

R&D activities in German nuclear sector

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Source: www.sueddeutsche.de

Use of nuclear energy technology in Germany



NPP units in operation(blue) and already shutdown (grey)

- At present still 9 nuclear power plants (NPP) in operation with total electrical output of ~12 GWe
- Gradual NPPs shutdown until the end of 2022
- 37 NPP have been constructed until the end of 1980
- High tech usage of nuclear technology for medical processes required beyond 2022: Mo⁹⁹ production
- Nuclear safety & radiation protection further required
- Nuclear technology industries:
 - Uranium supply companies, fuel rod producing companies, planners and constructors of nuclear facilities, companies specialized in the transport of nuclear fuels, treatment and storage of nuclear waste, decommissioning and decontamination

<http://www.bmwi.de/DE/Themen/Energie/Konventionelle-Energietraeger/uran-kernenergie,did=156054.html>

Overview of nuclear facilities in Germany: type, operation, status and site

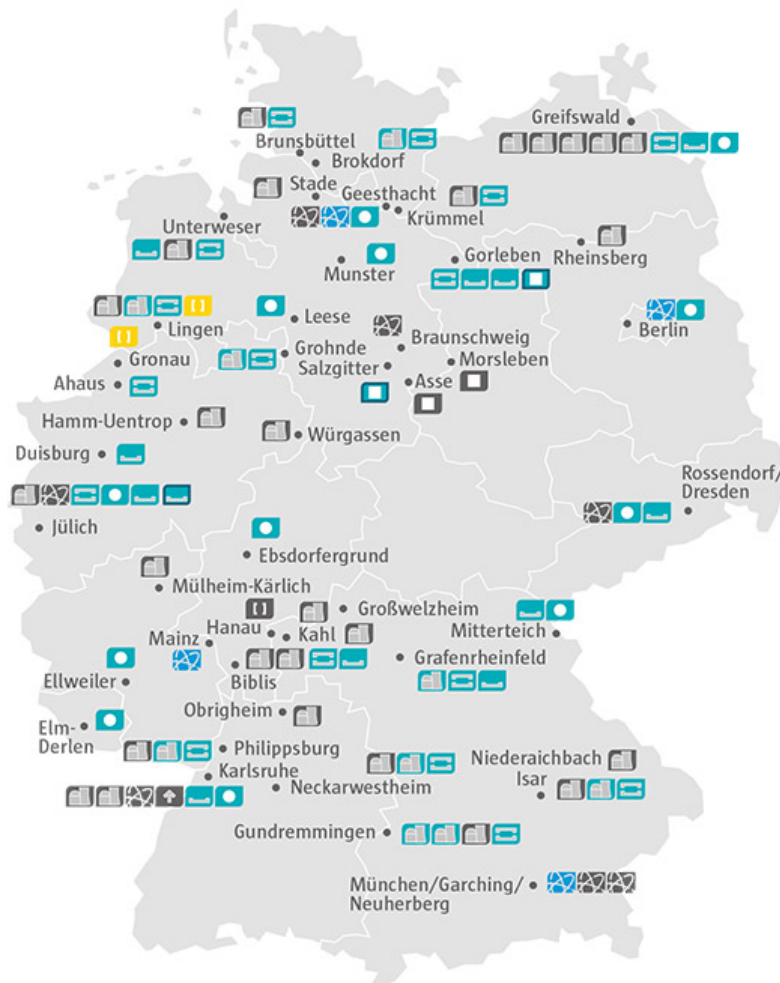
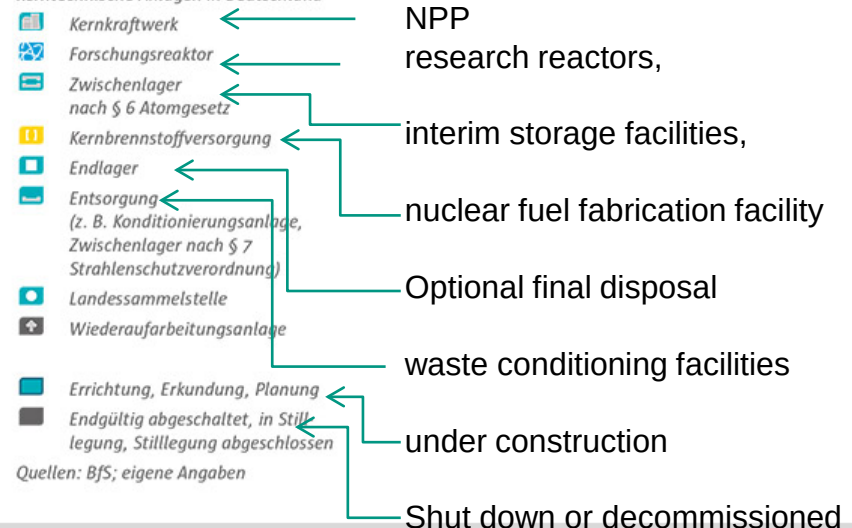


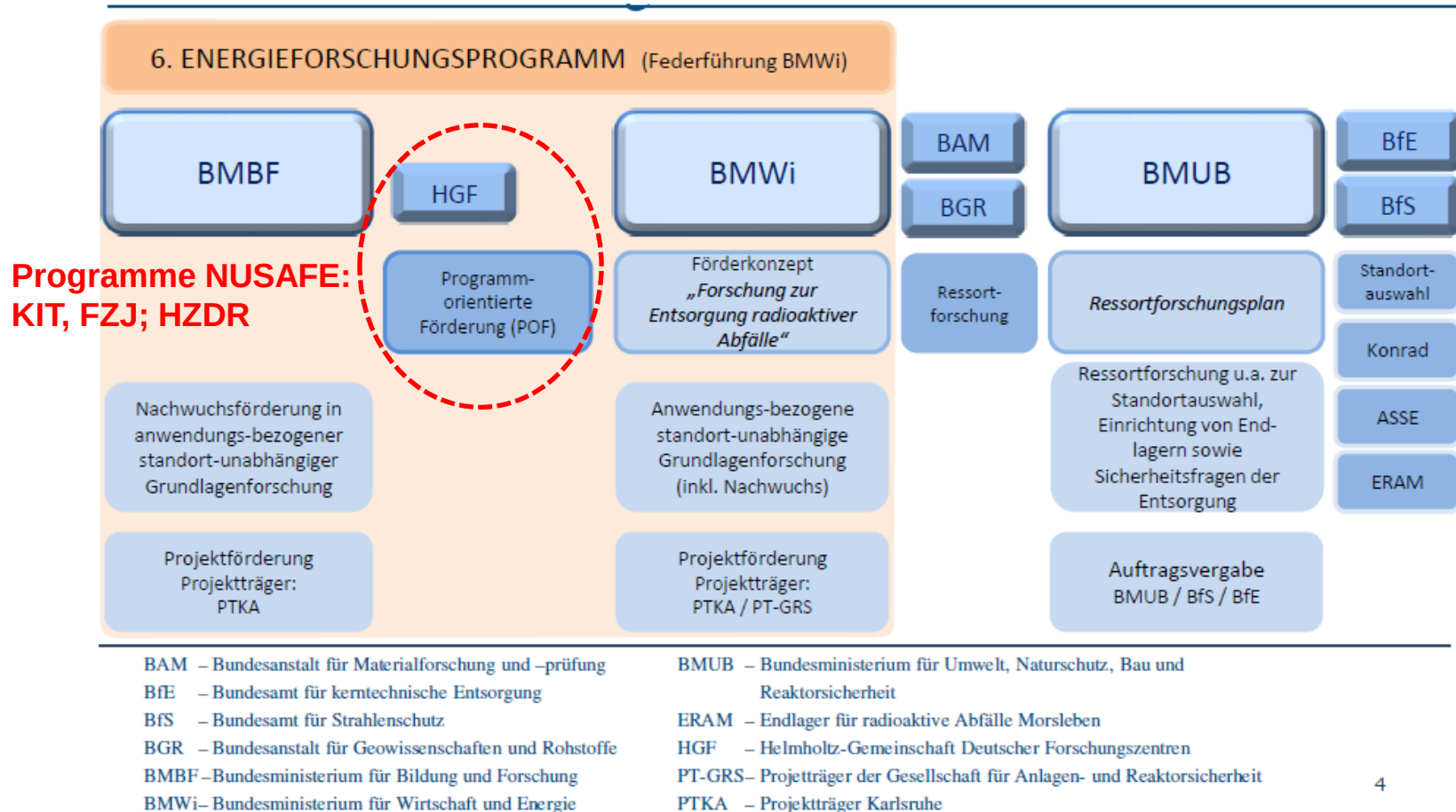
Abb. 3

Kerntechnische Anlagen in Deutschland



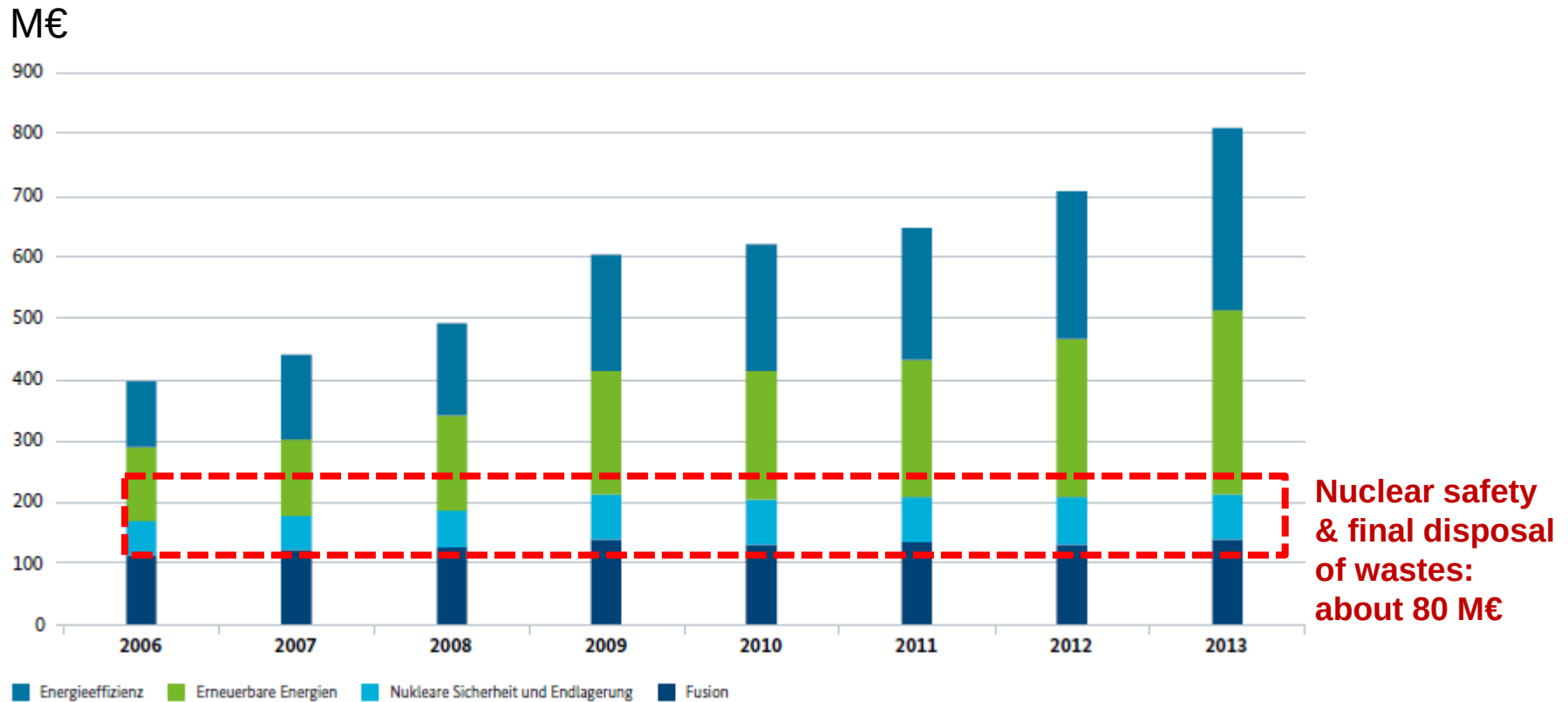
Quellen: BfS; eigene Angaben

German governmental energy research program: overall organizational chart



Source BMWi: **MR Dr. Hans-Christoph Pape**

German national energy research program: portfolio and budget

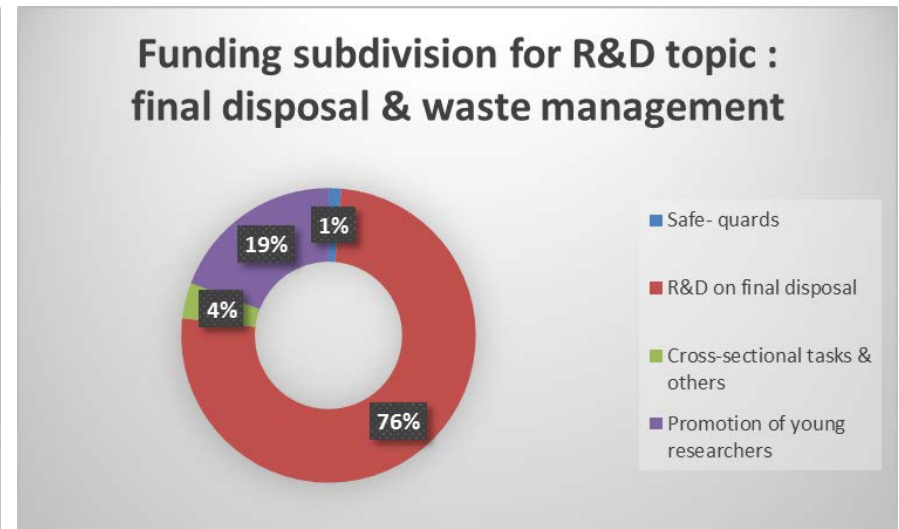
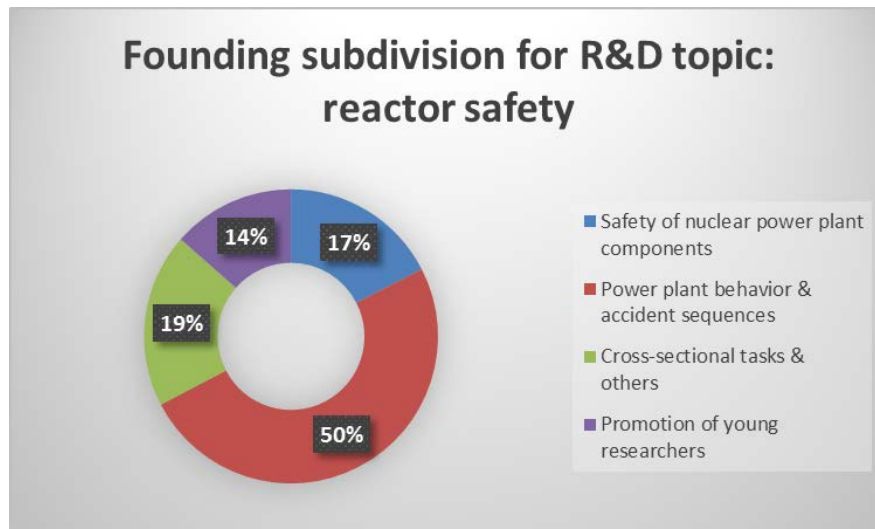
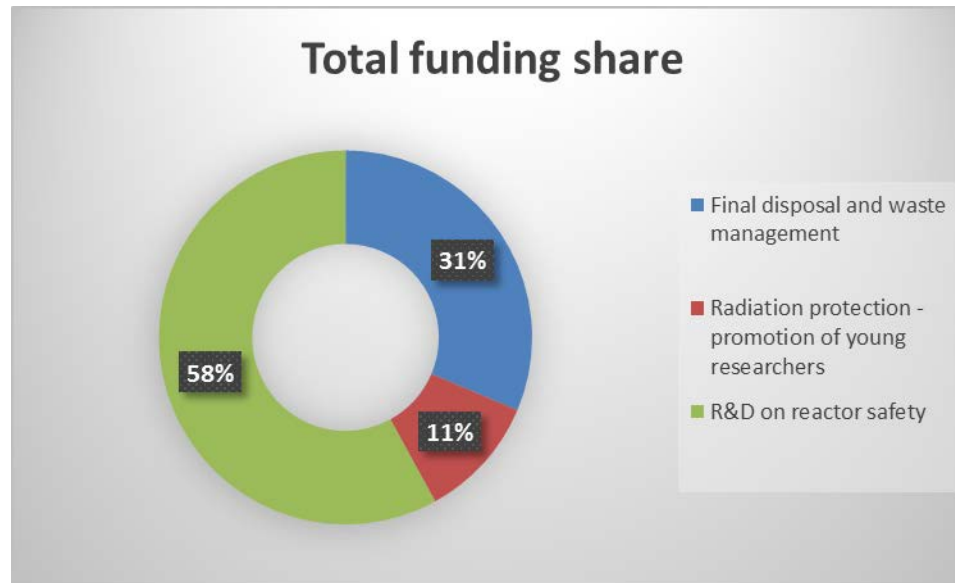


Source BMWi: Bundesbericht Energieforschung 2014

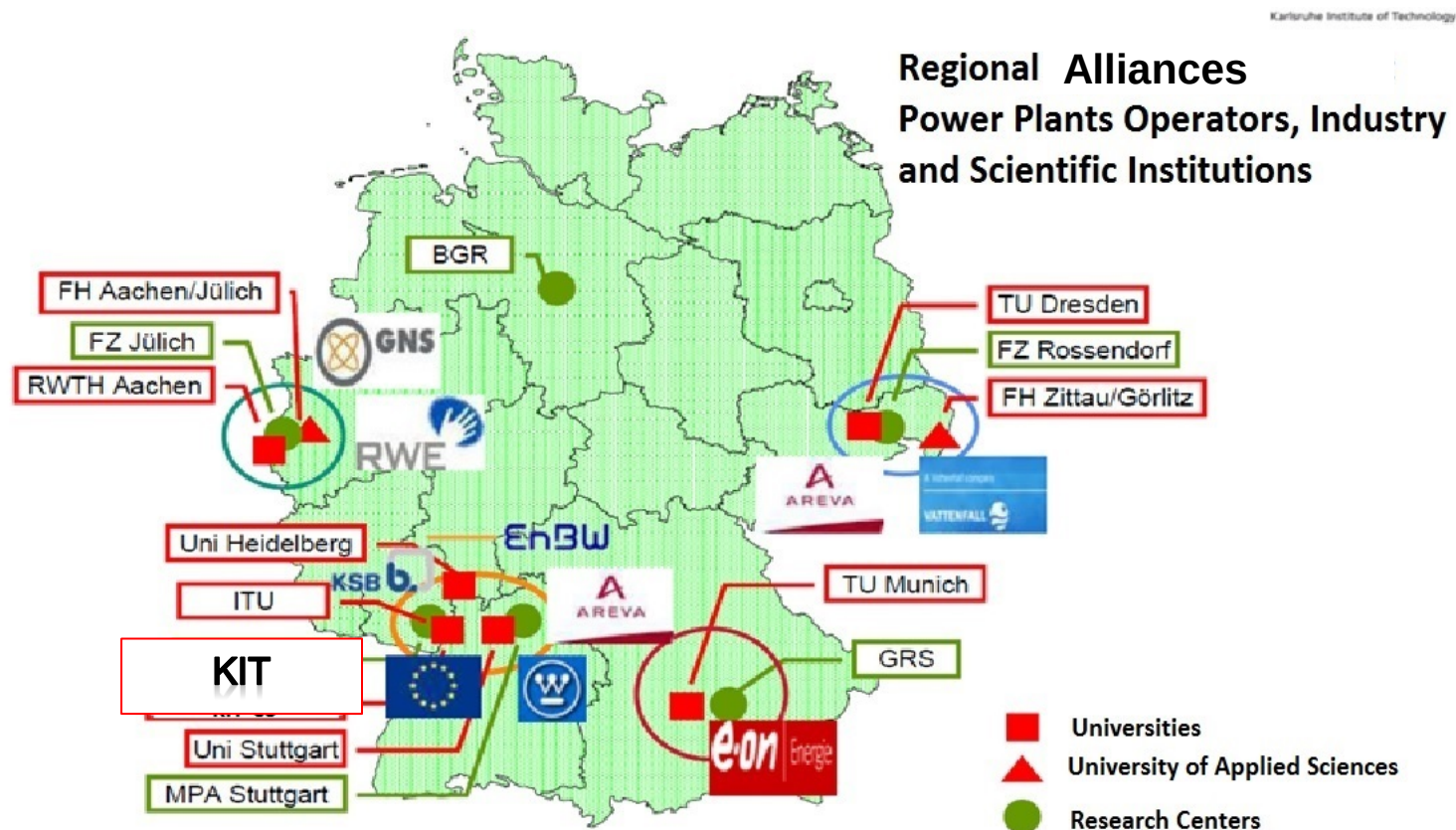
Nuclear safety research: BMWi & BMBF founding amount with number of granted projects in 2014

Funding Themes and Funding Programmes	Cash flow in M€			No of Projects		Founding amount (M€)
	2012	2013	2014	ongoing in 2014	newly granted in 2014	newly granted in 2014
Final disposal & waste management	12.30	13.23	13.58	98	17	10.39
Research on final disposal	9.84	10.39	10.25	77	11	5.59
Cross-sectional tasks & other	0.54	0.53	0.53	1	1	1.61
Safe-guards	0.18	0.15	0.19	1	-	-
Promotion of young researchers	1.74	2.17	2.61	19	5	3.20
Research on reactor safety	24.38	23.43	25.10	140	37	23.18
Safety of nuclear power plant components	5.28	4.01	4.38	38	15	7.50
Power plant behavior & accident sequences	11.25	12.09	12.51	58	16	8.76
Cross-sectional tasks & other	5.08	5.72	4.81	22	4	5.59
Promotion of young researchers	2.77	1.62	3.39	22	2	1.33
Radiation protection- Promotion of young researchers	4.91	4.95	4.61	60	18	11.94
Total	41.59	41.61	43.29	298	72	45.52

Source: BMWi Bundesbericht Energieforschung 2014



German Nuclear Competence Centers & Regional Alliances



(Quelle: H. Pamme, RWE Power)

Helmholtz Association of German Research Centers **HGF**

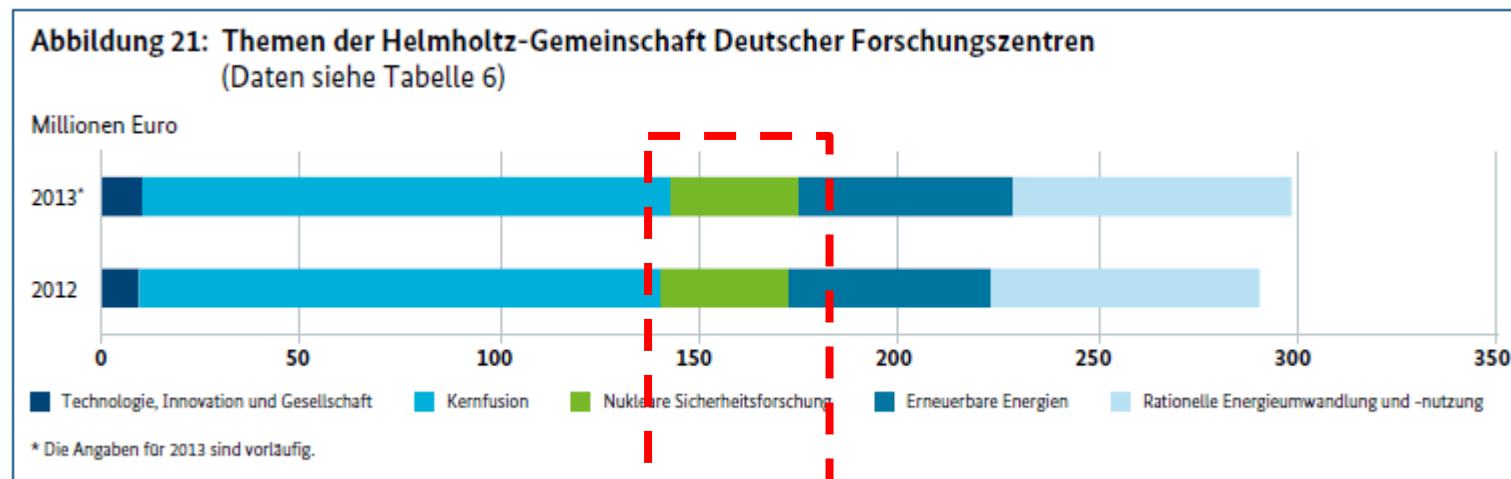


18 centers

**Programme Nuclear Waste
Management, Safety and Radiation
Research (NUSAFE)
in KIT Karlsruhe
FZJ Jülich
HZDR Rossendorf**

Source www.helmholtz.de

Founding for R&D topics within the **HGF**



Nuclear safety research about 30 M€

Source: BMWi Bundesbericht Energieforschung 2014

KIT in the Helmholtz-Association of German National Research Centers (HGF)



Helmholtz - Mission

12 Programs
27 Institutes
3.901 Employees

University - Mission

11 Faculties
130 Institutes
5.181 Employees
22.500 Students

ca. 3200 Doctoral Students

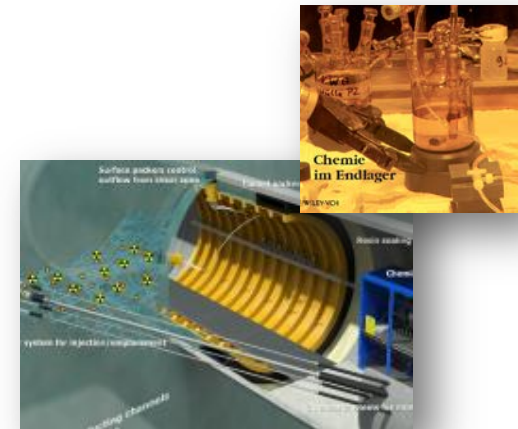
361 Mio. € Budget
27 Mio. € State BW
210 Mio. € Federal Republic
124 Mio. € Third Party

374 Mio. € Budget
189 Mio. € State BW
0 Mio. € Federal Republic
185 Mio. € Third Party

- High thematic overlap
- Excellent synergy

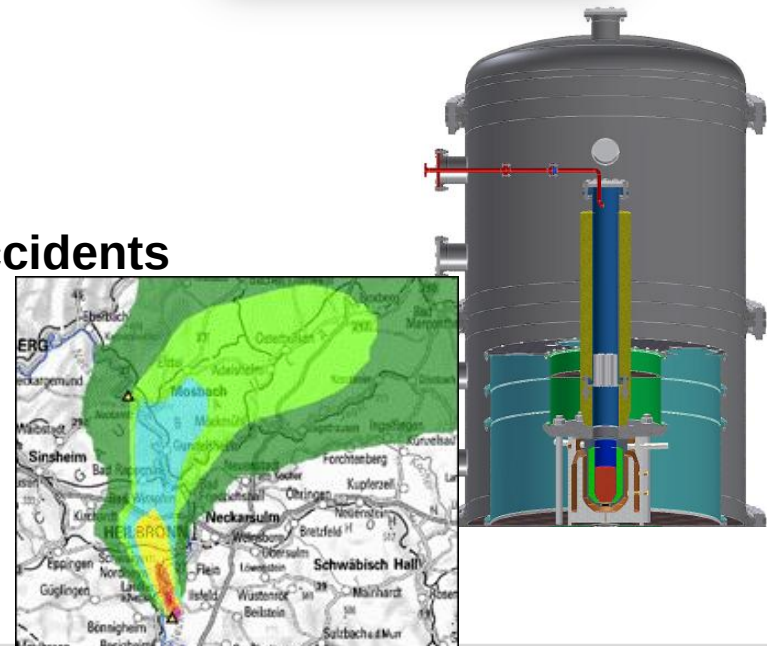
Topic Nuclear Waste Management

- Safety Research for Nuclear Waste Disposal
- Waste Management Strategies
- Decommissioning of nuclear facilities



Topic Reactor Safety

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

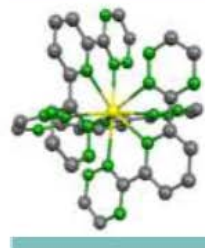


Topic: Safety Research for Nuclear Waste Management

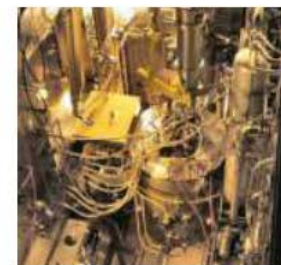
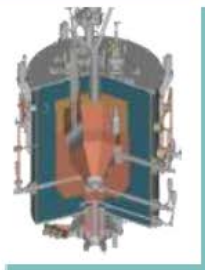
Long term safety of Nuclear Waste Disposal



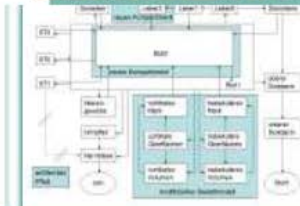
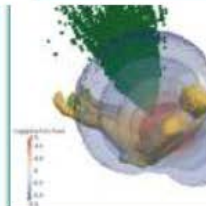
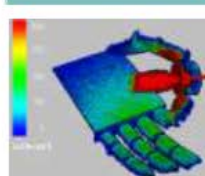
Reduction of Radiotoxicity
(Partitioning + Transmutation)



Vitrification of high level liquid waste



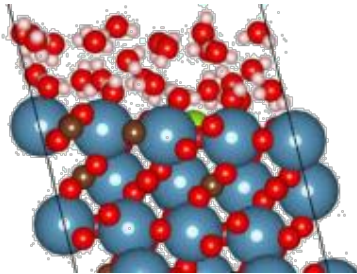
Radiation protection



Long-term safety of nuclear waste disposal

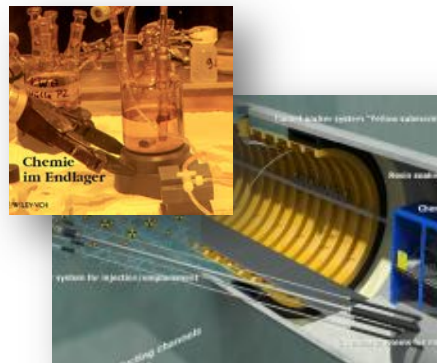
Basic Investigations

Molecular Process Understanding



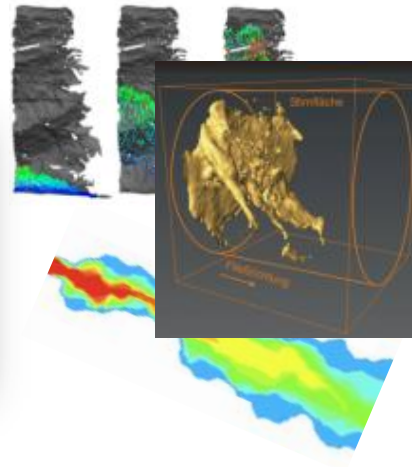
Applied Investigations

Radionuclide-Retention in the Multibarrier System



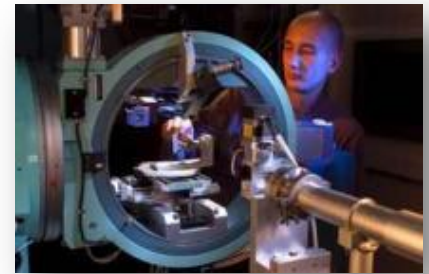
Geochemistry Modeling Tool Box

Thermodynamic data
Coupled transport codes



Development of Speciation Methods

Molecular Structure of Trace Actinides



Safety Case - Performance Assessment

Immobilisation of HLLW - Development and application of Vitrification Technology



Vitrification of WAK-HLLWC at the VEK (Sept. 2009- Nov. 2010)

Institute for Nuclear Waste Disposal - INE

- Development of core process technique
- Glass melter design and construction
- Glass matrix development

Process parameters

- HLLWC
 - 56 m³ HLLWC
 - $7.7 \cdot 10^{17}$ Bq total
 - 408 kg Platinum metals
- Product (incl. from rinsing process)
 - 56 t Glass
 - 140 canisters

Plant availability: 97 %

Transport to intermediate storage
(ZLN, Lubmin)

- 5 CASTOR containers (each 28 canisters)



February 26, 2011

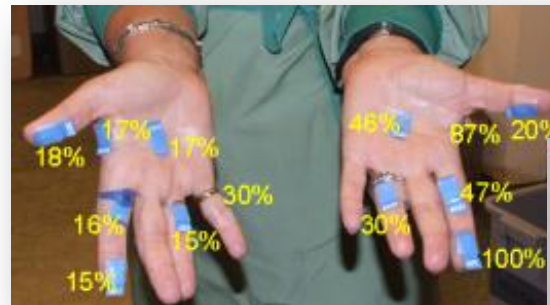
Decommissioning of nuclear facilities

- Development of innovative decontamination technologies
- Technologies for dismantling reinforced concrete
- Development of project management systems for decommissioning projects
- Technologies for retrieving waste

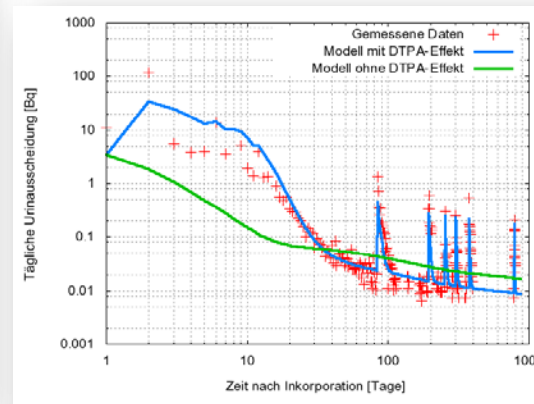
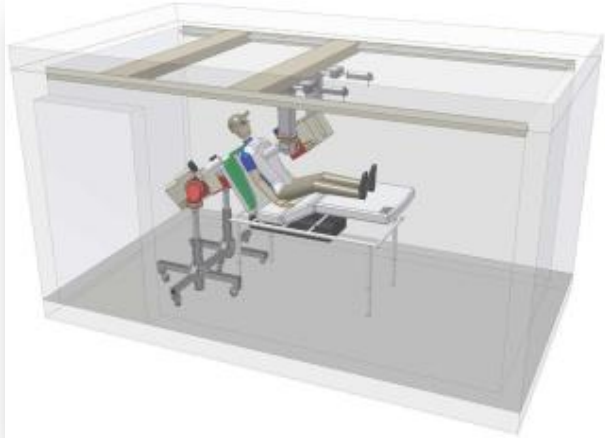
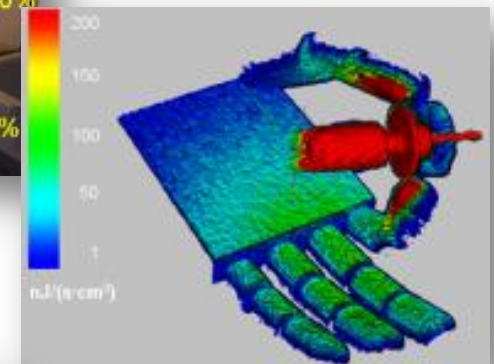


Research for radiation protection- Individual external and internal dosimetry

- Recording and simulation of radiation fields and doses at certain handling procedures e.g. in nuclear medicine
- Simulation of radiation fields in intermediate storage facilities



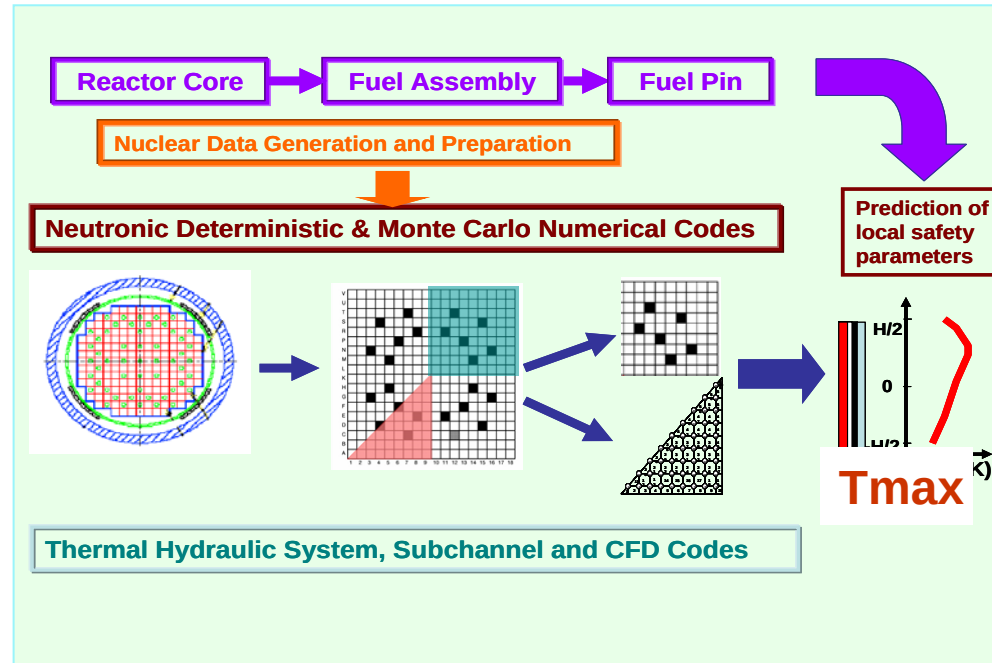
- In-vivo detection of incorporated radionuclides
- Analysis and modelling of radionuclide biokinetics



Topic: Safety Research for Reactor Safety

Plant operation and Design Basis Accidents:

Extension of
Safety Analysis
Tools for the
Prediction of Local
Safety Margins



New developments in NURESIM:

- New flexible TH / Neutronic – coupling and Multi-Scale CFD Development
- Enhanced prediction accuracy of local parameters at FA /pin-level

KIT experimental facilities: MOCKA & DISCO



MOCKA

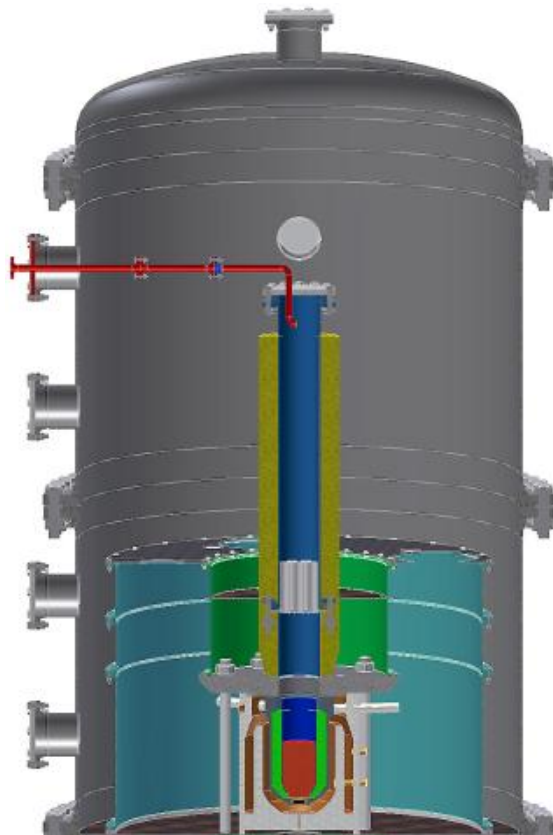


DISCO: Corium Dispersion Experiments

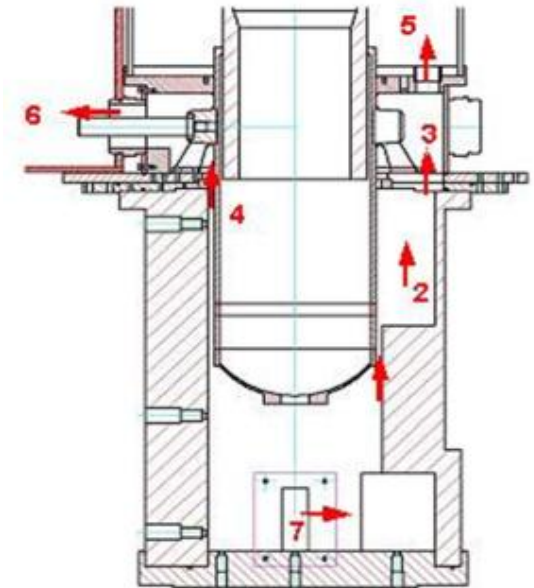
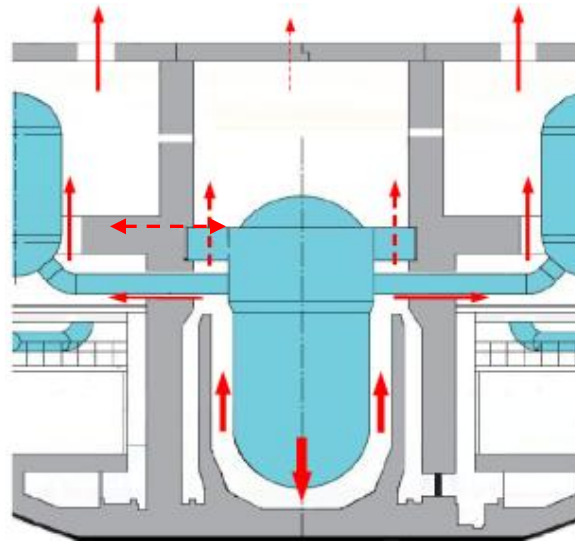
Containment integrity after melt ejection under direct containment heating, H₂ combustion and fuel-coolant interaction

DISCO-H

CONTAINMENT
 $V = 14 \text{ m}^3$



DCH test with KONVOI and French P4 geometry

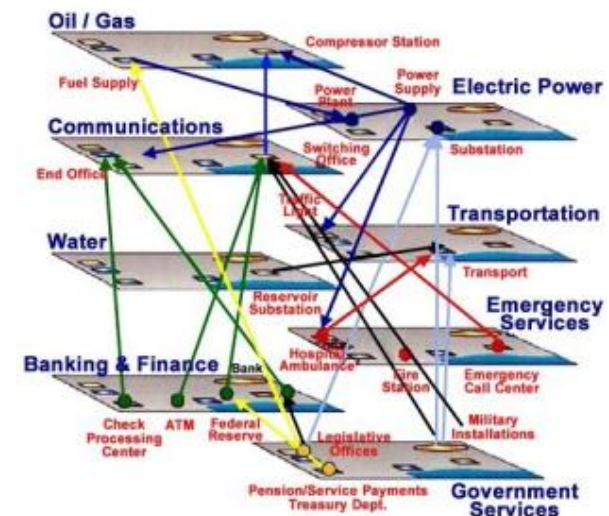


■ RODOS Improvements

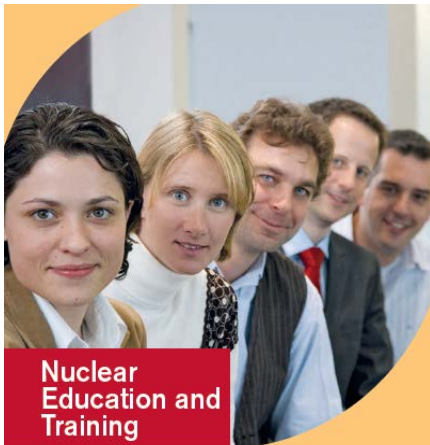
- Source term estimations based on modeling and monitoring
- Advanced dispersion models in the atmospheric and aquatic environments
- Improved countermeasure models supporting the selection of robust measures

■ Analytical Platform

- Analyze a nuclear emergency in near real-time and provide information to experts and public
- Provide a central deposit for information on a European level



AREVA Nuclear Professional School at KIT



Nuclear Education and Training

AREVA Nuclear Professional School at the Karlsruhe Institute of Technology

The AREVA Nuclear Professional School helps to preserve the high level competence on nuclear technology and provides an excellent education program. The combination of special lectures in nuclear sciences and engineering with AREVA's industrial experience provides best prerequisites for cutting-edge research.



"We are proud to offer a high level training program covering a huge nuclear technology scope. The partnership between AREVA and KIT perfectly combines science and industry. Together we play an active role in creating the future of nuclear energy. And our students can be a part of it."

Prof. Andreas Class, Head of the AREVA Nuclear Professional School

We offer:

Training in reactor physics, thermo hydraulics, material sciences and mechanical strength, reactor design, safety systems, etc. taught by senior scientists in Nuclear Technology.

Two year advanced studies program Working in projects at the KIT institutes on

- Pressurized water reactors
- Boiling water reactors
- Innovative light water reactors

PhD positions

Research topics at the KIT on light water reactors

Duration: 3 years

Prerequisites

- Master thesis of a German University or similar degree
- Average mark: 2,0 or better

PhD students have the opportunity to attend the training courses of the AREVA Nuclear Professional School.



Karlsruhe Institute of Technology



On October 01, 2009, the Karlsruhe Institute of Technology (KIT) was founded by a merger of Forschungszentrum Karlsruhe and Universität Karlsruhe.

KIT bundles the missions of both precursory institutions: A university of the state of Baden-Wuerttemberg with teaching and research tasks and a large-scale research institution of the Helmholtz Association conducting program-oriented preminent research on behalf of the Federal Republic of Germany. Within these missions, KIT is operating along the three strategic fields of action of research, teaching, and innovation. www.kit.edu

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More information on the AREVA Nuclear Professional School
Prof. Dr.-Ing. habil.
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Karlsruher Institut für Technologie (KIT)
Institut für Kern- und Energietechnik (IKET)
Hermann-von-Helmholtz-Platz 1 D
76344 Eggenstein-Leopoldshafen
secretary@anps.kit.edu



Courtesy: www.anps.kit.edu

EU Projects

with HGF contribution > 65 → KIT participates in >50 projects



German Coordination of EURATOM Projects : Fission

1. **PREPARE** - Innovative integrative tools and platforms to be prepared for radiological emergencies and post-accident response in Europe, AC: Fission-2012-3.1.1, Coordinator: [Karlsruhe Institute of Technology \(KIT\)](#)
2. **DARK.RISK** - Studies on a cohort of Serbian children exposed to x-irradiation to determine the contribution of the non-coding genome to susceptibility at low doses, AC: Fission-2012-3.1.1, Coordinator: HZ München- German Research Center for Environmental Health
3. **ALISA** - Access to Large Infrastructures for Severe Accidents, Activity Code: Fission-2011-4.2.1, Coordinator: [Karlsruhe Institute of Technology](#)
4. **FIRST-NUCLIDES** - Fast / Instant Release of Safety Relevant Radionuclides from Spent Nuclear Fuel, Activity Code: Fission-2011-1.1.1, Coordinator: [KIT](#)
5. **HPMC** - High performance Monte Carlo reactor core analysis, Activity Code: Fission-2011-2.3.1, Coordinator: [Karlsruhe Institute of Technology](#)
6. **PROCARDIO** - Cardiovascular Risk from Exposure to Low-dose and Low-dose-rate Ionizing Radiation, AC: Fission-2011-3.1.1, Coordinator: HZ München - German Research Center for Environmental Health
7. **EPIRADIO** - Combining epidemiology and radiobiology to assess cancer risks in the breast, lung, thyroid and digestive tract after exposures to ionizing radiation with total doses in the order of 100 mSv or below, AC: Fission-2010-3.1.1, Coordinator: HZ München - Deutsches Forschungszentrum für Gesundheit und Umwelt
8. **NERIS-TP** - Towards a self sustaining European Technology Platform (NERIS-TP) on Preparedness for Nuclear and Radiological Emergency Response and Recovery Activity Code: Fission-2010-3.3.1, Coordinator: [Karlsruhe Institute of Technology](#)
9. **CROCK** - CRYSTALLINE ROCK RETENTION PROCESSES, Activity Code: Fission-2010-1.1.2, Coordinator: [Karlsruhe Institute of Technology](#)
10. **ERINDA** -European research Infrastructures for Nuclear Data Applications, AC: Fission-2010-4.2.1, Coordinator: Helmholtz-Zentrum Dresden-Rossendorf (HZDR)
11. **LONGFLIFE**-Treatment of long term irradiation embrittlement effects in RPV safety assessment, AC: Fission-2009-2.1.2, Coordinator: HZ Dresden-Rossendorf
12. **THINS** - Thermal-hydraulics of innovative nuclear systems, Activity Code: Fission-2009-2.3.1, Coordinator: [Karlsruhe Institute of Technology](#)
13. **LACOMEKO** - Large scale experiments on core degradation, melt retention and containment behavior, AC: Fission-2009-2.3.3, Coordinator: [KIT](#)
14. **EU-NMR-An** - Towards a European competence center for nuclear magnetic resonance on actinides, Activity Code: Fission-2008-4.2.1, Coordinator: [KIT](#)
15. **ReCosy** - Redox phenomena controlling systems, Activity Code: Fission-2007-1.1.1, Coordinator: [Karlsruhe Institute of Technology](#)
16. **MADEIRA** - Minimizing activity and dose with enhanced image quality by radiopharmaceutical administrations, AC:Fission-2007-3.2-01, Koordinator: HZ München - Deutsches Forschungszentrum für Gesundheit und Umwelt
17. **CARBOWASTE** - Treatment and disposal of irradiated graphite and other carbonaceous waste, AC: Fission-2007-6.0.01, Coordinator: Forschungszentrum Jülich
18. **GETMAT** - Gen IV and transmutation materials, Activity Code: Fission-2007-6.0.02, Coordinator: [Karlsruhe Institute of Technology](#)
19. **SAFEST** - Severe Accident Facilities for European Safety Targets, Activity Code: Fission-2013-4.1.2 , Coordinator: [Karlsruhe Institute of Technology](#)
20. **Cebama** - Cement-based materials, properties, evolution, barrier functions, Activity Code: NFRP-06-2014 , Coordinator: [Karlsruhe Institute of Technology](#)
21. **CONCERT** - European Concerted Programme on Radiation Protection Research, Activity codeNFRP-07-2015 , Coordinator: Bundesamt für Strahlenschutz (BfS)

Representation of German (KIT) scientists in European and international organisations and committees

Memberships:

- **Bodies of European Platforms NUGENIA, SNETP, ESNII, MELODI**
- **OECD-NEA Nuclear Science Committee**
- **OECD-NEA Nuclear Development Committee**
- **OECD-NEA Salt Club**
- **OECD-NEA WG on Liquid Metals, Transmutation**
- **Steering Committee of IAEA / INPRO**
- **Advisory board of IAEA International Decommissioning Network (IDN)**
- **IAEA Technical Working Group – Light Water Reactors**
- **IAEA Consultant Group - KIND Coordinated Project**
- **Generation IV International Forum - Supercritical Water-Cooled Reactors**
- **Scientific Committee / Steering Committee of international conferences e.g. NURETH, MIGRATION, ...**

