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The Role of Computer-Based Educational Laboratories in Nuclear Engineering University Programmes

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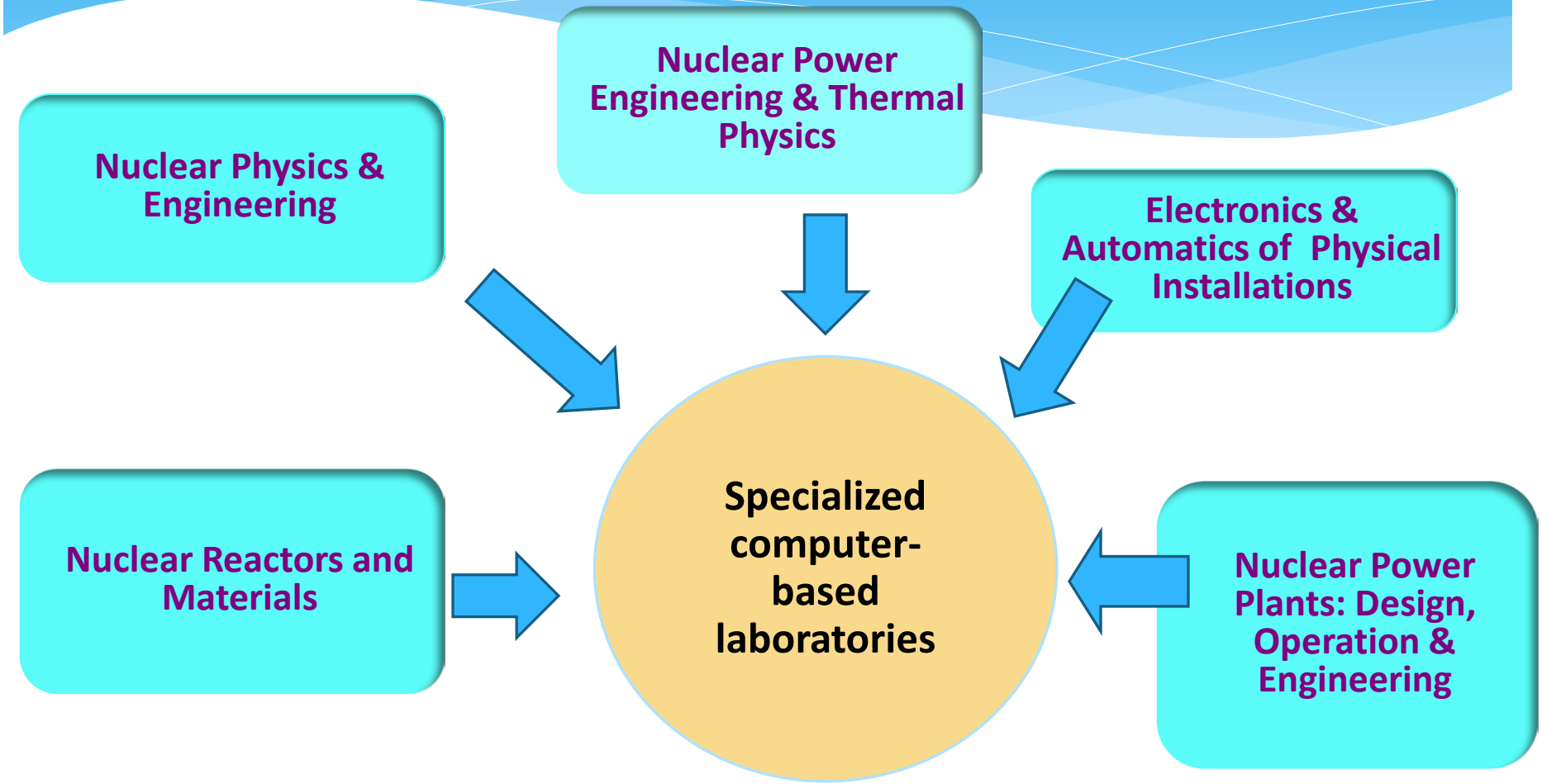
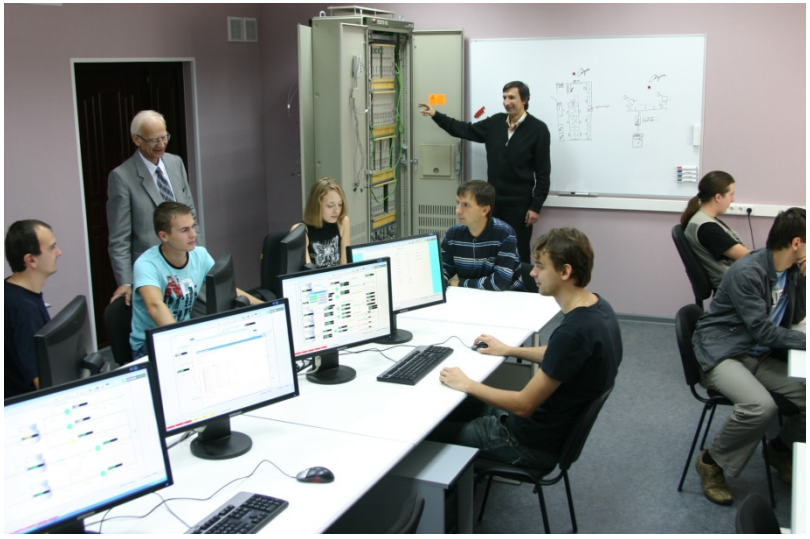
Directions of Educational Programmes on Nuclear Engineering



Background

Educational and other training programmes increasingly rely on modern information technology and the use of a variety of technical training tools, computer simulation systems and training simulators

The modern level of the computer technology**, mathematical methods of simulation and special tools provides a possibility to develop a real time simulation software package that is compact, has a reasonable cost and can be used not only in NPP training simulators, but also in specialized educational laboratories in universities.**



NRNU MEPhI. Educational and research laboratory 'Reactor physics, control and safe operation of WWER type NPP'

The specialized Educational and research laboratory 'Reactor physics, control and safe operation of WWER type NPP' is based on the computer simulator of WWER -1000 and offers the real-time monitoring of data available to the WWER -1000 NPP control room operators, and provides a possibility to investigate reactor behavior in normal and abnormal situations.

The laboratory supports interactive technologies and team-based activities that enable students to build their knowledge through required gateway courses and explore problems relevant to real life situations.

NRNU MEPhI. Educational and research laboratory 'Reactor physics, control and safe operation of WWER type NPP'

General learning objectives of the lab training

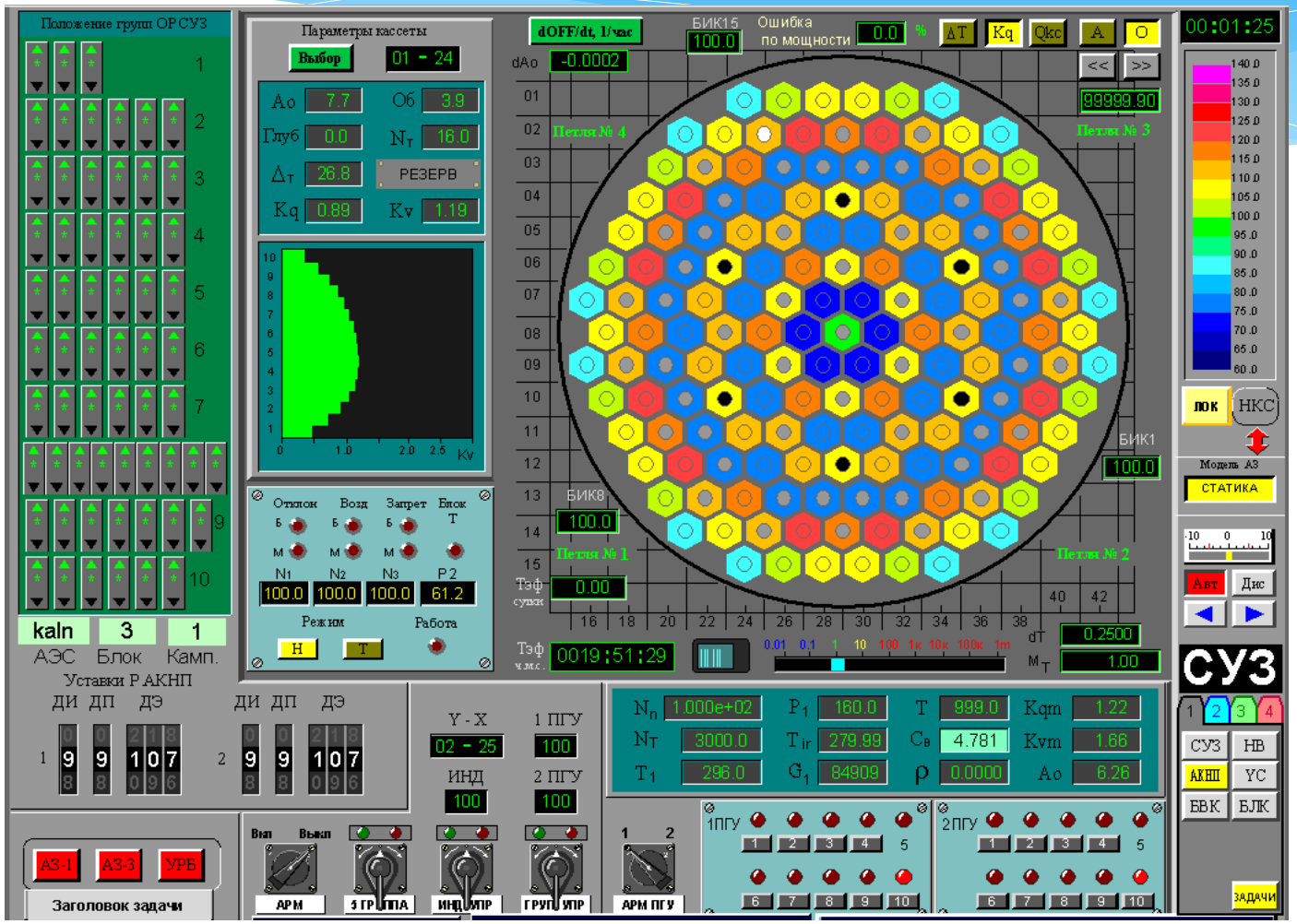
- Mastering theoretical knowledge on the reactor core and NPP equipment, technological systems of NPP, neutron physical and technological processes in NPP equipment, operation conditions and safe operation rules, control and protection systems structure, NPP control algorithms

- Mastering WWER-1000 (1200) NPP control principles under standard operation conditions and nonstandard ones which help to suppress xenon oscillation of local power in the reactor core if it arises, to form different fuel loadings depending on different strategies of the fuel cycle, define neutron physical parameters of the core

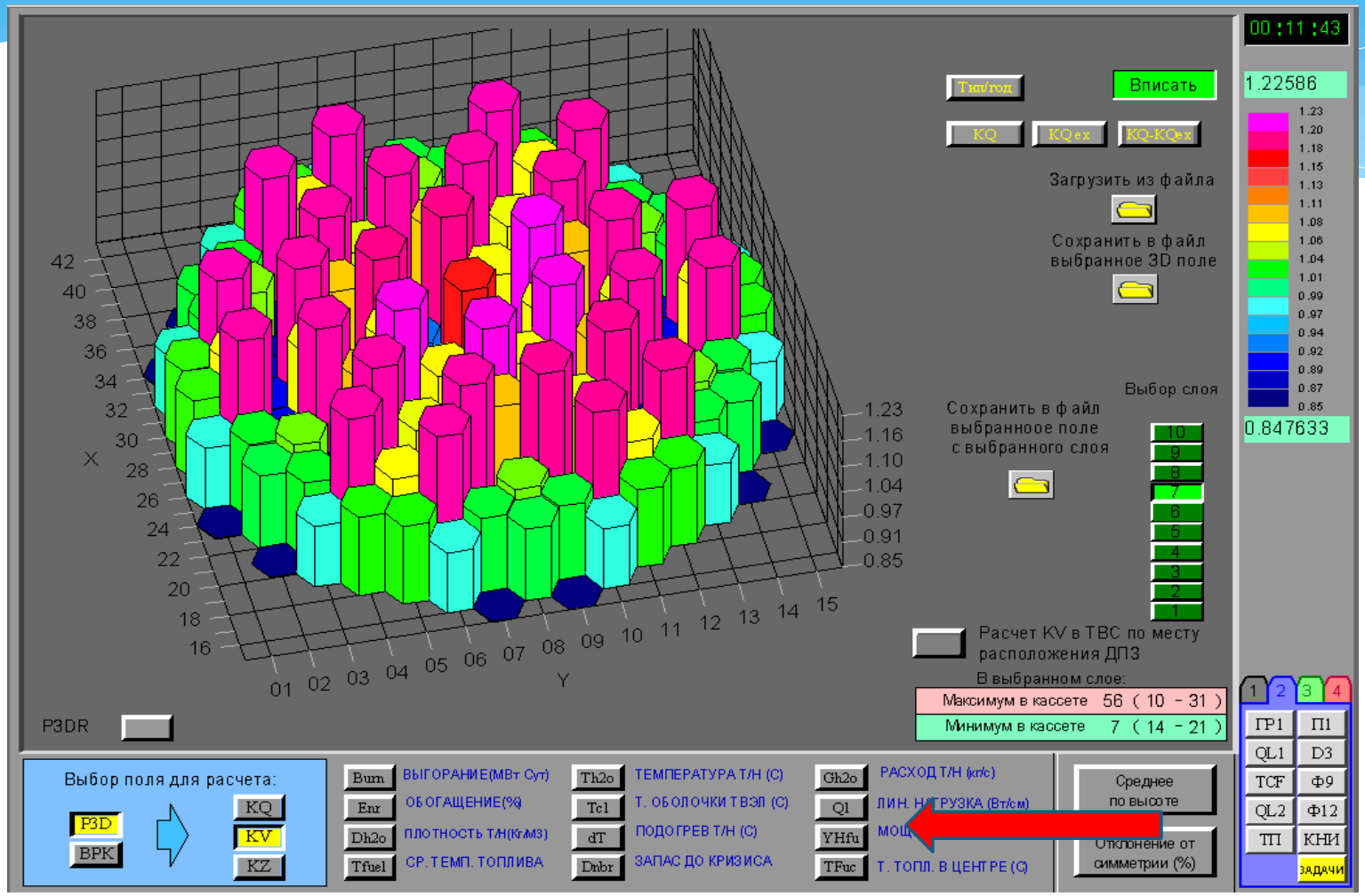
Main topics of the practical sessions

- **Static and Dynamic characteristics of the reactor as an object of control**
- **Reactor Power Control**
- **Control and Protection Systems of the Reactor**
- **Automatic Reactor Power Controller**
- **Operation Conditions with Irregularities in Operation**
- **Startup Regimes of the Reactor Facility**
- **Spatial Instability of the Neutron Field**
- **Neutron characteristics of control rods**
- **Determination of Reactivity Coefficients in Calculations and Experiments**
- **Reactor re-criticality**
- **Fuel Cycle of the Reactor Facility**

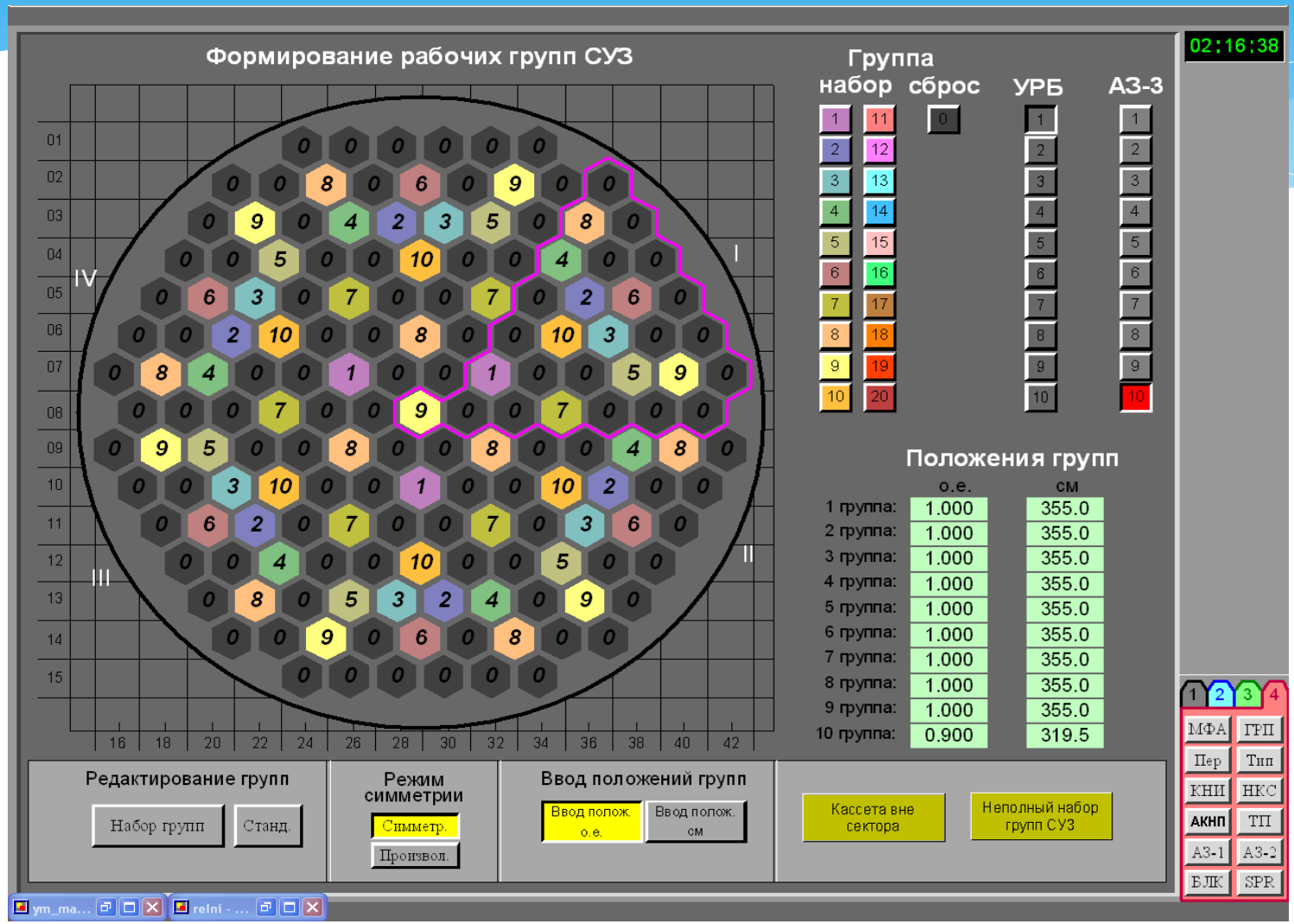
Main screen format. WWER-1000 reactor core



Screen format. WWER reactor core 3D diagram



Screen format. Control rods location and CR banks configuration



Scope of simulation

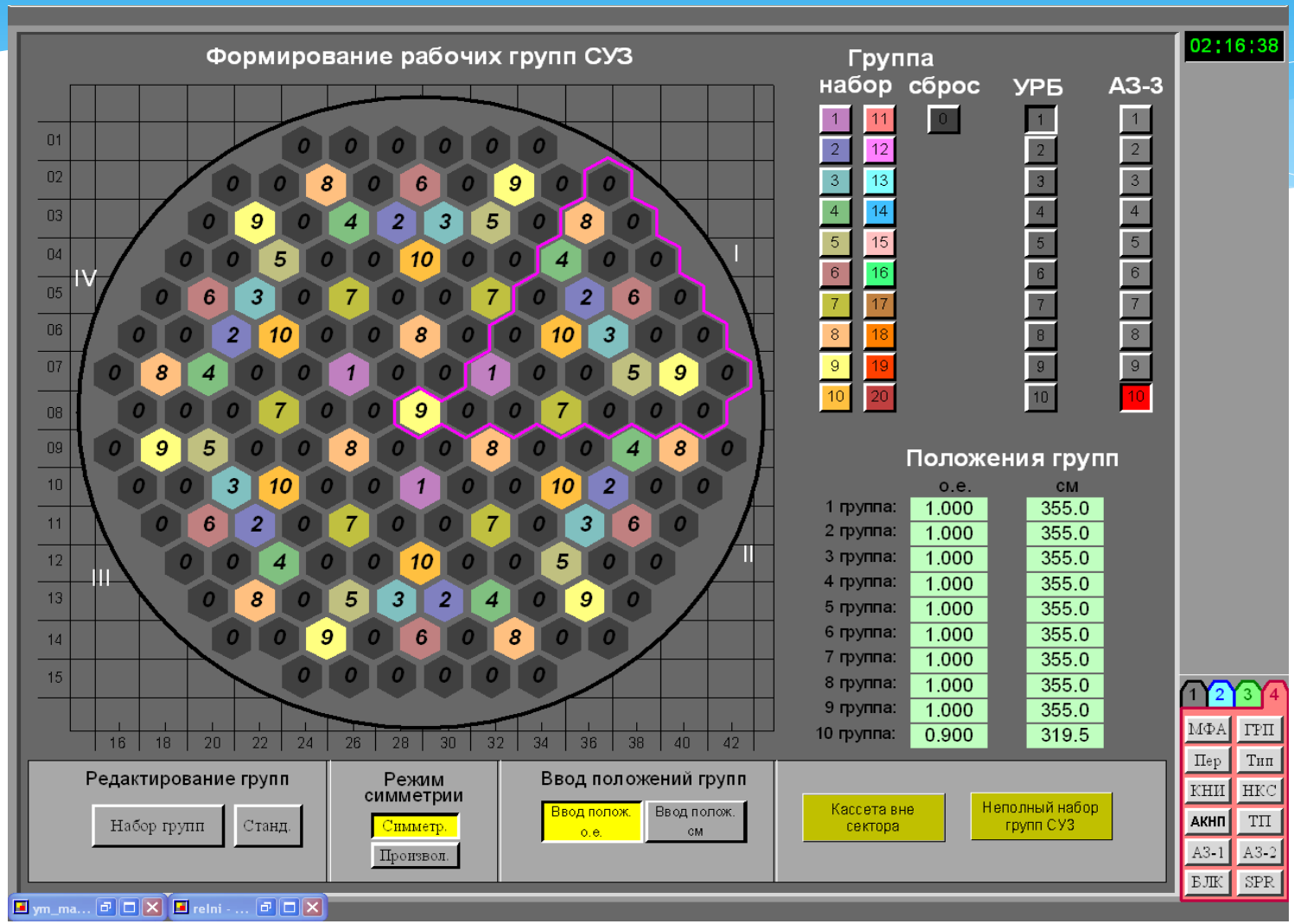
NPP equipment

- Reactor and primary circuit
- Control rod and boron regulation and protection systems
- In-core and ex-core instrumentation systems

Simulated physical phenomena in reactor core

- Transients on prompt and delayed neutrons
- Xenon transients coursed by changes of reactor power level
- Xenon radial and axial power distribution oscillations
- Samarium poisoning
- Fuel burn up (without core refueling)
- Residual heat

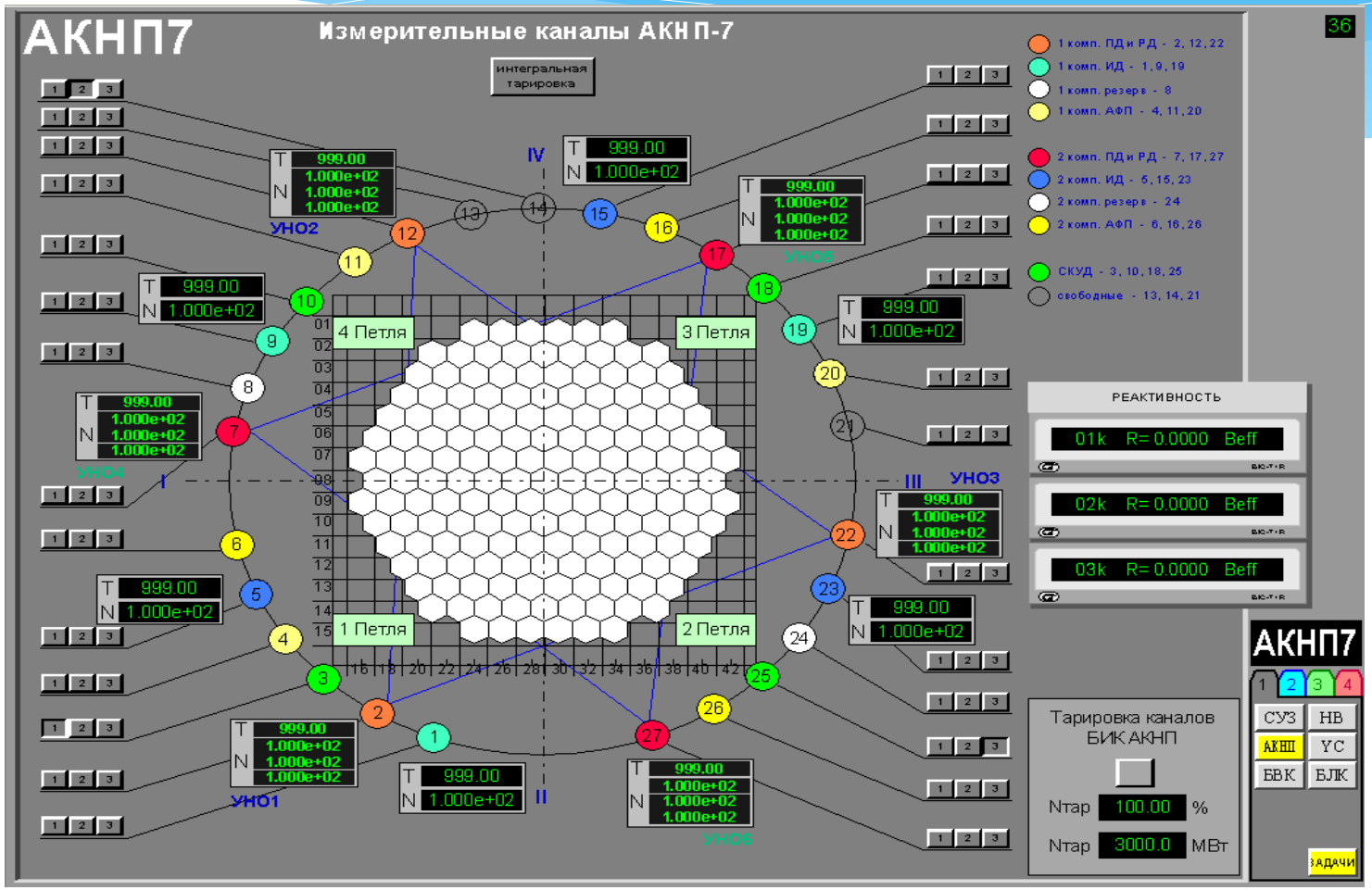
Screen format. Control rods location and CR banks configuration



Reactor core computational features

- Statics and dynamics reactor core computational modes
- Boron regulator to find a critical boron concentration for an arbitrary core state
- Reactor core model easy connection or disconnection from the primary circuit model (boundary conditions for core thermal-hydraulics model)
- Ex-core instrumentation model allows to reproduce directly real plant measurements

Screen format. Ex-core instrumentation model



Introduction of the laboratory in university educational programmes

The laboratory ‘Reactor physics, control and safe operation of NPP' has been intensively used to implement educational and research programmes of MEPhI
In 2011-2013 under the IAEA TC programme similar laboratories were successfully implemented at technical universities of Armenia, Belarus and Ukraine.

* **STATE ENGINEERING UNIVERSITY OF ARMENIA ("POLYTECHNIC")**

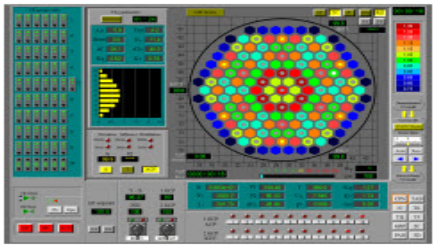
Introduction of the laboratory in university educational programmes

Belorussian State University

Belorussian State University of Informatics and Radio electronics

Division of Nuclear Power
- Nuclear Power Engineering
- Nuclear Power Technology Development
- INPRO
- Infrastructure
- Meetings
- Publications
- Information Systems & Databases

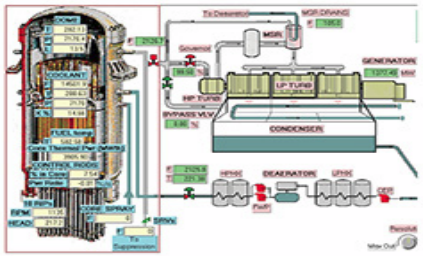
IAEA Collection of PC-Based Simulators for Education



The International Atomic Energy Agency (IAEA) has established a programme in nuclear reactor simulation computer programs to assist Member States in education and training. The objective is to provide, for a variety of advanced water-cooled reactor types, insight and practice in their operational characteristics and their response to perturbations and accident situations. To achieve this, the IAEA arranges for the supply or development of simulation programs and training material, sponsors training courses and workshops, and distributes documentation and computer programs.

Currently the IAEA has simulation programs available for distribution that simulate the behaviour of the following reactor types:

- Conventional Boiling Water Reactor (BWR)
- Passive BWR
- Conventional Pressurized Heavy Water Reactor (PHWR): Introduction to CANDU and CANDU 9 Manual
- Advanced PHWR
- Conventional Pressurized Water Reactor (PWR)
- Passive PWR
- Russian-type PWR: WWER-1000



These desktop simulator codes provide insight and understanding of the designs as well as a clear understanding of the operational characteristics of the various reactor types. The simulators operate on personal computers and are provided for a broad audience of technical and non-technical personnel as an introductory educational tool. The preferred audience, however, are faculty members interested in developing nuclear engineering courses with the support of these very effective hands-on educational tools. The application of the simulator programs is limited to providing general response characteristics of selected types of power reactor systems and they are not intended to be used for plant-specific purposes such as design,

Implementation of Computer-Based Educational Laboratories in Nuclear Engineering University Programmes

- On November 2013 The National Research Nuclear University MEPhI in cooperation with The International Atomic Energy Agency has hold the Regional workshop on «The role of computer-based educational laboratories in Nuclear Engineering University Programs», which was directed to improve university programs for nuclear engineering education using implementation of modern training technologies based on computer simulating systems and virtual laboratories.
- This year the university is planning to organize the second regional workshop on this topic. The main objective - to share hands-on experience in implementing modern simulation technologies to nuclear engineering education and training in order to improve Nuclear Engineering Educational Programmes. A special attention will be paid to use of special educational means to conduct practical training on Bachelor's and master's levels

Thank you for your attention!

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