„Eugene Wigner" Course for Reactor Physics Experiments 2009

General

To continue the tradition of the previous years, and to fully utilise the benefits of international co-operation and to promote the knowledge in nuclear engineering a ***21 day course*** is being organised **starting at 2 September 2009**.

The language of the course is English. The main emphasis of the course is to ***perform reactor physics experiments*** on three different research- and training reactors in three different cities (Budapest, Prague and Vienna). The experimental work is preceded by theoretical lectures aiming to prepare the participants for the experiments (Bratislava), and realise a visit of NPP V1 as well as Radwaste treatment centre in Jaslovské Bohunice. The participants' work will be evaluated, and upon success the participants will get a certificate. If the participant is a graduate or PhD student of a European university, she/he may get credits to acknowledge the successful completion of this course. The students' home university determines finally the accepted credit (ECTS) value. The ENEN-recommended value is ***6 ECTS***. The detailed description of the course is given below.

The Quality Assurance Committee of the European Nuclear Education Network (ENEN) Association has recommended this course to the ENEN General Assembly to entitle with the quality label "International ENEN Exchange Course", which means that the quality control of the ENEN Association assures that the acquired knowledge of the participants will fulfil the requirements of the European Nuclear Education and fits in the ECTS system.

Participation

The course is open to the following categories of persons:

- Undergraduate, graduate and PhD students;
- Young professionals working in different nuclear installations.

Basic knowledge of reactor physics theory is requested. This knowledge has to be attested by a professor of the student's home university or by a professional leading person in the nuclear installation where the participant is working in.

The number of participants is limited to 10. The application is subject of a selection procedure, and may be refused, if the course is already fully booked, or if the selection committee decides so, due to any reason.

The application deadline is ***31st of May 2009*** (via email). The selection will be made till *15th of June 2009*. Each applicant will be informed about his/her acceptance and about the details of the payment (see below). The deadline for the payment is ***1st July 2009***.

The candidates should fill in the Application Form (Appendix I), provide the necessary attachments, and send via email them to the following address:

Dr. Ján Haščík, Department of Nuclear Physics and Technology
Slovak University of Technology in Bratislava
Ilkovičova 3; 812 19 Bratislava; Slovakia.
Phone: +421-2-602-91-289; *Fax*: +421-2-654-27-207; e-*mail*: jan.hascik@stuba.sk.

Cost of the course:

The fee of the 21 day course is **€ 2 500.** According to the ENEN Association policy students of ENEN member universities get a reduction **€ 500.**

PAYMENT DETAILS
Bank name: Poštová banka, a.s.
Bank address: Prievozská 2/B, 824 64 Bratislava 26, Slovakia
Account name: Slovenská spektroskopická spoločnosť
Account number: 0020096353
IBAN: SK31 6500 0000 0000 2009 6353
BIC/SWIFT: POBNSKBA
Payment description: EWC 2009 - first name, family name
Deadline for payment of the EWC 2009 participation fee is **July 1, 2009**. Bank transfer commission fees should be covered by participant. Please do not forget to fill in "**Payment description**", that allows your payment to be traced.

The cost of the course includes:

- the tuition fee (lectures, laboratory exercises)
- utilization of 3 research reactors;
- participation at a technical tour to a NPP and radwaste treatment centre;
- the textbooks;
- the welcome dinner;
- the farewell dinner.

Not included are:

a)

- the accommodation during the course;
- the transport tickets between the four countries during the course;
- the transport tickets inside the cities from the accommodation place to the experimental facilities and back;

b)

- the travel to the "starting place" (Bratislava, Slovak Republic) and back to his/her home country (from Prague, Czech Republic);
- the cost of the meals (with the exception of the welcome and farewell dinner);
- personal insurances;
- visa (if necessary).

For arranging the not-included items there are two different options:

1. All additional costs (accommodation, travel, meals etc.) during the course can be arranged and paid ***individually*** by the participants. The organisers are ready to assist in finding and reserving accommodation at moderate price in the different cities when required timely in advance.
2. A "package" is offered for **€ 1500,** which includes accommodation cost (about ***€ 55/night*** comfort level), transport tickets between the four countries *during* the course and transfer costs inside the cities (category "***a***" in the list above). The organisers will arrange the reservations and payment of the accommodation and of the travel tickets for the participants choosing this option. This is a cheap and simple solution. However, this still does not include category "***b***", i.e. meals, personal insurances, visa (if necessary at all). These latter should be paid and arranged individually in any case.

Important note: The organizers of the course do not accept liability for the payment of any cost or compensation that may arise from damage to or loss of personal property, or from illness, injury, disability or death of a participant while he/she is travelling to and from or attending the course. The participants are **well advised to take insurance** against these risks.

DETAILED DESCRIPTION OF THE COURSE

1. Overall time-table

The participants work and travel together. On the first week they follow the preparatory theoretical courses in Bratislava, and a visit to an operating NPP and radioactive waste treatment centre nearby. Following this introductory period, they travel first to Budapest, then to Vienna and finally to Prague, and perform the reactor-experiments. The experiments will be performed in smaller groups. At the end there will be a one-day evaluation session (“examination”) in Prague. The following table shows the timetable summarised:

September 2 – 22, 2009 (21 day)

day	*date*	*Place*	*date*	*place*	*date*	*place*
Wed	2.9.	arrival + free day	9.9.	Budapest	16.9.	travel
Thu	3.9.	Bratislava	10.9.	self study + travel	17.9.	Prague
Fri	4.9.	NPP J. Bohunice	11.9.	Vienna	18.9.	Prague
Sat	5.9.	Bratislava	12.9.	self study	19.9.	Prague
Sun	6.9.	travel + free day	13.9.	free day	20.9.	Prague, self study
Mon	7.9.	Budapest	14.9.	Vienna	21.9.	Prague, evaluation + free day
Tue	8.9.	Budapest	15.9.	Vienna	22.9.	Prague, departure

2. The theoretical courses:

The theoretical lectures will be held in the lecture halls and laboratories of the Slovak University of Technology, Ilkovicova 3, Bratislava, (Slovak Republic).

2.1 Nuclear Safety

(2 hours lecture, Prof. Dr. V. Slugen [Bratislava])

- General information about nuclear safety
- Defence in depth (accident prevention and mitigation)
- Safety culture
- Legislative rules
- Physical protection
- Safeguards at research reactors
- Application of nuclear safety at research reactors
- Emergency preparedness

2.2 Survey of research reactors and associated systems

(2 hours lecture, Dr. M. Villa [Vienna])

Survey of research reactors' use (overview, reactor utilisation in physics, chemistry, medicine, biology, training purposes and industrial applications)

Selected systems and components

- Fuel elements for research reactors
- Safety and control systems (including control rod and neutron detectors)
- Cooling and ventilation systems
- Experimental facilities

2.3 Instrumentation for nuclear measurements

(2 hours lecture, Prof. Dr. M. Miglierini [Bratislava])

- Principles of detection.
- Gas-filled detectors. Scintillation detectors. Semiconductor detectors.
- Neutron detectors
- Single-channel analyser, multichannel analyser, multiscaler mode

2.4 Data evaluation techniques (related to the practical exercises)

(2 hours lecture, Prof. Dr. Sz. Czifrus [Budapest])

- Principles of parameter estimation
- Maximum likelihood method, the method of least squares, some illustrative examples
- Solution of the least squares equations

- Statistical properties of the estimated parameters (expectation value, standard deviation)
- Confidence intervals
- Goodness of fit tests

2.5 Radiation protection and dosimetry

(2 hours lecture, Dr. R. Hinca [Bratislava])

- Physical and biological dose – definitions, units, interpretations
- Harmful effects of ionizing radiations on human body – deterministic and stochastic effects
- Structure of health physics regulations (laws, decrees, guidelines, standards) for limiting the emission and immission of radioactivity
- Sources of radioactivity in the environment – natural and artificial radionuclides.
- Determination of external and internal dose
- Activity of health physics services at workplaces

2.6 Methods of reactivity measurements

(2 hours lecture, Prof. Dr. J. Hascik [Bratislava])

- Introduction into the measurements of reactivity, definition and units
- Source jerk method
- Inverse count rate
- Rod drop method
- Inverse kinetics
- Positive period method

2.7 Laboratory practices related to reactor physics and nuclear measuring techniques

(2 x 2 hours laboratory exercises, 2.7a Prof. Dr. J. Hascik,& Prof. Dr. V. Slugen, 2.7b Prof. Dr. M. Miglierini, & Dr. R. Hinca [Bratislava])

2.7.a ***Determination of Fermi age***

- The experiment is performed using a PuBe neutron source in a graphite pile.
- The density distribution of 1.4 eV neutrons is measured along the vertical axis of the pile by a corona type neutron detector with Indium filter.
- Estimation of Fermi age is performed from the neutron density distribution.

2.7.b ***Gamma spectrometry measurements***

- Gamma spectrometry with scintillation and semiconductor detectors
- Energy and efficiency calibration
- Net peak area computation method for activity determination
- Peak area corrections
- Identification of radionuclides in outlet filters from nuclear power plant

Timetable of the Bratislava-part: 2. - 6.9.2009

2nd September (Wednesday)	14:00 -	Arrival, occupying accommodation
	18:00-20:00	Opening ceremony welcome buffet (FEI STU, B-Klub, block A, ground floor)
3rd September (Thursday)	08:30 – 08:45	Organisational matters
	08:45 – 10:15	Lecture 2.3
	10:30 – 12:00	Lecture 2.2
	12:00 – 14:00	Lunch break
	14:00 – 15:30	Lecture 2.4
	15:45 – 17:15	Lecture 2.5
4th September (Friday)	07:00 – 16:45	Technical tour to Nuclear & Decommissioning Company j.s.c. at Jaslovské Bohunice visit to NPP V1 and to a Radwaste Treatment Centre
5th September (Saturday)	08:45 – 10:15	Lecture 2.1
	10:15 – 12:00	Lecture 2.6
	12:00 – 14:00	Lunch break
	14:00 – 15:30	Exercises 2.7a group A; 2.7b group B
	15:45 – 17:15	Exercises 2.7b group A; 2.7a group B
6th September (Sunday)		Travel to Budapest by train

3. Reactor experiments in Budapest:

The reactor experiments will be performed at the 100 kW training reactor of the Institute of Nuclear Techniques (INT) of the Budapest University of Technology and Economics (BME) (Budapest, Hungary).

3.1 Determination of the distribution and of the absolute value of the thermal neutron flux by activation method

The experiment involves the determination of the relative distribution of the thermal neutron flux along a vertical axis of the active core, furthermore, determination of the absolute value of the thermal neutron flux at the center of the reactor.

3.2 Measurement of delayed neutron parameters and determination of uranium concentration

Half lives and relative intensities of some delayed neutron groups are determined. In the second part of the exercise the ^{235}U concentration of a depleted uranium sample is estimated by comparing the delayed neutron intensities in the sample of interest and in uranium standard.

3.3 Measurement of void coefficient and the reactivity worth of neutron absorbers

The void coefficient of the reactivity and the reactivity worth of neutron absorber is studied, when moving a void and a neutron absorber respectively along a vertical axis in the active core.

4. Reactor experiments in Vienna:

The reactor experiments will be performed at the TRIGA Reactor Facility of the Atominstitut der Österreichischen Universitäten (Vienna, Austria).

4.1 Fission chambers (FC), compensated ionisation chambers (CIC), self-powered (SP) detectors

These detectors will be exposed to various level of neutron fluxes and their sensitivity and time behaviour will be determined. For FC and CIC the discrimination between the neutron and gamma signal will be demonstrated. For SP the signal time behaviour will be shown after reactor shut down.

4.2 Reactor power calibration and temperature coefficient of reactivity

The reactor is operated at 10 W, rod positions, water- and fuel temperature is noted, then the reactor power is raised to 100 kW, again the values are noted. From the difference in rod position and fuel temperature the fuel temperature coefficient can be determined. Then the reactor is operated for 90 min only with convection cooling and the increase of water temperature is monitored. Comparing the temperature increase with the value from a previous calibration the thermal reactor power can be determined.

4.3 Critical experiment

Ten fuel elements are removed from the reactor core and consecutively reloaded. The neutron count rate is measured after each step. At each step measurements are performed with all control rods up and then down. Criticality is reached with all control rods up after reloading of five fuel elements.

4.4 Demonstration of a prompt critical power excursion *(requires only a short time)*

Due to the strong negative temperature coefficient of reactivity TRIGA reactors allow prompt critical excursion to 1000 times the normal power mode without any damage to the core. This is demonstrated using a pneumatic rod, which is removed promptly from the critical core. Typical power levels of 250 to 300 MW are reached for a time period of about 40 ms.

5. Reactor experiments in Prague:

The reactor experiments will be performed at the research reactor facility of the Czech Technical University in Prague (CTU) (Czech Republic).

5.1 Measurements of reactivity by various methods

Reactivity measurements in the subcritical state by “source jerk” method (using quickly moveable external neutron source), reactivity measurements in the supercritical reactor by “positive period” method, “rod drop” method (control rod worth measurement)

5.2 Study of nuclear reactor dynamics

Mathematical model of the research reactor dynamics, study of the reactor response to the negative / positive periodical reactivity change, study of the influence of the bubbly boiling to the VR-1 reactor operation, simulation of the selected operating conditions of a WWER-type power reactor: approaching to the critical state with modeling of the dilution of boric-acid concentration and change the operating group of the control rods

5.3 Digital control and safety systems of the research reactors and reactor operation

Digital control and safety systems based on microprocessors, the operational power measurement and independent power protection systems, the control system and the human-machine interface (control desk), the start-up of the reactor, the operation in manual and automatic mode, the changes of the power (increasing, decreasing), the shutdown of the reactor because of various reasons can be demonstrated, various inspections and checks of the digital control and safety system.

Appendix I.

APPLICATION FORM

Applicant's personal data

Surname:……; First name:……..…….

Place and date of birth:……..……..….

No. of passport (necessary for entering in the nuclear installations): ……

Mailing address:……..……..……

Tel:…… Fax:……..……...

e-mail:…….. Univ. ID-code (if any)…..……

Parameters of the home institution

Name of the institution:……..…….

Responsible person's name and

title:…….……..

Mailing address:……..……..……

Tel:……..…… Fax:……..……...

Hereby I apply for participation in the „Eugene Wigner Training Course on Reactor Physics Experiments 2009". I accept that my application is subject of a selection procedure, and may be refused, if the course is already fully booked, or if the selection committee decides so, due to any reason. I will receive a notification about my acceptance from the organisers. I understand that my travels *to the course and back* as well as my *insurances* and the acquisition of the necessary *visa* have to be arranged and paid individually if I will be selected for participation.
I am a regular (PhD) student of a member university of ENEN, so I am eligible for the reduced course fee (€ 2 000)…… Yes☐/No☐
I will organise individually my accommodations and travels during the course…….. Yes☐/No☐
I ask the organisers to arrange my accommodations and travels during the course. I'll transfer € 1500 for covering these costs in addition to the course fee (€ 2500 /€ 2 000)…….. Yes☐/No☐

Attachments:

1. A Curriculum Vitae (English knowledge must be explicitly stated)
2. A letter of recommendation signed by a responsible person of the sending institute (for getting the reduced fee it must be an ENEN Association member university). Your theoretical background in reactor physics should be explicitly mentioned in this letter.

Date …….. ……..
signature