

PSI: Swiss competence centre for nuclear energy

Generation IV International Forum
Workshop on Molten Salt Reactor

Dr. Maria Marques : Deputy Head

Villigen, 10th December 2025





Swiss Free Electron
Laser SwissFEL



Swiss Neutron Sources SINQ
and UCN



Swiss Light Source SLS

Proton Therapy

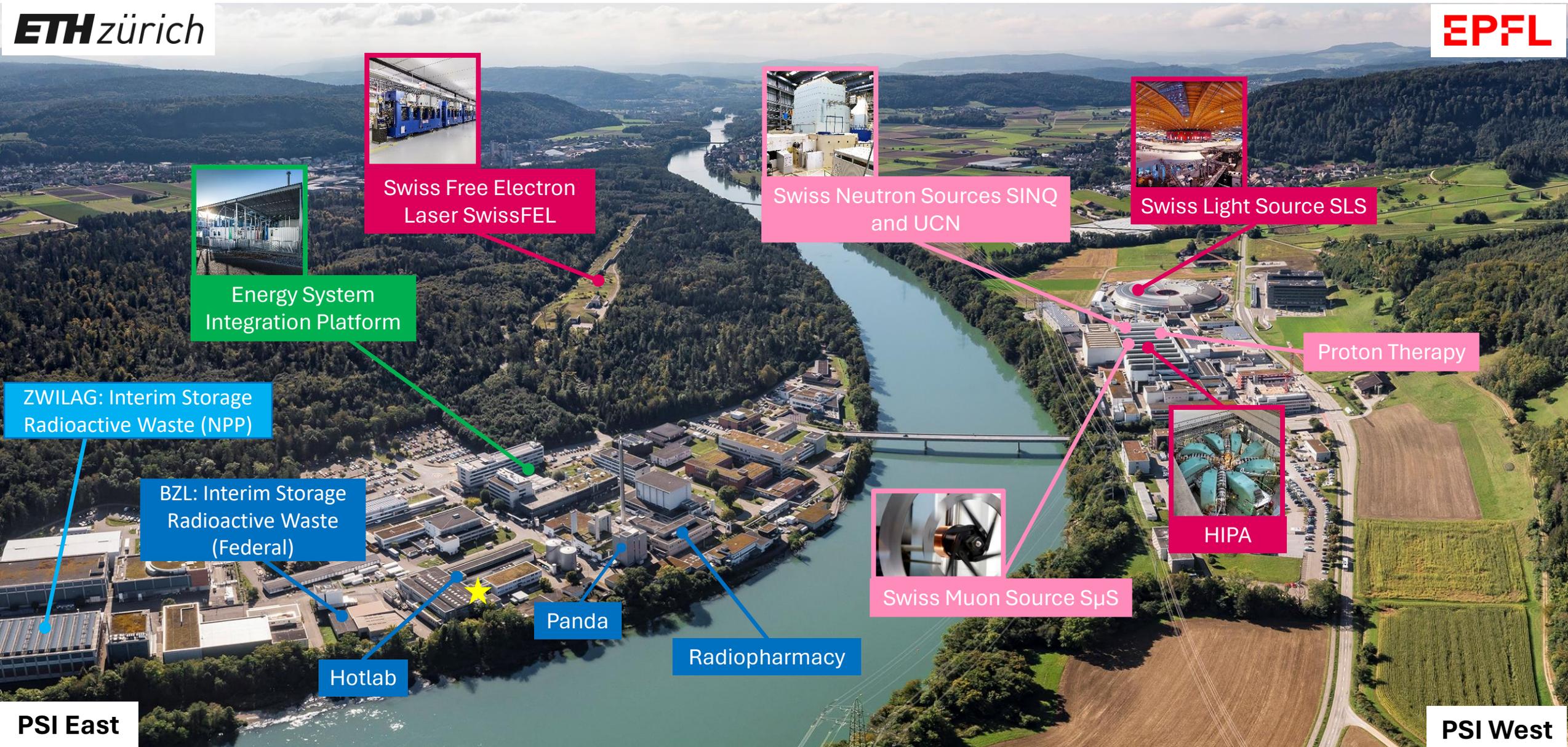


HIPA



Swiss Muon Source S μ S





Swiss Free Electron
Laser SwissFEL



Swiss Neutron Sources SINQ
and UCN



Swiss Light Source SLS



Energy System
Integration Platform

Proton Therapy



HIPA



Swiss Muon Source SμS

ZWILAG: Interim Storage
Radioactive Waste (NPP)

BZL: Interim Storage
Radioactive Waste
(Federal)

Panda

Radiopharmacy

Hotlab

Key Figures

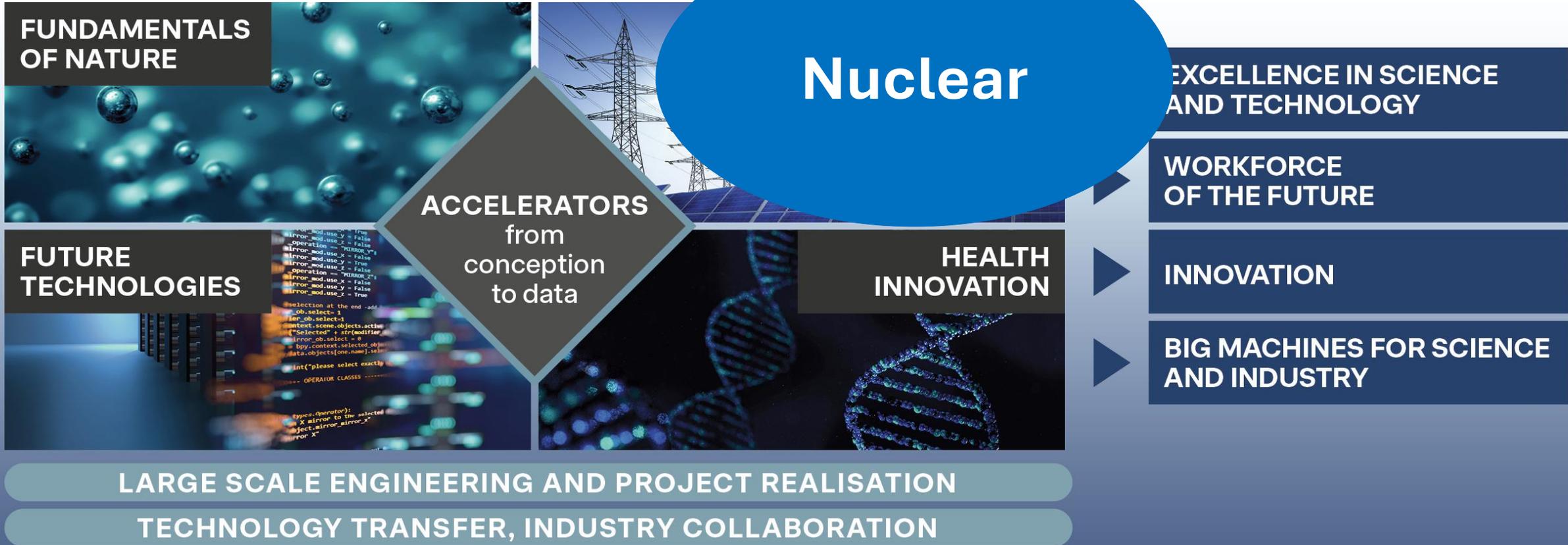


<p>ETHZ Swiss Federal Institute of Technology Zurich</p> 	<p>EPFL Swiss Federal Institute of Technology Lausanne</p> 	<p>PSI Paul Scherrer Institute</p> 	<p>Empa Swiss Federal Laboratories for Materials Testing</p> 	<p>WSL Swiss Federal Research Institute for Forestry, Snow and Landscape</p> 	<p>Eawag Swiss Federal Institute of Aquatic Science and Technology</p> 
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PSI funds (global budget)	330 MCHF
External funding	130 MCHF
Staff (PSI and affiliated)	2500
• Professors at ETH, EPFL, universities	65
• Engineers and technicians	1000
• Postdocs, PhD students, apprentices	720
External users: people / visits	2100 / 3400 per year
Number of scientific publications (in-house)	1300 per year
Patient visits (proton therapy treatment)	6000 per year

Numbers: State as of 2023

Accelerators for Science, Technology and Medicine



ETH zürich



PSI

EPFL



Empa

Materials Science and Technology

eawag
aquatic research

ETH DOMAIN



Research Committee	Prof. Dr. Marco Stampanoni
Human Resources Management	Karsten Bugmann
Center for Proton Therapy	Prof. Dr. Damien Weber

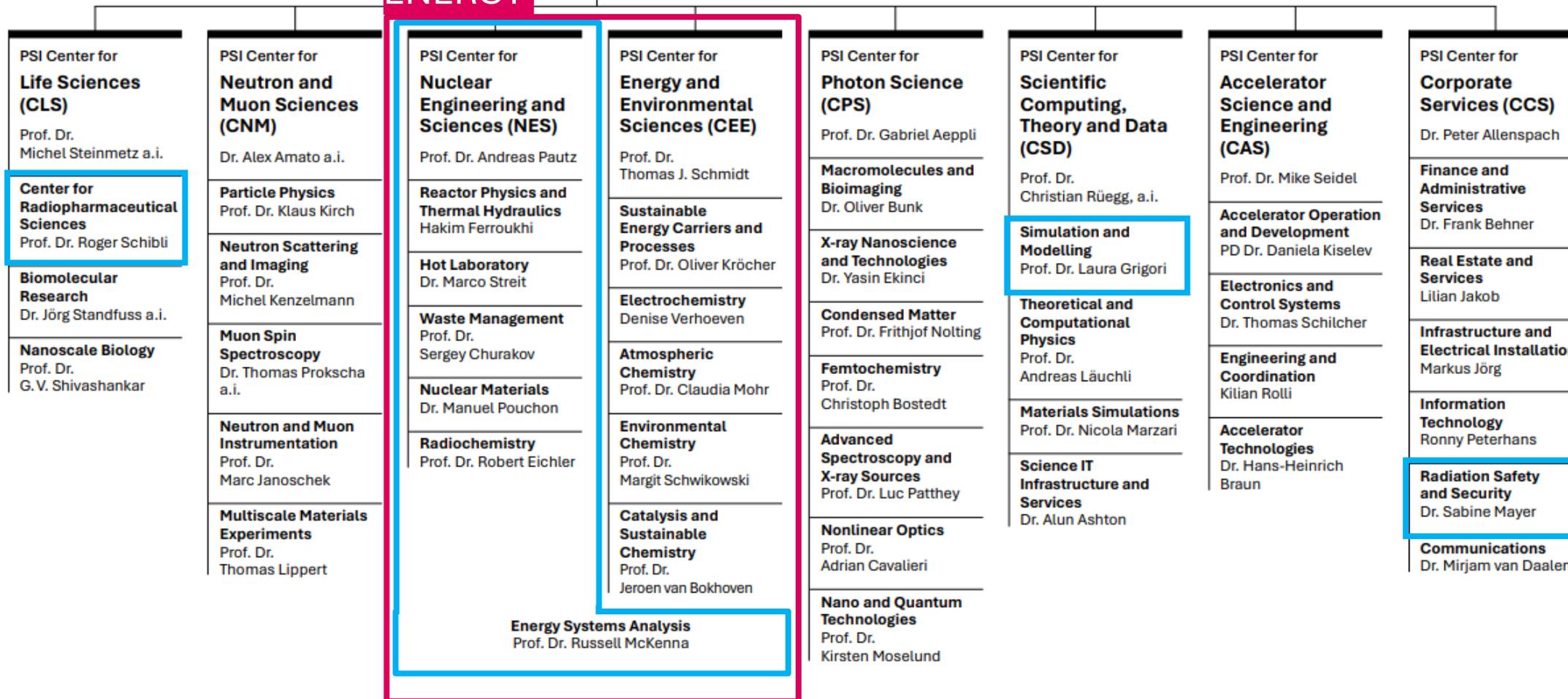
Director:
Prof. Dr. Christian Rüegg

Members of the board of directors:

Prof. Dr. Gabriel Aeppli*
Dr. Peter Allenspach
Prof. Dr. Andreas Pautz
Prof. Dr. Thomas J. Schmidt
Prof. Dr. Mike Seidel
Dr. Thierry Strässle*

Directorate Support	Dr. Thierry Strässle
Human Resources Management	Karsten Bugmann
Safety	Dr. Werner Roser
Communications	Dr. Mirjam van Daalen
Science	Dr. Ines Günther-Leopold Dr. Michèle Erat
Finance and Administrative Services	Dr. Frank Behner
Technology Transfer	John Millard

ENERGY



Core Missions of Nuclear Research at PSI

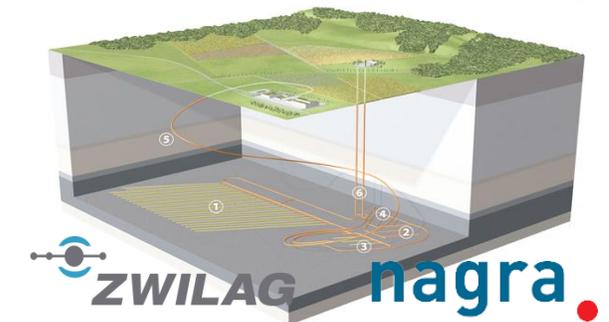


- **Scientific–technical support** to the Swiss nuclear regulator and expertise for NPP operators, enabling safe long-term operation (>60 years) of Switzerland’s LWR fleet
- **Post-irradiation examination** of spent nuclear fuel for Swiss power plants, to optimize safety and performance
- **Scientific contributions** to the full radioactive waste disposal path, especially to Nagra’s analyses for the Sectoral Plan on Deep Geological Repositories
- **Education and training** of the next generation of radiochemists, nuclear scientists, and engineers (Master’s, PhDs, Postdocs)



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Nuklearsicherheitsinspektorat ENSI
Inspection fédérale de la sécurité nucléaire IFSN
Ispettorato federale della sicurezza nucleare IFSN
Swiss Federal Nuclear Safety Inspectorate ENSI



PAUL SCHERRER INSTITUT

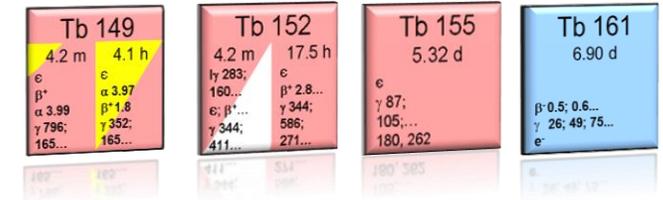


ETH Zürich

Additional key nuclear research activities



Support of **medical research**, through the production and investigation of (new) medical radionuclides for cancer therapy and diagnostics (PSI research infrastructure project IMPACT-TATTOOS, 2025–2028).“



Technology Monitoring: Assessment of developments in advanced reactor designs (focus on safety and sustainability) (by request of SFOE, Art. 74a KEG)



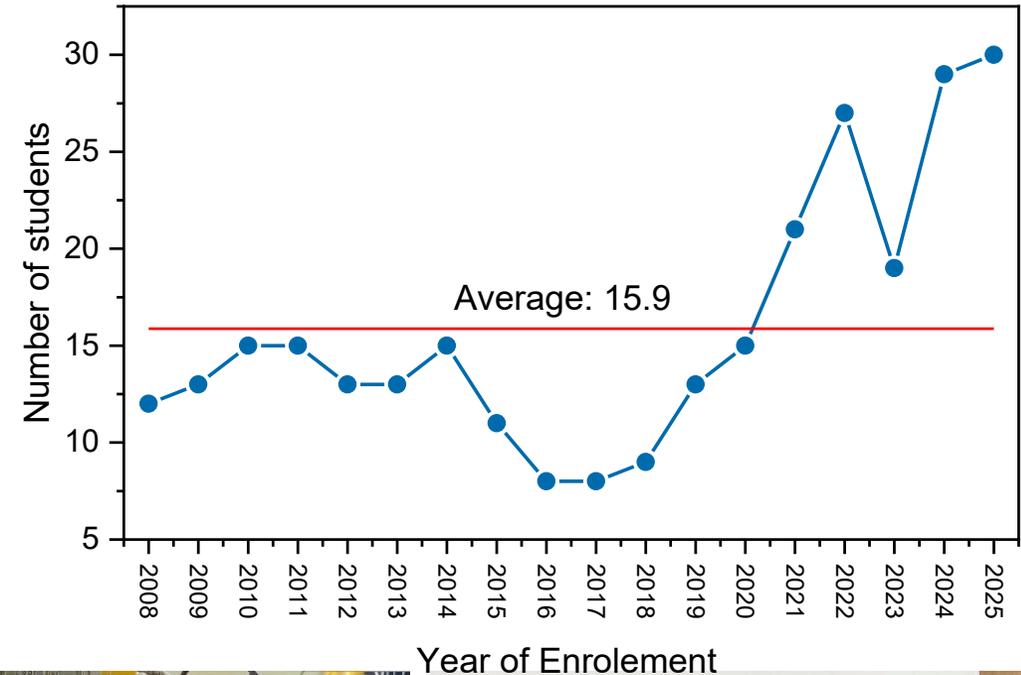
Industrial research platform for Generation-III and -IV reactor technologies: maintain, deploy, and extend PSI’s excellent infrastructures for new international nuclear developments



EPFL/ETH/PSI Nuclear Engineering Master



- The **Swiss Master program in Nuclear Engineering** is the first **joint master program** of ETHZ and EPFL, with strong support from PSI.
- **More than 200 graduates since it's creation**, of which >80% performed their master thesis project at PSI, and of which **60% stay** in Switzerland!
- **Very positive trend** of number of students in the past few years



International Atomic Energy Agency MSc evaluation Jan 2024:

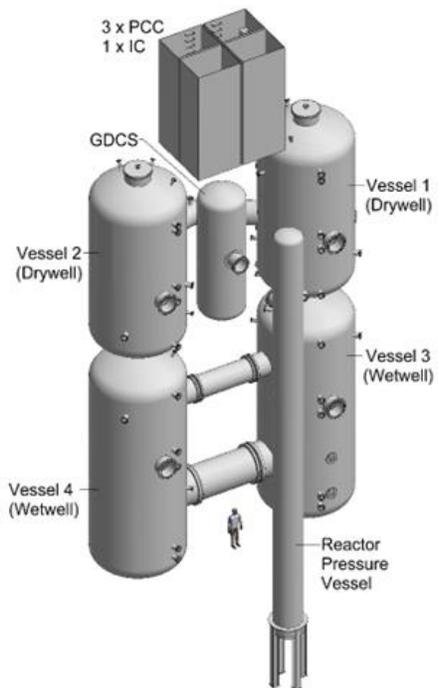
“...exemplary programme ..., with excellent teaching and superb facilities, to provide a world class nuclear education experience for the students....”



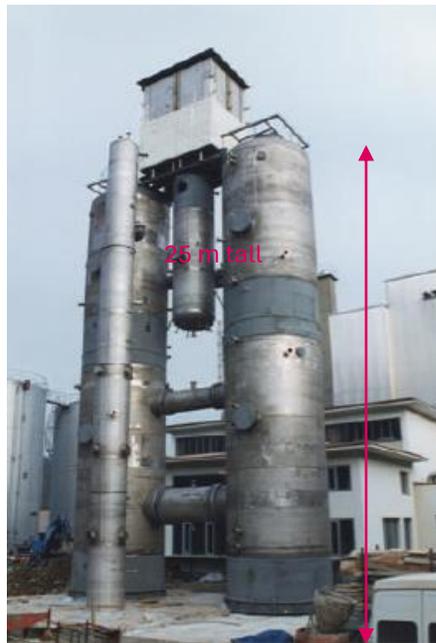
Recognition of EPFL/CROCUS research reactor as **Collaboration Center of the International Atomic Energy Agency**

Core activities:

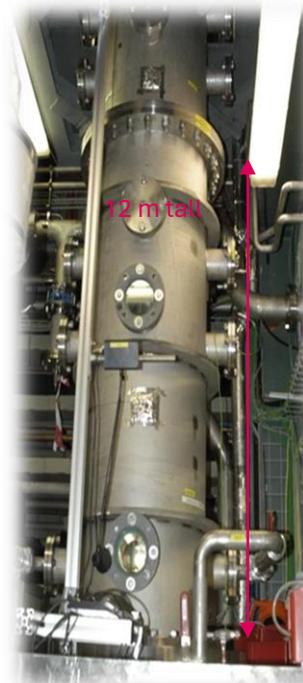
- Safety analyses of steady-state, transient, and accident conditions
- Advancement of multi-physics and multi-scale simulation
- Maintenance and improvement of nuclear data libraries (e.g., TENDL)
- Experimental support to reactor operations and fuel management



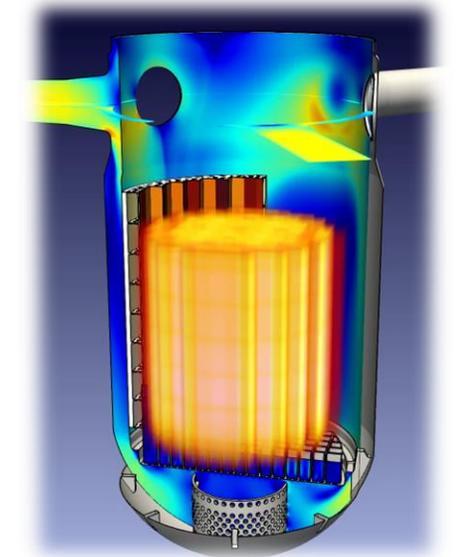
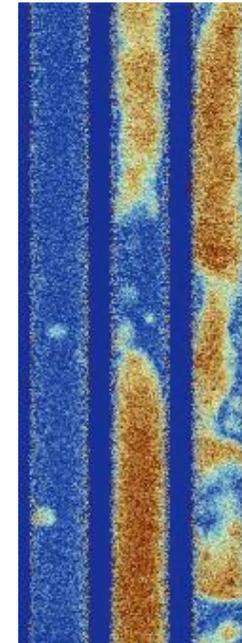
Panda: Containment thermal-hydraulic facility



Mini-VEFITA: small-scale pool scrubbing test facility for **retention** of iodine species



High-resolution imaging techniques for high-pressure boiling experiments (Diaz et al 2023)

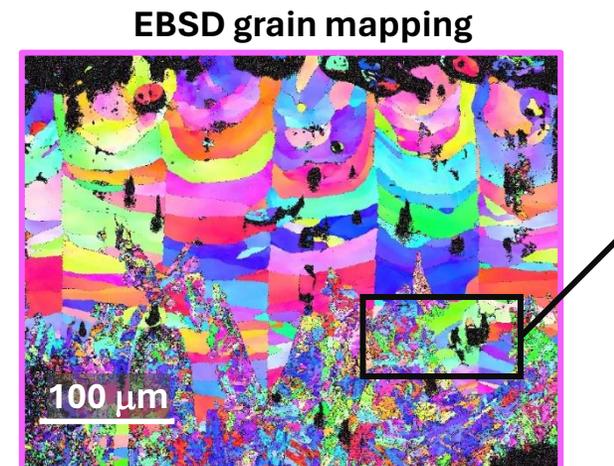
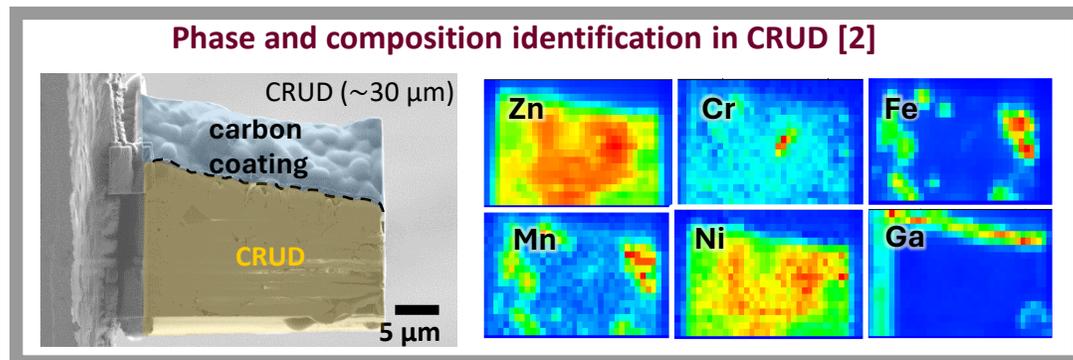


Heat and fluid flow modeling

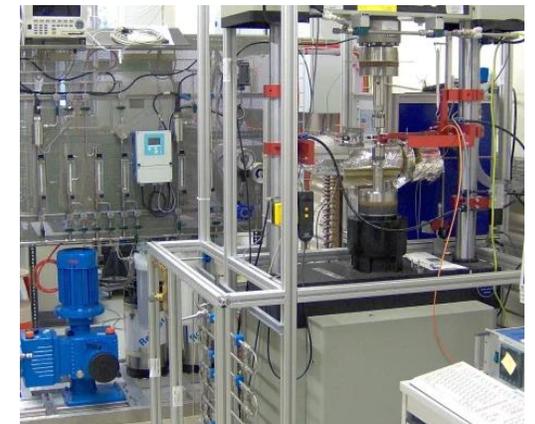
Nuclear Fuel & Material Integrity

Core Activities:

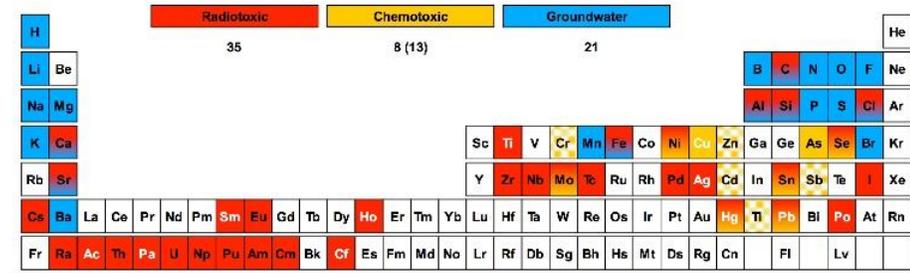
- Ageing & degradation of reactor components and fuels
- Radiation damage studies on structural and target materials
- Evaluation/Qualification of advanced alloys and fuels
- Post-irradiation examination & failure analysis
- Irradiation testing at SINQ and hot-cell facilities
- Advanced manufacturing



Thermo-mechanical (corrosion) fatigue facility



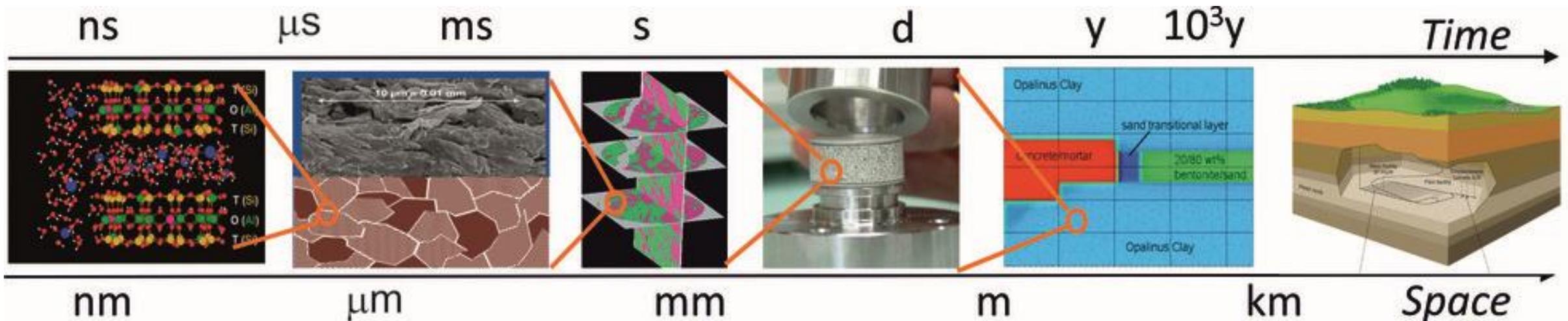
Geochemistry of deep geological repository



Core Activities:

- Radionuclide retention and migration in engineered and natural barriers
- Geochemical processes controlling repository performance
- Development and validation of reactive transport and geochemical models
- Thermodynamic database development for safety assessment
- Laboratory and in-situ experiments in underground research facilities

Important contribution to the Swiss site selection process through an extensive experimental and modelling program spanning over 30 years.



Analytical & operational support

PSI's “**Hot Laboratory**” is one of the few laboratories in Europe and **only Swiss laboratory** still able to examine **highly radioactive materials**:

- Post irradiation examination of **irradiated full length fuel rods**
- Detailed characterization of nuclear fuel
- Analysis of **highly radioactive materials** such as targets from **SINQ, CERN,**

Excellent analytical infrastructure, unique in combination with PSI's large-scale research facilities (“microscopes” like SINQ and SLS)



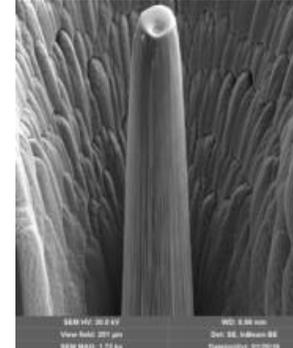
Hotcells



Deliver of fuel rods



Hot Lab Shielded
FIB

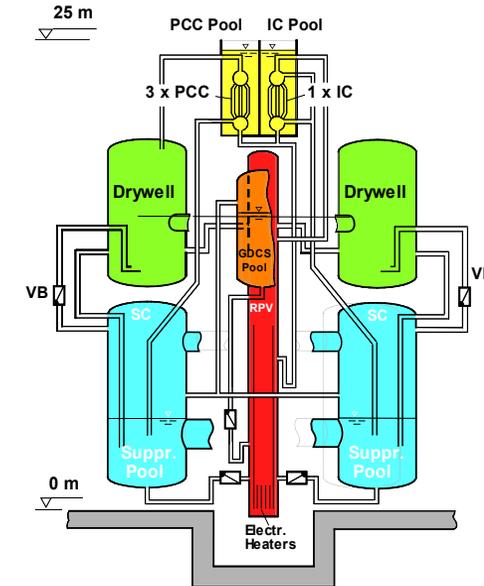
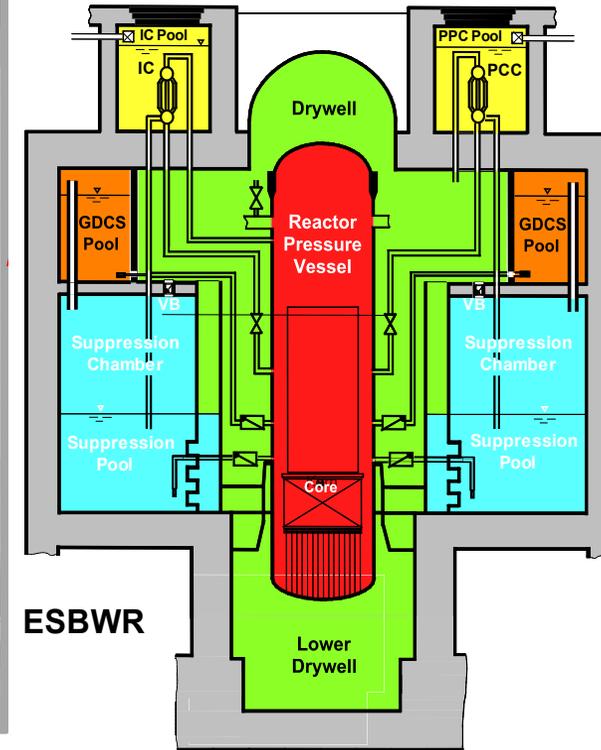


Fabrication of Micro-
Specimens



Imaging at the Swiss Light Source
(SLS)

Experimental Large-Scale Facilities, e.g. PANDA



Scaling:

- Height ~ 1 : 1
- Volume ~ 1 : 40
- Power ~ 1 : 40

- **PANDA**: an internationally recognized reference facility (according to OECD/NEA a "research facility of critical importance") for studying containment safety phenomena.
- Since July 2021, PSI has been working on the **OECD/NEA project "PANDA-SMR"**, involving many OECD member states and placing a particular focus on **small modular reactors (SMRs)**.

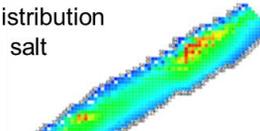
PSI-NES ist das Schweizer Kompetenzzentrum für MSR!



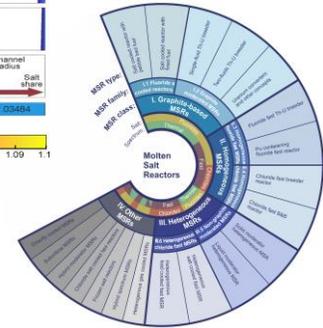
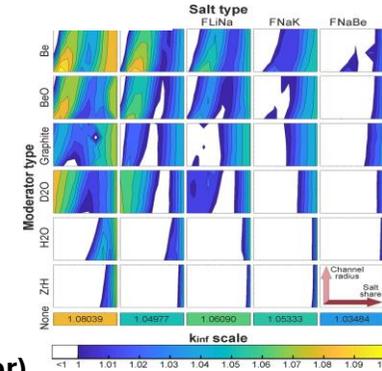
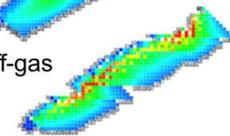
PSI vertritt CH in
VHTR(2006),
GFR(2006-2015),
Seit 2015 MSR



FPs distribution
 in fuel salt



and in off-gas
 system

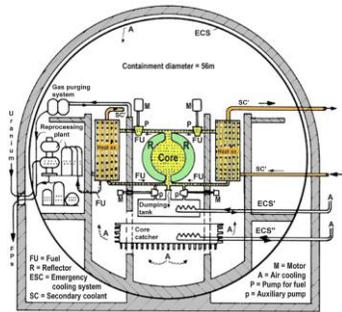


2017 GIF MSR Workshop am PSI **EVOL (2010-2013, observer),**
SAMOFAR (2015-2019), SAMOSAFER (2019-2023)

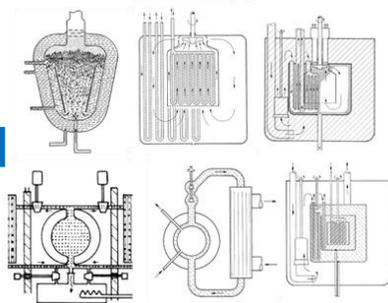
2020 IAEA MSR Taxonomy (IAEA TRS-489)



2014 SRF 10 vor 10: MSR Forschung in CH
 (M. Zimmermann)



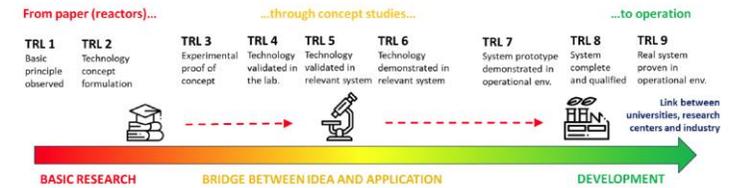
EIR (PSI) study (report nr. 411, 1980)
moltensalt.org/references/static/downloads/pdf/EIR-411.pdf



1970s -1980s EIR -> MSR Forschung



**copenhagen
 atomics**



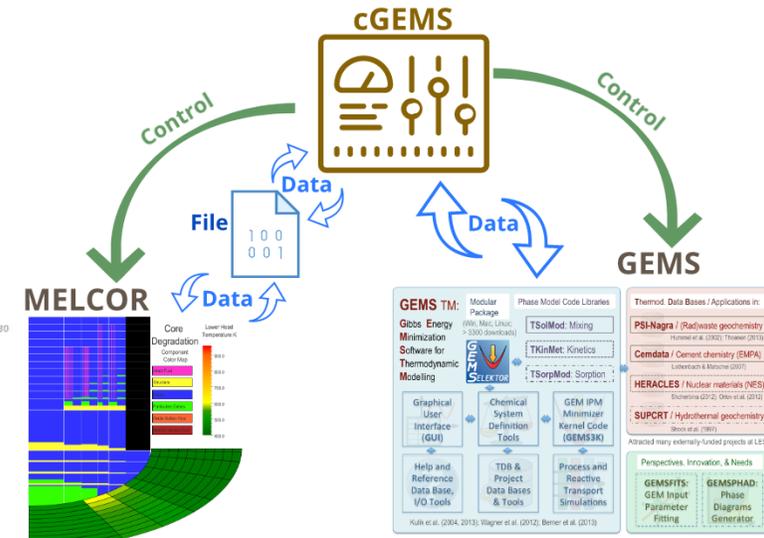
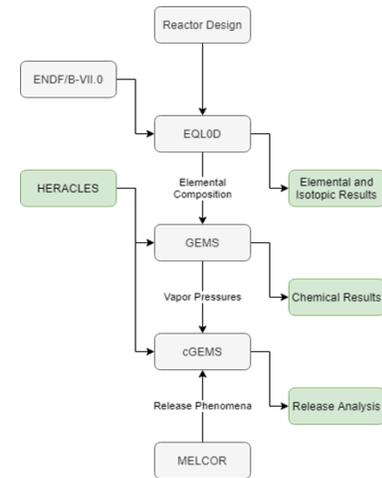
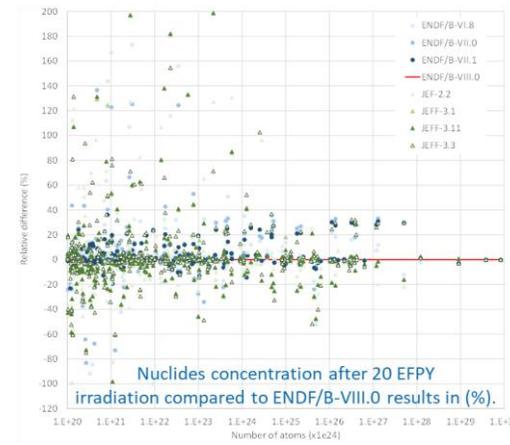
4. EU MSR Projekt «ENDURANCE» (2024-2028)
erneut mit starker PSI-Beteiligung.

Seit 2022: J. Krepl
GIF MSR Chair
(wiedergewählt 2024)

Major MSR tools/competences at PSI



- **EQL0D & EQL3D**
equilibrium cycle procedures.
- **GEMS**
Gibbs Energy Minimization Software.
- **cGEMS**
(GEMS-MELCOR) coupling for severe accidents simulation.
- **AMoDy**
Molecular dynamics tool.
- **TRACE-PARCS**
system code for MSR transient analysis.
- **GeN-Foam / Atari**
multi-physics tools for MSR core analysis.



GEMS TM: Modular Package (for MELCOR) > 1300 Downloads

Phase Model Code Libraries: TSoMod: Mixing, TKinMet: Kinetics, TSoMod: Sorption

Thermodynamic Data Bases / Applications in: PSI-Nagra / (radio)waste geochemistry, Cemdata / Cement chemistry (EMPA), HERACLES / Nuclear materials (NES), SUPCRT / Hydrothermal geochemistry

GEMS TM: Gibbs Energy Minimization Software for Thermodynamic Modeling

Graphical User Interface (GUI): Help and Reference Data Base, I/O Tools

Chemical System Definition Tools: TDB & Project Data Bases & Tools

GEM IPM Minimizer Kernel Code (GEMSK): Process and Reactive Transport Simulations

Other tools: GEMSFITS: GEM Input Parameter Fitting, GEMSPHAD: Phase Diagrams Generator

