

Experience gained from NSC benchmarks



- Series of benchmarks to validate/develop 3D Kinetics and ThermalHydraulics coupling (core, vessel, plant)
 - PWR Main Steam Line Break (TMI-1)
 - BWR Turbine Trip (Peach Bottom)
 - VVER Cooling Transient (Kozloduy-6)
- Systematic approach with several exercises (cf. Specifications)
 - 0D/3D kinetics
 - Neutronics with/without TH feedback
 - Core boundary conditions/Core-plant coupling
- Community of experts in TH/N
 - Workshops
 - Conferences (PHYSOR, M&C, NURETH)

Assessment of the calculations



- Need for reference solutions
 - Code prediction
 - Measurement data
- Sensitivity analysis
 - Identify the most sensitive parameters among the uncertain ones
 - Examples: core pressure drop, vessel mixing coefficient, gap heat transfer coefficient...
- How to compare the results?



OECD/NRC Boiling Water Reactor Peach Bottom 2 Turbine Trip Benchmark

4th Workshop, Seoul, KOREA

SINGULAR VALUES WITH AVAILABLE MEASURED DATA

CORE INLET ENTHALPY and CORE AXIAL PRESSURE DROP

Standard Statistical Methodology:

$$e_i = x_i - x_{MEASURED}$$

$$\sigma = \pm \sqrt{\frac{\sum (x_i - x_{MEASURED})^2}{N - 1}}$$

$$FOM = \frac{e_i}{\sigma}$$



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1-D DISTRIBUTION

CORE AVERAGE AXIAL VOID FRACTION DISTRIBUTION

Standard Statistical Methodology:

Using EXELON results as reference for these preliminary comparisons. The EXELON RETRAN model has been validated against the measured data

$$e_i = x_i - x_{EXELON}$$

$$\sigma = \pm \sqrt{\frac{\sum (x_i - x_{EXELON})^2}{N - 1}}$$



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TIME HISTORIES WITH AVAILABLE REFERENCE DATA (MEASURED DATA AND/OR EXELON DATA)

- Using ACAP for time history code-to-data analyses: D'Auria FFT, ME, and CWT methods. Dome Pressure.
- Using ACAP for time history code-to-code analyses: D'Auria FFT, and ME. Core Exit Pressure, Total Jet Pump Flow, Total Core Inlet Flow , Turbine Bypass Flow, Turbine Inlet Pressure.
- These methods will be summarized at the end of the presentation

These methodologies are discussed in “Automated Code Assessment Program: Technique Selection and Mathematical Prescription”, ARL, PSU, April 1998



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CORE INLET ENTHALPY

$$x_{MEASURED} = 1209.06 \text{ kJ / kg}$$

$$\sigma = \pm \sqrt{\frac{\sum (x_i - x_{MEASURED})^2}{N - 1}} = \pm 2.917$$

	CEA	EXE	FRA	GRS	IBE	NET	NFI	NUP
VALUE	1206.00	1209.06	1208.30	1206.30	1209.38	1204.95	1210.50	1209.09
DEVIATION	-3.055	0.000	-0.755	-2.755	0.325	-4.105	1.445	0.035
FOM	-1.047	0.000	-0.259	-0.944	0.111	-1.407	0.495	0.012

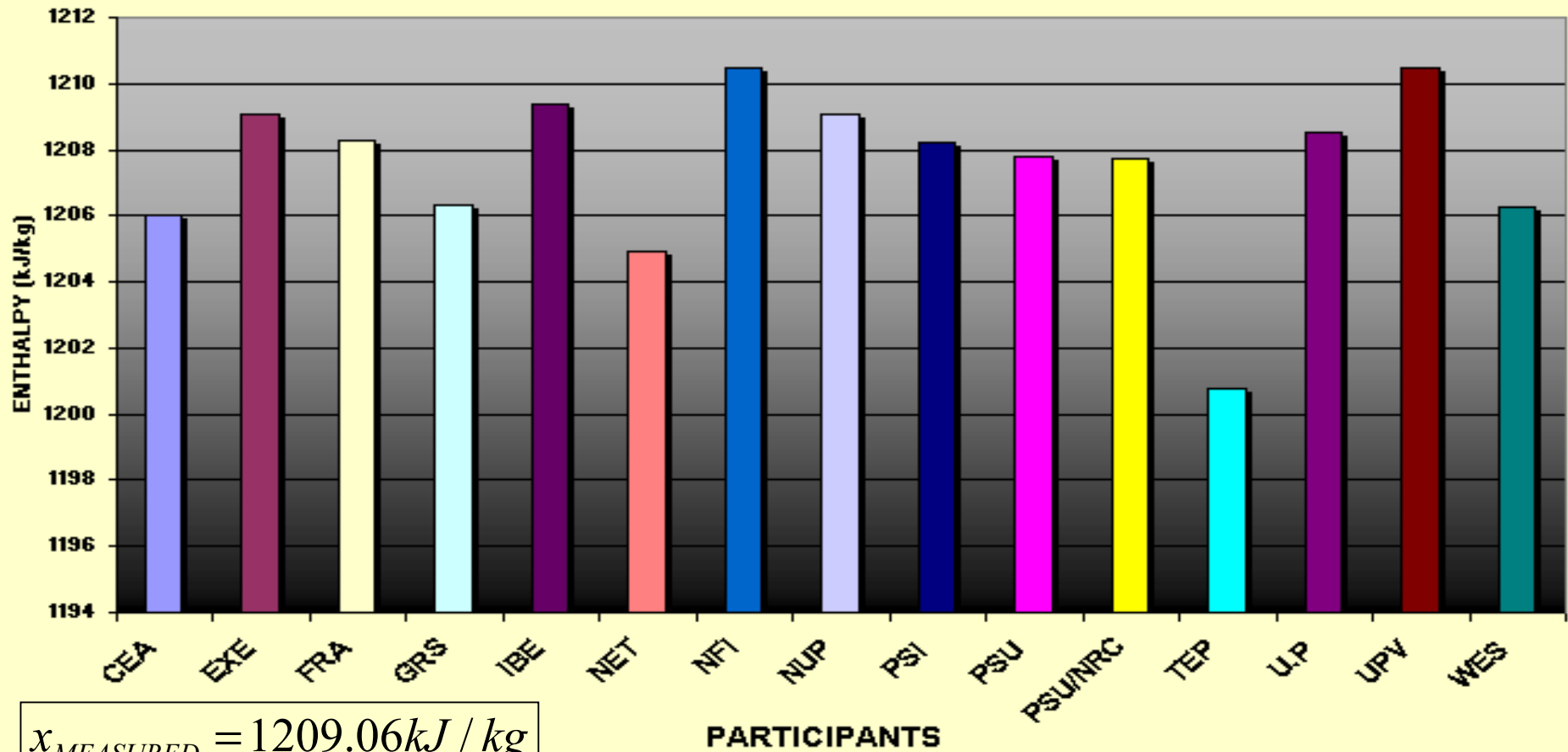
	PSI	PSU	PSU/NRC	TEP	U.P	UPV	WES
VALUE	1208.24	1207.80	1207.70	1200.80	1208.50	1210.49	1206.27
DEVIATION	-0.815	-1.255	-1.355	-8.255	-0.555	1.435	-2.785
FOM	-0.279	-0.430	-0.465	-2.830	-0.190	0.492	-0.955



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CORE INLET ENTHALPY



Combine uncertainty analysis with multi-physics



- Take into account uncertainty analysis in benchmarks
 - Specific benchmarks, e.g. BEMUSE
 - TH/N benchmarks, e.g. BFBT
 - Optional exercise
 - Take into account uncertainties on input data (boundary conditions, geometry..., provided by the Specifications) and on models and produce results with “errors”
 - Compare with measurement uncertainties