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THE LOS ALAMOS NEUTRON SCATTERING CENTER

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ABSTRACT

The Los Alamos Neutron Scattering Center (LANSCE) is a new pulsed spallation neutron source at the Los Alamos National Laboratory for neutron scattering research in the structure and dynamics of materials. LANSCE is expected to achieve the world's highest peak thermal neutron flux of 1.7×10^{16} n/cm²-sec at 12 Hz by 1988. The scientific potential and development plans for the facility are described.

I. INTRODUCTION

The Los Alamos Neutron Scattering Center,¹ which is just beginning operation at the Los Alamos National Laboratory, is a pulsed spallation neutron source for neutron scattering research in the structure and dynamics of materials important to solid state physics, chemistry, metallurgy, polymers and biology. The peak thermal flux of LANSCE is expected to reach 1.7×10^{16} n/cm²-sec by 1988, which is a factor of forty increase beyond present pulsed source capabilities in the United States and which should be competitive with the best reactor neutron sources for materials research. The goal of LANSCE is to become a world-class national user facility for materials research with the development of neutron scattering instrumentation, targets and moderators, accelerator and beam lines, experimental support facilities, research programs, and an involved user community. Based at the world's highest current proton accelerator, the Los Alamos Meson Physics Facility (LAMPF), LANSCE has the potential for an order-of-magnitude further upgrade at a small fraction of the construction cost for a new "green field" facility of comparable capability. Provided the support of the materials research community and the DOE, LANSCE can keep the U.S. at the forefront of neutron scattering research through the remainder of this century and beyond.

II. THE LANSCE FACILITY

The general principles of operation and instrumentation of pulsed spallation neutron sources are described in several excellent reviews.² The neutrons are produced at LANSCE by the collision of 800 MeV protons from the LAMPF accelerator, compressed to a 0.27 μ s wide burst by the Proton Storage Ring, with the neutron rich target nuclei of a W or U target. The typically 1 - 4 MeV neutrons from these "spallation nuclear reactions" are slowed down in hydrogenous moderators surrounding the target to the energies (0.5 meV to 10 eV) and wavelengths (0.1 Å to 13 Å) required for materials research. A neutron burst is produced with pulse widths varying with energy from 2 μ s at 1 eV to 100's of μ s at 1 meV.

In an elastic scattering experiment, the time of flight of the neutron from a moderator to a detector determines the neutron energy. In an inelastic scattering experiment, an additional monochromatization of the neutron is required using, for example, choppers or Bragg reflection from crystals. The energy resolution in an elastic scattering experiment is principally determined by the ratio of the pulse width to the total time of

flight. Higher resolution is obtained by increasing the length of the flight path. In an inelastic experiment, the monochromator resolution is usually matched to the moderator pulse width. The small moderator sizes required to maintain narrow neutron pulse widths also lead to a non-Maxwell-Boltzmann spectrum which, compared to a reactor neutron source, has a much higher flux of epithermal neutrons ($E > 100$ meV). This opens up qualitatively new areas for materials research, e.g., high energy excitations.³ In practice, the moderator design can be optimized within limits to produce the intensity, pulse width, and spectrum required for particular scientific applications, e.g., 20 K cold liquid H₂ moderators for long wavelength neutron production for small angle neutron scattering studies of biological, polymer, and metallurgical materials.

The Los Alamos Neutron Scattering Center, LANSCE, is the name given to the materials research program at the facility created by the combination of the older Weapons Neutron Research facility (WNR) at Los Alamos with a new \$22M Proton Storage Ring (PSR). By compressing one in every ten LAMPF macropulse, a pulsed neutron source is created with a design goal of 100 μ A time average proton current, 12 Hz repetition rate, 0.27 μ s proton pulse width and 1.7×10^{16} n/cm²-sec peak thermal flux. The PSR first accepted proton beam on April 26, 1985, and demonstrated operation at 30% (30 μ A) of the design goal in December 1985. The PSR commissioning is expected to continue through 1986 and 1987 with increasing fractions of the beam time allocated for neutron scattering research. Reliable operation at the design goal should be achieved by 1988.

Currently available neutron scattering instrumentation at LANSCE includes: a Be-BeO Filter Difference spectrometer for vibrational spectroscopy; a Constant Q Spectrometer for the study of phonons and magnons in single crystals; a Laue-TOF Single Crystal Diffractometer; a High Intensity Powder Diffractometer (9 m flight path); a Neutron Powder Diffractometer (32 m flight path); and a Low Q Diffractometer for studies of large scale structures in biology, polymers, and metallurgy. A proton beam multiplexing system and new target areas are being constructed to allow simultaneous use by the four major research programs in neutron scattering, nuclear physics, neutrinos, and defense programs. An \$18M expansion of the experimental support facilities at LANSCE, to begin construction in FY87, will provide for longer flight paths, sample preparation labs, data acquisition systems, user office space and several new state-of-the-art instruments.

III. SCIENTIFIC POTENTIAL OF LANSCE

General discussions of the scientific justification for advanced facilities for neutron scattering research can be found in several places, most recently the Shelter Island Workshop.⁴ From the research experience in the past few years with the much lower intensity PNS, KEK, and WNR pulsed neutron sources, it is straightforward to extrapolate that LANSCE will be competitive with the best reactor sources for conventional areas of thermal neutron scattering research, and in addition LANSCE will provide several unique characteristics which will be particularly advantageous for many kinds of experiments.

The orders of magnitude higher epithermal neutron flux of LANSCE will facilitate experiments on high energy phonons and magnons, single particle excitations, measurement of the momentum distribution of quantum solids and

fluids, determinations of the structures of liquids and amorphous materials, vibrational spectroscopy at low momentum transfers and of hydrogen in materials, etc.

The time-of-flight method is particularly suited to experiments requiring a large dynamic range in momentum or energy transfer, to special sample environments such as high pressure and temperature, to experiments requiring a broad survey in reciprocal space such as structural phase transitions involving superlattice formation, to exceptional resolution for powder diffraction, to some kinds of stroboscopically pulsed sample environment experiments, etc.

LANSCE personnel are actively designing and beginning construction of novel time-of-flight instruments which can take advantage of the unique source characteristics including a chopper spectrometer, quasielastic spectrometer, high resolution powder diffractometer, and polarization analysis instrument in the next three years. LANSCE staff are also working on new concepts to further improve the utilization of the neutron source including boosted targets, cryogenic moderators, and high speed data acquisition and on-line analysis systems. In the longer term, LANSCE is beginning planning for potential further accelerator and target upgrades which would utilize a much larger fraction of the greater than 1 mA capability of the LAMPF accelerator. For example this could provide a world-class cold neutron source for the U.S. in the 1990's to address the rapidly growing scientific demand for cold neutrons for research in biology, polymer science, metallurgy, ultrahigh resolution spectroscopy, neutron optics, and fundamental physics.

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