

HUN
REN



Centre for
Energy Research

HUN-REN
Hungarian Research Network

Strategic directions in nuclear research in Hungary

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Research. Innovation. Impact.

Paks NPP – 4 Units VVER-440

- Operational licences extended until 2032-2036. Further extension is decided.
- The new „slim fuel” design is introduced in 2022 (thinner wall, smaller diameter)
- Fuel supply diversification is on the agenda

Paks II. – Extending the capacities with two VVER-1200 reactors.

- Construction licence with conditions issued by HAEA in 2022.

SMR – The new SMR designs, and possible implementation will be investigated

Budapest Research Reactor and Budapest Neutron Centre (BNC)

- Installed in 1959, licence will expire in 2023, licence extension is planned +10yrs
- Operated by Centre for Energy Research, owner is the Hungarian Academy of Sciences
- The research reactor is mainly used for beamline science (neutron physics, materials sciences). The facility is a member of the E-RIHS, CERIC, LENS networks.
- Fresh fuel supply secured for the next 4-5 years, (TVEL, 2020.)
- Roadmap is prepared for the future use of BNC

Training reactor at the Technical University (BME NTI)

- Installed in 1971, 100kW power, (still using the original fuel assemblies)

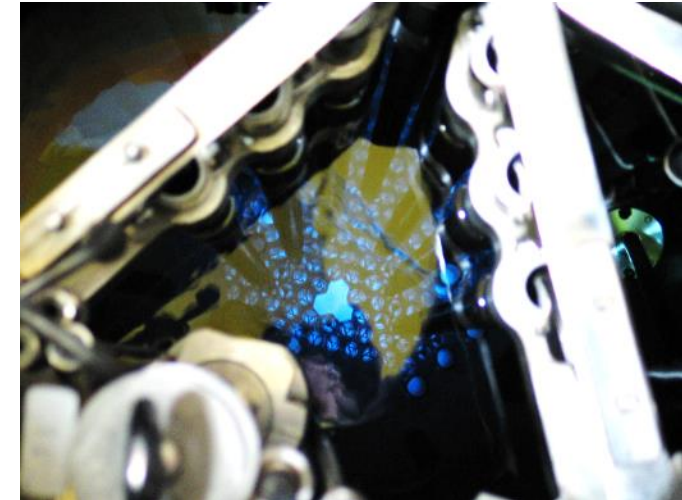


The history started in '50s

- 1959 KFKI Research reactor
- 1971 BME Training reactor
- PAKS, Generation II. units 1982-1987, 4 units has been commissioned

Safety of Paks is acceptable by European standards because:

- Conservative design of VVER-440/V213 units
- Quality requirements during the construction of the units
- The man-machine interfaces were replaced in due time by modern tools
- The timely review of the safety of the units by adequate tools widely accepted
- The operation of modern safety authority
- The safety improvement program executed on all the units.



- Nuclear R&D has a long tradition in Hungary
- In the '90s, the national research and design institutes were more and more supported the operation of Paks NPP
- 2007: preparation of the new units, Teller and Lévai projects.
- 2009: the Government decided to strengthen the **national R&D**. First stage was the creation of the **Vision report**.
- 2015: National Policy on the Management of Radioactive Waste and Spent Fuel
 - Research on the closure of the fuel cycle is part of the program
- 2023 National Energy Strategy updated: nuclear and renewable sources are in the energy mix.

The national R&D program is based on three pillars:

- Paks units 1-4– maintaining competence for the extended lifetime.
- Paks units 5-6– safety depends on the knowledge of the new technology.
- Modernising the fuel cycle (reduced radioactive waste, supply of nuclear fuel in the long term) – national, regional and worldwide problem. The main tool will be the deployment of new generation fast reactors

Regional collaboration with Poland, Czech Rep., Slovakia
V4G4 Centre of Excellence was founded in 2013.



The Centre for Energy Research (EK or CER) is a member of the Hungarian Research Network (HUN-REN) since 2019. The new research network (HUN-REN) is under the supervision of the Parliament.

EK is the strongest Hungarian institute in nuclear studies: nuclear safety, security and fusion engineering are in the portfolio.

The staff stabilized around 450 people, 80% researchers.

EK successfully re-newed its contract with IAEA to be a Collaborating Centre in Nuclear Forensics for IAEA.

EK is the main consultant of Paks NPP is nuclear safety related matters and the TSO of the Hungarian Atomic Energy Authority





Nuclear Safety

Research on the safety of Paks NPP: coupled code development, OECD NEA related projects
Closing the fuel cycle (long term international projects), ALLEGRO (Euratom)
Fusion energy (Diagnostics, plasma physics research), ITER (Eurofusion), JT-60SA, Wendelstein

Energy storage, hydrogen economy

Cathalitic water splitting, methane dry reforming (H₂ and synthetic fuel)
Energy storage in the grid, stability of the electric network
Electric network topology analysis, study of transients

Materials sciences and energy saving

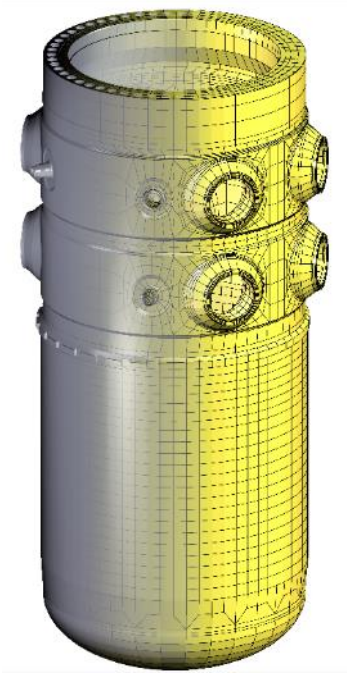
Sensor development on physical, chemical, biological phenomenon
Functional materials (think layers, 2D materials), ERA-NET
Heritage science (supporting museums with analytical capabilities), H2020

Environment chemistry

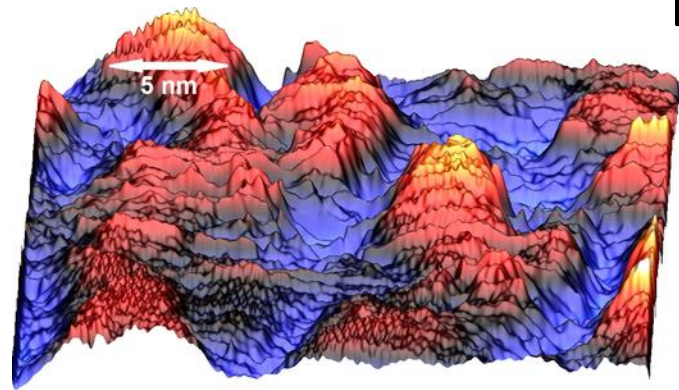
Sewage water cleaning with advanced oxidation technology
Safe storage of radioactive waste (Euratom)

Space research (space dosimetry)

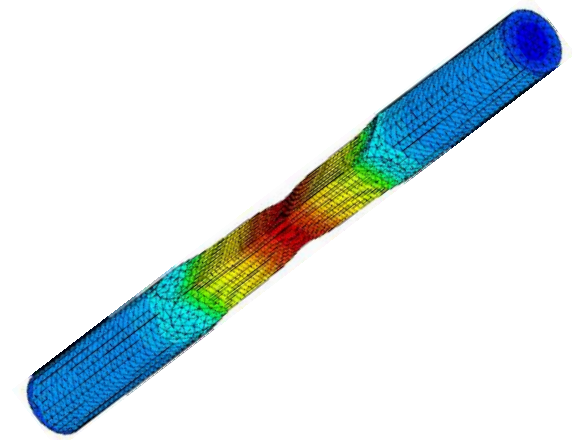
Development of radiation sensors and space weather, ESA
Power supply and I&C for satellites

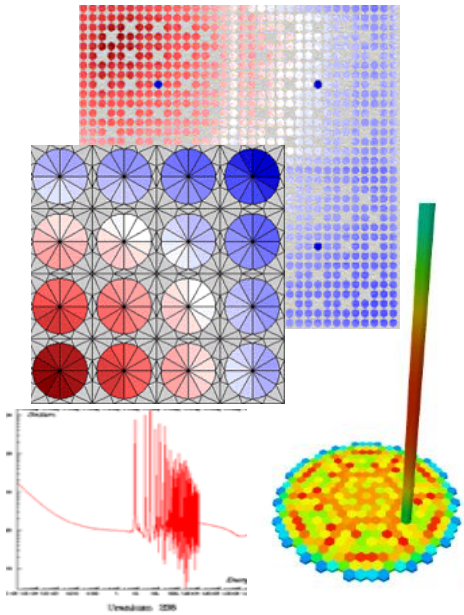


Reactor pressure vessel structural integrity

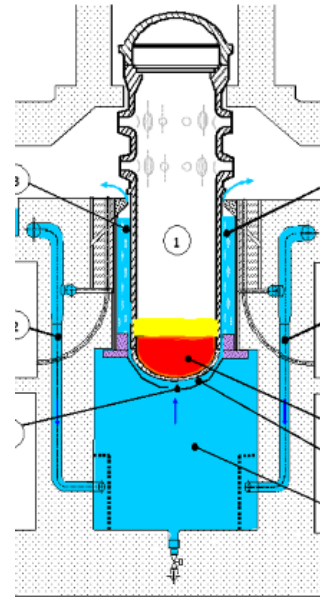


Graphene nanoengineering

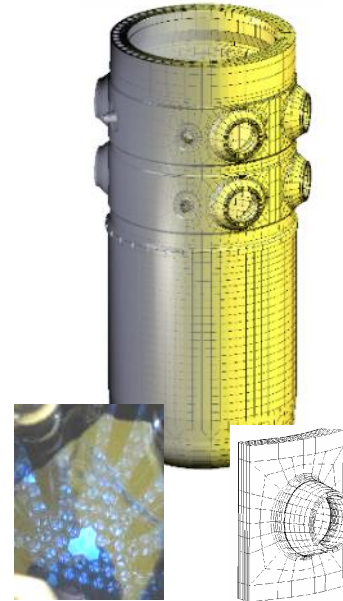




Reactor physics,
Neutron transport
calculations,
Reactor core design
Subcriticality analysis
Multi physics hot
channel calculations



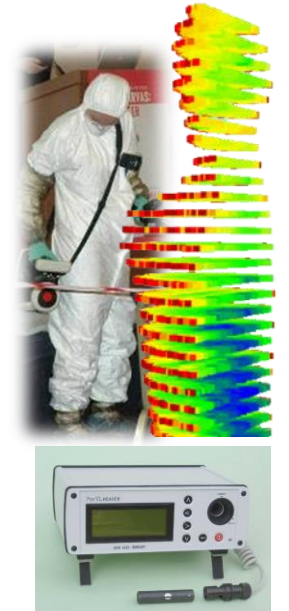
Thermal hydraulics,
Ex-vessel cooling tests
Computational Flow
Dynamics
Severe accident
simulations



Structure integrity
analysis,
Fuel cladding thermo-
mechanical properties,
Radiation damage
studies



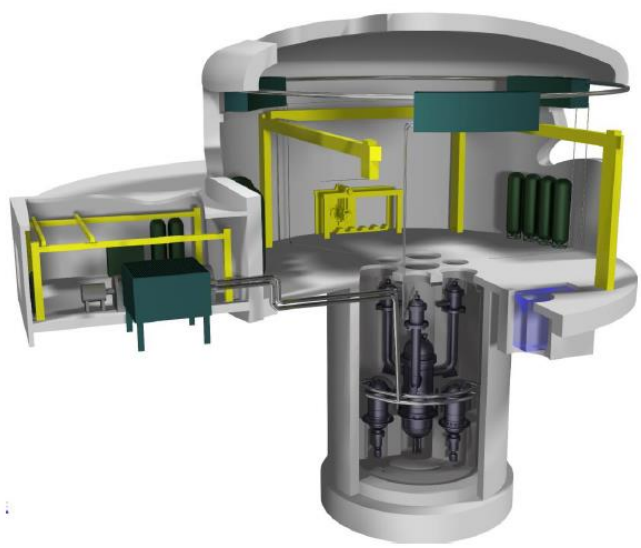
Digital I&C systems
Human-machine
interface
Reactor training
simulator
Core monitoring



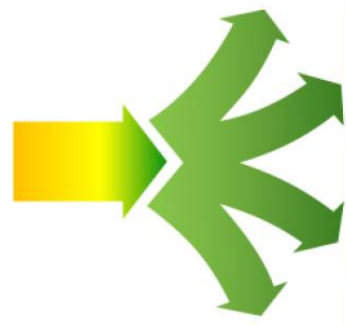
Radiation protection,
low dose effects,
athmospheric
dispersion,
environmental
monitoring



DESIGN THERMODYNAMICS CORE DESIGN



- FP7 Projects
- V4G4 CoE Research
- National Research Projects
- Other International Research



- WP1 – Core Safety
- WP2 – Materials and Technologies
- WP3 – Decay Heat Removal
- WP4 – Integration of Results
- WP5 – Education and Training
- WP6 – Dissemination of Results



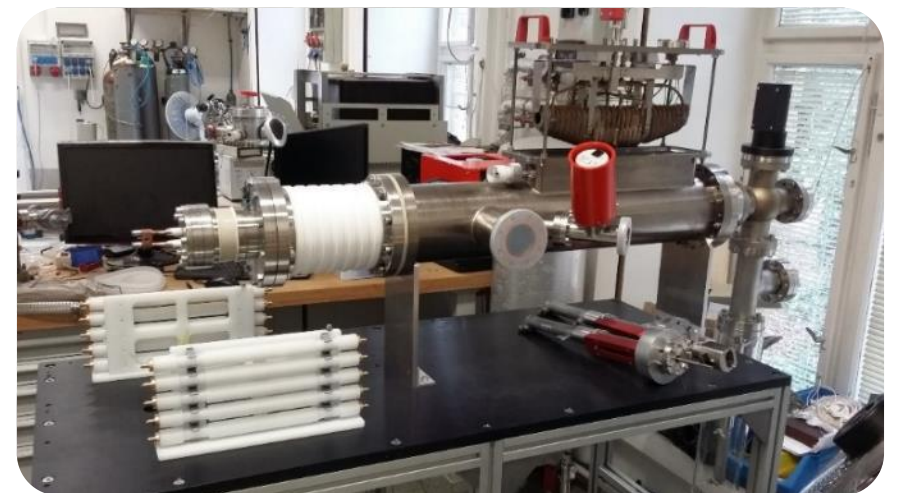
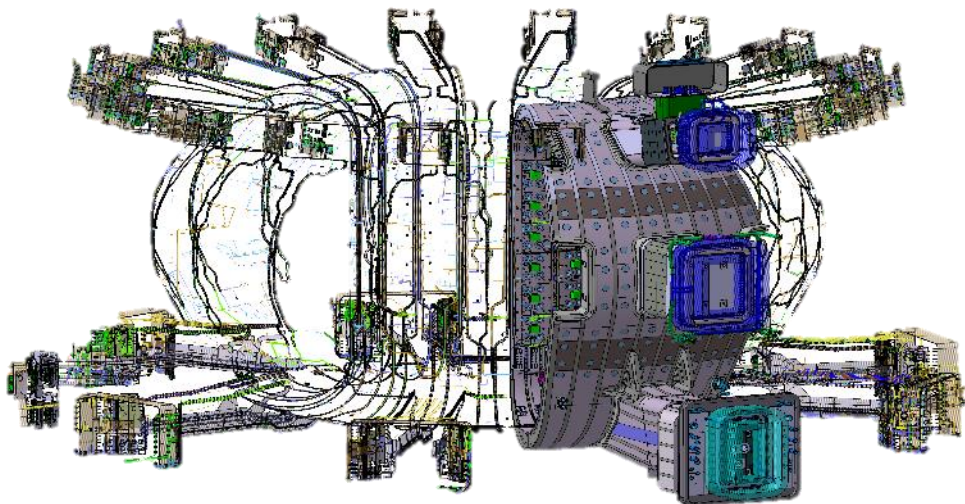
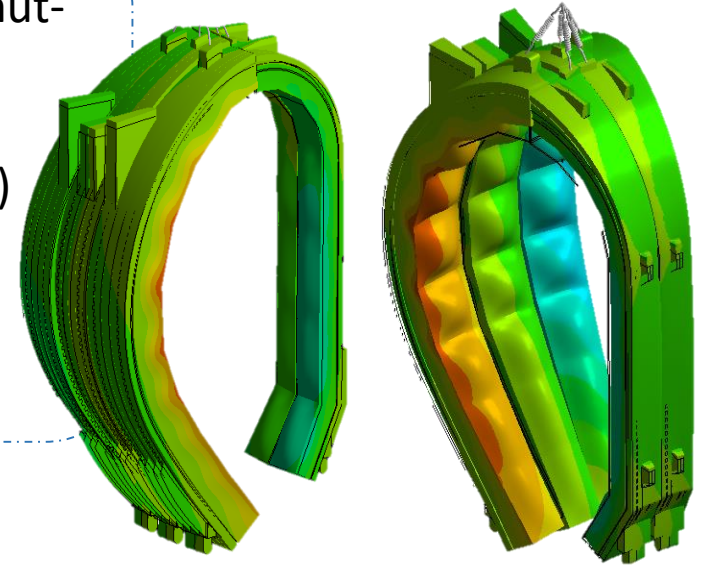
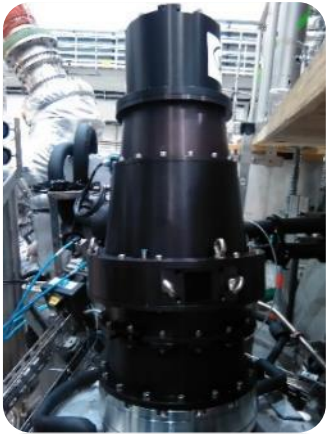
Future R&D on GFR



V4 Collaboration



- Shattered Pellet Disruption Mitigation – the Emergency shut-down system for ITER
- Plasma diagnostics on tokamak (MAST, ASDEX, W-7X, etc.)
- IFMIF-DONES Test Design
- ITER electrical diagnosis, signal transmitting line

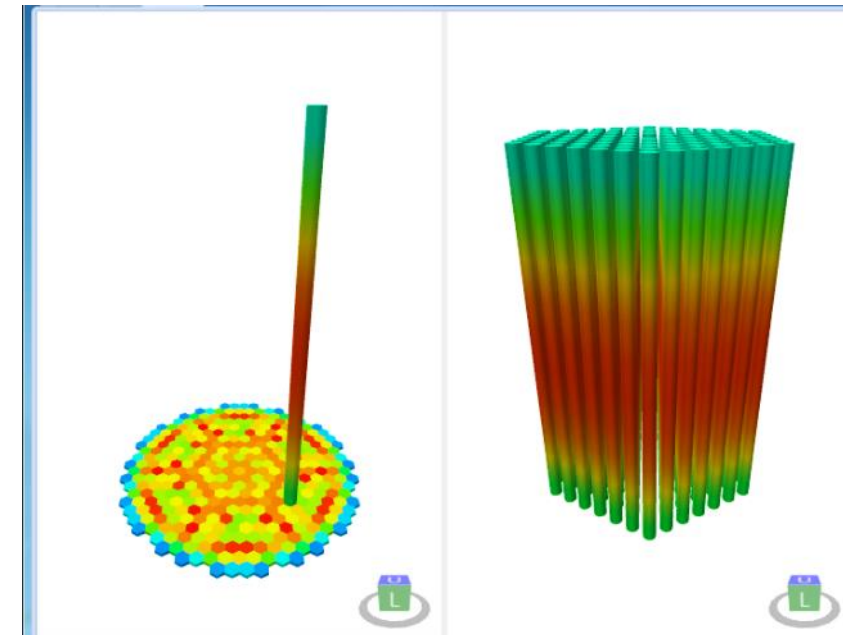


Instrumentation & Control of Nuclear Power Plant

- The first training simulator in Paks NPP was developed by Nokia and KFKI
- The Simulator will be refurbished by 2024. Presently all models running in the Simulator were developed by EK-CER

Other in house developed products:

- VERONA core monitoring is used by the operators to get data on operational margins even at the level of fuel rods
- PAZAR core noise diagnostics software is used to get data on the moderator temperature coefficient
- CERTA-VITA software is used by the Safety Authority to monitor the plant status online.





The research reactor provides neutron source for basic and applied neutron physics research

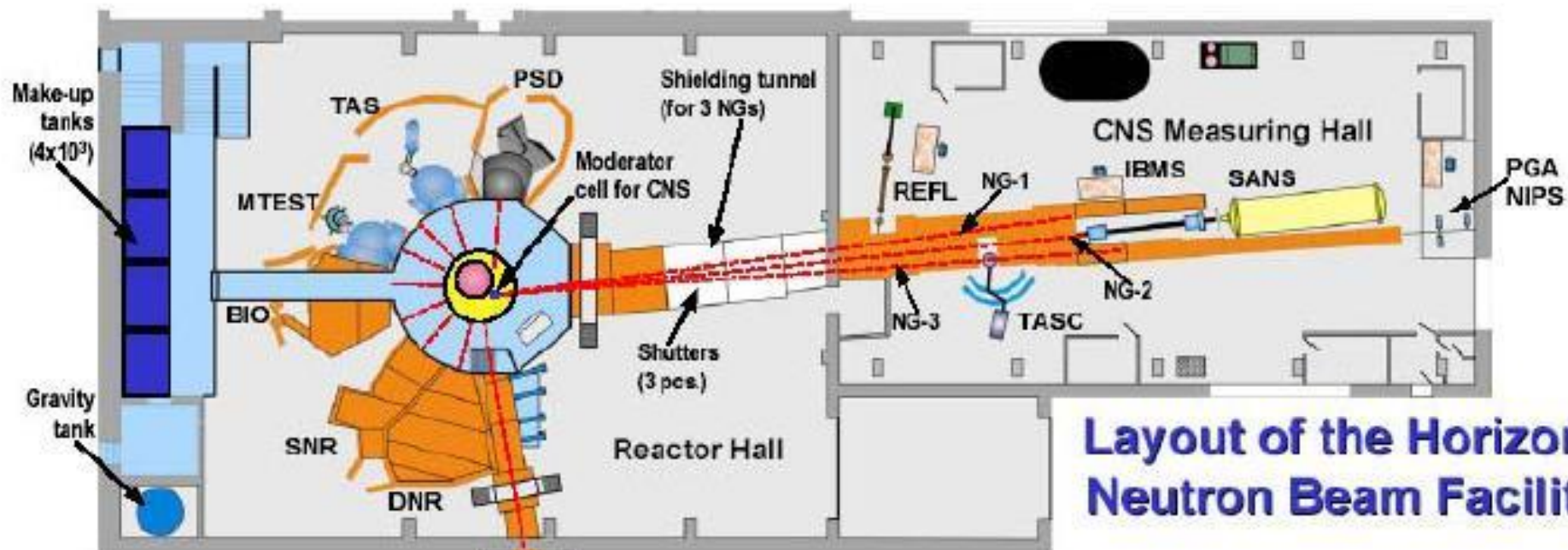
Reactor power:

10 MW, average 3500 h/year

- thermal neutron flux: $2.5 \cdot 10^{14}$ n/cm²s

- fast neutron flux: $1 \cdot 10^{14}$ n/cm²s





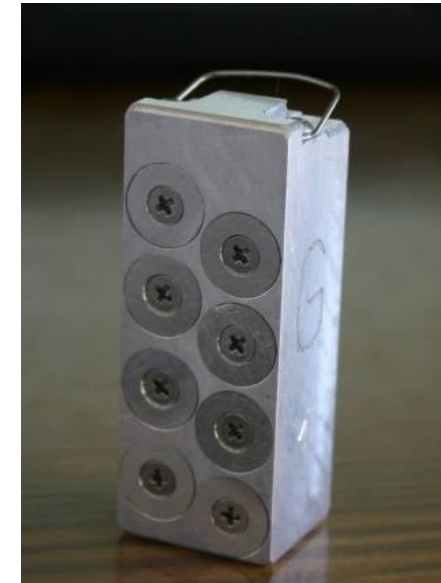
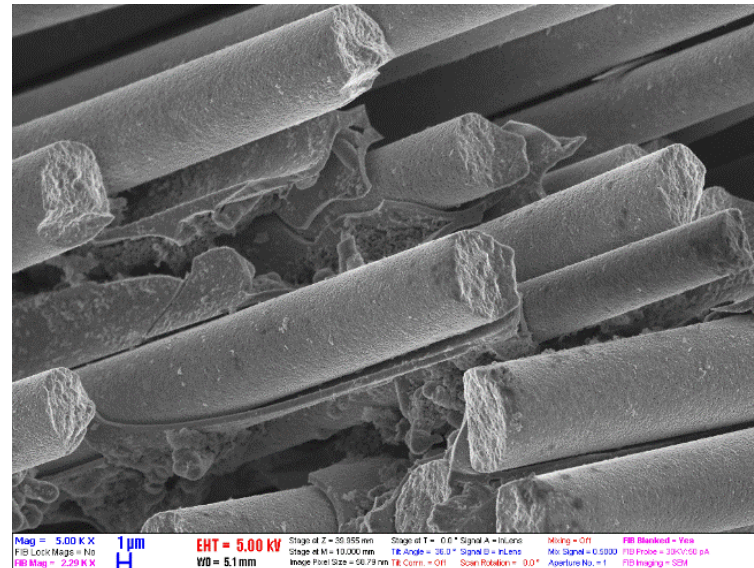
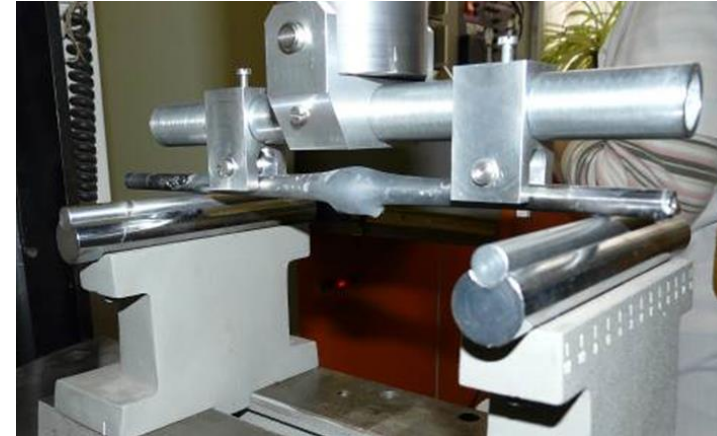
Facilities in Reactor Hall

TOF	Time-of-flight spectrometer (under construction)	TOF (neutron guide)
DNR	Dynamic neutron radiography	TOF (measuring hall)
SNR	Static neutron radiography	
BIO	Port used for biological experiments	
MTEST	Material testing diffractometer	
TAS	Triple axis spectrometer	
PSD	Powder neutron diffractometer	

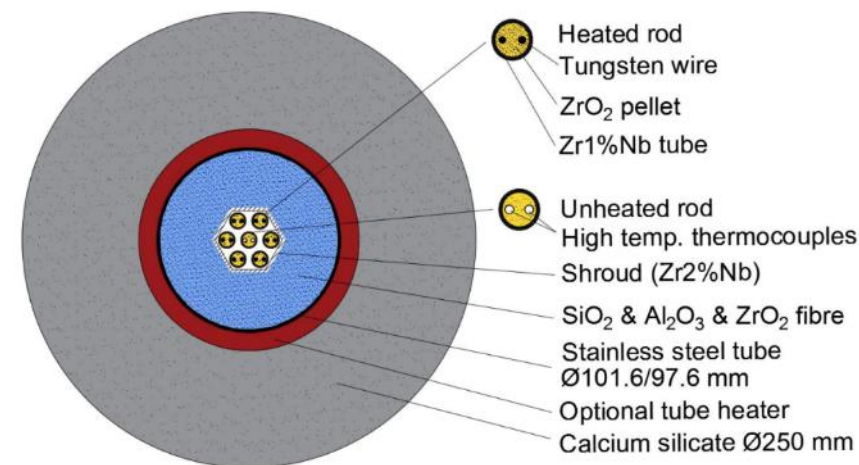
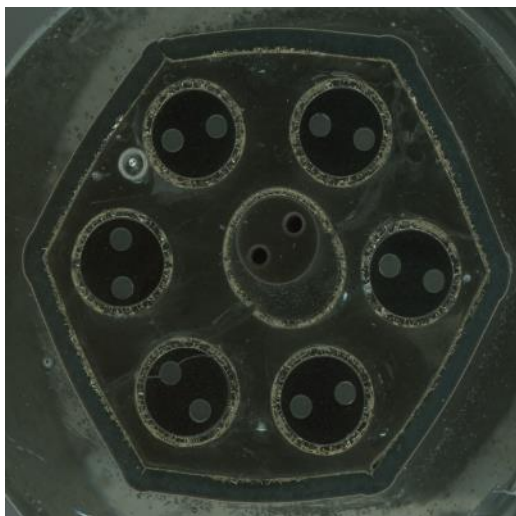
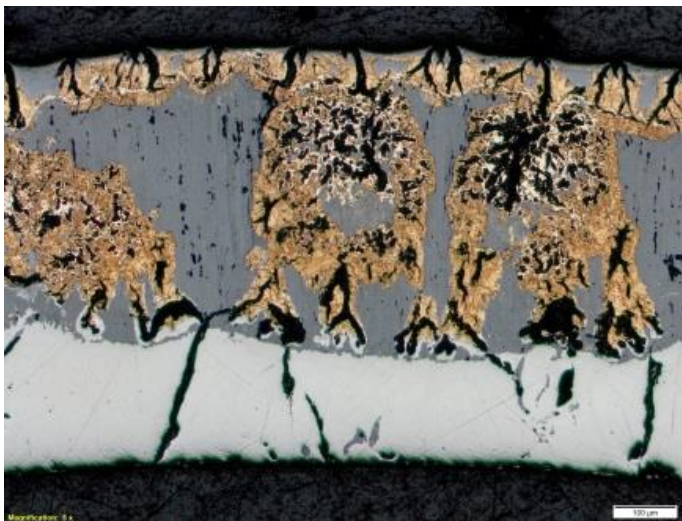
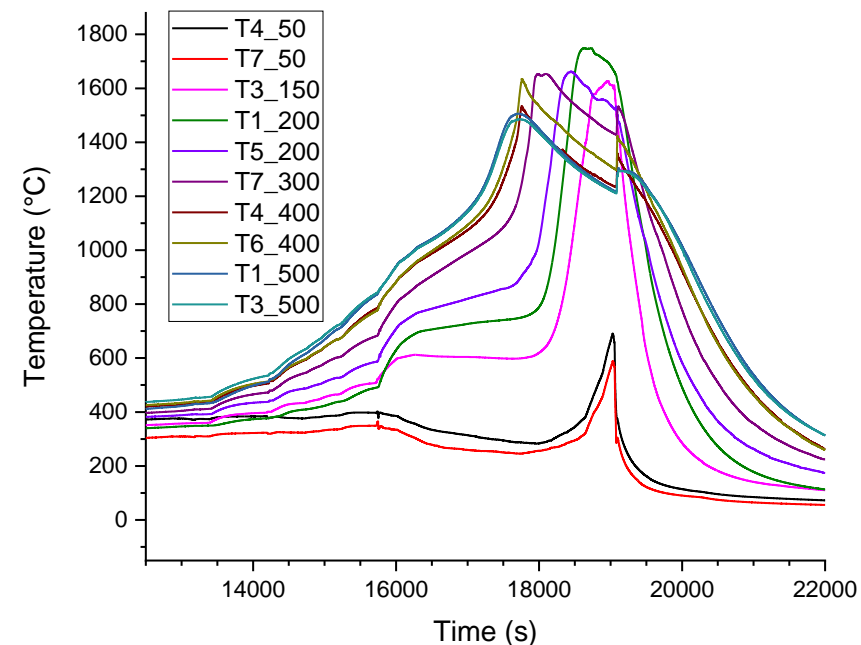
Facilities in CNS Measuring Hall (with 3 NGs)

REFL	Reflectometer
TASC	Triple axis spectrometer on CNS
SANS	Small-angle scattering spectrometer
PGAA	Prompt gamma activation analysis
NIPS	Neutron-induced prompt gamma-ray spectrometer
IBMS	In-beam Mössbauer spectrometer (under construction)

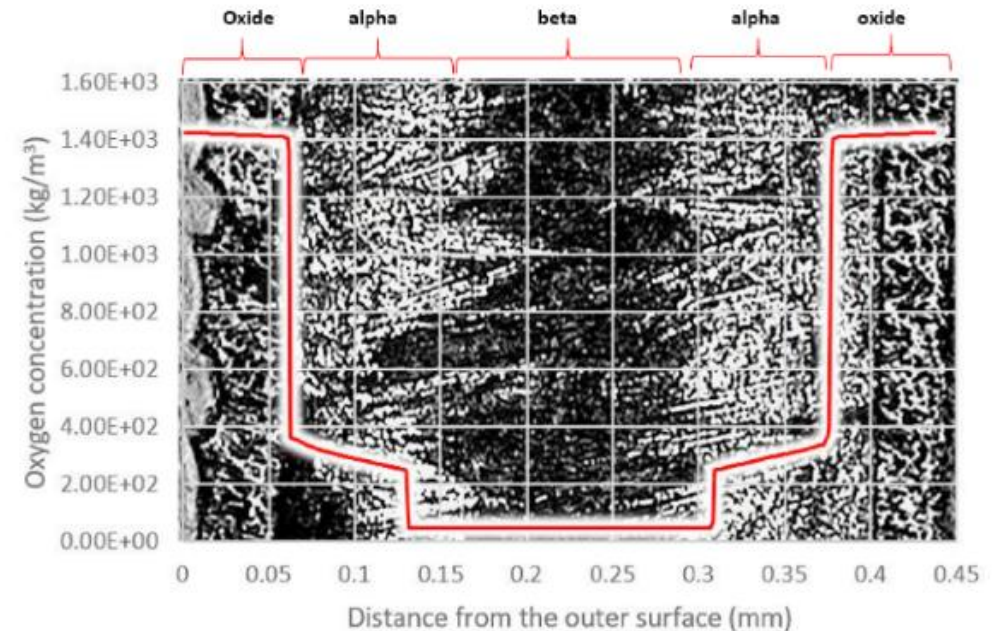
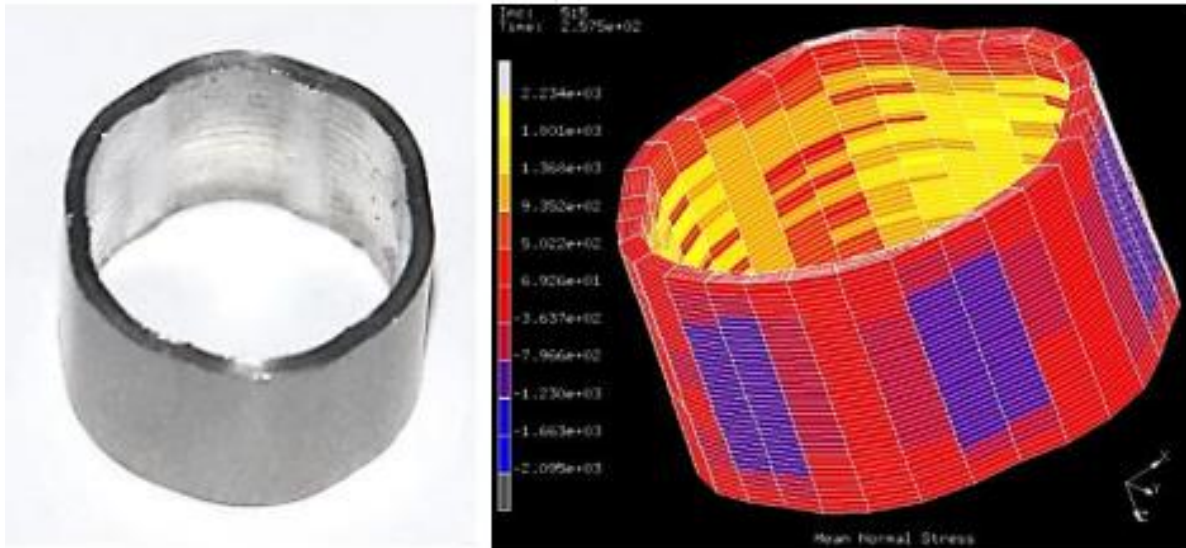
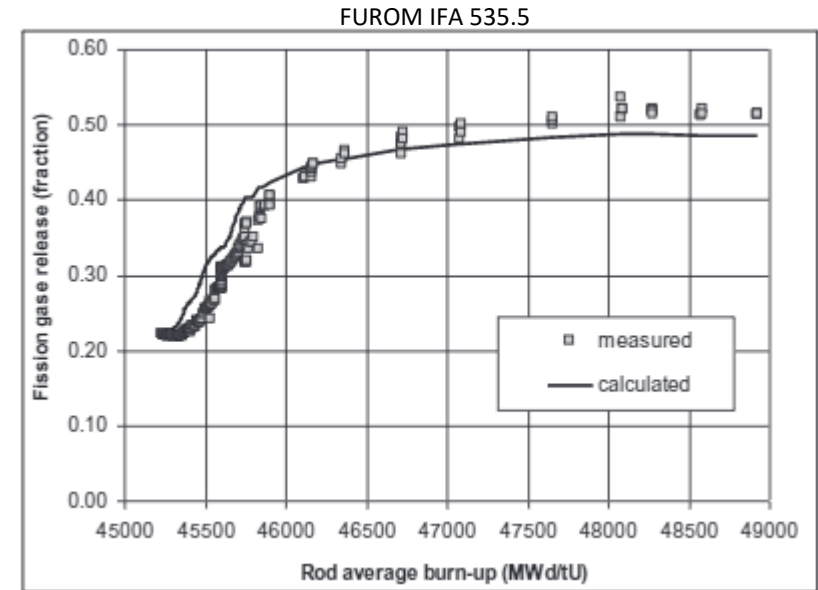
- irradiation in the Budapest Research Reactor
- high temperature oxidation
- creep tests
- mechanical tests
- SEM/EDX/LOM post-test examinations
- Zr alloys, SiC, stainless steel



- CODEX – Core Degradation EXperiment
- simulation of reactor incidents and accidents
- up to 2000 °C
- on-line measurements (temperatures, gas composition, levels, flowrates,...)
- PWR and VVER bundles
- post-test examination of damaged fuel



- application of computer codes (FRAPTRAN, TRANSURANUS, FUROM) in safety analyses
- leaking fuel rod simulation
- VVER specific model developments
- validation activities
- support and post-test analyses of experiments



OECD

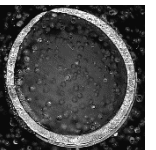
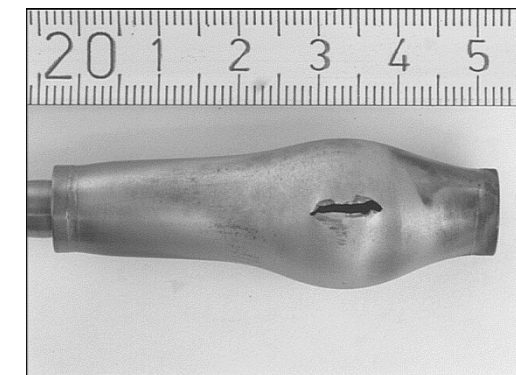
- Halden Reactor Project
- Framework for Irradiation Experiments (FIDES)
- Studsvik Cladding Integrity Project

EURATOM

- STRUMAT and MAGIC RR
- R2CA – LOCA and RIA
- SARNET, SAFEST – severe accident
- ESNII Plus, PuMMA, SafeG – Generation IV reactors

IAEA

- Testing and Simulation for Advanced Technology and Accident Tolerant Fuels (ATF-TS) – burst testing ATF cladding provided by foreign partners



Thank you for your attention!

