UW Blanket Activity

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ARIES Project E-Meeting
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UCSD

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- Expected overall TBR and Mn for SiC system

Preliminary Design Parameters

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Average OB heat flux	0.7 - 1 MW/m2
max OB NWL	7 - 10 MW/m2
max SiC/SiC temp.	1100 – 1400 oC
Breeder exit temp.	~ 1000 oC
SiC/SiC thermal conductivity	20 – 30 W/mk
FW location at midplane – IB , OB	3.5 , 6 m
Top/bottom FW radii – IB , OB	3.5 , 4 m

FW Design Characteristics

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- FW design is still evolving
- FW consists of array of bundles overlapped toroidally to intercept surface heat flux
- Horizontal cross sections at midplane (R = 6 m) and at top/bottom ends (R = 4 m) are shown in Figs. 1 and 2
- Single FW bundle (shown in Fig. 3) consists of set of twisted tubes surrounding a straight central tube
- Breeder flows poloidally in SiC/SiC tubes.
- Tube wall is 0.3 cm thick and breeder tube diameter is 1 cm
- Number of tubes and dimensions will be optimized later
- Plasma facing FW surface needs protective coating. Few mm of SiC (or Be) coating could be sprayed on FW in factory or in-situ
- FW design is also applicable to divertor system

Fig. 1. IB or OB FIRST WALL AT MIDPLANE

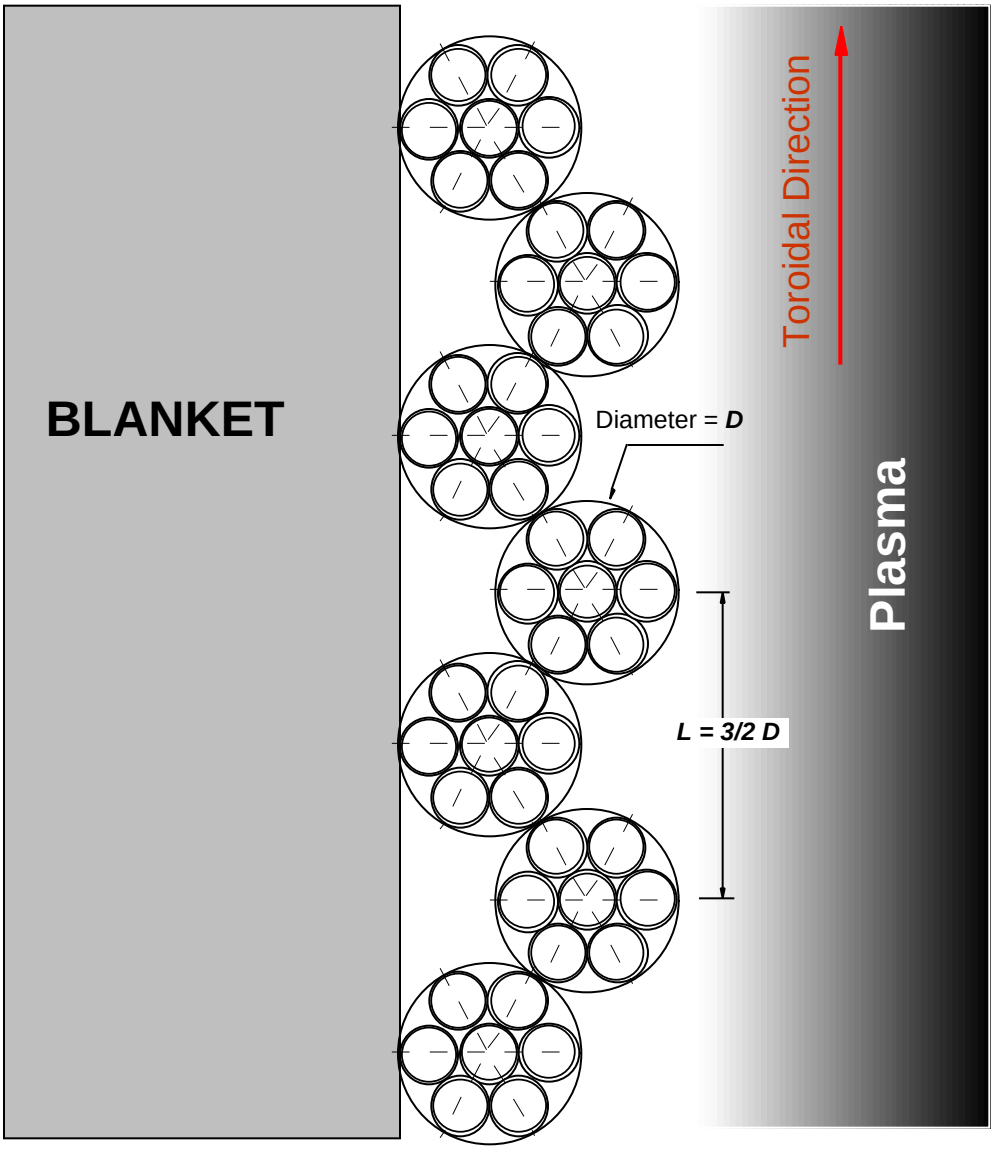

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Fig. 2 OB FIRST WALL AT TOP/BOTTOM

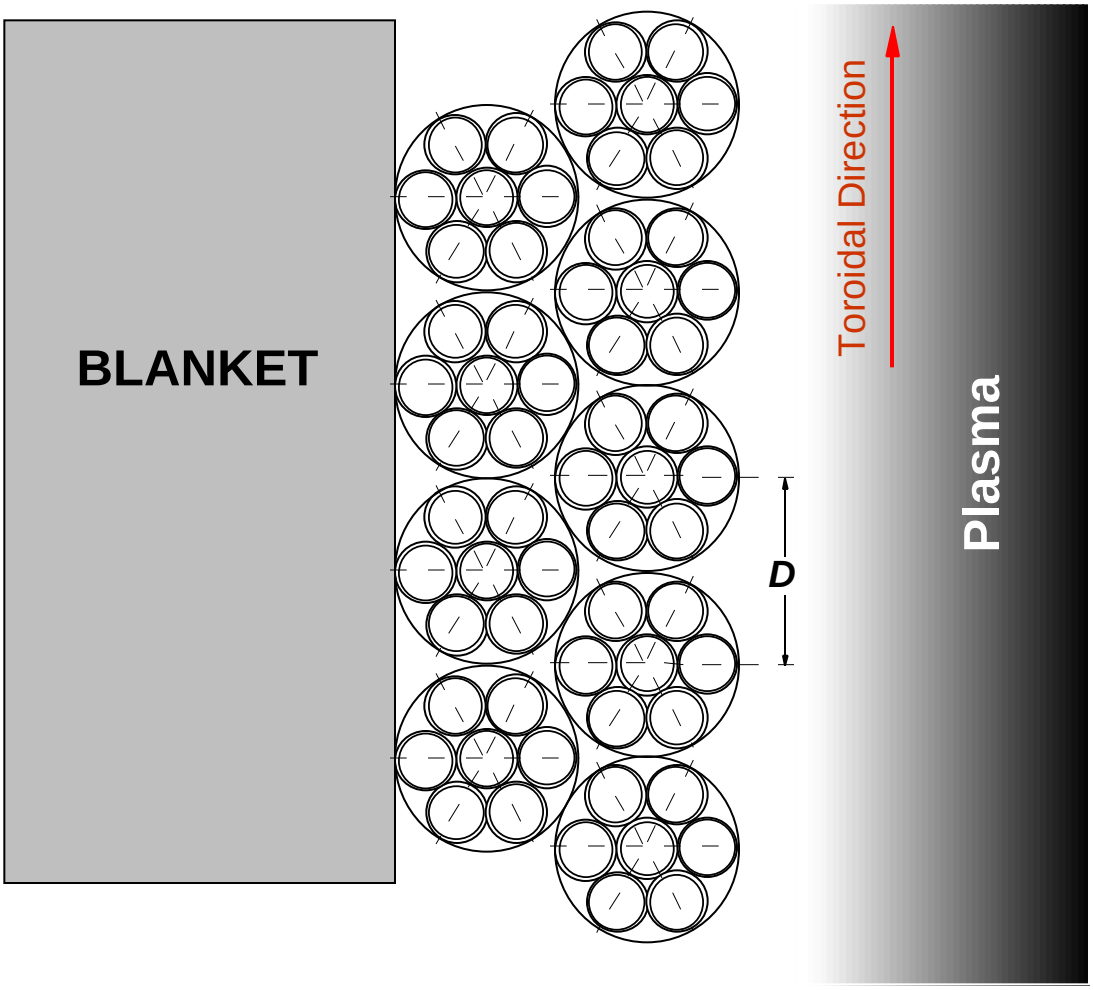
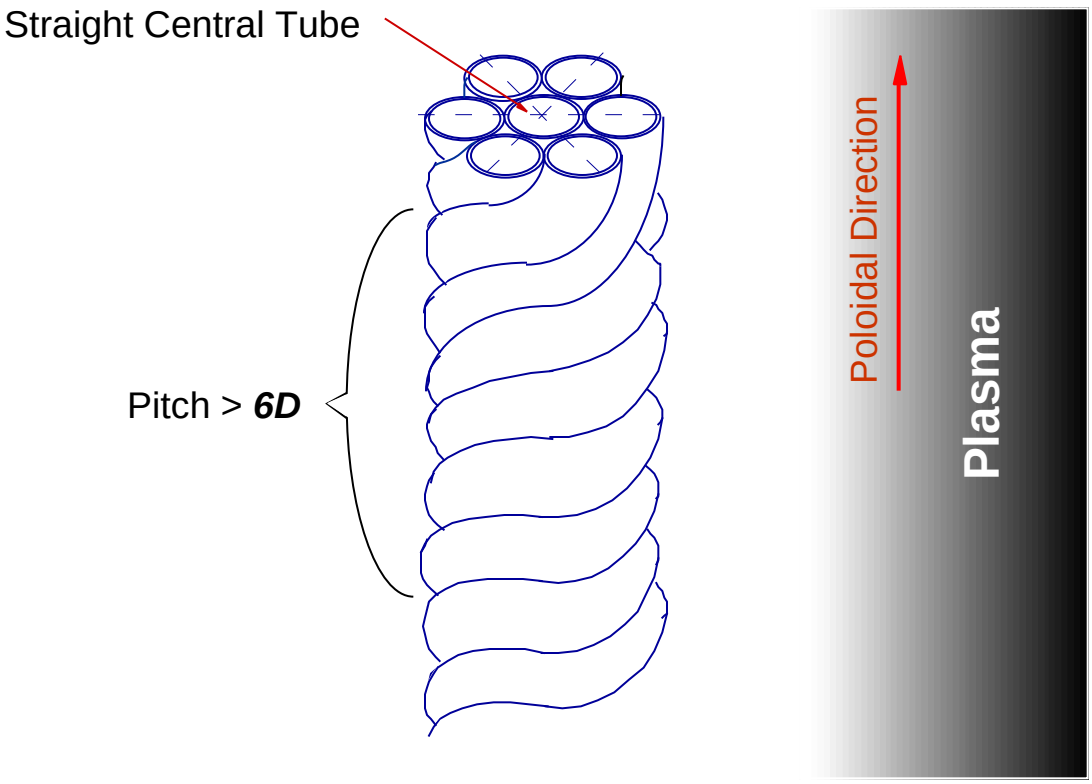


Fig. 3 Bundle of Twisted Tubes



Blanket Design Characteristics

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- Blanket design is at an early stage of development

- Currently investigating two blanket options:

  – Breeder flowing poloidally in square cells
    (similar to ARIES-ST and Tauro designs)

  – Stagnant breeder pool with:
    - large bubbling of helium for tritium extraction
    - coolant flowing in SiC channels for heat removal .

- No decision has been made yet on preferred option.

FW/Blanket Design Issues

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	Expected values
- Heat flux handling capacity	> 1 MW/m2
- Thermal conversion efficiency	50 – 60%
- Max temp. of SiC/SiC structure	1400 oC
- Max. temp. of breeder	1000 oC
- Optimum FW composition/dimension	
- FW spray coating: SiC or Be	
- FW outgasing	
- Manifolding and attachments	
- Accommodation of Kink stabilizing shell	
- Blanket segmentation	
- Flowing or stagnant breeder in blanket	
- Compatibility of breeder with SiC at high temp.	
- SiC content in blanket	10 - 20%
- IB blanket thickness	20 - 50 cm
- OB blanket thickness	50 - 80 cm
- Breeding capacity of candidate breeders	
- Others ?	

Breeding Potential of LiPb and LiSn Breeders

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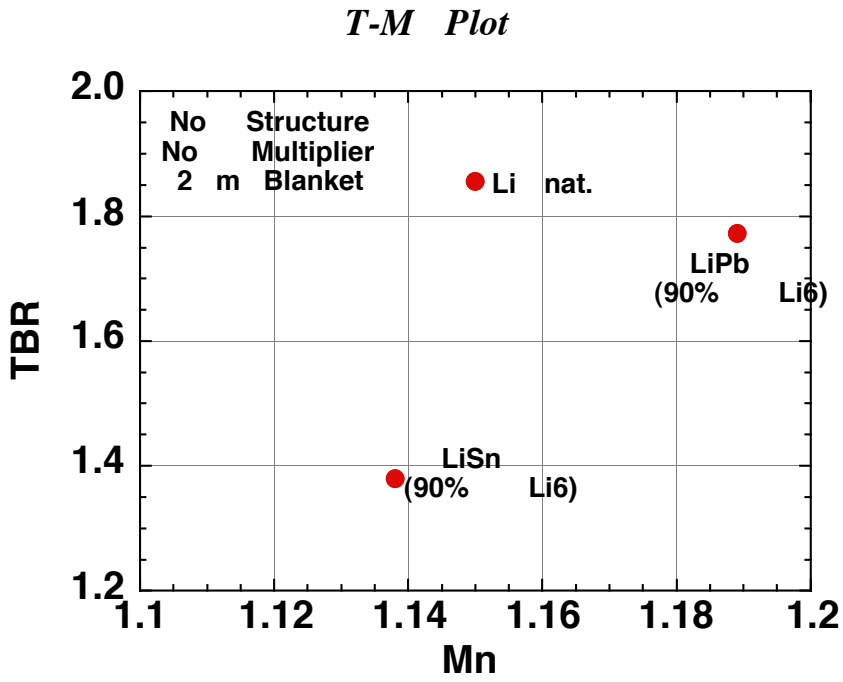

- Li25Sn75 has lower breeding potential than Li17Pb83
- LiPb and LiSn with natural Li have TBR of 1.6 and 0.5, respectively
- FW/Blanket structure, penetrations, and geometry will degrade overall TBR to 1.1 or less

Breeding Capacity of LiPb and LiSn in Realistic Design

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- Starting dimension/composition:
  - 20 cm thick IB blanket and 50 cm thick OB blanket (ARIES-RS type blanket)
  - 15 % SiC structure in blanket
  - 90% enriched Li
  - 5 cm thick FW (2 cm SiC, 3 cm LiPb)
- No breeding blanket behind divertor
- Breeder-cooled divertor and HT shield
- Required TBR = 1.1
- Results:

Breeder/structure	**LiPb/SiC** (85/15)	**LiSn/SiC** (85/15)	ARIES-RS **Li/V** (90/10)
Overall TBR	1.07	0.85	1.1

- To increase TBR:
  - Thicken blanket
  - Reduce SiC content in blanket
  - Reduce SiC content in FW

TBR of LiPb/SiC and LiSn/SiC Blankets

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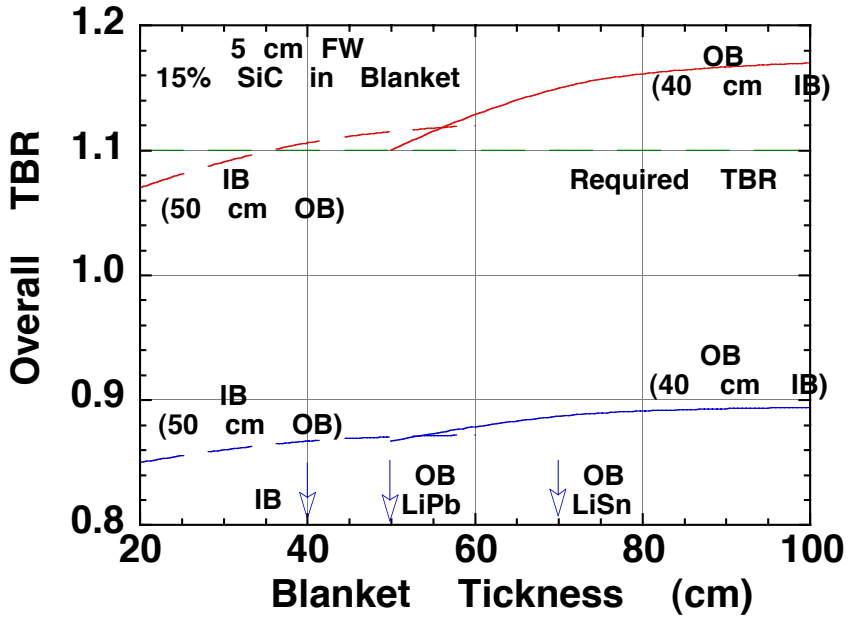

- LiPb/SiC blanket satisfies breeding requirements with:
  - 40 cm thick LiPb/SiC IB blanket
  - 50 cm thick LiPb/SiC OB blanket
  - 15% SiC structure in blanket
  - 5 cm thick LiPb/SiC FW

- LiPb/SiC blanket has ~5% excess breeding capability

- LiSn/SiC blanket does not meet breeding requirements. Thick blankets increase TBR to ~ 0.9:
  - 40 cm thick LiSn/SiC IB blanket
  - 70 cm thick LiSn/SiC OB blanket
  - 15% SiC structure in blanket
  - 5 cm thick LiSn/SiC FW

Sensitivity of TBR to SiC Content in Blanket

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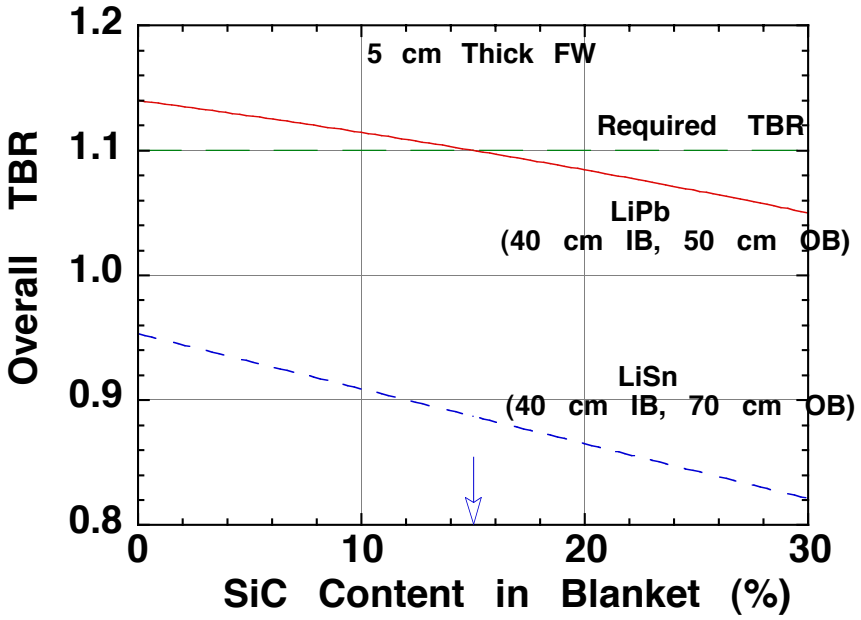

- If design calls for more (or less) SiC content than 15% in blanket, LiPb/SiC blanket thickness will be used to adjust TBR to 1.1

- LiSn/SiC blanket without SiC structure has TBR of 0.95

Sensitivity of TBR to SiC Content in FW

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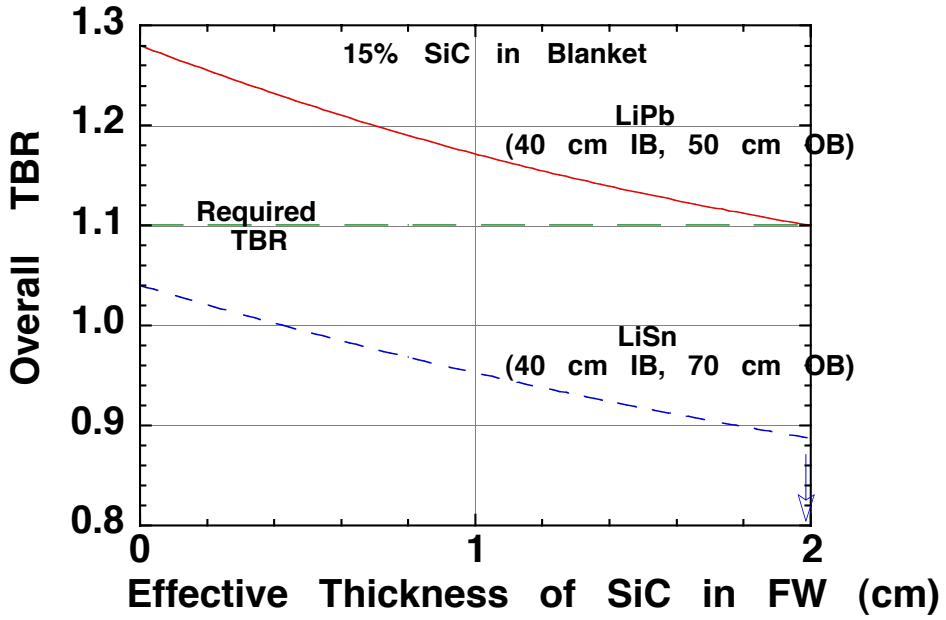

- SiC of FW has larger impact on breeding than SiC of blanket
- Each mm of FW SiC changes TBR by ~1%
- Lower SiC content in FW allows thinner OB LiPb/SiC blanket than 50 cm and/or higher SiC structure in blanket than 15%
- LiSn/SiC blanket will not breed unless SiC in BOTH FW and blanket is reduced to 1 cm.
- Is 1 cm SiC structure sufficient to support 40-70 cm thick LiSn blanket?

Conclusions

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- Proposed FW/blanket design potentially offers high heat flux handling capability and high thermal conversion efficiency
- LiPb/SiC blanket satisfy breeding requirements (TBR = 1.1) with excess breeding capability
- LiSn/SiC will not meet breeding requirements unless SiC structure is limited to 1 cm or less in both FW and blanket
- Beryllium multiplier could enhance breeding potential of LiSn/SiC blanket
- Overall Mn will not exceed 1.1 for both breeders, meaning larger machine than ARIES-RS (Mn = 1.2) for same net output power.