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Facility for Duplicating 14-MeV Neutron Effects in Fusion Power Reactors

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FACILITY FOR DUPLICATING 14 MEV NEUTRON EFFECTS IN FUSION POWER REACTORS

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ABSTRACT

The study of the neutron effects that will occur in a controlled fusion reactor requires a 14 MeV neutron flux one thousand times larger than presently available. This interim report describes a practical means for achieving such a flux.

LASL Sherwood personnel believe that important ingredients of forthcoming technical fusion feasibility studies are

1) the demonstration that reactor wall materials can maintain their structural integrity when bombarded by the intense flux of neutrons produced in a D-T fusion reactor, and
2) the demonstration of efficient tritium breeding blankets.

The main obstacle presently preventing these demonstrations is the non-existence of a neutron source whose neutron flux and primary neutron spectrum are comparable to that emitted by a D-T burning fusion reactor, i.e., approximately 10^{15} neutrons-cm^{-2}-sec^{-1} at 14 MeV.

Our recent survey of neutron sources is summarized in Table I and compared with a fusion power reactor. Of all possible sources considered and listed in Table I only an Ion Accelerator, which utilizes a dense gas target for neutron production from the D-T reaction, can satisfy all of the conditions required for the demonstration and study of neutron effects. As one measure of the efficiency of each of the neutron sources listed, Table I gives the rate of helium built-up due to (n,xα) reactions in niobium for each source and compares it with the helium production expected for fusion

TABLE I

Neutron Source	Spectrum		Flux	Helium
	D-T	Type	n/cm^{2}sec	ppm/month
Fusion Power Reactor	Yes		1×10^{15}	30.
Ion Accelerator - Gas Target	Yes		3×10^{14}	9.0
- Metal Target	Yes		5×10^{11}	.015
LAMPF Beam Dump	No	Copper	2×10^{12}	.017
Dense Plasma Focus at 5 MJ	Yes		1×10^{12}	.030
Experimental Breeder Reactor II	No	Fission	3×10^{15}	.008
Electron Linac (e, γ, n)	No	Uranium	6×10^{11}	.0001
Boosted Electron Linac	No	Fission	6×10^{12}	.0003
			n/cm^2	ppm
Thermonuclear Bomb	Yes		1×10^{17}	.0012
minimum needed for metallurgy				.001

reactor neutrons. Table I shows that only the gas target Ion Accelerator would be comparable to the fusion reactor in this respect. All other sources are several to many orders of magnitude too weak, and may have an incorrect neutron spectrum as well.

Our conception of the gas target Ion Accelerator, shown schematically in Fig. 1, utilizes a one ampere tritium ion beam from an ion source of the type developed at Oak Ridge National Laboratory, ORNL, a standard 300 keV accelerator column (design codes for which exist at LASL from the Meson factory (LAMPF) development), a dense ($\sim 10^{19}$ molecules-cm^{-3}) deuterium gas target in the form of a supersonic jet directed across the ion beam to minimize differential pumping requirements, and a tritium recovery dump which utilizes the existing LASL Tritium Facility for recovery and processing to allow reuse of the tritium (Tritium cost = \$14 X 10^3/gm). Our preliminary design of the target features a hypersonic wind tunnel at Mach 5 with entrance and exit holes for the tritium beam protected by differential pumping sections.

Although we have not yet optimized our design we conclude that this neutron facility can produce 8 X 10^{14} neutrons-sec^{-1} in a 1 cm^3 reaction volume by using a 500 horsepower wind tunnel compressor, 500 horsepower for the differential vacuum pumps, a 300-500 kW ion source power supply, and a cryosorb tritium recovery pump as a dump for the 50 keV tritium beam which emerges from the gas target. Assuming the sample subtends a third of the neutrons, this leads to the flux, 3 X 10^{14} neutrons-cm^{-2}-sec^{-1}, as given in Table I. Larger areas could be irradiated at this same flux by stacking up several ion beams.

The major technical developments required for the facility are the ion beam and the dense gas target. The facility would profit strongly from the ongoing beam development programs at ORNL and at the Lawrence Radiation Laboratory (LRL) which have already produced 1 amp beams at several to several hundred keV. The primary development which therefore remains in this area involves the focusing of the beam through differential pumping ports of

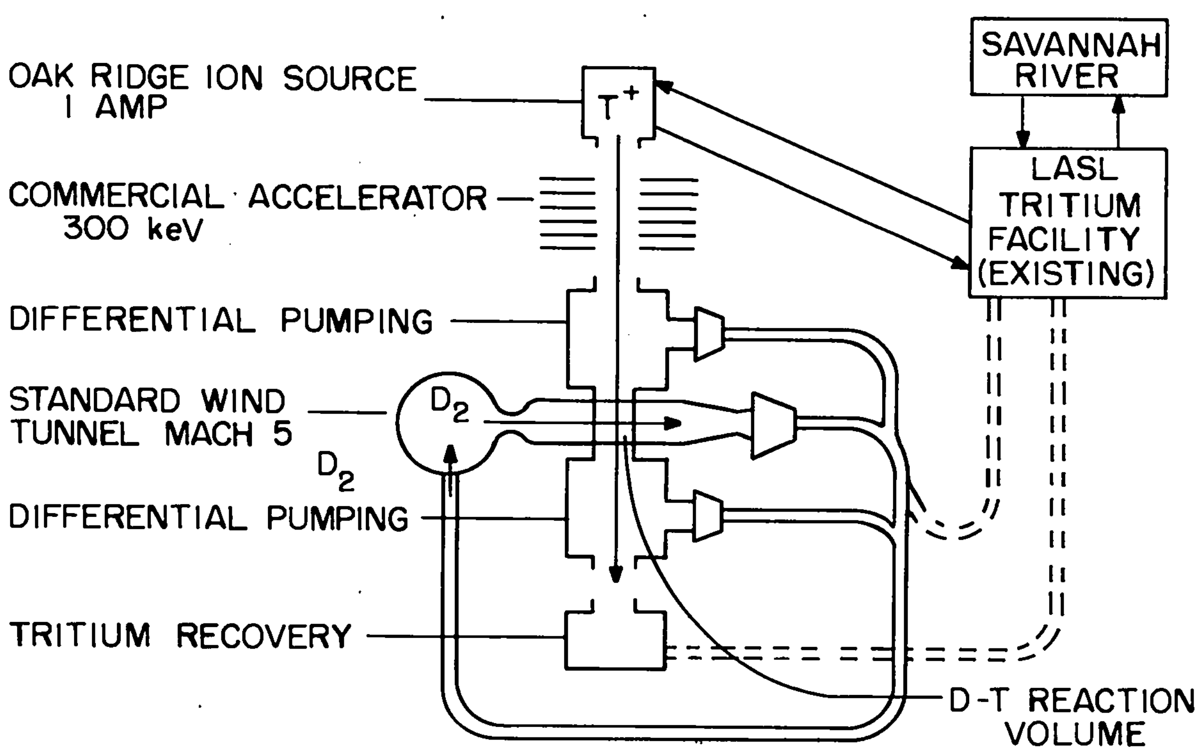

Figure 1

1-2 cm diameter, a development which is considered to be technically feasible. It is noteworthy that the neutral injection program at ORNL and LRL depend upon focusing requirements which actually are more stringent than ours. The use of a 300 keV beam energy is expected to stiffen the beam and thus to simplify the problem. Hypersonic wind tunnels of the type described have already been built.

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