Needs for a Multiplier and Impact of Plasma Stabilizing Shell on TBR

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Outlines

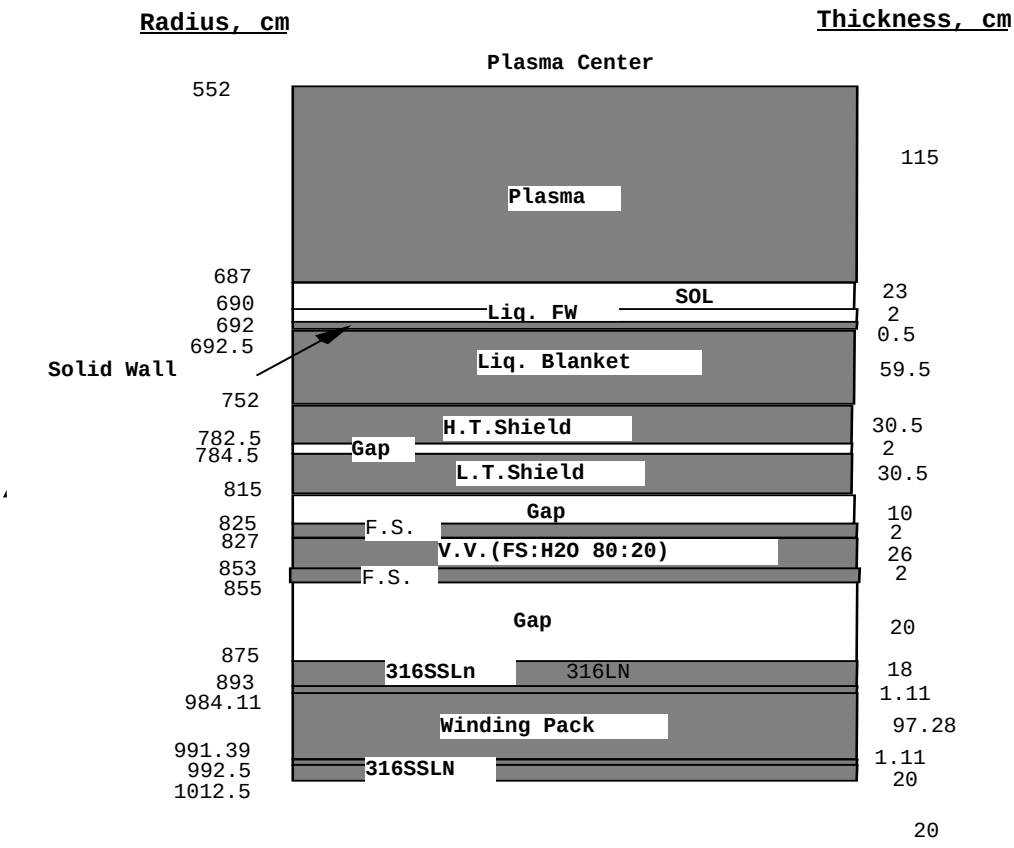
- Evaluate the local Tritium Breeding Ratio (TBR) in the CliFF Configuration with the combination of breeder/structure:

  Flibe/Ferritic Steel
  Flibe/SiC

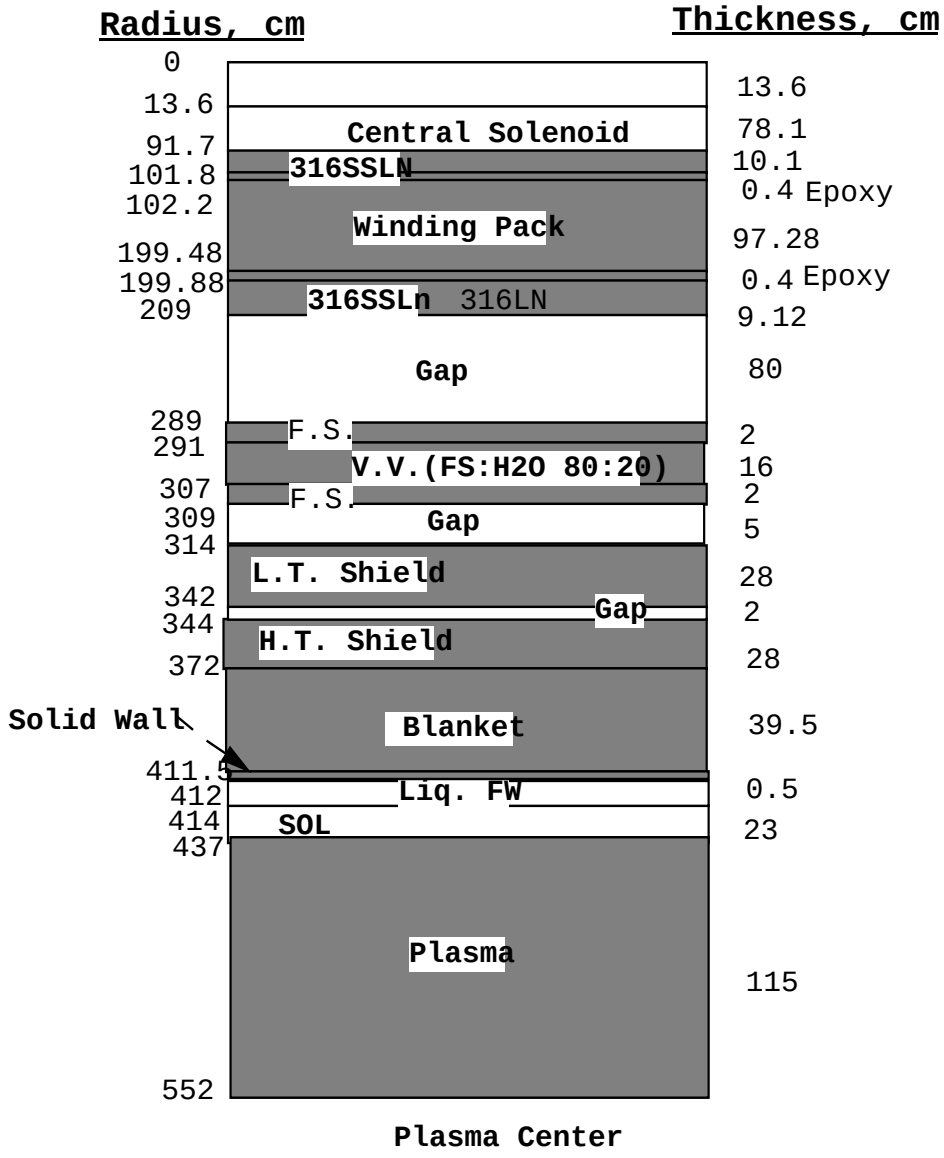
- Assess factors that affect local TBR

  - Li-6 Enrichment
  - Inclusion of a multiplier Zone (with Beryllium)

- Assess impact of inclusion of a plasma stabilizing shell at the FW on TBR



Radial Build of the O/B CLiFF Concept

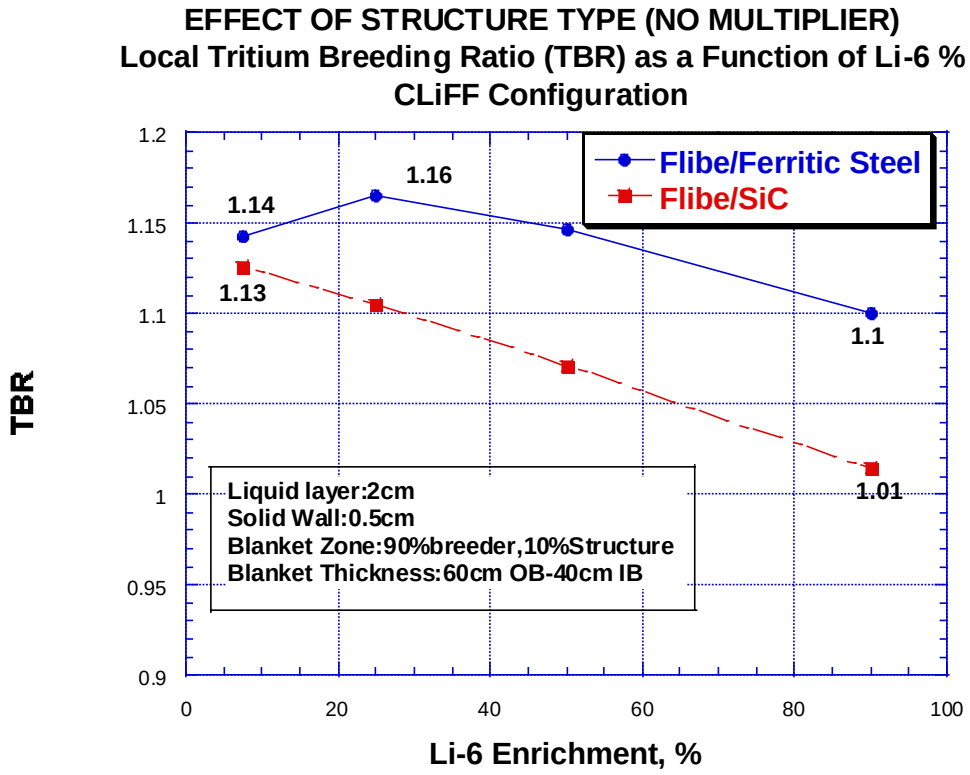


High Temp. Shield:15% strc.(V),80%strc.(FS),5
Low Temp. Shield:95% strc.(FS),5%Liq.
Blanket :90%Liq.,10%strc.

Radial Build of the I/B CLiFF Concept

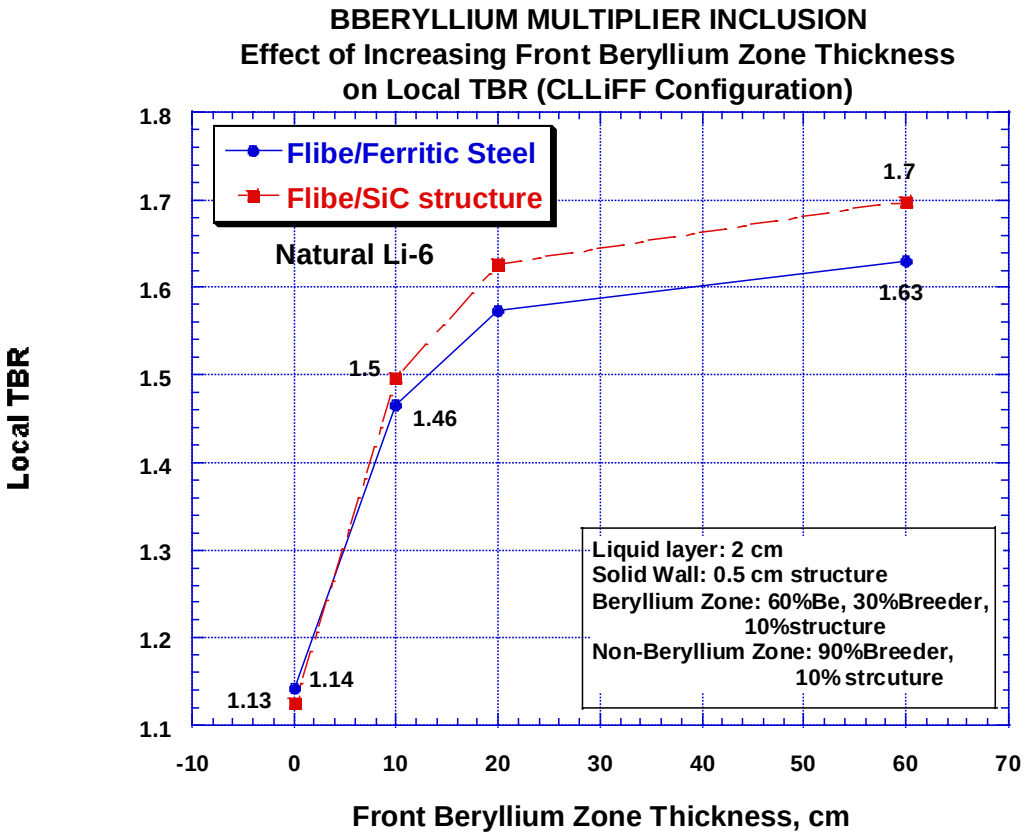
Effect of Structure Type on TBR (no Be multiplier)

- **Without a Beryllium Multiplier, local TBR is *marginal.***
- **Flibe/SiC combination gives lower TBR at all Li-6 enrichment than Flibe/Ferritic Steel combination**
- **Local TBR in the case of Flibe/SiC decreases with Li-6 enrichment whereas it peaks around 25% Li-6 enrichment in the case of Flibe/FS.**



Effect of Beryllium Multiplier on TBR

- **With Beryllium multiplier zone and *natural Li-6*, local TBR increases drastically as the front Be zone thickness increases.**
- **Effect of Beryllium is more pronounced in the Flibe/SiC combination than in the Flibe/F.S. case. Local TBR can be larger in with Flibe/SiC than with Flibe/F.S. (Contrary to the no Be case).**
- **At front Be zone thickness of ~10 cm, local TBR seems adequate (TBR = 1.5 with SiC, 1.46 with Ferritic Steel).**

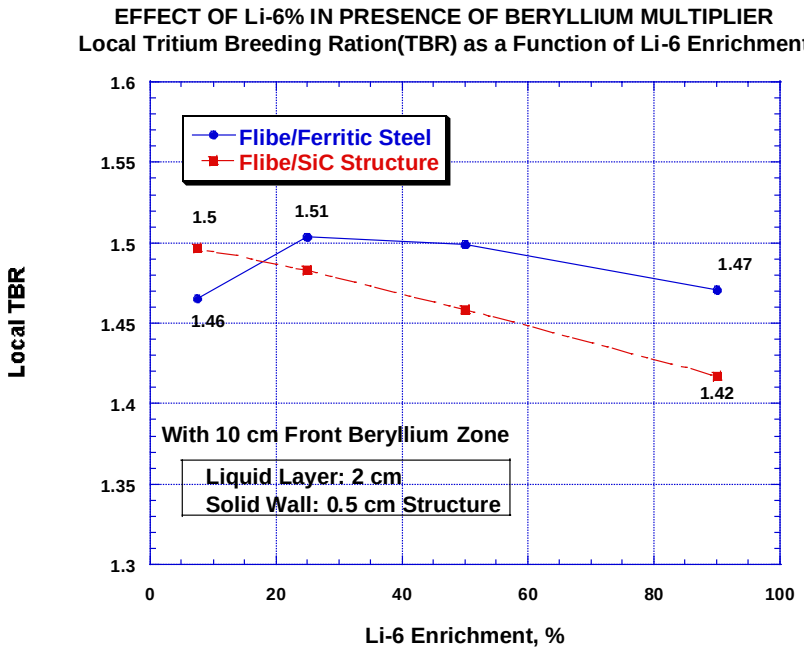


Effect of Li-6 Enrichment (With Be Multiplier)

- **Local TBR with Flibe/SiC still also decrease with Li-6 enrichment in the presence of 10 cm-thick Be multiplier zone. It maximizes around 25%Li-6 with the Flibe/SiC combination.**

General Remarks

- Inclusion of a front Beryllium multiplier zone is needed to improve tritium breeding with Flibe, especially with SiC structure.
- Enriching Li-6 has a adverse effect on local TBR if SiC is used as the structure
- In the Case of Flibe/SiC, adequate local TBR (~1.5) can be realized with a front Beryllium zone of 10 cm .

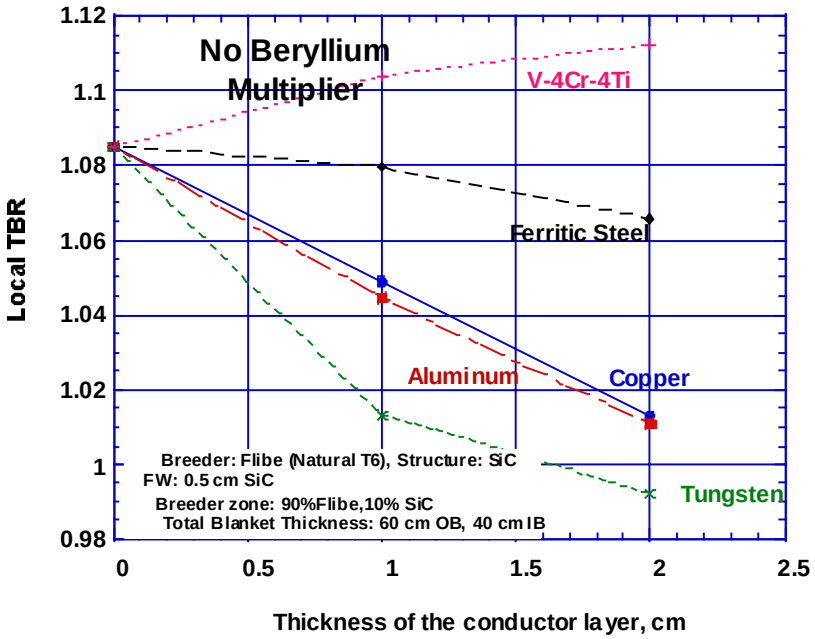


Factors Affecting TBR upon Inclusion of a Plasma Stabilizing Shell at First Wall

- Location of the conducting shell (in front of the FW or deeper in the blanket).
- The type of breeder and structure (e.g. in ARIES we have LiPb(90%Li-6)/SiC VS Flibe(25%Li-6)/FS in old CliFF design, and Flibe(natural)/SiC with a beryllium multiplier in recent CliFF design of APEX).
- The degree of lithium enrichment.
- The type of solid conducting shell (e.g. Cu, Al, FS, W, V alloy)
- Whether or not there is already a FW to act as a structural support and the conducting shell is placed in front of it.
- Whether or not there is a front beryllium-multiplying zone in the blanket.

Effect of Stabilizing Shell at FW on TBR in Flibe/SiC System (No Be Multiplier)

- **Removal of the liquid conductive shell itself (2m thick) leads to ~4% drop in TBR (from TBR=1.13 to TBR=1.09).**
- **Including a tungsten shell at the first wall has the worst impact on TBR. TBR drop by ~ 9% at d=2m. The absolute value for the TBR drops below unity (TBR=0.99)**
- **The inclusion of a vanadium shell improves TBR by +3% in this system (natural Li) at d=2cm.**

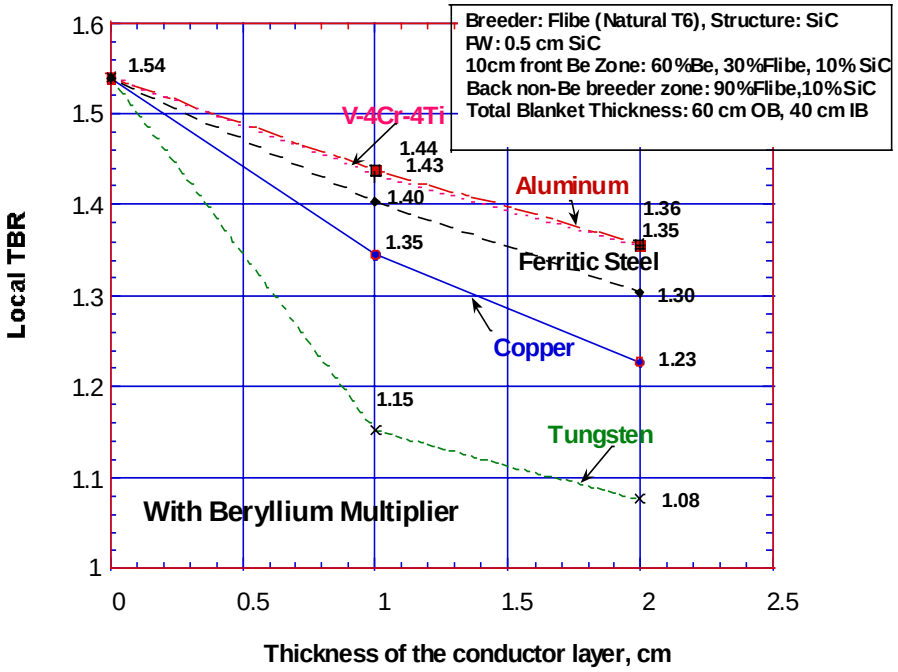


The % change in TBR upon including a conducting shell of thickness d (Flibe with natural Li/SiC structure- no Be multiplying zone)

Material of Conducting shell	d= 1 cm	d=2 cm
Cu	-3.4%	-6.6%
Al	-3.7%	-6.8%
Ferritic Steel	-0.51%	-1.8%
W	-6.6%	-8.6%
V	+1.8%	+2.5%

Effect of Stabilizing Shell at FW on TBR in Flibe/SiC System (With Be Multiplying Zone)

- **Removal of the liquid convective layer itself (2m thick) leads to an increase TBR by ~3% (from TBR=1.5 to 1.54).**
- **Placing W as a conducting shell at the FW in front of the beryllium multiplying zone gives the largest adverse impact on TBR (up to ~-30% for 2 cm shell). The least impact is with V and Al conductors (~-12% for 2 cm shell).**



The % change in TBR upon including a conducting shell of thickness d (Flibe with natural Li/SiC structure- with 10 cm front Be multiplying zone)

Material of Conducting shell	d= 1 cm	d=2 cm
Cu	-12.6%	-20.3%
Al	-6.5%	-11.8%
Ferritic Steel	-8.8%	-15.3%
W	-25.2%	-30%
V	-6.9%	-11.9%

Remarks

- In the latest CliFF design, a front beryllium multiplying zone (60%Be, 30%Flibe, 10% SiC) of a thickness of 10 cm is most likely to be adopted (optimized design is now in progress in APEX Task III). Natural lithium gives the largest local TBR (TBR=1.5).

- In Flibe/SiC system that deploys a beryllium multiplying zone, the presence of the convective layer degrades the multiplication effect of Be.

- In Flibe/SiC system with Be multiplier, using tungsten as the conducting shell gives the largest adverse impact on TBR (up to ~-30% for shell thickness d=2 cm) and the absolute value becomes TBR=1.08, which is not acceptable to meet tritium self-sufficiency condition.

- The least impact is with V and Al conductors (TBR drops by~-12% for 2 cm shell).