Accelerator Production of Tritium

An Assured Source for Nuclear Deterrence

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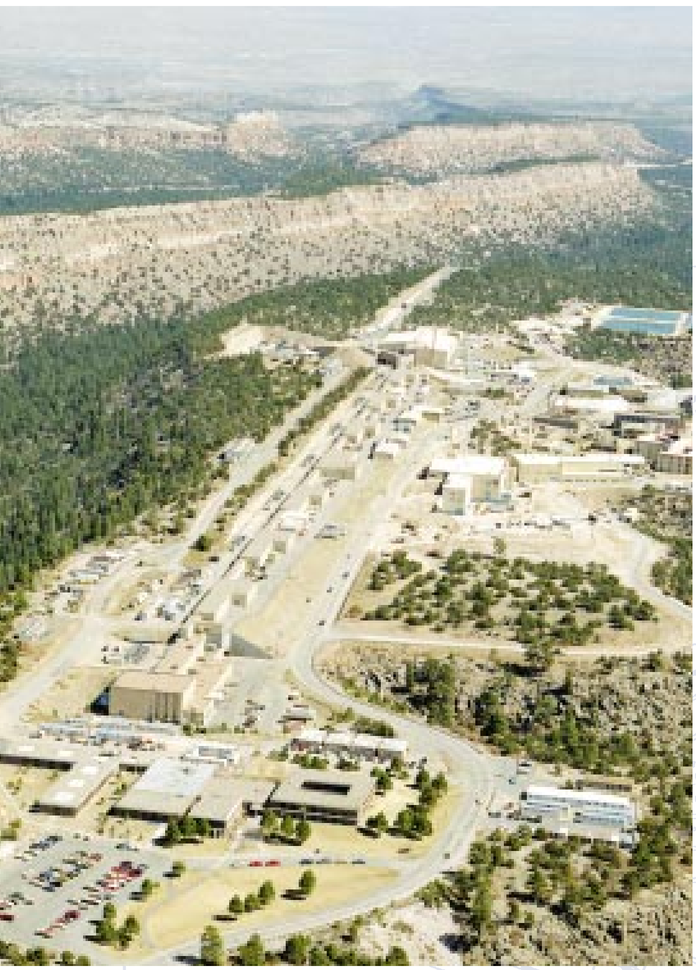
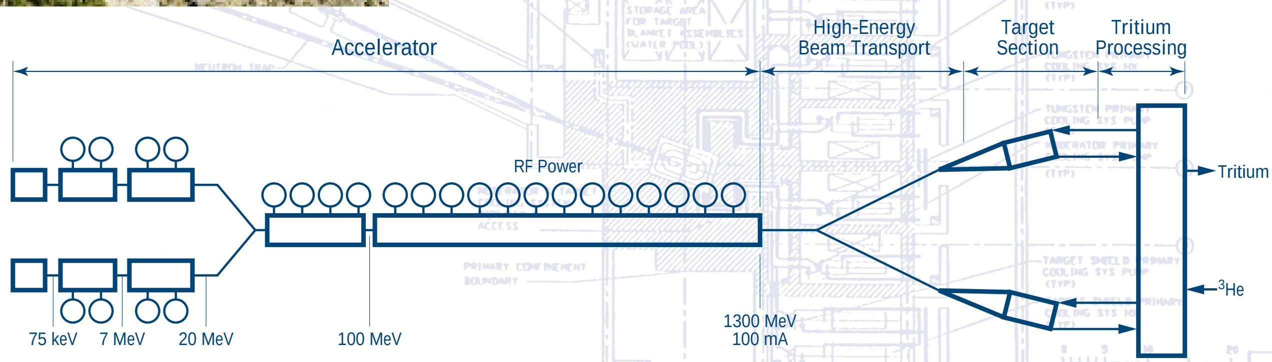


The Los Alamos Neutron Science Center, where APT components are being tested. The APT facility will be built elsewhere



Los Alamos
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What does Tritium have to do with National Defense?

For 50 years, the existence of nuclear weapons has been an important component of the United States' strategy to deter major international war. Today, maintaining an adequate defense through both conventional and nuclear arms remains the best means to ensure continued peace.

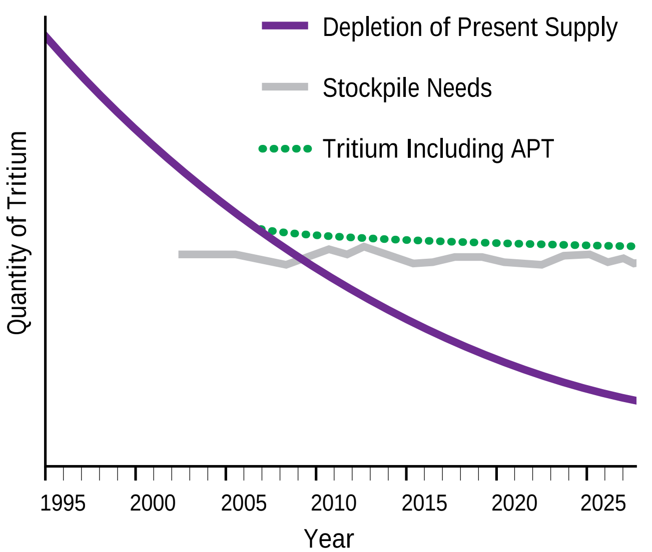
"APT is a viable option for meeting U.S. needs for tritium production." —JASON review 1995

Tritium is required to maintain the nuclear part of our defense structure. Tritium decays at the rate of 5.5% per year and must be continuously replenished. Therefore, the production of tritium is essential to sustain the nation's defense.

Currently, tritium requirements are being met through reuse of tritium recovered from dismantled nuclear weapons; however, this will not be sufficient for future needs. The Department of Defense (DoD) estimates that to maintain the strategic nuclear weapons remaining in the enduring stockpile, a tritium production capability must come on-line by 2007. However, depending on international negotiations, it could be needed as early as 2005.

What's the Source of Tritium?

Tritium is a radioisotope of hydrogen made in small quantities in nature by cosmic rays. Although it does exist naturally, it is rare. To obtain the quantities required for national defense needs, it must be man-made. Before 1988, tritium was produced in dedicated military-material production reactors until they were shut down because of safety concerns. Presently, there are only two systems that can produce tritium: one involves nuclear reactors, and the other, accelerators.



Tritium is lost to radioactive decay at the rate of 5.5% per year. In the time frame 2005–2011, new supplies of tritium must be produced to maintain the nation's nuclear stockpile.

National Program to Produce Tritium

In March of 1995, the Department of Energy (DOE) released a Programmatic Environmental Impact Statement (PEIS) that considered several types of nuclear reactors (including the use or purchase of an existing commercial nuclear reactor) and an accelerator for the new source of tritium. Although reactors can produce tritium, they face institutional issues associated with their potential impact on the environment, safety, and health. With this in mind, the Secretary of Energy announced in October 1995 the decision to pursue a "dual-track" strategy, funding both reactor- and accelerator-based systems for a three-year period, after which the DOE will select the most promising method. This announcement was followed up with a formal Record of Decision signed by the DOE on December 5, 1995.

How Does an Accelerator System Produce Tritium?

In APT, tritium is made by capturing neutrons in ^{3}He (helium gas). To supply the neutrons, protons are energized in a linear accelerator and used to bombard a heavy-metal target made of tungsten and lead, creating neutrons in a process known as "spallation." The resulting neutrons are moderated (slowed) by collisions with water, increasing the efficiency of their capture in the helium gas flowing through the target to make tritium. The tritium is extracted from the gas continuously, providing supply to the stockpile.

National Plans for an Accelerator-Based Tritium Production System

Scientists and engineers from several US national laboratories and industries have put together the accelerator-based system design that has been extensively reviewed. Those reviews have concluded that an accelerator production of tritium (APT) system will easily, safely, and adequately meet the nation's tritium needs.

To prepare for the possible construction of this vital system, national laboratory partners —Los Alamos, Savannah River, Brookhaven, Livermore, and Sandia—will complete several important technology demonstrations and plant-prototype developments. Scientists will soon verify the tritium production efficiency of APT using low-power prototype targets in the Los Alamos Neutron Science Center. They will also fabricate and operate a full-power, low-energy engineering model of the accelerator to substantiate its long-term performance. A prime contractor will be selected by competitive bid to contribute to the conceptual design and to lead the engineering effort and the construction of a full-scale plant at the DOE's preferred alternative, the Savannah River Site, in South Carolina.

The system design behind the APT facility is based on well-established, existing technology in the areas of operational accelerators, tritium extraction, and neutron targets. In the words of one of the review committees, “APT is a viable option for meeting the US needs for tritium production.”

How Does APT Compare to Reactor Production of Tritium (RPT)?

APT is a very safe and environmentally benign system. The fundamental reason for this is that neutrons are produced by the spallation process rather than by nuclear fission. APT will produce the required neutrons without fissile materials or a nuclear chain reaction, avoiding the production of long-lived radioactive products such as plutonium or neptunium. Additionally, the constant extraction of tritium from the target not only provides tritium to the stockpile quickly, but avoids any radioactive buildup.

Should the DOE decide to pursue the alternative of purchasing a commercial nuclear reactor or irradiation services from such a reactor, there will be substantial issues related to nuclear proliferation. In the words of one of the US nuclear reactor vendors, “use of a commercial reactor facility for this purpose, and the resulting blurring of the line between commercial and military uses of nuclear energy, may alter the perception of the rest of the world community of US nonproliferation efforts and policies.”

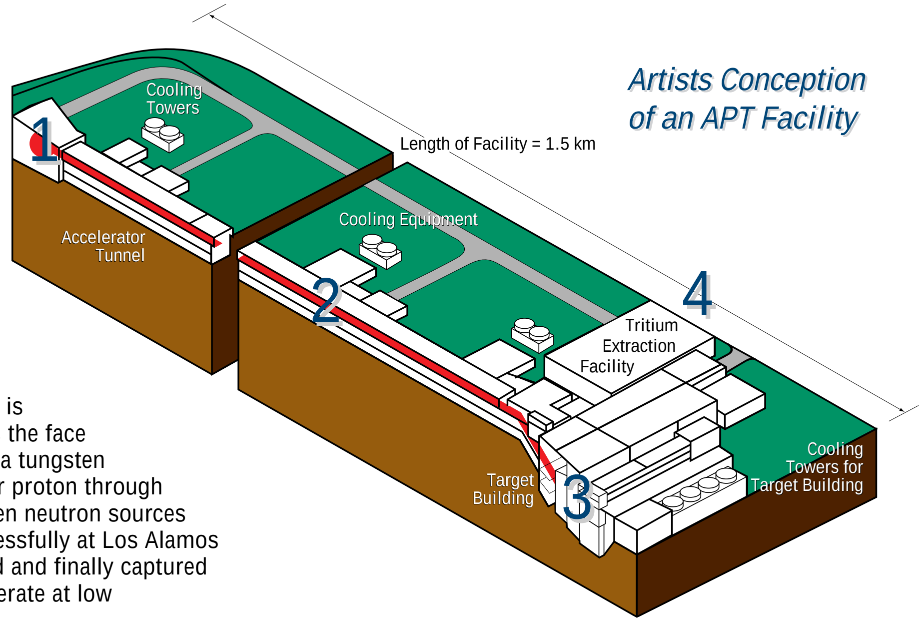
Are There Other Uses or Benefits from APT?

Although the APT system will be dedicated to production of tritium, the high-power accelerator technology may have significant advantages for several other applications, such as:

- producing medical radioisotopes
- destroying radioactive wastes
- producing energy without long-lived nuclear waste
- making material for space-power applications
- studying radiation damage
- producing neutrons for basic and applied research

Some of these powerful potential applications will be pursued in addition to, and concurrently with, the APT system by other DOE-funded programs. The side benefits of APT technology address global concerns, and pursuing them will demonstrate positive leadership in the world and create an influential impact on US/international relations—not only technically, but socially and politically as well.

APT Accelerator Production of Tritium	VS.	RPT Reactor Production of Tritium
no fissile materials		*fissile material (uranium)*
no fission process		*fission process required*
no spent nuclear fuel produced		*produces spent nuclear fuel*
produces 55 m^3 low-level radioactive waste per year		*produces 3600 m^3 low-level radioactive waste per year*
no chance of a criticality accident		*chance of a criticality accident*
minimal environmental effects		*significant environmental effects*
no nuclear proliferation issues		*nuclear proliferation concerns*
engineering simplicity provides inherent safety advantages		*engineering complexity provides complex safety issues*
constant extraction of tritium		*tritium builds up, potential for large release*
immediate shutdown possible		*slow shutdown, large amount of residual heat, continuous cooling required*
easily scaled to stockpile needs		*difficult to scale to stockpile needs*



Artists Conception of an APT Facility

1 *Injector Section* The proton beam that is used to produce tritium begins in the APT injector. This beam is formed by ionizing hydrogen atoms and accelerating them to form a low-energy proton beam.

2 *Accelerator Section* Here the proton beam is accelerated until it ultimately reaches 92% the speed of light. The accelerator is approximately 1.5 kilometer (~1 mile) long and uses proven technology.

3 *Target Building* At the accelerator exit, the beam is expanded to distribute the protons evenly across the face of the target. The expanded proton beam strikes a tungsten and lead target to produce about 26 neutrons per proton through a nuclear process known as “spallation.” Tungsten neutron sources using the spallation process have operated successfully at Los Alamos over the past 20 years. Neutrons are then slowed and finally captured in ^{3}He to produce tritium. The APT target will operate at low temperature and pressure.

4 *Tritium Extraction Facility* The tritium produced in the target is extracted continuously and purified. The technology for this process was successfully demonstrated at full scale for the fusion energy program. In addition, the process has been designed and tested to prevent release of radioactive tritium to the environment.

APT Rests on a Solid Foundation

APT will use a modern, higher-power version of the same kind of proton linear accelerators that have been in operation for over 40 years. These accelerators have performed well under long-term, factory-like conditions, operating 24 hours / day, 7 days / week, with periodic shutdowns for maintenance. Virtually all APT components have been sufficiently demonstrated to provide confidence that the plant will operate as designed and produce all the tritium required to supply the stockpile.

Are APT Costs Reasonable?

The total estimated cost of the APT facility, including the four years of work preceding construction and commissioning is ~$2.9 B. The operating cost of the plant will depend on the cost of electricity and will range between $120 M and $200 M per year.

Although the annual operating costs for APT will be higher than for RPT (if the DOE is able sell the electricity produced by an RPT system), such comparisons do not take into account the true costs associated with disposition of spent nuclear fuel. Further, it is largely the institutional issues, such as licensing, nonproliferation, and public acceptance that are potential barriers to reactor implementation. Overcoming these barriers could drive the cost of a reactor well beyond that of an accelerator.

Project Office

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