The HAPL Program:
Integrated program to develop the science and technologies for Fusion Energy with Laser Direct Drive

19th HAPL meeting
Oct 22-23, 2008
Madison, WI
54 participants, 10 students

Government Labs
1. NRL
2. LLNL
3. SNL
4. LANL
5. ORNL
6. PPPL
7. SRNL

Universities
1. UCSD
2. Wisconsin
3. Georgia Tech
4. UCLA
5. U Rochester, LLE
6. UC Berkeley
7. UNC
8. Penn State Electro-optics

Industry
1. General Atomics
2. L3/PSD
3. Schafer Corp
4. SAIC
5. Commonwealth Tech
6. Coherent
7. Onyx
8. DEI

9. Voss Scientific
10. Northrup
11. Ultramet, Inc
12. Plasma Processes, Inc
13. PLEX Corporation
14. APP
15. Research Scientific Inst
16. Optiswitch Technology
17. ESLI

HAPL "Business Model" for IFE development

1) Develop science & technology as an integrated system

2) Pick approaches that:

a) Lead to an attractive power plant

technically, economically, environmentally

b) Requires less investment to develop

c) Value simplicity and durability

3) Encourage competition

4) Managed by one institution, partnership among many.

a) Synergies with other fusion approaches

b) Engage non fusion community (e.g. materials)

b) Encourages alternative views, avoids "groupthink"

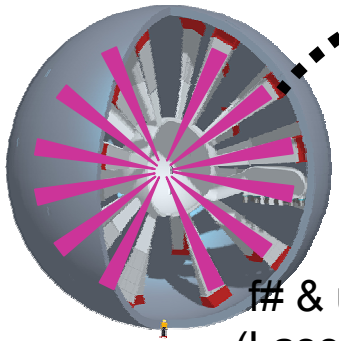
5) Staged program with well defined "go / no-go" points

a) S&T advances pace program, *not* mandates

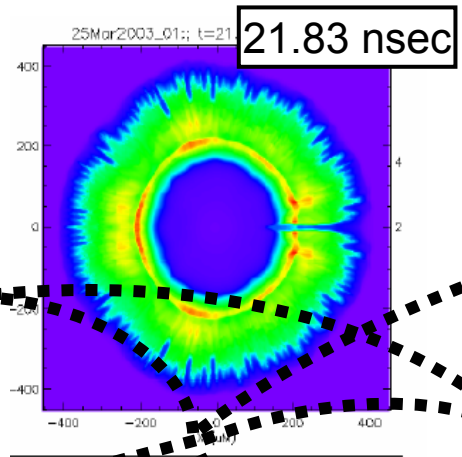
An "integrated systems" approach is essential

Much harder, but much more likely to yield something that works!

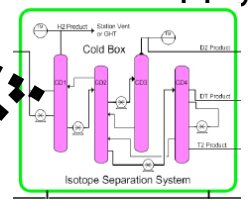
Blanket- (tritium breeding)



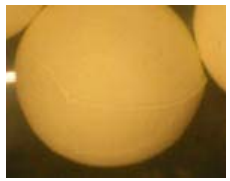
Example: target physics



tritium supply

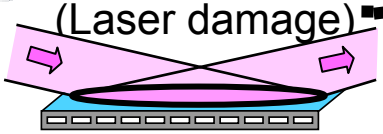


Target fabrication



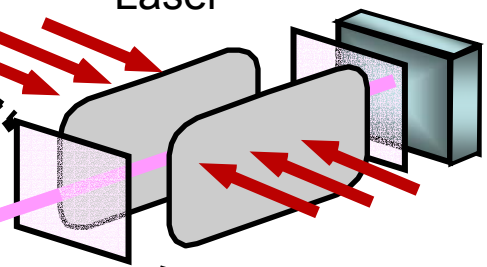
f# & uniformity (Laser damage)

Final optics

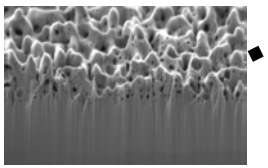


Emission Damage

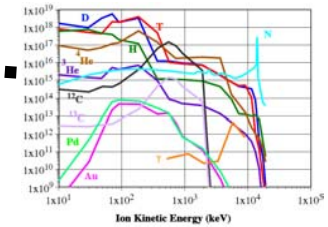
Laser



First wall (survival)

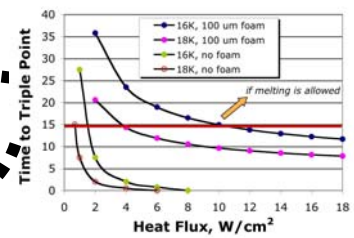


target emissions



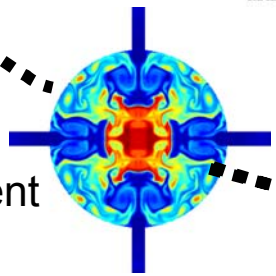
DT strength (acceleration)

target injection survival



GAIN = 160 ☺

Chamber environment



simulations A. J. Schmitt

3 bal

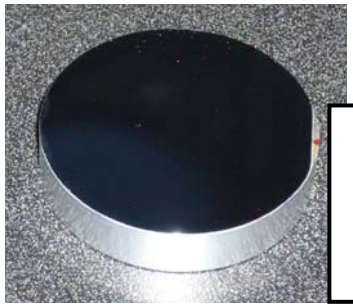
The keys to *economically attractive fusion power:*

Simplicity, Durability, Performance

Encourage competition.
It leads to innovation and a better product.
And leads to it faster

HAPL generated credible solutions for most key components needed for IFE (1 of 2)

Final Optics:
High Laser Damage Threshold Grazing Incidence Metal Mirror



10 M shots at 3.5 J/cm^2 *(not a limit!)*

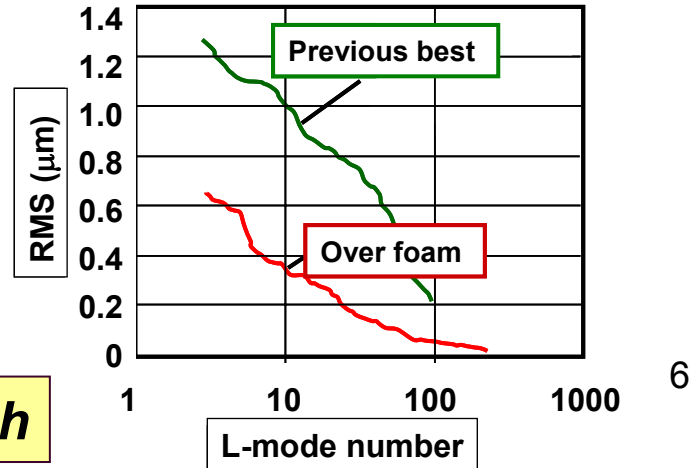
Penultimate Optics:
Neutron Resistant Dielectric Mirror

Laser Damage Threshold (Al_2O_3/SiO_2)

No dpa	0.001 dpa	0.01dpa	0.1 dpa
86-87%	84-86%	78-83%	83-84%

Target Fabrication:
Mass Produced Foam Shells

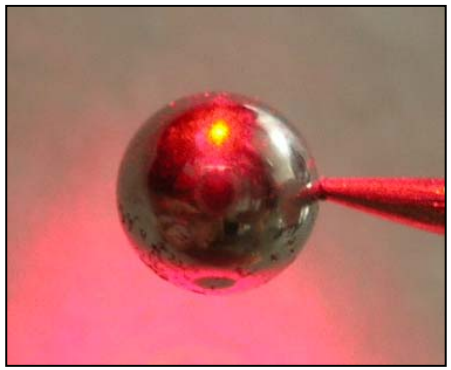
Target Fabrication:
Smooth DT ice layers over foam



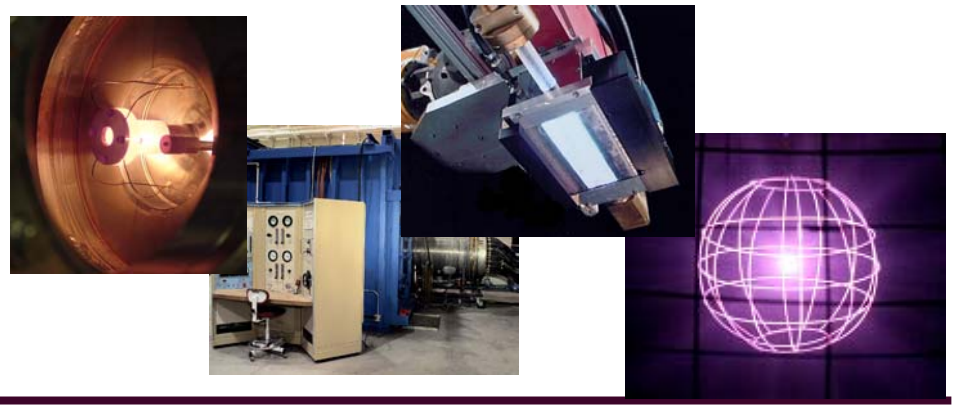
Estimate Target Cost 16 ¢ each

HAPL generated credible solutions for most key components needed for IFE (2 of 2)

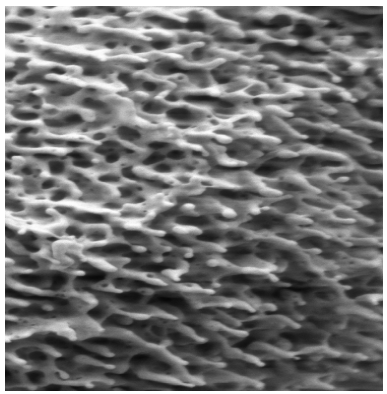
Target Engagement:
Glint system: accuracy 35 microns

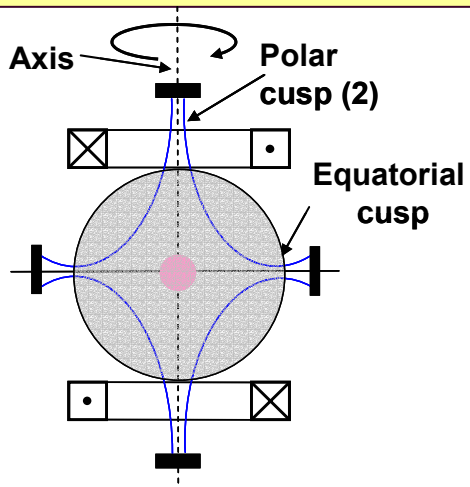


First wall experiments & modeling
Study threats on Chamber Wall



Developing two chamber concepts
Engineered Wall ***Magnetic Intervention***





Conceptual designs for ancillary components:

- Chamber/structure
- Blanket
- Tritium Breeding/processing
- Vacuum system
- Power conversion

HAPL team had over 210 publications /presentations

http://aries.ucsd.edu/HAPL/

Target Injection	Frey	2		sion	Fusion Sci. Technol. 47, 4, Part 2, 1143
Target Fabrication & Properties	Frey	2007	D. T. Frey, N. B. Alexander, A. S. Bozek, D. T. Goodin, R. W. Stemke, T. J. Drake, D. Bitner	Mass Production Methods for Fabrication of Inertial Fusion Targets	Fusion Science & Technology 51 (4) 2007, 786-790.
Driver Technology	Friedman	2002	Friedman, M.; Myers, M.; Swanekamp, S. B.; Chan, Y.; Sethian, J. D.; Obenschain, S.	Suppressing the transit-time instability in large-area electron-beam diodes	Applied Physics Letters 81 (9) 2002, 1597 – 1599.
Driver Technology	Friedman	2004	Friedman, M.; Myers, M.; Hegeler, F.; Swanekamp, S. B.; Wolford, M. F.; Sethian, J. D.; Ludeking, L.	Emission of an intense large area electron beam from a slab of porous dielectric	Journal of Applied Physics 96 (12) 2004, 7714-7722.
Driver Technology	Friedman	2004	M. Friedman, et al	Initiation and prevention of the transit time instability in large area diodes	Journal of Applied Physics 95 (5) 2004, 2797 - 2799.
Target Injection	Frolov	2005	B. K. Frolov, A.Yu. Pigarov, S. I. Krasheninnikov, R.W. Petzoldt, D.T. Goodin	Simulation of Afterglow Plasma Evolution in an Inertial Fusion Energy Chamber	Journal of Nuclear Materials 337–339 206–210
Driver Technology	Gentile	2003	C.A. Gentile, H.M. Fan, J.W. Hartfield, R.J. Hawryluk, F. Hegeler, P.J. Heitzenroeder, C.H. Jun, L.P. Ku, P.H. LaMarche, M.C. Myers, J.J. Parker, R.F. Parsells, M. Payen, S. Raftopoulos, J.D. Sethian, F. Hegeler	Development of a Silicon Based Electron Beam Transmission Window for Use in a KrF Excimer Laser System	Fusion Science and Technology. Vol. 43, Num 3, pp 414 – 419. May 2003.
Driver Technology	Gentile	2003	C.A. Gentile, R. Parsells, J.E. Butler, J.D. Sethian, L. Ciebiera, F. Hegler, C. Jun, S. Langish, M. Myers	The Development of a Hibachi Window for Electron Beam Transmission in a KrF Laser	PPPL Report Num. 3900, November 2003.
Blanket & Systems Design & Engineering	Gentile	2006	C.A. Gentile, T. Kozub, S. Langish, C. Priniski, L. Ciebiera	Fusion Test Facility (FTF) Target Chamber Tritium Recovery, Processing and Purification System	Proceedings TOFE, Nov 2006.
Blanket & Systems Design & Engineering	Gentile	2008	C.A. Gentile, T. Kozub, S. Langish, L. Ciebiera, A. Nobile, J. Wermer, K. Sessions	Inertial Fusion Energy Power Reactor Fuel Recovery System	Fusion Science and Technology. Vol. 54, Num. 2. pp 371 – 374, August 2008.
Chamber Dynamics	Gentile	2010	C.A. Gentile, W.R. Blanchard, T.A. Kozub, M. Aristova, C. McGahan, S. Natta, K. Pagdon, J. Zelenty	A Concept for a Low Pressure Noble Gas Fill Intervention in the IFE Fusion Test Facility (FTF) Target Chamber	PPPL Report Num. PPPL 4478, January 2010.
Chamber Materials & Engineering	Gilliam	2005	S.B. Gilliam, S.M. Gidcumb, N.R. Parikh, D.G. Forsythe, B.K. Patnaik, J.D. Hunn, L.L. Snead, G.P. Lamaze	Retention and surface blistering of helium irradiated tungsten as a first wall material	Journal of Nuclear Materials 347 (2005) 289–297.
Chamber Materials & Engineering	Gilliam	2005	S.B. Gilliam, S.M. Gidcumb, D. Forsythe, N.R. Parikh, J.D. Hunn, L.L. Snead, G.P. Lamaze	Helium retention and surface blistering characteristics of tungsten with regard to first wall conditions in an inertial fusion energy reactor	Nuclear Instruments and Methods in Physics Research B241 (2005) 491–495.
Target Fabrication and Properties	Goodin	2001	D.T. Goodin, A. Nobile, N. B. Alexander, R.W. Petzoldt	Progress Towards Demonstrating IFE Target Fabrication and Injection	Proc. of 2nd International Conf. on Inertial Fusion Sciences and Applications, page 746
Target Injection	Goodin	2001	D.T. Goodin, N. B. Alexander, C. R. Gibson, A. Nobile, R. W. Petzoldt, N.P. Siegel, L. Thompson	Developing Target Injection and Tracking for Inertial Fusion Energy Power Plants	Nucl. Fusion 41, 5, 527

The HAPL Program produced > 31 students

HAPL meeting, General Atomics, August, 2006

UCSD
UCLA
Wisconsin
Georgia Tech
U Rochester
U North Carolina
Duke
Princeton