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Neutronics Parameters for Preferred Chamber Configuration with Magnetic Intervention

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Blanket Configuration

Top Blanket:

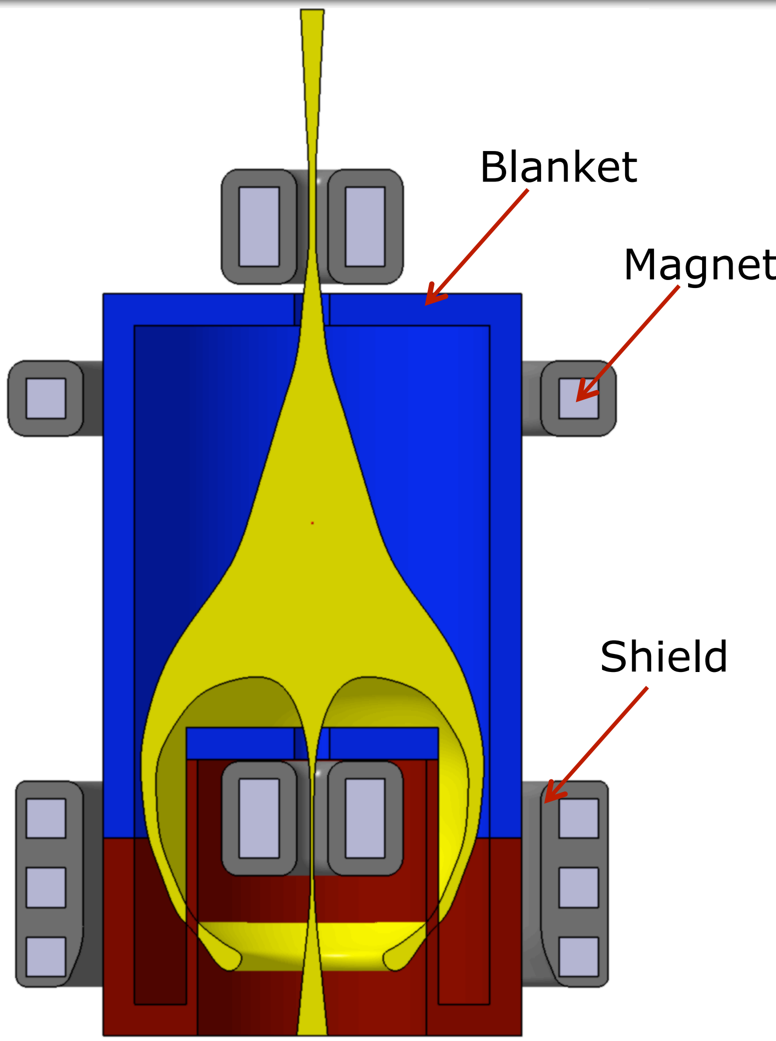
- 5 m above target
- 4.5 m outer radius
- 0.45 m inner radius

Bottom Blanket:

- 5.2 m below target
- 3.2 m outer radius
- 0.45 m inner radius

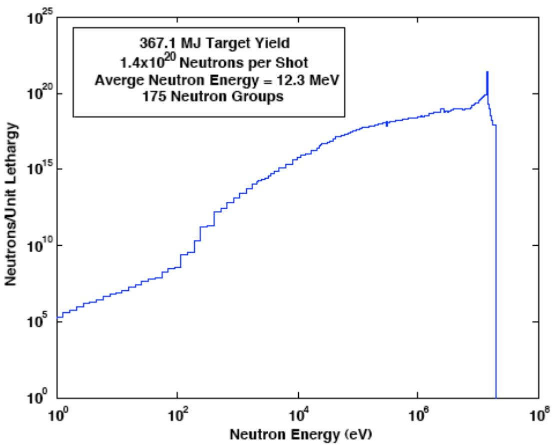
Side Blanket:

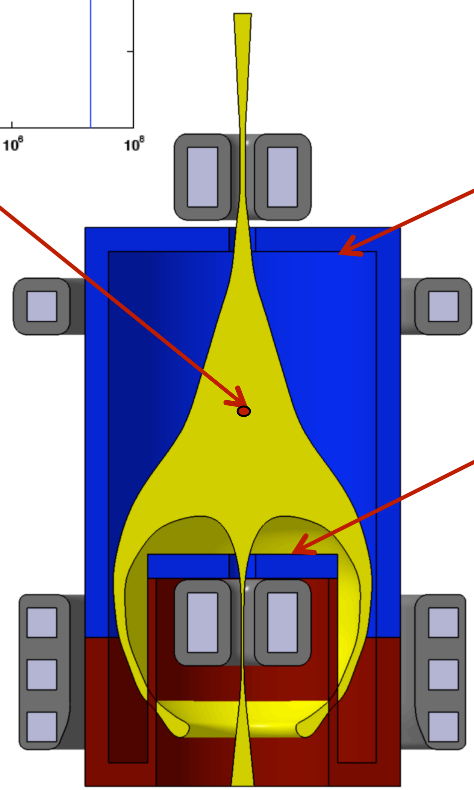
- 4.5 m radius
- 13 m height
  - 5 m above target
  - 8 m below target

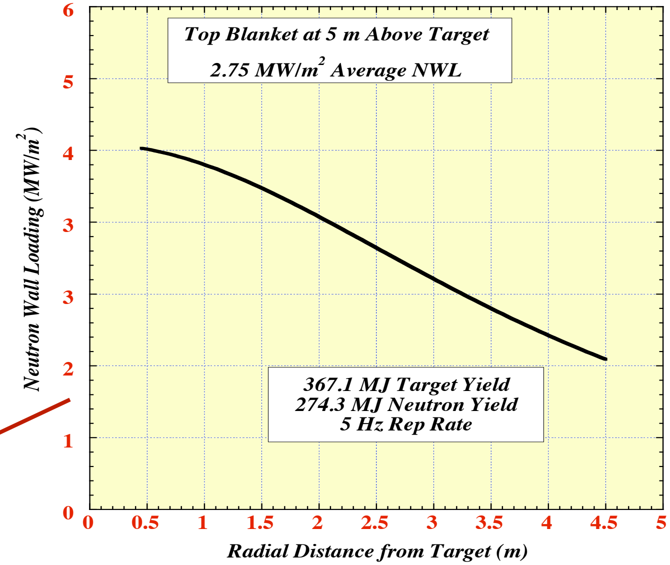


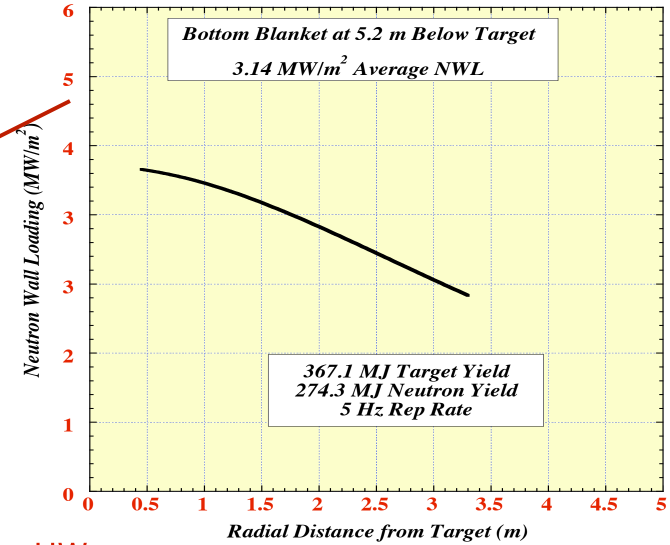
Neutron Wall Loading Distribution

(Top and Bottom Blankets)



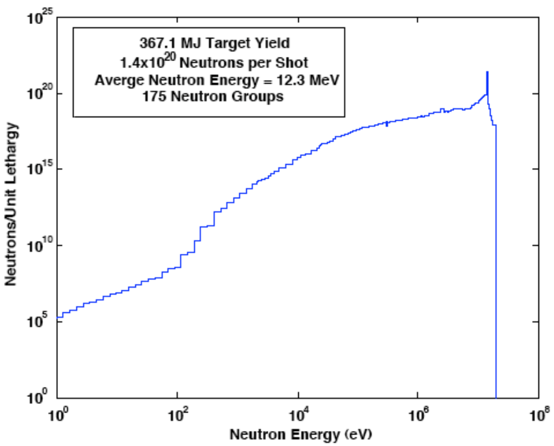


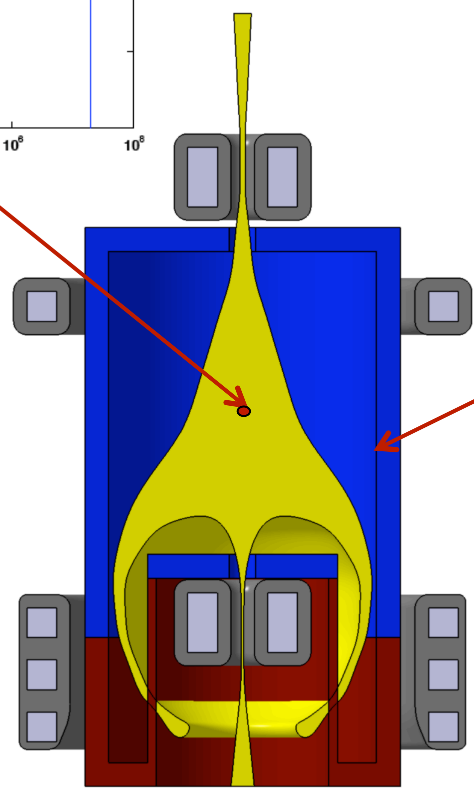


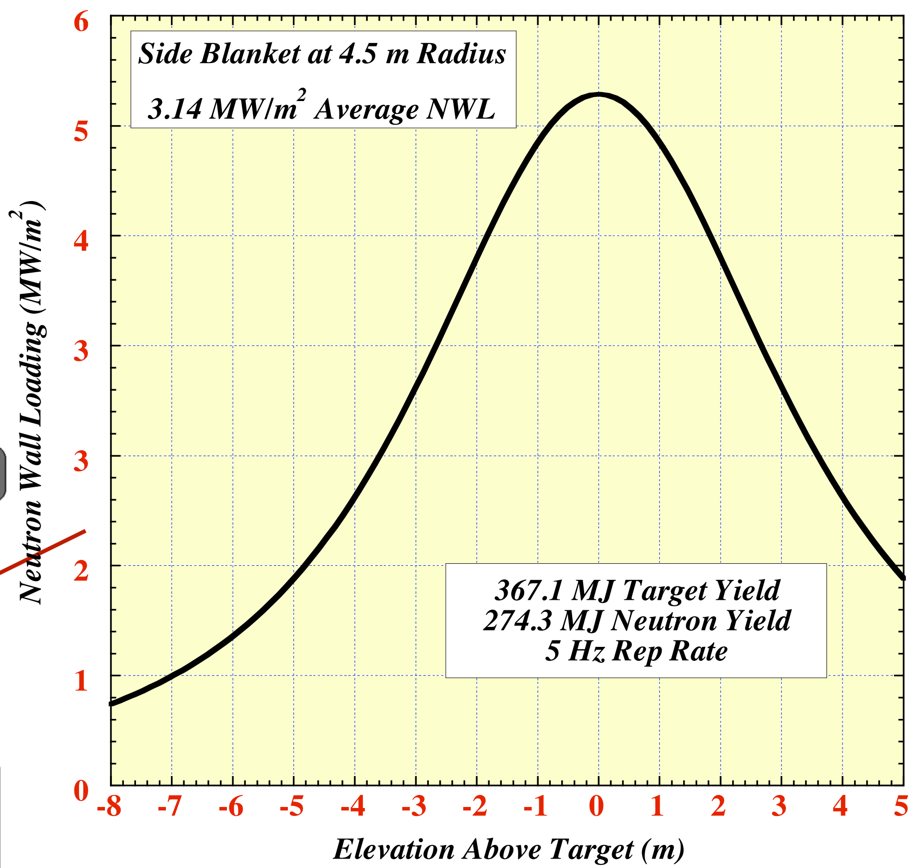


Neutron Wall Loading Distribution

(Side Blanket)







Peak Neutron Wall Loading is 5.4 MW/m² in side blanket at target level

Blanket Design Options

- Two blanket design options considered with low electrical conductivity SiC_f/SiC composite structure (required for dissipating the magnetic energy resistively)
  - LiPb/SiC
  - Flibe/Be/SiC
- With Flibe a 1 cm thick Be insert is attached to back wall of FW coolant channel

Nuclear Design Requirements

- Tritium self-sufficiency
  - Overall TBR >1.1
    - Breeding blanket coverage lost by the two point cusps is *0.4%*
    - Breeding blanket coverage lost by 40 beam ports is *0.7%*
    - Total breeding blanket coverage lost is negligible ***1.1%***
- Shield and VV are lifetime components
  - Peak end-of-life radiation damage <200 dpa
- Magnet is lifetime component
  - Peak fast neutron fluence $<10^{19}$ n/cm^2 (E>0.1 MeV)
  - Peak insulator dose $<10^{10}$ Rads
- Vacuum vessel is reweldable
  - Peak end-of-life He production <1 He appm

Dimensions That Satisfy All Nuclear Design Requirements

	Flibe Blanket	LiPb Blanket
Blanket Thickness (cm)	100	80
Lithium Enrichment	7.5% Li-6	10% Li-6
Magnet Shield Thickness (cm)	25	45
Vacuum Vessel Thickness (cm)	10	10

Tritium Breeding

	Flibe Blanket	LiPb Blanket
Local TBR	**1.204**	**1.217**
Top Blanket Contribution to TBR (12.57% coverage)	**0.151**	**0.153**
Bottom Blanket Contribution to TBR (7.16% coverage)	**0.086**	**0.087**
Side Blanket Contribution to TBR (79.18% coverage)	**0.953**	**0.964**
Overal TBR	**1.190**	**1.204**

Nuclear Heating

	Flibe Blanket	LiPb Blanket
Peak Nuclear Heating in Blanket (W/cm³)		
SiC	**28**	**28**
Be	**33**	**--**
Breeder	**41**	**80**
Blanket Nuclear Energy Multiplication	**1.232**	**1.168**
Top Blanket Nuclear Heating (MW) (12.57% coverage)	**212.4**	**201.4**
Bottom Blanket Nuclear Heating (MW) (7.16% coverage)	**121.0**	**114.8**
Side Blanket Nuclear Heating (MW) (79.18% coverage)	**1338.0**	**1268.9**
Total Blanket Nuclear Heating (MW)	**1671.4**	**1585.1**

Peak Damage Parameters in Blanket

	Flibe Blanket	LiPb Blanket
Peak SiC Atomic Displacements per FPY		
C Sublattice (dpa/FPY)	**40**	**83**
Si Sublattice (dpa/FPY)	**42**	**63**
Average in SiC (dpa/FPY	**41**	**73**
Peak SiC Helium Production per FPY		
C Sublattice (appm/FPY)	**7,314**	**7,059**
Si Sublattice (appm/FPY)	**2,172**	**1,957**
Average in SiC (appm/FPY)	**4,743**	**4,508**
Peak SiC Hydrogen Production per FPY		
C Sublattice (appm/FPY)	**4**	**4**
Si Sublattice (appm/FPY)	**3,862**	**3,512**
Average in SiC (appm/FPY)	**1,933**	**1,758**
Peak SiC Burnup per FPY		
C Sublattice (%/FPY)	**0.32%**	**0.29%**
Si Sublattice (%/FPY)	**0.60%**	**0.54%**
Total in SiC (%/FPY)	**0.92%**	**0.83%**

Peak Damage Parameters in Shield, Magnet, and VV

	Flibe Blanket	LiPb Blanket	Design Limit
Peak EOL Shield Damage (dpa)	0.04	3.6	200
Peak EOL Magnet Fast Neutron Fluence (n/cm^2)	1.03×10^{18}	2.84×10^{17}	10^{19}
Peak EOL magnet insulator dose (Rads)	3.39×10^{9}	4.32×10^{9}	10^{10}
Peak EOL VV He production (appm)			
FS	0.12	0.50	1
SS	2.9	487	1

Summary and Conclusions

- All neutronics requirements can be satisfied with a Flibe/Be/SiC or a LiPb/SiC blanket in HAPL with the present magnetic intervention configuration
- Tritium self-sufficiency can be achieved for both blankets with overall TBR >1.1
- ~5% higher blanket nuclear heating obtained with Flibe
- Peak dpa values in SiC are ~80% higher in LiPb blanket but peak gas production and burnup values are ~10% lower
- The shield is lifetime component and magnets are well shielded for both blanket design options
- The vacuum vessel is reweldable if it is made of ferritic steel
- If austenitic SS VV is used, it will be difficult to meet rewelding criterion with LiPb blanket while rewelding will be possible with Flibe blanket if thickness is increased by ~10 cm