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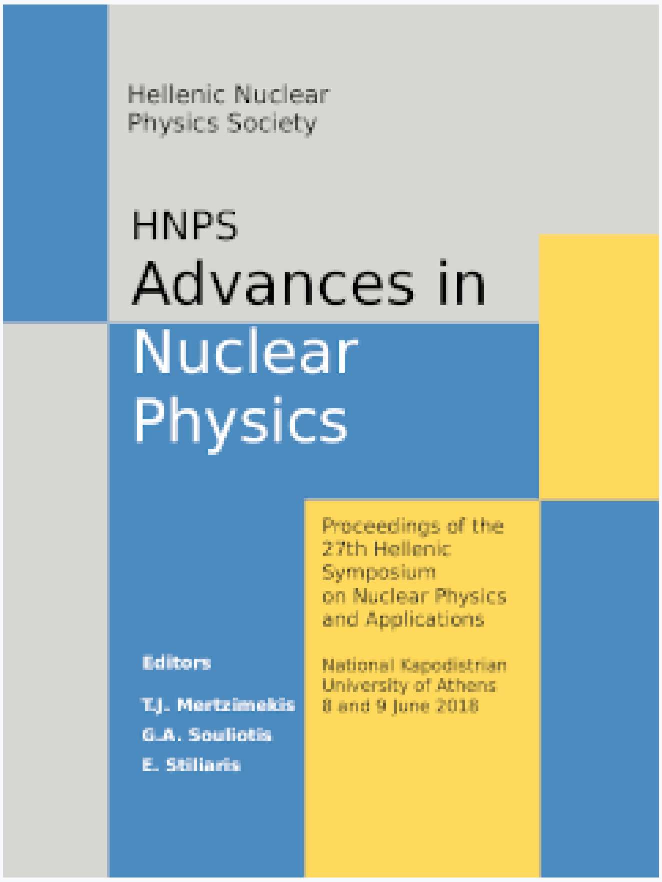

Aggregate abstracts-only section (multiple authors)

Abstracts only no papers submitted

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Particle-hole symmetry breaking due to Pauli blocking

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Particle-hole symmetry has been used on several occasions in nuclear structure over the years. We prove that particle-hole symmetry is broken in nuclear shells possessing the proxy-SU(3) symmetry [1,2]. The breaking of the symmetry is rooted in the Pauli principle and the short-range nature of the nucleon-nucleon interaction. The breaking of the symmetry explains the dominance of prolate over oblate shapes in deformed nuclei [3] and determines the regions of prolate to oblate shape transitions in the nuclear chart [2].

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Viscosity of nuclear matter

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Shear viscosity is one of basic transport coefficients of matter. Theoretically, it was claimed that there exists a low bound of 1/4pi for the shear viscosity over entropy density (eta/s) for all kind of matter. For macroscopic systems, the shear viscosity is measurable in a direct way, however, much difficult for microscopic system, especially for nuclear and quark matter. In this talk, I will give an example of eta/s for quark matter results from ultra-relativistic heavy-ion collision experiment, and then turn to some phenomenological calculations and indirect extract of eta/s for nuclear matter in low temperature and the INDRA data.

An in-situ method for mapping radioactivity at beach sands using the mobile gamma-ray spectrometry

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In the frame of the IAEA Coordinated Research Project (G42006), a new method is applied for mapping Natural Occurring Radionuclide Materials (NORMs) at specific beach sand areas. Beach sand areas are sensitive marine systems since they are affected from anthropogenic activities (e.g. coastal industry) and request regular monitoring and radiological maps due to the humans' interaction (especially during dry periods).

The proposed method for mapping radioactivity was applied at the Lesvos Island (Greece) since it is a known area with enhanced NORMs compared to the worldwide background values. The enhanced values are due to the mineralogy of the specific area and not from the anthropogenic activities. The Lesvos Island is located in the Aegean microplate, near the south-western sector of the North Anatolian fault. The presence of this fault has led to cutting the island from Asia Minor, and is responsible for several devastating earthquakes, which occurred in the region. It is a semi-enclosed coastal ecosystem at the North-West part of the island. Also, the volcanic activity in the island was a result of the collision of Eurasian lithospheric plate in the north, with the African lithospheric plate in the south. The volcanic activity at Lesvos, caused the exit of huge quantities of lava, ash and other materials that they covered large areas. Moreover, Lesvos has significant geothermal potential, as evidenced by the existence of numerous hot springs and geothermal fields of low, medium and high enthalpy.

An in-situ method for rapid radiological characterization and mapping of beach sands has been developed in the frame of G42006 Coordinated Research Project. New results and radiological maps obtained in two selected beaches located in Lesvos Island, Aegean Sea, Greece. The method was developed based on mobile in situ gamma-ray spectroscopy and it was focus on mapping radium's ^{226}Ra progeny (^{214}Bi). The method provides measurements of ^{214}Bi concentrations (in Bq/kg). For quantification purpose, inter-calibration was occurred between measurements obtained by two different in situ systems; KATERINA a NaI(Tl) based low to medium resolution spectrometer [1] and GeoMAREA [2] a $CeBr_3$ based medium resolution spectrometer. The former was used for the mapping of the beaches and the later for measurement of sediment samples (in order to calibrate the gamma-ray intensity of the photopeak in absolute units). Although, the measurement of the samples took place in the laboratory, for operational purposes, the quantification process would be feasible to be performed in the field in less than 24h (during the night after the end of each survey of the experimental work).

According to the aforementioned geological setting and the high touristic attraction that characterize the northern part of the Island, two beaches were selected for the demonstration of the developed methodology. The first one (Anaksos beach) is located at the northern-west and the second (Tsonia beach) at the northern-east part of the Island on both sides of Molyvos village which is the top touristic destination of the island.

Acknowledgments

Dr. C. Tsabaris would like to acknowledge IAEA for supporting this work under the G42006 Coordinated Research Project "In Situ Measurements for Rapid Environmental Mapping of Contaminated Sites". The specific project that is implemented from HCMR is entitled "In-situ method development for rapid radiological characterization and mapping of beach sands".

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U-series geochronology of fossil bones using γ-spectrometry in comparison to ^{14}C dating results

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The ^{238}U, ^{235}U and ^{232}Th series radionuclides as well as ^{40}K content have been measured using γ-spectroscopy of fossil bones collected from a late Pleistocene excavation site. The U-series dating method has been applied and an age ranges from 17 ± 5 kya due ^{235}U-method up to 19 ±3 and 27 ±4 kya based on the ^{238}U-method according to chemical constant taken into account. These results prove to be in proper agreement within measurements uncertainty compared to ^{14}C-method on the bone collage giving age 23.8 ± 0.14 kya. The radiocarbon age demonstrates that a chemical constant 1.332 (±0.002) $x10^{-3}$ ky^{-1} should be considered for the fossil bones studied. U-series dating method based on γ-spectrometry instrumentation proves to be effective regarding to accurate geochronology of Quaternary fossil bones even from the recent past.

Raindrop "age" estimation by in-situ, continuous monitoring of atmospheric radon progenies

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Radon ^{222}Rn emanation and decay brings the radioisotopes of polonium ^{218}Po, lead ^{214}Pb and bismuth ^{214}Bi in the atmosphere. All strongly tends to attach onto the surface of existing aerosols forming radioactive aerosols. Radioactive aerosols participate in atmospheric processes regarding cloud formation, raindrop creation and precipitation. In the present work, the ratio of the activity concertation of $^{214}Bi/^{214}Pb$ was used to estimate the "age" of raindrops, the elapsed time between the start of droplets formation in the cloud and the deposition of raindrops on the soil. To this end, hourly atmospheric data of ^{214}Pb and ^{214}Bi counting rates were continuously obtained during the period from October 2017 to March 2018 at the facilities of HCMR in south Attica, by means of the underwater detection system GeoMAREA. The system is based on a 2"x2" $CeBr_3$ scintillation crystal providing medium resolution gamma-ray spectra. The proposed method is based on the application of Bateman equation and the assumption of radioactive equilibrium between ^{222}Rn and its progenies in two distinct cases; in cloud before the initialization of droplets formation and in the proximity of the detection system during calm, no wind and no rain conditions. The former concerns the estimation of the initial activity concentration ratio of ^{218}Po, ^{214}Pb and ^{214}Bi in the cloud while the latter, the calculation of the full energy photo-peak detection efficiency ratio for 352 keV and 609 keV photo-peaks corresponding to ^{214}Pb and ^{214}Bi respectively. The results obtained from data analysis of 50 precipitation events reveal raindrop "ages" in the order of magnitude of several minutes up to almost two hours.

The proton spin puzzle from Lattice QCD *

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Quantum Chromodynamics (QCD) is the theory of the strong interactions that binds quarks and gluons to form the nucleons, the fundamental constituents of the visible matter.

Understanding nucleon structure is considered a milestone of hadronic physics and new facilities are planned devoted to its study. A future Electron-Ion-Collider proposed by the scientific community will greatly deepen our knowledge on the fundamental constituents of the visible world. To achieve this goal, a synergy between the experimental and theoretical sectors is imperative, and Lattice QCD is in a unique position to provide input from first principle calculations. Over the last years Lattice QCD has made significant progress yielding results that can be compared to experimental measurements with controlled systematics.

In this talk we will discuss recent progress in nucleon structure from Lattice QCD using state-of-the-art simulations with pion mass tuned at its physical value. Emphasis will be given on quantities that have implication on the proton spin in order to address the question: "Where does the spin of proton come from"? Along the line of understanding this long-standing puzzle we will also highlight developments on the evaluation of the gluon momentum fraction. A summary of the decomposition found in this work is shown in Fig. 1.

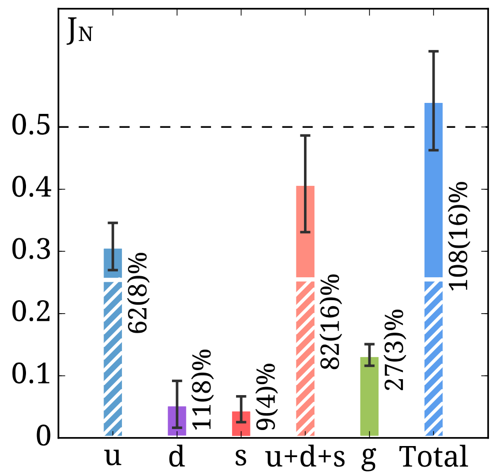

Figure 1: The proton spin decomposition

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Strongly interacting nucleons: from few to many*

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We will discuss nuclei, neutron stars, and ultracold atomic gases. The unifying theme will be the interplay of two- (or higher-) body interactions, wave function correlations, and the methods employed to solve the quantum many-particle problem. After some pedagogical comments on nuclear forces and many-body methods, we focus on some of our group's recent results. The problems tackled include quasiparticle excitations, systems of reduced dimensionality, as well as the interplay of external fields and strong correlations. Throughout, we will attempt to make connections with current or future experimental measurements.

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Results of efficiency, accuracy, spatial resolution of a coded aperture imaging system*

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The detection of point and extended γ radioactive sources in the three-dimensional (3D) space is important in the domain of nuclear security and nuclear medicine applications. In this study, coded aperture imaging of two γ-cameras combines with a triangulation method in order to achieve the 3D localization and resolution of radioactive hot-spots placed in the Fully Coded Field of View ($FCFOV_S$) of the device [1]. Four wafers of 1mm thick CdTe, in planar set-up, with total surface 4.4x4.4cm^2 form a pixelated, spectroscopic CMOS detector [2]. The detector pixel pitch is 350 μm and the detectable photon energy ranges from 15 keV up to 240 keV with an energy resolution of 3-4 keV Full Width at Half Maximum (FWHM). Each γ-camera consists of the CMOS detector and an invert type of the No-Two-Holes-Touching (NTHT), Modified Uniformly Redundant Array (MURA) [3] coded aperture or mask. Four different masks were used, each one for a different range of source – γ-camera

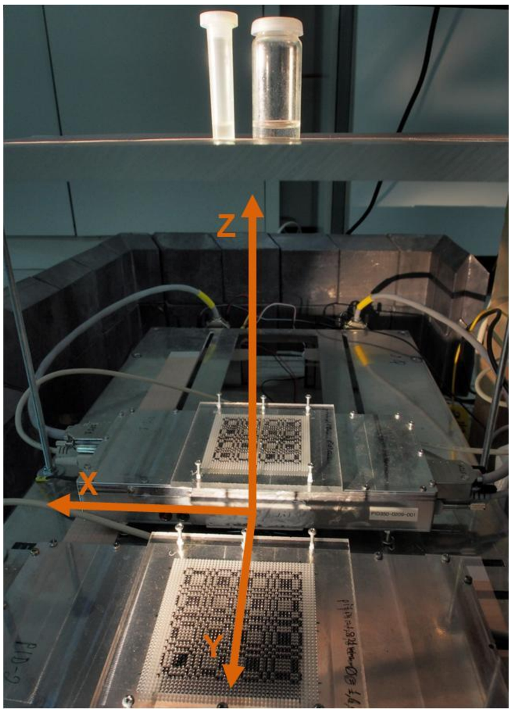

Figure 1: The experimental set-up for the localization of two ^{99m}Tc hot-spots (vials on top) and the coded aperture imaging system consisted by two γ-cameras with MURA rank 19 masks.

Monte-Carlo simulation code developed with emphasis on its fast response, in order to distinguish the optimal design parameters of the coded apertures and their geometrical combination with the pixelated detectors. Experimental localization of point and extended radioactive sources of ^{241}Am, ^{99m}Tc, ^{57}Co, ^{137}Cs, were conducted in order to characterize the experimental device in terms of its efficiency, localization accuracy and spatial resolution.

The results indicate that the device could be useful in the decommissioning of nuclear facilities, the nuclear security imaging applications and the intraoperative nuclear medicine imaging with portable γ-cameras. Specifically, the localization accuracy is better than 1% for point sources and 3% for extended hot-spots, considering γ-emitters with photo-peak in the range of 15 to 240 keV. The spatial resolution ranges from 2.5 cm to 4 cm, depending on the source – γ-camera distance. The sensitivity of the device is such, that 30 MBq hot-spots, placed about 20 cm from the device, can be accurately localized with counting time less than 3 seconds.

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KIDS functional for applications in homogeneous matter and finite nuclei *

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We have developed a method for extracting a generalized Skyrme-type energy density functional (EDF) for nuclei from a given, immutable equation of state (EoS) of homogeneous nuclear matter. The scheme utilizes a natural and versatile EoS Ansatz for symmetric and pure-neutron matter [1]. The Ansatz and subsequent scheme are dubbed KIDS (Korea: IBS-Daegu-SKKU) for the locale or institute of the original developers.

We apply the scheme to closed-(sub)shell nuclei to show that a good-quality Skyrme force model can easily be reverse-engineered from a good-quality EoS without refinement or extensive fitting [2]. Then the bulk and static nuclear properties are found practically to be independent of the assumed value for the effective mass, which is a unique result in bridging nuclear EDF theory for finite and homogeneous systems.

Future applications abound: Our methodology will allow us to study the effects of the EoS parameters and of the effective mass on nuclear observables while retaining the freedom to vary major EoS parameters and the effective mass independently. An exploration of symmetry-energy parameters is underway [3]. Finally, it remains feasible to constrain the momentum dependence based on microscopic calculations of the effective mass or polarized matter and the spin-orbit coupling from, e.g., relativistic approaches.

In this talk I will present briefly the basic ideas behind the KIDS functional and our results on finite nuclei.

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Contributions of high Ye ejecta of neutron star mergers in the r-process nucleosynthesis

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The r-process is responsible for the production of about half of the heavy elements observed in the solar abundances. The site of the r-process was unknown until recent observations. The gravitational wave event GW170817, which was identified as a binary Neutron Star Merger (NSM), was followed by the detection of an electromagnetic counterpart (EM170817) that is consistent with predictions for a kilonova/macronova associated with r-process nucleosynthesis [1,2]. In particular the observation of a bright, fast fading UV component.

Since the complicated atomic structure of lanthanides implies high opacity ejecta, this indicates the presence of material with relatively high electron fractions and consequently low lanthanide production [3,4,5]. We present the study of nucleosynthesis for the conditions of high Ye outflows from NSMs and investigate if this could be the site for the production of the elements of the r-process abundance pattern for A <100.

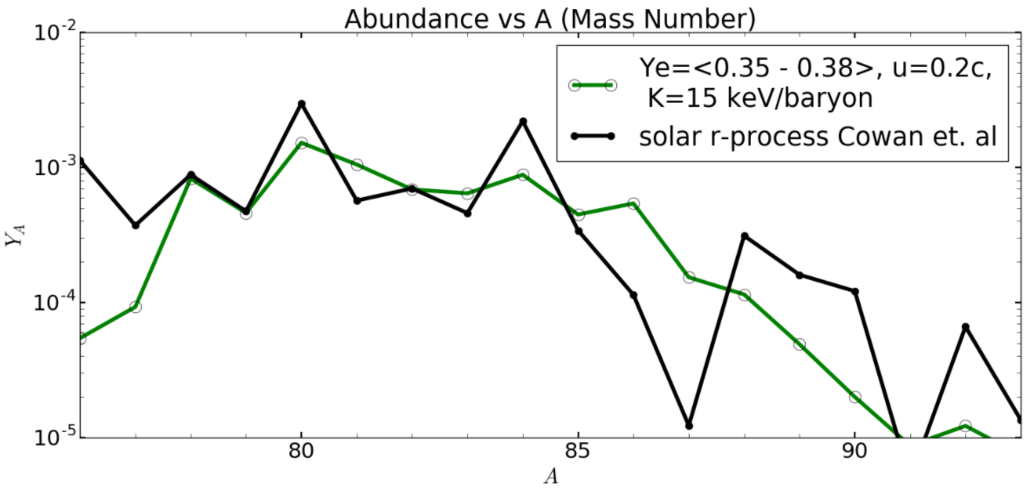

Figure 1: Abundance vs Mass number for a range of high Ye ejecta

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The sensitivity of p-MOSFET dosemeter heavy ions

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The p-MOSFET dosimeter studied in this work has been manufactured at LAAS-CNRS Laboratory in Toulouse France, for applications in personal and space dosimetry. They are proposed for proton, neutrons, heavy ions and electron and photon dose measurements. The current study investigates the sensitivity of the p-MOSFET electronic dosimeter to heavy ions regarding to be used in space applications. Irradiations to heavy ions have been performed at HIMAC accelerator. Two types of p-MOSFETs, with LiF and without LiF converter have been studied. The irradiations were performed in two doses, 10 mGy and 25 mGy and energies ranging from 150 MeV/n to 500 MeV/n.

Feasibility studies of (n,xn) reactions with HPGe detectors at the CERN nTOF facility*

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(n,xn) reactions are of particular importance for nuclear technology achievements, due to the production of extra neutrons in reactors, as well as for nuclear model validation, due to the reduction of uncertain parameters which may affect the calculated cross sections. There is a lack of accurate experimental data though, in the region above 15 MeV, where the cross section of (n,xn) reactions increases significantly. The cross section for the exit channels of these reactions can be determined via the prominent gamma rays emitted from the residual nuclei after applying the appropriate corrections with the help of statistical model calculations. The HPGe detectors, however, appropriate for gamma-ray spectroscopy, saturate due to the gamma-flash which follows the neutron beam produced through spallation process. At the CERN nTOF facility the neutrons are produced via spallation of 20GeV protons on a Pb target and are accompanied by a strong gamma-flash burst which indeed saturates the HPGe detectors and makes the (n,xn) measurements impossible.

Feasibility tests will be presented, which have been performed during the last four years, with several types of HPGe detectors in both experimental areas of the nTOF facility, in order to investigate the appropriate pre-amplification system to overcome the saturation problems.

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Radiological impact assessment in the marine environment: Exploring the innovation *

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The routine monitoring for radiological impact assessment in the marine environment has not been included in the REM program of EURATOM (Radioactivity Environmental Monitoring – contractual obligation of the European Union Member States). Thus, measurements of radioactivity in the marine environment have been an issue of research, primarily in the field of radioecology and secondarily as a complement to REM in ad hoc cases in areas of potential radioactive pollution such as ports being visited by nuclear powered vessels and in areas affected by global and/or regional/interregional fallout. The Environmental Radioactivity Laboratory (ERL) has started recording the levels of radioactivity in the Greek marine environment in the early seventies by means of gross beta measurements, which is a rather rough method requiring the exclusion of Cs-137 from the measured fission products (as it behaves as K-40, the major natural radionuclide in seawater). Following up, a more accurate method has been introduced, based on the co-precipitation of Cs-137 with Ammonium Phospho Molybdate and the use of Cs-134 as a carrier and yield tracer. This method is still carried out in ERL, using γ-spectrometry, as the Laboratory is officially involved in the Greek marine environment radioactivity control. Currently, ERL is in the process of developing innovative methods for urgent and/or emergency measurements and cost efficient tools for routine checking and monitoring incidental/accidental releases of radioactive substances in the marine environment based on the satellite remote detection of Cs-137. In the present study, the time evolution of the radiological monitoring in the Eastern Mediterranean Sea is being presented based on the data that has been collected by ERL during the last five decades and the innovation technique is also mentioned as well.

Key words: marine radioactivity, Cs-137 in seawater, fission products in seawater, remote recording of C-137

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Study of deuteron elastic scattering on ^{nat}O at energies and angles suitable for EBS (Elastic Backscattering Spectroscopy)

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Oxygen (99.76% ^{16}O, 0.04% ^{17}O, and 0.2% ^{18}O) is the third most abundant element by mass in the universe and it comprises ~21% of the earth's atmospheric volume in molecular form. Common uses of oxygen include production of steel, plastics and textiles, brazing, welding and cutting of steels and other metals. As it is highly reactive, oxygen-induced corrosion, or even simple oxidization, is a well-known problem in most technological materials. Thus, the accurate quantitative determination of oxygen depth profile concentrations in various targets is of critical importance. At the same time, it constitutes a major challenge for all Ion Beam Analysis (IBA) techniques because oxygen usually coexists in various complex matrices along with several other low- and medium-Z elements.

Among all IBA techniques, Nuclear Reaction Analysis (NRA) seems to be the most prominent one for oxygen depth profiling studies, usually via the simultaneous implementation of the $^{16}O(d,\alpha_0)$, $^{16}O(d,p_0)$ and $^{16}O(d,p_1)$ reactions, which yield high-energy proton and α-particle peaks, due to their relatively high Q-values, with reduced background contributions. EBS (Elastic Backscattering Spectroscopy) is usually performed in parallel, along with NRA, and it is critical for the complete description of the matrix. There exist several datasets in literature suitable for d-EBS, but there is a considerable lack of data at higher energies, namely above $E_{d,lab}$~2 MeV, which would facilitate oxygen depth profiling studies at higher depths.

This problem, along with the study of the influence of the different reaction mechanisms in deuteron elastic scattering on oxygen were the main motivations of the present work, where differential cross-sections were determined in the projectile energy range $E_{d,lab}$ = 1500–2500 keV (in energy steps of ~10-20 keV) and for six detector angles between 120° and 170° (in steps of 10°). The target used was a thin oxygen-containing foil, with an ultra-thin Au layer evaporated on top for normalization purposes. The measurements were performed using the 5.5 MV TN11 HV Tandem Accelerator of N.C.S.R. "Demokritos", Athens, Greece and a high-precision goniometer. The results from the present work, in both graphical and tabular forms, will soon become available to the scientific community through IBANDL (www-nds.iaea.org/ibandl/).

Cancer Lesions Detectability Limits in SPECT Breast Imaging

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Breast imaging for early stage cancer diagnosis is still mainly relying on planar imaging techniques. Due to spatial resolution and sensitivity limitations in combination with absorption effects, whole-body PET and SPECT clinical scanners show a poor performance in three-dimensional tomographic imaging. In order to exercise in detail, the detectability limits of small breast cancer lesions in a highly noisy background, a dedicated SPECT study with a breast phantom is presented in this work. The practical goal of the current analysis is to accurately define the tomographic limits of this method to successfully deliver accurate clinical tomographic images of various small-volume and specific activity concentrations in a controllable signal-to-noise environment.

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Scintillators calibration using a semi-empirical method based on Monte Carlo simulations *

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In this work the detection efficiency calibration of underwater gamma ray spectrometers for measurements in the marine environment is presented. The calibration concerns systems consisting of different crystal materials (NaI(Tl), $CeBr_3$) and dimensions (1.5" x 1.5", 2" x 2", 3" x 3"), as well as different enclosure materials (acetal, stainless steel, carbon fiber).

Monte Carlo simulation is a powerful validated tool for gamma ray spectroscopy applications, but requires high computational time especially for transport problems in the seawater, in which photons are highly attenuated. For this reason, a semi-empirical methodology was adopted using analytical expression and conversion factors along with M.C. simulations, in an attempt to reduce the necessary computational time. The efficiency calibration was performed via Monte Carlo simulations for a wide energy range from 200 to 2600 keV.

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Investigation of precipitation characteristics by in-situ, continuous monitoring of atmospheric radon progenies in south Attica

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Radon emanates from the soil and enters the atmosphere where it is upwardly transported by air masses up to cloud formation altitudes. Radon ($^{222,220}Rn$) decays to radioisotopes of lead, bismuth and thallium which are accumulated in the atmospheric air, mainly attached on aerosols, participating in several complex atmospheric processes such as cloud formation, raindrop creation and precipitation. Consequently, rainwater is rich in radon progenies so, they are widely used as radio-tracers of precipitation characteristics. In the present work, in-situ atmospheric measurements of ^{214}Pb, ^{214}Bi and ^{208}Tl before and during precipitation events took place in the region of Anavyssos in south Attica. Hourly data were continuously obtained during the period from October 2017 to March 2018, by means of the underwater detection system GeoMAREA. The system is based on a 2"x2" $CeBr_3$ scintillation crystal providing medium resolution gamma-ray spectra. Meteorological data were also obtained for statistical analysis, possible association with radioactivity data and scientific interpretation. ^{214}Pb and ^{214}Bi counting rates were increased during and after a number of 87 precipitation events showing also significant statistical variation with the wind direction. Moreover, although no direct association with temperature, humidity and rain height was found, a non-linear association of total gamma-ray, ^{214}Pb and ^{214}Bi counting rates per rain mass with rain intensity was observed. On the contrary, ^{220}Rn progeny of ^{208}Tl counting rates revealed no statistical significant changes during precipitation events and showed no association with any of the obtained meteorological parameters.

Characterization of Fe^+ irradiated materials using nuclear analytical techniques

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FeCr ferritic martensitic steels are candidate structural materials for fusion energy applications due to their radiation resistance and good mechanical properties. The 14 MeV neutron induced radiation damage is currently investigated employing self-ion irradiations on thin FeCr polycrystalline films. It has been established that Fe^+ irradiation with ion energy of 490 keV, which corresponds to the mean energy of Primary Knock-on Atoms (PKA) produced by 14 MeV neutrons, induces drastic changes both in the magnetic and the structural properties of the FeCr alloy films.

In the framework of further investigating and characterizing the observed phenomena and defect structures, Fe^+ irradiations were carried out at two laboratories, namely at JANNuS (CEA, France) and at HZDR (Dresden, Germany). They have been performed both on the FeCr samples of interest (with 0, 5, 10 and 15 at% Cr) deposited on MgO and Si/SiO_2 substrates and on reference silicon wafers, at irradiation fluences up to 2.5×10^{16} at/cm^2.

The present work concerns the characterization of the 490 keV Fe^+ ion irradiations on Fe and Si in terms of fluence, implantation profile and possible contamination, employing Nuclear Reaction Analysis (NRA) and Rutherford Backscattering Spectrometry (RBS) using a deuteron beam at 1200 and 1350 keV. The experiments were performed at the 5.5 MV Tandem laboratory at NCSR ''Demokritos'', employing a surface barrier detector at 170° with respect to the beam direction. The iron and silicon samples that were irradiated with 490 keV Fe^+ ions have been characterized, using the SIMNRA code, with the following most prominent results. The ion distribution for the implanted Fe^+ provided by the Stopping and Range of Ions in Matter software package (SRIM) was verified with the simulations, while carbon contamination was found on the samples irradiated at JANNuS.

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PhoSim: A Software Simulation Package Designed for Macroscopic and Microscopic Studies in the Time-Resolved Optical Tomography

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PhoSim is an optical ray tracing Monte-Carlo simulator capable of reproducing the physical processes taking place in a tissue environment when illuminated by Near-Infrared radiation. From a macroscopic point of view this can be accomplished by the proper manipulation of the Henyey-Greenstein phase parameter g, which represents a simple and analytical solution for the fast generation of a random scattering angle photon distribution. Microscopically, the program can simulate certain biological structures by placing a proper density of subcellular organelles inside the volume of interest, proportional to the wavelength of the radiation used at the study (~750-1000 nm). The new version of this software package is able to create different type of phantoms in multilayer environments and it is also equipped with a detailed Fate and Time of Flight information of each traveling photon. PhoSim is a simple and useful tool for Time-Resolved Optical Tomographic studies; its basic functions and capabilities with optical tomographic examples are presented in this work.

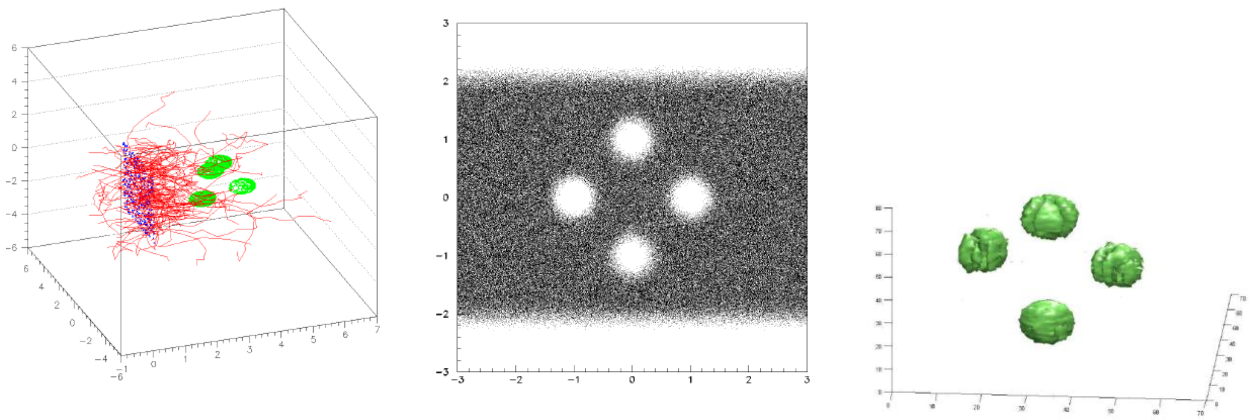

Figure 1: Phantom simulation with PhoSim. *Left:*3D ray-tracing snapshot of four spherical object inside a highly diffused medium *Center:* Planar image after time filtering. *Right:* Tomographic Reconstruction of the phantom.