



3-D Estimate of SR and VV Lifetimes of ARIES-ACT-1

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ARIES Project Meeting

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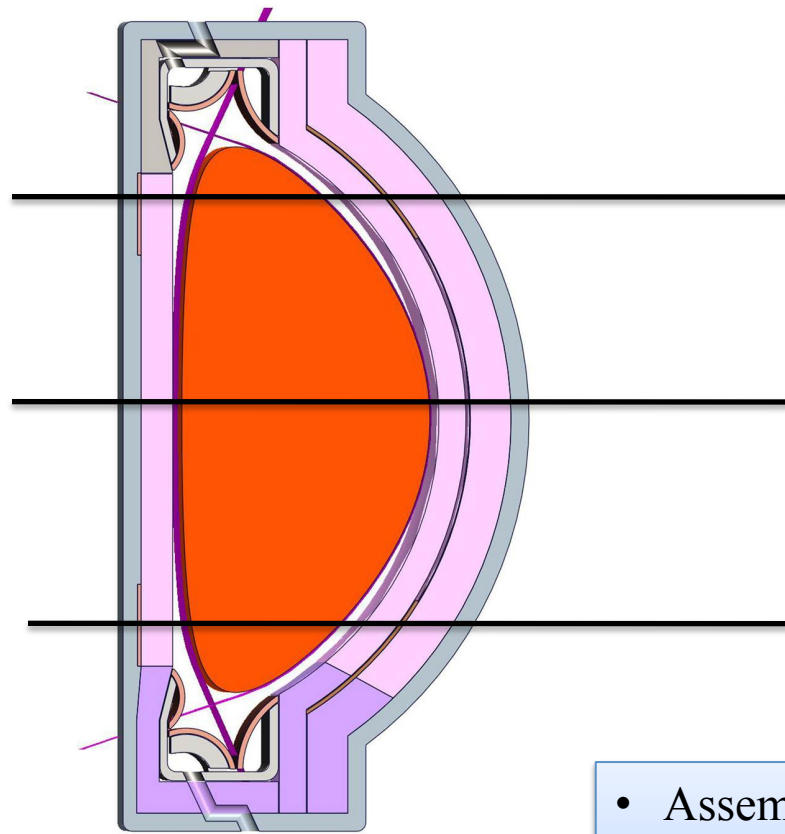


Background Info

- 2 cm wide assembly gaps between 16 toroidal modules allow neutrons to stream through, increasing radiation level behind blanket.
- Gaps will close during operation due to thermal expansion and neutron-induced swelling.
- Examined streaming through range of gap widths: 0, 1, and 2 cm
- 3-D streaming analysis determined:
 - Peaking in radiation damage due to streaming
 - dpa, He production, and He/dpa ratio at Structural Ring and Vacuum Vessel
 - Lifetimes of these components based on 200 dpa limit.



Evolution of Assembly Gaps during Operation



**Relative
Change**

Temperature

**Neutron-induced
Swelling at EOL**

Top

High

Low

Middle

Medium

High

Bottom

Low

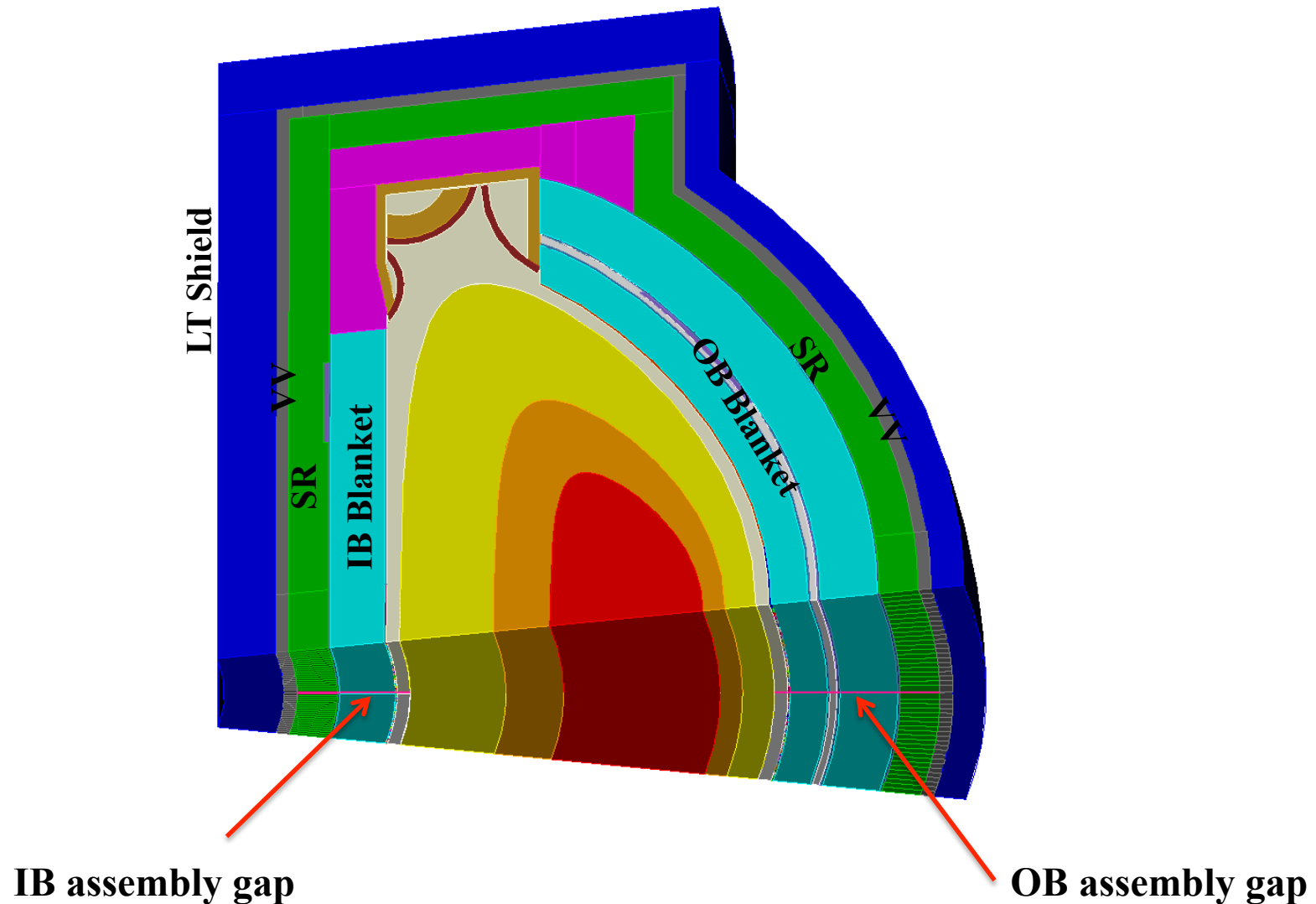
Low

- Assembly gaps will not close completely during operation.
- They shouldn't to allow removal of components.
- Gaps will close non-uniformly in all directions.

LiPb-out (with lowest temp)
LiPb-in (with highest temp)

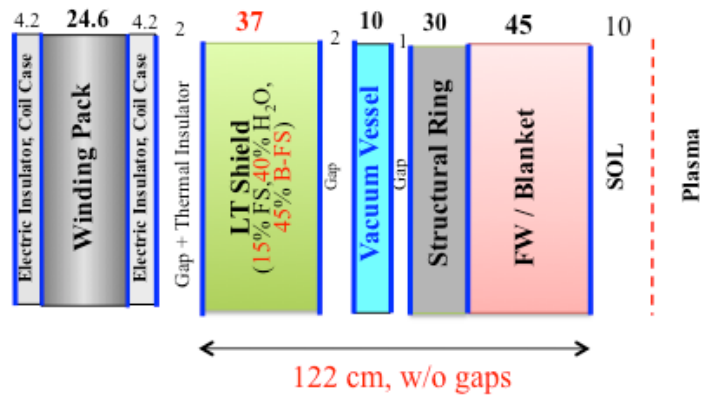


3-D Model of ARIES-ACT-1 with SiC/LiPb Blanket (1/32nd module; 22.5 degree)



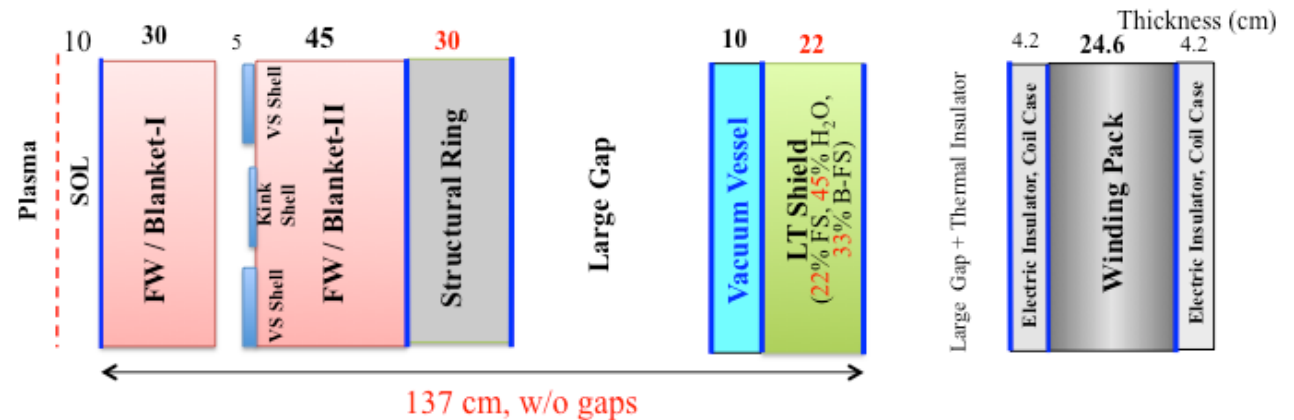


ARIES-ACT-1 Radial Build

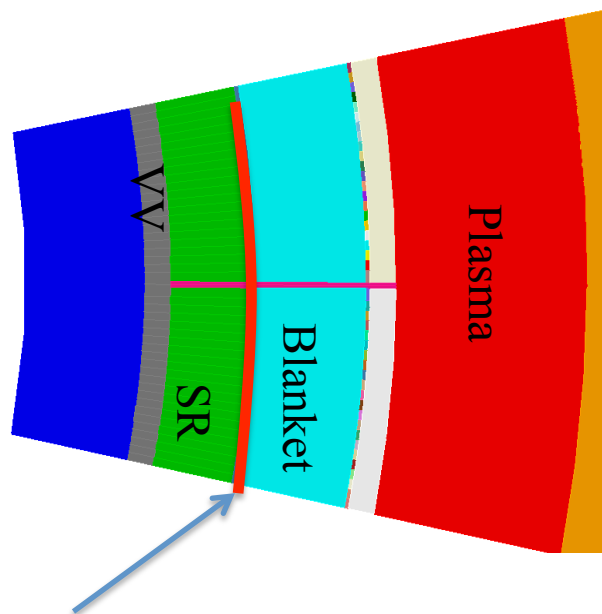


Inboard
Peak NWL $\sim 3 \text{ MW/m}^2$

Outboard
Peak NWL = 4.5 MW/m^2



Inboard Structural Ring

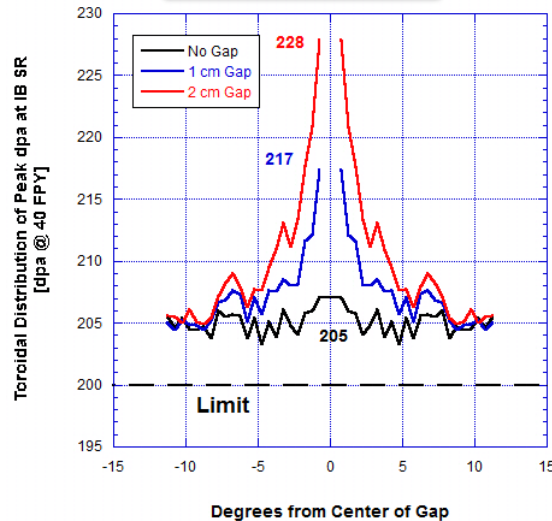


Damage along
red surface of SR

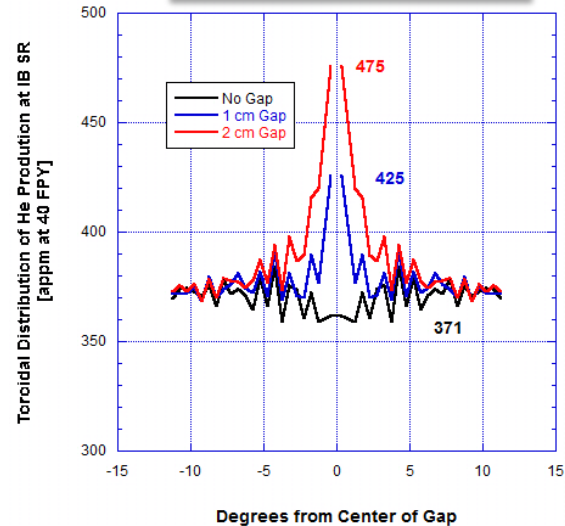


IB SR: dpa, He, and dpa/He ratio

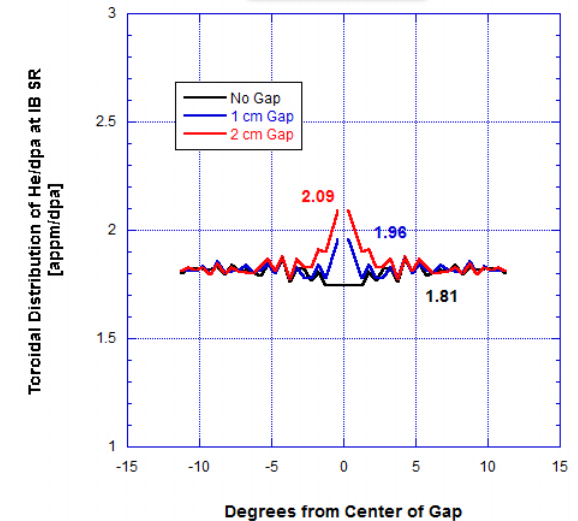
dpa @ 40 FPY



He appm @ 40 FPY

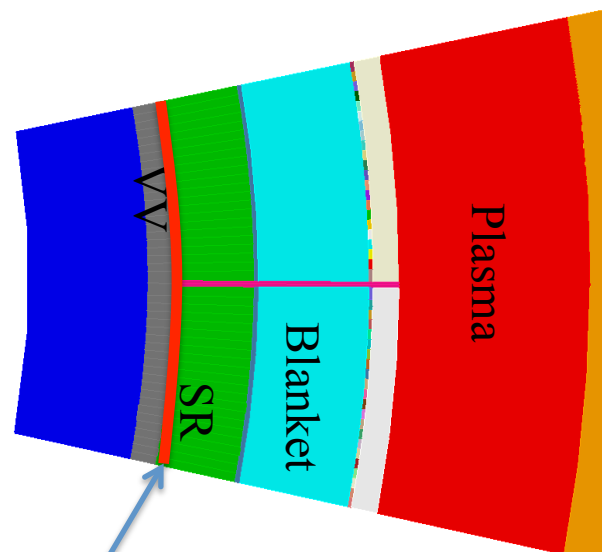


He / dpa



- IB SR should be replaced once during plant lifetime.
- SR is not reweldable around midplane (He production $\gg$ 1 appm).
- For IB SR, He/dpa ratio ~ 2

Inboard Vacuum Vessel

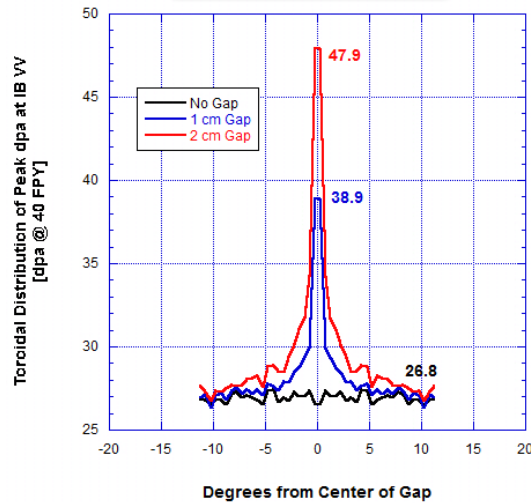


Damage along
red surface of VV

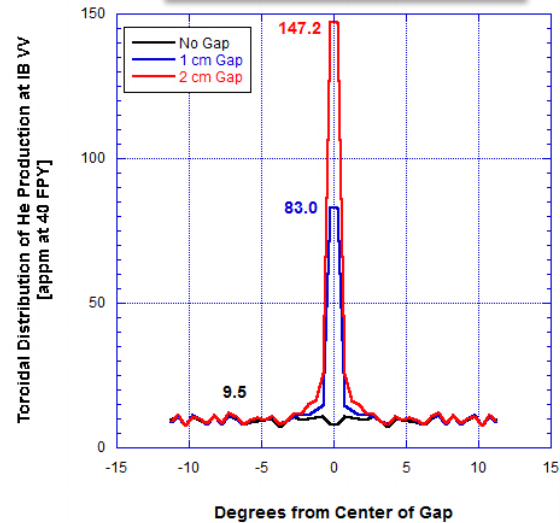


IB VV: dpa, He, and dpa/He ratio

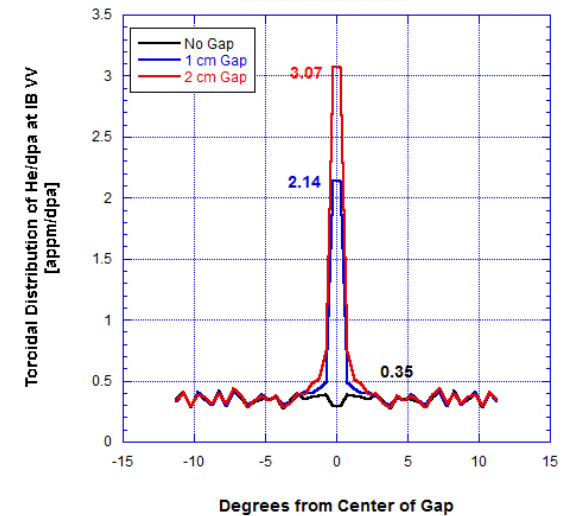
dpa @ 40 FPY



He appm @ 40 FPY

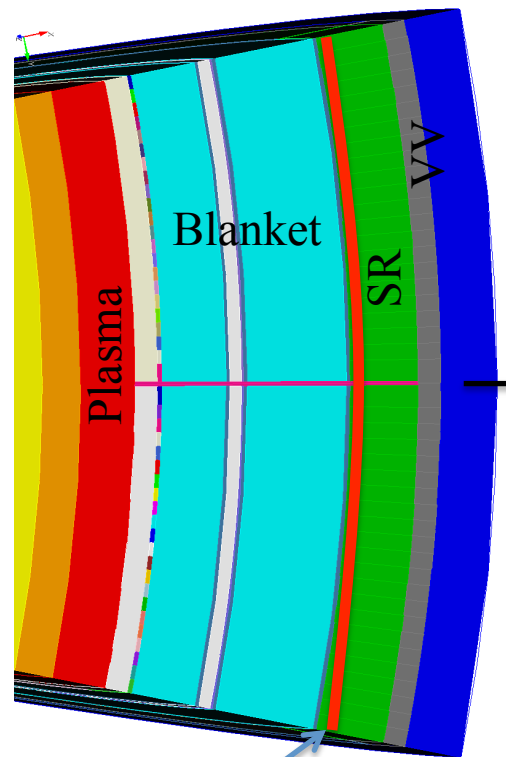


He / dpa



- IB VV is lifetime component (< 200 dpa @ 40 FPY), but not reweldable around midplane (He production >> 1 appm).
- For IB VV, He/dpa ratio = 0.4 - 3

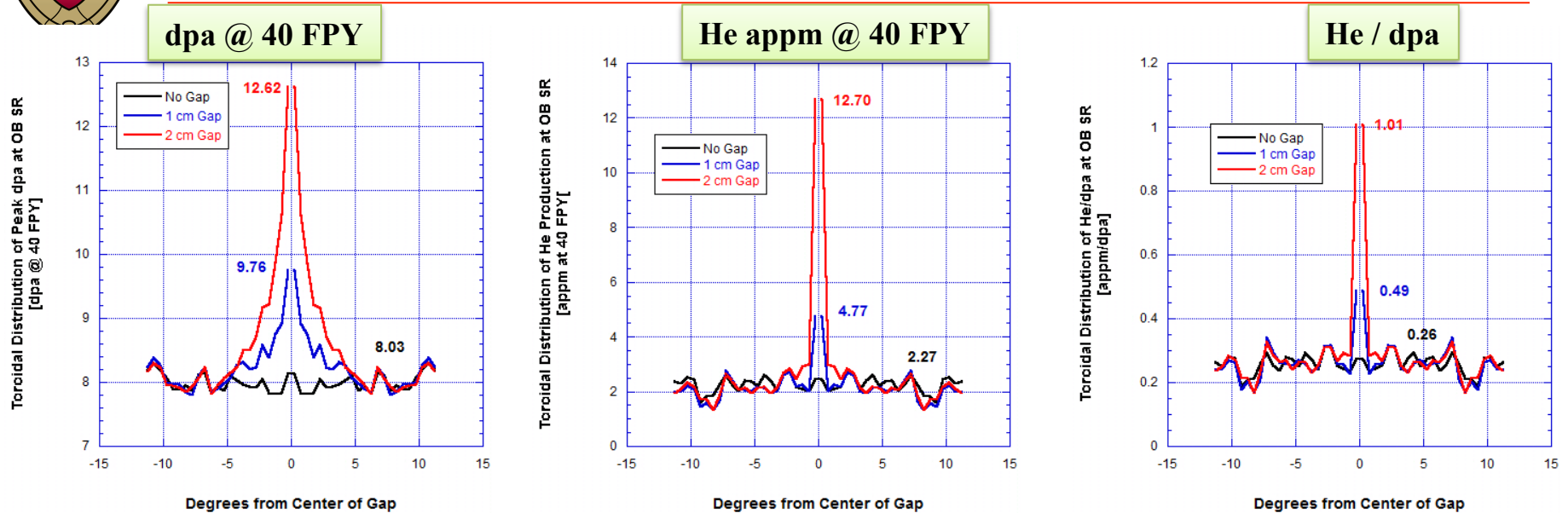
Outboard Structural Ring



Damage along
red surface of SR

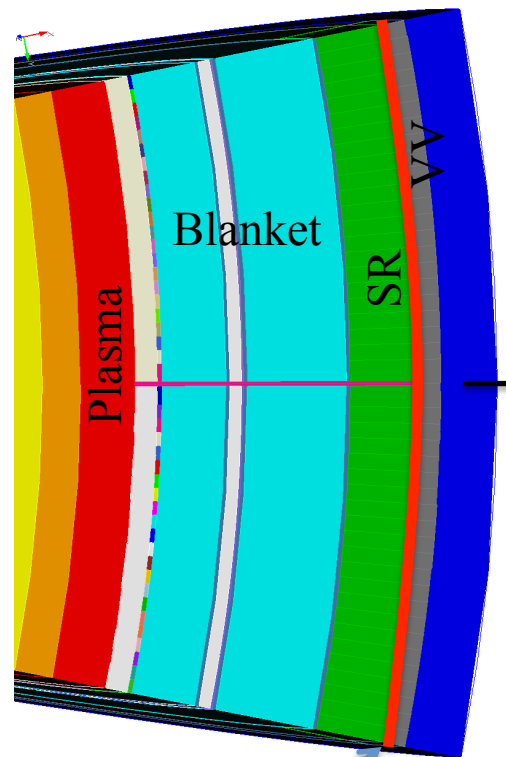


OB SR: dpa, He, and dpa/He ratio



- OB SR is permanent component (< 200 dpa @ 40 FPY), but not reweldable around midplane (He production > 1 appm).
- For OB SR, He/dpa ratio = 0.3 - 1

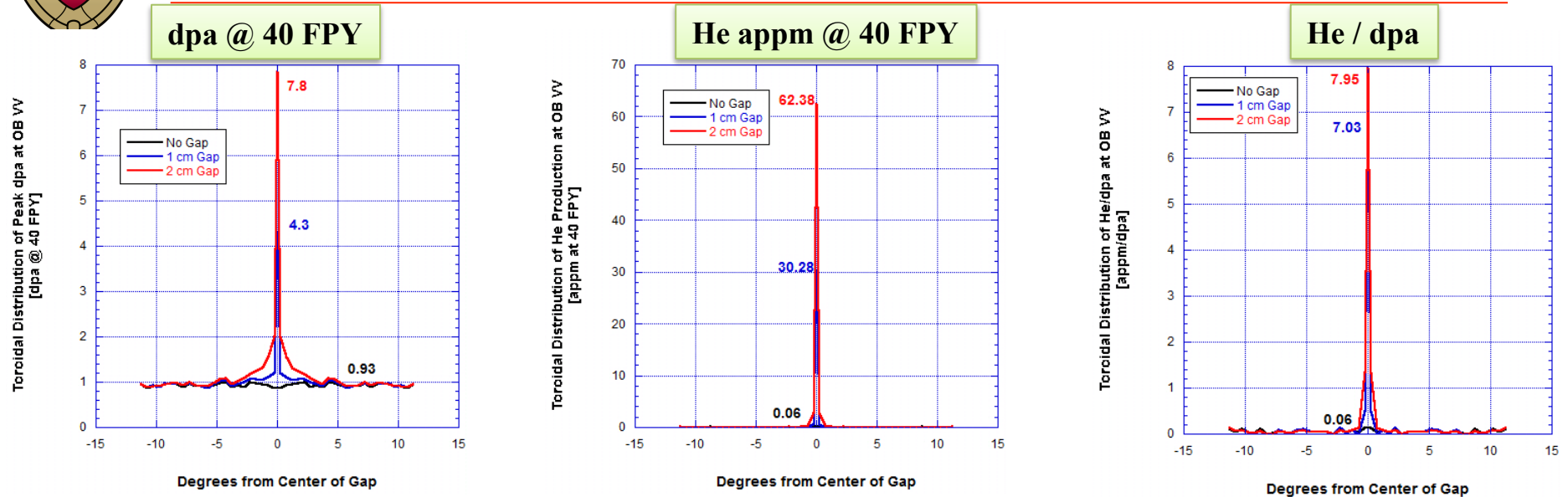
Outboard Vacuum Vessel



Damage along
red surface of VV



OB VV: dpa, He, and dpa/He ratio



- OB VV is lifetime component ($\ll 200$ dpa @ 40 FPY) and reweldable away from gaps (He production < 1 appm).
- For OB VV, He/dpa ratio = 0.06 - 8



Summary of Results

	Inboard			Outboard		
	dpa	He appm	He/dpa*	dpa	He appm	He/dpa*
	@40 FPY	@40 FPY	ratio	@40 FPY	@40 FPY	ratio
SR:						
2 cm gap	228	475	~2	13	13	1
1 cm gap	217	425	~2	10	5	0.5
No gap	205	371	~1.8	8	2	0.26
VV:						
2 cm gap	48	147	~3	8	62	~8
1 cm gap	39	83	~2	4	30	~7
No gap	27	10	~0.4	1	0.06	0.06

* Ratio of 10 for FS @ FW.



Conclusions

- UW/ORNL study will determine sensitivity of dpa (and lifetime) to uncertainty in nuclear data.
- Structural ring:
 - IB SR should be replaced once during plant lifetime
 - Not reweldable
 - He/dpa ratio = 0.3 – 2
- Vacuum vessel:
 - Lifetime component:
 - IB dpa @ 40 FPY = 27 – 48
 - OB dpa @ 40 FPY = 1 - 8
 - Not reweldable around IB midplane
 - Reweldable away from OB assembly gaps
 - He/dpa ratio = 0.06 - 8