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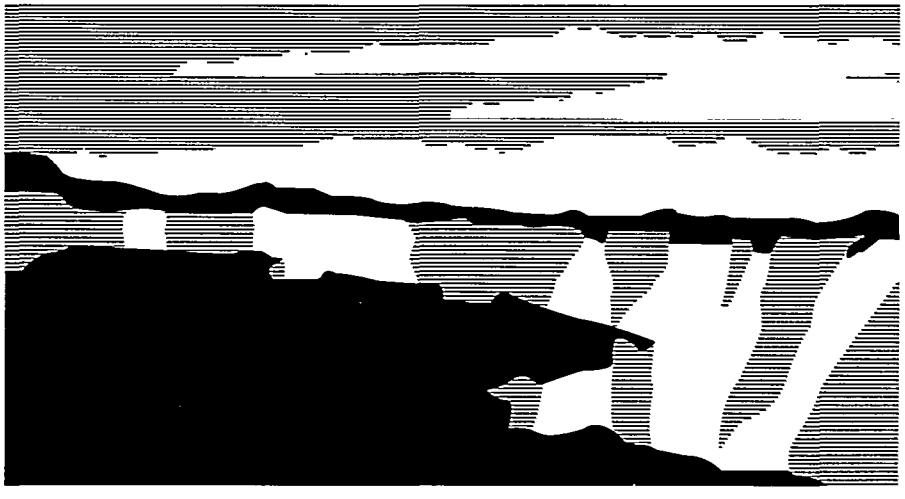

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A PROPOSAL FOR A LONG-PULSE SPALLATION SOURCE AT LOS ALAMOS NATIONAL LABORATORY

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ABSTRACT

Los Alamos National Laboratory is proposing a new spallation neutron source that will provide the U.S. with an internationally competitive facility for neutron science and technology that can be built in approximately three years for less than $100 million. The establishment of a 1-MW long-pulse spallation source (LPSS) at the Los Alamos Neutron Science Center (LANSCE) will meet many of the present needs of scientists in the neutron scattering community and provide a significant boost to neutron research in the U.S. The new facility will support the development of a future, more intense spallation neutron source, that is planned by DOE's Office of Energy Research. Together with the existing short pulse spallation source (SPSS) at the Manual Lujan, Jr. Neutron Scattering Center (MLNSC) at Los Alamos, the new LPSS will provide U.S. scientists with a complementary pair of high-performance neutron sources to rival the world's leading facilities in Europe.

1. World Class Performance in Several Areas

It has been recognised for over a decade that the U.S. needs new neutron sources and instrumentation if it is to carry out forefront neutron scattering research and compete in this arena with its international competitors in Europe and Japan. The 1 MW LPSS proposed by Los Alamos National Laboratory will provide advanced capabilities for neutron scattering and support the application of neutron scattering techniques to basic and applied research in disciplines such as materials science, structural biology, engineering, chemistry, and polymer science. Operating as a user facility, the proposed LPSS will provide U.S. universities, National Laboratories and industries with capabilities that will contribute strongly to the U.S. Department of Energy vision of being a major partner in world-class science and technology.

The principal focus of the LPSS will be on neutron scattering investigations that require cold or thermal neutrons. In many areas of neutron scattering research that use this part of the neutron spectrum — such as high resolution spectroscopy, reflectometry, moderate resolution powder diffraction, multiplexed backscattering, and Fourier methods — a 1 MW LPSS will outperform the ILL by a factor of between 3 and 4. In other areas — neutron spin echo, small-angle scattering, and Laue diffraction, for example — performance similar to that of the ILL is anticipated. In a few areas — notably three-axis spectroscopy that concentrates on single points in Q,E space — the 1 MW LPSS will not perform as well as the ILL. The anticipated instrument performance, which has been documented at a recent workshop [1] held at Lawrence Berkeley National laboratory, will support a scientific program oriented towards macromolecular and

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soft-condensed matter science, areas which have grown significantly in the past few years and are expected to be of continuing importance.

The LPSS facility will establish the only high-intensity, ultracold neutron (UCN) source in the U.S. The importance of such a source has been acknowledged in long-range plans by the Nuclear Science Advisory Committee. UCNs are critical for our understanding of such issues as the origin of parity violation in elementary particle and nuclear interactions and the detailed nature of time reversal nonconservation. The precise measurement of neutron lifetime using UCNs is also critical for a number of issues in astrophysics and cosmology, such as the relative abundance of light elements predicted by the "Big Bang" theory. Installation of a UCN source at the LPSS will project the U.S. into an immediate position of leadership in this exciting area of fundamental research.

Science-based stockpile stewardship is a Department of Energy program that will ensure the safety, security, and reliability of the nuclear weapons stockpile without nuclear testing. The LPSS will provide high-energy neutrons for tomographic surveillance of nuclear weapons as well as long-wavelength neutrons for other types of non-destructive evaluation such as cold neutron radiography and depth profiling. By providing enhanced capability for examining issues such as explosive safety, polymer aging, and surface corrosion, the LPSS will make important contributions to understanding materials aging that will occur as nuclear weapons remain in the stockpile beyond their design lifetime.

Of the 15 beam lines envisaged for the new LPSS, 14 will be available for neutron scattering research and one will be equipped for high-energy neutron radiography. In addition to an intense source of ultracold neutrons, the facility will include a cell for testing new spallation neutron target systems, and a materials irradiation capability. If required, the facility could be used to produce neutron-rich radioisotopes, such as ^{99}Mo, for medical diagnostic or industrial applications. The LANSCE linac also has sufficient capacity to continue producing neutron-deficient isotopes at or above its present rate after the LPSS is installed.

2. Cost Effectiveness and Timeliness

Preliminary cost estimates indicate that the LPSS can be designed and constructed at Los Alamos for approximately $72M. At this stage, the project contingency is estimated at 30%, implying a Total Estimated Cost (TEC) of $95M. The facility is a cost-effective method for obtaining an advanced neutron scattering capability in the U.S., the necessity for which has been recognised by the scientific community and the DOE for over a decade. We estimate that the LPSS facility can be brought on-line quickly, with a design and construction time of three years. The facility thus provides a means of meeting the immediate need for a more powerful neutron source in the U.S. In addition, with its target testing and irradiation facilities and the experience it will provide with the operation of a 1 MW spallation target system, the proposed LPSS will provide important data to support future development of spallation technology for neutron production.

The cost and schedule estimates are based on our prior experience with spallation sources at the MLNSC and our Weapons Neutron Research (WNR) facility, and with our experience in constructing and commissioning accelerators. We can provide the LPSS capability at this cost by using an existing proton accelerator which produces the world's most powerful beam of protons. In addition, we will capitalize on our existing buildings and structures and use proven technologies. Operation of the facility also will be cost effective (at a marginal cost of $11M per year for eight months of operation) because the accelerator is already run by the DOE Office of Defense Programs at low power for the MLNSC and the WNR facility.

The existing linear accelerator is already capable of delivering about 750 kW of proton beam to an LPSS target and simultaneously accelerating the H^- ions needed for the existing short-pulse spallation source. Modifications to the linac will ensure that it can provide the additional 250

kW required to reach 1 MW in a reliable manner. Most importantly, these modifications are sufficiently minor that no extensive facility commissioning will be required. When one considers the history of spallation neutron sources and the time which has been required to bring their performance up to design specification, the real advantage of using an existing accelerator becomes very clear.

3. Existing Infrastructure

Los Alamos can provide an LPSS in a timely and cost-effective manner by using existing buildings and equipment with a replacement value of $38M, proven technology, experienced personnel, current resources, and Laboratory infrastructure. The LPSS target, shielding monolith, and support systems will be housed in an existing building at the end of the 800-MeV proton linear accelerator already operational at LANSCE. The facility is already equipped with utilities and ancillary support systems including lifting cranes; water cooling systems; vacuum, cryogenic, and air handling systems; waste treatment and disposal facilities; an electrical substation with transformers that can provide power for experiments; remote handling manipulators and control systems that can be used to handle targets and other radioactive components; and existing shielding. These systems constitute a considerable infrastructural investment and will be used to the fullest extent possible to support the LPSS.

As many of the presentations at this meeting have demonstrated, Los Alamos has in place the core of the team which will be needed to design the target for a new spallation source. In addition this team has many of the tools it will need, ranging from a powerful suite of Monte Carlo codes for simulating target performance, to irradiation facilities for qualifying materials, and a place to test the performance of mocked up targets in a proton beam. In addition, we are beginning to gain experience with simulations of neutron spectrometers so that the true merits of long pulses can be determined.

4. Looking to the Future

Neutron science has contributed to many advanced technologies and underpins U.S. economic competitiveness in vitally important industrial sectors such as automotive, aerospace, electronics, biotechnology, pharmaceuticals, materials, chemicals, and petrochemicals. The proposed LPSS is an important tool for continued contributions in many of these areas.

In addition to providing a powerful tool in the short term, the proposed LPSS will also support the development of future neutron sources in the U.S. by serving as a technological test-bed. The target test cell included in the LPSS shielding monolith will aid in the study and optimization of new spallation target concepts and the development of new designs for target systems for advanced spallation neutron sources. The materials irradiation capabilities of the LPSS will be employed for materials characterization experiments that support future spallation target designs, the nuclear weapons program, and the domestic fusion program. Data provided by the LPSS will support the National Ignition Facility (NIF) design efforts at Lawrence Livermore National Laboratory.

With spallation technology serving as the basis for future neutron sources in the U.S., the neutron scattering community will need to obtain more experience using time-of-flight methods by designing, building and using instrumentation at a high-power pulsed spallation neutron source. The proposed LPSS facility will enable scientists at the national laboratories and other members of the neutron scattering community to gain this valuable experience. This knowledge will support projects to build and operate even more powerful spallation neutron sources in the future.

Technical obstacles that may limit the ultimate performance obtainable with a SPSS are already apparent. The accelerator rings which provide the short proton pulses needed at an SPSS have a limited capacity to store protons, and thermal shocks make spallation target

technology more difficult with short pulses. A LPSS is an alternative path towards future neutron sources that avoids these limitations. The proposed new facility provides a cost-effective way of exploring the LPSS technology and evaluating its potential for future neutron sources.

5. Acknowledgments

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6. References

[1] Proceedings of a workshop on Neutron Instrumentation for a Long-Pulse Spallation Source, held at Lawrence Berkeley National Laboratory, April 18-21, 1995.