The Plan to Develop Laser Fusion Energy

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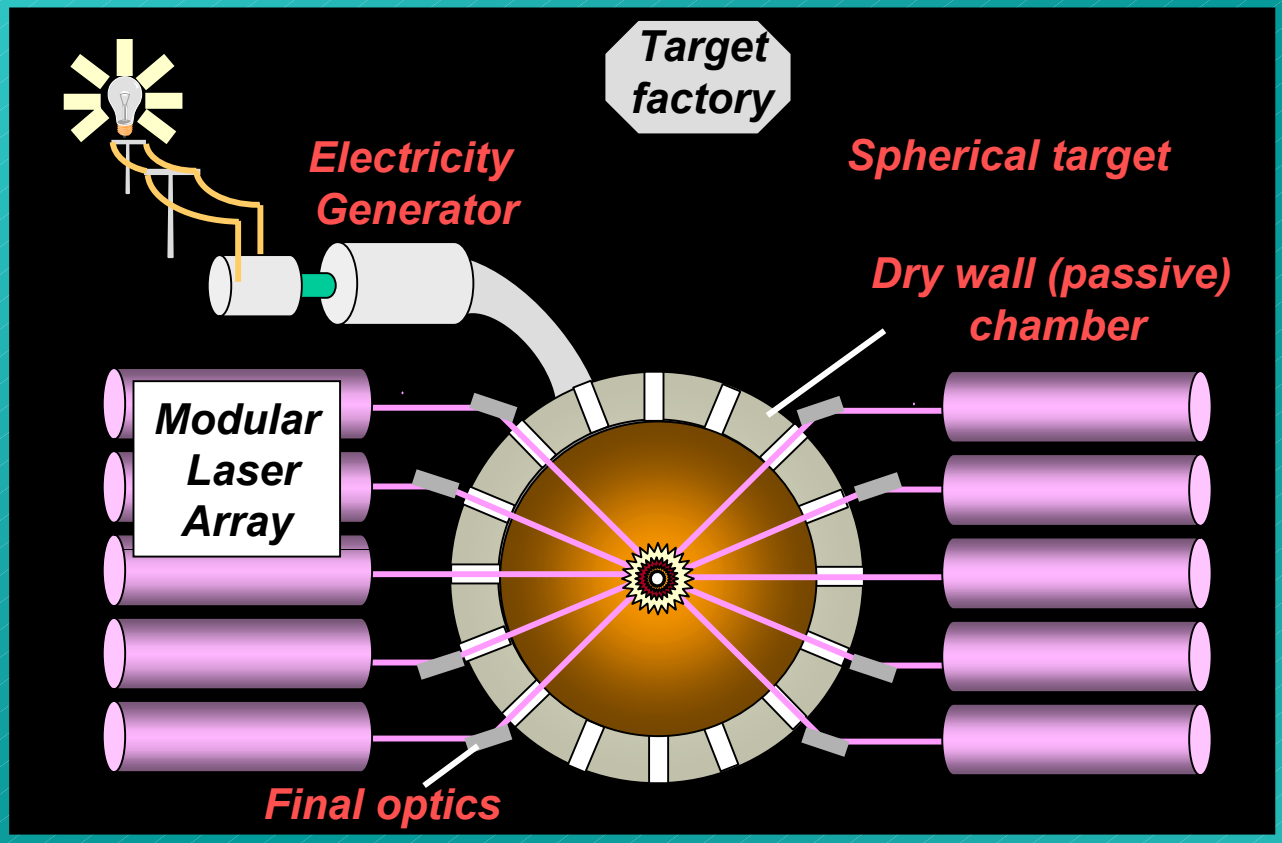
Lasers and direct drive targets can lead to an attractive power plant…



Modular, separable parts: lower development costs, economical upgrades

Targets are simple spherical shells: "fuel" lends itself to automated production

Pursuing dry wall (passive) chamber because of simplicity. Others possible

Past power plant studies have shown concept economically attractive

We are developing Laser IFE as an integrated system.

(8 Government labs, 7 Universities, 8 Private Industries)

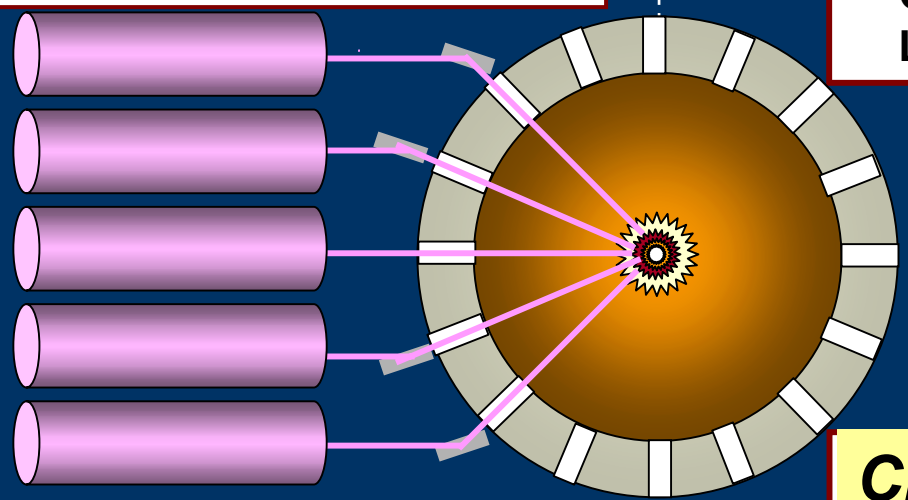
Lasers

KrF: NRL

Titan PSD, SAIC, PPPL, Georgia Tech, Commonwealth Tech

DPSSL: LLNL

Crystal Systems, Litton, Onyx Corp, Northrup, UR/LLE



Target Fabrication

GA: Fab, charac, mass production
LANL: Adv foams
SCHAFER: DvB foams

Target Injection

GA: Injector, Injection & Tracking
LANL: DT mech prop, thermal resp.

Direct Drive Target Design

NRL- Target design
LLNL: Yield spectrum, design

Chambers and Materials

WISCONSIN: Yield spectrum / Chambers
LLNL: Alt chamber concepts, materials
UCSD/ANL/INEEL: Chamber dynamics
SNL: Materials response x-rays/ions
ORNL/UCLA/UCSB/Wisconsin: Materials

Final Optics

LLNL: X-rays, ions, neutrons
UCSD: Laser, debris mitigation

The program capitalizes on two main thrusts in DOE

ICF Program
(NNSA/Defense Programs):

Single shot lasers
Ignition Target Design
Target experiments
Single Shot Target fab

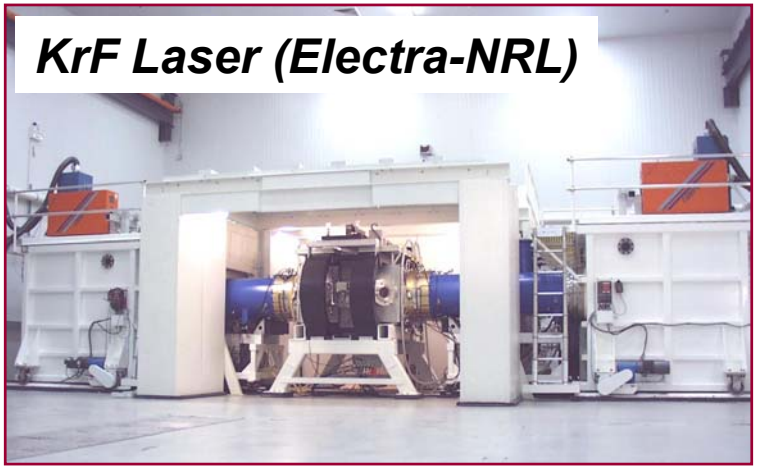
Fusion Program
(Office of Science):

System studies (ARIES)
Blanket/Breeders
Materials
Threats to wall (ELM)

Laser Fusion Energy (HAPL) Program

Rep-Rate Lasers
High Gain Target Design & Experiments
Mass Production of Targets
Target Injection
Final Optics
Chambers

Highlights of Progress: Laser Development

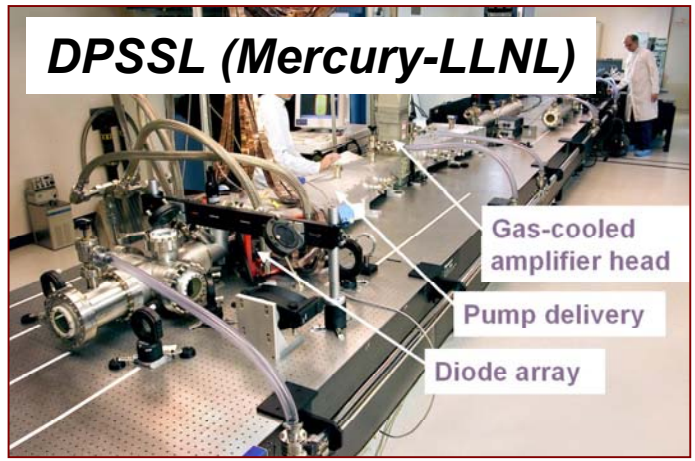


Developed:

- ***First Generation Pulsed Power (5 Hr run)***
- ***High transmission e-beam window***
- ***Advanced Solid State Switch***
- ***KrF Kinetics Code***

Outstanding Issues:

- **Durability**
- **Efficiency**
- Cost
- Beam Quality



Developed:

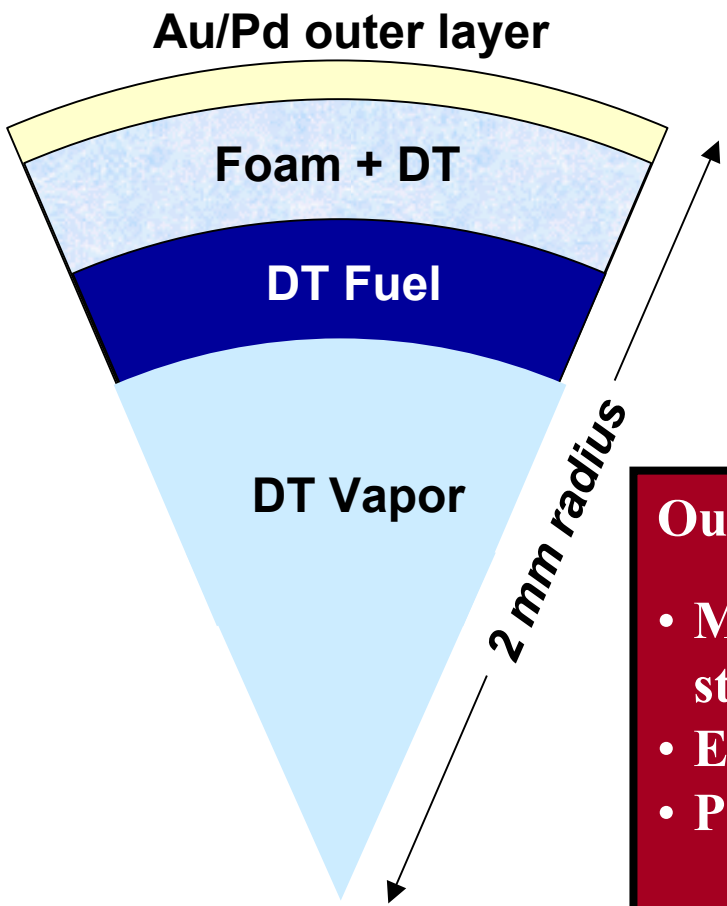
- ***160 kW diode arrays***
- ***Large, high quality crystals***
- ***Gas cooling of amplifier head***
- ***12 J laser light!***

Outstanding Issues:

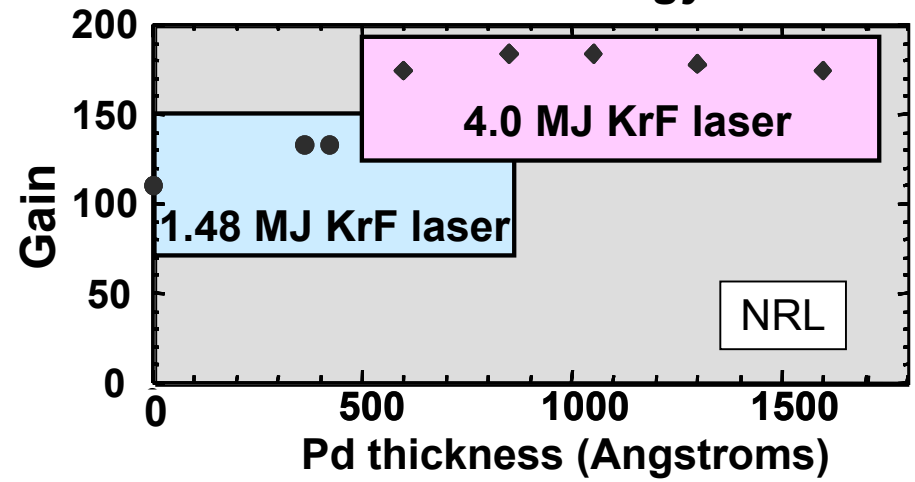
- **Cost**
- **Beam Quality**
- Efficiency
- Durability

Highlights of Progress: Target Design

High Gain Target
(sector of spherical target)



1-D Pellet Gain 120-180-
sufficient for Energy



Outstanding Issues:

- **Multi dimensional modeling showing gain and stability needed for fusion energy**
- **Experiments validating underlying codes**
- **Power Plant considerations:**
  Fabrication, injection, tritium inventory, etc

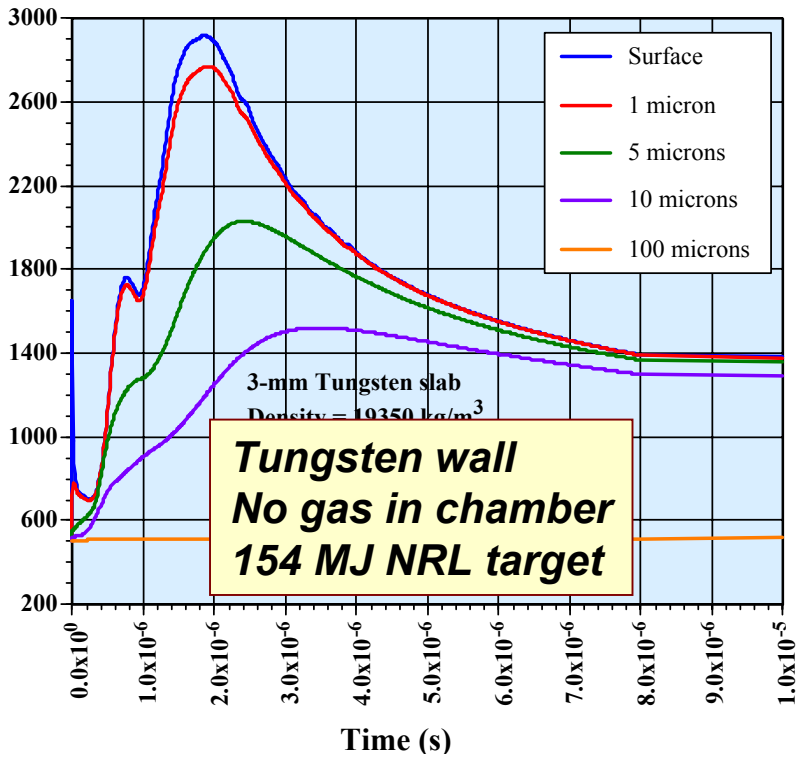
•NRL and LLNL are collaborating to evaluate a broad suite of target designs
•We are benchmarking underlying codes with experiments on Nike & Omega

Highlights of Progress: Chamber Design

- ***Modeling has established a chamber operating window…***
  (but window is "small" and long term material behavior an issue)

- ***Portfolio of solutions has been identified***

- ***Experimental evaluations underway:***
  Materials: (Z, RHEPP, ZAPPER, ORNL triple ion beam)
  Target Survival (DT target warm-up)
  Chamber Clearing

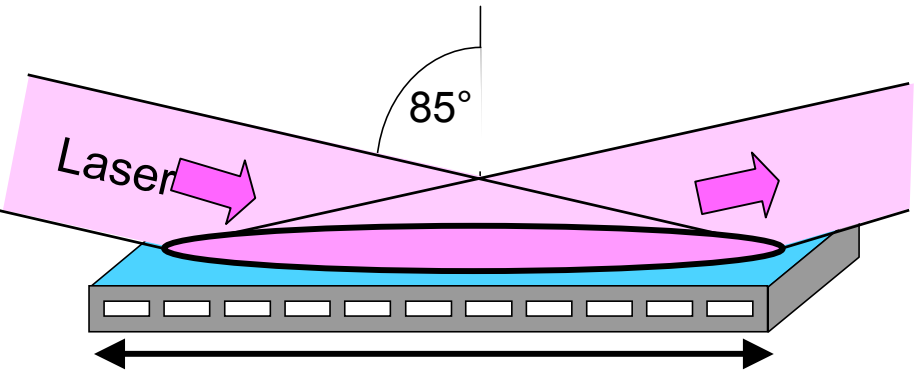


Outstanding Issues:

- **Integrated design with wall + target survival, based on experimental data**
- **Chamber dynamics/clearing**
- Efficiency

UCSD
Wisconsin
SNL
ORNL
LLNL
UCSD

Highlights of Progress: Final Optics



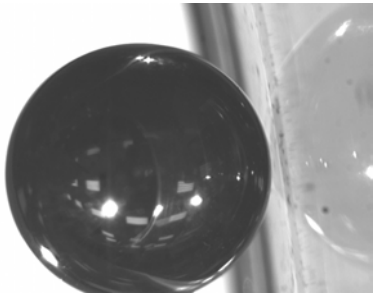
Demonstrated
high reflectivity,
high laser damage threshold,
for grazing incidence aluminum mirror

Outstanding Issues:

- **Laser damage @ large area, long life**
- **Debris, dust, and crud**
- **Fabrication**
- Ions
- Neutrons
- X-rays

UCSD (Experiments)
UCLA (modeling)

Highlights of Progress: Target Fabrication



Developed thin Au/Pd coatings with high DT permeability and IR reflectivity.

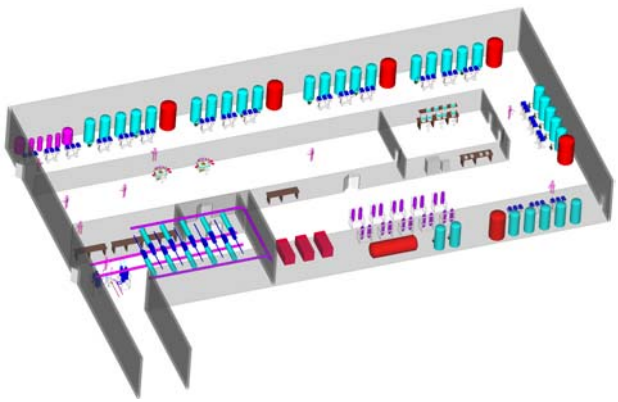
General Atomics

Established chemistry for foam shells

Schafer Corp

Issues:

- **Smooth cryogenic DT Layer**
- **IFE quality, over-coated foam shells**

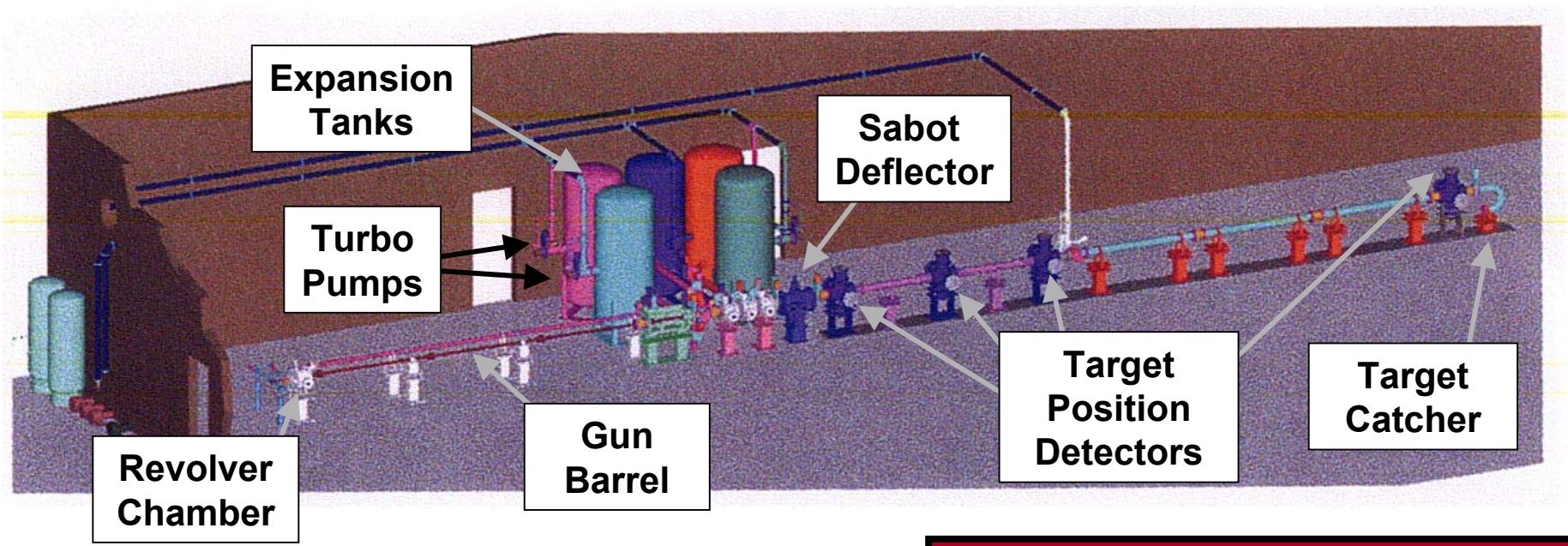


Targets $0.16 each from chemical process plant methodology

General Atomics

Highlights of Progress: Target Injection

1.Started Const of Gas Driven Target Injector
2.Demonstrated Concept of Separable Sabot
3.Determining needed properties of DT



Issues:

DT mechanical/thermal properties
Injector
In Flight Tracking
Sabot Separation

General Atomics, LANL

We are following a three phase program to develop Laser Fusion Energy

Phase III
Engineering Test Facility
start ~2014, operating 2020

- **2-3 MJ, 60 laser beam lines**
- **High gain target implosions**
- **Optimize chamber materials & components.**
- **Generate ~ 300 MW electricity from fusion**

Establish: Target physics, Full scale Laser technology, Power Plant design

?

Phase II
Integrated Research Experiments and more
start ~2006

- ***Laser facility*** **-full energy beam line hits injected targets**
- ***Target facility-*** **inject targets into chamber environment**
- ***Power Plant Design***
- ***Material Development***

Target Design-II
- 3D Modeling
- High energy (MJ) NIF exp

Develop Viable: Target designs, scalable laser tech, target fab/ injection, final optics, chamber

?

Phase I:
Establish science and technology
Start 1999

Lasers
- **Electra KrF**
- **Mercury DPPSL**

Other Comp
- **target fabrication**
- **target injection**
- **final optics**
- **Chamber/materials**

Target Design-I
- 2D/3D Modeling
- Nike, Omega experiments

The Laser Fusion Energy Program

Lasers and direct drive targets can lead to an attractive power plant.

We are developing Laser IFE as an integrated system:
Lasers, target design, target fabrication, final optics, chambers

The program capitalizes on two main thrusts in DOE:
ICF Program *(NNSA/Defense Programs):*
Lasers, Target design, Target Fabrication
Fusion Program *(Office of Science):*
Fusion materials/components, power plant studies

We have made significant advances in all areas:
Lasers, target design, target fabrication, final optics, chambers

We are pursuing a three phase program to develop Laser Fusion Energy
Must meet specific goals before going to next phase