An Overview of Major North American Neutron Sources

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Major North American Neutron Scattering Facilities

- Intense Pulsed Neutron Source (IPNS) at Argonne National Lab
- High Flux Isotope Reactor at Oak Ridge National Lab
- National Institute of Standards and Technology Center for Neutron Research (NCNR)
- Neutron Program for Materials Research at Chalk River Laboratories (Chalk River)
- Lujan Center at Los Alamos Neutron Science Center (LANSCE)
- Low Energy Neutron Source (LENS) at the Indiana University Cyclotron Facility
- Spallation Neutron Source (SNS) at Oak Ridge National Lab
Information for Users

- Intense Pulsed Neutron Source at Argonne National Lab

- High Flux Isotope Reactor at Oak Ridge National Lab

- National Institute of Standards and Technology Center for Neutron Research

- Neutron Program for Materials Research at Chalk River Laboratories (Chalk River)

- Lujan Center at the Los Alamos Neutron Science Center (LANSCE)

- Low Energy Neutron Source at Indiana University Cyclotron Facility (LENS at IUCF)
  [http://www.iucf.indiana.edu/materialscience.shtml](http://www.iucf.indiana.edu/materialscience.shtml)

- Spallation Neutron Source (SNS) at Oak Ridge National Lab
  [http://www.sns.gov](http://www.sns.gov)
IPNS Mission and Metrics

IPNS – The first user-dedicated accelerator-based neutron source in the world, commissioned in 1981. 8 billionth pulse delivered April 2004

- 400 experiments, 240 users, 150-200 publications per year
- Improvements will increase user base
  - 75% of time available to users
  - Proposal calls every 6 months
  - 95% operational reliability
  - 10 instruments in user program (13 available)
  - 26 weeks of operation
  - User friendly
  - 3-4 personnel/instrument
  - Limited travel funds available
  - New users welcome!
  - www.pns.anl.gov
IPNS Completed Upgrades

GPPD - world-class diffraction, 25m flight path, supermirror guide (gain factor x6), frame-definition chopper, data collection in 1 minute

SASI (formerly SAD) - larger area detector, new DAS and scattering tank

QENS - simultaneous collection of quasi-elastic, inelastic, and diffraction data, supermirror guide (gain factor x2.5)
Pending and On-going Upgrades

SCD - new detectors and DAS have been installed, tests of focusing optics (~100 gain in 200µm spot), polarization tests (90% polarization of 3Å neutrons)

Spin echo- small angle scattering instrument, 1st of its kind in US

SEPD, new collimators, guide and detectors will optimize this diffractometer for magnetic, parametric studies.
IPNS Additional Capabilities

New Ancillary devices:
- 7T Magnet
  1.5K - T - 300K
- Convection Cryofurnace
  In construction
  20K - T – 600K

intensity boost of 2.5 for small angle diff. and reflectometers due to new coupled solid methane moderator

ISAW display of 90 diffraction patterns from the catalyst reactor cell mounted in GPPD showing changes in a catalyst while on-stream
The CNS is the only high-flux reactor-based source of neutrons in the US with 85 MW of power

- Stations for 15 beams
- Current upgrades/installation
  - Cold source and guide hall
  - Larger beam tubes for thermal instruments (complete)
  - Improved triple axis instruments (3 in user program) with new data acquisition software (SPICE)
  - Four new and upgraded instruments in ‘04 (one currently commissioning)
- Expanded user program begun 2003

CNS Scientific Program

- Structure and dynamics of materials
- Large scale structures
- Instrument design and development
Cold Source and Guide Hall

- 17,000 sq. ft. guide hall – completed in 2003
- Includes 2 new labs and 2 shops

- New LH$_2$ cold source
- Complete installation - 2005
- Commissioning - 2006
Thermal Neutron Instrumentation

HB-1

HB-1A (Ames Lab)

- US/Japan Wide Angle Neutron Diff. (HB-2C)
- Residual Stress (HB-2B, partnering with ORNL Center for Residual Stress)
- Reflectometer & SNS Test Station HB-2D

HB-2 instruments

HB-3

• 3 triple axis instruments in user program now
• > 3 times flux gain due to upgrades

Powder (HB-2A) and Single Crystal (HB-3A) Diffs. (2005)

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY
Cold Instrument Guide Hall

Instruments commissioning in 2006

- SANS I and SANS II
  - tanks (delivery Aug. ‘04)
  - Guides and enclosures received
  - 1-meter 2-d SANS detectors tested

- Reflectometer

- US/Japan cold triple axis (partnering with BNL)

- SANS II built with ORNL Center for Structural and Molecular Biology
Instrument Installation Schedule

HFIR Center for Neutron Scattering

2003
2004
2005
2006
2007
2008

HB-1A
Triple-Axis
Spectrometer
Low-energy excitations, magnetism, structural transitions

HB-2A
Powder Diffractometer
Structural studies, magnetic structures, texture and phase analysis

HB-2C
WAND
Diffuse-scattering studies of single crystals and time-resolved phase transitions

HB-2D
Residual Stress Spectrometer
Medium-energy excitations in small or weak scattering samples

HB-2E
SANS
Polymer blends, flux lattices in high-Tc materials, soft materials processing and structure

HB-3A
Four Circle Diffractometer
Small unit-cell crystal structural studies, particularly H-bonding

HB-3B
High-Resolution Spectrometer
Medium- and high-resolution inelastic scattering at thermal energies

HB-4D
Nuclear Physics
Fundamental nuclear physics

CG-1
STAR
Highly correlated electronic systems, quantum magnetism, molecular and nanocluster magnetic systems

CG-2
SANS
Biomaterials, pharmaceuticals, polymers

CG-3
SANS

CG-4A
USANS
Colloids, polymers, nanoclusters

CG-4B
Reflectometer
Thin films, interfaces and surfaces, liquid crystals, biomembranes, surfactants

CG-4C
U.S./Japan Cold Triple-Axis
Highly correlated electronic systems, quantum magnetism, molecular and nanocluster magnetic systems, superconductivity

Cold Source Refrigeration Unit

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY
In 2003 there were 1928 Research Participants from >150 universities, 41 US corps., 31 US govt. labs, 19 NIST divs. & off.
Cold Neutrons for Biology and Technology

Consortium:

AND/R
- vertical sample reflectometer
- biological membrane research
- polarized neutron capability
- 2-D position sensitive detector (off-specular reflection capability)
- $10^{-8}$ reflectivity capability

DOPC 1000 layers
Maximize instrumental efficiency
• World’s most intense monochromatic cold neutron beam
• Maximize solid angle and efficiency of detection system

Structure of fluctuating systems
• Colossal magnetoresistance (CMR)
• Quantum magnets and spin chains

MACS: Multi-Analyzer Crystal Spectrometer

20 channel analyzer system
Future Directions for Instrumentation at the NCNR

Optimize for Focused Regions of $Q$-$\omega$
- MACS (double-focusing, under development)
- Thermal 3-axis (double-focusing, polarized beams)

Utilize Broad Wavelength Bands
- Spin Echo ("3-axis", large analyzer areas, resonant methods)
- "MAGNIFIER" (multi-wavelength reflectometer)
- Laue Diffraction
- Neutron Imaging

BT7 3-axis
Photo: 5/26/04
NRU REACTOR: a multipurpose facility

Canada’s neutron source is the NRU reactor at Chalk River Laboratories

- NRU began operating in 1957
- Multi-purpose thermal neutron source ($120 \text{ MW}_{\text{th}}$)
  - Production of medical isotopes
  - Testing of components for nuclear power stations
  - Neutron scattering experiments on materials of all kinds
- Flux $\sim 3 \times 10^{18}/\text{m}^2/\text{s}$
- On-power fuelling: 80% availability
- Continuous proposal process

http://neutron.nrc.gc.ca
• 5 Existing Thermal Neutron Spectrometers
• 2 under development
  – Reflectometer
  – Low Angle Scattering Instrument with 2D detector
The Future: Canadian Neutron Facility

Options under evaluation by NRC

“An opportunity for governments to invest strategically in Canada’s infrastructure for science and industry.”

A multi-purpose neutron source with power and flexibility to meet the needs of the next 40 years.

http://www.cnf.gc.ca
Lujan Center at the Los Alamos Neutron Science Center

- operation: 8 months per year
- 2 proposal calls per year

- Four new & two rebuilt scattering instruments:
  FPs 1, 2, 4, 11, 15, 16
NPDF: Neutron Powder Diffractometer
Optimized for Pair Distribution Function analyses

- High resolution: $\Delta d/d \sim 0.15\%$ in backscattering
- Environment: 10-700 K
- Typical data-collection time: 2 hours
  > 1000 data sets collected in 2002-03
- Upgraded (from NPD) completed 9/27/2002 in only nine months
- Funded in part by NSF in consortium of 5 universities

160 PSDs in backscattering
124 SED tubes at 90°
Low-angle detectors in future

Instrument scientist: Thomas Proffen
tproffen@lanl.gov

ACAnewsletter, Summer 2003
ASTERIX – Polarized-beam Reflectometer – New in 2002 (with 11T applied field capability)

- Polarized and non-polarized beam operation
- Vertical sample geometry (SPEAR reflectometer – horizontal)
- Range of reflectivity down to $1 \times 10^{-7}$
- PSD accumulates both specular and non-specular reflectivity
- First in US with polarized beam at 11 T

Mike Fitzsimmons, Instrument Scientist
Upgrades at LANSCE and the Lujan Center 2005-2010

• “LANSCE-R Project” will revitalize the accelerator for life extension, higher reliability, and enable future advanced spallation sources
  – ca $100M beginning in FY07
  – Funded by NNSA
• “LANSCE Capability Upgrade Project” will enhance sources at LANSCE for neutron scattering and fundamental physics
  – Ca $200M beginning in FY09
  – Partnerships being sought
• Instruments under consideration
  – New: Backscattering Spectrometer
  – New: IN500 (feasibility test underway)
  – New: LAPTRON (High P Diffraction and Radiography)
  – Upgrade: Single crystal diffraction, Small-angle
An Overview of Major North American Neutron Sources

Major North American Neutron Scattering Facilities

Acknowledgements

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