

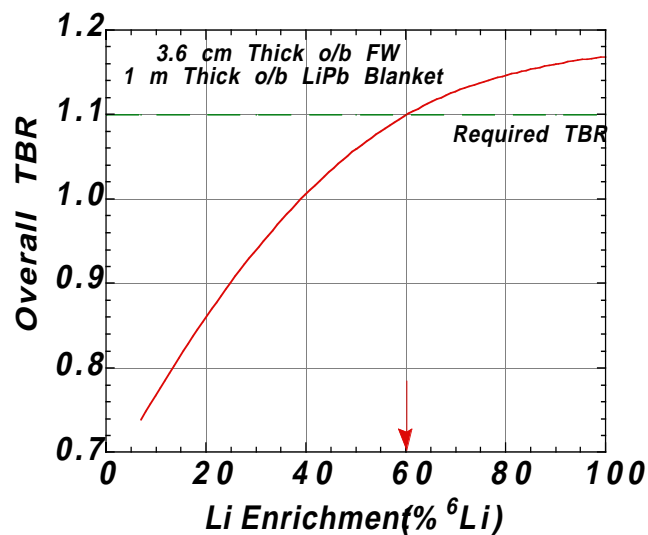
Final 3-D Neutronics Results

Laila El-Guebaly
Fusion Technology Institute
University of Wisconsin - Madison

ARIES E-Meeting
4 December 1998
PPPL

Nuclear Parameters

- 20 cm thick helium cooled i/b shield is optimal for ARIES-ST
- Overall **TBR= 1.1** (1 m thick LiPb/FS/SiC/He Blanket, 60% enriched Li)



- Overall **M_n= 1.11** (excluding heating of TF coil and LT div. shield)
- FW/B **End-of-Life Fluence= 18 MWy/m²** for FS
- **Lifetimes:**

o/b FW/Blanket/Manifolds	3 FPY
i/b FW/Shield	3 FPY
Div. Plates and Manifolds	3 FPY
 Center Post	 6 FPY
 TF-coil Shell	 40 FPY
PF Magnets	40 FPY
Div. HT and LT shields	40 FPY

Nuclear Heat Loads to All Components



($P_f = 2859$ MW , $P_n = 2287$ MW)

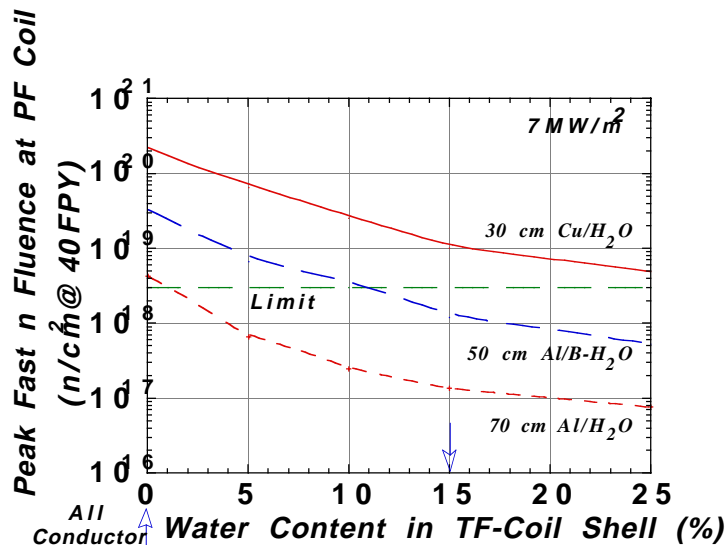
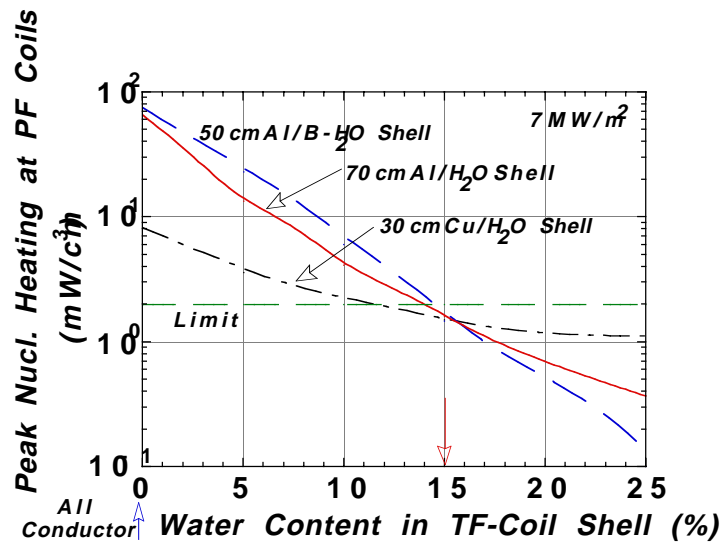
<u>Nuclear Heating (MW)</u>	<u>Inboard</u>	<u>Outboard</u>	<u>Divertor</u>	<u>Total</u>
Inboard W Shells	71	----	----	71
FW or Div. Plates	18	100	42	160
Blanket	----	1929	----	1929
Manifolds	----	15	64	79
Shield	199	-----	95	294
Total	288	2044	201	2533
				($\Rightarrow M_n=1.11$)
Surface Heating	117	198	345	660
Total Thermal Power	405	2242	546	~3200

Low Grade Heat (MW):

CP	164	
TF-coil Shell	39	(21 in collar + 18 in shell)
Total in TF coil	203	
Div. LT Shield	8	
Total	211	(9% of P_n or 6% of P_{th})

Radiation Damage to PF Coils

- PF coils 1,2 are well protected by HT and LT divertor shields
- Outboard blanket and TF-coil shell protect PF coils 3,4,5. One of following options should be considered to satisfy PF magnets radiation limits:
 - 30 cm thick Cu/H₂O (85/15) TF-coil shell
 - 50 cm thick Al/B-H₂O (85/15) TF-coil shell
 - 70 cm thick Al/H₂O (85/15) TF-coil shell



Radiation Streaming Through NBI

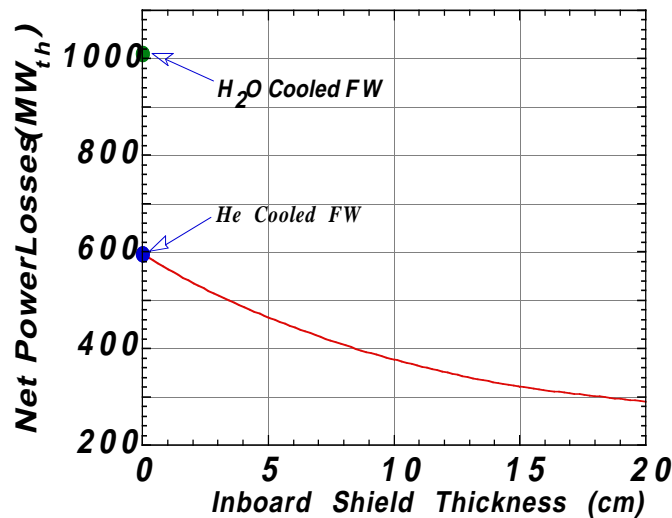
- 2 NBI's were included in 3-D model
- NBI sets on insulator between upper and middle TF-coil shells
- Neutrons streaming through NBI will induce swelling in insulators
- Swelling depends on insulator type and fluence level
- Spinel has high radiation resistance to swelling (compared to BeO, Al₂O₃, MgO)
- 10²² n/cm² fast n fluence ($E_n > 0.1$ MeV) results in 1% swelling in spinel
- 3-D calculations indicate that fast n flux ($E_n > 0.1$ MeV) at insulator is 5×10^{12} n/cm²s, resulting in < 1% swelling at end of plant life (40 FPY). This means spinel will exhibit no significant change in volume and will not cause any stress problem to TF-coil shell.

20 cm Thick He-Cooled Inboard Shield is Optimal for ARIES-ST

- Inboard power losses (and thus COE) minimize near 20 cm thick shield
- Net i/b power losses (in MW_{th})=

$$P_{\Omega}/\eta + NH_{CP} + PP/\eta - [SH + NH_{FW/Shell} + NH_{shield} + 0.9 PP]$$

where P_{Ω} is CP Joule losses,
 η is thermal conversion efficiency,
SH is Surface Heating,
NH is Nuclear Heating,
PP is He Pumping Power (90% of PP is recovered as thermal heat)



- Designs with i/b shields thinner than 20 cm will have higher COE (and lower breeding, higher CP damage, shorter CP lifetime, higher Cu radwaste stream, and higher CP decay heat)