21st SYMPOSİUM OF THE HELLENİC NUCLEAR PHYSİCS SOCIETY
HNPS-2012

MAY 25-26, 2012 - ATHENS, GREECE

National Centre for Scientific Research “Demokritos”

Organized by

- The TANDEM Accelerator Laboratory
- The Institute of Nuclear and Radiological Sciences and Technology, Energy and Safety

NCSR “Demokritos”

Under the auspices of the Hellenic Nuclear Physics Society

SPONSORS:

- TANDEM Accelerator Laboratory
- Environmental Radioactivity Laboratory
- Institute of Nuclear and Radiological Sciences and Technology, Energy and Safety
- Institute of Nuclear and Particle Physics
SCIENTIFIC PROGRAM

Friday 25/5/2012

08:30-09:00 REGISTRATION
09:00-09:10 Welcome addresses

SESSION 1 Chair: G. Lalazissis, Dept. of Physics, AUTH
09:10-09:30 E. Kossionides, Tandem Lab, INPP, NCSR "Demokritos"
40 years of "beam on target" at the Tandem accelerator
(invited talk)
09:30-09:50 R. Vlastou, Dept. of Physics, NTUA
New measurements of the 241Am(n,2n)240Am cross section
09:50-10:10 M. Zamani, Dept. of Physics, AUTH
Fission induced by light particles at intermediate energies
10:10-10:30 T. Alexopoulos, Dept. of Physics, NTUA
ATLAS New Small Wheel Upgrade: Micromegas
10:30-10:50 G. Souliotis, Dept. of Chemistry, NKUA
Studies of the process of N/Z equilibration in peripheral and
semiperipheral heavy-ion collisions at 15 MeV/nucleon
10:50-11:10 T. Konstantinopoulos, Tandem Lab, NCSR "Demokritos"
In search of nuclei exhibiting E(5) critical-point symmetry features

11:10-11:30 COFFEE BREAK

SESSION 2 Chair: H. Florou, INRaSTES, NCSR "Demokritos"
11:30-12:00 P. Kritidis, INRaSTES, NCSR "Demokritos"
Measurements of radioactivity in Athens after the nuclear accident
in Fukushima, Japan (invited talk)
12:00-12:20 A. Ioannidou, Dept. of Physics, AUTH
Radionuclides from the Fukushima accident in Thessaloniki,
Greece and Milano, Italy - measurements and modeling
approaches
12:20-12:40 M. Sotiropoulou, INRaSTES, NCSR "Demokritos"
The Application of the ERICA Tool to Radioactivity
Measurements for Environmental Impact Assessment: The
Case Study of Fukushima …
12:40-13:00  A. Clouvas, Dept. of Electrical Engineering, AUTH
Radon in Soil: Experimental measurements and Theoretical calculations

13:00-13:20  C. Tsabarlis, Inst. of Oceanography, HCMR
Experimental Set Up for the Determination of Natural Radionuclides in Formation Waters Produced in Oil and Gas Exploration Fields

Radiological Modelling at Thermaikos Gulf

SESSION 3  Convener: S. Harissopulos, Tandem Lab
15:00-15:30  POSTER SESSION

SESSION 4  Chair: R. Vlastou, Dept. of Physics, NTUA
15:30-15:50  E. Mavrommatis, Physics Department, NKUA
β-Decay Half-Lives of Nuclei in the Crust of Neutron Stars: The ANN Model

15:50-16:10  T.S. Kosmas, Dept. of Physics, Univ. of Ioannina
Astrophysical neutrino signals and the role of nuclear structure

16:10-16:30  Ch. C. Moustakidis, Dept. of Physics, AUTH
Nuclear Equation of State Effects on the r-mode Instability of Neutron Stars

16:30-16:50  D. Petrellis, INPP, NCSR "Demokritos"
Nuclear physics aspects of the p-process

16:50-17:10  COFFEE BREAK

SESSION 5  Chair: M. Zamani, Dept. of Physics, AUTH
17:10-17:30  I. Savvidis, Dept. of Physics, AUTH
Neutron Detection via 14N(n,p)14C reaction Using the Spherical Proportional Counter

17:30-17:50  M. Kokkoris, Dept. of Physics, NTUA
Experimental study and FLUKA simulations of a prototype micromegas chamber in a mixed neutron and photon radiation field …

17:50-18:10  T. J. Mertzimekis, Physics Department, NKUA
The Application of the High-Velocity Transient Field for the g(21+) Measurement in the Neutron-rich 72Zn
18:10-18:30  N. Patronis, Dept. of Physics, Univ. of Ioannina  
One neutron transfer reactions around 68Ni: First results from the \(^{66}\text{Ni}(d,p)^{67}\text{Ni}\) experiment

18:30-19:30  HNPS General Assembly & Elections

Saturday 26/5/2012

SESSION 6  
Chair: E. Stiliaris, Physics Department, NKUA

09:00-09:20  K. Mergia, INRaSTES, NCSR "Demokritos"  
Research activities of NCSR “Demokritos” for the European Fusion Technology Program

09:20-09:40  Z. Kotsina, INRaSTES, NCSR "Demokritos"  
Radiation damage studies of Fe-Cr alloys for Fusion applications using ion beams

09:40-10:00  A. Godelitsas, Geology Dept., NKUA  
Activities of the University of Athens at SUL-X and FLUO beamlines of ANKA Synchrotron facility in Earth & Environmental Sciences

10:00-10:20  J. Kalef-Ezra, Medical School, University of Ioannina  
Applications of a Novel Whole Body Counter in Radiation Protection and Human Body Composition Studies

10:20-10:40  A.-N. Rapsomanikis, Physics Department, NKUA  
Phantom Experimentation on SPECT and Infrared Tomography

10:40-11:00  M. Zioga, Physics Department, NKUA  
Image Reconstruction in the Positron Emission Tomography

11:00-11:30  COFFEE BREAK

SESSION 7  Chair: E. Mavrommatis, Physics Department, NKUA

11:30-11:50  N. G. Nicolis, Dept. of Physics, Univ. of Ioannina  
Population of isomeric states in neutron-induced reactions on \(^{197}\text{Au}\)

11:50-12:10  M. Diakaki, Dept. of Physics, NTUA  
Characterization of actinide targets for fission cross section measurements
12:10-12:30    V. Paneta, Tandem Lab, INPP, NCSR "Demokritos"
Differential cross-section measurements for the $^7\text{Li}(p,p^0)^7\text{Li}$, $^7\text{Li}(p,\alpha^0)^4\text{He}$, $^{19}\text{F}(p,p^0)^{19}\text{F}$ and $^{19}\text{F}(p,\alpha^0)^{16}\text{O}$ reactions

12:30-12:50    V. Tsakstara, Dept. of Physics, Univ. of Ioannina
Studying nuclear responses to Supernova neutrinos

12:50-13:10    D.K. Papoulias, Dept. of Physics, Univ. of Ioannina
Lepton -flavor violating neutral-current exotic $\nu$-nucleus processes

13:10-13:30    P.G. Giannaka, Dept. of Physics, Univ. of Ioannina
Realistic nuclear structure calculations for orbital e-capture by nuclei

13:30-15:00    LUNCH

SESSION 8    Chair: I. Stamatelatos, INRaSTES, NCSR "Demokritos"
15:00-15:20    K. Eleftheriadis, INRaSTES, NCSR "Demokritos"
Radioactive tracers for long range transport of biomass burning aerosols

15:20-15:40    T. Vasilopoulou, INRaSTES, NCSR "Demokritos"
Large Sample Neutron Activation Analysis for Cultural Heritage Studies

15:40-16:00    A. Savidou, INRaSTES, NCSR "Demokritos"
Techniques Used for Clearance of Radioactive Waste

16:00-16:20    D. L. Patiris, Inst. of Oceanography, HCMR
Sediment measurement of samples from Tigris and Euphrates estuary by means of gamma-ray spectroscopy

16:30    CLOSING OF THE SYMPOSIUM

Posters to be displayed at the poster session

P1.    A. Kalamara, Dept. of Physics, NTUA
Monte Carlo MCNP modeling of a HPGe detector and its efficiency for extended sample geometry

P2    E. Androulakaki, Dept. of Physics, NTUA
In situ Gamma-Ray Measurements of Marine Sediment using Monte Carlo Simulation

P3    A. Godelitsas, Geology Dept., NKUA
Heavy metals and radionuclides in the northern coastal zone of Ikaria
I. Tzifas, Geology Dept., NKUA
High uranium concentrations in sedimentary rocks of Epirus (NW Greece)

J. Kalef-Ezra, Medical School, University of Ioannina
Induced Radioactivity in Medical Accelerators

E. Vagena, Dept. of Physics, AUTH
Measurements and Monte Carlo simulations of neutron production at a medical accelerator

S. Valakis, Medical School, University of Ioannina
Effect of Radon Concentration in Air on the Quality of Radioactivity Measurements in the Human Body

H. Florou, INRASITES, NCSR "Demokritos"
Indicative Radiation Dose Rates in Selected Areas of Elevated Natural radioactivity in Greece

F. Panagiotopoulos, Physics Department, NKUA
3D Modeling of the New Microbeam Setup at INP, NCSR “Demokritos”

K. Stamou, Physics Department, NKUA
A Nuclear Electromagnetic Moments Database

A. Kanellakopoulos, Physics Department, NKUA
Characterization of Nuclear Targets and Thin Films Using Ion-Beam Techniques

N. Gazis, Dept. of Physics, NTUA & CERN
Fabrication and validation of the prototype supporting system for the CLIC Two-Beam Modules

F. Noli, Dept. of Chemistry, AUTH
N- and O-depth distribution by NRA for the investigation of the corrosion resistance of plasma nitrided and oxidized CoCrMo alloy

V. Foteinou, Tandem Lab, INPP, NCSR "Demokritos"
Proton capture reactions for the p-process nucleosynthesis: the case of the Mo isotopes

G. Provata, Tandem Lab, INPP, NCSR "Demokritos"
Systematic measurements of (alpha, gamma) reaction cross sections for astrophysics applications
Session 1

Forty years of “beam on target” at the Tandem Accelerator

Invited Talk

E. Kossionides

Tandem Accelerator Laboratory,
Institute of Nuclear and Particle Physics,
NCSR “Demokritos”, 15310 Aghia Paraskevi, Athens, Greece
New measurements of the $^{241}$Am(n,2n)$^{240}$Am cross section

A. Kalamara¹, M. Diakaki¹, R. Vlastou¹, M. Kokkoris¹, A. Tsinganis¹, S. Ashley² and A. Lagoyannis²

¹Department of Physics, National Technical University of Athens, 157 80 Athens, Greece,
²Institute of Nuclear Physics, NCSR "Demokritos", 153 10 Aghia Paraskevi, Greece

Studies of (n,xn) reactions on minor actinides are of considerable significance, both for their importance to fundamental research in Nuclear Physics, as well as for practical applications, especially for the development of fast reactors since they affect the neutron balance in the reactor core. The study of $^{241}$Am(n,2n)$^{240}$Am reaction is important as Am is one of the most abundant isotopes in the spent fuel cycle and one of the most highly radiotoxic among the actinides. Five recent works provide data from threshold to 20 MeV, with severe discrepancies among them in the energy region 10 to 12 MeV.

In order to resolve these discrepancies between the existing data, new measurements have been performed at the 5 MV Tandem T11/25 accelerator laboratory of NCSR "Demokritos", with a high purity Am target provided by IRMM. Due to its high radioactivity (~5GBq), the Am target was placed inside a 3mm lead cylindrical shielding and was irradiated with 10.4 MeV neutrons for three days. Gamma-ray spectra were taken at a distance of ~10cm from a Ge detector, before and after the irradiation, to ensure that there is no contamination in the 987.8keV photopeak from the decay of the $^{240}$Am residual nucleus. The efficiency of the detection setup, including the extended geometry of the Am sample, was extracted by using two different techniques, an experimental and a simulated one. The cross section at 10.4MeV has thus been deduced with respect to the $^{27}$Al(n,α)$^{24}$Na, $^{93}$Nb(n,2n)$^{92}$mNb and $^{197}$Au(n,2n)$^{196}$Au reference reactions, implementing the activation technique.
Session 1

Fission induced by light particles at intermediate energies

M Zamani, M. Fragopoulou and S. Stoulos

Aristotle University of Thessaloniki, Thessaloniki 541 24

The interest of medium energy nuclear data, i.e. in the range of 500-1000MeV, is peaked last years in spallation sources for their applications in accelerator - driven systems (ADS).

Fission studies takes a big part of research on the reaction mechanism at intermediate energies because it can be produced directly by the interaction of projectile – target at large as well as small impact parameters but also as the ending effect of spallation reactions. Most of the data are referred to the fission induced by protons due to the applications in the spallation targets. A lot of results on fission mechanism have been collected from 60s using deuterons and alpha particles as projectiles but at low energies. This presentation deals with fission experimental data at intermediate energies when deuterons are used as projectiles and the systematic collected for actinides and subactinides.
The luminosity upgrade of the Large Hadron Collider at CERN (sLHC) foresees a luminosity increase by a factor 10 compared to the LHC. To cope with the corresponding increase in background rates, the Muon System of the ATLAS experiment at CERN will likely need major changes in, at least, the highest rapidity region. The MAMMA-ATLAS R&D activity is focused on the development of large-area muon detectors based on the bulk Micromegas technology as candidates for such an upgrade. The detectors will combine trigger and precision tracking in a single device. Their low costs, compared to other detector technologies, and their potential for industrial production make the bulk-Micromegas excellent candidates for mass-construction of large muon chambers. Beam tests of several size prototype chambers have been performed since 2009, as well as several tests with different types of resistive coating of the readout electrodes, in order to reduce sparking of the chambers. The performance results of these new resistive types of micromegas will be presented.
Session 1

Studies of the process of N/Z equilibration in peripheral and semiperipheral heavy-ion collisions at 15 MeV/nucleon

George A. Souliotis

Laboratory of Physical Chemistry, Department of Chemistry, National and Kapodistrian University of Athens, Athens 15771.

The results of recent experimental studies of peripheral and semi-peripheral collisions of $^{86}$Kr (15MeV/nucleon) projectiles on $^{64,58}$Ni and $^{124,112}$Sn targets will be presented [1]. The motivation of the present work is the possibility to extract information on the properties of the nuclear effective interaction (via comparisons with microscopic transport models) as manifested in the mechanism of nucleon exchange and the process of N/Z equilibration [2,3]. Experimentally, the method of heavy-residue isoscaling [2] was applied to the present data. From a theoretical point-of-view, we have performed preliminary calculations using the code CoMD (Constrained Molecular Dynamics) of A. Bonasera and M. Papa [4]. The code implements an effective interaction with a nuclear-matter compressibility of K=200 (soft EOS) with several forms of the density dependence of the nucleon symmetry potential. CoMD imposes a constraint in the phase space occupation for each nucleon (restoring the Pauli principle at each time step of the collision). Results of the calculations and comparisons with our experimental data will be presented. The importance of such studies to the field of astrophysics (e.g. modeling of core-collapse supernovae and neutron stars) will be pointed out. Finally, the prospects to extend the experimental studies using neutron-rich radioactive beams at existing or planned radioactive beam facilities will be outlined.

Session 1

In search of nuclei exhibiting E(5) critical-point symmetry features

T. Konstantinopoulos\textsuperscript{a}, S. Harissopulos\textsuperscript{a}, S.F. Ashley\textsuperscript{a}, M.Axiotis\textsuperscript{a}, A. Lagoyannis\textsuperscript{a}, Th. J. Mertzimekis\textsuperscript{a}, A. Spyrou\textsuperscript{a}, R. Vlastou\textsuperscript{b}, A. Dewald\textsuperscript{c}, T. Braunroth\textsuperscript{c}, A. Fitzler\textsuperscript{c}, C. Fransen\textsuperscript{c}, M. Hackstein\textsuperscript{c}, W. Rother\textsuperscript{c}, B. Saha\textsuperscript{d}, A. Linnemann\textsuperscript{d}, O. Möller\textsuperscript{d}, K.O. Zell\textsuperscript{d}, A. Herzan\textsuperscript{e}, R. Julin\textsuperscript{e}, U. Jakobsson\textsuperscript{e}, P. Jones\textsuperscript{e}, S. Ketelhut\textsuperscript{e}, P. Nieminen\textsuperscript{e}, P. Peura\textsuperscript{e}, P. Rakhila\textsuperscript{e}, T. Grahn\textsuperscript{e}, K. Hauschild\textsuperscript{e,f}, D. R. Napoli\textsuperscript{e}, N. Marginean\textsuperscript{e}, C. Rusu\textsuperscript{e}, G. de Angelis\textsuperscript{g}, C. Ur\textsuperscript{h}, D. Bazzacco\textsuperscript{h}, E. Farnea\textsuperscript{h}, P. Petkov\textsuperscript{j}, D. Balabanski\textsuperscript{j}.

\textsuperscript{a} Tandem Accelerator Laboratory, Institute of Nuclear and Particle Physics, NCSR “Demokritos”, 15310 Aghia Paraskevi, Athens, Greece
\textsuperscript{b} Physics Department, National Technical University of Athens, Greece
\textsuperscript{c} Institut für Kernphysik, Universität zu Köln, Zulpicherstr, 77, D-50937 Köln, Germany
\textsuperscript{d} Institut für Kernphysik, Technische Universität Darmstadt, Germany
\textsuperscript{e} Department of Physics, University of Jyväskylä, P.O. Box 35, 40014 Jyväskylä, Finland
\textsuperscript{f} CSNSM, IN2P3-CRNS, F-91405 Orsay, France
\textsuperscript{g} INFN, Laboratori Nazionali di Legnaro, Italy
\textsuperscript{h} Dipartimento di Fisica dell’Università and INFN, Padova, Italy
\textsuperscript{i} INRNE, Bulgarian Academy of Sciences, Sofia, Bulgaria
\textsuperscript{j} Dipartimento di Fisica, Università di Camerino, Italy

The E(5) critical point symmetry which was introduced in 2000 [1] describes the shape change of a spherical harmonic vibrator to that of a ‘γ-soft’ rotor. A series of publications have proposed a number of nuclei as possible E(5) candidates [2, 3, 4, 5] but still the experimental confirmation of the E(5) symmetry in nuclear structure remains an open question. Our group in NCSR ‘Demokritos’ has worked in collaboration with the Universities of Cologne and Jyväskylä among others, in order to pinpoint nuclei which exhibit the E(5) characteristics. To that end, lifetime measurements have been carried out in three of the most promising candidates, namely \textsuperscript{128}Xe, \textsuperscript{130}Xe and \textsuperscript{102}Pd. Our results and conclusions will be presented.

Radioactivity measurements one year after the nuclear accident in Fukushima, Japan

P. Kritidis

Environmental Radioactivity Laboratory
Institute of Nuclear and Radiological Sciences and Technology, Energy and Safety
NCSR “Demokritos”, 153.10 Aghia Paraskevi, Athens, Greece

After the nuclear accident in Fukushima Daichi power plant, radioactive pollutants were transferred by air masses to various regions of the Northern hemisphere, including Europe. Very low concentrations of 131I, 137Cs and 134Cs in airborne particulate matter were measured in Athens during the period of March 24 to April 28, 2011. The maximum air concentration of 131I was measured on April 6, 2011 and equaled 490±35 mBq m\(^{-3}\). The maximum concentrations of the two cesium isotopes were measured on the same day and equaled 180±40 mBq m\(^{-3}\) for 137Cs and 160±30 mBq m\(^{-3}\) for 134Cs. The average activity ratio of 131I/137Cs in air was 3.0±0.5, while the corresponding ratio of 137Cs/134Cs equaled 1.1±0.3. No artificial radionuclides were detected in air after April 28, 2011. Traces of 131I were measured in grass, soil, sheep milk and meat. The total deposition of 131I (dry and wet) was 34±4 Bq m\(^{-2}\), while this of 137Cs was less than 10 Bq m\(^{-2}\). The maximum concentration of 131I in grass was 2.1±0.4 Bg kg\(^{-1}\), while 134Cs was not detected. The maximum concentrations of 131I and 137Cs in sheep milk were 1.7±0.16 Bq kg\(^{-1}\) and 0.6±0.12 Bq kg\(^{-1}\) respectively. Concentrations of 131I up to 1.3±0.2 Bq kg\(^{-1}\) were measured in sheep meat. Traces of 131I were found in a number of soil samples. The radiological impact of the Fukushima nuclear accident in Athens region was practically negligible, especially as compared to that of the Chernobyl nuclear accident and also to that of the natural radioactivity.
Radionuclides from the Fukushima accident in Thessaloniki, Greece and Milano, Italy - measurements and modelling approaches

A. Ioannidou\textsuperscript{1,4}, M. Manolopoulou\textsuperscript{1}, S. Stoulos\textsuperscript{1}, E. Vagena\textsuperscript{1}, C. Papastefanou\textsuperscript{1}, E. Giannakaki\textsuperscript{2,3}, L. Gini\textsuperscript{4}, S. Manenti\textsuperscript{4}, F. Groppi\textsuperscript{4}

\textsuperscript{1}Nuclear Physics & Elementary Particle Physics Division, Aristotle University of Thessaloniki, Greece
\textsuperscript{2}Laboratory of Atmospheric Physics, Aristotle University of Thessaloniki, Greece
\textsuperscript{3}Finnish Meteorological Institute, Kuopio Unit, Kuopio, FI-70211, Finland
\textsuperscript{4}Università degli Studi di Milano and INFN, LASA Laboratory, Milano, Italy

Analysis of $^{131}$I, $^{137}$Cs and $^{134}$Cs in airborne aerosols were carried out in daily samples in Thessaloniki, Greece (40$^\circ$N) and Milano, Italy (45$^\circ$N) after the Fukushima accident during March-April, 2011. High volume samplers with glass fiber filters as collection substrates were used for air samplings. Sampling duration of 23 hours and flow rate of about 60 cfm resulted in a total daily air volume throughput on average 2200 m$^3$. All samples were counted in HPGe detectors. All detectors were calibrated with reference sources and standard geometries with overall uncertainties no more than 3%.

The different maxima found in radionuclide concentrations were related to complicated long-range air mass transport from Japan across the Pacific, the North America and the Atlantic Ocean to Central Europe [1]. The maximum $^{131}$I activity concentration observed in Milano, Italy was almost similar with the highest value (497 $\mu$Bq m$^{-3}$) observed in Thessaloniki, Greece, and the highest observed value (490$\mu$Bq m-3) in Athens Greece [2] but was lower than the one observed (810 $\mu$Bq m$^{-3}$) in Svalbard [3] and in Lithuania (3700 $\mu$Bq m$^{-3}$, [4]). The maximum $^{137}$Cs activity concentration at Milano was 63 $\mu$Bq m$^{-3}$, while in Thessaloniki, Greece was 145 $\mu$Bq m$^{-3}$ and in Svalbard was as high as 675 $\mu$Bq m$^{-3}$.

The $^{134}$Cs/$^{137}$Cs activity ratio was about 1, related to the burn-up history of the damaged nuclear fuel of the damaged nuclear reactor. The presence of more than one peak of $^{131}$I and $^{137}$, $^{134}$Cs indicates that the radionuclides were continuously transferred from Fukushima, Japan to Europe till the end of April, 2011. The large $^{131}$I/$^{137}$Cs ratio, observed during the first days after the accident, as high as 18, followed by lower values during the next days, as low as 3, reflects not only the initial release ratio but also the different volatility, attachment and removal of the two isotopes during transportation due to their different physiochemical properties.

The NOAA HYSPLIT model was used to assess the transport pattern and to explain the deviation in radionuclide activity concentrations found in Thessaloniki, Greece and Milano, Italy. Thirteen days (312) back-trajectories were calculated for different arrival height and for 12 UTC time. The results showed that the measured activities at both sites of investigation resulted from a complicated air mass transport, arrival time, arrival height, meteorology and downward air mass transport.

The growing international interest in the dose rate and risk assessment of ionizing radiation from anthropogenic sources and NORM industrial activities to non-humans has led to the development of suitable software programs, based on real-time measurements that enable the evaluation of the radiological risk to wildlife.

The ERICA Integrated Approach has been developed under the 6th Framework Program of the EC, for the assessment and management of environmental risks from ionizing radiation. The ERICA Tool, which is the supporting software of the ERICA Integrated Approach, fed by the appropriate radiological data and performing the necessary calculations, is capable to estimate the dose rates and eventually the possible risks and effects to natural organisms. The Tool can also provide the respective levels of the activity concentrations in biota, from the introduced activity concentrations in abiotic components combined to the Tool benchmark radiological data bases.

In this study, the ERICA Tool was applied aiming to simulate the real time measurements of radionuclides ($^{137}$Cs, $^{134}$Cs and $^{131}$I) after the Fukushima N. P. P. accident, in terrestrial ecosystem components, either abiotic and biota. For this purpose, samples of soil, grass and tissues of primary mammals (sheeps and goats) were collected, treated and measured by use of a high resolution gamma spectrometry system (HpGe detector of 90% relative efficiency). The results obtained fed the ERICA Tool, in order to estimate the dose rates received by the selected animals and plants.

The estimated dose rates was found to be much lower than the 10 $\mu$Gy*h$^{-1}$, which is the reported screening level for measurable effects to non-humans. Nevertheless, the derived radiological risk showed a minor contribution to the natural background radiological impact, indicating no significant changes to the radiological status of “uncertainty to radiation well-being zone”, according to the conceptual model of responses of the various levels of life organization to all possible dose rates of ionizing radiation in the environment.

**Keywords**: Radionuclides, $^{137}$Cs, $^{134}$Cs, $^{131}$I, Radiological risk, ERICA Tool, Impact to non-humans, Terrestrial ecosystem.
Session 2

Radon in Soil: Experimental measurements and Theoretical calculations

A Clouvas$^1$, S Xanthos$^{1,2}$, M Antonopoulos-Domis$^1$

$^1$Nuclear Technology Laboratory, Department of Electrical and Computer Engineering, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece.
$^2$Department of Automation, Alexander Technological Educational Institute of Thessaloniki, GR-57400 Thessaloniki, Greece.

Radon concentration as function of the soil depth (0-2.6 m) was measured during the years (2002-2003), (2003-2004), (2010-2011), (2011-2012) in a location of the Aristotle University campus. Radium distribution in soil was found constant. On the contrary, as expected, radon concentration increases with soil depth. However, radon concentration does not follow the well known monotonous increase, which levels off to a saturation value. Radon concentration increases up to a soil depth of about 80 cm, seems to remain constant at depths of 80-130 cm and then increases again. The experimental distribution was reproduced by solving the general transport equation (diffusion and advection). The main finding of the numerical investigation is that the aforementioned, experimentally observed, profile of radon concentration can be explained theoretically by the existence of two soil layers with different diffusion-advection characteristics. Soil sample analysis verified the existence of two different soil layers. Different boundary conditions of the radon concentration at the soil surface were used for the solution of the diffusion-advection equation. It was found that the calculated radon concentration in the soil is, away from the soil surface, the same for the two boundary conditions used. However, from the (frequently used) boundary condition of zero radon concentration at the soil surface, the experimental profile of the radon concentration at the soil surface cannot be deduced. On the contrary, with more appropriate boundary condition the radon concentration at the soil surface could be deduced from the experimental profile. The equivalent diffusion coefficient could be uncovered from the experimental profile, which can then be used to estimate the radon current on the surface of the soil (exhalation rate). The exhalation rate of radon from soil was measured independently in the same location during the years 2010-2011 and 2011-2012. About 40 measurements in each time period were performed. In both time periods the mean radon exhalation rate was about the same (18 Bq m$^{-2}$ h$^{-1}$). From the radon distribution in soil, the radon exhalation rate was indirectly deduced, using the diffusion advection equation and it was found in very good agreement compared to the direct exhalation measurements.
Experimental Set Up for the Determination of Natural Radionuclides in Formation Waters Produced in Oil and Gas Exploration Fields

C. Tsabaris\textsuperscript{1}, D. Patiris\textsuperscript{1}, G. Eleftheriou\textsuperscript{1,2}, E. Androulakaki\textsuperscript{1,2}, A. Prospathopoulos\textsuperscript{1}, M. Kokkoris\textsuperscript{2}, F. Papa\textsuperscript{2}, S. Alexakis\textsuperscript{1}, R. Vlastou\textsuperscript{2}, C.A. Kalfas\textsuperscript{3}

\textsuperscript{1}Institute of Oceanography, Hellenic Centre for Marine Research, 19013 Anavyssos, Greece
\textsuperscript{2}Department of Physics, National Technical University of Athens, 15780 Zografou, Greece
\textsuperscript{3}National Centre for Scientific Research ‘‘Demokritos’’, Institute of Nuclear Physics, GR-15310 Agia Paraskevi, Greece

In this work a new calibration method using extended water samples is presented for natural occurring radionuclide materials (NORM) measurements. The method aims to contribute to a future waste management policy related to the presence of NORM close to offshore industries for oil and gas exploration. The main issue of exploration and production waste stream in the aforementioned fields is the formation waters and their mixture with sea bottom material. Their disposal affects the entire marine ecosystem due to the high concentration of NORM. Also, the quality of formation water is critical since it is used from personnel for the drilling and cleaning purposes. Previous results [1] have shown that, $^{226}$Ra concentration ranges from 5 Bq/L to 28 Bq/L and the total activity in formation water is in the range of 16–840 Bq/L (due to enhanced levels of dissolved $^{226}$Ra, $^{214}$Pb, $^{214}$Bi).

The method consists of the photopeak efficiency calibration and the minimum detectable activity calculation using a broad energy HpGe detector. The efficiency is calculated for all gamma ray emitters of NORM ($^{40}$K, $^{210}$Pb, $^{214}$Pb, $^{214}$Bi, $^{226}$Ra, $^{235}$U, $^{228}$Ac, $^{208}$Tl) using the $^{152,153}$Eu standard source diluted in aquatic extended sample. The data were reproduced using Monte Carlo simulations. The developed method is characterised by immediate results since no pre-treatment is required, keeping the safety standards minimising the exposure of personnel. Moreover, the small quantity of the sample exhibits low ecological impact in case of disposal of the sample after the measurement.

The control of the marine radioactivity in similar activities that will take place in the Hellenic Seas has large society impact, so monitoring tools have to be applied combining systematic laboratory measurements with continuous monitoring installations (before and after the drilling operations).

The dispersion and the fate of the radionuclides in the marine environment are of great concern for coastal radioecology and radioprotection. Approaches to the management of the risk in radioecology have to take into account geographic, climatic, living and dietary habit, as well as ecosystem characteristics. An effective tool that can combine these parameters and give reliable dispersion estimations is radiological modeling. Modeling exercises have given significant information for the vulnerability of different environments. Thus, the environmental sensitivity of each location can be set as a scientific parameter in the environmental management and the policy making.

In this work, the radiological model of Thermaikos Gulf ecosystem has been designed based on the MOIRA-PLUS decision support system [1], properly modified for the marine environment. Radioactive fallout contamination exercises have also been performed for $^{90}\text{Sr}$ and $^{137}\text{Cs}$ radioisotopes, within the frame of environmental sensitivity analysis. The model’s performance has been calibrated, taking into account the available $^{137}\text{Cs}$ deposition estimations and published experimental concentrations to the sediment, the water and the fish at the Gulf, from the time of the Chernobyl accident up to now. The radiation doses to adults – assuming that all of their food intake from the marine pathway comes from the local environment – after the first year of one instantaneous deposition of 1000 Bq/m$^2$, were found 0.72 $\mu$Sv for $^{137}\text{Cs}$ and 8.8 $\mu$Sv for $^{90}\text{Sr}$, respectively. The results are consistent with model estimations in northern seas.

* The work is supported by the FMO / EEA FM Grants through the EL0086 – NTUA Scholarship and Mobility Program 2004 – 2011, within the framework of Environmental Sensitivity working group of IAEA EMRAS II project.
Lately the crust of neutron stars is under intense investigation [1]. Neutron-rich nuclei play a significant role. Assuming nuclear and beta equilibrium (cold catalyzed matter) they determine the crust’s composition and properties. Neutron star crust out of equilibrium is considered one of the possible sites where they are produced via r-process nucleosynthesis [2]. Since experimental information of the properties of neutron-rich nuclei is still limited theoretical models are needed. We focus on their $\beta^-$-decay half-lives ($T_{\beta^-}$). A number of useful approaches to modeling $T_{\beta^-}$ has been proposed and applied. Among these there is the statistical global model that we have developed for the systematics of $\beta^-$-lifetimes of the ground state of nuclei that decay exclusively by this mode in the form of a fully connected, multilayer feed-forward Artificial Neural Network (ANN) [3] using data from Nubase2003 [4]. Several tests of its performance have been made as reported in Ref. [3]. We have recently checked its predictive performance for the $T_{\beta^-}$ of all neutron-rich nuclides that have been experimentally studied after Nubase2003 has been published. The conclusion is that in predictive performance the ANN model can match or even surpass that of established theoretical and phenomenological approaches based on quantum theory and can therefore provide a valuable complementary tool for explaining $\beta^-$-decay systematics.

In this work we give predictions of the ANN model for the $T_{\beta^-}$ half-lives of neutron-rich nuclides that are considered to be present in the crust of neutron stars built from cold catalyzed matter. We also present some results from our study of $T_{\beta^-}$ of nuclei synthesized via the r-process [5]. A comparison is made of the ANN $T_{\beta^-}$ values with available experimental ones as well as with those of two conventional QRPA based approaches [6]. The study of other properties of neutron-rich nuclides relevant to the physics of neutron stars crust with artificial intelligence techniques is in progress.

* PYTHaim Group: URL: http://www.pythaim.phys.uoa.gr, E-mail: pythaim@phys.uoa.gr
During the last decades, the physics of neutrinos has gained intense interest in nuclear and astro-particle physics as well as in the areas of space sciences like cosmology and astronomy. Specifically, regarding the role of neutrinos in the evolution of massive stars, explosive nucleo-synthesis, etc. [1], recent stellar evolution models describing the explosion mechanism of type II supernovae have provided us with important informa-tion [1]. However, uncertainties on astrophysical interactions of neutrinos with matter are intimately related to our understanding of the neutrino-nucleus cross sections. In addition, neutrino experiments need improvements over systematic errors originating from neutrino-nucleus cross section uncertainties at low and intermediate nuclear excitation energies.

The present work focuses on the role of neutrino-nucleus interactions in analysing the neutrino signals recorded by terrestrial experiments. We also investigate their scattering inside the matter of stars (supernova, etc.) that determine the shape of the neutrino-energy spectra [1]. We pay special attention on the parameterizations of the supernova neutrino energy spectra and the use of the low-energy beta-beam spectra originating from boosted radioactive nuclei, $^6$He and $^{18}$Ne, for their interpretation.

This study may provide useful informations for the neutron spallation sources (SNS) experiments at the Oak Ridge National Laboratory (ORLaND), Tennessee, USA, and at Lund Sweden, as well as for other sources of intermediate energy neutrinos like the beta-beam neutrinos.

References

We study the effect of nuclear equation of state on the r-mode instability of a rotating neutron star. We consider the case where the crust of the neutron star is perfectly rigid and we employ the relative theory introduced by Lindblom et. al. [1]. The gravitational and the viscous time scales, the critical angular velocity and the critical temperature are evaluated by employing a phenomenological nuclear model for the neutron star matter. The predicted equations of state for $\beta$-stable nuclear matter parameterized by varying the slope parameter $L$ of the symmetry energy at saturation density on the interval 50 MeV- 110 MeV. The effects of the density dependence of the symmetry energy on r-mode instability properties are presented and analyzed. A comparison of theoretical predictions with observed neutron stars in low-mass x-ray binaries are also performed and analyzed.

* This work was supported by the German Science Council (DFG) via SFB/TR7.

The impact of nuclear physics input on the production of heavy elements is one of the most important aspects of nuclear astrophysics. Among the various nucleosynthesis processes the p-process is still not well understood, partly due to uncertainties concerning the p-process site and partly because of uncertainties in nuclear reaction rate data.

In this study we focus on the impact of uncertainties relating to reaction rates on the final abundances. In doing so, an extended reaction network is used to simulate p-process flows. By comparing reaction rate data from two different libraries maximum upper and lower limits on rate values are established and their effect on the final production of p-nuclei is examined.
Neutron Detection via $^{14}$N(n,p)$^{14}$C reaction Using the Spherical Proportional Counter

I. Giomataris$^1$, I. Savvidis$^2$, S. Aune$^1$, E Bougamont$^1$, M. Chapelier$^1$, Ph.Charvin$^1$, P. Colas$^1$, J. Derre$^1$, E. Ferrer$^1$, G Gerbier$^1$, M. Gros$^1$, X.F. Navick$^1$, Th. Papaevagelou$^1$, P. Salin$^3$

1 IRFU, Centre d’études de Saclay, 91191 Gif sur Yvette CEDEX, France
2 Aristotle University of Thessaloniki, Greece
3 APC, Université Paris 7 Denis Diderot, Paris, France

A large volume (1m3) spherical proportional counter has been developed, for low flux neutron measurements. The detector consists of a large spherical gas volume with a central electrode forming a radial electric field. New gas mixtures, (Ne, C$_2$H$_6$, N$_2$) and (Ar,CH$_4$,N$_2$) have been studied for thermal and low energy neutron detection, in comparison with typical $^3$He counters, providing a new way for the low energy neutron spectroscopy. The neutrons are detected via the $^{14}$N(n,p)$^{14}$C reaction. In this presentation we have been studied the optimum gas mixture, gas pressure and also the optimum high voltage supply on the sensor of the detector, to achieve the maximum amplification and better resolution. The thermal neutrons are well detected giving a proton peak well separated from the cosmic ray background.
Experimental study and FLUKA simulations of a prototype micromegas chamber in a mixed neutron and photon radiation field – Further developments

T. Alexopoulos\textasciitilde{}a, F. Cerutti\textasciitilde{}b, N. Charitonidis\textasciitilde{}b,c, M. Diakaki\textasciitilde{}a, E. Gazis\textasciitilde{}a, M. Kokkoris\textasciitilde{}a, A. Kyrtsos\textasciitilde{}a, E. Skordis\textasciitilde{}a, A. Tsinganis\textasciitilde{}a,b, G. Tsipolitis\textasciitilde{}a, R. Vlastou\textasciitilde{}a

\textit{\textasciitilde{}a} Department of Physics, National Technical University of Athens, Zografou Campus 157 80, Athens, Greece. \\
\textit{\textasciitilde{}b} CERN, CH-1211 Geneva 23, Switzerland. \\
\textit{\textasciitilde{}c} École Polytechnique Fédérale de Lausanne (EPFL), CH-1015 Lausanne, Switzerland.

Detectors based on the micromegas principle have already been used in several atomic, nuclear and particle physics experiments. They have also been proposed as one of the options to upgrade the ATLAS muon spectrometer in the very forward/backward region. To meet this end, it is imperative to study their performance in a mixed (neutron and gamma) radiation field. The general–purpose Monte-Carlo code FLUKA has been employed in the present work in order to study the effect of 5.5 MeV neutrons impinging on a prototype micromegas detector developed for sLHC. The response of the detector to the photons originating from the inevitable neutron inelastic scattering on the surrounding materials of the experimental facility was also studied, through comparisons with experimental data.

Furthermore, preliminary data on the performance of a 4-fold micromegas detector, especially designed for the study of (n,f) reactions in rare actinides in the framework of the n_TOF experiment at CERN, are presented. This detector will be soon implemented at NCSR ‘Demokritos’ for the study of the $^{237}$Np(n,f) total reaction cross section using monoenergetic neutron beams as provided by the 5.5 MV HV TN-11 tandem accelerator of the institute of nuclear and particle physics.

\textit{Keywords}: Micromegas gaseous detector; FLUKA; Neutron and fission cross-section

\textit{PACS No}: 29.40.-n, 24.10.Lx, 25.40.Dn, 25.40.Fq
The first successful application of the recently developed High-Velocity Transient Field Technique (HVTF) on European soil was performed at GANIL. HVTF is an extension of the well established Transient Field (TF) technique, which utilizes immense hyperfine magnetic fields (~10-100 kG) capable of inducing a spin precession of an excited nucleus. With the advent of radioactive beams, detailed explorations of such hyperfine fields have been carried out at larger-than-usual ion velocities in an effort to introduce the technique to large radioactive beam facilities.

The neutron-rich radioactive $^{72}$Zn isotope is an ideal playground for HVTF. Coulomb excitation populated the $2_1^+$ state in $^{72}$Zn nuclei, produced as fast secondary beams at GANIL and INFN-LNS, aiming to (a) calibrate the hyperfine field at these beam energies and (b) measure the $g$ factor of $2_1^+$ directly. The successful outcome of these experiments will be reported and future plans for the HVTF application to magnetic-moment measurements in exotic nuclear systems will be briefly described.

(*) This work has been supported partially by LIBRA (FP7-REGPOT-Capacities)
Theoretical studies indicate that the size of shell gaps can alter when changing the N/Z ratio leading to changes in magic numbers when going away from the line of stability. One of the most interesting regions of the chart of nuclides is around $^{68}\text{Ni}$. The observation of the high excitation energy of the first $2^+$ state of this nucleus, in combination with the minimum in the systematics of $\text{B(E2;}_2^+\rightarrow_0^+)\$, has led to interpretations in terms of a harmonic oscillator subshell closure. On the other hand, the two-neutron separation energies in the N=40 region do not present any irregularity - characteristic of a shell closure. In view of this controversial experimental evidence, the single particle character of the $^{67}\text{Ni}$ has been decided to be investigated.

In the last four decades the one-nucleon transfer reactions have been proved to be the workhorse for the deduction of spectroscopic information for nuclei at or near the valley of stability. Nowadays, the development of radioactive ion beams allows access to nuclei that were previously unapproachable. Accordingly, the excitation spectrum of $^{67}\text{Ni}$ was studied by performing the $^{66}\text{Ni(d,p)}^{67}\text{Ni}$ reaction study in inverse kinematics with an energy of 3 MeV/u. The experiment was realized at the REX-ISOLDE radioactive ion beam facility in CERN. The MINIBALL setup was used in combination with the newly built T-REX particle detection array. In this experiment, levels with excitation energies up to 6 MeV have been populated and extensive new spectroscopic information was deduced. The first results of the analysis will be presented with emphasis to the abilities of the T-REX particle detection array.
Session 6

Research activities of NCSR “Demokritos” for the European Fusion Technology Program

K. Mergia1, G. Apostolopoulos1, Z. Kotsina1, K. Papamichail1, T. Vasilopoulou1, M. Gjoka1, M. Pissas1, T. Lagoyannis2, S. Harissopoulos2, I. E. Stamatelatos1 and S. Messoloras1

1 Institute of Nuclear & Radiological Sciences & Technology, Energy & Safety NCSR Demokritos Aghia Paraskevi, Athens, Greece
2 Tandem Accelerator Laboratory, NCSR “Demokritos”, Aghia Paraskevi, Athens, Greece

The realization of fusion for energy production strongly depends on advances in a diversity of science fields and technological sectors. To the one end the development of structural materials withstanding the high temperatures and intense radiation fields of the plasma and also advances in high temperature superconductors for the plasma magnetic confinement are required. To the other end plasma diagnostics and detectors are of paramount importance for plasma engineering and control. Fusion research in Europe is co-ordinated by EFDA, the European Fusion Development Agreement, which is the umbrella organization of all fusion research laboratories in Europe. EFDA is part of the EURATOM program of the European Commission. A consortium of researchers from different Institutes of NCSR “Demokritos” (NCSRD) participates in the EFDA technology activities. The NCSRD consortium is active in two main Fusion technology areas, the one concerns fusion related materials research and development and the other refers to the interactions of plasma produced neutrons with matter and the containment vessel.

The objective of the European Fusion Materials Program, within the framework of EFDA, is to develop materials suitable for the future fusion reactor. In FP7 the goals of the program are more science than technology driven. NCSRD is active in research related to investigation of the physical properties of iron-based steels and the fundamental understanding of their changes under different irradiation conditions. The NCSRD TANDEM and other European ion beams are utilized in order to understand the degradation of materials under irradiation.

In addition, NCSRD group investigates neutron streaming and activation effects in tokamaks and fusion power plants using computational tools.

* kmergia@ipta.demokritos.gr; www.hellasfusion.gr
Session 6

Radiation damage studies of Fe-Cr alloys for Fusion applications using ion beams

Z. Kotsina, G. Apostolopoulos, K. Mergia, S. Messoloras

Institute of Nuclear and Radiological Science and Technology, Energy, and Safety
National Centre for Scientific Research “Demokritos”
15310 Aghia Paraskevi Attikis, Greece

A. Lagogiannis, S. Harissopulos

Institute of Nuclear and Particle Physics
National Centre for Scientific Research “Demokritos”
15310 Aghia Paraskevi Attikis, Greece

Ferritic-martensitic steels are considered as prime candidates for the first wall and blanket structural materials in future fusion reactors. They are based on Fe-Cr alloys with Cr up to 12%. Therefore, as a first step towards understanding the irradiation behaviour of these steels, we study pure Fe-Cr alloys as a “model system”. The flexibility offered by ion beams in accurately defining irradiation conditions, allows us to perform controlled experiments that will aid in the validation of recent theories of radiation damage.

Radiation damage studies are performed at the TANDEM accelerator of NCSR "Demokritos" by using a 5MeV proton beam directly on the sample and reaching fluences of $\sim 10^{15}$ protons/cm$^2$. Proton irradiations were carried out at cryogenic temperatures. The subsequent defect evolution was studied during isochronal annealing experiments up to 350K. Electrical resistivity was used as an estimate of the damage level in the material. Initial results will be presented from irradiation experiments on Fe of different purities.
Session 6

Activities of the University of Athens at SUL-X and FLUO beamlines of ANKA Synchrotron facility (KIT, Germany) in Earth & Environmental Sciences

A. Godelitsas1, T.J. Mertzimekis1, P. Gamaletsos1, N. Chatzikonstantinou1  
J. Göttlicher2, R. Steininger2, R. Simon2

1University of Athens (UoA), NUSTRAP Collaboration  
2Karlsruhe Institute of Technology, Institute for Synchrotron Radiation, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

ANKA is the Synchrotron light source of the Karlsruher Institute of Technology/KIT (Germany), providing light from hard X-rays to the far-infrared for research and technology (http://ankaweb.fzk.de/). The SUL-X beamline combines fluorescence, absorption and diffraction measurements mostly on geological and environmental materials with microfocusing capabilities (μ-XRF/-XAFS/-XRD) whereas the FLUO beamline is dedicated to trace element detection at sub-ppm level and 2D/3D elemental mapping with μm resolution. The previous activities of the NUSTRAP collaboration of UoA (http://magneticmoments.info/nustrap/index.php), at ANKA facility, with regard to Earth & Environmental Sciences, concerned the following topics: 1) Hazardous elements in anthropogenic (e.g. Athens urban particulates, Figure 1, [1]) and natural (i.e. Saharan dust [2]) atmospheric particles, 2) Actinides in mining products (e.g. Al-ores from Greece [3]) and 3) Actinides in sedimentary rocks (e.g. U in limestones of central Greece [4]).

![Figure 1: Synchrotron μ-XRF investigation (FLUO beamline) of the respirable fraction (PM$_{2.5}$) of Athens urban particulate matter and As $K$-edge μ-XANES spectra (SUL-X beamline) of an As hot spot. The dash-dotted line is the spectrum of an As(III) reference compound (As$_2$O$_3$), the dashed line represents an As(V) reference compound (As$_2$O$_5$). Energy has been calibrated to the first derivative of the Au-$L_{III}$ edge (11.919 keV) [1]](image)

Our recent activities at ANKA concern the following topics: 1) Hg and other heavy metals in coastal/lagoon sediments of western Greece, 2) Fe- and As-biominerals from Aegean submarine volcanoes, 3) Hazardous elements in Al-ore (bauxite) and solid wastes (red mud) from Ajka plant (Hungary), and 4) Au and Ag in mining products of Greece.

[2] A. Godelitsas et al., (to be submitted)  
[4] A. Godelitsas et al., (to be submitted)
Whole body counting refers to the measurement of X and γ-radiation emitted from the human body. A prototype multidector shadow-shield whole body counter (WBC) was designed, constructed and tested at the Ioannina University Medical Physics Laboratory (IUMPL) as a tool in radiation protection and in biomedical research [1]. The counter is equipped with sixteen NaI(Tl) detectors located at the central region of a shielded tunnel made of 10 cm thick lead bricks. During the first year of operation of the counter in its current form it was used among others for the in vivo quantification of potassium in the human body, the assessment of accidental internal contamination of members of the public and workers that handle unsealed radioactive sources and for the evaluation of contamination of patients treated with open radioactive sources.

A. Potassium is important for vital processes in vertebrates and is mainly found inside living cells and is absent in fat. The naturally occurring radioisotope ⁴⁰K results in the emission of 3.3 photons 1.46 MeV in energy per second per gram of potassium. Total body potassium, TBK, measured in 37 healthy adult subjects was correlated with age and gender as well as with their fat free mass, assessed by dual X-ray absorptiometry.

B. Internal contamination with ²¹⁴Bi of 180 and 450 Bq was found in two volunteers for TBK measurements. Their contamination was attributed to previous ingestion of water with high radium concentration and the radium retention in their body.

C. Among the radiation workers monitored for internal occupational exposure at UIMPL, three were found to be contaminated with 0.8 to 2 kBq of the short-lived ⁹⁹ᵐTc. They were medical doctors, that earlier the same day injected ⁹⁹ᵐTc containing radiopharmaceutical to their patients. Their contamination was not noticed by the standard work procedures.

D. Two patients with bone metastasis treated with ¹⁵³Sm-EDTMP for pain relief were scanned two weeks after ¹⁵³Sm administration, i.e. a radionuclide that decays with a half-life of 46.3 h. The detected long-lived ¹⁵²Eu and ¹⁵⁴Eu radionuclides in their body (30 and 25 kBq, respectively, on the average) were attributed to contamination during ¹⁵³Sm production process at a nuclear reactor. Contaminations at such levels result in long-term irradiation of the patient, his relatives, caregivers, general public, and could cause “innocent alarms” in radiation monitoring used for homeland security.

The examples given demonstrate the range of applications of the UIMPL high-sensitivity multi-detector WBC in radiological protection and in biomedical research.

The Single Photon Emission Computed Tomography (SPECT) using simple $\gamma$-radionuclides has been established as a standard technique in the physiological and functional nuclear imaging. On the other hand, accurate reconstruction of abnormalities inside biological tissues based on the detected temperature distribution obtained at the surface of the skin presents a major challenge in emission thermography. The present work focuses on the experimental study with these modalities using appropriately constructed $^{99m}$Tc and thermal phantoms. Special emphasis was given to the relationship between the physical characteristics, such as the location and the emission power of an embedded heat source inside an absorbing medium and the measured temperature distribution by means of infrared imaging. Those thermal phantoms were studied at temperature 35-40°C, which corresponds to mammal’s core temperature. The obtained planar information was further analyzed to reconstruct the tomographic images, and from them, the final 3D image of the phantoms. The reconstruction procedure was performed with iterative algorithms based on MLEM and accelerated ART techniques. Results for both modalities, SPECT and Infrared Tomography, are comparatively presented in this study and the advantage of each method is thoroughly discussed.

Figure 1: Phantoms used in this study. Top: A Gel-Phantom with cylindro-conoidal tubes and capillaries filled with $^{99m}$Tc solution used in SPECT. Bottom: A thermal phantom used in infrared tomography. Planar images of each phantom and the 3D-reconstructed tomogram are shown.
Positron Emission Tomography (PET) has become a valuable tool with a broad spectrum of clinical applications in nuclear imaging. PET scanners can collect in vivo information from positron radiotracer distributions, which is further reconstructed to a tomographic image with the help of well established analytical or iterative algorithms. In this current work, an innovative PET image reconstruction method from raw data based on a simple mathematical model is presented. The developed technique utilizes the accumulated density distribution in a predefined voxelized volume of interest. This distribution is calculated by intersecting and weighting the two-gamma annihilation line with the specified voxels. To test the efficiency of the new algorithm, GEANT4/Gate simulation studies were performed. In these studies, a cylindrical PET scanner was modeled and the photon interaction points are validated on an accurate physical basis. Several phantom geometries with different positron radiotracers were used and the reconstructed results were compared to the original phantoms.
Session 7

Population of isomeric states in neutron-induced reactions on $^{197}$Au

N.G. Nicolis$^1$, R. Vlastou$^2$, C.T. Papadopoulos$^2$, M. Kokkoris$^2$, M. Diakaki$^2$

$^1$Department Physics, The University of Ioannina, Ioannina 45110, Greece.
$^2$Department of Physics, National Technical University of Athens, Athens, Greece.

Excitation functions of product yields in neutron-induced reactions on $^{197}$Au were recently obtained using the 5.5-MV Tandem Van de Graaff accelerator at the National Centre of Scientific Research “Demokritos” [1]. Cross sections of the $^{197}$Au(n,2n)$^{196}$Au, the second isomeric state (12$^-$) and the sum of ground (2$^-$) plus the first isomeric state (5$^+$) of $^{196}$Au were combined with available database excitation functions and compared with statistical model calculations [1,2]. The inability of the model to describe the high-energy part of the second isomeric excitation function suggested the need for modifications in the effective moment of inertia or the introduction of a rotational gamma band, predicted but not yet observed in $^{196}$Au [1,2,3]. In a local statistical model analysis, Avrigeanu et al. obtained a consistent description of all available reaction data [4]. However, this was achieved assuming (a) a lower location of the gamma continuum in the residual nuclei compared to the earlier calculations, and (b) one rigid-body value for the moment of inertia for $^{196}$Au together with one-half rigid-body value for the nearby $^{194}$Ir residual nucleus.

In the present work, we study the possibility for an alternative description promoting the “missing gamma band” scenario. We examine the population of high spin states in the residual nuclei as influenced by (a) the entrance and exit channel neutron penetrabilities and (b) the effect of the nuclear quasi-continuum gamma decay. Gross features in the population of entry states of the evaporation residues were obtained with the statistical model code CASCADE [5]. Furthermore, the effect of the nuclear quasi-continuum in the population of the isomeric states in $^{196}$Au was simulated with the statistical code GAMBLE [6]. We discuss the sensitivity of model parameters in the description of the available experimental excitation functions.

In this work the characterization of thin actinide targets (\(^{237}\text{Np},^{238}\text{U},^{235}\text{U}\)), manufactured for measurements of fission cross section, will be presented. These targets have been already used at the n_TOF facility at CERN for the measurement of the \(^{237}\text{Np}(n,f)\) cross section with use of a white neutron beam and the FIC ionization chamber. They will further be used for the re-measurement of this cross section using monoenergetic neutron beams produced via the \(^{2}\text{H}(d,n)^{3}\text{He}\) reaction at the Institute of Nuclear Physics at N.C.S.R. “Demokritos”, implementing a new MicroMegas detector constructed at CERN for these measurements, in the context of the n_TOF collaboration.

The determination of the mass of the actinide content of each target has been performed via alpha spectrometry, utilizing two SSB detectors, with 50mm\(^2\) and 3000mm\(^2\) active surface, in order to combine good resolution and good statistics respectively and obtain a smaller error in the final mass result. The impurities of the targets were quantitatively estimated with the same technique.

The homogeneity of the samples was examined with two independent methods. Firstly, RBS measurements were performed using a proton beam of 2 MeV, provided by the 5.5 MV Tandem Van de Graaff accelerator of the N.C.S.R. “Demokritos”. The thickness of each target was quantitatively estimated in various points. Secondly, CR-39 plastic track detectors were used to measure the alpha tracks from the surface of the targets and provide an image of the activity of the surface.
Session 7

Differential cross-section measurements for the $^7\text{Li}(p,p^0)^7\text{Li}$, $^7\text{Li}(p,\alpha^0)^4\text{He}$, $^{19}\text{F}(p,p^0)^{19}\text{F}$ and $^{19}\text{F}(p,\alpha^0)^{16}\text{O}$ reactions

V. Paneta$^{1,2}$, A. Kafkarkou$^2$, M. Kokkoris$^2$, A. Lagoyannis$^1$

$^1$Tandem Accelerator Laboratory, Institute of Nuclear Physics, NCSR “Demokritos”, 15310 Aghia Paraskevi, Athens, Greece.

$^2$Department of Physics, National Technical University of Athens, Zografou campus, 15780 Athens, Greece.

The quantitative determination of lithium and fluorine in various samples is of great importance for material science as well as for medical, biological and environmental studies. Among Ion Beam Analysis (IBA) methods, Elastic Backscattering Spectroscopy (EBS) and Nuclear Reaction Analysis (NRA) are widely used for the quantification of the abundance of individual light isotopes in complex samples, providing simultaneously depth profiling data. The existing differential cross-section datasets in the literature, necessary for the implementation of these techniques, concerning lithium and fluorine, are unfortunately inadequate and discrepant in many cases, thus limiting the applicability of both methods. The present study aims at contributing in this field by providing correlated and validated differential cross-section datasets concerning the $p^+^7\text{Li}$ and $p^+^{19}\text{F}$ reaction channels, over a wide range of energies and detection angles.

More specifically, differential cross sections of the $^7\text{Li}(p,p^0)^7\text{Li}$, $^7\text{Li}(p,\alpha^0)^4\text{He}$, $^{19}\text{F}(p,p^0)^{19}\text{F}$ and $^{19}\text{F}(p,\alpha^0)^{16}\text{O}$ reactions have been determined for proton energies $E_{\text{lab}}=1500$-$7000$ keV, using a variable energy step and for detection angles between $140^\circ$-$170^\circ$ in steps of $10^\circ$. The measurements were performed using the proton beam of the 5.5 MV TN11 Tandem Accelerator of N.C.S.R. “Demokritos”, Athens, Greece. To validate the obtained results, benchmarking measurements were performed, using thick and mirror-polished BaF$_2$ and LiF targets. The experimental data are compared to data from literature, when available, and similarities and discrepancies are presented and analyzed.
Studying nuclear responses to Supernova neutrinos

V. Tsakstara and T.S. Kosmas

Theoretical Physics Section, University of Ioannina, GR 45110 Ioannina, Greece

Abstract

Supernova neutrinos are key particles in investigating the structure and evolution of distant stars, the neutrino-driven explosion mechanisms of massive stars, but also in deepening our knowledge on the fundamental interactions and the nuclear weak responses.

In this work, we apply the convolution procedure in order to compute folded cross sections from theoretical neutrino-nucleus cross sections obtained with realistic nuclear structure calculations \[1,2\]. We assume specific spectral distributions describing supernova neutrino-energy spectra \[2\] and we adopt various models for the supernova neutrino spectra such as those described by two-parameter Fermi-Dirac and power-law distributions.

Convoluted (double-differential, \(d^2\sigma/dQd\omega\), single-differential, \(d\sigma/d\omega(\omega)\), total, \(\sigma_{\text{tot}}\)) and flux averaged, \(\langle\sigma_{\text{tot}}\rangle\) cross sections for inelastic \(\nu\)-scattering on \(^{128,130}\text{Te}\) and \(^{64,66}\text{Zn}\) isotopes are extensively discussed \[3\]. The original cross sections have been calculated by using the quasi particle random phase approximation (QRPA) \[1\]. The concrete nuclear regimes selected, \(^{128,130}\text{Te}\) and \(^{64,66}\text{Zn}\), are contents of the detectors of the multipurpose CUORE and COBRA rare-event experiments \[4,5\]. The folded cross section presented, may provide useful information about the efficiency of the \(\text{Te}\) and \(\text{Zn}\) detector-materials of the above experiments in their potential use for supernova neutrino searches.

References


Lepton - flavor violating neutral-current exotic $\nu$-nucleus processes

D.K. Papoulias and T.S. Kosmas

Division of Theoretical Physics, University of Ioannina, GR 45110 Ioannina, Greece

Abstract

The flavour changing neutral current (FCNC) neutrino-nucleus reactions of the form $\_\_N (\nu_\alpha, \nu_\beta) A N^*_\alpha$ and $\_\_N (\bar{\nu}_\alpha, \bar{\nu}_\beta) A N^*_\alpha$, with $\alpha \neq \beta$, are studied within the context of the Seesaw mechanism. The recent discovery of neutrino oscillations indicates the existence of massive neutrinos in contrast to the massless neutrinos predicted by the Standard Model. In this description we have been inspired from other lepton flavour violating (LFV) processes extensively studied previously like the $\mu^- \rightarrow e^-$ conversion in nuclei, [1,2]. The Seesaw mechanism extends the Standard Model by adding a heavy right-handed neutrino singlet, $N_R$, per neutrino generation.

FCNC neutrino-Nucleus reactions have important applications in Astrophysics and hence a detailed study of such processes is of significant importance. From a nuclear theory point of view, the Donnelly-Walecka model for cross sections calculations is employed, [3]. The single-particle transition matrix elements are obtained from a Mathematica code constructed for this purpose using the compactified formalism of Ref. [4].

References

Realistic nuclear structure calculations for orbital e-capture by nuclei

P.G. Giannaka and T.S. Kosmas

Division of Theoretical Physics, University of Ioannina, GR 45110 Ioannina, Greece

Abstract

The capture of orbital electrons from their atomic nuclei, is one of the most important weak interaction processes in studying the evolution and dynamics of massive stars. Especially for nuclei of the iron (Fe) mass region the role of $e^-$-capture is crucial in the phase of stellar core collapse. From a nuclear theory point of view, a realistic treatment of electron capture on medium-heavy and heavy nuclei provides significant information for the hydrodynamical astrophysical simulations.

In this work, we study extensively the $e^-$-capture process on "iron group peaked nuclei" in a set of isotopes that are important for searching the explosive nucleosynthesis [1]. To this aim, we improved our codes which use compact analytical expressions for the required reduced matrix elements of all basic multipole operators (isospin representation)[2,3]. Up to now we have constructed the ground state of the nuclear isotope chosen in the context of the BCS method. Also, we have calculated their excited states by solving the QRPA equations, using as residual two-body interactions that of the Bonn C-D one-meson exchange potential.

References

Biomass burning caused by anthropogenic activity such as agriculture practices or naturally occurring forest fires is a frequent phenomenon causing global environmental concern for many reasons. Release of certain radioactive or other hazardous compounds from forest fires occurring over contaminated land is one such issue for concern. The physicochemical processing occurring on smoke particles released in the atmosphere during long range transport is also another topic of interest.

This work presents first results from atmospheric measurements conducted during August 2010 in the Demokritos ERL sampling site for ambient TSP aerosol collected by a High Volume Sampler and analyzed for total $\beta$ radioactivity and $\gamma$ spectrometry. Filters were analyzed after a period of 4 days past sampling in order to allow decay of short lived Radon and Thoron daughters. Parallel measurements of aerosol physicochemical properties at the GAW DEM station were also employed.

It was observed that enhanced levels for total beta radioactivity were observed in the period of 12-18 of August compared to the remaining period. An average value of 2.0 ± 0.3 mBq/m$^3$ was measured over the first period compared to 1.0 ± 0.2 mBq/m$^3$ found for the rest of the sampling period. The latter is found equivalent to the background levels observed at the site during the summer months. It was also observed that during the enhancement in radioactivity organic and elemental carbon levels were also enhanced above the mean value of long term observations at the site. Especially for organic carbon a higher mean value of 4.4 ± 1.1 $\mu$g/m$^3$ was observed during the “episode” period compared to the rest of the time when 2.4 ± 0.7 $\mu$g/m$^3$ was measured.

Air mass back trajectory analysis indicated that the origin of the air mass crossing Athens during the 12-18$^{th}$ of August was the European Russian central plains where extensive forest fires were raging. The enhanced organic carbon values is a strong signal for forest fires. The enhanced radioactivity is initially attributed to higher amounts of natural radioactive isotopes like $^{210}$Po (Savidou et al., 2006), $^{40}$K and $^{7}$Be normally found in vegetation and released in the smoke.


Keywords:
natural radioactive isotopes, organic carbon, elemental carbon, biomass burning/forest fires
Available methods employed for compositional characterization of whole objects are either invasive or have limited penetration depth in matter (such as X-rays and charged particles). However, since neutrons and gamma rays have penetration depths within materials of the order of several centimeters, depending on their energy and sample material properties, neutron activation provides a technique capable to provide composition analysis of the inner structure of large volume samples (up to several litters in volume).

The Large Sample Neutron Activation Analysis (LSNAA) method incorporates neutron irradiation of the object of interest in a research reactor thermal neutron column and subsequent measurement of the activity induced by a HPGe based gamma spectrometry system with collimated gamma scanning and gamma attenuation measurement options included. The parameters that differentiate LSNAA from conventional instrumental NAA are the corrections required for self-absorption of gamma rays emitted by activation products, self-shielding of the activating neutrons, sample asymmetry, the geometric volume factor and other factors. Moreover, the technique enables identification of inhomogeneities in induced activity distribution within the sample and correction of their effect on the interpretation of gamma spectrometry data.

In this work, the application of LSNAA in cultural heritage studies is discussed and studies shown the unique capabilities of the technique for non-destructive compositional analysis of precious objects and artefacts that need to be preserved intact and cannot be damaged for sampling purposes are presented.

* This work was supported in part by the IAEA CRP-14565 and the European Commission through the Key Action: Strengthening the European Research Area, Research Infrastructures, contract no RII3-CT-2003-505925.
Session 8

Techniques Used for Clearance of Radioactive Waste

Anastasia Savidou


The present work concerns the techniques that were developed at NSCR “Demokritos” for verification of compliance with the clearance limits, before removal of radioactive waste items or drums from regulatory control.

The estimates of total radioactivity present in waste will be derived directly from field radiological measurements, supplemented by analytical data and in some cases through computational models. These estimates include:

- Limited sampling and full analyses to establish ratios of radionuclides (scaling factors [4]) present in radioactive waste
- No-destructive gamma spectroscopy to support computational methodologies for determination of radionuclides
- Direct measurement of $\alpha$ or/and $\beta-\gamma$ contamination

The applied practice in Greece for release of materials from regulatory control is the compliance with the general clearance levels in Bq/g that are referred in the Greek Radiation Protection Regulation [1]. These limits are in accordance with the EU publication RP 122 (Part I) [2]. The adopted strategies in EU for removal of materials from regulatory control are either compliance with the mass specific general clearance levels mentioned in RP122 or with the mass and surface specific conditional clearance criteria for recycling of metals mentioned in RP89 [3]. For clearance of radioactive waste at NCSR “Demokritos”, the mass specific clearance criterion is followed when the surface specific clearance criterion mentioned in RP89 is satisfied.

The reduction of the volume of radioactive waste following a clearance procedure is very essential, since limits substantially the cost of management and final disposal.


Session 8

Sediment measurement of samples from Tigris and Euphrates estuary by means of gamma-ray spectroscopy

D.L. Patiris\textsuperscript{1}, C. Tsabarisis\textsuperscript{1}, E. Androulakaki\textsuperscript{1,2}, G. Eleftheriou\textsuperscript{1,2}, D. Papageorgiou\textsuperscript{1,2}, F. Pappa\textsuperscript{2}, Sgouros G\textsuperscript{3} and C. Anagnostou\textsuperscript{1}.

\textsuperscript{1}Institute of Oceanography, Hellenic Centre for Marine Research, 19013 Anavyssos, Greece
\textsuperscript{2}Department of Physics, National Technical University of Athens, 15780 Zografou, Greece
\textsuperscript{3}MARITECH, Marine Project Services, P.O. box 70384, 16610 Glyfada, Greece

Tigris and Euphrates rivers are the two defining rivers of Mesopotamia. Both emerge in eastern Turkey and cross Syria and Iraq before they unite to Shatt al-Arab River (which is a distance of 200 km before discharging in Persian Gulf). Fifty-two samples of seabed sediment were collected from the estuary of Shatt al-Arab River. The samples were sent to Marine Radioactivity Laboratory of the Hellenic Centre for Marine Research for activity concentration measurements of natural and artificial radioisotopes. The measurements realized by means of a High Purity Germanium detector after a standardized sample pre-treatment technique. The results exhibit relative low concentration of several natural radioisotopes (\textsuperscript{226}Ra, \textsuperscript{228}Ra, \textsuperscript{224}Ra and \textsuperscript{40}K) and very low concentration of \textsuperscript{137}Cs and \textsuperscript{235}U. In the case of radium radioisotopes and potassium an inverse relation of the activity with the dry density of sediment was found revealing strong dependency of radioisotopes adsorption with grain characteristics and decreases from fine- to coarse-grained sediment.
POSTER PRESENTATIONS
Monte Carlo MCNP modeling of a HPGe detector and its efficiency for extended sample geometry


*National Technical University of Athens, Department of Physics, Athens, Greece
†NCSR “Demokritos”, Institute of Nuclear Physics, Athens, Greece

The absolute detection efficiency of HPGe detectors in gamma-ray spectroscopy is of particular importance for cross section measurements. In the cases of samples of various types with extended geometry, the determination of detection efficiency using Monte Carlo techniques is inevitable, since calibration sources cannot be produced for all types of samples. In order to achieve accurate results, the effect of precise modeling of the detector itself is of vital importance and can be verified by comparing the simulations of the detector response with experimental results taken with point calibration sources.

In the present work, an 80% HPGe detector has been characterized by means of MCNP5 Monte Carlo simulations. The detector model has been developed in steps, in order to check the effect of various parameters, such as dead layer, rounded front edges, absorbers and geometry, on the gamma ray efficiency in comparison with experimental measurements with a point $^{152}$Eu source. This detector model was then utilized to simulate the experimental spectrum of an extended $^{241}$Am sample with complex shielding and geometry in order to specify in a realistic way the density of the $^{241}$Am content, compared to the nominal one. The results were used to determine the efficiency of the system for the detection of the 987.8keV transition, arising from the deexcitation of $^{240}$Am. The absolute yield of this gamma ray is required to define the cross section of the $^{241}$Am(n,2n)$^{240}$Am reaction, implementing the neutron activation method.
In situ Gamma-Ray Measurements of Marine Sediment using Monte Carlo Simulation

E. Androulakaki 1,2, C. Tsabarlis 1, M. Kokkoris 2, G. Eleftheriou 1,2, D.L. Patiris 1, R. Vlastou 2

1 Institute of Oceanography, Hellenic Centre for Marine Research, 19013 Anavyssos, Greece
2 Department of Physics, National Technical University of Athens, 15780 Zografou, Greece

This work outlines the progress in developing a new method for in situ radioactivity measurements of marine sediments. The method combines the underwater gamma-ray spectrometer (a system named KATERINA based on a NaI(Tl) detector) of the Hellenic Centre for Marine Research with Monte-Carlo calculations using the MCNP5 code. This method aims at allowing for an accurate quantitative determination of activity concentrations in marine sediments (using the in situ system), which can be applied in different areas and for variable sediment structures.

As a first step, the MCNP5 code has been successfully applied for the standard $4\pi$ geometry in the aquatic environment, reproducing results of marine efficiency obtained in the past by implementing the GEANT4 code [1]. The experimental set up geometry was introduced in MCNP5 in great detail. Moreover, a first simulated estimation of the efficiency for sediment measurements is presented for $^{40}$K (1461 keV). For this purpose a new model was constructed taking into account a typical experimental geometry set-up (with the detector being situated in close contact with the seabed). In order to validate the Monte-Carlo results, activity measurements were also performed in sediment samples collected from Basilica, Cyprus, where the in situ system was deployed. The samples were analysed using a HPGe detector for inter-calibration purposes. In the present work the effects of the porosity/water diffusion and the density of the marine sediments are being presented and their importance in the accuracy of the obtained results is discussed.

Heavy metals and radionuclides in the northern coastal zone of Ikaria island (Greece)

A. Godelitsas\textsuperscript{1}, F. Fouskas\textsuperscript{1}, Ch. Tsabaris\textsuperscript{2}, A. Argyraki\textsuperscript{1}, S. Poulos\textsuperscript{1}

\textsuperscript{1}University of Athens, Panepistimioupoli Zographou, 15784 Athens, Greece
\textsuperscript{2}Hellenic Center of Marine Research, 19013 Anavyssos, Greece

Within the frame of the present study the possible occurrence of heavy metals and radionuclides in the northern coastal zone of Ikaria island (Karavostamo, Armenistis and Nanouras bays), east Aegean, Greece, was investigated. The samples were collected from three parallel zones including the bottom of the sea in the depth of 2 m. In the last case, various sea shells were also collected. A portable radioactivity detector with NaI(Tl) crystal was used during the land sampling. The initial study of samples concerned particle-size determination using analytical sieves and mineralogical investigation using XRD. The heavy metal and trace element content, in the coastal sea sediments (2 m depth), was determined by means of ICP-MS whereas SEM-EDS was complementary used. The contained radionuclides and the relevant radioactivity were measured using a \( \gamma \)-ray spectrometry set-up equipped with HPGe detector. All samples were found to be relatively coarse (sand up to 100\% and pebbles up to 15\%) with absence of silt and clay fractions. The XRD patterns showed the presence of typical granite minerals (quartz, feldspars, micas) in the areas of Nanouras and Armenistis located onto the granite of W. Ikaria, while amphiboles and tourmaline were detected in the samples of Karavostamo due to neighboring metamorphic rocks. The geochemical diagrams proved that the immature sea sediments from the granitic areas are enriched in Rb/LREE and depleted in Ni, exhibiting an expected Eu negative anomaly. On the other hand, the Karavostamo immature sediments seem to be weathering products of rather basic rocks. The enrichment (EF) and geoaccumulation (I_{geo}) factors indicated relative enrichment in Pb and As most probably due to anthropogenic sources, such as the wooden boats pigments. The carbonate sea shells were found to be affected by Fe but not heavy metals. The natural radioactivity of all samples is attributed mainly to \(^{40}\)K (231 to 1476 Bq/Kg) and in small extent to \(^{238}\)U and \(^{232}\)Th radionuclide series. The contribution of anthropogenic radionuclides is minor, due to small quantities of \(^{137}\)Cs (<5 Bq/Kg). The increased activity of \(^{40}\)K corresponds to abundant K-contained granitic minerals. Natural actinides (U and Th) are due to the existence of primary silicate and phosphate minerals (zircon, xenotime, monazite) and the occurrence of secondary phosphates like rabdophane. The natural radioactivity at the northern coast of Ikaria is lower compared to that of the southern coast of the island where the thermal springs are located. The recorded activities are in line with the reported values for other areas of Cyclades and northern Greece covered with granitic rocks.
High uranium concentrations in sedimentary rocks of Epirus (NW Greece)

I. Tzifas, A. Godelitsas, E. Androulakaki, G. Eleftheriou, M. Kokkoris and T.J. Mertzimekis

1University of Athens. Panepistimioupoli Zographou, 15784 Athens, Greece
2National Technical University of Athens, Zographou, 15780 Athens, Greece

Epirus region (NW Greece) is generally composed of Mesozoic (250-65 million years old) sedimentary and ophiolitic rocks derived from the Tethys paleo-Ocean. The sedimentary rocks are mostly limestones and shales while the ophiolitic rocks represent old oceanic crust (a sequence of ultrabasic and basic rocks originating in Earth’s mantle). Ophiolites, limestones and shales are fundamentally poor in actinide elements (<0.1, 2.2 and 3.5 ppm respectively) and therefore no elevated actinide concentrations would be expected in Epirus region. However, it is known (internal reports from Greek Atomic Energy Commission and IGME) that in some areas the natural radioactivity is high due to the presence of phosphate-bearing sedimentary rocks (phosphorites). Phosphorites are marine sediments containing an average of 120 ppm U, and may significantly contribute in U geochemical anomalies. Additionally, they are rich in light rare-earth elements/LREE, but not in Th (6.5 ppm) and other HFSE. Uranium in the ocean waters (3.2 ppb) follows anoxic pathways and it is mainly removed from the solution by chemical processes taking place at the interface of organic-rich sediments. It is therefore correlated to organic carbon whereas the diagenetic cycle of the element may include reduction of $U^{6+}$ to $U^{4+}$ related to sulfate bio-reduction. Samples from Epirus region concerning laminated phosphatized limestones (sample: DRYM1), bedded chert-rich limestone (sample: PER1) and tectonized/re-processed phosphatized limestone (sample: PER2), were scanned in the field using a portable radiation detector. Bulk geochemical analyses using ICP-OES/MS showed variable U concentrations with a notable value of 648 ppm in the case of the dark organic-rich part of the sample PER2 (Figure 1).

![Figure 1: Radioactive rock from Perivleptos, near Ioannina (Epirus, NW Greece); the white carbonate-rich part (sample PER2A) contains 7 ppm U whereas the dark phosphate-/organic-rich part (sample PER2B) contains 648 ppm U yielding the γ-ray spectrum showed at the left (the rest of spectra correspond to other sedimentary rocks of Epirus containing 3-18 ppm U).](image)

Gamma-ray measurements using HPGe showed that the above geological material exhibits high radioactivity mainly due to $^{238}$U-series ($^{234}$Pa: 8182 Bq/Kg, $^{226}$Ra: 6852 Bq/Kg, $^{214}$Pb: 7260 Bq/Kg, $^{210}$Bi: 6232.18 Bq/Kg). Powder-XRD, SEM-EDS and further chemical analyses indicated abundant apatite and organic matter, besides calcite, which should be associated to the high U content. Relatively high concentrations of Cd, probably related to apatite, were also revealed. On the other hand, the rock is geochemically depleted in LILE (e.g. Cs, Rb, K), as well as in As, Sb and Se in contrast to red soils (“Terra Rossa”) of the region. The sample is going to be subjected to further microscopic (TEM) and Synchrotron-based investigation (EXAFS) in order to elucidate the nature of U in the matrix.
Induced Radioactivity in Medical Accelerators

John Kalef-Ezra

Medical Physics Laboratories of University of Ioannina and Ioannina University Hospital
451.10 Ioannina, Greece

External-beam radiation therapy mostly uses X-rays in the MeV-energy region for cancer treatment. However, linear accelerators (linac) operated above 6 MV, and mostly those operated above 15 MV in the photon mode, induce delayed nuclear activation by photonuclear reactions and by interactions of the thus produced neutrons with matter. The sources of activation are the accelerator and its accessories, the patient and support system, the building structural materials, the air in the room, and any other item present in the room. The principle radionuclides of importance for staff radiological safety emit $\beta^-$ or/and $\beta^+$ rays followed by $\gamma$-rays, with half-lives ranging between 1 min to few years.

During commissioning of a Clinac 2100 DHX linac by Varian that produces photon (6 and 18 MV) and electron beams (up to 20 MV), delayed activation was studied at twenty locations in a well-ventilated treatment room at the Ioannina University Hospital (IUH). A portable dose rate meter with spectroscopic capabilities was used. Personal badges containing thermoluminescent dosimeters were used to monitor staff radiological burden.

The initial $H^*(10)$ rate at each location following 18 MV X-ray irradiations depends among others on the machine output, the dose rate, the dimensions of the irradiation field and the irradiation history. For example, after a 20 s - long 10 cm x 10 cm irradiation resulting in a 3.0 Gy dose in water at a distance 1.0 m from the photon producing target, initial rates of $\sim$10 $\mu$Sv/h were found close to the beam exit window, the portal imager with patient in place and close to wedge filters made of steel. Initial $H^*(10)$ rates of $\sim$5 $\mu$Sv/h were found 1.0 m away from the target along the central beam-line, and close to the portal imager with no patient in place. An initial rate of $\sim$2.5 $\mu$Sv/h was found close to the patient’s bed, $\sim$1 $\mu$Sv/h close to the directly irradiated walls and at least an order of magnitude lower at the maze. Dose rates decreased gradually at a rate that depended on type of radionuclide formed.

At the majority of the studied locations, $\beta^+$ emitters, such as the ($\gamma$,n) products $^{13}$N, $^{15}$O, $^{53}$Fe, and $^{62}$Cu, are the main short-term dose contributors reaching a saturation level within $\sim$1 h of clinical use. Radionuclides of longer half-life, produced by either photon or neutron interactions primarily at the linac head, such as $^{56}$Mn, $^{64}$Cu, $^{57}$Ni and $^{187}$W, build-up their activity during the workday. Measurements carried out after a 3 month-long period during which no 18 MV irradiation was carried out, showed the presence at the linac head of the neutron capture product $^{124}$Sb, that decays with a half-life of 60 d. Practically only nuclides of short half- life, such as $^{15}$O, $^{38}$K $^{49}$Ca, $^{53}$Fe and $^{57}$Mn, were formed in the directly exposed walls, made of 16 cm of iron and 235 cm of concrete. $^{28}$Al formation was found among others at the aiming lasers installed in the treatment room.

Based on the findings of the present study, a realistic work-plan was developed and adopted to keep the staff doses as low as reasonably practical. Its application, combined with the appropriate room design, resulted, so far, in non-reportable IUH staff doses.
Measurements and Monte Carlo simulations of neutron production at a medical accelerator

Eleni Vagena and Metaxia Manolopoulou

School of Physics, Aristotle University of Thessaloniki, Thessaloniki 54124, Greece

Electron accelerators are being routinely used for cancer treatment. Due to high operational energy (up to 25 MeV), a significant number of neutrons is created by ($\gamma$,n) reactions when high energy photons interact with the materials of the accelerator head. Neutron leakage radiation reaches the patient, contributing additional unwanted dose to the patient and thus the total neutron fluence must be measured precisely. Neutron activation detectors are one of the best options for the measurement of the leaked neutrons, yet the majority of previous studies are calculating neutron fluencies with Monte Carlo simulations. Usually gold and indium are used as activation detectors in experimental studies.

In this preliminary work, we measured neutron fluencies with neutron activation technique. The LINear ACcelerator (LINAC) under consideration is a 18 MeV Varian Clinac 2100C electron accelerator operating at Papageorgiou Hospital, Thessaloniki, Hellas. We measured the total neutron and photon fluence at the isocenter within a 10x10 cm2 X-ray field by nickel, indium, and natural uranium activation foils. All foils returned comparable results. For instance, the total neutron fluence derived from indium foil is $7 \times 10^6$ n/cm$^2$/Gy. This number is in the range with other studies of similar accelerators.

The results of our Monte Carlo simulations, which replicate the experimental set up, are presented and discussed.
Effect of Radon Concentration in Air on the Quality of Radioactivity Measurements in the Human Body

Stratos Valakis\textsuperscript{1,2}, Stavroula Pallada\textsuperscript{1}, Kostas Potiriadis\textsuperscript{3}, Maria Kolovou\textsuperscript{3}, Ion StamateIatos\textsuperscript{2}, John Kalef-Ezra\textsuperscript{1}

\textsuperscript{1}Medical Physics Laboratory, University of Ioannina, 451.10 Ioannina, Greece
\textsuperscript{2}Nuclear Reactor Laboratory, NCSR “Demokritos”, 153.10 Agia Paraskevi, Greece
\textsuperscript{3}Environmental Radioactivity Control Department, GAEC, 153.10 Agia Paraskevi, Greece

A prototype shadow-shield whole body counter was designed, constructed and tested at the University of Ioannina Medical Physics Laboratory as a tool in radiation protection and in biomedical research [1]. Fourteen cylindrical NaI(Tl) detectors with nominal active diameter and height of 15 and 5 cm, respectively, were arranged above or below the subject to be scanned and two NaI(Tl) detectors, 29 by 10 cm, were placed laterally at the central region of a 2.0 m long shielding tunnel made of 10 cm thick lead bricks. In this study, the effect of temporal variations in radon concentration in air on the quality of measurements is discussed and correction methods are presented.

Radon concentration in air was assessed using E-PERM electret and CR-39 track detectors over short and long time periods, respectively. Two methods were examined aiming to reduce the effect of Rn fluctuations on the measurements. First, two fans were installed in the room, which reduced by pressurization the radon concentration by almost an order of magnitude, down to 40 Bq/m\textsuperscript{3}. Second, the peak at the 1.76 MeV spectral region (related to the $^{222}$Rn product $^{214}$Bi) was used to correct for the interference of the Rn products to the lower energies of the spectrum in human and background measurements. Corrections were based on either Monte Carlo simulations or on experimental data obtained in humanoid phantoms.

Twenty measurements carried out over a 1 month time period under inadequate ventilation conditions in two humanoid phantoms loaded with either 90 or 140 g of K indicated a long-term precision error (68.3%) of 8.0 g of the K measurements which was reduced to 2.8 g applying corrections based on spectral shape.

Double measurements carried out in groups of at least ten volunteers measured during five time periods with no forced air ventilation, indicated a relative short-term precision error of the total body potassium (TBK) in vivo measurements based on the 1.46 MeV emission of $^{40}$K ranging from 3% to 6.5% (mean value 4.5%). On the other hand, double TBK measurements carried out in 40 subjects with forced ventilation and sealing of obvious Rn entry routes in the room, resulted in a 3% relative precision error. Application of spectrum corrections further reduced the error.

In conclusion, radon control coupled with corrections for the interference of its decay products improved the performance characteristics of the counter.

Indicative Radiation Dose Rates in Selected Areas of Elevated Natural radioactivity in Greece

Florou H., Trabidou G., Kritidis P.

Institute of Nuclear and Radiological Sciences and Technology, Energy and Safety
NCSR "Demokritos", 153.10 Aghia Paraskevi, Athens, Greece

The natural radiation status has been evaluated in three selected areas, two in the insular and one in the inland Greece of characteristic geological features and the impact of the chronic low level radiation on man and non-humans from various exposure pathways is assessed. The studied areas are described as: a) the island of Milos, located at 36° 42´N, 24° 27´E, is part of the Hellenic volcanic arc in the southern Aegean Sea, in Greece. This is parallel to the subduction zone of the lithospheric plates of the Eastern Mediterranean. The presence of geothermal vents in the Island results to direct and indirect influence on the abiotic material and organisms at all levels of life organization, as the underground hydrothermal fluids of elevated natural radioactivity emitted through the vents. Therefore, as some volcanic areas (in Greece and worldwide) are characterized by elevated concentrations of natural radionuclides, gamma-radiation measurements of abiotic materials (soil, ore, sediment, spring water, seawater) from the terrestrial and marine environment are of particular radiological interest. b) The island of Ikaria, 37° 59´N, 22° 58´E, is located in the eastern Aegean Sea. In the littoral zone around the island there are several geothermal springs of elevated natural background radioactivity and in the sub-littoral zone some springs emerge under the strata through the surface of the bottom to the seawater layer above. c) Loutraki, cited at 37° 36´N, 26° 17´E, is located in Korinthiako gulf in central Greece. It is the southwestern edge of the Hellenic volcanic arc. Several springs are located in the littoral and sub-littoral zone and in the part of the area considered. The geological origin of the three studied areas, characterized by the presence of geothermal springs and vents seems to have an apparent influence to the concentrations of natural radionuclides in the abiotic components, which present elevated values compared to the mean background of Greece. Therefore, the metallic and/or thermo-metallic springs can be considered the responsible agents of carrying on natural radionuclides in the environmental abiotic components and biota consequently for the studied areas, especially for the island of Ikaria. Nevertheless, the derived dose rates, although higher compared to other Greek areas, are lower than the permissible maxima for human use, whereas for non-humans the estimated dose rates lie between the well-being and the physiological masking zone, according to the conceptual model of the ecosystem damage in terms of the various levels of life organization.

Key words: Natural radioactivity, Geothermal springs, Metallic springs, Volcanic arc, Aegean Sea
3D Modeling of the New Microbeam Setup at INP, NCSR “Demokritos” *

F. Panagiotopoulos\textsuperscript{1}, T.J. Mertzimekis\textsuperscript{2,3}, C. Stergiou\textsuperscript{1}, and S. Harissopulos\textsuperscript{3}

\textsuperscript{1} Department of Mechanical Engineering, TEI Piraeus, 12244, Aigaleo, Athens, Greece
\textsuperscript{2} Department of Physics, University of Athens, 15784 Zografou Campus, Athens, Greece
\textsuperscript{3} Tandem Accelerator Lab, INP, NCSR “Demokritos”, 15310 Ag. Paraskevi, Athens, Greece

The newly installed, state-of-the-art microbeam setup has a central role in the future expansion of research activities at the Tandem Accelerator Laboratory of NCSR “Demokritos”, especially regarding applications of nuclear physics. The setup will deliver beams of micrometer size through a specially designed set of beamlines and optical components.

The large range of applications requires excellent knowledge of the beam optics, which depends largely on the space configuration and detailed positions of all focusing components. For that purpose, a detailed 3D modeling of the complete beamline has been carried out, using advanced CAD imprinting techniques. Special emphasis was given in the development of a library of modular 3D parts that will enhance the flexibility and reusability of the beam components in various configurations. In addition, the 3D modeling of the microbeam setup will assist in the accurate beam optics modeling by special simulation software in the near future.

* This work was partially supported by FP7 (LIBRA)
A Nuclear Electromagnetic Moments Database

Konstantinos Stamou\textsuperscript{1}, Thanassis Psaltis\textsuperscript{1}, Theo J. Mertzimekis\textsuperscript{1,2}

\textsuperscript{1}Department of Physics, University of Athens, 15784 Zografou Campus, Athens, Greece
\textsuperscript{2}Tandem Accelerator Lab, NCSR “Demokritos”, 15310 Ag. Paraskevi, Athens, Greece

The latest upgrade of the Nuclear Electromagnetic Moments Database is described in detail. The database has recently reached a RC3 status after its entire redesign of the server engine. The database has been upgraded to a new operational framework based on MYSQL, PHP and XML online technologies, improving its performance, visual content and serving capabilities. It comprises all data on magnetic dipole and electric quadrupole found in relevant printed nuclear databases as well as a large variety of new information found in literature.

The dynamic content is supported by a blog, which contains all information scanned from e-journals and preprint archives on a weekly basis. The url of the database is http://magneticmoments.info.

(This abstract refers to a poster, therefore no presenter is underlined)
Characterization of Nuclear Targets and Thin Films Using Ion-Beam Techniques

Anastasios Kanellakopoulos¹, Varvara Lagaki¹, Theo J. Mertzimekis¹,², Valentina Paneta³,

¹Department of Physics, University of Athens, 15784 Zografou Campus, Athens, Greece
²Tandem Accelerator Lab, NCSR “Demokritos”, 15310 Ag. Paraskevi, Athens, Greece
³Institute of Nuclear Physics, NCSR “Demokritos”, 15310 Ag. Paraskevi, Athens, Greece

We report on the characterization of nuclear targets and thin films using standard ion-beam techniques at the Tandem Accelerator Laboratory (TAL) of NCSR “Demokritos”. A bunch of nuclear targets made out of natural carbon were manufactured at the TAL chemistry lab for multi-purpose use. Earlier made thin films of various elemental composition were available for measurements.

The characterization was carried out with the application of Rutherford Backscattering (RBS) and standard Nuclear Reaction Analysis (NRA) using both large and small goniometric chambers available at TAL. Protons and deuterons were used as primary beams to bombard the samples at several beam energies and detection angles. Results from the measurements and simulations will be presented.
Fabrication and validation of the prototype supporting system for the CLIC Two-Beam Modules

Nikolaos Gazis\textsuperscript{1,2}, Germana Riddone\textsuperscript{1}, Alexander Samoshkin\textsuperscript{1}, Sylvain Griffet\textsuperscript{1}

\textsuperscript{1}CERN - European Organization for Nuclear Research, CH-1211, Geneva 23, Switzerland.
\textsuperscript{2}National Technical University of Athens, Heroon Polytechniou 9, 15780 Zografou, Greece.

The micron-precision RF structures are mounted and aligned on specially developed supporting girders, which provide stability and re-positioning. The supporting girders have stiffness and damping specifications imposed by stringent beam physics and RF requirements. In addition, several constraints, such as allocated space and weight limitation have to be taken into consideration for the design optimization of the girders and the rest of the components of the supporting system. This study presents different support concepts following various fabrication techniques and materials. Extensive qualification measurements and material experiments have been performed on the first prototype units, and the main results are also reported.
N- and O-depth distribution by NRA for the investigation of the corrosion resistance of plasma nitrided and oxidized CoCrMo alloy

F. Noli1, P. Misaelides1, A Lagoyannis2

1 Department of Chemistry, Aristotle University, GR-54124 Thessaloniki, Greece
2 Tandem Accelerator Laboratory, Nuclear Physics Institute, NCSR Demokritos, GR-15310 Aghia Paraskevi- Attiki, Greece

The CoCrMo alloy has been widely used for biomedical applications (orthopaedic prosthesis) because of its corrosion resistance. On the other hand it is found that plasma nitriding at moderate temperature (~400°C) can improve the wear and fatigue resistance of the alloys. Thick nitride layers consisting of a supersaturated nitrogen solution (nitrogen concentration is ~30 at.%) in the matrix can be produced and can also affect the tribological and corrosion properties. Nuclear Reaction Analysis (NRA) in combination with Rutherford Backscattering Spectrometry (Ed: 1.75 MeV) was applied in order to obtain information about the N-and O-depth distribution in the surface of plasma nitrided and oxidized CoCrMo samples. The nitrogen depth distribution was determined using the 14N(d,α)12C and the 14N(d,p)15N nuclear reactions whereas the oxygen by the 16O(d,p)17O (Ed: 1.35 MeV). Investigation of the corrosion behaviour of the samples was performed using electrochemical techniques (potentiodynamic polarization and cyclic voltammetry). The samples were electrochemically treated in simulated body fluid 0.9% NaCl (37 °C) in order to study their pitting corrosion resistance.

The samples subjected to plasma nitridation and oxidation exhibited the lowest deterioration and better resistance to corrosion compared to the nitrided and the untreated material. This could be attributed to the modified surface region with the high nitrogen content and the presence of oxygen.

Keywords: plasma nitridation; RBS; NRA; corrosion; CoCrMo alloy;

![NRA spectra of the CoCrMo+N+O and CoCrMo+N samples prior and after the corrosion testing in 0.9% NaCl solution.](image)

Fig. 1: NRA spectra of the CoCrMo+N+O and CoCrMo+N samples prior and after the corrosion testing in 0.9% NaCl solution.
Proton capture reactions for the p-process nucleosynthesis: the case of the Mo isotopes

V. Foteinou, G. Provatas, M. Axiotis, A. Lagoyannis, P. Demetriou and S. Harissopulos
Tandem Accelerator Lab., NCSR “Demokritos”, 153 10 Aghia Paraskevi, Athens, Greece.

H.-W. Becker, D. Rogalla
DTL–Institut für Experimentalphysik III, Ruhr–Universität Bochum, 40781 Bochum, Germany.

We report on recent (p,γ) reaction cross section measurements in the Mo isotopes at energies relevant to p process by employing the 4π γ-summing method [1]. The aim of these measurements was to derive an extended database of proton-induced capture reaction cross sections to test the predictions of the existing database of proton-nucleus optical model potentials that are used in abundance calculations of p nuclei.

References
Systematic measurements of \((\alpha,\gamma)\) reaction cross sections for astrophysics applications

G. Provatas, V. Foteinou, M. Axiotis, A. Lagoyannis, P. Demetriou and S. Harissopulos

Tandem Accelerator Lab., NCSR “Demokritos”, 153 10 Aghia Paraskevi, Athens, Greece.

H. -W. Becker, D. Rogalla

DTL–Institut für Experimentalphysik III, Ruhr–Universität Bochum, 40781 Bochum, Germany.

A major nuclear physics uncertainty entering abundances calculations of p-process nucleosynthesis refers to the alpha-particle nucleus optical model potential (\(\alpha\)-OMP). Aiming at developing a global microscopic \(\alpha\)-OMP we performed a series of \((\alpha,\gamma)\) reaction cross-section measurements by using the 4\(\pi\) \(\gamma\)-summing technique [1]. The present contribution reports on the results of a number of \((\alpha,\gamma)\) reactions cross-section measurements in the Ni-Pd region. The data are compared with statistical model predictions