US TRITIUM ACTIVITIES

R. Scott Willms
Los Alamos National Laboratory
Mail Stop E-526
P. O. Box 1663
Los Alamos, NM 87545, USA
1-505-667-5802

Robert Rabun
Savannah River Site
735-H
Aiken, SC 29808, USA
1-803-208-8755

ABSTRACT

Since the last international tritium conference in 1995 the US continues its active interest in better understanding tritium and in using it safely and efficiently. US governmental tritium interests center around five major activities: 1) inertial confinement fusion, 2) fusion energy sciences (both magnetic and inertial), 3) tritium facility decontamination and decommissioning, 4) tritium production and 5) national defense applications. While the US interests have, roughly speaking, stayed the same, there have been significant changes in the US tritium community. There have been shifts in program emphases and changes in US tritium facilities with certain facilities either shutdown or being shutdown, and with new facilities under construction. This paper will provide an overview of the US tritium activities and associated facilities.

I. INTRODUCTION

The US has had an active interest in tritium research especially since the 1950's when large-scale use of tritium began. The present US interest in tritium centers around five major activities: 1) inertial confinement fusion, 2) fusion energy sciences (both magnetic and inertial), 3) tritium facility decontamination and decommissioning, 4) tritium production and 5) national defense applications. This paper will first summarize the status of US activities that involve tritium and then discuss the status of government-sponsored tritium facilities. This topic was last addressed by Anderson and LaMarche.[1]

II. ACTIVITIES

A. Inertial Confinement Fusion

The US is interested in the science of thermonuclear fusion and a promising means of doing this is referred to as "inertial confinement fusion" or ICF. This work is being funded by the Department of Energy's (DOE) National Nuclear Security Agency (NNSA). The NNSA is primarily pursuing laser-driven ICF though other drivers such as Z-pinches are also being studied. Presently the flagship US ICF facility is the Omega Laser at the Laboratory for Laser Energetics which is part of the University of Rochester. The next step beyond Omega is the National Ignition Facility (NIF) which is presently under construction at the Lawrence Livermore National Laboratory (LLNL). NIF will be the first ICF facility capable of igniting an ICF target. The NIF is scheduled to achieve "first laser light" in 2003, to begin imploding DT cryogenic targets in 2008, and to achieve fusion ignition in 2011. Fiscal Year (FY) 2002 NIF construction funding is $245M. The overall FY2002 ICF budget in the US is $505M.

B. Fusion Energy Sciences

The US is interested in using controlled thermonuclear fusion as a means to produce energy. This work is directed by the DOE's Office of Fusion Energy Sciences (OFES). At the time of the last tritium conference, the US had a stated goal of producing energy by this means. Since that time, the US revised its goal. The new goal is to study the fundamental science of fusion energy with a view to possibly using this understanding produce energy in the future. This science-oriented program is being funded at about two-thirds of previous levels with FY 2002 funding at $248M. At the previous tritium conference the US was a full partner in the International Thermonuclear Experimental Reactor (ITER) Project and was performing tritium R&D as part of that project. Since that time the US has withdrawn from ITER, though the US continues its interest in burning plasma experiments. While the OFES is primarily interested in magnetically confined plasmas, it has increased its interest in other "alternate" confinement schemes including inertial confinement methods.

C. Decontamination and Decommissioning

Due to a variety of reasons, a number of US tritium facilities either have been or are being shutdown. The decontamination and decommissioning (D&D) of such facilities is the combined responsibility of the organization that operated the facility and the DOE Office of Environmental Management (EM). In an effort to reduce the cost, schedule and hazard risk associated with D&D, EM began what are called Large Scale Demonstration and Deployment Projects (LSDDP). For these projects, funds are made available to demonstrate technologies which hold promise to meet the program's objectives. Then, successful technologies are deployed where appropriate

needs exist. The first tritium LSDDP, now complete, was hosted by the Mound Site tritium facilities, and a subsequent tritium LSDDP is presently being hosted by Los Alamos National Laboratory (LANL). Beyond the host sites, participation is open to others and essentially all of the DOE tritium facilities have and are participating. There is also international participation in LSDDP.

D. Tritium Production

The US presently has no capability to produce tritium. The NNSA pursued two options for beginning new production with the projects titled 1) Accelerator Production of Tritium (APT) and 2) Commercial Light Water Reactor (CLWR). Both concepts are based on the generation of neutrons which in turn is used to breed tritium. The APT design would use a linear accelerator to produce spallation neutrons, while CLWR would use a light water fission reactor to produce neutrons. On December 22, 1998 the DOE announced that it had chosen CLWR as the primary option. This option will irradiate lithium aluminate rods, capture the bred tritium on zirconium-based getters, and extract the tritium at the Savannah River Site (SRS). While no actual start date has been set, the US is to be ready to begin irradiations in 2003. The APT was funded through FY2001 to complete the design so that it would available, if needed.

E. National Defense Applications

Tritium is used in national defense applications. Generally, the US activity in this area is the same as at the time of the last tritium conference. However. budget and other concerns led to a reconfiguration of defense activities. A number of facilities either have been or are being shutdown, and most defense tritium activities are being consolidated at SRS and LANL. In general, routine or "production" activities are performed at SRS, and R&D activities are performed at LANL.

III. FACILITIES

US government tritium facilities are presented here by facility status—1) facilities that are shutdown, 2) facilities that are shutting down, 3) facilities that are operating and new facilities. The locations of US facilities are summarized on figure 1.

A. Shutdown Facilities

The tritium facilities at Sandia National Laboratory-Livermore, and at the Pinellas facility have been completely shutdown.

B. Facilities That Are Being Shutdown

1. Mound Tritium Facilities. The Mound tritium facilities are located at the Mound Site in Miamisburg, Ohio. The Mound Site operating years with alpha emitters were 1948 – 1980 and with tritium were 1957 – 1998. The facilities were used to investigate a wide variety of tritium topics including analytical development, radioluminescence, tritium inventory control and topics relevant to national defense. As part of a reconfiguration of US defense activities, the facilities stopped operations in 1998, and the focus was turned to facility D&D.

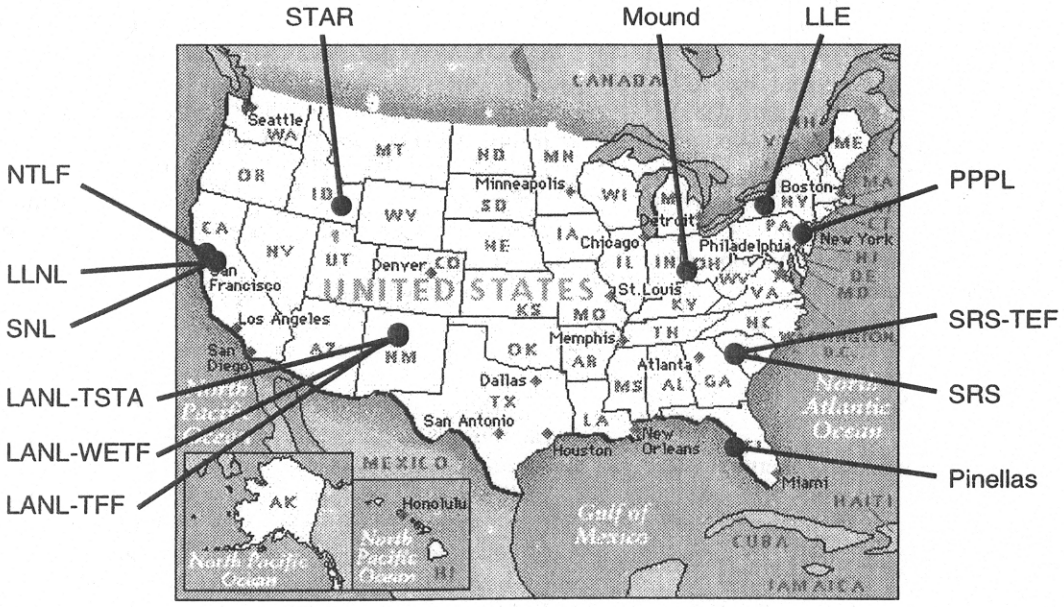

Figure 1 Locations of US Government-Sponsored Tritium Facilities

Ownership has been transferred from NNSA to EM. The bulk tritium inventory (usable tritium) has been removed and transferred to SRS. Remaining is an estimated 60 grams of tritium held up in hydride beds, zeolite beds, carbon traps, oils and organic residues. Closure completion is planned for 2006. The facilities are shown on figure 2.

The Mound site hosted the first tritium LSDDP project which was focused on demonstrating new tritium D&D technologies. A wide variety of new technologies were demonstrated. These are documented in Innovative Technology Summary Reports which are available from the DOE-EM Office of Science and Technology. Two particularly successful technologies that were demonstrated are a solidification agent for tritiated oils (Nochar Petrobond®) and a tubing crimper which produced leak-tight seals (Burndy).

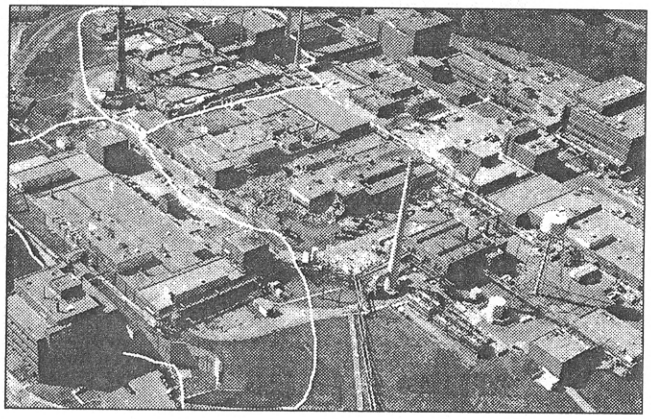

Figure 2 The "Main Hill Tritium Complex" (circled in white) at the Mound Site

2. Tritium Systems Test Assembly (TSTA). TSTA, located at LANL, is owned by the DOE-SC. The building is shown on figure 3. The facility was dedicated in 1982 and began operating with tritium in 1984. The facility was established to develop and demonstrate fusion energy fuel cycle technologies. The facility included all of the sub-systems necessary for processing magnetic fusion reactor exhaust and preparing it for reinjection. These full-scale sub-systems were fully integrated into a "loop" so that sub-system interactions could be tested. In addition a number of "off-loop" systems were available for stand-alone testing. A key part of the TSTA program was a collaboration with the Japan Atomic Energy Research Institute (JAERI) which jointly operated TSTA for a major part of its history. Recent investigations focused on tritium testing of an experimental room detritiation system connected to the TSTA 3000 m^3 test cell, and testing the cryogenic distillation system with a view to better understanding system tritium inventory and computer model validation.

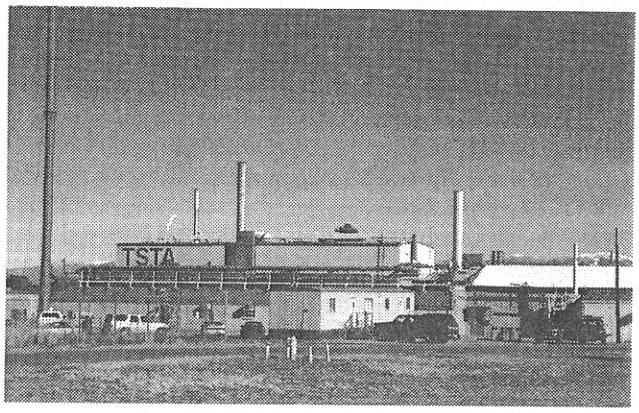

Figure 3 TSTA Building

In 1999 a DOE-SC review of the facility determined that TSTA would be shutdown. Facility closure activities began in 2000 and the last experimental operations were completed in 2001. The tritium inventory of about 140 grams has been reduced by returning the bulk tritium to SRS and by disposing of tritiated water waste. A picture of tritiated water waste being buried is shown on figure 4. The remaining inventory, estimated to be about 20 grams, exists mostly as holdup in process components such as hydride and zeolite beds. It is planned that stabilization of the facility will be completed in 2003. Thereafter the facility ownership will be transferred to DOE-EM which will be responsible for completing closure. Centered on TSTA, LANL has recently begun hosting a follow-on to the Mound LSDDP. The new program is focused on deploying D&D technologies that were demonstrated in the previous LSDDP at tritium facilities throughout the US.

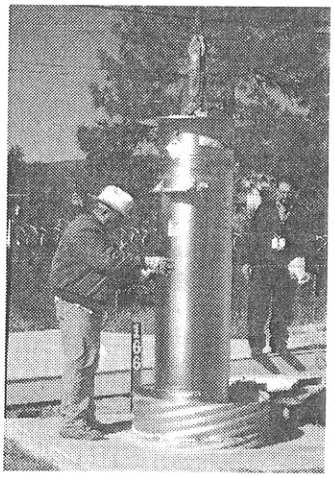

Figure 4 TSTA tritiated water waste disposal

3. National Tritium Labelling Facility (NTLF). The NTLF is located at the Lawrence Berkeley National Laboratory in Berkeley, California. The facility is owned by the National Institutes of Health (NIH). One of the NTLF labs is shown on figure 5. The facility was established in 1982 to develop methods for incorporating tritium into compounds for chemistry and healthcare applications. Among the facility's unique capabilities are biological tracer tritium R&D, tritium NMR spectroscopy, an array of tritium labeled reagents and the analysis of tritium-labeled compounds. The facility tritium inventory was maintained below 1.6 grams. Beyond its traditional work, the NTLF performed work on processing of tritiated mixed waste and high sensitivity tritium inventory measurements.

In 2001 NIH decided to close the NTLF and operations there ceased in December, 2001. A closure plan is being prepared, and shutdown activities are expected to begin early in 2002. It is expected that the work will be performed by a contracting firm.

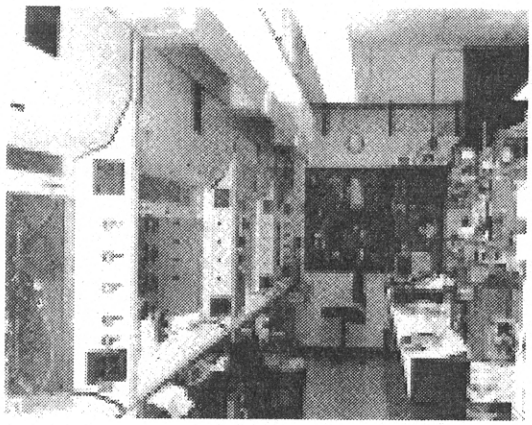

Figure 5 NTLF radio-synthesis lab

C. Operating Facilities

1. SRS Building 233-H. This facility, often referred to as the Replacement Tritium Facility (RTF), is located at the Savannah River Site in Aiken, South Carolina. The facility came on-line in 1994. The facility performs large-scale, routine ("production"), national defense tritium activities for the NNSA. The facility control room was recently updated with a state-of-the-art system. New processing capabilities are being installed in Building 233-H so that older SRS facilities can be retired. The facility's tritium containment components are shown on figure 6.

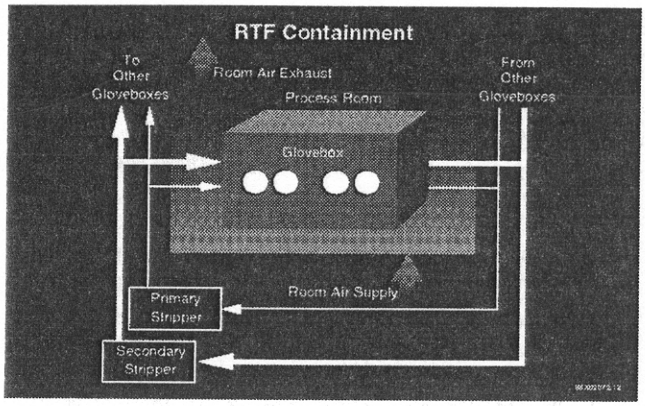

Figure 6 RTF tritium containment components

2. SRS Buildings 232-H and 234-H. These facilities, which are part of the original tritium operations at SRS, began operating in 1957. Presently operations in these buildings support activities in Building 233-H. As these functions become available within 233-H, it is planned that buildings 232-H and 234-H will be closed. These shutdown activities will begin in the next few years. The exhaust stacks from 232-H and 234-H are shown in figure 7. Among the operations in Building 232-H is tritium recovery from tritiated water. Recently a waste-free tritiated water processing system based on a palladium membrane reactor was installed, and its operation will be compared with the present hot metal bed-based system.

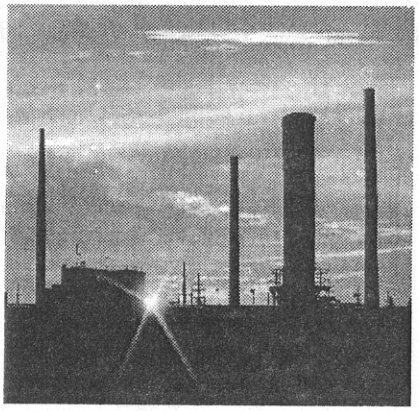

Figure 7 Exhaust stacks from Buildings 232 and 234-H

3. Tritium Science and Fabrication Facility (TSFF) and the Weapons Engineering Tritium Facility (WETF). These two facilities, located at LANL, are owned by the NNSA. Handling large amounts of tritium, these facilities are used to perform research in support of NNSA tritium interests. Tritium operations in TSFF began in 1974. WETF, built to replace the LANL High Pressure Tritium Laboratory (now shutdown), began operating with tritium in 1992. Work in one of the TSFF gloveboxes is

shown on figure 8. Recently there have been a number of refurbishment activities at WETF including the reconstruction of the facility roof and the addition of an office building. It is planned that activities in TSFF will be moved to WETF, and TSFF will be shutdown.

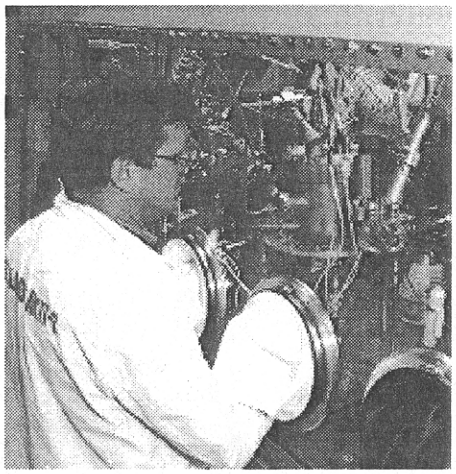

Figure 8 Work in a TSFF glovebox

4. Target Fabrication Facility (TFF). The TFF at LANL is owned by the NNSA. It was constructed to fabricate ICF targets and fill them with tritium. It began operations with tritium in 1988. The facility continues to fabricate targets, but target filling operations have been moved to WETF. The TFF continues to handle tritium-filled targets and maintains a tritium laboratory with a tritium inventory less than 1.6 grams. The laboratory is equipped with an array of equipment for characterizing tritiated materials including metallography and scanning electron microscopy. An example of the ICF targets handled in TFF is shown on figure 9.

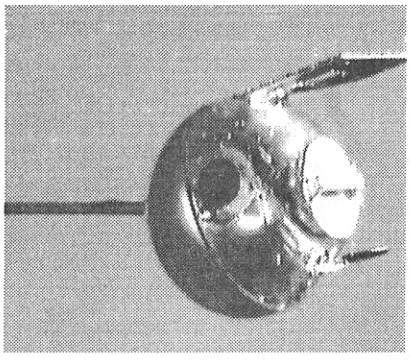

Figure 9 ICF target handled in TFF (2.4 mm diameter)

5. LLNL Tritium Facility. The tritium facility at LLNL is owned by NNSA. The facility has been operating with tritium since 1958. In recent years it was thought that this facility would be closed. However, it is now planned that either the existing facility or a new facility will continue to operate with tritium. Presently the facility recovers and recycles tritium from self-illuminating devices, maintains the US fleet of tritium shipping containers (UC-609) and supports Mound tritium facility D&D. In the coming years, the facility will be configured to fill ICF targets for the NIF. The facility, shown in figure 10, is capable of handling up to 30 grams of tritium.

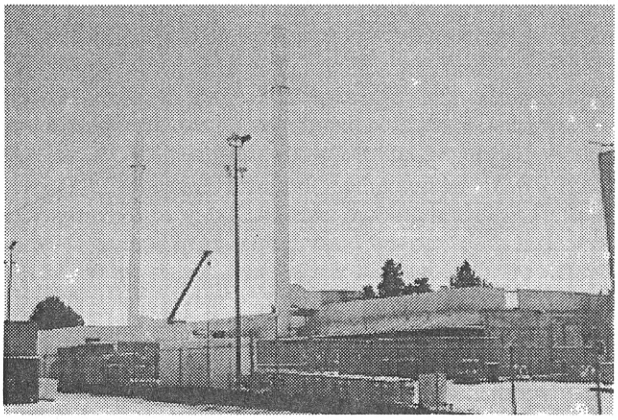

Figure 10 LLNL tritium facility

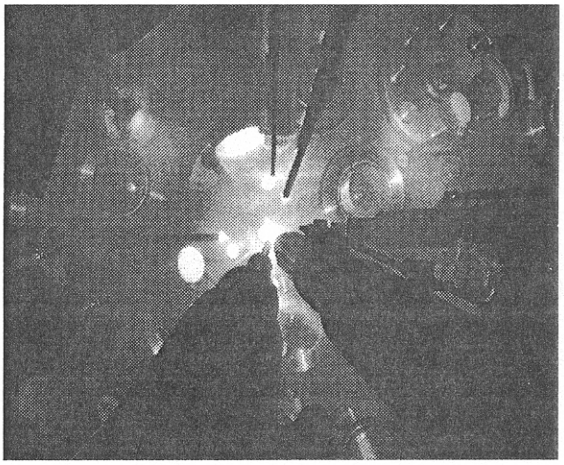

Figure 11 View inside the Omega Laser target chamber

6. Omega Laser Tritium Facility. The Omega Laser is part of the Laboratory for Laser Energetics at the University of Rochester in Rochester, New York. This facility, owned by the NNSA, is presently the largest ICF laser in the US. Targets filled with DT are shot at Omega and a tritium facility has been constructed to support this activity. The facility has been operating since 1995 and is now undergoing a substantial upgrade to support the filling, beta layering and handling of targets with larger amounts

of tritium. The upgrade is presently being tested with deuterium and will soon transition to tritium testing. Targets will be filled with about 0.75 Ci/target. The site tritium license is for 1.0 grams and 0.6 grams is on site. The facility includes a rather aggressive gaseous effluent tritium cleanup system since the site has a very low regulatory limit for tritium air emissions. Figure 11 is a view inside the Omega Laser target chamber.

7. Princeton Plasma Physics Laboratory (PPPL) Tritium Facility. PPPL, located in Princeton, New Jersey, is owned by the DOE-SC. The institution performs magnetic fusion experiments. The largest such experiment in the US was the Tokamak Fusion Test Reactor (TFTR) which is the only US magnetic fusion experiment that operated with tritium. For those operations a tritium facility was constructed and brought on-line in 1993. While TFTR is shutdown and D&D is nearing completion, the tritium facility continues to operate to support TFTR D&D and to be available for possible future PPPL devices. During TFTR operations the tritium inventory was nearly 5 grams, but the inventory has been reduced and the regulatory upper limit is now 1.6 grams. Recently this facility joined the TSTA/JAERI collaboration to study tritiated facility D&D technologies. PPPL personnel are also studying methods for characterizing and removing tritium inventory from fusion reactor in-vessel components. Figure 12 shows an example of TFTR D&D activities.

Figure 12 Training for TFTR D&D activities

D. New Facilities

1. Safety and Tritium Applications Research (STAR) Facility. The STAR facility is being constructed at the Idaho National Engineering and Environmental Laboratory (INEEL) by the DOE-SC. The purpose of the facility will be to study fusion energy sciences tritium issues. Existing equipment has been removed from the building which will house the facility (see figure 13). Equipment installation is proceeding, and it is planned that the facility will be operational in 2002. The facility will be able to handle tritium (up to 1.6 grams) and beryllium, an important capability for studying certain fusion reactor blanket concepts. The facility will also house the Tritium Plasma Experiment, a Sandia National Laboratory experiment which will be moved from TSTA to STAR.

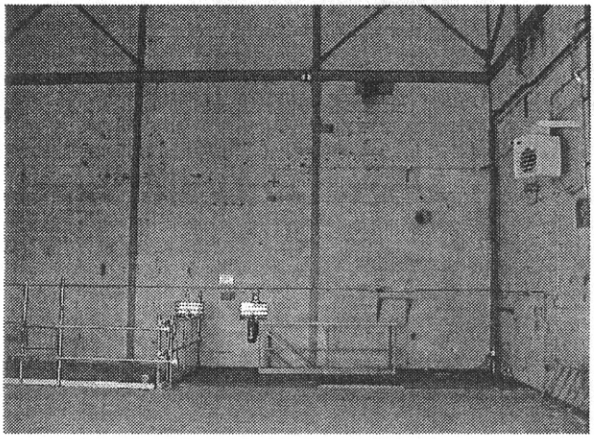

Figure 13 Inside STAR building after existing equipment removal (October, 2001)

2. Tritium Extraction Facility (TEF). A new tritium extraction facility is being constructed at SRS by the NNSA. This facility will be used to extract tritium from lithium aluminate rods after they have been irradiated in a light water fission reactor. Construction is well underway (see figure 14) with the foundation complete for the underground portion of the project. The facility will be closely integrated with Building 233-H operations. It is planned that the facility will be operational in 2006.

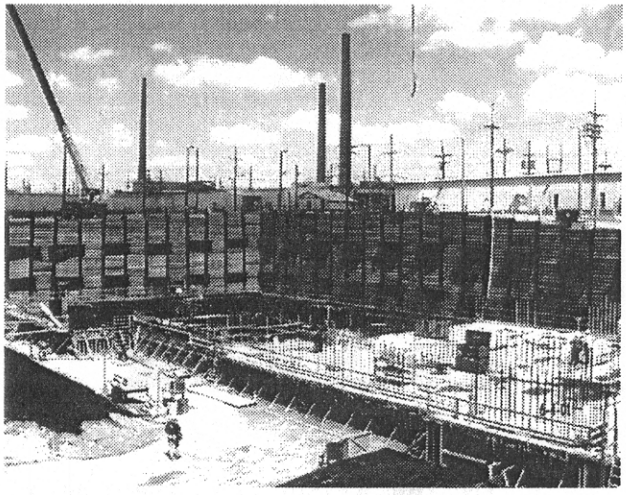

Figure 14 TEF below grade construction (June, 2001)

IV. CONCLUSIONS

Since the last international tritium conference the US tritium interests have, roughly speaking, remained the same. However, there have been changes in emphasis. These changes include:

- Increased interest in inertial fusion (both ICF and IFE)
- Termination of US activity on ITER
- Preparation for light water reactor-based tritium production
- Increased interest in tritium facility shutdown technologies

The status of US tritium facilities has changed considerably. Three facilities are being shutdown (Mound, TSTA and NTLF) and two new facilities are being constructed (STAR and TEF). Significant consolidation activities are expected with existing facilities—SRS Building 232-H and 234-H activities will be consolidated into Building 233-H, and LANL TSFF facilities will be consolidated into WETF. With the increased activity on ICF, increased capabilities are expected for the Omega Laser and LLNL.

REFERENCES

1. J. L. Anderson and P LaMarche, "Tritium Activities in the United States," *Fusion Technol.*, **28(3)**, 479-490 (1995).