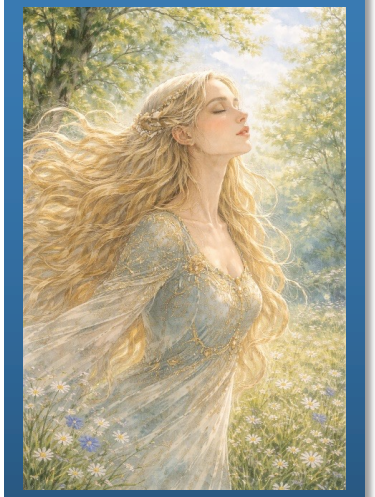


Gersemi (“treasure”) is the daughter of Freya and Óðr, and twin sister of Hnoss, in Norse mythology. She is goddess of freedom and beauty.

GERSEMI – **G**aining **E**nhanced **R**esolution with **S**pin **E**cho for **M**ultiscale **I**nvestigations

A high-resolution Neutron Spin Echo instrument for the ESS

Daria Noferini (ESS) and Felix Roosen-Runge (Lund University)

Spectroscopy STAP 21.04.2026

A community proposal

A large group of active proposers…

Coordination group:

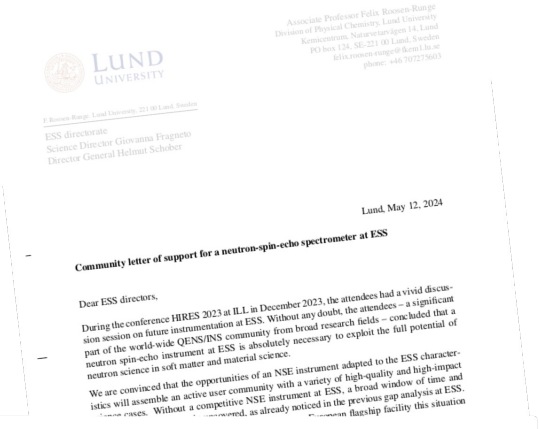
Benedetta Rosi, Daria Noferini, Felix Roosen-Runge, Ingo Hoffmann, Mads Bertelsen

Contributors:

Andrew McCluskey, Anna Stradner, Antonio Faraone, Arantxa Arbe, Bela Farago, Christian Beck, David Callaway, Elizabeth Kelley, Hanna Barriga, Luigi Paduano, Margarita Kruteva, Marie Plazanet, Maths Karlsson, Max Wolff, Michael Monkenbusch, Michihiro Nagao, Olaf Holderer, Orsolya Czakkel, Peter Falus, Peter Fouquet, Peter Schurtenberger, Ralf Biehl, Stéphane Longeville, Tadanori Koga, Theresia Heiden-Hecht, Tilo Seydel

A community proposal

an even larger group of supporters…



Lund, May 12, 2024

Community letter of support for a neutron-spin-echo spectrometer at ESS

Dear ESS directors,

During the conference HIRES 2023 at ILL in December 2023, the attendees had a vivid discussion session on future instrumentation at ESS. Without any doubt, the attendees – a significant part of the world-wide QENS/INS community from broad research fields – concluded that a neutron spin-echo instrument at ESS is absolutely necessary to exploit the full potential of neutron science in soft matter and material science.

We are convinced that the opportunities of an NSE instrument adapted to the ESS characteristics will assemble an active user community with a variety of high-quality and high-impact

Letter of support from HIRES conference (2023), more than 100 signatures

ESS NSE Workshop

16 September 2025
European Spallation Source ERIC (+ online via zoom)
Europe/Stockholm timezone

About 60 participants

2F DN
Fédération Française de Diffusion Neutronique

"The 2FDN strongly supports the implementation of GERSEMI in the upcoming ESS instrumental suite"

Letter of support from the French Federation for neutron Scattering

A community proposal

and strong commitments

*"[…] Drawing on our extensive experience at JCNS, we **strongly recommend** the development of the next-generation NSE instrument, GERSEMI, at ESS. This would not only **make use of the unique characteristics of the ESS source**, but also establish a **world-leading platform** for studying nanoscale dynamics, enabling **transformative science across a broad range of disciplines**."*

Stephan Förster – JCNS Director

NEUTRONS FOR SOCIETY

*"I would like to express my **strong support** for your proposal … [GERSEMI] would significantly **enhance the capabilities** of the ESS instrument suite. […] ILL provides world-leading capabilities in NSE spectroscopy and could be well placed to **support ESS in the design and construction of such an instrument.**"*

Ken Andersen– ILL Director

*"The LLB is firmly convinced of the **scientific relevance and strategic importance** of the GERSEMI project for the European Spallation Source (ESS). High-resolution neutron spin-echo has been identified as one of the most critical missing capabilities in the ESS capability gap analysis, further underlining the **importance and timeliness of this development**. The implementation of a neutron spin-echo spectrometer would represent **a major step forward** […] On behalf of the LLB, I would like to express our strong support for the GERSEMI instrument project. I confirm our **full commitment to actively contribute to its scientific and instrumental development.**"*

Arnaud Desmedt – LLB Director

Orphée Laboratoire Léon Brillouin

For which community?

Potential user community

Primarly optimised for…

Soft matter (including complex fluids) and **life science**

As main user communities

Versatile to accommodate…

Hard condensed matter and **magnetism**

As communities with potential to grow

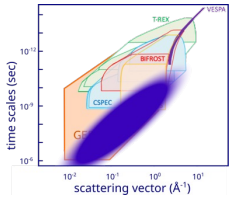
A truly interdisciplinary instrument for high resolution spectroscopy

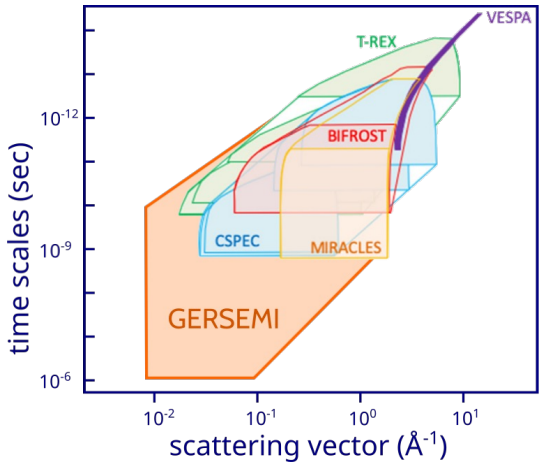
Ideally complemented by a Wide Angle NSE at ESS in the future!

Why NSE?

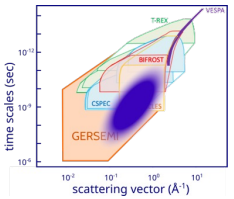
The high-resolution gap

protein dynamics

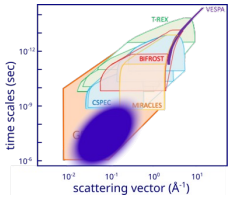




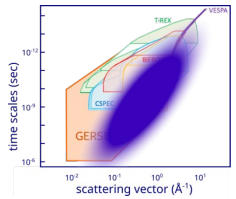
magnetism



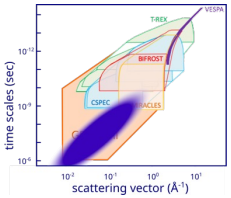
lipid membrane dynamics

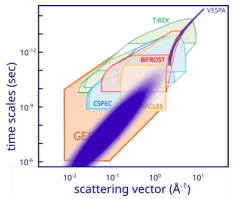


energy materials

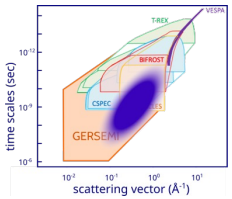


formulations: food & pharma





polymers



complex liquids

life science

soft matter

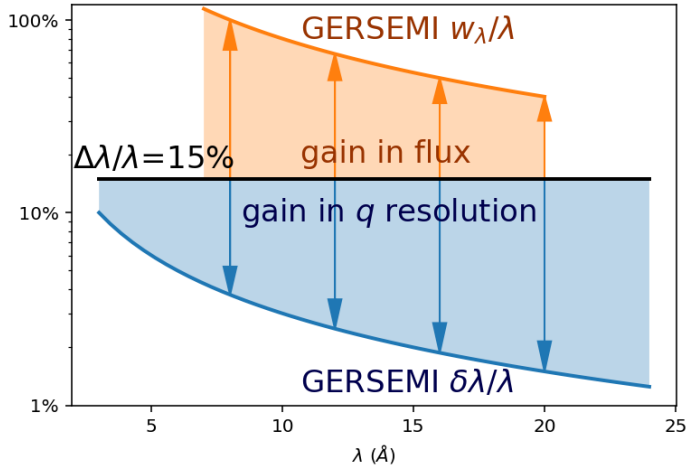
materials science

Enabling factors for new science

Benefits due to the ESS source

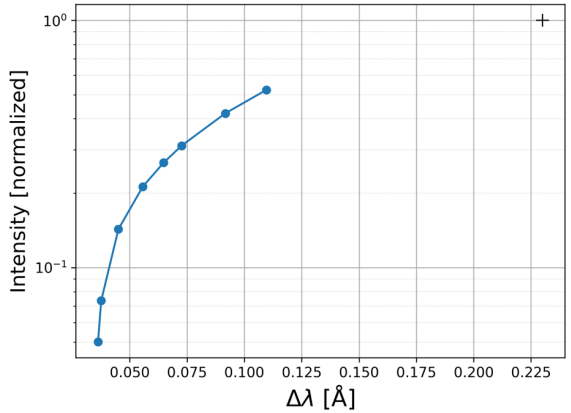
decoupling of wavelength band and monochromatization

tunability of monochromatization



gain in flux due to wider wavelength band

gain in q resolution due to better monochromatization



monochromatization can be improved by a factor >10

[concept calculations]

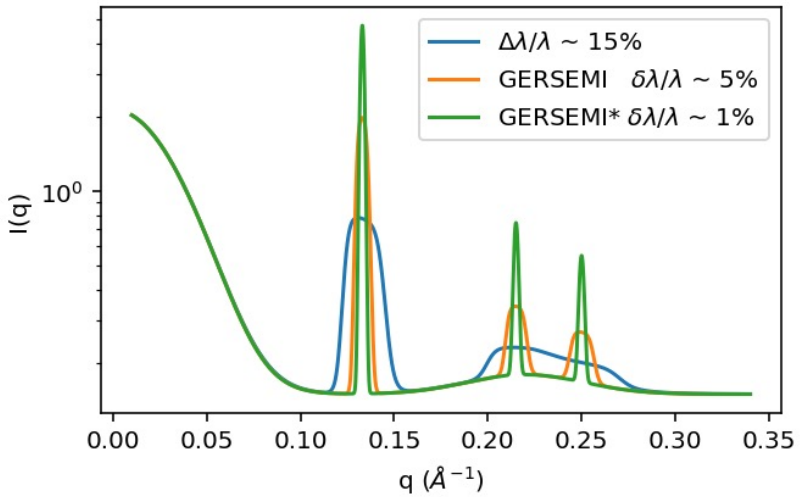
[chopper simulations]

→ new opportunities for impactful science

Enabling factors for new science

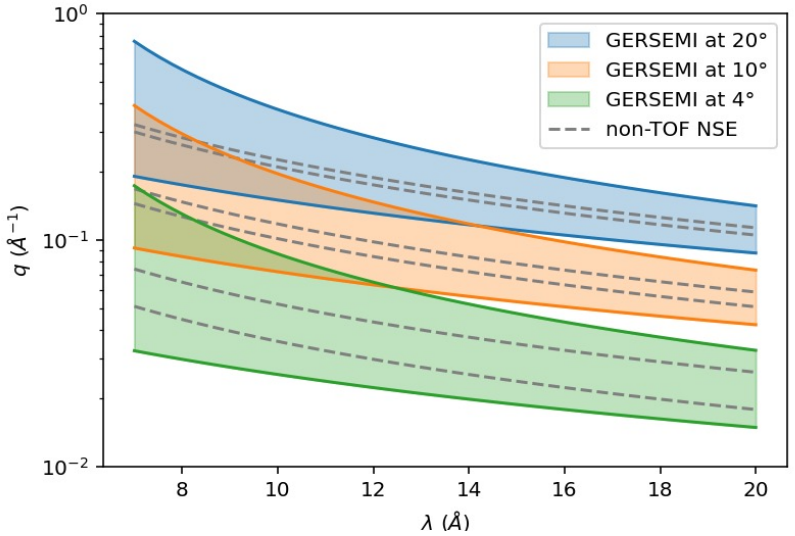
Dynamics during structure formation

high q resolution



less shadowing due to de Gennes narrowing

broader q range



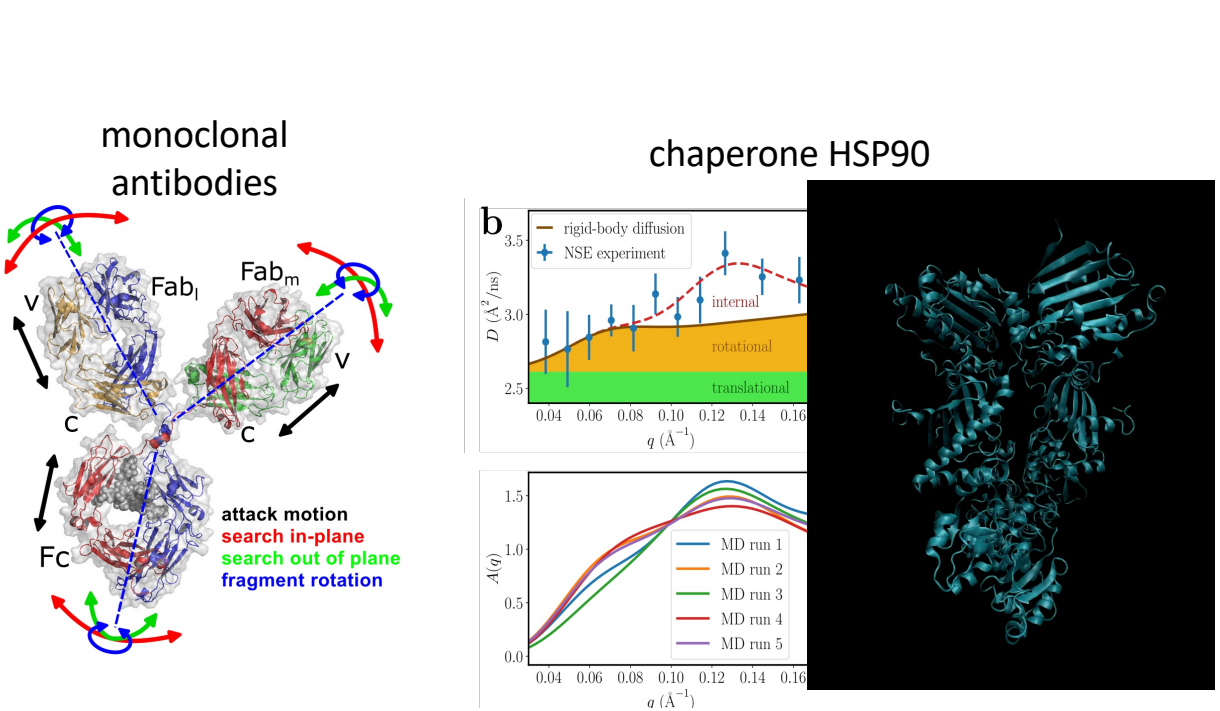
coverage over (several) peaks

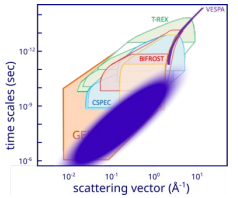
→ optimal to characterize dynamics during structure formation (also time-resolved)

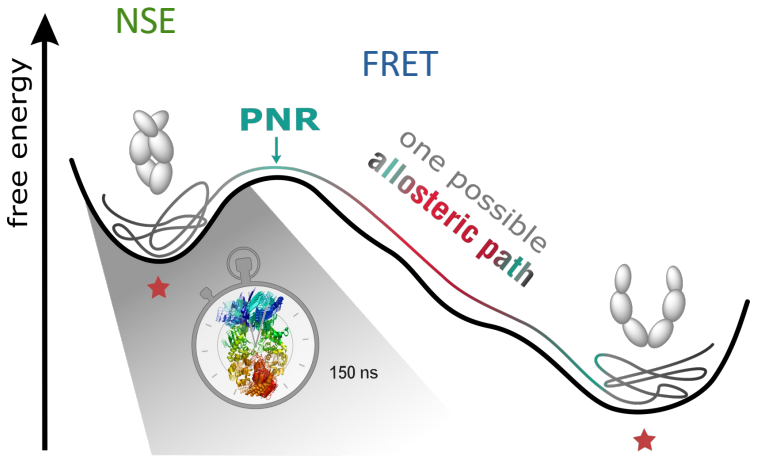
→ novel opportunities for structured materials (e.g. energy materials, liquid crystals)

Scientific case

Protein motions and allostery







→ detailed mechanisms of protein domain motions

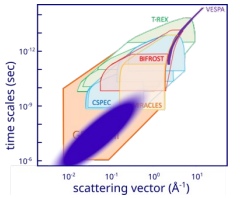
→ understanding of allosteric pathways

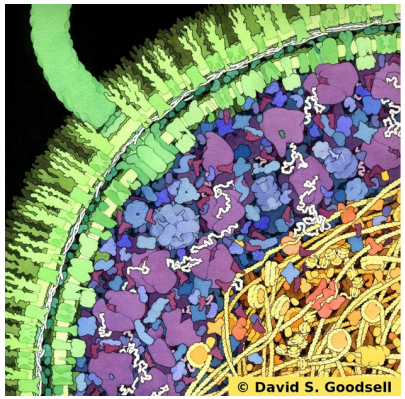
R. Biehl et al. Comm. Biol. 8 (2025)

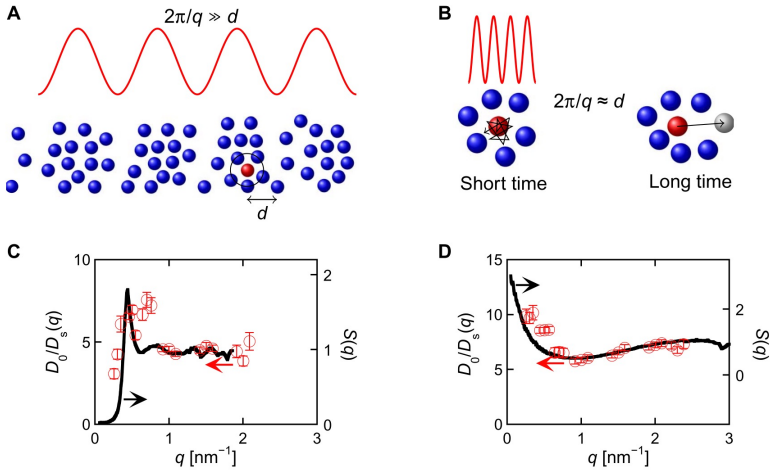
B. Sohmen et al. Advanced Science 10 (2023)

Scientific case

Protein diffusion in biological solutions







→ understanding of dynamical arrest, clustering, assembly and gelation

→ understanding of function and disease

→ understanding of physiological processes (e.g. hemoglobin distribution)

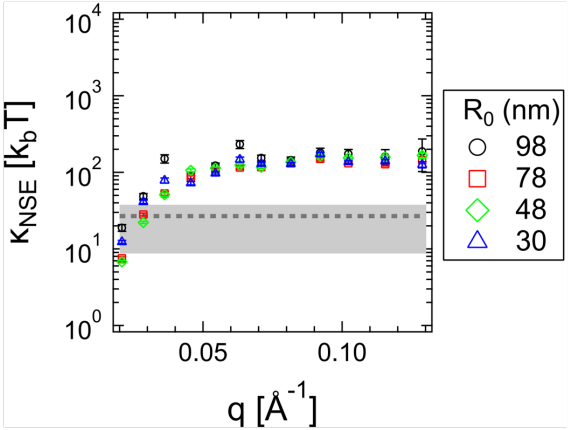
→ mechanism of cage diffusion in crowded systems

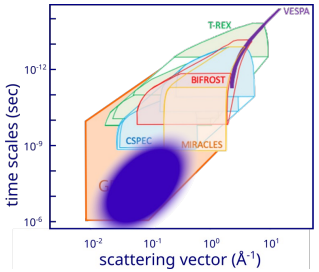
Scientific case

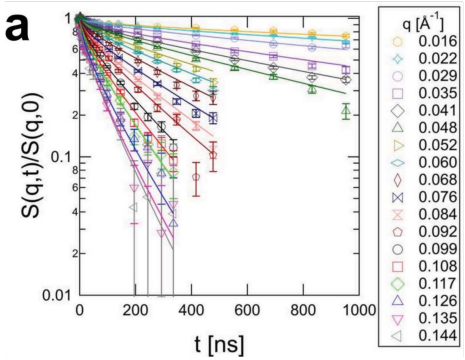
Understanding and adaptation of lipid remodeling

Doing more:

single configuration
at GERSEMI
→ full exploitable ranges for membrane dynamics



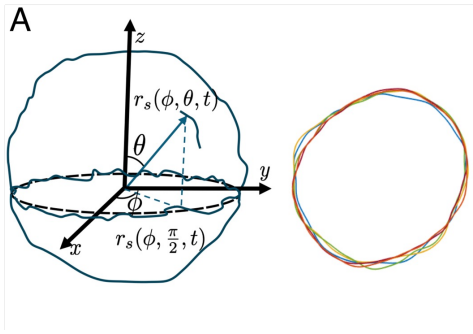




Or doing better:

new theories
→ influence of bending rigidity, compressibility and membrane viscosity

overlap with nsXPCS@XFEL



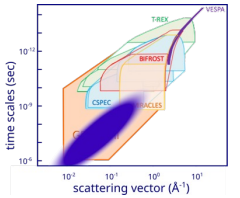
R.Granek et. al. EPJE 47:12 (2024)

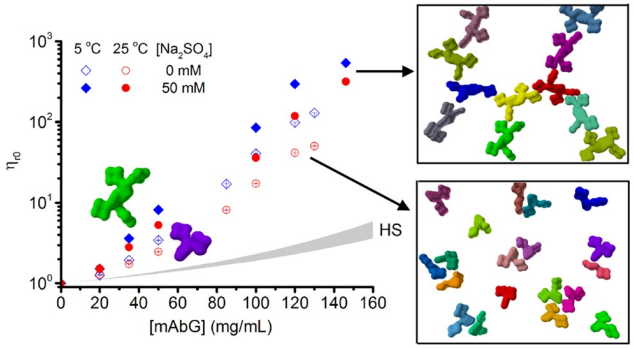
I. Hoffmann et. al. J. Appl. Cryst, 59 (2026).

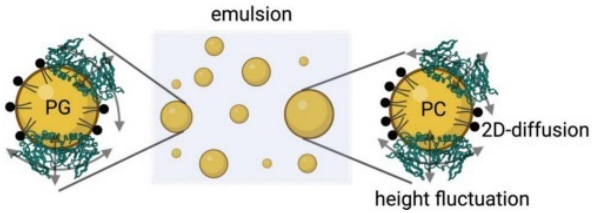
H. Faizi et. al. PNAS 121 (2024)

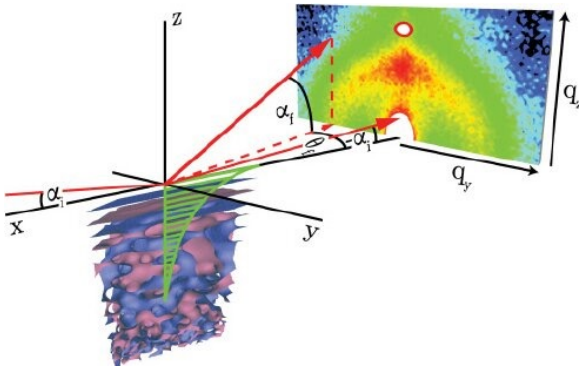
Scientific case

Formulations in food and pharma









→ viscosity increase

→ emulsion stabilization

→ surface effects (GINSES)

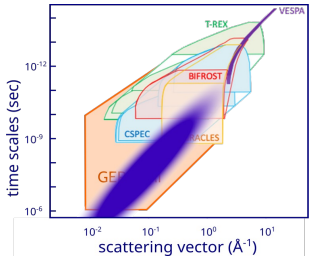
→ predictive understanding for formulation optimization

P.D. Godfrin et al. J. Phys. Chem. B 120 (2016).

T. Heiden-Hecht et al. J. Coll. Interf. Sci. 703 (2026).

Scientific case

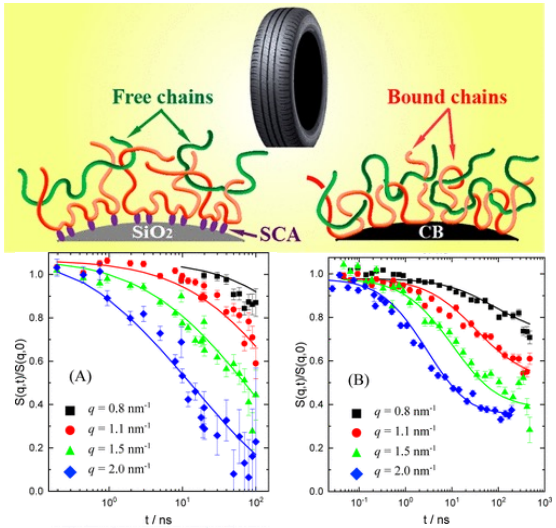
Viscoelastic properties and response in advanced polymer systems



GERSEMI → understand and optimize advanced polymer materials, using the excellent characteristics for standard runs and exploiting novel opportunities (e.g. GINSES)

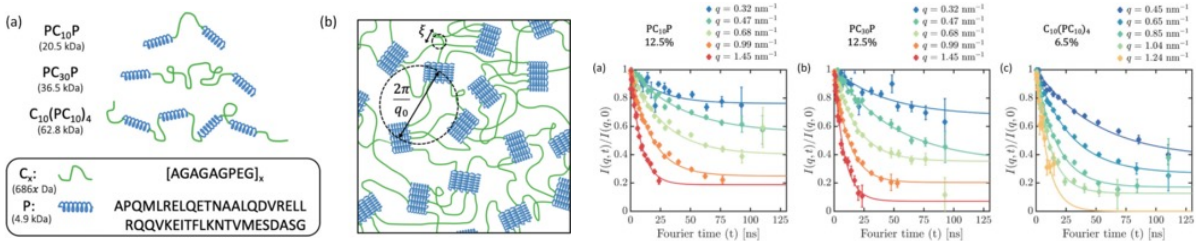
Tires

(nanocomposites, reinforced rubbers)



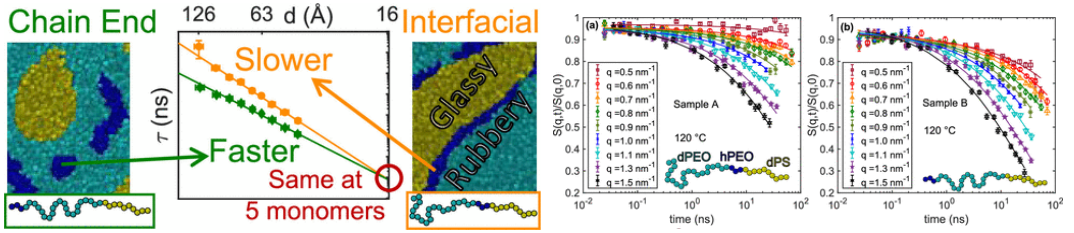
Associative networks

(self-healing materials, hydrogels)



Interface dynamics

(phase separating systems, grafted chains, brushes)

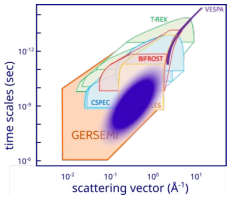


T. Koga et al., Macromolecules 58, 17 (2025).
D. Musino et al., ACS Macro Lett. 9, 6, (2020).
R. Lund et al., Macromolecules 58, 18 (2025).
A. Rao et al., Phys. Rev. Materials **7** 075602 (2023).
Goswami et al., Macromolecules 56, 3 (2023).
J. Witte et al., Macromolecules 53, 5 (2020)

Scientific case

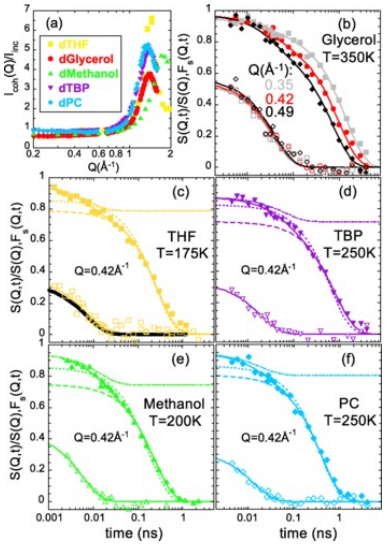
Glass and gel transitions and complex fluids

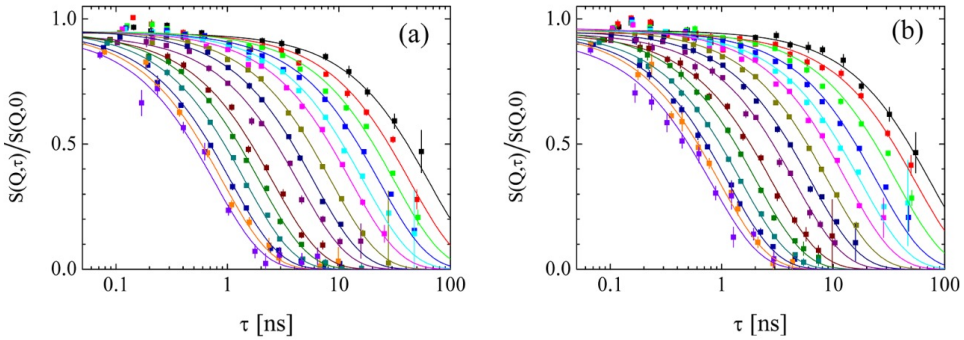
Green solvents, batteries, cosmetics, catalysis pharmaceuticals…



GERSEMI → access to slow dynamics, higher max q and wider q-range than traditional high-res NSE, coh/inc contributions

Glass transition and arrest phenomena. Detail the role of supramolecular aggregates. Understand dynamics of multi-component and multi-domain solutions with surfactants, biomaterials etc. Transport in confinement.





3-methyl pyridine/D_2O without (3D, left) and with (2D, right) antagonistic salt

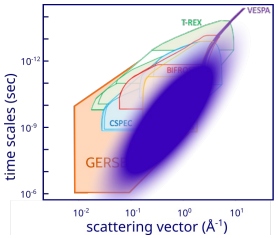
A. Arbe, Phys. Rev. Lett. 134, (2025)

H. Frielinghaus et al. Phys. Rev. Res., 5 (2023)

Scientific case

Optimising energy materials

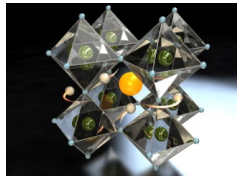
Materials for next-generation batteries, fuel cells, hydrogen storage…

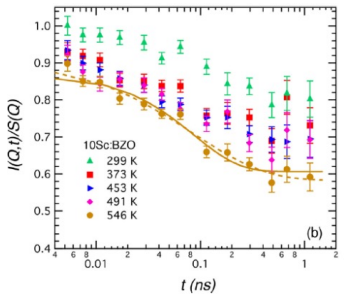


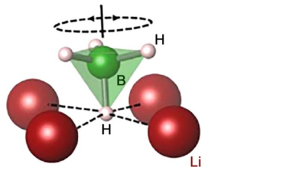
GERSEMI → access to long time dynamics, flexible q resolution (minimise effect of Bragg peaks), sample environment, polarisation analysis

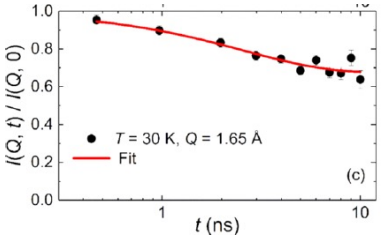
Solid state systems
(proton conducting oxides, oxohydrides, borohydrides…)

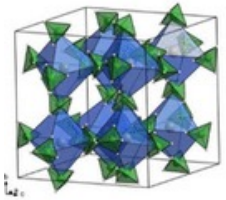
Soft matter
(ionic liquids, molten salts, polymers…)

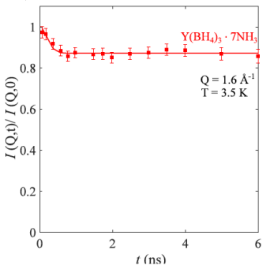


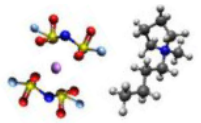


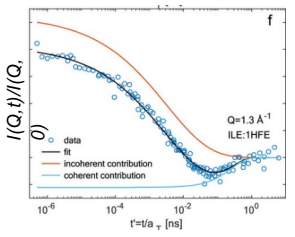


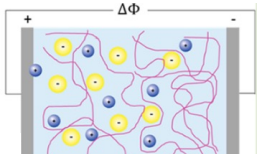


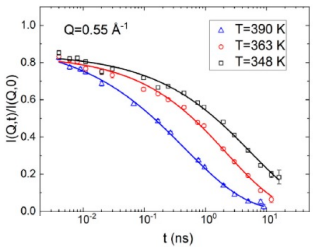


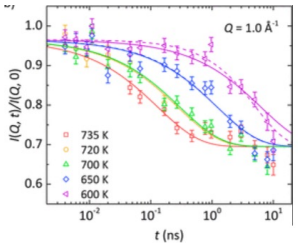












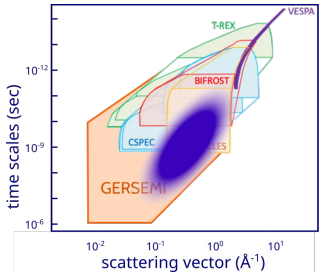
D. Noferini et al., J. Phys . Chem. C, 120 (2016). J. B. Grinderslev et al., J. Phys. Chem. C, 128 (2024). C. Eklöf-Österberg et al., J. Phys. Chem. C, 123 (2019).

F. Lundin et al. J. Phys. Chem. C, 126 (2022). P. Falus et al. Front. Soft Matter, 3:1161141, (2023). W. S. Loo et al. ACS Macro Lett., 9, P. Luo et al. J. Phys. Chem. Lett. 12, (2021).

Scientific case

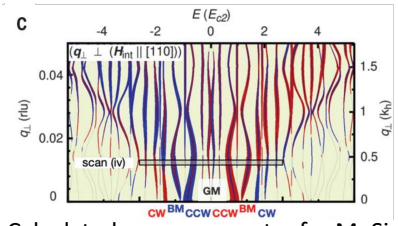
Understanding magnetic relaxations for spintronics potentials

NSE offers some unique opportunities for slow ns dynamics



Spin glasses, spin ice, flux line lattices, skyrmions

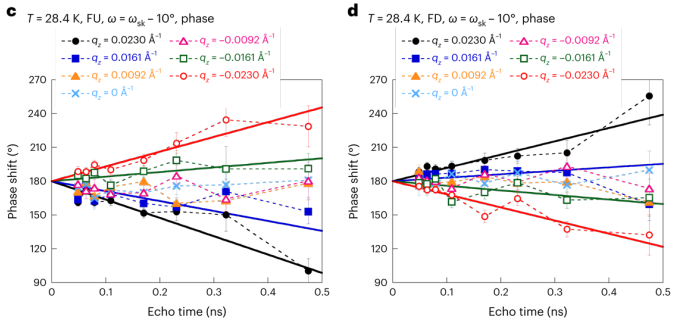
Paramagnetic echo: Echo only from magnetic scattering → weak magnetic signal on top of strong nuclear signal



Calculated magnon spectra for MnSi

More skyrmions materials have energies too small for TAS

Ferro magnetic echo: magnetic field on the sample possible!



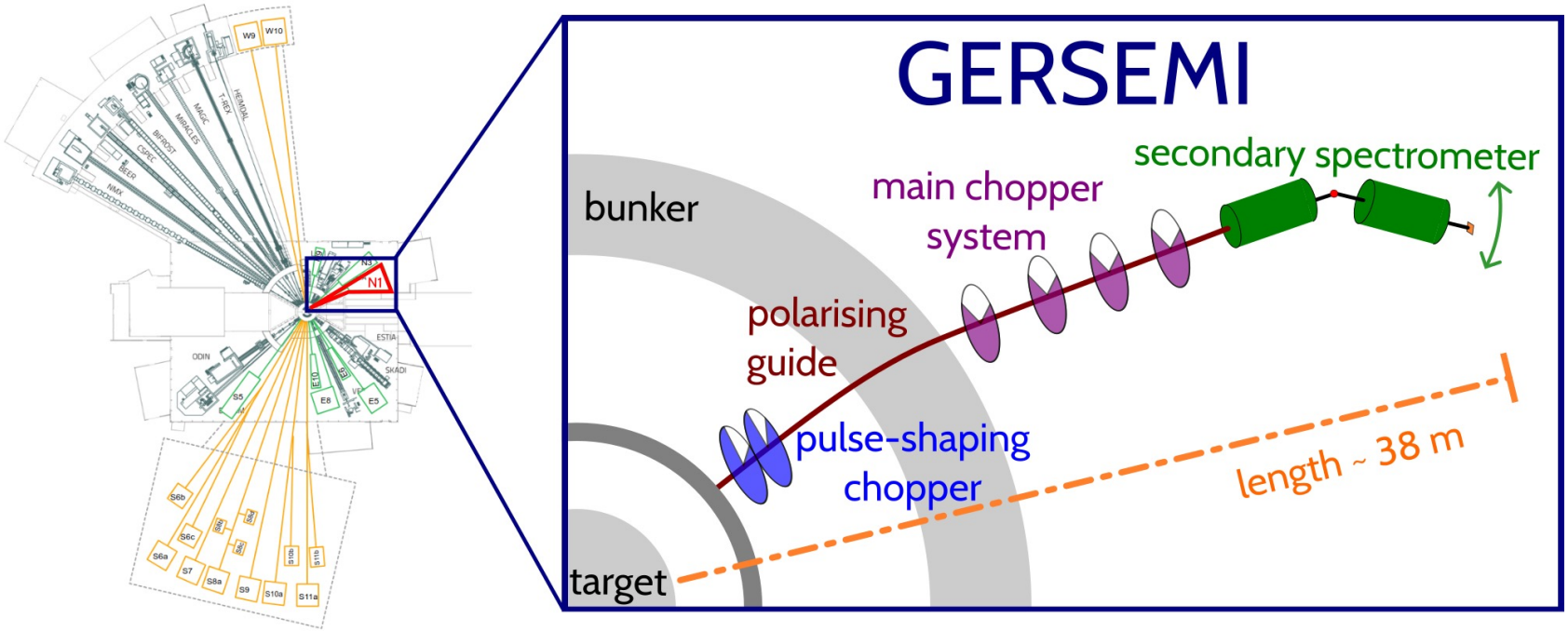
Asymmetric phase of NSE signal in magnetic field up (left) and down (right) in MnSi

Not main focus on GERSEMI, but prepared for new scientific opportunities in the field

T. Weber et. al. Science, 375, (2022)

Where and how?

Proposed location at ESS



Beamport N1 in D03 → non-magnetic floor, “non-magnetic neighbours”, sufficient space and floor load.
Easy access to life science and chemical laboratories in D04.

Where and how?

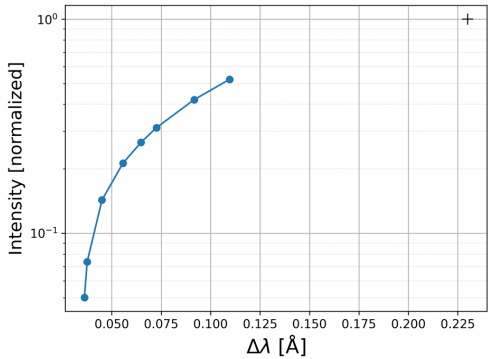
Primary Spectrometer

Based on the ESSENSE proposal.

Four disk choppers, out of bunker. Frequency: 14 Hz (→ low risk). $\Delta\lambda$ = 8 Å, λ_i = 3—25 Å. Background and frame overlap suppression.

Pulse shaping chopper. Double blade co-rotating disks, at about 7 m from moderator (in bunker). Frequency: 7-168 Hz → $\Delta\lambda$ = 0.035 —0.3 Å.

Polarising guide with a kink polariser, an adiabatic flipper, and a transmission V polariser, to cover the large wavelength band



The future instrument team will need to do some refinement, but the design is already quite solid with very low technical risks

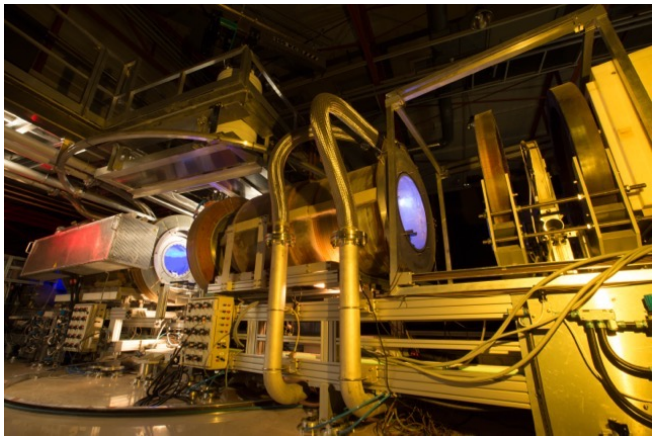
S. Pasini, J. Phys.: Conference Series, 746, (2016).

Where and how?

Secondary Spectrometer

Two possible designs:
superconducting coils (J-NSE-Phoenix) or water-cooled resistive coils (IN15)

Credits: Olaf Holderer



Credits: Bela Farago

The future instrument team will assess the best solution for the GERSEMI,
with the “luxury of the choice” between two extremely valid and already proven solutions

S. Pasini et al. Rev. Sci. Inst., 90, (2019). *B. Farago et al. Neutron News, 26, (2015).*

Where and how?

Sample environment

Flexibility for the different scientific cases.
Sample area with two rotation motors that allow scans for single crystals and other oriented samples.
Sufficient space to accommodate complex sample environments for combined characterisations *etc.*
Requirement: low magnetic permeability to avoid beam depolarisation.

Cryofurnace → *T* range: 2–800 K

Dilution insert or ^{3}He insert→ mK temperatures

"Bio-oven" →*T* range -20 – 120 °C at ambient pressure. Equipped with humidity cell.

High *T* furnace → *T* range 300 –1300 K

Low field (2T) magnet, in ferromagnetic echo mode

High pressure cells

In conclusion…

GERSEMI closes the high-energy resolution gap identified at the ESS, bridges neutron spectroscopy with complementary techniques and allows investigations on a vast universe of societally relevant science across multiple fields.

GERSEMI will match the outstanding performance of similar instruments and, thanks to the use of the long pulsed source of the ESS, it will unlock additional capabilities for the entire neutron community

GERSEMI's design is based on established and proven technologies and has minimal technical risks and is backed-up by the world-leading high-resolution expertise of JCNS, ILL, LLB, and NIST, ensuring a solid path to full performance.

GERSEMI is strategically essential to preserve and strengthen the European high-resolution ecosystem and is supported by an enthusiast community ready to exploit its unique features from day 1.

Thank you for your attention!