ARIES-AT First Wall/Blanket Design Assessment

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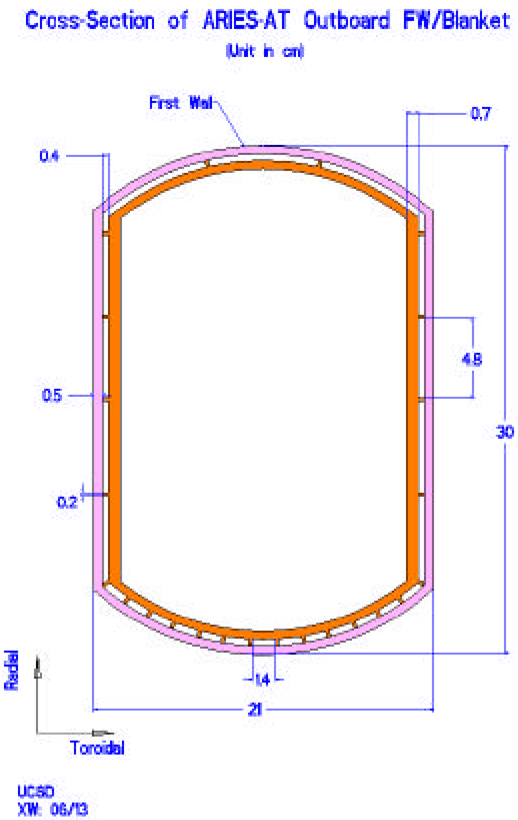
Background:
Configuration of First Wall and Blanket

- First wall configuration with 17Li-83Pb flow paths

- 17Li-83Pb flow paths

  - Front: 3 sections
    - 0.4 cm X 7 cm
  - Back: 13 sections
    - 0.4 cm X 1.4 cm
  - Side: 8 sections
    - 0.4 cm X 5 cm
  - Middle: 1 section
    - 17.8 cm X 24.5 cm

- 17Li-83Pb flows up the front, back and side channels, then downward through the large central channel and out of the blanket Inlet temp 764 C



Summary of Cases Considered for Analysis

- Case A* : ARIES-AT strawman results @ peak NWL=5MW/m^2, SiC k = 20W/k

  First Wall : T_{LiPb} (out) not reported; T_{FW} (Hot Spot) = 996 C
  (slug flow with moving coordinate for first wall)
  Return Tube: T_{LiPb} (out) = 1100 C; T_{wall} (Hot Spot) = 994 C

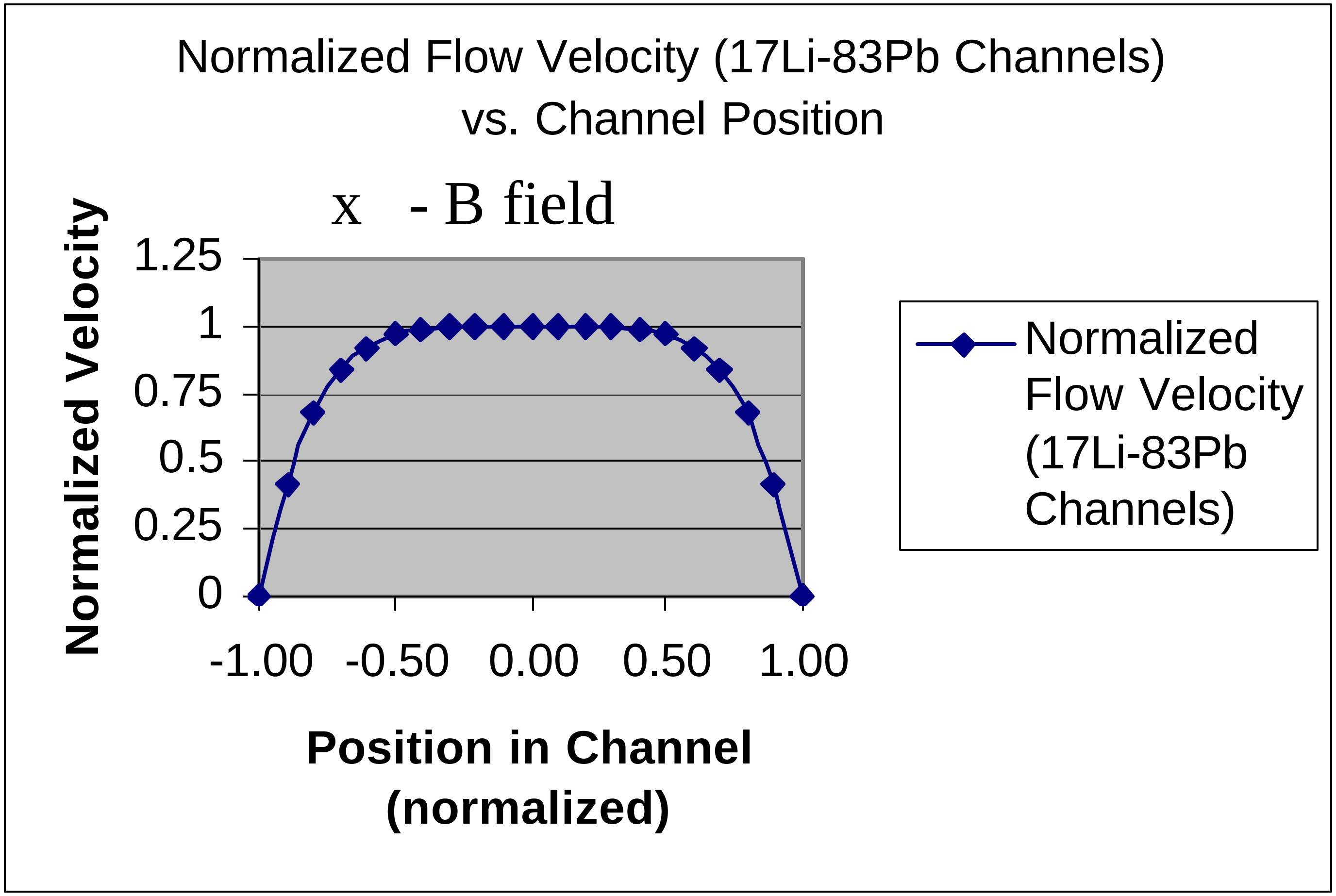
- Case B* : UW Benchmark of ARIES-AT results

  First Wall : T_{LiPb} (out) = 830 C; T_{FW} (Hot Spot) = 950 C
  Return Tube : T_{LiPb} (out) = 1112 C; T_{wall} (Hot Spot) = 1035 C
  (energy balance rough estimate)

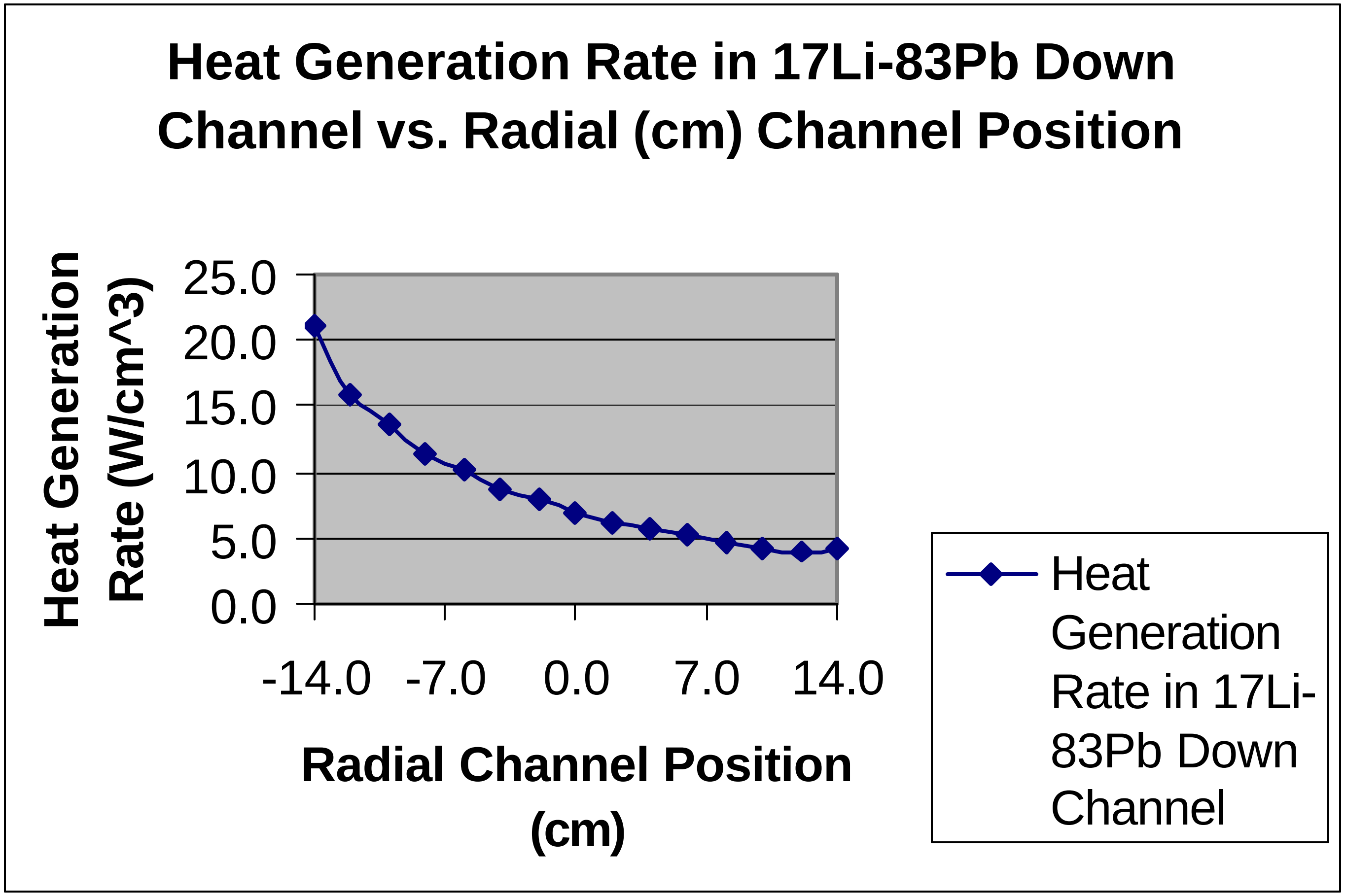
- Case C : Finite element heat transfer (FEHT) moving coordinate poloidal flow analysis with energy deposition profile, flow velocity profile and mass flow consistency (* these characteristics are not included in Case A or B)

- Case D : FEHT analysis with swirl flow at ARIES-AT strawman conditions

Flow Velocity Distribution in 17Li-83Pb Channels (from UCLA flow analysis, B field into page)

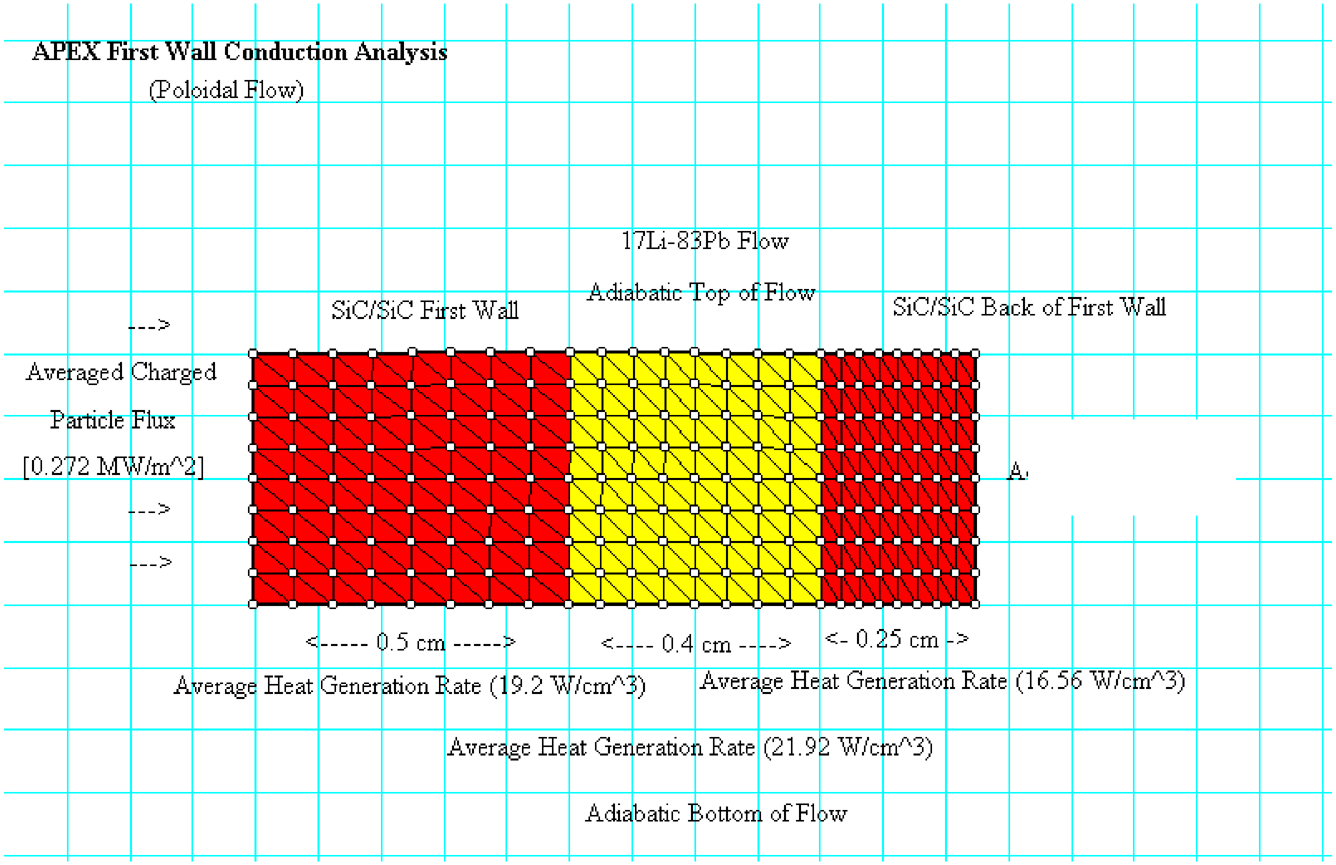


Volumetric Heat Generation Rate Used in Down Flowing 17Li-83Pb Channel (ARIES-AT, at peak wall loading of 5 MW/m^2)



Case C:
Finite Element Heat Transfer Model (FEHT)

- Solves steady-state and transient two-dimensional conduction heat transfer problems using triangular finite elements
- Problem specification shown below (FW upward flow with peak wall loading of 5 MW/m^2)



Case C:
First wall and Blanket Upward Flow Using FEHT

- Poloidal average heat loads shown on previous schematic
  - taken from ARIES-AT strawman conditions

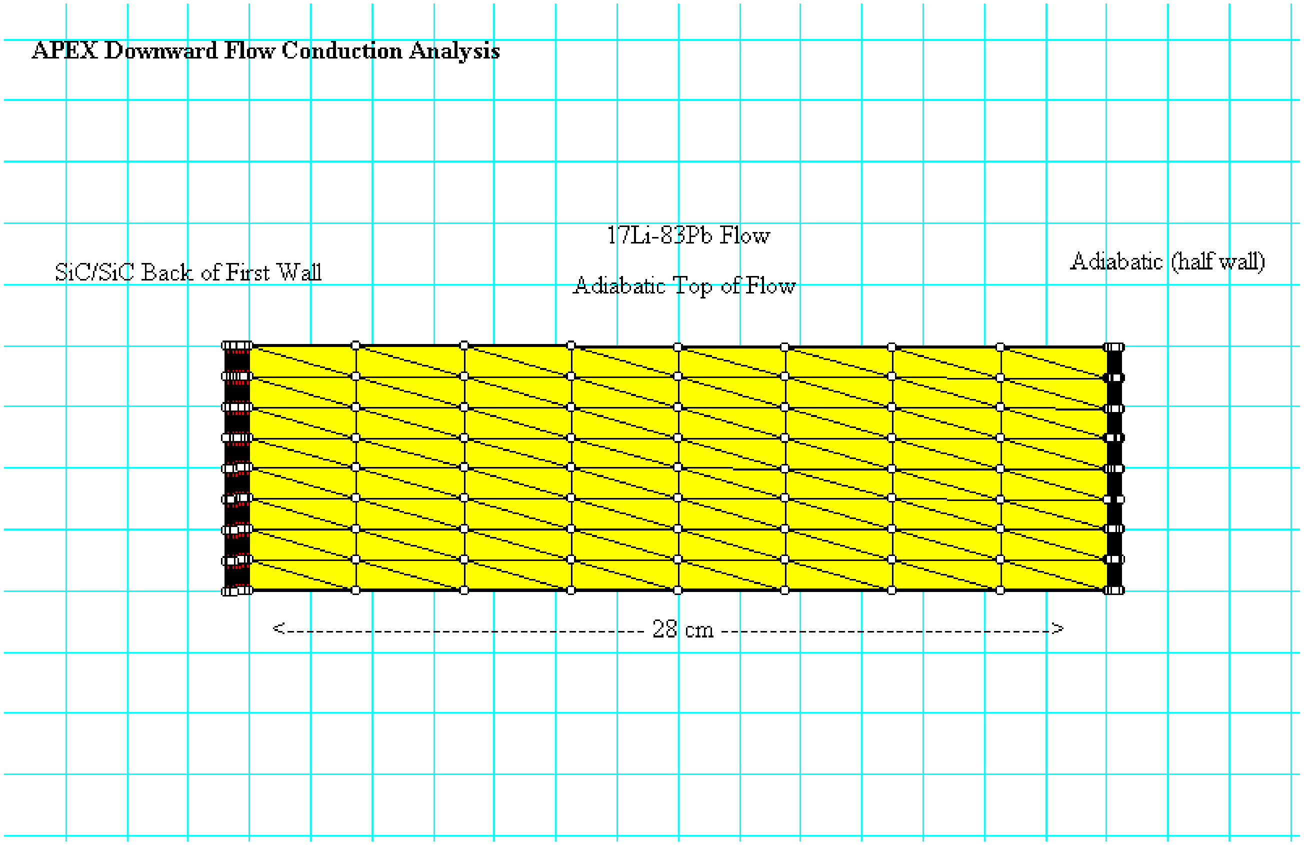
- Transverse thermal conductivity of SiC/SiC will be assumed to be 15 W/m-K (ARIES used 20 W/m-K)

- Velocity profiles from UCLA analysis will be used to modify density of 17Li-83Pb to mimic convective flow effects

- Maximum SiC/SiC first wall temperatures (hot spots) will be determined, along with bulk fluid temperatures leaving the top of the blanket

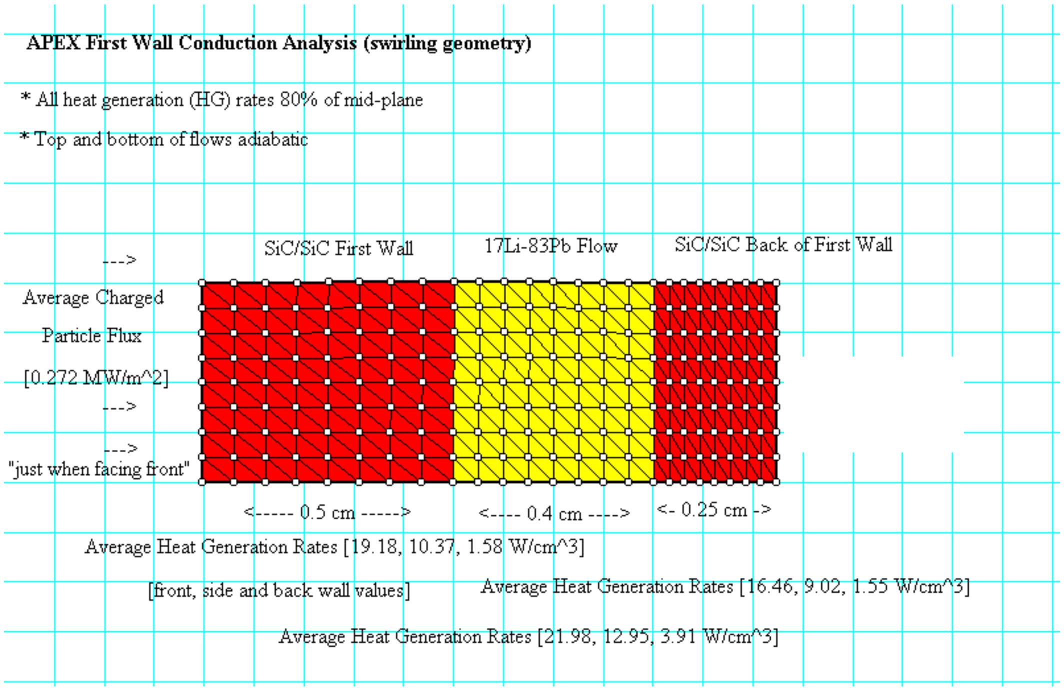
Case C:
Analysis of Downward Flowing Channel (SiC/SiC and 17Li-83Pb) Blanket

- Below is a schematic of the downward flow return channel



Case D:
Swirling the First Wall Flow (ARIES-AT conditions)

- It is believed that swirling the flow will reduce the exposure to high heat fluxes and reduce the thermal loads on the SiC/SiC first wall
- Provided below is a schematic of the finite element model used



Case D:
Swirling the First Wall Flow

- The heat loads (volumetric and surface) will be discretized with front, back and side loads used for the four distinct positions (as the wall wraps around)
- Otherwise the geometry of the flow will be the same
- Additional length for the channel is required, so additional residence time is needed for the flow (at constant velocity)
- The residence time is 1.85 seconds (4.2 m/s for 775 cm channel)
- A second calculation will be performed for twice the velocity and half the residence time to give insight into the temperature dependence