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NEWS FROM IPNS

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ABSTRACT

Under the Scientific Facilities Initiative, IPNS is planning to double its operation to 32 weeks/yr. Additional scientific and technical support staff will be added for the greatly expanded user program. The IPNS Upgrade Feasibility Study was published in April, 1995 and is a thoroughly documented study on a 1-MW pulsed spallation neutron source at Argonne, including cost and schedule. A new booster target (^{235}U-Mo alloy) has been designed that will increase the neutron flux by a factor of ~3 and construction will begin soon. A new small angle diffractometer (SAND) is in the final stages of commissioning, a prototype inelastic scattering spectrometer for Chemical Excitations (CHEX) was recently constructed and an upgraded quasielastic spectrometer (QENS) has been designed. IPNS has gained considerable operating experience with solid methane moderators, including controlled heating at periodic intervals in order to anneal the accumulated radiation induced stored energy.

1. Scientific Facilities Initiative (SFI)

A highly coordinated effort was put forth by the national labs to obtain funding for a range of Department of Energy (DOE) facilities that are operating well below their optimum level. For a relatively small increase in operating funds, facilities for physical sciences, high energy physics and nuclear physics research can significantly increase their operating effectiveness. IPNS, along with the other DOE neutron, synchrotron and electron microscope facilities, is scheduled to receive a significant increase in funds for the next year and beyond. Although the final bill has not been passed, the SFI has wide support and is very likely to succeed.

Under the SFI, IPNS will double its operating time. There are also funds for a significant increase in operating personnel for both the accelerator and neutron source groups and support personnel for the neutron scattering instruments. The goal is to have an instrument scientist, support person and post doc for each IPNS instrument. In addition, support personnel will be hired for ancillary equipment, data analysis and detectors/electronics. The goal is to operate 28 weeks in 1996 vs. 16 weeks in 1995, and to ramp up to 32 weeks/yr. operation.

2. IPNS Upgrade

Over the last 20 years, the United States has fallen alarmingly behind other scientific communities in the availability of up-to-date neutron sources and instrumentation. In June 1992, the DOE requested the formation of a panel to report on key issues concerning possible new sources, emphasizing especially the comparison of reactors and pulsed spallation neutron sources. The Panel, chaired by Professor Walter Kohn (UCSB) organized a broad Review of Neutron Sources and Applications, with the participation of 70 national and international

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experts, in Oak Brook, Illinois. The Kohn Panel's report was published in January 1993[1] and the Oak Brook findings and conclusions were published in January 1994.[2]

After reviewing the capability and cost-effectiveness of different alternatives, the Kohn Panel concluded that the United States urgently needed to construct a complementary pair of neutron sources: a next-generation research reactor, the Advanced Neutron Source (ANS), and a powerful pulsed spallation source (PSS). Unfortunately, the ANS was canceled in February, 1995. The Kohn Panel's second recommendation was to "immediately authorize the development of competitive proposals for the cost-effective design and construction of a 1-MW PSS." The cancellation of the ANS puts even more emphasis on the development of PSSs for the nation's future. Subsequent to the Kohn Panel recommendations, two workshops took place in the United States within the PSS community. One workshop further evaluated accelerator prospects (Santa Fe, February 1993)[3]; the other addressed technological and scientific applications of a 1-MW PSS (Argonne, May 1993).[4]

Argonne National Laboratory (ANL) has recently completed a feasibility study for a 1-MW PSS dedicated for slow neutron scattering in response to the Kohn Panel's recommendation for a cost-effective design and construction of a dedicated 1-MW PSS, the IPNS Upgrade.[5] The project leader for the accelerator, cost and schedule was Y. Cho; for the target stations it was J. Carpenter; and for the instruments it was K. Crawford. The development of the design and preparation of the Feasibility Study greatly benefited from the expertise in the Advanced Photon Source project. The methodologies used for this study were essentially identical to those used for the APS and greatly enhance the quality and reliability of this study. Details of the IPNS Upgrade Feasibility Study are given in other papers at this meeting by Y. Cho and J. Carpenter.

The Argonne proposal is for a 400 MeV, 500 mamp linac and rapid cycling synchrotron system operating at 30 Hz. The beam will be injected into two target stations for neutron scattering, each of which has 18 beam lines. The proposal uses buildings and infrastructure of the former Zero Gradient Synchrotron (ZGS) facility. The ZGS Ring Building can house the synchrotron, about 200 meters in circumference, and has enough radiation shielding to accommodate a 1-MW accelerator system. Two of the former ZGS experimental buildings can house the neutron-generating target stations and associated neutron beamlines. It is estimated that the use of existing buildings saves about $175 million in construction costs.

If the project is initiated in FY 1997, the total estimated construction cost (TEC) is $478 million (in 1995 dollars), or $559 million in inflated dollars for the year in which they are spent. The facility commissioning would start at the beginning of FY 2001. Construction of new components and refurbishment of existing facilities will not interfere with the present IPNS operations, except for reworking and relocation of the scattering instruments. An interval as short as a few months will be required to rework the scattering instruments and install them in their new locations. The accelerator commissioning period will be followed by commissioning of the target stations and instruments. Details of the cost and schedule appear in the IPNS Upgrade Feasibility Study[5].

The IPNS Upgrade is a 1-MW source that can easily be upgraded to 5-MW by injecting the beam from the 2-GeV RCS into a 10-GeV RCS. Studies on this option have been underway since the 1-MW Feasibility Study was completed and a feasible concept, including siting, has been developed, the details of which are discussed in another paper at this meeting. This design has the very large advantage of permitting full operation of the 1-MW source while the 10-GeV ring and target areas are under construction. Connecting the 2- and 10-GeV rings can be done quite quickly. In addition, no additional capabilities need to be built into the 1-MW facility for future enhancement to 5-MW, thereby avoiding any extra costs for the 1-MW source.

3. Booster Target

IPNS operated with a 77% enriched uranium target from 1988-1991, and measured a factor of ~3 increase in neutron beam current over the depleted uranium target. This target failed (as determined by the presence of fission gases) and the depleted uranium target that had been in use from 1981-1988 was reinserted. It failed approximately 6 months later and metallurgical inspection revealed that the failure mechanism was anisotropic growth of the uranium metal which caused cracks in the Zircaloy cladding.[6] It is quite reasonable to assume that this was the same failure mechanism for the failed booster target. With this in mind, the design for the new booster target uses an alloy that does not have anisotropic growth under irradiation or fatigue, ^{235}U-10 w/o Mo. The target has been fully designed and safety documentation has been written. At the request of the U.S. Department of Energy (DOE), an additional study was done to determine if significant corrosion occurred during a loss of coolant accident (LOCA) that would contribute to the radiation released during the LOCA. The study showed only a minor contribution and this report is now undergoing an independent review. We have been in close communication with the DOE during the review process and are confident that the final report will be quickly approved when submitted following this final internal review. The target will be built at the Y-12 plant at Oak Ridge, TN, as was the first booster target. It is anticipated that fabrication will take approximately one year.

4. Instrument Development

4.1 New Small Angle Diffractometer (SAND)

A new small-angle neutron diffractometer SAND at IPNS is now being commissioned. This instrument builds upon the more than 15 years experience with pulsed neutron small-angle diffraction at IPNS, and incorporates many new features to improve both Q_{min} and Q_{max} as well as improving the ease of instrument operation. The present small-angle diffractometer SAD at IPNS has been severely oversubscribed for several years, with proposals exceeding operating time by a factor of 2 to 3. Because of this, and because experience led us to believe we could now build a significantly improved instrument, consideration of a second SANS instrument at IPNS was begun in 1986. Work on SAND has proceeded slowly, as permitted by concurrent commitments to other, higher-priority projects, but the instrument is now near completion. Figure 1 shows the SAND layout and details are discussed elsewhere in these proceedings.

SAND is designed to make a value of Q_{min} down to 0.002 $Å^{-1}$ readily accessible for those experiments which require it. SAND includes a chopper to allow operation with much longer wavelengths (up to 28 Å), and will eventually have a second set of collimators having smaller angular divergence, both of which will serve to reduce Q_{min} from the ~0.005 $Å^{-1}$ available on SAD. A second goal is to increase the maximum Q value accessible, and to provide better counting statistics for the higher-Q data where the scattering cross-section is usually quite small. This goal is achieved by using a larger area detector (40x40 cm^2) for SAND, and by including an array of linear position-sensitive detectors (LPSDs) at higher scattering angles.

Based on experience with SAD, SAND incorporates features to facilitate the alignment of the instrument components and of the sample, to improve access for various types of sample environment equipment, and to permit in situ calibration of the area detector.

The area-detector portion of SAND is expected to be operational with the coarse soller collimators in late 1995. The chopper is being bench-tested and will also be incorporated in the instrument in 1995. It is expected that SAND will be placed in the user program in this configuration in Spring, 1996. The schedule calls for bringing the LPSD bank on line in late 1996. The last item to be added will be the set of fine soller collimators, and the schedule for these will depend on the outcome of the efforts to develop the appropriate fabrication technology. Details are discussed in another paper at this meeting by K. Crawford.

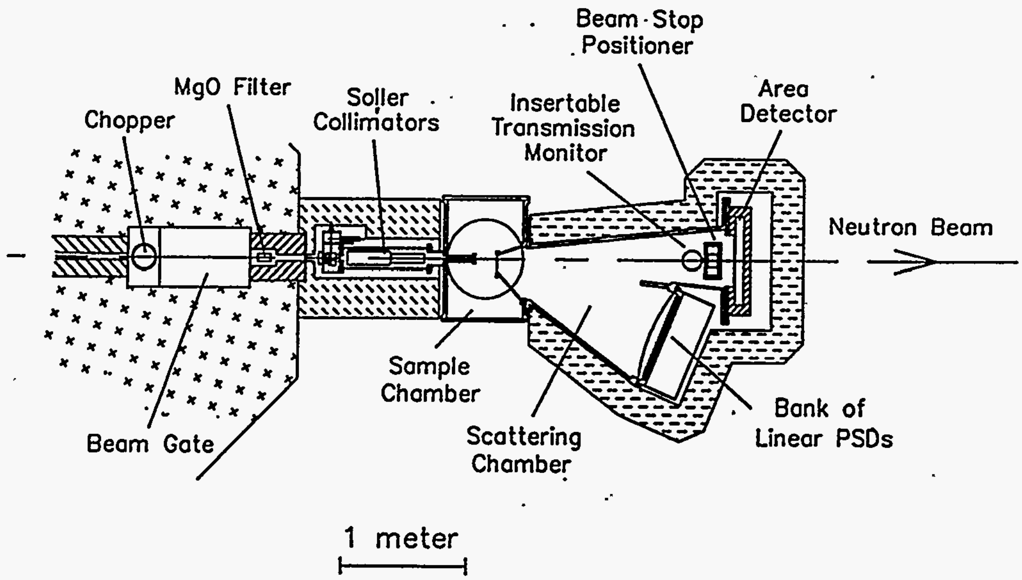

Figure 1: Small Angle Neutron Diffractometer (SAND)

4.2 Chemical Excitations Spectrometer (CHEX)

A prototype inelastic scattering spectrometer for Chemical Excitations (CHEX) was recently constructed at IPNS. The first data were taken in early October, 1995. The instrument is based on well known time focusing principles and the expected dynamic range is 0-500 meV. The instrument views the liquid methane moderator at 100 K, which provides a higher flux of short wavelength neutrons than the solid methane moderators. Chemical spectroscopy such as hydrogen bonding and vibrational density of states will be studied at CHEX. Details are discussed in another paper at this meeting by F. Trouw.

5. New Instruments

5.1 Upgraded Quasielastic Neutron Spectrometer (QENS)

QENS is a crystal-analyzer spectrometer at IPNS optimized to provide ~70 meV resolution for quasielastic scattering, but it also has very good resolution for chemical spectroscopy at excitation energies up to ~150 meV. The "white" beam from the source is incident on the sample, so a separate detector can be mounted to monitor diffraction from the sample. This allows a careful following of phase changes, in situ sample growth or modification, etc., concurrently with the quasielastic- and inelastic-scattering measurements. QENS has three focused-crystal-analyzer arms mounted on a rotating table so that a wide range of scattering angles can be covered. For the past year QENS has been viewing a solid CH_4 moderator at 25K, and this has resulted in a factor of ~5 increase in data rate for most experiments, when compared to the previous liquid CH_4 moderator which operated at ~100K. This higher intensity has made the instrument even more attractive, and demand is rapidly increasing.

The upgrade of QENS, now in the planning stage, will replace the rotating instrument table having 3 detector banks with a fixed instrument having 16 analyzer-detector banks plus 2 diffraction detector banks. Figure 2 shows this planned arrangement. Quasielastic resolution will be kept at ~70 μeV for each of the banks. The incorporation of 16 analyzer banks will allow sampling of the full angular range (~15°- 165°) for inelastic scattering without rotating the instrument. Eliminating the need to rotate will allow the use of improved shielding and will simplify the types of sample environment required. The upgrade will also result in a factor of ~5 increase in the analyzer solid angle, leading to an additional factor of ~5 increase in useful data rate. It is expected that this upgraded version of QENS will be operational in about 2 years. Both QENS and the QENS Upgrade are discussed in further detail elsewhere in these proceedings by F. Trouw.

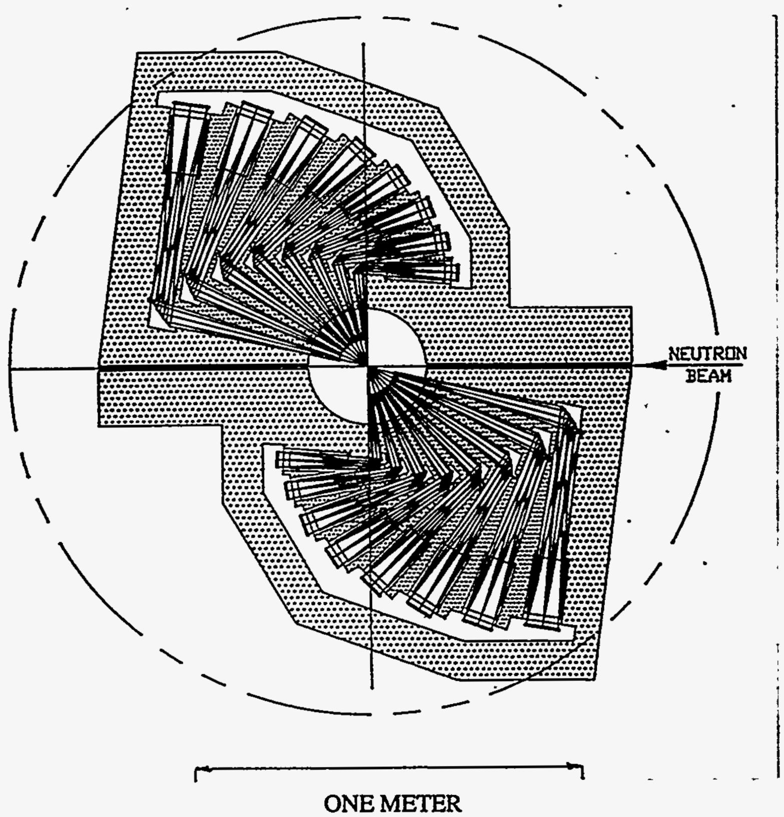

Figure 2: Upgrade of QENS

5.2 Powder Diffractometer

Two new powder diffractometers are being considered for construction at IPNS and eventual transfer to the IPNS Upgrade. The first of these is a 50-meter, multiple-scattering-angle diffractometer which would achieve a resolution of about 1×10^{-3} in back scattering. This diffractometer would be optimized for state-of-the-art structure refinement. A high count rate (comparable to the present GPPD, which is on a 20 meter flight path) would be maintained by the use of a neutron guide along the incident flight path, large detector areas, and multiple scattering angles in order to make optimum use of the full 30-Hz repetition rate. Bandpass choppers would prevent frame overlap, while making use of the highest-intensity part of the spectrum. Such a design was first described by J. Jorgensen at a workshop at Los Alamos in 1986.[7]

Another instrument under consideration is a dedicated high-pressure diffractometer based on the Nelmes-Besson opposed-anvil pressure cell. This new pressure cell design has achieved excellent results in experiments at ISIS and LANSCE. Our plan is to share the neutron beam of SCD, using the beam after it passes through the SCD sample position. By constructing a dedicated instrument, almost a full circle of detectors at a scattering angle of 90° could be employed. This would give excellent count rates at IPNS. This instrument would also be useful for small samples.

6. IPNS Operation

6.1 Accelerator

The IPNS accelerator system has maintained its excellent operating record. Figures 3 & 4 show availability and average target current.

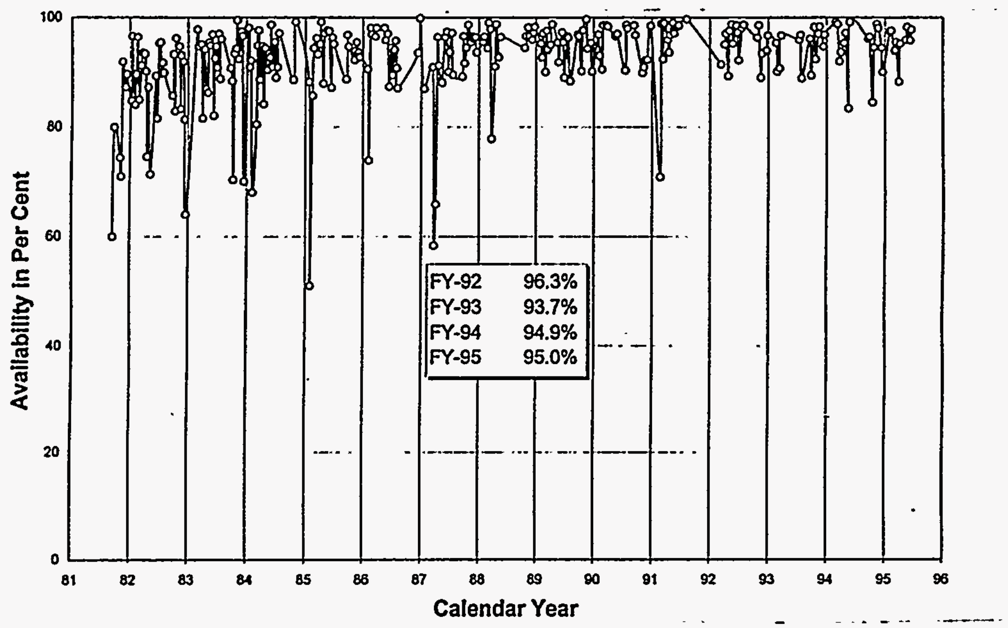

Figure 3: IPNS Accelerator System Availability

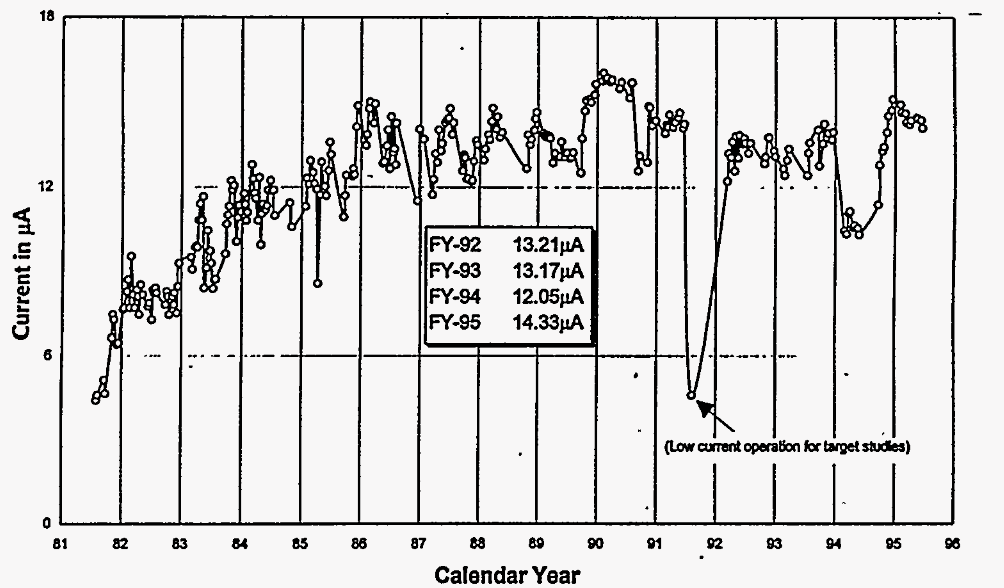

Figure 4: IPNS Accelerator Average Target Current

6.2 User Program

IPNS continues to run one of the most active user programs at a U.S. neutron scattering source. Table 1 below shows the results since IPNS began operation. Fiscal year (FY) 1995 finished at the end of September, 1995, and the data have not been fully tabulated, but they will show a slight increase over FY 1994. The decrease in number of experiments performed following

1989-90 was due to the removal of the booster target and a decrease in operating time. As discussed above, it is anticipated that both of these situations will be reversed soon. In May, 1996, IPNS will mark the 15th Anniversary of the first proton beam on target and a celebration is being planned. Argonne National Laboratory will also be celebrating its 50th Anniversary during 1996.

TABLE 1: IPNS USER PROGRAM

	FY82	FY83	FY84	FY85	FY86	FY87	FY88	FY89	FY90	FY91	FY92	FY93	FY94
NO. OF EXPERIMENTS PERFORMED	94	110	210	180	212	223	257	323	330	273	210	248	281
VISITORS TO IPNS FOR AT LEAST ONE EXPERIMENT:													
ARGONNE	37	41	49	44	52	55	57	60	61	60	53	48	49
OTHER GOV. LABS	8	9	8	7	11	15	18	16	19	15	14	18	13
UNIVERSITIES	27	33	45	51	79	78	89	94	120	92	62	64	63
INDUSTRY	5	5	9	7	13	24	20	24	36	18	20	16	15
FOREIGN	12	18	39	35	27	24	17	26	18	27	14	25	32
	89	106	150	143	182	196	201	220	254	212	163	171	172

6.3 Cold Moderator Development

In September, 1994, a new cold solid methane moderator was installed in the "H" position, which serves three instruments: GLAD, QENS, and HRMECS. We continue operating the grooved solid methane moderator in the "C" position and the liquid methane moderator in the "F" position. The new "H" moderator contains Aluminum foam for heat transfer and Gadolinium poisoning (17 w/o Gd in Al, 0.5 mm thick) 2.5 cm beneath the viewed surface. Both solid methane systems are operated at about 25 K and melted at approximately 60 hour intervals to anneal out the stored energy and remove accumulated Hydrogen. The schedule is dictated by the observation of unprogrammed "burps" that take place irregularly at somewhat less than three day intervals in the "C" moderator.

Figure 5 shows a spontaneous burp of the "C" moderator that took place after 47 hours irradiation with about 15 μA proton current on the depleted Uranium target. It was determined that such a spontaneous burp does not remove all the stored energy, because subsequent scheduled annealing produces another energy release even following a relatively short irradiation. We also find that little Hydrogen gas evolves during warming up to about 65 K, but that the gas comes off rapidly as warming takes place through this temperature (recall that methane melts at about 90 K.) We recently increased the moderator temperature slightly in an effort to eliminate the unscheduled "burps".

The colder moderator, compared to the previous liquid methane "H" moderator (~100 K) not only produces a greater flux of long-wavelength neutrons, but also extends the sharp slowing-down pulse shape to lower energies (with sacrifice of some flux in the ~10 meV region.) This extends the useful range of HRMECS to E_0 below 4 meV, where it achieves about 150 μeV elastic resolution. The counting rate in QENS in the near-elastic range (E_f = 3.7 meV) has increased by about a factor of 5 with little resolution change, so that the typical measuring time for quasielastic scattering from hydrogenous samples is now 2-3 hours. GLAD enjoys cleaner resolution in the longer-wavelength range. The systems have operated with little trouble in recent times.

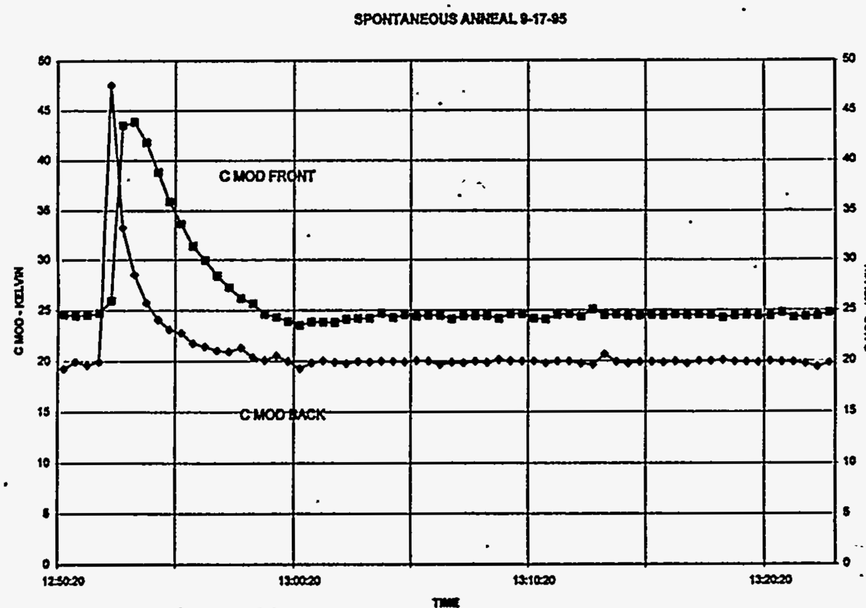

Figure 5: Spontaneous Burp of "C" Moderator

7. New Procedure for Fast Access to the IPNS Powder Diffractometers

Beginning in October, 1995 a procedure will be implemented for obtaining fast turn-around on the Special Environment and General Purpose Powder Diffractometers. A small fraction of the operating time on each of these instruments will be available on a first-come first-served basis, without the need to write the standard four page proposal. A short, one-page form will need to be completed indicating any potential hazards. Interested users should contact the instrument scientists, J. Jorgensen (SEPD) or J. Richardson (GPPD), to learn the backlog for each instrument. Samples will be shipped to IPNS and data collection will be done when time becomes available without requiring the user to come to IPNS. The raw data can then be accessed on the instrument computer. Similar to other experiments performed at IPNS, users will be responsible for data analysis. This service will be limited to short (less than one-day) experiments involving only room-temperature data collection for samples that present no special handling problems. The time allocated to a single user will be limited to allow access for as many different users as possible.

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8. Computing at IPNS

IPNS still uses DEC VMS computers for data acquisition and analysis, although most of the staff have personal computers or a workstations for other tasks. Some Unix workstations have been introduced for special needs and we have converted our accelerator control system to EPICS, running on Sun workstations. File sharing among personal computers is handled by a Windows NT server. We are investigating the use of Windows NT for data analysis using MS Powerstation Fortran and Visual C++. Windows NT is also used for the IPNS Web-Server (http://pnsjph.pns.anl.gov).

Graphics applications at IPNS were converted several years ago from CA-DISSPLA to GKS using a library of routines called GPLOT. We have now converted many of our graphics applications to PGPLOT, a free graphics library available from Cal Tech which runs on many different computer systems. PGPLOT has been extended with some routines written here, and we are looking at PGPLOT extensions from other laboratories.

A visualization package has been developed, called TOF_VIS, which can be used to quickly survey the experimental data and to analyze detector performance. This started as an application for the GLAD spectrometer and has been generalized for use by other instruments, including some at ISIS. Development will continue on TOF_VIS. For more general data visualization we have purchased IDL software and for analyzing powder diffraction data, we have adopted GSAS.

IPNS has been helping to initiate a number of proposals to increase computing cooperation and collaboration within the neutron scattering community. We hosted the first Workshop on Software Development at Neutron Scattering Sources (SoftNeSS'94) in October, 1994. Following the recommendations of that workshop, we have set up a Web server for neutron scattering in general (http://www.neutron.anl.gov) and a neutron scattering mailing list which now has over 400 subscribers. To subscribe to this list, send an E-mail message to "neutron-request@anl.gov" with the word "SUBSCRIBE" as the first line of the message and you will receive further instructions. We also helped to initiate a follow-up workshop to establish a standard format for the exchange of neutron and X-ray data (SoftNeSS'95) and are currently involved in implementing the new format using NCSA's HDF.

9. Acknowledgments

Almost all of the work discussed in this article and many of the words of the article are the result of effort by other members of IPNS, the neutron scattering group and the APS at Argonne. The operation of IPNS is funded by the U.S. Department of Energy, BES-Materials Science, under contract W-31-109-ENG-38, and the National Science Foundation (DMR-91-20000) through the Science and Technology Center for Superconductivity.

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