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4th October, 2004

Predictions of the Phase Distribution in a Nuclear Fuel Bundle using MATRA, MARS(COBRA-TF) and CFX

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OUTLINE

MATRA – Subchannel Analysis Code

MARS(COBRA-TF) – System Analysis Code

CFX – Commercial CFD Code

BFBT Task(KAERI)

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MATRA – Subchannel Analysis Code

by D. H. Hwang

MATRA (I)

❑ KAERI'S IN-HOUSE CODE BASED ON COBRA-IV-I

● USER FRIENDLY FEATURES

- **PC VERSION CODED BY FORTRAN90**
- **FREE UNIT SYSTEM**
- **GRAPHIC USER INTERFACE FOR I/O**

● ENHANCED CODE CAPABILITY

- **APPLICABLE TO SQUARE/NON-SQUARE BUNDLES**
- **VARIOUS OPTIONS FOR SOLUTION SCHEME & T/H MODEL**
- **TWO-PHASE MIXING MODEL: EQUAL-VOLUME EXCHANGE & VOID DRIFT(EVVD) (COBRA-IV-I , EQUAL-MASS EXCHANGE(EM) MODEL)**

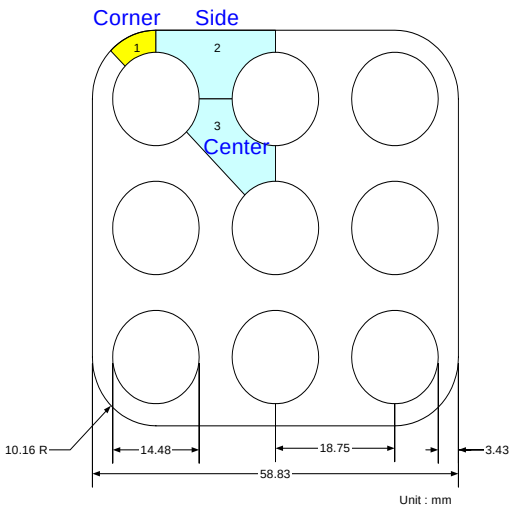
$$w'_{i\leftrightarrow j} = \left(w'_{ij}\right)_{SP} \cdot \theta \cdot \left[\left(\alpha_j - \alpha_i\right) - K_{VD}\frac{G_j - G_i}{G_{avg}}\right]$$

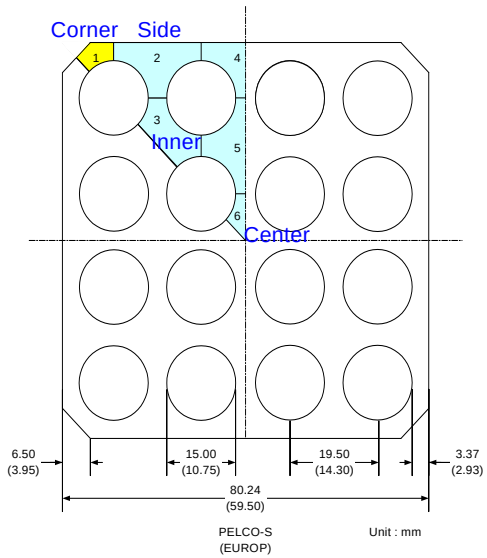
MATRA (II)

❑ ANALYSIS OF SUBCHANNEL ENTHALPY

● TEST DATA

- **GE 9-ROD BUNDLE (BWR)**
- **ISPRA 16-ROD BUNDLES (PWR & BWR)**
- **PRESSURE = 69~160 BAR, MASS FLUX = 0.7~3.2 Mg/M^2-SEC**

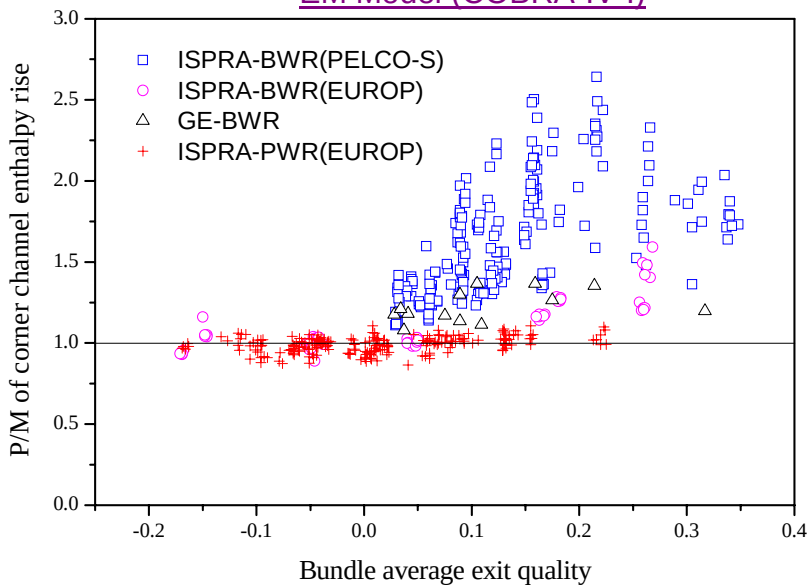




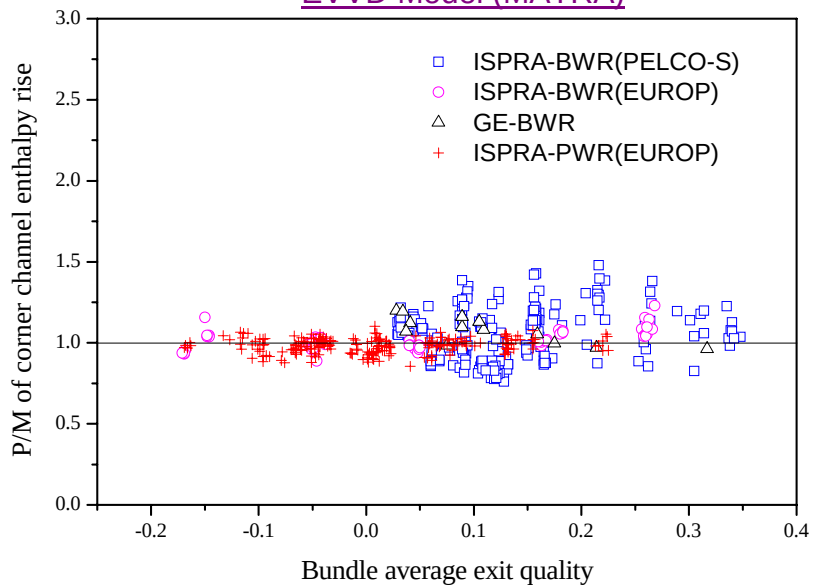
MATRA (III)

❑ PRED./MEAS. OF ENTHALPY-RISE

EM Model (COBRA-IV-I)



EVVD Model (MATRA)



Ref) D.H. Hwang, et. al., Nucl. Engng. Des. 199, 257-272 (2000)

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MARS – System Analysis Code

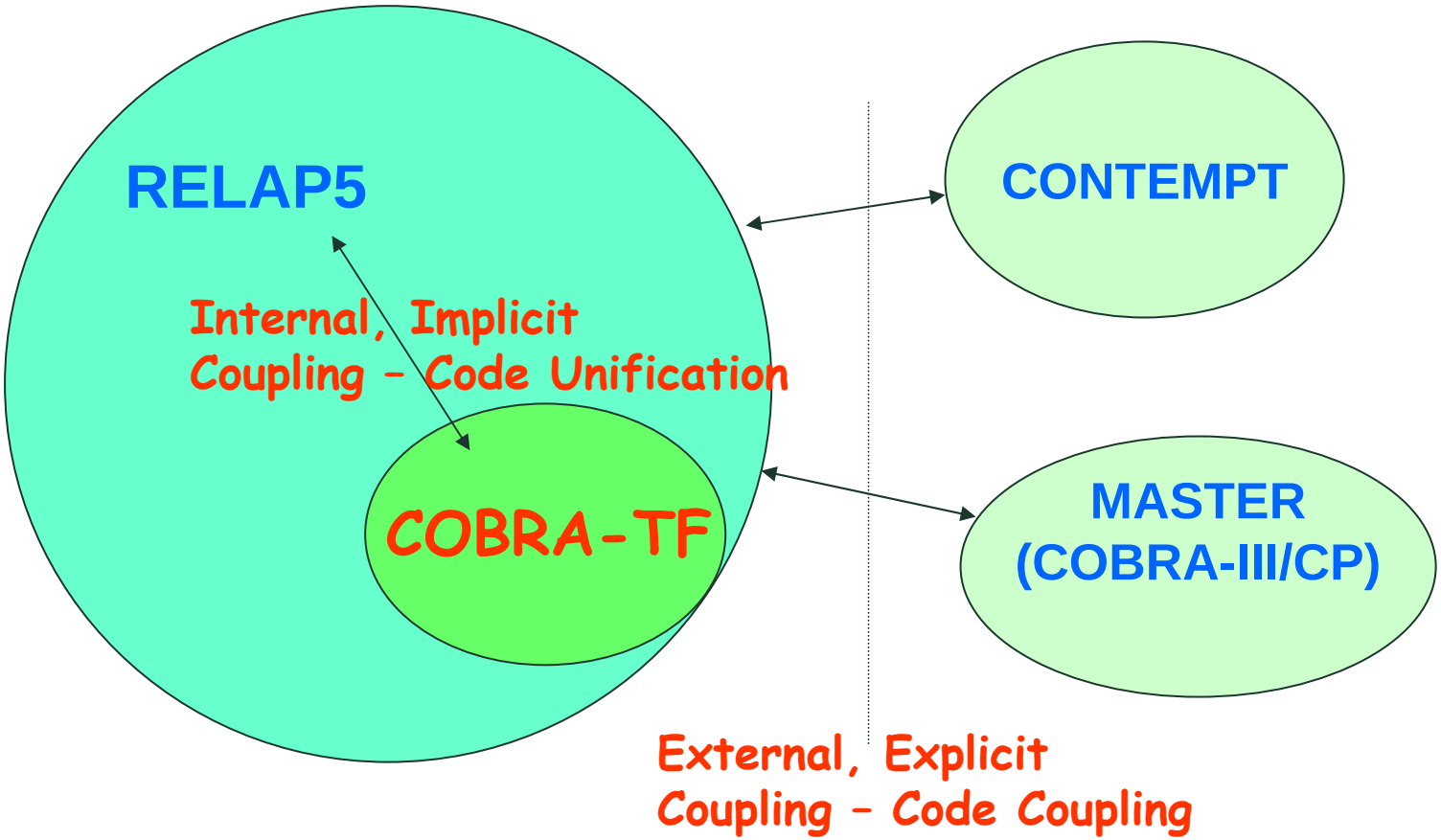
by J.-J. Jeong

MARS (I): RELAP + COBRA-TF + α

❑ **MARS : Coupled Code System for the Realistic Analysis of Nuclear System Transients**

- **RELAP5** – **One-Dimensional Transient T/H Model**
  (1D Module) – **Component Models**
  – **Versatility**
- **COBRA-TF** – **3D Transient T/H Model**
  (3D Module) – **Reflood Model**
  – **Subchannel Analysis**
- **MASTER** – **3D Steady & Transient Reactor Kinetics**
  – **COBRA-III/CP Subchannel Module**
- **CONTEMPT** – **Transient Containment T/H Analysis**

MARS (II): RELAP + COBRA-TF + α



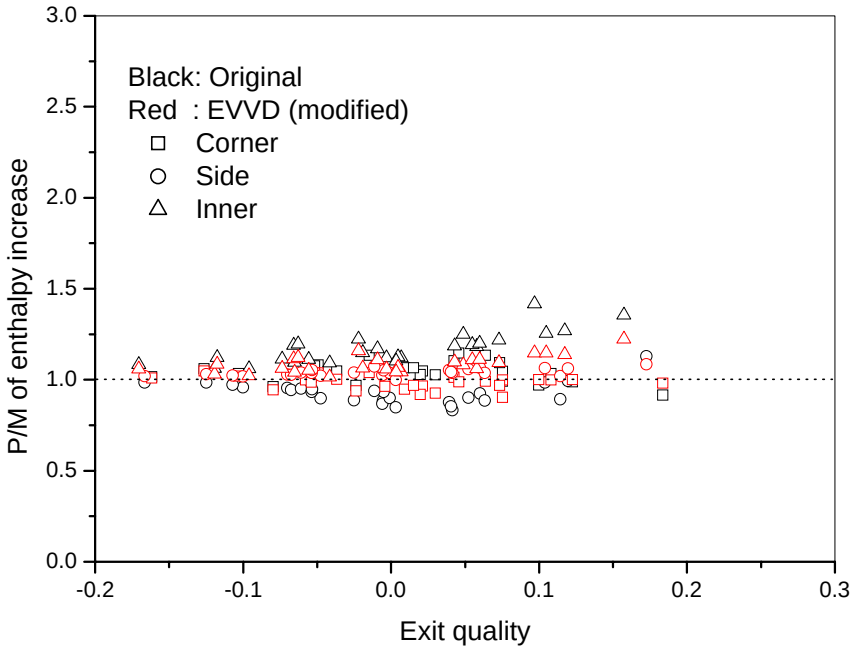
MARS (III): RELAP + COBRA-TF + α

❑ COBRA-TF IN THE MARS CODE

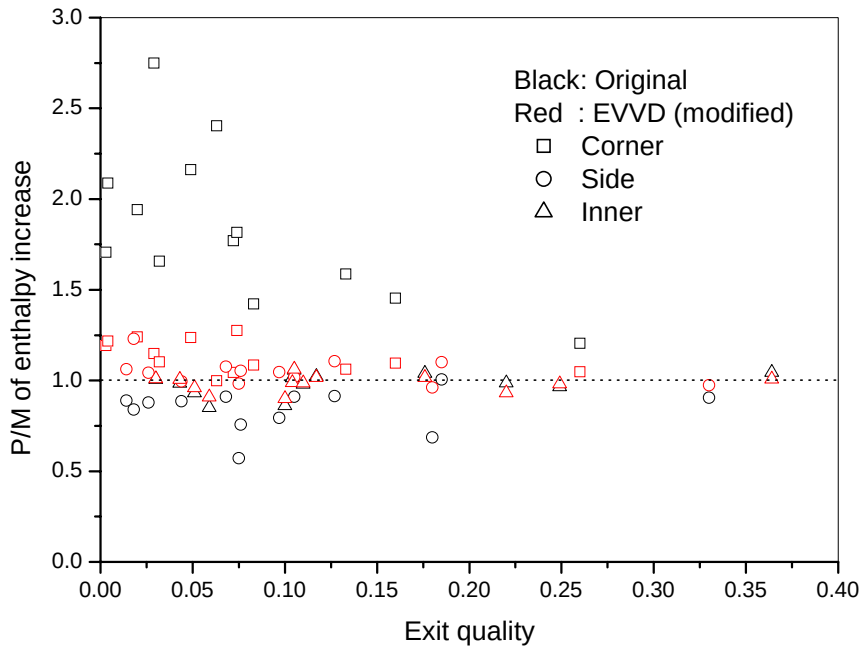
- **Two-Fluid, Three-Field Model for Two-Phase Flows**
- **The Lahey's Void Drift Model for Subchannel Flow Mixing (Modified Similar to That of MATRA)**
- **The Prediction Capability of Subchannel Flow Distribution was Validated using GE 9-Rod Bundle (BWR) and ISPRA 16-Rod Bundle (PWR) Tests**

MARS (IV): RELAP + COBRA-TF + α

❑ PRED./MEAS. OF ENTHALPY-RISE



ISPRA 16-Rod Bundle Test



GE 9-Rod Bundle Test

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CFX – Commercial CFD Code

by W. K. In

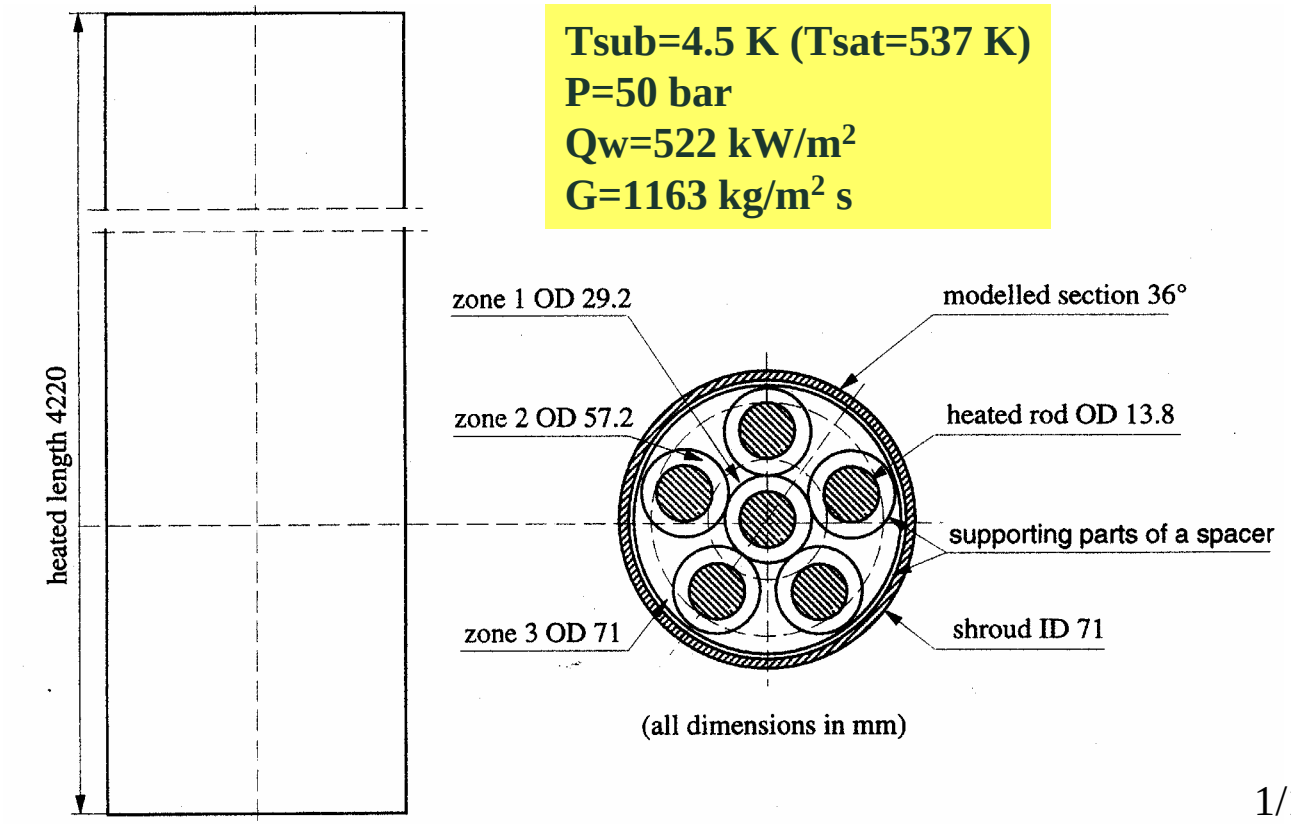
CFX (I)

❑ MULTI-PHASE MODELS IN CFX-4.4

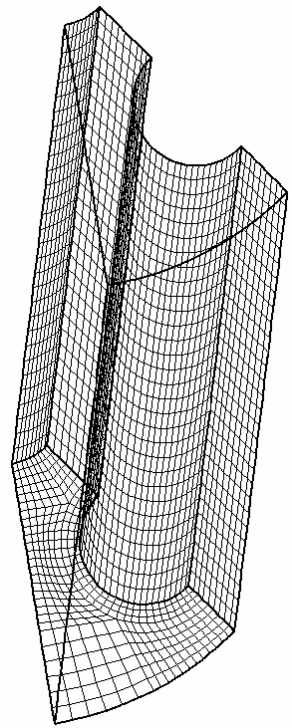
- **MULTI-FLUID MODEL**
- **HOMOGENEOUS MODEL**
- **ALGEBRAIC SLIP MODEL**
- **BOILING MODEL (RPI – WALL HEAT PARTITION MODEL)**
- **TURBULENT MULTI-PHASE MODEL (SATO & HOMOGEN.)**
- **MUTIPLE-SIZE-GROUP(MUSIG) MODEL (BUBBLE BREAKUP & COALESCENCE)**

CFX (II)

❑ TEST CASE: 6-ROD BUNDLE(FT-6a) IN FRIGG LOOP

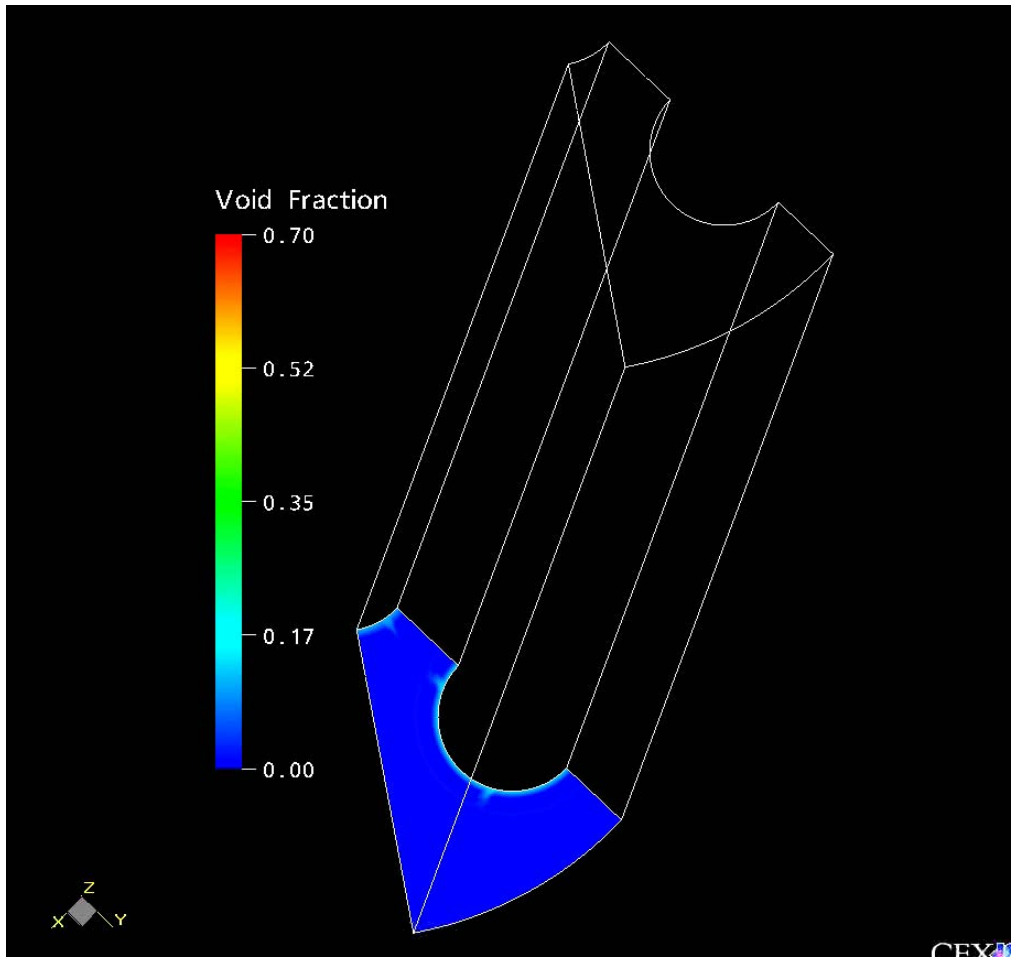


Tsub=4.5 K (Tsat=537 K)
P=50 bar
Qw=522 kW/m^2
G=1163 kg/m^2 s



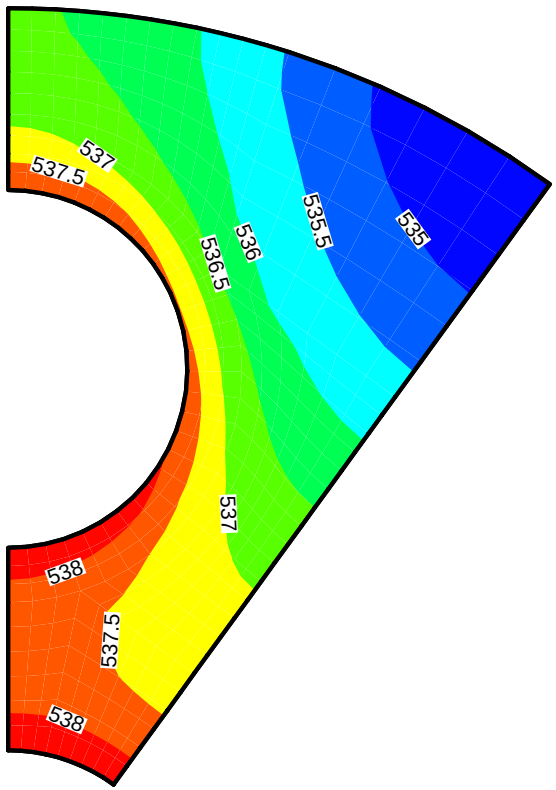
18x18x30
1/10 FT-6a, L=1.2m

CFX (III): VOID DISTRIBUTION

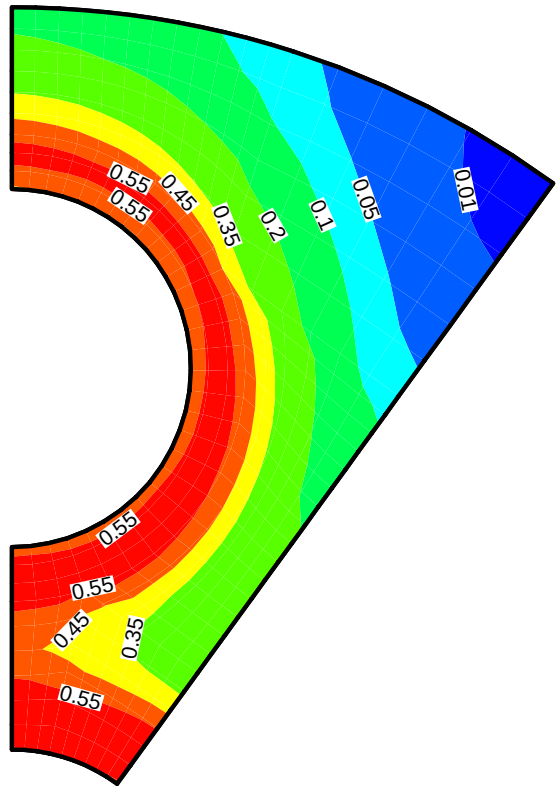


CFX (IV): LIQUID TEMP. & VOID FR.

1148 mm DOWNSTREAM

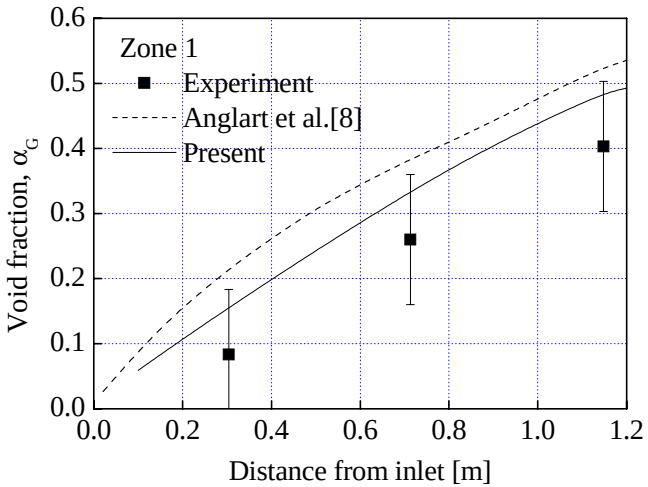


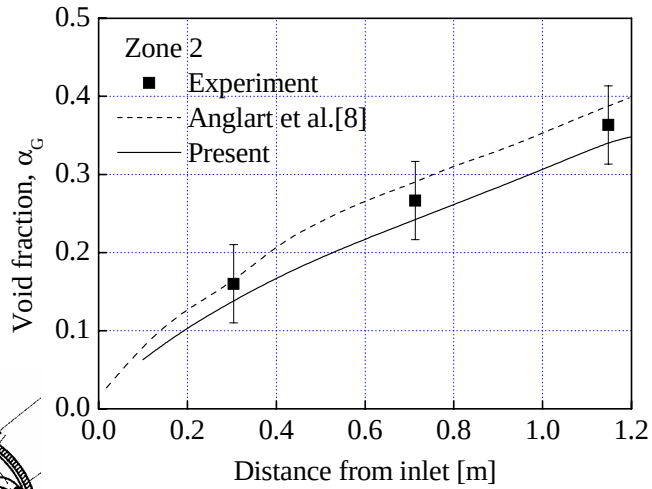
LIQUID TEMPERATURE

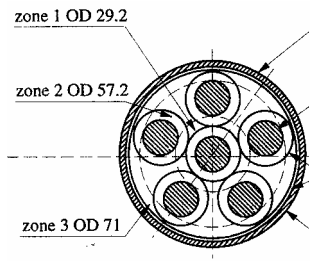


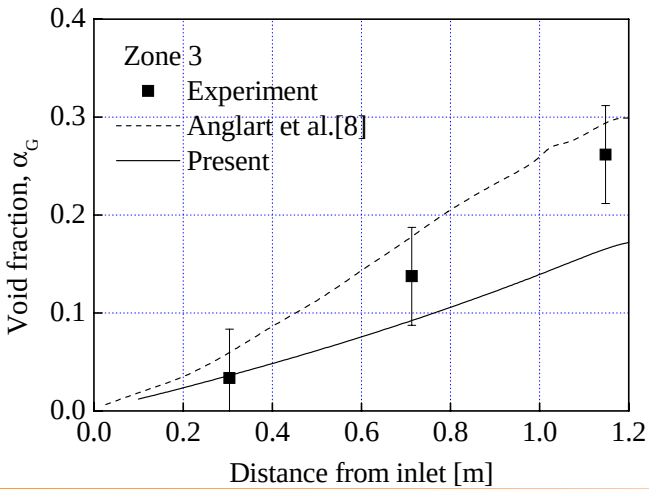
VOID FRACTION

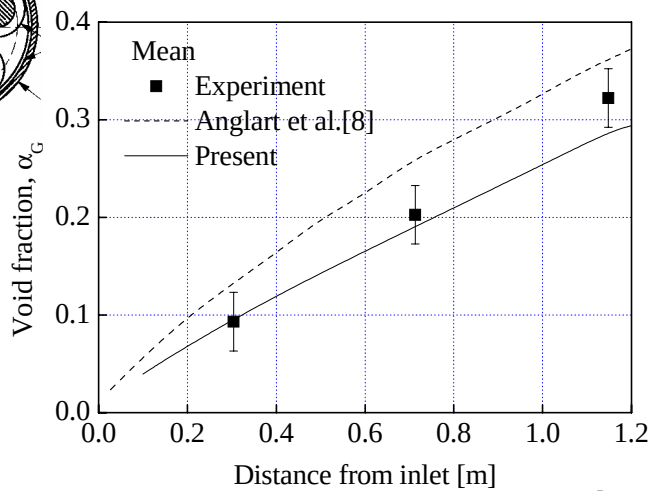
CFX (V): AXIAL DISTRIBUTION



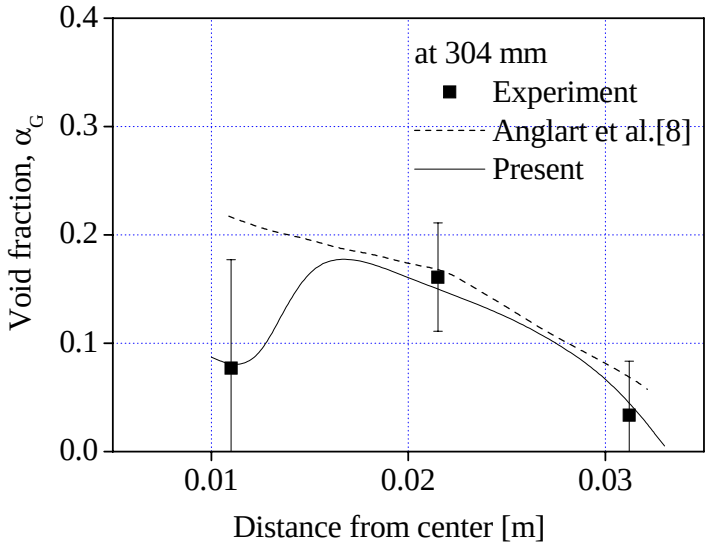


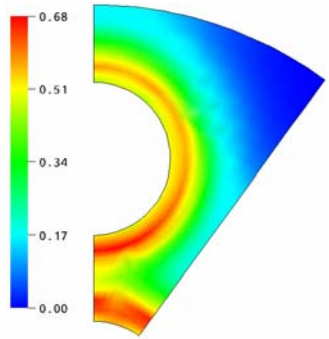


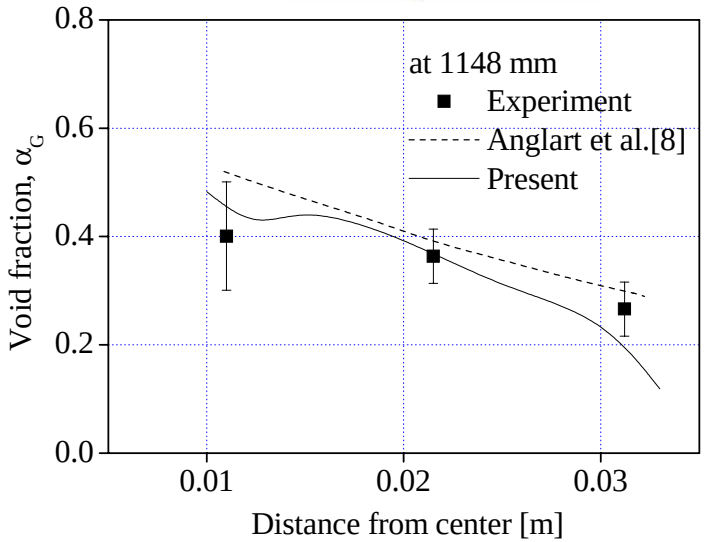


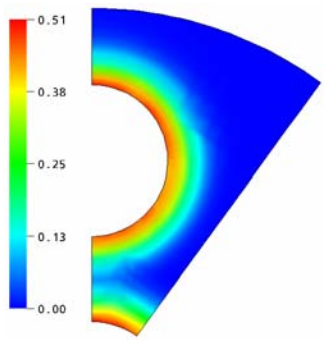


CFX (VI): RADIAL DISTRITION









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BFBT TASK – KAERI

by D. H. Hwang, J.-J. Jeong and W. K. In

BFBT TASK (KAERI)

❑ KAERI 'S PARTICIPATION IN BFBT

- **VOID DISTRIBUTION BENCHMARK**
  - **EXERCISE 1 – MATRA, MARS(COBRA-TF)**
  - **EXERCISE 2 – CFX**
  - **EXERCISE 3 – MARS(COBRA-TF)**
- **CRITICAL POWER BENCHMARK**
  - **EXERCISE 1, IF POSSIBLE - MATRA**

❖ **BILATERAL COLLABORATION BETWEEN KAERI & FZK**

- FZK (GERMANY) WILL ALSO PARTICIPATE IN THE BENCHMARK USING MATRA
- DETAILED TASKS OF FZK WILL BE DECIDED AFTER AN AGREEMENT WITH KAERI