The High Average Power Laser Program- Program Overview

A multi-institutional integrated program to develop fusion energy with lasers *February 10, 2003*

The Program

The plan capitalizes on the substantial investment in lasers and target design by DoE/NNSA Defense Programs.

The plan reduces risk and development costs by exploiting the modularity of a laser based fusion power plant . (For example, the laser consists of many identical beam lines.)

Research has significant near term spin-offs that can fulfill the Nation's Defense, Energy, and Science needs: (e.g. Laser S&T, compact durable pulsed power, nano-technology)

The Three Phases to Develop Fusion Energy

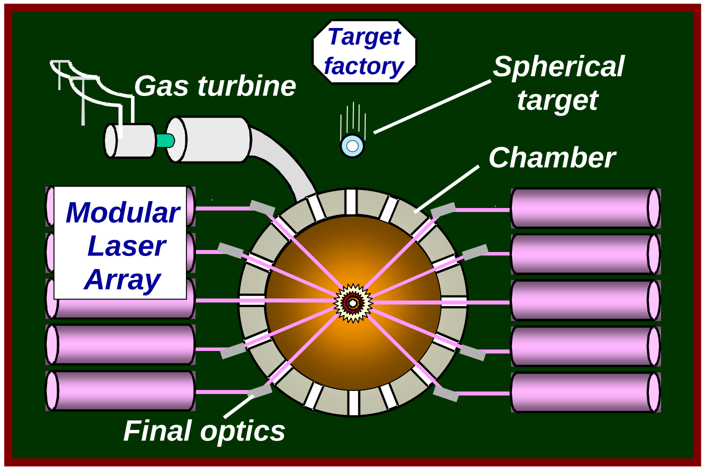
Phase I: Develop critical science and technologies: Laser driver, target fabrication, optics, reaction chamber.
Current program @ $25M/year. Should finish by 2006.

Phase II: Develop, test / integrate full size components.
Ensure key components can work together with the required efficiency, precision, and durability.

Phase III: The Engineering Test Facility (ETF).
A single facility to resolve the critical issues for fusion energy:
1) optimize laser-target and target-chamber interactions;
2) develop materials and components;
3) demonstrate substantial net electricity generation from fusion.

Construction of ETF could start within ten to twelve years, with the basic issues resolved and net electricity generated before 2030. ETF success should attract private sector investments in fusion.

The Concept



An array of high-energy laser beams illuminate a cryogenic target that has been injected into a chamber.

The deuterium-tritium fuel in the target undergoes thermo-nuclear burn, and the energy is used to generate electricity.

We are developing the main components simultaneously. "Systems approach" ensures a commercially viable product.

The Participants

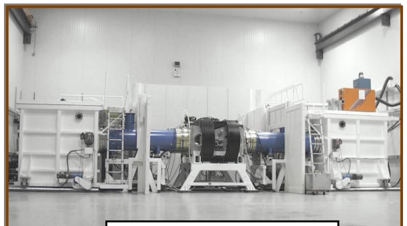
DoD/DoE Labs: Naval Research Laboratory, Lawrence Livermore National Laboratory, Sandia National Laboratory, Los Alamos National Laboratory, Oak Ridge National Lab, Princeton Plasma Physics Laboratory.
Industry: General Atomics, Titan-Pulse Sciences Division, Schafer Corp, Science Applications International Corp, Northrop, Onyx, DEI, Coherent, Inc. Commonwealth Technology, Inc.
University: UC San Diego, Univ. of Wisconsin, UCLA, UC Santa Barbara, UC Berkeley, Georgia Inst of Technology and Univ of Rochester Lab for Laser Energetics

The High Average Power Laser Program- Recent Progress

A multi-institutional integrated program to develop Fusion Energy with lasers *February 10, 2003*

1. Krypton fluoride (KrF) lasers:

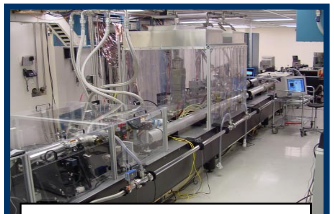
- Electra first laser light (200 J pulse) in repetitively pulsed operation
- New pattered cathode increases electron beam deposition in laser gas
- Demonstrated advanced high-speed, high voltage solid-state switch



Electra KrF laser

2. Diode Pumped solid state (DPSSL) lasers:

- Mercury operated at 10 Hz as laser system
- Significant advances in laser crystal growth

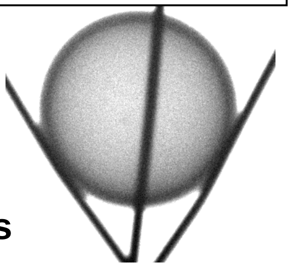


Mercury DPSSL laser

3. Targets: progress in use of advanced materials (low density foams)

- Batch production of foam shells with required dimensions and density
- Projected target cost: $0.16 each. (economic projections require < $0.25)
- Addition of foam underlay produced ultra-smooth cryogenic DT layer needed for smooth implosions
- Foam insulation coating helps protects target during injection into chamber

X-ray picture of mass-produced fusion scale foam shell

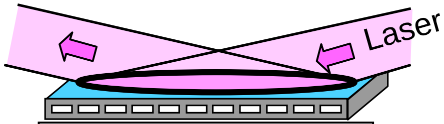


4. Reaction Chamber: progress in modeling and use of advanced first wall materials

- Modeling established chamber operating window with tungsten/advanced steel first wall
- Began exploration of new chamber wall based on advanced nano-structured materials
- Experiments indicate less helium retained at IFE wall temperatures
- Modeling shows IFE target distributes ions over longer range in wall, mitigates retention issues

5. Final Optics:

- Demonstrated the needed laser damage threshold for grazing aluminum mirror concept



Grazing Incidence Mirror

6. Program recognition from fusion community:

- Major component of DOE/FESAC energy fusion development path
- Lead US Inertial Fusion Energy Presentation at 19th IAEA Fusion Conference
- Fusion Power Associates Award