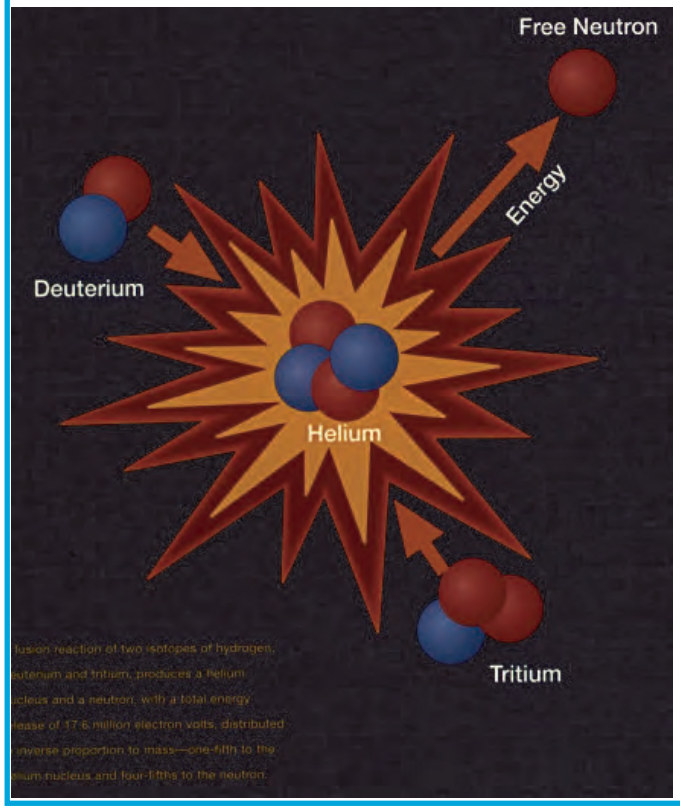
Magnetized Target Fusion (MTF)
(a.k.a. Magneto- Inertial Fusion):
Can an unexplored, low-cost pathway accelerate the development of fusion power?

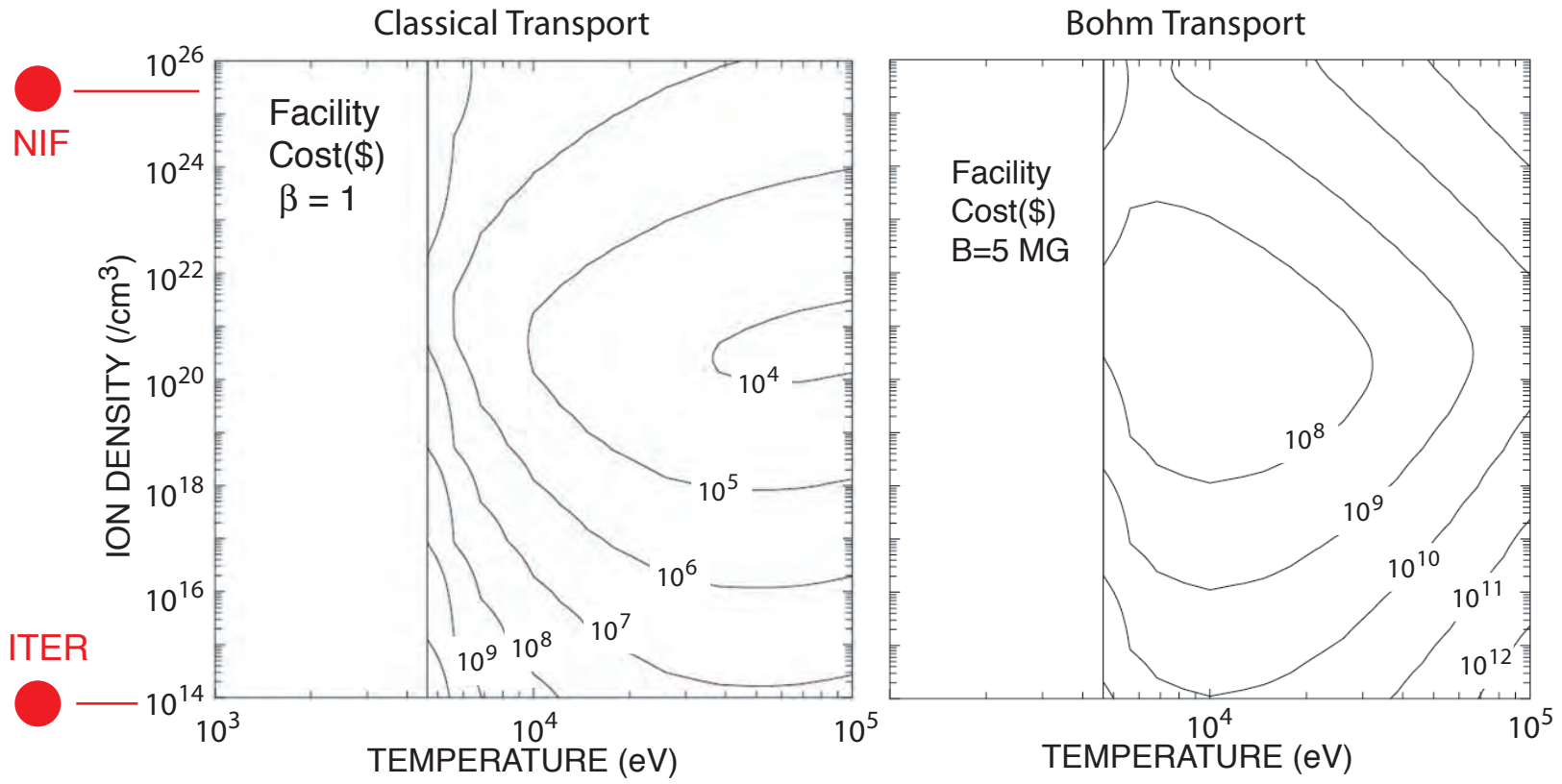


Irvin R. (Irv) Lindemuth
Dept. of Physics, University of Nevada, Reno
formerly (retired, 2003)
Asst. Assoc. Director, Team Ldr., Project Ldr.
Los Alamos National Laboratory
Los Alamos NM

Prepared for
SOFE Town Hall Meeting on
Accelerating the Development of Fusion Power
Chicago, Ill., June 27, 2011

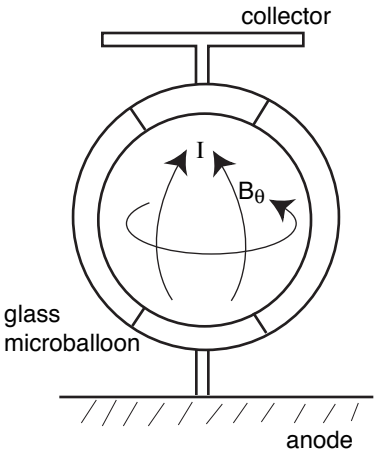
Acknowledgement: much of this presentation is due to the original insight of Prof. Richard E. Siemon, UNR

A simple first-principles analysis gives surprisingly accurate estimates of the minimum size, mass, energy, power, and cost of MCF and ICF facilites (SOFE paper SO4A-5, Thursday, 11:15 AM)



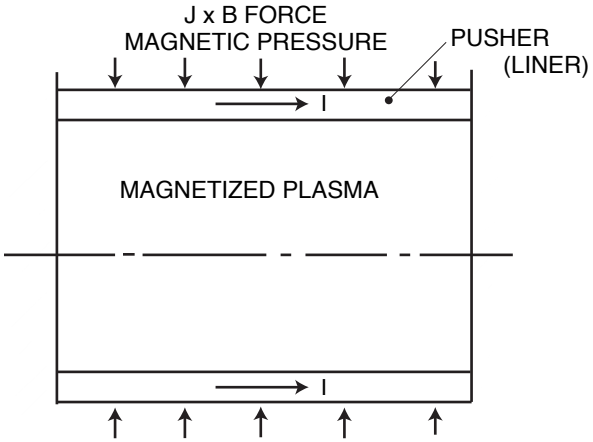
- **Operation at an intermediate density leads to reduced facility costs because of lower power (when compared to NIF) and lower energy (when compared to ITER)**

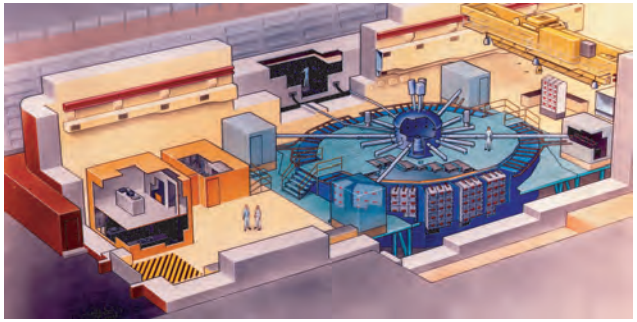
Can the intermediate density space be accessed?



- The first neutrons of the U.S. particle beam program were produced by Sandia's "Phi" magnetized target imploded at 1/10 NIF's implosion velocity (Physics Today, August 1977).

- The liner velocity required to compress a magnetized plasma is orders of magnitude less than required in ICF.





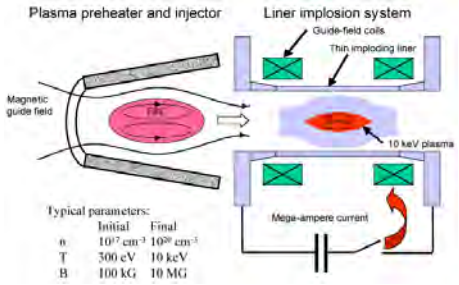
- The Atlas capacitor bank (Nevada Test Site) designed to create high energy density environments is serendipitously ideal for driving magnetized targets.

- Sandia is again pursuing magnetized targets (MagLIF, Slutz et al., PoP 2010).

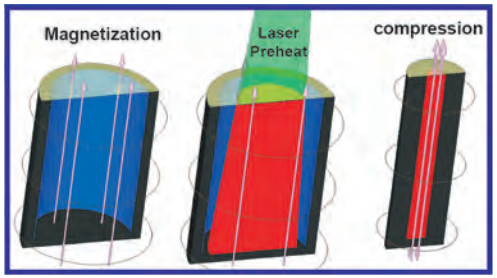
- U. of Rochester is observing neutron enhancement on Omega (Betti et al.).

- AFRL/LANL are imploding FRC plasmas (papers 1P1B-14, SO2B-3, IO4A-5).

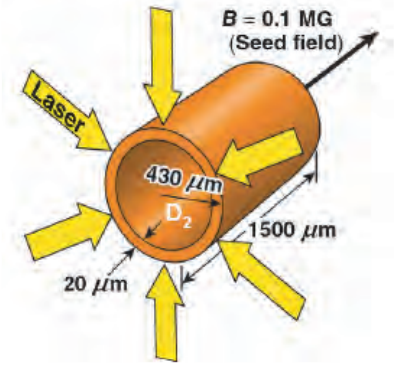
The > 1e4 density, > 1e2 velocity range of MTF admits many plasma/ driver combinations; plasma may be magnetically or wall confined with simple magnetic topology; pulse-shaping is not needed



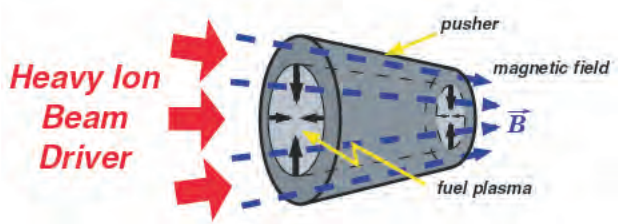
AFRL/LANL/UNR FRC/Shiva-Star
(J. Degnan, G. Wurden et al.)



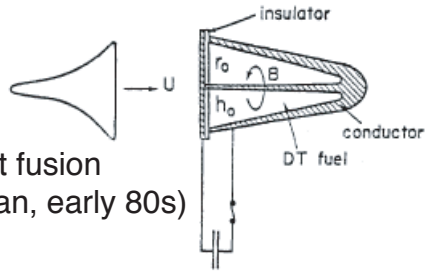
SNL "Z" MAGLIF (S. Slutz et al.)



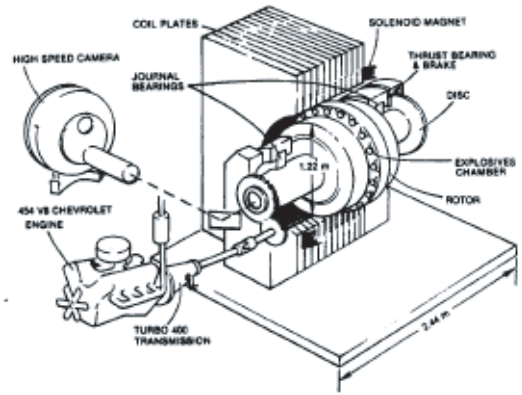
LLE Omega (Fiksel,Hohenberger et al._



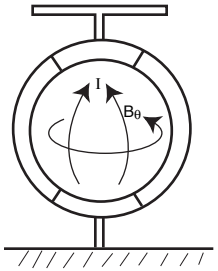
HIF (Kemp et al.)



impact fusion
(Tidman, early 80s)

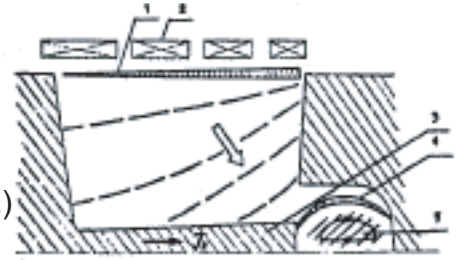


NRL LINUS (Turchi et al., 70s-80s)
Reciprocating 0.1 mm/μs liquid liner



SNL e-beam Φ-target (late 70s)

Plasma-jet liner (Witherspoon et al.)



Russian (Kurtmullaev et al, 70s-80s)

Controlled Fusion is a long-term, expensive proposition--or is it????

	ITER	*MTF example*	*NIF*
Cost ($M)	10,000	51	3,000
n_i *(/cm^3)*	10^{14}	10^{20}	1.4×10^{25}
ρ *(g/cm^3)*	4.2×10^{-10}	4.2×10^{-4}	57
T (keV)	8	8	8
p (atm)	2.6	2.6×10^{6}	3.6×10^{11}
B (kG)	50	1,000	0
τ_L *(s)*	0.9	9×10^{-7}	6.6×10^{-12}
M (mg)	350	1.7	0.01
a (cm)	240	0.6	3.5×10^{-3}
V (m^3)	8.3×10^{2}	4.0×10^{-6}	1.8×10^{-13}
E_{plas} *(J)*	3.2×10^{8}	1.6×10^{6}	9.3×10^{3}
P_{heat} *(W)*	1.3×10^{8}	9.0×10^{10}	1.1×10^{14}
I_{heat} *(W/cm^2)*	18	1.0×10^{10}	7.5×10^{17}

- **ICF and MCF differ by 10^{10}--10^{12} in fuel density and time scale and by more than 10^{15} in burning fuel volume. The vast parameter space between these two extremes is unexplored.**
- **MTF can be investigated using machines that already exist (e.g., Atlas $50M).**
- **The low cost and size of experimental facilities should significantly reduce fusion's development time.**
- **Unfortunately, unless the US program adopts a "balanced portfolio" approach, MTF (and other alternate concepts) will never have a chance to reach technical maturity.**