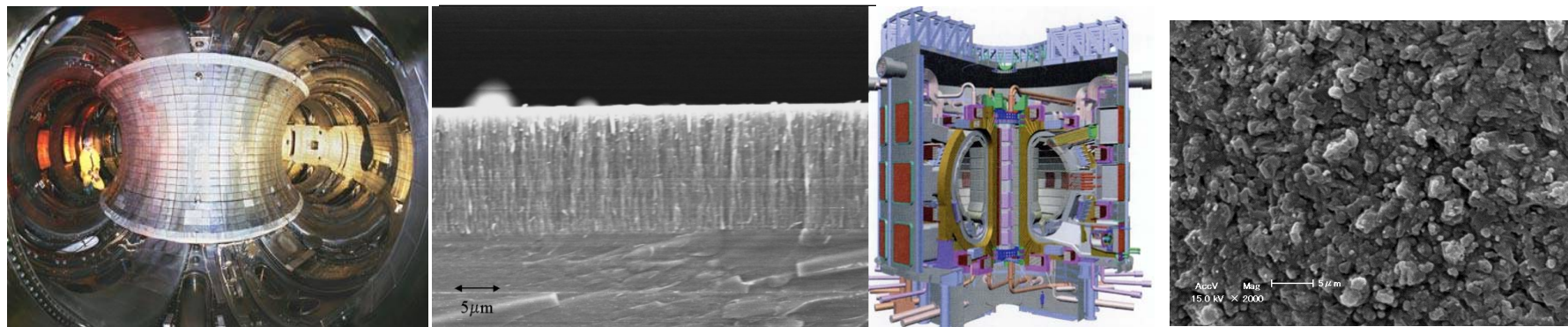


ダイバータおよびPWI合同研究会, 7月23日, 筑波大学



Liダイバータのトリチウムバランス に与える影響

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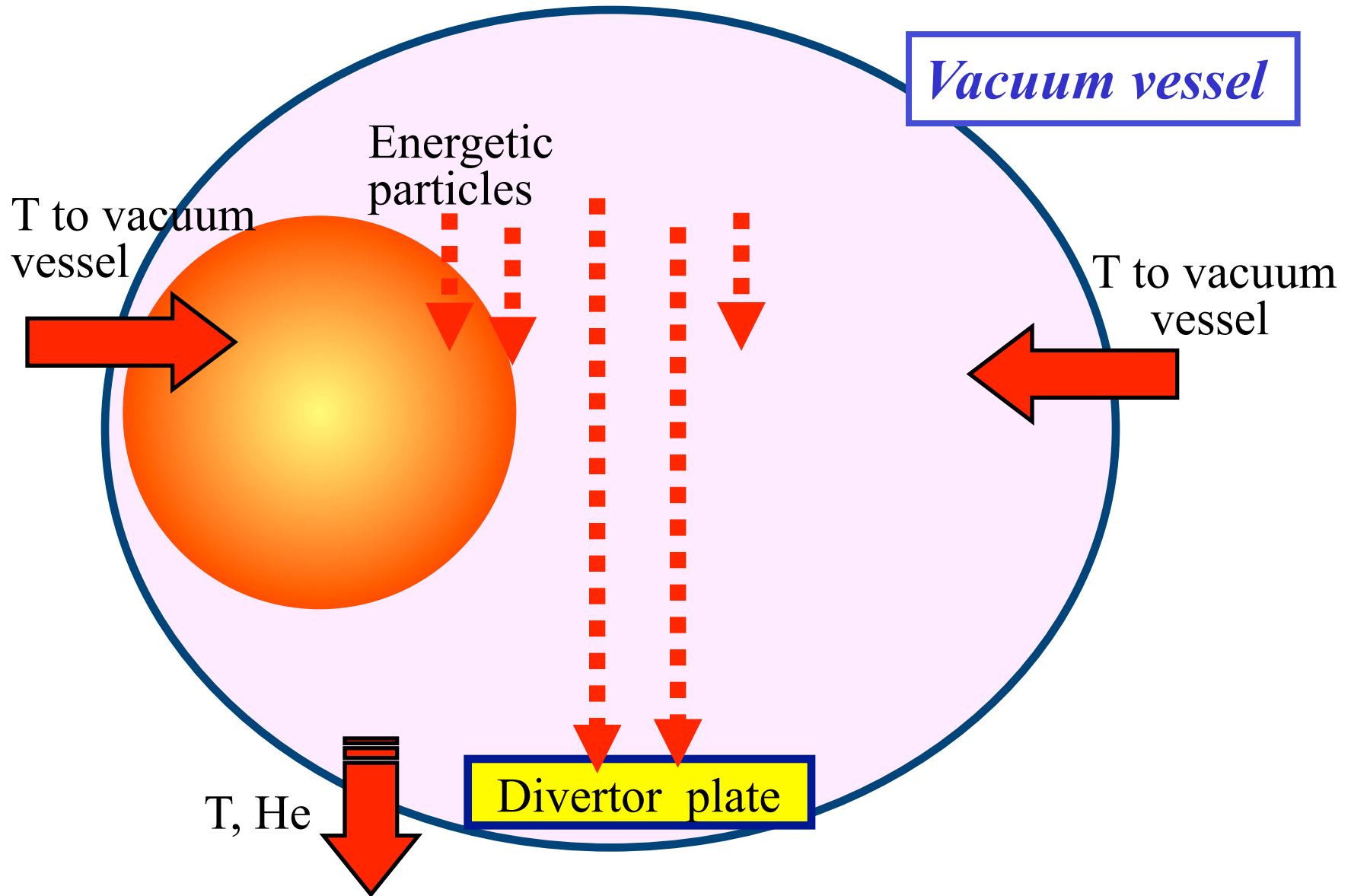


Figure Schematic diagram of Li flow in Li divertor system.

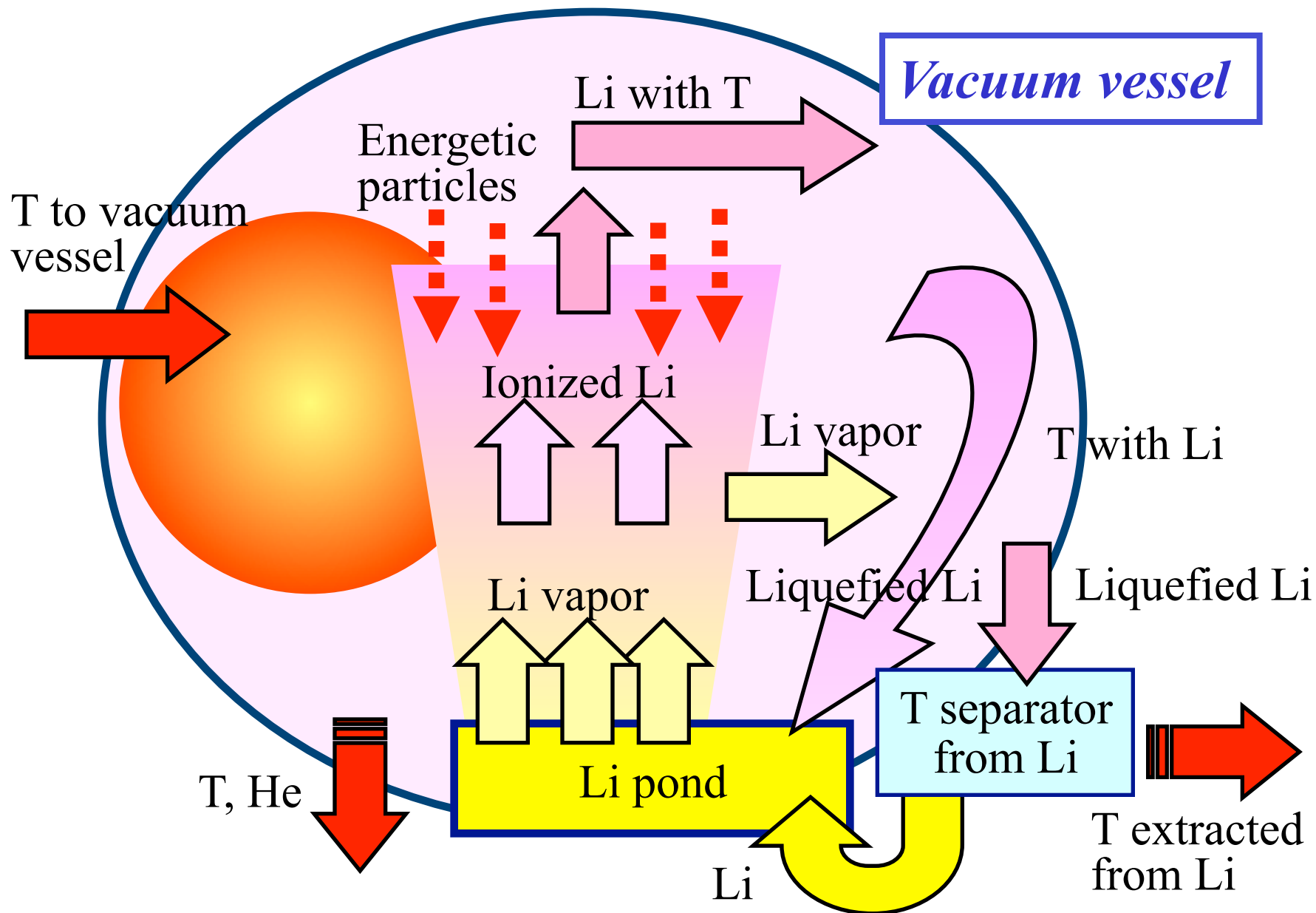
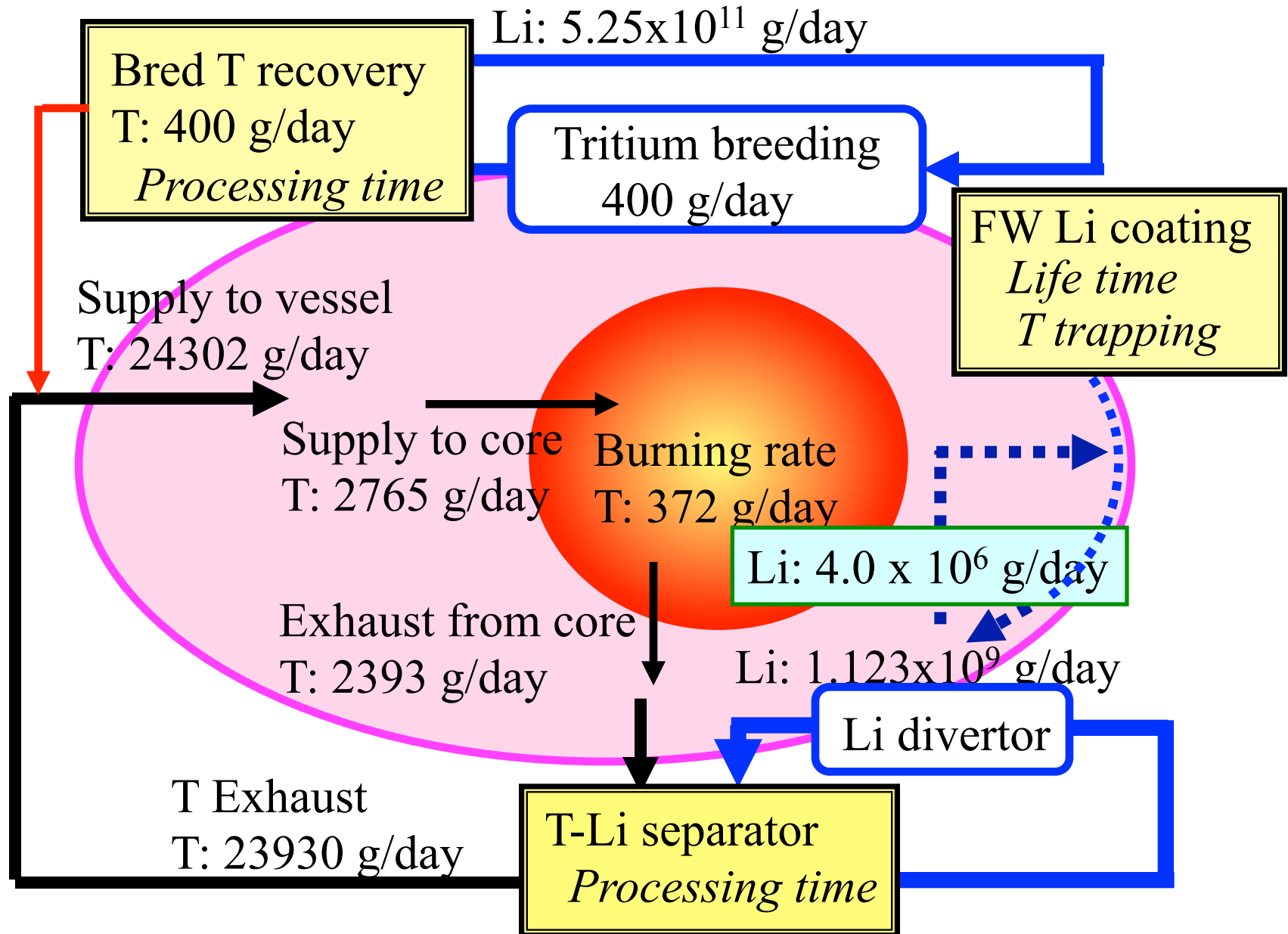


Figure Schematic diagram of Li flow in Li divertor system.

Tritium and Li flows in ST from Design by Nagayama



Li in NSTX (DR. M. Ono) 032712PPPL 1

Ionization of Li at the surface of Li protector placed on the bottom of the divertor which is in the liquid condition.

Fusion output is 3000 MW

Heat to divertor is 20% of output : 600 MW

The amount of ionization : 6 moles/s----- 42g/s ($\sim 4 \times 10^6$ g/day)

The amount of evaporation : 55 l/s-----24000 g/s ($\sim 2 \times 10^9$ g/day)

Tritium from divertor : 2.4×10^4 g/day (Trapping of T to Li : 100%)

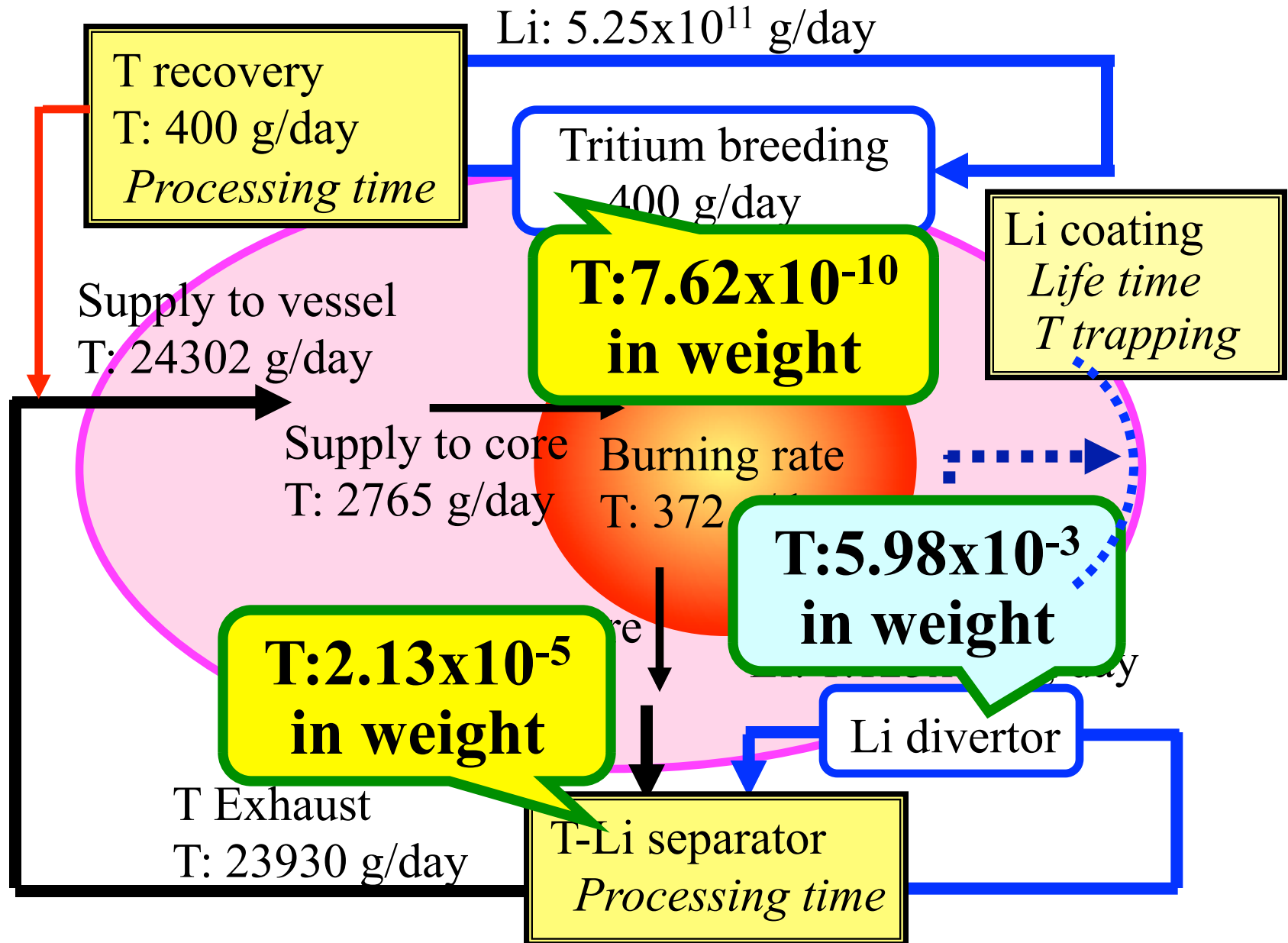
T concentration in Li : Evaporation dominant 1.2×10^{-5} in weight

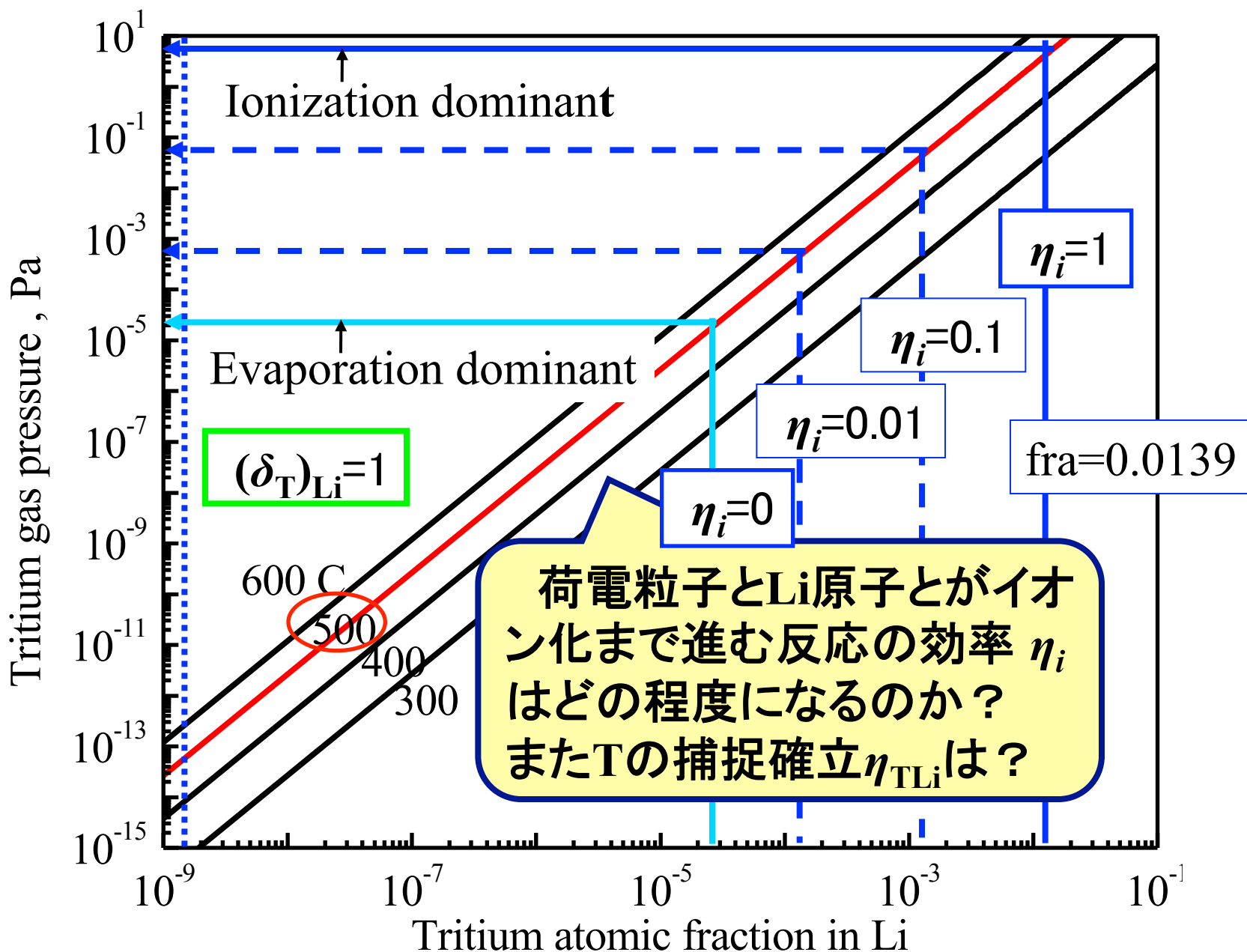
Radiation dominant 6×10^{-3}

Heat of evaporation 147 kJ/mol (~ 21 kJ/g)

Ionization energy 1.96×10^4 kJ/mol ($\sim 2.8 \times 10^3$ kJ/g)

Tritium and Li flows in ST from Design by Nagayama





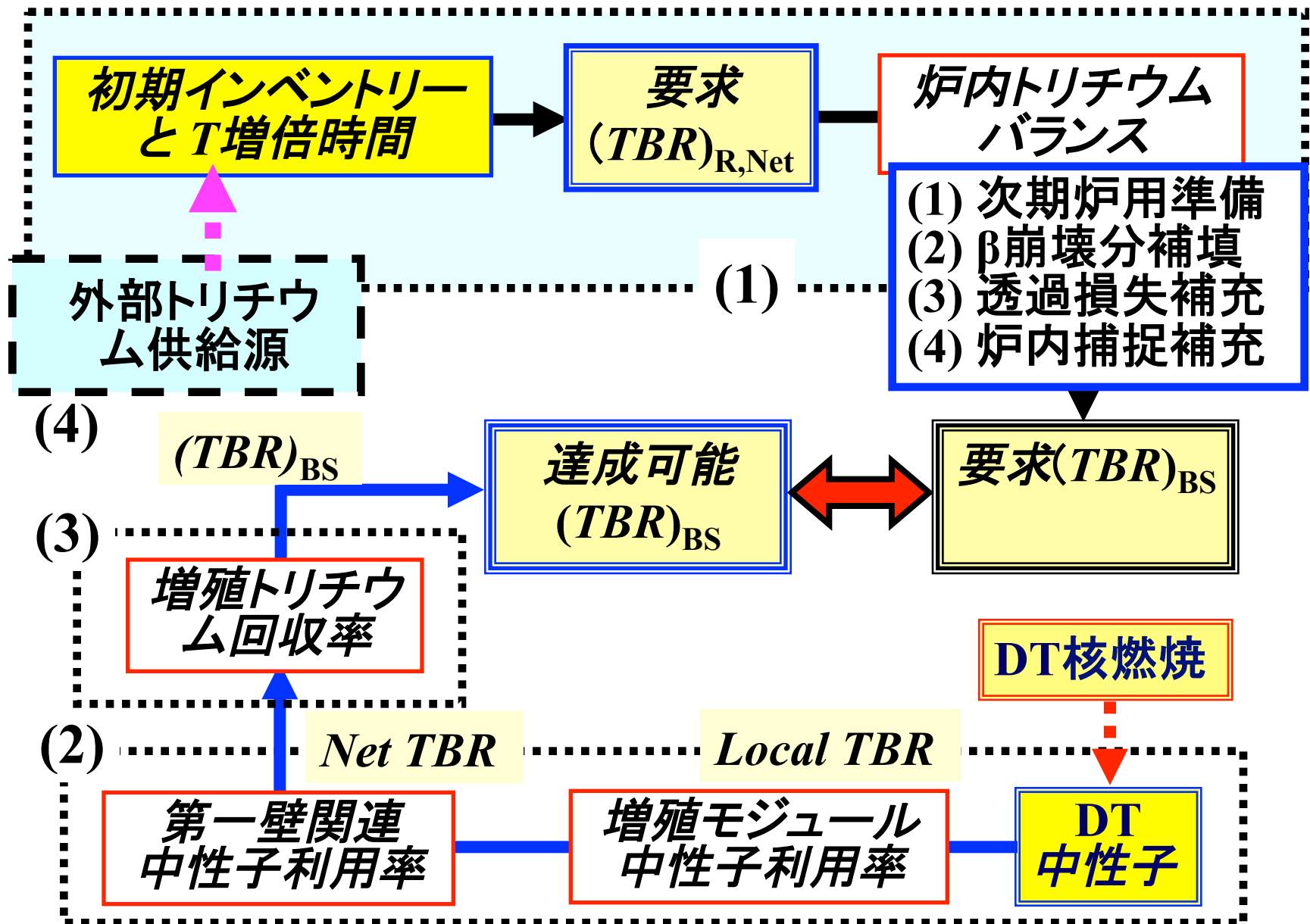


Figure Tritium required in a DT fusion reactor.

要求 $(TBR)_{BS}$ の主要因

(1) 次期炉用準備

炉の初期インベントリ（活性動的トリチウムインベントリ、貯蔵トリチウムおよび不活性トリチウムインベントリの和）をどれだけ期間をかけて準備するか。

(2) トリチウムの β 崩壊

炉内トリチウムインベントリの β 崩壊分(6.5%/年の減少)の補填。

(3) 透過による損失

プラズマ駆動透過とガス駆動透過による損失補充

(4) 捕捉による損失

プラズマ対向材料再付着層へのトリチウム捕捉(時定数大)と第一壁や配管への吸着、吸収(時定数小)

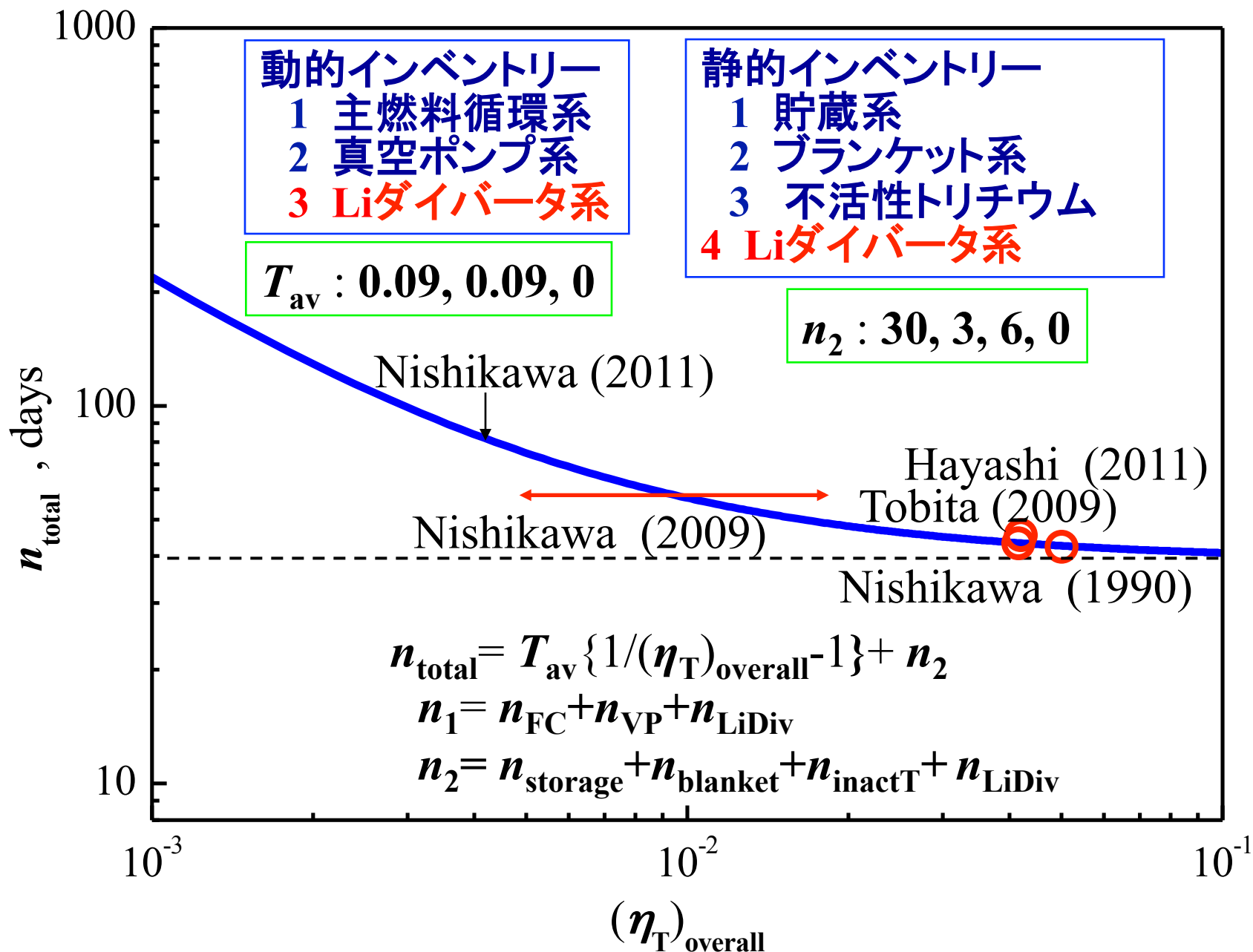


Figure Overall burning efficiency and total tritium inventory.

Table $(TBR)_{BS}$ required 計算式

$$\begin{aligned}
 & (TBR)_{BS} \text{ required} - \underbrace{(TBR)_{R,Net}}_{\text{次期炉準備}} \\
 & = \underbrace{\{(\delta_T)_{overall}/(\eta)_{overall}\}}_{\text{再付着層捕捉}} \underbrace{\{1-f'_{Decay}(\beta_{trap})_{VV}\}}_{\text{捕捉T回収}} + \underbrace{(\theta_P)_{overall}/(\eta)_{overall}}_{\text{透過損失}} \\
 & + \underbrace{(Q_T)_{decay}/(T_{burn})}_{\text{放射性崩壊}}
 \end{aligned}$$

$$\begin{aligned}
 (TBR)_{R,Net} &= 1 + \underbrace{[\{18(0.01/(\eta)_{overall}) + 39\}/f'_{TWT}]}_{\text{炉のトリチウムインベントリー}} / (365 T_{WT})
 \end{aligned}$$

$$(Q_T)_{decay} = \{\text{T total inventory}\} (1.53/10000)$$

$$T_{burn} = \eta_{PL1} \eta_{TR1} \eta_{BUP} Q_{T1}$$

$$(\eta)_{overall} = T_{burn} / (Q_{T1} + Q_{T2})$$

Tritium inventory in trap (Roth et al.)

Sum of both processes:
comparison of
materials options

ITPA SOL/DIV
assessment

ITER condition

Nishikawa

δ_T

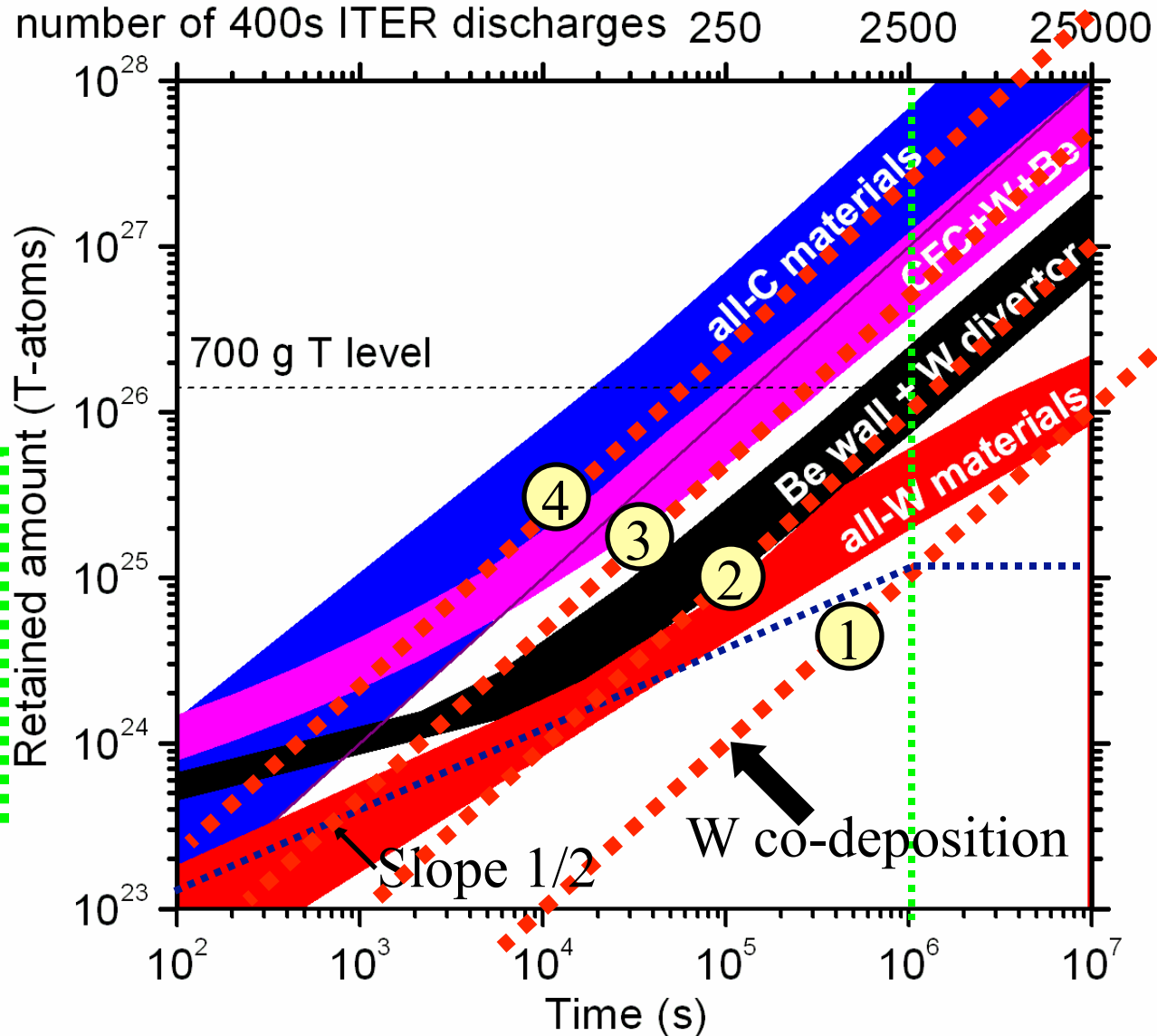
All W: 1 (3/10000)

Be+W: 10 (3/1000)

Mix: 50 (1.5/100)

All C: 250 (7.5/100)

Contribution to the
IAEA, Geneva 2008



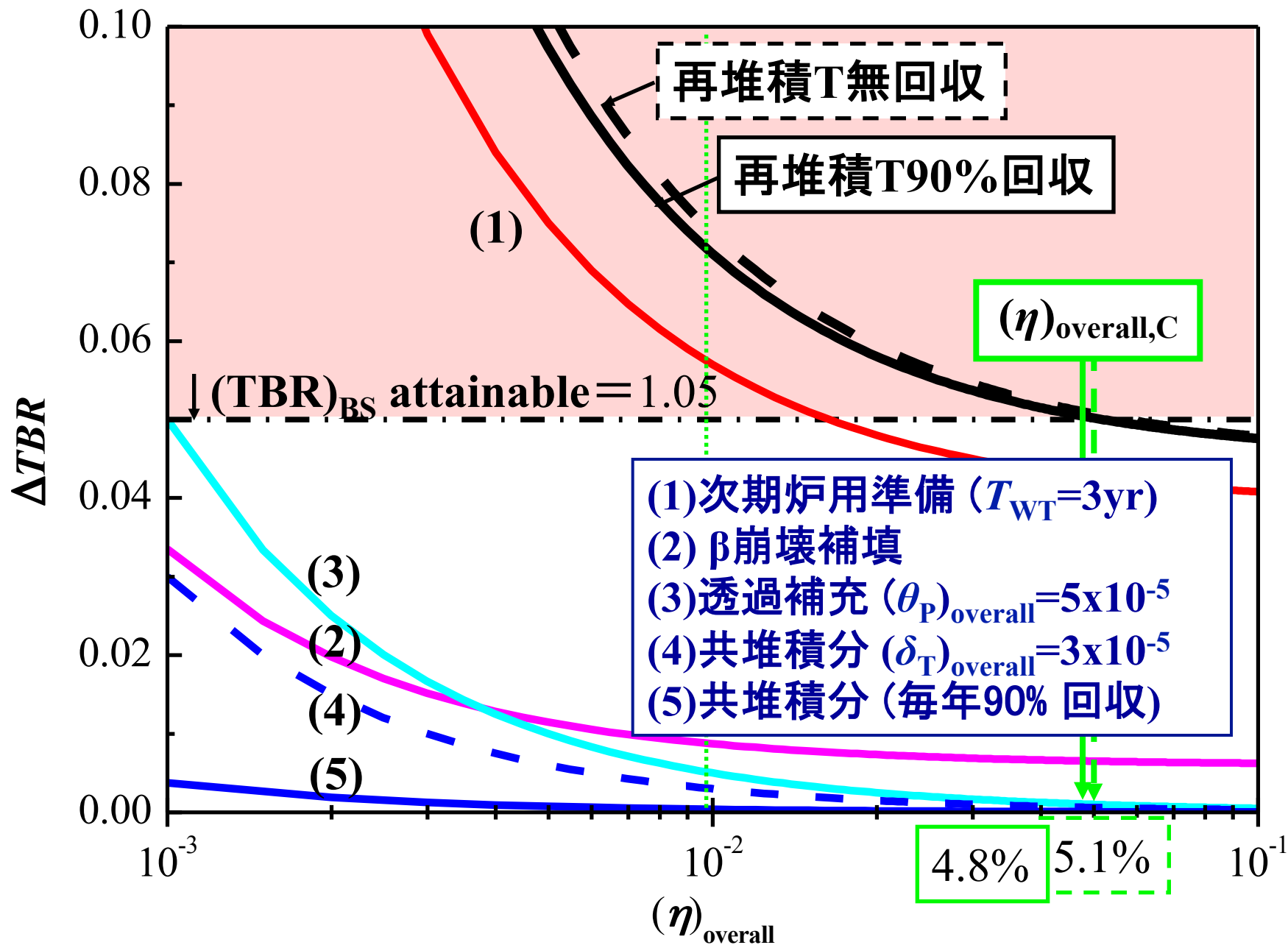


Figure Comparison of Contribution to $(TBR)_{BS}$ required.

Liからのトリチウム回収法

1) 熔融塩による抽出

V.A. Maroni et al., Nucl. Technol., (1975)

H. Moriyama et al., Nucl. Technol., (1991)

2) イットリウムゲッターによる回収

S.D. Clinton and J.S. Watson, 7th Symposium on
Eng. Problems of Fusion Res., (1977)

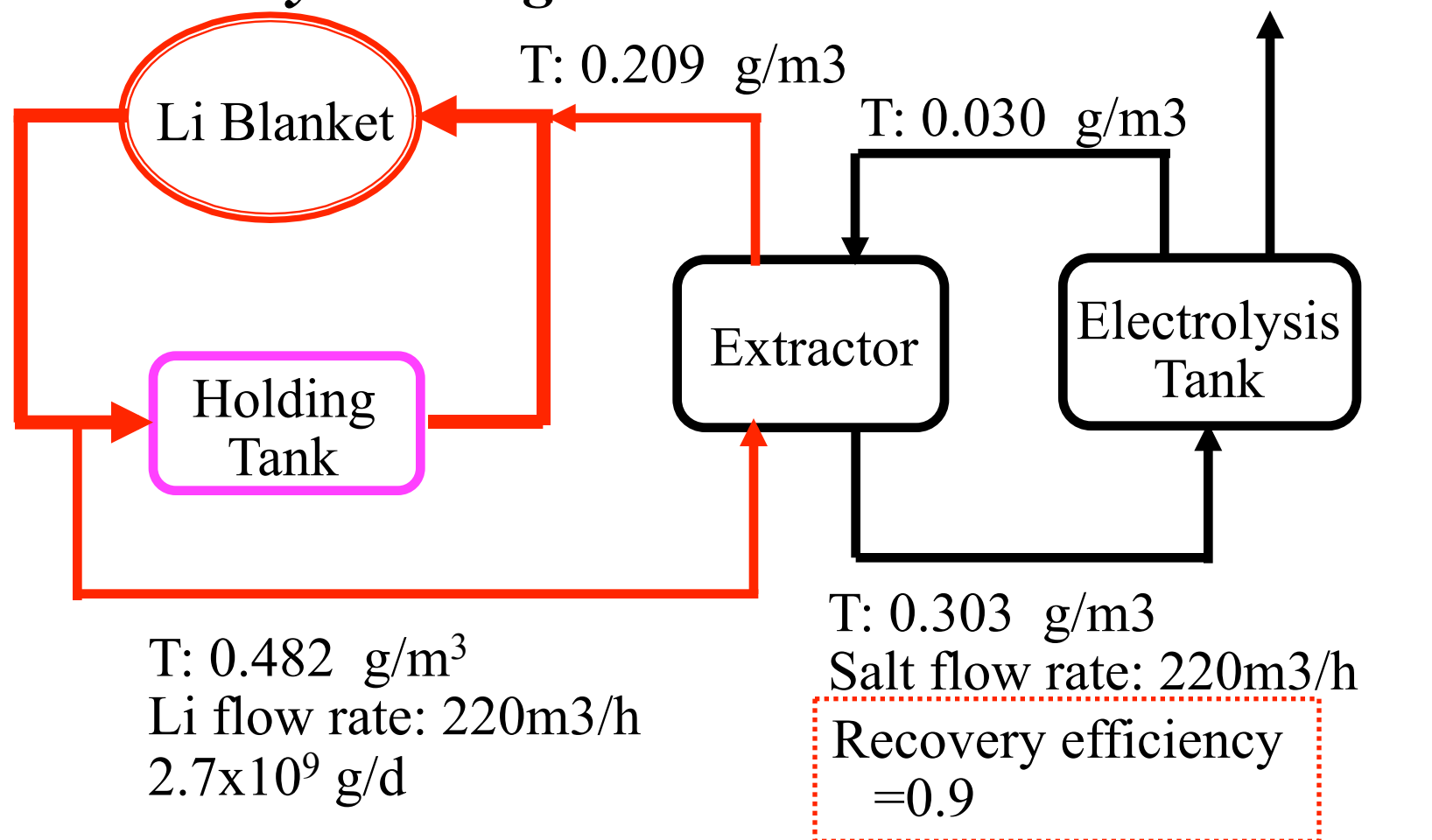
3) 水素透過窓法 (Nb 窓)

S. Tanaka et al., J. Nucl. Mater., (1981)

4) 分留法 (1240K)

H.R. Ihle and CH. Wu, 2nd Int. Conf. on Hydrogen
in Metals, (1977)

Breeding rate: 1440 g/d
 T Inventory: 0.8kg ~1wppm
Li inventory: 8×10^8 g



Conceptual tritium recovery system from Li blanket by Moriyama.

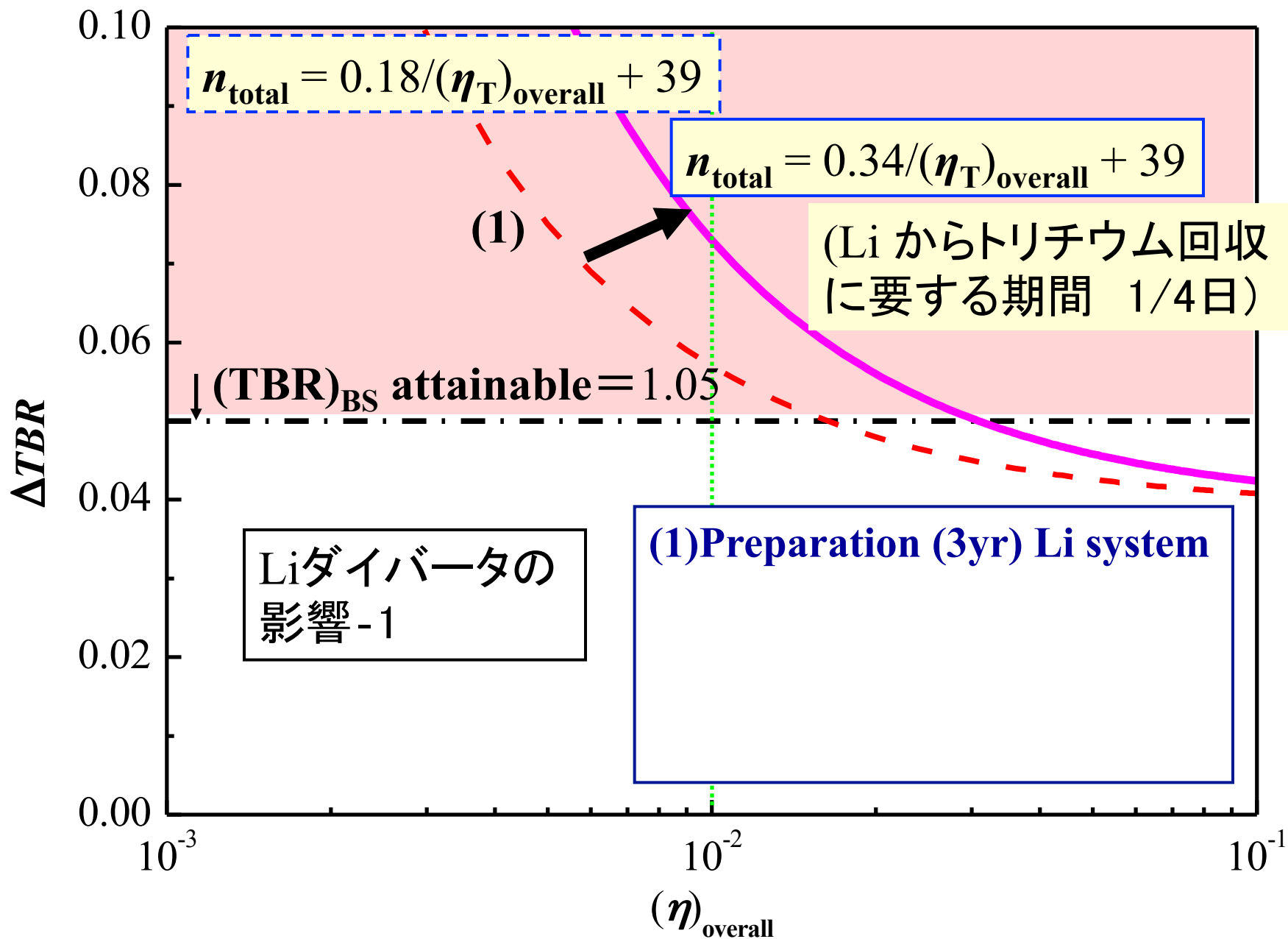


Figure Comparison of Contribution to TBR (Li system).

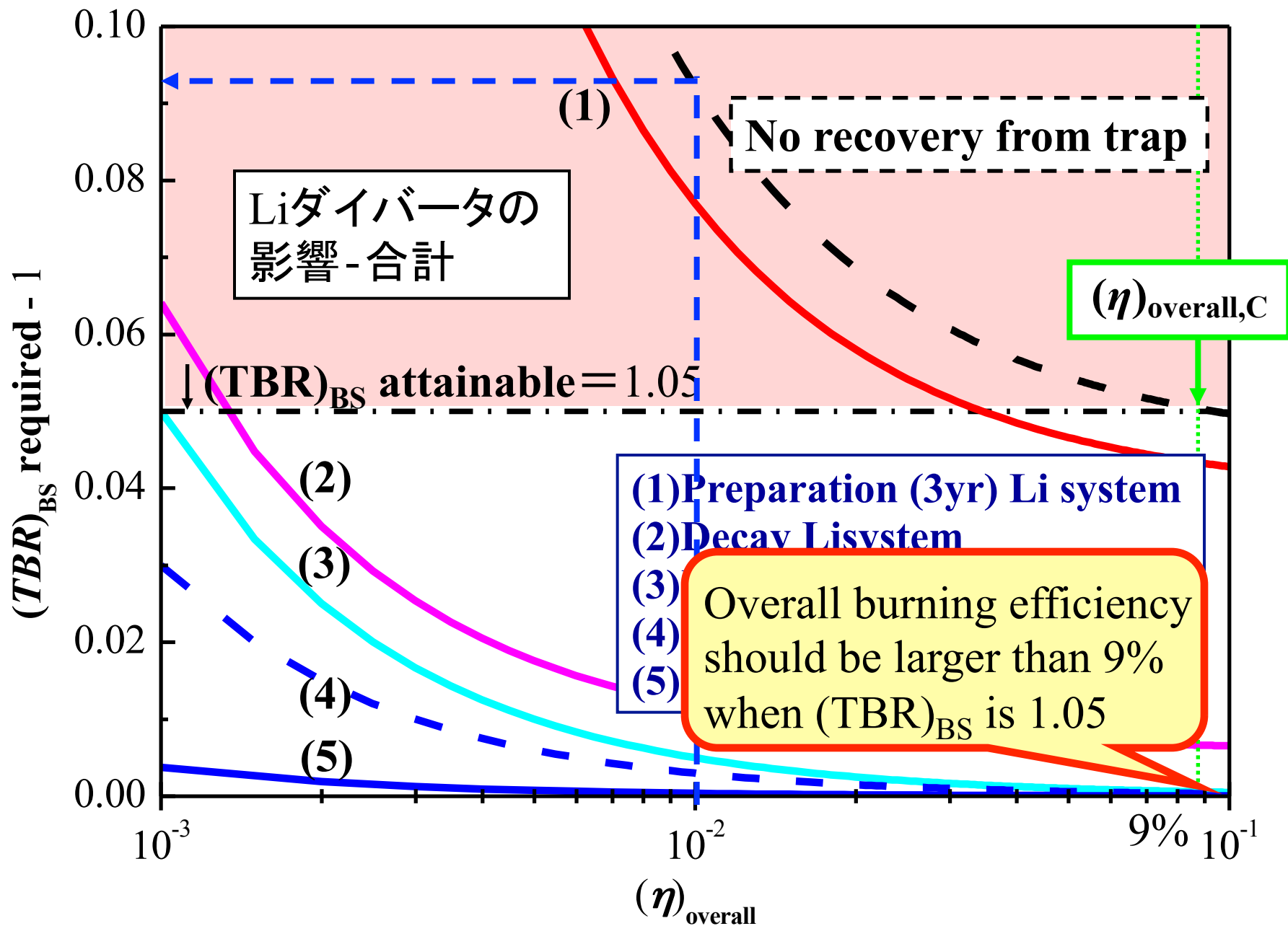


Figure Comparison of Contribution to TBR (Li system).

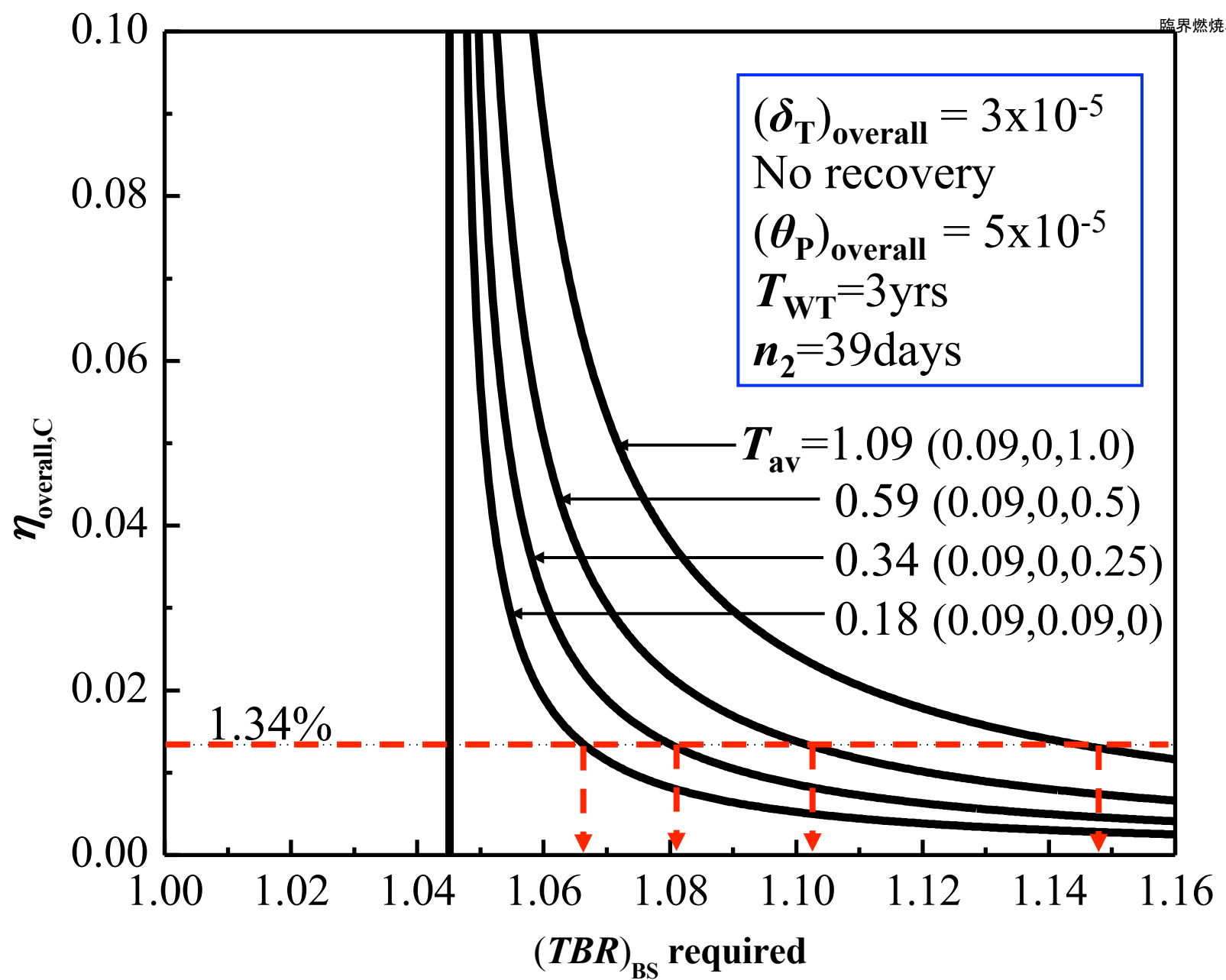


Figure Critical overall burning efficiency from tritium balance.

トリチウムバランスからの問題点

1. エネルギー回収におけるLiの利用効率の測定と主反応の特定
2. ダイバータLiへのトリチウム捕捉率の定量
3. PWI現象がどのように変わるのか？
4. Liからのトリチウムの効果的回収法(回収システムのトリチウム平均滞留時間が1/4日程度で回収効率が大)の開発
5. 真空排気に要求される機能の変化

