

**DIRECT CONTACT
HEAT TRANSFER
between
LIQUID BLANKET
and
GAS COOLANT**

A New Concept for APEX Task IV

DIRECT CONTACT HEAT TRANSFER

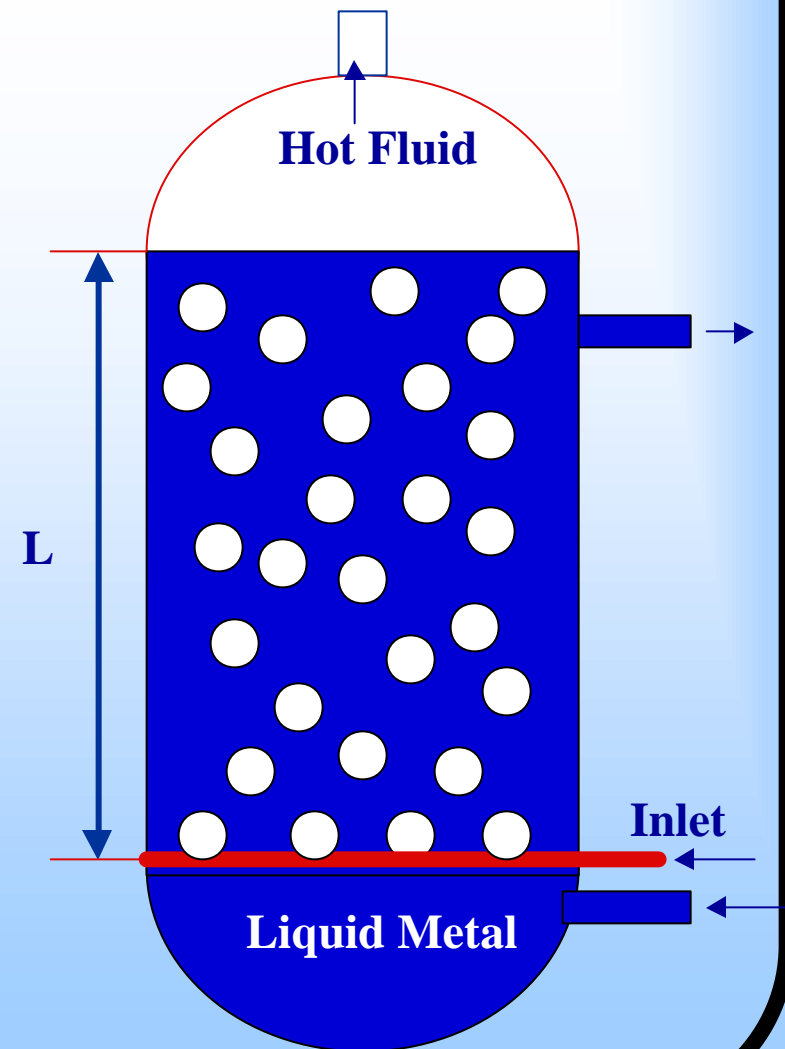
- **BACKGROUND and MOTIVATION**
- **PREVIOUS WORK**
- **CONCEPTUAL IDEA**
- **ISSUES TO BE CONSIDERED**
- **CURRENT OBSERVATIONS**

Background for Direct Contact Heat Exchange

- **Direct contact heat transfer can allow for more efficient energy exchange; i.e., smaller volumes with larger power exchange ~ an order of magnitude increase in heat transfer**
- **Direct contact heat exchange has been considered => but there is a need to determine local energy exchange coefficients & associated fluid-fluid issues for a range of reactor applications.**

Direct Contact Heat Exchange: Past Concepts

- Previous concepts considered liquid metal transfer of heat from nuclear power energy source to a working fluid for power production
 - within the reactor
 - within an intermediate Hx
 - within breeder/blanket
- Key issues in design are the interfacial transport of energy between two fluids as well as the associated chemistry in the multiphase system .



Past Direct Contact Heat Exchange Investigations

<u>Investigator</u>	<u>Fluids</u>	<u>Apparatus/Injector</u>	<u>Comments</u>
• Numerous	Hg/N ₂	~5-10cm tube w gas pipe	Isothermal flow w MHD appl.
• Branover	Hg/Stm	8cm tube; ~1mm nozzle	Heated flow for MHD appl.
• Branover	Pb/H ₂ O	20cm tube; similar nozz.	Natural convection loop
• Sideman/Gat	Pent/H ₂ O	7cm tube; 0.5mm nozzle	L? T~.3-2* => hv = 18 kW/m ³ K
• Smith/Kazimi	Pent/H ₂ O	22cm tube;0.5mm nozzle	L? T~1* => hv =45-60 kW/m ³ K
• CRIEPI	PbBi/H ₂ O	25cm tube; 1mm nozzle	L? T~2-3* =>hv=30-55kW/m ³ K
• Kranert et al.	LiPb/H ₂ O	30cm tube; 1-5mm nozz.	Transient injection of water**
• Baker et al.	Sn/H ₂ O	10x20cm box; tuyere varied	Quasi-steady water injection+
• Abdulla et al.	Pb/H ₂ O	10x50cm box; 1-3mm nozzle	Quasi-steady water injection+

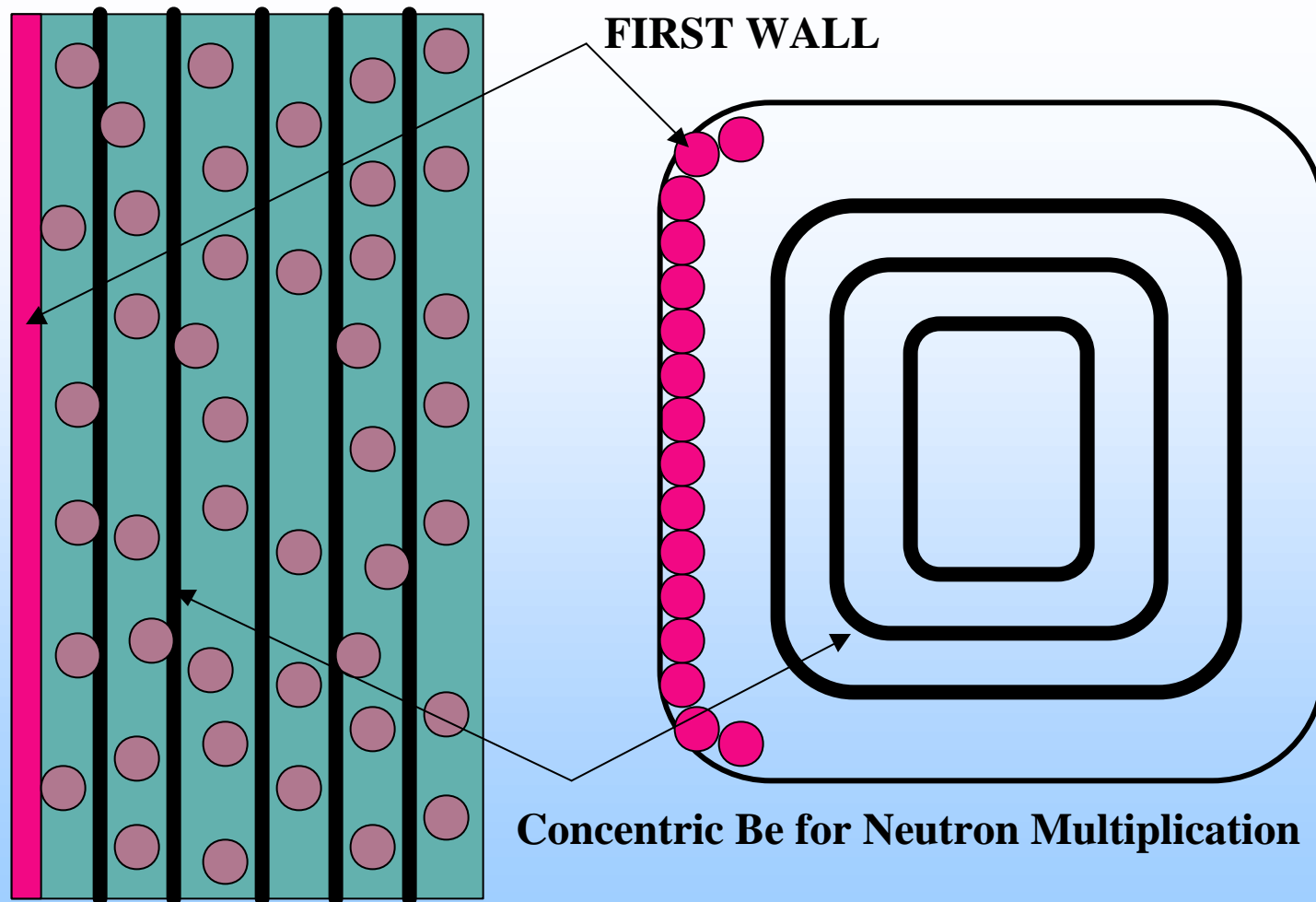
* ?T was less than 100K betw. fluids with temp/flow sensors to measure h and L

** ?T was more than 300K betw. fluids with temp/press/flow sensors for HT/stability

+ ?T was more than 400K betw.fluids with cont. Xray imaging for void measurement

Blanket Concept w Direct Contact Heat Exchange

BLANKET MODULE FILLED w FLIBE and COOLED by INJECTED GAS



TECHNICAL ISSUES to be CONSIDERED

- **Blanket-coolant combinations (e.g.,Flibe-He)**
- **Accommodation of the high pressure (2,4,8MPa)**
- **First-wall cooling conceptual approach**
- **Gas coolant injection scheme and associated gas void distribution and volumetric heat transfer**
- **Breeder-Coolant (B-C) Considerations**
(Tritium Removal and Inventory Management)
- **Develop a set of figures of merit (e.g. thermal eff.) and consider a range of B-C combinations**

Current Issues and Proposed Path Forward

- **Develop a candidate B-C combination**
- **Analyze candidate for advanced APEX fusion reactor performance parameters**
- **Address issues with more detailed calculations**
- **Consider alternative B-C combinations and perform scoping comparison calculations**