The European Nuclear Experimental Educational Platform – ENEEP: Progress, Prospects and Remote Education Capabilities

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Jožef Stefan Institute, Ljubljana, Slovenia

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Introduction

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 847555

Introduction

The ENEEP project

- **2019**: EURATOM project call - Availability and use of research infrastructures for education, training and competence building
- Five EU research organizations apply with the idea of ENEEP:
  - Jožef Stefan Institute - Ljubljana
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- **ENEEP: European Nuclear Experimental Educational Platform**

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Introduction

Our past experience

Long-term experimental nuclear education:

- Four ENEEP partners involved in the ENEN Eugene Wigner course (2003-2008)
- Four ENEEP partners established EERRI initiative (2009-present) - Group Fellowship training programme
- Numerous dedicated courses for:
  - University students & young professionals (EU, USA, other)
  - NPP operators

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Introduction

Our advantages

- Close geographic location in Central Europe
- Good travel connecions
- Shared visa policy (Schengen area)
- Four research reactors:
  - TRIGA reactor / JSI
  - Training reactor VR-1 / CTU
  - TRIGA reactor / TU Wien
  - Training reactor / BME
- Laboratories / STU

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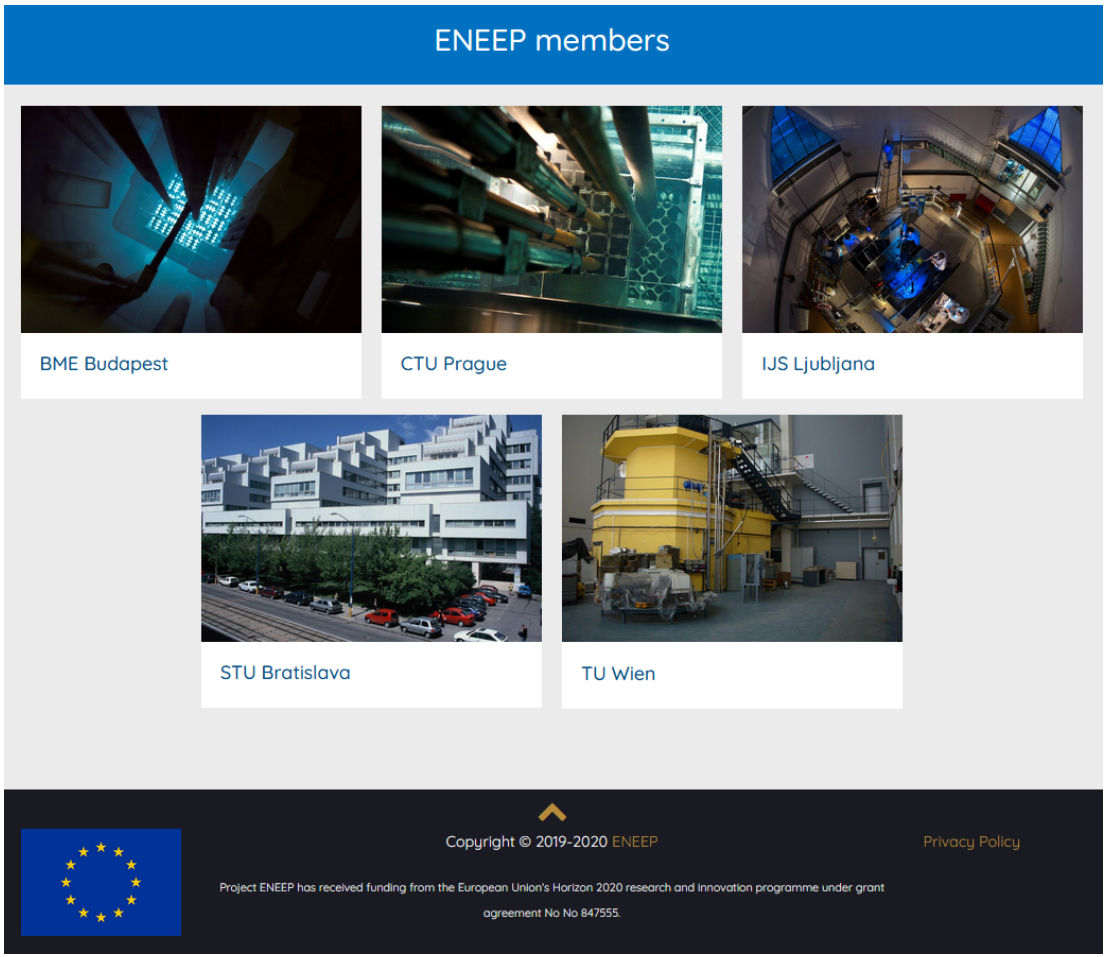
Introduction

Our facilities



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Introduction

Our mission

Our mission is

to fulfill the needs of European users in order to significantly enhance their experimental education and hands-on activities in nuclear curricula, particularly in the field of nuclear safety and radiation protection.

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ENEEP Project structure

Workpackages

- **WP1**: Post-grant requirements
- **WP2**: Consortium coordination & management
- **WP3: Capabilities, users and SWOT analysis of ENEEP**
- **WP4: Establishment of ENEEP**
- **WP5: Demonstration of ENEEP**
- **WP6**: Dissemination and feedback

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ENEEP Project structure

WP3: Capabilities, Users & SWOT Analysis

WP3: foundations for ENEEP

- **Capabilities** - databases on:
  - Facilities
  - Experiments
  - Instruments
- **Potential users** $\rightarrow$ establishing contact, promotion
- **SWOT analysis** $\rightarrow$ directions

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ENEEP Project structure

WP4: ENEEP establishment

WP4: ENEEP legal status, implementation, procedures

- Agreement on structure & legal status of ENEEP → Association, est. in Jan. 2022
- Applications to ENEEP → internal procedure
- Facility access requirements
- Procedures for group activities (based on WP3)
- Shortlist of novel activities
- Implementation workflow
- Facility operation schedule

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ENEEP experiments

eneep.org/experiments

Measurement of the diffusion length and the Fermi age of neutrons

Slovak University of Technology in Bratislava, Exercise STU-02

Main topic: Neutron-physical parameters of moderators

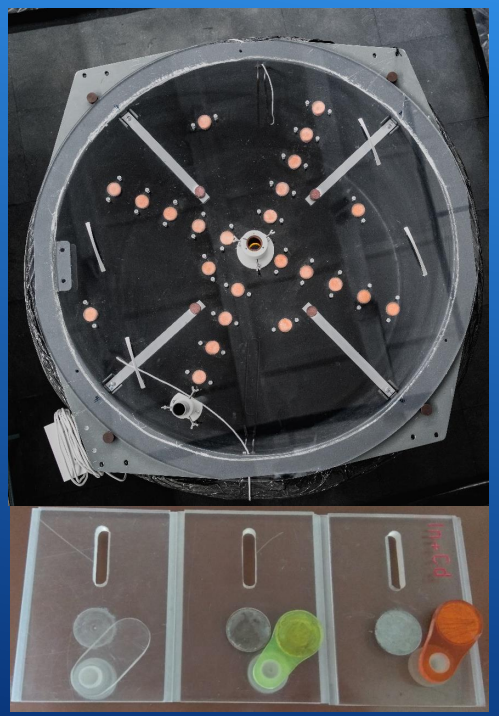
Keywords: Diffusion length, Fermi age, moderator, activation analyses, gamma and neutron measurement, neutron detectors, neutron radionuclide source

Purpose: The experiment demonstrates the fundamentals of neutron moderation and parasitic absorption in one of the most frequently used moderators. Diffusion length and Fermi age are parameters, which are used to categorize moderator materials in terms of their application. Within the measurement of neutron flux distribution in water or graphite the students apply fundamentals of the neutron slowing down and diffusion theory. At the end, students will be able to quantitatively characterize the main parameter of neutron moderators.

Level of exercise:	☐Basic	☒Advanced	☒Complex
Level of education:	☒BSc	☒MSc	☒PhD

What you will learn:
The students will learn how to measure neutron flux and, based on theoretical knowledge, and to determine the basic parameters of neutron moderators.

Important information:
- Minimal size of student group: 2
- Maximal size of student group: 4
- Overall duration of the experiment (in wall clock hours): 6



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ENEEP experiments

eneep.org/experiments

Void coefficient of reactivity

Jožef Stefan Institute, Exercise JSI-05

Jožef Stefan Institute TRIGA REACTOR

Main topic: Reactor Physics

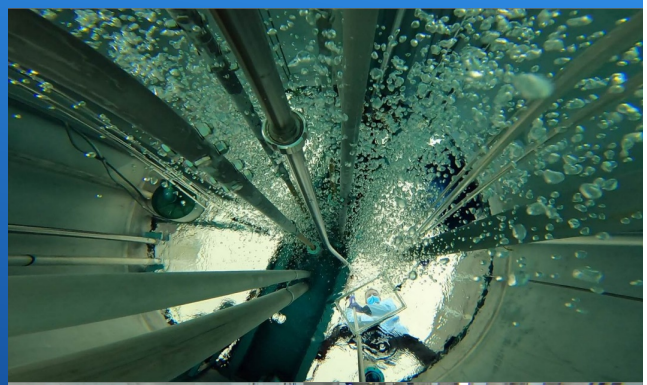
Keywords: Void formation, coolant boiling, void coefficient of reactivity

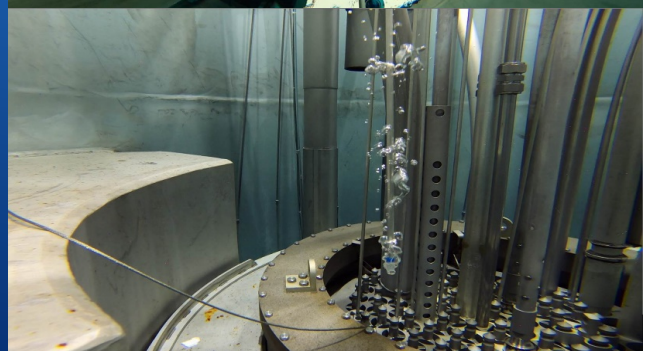
Purpose: The void coefficient of reactivity is one of the most important coefficients of reactivity for safe reactor operation. The JSI TRIGA reactor is equipped with an electro-pneumatic system with which air can be injected into the reactor core to simulate void formation through boiling. The purpose of the experiment is the measurement of the magnitude of the void coefficient as a function of the radial location in the reactor core.

Level of exercise:	☐ Basic	☒ Advanced	☒ Complex
Level of education:	☒ BSc	☒ MSc	☒ PhD

What you will learn:
Students will observe the change in reactivity caused by the presence of air bubbles in the reactor core and understand the magnitude and sign of the reactivity coefficient, depending on the location in the reactor core where air bubbles are injected.

Important information:
- Minimal size of student group: 4
- Maximal size of student group: 12
- Overall duration of the experiment (in wall clock hours): 3-4





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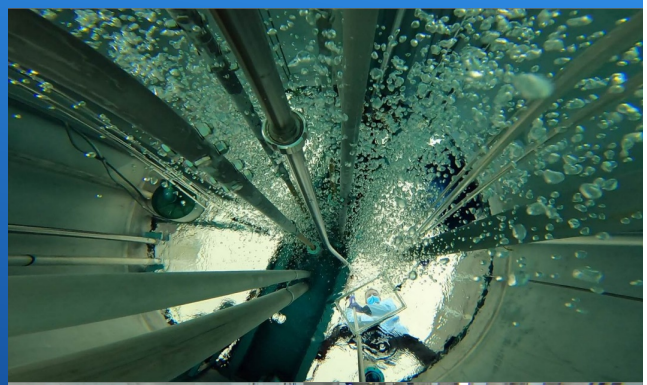

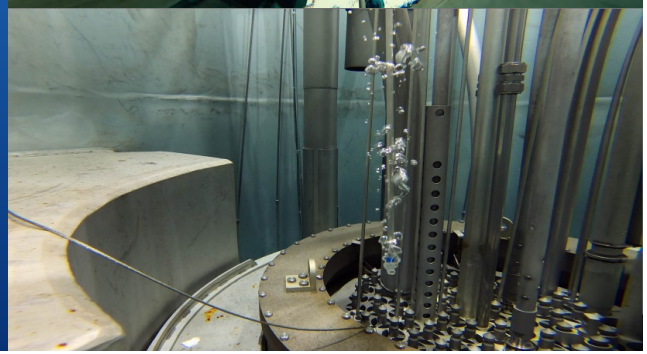

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ENEEP experiments

eneep.org/experiments

Reactivity Values of Fuel Elements

TU Wien, Exercise TUW-06

Main topic: Reactor Physics

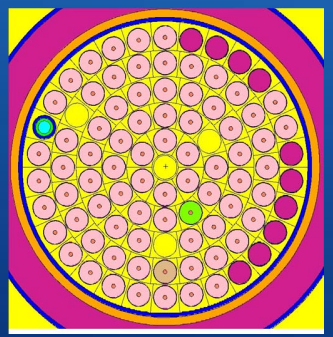
Keywords: fuel elements, reactivity worth, reactivity, reactor core

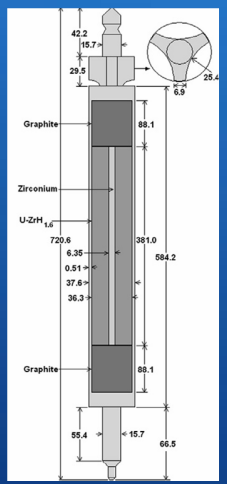
Purpose: This exercise examines the reactivity worth of fuel elements on different positions in the reactor core. A visual representation of reactivity worth may be obtained by plotting the horizontal distance of the fuel element to the core centre against the excess reactivity. The participants will learn the meaning of reactivity worth of fuel elements. They will become familiar with the effect of the horizontal distance of fuel elements on the reactivity of the core.

Level of exercise: ☐Basic ☒Advanced ☐ Complex
Level of education: ☒BSc ☒MSc ☒PhD

What you will learn:
During this experiment the participants will gain an understanding of reactivity worth of fuel elements. They will become familiar with the effect of the horizontal distance of fuel elements on the reactivity of the core.

Important information:
- Minimal size of student group: 4
- Maximal size of student group: 8
- Overall duration of the experiment (in wall clock hours): 3





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ENEEP experiments

eneep.org/experiments

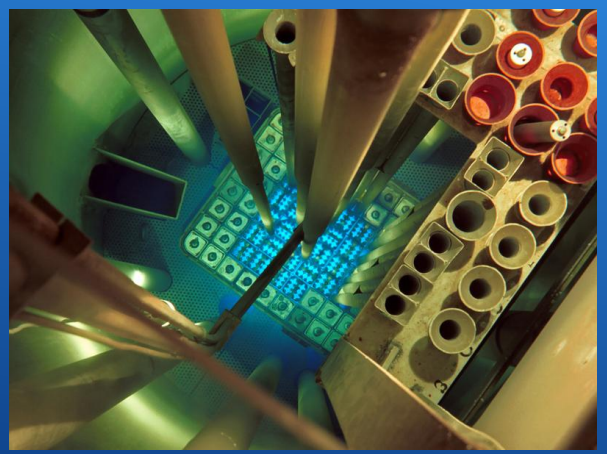
Reactor operation exercise

BME Training Reactor, Exercise BME-07

Main topic: Reactor Physics / Nuclear reactor operation

Keywords: reactor operation, safety of reactors

Purpose: This exercise is aimed at making the students familiar with the structure, operation, nuclear and technological measuring systems and control systems of nuclear reactors. In order to achieve these goals, students first study the characteristics of the control and safety systems and familiarize with the various nuclear and technological measurements. This is followed by the second part of the exercise when the students actually operate the reactor and study the behavior of the reactor and the control and safety systems in reality.



Level of exercise:	☒Basic	☒Advanced	☐Complex
Level of education:	☒BSc	☒MSc	☐PhD

What you will learn:
Students learn how a nuclear reactor is controlled and operated. They also learn how the safety systems intervene in case an error (either human or electronic) occurs. They also obtain information on the systems measuring the technological parameters and their role in the safe operation of the reactor.

Important information:
- Minimal size of student group: 2
- Maximal size of student group: 6
- Overall duration of the experiment (in wall clock hours): 4

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ENEEP Project structure

WP4: ENEEP establishment

WP4: Shortlist of novel activities

- Brainstorming for novel education activities
- Objective: ENEEP up-to-date with scientific development, methods, detectors, etc.
- **Shortlist**: 17 new experiments for implementation
- Examples:
  - Flux redistribution
  - Experiments with D-D & D-T neutron generator
  - Neutron radiography in practice
  - Cherenkov reactor power meter (steady-state & pulse)
  - SiC neutron detectors
  - Fuel element gamma spectrometry

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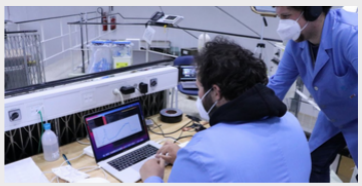
ENEEP Project structure

WP4: ENEEP establishment

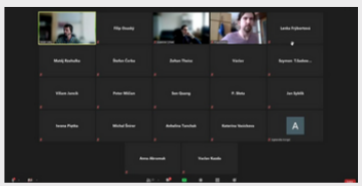
Remote Reactor Physics Exercises for Slovak students at the VR-1 Training Reactor of CTU in Prague

April 26, 2021 • NewsEditor



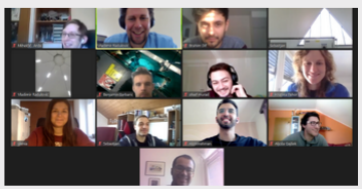
Testing a new exercise at the JSI TRIGA reactor - Cherenkov radiation-based power meter

April 22, 2021 • NewsEditor



V4 Nuclear Training course – Simulation workshop

April 19, 2021 • NewsEditor



Remote experimental reactor physics course at University of Ljubljana, Faculty of Mathematics and Physics

March 5, 2021 • NewsEditor

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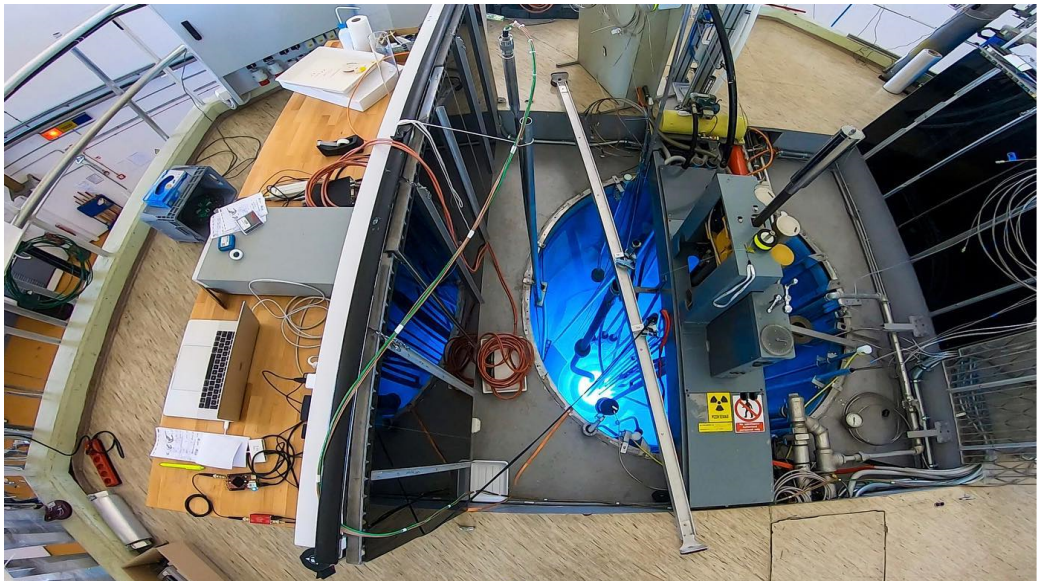
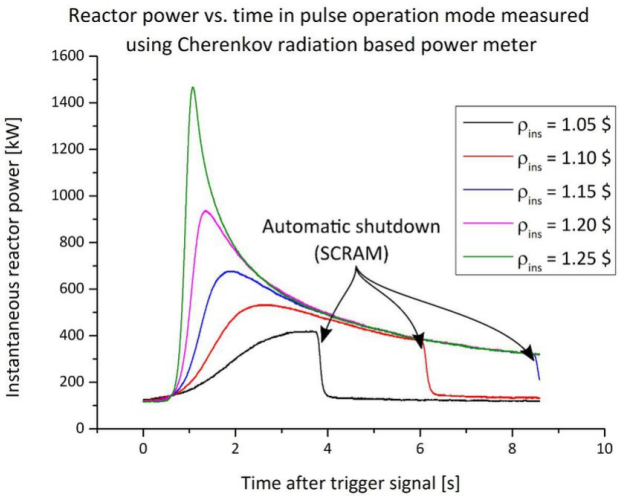
WP4: ENEEP establishment





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ENEEP Project structure

WP5: ENEEP demonstration

WP5: Demonstration of ENEEP capabilities

- 2-week group activities at 2 ENEEP partner facilities (10 participants)
- 1-week group activities at 1 ENEEP partner facility (10 participants)
- Individual activities

Announcement to be made shortly

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Remote capabilities

Motivation

- **Covid-19** $\leftrightarrow$ travel

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Remote capabilities

Motivation

- **Covid-19** $\leftrightarrow$ travel
- But not only:
  - Wider coverage, if travelling is not possible (Univ. budget!)
  - Flexibility
  - Experience - some aspects benefit from remote format

  ENEEP remote capabilities:
  - JSI
  - CTU

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Remote capabilities

JSI case

- Regular courses organized for Uppsala University (in person); September 2020 $\rightarrow$ migration to remote format
  - Muptiple connections in parallel (Zoom), interaction with equipment
- October 2020 - June 2021: 2 $\times$ 1-semester practical exercises at JSI TRIGA reactor for Physics students at University of Ljubljana
  - One Zoom connection, several devices (laptops, tablet)
- July 2021 Contribution to MOBIL-APP virtual mobility (Aix-Marseille University)

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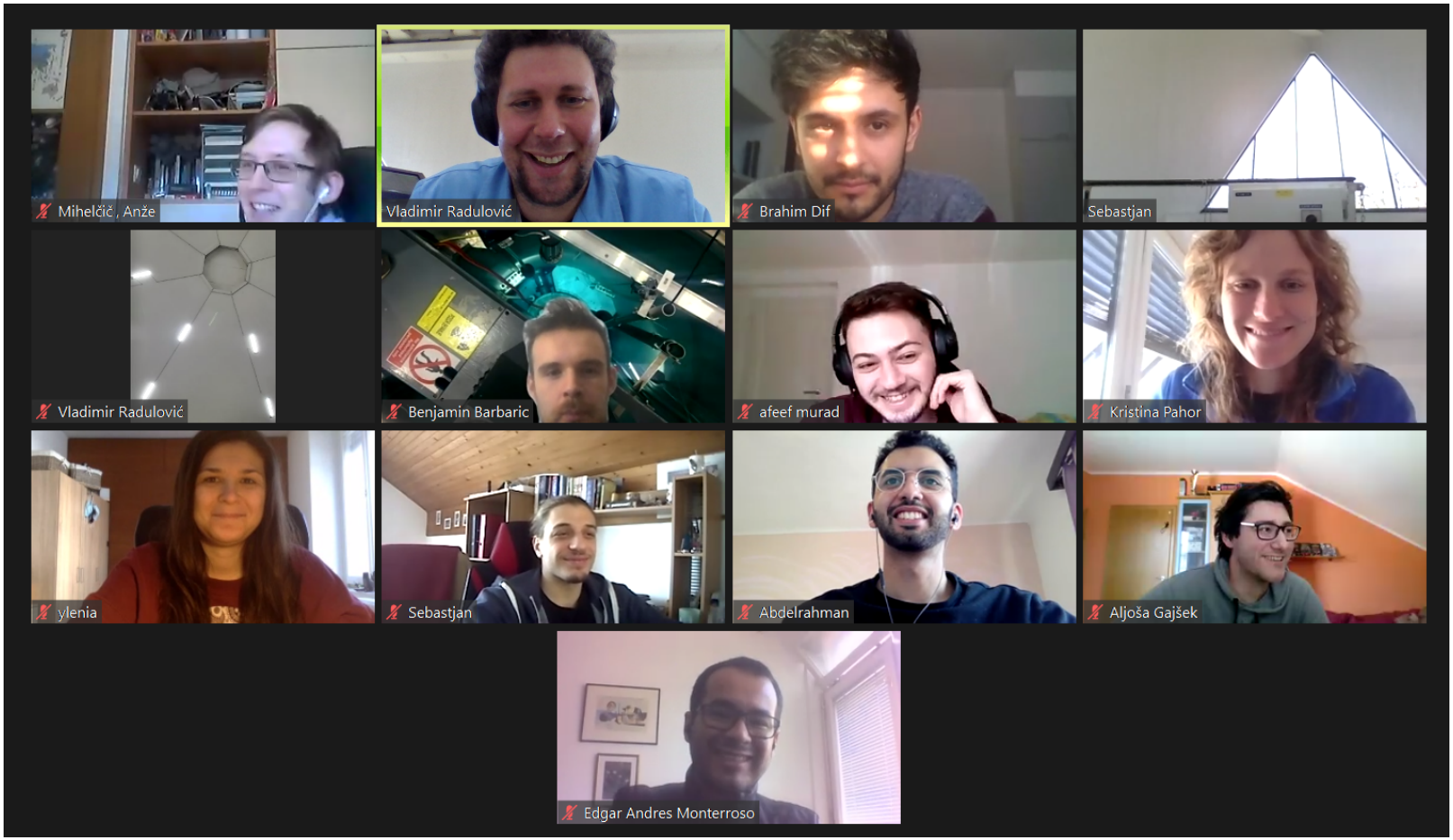
Remote capabilities

JSI case



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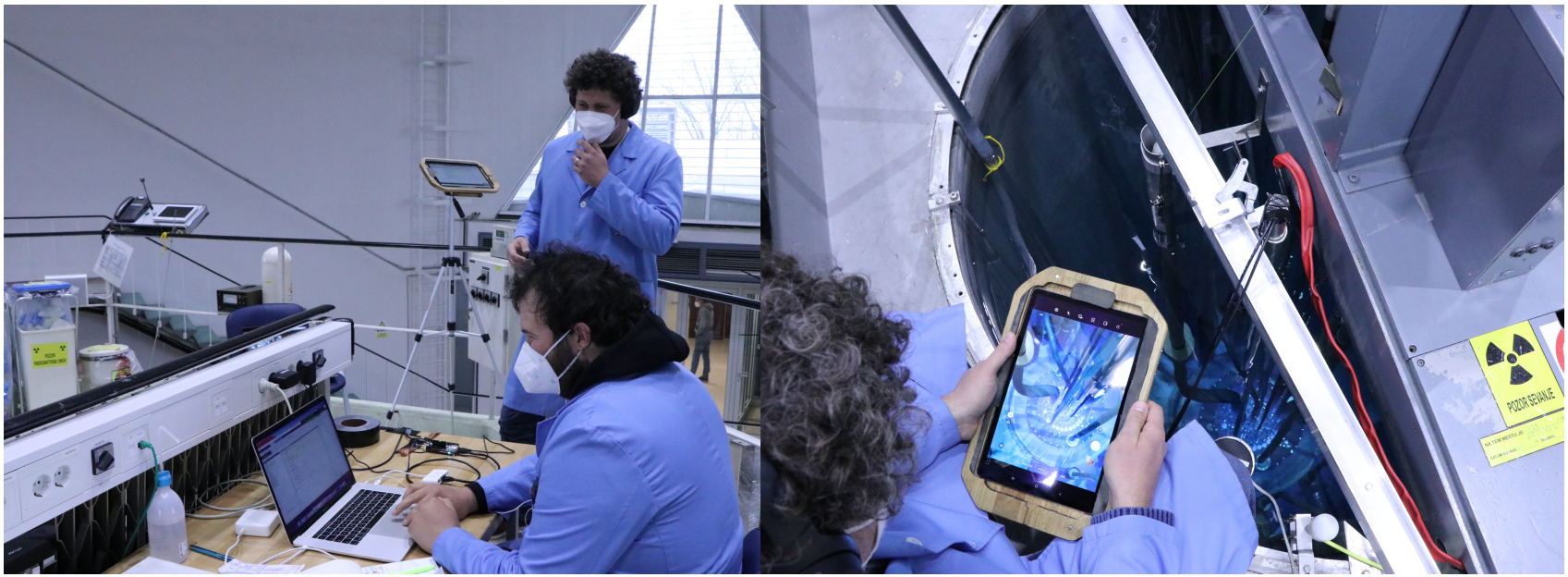
Remote capabilities

JSI case



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Conclusions

- Existing needs for nuclear education
- ENEEP initiative → Dedicated platform providing experimental nuc.ear education
- Several formats, taylorable, group/individual
- Remote capabilities
- **Contact us!**
- eneep.org

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