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Importance of International Cooperation in R&D Field for Increase of Nuclear Safety and New Build Projects

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UJV Group

PEOPLE I INNOVATION I TECHNOLOGY

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- **OECD/NEA activities and projects**
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INTRODUCTION

- International cooperation in nuclear safety research and development (R&D) has a long tradition, beginning with President Eisenhower's "Atoms for Peace" speech to the UN General Assembly in 1953.
- The interest of all nations in avoiding nuclear accidents has stimulated cooperation between countries throughout the decades of operation of nuclear fission reactors.
- As a result, international cooperation in the field of nuclear safety has been, and continues to be, unusually intensive.

INTRODUCTION

- **One of the most important elements of the nuclear safety is the safety assessment (deterministic and probabilistic safety analyses), which serves among other in licensing of new NPP.**
- **The principal role of the NPP safety analysis is historically reflected in the name of the basic document of each NPP, the “Safety Analysis Report (SAR)”**
- **The safety assessment / analysis of a nuclear power plant (NPP) is an essential activity in all phases of the NPP life cycle:**
  - **Designing**
  - **Licensing**
  - **Startup**
  - **Operation (with regular updates of SAR and Periodic Safety Reviews, PSR)**
  - **Design modifications**
  - **Decommissioning**

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EU activities and projects

(with focus on SNETP technology platform)

EU activities and projects

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- The European Union's involvement in nuclear research over the past decades has been carried out through the instrument of the Framework Programmes (FP).
- The FP1-FP7 programmes have been followed by Horizon2020 (2014-2020) and by the current Horizon Europe (2021-2027) programme.
- An important role in the shaping of European energy policies and organization of cooperation in nuclear research, development and innovation plays the SNETP association and technology platform.

EU activities - SNETP

SNETP: *THE EUROPEAN TECHNOLOGY AND INNOVATION PLATFORM (ETIP)*

- SNETP was set up in 2007 under the auspices of the European Commission with the goal to **support technological development for enhancing safe and competitive nuclear fission in a climate-neutral and sustainable energy mix**.
- In line with the objectives of the SET-Plan and the European Green Deal, SNETP aims to contribute to:
  - Lowering European greenhouse gas emissions
  - Assuring security of energy supply for Europe
  - Stabilizing electricity prices in Europe
- The association gathers various types of stakeholders: industry, research centres, safety organisations, universities, non-governmental organisations, SMEs, etc.
- SNETP public website: https://snetp.eu/
- SNETP members area: https://snetp.flexx.camp/2/

EU activities – SNETP members

Today, SNETP gathers over **100 European stakeholders from 25 different countries:**

EU activities – SNETP composition

SNETP is composed of a General Assembly, a Presidency, a Governing Board, three Pillars (NUGENIA, ESNII and NC2I), three Committees (Committee for Scientific and Industrial Innovation, International and European Affairs Committee and the Stakeholders Engagement Committee) and a Support Office.

Gen II = existing light water reactors
GEN III = new LWR
GEN IV = advanced reactors

SNETP is the European Technology & Innovation platform for Nuclear Energy focused on Gen II-III and IV reactors with electric and non-electric applications

EU activities – SNETP pillars

The basic three pillars of the SNETP:

- The **Nuclear Generation II & III Alliance (NUGENIA)** is dedicated to the R&D of nuclear fission technologies, with a focus on safe and efficient operation of Gen II & III nuclear plants.
- The **European Sustainable Nuclear Industrial Initiative (ESNII)** focuses on industrial initiatives aiming to demonstrate Generation IV technologies with closed fuel cycles, to exploit the full potential of nuclear energy ensuring best use of uranium resources and waste minimization.
- The **European Nuclear Cogeneration Industrial Initiative (NC2I)** aims at demonstrating innovative and competitive energy solutions for the low-carbon cogeneration of heat and electricity, and hydrogen production based on nuclear energy.

A new area of work:

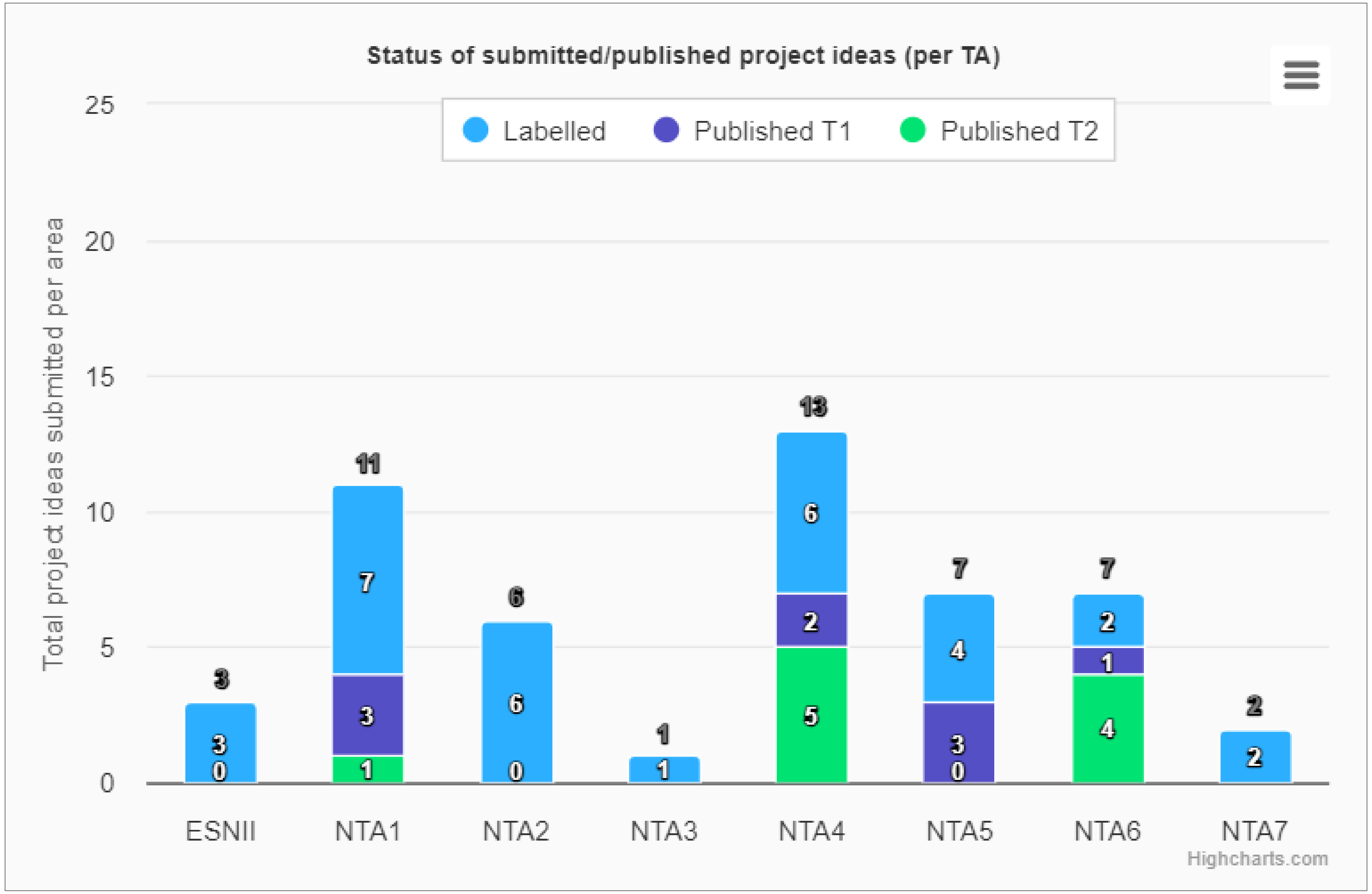
- The **European SMR pre-Partnership** was initiated after the 1st EU Workshop on Small Modular Reactors (SMRs) in June 2021. The objective of this initiative is to identify enabling conditions and constraints towards safe design, construction and operation of SMRs in Europe in the next decade and beyond in compliance with the EU legislative framework in general and to the Euratom legislative framework in particular. https://snetp.eu/wp-content/uploads/2023/07/EU-SMR-pre-Partnership-summary-17-July-2023.pdf

EU activities – SNETP mission and services

- **Building strategic vision & roadmapping**: enable members to express their R&D needs and priorities; identify research gaps, promote innovation initiatives, etc. SNETP develops a Strategic Research and Innovative Agenda (SRIA) to ensure that fission energy is generated in a way that meets the criteria for sustainable development and is compliant with safety requirements;
  https://snetp.eu/documents/
- **Support for development of project ideas** and proposal + labelling of them. The online SNETP Open Innovation Platform (SOIP) was created to serve to this process.
- **Dissemination of results of research projects and other SNETP activities.**
- **Establishing active networking to address cross sectorial challenges** and to promote partnership around innovative ideas:
  - Facilitating synergies with other technology platforms;
  - Interacting with international initiatives in the field of nuclear energy (i.e. SET Plan, GIF, OECD, IAEA, the Generation IV International Forum, etc.);

EU activities – SNETP Open Innovation Platform (SOIP)

The SNETP Open Innovation Platform (SOIP) is an online tool for sharing information within SNETP community on R&D&I project ideas.



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EU activities – SNETP projects portfolio

ESFR-SIMPLE
The topic of pool scrubbing is of major relevance both in Boiling Water Reactors and Pressurized Water Reactors as it plays a vital role in mitigating the source-term to the environment by retention of fission products passing through water pools.

OperaHPC
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NPHyCo
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IPRESCA
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GEMINI 4.0
The objective of the GEMINI 4.0 project is to demonstrate that the high temperature nuclear cogeneration system developed in GEMINI+ can provide a global solution for the competitive and safe decarbonization of industrial activities.

HARPERS
HARPERS main objective is to establish and clarify the benefits and added value of more aligned and harmonized regulations, practices and standards in decommissioning and radioactive waste management, including possibilities for shared processing, storage and disposal facilities between Member States (MS).

ANSELMUS
The global objective of the ANSELMUS project is to support the deployment of Heavy Liquid Metal (HLM) cooled advanced reactors in Europe.

SASPAM-SA
The key objective of SASPAM-SA is to investigate the applicability and transfer of the operating large-LWR reactor knowledge and know-how to the near-term deployment of integral PWR (iPWR), in the view of Severe Accident (SA) and Emergency Planning Zone (EPZ) European licensing analyses needs.

STRUMAT-LTO
STRUMAT-LTO addresses remaining gaps and open issues in RPV embrittlement to support safe long-term operation of LWR NPPs, including the scenario of LTO > 60 years.

ACES
The outcome of ACES will support the long-term operation of nuclear power plants, by using more realistic approaches for the integrity assessment of reinforced concrete SCC's and provide evidence by large scale tests.

APAL
One of the most limiting safety assessments for long term operation (LTO) of nuclear power plants (NPP) is the reactor pressure vessel (RPV) integrity assessment for pressurized thermal shock (PTS). The goal of APAL is to demonstrate the safety margin against fast fracture initiation or RPV failure.

BESEP
The overall objective of BESEP is to support safety margins determination by developing best practices for safety requirements verification against external hazards, using efficient and integrated set of Safety Engineering practices and probabilistic safety assessment.

ENTENTE
The overarching objective of the European Database for Multiscale Modelling of Radiation Damage (ENTENTE) project is to capitalise on past projects and expert groups beyond national borders.

FRACTESUS
The goal of this project is to join European and international efforts to establish the foundation of small specimen fracture toughness validation and demonstration to achieve change in code and standards allowing to address the various national regulatory authority concerns.

INCEFA-SCALE
The objective is to continue work, advancing ability to predict lifetimes of Nuclear Plant components when subjected to Environmental Assisted Fatigue loading.

INNO4GRAPH
INNO4GRAPH aims to develop a set of physical and digital tools and methods to be used in two different phases of European graphite reactor dismantling projects.

PASTELS
The overall objective of PASTELS is to improve the ability of European nuclear actors to design and deliver innovative passive safety systems and simulate their behaviour to support the safety demonstration.

PLEIADES
The PLEIADES project aims at demonstrating a digitally enhanced approach for a set of key decommissioning and dismantling (D&D) tasks in real life examples from selected projects in Europe.

PREDIS
Among others, PREDIS objectives are to develop solutions, methods, processes, technologies and demonstrators, for future treatment and conditioning of waste for which no or inadequate solutions are currently available.

PUMMA
The PUMMA project will define different options for Pu management in Generation-IV systems and evaluate the impact on the whole fuel cycle in addition to safety and performance aspects.

R2CA
The project mainly aims at consolidating assessments of the radiological consequences (RC) of explicit DBA and DEC-A reactor accidental situations through updated calculation schemes and harmonized methodologies from which some rationales for EP&R action optimization will be derived.

LD-SAFE
Validate the laser cutting technology for the dismantling of the most challenging components of power nuclear reactors in air and underwater. Demonstrate that the in-air and underwater laser cutting technologies are a relevant alternative to the conventional techniques used for the segmentation of the power nuclear reactors internals (RVI) and pressure vessels (RPV).

AMHYCO
The main objective of AMHYCO is to propose innovative enhancements on the way combustible gases are managed in case of a severe accident in EU Gen II/III reactors in operation.

SafeG
The global objective of the SafeG project is to further develop the GFR technology and strengthen its safety. The project shall support the development of nuclear low-CO2 electricity and industrial process heat generation technology.

MIMOSA
The global objective of MIMOSA is to develop an accessible, cost/risk optimised multi-recycling strategy of LWR spent fuels in the EU, based primarily on multi-recycling of Pu (and Reprocessed U) in LWRs combined with the Cl MSR, using already available infrastructure in the EU.

SEAKNOT
The global objective of SEAKNOT is to Manage, exploit and assess knowledge in the Severe Accident (SA) field.

TANDEM
The global objective of TANDEM is to address SMR safety issues related to the light-water SMR integration.

iWeld
The global objective of the iWeld project is to transform the practice of ultrasonic inspection of thick welds across several industry sectors, building upon recent advances in the nuclear energy context and the versatility of artificial intelligence.

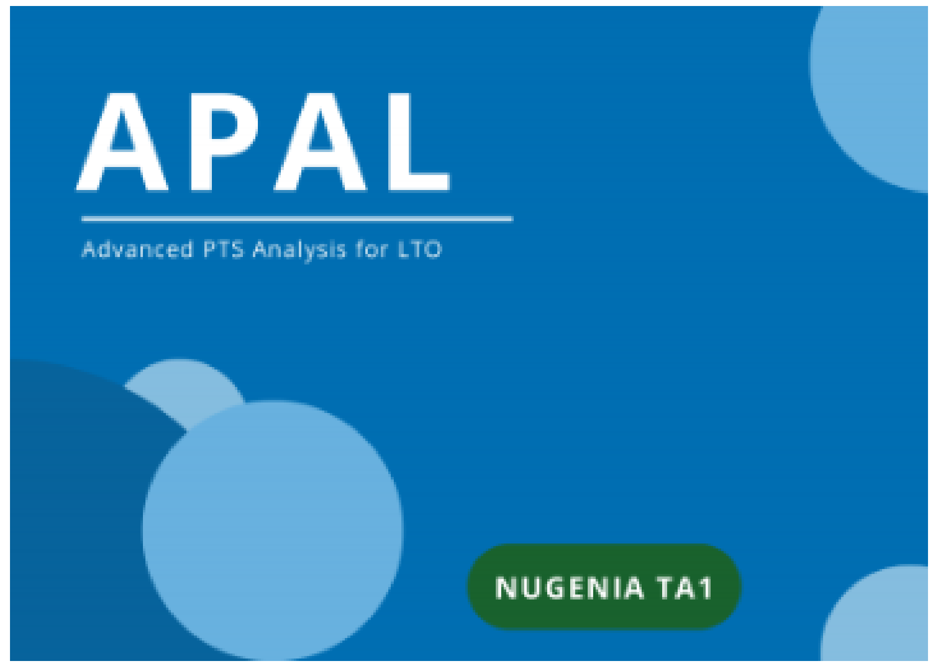
GO-VIKING
The overall objective of GO-VIKING is to increase the expertise and improve the tools and skills of the European nuclear stakeholders for the analysis of complex FIV phenomena.

ASSAS
The main objective of ASSAS is to develop a proof-of-concept for a basic-principles severe accident simulator, that will feature a generic western-type PWR.

MUSA
The overall objective of the Management and Uncertainties of Severe Accident (MUSA) project is to assess the capability of SA codes when modelling reactor and SFP (Spent Fuel Pool) accident scenarios of Gen II and III.

TeaM CABLES
TeaM Cables aims at providing NPP operators with a novel methodology for efficient and reliable NPP cable ageing management.

EU activities – SNETP projects portfolio (examples with details)



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https://www.apal-project.eu/

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https://www.pastels-h2020.eu/

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https://www.safeg.eu/

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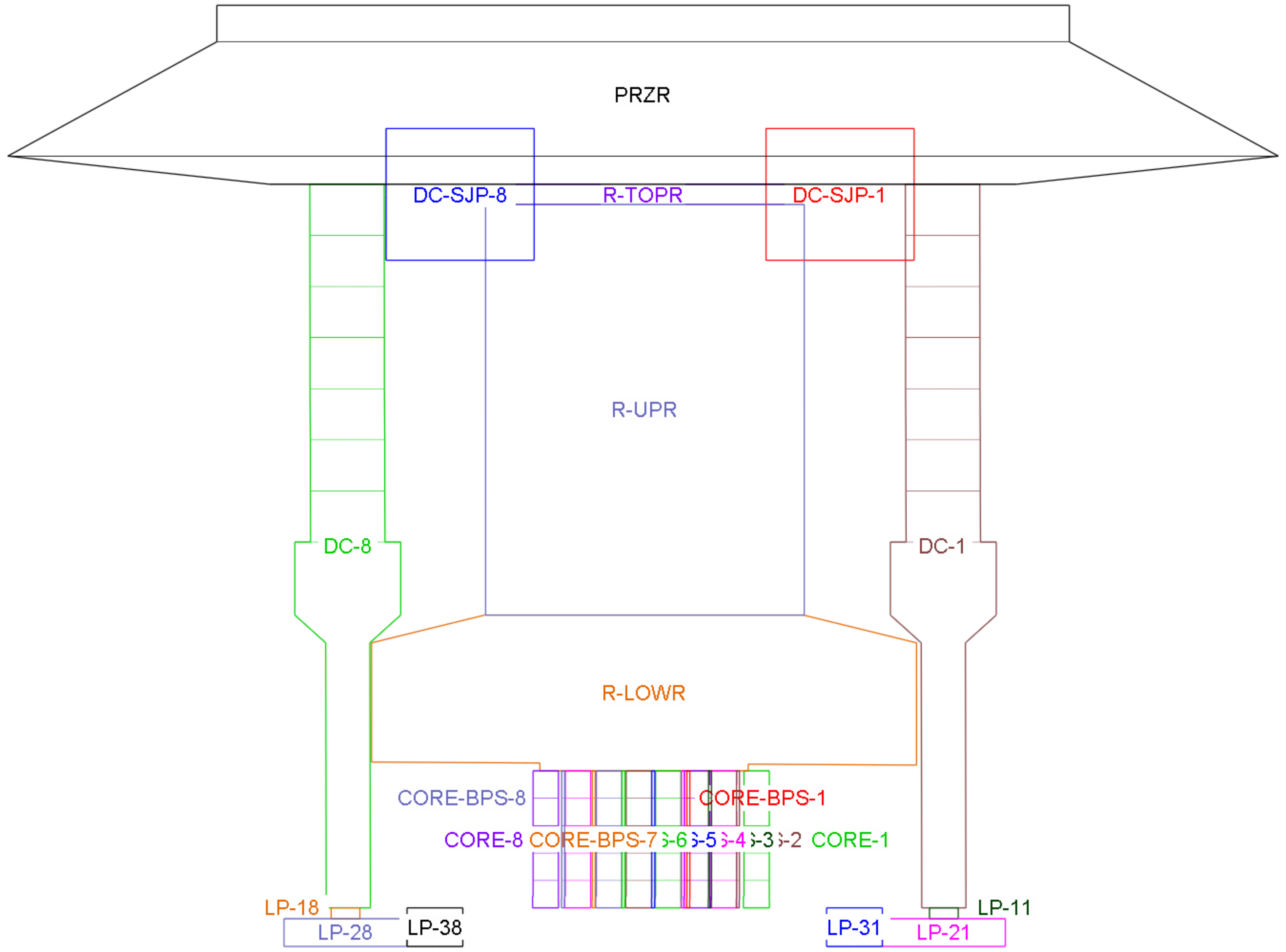
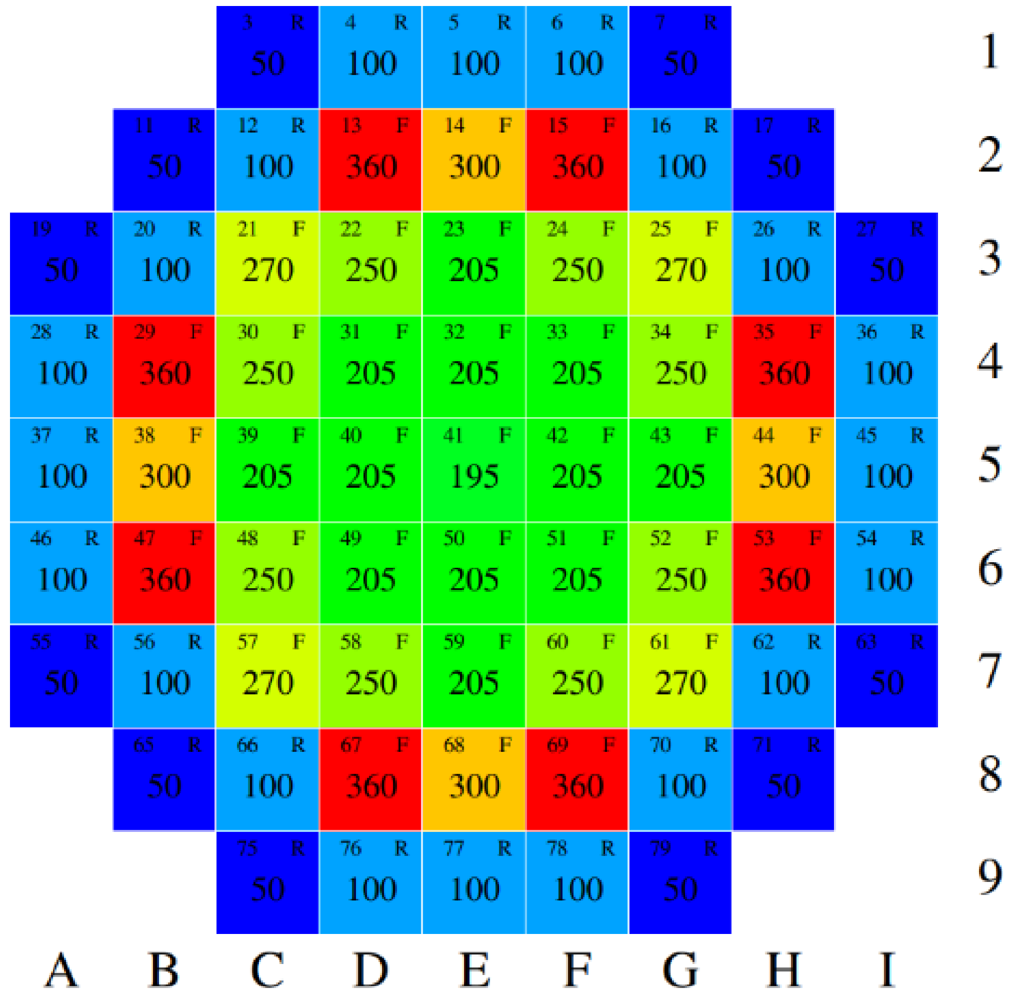
EU activities and projects – example of UJV Rez results

UJV Rez participated currently in more than 10 EU projects. An example from the UJV Rez work in the EU project **McSAFER** is shown below (modelling and analysis of **NuScale** reactor).
https://mcsafer-h2020.eu/

Thermal Hydraulics Model of NuScale for ATHLET:



NuScale core model in DYN3D:



OECD/NEA activities and projects

OECD/NEA activities and projects

Main OECD/NEA activities and tools related to international cooperation in the field of nuclear safety:

- **8 standing committees**
  - The Committee on Safety of Nuclear Installations (CSNI) is the most important for nuclear safety
- **74 working parties and expert groups**
  - Working Group on the Analysis and Management of Accidents (WGAMA)
  - Expert Group on Small Modular Reactors (EGSMR)
  - CSNI Code Validation Matrix (CCVM)
  - International Standard Problems (ISP) and Benchmarks
- **26 international joint projects**
  - HALDEN, PKL1-4, ROSA1-2, ATLAS1-3, THAI1-3, ETHARINUS, RBHT etc.
- **NEA Data Bank**

OECD/NEA activities and projects

Examples of participation of Czech organizations in the OECD/NEA activities:

- ATLAS-3 project
  - Computer codes validation on data from Korean experimental loop ATLAS modelling APR1400
  - https://www.oecd-nea.org/jcms/pl_24812/advanced-thermal-hydraulic-test-loop-for-accident-simulation-atlas-project

- RBHT project
  - Computer codes validation on data from the Penn State University (PWR rod bundle heat transfer)
  - https://www.oecd-nea.org/jcms/pl_25253/rod-bundle-heat-transfer-rbht-project

- Status Report on Best Practice in Safety Analysis of Design Extension Conditions DEC-A

- ISP-51 project
  - Computer codes validation on data from Chinese experimental loop ACME modelling AP-1200

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IAEA activities and projects

IAEA activities and projects

The following IAEA activities and projects are most relevant to int'l cooperation in the area of nuclear safety:

- **IAEA Coordinated Research Projects (CRP's)**
  - Benchmark of Transition from Forced to Natural Circulation Experiment with Heavy Liquid Metal Loop (2022-2026)
  - Fuel Modelling Exercises for Coated Particle Fuel for Advanced Reactors Including Small Modular Reactors
  - Challenges, Gaps and Opportunities for Managing Spent Fuel from Small Modular Reactors
- **IAEA consultation groups preparing Safety Standards**
  - Licensing Process for Nuclear Installations (DS539)
  - Safety demonstration of innovative technology in power reactor design (DS537)
  - Development and Application of Level 2 Probabilistic Safety Assessment for Nuclear Power Plants (DS528)
- **IAEA consultation groups preparing Safety Reports and TECDOC's**
- **IAEA Projects to Strengthen Safety Against External Hazards at Nuclear Installations**
- **IAEA Initiative to Support the Safe and Secure Deployment of SMRs**

US NRC and DOE programmes

US NRC and DOE programmes

The US NRC international programmes devoted to distribution of advanced computer codes have become extremely beneficial for smaller countries operating nuclear power plants (https://www.nrc.gov/about-nrc/regulatory/research/obtainingcodes.html):

1) US NRC Code Application and Maintenance Program (CAMP)

- International program on thermal-hydraulic research and code development activities started in 1980's
- Collaborate on NRC thermal-hydraulic system safety analysis codes and neutronics codes (TRACE, SNAP, PARCS and RELAP5) to promote worldwide reactor safety
- Receive feedback on code strengths and deficiencies from a wider user community (independent assessment)

US NRC and DOE programmes

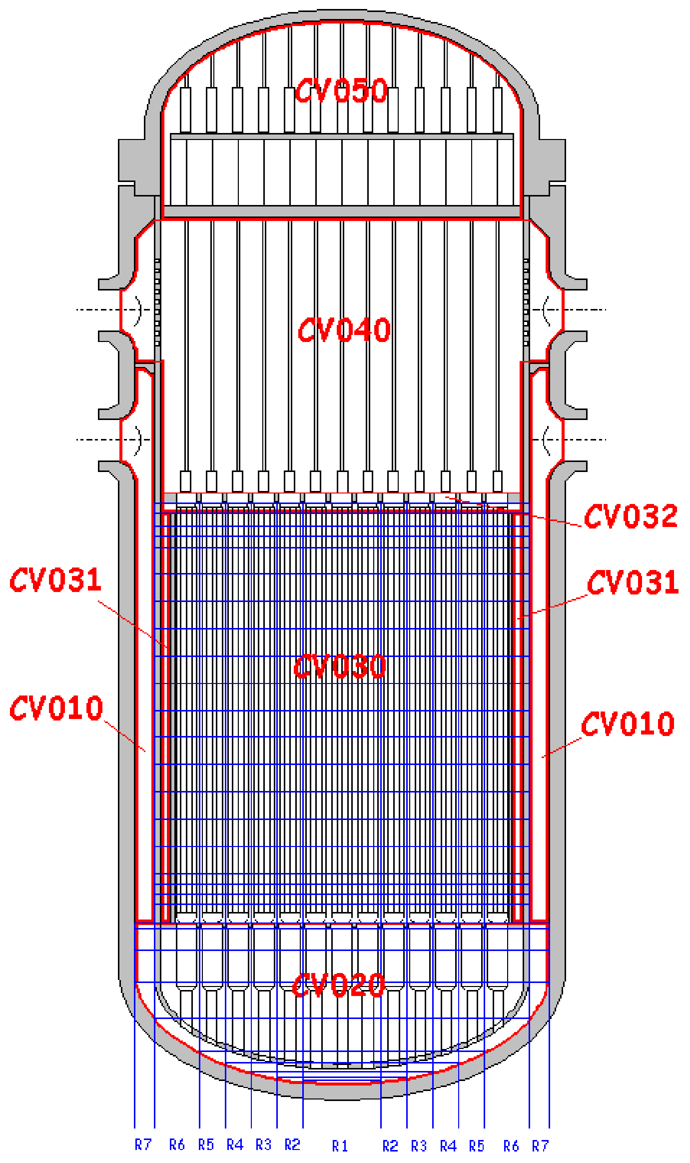
2) US NRC Cooperative Severe Accident Research Program (CSARP)

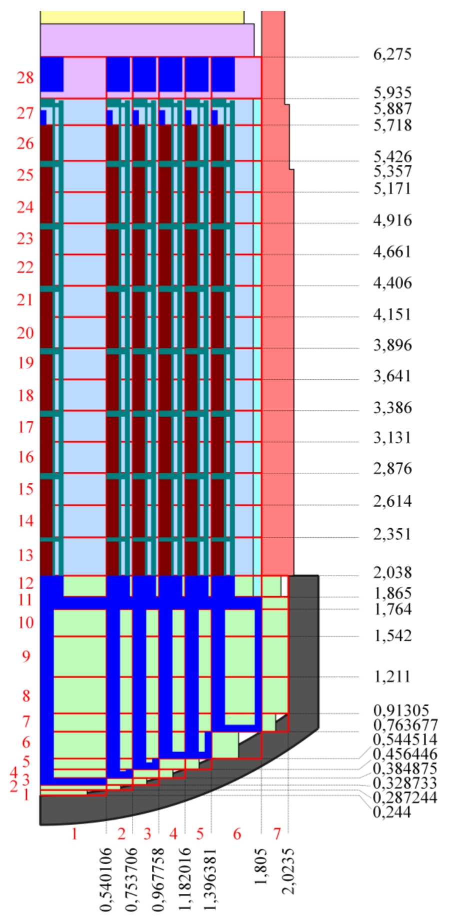
- International program on severe accident phenomenological started in 1988
- Share experiments, analysis and NRC developed analytical codes MELCOR and MACCS

3) Radiation Protection Computer Code Analysis and Maintenance Program (RAMP)

- Development, maintenance, and distribution of the NRC’s suit of radiation protection, dose assessment, and emergency response computer codes (RASCAL, RADTRAD, VARSKIN, GALE, DandD, HABIT, Radiological Toolbox, PiMAL)

Nodalization of VVER-1000 for MELCOR:





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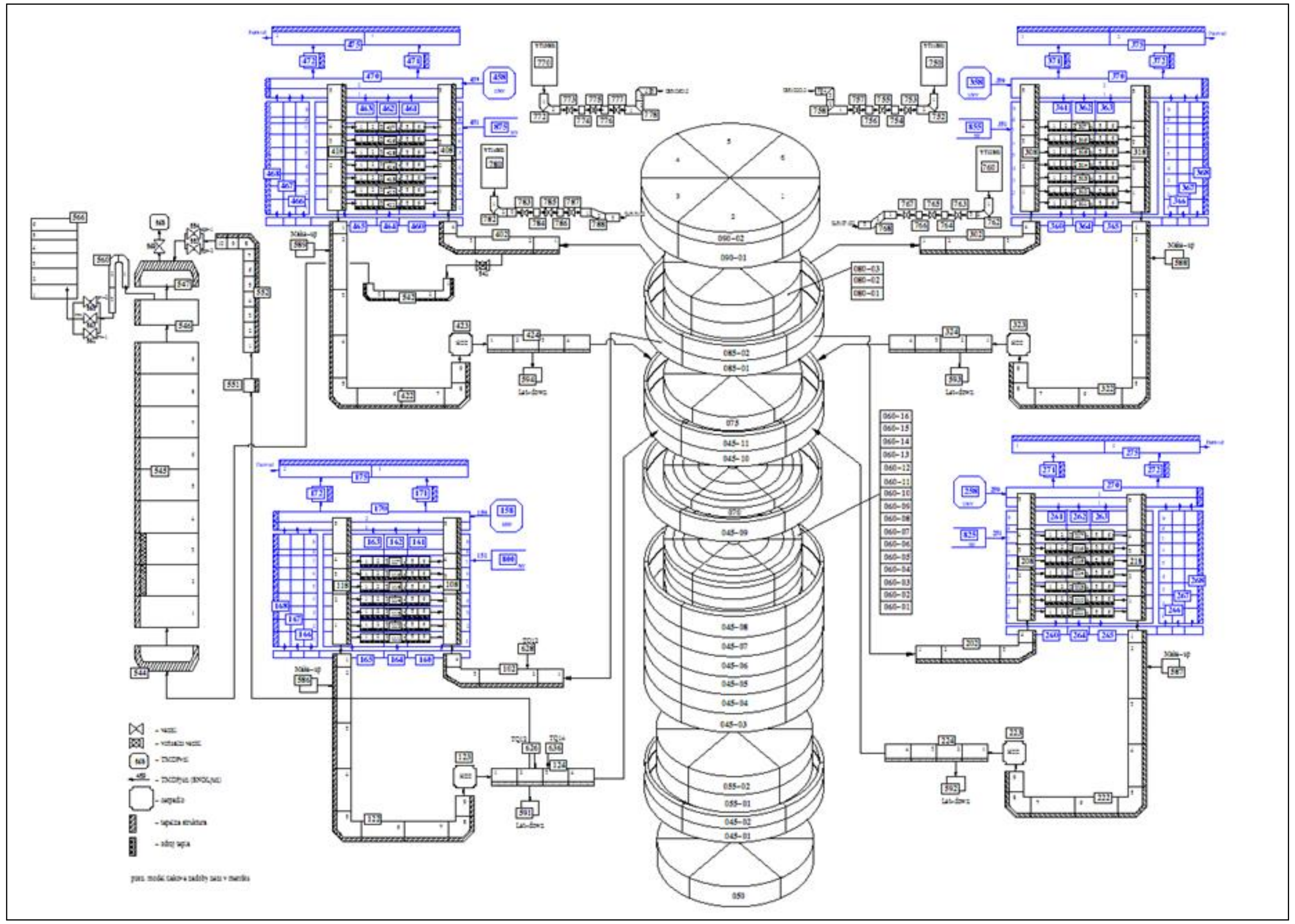
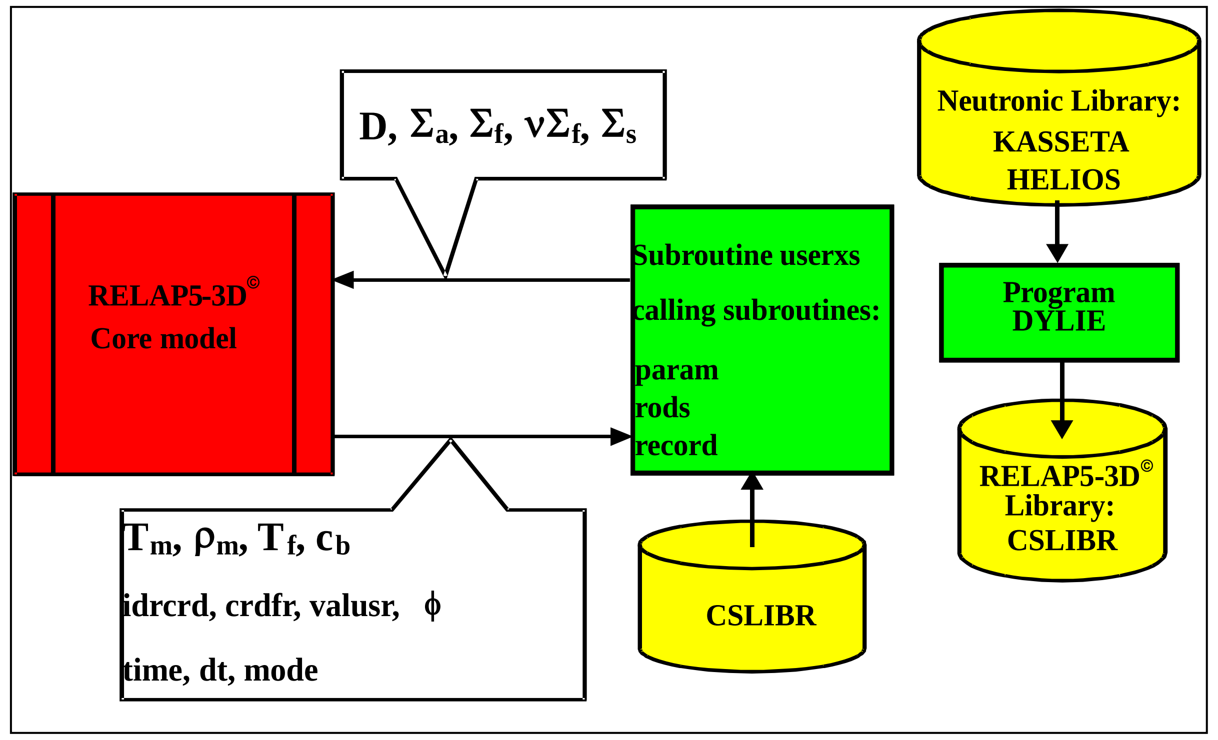
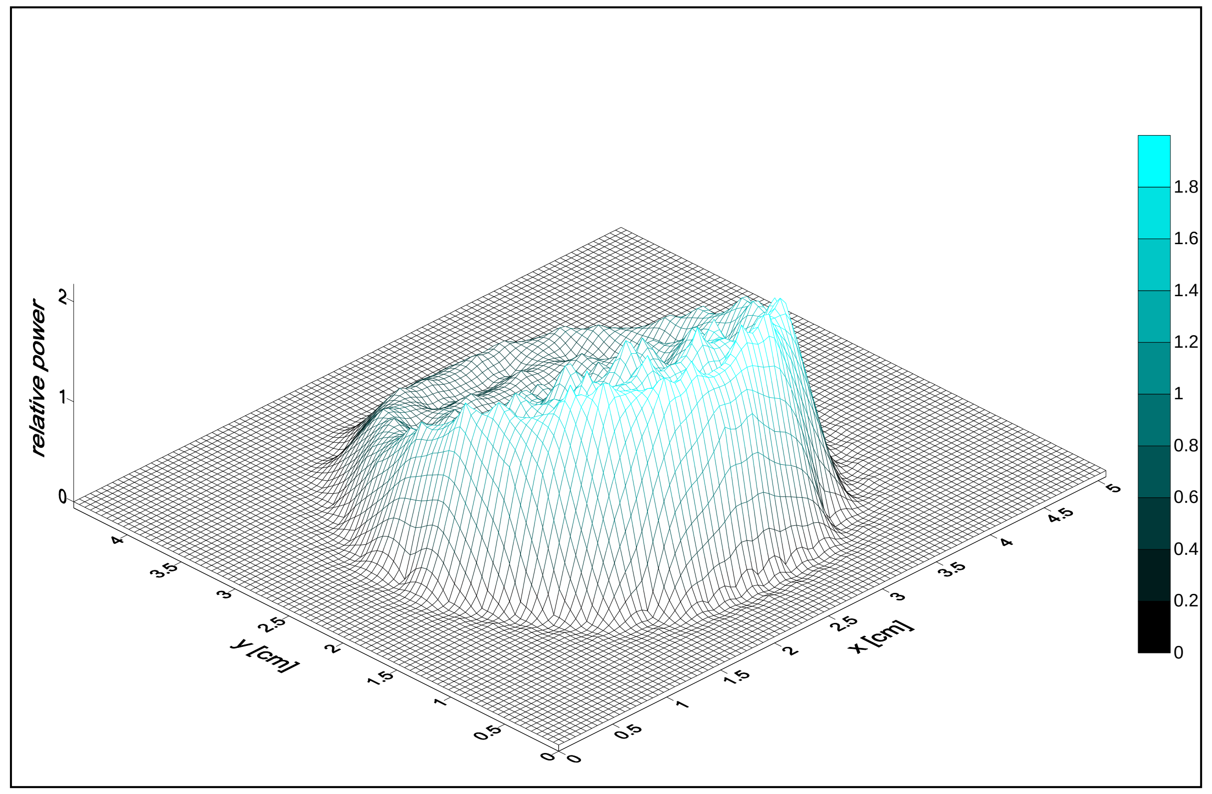
US NRC and DOE programmes

- **US DOE International RELAP User Group (IRUG)**
  - Development, assessment and distribution of advanced 3D thermal-hydraulic and neutronic code RELAP5-3D
  - Example of application of RELAP5-3D to VVER-1000 modelling and analysis:







SUMMARY

- International cooperation in the field of nuclear safety research and development and innovations has traditionally been strong and is growing today
- Active involvement of Czech organizations in the international R&D projects enables effective building of know-how, which is consequently applied in support of existing and planned NPPs
- Key tasks in the area of safety assessment for existing power plants:
  - Support for long-term operation (LTO)
  - Continuous improvement of safety and economic factors
  - Licensing of new fuels and mixed cores
- Key tasks for new builds (big PWR units and LW-SMR):
  - Building know-how for licensing analyses of PWR and LW-SMR
  - Active participation in the preparation of licensing framework for SMR
  - Preparation for independent review of SMR designs

Thank you for your attention

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