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A Progress Report on the Spallation Neutron Source

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Introduction

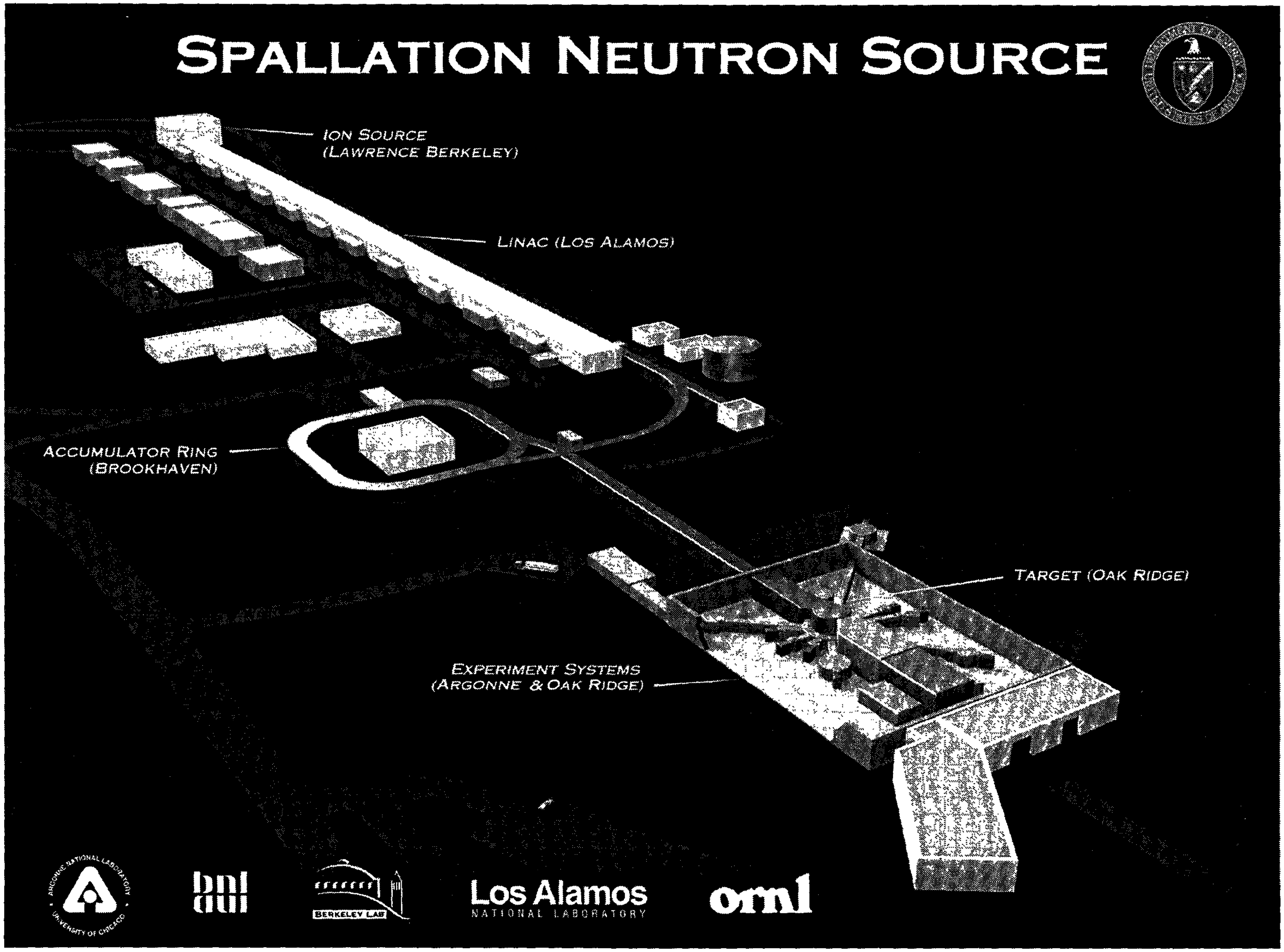
The neutron science community has been working to gain new neutron sources and improved instrumentation since the 1970s. In FY 1996, the Department of Energy (DOE) provided $8 million to initiate the R&D and conceptual design studies on a next-generation, accelerator-based spallation neutron source. This presentation is a brief overview of the status of the design and funding efforts on this new neutron source, which is called the Spallation Neutron Source (SNS).

The SNS Collaboration

Figure 1 is a schematic representation of the SNS. It also highlights the fact that the SNS will be designed and constructed by a collaboration of five DOE National Laboratories. The design selected for SNS is an H^- ion source, a 1-GeV conventional linac, an accumulator ring, and a mercury target with water and supercritical hydrogen moderators that provide pulsed neutrons to 18 beam lines.

When Oak Ridge National Laboratory (ORNL) was asked by DOE to assume responsibility for the design of SNS, we decided to establish a full collaboration that focussed the considerable expertise of the DOE National Laboratory system. Not only were we seeking to involve those laboratories with recognized expertise in accelerator/target/instrument technologies, but we sought laboratories that also were experienced in the operation and/or design of major neutron facilities. This added dimension enhanced our connection with the neutron science community, who are our ultimate customers, and provided an understanding of the essential elements of a successful neutron facility.

The Lawrence Berkeley National Laboratory is responsible for the front-end systems of SNS (H^- ion source, RFQ, and initial beam chopping). Los Alamos National Laboratory (LANL) is responsible for the conventional linac accelerator system, which accelerates the H^- ions to 1-GeV energy. LANL also directs the integrated controls systems effort for SNS. Brookhaven National Laboratory is responsible for the accumulator ring and


SPALLATION NEUTRON SOURCE
ION SOURCE
(LAWRENCE BERKELEY)
LINAC (LOS ALAMOS)
ACCUMULATOR RING
(BROOKHAVEN)
TARGET (OAK RIDGE)
EXPERIMENT SYSTEMS
(ARGONNE & OAK RIDGE)
bnl
BERKELEY LAB
Los Alamos
NATIONAL LABORATORY
ornl

the associated beam transport systems. Argonne National Laboratory is primarily responsible for instrument development. ORNL is responsible for developing the mercury target, conventional facilities, and overall project coordination and management. ORNL is also responsible for final operations of the SNS for the DOE and scientific community, and for establishing the staff and expertise for operating and upgrading the SNS in the future.

Reference Design

The schematic for the SNS reference design is shown in Figure 2. The 1-megawatt (MW) beam power is achieved by injecting ~1 ms pulses of H^- from the linac at 1 GeV, through a stripper foil, into the accumulator ring as H^+. The ring accumulates about 1200 linac pulses and compresses them into ~1 μs pulses, which are delivered to the mercury target at a frequency of 60 Hz. The H^+ beam is converted to neutrons as a result of the spallation nuclear reaction process; the neutrons are slowed in water, or supercritical hydrogen moderators, and directed to the instruments at the end of the beam lines.

The reference design parameters are listed in Figure 3. The SNS is designed to be upgradeable to significantly higher powers in the future. An initial upgrade to 2 MW requires only minor system improvements, but the ring and shielding are already capable of accommodating the increased powers. The design of the accelerator systems was made to be robust and flexible so that a variety of higher-power upgrades would be possible. This facilitates future upgrades that will be selected based on current technologies and neutron community needs at the time.

Since additional technical presentations in this meeting detail the capabilities and features of SNS, I will not elaborate further on those here.

The Joint Institute for Neutron Sciences

The SNS will be a designated user facility accessible to scientists and engineers from universities, industries, and government laboratories from all over the world. Based on user interests and needs, it is expected that 1000–2000 users will utilize SNS facilities each year. ORNL has 14 user facilities at present, including the High Flux Isotope Reactor (HFIR), which provides the highest thermal neutron flux of any research reactor for neutron scattering, and thus has a long history of user facility operation.

In order to facilitate user access to the SNS and HFIR, the state of Tennessee has provided $8 million for the construction of a Joint Institute for Neutron Sciences (JINS). The JINS is a joint venture between the University of Tennessee (UT) and ORNL. State funds will be provided to UT to construct the JINS facility on DOE land adjacent to SNS. The facility will be operated by ORNL and UT for the benefit of the neutron science user community.

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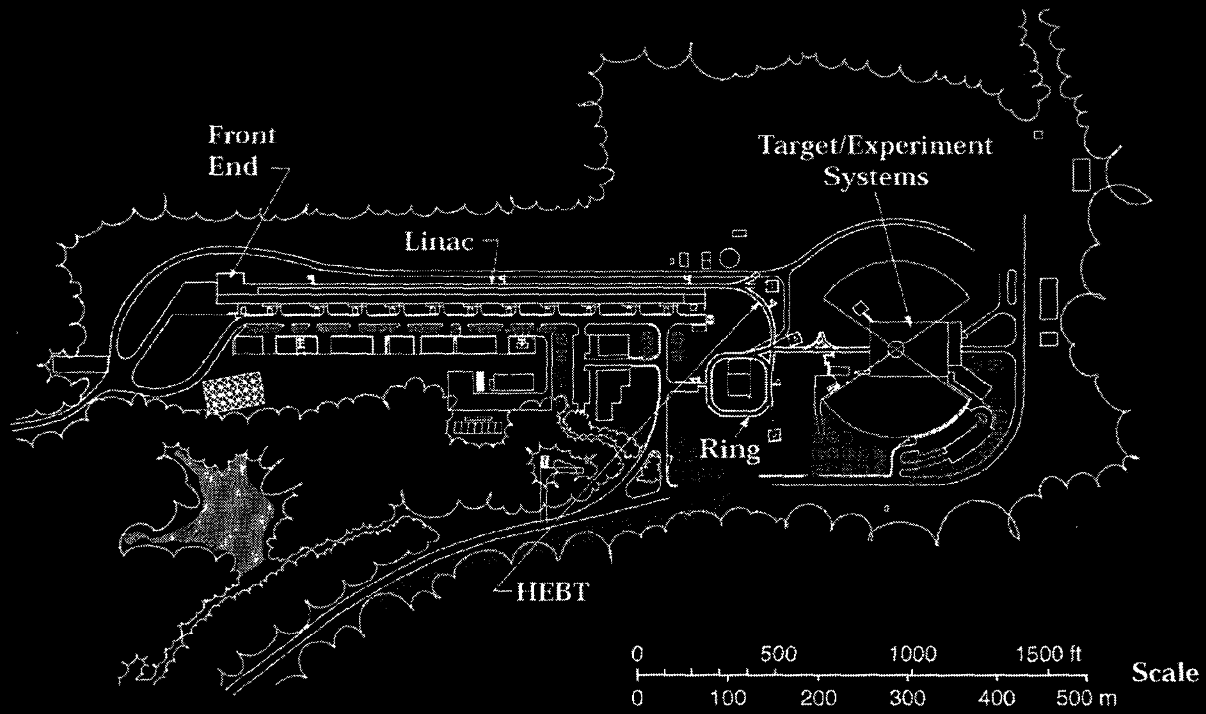
Spallation Neutron Source Reference Design



ORNL 98-3720A/jcp

Design Parameters

	Initial *1 MW*	Upgrade *to 2 MW*
Pulse repetition rate (Hz)	60	
Peak ion source H^- current (mA)	35	70
Front-end efficiency (%)	>80	
Linac length (m)	493	
Linac capture-acceleration efficiency (%)	100	
Linac beam duty factor (%)	6	
Linac final beam energy (GeV)	1.0	
Accumulator ring circumference (m)	220.7	
Ring controlled injection loss (%)	< 4	
Ring orbit rotation time (ns)	841	
Pulse length at ring injection (ns)	546	
Kicker gap at ring injection (ns)	295	
Ring filling fraction (%)	65	
Number of injected turns	1158	
Ring filling time (ms)	0.97	
Protons per pulse on target	1.04×10^{14}	2.08×10^{14}
Protons per second on target	6.3×10^{15}	1.25×10^{16}
Time average beam current on target (mA)	1.0	2.0
Target	Hg	
Beam power on target (MW)	1.0	2.0

JINS will provide an intellectual focus for neutron science and a gateway for users of SNS and HFIR. It will provide teleconferencing facilities, conference rooms and meeting space, offices, laboratory space, education and training facilities, and a nucleus for all interested universities and industries wishing to utilize SNS.

Status of the SNS Project

The DOE Office of Energy Research (ER) provided $8 million in FY 1996 to initiate the R&D and conceptual design of the SNS. The five DOE National Laboratory Collaboration was formed to accomplish this. In FY 1997 the SNS requested $23 million and received $8 million to continue this design process. The result was the reference design discussed above and a comprehensive *Conceptual Design Report* (CDR). This design was guided by performance requirements provided by DOE and the neutron science community. The first neutron users meeting (User's Workshop on Instrumentation Needs and Performance Metrics) was held in Oak Ridge October 31–November 1, 1996, to define instrumentation needs for SNS.

In June 1997 the DOE ER held a comprehensive review of the CDR. A team of 60 external experts from other laboratories, universities, and industry spent a week examining the project cost, schedule, technical scope, and management structure. In addition, an Independent Cost Estimation (ICE) team from industry assessed the costing methodology. and cost. The SNS was approved to continue preparation for construction with recommendations to extend the schedule one year and enhance funding for instrument R&D, and the ICE team validated the cost to within 2% of the SNS estimate.

In FY 1998 the SNS requested $43 million and received $23 million to continue preparations for construction. These funds were used to prepare a request to DOE for a construction line item start in FY 1999, based on the funding profile and construction schedule shown in Figure 4 and Figure 5, respectively.

In June 1998 DOE held a second review of the technical progress, cost, schedule, and management readiness of SNS to proceed with the start of Title I design and construction activities. The work plans were presented for the first half of FY 1999, and the project was judged ready to initiate construction and design activities on October 1, 1998, pending approval of the construction line item request and funding from Congress.

In the deliberations of Congress on the FY 1999 budget, the following actions were taken. The Senate Appropriations Committee recommended the full funding requested by the project of $157 million in FY 1999 and a construction line item. The House recommended $100 million and a line item. In action by the Conference Committee on Appropriations, it was recommended that construction line item approval and $130 million be provided for the SNS Project. Both houses of congress have approved this recommendation, and the bill has been signed into law.

ORNL 97-127699D/djr

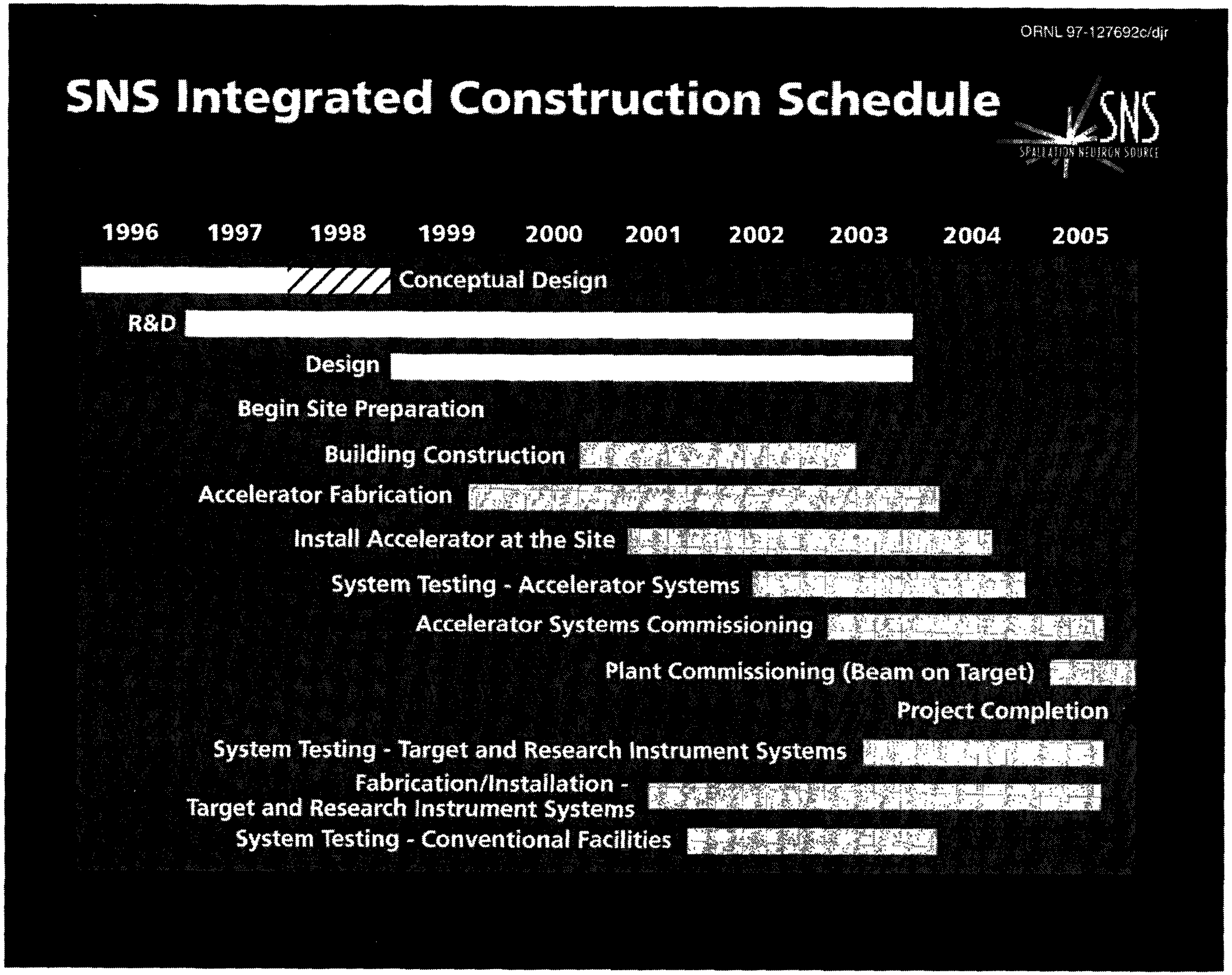
Financial Summary - Spallation Neutron Source

(Optimum Profiles for a 7 Year Schedule)

SNS SPALLATION NEUTRON SOURCE

Budget Authority (BA) in Actual Year Millions of Dollars

Fiscal Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	*Total*
TEC				128	197	255	253	185	78	43	1,139
R&D											
OPEX				26	15	12	8	4	3		68
Capital				2	1						3
Pre-Ops				1	1	1	2	6	16	57	84
Prior Year	8	8	23								39
Total	8	8	23	157	214	268	263	195	97	100	*1,333*



ORNL 97-127692c/djr
SNS Integrated Construction Schedule
SNS
SPALLATION NEUTRON SOURCE
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
Conceptual Design
R&D
Design
Begin Site Preparation
Building Construction
Accelerator Fabrication
Install Accelerator at the Site
System Testing - Accelerator Systems
Accelerator Systems Commissioning
Plant Commissioning (Beam on Target)
Project Completion
System Testing - Target and Research Instrument Systems
Fabrication/Installation - Target and Research Instrument Systems
System Testing - Conventional Facilities

Progress on SNS

The SNS Project is ready to initiate Title I design and construction activities beginning in FY 1999. The project management systems, plans and schedules, technical baselines, and detailed work plans and schedules for FY 1999 are in place and have been approved by DOE. There are mechanisms in place to coordinate interface issues among the collaborating laboratories and agreements to accomplish the work. A second neutron user's meeting will be held November 9–11, 1998 in Oak Ridge to initiate a formal User's Group for SNS, and to engage the scientific community in the actual selection, design, and construction of the instruments that will be used on SNS. The initial design of SNS of 1 MW will deliver a beam 6–10 times more powerful than any existing pulsed neutron source. The design and flexibility built into the SNS means that it can be economically upgraded to significantly higher powers with the addition of experimental capability in the future. This should provide the needed capability to the neutron science community for an intense neutron source well into the next century.

Acknowledgements

I wish to acknowledge the members of the SNS collaboration for whom I am reporting. Although the members are too numerous to detail, I wish to acknowledge the laboratory groups by noting the Senior Team Leaders at each lab — Kent Crawford at Argonne National Laboratory; Bill Weng at Brookhaven National Laboratory; Rod Keller at Lawrence Berkeley National Laboratory; Dave Gurd and Bob Hardekopf at Los Alamos National Laboratory; and Tony Gabriel and Jim Lawson at Oak Ridge National Laboratory.