E7-2001-239

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«SANDANSKI-2»: EUROPEAN EAST–WEST COORDINATION MEETING ON NUCLEAR SCIENCE

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Germany

Europhysics Conference

European East-West
Coordination Meeting on Nuclear Science

5 – 9 May 2001, SANDANSKI, Bulgaria

Chairman: W. von Oertzen (EPS-NPB)
Vice-Chairmen: Yu.Ts. Oganessian (JINR), J. Stamenov (INRNE)
Scientific Secretary: R. Kalpakchieva (EPS-NPB and JINR)

Organizing Committee: from NPB – J. Deutsch, A. Kugler, C. Leclercq-Willain, R. Lovas, Yu. Novikov, R.A. Ricci,
from JINR – A.N. Mezentsev, P.N. Bogoliubov, N.M. Dokalenko
from INRNE – D. Karadjov, M. Milanov, S. Manov, P. Petkov

The Nuclear Physics Board of the European Physical Society, together with the Joint Institute for Nuclear Research (Dubna), the Institute for Nuclear Research and Nuclear Energy (Sofia) and the Committee on the Use of Atomic Energy for Peaceful Purposes (Bulgaria), organized an **"East-West Coordination Meeting on Nuclear Science"**. The meeting took place in the town of Sandanski (Bulgaria) from 5 – 9 May 2001 and was the second of this type.

The aim of the meeting was to foster and support scientific collaborations in nuclear physics between eastern and western countries, which is among the primary issues in the activities of the European Physical Society and of its Nuclear Physics Division.

For this reason, it was necessary to consider the status of cooperation between the institutes and laboratories in West- and East- Europe in the field of nuclear physics. For the presentations and discussions at the meeting the following topics were accepted:

TOPICS:	Group Leaders
• Nuclear reactions at low and intermediate energies	*G. Auger (F), M. di Toro (I)*
• Radioactive beams and exotic nuclei	*B. Jonson (S), J. Vaagen (N)*
• Heavy and superheavy nuclei	*S. Hofmann (D), A. Sobiczewski (PL)*
• Nuclear spectroscopy	*G. de Angelis (I), P.H. Heenen (B)*
• Fundamental aspects in nuclear physics	*J. Deutsch (B), Ch. Briancon (F)*
• Accelerator applications of nuclear physics	*R. Mach (CZ), M. Pavlovic (SK)*
• Public awareness of nuclear science	*A. van der Woode (NL)*

Each topic had its "Group Leaders", who suggested the reports for the Plenary sessions in the field, which they represented. As indicated in the programme, time was also reserved for Discussion sessions, where, in addition to evaluating the work of the existing collaborations, their scientific aims and future development were discussed. These discussions were also aimed at stimulating the creation of new collaborations.

The Group Leaders finally summarized the status of cooperation between the institutes and laboratories in West and East Europe by drawing up documents, reflecting:

a) The scientific significance of the subject
b) The availability and progress in experimental facilities
c) The collaborating institutes/laboratories and groups, also identifying future collaborations
d) Possible sources of financing the projects
e) The situation of young scientists, both in the East and the West.

One of the final aims of the Sandanski-2 meeting was to outline organizational steps towards addressing financial bodies and authorities in Europe and also National Institutions, so as to encourage the undergoing successful collaborations and to help in the implementation of new collaboration projects.

During the Sandanski-2 meeting a special event took place - the Diplomas and Medals associated with the Lise Meitner Prize for the year 2000 were delivered to Prof. Gottfried Muenzenberg and Prof. Yuri Ts. Oganessian. This new prize for Nuclear Science in the name of Lise Meitner was created by the Nuclear Physics Board of the EPS with sponsorship from the company EURISYS MESURES. The third recipient of the prize Prof. Peter Armbruster (GSI, Darmstadt) had received his diploma and medal earlier. The prize was awarded for their unique work, over a long period, on the synthesis of heavy elements, which has led to the discovery of the new elements in the region of nuclear charges Z=102 to 105 (Dubnium), as well as Bohrium (Z=107), Hassium (Z=108) and Meitnerium (Z=109). These discoveries involved extensive developments of experimental techniques, and the use of a specific reaction mechanism, the "cold" fusion of two heavy nuclei. Because of this work the study of the properties of very heavy elements (Z=108 -118) is a very active field in nuclear science.

Enclosed are the scientific programme of the meeting, the lists of participants and NPB members, a short summary on the Scientific and executive issues on the East – West Collaborations and an Executive summary. Detailed information on the Sandanski-2 Meeting is available on the WEB-site: http://www.sandanski.ru/.

Scientific Programme

May 5 (SATURDAY)

SESSION 1 9:00 - 11:00	**Nuclear reactions at low and intermediate energies** Chairman: W. von Oertzen

OPENING

01-1	Backtraced neutron multiplicities in capture reactions leading to superheavy nuclei *F. Hanappe, Brussels*	- 30 min
01-2	Nuclear rainbows in heavy-ion scattering *H.G. Bohlen, Berlin*	- 30 min
01-3	Fragmentation reverse experiment in Catania with Chimera detector *E. Geraci, Catania*	- 20 min
01-4	Some regularities in the heavy ion reactions of ^{18}O(35 MeV/A) with ^{181}Ta and ^{9}Be. *A.G. Artukh, Dubna*	- 20 min

11:00 - 11:20 **Coffee break**

SESSION 2 11:20 - 12:30	**Accelerator applications of nuclear physics** Chairman: R. Mach

02-1	SAD (Dubna ADTT Project) *V.N. Shvetsov, Dubna*	- 15 min
02-2	Transmutation of ^{129}I from nuclear waste *A. Kugler, Rez near Prague*	- 15 min
02-3	ADTT and fusion related activities at NPI Rez *J. Dobes, Rez near Prague*	- 20 min
02-4	GeV proton induced spallation reactions *D. Hilscher, Berlin*	- 20 min

12:30 - 15:00 **Lunch**

SESSION 3 15:00 - 16:00	**Nuclear reactions at low and intermediate energies** Chairman: R. Lovas

03-1	Fusion and quassifission in reactions with heavy ions *W. Scheid, Giessen*	- 20 min
03-2	Fission time scales from neutrons and gamma rays *R.P. Schmitt, College Station, Texas (USA)*	- 20 min
03-3	*Collective aspects of nuclear dynamics* *S. Aberg, Lund*	- 20 min

16:00 - 16:20 **Coffee break**

SESSION 4	**Public awareness of nuclear science**
16:20 - 17:20	Chairman: J. Deutsch

04-1	Public awareness of nuclear physics *A.van der Woude, Groningen*	- 30 min
04-2	INTAS and its role for developing of the cooperation in Europe *F. Ferrini, Brussels*	- 20 min
04-3	The Russian Foundation for Basic Research and fundamental investigations *A. Kirillin, Moscow*	- 10 min

17:20 - 17:40 **Coffee break**

SESSION 5	**Reports from Institutions**
17:40 - 18:45	Chairman: A. van der Woude

05-1	Exotic nuclear mass distributions studied in East-West collaborations *A. Krasznahorkay, Debrecen*	- 25 min
05-2	Dipole excitations in Ar isotopes *V.V. Voronov, Dubna*	- 20 min
05-3	New JINR neutron source for nuclear physics IREN and its scientific program *W.I. Furman, Dubna*	- 20 min

20:00 ***WELCOME RECEPTION***

May 6 (SUNDAY)

SESSION 6	**Accelerator applications of nuclear physics**
9:00 - 10:10	Chairman: J. Stamenov

06-1	Life science investigations at FLNR's accelerators *S.N. Dmitriev, Dubna*	- 20 min
06-2	Pilot research facility MCIRI for production of stable isotopes by the method of ion cyclotron resonance heating in plasma *A. Karchevsky, Moscow*	- 20 min
06-3	Feasibility study of a Combined Neutron Centre for European Research and Technology *E. Klein, Gif sur Yvette*	- 30 min

10;10-10:30 **Coffee break**

SESSION 7	**Nuclear reactions at low and intermediate energies**
10:30 - 12:10	Chairman: J.B. Natowitz

07-1	Problems in sub-barrier fusion *N. Rowley, Strasbourg*	- 40 min
07-2	Lepton spectroscopy in nuclear collisions at 1-2 AGeV with HADES *J. Friese, Garching*	- 30 min

07-3 Trends in nuclear physics and the role of international collaborations in keeping small centers of nuclear sciences alive - 30 min
Z. Sujkowski, Swierk

12:10 - 13:00 **Lunch**

<u>13:15</u> EXCURSION to Rila Monastery

20:00 ***OFFICIAL DINNER***

May 7 (MONDAY)

SESSION 8 **Heavy and superheavy nuclei**
9:00 - 10:40 Chairman: Yu.Ts. Oganessian

08-1 Heavy nuclei research at the Flerov Laboratory of Nuclear Reactions - 30 min
M.G. Itkis, Dubna

08-2 Prospects of synthesizing superheavy elements at GSI - 30 min
S. Hofmann, Darmstadt

08-3 Search for super heavy elements at GANIL - 20 min
G. Auger, Caen

08-4 A dedicated cw linac for the synthesis of heavy and superheavy nuclei at GSI - 20 min
R. Tiede, Frankfurt am Main

10:40 - 11:00 **Coffee break**

SESSION 9 **Heavy and superheavy nuclei**
11:00 - 13:05 Chairman: A. Sobiczewski

09-1 The SHIPTRAP project: A capture and storage facility for heavy radionuclides from SHIP - 20 min
G. Marx, Darmstadt

09-2 Nuclear structure and formation mechanism of heavy shell-stabilized nuclei - 25 min
P. Reiter, Garching

09-3 Fusion Mechanisms of Synthesis of Heavy and Superheavy Elements - 20 min
Y. Abe, Kyoto

09-4 Synthesis of superheavy nuclei. Theoretical problems standing on the way - 20 min
V.I. Zagrebaev, Dubna

09-5 Properties of superheavy nuclei predicted by microscopic mean-field calculations - 20 min
P.H. Heenen, Brussels

09-6 Superheavies in mean-field theories - 20 min
Th. Buervenich, Frankfurt/M

13:10 - 15:00 **Lunch**

SESSION 10 **Heavy and superheavy nuclei**
15:00 - 16:40 Chairman: G. Muenzenberg

10-1 On-line gas chemistry as a tool to study nuclear decay properties and the chemical behaviour of heaviest elements - 25 min
H. Gaeggeler, Villigen

10-2 Progress in the theoretical study of the chemistry of heaviest elements - 25 min
V. Pershina, Darmstadt

Nuclear spectroscopy

10-3 RISING - Rare Isotope Spectroscopic Investigations at GSI - 25 min
H.J. Wollersheim, Darmstadt

10-4 Nuclear structures in light mass N=Z nuclei - 25 min
D. Napoli, Legnaro

16:40 - 17:00 Coffee break

SESSION 11 **Nuclear spectroscopy**
17:00 - 18:30 Chairman: C. Leclercq-Willain

11-1 Nuclear shapes studies with EB, RFD and HECTOR devices - 25 min
A. Maj, Krakow

11-2 Projects at the Tandem Accelerator in Cologne - 25 min
J. Jolie, Koeln

11-3 Quadrupole deformations of drip-line nuclei - 20 min
M.V. Stoitsov, Sofia

11-4 Spectroscopic studies of the heaviest nuclei with N~Z - 20 min
D. Bucurescu, Bucharest

18:30 Attribution of the *Lise Meitner Prize*

May 8 (TUESDAY)

SESSION 12 **Fundamental aspects in nuclear physics**
9:00 - 10:45 Chairman: S. Jullian

Non-accelerator neutrino physics: **(60 min)**
Coordinators: A.A. Smolnikov and G. Szklarz

12-1 Introduction and direct neutrino mass measurements - 20 min
G. Szklarz, Orsay

12-2 Double beta-decay:
NEMO-experiment - *O.I. Kochetov, Dubna* - 10 min
Ge-experiments and Xe exp. Project - *A.A. Smolnikov, Dubna* - 10 min

12-3 Solar neutrino - *A.A. Smolnikov, Dubna* - 10 min

12-4 + short contributions: - 10 min
TGV - *V.G. Egorov, Dubna;*
Neutrino magnetic moment - *L. Bogdanova (Moscow)*

Weak interactions at low- and intermediate energy: **(45 min)**
Coordinators: V.G. Egorov and N. Severijns

12-5 Introduction - 25 min
Symmetry tests in nuclear beta-decay
N. Severijns (Leuven), O. Naviliat (Caen)

12-6 Fundamental symmetries in muon capture - 20 min
V.G. Egorov, Dubna

10:45 - 11:05 **Coffee break**

SESSION 13 **Fundamental aspects in nuclear physics**
11:05 - 12:20 Chairman: Yu.V. Gaponov

Fundamental properties of the neutron: **(75 min)**
Coordinators: H.Börner (V. Nesvizhevsky) and Yu.V. Gaponov

13-1 Introduction - Symmetry tests in neutron decay - 15 min
V. Nesvizhevsky, Grenoble

13-2 Studies with ultra cold neutrons - 20 min
M. Pendlebury, Brighton

13-3 Prospects of neutron EDM experiment at PSI - 15 min
A. Serebrov, Gatchina

13-4 Studies with ultra cold neutrons - 10 min
M. van der Grinten

13-5 + short contributions (5 min each): *G.V.Danilyan, V.V.Fedorov, V.R.Skoy* - 15 min

12:20-15:00 **Lunch**

SESSION 14 **Parallel Sessions by Topics**
15:00 – 16:40 Chairmen: The Group Leaders

Heavy and Superheavy Elements **Conference Hall**
Nuclear Spectroscopy

With contributions by:
a) Present status of heavy element research in Japan
H.Kudo, Niigata
b) Quadrupole moment measurements from Leuven & Sofia
D.Balabanski, Sofia

Nuclear Reactions **Blue Hall**
RIB and Exotic Nuclei

Fundamental Aspects **OrgComm Hall**
Accelerator Applications

16:40 – 17:00 **Coffee break**

SESSION 15 **Parallel Sessions by Topics (Continuation)** as in Session 14
17:00 - 18:30 Chairmen: The Group Leaders

18:30 **Meeting of the Group Leaders and the NPB East-West Task Force (OrgComm Hall)**

May 9 (WEDNESDAY)

SESSION 16 **Radioactive beams and exotic nuclei**
9:00 - 11:00 Chairman: Yu.N. Novikov

16-1	Exotic nuclei from projectile fragmentation - the GSI program and its future perspectives *G. Muenzenberg, Darmstadt*	- 40 min
16-2	Status of the Dubna Radioactive Beams project (DRIBs). The physics research program. *Yu.Ts. Oganessian, Dubna*	- 40 min
16-3	Present status and perspectives of experiments with RNBs at GANIL *M. Lewitowicz, Caen*	- 40 min

11:00 - 11:20 Coffee break

SESSION 17 **Radioactive beams and exotic nuclei**
11:20 - 12:50 Chairman: N. Rowley

17-1	A case study: Achievements in an East-West collaboration – the RNBT (Russian-Nordic-British Theory) collaboration *J. Vaagen, Bergen*	- 30 min
17-2	Preliminary results of the first experiment with a cyclotron primary exotic beam: the t+t reaction *G.M. Ter-Akopian, Dubna*	- 20 min
17-3	What can we learn from fragmentation of halo nuclei? *L. Chulkov, Darmstadt & Moscow*	- 20 min
17-4	Relativistic Hartree-Bogoliubov theory and applications to exotic nuclei and superheavy nuclei *G. Lalazissis, Thessaloniki*	- 20 min

12:50 - 14:30 Lunch

SESSION 18 **Summary and Discussion**
14:30 - 15:00 **Chairmen: W. von Oertzen, Yu. Oganessian, J. Stamenov**

CLOSING

15:15 ***EXCURSION to Rozhen***

A Short Summary on the Scientific and Executive Issues

Compiled from individual contributions by W. von Oertzen,
chairman of the EPS Nuclear Physics Board

East-West collaborations in different fields in nuclear science have presented their work during the 5 days of the Meeting from 05.05.01 to 09.05.01. There have been 115 participants and 66 reports, but still the organizers could not aspire to cover all subjects of nuclear science. Therefore the list of subjects was an operational selection, which gives a good overview on the strength of nuclear science in Europe. To mention a few subjects, which were missing: there are very large collaborations concerned with the construction and operation of large detection systems, designed for the study of ultra-relativistic nucleus-nucleus collisions, and there are numerous groups engaged in very large scale neutrino detectors. Both projects are at the borderline of particle physics and nuclear physics, and they form a large community, which, however, was not represented at Sandanski. The following list shows the subjects, which were covered in plenary sessions:

1) Nuclear reactions at low and intermediate energies
2) Radioactive beams and exotic nuclei
3) Heavy and super-heavy nuclei
4) Nuclear spectroscopy
5) Fundamental aspects in nuclear physics
6) Accelerator applications of nuclear physics
7) Public awareness of nuclear science

With this selection, the strength of European nuclear science has been made visible. Also lines of research for the further development can be defined on the basis of the very successful work, which has been performed in strong east-west collaboration. We refer to the proceedings of the Sandanski meeting as **a complete slide report** to be found under the address: http://www.sandanski.ru.

The physics community in Europe has now at its disposal stable beams at accelerators in the low energy regime of 3-8 MeVA in Belgium, France (Vivitron-Tandem), Italy (Tandem accelerators in Legnaro and Catania) and Germany (Tandem accelerators in Cologne and Munich); further a well-balanced choice of medium energy accelerators are in full operation, mostly heavy ion cyclotrons at Jyväskyla (Finland), CYCLONE at Louvain (B), LNS (Catania, I), at HMI (Berlin, D) and at JINR (Dubna). Accelerators for very heavy ions are available at GANIL (Caen, F) and at higher energies at GSI (Darmstadt, D) all these institutions have pursued research programmes in bi-national and larger co-operations.

The topic of ***nuclear reactions*** is a very general subject. There are well-defined issues where European nuclear science has played a leading role. The aim of nuclear reaction studies is to understand completely the dynamics of the strongly interacting nuclear matter, to study the equation of state as a function of its density and temperature and to use the interplay of nuclear dynamics and nuclear structure in the production of new nuclides and elements giving access to the study of their structural spectroscopic properties.

In the last years the improvement of accelerators and detectors and the possibility of using unstable beams has largely increased the amount of unique results in the field in Europe with substantial contributions from East-West collaborations. We have seen this at the meeting in many reports involving nuclear reactions on the following topics:

- Structure of exotic light ions
- Elastic scattering and cold EOS
- Hot nuclei and collective response under extreme conditions
- Fusion-fission dynamics
- Liquid-gas phase transition and multi-fragmentation
- Production of unstable secondary beams
- Isospin dynamics: from neutron skin to neutron stars
- Hadron properties in hot and dense nuclear matter

For the future we can foresee a further development of nuclear reaction studies with unstable beams. Attention will be paid at the future Radioactive Ion Beam facilities of GSI and of the EURISOL project, which will allow studying new phases of the asymmetric nuclear matter, also in high baryon density regions. The complete understanding of the fusion reactions at the Coulomb barrier and below has remained the subject of intensive activity both experimentally and theoretically. It became of primary importance for the production of the heaviest elements, which will be made visible under the subject of heavy and super-heavy elements. We stress the importance of the participation of eastern teams to the success of these collaborations. Further, the nuclear reaction studies are organized in big collaborations; the ones that have been presented at the meeting are listed below:

The HADES project: Hadron properties in strongly interacting matter. The experiment, planned at the GSI, has been set up over the past 6 years by a European collaboration of about 120 scientists in 19 institutions from 9 countries. The size of the collaboration and the time-scale for the hardware set-up reflect the complexity and the technological challenges of the project. Without the high level contributions from collaboration partners in Bratislava (Slovakia), Cracow (Poland), Dubna, RAS, ITEP and MEPHI (Russia), Rez (Czech Rep.) the experiment could not have been performed. The project was supported by INTAS, NATO, EC, WTZ and national funds.

The INDRA Project (GANIL): Dynamics and Thermodynamics of nuclear fragmentation. Fragmentation events are of great interest for the study of transport properties of nuclear matter and of its liquid-gas phase transition. INDRA represents a 4-π detector for charged reaction products. We emphasize the very fruitful collaborations with groups from eastern countries:

- Convention CNRS (F)-Academy of Sciences of Romania
- Convention IN2P3-IFIN (Romania)
- Network MENRT (F) “France-Poland-Romania-Croatia”

The main results, with a great international resonance, have been: evidence for vaporisation events; evidence of a new dissipation mechanisms; evidence of a spinodal decomposition contribution in multi-fragmentation events as a clear signature of a first order phase transition.

The CHIMERA Project (Catania): Isospin effects on the fragmentation process of nuclei. CHIMERA is a new generation 4-π detector, with 94% coverage of the solid angle, high granularity (1192 detection modules), low detection thresholds and good mass resolution up to around 40 mass units. The last point is for studies of reactions with different total isospin, which can give direct information on the symmetry term in the nuclear equation of state. The first experimental run performed in March/April 2000 has produced first results: A stiff behaviour of the symmetry term of the nuclear EOS, a fact that is of interest for the neutron skin of heavy elements as well as for neutron stars.

The COMBAS separator (Dubna): Projectile fragmentation mechanisms.
The COMBAS 8-magnets system allows the separation and study of nuclear products emitted at forward angles (within 6 msr) in projectile fragmentation reactions. The device was set up at the FLNR of JINR-Dubna in order to optimize the production of secondary unstable ion beams. It represents a collaboration between JINR-Dubna, INR-Kiev, INP-Cracow, GSI-Darmstadt and LNS-Catania and is supported by INTAS (93-496 and 99-1780) and by RFBR (96-02-17214). The apparatus was completed at the end of 1999 and data from ^{18}O collisions at 35 AMeV have been presented at the Sandanski meeting. Some interesting features have been found, like:

- The presence of a large dissipative mechanism.
- Clear neutron enrichment in the case of the heavier target, and
- Evidence of a complex reaction mechanism with deviations from the widely used LISE fragmentation code.

Some conclusions from the nuclear reactions group:

The European Agencies should: Increase the possibility to exchange students, post-docs and young physicists. Support also smaller groups at universities and institutes, with the capability to educate students. Stimulate joint theory-experiment proposals. The National Agencies in addition should help the collaborations by introducing formal Exchange Schemes, and reduce the disadvantages (in social security and pension funds) for medium term stays outside the home institute.

European laboratories have played the leading role in experimental and theoretical work on the synthesis of new ***heavy and superheavy elements***. European nuclear scientists will certainly keep their internationally leading role and strengthen their mutual collaborations in the field of heavy and super-heavy nuclei. The work originally concentrated around the laboratories GSI (Darmstadt) and JINR (Dubna), in close collaboration with groups from many other research centers and universities. As a result we have witnessed a unique success story in the discovery of elements in the region from Z=106-116. Studies for the synthesis of super-heavy elements have now been accomplished also at GANIL and were also reported at Sandanski 2. In the last decade, the investigations in this field have gained new impetus from instrumental and accelerator developments.

East-West collaboration has been essential in this domain, both in experiments and in theoretical work. Extensive theoretical studies of structure and such properties as deformation, mass, alpha-decay energies and half-lives, fission barriers and the associated half-lives of super-heavy nuclei have been done. A large region of nuclei with proton number Z=82-130 and neutron number N=126-190 has been considered, covering nuclei already known (to test theoretical methods) and nuclei to be synthesized (to give guiding lines to experiments). Extensive studies of the mechanism of reactions leading to production of super-heavy nuclei have been done in various approaches.

The experiments supported by INTAS started in 1998 with a study of element 112. These preparatory experiments resulted in the discovery of element 114 in the same year. Subsequent irradiations in 2000 led to the identification of element 116 by observation of one decay chain (further two chains were found in May 2001). These results represent a first step into the theoretically predicted region of spherical super-heavy nuclei. Many new results have been obtained in the study of fusion-fission dynamics with the use of the CORSET and DEMON devices.

Chemical studies of Rf, Sg and Bh have been performed in order to investigate whether relativistic effects alter the chemical properties of these elements. This joint effort was very successful and allowed to position these elements in the periodic table. Theoretical studies of the relativistic effects in the chemical properties of super-heavy nuclei have also been extensively studied.

From the various presentations given at Sandanski-2 we can anticipate an intensified activity in the field of super-heavy nuclei in the next decade:
In theory, experiments and chemistry: In calculations of the properties of even-even, odd and odd-odd heavy nuclei; theoretical studies of the properties of spherical super-heavy nuclei, to the region of which experimental studies have been recently significantly approached; theory of the synthesis of super-heavy nuclei. The main instruments for the experiments are available now: the time-of-flight detector system CORSET plus the neutron detection system DEMON, the separators VASILISSA and DGFRS at FLNR, SHIP at GSI, LISE at GANIL, RITU at JYFL, GARIS at RIKEN and RMS at JAERI. Preparations are underway to study reactions with radioactive beams. In chemistry, future effort will concentrate on first-ever chemical studies of Hs and element 112.

Nuclear science has continued to produce a wide spectrum of new and sophisticated instrumentation and a steady development of accelerator techniques. ***Accelerator applications*** have flourished enormously in the last decade. From the list of ion beam applications of nuclear science we mention two major developments:

1) One of the most outstanding recent achievements is connected to the application of hadron beams for cancer therapy. In Europe proton beams from nuclear physics accelerators are used for the cancer (melanoma) of the eye at the IPN Orsay (F), HMI-Berlin (D), PSI (CH) and are in preparation at LNS-Catania (I) and in several eastern European countries. Cancer therapy with higher energies penetrating into a depth of 5 cm and more in the human body tissue have been started with proton beams at IPN (Orsay) and with heavy ion beams of 200 MeVA (^{12}C ions) at GSI-Darmstadt (D). It can be foreseen that in the next 10 years this application will be widely spread and collaborations should be supported via national and trans-national European institutions.
2) Ion beam accelerators have reached a technical status, where they are operated with high intensity and high stability for experiments and operation of long duration. Protons with mA's beam current at PSI (CH) are used for a neutron-spallation source, heavy ions at GANIL and GSI with currents of more than 1.00 μA-particles – for the production of radioactive secondary beams or in the synthesis of heavy elements. Many industrial applications with high intensity beams are starting to be realized. The plans for neutron sources as spallation sources (Austron, ESS, Rutherford Lab. and others) are based on this development. Other directions, which are pursued in several countries, aim at accelerator driven under-critical fission reactors for energy production and transmutation of nuclear waste.

The nucleus as the scene of the Three ***fundamental interactions*** (electromagnetic, weak and strong) has served as a unique laboratory for the study of their symmetry properties and their relation to the structure of small quantal systems. There are actually several possibilities to search for physics beyond the Standard Model of elementary particles by observations of rare decays (non-accelerator neutrino physics and low level counting experiments in underground laboratories). Important insights are gained by symmetry tests related to nuclear β-decay and μ–capture and a wide spectrum of fundamental experiments with neutrons is pursued at reactors. This field of research has a long tradition of collaborating groups from the East and the West. They are based on large laboratories in the East, such as Gatchina (St. Petersburg), and in the West at PSI (CH) and ILL (Grenoble). The unique underground Grand Sasso laboratories in Italy are preparing for an extended study in various experiments with long duration and very low background.

We can draw the following conclusions; they are listed by the 3 sub-topics:

i) Non-accelerator neutrino physics. East-West collaborations play a central role in the investigations of the solar neutrino deficit and the neutrino-less double beta decay, as well as in direct neutrino mass measurements. Two points are worth mentioning: The availability of large amounts of various separated isotopes is crucial. In that respect the Kurchatov-JINR joint project MCIRI of isotope separation in large quantities, using the Ion Cyclotron Resonance method is very promising. This field needs a strong support from nuclear theory.

ii) Symmetry-tests in nuclear beta-decay and muon-capture.
East-West collaborations are very efficient and continue to develop. It seems however that the number of collaborating teams could be increased in view of the interest in the field and the novel experimental infrastructures and possibilities available. The theoretical support to these experiments could and should also be increased.

iii) Symmetry-tests performed with neutrons.
These activities have a long-standing successful history and it is expected that they will further continue and even grow taking into account the planned experiments and projects. We shall mention a few important points:

- For the physics programme with cold neutrons it is necessary to increase the available beam time at ILL in order to accommodate the experiments of East-West collaborations.
- With the out-phasing of the JINR IBR30, the IREN facility at JINR becomes essential. It will provide unique opportunities for a broad spectrum of activities in the field of fundamental and applied nuclear physics.
- The community is also looking forward to the completion of the high-flux PIK- PNPI reactor and for the new instrumentation at the recently constructed Munich reactor.
- All initiatives for increasing the available density of UCN should be pursued with vigour.
- Attention should be also paid to good theoretical support for searches of new physics beyond the Standard Model, including the electromagnetic corrections in both the Standard Model theory and in the different scenarios beyond it as well as in UCN physics.

The recent technical break-through realized in the field of ***nuclear spectroscopy*** due to the development and operation of big Ge arrays, like EUROBALL, Gammasphere or GASP, has boosted a renewed interest in the field. Both in experimental and theoretical physics new developments have appeared, as well as new aspects related to nuclear astrophysics have emerged as a very important field in nuclear science. Investigations in this latter field are a consistent part of the present experimental programmes at the major heavy ion beam facilities in Europe and represent one of the major issues for the experimentation with the future unstable beam accelerators.

Co-operation between eastern and western countries in the field of Nuclear Spectroscopy, existing already since many years, is often, but not always, related to large multi-national collaborations. Most east-west collaborations are based on mutual agreements on a bilateral base. The funding is based on local (agreements between laboratories), national (local funding agencies), but also EU programmes (mobility provided by Large Scale Facility programmes, investment by Research and Technical Development or Concerted Actions programmes). In many cases technical developments were realized in the eastern laboratories and therefore produced a local support to research activity in the east countries, which is essential both for creation of motivation and attraction to students. Examples are projects like EUROBALL and GASP at LNL (Legnaro, http://www.lnl.infn.it/pages/research.html) and at IRES (Strasbourg, http://ireswww.in2p3.fr), and the projects EXOGAM (http://www.ganil.fr/exogam/) and VAMOS (http://www.ganil.fr/vamos/index.html) at GANIL (Caen) (M.Lewitowicz@ganil.fr), EXOTAG (http://physs118.phys.jyu.fi/exotag.html), R3B at GSI (Darmstadt). The ancillary detectors of EUROBALL in particular offer clear examples of relatively small size technical developments placed in eastern laboratories and used in a broad scientific programme (for more details see: G. de Angelis – Nuclear Spectroscopy slide report - www.sandanski.ru).

Major developments have been seen also in **nuclear structure theory** in the last ten years. The shell model has been extended to the study of medium mass nuclei within realistic bases. The mean field approximation has been extended by new approaches for example in the relativistic mean field approximation. The effect of the coupling between bound and continuum states, as well as the particle unstable nuclei have been also extensively studied. Collaborations in nuclear theory like the RNB, mentioned below, and those based on personal contacts are supported by national and international resources (EU, INTAS, NATO).

Future collaborative activities in nuclear spectroscopy

New perspectives in the field of nuclear spectroscopy are foreseen due to the development of new Ge technology (position-sensitive Ge-detectors, tracking arrays) together with the availability of facilities for unstable nuclear beams. Such as:
a) new collective nuclear modes – new forms of pairing, wobbling motion etc.; b) Isospin symmetries – often used as a means of investigating microscopic aspects of the nuclear structure, mirror nuclei; c) exotic shapes and exotic excitations - shape coexistence phenomena, Jacobi instability, Giant Dipole Resonance built on super deformed shapes, clustering phenomena, etc.

The **Rising** project (Rare Isotope Spectroscopy Investigation at GSI) will use the Euroball composite gamma detectors (clovers and clusters) to investigate important aspects of nuclear physics at the drip-line by means of unstable beams produced by fragmentation reactions or fission at GSI. Three different experimental campaigns are foreseen (http://www-aix.gsi.de/~wolle/EB at GSI/main.html).

Nuclear spectroscopy at low multiplicity will also be investigated by the **Miniball** collaboration, using an array of segmented germanium detectors. Unstable nuclear beams here will be provided by the Rex ISOLDE accelerator (CERN) (http://www.uni-koeln.de). A new project is now starting at LNL using a new germanium array coupled to the large acceptance magnetic spectrometer Prisma (http://www.lnl.infn.it), which uses a ray tracing technique to reconstruct the trajectories of the recoiling nuclei (Napoli@lnl.infn.it).

The technology of germanium detectors has opened the possibility of reconstructing, through the knowledge of the energy and position in the scattering processes, the history of a gamma ray into a germanium crystal. Such tracking devices (The **Mars** project at LNL and the **Agata** project at GSI) act as a directional Compton spectrometer allowing previously unreachable gamma efficiency at high multiplicity (see: http://ikp193.ikp.kfa-juelich.de/tmr98/ and http://axpd30.pd.INFN.it/MARS/index.html).

The study of nuclear magnetic and electric multipole moments far from stability requires spin-oriented radioactive beams. This issue is addressed by the EXOSORBE RTD project for development of exotic spin-oriented radioactive beams, which has been recently submitted to the EU.

An important initiative in this respect is the Research Training Proposal: **New Shells in Exotic Nuclei**, which has been submitted to the EC by a group of 12 different laboratories. This project brings together experimentalists and theoreticians and includes two laboratories from Eastern Europe (Debrecen and Bucharest) both involved in theory and experiment. Its primary goal is to make a significant step forward in the knowledge and understanding of nuclear systems, which are at the edge of nuclear stability (nguyen@ipno.in2p3.fr).

Suggestions concerning the interaction with funding agencies:

Members of the working group are familiar with INTAS, NATO, EU, National and Local funding. Basically all these provide mobility resources for researchers from eastern institutions, some of them also infrastructure investments to be used in the hosting laboratory during the supported period. They all fail in providing infrastructures for the east institutions once the researcher has finished his supported period. A possible solution could be to allocate at the end of the supported period infrastructure resources to the home institutions. In addition, resources for computing possibilities in the home institutions, to allow data analysis, must be approved also.

A word on nuclear Theory:

Nuclear theory is not an isolated field. It is strongly related to research performed in other branches of physics. It plays a decisive role both in the planning of experiments and in the interpretation of their results. Collaborations in nuclear physics must take into account these two features and also the fact that nuclear theory groups are small. Large-scale experimental projects should devote part of their funding to theory. The interactions with experimentalists as well as between theory groups, developing different approaches for the interpretation of experimental data, should be improved.

As a special case with now a successful history of more than 10 years is the Russian Nordic Theory Collaboration (RNB).

RNB Physics – Its Identity

In RNB (Radioactive Nuclear Beam) physics, or drip-line physics, matter is studied at the extremes of nuclear existence. Reactions with dripline nuclei, the essence of RNB physics in practice, are exotic heavy ion reactions for which the theoretical framework is still very incomplete.

Although the triggering discoveries happened in the West, the eastern countries were well prepared for pursuing research. For historic reasons, cluster and few-body aspects of matter had been the subject of much attention, and experiments aimed at creating exotic matter had already been tried at Dubna. A large human resource, an excellent student training program, which often integrated theory and experiment (like that at MSU and Kurchatov Institute as an example), and still usable experimental facilities were present. This became a crucial resource for the development of RNB physics.

1. East-West Asymmetry

The high market value of the Eastern competence has implied a net outflow of intellectual capital. Although it has implied that East European scientists have had a chance to be involved in many more interesting projects, measures have to be taken to prevent erosion of the home base, to avoid a brain drain, which would also hurt the field in Europe as a whole and internationally if the source dries up. East-West joint ventures and collaboration are essential for successful research and future European leadership in RNB physics.

RNB physics has been driven by outstanding experimental discoveries. While these have taken place at major laboratories (you need a radioactive beam!), work on putting the discoveries within a theoretical framework has bloomed at a number of universities. A great number of theses, both experimental and theoretical, have resulted. The scale of RNB physics gives the participants more than just a piece of the cake. The recent theoretical advances have influenced RNB physics conceptually by adding new perspectives (such as from few-body threshold phenomena). The methodology has correspondingly been changed and a theory framework with growing predictive power is emerging.

Our case-study, the RNBT (Russian-Nordic-British Theory) collaboration, has made important contributions, making theory a useful tool for RNB programmes and a guide for experiment.

2. The RNBT Collaboration

At the RNB-1991 conference in Louvain-la-Neuve, theory was hardly visible in the main programme. Among the contributed papers were, however, two which formed the basis of a 1993 Physics Report, to become one of the most cited works in RNB physics, with focus on halo structures, such as that of ^{6}He, named Borromean by the authors. The immediate success of this first major work by the RNBT collaboration showed the need for theory efforts, which could support the rapid experimental development in RNB physics.

3. RNBT is topical. The physics of nuclear halos and their reactions. RNBT has a logo – the Borromean rings. RNBT has a meeting and training forum aimed at young scientists; The HALO'xx Study Weekends, which annually are attended by 50-70 participants. RNBT has involving national, regional and EU programme resources. INTAS has been very helpful, but Eastern mobility has largely depended on Western collaborators.

4. Perspectives and Recommendations

The Sandanski meeting was also about shortcomings and how we may do better. We have already mentioned the developing East-West asymmetry that should be counteracted. INTAS and other funding agencies may be interested in supporting the idea of locating more training of young people in Eastern European countries, providing support for Western participants in eastern institutions.

Only a few Eastern experimental facilities are now up-to-date in RNB physics, Dubna being an outstanding exception. It is of prime importance to keep the Eastern experimental facilities at a high level for science and training.

Large networks of theoreticians should also be developed in order to put together physicists using different but complementary methods. This issue has benefited from the existence of a permanent meeting point, **the ECT* in Trento**, with the possibility to organize easily workshops and collaboration meetings, and it has become the source for collaborations between theoreticians. The number of nuclear theoreticians is in decline, the more it is important that theoreticians from Eastern Europe have easy access to such a meeting point and benefit from support for their travel and living expenses.

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EUROPEAN PHYSICAL SOCIETY
Nuclear Physics Board
The Chairman

A Summary on Issues of East-West Collaborations in Nuclear Science

From the "East-West Coordination meeting on Nuclear Science" in the town of ***Sandanski*** (Bulgaria) from 5 - 9 May 2001, the second of this type.

Organized by:
EPS, Nuclear Physics Board
Joint Institute for Nuclear Research, Dubna
Bulgarian Academy of Sciences - Institute for Nuclear Research and Nuclear Energy, Sofia
Committee on the Use of Atomic Energy for Peaceful Purposes, Bulgaria

The ***Sandanski-2 meeting*** on **East-West collaborations in Nuclear Science** has been held as an EPS-Conference (http://www.sandanski.ru) in May 2001 in the town of **Sandanski (Bulgaria)**, about 6 years after the first meeting of this kind. 115 scientists from 17 European countries, the USA, Japan and the Joint Institute for Nuclear Research in Dubna participated in the meeting. The scientific programme included 66 oral contributions. Thus the Sandanski-2 meeting provided the chance to overview the recent progress achieved in the field of nuclear science. The present date also marks the 10-year period, during which substantial political and economic changes have taken place in Eastern Europe. These changes have had also a decisive impact on the scientific community in these countries, because the support for basic and applied science has decreased dramatically due to the collapse of their economic systems. Nevertheless educational institutions in Eastern Europe have continued to attract motivated young students and have produced well-trained young scientists. It should be also noted that, in spite of the difficult economic situation in the East, there are still good resources - experimental set-ups, technical and scientific manpower, and a well-trained human intellectual reserve. At the present meeting excellent results, obtained there, have been presented. Evidently, the conditions vary in the different eastern countries, and they differ strongly from one to another institute or laboratory. Improving their working conditions is not easy. This statement holds true especially for university laboratories and smaller institutes. Everyone is aware that the future working conditions may become rather unattractive, which in turn is likely to discourage the next generation of students to embark on the study of science.

Collaborations in nuclear science existed in many fields before. However, at the Sandanski-2 meeting it was demonstrated that scientific contacts have been further developed considerably in the last 5 years. Many national and European institutions, having realized the difficult situation of scientists in the East, have installed support programs for the funding of local activities for scientists in their eastern institutions (e. g. The Soros Foundation), or more extensively to fund collaborations between eastern and western scientists (by NATO Science, INTAS, WTZ-Germany, CNRS-France, INFN-Italy, etc.). Many highly experienced scientists working in basic nuclear science now spend their working time in Western Europe, the United States and in Japan. It cannot be overlooked that a major brain drain from the poorer eastern countries in Europe is taking place. These people are of course very welcome in the western institutions; however, in the mid-term a collapse of the scientific community in the east can be anticipated. On the other hand, we must admit that the situation in the West is also disturbing. There, young people go less to physics, and finally most of them go to industry.

The EPS and the Nuclear Physics Board therefore have created particular action committees and "task forces" engaged in issues of east-west collaborations.

At the Sandanski-2 meeting on East-West collaborations in nuclear science the majority of the large collaborations have been present. The scientific program has been organized to cover the major fields of basic science (individual summaries and a shorter summary can also be found under (http://www.sandanski.ru), and it can be summarized by the following items:

1) Nuclear reactions at low and intermediate energies
2) Radioactive beams and exotic nuclei
3) Heavy and super-heavy nuclei
4) Nuclear spectroscopy
5) Fundamental aspects in nuclear physics
6) Accelerator applications of nuclear physics
7) Public awareness of nuclear science

Although the list of these themes does not cover all collaborations, the subjects illustrate the main directions of research in basic nuclear science, which also in the future will play a major role. With this selection, the strength of European nuclear science has been made visible, but also lines of research for the further development can be defined on the basis of the very successful work, work that has been performed in strong East-West collaborations. The future development of these fields is covered in the mentioned separate scientific summaries of the conference (www.sandanski.ru /scientific summary), which have been produced with the help of the participants and group leaders of the Sandanski-2 meeting. The high level of research done in these collaborations is documented in the **complete slide report** to be found on the web-site of the conference, and it is reflected in the fact that the results presented also appear in the first ranks of international research conferences. The contributions of the partner institutions and scientists from the eastern European countries are very important and are well documented in the corresponding presentations.

In these presentations we can see the impact of several very successful national (mostly bilateral) programs for support of research in collaboration with scientists from eastern European research institutions. These have played a major role in stabilizing the scientific communities in the East. There are also trans-national European programs directed to support East-West collaborations, which have been introduced recently. Such programs as INTAS (www.intas.be), NATO Science (www.nato.int/science) support research in nuclear science and have served very well already in the past ten years. It is understandable that this support has been only a part of the total resources needed for any investigation. However, the grants given within these programs have been of great moral importance for the participants. They have been a way to make a specific investigation more visible, they have underlined that it is of major significance and have helped to give it a higher priority in the respective home institutes, etc.

The documentation of the excellence of the research presented at the Sandanski-2 meeting is not a convenient bench to rest upon. It has to be taken as a basis and a signal to make all efforts to co-ordinate and support in the future the activities on a European scale so as to prevent a possible collapse of the scientific communities in the eastern countries in the near future. This gains importance through the pending entries of many eastern countries into the European Union.

Scientific excellence in Europe has been achieved with a large contribution by the scientists from East Europe. European science needs the scientists from the eastern European countries as strong partners in the future. Thus another very important conclusion from the Sandanski-2 meeting is obvious, that these collaborations improve the use of the available European infrastructure resources in a very effective way. The national and European institutions have to increase therefore their funding of collaborations with East Europe, existing successful collaborations have to be further developed and new ones must be created according to the needs of science. This is also needed if a balance is to be achieved in Europe between east and west.

As another possible conclusion from the Sandanski-2 meeting, we forward the recommendation to create European structures for the support of scientists in their eastern home institutions in such a way, that they can return and continue to work at home under appropriate conditions. Conditions, which will allow them to collaborate in European projects and to attract young people into their home institutions.

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60. Napoli D.

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62. Kudo H.

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EAST-WEST COORDINATION MEETING ON NUCLEAR SCIENCE

MAY 5-9, 2001

	Friday 4.05.	Saturday 5.05.	Sunday 6.05.	Monday 7.05.	Tuesday 8.05.	Wednesday 9.05.	Thursday 10.05.
9:00	**EPS-NPB MEETING**	OPENING Hanappe 30'	Dmitriev 20' Karchevsky 20' Klein 30'	Itkis 30' Hofmann 30'	**Non-accelerator neutrino physics:** 60' Szklarz, Smolnikov, Egorov, Kochetov, Bogdanova	Muenzenberg 40' Oganessian 40'	*Departure*
10:00		Bohlen 30' Geraci 20' Artukh 20'	*Coffee Break* Rowley 40'	Auger 20' Tiede 20' *Coffee Break*	**Weak interactions:** 45' Severijns, Egorov, Naviliat *Coffee Break*	Lewitowicz 40'	
11:00		*Coffee Break* Shvetsov 15' Kugler 15'	Friese 30' Sujkowski 30'	Marx 20' Reiter 25' Abe 20'	**Fundam. properties of the neutron:** 75' Nesvizhevsky, Gaponov, Pendlebury, Serebrov, van der Grinten, Danilyan, Fedorov, Skoy	*Coffee Break* Vaagen 30' Ter-Akopian 20'	
12:00		Dobes 20' Hilscher 20'	*Lunch*	Zagrebaev 20' Heenen 20' Buervenich 20'		Chulkov 20' Lalazissis 20'	
13:00		*Lunch*	*Excursion*		*Lunch*		
14:00						**Summary**	
15:00		Scheid 20' Schmitt 20'		Gaeggeler 25' Pershina 25'	**Parallel sessions:** *1) Heavy & superheavy nuclei Nuclear Spectroscopy* Contributions by: Kudo, Balabanski *2) Nuclear Reactions RIB & exotic nuclei* *3) Fundamental aspects Accelerator Applications*	CLOSING	
16:00		Aberg 20' *Coffee Break* van der Woude 30'		Wollersheim 25' Napoli 25' *Coffee Break*	*Coffee Break*		
17:00		Ferrini 20' Kirillin 10' *Coffee Break* Krasznahorkay 25'		Maj 25' Jolie 25'	**Parallel sessions:** *continued*	*Excursion*	
18:00		Voronov 20' Furman 20'		Stoitsov 20' Bucurescu 20' Lise Meitner Prize	Meeting of the Group Leaders and the NPB E-W Task Force		
19:00	19:00-22:00 Arrival Registration *Dinner*			*Dinner*	*Dinner*	*Dinner*	
20:00		*Welcome Reception*	*Official Dinner*				

фон Эрцен В., Калпакчиева Р. E7-2001-239
«Сандански-2»: европейское совещание по сотрудничеству Восток–Запад в области ядерной науки

«Сандански-2» — европейское совещание по сотрудничеству Восток–Запад в области ядерной науки состоялось 5–9 мая 2001 г. в городе Сандански, Болгария. Это второе совещание такого рода. Представлена мотивация его проведения, научная программа, список участников, а также научные и организационные выводы, сделанные на основании 66 докладов. В совещании приняли участие 115 ученых из 17 европейских стран, США, Японии и ОИЯИ. Полную информацию о работе совещания можно получить по адресу: http://www.sandanski.ru/, а также на компакт-диске.

Сообщение Объединенного института ядерных исследований. Дубна, 2001

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von Oertzen W., Kalpakchieva R. E7-2001-239
«Sandanski-2»: European East–West Coordination Meeting on Nuclear Science

«Sandanski-2» is a European East–West Coordination Meeting on Nuclear Science, which took place on the 5–9 May 2001 in the town of Sandanski, Bulgaria. It is the second meeting of this type. Here we present the motivations for holding this meeting, its scientific programme, the list of participants, as well as a short summary of the scientific and executive issues, which were presented by 66 reports. At the meeting 115 scientists from 17 European countries, the USA, Japan and JINR were present. Complete information on the Meeting is available on a CD and can also be found under the address: http://www.sandanski.ru/.

Communication of the Joint Institute for Nuclear Research. Dubna, 2001

Макет Т.Е.Попеко

Получено 08.11.2001. Подписано в печать 12.11.2001
Формат 60 × 90/16. Офсетная печать. Уч.-изд. л. 3,38
Тираж 400. Заказ 52944. Цена 4 р.

Издательский отдел Объединенного института ядерных исследований
Дубна Московской области