HYSPEC: A High Performance Hybrid Spectrometer for the Single Crystal Studies at the Pulsed SNS

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Managed by Brookhaven Science Associates for the US Department of Energy

HYSPEC IDT

Scientific case

- ❑ *Coherent collective excitations in single crystals:*
  - lattice dynamics (phonons)
  - spin dynamics (magnons, critical scattering)
- ❑ *Structure and dynamics of partially ordered and glassy phases*
  - spin glasses
  - charge glasses
  - correlated amorphous phases
- ❑ *Study of the microscopic physical properties of samples in a variety of extreme environments:*
  - magnetic field
  - pressure
  - temperature
- ❑ *Characterization of spin-dependent cross-sections by means of polarization analysis*

Design constraints

Small samples

Bulky sample environment
- magnetic field
- temperature
- pressure

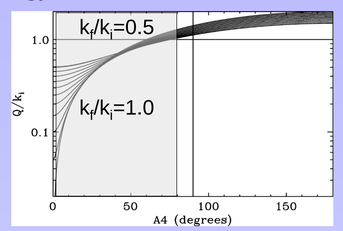
Polarized beam

Secondary flight-path and analyzer performance

Uncertainty of the flight time in the analyzer gives largest contribution to the energy resolution.

Analyzer resolution for the lengths of the secondary flight path L_{SD} = 4 m and L_{SD} = 5 m and for the time burst width (FWHM) at the sample Δt=40 μs

L_{SD}	$\Delta t/t$	$\Delta E/E$
E_f=5.0 meV		
4 m	0.0098	2.0%
5 m	0.0078	1.6%
E_f=14.7 meV		
4 m	0.0168	3.3%
5 m	0.0134	2.6%
Ef=60.0 meV		
4 m	0.0339	6.8%
5 m	0.0271	5.4%



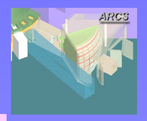
60° - 90° coverage of the scattering angle by detector array gives, for $0.5<k_f/k_i<1$, access to interval in Q where the cross-section typically varies by a factor >2

Moving the analyzer is cost-effective!

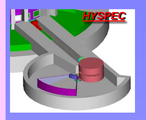
HYSPEC
Winning hybrid technology

Place in the SNS instrument suite

High energy transfer
10-1000 meV Fermi Chopper Spectrometer
- E = 10 - 1000 meV
- Q = 0.1 – 22 Å^{-1}

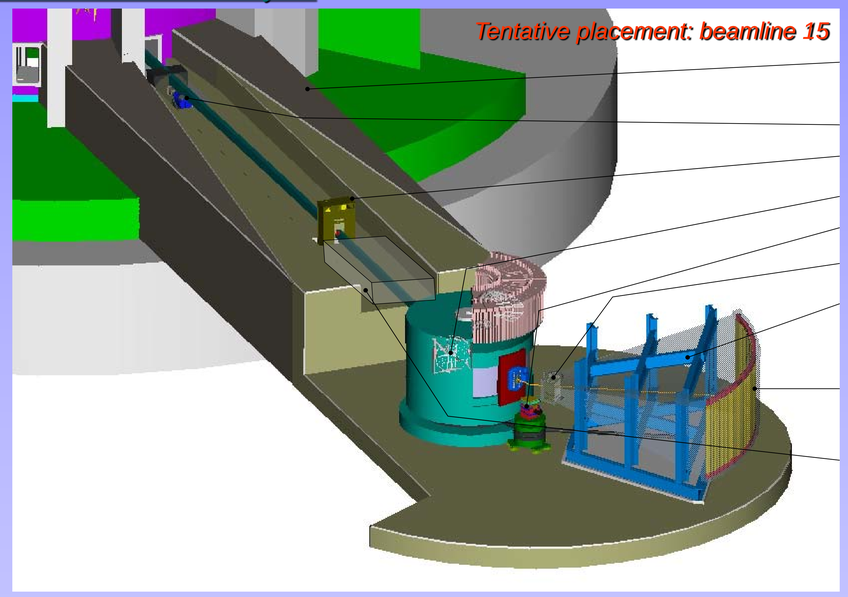


High intensity at moderate resolution and medium energy transfer + polarized beam
Crystal Monochromator Hybrid Spectrometer
- E = 2.5 - 90 meV
- Q = 0.1 – 8 Å^{-1}



High resolution and low energy transfer
10-100 μeV Multichopper Spectrometer
- E = 2 - 20 meV
- Q = 0.1 - 4 Å^{-1}

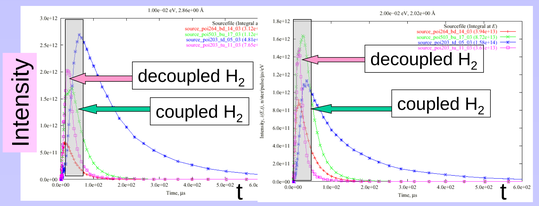
Instrument schematic layout



- *Poured In Place Permanent Shielding*
- *T(0) Chopper*
- *Disk Chopper*
- *Monochromator*
- *Goniometer*
- *Radial Collimiator*
- *Flight Chamber (vacuum or gas-filled)*
- *Detectors*
- *Primary Beamstop Incorporated into the Curved Guide Shielding*

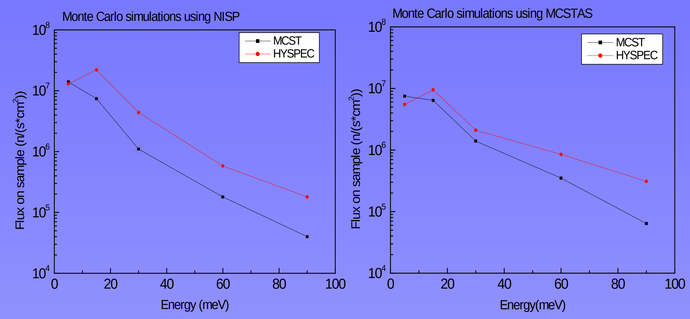
Choice of the moderator

E_i = 10 meV E_i = 20 meV



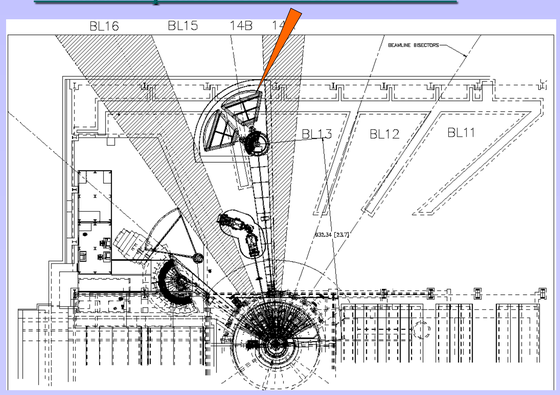
Coupled supercritical hydrogen. Figure of merit is the integral flux within 30-50 μs time window, defined by the length of the secondary flight-path

Primary spectrometer (monochromator) performance



Comparison of the neutron current through 2 cm tall sample provided by the hybrid model (red) and a traditional time-of-flight scheme (black)

Tentative placement: beamline 14B



HYSPEC Instrument Development Team

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Principal features

❑ *High flux on sample: tall neutron guide + efficient vertical focusing by curved crystal monochromator.*

❑ *Low background with bulky sample environments: collimator(s)+slit(s) define scattering volume seen by detector(s) and restrict analyzer acceptance to scattering from sample only. Scattering from cryostat, magnet, pressure cell, etc., is mostly rejected.*

❑ *Polarized beam option: Heusler monochromator for polarized incident neutron beam at E_i = 5 - 100 meV, bender polarizers in the scattered beam for polarization analysis at E_f < 15 meV.*

❑ *Continuous wavevector coverage: all scattering angles are accessible by moving the detector.*

❑ *Flexibility: both energy and wavevector resolutions are easily adjustable; typical resolutions are 1% to 10%. Different crystal reflections may be used for the monochromator to shape the resolution function.*

Why hybrid?

Crystal monochromator is the best focussing device for thermal neutrons
- ***gains a factor 2 or more for E_i>15meV***
- ***shapes resolution function, cutting ugly high-energy tail***

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