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Status of the Intense Pulsed Neutron Source (IPNS)

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Abstract

IPNS operates its user program 25 weeks/year and has a call for proposals every 6 months for 11 instruments. A significantly upgraded quasielastic neutron spectrometer (QENS) was commissioned in 2000. An enhancement plan that would approximately double the scientific throughput of IPNS was recently reviewed and highly recommended to an advisory committee of the Department of Energy, the funding office for IPNS. IPNS has lead responsibility for neutron scattering instruments for the Spallation Neutron Source (SNS) being built at Oak Ridge National Laboratory (ORNL). We also have the lead role in developing a proposal for a long wavelength target station (LWTS) for the SNS, including instruments, to be submitted in January 2001 to the National Science Foundation.

1. User Program

There are currently 11 instruments in full user mode and 2 instruments with less user support, but active scientific programs. IPNS operates 25 weeks with just over 200 users coming to IPNS for one or more experiments each year. Proposals are solicited every 6 months, with 75% of the beam time for most instruments allocated by a Program Advisory Committee. The 36th round of approved user experiments will begin in Jan. 2001. The over-subscription ratio remains at more than 2.

IPNS User Statistics

Fiscal year	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**00**
Number of experiments performed	257	323	330	273	210	248	281	279	320	353	384	328	397
Visitors to IPNS for at least one experiment:													
Argonne	57	60	61	60	53	48	49	55	58	60	66	65	68
Other govt. labs	18	16	19	15	14	18	13	16	18	29	33	21	21
Universities	89	94	120	92	62	64	63	83	85	91	97	93	103
Industry	20	24	36	18	20	16	15	12	7	6	6	6	10
Foreign	12	26	18	27	14	25	32	33	33	42	23	23	28
	201	220	254	212	163	171	172	199	201	228	225	208	230

The IPNS accelerator system has maintained its excellent (≥ 95%) reliability, with improved operation in recent years. Reliability and average current figures are shown below. Key to the outstanding reliability is the ability to identify subsystems that are responsible for down time. Also shown below are historical records of time lost for various systems. It is clear that attention given to those systems most responsible for lost time resulted in improvements.

Over the past two years there were two unscheduled changes in the target-moderator system: a target was replaced in April 1999 (275 mA-hrs on old target, and all three moderators were changed out during Summer 2000 (two solid-CH_4, one liquid-CH_4). All changes were carried out with minimal lost time. At the time of the moderator change, an automated anneal system was installed for the solid-CH_4 moderators; this will allow annealing on a schedule dictated by the needs of instruments rather than the availability of technical personnel.

2. Recent Meetings Organized by IPNS

IPNS continues to run one of the most active user programs at a U.S. neutron scattering source and to foster scientific interactions with the user community, as evidenced by the many meetings organized by IPNS in the past three years:

Workshop on Chemical Spectroscopy, Protein Folding, and Polymer Dynamics, ANL (Oct. 10-11, 2000)

Structure, Dynamics & Charge Transport in Polymeric Materials, ANL (June 19-23, 2000)

Workshop on Long Wavelength Powder Diffraction, ANL (May 12, 2000)

Workshop on Magnetic Neutron Scattering, ANL (April 27-28, 2000)

SNS-LWTS Workshop, ANL (Jan. 24-27, 2000)

Workshop on Inelastic Neutron Scattering, ANL (Nov. 1, 1999)

Workshop on Disordered Materials, ANL (Oct. 16-17, 1998)

Workshop on Advanced Materials for Extreme Environments: New Experimental Opportunities in Neutron Scattering, ANL (Sept. 11-12, 1998)

SNS-ORNL Workshop, ANL (June 1998)

ICANS XIV, Starved Rock Lodge, Utica, IL (June 14-19, 1998)

3. Instrument Upgrades underway

IPNS has a program of continuous instrument upgrades. Activities since the last ICANS were focussed on QENS and HRMECS.

QENS – An upgrade, representing a complete re-construction of the original instrument, was completed in 2000. Enhancements include expanded analyzer and detector coverage, improved energy resolution, expanded Q range (x3), and higher data rate (x5). The inclusion of LN_2 cooling of Be filters, now underway, will give an additional factor of x2 in data rate, with a total gain of 10 times. QENS is a crystal-analyzer inelastic scattering instrument with 90 μeV elastic scattering resolution and inelastic scattering resolution of approximately 3-4% of the energy transfer. QENS is useful for quasielastic scattering measurements that determine the diffusion rates of both molecular rotation and translation on the typical time-scales of simple liquids, adsorbates etc. The momentum transfer range (0.5-2.5 $Å^{-1}$) probes length scales ranging from about 1-10 Å, typical of molecular rotation and translation. QENS is also capable of measuring vibrational excitations up to a few hundred meV, providing access to both external and internal vibrational modes for hydrogenous systems.

HRMECS – A major upgrade is nearly complete, and will give HRMECS full detector coverage from -20 to +140°, with Linear Position Sensitive Detectors (LPSDs) at low scattering angles. HRMECS now generates S(Q,E) data in Q and E ranges for which it was originally designed. LPSDs at low angle make possible the study of collective motions and relaxation processes of atoms in glasses and liquids by neutron Brillouin scattering over a wavelength regime inaccessible by light scattering and dielectric spectroscopy. Improved Q resolution allows determination of spectral features in S(Q,E) such as Fermi-liquid-like exponents in strong-correlation systems, Haldane gaps in one-dimension Heisenberg antiferromagnets, and flux lattice dynamics in superconductors.

3. IPNS Enhancement Project

IPNS is proposing a program to enhance the productivity of IPNS and expand and broaden the user community for SNS. Plans include increasing operation, significant instrument enhancements, an accelerator upgrade and maintenance program, an expanded research program in MSD coupled with the instrument improvements, and direct funding to universities for enhanced collaborations. Elements of this plan are highlighted below:

Accelerator upgrade and maintenance - IPNS accelerator systems continue at the remarkable level of 95% reliability, but have not had proper funds or effort to maintain and upgrade the aging facility. Accelerator improvements and proper levels of spare parts would increase the proton current by 30% and are necessary to maintain the 95% reliability for at least the next ten years. A program of replacing and upgrading equipment will phase in over several years, as existing spares are expended or failed units replaced with new. Critical components will be acquired in the first couple of years to support increased operation, and then replacements completed over the succeeding years before existing spares are exhausted.

Target/moderator/reflector improvements - We have evaluated the prospect for increasing the intensities of all neutron beams by replacing the present H_2O coolant with D_2O and the present inner graphite reflector with beryllium. Calculations indicate 20-30% gains. Appropriate beryllium parts are on hand, which will require machining to required shapes. A new "clam shell" design will facilitate changes in the moderators as this is periodically necessary, and enable reuse of the reflector, contrary to practice with the graphite which must be replaced each time. Minor changes to the cooling circuit will preserve D_2O.

We will evaluate the benefits of changing the “C” solid methane moderator to a "coupled" configuration, with substantial gains for SANS instruments. This depends on successful implementation of means for trimming the resulting long-time tail on the pulses in the two reflectometers, through use of “Drabkin” filters. The beryllium, D_20 and moderator improvements will result in no penalty for instruments and will multiply those gains from the accelerator improvements discussed above.

Additional operation - Increasing IPNS operation from the current 25 weeks/yr. to 30 weeks/yr. requires additional scientific staff, scientific support, accelerator staff, M&S and electricity. This buildup can be achieved very quickly and will almost immediately increase scientific throughput by 20%.

Instrument Enhancement - Taken together, this project will lead to a large increase in scientific capabilities at IPNS. Increased data rates will allow us to serve more users and carry out more demanding experiments. Instrument modifications will provide scientific capabilities not previously available, in anticipation of the needs of future SNS users. Many of these enhancements simply involve purchase and installation of “off the shelf” equipment, and so entail little or no technical risk. This development plan will address all aspects of the IPNS facility felt to be amenable to improvements that are cost-effective and capable of yielding tangible gains in the short-term. These gains will be in scientific throughput (more science) and new scientific capabilities (new science).

Typical data rate gains, which multiply those gains discussed above, anticipated for scientific problems addressed by the enhancement plan are:

Instrument	Projected Gain	Instrument	Projected Gain
GPPD	5	LRMECS	6
SEPD	9	HRMECS	2
GLAD	2	QENS	32
HIPD/Midas	12	SAD	9
SCD	6	SAND	3

This will result in new scientific capabilities:

- Full S(Q,E) measurements on single crystals, glasses and liquids
- Polarized neutron SANS studies of magnetic nanostructures
- SANS on polymer and magnetic thin films
- Parametric studies on single crystals
- Powder diffraction studies of complex materials, e.g., pharmaceuticals
- Dynamics of low-dimensional magnetic systems
- Diffuse scattering
- Magnetic structures and large cells
- Increased detail for probing in magnetic layers and interfaces

4. Neutron / X-ray School (at ANL)

During the two-week period of August 14-26, 2000 Argonne National Laboratory once again hosted the National School on Neutron and X-Ray Scattering funded by the DOE. The success of the previous year was so overwhelming that additional funds were provided by DOE to increase the size of the school from 48 to 60 graduate students. Additional funding was provided by the National Science Foundation. This school fulfills a continuing need for training graduate students in the utilization of national user facilities, and it is our intention to offer this course at Argonne in the future. To that end, many students from last year's school are currently utilizing national user facilities not only at ANL but also throughout the country.

The formal program included 32 hours of lectures given by an internationally known group of scientists recruited from universities, national laboratories and industry.

The scope of the school was formative with a robust background of scattering theory presented by Sunil Sinha, as well as lectures given on x-ray instrumentation (Michael Hart) and neutron instrumentation (Thom Mason). Jim Rhyne spoke extensively regarding access to neutron facilities, in his role as President of the Neutron Scattering Society of America. Hands-on portions of the school were quite extensive. Initially, computer based training was emphasized in order to provide genuine exercises in the complementarily of real and reciprocal space. Students had extensive tours of the Advanced Photon Source (APS) and IPNS, followed by experiments at these facilities. Experiments were designed to demonstrate the diverse properties of neutrons and x-rays as manifested by scattering experiments. The program included experiments in either "soft matter" (neutron reflectivity, SANS, and EXAFS), in "materials science" (neutron powder diffraction, standing waves and x-ray reflectivity) or solid state physics (single crystal x-ray diffraction, inelastic neutron scattering and inelastic x-ray scattering). Implementing the practical aspects of the program for 60 students was an enormous coordinated effort. More than forty instructors, from APS, IPNS, SNS, Materials Science and Chemistry Divisions at ANL, and several Collaborative Access Teams (CATs) at APS gave generously of their time.

We are proud to report that from all indications, both verbal and on the written survey form, the students ranked the components of the school quite favorably and indicated their intention of returning to ANL or other national user facilities. It is our intention to hold the school again in the summer of 2001.

6. IPNS Involvement with the Spallation Neutron Source (SNS)

SNS, a 2 MW spallation neutron source, is under construction at ORNL and is scheduled for competition in 2006. Argonne has lead responsibility for the neutron scattering instruments and a team of approximately 50 scientists, engineers and designers has been formed under the leadership of Kent Crawford (Associate Division Director at IPNS). Scientists are being hired by ORNL to work at IPNS during the R&D, design and procurement phases of the instruments; moving to ORNL with the instruments. Based on the fact that IPNS is the DOE's most active pulsed neutron user facility and technology center, we will continue the role of training the user community as we will lead the development and construction of neutron scattering instruments.

ANL scientists are deeply involved in the development of a proposal for construction of a second target station at SNS. If successful, this construction project would be funded by the U.S. National Science Foundation (NSF). IPNS and Materials Science Division (MSD-ANL) scientists co-organized numerous workshops defining the scientific case, and engaged in conceptualization and preliminary designs of instruments for the LWTS. The target and moderator group from ANL, including scientists in IPNS and elsewhere at ANL, is preparing a conceptual design for the target station.

Involvement of IPNS and ANL in this project is expected to continue through the construction of instruments, and potentially to future operation of instruments.

The LWTS is currently proposed for 10 Hz operation, with a solid metal target, and solid and liquid methane moderators. Dramatic gains in per pulse flux are predicted from independent optimization of the LWTS target station / moderator system. This is expected to generate time-average fluxes at long wavelengths comparable to those at the 60 Hz High Powered Target Station (HPTS-SNS).

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