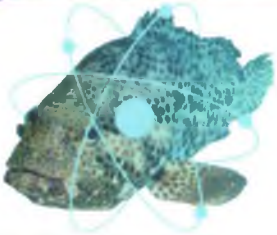

CHERNE 2015

11-й семинар по европейскому сотрудничеству в области высшего образования и исследований по ядерной инженерии и радиологической защите

Минск, Белорусский государственный университет,
1—5 июня 2015 г.

11th Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection

Minsk, Belarusian State University, 1—5 June 2015

Министерство образования Республики Беларусь
Белорусский государственный университет
Образовательная сеть «CHERNE»
ООО «ДП ЮНИЛАБ»

Ministry of Education of the Republic of Belarus
Belarusian State University
Academic Network «CHERNE»
LTD «DP UNILAB»

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Настоящее издание содержит информацию об 11-м ежегодном семинаре Европейской образовательной сети «CHERNE» («Сотрудничество для развития высшего образования в области радиологической и ядерной инженерии») и тезисы докладов участников. В семинаре принимали участие представители университетов Испании, Бельгии, Германии, Чехии, Италии, Греции и БГУ, входящих в сеть «CHERNE».

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INTRODUCTION

CHERNE (Cooperation for Higher Education on Radiological and Nuclear Engineering) is a wide-scope open academic network focused on teaching and learning activities with the main objective of enhancing educational and scientific cooperation, as well as competence and equipment sharing between its partners in the field of nuclear and radiological sciences and technology.

GOALS OF CHERNE:

- sharing competencies and facilities in organizing teaching activities for their students, mainly at the Master level
- enhancing the mutual support by learning from each other, by exchanging experiences and by regular mutual reflections

CHERNE ACTIVITIES can be classified in the following chapters:

1. Erasmus bilateral agreements
2. Professor and Student exchanges
3. Courses and Seminars
4. Workshops
5. Presence at International Conferences
6. ERASMUS Intensive Programmes
7. International intensive courses

CHERNE PLATFORM is at the web-site http://www.cherne.ntua.gr/content/organization

CHERNE Workshops:

1st Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection
Date: 04/05/2005 to 06/05/2005
City: Valencia

2nd Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection
Date: 13/03/2006 to 15/03/2006
City: Valencia

3rd Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection
Date: 08/02/2007 to 10/02/2007
City: Prague

4th Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection
Date: 26/05/2008 to 28/05/2008
City: Favignana Island

5th Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection
Date: 08/06/2009 to 10/06/2009
City: Jülich

6th Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection
Date: 07/06/2010 to 09/06/2010
City: Coimbra

7th Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection
Date: 30/05/2011 to 01/06/2011
City: Brussels

8th Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection
Date: 28/05/2012 to 30/05/2012
City: Athens

9th Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection
Date: 06/06/2013 to 07/06/2013
City: Salamanca

10th Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection
Date: 26/05/2014 to 28/05/2014
City: Thessaloniki

11th Workshop on European Collaboration for Higher Education and Research in Nuclear Engineering and Radiological Protection
Date: 01/05/2015 to 05/06/2015
City: Minsk
This **11th Workshop in Minsk** will focus on:

New Needs and Opportunities for CHERNE Network
under the umbrella of nuclear knowledge management

This Workshop in Minsk will review the challenges related to nuclear education and training, the initiatives recently undertaken to meet them, and the future needs with regard to the present day situation and the expected future developments for acquiring, creating, transferring and exploiting nuclear knowledge.
There is a real risk of the loss of nuclear knowledge if no measures are taken, and preservation of skills in the nuclear field requires a general effort. It is very important for accident prevention, safety of NPP operation and peaceful application of nuclear technology that workers have the right training and experience, with technological and organizational support. These conditions can only be established and sustained over time with the strategy of knowledge management. Nuclear knowledge management (NKM) came to the forefront in the IAEA as a formal program only in the 21st century. Knowledge is the most valuable asset for nuclear energy industry without which the industry cannot operate safely and economically. NKM focuses on knowledge creation, identification, sharing, transfer, protection, validation, storage, dissemination, preservation or utilization. In a situation where nobody could expect big investments in nuclear education, where many retiring university professors are not replaced, an open network such as CHERNE is a way to share the remaining resources and thus to maintain the quality of nuclear education at a level which cannot be assured by individual institutions alone.

Some of the challenges could be:
• How to answer expectations of our CHERNE Members,
• How to enlarge the educational collaboration between our Members,
• How to enlarge the educational and training collaboration with industry,
• How to improve the visibility and attractiveness of CHERNE nuclear training for more European and non-European students in view of the strong competition from other networks and centers of nuclear education.
• How to make available teaching material, in particular through the use of new information technologies, online and distance courses.
• How to give a new impetus to the teaching of interdisciplinary courses appropriate both to nuclear physicists, chemists and engineers.

PROGRAMME

June, 1th, Monday		
Arrival		
19.00	**Registration and Welcome**	
June, 2nd, Tuesday		
9.00 – 9.45	**Registration**	
10.00 – 11.00	**Opening of the Workshop**	
	10.00 – 10.15	**Welcome to the Belarusian State University**
	10.15 – 10.45	**Summary by the Secretary "Ten years of CHERNE, an overview of our Network" (José Rôdenas, Spain)**
	10.45 – 11.00	**Presentation of new institution in CHERNE:** *Universidade da Beira Interior (UBI), Covilhã (Portugal)* *Università degli Studi di Milano (Italia)*
11.00 – 12.00	**Special Session from the Host University "Towards Managing Knowledge"**	
	11.00 – 11.45	**Presentation by Managing Director of the Nuclear Knowledge Management Institute Andreas Brandner (Austria)**
	11.45 – 12.00	**Discussion**
12.00 – 12.30	Coffee Break	
12.30 – 13.30	**CHERNE Annual Council: Part I (restricted to CHERNE Members)**	
13.30 – 14.30	Lunch	
14.30 – 15.30	**Visit to the BSU History Museum**	
16.00 – 19.00	City Tour	
June, 3rd, Wednesday		
9.00 – 20.00	**Visit to the Belarusian NPP site** (Grodno region)	
June, 4th, Thursday		
9.00 – 10.15	**Session 1 "Evolution, Future and Lessons Learned from Nuclear Education Development in Different Countries" (Moderator: J. Rôdenas)**	
	9.00 – 9.15	**The European Cost Network Norm4Building: possibilities for students and young researchers (Herwig Janssens, Belgium)**
	9.15 – 9.30	**RADAM – A course in RAdiation Detection And Measurement (Friedrich Hoyler, Germany)**
	9.30 – 9.45	**XIMER 2009-2015: 7 year experiences with a CHERNE course on measurements of environmental radioactivity (Isabelle Gerardy, Belgium)**
	9.45 – 10.00	**Nuclear education at the Faculty of Chemistry of the Belarusian State University: from innovation lecturing to open distance labs (Tatsiana Savitskaya, Belarus)**
10.00 – 11.00	**Session 2 "New Education and Training Methods: Experience at CHERNE Member Institutes" (Moderator: I. Gerardy)**	
	10.00 – 10.15	**Laboratory practice for development of practical skills of chemical faculty students (Svetlana Ovsiannikova, Belarus)**
	10.15 – 10.30	**Upgrade of students competences by international educational practice (Natallia Babaryka, Belarus)**
	10.30 – 10.45	**Distance learning to support the building competence via professional postgraduate education in nuclear and radiation safety and opportunities for co-operation (Andrey Timoshenko, Belarus)**
	10.45 – 11.00	**Implementation of portal of nuclear knowledge BelNET (Svetlana Sytova, Belarus)**
11.00 – 11.30	Coffee Break	

11.30 – 13.30	**Session 3 "Nuclear and Radiological Research in CHERNE Member Institutes" (Moderator: F. Hoyler)**	
	11.30 – 11.45	**Design and characterization of a new neck phantom for the quantification of iodine in the thyroid by X-ray fluorescence (Isabelle Gerardy, Belgium)**
	11.45 – 12.00	**Status of the light collection system of WA104/ICARUS experiment (Francesco Tortorici, Italy)**
	12.00 – 12.15	**Radiation stability of the ods alloys against swift heavy ions impact (Vladimir Uglov, Belarus)**
	12.15 – 12.30	**Comparison of adult reference voxel phantoms with UF-NCI series hybrid voxel phantoms (K. Makarevich, Belarus)**
	12.30 – 12.45	**Secondary neutrons in the beam of bremsstrahlung of medical linear accelerator CLINAC 2300C/D (Kiril Verenich, Belarus)**
	12.45 – 13.00	**The dispersion of the pulse amplitudes of ionization fission chambers due to the characteristics of ^{235}U fission fragments variation (Philip Speranski, Belarus)**
	13.00 – 13.15	**Structural mechanics optimization of the AISHA ion source (Francesco Noto, Italy)**
	13.15 – 13.30	**Neutron spectrum determination of a sub-critical nuclear reactor by multi-disc neutron activation technique (Pavlos Koseoglou, Greece)**
13.30 – 14.30	**Visit to the Faculty of Physics: Trainer-Simulator of Reactor Room VVER-1000**	
14.30 – 16.00	Lunch	
19.00 – 22.00	Concert "Straus invites…" (the National Opera and Ballet Theatre)	
June, 5th, Friday		
9.00 – 10.30	**Round Table Discussion: Analysis and discussion on courses and programs proposed for CHERNE partners for next year (Moderator: H. Janssens)**	
10.30 – 11.00	Coffee Break	
11.00 – 12.00	**Round Table Discussion: Future CHERNE organizational aspects and Perspectives for the CHERNE Network (Moderator: J. Rôdenas)**	
12.00 – 12.30	**Conclusions of the Workshop. Closing of the Workshop.**	
12.30 – 13.30	**CHERNE Annual Council : Part II (restricted to CHERNE Members)**	
13.30 – 15.00	Farewell Lunch	
June, 5-6th		
Departure		

THE BELARUSIAN STATE UNIVERSITY IS THE LEADING NATIONAL UNIVERSITY

A. TOLSTIK
Minsk, Belarusian State University, Vice-Reactor for Education

Keywords: Belarusian State University, nuclear education, CHERNE

The Belarusian State University (BSU), founded in 1921, is the main educational and scientific establishment in the Republic of Belarus. It includes 24 faculties and educational institutes, 4 scientific research institutes, 5 national scientific centers, and 12 unitary scientific and production enterprises. It admits more than 30.000 students majoring in 70 subjects with fundamental sciences being the top priority. The BSU is accredited for compliance with the standards of ISO 9001.
The International activity of the BSU is reach of events, foreign partners and forms of cooperation. Today our university has over 350 international agreements concluded with HEI's and scientific institutes out of more than 50 countries of the world and that makes the BSU country's leader in this field. The BSU is in 5%-top universities according to the "Webometrics Ranking of World Universities", the second one in the ranking of the universities of CIS, Georgia, Latvia, Lithuania and Estonia.
In 2007, a decision by the Government of Belarus put the country on the path to introduce nuclear power, with the aim to start up the first unit nuclear power reactor by 2017.
A nuclear power program is a major undertaking that requires careful planning, preparation and investment in time and human resources. In 2008, according to the National Nuclear Program the Belarusian State University (BSU) started to train students in the nuclear field. Now two faculties (the Faculty of Physics and the Faculty of Chemistry) separately offer programs leading to Diploma in the nuclear field. Following the national established criteria courses are arranged under the traditional headings of Chemistry and Physics with emphasis on Nuclear and Radiochemistry, Nuclear Physics and Technology. About 200 students are being training now.
Summing the activity in the nuclear education and research area we note with satisfaction that the enthusiasm of students, professors, researchers of the Belarusian State University promoted an awareness of the importance of nuclear sustanable development of Belarus. In addition, we consider our membership in CHERNE is very important for developing, sharing and promoting excellence in nuclear education, implementation of in-depth nuclear training and student exchange programmes, joint research activities to share scientific knowledge and infrastructure, the cross-cultural relations.

CHALLENGES OF MANAGING NUCLEAR KNOWLEDGE

A. BRANDNER
Vienna, NKMI Nuclear Knowledge Management Institute, Managing Director

Keywords: Nuclear Knowledge Management; Nuclear Acceptance; Knowledge Loss Risk

Nuclear knowledge is unique in many ways: it is complex, involving high development costs, often requiring significant governmental support. It must be developed and retained over a long time frame, and special constraints exist due to the dual - peaceful and non-peaceful - nature of nuclear technologies. The managing of nuclear knowledge is a challenge, but it can be learned and it has to be learned - it does not appear on its own. Countries, without a vital knowledge ecosystem and incompetent to manage nuclear knowledge for safe, secure and sustainable operations, should not step into nuclear energy. And even knowledge-rich countries should be aware, that knowledge is not a stable or reliable resource. The most important knowledge resource – the human being – goes home every evening. The problem of generation change and decreasing interest in nuclear studies is well known. The codified knowledge – like documentations - seem to be more reliable, but the handling of a constantly growing number of millions of documents, stored in continuously changing databased, is creating new questions about the consistency, usability, availability and accuracy. Also the third relevant knowledge resource - the external knowledge of suppliers, TSOs, international partners, academia and the public – is everything else than reliable. Within the lifetime of a nuclear power plant political and economic relations change significantly and lost public acceptance can hardly be regained. Public knowledge and acceptance are critical resources that need to be managed as resources.

Without a very detailed understanding of knowledge needs, the consequent maintenance of human, structural and external knowledge, and the active mitigation of knowledge loss risks, the use of nuclear technologies is not responsible. This is true for nuclear licensees, and also for countries as a whole. Looking at the reality of Nuclear Knowledge Management around the world, one should be alert. Sustainable Nuclear Knowledge Management programs that are fully integrated into the management systems and anchored in a safety-oriented knowledge culture are still rare. This is why we see a major responsibility of the regulatory bodies to be leaders in the knowledge management agenda, to set high standards for and to inspect the knowledge management practices of licensees. Recently the Federal Authority for Nuclear Regulation in the U.A.E. has received the Knowledge Management Excellence Award of Middle East Governmental Bodies. We recommend this case to other regulators and suggest establishing a serious European program to strengthen the Knowledge Management competence of regulators and nuclear organizations. We also recommend to strengthen the educational programs for Nuclear Knowledge Management and to establish an international certification for Knowledge Management professionals.

THE EUROPEAN COST NETWORK NORM4BUILDING: POSSIBILITIES FOR STUDENTS AND YOUNG RESEARCHERS

W. SCHROEYERS[1], S. SCHREURS, H. JANSSENS[2]
Hasselt University, Nuclear Technological Centre NuTeC, Diepenbeek, Belgium
[1] Corresponding author: wouter.schroeyers@uhasselt.be
[2] Presenting author

Keywords: new research network, reuse of NORM residues in building materials

Background: The depletion of energy resources and raw materials demands the introduction of sustainability in the construction sector and in the construction material production. In the development of new synthetic building materials the reuse of various waste or residue streams becomes a necessity. A specific class of residues, for which the use in building materials offers interesting reuse options, originate from NORM (naturally occurring radioactive materials) processing industries. NORM residues, such as fly ash produced in large quantities from coal burning, slags from steelworks and metal recycling industries, phosphogypsum of the phosphate industry and red mud of the aluminium processing industry, were already investigated for application in building materials. Current innovations in the building industry, such as the emerging field of Alkali-Activated Materials (Geopolymers/inorganic polymers), can open up promising new reuse pathways for NORM residues in building materials.

Objectives NORM4BUILDING: The main objective of the new COST Action 'NORM4BUILDING' is the exchange of multidisciplinary knowledge and experiences (radiological, technical, economical, legislative, ecological) to stimulate the reuse of NORM residues in new tailor-made sustainable building materials in the construction sector while considering the impact on both external gamma exposure of building occupants and indoor air quality. By improving radiological impact assessment models for the reuse of NORM residues in building materials the new COST Action aims to further stimulate justified uses of NORM residues in different types of newly developed building materials. Based on these models, the COST Action aims at investigating realistic legislative scenarios so that the authorities concerned can allow reuse pathways for NORM that can be accepted from a radioprotection point of view in accordance with the Lead Marked Initiative (LMI) and sustainable construction.

A European network with several possibilities for students and young researchers: In the presentation the approach and new initiatives of the NORM4BUILDING network will be presented. The NORM4Building materials network is an open network of researchers and offers a lot of opportunities for students and young researchers of the participating countries. The COST network will organise workshops, meetings, training schools (including summer schools) for students and researchers and offers the possibility of short time scientific meetings to several European institutes.

XIMER 2009–2015: 7 YEAR EXPERIENCES WITH A CHERNE COURSE ON MEASUREMENTS OF ENVIRONMENTAL RADIOACTIVITY

W. SCHROEYERS[1], S. SCHREURS[1], H. JANSSENS[1]
C. LICOUR[2], I. GERARDY[2]
[1] Hasselt University, Nuclear Technological Centre NuTeC, Diepenbeek, Belgium
[2] ISIB, Haute Ecole Paul Henri Spaak, Brussels, Belgium

Key words: XIMER, intensive course, radiation measurements, nuclear physics

XIMER is an intensive 2-week course organised since 2009 by Hasselt University (previously XIOS Diepenbeek) and ISIB Brussels for the CHERNE network, on the measurements of environmental radioactivity. The course is focused on practical aspects, including field trips and almost four days of laboratory measurements. Both the artificial and natural contaminations are examined. The techniques used include low-level dosimetry, gamma spectrometry with scintillators and with HPGe, indoor and soil radon measurements. During the field trips, a combination of in situ measurements with laboratory measurements on samples is used for a better understanding of the situation.

The course is foreseen for students having a basic knowledge in radiation measurements and nuclear physics (last year of bachelor or master level). Besides the application of these measurements to environmental situations, the output is also a better understanding of our radioactive environment and a better evaluation of what is harmful and what is inevitable.

The evaluation of the students is based on written reports on the exercises, and oral presentations of the results on the last day.

RADAM – A COURSE IN RADIATION DETECTION AND MEASUREMENT

F. HOYLER[1], **U. SCHRÖER, M. MARTEN-TÖLLE**
FH Aachen, Campus Jülich, Heinrich-Mußmann-Str. 1, D-52428 Jülich
[1]Corresponding author (hoyler@fh-aachen.de)

Keywords: Education, student laboratory in radiation detection

Since many years the CHERNE Network offers courses for the students of the participating institutions in the nuclear field. Most of these offers have been organized in the "ERASMUS Intensive Program" (IP) framework. The rules required to organize a course of at least 10 working days. The team of the FH Aachen Campus Jülich organized several editions of a summer school on nuclear chemistry (JUNCS) in the past. It consisted of two parts: first week practical introduction to nuclear measurement techniques, second week laboratory in nuclear chemistry. It turned out that often the participants had either experience in measurement techniques but deficiencies in chemistry or vice versa. Moreover for some of the participants it was difficult to find the time for the full period of two weeks. Thus already before the end of the funding of IP-projects the idea was developed to divide the program into two independent parts. One of the two parts is the course RADAM which is the subject of this contribution.

The first RADAM edition took place in the last week of August 2014. Nine Participants took part. There were two students from Thessaloniki, one from Catania, and one from Hasselt. The group was completed by 5 students from the master course EMINA of FH Aachen. These participants were students which had less experience in practical measurements than their fellow students. The first two days started with basic techniques: counting statistics, determination of counting efficiency, energy calibration, and peak analysis in γ-spectrometry. Initially it was foreseen that the students may then choose between different experiments, but due to manpower and also due to the fact that all participants did not have much experience the following experiments were performed by groups of three students per experiment during the following 2 days: γγ-coincidences (including fast-slow data acquisition), Liquid-Scintillation counting ,Alpha-spectrometry using Si-surface barrier detectors, γ-spectrometry using HPGe-detectors, energy dispersive X-Ray fluorescence. The last day was devoted to final data analysis and the preparation of short presentations covering all the experimental activities. The feedback by students was very positive, therefor it is planned to keep the format also for the 2nd edition. However the students will be offered experiments from the following list: LSC, α-spectrometry and energy loss determination, γ-spectrometry on environmental samples using HPGe-detectors (possibly with efficiency determination using Monte-Carlo techniques), γγ-coincidences and angular correlation, X-Ray fluorescence, neutron activation analysis and lifetime measurements, neutron detection and n-spectrometry using Bonner spheres, nuclear waste assay system for 200l drums. It will then be decided according to the interest which experiments will be performed.

Students should be familiar with basic nuclear physics including the interaction of ionizing radiation with matter. Moreover it is recommended to be familiar with some basic facts on statistics and radiation detectors as can be found in "Radiation Detection and Measurement" of Glenn.F.Knoll or similar reading. This course is part of the lecture "Detection of Nuclear Radiations" (EMINA course number 310220) and is honored with 2 ECTS upon successful participation.

There will be no fee charged. Students have to pay for subsistence and travel. In the first edition the foreign students occupied an apartment for 25€/night. It can be guaranteed that housing will be less than 40€/night. Deadline for registration is July 1st, 2015.

DESIGN AND CHARACTERIZATION OF A NEW NECK PHANTOM FOR THE QUANTIFICATION OF IODINE IN THE THYROID BY X-RAY FLUORESCENCE

F. POZUELO, C. LICOUR, J. BARE, I. GERARDY
Bruxelles, Institut Supérieur Industriel de Bruxelles, Haute-Ecole P.-H. Spaak

Keywords: Thyroid, Iodine quantification, XRF, PLA

Thyroid gland metabolizes iodine with the aim of synthesizing hormones which help to regulate metabolism. Insufficiency of iodine may lead to risk of gland disease due to the disorder in the production of thyroid hormones. An optimal iodine concentration within the thyroid is essential for the proper functioning of the organism. In that way quantification of iodine in vivo is of public interest.
X-ray fluorescence, a non-invasive method, allows quantifying the iodine contained in the thyroid. For in vivo studies, neck geometry varies in each patient. These variations may lead to complications in the evaluation of the thyroid iodine content.
3D printing is a technique that allows creating a more accurate and adaptable to the real patient neck phantom which includes thyroid lobes and other organs within. PLA is a material that may be used in 3D printers and its properties are similar to human tissue in terms of density (ρ=1.25 g/cm3) and components ($C_3H_4O_2$). In this study, the PLA attenuation coefficients have been evaluated for a wide range of energies from 22 to 1332 keV. For each characteristic energy, several thicknesses of PLA manufactured by 3D printing technique have been introduced between the source and the detector in order to evaluate by Beer-Lambert law the attenuation coefficient of the material.

STATUS OF THE LIGHT COLLECTION SYSTEM OF WA104/ICARUS EXPERIMENT

V. BELLINI[1,2], M. BONESINI[3], A. FALCONE[4,5], F. MAMMOLITI[1,2], G. L. RASELLI[4], M. ROSSELLA[4], F. TORTORICI[2,6], C. VIGNOLI[7]

[1]Dipartimento di Fisica ed Astronomia, Università di Catania, via Santa Sofia 64, I-95123 Catania, Italy

[2] INFN - Sezione di Catania, via Santa Sofia 64, I-95123 Catania, Italy

[3] INFN – Sezione di Milano Bicocca, Dipartimento di Fisica G. Occhialini, Piazza della Scienza 3, I-20126 Milano, Italy

[4] INFN – Sezione di Pavia, Via Agostino Bassi 6, I-27100 Pavia, Italy

[5] Dipartimento di Fisica, Università di Pavia, Via Agostino Bassi 6, I-27100 Pavia, Italy

[6] Centro Siciliano di Fisica Nucleare e Struttura della Materia - via Santa Sofia 64, I-95123 Catania, Italy

[7] INFN – Sezione Laboratori Nazionali del Gran Sasso, Via G. Acitelli, 22, I-67100 Assergi, Italy

Corresponding Author: Francesco Tortorici, CSFNSM & INFN – Sezione di Catania, Via Santa Sofia 64, I-95123 Catania, Italy. Email address: francesco.tortorici@ct.infn.it

Keywords: WA104, ICARUS, LAr-TPC, Light Collection, Neutrino Detector

The ICARUS T600 cryogenic detector is the biggest LAr-TPC realized ever, with the cryostat containing 760 tons of LAr (476 tons active mass). Nowadays, it represents the state of the art of this technique and it marks a major milestone in the practical realization of large-scale LAr detectors. WA104 is essentially its refurbishing into a larger scale with upgraded electronic and, moreover, a light collection system.

Scintillation light emission in LAr is due to the radiative decay of excited molecules (Ar^*2) produced by ionizing particles, releasing monochromatic VUV photons (λ~128 nm) in transitions from the lowest excited molecular state to the dissociative ground state. This isotropic light signal propagates with negligible attenuation throughout each TPC volume. Indeed, LAr is fully transparent to his own scintillation light, with measured attenuation length in excess of several tens of meters and Rayleigh-scattering length of the order of 1 m. As photons from scintillation light propagate from the production point to the light detectors, they keep information about the time of generation, i.e. the ionizing particle interaction time and the time evolution of the interaction event in LAr. Scintillation light will be revealed in the T600 detector by a refurbished light detection system, with the following aims: 1) The generation of a light-based trigger signal 2) The identification of the time of occurrence of each interaction with high precision 3) Identification of event topology for fast selection purposes, also using an artificial neural network.

Such Neural Network is being trained on Monte Carlo events representing cosmic muons from above and electromagnetic showers generated by neutrino interactions within the LAr medium. The neutrinos will come from the Fermilab Neutrino Booster.

STRUCTURAL MECHANICS OPTIMIZATION OF THE AISHA ION SOURCE

F. NOTO[1], L. CELONA[1], L. ANDÒ[1], F. CHINES[1], G. CIAVOLA[1,3], G. COSTA[1], G. CUTTONE[1], S. GAMMINO[1], O. LEONARDI[1], S. MARLETTA[1], D. NICOLOSI[1], G. TORRISI[1,2]

[1] INFN - Laboratori Nazionali del Sud, Via S. Sofia 62, 95125 Catania, Italy
[2] Università Mediterranea di Reggio Calabria, Dipartimento di Ingegneria dell'Informazione, delle Infrastrutture e dell'Energia Sostenibile, Via Graziella, 89100 Reggio Calabria, Italy
[3] CNAO Foundation, Strada Campeggi, 53, Pavia PV, Italia

Keywords: ECR, Ion Source, FEM Analysis

Different facilities for hadrontherapy have been built or designed in the recent past and Italy is present in the field either with synchrotron-based and with cyclotron-based facilities. For both types of accelerators the availability of high brightness multiply charged ion beams is essential and R&D efforts in this subject are increasing. In order to cope the stringent requests of a hospital environmental at INFN-LNS a new ion source called AISHa is under realization exploiting all the knowledge acquired in last decades in the ion source design and realization.
Therefore the AISHa source has been designed by keeping in mind the typical requirements of hospital-based facilities, where the minimization of the mean time between failures (MTBF) is a key point together with the maintenance operations, which should be fast and easy. Some critical parts of the body source, in particular the plasma chamber and the hexapole containment chamber, have been studied and optimized with the FEM software.
In the paper the entire structure will be described, with a particular attention to thermo-mechanical simulations of the plasma chamber and the electrostatic and structural simulation of the hexapole containment chamber.

NEUTRON SPECTRUM DETERMINATION OF A SUB-CRITICAL NUCLEAR REACTOR BY MULTI-DISC NEUTRON ACTIVATION TECHNIQUE

P. KOSEOGLOU[1,2], E. VAGENA[1], S. STOULOS[1], M. MANOLOPOULOU[1]
[1]Department of Physics, Aristotle University of Thessaloniki, Thessaloniki GR 54 124, Greece.
[2]Institut für Kernphysik, Technische Universität zu Darmstadt, Schlossgartenstr. 9, 64289 Darmstadt, Germany.

Key words: multi-disc neutron activation technique, SANDII code

The neutron spectrum of the sub-critical nuclear reactor of Aristotle University of Thessaloniki was measured in three radial distances from the reactor core. The multi-disc neutron activation technique was applied. Fifteen elements have been irradiated and 40 reactions in total (n,γ), (n,p) and (n,α), were determined in each position. Due to the relevant low neutron flux, discs instead of foils were used, so the gamma self-absorption factors had to be calculated for the gamma lines used to determine the induced activity of the discs. The specific activities calculated for all the isotopes were the input to the SANDII code, which is provided by NEA Data Bank and it was built specifically for the neutron spectrum de-convolution when neutron activation technique is used. For the optimization of the results a technique was used to minimize the influence the initial spectrum shape which SANDII uses.

NUCLEAR EDUCATION AT THE FACULTY OF CHEMISTRY OF THE BELARUSIAN STATE UNIVERSITY: FROM INNOVATION LECTURING TO OPEN DISTANCE LABS

T. SAVITSKAYA, I. KIMLENKA, O. SHADYRO, D. SVIRIDOV
Minsk, Belarusian State University, Chemistry Faculty

Key words: knowledge management, lectures in podcasting, distance labs

The Faculty of Chemistry was opened in 1931. There are 8 Departments, 6 Scientific Research Laboratories, about 850 students at the faculty. 190 members on staff including more than 92 lecturers, 18 doctors of science, 55 candidates of science (PhD), 1 academician, and 2 corresponding members of the National Academy of Sciences of Belarus are involved in the learning process. Faculty of Chemistry is the only establishment in Belarus to give students the diploma in Chemistry. It works in close contact with the Scientific Research Institute for Physical and Chemical Problems, which originally stemmed from the Faculty itself, but later separated in 1978. Many students are engaged in scientific research thanks to the support of the Institute. The unique complex of Faculty-Institute is a very good background to be accepted into the European universities research space. It is very important for BSU because of our republic education system's adding to the Bolognese process.

As we live in the period of the history that is determined by the sociologists as the knowledge society with the triangle of knowledge at the bottom. The triangle of knowledge means the community of education, research and innovation. The strategy of knowledge society development is favored by the openness of educational resources, novel methods of education and teaching, including distance learning. We would like to share our experience in the development of innovation methods of teaching and methodological support for students of the specialty "high energy chemistry". First of all it is an active learning method or in other words cooperative learning method that we used at laboratory classes for ten years [1]. We amassed the information for analysis of its usage and are ready to discuss it. What is more, the knowledge management strategy was appeared in the focus of our activity. The issues of knowledge capture, knowledge preservation, knowledge loss risk assessment and nuclear knowledge portal development are under consideration and resulted in the introduction of the Nuclear knowledge management course into the curriculum, development of the special kinds of teaching book "two in one" improving English language and communication skills, lectures in podcasting and distance labs.

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LABORATORY PRACTICE FOR DEVELOPMENT OF PRACTICAL SKILLS OF CHEMICAL FACULTY STUDENTS

S. OVSIANNIKOVA, S. LEINOVA, G. SOKOLIK
Minsk, Belarusian State University, Radiochemistry Laboratory

Key words: radionuclides, gamma-beta-radiometry, gamma- and alpha-spectrometry, radiochemical analysis, radionuclide fractionation

One of the most important components of higher education for preparation of specialists in the field of Nuclear Engineering and Radiological Protection is training in radionuclide's identification and choosing the most suitable experimental procedure for determination of different nature radionuclides in diverse objects.

Laboratory practice in the frame of special discipline "Radionuclides in the Environment" intends for the 4- year level educational students of Chemical Faculty of Belarusian State University (BSU), which specialized at the department of Radiation Chemistry and Pharmaceutical Technologies. It includes an acquaintance of students with the nondestructive methods of radionuclide identification such as the radiometry and gamma-spectrometry as well as with the destructive methods based on the radiochemical analysis. The schedule of this laboratory practice includes mastering the methods of sampling and preparation of different samples for radionuclide determination. Much attention in this laboratory practice is given to mastering the main steps of radiochemical analysis including selection and using the radioactive and nonradioactive tracer for definable radionuclide, accomplishment of the radionuclide transfer into solution, its separation and cleaning, preparation of measurement target, radionuclide identification, measurement of its activity, control of radiochemical purity of the radionuclide compound separated onto the measurement target, estimation of chemical yield of radionuclide during radiochemical analysis and calculation of radionuclide activity concentration in the sample under investigation.

In addition, students get acquainted with possibilities of different measuring devices and they study to establish most suitable equipment for realization of particular measurements. They also study to calibrate gamma- and alpha- spectrometers and to determine their measuring factor using the standard sources of ionizing radiation, master statistical methods of data processing.

Moreover, laboratory practice includes student's acquaintance with chemical fractionation procedures for investigation of radionuclide species in soils and natural waters. It helps to estimate migration potentialities of radionuclides and to compare their capabilities to redistribution in ecosystems.

Generally, this laboratory practice can form a basis for development practical skills of students in radiometry and radiochemistry.

UPGRADE OF STUDENTS COMPETENCES BY INTERNATIONAL EDUCATIONAL PRACTICE

S. KOBYASHEVA, N. BABARYKA
Minsk, Belarusian State University, Chemistry Faculty

Keywords: international student practice, competences

Participating of the students in international educational practices is one of the most effective tools to improve their professional skills, and therefore to ensure training of high-quality specialists with enough theoretical and practical knowledge. Students of the Chemistry Faculty of the Belarusian State University, which specialize in high-energy chemistry, take an active part in diverse international programs. Among them one can distinguish the International Student Practice that is organized by the educational and scientific center of the Joint Institute for Nuclear Research (JINR), Dubna, Russian Federation. JINR is an international intergovernmental scientific research organisation that was created with the aim of uniting the efforts, scientific and material potentials of its Member States for investigations of the fundamental properties of matter. Unique choice of experimental facilities is available at the Institute, which include the only in Europe and Asia superconducting accelerator of nuclei and heavy ions, cyclotrons that are used for experiments on the synthesis of heavy and exotic nuclei, the unique IBR-2 reactor that is used for nuclear physics research with neutrons, and a proton accelerator – the phasotron that is used for ray therapy. The IBR-2 reactor produces one of the most intense pulse neutron flux at the moderator surface among the world reactors: ~10^{16} n/cm^2/s, with a power of 1850 MW in pulse.

Students of the Chemistry Faculty have a chance to participate in a three-week long practice in JINR. The practice consists of both theoretical lectures and direct practical training with obligatory fulfillment of the scientific project on the unique equipment of JINR laboratories. Scientific directions of the projects are diverse - nuclear physics, biophysics, nanotechnologies and new materials, reactors and apparatuses. At the closing session of the practice students present results of their practical work in the form of reports and speeches.

One more advantage of the practice is its international character – students from Belarus work with their colleagues from South Africa and Serbia. Working in international teams is important to share experiences and learning, as well as to practice speaking English.

Competences developed during the practice are useful for students in preparing their course and graduation projects, and of course in their future job in the field of high-energy chemistry.

RADIATION STABILITY OF THE ODS ALLOYS AGAINST SWIFT HEAVY IONS IMPACT

V. UGLOV
Minsk, Belarusian State University, Physics Faculty

Keywords: nanooxides, radiation stability, amorphization, ion tracks

Being considered as promising candidate materials for future reactors, oxide dispersion strengthened (ODS) alloys are subject of extensive irradiation testing with various radiation sources. The dispersion of nano-sized oxides associated with the ferritic matrix confers very good creep strength at high temperature and resistance to radiation swelling at high dose. The ferritic ODS steels have superior void swelling resistance by virtue of the inherently favorable interaction between point defects. Besides, the dispersions also act as trapping sites for irradiation induced point defects thereby enhancing the swelling resistance. In addition, the dispersed oxide particles impede the movement of dislocations providing the required high temperature creep resistance, which is otherwise low in ferritic steels. In this paper we present the results of TEM studies of Fe-16Cr-3W ferritic steel (Cr16) ODS alloy irradiated with 700 MeV Bi ions.

The materials used in our studies were Fe-16Cr-3W ferritic steel reinforced with yttrium oxides (VNIINM, Moscow). High energy ion irradiation at room temperature were performed at the U-400 (Bi) cyclotrons at FLNR JINR, Dubna. Average Bi ion flux was 10^9 $cm^{-2}s^{-1}$.

At the present work, microstructure of Cr16 ferritic steel reinforced with yttrium oxide particles irradiated with bismuth ions (700 MeV, 1.5×10^{12}, 1.5×10^{13} cm^{-2}) and at 300K has been studied using high resolution transmission electron microscopy. The ferritic matrix of Cr16 steel is a solid solution α-Fe(Me), there Me=Cr,W. Inside it grains face-centered cubic CrN and hexagonal Cr_2N precipitates are observed. On the boundary of grains $(Cr,W)_{23}C_6$, c-$Y_2Ti_2O_7$ and o-$Y_2Ti_2O_5$ nanoparticles are detected. Analysis of selected area diffraction patterns (SAD) from 30 particles has shown 18 orthogonal o-$Y_2Ti_2O_5$ and 12 cubic c-$Y_2Ti_2O_7$ structures. Total concentration of Y-Ti oxides in Cr16 samples is estimated to be ~10^{15} cm^{-3}.

The first conclusion, which can be done after analysis of Bi ion irradiated Cr16 specimens, is absence of specific features observed for metal NPs in oxide matrices bombarded with swift heavy ions like shaping along ion beam direction or formation of satellites around of NPs followed by their partial dissolution.

The amorphous latent tracks (diameter ~10 nm) in $(Cr,W)_{23}C_6$, c-$Y_2Ti_2O_7$ and o-$Y_2Ti_2O_5$ nanoparticles in Cr16 steel at Bi ion fluence 1.5×10^{12} cm^{-2} were revealed. The Bi ion (1.5×10^{13} cm^{-2}) latent tracks in (Y,Ti) oxide particles and cubic to orthogonal phase transition in the part of nanocrystal faced to the ion beam entrance are observed. Phase transition and latent track formation in $Me_{23}C_6$ is of interest because carbides are known as materials demonstrating very high resistivity to damage formation via electronic excitations. By our knowledge, till now no latent tracks have been revealed after swift heavy ion bombardment in any carbide including the most studied SiC. No lattice disorder due to dense ionization was found in both conventional and nanostructured (grain size 36 nm) silicon carbide. Further work is planned to find the S_e threshold of track formation and track sizein $(Cr,W)_{23}C_6$ particles in ferritic matrixas a function of electronic stopping power.

Electronic stopping power of Bi ions in c-$Y_2Ti_2O_7$ calculated for the density 4.8 g/cm^3 is 40 keV/nm. This value is much higher than those, 19 keV/nm, for which the amorphous latent tracks have been revealed in c-$Y_2Ti_2O_7$ particles after 74 MeV Kr ion irradiation. As was expected, multiple Bi ion track overlapping led to complete amorphization of carbide and Y-Ti oxide NPs. All nanoparticles have the same diffraction contrast that can be only if they are amorphous. So, the multiple track overlapping (1.5×10^{13} cm^{-2}) leads to complete amorphization of carbide and (Y,Ti) oxide particles in Cr16 samples.

DISTANCE LEARNING TO SUPPORT THE BUILDING COMPETENCE VIA PROFESSIONAL POSTGRADUATE EDUCATION IN NUCLEAR AND RADIATION SAFETY AND OPPORTUNITIES FOR CO-OPERATION

A. TIMOSHCHENKO, E. AVDANINA, I. DUBOVSKAYA, M. DEZHURKO, A. ZAITSEVA, L. ISACHENKOVA
Minsk, Belarusian State University, Physics Faculty

Keywords: Professional education and training, Nuclear and radiation safety, Distance learning

The long time experience of Belarus in international co-operation on professional education and training in nuclear and radiation technologies and their safety may be used for developing CHERNE activities. Except the main IAEA post-graduate course on education and training in radiation, transport and waste safety established in Belarus at the state level with issuing the diploma on re-training with awarding by qualification of "Radiation safety specialist" there is an opportunity to co-operate in conducting of a number of special training courses related to the particular subjects of the field of nuclear and radiation technologies. There could be such topics as "Radiation measurements and instrumentation", "Physical protection of radiation sources", "Emergency monitoring", different special topics in medical physics, etc. In addition, the development of the educational laboratory equipment at the nuclear physics department of Belarus state university provides the opportunity to organize the different types of distance lessons including practical exercises in radiation measurement laboratory. There is an opportunity to use a range of cyber-platforms in co-operation with some Belarus counterparts. For this purpose the wide internationally used cyber-platform CLP4NET may also be used. As example, the details of distance implementation of labs at the nuclear physic department are demonstrated in the report.

IMPLEMENTATION OF PORTAL OF NUCLEAR KNOWLEDGE BelNET

S. CHARAPITSA, I. DUBOVSKAYA, A. LOBKO, A. MAZANIK, T. SAVITSKAYA, S. SYTOVA, A. TIMOSHCHENKO
Minsk, Belarusian State University

Keywords: nuclear knowledge management, portal, free software

The International Atomic Energy Agency (IAEA) pays close attention to the problems of nuclear knowledge management. Nowadays under the auspices of the IAEA numerous national and international portals of nuclear knowledge are created in Europe, Asia, Africa, America. It is planned to create a network of information resources on nuclear knowledge. This means that a unified information space in the field of nuclear knowledge is forming in the world. Every developed country with its own nuclear industry has to create and maintain a national portal of nuclear knowledge, integrated into the global system of nuclear knowledge management. In Belarus at present, in connection with the construction of nuclear power plant several websites of individual agencies provide some information on nuclear subjects, that is far from completeness.

The development of computer technology, new requirements for the volume, complexity and speed of information transfer, as well as the rapid growth of mobile applications with specific requirements on the amount and form of presentation are constantly formulating requests for new effective algorithmic, architectural and software solutions. Portal of nuclear knowledge should be complex programming system based on such modern technologies.

BSU is currently developing an educational and research web portal nuclear knowledge BelNET (***Bel***arusian *N*uclear ***E***ducation and ***T***raining Portal). In the future, this specialized electronic portal could grow into a national portal of nuclear knowledge. Currently, the concept of the portal BelNET, its structure and taxonomy are developed. Analysis of the requirements and conditions for its functioning was done. The information model and architecture of the portal, as well as algorithms and methods of software implementation are realized. At present, software of portal BelNET implemented all the basic functions of the portal, including the ability to remotely (via the Internet) open content editing, sorting functions, filters, etc. Filling of portal BelNET by knowledge is at the beginning.

Software of portal BelNET is free software based on electronic system eLab of client-server architecture . The system runs under Windows and Linux in web-based multiplayer mode, with the separation of access rights through widespread browsers: Internet Explorer, Mozilla Firefox, Google Chrome, Opera, and others. Portal BelNET is available at http://lar.inpnet.net/el/belnet/.

COMPARISON OF ADULT REFERENCE VOXEL PHANTOMS WITH UF-NCI SERIES HYBRID VOXEL PHANTOMS

K. MAKAREVICH, V. MINENKO, K. VIARENICH, S. KUTEN
Minsk, Research Institute for Nuclear Problems of BSU

Keywords: voxel phantom of a human, hybrid phantom of a human, ICRP

ICRP Publication 110 provides new reference voxel computational phantoms of adult male and female. These phantoms were created using CT images of Caucasian man and woman with height and weight close to average. These phantoms match all the reference organ masses that are provided in ICRP publication 89. Reference phantoms have more than 140 various tissues segmented, which correspond to the human body composition not only from the point of view of geometry, shape and location but also in their chemical composition and density. Unfortunately this publication doesn't include phantoms of children.

Meanwhile Bolch and Lee developed a series of hybrid phantoms based on CT images of average Americans (UF-NCI series). Hybrid phantoms are described using sophisticated 3D surfaces that closely describe shape of internal organs and outer shape of human body. UF-NCI series consists not only of adult male and female phantoms but also of phantoms of newborn, child and adolescent both males and females. These phantoms describe human anatomy in more detail, because they include more than 200 various tissues and organs. Hybrid phantom can be converted into a voxel phantom with any desirable voxel resolution. This suggests that UF-NCI series phantoms are more preferable for assessment of doses on patients of various ages.

We considered a number of checks to find out whether the UF-NCI series of phantoms is suitable for dose calculations. As a first step to answer this question we compared reference adult voxel phantoms with hybrid voxel phantoms both for male and female. In the course of this we calculated and compared masses and volumes of all organs and bones, that are segmented in reference and hybrid phantoms. The comparison resulted in the following. Masses and volumes of some organs (brain, heart, liver, thymus and thyroid) didn't vary more than in 15%. But many organs and tissues that are important for effective dose estimation vary more than in 20%, and in some cases as much as 50%. These organs are breasts, gallbladder, bladder and muscle tissue. What concerns bone tissue, many bones differ about 10-20%. Also worth noting, that some tissues are not segmented in hybrid phantoms (such as spongiose tissue, cartilage, lymphatic nodes).

Next step will be comparison of hybrid voxel phantoms of newborn, children and adolescent with reference anatomy data from ICRP publication 89.

But one can decide how these differences are important for effective dose assessment for certain methods and irradiation devices only by calculating dose distributions in organs and tissues for corresponding typical irradiation procedures.

SECONDARY NEUTRONS IN THE BEAM OF BREMSSTRAHLUNG OF MEDICAL LINEAR ACCELERATOR CLINAC 2300C/D

K. VIARENICH, V. MINENKO, S. KUTEN, A. KHRUSHCHINSKY
Minsk, Institute for Nuclear Problems of BSU

Keywords: medical linear accelerator, Monte-Carlo method, photoneutrons

Bremsstrahlung radiation from medical linear accelerators of electrons with energies from 10 to 25 Mev is widely used in modern methods of irradiation of malignant tumors. Practically all oncology clinics in Belarus successfully use new methods of modulated irradiation such as intensity modulated radio therapy (IMRT) and Volumetric modulated arc therapy (VMAT). But the use of high-energy radiation in these methods is connected to occurrence of undesirable neutron radiation with higher fluxes than in ordinary irradiation methods.

Neutron radiation is emitted by the target, filter and other elements of accelerator head during beam formation of photons with energy higher than 10 MeV. Neutrons are emitted due to photonuclear reactions, when energy of incident photon is higher than threshold energy of (γ,n) reaction. The threshold and cross-section of the reaction vary depending on the atomic number of the material. That's why the main sources of photoneutron emitting are elements of accelerator head which are made of high-Z materials (tungsten and lead).

Neutron radiation is especially dangerous because of its high biological effectiveness which is a dozen times higher than that of photon radiation. Because of its danger neutron radiation it's important to know contribution of neutrons into therapy beam for patient dose estimation as well as its contribution to scattered radiation inside and outside the treatment room for estimation of irradiation doses of personnel and public.

Due to several reasons experimental investigations of neutron fields in working area of accelerator are difficult to perform, that's why these fields are studied mainly using particle transport modelling using Monte-Carlo methods.

Using MCNP Monte-Carlo particle transport modelling computer code we made a detailed model of accelerator head and performed estimations of secondary neutrons field around medical linear accelerator Clinac-2300C/D with electron energy 18 MeV in treatment room of Belarusian Republic Centre of Oncology. The photon fluence, dose distribution profile of the reference field (10x10 cm^2 at the isocenter) were calculated. Inhomogeneity and symmetry were estimated.

Average energies of neutrons coming from the accelerator head were calculated. Neutron fluxes in reference points around the accelerator head and near the walls of the treatment room were obtained. Average neutron energies at the points around the accelerator head were ranged from 0,5 to 0,7 MeV for the 10x10 cm^2 field.

THE DISPERSION OF THE PULSE AMPLITUDES OF IONIZATION FISSION CHAMBERS DUE TO THE CHARACTERISTICS OF ^{235}U FISSION FRAGMENTS VARIATION

A. KHRUSHCHINSKY, S. KUTEN
Research Institute for Nuclear Problems of Belarusian State University, Minsk, Belarus, Ph. D.
P. SPERANSKY
Department for Nuclear and Radiation Safety of the Ministry for Emergency Situations of the Republic of Belarus, Minsk, Belarus, MSc.

Keywords: ionization fission chamber, WWER, power level control, Bethe-Bloch formula, amplitudes of ionization pulse.

In pressurized water reactors WWER main way of in operation control of power level is a measurement of the neutron flux distribution with ionization chambers placed in the channels of the concrete reactor cavity and instrumental channels of fuel assemblies. Neutron entering the radiator of the ionization fission chamber (the electrode coated with a thin layer of uranium) with a certain probability causes fission of uranium what produces a number of fragments flying around in various directions. Some of them gets into the working chamber volume and cause a strong gas ionization along the track which is determined by the charge (Z), the mass (M) and energy (E) of the fragment, as well as by the properties of the working gas. We would consider argon to be the working gas. The dependence of the charge created by fragments with the Z, M and E characteristics variation leads to a statistical dispersion of the electric pulse values which is important for the chamber operating in pulsed mode (this mode is considered below).

Two conventional programs GEF [1] (a general description of fission observables) and SRIM [2] (the stopping and range of ions in matter) were used to calculate the distribution of the ionization pulse amplitudes for the case when the incident neutrons has homoenergetic thermal spectrum (E=0.25 eV and E=0.025 eV), the spectrum of neutrons typical for VVER-1000, Watt spectrum for the ionization chambers based on uranium 235 with argon under atmospheric pressure as a working gas.

For the first type of incident neutrons there are two well separable peaks on the impulse distribution corresponding to the two humps on the uranium fission fragment curve. The first (smaller by amplitude of ionization) corresponds to fragments with a small values of the charge and mass but high values of energy, and the second (larger by amplitude of ionization) corresponds to fragments with a higher values of charge and mass and low energy value. It is immediate corollary of the fact that the ionization losses in accordance with the Bethe-Bloch formula are proportional to the square of the effective charge, which in turn is proportional to the charge of the nucleus fragments and conversely proportional to the square of the fragment speed.

In the case of Watt spectrum and spectrum of the WWER-1000 only one maximum is present on the distribution function and it is shifted to higher values of total ionization along the fragment track.

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CONTENTS

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