HYSPEC: A High Performance Polarized Beam Hybrid Spectrometer at the SNS Beamline 14B

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Science case

- Characterization of spin-dependent cross-sections by means of polarization analysis
- 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 extreme environments:
  - temperature
  - pressure
  - magnetic field

Instrument Development Team

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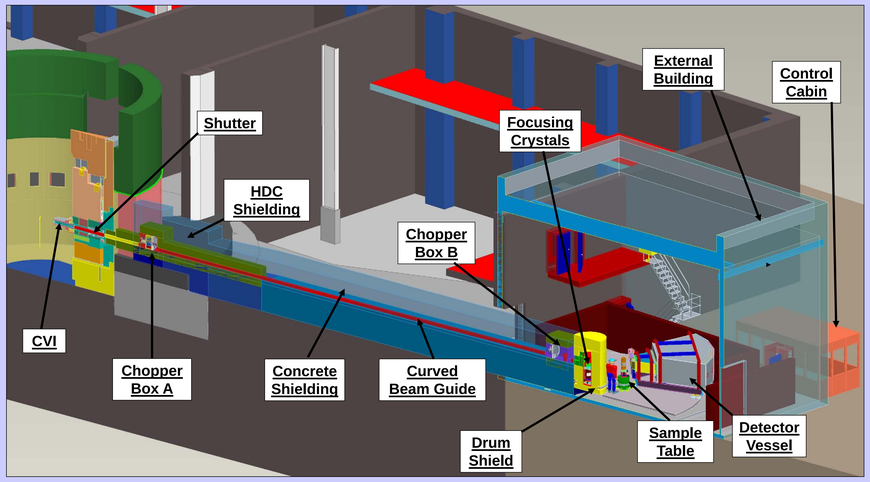
Abstract

The HYSPEC instrument, currently under construction at the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory is a direct geometry time of flight spectrometer that utilizes Bragg focusing optics to obtain a high intensity neutron beam at the sample position for neutron energies in the range $3.6 < E_I < 90$ meV. HYSPEC will also have the capability to perform full polarization analysis in inelastic mode. It is being developed as a collaborative effort of the Instrument Development Team (IDT) composed of scientists from the leading US Universities and National Laboratories and an international group of prominent neutron scattering experts, aimed at designing and building a conceptually new high-flux polarized beam inelastic neutron spectrometer at the pulsed SNS.

HYSPEC BEAMLINE 14B LAYOUT



Description of the beamline setup

◆ CVI and Shutter

The neutrons exit from the face of the 100mm wide x 120mm tall liquid-hydrogen moderator through the Core Vessel Insert (CVI), which does not contain guide but is tapered to allow the beam to expand vertically. CVI was the first HYSPEC element to be installed (September, 2006). In the shutter and the target monolith wall the neutrons are transported by m = 3 supermirror guide, which continues to vertically expand up to a height of 150mm tall at 6.4 m from the moderator. Beyond this the guide is constant at 150mm tall and 40mm wide.

◆ Chopper box A

In the region known as chopper box A two neutron choppers are located. A vertical axis T0 chopper of the same design as used for the ARCS and SEQUOIA beamlines at the SNS operating at 30 or 60Hz is located at 8.5m from the moderator. This chopper reduces the high energy component of the neutron beam. The second chopper is a 60Hz frame overlap disk chopper located at 9.33m which removes the very low energy neutrons.

◆ Curved guide

Following the chopper box A there is a 24m long curved neutron guide, with a radius of curvature of 2.56km, with m=3 supernirror on the top, bottom and the concave inner curved surface and m=2 supermirror on the convex inner curved surface. At the end of the curved guide is the secondary shutter and then chopper box B. The curved guide, the disk chopper in chopper box A, the secondary shutter and the two choppers in chopper box B share a common (windowless) vacuum.

◆ Chopper box B

In chopper box B there are two choppers, a 60Hz disk chopper that is used for order suppression and frame overlap, and a short straight bladed Fermi chopper. The Fermi chopper can operate between 60Hz and 540Hz in 30Hz intervals and is used to select the energy of the incident neutron beam. After the Fermi chopper neutrons continue up to the drum shield housing the focusing crystals array where the guide ends.

◆ Focusing crystals (Non-polarizing and Polarizing)

The neutron beam from the Fermi chopper is vertically focused onto the sample using one of two arrays of crystals. One such array consists of Highly Oriented Pyrolitic Graphite (HOPG) crystals with a mosaic spread of ~48' (ZYB). The other is an array of Heusler crystals in a magnetic frame, which can be used to polarize the neutron beam.

◆ Sample and detector vessel

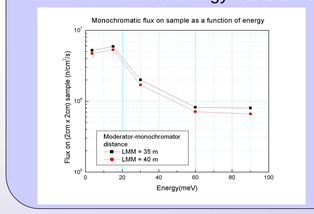
The sample is mounted on a goniometer for orientation and can rotate so as to follow the neutron beam reflected by focusing crystals. Around the sample axis the detector vessel with 60 degrees angular acceptance can be rotated. The detector vessel is filled with Ar gas and contains array of 160 1.2m long vertically oriented ^{3}He LPSD tubes at a distance of 4.5m from the sample.

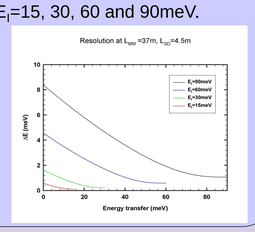
◆ Polarization Analyzer

Scattered beam polarization will be analyzed by a wide-angle supermirror transmission polarizer, which is developed by PSI. As an option, a ^{3}He wide angle transmission polarization analyzer will be available to be installed in front of the detector vessel for polarization analysis of neutrons with energies above 20 meV.

Neutron flux and resolution

The flux at the sample position (in non-polarized mode), obtained from Monte Carlo simulations for two moderator-to-monochromator distances, L_{MM} = 35m and 40m, as a function of the incident neutron energy (left). On the right, the resolution is shown as a function of neutron energy transfer for 4 incident energies, E_I=15, 30, 60 and 90meV.

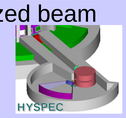




Place among SNS Instruments

- ARCS, SEQUOIA - high energy transfer Fermi Chopper Spectrometers
  - E = 10 -1000 meV
  - Q = 0.1 – 22 Å^{-1}

- HYSPEC – focusing crystal polarized beam spectrometer
  - E = 2.5 - 90 meV
  - Q = 0.1 – 8 Å^{-1}



- CNCS – high resolution disc chopper cold neutron spectrometer
  - E = 2 - 20 meV
  - Q = 0.1 - 4 Å^{-1}

Superior performance for

- Small samples

- Bulky sample environment
  - magnets
  - furnaces/cryostats
  - pressure cells

- Polarized beam

Summary

HYSPEC's planned commissioning in 2010/11 will open open exciting new opportunities for neutron studies of condensed matter systems. For updates and more, check http://neutrons.phy.bnl.gov/HYSPEC.