RACE/HP Target cooling

André BERGERON
CEA-Saclay

Target cooling

- Requirements
- Needs
- Current designs
  - One plate
  - Multi-plates
  - TRADE
  - Hollow cylinder with bottom
    - Cooling at normal operations, Accidental situations

Design features

- Forced cooling
  - No boiling at wall surfaces
    - During normal operations
      - No two-phase flow within the cooling system
  - No Critical Heat Flux
    - Normal and transient and accidental operations
      - No release of radioctive wastes
  - System pressure close to the core bottom pressure

Current design

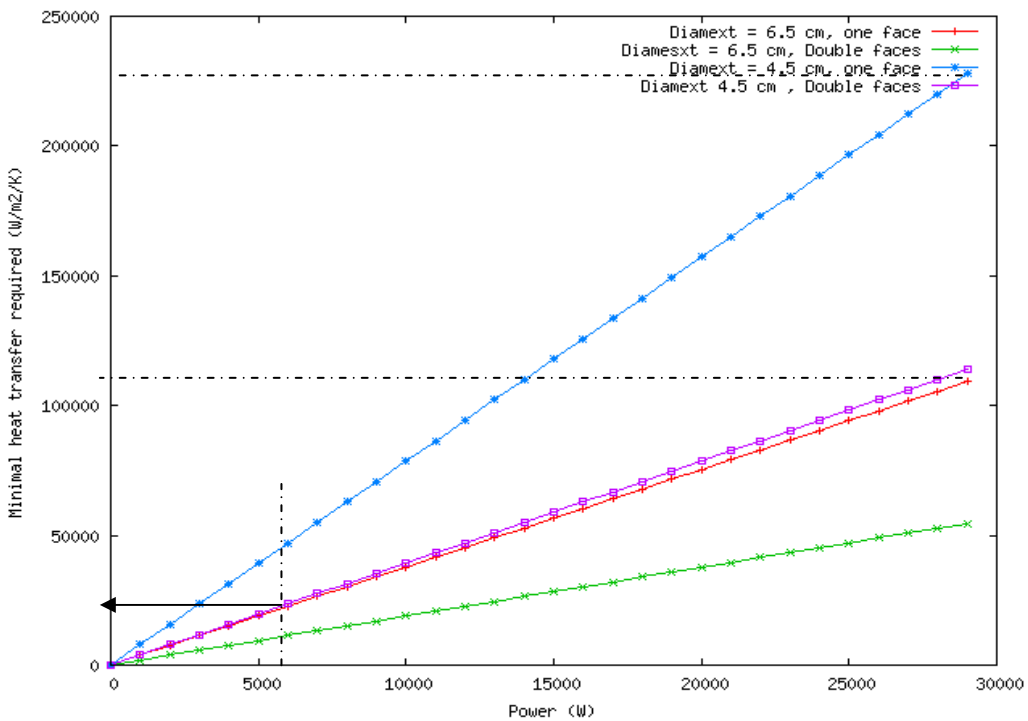
- Outlet pressure : 1.6 bars
- Pool temperature : 25 °C
- Central core target delivering 30 Kw power
  - Only one plate
  - Multi-plates
  - TRADE-like
  - Hollow target
    - Simple hollow
    - With Bottom

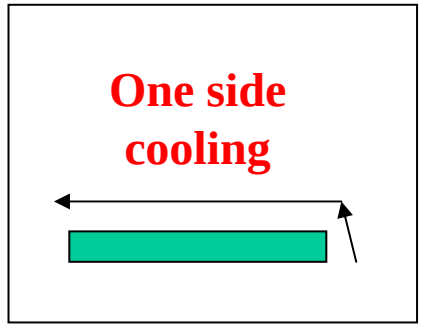
Current design

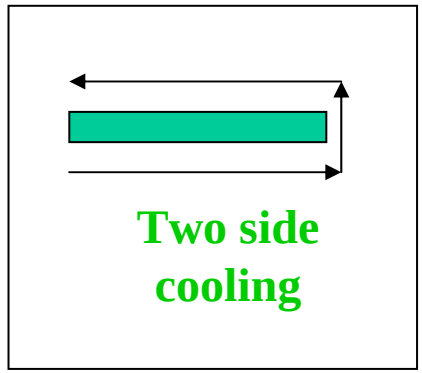
- No boiling
  - Twall = Tliquid + Phi/h < Tsat(Pressure) + Dtsat
    - Tsat = 113.5 °C
    - Dtsat overheat at ONB
      - Not considered for depending on a correlation choice and brings uncertainties
      - So the criterion is : Twall < 113.5 °C
- No Critical Heat Flux
  - Sudo and Groeneveld CHF assesment
    - Normal incidental range, and accidental range
      - Loss of pumps → Taking into account by the external circuit
      - Pipe break : Minimal time to shut off the beam. During this time flow decreasing and CHF behavior to be investigation
      - Free convection starts : CHF and flow rate to be evaluate

Current design

- One plate
  - Coolant velocity too high to avoid boiling at the wall surface

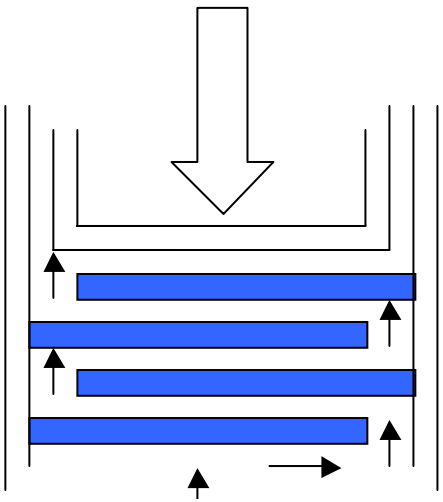


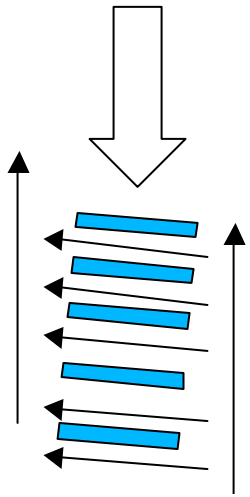


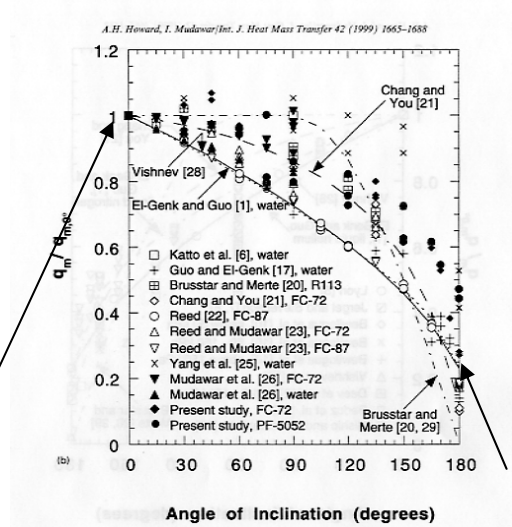


Multi-plates

- Multi-plates like solutions
  - Horizontal : Good except for free cooling start-up and Critical Heat flux problem due to horizontal downward facing
  - Some inclination required







Upward facing reference

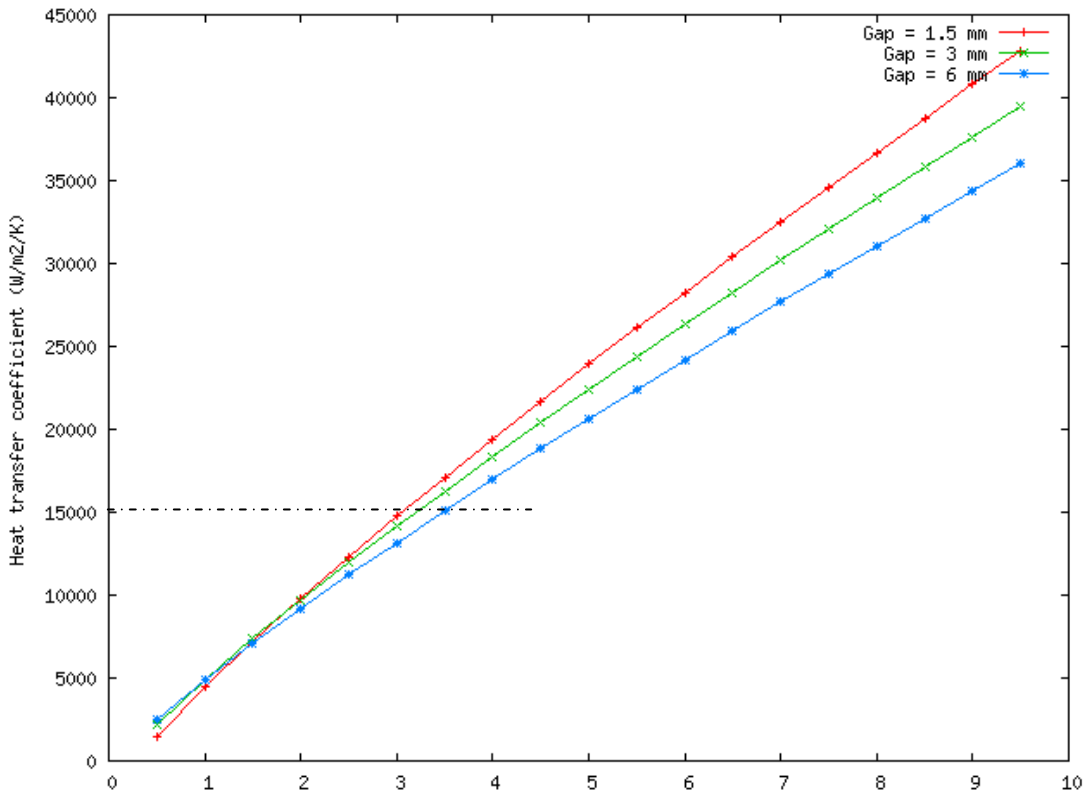
Critical Heat flux and inclination problems

Pool boiling but….

Downward facing

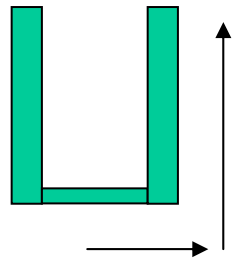
Multi-plates : 6 kW per plates, Double faces

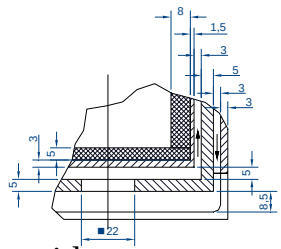
- Coolant velocity choices, gap size
  - Heat transfer around 15000 W/m^2/K
  - Gap size 3 mm

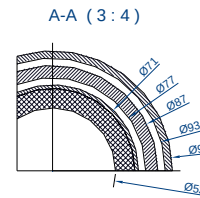


TRADE and RACE hollow design

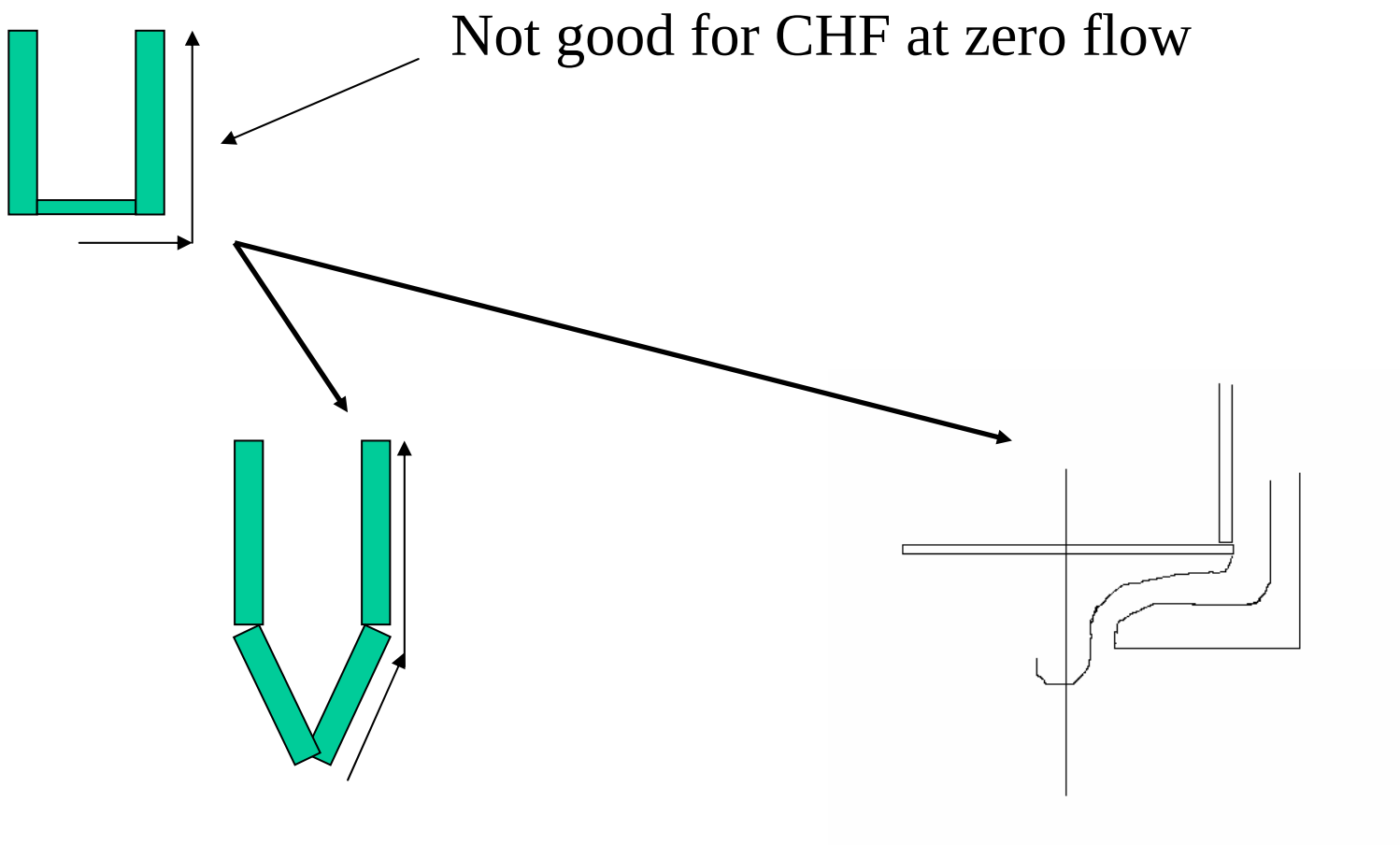
- TRADE : Available solution from TRADE target
- Hollow cylinder with bottom
  - Recommendation : Some inclination for the bottom plate
  - From calculation taking into account uncertainties
    - First step : Classical ingeneering heat transfer correlation
      - Penalyzing (Never fully established)
      - Heat transfer coefficient : 14500 W/m2/K
        - 3.6 m/s in a 3 mm gap
        - Maximal heat flux **126 W/cm2**
    - Second step : Finest calculation of the proposed coolant circuit and velocity with CFD tool
    - Last step : Experimental verification on external experimental mock-up
      - Normal, transients, full loss of coolant due to pipe break





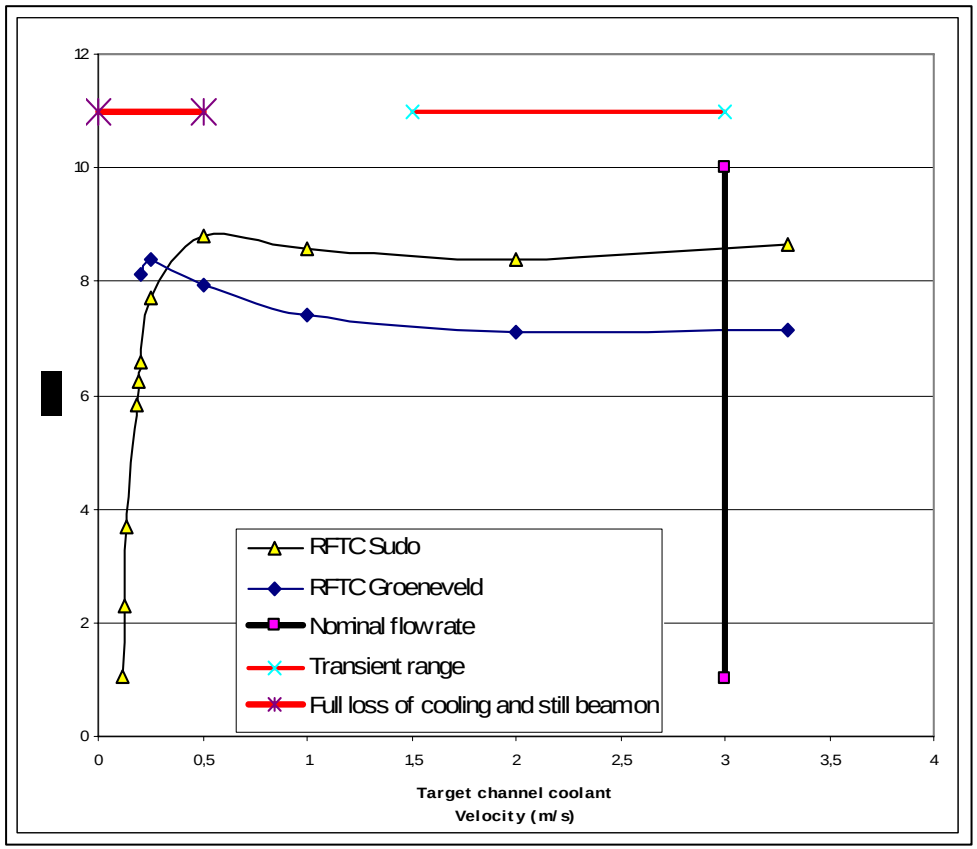


Hollow design enhancement for free cooling



TRADE and hollow design

- CHF considerations
  - Sudo'CHF correlation suitable for small gap size and classical Groeneveld look-up table



Current work

- Preparation of the thermalhydraulic experimental program (FZK)
  - Due to June 2006
- Fully loss of flow rate
  - Transient computation to evaluate the time for pure free convection starting
  - Ultimate calculations with full power and pure free convection