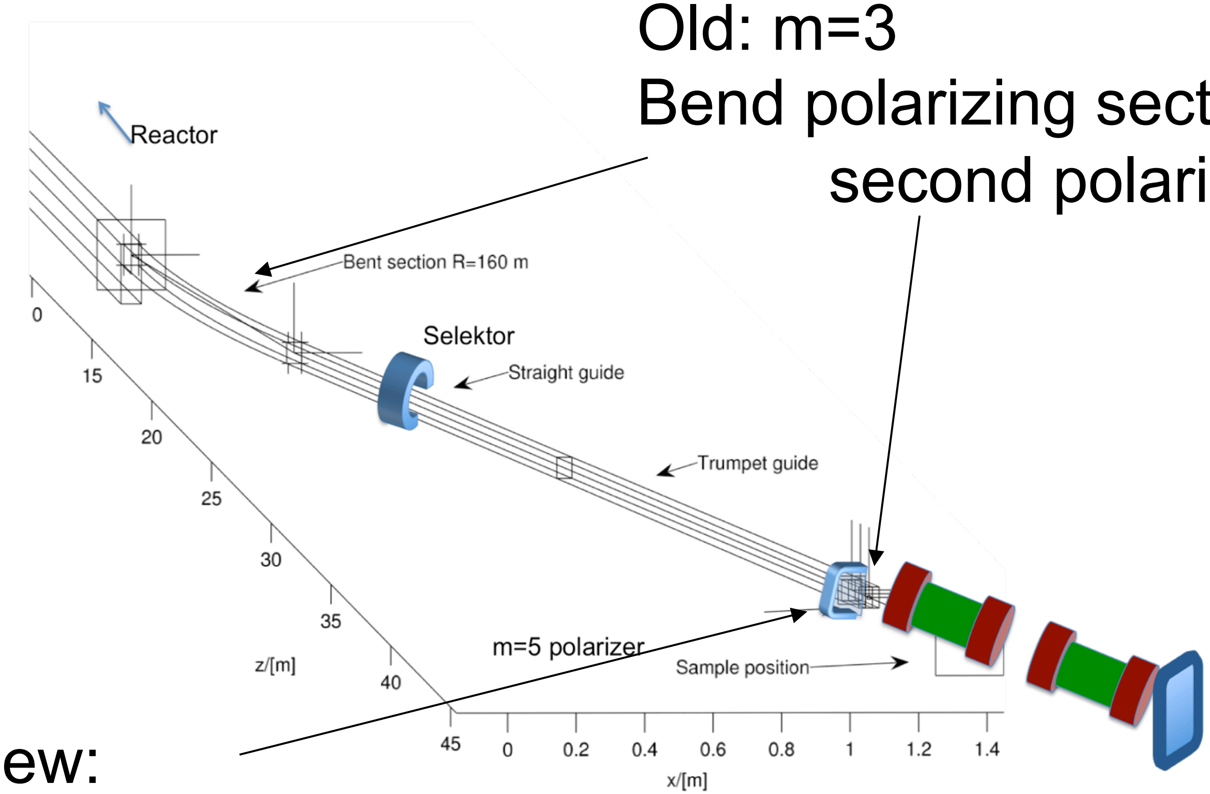
Häußler W. et al. Neutron News (2011)

Neutron Guide System schematically



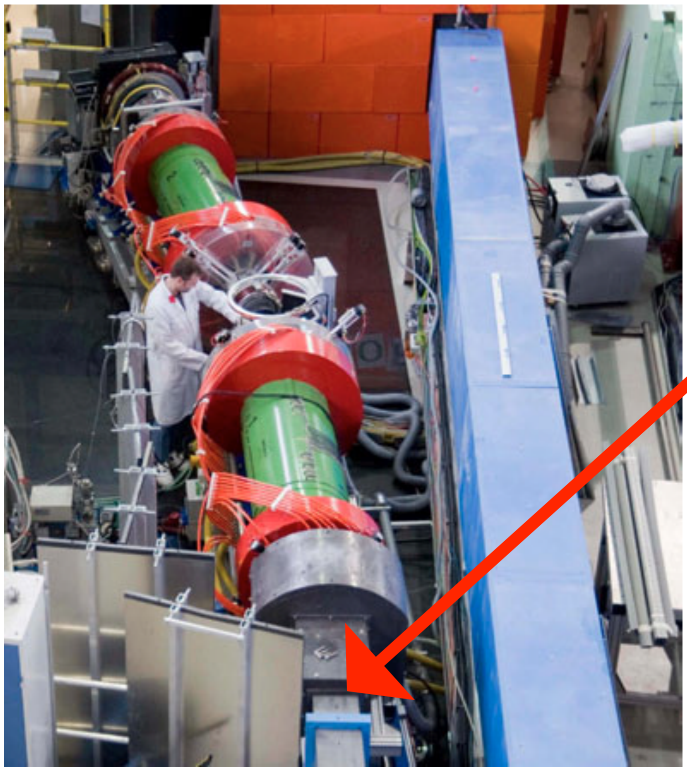
J-NSE: Polarization

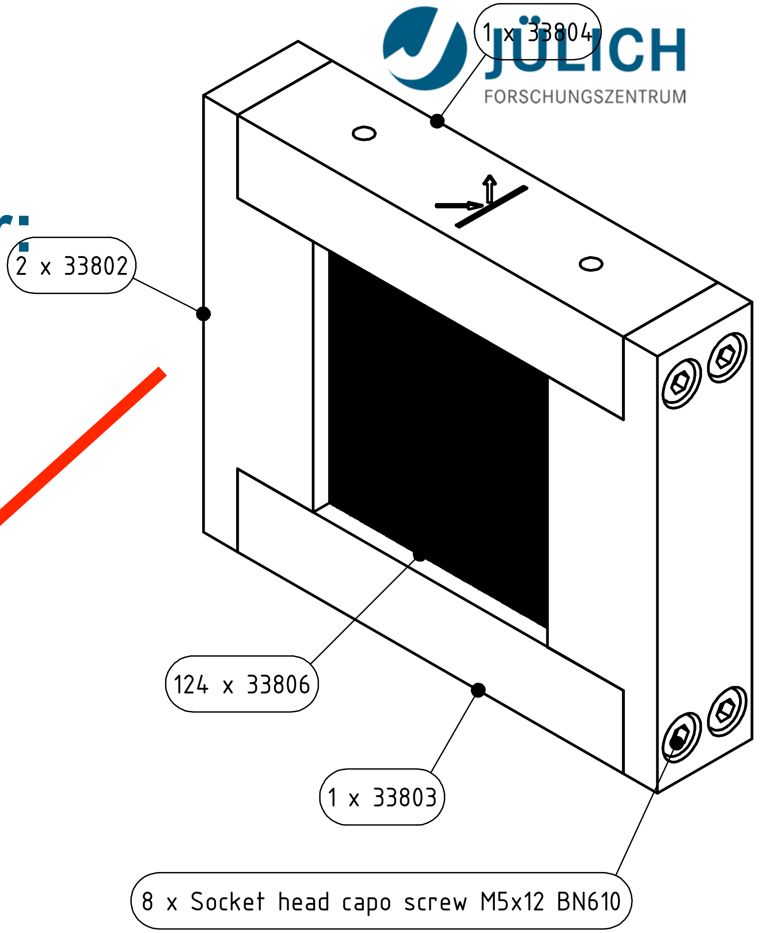
Old: m=3
Bend polarizing section (λ<8Å)
second polarizer (λ>8Å)



New:
Only 1 m=5 polarizer for all λ (5Å<λ<17Å)

New all wavelength polarizer:





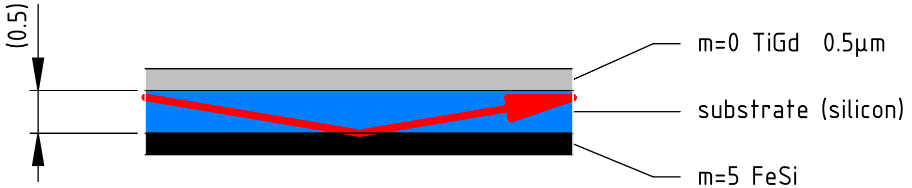
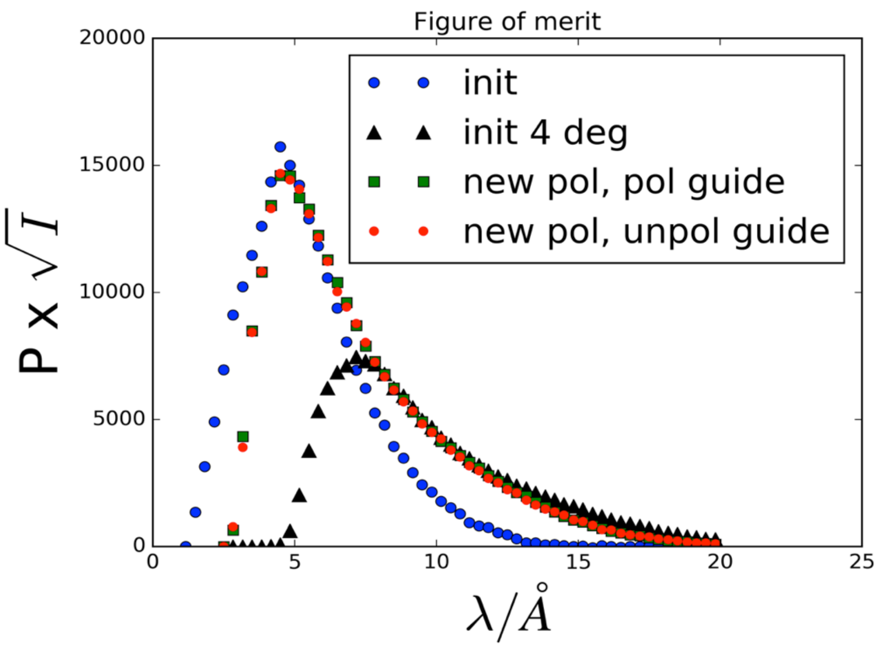


Figure of merit



Old config:

J-NSE has been rotated by 4°for λ>8Å → single reflection at second polarizer

New:

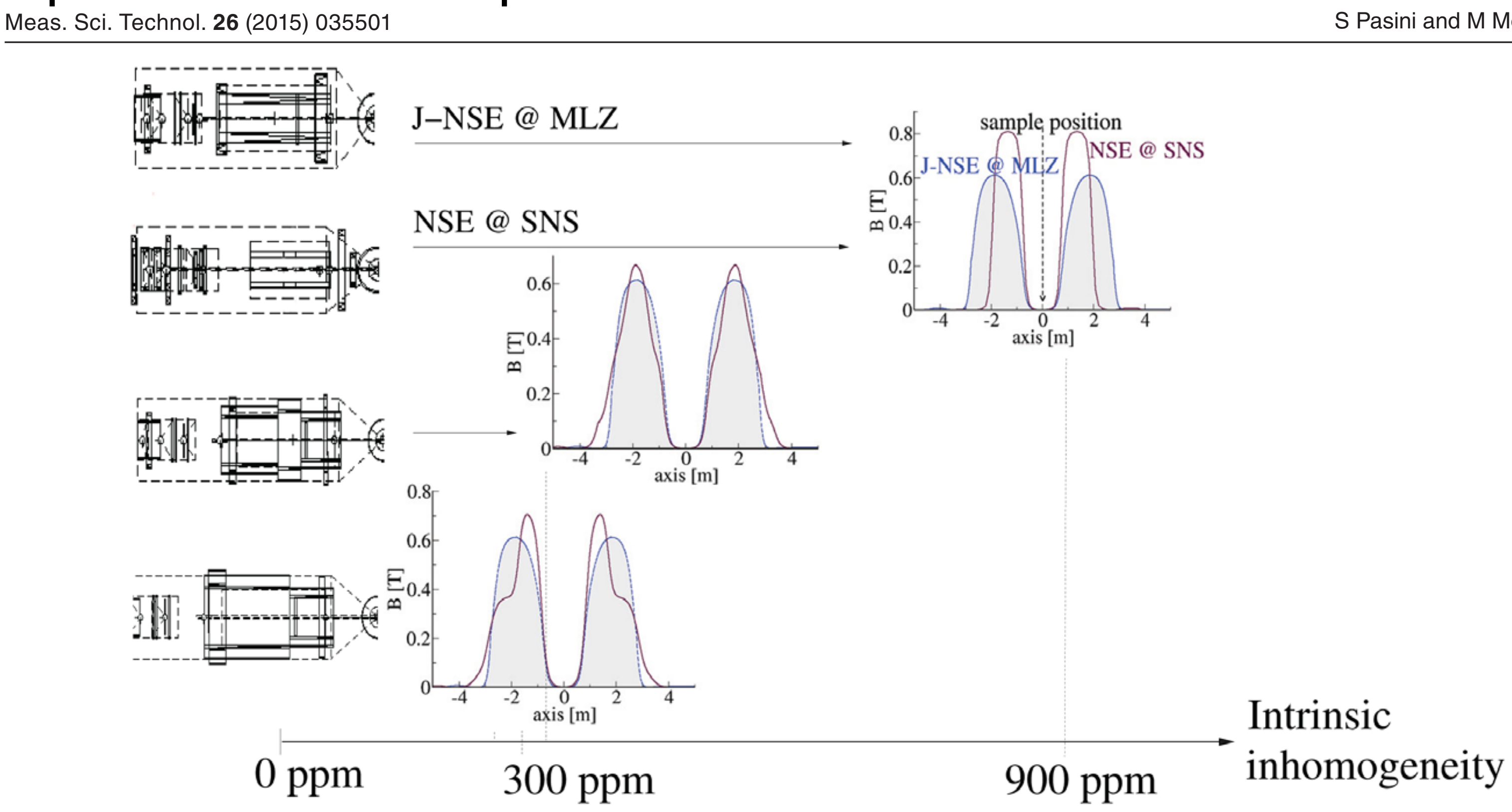
Same instrument setting for all λ.

→ Easier handling

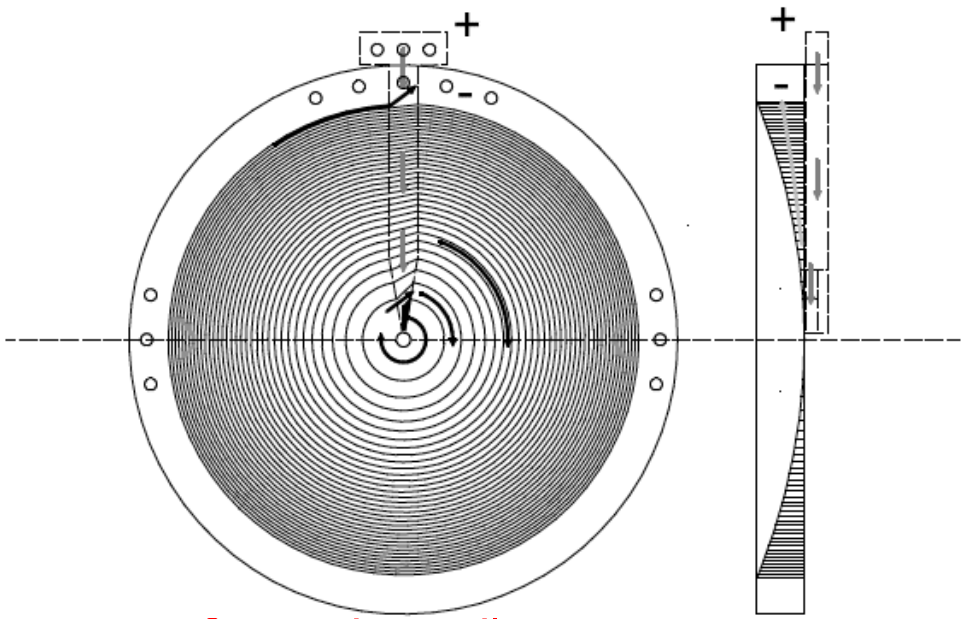
→ Slightly better FOM around main wavelengt (λ=8Å)

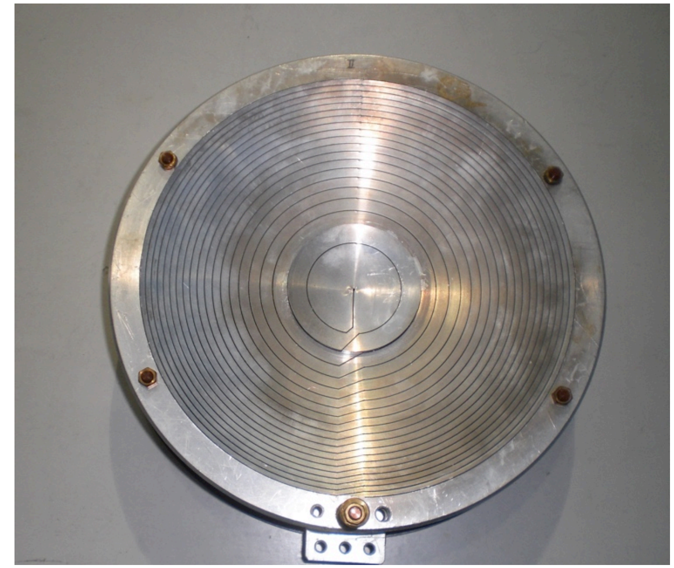
J-NSE upgrade 2017 → S. Pasini

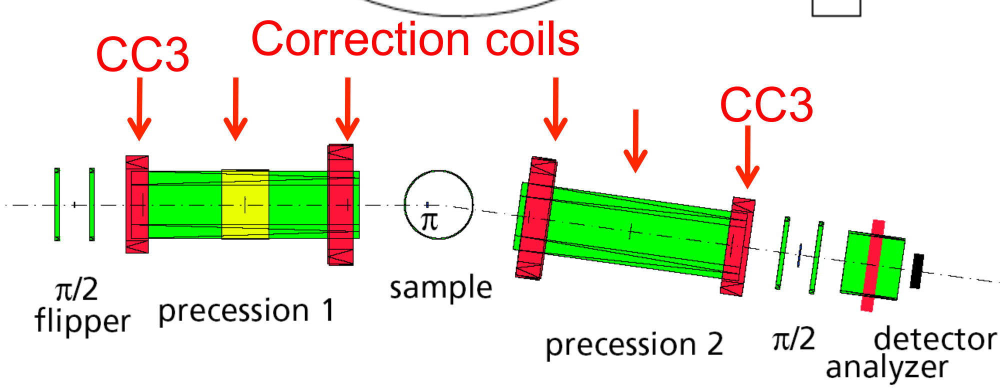
Optimized field shape coils

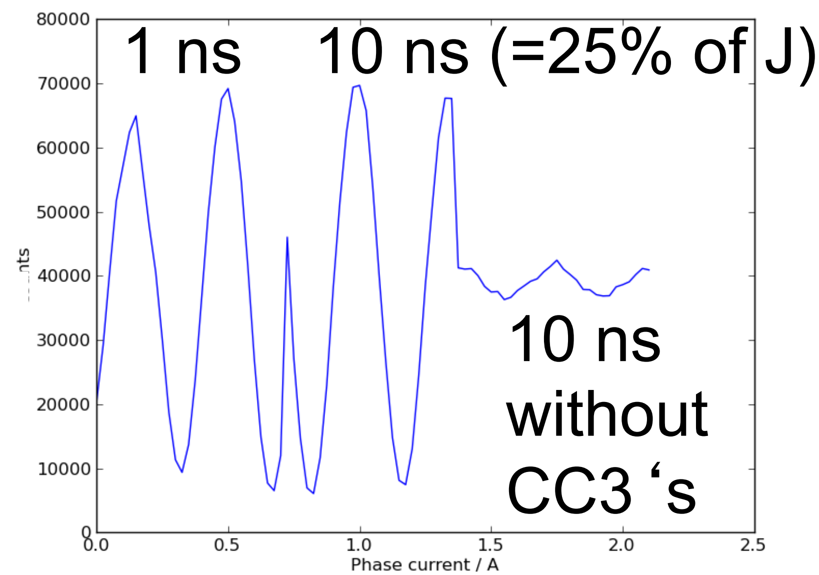


Required homogeneity

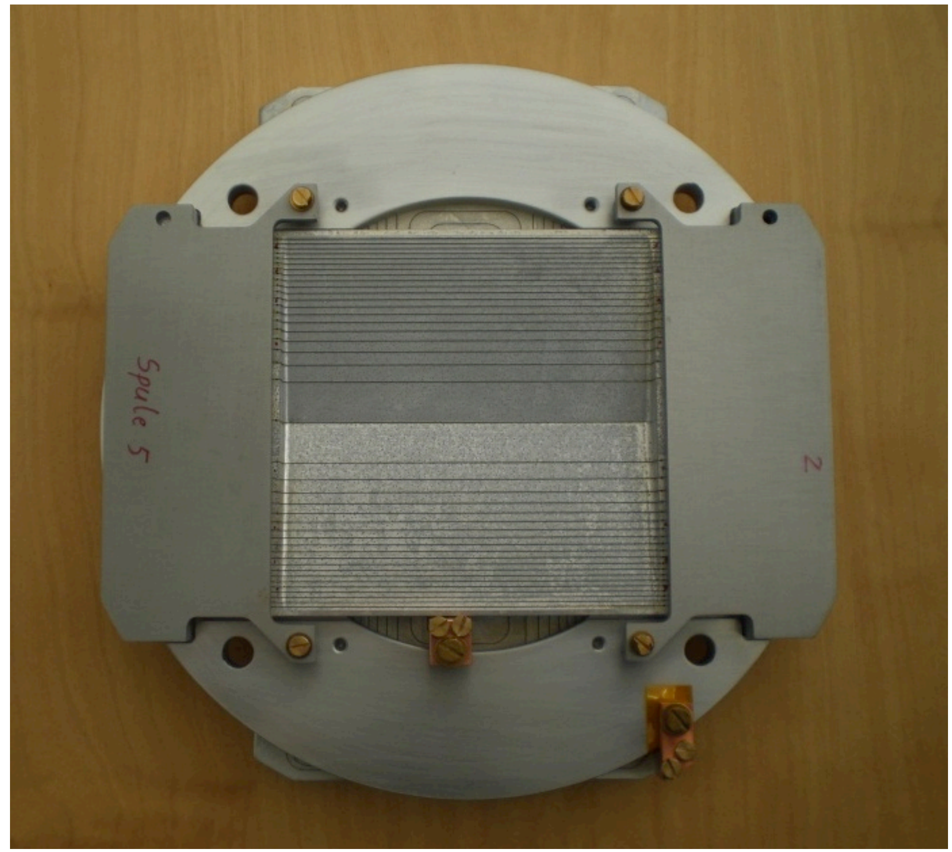






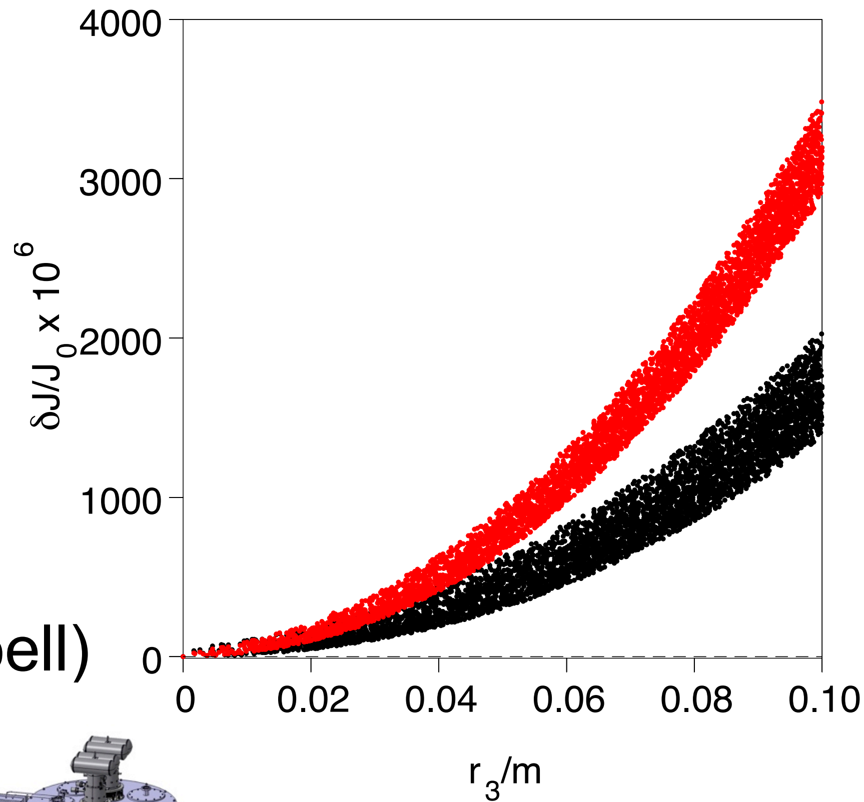


Correction Coils

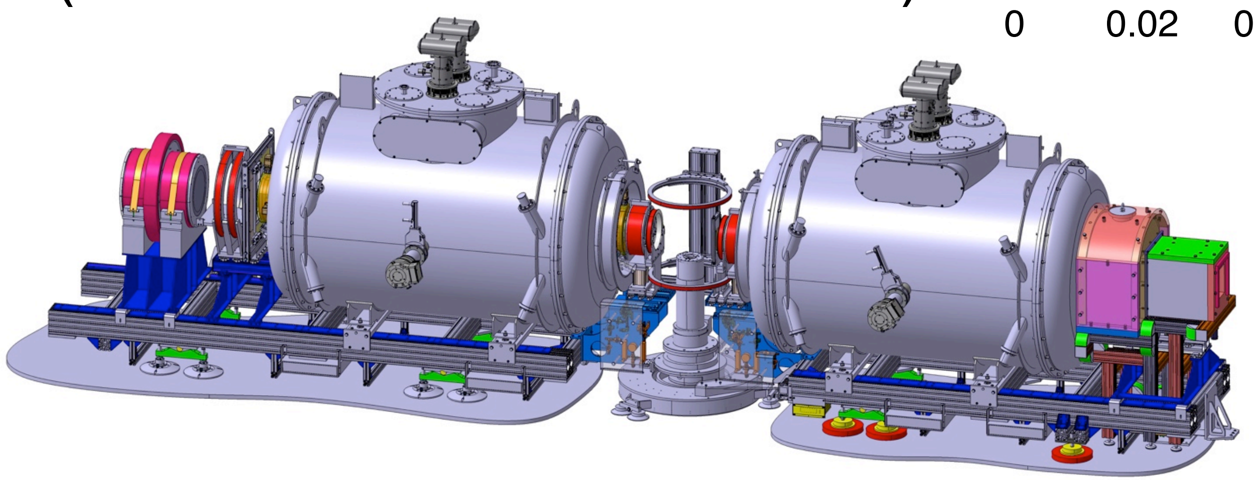


The upgrade

- Optimized field shape
  → Stefano Pasini



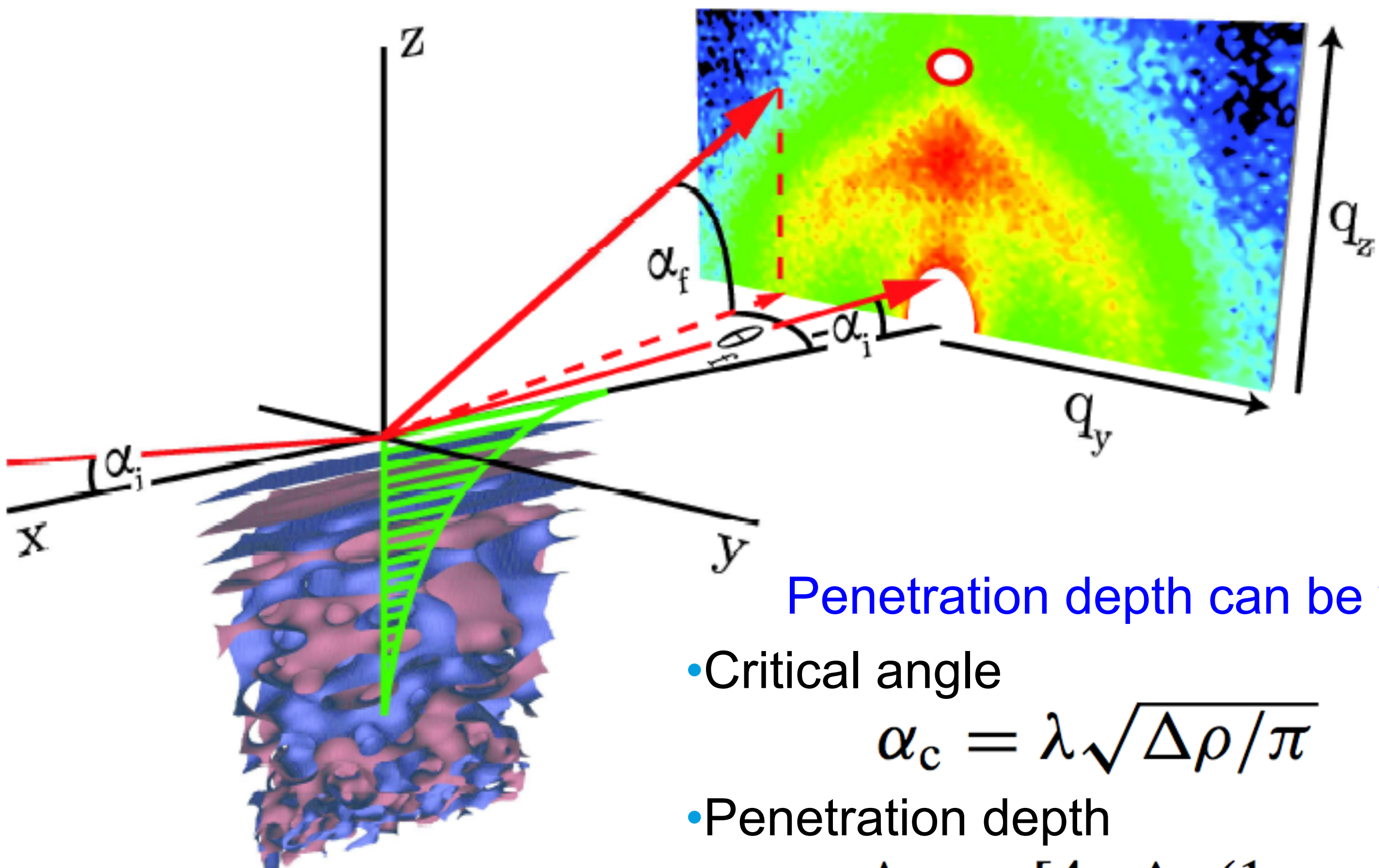
- Superconducting coils
  (Manufacturer: Babcock Noell)



J-NSE science example:
The „hidden“ interface dynamics

- Solid liquid interface
- Difficult to access: Advantage of neutrons
- Structure GISANS
- Dynamics? Modified by rigid boundary condition?
- → intensity issue

Scattering geometry



Penetration depth can be varied:

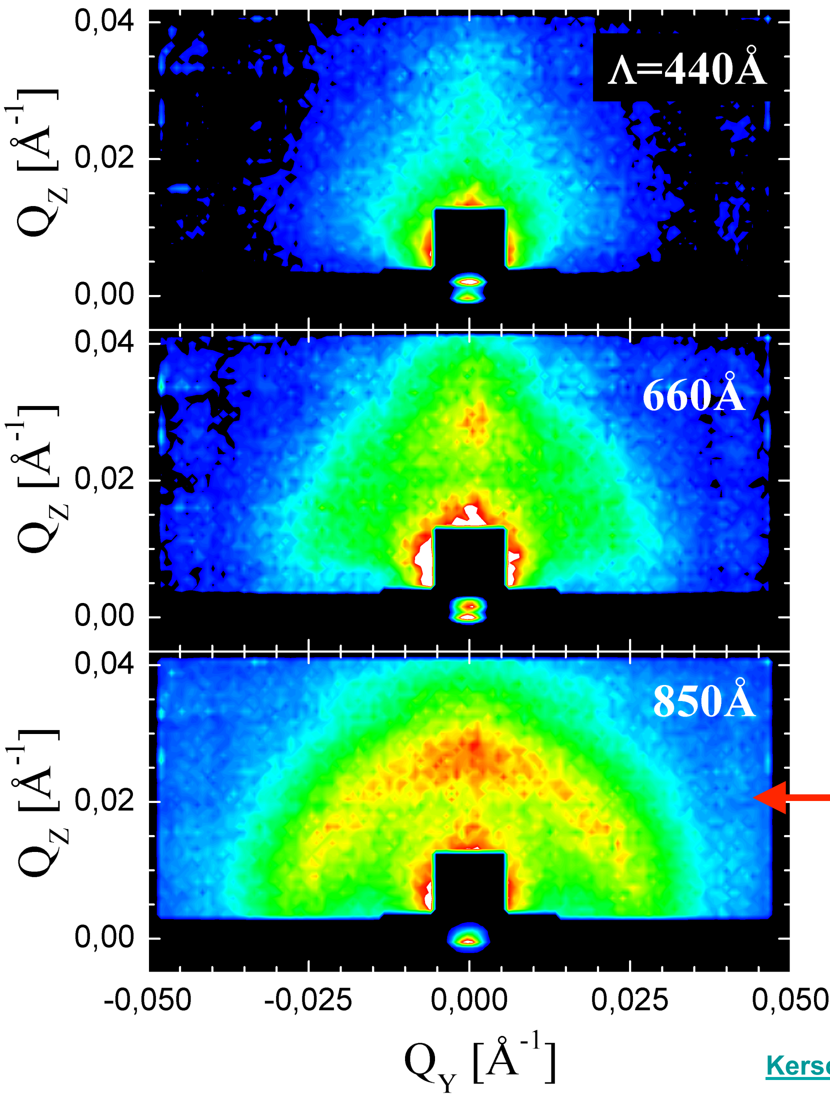
- Critical angle

$$\alpha_c = \lambda\sqrt{\Delta\rho/\pi}$$

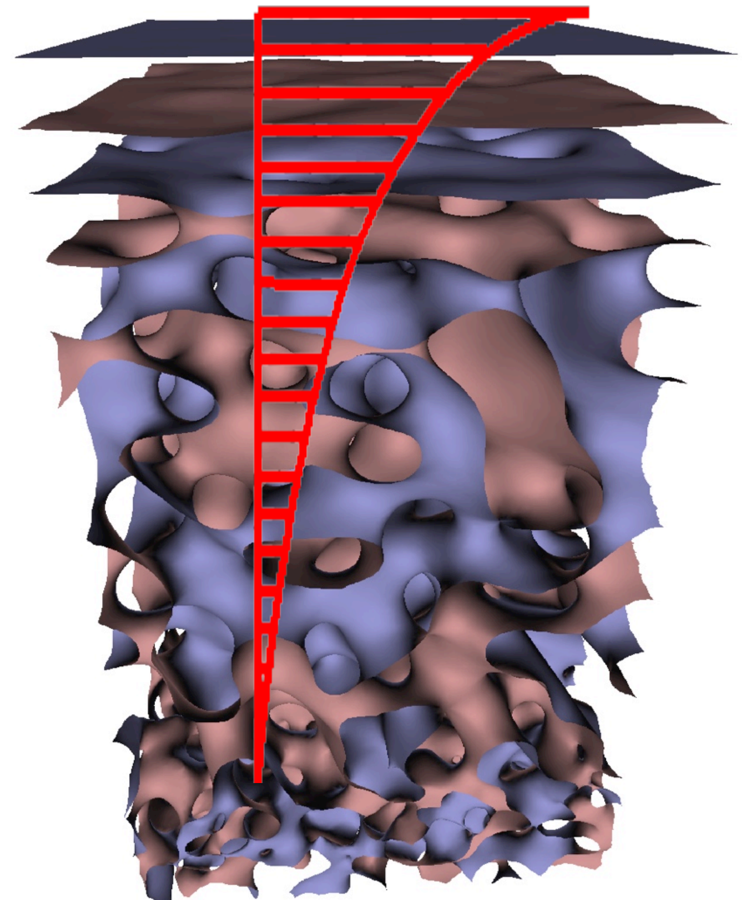
- Penetration depth

$$\Lambda_{in} = [4\pi\,\Delta\rho(1-\alpha_{in}^2/\alpha_c^2)]^{-1/2}$$

Structure: GISANS

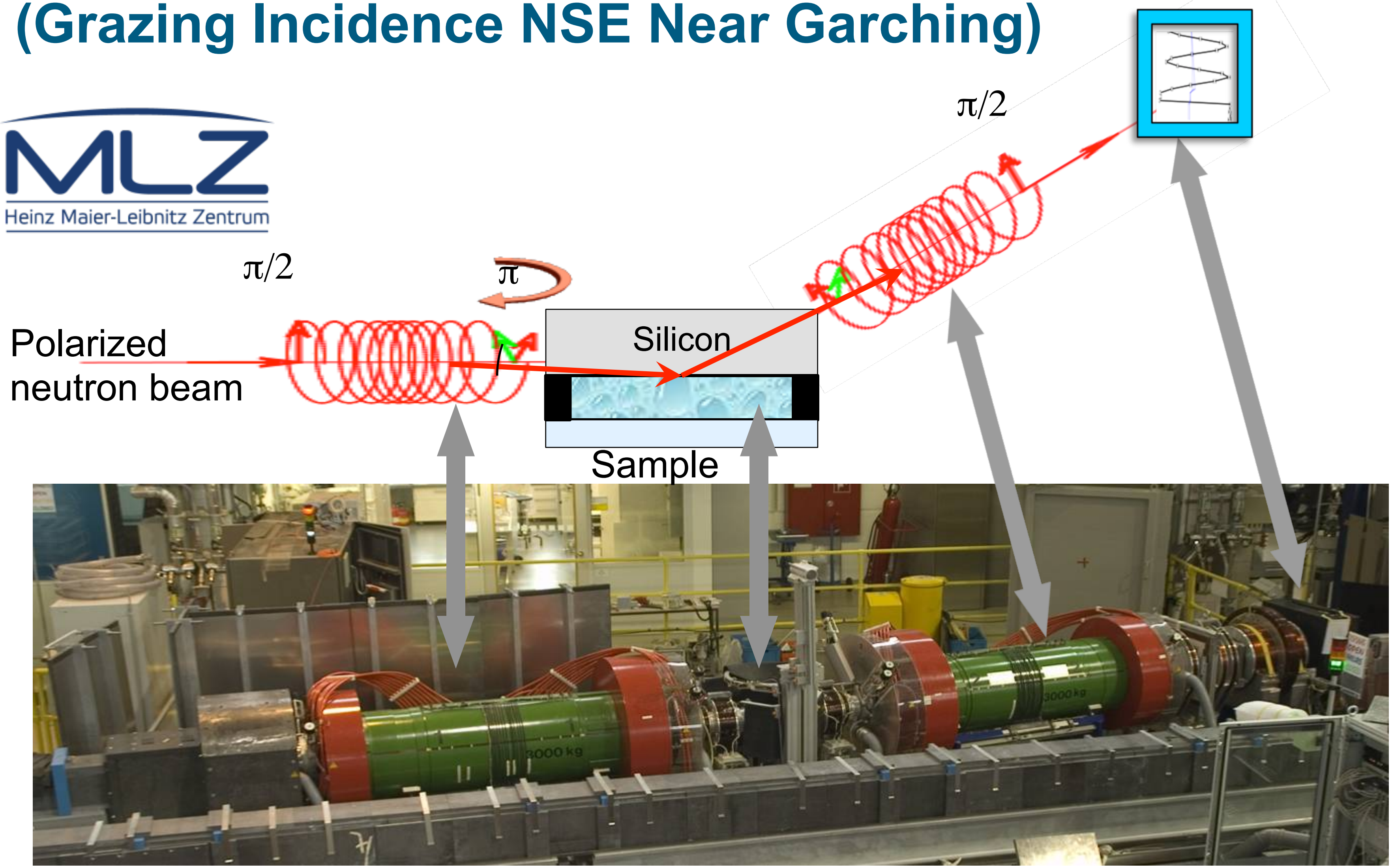


Structure from Computer Simulations:



Kerscher M. et al., Phys. Rev. E (2011)

Extend to near interface dynamics → GINSENG (Grazing Incidence NSE Near Garching)



Count rate direct geometry

Very low background due to new PE-shielding of TofTof-neutron guide.

Count rate: 3-8 cps

Background: 3 cps

Q=0.08 A^-1

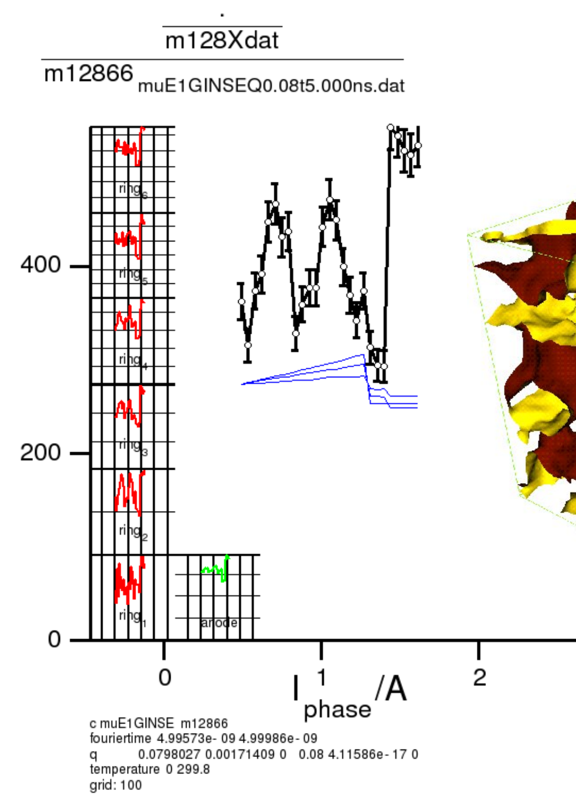
Leads to reasonable echos

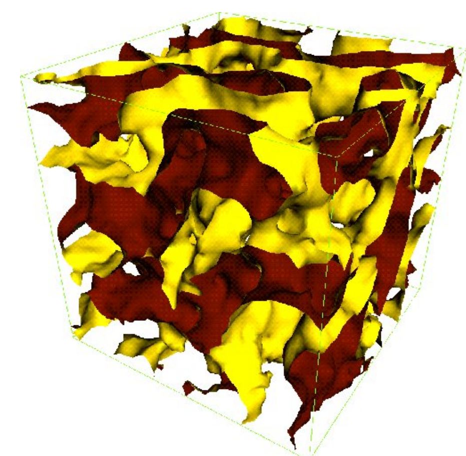
(acquisition time 395 sec./point,

Displayed sum of

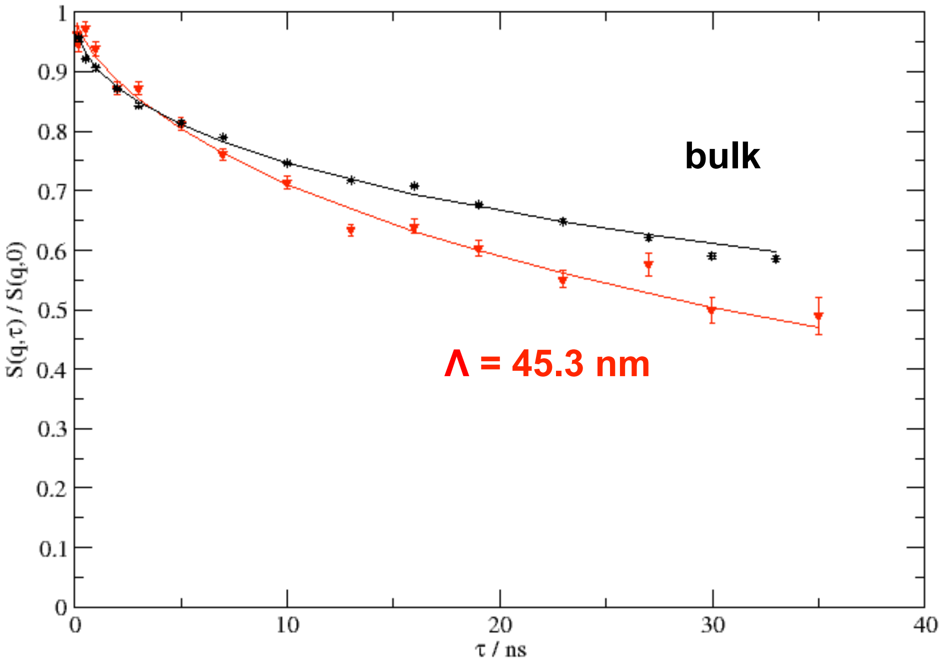
middle ¼ area

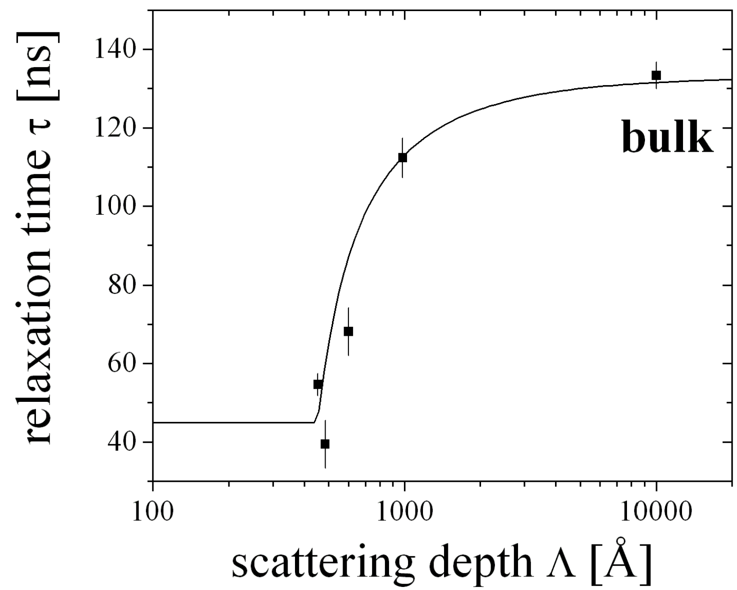
of detector (show3-command))





Near interface dynamics





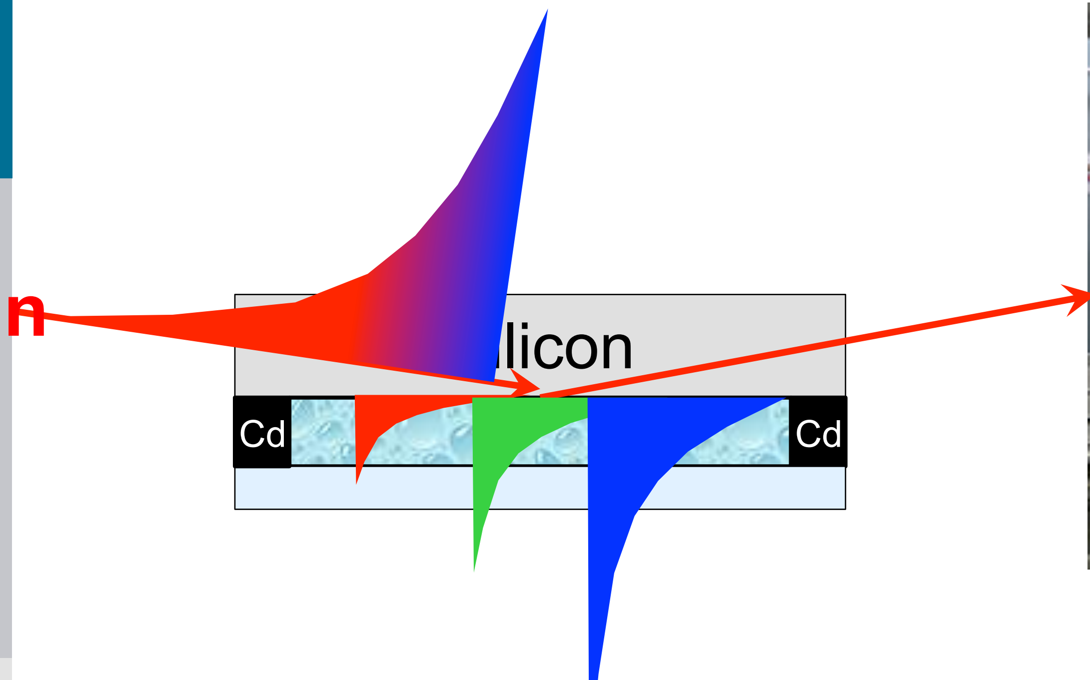
→ Modified dispersion relation at the interface (Seifert)

→ Long wavelength undulations modified:

Bulk:	$\omega(k) \sim k^3$
Interface:	$\omega(k) \sim k^2$

Frielinghaus H. et al., Phys. Rev. E (2012)

GINSES at a spallation source: SNS-NSE

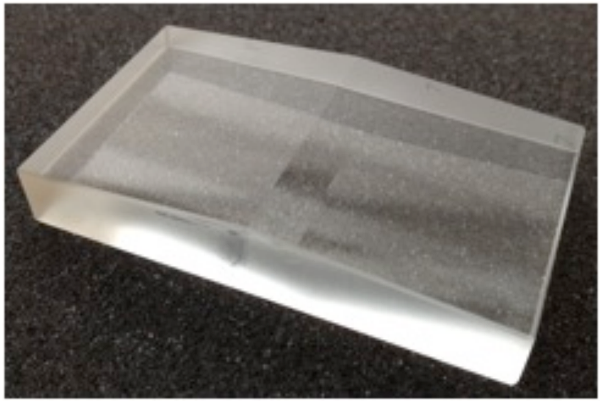


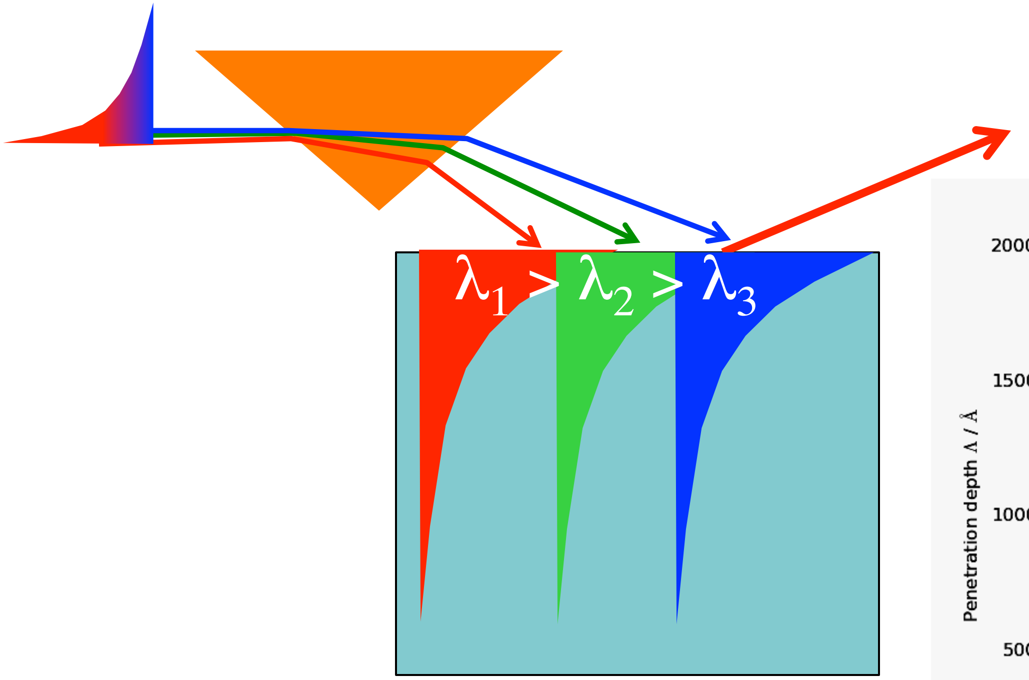
- Pulsed source
→ Varying incident angle

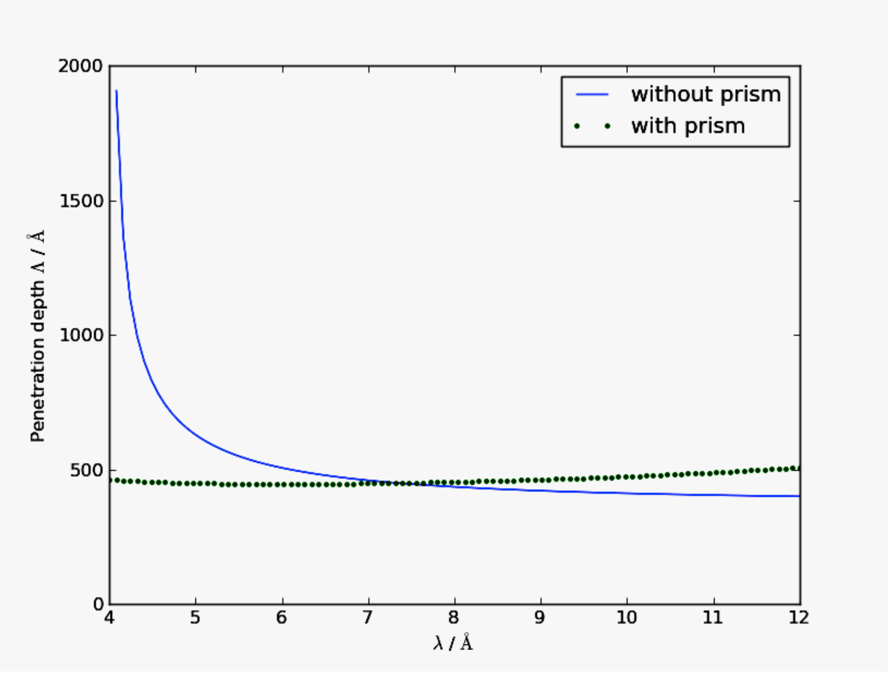
- Intensity – weaker scattering samples

GINSES at Spallation Sources

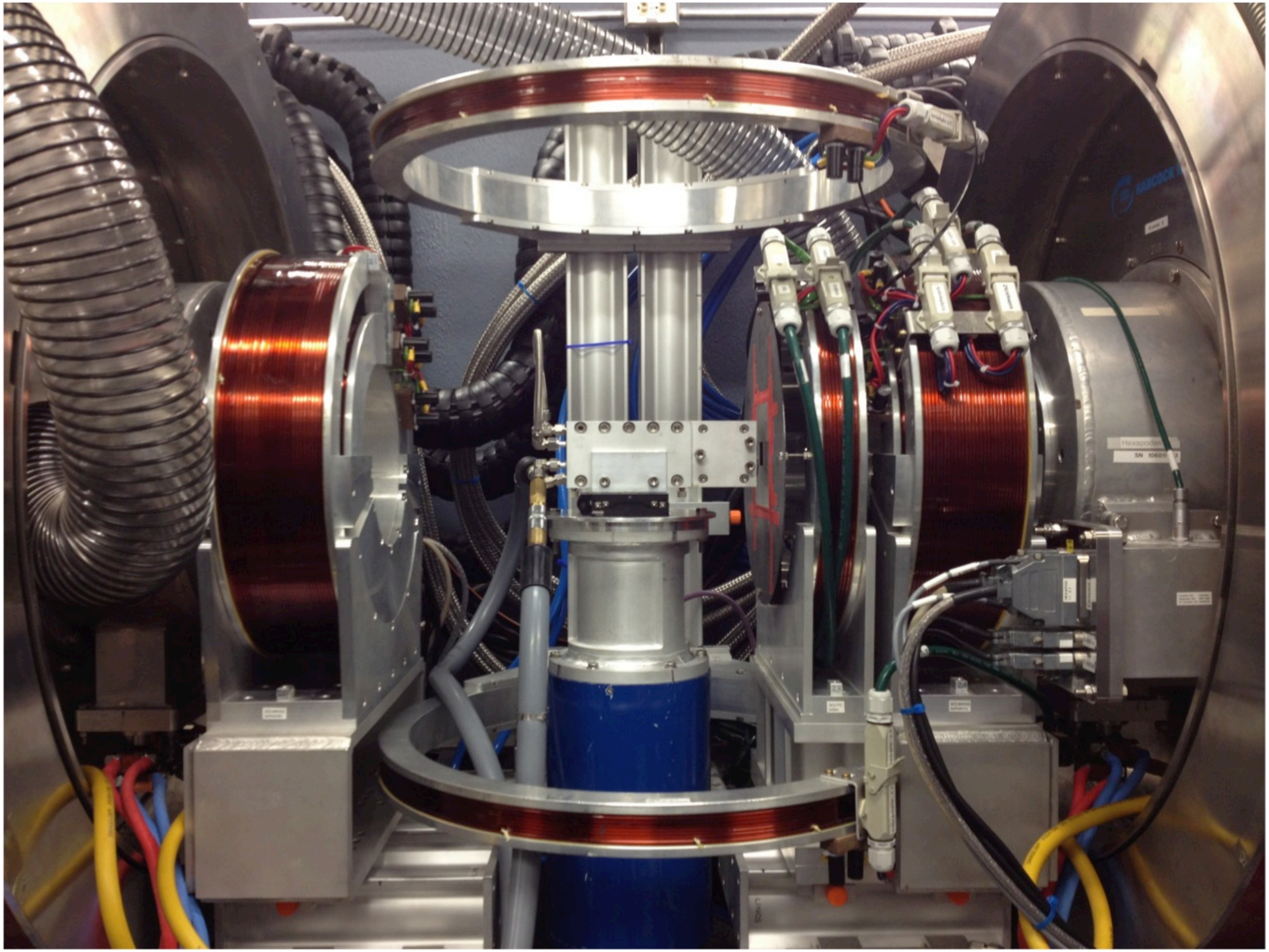
$$\alpha_c = \lambda\sqrt{\Delta\rho/\pi}$$







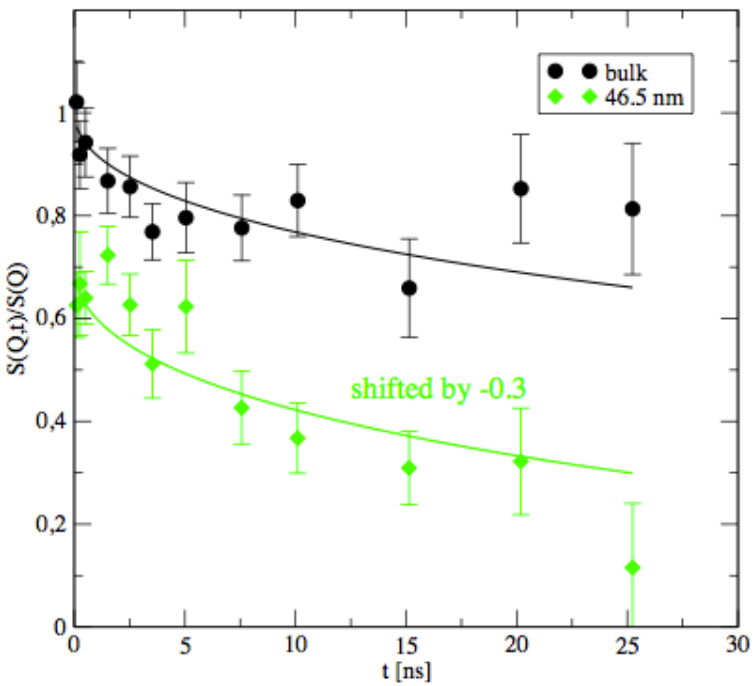
Frielinghaus H. et al., Nucl. Instr. Meth. A (2012)



Prism corrected GINSES

- Pulsed source:
  Constant penetration depth

Rates:
Bulk: 152 ns
Interf.: 99 ns

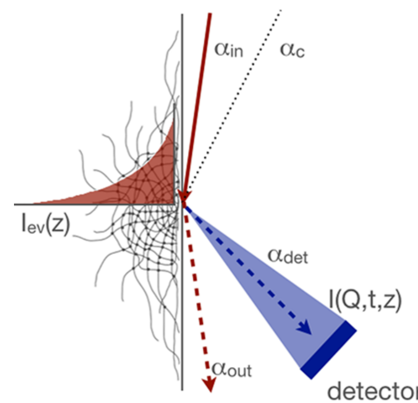


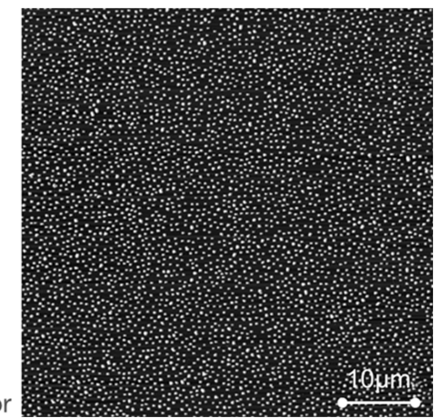
- Continuous source: change wavelength setting without readjustment of sample (ease of operation/reliability)

Intensity?

Towards other samples than strongly scattering microemulsions...

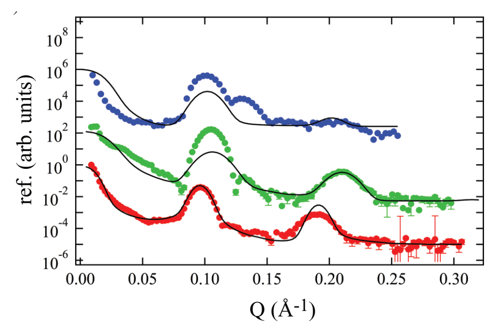
e.g. polymers at interfaces

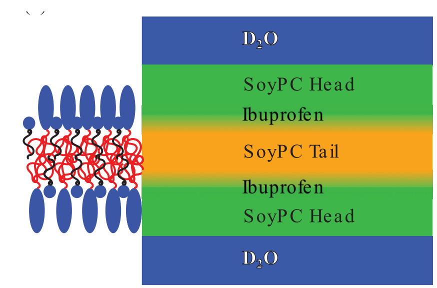




Gawlitza K., et al, Macromolecules (2015)

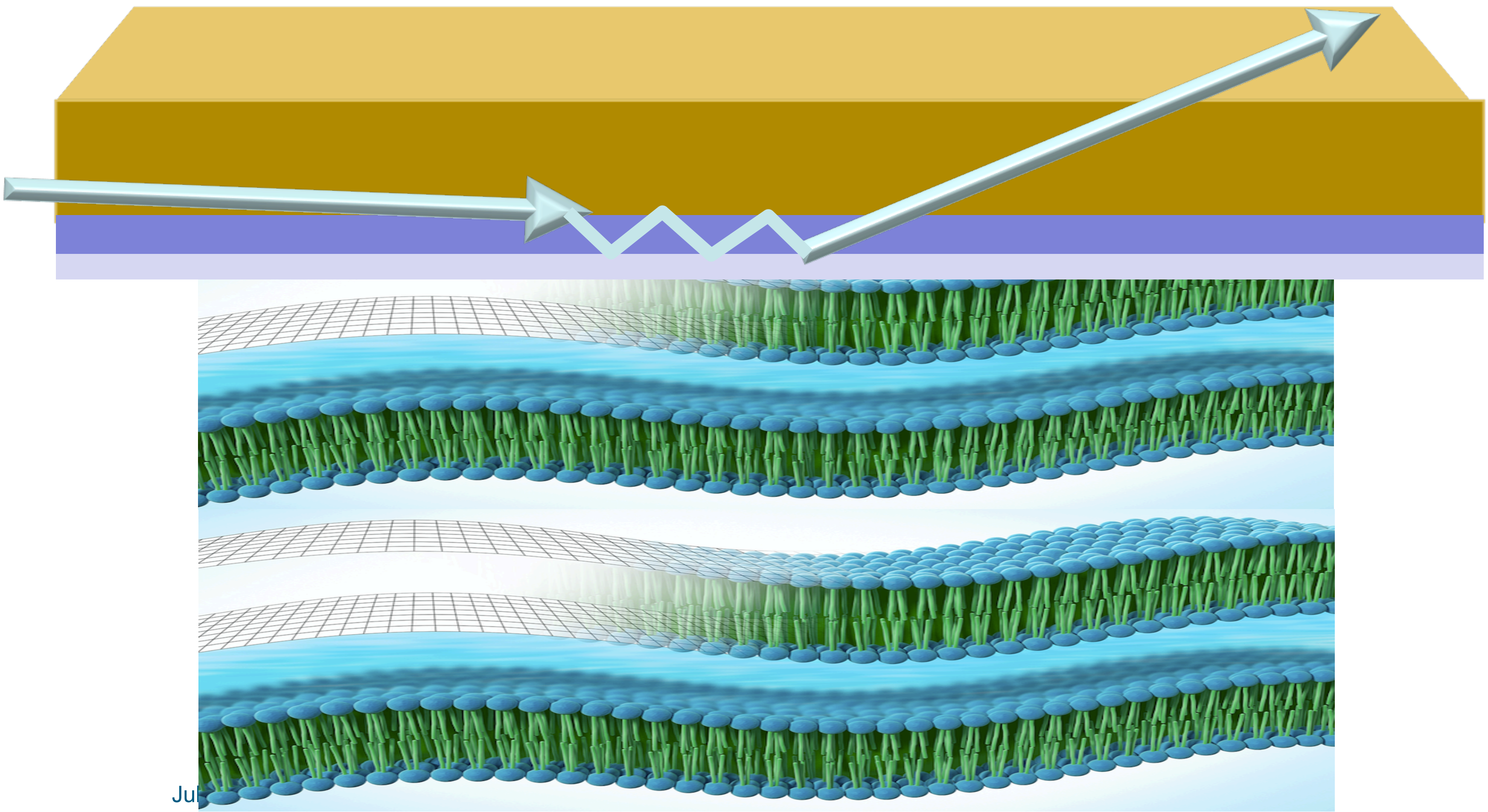
Phospholipid membranes





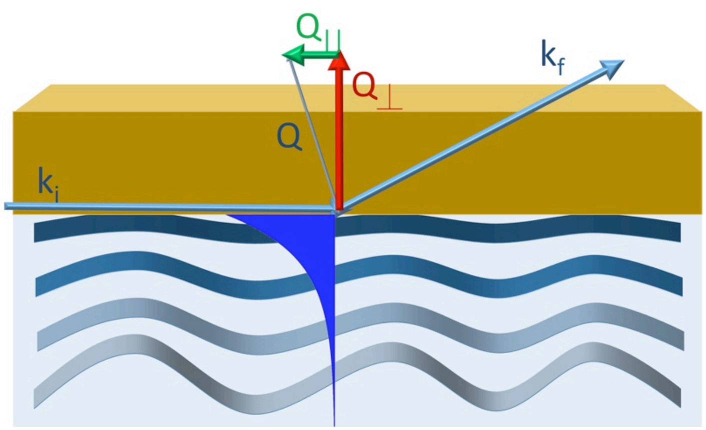
Jaksch S., et al, Phys. Rev. E (2015)

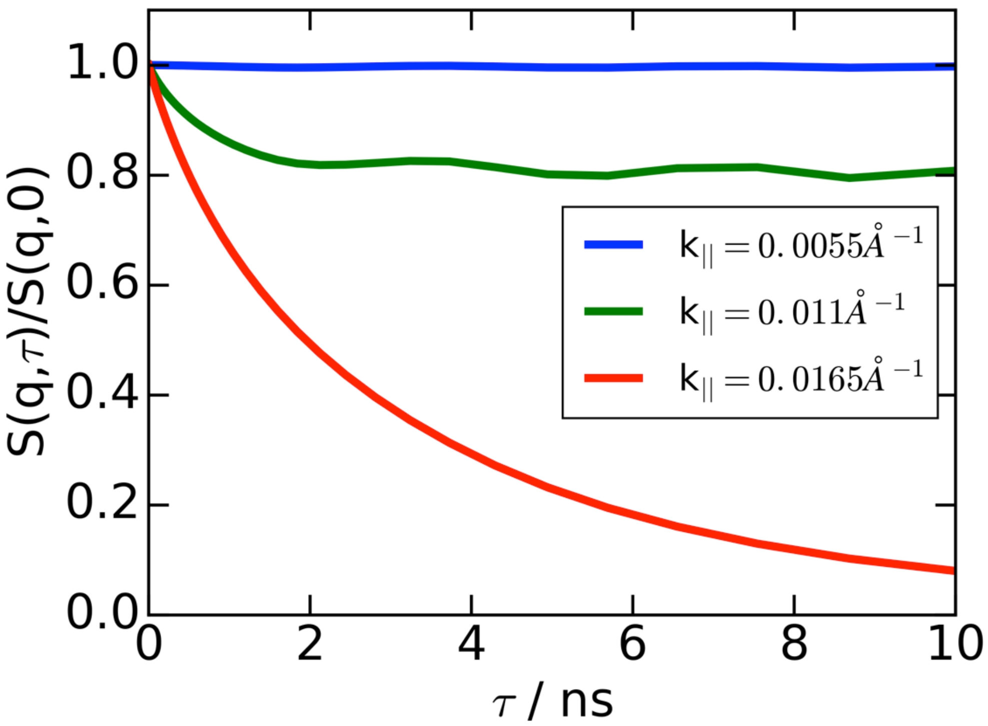
GINSES with a Resonator



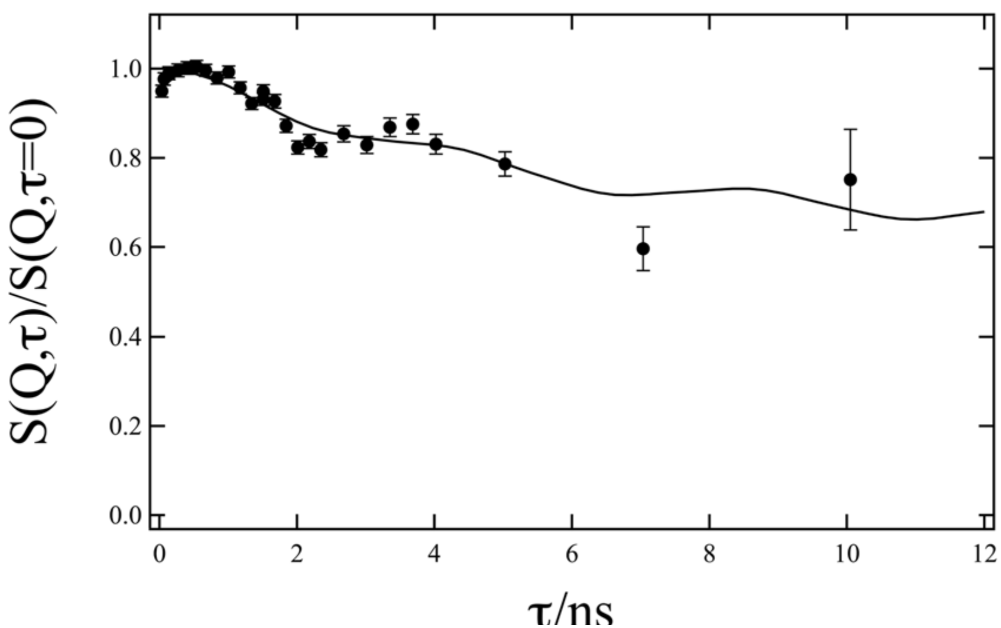
Waves at interfaces

Lamellar structure
at interfaces





SoyPC



@sns-nse, S. Jaksch, H. Frielinghaus, M. Gvaramia, O. Holderer, M. Ohl, Sci Rep. 2017

Summary/Outlook

- J-NSE: The past and the future
- Access to interface dynamics
- Polymers/Gels/Membranes
- Intensity 1 : Good (cold) source
- Intensity 2 : advanced neutron optics
  + Prism
  + Resonator