Hochschule Zittau/Görlitz
UNIVERSITY OF APPLIED SCIENCES

Institute of Process Technology, Process Automation and Measuring Technology
IPM HOCHSCHULE ZITTAU/GÖRLITZ

VALIDATION OF AN INNOVATIVE CORE STATE DIAGNOSIS SYSTEM FOR SEVERE ACCIDENTS IN PWR BY USING AN EXPERIMENTAL RIG

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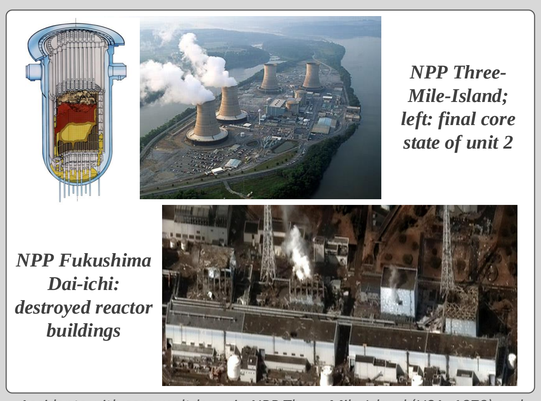
INTRODUCTION

Motivation

- **Severe accidents** in PWR **can lead to a core meltdown** in the reactor pressure vessel (RPV)
- To initate emergency actions **for accident management it is important to recognize** the beginning as well as the progress of **the core meltdown**
- **Currently no measuring system is available** which can detect the processes in the reactor pressure vessel during a core melt accident in a sufficient degree



Accidents with core meltdown in NPP Three-Mile-Island (USA, 1979) and NPP Fukushima Dai-ichi (Japan, 2011)

Cooperative project

„Non-Invasive Condition Monitoring of Nuclear Reactors for Detection of Level Changes and Deformation of the Core“

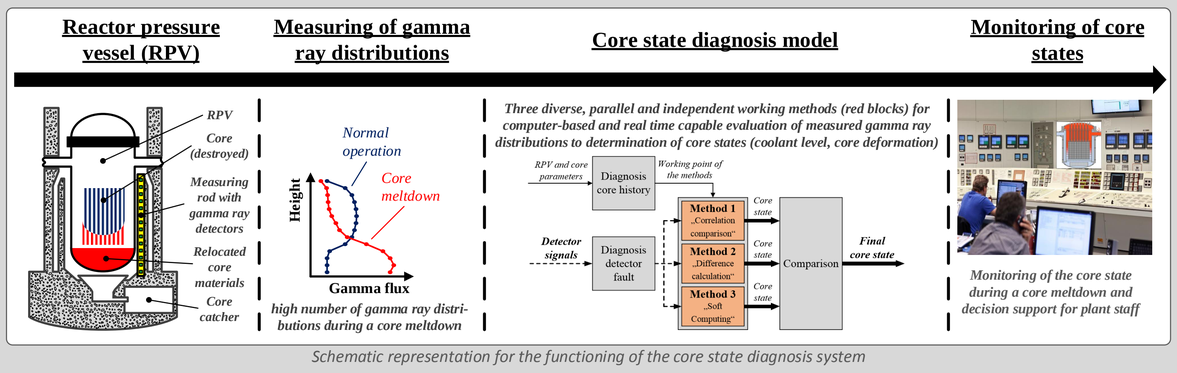
In line with the cooperative project between the Technical University Dresden (TUD) and the Institute of Process Technology, Process Automation and Measurement Technology (IPM) of Zittau/ Goerlitz University of Applied Sciences a innovative measurement system for the core state diagnosis during severe accidents in pressurized water reactors (PWR) is going to be developed.

Benefits e.g.

Diverse coolant level measuring | Complete diagnosis for the „In-Vessel phase“ of a core meltdown | Time overview for a core meltdown | Estimation of risks during a core meltdown (e.g. steam explosion in the case of RPV re-flooding) | Decision support for plant staff in the case of a core meltdown | No intervention in the system „RPV“ | Independent of temperature and pressure in RPV

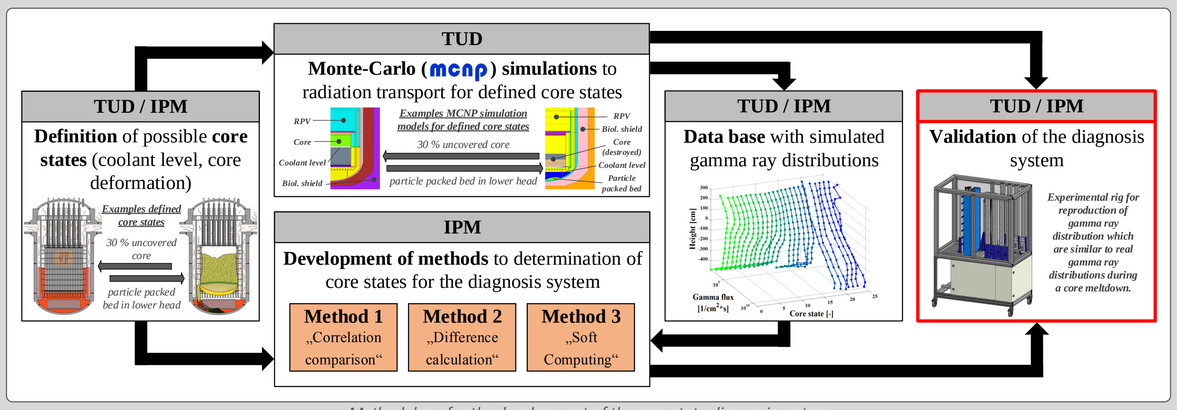
INNOVATIVE CORE STATE DIAGNOSIS SYSTEM

Functioning – non-invasive measurement of gamma ray distributions



Schematic representation for the functioning of the core state diagnosis system

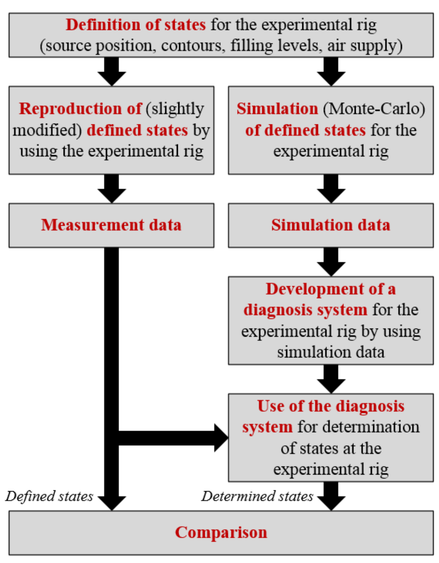
Development methodology – simulation data for method development



Methodology for the development of the core state diagnosis system

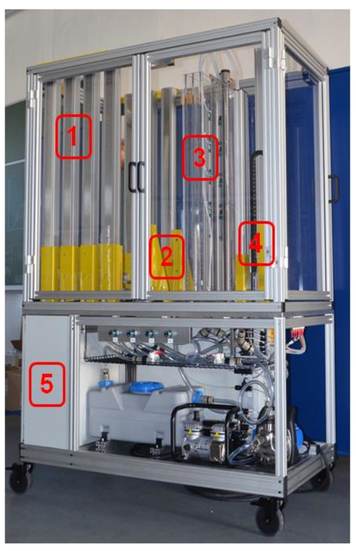
VALIDATION OF THE CORE STATE DIAGNOSIS SYSTEM

Validation methodology



Validation methodology for the diagnosis system

Experimental rig for validation support



Construction

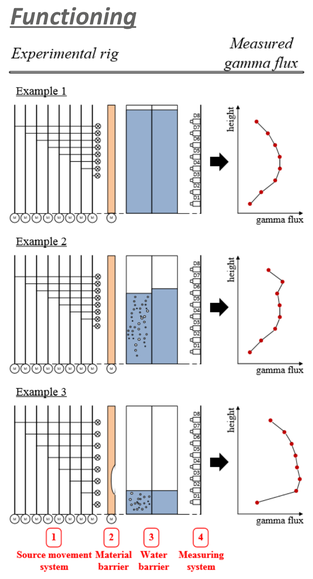
Purpose of the experimental rig:

Validation of the diagnosis system with real measuring data

Experimental rig subsystems:

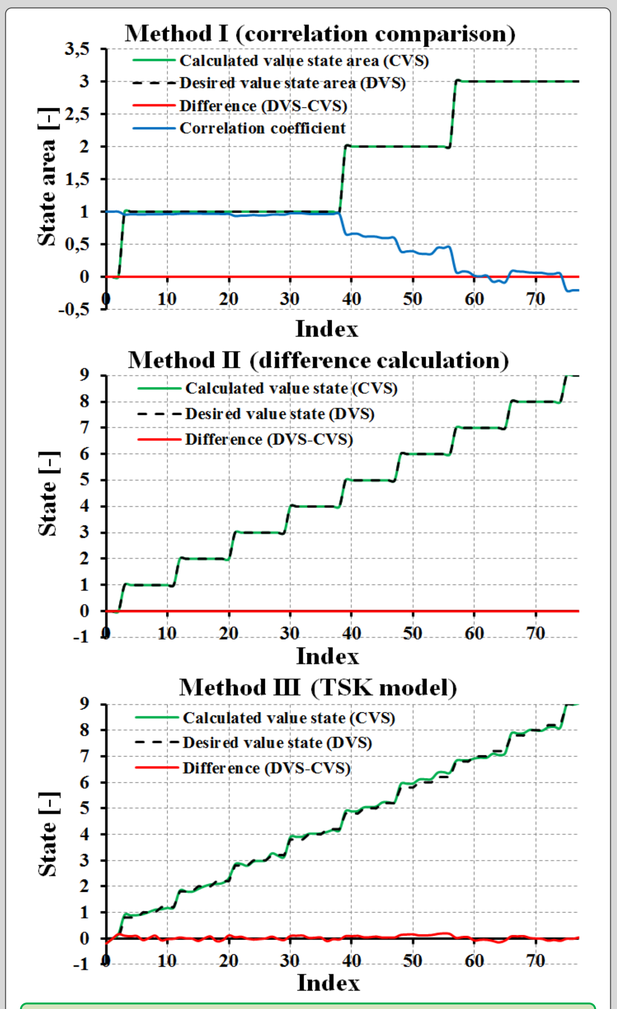
- ***source movement system*** 1
  Simulation source term movement or creation of changable gamma ray distributions by using 8 CS-137 sources
- ***Material barrier*** 2
  Reproduction of penetrating material structures
- ***Water barrier with compressed air inlet*** 3
  Simulation of water level changes and coolant boiling
- ***Measuring system*** 4
  8 gamma radiation detectors (scintillation counters) for measuring of gamma ray distributions
- ***Rack, switch cabinets, control unit*** 5

Functioning



Construction and functioning of the experimental rig for validation support

First validation results



- ✓ ***100 % correct determined states by the methods for state diagnosis on the experimental rig***
- ✓ ***First successful validation of the (core) state diagnosis system – detection of water levels and source re-location***

Results of the identification analysis for methods 1, 2 and 3; green: calculated values , Black dashed: desired values, red: differences between calculated and desired values

Simulation and measurement data for development and validation of state diagnosis methods

Simulation data of defined experimental rig states

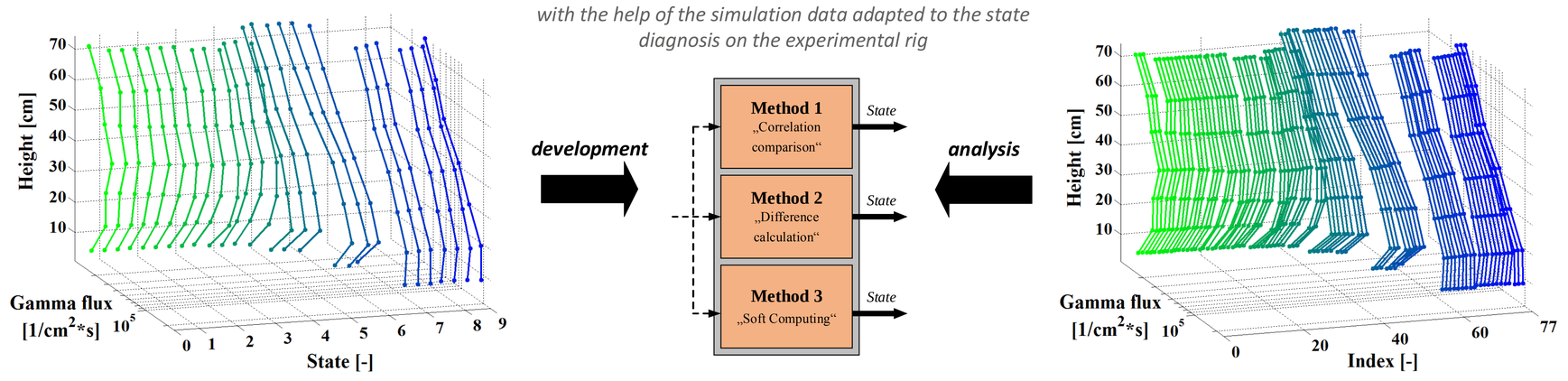
for the development of the experimental rig methods

Methods for state diagnosis on the experimental rig

three diverse methods of the core state diagnosis system with the help of the simulation data adapted to the state diagnosis on the experimental rig

Measurement data of defined experimental rig states

for analysis of the experimental rig methods



Simulations data from MCNP simulations and measurement data from the experimental reproduction of defined experimental rig states

SUMMARY

- **Development of a non-invasive measurement system for core state diagnosis** during severe accidents in pressurized water reactors (measurement of **gamma ray distributions** outside the RPV)
- For the diagnosis system development of **methods for the** computer-based and real-time capable **evaluation of measured gamma ray distributions**
- **Validation** of the core state diagnosis system **by using an experimental rig**
- ✓Results of a **first successful validation experiment** show clearly the suitability of the developed core state diagnosis methods - *detection of water levels and source re-location*

OUTLOOK

- **Further validation experiments with slightly modified experimental rig states** – *analysis of the method behavior for unknown gamma ray distributions*
- **Implementation of the findings and analyzes** from the validation experiments **in the core state diagnosis system**
- **Development of parameters for quality evaluation** of the data bases (number of gamma ray distributions) for the creation of the core state diagnosis methods
- **Testing of the** core state **diagnosis system with** further **Monte-Carlo simulation results**

Project duration: 01.07.2012 – 30.06.2015
Project leader: Prof. Dr.-Ing. Alexander Kratzsch (IPM); Prof. Dr.-Ing. habil. Uwe Hampel (TUD)
Project employees: Dipl.-Ing. (FH) Daniel Fiß, M.Eng. Dipl.-Ing. (FH) Sebastian Schmidt, Steffen Härtelt (IPM); Dr.-Ing. Carsten Lange, M.Sc Carsten Brachem (TUD)

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