

Institute for Nuclear Research and Nuclear Energy Bulgarian Academy of Sciences



2010

**Present
State**

**Future
Prospects**

Short History

The **Physical Institute of the Bulgarian Academy of Sciences (BAS)** was established on 1 July 1946 by academician **Georgi Nadjakov** who became its first director.

JINR, Dubna, was established on 26 March 1956



Acad. G. Nadjakov was signing the Protocol together with 10 representatives of other countries.

An aerial photograph of Sofia, Bulgaria, showing the city's layout and surrounding mountains. A large red oval is drawn over the city center, highlighting the area where the Physical Institute of BAS and later INRNE are located. The text is overlaid on the image.

In the autumn of 1955 the Bulgarian government took a decision to build a research nuclear reactor.

In 1962 the **Physical Institute of BAS** was renamed as the **Physical Institute with a Nuclear Experimental Facility**.

In 1972 it was split into **Institute for Nuclear Research and Nuclear Energy (INRNE)** and Institute of Solid State Physics.

Mission

The Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences is the biggest leading complex centre in Bulgaria for scientific research and applications of the nuclear science and technologies and studies of their interactions with the environment.

Vision

INRNE guarantees a high quality performance of research and innovation activities, addressed to support important national programs, keeping abreast with the modern scientific achievements. With its long standing experience and active collaboration with leading European and International institutions, INRNE contributes to the progress of the physical science.

INSTITUTE FOR NUCLEAR RESEARCH AND NUCLEAR ENERGY

SCIENTIFIC COUNCIL

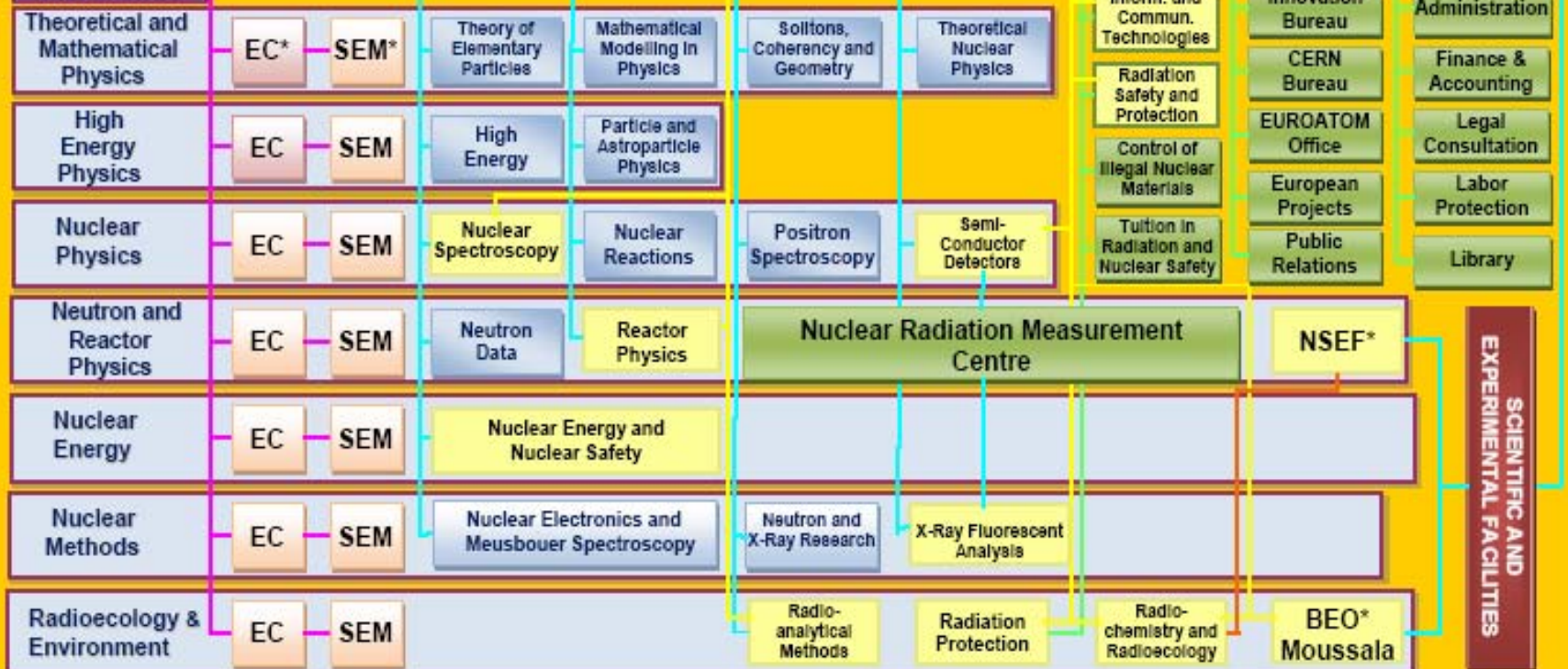
DIRECTORATE

LABORATORIES

NUCLEAR TECHNOLOGICAL
AND EDUCATION CENTRE

DEPARTMENTS

DIVISIONS



SCIENTIFIC AND
EXPERIMENTAL FACILITIES



CERTIFICATE

IQNet and Quality Austria
hereby certify that the organization

**Institute for Nuclear Research and
Nuclear Energy of Bulgarian
Academy of Science**
BG-1784 Sofia, 72, Tsarigradsko Chaussee Blvd

Scope of application:
NSEC, RF, RAM, NPPSA, NFPA, NS, SemiCD, DNI, X-RAYFA, CLRP, BEO, NSRC, IT
has implemented and maintains a

Quality Management System

which fulfills the requirements of the following standard

ISO 9001:2000

Issued on: 2007-08-03
Validity date: 2010-04-08
QA certified since: 2003-06-11
Registration Number: AT-03312/0


René Wasmer
President of IQNet


Viktor Seitschek
BOARD of
Quality Austria



IQNet Partners*:
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CQM China CQS Czech Republic Cso Cert Croatia DQS Germany DS Denmark ELIOT Greece FCIV Brazil
FONDONORMA Venezuela HKQAA Hong Kong China ICONTEC Colombia IMNC Mexico Inspecta Certification Finland
IRAM Argentina JQA Japan KPC Korea MSZT Hungary Nemko AS Norway NSAI Ireland PCDC Poland QMI Canada
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SQS Switzerland SRAC Romania TEST St Petersburg Russia YUQS Serbia
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* The list of IQNet partners is valid at the time of issue of this certificate. Updated information is available under www.iqnet-certification.com



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Academy of Science**
BG-1784 Sofia, 72, Tsarigradsko Chaussee Blvd

Scope of application:
NSEC, RF, RAM, NPPSA, NFPA, NS, SemiCD, DNI, X-RAYFA, CLRP, BEO, NSRC, IT
has implemented and maintains a

Environmental Management System

which fulfills the requirements of the following standard

ISO 14001:2004

Issued on: 2007-08-03
Validity date: 2010-04-08
QA certified since: 2004-04-09
Registration Number: AT-00357/0


René Wasmer
President of IQNet


Viktor Seitschek
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Quality Austria

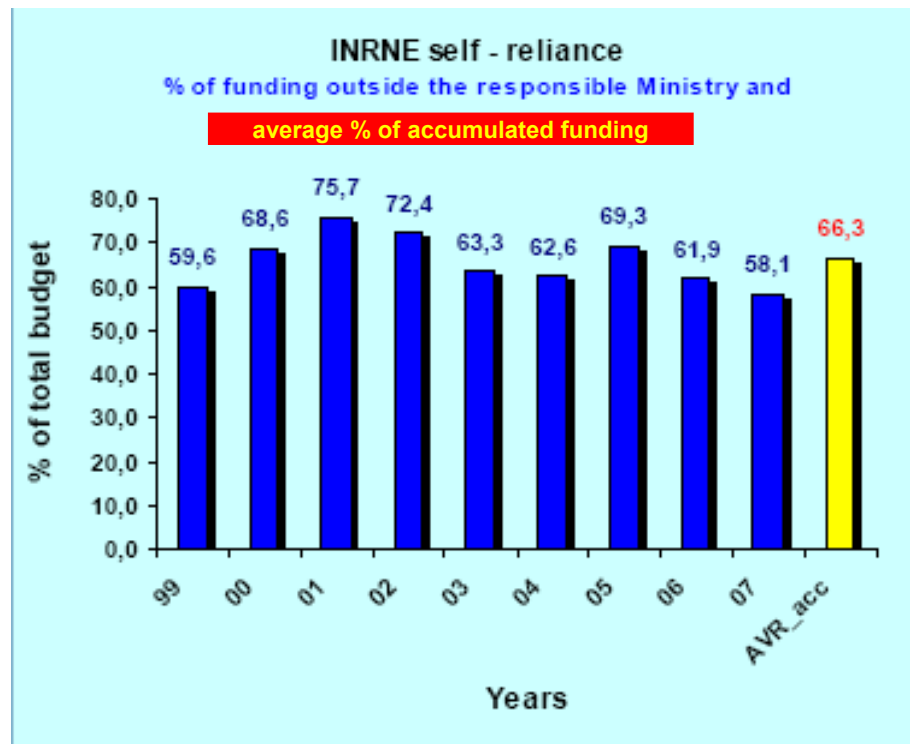
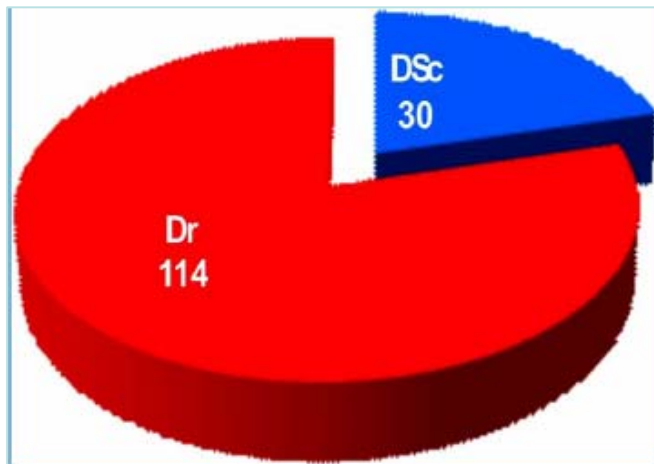
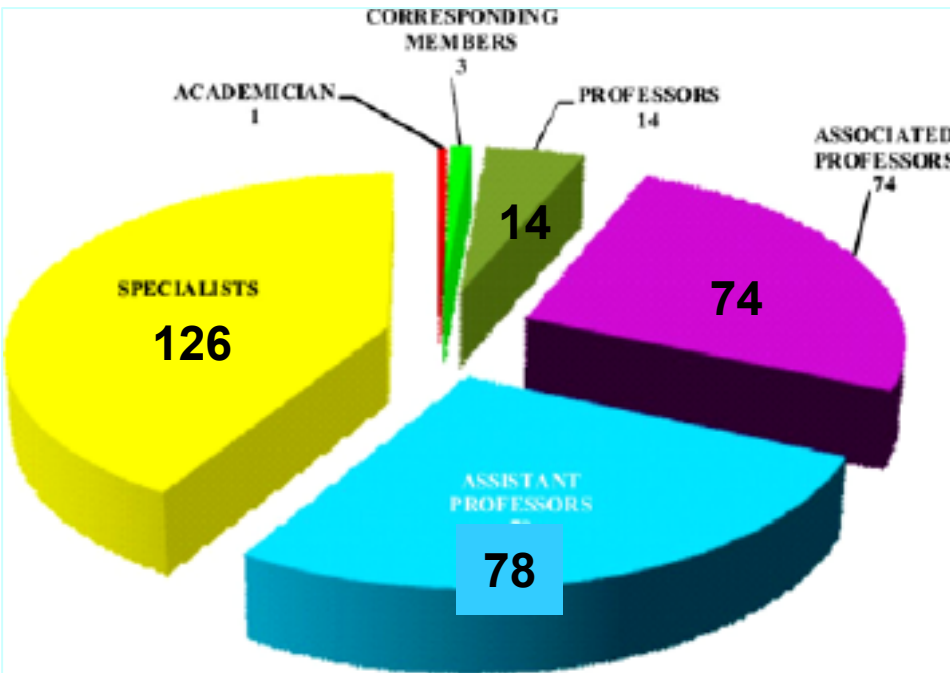


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FONDONORMA Venezuela HKQAA Hong Kong China ICONTEC Colombia IMNC Mexico Inspecta Certification Finland
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Since 2003/2004 INRNE
BAS is certificated
according to

ISO 9001:2000 №3312/0
ISO 14001:2004 №357/0

Staff and Budget



Main Topics of Activities

- Theory of the elementary particles, fields and atomic nuclei
- Nuclear physics and astrophysics
- High energy physics
- Nuclear methods
- Nuclear instrumentation
- Radiochemistry
- Dosimetry and radiation safety
- Neutron physics
- Reactor physics
- Nuclear energy and nuclear safety
- Monitoring and management of environment

Research at the Bulgarian Academy of Sciences

Scores by the 2009 Science Review Committee for INRNE



	Quality and Productivity	Relevance: Socio-economic Impact	Prospects
Unit 1	A	A	A
Unit 2	B	A	B
Unit 3	B	A	B

Unit 1: Theoretical and experimental nuclear and particle physics and astrophysics, including mathematical theory

Unit 2: Applications

Unit 3: Facilities

Recommendations for the whole Institute

- **All three INRNE's Units are currently well placed in the national and international context**, having gained considerable experience in international collaborations
- **Links with industry need developing and strengthening.** Given the number of products already developed by INRNE for practical applications, this should be quite achievable

	Quality and Productivity	Relevance: Socio-economic Impact	Prospects
Institute for Solid State Physics	B	A	A
Institute for Electronics	B	A	B

23 projects in 2009:

- 11 – fundamental problems
- 12 – nuclear energy and safety tasks, other applied and environmental problems
- 14 - supported by national organizations
- 9 - supported by foreign organizations

Publication Activity

Year	2003	2004	2005	2006	2007	2008	2009
Scientific books and monographs	2	1	2	2	2	3	4
Articles in foreign journals	114	144	137	143	191	221	192
Articles in Bulgarian journals	14	13	28	15	39	26	29
Reports in proceedings of conferences held abroad	79	68	99	102	106	120	135
Reports in proceedings of conferences held in Bulgaria	41	39	70	71	59	86	66
Popular science articles and books	21	9	16	15	4	5	6
TOTAL:	271	274	352	348	401	461	432

Collaboration agreements with:

- Faculty of Physics of Sofia University “St. Kliment Ohridski”
- South-West University “Neofit Rilski” (Blagoevgrad)
- American University in Bulgaria (Blagoevgrad)
- Konstantin Preslavsky University of Shoumen
- Technical University (Sofia)
- University of Mining and Geology “St. Ivan Rilski” (Sofia)

Lecture courses on:

general physics, quantum mechanics, astrophysics, biophysics, radiochemistry, isotope geology, nuclear electronics and other subject

The INRNE has a programme accreditation from the National Evaluation and Accreditation Agency for Doctor's degree in the following scientific disciplines:

- 01.03.01 Theoretical and Mathematical Physics
- 01.03.04 Nuclear Physics
- 01.03.05 Physics of Elementary Particles and High Energies
- 01.03.06 Neutron Physics and Physics of Nuclear Reactors
- 01.05.12 Radiochemistry
- 02.06.04 Nuclear Reactors



OPERATIONAL PROGRAMME "HUMAN RESOURCES DEVELOPMENT"

**CONTRACT BG051PO001/07/3.3-02/53/17.06.2008:
Fundamental and Applied Nuclear Research**

Specific goals:

- o Fostering the interdisciplinary cooperation among the young scientists at INRNE and FMI at Sofia University
- o Improving the quality of life and working conditions of the young scientists
- o Fostering the scientific contacts of the young scientists through participation in international conferences
- o Training the young scientists in scientific communication through active participation in scientific seminars



Bulgarian Academy of Sciences Institute for Nuclear Research and Nuclear Energy International collaboration



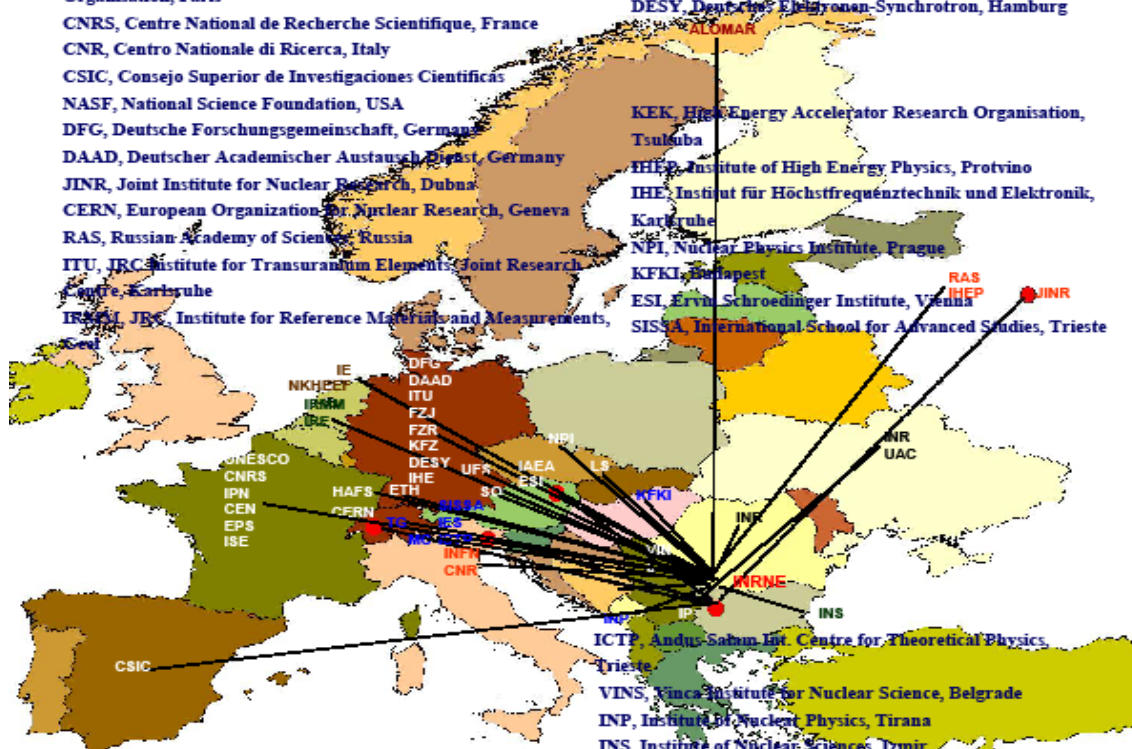
IAEA, International Atomic Energy Agency, Vienna
UNESCO, United Nations Educational, Scientific and Cultural
Organisation, Paris

ETH, Eidgenössische Technische Hochschule, Zuerich
MIT, Massachusetts Institute of Technology
DESY, Deutscher Elektronen-Synchrotron, Hamburg

CNRS, Centre National de Recherche Scientifique, France
CNR, Centro Nazionale di Ricerca, Italy
CSIC, Consejo Superior de Investigaciones Científicas
NASF, National Science Foundation, USA
DFG, Deutsche Forschungsgemeinschaft, Germany
DAAD, Deutscher Akademischer Austausch Dienst, Germany
JINR, Joint Institute for Nuclear Research, Dubna
CERN, European Organization for Nuclear Research, Geneva
RAS, Russian Academy of Sciences, Russia

KEK, High Energy Accelerator Research Organisation,
Tsukuba
IHEP, Institute of High Energy Physics, Protvino
IHE, Institut für Höchstfrequenztechnik und Elektronik,
Karlsruhe
NPI, Nuclear Physics Institute, Prague
KFKI, Budapest
ESI, Erwin Schrodinger Institute, Vienna
SISSA, International School for Advanced Studies, Trieste

ITU, JRC, Institute for Transuranium Elements, Joint Research
Centre, Karlsruhe
IRMM, Institute for Reference Materials and Measurements,
Geel

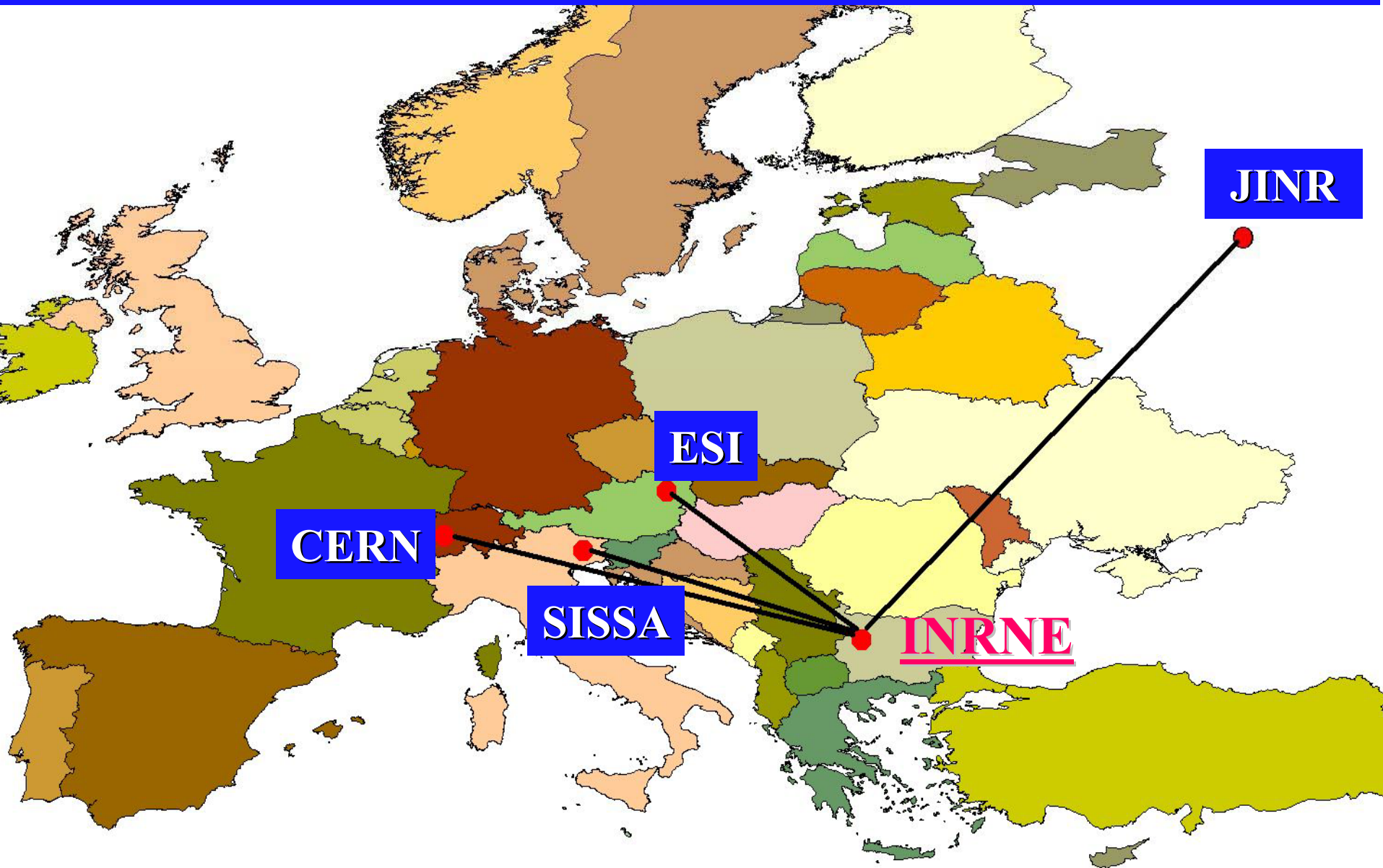


IE, JRC, Institute for Energy, Petten
IES, JRC, Institute for Environment and Sustainability
FZJ, Forschungszentrum Jülich, Jülich
FZR, Forschungszentrum Rossendorf, Rossendorf
KFZ, Karlsruhe Forschungszentrum, Karlsruhe
IRE, Institut National des Radioéléments, Fleurus
IPN, Insitute Physique Nuclaire, Orsey
CEN, Centre d'Etudes Nucléaire de Saclay, Saclay
FERMILAB, Fermi National Accelerator Laboratory, Batavia
INFN, Istituto Nazionale di Fisica Nucleare, Italy
NIKHEEF, the Netherlands

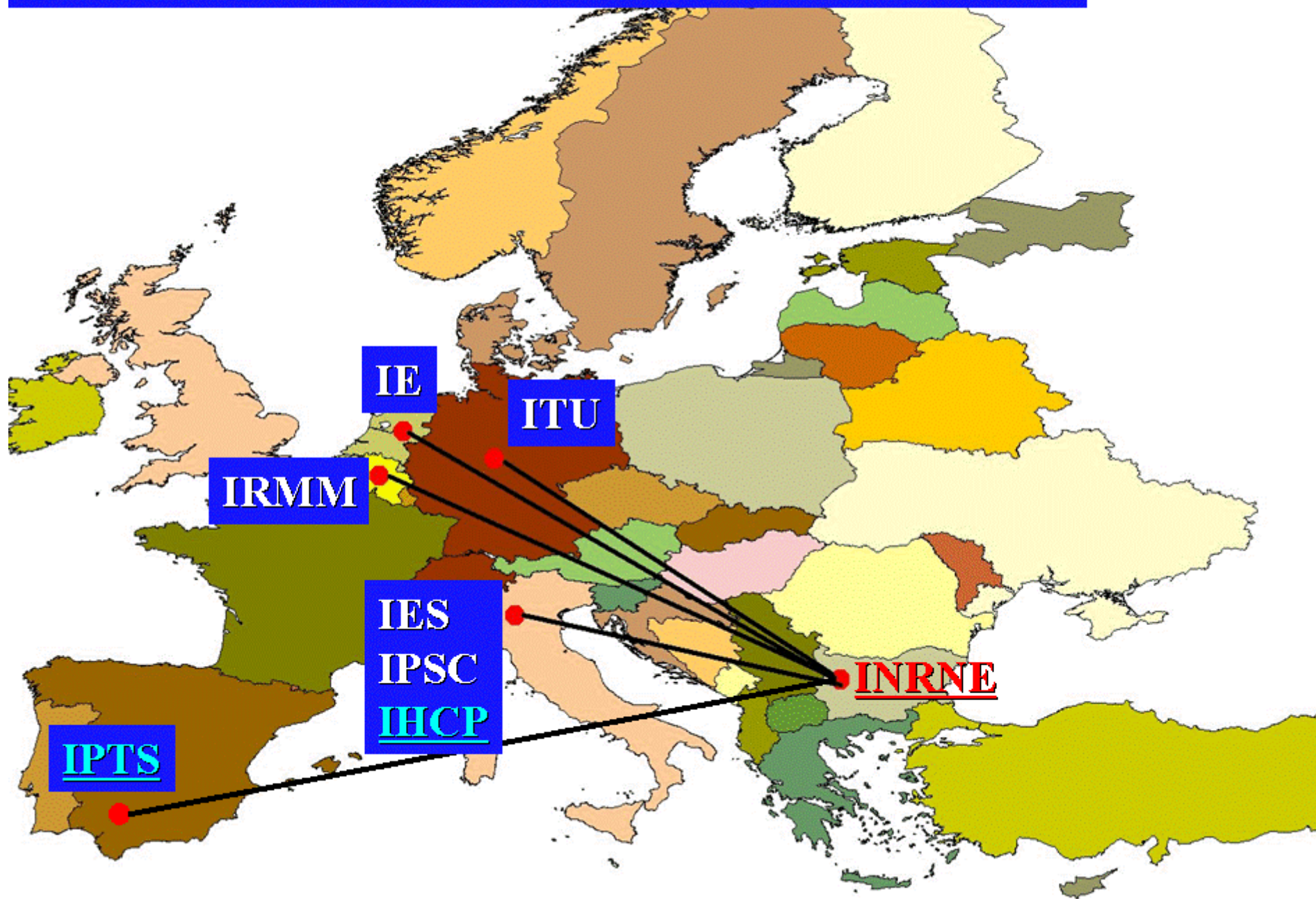
ICTP, Andru-Sabun Inst. Centre for Theoretical Physics,
Trieste
VINS, Vinca Institute for Nuclear Science, Belgrade
INP, Institut of Nuclear Physics, Tirana
INS, Institute of Nuclear Sciences, Izmir
INR, Institute of Nuclear Research UNAS, Kiev
UAC, Ukrainian Antarctic Centre, MES, Kiev

European High Mountain and High Latitude Stations:
UFS, Germany,
HARS JFJ and GG (HAFS), Switzerland, Sonnblick
Observatorium
(SO), Austria, Monte Cimone (MC) and Testa Grigia
(TG) RS, Italy,
Lomnický štít Observatory (LS), Slovakia, ALOMAR
Obs., Norway
EPS, European Physical Society, Mulhouse
ESF, European Science Foundation, Strasbourg
DOE, Department of Energy, USA
and others

INRNE – International Scientific Centers Collaboration



INRNE – JRC Scientific Connections

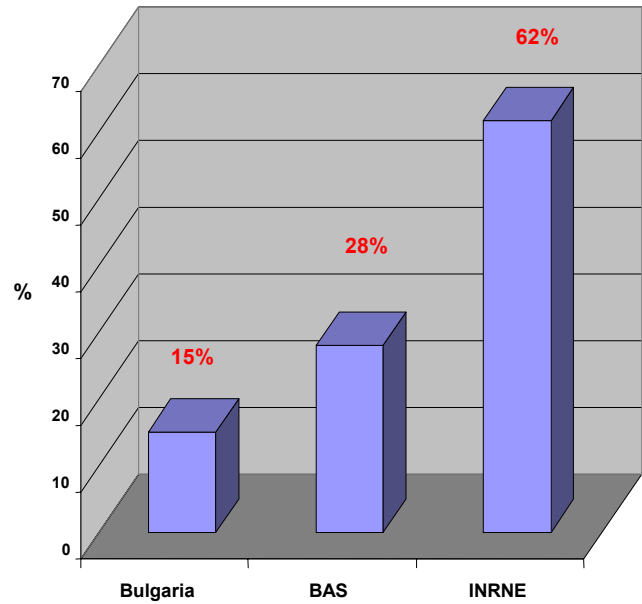


INRNE Sixth Framework Programme Factsheet*

42	INRNE submitted projects
≈ 9%	INRNE part of BAS projects
26	INRNE excepted and funded projects
62%	INRNE success rate
≈ 29%	Bulgarian Academy of Sciences success rate
15%	Bulgaria success rate
≈ 1/5	INRNE part of EC contribution for BAS projects
≈ 2/3	BAS recovering of Bulgaria FP6 participation fee
≈ 13%	INRNE recovering of Bulgaria FP6 participation fee
≈ 85% 22 / 26	Joint projects with EC JRC or with active EC JRC participation
≈ 2/3	INRNE labs and departments participation in FP6 projects (successful and unsuccessful)
<p><i>* according to BAS (Bulgarian Academy of Sciences), INRNE (Institute for Nuclear Research and Nuclear Energy of BAS) and MES (Ministry of Education and Science of Republic of Bulgaria) data</i></p>	

Participation in projects

FP6 Projects Success Rate



INRNE Seventh Framework Programme Participation

38 submitted projects

12 accepted and funded projects

- 5 – EURATOM
- 6 – JRC
- 1 – others

- 8 – acting
- 4 – finalized

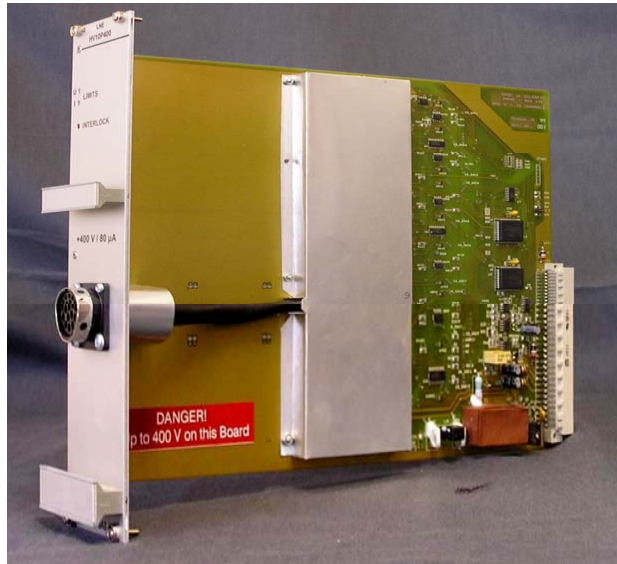
- 3 projects are under negotiations and 3 projects are under evaluation

FP7 Projects Success Rate: 36%



CERN - INRNE

CMS experiment





**Bulgaria since 1999 Member
State of CERN**

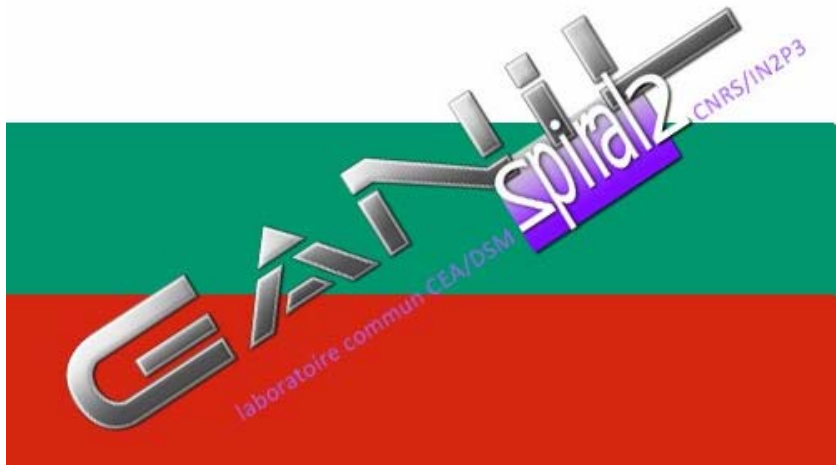
**Member of CMS since 1991,
CMS MoU signed in 1999**



INRNE Computer cluster GRID



Bulgarian Participation in SPIRAL2 Project



Bulgaria at GANIL (National Large Heavy Ion Accelerator), Caen, France

- **more than 20 experiments in the period 1995 – 2008**
- **about 35 scientific papers published**

(1) The consortium agreement between the Bulgarian parties **has been signed (consortium BULSPIRAL2)**

- **INRNE – Bulgarian Academy of Sciences**
- **University of Sofia, Department of Atomic Physics**
- **Technical University of Sofia, Department of Precision Engineering and Measurement Instruments**
- **Bulgarian SME's**

(2) The Bulgarian contribution to the construction will be in-kind and the 50:50 principle will be followed

- **Platforms, support frames and diagnostic chambers for the LINAC (prototypes enter production phase)**
- **HV power supplies for the PARIS spectrometer (prototypes are in design phase – Spiral2PP project)**

(3) Involvement in the scientific programme of Spiral2PP (signed Letters of Intent**)**

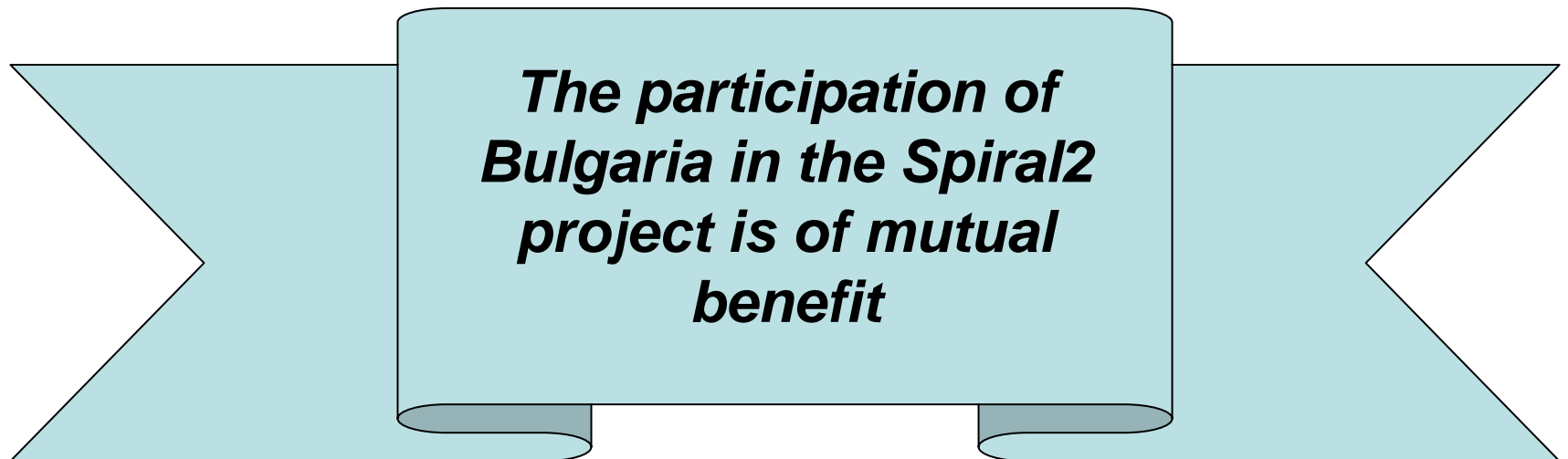
- **nuclear moments**
- **lifetimes of nuclear states**
- **studies of giant resonances**

(4) Research infrastructure development

- investment is needed for infrastructure development of the different Bulgarian research institutions, both in the construction and in the operation phase of the project
- Bulgarian SME's can meet the high standards of the Spiral2 project and produce scientific equipment for it
- transfer of know-how and technologies to Bulgarian SME's

(5) Bulgarian role in the project

- visibility of Bulgaria in the project
- considerable contribution to the construction phase
- contribution to the scientific programme



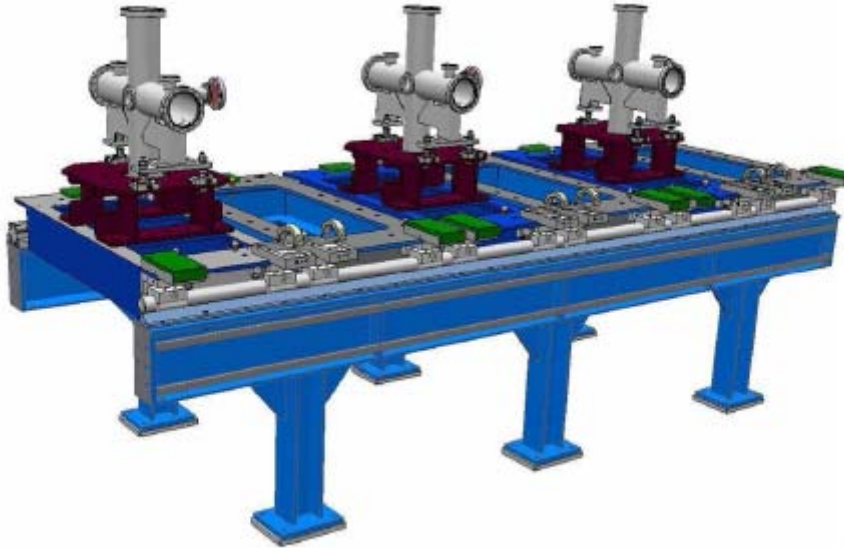


Figure 2 : A type frame equipped and assembled, 4 expected

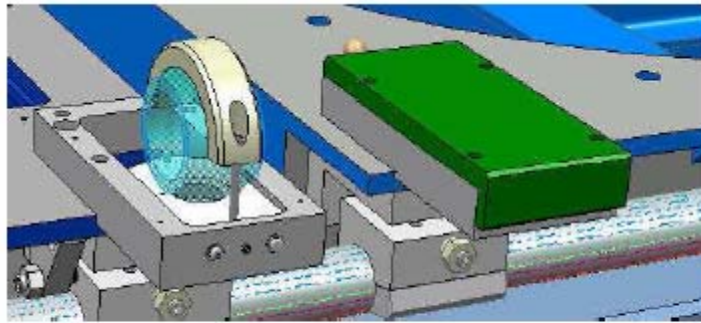


Figure 7 : box alignment

In a next future, the platform will be fully set-up with another diagnostic detector, the beam position monitor, and a quadrupole doublet magnet.

Scientific Experimental Facilities

Nuclear Scientific-Experimental Centre (NSEC)

According to the governmental decision from 2001 the research reactor IRT-2000 is in the reconstruction into reactor with low power 200kW – IRT-200

RERTR project - Retransportation of HE spent fuel



FUTURE UTILIZATION OF THE RESEARCH REACTOR IRT IN SOFIA AFTER ITS RECONSTRUCTION

INRNE-BAS, 72 Tzarigradsko Shossee, 1784 Sofia, Bulgaria



Integrated Management System

ISO 9001:2000 for quality, ISO 14001:2004 for environment, Bulgarian Nuclear Regulatory Agency requirements, Governmental requirements for occupational health and safety, and for security. Implemented from 2003 and certified by the Quality Austria.

Support

- Bulgarian Government
- IAEA project BUL/4/014 "Refurbishment of the Research Reactor"
- US DOE program RRRFR for spent nuclear fuel return back to Russia
- US DOE program RERTT for conversion to LEU fuel
- EC PHARE program for monitoring system for IRT site and individual dosimetry control.



The Research Reactor IRT was built and put into operation in 1961. It was temporarily shut down in 1989 for improvement. The reconstruction of the IRT is being carried out under the decision of the Council of Ministers of Republic of Bulgaria from 2001.

STRATEGY for sustainable utilization of the IRT as a national base for:

- Education and training of students, physicists and engineers in the field of nuclear science and nuclear energy,
-

Education and training

Nuclear Energy Course for the Master of Science Degree of the Technical University in Sofia: types of research reactors, safety, reactor physics and thermo-hydraulic characteristics, accident analyses, fresh and spent fuel management, radioactive waste management.

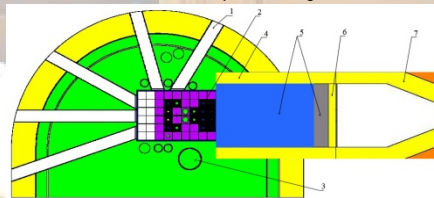


Boron Neutron Capture Therapy

National Network with the Medical University in Sofia, the Institute of Experimental Pathology and Parasitology and the Institute of Electronics of the Bulgarian Academy of Sciences, the Faculty of Physics of Sofia University and the National Centre of Radiobiology and Radiation Protection

Contacts and Experience Sharing with EC JRC-HFR, the Netherlands; VTT, Finland and NRI-Rez, the Czech Republic.

Expected benefit: human, social and economical for patients from Balkan region
MCNP neutron transport modelling of BNCT channel



- (MT tube design):
1. Horizontal channel
 2. Fuel cell
 3. Vertical channel
 4. Lead reflector (10 cm)
 5. Filler-Moderator: Al₂O₃ (cm)
 6. PTFE (13 cm), Cadmium (0.05 cm) 6. Lead photon shield (6 cm)
 7. Lead collimator (15 cm);



IRT reconstruction:

- reactor of thermal power 200 kW;
- low enriched uranium-235 fuel enrichment;
- six vertical and seven horizontal experimental channels: maximal fast neutron flux - $3 \cdot 10^{12}$ n/cm²s; maximal thermal flux - $8 \cdot 10^{12}$ n/cm²s;
- channel for medical BNCT: epithermal neutron flux - $5 \cdot 10^9$ n/cm²s.

Production of Isotopes for the industry, geology and agriculture, medical therapy and diagnostics

Element Activation Analysis for industrial production, medicine, chemistry, criminology, etc.



Monitoring

the IRT site and individual dosimetry control is being carried out continuously from 1961.



BEO Moussala (Basic Environmental Observatory)

INRNE BEO Centre of Excellence

Historical dates

- 1932 - Inauguration of Meteorological Station on peak Moussala.
- 1959 - Opening of Cosmic Ray Station on peak Moussala.
- 1983 - Destroy of Cosmic Ray Station (fired).
- 1993 - Start of Bulgarian-French project OM2 for monitoring and management of high mountain ecosystems.
- 1999 - Inauguration of Basic Environmental Observatory (BEO) - Moussala.
- 2002 - Creation of BEO Centre of Excellence

EC FP5, FP6 projects HIMONTONET and BEOBAL (INCO-CT-2005-016663)

Main Fields of Research

- Atmospheric physics and chemistry
- Cosmic Ray Physics and Astrophysics
- Sun - Earth interactions
- Complex environmental monitoring and ecotoxicological studies
- Control of long range radionuclides and toxic elements transport
- Sensor and detector development
- Complex measuring device design

42°11'N, 23°35'E, 2925m
Peak Moussala, Rila Mountain
BULGARIA

<http://www.beo.inrne.bas.bg>
<http://beo-db.inrne.bas.bg>

21/12/2006

Twinning with leading European institutes and observatories

- Leibniz Institute for Tropospheric Research, Leipzig - Germany
- DWD (Deutsche Wetter Dienst), GAW station, Hohenpeisenberg observatory, Germany

Apparatuses and Systems

- Automatic meteorological station
- Cloud and rain acidity measurement
- Gas analyzer (Environment) - NO, CO, CO₂
- * VOC volatile organic compounds
- * ¹⁴C/¹²C ratio active measurement atmospheric CO₂
- UV flux meter
- Integrated nephelometer (TCI)
- * MAAP multy angle absorption
- SMPS scanning mobility particle
- Device for controlling of aerosols
- ²¹⁰Pb air concentration estimation
- X-ray fluorescent spectrometer
- Thermoluminescent detectors (TL)
- ²²⁰Rn active device and alpha spectrometer
- Gamma background probe (Technidata)
- High temperature semiconductor spectrometer
- SBN-90 gamma background monitor
- MICROTOPS II ozonometer
- Gamma and neutron detector (Harwell 3208)
- Passive neutron detector
- Active neutron flux meter based on SNM15
- Moun Cerenkov telescope
- LET spectrometer device Liulin
- * Automatic forest fire control system
- Complex monitoring sampling (radiological, chemical, hydrological, biological, geological)
- Informational system
- Telecommunication system

* Future developments



BEO MOUSSALA

BEO has been validated by EC and ESF survey in July 2007 as research infrastructure of pan-European importance (num. 562)

04/01/2007

Control of illicit trafficking of Nuclear Materials



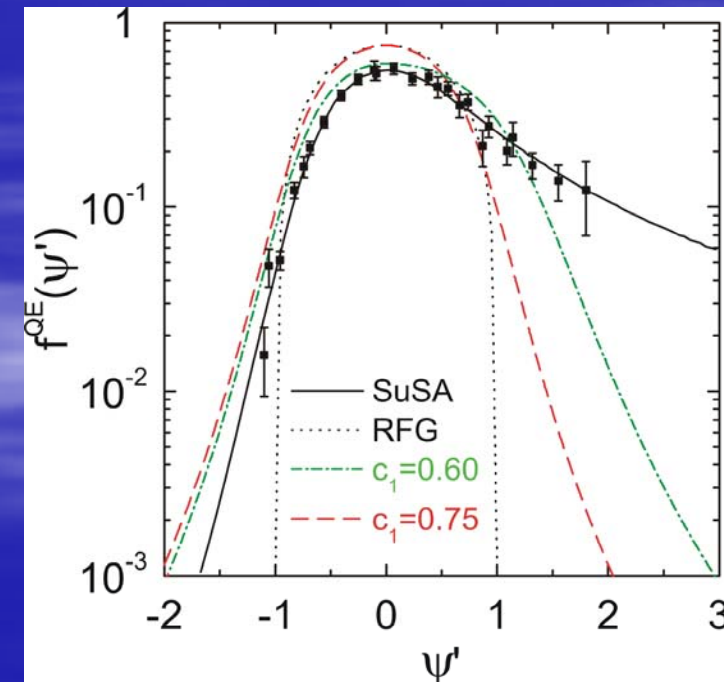
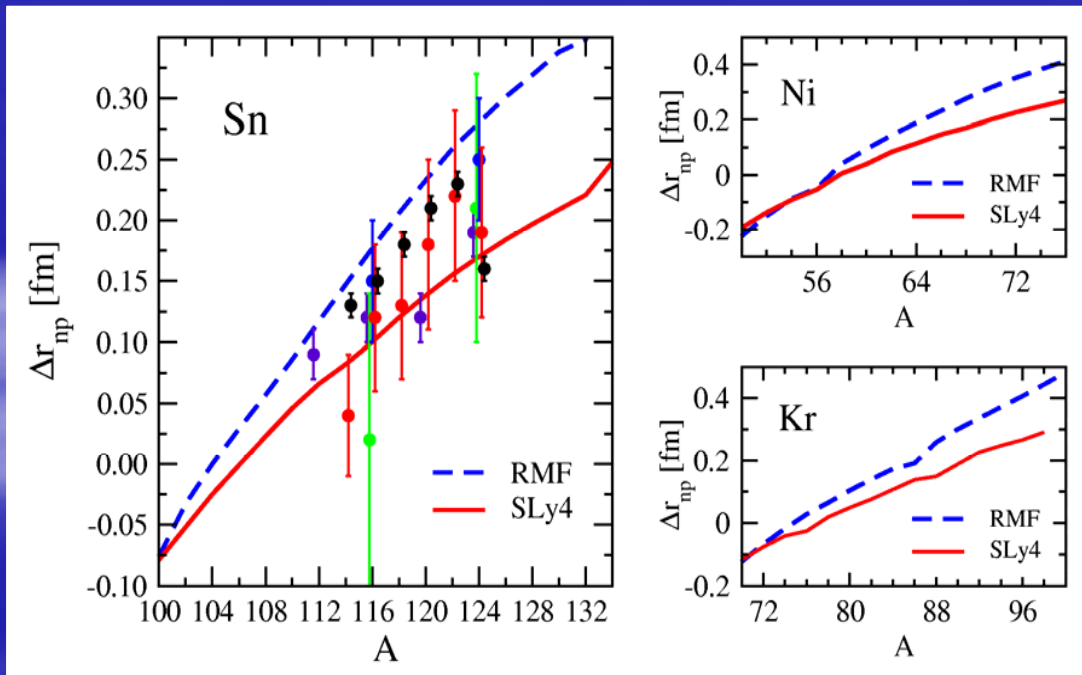
Nuclear Physics Measurements Center



Laboratory

Theoretical Nuclear Physics

- nucleon-nucleon correlation effects on nuclear structure and reactions
- symmetries in nuclear physics
- exotic nuclei and few-body systems
- advanced studies of many-fermion systems



LABORATORY THEORETICAL NUCLEAR PHYSICS

Status 2004 - 2008

Staff: 15 scientists

Published:

- **3** monographs: Oxford University Press (1988, 1991), Springer-Verlag (1993)
- **65** papers in journals abroad
- **9** papers in Bulgarian journals
- **26** papers in conference proceedings abroad
- **45** papers in conference proceedings in Bulgaria

Contracts with the National Science Fund: Φ -905, Φ -1416, Φ -1501, Φ -1502, ДО 02-285

Physical Review C – 36

Physics Letters B – 4

Journal of Physics G – 4

Physical Review Letters – 3

Physics of Atomic Nuclei – 3

International Journal of Modern Physics E – 3

International Journal of Quantum Chemistry – 3

Progress of Theoretical Chemistry and Physics – 2

European Physical Journal A – 1

Computer Physics Communications – 1

Central European Journal of Physics – 1

Radiation Protection Dosimetry – 1

Journal of Optoelectronics and Advanced Materials – 1

Israeli Journal of Chemistry – 1

Izvestiya RAN, ser. phys. - 1

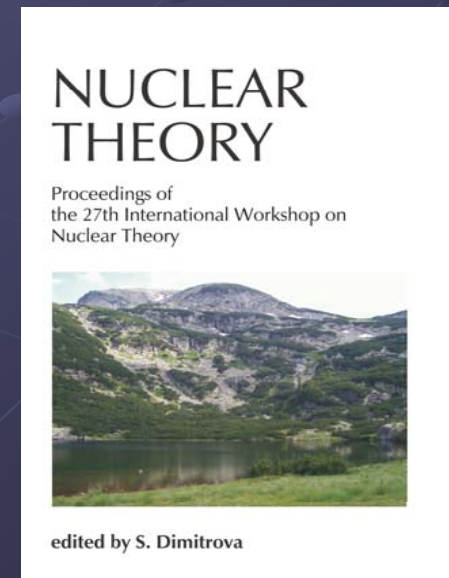
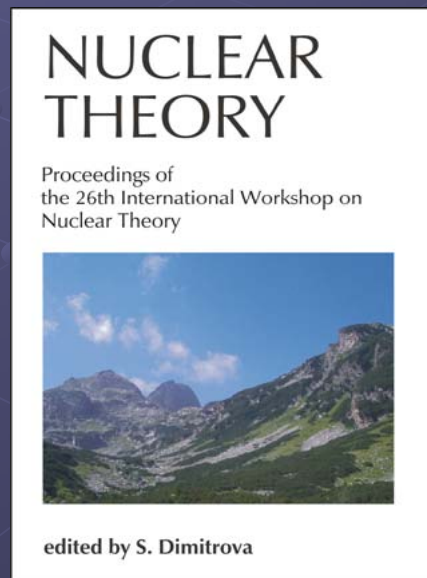
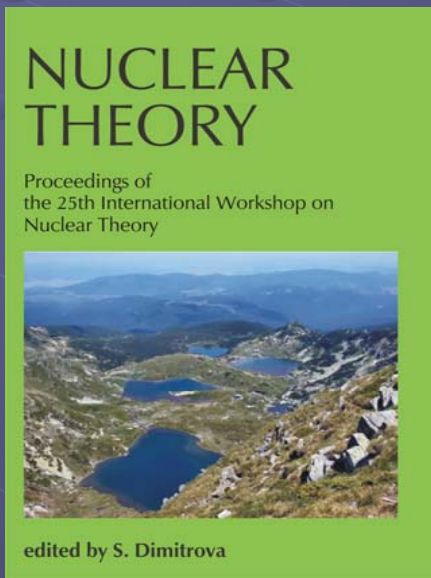
● International Collaborations with:

- GSI (Darmstadt) Project ELISe, H. Simon et al.
- University of Giessen, Prof. W. Scheid
- N.C.S.R. “Demokritos”, Prof. D. Bonatsos
- University of Tübingen, Prof. H. Müther
- The Royal Society in London, University of Oxford, Prof. P.E. Hodgson
- CSIC and Complutense University of Madrid,
Prof. E. Moya de Guerra, Prof. J. Dukelsky, Prof. P. Sarriguren,
Dr. J.M. Udias
- University of Seville, Prof. J. A. Caballero
- Kyushu University, Prof. Y. Watanabe
- INFN, Italy, Prof. C. Ciofi degli Atti (Perugia), Prof. C. Giusti
(University of Pavia), Dr. M. Barbaro (University of Torino) and
Prof. N. Lo Iudice (University of Naples)
- CNRS, Paris, Prof. J. Maruani
- JINR, Dubna, Prof. V. Lukyanov
- University of Thessaloniki, Prof. S. Massen
- University of Louisiana, Prof. J. Draayer

INTERNATIONAL WORKSHOP ON NUCLEAR THEORY

Rila Mountains, Bulgaria

- organized annually since 1981
- participants from:
 - France, Greece, Germany, Nederland, Italy, Mexico, Japan, U.K., U.S.A., Spain, Poland, Russia, Romania and others
 - INRNE, Sofia University, Ruse University, University of Shumen
- 8 volumes of proceedings



INRNE - BAS

BULGARIAN ACADEMY OF SCIENCES

INSTITUTE
FOR NUCLEAR RESEARCH
AND
NUCLEAR ENERGY



ANNUAL REPORT
2007

INRNE ANNUAL REPORT 2007

INRNE - BAS

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AND
NUCLEAR ENERGY



ANNUAL REPORT
2008

PERIODICAL PUBLICATIONS

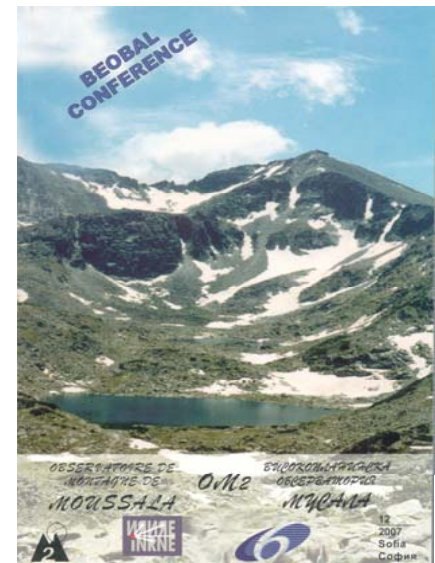
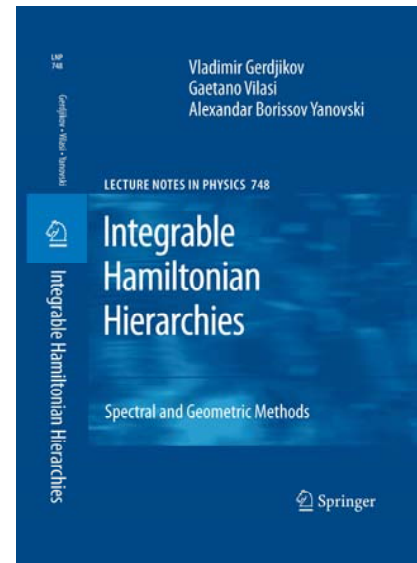
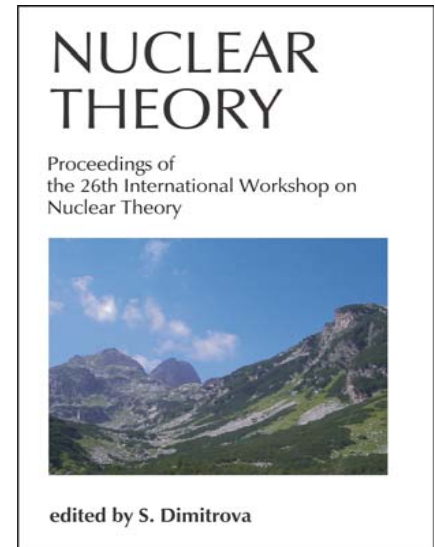
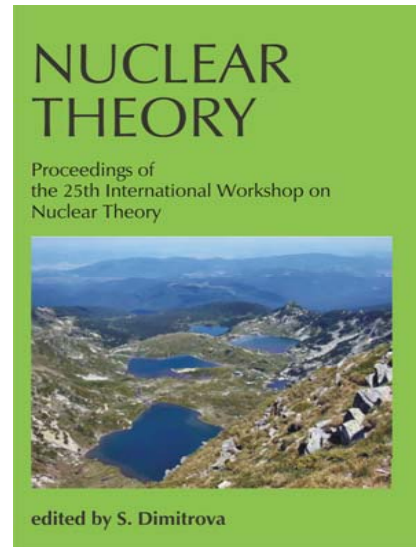
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ANNUAL REPORT
2009





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