Summaries and future projections

P. A. Egelstaff
Physics Department
University of Guelph
Ontario
CANADA

PART A: A SUMMARY OF THE PLENARY SESSIONS

Overviews

The overview session is best assessed by comparing such sessions from successive ICANS meetings. In this way it can be seen that while all sources are still experiencing teething troubles, they all are making substantial progress. Also, we might say that this meeting has celebrated the maturing of ISIS. It is approaching 100 μA and long periods of steady running on ~10 instruments. We could take the combination of these three items as the measure of a mature modern installation.

The emphasis at both ISIS and LANSCE is now on reliability and uniform operation. This is also an indication of maturity because it shows that the early phase of just getting the source to work is over. At IPNS, the new topic is the booster target. We look forward to news of its operating characteristics. If the design performance is achieved, IPNS will be able to continue to be competitive with the other two sources. KENS works at a lower current and fewer days than the other sources, but it continues to produce good results in cases where some resolution can be sacrificed to increase intensity. Because of the steep relationship between intensity and resolution, they can do this successfully.

In reviewing the progress announced during the first session, a "hardened reactor user" was overheard to say that pulsed sources have now proved that they are here to stay.

Current Problems

The second session was devoted really to current problems. These included problems with several types of targets and moderators and with the performance of storage rings and of shields. It was possible during this session to pick up an unduly pessimistic view of the progress being made with pulsed sources. This session involved a frank debate over the technical problems that have prevented the full realization of the optimistic predictions of earlier years. A reasonable conclusion would be that the problems discussed are being resolved slowly and, therefore, those predictions were justified—albeit over a longer time scale. Alternatively, we can say that we are learning how to design targets and moderators, how to operate accelerators and storage rings, and how to shield sources and experiments in the necessary depth and detail required to meet the initial specifications. Probably the depth required had not been appreciated or had not been fully funded, and consequently the necessary work had to be extended over many years. However, papers in this session revealed that reasonable solutions are possible and in many cases in hand, so that at the next ICANS meeting we can expect fewer problems to be reported.

Moderators and New Instruments

The fertility of this field is (perhaps) demonstrated most aptly by the avid discussion of new moderators, new instruments and new techniques in data handling and data reduction. New kinds of experiments were debated in a similar way also. While experience shows that not all these ideas will survive the test of time, there seems to be no doubt that a number of them will do so. Consequently, we can expect that future ICANS meetings will see the successful outcome of many of the proposals discussed this week, and the benefits that accrue to a field as fertile as this one. Of course, they will be optimized in different ways for each of the various scientific fields.

Future Sources

No less than six future sources were discussed at this meeting. They may be divided into reactors (Maple and Advanced Neutron Source), C. W. accelerator (PSI Source), time-structured (Advanced Spallation Source), and pulsed accelerators (Aspun and KENS II). This discussion also demonstrates the fertility of the field and the benefits to be expected in the long run. In each case, the technical situation, operating characteristics, and funding were described clearly and frankly. The attainable flux levels and operating characteristics for the next decade are, thus, reasonably clear. Over the foreseeable future reactor fluxes will lie in the 10^{14}-10^{16} n/cm^2/sec range, with the lower end being regarded as a worthwhile lower limit for useful experiments and available in many places. For pulsed sources an output of 10^{15} to 10^{16} protons per second is probably the maximum that can be expected in the foreseeable future. The emphasis by the users at this meeting on reliable scheduled operation from the accelerators is likely to dominate technical improvements over the next few years. Thus, the need for consolidation rather than brighter sources may delay further development of some of these ideas. Nevertheless, the idea that existing sources could be upgraded over the next decade, so that they might exploit some of the ideas discussed for new sources is a good idea which will be found on the agenda of future meetings.

The Scientific Programs

An exciting scientific program for pulse neutron sources was described at this meeting. However, an ICANS meeting is not the proper forum at which to judge its quality. Rather, the various elements of this program will be rated on their merit by each discipline over the next few years at meetings devoted to research in each discipline.

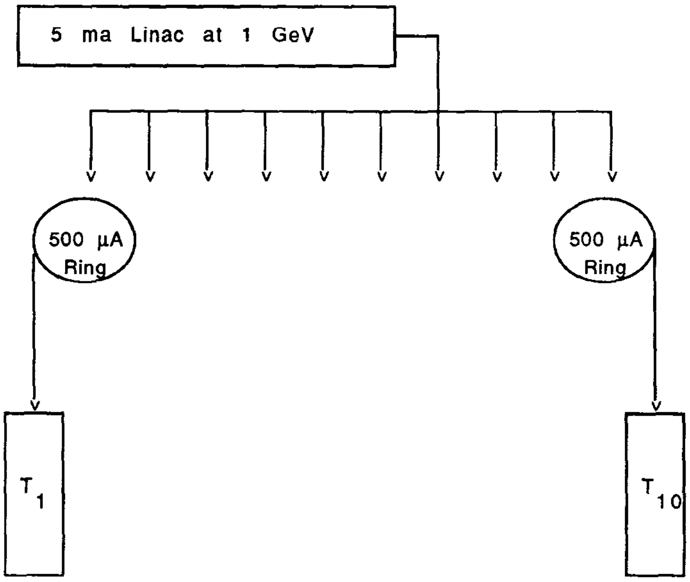
PART B: PROSPECTS FOR THE FUTURE

Some short-ranged projections have been given in the summary above, and so this section will be devoted to longer-ranged speculations that might provoke a fertile discussion.

The kinds and numbers of instruments at reactors are large, but they have taken about 30 years to develop and are still developing. This sets the relevant time scale. We might imagine that for pulsed accelerators, this process has gone about one-third as far as for reactors. Consequently, in about 15-20 years time, we might expect each accelerator source to have 30-40 instruments (maybe on more than one target), and that they will, in many cases, be complementary to the reactor instruments. In parallel with this gradual development, there will be an expansion in users: at present the users are fewer on the accelerators, but in 15-20 years we may expect them to equal or exceed the number at a large reactor. It is notable also that as this process of instrumental development takes place, the instrument scientists and users age in years. That is, new institutions attract young people and we see today that the accelerators have youth on their side compared to the staff at reactors. However, this difference is likely to disappear on the same time scale.

Accelerators are capable of supplying three types of sources—pulsed, time-structured and C. W. The proper roles for each are not yet clear, but will probably depend on the quality of the instruments developed for each type of source. Time-structured sources may, in particular, spawn new instruments. If this is so, the above 15-20 year time scale will apply to this source differentiation, also.

Another possibility is the multipurpose accelerator source. Several speakers pointed out that they would like to increase pulse length at the expense of resolution. This is easily accomplished through using large, high-temperature moderators. If the pulse repetition frequency is high and this type of moderator is taken to an extreme, it would overlap the structure of a time-structured source. Further, if several targets with different setups were used on one source, the distinction between these two different classes of sources may not be important. Moreover, the ideal pulse repetition frequency may vary from experiment to experiment or instrument to instrument, from 0.1 Hz giant pulses to 100 Hz normal pulses. Thus, giving the experimentalist some control over both pulse length and frequency may become an important future requirement. While it is not easy, at present, for the designer to meet these varied requirements, there is an important respect in which an accelerator source differs from a reactor source, which should be exploited. This is multiplexing. One can imagine a high-current accelerator feeding several storage rings, each of which services a different class of users. Thus, in 20 years, we may see a cluster of storage rings and associated sources surrounding a high current accelerator. In this event, the number of users could greatly exceed those at the typical reactor. Figure 1 shows such an assembly, using a 5 ma linac feeding 10 storage rings each accepting 500 μA. The larger the installation, the larger will be the number of users and the more user friendly will both the organization and the instruments need to be. Thus, user friendliness becomes an important goal of management, while management friendliness or administrator friendliness will be of lesser importance



Each experimental class has optimized facilities, due to multiple targets, T_1 --- T_{10}

Fig. 1 A High Power Accelerator could run many sources of different kinds.

Many of today's instruments are designed to have a high productivity, and sometimes they have been criticized for putting productivity ahead of the scientific method. In the early days of the three-axis spectrometer and the constant-Q method, Bert Brockhouse praised this instrument for discarding most of the neutrons in both the incident and scattered beams. "It gives me only the points I want," he said "on a point-by-point basis at a human speed." Then he continued, "For this reason, when my first experiment is concluded, I have had time to interpret it, and have planned the next experiment!" As neutron sources proliferate and are used on a daily basis, we shall probably see a return to this notion of operating experiments at a "human speed", and thinking more deeply about the scientific method while they are in progress.

Because neutrons have so many useful properties and could be used by scientists in so many disciplines, there is need for a wide variety of sources and a variety of geographical locations. We may compare the availability of neutrons to photons (i.e., light- or x-rays). The difference lies in the absence of laboratory or local sources in the neutron case, compared to their ready availability in the case of photons. Neutron scattering will not develop unless this gap is closed. During the next 20 years, more attempts to close this gap will be made. On one hand, we can expect multiplexed accelerators offering a broad spectrum of options to an immense number of users, and on the other hand, we may expect inexpensive 10^{14} n/cm^2 s reactors (e.g., the Maple) to become much more widespread. It is unlikely that the potential of neutron scattering in condensed-matter research will ever be realized unless the availability of medium-class sources proliferates in such ways. Thus, it is perhaps of greatest importance that designers regard cheapness, reliability and simplicity of operation as the primary goals for sources in this class.

Some interesting predictions may be made by time projections of past experience. For example, the role of boosters on pulsed sources is changing. The Harwell electron linac booster (about 25 years ago) had a gain of 10, while the IPNS booster on a brighter source has a gain of 3. There are no plans for boosters on brighter sources. The reason seems to be that as the source brightness is increased, the instrument performance may be improved and the penalties of using a booster become more serious. To compensate for the defects, the booster gain is reduced; therefore, one can predict that boosters will disappear in about 10 years.

Another prediction in this class can be made by plotting the time-from-conception to regular use for each decade's high flux sources. This is shown in Fig. 2 for the most advanced source in four different periods (the time includes funding delays and other difficulties). It can be seen that the time scale increases uniformly, and if extrapolated for the case of the ANS, this graph predicts about 25-30 years. This is about twice the minimum time scale given by the designers. Thus, if the project was conceived during the late 70's, this argument would predict regular use in the early years of the next century. Such a time scale is close to the length of a research scientist's career and, hence, is likely to be unacceptable. If major projects are to be built successfully, this problem needs to be solved: it is, of course, a problem common to several fields.

Finally, there has been some speculation at this meeting on the ultimate source. My version of this is shown in Fig. 3, the $(ING)^2$. An international group is likely to develop it, and $(ING)^2$ would provide the ultimate in C.W. sources for cold neutrons, thermal neutrons, and flux traps as well as the ultimate in pulsed sources, particularly in the field of giant pulses. It is also the ultimate in speculations.

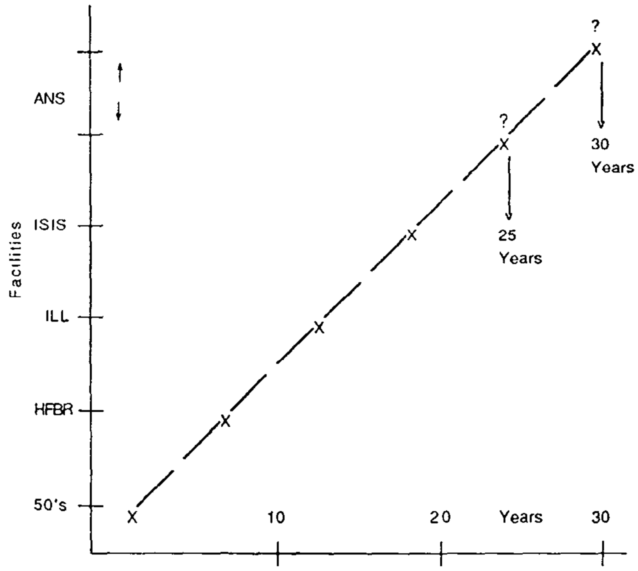


Fig. 2 Time from conception to regular use.

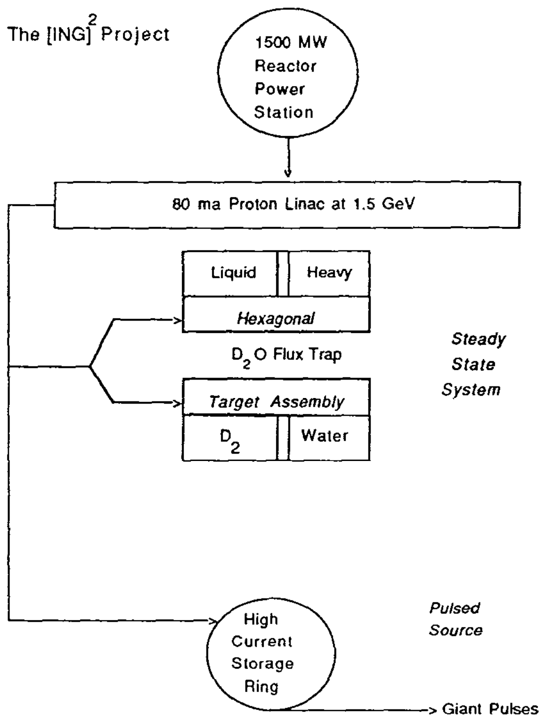


Fig. 3 Inter-National Group for an Intense Neutron Generator.