Radiation Streaming in Gaps Between ITER First Wall/Shield Modules

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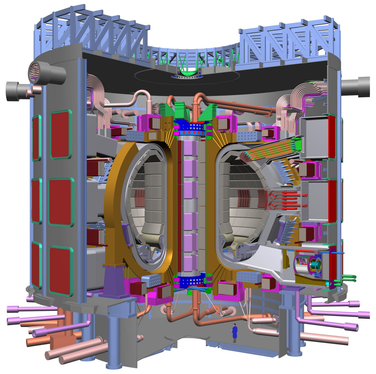
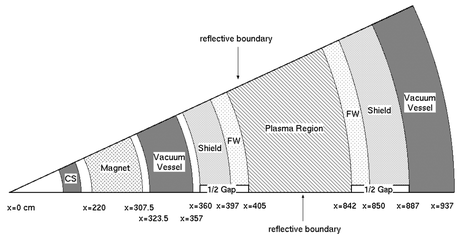
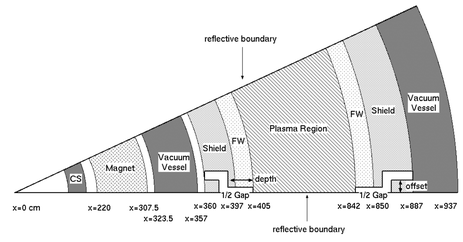
Introduction

- ITER design has gaps between FWS modules
- Gaps allow increased levels of radiation to reach VV, magnets
- U.S. responsible for design of modules 7, 12, 13
- MCNPX used to analyze the effect of these gaps to give guidance to the U.S. FWS design team
- Simple 3-D homogenized models created for module 7 and mid-plane locations
- Examined fast neutron fluence, He production, and nuclear heating at the VV and magnets

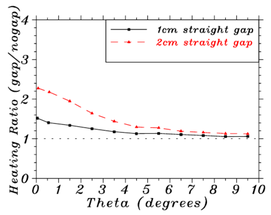


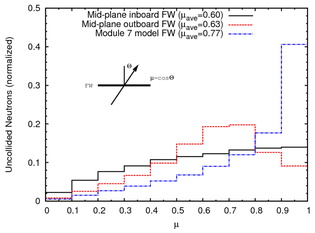
Mid-plane location with vertical gaps





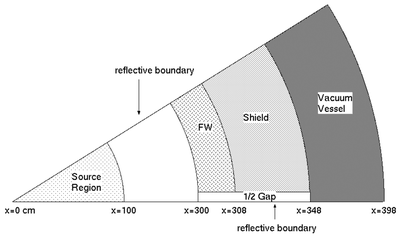
Nuclear Heating at Back of VV/front of IB magnet

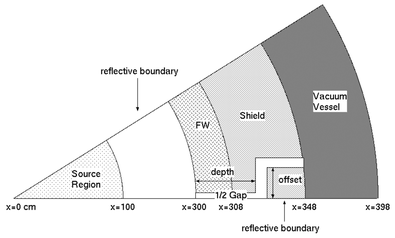




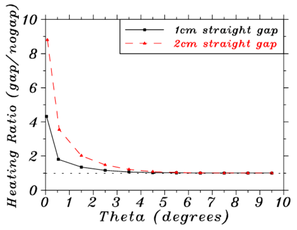
- Gap effect enhancement at front of the IB magnet substantially smaller at mid-plane vs. module 7
  - ➢Due to a more tangential neutron source at mid-plane
- Stepped gaps lead to slight reduction in radiation parameters

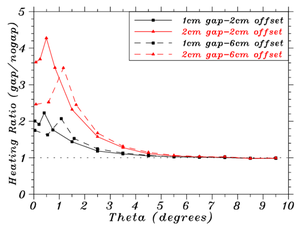
Module 7 location with vertical gaps





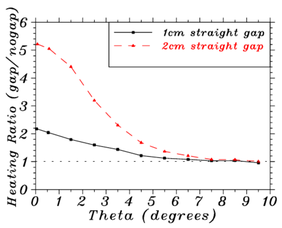
Nuclear Heating at Front of VV





- He production enhancement is higher (up to 35 for a straight gap and 7 for a stepped gap at the VV front)

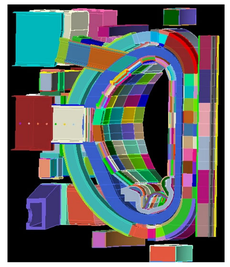
Nuclear Heating at Back of VV/Magnet

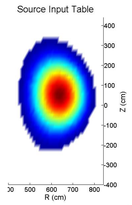


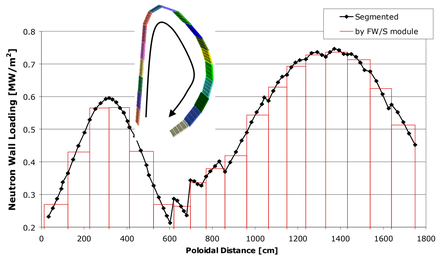
- Less peaking than at the front of the VV
- Fast neutron fluence enhancement up to 7 for a straight gap at the VV back/Magnet

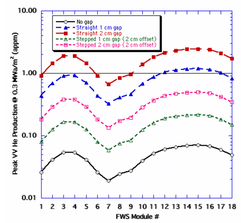
Apply poloidal variation of NWL with module 7 gap effect to obtain VV peak He production

- Detailed 3-D plasma source and analysis used for NWL calculation









- Stepped gaps meet reweldability limit at all locations
- 1 cm straight gap meets reweldability limit at most locations

Combined impact of straight vertical and horizontal gaps on total IB magnet heating

Vertical gap (cm)	Horizontal gap (cm)	Relative total IB magnet heating
0	0	1
1	0	1.14
1	1	1.23
1.4	1	1.31
1.4	1.4	1.36
2	0	1.44
2	2	1.75

- Up to 75% increase in total IB magnet heating with gaps
- Adding horizontal gaps increases total IB magnet heating (8% for 1 cm gap, 20% for 2 cm gap)

Summary of Module 7 Vacuum Vessel Results

- A stepped gap reduces local peaking but not the relative average parameters
- Doubling the width of a straight gap or stepped gap with small offset doubles VV peak parameters
- For a stepped gap with large offset, doubling gap width increases VV peak parameters 60-70%
- The effect of modifying the gap shape is more pronounced for He production than heating
- The effect of changing the stepped gap offset more pronounced for He production than heating

Conclusions

- Significant radiation streaming effects are seen due to gaps between modules
- Streaming effects are more pronounced for He production and fast neutron fluence than heating
- Stepped gaps reduce local peaking but have little effect on relative averages of radiation parameters
- Combined vertical and horizontal gaps show increases up to 75% in total IB magnet heating

Acknowledgments:

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