Progress in gaseous detectors

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A brief review on Micromegas detector with current developments and future projects will be presented. The detector is used in several experiments in both particle and nuclear physics. Particular attention will be devoted to the neutron detection and to large volume devices for nuclear astrophysics and nuclear structure experiments. This device is also used for solar axion search at CERN. A new development aiming to reach picoseconds time resolution is under way by an international collaboration. This is a challenge for future ultra-high-luminosity accelerators as well as for particle identification.

A new type of gaseous detector based on a spherical geometry will also be presented. The detector consists of a large spherical gas volume with a central electrode forming a radial electric field. A small spherical sensor located at the center is acting as a proportional amplification structure.

The spherical detector combining sub-keV energy threshold and versatility of the target (Ne, He, H) opens the way to search for ultra-light dark matter WIMPs down to 100 MeV. The next project NEWS-G, under construction, is a large detector that consists in a selected pure copper sphere of 1.4 meter of diameter to be installed at SNOLAB-Canada. This device can detect neutrinos from a nuclear reactor through neutrino-nucleus elastic interaction, neutrinos from supernova explosions and is competitive for double beta decay search using Xe-136 high-pressure gas target.

CALIBRA, a national research infrastructure for accelerator-based research and applications: A progress report

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CALIBRA stands for "Cluster of Accelerator Laboratories for Ion-Beam Research and Applications", which is the title of the proposal submitted in 2013 to the General Secretariat for Research and Technology (GSRT), the Greek funding agency, within its call for the establishment of the national roadmap of research infrastructures. The CALIBRA proposal has been evaluated by an international expert committee as an excellent proposal with a score of 19/20. This score ranked CALIBRA in the top ten positions in the list of 75 evaluated proposals that were submitted by scientists from all scientific disciplines.

The project aims at establishing and operating an accelerator-based research infrastructure open to the national and the European scientific community to conduct research at excellence level, develop innovative applications of increased socioeconomic impact, and provide highly-specialized services, unique at the country level, to the public and private sector. CALIBRA strives for contribution to the goals of the National Strategy in Research and Technology regarding the country's thematic priorities for smart specialization (RIS3), with emphasis in human health and radiopharmaceuticals, future energy sources, materials of technological interest, cultural heritage, environmental monitoring and the development of instrumentation and its testing under harsh irradiation environments.

CALIBRA is implemented at the Tandem Accelerator Laboratory of the Institute of Nuclear and Particle Physics (INPP), one of the five research institutes of the National Centre for Scientific Research "Demokritos", Athens, Greece. The project had its kickoff meeting in November 6, 2017, that was attended by more than 60 scientists from 17 Greek research performing institutions and state organizations. As of today, CALIBRA is evolving very successfully and a progress report will be presented.

Acknowledgments

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A novel Beam Loss Monitor for the ESS Linac, based on a Micromegas neutron detector

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The detection and continuous monitoring of beam losses is crucial for the safe operation for high intensity linear accelerators, such as the ESS Linac, because even the loss of a small fraction of the beam could result in significant irradiation and damage of accelerator equipment. A Beam Loss Monitor (BLM) system must be capable of detecting the smallest possible fraction of beam loss, approaching 0.01 W/m, in order to prevent activation of machine components and allow hands-on maintenance. A common way to monitor losses is by detecting the secondary radiation that follows the impact of the lost particles to the accelerator materials. However, especially at the first stages of the accelerators (proton energies <100 MeV), typical BLMs based on charged particle detection (i.e. Ionization Chambers) are not suitable because the expected particle fields will be dominated by neutrons and photons. Another issue is the photon background induced by the RF cavities, due to field emission from the electrons forms the cavity walls, resulting in bremsstrahlung photons.

The idea for the new BLM system (ESS-nBLM) is to use Micromegas detectors that are designed to be sensitive only to fast neutrons and insensitive to low energy photons (X and gammas) and to thermal neutrons, since they may not be directly correlated to beam losses. The appropriate configuration of the Micromegas operating conditions will allow excellent timing, strong intrinsic suppression of gamma background and possibility to count individual neutrons, extending thus the dynamic range to very low particle fluxes. The concept of the ESS-nBLM system, as well as the performance of detector prototypes from tests in several irradiation facilities, will be presented here.

The Nuclear Engineering and EMINE Master Programme, at KTH Royal Institute of Technology, in Stockholm, Sweden

Elina Charatsidou
Students Ambassador of Royal Institute of Technology

Elina Charatsidou is a graduate from the Physics Department of AUTH. She is currently studying at KTH, Royal Institute of Technology in Stockholm, Sweden. She is enrolled at the Nuclear Energy Engineering Master's Program, and she is the student ambassador at the master's program as well. Through this position at KTH, she is responsible for informing institutions and perspective students worldwide, about studies in Sweden, at KTH, and at the Nuclear Energy Engineering and EMINE Master's Programs. During the presentation, information will be given for the application process students should follow, information for dates and deadlines, steps to be taken after they are being accepted at KTH, as well as information about the student life in Stockholm, tuition fees, courses included in the curriculum, and future job perspectives offered in Sweden. Lastly, students will have the opportunity to ask specifically directed questions for any of the aforementioned topics, receiving answers coming from a student with similar educational background, and based on the training she has received as a student ambassador as well as from experience gained throughout this year.

From Nuclei to Stars with a Relativistic Density Functional

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A generalized relativistic density functional (gRDF) with density-dependent meson-nucleon couplings [1-4] is developed for a unified description of nuclei and strongly interacting matter, in particular for astrophysical applications. The parameters of this phenomenological model are obtained from a fit to nuclear binding energies, charge form factor data (charge and diffraction radii, surface thicknesses) and spin-orbit splitting of a set of nuclei. The resulting nuclear matter parameters are very reasonable and the predicted neutron matter equation of state (EoS) is consistent with ab-initio calculations using chiral effective field theory. The nuclear symmetry fulfills current experimental and theoretical constraints.

Light and heavy nuclei are included as explicit degrees of freedom. Their dissolution is described with the help of medium-dependent mass shifts that mainly originate from the action of the Pauli principle. Consistency with the virial EoS at very low densities is achieved by including two-nucleon correlations in the continuum in an effective way [5]. The emission of light nuclei in heavy-ion collisions [6] and α-particle correlations at the surface of Sn nuclei [7] are studied as examples for experimental tests of the model.

EoS tables for astrophysical simulations [8], e.g., core-collapse supernovae and neutron-star mergers, are generated in a wide range of densities, temperatures and isospin asymmetries. Thermodynamic properties and the chemical composition of compact star matter are extracted. A first-order phase transition at high densities is modeled with a modified excluded-volume mechanism [9]. Finally, some problems [10] are discussed and an outlook is given.

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First Coherent Elastic ν-Nucleus Scattering (CEνNS) measurements and the potential new physics involved

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Motivated by the recent observation of coherent elastic neutrino-nucleus scattering (CEνNS) at the COHERENT experiment [1-2], we explore its potential in probing important nuclear structure parameters. By means of a dedicated statistical analysis [3-5], constraints are extracted on the harmonic oscillator size parameter, the neutron radial moments as well as on important parameters entering the definition of the neutron form factors. The attainable sensitivities and the prospects of improvement regarding the next phase of the COHERENT experiment are also considered and analyzed on the basis of two upgrade scenarios [6].

Finally, encouraged by our successful application of the Non-Standard-Interactions (NSIs) and the novel vector Z' or the scalar φ mediators [NSI and U'(1) scenarios] to the CEνNS event rates measured at Oak Ridge with the COHERENT neutrino experiment, we provide improved interpretation of these data and subsequently we extract sensitive constraints to the standard and non-standard model physics [6].

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Exploring the astrophysical conditions for the creation of the first r-process peak, and the impact of nuclear physics uncertainties

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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 fast fading optical counterpart consistent with the predictions for a kilonova, associated with r-process nucleosynthesis. The observation of bright, fast fading UV component, established the production of heavy elements in the aftermath of NSM. The complicated atomic structure of lanthanides implies high opacity ejecta which would shift the wavelength of the observed light to the red; the blue color of the emission spectra at early time indicates that part of the ejecta only contains relatively high Ye and consequently low lanthanide production. We present a study of nucleosynthesis for conditions of high Ye outflows from NSMs and investigate the effect of uncertainties in nuclear masses as well as in beta decay rates and the astrophysical conditions under which this could be the site for the production of the elements of the r-process abundance pattern for A < 100.

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Microscopic description of induced fission dynamics with nuclear energy density functional

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Static and dynamic aspects of the fission process are analyzed in a self-consistent framework based on energy density functional. Multidimensional constrained mean-field calculations in the collective space determine the potential energy surface of the fissioning nucleus, the scission line, the single-nucleon wave functions, energies, and occupation probabilities. Induced fission dynamics is described using the time-dependent generator coordinate method in the Gaussian overlap approximation. The position of the scission line and the microscopic input for the collective Hamiltonian is analyzed as functions of the strength of the pairing interaction, as well as the effect of static pairing correlations on charge yields and total kinetic energy of fission fragments [1]. Finite temperature (FT) effects on induced fission dynamics using the TDGCM+GOA collective model are investigated. The resulting charge and mass fragment distributions are analyzed as functions of the internal excitation [2].

Acknowledgments
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Proxy-SU(3) predictions

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Using a new approximate analytic parameter-free proxy-SU(3) scheme, we make simple predictions of shape observables for deformed nuclei, namely γ and β deformation variables, BE(2)s, lifetimes, spectra, the global feature of prolate dominance and the locus of the prolate-oblate shape transition.

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A mechanism for shape coexistence

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A mechanism for shape coexistence is proposed. The mechanism is activated by large deformation and involves the coupling of the nuclear shells 6-14, 14-28, 28-50, 50-82, 82-126 with the harmonic oscillator shells 2-8, 8-20, 20-40, 40-70, 70-112 respectively. The outcome is, that the phenomenon may occur in certain islands on the nuclear map. The mechanism predicts without any parameters, that nuclei with either proton number (Z), whether neutron number (N) between 8, 18-20, 34-42, 60-72, 96-116 are candidates for shape coexistence. Predictions for the energy and the shape of the 0_2^+ states are made. In the $N{\sim}20$ island of inversion the mechanism predicts, that an inversion of the 0_1^+ states occurs at N=18.

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State-of-the-art of neutron activation analysis at Frank Laboratory of Neutron Physics of Joint Institute for Nuclear Research, Dubna, Russia

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The history of the development of neutron activation analysis in the Laboratory of Neutron Physics at Joint Institute for Nuclear Research is briefly outlined. Created under initiative of Academician I.M. Frank in the 1960s,a small group now turned into a large international team involved in projects in the framework of programs coordinated and supported by IAEA, the European Union, the Russian Fund for Basic Research(RFBR), as well as grants of Plenipotentiaries of JINR member states. Modernization of the pneumatic system equipped with three automatic sample changers and created NAA database to automate the measurement and processing of gamma spectra of induced radionuclides are described. Experience in the Life Sciences and Materials Science is summarized. Examples are given of projects related to the monitoring of atmospheric deposition of heavy metals and radionuclides carried out in the framework of the United Nations Program on Long-Range Transboundary Air Pollution in Europe (UNECE ICP Vegetation), a project to assess the state of the environment in Egypt, based on the analysis of soil and the sediment basin of the river Nile, as well as project on monitoring trace elements in aquatic ecosystem in the Western Cape, South Africa («Mussel Watch Program»), etc. In combination with microscopy, the synthesis of nanoparticles of various metals via biotechnology is studied. Our investigations on applying NAA to solve the problem of industrial wastewater treatment were awarded Gold Medals by the European Union, in 2013 and 2015. New areas of research –study of natural medicinal plants and search for cosmic dust in natural planchettes (Arctic and Antarctic mosses, Siberian peat bog cores, etc) –reflect the public and scientific interest in these topics. Future extensions of th sector΄s research isconnected with the radioecological studies using precision gamma-spectrometry and a low-background laboratory for carrying out measurements of natural and anthropogenic radioactivity. Perspective of creating the Centre of Collective Useageat the planned Dubna Neutron Source of the fourth generation (DNS-4) to be put into operation in 2035-2036is mentioned.

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GeoMAREA: A Gamma-ray spectrometer for in-situ marine environmental applications

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A new medium resolution (based on a 2x2'$CeBr_3$ crystal) gamma-ray spectrometer named "GeoMAREA" was developed and applied for measuring radioactivity in aquatic environments. The system is capable for qualitative and quantitative measurement of radionuclides in aquatic environments with maximum depth of deployment up to 600m. A special software is developed to fulfill different demands of the end-users in order to: a) provide real time data using the cable mode, b) perform communication tasks with a data center transferring (near) real time data, c) provide time series in sequential buffers for continuous monitoring in a stand-alone mode and d) provide profile data and subsequently maps using mobile vehicles (underway mode). The spectrometer was calibrated first using point sources for energy, energy resolution and efficiency. The system offers activity concentrations of all detected gamma-ray emitters in Bq/m^3 using the marine efficiency calibration, which is reproduced via the MCNP5 code [1]. Two experimental points were used for validation of the theoretical estimation obtained by two reference sources (^{137}Cs, and ^{40}K) diluted in a water-filled tank. Currently, GeoMAREA is deployed in a closed aquatic system where groundwater discharges (Anavalos, Kyberi, Greece). A first estimation of the intrinsic background of the crystal at the emission energy area of ^{40}K is estimated. Additionally, an inter-comparison exercise with the low resolution system KATERINA II [2], is also described.

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Response of Radiation Portal Monitors to gamma radiation and detection capability of Orphan Radioactive Sources in scrap loads

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Radiation Portal Monitors (RPM) are commonly used to detect and intercept unauthorized movement of nuclear and other radioactive materials both at borders and within States**.** Furthermore, portal radiation detectors are commonly used by steel industries in the probing and detection of radioactivity contamination in scrap loads. The detectors typically used in RPM are organic scintillating detectors. In this work two different Radiation Portal Monitors were studied: The first one is located in the “EVZONI” Greek border. This RPM is a double pillar portal monitor with two polystyrene (PS) scintillating detectors per pillar. Spatial and Spectral response measurements were conducted with four radioactive point sources (Cs-137, Co-60, Eu-152 and Ba-133). Through the electronic circuit of the detector an energy region- of interest window can be determined in order to focus on the detection of certain radionuclides. The response was taken for three energy regions (low energy, high energy and total energy response). Simulations of the detector were carried out using the MCNP code. The measured spatial response of the plastic detector depends both on the energy window used and on the radioactive source itself. MCNP simulations can describe sufficiently the total energy response characteristics, while in the other two cases are qualitative and quantitative discrepancies, which can be explained due to the light transfer mechanisms (attenuation) within the scintillation volume. Light transfer mechanisms are only modeled in optical simulation tools (e.g. GATE) and not in gamma ray particle simulation tools (MCNP). Minimum Alarm Activities for unshielded Cs-137 and Eu-152 point sources were estimated to 5.2 μCi Cs-137 and 3 μCi Eu-152. The second Radiation Portal Monitor is a portal monitor with two PVT scintillating detectors per portal. This RPM is located inside a steel factory in order to detect radioactivity contamination in scrap loads. The RPM was opened, and all principal materials were simulated. Simulations were validated by comparison with corresponding measurements. An experiment with a uniform cargo along with two sets of experiments with different scrap loads and radioactive sources (Cs-137 and Eu-152) were performed and simulated. Simulated and measured results suggested that the nature of scrap is crucial when simulating load-detector experiments. The simulated results were in very good agreement in the case of the uniform cargo. For scrap loads, simulated densities 1.3 and 1.4 g cm^{-3} produce results that are close to the measured ones. Using Monte Caro simulations, a series of runs were performed in order to estimate the Minimum Alarm Activities “MAA” for Cs-137, Co-60 and Ir-192 sources for various simulated scrap densities. The highest MAA values for the highest average scrap density tested ($\rho = 1.3$ g · cm^{-3}) were 5 mCi for Cs-137, 0.2 mCi for Co-60 and 18 mCi for Ir-192. Finally Monte Carlo simulations were performed for the determination of the distance needed from an unshielded and lead shielded Cs-137 radioactive source in order to detect the source. The results were compared with analytic calculations and with the results obtained from web (on line dose rate calculators).

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Elemental Analysis of Sand Samples by Radio-activation

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The aim of this study is to carry out elemental analysis of sand samples using photon activation analysis. Sand samples were collected different location from Antalya in Turkey. Each sand samples were irradiated at an end point energy of 18 MeV from a clinical electron linear accelerator. Samples were counted using high purity germanium detector. Afterwards, gamma-ray spectra were analyzed using computer software and major, minor and trace elements were defined for sand samples. (γ,n), $(\gamma,2n)$, (γ,p) and (γ,γ') reactions have occurred with the stable elements in sand samples by photon activation analysis. Details of this study can be found in reference [1].

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Electret Ion Chambers for Environmental Gamma Monitoring

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Electret ion chambers (EIC) are inexpensive, light-weight, commercially available, passive charge-integrating devices for accurate measurement of different radiations. EIC are mainly used for short- or long-term radon measurements. However, with small modifications EIC can be used for other type of radiations. Particularly, electret ion chambers become gamma monitors when sealed in a radon leak tight enclosure. The use of EIC as gamma monitors is not relative common (in comparison to TLDs which are used in the majority environmental gamma monitoring). The main scope of this work is to investigate the capabilities of electret ion chambers to measure ambient gamma dose equivalent H*(10) or ambient gamma dose equivalent rate. The ambient equivalent dose H*(10) is a measurable equivalent of the effective dose, which quantifies the risk to human health associated to radiation exposure. This quantity was introduced by the International Commission on Radiation Units and Measurements (ICRU) back in 1985 and its use is also strongly recommended by ICRP, IAEA and other organizations and metrological institutes such as NIST, NPL. The capabilities of electret ion chambers to measure mean ambient dose equivalent rates were investigated by performing both laboratory and field studies of their properties. First, electret ion chambers were "calibrated" to measure ambient gamma dose equivalent in the Ionizing Radiation Calibration Laboratory (IRCL) of the Greek Atomic Energy Commission. The electret ion chambers were irradiated with different gamma photon energies and different angles. Calibration factors were deduced (electret's voltage drop due to irradiation in terms of ambient dose equivalent). Based on these calibration factors, the mean ambient gamma dose equivalent rate was measured with electret ion chambers (for three times five months period) at eight locations belonging to the Greek early system network (which is based on Reuter-Stokes ionization chambers). In the same locations, in-situ gamma spectrometry measurements were performed with portable germanium detectors and the gamma ambient dose equivalent rates were deduced. The mean ambient dose equivalent rate measured with the passive dosimeters in the different locations was compared with those measured by the portable germanium detectors and Reuter-Stokes ionization chambers. The influence of cosmic radiation and the intrinsic voltage loss when performing long-term environmental gamma measurements with electret ion chambers was estimated.

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The APAPES project at the tandem accelerator facility of "Demokritos": A progress report

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The APAPES project (atomic physics with accelerators: projectile electron spectroscopy) has established in Greece the discipline of Atomic Physics with accelerators. The experimental setup is currently fully operational at the tandem accelerator facility of "Demokritos" [1]. The APAPES research interests are primarily focused on collision dynamics investigations by exploiting the possibilities offered by the metastable He-like (1s2s ^{1,3}S) ion beams at collision energies of few MeV/u [2]. He-like beams are routinely delivered by tandem accelerators in a (1s^2 ^{1}S, 1s2s ^{1,3}S) mixed-state content. However, our group has developed a technique that allows for determining the ion beam content and, in cases, even separating the contributions of the ground, 1s^2 ^{1}S, and metastable, 1s2s ^{1,3}S, ion beam states, to the Auger projectile electron spectra [3,4]. Based on this, we have initiated a systematic isoelectronic investigation on: (a) the production of Li-like 1s2s(3S)nl ^{2,4}L states by direct nl transfer and transfer-excitation processes. These studies, among others, shed light onto the long-standing controversy about the population enhancement of the 1s2s2p ^{4}P state from higher lying quartet states through the selective cascade feeding mechanism [5,7]. (b) The production of 2s2p ^{1,3}P hollow states by excitation, double excitation and transfer loss processes. Our experimental data are in accordance with state-of-the-art theoretical three-electron atomic orbital coupled channel calculations using the semi-classical close-coupling approach [8]. Here, experimental results to date will be reported, while the overall progress of the APAPES project and near future plans will be reviewed.

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Production of hollow 2s2p 3,1P states in collisions of C4+ (1s2 1S, 1s2s 1,3S) ions with gas targets

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The production of the doubly-excited 2s2p 3,1P hollow states in collisions of fast (few MeV/u) He-like C4+ (1s2, 1s2s) mixed-state ion beams with gas targets is reported. He-like beams are routinely delivered by tandem accelerators in a (1s2 1S, 1s2s 1,3S) mixed-state, the content of which depends on the type of ion-stripper (gas or foil), as well as the stripping energy [1]. Based on metastable fraction-controlled measurements of the Auger decay spectra of the 2s2p 3,1P states [2] and a technique developed by our group that allows for determining the ion beam content [3,4], we have initiated a systematic isoelectronic investigation on the processes contributing to the production of the doubly excited 2s2p 3,1P hollow states. These include the first order process of direct electron excitation, the second order processes of double electron excitation and the process of electron transfer-loss. So far, we have performed experiments for collision energies between 0.5 and 1.5 MeV/u C4+ with H2, He, Ne and Ar gas targets. Our experimental results are accompanied, for the case of He gas targets, with state-of-the-art theoretical three-electron atomic orbital coupled channel calculations using the semi-classical close-coupling approach [5]. Calculations are seen to overall reproduce the experimental data after accounting for the ion beam metastable content, and thus, provide valuable quantitative information about the processes involved.

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Neutron induced reactions on Ge isotopes and isomeric cross section study

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Studies of neutron induced reactions are of considerable interest, both for their importance to fundamental research in Nuclear Physics and Astrophysics as well as for practical applications such as fusion reactor technology, medicine and industry. In the energy region up to 20 MeV, many reaction channels, which may proceed via different reaction mechanisms, are open and therefore can be simultaneously studied both experimentally and theoretically. Concerning Ge, besides its importance as semi-conducting material, (n, 2n) reactions on even-even Ge isotopes present high cross sections of hundreds of millibarns, thus increasing considerably the number of neutrons in neutron fields. In addition, some of the residual nuclei following (n, 2n) and (n, α) reactions on Ge isotopes, are produced in an isomeric state. The experimental determination of isomeric cross sections is of fundamental interest for studying the spin distribution of level density in the compound nucleus. Therefore, more experimental data are needed both for reliable practical applications as well as for testing theoretical calculations and improving the systematic development of model parameters.

In the present work, cross sections for the ^{70,76}Ge (n, 2n) and ^{72,74}Ge (n, α) reactions have been measured at the 5.5 MV tandem T11/25 Accelerator Laboratory of NCSR "Demokritos", using the activation technique. Monoenergetic neutron beams have been produced in the ~17-19 MeV energy region, by means of the ^{3}H (d, n) ^{4}He reaction. The maximum flux has been determined to be of the order of 10^5n/cm^2 s, while the flux variation of the neutron beam was monitored by using a BF_3 and a liquid scintillator detector. The cross section has been deduced with respect to the ^{27}Al (n, α) ^{24}Na, ^{197}Au (n, 2n) ^{196}Au and ^{93}Nb (n, 2n) ^{92m}Nb reference reactions. After the end of the irradiations, the activity induced by the neutron beams at the targets and reference foils, has been measured by HPGe detectors. Statistical model calculations using the EMPIRE and TALYS codes and taking into account pre-equilibrium emission were performed on the data measured in this work as well as on data reported in literature.

Cross-section measurement of ^{241}Am (n, f) reaction at the Experimental Area 2 of the nTOF facility at CERN: First Results

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Actinides are among the main components of radiotoxicity in nuclear waste. They are mainly produced by successive neutron capture reactions and α decays derived from ^{238}U which is present in the nuclear amplifiers. It is commonly accepted by the scientific community that this issue can be addressed through the development of fast neutron reactors and energy boosters (4th generation reactors, ADS systems [1]). The condition for the safe design and operation of these systems is the accuracy of nuclear data.

The ^{241}Am isotope ($T_{1/2}$ = 433 years) is highly present in nuclear waste, accounting for about 1.8% of the actinide mass in PWR UOx nuclear reactors' waste [2]. In addition, the ^{241}Am isotope is further produced by the β decay of the ^{241}Pu isotope ($T_{1/2}$ = 14.3 years). Given the high production rate of ^{241}Am isotope, its incineration with concurrent energy production is considered to be of utmost importance for the design and implementation of the recycling of existing nuclear waste. Sensitivity studies of the proposed systems for energy production showed that high-precision measurements of the cross-section of the ^{241}Am(n,f) reaction are required.

In the present work, the ^{241}Am (n, f) reaction cross-section was measured in the Second Experimental Area of the nTOF facility at CERN, using an array of Micromegas detectors. For the measurement, six targets of ^{241}Am with average activity of 17 MBq per sample were coupled with an equal number of detectors in a common chamber. Additionally two ^{235}U and two ^{238}U samples were coupled with Micromegas detectors utilizing the neutron flux determination. In the present work, an overview of the experimental set-up and the adopted data analysis technique is presented along with preliminary results.

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Mass measurements of neutron-deficient lanthanides around the neutron shell closure N=82

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Neutron-deficient lanthanides are a subject of interest from many perspectives. Not only can they provide information about the neutron shell closure at N=82, but they can also indicate where the proton drip-line lies in this region. In addition, since some lanthanides are anchors of alpha decay chains, they can give valuable information about the progenitors and intermediate nuclei. To this end, the masses of neutron-deficient lanthanides, approaching the atomic number 150, were measured at TRIUMF's Ion Trap for Atomic and Nuclear science (TITAN). TITAN specializes in high-precision mass measurements and in-trap decay spectroscopy, which recently was equipped with a Multi-Reflection Time of Flight mass spectrometer (TITAN MR-ToF) that can be used either as an isobaric separator or a mass spectrometer. For this experiment, radioactive ion beam from the TRIUMF's Isotope Separator and Accelerator (ISAC) was used to trap and measure neutron-deficient lanthanides in TITANs Multi-Reflection Time of Flight mass spectrometer. Mass-selective re-trapping was used for the first time with radioactive beam and resulted in suppression of the background by four orders of magnitude. This allowed the measurement of the masses of neutron-deficient lanthanides, Yb and Tm. Not only were many uncertainties reduced but also some measured for the first time. Preliminary results on the impact of these mass measurements to the evolution of the neutron shell closure at N=82 will be presented.

Neutrons capture cross-sections for ^{74}Se in the keV energy region using activation methods at a medical linear accelerator facility.

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Neutron capture reactions play an important role in the galactic chemical evolution since they are responsible for the synthesis of the nuclei heavier than iron. The (n, γ) cross section of selenium isotope ^{74}Se from 10 keV to 1 MeV was experimentally determined via activation methods using a bremsstrahlung photon beam delivered by an electron medical accelerator. The generation of ^{75}Se nuclei proceeds via both neutron capture and photonuclear reactions at a medical linear accelerator environment, and the respective photon and neutron emission contribution has been calculated. The theoretical estimation of both the photonuclear and the neutron-capture cross-section of the ^{74}Se were performed using the TALYS 1.8 code, whilst the weighted neutron capture cross-section was calculated using the FISPACT-II code with a reference neutron spectrum. The results prove that the methodology applied in this work is useful to carry out similar nuclear astrophysics studies at medical centers in the future.

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Study of the ^{165}Ho (n, 2n) ^{164}Ho^{g-m} reaction at near threshold energies

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The aim of the present work is the study of the ^{165}Ho(n,2n)^{164}Ho^{g} and ^{165}Ho(n,2n)^{164}Ho^{m} reactions at near threshold energies (E_{th}=8.04 MeV). This study is important for fundamental research purposes given that the comparison of the experimental data with the theoretical calculations improves the latter, as far as the performance of different models (e.g. level density models) and their parametrization is concerned [1,2]. The contribution of the present study is also essential for the Nuclear Technology as it goes with the need for enrichment of the fast neutron data libraries, so as to identify the best isotopes to be used as neutron absorbers or structural materials in fast neutron reactors and accelerator driven systems [3,4].

Up to now there is absence of experimental data at near threshold energies, whereas the data at higher energies present important discrepancies [5]. For these reasons, three irradiations were performed at the energies of 10.1, 10.4 and 10.7 MeV. The quasi-monoenergetic neutron beams were produced in the 5.5 MV Tandem Van de Graaff accelerator of the Institute of Nuclear and Particle Physics at N.C.S.R. "Demokritos" via the ^{2}H(d,n)^{3}He (D-D) reaction. The reactions cross section at the above-mentioned energies were determined with the Activation Technique, with the ^{27}Al(n,α)^{24}Na and ^{197}Au(n,2n)^{196}Au reactions used as reference [6] for the neutron flux calculations.

The induced activity at the Ho targets was measured using the Canberra broad energy HPGe detector BE5030. The usage of a broad energy detector was necessary given that the γ-rays emitted from ^{164}Ho^{m-g} are located between 37.34-91.39 keV. On the other hand, the reference foils activity was measured in an 80% relative efficiency HPGe detector. Both detectors were characterized with the GEANT4 Monte Carlo code [7] by reproducing the experimental efficiency data accrued with different calibration sources at different geometries.

During this presentation the experimental conditions, the data analysis and the adopted methods of the present study will be discussed in detail, whereas preliminary data will be displayed.

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NLD Equation of state for compressed, hot and relativistic nuclear matter

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We investigate the properties of compressed and hot hadronic matter within the Non-Linear Derivative (NLD) formalism. The novel feature of the NLD model is an explicit momentum dependence of the mean-fields, which is regulated by cut-off's of natural hadronic scale. It is covariantly and thermodynamical-consistently formulated at the basis of a field-theoretical level. We show that the NLD model describes adequately all the empirical information of cold nuclear matter as function of density (equation of state) and, in particular, as function of particle momenta (optical potential). Finally, we present predictions of the NLD approach for hot and compressed hadronic matter in terms of the Equation of state as function of density and temperature. These studies are relevant for the forthcoming experiments at FAIR@GSI. They are also important for astrophysical purposes, e.g., static neutron stars and dynamic neutron star binary systems.

Nuclear symmetry energy effects on the bulk properties of neutron rich-finite nuclei

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We systematically study the effect of the nuclear symmetry energy in the basic properties of finite, neutron-rich, heavy nuclei where symmetry energy plays a dominant role. We employ a variational method, in the framework of the Thomas-Fermi approximation, to study the effect of the symmetry energy on the neutron skin thickness and symmetry energy coefficients of various nuclei. The isospin asymmetry function a(r) is directly related to the symmetry energy as a consequence of the variational principle. In addition to this, the Coulomb interaction is included in a self-consistent way. The energy density of the asymmetric nuclear matter that is used has its origins in a momentum- dependent interaction.

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Constraints on neutron stars equation of state using the tidal deformability derived from BNS mergers

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The purpose of this work is the study of neutron stars (NS) equation of state (EOS) using constraints on tidal deformability derived from observation of binary neutron star (BNS) mergers, such as GW170817. The mathematical formalism of TOV equations is introduced [1], and then for a variety of EOS the system is solved numerically, allowing us to determine the mass, the radius, the tidal love number k_2 and the tidal deformability λ of the NS, each one of them unique for each EOS. Moreover, for a fixed value of chirp mass $M_{chirp}=1.188\ M_{\odot}$ [3] under the assumption that $m_2<m_1$ (where m_1 is the heavier component mass of BNS system), the effective (mass-weighted) tidal deformability $\tilde{\Lambda}$ of the binary system is determined for each EOS [2,3,5]. We consider an upper limit of $\tilde{\Lambda}\leq 800$ (GW170817) [3] and a lower limit of $\tilde{\Lambda}\geq 400$ (AT2017gfo) [8]. Also, we construct the $\Lambda_1-\Lambda_2$ space and we compare the behaviour of EOS with the most recent LIGO's data [4,6,7]. We found out that the most EOS models give values of $\tilde{\Lambda}$ less than the upper limit and that the most stiff EOS are excluded.

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Towards the Keplerian sequence: Realistic Equations of state in rapidly rotating neutron stars

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Neutron stars are among the densest known objects in the universe and an ideal laboratory for the strange physics of super-condensed matter. In the present work, we investigate the Keplerian (mass-shedding) sequence of rotating neutron stars by implying realistic equations of state based on various theoretical nuclear models. In particular, we compute the moment of inertia, angular momentum and eccentricity of neutron stars stable against mass-shedding and secular axisymmetric instability. We mainly focus on the dependence of these properties from the bulk properties of neutron stars. Another property that studied in detail is the dimensionless spin parameter (kerr parameter) of rotating neutron stars at the mass-shedding limit. In addition, supramassive time evolutionary rest mass sequences, which have their origin in general relativity, are explored. Supramassive sequences have masses exceeding the maximum mass of a non-rotating neutron star and evolve toward catastrophic collapse to a black hole. Important information can be gained from the astrophysical meaning of the kerr parameter and the supramassive sequences in neutron stars. Finally, the effects of the Keplerian sequence, in connection with the latter, may provide us constraints on the high density part of the equation of state of cold neutron star matter.

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Dense matter and the effects of the speed of sound bounds on the bulk properties of neutron stars in the Keplerian sequence

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The observation of rapid rotating neutron stars may provide rich information concerning the properties of nuclear matter at high densities. We study the effects of the upper limit of the speed of sound in dense matter on the bulk properties of rapid rotating (at the Kepler limit) neutron stars.

In particular, we investigate possible constraints on the maximum mass, the Kepler frequency, the moment of inertia, the Kerr parameter and the deformation. In general, the rapid rotating neutron stars may provide more information about the dense matter.
Finally, we also explore the critical astrophysical question in which extent the bound of the speed of sound, especially the lower limit, prevent a neutron star to simulate the bulk properties of a black hole. This will help to distinguish a neutron star from a black hole with the same mass and angular momentum.

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Radiological Study of Anavalos Submarine Groundwater Discharge at Kiveri, Greece

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Submarine groundwater discharges are known to be a significant source of chemical substances, nutrients and pollutants in the coastal zone [1], while in some cases the amount of water from submarine sources are much greater than the terrestrial discharges [2]. In addition, significant amounts of radionuclides are also discharged since groundwater is particularly enriched in natural radionuclides, mainly due to weathering from the subsoil. For this reason a number of natural radionuclides have been extendedly used as radio-tracers of hydrological processes [3]. As a result the radiological study of submarine springs is significant for the qualitative characterization of the water as well as for the estimation of key parameters like water age, groundwater and seawater mixing, groundwater coastal residence time, discharge rate and flux.

In this work, a preliminary study of Anavalos submarine springs at Kiveri by a variety of radiometric measurements is presented. The main geomorphological features, the catchment area hydrology and the origin of the groundwater outflows are discussed reviling the significance of the study area as a test site of radio-tracers application. Lab-based and in situ measurements were performed for the determination of the main radionuclides found in the groundwater, including radium isotopes pre-concentration and direct measurement of water samples with an HPGe detector as well as underwater gamma ray spectrometry. Finally, regarding water quality the main heavy metal concentrations and basic physical properties are also presented.

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First results of the Performance of the DIAPHANE Detector in Apollonia's Tumulus

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The DIAPHANE detector is a plastic scintillator comprised of three detecting planes, which was established next to Apollonia's tumulus in the frame of the ARCHé project (a collaboration of three French universities with the Aristotle University of Thessaloniki), during the summer of 2018. The objective of this project was the investigation of the effectiveness of muon tomography and of this specific detector on a small scale geological structure. For this purpose, open sky data obtained by the DIAPHANE detector oriented vertically for a total operating time of 21.5 hours was processed and analyzed. First results of the performance of the detector and the cosmic muons angular distribution are presented.

Studying nanoscale Li diffusion in rutile TiO2 using the β- and α-decay of 8Li with β-NMR and α-radiotracer techniques

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The diffusion of Li+ in rutile TiO2 has been studied extensively with a plethora of experimental and computational methods, as Li+ is known to move very fast through the c-axis channels, making it a prime candidate for a Li-ion battery anode material. Nonetheless, there are still many puzzling aspects of rutile lithiation, such as why the Li+ uptake is so limited, as well as why there is such disagreement between the diffusion rates found with different techniques or between the theoretically and experimentally found diffusion barrier. To elucidate the properties of the Li motion in rutile we applied the β-NMR technique, which uses the asymmetry of the β-emissions from a spin-polarized beam of 8Li to detect the fluctuation of the electric field gradient (EFG) felt by 8Li due to its diffusing motion. Above 200 K, we found an Arrhenius relationship of the fluctuation rate with temperature, with activation energy in agreement with other studies, but with a corresponding diffusion rate significantly faster than other reported values. In addition, below 100 K a second Arrhenius-like component was revealed, which was attributed to the formation of Li-polaron complexes at that temperature range. This second component was thought to be non-diffusing.

Nonetheless, β-NMR infers indirectly the diffusion rate, based on the fluctuation rate of the EFG due to the 8Li+ motion, with the assumption that all fluctuations correspond to Li hopping. A direct technique applicable to the nanoscale could give further insights into the Li motion in rutile. To that end, we developed and employed the 8Li α-radiotracer technique, which makes use of the rapid attenuation of the subsequent α-particles from the decay of 8Li inside the sample.

We implanted a pulsed beam of 8Li+ within 120 nm of the surface of a c-axis oriented single-crystal rutile TiO2. We placed the α-detector at a grazing angle from the surface and thus the rapid attenuation of α provided a sensitive monitor of the distance from the surface. Our main findings were that Li+ traps (with a probability > 50 %) at the sample surface, which explains the suppressed Li intercalation in rutile. In addition, we found that the temperature dependence of Li diffusivity is described by a bi-Arrhenius expression, with a diffusion barrier in agreement with other studies above 200 K, but with a second, previously unknown component at lower temperatures, with activation energy in agreement with DFT calculations and our β-NMR measurements. Thus, we established that (at least part of) the second Arrhenius component revealed with β-NMR at low-T is related to actual diffusion. As it is possible to perform both β-NMR and α-radiotracer measurements at the same time, using the same radioactive 8Li+ beam, we believe that the coupling of the two techniques can become a valuable tool in the study of Li diffusion in the nanoscale.

An Investigation on Gamma-Ray Shielding Properties of Zr-Based Bulk Metallic Glasses

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Studies on bulk metallic glasses (BMGs) have grown considerably, especially in recent years, due to their noticeable properties such as high glass forming ability, corrosion resistance, and large elastic limit, chemical, mechanical and magnetic properties. Among the known and studied samples of BMGs, Zr-based ones have been appointed as possible examples in biomaterial and structural material studies due to their good mechanical and corrosive properties and good biocompatibility. In this study, considering the importance of Zr-based BMGs, an investigation on their gamma-ray shielding properties have been done where five different samples have been utilized which are $Zr_{51}Al_{14.2}Ni_{15.9}Cu_{18.9}$, $Zr_{52}Al_{12.9}Ni_{13.8}Cu_{21.3}$, $Zr_{53}Al_{11.6}Ni_{11.7}Cu_{23.7}$, $Zr_{54}Al_{10.2}Ni_{9.4}Cu_{26.4}$ and $Zr_{55}Al_{8.9}Ni_{7.3}Cu_{28.8}$. Mass attenuation coefficients of the samples have been obtained by using Geant4 and XCOM between 0.1-15 MeV incident photon energy. Also, mean free path (MFP), half-value layer (HVL), tenth-value layer (TVL), effective atomic number (Z_{eff}) and electron density (N_{eff}) values of the samples in the given energy range have been obtained. Obtained results have been graphed for better visual comparison and interpretation.

Investigation of Photon Attenuation Properties of CR-39 Lens

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CR-39 is shortening of Colombia Resin-39, which is the 39th formula of a thermosetting plastic; also, it is called allyl diglycol carbonate (ADC) monomer [1-3]. CR-39 is used in production of the eyeglass lenses [4] and nuclear track detectors [5]. The aim of this study is to explore photon attenuation parameters of CR-39 lens, which are linear attenuation coefficient (LAC), mass attenuation coefficient (MAC), half value layer (HVL), tenth value layer (TVL), mean free path (MFP), effective atomic number (Z_{eff}) and effective electron density (N_{eff}). MACs were determined theoretically using WinXCom [6] and with simulation using Geant4 [7-9] in the energy range from 0.01 to 20 MeV. Also, obtained MACs of CR-39 lens were compared with MACs of pure aluminium and lead. Theoretically obtained Z_{eff} values were compared with Z_{eff} results obtained by the AutoZeff [10].

The results of this study are;

- the theoretically obtained MACs values are in agreement with MACs obtained results from simulation software.
- the theoretically obtained Z_{eff} values are in agreement with Z_{eff} obtained by the AutoZeff.
- the MACs of CR-39 lens are much lower than MACs of pure lead whereas there is not too much differences between MACs of CR-39 and pure aluminium.
- the HVLs, TVLs and MFPs rise with increasing photon energy while the LACs and MACs reduce with increasing photon energy.

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Dental restoration materials as personal accidental dosimeters

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Radiation accidents led to the birth of an area in physics, accidental dosimetry. Thermoluminescence (TL) is a basic application tool in radiation dosimetry. Its main application is on the determination of absorbed dose due to radiation events, over and above the normal background radiation. Several materials have been studied as potential accidental dosimeters [1]. The attention is focused on materials which can be found in the anthropogenic environment, but also on materials that are probable to be found on a person, or even assembled in a person, like biomaterials which are widely used in surgical and dentistry applications [2]. Feldspathic porcelain (FP) has been widely used in dentistry and is the most applied material as veneer layer in metal-ceramic restorations. The present work is aiming to prove this material as an accidental personal dosimeter. For this purpose, freshly prepared and *in-vitro* aged samples were examined, and the measurements were also applied in *in-vivo* aged samples which were collected from patients. The majority of relevant scientific works are referred only to laboratory prepared samples [3]. It is a unique experiment that aims to study both in-vitro and in-vivo aged samples and their dosimetric properties. Additionally, characterization analysis (FTIR, XRD, SEM-EDS) was applied to every step of the aging, in order to examine if TL can be established as a characterization method of the aging progress of FP.

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On the possibility of dating calcium sulphate samples: Luminescence and dose rate measurements

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Calcium sulfates (dehydrate, hemihydrate and anhydrous $CaSO_4$) have been widely used as a main component of artifacts, including paintings and sculptures. In direct dating, Luminescence techniques are widely used because of their absolute results. Preliminary Thermoluminescence (TL) measurements on commercial gypsum [1] and both commercial and mineral calcium sulfates [2] indicated the presence of stable TL peaks along the dehydrate and hemihydrate samples, despite their water content.

In the framework of this study, the three aforementioned groups of calcium sulfates are being investigated regarding their luminescence properties, including their TL, optically stimulated luminescence (OSL) and infrared stimulated luminescence (IRSL) properties. Their TL, OSL and IRSL features are further supported by dose response measurements, in order to investigate their linearity behavior and to estimate their lowest detection dose limits (LDDL). The calcium sulfates under study -both of commercial and mineral origin- are additionally characterized by means of Fourier Transform Infrared spectroscopy (FTIR) and X-Rays Diffractometry (XRD).

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MottCalc: A new tool for calculating Mott scattering differential cross sections for analytical purposes

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ERDA (Elastic Recoil Detection Analysis), especially due to the recent evolution of ToF (Time of Flight) capabilities, has emerged as one of the most prominent IBA (Ion Beam Analysis) techniques for the accurate quantitative determination of elemental depth profile concentrations in near surface layers of various matrices. However, the occurrence of Mott scattering in all practical ERDA implementations, e.g. traditional (with an absorber foil in front of the detector), transmission, or ToF, requires a careful treatment in the subsequent spectral analysis, since the corresponding cross sections may present very strong deviations from the Rutherford ones, which in certain cases allow their use for the detection of light elements [1]. Mott scattering occurs only during the interaction of identical nuclei (beam – target) and, according to the indistinguishability principle, the elastic scattering in such case can only be calculated quantum mechanically, leading to an interference term contributing to the reaction's cross section. This contribution strongly depends on the J of the ground state of the interacting nuclei and the phenomenon is described by a well-known analytical formula in literature. Nevertheless, it is important to note here that widely used analytical codes (e.g. SIMNRA, DF, POTKU), surprisingly, do not presently provide theoretical differential cross-section calculations for Mott scattering.

In order to address this problem, a new software support tool has been developed, MottCalc, able to calculate both angular and energy distributions in the case of pure Mott elastic scattering (i.e. excluding nuclear perturbations) and create the appropriate R33 files, suitable for direct implementation in all analytical codes. 314 isotopes are available for the user as both target and incident nuclei, while the screening effect is taken into account by implementing the Andersen model. The tool is available in two different versions, namely as Excel spreadsheet (which provides detailed information about the screening factor and the cross sections in both the lab and center of mass reference frames, as well as comparisons with the Rutherford values if the interference term is ignored) and as stand-alone application (which can produce R33 files for energy or angular distributions for analytical purposes). Both versions are already available to the scientific community for download and testing via the web page of the Nuclear Physics group at NTUA.

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PIGE measurements at the Tandem Lab “Demokritos” – An overview

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Particle Induced Gamma – ray Emission (PIGE) is a widely used Ion Beam Analysis technique suitable for the detection and quantification of low Z elements in complex matrixes. While its use has started as early as the 1960’s, its analytical power hasn’t been full explored mainly because of the lack of suitable and reliable cross section data and dedicated computer codes for the analysis of the experimental results. IAEA has launched in 2012 a Coordinated Research Program aiming at curing these drawbacks and enhancing PIGE use. The Tandem Accelerator group, participating in this effort, has measured a number of gammas producing differential cross section data and made them available to the scientific community through the IBANDL database. Moreover, in an effort to validate the new results, as well as existing ones, a new method for benchmarking differential cross section data has been established. Finally, a new computer code named PiGreCo, has been developed in order to facilitate and spread PIGE use for the quantification of light elements. An overview of this ongoing effort will be presented.

Angular Distribution of Elastic Neutron from ^{19}F and ^{12}C Targets

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Neutron elastic or inelastic scattering cross sections for light nuclei have been required for development of fusion reactor designs. Using TALYS 1.8 nuclear code, we have calculated neutron elastic angular distribution from ^{19}F and ^{12}C target nuclei at some energy. Theoretically evaluated cross section of elastic scattering have been presented in graphs and compared with experimental values which are available in EXFOR nuclear data library. Theoretically evaluated and experimental cross section values are in good agreement.

Measurement of the Differential Elastic Scattering Cross Sections for Deuterons on Light Elements, at Energies and Angles Suitable for EBS

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Light elements find various technological applications in the industry. They are crucial in the field of material analysis due to their presence in glasses, ceramics, and polymers, while they are also frequently added in metallic alloys in order to improve their corresponding properties, such as, hardness, wear and heat resistance, or rigidity. Nitrogen and silicon are heavily used in the semiconductor and insulator technology, since the latter is the key component in wafers on which integrated circuits are built and the former is a common dopant for the creation of n-type semiconductor. Beryllium has also recently emerged as an important material in plasma facing components of controlled fusion devices, while lithium, due to the high neutron cross section (~940 barn) of ^{6}Li, that readily fissions, is the main source of tritium which is used in biochemical research, thermonuclear weapons and future controlled fission. Consequently, the accurate quantitative determination of light-element depth profile concentrations in a variety of matrices is of enormous importance in contemporary science and technology. This determination can best be accomplished via the implementation of IBA (Ion Beam Analysis) techniques and more specifically via ERDA (Elastic Recoil Detection Analysis), for ultra-thin surficial layers and NRA (Nuclear Reaction Analysis) due to the production of isolated peaks (due to the high Q-values involved) with negligible background. At the same time, the use of a deuteron beam provides high depth resolution, deep layer analysis and allows for the simultaneous study of most of the light isotopes/elements coexisting in a target. The implementation of d-NRA could be further greatly enhanced if one could also coherently analyze the elastic scattering spectra which are simultaneously acquired using the same experimental and electronics setup. However, the general applicability of d-EBS is still limited nowadays, mostly because of the lack of reliable and coherent datasets of differential cross-sections in literature for energies and angles suitable for IBA. Hence in the present work a comprehensive review is presented concerning results obtained over the last 3 years for deuteron elastic scattering on many important stable light elements and isotopes, such as ^{6}Li, ^{7}Li, ^{9}Be, ^{nat}N, ^{19}F, ^{23}Na, ^{nat}Si and ^{31}P at energies and angles suitable for analytical purposes. In several cases the obtained differential cross-section datasets were also benchmarked using thick targets of accurate stoichiometry. All measurements were carried out at the 5.5 MV Tandem Accelerator of N.C.S.R. "Demokritos", Athens, Greece. The experimental setup consisted of a high-precision goniometer, along with six silicon surface barrier (SSB) detectors (500μm in thickness). Most of the obtained differential cross-section datasets are already available to the scientific community via IBANDL (Ion Beam Analysis Nuclear Data Library - https://www-nds.iaea.org/exfor/ibandl.htm)

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Production Cross–Section Calculations of ^{62}Cu via Charged Particles Induced Reactions

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The improvements in medical applications, where radioisotopes and radiopharmaceuticals have been utilizing frequently, attracted various scientific and industrial studies which led to perform many clinical, experimental and theoretical studies. One of the noticeable radioisotopes among a wide broad could be given as ^{62}Cu, which is a known and used as β^+emitter with a half-life value of 9.67 minutes. ^{62}Cu generally used as a tracer in conjunction with ^{64}Cu and uses cerebral and myocardial blood flow for in-vivo applications. By considering the importance of this radioisotope, production cross–section calculations of ^{62}Cu via charged particles induced reactions have been investigated by using phenomenological level density models. Two Component Exciton Model has been employed for the cross–section calculations of $^{62}Ni(p,n)^{62}Cu$, $^{61}Ni(d,n)^{62}Cu$, $^{62}Ni(d,2n)^{62}Cu$ and $^{59}Co(\alpha,n)^{62}Cu$ reactions where Constant Temperature Fermi Gas, Back Shifted Fermi Gas and Generalized Superfluid models have been employed as the level density models. All obtained calculation results have been compared with the experimental data taken from the Experimental Nuclear Reaction Data (EXFOR) Library by figuring all them via graphical representation for each reaction route. In addition to visual analysis by graphical representations, a mathematical comparison of the obtained calculation results have been done by using a relative variance analysis, which also used for the appointment of the best level density model for each reaction route.

gSPEC at FAIR

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Nuclear electromagnetic moments are extremely sensitive probes of nuclear structure providing critical information on the nuclear wavefunctions the shapes of nuclei. The importance of moments measurements is more than ever highlighted today by the urge to understand the evolution of structure at the extremes of the nuclear chart, which are almost completely unexplored. FAIR is a flagship European nuclear facility under construction, which aims at producing currently unavailable exotic species, laying grounds for new and important discoveries on both proton– and neutron–rich sides of the isotopic chart regarding nucleon-nucleon interaction, magic shells, deformation, and shape evolution/coexistence among others.

gSPEC is a recently proposed experimental apparatus at FAIR to focus on magnetic moments measurements. The experimental setup will incorporate the state–of–the–art segmented DEGAS detectors in an optimized configuration inside a strong magnet. The novel physics cases targeted by gSPEC, the technical design and challenges, as well as preliminary R&D work will be reported.

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Investigating the structure properties of the low–lying states of ^{140}Ba *

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The neutron–rich $^{144\text{-}146}$Ba isotopes have been studied recently in terms of their experimental B(E3) values [1,2]. Although featuring large uncertainties, the results were found to be significantly larger than any theoretical calculation. Similar questions exist for the slightly lighter isotope ^{140}Ba, which is particularly interesting since it is located at the onset of octupole correlations. The lifetimes of the lower lying states are completely unknown, with the sole exception of the first 2^+ state [3].

In this work, we report on the outcome of a first attempt to populate the states of interest using the 2n–transfer reaction ^{138}Ba(^{18}O,^{16}O)^{140}Ba. The experiment was carried out at the 9MV Tandem Accelerator Lab of IFIN–HH in Bucharest, using a specially manufactured ^{nat}Ba target sandwiched between two Au layers taking special precautions to avoid barium's quick oxidation. Four energies below the Coulomb barrier (61, 63, 65, and 67 MeV) have been tested. The subsequent γ–decays were measured using the RoSPHERE array, consisting of 15 Ge detectors and 10 $LaBr_3$(Ce) scintillators.

The preliminary results from the test run report on the level population strengths and the limits in lifetime measurements, which are expected to provide new information on the structural effects in neutron–rich barium isotopes, especially regarding quadrupole and octupole degrees of freedom. GRAZING and PACE4 calculations are also presented and compared with the results.

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HFB Calculations for Nucleon Densities of Nickel Isotopes

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The ground state properties of the nuclei are generally calculated using two different methods, namely Skyrme-Hartree-Fock (SHF) and the Skyrme-Hartree-Fock-Bogolyubov (SHFB) methods. In this study, the densities and rms radii for both proton and neutron of Nickel isotopes were calculated using Hartree-Fock-Bogolyubov method with different Skyrme set parameters, especially SLy4, SkM*, and SIII set parameters. Theoretical calculated charge density compared with experimental data of Angeli and Marinova (2013).

Study of the neutron induced fission cross-section of ^{237}Np at CERN's nTOF facility in the MeV region

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The accurate knowledge of neutron-induced fission cross-sections of isotopes involved in the nuclear fuel cycle is essential for the optimum design and safe operation of next generation nuclear systems. Such experimental data can additionally provide constraints for the adjustment of nuclear model parameters used in the evaluation process, resulting in a further understanding of the nuclear fission process.

In this respect measurements of the ^{237}Np(n,f) cross section have been performed at the n_TOF facility at CERN in the horizontal 185 m flight-path (EAR1) which were discrepant by 7% in the MeV region. The neutron-induced fission cross section of ^{237}Np(n,f) was recently restudied at the EAR2 19.5 m vertical beam-line at CERN’s n_TOF facility, over a wide range of neutron energies, from 100 keV up to 15 MeV, using the time-of-flight technique and a modern set-up based on Micromegas detectors, in an attempt to resolve the aforementioned discrepancies and to provide accurate data of a reaction that is frequently used as a reference one in measurements related to feasibility and design studies of advanced nuclear systems.

Interesting preliminary results with a high statistical accuracy that seem to resolve the discrepancies will be presented along with a brief discussion concerning the facility and the analysis.

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Measurement of the ^{234}U (n, f) cross section in the 15-19 MeV energy range

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Neutron induced fission cross sections of actinides present special interest, since they lead to the design optimization of new generation reactors (Generation IV) as well as Accelerator Driven Systems (ADS). In the present work, the $^{234}U(n,f)$ cross section was measured for which only a few available discrepant data exist in literature leading to poor evaluations. More specifically, four irradiations were performed at the 5.5 MV Tandem Accelerator Laboratory of NCSR "Demokritos" using quasi-monoenergetic neutrons produced by the $^{3}H(d,n)^{4}He$ reaction in the 14.8-19.2 MeV energy range. The $^{234}U(n,f)$ cross section was measured relatively to the $^{235}U(n,f)$ and $^{238}U(n,f)$ reference ones and in order to perform the in-beam measurements for each of the actinide targets (^{234}U, ^{238}U, ^{235}U), a Micromegas detector was used to record the fission fragments. The target-detector pairs were placed in an Al chamber filled with a Ar:CO_2 (in 80:20 volume fraction) gas mixture at atmospheric pressure and temperature. The efficiency of the Micromegas detectors was estimated by Monte-Carlo simulations using the GEF and FLUKA codes. In addition, a detailed study of the neutron energy spectra was carried out by coupling both NeuSDesc and MCNP5 codes in order to take into account and correct for the contribution of low energy parasitic neutrons in the fission yields.

Measurement of the ^{203}Tl (n, 2n) ^{202}Tl reaction cross section at 17.7 MeV and 19.3 MeV

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The cross section of the reaction ^{203}Tl(n,2n)^{202}Tl, has been measured by the activation method, at neutron energies 17.7 MeV and 19.3 MeV, relative to the ^{197}Au(n,2n)^{196}Au and the ^{93}Nb(n,2n)^{92m}Nb reference reaction cross sections. The monoenergetic neutron beam was produced at the 5.5 MV Tandem accelerator of NCSR Demokritos, by means of the ^{3}H(d,n)^{4}He reaction, implementing a Ti-tritiated target consisted of 2.1 mg/cm^{2}Ti-t layer on a 1 mm thick Cu backing for good heat conduction. The target assembly was placed at about 2 cm from the tritium target thus limiting the angular acceptance to ±15°, where the produced neutrons are practically isotropic and monoenergetic. The flux variation of the neutron beam was monitored by a BF_3 detector placed at a distance of 3 m from the neutron source and a BC501A liquid scintillator.

After the end of the irradiation, the activity induced by the neutron beam at the target and reference foils was measured by a HPGe detector of 50% relative efficiency, which was properly shielded with lead blocks in order to reduce the contribution of the natural radioactivity. Monte Carlo simulations implementing the MCNP code have been carried out in order to account for gamma-ray self-absorption effects as well as for the estimation of the neutron flux by means of the reference foils.

^{nat}Mg (p, p) ^{nat}Mg differential cross-section measurement relevant to the EBS technique

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Magnesium (^{24}Mg 78,99%, ^{25}Mg 10%, ^{26}Mg 11,01%) is a widely used metal, implemented mainly as an alloy in electronic devices. Thus, the precise quantitative determination of magnesium depth profile concentrations is of high importance. Its quantification, when present in high-Z matrices, presents a strong challenge for most of the analytical techniques as it forms complex compounds due to its highly reactive character. Among the commonly used Ion Beam Analysis methods for Magnesium depth profiling, deuteron probed Nuclear Reaction Analysis and proton Elastic Backscattering Spectroscopy are the most promising. Nuclear Reaction Analysis is more suitable in the case where magnesium coexists with other light elements in the under-study sample, as the peaks of the detected products are well separated. On the other hand, regarding radiation safety precautions arising from the neutron producing reactions, proton EBS is preferable. The use of the latter technique for the depth profiling of Magnesium has been enhanced by the existence of evaluated and benchmarked differential cross sections produced via SigmaCalc [1]. By examining the literature, one can discover the lack of coherent experimental differential cross-section datasets for magnesium, over a broad angular range, for energies above ~2.7 MeV, (above the existing SigmaCalc evaluation), which restricts the use of the technique and its advantageous probing depth. Towards the goal of extending the evaluation, in the present work we report on the differential cross section measurements of the $^{nat}Mg(p,p)^{nat}Mg$ reaction, in the proton beam energy range between 2500 to 4200 keV and at six detection angles (120◦ to 170◦ with a 10◦ step). The obtained results are validated through a rigorous benchmarking procedure and compared with the existing ones from the literature.

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Production of Isotopes of medical interest in p + ^{nat}Mo reactions

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Medical radioisotopes are used to label some special chemical compounds to form radiopharmaceuticals, which are used extensively in the field of nuclear medicine in three main branches: i) diagnostic procedures, resulting in images of the involved organs via emission tomography, ii) radionuclide techniques that are used for the analysis of important substances in blood or tissue samples, and iii) radiation therapy, where the tissues or organs are treated with radiation and restored to their normal functions.

In the present work, we study the production of molybdenum and technetium isotopes motivated by their uses in nuclear medicine. Excitation functions of interest involve: $^{nat}Mo(p,x)^{99}Mo$, $^{nat}Mo(p,x)^{94g}Tc$, $^{nat}Mo(p,x)^{95g}Tc$, $^{nat}Mo(p,x)^{96(m+g)}Tc$ and $^{nat}Mo(p,x)^{99m}Tc$. We present a comparison between recently published experimental data [1] with theoretical calculations using the code TALYS [2]. We discuss the role of various Mo isotopes in the natural Mo target on the production yields.

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Simulation of a muographic analysis of a volcanic dome in Geant4

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Here we present a Monte Carlo simulation of a muographic campaign on Methana volcano, Greece. In order to estimate the absorption parameters and the pattern of muon scattering at various injection energies (GeV to TeV), a radar-derived digital terrain model (DTM) was submitted to irradiation by horizontal muons in Geant4, and the penetrating muons were collected by a hypothetical MicroMegas particle detector. Monte Carlo simulation demonstrated that muon energies at least as high as 10 TeV are required for whole-scale radiography of Methana and one has to reduce the scale of study to smaller structures (e.g. ~ 600 m - wide volcanic domes) in order to exploit the more affluent lower energy muons (~ 600 GeV). Coulomb scattering, on the other hand, causes deflection of muon trajectories away from the detector, resulting in loss of information. Monte Carlo simulation confirmed that by progressively increasing the injection energy the scattering angles become more tightly distributed (i.e. smaller standard deviations). Another effect of scattering is that it adds Gaussian blurring to the scanned objects. With the intention of improving contrast and disclosing hidden objects in the muographic image we recommend the use of spatial operators (filters) employed in image analysis.

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^{112}Sn, ^{114}Sn, ^{118}Sn and ^{124}Sn (γ, n) average cross section measurement near to reaction threshold compared with TALYS theoretical calculations

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Bremsstrahlung photon beam delivered by linear electron accelerator has been used to determine the near threshold photonuclear cross section data of nuclides. The (γ, n) cross section data was obtained for the astrophysical important isotopes of Tin [^{112}Sn, ^{114}Sn, ^{118}Sn and ^{124}Sn]. Moreover, theoretical calculations have been applied using the TALYS 1.6 code. The photon flux was monitored by measuring the photons yield from seven well known (γ, n) reactions from the threshold energy of each reaction up to the end-point energy of the photon beam used. An integrated cross-section 39 ± 8 mb is calculated for the photonuclear reaction ^{112}Sn (γ, n) at the energy 10.8 - 14 MeV. The integrated cross-section of ^{114}Sn (γ, n) reaction at the energy 10.3 - 14 MeV was also estimated 54 ± 11 mb while the integrated cross-section of ^{118}Sn (γ, n) reaction at the energy 9.3 - 14 MeV was determined as well 1.1 ± 0.4 mb. Moreover, an integrated cross-section 73 ± 9 mb is calculated for the photonuclear reaction ^{124}Sn (γ, n) at the energy 8.5 - 14 MeV. The average cross section estimated using the TALYS code were 45 ± 7mb for ^{112}Sn, 47 ±6 mb of ^{114}Sn, 1.8 ± 0.3 mb of ^{118}Sn and 65 ± 8 mb of ^{124}Sn. A satisfactorily reproduction of the available experimental data of photonuclear cross section at the energy region below 20 MeV could be achieved. The data obtained were compared with the experimental published data 31 ± 5 mb of ^{112}Sn, 65 ± 9 mb of ^{114}Sn and 75 ± 8 mb of ^{124}Sn [1]. A good agreement between the previous and these new experimental results of ^{112}Sn, ^{114}Sn, and ^{124}Sn is presented, while the ^{118}Sn (γ, n) average cross sections is measured for the first time.

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Measurement of differential cross sections of deuteron elastic scattering on ^{31}P for EBS purposes

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Phosphorus (with ^{31}P being the only stable isotope) is a light chemical element, essential for life, and highly reactive. Phosphorus is an important component in steel production (namely it is used as an alloying element in copper with oxygen in order to increase the hydrogen embrittlement resistance compared to normal copper), in glass manufacturing and it is also used as a dopant for n-type semiconductors. Thus, the accurate quantitative determination of phosphorus depth profile concentrations, especially in light element matrices, is important in many technological, medical, archaeological and environmental studies.

Several IBA (Ion Beam Analysis) techniques can be applied to achieve this goal, namely ERDA (Elastic Recoil Detection Analysis) for thin, surficial layers, p-EBS (Elastic Backscattering Spectroscopy) due to the existence of evaluated and benchmarked differential cross-section datasets in literature and NRA (Nuclear Reaction Analysis). The latter, especially d-NRA (via the simultaneous implementation of ^{31}P(d,p_x) and ^{31}P(d,α_x) reactions), seems to be the most promising technique for phosphorus depth profiling in complex matrices, since it yields isolated high-energy peaks with practically no background. However, d-NRA's full implementation is usually impeded by the significant lack of the associated d-EBS differential cross-section datasets in literature.

In order to address this problem, the differential cross sections of deuteron elastic scattering on ^{31}P were determined in the present work for the first time, in the projectile energy range $E_{d,lab}$= 900-2400 keV (in energy steps of ~10-30 keV), suitable for analytical purposes. The experimental setup consisted of five silicon surface barrier (SSB) detectors, placed at the angles between 130° and 170° (in steps of 10°) in a high-precision goniometer. The implemented target was a thin GaP layer, which was created by evaporating high-purity GaP powder on top of a thin C stripping foil, with the Ga presence needed for normalization purposes. The measurements were performed at the 5.5 MV TN11 HV Tandem Accelerator of N.C.S.R. "Demokritos", Athens, Greece. The obtained differential cross-section datasets were benchmarked against a polished GaP crystal and the deviations from the corresponding ones using Rutherford's formula will be discussed and analyzed. The results of the present work will soon be available to the scientific community via IBANDL (www-nds.iaea.org/ibandl/) in both graphical and tabular forms.

Cross–section measurements of the reaction ^{107}Ag (p, n)^{107}Cd at energies inside the Gamow window

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We report on experimentally deduced cross sections of the $^{107}Ag(p,n)^{107}Cd$ reactions at energies inside the astrophysically relevant Gamow window. A beam of protons was accelerated at three energies, namely 2.2, 3.5 and 4 MeV, by the Tandem Van De Graaff Accelerator of the INPP, NCSR "Demokritos" and impinged a thin target of ^{nat}Ag inducing a transfer reaction. The de–exciting ^{107}Cd nuclei emitted characteristic γ radiation recorded in three high–purity Germanium (HPGe) detectors of 100% relative efficiency, placed at 0^0, 90^0, 165^0 with respect to the incident proton beam.

The deduced in–beam cross sections have been compared to existing measurements for the two higher energies (3.5 and 4 MeV) and found in fair agreement within the experimental error. An existing energy threshold at 2.2 MeV of the reaction did not allow for a cross section at the lower energy point. The data can be used to fine tune theoretical models in a region of the nuclear chart where reactions rates are relatively unknown. To that direction, the present results are compared to predictions of the the Hausser–Feshbach statistical model performed with the latest TALYS code (v1.9).

Retention of Radionuclides onto Natural (Raw and Modified) Materials

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In this work the possibility of retention of radionuclides onto natural materials it was investigated with application of nuclear spectrometry techniques. The natural materials used for the sorption of uranium and thorium from aqueous solutions of different initial concentrations were bentonite (a clay mineral) and wastes of pomegranate. The sorption of europium and barium, which can be studied as analogues of the trivalent actinides and radium respectively, was also investigated. The concentration of the metals in the solution was determined with gamma- and alpha-spectrometry using radioactive tracers.

The materials (sorbents) were used in raw form and after modification. Bentonite was studied for removal of uranium cationic species and after chemical modification for removal of uranium anionic species respectively in different pH region. The modification of pomegranate wastes with acidic and alkaline reagents was tested as a possible method for increasing the sorption capacity.

The effect of various parameters such as pH, sorbent dosage, concentration and time on the sorption capacity of the materials was also explored as well as the presence of competitive ions and humic acid in the solution. The results demonstrated that the investigated materials are low cost and efficient sorbents with possible applications in nuclear waste management.

Study of the ^{232}Th(n,f) Cross section at NCSR 'Demokritos' using Micromegas Detectors

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The accurate knowledge of neutron-induced fission cross sections in actinides, is of great importance when it comes to the design of fast nuclear reactors, as well as accelerator driven systems. Specifically for the ^{232}Th(n,f) case, the existing experimental datasets are quite discrepant in both the low and high energy MeV regions, thus leading to poor evaluations, a fact that in turn implies the need for more accurate measurements.

In the present work, the total cross section of the ^{232}Th(n,f) reaction has been measured relative to the ^{235}U(n,f) and ^{238}U(n,f) ones, at incident energies of 7.2, 8.4, 9.9 MeV and 14.8, 16.5, 17.8 MeV utilizing the ^{2}H(d,n) and ^{3}H(d,n) reactions respectively, which generally yield quasi-monoenergetic neutron beams. The experiments were performed at the 5.5 MV Tandem accelerator laboratory of N.C.S.R. "Demokritos", using a Micromegas detector assembly and an ultra thin ThO_2 target, especially prepared for fission measurements at n_ToF, CERN during its first phase of operations, using the painting technique. The masses of all actinide samples were determined via α-spectroscopy. The produced fission yields along with the results obtained from activation foils were studied in parallel, using both the NeusDesc [1] and MCNP5 [2] codes, taking into consideration competing nuclear reactions (e.g. deuteron break up), along with neutron elastic and inelastic scattering with the beam line, detector housing and experimental hall materials. Since the ^{232}Th(n,f) reaction has a relatively low energy threshold and can thus be affected by parasitic neutrons originating from a variety of sources, the thorough characterization of the neutron flux impinging on the targets is a prerequisite for accurate cross-section measurements, especially in the absence of time-of-flight capabilities. Additional Monte-Carlo simulations were also performed coupling both GEF [3] and FLUKA [4] codes for the determination of the detection efficiency.

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Neutron induced transmutations to tungsten for fusion energy applications

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Tungsten is a candidate Plasma Facing Material in future fusion plants presenting high melting point, high thermal conductivity, low coefficient of thermal expansion, high sputtering threshold energy, low tritium retention and low neutron activation properties. In this work the results of neutron activation analysis to investigate the transmutations that occur during fission neutron irradiation of tungsten materials are presented.

Three types of tungsten materials were irradiated at the BR2 research reactor, SCK-CEN, Belgium, at doses of 0.1 displacements per atom (dpa) at the irradiation temperatures of 600, 800, 900 and 1200 C. The induced activity was evaluated by the measurement of the emitted gamma rays using a germanium detector based spectrometry system. The activity of 185W, 181W, 188W, 188Re and 182Ta was determined and the pathways of the production of the active nuclides were examined.

The experimental results were compared against theoretical calculations performed using FISPACT-II radionuclide inventory code and a satisfactory agreement was observed between calculated and experimental data. This work will contribute to the evaluation of the modification of the tungsten material properties induced by neutron irradiation for fusion energy applications.

Characterization of “Neoptolemos”*

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The study of charged particle capture reactions is of major importance for the understanding of the production of p-nuclei. The term p-nuclei refer to 35 stable neutron-deficient nuclei, from ^{74}Se to ^{196}Hg. The p-process nucleosynthesis models developed in order to reproduce the p-nuclei abundances incorporate a network of more than 20000 nuclear reactions. These models fail in the case of the light p-nuclei. Apart from improvements of the astrophysical models it is important to reduce the uncertainties originating from nuclear physics parameters entering in the calculations and thus the measurement of cross-sections of particle capture reactions in medium-mass nuclei.

One of the techniques developed for this kind of studies, is the so-called γ-ray angle-integrated. This in-beam method is based on the use of a large volume NaI(Tl) detector which combines the high efficiency of γ-ray detection with a 4π geometry. The working principle of such a detector relies on its large volume and its long response time (400 ns). The latter leads to the detection of the sequential photons emitted in a γ-cascade as one “event” with energy equal to the sum of the energies of the involved photons. Of imperative importance is the determination of the efficiency of the setup, which is not trivial as it depends both on the sum-energy of the event and on its multiplicity.

In the present work the characterization of such a detector, the “Neoptolemos” setup, located at the Tandem Accelerator Laboratory of the Institute of Nuclear and Particle Physics of the N.C.S.R. “Demokritos”, is presented. “Neoptolemos” consists of a cylindrically shaped NaI(Tl) crystal 14 x 14 inches (length x diameter) segmented in two optically isolated parts. In order to determine the summing efficiency of the setup, a code based on the GEANT4 simulation toolkit was developed, incorporating the full detector geometry. Some preliminary simulation results along with their comparison to radiation source measurements for verification will be presented.

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Isotope production in 1-200 MeV p + $^{54-58}$Fe reactions *

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Natural iron is an important structure material because of its use in alloys employed in various low and high-energy physics applications. Natural iron occurs with an isotopic composition of ^{54}Fe (5.85%), ^{56}Fe (91.75%), ^{57}Fe (2.12%) and ^{58}Fe (0.28%). The study of proton-induced reactions on natural Fe provides information on the behavior of the material under bombardment and the production of various isotopes. Reactions with isotopically enriched targets indicate the conditions for optimal production of a particular isotope.

In the present work, we study the production cross section of ^{51}Cr, ^{52}Fe, ^{52,54}Mn, ^{55,56,57}Co in proton-induced reactions on ^{nat}Fe. Experimental cross sections [1] are compared with calculations performed with the code TALYS [2]. Having established a good description of the p + ^{nat}Fe reaction, we examine the dependence of production cross sections on the neutron excess of the Fe natural isotopes. We also compare the predictions of the code TALYS with an alternative approach that combines the intranuclear cascade code ISABEL [3,4] with the sequential binary decay code MECO [5].

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Characterization of the Canberra BE5030 Broad Energy High Purity Germanium Detector by means of the GEANT4 Monte Carlo simulation package

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Broad Energy HPGe detectors are a very important tool of the γ-ray spectroscopy, since it offers the ability to perform activity measurements in a wide energy region between 3 keV to 3 MeV. The detector-window of these detectors is consisted of carbon fibers, whereas the tiny dimensions of the front-contact crystal dead-layer minimizes the low energy γ-rays attenuation, utilizing the detection of low energy γ-rays (E_γ<100 keV).

In the present work the characterization of the Canberra BE5030 HPGe detector of the Environmental Radioactivity Monitoring Department, Greek Atomic Energy Commission with GEANT4 MC Simulations will be presented [1]. To achieve this, experimental data were recorded using sources at different source to detector-window distances and were compared with the simulated ones via the GEANT4 package and using the Penelope GEANT4 Physics List [2,3]. The comparison was performed for different detector geometries, so as to identify the optimum geometry for which the best consistency is achieved between the experiment and the simulation.

The BE5030 HPGe detector was used for the detection of the γ-rays emitted from the ^{164}Ho decay, produced in the 5.5 MV Tandem Van de Graaff accelerator of the Institute of Nuclear and Particle Physics, N.C.S.R. "Demokritos"

In this presentation, the comparison graphs of the experimental and the simulated efficiency data will be displayed, along with the comparison of the ^{164}Ho decay experimental spectrum with the respective simulation.

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Comparative dosimetric radiotherapy analysis in rectal cancer

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Radiation therapy is an effective and safe method of treating neoplasm. The use of preoperative radiotherapy in locally advanced rectal cancer may increase total survival and reduce the local recurrence. The aim of this study is the comparative dosimetric analysis of four different radiotherapy techniques, 3DCRT (3D Conformal Radiation Therapy), IMRT (Intensity Modulated Radiotherapy) with the use of three and four radiation beams, and VMAT (Volumetric Modulated Arc Therapy) in rectal cancer.

It was proved that the bladder's minimum dose is significantly lower in the VMAT technique versus the other methods ($p = 0.003$ $F = 2.38 > F_{crit} = 1.69$). A reluctant tendency of the minimum dose for head and neck seems to exist with the IMRT technique with both three and four field ($p = 0.000318$, $F = 9.120995 > F_{crit} = 3.135918$). For bowel bag lower doses were observed with the IMRT technique ($p = 0.003$ $F = 0.000318 > F_{crit} = 3{,}135{,}918$, while there was no statistically significant difference for the PTV50 volume in terms of the median dose. The Conformity Index (CI) in DMLC technique was higher than the other methods while there is no significant difference in the Homogeneity Index (HI), even though VMAT technique achieved better homogeneity. Finally, irradiation time with the VMAT is significantly lower.

Radon retrospective dosimetry in different environments

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In the present study retrospective dosimetry measurements of radon (^{222}Rn) were performed. Radon is a radioactive gas, released from the soil and from building materials and it is concentrated in the interior of residential buildings. Inhalation of radon is an important factor in public health because it is the primary cause of lung cancer. Radon measurements may not be representative of a person's cumulative exposure during his lifetime.

To evaluate measurements in different environments, alpha spectrometry was employed in estimating exposure to radon in various locations over a long period of time through exposure of plastic and glass surfaces. Following these measurements, the Conversion Factor (CF) was calculated. This factor correlates the measured surface concentrations of ^{210}Po with the ^{222}Rn concentrations in the environments under study. In this presentation three experiments were performed.

In the first experiment, samples of glass and plastic were collected from a basement with relatively high radon concentration. Following exposure, the samples were measured in the α-spectrometer system and the corresponding CFs were calculated. In the second experiment, samples of plastic and glass were placed inside the cave of Perama. The samples were left there for 2 months in the deepest point of the cave, in which the radon concentration was measured before equal to 925 ± 418 Bq m^{-3} [1]. Following exposure, the samples were measured in the same α-spectrometer system and the corresponding CFs were calculated. In the third experiment, samples of plastic material were placed inside a tube of 0.5 m in length and 6cm in diameter and stayed there for 5.4 months. The tube was placed in soil so that its top was 5 cm higher than ground surface. At the same time, 7338 measurements of radon emanation were performed over a 6 months period, with the Barassol II Algade system, of which the radon detector also was placed in the tube. These measurements showed that the mean concentration of ^{222}Rn inside the tube is 27747 ± 9255 Bq m^{-3}. The samples were measured with the α-spectrometer system and the corresponding CF conversion factors were calculated.

The results of the first two experiments were significantly similar and provided CFs ranging from (1.6 ± 0.4) 10^{-3} (Bq m^{-2} ^{210}Po / Bq m^{-3} ^{222}Rn) to (2.11 ± 0.98) 10^{-3} (Bq m^{-2} ^{210}Po / Bq m^{-3} ^{222}Rn). The average value of CF calculated from the tube in soil experiment was orders of magnitude lower and equal to (6 ± 11) 10^{-6} (Bq m^{-2} ^{210}Po / Bq m^{-3} ^{222}R). The difference is attributed to soil humidity condensing to water droplets on the surface of the plastic material.

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Cross section measurements of (n,p) reactions on Ge isotopes

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Excitation functions of neutron induced reactions are of considerable importance to fundamental research in nuclear physics and practical applications. Natural Germanium is a very important semi-conducting material and the available cross section data cover mainly the energy range below 15MeV. At higher energies only few data exist in literature which cannot be considered as a reliable basis for applications and for testing nuclear models. In the present work, cross section of the (n,p) reactions have been experimentally measured on two natural isotopes of Germanium (^{72}Ge(n,p)^{72}Ga , ^{73}Ge(n,p)^{73}Ga), via the activation method relative to the ^{27}Al(n,α)^{24}Na, ^{93}Nb(n,2n)^{72m}Nb and ^{197}Au(n,2n)^{196}Au reactions. The cross sections were measured for neutron beams at 17.7MeV and 19.3MeV at the 5.5MV Tandem Van de Graaff accelerator of NCSR "Demokritos". The quasi-monoenergetic neutron beams were produced via the ^{3}H(d,n) ^{4}He reaction, using a Ti-tritiated target of 373GBq activity. A BF_3 detector placed 3m away from the neutron source, as well as a BC501A liquid scintillator were used for the monitoring of the neutron flux.

The characteristic gamma-rays for the de-excitation of the residual nuclei 834.13, 2201.59, 629.97 keV and 297.32 have been used for the two reactions, respectively. After the irradiation process, the gamma-rays produced by the activated foils, were measured by HPGe detectors of 16%, 50% and 80% absolute efficiencies. Statistical model calculations, using the codes EMPIRE, TALYS and taking into account pre-equilibrium emission, were performed on the data measured in this work as well as on data reported in the literature.

Hot particles in air filters collected in Finland immediately after the Chernobyl accident

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Following the accident at the Chernobyl nuclear power plant on 26 April 1986, about 2 $\times$ 10^{18} Bq of condensable radioactive materials were released, the majority of which was deposited in Europe (IAEA, 1986). Most of the released radioactive material was in particulate form, whereas noble gases and most of iodine were in gaseous form. Sometimes their activities may be so high that even a single particle may cause a severe health hazard. Radioactive particles released from Chernobyl have been described by many as "hot particles" where "hot" is synonymous with "highly radioactive".

In the Chernobyl accident most of the particulate material was deposited within 20 km of the plant, but about one-third was transported even thousands of kilometres. Air masses originating from Chernobyl on 26 April 1986 arrived in Finland very early after the accident (Pollanen et al., 1997).

Identification of the hot particles in filters collected in Helsinki Finland between 26-28 April 1986 was done by autoradiography technique (Cyclone Plus of PerkinElmer) in the University of Milano, Italy. Morphology and elemental information for particle characterization will be given by SEM analysis.

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Application of Nuclear Spectrometry Techniques for the Investigation of the Sorption of Radionuclides

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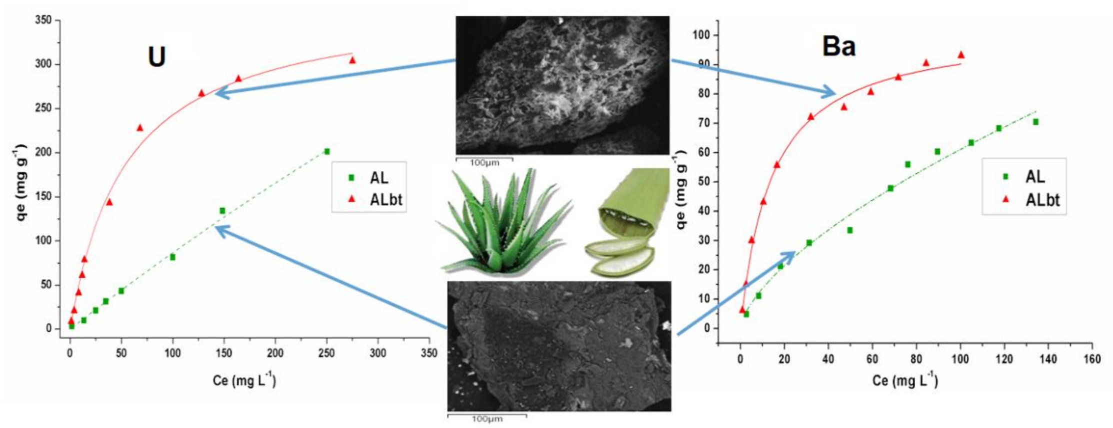
Radioactive pollutants present in liquid wastes can be removed by using agricultural byproducts as sorbents. The sorption of uranium, thorium and barium (which is used as analogue of the radium) was explored using a batch technique in aqueous solutions of different initial concentrations. The investigation was performed with gamma- and alpha-spectrometry using radioactive tracers as well as optical spectroscopy (UV-Vis).

Recycling and modification of *Aloe-Vera* was tested as a possible method for the production of biosorbents. The modification was achieved after chemical treatment with acidic and alkaline reagents.

The overall objective of this study was first, to apply nuclear spectrometric techniques for determination of the sorption capacity and second, to investigate whether sorbents based on agricultural wastes could be used for the removal of radionuclides from low level wastewater.

The results showed significant sorption capacity of the tested materials for most of the radionuclides under investigation demonstrating that it is possible to use them for applications in radioecology.



Environmental monitoring programme around a phosphogypsum disposal area

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Radionuclides of natural origin of the Uranium and Thorium series and the Potassium-40 are present in most materials. These materials are commonly referred to as Naturally Occurring Radioactive Materials (NORMs). In Greece there are few industries involving NORM, among which 3 fertilizer industries of which only one is still in operation. This industry has been under operation since 1965 and is located in the northern part of Greece.

The aim of this work is to present the annual monitoring programme of this industry as it has been designed and systematically implemented since 2003 by the Environmental Radioactivity Department of the Greek Atomic Energy Commission (EEAE), that is the national competent authority for the control, regulation and supervision in the fields of nuclear energy, nuclear technology, radiological and nuclear safety and radiation protection.

The phosphogypsum produced by the industry is deposited continuously near the industry, by the sea side, in an open land disposal area of about 500000 m^2. The estimated phosphogypsum mass is about 13 million tons. Thus, emphasis is given on the measurements of the ground waters. Ground water samples are received from 20 drills distributed around the disposal area. The concentration of ^{226}Ra and uranium isotopes is determined in each sample by alpha spectrometry measurements.

Finally, after an EEAE recommendation, a drainage channel was constructed around the phosphogypsum disposal area in order to prevent the underground runoffs. The influence of this channel on the above mentioned measurements is presented.

A Comparative Study of Stopping Power Calculations Implemented in Monte Carlo Codes and Compilations *

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The stopping power calculations, inherently implemented in all widely used, general purpose Monte Carlo codes, play a critical role in the determination of any expected reaction yield, when charged particles are present either as beam particles or reaction products. Small changes in the stopping power values, and therefore in the corresponding particle energies, can lead to significant changes in the cross sections involved. This effect may be critical in a variety of problems, ranging from detector physics to dose calculations and – to the authors' best knowledge – it has never been thoroughly investigated in the past.

Thus, the aim of the present work is to examine the differences in the stopping power calculations between GEANT4, FLUKA, MCNP/MCNPX and PHITS and to compare the results (whenever possible) against the widely used and partially benchmarked stopping power compilations, as implemented in the SRIM2013, PSTAR and ASTAR (ICRU) codes. In the particular case of GEANT4, most of the available models for the electromagnetic interactions were independently tested.

More specifically, in all Monte Carlo codes, protons, alpha particles, ^{12}C, ^{16}O and ^{56}Fe ions were generated as beam particles in the energy range between 1 and 1000 MeV/u and were subsequently transported, impinging on a variety of infinitely thick, pure, single–element targets, such as aluminum, iron, copper and silicon, which are typically used as shielding materials or components in complex devices. Water was also examined, being a close substitute for biological tissue. In all the simulations the process of multiple scattering was disabled, while, in certain cases, tables with stopping power values were generated for comparison. The obtained results show large discrepancies for specific beam particle – target combinations in certain energy ranges. They also deviate, especially at low energies, from the SRIM2013, PSTAR and ASTAR predictions. The final values are presented in graphical form and the observed similarities and discrepancies are discussed and analyzed. Since stopping power calculations have not yet been fully benchmarked against experimental data over a broad energy range, the final assessment of the obtained results relies on the user.

Acknowledgments
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Radiation dose response of TL dosimeters at elevated temperatures

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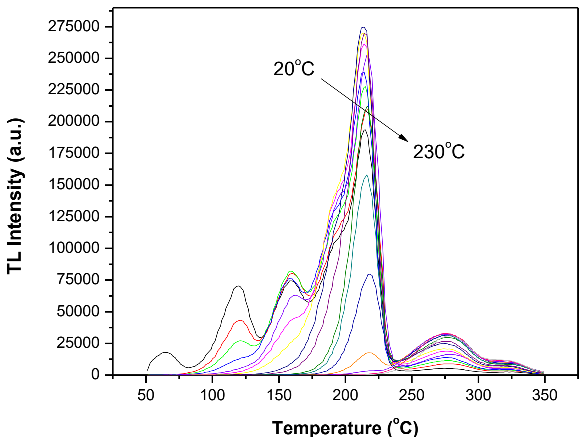
In the present work we investigate the sensitivity of the main dosimetric thermoluminescence (TL) peak of various dosimeters to ionizing radiation [1]. Specifically, we studied the radiation dose response of the main dosimetric peak as a function of the irradiation temperature between room temperature and 230^0C. The studied dosimeters were of the Lithium Fluoride family (LiF: Mg^+, Ti^+), Beryllium Oxide (BeO: Li^+, Al^+) and Calcium Sulfate (CaSO4: Tm^+, Dy^+). In the case of LiF: Mg^+, Ti^+, which is the most commonly used dosimeter, two different families were investigated, namely the Harshaw-Bicron (TLD-600, TLD-700) and the Polish (MTS-600, MTS-700) [2]. All experimental complex TL glow curves were analyzed into individual peaks using a computerized glow curve deconvolution (CGCD) analysis.

Characteristic examples of TL glow curves obtained at various temperatures are shown in Fig.1. On the other hand, the integrated signals of the dosimetric peak 5 obtained by the CGCD analysis are shown in Fig.2 for all the species of LiF dosimeters. An increase of the TL response at the irradiation temperature around 110^0C is observed.



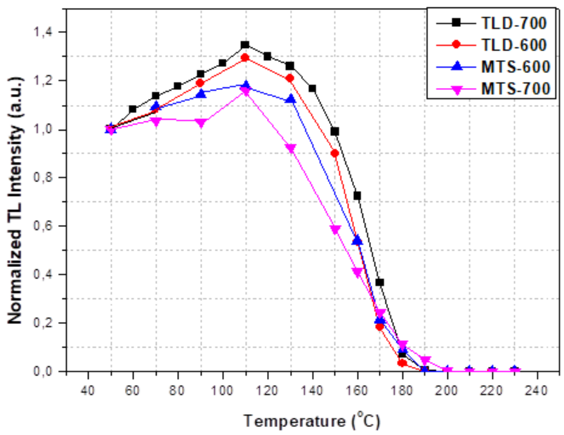


Figure 1 (left): TL intensities versus Temperature for TLD-700 for the dose of 1,9 Gy.
Figure 2 (right): Normalized TL intensities of peak 5 for all four samples of LiF family.

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^{137}cs vertical distribution at the Aegean sea: a study on mixing and advection of seawater masses

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Oceanographic phenomena can be studied using radiometric techniques as complementary tools in oceanographic measurements. A work combining radiometry and oceanography has been implemented previously in deep basins of Aegean Sea [1] and at the deep Cretan basin in May of 2014 [2].

In this work radiological measurements were performed in samples collected from 7 stations of the Aegean Sea, during March 2017. The primary goal was to determine the activity concentration of ^{137}Cs and to study the seawater mixing processes through the vertical distribution of ^{137}Cs in the deep basins of Aegean Sea. The activity concentrations of ^{137}Cs were combined with oceanographic data (salinity (S), temperature (Θ), dissolved oxygen (DO)) to identify the water masses.

Previous measurements of ^{137}Cs and corresponding oceanographic data were also utilized in order to investigate the water mass interactions, mixing and circulation. The long lifetime of ^{137}Cs, the absence of recent ^{137}Cs inputs in the Aegean Sea (e.g. nuclear tests, nuclear accidents), as well as the fact that it is mainly in soluble phase in the seawater column, makes this tracer the most appropriate to study oceanographic processes and interactions of the different water masses in the Aegean Sea.

The Θ/S and Cs/S diagrams were created and identified the characteristic water masses, their movement and their transformations. ^{137}Cs has been effectively used for the study of the water masses at the Aegean Sea.

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Geant4 Simulations of the gSPEC Experimental Apparatus

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A new setup (gSPEC) for the measurements of magnetic moments in exotic species is proposed for development at FAIR, the international nuclear facility currently under construction in Darmstadt, Germany. The experimental setup will use a few of the state–of–the–art segmented DEGAS detectors available at GSI, acquire a new large dipole magnet to induce external magnetic fields required for the application of the Time–Differential Perturbed Angular Distribution (TDPAD) technique and integrate ancillary detection systems as part of a research plan to study the properties of exotic species that will made available at FAIR.

At the current stage, the envisioned gSPEC setup is still in R&D. Several configurations of the detectors are considered, but optimization relies on detailed simulations of the total efficiency in various geometries. In this work, DEGAS detectors and a split-pole superconducting magnet are studied using the latest GEANT4 simulation package. The simulations aim to offer insight on the detector setup performance before gSPEC is actually constructed.

Radiological Characterization of Contaminated Pipes of Different Dimensions and Densities

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The present work concerns a preliminary work for development of a technique for radiological characterization and segregation of raw historical radioactive waste in different management routes.

The efficiency of a 3x3 NaI (Tl) detector for a contaminated pipe - detector configuration was evaluated by Monte Carlo simulations performed by using the MCNP code. Three activity distributions at the internal surface of the pipe were modelled: i) homogeneous activity distribution ii) over a ring at the one edge iii) over a ring at the middle. The non-homogeneous activity distributions represent the worst envisaged cases of inhomogeneity. The models were validated against experimental measurements [1].

The measurements bias due to possible inhomogeneity in the distribution of the activity was examined for pipes of different density and dimensions.

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A detailed study of the high energy neutron flux (15-20 MeV) at NCSR 'Demokritos' using a BC501A liquid scintillator

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Neutron induced reactions, especially the (n,p), (n,xn) and (n,f) ones, are of considerable importance for the fundamental nuclear physics research as well as for nuclear technology, medical and industrial applications. These reactions, for the highest possible neutron beam energies, have been studied by our group in a variety of medium and high-Z targets at the 5.5 MeV Tandem Accelerator of NCSR 'Demokritos', where such neutrons are produced via the $^{3}H(d,n)$ reaction. The primary deuteron beam, as well as the secondary neutron one, may further induce parasitic neutrons having lower energies and thus the accurate characterization of the total neutron beam flux impinging on the targets under study is mandatory in order to extract reliable cross section values.

The current study was carried out for neutron beam energies ranging between 14.8 to 19.2 MeV and included neutron/gamma discrimination and neutron monitoring utilizing a BC501A liquid scintillator, followed by a pulse shape discrimination-capable circuit. Tests were conducted in order to determine the characteristics and limitations of the employed experimental setup.

The deconvolution of the acquired spectra was performed using the DIFBAS computer code. The algorithm is based on the Bayesian conditional probability and the covariance filter method was employed to calculate the *a posteriori* neutron flux spectrum along with its covariance matrix.

The produced neutron beam proved to be practically monoenergetic for low energy deuterons, while at higher deuteron beam energies, the strong presence of parasitic and scattered neutrons was revealed.

^{198}Hg(n,2n)^{197m}Hg reaction cross sections at 17.7 and 19.3MeV

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The cross-section of ^{198}Hg(n, 2n)^{197m}Hg nuclear reaction was measured for neutron energy 17.7MeV and 19.3MeV by the activation method with respect to the ^{27}Al(n,α)^{24}Na, ^{93}Nb(n, 2n)^{92m}Nb and^{197}Au(n,2n)^{196}Au reference reactions. In this energy region there are no experimental data available in literature, while at lower energies, below 15 MeV, the existing data are scarce and discrepant. The high-energy neutron beam was produced by means of the ^{3}H(d,n)^{4}He reaction using a Ti-tritiated target of 373 GBq activity,in the Tandem Van der Graaf 5.5MV accelerator of the National Center for Scientific Research "Demokritos". The target assembly was placed at about 2 cm from the tritium target, limiting the angular acceptance to ±15°, so that the produced neutrons were practically isotropic and monoenergetic. The flux variation of the neutron beam was monitored by a BF_3 detector placed at a distance of 3 m from the neutron source and a BC501A liquid scintillator. After the end of the irradiation, the target and reference foils were measured with gamma-ray spectroscopy implementing HPGe detectors of 16%, 50% and 80% absolute efficiencyies.The ^{198}Hg(n, 2n)^{197m}Hg reaction is contaminated by the ^{199}Hg (n,3n)^{197m}Hg reaction. Theoretical calculations based on the EMPIRE code were used to estimate the contribution of the contaminant reaction and deduce the corrected cross section of the ^{198}Hg(n, 2n)^{197m}Hg reaction.

Development of a semi-empirical calibration method by using a $LaBr_3(Ce)$ scintillation detector for NORM samples analyses

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The last decade $LaBr_3(Ce)$ scintillation detectors have become commercially available and are very promising due to their high light yield (> 65000 photons/MeV) that results in a better energy resolution compared to NaI(Tl) detectors (< 3% FWHM at ^{137}Cs), their decay time of 35 ns and their material density (5.29 g/cm^3) [1, 2]. Also, there is no need for nitrogen cooling and it is easier to be simulated comparing to HPGe detectors. Thus, $LaBr_3(Ce)$ detectors could be a suitable choice for environmental radiation monitoring [3] and in-situ measurements of NORM [4].

In this study, a semi-empirical calibration method for NORM samples measurement was developed based on a combination of experimental gamma spectrometry measurements and MCNPX simulations. The aim of this work is to provide us with full energy peak efficiency calibration curves in a wide photon energy range which is of particular importance when selected photon energies of ^{234}Th, ^{214}Pb, ^{214}Bi, ^{228}Ac, ^{208}Tl and ^{226}Ra are to be measured with accuracy.

A Canberra scintillation detector $LaBr_3(Ce)$ (Model LABR-1.5x1.5) and four reference multi-nuclide volume sources made of epoxy material of different densities were used. Experimental efficiency calculations were performed with the volume sources adapted on an acetal holder which was positioned in a vertical direction along the detector axis of symmetry. MCNPX simulations were performed in order to evaluate the full energy peak efficiency calibration for this source-detector configuration. The models were validated by using the experimental results. Then, nominal samples were analyzed for evaluation of the laboratory technique.

The accurate NORM samples analyses will be helpful for validating the in-situ techniques which will be developed for large volume sources radiological characterization.

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Characterization of a neutron irradiation facility based on radionuclide sources using Monte Carlo simulations and activation dosimetry

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The characterization of an irradiation facility based on radionuclide neutron sources is discussed. The facility was developed by modifying an existing Prompt Gamma Neutron Activation Analysis (PGNAA) system for bulk samples analysis [1]. The main modifications included the utilization of two ^{239}Pu-Be sources with a total activity of 444 GBq and the installation of a sample holder which enabled insertion of samples close to the sources. Monte Carlo simulations using MCNP6 code were performed to predict neutron fluence at the positions of the samples. A detailed model of the irradiation facility was developed, including the actual size and shape of the sources, their containment, the graphite reflector as well as the shielding of the facility, which comprised boron- and lead- doped polyethylene. Moreover, the samples and their aluminum holder were described in detail.

The results of the simulations were compared against neutron fluence measurements performed employing the activation foil technique. In particular, disc-shaped gold, indium, manganese, titanium, iron, zinc, copper, aluminum and cobalt foils were used. After the irradiation, gamma measurements were performed using a germanium detector based spectrometry system. The results of the study provide important information on the neutron fluence and energy spectrum at the irradiation positions of the facility, which will be used to study the effect of fast neutron irradiation on samples as well as in neutron dosimetry research.

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Inter-comparison exercise utilizing x- and γ-ray spectrometry

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Radionuclides are characterized by their nuclear and chemical behavior. Additionally, the geochemical characteristics of radionuclides result in their accumulation in the sediments via sorption processes. In this work the radionuclide activity concentrations obtained by gamma-ray spectrometry (HPGe detector) were converted to metal concentrations as described in [1]. The results were compared with the measured metal concentrations obtained by atomic spectrometry (X-ray fluorescence system-XRF). The samples originate from the coastal environment of two Greek areas, characterized by elevated values of natural radionuclides (e.g. ^{226}Ra) and metals. The preliminary study revealed a good agreement among the concentrations of potassium calculated via activity concentrations of ^{40}K and those of XRF measurement, while a great divergence was observed for the thorium case. These differences can be attributed to the low statistics, as well as to the calibration set-up of Th XRF measurement.

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An upgrade of the UoA nuclear electromagnetic moments database

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A unique worldwide database of nuclear electromagnetic moments data has been hosted online at the University of Athens since 2012 (url: http://magneticmoments.info) [1]. The database features experimentally deduced values of magnetic dipole and electric quadrupole moments of ground and excited states, alongside with additional spectroscopic information (half-lives, spin etc). Elementary particle data are also available, adopting directly the Particle Data Group Evaluations (PDG).

We report on a recent upgrade of the database which has focused on syncing level energies, half-lives, and spin/parity values with the ENSDF database [2]. Mass–excess values have been added in sync with the AME2016 evaluation [3]. Additionally, an exhaustive search of published literature has resulted in over a hundred new or updated entries of magnetic dipole moments μ, and electric quadrupole moments Q. A major incorporation to the database is about a thousand experimental data values of nuclear charge radii (rms, $\delta\langle r^2\rangle$) that started in 2017 and is reported for the first time.

The effort to gather and analyze the above data for the benefit of the community is substantial, due to the rapid publication of all the related papers, making this database a quick and user-friendly way to access them. A key feature of this database is the inclusion of the DOI (digital object identifier) and NSR keywords linked to the original citations. Future plans include persistence in frequent data updates, upgrade of the database skeleton and frontend, as well as incorporation of a nuclear moments evaluation currently in the works.

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Differential cross-section measurements of the $^{31}P(p,p'\gamma)^{31}P$ reaction for target characterization using the PIGE technique

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Phosphorus (natural abundance: 100% ^{31}P) is a highly reactive light element which is met in natural heritage and in many geological, environmental, medical and technological applications. Many phosphate compounds are commonly used for fertilizers and pesticides, but also for detergents. Moreover, phosphorus is used as a dopant for n-type semiconductors, and it is important in archeology, where the precise bulk quantification with the minimum possible sample damage is desired. Among the most common least destructive techniques used for quick and accurate bulk analysis (if the determination of depth profile concentrations is not required) are the Ion Beam Analysis (IBA) ones, namely Particle Induced X-ray Emission (PIXE) and Particle Induced Gamma-ray Emission (PIGE). In the case of matrices where phosphorus coexists with other light elements (e.g. F, B, Al etc.), PIGE can provide more detailed information allowing for the simultaneous determination of several main light isotopes. However, there is a lack of differential cross-section datasets for the $^{31}P(p,p'\gamma)^{31}P$ reaction in literature, with just two measurements [1, 2] at 90° available in the Ion Beam Analysis Nuclear Data Library (IBANDL, https://www-nds.iaea.org/exfor/ibandl.htm). These datasets have an overlap at a limited energy range where the discrepancies are negligible; nevertheless, it is crucial for the applications, but also for theoretical calculations, to have differential cross sections for multiple angles and higher energies. Therefore, an experiment was conducted at the 5.5 MV HV Tandem Accelerator Laboratory of the Institute of Nuclear and Particle Physics (INPP) of the National Center for Scientific Research "Demokritos" (NCSR – "D") in Athens, Greece, using proton beam energies $E_p \sim 2.6 – 4$ MeV and four (4) HPGe detectors placed at 0°, 55°, 90° and 165° with respect to the beam direction. The obtained results will be presented.

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Angular Elastic Neutron Distribution Of ^{122}Te and ^{11}B

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In fission and fusion reactor designs, it is important to calculate cross-section for nuclear reactions which are induced by neutron. Angular distribution of ^{122}Te and ^{11}B have been theoretically calculated at different incident energy using TALYS 1.8 nuclear reaction code. Evaluated theoretical results are compared with available experimental data in EXFOR International Nuclear Data Library. Results show that, theoretically evaluated and experimental values are in good agreement.

^{237}Np reactions with fast neutrons: a phenomenological study

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Neptunium presents various opportunities as nuclear fuel, especially in deep–space mission power generators. Neutron activation of ^{237}Np leads to the production of ^{238}Np which can subsequently provide ^{238}Pu via β–decay. Furthermore, ^{237}Np is part of the nuclear spent fuel of PWR, raising waste management concerns due to its long half-life as an α-emitter. The scarcity of experimental data [1] in the fast neutron energy range highlights the necessity to investigate the radiative neutron capture and neutron–induced fission cross sections of this radioisotope. In the present work, statistical modeling of these reactions is performed using TALYS [2] in an extended range of neutron energies between 100 keV and 20 MeV. In total, 72 different combinations of code parameters were selected [3–5] to study the level density and γ-strength function dependence of the cross section in ^{238}Np. Preequilibrium and compound nucleus formation phenomena are also examined. Theoretical calculations are compared to available experimental total cross section data found in literature [1,6] in an attempt to investigate any discrepancies between experiment and theory and validate statistical uncertainties.

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Natural radioactivity content in Italian bottled mineral waters

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The bottled water industry is fast growing worldwide. With a total of ~440 billion liter consumption and ~$240 billion value of the global bottled water market, many issues arise concerning the energy needed for the production and transportation, the environmental footprint, the increase of the plastic pollution, the privatization and without any public control exploitation of the water resources etc. Although the consumption of bottled water is generally accepted as a healthy practice, in some cases the existence of natural radionuclides and thus of radioactivity in bottled water could pose a risk for the public health. especially in the case of increased consumption. The most common radioactive isotopes found in bottled waters are uranium, radium, polonium and in less extent thorium, due to its low solubility in water. These isotopes if exist in excess, may pose a threat for the public health and the monitoring for the radioactivity content is needed.

This work deals with gross alpha and beta measurements as well as uranium, radium and polonium radioactivity in 30 brands of bottled water produced in Italy. There are more than 240 brands and 140 bottling water factories through over Italy. This study aims to confront the lack of data for radioactivity in Italian bottled waters. Water samples from 30 Italian brands were measured using the LSC method to measure the gross alpha and beta content as well as the activity concentration of uranium, radium and polonium isotopes. Also applying another method, in which the radium and polonium isotopes were first, sorbed onto small polyamide pieces of 2.3 cm × 2.3 cm surface, coated with a thin film of MnO_2 and then measured by α-spectrometry. The details of the measurement methods were presented elsewhere [1, 2].

The analysis using the MnO_2 thin films showed that the radium activity in waters varied from 4.7-69.3 $mBqL^{-1}$ and the polonium activity varied from 5.9-26.8 $mBqL^{-1}$. The measurements with the LSC method showed uranium concentrations varying from 0.6-116.6 $mBqL^{-1}$, while the radium activities exhibited variations from 1.7-36.4 $mBqL^{-1}$. Finally the gross beta activity values varied from 1.9-1584.9 $mBqL^{-1}$ and the gross alpha from 0.6-329.4 $mBqL^{-1}$.

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Reactions between irradiation defects and carbon solute atoms in Fe studied by resistivity recovery measurements

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Reduced-activation ferritic/martensic (RAFM) steels are the primary choice for the structural materials of future fusion power plants due to their high resistance to radiation damage accumulation and swelling. Carbon is one of the most important alloying elements in steels playing a key role in the development of the microstructure and the mechanical properties. Furthermore, carbon has a great influence on the irradiation response due to its strong interaction with radiation defects. Previous studies have shown the formation of carbon-defect complexes which exhibit reduced mobility and have a significant impact on the recovery of radiation damage.

In this work we investigate the interactions between carbon atoms and radiation defects in Fe as a model material for the behaviour of more complex RAFM steels. Pure and C-doped Fe specimens were irradiated with 5 MeV protons at the NCSR-"Demokritos" TANDEM accelerator. Irradiations were carried out at cryogenic temperature (T=25 K) where the defects created by the irradiating particles remain initially immobile in the lattice. During the subsequent post-irradiation isochronal annealing up to 700 K the defects start to migrate and interact either mutually or with the C impurities. The defect evolution is observed by *in-situ* electrical resistivity recovery measurements. Comparison of results from pure and C-doped specimens reveals the effect of C solute atoms on the defect kinetics. The most important observation is the trapping of interstitial defects by carbon atoms and the migration of carbon at T>300 K.

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Proton-Induced Spallation Reactions on Fe targets *

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Measured excitation functions of 16 reaction products in ^{A}Fe(p,x) reactions are compared with model calculations in a wide energy range. Reaction products of interest involve ^{36}Cl, ^{38}Ar, ^{42,43}K, ^{44}Ti, ^{46,47,48}Sc, ^{48,51}Cr, ^{52}Fe, ^{52,54}Mn and ^{55,56,57}Co. Experimental data were obtained from an International Nuclear Data Committee (INDC) compilation on proton induced reactions on ^{56}Fe from threshold to 2.6 GeV [1] and recent measurements of excitation functions of proton-induced reactions on ^{nat}Fe in the energy region from threshold up to 45 MeV [2].

At energies less than 200 MeV, excitation functions calculated with the code TALYS [3] are in good agreement with the experimental data, apart from some discrepancies for the Sc, Ti and K isotopes. Isotopic distributions are also calculated in the framework of the intranuclear cascade code ISABEL [4,5] coupled with the sequential binary decay code MECO [6]. A good agreement is found with the majority of the experimental data in the energy range from 50 to 1500 MeV.

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Determination of Natural Radionuclides in the Region of Oil Shale-Fired Power Plants in Northwest Greece

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Large amounts of NORM ((Naturally Occurring Radioactive Material) are produced every year from the oil shale-fired power plants. The activity concentrations of the natural radionuclides, present elevated values on the ground and in the atmosphere in areas near the plants and therefore it is worth to evaluate their dispersion and to assess the radiological status.

Using gamma spectrometry with a HP-germanium detector in a low background configuration, activity concentrations for the ^{238}U, ^{232}Th and ^{40}K in soil and water samples around the oil shale-fired power plants in northwest Greece were measured. Furthermore alpha-ray spectrometry with appropriate radiochemical separations was applied for the determination of the uranium isotopes (^{238}U and ^{234}U). The resulting determined enrichment (EFs) and contamination factors (CFs) also provide an estimation of the radiation hazard and the pollution in these regions.

Macroscopic X-ray fluorescence characterization of Platinum Group Mineral inclusions in archeological gold

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In May 2015, a team from the University of Cincinnati discovered an unlooted Mycenaean grave near the Palace of Nestor in Pylos Messenia. Among the excavated goods, four gold signet rings were found, decorated with Minoan rituals [1, 2]. The holistic macro-XRF (MA-XRF) imaging analysis of the external surface of the rings using the state of art LANDIS-X mobile x-ray scanner [3], offered the unique possibility of identifying several platinum group mineral inclusions (PGMs) containing elements such as osmium, iridium and ruthenium. The presence of PGM inclusions in ancient gold objects is considered a clear indication that the gold and the PGM inclusions became associated as a result of fluvial transport [4].

The aim of the present work is the detailed characterization of the PGM inclusions in terms of their morphological and compositional profile. Since it is first time that PGM inclusions are detected in Mycenaean gold, it is expected that the results of the present work will provide a sound basis for comparison of Mycenaean gold with other Bronze Age gold artefacts found in Egypt and elsewhere, shedding a first light to the mystery of the wealth acquisition of the Mycenaean reign.

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TL Dose response of Beryllium Oxide (BeO) radiation dosimeter at elevated temperatures

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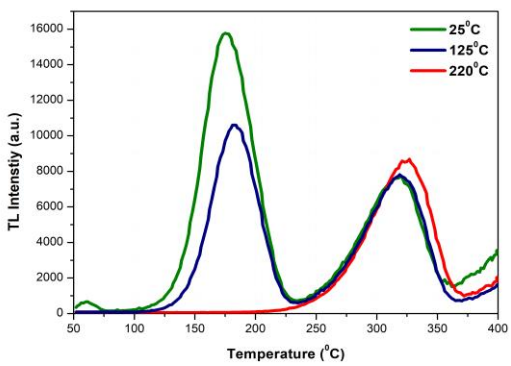
Beryllium oxide is a radiation detector and a dosimetric material that is widely studied due to its interesting characteristics, as well as its commercial availability and low cost. It presents strong thermoluminescence (TL) intensity, high sensitivity in ionizing radiation, as well as tissue-equivalent properties ($Z_{Eff} \approx 7.14$), making it an ideal luminescence dosimeter. An important characteristic of thermoluminescent dosimeters (TLD) is the TL dose response, which determines the dose range of usability of the dosimeter subject to dose response linearity. Also, determines the precision of dose measurement as a function of dose.

In the present study, the dose response linearity of the glow peaks in $BeO:Li^+,Al^+$ has been demonstrated, for three different irradiation temperatures of 25^0C, 125^0C and 220^0C. The kinetic parameters of the traps were determined, using Computerized Curve Deconvolution (CCD) method.

Fig. 1 shows examples of glow curves obtained for the same dose at the three irradiation temperatures (25^0C, 125^0C, 220^0C). Fig. 2 shows the TL dose response of both peaks at room temperature.



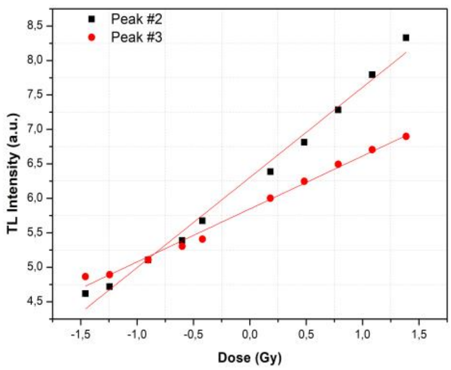


Figure 1: (Left): BeO TLD dose response curves which were obtained in three different irradiation temperatures (25^0C, 125^0C, 220^0C) for a dose of 0.38 Gy.
Figure 2: (Right): BeO TLD dose response of the second (#2) and third (#3) peak at 25^0C following $^{90}Sr/^{90}Y$ irradiation.

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