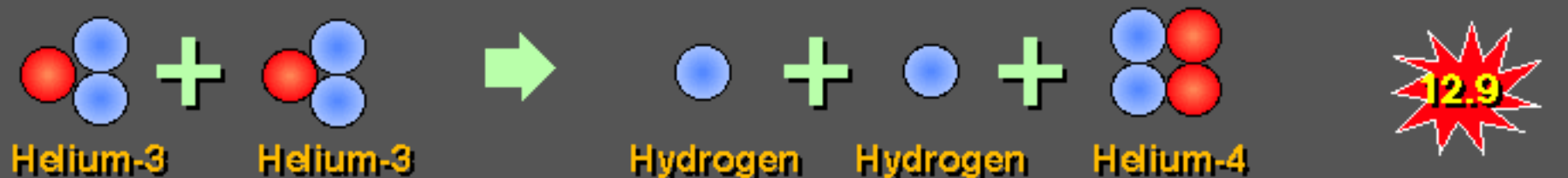
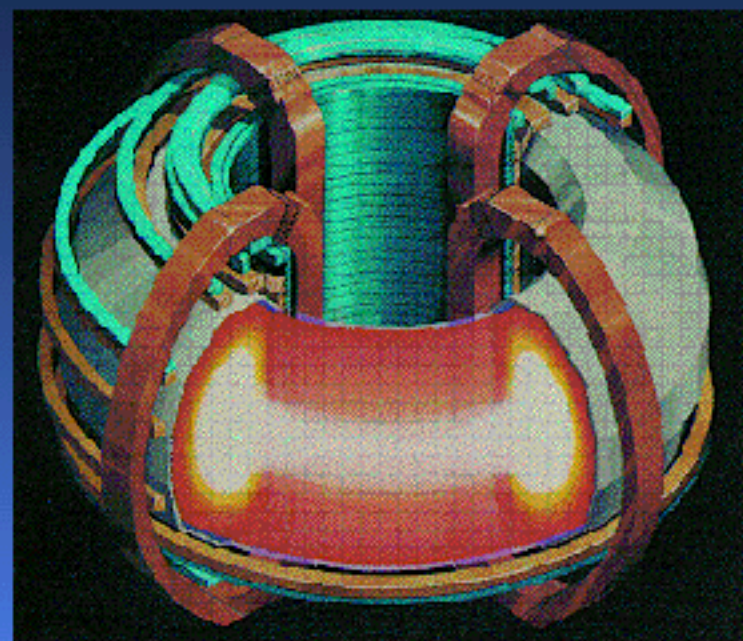
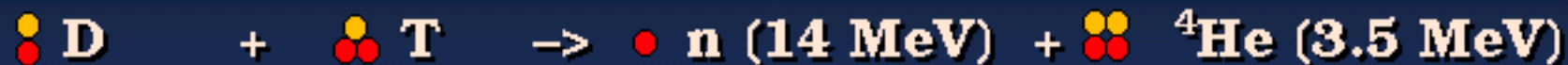


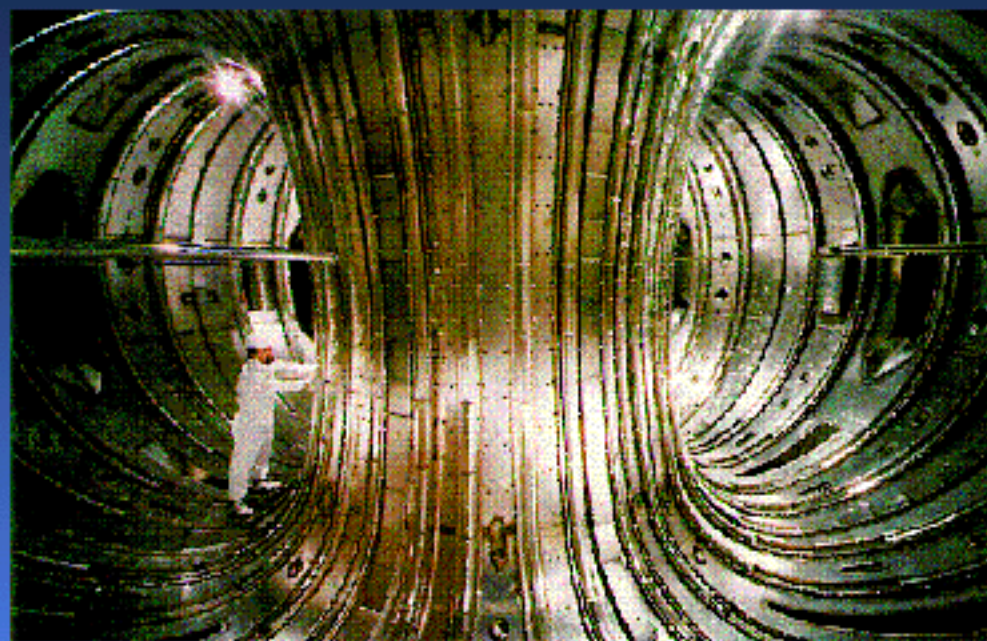
Fusion Fuel Cycles



The Tokamak is the Leading Magnetic Fusion Concept for the DT Fuel Cycle



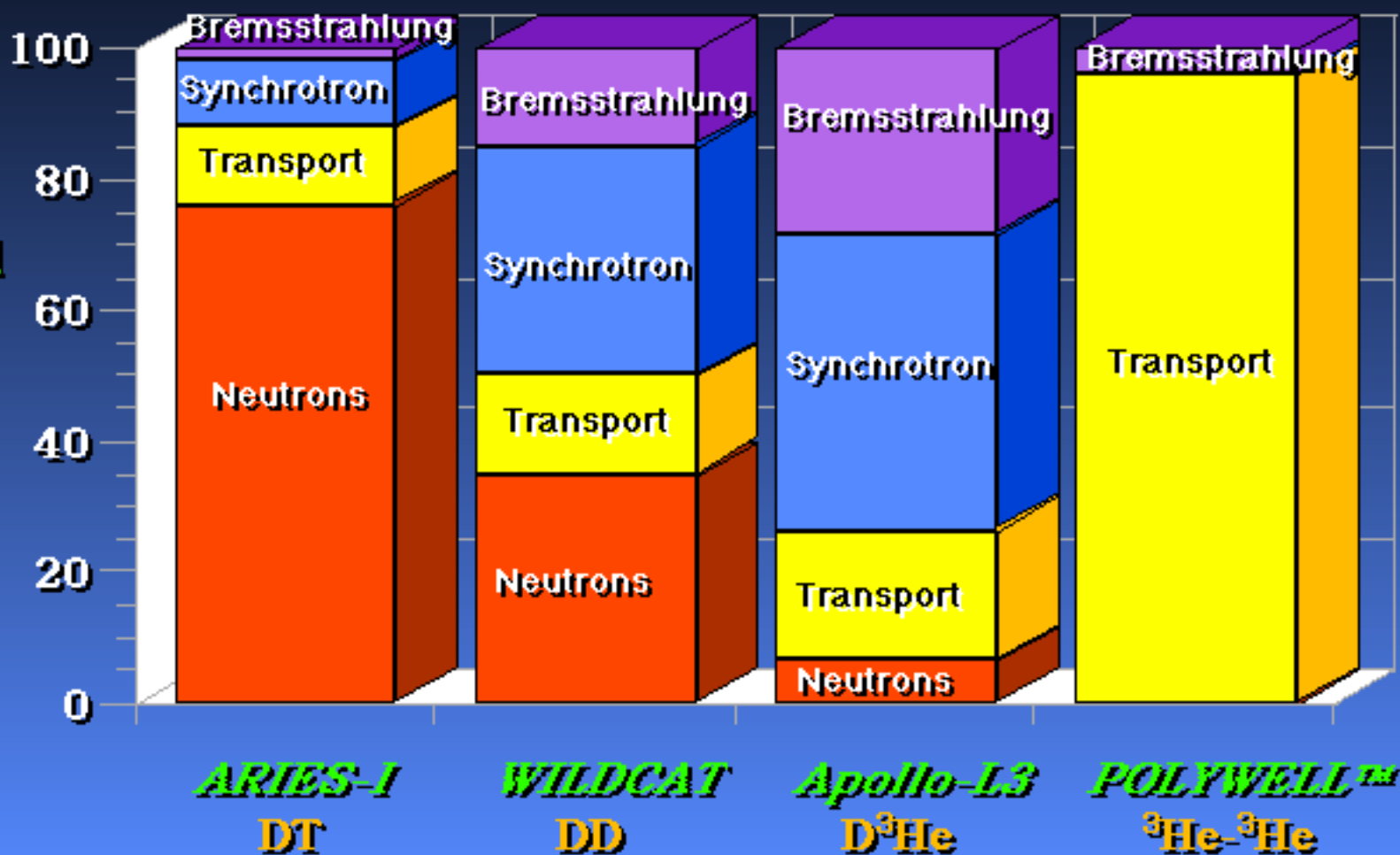
Schematic of a Tokamak



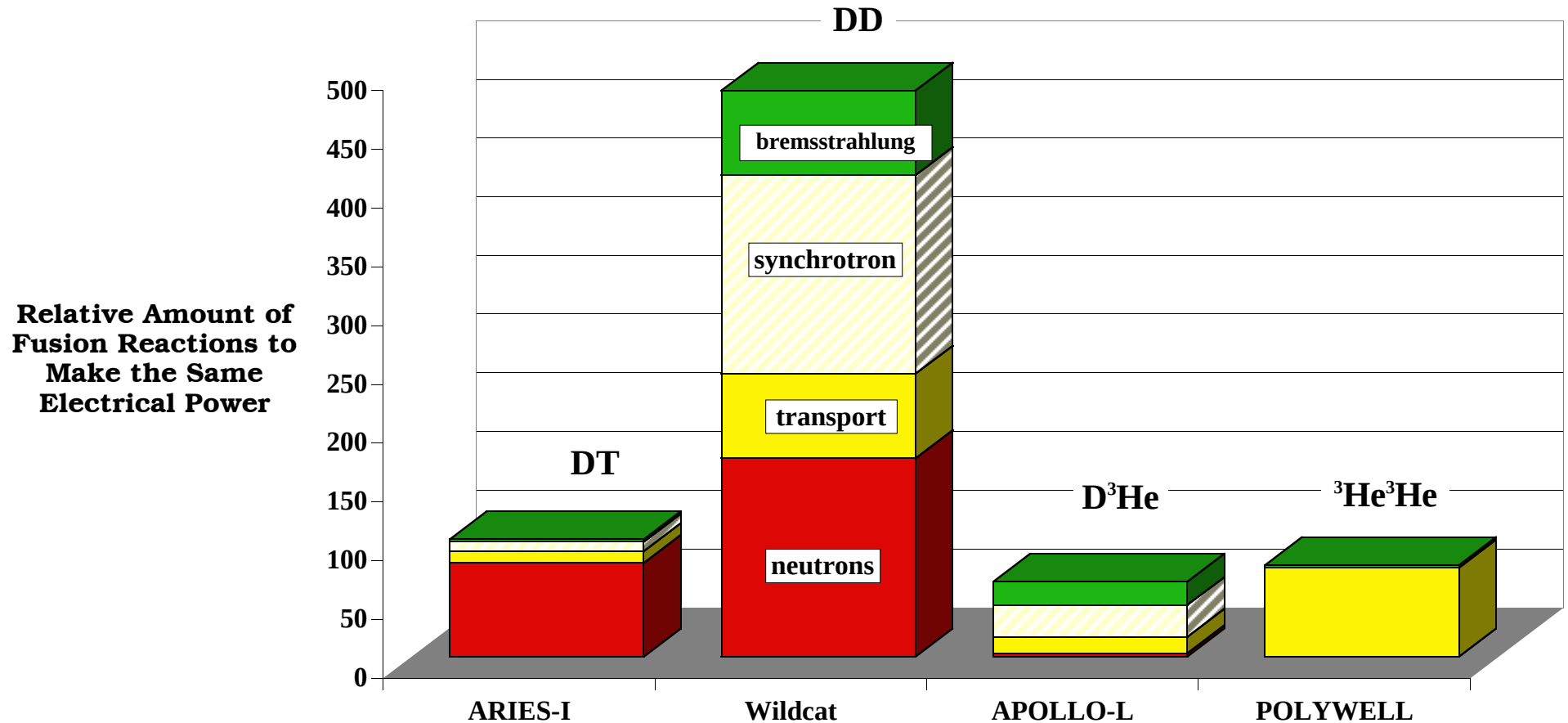
Joint European Torus – JET
~ 40 MW

The Form of Energy Release is Quite Different in DT, DD, D³He and ³He-³He Fuel Cycles

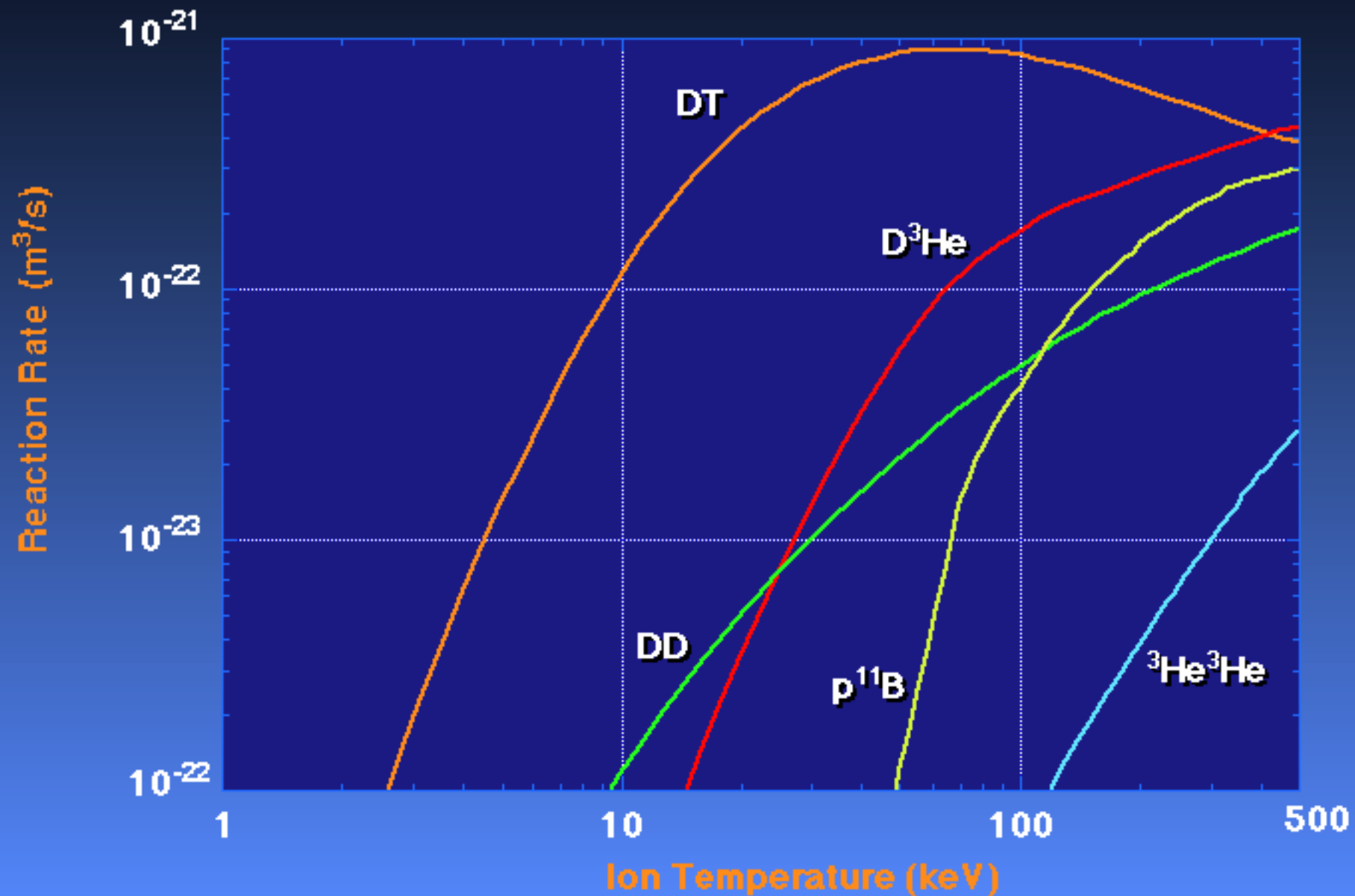
Fraction of Total Energy Released



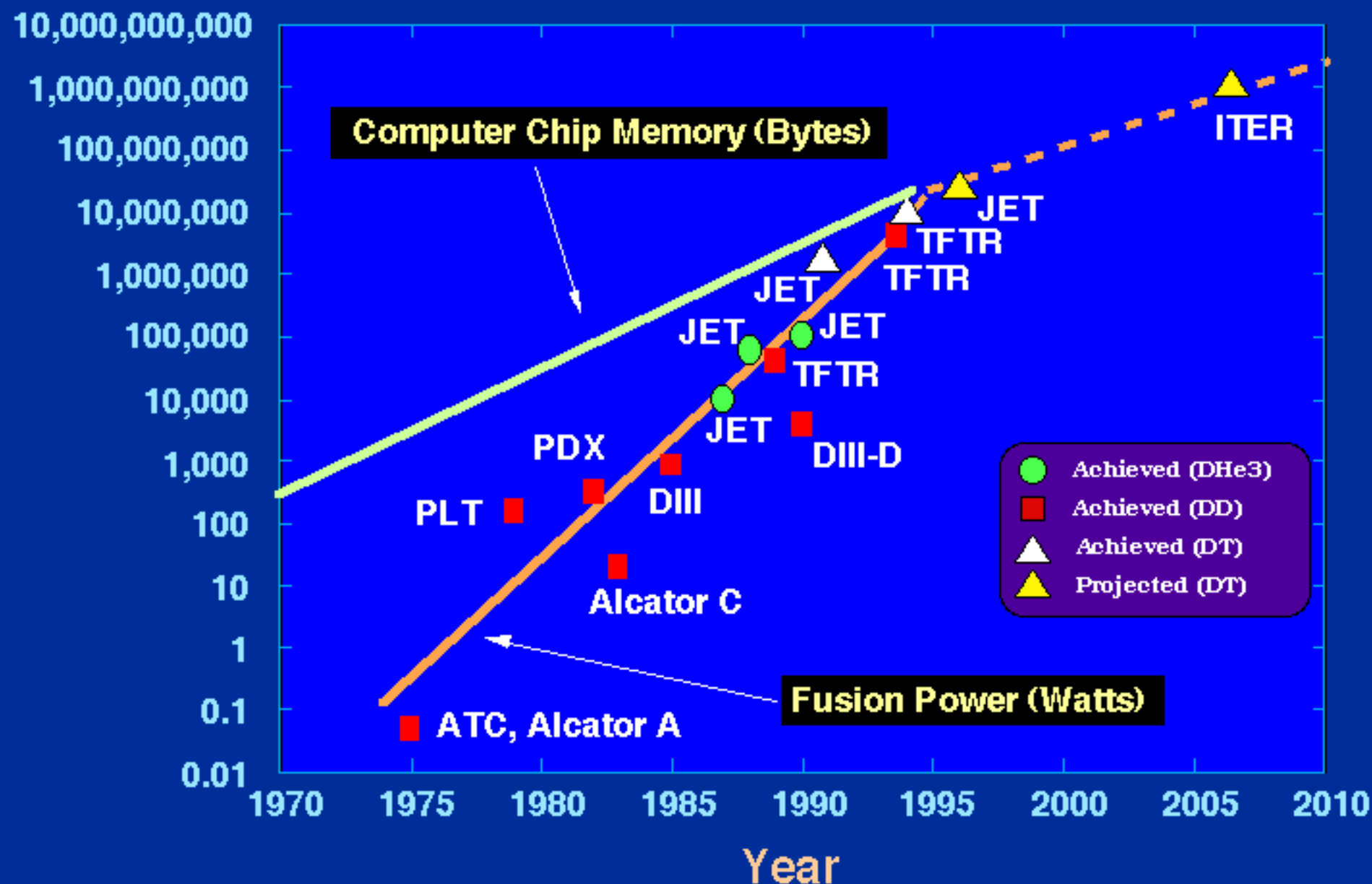
The Amount and Form of Energy Required to Make Fusion Power is Quite Dependent on the Fusion Fuel Cycle



Maxwellian Fusion Reaction Rates



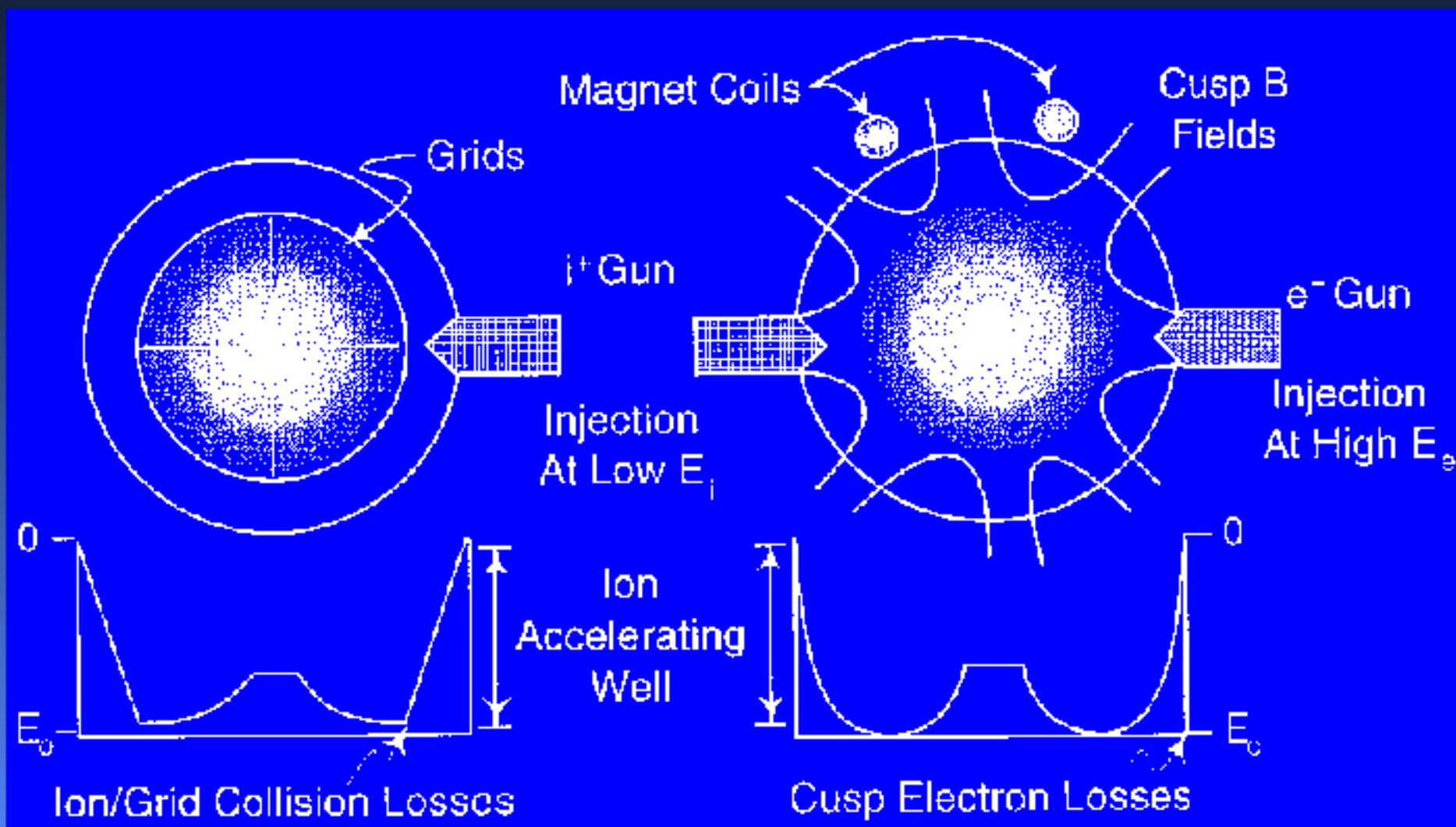
Magnetic Fusion Has Made Outstanding Progress During the Past 15 Years



There Are 2 Basic Approaches to IEF

Purely Electrostatic

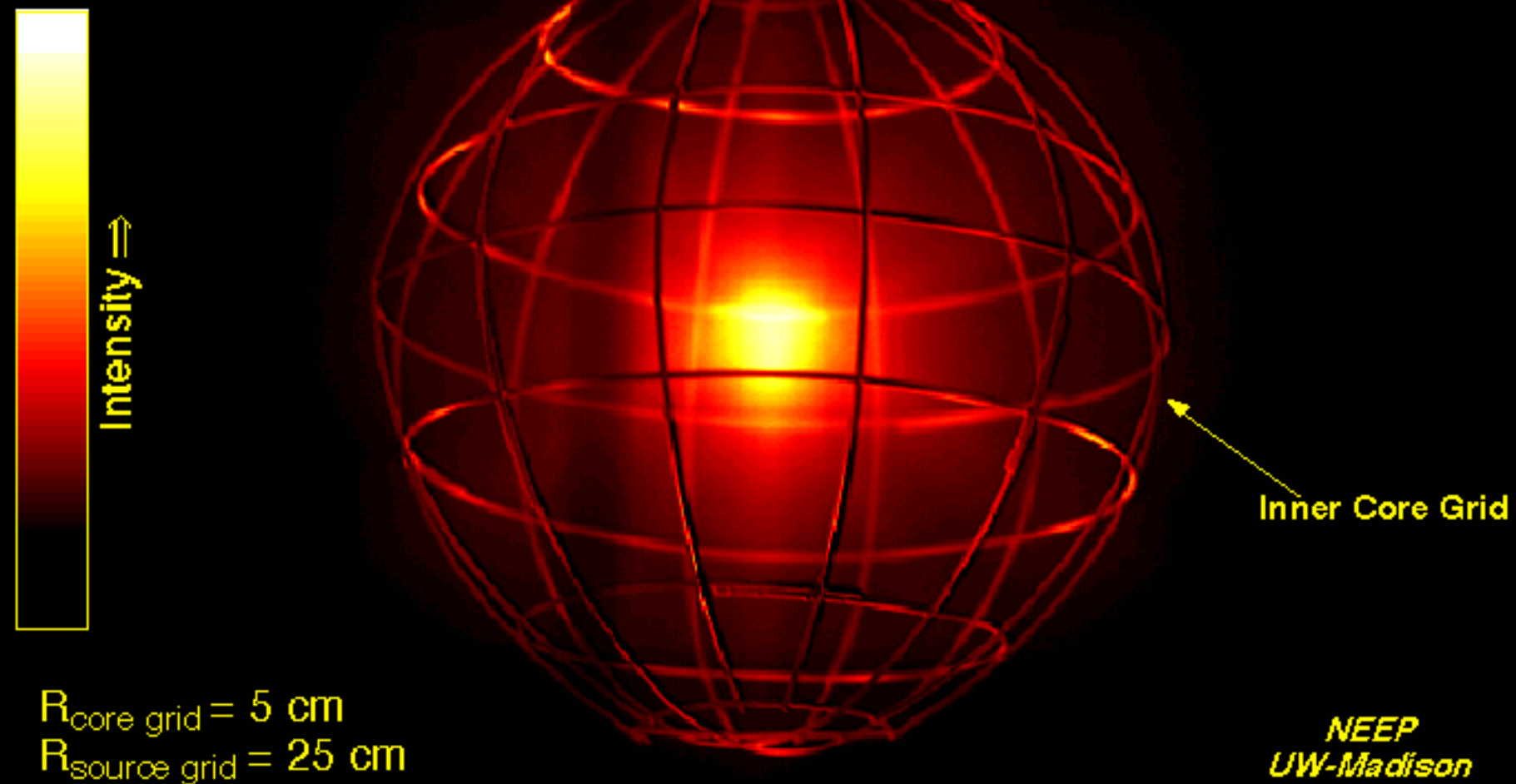
Virtual Cathodes (Established by Excess Electrons)



Spherically Convergent Ion Focus Experiment

Converged Core
 H_{α} filtered

18 kV bias
 $P_H \approx 2 \times 10^{-4}$ torr
Source Plasma ON



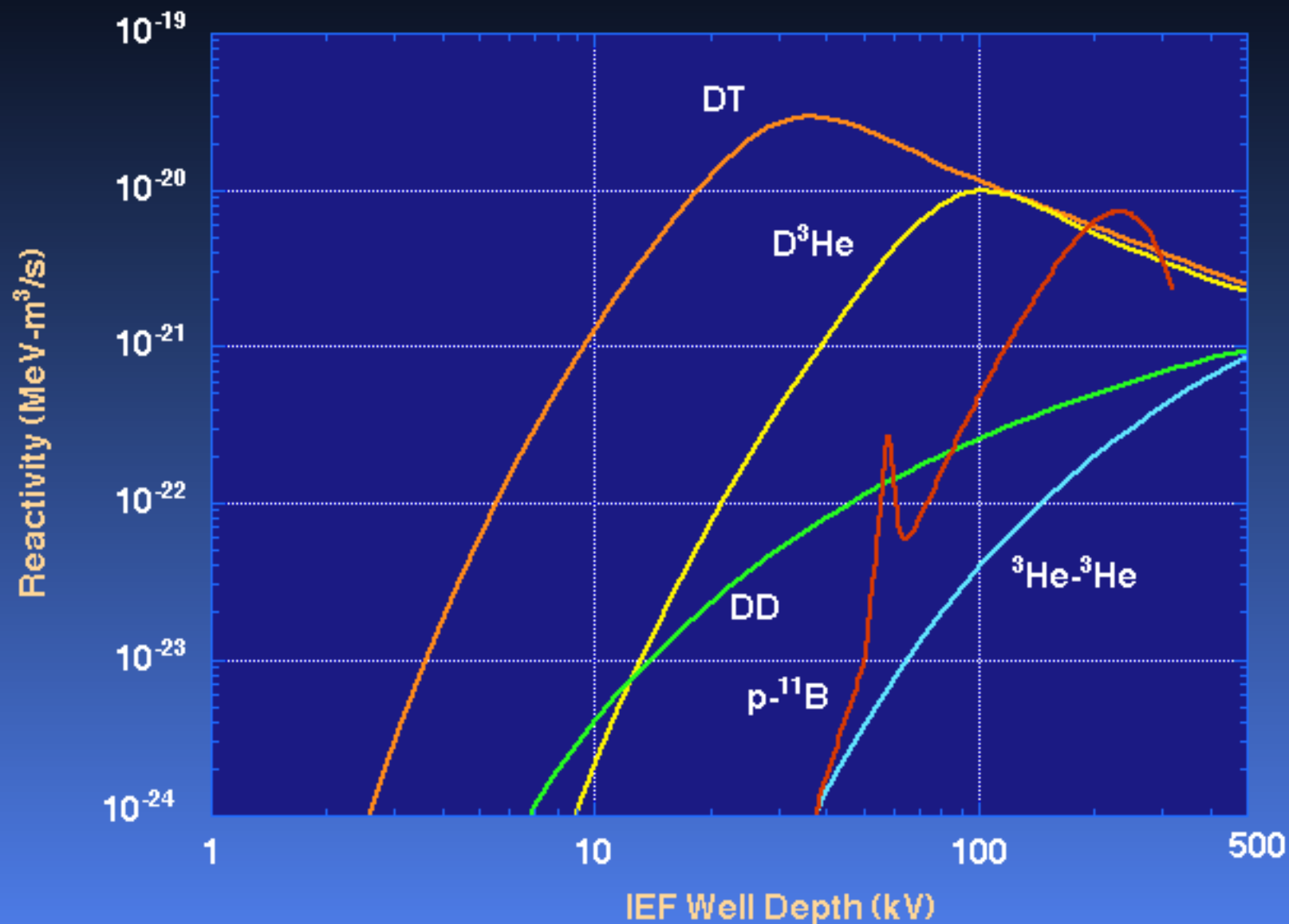
Intensity

Midplane Intensity Profile :

HWHM $\approx 0.9 \text{ cm}$

Δr

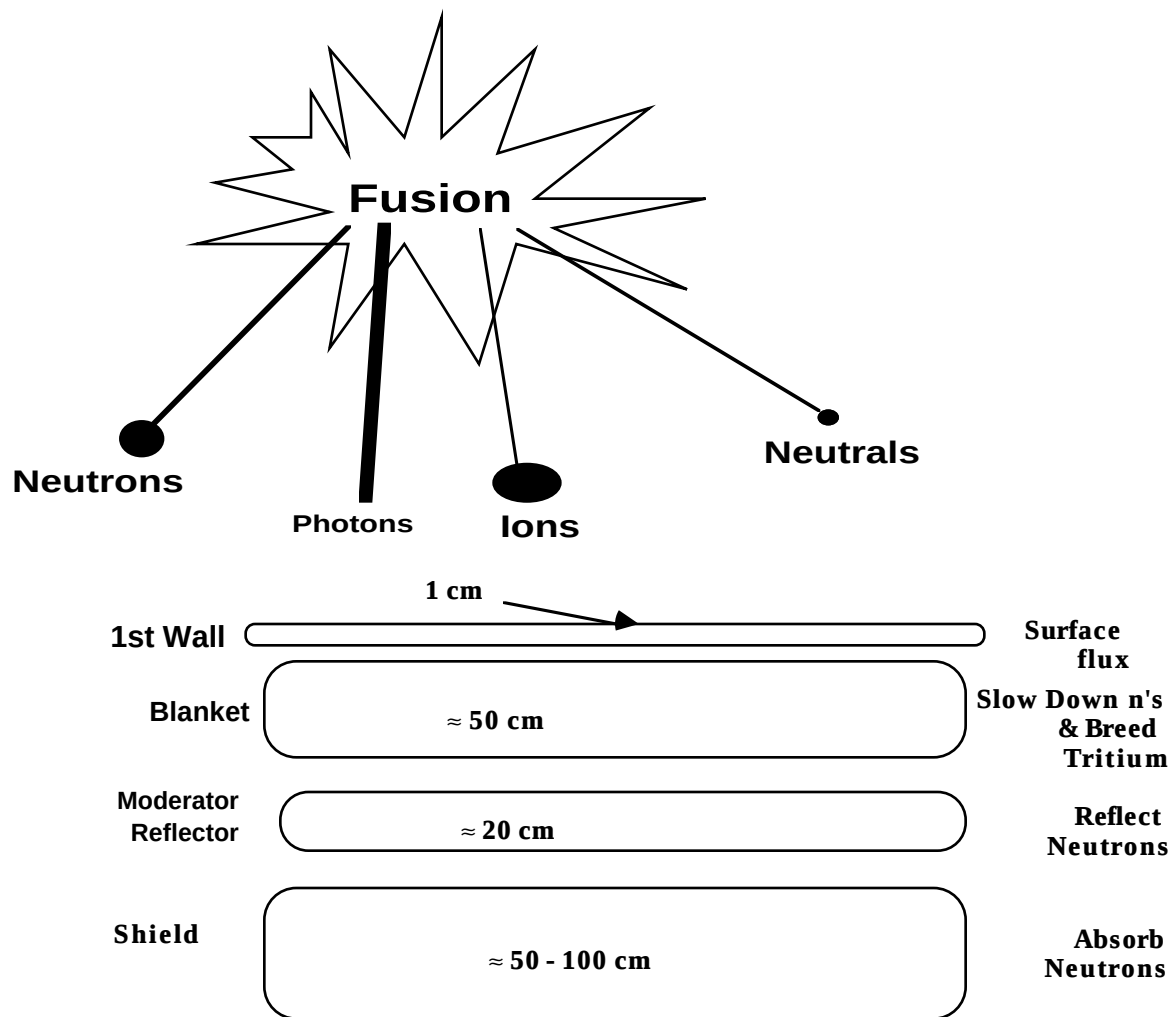
Reactivities ($\Sigma E_{\text{fus}} \sigma v$) versus IEF Well Depth



Blanket and Shield Design

Objective: *To convert TN heat into useful energy, i.e.,*

**Steam
Fissile Fuel
Synthetic Fuel
Electricity (directly)**



Chamber Pressure

Magnetic $\approx 10^{-5}$ torr

Laser ≈ 1 torr

HIB $\approx 10^{-4}$ torr

LIB $\approx 1-100$ torr

What Kind of Materials are in Fusion Reactors?

Chamber Gas He, Ne, Xe

Blankets

Structure Steel, V, SiC, C, Ti Alloys

Breeder Li, Li₂O, LiAlO₂, Pb-Li.
H₂O +LiOH

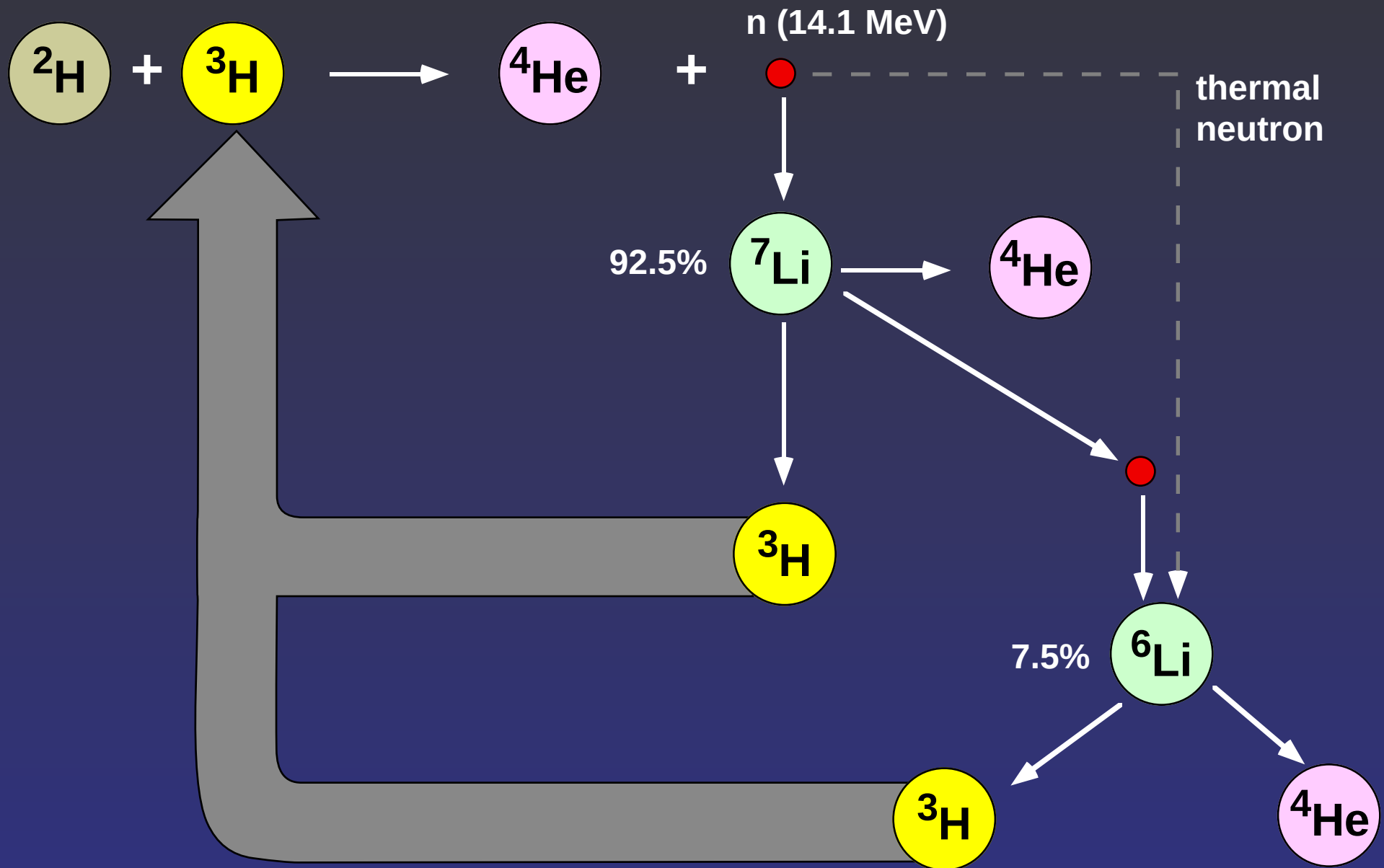
Coolants H₂O, Li, He, Pb-Li, Li₂O

n Multipliers Be, Pb, Zr

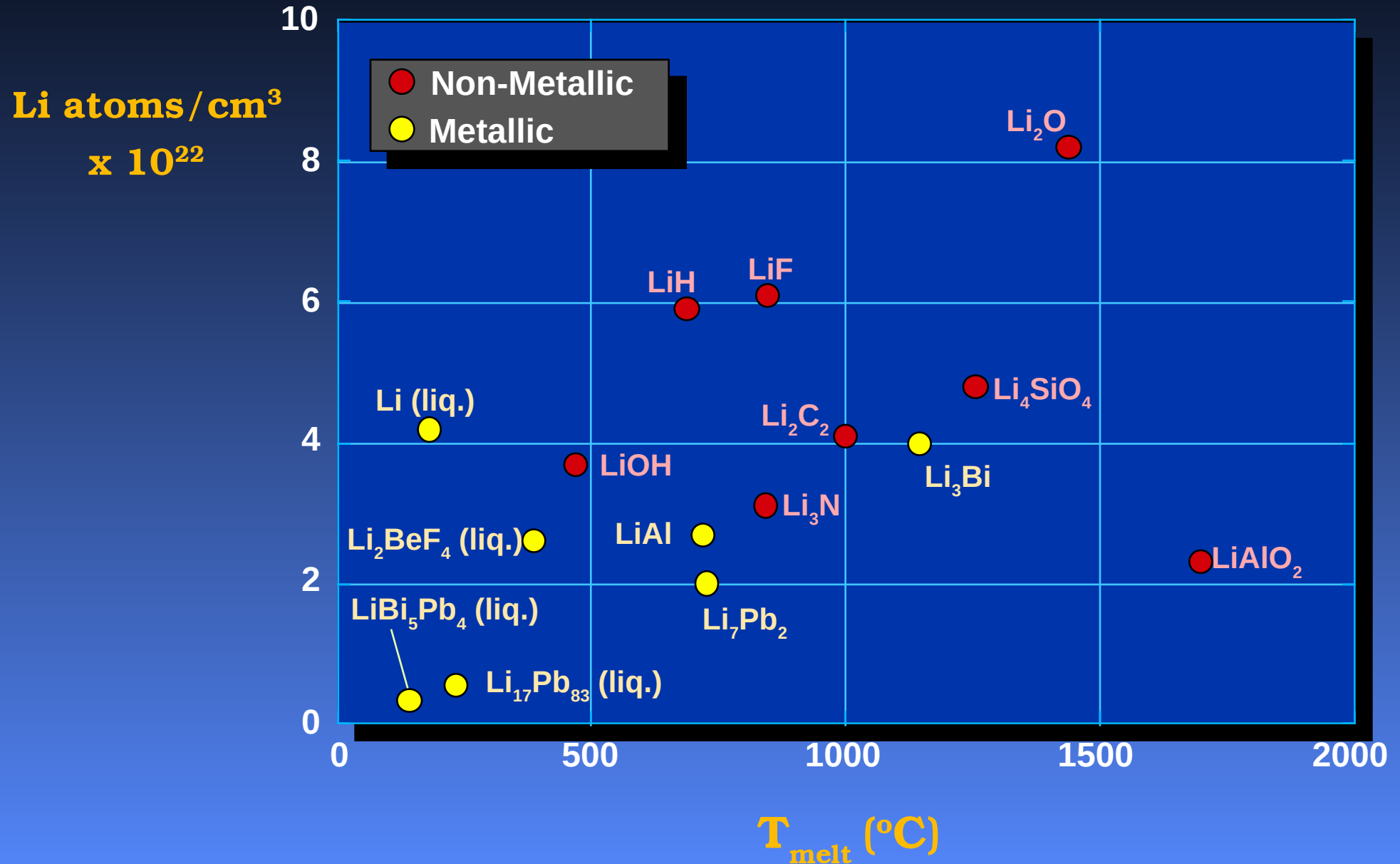
Moderator/Reflector Steel, C

Shield Steel, B, Pb, W, Concrete

The DT Fusion Cycle Uses D and Li Fuels



Potential Lithium Containing Materials That Could Be Used to Breed Tritium



Information Summary of Candidate Breeder Materials

	Li(liquid)	LiPb ₄ (liq)	LiBi ₅ Pb ₄ (liq)	Li ₇ Pb ₂ (s)	LiAl(s)	Li ₂ O(s)	LiAlO ₂ (s)	LiOH(liq)
Materials Data Base	Good	Poor	Zero	Fair	Fair	Fair	Fair	Fair
MP °C	180	235	125	726	700	1440	1600	0
T _{min} °C	230	285	175	270	250	500	450	10
T _{max} °C	400	550	400	330	310	800	850	200
Reason for T _{max}	Corrosion	Corrosion	Corrosion	<-----Sintering----->				Corrosion
Breeding Capability	Good	Good	Good	Excellent	Poor	Good	Poor	Good
Steady Tritium recovery	Excellent	Excellent	Excellent	Poor	Poor	Poor	Fair	Excellent
Reactor Relevant	Very Good	Very Good	Very Good	poor	Poor	?	?	Poor
Chemical Reactivity	Bad	Fair	Fair	Poor	Poor	Hygroscopic	Best	Best

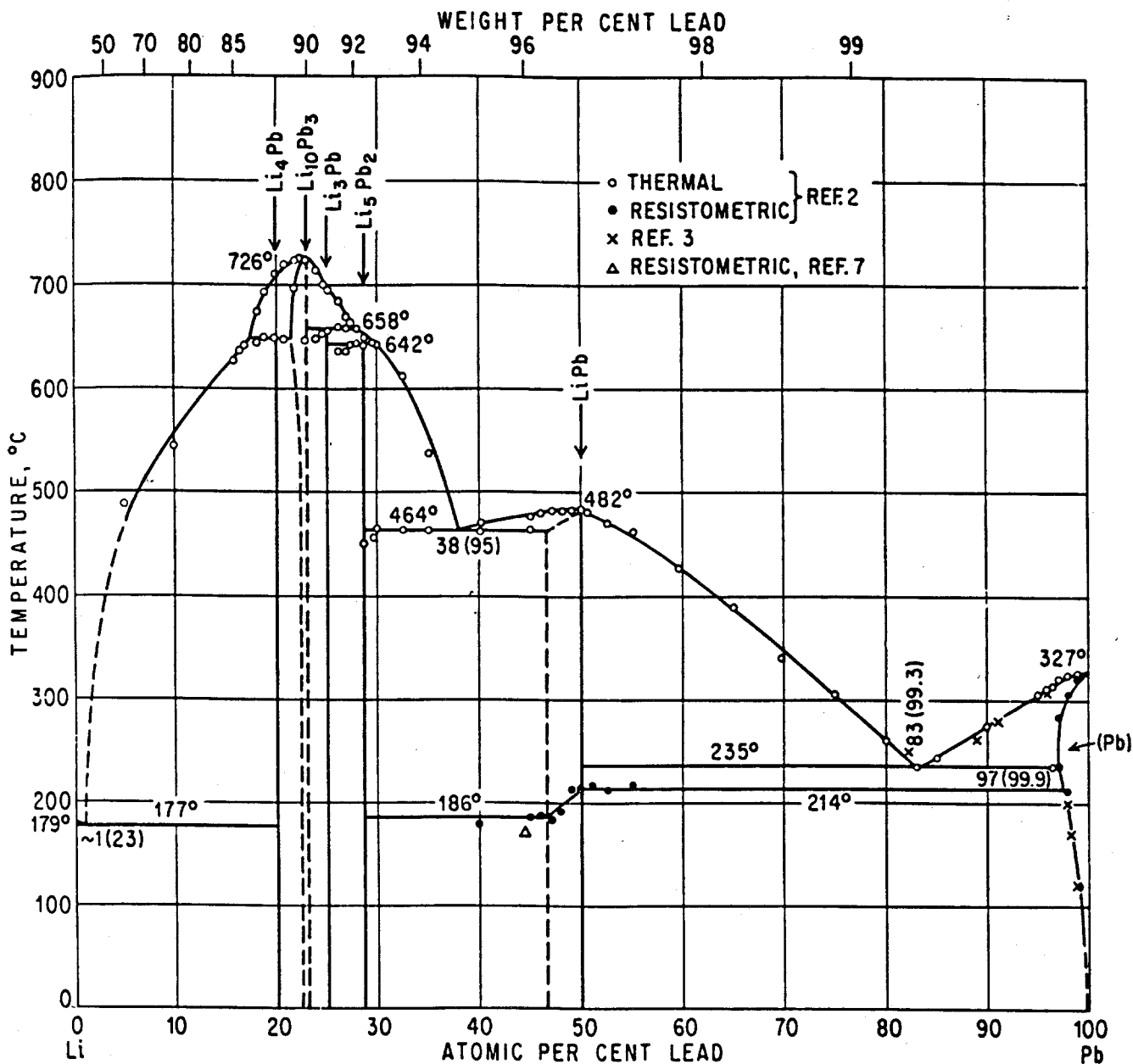
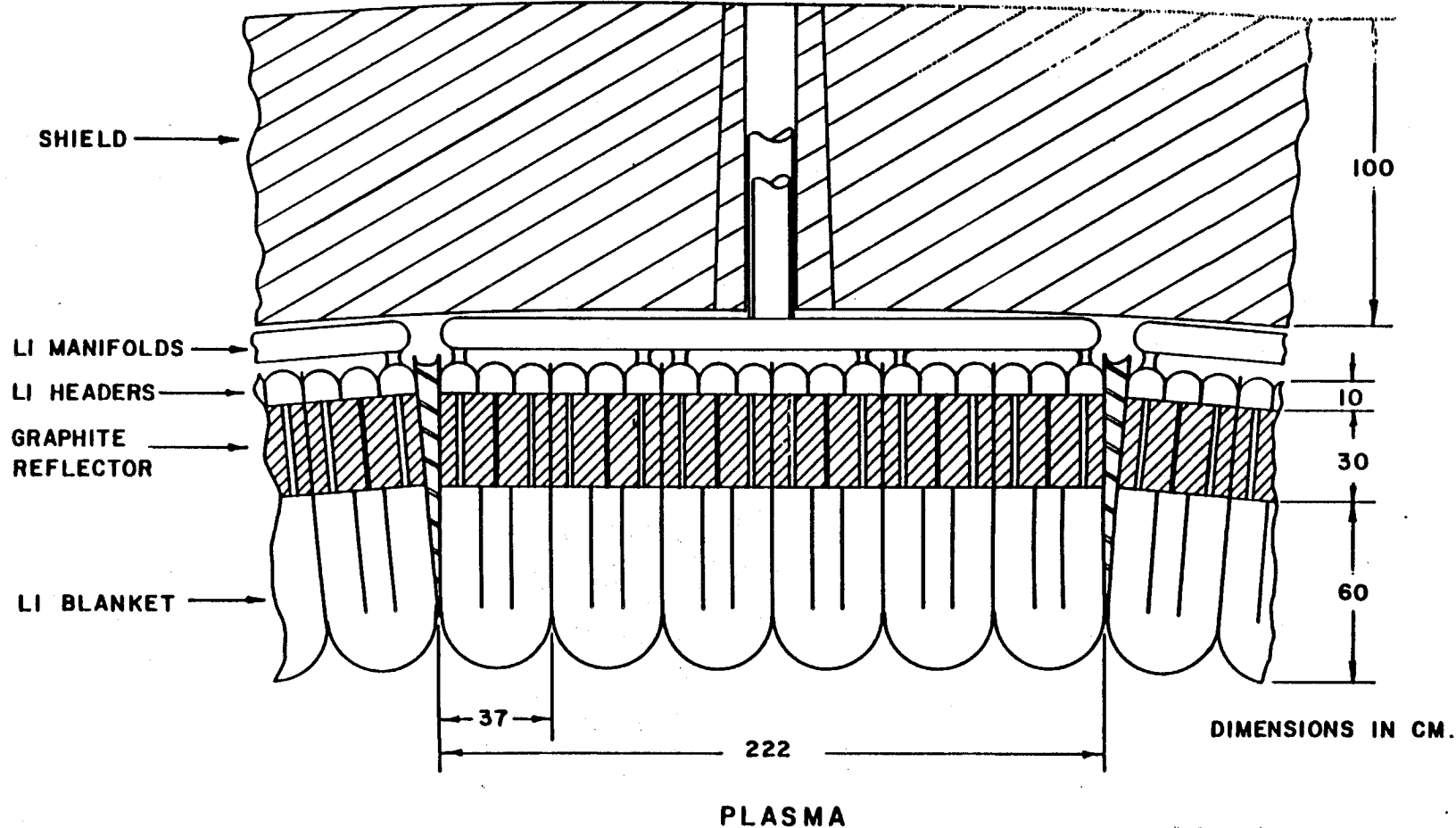


Fig. 497. Li-Pb. (See also Note Added in Proof.)

An Old Example of a Li Self-Cooled Blanket – UWMAK-III, 1976



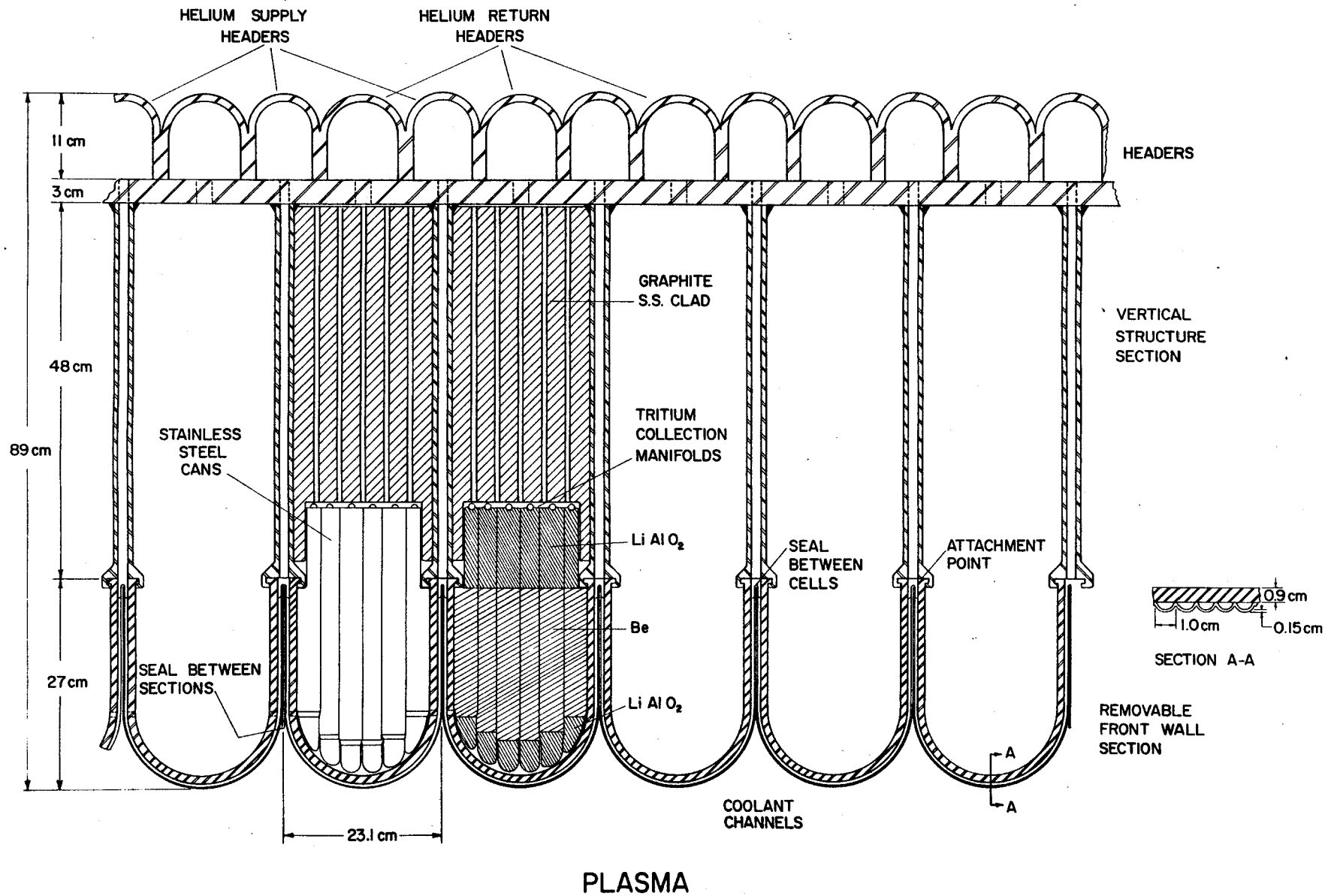
Structure: TZM

Breeder: Li

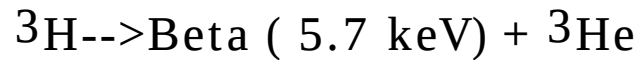
Coolant: Li

Reflector: C

BLANKET SECTION FOR UWMAK - II



Tritium Decay



$$t_{1/2} = 12.35 \text{ y} \qquad 5.6\% \text{ y}^{-1}$$

Tritium Costs

Activity = 10,000 Ci/g

Cost $\approx$ \$ 30,000/g 30\$B/tonne

Biological Effects

- Biological half life $\approx$ 10 days
- Ingested Dose 1 Ci $\approx$ 70 mrem
- Maximum Permissible Body Burden $\approx$ 1 mCi
- Oxide forms (HTO, T₂O) greater hazard than gaseous forms

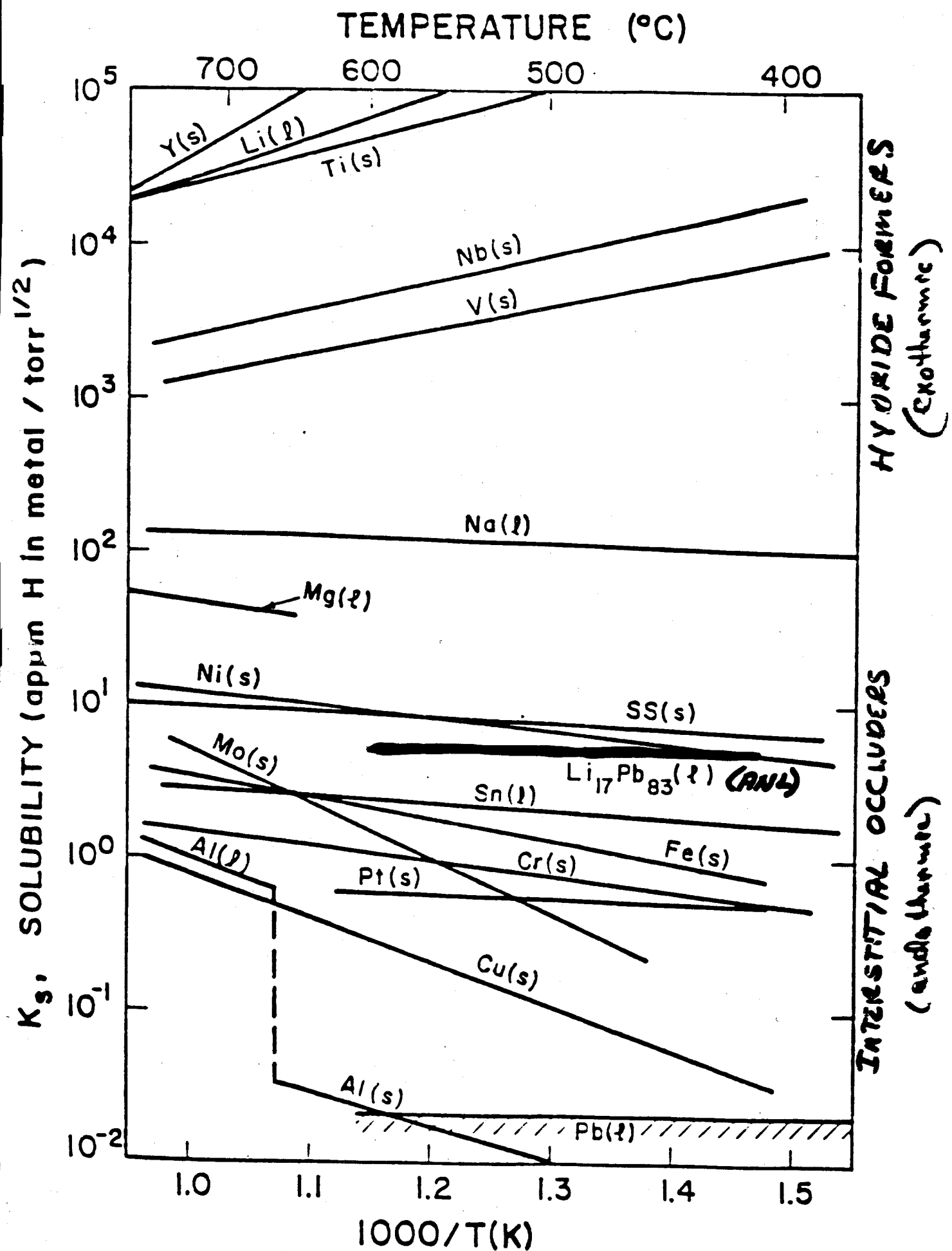


Figure VI.5-1

THE SOLUBILITY OF HYDROGEN IN SELECTED METALS AND ALLOYS
AS A FUNCTION OF TEMPERATURE.

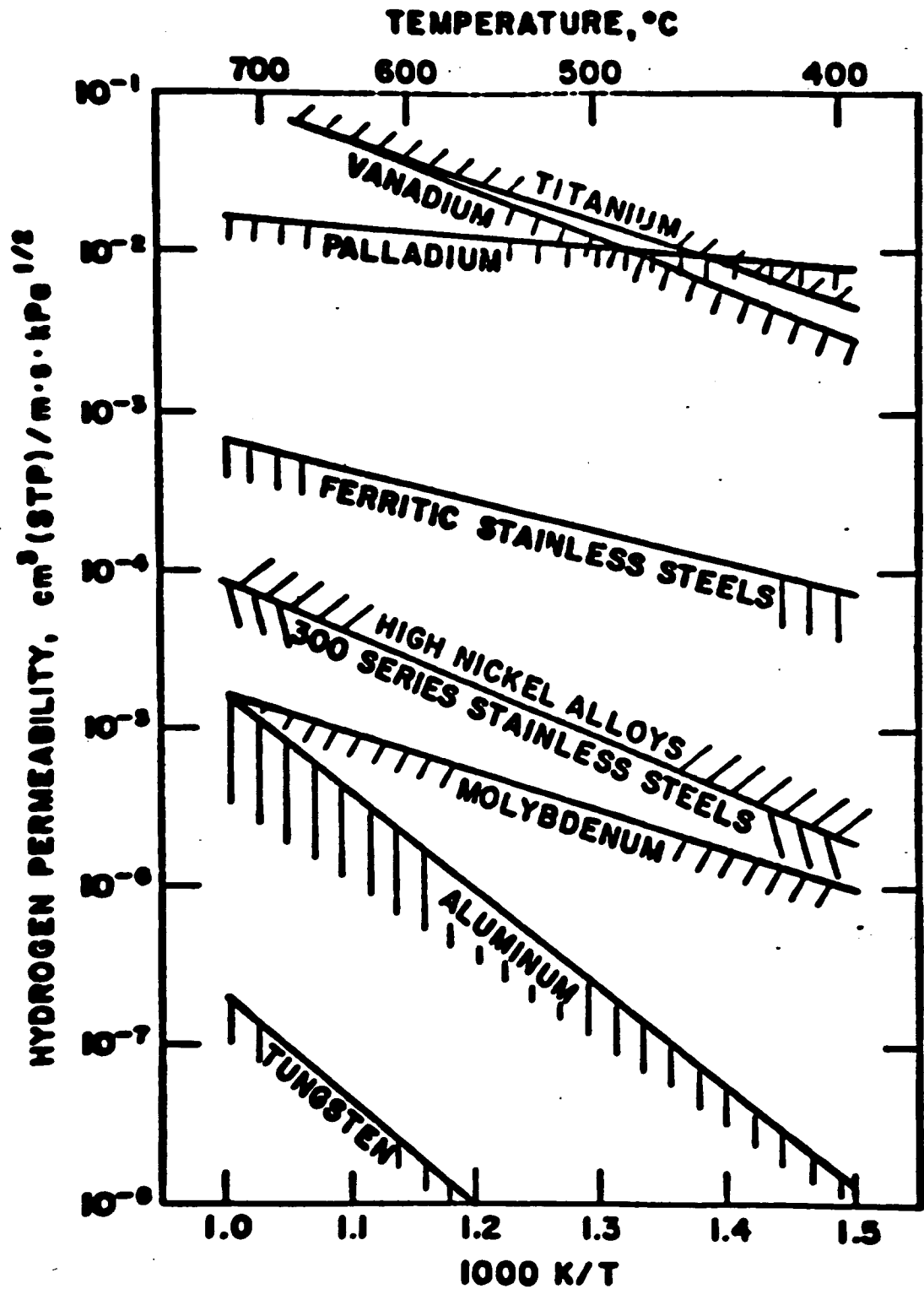


Figure 1. Hydrogen permeability curves for selected metals and alloys.

Radiological Hazards of Pu and T2 in a 1 GWePower Plant			
	<u>Units</u>	<u>Plutonium</u>	<u>Tritium</u>
Inv. Outside Blanket	kg	900	25
Annual Flow Outside Blk.	kg/y	1600	32 (BR=1.25)
MPC (air)			
Insoluble ²³⁹Pu, HT or T₂ gas	Ci/km³	0.001	40,000
Sol. ²³⁹Pu, HTO vapor	Ci/km³	0.0006	200
BHP (air)			
Pure ²³⁹Pu, T₂	km³/g	63 to 1,000	0.25
Reactor Pu*, T in HTO	km³/g	300 to 5,000	50
BHP (air)/GWe• y			
Insoluble Pu, T₂	million km³/y	450	0.008
Soluble Pu, HTO	million km³/y	7,500	1.6
BHP (air) /GWe			
Insoluble Pu, T₂	million km³	270	0.006
Soluble Pu, HTO	million km³	4,500	1.25
MPC (water)	Ci/km³	5,000	3,000,000
BHP (water)			
Pure ²³⁹Pu in Soluble Compound	m³/g	12,500	
Reactor Pu* in Soluble Compound	m³/g	62,500	
Pure Tritium in HTO	m³/g		3,300,000
BHP/GWe•y	km³ water/y	94	110
BHP/GWe	km³ water	56	83

* ²³⁸Pu, ²³⁹Pu, ²⁴⁰Pu, ²⁴¹Pu, ²⁴²Pu