Recent progress at LANSCE

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Since the last ICANS meeting in 1986, a new construction project, funded at the level of $17.5 million by the U.S. Department of Energy, has been started at the Los Alamos Neutron Scattering Center (LANSCE). This project comprises an experimental hall with an area of 1700 square meters, a support building which includes both laboratories and offices, and four new spectrometers. The experimental hall was occupied in April of this year and we anticipate the use of the support building within six months. Both of these buildings, an artist's impression of which is shown in Fig. 1, are essential for the national user program which is described below.

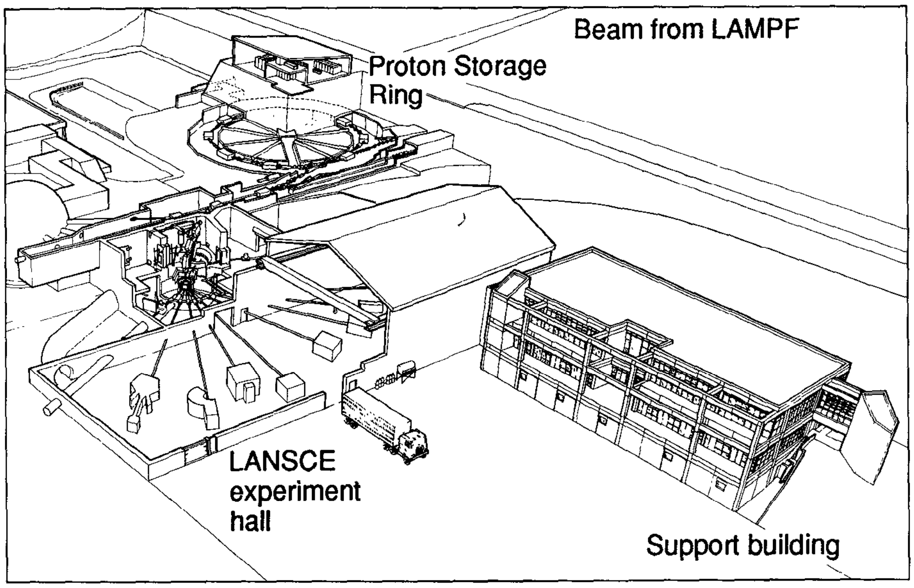

Fig. 1 Artist's impression of the new LANSCE facility.

The four instruments included in the construction project are a medium-resolution powder diffractometer (NPD), a reflectometer for surface studies, a high-resolution chopper spectrometer with a Brillouin scattering option, and a back-scattering spectrometer. Design workshops for each of these instruments have been held and have involved participation of scientists from both the United States and Europe.

The first incarnation of the NPD (c.f. Fig. 2) was installed in August of this year, in time to benefit from several weeks of beam. Experiments have been performed on a number of samples and the spectrometer has been found to have the predicted resolution (currently the highest for any US powder diffractometer) and low background. In future, new detector banks, comprising linear, position-sensitive detectors, will be added, and the instrument should reach its "final" configuration within two years.

Fig. 2 The Neutron Powder Diffractometer (NPD) recently installed in the new experimental hall.

During the past two weeks, first measurements have been made with our prototype reflectometer, yielding data such as those shown in Fig. 3. Since no serious effort has yet been made to reduce background on this instrument, the results in the figure are encouraging. The reflectometer has a novel design involving two beams incident on the horizontal plane of the scattering sample at different angles. Although the instrument will be in regular use from 1989 onwards, it will not be included fully in the user program until 1990.

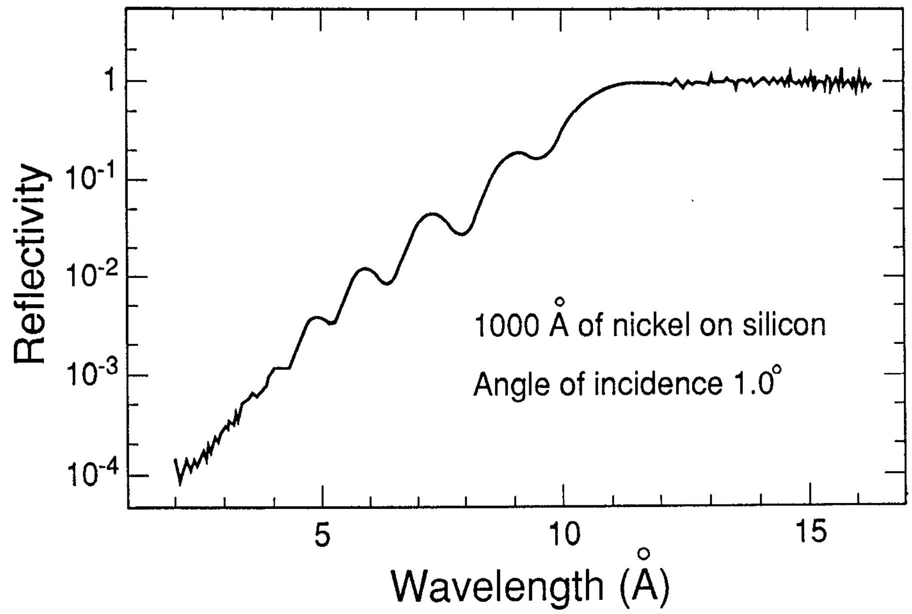

Fig. 3 One of the first reflectivity profiles obtained with the LANSCE reflectometer.

Detailed design is already in progress for the chopper spectrometer and we anticipate the installation of the incident beam line by next year. The first operational part of this instrument will involve the low-angle detectors needed for Brillouin scattering, some of which should be installed by next year. The vacuum tank containing the high-angle detectors is unlikely to be available before 1990, however, and the full compliment of detectors will not be implemented until 1991.

The last of the four new instruments, the back-scattering spectrometer, has been designed conceptually but not in detail. This spectrometer will be positioned at the end of a ^{58}Ni-coated guide viewing the existing liquid-hydrogen moderator. The guide tube will be ordered in the very near future, but a debate concerning the relative merits of straight and curved guides has to be concluded first.

Part of our construction program involves making four additional penetrations in the existing bulk-shield and bringing these beams into the new experimental hall. The penetrations will be made next year, but upgraded and new moderators will not be installed until 1991 or 1992. One of our current exercises is to determine the locations and identities of the new moderators and the disposition of the spectrometers they will serve. Plans in this area are far from concrete, but it appears likely that we will install at least one liquid-methane moderator. In all probability the existing (or renovated) versions of the single crystal diffractometer (SCD) and the filter-difference spectrometer (FDS) will be moved to the new experimental hall when the upgraded moderators are installed. Options for less conventional moderators, such as mixtures of metal hydride and liquid hydrogen, are also being studied.

This year was the first in which LANSCE ran a formal user program, similar to the widely-copied ILL model, with proposals examined by an External Program Advisory Committee (EPAC). LANSCE shares this committee with the IPNS, and it is our intention to hold joint meetings at which proposals for the two centers are examined at the same time. Operational issues prevented such a joint meeting in 1988, but one is planned for March of next year. A policy for the distribution of LAMPF protons between the LANSCE target and the Weapons Neutron Research facility has been agreed. Essentially this policy results in LANSCE spectrometers being available to external users for non-classified research during about 60% of each 6-month LAMPF run-cycle. Classified measurements may also be performed, and may occupy up to 20% of the available beam time. Such experiments are chosen on the basis of proposals which are examined by an Internal Program Advisory Committee (IPAC). It was gratifying to observe that beam time was over-subscribed by a factor of about two in 1988, with a total of 102 proposals submitted for non-classified research on 5 spectrometers. In addition there were 12 proposals for research of programmatic interest to Los Alamos National Laboratory.

Unfortunately, statistics for beam availability were unimpressive this year. Although the overall beam availability was about 64% during the six weeks of cycle 52 (18th August to 3rd October), cycle 51 (15th June to 22nd July) averaged only 30%. The technical reasons for this poor performance will be discussed in more detail by Bob Macek in a later presentation. To a limited extent the numbers are reduced by our definition of availability. Beam is defined as available only when the proton current exceeds 50% of the planned value (30 μA at 15 Hz for most of 1988). Since the potential exists for unacceptable radiation levels to be generated in the neutron scattering halls during PSR tuning, the latter operation has to be carried out at reduced proton current. Tuning accounted for 13% of scheduled time in cycle 51 and 9% during cycle 52.

The peculiarity of our accounting system for beam availability does not really reduce the severity of our problems in this area, however, and an increase of availability is the major short-term priority at LANSCE. I believe that Bob Macek and his group have now identified many of the improvements to existing hardware which will be required to ensure improved reliability. These will be implemented as rapidly as possible as part of the Laboratory plan to ensure that PSR reaches its full potential within the next three years.

In spite of the poor reliability of PSR, we were able to carry out 42 of the 49 experiments approved by EPAC and all 8 of the experiments ratified by IPAC. However, 22 experiments had to be rescheduled and user satisfaction was only achieved by using LANSCE discretionary time. Even so, 33 experiments in support of the LANSCE research program were accomplished during discretionary periods.

Although PSR was originally designed to deliver 100 μA of protons, we have been unable to increase the current beyond about 35 μA without compromising hands-on maintenance. The problem has been traced to the H^0 injection scheme which, when it was implemented, was seen as a cost-effective attempt to solve a difficult technical problem. Unfortunately, the scheme results in an unprecedented increase in beam emittance before injection and to a non-Gaussian beam profile. Both of these features, which will be discussed in Macek's talk, lead to unacceptable spill for proton currents above about 35 μA. To achieve the 100 μA of which PSR is capable will therefore require a modification of the injection scheme. The management of Los Alamos Laboratory has decided that this task has high priority and that it will be accomplished within the coming three years.

Those of you who visited LANSCE prior to the 1988 run cycles will remember that experimenters had no access to their spectrometers during proton beam delivery. At that time, unforeseen spills of the protons could have caused massive radiation doses close to the neutron spectrometers. Solution of this problem was our first priority in 1988. A triply-redundant system of fail-safe instrumentation has been installed to detect beam spills and unacceptable radiation levels. The system is able to interrupt the proton beam sufficiently rapidly to prevent unreasonable exposure of personnel to radiation fields. However, as mentioned above, it is necessary to diminish the proton current during tuning operations, when beam spill is inherently more likely, in order to avoid trips of the safety instrumentation. To be able to tune without incurring this reduction of current will require the installation of additional shielding around the pipe through which protons pass from PSR to the LANSCE target.

During the past year we have made a concerted effort to understand the shielding requirements for neutron beam lines and spectrometers at a high-current spallation source. On the basis of Monte Carlo calculations which he will describe at this meeting, Gary Russell has been able to generate an algorithm for effective shielding which minimizes the amount of unnecessary material. This cost-effective solution, shown schematically in Fig. 4, has been implemented on NPD and found to work well.

A development at LANSCE that has paid dividends recently is the Generalized Structure Analysis System (GSAS), which is used to treat diffraction data obtained with both powders and single crystals. This software, which was written by Allen Larson and Bob Von Dreele, is currently in use at more than 35 sites in addition to LANSCE. The programs were written with the ability to refine simultaneously multiple, independent data-sets. It has proved particularly useful to combine data obtained with x-rays and neutrons on the same powder sample. The crystallographic structure obtained from the refinement is more accurate than could be obtained with either technique alone and local minima in the least-squares refinement are avoided. Furthermore, the maximum level of structural complexity which can be treated is increased when independent data sets are used. I believe this to be a true example of what is meant by the complementarity of x-rays and neutrons: the simultaneous use of both probes to solve complex structural problems.

A LANSCE initiative which may revolutionize the way in which pulsed-source data are analyzed involves the use of maximum entropy methods. Devinder Sivia, who will talk tomorrow, has already demonstrated the power of this method in the treatment of data obtained on the FDS. However, I believe that the method may have use beyond the simple implementation of data treatment algorithms. The maximum entropy method provides an impartial assessment of the information content of data. Thus, it may be used to rank the relative effectiveness of different spectrometer resolution functions. In particular, Devinder has shown that resolution functions with one sharp edge are superior to symmetric functions of the same variance. At pulsed spallation sources, where the physics of the neutron moderation usually leads to asymmetric lineshapes, this observation may have far-reaching consequences.

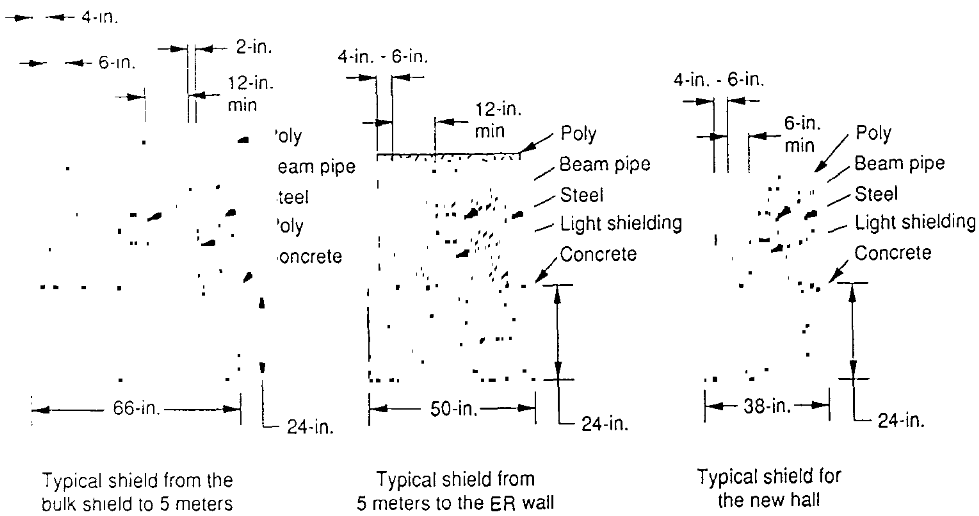

Fig. 4 Cross section of LANSCE beam line shielding which has been optimized with the help of detailed, neutron-transport codes.

In conclusion, the past year has been one of great change at LANSCE. It has been an exciting time during which new developments have occurred almost daily.