OECD / NEA workshop NI 2050

Paris, 7th and 8th July 2015

Overview on the German situation with a focus on the HGF programme:

Nuclear Waste Management, Safety and Radiation Research (NUSAFE)

Programme speaker – Dirk Bosbach

Presentation given by Th. Walter Tromm

HELMHOLTZ ASSOCIATION

NUSAFE programme structure for POF-3
Budget 2015 -2019: ~ 45 Mill Euro/a

- **Topic 1**

  Nuclear Waste Management (67%)

  Speaker: Prof. Dr. Horst Geckeis

  - **Safety Research for Nuclear Waste Disposal**
  - **Waste Management Strategies**

- **Topic 2**

  Reactor Safety (33%)

  Speaker: Dr. Sören Kliem

  - **Reactor Operation and Design Basis Accidents**
  - **Beyond Design Basis Accidents and Emergency Management**

HGF-NUSAFE budget 2015 – 2019
~ 17,5 Mill Euro / a
for the topics:

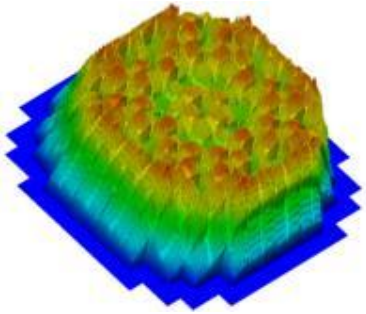
- Reactor Operation and DBA
- Safety research for innovative reactors
- Partitioning and Transmutation
- Beyond Design Basis Accidents
- Emergency Management

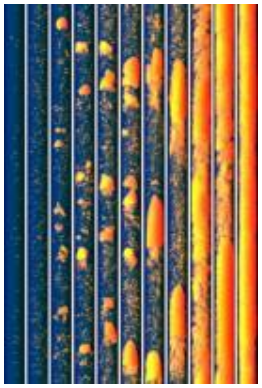
Reduction of about 10 % against budget 2010-2014

Partial transfer of research topics into non-nuclear programmes

JÜLICH FORSCHUNGSZENTRUM
HZDR HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF
KIT Karlsruhe Institute of Technology
NUSAFE
HELMHOLTZ ASSOCIATION

Reactor Operation and Design Basis Accidents





Neutron kinetics

High accuracy modelling and extension to different reactor types

Thermal hydraulics

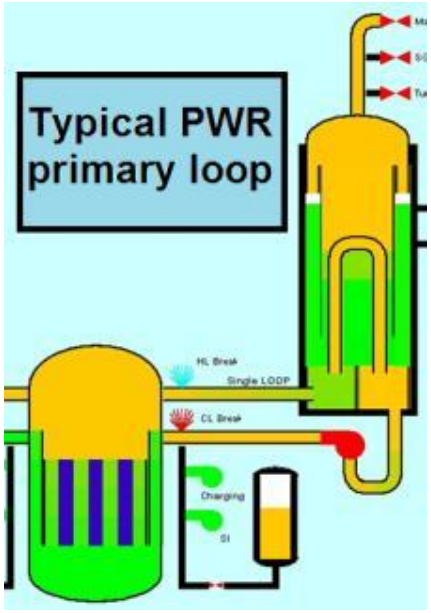
Computational Fluid Dynamics (CFD): Integrative flow regime modelling

Materials behaviour

Clarification of irradiation induced damages and underlying mechanisms

Coupling

Multi-Physics Modelling



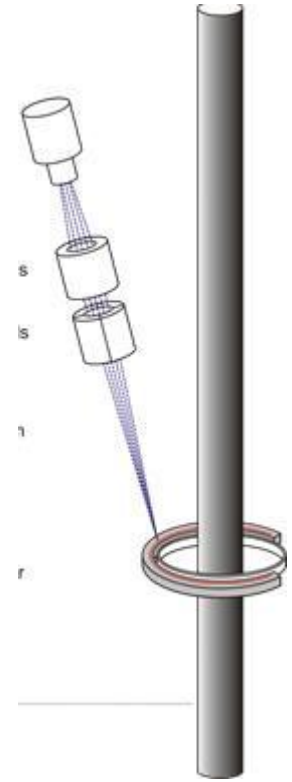
Multi-Scale Modelling

NUSAFE

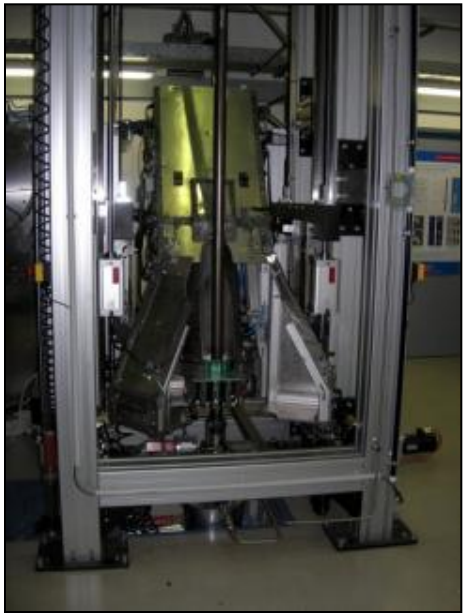
HELMHOLTZ ASSOCIATION

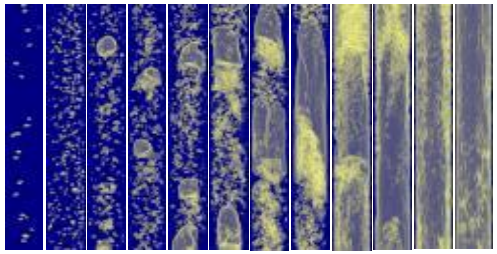
Thermal hydraulics

Validation of CFD models by large-scale experiments with innovative measuring techniques

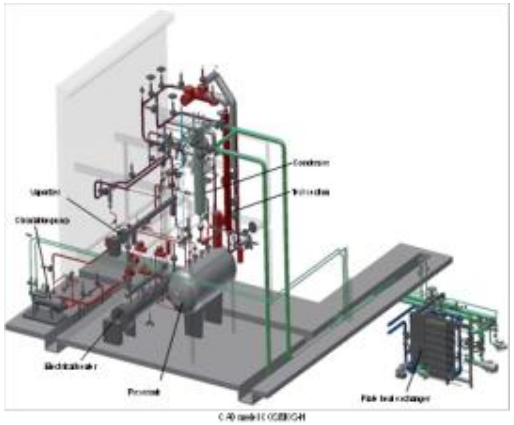


Ultrafast X-ray tomography @ TOPFLOW





TOPFLOW Pressure chamber



COSMOS facility

NUSAFE

HELMHOLTZ ASSOCIATION

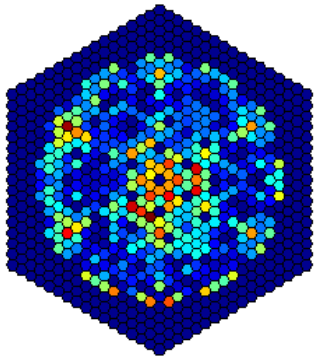
Materials research

- **Cladding materials behaviour during reflooding (QUENCH-LOCA test series)**

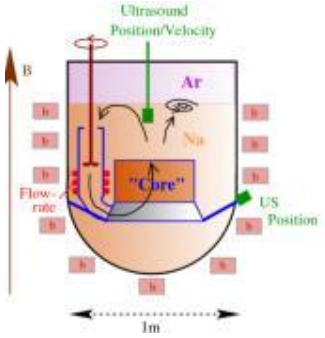
- Unique large-scale bundle experiments
- Investigation of ballooning and hydrogen uptake

- Mechanical properties: Quantification of the influence of oxygen and hydrogen
- Modelling of the hydrogen uptake

Safety research for innovative reactors



- **Advanced codes for safety analysis of innovative reactors**
  - Validated steady state analysis tool
  - Core design with reduced sodium void feedback effect
  - Accident analysis tool for liquid metal cooled fast reactor cores



- **Measurement techniques for liquid metal flows**
  - New measurement techniques available
  - Large-scale demonstration at the DRESDYN test facility

NUSAFE HELMHOLTZ ASSOCIATION

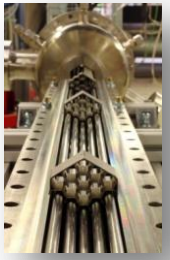
Transmutation: Contribute to the European P&T strategy with unique concepts and research facilities

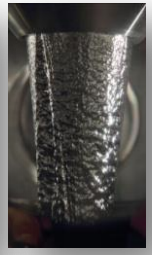
Coupling accelerator-core
➡ **Safety**

- **Neutronics** (static & kinetics)
- Support for **MYRRHA** design & licensing

Fuel–nuclear data-core design
➡ **Performance**

- Facility: **nELBE**
- **New nuclear data** (E_n> 20 MeV): inelastic scattering, (n,xn), (n,f)



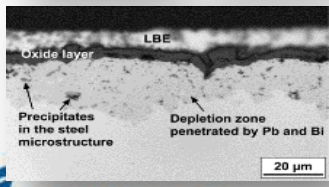


Thermal-hydraulics
➡ **Instrumentation/ Components**

- **KALLA**
- **Heat transfer** in liquid metal-cooled core
- Neutron **spallation target** design

Tailored materials
Coolant chemistry control
➡ **Corrosion protection**

- Advanced **surface alloys** – GESA
- New **advanced materials** (ODS, SiC)
- Oxygen detection in coolant (**sensors**)

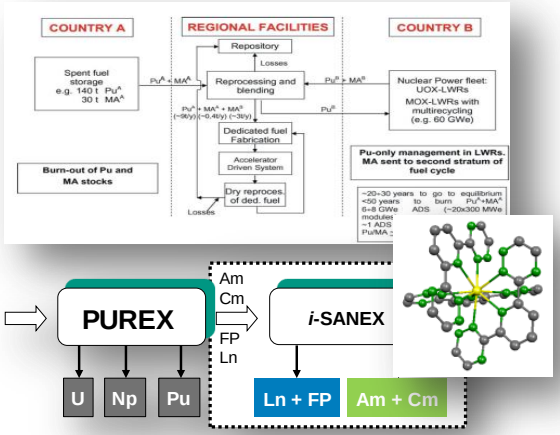


NUSAFE

Waste management strategies, Partitioning & Conditioning

Aim: - Contribute to the **European P&T strategy** with unique concepts

- Provide innovative contributions to the **international ‚Conditioning' concept**



P&T strategies

Partitioning

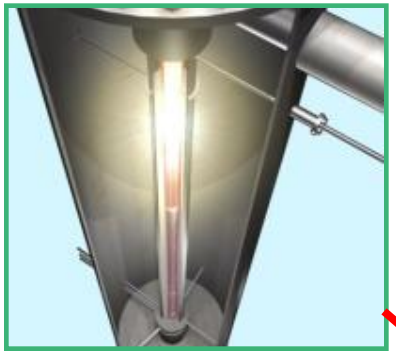
- Innovative separation processes:
  Understanding ligand selectivity **(molecular scale)**
- **New approach:** Complexation in aqueous phase
- **Improved/simplified processes**:
  From multi cycle to single cycle (***"Am(III) alone"***)

Conditioning

- Tailored ceramics for AN and FP immobilization
- Selection of promising radiation resistent **ceramic waste forms** (hafnates in pyrochlore structure)

NUSAFE HELMHOLTZ ASSOCIATION

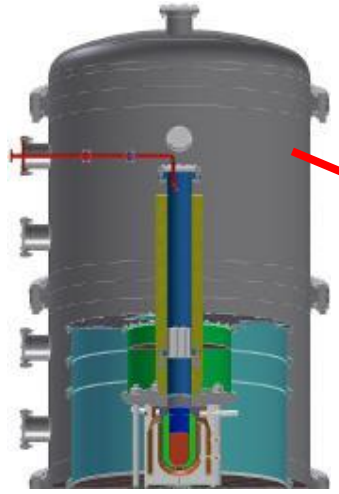
Beyond Design Basis Accidents for LWRs



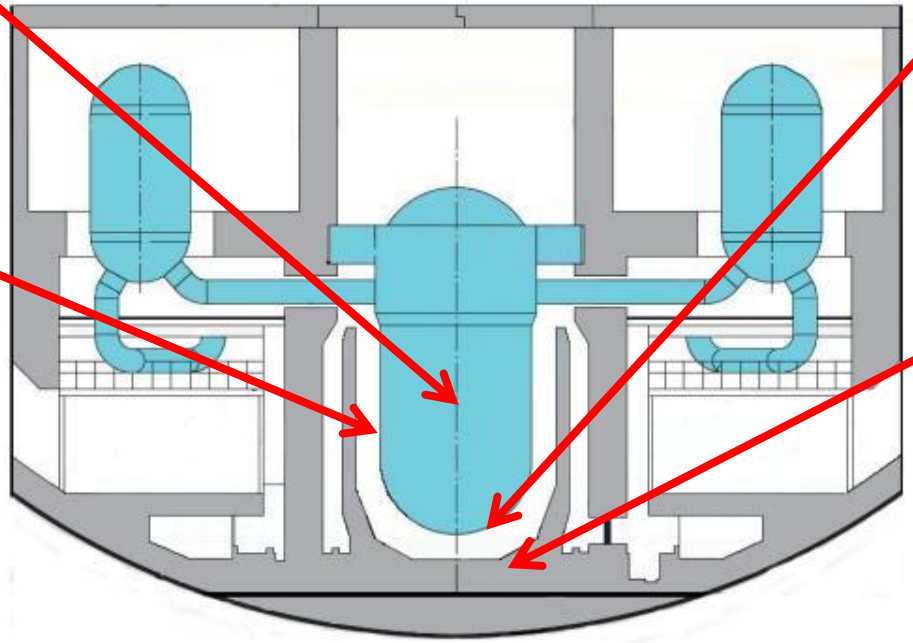
QUENCH

- Core coolability and debris cooling
- Fuel coolant interaction
- Molten corium concrete interaction
- Hydrogen mixing and combustion

LIVE



DISCO



MOCKA

European SAFEST platform

NUSAFE

HELMHOLTZ ASSOCIATION

BDBA: Containment behaviour

HYKA: Large scale flame instabilities in various mixtures

REKO: Operational behaviour of hydrogen recombiners

INA, SAAB, IN-EX:
Aerosol generation, interaction and pool scrubbing

SETCOM:
Wall condensation

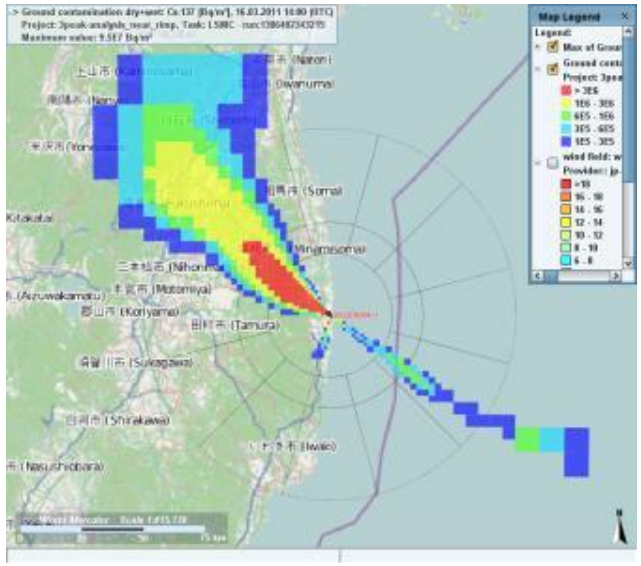
- Single-phenomena investigation
- Lumped parameter code application

- Multi-phenomena interactions
- Complementary use of integral & CFD codes

NUSAFE HELMHOLTZ ASSOCIATION

Emergency management

- **RODOS (real-time on-line decision support) system**



- Development of a decision support system
- Installed in 10 European countries

- **Development directions**
  - Source term
  - Advanced dispersion models
  - Countermeasure models

NUSAFE HELMHOLTZ ASSOCIATION

Legacy waste/Decommissioning/Safeguards

Aim:
- Develop strategies and technologies for decommissioning
- Develop technologies for waste characterization/treatment/ decontamination
- Contribute to the IAEA safeguards support programme






Scientific coordination of the German IAEA **safeguards** support programme

Innovative waste **characterization** methods

Optimization of **decontamination/treatment** procedures for decommissioning and legacy waste (incl. **i-graphite**)

Decommissioning scenarios, procedures, technologies

Mature **vitrification** technology
-Appl. China, Russia, residues

NUSAFE

Helmholtz Experimental Research Platform on Waste Management Strategies and Decommissioning of Nuclear Facilities *(HOVER)*

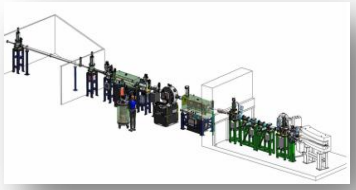
Background:

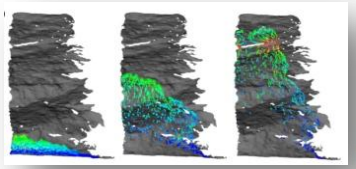
- **Phase-out decision** in Germany after Fukushima accident
- **interim storage on site** of the NPPs for longer time scales

Research- and Infrastructure Platform:

- (Large-scale) development of **innovative decommissioning technologies and strategies for NPPs**
- Taking into accoount the requirements of **radiation protection**
- **Elucidation of the behaviour of radioactive waste**
  with newest analytical, spectroscopic and theoretical methods
- Identification of relevant **migration processes** and quantification of **radionuclide behaviour** in waste disposal systems

  (atomistic scale ➔ macro scale, ➔**„Upscaling“ to pilot plant scale**)





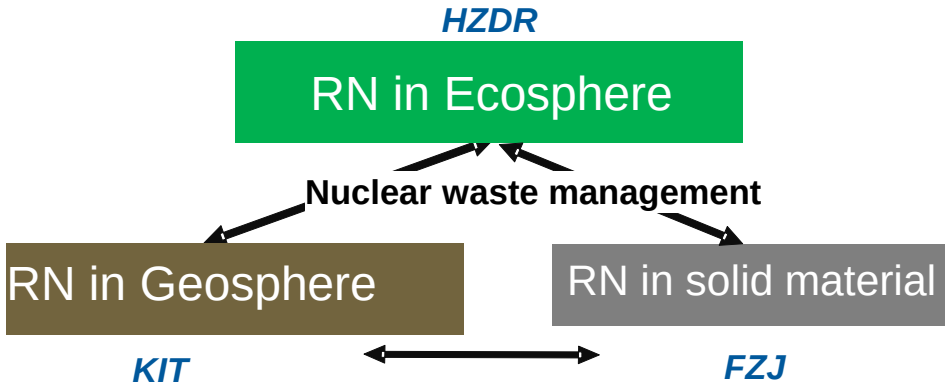
NUSAFE

HELMHOLTZ ASSOCIATION

Helmholtz Experimental Research Platform on Waste Management Strategies and decommissioning of nuclear facilities *(HOVER)*

HGF-*NUSAFE*:

- Synergistic combination of HGF competences and expertise



User Perspective:

- **Close cooperation in Germany** with universities, authorities, ministries and industry (extending the knowledge and expertise)
- **Integration in international cooperations:**

  (IGD-TP, SNETP, MELODI, OECD-NEA, IAEA, CEA, ANDRA, PSI, NAGRA, SKB, JAEA, KAERI, US-NRC, US-DOE etc.)

Schedule and costs:

- Schedule: build: 2016 – 2019; operation: >2050
- Estimated costs:
  - Planning: ca. 3 Mio Euro
  - Build: ca. 38 Mio Euro
  - Operation: ca. 3 Mio Euro/a

NUSAFE

HELMHOLTZ ASSOCIATION

Projects Funded by Ministry of Economy (BMWi) in the scope of reactor safety research

Budget 2015: 22,7 Mio € (58 Mio € until 2018)

As an example of funding:

- Contributions to multi-national research projects under the umbrella of OECD/NEA such as: SCIP-3, Halden, BIP-3, THAI-3
- National EASY-partnership in Germany:
  Investigations on passive systems:
  INKA-test facility
  Partners: GRS, AREVA, RWTH, TU-DD, TH Deggendorf
  Budget ~ 2.3 Mio € within 3 years

In Future:

- More investigations on shut-down and decommissioning of NPPs
- Assessment of the safety of transport and interim storage of nuclear waste and
  in depth analysis on the long term interim storage of fuel elements
  (high level waste, higher burn-up, embrittlement of fuel rods, etc.)

HELMHOLTZ | ASSOCIATION

Co-operations and networking

Participation in main European Networks

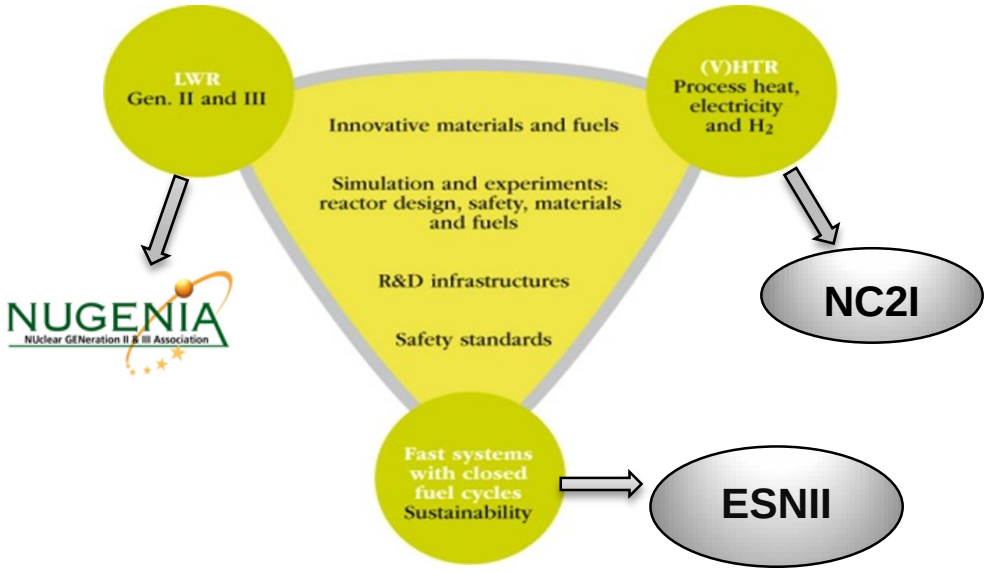
Participation in:

Advisory boards / Committees

IAEA

NEA Nuclear Energy Agency

SNETP
Sustainable Nuclear Energy Technology Platform



NERIS

EERA
European Energy Research Alliance

igd·tp
safe solutions for radioactive waste