Status of the Intense Pulsed Neutron Source

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Introduction

In December 1987, the 1000th experiment was performed at IPNS. This is a significant milestone and reflects the great deal of work and progress that have taken place since the first experiments were performed in 1981. Since that time, the average proton current has increased from 4 μA to 14-15 μA. The reliability has averaged 91% since 1981, by far the world's record for pulsed neutron sources. We have gone from room temperature polyethylene to cryogenic methane moderators, from a depleted uranium to a 77% enriched uranium (Booster) target, and from 4 to 11 neutron scattering instruments. Unfortunately, funding has not kept pace in the same ratio, and staff and operating time have been essentially constant over this same time period. For the past 3 years, most of the budget shortfall was covered by a project for the Strategic Defense Initiative (SDI) involving the study of neutral particle beams using our linac with the help of members of our accelerator staff. In addition to SDI funds, we are in the process of pursuing other funding sources such as industry and the National Science Foundation.

IPNS is not unique in having concerns about the level of funding, and the future looks good despite these concerns. This report details the progress made at IPNS during the last two years. Other papers in these proceedings discuss in detail the status of the enriched uranium Booster target, the two instruments that are under construction, GLAD and POSY II, and a proposal for research on an Advanced Pulsed Neutron Source (ASPUN) that has been submitted to the Department of Energy (DOE). Further details on IPNS are available in the IPNS Progress Report 1987-1988, available by writing the IPNS Division Office.

Operating status of the accelerator system

On September 19, 1987, the accelerator system delivered the two billionth proton pulse to the IPNS neutron target. The total, as of October 1, 1988, has risen to 2,341,622,103 pulses.

The average beam current showed another gratifying increase of 5% since the 1986 ICANS report. A few new techniques were uncovered to help increase the beam current, but most of the gain came from effective utilization of the new equipment installed in 1985 and 1986. Figure 1 is a plot of weekly average proton current on the neutron target since turn-on in 1981; each point represents on average about 148 hours of operation. Although the average beam current has increased since late 1985,

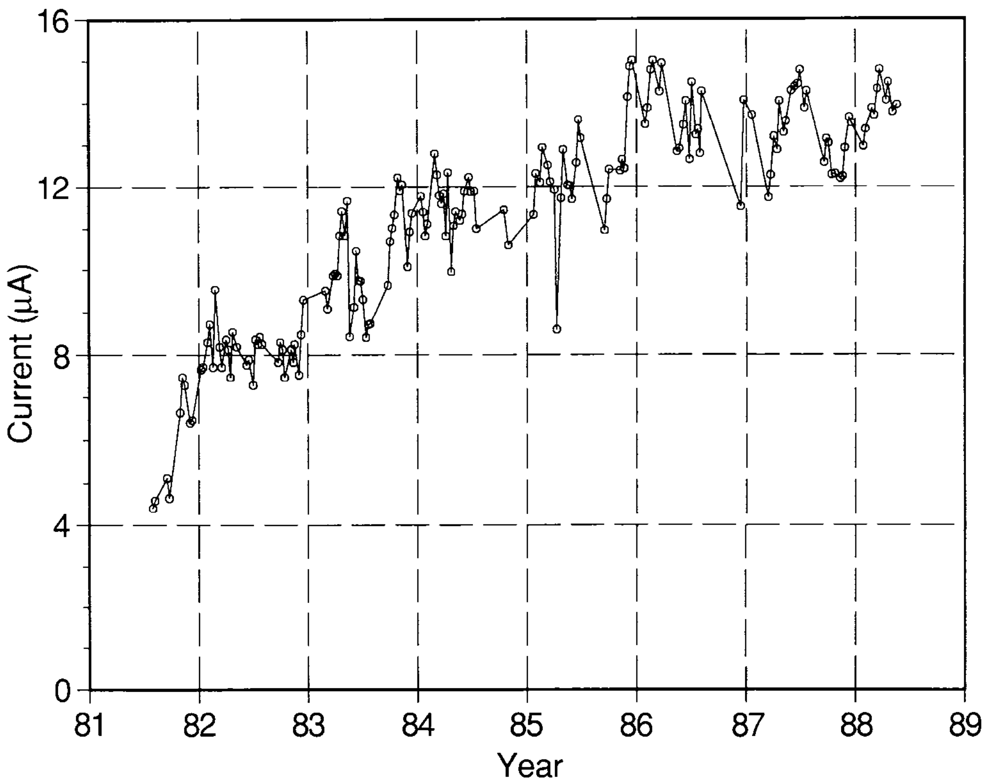

Fig. 1 Average target current of IPNS.

the rate of increase has diminished. Concurrently, the IPNS accelerator group has been involved very heavily with activities outside of IPNS since that time so effort devoted to beam current increase has been minimal.

Two factors should be mentioned in connection with the 5% current increase. The first of these is the use of 80 $\mu g/cm^2$ carbon H^- stripping foils. These foils last a long time (about 40-50 million beam pulses), and eight hours with the old polyparaxylene foils. This feature allows an increase in the long-term, not peak, average current. The second item is substantial improvement in the stability of our extracted beam current sensing toroids. By providing better low inductance image current return paths, we have decreased the dependence of these devices on the spatial properties of the extracted beam pulse. The synchrotron is operated "beam loss limited", and the toroid signals are input data to the "beam loss" computation. Stable, repeatable toroid data allow the synchrotron to be operated very close to the empirically determined "acceptable loss" which, in turn, increases long-term average current on target.

The brightest spot of the IPNS accelerator operation continues to be the operating reliability, that is, the availability to deliver protons as scheduled. Reliability over more than 6200 scheduled hours during the last two years continued to be excellent at

91.9%, despite a spate of serious breakdowns during the first two months after turn-on in August 1986. During the remaining 19 months to June 1988, as-scheduled availability equaled our goal of 94%. Figure 2 is a plot of this availability, averaged weekly. Note the density of points near 100% since late 1987. In fact, during 8 of the last 9 months of operation, availability has exceeded 95%. Even in months when availability is less than is desired, the experiment time is seldom lost, since the IPNS does not run parasitic on another program, but rather is dedicated solely to neutron science and experiments can be rescheduled without the complication of other pograms competing for accelerator time.

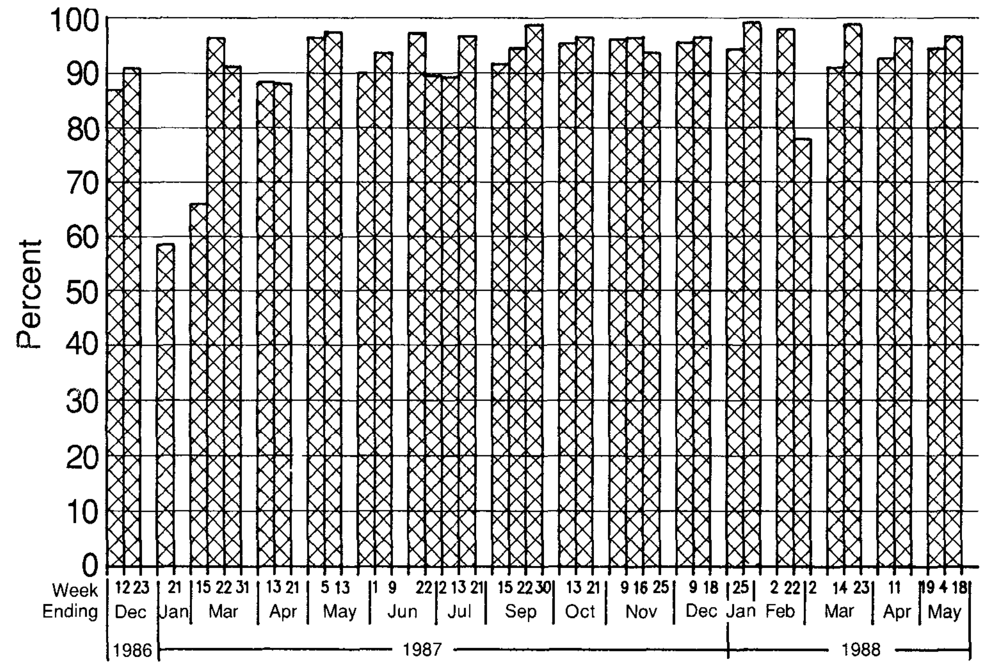

Fig. 2 Reliability of IPNS.

Of very great significance is the success of our beam loss limited operation. Automatic devices as well as operator attitudes help keep proton losses in the accelerator limited to about 1.5 μA. As a result, the residual radiation levels around the synchrotron are no higher, on average, than they were two years ago, and in several of the very high loss regions, residual radiation has actually decreased. Thus, the repairability of the RCS continues to be good! No internal damage to the synchrotron aperture has occurred since the loss limits and protective collimators have been in use.

The most significant equipment upgrade now underway is the installation of 3 new power supplies which drive 7 of the horizontal steering dipole magnets in the 50 MeV H^- transport line from the linac to the RCS. These magnets provide a 180° bend to the beam, so their field stability is very critical. The old power supplies, while not particularly prone to breakdown, would often develop periods when their output currents were extremely unstable, making precise injection tuning difficult. The new power supplies will allow more stable injection position control, which should provide the operators with a better opportunity to adjust the injection focusing precisely. Thus, a better match of the linac beam emittance to the synchrotron acceptance can be achieved.

Over the last 4 years, it became increasingly apparent that the beam was clipping the upper portion of the magnet aperture and was causing a good deal of the low energy beam loss in the synchrotron. Our limited diagnostics indicate that, in at least two places, the center of the beam is about 3 mm above the geometric center of the main magnet aperture. This translates into an effective loss of about 5% of the vertical aperture. Computer studies are underway to analyze whether sufficient and appropriately located space is available in the synchrotron lattice to add vertical steering dipole magnets. The hope would be to lower, in as many locations as possible, the vertical orbits.

Halo collimators and added vertical steering in the 50 MeV transport line are also being discussed as possible ways to minimize vertical beam losses. In beam loss limited operation, the prevention of a single proton lost should result in nine additional protons on the neutron target.

Table I Accelerator operating summary.

	11/81-7/83	10/83-2/85	3/85-7/86	8/86-6/88
Average beam current (μA)	8.65	11.90	12.89	13.47
Operating efficiency (%)	89.6	89.3	93.9	91.9
Scheduled operating time (h)	7191	5567	5263	6237
Available operating time (h)	6443	4973	4942	5732
Total pulses on target (x 10^8)	6.27	4.91	6.02	6.21
Total μA hours	55,732	59,179	63,702	77,210
Total protons on target (x 10^{21})	1.08	1.22	1.54	1.73
SDI linac operation (h)	0	0	1000	3125

Other accelerator activities

The IPNS participation in the Strategic Defense Initiative (SDI) was presented in the previous ICANS report. The participation has continued in the operation of the linac and the first Neutral Particle Beam (NPB) test beam line A. Design and construction of a larger ANL-SDI beam line (B) started in late 1986, and the first test beam was sent down this new line on April 22, 1987. Figure 3 shows the layout of the IPNS accelerator system and the NPB beam lines. The beam optics design was supplied by members of the ANL Engineering Division (ENG), while IPNS personnel supplied much of the hardware design, installation planning and about 90% of the installation labor and initial testing effort. During the past two years, over 35,000 manhours of IPNS accelerator personnel effort was assigned to SDI beam line construction and experiment support.

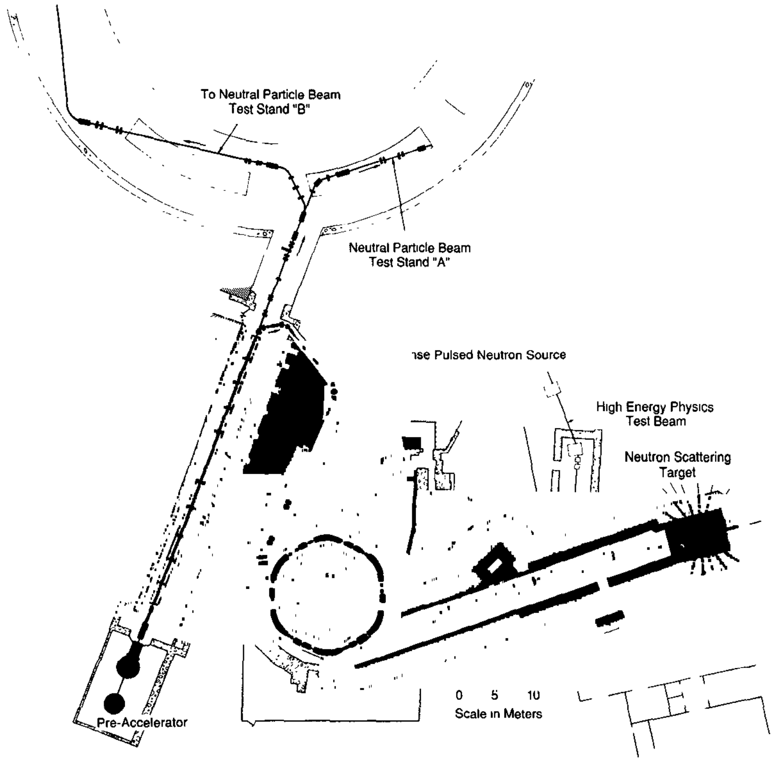

Fig. 3 IPNS accelerator system and NPB beam lines.

In contrast to the SDI line A where almost all of the hardware was surplus, most of the line B apparatus was new. The overall beam line is 70 m long and consists of 7 horizontal steering dipole magnets, 4 vertical steering dipole magnets, 16 quadrupole magnets, power supplies, 4 sets of four-motion collimators, 12 sets of two dimensional segmented Faraday cup diagnostic devices, 5 beam toroids, several vacuum pumps and isolation valves, and a debuncher to reduce beam energy spread. IPNS worked closely with the ANL Engineering and Electronics Divisions to provide computer control and status readout of all these devices.

After a brief shakedown and characterization period on line B, a large team from Los Alamos joined us to install a permanent magnet beam expansion telescope and a considerable amount of sophiticated diagnostic equipment to help judge the performance of the telescope. Its purpose was to achieve a very low divergence beam; the divergence goals were met for the most part. The most active program now underway is the test operation of a new type of beam expansion telescope that was recently installed in SDI line B. It includes trim multipole magnets, which should reduce higher order magnetic aberrations and thus further decrease divergence.

Operation and experiments on SDI line A were interspersed with line B construction and operation. A total of more than 3100 hours of beam time was used on both beams. Experimental topics included beam neutralization techniques and materials, radiation damage, target composition, and the sensing of neutral beam properties. The non ANL experimenters were assisted by ENG and IPNS personnel.

Future expansion, and even future operation, of the SDI facilities beyond Fall 1988 is, at the present, quite uncertain. A considerable reduction from the past 2 years in our SDI participation is certain. Proposals to utilize the IPNS RCS to accelerate deuterium ions have been made by the ANL-SDI office to military sponsors. A 100 m expansion of line B has also been proposed to obtain a more precise measurement of beam quality. While the military sponsors show some interest in these new activities, there has not yet been a firm financial commitment.

Instruments

Figure 4 shows the instruments now operating at IPNS, the specifications of which are given in Table 2. Improvements on existing IPNS instruments and ancillary equipment are occurring constantly. Most notable since the last ICANS report is the commissioning of the Low Temperature Chopper Spectrometer (PHOENIX). PHOENIX, in addition to the Polarized Neutron Reflectometer (POSY) and the Quasielastic Neutron Spectrometer (QENS), was built by a Participating Research Team (PRT). In this mode, a significant fraction of the financial and manpower burden is borne by a group of scientists with considerable help from IPNS. These three PRT instruments were added to the user program in 1987 at which time non-PRT members could apply for 25% of the instrument time. The remaining 75% is allocated by the PRT to its members, and manpower is provided by the PRT in a collaborative mode for non-PRT users of the instrument. Neutrons are supplied free of charge to the PRT instruments, and this method of instrument construction and operation (modeled after the synchrotron sources) is an extremely effective way of getting extra instruments and dedicated scientists at the facility.

The instruments for elastic or total scattering consist of two powder diffractometers (SEPD Special Environment Powder Diffractometer, GPPD General Purpose Powder Diffractometer), which have excelled at high resolution and special environment work, coupled with the on-line capability of the Rietveld method and also have proved useful for amorphous systems. As one might expect, these instruments are now used increasingly with furnaces, cryostats, and pressure cells. Over the past 2 years, there has been considerable work on the powder diffractometers on structural and defect studies of the high-T_c superconductors and the determination of residual strains in composite materials. The Single Crystal Diffractometer (SCD) is based on the Laue technique with a two-dimensional (30 x 30 cm) position-sensitive scintillation detector based on the Anger method, designed and built at Argonne, and has investigated crystal structures and a variety of problems involving superstructures, diffuse scattering, and recently, texture determination. The Small Angle Diffractometer (SAD) also includes a two-dimensional position-sensitive detector and is used to investigate metallurgical, polymer, and biological systems. A new detector for the SAD was purchased, which will allow a factor of four increase in total data rate. The broad scientific interest in the SAD and large oversubscription have resulted in the decision to build a second small angle diffractometer, SAD II, dedicated for polymer research.

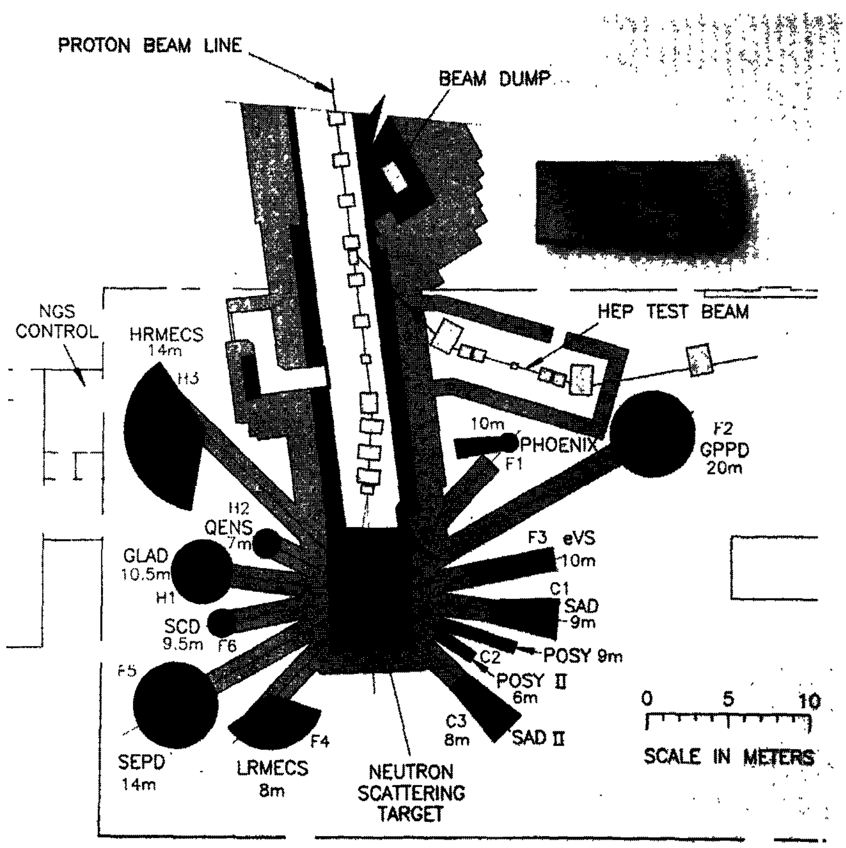

Fig. 4 IPNS neutron scattering instrument layout.

The two chopper spectrometers (LRMECS—Low Resolution Medium Energy Chopper Spectrometer, HRMECS—High Resolution Medium Energy Chopper Spectrometer) have proved exceptionally versatile in a variety of problems involving measurements of S(Q,E). Experiments on amorphous materials, electronic transitions, and momentum distributions have all made use of the abundant epithermal spectrum. Based on the very heavy demand for beam time by the groups involved in momentum density—n(p)—measurements in quantum liquids and solids, a new instrument, PHOENIX, was built as a joint construction effort by scientists from Argonne, Harvard University, Penn State University, and University of Illinois Urbana.

The Quasielastic Neutron Scattering Spectrometer performs studies on molecular spectroscopy and diffusion. It takes advantage of good energy resolution (70 μeV), coupled with the ability to measure energy changes as a function of momentum transfer.

Table 2

IPNS NEUTRON SCATTERING INSTRUMENTS

Instrument (Instrument Scientist(s))	Beam Line	Range: Wave Vector* ($Å^{-1}$)	Range: Energy (eV)	Resolution: Wave Vector ($Å^{-1}$)	Resolution: Energy (eV)
Special Environment Powder Diffractometer (J. Jorgensen/K. Volin)	F5	0.5-50	**	0.35%	**
General Purpose Powder Diffractometer (J. Faber/R. Hitterman)	F2	0.5-100	**	0.25%	**
Single Crystal Diffractometer (A. Schultz)	F6	2-20	**	2%	**
Small Angle Diffractometer (J. Epperson/P. Thiyagarajan)	C1	0.006-0.35	**	0.004	**
Quasielastic Neutron Spectrometer (F. Trouw)	H2	0.42-2.59	0-0.1	~0.2	0.02 E_o
Low Resolution Medium Energy Chopper Spectrometer (C. Loong)	F4	0.1-30	0-0.6	0.02 k_o	0.05 E_o
High Resolution Medium Energy Chopper Spectrometer (D. Price)	H3	0.3-9	0-0.4	0.01 k_o	0.02 E_o
PHOENIX (P. Sokol/K. Herwig)	F1	0.3-30	0.1-0.8	0.01 k_o	0.02 E_o
Polarized Neutron Reflectometer (G. Felcher)	C2	0.0-0.07	**	0.0003	**

* Wave Vector, $k = 4\pi\sin\theta/\lambda$.
** No energy analysis.

INSTRUMENTS NOT YET IN THE USER PROGRAM

Beam Line	Instrument	Flight Path Length (m)
H1	Glass, Liquid and Amorphous Material Diffractometer (under construction)	10.5
C3	Small Angle Diffractometer II (under development)	8.0
C2	Neutron Reflectometer II	6.0
F3	eV Spectrometer	10.0

The Polarized Neutron Reflectometer has become a state-of-art instrument for obtaining magnetic information in thin films or near the surface of bulk materials. The very interesting basic information is coupled with some very promising applied interest, for example magnetic hysteresis in materials for recording heads. A second reflectometer (POSY II) has been recently constructed. Funded in part ($150,000) by IBM, this unpolarized version of POSY will be used primarily for studies of interfaces and interdiffusion in polymers, taking advantage of the large scattering contrast of H and D. The eV Spectrometer (eVS), designed to measure energy transfer to many eV, is temporarily dormant due to difficult background problems.

The Glass, Liquid and Amorphous Material Diffractometer (GLAD) is under construction as a PRT instrument and will be a world class instrument when completed. This new instrument, which will feature high intensity with low-to-moderate resolution and emphasis on low-angle detector banks to simplify inelasticity corrections, is discussed in detail in another paper in these proceedings.

Chopper development at IPNS

A number of chopper-related development projects have been and are underway at IPNS. These include choppers for the reduction of backgrounds due to delayed neutrons, choppers to remove the prompt pulse of high energy neutrons from the beam, a chopper for lower energies, and improved chopper control systems for all of these.

The "delayed-neutron choppers" are lightweight drum choppers that "open" twice per revolution, i.e., they run at 15 Hz rather than the 270 Hz typically used for our other choppers. Two such choppers have been fabricated and installed, one in the GPPD incident beam line at the point where the line exits the biological shield, and a second in a similar position in the SEPD incident beam line. The basic design consists of a 40-cm-diameter, 11.5-cm-high, and 1-cm-thick cylindrical shell of B_4C powder held in place by epoxy and supported by a thin aluminum shell and aluminum top and bottom plates. The chopper is rotated about the cylindrical axis which is vertical, normal to the incident beam. Each of the chopper shells has a pair of diametrically opposed openings which are designed to allow unimpeded transmission of the entire width of the beam over the time frame of interest to the instruments (nominally the time-of-flight range of 3-30 ms, measured at the detectors). The present design parameters lead to an "open" fraction of the chopper circumference of ~1/3 for the GPPD and ~1/2 for the SEPD. Consequently, these choppers should remove from the beam roughly 2/3 and 1/2, respectively, of the total number of delayed neutrons having energies low enough to permit detection in the ^3He detectors used on the instruments. However, Monte Carlo simulations have shown that the delayed-neutron contribution to the background should be reduced by factors of 10-100 in the long-wavelength part of the spectrum where the delayed-neutron background would otherwise be most serious. These choppers were installed in Summer 1988, so experience with them is currently insufficient to provide quantitative details of their performance.

A prompt-pulse-removal chopper ("t_o chopper") has been designed and fabricated, and was installed in the PHOENIX incident beam line in Fall 1988. This chopper design is similar to that used in our standard Fermi choppers, except that it contains no slit package, and the opening through the beryllium pieces, which form the body of the chopper, has been widened somewhat to allow transmission of the desired bandwidth at the various different incident energies used on the instrument. The chopper will be phased to be closed totally at the time of the prompt burst of fast neutrons, and so it should remove most of these from the beam. Since these fast neutrons, which can thermalize in the Fermi chopper or in the collimators or shielding, form a major component of the background in chopper instruments, this additional chopper should lead to significant background reduction in PHOENIX. If this in fact proves to be so, additional to choppers will be provided for use on LRMECS and HRMECS as well.

Since a number of users have requested that LRMECS and HRMECS be able to provide lower incident energies, an additional Fermi chopper, optimized for transmission of 10 meV neutrons, has been fabricated and tested. Unfortunately, this chopper also allows significant transmission of higher energy neutrons, and for some experiments, these can produce background in the time frame of interest on the chopper spectrometers. If necessary, these higher energy neutrons can be removed with a filter or by a t_o chopper, so the 10 meV chopper can be regarded as satisfactory, and it is available now for configuration in those experiments which desire it.

A new chopper control system is being designed to operate the Fermi choppers and the t_o choppers. This system will implement the same algorithms used in our present chopper controllers, but will be based on readily available PC components to make it more easily programmable and significantly less expensive to reproduce. The lower expense is particularly important since a number of additional controllers will be required to handle the anticipated to choppers (at least three expected in the next 1-2 years) and choppers for GLAD (one or two expected) in addition to the three Fermi choppers that are controlled currently—for LRMECS, HRMECS, and PHOENIX. Development of this new control system is expected to be completed by mid 1989, and additional controllers will be built as needed. A different chopper controller has been developed to drive and control the delayed-neutron choppers, which have much less stringent control requirements. Two of these controllers were placed in operation in Summer 1988, controlling the GPPD and SEPD delayed-neutron choppers.

The floor space devoted to chopper control has been expanded to handle all the new chopper control systems, which are anticipated to be running simultaneously at IPNS. As part of this expansion, considerable care has been devoted to the redesign of the mounting and interconnection of the control systems and monitoring equipment, so chopper control is being turned into a "chopper system command center", optimized for the operation, monitoring, and maintenance of this equipment.

Data acquisition

Introduction

Since the 1986 ICANS-IX Meeting, we have continued to refine and improve the data acquisition system (DAS). Refinements to the existing system include replacement of the encoding electronics for some of the area detectors, development of high-level graphics routines for the GKS graphics system, and installation of cluster software to link our computers. A digital Private Branch Exchange (PBX) telephone system was installed at Argonne last year, permitting us to make significant improvements in access to the IPNS computer systems.

Major changes that have taken place include the conversion of the PDP instrument computer software to run on VAXstations, and the installation of VAXstations as instrument computers on the Glass, Liquid, and Amorphous Material Diffractometer (GLAD) and the Neutron Reflectometer (POSY II) instruments and as replacements for the PDP computers on two instruments. Replacement of the remaining PDP computers with VAXstations is expected to be done over the next several years. VAXstations are also being used to increase the data analysis capacity at IPNS. An optical disk storage system for virtual on-line storage of large amounts of data is under consideration. Finally, new linear position-sensitive detector (PSD) encoding modules and a new hardware-based FASTDAS histogramming system have been developed for GLAD. (Details of the GLAD PSD encoding and the FASTDAS system are presented elsewhere in these Proceedings).

Data encoding modules

The area PSD, which has been in use on the Small Angle Diffractometer (SAD), uses the rise-time method of position encoding. During the past year, we have purchased two additional detectors which use this same encoding method for SAD II and for POSY II. The two new detectors have come with their own sets of signal-processing electronics, and we have developed a new digitizer module to interface with these electronics to provide digitized position and time of flight information. A similar set of signal-processing electronics and a digitizer module have also been provided to replace the old units in use on SAD, which were becoming unreliable. This compatibility among these three detectors should simplify maintenance of the units.

Use of VAXstations

All of the initial eight IPNS instrument computer systems were based on DEC PDP-11 computers. Several new IPNS instruments need greater on-line computing capabilities and disk storage capacity than is available on the current PDP systems. Furthermore, with the increased data rates expected with the new Booster target, several existing instruments can benefit from the increased computing and storage capacity available on the VAXstations. Finally, the PDP-11 systems are starting to show their age (the oldest have been in continuous operation for more than 8 years) and their failure rate is increasing. For these reasons, we have purchased four DEC VAXstation-II GPX workstations, each with at least 300 Mbytes of disk storage. Our instrument operating software has been converted for use on VAX computers (with some enhancements to take advantage of the VAX capabilities), and we will start using all four of these as instrument computers in Fall 1988. Two of the new systems will be on GLAD and POSY II, and the other two will replace the PDP computers on SAD and the Single Crystal Diffractometer (SCD). The remaining instruments will be converted from PDP-11 to VAXstation-based systems at a rate governed by need and budget.

The four VAXstations procured as instrument computers initially were used very successfully for data analysis. Now that these four are going to be used as instrument computers, a VAXstation 3200 system has been bought for data analysis. The addition of the VAXstations has not only improved the instrument computer situation, but also increased the total computing capacity available for data analysis since the VAXstation instrument computers place significant computing capacity at each instrument. It is expected that in the future more data analysis will be done directly at the instrument as the data are being collected, rather than on one of the central computers in the system. Our central VAX systems will continue to be used by the VAXstations for data storage and archiving as well as program development and network services.

Graphics improvements

Until recently, IPNS has used the DISSPLA graphics package from Computer Associates (CA) for most of the graphics programs developed for data analysis. Since DISSPLA is an expensive commercial package, we could only use it on our VAX-11/780, thus preventing us from using all of our computers efficiently. Most of our graphics routines have now been converted to utilize GKS graphics, which is available on all of our computers. This was accomplished by writing a set of high-level graphics tools, called GPLOT, based on the GKS standard. VAX-GKS was the first graphics software package to support the VAXstation, and the use of GKS allowed us to develop device-independent graphics software that could be run on the VAXstation as well as our other graphics devices. The VAXstations produce high resolution color graphics very quickly, which will allow users to interact effectively with data collection and data analysis. This should also pave the way for more interactive modes of data analysis, although in many cases a considerable amount of software modification will be required.

Among other graphics enhancements, we have added a PostScript-compatible laser printer, which provides more flexibility and higher resolution than our other graphics devices.

Networking and clustering

For several years, all of our computers have been linked together by a DECNET/ETHERNET network served by terminal servers, so access to any of these systems and transfer of information among them has become quite straightforward. Two recent developments have expanded these networking capabilities.

During 1987, Argonne installed a digital PBX telephone system which allowed a number of improvements in our computer network. The PBX provides lab-wide network support through the use of bridges to connect divisional ETHERNET segments into one large network. This allows us to access printers and computers in other buildings. The new PBX also allows users in other buildings to have high speed terminal access to our computer facilities.

To simplify access and connection speed among our computer systems, we are joining some of them together in a cluster. This will make it more efficient to store files centrally and still use the VAXstations for data analysis without the necessity of keeping multiple copies of files. Some of the new instruments which have come on-line have strained our computing and data storage capacity severely, and this demand is expected to increase even more with the Booster target; therefore, the cluster is expected to continue expanding.

Data archiving/retrieval

As the amount of on-line disk space increased, it became increasingly difficult to provide file backup. It took typically four high-density tapes to store the data from one disk,and an operator was required to change tapes. We have solved this problem recently by purchasing a helical-scan tape unit which permits us to store the contents of several disks on a single tape cartridge. This has eliminated the need for an operator to change tapes during the backup operation. Because of the cheaper and more compact storage, we will now be able to keep monthly full backup tapes permanently, instead of reusing the tapes after one year.

The installation of the Booster target is expected to result in a large increase in the rate of data collection and the need for data storage facilities. Fortunately, disk technolcgy has kept pace with our need for online storage, and we were able to make a significant increase in our disk storage capacity this past summer. Careful management of data storage will continue to be necessary, however. Some instruments already require frequent archiving of data to tape. The optical disk system under consideration would provide the ability to store this data where it could be accessed quickly with no operator intervention.

Booster target

Since the last Progress Report 1985-1986, in which the design of the Booster target was described in detail, numerous difficulties have had to be overcome in the process of fabricating the Booster target. In the end, we have succeeded—all the required disks and spares have been completed, and insertion and testing are underway. Throughout, we enjoyed the helpful cooperation of our colleagues at the Oak Ridge Y-12 facility where the disk processing was carried out as well as many groups at Argonne. Details of Booster target fabrication and performance are given in another paper in these proceedings.

Moderators

Moderators are also covered in a subsequent paper. Based on operating difficulties with solid methane and the lack of experience with booster operation, startup in the fall of 1988 will include liquid hydrogen (T > 14 K) in the C moderator, that which is viewed by SAD, POSY and POSY II. This will result in a loss of long wavelength neutrons, which should be more than offset in most wavelength regimes by the enhanced flux from the Booster target. The moderator design will permit a return to solid methane in C after we have gained sufficient operating experience on the Booster target.

Examples of some recent scientific results

To illustrate the performance of some of the IPNS scattering instruments, some recent experimental results are discussed. A study was undertaken to investigate the motion of molecules in the pores of molecular sieve zeolites which are used as catalysts in shape-selection hydrocarbon transformation reactions. Figure 5 shows the pore or channel structure in ZSM-5 through which molecules can diffuse. A molecular dynamics calculation followed the rate of diffusion in the various directions, b clearly being the easiest direction. Figure 6 shows the near-elastic energy region measured for the catalytic material with (symbols connected by a line) and without (solid line) methane. The additional broad component when the methane is present is the quasielastic scattering due to translational and rotational diffusion. The widths of the data yield a translational diffusion constant of 2.4 x 10^5 cm^2-sec^{-1} at a momentum transfer of 1 $Å^{-1}$, which is in very good agreement with the simulations and previous NMR results.

The large difference in scattering by hydrogen and deuterium was used to study the interface separating two different molecular weight polymers. Figure 7 shows results from POSY which was used to study the reflectivity of a bilayer of deuterated and normal polystyrene (PS) on silica glass. The oscillations (dots) are due to interference of the reflections from the front and back face of the upper deuterated PS layer. After a short anneal (140°C for 5 minutes) the much lighter, deuterated PS has diffused and the change of the period of the oscillations (squares) was used to generate the change in profile shown in Figure 8. These results were our first measurements showing the power of neutron reflectivity for studying polymer diffusion and resulted in the decision to build POSY II.

These are only two examples of recent results and many more examples are detailed in the IPNS Progress Report 1987-1988, published in October, 1988.

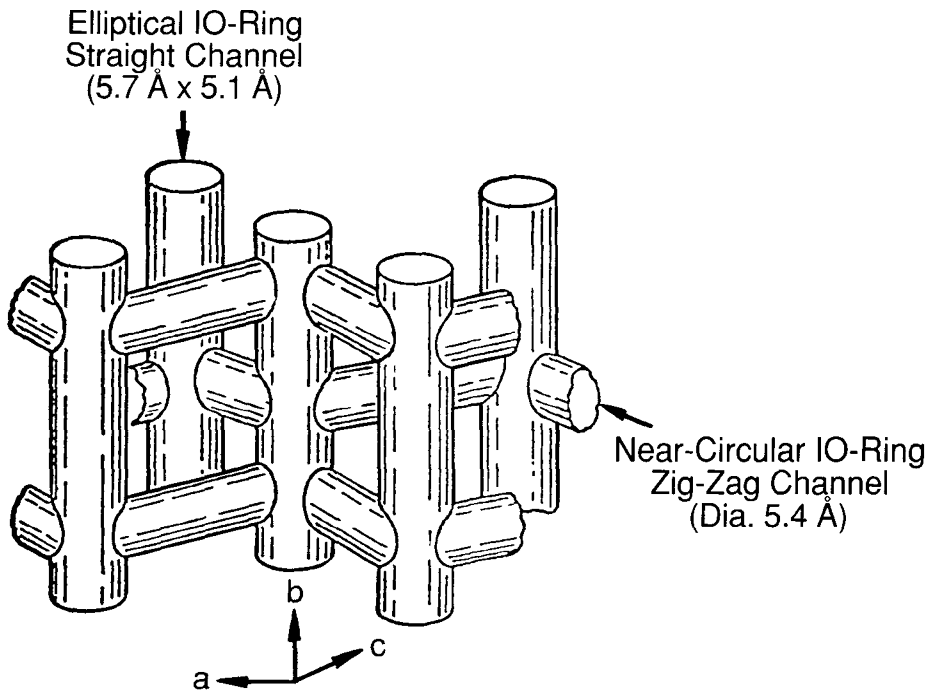

Fig. 5 Diagram of the channel structure of ZSM-5 zeolite.

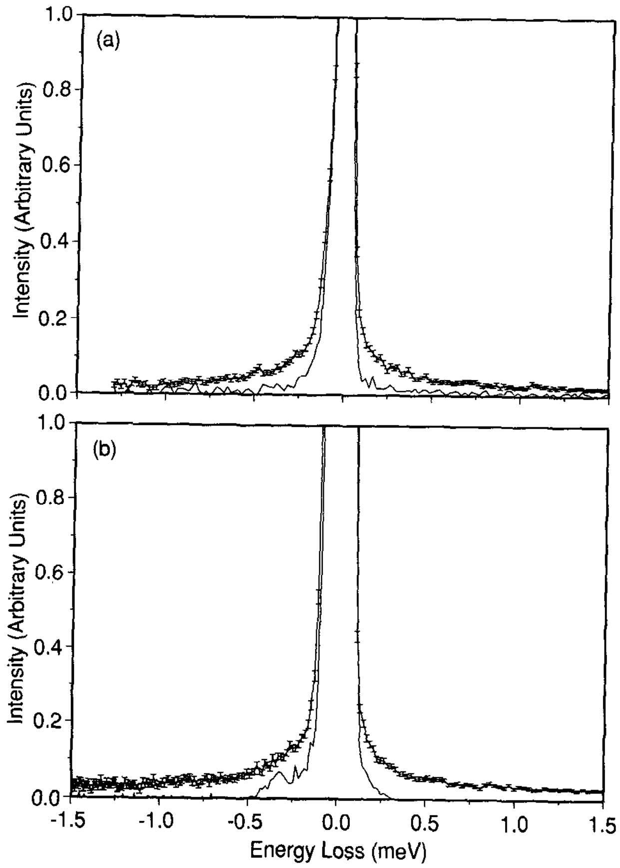

Fig. 6 Quasielastic scattering from silicate (solid line) and silicate plus methane (symbols connected by line) measured on (a) QENS at 300 K and (b) IN6 (ILL) at 80 K.

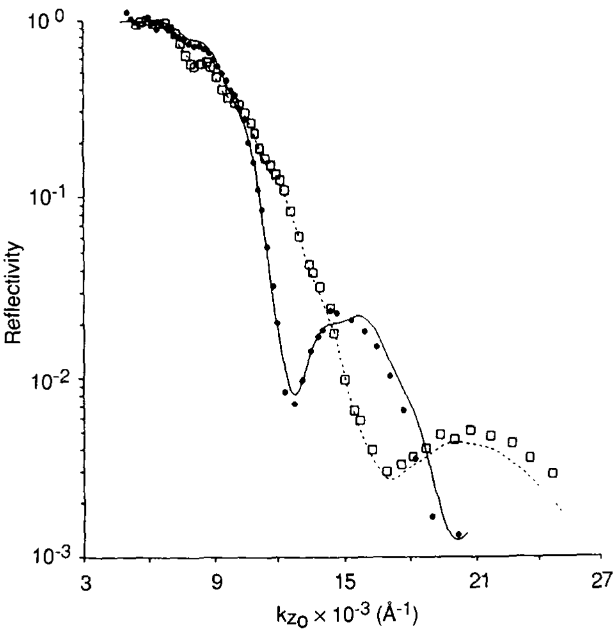

Fig. 7 The reflectivity of a bilayer of d-PS/PS on silica glass as deposited (dots) and after a short anneal (squares).

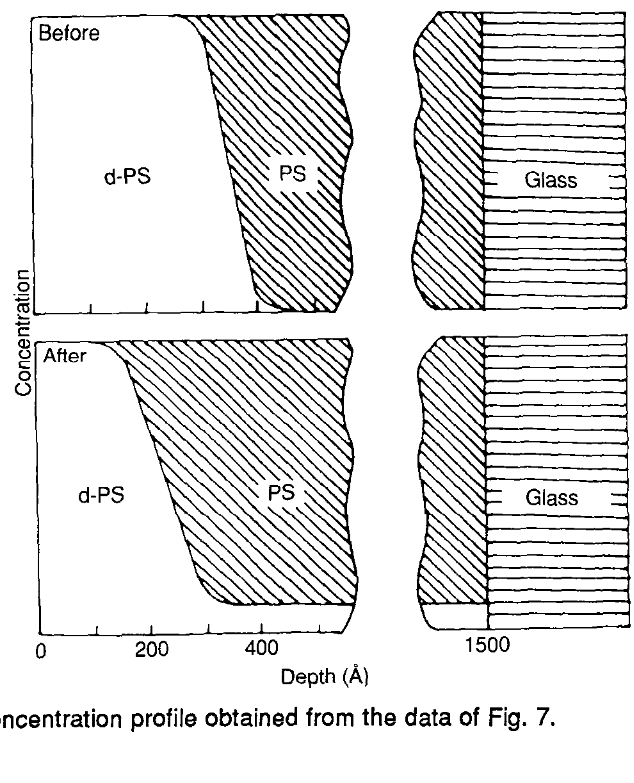

Fig. 8 The concentration profile obtained from the data of Fig. 7.

User program

The operating statistics shown in Table 3 clearly indicate an increase in the number of experiments and scientists at IPNS despite a small decrease in operating time. The increase is due to the proton current increase and the increase in neutron scattering instruments (4 in 1982 vs 11 in 1988).

Table 3 IPNS user program.

	FY83+	FY84	FY85	FY86	FY87	FY88
Weeks of operation	26	29	21	22	21	18*
No. of experiments performed	110	210	180	212	223	226
Visitors to IPNS for at least one experiment:						
Argonne	41	49	44	52	55	54
Other government labs	9	8	7	11	15	17
Universities	33	45	51	79	78	79
Industry	5	9	7	13	24	17
Foreign	18	39	34	27	24	16
TOTAL	106	150	143	182	196	183

+ FY83 = Fiscal year 1983 = October 1982 through September 1983.
* 2 weeks to be run early in FY89.

Recent and planned conferences and workshops

We continue our strong commitment to sponsor conferences and workshops in connection with our efforts to spread the news about neutrons in general, and the capabilities of IPNS in particular. Financial and technical assistance from both the University of Chicago and Argonne's Division of Educational Programs is greatly acknowledged.

Conferences and Workshops

December 8-9, 1986
Third IPNS User Meeting

May 12-13, 1987
Design Vorkshop for an Advanced Chopper Spectrometer at LANSCE

October 26-29, 1987
International Conference on Techniques and Applications of Small Angle Scattering

November 6-7, 1987
Workshop on X-ray and Neutron Scattering from Magnetic Materials

October 3-7, 1988
International Collaboration on Advanced Neutron Sources (ICANS-X), Joint Sponsorship with LANSCE at Los Alamos National Laboratory

Planned Meetings
October 24-26, 1988
Workshop on Momentum Distributions

November 14-15, 1988
Fourth IPNS User Meeting

November 16-18, 1988
Short Course on Neutron Powder Diffraction and Rietveld Analysis

Figure 9 shows that the requested beam time under the user program remains high and is dominated by non-Argonne scientists. The large increase in university users is due to the establishment of PRT's and a number of groups consisting of faculty, post-doctoral appointees and graduate students which focus their research at IPNS.

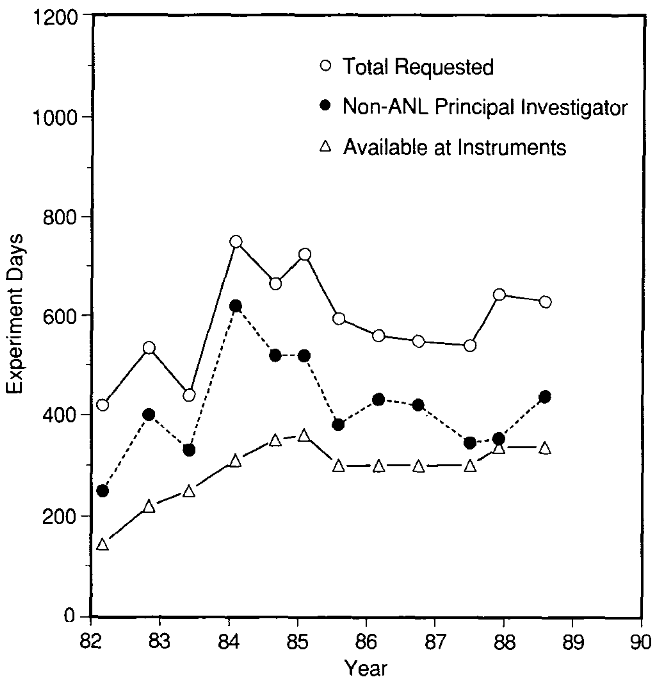

Fig. 9 Experimental beam time requested under the IPNS User Program.

Advanced Pulsed Neutron Source (ASPUN)

The need for more intense neutron sources has been the subject of many meetings and reports. The most thorough workshop took place at Shelter Island, New York, in October 1984. The major findings of the workshop were:

1. The case for a new higher flux neutron source is extremely strong, and such a facility will lead to qualitatively new advances in condensed matter science.

2. To a large extent, the future needs of the scientific community could be met with either a 5 x 10^{15}n-cm^{-2}-s^{-1} steady state source or a 10^{17}n-cm^{-2}-s^{-1} peak flux spallation source.

The scientific output and future of pulsed neutron sources have been growing steadily in recent years. It is the goal of the ASPUN project to develop fully the potential of pulsed neutron sources by designing the next generation source. The goal of present generation pulsed sources is in the 100-200 μA range, which would yield a neutron flux that is a factor of 3-6 higher than IPNS when operating with the enriched uranium (Booster) target.

The ASPUN project would increase proton currents by a factor of 20 or more beyond the design goals of presently operating sources. This project would be the 10^{17}n-cm^{-2}-s^{-1} peak flux spallation source as recommended by the Shelter Island report. Funds for a design effort to start in fiscal year 1990 have been requested of the Department of Energy. Details of ASPUN are given in another paper in these proceedings.

Conclusion

The report on DOE neutron sources that was released in December, 1987, and chaired by P. Pincus, praised IPNS for its effectiveness as a user facility and its world leadership role in instrument development. An extended tenure of operation was recommended as well as support for pulsed neutron instrumentation and development of next generation sources. The ever increasing instrument capability, the Booster target and our very active involvement with the scientific user community guarantee a productive scientific future for IPNS.

Acknowledgments

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