Neutronics Results for Liquid Metal Protected ICF Chambers and Extrapolation to Thick Liquid Metal Concepts in APEX

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LIBRA-SP
Self-Pinched Light Ion Beam Chamber
(1995)

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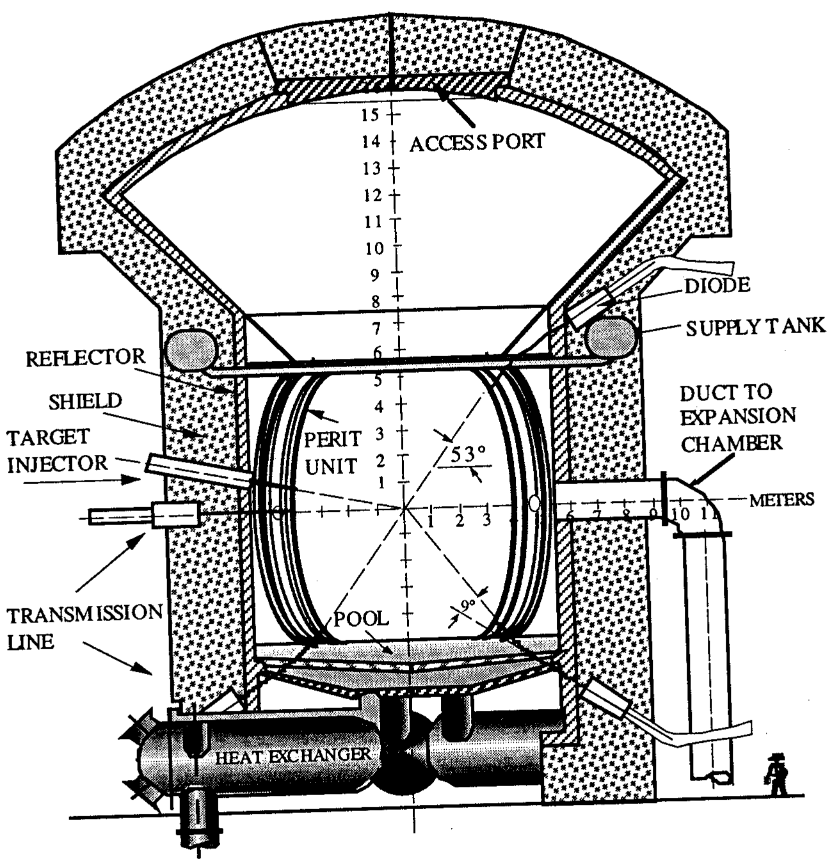

PERIT (PErforated RIgid Tubes) used for wall protection
0.5 PERIT packing fraction
PERIT tubes consist of 8% HT-9 and 92% $Li_{17}Pb_{83}$

Neutronics for LIBRA-SP Chamber

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Chamber wall radius	5.2 m
Inner radius of blanket	4 m
Neutron wall loading	7.4
% Li6	90
TBR	1.48
M	1.182
PERIT dpa/FPY	94
PERIT He appm/FPY	436
PERIT He/dpa	4.64
Chamber dpa/FPY	4.2
Chamber He appm/FPY	0.9
Chamber He/dpa	0.21

Relative Attenuation in Thick Liquid Metal Region

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- Variation of structure dpa and He production with liquid metal protection thickness was used to determine the e-fold distance for Li, $Li_{17}Pb_{83}$, and Flibe

	Structure dpa		Structure He Prod.	
	e-fold	10-fold	e-fold	10-fold
Li (nat. Li)	22.4 cm	52 cm	18.7 cm	43 cm
Li (90% Li6)	20 cm	46 cm	18.4 cm	42 cm
LiPb (nat. Li)	19.7 cm	45.3 cm	8.7 cm	20.1 cm
LiPb (90% Li6)	16.3 cm	37.5 cm	8.7 cm	20 cm
Flibe (nat. Li)	13.4 cm	31 cm	13 cm	30 cm
Flibe (90% Li6)	12.7 cm	29.4 cm	12.3 cm	28.3 cm

- The e-fold for He production is not sensitive to enrichment while the e-fold for dpa decreases with increasing enrichment

- Flibe is the best for dpa attenuation

- LiPb is the best for He production attenuation

- Li is the worst for attenuating structure dpa and He production

- Some second order corrections due to geometrical and spectral differences in ICF and MCF systems are expected

Estimate of Required Liquid Metal Thickness for Structure and VV Protection

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- The e-fold distances for each material and response were used to determine how much thickness is needed for the steel structure to be lifetime component (assuming 200 dpa limit in 30 FPY) and for VV to be reweldable (1 He appm in 30 FPY)

- A neutron wall loading of 7 MW/m^2 is assumed at the front surface of the liquid metal

- For steel structure to be lifetime component required thicknesses of liquid metal in front of it are as follows

Li (nat.)	60 cm
Li (90% Li6)	54 cm
LiPb (nat.)	53 cm
LiPb (90% Li6)	44 cm
Flibe (nat. Li)	36 cm
Flibe (90% Li6)	35 cm

- For VV reweldability required thicknesses of liquid metal in front of it are as follows

Li (nat.)	189 cm
Li (90% Li6)	186 cm
LiPb (nat.)	88 cm
LiPb (90% Li6)	88 cm
Flibe (nat. Li)	131 cm
Flibe (90% Li6)	124 cm

OBJECTIVE

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- Liquid metal wall protection approach has been used extensively in inertial fusion chamber designs (HIBALL, HYLIFE, LIBRA, LIBRA-LiTE, LIBRA-SP) in the past 20 years

- Neutronics results will be summarized for several of these designs carried out at UW

- Results will be extrapolated to estimate amount of liquid metal needed for structure and VV in the thick liquid metal concepts considered in the APEX project

HIBALL
Heavy Ion Beam Driven Fusion Reactor
(1981)

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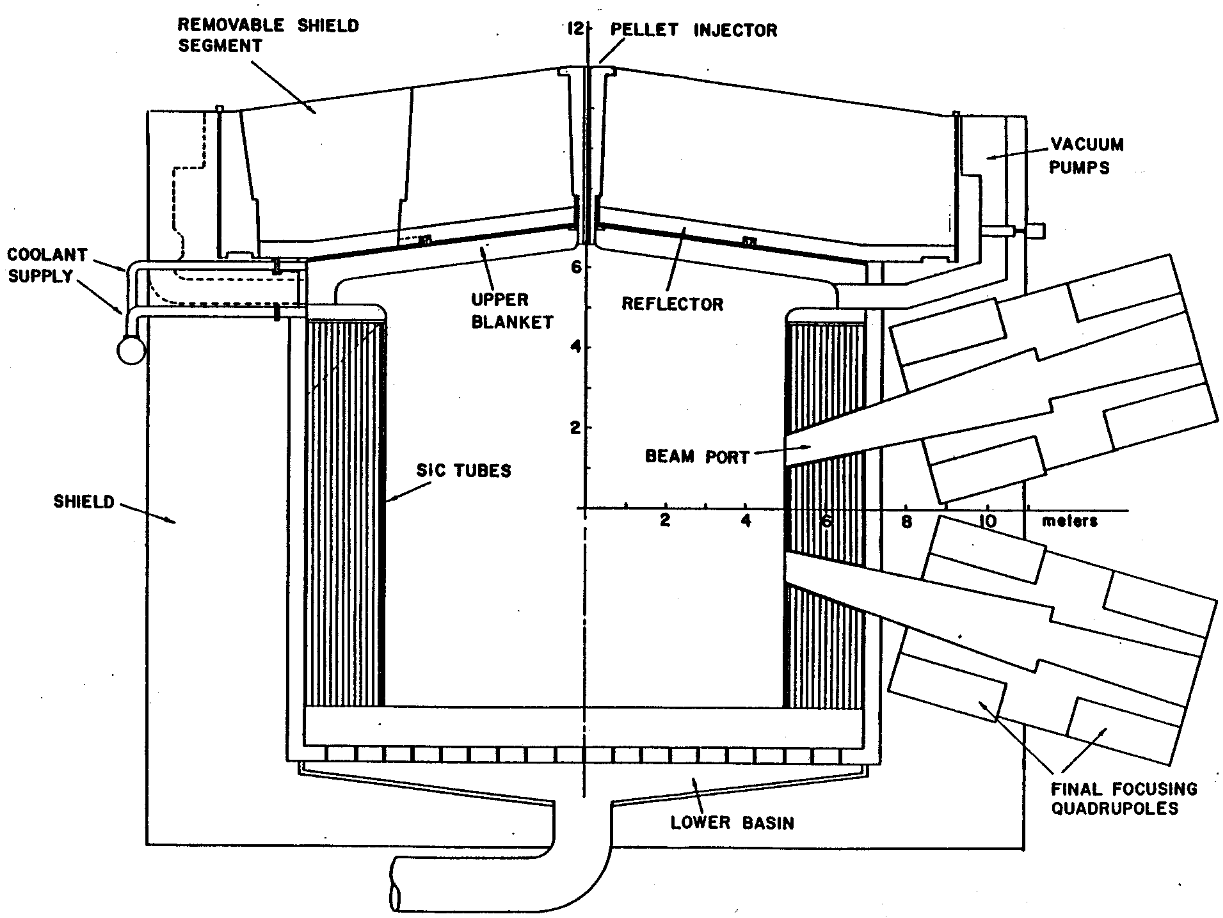

Wall Protection in HIBALL

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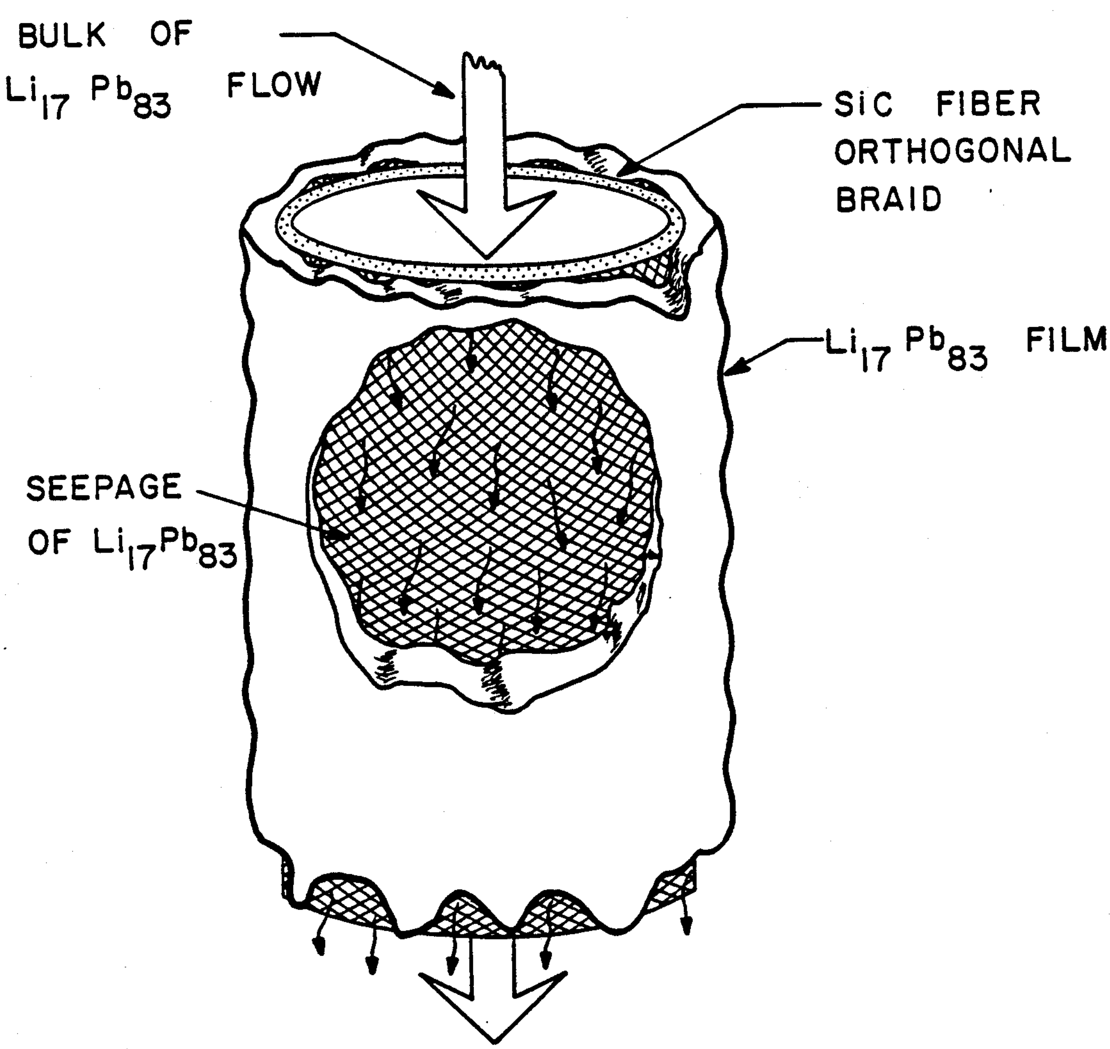
Ferritic steel chamber wall protected by a blanket made of flexible SiC porous INPORT (INhibited flow PORus Tubes) tubes in which $Li_{17}Pb_{83}$ flows

Tubes consist of 98% $Li_{17}Pb_{83}$ (natural Li) and 2% SiC

Packing fraction of tubes 33%



Significant Spectrum Softening Results From Wall Protection

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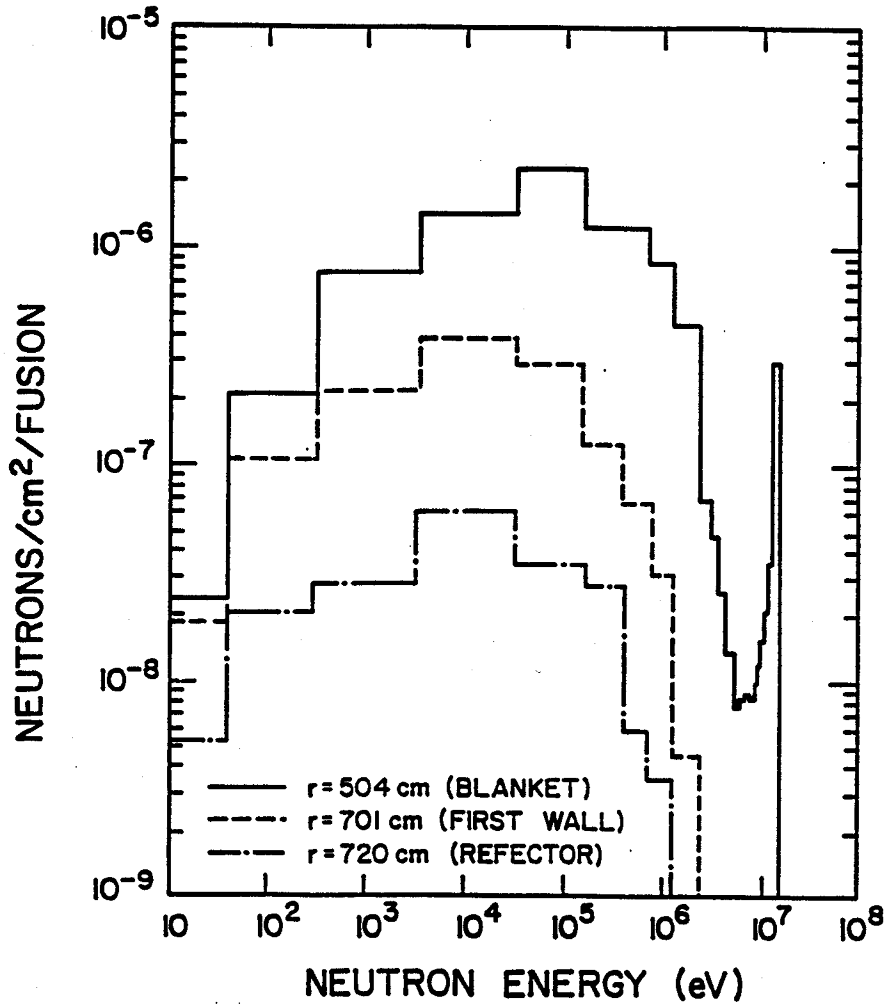

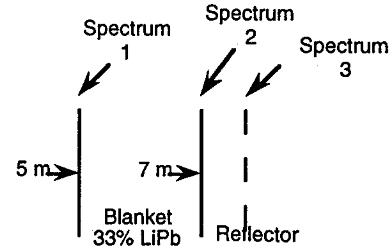

Effective LiPb thickness 66 cm
Natural Li in LiPb

He production in structure drops faster than dpa as liquid metal protection increases

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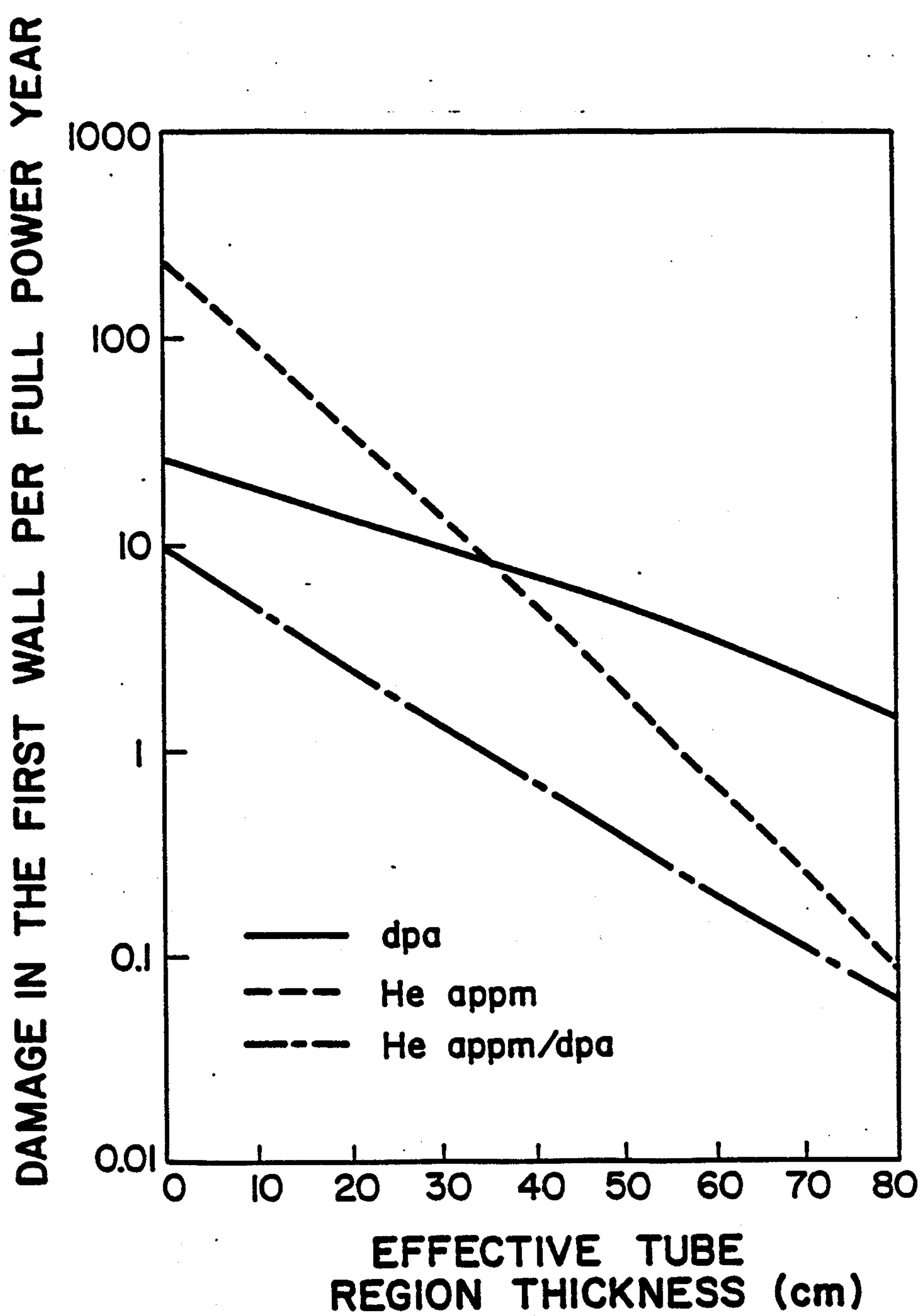
HIBALL
4.54 MW/m^2 wall loading



LIBRA-LiTE
Ballistic Focus Light Ion Beam Chamber
(1991)

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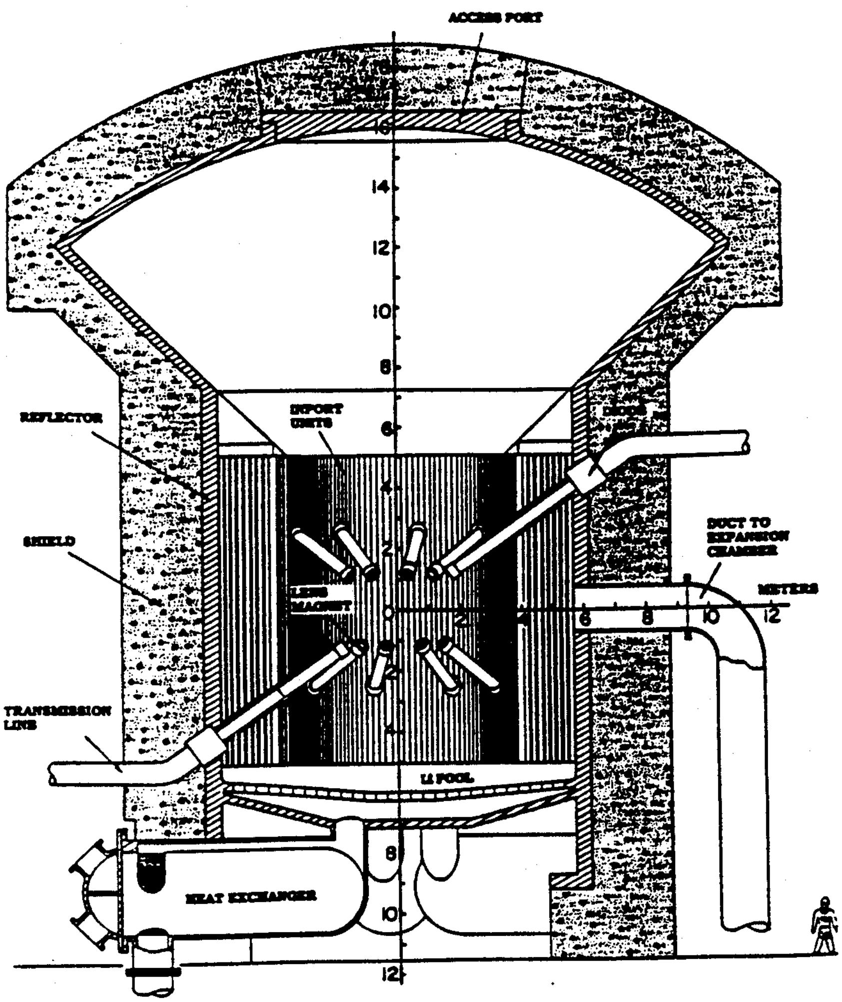

- Chamber radius= 5.7 m.
- INPORT tubes with 0.33 packing fraction. 2% HT-9 and 98% breeder in tubes.

TBR vs. dpa Rate for the Different Design Options (Li)

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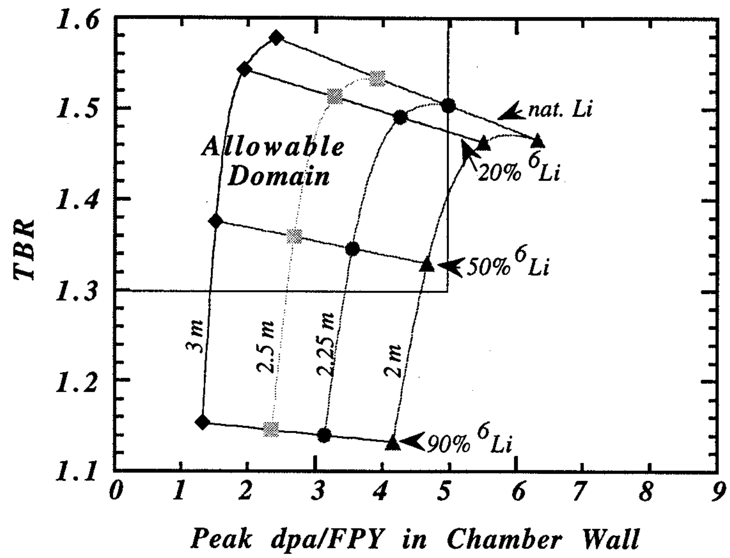

TBR vs. dpa Rate for the Different Design Options (LiPb)

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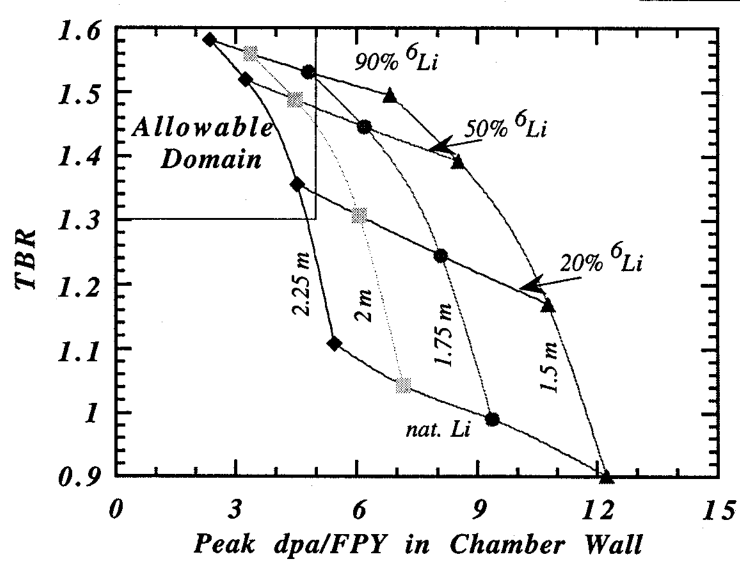

Neutronics Parameters for LiPb vs. Li

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	Li	LiPb
Chamber wall radius	5.7 m	5.7 m
Inner radius of blanket	3.45 m	4 m
Effective thickness	0.74 m	0.56 m
Neutron wall loading	13.6	10.1
% Li6	7.42	90
TBR	1.504	1.524
M	1.144	1.174
INPORT dpa/FPY	90	122
INPORT He appm/FPY	803	598
INPORT He/dpa	8.92	4.90
Chamber dpa/FPY	6.64	6.87
Chamber He appm/FPY	25	2
Chamber He/dpa	3.82	0.27