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Sandia National Laboratories

FALCON
Reactor-Pumped Laser
Description & Program Overview*

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FALCON Reactor-Pumped Laser Program

The FALCON (Fission Activated Laser CONcept) reactor-pumped laser program at Sandia National Laboratories is examining the feasibility of high-power systems pumped directly by the energy from a nuclear reactor. In this concept we use the highly energetic fission fragments from neutron induced fission to excite a large volume laser medium. This technology has the potential to scale to extremely large optical power outputs in a primarily self-powered device. A laser system of this type could also be relatively compact and capable of long run times without refueling. [VG-2, VG-3, VG-8]

MASTER

Device Description

A general design for a FALCON reactor-laser system includes a nuclear gain generator, a lasant flow system, an optical extraction system, a heat exchanger, and systems for controlling

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both the laser beam and the overall device. The gain generator consists of an array of laser channels containing fissile material. Neutrons impinging on this region cause fissions and subsequent excitation of the laser medium. Coupling many of these channels forms a module that can have a substantial laser output. Several optical designs are being considered; they include both oscillator amplifiers and coupled resonators. [VG-1, VG-7]

Status

There has been substantial technical progress in demonstrating the key features of reactor driven laser operation, and many different organizations have contributed to these efforts. [VG-4, VG-5, VG-6]

Reactor-laser experiments in the Sandia research reactors have consistently demonstrated lasing in gas lasers at pump rates representative of full-scale systems. In these experiments we have shown efficient coupling of the reactor energy to the laser medium. We have also demonstrated a number of candidate laser materials that are attractive for FALCON and that show both excellent atmospheric transmission and reasonably high conversion efficiencies. Both laboratory and reactor experiments are being performed in conjunction with laser kinetics modeling to confirm the optimum laser parameters for a FALCON system. [VG-5, VG-6]

We have performed reactor design studies showing that these systems can be scaled to extremely large power outputs. Due to the long range of the primary fission neutrons, large volumes of laser media can be pumped, and conceptual designs have been developed for megawatt class systems. These reactor designs are based on a direct pumping concept that matches the excitation requirements of the laser. The use of a nuclear reactor to directly pump a laser medium eliminates the need for thermal to electric conversion and its associated equipment and resultant inefficiencies. On the other hand, the issues of nuclear technology and safety must be addressed. [VG-7]

The reactor designs that are being considered for FALCON involve unique configurations to allow efficient coupling of the reactor and laser media. Most features of these reactors, however, generally fall within the range of current test reactor technology. For example, specific power, fuel element heat fluxes, core dimensions, fuel element designs, and reactor control systems are all at levels of current reactor technology and thus should not be obstacles to the design of future test or operational systems.

A primary issue in the development of large scale reactor lasers has been the efficient extraction of a high quality beam from the multi-channel gain regions of the laser exciter. Approaches are being examined that minimize the medium disturbances caused by the fission energy deposition process.

Analysis of these approaches using physical optics and detailed fluid dynamics indicates that we can achieve good beam quality with near-term optical technology. Experiments to validate these important beam quality issues are in progress.

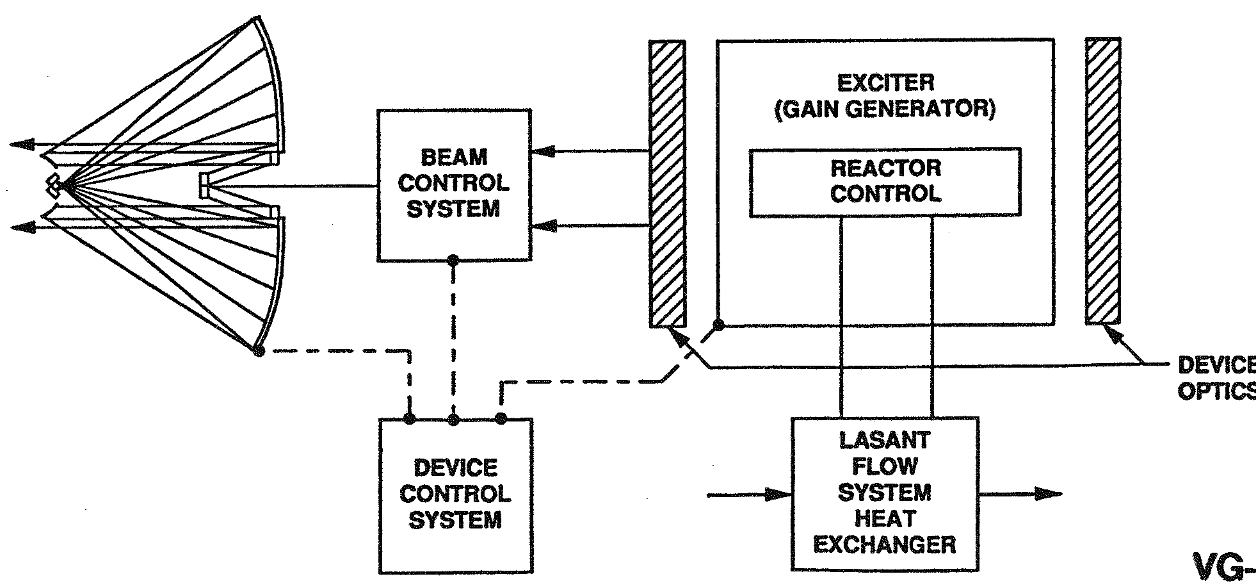
Scaling Experiments

A series of reactor experiments is being designed to demonstrate beam quality and scaling in the FY91-FY92 time frame. Tests performed on existing reactor facilities at Sandia National Laboratories and at Idaho National Engineering Laboratory will demonstrate scientific feasibility and scalability. Tests to demonstrate near-full-scale system operation will require enhanced test reactor capabilities and conceptual designs to address these requirements have been developed. [VG-9]

Closure

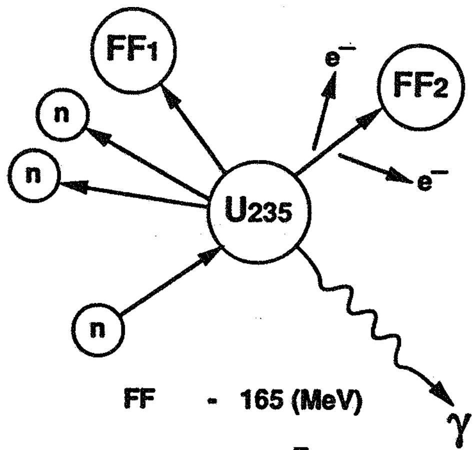
In summary, FALCON is a nuclear reactor pumped CW laser system that can be scaled to very high powers (100 MW or more) with essentially near-term technologies. Issues that are currently being addressed include the detailed optical system design and the achievable beam quality. Longer term issues involve mission analysis, total system cost, and the difficulties associated with the use of nuclear technology. [VG-10]

FALCON
REACTOR LASER CONCEPT

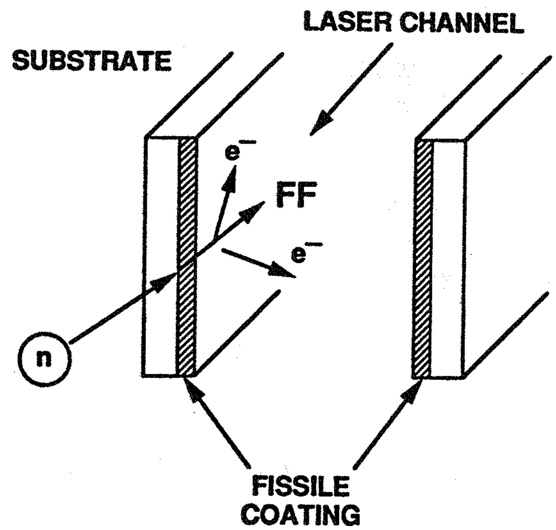


VG-1

FISSION PUMPING CONCEPT



FF	-	165 (MeV)
γ	-	7
n	-	5
DECAY	-	13
ν	-	10
		200 MeV



VG-2

POTENTIAL ADVANTAGES OF HIGH POWER REACTOR - LASER SYSTEMS

- HIGH POWER SCALING (1 - 100 MW)
- SELF POWERED
- COMPACT GAIN GENERATOR
- HIGH ENERGY CONTENT - EXTENDED RUN TIMES
- NEAR TERM TECHNOLOGY

POTENTIAL ISSUES

- BEAM QUALITY
- NUCLEAR / RADIOLOGICAL ISSUES

VG-3

FALCON Research Program

- Funded by DOE – Defense Programs (DP)
- Sandia National Laboratories – Lead Laboratory
  - Reactor Laser Experiments
  - Physics/Kinetics Experiments
  - Beam Quality Experiments
  - Concept Definition Studies
- Idaho National Engineering Lab / Argonne National Lab
  - Scaling Experiments – TREAT Reactor
- Major Contractors
  - University of Illinois – Laser Kinetics Modeling
  - Science Research Labs – e-Beam Experiments
  - Lockheed – Medium Characterization
  - W. J. Schafer – System/Architecture Studies
  - Kaman – Corrective Optics
  - Air Force Weapons Laboratory – Optical Systems Design
  - ORNL / LANL – Nuclear Materials Support
  - Mission Research – Optics Design

VG-4

Reactor-Pumped Laser Research History

- First Nuclear-Pumped Laser – 1974
  (LLNL – Xe2, LANL – HF – gamma)
- First Reactor-Pumped Laser – 1974
  (SNLA – CO – Fission Fragments)
- Other Reactor-Pumped Lasers – 1975
  - Noble Gas, C, Hg
  - NASA, LANL, Univ. of Ill., SNLA, Univ. of Florida, USSR
- FALCON (SNLA), Centauraus (LLNL) – 1984
- Gain in XeF (SNLA) – 1985
- Lasing Confirmation (SNLA – Xe-Ar) – 1987

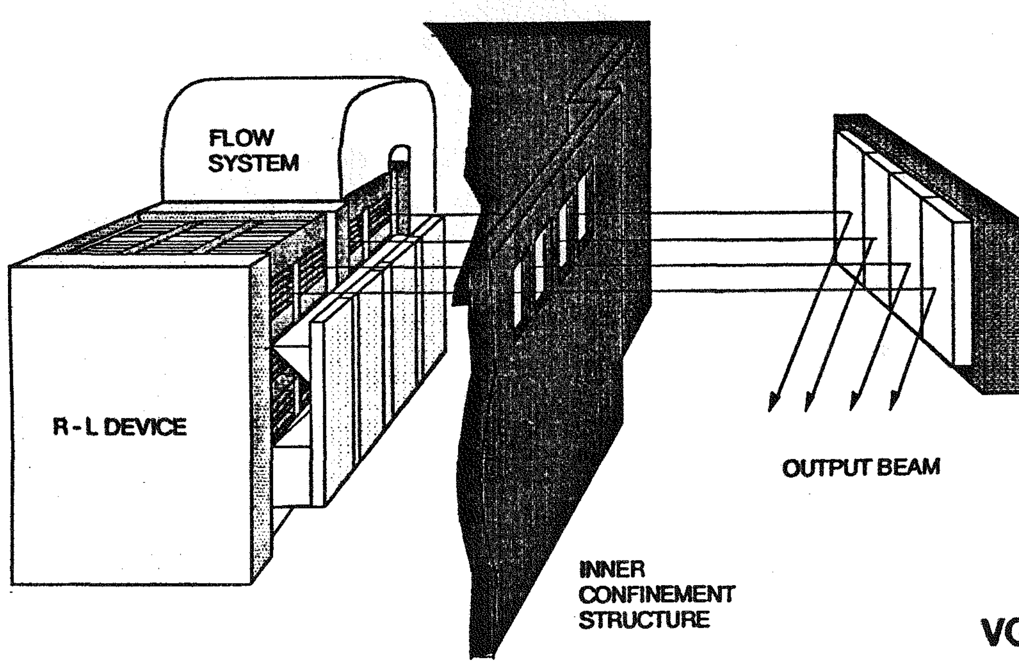
VG-5

FALCON Program Milestones

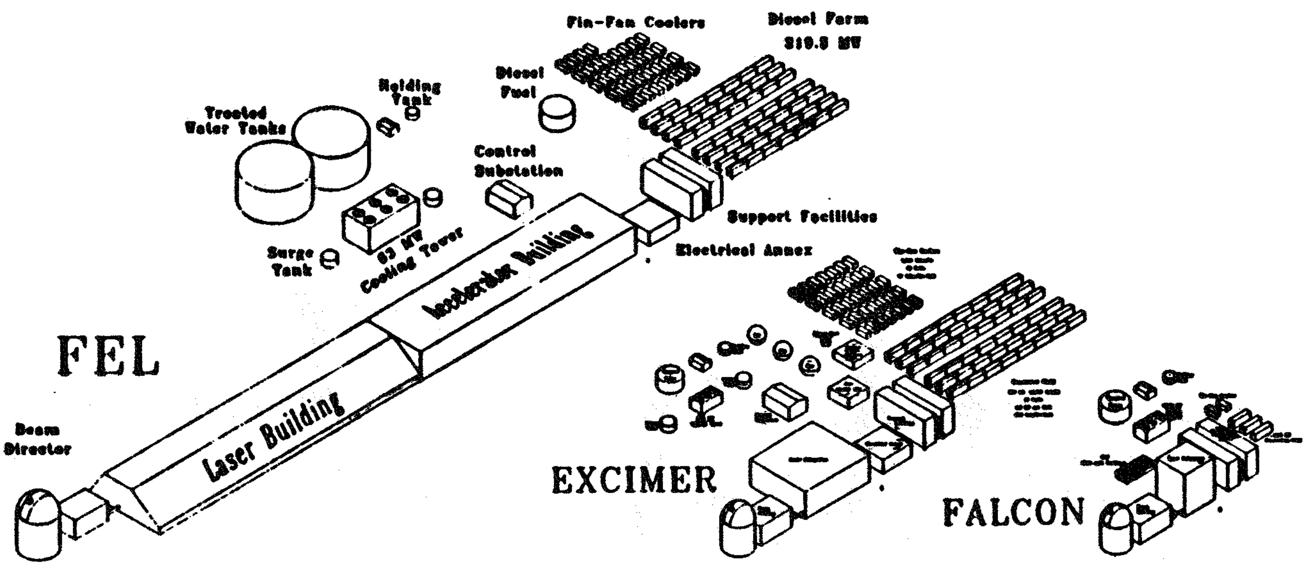
- Excimer Gain Measured -- 1986
- Rare Gas Laser Demonstration -- 1987
- Fission-Induced Medium Index Gradient Measured -- 1987
- Rare-Gas Laser Parameter Measured (gain, Eff, Isat) -- 1988
- Rare Gas Laser Kinetics -- 1989
- CW Exciter Design -- 1989
- Reactor-Pumped Ne Laser (0.58 um) -- 1990
- Medium Quality Measured -- 1990
- Multi-Channel CW Extraction Experiment (ACRR) -- 1991

VG-6

MW CLASS LASER SYSTEM



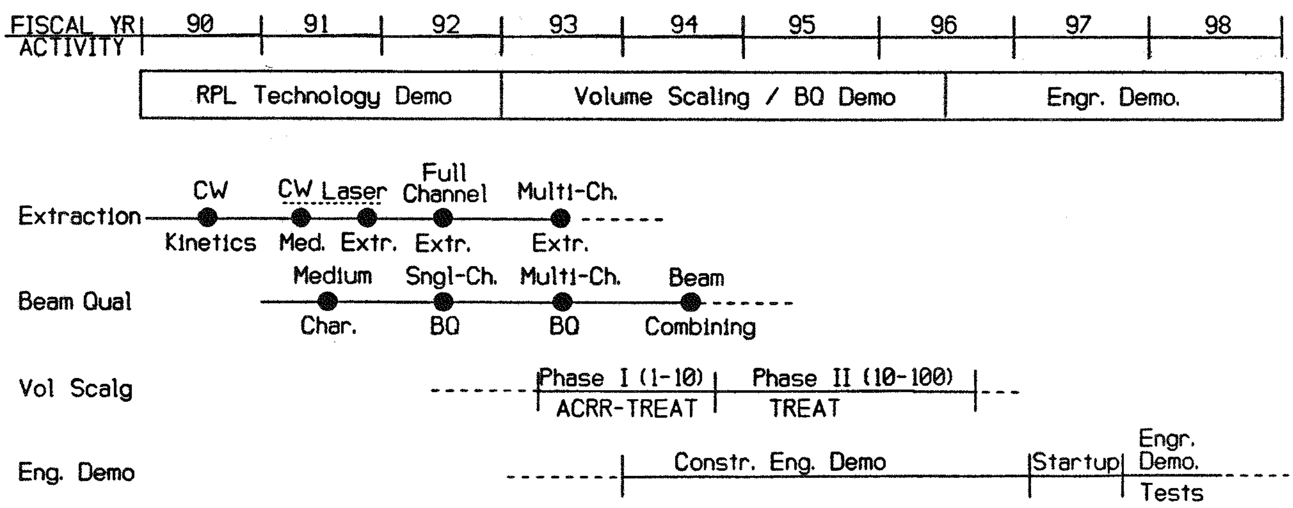
VG-7



VG-8

DOE Reactor Pumped Laser Program Plan

(Major Milestones/Activities)



SUPPORTING TECHNOLOGY PROGRAMS:

- Laser Medium Characterization
- In-Pile Med Char Expts
- Optics Development
- Laser Physics
- Nuclear Technology
- Systems and Missions
- Engineering Demo Facility

VG-9

Conclusions

- Scalable to High Powers (1 to 100 MW)
- Device Technology is Near Term
  - Low Temperature
  - Low Pressure
  - Relatively Modest Size
- Potentially Cost Effective at High Power
- Scaling & B/Q Issues -- Addressed in Near Term
- Key Issues
  - Mission -- Unique Role
  - System Cost
  - Nuclear Technology
  - Beam Quality

VG-10