NURESAFE WP3.3
Multiscale BWR Thermal-Hydraulics

Status of KIT Contributions to WP3.3

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Outline

- **KIT Contributions as planned to Task 3.3.1**

  “Development and validation of BWR thermal hydraulics modelling at system scale and sub-channel scale”

- **Status of code validation using BFBT Data**
  - Validation of ATHLET using the BWR NUPEC BFBT tests for void fraction and critical power
- **Modeling of the Oskarshamn-2 core with ATHLET**
  - Development of an integral plant model of the Oskarshamn-2 plant for the analysis of an ATWS transient (consistent with ATHLET input in WP1.3 - D13.21)
- **Modeling of the Oskarshamn-2 core with subchannel codes**
  - Input decks for COBRA-TF, SUBCHANFLOW, FLICA4 developed and successfully tested
- **Conclusion & Outlook**

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KIT Contributions to Task 3.3.1

- **Specific non disclosure agreement with OKG was signed and the Oskarshamn-2 data can be used within the NURESAFE project (Final notification on 9.10.2013).**
- **Received updated version (20.11.2013) of NURESAFE COBRA-TF from PSU with several open issues fixed. Still SALOME integration work to be performed at GRS (SP1).**
- **Emails exchange (21.11.2013) with an assessment at KIT of the COBRA-TF version.**
  - Some bug fix proposed.
  - Non-regression test run reporting the results.
- **Using ATHLET Mod3.0 Cycle A for the WP1.3 and WP3.3 task**

Non-Disclosure Agreement with OKG

Non-Disclosure Agreement – NURESAFE Oskarshamn-2 (O2) 1999 BWR Stability Study.

The undersigned may, when working on the Oskarshamn-2 study come into contact with or obtain knowledge of confidential information of a technical, commercial or other nature, which OKG wishes to protect with respect to its responsibility towards society, the E.ON-group, business relations, shareholders and individuals.

Thus, the undersigned undertakes to:

- neither during nor after co-operation with OKG use such information or documentation for any purpose other than to participate in the NURESAFE Oskarshamn-2 study.
- use the information exclusively for model and code improvements for BWR plant simulations including uncertainty analyses in modelling.
- not to make copies of the information and not to reveal to any unauthorized third party not bound by similar undertakings as those provided herein such information without OKG's written consent in each individual case.
- provide feedback on deficiencies or errors they may find in the data.
- inform the NURESAFE committee before publishing any study results for which the Oskarshamn-2 data have been used.

The undersigned is aware that any breach of this commitment of professional confidentiality may result in a liability to pay damages.

DISCLAIMER
Neither the organisations participating in NURESAFE, nor OKG, nor any person acting on behalf of any of these organisations, assume any liability for any direct, indirect, special or consequential damages in connection with or related to the use of any data and information disclosed by them.

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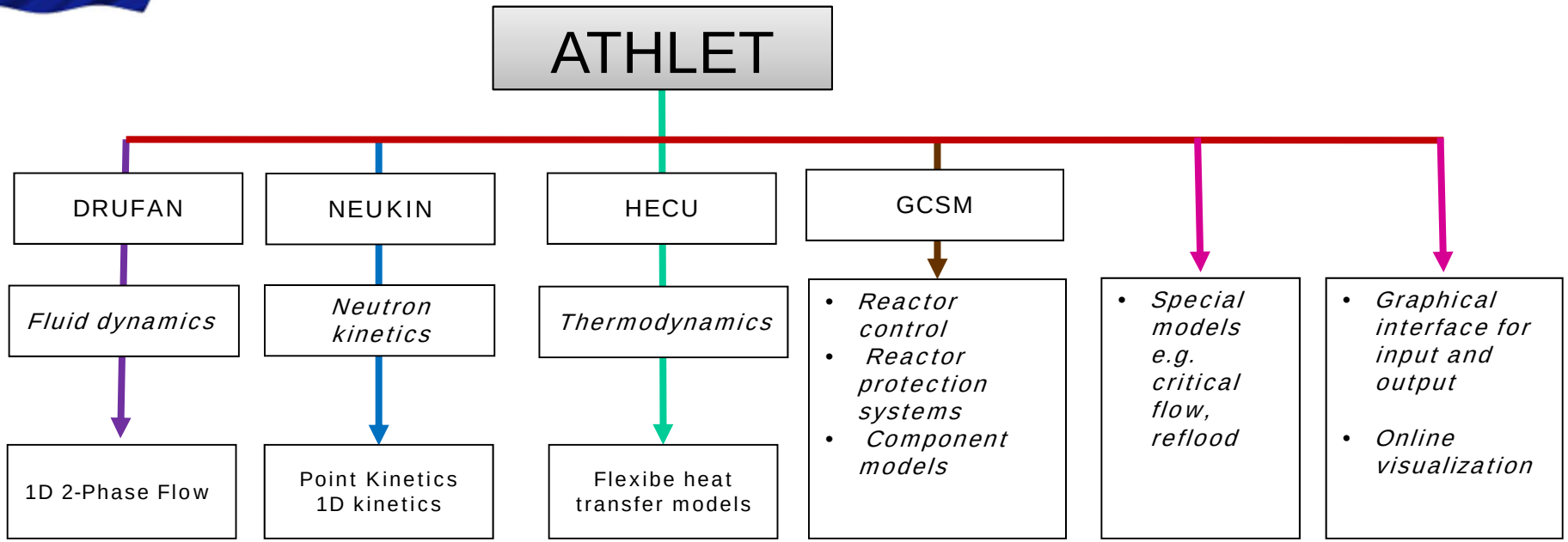
ATHLET: Main Features

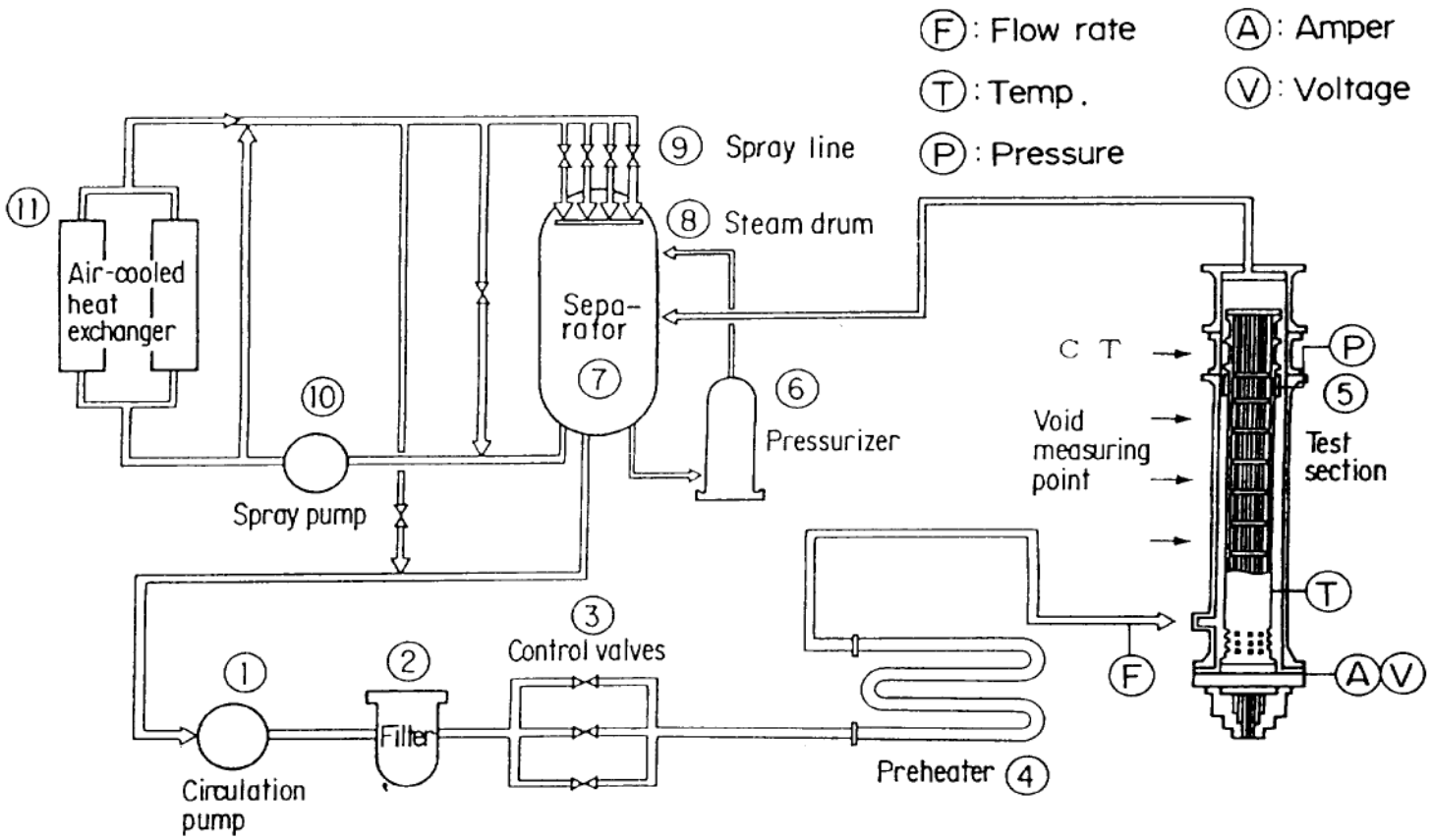


ATHLET: Analysis of Transients as well as LOCAs of Light Water Reactors (PWR, BWR, VVER, RBMK)

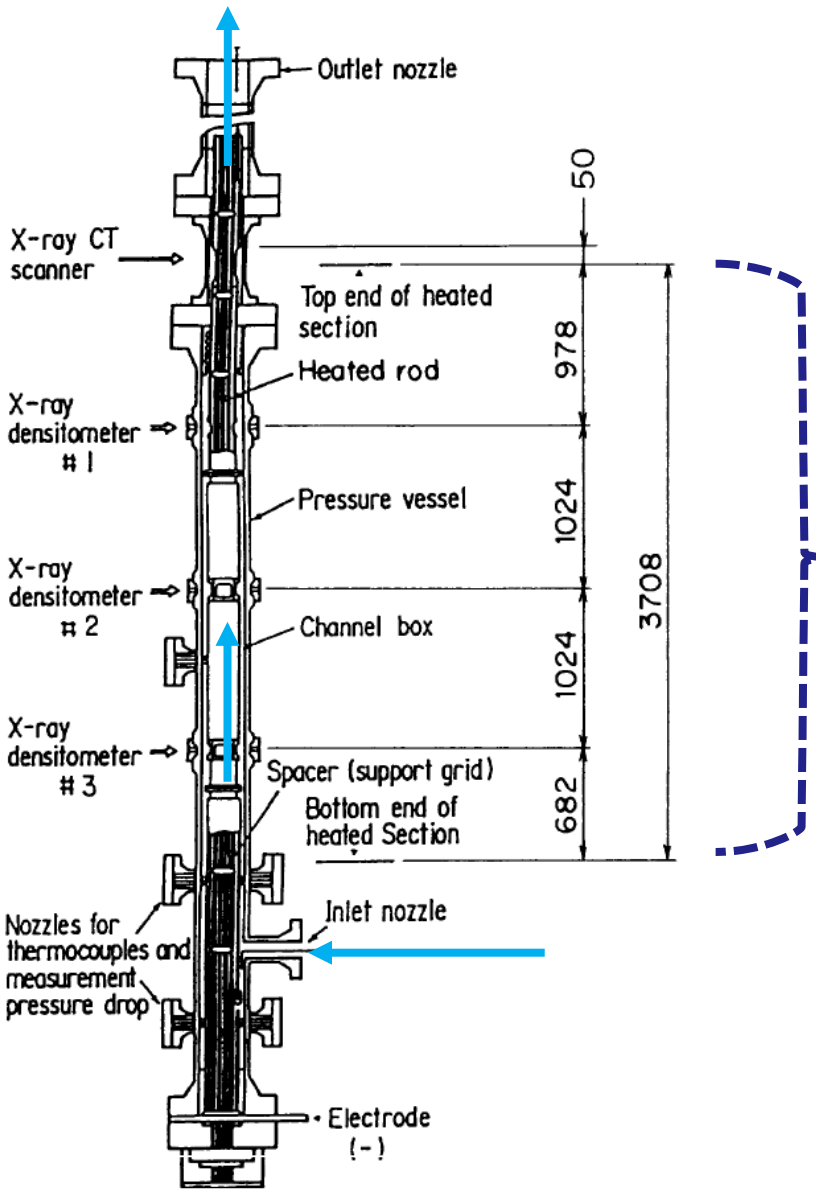
- **ATHLET (Analyse der Thermohydraulik für LEcks und Transienten)**

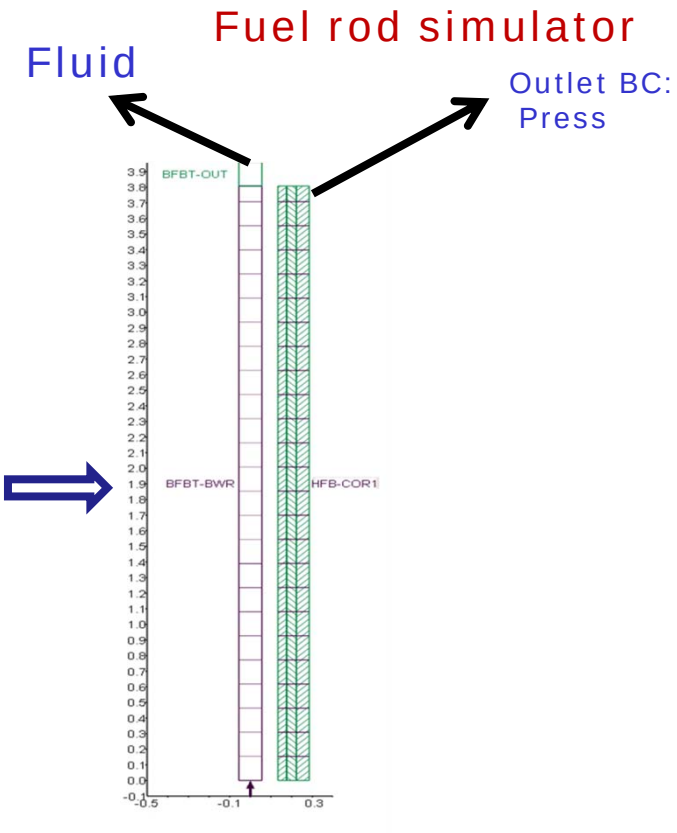
BFBT : BWR Full-Size Fine-Mesh Bundle Test

- **NUPEC BFBT experimental facility**



BFBT Model with ATHLET (1)



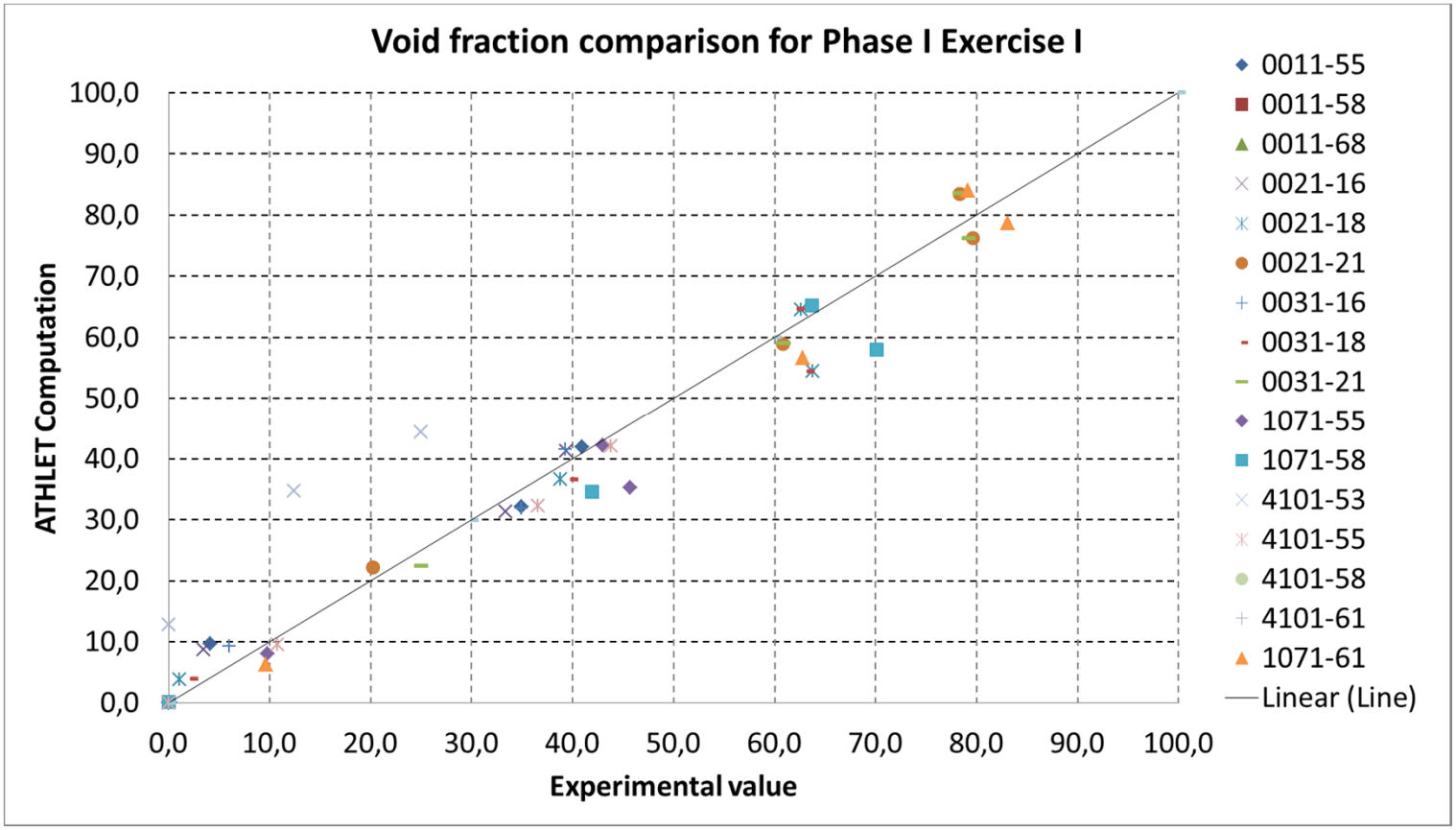


ATHLET Nodalization

ATHLET validation using the BFBT data

- **From the OECD/NEA BFBT benchmark, several exercises will be modeled.**
  - The total number of test cases still to be decided
- **Phase I – Void distribution benchmark**
  - Exercise 1: Steady-state sub-channel grade benchmark
  - Exercise 3: Transient macroscopic grade benchmark
    - Turbine trip and pump trip
- **Phase II – Critical power benchmark**
  - Exercise 0: Steady-state pressure drop benchmark
    - Single phase and two phase
  - Exercise 1: Steady-state critical power benchmark
    - Assemblies C2A, C2B, C3

ATHLET Validation based on BFBT Data



- **Next steps:**
  - Double check the results which show higher discrepancies.
  - Continue with the next exercises.

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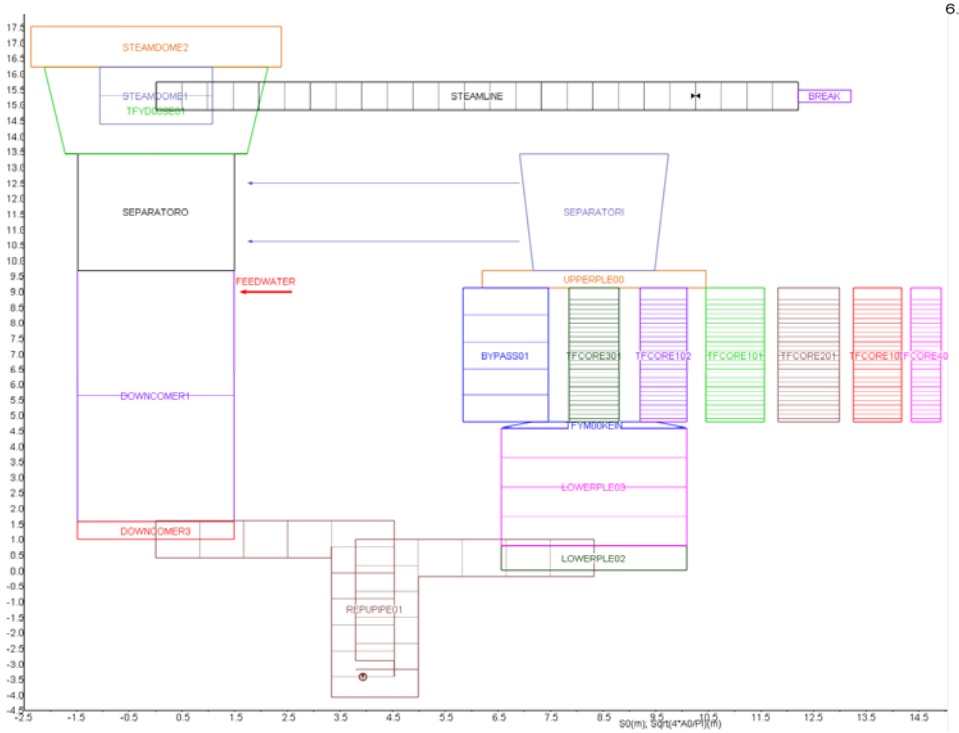
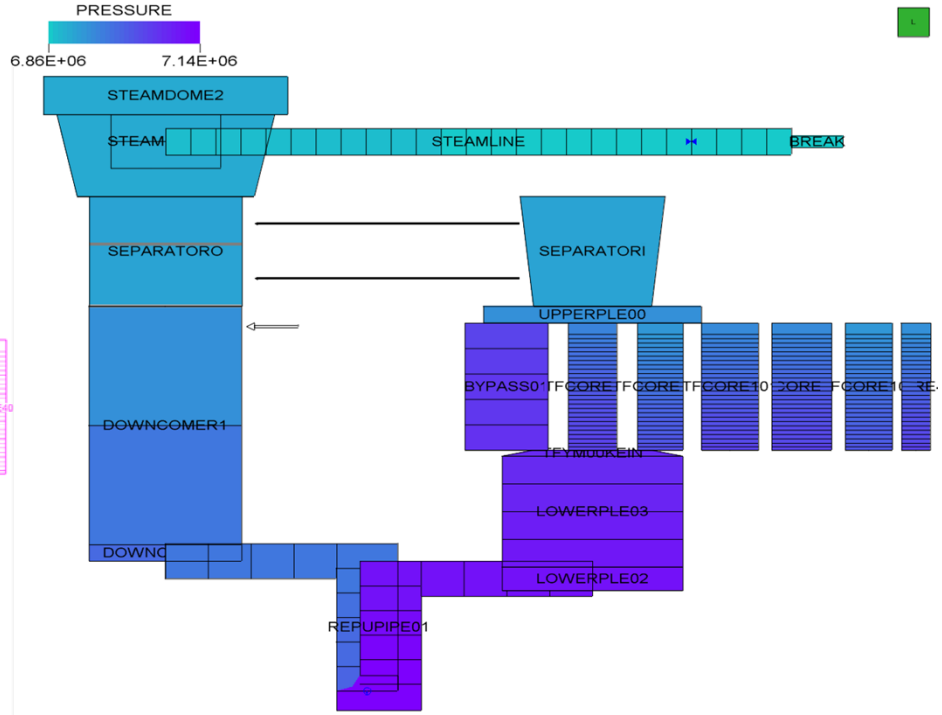
ATHLET model for O-2

- **ATHLET input deck from D13.21 received on (3.12.2012)**
  - Modifications performed to use the point kinetic model.

Model contains: Downcomer, Recirculation Loop and Pump, Lower Plenum, Steam Separator, Steam Dome, Core Model, Core Bypass, Steam Line.

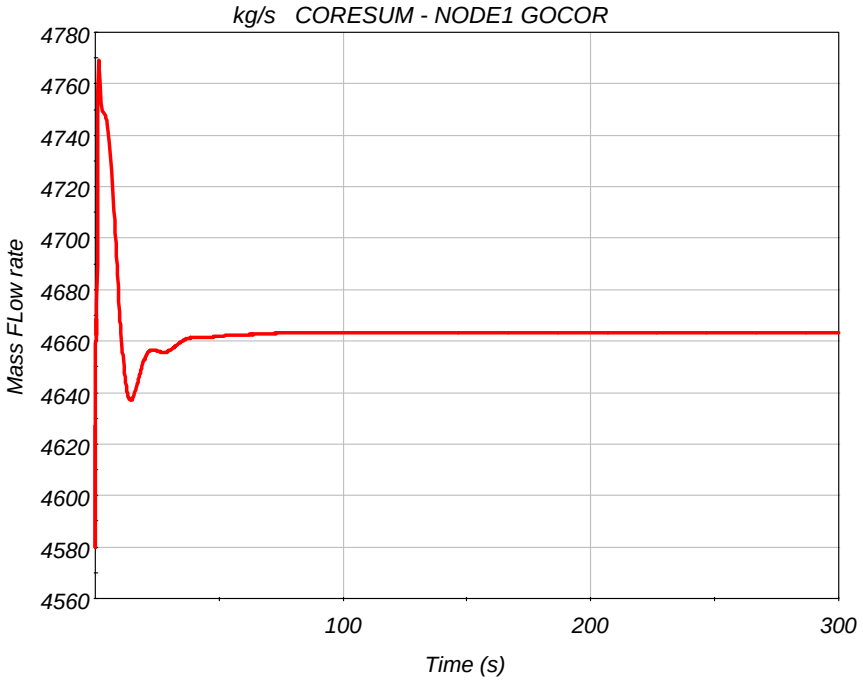


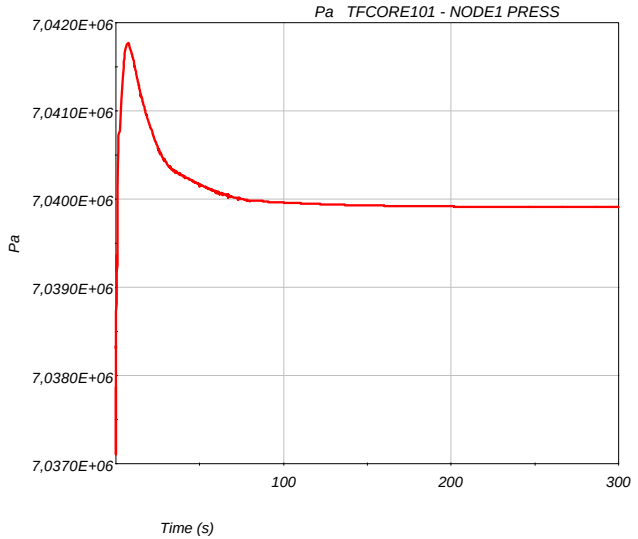


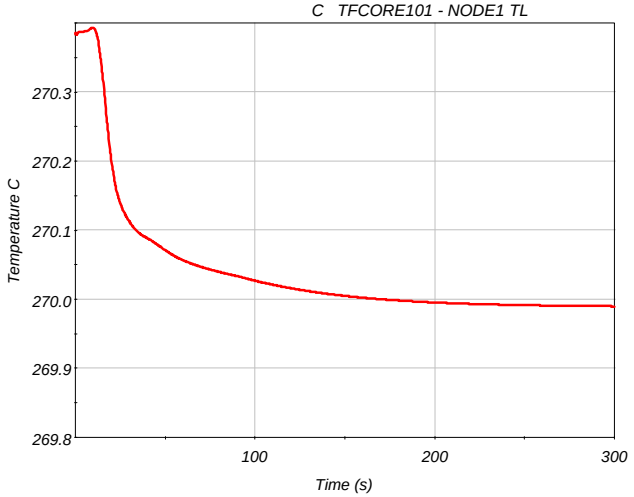
Preliminary results for the SS at HFP

- **Results from ATLAS**

Steady State convergence achieved after 300s







Preliminary results for the SS at HFP

- **Comparison of values against measured data.**
  - Using a simple point kinetics model imposing the nominal power and no reactivity insertion.

Parameter	Benchmark	ATHLET 3.0	Discrepancy with reference
Steam dome pressure	NON-DISCLOSURE AGREEMENT		-0.375%
Feedwater Temperature			-0.049%
Core Inlet Temperature			-0.760%
Total Core Flow Rate			1.234%
Steam Flow Rate			0.597%

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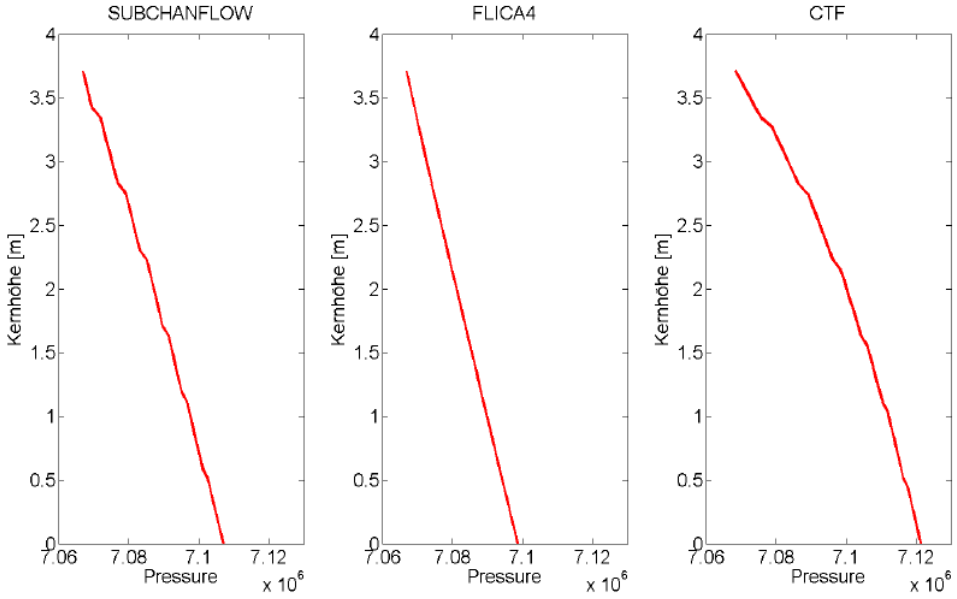
O2 Modeling with subchannel codes

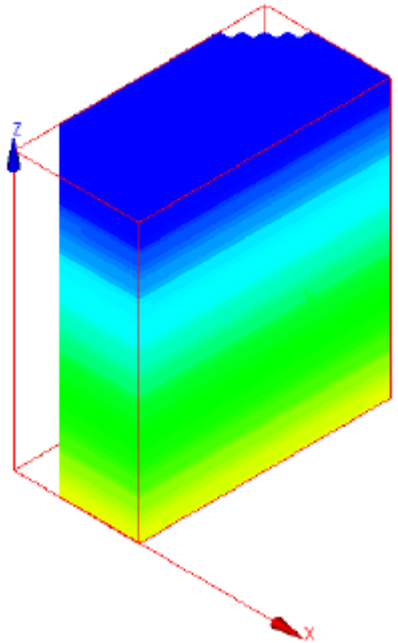
- **Oskarshamn-2 Core has being modeled with COBRA-TF, SUBCHANFLOW and FLICA4**
- **Code versus measured data comparison**

Parameter at HFP	Benchmark	SCF	FLICA4	CTF
Thermal Power (MW)	NON-DISCLOSURE AGREEMENT			
Core inlet Temperature (K)				
Core Inlet Mass Flow (kg/s)				
Core outlet Temperature (K)				
Average void fraction (-)				
Void fraction at core outlet (-)				
Presure drop in the core (kPa)				
Average flow velocity in the core (m/s)				

Results: Pressure drop

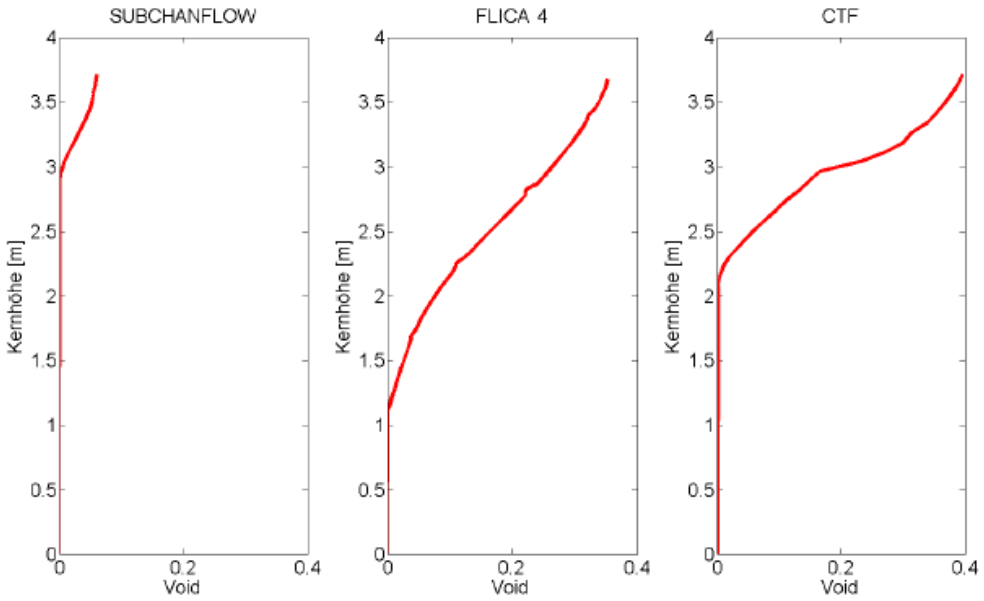
- **3D Power distribution take from converge steady state TRACE/PARCS**

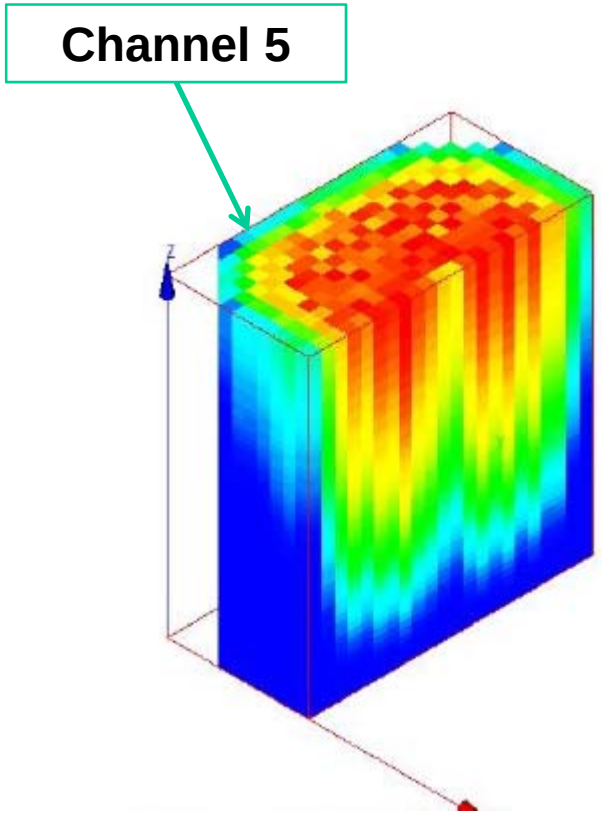




	Benchmark	SUBCHANFLOW	FLICA4	CTF
Average Pressure drop in the core (kPa)	Ref.	-1.9%	-12.8%	+16.3%

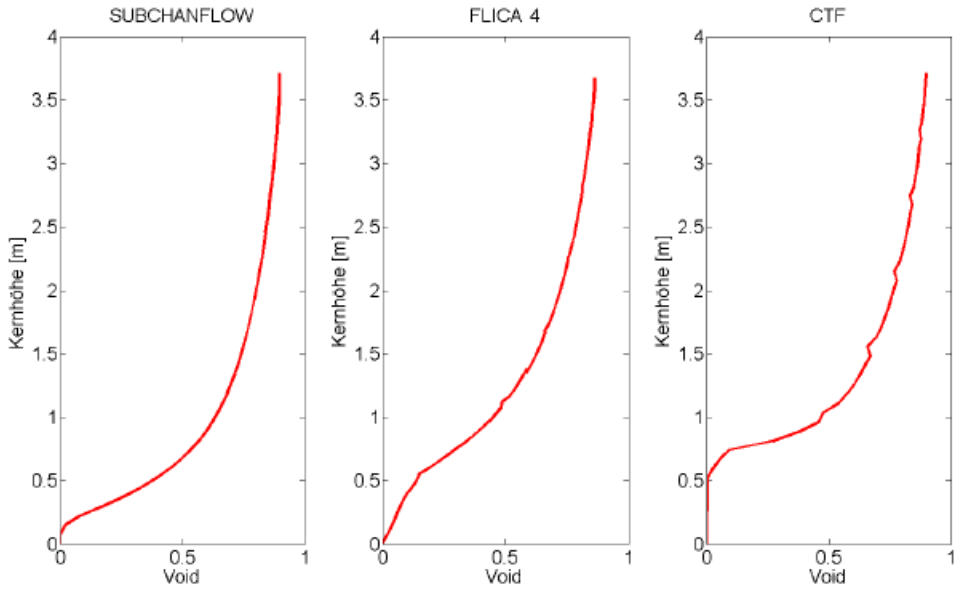
Results: Void fraction in channel 5

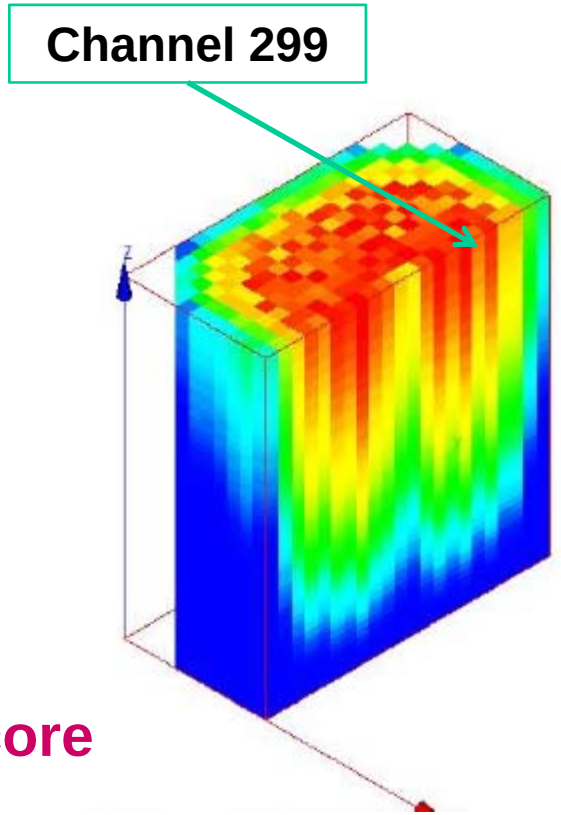




- **Very different onset of boiling**
- **Effects of subcooled boiling are modeled differently**

Results: Void fraction in channel 299





- **Similar vapor volume fraction at the core outlet**
- **The position of the spacers grids in FLICA and COBRA-TF can be seen clearly**

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Conclusions and Outlook

- **SUBCHANFLOW, CORA-TF and FLICA4 model for O2 core completed**
  - Good agreement between O2 reference values and predictions,
  - FLICA4 and SUBCHANFLOW models developed as a backup solution for O2
- **Continuing with the AHTLET validation using the BFBT data**
- **Verification of ATHLET model completed:**
  - Good agreement between the ATHLET model and the measured data.
  - Extensions of the model to ATWS needed, add more components
- **On time for the T0+18 deadline.**