Impact of Water-Free VV on ARIES-ACT-SiC Inboard Radial Build

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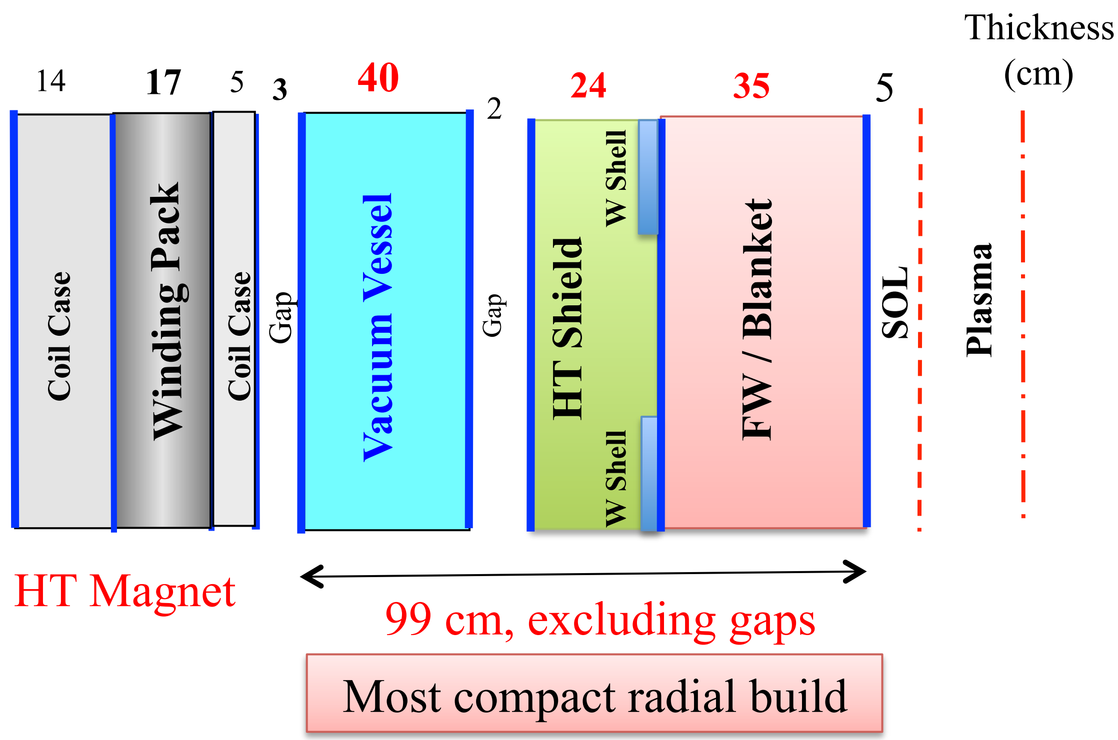
2006 ARIES-AT Inboard Radial Build

(Peak IB Γ = 3.2 MW/m²)



VV:

- 13% FS Structure
- 22% H_2O
- 65% WC

HT Shield:

- 15% SiC Structure
- 10% LiPb
- 70% B-FS filler
- 5% W Shell

Ref.: L.A. El-Guebaly, "Nuclear Performance Assessment of ARIES-AT," Fusion Engineering and Design 80 (2006) 99-110.

Proposed Changes for ARIES-ACT

Impact on radial Build

(Increase ↑ or decrease ↓)

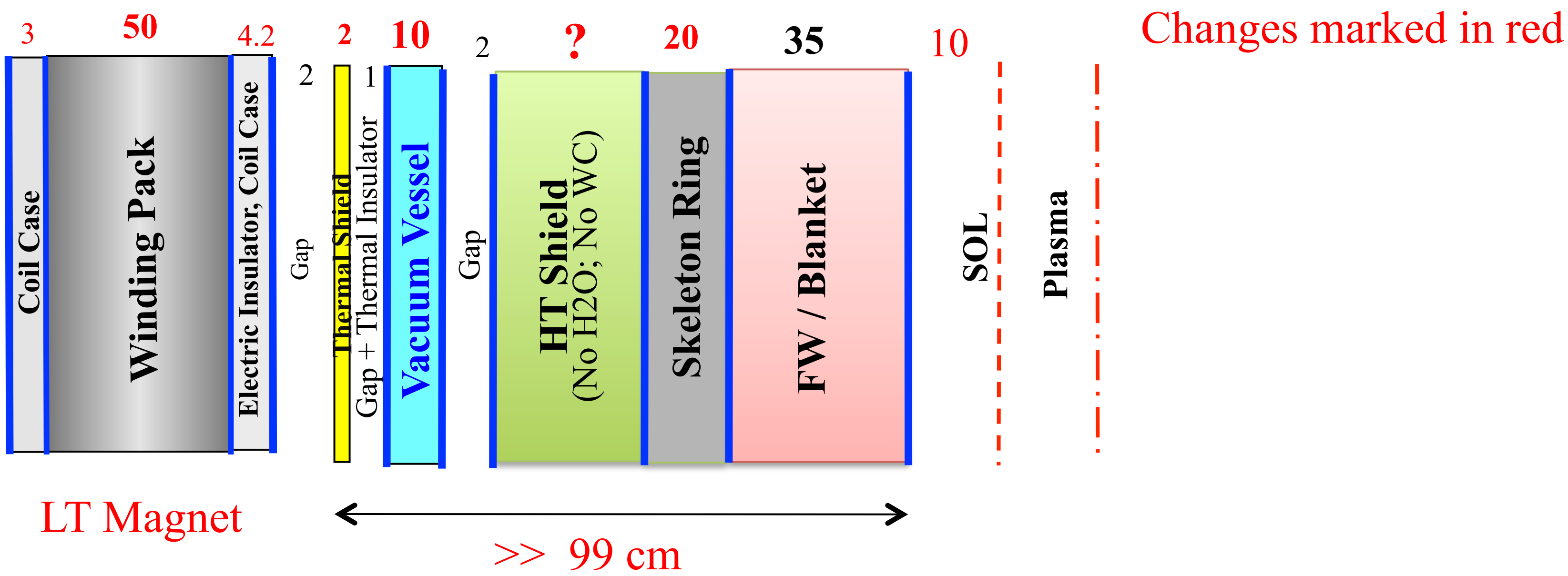
- LT magnet replacing HT magnet.
- 20 cm thick Skeleton Ring (formerly HT shield)
- He cooled Skeleton Ring (formerly HT shield):
  - Replace LiPb by He ↑↑
  - Replace SiC structure by FS structure ↓
- 10 cm thick He-cooled VV:
  - no water ↑↑↑↑↑
  - Exclude materials with high decay heat (such as WC) to control FS temperature during LOCA. To be confirmed* ↑↑↑↑↑
- 2 cm thick He-cooled Thermal Shield between VV and magnets. ↓
- Minor changes: higher NWL, 70% Li enrichment, 3Cr-3WV or 316-SS steel for VV, thinner coil case, HT magnet composition.

⇒ Most changes lead to larger radial build

* SiC structure of FW/blanket generates low decay heat and can tolerate higher temp than FS structure. Is there a need to exclude W (or WC) for Shielding Block behind IB assembly gaps?

ARIES-ACT-SiC Inboard Radial Build

(Peak IB Γ = 3.3 MW/m^2)

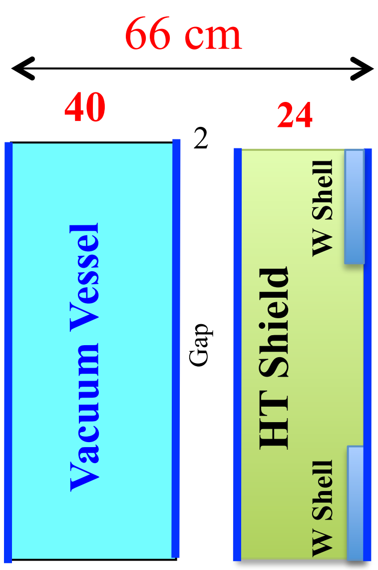


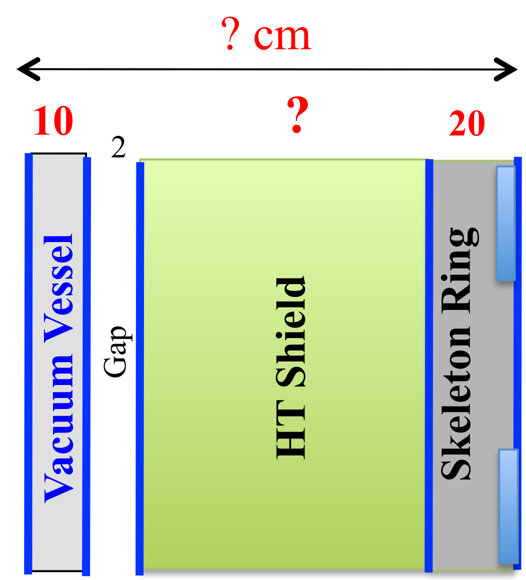
HT shield thickness **and** composition will be optimized to protect magnet.

ARIES-ACT-SiC Radiation Limits

Calculated Overall TBR	1.05 (TBD from 3-D analysis)	
Net TBR (for T self-sufficiency)	~1.01	
Damage to Structure	3%	Burnup for SiC structure
(for structural integrity)	200	dpa for advanced FS Struc.
Helium Production @ VV (for reweldability of FS structure)	1	He appm
LT S/C Magnets (@ 4 K):		
Peak fast n fluence to Nb_3Sn (E_n > 0.1 MeV)	10^{19}	n/cm^2
Peak nuclear heating	2	mW/cm^3
Peak dpa to Cu stabilizer	6×10^{-3}	dpa
Peak dose to GFF polyimide insulator	$< 10^{11}$	rads
Plant Lifetime	40	FPY
Availability	85%	
Operational Dose to Workers and Public	< 2.5	mrem/h

ARIES-ACT-SiC Inboard Options





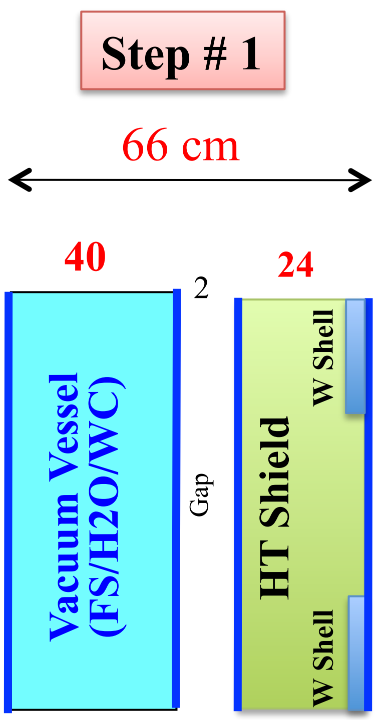
Option I

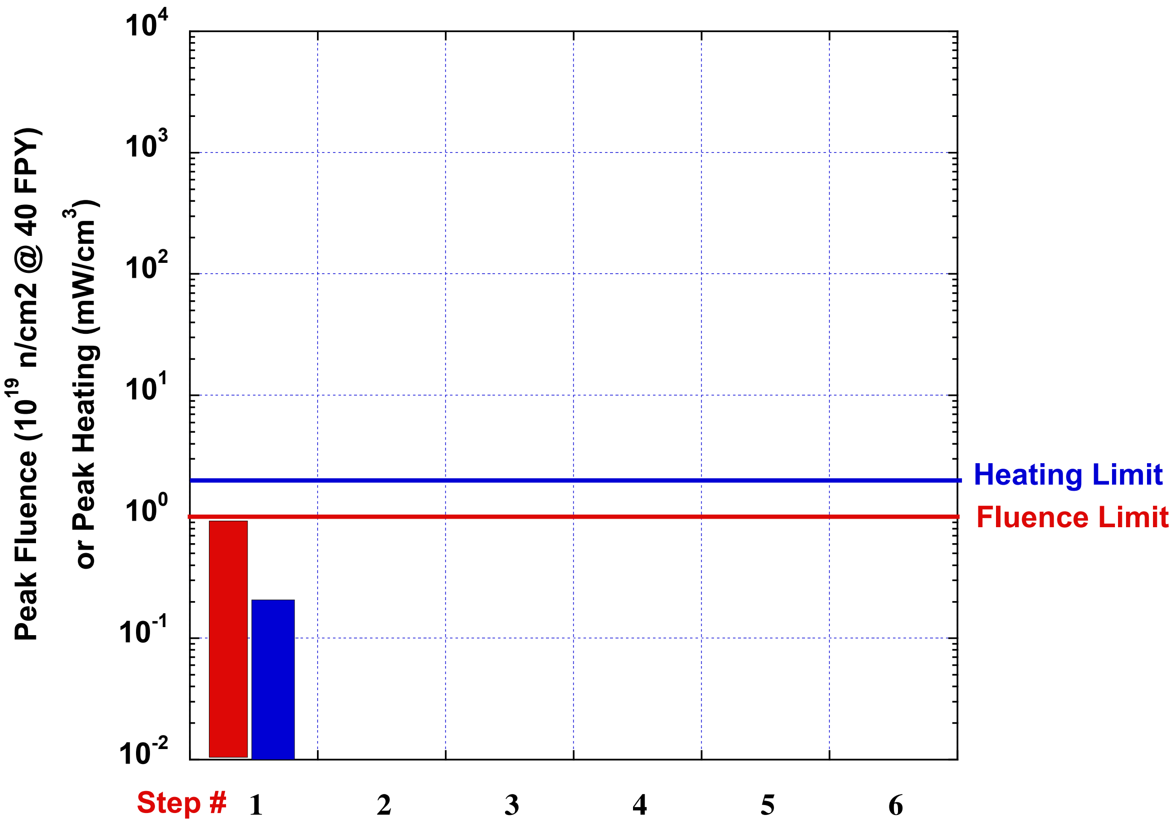
Thick VV with H_2O and WC filler
Thin HT shield/Skeleton Ring
(a la ARIES-AT)

Option II

Thin He-cooled VV
Thick HT shield

ARIES-ACT-SiC Inboard Options (Cont.)



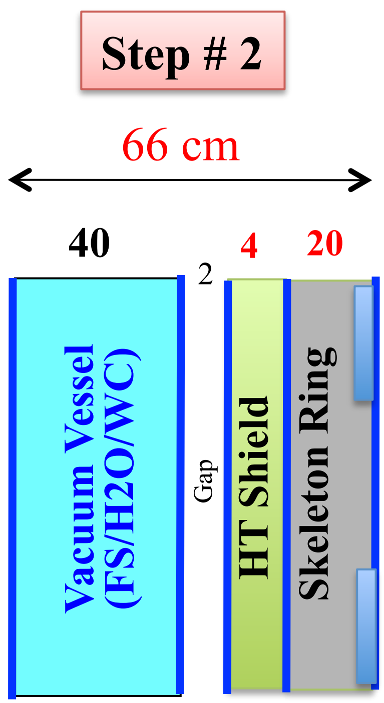


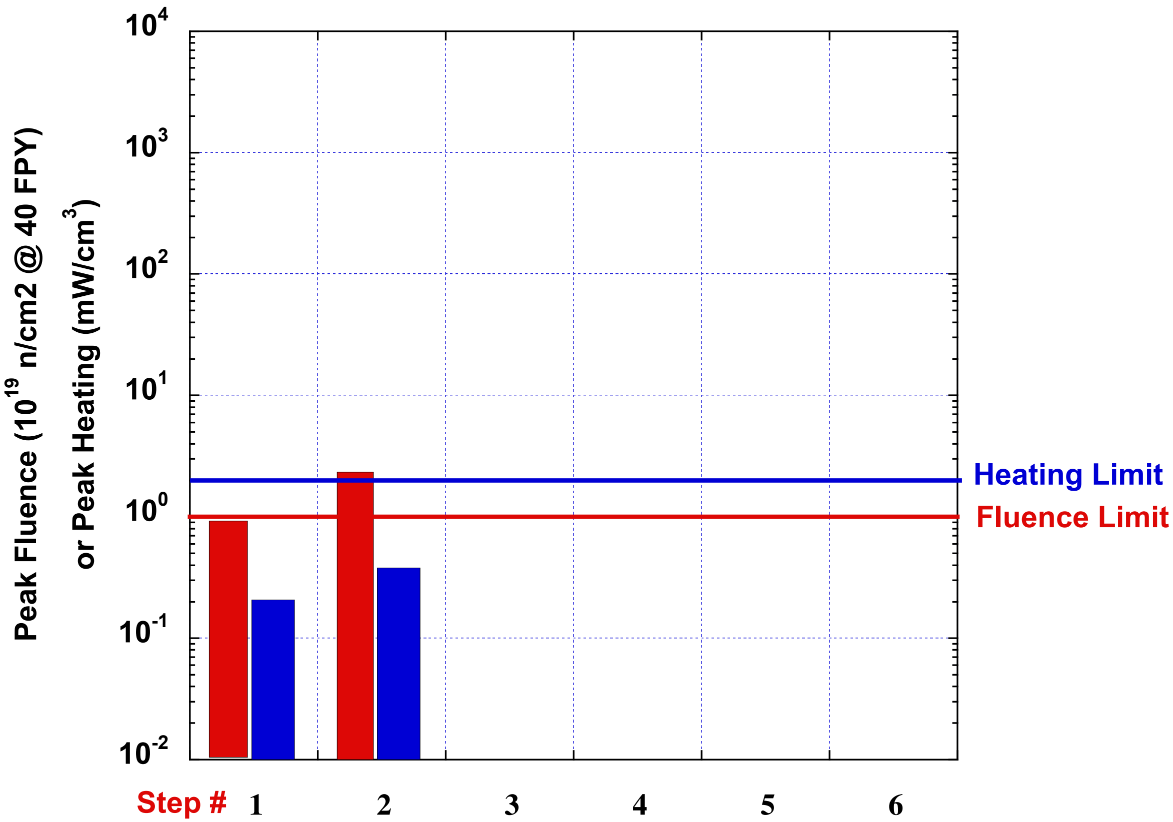
a la ARIES-AT:

40 cm VV with H_2O and WC filler

Thin (24 cm) HT shield (LiPb cooled)

ARIES-ACT-SiC Inboard Options (Cont.)





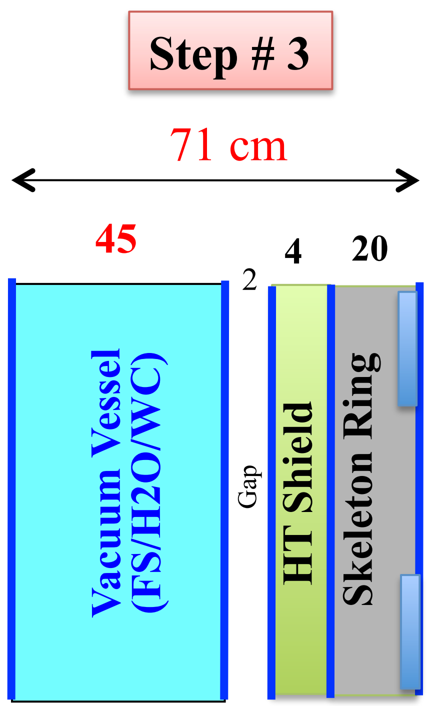
ARIES-ACT Parameters with:

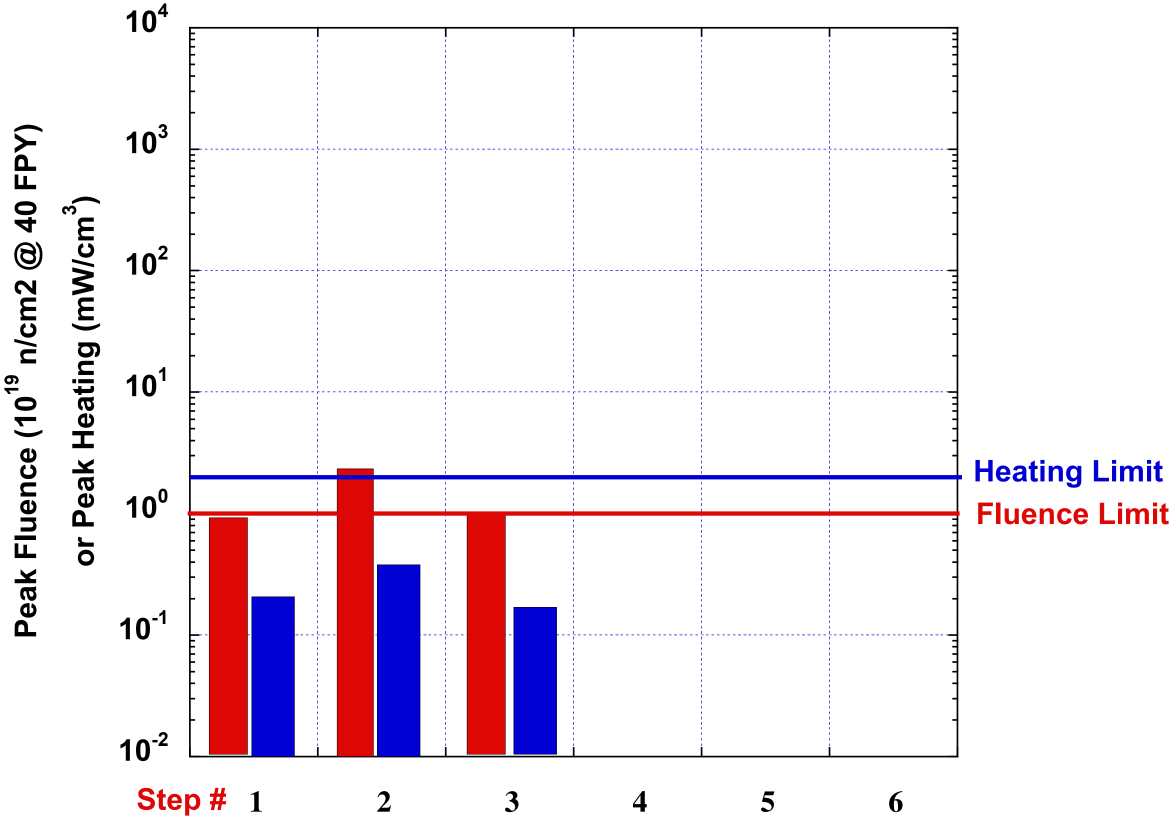
40 cm VV (H_2O and WC filler)

20 cm Skeleton Ring (80% ODS-FS, 20% He)

4 cm HT shield (He cooled)

ARIES-ACT-SiC Inboard Options (Cont.)

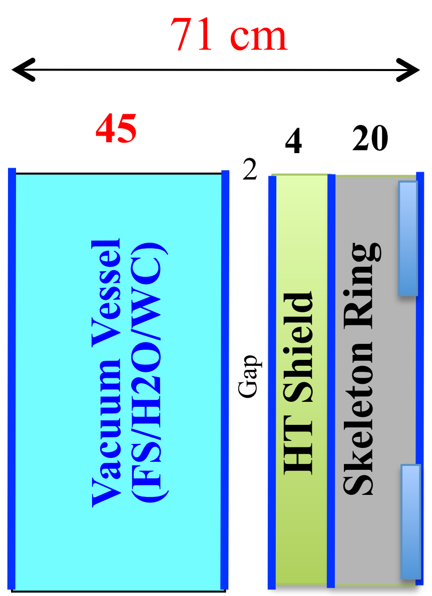




ARIES-ACT Parameters with:
45 cm VV (H_2O and WC filler)
4 cm HT shield
20 cm Skeleton Ring

ARIES-ACT-SiC Inboard Options (Cont.)

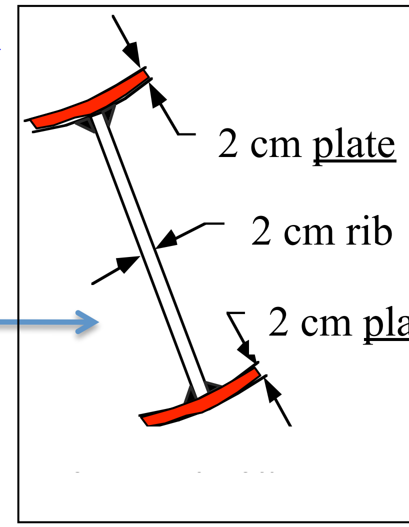
Step # 3

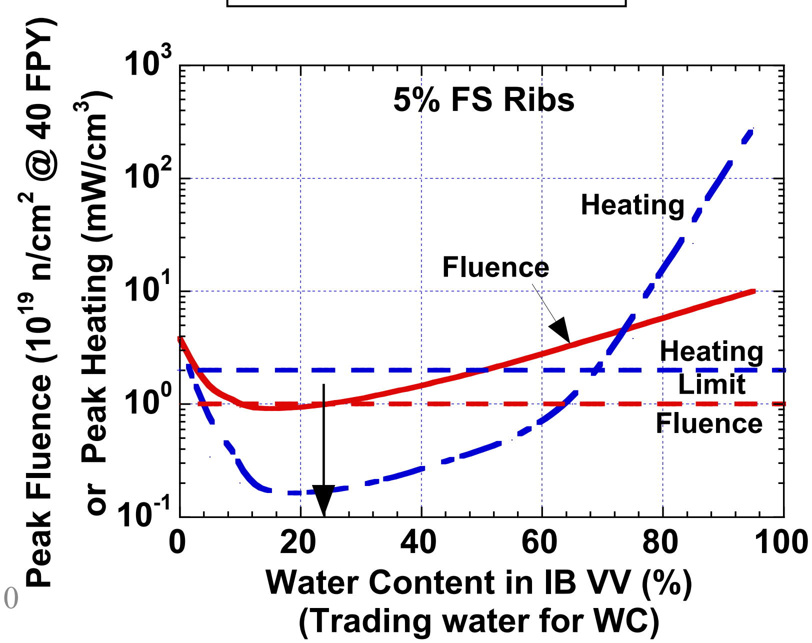


ARIES-ACT Parameters with:
45 cm VV (H_2O and WC filler)
4 cm HT shield
20 cm Skeleton Ring

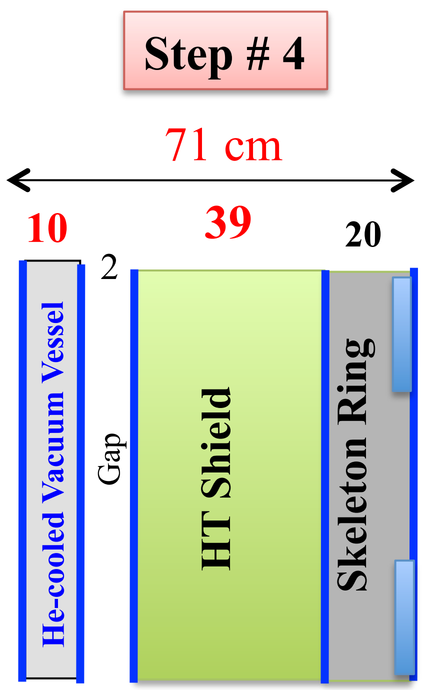
ARIES-AT VV

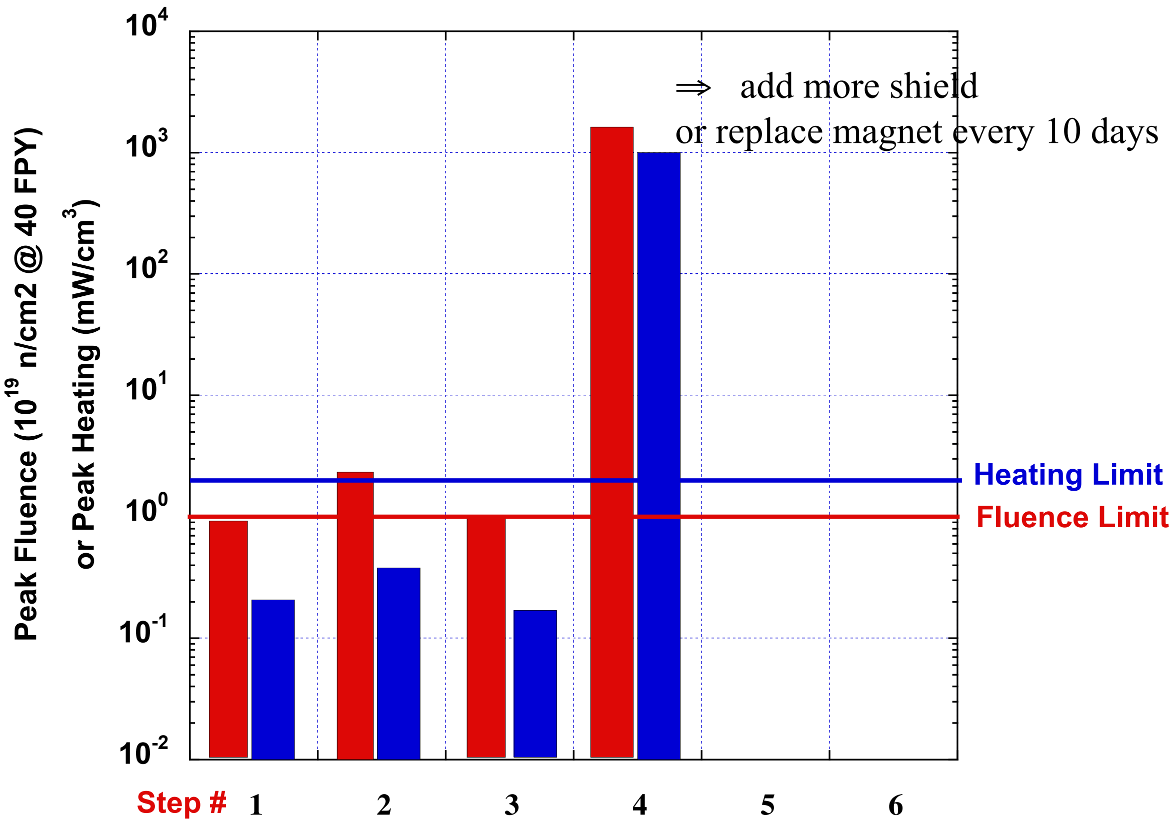
H_2O and WC
with 5% FS ribs





ARIES-ACT-SiC Inboard Options (Cont.)





ARIES-ACT

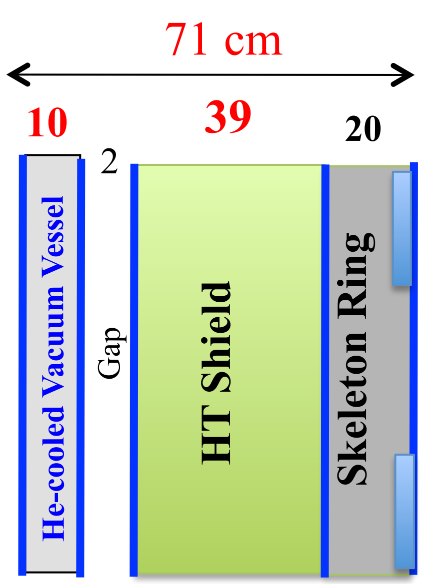
10 cm He-cooled VV

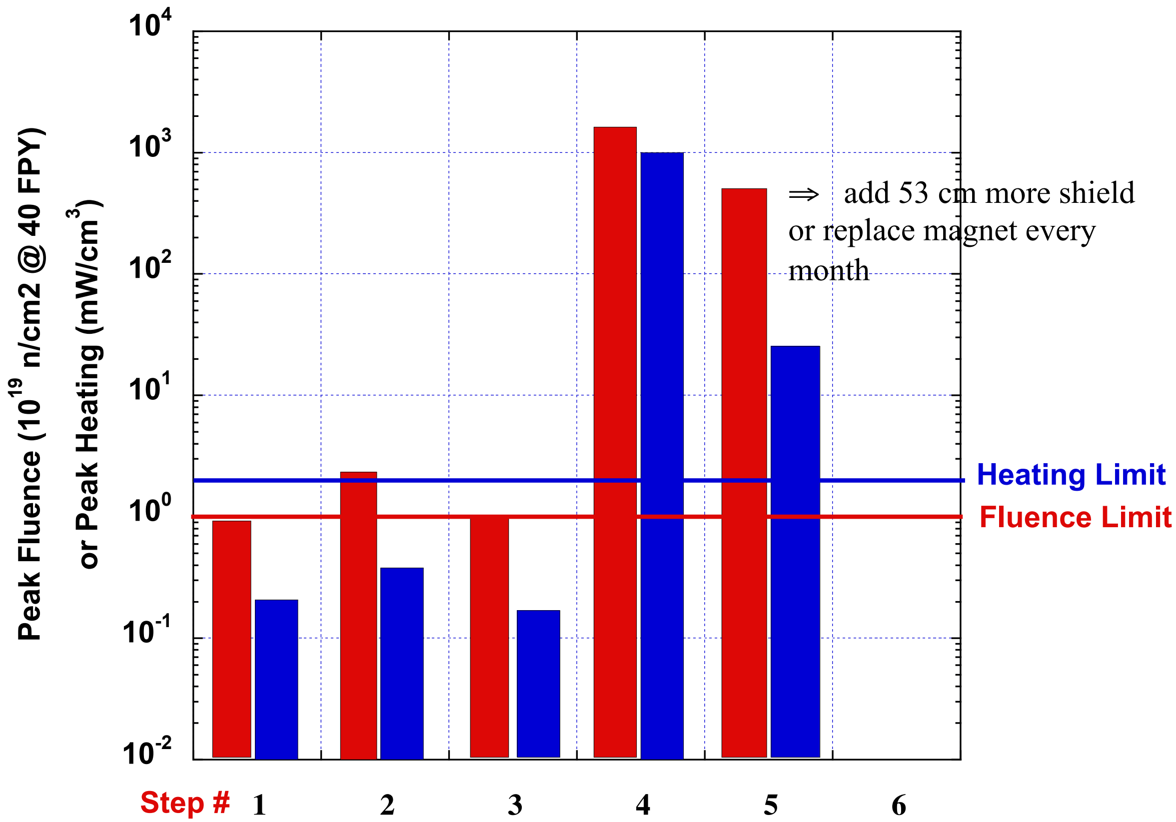
39 cm HT shield (FS/He; 90/10)

20 cm Skeleton Ring (FS/He; 80/20)

ARIES-ACT-SiC Inboard Options (Cont.)

Step # 4





ARIES-ACT

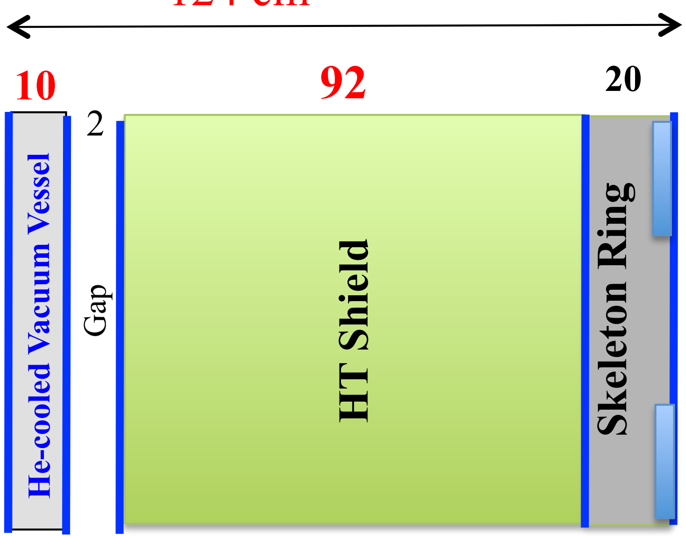
10 cm He-cooled VV

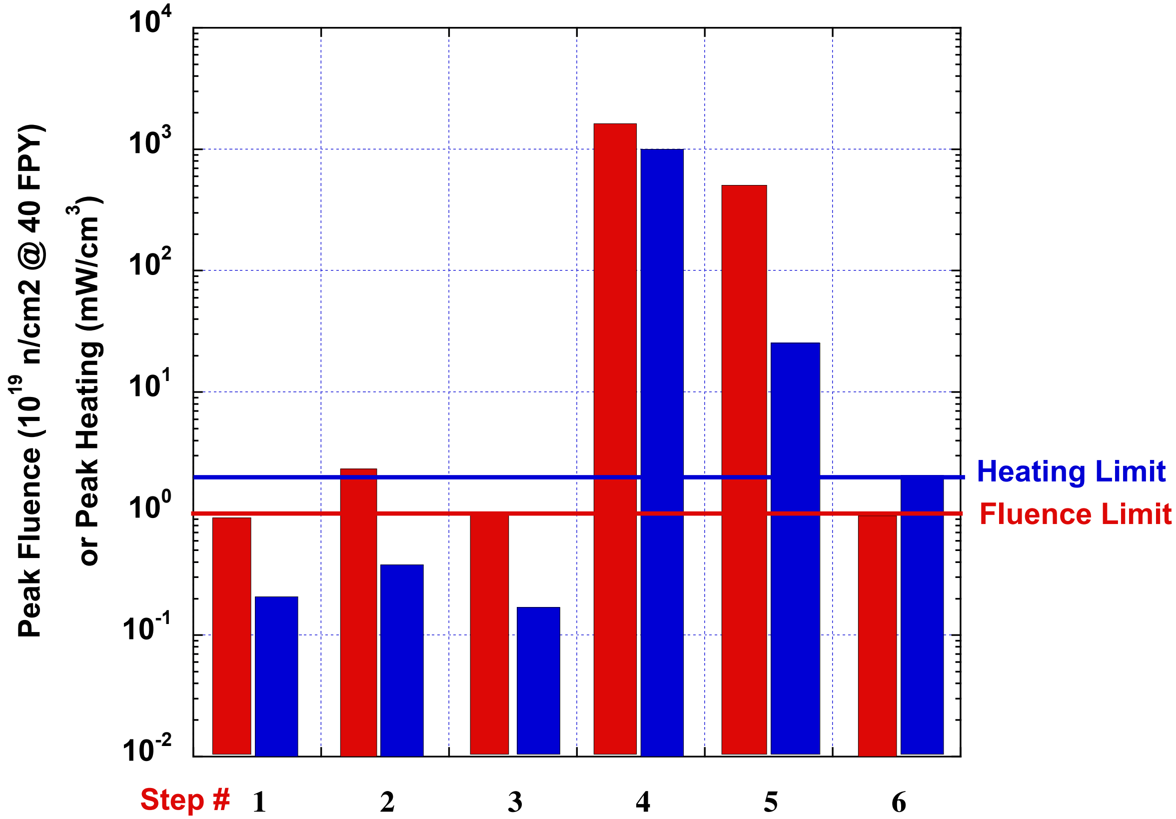
39 cm HT shield (FS/B-FS/He; 20/70/10)

20 cm Skeleton Ring

ARIES-ACT-SiC Inboard Options (Cont.)

Step # 6





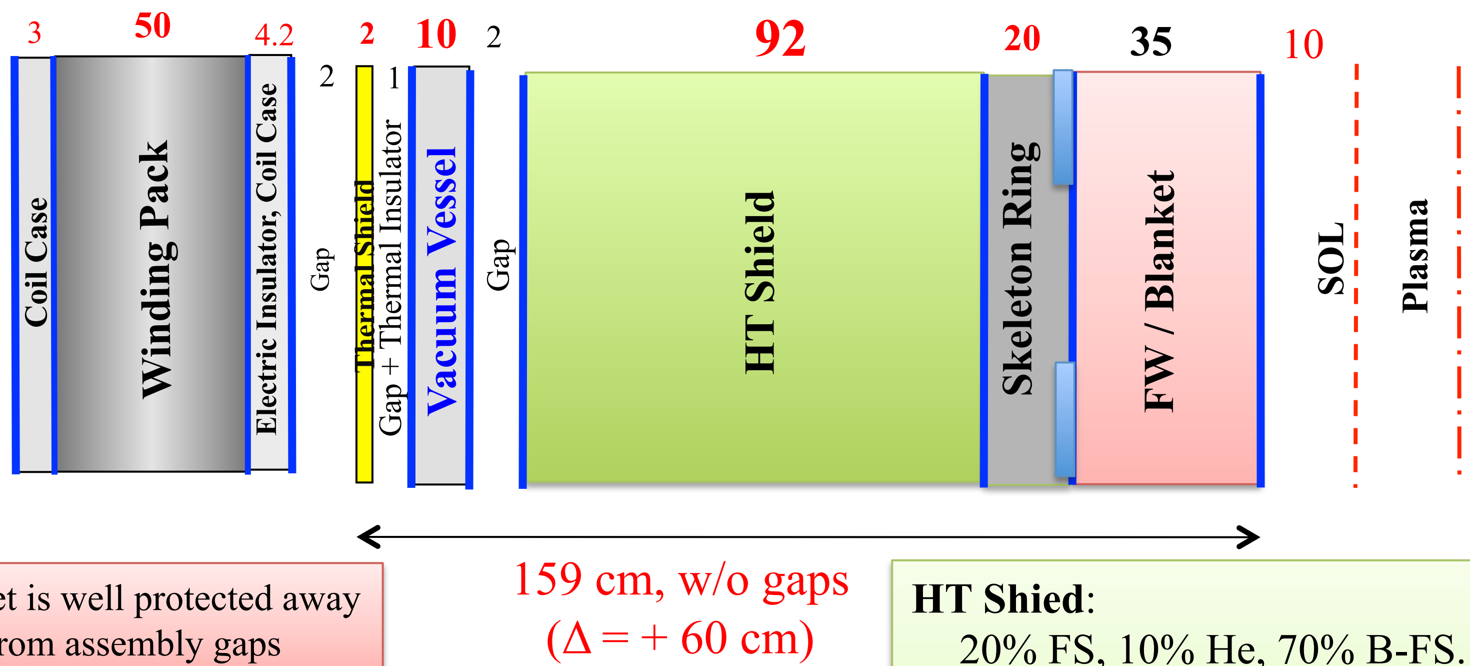
ARIES-ACT

10 cm He-cooled VV

92 cm HT shield (FS/B-FS/He)

20 cm Skeleton Ring

92 cm Thick He-Cooled IB Shield Protects Magnets of ARIES-ACT-SiC



Magnet is well protected away from assembly gaps

HT Shied:
- 20% FS, 10% He, 70% B-FS.
- Permanent component
- Not reweldable.
- Impact of n streaming through gaps TBD.

Vacuum Vessel:
- 10 cm thick FS/He (90/10).
- Permanent component (< 1 dpa peak).
- Reweldable (< 0.01 He appm peak).
- Impact of n streaming through gaps TBD.

Skeleton Ring:
- 80% FS, 20% He.
- Replaceable every 10 FPY.
- Not reweldable.
- Impact of n streaming through gaps TBD.

Compositions

	Thickness (cm)	Composition (volume %)
FW/Blanket	35	6% SiC, 94% LiPb (LiPb @ 700 ^{o}C; 8.8 g/cm^3 density; $Li_{15.7}Pb_{84.3}$ with 70% Li enrichment)
Skeleton Ring	20	80% ODS FS, 20% He
HT Shield	92	20% MF82H FS structure, 70% B-FS Filler 10% He
Vacuum Vessel	10	90% 3Cr-3WV FS (or 316-SS) structure, 10% He
He-cooled Thermal Shield	2	20% steel, 80% He (@ 80-100 k)
Coil Case	3	95% JK2LB steel, 5% LHe
Winding Pack (from ASC)	50	75% JK2LB steel, 12% Cu, 2% Nb_3Sn, 8.5% LHe, 2.5% GFF Polyimide

Conclusion

H_2O/WC-free VV

and

He-cooled shield

increase IB radial build by 66 cm