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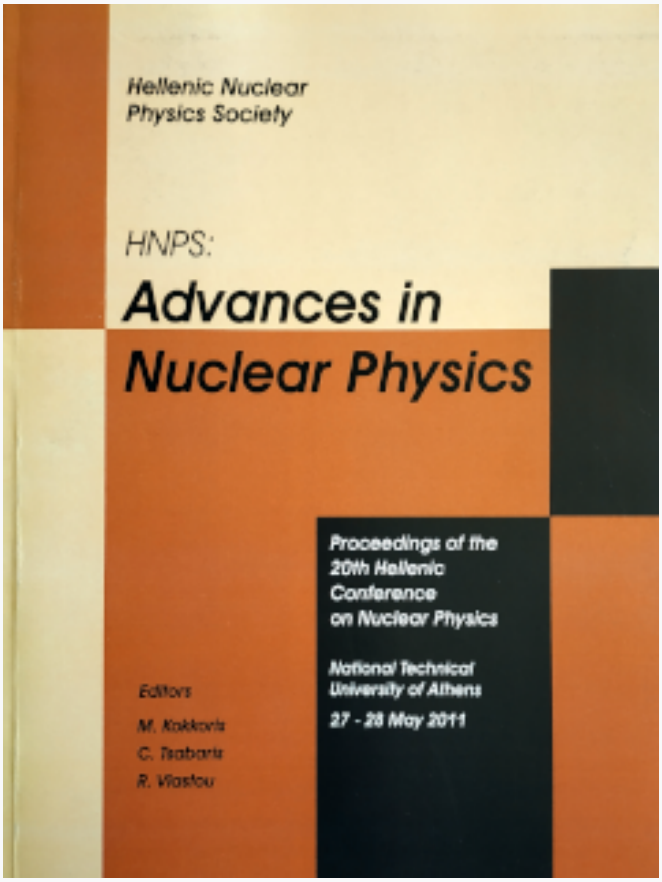

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NuPECC Long Range Plan 2011: A Summary of Nuclear Theory

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Abstract

In December 2010 the European Science Foundation (ESF) has launched its Forward Look on European Nuclear Physics or Long Range Plan Perspectives of Nuclear Physics in Europe (LRP2010), initiated and carried through by the Nuclear Physics European Collaboration Committee (NuPECC). Its goal is to address the perspectives and plans for Nuclear Physics in the period from 2010 to approximately 2025 and attempt to identify the most important areas for future development.

In this talk a brief summary is presented of the part of LRP2010 that refers to Nuclear Theory in all scientific themes treated: Hadron Physics, Phases of Strongly Interacting Matter, Nuclear Structure and Dynamics, Nuclear Astrophysics, Fundamental Interactions and Nuclear Physics Tools and Applications. The following recommendations of how best to develop Nuclear Theory in Europe are issued: 1) Strong support of advanced studies related to the experimental roadmap and the improvement of the link between Nuclear Theory and Quantum Chromodynamics; 2) Strengthening of theory support to experiment by developing the collaboration between national theory groups through new transnational programs; 3) Strengthening of the financial basis of the theoretical research infrastructure ECT* in Trento to increase its involvement in European theory initiatives; 4) Investment in high performance computing facilities dedicated to Nuclear Physics projects.

We refer the reader to the original text of LRP2010 at NuPECC's web site [1].

References

[1] NuPECC Long Range Plan 2010: Perspectives of Nuclear Physics in Europe, edited by G. Rosner et al, NuPECC Report, NuPECC, December 2010. http://www.nupecc.org/index.php?display=lrp2010/main

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Nuclear Tracks in Solids

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The passage of ionizing particles through most insulating solids creates narrow paths of intense damage on an atomic scale. These damage tracks may be revealed and made visible in an optical microscope by treatment with a properly chosen chemical reagent that preferentially attacks the damaged material. Track techniques were developed along with quantitative methods for precise identification of individual particles. Track detectors have been applied extensively in a number of fields, including geochronology, cosmic rays physics, nuclear physics and radiation dosimetry. The event by event presentation of nuclear reactions in nuclear track detectors has been used in nuclear physics research last twenty years for cross section measurements, fragmentation, multifragmentation analysis and ADS physics. This presentation is a revue article on history and development of Solid State Nuclear Track Detectors (SSNTDs). Last results of inelastic and fission cross sections at GeVs obtained by our group are given.

Fission properties of actinide nuclei at energies 26.5 and 62.9 MeV

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Fission properties of actinide nuclei ^{232}Th, ^{237}Np, ^{238}U, ^{239}Pu and ^{241}Am, are studied using the multi-modal random neck rupture model coupled with the nuclear statistical and pre-equilibrium exciton model. Total fission cross sections, fission fragment mass yields and pre- and post-scission neutron multiplicities are calculated with the nuclear reaction code TALYS and are compared with the recent measurements of proton-induced fission at energies of 26.5 and 62.9 MeV, carried out at the Louvain-la-Neuve cyclotron facility.

A modern nuclear spectroscopy software package

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The software package includes a program for spectra analysis – SPECTRW – and a set of auxiliary programs for sample activity determination, summing up corrections etc.
The SPECTRW program has been developed aiming at three main objectives:

- Analyze x, γ or particle spectra collected with almost any commercially available multi-channel analyzer (ADC card + Software) . It accepts ASCII data files with extension ".SPE" in a particular format , SPECHTECH MCA's (UCS20, 30) with extension ".tsv", CANBERRA MCA's (GENIE 20000) with extension ".iec", FAST ComTec SPA-3 MCA with extensions ".mp" or ".mpa" and ORTEC MCA's (MAESTRO) with extension ".spe".
- Use a Monte Carlo based algorithm to produce - in a very short time - simulated spectra in order to be compared with those recorded experimentally.
- Test the behavior of gamma ray detectors (FWHM and linearity response) and determine their efficiency curve for any radioactive source geometry.

Some of the analysis capabilities are:

- It can analyze simultaneously up to 8 spectra in one window. They can be displayed either one at the time or any of them in an overlay mode. For more than 8 spectra, multiple windows can be used.
- It can de-convolute a complex spectrum peak with up to 18 individual photo-peaks. In addition to Gaussian fitting (with variable asymmetry), it can use integration to estimate the photopeak counts.
- The background estimation includes a polynomial up to 5^{th} order and a step function.
- It has a facility to detect automatically and mark the various photo-peaks.
- It can re-calibrate any desired spectrum.
- It can re-construct any recorded spectrum to match the calibration properties of a reference spectrum.
- It can subtract 2 spectra or add 2 or more spectra, after matching selected photo-peaks in order to correct for any possible shifting during accumulation.
- It can identify X-ray and gamma-ray peaks and mark (on the spectrum) the position, energies and branching ratio for a particular isotope (gamma-rays) or the position and identity (Kα, Kβ etc) for a particular element (X-rays).
- Any displayed spectra (including analysis information) can be hard copied to a postscript file. For publication purposes, a facility exists to help users create postscript files with vertical or horizontal markings of their own choice**.**

The package can run in Windows 98 → XP, VISTA and WINDOWS 7.
It might be possible to adopt SPECTRW (and the auxiliary programs) to LINUX environment.

The installation of PAPAP at the Tandem Laboratory of the Institute of Nuclear Physics NCSR "Demokritos"

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PAPAP (Petit Accelerateur Pour AstroPhysique) is a low energy (up to 250 kV) high current (1 mA on target) electrostatic accelerator. Last year, it was transferred from C.S.N.S.M. Orsay to the Institute of Nuclear Physics at NCSR Demokritos. We report on the current status of its installation at our institute and future plans of its use.

Proton elastic scattering differential cross-section measurements for ^{12}C

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Proton Elastic Backscattering Spectrometry (EBS) is a widely used method for light element detection in a variety of matrices. The application of this method requires differential cross-section data over a wide range of energies and detector angles. The present work aims at contributing in this field through the differential cross-section measurements for the elastic proton scattering on ^{12}C. There already exists an evaluation of the $^{12}C(p,p_0)^{12}C$ cross section in the energy range up to 3.5 MeV [1]. In order to extend this theoretical evaluation to higher proton beam energies, reliable experimental data are needed.

The present experiment was carried out using the proton beam provided by the 5.5 MV TN11 VdG Tandem accelerator of N.C.S.R. "Demokritos". Proton energies ranged from 2700 to 7000 keV in steps of 25 keV or even smaller (close to narrow resonances). The scattered protons were detected at four backward angles, namely, at 140°, 150°, 160° and 170° with respect to the beam axis, using four thick (1000 μm) Si surface barrier detectors. The target consisted of a thin carbon foil and a thin Au layer that was evaporated onto the carbon foil for normalization purposes. The obtained experimental and evaluated results were validated through benchmarking experiments using a high-purity, mirror-polished, thick, glassy carbon target and were compared with existing data, when present.

References

[1] A.F. Gurbich, Nucl. Instr. and Meth. B 136-138 (1998) 60.

Investigation of composite surface coatings using ion-beam analysis techniques.

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Composite Al_2O_3/Cr/TiN coatings were prepared on AISI 321 stainless steel substrate using plasma detonation techniques. Additionally, TiN-Ni coatings produced on Ti-6Al-4V substrate using a duplex treatment consisting of plasma nitriding followed by deposition of a TiN-Ni layer by sputtering of a composite Ti-Ni target using 1.2 keV Ar^+ ions. The thickness as well as the composition and element depth distribution of the coatings were investigated by Rutherford Backscattering Spectrometry (RBS) and Nuclear Reaction Analysis (NRA) using deuterons as projectiles. The aluminum depth distribution was determined using the 991 keV resonance of the $^{27}Al(p,\gamma)^{28}Si$ whereas the carbon distribution using the $^{12}C(d,p)\ ^{13}C$ reaction. The nitrogen depth profiles were also determined using the $^{14}N(d,\alpha)^{12}C$ and $^{14}N(d,p)^{15}N$ nuclear reactions. The microstructure and surface morphology of the samples were also examined by X-ray diffraction (XRD), transmission and scanning electron microscopy (TEM-SEM).

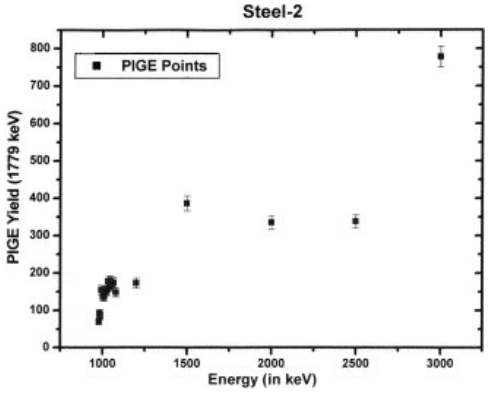

Fig. 1. Aluminum depth distribution on a coated with Al_2O_3 /Cr/TiN steel sample using the $^{27}Al(p,\gamma)^{28}Si$ nuclear reaction.

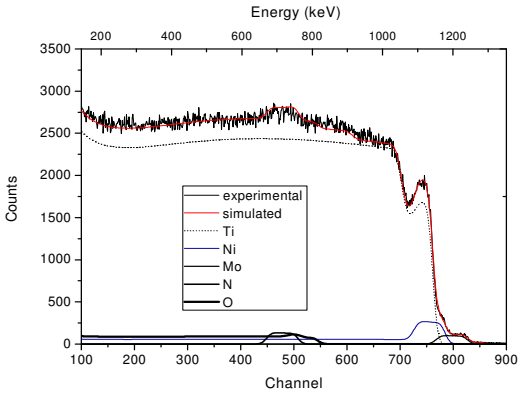

Fig. 2: d-RBS spectrum of the TiN-Ni coating on Ti-6Al-4V sample.

Controls and measurements governing the imports of food and feedstuffs originating from Japan following the accident at Fukushima nuclear power plants.

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[(2)] *NRSR Demokritos*

The release of radionuclides after the accident at Fukushima nuclear power plants and waste storage facilities, has affected many prefectures of Japan. In response to this accident, European Commission has published and put into the force a new directive at 15/3/2011 and a revised version at 4/4/2011 in order to control the imported food and feedstuffs from Japan. According this directive, the measurement of Cs-137, Cs-134 and I-131 concentrations are mandatory for any load of foods and feedstuffs imported from Japan to the European countries. Additionally, the permisible concentration limits for Pu-238, Pu-239/240, Am-241 and Sr-90 are provided. These limits are applicable in case of an EU member state decides to perform additional measurements.

Information about the extent of radioactive contamination caused by the Fukushima accident was available through the IAEA emergency information system and the radioactivity measurements on environmental samples performed by the Japanese authorities are distributed through the Rapid Alert System for Food and Feed (RASFF) of EC.

Based on the available information, on the EU directive and on the data about the imported goods from Japan, experts from GAEC and NRSR Demokritos, under the coordination of Hellenic Food Authority (EFET), proposed the exact measuring procedures implemented to control the imported food and feedstuffs. The main imports from Japan to Greece are the feedstuffs.

This paper presents the procedures activated in Greece and the measurements performed until now. Gamma spectroscopic measurements performed in any imported food and feedstuff load come from Japan. Even if it is judged as unlike to have plutonium or americium contamination in absence of I-131 or Cs-137 contamination, a-spectroscopic measurements are performed randomly, to determine the plutonium isotopes and the Am-241 concentration.

In-situ and automated quantitative radionuclide characterization in aquatic ecosystems

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The underwater gamma-ray NaI(Tl) spectrometer named "KATERINA" has been developed for in-situ measurements of radioactivity in any aquatic environment. The system is designed for qualitative and quantitative radionuclide detection up to a maximum deployment depth of 400 m, providing volumetric activities in absolute units (Bq/m^3 or Bq/l) for all gamma-ray emitters in the energy range from threshold energy (50 keV) to 3000 keV. It has been already deployed acquiring radon daughters in several submarine regions where groundwater discharges into the coastal zone, as well as measuring natural radioactivity in magmatic regions of Adriatic Sea.

Recently, the system was deployed in Marmara Sea (April 2011) where is utilized to monitor radon emanation along with a network of underwater seismographs, just above the active submarine fault of the region. It is scheduled to operate for five months acquiring gamma-ray spectra every 12 h. In order to achieve long time stand-alone operation without any surveillance, the system has been upgraded by means of a special memory and microcontroller. The obtained data along with the seismic records are expected to contribute significantly to the short-time earthquake prediction research efforts.

A new spectroscopy software has also been developed for automated analysis of NaI(Tl) gamma-ray spectra based on wavelet smoothing technique. The algorithm provides peak detection, net area calculation, energy auto-calibration, radionuclide identification and direct activity calculation. Future implementation includes the incorporation of the specific software in "KATERINA", forming an integrated early-warning system for coastal radioactivity monitoring near nuclear power plants and TENORM related industries (bauxite, fertliser etc).

Keywords: Underwater gama-ray spectrometry;Radon progenies; Seismic precursors;TENORM; Marmara Sea

Applications of "Demokritos" INP tandem accelerator in earth and environmental sciences

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In the last two decades technological developments have revitalized a new area of research in Earth Sciences focused on the structure and reactivity of mineral surfaces. Mineral surface science is closely associated to the fields of molecular geochemistry and biogeochemistry in that it investigates geochemical processes at the molecular level, and it has contributed to the recent establishment of nanogeoscience (including nanomineralogy and nanogeochemistry). Nanogeoscience is also associated with the study of micro/nanopores in geologic media and consequently to the study of micro/nanoporous minerals such as zeolites. Moreover, part of the research in nanogeoscience concerns the surface chemical behavior of sparingly soluble salts and, in particular, carbonate minerals such as calcite (the trigonal $CaCO_3$ polymorph). This common mineral plays a major role in the global CO_2 cycle, participates in key biomineralization processes, and shows high reactivity in fluids, thereby controlling the geoavailability and bioavailability of certain contaminants. The physicochemical processes that affect environmental availability of contaminants are strongly related to environmental mineralogy-geochemistry and, in general, to Environmental Sciences. The combined utilization of advanced microscopic and spectroscopic techniques, such as AFM, STM, TEM, SIMS, LIBS and XPS, has enabled the study of those processes occurring in-situ and ex-situ at mineral interfaces on a microscale and nanoscale. The contribution of particular accelerator-based techniques, such as NRA and RBS, is also vital in the study of mineral surfaces and interfaces. This presentation is actually a review with regard to the historical utilization of the Van de Graaff Tandem Accelerator of NCSR "Demokritos" in Earth and Environmental Sciences. The RBS, NRA and NRRA data obtained (using p, d and ^{12}C beams and various mineral crystals and rock specimens as targets) were complementary supported by in-situ AFM, XPS, laser-μRaman, solid-state MAS NMR, IR, EPR, and EXAFS techniques. The final goal was the elucidation of chemical processes on mineral and rock surfaces, related to dissolution, sorption, and crystal growth phenomena (e.g. interaction with hazardous heavy metals and radionuclides). A major part of the work concerned chemically modified microporous/nanoporous aluminosilicate minerals, specifically zeolites, as well as micas and other granitic minerals. Similar studies concerned carbonate (calcite, aragonite) and sulphate (gypsum) mineral surfaces interacted with dissolved hazardous heavy metal ions, whereas special emphasis was given to Greek marble showing archeological interest.
A more recent project, using d beams and the $^{12}C(d,p)^{13}C$ reaction together with laser-μRaman and SEM-EDS), concerned mineral growth on metallic lead exposed in the polluted atmosphere of Athens. The plans for future work are mostly related to the use of new facilities being developed in the frame of LIBRA Center of Excellence (http://libra.inp.demokritos.gr/index.html).

A centennial of the nucleus discovery: The life and works of Ernest Rutherford

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Abstract

The year 2011 coincides with the centennial anniversary of the discovery of the nucleus. In 1911, Sir Ernest Rutherford was the first one to postulate the existence of a heavy positive body in the center of the atom, the nucleus. His experimental proof of the existence of the nucleus acted as the founding cornerstone for the field of Nuclear Physics. A brief review of his major scientific achievements will be presented.

Operational status of the CASTOR calorimeter at CMS with proton and heavy-ion beams

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Abstract

The CASTOR calorimeter is a unique Cerenkov-type calorimeter installed at very forward angles of the CMS detetor, at LHC. Primarily built to explore the physics of long-penetrating objects in heavy-ion collisions, CASTOR now serves as an instrument for a broader collection of physics topics, varying from low-x QCD to exotic events in Pb+Pb collisions. The experience from the operation of the calorimeter during the first phase of the LHC runs with proton and Pb beams is presented.

The Micromegas Detector in Nuclear Physics

T. Papaevangelou

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The Micromegas is a gaseous detector that combines the principles of ionization and proportional chambers. This coupling is made possible by the presence of a micromesh, which separates the active volume in two regions where two different electric fields establish respectively a charge drift and a charge multiplication regime. The working principle, the Micromegas types, the advances in the manufacturing techniques and its main characteristics will be presented. Those characteristics make the Micromegas detector suitable for a wide range of nuclear physics experiments, from neutron and ion beam monitoring to measurements inside nuclear reactor cores.

The Muon ATLAS MicroMegas Activity (MAMMA)

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(On behalf of the MAMMA collaboration)

The luminosity upgrade of the Large Hadron Collider at CERN (sLHC) foresees a luminosity increase by a factor ~5 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 the very forward/backward region (the high rapidity region). The Muon ATLAS MicroMegas Activity (MAMMA) is focused on the development and testing of large-area muon detectors based on the resistive coating bulk-Micromegas technology as candidates for such an upgrade. This technology has undergone extensive tests with hadron beams at the CERN-SPS area, X-rays in the lab, as well as tests in a neutron beam at the TANDEM accelerator of the N.C.S.R. “Demokritos”. In addition a set of prototype chambers have been installed in the ATLAS cavern and are taking data in real LHC conditions. Results on the performance of these chambers will be presented.

Monte Carlo calculation of electrons and bremsstrahlung photons produced by U targets irradiated with a 20 MeV electron beam

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The Monte Carlo N-Particle Transport Code (MCNP) is an important tool to study particle transport and interaction with matter. It can be used for neutron, photon, and electron as well as for coupled studies. In this work, MCNPX code has been used to study electron and photon production from Uranium targets of various thicknesses, ranging from 0.63 μm to 5 cm. The LINAC nominal energy is taken to be 20 MeV with a circular field size of 4 cm in diameter. The flux and the spectrum of electrons and photons escaping the outer surface of the target have been estimated. Electrons escaping from thin targets (up to 7.5 μm) are 6 – 7 % and from 0.18 mm targets about 0.7% of the initial electrons. Electron production presents a peak around 0.1 mm (about 25% of the initial electrons) and then decreases with target thickness. Concerning photon production, it is found that for thin targets the produced photons are lower than 1% per initial electron. For thicker targets of the order of 0.1 mm, photon production increases up to few tenths of % per initial electron. A decrease in photon production is observed when target thickness is higher than 0.2 mm.

Progress on a Spherical Proportional Counter for Nuclear Reactor and Supernova Neutrino Detection

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A large volume spherical proportional counter is under investigation for low energy neutrino detection, from nuclear reactors and supernova explosion. The neutrino detection based on the coherent scattering and the observation of the recoil nucleus of the gas in the drift volume. Because the neutrino is light, the recoil of nuclei is extremely small and the challenge is at the low threshold required (typically below 100 eV). The energy threshold has been pushed down to about 25 eV and single electrons are clearly collected and detected. For the low energy calibration we have been used a pulsed UV lamp extracting photoelectrons from the inner metallic surface of the detector. For higher energies the 8keV X-ray peak of the cupper of the detector is also a useful calibration point. In this paper we present also the first results of the detection of the low energy Ar recoils from an Am-Be neutron source, since they are similar to that we expect from the neutrino recoils.

The RHVT Approach and its Application to Λ - Hypernuclei

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An investigation is carried out which is a continuation of our contribution to the previous HNPS symposium.The Gauss single particle potential is again assumed for the motion of the Λ particle in Λ-hypernuclei. The quantum mechanical re-normalized hypervirial theorems (RHVT) approach is employed, as well as the rigid core model. In that framework, the two potential parameters are determined by least-squares fitting of the 1s energies of the Λ particle (for which the renormalization parameter becomes 1) using the experimental results which are quite numerous. With the potential parameter best fit values obtained in this way, the renormalization para- meters χ_{nl} are then determined for the 1p , f and d states by varying each one of these parameters until the pertinent RHVT energy theoretical expression is squared – least fitted to the corresponding limited Λ energy experimental results. An attempt is also made to investigate the use of " trial" analytic Λ- energy expressions, for the 1s and 1p states, which incorporate the corresponding truncated HVT ones.

Differential cross-section measurements for the p+^{19}F system

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Fluorine is a highly regarded chemical element with numerous applications, mainly, in material science and technology. It is used in solid state electronics as a dopant in the gate electrodes of MOSFETs in order to enhance their radiation resistance, and also small quantities of fluorine are used in various substances in order to decrease the frictional forces between these substances. Thus, the quantitative determination of the fluorine depth profile in heavy and light substrates is of great importance.

Ion Beam Analysis (IBA) techniques, especially Nuclear Reaction Analysis (NRA) and Elastic Backscattering Spectroscopy (EBS), are generally among the most accurate, sensitive and non-destructive methods for material analysis, which can determine the depth profile of an element. Generally, proton beams are preferred because with such beams greater material depths can be probed. The only problem that impedes the implementation of such techniques in material analysis is the lack of accurate differential cross-section values for the involved reactions. In the case of fluorine, there are some datasets for various reactions in IBANDL, which are suitable for material analysis. However, additional measurements are required for comparison reasons and also for theoretical evaluation purposes.

In this work, the reactions $^{19}F(p,p_o)^{19}F$, $^{19}F(p,\alpha_o)^{16}O$ and $^{19}F(p,\alpha_{1,2})^{16}O^*$ were studied for the proton beam energy range between 1500keV and 7000keV and for detection angles between 140^o and 170^o. The experiments were conducted at N.C.S.R "Democritos" using the 5.5MV TN11 VdG Tandem accelerator. The target consisted of a thin LiF layer deposited on a thin carbon backing and covered by a thin gold layer. Preliminary results will be presented along with comparisons with already existing data.

Full Energy Peak Efficiency Calibration of a High Purity Germanium Detector by using the Monte Carlo Method

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A Monte Carlo based computational method enabling characterization of a High Purity Germanium detector (HPGe) detector's full energy peak efficiency for point gamma ray source geometry was developed. The method was based on three dimensional MCNP simulation of the detection system (gamma ray source - detector - shielding) and estimation of the full energy peak efficiency in the range of 60 - 1408 keV. The detector model optimization was performed semi-empirically by varying the thickness of the germanium crystal inactive layer, known as 'dead' layer, to achieve best agreement with experimental full energy peak efficiency data. The later were obtained by using calibrated point gamma ray sources. The detector model was used to study the increase of the germanium 'dead' layer with time associated with a decrease of the detector efficiency. This study resulted in an average increase of crystal dead layer thickness of 45 % and subsequent average decrease of detector efficiency of 5.5 %, over the photon energy range studied, after 8 years of non continuous operation including extended warm up periods. The calculated full energy peak efficiency by the optimized model agreed within 3 % with the measured ones for all studied gamma ray energies. The optimum dead layer thickness value was found to be of about two times its nominal value as stated by the manufacture.

X-ray applications in marine sedimentology

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X-rays (125-0.125 keV) were discovered in 1896 by Röntgen who described their most important properties; since then numerous researchers have worked to unravel their behavior in various applications. The present contribution aims at providing some basic information on the applications of X-rays in marine sedimentology, which are used routinely at the Institute of Oceanography of HCMR, rather than getting into the interaction of electromagnetic radiation with matter, a complex subject encompassing many aspects of modern physics. The most 'simple' application is the SediGraph™ method for determining the mass distribution of particles as a function of size. The method is based on two well-established and well-understood physical phenomena—gravitational sedimentation and low energy X-ray absorption. Stokes' law describes the gravitational sedimentation of a particle (sphere) as a function of particle diameter. The SediGraph uses a beam of X-ray collimated into a thin horizontal band to measure directly particle mass concentration in the liquid medium. The homogeneous dispersion begins to settle as transmitted X-ray intensity is continuously monitored. During the sedimentation process, the largest particles are first to settle below the measuring zone and, finally, all particles settle below a certain level leaving only clear liquid and attenuation of the X-ray beam diminishes. In our laboratory, Sedigraph 5100 is used since 1995, providing particle size distribution of thousands of samples in the range 0.1-63 μm, with great accuracy.

Qualitative and quantitative determination of the mineral composition of rocks and sediments is based on the theory of X-ray diffraction. A simple method for obtaining the conditions for diffraction was described in 1912 by W. L. Bragg who considered the diffraction as the consequence of contemporaneous reflections of the X-ray beam by various lattice planes belonging to the same family. When a monochromatic X-ray beam with wavelength lambda is projected onto a crystalline material at an angle theta, diffraction occurs only when the distance traveled by the rays reflected from successive planes differs by a complete number n of wavelengths. By varying the angle theta, the Bragg's Law conditions ($n\cdot\lambda = 2d \cdot \sin\theta$) are satisfied by different d-spacings in polycrystalline materials. Plotting the angular positions and intensities of the resultant diffracted peaks of radiation produces a pattern, which is characteristic of the sample. Where a mixture of different phases is present, the resultant diffractogram is formed by addition of the individual patterns. HCMR-IO is using Rigaku D/Max B system since 1988. Recently, software upgrades and purchasing of mineral databases permit semi-quantitative determination of mineral composition in sediments, applying the Rietveld whole pattern fitting method.

X-ray fluorescence analysis (XRF) is one of the best analytical techniques to perform elemental analysis in all kind of samples, no matter if liquids, solids or loose powders must be analyzed. XRF combines highest accuracy and precision with simple and fast sample preparation for the analysis of elements from Beryllium (Be) to Uranium (U) in the concentration range from 100 % down to the ppm-level. The sequential spectrometer employs an optical assembly called a 'goniometer', which is equipped with two concentric, rotatable shafts. These enable the analyzing crystal to turn through angular increments (theta degrees), while the detector rotates through 2-theta degrees to intercept the diffracted beam. Spectral peaks are detected at various wavelengths, according to the conditions described by Bragg's Law. The results of continuous scanning over an angular range can be plotted as a spectral pattern, from which the elements present in a sample may be identified. Individual peak intensities are measured to determine element concentrations. HCMR-IO is using Panalytical's (former Philips) PW 2400 continuous wavelength dispersion spectrometer, which was upgraded in 2007. Participation in blind intercomparison tests has proved that analytical precision and accuracy are very high. Materials analyzed are mostly marine sediments, but other applications have been prepared according to customer requirements (bauxite, magnesite). Energy dispersive (EDXRF) analysis is also performed in the laboratory in material examined under a Philips XL-20 scanning electron microscope (SEM).

Comparative radiation impact assessment in marine and terrestrial biota

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The external radiation dose rates to non –humans inhabited an area of elevated natural background have been evaluated, considering two different ecosystems, i. e. marine and terrestrial. In situ measurements and laboratory treatment and γ-spectrometry of the samples of soil, sediment and seawater have been performed during the period 1994-2004.
From the obtained results some comments can be derived in terms of the environmental characteristics of the type of ecosystem considered i.e., marine ecosystem, terrestrial ecosystem. It is noteworthy that the selected ecosystems are located in an island that consequently means more or less isolation of significant external influence impact factors from inland regions. For the external dose rates calculation mathematical equations were used in terms two–simple model approach i.e., infinitive and semi-infinitive environment according to the population habitats as:
1a. inside the soil or sediment
1b. in the seawater
2a. on the soil
2b. on the sediment – sea water interface

Keywords: marine biota, terrestrial biota, external dose rates, natural radioactivity, population habitat

The use of natural and anthropogenic radionuclides in calculating the recent sedimentation rates in the marine environment

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Several radionuclides can be used as tracers of various marine processes, including sedimentation. Recent (decadal) sediment accumulation can be assessed using ^{210}Pb (half-life 22.3 yr) and ^{137}Cs (half-life 30.7 yr). The natural radionuclide ^{210}Pb is continuously introduced into the marine environment from the atmosphere, after decay of ^{222}Rn exhaled from the continental crust, and within the water column, mainly through the radioactive decay of dissolved ^{226}Ra. Because of its reactivity, it rapidly becomes associated with suspended matter and, therefore, subject to sedimentation. The down-core activity of ^{210}Pb is determined through its a-emitting granddaughter ^{210}Po, assuming secular equilibrium with ^{210}Pb.

^{137}Cs is a bomb-derived radionuclide, first introduced into the atmosphere in 1954 with the onset of weapon testing. Often ^{210}Pb derived accumulation rates are verified by noting that the maximum penetration depth of ^{137}Cs corresponds to sedimentation since 1954. Peaks occurring in the vertical distribution of ^{137}Cs activity along the sediment core correspond to 1963 (the year of maximum fallout from atmospheric weapon testing) and 1986 (related to the Chernobyl event).

A characteristic ^{210}Pb profile consists of an upper region of homogeneous activity (i.e., the surface mixed layer) above a region of logarithmically decreasing activities, which eventually reach levels supported by ^{226}Ra at depth in the seabed. However, in areas with episodic and rapid depositional events layers of low activity are observed in the profile and provide a record of past depositional events. For these types of profiles, a sediment accumulation rate can be estimated if an overall decrease in activities is observed and a best-fit linear regression can be reasonably applied to the data.

Several studies have been carried out in Greek marine and freshwater environments. The active sedimentation rates (100-120 years) were calculated in two cores collected in the Northern Evia Gulf and in two cores from the Alkyonides Gulf. These gulfs are two similar, asymmetric sedimentation basins concerning their morphology and geological structure; they are characterized by high seismicity and constitute two of the most active regions of Central Greece in terms of neotectonic deformation. The comparison between the two basins showed that the sedimentation is faster in the vicinity of the main faults, which control their evolution and the location of the depocenters, and decreased towards the non-faulted opposite margin. Nevertheless, it appeared that in the Alkyonides Gulf the recent sedimentation is slower than in the Northern Evia Gulf.

Sediment accumulation rates were also studied in the Axios, Pinios and Aliakmon rivers estuaries and were correlated to pollutants concentrations in the sediments and their origin. Sediment accumulation appeared to be regulated by variations in the riverine discharge, shelf transport pathways and winnowing processes. Furthermore, the use of ^{210}Pb and ^{137}Cs was tested in the study of the pollution history in sediments in the vicinity of the airport in the eastern part of Thessaloniki gulf.

Finally, the recent sedimentation processes were studied in Vegoritis Lake in Northern Greece, where the ^{210}Pb profile revealed the dramatic lowering of water level that occurred during the second half of the last century due to human pressures.

Cs-137 in marine sediments from the Eastern Mediterranean during the last 27-year period

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A survey of ^{137}Cs inventory in sediments from the Greek marine environment is presented during the period 1984 to 2011, based on published and unpublished data of ERL/INT-RP/NCSRD. A retrospective summary of the ^{137}Cs impact assessment is also attempted, based on data covered the period prior to and after Chernobyl up to 2011. Therefore, the sinking time and the ecological half-life of ^{137}Cs are also estimated in some specific areas of the Eastern Mediterranean and the findings are compared to the deposition data of the first days of Chernobyl impact. By evaluating all these findings and estimations, the decrease of ^{137}Cs activity concentrations by the ecological half life (the parameter matching the physical half life and the effective half life) is justified up to the present, while the fallout from the Fukushima accident has not been detected yet, although it was clear in the measurements of fallout, aerosols and the terrestrial ecosystem components since its arrival date in Greece on March 24th.

Keywords: ^{137}Cs activity concentrations, Sediments, Marine environment, Chernobyl fallout

Pre-Decommissioning Radiological Characterization at the Greek Research Reactor

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At the end of the lifetime of any nuclear facility or of parts of such facilities is the decommissioning and dismantling. It is necessary to plan the decommissioning works due to radiological, safety and financial aspects as well. First of all it is necessary to have a good overview of the radiological situation. With this knowledge it is possible to plan the radiological aspects, e.g. the exposition of personnel which means in fact the radiation protection measure during works. Moreover this knowledge is also necessary to calculate the mass flow of the radioactive waste and the amount of materials which could undergo the measures for free releasing. By knowing the mass flow it is possible to determine the needed radioactive waste containers, storage buildings, decontamination techniques/ areas and the needed man power to perform this task.

One method to get the information about the radiological situation beside dose rate measurements is to take samples and carry out the nuclide specific measurements. However, a major disadvantage of sampling is that the components will be destroyed by taking samples, e.g. by drilling or abrasive methods. These methods therefore cannot be applied to nuclear facilities or parts of nuclear facilities, which are in operation or should be operated after reconditioning or replacing with new parts.

Within the framework of the 5 MW open pool type Greek Research Reactor (GRR-1) refurbishment program, the old reactor Primary Cooling System (PCS) will be dismantled. For the pre-dismantling radiological characterization of GRR-1 PCS piping, heat exchangers and delay tanks, a method was established using the in-situ gamma spectrometry that is a non destructive method. The monitoring of the gamma activity inside the circuit was carried out by a portable NaI(Tl) spectrometer and the prediction of the gamma ray detector efficiency was realized by Monte Carlo calculations performed using the MCNP code.

The results of this study indicated that (i) the part of the piping system from heat exchangers back to the pool is uniformly contaminated by Ag108m, at levels about 3 times higher than the general clearance level of 0.1 Bq/g, given in the Greek Radiation Protection Regulation, (ii) the entire volume of the exchangers seems to be contaminated by Ag-108m of the order of the general clearance level (iii) the contamination levels of the other parts (piping and delay tanks) of the PCS are below the applied method minimum detection limits (well below clearance levels for potential gamma emitters). Since all Co-60 measurements were below the minimum detection limits, it can be assumed that the presence of other corrosion products such as Fe-55 and Ni-63 is not significant. Moreover, since no Cs-137 activity was detected inside the circuit, the presence of other fission products may also be insignificant.

Besides the non-destructive character of the in-situ gamma spectrometry that is an advantage for facilities in operation, even in cases of facilities that are not in function, the use of the method for pre-dismantling characterization represents a cost effective technology in comparison to sampling and offsite analyses. The preliminary use of the method limits the number of necessary samples for full laboratory analyses. Furthermore it is an adequately sensitive technique and involves lower worker exposure than taking samples.