

# Neutronics Parameters for Preferred Chamber Configuration with Magnetic Intervention

**Mohamed Sawan**

Ed Marriott, Carol Aplin  
*UW Fusion Technology Inst.*

Rene Raffray

*UCSD*

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# Blanket Configuration

## Top Blanket:

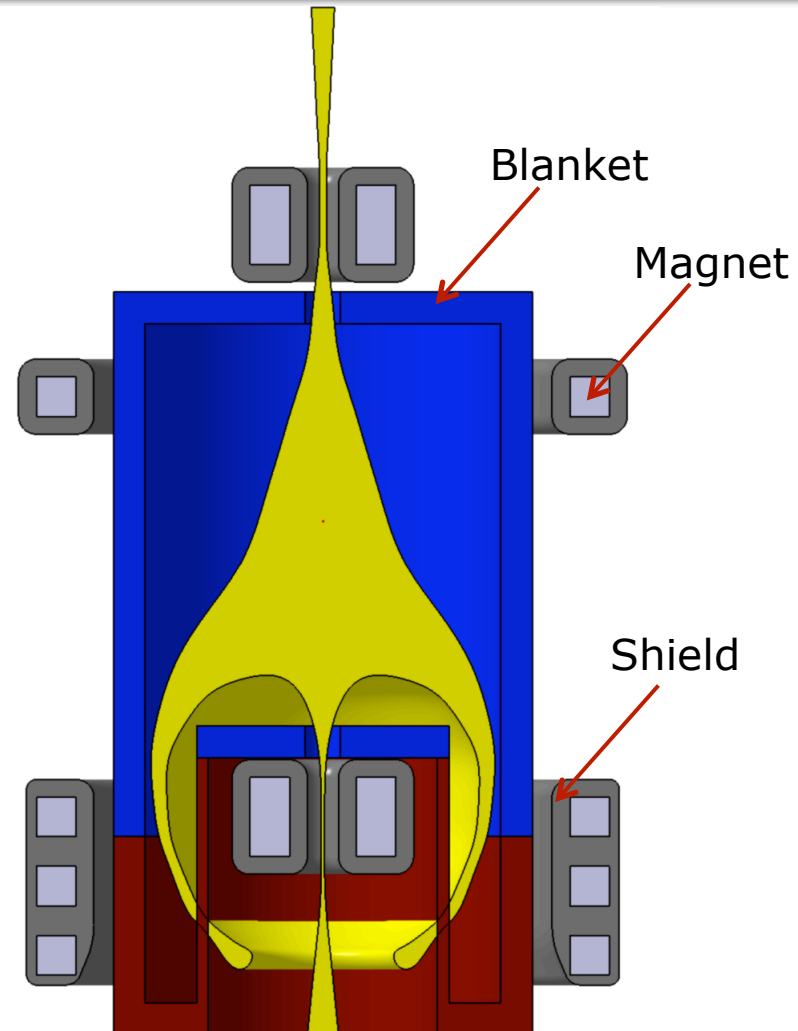
- 5 m above target
- 4.5 m outer radius
- 0.45 m inner radius

## Bottom Blanket:

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

## Side Blanket:

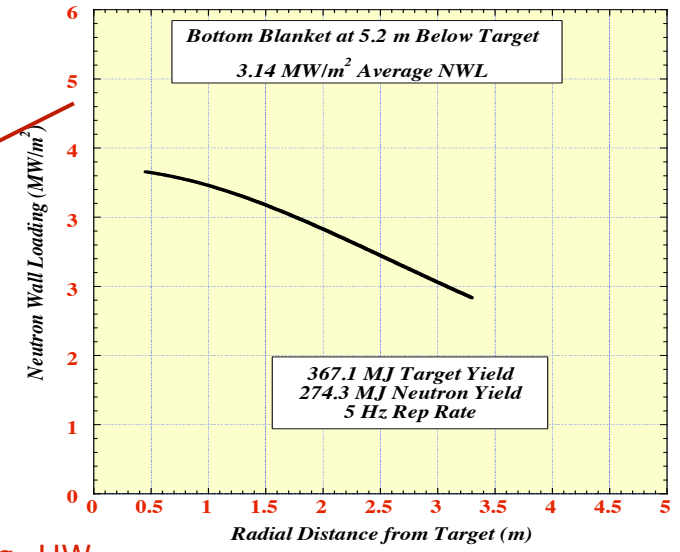
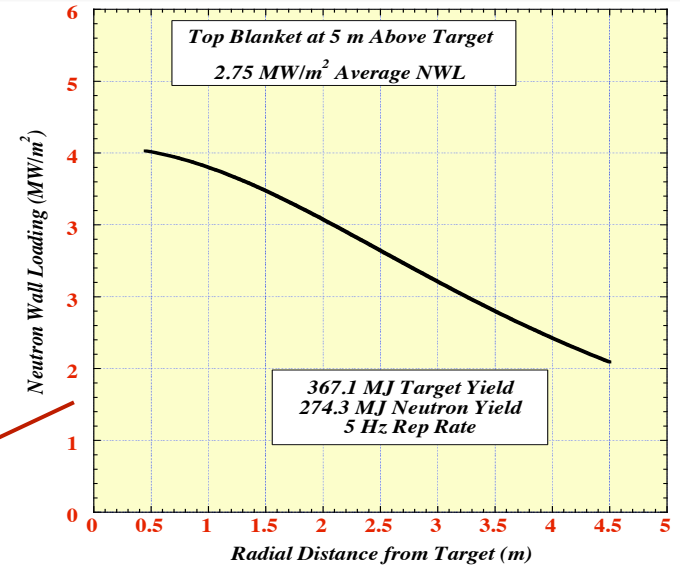
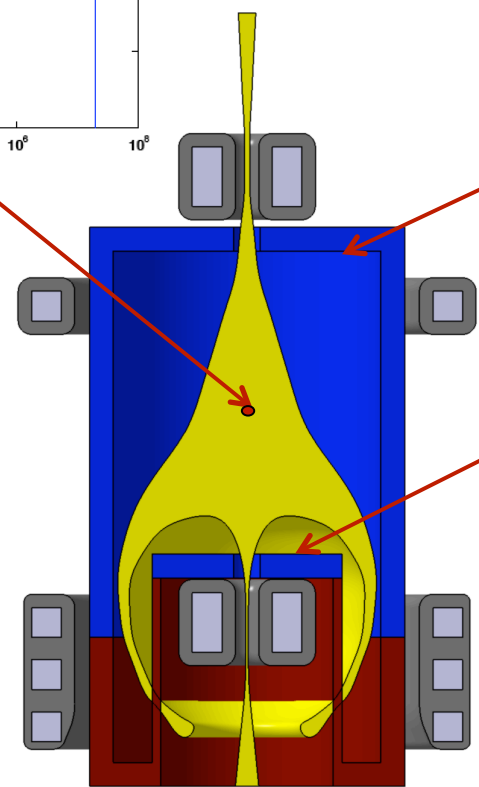
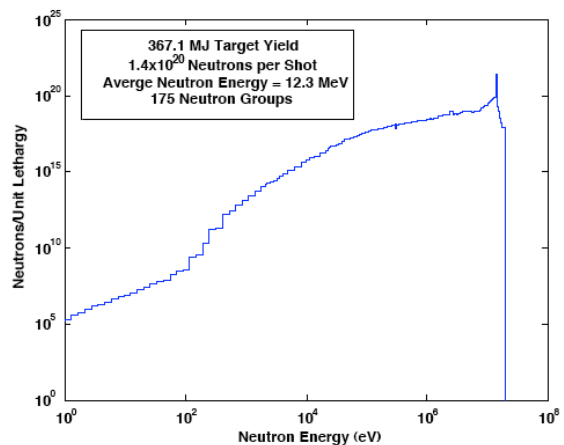
- 4.5 m radius
- 13 m height
  - ❑ 5 m above target
  - ❑ 8 m below target





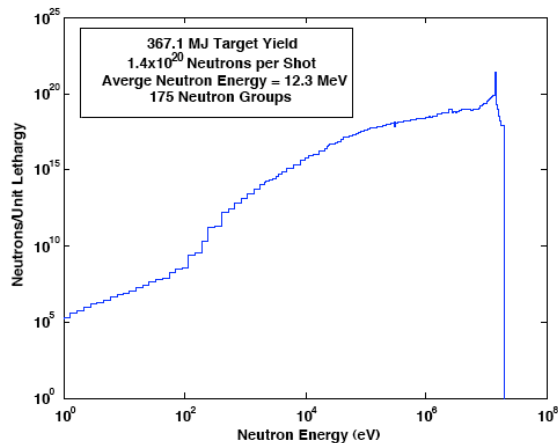
# Neutron Wall Loading Distribution

## (Top and Bottom Blankets)

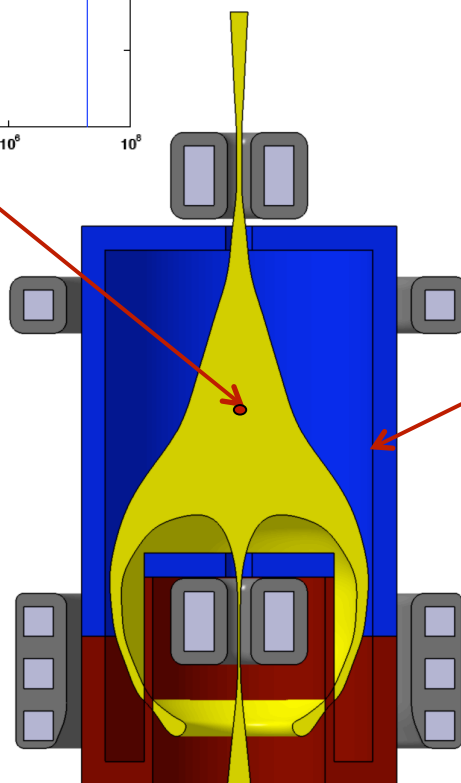




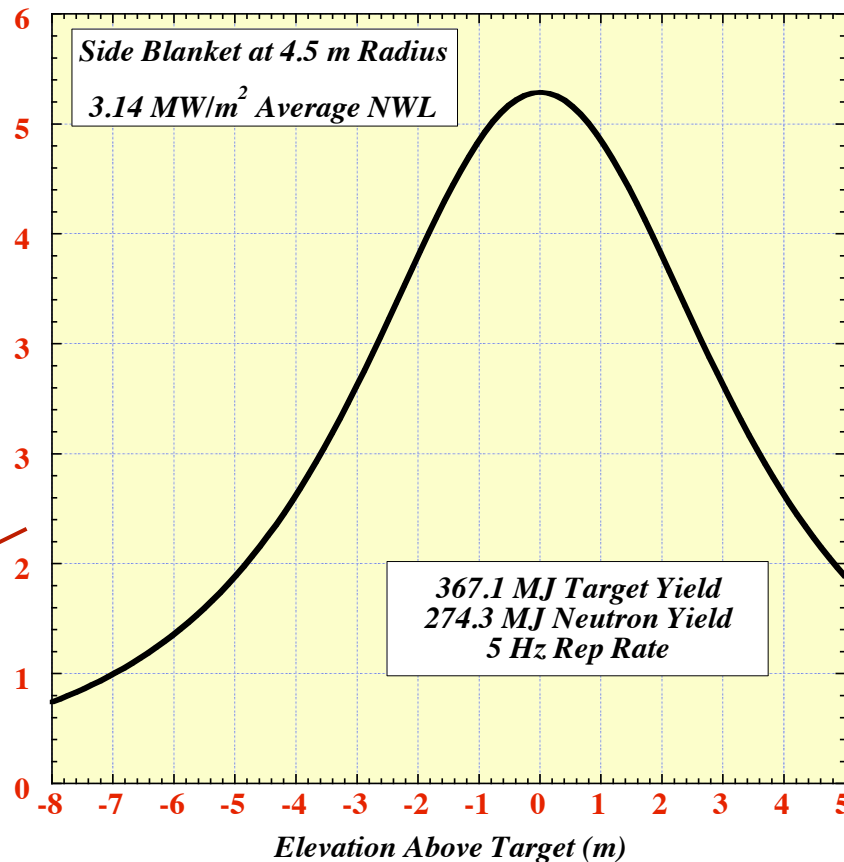
# Neutron Wall Loading Distribution (Side Blanket)



*Peak Neutron Wall Loading is 5.4 MW/m<sup>2</sup> in side blanket at target level*



Neutron Wall Loading (MW/m<sup>2</sup>)





# Blanket Design Options

- Two blanket design options considered with low electrical conductivity SiC<sub>f</sub>/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<sup>2</sup> (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

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



# Tritium Breeding

	<b>Flibe Blanket</b>	<b>LiPb Blanket</b>
<b><i>Local TBR</i></b>	<b>1.204</b>	<b>1.217</b>
Top Blanket Contribution to TBR (12.57% coverage)	<b>0.151</b>	<b>0.153</b>
Bottom Blanket Contribution to TBR (7.16% coverage)	<b>0.086</b>	<b>0.087</b>
Side Blanket Contribution to TBR (79.18% coverage)	<b>0.953</b>	<b>0.964</b>
<b><i>Overall TBR</i></b>	<b>1.190</b>	<b>1.204</b>





# Nuclear Heating

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	<b>Flibe Blanket</b>	<b>LiPb Blanket</b>
<b><i>Peak Nuclear Heating in Blanket (W/cm<sup>3</sup>)</i></b>		
<b><i>SiC</i></b>	<b>28</b>	<b>28</b>
<b><i>Be</i></b>	<b>33</b>	<b>--</b>
<b><i>Breeder</i></b>	<b>41</b>	<b>80</b>
<b><i>Blanket Nuclear Energy Multiplication</i></b>	<b>1.232</b>	<b>1.168</b>
Top Blanket Nuclear Heating (MW) (12.57% coverage)	<b>212.4</b>	<b>201.4</b>
Bottom Blanket Nuclear Heating (MW) (7.16% coverage)	<b>121.0</b>	<b>114.8</b>
Side Blanket Nuclear Heating (MW) (79.18% coverage)	<b>1338.0</b>	<b>1268.9</b>
<b><i>Total Blanket Nuclear Heating (MW)</i></b>	<b>1671.4</b>	<b>1585.1</b>



# Peak Damage Parameters in Blanket

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

# Peak Damage Parameters in Shield, Magnet, and VV

	<b>Flibe Blanket</b>	<b>LiPb Blanket</b>	<b>Design Limit</b>
Peak EOL Shield Damage (dpa)	<b>0.04</b>	<b>3.6</b>	<b>200</b>
Peak EOL Magnet Fast Neutron Fluence (n/cm <sup>2</sup> )	<b>1.03x10<sup>18</sup></b>	<b>2.84x10<sup>17</sup></b>	<b>10<sup>19</sup></b>
Peak EOL magnet insulator dose (Rads)	<b>3.39x10<sup>9</sup></b>	<b>4.32x10<sup>9</sup></b>	<b>10<sup>10</sup></b>
Peak EOL VV He production (appm)			
FS	<b>0.12</b>	<b>0.50</b>	<b>1</b>
SS	<b>2.9</b>	<b>487</b>	<b>1</b>

# 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