OAK RIDGE National Laboratory

Time-of Flight Wide-Angle Neutron Spin-Echo at STS

EXPANSE

Proposed Instrument Characteristics and New Science Opportunities

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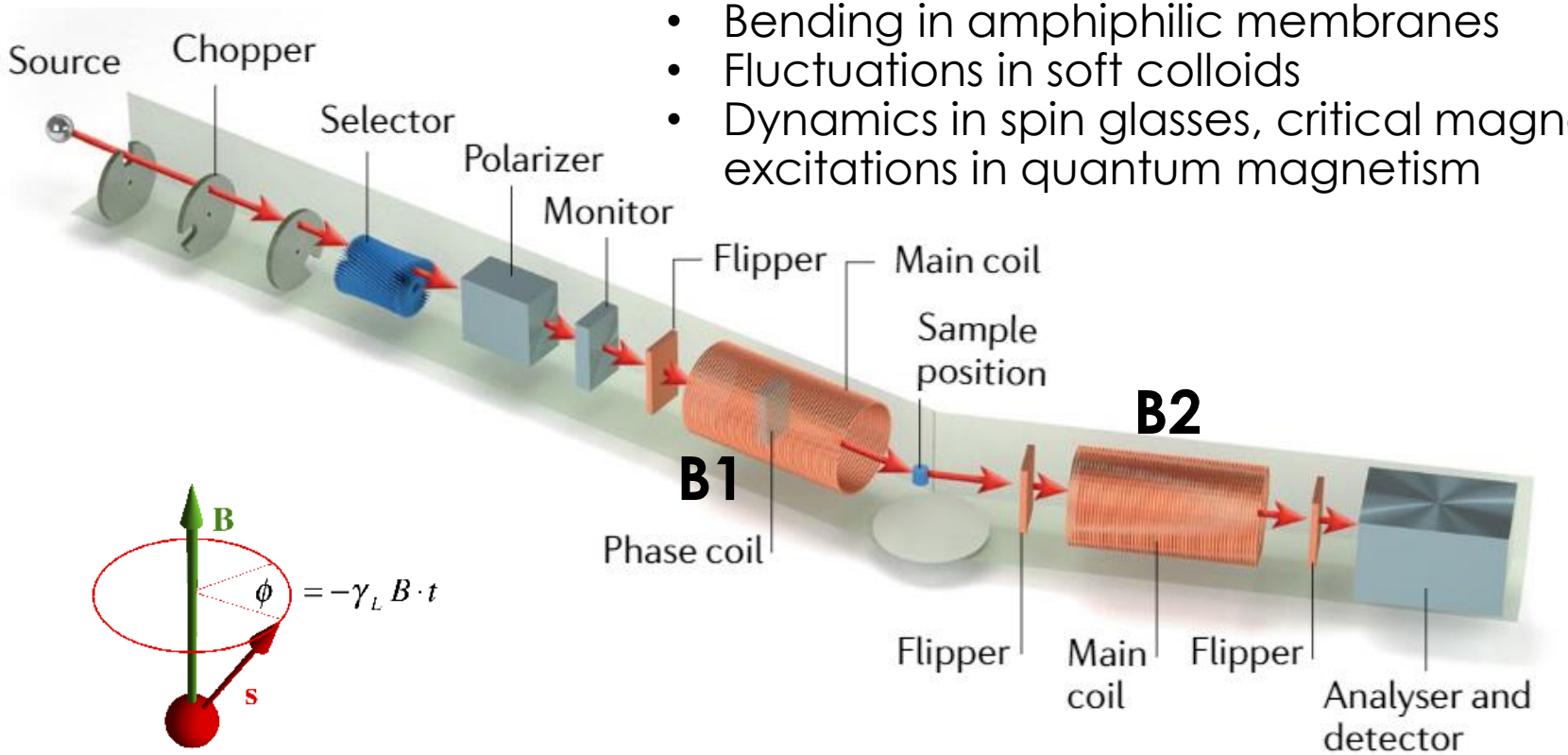
U.S. DEPARTMENT OF ENERGY

Neutron Spin Echo Spectrometer

- High energy resolution (~1 neV)
  - Slow relaxation in polymers
  - Bending in amphiphilic membranes
  - Fluctuations in soft colloids
  - Dynamics in spin glasses, critical magnetic fluctuations, emergent excitations in quantum magnetism

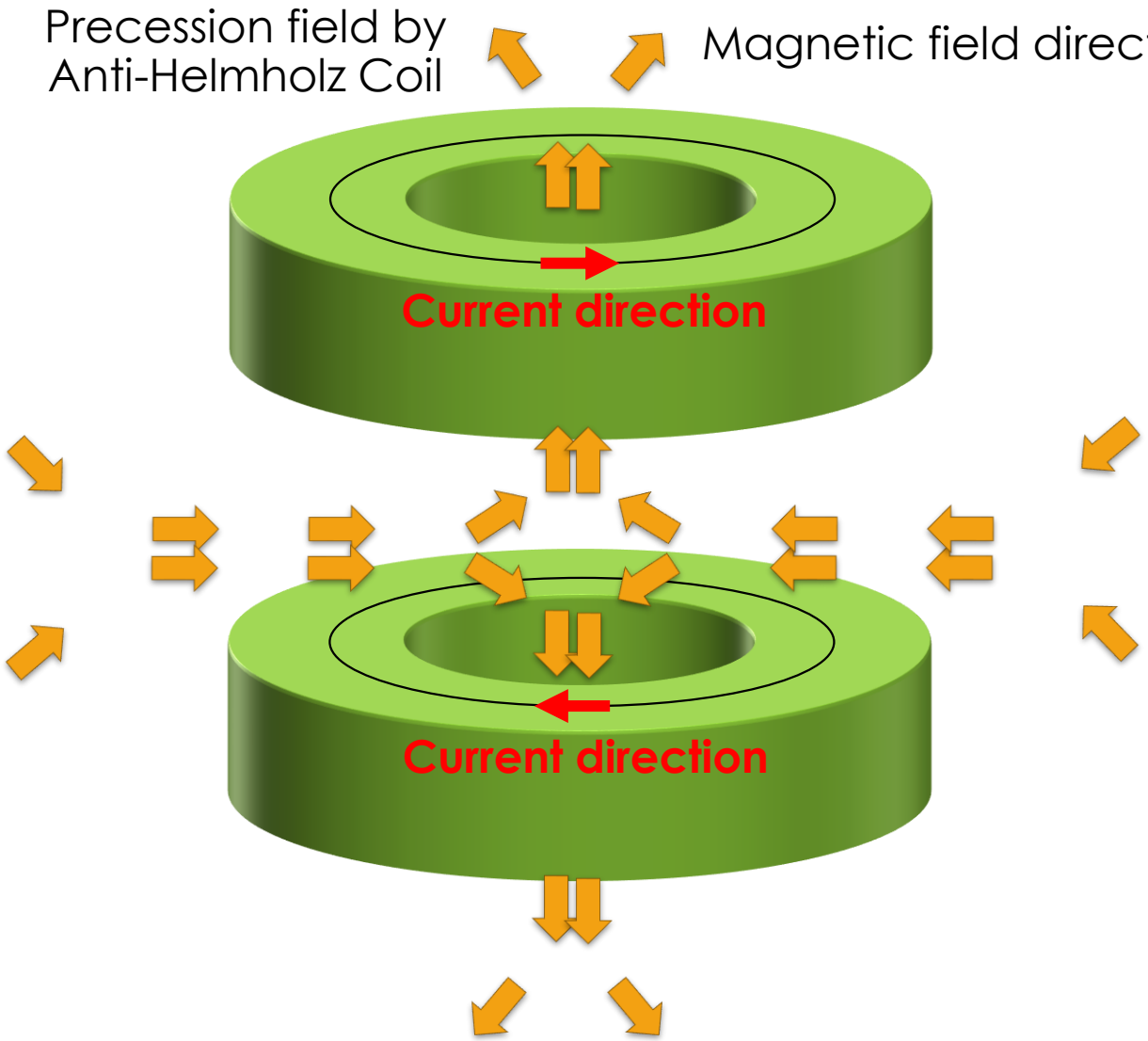


- Neutron's **spin precesses in the field B1 and B2**
- Neutron's energy change can be observed from the polarization of the beam
- Intermediate scattering function, $S(Q,t)$

- Achieving higher energy resolution by high field integrals

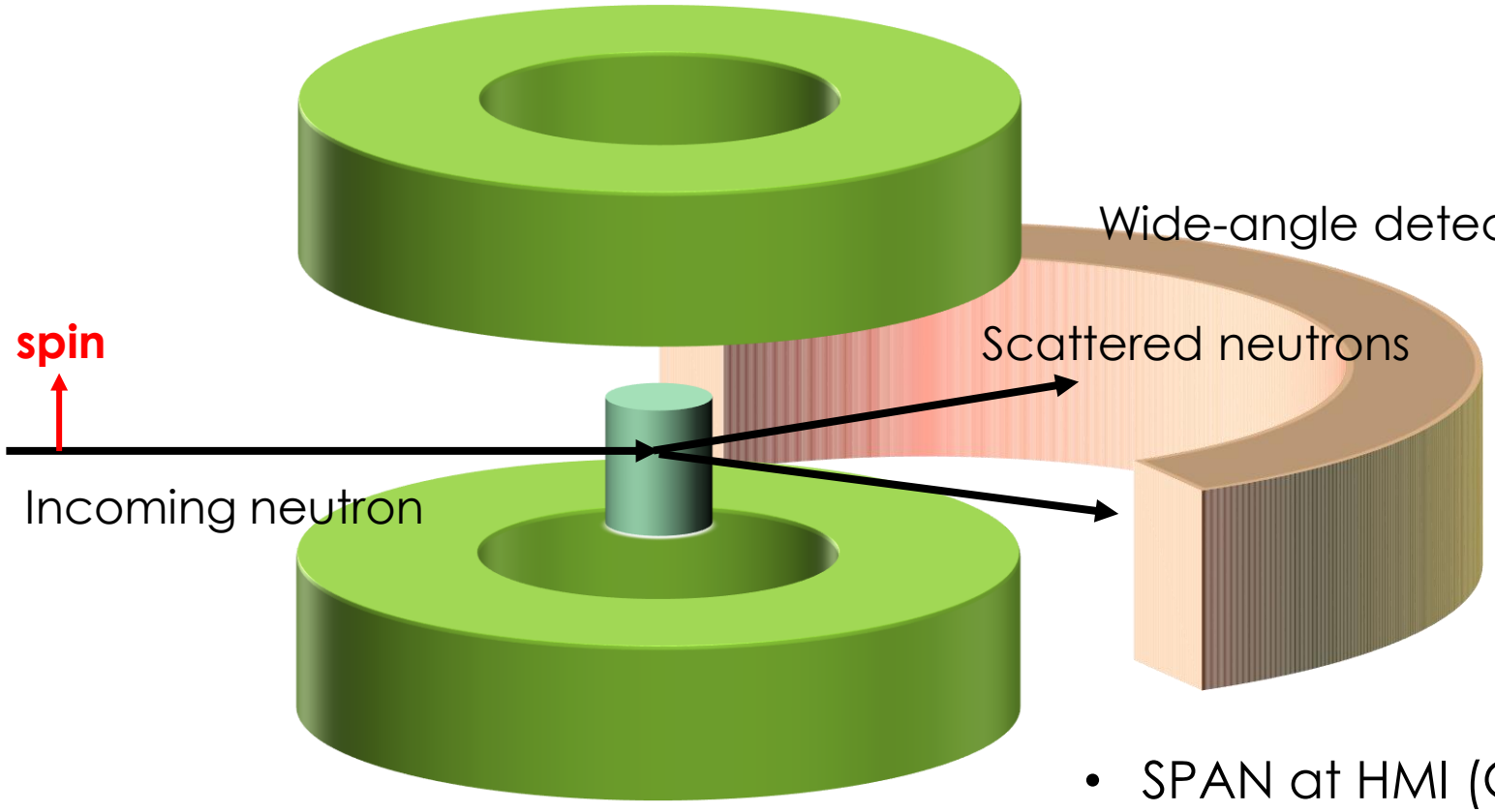
Image from Gardner *et al. Nature Reviews*, **2**, 103 (2020)
Image from Dissertation, Marcus Henning, Eberhard Karls Universität Tübingen (2011)

Wide-Angle Neutron Spin Echo Spectrometer



P. Fouquet, G. Ehlers, B. Farago, C. Pappas, F. mezei, *J. Neutron Res.* **15**, 39 (2007)

Wide-Angle Neutron Spin Echo Spectrometer



SPAN, HMI

WASP, ILL

- SPAN at HMI (Germany) , reactor closed
- WASP at ILL (France) , the only Wide-angle NSE

<u>Nothing like this in U.S.</u>

OAK RIDGE National Laboratory | SPALLATION NEUTRON SOURCE

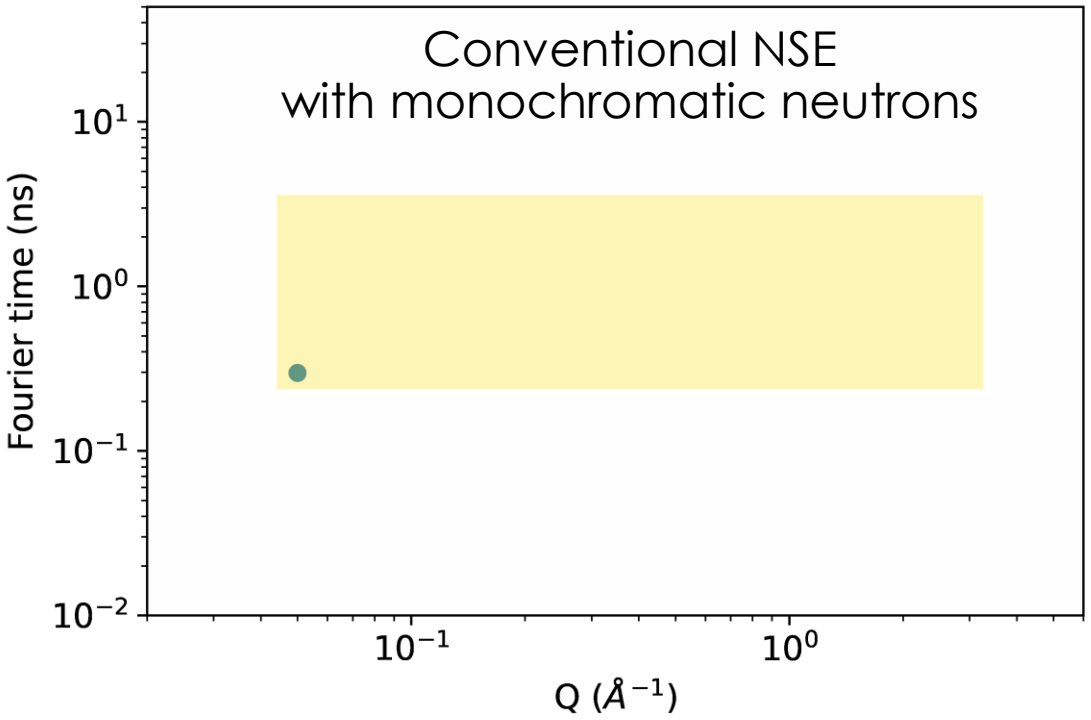
P. Fouquet, G. Ehlers, B. Farago, C. Pappas, F. mezei, *J. Neutron Res.* **15**, 39 (2007)
Photos by courtesy of Dr. Peter Falus (ILL)

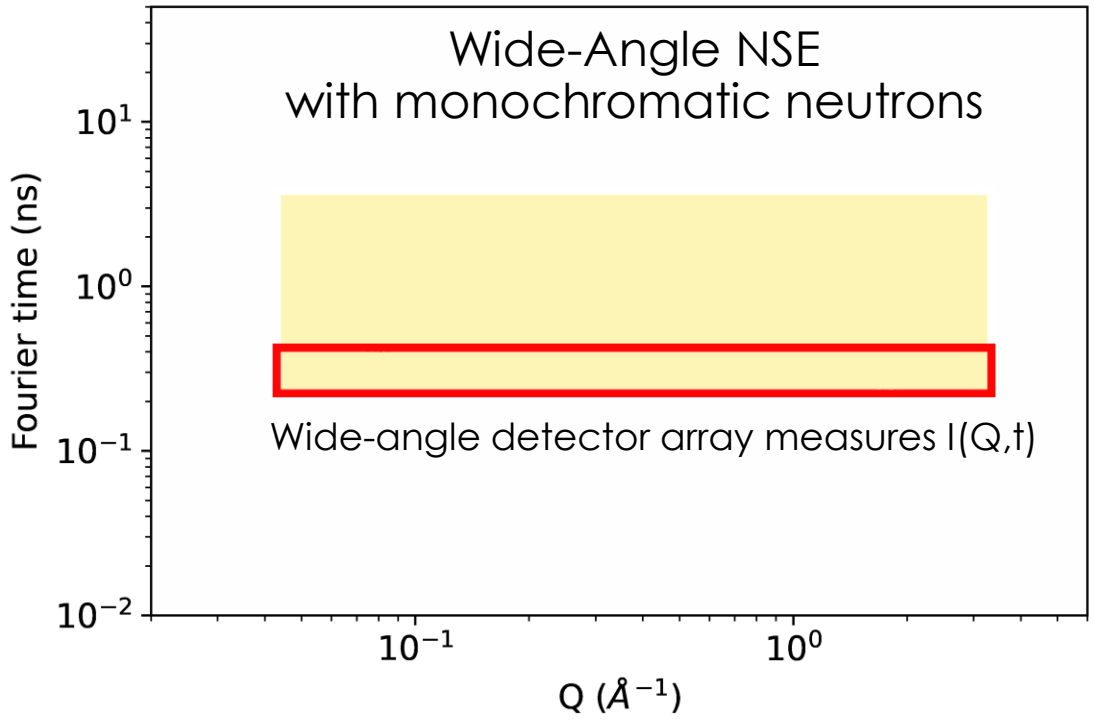
Collecting Data with Wide-Angle Neutron Spin Echo

$$S(Q,t)$$

Wide-Angle Neutron Spin Echo

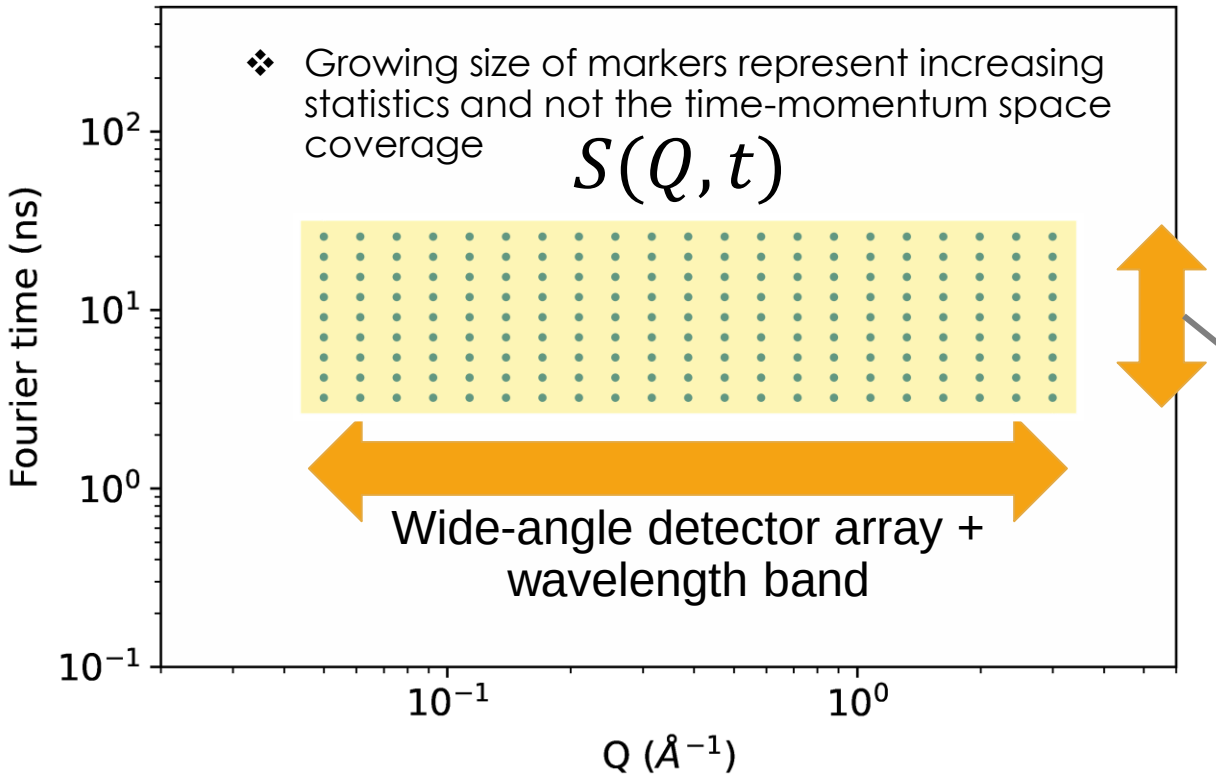
- Limited in resolution (longest possible Fourier time)
- Simultaneous access to wide-q ranges is possible

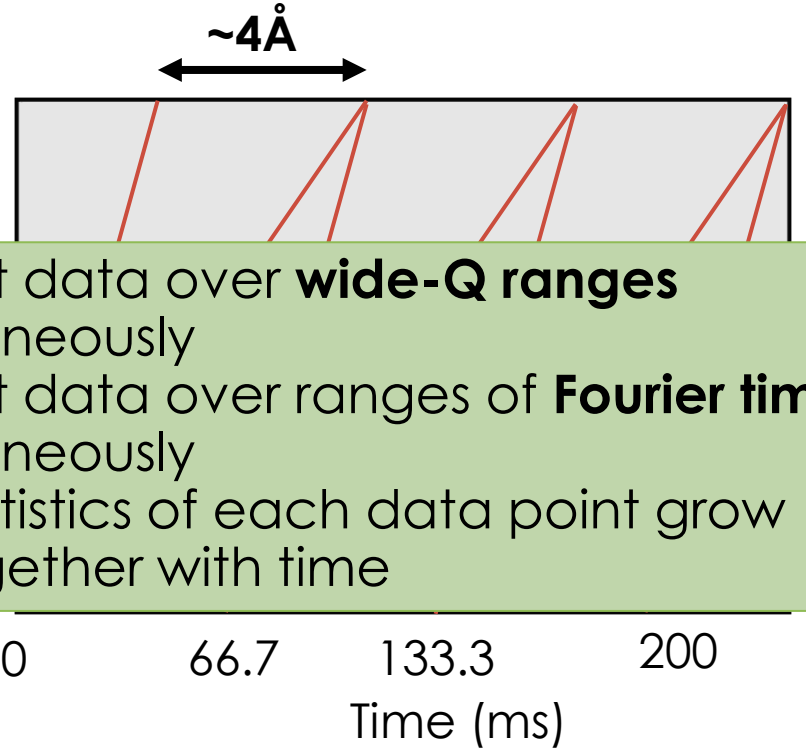




STS + Wide-Angle Spin Echo Spectrometer : **EXPANSE**

- Time-of-flight source (STS) will enable ~4 Å wavelength band
  - Assuming 60m from the source, 15Hz
  - More than a single Fourier time per pulse
  - Ex) For 0.27 T.m field integral,
    - 4-8A wavelength band: 3 ~ 26 ns
    - 8-12A wavelength band: 26 ~ 87 ns





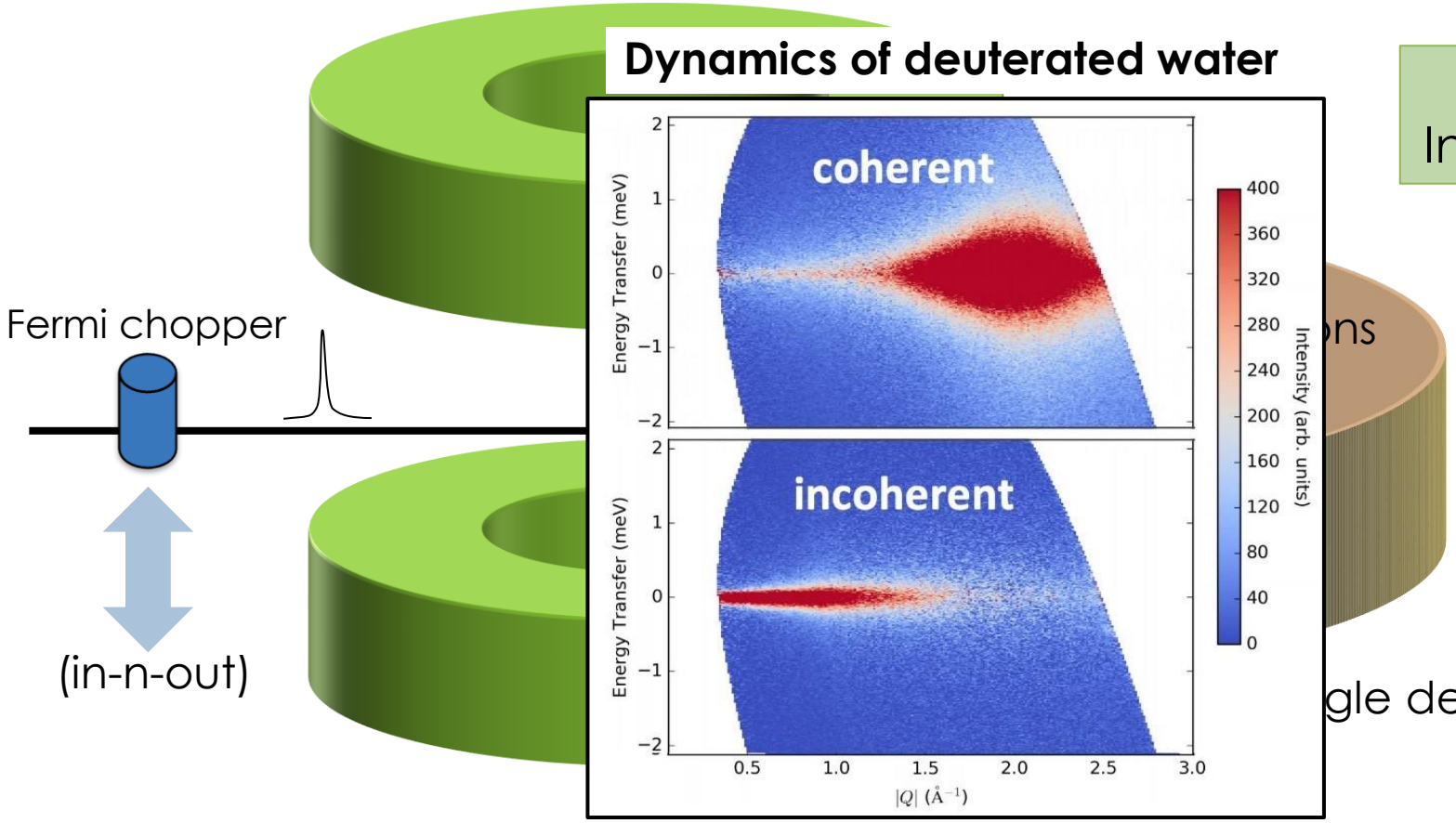
- Collect data over **wide-Q ranges** simultaneously
- Collect data over ranges of **Fourier times** simultaneously
  - Statistics of each data point grow together with time

~4Å wavelength band

- Opens **a new opportunity** for NSE for time-resolved experiments
  - Time scale will still be limited (~hour)

STS + Wide-Angle Spin Echo Spectrometer : **EXPANSE**

- Expand the capability by another level
  - With the **high-speed Fermi chopper**, instrument can be used as a **direct-geometry inelastic neutron spectrometer** $S(Q,\omega)$



Energy resolution 10-300 μeV
Incident energy range 0.5-9 meV

Use of polarized neutrons for Distinguishing

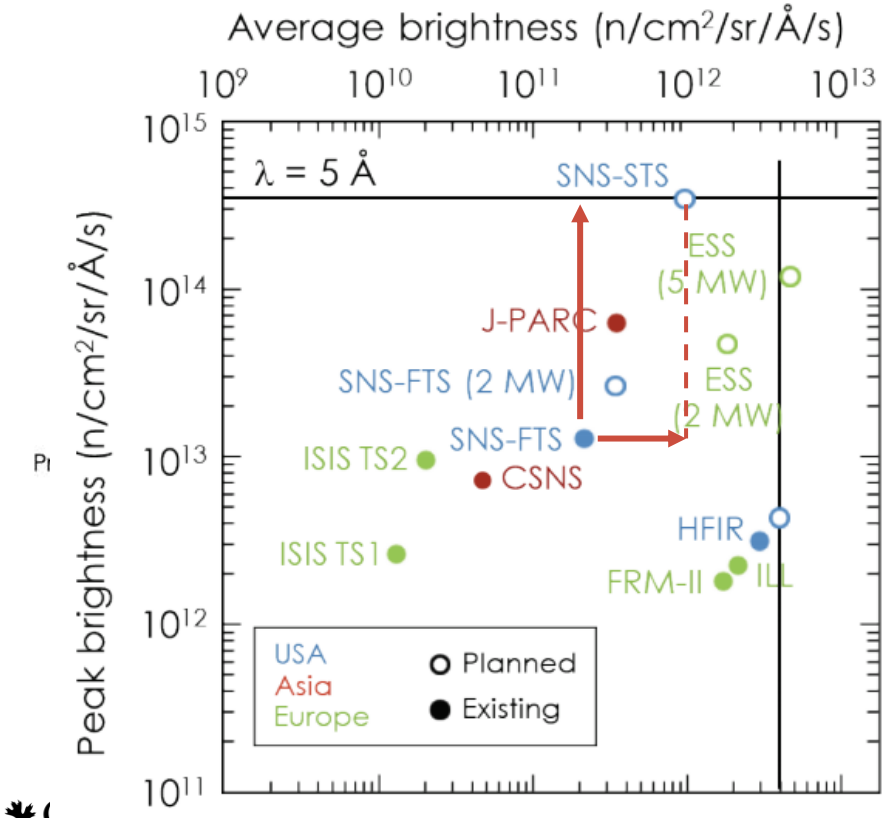
Coherent dynamics
and
Incoherent dynamics

Arbe et. al., Phys. Rev. Research 2, 022015(R) (from LET, ISIS)
https://www.isis.stfc.ac.uk/Pages/SH20_PLET.aspx

EXPANSE at STS

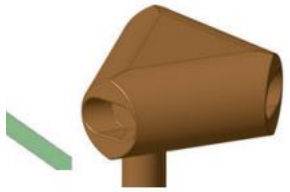
Ideal beamline for EXPANSE
ST-22

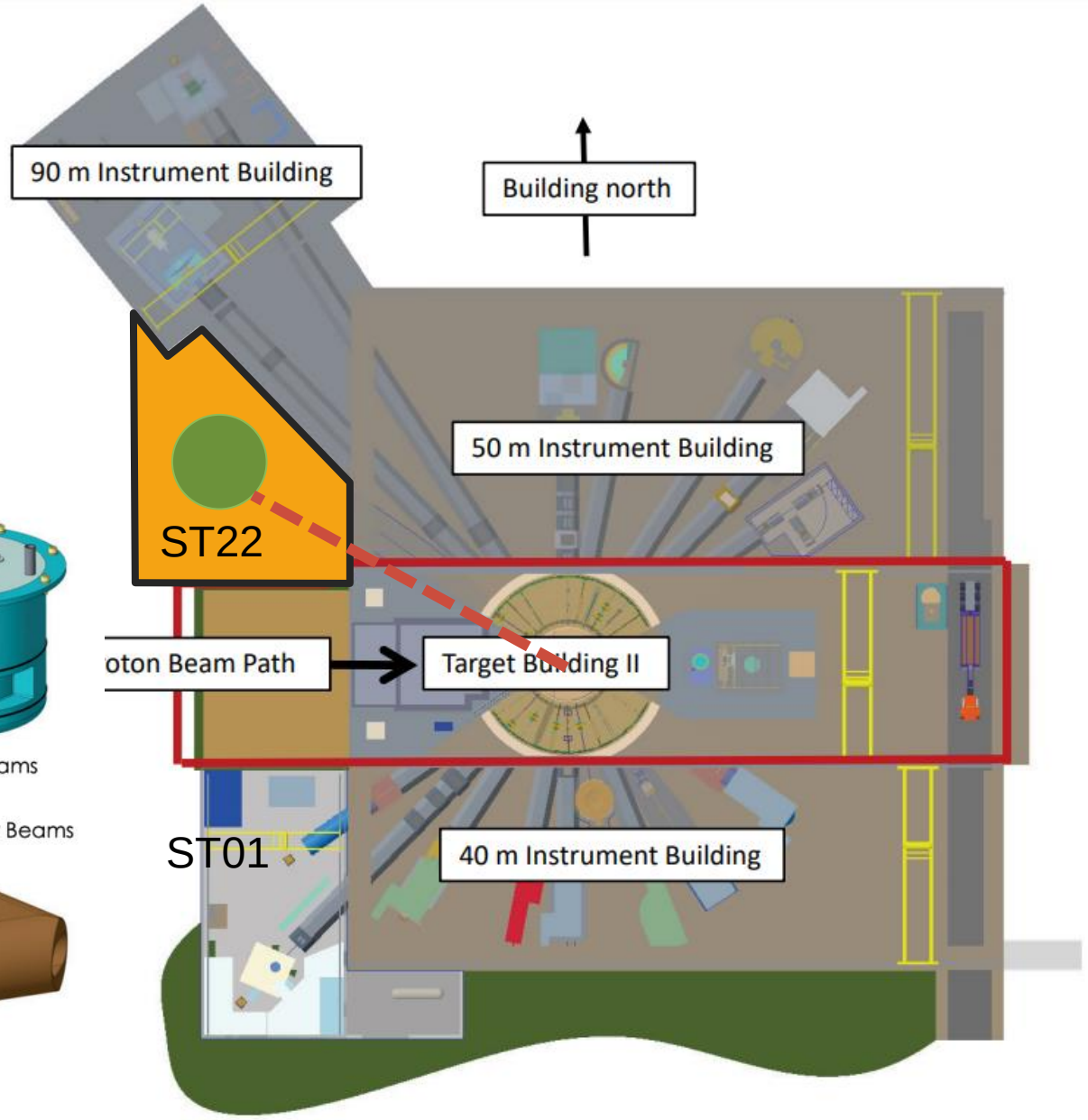
Tube moderator
(better cold neutron flux)



al) Moderator Beams

(Tube) Moderator Beams





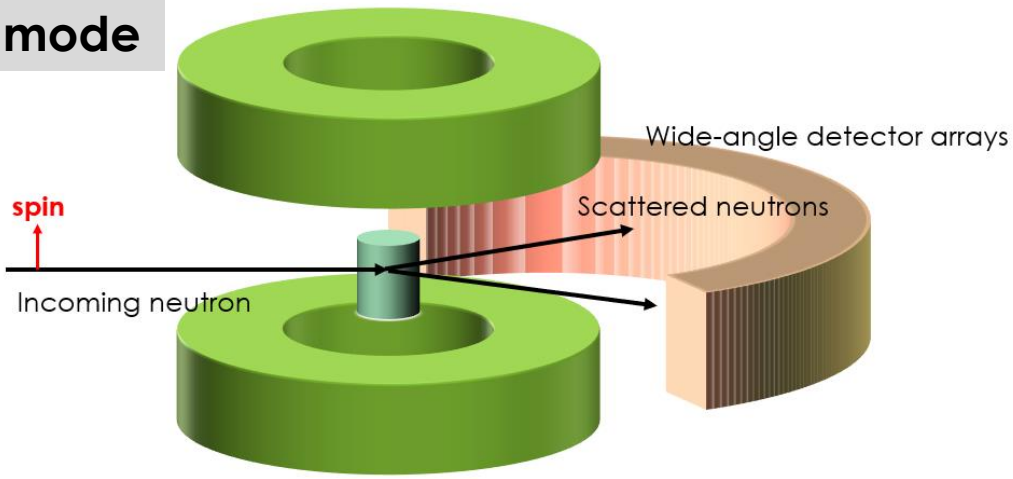
National Laboratory | SOURCE

EXPANSE at STS

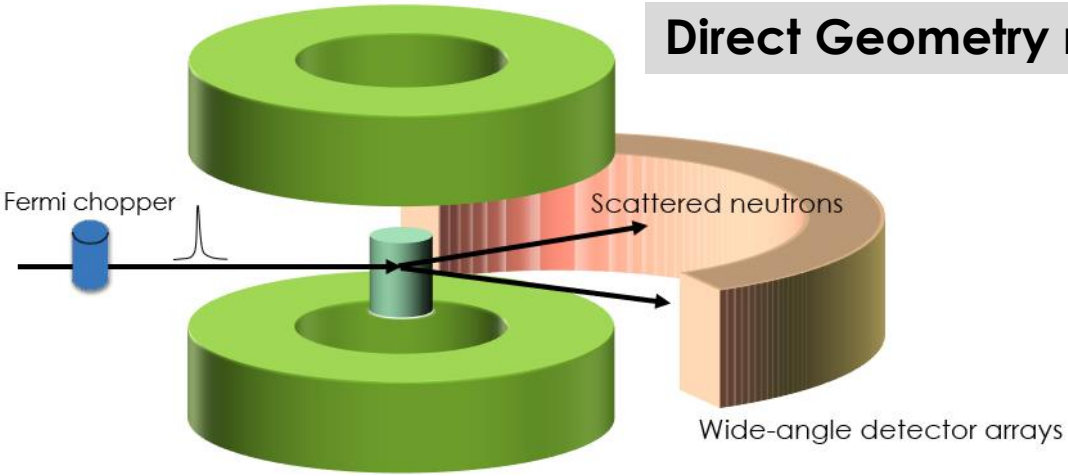
- Collect data over **wide-Q ranges** simultaneously
- Collect data over ranges of **Fourier times** simultaneously

We expand the capability of the instrument by adding a direct geometry inelastic mode to measure S(Q, ω)

NSE mode



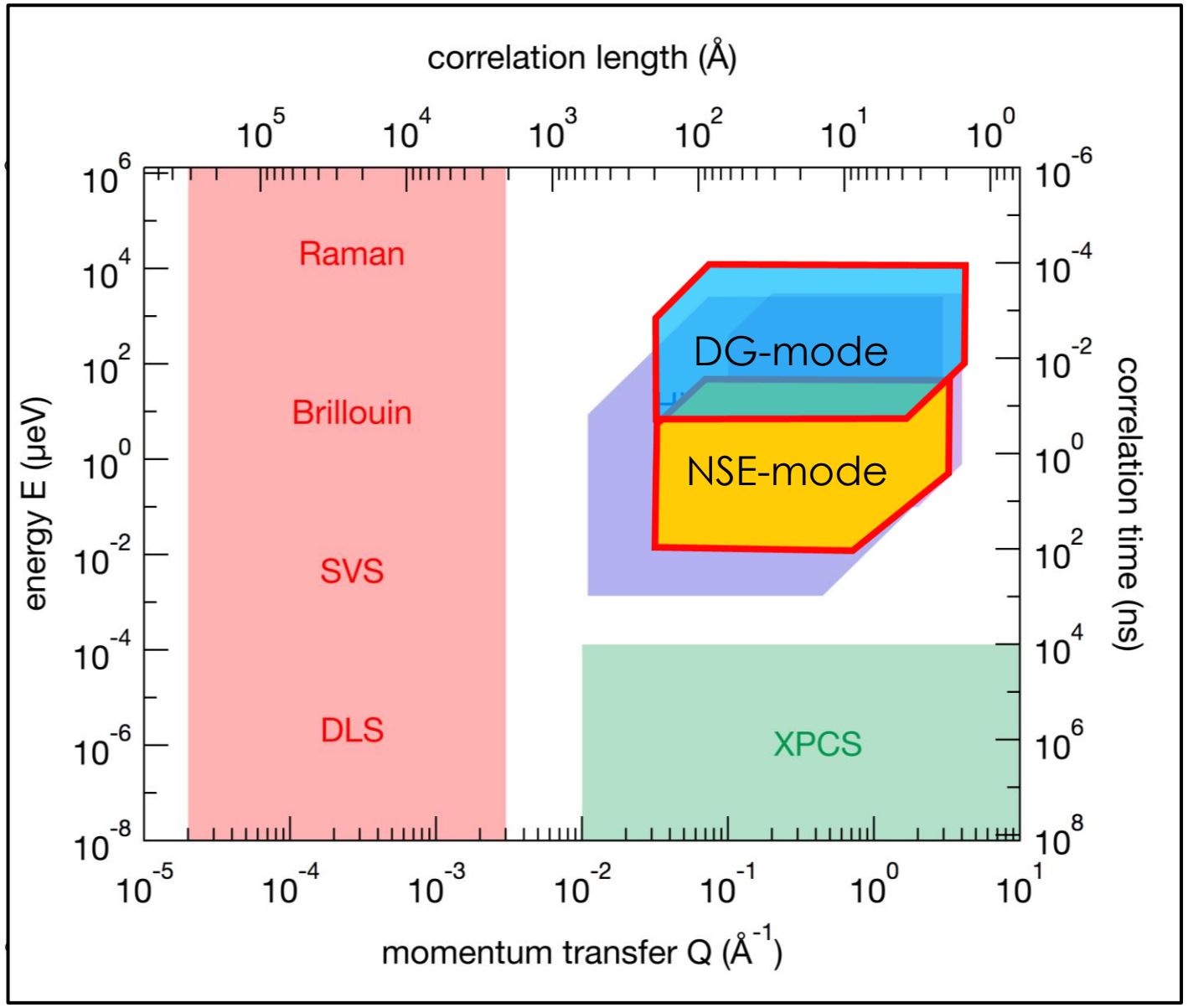
Direct Geometry mode



- Spin-Echo mode: S(Q, t)
  - 0.05 $Å^{-1}$< Q < 3.5 $Å^{-1}$ and 30 ps < t < 90 ns (using 4-12 Å wavelength range)
- Direct Geometry inelastic mode: S(Q, ω)
  - Energy resolution 10-300 ueV with incident energy range 0.5-9 meV

EXPANSE at STS

Beamline 22	Next to 90m building
Available wavelength	4-16 Å
Wavelength band	~4Å (15 Hz)
Incident beam divergence	< 1.5 °
Maximum field integral	0.27 Tm
Detector solid angle	180° x 2.5° array of He3 tube detectors
Momentum transfer range	0.05 – 3.5 $Å^{-1}$
Fourier time range	30 ps – 90 ns (using 4-12Å)
Direct geometry mode	Energy resolution 10-300 μeV Incident energy range 0.5 – 9 meV Corresponds to 0.1ps – 100ps



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