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Modeling a Hypothetical Fusion Blanket Design Using MELCOR-TMAP

October 2024

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Systems Level Fuel Cycle Modeling in TMAP8 – A Demonstration

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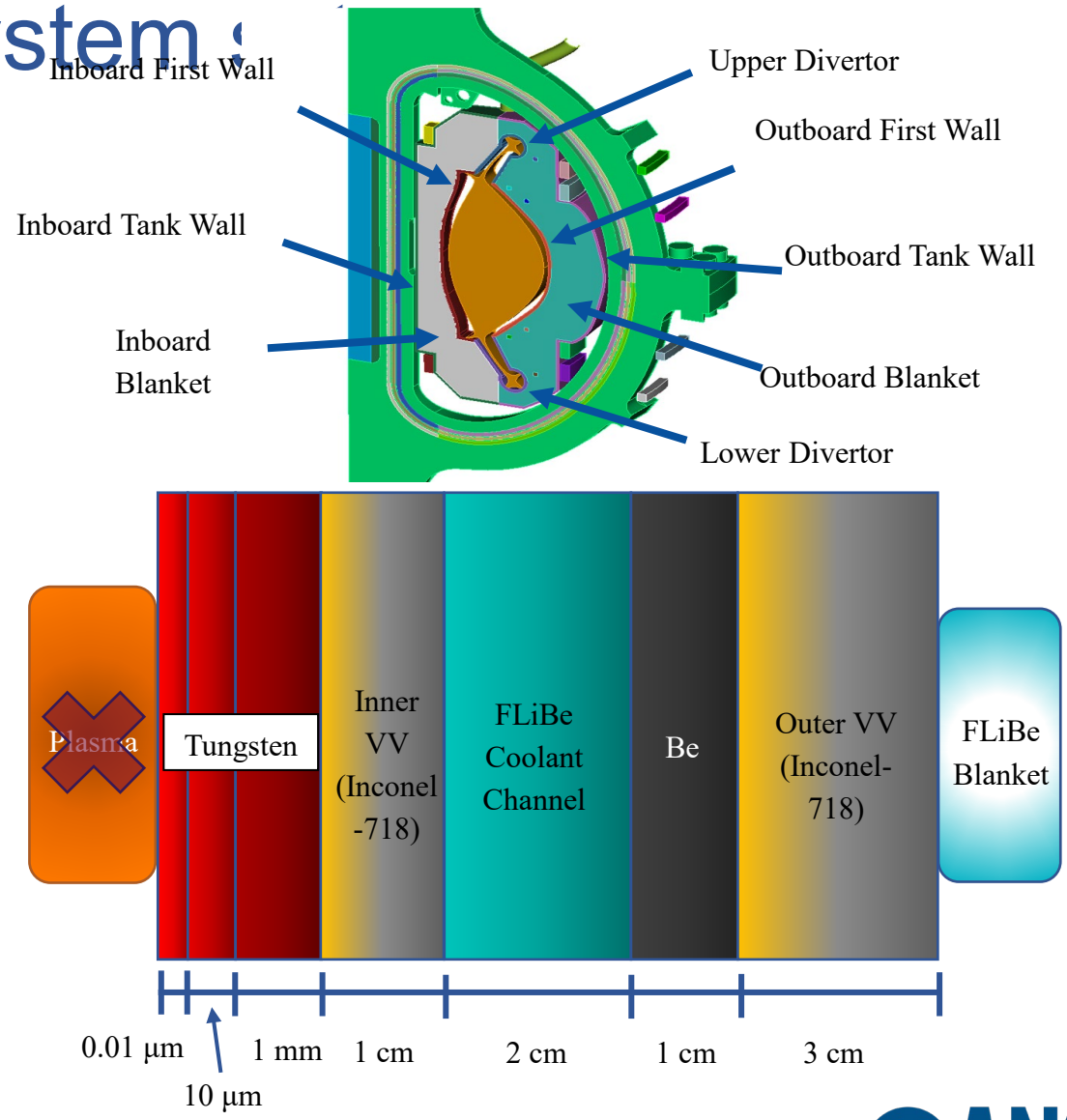
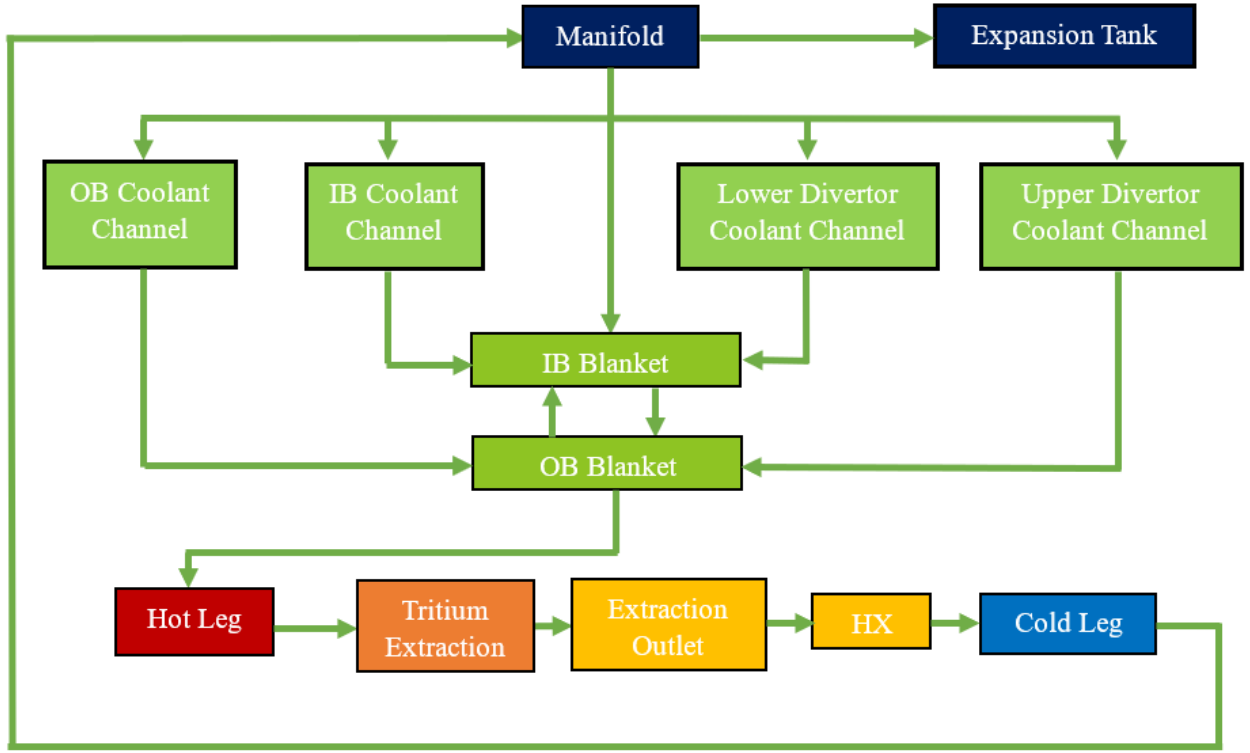
Liquid Immersion Blanket system s

- Major components modeled in 1D simulation
- Divided into two sections, inboard and outboard
- Neutronics from MCNP analysis – plasma not modeled
- Coolant channels and blanket from vertically stacked CVs
- Tungsten split into three material types – First wall, near first wall and regular tungsten



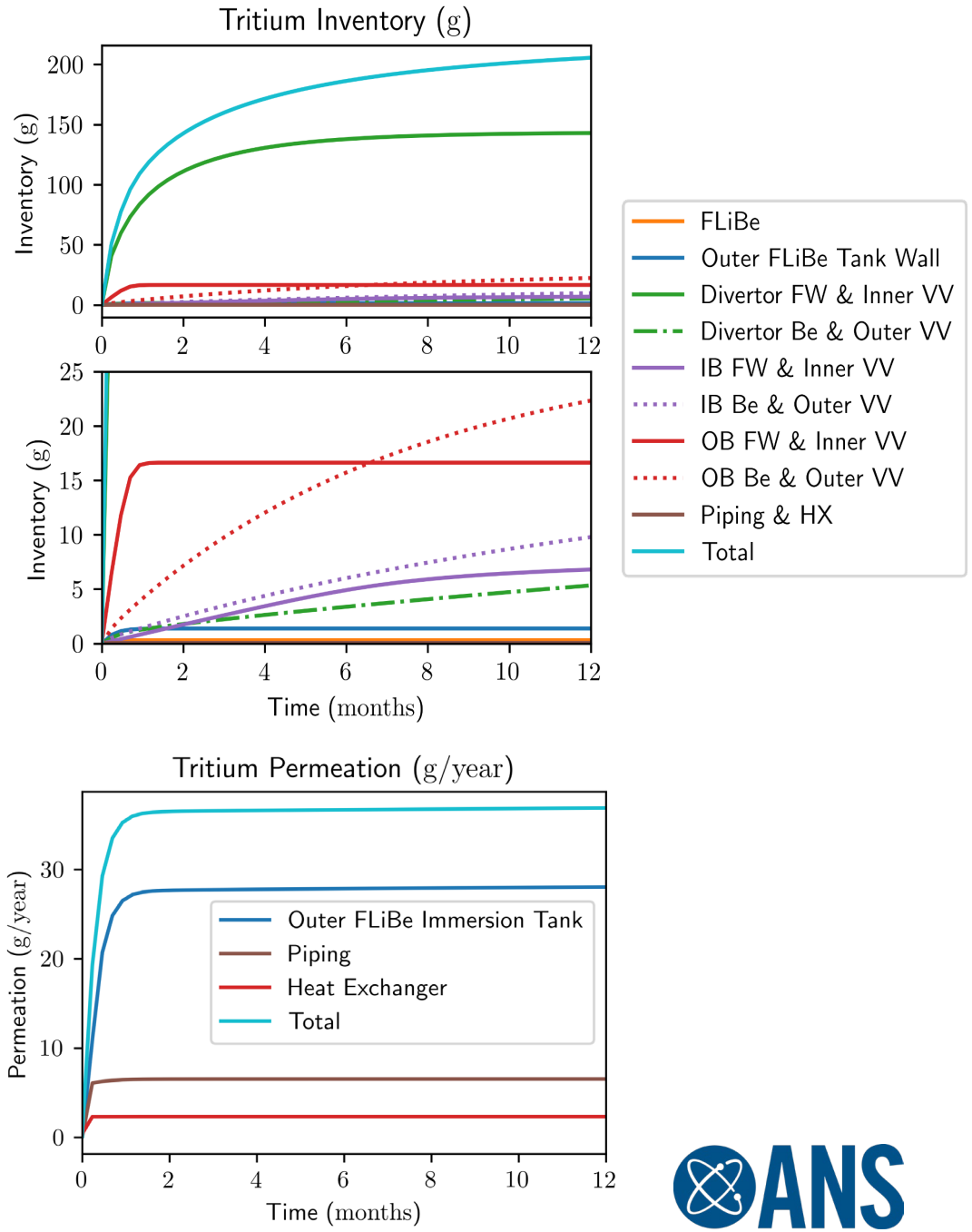
MELCOR system connections

- System operated as a closed-loop after steady-state was reached
- Tritium extraction system was modeled as a black box with an assumed efficiency positioned immediately prior to the heat exchanger system



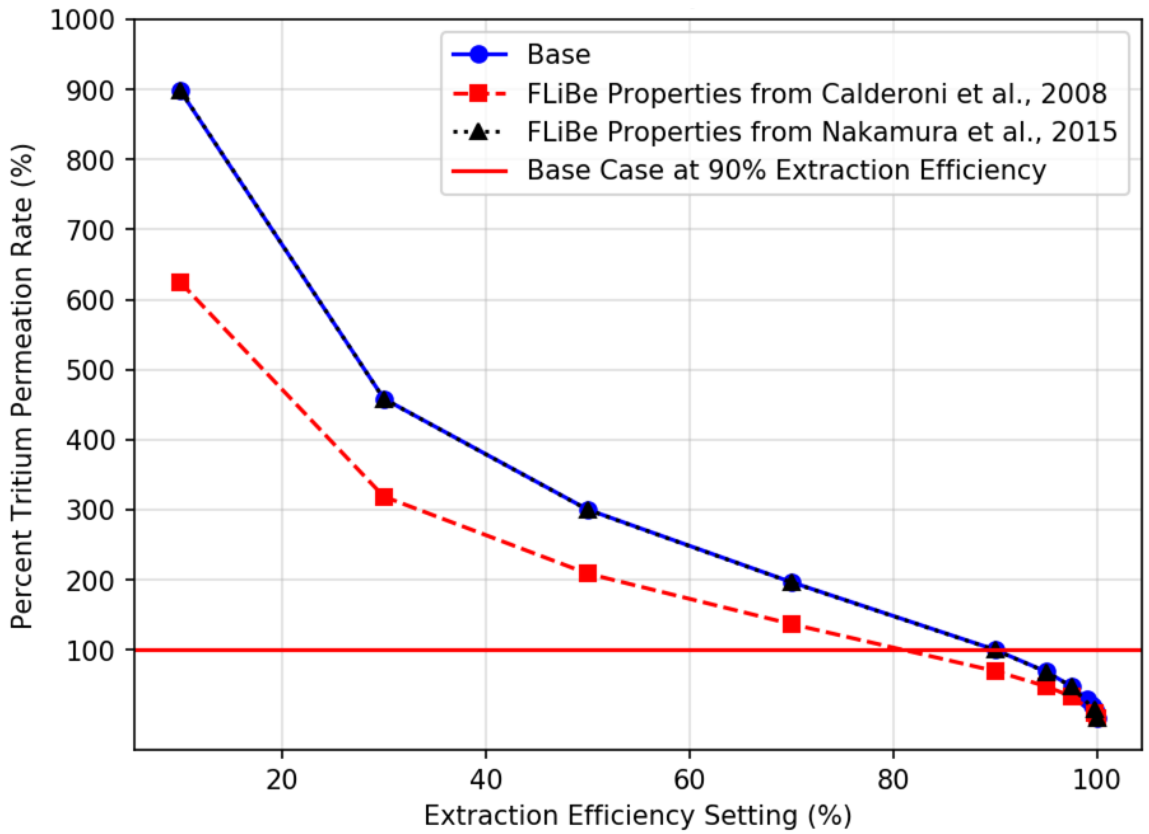
Steady-state tritium inventory

- All numbers are assuming 90% Tritium extraction system efficiency
- Permeation from the tank wall accounts for the majority of tritium migration at steady-state at 28 grams per year
- Pipes accounted for ~18% of tritium permeation
- A 100 μm tungsten permeation barrier was included, yielding a permeation rate of only 2.3 g/year tritium permeation through the heat exchanger in the base case
- Time to reach steady-state inventory was on the order of one year
- Total steady-state inventory was between 203 (10% TES efficiency) and 230 (99.99%) grams per year



Tritium permeation rate as a function of TES efficiency

- Tritium extraction system modeled as black box having between 10 and 99.99% single pass efficiency
- Observed a 6-9x reduction in tritium permeation rate throughout the system at 90% single-pass efficiency compared to 10% efficiency base case



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