Perspective on IFE Reactor Designs

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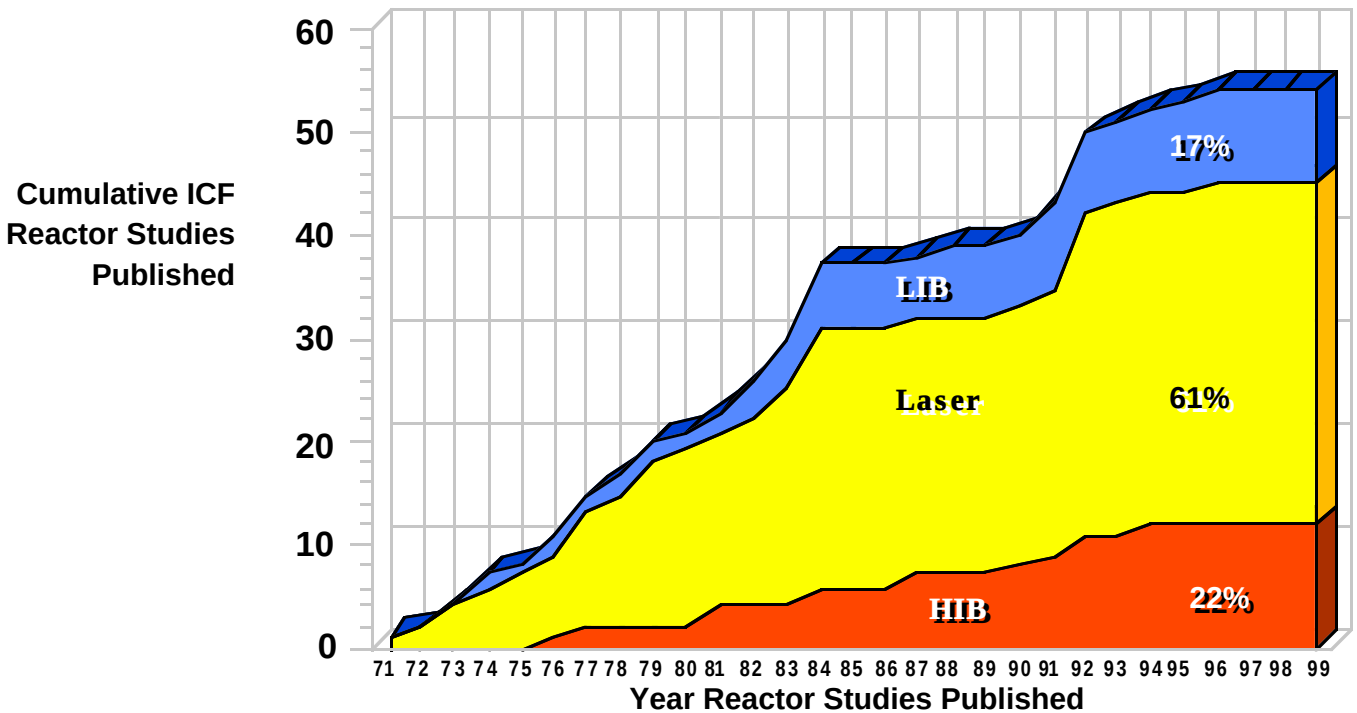
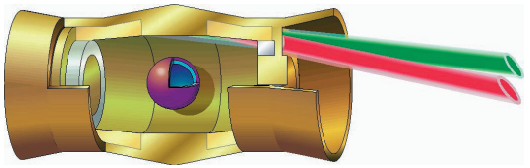
Approximately 80% of the IFE Reactor Designs are 15 Years Old and Need to Incorporate Recent Target, Driver, and Chamber Improvements

- The level of research on IFE power plants has historically been much lower (by a factor of ≈ 10) than for MFE power plants
- In spite of the lower level of investment, there have been over 50 individual IFE power plants analyzed since 1972



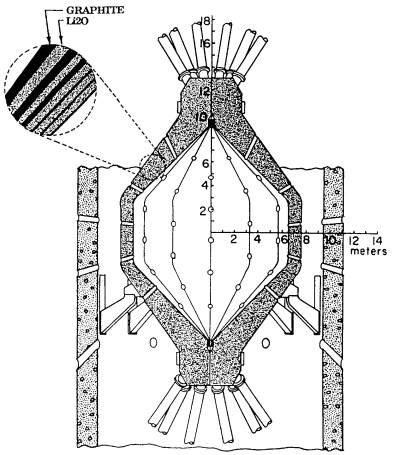
The Environmental, Safety, and Economic Features of IFE Power Plants are Greatly Influenced by 3 Factors

- **Target Designs**



- **Driver Technology**

- **Reactor Chamber Design**



Examples of Laser Driven Dry Wall IFE Designs

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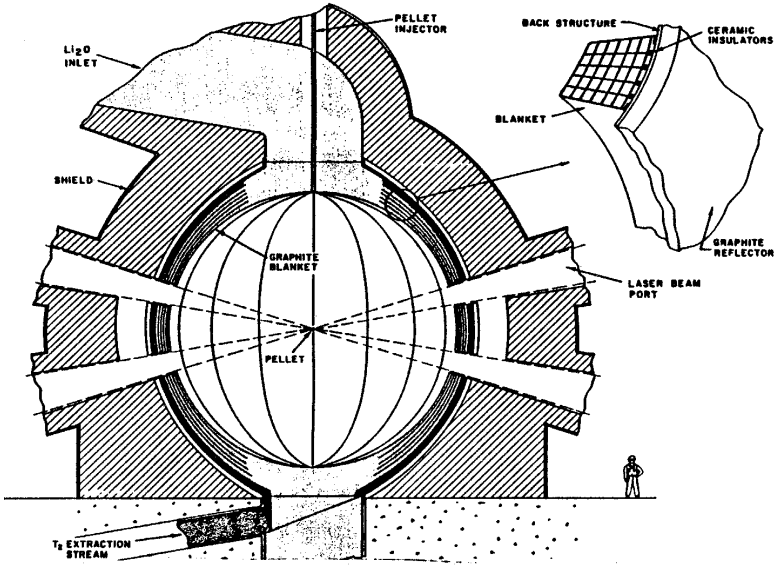
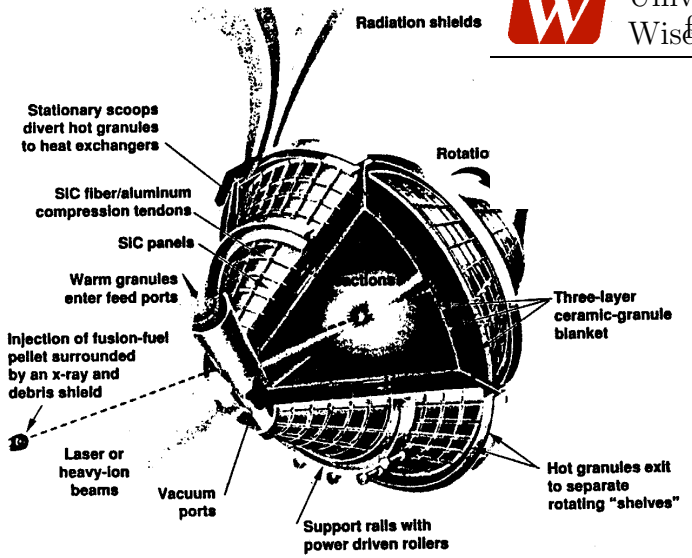
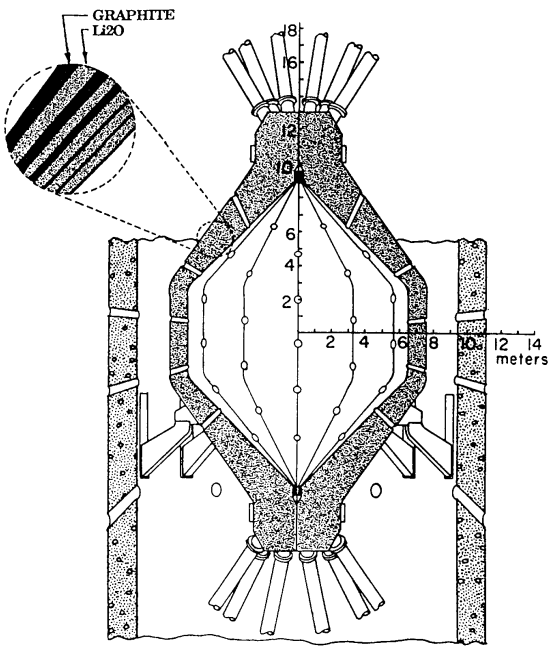


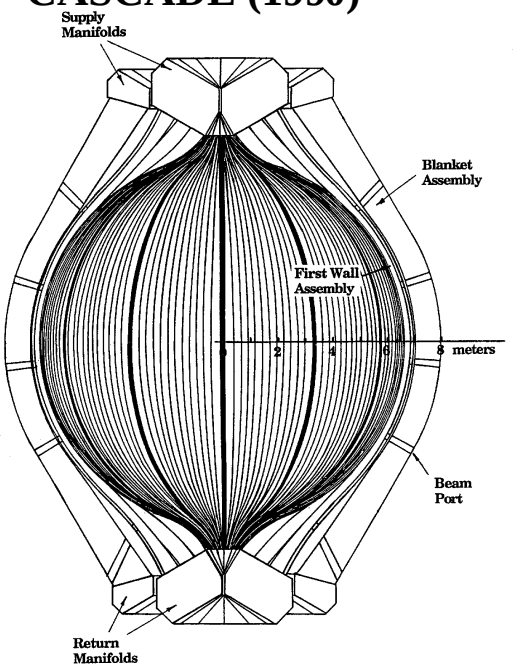
SOLASE (1977)



CASCADE (1990)

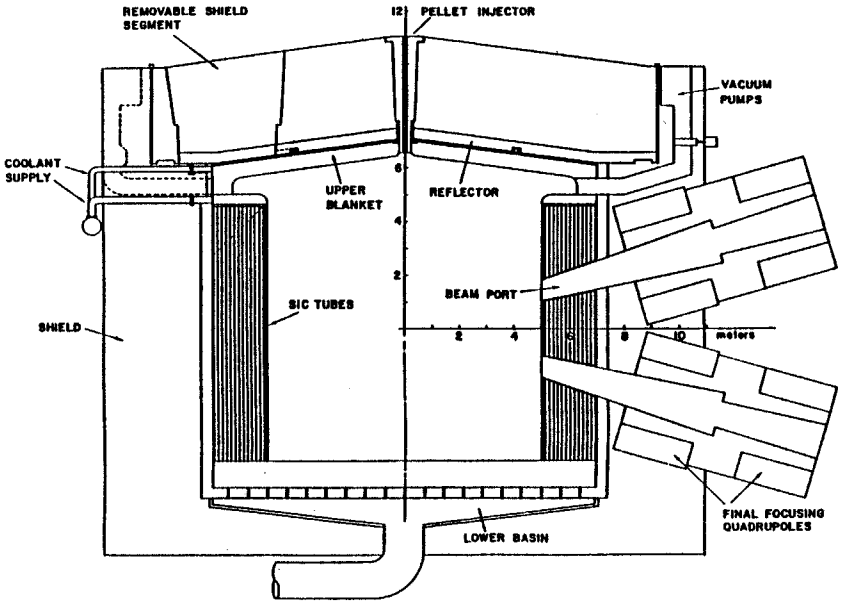


SOMBRERO (1992)

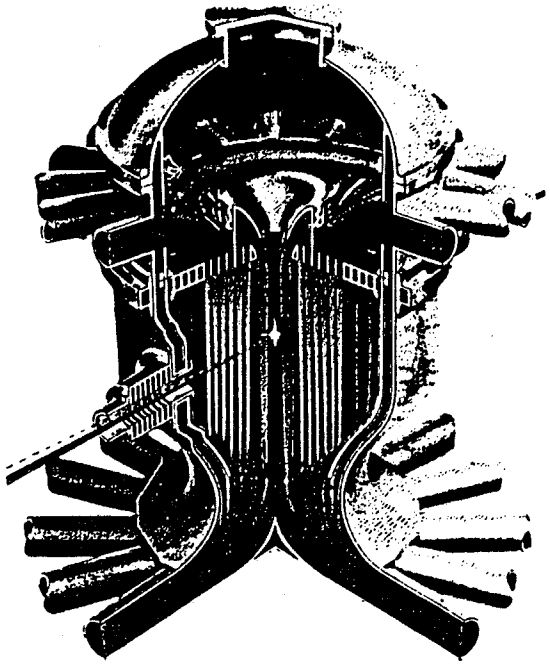


SIRIUS-P (1993)

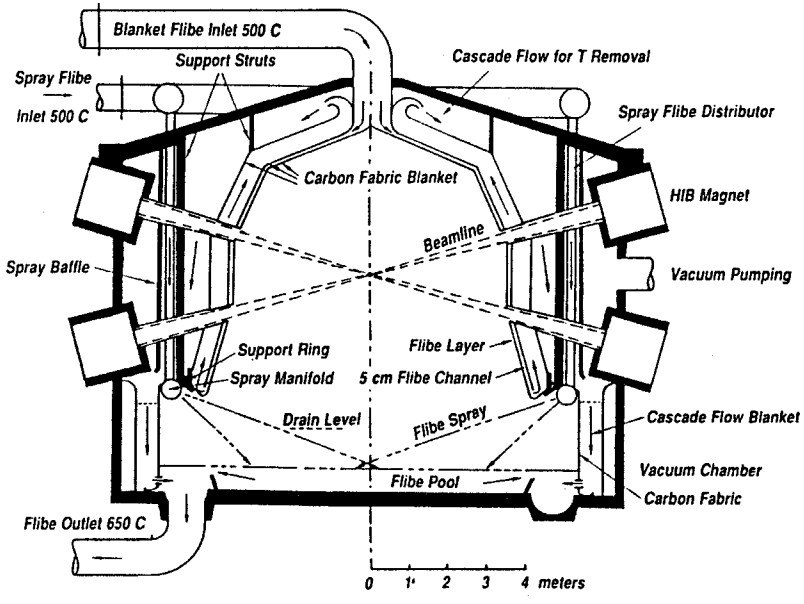
Heavy Ion Beam Driven Reactor Designs



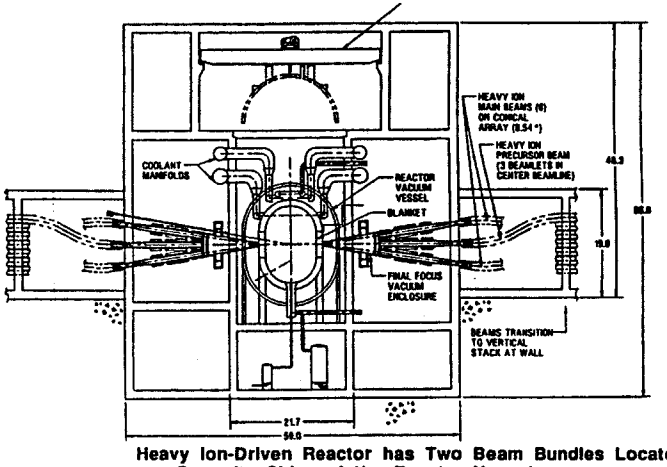
HIBALL (1981)



HYLIFE (1985)



OSIRIS (1992)



Heavy Ion-Driven Reactor has Two Beam Bundles Located on Opposite Sides of the Reactor Vessel

PROMETHEUS-H (1992)

Three Light Ion Beam Propagation Schemes Have Been Utilized

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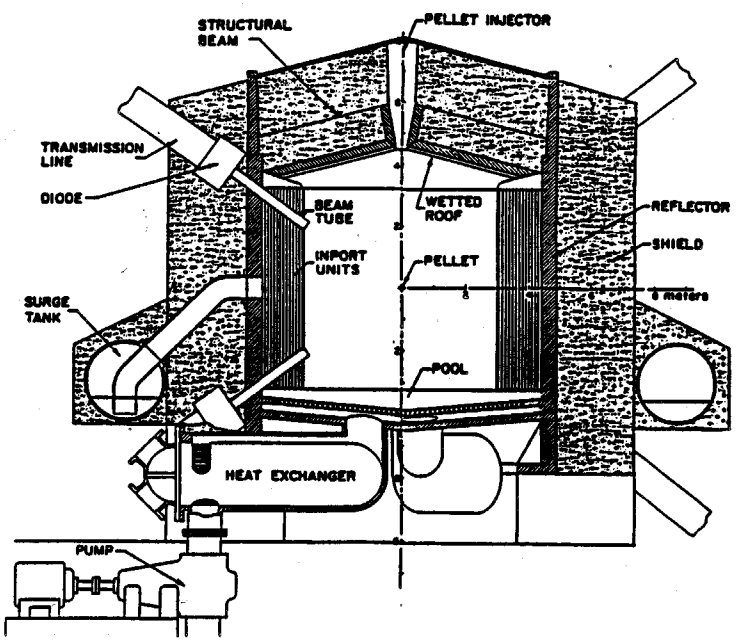
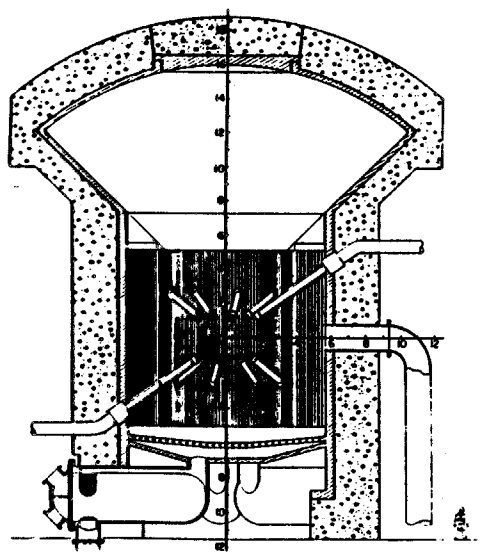
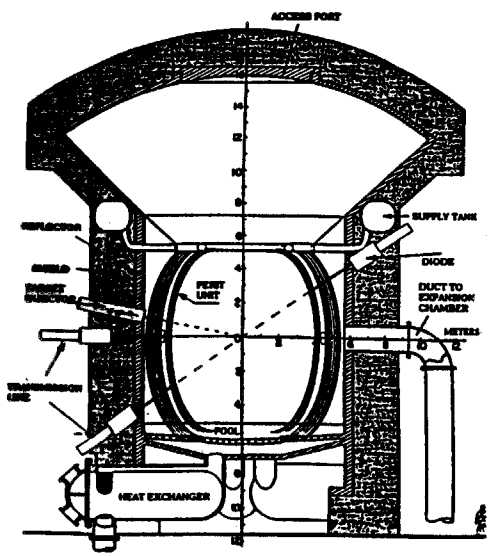






LIBRA (1989)

Channel beam propagation
Driver technology, HELIA
Li + ions, 25-35 MeV
Energy on target, 4 MJ
Target gain, 80
Rep-rate, 3

LIBRA-Lite (1991)

Ballistic beam propagation
Driver technology, HELIA
Li + ions, 25-35 MeV
Energy on target, 6 MJ
Target gain, 100
Rep-rate, 3.9

LIBRA-SP (1995)

Self-pinched beam propagation
Driver technology, HELIA
Li + ions, 30 MeV
Energy on target, 7.2 MJ
Target gain, 82
Rep-rate, 3.9

Historical Trends in Laser Fusion Power Plant Designs

Time Period	*Driver/Target Related*	*Reactor Chamber Related*
70's	• Long Wavelength Lasers • Low Driver Energy ≈ 1 MJ • High Gain Curves • Direct Drive	• Liquid Li Emphasis • Wetted FW Protection • High Rep Rate (10-100 Hz) • Internal Liquid Protection Introduced
80's	• Short Wavelength Lasers • Higher Driver Energy ≈ 1-5 MJ • Lower Gain Curves • Indirect Drive Considered	• Solid Li Compounds for T_2 • Granular Solids FW Protection • Lower Rep Rate (1-10 Hz)
90's	• KrF/DPSSL Lasers • Driver Energy ≈ 5 M • Fast Ignitor Concept Explored • Grazing Incidence Angle Mirrors • Direct Drive More Prominent	• Fluidized LiO_2 Coolant • Dry FW Reanalyzed for Direct Drive • Emphasis on SiC/C FW • Liquid Metal “Curtains” for Indirect Drive

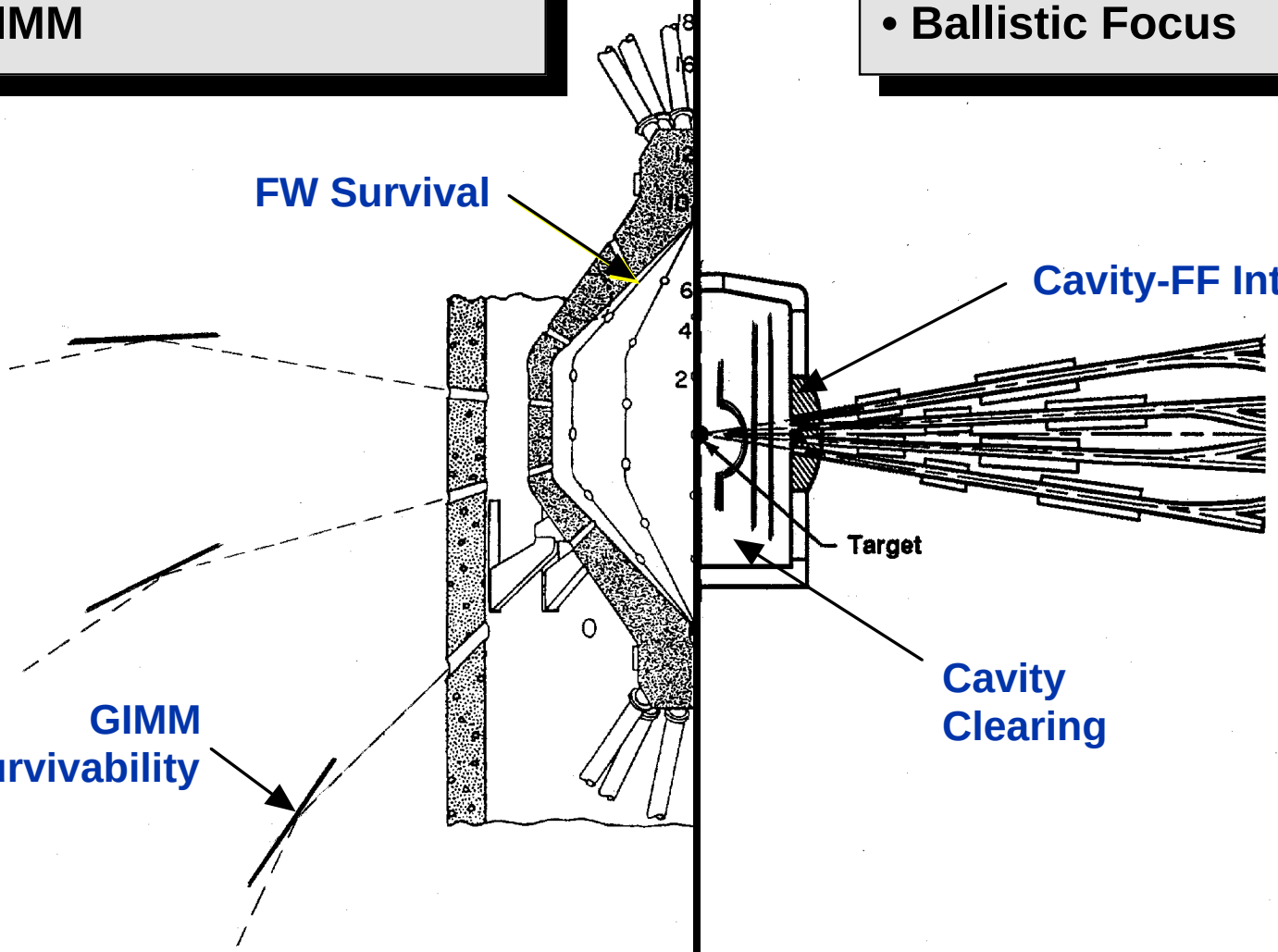
Critical IFE Chamber Technology Issues

Lasers

- **Direct Drive**
- **Dry Wall/Gas Protection**
- **GIMM**

Ions

- **Indirect Drive**
- **Liquid Metal FW Protection**
- **Ballistic Focus**



The Driver and Conventional Power Conversion Equipment Dominate the Capital Cost of IFE Power Plants

Example

	% of Total Capital Cost in Category				
	Driver	Chamber	Bldgs.	Heat Transfer/ Turbine/Electric	Other
SOMBRERO	31	9	15	34	11
OSIRIS	37	8	9	34	12

Conclusion: Highest leverage is gained through the driver. The cost of the chamber is only of secondary importance with respect to the capital cost.

What a Difference a Decade Makes!

	Situation in 1990	**Situation Today**
Target Design & Output	Plastic Ablator & Legislated	Foam with High Z Detailed Implosion-Explosion Calc.
Target Heating	T≈ 10 °K	T≈ 0.5 °K
Chamber Protection	Simple Untested Opacities	SOA Opacities
Chamber FW & Structure	C-C Weaves, Assumed Properties	C-C, SiC? Measured HT Irradiated properties
Neutronics	Pulsed (DKR-ICF) Rad. Dam.(1-D TDA)	Pulsed (ALARA) Rad. Dam.(3D-MCNP)
Breeding Material	Solid Breeders	Solid Breeders (erosion, attrition?)
Tritium Inventory	Solubility **Dominated**	Irradiation Traps
Coolant	Solid Particles/He	Same?

Major Conclusions

- **Target injection and survival has become a major issue in all IFE reactor designs.**

- **Cavity clearing rates and liquid jet stability are still a major issue in liquid metal/salt protected ion driven IFE reactors.**

- **Neutron radiation damage issues for all IFE reactor designs are still unsolved (same conclusion for MFE reactors designs).**

- **Capital costs of IFE drivers must be reduced if moderate sized power plants are ever to be economically attractive.**